M.A.M SCHOOL OF ENGINEERING

Accredited by NAAC

Approved by AICTE, New Delhi. Afflicated to Anna University, Chennai.

Trichy – Chennai Trunk road, Siruganur, Tiruchirappalli – 621 105.

DEPARTMENT OF AERONAUTICAL ENGINEERING

Teacher Teach Teachers Scheme (TTT)

Title: Stress Analysis in Aircraft

Venue: Aerodynamics Laboratory

Date & Time: 14.02.2020 & 04.00 pm to 05.00 pm

Mentor Faculty	Faculty Attended
Dr.P.V.K. Perumal	Dr.K.Chandrasekaran Mr.K.M.Sridhar Mr.Dineshbabu Ms.V.Priyadharshini Ms.J.Jebapriyadharshini

Dept.of Aeronauti Engg

13/2/20

HOD/AERO

Head of the Department
Aeronautical Engineering
M.A.M.School of Engineering
Siruganur,Trichy - 621 105.

Scanned with CamScanner

Contents

- The primary purpose of this reader is to describe the use of analysis equations and methodologies of structures for design purposes. It is common these days that we hear from industry that the students graduating with engineering degrees do not know how to design whether it is structures, or mechanical systems, or systems from other engineering disciplines. We therefore put the emphasis in this course on design.
- Anybody who has some understanding of the design process, however, realises that without a thorough understanding of the use of analysis methods it will not be possible to design at least a reliable system. It is, therefore, important to establish a sound and firm analysis foundation before one can start the design practice.
- The approach used in this reader, however, is different from the traditional one in which analysis and designs are taught in different portions of the course. Instead we will use an approach in which small portions (sections) of topics from analysis are first introduced immediately followed by their design implementation.
- A more detailed description of the outline and the contents of the reader is provided in the following. The reader is divided into two primary sections because of a very important concept, called statical determinacy, that has a very strong influence on the way structures are designed. It is of course too early to completely describe the impact of statical indeterminacy on design.
- It will be sufficient to state at this point that statical determinacy simplifies the design process of a structure made of multiple components by making it possible to design individual components independent from one another. Structural indeterminacy on the other hand causes the internal load distribution in a given structural system to be dependent on the dimensional and material properties of the individual component that are typically being designed. T
- hat is, as the design of the individual components change the loads acting on those components for which they are being designed also change. Hence, individ1 2 ual components cannot be designed independently as the design changes in these components and the other components around them alter the loads that they are being designed for.
- The resulting process is an iterative one requiring design of all the individual components to be repeated again and again until the internal load redistribution stabilises, reaching an equilibrium state with the prescribed external loading.

M.A.M SCHOOL OF ENGINEERING

Accredited by NAAC

Approved by AICTE, New Delhi. Afflicated to Anna University, Chennai.

Trichy – Chennai Trunk road, Siruganur, Tiruchirappalli – 621 105.

DEPARTMENT OF AERONAUTICAL ENGINEERING

Teacher Teach Teachers Scheme (TTT)

Title: Composite Materials in Aircraft Design

Venue: Aerodynamics Laboratory

Date & Time: 10.02.2020 & 04.00 pm to 05.00 pm

Mentor Faculty	Faculty Attended
Dr.K.Chandrasekaran	Mr.K.M.Sridhar Mr.Dineshbabu Ms.V.Priyadharshini Ms.J.Jebapriyadharshini

HOD/AERO

Head of the Department
Aeronautical Engineering
M.A.M.School of Engineering
Siruganur,Trichy - 621 105.

Scanned with CamScanner

Contents

- Composite materials are widely used in the Aircraft Industry and have allowed engineers to overcome obstacles that have been met when using the materials individually.
- The constituent materials retain their identities in the composites and do not dissolve or otherwise merge completely into each other. Together, the materials create a 'hybrid' material that has improved structural properties.
- The development of light-weight, high-temperature resistant composite materials will allow the next generation of high-performance, economical aircraft designs to materialize. Usage of such materials will reduce fuel consumption, improve efficiency and reduce direct operating costs of aircrafts.
- Composite materials can be formed into various shapes and, if desired, the fibres can be wound tightly to increase strength. A useful feature of composites is that they can be layered, with the fibres in each layer running in a different direction.
- This allows an engineer to design structures with unique properties. For example, a structure can be designed so that it will bend in one direction, but not another.
- n a basic composite, one material acts as a supporting matrix, while another material builds on this base scaffolding and reinforces the entire material. Formation of the material can be an expensive and complex process.
- In essence, a base material matrix is laid out in a mould under high temperature and pressure. An epoxy or resin is then poured over the base material, creating a strong material when the composite material is cooled. The composite can also be produced by embedding fibres of a secondary material into the base matrix.
- Composites have good tensile strength and resistance to compression, making them suitable for use in aircraft part manufacture. The tensile strength of the material comes from its fibrous nature. When a tensile force is applied, the fibres within the composite line up with the direction of the applied force, giving its tensile strength.
- The good resistance to compression can be attributed to the adhesive and stiffness properties of the base matrix system. It is the role of the resin to maintain the fibres as straight columns and to prevent them from buckling.

M.A.M SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Teacher Teach Teachers

Report

The Session was initiated by Mr. G. Rajesh Kumar, AP/CSE, where he started describing about "Quantum Computing"

The agenda includes the seminar on

- Introduction of Quantum Computing
- The need for speed
- Classical vs Quantum bits
- Quantum Computing Power
- Practical Quantum Computer Applications
- Quantum Computing History
- Quantum Computing Problems

Then the session came to an end with the hand on programming with Quantum Computing.

HOD **PRINCIPAL**

M.A.M SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Teacher Teach Teachers

Date : *26-10-2019*

Speaker :

Mr.G.Rajesh Kumar, M.E.,
Assistant Professor/ CSE

Staff Attended :

1. Mr. T.Ashok
2. Ms. S.Murugavalli
3. Mrs. D.Sumathi
4. Mrs.V.Vidhya
5. Mr. S.Nayagan
6. Mr. K.Sathish Kumar

Topic : Quantum Computing.

Venue : AB105 CSE Department

Enclosure : Report, PPT.

HOD **PRINCIPAL**

Quantum Computing

The Next Generation of Computing Devices?

by Heiko Frost, Seth Herve and Daniel Matthews

What is a Quantum Computer?

- *Quantum Computer*
  - *A computer that uses quantum mechanical phenomena to perform operations on data through devices such as superposition and entanglement.*
- *Classical Computer (Binary)*
  - *A computer that uses voltages flowing through circuits and gates, which can be calculated entirely by classical mechanics.*

The Need For Speed...

- *Classical Digital Computer*
  - *Moore's Law: # of transistors on chip doubles every 18 months—microprocessor circuits will measure on atomic scale by 2020-2030*
  - *Downscaling of circuit board layout/components is leading to discrepancies.*
    - *Copper traces are actually crystallizing and shorting out!*
    - *Emergence of quantum phenomena such as electrons tunneling through the barriers between wires.*
  - *Serial Processing – one operation at a time*
    - *64-bit classical computer operates speeds measured in gigaflops (billions of floating-point operations per second).*
- *Quantum Computer*
  - *Harnesses the power of atoms and molecules to perform memory and processing tasks*
  - *Parallel Processing – millions of operations at a time*
    - *30-qubit quantum computer equals the processing power of conventional computer that running at 10 teraflops (trillions of floating-point operations per second).*

Classical vs Quantum Bits

- *Classical Bit*
  - *2 Basic states – off or on: 0, 1*
  - *Mutually exclusive*
- *Quantum Bit (Qubit)*
  - *2 Basic states – ket 0, ket 1:* $|0\rangle$, $|1\rangle$
  - *Superposition of both states – (not continuous in nature)*
    - *Quantum entanglement*
      - *2 or more objects must be described in reference to one another*
      - *Entanglement is a non-local property that allows a set of qubits to express superpositions of different binary strings (01010 and 11111, for example) simultaneously*

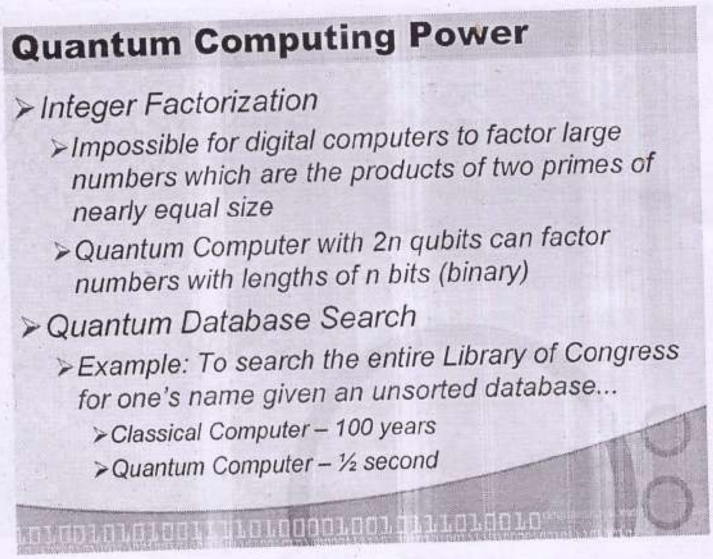
Pure Quibit State:

$\Psi = a|0\rangle + b|1\rangle$

where $a, b \in £$

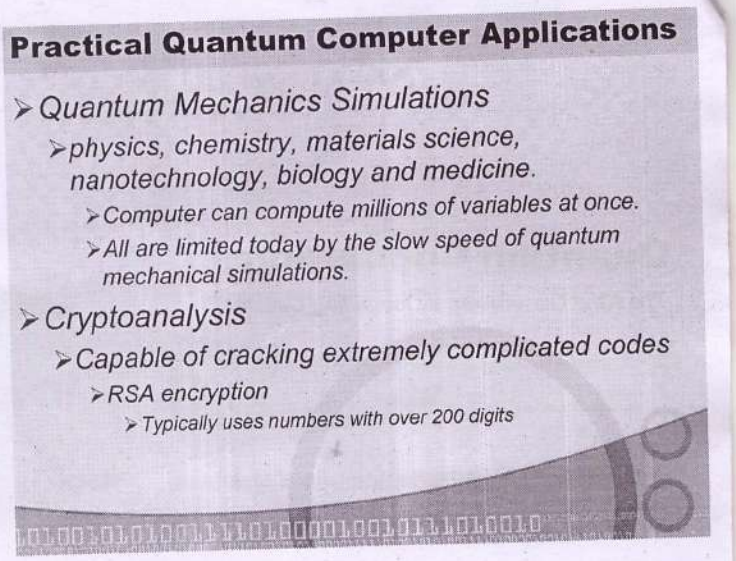
s.t. $1 = \sqrt{|a|^2 + |b|^2}$

$\boxed{\therefore \text{ 8 Possible States per Qubit}}$



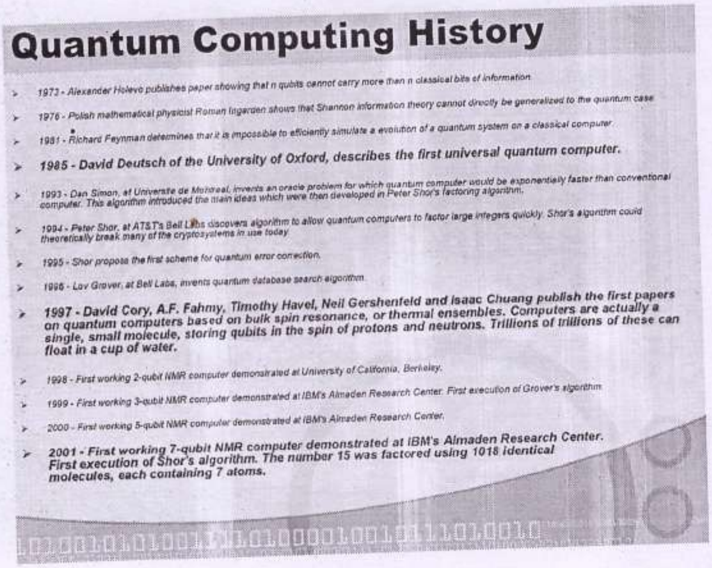
Quantum Computing Power

- *Integer Factorization*
  - *Impossible for digital computers to factor large numbers which are the products of two primes of nearly equal size*
  - *Quantum Computer with 2n qubits can factor numbers with lengths of n bits (binary)*
- *Quantum Database Search*
  - *Example: To search the entire Library of Congress for one's name given an unsorted database...*
    - *Classical Computer – 100 years*
    - *Quantum Computer – ½ second*



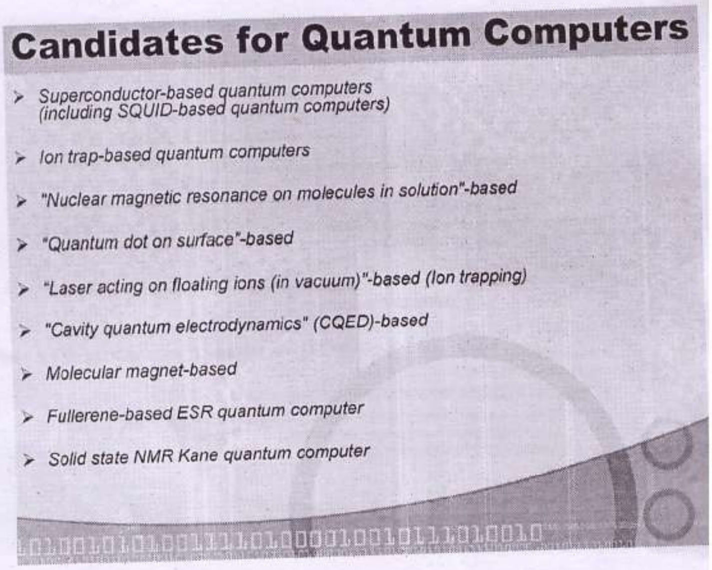
Practical Quantum Computer Applications

- *Quantum Mechanics Simulations*
  - *physics, chemistry, materials science, nanotechnology, biology and medicine.*
    - *Computer can compute millions of variables at once.*
    - *All are limited today by the slow speed of quantum mechanical simulations.*
- *Cryptoanalysis*
  - *Capable of cracking extremely complicated codes*
    - *RSA encryption*
      - *Typically uses numbers with over 200 digits*



Quantum Computing History

- *1973 - Alexander Holevo publishes paper showing that n qubits cannot carry more than n classical bits of information*
- *1976 - Polish mathematical physicist Roman Ingarden shows that Shannon information theory cannot directly be generalized to the quantum case*
- *1981 - Richard Feynman determines that it is impossible to efficiently simulate a evolution of a quantum system on a classical computer*
- **1985 - David Deutsch of the University of Oxford, describes the first universal quantum computer.**
- *1993 - Dan Simon, at Universite de Montreal, invents an oracle problem for which quantum computer would be exponentially faster than conventional computer. This algorithm introduced the main ideas which were then developed in Peter Shor's factoring algorithm.*
- *1994 - Peter Shor, at AT&T's Bell Labs discovers algorithm to allow quantum computers to factor large integers quickly. Shor's algorithm could theoretically break many of the cryptosystems in use today*
- *1995 - Shor propose the first scheme for quantum error correction.*
- *1996 - Lov Grover, at Bell Labs, invents quantum database search algorithm*
- **1997 - David Cory, A.F. Fahmy, Timothy Havel, Neil Gershenfeld and Isaac Chuang publish the first papers on quantum computers based on bulk spin resonance, or thermal ensembles. Computers are actually a single, small molecule, storing qubits in the spin of protons and neutrons. Trillions of trillions of these can float in a cup of water.**
- *1998 - First working 2-qubit NMR computer demonstrated at University of California, Berkeley.*
- *1999 - First working 3-qubit NMR computer demonstrated at IBM's Almaden Research Center. First execution of Grover's algorithm*
- *2000 - First working 5-qubit NMR computer demonstrated at IBM's Almaden Research Center.*
- **2001 - First working 7-qubit NMR computer demonstrated at IBM's Almaden Research Center. First execution of Shor's algorithm. The number 15 was factored using 1018 identical molecules, each containing 7 atoms.**



Candidates for Quantum Computers

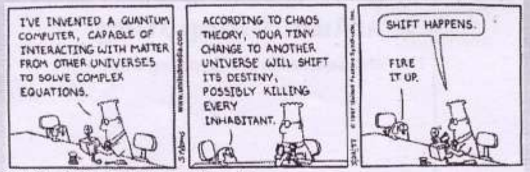
- *Superconductor-based quantum computers (including SQUID-based quantum computers)*
- *Ion trap-based quantum computers*
- *"Nuclear magnetic resonance on molecules in solution"-based*
- *"Quantum dot on surface"-based*
- *"Laser acting on floating ions (in vacuum)"-based (Ion trapping)*
- *"Cavity quantum electrodynamics" (CQED)-based*
- *Molecular magnet-based*
- *Fullerene-based ESR quantum computer*
- *Solid state NMR Kane quantum computer*

antum Computing Problems

- Current technology
  - ≈ 40 Qubit operating machine needed to rival current classical equivalents.
- Errors
  - Decoherence - the tendency of a quantum computer to decay from a given quantum state into an incoherent state as it interacts with the environment.
    - Interactions are unavoidable and induce breakdown of information stored in the quantum computer resulting in computation errors.
  - Error rates are typically proportional to the ratio of operating time to decoherence time
    - operations must be completed much quicker than the decoherence time.

Research References

- http://www.qubit.org
- http://www.cs.caltech.edu/~westside/quantum-intro.html
- http://computer.howstuffworks.com/quantum-computer1.htm
- http://en.wikipedia.org/wiki/Quantum_computers
- http://www.carolla.com/quantum/QuantumComputers.htm



Copyright © 1997 United Feature Syndicate, Inc.
Redistribution in whole or in part prohibited

M.A.M SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Teacher Teach Teachers

Date : *11-01-2020*

Speaker :

Mr.K.Sathish Kumar, M.E.,
Assistant Professor/ CSE

Staff Attended :

1. Ms. S.Murugavalli
2. Mr.G.Rajesh Kumar
3. Mrs.V.Vidhya
4. Mrs.P.Sivamalar
5. Mr. K.Sathish Kumar
6. Mrs. D.Sumathi

Topic : Graphics & Multimedia.

Venue : Peter Norton Lab

Enclosure : Report, PPT.

11/1/2020

HOD

PRINCIPAL

M.A.M SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Teacher Teach Teachers

Report

The Session was initiated by Mr. K.Sathish Kumar, M.E., AP/CSE, where he started describing about "Graphics & Multimedia"

The agenda includes the seminar on

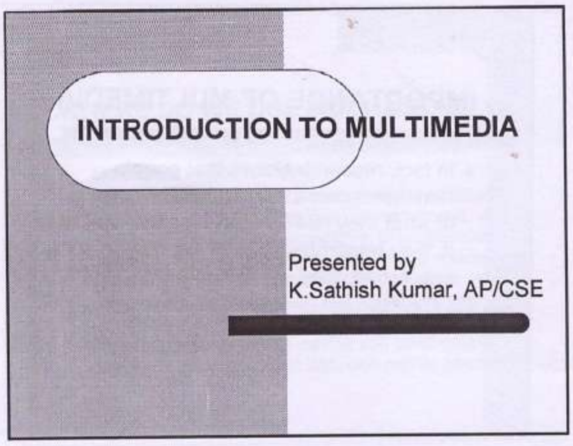
- Introduction of Graphics & Multimedia
- Graphical Representation
- Features of Graphics.
- Types of Media
- Multimedia Applications
- Advantages of Multimedia
- Difference between 2D & 3D Graphics.

Then the session came to an end with the hand on creative designing with Graphics & Multimedia software tools.

11/1/2020

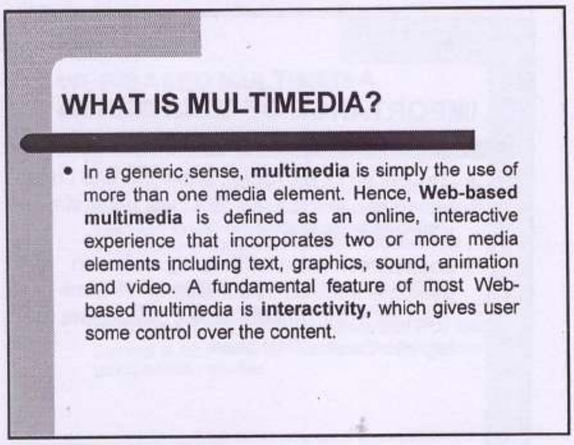
HOD

PRINCIPAL



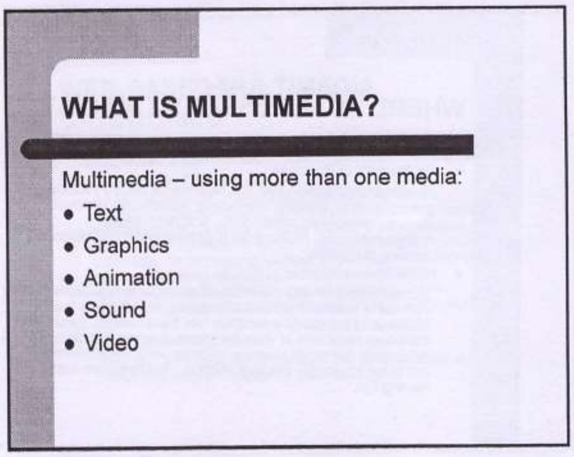
INTRODUCTION TO MULTIMEDIA

Presented by
K.Sathish Kumar, AP/CSE



WHAT IS MULTIMEDIA?

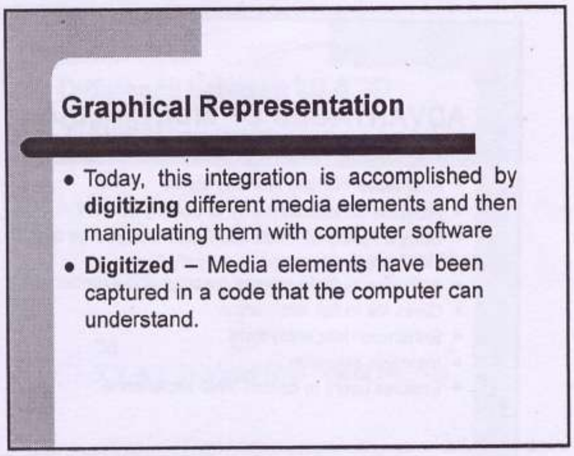
- In a generic sense, **multimedia** is simply the use of more than one media element. Hence, **Web-based multimedia** is defined as an online, interactive experience that incorporates two or more media elements including text, graphics, sound, animation and video. A fundamental feature of most Web-based multimedia is **interactivity,** which gives user some control over the content.



WHAT IS MULTIMEDIA?

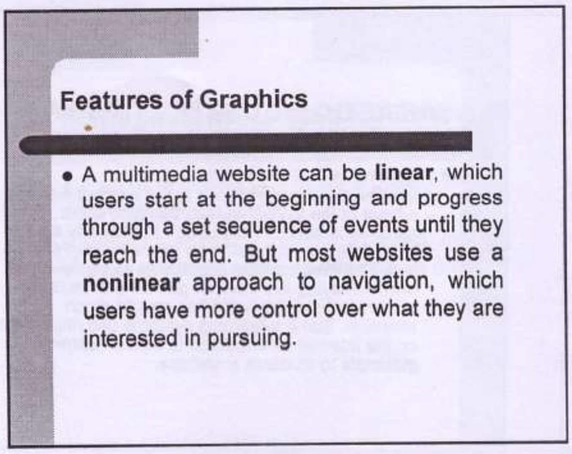
Multimedia – using more than one media:

- Text
- Graphics
- Animation
- Sound
- Video



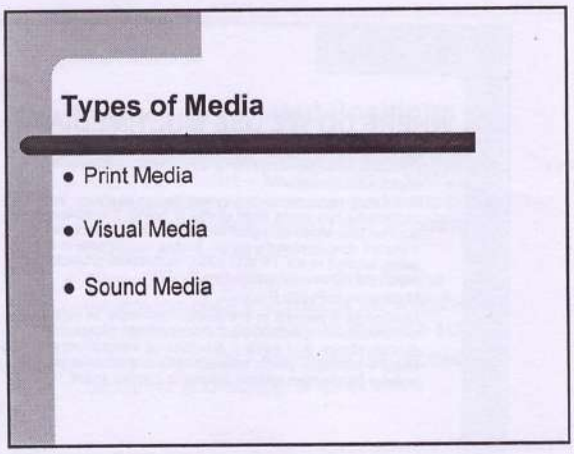
Graphical Representation

- Today, this integration is accomplished by **digitizing** different media elements and then manipulating them with computer software
- **Digitized** – Media elements have been captured in a code that the computer can understand.



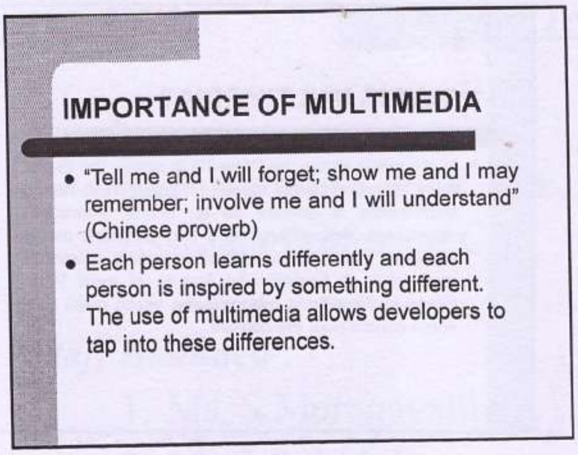
Features of Graphics

- A multimedia website can be **linear**, which users start at the beginning and progress through a set sequence of events until they reach the end. But most websites use a **nonlinear** approach to navigation, which users have more control over what they are interested in pursuing.



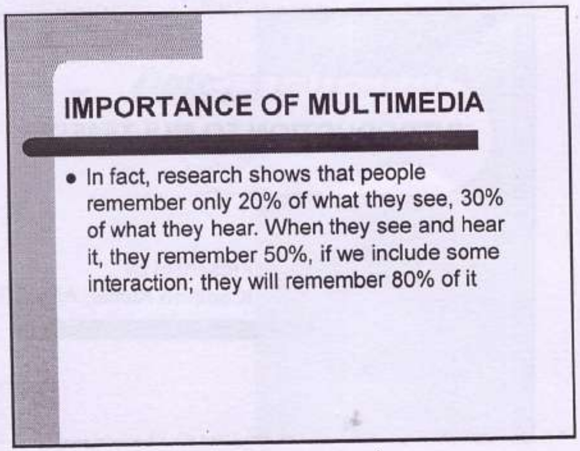
Types of Media

- Print Media
- Visual Media
- Sound Media



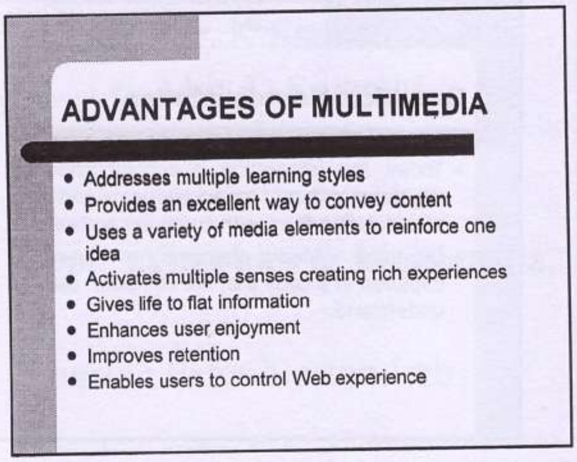
IMPORTANCE OF MULTIMEDIA

- "Tell me and I will forget; show me and I may remember; involve me and I will understand" (Chinese proverb)
- Each person learns differently and each person is inspired by something different. The use of multimedia allows developers to tap into these differences.



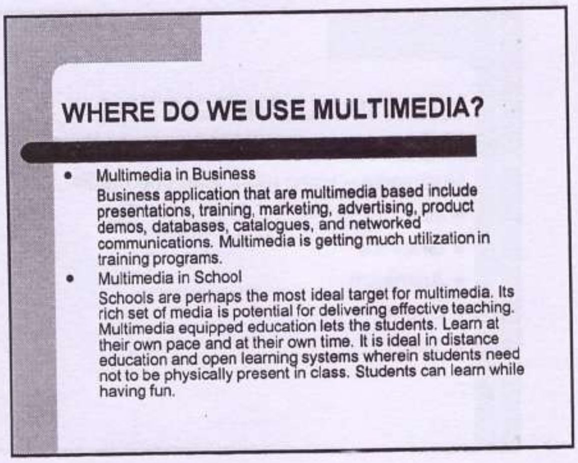
IMPORTANCE OF MULTIMEDIA

- In fact, research shows that people remember only 20% of what they see, 30% of what they hear. When they see and hear it, they remember 50%, if we include some interaction; they will remember 80% of it



ADVANTAGES OF MULTIMEDIA

- Addresses multiple learning styles
- Provides an excellent way to convey content
- Uses a variety of media elements to reinforce one idea
- Activates multiple senses creating rich experiences
- Gives life to flat information
- Enhances user enjoyment
- Improves retention
- Enables users to control Web experience

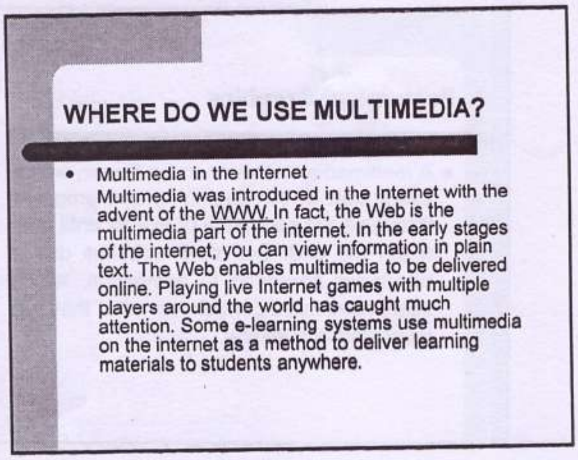


WHERE DO WE USE MULTIMEDIA?

- Multimedia in Business
  Business application that are multimedia based include presentations, training, marketing, advertising, product demos, databases, catalogues, and networked communications. Multimedia is getting much utilization in training programs.
- Multimedia in School
  Schools are perhaps the most ideal target for multimedia. Its rich set of media is potential for delivering effective teaching. Multimedia equipped education lets the students. Learn at their own pace and at their own time. It is ideal in distance education and open learning systems wherein students need not to be physically present in class. Students can learn while having fun.

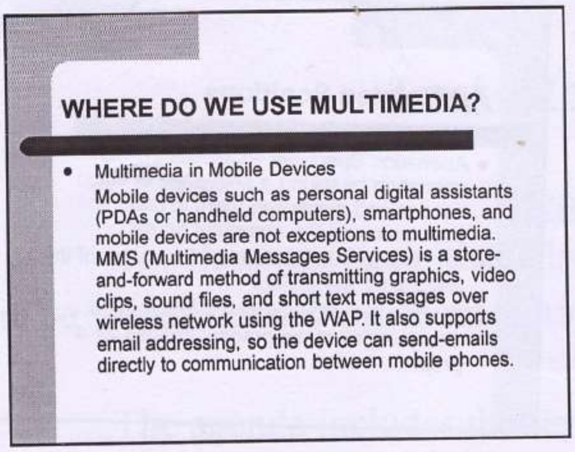
WHERE DO WE USE MULTIMEDIA?

- Multimedia at Home
  From cooking to gardening, home design to repair, indeed multimedia has made itself useful at home. It enables you to convert your video to digital format, store your pictures in a compact disc, and many more. Today, multimedia is also being applied in our TV and soon, multimedia projects will reach out homes via interactive TV (iTV).
- Multimedia in Public Places
  Multimedia is present in standalone terminals, or kiosks, in airport terminals, hotels, mall, train stations, museums, grocery stores, and more. It provides us information and help about a particular place. Interactive kiosks enables you to make a transaction without talking to a sales agent.



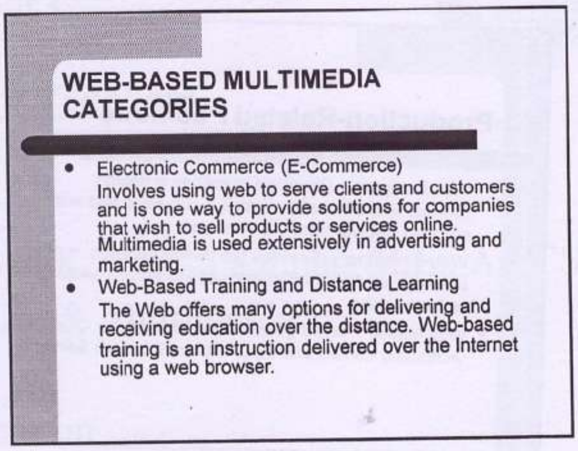
WHERE DO WE USE MULTIMEDIA?

- Multimedia in the Internet
  Multimedia was introduced in the Internet with the advent of the WWW. In fact, the Web is the multimedia part of the internet. In the early stages of the internet, you can view information in plain text. The Web enables multimedia to be delivered online. Playing live Internet games with multiple players around the world has caught much attention. Some e-learning systems use multimedia on the internet as a method to deliver learning materials to students anywhere.



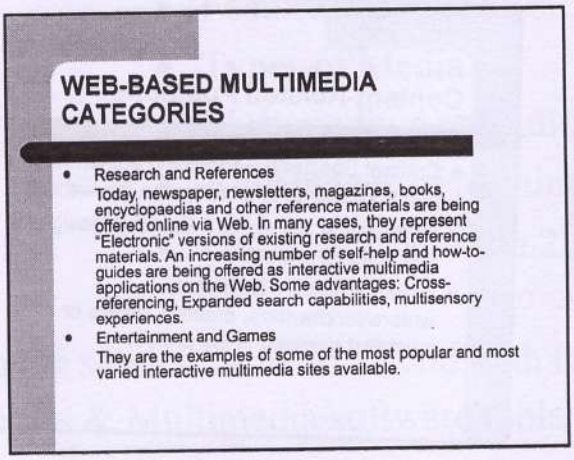
WHERE DO WE USE MULTIMEDIA?

- Multimedia in Mobile Devices
  Mobile devices such as personal digital assistants (PDAs or handheld computers), smartphones, and mobile devices are not exceptions to multimedia. MMS (Multimedia Messages Services) is a store-and-forward method of transmitting graphics, video clips, sound files, and short text messages over wireless network using the WAP. It also supports email addressing, so the device can send-emails directly to communication between mobile phones.



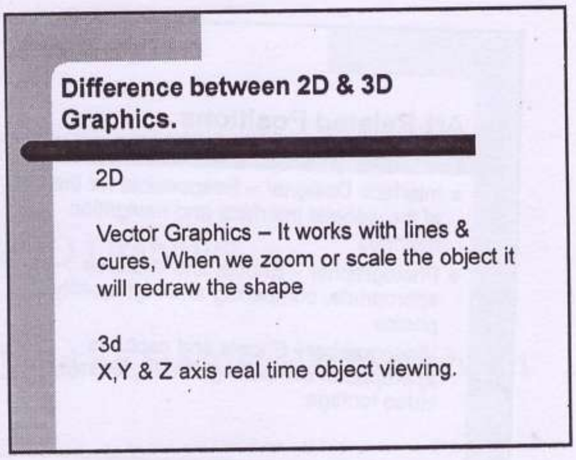
WEB-BASED MULTIMEDIA CATEGORIES

- Electronic Commerce (E-Commerce)
  Involves using web to serve clients and customers and is one way to provide solutions for companies that wish to sell products or services online. Multimedia is used extensively in advertising and marketing.
- Web-Based Training and Distance Learning
  The Web offers many options for delivering and receiving education over the distance. Web-based training is an instruction delivered over the Internet using a web browser.



WEB-BASED MULTIMEDIA CATEGORIES

- Research and References
  Today, newspaper, newsletters, magazines, books, encyclopaedias and other reference materials are being offered online via Web. In many cases, they represent "Electronic" versions of existing research and reference materials. An increasing number of self-help and how-to-guides are being offered as interactive multimedia applications on the Web. Some advantages: Cross-referencing, Expanded search capabilities, multisensory experiences.
- Entertainment and Games
  They are the examples of some of the most popular and most varied interactive multimedia sites available.



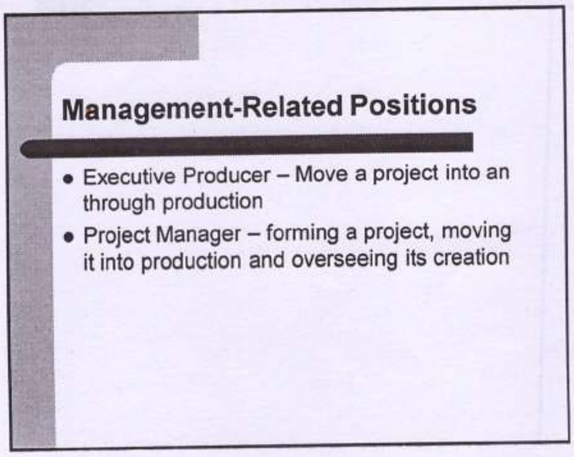
Difference between 2D & 3D Graphics.

2D

Vector Graphics – It works with lines & cures, When we zoom or scale the object it will redraw the shape

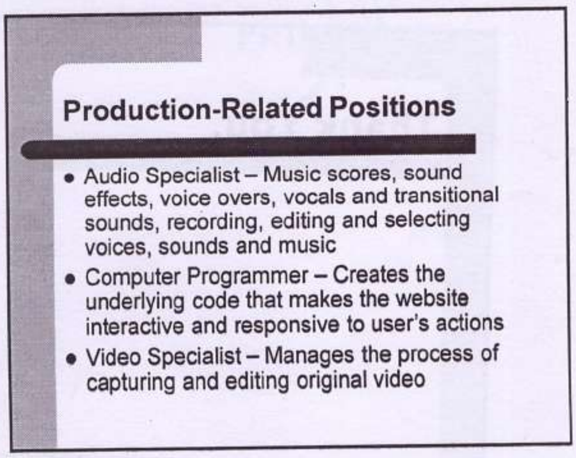
3d

X,Y & Z axis real time object viewing.



Management-Related Positions

- Executive Producer – Move a project into an through production
- Project Manager – forming a project, moving it into production and overseeing its creation



Production-Related Positions

- Audio Specialist – Music scores, sound effects, voice overs, vocals and transitional sounds, recording, editing and selecting voices, sounds and music
- Computer Programmer – Creates the underlying code that makes the website interactive and responsive to user's actions
- Video Specialist – Manages the process of capturing and editing original video

Production-Related Positions

- Web Designer – Develops or refines a design process and efficiently creates a cohesive and well-planned website from the front end
- Web Developer – Ensures the communication between the front end of the website and its back end is working
- Web Master – Making sure the web page is technically correct and functional on the Web Server

Art-Related Positions

- Animation Specialist – Creates 2D/3D animation by taking a sequence of static images and displaying them in rapid succession on the computer screen
- Art Director – Coordinate the creation of the artwork for the project
- Graphic Artist/Designer – Creating and designing all of the graphic images for a project

Art-Related Positions

- Interface Designer – Responsible for the look of the website interface and navigation methods
- Photographer – Shoots and captures appropriate, compelling and high quality photos
- Videographer - Shoots and captures appropriate, compelling and high quality video footage

Content-Related Positions

- Content Specialist – Providing authenticity and accuracy of information on the website
- Instructional Specialist – Expert in designing instructional projects
- Writers/Editors – Technical writers/scriptwriters, creative writers or journalist involved in the project

Thank You.

11/1/2020

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affilated to Anna University, Chennai)

Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – ODD

TEACHER TEACH TEACHERS

21.07.2019

Speaker: **Mr. PURUSHOTHAMAN**
HOD / EEE
Department of EEE

Staff Attended:

1. Mr.A.Senthamarai kannan Asso.Prof/EEE
2. Mr. M.Ranjith kumar AP/EEE
3. Mr. G.Purushothaman HOD/EEE
4. Ms.K.Vinothini AP/EEE
5. Mr. Ismail Gani AP/EEE

Topic:

Electrical Measurement and Instrumentation

Venue:

Circuits Lab

Report encl:

21st July 2019 & 1.30 P.M to 2.30 P.M

G. 21/7/2019.

HOD/EEE

PRINCIPAL

Scanned with CamScanner

EVEN SEMESTER
2017-2018

BE8254- BASIC ELECTRICAL AND INSTRUMENTATION ENGINEERING
Measurement and Instrumentation

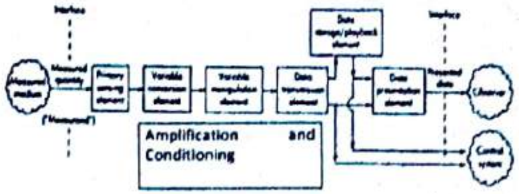
G.PURUSHOTHAMAN
Assistant Professor,
M.A.M. School of Engineering,
Siruganur,
Tiruchirapalli – 621 105.

INTRODUCTION OF MEASUREMENTS AND INSTRUMENTS

- Measurement means to monitor a processes or a operation and using an instrument , express the parameter, quantity or a variable in terms of meaningful numbers.

Basic components in a measurement system

Basic components in a measurement system are shown below:



It is also important to mention that a power supply is an important element for the entire system.

INSTRUMENTATION CHARACTERISTICS

Divided into two categories:

1. Static characteristics.
2. Dynamic characteristics

- Static characteristics refer to the comparison between steady output and ideal output when the input is constant
- Dynamic characteristics refer to the comparison between instrument output and ideal output when the input changes

STATIC CHARACTERISTICS

1. ACCURACY

- Accuracy is the ability of an instrument to show the exact reading.
- Always related to the extent of the wrong reading/non accuracy.
- Normally shown in percentage of error which of the full scale reading percentage.

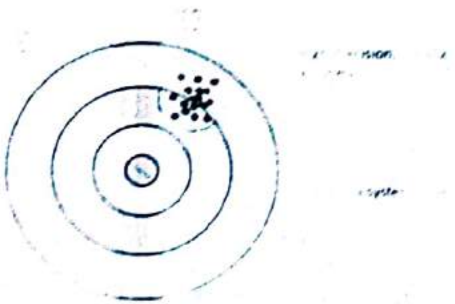
STATIC CHARACTERISTICS

2. PRECISION

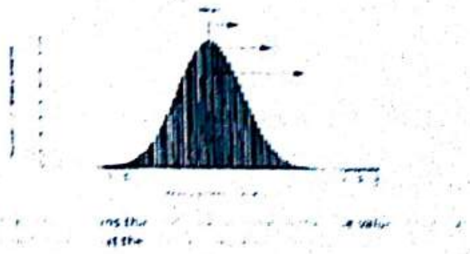
- An equipment which is precise is not necessarily accurate.
- Defined as the capability of an instrument to show the same reading when used each time (reproducibility of the instrument)

STATIC CHARACTERISTICS

Accuracy vs Precision



Accuracy vs Precision



STATIC CHARACTERISTICS

3. TOLERANCE

- Closely related to accuracy of an equipment where the accuracy of an equipment is sometimes referred to in the form of tolerance limit.
- Defined as the maximum error expected in an instrument.
- Explains the maximum deviation of an output component at a certain value.

STATIC CHARACTERISTICS

4. RANGE & SPAN

- Defined as the range of reading between minimum value and maximum value for the measurement of an instrument.
- The range expressed by stating the lower and upper values.
- Then range of that instrument is −100°C to 100 °C

The span of an instrument is the algebraic difference between lower and upper values. which has a reading range of −100°C to 100 °C So Span is 200 °C.

STATIC CHARACTERISTICS

5. BIAS

- Constant error which occurs during the measurement of an instrument.
- This error is usually rectified through calibration.

Example :

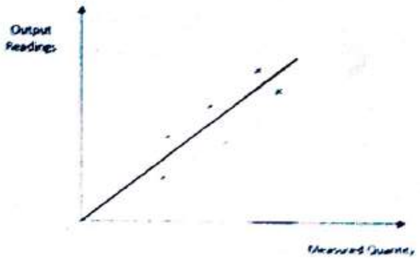
A weighing scale always gives a bias reading. This equipment always gives a reading of 1 kg even without any load applied. Therefore, if A with a weight of 70 kg weighs himself, the given reading would be 71 kg. This would indicate that there is a constant bias of 1 kg to be corrected.

STATIC CHARACTERISTICS

6. LINEARITY

- Maximum deviation from linear relation between input and output.
- The output of an instrument has to be linearly proportionate to the measured quantity.
- Normally shown in the form of full scale percentage (% fs).
- The graph shows the output reading of an instrument when a few input readings are entered.
- *Linearity = maximum deviation from the reading of x and the straight line.*

6. LINEARITY



STATIC CHARACTERISTICS

7. SENSIVITY

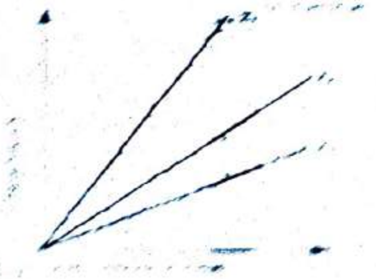
- Defined as the ratio of change in output towards the change in input at a steady state condition.
- Sensitivity (K) = $\frac{\Delta\theta_o}{\Delta\theta_i}$

$\Delta\theta_o$: change in output; $\Delta\theta_i$: change in input

Example 1:

The resistance value of a Platinum Resistance Thermometer changes when the temperature increases. Therefore, the unit of sensitivity for this equipment is Ohm/°C.

7. SENSIVITY



STATIC CHARACTERISTICS

8. DEAD SPACE / DEAD BAND

STATIC CHARACTERISTICS

9. RESOLUTION or DISCRIMINATION

- The smallest change in input reading that can be traced accurately.
- Given in the form % of full scale (% fs).
- Avail [illegible] instrument [illegible]

STATIC CHARACTERISTICS

10. THRESHOLD

- When the reading of an input is increased from zero, the input reading will reach a certain value before change occurs in the output.
- The minimum limit of the input reading is 'threshold'.

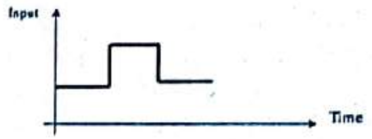
DYNAMIC CHARACTERISTICS

- Explains the behaviour system of instruments system when the input signal is changed.
- Depends on a few standard input signals such as 'step input', 'ramp input' and 'sine-wave input'.

DYNAMIC CHARACTERISTICS

Step Input

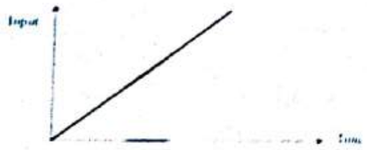
- Sudden change in input signal from steady state.
- The output signal for this kind of input is known as 'transient response'.



DYNAMIC CHARACTERISTICS

Ramp Input

- The signal changes linearly.
- The output signal for ramp input is 'ramp response'.



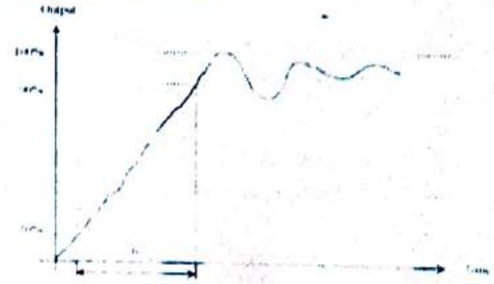
DYNAMIC CHARACTERISTICS

Sine-wave Input

- The signal is harmonic.
- The output signal i 'frequency response'.

EXAMPLE OF DYNAMIC CHARACTERISTICS

Response from a 2nd order instrument:



EXAMPLE OF DYNAMIC CHARACTERISTICS

[illegible] 2nd order [illegible]

- [illegible]

[illegible] the [illegible] % to 9

[illegible] stat[illegible]

[illegible] (s)

[illegible] for out[illegible] stat

ERRORS IN MEASUREMENT.

- Error in the measurement of a physical quantity is its deviation from actual value.
- Errors will creep into all measurement regardless of the care which is exerted

Types of Errors

- Thus, we see that there are different sources of errors and generally errors are classified mainly into three categories as follows
- Gross errors
- Systematic errors
- Random errors

Gross Errors

- These errors are due to the gross blunder on the part of the experimenters or observers.
- These errors are caused by mistake in using instruments, recording data and calculating measurement results.

Systematic Errors

- These are inherent errors of apparatus or method.
- These errors always give a constant deviation.
- On the basis of the sources of errors, systematic errors may be divided into following sub-categories :

- **Constructional Error**
- **Errors in Reading or Observation**

Constructional Error

- None of the apparatus can be constructed to satisfy all specifications completely.
- This is the reason of giving guarantee within a limit.
- A manufacturers always mention the minimum possible errors in the construction of the instruments.

Errors in Reading or Observation

- Construction of the Scale
- Fitness and Straightness of the Pointer
- Parallax
- Efficiency or Skillness of the Observer

Random Errors

- After corrections have been applied for all the parameters whose influences are known.
- There is left a residue of deviation, These are random error.

- Their magnitudes are not constant.
- Persons performing the experiment have no control over the origin of these errors.
- These errors are due to so many reasons such as noise and fatigue in the working persons.

ANALYSIS OF THE ERRORS

- Arithmetic Mean
- Deviation
- Standard Deviation
- [illegible]

Arithmetic Mean

- When a set of readings of an instrument is taken
- the individual readings will vary somewhat from each other
- the experimenter is usually concerned with the mean of all the readings

Arithmetic Mean

- If each reading is denoted by x and there are n readings, the arithmetic mean is given by

Scanned with CamScanner

Deviation

- The deviation, d, for each reading is given by

$$\boxed{d_i = x_i - x_m}$$

- The average of the absolute value of the deviations is given by

$$\boxed{|\bar{d}_i| = \frac{1}{n}\sum_{i=1}^{n}|d_i|}$$

Standard Deviation

- It is also called root mean-square deviation. It is defined as

$$\boxed{\sigma = \left[\frac{1}{n}\sum_{i=1}^{n}(x_i - x_m)^2\right]^{1/2}}$$

M.A.M SCHOOL OF ENGINEERING

(Accredited by N.A.A.C)
(Approved by AICTE, New Delhi Affiliated to | Anna University, Chennai
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – EVEN

TEACHER TEACH TEACHERS

25.02.2020

Speaker: Mr. **MEENAKSHI M.**
Assistant Professor
Department of EEE

Staff Attended:

1. Mr. G.Purushothaman HOD/EEE
2. Mr.A.Senthamarai kannan Asso.Prof/EEE
3. Mr. Ranjith Kumar AP/EEE
4. Ms. Vinothini AP/EEE
5. Mr. Ismail Gani AP/EEE

Topic:

"Design of Solar Panel Standalone Home Load"

Venue:

Circuits Lab

Report encl:

25th February 2020 & 1.30 P.M to 2.30 P.M

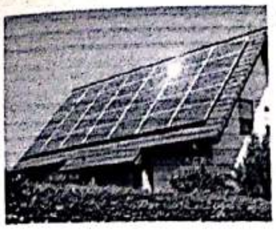
25/2/2020.

HOD/EEE

PRINCIPAL

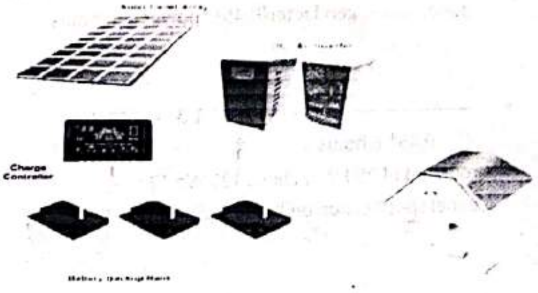
Scanned with CamScanner

DESIGN OF SOLAR PANEL FOR STANDALONE HOME LOAD



By
M.Meenakshi/AP/EEE
M.A.M School of Engineering

Solar Panel With Home Load



Major System Components &It's Working

- **Solar PV panel(solar PV module)**
  PV module converts sunlight into DC electricity.
- **Solar charge controller**
  Charge controller regulates the voltage and current coming from the PV panels going to the battery.
- **Inverter**
  Inverter converts DC output of PV panels into pure AC power to the AC applications.
- **Battery bank**
  Battery stores the energy for supplying to electrical appliences when there is a demand

Design Procedure For Solar PV system

Step1: Determine the total load of the home/day

Step2:Calculate the number of panels

Step3: Determine the size of the battery

Step4: Determine the rating of the charge controller

Step5: Determine the rating of the inverter.

Determination of Total Load

Determine the power consumption demands,
calculate total watt-hour per day used by the appliences

Sl no	DEVICE	POWER(watts)	HOURS/DAY	ENERGY/Wh
1	PORTIGO LIGHT	12	2	24
2	HALL LIGHT	40	2	80
3	HALL FAN	90	2	180
4	KITCHEN LIGHT	40	1	40
5	ROOM LIGHT	12	1	12
6	ROOM FAN	90	2	180
		284		516

Total energy required per(watt-hour) = 516 Wh
Total Load = 284 Watts

Solar PV system Panel design

$$\text{Formula} = \frac{\text{Total energy required per day(Wh)}}{\text{panel power gen factor(0.45) * power gen hour}} * 1.3$$

$$= \frac{516}{0.45 * 6\ \text{hours}} * 1.3 = 248\ [illegible]$$

= rounded of 250 Wp(chose 125 Wp *2 nos)

panel specification on board(125 Wp [illegible]

Solar PV system Panel design

$$\text{Formula} = \frac{\text{Total energy required per day(Wh)}}{\text{panel power gen factor(0.45)} * \text{power gen hours}} * 1.3(30\%)$$

$$= \frac{516}{0.45 * 6 \text{ hours}} * 1.3 = 248 \text{ Wp}$$

= rounded of 250 Wp(chose 125 Wp *2 nos)
panel specification on board(125 Wp ,12 v)

Battery design

Battery Capacity (Ah) =

Total Energy (Watt hours) required [illegible]

Battery Efficiency (0.85) x Battery DOD (0 6) x Battery voltage (12 or 24)

Battery Capacity (Ah) = [illegible]

Battery Capacity (Ah) = [illegible]

Design Of Charge Controller

Charge Control Rating = Panel Isc x Number Of Panel x 1 3 (30%)

Charge Control Rating = 7.5 x 2 x 1.3 = 19.5 Amps

Charge Control = 20 Amps x 12 V

Inverter design Procedure

An inverter [illegible]
needed

The input rating [illegible]
the total watt of appliances [illegible]

The [illegible]
battery

The inverter size should [illegible]
of appliances [illegible]
In case of [illegible]
inverter size should [illegible]
(Due surge current during [illegible])

Design of Inverter

$$\text{Formula} = \frac{\text{Rated Load (watts)}}{\text{Inverter Power Factor 0 8 (80\%)}} \times 1\ 3\ (30\%)$$

$$\text{Inverter} = \frac{284}{0.8} \times 1.3 = 461 \text{ VA}$$

Inverter = 600 VA

For safety, the inverter should be considered 25-30% bigger size

Ratings of the solar PV system

Total Energy Required per [illegible]

Total Load = 284 Watts
(Rated loads)

125 Wp panel x 2 nos = 250 Wp
(125 Wp x 12V PANEL)

Battery Capacity [illegible]

Charge Control = 20 Amps x 12 V

Inverter = 600 VA

With the help of these procedure we can design a solar PV system for any kind of stand Alone load

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affiliated to Anna University, Chennai)
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – EVEN

TEACHER TEACH TEACHERS

Speaker: **Ms. DHANALAKSHMI D.**
Assistant Professor
Department of EEE

Staff Attended:

1. Mr. G.Purushothaman HOD/EEE
2. Mr.A.Senthamarai kannan Asso.Prof/EEE
3. Mr. Ranjith Kumar AP/EEE
4. Mrs. Meenakshi AP/EEE
5. Ms. Vinothini AP/EEE
6. Mr. Ismail Gani AP/EEE

Topic:

"Artificial Intelligence"

Venue:

Circuits Lab

Report encl:

4th February 2020 & 1.30 P.M to 2.30 P.M

G. 4/2/2020.

HOD/EEE

PRINCIPAL

Scanned with CamScanner

Artificial Intelligence

By
Ms. D Dhanalakshmi AP / EEE
M.A.M School of Engineering

What is Artificial Intelligence?

Answer The power of a machine to copy intelligent human behavior

Right???

Robots at Artemis

Are they really intelligent?

A robot is only as smart as its initial program.

Answer: The power of a machine to copy and learn from intelligent human behavior

Artificial Intelligence VS. Robot

AI

Programmed to think

Social Interaction

[illegible]

Robot

[illegible]

Artificial Intelligence Tests

Turing Test

Developed by Alan Turing

Involves an interpreter, a human, and a computer.

The computer and human have separate conversations with the interpreter

If the interpreter can't guess which is the computer or if the interpreter gets it wrong then the computer has Artificial Intelligence.

Artificial Intelligence Tests

Imitation Game

First test involves an interpreter, a male, and a female

Female pretends to be male

[illegible]

[illegible]

Scanned with CamScanner

Artificial Intelligence Tests

Imitation Game

Involves two tests

First test involves an interpreter, a male, and a female

Female pretends to be male

Interpreter tries to figure out who is who

Second test is similar to turing test

Compares both tests

Artificial Intelligence Tests

Turing Test [illegible]

[illegible]

Turing test the computer [illegible]

[illegible]

Examples

1.CleverBot

Cleverbot

2.Autonomous Cars

3.Drones

4.Watson

Problems

Although AI is advancing [illegible]

AI Controversies

Potential job takeover

Growing laziness

Growing Cost

Priority Argument

Robot Relationships?

Why it Matters

This is because we may be interacting with it on a day to day basis

We [illegible]

[illegible]

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affiliated to Anna University, Chennai)
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – ODD

TEACHER TEACH TEACHERS

19.08.2019

Speaker: **Mr. RANJITH KUMAR M.**
Assistant Professor.
Department of EEE

Staff Attended:

1. Mr.A.Senthamarai kannan Asso.Prof/EEE
2. Mr. G.Purushothaman HOD/EEE
3. Ms.K.Vinothini AP/EEE
4. Ms.Dhanalakshmi AP/EEE
5. Mr. Ismail Gani AP/EEE

Topic:

"Power System"

Venue:

Circuits Lab

Report encl:

19th August 2019 & 1.30 P.M to 2.30 P.M

19/8/2019

HOD/EEE

PRINCIPAL.

Scanned with CamScanner

MANAGEMENT AND OPTIMIZATION OF SOLAR POWER CONVERSION TO SUPPLEMENT TERRESTRIAL POWER SYSTEMS.

BY

Mr. RANJITH KUMAR AP / EEE
M.A.M SCHOOL OF ENGIEERING

CONVENTIONAL RESOURCES

- FOSSIL FUELS
- HYDRO RESOURCES
- NUCLEAR RESOURCES USING FISSION

ENVIRONMENTAL ASPECTS OF ENERGY

- TRADE-OFF BETWEEN ENERGY AND ENVIRONMENT
- ECOLOGICAL UNBALANCE
- GLOBAL WARMING
- RADIATION HAZARDS

NON-CONVENTIONAL RESOURCES

- SOLAR ENERGY
- WIND ENERGY
- BIOMASS ENERGY
- OCEAN WAVE ENERGY
- OCEAN THERMAL ENERGY CONVERSION
- GEOTHERMAL ENERGY
- OCEAN TIDAL ENERGY

AND

- NUCLEAR FUSION

LIMITATIONS OF SOLAR ELECTRIC POWER GENERATION INSTALLATIONS ON EARTH

- Effects of day/night cycles
- Shadowing due to clouds, fog, snow, precipitation etc.
- Weather effects
- Reduced solar-radiation intensity
- Overall variable and discontinuous power output

LIMITATIONS OF SOLAR ELECTRIC POWER GENERATION INSTALLATIONS ON EARTH

HENCE:

SOLAR POWER SATELLITE CONCEIVED

Scanned with CamScanner

SALIENT ADVANTAGES OF SPS

- More intense (about eight times on average) solar radiation available
- Unaffected by weather, clouds etc.
- SPS illuminated almost all the time (except eclipse periods). Hence expensive storage not required
- Lack of gravity simplifies structure
- Waste heat re-radiated back into space, instead of warming the biosphere.

SOLAR TO ELECTRIC CONVER

- THERMAL ELECTRIC CONVERSION
- SOLAR DYNAMIC CONVERSION
- DIRECT CONVERSION THROUGH PHOTOVOLTAICS

SOLAR TO ELECTRIC CONVERSION

Contd....

POINTS FOR CHOICE:

- Energy conversion efficiency
- Cost effectiveness
- Material and system transportation convenience
- Technology status
- Specific feasibility problems

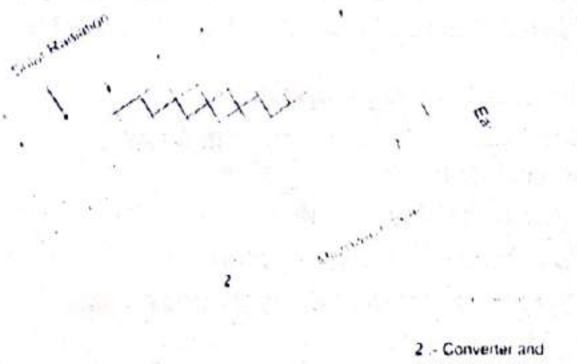
MAIN PARAMETERS FOR CONSIDERATION OF PHOTOVOLTAIC POWER GENERATION ON SPS

- Energy conversion efficiency
- Life-expectancy
- Tolerance to space-radiation environment
- Power-production capacity per unit area
- Production cost including material processing cost

MAIN PARAMETERS FOR CONSIDERATION OF PHOTOVOLTAIC POWER GENERATION ON SPS

Contd.....

- Amenability to mass production
- Consideration for optimized mass
- Overall bulk and portability



Satellite solar power [illegible]

BRIEF HISTORICAL MILESTONES

- 1899-1900 NIKOLA TESLA Proposed use of radio waves power transmission
- 1930's Use of microwaves proposed for power transmission
- 1945 Clarke putforth the concept of geo-stationary satellite in Science-fiction
- 1962 Satellite communication begins with Telstar I first rectenna build

BRIEF HISTORICAL MILE-STONES

- 1963 First rectenna built
- 1964 **W.C. BROWN** succeeded in microwave powered helicopter using 2.45 GHz
- 1964 **IEEE** Conference on Energy Sources [illegible] session on Microwave Power Transmission
- 1965-66 Commercial Satellite Communication Service Introduced
- 1968 PETER GLASER proposed Solar Power Satellites
- 1973-74 Glaser was granted a patent for possible microwave power transmission from SPS to earth

BRIEF HISTORICAL MILE-STONES

(Contd....)

- 1975 84% efficient microwave to DC conversion demonstrated
- 1983 US Patent for a system for power transmission from SPS & direct conversion to 60 Hz, 3-Phase
- 1999-2000 SPS Exploratory Concept examined by NASA

BRIEF HISTORICAL MILE-STONES

- 2001-2002 Technology Maturation program for SPS pursued by NASA
- 2004 A Report on possible design of SPS prepared by **NASA**
- 2007-2010 many nations in the world considering such projects. Japan announced plans to have its first SPS in operation by 2040

POSSIBLE TRANSMISSION TECHNIQUES

- MICROWAVES
- LASER BEAMS

METHODOLOGY OF TRANSMISSION AND UTILIZATION

- DIRECT TRANSMISSION OF MICROWAVE POWER TO HOMES OR SMALLER ANTENNA FEEDING TO UTILITY SYSTEM/EQUIPMENT
- TRANSMISSION TO LARGE CENTRAL EARTH STATION & FEEDING TO TERRESTRIAL POWER SYSTEM (POWER GRID)

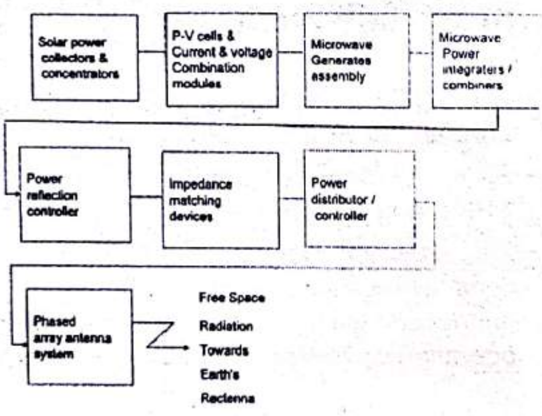
Scanned with CamScanner

MAIN SUBSYSTEMS OF SOLAR POWER SATELLITE

- SOLAR POWER COLLECTOR AND SUB-TRACKER SUB-SYSTEM
- POWER CONVERSION SUB-SYSTEM
- POWER TRANSMISSION SUB-SYSTEM
- TELEMETRY, TRACKING & COMMAND SUB-SYSTEM
- ANTENNA SUB-SYSTEM
- PROPULSION & ATTITUDE STABILIZATION SUB-SYSTEM

SOLAR POWER SATTELLITE LOCATION OPTIONS

- GEO-SYNCHRONUS-STATIONARY ORBIT (3600 KM FROM EARCH)
- MEDIUM EARTH ORBIT (MEO AROUND 10000 KM)
- LOW EARCH ORBIT (LEO AROUND 800-1000 KM)
- HIGH ALTITUDE PLATFORM (HAP. LESS THAN 100 KM)



Power Transmission Subsystems al SPS

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affiliated to Anna University, Chennai
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – ODD

TEACHER TEACH TEACHERS

04.10.2019

Speaker: **Mr. ISMAIL GANI M.**
Assistant Professor
Department of EEE

Staff Attended:

1. Mr. G.Purushothaman HOD/EEE
2. Ms.K.Vinothini AP/EEE
3. Ms.Dhanalakshmi AP/EEE
4. Mr.A.Senthamarai kannan Asso.Prof/EEE
5. Mr. Ranjith Kumar AP/EEE

Topic:

"Synchronous Motor"

Venue:

Circuits Lab

Report encl:

4th October 2019 & 1.30 P.M to 2.30 P.M

4/10/2019.

HOD/EEE

PRINCIPAL

Scanned with CamScanner

ELECTRICAL MACHINES

SYNCHRONOUS MOTOR

AP/EEE–M.A.M.S.E

Characteristic features of a synchronous motor

- Synchronous motor will run either at synchronous speed or will not run at all.
- The only way to change its speed is to change its supply frequency. (As Ns = 120f / P)
- Synchronous motors are not self starting. They need some external force to bring them near to the synchronous speed.
- They can operate under any power factor, lagging as well as leading. Hence, synchronous motors can be used for power factor improvement.

Characteristic features of a synchronous motor

- Synchr[illegible] motor will run either at synchronous speed or will not run at all.
- The on[illegible] change its speed is to change its [illegible] frequency (As Ns = 120f / [illegible]
- Synch[illegible] motors are not self starting. They need some external force to bring [illegible] near to the synchronous speed
- They ca[illegible] under any power factor, lagging [illegible] leading. Hence synchr[illegible] can be used for power factor [illegible]

Effect of changes in load on, I, δ, and p. f. of synchronous motor

[illegible]

Synchronous motor Principle of operation

- The stator is wound for the similar number of poles as that of rotor, and fed with three phase AC supply. The 3 phase AC supply produces rotating magnetic field in stator. The rotor winding is fed with DC supply which magnetizes the rotor.
- Now, the stator poles are revolving with synchronous speed (let's say clockwise). If the rotor position is such that, N pole of the rotor is near the N pole of the stator (as shown in first schematic of above figure), then the poles of the stator and rotor will repel each other, and the torque produced will be anticlockwise.

Synchronous motor starting methods

The various methods to start the synchronous motor are,

1. Using pony motors
2. Using damper winding
3. As a slip ring induction motor
4. Using small DC Machine coupled to it.

1. Using pony motors

In this method, the rotor is brought to the synchronous speed with the help of some external device like small induction motor. Such an external device is called 'pony motor'.

Once the rotor attains the synchronous speed, the d.c. excitation to the rotor is switched on. Once the synchronism is established pony motor is decoupled. The motor then continues to rotate as synchronous motor.

Contd..

3. As a Slip Ring Induction Motor

- The above method of starting synchronous motor as a squirrel cage induction motor does not provide high starting torque. So to achieve this instead of shorting the damper winding, it is designed to a form a three phase star or delta connected winding. The three ends of this winding are brought out through slip rings. An external rheostat then can be introduced in series with the rotor circuit. So when stator is excited, the [illegible] as a slip ring induction motor and due to resistance added in the rotor [illegible] high starting torque. The resistance is then gradually cut off as motor gathers speed. After motor attains speed near synchronous
- [illegible] then motor gets pulled into synchronism and [illegible] speed. The damper winding is shorted by shorting the [illegible]

Contd..

Contd..

- The stator poles are rotating with synchronous speed, and they rotate around very fast and interchange their position. But at this very soon, rotor cannot rotate with the same angle (due to inertia), and the next position will be likely the second schematic in above figure. In this case, poles of the stator will attract the poles of rotor, and the torque produced will be clockwise.
- Hence, the rotor will undergo to a rapidly reversing torque, and the motor will not start.

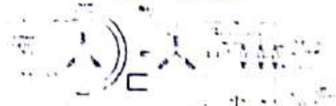
Contd..

2. Using Damper Winding

In a synchronous motor, in addition to the normal field winding, the additional winding consisting of copper bars placed in the slots in the pole faces. The bars are short circuited with the help of end rings. Such an additional winding on the rotor is called damper winding. This winding as short circuited, acts as a squirrel cage rotor winding of an induction motor. The schematic representation of such damper winding is shown in the Fig.48.

Contd..

- The initial resistance added in the rotor not only provides high starting torque but also limits high inrush of starting current. Hence it acts as a motor resistance starter.
- The synchronous motor started by this method is called a slip ring induction motor is shown in the Fig 49.



Effect of changes in excitation on the performance synchronous motor

[illegible]

Contd..

- But, if the rotor is rotated up to the synchronous speed of the stator by means of an external force (in the direction of revolving field of the stator), and the rotor field is excited near the synchronous speed, the poles of stator will keep attracting the opposite poles of the rotor (as the rotor is also, now, rotating with it and the position of the poles will be similar throughout the cycle). Now, the rotor will undergo unidirectional torque. The opposite poles of the stator and rotor will get locked with each other, and the rotor will rotate at the synchronous speed.

Contd..

- Once the rotor is excited by a three phase supply, the motors starts rotating as an induction motor at sub synchronous speed. Then DC supply is given to the field winding. At a particular instant motor gets pulled into synchronism and starts rotating at a synchronous speed. As rotor rotates at synchronous speed, the relative motion between damper winding and the rotating magnetic field is zero. Hence when
- motor is running as synchronous motor, there cannot be any induced EMF in the damper winding. So damper winding is active only at start, to run the motor as an induction motor at start. Afterwards its is out of the circuit. As damper winding is short circuited and motor gets started as induction motor, it draws high current at start so induction motor starters like star-delta, autotransformer etc. used to start the synchronous motor as an induction motor.

Contd..

4. Using Small D.C. Machine

Many a times a large synchronous motor is provided with a coupled DC machine. This machine is used as a DC motor to rotate the synchronous motor at a synchronous speed. Then the excitation to the rotor is provided. Once motor starts running as a synchronous motor, the same DC machine acts as a DC generator called exciter. The field of the synchronous motor is then excited by this exciter itself.

Contd

[illegible]

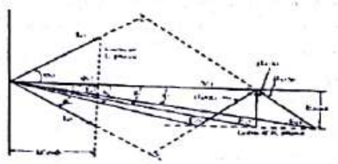


Figure: 51. Phasor diagram showing effect of changes in field excitation on armature current, power angle and power factor of a synchronous motor

- In below fig, *OA* represents applied voltage / phase of the motor and *AB* is the back EMF./ phase, E_b. *OB* is their resultant voltage *ER*. The armature *B* current is *OI* lagging behind *ER* by an angle q = *ER* or vector *OB* represents (to some suitable scale) the main current *I*.
- *OY* is drawn at an angle f with *OB* (or at an angle q with *C A*). *BL* is drawn perpendicular to *OX* which is at right angles to *O Y*. Vector *OB*, when referred to *O Y*, also represents, on a different scale, the current both in magnitude and phase

- As V is constant, power input is dependent on B L. If motor is working with a constant intake, then locus of B is a straight line || to OX and ^ to OY i.e. line EF for which BL is constant. Hence, EF represents a constant-power input line for a given voltage but varying excitation. Similarly, a series of such parallel lines can be drawn each representing a definite power intake of the motor. As regards these constant-power lines, it is to be noted that

1. For equal increase in intake, the power lines are parallel and equally-spaced
2. Zero power line runs along OX
3. The perpendicular distance from B to OX (or zero power line) represents the motor intake

- If excitation is fixed i.e. AB is constant in length, then as the load on motor is increased, increases. In other words, locus of B is a circle with radius = AB and centre at A. With increasing load, B goes on to lines of higher power till point B1 is reached.
- Any further increase in load on the motor will bring point B down to a lower line. It means that as load increases beyond the value corresponding to point B1, the motor intake decreases which is impossible.
- The area to the right of AY 1 represents unstable conditions. For a given voltage and excitation, the maximum power the motor can develop, is determined by the location of point B1 beyond which the motor pulls out of synchronism.

Contd..

- The circle represented by equation (1) has a centre at some point O' on the line OX. The circle drawn with centre as O' and radius as O'B represents circle of constant power. This is called Blondel diagram, shown in the Fig. 2.
- Thus if excitation is varied while the power is kept constant, then working point B while move along the circle of constant power.

Let O'B = Radius of circle = r

OO' = Distant d

Applying cosine rule to triangle OBO',

- Now OB represents resultant ER which is Ia Zs. Thus OB is proportional to current and when referred to OY represents the current in both magnitude and phase.

OB = Ia = I say

Substituting various values in equation (2) we get,

r2 = I2 + d2 − 2dI cos?

[illegible]

Comparing equations (1) and (3) we get,

[illegible]

Thus the point O' is independent of power Pm and is a constant for a give motor operating at a fixed applied voltage V

Contd..

- Thus the point O' is independent of power Pm and is a constant for a give motor operating at a fixed applied voltage V.
- Comparing last term of equations (1) and (3),

$$d^2 - r^2 = \frac{P_m}{R_a}$$

$$r^2 = \left(d^2 - \frac{P_m}{R_a}\right)$$

$$r = \sqrt{d^2 - \frac{P_m}{R_a}}$$

$$= \sqrt{\left(\frac{V}{2R_a}\right)^2 - \frac{P_m}{R_a}}$$

$$\boxed{r = \frac{1}{2R_a}\sqrt{V^2 - 4P_m R_a}}$$

The equation shows that as power Pm must be real, then 4Pm Ra ? V2. The maximum possible power per phase is

Contd..

[illegible]

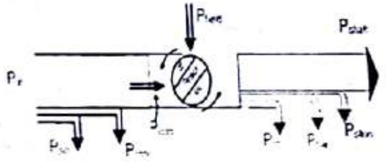
And the radius of the circle for maximum power is zero. Thus at the time of maximum power, the circles becomes a point O'. While when the power Pm = O, then r = V/2Ra = OO'

This shows that the circle of zero power passes through the points O and A.

The radius for any power Pm is given by,

[illegible]

Power flow i synchronous motor

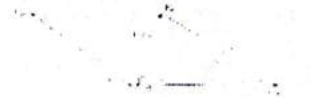


Contd..

Where

- P = Power input to the motor
- P = Power loss as stator copper loss P = Power loss as core loss
- P = Power in the air gap
- P = Power loss as field copper loss
- P = Power loss as friction and windage loss P = Power loss as stray loss
- P = Shaft output of the machine
- Power input to a synchronous motor is given by P = 3V I cosΦ = √3 V I cosΦ in stator as per the diagram there will be core loss and copper loss taking place. The remaining power will be converted to gross mechanical power
- Hence P = Power input to the motor − total losses in stator.

Contd..



From the phasor diagram we can write Power input /phase P = V I cosΦ Mechanical power developed by the motor P [illegible] − Φ Assuming iron losses as negligible stator [illegible] P Power output [illegible] (field cu loss + friction & windage loss + stray loss)

Torque developed in Motor

- Mechanical power is given by $P_m = 2\pi N_s T_g/60$ where Ns is the synchronous speed and the Tg is the gross torque developed
- $P_m = 2\pi N_s T_g/60$
- Hence $T_g = 60 P_m/2\pi N_s$
- $T_g = 9.55 P_m/N_s$ N-m
- Shaft output torque $T_{sh} = 60 \times P_{out}/2\pi N_s$
- $T_{sh} = 9.55 P_{out}/N_s$ N-m

Numerical problems

- A 75 KW 3-phase Y connected, 50 Hz, 440V cylindrical rotor synchronous motor operates at rated condition with 0.8pf leading. The motor efficiency excluding field and stator losses is 95% and Xs 2.5Ω calculate (i) mechanical power developed (ii) armature current (iii) back EMF (iv) power angle and (v)max or pull out toque of the motor
- A 50 Hz, 6 pole, 3-Φ, and star connected synchronous motor has a synchronous reactance of 1. [illegible] Ω/phase and negligible armature resistance. The excitation is such as to give an open circuit voltage of [illegible] the motor is connected to 11 kV, 50 Hz supply. What maximum load can the motor supply before losing synchronism. What is the corresponding motor torque, line current and power factor

Contd..

[illegible] Hz, [illegible] synchronous [illegible] negligible [illegible] excitation [illegible] voltage [illegible] maximum [illegible] corre[illegible] current [illegible]

V and inverted V curve of synchronous motor

- [illegible] current of [illegible] for [illegible] the phase [illegible] variation [illegible] noted [illegible] case in [illegible]
- [illegible] copper [illegible] diagrams [illegible] electrical [illegible] capac[illegible] vided [illegible]

Contd..

[illegible]

Numerical problems

[illegible] 115V, [illegible] synchronous [illegible] the induc[illegible] per phase [illegible] friction [illegible] watts [illegible] output [illegible] efficiency [illegible] output?

[illegible] 115 V, [illegible] synchrono[illegible] the induc[illegible] friction [illegible] output [illegible] output?

Contd.

- The excitation of a 415V, 3-phase, and mesh connected synchronous motor is such that the induced EMF is520V.the impedance per phase is (0.85+j6.0) Ω. If the friction and iron losses are constant at 800 watts, calculate the power output, line current, power factor and efficiency for maximum power output?

Hunting

- Sudden changes of load on synchronous motors may sometimes set up oscillations that are superimposed upon the normal rotation, resulting in periodic variations of a very low frequency in speed. This effect is known as hunting or phase-swinging. Occasionally, the trouble is aggravated by the motor having a natural period of oscillation approximately equal to the hunting period. When the synchronous motor phase-swings into the unstable region, the motor may fall out of synchronism

Damper winding

- The tendency of hunting can be minimized by the use of a damper winding. Damper windings are placed in the pole faces. No EMFs are induced in the damper bars and no current flows in the damper winding, which is not operative.
- Whenever any irregularity takes place in the speed of rotation, however, the polar flux moves from side to side of the pole, this movement causing the flux to move backwards and forwards across the damper bars. EMFs are induced in the damper bars forwards across the damper winding.
- These tend to damp out the superimposed oscillatory motion by absorbing its energy. The damper winding, thus, has no effect upon the normal average speed, it merely tends to damp out the oscillations in the speed, acting as a kind of electrical flywheel. In the case of a three-phase synchronous motor the stator currents set up a rotating MMF rotating at uniform speed and if the rotor is rotating at uniform speed, no EMFs are induced in the damper bars.

Synchronous condenser

- An over excited synchronous motor operates at unity or leading power factor. Generally, in large industrial plants the load power factor will be lagging. The specially designed synchronous motor running at zero load, taking leading current, approximately equal to 90°. When it is connected in parallel with inductive loads to improve power factor, it is known as synchronous condenser. Compared to static capacitor the power factor can improve easily by variation of field excitation of motor. Phasor diagram of a synchronous condenser connected in parallel with an inductive load is given below.

Contd.

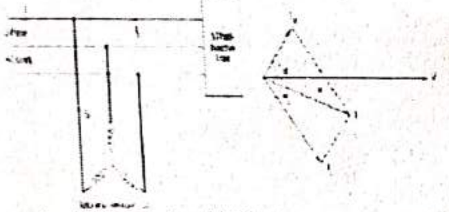


Figure 5.3 Synchronous condenser and phasor diagram

Bolden's two reaction theory

- In case salient pole machines the air gap is non uniform and it is smaller along pole axis and is larger along the inter polar axis.
- These axes are called direct axis or d-axis and quadrature axis or q-axis. Hence the effect of MMF when acting along direct axis will be different than that when it is acting along quadrature axis.
- Hence the reactance of the stator cannot be same when the MMF is acting along d – axis and q- axis.

Contd.

- As the length of the air gap is small along direct axis reluctance of the magnetic circuit is less and the air gap along the q – axis is larger and hence the along the quadrature axis will be comparatively higher.
- Hence along d-axis more flux is produced than q-axis. Therefore the reactance due to armature reaction will be different along d-axis and q-axis. This reactance's are
- X_{ad} = direct axis reactance; X_{aq} = quadrature axis reactance

Contd.

- Blondel's two-reaction theory considers the effects of the quadrature and direct-axis components of the armature reaction separately.
- Neglecting saturation, their different effects are considered by assigning to each an appropriate value of armature-reaction "reactance," respectively X_{ad} and X_{aq}.
- The effects of armature resistance and true leakage reactance (X_l) may be treated separately, or may be added to the armature reaction coefficients on the assumption that they are the same, for either the direct-axis or quadrature-axis components of the armature current

Contd.

- Thus the combined reactance values can be expressed as $X_{sd} = X_{ad} + X_l$ and $X_{sq} = X_{aq} + X_l$ for the direct and cross-reaction axes respectively
- In a salient-pole machine, X_{aq}, the quadrature-axis reactance is smaller than X_{ad}, the direct axis reactance, since the flux produced by a given current component in that axis is smaller as the reluctance of the magnetic path consists mostly of the inter polar spaces.
- It is essential to clearly note the difference between the quadrature and direct axis components I_{aq} and I_{ad} of the armature current [illegible] and the reactive and active components I_{aa} an [illegible]

Phasor diagrams

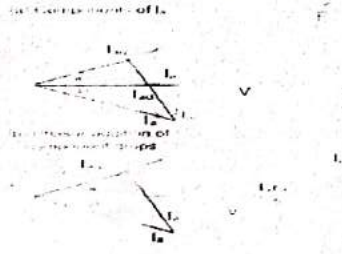


Figure [illegible] Phasor diagrams of [illegible]

Slip test

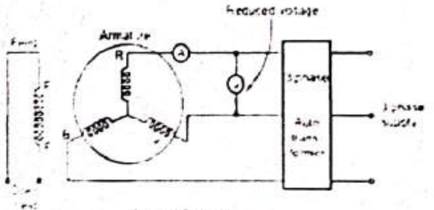


Figure [illegible] Slip test

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affiliated to Anna University, Chennai
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – EVEN

TEACHER TEACH TEACHERS

10.1.2020

Speaker: **Ms. VINOTHINI K.**
Assistant Professor
Department of EEE

Staff Attended:

1. Mr. G.Purushothaman HOD/EEE
2. Ms.Dhanalakshmi AP/EEE
3. Mr.A.Senthamarai kannan Asso.Prof/EEE
4. Mr. Ranjith Kumar AP/EEE
5. Mrs. Meenakshi AP/EEE
6. Mr. Ismail Gani AP/EEE

Topic:

"Solar Tree"

Venue:

Circuits Lab

Report encl:

10th January 2020 & 1.30 P.M to 2.30 P.M

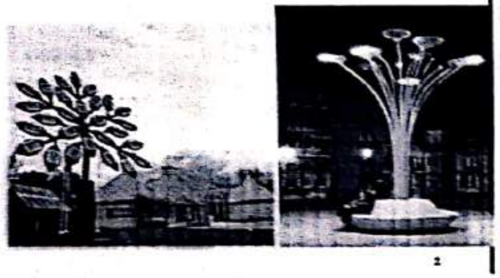
G. 10/1/2020.

HOD/EEE

PRINCIPAL

Scanned with CamScanner

“SOLAR TREE”



INDEX

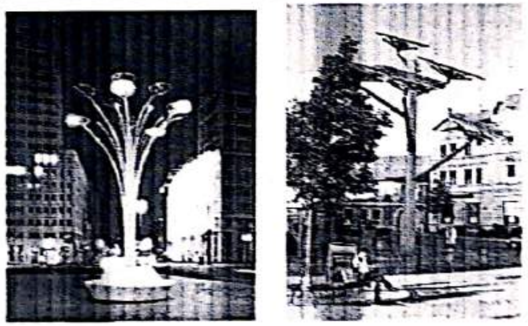
INTRODUCTION

- **solar energy** is the best option.
- **Solar tree** sounds like the perfect solution for our future energy needs.
- **A solar tree** is an artificial tree with **photo-voltaic cells** arranged in **Fibonacciseries** manner.
- Uses multiple no. of solar panels which forms the shape of a tree.

HISTORY

1. In 1800 solar energy plants developed .
2. In 1839 **Alexandre Edmond** discovered the photo voltalic effect.
3. In 1941 **Russell ohl** invented solar cell .
4. Solar Tree Foundation which began in 2008 by **Rein Triefeldt**
5. In 2012 Ross **Lovegrove** designed the solar tree

WHAT IS SOLAR TREE ?



WHAT IS SOLAR TREE

A solar tree is a decorative means of producing solar energy and also electricity. It uses multiple no. of solar panels which forms the shape of a tree. The panels are arranged in a tree fashion in a tall tower/pole

TREE stands for

T= TREE GENERATING

R=RENEWABLE

E=ENERGY and

E=ELECTRICITY

This is like a tree in structure and the panels are like leaves of the tree which produces energy

COMPONENTS OF SOLAR TREE

The solar tree consists of mainly five parts as shown

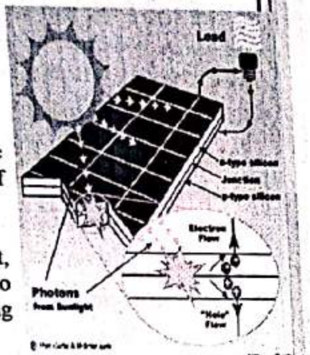
- [illegible]lar pa[illegible]
- [illegible]ng to[illegible]
- [illegible]Ds
- [illegible]tteries
- [illegible]ms [illegible]

WHY WE CALLED IT AS SOLAR TREE

- Trees can produce their own food material by the process called PHOTOSYNTHESIS
- [illegible]es are [illegible] materials for human beings
- [illegible]wise [illegible] solar plates are producing energy [illegible] the sun

BLOCK DIAGRAM

OLAR PANELS WORK?



voltaic cell converts sunlight lectric energy and this effect is wn as photovoltaic effect.

➢Solar cells essentially create electricity by converting photons of light into electrons.

➢Solar cell producing direct current, or DC, this DC current is converted to alternating current, or AC by using inverter.

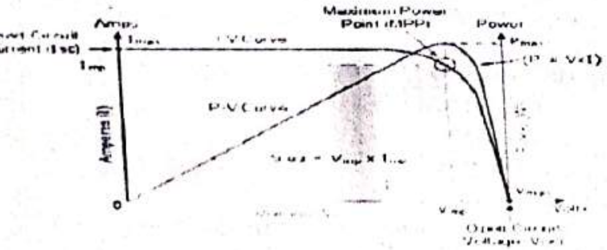
ADVANTAGES OF SOLAR PANEL

- o Ecologically Friendly
- o Decreased Electrical Bill
- o Low Maintenance
- o Efficiency

SPECIFICATIONS

		CSSP-200P	CSSP-210P	CSSP-220P	CSSP-230P	CSSP-240P
Nominal Maximum Power at STC (Pmax)		200W	210W	220W	230W	240W
Optimum Operating Voltage (Vmp)		28.5V	28.9V	29.3V	29.7V	30.4V
Optimum Operating Current(Imp)		6.93A	7.28A	7.52A	7.71A	7.91A
Open Circuit Voltage (Voc)		36.7V	36.4V	36.6V	36.8V	37.3V
Short Circuit Current (Isc)		7.66A	7.97A	8.18A	8.34A	8.51A
Operating Temperature		-40℃~+85℃				
Maximum System Voltage		1,000V (IEC) 600V (UL)				
Maximum Series Fuse Rating		15A				
Power Tolerance		±5W				
Temperature Coefficient	Pmax	-0.45%/℃				
	Voc	-0.35%/℃				
	Isc	0.068%/℃				
	NOCT	45℃				

V-I CHARACTERSTIC



V-I CHARACTERSTIC

- o The power delivered by a solar cell is the product of current and voltage (I x V). If the multiplication is done, point for point, for all voltages from short-circuit to open-circuit conditions,
- o The power curve above is obtained for a given radiation level.
- o With the solar cell open-circuited, that is not connected to any load, the current will be at its minimum (zero) and the voltage across the cell is at its maximum, known as the solar cells open circuit voltage, or Voc.
- o At the other extreme, when the solar cell is short circuited, that is the positive and negative leads connected together, the voltage across the cell is at its minimum (zero) but the current flowing out of the cell reaches its maximum, known as the solar cells short circuit current, or Is

NEED OF SOLAR TREE

- o **Due to less land requirement**

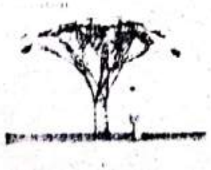
  It require less land as compare to traditional PV system. So we require such a plant which can generate max. energy using minimum land.
- o **Efficient energy generation**

  It can generate energy very efficiently as compare to traditional system.
- o **It can collect energy from wind**

  The stem are flexible so that they can rotate in any direction and by shaking themselves they produce energy also from wind as in the case of a natural tree.

WHY IT IS BETTER THAN A TRADITIONAL SYSTEM

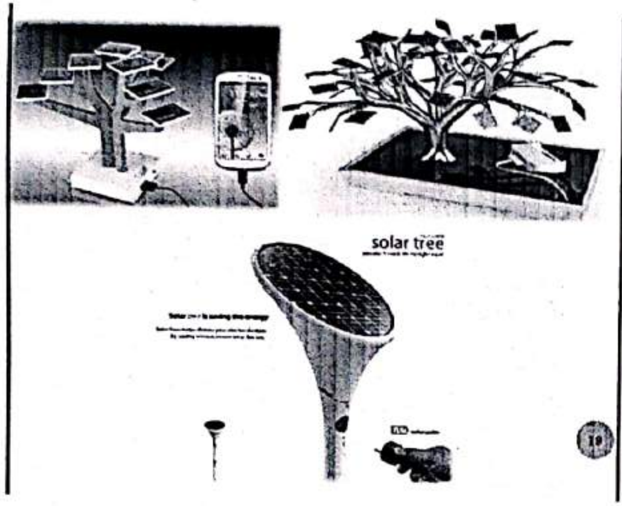
- o [illegible] the traditional system we require [illegible] size [illegible] land [illegible] example [illegible] 2 MW power fr[illegible] [illegible] quires [illegible] thousan[illegible]
- o [illegible] the sa[illegible] requ[illegible] of [illegible]



SOLAR TREE IN INDIA

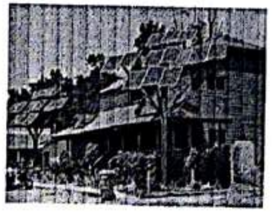
- o India being [illegible] developing country and highly populated requires a power plant where maximum energy can be generated by using minimum land.
- o [illegible] first try [illegible] from sun [illegible] untry [illegible] ng en[illegible]

- o The Salient Features of the Solar Power Tree are:
  - [illegible] ly 4 sq[illegible] Powe[illegible] layout [illegible] f land
  - [illegible] the pl[illegible] ght, on [illegible] s for o[illegible] possil[illegible] wer in [illegible] layout
  - [illegible] tery b[illegible] gives [illegible]
  - [illegible] ted w[illegible] self-cl[illegible] the [illegible]
  - [illegible] ted co[illegible] Lakh [illegible]



APPLICATION

- Street light
- House supply
- Industrial power supply
- Mobile charger



ADVANTAGES

- No air pollution
- We wouldn't have to worry as much about future energy sources
- People in poor country would have access to electricity
- People can save money
- Land requirement is very less

DISADVANTAGES

As we know nothing is perfect in the world, so is Solar tree.

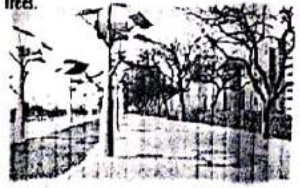
Here are some of its disadvantages

- Cost is high
- May cause hazards to the birds and insects
- Hazards to eyesight from solar reflectors

FUTURE OF SOLAR TREE

Getting electrical power instantly

We can charge our electrical vehicles and also enrich the environment with eco-friendly solar trees.



CONCLUSION

- To fulfils the increasing energy demand the people.
- Saving of land. this project is very successful one.
- This can provide electricity without any power cut problem.

REFERENCES

- http://en.wikipedia.org/wiki/solar tree
- http://articles.economictimes.indiatimes.com/
- http://en.wikipedia.org/wiki/solar energy
- http://books.google.co.in/books?id=[illegible] MuCe8 [illegible]
- http://en.wikipedia.org/wiki/renewable energies
- http://[illegible] ques [illegible]

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affiliated to Anna University, Chennai
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – ODD

TEACHER TEACH TEACHERS

Speaker: **Mr. SENTHAMARAI KANNAN A.**
Associate Professor
Department of EEE

Staff Attended:

1. Mr. G.Purushothaman HOD/EEE
2. Ms.K.Vinothini AP/EEE
3. Ms.Dhanalakshmi AP/EEE
4. Mr. Ismail Gani AP/EEE
5. Mr. Ranjith Kumar AP/EEE

Topic:

"Electrical Machines"

Venue:

Circuits Lab

Report encl:

13th September 2019 & 1.30 P.M to 2.30 P.M

13/9/2019.

HOD/EEE

13

PRINCIPAL

Scanned with CamScanner

ELECTRICAL MACHINES – II

STATING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

Mr. A. Senthamaraikannan
ASP/EEE/M.A.M.SE

Starting methods

Full Voltage Starting Method for Squirrel Cage Induction Motor:

Direct on Line Starting Method

- This method is also known as the DOL method for starting the three phase squirrel cage induction motor. In this method we directly switch the stator of the three phase squirrel cage induction motor on to the supply mains. The motor at the time of starting draws very high starting current (about 5 to 7 times the full load current) for the very short duration. The amount of current drawn by the motor depends upon its design and size. But such a high value of current does not harm the motor because of rugged construction of the squirrel cage induction motor.

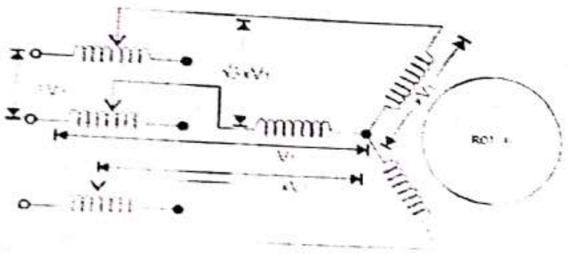
Contd..

Reduced voltage method for starting squirrel cage induction motor:

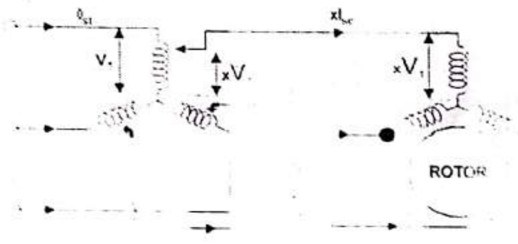
In reduced voltage method we have three different type of starting method and these are written below:

- ➢ Stator resistor starting method
- ➢ Auto transformer staring method
- ➢ Star delta starting method
- ➢ Now let us discuss each of these methods in detail.
- ➢ Stator Resistor Starting Method

Stator resistor starting method

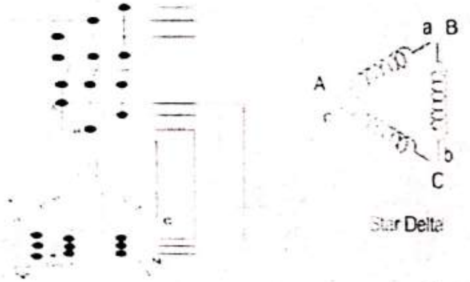


Auto Transformer Starting Method



Pertaining [illegible] Auto Transfer Starting

Star-Delta Starting Method



Addition of External Resistances in Rotor Circuit

- [illegible] starting [illegible] starting [illegible] and [illegible] power fact[illegible] shown [illegible] ee slip [illegible] ed to [illegible] rotor [illegible] ting [illegible] stance [illegible] uit. Th [illegible] ased [illegible] ds up [illegible] axim [illegible] n per [illegible] oper [illegible] r wh [illegible] oper [illegible] ding [illegible]

Contd..

- [illegible] induction motor the value [illegible] maximum torque is directly pro[illegible] to [illegible] of the supply voltage [illegible] synchronous mac[illegible] the [illegible] torque [illegible] directly pro[illegible] the supply voltage.
- [illegible] can ea[illegible] speed [illegible] with sync[illegible] annot [illegible] d) Indu[illegible] torque [illegible] or has [illegible]
- [illegible] in mo[illegible] facto[illegible] th the [illegible] r we [illegible] supp[illegible]

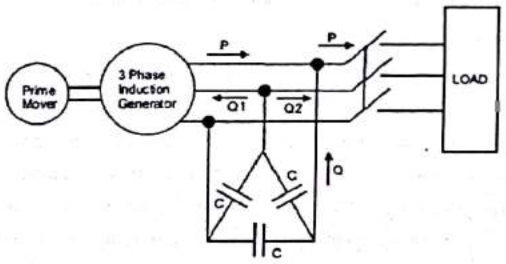
Contd..

- It [illegible] single excited machine mean[illegible] there is no requirement of d[illegible] excitation whi[illegible] synchronous mo[illegible]tor is d[illegible] excited motor means there is re[illegible] excita[illegible]
- In [illegible] on inc[illegible] of th[illegible] d[illegible] peed [illegible] rema[illegible] c[illegible]

Induction Generator

- Induction machine is sometimes used as a generator. It is also called Asynchronous Generator. What are the conditions when the poly phase (here three phase) induction machine will behave as an induction generator? The following are conditions when the induction machine will behave as an *induction* generator are written below:
- Slip becomes negative due to this the rotor current and rotor emf attains negative value.
- The prime mover torque becomes opposite to electric torque. Now let us discuss how we can achieve these conditions. Suppose that an induction machine is coupled with the prime mover whose speed can be controlled. If the speed of the prime mover is increased such that the slip becomes negative (i.e. speed of the prime mover becomes greater than the synchronous speed).

Isolated Induction Generator



Contd..

- This type of generator is also known as self excited generator. Now why it is called self excited? It is because it uses capacitor bank which is connected across its stator terminals
- The function of the capacitor bank is to provide the lagging reactive power to the induction generator as well as load.
- The cumulative process of voltage generation continues till the saturation curve of the induction generator cuts the capacitor load line at some point. This point is marked as f in the given curve.

Contd..

iii) Number of stator slots and conductors per slot

Considering the guide lines for selection of number of slots

Selecting the number of slots/pole/phase = 3

Total number of slots = 3 x 12 x 3 =108

Slot pitch = πD/S

= π x 132/ 108

= 2.84 cm (quite satisfactory)

Number of conductors per slot = 2472/108 = 24

Hence total number of conductors = 24 x 108 = 2592

Turns per phase = 2592/6 = 432

- Slot loading
- Full load current = 500 x 10³ / (√3 x 6600) = 43.7 amps
- Slot loading = current per conductor x number of conductors/slot
- = 43.7 x 24
- = 1048.8 (satisfactory)

Contd..

Speed control of Induction Machines

- Speed control by changing applied voltage
- From the torque equation of the induction machine given in eqn.17, we can see that the torque depends on the square of the applied voltage. The variation of speed torque curves with respect to the applied voltage is shown in fig. 18. These curves show that the slip at maximum torque s' remains same, while the value of stall torque comes down with decrease in applied voltage. The speed range for stable operation remains the same.
- Rotor resistance control
- For all its advantages, the scheme has two serious drawbacks. Firstly, in order to vary the rotor resistance, it is necessary to connect external variable resistors (winding resistance itself cannot be changed). This therefore necessitates a slip-ring machine, since only in that case rotor terminals are available outside. For cage rotor machines, there are no rotor terminals. Secondly, the method is not very efficient since the additional resistance and operation at high slips entails dissipation.

Contd..

- Cascade control
- T[illegible] rotor [illegible] more [illegible] gener[illegible] the s[illegible] to a[illegible] The [illegible] ry slip [illegible] first [illegible] e use[illegible] till bet[illegible] coupl[illegible] chine [illegible] calle[illegible]

Contd..

- Pole changing schemes
- So[illegible] nes ha[illegible] stator [illegible] capa[illegible] be[illegible] to form [illegible] pole [illegible] Sin[illegible] of th[illegible] ven by [illegible] (in [illegible] ber o[illegible] rresp[illegible] ch[illegible] eed [illegible] ondin[illegible] ne[illegible] oper[illegible]

M.A.M SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi Affilated to Anna University, Chennai)
Trichy – Chennai Trunk Road, Siruganur, Trichy – 621 105

Department of Electrical and Electronics Engineering

Academic year: 2019-2020 – EVEN

TEACHER TEACH TEACHERS

06.03.2020

Speaker: **Mr. PURUSHOTHAMAN**
HOD / EEE
Department of EEE

Staff Attended:

1. Mr.A.Senthamarai kannan Asso.Prof/EEE
2. Mr. M.Ranjith kumar AP/EEE
3. Mr. G.Purushothaman HOD/EEE
4. Ms.K.Vinothini AP/EEE
5. Mrs. Meenakshi M AP/EEE
6. Mr. Ismail Gani AP/EEE

Topic:

"Three Phase Transformers"

Venue:

Circuits Lab

Report encl:

6th March 2020 & 1.30 P.M to 2.30 P.M

6/3/2020

HOD/EEE

PRINCIPAL

Scanned with CamScanner

THREE PHASE TRANSFORMERS

G PURUSHOTHAMAN
AP/EEE
M.A.M. SCHOOL OF ENGINEERING

3-Phase Transformer Construction, Principal, Working, Operation Advantages Over 1-Phase Transformer

- Introduction
- Advantages
- Construction
- Principal
- Working

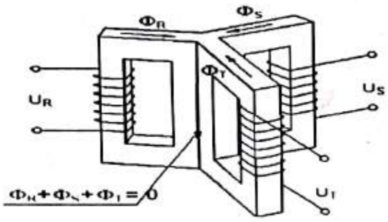
Introduction

- The generation of an electrical power is usually three phase and at higher voltages like 13.2 KV, 22 KV or some what higher.
- Similarly transmission of an electrical power is also at very high voltages like 110 KV, 132 KV, 400 KV.
- To step up the generated voltages for transmission purposes it is necessary to have three phase transformers.

Advantages

- Less space
- Weight Less
- Cost is Less
- Transported easily
- Core will be smaller size
- More efficient
- Structure, switchgear and installation of single three phase unit is simpler

Principal of Operation



- The three cores are arranged at 120° from each other. Only primary windings are shown on the cores for simplicity.
- The primaries are connected to the three phase supply.
- The three fluxes is also zero at any instant.

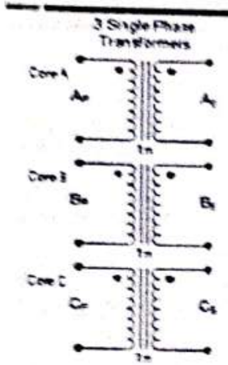
- Hence the centre leg does not carry any flux
- So if centre leg is removed any two legs provide the return path for the current and hence the flux in the third leg.
- This is the general principle used in the design of three phase core type transformers.

Three Phase Transformer Connections

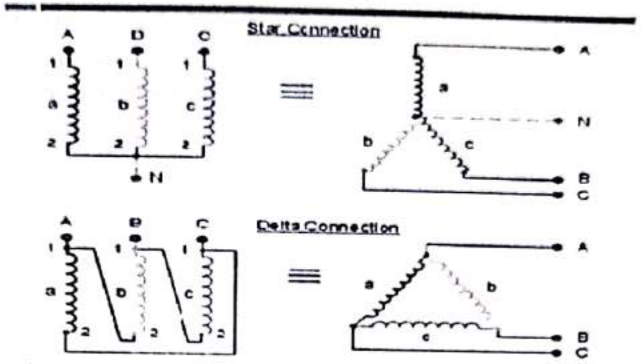
- The primary and secondary winding of three phase transformers or three phase winding can be connected in different ways such as in star or in delta. With suitable connection the voltage can be raised or lowered.
- In this section different commonly used connections for three phase transformers are discussed.

- Star Star connection
- Delta-Delta connection
- Star Delta connection
- Delta-Star connection

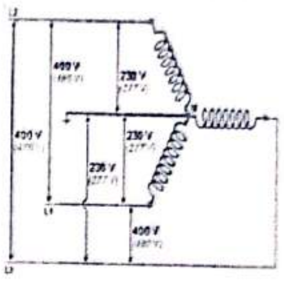
Scanned with CamScanner



Primary Configuration		Secondary Configuration	
Delta (Mesh)	△	Delta (Mesh)	△
Delta (Mesh)	△	Star (Wye)	Y
Star (Wye)	Y	Delta (Mesh)	△
Star (Wye)	Y	Star (Wye)	Y
Interconnected Star	⅄	Delta (Mesh)	△
Interconnected Star	⅄	Star (Wye)	Y

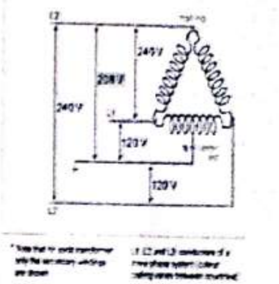


3-phase, Wye-connected transformer



3-phase, Delta-connected transformer

(shown is a split-phase or high leg delta type)



Parallel Operation of Three Phase Transformer

- The transformers are connected in parallel when load on one of the transformers is more then it capacity

- The reliability is increased with parallel operation than to have single larger unit.

- The Transformers connected in parallel must have same polarity so that the resultant voltage around the local loop is zero. With improper polarities there are chances of dead short circuit.

- The relative phase displacements on the secondary sides of the three phase transformers to be connected in parallel must be zero. The transformers with same phase group can be connected in parallel

- As the phase shift between the secondary voltages of a star/delta and delta/star transformers is 30°, They cannot be connected in parallel.

- But transformers with +30° and -30° phase shift can be connected in parallel by reversing phase sequence of one of them

- The voltage ratio of the two transformers must be same. This prevents no load circulating current when the transformers are in parallel on primary and secondary sides.

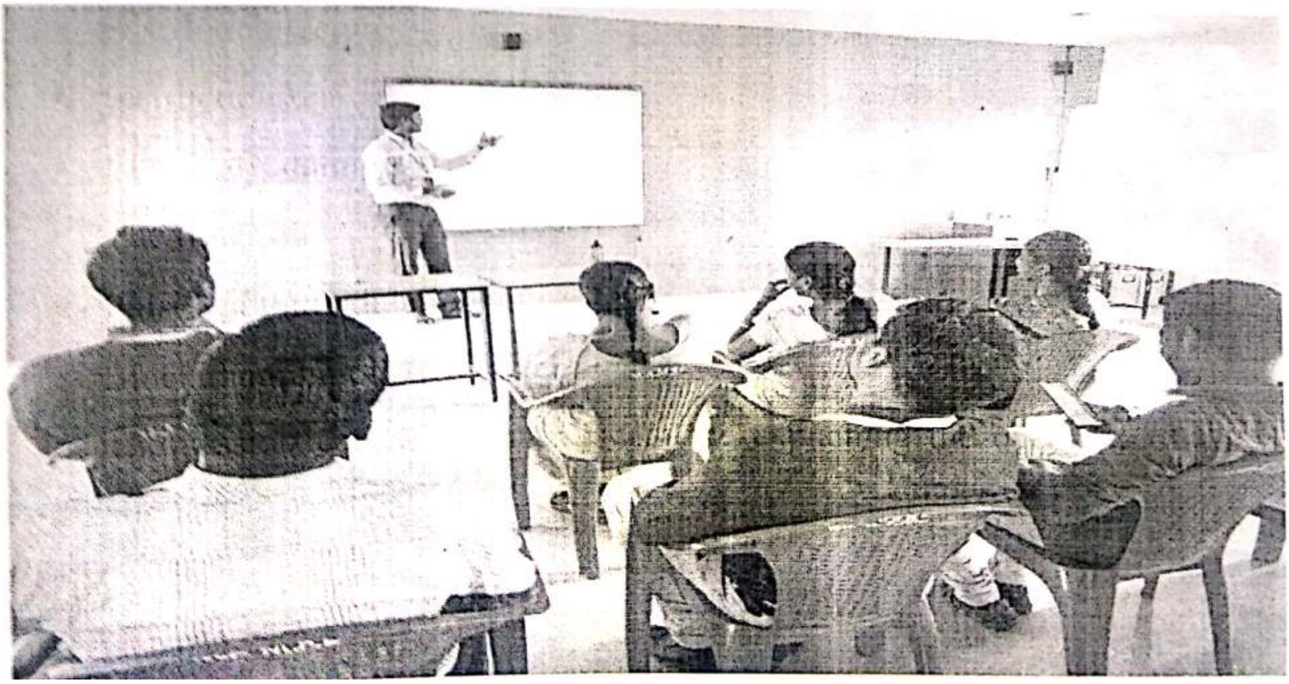
- [illegible] the [illegible] less [illegible] difference [illegible] circulating current [illegible] in [illegible] e 12i [illegible]

REPORT

The session was initiated by Mr. K.Karthikeyan Assistant Professor/ECE. He explained about ARM Processor and its Applications and discuss about the following topics

- ARM architecture
- Instruction set
- LPC 214X-family
- The timer unit
- Pulse width modulation unit
- Block diagram of ARM 9

The session comes to an end with the explaining the overview of ARM Processor and its Application.



Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.
Academic year (2019-2020) Even semester

Department of Electronics & Communication Engineering

Teacher Teach Teacher (TTT)

Date:16-03-2020

Speaker: Mr.K.Karthikeyan

Assistant professor– Electronics and Communication Engineering

Staff attended:

1. Mrs.K.Umarani
2. Mr.G.Sathesh kumar
3. Mr.A.Karthick kumar
4. Mr.Arumugasamy
5. Mr.K.Saravanan
6. Mrs.Berbeth mary
7. Mrs.A.Subha pradha

Topic:

ARM Processor

Venue:

Smart class

Date & Time:
16th-march-2020&1.30 pm -2.30 pm

**enclosure: Report

17/3/20.
HOD/ECE

Scanned with CamScanner

REPORT

The session was initiated by Mr.A.Karthick kumar, Assistant Professor/ECE. he explained about Embedded system design process and discuss about the following topics

- Design model
- Design methodologies
- Design flows
- Requirement analysis
- Quality assurance techniques
- Designing with computing platform

The session comes to an end with the explaining the overview of Embedded system design process and its Application.

HOD/ECE

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.
Academic year (2019-2020) Even semester

Department of Electronics & Communication Engineering

Teacher Teach Teacher (TTT)

Date: 09-03-2020

Speaker: Mr.A.Karthick kumar

Assistant professor–Electronics and Communication Engineering

Staff attended:

1. Mrs.K.Umarani
2. Mr.G.Sathesh kumar
3. Mr.K.Karthikeyan
4. Mrs.Berbeth mary
5. Mrs.A.Subha pradha
6. Mr.Arumugasamy
7. Mr.K.Saravanan

Topic:

Embedded system design process

Venue:

Smart class

Date & Time:

9th march-2020&1.30 pm to 2.30 pm

**enclosure: Report

HOD/ECE 11/3/20

Scanned with CamScanner

The *Acorn Business Computer* (ABC) plan required that a number of second processors be made to work with the BBC Micro platform, but processors such as the Motorola 68000 and National Semiconductor 32016 were considered unsuitable, and the 6502 was not powerful enough for a graphics-based user interface.[19]

According to Sophie Wilson, all the processors tested at that time performed about the same, with about a 4 Mbit/second bandwidth.[20]

After testing all available processors and finding them lacking, Acorn decided it needed a new architecture. Inspired by papers from the Berkeley RISC project, Acorn considered designing its own processor.[21] A visit to the Western Design Center in Phoenix, where the 6502 was being updated by what was effectively a single-person company, showed Acorn engineers Steve Furber and Sophie Wilson they did not need massive resources and state-of-the-art research and development facilities.[22]

Wilson developed the instruction set, writing a simulation of the processor in BBC BASIC that ran on a BBC Micro with a 6502 second processor.[23][24] This convinced Acorn engineers they were on the right track. Wilson approached Acorn's CEO, Hermann Hauser, and requested more resources. Hauser gave his approval and assembled a small team to implement Wilson's model in hardware.[*citation needed*]

Acorn RISC Machine: ARM2[edit]

The official *Acorn RISC Machine* project started in October 1983. They chose VLSI Technology as the *silicon partner*, as they were a source of ROMs and custom chips for Acorn. Wilson and Furber led the design. They implemented it with efficiency principles similar to the 6502.[25] A key design goal was achieving low-latency input/output (interrupt) handling like the 6502. The 6502's memory access architecture had let developers produce fast machines without costly direct memory access (DMA) hardware.

The first samples of ARM silicon worked properly when first received and tested on 26 April 1985.[3]

The first ARM application was as a second processor for the BBC Micro, where it helped in developing simulation software to finish development of the support chips (VIDC, IOC, MEMC), and sped up the CAD software used in ARM2 development. Wilson subsequently rewrote BBC BASIC in ARM assembly language. The in-depth knowledge gained from designing the instruction set enabled the code to be very dense, making ARM BBC BASIC an extremely good test for any ARM emulator. The original aim of a principally ARM-based computer was achieved in 1987 with the release of the Acorn Archimedes.[26] In 1992, Acorn once more won the Queen's Award for Technology for the ARM.

Scanned with CamScanner

ARM PROCESSOR

ARM, previously **Advanced RISC Machine**, originally **Acorn RISC Machine**, is a family of reduced instruction set computing (RISC) architectures for computer processors, configured for various environments. Arm Holdings develops the architecture and licenses it to other companies, who design their own products that implement one of those architectures—including systems-on-chips (SoC) and systems-on-modules (SoM) that incorporate memory, interfaces, radios, etc. It also designs cores that implement this instruction set and licenses these designs to a number of companies that incorporate those core designs into their own products.

Processors that have a RISC architecture typically require fewer transistors than those with a complex instruction set computing (CISC) architecture (such as the x86 processors found in most personal computers), which improves cost, power consumption, and heat dissipation. These characteristics are desirable for light, portable, battery-powered devices—including smartphones, laptops and tablet computers, and other embedded systems[3][4][5]—but are also useful for servers and desktops to some degree. For supercomputers, which consume large amounts of electricity, ARM is also a power-efficient solution.[6]

Arm Holdings periodically releases updates to the architecture. Architecture versions ARMv3 to ARMv7 support 32-bit address space (pre-ARMv3 chips, made before Arm Holdings was formed, as used in the Acorn Archimedes, had 26-bit address space) and 32-bit arithmetic; most architectures have 32-bit fixed-length instructions. The Thumb version supports a variable-length instruction set that provides both 32- and 16-bit instructions for improved code density. Some older cores can also provide hardware execution of Java bytecodes; and newer ones have one instruction for JavaScript. Released in 2011, the ARMv8-A architecture added support for a 64-bit address space and 64-bit arithmetic with its new 32-bit fixed-length instruction set.[7] Some recent Arm CPUs have simultaneous multithreading (SMT) with e.g. Arm Neoverse E1 being able to execute two threads concurrently for improved aggregate throughput performance. ARM Cortex-A65AE for automotive applications is also a multithreaded processor, and has Dual Core Lock-Step for fault-tolerant designs (supporting Automotive Safety Integrity Level D, the highest level). The Neoverse N1 is designed for "as few as 8 cores" or "designs that scale from 64 to 128 N1 cores within a single coherent system".[8]

With over 130 billion ARM processors produced,[9][10][11][12] as of 2019, ARM is the most widely used instruction set architecture (ISA) and the ISA produced in the largest quantity.[13][4][14][15][16] Currently, the widely used Cortex cores, older "classic" cores, and specialized SecurCore cores variants are available for each of these to include or exclude optional capabilities. The British computer manufacturer Acorn Computers first developed the Acorn RISC Machine architecture (ARM)[17][18] in the 1980s to use in its personal computers. Its first ARM-based products were coprocessor modules for the 6502B based BBC Micro series of computers. After the successful BBC Micro computer, Acorn Computers considered how to move on from the relatively simple MOS Technology 6502 processor to address business markets like the one that was soon dominated by the IBM PC, launched in 1981.

Scanned with CamScanner

destination is found from database and displayed by the renderer. The system block diagram may be refined into two block diagrams - hardware and software.

System integration After the components are built, they are integrated. Bugs are typically found during the system integration. Good planning can help us to find the bugs quickly. By debugging a few modules at a time, simple bugs can be uncovered. By fixing the simple bugs early, more complex or obscure bugs can be uncovered. System integration is difficult because it usually uncovers problems. The debugging facilities for embedded systems are usually much more limited than the desktop systems. Careful attention is needed to insert appropriate debugging facilities during design which can help to ease system integration problems.

Summary

In the Embedded system design process, information is first collected and refined in the Requirement step. Specification uses the refined information to describe the functions of the system which accurately reflects the customer's requirements and also serves as the contract between the customer and the designer. The functions described by the specification are implemented by the Architecture design. The architectural design describes the components we need which will include both the hardware and software components. After the components are built, they are integrated to get the final system.

Scanned with CamScanner

EMBEDDED SYSTEM DESIGN PROCESS

Design process steps: There are different steps involved in Embedded system design process. These steps depend on the design methodology. Design methodology is important for optimizing performance, and developing computer aided design tools. It also makes communication between team members easier. They are requirements gathering, specification formulation, architecture design, building of components, and system integration. Figure 1. Steps in Design process The steps in the design process can be viewed as top down view and bottom up view. Top down view begins with the most abstract description of the system and concludes with concrete details. Bottom–up view starts with components to build a system. Bottom–up design steps are shown in the figure as dashed-line arrows. We need bottom–up design because we do not have perfect insight into how later stages of the design process will turn out. The major goals of the design to be considered are : • Manufacturing cost; • Performance (both overall speed and deadlines) and • Power consumption. The tasks which need to be performed at each step are the following. • We must analyze the design at each step to determine how we can meet the specifications. • We must then refine the design to add details. • We must verify the design to ensure that it still meets all system goals, such as cost, speed, and so on. We will discuss each step of the design process in detail. 1.1 Requirements Informal descriptions gathered from the customer are known as requirements. The requirements are refined into a specification to begin the designing of the system architecture. Requirements can be functional or non-functional requirements. Functional requirements need output as a function of input. Non-functional requirements includes performance, cost, physical size, weight, and power consumption. Performance may be a combination of soft performance metrics such as approximate time to perform a user-level function and hard deadlines by which a particular operation must be completed. Cost includes the manufacturing, nonrecurring engineering(NRE) and other costs of designing the system. Physical size and weight are the physical aspects of the final system. These can vary greatly depending upon the application. Power consumption can be specified in the requirements stage in terms of battery life.

Architecture Design

The specification describes only the functions of the system. Implementation of the system is described by the Architecture. The architecture is a plan for the overall structure of the system. It will be used later to design the components.The architecture will be illustrated using block diagrams as shown below. Example: A basic block diagram of the GPS system shows the major operations and the data flow among the blocks. Figure 3. GPS system data flow and operations This block diagram(figure 3) is an initial architecture that is not based either on hardware or on software but combination of both. This block diagram explains about GPS navigating system where GPS receiver gets current position and the destination is taken from user, digital map for source to

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Teacher Teach Teacher (TTT) Programme

ACADEMIC YEAR 2019- 20 (ODD SEMESTER)

Sl.No.	Name of the Faculty	Syllabus	Date & Session
1	Dr.P.Ranjith kumar	Computer Integrated Manufacturing	07/09/2019 FN
2	R.Ramanathan	Manufacturing Method by using Various Sheet Metals / Materials.	12/10/2019 FN

HoD

M.A.M. SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Teachers Teach Teacher (TTT) Programme

ACADEMIC YEAR 2019-20 (EVEN SEMESTER)

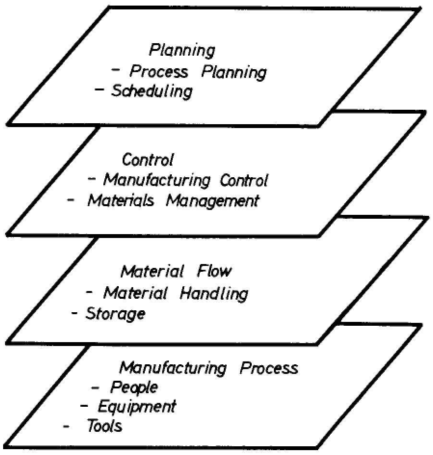
Sl.No.	Name of the Faculty	Syllabus	Date & Period
1	Dr.M.Panneerselvam	Design of Various Mechanical Elements.	03/01/2020 FN
2	Dr.K.Chandrasekaran	Optimazation Tools and Technique Composite Materials	15/02/2020 FN

HoD

Introduction to Computer Integrated Manufacturing (CIM)

1. Flexible Manufacturing System (FMS)
2. Variable Mission Mfg. (VMM)
3. Computerized Mfg. System (CMS)

Four-Plan Concept of Manufacturing



CIM System discussed:

- Computer Numerical Control (CNC)
- Direct Numerical Control (DNC)
- Computer Process Control
- Computer Integrated Production Management
- Automated Inspection Methods
- Industrial Robots etc.

A CIM System consists of the following basic components:

I. Machine tools and related equipment
II. Material Handling System (MHS)
III. Computer Control System
IV. Human factor/labor

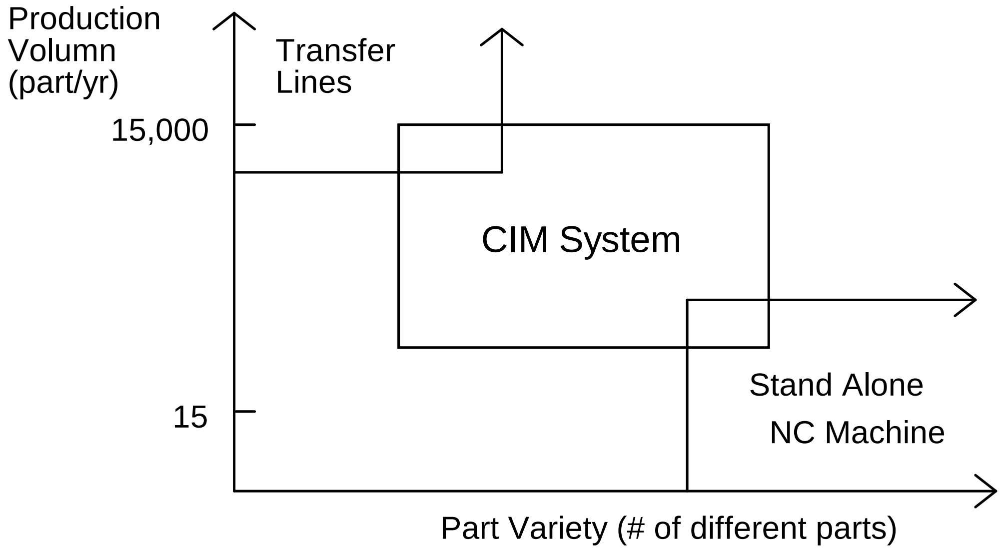
CIMS Benefits:

1. Increased machine utilization
2. Reduced direct and indirect labor
3. Reduce mfg. lead time
4. Lower in process inventory
5. Scheduling flexibility
6. etc.

CIM refers to a production system that consists of:

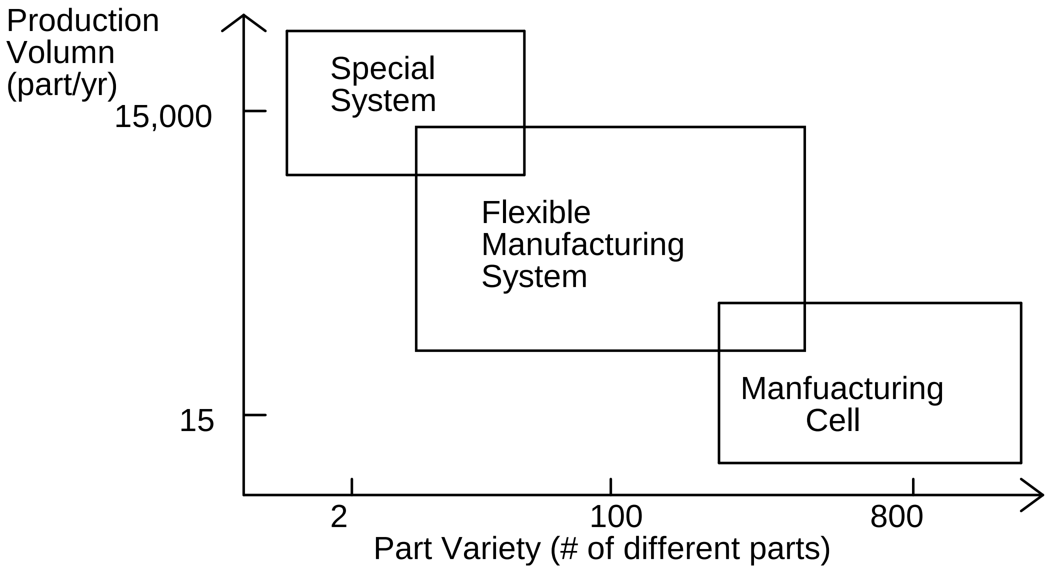
1. A group of NC machines connected together by
2. An automated materials handling system
3. And operating under computer control

Why CIMS?
In Production Systems



1. Transfer Lines: is very efficient when producing "identical" parts in large volumes at high product rates.
2. Stand Alone: NC machine: are ideally suited for variations in work part configuration.

In Manufacturing Systems:



1. Special Mfg. System: the least flexible CIM system. It is designed to produce a

very limited number of different parts (2 - 8).

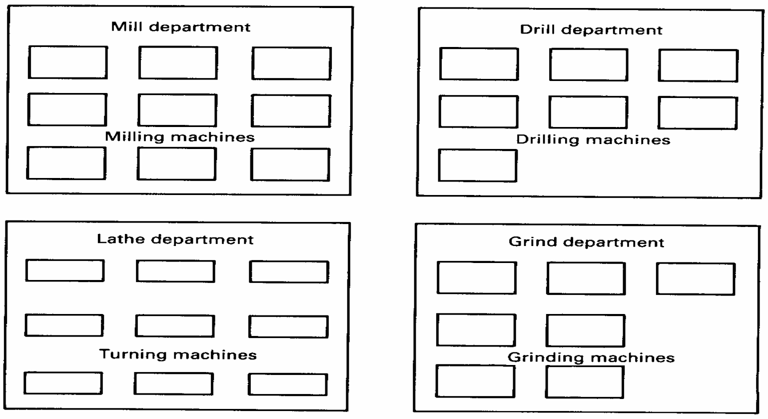
2. Mfg. Cell: the most flexible but generally has the lowest number of different parts manufactured in the cell would be between 40 - 80. Annual production rates rough from 200 - 500.
3. Flexible Mfg. System: A typical FMS will be used to process several part families with 4 to 100 different part numbers being the usual case.

General FMS

Conventional Approaches to Manufacturing

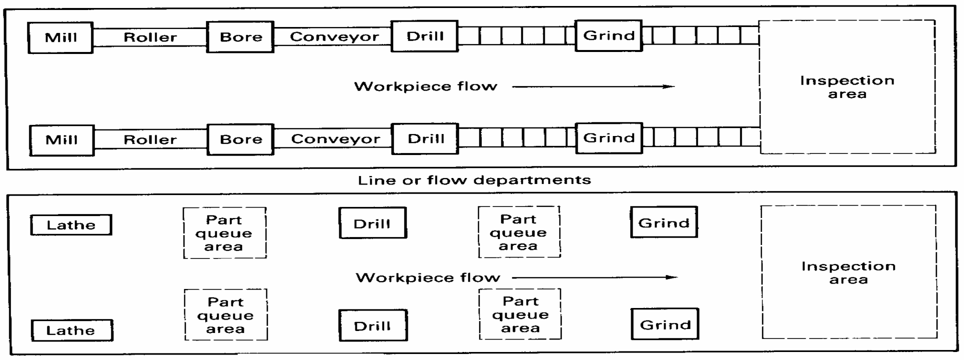
Conventional approaches to manufacturing have generally centered around machines laid out in logical arrangements in a manufacturing facility. These machine layouts are classified by:

1. Function - Machines organized by function will typically perform the same function, and the location of these departments relative to each other is normally arranged so as to minimize interdepartmental material handling. Workpiece produced in functional layout departments and factories are generally manufactured in small batches up to fifty pieces (a great variety of parts).



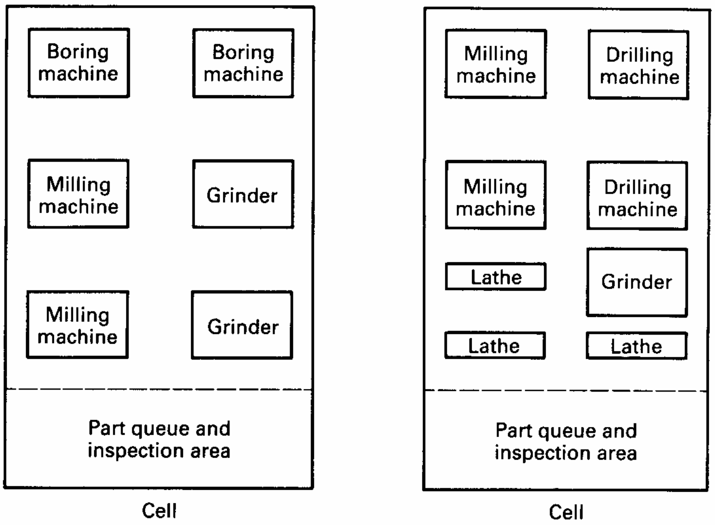
Machine layout by function.

2. Line or flow layout - the arrangement of machines in the part processing order or sequence required. A transfer line is an example of a line layout. Parts progressively move from one machine to another in a line or flow layout by means of a roller conveyor or through manual material handling. Typically, one or very few different parts are produced on a line or flow type of layout, as all parts processed require the same processing sequence of operations. All machining is performed in one department, thereby minimizing interdepartmental material handling.



Line or flow machine layout.

3. Cell - It combines the efficiencies of both layouts into a single multi-functional unit. It referred to as a group technology cell, each individual cell or department is comprised of different machines that may not be identical or even similar. Each cell is essentially a factory within a factory, and parts are grouped or arranged into families requiring the same type of processes, regardless of processing order. Cellular layouts are highly advantageous over both function and line machine layouts because they can eliminate complex material flow patterns and consolidate material movement from machine to machine within the cell.



Machine layout by cell based on part families to be processed

Manufacturing Cell

Four general categories:

1. **Traditional stand-alone NC machine tool** - is characterized as a limited-storage, automatic tool changer and is traditionally operated on a one-to-one machine to operator ratio. In many cased, stand-alone NC machine tools have been grouped together in a conventional part family manufacturing cell arrangement and operating on a one-to-one or two-to-one or three-to-one machine to operator ratio.

2. **Single NC machine cell or mini-cell** - is characterized by an automatic work changer with permanently assigned work pallets or a conveyor-robot arm system mounted to the front of the machine, plus the availability of bulk tool storage. There are many machines with a variety of options, such as automatic probing, broken tool detection, and high-pressure coolant control. The single NC machine cell is rapidly gaining in popularity, functionality, and affordability.

3. **Integrated multi-machine cell** - is made up of a multiplicity of metal-cutting machine tools, typically all of the same type, which have a queue of parts, either at the entry of the cell or in front of each machine. Multi-machine cells are either serviced by a material-handling robot or parts are palletized in a two- or three-machine, in-line system for progressive movement from one machining

station to another.

FMS - sometimes referred to as a flexible manufacturing cell (FMC), is characterized by multiple machines, automated random movement of palletize parts to and from processing stations, and central computer control with sophisticated command-driven software. The distinguishing characteristics of this cell are the automated flow of raw material to the cell, complete machining of the part, part washing, drying, and inspection with the cell, and removal of the finished part.

I. Machine Tools & Related Equipment

- Standard CNC machine tools
- Special purpose machine tools
- Tooling for these machines
- Inspection stations or special inspection probes used with the machine tool

The Selection of Machine Tools

1. Part size
2. Part shape
3. Part variety
4. Product life cycle
5. Definition of function parts
6. Operations other than machining - assembly, inspection etc.

II. Material Handling System

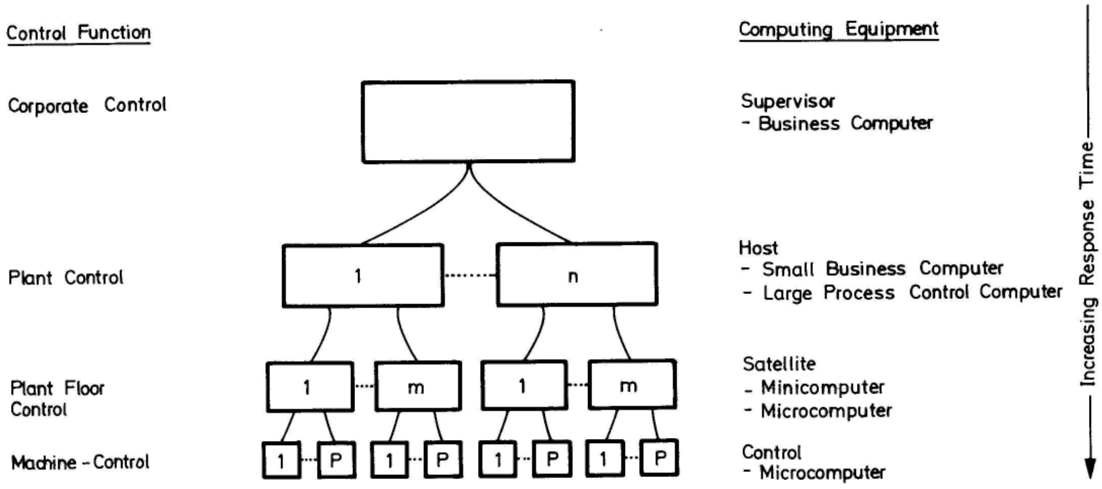
A. The primary work handling system - used to move parts between machine tools in the CIMS. It should meet the following requirements.

i). Compatibility with computer control
ii). Provide random, independent movement of palletized work parts between machine tools.
iii). Permit temporary storage or banking of work parts.
iv). Allow access to the machine tools for maintenance tool changing & so on.
v). Interface with the secondary work handling system
vi). etc.

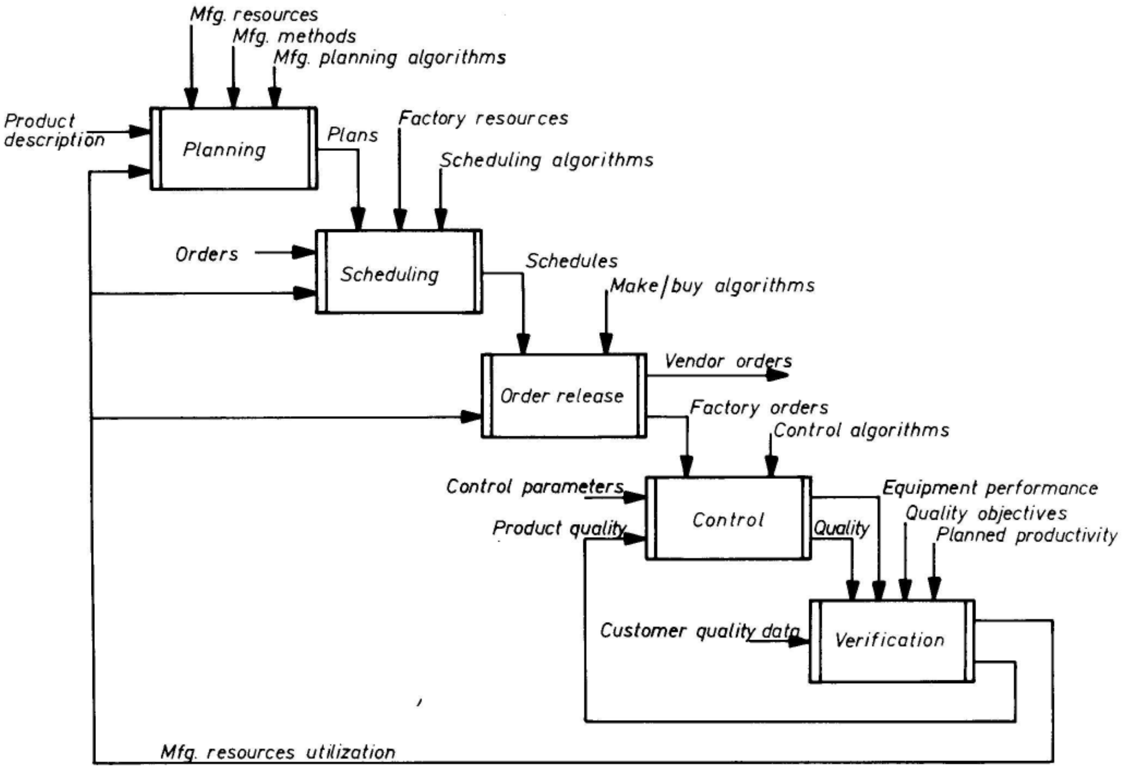
B. The secondary work handling system - used to present parts to the individual machine tools in the CIMS.

i). Same as A (i).
ii). Same as A (iii)
iii). Interface with the primary work handling system
iv). Provide for parts orientation & location at each workstation for processing.

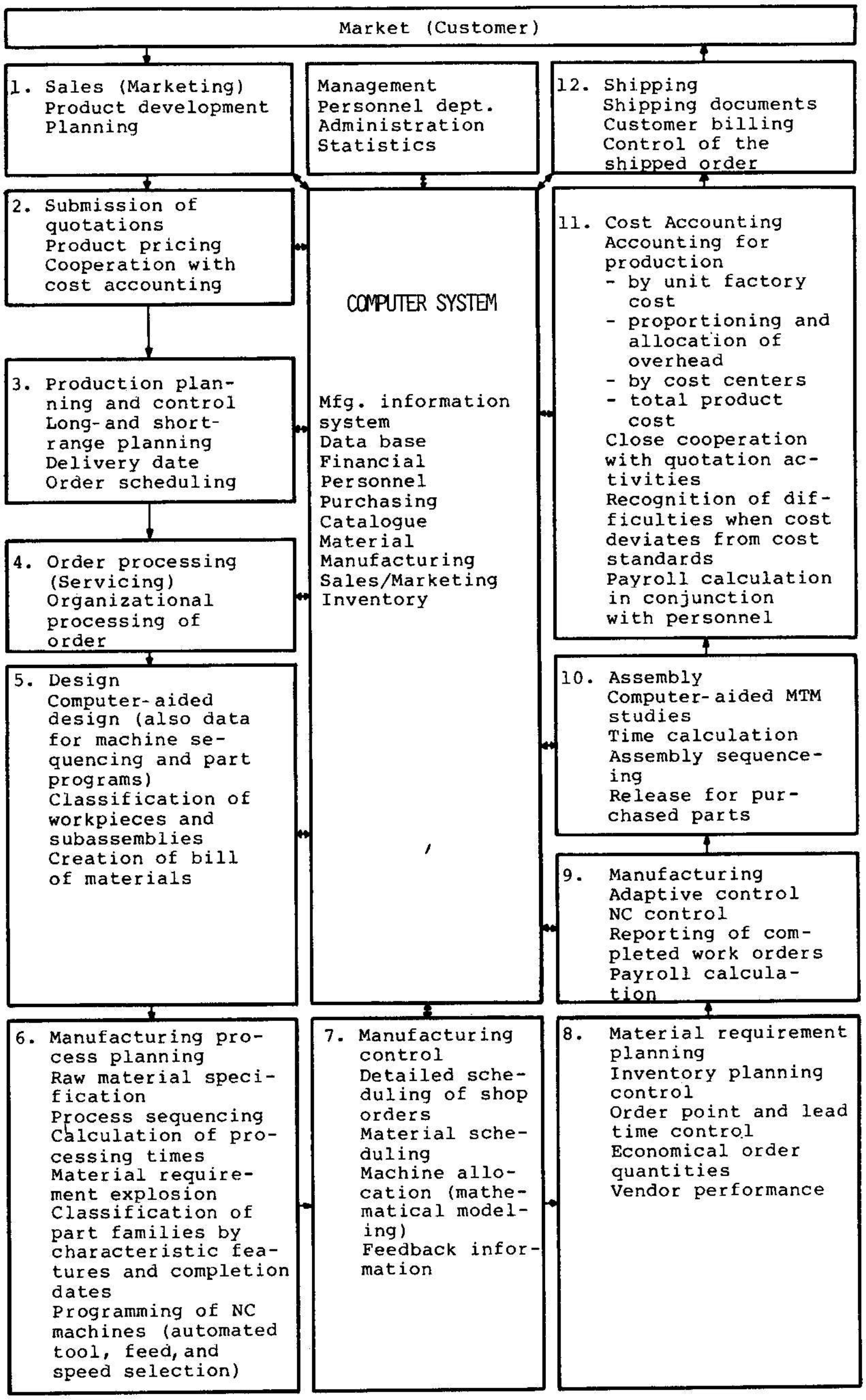
III. Computer Control System - Control functions of a firm and the supporting computing equipment



Control Loop of a Manufacturing System

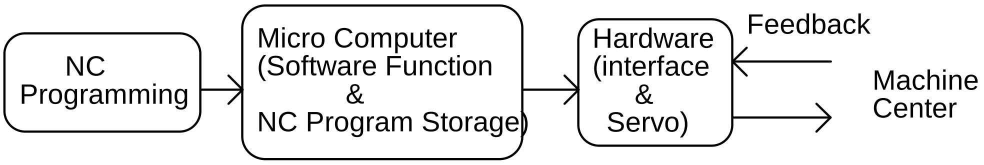


IV. Functions of the computer in a manufacturing organization



V. Functions of Computer in CIMS

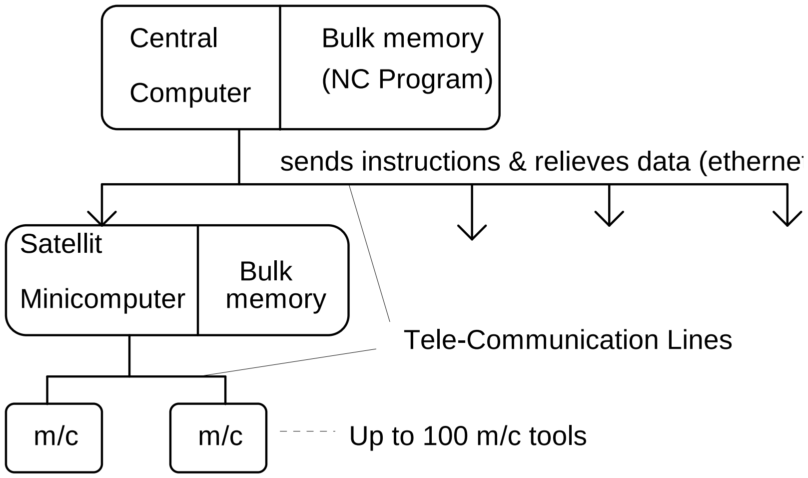
1. Machine Control – CNC



2. Direct Numerical Control (DNC) - A manufacturing system in which a number of m/c are controlled by a computer through direct connection & in real time.

Consists of 4 basic elements:

- Central computer
- Bulk memory (NC program storage)
- Telecommunication line
- Machine tools (up to 100)



3. Production Control - This function includes decision on various parts onto the system.

Decision are based on:

- red production rate/day for the various parts
- Number of raw work parts available
- Number of available pallets

4. Traffic & Shuttle Control - Refers to the regulations of the primary & secondary transportation systems which moves parts between workstation.

5. Work Handling System Monitoring - The computer must monitor the status of each cart & /or pallet in the primary & secondary handling system.

6. Tool Control

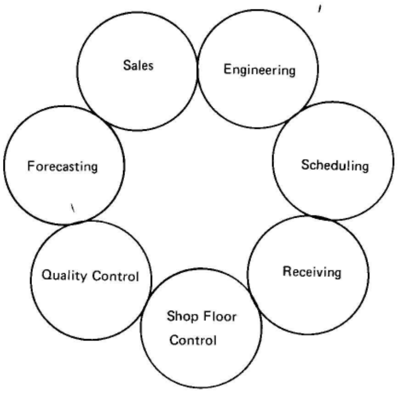
- Keeping track of the tool at each station
- Monitoring of tool life

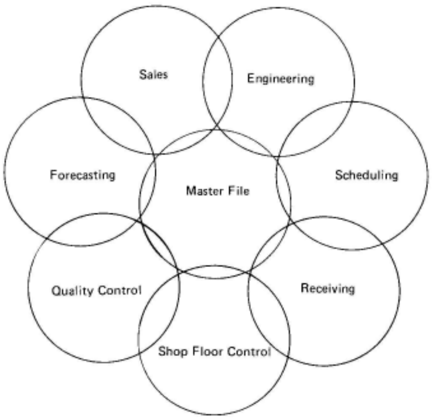
7. System Performance Monitoring & Reporting - The system computer can be programmed to generate various reports by the management on system performance.

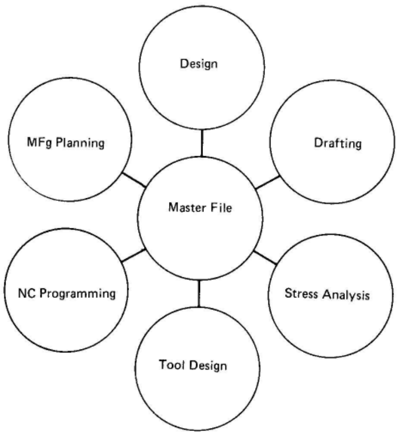
- Utilization reports - summarize the utilization of individual workstation as well as overall average utilization of the system.
- Production reports - summarize weekly/daily quantities of parts produced from a CIMS (comparing scheduled production vs. actual production)
- Status reports - instantaneous report "snapshot" of the present conditions of the CIMS.
- Tool reports - may include a listing of missing tool, tool-life status etc.

8. Manufacturing data base

- Collection of independent data bases
- Centralized data base
- Interfaced data base
- Distributed data base







Production Strategy

The production strategy used by manufacturers is based on several factors; the two most critical are customer lead time and manufacturing lead time.

Customer lead time identifies the maximum length of time that a typical customer is willing to wait for the delivery of a product after an order is placed.

Manufacturing lead time identifies the maximum length of time between the receipt of an order and the delivery of a finished product.

Manufacturing lead time and customer lead time must be matched. For example, when a new car with specific options is ordered from a dealer, the customer is willing to wait only a few weeks for delivery of the vehicle. As a result, automotive manufacturers must adopt a production strategy that permits the manufacturing lead-time to match the customer's needs.

The production strategies used to match the customer and manufacturer lead times are grouped into four categories:

1. Engineer to order (ETO)
2. Make to order (MTO)
3. Assemble to order (ATO)
4. Make to stock (MTS)

Engineer to Order

A manufacturer producing in this category has a product that is either in the first stage of the life-cycle curve or a complex product with a unique design produced in single-digit quantities. Examples of ETO include construction industry products (bridges, chemical plants, automotive production lines) and large products with special options that are stationary during production (commercial passenger aircraft, ships, high-voltage switchgear, steam turbines). Due to the nature of the product, the customer is willing to accept a long manufacturing lead time because the engineering design is part of the process.

Make to Order

The MTO technique assumes that all the engineering and design are complete and the production process is proven. Manufacturers use this strategy when the demand is unpredictable and when the customer lead-time permits the production process to start on receipt of an order. New residential homes are examples of this production strategy. Some outline computer companies make personal computer to customer specifications, so they followed MTO specifications.

Assemble to Order

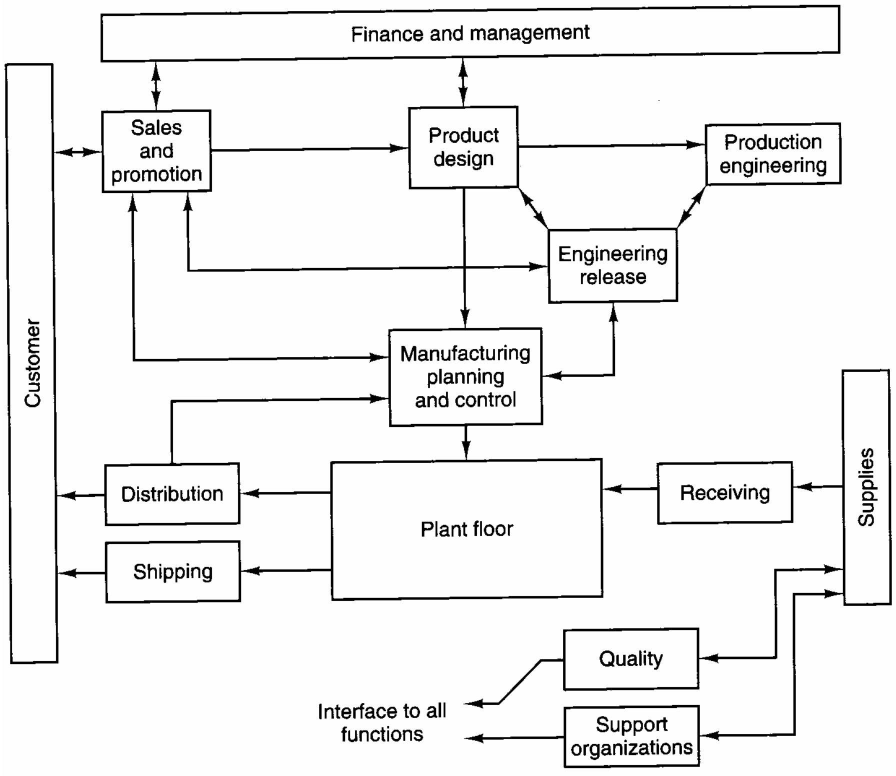
The primary reason that manufacturers adopt the ATO strategy is that customer lead time is less than manufacturing lead time. An example from the automotive industry was used in the preceding section to describe this situation for line manufacturing systems. This strategy is used when the option mix for the products can be forecast statistically: for example, the percentage of four-door versus two-door automobiles assembled per week. In addition, the subassemblies and parts for the final product are carried in a finished components inventory, so the final assembly schedule is determined by the customer order. John Deere and General Motors are examples of companies using this production strategy.

Make to Stock

MTS, is used for two reasons: (1) the customer lead time is less than the manufacturing lead time, (2) the product has a set configuration and few options so that the demand can be forecast accurately. If positive inventory levels (the store shelf is never empty) for a product is an order-winning criterion, this strategy is used. When this order-winning criterion is severe, the products are often stocked in distribution warehouses located in major population centers. This option is often the last phase of a product's life cycle and usually occurs at maximum production volume.

Manufacturing Enterprise (Organization)

- In most manufacturing organizations the functional blocks can be found as:
- A CIM implementation affects every part of an enterprise; as a result, every block in the organizational model is affected.



Sales and Promotion

- The fundamental mission of sales and promotion (SP) is to create customers. To achieve this goal, nine internal functions are found in many companies: sales, customer service, advertising, product research and development, pricing, packaging, public relations, product distribution, and forecasting.

sales and promotion interfaces with several other areas in the business:

- The customer services interface supports three major *customer* functions: order entry, order changes, and order shipping and billing. The order change interface usually involves changes in product specifications, change in product quantity (ordered or available for shipment), and shipment dates and requirements.
- Sales and marketing provide strategic and production planning information to the *finance and management* group, product specification and customer feedback information to *product design*, and information for master production scheduling to the *manufacturing planning and control group*.

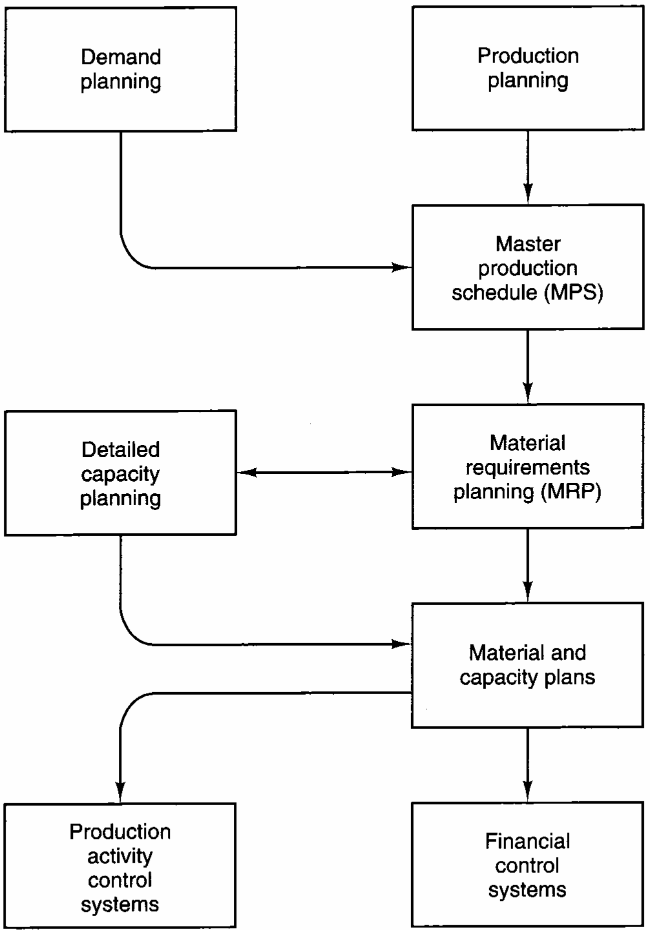
Product/Process Definition Engineering

- The unit includes *product design*, *production engineering*, and *engineering release*.
- The product design provides three primary functions: (1) product design and conceptualization, (2) material selection, and (3) design documentation.
- The production engineering area establishes three sets of standards: work, process, and quality.
- The engineering release area manages engineering change on every production part in the enterprise. Engineering release has the responsibility of securing approvals from departments across the enterprise for changes made in the product or production process.

Manufacturing Planning and Control (MPC)

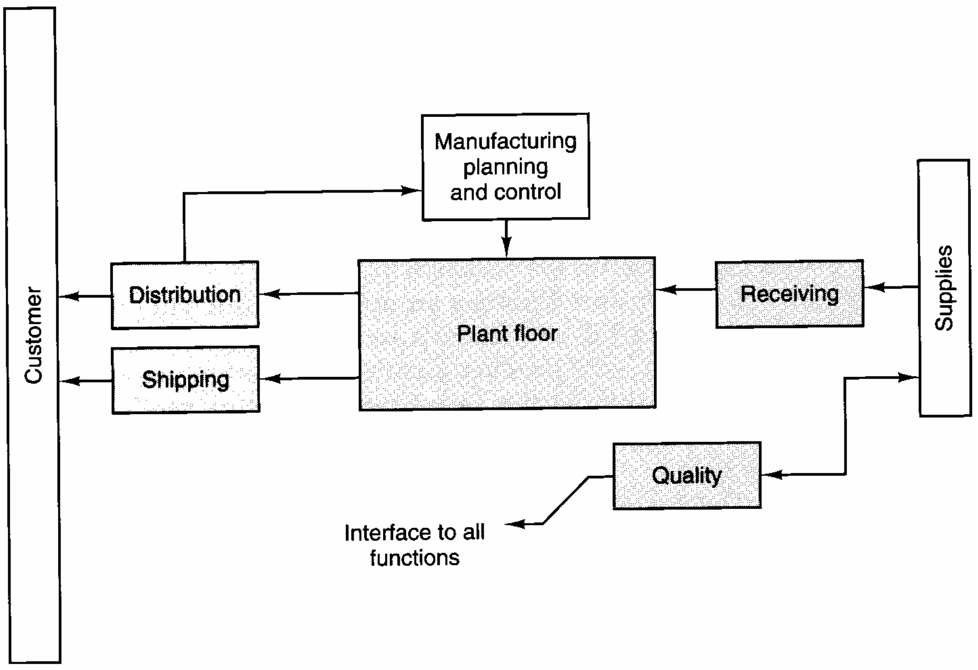
- The manufacturing planning and control unit has a formal data and information interface with several other units and departments in the enterprise.
- The MPC unit has responsibility for:
    1. Setting the direction for the enterprise by translating the management plan into manufacturing terms. The translation is smooth if order-winning criteria were used to develop the management plan.
    2. Providing detailed planning for material flow and capacity to support the overall plan.
    3. Executing these plans through detailed shop scheduling and purchasing action.

MPC Model for Information Flow



Shop Floor

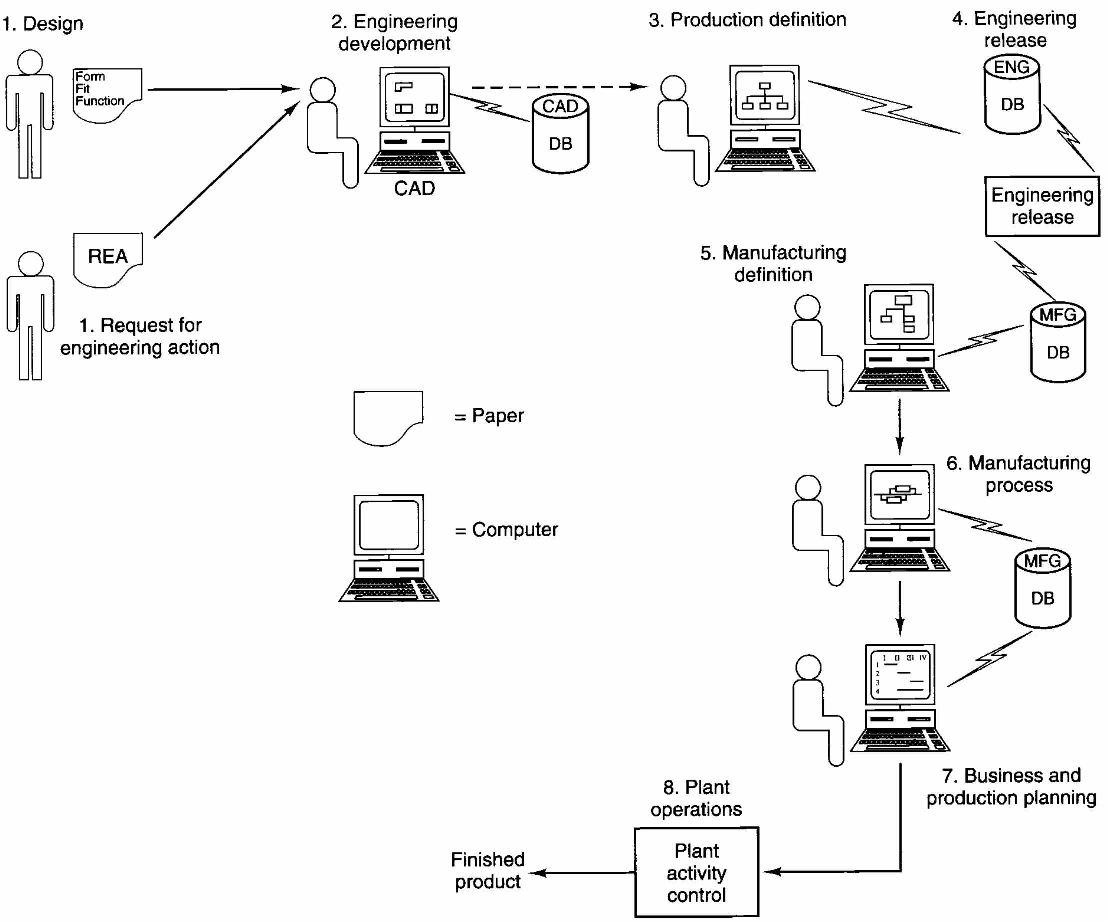
- Shop floor activity often includes job planning and reporting, material movement, manufacturing process, plant floor control, and quality control.
- Interfaces with the shop floor unit are illustrated.



Support Organization

- The support organizations, indicated vary significantly from firm to firm.
- The functions most often included are security, personnel, maintenance, human resource development, and computer services.
- Basically, the support organization is responsible for all of the functions not provided by the other model elements.

Production Sequence :one possibility for the flow required to bring a product to a customer



OPTIMIZATION

An introduction

A. Astolfi

First draft – September 2002
Last revision – September 2006

Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Introduction

Optimization is the act of achieving the best possible result under given circumstances.
In design, construction, maintenance, ..., engineers have to take decisions. The goal of all such decisions is either to minimize effort or to maximize benefit.
The effort or the benefit can be usually expressed as a function of certain design variables. Hence, optimization is the process of finding the conditions that give the maximum or the minimum value of a function.
It is obvious that if a point $x^\star$ corresponds to the minimum value of a function $f(x)$, the same point corresponds to the maximum value of the function $-f(x)$. Thus, optimization can be taken to be minimization.
There is no single method available for solving all optimization problems efficiently. Hence, a number of methods have been developed for solving different types of problems.
Optimum seeking methods are also known as mathematical programming techniques, which are a branch of operations research. Operations research is *coarsely* composed of the following areas.

- Mathematical programming methods. These are useful in finding the minimum of a function of several variables under a prescribed set of constraints.
- Stochastic process techniques. These are used to analyze problems which are described by a set of random variables of known distribution.
- Statistical methods. These are used in the analysis of experimental data and in the construction of empirical models.

These lecture notes deal mainly with the theory and applications of mathematical programming methods. Mathematical programming is a vast area of mathematics and engineering. It includes

- calculus of variations and optimal control;
- linear, quadratic and non-linear programming;
- geometric programming;
- integer programming;
- network methods (PERT);
- game theory.

The existence of optimization can be traced back to Newton, Lagrange and Cauchy. The development of differential methods for optimization was possible because of the contribution of Newton and Leibnitz. The foundations of the calculus of variations were laid by Bernoulli, Euler, Lagrange and Weierstrasse. Constrained optimization was first studied by Lagrange and the notion of descent was introduced by Cauchy.

Despite these early contributions, very little progress was made till the 20th century, when computer power made the implementation of optimization procedures possible and this in turn stimulated further research methods.
The major developments in the area of numerical methods for unconstrained optimization have been made in the UK. These include the development of the simplex method (Dantzig, 1947), the principle of optimality (Bellman, 1957), necessary and sufficient conditions of optimality (Kuhn and Tucker, 1951).
Optimization in its broadest sense can be applied to solve any engineering problem, *e.g.*

- design of aircraft for minimum weight;
- optimal (minimum time) trajectories for space missions;
- minimum weight design of structures for earthquake;
- optimal design of electric networks;
- optimal production planning, resources allocation, scheduling;
- shortest route;
- design of optimum pipeline networks;
- minimum processing time in production systems;
- optimal control.

1.2 Statement of an optimization problem

An optimization, or a mathematical programming problem can be stated as follows.
Find

$$x = (x^1, x^2, ..., x^n)$$

which minimizes

$$f(x)$$

subject to the constraints

$$g_j(x) \leq 0 \tag{1.1}$$

for $j = 1, \ldots, m$, and

$$l_j(x) = 0 \tag{1.2}$$

for $j = 1, \ldots, p$.
The variable x is called the design vector, $f(x)$ is the objective function, $g_j(x)$ are the inequality constraints and $l_j(x)$ are the equality constraints. The number of variables n and the number of constraints $p + m$ need not be related. If $p + m = 0$ the problem is called an unconstrained optimization problem.

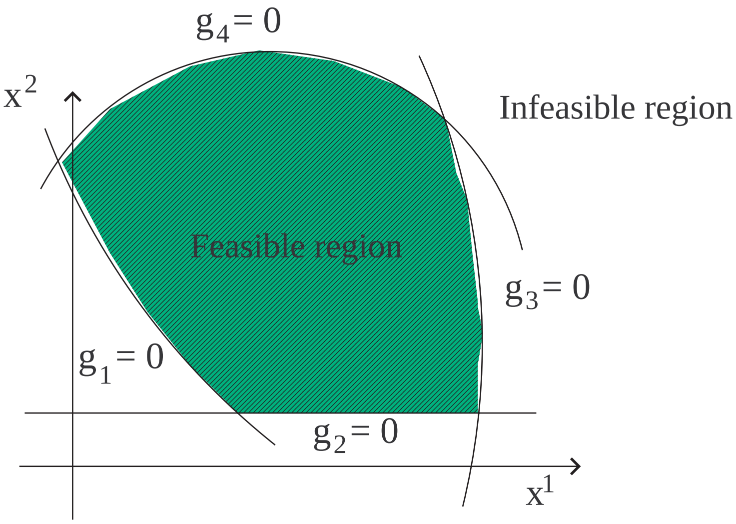


Figure 1.1: Feasible region in a two-dimensional design space. Only inequality constraints are present.

1.2.1 Design vector

Any system is described by a set of quantities, some of which are viewed as variables during the design process, and some of which are preassigned parameters or are imposed by the *environment*. All the quantities that can be treated as variables are called design or decision variables, and are collected in the design vector x.

1.2.2 Design constraints

In practice, the design variables cannot be selected arbitrarily, but have to satisfy certain requirements. These restrictions are called design constraints. Design constraints may represent limitation on the performance or behaviour of the system or physical limitations. Consider, for example, an optimization problem with only inequality constraints, *i.e.* $g_j(x) \leq 0$. The set of values of x that satisfy the equations $g_j(x) = 0$ forms a hypersurface in the design space, which is called constraint surface. In general, if n is the number of design variables, the constraint surface is an $n-1$ dimensional surface. The constraint surface divides the design space into two regions: one in which $g_j(x) < 0$ and one in which $g_j(x) > 0$. The points x on the constraint surface satisfy the constraint critically, whereas the points x such that $g_j(x) > 0$, for some j, are infeasible, *i.e.* are unacceptable, see Figure 1.1.

1.2.3 Objective function

The classical design procedure aims at finding an acceptable design, *i.e.* a design which satisfies the constraints. In general there are several acceptable designs, and the purpose

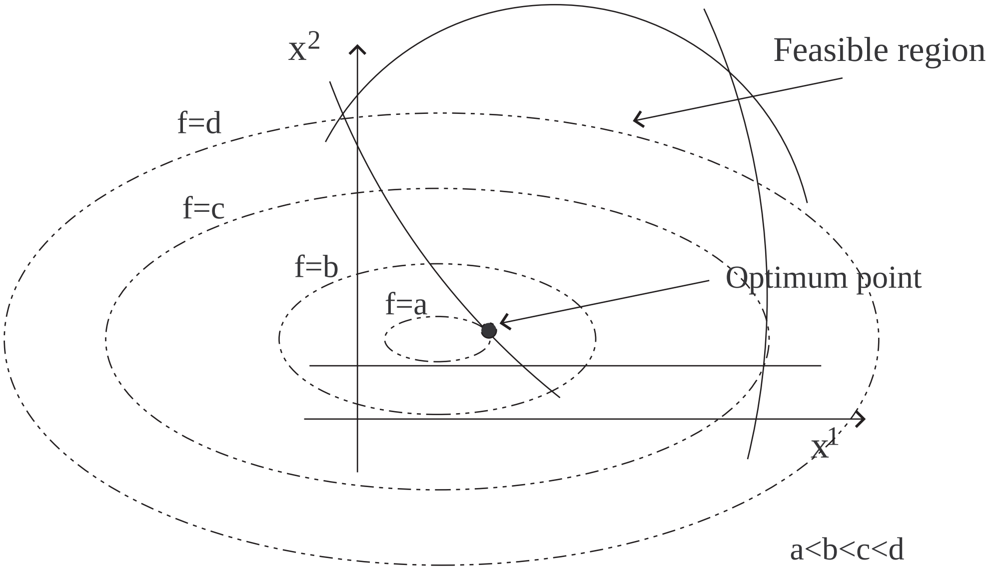


Figure 1.2: Design space, objective functions surfaces, and optimum point.

of the optimization is to single out the best possible design. Thus, a criterion has to be selected for comparing different designs. This criterion, when expressed as a function of the design variables, is known as objective function. The objective function is in general specified by physical or economical considerations. However, the selection of an objective function is not trivial, because what is the optimal design with respect to a certain criterion may be unacceptable with respect to another criterion. Typically there is a trade off performance–cost, or performance–reliability, hence the selection of the objective function is one of the most important decisions in the whole design process. If more than one criterion has to be satisfied we have a multiobjective optimization problem, that may be approximately solved considering a cost function which is a weighted sum of several objective functions.

Given an objective function $f(x)$, the locus of all points x such that $f(x) = c$ forms a hypersurface. For each value of c there is a different hypersurface. The set of all these surfaces are called objective function surfaces.

Once the objective function surfaces are drawn, together with the constraint surfaces, the optimization problem can be easily solved, at least in the case of a two dimensional decision space, as shown in Figure 1.2. If the number of decision variables exceeds two or three, this graphical approach is not viable and the problem has to be solved as a mathematical problem. Note however that more general problems have similar geometrical properties of two or three dimensional problems.

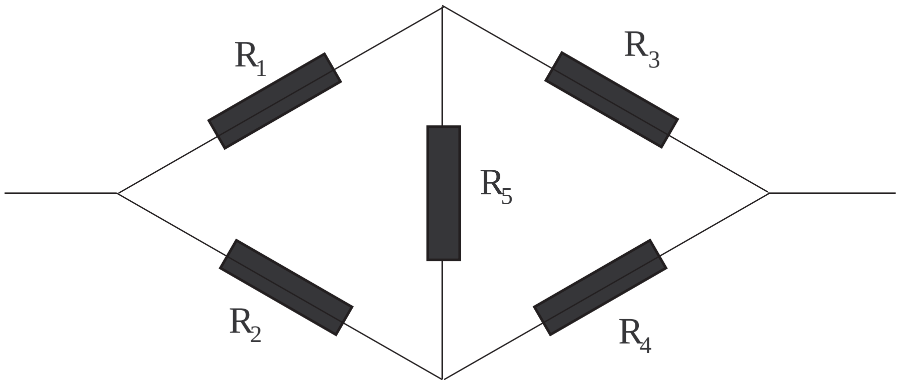


Figure 1.3: Electrical bridge network.

1.3 Classification of optimization problems

Optimization problem can be classified in several ways.

- Existence of constraints. An optimization problem can be classified as a constrained or an unconstrained one, depending upon the presence or not of constraints.
- Nature of the equations. Optimization problems can be classified as linear, quadratic, polynomial, non-linear depending upon the nature of the objective functions and the constraints. This classification is important, because computational methods are usually selected on the basis of such a classification, *i.e.* the nature of the involved functions dictates the type of solution procedure.
- Admissible values of the design variables. Depending upon the values permitted for the design variables, optimization problems can be classified as integer or real valued, and deterministic or stochastic.

1.4 Examples

Example 1 A travelling salesman has to cover n towns. He plans to start from a particular town numbered 1, visit each one of the other $n-1$ towns, and return to the town 1. The distance between town i and j is given by d_{ij}. How should he select the sequence in which the towns are visited to minimize the total distance travelled?

Example 2 The bridge network in Figure 1.3 consists of five resistors R_i, $i = 1, \ldots, 5$. Let I_i be the current through the resistance R_i, find the values of R_i so that the total dissipated power is minimum. The current I_i can vary between the lower limit $\underline{I}_i$ and the upper limit $\bar{I}_i$ and the voltage drop $V_i = R_i I_i$ must be equal to a constant c_i.

Example 3 A manufacturing firm produces two products, A and B, using two limited resources, 1 and 2. The maximum amount of resource 1 available per week is 1000 and the

Article type	w_i	v_i	c_i
1	4	9	5
2	8	7	6
3	2	4	3

Table 1.1: Properties of the articles to load.

maximum amount of resource 2 is 250. The production of one unit of A requires 1 unit of resource 1 and 1/5 unit of resource 2. The production of one unit of B requires 1/2 unit of resource 1 and 1/2 unit of resource 2. The unit cost of resource 1 is $1 - 0.0005u_1$, where u_1 is the number of units of resource 1 used. The unit cost of resource 2 is $3/4 - 0.0001u_2$, where u_2 is the number of units of resource 2 used. The selling price of one unit of A is

$$2 - 0.005x_A - 0.0001x_B$$

and the selling price of one unit of B is

$$4 - 0.002x_A - 0.01x_B,$$

where x_A and x_B are the number of units of A and B sold. Assuming that the firm is able to sell all manufactured units, maximize the weekly profit.

Example 4 A cargo load is to be prepared for three types of articles. The weight, w_i, volume, v_i, and value, c_i, of each article is given in Table 1.1.
Find the number of articles x_i selected from type i so that the total value of the cargo is maximized. The total weight and volume of the cargo cannot exceed 2000 and 2500 units respectively.

Example 5 There are two types of gas molecules in a gaseous mixture at equilibrium. It is known that the Gibbs free energy

$$G(x) = c_1x^1 + c_2x^2 + x^1log(x^1/x_T) + x^2log(x^2/x_T),$$

with $x_T = x^1 + x^2$ and c_1, c_2 known parameters depending upon the temperature and pressure of the mixture, has to be minimum in these conditions. The minimization of $G(x)$ is also subject to the mass balance equations:

$$x^1a_{i1} + x^2a_{i2} = b_i,$$

for $i = 1, \ldots, m$, where m is the number of atomic species in the mixture, b_i is the total weight of atoms of type i, and a_{ij} is the number of atoms of type i in the molecule of type j. Show that the problem of determining the equilibrium of the mixture can be posed as an optimization problem.

Chapter 2

Unconstrained optimization

2.1 Introduction

Several engineering, economic and planning problems can be posed as optimization problems, *i.e.* as the problem of determining the points of minimum of a function (possibly in the presence of conditions on the decision variables). Moreover, also numerical problems, such as the problem of solving systems of equations or inequalities, can be posed as an optimization problem.

We start with the study of optimization problems in which the decision variables are defined in $I\!\!R^n$: unconstrained optimization problems. More precisely we study the problem of determining local minima for differentiable functions. Although these methods are seldom used in applications, as in real problems the decision variables are subject to constraints, the techniques of unconstrained optimization are instrumental to solve more general problems: the knowledge of good methods for local unconstrained minimization is a necessary pre-requisite for the solution of constrained and global minimization problems.

The methods that will be studied can be classified from various points of view. The most interesting classification is based on the information available on the function to be optimized, namely

- methods without derivatives (direct search, finite differences);
- methods based on the knowledge of the first derivatives (gradient, conjugate directions, quasi-Newton);
- methods based on the knowledge of the first and second derivatives (Newton).

2.2 Definitions and existence conditions

Consider the optimization problem:

Problem 1 *Minimize*

$$f(x) \qquad \text{subject to } x \in \mathcal{F}$$

in which $f : I\!\!R^n \to I\!\!R$ *and*[1] $\mathcal{F} \subset I\!\!R^n$.

With respect to this problem we introduce the following definitions.

Definition 1 *A point $x \in \mathcal{F}$ is a global minimum*[2] *for the Problem 1 if*

$$f(x) \leq f(y)$$

for all $y \in \mathcal{F}$.

A point $x \in \mathcal{F}$ is a strict (or isolated) global minimum (or minimiser) for the Problem 1 if

$$f(x) < f(y)$$

---

[1] The set $\mathcal{F}$ may be specified by equations of the form (1.1) and/or (1.2).

[2] Alternatively, the term *global minimiser* can be used to denote a point at which the function f attains its global minimum.

for all $y \in \mathcal{F}$ *and* $y \neq x$.
A point $x \in \mathcal{F}$ *is a local minimum (or minimiser) for the Problem 1 if there exists* $\rho > 0$ *such that*

$$f(x) \leq f(y)$$

for all $y \in \mathcal{F}$ *such that* $\|y - x\| < \rho$.
A point $x \in \mathcal{F}$ *is a strict (or isolated) local minimum (or minimiser) for the Problem 1 if there exists* $\rho > 0$ *such that*

$$f(x) < f(y)$$

for all $y \in \mathcal{F}$ *such that* $\|y - x\| < \rho$ *and* $y \neq x$.

Definition 2 *If* $x \in \mathcal{F}$ *is a local minimum for the Problem 1 and if* x *is in the interior of* $\mathcal{F}$ *then* x *is an unconstrained local minimum of* f *in* $\mathcal{F}$.

The following result provides a sufficient, but not necessary, condition for the existence of a global minimum for Problem 1.

Proposition 1 *Let* $f : I\!R^n \to I\!R$ *be a continuous function and let* $\mathcal{F} \subset I\!R^n$ *be a compact set*[3]. *Then there exists a global minimum of* f *in* $\mathcal{F}$.

In unconstrained optimization problems the set $\mathcal{F}$ coincides with $I\!R^n$, hence the above statement cannot be used to establish the existence of global minima. To address the existence problem it is necessary to consider the structure of the level sets of the function f. See also Section 1.2.3.

Definition 3 *Let* $f : I\!R^n \to I\!R$. *A level set of* f *is any non-empty set described by*

$$\mathcal{L}(\alpha) = \{x \in I\!R^n \ : \ f(x) \leq \alpha\},$$

with $\alpha \in I\!R$.

For convenience, if $x_0 \in I\!R^n$ we denote with $\mathcal{L}_0$ the level set $\mathcal{L}(f(x_0))$. Using the concept of level sets it is possible to establish a simple sufficient condition for the existence of global solutions for an unconstrained optimization problem.

Proposition 2 *Let* $f : I\!R^n \to I\!R$ *be a continuous function. Assume there exists* $x_0 \in I\!R^n$ *such that the level set* $\mathcal{L}_0$ *is compact. Then there exists a point of global minimum of* f *in* $I\!R^n$.

Proof. By Proposition 1 there exists a global minimum $x_\star$ of f in $\mathcal{L}_0$, *i.e.* $f(x_\star) \leq f(x)$ for all $x \in \mathcal{L}_0$. However, if $x \notin \mathcal{L}_0$ then $f(x) > f(x_0) \geq f(x_\star)$, hence $x_\star$ is a global minimum of f in $I\!R^n$. $\triangleleft$

It is obvious that the structure of the level sets of the function f plays a fundamental role in the solution of Problem 1. The following result provides a necessary and sufficient condition for the compactness of all level sets of f.

---

[3] A compact set is a bounded and closed set.

Proposition 3 *Let $f : I\!R^n \to I\!R$ be a continuous function. All level sets of f are compact if and only if for any sequence $\{x_k\}$ one has*

$$\lim_{k\to\infty} \|x_k\| = \infty \quad \Rightarrow \quad \lim_{k\to\infty} f(x_k) = \infty.$$

Remark. In general $x_k \in I\!R^n$, namely

$$x_k = \begin{bmatrix} x_k^1 \\ x_k^2 \\ \vdots \\ x_k^n \end{bmatrix},$$

i.e. we use superscripts to denote components of a vector. $\diamond$

A function that satisfies the condition of the above proposition is said to be radially unbounded.

Proof. We only prove the necessity. Suppose all level sets of f are compact. Then, proceeding by contradiction, suppose there exist a sequence $\{x_k\}$ such that $\lim_{k\to\infty} \|x_k\| = \infty$ and a number $\gamma > 0$ such that $f(x_k) \le \gamma < \infty$ for all k. As a result

$$\{x_k\} \subset \mathcal{L}(\gamma).$$

However, by compactness of $\mathcal{L}(\gamma)$ it is not possible that $\lim_{k\to\infty} \|x_k\| = \infty$. $\triangleleft$

Definition 4 *Let $f : I\!R^n \to I\!R$. A vector $d \in I\!R^n$ is said to be a descent direction for f in $x_\star$ if there exists $\delta > 0$ such that*

$$f(x_\star + \lambda d) < f(x_\star),$$

for all $\lambda \in (0, \delta)$.

If the function f is differentiable it is possible to give a simple condition guaranteeing that a certain direction is a descent direction.

Proposition 4 *Let $f : I\!R^n \to I\!R$ and assume*[4] *∇f exists and is continuous. Let $x_\star$ and d be given. Then, if $\nabla f(x_\star)'d < 0$ the direction d is a descent direction for f at $x_\star$.*

Proof. Note that $\nabla f(x_\star)'d$ is the directional derivative of f (which is differentiable by hypothesis) at $x_\star$ along d, *i.e.*

$$\nabla f(x_\star)'d = \lim_{\lambda\to 0^+} \frac{f(x_\star + \lambda d) - f(x_\star)}{\lambda},$$

---

[4] We denote with ∇f the gradient of the function f, *i.e.* $\nabla f = [\frac{\partial f}{\partial x^1}, \cdots, \frac{\partial f}{\partial x^n}]'$. Note that ∇f is a column vector.

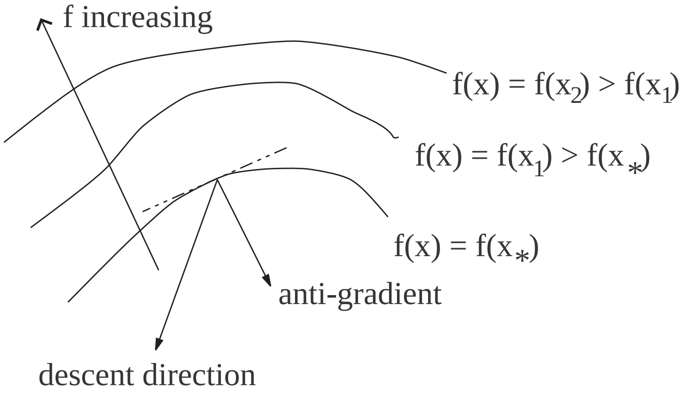


Figure 2.1: Geometrical interpretation of the anti-gradient.

and this is negative by hypothesis. As a result, for $\lambda > 0$ and sufficiently small

$$f(x_\star + \lambda d) - f(x_\star) < 0,$$

hence the claim. $\triangleleft$

The proposition establishes that if $\nabla f(x_\star)'d < 0$ then for sufficiently small positive displacements along d and starting at $x_\star$ the function f is decreasing. It is also obvious that if $\nabla f(x_\star)'d > 0$, d is a direction of *ascent*, *i.e.* the function f is increasing for sufficiently small positive displacements from $x_\star$ along d. If $\nabla f(x_\star)'d = 0$, d is orthogonal to $\nabla f(x_\star)$ and it is not possible to establish, without further knowledge on the function f, what is the nature of the direction d.

From a geometrical point of view (see also Figure 2.1), the sign of the *directional derivative* $\nabla f(x_\star)'d$ gives information on the angle between d and the direction of the gradient at $x_\star$, provided $\nabla f(x_\star) \neq 0$. If $\nabla f(x_\star)'d > 0$ the angle between $\nabla f(x_\star)$ and d is acute. If $\nabla f(x_\star)'d < 0$ the angle between $\nabla f(x_\star)$ and d is obtuse. Finally, if $\nabla f(x_\star)'d = 0$, and $\nabla f(x_\star) \neq 0$, $\nabla f(x_\star)$ and d are orthogonal. Note that the gradient $\nabla f(x_\star)$, if it is not identically zero, is a direction orthogonal to the level surface $\{x : f(x) = f(x_\star)\}$ and it is a direction of ascent, hence the anti-gradient $-\nabla f(x_\star)$ is a descent direction.

Remark. The scalar product $x'y$ between the two vectors x and y can be used to define the angle between x and y. For, define the angle between x and y as the number $\theta \in [0, \pi]$ such that[5]

$$\cos\theta = \frac{x'y}{\|x\|_E \|y\|_E}.$$

If $x'y = 0$ one has $\cos\theta = 0$ and the vectors are orthogonal, whereas if x and y have the same direction, *i.e.* $x = \lambda y$ with $\lambda > 0$, $\cos\theta = 1$. $\diamond$

---

[5] $\|x\|_E$ denotes the Euclidean norm of the the vector x, *i.e.* $\|x\|_E = \sqrt{x'x}$.

We are now ready to state and prove some necessary conditions and some sufficient conditions for a local minimum.

Theorem 1 *[First order necessary condition] Let* $f : I\!R^n \to I\!R$ *and assume* ∇f *exists and is continuous. The point* $x_\star$ *is a local minimum of* f *only if*

$$\nabla f(x_\star) = 0.$$

Remark. A point $x_\star$ such that $\nabla f(x_\star) = 0$ is called a stationary point of f. ◇

Proof. If $\nabla f(x_\star) \neq 0$ the direction $d = -\nabla f(x_\star)$ is a descent direction. Therefore, in a neighborhood of $x_\star$ there is a point $x_\star + \lambda d = x_\star - \lambda \nabla f(x_\star)$ such that

$$f(x_\star - \lambda \nabla f(x_\star)) < f(x_\star),$$

and this contradicts the hypothesis that $x_\star$ is a local minimum. ◁

Theorem 2 *[Second order necessary condition] Let* $f : I\!R^n \to I\!R$ *and assume*[6] $\nabla^2 f$ *exists and is continuous. The point* $x_\star$ *is a local minimum of* f *only if*

$$\nabla f(x_\star) = 0$$

and

$$x' \nabla^2 f(x_\star) x \geq 0$$

for all $x \in I\!R^n$.

Proof. The first condition is a consequence of Theorem 1. Note now that, as f is two times differentiable, for any $x \neq x_\star$ one has

$$f(x_\star + \lambda x) = f(x_\star) + \lambda \nabla f(x_\star)' x + \frac{1}{2} \lambda^2 x' \nabla^2 f(x_\star) x + \beta(x_\star, \lambda x),$$

where

$$\lim_{\lambda \to 0} \frac{\beta(x_\star, \lambda x)}{\lambda^2 \|x\|^2} = 0,$$

or what is the same (note that x is fixed)

$$\lim_{\lambda \to 0} \frac{\beta(x_\star, \lambda x)}{\lambda^2} = 0.$$

---

[6] We denote with $\nabla^2 f$ the Hessian matrix of the function f, *i.e.*

$$\begin{bmatrix} \frac{\partial^2 f}{\partial x^1 \partial x^1} & \cdots & \frac{\partial^2 f}{\partial x^1 \partial x^n} \\ \vdots & \ddots & \vdots \\ \frac{\partial^2 f}{\partial x^n \partial x^1} & \cdots & \frac{\partial^2 f}{\partial x^n \partial x^n} \end{bmatrix}.$$

Note that $\nabla^2 f$ is a square matrix and that, under suitable regularity conditions, the Hessian matrix is symmetric.

Moreover, the condition $\nabla f(x_\star) = 0$ yields

$$\frac{f(x_\star + \lambda x) - f(x_\star)}{\lambda^2} = \frac{1}{2} x' \nabla^2 f(x_\star) x + \frac{\beta(x_\star, \lambda x)}{\lambda^2}. \tag{2.1}$$

However, as $x_\star$ is a local minimum, the left hand side of equation (2.1) must be non-negative for all λ sufficiently small, hence

$$\frac{1}{2} x' \nabla^2 f(x_\star) x + \frac{\beta(x_\star, \lambda x)}{\lambda^2} \geq 0,$$

and

$$\lim_{\lambda \to 0} \left(\frac{1}{2} x' \nabla^2 f(x_\star) x + \frac{\beta(x_\star, \lambda x)}{\lambda^2} \right) = \frac{1}{2} x' \nabla^2 f(x_\star) x \geq 0,$$

which proves the second condition. ◁

Theorem 3 (Second order sufficient condition) *Let $f : I\!\!R^n \to I\!\!R$ and assume $\nabla^2 f$ exists and is continuous. The point $x_\star$ is a strict local minimum of f if*

$$\nabla f(x_\star) = 0$$

and

$$x' \nabla^2 f(x_\star) x > 0$$

for all non-zero $x \in I\!\!R^n$.

Proof. To begin with, note that as $\nabla^2 f(x_\star) > 0$ and $\nabla^2 f$ is continuous, then there is a neighborhood Ω of $x_\star$ such that for all $y \in \Omega$

$$\nabla^2 f(y) > 0.$$

Consider now the Taylor series expansion of f around the point $x_\star$, *i.e.*

$$f(y) = f(x_\star) + \nabla f(x_\star)'(y - x_\star) + \frac{1}{2}(y - x_\star)' \nabla^2 f(\xi)(y - x_\star),$$

where $\xi = x_\star + \theta(y - x_\star)$, for some $\theta \in [0, 1]$. By the first condition one has

$$f(y) = f(x_\star) + \frac{1}{2}(y - x_\star)' \nabla^2 f(\xi)(y - x_\star),$$

and, for any $y \in \Omega$ such that $y \neq x_\star$,

$$f(y) > f(x_\star),$$

which proves the claim. ◁

The above results can be easily modified to derive necessary conditions and sufficient conditions for a local maximum. Moreover, if $x_\star$ is a stationary point and the Hessian matrix

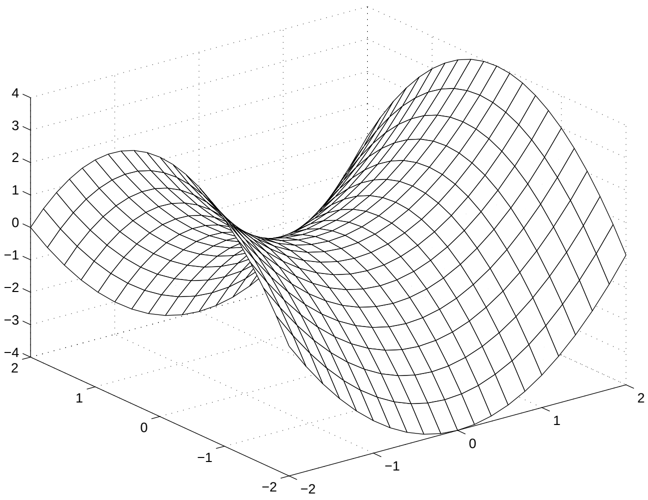


Figure 2.2: A saddle point in $I\!R^2$.

$\nabla^2 f(x_\star)$ is indefinite, the point $x_\star$ is neither a local minimum neither a local maximum. Such a point is called a saddle point (see Figure 2.2 for a geometrical illustration).
If $x_\star$ is a stationary point and $\nabla^2 f(x_\star)$ is semi-definite it is not possible to draw any conclusion on the point $x_\star$ without further knowledge on the function f. Nevertheless, if $n = 1$ and the function f is infinitely times differentiable it is possible to establish the following necessary and sufficient condition.

Proposition 5 *Let $f : I\!R \to I\!R$ and assume f is infinitely times differentiable. The point $x_\star$ is a local minimum if and only if there exists an even integer $r > 1$ such that*

$$\frac{d^k f(x_\star)}{dx^k} = 0$$

for $k = 1, 2, \dots, r-1$ and

$$\frac{d^r f(x_\star)}{dx^r} > 0.$$

Necessary and sufficient conditions for $n > 1$ can be only derived if further hypotheses on the function f are added, as shown for example in the following fact.

Proposition 6 (Necessary and sufficient condition for convex functions) *Let $f : I\!R^n \to I\!R$ and assume ∇f exists and it is continuous. Suppose f is convex,* i.e.

$$f(y) - f(x) \geq \nabla f(x)'(y - x) \tag{2.2}$$

for all $x \in I\!R^n$ and $y \in I\!R^n$. The point $x_\star$ is a global minimum if and only if $\nabla f(x_\star) = 0$.

Proof. The necessity is a consequence of Theorem 1. For the sufficiency note that, by equation (2.2), if $\nabla f(x_\star) = 0$ then

$$f(y) \geq f(x_\star),$$

for all $y \in I\!R^n$. ◁

From the above discussion it is clear that to establish the property that $x_\star$, satisfying $\nabla f(x_\star) = 0$, is a global minimum it is enough to assume that the function f has the following property: for all x and y such that

$$\nabla f(x)'(y - x) \geq 0$$

one has

$$f(y) \geq f(x).$$

A function f satisfying the above property is said pseudo-convex. Note that a differentiable convex function is also pseudo-convex, but the opposite is not true. For example, the function $x + x^3$ is pseudo-convex but it is not convex. Finally, if f is strictly convex or strictly pseudo-convex the global minimum (if it exists) is also unique.

2.3 General properties of minimization algorithms

Consider the problem of minimizing the function $f : I\!R^n \to I\!R$ and suppose that ∇f and $\nabla^2 f$ exist and are continuous. Suppose that such a problem has a solution, and moreover that there exists x_0 such that the level set

$$\mathcal{L}(f(x_0)) = \{x \in I\!R^n \ : \ f(x) \leq f(x_0)\}$$

is compact.

General unconstrained minimization algorithms allow only to determine stationary points of f, *i.e.* to determine points in the set

$$\Omega = \{x \in I\!R^n \ : \ \nabla f(x) = 0\}.$$

Moreover, for almost all algorithms, it is possible to exclude that the points of Ω yielded by the algorithm are local maxima. Finally, some algorithms yield points of Ω that satisfy also the second order necessary conditions.

2.3.1 General unconstrained minimization algorithm

An *algorithm* for the solution of the considered minimization problem is a sequence $\{x_k\}$, obtained starting from an initial point x_0, having some convergence properties in relation with the set Ω. Most of the algorithms that will be studied in this notes can be described in the following general way.

1. Fix a point $x_0 \in I\!R^n$ and set $k = 0$.

2. If $x_k \in \Omega$ STOP.
3. Compute a direction of research $d_k \in I\!R^n$.
4. Compute a step $\alpha_k \in I\!R$ along d_k.
5. Let $x_{k+1} = x_k + \alpha_k d_k$. Set $k = k + 1$ and go back to 2.

The existing algorithms differ in the way the direction of research d_k is computed and on the criteria used to compute the step α_k. However, independently from the particular selection, it is important to study the following issues:

- the existence of accumulation points for the sequence $\{x_k\}$;
- the behavior of such accumulation points in relation with the set Ω;
- the speed of convergence of the sequence $\{x_k\}$ to the points of Ω.

2.3.2 Existence of accumulation points

To make sure that any subsequence of $\{x_k\}$ has an accumulation point it is necessary to assume that the sequence $\{x_k\}$ remains bounded, *i.e.* that there exists $M > 0$ such that $\|x_k\| < M$ for any k. If the level set $\mathcal{L}(f(x_0))$ is compact, the above condition holds if $\{x_k\} \in \mathcal{L}(f(x_0))$. This property, in turn, is guaranteed if

$$f(x_{k+1}) < f(x_k),$$

for any k such that $x_k \notin \Omega$. The algorithms that satisfy this property are denominated descent methods. For such methods , if $\mathcal{L}(f(x_0))$ is compact and if ∇f is continuous one has

- $\{x_k\} \in \mathcal{L}(f(x_0))$ and any subsequence of $\{x_k\}$ admits a subsequence converging to a point of $\mathcal{L}(f(x_0))$;
- the sequence $\{f(x_k)\}$ has a limit, *i.e.* there exists $\bar{f} \in I\!R$ such that
$$\lim_{k\to\infty} f(x_k) = \bar{f};$$
- there always exists an element of Ω in $\mathcal{L}(f(x_0))$. In fact, as f has a minimum in $\mathcal{L}(f(x_0))$, this minimum is also a minimum of f in $I\!R^n$. Hence, by the assumptions of ∇f, such a minimum must be a point of Ω.

Remark. To guarantee the descent property it is necessary that the research directions d_k be directions of descent. This is true if

$$\nabla f(x_k)' d_k < 0,$$

for all k. Under this condition there exists an interval $(0, \alpha_\star]$ such that

$$f(x_k + \alpha d_k) < f(x_k),$$

for any $\alpha \in (0, \alpha_\star]$. $\diamond$

Remark. The existence of accumulation points for the sequence $\{x_k\}$ and the convergence of the sequence $\{f(x_k)\}$ do not guarantee that the accumulation points of $\{x_k\}$ are local minima of f or stationary points. To obtain this property it is necessary to impose further restrictions on the research directions d_k and on the steps α_k. $\diamond$

2.3.3 Condition of angle

The condition which is in general imposed on the research directions d_k is the so-called condition of angle, that can be stated as follows.

Condition 1 *There exists $\epsilon > 0$, independent from k, such that*

$$\nabla f(x_k)' d_k \leq -\epsilon \|\nabla f(x_k)\| \|d_k\|,$$

for any k.

From a geometric point of view the above condition implies that the cosine of the angle between d_k and $-\nabla f(x_k)$ is larger than a certain quantity. This condition is imposed to avoid that, for some k, the research direction is orthogonal to the direction of the gradient. Note moreover that, if the angle condition holds, and if $\nabla f(x_k) \neq 0$ then d_k is a descent direction. Finally, if $\nabla f(x_k) \neq 0$, it is always possible to find a direction d_k such that the angle condition holds. For example, the direction $d_k = -\nabla f(x_k)$ is such that the angle condition is satisfied with $\epsilon = 1$.

Remark. Let $\{B_k\}$ be a sequence of matrices such that

$$mI \leq B_k \leq MI,$$

for some $0 < m < M$, and for any k, and consider the directions

$$d_k = -B_k \nabla f(x_k).$$

Then a simple computation shows that the angle condition holds with $\epsilon = m/M$. $\diamond$

The angle condition imposes a constraint only on the research directions d_k. To make sure that the sequence $\{x_k\}$ converges to a point in Ω it is necessary to impose further conditions on the step α_k, as expressed in the following statements.

Theorem 4 *Let $\{x_k\}$ be the sequence obtained by the algorithm*

$$x_{k+1} = x_k + \alpha_k d_k,$$

for $k \geq 0$. Assume that

(H1) ∇f *is continuous and the level set* $\mathcal{L}(f(x_0))$ *is compact.*

(H2) There exists $\epsilon > 0$ *such that*

$$\nabla f(x_k)' d_k \leq -\epsilon \|\nabla f(x_k)\| \|d_k\|,$$

for any $k \geq 0$.

(H3) $f(x_{k+1}) < f(x_k)$ *for any* $k \geq 0$.

(H4) The property

$$\lim_{k\to\infty} \frac{\nabla f(x_k)' d_k}{\|d_k\|} = 0$$

holds.

Then

(C1) $\{x_k\} \in \mathcal{L}(f(x_0))$ *and any subsequence of* $\{x_k\}$ *has an accumulation point.*

(C2) $\{f(x_k)\}$ *is monotonically decreasing and there exists* $\bar{f}$ *such that*

$$\lim_{k\to\infty} f(x_k) = \bar{f}.$$

(C3) $\{\nabla f(x_k)\}$ *is such that*

$$\lim_{k\to\infty} \|\nabla f(x_k)\| = 0.$$

(C4) Any accumulation point $\bar{x}$ *of* $\{x_k\}$ *is such that* $\nabla f(\bar{x}) = 0$.

Proof. Conditions (C1) and (C2) are a simple consequence of (H1) and (H3). Note now that (H2) implies

$$\epsilon \|\nabla f(x_k)\| \leq \frac{|\nabla f(x_k)' d_k|}{\|d_k\|},$$

for all k. As a result, and by (H4),

$$\lim_{k\to\infty} \epsilon \|\nabla f(x_k)\| \leq \lim_{k\to\infty} \frac{|\nabla f(x_k)' d_k|}{\|d_k\|} = 0$$

hence (C3) holds. Finally, let $\bar{x}$ be an accumulation point of the sequence $\{x_k\}$, *i.e.* there is a subsequence that converges to $\bar{x}$. For such a subsequence, and by continuity of f, one has

$$\lim_{k\to\infty} \nabla f(x_k) = \nabla f(\bar{x}),$$

and, by (C3),

$$\nabla f(\bar{x}) = 0,$$

which proves (C4). ◁

Remark. Theorem 4 does not guarantee the convergence of the sequence $\{x_k\}$ to a unique accumulation point. Obviously $\{x_k\}$ has a unique accumulation point if either $\Omega \cap \mathcal{L}(f(x_0))$ contains only one point or $x, y \in \Omega \cap \mathcal{L}(f(x_0))$, with $x \neq y$ implies $f(x) \neq f(y)$. Finally, if the set $\Omega \cap \mathcal{L}(f(x_0))$ contains a finite number of points, a sufficient condition for the existence of a unique accumulation point is

$$\lim_{k \to \infty} \|x_{k+1} - x_k\| = 0.$$

◇

Remark. The angle condition can be replaced by the following one. There exists $\eta > 0$ and $q > 0$, both independent from k, such that

$$\nabla f(x_k)' d_k \leq -\eta \|\nabla f(x_k)\|^q \|d_k\|.$$

◇

The result illustrated in Theorem 4 requires the fulfillment of the angle condition or of a similar one, *i.e.* of a condition involving ∇f. In many algorithms that do not make use of the gradient it may be difficult to check the validity of the angle condition, hence it is necessary to use different conditions on the research directions. For example, it is possible to replace the angle condition with a property of linear independence of the research directions.

Theorem 5 *Let $\{x_k\}$ be the sequence obtained by the algorithm*

$$x_{k+1} = x_k + \alpha_k d_k,$$

for $k \geq 0$. Assume that

- *$\nabla^2 f$ is continuous and the level set $\mathcal{L}(f(x_0))$ is compact.*
- *There exist $\sigma > 0$, independent from k, and $k_0 > 0$ such that, for any $k \geq k_0$ the matrix P_k composed of the columns*

  $$\frac{d_k}{\|d_k\|}, \frac{d_{k+1}}{\|d_{k+1}\|}, \ldots, \frac{d_{k+n-1}}{\|d_{k+n-1}\|},$$

  is such that

  $$|\mathrm{det} P_k| \geq \sigma.$$

- $\lim_{k \to \infty} \|x_{k+1} - x_k\| = 0$.
- *$f(x_{k+1}) < f(x_k)$ for any $k \geq 0$.*
- *The property*

  $$\lim_{k \to \infty} \frac{\nabla f(x_k)' d_k}{\|d_k\|} = 0$$

  holds.

Then

- $\{x_k\} \in \mathcal{L}(f(x_0))$ *and any subsequence of* $\{x_k\}$ *has an accumulation point.*
- $\{f(x_k)\}$ *is monotonically decreasing and there exists* $\bar{f}$ *such that*
$$\lim_{k\to\infty} f(x_k) = \bar{f}.$$
- *Any accumulation point* $\bar{x}$ *of* $\{x_k\}$ *is such that* $\nabla f(\bar{x}) = 0$.

Moreover, if the set $\Omega \cap \mathcal{L}(f(x_0))$ *is composed of a finite number of points, the sequence* $\{x_k\}$ *has a unique accumulation point.*

2.3.4 Speed of convergence

Together with the property of convergence of the sequence $\{x_k\}$ it is important to study also the speed of convergence. To study such a notion it is convenient to assume that $\{x_k\}$ converges to a point $x_\star$.

If there exists a finite k such that $x_k = x_\star$ then we say that the sequence $\{x_k\}$ has finite convergence. Note that if $\{x_k\}$ is generated by an algorithm, there is a stopping condition that has to be satisfied at step k.

If $x_k \neq x_\star$ for any finite k, it is possible (and convenient) to study the asymptotic properties of $\{x_k\}$. One criterion to estimate the speed of convergence is based on the behavior of the error $\mathcal{E}_k = \|x_k - x_\star\|$, and in particular on the relation between $\mathcal{E}_{k+1}$ and $\mathcal{E}_k$.

We say that $\{x_k\}$ has speed of convergence of order p if

$$\lim_{k\to\infty} \left(\frac{\mathcal{E}_{k+1}}{\mathcal{E}_k^p} \right) = C_p$$

with $p \geq 1$ and $0 < C_p < \infty$. Note that if $\{x_k\}$ has speed of convergence of order p then

$$\lim_{k\to\infty} \left(\frac{\mathcal{E}_{k+1}}{\mathcal{E}_k^q} \right) = 0,$$

if $1 \leq q < p$, and

$$\lim_{k\to\infty} \left(\frac{\mathcal{E}_{k+1}}{\mathcal{E}_k^q} \right) = \infty,$$

if $q > p$. Moreover, from the definition of speed of convergence, it is easy to see that if $\{x_k\}$ has speed of convergence of order p then, for any $\epsilon > 0$ there exists k_0 such that

$$\mathcal{E}_{k+1} \leq (C_p + \epsilon)\mathcal{E}_k^p,$$

for any $k > k_0$.

In the cases $p = 1$ or $p = 2$ the following terminology is often used. If $p = 1$ and $0 < C_1 \leq 1$ the speed of convergence is linear; if $p = 1$ and $C_1 > 1$ the speed of convergence is sublinear; if

$$\lim_{k\to\infty} \left(\frac{\mathcal{E}_{k+1}}{\mathcal{E}_k} \right) = 0$$

the speed of convergence is superlinear, and finally if $p = 2$ the speed of convergence is quadratic.

Of special interest in optimization is the case of superlinear convergence, as this is the kind of convergence that can be established for the *efficient* minimization algorithms. Note that if x_k has superlinear convergence to $x_\star$ then

$$\lim_{k\to\infty} \frac{\|x_{k+1} - x_k\|}{\|x_k - x_\star\|} = 1.$$

Remark. In some cases it is not possible to establish the existence of the limit

$$\lim_{k\to\infty} \left(\frac{\mathcal{E}_{k+1}}{\mathcal{E}_k^q} \right).$$

In these cases an estimate of the speed of convergence is given by

$$Q_p = \limsup_{k\to\infty} \left(\frac{\mathcal{E}_{k+1}}{\mathcal{E}_k^q} \right).$$

◇

2.4 Line search

A line search is a method to compute the step α_k along a given direction d_k. The choice of α_k affects both the convergence and the speed of convergence of the algorithm. In any line search one considers the function of one variable $\phi : I\!R \to I\!R$ defined as

$$\phi(\alpha) = f(x_k + \alpha d_k) - f(x_k).$$

The derivative of $\phi(\alpha)$ with respect to α is given by

$$\dot{\phi}(\alpha) = \nabla f(x_k + \alpha d_k)' d_k$$

provided that ∇f is continuous. Note that $\nabla f(x_k + \alpha d_k)' d_k$ describes the slope of the tangent to the function $\phi(\alpha)$, and in particular

$$\dot{\phi}(0) = \nabla f(x_k)' d_k$$

coincides with the directional derivative of f at x_k along d_k.

From the general convergence results described, we conclude that the line search has to enforce the following conditions

$$f(x_{k+1}) < f(x_k)$$

$$\lim_{k\to\infty} \frac{\nabla f(x_k)' d_k}{\|d_k\|} = 0$$

and, whenever possible, also the condition

$$\lim_{k\to\infty} \|x_{k+1} - x_k\| = 0.$$

To begin with, we assume that the directions d_k are such that

$$\nabla f(x_k)'d_k < 0$$

for all k, *i.e.* d_k is a descent direction, and that it is possible to compute, for any fixed x, both f and ∇f. Finally, we assume that the level set $\mathcal{L}(f(x_0))$ is compact.

2.4.1 Exact line search

The exact line search consists in finding α_k such that

$$\phi(\alpha_k) = f(x_k + \alpha_k d_k) - f(x_k) \leq f(x_k + \alpha d_k) - f(x_k) = \phi(\alpha)$$

for any $\alpha \geq 0$. Note that, as d_k is a descent direction and the set

$$\{\alpha \in I\!R^+ \; : \; \phi(\alpha) \leq \phi(0)\}$$

is compact, because of compactness of $\mathcal{L}(f(x_0))$, there exists an α_k that minimizes $\phi(\alpha)$. Moreover, for such α_k one has

$$\dot{\phi}(\alpha_k) = \nabla f(x_k + \alpha_k d_k)'d_k = 0,$$

i.e. if α_k minimizes $\phi(\alpha)$ the gradient of f at $x_k + \alpha_k d_k$ is orthogonal to the direction d_k. From a geometrical point of view, if α_k minimizes $\phi(\alpha)$ then the level surface of f through the point $x_k + \alpha_k d_k$ is tangent to the direction d_k at such a point. (If there are several points of tangency, α_k is the one for which f has the smallest value).

The search of α_k that minimizes $\phi(\alpha)$ is very *expensive*, especially if f is not convex. Moreover, in general, the whole minimization algorithm does not gain any special advantage from the knowledge of such *optimal* α_k. It is therefore more convenient to use approximate methods, *i.e.* methods which are computationally simple and which guarantee particular convergence properties. Such methods are aimed at finding an interval of acceptable values for α_k subject to the following two conditions

- α_k has to guarantee a sufficient reduction of f;
- α_k has to be sufficiently distant from 0, *i.e.* $x_k + \alpha_k d_k$ has to be sufficiently away from x_k.

2.4.2 Armijo method

Armijo method was the first non-exact linear search method.

Let $a > 0$, $\sigma \in (0,1)$ and $\gamma \in (0,1/2)$ be given and define the set of points

$$A = \{\alpha \in R \; : \; \alpha = a\sigma^j, \; j = 0, 1, \ldots\}.$$

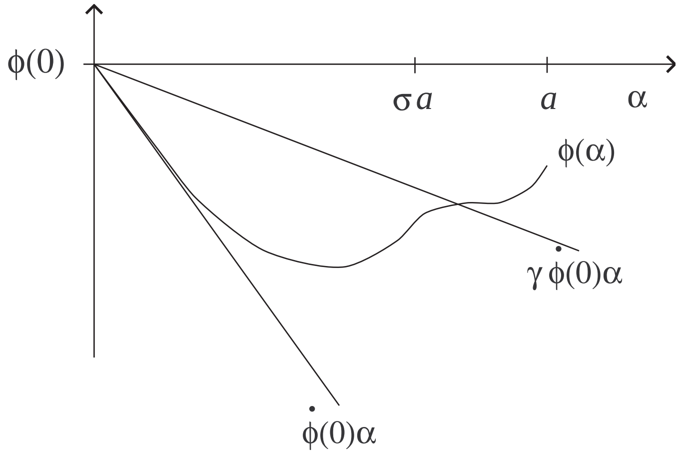


Figure 2.3: Geometrical interpretation of Armijo method.

Armijo method consists in finding the largest $\alpha \in A$ such that

$$\phi(\alpha) = f(x_k + \alpha d_k) - f(x_k) \leq \gamma \alpha \nabla f(x_k)' d_k = \gamma \alpha \dot{\phi}(0).$$

Armijo method can be implemented using the following (conceptual) algorithm.

Step 1. Set $\alpha = a$.

Step 2. If

$$f(x_k + \alpha d_k) - f(x_k) \leq \gamma \alpha \nabla f(x_k)' d_k$$

set $\alpha_k = \alpha$ and STOP. Else go to **Step 3.**

Step 3. Set $\alpha = \sigma\alpha$, and go to **Step 2.**

From a geometric point of view (see Figure 2.3) the condition in **Step 2** requires that α_k is such that $\phi(\alpha_k)$ is below the straight line passing through the point $(0, \phi(0))$ and with slope $\gamma\dot{\phi}(0)$. Note that, as $\gamma \in (0, 1/2)$ and $\dot{\phi}(0) < 0$, such a straight line has a slope smaller than the slope of the tangent at the curve $\phi(\alpha)$ at the point $(0, \phi(0))$.
For Armijo method it is possible to prove the following convergence result.

Theorem 6 *Let $f : I\!R^n \to I\!R$ and assume ∇f is continuous and $\mathcal{L}(f(x_0))$ is compact. Assume $\nabla f(x_k)' d_k < 0$ for all k and there exist $C_1 > 0$ and $C_2 > 0$ such that*

$$C_1 \geq \|d_k\| \geq C_2 \|\nabla f(x_k)\|^q,$$

for some $q > 0$ and for all k.
Then Armijo method yields in a finite number of iterations a value of $\alpha_k > 0$ satisfying the condition in **Step 2***. Moreover, the sequence obtained setting $x_{k+1} = x_k + \alpha_k d_k$ is such that*

$$f(x_{k+1}) < f(x_k),$$

for all k, and

$$\lim_{k\to\infty} \frac{\nabla f(x_k)'d_k}{\|d_k\|} = 0.$$

Proof. We only prove that the method cannot loop indefinitely between **Step 2** and **Step 3**. In fact, if this is the case, then the condition in **Step 2** will never be satisfied, hence

$$\frac{f(x_k + a\sigma^j d_k) - f(x_k)}{a\sigma^j} > \gamma \nabla f(x_k)'d_k.$$

Note now that $\sigma^j \to 0$ as $j \to \infty$, and the above inequality for $j \to \infty$ is

$$\nabla f(x_k)'d_k > \gamma \nabla f(x_k)'d_k,$$

which is not possible since $\gamma \in (0, 1/2)$ and $\nabla f(x_k)'d_k \neq 0$. ◁

Remark. It is interesting to observe that in Theorem 6 it is not necessary to assume that $x_{k+1} = x_k + \alpha_k d_k$. It is enough that x_{k+1} is such that

$$f(x_{k+1}) \leq f(x_k + \alpha_k d_k),$$

where α_k is generated using Armijo method. This implies that all acceptable values of α are those such that

$$f(x_k + \alpha d_k) \leq f(x_k + \alpha_k d_k).$$

As a result, Theorem 6 can be used to prove also the convergence of an algorithm based on the exact line search. ◇

2.4.3 Goldstein conditions

The main disadvantage of Armijo method is in the fact that, to find α_k, all points in the set A, starting from the point $\alpha = a$, have to be tested till the condition in **Step 2** is fulfilled. There are variations of the method that do not suffer from this disadvantage. A criterion similar to Armijo's, but that allows to find an acceptable α_k in one step, is based on the so-called Goldstein conditions.

Goldstein conditions state that given $\gamma_1 \in (0, 1)$ and $\gamma_2 \in (0, 1)$ such that $\gamma_1 < \gamma_2$, α_k is any positive number such that

$$f(x_k + \alpha_k d_k) - f(x_k) \leq \alpha_k \gamma_1 \nabla f(x_k)'d_k$$

i.e. there is a sufficient reduction in f, and

$$f(x_k + \alpha_k d_k) - f(x_k) \geq \alpha_k \gamma_2 \nabla f(x_k)'d_k$$

i.e. there is a sufficient distance between x_k and x_{k+1}.

From a geometric point of view (see Figure 2.4) this is equivalent to select α_k as any point such that the corresponding value of f is included between two straight lines, of slope

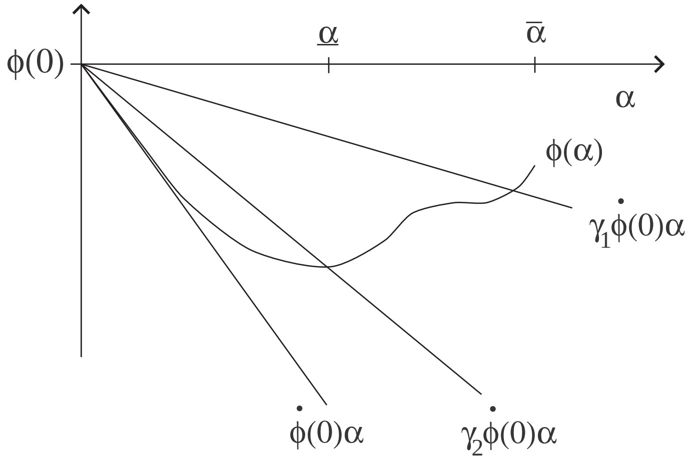


Figure 2.4: Geometrical interpretation of Goldstein method.

$\gamma_1 \nabla f(x_k)' d_k$ and $\gamma_2 \nabla f(x_k)' d_k$, respectively, and passing through the point $(0, \phi(0))$. As $0 < \gamma_1 < \gamma_2 < 1$ it is obvious that there exists always an interval $I = [\underline{\alpha}, \overline{\alpha}]$ such that Goldstein conditions hold for any $\alpha \in I$.

Note that, a result similar to Theorem 6, can be also established if the sequence $\{x_k\}$ is generated using Goldstein conditions.

The main disadvantage of Armijo and Goldstein methods is in the fact that none of them impose conditions on the derivative of the function $\phi(\alpha)$ in the point α_k, or what is the same on the value of $\nabla f(x_{k+1})' d_k$. Such extra conditions are sometimes useful in establishing convergence results for particular algorithms. However, for simplicity, we omit the discussion of these more general conditions (known as Wolfe conditions).

2.4.4 Line search without derivatives

It is possible to construct methods similar to Armijo's or Goldstein's also in the case that no information on the derivatives of the function f is available.

Suppose, for simplicity, that $\|d_k\| = 1$, for all k, and that the sequence $\{x_k\}$ is generated by

$$x_{k+1} = x_k + \alpha_k d_k.$$

If ∇f is not available it is not possible to decide *a priori* if the direction d_k is a descent direction, hence it is necessary to consider also negative values of α.

We now describe the simplest line search method that can be constructed with the considered hypothesis. This method is a modification of Armijo method and it is known as parabolic search.

Given $\lambda_0 > 0$, $\sigma \in (0, 1/2)$, $\gamma > 0$ and $\rho \in (0, 1)$. Compute α_k and λ_k such that one of the following conditions hold.

Condition (i)

- $\lambda_k = \lambda_{k-1}$;
- α_k is the largest value in the set
$$A = \{\alpha \in I\!R \ : \ \alpha = \pm\sigma^j, \ j = 0, 1, \ldots\}$$
such that
$$f(x_k + \alpha_k d_k) \leq f(x_k) - \gamma\alpha_k^2,$$
or, equivalently, $\phi(\alpha_k) \leq -\gamma\alpha_k^2$.

Condition (ii)

- $\alpha_k = 0$, $\lambda_k \leq \rho\lambda_{k-1}$;
- $\min(f(x_k + \lambda_k d_k), f(x_k - \lambda_k d_k)) \geq f(x_k) - \gamma\lambda_k^2$.

At each step it is necessary to satisfy either Condition (i) or Condition (ii). Note that this is always possible for any $d_k \neq 0$. Condition (i) requires that α_k is the largest number in the set A such that $f(x_k + \alpha_k d_k)$ is below the parabola $f(x_k) - \gamma\alpha^2$. If the function $\phi(\alpha)$ has a stationary point for $\alpha = 0$ then there may be no $\alpha \in A$ such that Condition (i) holds. However, in this case it is possible to find λ_k such that Condition (ii) holds. If Condition (ii) holds then $\alpha_k = 0$, *i.e.* the point x_k remains unchanged and the algorithms continues with a new direction $d_{k+1} \neq d_k$.
For the parabolic search algorithm it is possible to prove the following convergence result.

Theorem 7 *Let $f : I\!R^n \to I\!R$ and assume ∇f is continuous and $\mathcal{L}(f(x_0))$ is compact. If α_k is selected following the conditions of the parabolic search and if $x_{k+1} = x_k + \alpha_k d_k$, with $\|d_k\| = 1$ then the sequence $\{x_k\}$ is such that*

$$f(x_{k+1}) \leq f(x_k)$$

for all k,

$$\lim_{k\to\infty} \nabla f(x_k)' d_k = 0$$

and

$$\lim_{k\to\infty} \|x_{k+1} - x_k\| = 0.$$

Proof. (Sketch) Note that Condition (i) implies $f(x_{k+1}) < f(x_k)$, whereas Condition (ii) implies $f(x_{k+1}) = f(x_k)$. Note now that if Condition (ii) holds for all $k \geq \bar{k}$, then $\alpha_k = 0$ for all $k \geq \bar{k}$, *i.e.* $\|x_{k+1} - x_k\| = 0$. Moreover, as λ_k is reduced at each step, necessarily $\nabla f(x_{\bar{k}})'\bar{d} = 0$, where $\bar{d}$ is a limit of the sequence $\{d_k\}$. ◁

2.4.5 Implementation of a line search algorithm

On the basis of the conditions described so far it is possible to construct algorithms that yield α_k in a finite number of steps. One such an algorithm can be described as follows. (For simplicity we assume that ∇f is known.)

- Initial data. x_k, $f(x_k)$, $\nabla f(x_k)$, $\underline{\alpha}$ and $\overline{\alpha}$.
- Initial guess for α. A possibility is to select α as the point in which a parabola through $(0, \phi(0))$ with derivative $\dot{\phi}(0)$ for $\alpha = 0$ takes a pre-specified minimum value $f_\star$. Initially, *i.e.* for $k = 0$, $f_\star$ has to be selected by the designer. For $k > 0$ it is possible to select $f_\star$ such that

  $$f(x_k) - f_\star = f(x_{k-1}) - f(x_k).$$

  The resulting α is

  $$\alpha_\star = -2\,\frac{f(x_k) - f_\star}{\nabla f(x_k)' d_k}.$$

  In some algorithms it is convenient to select $\alpha \leq 1$, hence the initial guess for α will be $\min(1, \alpha_\star)$.
- Computation of α_k. A value for α_k is computed using a line search method. If $\alpha_k \leq \underline{\alpha}$ the direction d_k may not be a descent direction. If $\alpha_k \geq \overline{\alpha}$ the level set $\mathcal{L}(f(x_k))$ may not be compact. If $\alpha_k \notin [\underline{\alpha}, \overline{\alpha}]$ the line search fails, and it is necessary to select a new research direction d_k. Otherwise the line search terminates and $x_{k+1} = x_k + \alpha_k d_k$.

2.5 The gradient method

The gradient method consists in selecting, as research direction, the direction of the anti-gradient at x_k, *i.e.*

$$d_k = -\nabla f(x_k),$$

for all k. This selection is justified noting that the direction[7]

$$-\frac{\nabla f(x_k)}{\|\nabla f(x_k)\|_E}$$

is the direction that minimizes the directional derivative, among all direction with unitary Euclidean norm. In fact, by Schwartz inequality, one has

$$|\nabla f(x_k)' d| \leq \|d\|_E \|\nabla f(x_k)\|_E,$$

and the equality sign holds if and only if $d = \lambda \nabla f(x_k)$, with $\lambda \in I\!R$. As a consequence, the problem

$$\min_{\|d\|_E = 1} \nabla f(x_k)' d$$

---

[7] We denote with $\|v\|_E$ the Euclidean norm of the vector v, *i.e.* $\|v\|_E = \sqrt{v'v}$.

has the solution $d_\star = -\frac{\nabla f(x_k)}{\|\nabla f(x_k)\|_E}$. For this reason, the gradient method is sometimes called the method of the steepest descent. Note however that the (local) optimality of the direction $-\nabla f(x_k)$ depends upon the selection of the norm, and that with a proper selection of the norm, any descent direction can be regarded as the steepest descent.
The real interest in the direction $-\nabla f(x_k)$ rests on the fact that, if ∇f is continuous, then the former is a continuous descent direction, which is zero only if the gradient is zero, *i.e.* at a stationary point.
The gradient algorithm can be schematized has follows.

Step 0. Given $x_0 \in I\!R^n$.

Step 1. Set $k = 0$.

Step 2. Compute $\nabla f(x_k)$. If $\nabla f(x_k) = 0$ STOP. Else set $d_k = -\nabla f(x_k)$.

Step 3. Compute a step α_k along the direction d_k with any line search method such that

$$f(x_k + \alpha_k d_k) \leq f(x_k)$$

and

$$\lim_{k\to\infty} \frac{\nabla f(x_k)' d_k}{\|d_k\|} = 0.$$

Step 4. Set $x_{k+1} = x_k + \alpha_k d_k$, $k = k + 1$. Go to **Step 2**.

By the general results established in Theorem 4, we have the following fact regarding the convergence properties of the gradient method.

Theorem 8 *Consider $f : I\!R^n \to I\!R$. Assume ∇f is continuous and the level set $\mathcal{L}(f(x_0))$ is compact. Then any accumulation point of the sequence $\{x_k\}$ generated by the gradient algorithm is a stationary point of f.*

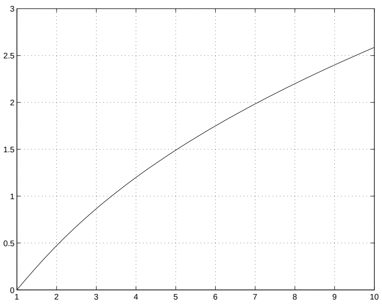


Figure 2.5: The function $\sqrt{\xi}\,\dfrac{\xi - 1}{\xi + 1}$.

To estimate the speed of convergence of the method we can consider the behavior of the method in the minimization of a quadratic function, *i.e.* in the case

$$f(x) = \frac{1}{2}x'Qx + c'x + d,$$

with $Q = Q' > 0$. In such a case it is possible to obtain the following estimate

$$\|x_{k+1} - x_\star\| \leq \sqrt{\frac{\lambda_M}{\lambda_m}} \frac{\sqrt{\frac{\lambda_M}{\lambda_m}} - 1}{\sqrt{\frac{\lambda_M}{\lambda_m}} + 1} \|x_k - x_\star\|,$$

where $\lambda_M \geq \lambda_m > 0$ are the maximum and minimum eigenvalue of Q, respectively. Note that the above estimate is exact for some initial points x_0. As a result, if $\lambda_M \neq \lambda_m$ the gradient algorithm has linear convergence, however, if λ_M/λ_m is large the convergence can be very slow (see Figure 2.5).

Finally, if $\lambda_M/\lambda_m = 1$ the gradient algorithm converges in one step. From a geometric point of view the ratio λ_M/λ_m expresses the ratio between the lengths of the maximum and the minimum axes of the ellipsoids, that constitute the level surfaces of f. If this ratio is big there are points from which the gradient algorithm converges very slowly, see *e.g.* Figure 2.6.

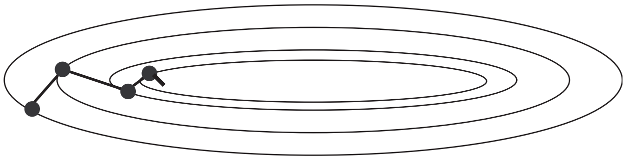


Figure 2.6: Behavior of the gradient algorithm.

In the non-quadratic case, the performance of the gradient method are unacceptable, especially if the level surfaces of f have high curvature.

2.6 Newton's method

Newton's method, with all its variations, is the most important method in unconstrained optimization. Let $f : I\!R^n \to I\!R$ be a given function and assume that $\nabla^2 f$ is continuous. Newton's method for the minimization of f can be derived assuming that, given x_k, the point x_{k+1} is obtained minimizing a quadratic approximation of f. As f is two times differentiable, it is possible to write

$$f(x_k + s) = f(x_k) + \nabla f(x_k)'s + \frac{1}{2}s'\nabla^2 f(x_k)s + \beta(x_k, s),$$

in which

$$\lim_{\|s\| \to 0} \frac{\beta(x_k, s)}{\|s\|^2} = 0.$$

For $\|s\|$ sufficiently small, it is possible to approximate $f(x_k + s)$ with its quadratic approximation

$$q(s) = f(x_k) + \nabla f(x_k)' s + \frac{1}{2} s' \nabla^2 f(x_k) s.$$

If $\nabla^2 f(x_k) > 0$, the value of s minimizing $q(s)$ can be obtained setting to zero the gradient of $q(s)$, *i.e.*

$$\nabla q(s) = \nabla f(x_k) + \nabla^2 f(x_k) s = 0,$$

yielding

$$s = -\left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k).$$

The point x_{k+1} is thus given by

$$x_{k+1} = x_k - \left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k).$$

Finally, Newton's method can be described by the simple scheme.

Step 0. Given $x_0 \in I\!R^n$.

Step 1. Set $k = 0$.

Step 2. Compute

$$s = -\left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k).$$

Step 3. Set $x_{k+1} = x_k + s$, $k = k + 1$. Go to **Step 2**.

Remark. An equivalent way to introduce Newton's method for unconstrained optimization is to regard the method as an algorithm for the solution of the system of n non-linear equations in n unknowns given by

$$\nabla f(x) = 0.$$

For, consider, in general, a system of n equations in n unknown

$$F(x) = 0,$$

with $x \in I\!R^n$ and $F : I\!R^n \to I\!R^n$. If the Jacobian matrix of F exists and is continuous, then one can write

$$F(x + s) = F(x) + \frac{\partial F}{\partial x}(x) s + \gamma(x, s),$$

with

$$\lim_{\|s\| \to 0} \frac{\gamma(x, s)}{\|s\|} = 0.$$

Hence, given a point x_k we can determine $x_{k+1} = x_k + s$ setting s such that

$$F(x_k) + \frac{\partial F}{\partial x}(x_k) s = 0.$$

If $\frac{\partial F}{\partial x}(x_k)$ is invertible we have

$$s = -\left[\frac{\partial F}{\partial x}(x_k)\right]^{-1} F(x_k),$$

hence Newton's method for the solution of the system of equation $F(x) = 0$ is

$$x_{k+1} = x_k - \left[\frac{\partial F}{\partial x}(x_k)\right]^{-1} F(x_k), \tag{2.3}$$

with $k = 0, 1, \ldots$. Note that, if $F(x) = \nabla f$, then the above iteration coincides with Newton's method for the minimization of f. $\diamond$

To study the convergence properties of Newton's method we can consider the algorithm for the solution of a set of non-linear equations, summarized in equation (2.3). The following local convergence result, providing also an estimate of the speed of convergence, can be proved.

Theorem 9 *Let $F : I\!R^n \to I\!R^n$ and assume that F is continuously differentiable in an open set $\mathcal{D} \subset I\!R^n$. Suppose moreover that*

- *there exists $x_\star \in \mathcal{D}$ such that $F(x_\star) = 0$;*
- *the Jacobian matrix $\frac{\partial F}{\partial x}(x_\star)$ is non-singular;*
- *there exists $L > 0$ such that*[8]

  $$\left\| \frac{\partial F}{\partial x}(z) - \frac{\partial F}{\partial x}(y) \right\| \leq L\|z - y\|,$$

  for all $z \in \mathcal{D}$ and $y \in \mathcal{D}$.

Then there exists and open set $\mathcal{B} \subset \mathcal{D}$ such that for any $x_0 \in \mathcal{B}$ the sequence $\{x_k\}$ generated by equation (2.3) remains in $\mathcal{B}$ and converges to $x_\star$ with quadratic speed of convergence.

The result in Theorem 9 can be easily recast as a result for the convergence of Newton's method for unconstrained optimization. For, it is enough to note that all hypotheses on F and $\frac{\partial F}{\partial x}$ translate into hypotheses on ∇f and $\nabla^2 f$. Note however that the result is only local and does not allow to distinguish between local minima and local maxima. To construct an algorithm for which the sequence $\{x_k\}$ does not converge to maxima, and for which global convergence, *i.e.* convergence from points outside the set $\mathcal{B}$, holds, it is possible to modify Newton's method considering a line search along the direction $d_k = -\left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k)$. As a result, the modified Newton's algorithm

$$x_{k+1} = x_k - \alpha_k \left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k), \tag{2.4}$$

---

[8] This is equivalent to say that $\frac{\partial F}{\partial x}(x)$ is Lipschitz continuous in $\mathcal{D}$.

in which α_k is computed using any line search algorithm, is obtained. If $\nabla^2 f$ is uniformly positive definite, and this implies that the function f is convex, the direction $d_k = -\left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k)$ is a descent direction satisfying the condition of angle. Hence, by Theorem 4, we can conclude the (global) convergence of the algorithm (2.4). Moreover, it is possible to prove that, for k sufficiently large, the step $\alpha_k = 1$ satisfies the conditions of Armijo method, hence the sequence $\{x_k\}$ has quadratic speed of convergence.

Remark. If the function to be minimized is quadratic, *i.e.*

$$f(x) = \frac{1}{2}x'Qx + c'x + d,$$

and if $Q > 0$, Newton's method yields the (global) minimum of f in one step. ◇

In general, *i.e.* if $\nabla^2 f(x)$ is not positive definite for all x, Newton's method may be inapplicable because either $\nabla^2 f(x_k)$ is not invertible, or $d_k = -\left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k)$ is not a descent direction. In these cases it is necessary to further modify Newton's method. Diverse criteria have been proposed, most of which rely on the substitution of the matrix $\nabla^2 f(x_k)$ with a matrix $M_k > 0$ which is *close in some sense* to $\nabla^2 f(x_k)$. A simpler modification can be obtained using the direction $d_k = -\nabla f(x_k)$ whenever the direction $d_k = -\left[\nabla^2 f(x_k)\right]^{-1} \nabla f(x_k)$ is not a descent direction. This modification yields the following algorithm.

Step 0. Given $x_0 \in I\!R^n$ and $\epsilon > 0$.

Step 1. Set $k = 0$.

Step 2. Compute $\nabla f(x_k)$. If $\nabla f(x_k) = 0$ STOP. Else compute $\nabla^2 f(x_k)$. If $\nabla^2 f(x_k)$ is singular set $d_k = -\nabla f(x_k)$ and go to **Step 6**.

Step 3. Compute Newton direction s solving the (linear) system

$$\nabla^2 f(x_k)s = -\nabla f(x_k).$$

Step 4. If

$$|\nabla f(x_k)'s| < \epsilon \|\nabla f(x_k)\| \|s\|$$

set $d_k = -\nabla f(x_k)$ and go to **Step 6**.

Step 5. If

$$\nabla f(x_k)'s < 0$$

set $d_k = s$; if

$$\nabla f(x_k)'s > 0$$

set $d_k = -s$.

Step 6. Make a line search along d_k assuming as initial estimate $\alpha = 1$. Compute $x_{k+1} = x_k + \alpha_k d_k$, set $k = k + 1$ and go to **Step 2**.

The above algorithm is such that the direction d_k satisfies the condition of angle, *i.e.*

$$\nabla f(x_k)' d_k \leq -\epsilon \|\nabla f(x_k)\| \|d_k\|,$$

for all k. Hence, the convergence is guaranteed by the general result in Theorem 4. Moreover, if ϵ is sufficiently small, if the hypotheses of Theorem 9 hold, and if the line search is performed with Armijo method and with the initial guess $\alpha = 1$, then the above algorithm has quadratic speed of convergence.

Finally, note that it is possible to modify Newton's method, whenever it is not applicable, without making use of the direction of the anti-gradient. We now briefly discuss two such modifications.

2.6.1 Method of the trust region

A possible approach to modify Newton's method to yield global convergence is to set the direction d_k and the step α_k in such a way to minimize the quadratic approximation of f on a sphere centered at x_k and of radius a_k. Such a sphere is called *trust region.* This name refers to the fact that, in a small region around x_k we are confident (we trust) that the quadratic approximation of f is a *good* approximation.

The method of the trust region consists in selecting $x_{k+1} = x_k + s_k$, where s_k is the solution of the problem

$$\min_{\|s\| \leq a_k} q(s), \tag{2.5}$$

with

$$q(s) = f(x_k) + \nabla f(x_k)' s + \frac{1}{2} s' \nabla^2 f(x_k) s,$$

and $a_k > 0$ the estimate at step k of the trust region. As the above (constrained) optimization problem has always a solution, the direction s_k is always defined. The computation of the estimate a_k is done, iteratively, in such a way to enforce the condition $f(x_{k+1}) < f(x_k)$ and to make sure that $f(x_k + s_k) \approx q(s_k)$, *i.e.* that the change of f and the estimated change of f are *close.*

Using these simple ingredients it is possible to construct the following algorithm.

Step 0. Given $x_0 \in I\!R^n$ and $a_0 > 0$.

Step 1. Set $k = 0$.

Step 2. Compute $\nabla f(x_k)$. If $\nabla f(x_k) = 0$ STOP. Else go to **Step 3**.

Step 3. Compute s_k solving problem (2.5).

Step 4. Compute[9]

$$\rho_k = \frac{f(x_k + s_k) - f(x_k)}{q(s_k) - f(x_k)}. \tag{2.6}$$

---

[9] If f is quadratic then $\rho_k = 1$ for all k.

Step 5. If $\rho_k < 1/4$ set $a_{k+1} = \|s_k\|/4$. If $\rho_k > 3/4$ and $\|s_k\| = a_k$ set $a_{k+1} = 2a_k$. Else set $a_{k+1} = a_k$.

Step 6. If $\rho_k \leq 0$ set $x_{k+1} = x_k$. Else set $x_{k+1} = x_k + s_k$.

Step 7. Set $k = k + 1$ and go to **Step 2**.

Remark. Equation (2.6) expresses the ratio between the actual change of f and the estimated change of f. ◇

It is possible to prove that, if $\mathcal{L}(f(x_0))$ is compact and $\nabla^2 f$ is continuous, any accumulation point resulting from the above algorithm is a stationary point of f, in which the second order necessary conditions hold.
The update of a_k is devised to enlarge or shrink the region of confidence on the basis of the number ρ_k. It is possible to show that if $\{x_k\}$ converges to a local minimum in which $\nabla^2 f$ is positive definite, then ρ_k converges to one and the direction s_k coincides, for k sufficiently large, with the Newton direction. As a result, the method has quadratic speed of convergence.
In practice, the solution of the problem (2.5) cannot be obtained analytically, hence approximate problems have to be solved. For, consider s_k as the solution of the equation

$$\left(\nabla^2 f(x_k) + \nu_k I\right) s_k = -\nabla f(x_k), \tag{2.7}$$

in which $\nu_k > 0$ has to be determined with proper considerations. Under certain hypotheses, the s_k determined solving equation (2.7) coincides with the s_k computed using the method of the trust region.

Remark. A potential disadvantage of the method of the trust region is to reduce the step along Newton direction even if the selection $\alpha_k = 1$ would be feasible. ◇

2.6.2 Non-monotonic line search

Experimental evidence shows that Newton's method gives the best result if the step $\alpha_k = 1$ is used. Therefore, the use of $\alpha_k < 1$ along Newton direction, resulting *e.g.* from the application of Armijo method, results in a degradation of the performance of the algorithm. To avoid this phenomenon it has been suggested to relax the condition $f(x_{k+1}) < f(x_k)$ imposed on Newton algorithm, thus allowing the function f to increase for a certain number of steps. For example, it is possible to substitute the *reduction* condition of Armijo method with the condition

$$f(x_k + \alpha_k d_k) \leq \max_{0 \leq j \leq M} [f(x_{k-j})] + \gamma \alpha_k \nabla f(x_k)' d_k$$

for all $k \geq M$, where $M > 0$ is a fixed integer independent from k.

	Gradient method	Newton's method
Information required at each step	f and ∇f	f, ∇f and $\nabla^2 f$
Computation to find the research direction	$\nabla f(x_k)$	$\nabla f(x_k)$, $\nabla^2 f(x_k)$, $-[\nabla^2 f(x_k)]^{-1}\nabla f(x_k)$
Convergence	Global if $\mathcal{L}(f(x_0))$ compact and ∇f continuous	Local, but may be rendered global
Behavior for quadratic functions	Asymptotic convergence	Convergence in one step
Speed of convergence	Linear for quadratic functions	Quadratic (under proper hypotheses)

Table 2.1: Comparison between the gradient method and Newton's method.

2.6.3 Comparison between Newton's method and the gradient method

The gradient method and Newton's method can be compared from different point of views, as described in Table 2.1. From the table, it is obvious that Newton's method has better convergence properties but it is computationally more expensive. There exist methods which preserve some of the advantages of Newton's method, namely speed of convergence faster than the speed of the gradient method and finite convergence for quadratic functions, without requiring the knowledge of $\nabla^2 f$. Such methods are

- the conjugate directions methods;
- quasi-Newton methods.

2.7 Conjugate directions methods

Conjugate directions methods have been motivated by the need of improving the convergence speed of the gradient method, without requiring the computation of $\nabla^2 f$, as required in Newton's method.

A basic characteristic of conjugate directions methods is to find the minimum of a quadratic function in a finite number of steps. These methods have been introduced for the solution of systems of linear equations and have later been extended to the solution of unconstrained optimization problems for non-quadratic functions.

Definition 5 *Given a matrix $Q = Q'$, the vectors d_1 and d_2 are said to be Q-conjugate if*

$$d_1' Q d_2 = 0.$$

Remark. If $Q = I$ then two vectors are Q-conjugate if they are orthogonal. ◇

Theorem 10 *Let $Q \in I\!R^{n \times n}$ and $Q = Q' > 0$. Let $d_i \in I\!R^n$, for $i = 0, \cdots, k$, be non-zero vectors. If d_i are mutually Q-conjugate,* i.e.

$$d_i' Q d_j = 0,$$

for all $i \neq j$, then the vectors d_i are linearly independent.

Proof. Suppose there exists constants α_i, with $\alpha_i \neq 0$ for some i, such that

$$\alpha_0 d_0 + \cdots \alpha_k d_k = 0.$$

Then, left multiplying with Q and d_j' yields

$$\alpha_j d_j' Q d_j = 0,$$

which implies, as $Q > 0$, $\alpha_j = 0$. Repeating the same considerations for all $j \in [0, k]$ yields the claim. ◁

Consider now a quadratic function

$$f(x) = \frac{1}{2} x' Q x + c' x + d,$$

with $x \in I\!R^n$ and $Q = Q' > 0$. The (global) minimum of f is given by

$$x_\star = -Q^{-1} c,$$

and this can be computed using the procedure given in the next statement.

Theorem 11 *Let $Q = Q' > 0$ and let d_0, d_1, $\cdots$, d_{n-1} be n non-zero vectors mutually Q-conjugate. Consider the algorithm*

$$x_{k+1} = x_k + \alpha_k d_k$$

with

$$\alpha_k = -\frac{\nabla f(x_k)' d_k}{d_k' Q d_k} = -\frac{(x_k' Q + c') d_k}{d_k' Q d_k}.$$

Then, for any x_0, the sequence $\{x_k\}$ converges, in at most n steps, to $x_\star = -Q^{-1} c$, i.e. *it converges to the minimum of the quadratic function f.*

Remark. Note that α_k is selected at each step to minimize the function $f(x_k + \alpha d_k)$ with respect to α, *i.e.* at each step an exact line search in the direction d_k is performed. ◇

In the above statement we have assumed that the directions d_k have been preliminarily assigned. However, it is possible to construct a procedure in which the directions are computed iteratively. For, consider the quadratic function $f(x) = \frac{1}{2}x'Qx + c'x + d$, with $Q > 0$, and the following algorithm, known as conjugate gradient method.

Step 0. Given $x_0 \in I\!R^n$ and the direction

$$d_0 = -\nabla f(x_0) = -(Qx_0 + c).$$

Step 1. Set $k = 0$.

Step 2. Let

$$x_{k+1} = x_k + \alpha_k d_k$$

with

$$\alpha_k = -\frac{\nabla f(x_k)'d_k}{d_k'Qd_k} - \frac{(x_k'Q + c')d_k}{d_k'Qd_k}.$$

Step 3. Compute d_{k+1} as follows

$$d_{k+1} = -\nabla f(x_{k+1}) + \beta_k d_k,$$

with

$$\beta_k = \frac{\nabla f(x_{k+1})'Qd_k}{d_k'Qd_k}.$$

Step 4. Set $k = k + 1$ and go to **Step 2**.

Remark. As already observed, α_k is selected to minimize the function $f(x_k + \alpha d_k)$. Moreover, this selection of α_k is also such that

$$\nabla f(x_{k+1})'d_k = 0. \tag{2.8}$$

In fact,

$$Qx_{k+1} = Qx_k + \alpha_k Qd_k$$

hence

$$\nabla f(x_{k+1}) = \nabla f(x_k) + \alpha_k Qd_k. \tag{2.9}$$

Left multiplying with d_k' yields

$$d_k'\nabla f(x_{k+1}) = d_k'\nabla f(x_k) + d_k'Qd_k\alpha_k = d_k'\nabla f(x_k) - d_k'Qd_k\frac{\nabla f(x_k)'d_k}{d_k'Qd_k} = 0.$$

◇

Remark. β_k is such that d_{k+1} is Q-conjugate with respect to d_k. In fact,

$$d_k'Qd_{k+1} = d_k'Q\left(-\nabla f(x_{k+1}) + \frac{\nabla f(x_{k+1})'Qd_k}{d_k'Qd_k}d_k\right) = d_k'Q\left(-\nabla f(x_{k+1}) + \nabla f(x_{k+1})\right) = 0.$$

Moreover, this selection of β_k yields also

$$\nabla f(x_k)'d_k = -\nabla f(x_k)'\nabla f(x_k). \tag{2.10}$$

◇

For the conjugate gradient method it is possible to prove the following fact.

Theorem 12 *The conjugate gradient method yields the minimum of the quadratic function*

$$f(x) = \frac{1}{2}x'Qx + c'x + d,$$

with $Q = Q' > 0$, *in at most* n *iterations,* i.e. *there exists* $m \leq n-1$ *such that*

$$\nabla f(x_{m+1}) = 0.$$

Moreover

$$\nabla f(x_j)'\nabla f(x_i) = 0 \tag{2.11}$$

and

$$d_j'Qd_i = 0, \tag{2.12}$$

for all $[0, m+1] \ni i \neq j \in [0, m+1]$.

Proof. To prove the (finite) convergence of the sequence $\{x_k\}$ it is enough to show that the directions d_k are Q-conjugate, *i.e.* that equation (2.12) holds. In fact, if equation (2.12) holds the claim is a consequence of Theorem 11. ◁

The conjugate gradient algorithm, in the form described above, cannot be used for the minimization of non-quadratic functions, as it requires the knowledge of the matrix Q, which is the Hessian of the function f. Note that the matrix Q appears at two levels in the algorithm: in the computation of the scalar β_k required to compute the new direction of research, and in the computation of the step α_k. It is therefore necessary to modify the algorithm to avoid the computation of $\nabla^2 f$, but at the same time it is reasonable to make sure that the modified algorithm coincides with the above one in the quadratic case.

2.7.1 Modification of β_k

To begin with note that, by equation (2.9), β_k can be written as

$$\beta_k = \frac{\nabla f(x_{k+1})'\dfrac{\nabla f(x_{k+1}) - \nabla f(x_k)}{\alpha_k}}{d_k'\dfrac{\nabla f(x_{k+1}) - \nabla f(x_k)}{\alpha_k}} = \frac{\nabla f(x_{k+1})'\left[\nabla f(x_{k+1}) - \nabla f(x_k)\right]}{d_k'\left[\nabla f(x_{k+1}) - \nabla f(x_k)\right]},$$

and, by equation (2.8),

$$\beta_k = -\frac{\nabla f(x_{k+1})' \left[\nabla f(x_{k+1}) - \nabla f(x_k)\right]}{d_k' \nabla f(x_k)}. \tag{2.13}$$

Using equation (2.13), it is possible to construct several expressions for β_k, all equivalent in the quadratic case, but yielding different algorithms in the general (non-quadratic) case. A first possibility is to consider equations (2.10) and (2.11) and to define

$$\beta_k = \frac{\nabla f(x_{k+1})' \nabla f(x_{k+1})}{\nabla f(x_k)' \nabla f(x_k)} = \frac{\|\nabla f(x_{k+1})\|^2}{\|\nabla f(x_k)\|^2}, \tag{2.14}$$

which is known as Fletcher-Reeves formula.
A second possibility is to write the denominator as in equation (2.14) and the numerator as in equation (2.13), yielding

$$\beta_k = \frac{\nabla f(x_{k+1})' \left[\nabla f(x_{k+1}) - \nabla f(x_k)\right]}{\|\nabla f(x_k)\|^2}, \tag{2.15}$$

which is known as Polak-Ribiere formula. Finally, it is possible to have the denominator as in (2.13) and the numerator as in (2.14), *i.e.*

$$\beta_k = -\frac{\|\nabla f(x_{k+1})\|^2}{d_k' \nabla f(x_k)}. \tag{2.16}$$

2.7.2 Modification of α_k

As already observed, in the quadratic version of the conjugate gradient method also the step α_k depends upon Q. However, instead of using the α_k given in **Step 2** of the algorithm, it is possible to use a line search along the direction α_k. In this way, an algorithm for non-quadratic functions can be constructed. Note that α_k, in the algorithm for quadratic functions, is also such that $d_k \nabla f(x_{k+1}) = 0$. Therefore, in the line search, it is reasonable to select α_k such that, not only $f(x_{k+1}) < f(x_k)$, but also d_k is approximately orthogonal to $\nabla f(x_{k+1})$.

Remark. The condition of approximate orthogonality between d_k and $\nabla f(x_{k+1})$ cannot be enforced using Armijo method or Goldstein conditions. However, there are more sophisticated line search algorithms, known as Wolfe conditions, which allow to enforce the above constraint. ◇

2.7.3 Polak-Ribiere algorithm

As a result of the modifications discussed in the last sections, it is possible to construct an algorithm for the minimization of general functions. For example, using equation (2.15) we obtain the following algorithm, due to Polak-Ribiere, which has proved to be one of the most efficient among the class of conjugate directions methods.

Step 0. Given $x_0 \in I\!R^n$.

Step 1. Set $k = 0$.

Step 2. Compute $\nabla f(x_k)$. If $\nabla f(x_k) = 0$ STOP. Else let

$$d_k = \begin{cases} -\nabla f(x_0), & \text{if } k = 0 \\ \\ -\nabla f(x_k) + \dfrac{\nabla f(x_k)' \left[\nabla f(x_k) - \nabla f(x_{k-1})\right]}{\|\nabla f(x_{k-1})\|^2} d_{k-1}, & \text{if } k \geq 1. \end{cases}$$

Step 3. Compute α_k performing a line search along d_k.

Step 4. Set $x_{k+1} = x_k + \alpha_k d_k$, $k = k + 1$ and go to **Step 2**.

Remark. The line search has to be sufficiently accurate, to make sure that all directions generated by the algorithm are descent directions. A suitable line search algorithm is the so-called Wolfe method, which is a modification of Goldstein method. ◇

Remark. To guarantee global convergence of a subsequence it is possible to use, every n steps, the direction $-\nabla f$. In this case, it is said that the algorithm uses a *restart* procedure. For the algorithm with restart it is possible to have quadratic speed of convergence in n steps, *i.e*

$$\|x_{k+n} - x_\star\| \leq \gamma \|x_k - x_\star\|^2,$$

for some $\gamma > 0$. ◇

Remark. It is possible to modify Polak-Ribiere algorithm to make sure that at each step the angle condition holds. In this case, whenever the direction d_k does not satisfy the angle condition, it is sufficient to use the direction $-\nabla f$. Note that, enforcing the angle condition, yields a globally convergent algorithm. ◇

Remark. Even if the use of the direction $-\nabla f$ every n steps, or whenever the angle condition is not satisfied, allows to prove global convergence of Polak-Ribiere algorithm, it has been observed in numerical experiments that such modified algorithms do not perform as well as the original one. ◇

2.8 Quasi-Newton methods

Conjugate gradient methods have proved to be more efficient than the gradient method. However, in general, it is not possible to guarantee superlinear convergence. The main advantage of conjugate gradient methods is in the fact that they do not require to construct and store any matrix, hence can be used in large scale problems.

In small and medium scale problems, *i.e.* problems with less then a few hundreds decision variables, in which $\nabla^2 f$ is not available, it is convenient to use the so-called quasi-Newton methods.

Quasi Newton methods, as conjugate directions methods, have been introduced for quadratic functions. They are described by an algorithm of the form

$$x_{k+1} = x_k - \alpha_k H_k \nabla f(x_k),$$

with H_0 given. The matrix H_k is an approximation of $[\nabla^2 f(x_k)]^{-1}$ and it is computed iteratively at each step.

If f is a quadratic function, the gradient of f is given by

$$\nabla f(x) = Qx + c,$$

for some Q and c, hence for any $x \in I\!R^n$ and $y \in I\!R^n$ one has

$$\nabla f(y) - \nabla f(x) = Q(y - x),$$

or, equivalently,

$$Q^{-1}[\nabla f(y) - \nabla f(x)] = y - x.$$

It is then natural, in general, to construct the sequence $\{H_k\}$ such that

$$H_{k+1}[\nabla f(x_{k+1}) - \nabla f(x_k)] = x_{k+1} - x_k. \tag{2.17}$$

Equation (2.17) is known as quasi-Newton equation.

There exist several update methods satisfying the quasi-Newton equation. For simplicity, set

$$\gamma_k = \nabla f(x_{k+1}) - \nabla f(x_k),$$

and

$$\delta_k = x_{k+1} - x_k.$$

As a result, equation (2.17) can be rewritten as

$$H_{k+1}\gamma_k = \delta_k.$$

One of the first quasi-Newton methods has been proposed by Davidon, Fletcher and Powell, and can be summarized by the equations

$$\text{DFP} \left\{ \begin{array}{rcl} H_0 & = & I \\ \\ H_{k+1} & = & H_k + \dfrac{\delta_k \delta_k'}{\delta_k' \gamma_k} - \dfrac{H_k \gamma_k \gamma_k' H_k}{\gamma_k' H_k \gamma_k}. \end{array} \right. \tag{2.18}$$

It is easy to show that the matrix H_{k+1} satisfies the quasi-Newton equation (2.17), *i.e.*

$$\begin{array}{rcl} H_{k+1}\gamma_k & = & H_k\gamma_k + \dfrac{\delta_k \delta_k'}{\delta_k' \gamma_k}\gamma_k - \dfrac{H_k \gamma_k \gamma_k' H_k}{\gamma_k' H_k \gamma_k}\gamma_k \\ & = & H_k\gamma_k + \dfrac{\delta_k' \gamma_k}{\delta_k' \gamma_k}\delta_k - \dfrac{\gamma_k' H_k \gamma_k}{\gamma_k' H_k \gamma_k}H_k\gamma_k \\ & = & \delta_k. \end{array}$$

Moreover, it is possible to prove the following fact, which gives conditions such that the matrices generated by DFP method are positive definite for all k.

Theorem 13 *Let* $H_k = H_k' > 0$ *and assume* $\delta_k'\gamma_k > 0$. *Then the matrix*

$$H_k + \frac{\delta_k\delta_k'}{\delta_k'\gamma_k} - \frac{H_k\gamma_k\gamma_k'H_k}{\gamma_k'H_k\gamma_k}$$

is positive definite.

DFP method has the following properties. In the quadratic case, if α_k is selected to minimize

$$f(x_k - \alpha H_k \nabla f(x_k)),$$

then

- the directions $d_k = -H_k\nabla f(x_k)$ are mutually conjugate;
- the minimum of the (quadratic) function is found in at most n steps, moreover $H_n = Q^{-1}$;
- the matrices H_k are always positive definite.

In the non-quadratic case

- the matrices H_k are positive definite (hence $d_k = -H_k\nabla f(x_k)$ is a descent direction) if $\delta_k'\gamma_k > 0$;
- it is globally convergent if f is strictly convex and if the line search is exact;
- it has superlinear speed of convergence (under proper hypotheses).

A second, and more general, class of update formulae, including as a particular case DFP formula, is the so-called Broyden class, defined by the equations

$$\text{Broyden}\left\{\begin{array}{lcl} H_0 & = & I \\ H_{k+1} & = & H_k + \dfrac{\delta_k\delta_k'}{\delta_k'\gamma_k} - \dfrac{H_k\gamma_k\gamma_k'H_k}{\gamma_k'H_k\gamma_k} + \phi v_k v_k', \end{array}\right. \tag{2.19}$$

with $\phi \geq 0$ and

$$v_k = (\gamma_k'H_k\gamma_k)^{1/2}\left(\frac{\delta_k}{\delta_k'\gamma_k} - \frac{H_k\gamma_k}{\gamma_k'H_k\gamma_k}\right).$$

If $\phi = 0$ then we obtain DFP formula, whereas for $\phi = 1$ we have the so-called Broyden-Fletcher-Goldfarb-Shanno (BFGS) formula, which is one of the preferred algorithms in applications. From Theorem 13 it is easy to infer that, if $H_0 > 0$, $\gamma_k'\delta_k > 0$ and $\phi \geq 0$, then all formulae in the class of Broyden generate matrices $H_k > 0$.

Remark. Note that the condition $\delta_k'\gamma_k > 0$ is equivalent to

$$(\nabla f(x_{k+1}) - \nabla f(x_k))' \, d_k > 0,$$

and this can be enforced with a sufficiently precise line search. ◇

For the method based on BFGS formula, a global convergence result, for convex functions and in the case of non-exact (but sufficiently accurate) line search, has been proved. Moreover, it has been shown that the algorithm has superlinear speed of convergence. This algorithm can be summarized as follows.

Step 0. Given $x_0 \in I\!R^n$.

Step 1. Set $k = 0$.

Step 2. Compute $\nabla f(x_k)$. If $\nabla f(x_k) = 0$ STOP. Else compute H_k with BFGS equation and set

$$d_k = -H_k \nabla f(x_k).$$

Step 3. Compute α_k performing a line search along d_k.

Step 4. Set $x_{k+1} = x_k + \alpha_k d_k$, $k = k + 1$ and go to **Step 2**.

In the general case it is not possible to prove global convergence of the algorithm. However, this can be enforced verifying (at the end of **Step 2**), if the direction d_k satisfies an angle condition, and if not use the direction $d_k = -\nabla f(x_k)$. However, as already observed, this modification improves the convergence properties, but reduces (sometimes drastically) the speed of convergence.

2.9 Methods without derivatives

All the algorithms that have been discussed presuppose the knowledge of the derivatives (first and/or second) of the function f. There are, however, also methods which do not require such a knowledge. These methods can be divided in two classes: direct research methods and methods using finite difference approximations.

Direct search methods are based upon the direct comparison of the values of the function f in the points generated by the algorithm, without making use of the necessary condition of optimality $\nabla f = 0$. In this class, the most interesting methods, *i.e.* the methods for which it is possible to give theoretical results, are those that make use cyclically of n linearly independent directions. The simplest possible method, known as the method of the coordinate directions, can be described by the following algorithm.

Step 0. Given $x_0 \in I\!R^n$.

Step 1. Set $k = 0$.

Step 2. Set $j = 1$.

Step 3. Set $d_k = e_j$, where e_j is the j-th coordinate direction.

Step 4. Compute α_k performing a line search without derivatives along d_k.

Step 5. Set $x_{k+1} = x_k + \alpha_k d_k$, $k = k + 1$.

Step 6. If $j < n$ set $j = j + 1$ and go to **Step 3**. If $j = n$ go to **Step 2**.

It is easy to verify that the matrix

$$P_k = \begin{bmatrix} d_k & d_{k+1} & \cdots & d_{k+n-1} \end{bmatrix}$$

is such that

$$|\mathrm{det} P_k| = 1,$$

hence, if the line search is such that

$$\lim_{k\to\infty} \frac{\nabla f(x_k)' d_k}{\|d_k\|} = 0$$

and

$$\lim_{k\to\infty} \|x_{k+1} - x_k\| = 0,$$

convergence to stationary points is ensured by the general result in Theorem 5. Note that, the line search can be performed using the parabolic line search method described in Section 2.4.4.

The method of the coordinate directions is not very efficient, in terms of speed of convergence. Therefore, a series of heuristics have been proposed to improve its performance. One such heuristics is the so-called method of Jeeves and Hooke, in which not only the search along the coordinate directions is performed, but also a search along directions joining pairs of points generated by the algorithm. In this way, the search is performed along what may be considered to be the most promising directions.

An alternative direct search method is the so-called simplex method (which should not be confused with the simplex method of linear programming). The method starts with $n + 1$ (equally spaced) points $x_{(i)} \in I\!R^n$ (these points give a simplex in $I\!R^n$). In each of these points the function f is computed and the vertex where the function f attains the maximum value is determined. Suppose this is the vertex $x_{(n+1)}$. This vertex is reflected with respect to the center of the simplex, *i.e.* the point

$$x_c = \frac{1}{n+1} \sum_{i=1}^{n+1} x_{(i)}.$$

As a result, the new vertex

$$x_{(n+2)} = x_c + \alpha(x_c - x_{(n+1)})$$

where $\alpha > 0$, is constructed, see Figure 2.7. The procedure is then repeated.

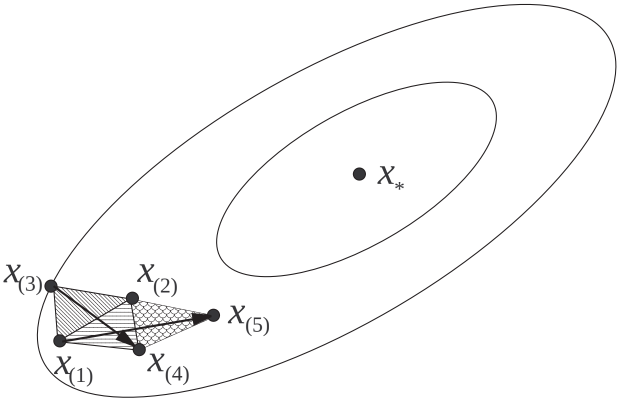


Figure 2.7: The simplex method. The points $x_{(1)}$, $x_{(2)}$ and $x_{(3)}$ yields the starting simplex. The second simplex is given by the points $x_{(1)}$, $x_{(2)}$ and $x_{(4)}$. The third simplex is given by the points $x_{(2)}$, $x_{(4)}$ and $x_{(5)}$.

It is possible that the vertex that is generated by one step of the algorithm is (again) the one where the function f has its maximum. In this case, the algorithm cycles, hence the next vertex has to be determined using a different strategy. For example, it is possible to construct the next vertex by reflecting another of the remaining n vertex, or to shrink the simplex.

As a stopping criterion it is possible to consider the condition

$$\frac{1}{n+1}\sum_{i=1}^{n+1}\left(f(x_{(i)})-\bar{f}\right)^2<\epsilon \tag{2.20}$$

where $\epsilon > 0$ is assigned by the designer, and

$$\bar{f}=\frac{1}{n+1}\sum_{i=1}^{n+1}f(x_{(i)}),$$

i.e. $\bar{f}$ is the mean value of the $f(x_{(i)})$. Condition (2.20) implies that the points $x_{(i)}$ are all in a region where the function f is *flat*.

As already observed, direct search methods are not very efficient, and can be used only for problems with a few decision variables and when approximate solutions are acceptable. As an alternative, if the derivatives of the function f are not available, it is possible to resort to numeric differentiation, *e.g* the entries of the gradient of f can be computed using the so-called forward difference approximation, *i.e.*

$$\frac{\partial f(x)}{\partial x_i}\approx\frac{f(x+te_i)-f(x)}{t},$$

where e_i is the i-th column of the identity matrix of dimension n, and $t > 0$ has to be fixed by the user. Note that there are methods for the computation of the optimal value of t, *i.e.* the value of t which minimizes the approximation error.

Chapter 3

Nonlinear programming

3.1 Introduction

In this chapter we discuss the basic tools for the solution of optimization problems of the form

$$P_0 \left\{ \begin{array}{l} \min\limits_x f(x) \\ g(x) = 0 \\ h(x) \leq 0. \end{array} \right. \tag{3.1}$$

In the problem P_0 there are both equality and inequality constraints[1]. However, sometimes for simplicity, or because a method has been developed for problems with special structure, we will refer to problems with only equality constraints, *i.e.* to problems of the form

$$P_1 \left\{ \begin{array}{l} \min\limits_x f(x) \\ g(x) = 0, \end{array} \right. \tag{3.2}$$

or to problems with only inequality constraints, *i.e.* to problems of the form

$$P_2 \left\{ \begin{array}{l} \min\limits_x f(x) \\ h(x) \leq 0. \end{array} \right. \tag{3.3}$$

In all the above problems we have $x \in I\!R^n$, $f : I\!R^n \to I\!R$, $g : I\!R^n \to I\!R^m$, and $h : I\!R^n \to I\!R^p$. From a formal point of view it is always possible to transform the equality constraint $g_i(x) = 0$ into a pair of inequality constraints, *i.e.* $g_i(x) \leq 0$ and $-g_i(x) \leq 0$. Hence, problem P_1 can be (equivalently) described by

$$\tilde{P}_1 \left\{ \begin{array}{l} \min\limits_x f(x) \\ g(x) \leq 0 \\ -g(x) \leq 0, \end{array} \right.$$

which is a special case of problem P_2. In the same way, it is possible to transform the inequality constraint $h_i(x) \leq 0$ into the equality constraint $h_i(x) + y_i^2 = 0$, where y_i is an auxiliary variable (also called *slack* variable). Therefore, defining the extended vector $z = [x', y']'$, problem P_2 can be rewritten as

$$\tilde{P}_2 \left\{ \begin{array}{l} \min\limits_z f(x) \\ h(x) + Y = 0, \end{array} \right.$$

with

$$Y = \left[\begin{array}{c} y_1^2 \\ y_2^2 \\ \vdots \\ y_p^2 \end{array} \right],$$

which is a special case of problem P_1.

---

[1] The condition $h(x) \leq 0$ has to be understood element-wise, *i.e.* $h_i(x) \leq 0$ for all i.

Note however, that the transformation of equality constraints into inequality constraints yields an increase in the number of constraints, whereas the transformation of inequality constraints into equality constraints results in an increased number of variables.
Given problem P_0 (or P_1, or P_2), a point x satisfying the constraints is said to be an admissible point, and the set of all admissible points is called the admissible set and it is denoted with $\mathcal{X}$. Note that the problem makes sense only if $\mathcal{X} \neq \emptyset$.
In what follows it is assumed that the functions f, g and h are two times differentiable, however we do not make any special hypothesis on the form of such functions. Note however, that if g and h are linear there are special algorithms, and linear/quadratic programming algorithms are used if f is linear/quadratic and g and h are linear. We do not discuss these special algorithms, and concentrate mainly on algorithms suitable for general problems.

3.2 Definitions and existence conditions

Consider the problem P_0 (or P_1, or P_2). The following definitions are instrumental to provide a necessary condition and a sufficient condition for the existence of local minima.

Definition 6 *An open ball with center* $x^\star$ *and radius* $\theta > 0$ *is the set*

$$B(x^\star, \theta) = \{x \in I\!R^n \mid \|x - x^\star\| < \theta\}.$$

Definition 7 *A point* $x^\star \in \mathcal{X}$ *is a constrained local minimum if there exists* $\theta > 0$ *such that*

$$f(y) \geq f(x^\star), \tag{3.4}$$

for all $y \in \mathcal{X} \cap B(x^\star, \theta)$.
A point $x^\star \in \mathcal{X}$ *is a constrained global minimum if*

$$f(y) \geq f(x^\star), \tag{3.5}$$

for all $y \in \mathcal{X}$.
If the inequality (3.4) (or (3.5)) holds with a strict inequality sign for all $y \neq x^\star$ *then the minimum is said to be strict.*

Definition 8 *The i-th inequality constraints* $h_i(x)$ *is said to be active at* $\tilde{x}$ *if* $h_i(\tilde{x}) = 0$. *The set* $I_a(\tilde{x})$ *is the set of all indexes* i *such that* $h_i(\tilde{x}) = 0$, i.e.

$$I_a(\tilde{x}) = \{i \in \{1, 2, \cdots, p\} \mid h_i(\tilde{x}) = 0\}.$$

The vector $h_a(\tilde{x})$ *is the subvector of* $h(x)$ *corresponding to the active constraints,* i.e.

$$h_a(\tilde{x}) = \{h_i(\tilde{x}) \mid i \in I_a(\tilde{x}).$$

Definition 9 *A point* $\tilde{x}$ *is a regular point for the constraints if at* $\tilde{x}$ *the gradients of the active constraints,* i.e. *the vectors* $\nabla g_i(\tilde{x})$, *for* $i = 1, \cdots, m$ *and* $\nabla h_i(\tilde{x})$, *for* $i \in I_a(\tilde{x})$, *are linearly independent.*

The definition of regular point is given because, the necessary and the sufficient conditions for optimality, in the case of regular points are relatively simple. To state these conditions, and with reference to problem P_0, consider the Lagrangian function

$$L(x, \lambda, \rho) = f(x) + \lambda' g(x) + \rho' h(x) \tag{3.6}$$

with $\lambda \in I\!R^m$ and $\rho \in I\!R^p$. The vectors λ and ρ are called multipliers.
With the above ingredients and definitions it is now possible to provide a necessary condition and a sufficient condition for local optimality.

Theorem 14 *[First order necessary condition] Consider problem P_0. Suppose $x^\star$ is a local solution of the problem P_0, and $x^\star$ is a regular point for the constraints.
Then there exist (unique) multipliers $\lambda^\star$ and $\rho^\star$ such that*[2]

$$\begin{aligned} &\nabla_x L(x^\star, \lambda^\star, \rho^\star) = 0 \\ &g(x^\star) = 0 \\ &h(x^\star) \leq 0 \\ &\rho^\star \geq 0 \\ &(\rho^\star)' h(x^\star) = 0. \end{aligned} \tag{3.7}$$

Conditions (3.7) are known as Kuhn-Tucker conditions.

Definition 10 *Let $x^\star$ be a local solution of problem P_0 and let $\rho^\star$ be the corresponding (optimal) multiplier. At $x^\star$ the condition of strict complementarity holds if $\rho_i^\star > 0$ for all $i \in I_a(x^\star)$.*

Theorem 15 *[Second order sufficient condition] Consider the problem P_0. Assume that there exist $x^\star$, $\lambda^\star$ and $\rho^\star$ satisfying conditions (3.7). Suppose moreover that $\rho^\star$ is such that the condition of strict complementarity holds at $x^\star$. Suppose finally that*

$$s' \nabla^2_{xx} L(x^\star, \lambda^\star, \rho^\star) s > 0 \tag{3.8}$$

for all $s \neq 0$ such that

$$\left[\begin{array}{c} \dfrac{\partial g(x^\star)}{\partial x} \\ \dfrac{\partial h_a(x^\star)}{\partial x} \end{array} \right] s = 0.$$

Then $x^\star$ is a strict constrained local minimum of problem P_0.

Remark. Necessary and sufficient conditions for a global minimum can be given under proper convexity hypotheses, *i.e.* if the function f is convex in $\mathcal{X}$, and if $\mathcal{X}$ is a convex set. This is the case, for example if there are no inequality constraints and if the equality constraints are linear. ◇

---

[2] We denote with $\nabla_x f$ the vector of the partial derivatives of f with respect to x.

Remark. If all points in $\mathcal{X}$ are regular points for the constraints then conditions (3.7) yield a set of points $\mathcal{P}$, *i.e.* the points satisfying conditions (3.7), and among these points there are all constrained local minima (and also the constrained global minimum, if it exists). However, if there are points in $\mathcal{X}$ which are not regular points for the constraints, then the set $\mathcal{P}$ may not contain all constrained local minima. These have to be searched in the set $\mathcal{P}$ and in the set of non-regular points. ◇

Remark. In what follows, we will always tacitly assume that the conditions of regularity and of strict complementarity hold. ◇

3.2.1 A simple proof of Kuhn-Tucker conditions for equality constraints

Consider problem P_1, *i.e.* a minimization problem with only equality constraints, and a point $x^\star$ such that $g(x^\star) = 0$, *i.e.* $x^\star \in \mathcal{X}$. Suppose that[3]

$$\text{rank}\frac{\partial g}{\partial x}(x^\star) = m$$

i.e. $x^\star$ is a regular point for the constraints, and that $x^\star$ is a constrained local minimum. By the implicit function theorem, there exist a neighborhood of $x^\star$, a partition of the vector x, *i.e.*

$$x = \left[\begin{array}{c} u \\ v \end{array}\right],$$

with $u \in I\!R^m$ and $v \in I\!R^{n-m}$, and a function ϕ such that the constrains $g(x) = 0$ can be (locally) rewritten as

$$u = \phi(v).$$

As a result (locally)

$$\left\{\begin{array}{l} \min\limits_x f(x) \\ g(x) = 0 \end{array}\right. \quad \Leftrightarrow \quad \left\{\begin{array}{l} \min\limits_{u,v} f(u,v) \\ u = \phi(v) \end{array}\right. \quad \Leftrightarrow \quad \min_v f(\phi(v), v),$$

i.e. problem P_1 is (locally) equivalent to a unconstrained minimization problem. Therefore

$$0 = \nabla f(\phi(v^\star), v^\star) = \left(\frac{\partial f}{\partial u}\frac{\partial \phi}{\partial v} + \frac{\partial f}{\partial v}\right)_{x^\star} = \left(-\frac{\partial f}{\partial u}\left(\frac{\partial g}{\partial u}\right)^{-1}\frac{\partial g}{\partial v} + \frac{\partial f}{\partial v}\right)_{x^\star}.$$

Setting

$$\lambda^\star = \left(-\frac{\partial f}{\partial u}\left(\frac{\partial g}{\partial u}\right)^{-1}\right)'_{x^\star}$$

yields

$$\left(\frac{\partial f}{\partial v} + (\lambda^\star)'\frac{\partial g}{\partial v}\right)_{x^\star} = 0 \qquad (3.9)$$

---

[3] Note that m is the number of the equality constraints, and that, to avoid trivial cases, $m < n$.

and

$$\left(\frac{\partial f}{\partial u} + (\lambda^\star)' \frac{\partial g}{\partial u}\right)_{x^\star} = 0. \tag{3.10}$$

Finally, let

$$L = f + \lambda' g,$$

note that equations (3.9) and (3.10) can be rewritten as

$$\nabla_x L(x^\star, \lambda^\star) = 0,$$

and this, together with $g(x^\star) = 0$, is equivalent to equations (3.7).

3.2.2 Quadratic cost function with linear equality constraints

Consider the function

$$f(x) = \frac{1}{2} x' Q x,$$

with $x \in I\!R^n$ and $Q = Q' > 0$, the equality constraints

$$g(x) = Ax - b = 0,$$

with $b \in I\!R^m$ and $m < n$, and the Lagrangian function

$$L(x, \lambda) = \frac{1}{2} x' Q x + \lambda'(Ax - b).$$

A simple application of Theorem 14 yields the necessary conditions of optimality

$$\begin{array}{rcl} \nabla_x L(x^\star, \lambda^\star) & = & Qx^\star + A'\lambda^\star = 0 \\ g(x^\star) & = & Ax^\star - b = 0. \end{array} \tag{3.11}$$

Suppose now that the matrix A is such that $AQ^{-1}A'$ is invertible[4]. As a result, the only solution of equations (3.11) is

$$x^\star = Q^{-1}A'(AQ^{-1}A')^{-1}b \qquad \lambda^\star = -(AQ^{-1}A')^{-1}b.$$

Finally, by Theorem 15, it follows that $x^\star$ is a strict constrained (global) minimum.

3.3 Nonlinear programming methods: introduction

The methods of non-linear programming that have been mostly studied in recent years belong to two categories. The former includes all methods based on the transformation of a constrained problem into one or more unconstrained problems, in particular the so-called (exact or sequential) penalty function methods and (exact or sequential) augmented Lagrangian methods. Sequential methods are based on the solution of a sequence of problems, with the property that the sequence of the solutions of the subproblems converge

---

[4] This is the case if rank$A = m$.

to the solution of the original problem. Exact methods are based on the fact that, under suitable assumptions, the optimal solutions of an unconstrained problem coincides with the optimal solution of the original problem.
The latter includes the methods based on the transformation of the original problem into a sequence of constrained quadratic problems.
From the above discussion it is obvious that, to construct algorithms for the solution of non-linear programming problems, it is necessary to use efficient unconstrained optimization routines.
Finally, in any practical implementation, it is also important to quantify the complexity of the algorithms in terms of number and type of operations (inversion of matrices, differentiation, ...), and the speed of convergence. These issues are still largely open, and will not be addressed in these notes.

3.4 Sequential and exact methods

3.4.1 Sequential penalty functions

In this section we study the so-called external sequential penalty functions. This name is based on the fact that the solutions of the resulting unconstrained problems are in general not admissible. There are also internal penalty functions (known as barrier functions) but this can be used only for problems in which the admissible set has a non-empty interior. As a result, such functions cannot be used in the presence of equality constraints.
The basic idea of external sequential penalty functions is very simple. Consider problem P_0, the function

$$q(x) = \begin{cases} 0, & \text{if } x \in \mathcal{X} \\ \\ +\infty, & \text{if } x \notin \mathcal{X} \end{cases} \tag{3.12}$$

and the function

$$F = f + q. \tag{3.13}$$

It is obvious that the unconstrained minimization of F yields a solution of problem P_0. However, because of its discontinuous nature, the minimization of F cannot be performed. Nevertheless, it is possible to construct a sequence of continuously differentiable functions, converging to F, and it is possible to study the convergence of the minima of such a sequence of functions to the solutions of problem P_0.
For, consider a continuously differentiable function p such that

$$p(x) = \begin{cases} 0, & \text{if } x \in \mathcal{X} \\ \\ > 0, & \text{if } x \notin \mathcal{X}, \end{cases} \tag{3.14}$$

and the function

$$F_\epsilon = f + \frac{1}{\epsilon} p,$$

with $\epsilon > 0$. It is obvious that[5]

$$\lim_{\epsilon \to 0} F_\epsilon = F.$$

The function F_ϵ is known as external penalty function. The attribute external is due to the fact that, if $\bar{x}$ is a minimum of F_ϵ in general $p(\bar{x}) \neq 0$, *i.e.* $\bar{x} \notin \mathcal{X}$. The term $\frac{1}{\epsilon}p$ is called penalty term, as it penalizes the violation of the constraints. In general, the function p has the following form

$$p = \sum_{i=1}^{m} (g_i)^2 + \sum_{i=1}^{p} (\max(0, h_i))^2. \tag{3.15}$$

Consider now a strictly decreasing sequence $\{\epsilon_k\}$ such that $\lim_{k \to \infty} \epsilon_k = 0$. The sequential penalty function method consists in solving the sequence of unconstrained problems

$$\min_x F_{\epsilon_k}(x),$$

with $x \in I\!\!R^n$. The most important convergence results for this methods are summarized in the following statements.

Theorem 16 *Consider the problem P_0. Suppose that for all $\sigma > 0$ the set*[6]

$$\mathcal{X}^\sigma = \{x \in I\!\!R^n \mid |g_i(x)| \leq \sigma, i = 1, \cdots, m\} \cap \{x \in I\!\!R^n \mid h_i(x) \leq \sigma, i = 1, \cdots, p\}$$

is compact. Suppose moreover that for all k the function $F_{\epsilon_k}(x)$ has a global minimum x_k. Then the sequence $\{x_k\}$ has (at least) one converging subsequence, and the limit of any converging subsequence is a global minimum for problem P_0.

Theorem 17 *Let $x^\star$ be a strict constrained local minimum for problem P_0. Then there exist a sequence $\{x_k\}$ and an integer $\bar{k} > 0$ such that $\{x_k\}$ converges to $x^\star$ and, for all $k \geq \bar{k}$, x_k is a local minimum of $F_{\epsilon_k}(x)$.*

The construction of the function F_ϵ is apparently very simple, and this is the main advantage of the method. However, the minimization of the function F_ϵ may be difficult, especially for small values of ϵ. In fact, it is possible to show, even via simple examples, that as ϵ tends to zero the Hessian matrix of the function F_ϵ becomes ill conditioned. As a result, any unconstrained minimization algorithm used to minimize F_ϵ has a very slow convergence rate. To alleviate this problem, it is possible to use, in the minimization of $F_{\epsilon_{k+1}}$, as initial point the point x_k. However, this is close to the minimum of $F_{\epsilon_{k+1}}$ only if ϵ_{k+1} is close to ϵ_k, *i.e.* only if the sequence $\{\epsilon_k\}$ converges slowly to zero.

We conclude that, to avoid the ill conditioning of the Hessian matrix of F_ϵ, hence the slow convergence of each unconstrained optimization problem, it is necessary to slow down the convergence of the sequence $\{x_k\}$, *i.e.* slow convergence is an intrinsic property of the method. This fact has motivated the search for alternatives methods, as described in the next sections.

---

[5] Because of the discontinuity of F, the limit has to be considered with proper *care*.

[6] The set $\mathcal{X}^\sigma$ is sometimes called the relaxed admissible set.

Remark. It is possible to show that the local minima of F_ϵ describe (continuous) trajectories that can be extrapolated. This observation is exploited in some sophisticated methods for the selection of initial estimate for the point x_k. However, even with the addition of this extrapolation procedure, the convergence of the method remains slow. ◇

Remark. Note that, if the function p is defined as in equation (3.15), then the function F_ϵ is not two times differentiable everywhere, *i.e.* it is not differentiable in all points in which an inequality constraints is active. This property restricts the class of minimization algorithms that can be used to minimize F_ϵ. ◇

3.4.2 Sequential augmented Lagrangian functions

Consider problem P_1, *i.e.* an optimization problem with only equality constraints. For such a problem the Lagrangian function is

$$L = f + \lambda' g,$$

and the first order necessary conditions require the existence of a multiplier $\lambda^\star$ such that, for any local solution $x^\star$ of problem P_1 one has

$$\begin{array}{l} \nabla_x L(x^\star, \lambda^\star) = 0 \\ \nabla_\lambda L(x^\star, \lambda^\star) = g(x^\star) = 0. \end{array} \tag{3.16}$$

The first of equations (3.16) is suggestive of the fact that the function $L(x, \lambda^\star)$ has a unconstrained minimum in $x^\star$. This is actually not the case, as $L(x, \lambda^\star)$ is not convex in a neighborhood of $x^\star$. However it is possible to render the function $L(x, \lambda^\star)$ convex with the addition of a penalty term, yielding the new function, known as augmented Lagrangian function[7],

$$L_a(x, \lambda^\star) = L(x, \lambda^\star) + \frac{1}{\epsilon}\|g(x)\|^2, \tag{3.17}$$

which, for ϵ sufficiently small, but such that $1/\epsilon$ is finite, has a unconstrained minimum in $x^\star$. This intuitive discussion can be given a formal justification, as shown in the next statement.

Theorem 18 *Suppose that at $x^\star$ and $\lambda^\star$ the sufficient conditions for a strict constrained local minimum for problem P_1 hold. Then there exists $\bar{\epsilon} > 0$ such that for any $\epsilon \in (0, \bar{\epsilon})$ the point $x^\star$ is a unconstrained local minimum for the function $L_a(x, \lambda^\star)$.*
Vice-versa, if for some $\bar{\epsilon}$ and $\lambda^\star$, at $x^\star$ the sufficient conditions for a unconstrained local minimum for the function $L_a(x, \lambda^\star)$ hold, and $g(x^\star) = 0$, then $x^\star$ is a strict constrained local minimum for problem P_1.

The above theorem highlights the fact that, under the stated assumptions, the function $L_a(x, \lambda^\star)$ is an (external) penalty function, with the property that, to give local minima

---

[7] To be precise we should write $L_a(x, \lambda^\star, \epsilon)$, however we omit the argument ϵ.

for problem P_1 it is not necessary that $\epsilon \to 0$. Unfortunately, this result is not of practical interest, because it requires the knowledge of $\lambda^\star$. To obtain a useful algorithm, it is possible to make use of the following considerations.

By the implicit function theorem, applied to the first of equation (3.16), we infer that there exist a neighborhood of $\lambda^\star$, a neighborhood of $x^\star$, and a continuously differentiable function $x(\lambda)$ such that (locally)

$$\nabla_x L_a(x(\lambda), \lambda) = 0.$$

Moreover, for any $\epsilon \in (0, \bar{\epsilon})$, as $\nabla^2_{xx} L_a(x^\star, \lambda^\star)$ is positive definite also $\nabla^2_{xx} L_a(x, \lambda)$ is locally positive definite. As a result, $x(\lambda)$ is the only value of x that, for any fixed λ, minimizes the function $L_a(x, \lambda)$. It is therefore reasonable to assume that if λ_k is a good estimate of $\lambda^\star$, then the minimization of $L_a(x, \lambda_k)$ for a sufficiently small value of ϵ, yields a point x_k which is a good approximation of $x^\star$.

On the basis of the above discussion it is possible to construct the following minimization algorithm for problem P_1.

Step 0. Given $x_0 \in I\!R^n$, $\lambda_1 \in I\!R^m$ and $\epsilon_1 > 0$.

Step 1. Set $k = 1$.

Step 2. Find a local minimum x_k of $L_a(x, \lambda_k)$ using any unconstrained minimization algorithm, with starting point x_{k-1}.

Step 3. Compute a new estimate λ_{k+1} of $\lambda^\star$.

Step 4. Set $\epsilon_{k+1} = \beta \epsilon_k$, with $\beta = 1$ if $\|g(x_{k+1})\| \leq \frac{1}{4}\|g(x_k)\|$ or $\beta < 1$ otherwise.

Step 5. Set $k = k + 1$ and go to **Step 2**.

In **Step 3** it is necessary to construct a new estimate λ_{k+1} of λ_k. This can be done with proper considerations on the function $L_a(x(\lambda), \lambda)$, introduced in the above discussion. However, without providing the formal details, we mention that one of the most used update laws for λ are described by the equations

$$\lambda_{k+1} = \lambda_k + \frac{2}{\epsilon_k} g(x_k), \tag{3.18}$$

or

$$\lambda_{k+1} = \lambda_k - \left[\nabla^2 L_a(x(\lambda_k), \lambda_k)\right]^{-1} g(x_k), \tag{3.19}$$

whenever the indicated inverse exists.

Note that the convergence of the sequence $\{x_k\}$ to $x^\star$ is limited by the convergence of the sequence $\{\lambda_k\}$ to $\lambda^\star$. It is possible to prove that, if the update law (3.18) is used then the algorithm as linear convergence, whereas if (3.19) is used the convergence is superlinear.

Remark. Similar considerations can be done for problem P_2. For, recall that problem P_2 can be recast, increasing the number of variables, as an optimization problem with equality constraints, *i.e.* problem $\tilde{P}_2$. For such an *extended* problem, consider the augmented Lagrangian

$$L_a(x,y,\rho) = f(x) + \sum_{i=1}^{p} \rho_i \left(h_i(x) + y_i^2\right) + \frac{1}{\epsilon}\sum_{i=1}^{p}\left(h_i(x) + y_i^2\right)^2,$$

and note that, in principle, it would be possible to make use of the results developed with reference to problem P_1. However, the function L_a can be analytically minimized with respect to the variables y_i. In fact, a simple computation shows that the (global) minimum of L_a as a function of y is attained at

$$y_i(x,\rho) = \sqrt{-\min\left(0, h_i(x) + \frac{\epsilon}{2}\rho_i\right)}.$$

As a result, the augmented Lagrangian function for problem P_2 is given by

$$L_a(x,\rho) = f(x) + \rho' h(x) + \frac{1}{\epsilon}\|h(x)\|^2 - \frac{1}{\epsilon}\sum_{i=1}^{p}\left(\min(0, h_i(x) + \frac{\epsilon}{2}\rho_i)\right)^2.$$

◇

3.4.3 Exact penalty functions

An exact penalty function, for a given constrained optimization problem, is a function of the same variables of the problem with the property that its unconstrained minimization yields a solution of the original problem. The term *exact* as opposed to *sequential* indicates that only one, instead of several, minimization is required.

Consider problem P_1, let $x^\star$ be a local solution and let $\lambda^\star$ be the corresponding multiplier. The basic idea of exact penalty functions methods is to determine the multiplier λ appearing in the augmented Lagrangian function as a function of x, *i.e.* $\lambda = \lambda(x)$, with $\lambda(x^\star) = \lambda^\star$. With the use of this function one has[8]

$$L_a(x, \lambda(x)) = f(x) + \lambda(x)' g(x) + \frac{1}{\epsilon}\|g(x)\|^2.$$

The function $\lambda(x)$ is obtained considering the necessary condition of optimality

$$\nabla_x L_a(x^\star, \lambda^\star) = \nabla f(x^\star) + \frac{\partial g(x^\star)'}{\partial x}\lambda^\star = 0 \tag{3.20}$$

and noting that, if $x^\star$ is a regular point for the constraints then equation (3.20) can be solved for $\lambda^\star$ yielding

$$\lambda^\star = -\left(\frac{\partial g(x^\star)}{\partial x}\frac{\partial g(x^\star)'}{\partial x}\right)^{-1}\frac{\partial g(x^\star)}{\partial x}\nabla f(x^\star).$$

---

[8] As in previous sections we omit the argument ϵ.

This equality suggests to define the function $\lambda(x)$ as

$$\lambda(x) = -\left(\frac{\partial g(x)}{\partial x}\frac{\partial g(x)'}{\partial x}\right)^{-1}\frac{\partial g(x)}{\partial x}\nabla f(x),$$

and this is defined at all x where the indicated inverse exists, in particular at $x^\star$.
It is possible to show that this selection of $\lambda(x)$ yields and exact penalty function for problem P_1. For, consider the function

$$G(x) = f(x) - g(x)'\left(\frac{\partial g(x)}{\partial x}\frac{\partial g(x)'}{\partial x}\right)^{-1}\frac{\partial g(x)}{\partial x}\nabla f(x) + \frac{1}{\epsilon}\|g(x)\|^2,$$

which is defined and differentiable in the set

$$\tilde{\mathcal{X}} = \{x \in I\!R^n \parallel \text{rank}\frac{\partial g(x)}{\partial x} = m\}, \tag{3.21}$$

and the following statements.

Theorem 19 *Let $\bar{\mathcal{X}}$ be a compact subset of $\tilde{\mathcal{X}}$. Assume that $x^\star$ is the only global minimum of f in $\mathcal{X} \cap \bar{\mathcal{X}}$ and that $x^\star$ is in the interior of $\bar{\mathcal{X}}$. Then there exists $\bar{\epsilon} > 0$ such that, for any $\epsilon \in (0, \bar{\epsilon})$, $x^\star$ is the only global minimum of G in $\bar{\mathcal{X}}$.*

Theorem 20 *Let $\bar{\mathcal{X}}$ be a compact subset of $\tilde{\mathcal{X}}$. Then there exists $\bar{\epsilon} > 0$ such that, for any $\epsilon \in (0, \bar{\epsilon})$, if $x^\star$ is a unconstrained minimum of $G(x)$ and $x^\star \in \bar{\mathcal{X}}$, then $x^\star$ is a constrained local minimum for problem P_1.*

Theorems 19 and 20 show that it is legitimate to search solutions of problem P_1 minimizing the function G for sufficiently small values of ϵ. Note that it is possible to prove stronger results, showing that there is (under certain hypotheses) a one to one correspondence between the minima of problem P_1 and the minima of the function G, provided ϵ is sufficiently small.
For problem P_2 it is possible to proceed as discussed in Section 3.4.2, *i.e.* transforming problem P_2 into problem $\tilde{P}_2$ and then minimizing analytically with respect to the new variables y_i. However, a different and more direct route can be taken. Consider problem P_2 and the necessary conditions

$$\nabla_x L(x^\star, \rho^\star) = \nabla f(x^\star) + \frac{\partial h(x^\star)'}{\partial x}\rho^\star = 0 \tag{3.22}$$

and

$$\rho_i^\star h_i(x^\star) = 0, \tag{3.23}$$

for $i = 1, \cdots, p$. Premultiplying equation (3.22) by $\frac{\partial h(x^\star)}{\partial x}$ and equation (3.23) by $\gamma^2 h_i(x^\star)$, with $\gamma > 0$, and adding, yields

$$\left(\frac{\partial h(x^\star)}{\partial x}\frac{\partial h(x^\star)'}{\partial x} + \gamma^2 H^2(x^\star)\right)\rho^\star + \frac{\partial h(x^\star)}{\partial x}\nabla f(x^\star) = 0,$$

where

$$H(x^\star) = \mathrm{diag}(h_1(x^\star), \cdots, h_p(x^\star)).$$

As a result, a natural candidate for the function $\rho(x)$ is

$$\rho(x) = -\left(\frac{\partial h(x)}{\partial x}\frac{\partial h(x)'}{\partial x} + \gamma^2 H^2(x)\right)^{-1} \frac{\partial h(x)}{\partial x}\nabla f(x),$$

which is defined whenever the indicated inverse exists, in particular in the neighborhood of any regular point. With the use of this function, it is possible to define an exact penalty function for problem P_2 and to establish results similar to those illustrated in Theorems 19 and 20.

The exact penalty functions considered in this section provide, in principle, a theoretically sound way of solving constrained optimization problem. However, in practice, they have two major drawbacks. Firstly, at each step, it is necessary to invert a matrix with dimension equal to the number of constraint. This operation is numerically ill conditioned if the number of constraints is large. Secondly, the exact penalty functions may not be sufficiently regular to allow the use of unconstrained minimization methods with fast speed of convergence, *e.g.* Newton method.

3.4.4 Exact augmented Lagrangian functions

An exact augmented Lagrangian function, for a given constrained optimization problem, is a function, defined on an augmented space with dimension equal to the number of variables plus the number of constraint, with the property that its unconstrained minimization yields a solution of the original problem. Moreover, in the computation of such a function it is not necessary to invert any matrix.

To begin with, consider problem P_1 and recall that, for such a problem, a sequential augmented Lagrangian function has been defined adding to the Lagrangian function a term, namely $\frac{1}{\epsilon}\|g(x)\|^2$, which penalizes the violation of the necessary condition $g(x) = 0$. This term, for ϵ sufficiently small, renders the function L_a convex in a neighborhood of $x^\star$. A *complete* convexification can be achieved adding a further term that penalizes the violation of the necessary condition $\nabla_x L(x, \lambda) = 0$. More precisely, consider the function

$$S(x, \lambda) = f(x) + \lambda' g(x) + \frac{1}{\epsilon}\|g(x)\|^2 + \eta\|\frac{\partial g(x)}{\partial x}\nabla_x L(x, \lambda)\|^2, \tag{3.24}$$

with $\epsilon > 0$ and $\eta > 0$. The function (3.24) is continuously differentiable and it is such that, for ϵ sufficiently small, the solutions of problem P_1 are in a one to one correspondence with the points (x, λ) which are local minima of S, as detailed in the following statements.

Theorem 21 *Let $\bar{\mathcal{X}}$ be a compact set. Suppose $x^\star$ is the unique global minimum of f in the set $\mathcal{X} \cap \bar{\mathcal{X}}$ and $x^\star$ is an interior point of $\bar{\mathcal{X}}$. Let $\lambda^\star$ be the multiplier associated to $x^\star$. Then, for any compact set $\Lambda \subset I\!R^m$ such that $\lambda^\star \in \Lambda$ there exists $\bar{\epsilon}$ such that, for all $\epsilon \in (0, \bar{\epsilon})$, $(x^\star, \lambda^\star)$ is the unique global minimum of S in $\mathcal{X} \times \Gamma$.*

Theorem 22 *Let*[9] $\mathcal{X} \times \Lambda \subset \tilde{\mathcal{X}} \times I\!R^m$ *be a compact set. Then there exists* $\bar{\epsilon} > 0$ *such that, for all* $\epsilon \in (0, \bar{\epsilon})$*, if* $(x^\star, \lambda^\star)$ *is a unconstrained local minimum of* S*, then* $x^\star$ *is a constrained local minimum for problem* P_1 *and* $\lambda^\star$ *is the corresponding multiplier.*

Theorems 21 and 22 justify the use of a unconstrained minimization algorithm, applied to the function S, to find local (or global) solutions of problem P_1.
Problem P_2 can be dealt with using the same considerations done in Section 3.4.2.

3.5 Recursive quadratic programming

Recursive quadratic programming methods have been widely studied in the past years. In this section we provide a preliminary description of such methods. For, consider problem P_1 and suppose that $x^\star$ and $\lambda^\star$ are such that the necessary conditions (3.7) hold. Consider now a series expansion of the function $L(x, \lambda^\star)$ in a neighborhood of $x^\star$, *i.e.*

$$L(x, \lambda^\star) = f(x^\star) + \frac{1}{2}(x - x^\star)' \nabla^2_{xx} L(x^\star, \lambda^\star)(x - x^\star) + ...$$

a series expansion of the constraint, *i.e.*

$$0 = g(x) = g(x^\star) + \frac{\partial g(x^\star)}{\partial x}(x - x^\star) + ...$$

and the problem

$$\widetilde{PQ}_1 \quad \left\{ \begin{array}{l} \min\limits_x f(x^\star) + \frac{1}{2}(x - x^\star)' \nabla^2_{xx} L(x^\star, \lambda^\star)(x - x^\star) \\ \frac{\partial g(x^\star)}{\partial x}(x - x^\star) = 0. \end{array} \right.$$

Note that problem $\widetilde{PQ}_1$ has the solution $x^\star$, and the corresponding multiplier is $\lambda = 0$, which is not equal (in general) to $\lambda^\star$. This phenomenon is called *bias* of the multiplier, and can be avoided by modifying the objective function and considering the new problem

$$PQ_1 \quad \left\{ \begin{array}{l} \min\limits_x f(x^\star) + \nabla f(x^\star)'(x - x^\star) + \frac{1}{2}(x - x^\star)' \nabla^2_{xx} L(x^\star, \lambda^\star)(x - x^\star) \\ \frac{\partial g(x^\star)}{\partial x}(x - x^\star) = 0, \end{array} \right. \tag{3.25}$$

which has solution $x^\star$ with multiplier $\lambda^\star$. This observation suggests to consider the sequence of quadratic programming problems

$$PQ_1^{k+1} \quad \left\{ \begin{array}{l} \min\limits_\delta f(x_k) + \nabla f(x_k)'\delta + \frac{1}{2}\delta' \nabla^2_{xx} L(x_k, \lambda_k)\delta \\ \frac{\partial g(x_k)}{\partial x}\delta = 0, \end{array} \right. \tag{3.26}$$

---

[9] The set $\tilde{\mathcal{X}}$ is defined as in equation (3.21).

where $\delta = x - x_k$, and x_k and λ_k are the current estimates of the solution and of the multiplier. The solution of problem PQ_1^{k+1} yields new estimates x_{k+1} and λ_{k+1}. To assess the local convergence of the method, note that the necessary conditions for problem PQ_1^{k+1} yields the system of equations

$$\begin{bmatrix} \nabla^2_{xx} L(x_k, \lambda_k) & \dfrac{\partial g(x_k)'}{\partial x} \\ \dfrac{\partial g(x_k)}{\partial x} & 0 \end{bmatrix} \begin{bmatrix} \delta \\ \lambda \end{bmatrix} = - \begin{bmatrix} \nabla f(x_k) \\ g(x_k) \end{bmatrix}, \tag{3.27}$$

and this system coincides with the system arising from the application of Newton method to the solution of the necessary conditions for problem P_1. As a consequence, the solutions of the problems PQ_1^{k+1} converge to a solution of problem P_1 under the same hypotheses that guarantee the convergence of Newton method.

Theorem 23 *Let $x^\star$ be a strict constrained local minimum for problem P_1, and let $\lambda^\star$ be the corresponding multiplier. Suppose that for $x^\star$ and $\lambda^\star$ the sufficient conditions of Theorem 15 hold. Then there exists an open neighborhood $\Omega \subset I\!R^n \times I\!R^m$ of the point $(x^\star, \lambda^\star)$ such that, if $(x_0, \lambda_0) \in \Omega$, the sequence $\{x_k, \lambda_k\}$ obtained solving the sequence of quadratic programming problems PQ_1^{k+1}, with $k = 0, 1, \cdots$, converges to $(x^\star, \lambda^\star)$.*
Moreover, the speed of convergence is superlinear, and, if f and g are three times differentiable, the speed of convergence is quadratic.

Remark. It is convenient to solve the sequence of quadratic programming problems PQ_1^{k+1}, instead of solving the equations (3.27) with Newton method, because, for the former it is possible to exclude converge to maxima or saddle points. $\diamond$

In the case of problem P_2, using considerations similar to the one above, it is easy to obtain the following sequence of quadratic programming problems

$$PQ_2^{k+1} \left\{ \begin{array}{l} \min\limits_{\delta} f(x_k) + \nabla f(x_k)'\delta + \dfrac{1}{2}\delta' \nabla^2_{xx} L(x_k, \lambda_k)\delta \\ \dfrac{\partial h(x_k)}{\partial x}\delta + h(x_k) \leq 0. \end{array} \right. \tag{3.28}$$

This sequence of problems has to be solved iteratively to generate a sequence $\{x_k, \lambda_k\}$ that, under hypotheses similar to those of Theorem 23, converges to a strict constrained local minimum of problem P_2.
The method described are the basis for a large class of iterative methods.
A first disadvantage of the proposed iterative schemes is that it is necessary to compute the second derivatives of the functions of the problem. This computation can be avoided, using the same philosophy of quasi-Newton methods.
A second disadvantage is in the fact that, being based on Newton algorithm, only local convergence can be guaranteed. However, it is possible to combine the method with global convergent methods: these are used to generate a pair $(\tilde{x}, \tilde{\lambda})$ sufficiently close to $(x^\star, \lambda^\star)$

and then recursive quadratic programming methods are used to obtain fast convergence to $(x^\star, \lambda^\star)$.
A third disadvantage is in the fact that there is no guarantee that the sequence of admissible sets generated by the algorithm is non-empty at each step.
Finally, it is worth noting that, contrary to most of the existing methods, quadratic programming methods do not rely on the use of a penalty term.

Remark. There are several alternative recursive quadratic programming methods which alleviate the drawbacks of the methods described. These are (in general) based on the use of quadratic approximation of penalty functions. For brevity, we do not discuss these methods. ◇

3.6 Concluding remarks

In this section we briefly summarize advantages and disadvantages of the nonlinear programming methods discussed.
Sequential penalty functions methods are very simple to implement, but suffer from the ill conditioning associated to large penalties (*i.e.* to small values of ϵ). As a result, these methods can be used if approximate solutions are acceptable, or in the determination of initial estimates for more precise, but only locally convergent, methods. Note, in fact, that not only an approximation of the solution $x^\star$ can be obtained, but also an approximation of the corresponding multiplier $\lambda^\star$. For example, for problem P_1, a (approximate) solution $\bar{x}$ is such that

$$\nabla F_{\epsilon_k}(\bar{x}) = \nabla f(\bar{x}) + \frac{2}{\epsilon_k}\frac{\partial g(\bar{x})}{\partial x} g(\bar{x}) = 0,$$

hence, the term $\frac{2}{\epsilon_k} g(\bar{x})$ provides an approximation of $\lambda^\star$.
Sequential augmented Lagrangian functions do not suffer from ill conditioning, and yield faster speed of convergence then that attainable using sequential penalty functions.
The methods based on exact penalty functions do not require the solution of a sequence of problems. However, they require the inversion of a matrix of dimension equal to the number of constraints, hence their applicability is limited to problems with a small number of constraints.
Exact augmented Lagrangian functions can be built without inverting any matrix. However, the minimization has to be performed in an extended space.
Recursive quadratic programming methods require the solution, at each step, of a constrained quadratic programming problem. Their main problem is that there is no guarantee that the admissible set is non-empty at each step.
We conclude that it is not possible to decide which is the best method. Each method has its own advantages and disadvantages. Therefore, the selection of a nonlinear programming method has to be driven by the nature of the problem: and has to take into consideration the number of variables, the regularity of the involved functions, the required precision, the computational cost, ...

Chapter 4

Global optimization

4.1 Introduction

Given a function $f : I\!R^n \to I\!R$, global optimization methods aim at finding the global minimum of f, *i.e.* a point $x^\star$ such that

$$f(x^\star) \le f(x)$$

for all $x \in I\!R^n$. Among these methods it is possible to distinguish between deterministic methods and probabilistic methods.
In the following sections we provide a very brief introductions to global minimization methods. It is worth noting that this is an active area of research.

4.2 Deterministic methods

4.2.1 Methods for Lipschitz functions

Consider a function $f : I\!R^n \to I\!R$ and suppose it is Lipschitz with constant $L > 0$, *i.e.*

$$|f(x_1) - f(x_2)| \le L\|x_1 - x_2\|, \tag{4.1}$$

for all $x_1 \in I\!R^n$ and $x_2 \in I\!R^n$. Note that equation (4.1) implies that

$$f(x) \ge f(x_0) - L\|x - x_0\| \tag{4.2}$$

and that

$$f(x) \le f(x_0) + L\|x - x_0\|, \tag{4.3}$$

for all $x \in I\!R^n$ and $x_0 \in I\!R^n$, see Figure 4.1 for a geometrical interpretation.

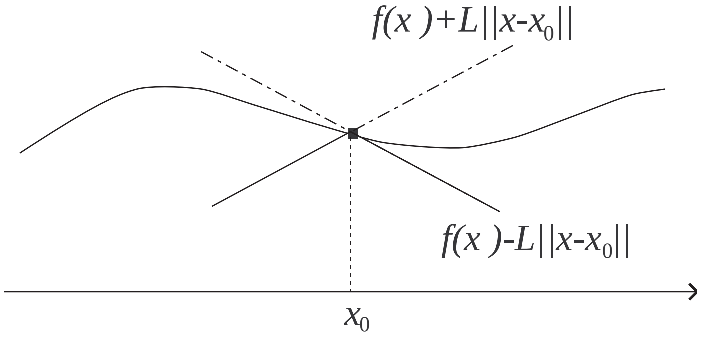


Figure 4.1: Geometrical interpretation of the Lipschitz conditions (4.2) and (4.3).

Methods for Lipschitz functions are suitable to find a global solution of the problem

$$\min_x f(x),$$

with

$$x \in I_n = \{x \in I\!R^n \mid A_i \le x_i \le B_i\},$$

and $A_i < B_i$ given, under the assumptions that the set I_n contains a global minimum of f, the function f is Lipschitz in I_n and the Lipschitz constant L of f in I_n is known. Under these assumptions it is possible to construct a very simple global minimization algorithm, known as Schubert-Mladineo algorithm, as follows.

Step 0. Given $x_0 \in I_n$ and $\tilde{L} > L$.

Step 1. Set $k = 0$.

Step 2. Let

$$F_k(x) = \max_{j=0,\cdots,k} \{f(x_j) - \tilde{L}\|x - x_j\|\}$$

and compute x_{k+1} such that

$$F_k(x_{k+1}) = \min_{x \in I_n} F_k(x).$$

Step 4. Set $k = k + 1$ and go to **Step 2**.

Remark. The functions F_k in **Step 2** of the algorithm have a very special form. This can be exploited to construct special algorithms solving the problem

$$\min_{x \in I_n} F_k(x)$$

in a finite number of iterations. ◇

For Schubert-Mladineo algorithm it is possible to prove the following statement.

Theorem 24 *Let $f^\star$ be the minimum value of f in I_n, let $x^\star$ be such that $f(x^\star) = f^\star$ and let $F_k^\star$ be the minima of the functions F_k in I_n. Let*

$$\Phi = \{x \in I_n \mid f(x) = f^\star\}$$

and let $\{x_k\}$ be the sequence generated by the algorithm. Then

- $\lim_{k \to \infty} f(x_k) = f^\star$;
- *the sequence $\{F_k^\star\}$ is non-decreasing and* $\lim_{k \to \infty} F_k^\star = f^\star$;
- $\lim_{k \to \infty} \inf_{x \in \Phi} \|x - x_k\| = 0$;
- $f(x_k) \geq f^\star \geq F_{k-1}(x_k)$.

Schubert-Mladineo algorithm can be given, if $x \in I_1 \subset I\!R$, a simple geometrical interpretation, as shown in Figure 4.2.

The main advantage of Schubert-Mladineo algorithm is that it does not require the computation of derivatives, hence it is also applicable to functions which are not everywhere

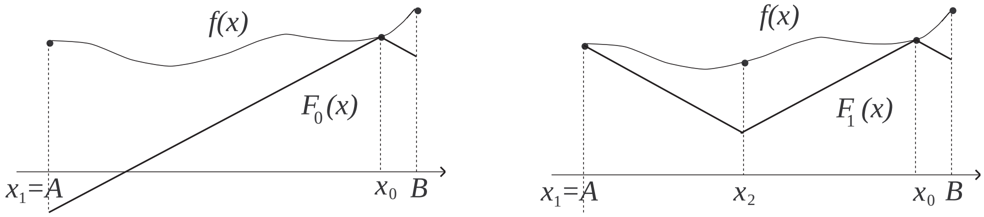


Figure 4.2: Geometrical interpretation of Schubert-Mladineo algorithm.

differentiable. Moreover, unlike other global minimization algorithms, it is possible to prove the convergence of the sequence $\{x_k\}$ to the global minimum. Finally, it is possible to define a simple *stopping* condition. For, note that if $\{x_k\}$ and $\{F_k^\star\}$ are the sequences generated by the algorithm, then

$$f(x_k) \geq f^\star \geq F_k^\star$$

and

$$f(x_k) \geq f^\star \geq f(x_k) + r_k,$$

where $r_k = F_k^\star - f(x_k)$ and $\lim_{k\to\infty} r_k = 0$. As a result, if $|r_k| < \epsilon$, for some $\epsilon > 0$, the point x_k gives a good approximation of the minimum of f.

The main disadvantage of the algorithm is in the assumption that the set I_n contains a global minimum of f in $I\!R^n$. Moreover, it may be difficult to compute the Lipschitz constant L.

4.2.2 Methods of the trajectories

The basic idea of the global optimization methods known as methods of the trajectories is to construct trajectories which go through all local minima. Once all local minima are determined, the global minimum can be easily isolated. These methods have been originally proposed in the 70's, but only recently, because of increased computer power and of a reformulation using tools from differential geometry, they have proved to be effective.

The simplest and first method of the trajectories is the so-called Branin method. Consider the function f and assume ∇f is continuous. Fix x_0 and consider the differential equations

$$\frac{d}{dt}\nabla f(x(t)) = \pm\nabla f(x(t)) \qquad x(0) = x_0. \tag{4.4}$$

The solutions $x(t)$ of such differential equations are such that

$$\nabla f(x(t)) = \nabla f(x_0)e^{\pm t},$$

i.e. $\nabla f(x(t))$ is parallel to $\nabla f(x_0)$ for all t. Using these facts it is possible to describe Branin algorithm.

Step 0. Given x_0.

Step 1. Compute the solution $x(t)$ of the differential equation

$$\frac{d}{dt}\nabla f(x(t)) = -\nabla f(x(t))$$

with $x(0) = x_0$.

Step 2. The point $x^\star = \lim_{t\to\infty} x(t)$ is a stationary point of f, in fact $\lim_{t\to\infty} \nabla f(x(t)) = 0$.

Step 3. Consider a perturbation of the point $x^\star$, *i.e.* the point $\tilde{x} = x^\star + \epsilon$ and compute the solution $x(t)$ of the differential equation

$$\frac{d}{dt}\nabla f(x(t)) = \nabla f(x(t)).$$

Along this trajectory the gradient $\nabla f(x(t))$ increases, hence the trajectory escapes from the *region of attraction* of x_0.

Step 4. Fix $\bar{t} > 0$ and assume that $x(\bar{t})$ is sufficiently away from x_0. Set $x_0 = x(\bar{t})$ and go to **Step 1**.

Note that, if the perturbation ϵ and the time $\bar{t}$ are properly selected, at each iteration the algorithm generates a new stationary point of the function f.

Remark. If $\nabla^2 f$ is continuous then the differential equations (4.4) can be written as

$$\dot{x}(t) = \pm\left[\nabla^2 f(x(t))\right]^{-1} \nabla f(x(t)).$$

Therefore Branin method is a continuous equivalent of Newton method. Note however that, as $\nabla^2 f(x(t))$ may become singular, the above equation may be meaningless. In such a case it is possible to modify Branin method using ideas borrowed from quasi-Newton algorithms. $\diamond$

Branin method is very simple to implement. However, it has several disadvantages.

- It is not possible to prove convergence to the global minimum.
- Even if the method yields the global minimum, it is not possible to know how many iterations are needed to reach such a global minimum, *i.e.* there is no stopping criterion.
- The trajectories $x(t)$ are attracted by all stationary points of f, *i.e.* both minima and maxima.
- There is not a systematic way to select ϵ and $\bar{t}$.

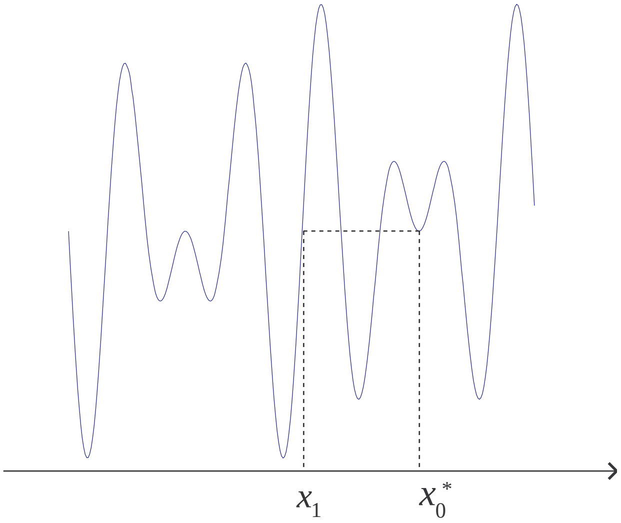


Figure 4.3: Interpretation of the tunneling phase.

4.2.3 Tunneling methods

Tunneling methods have been proposed to find, in an efficient way, the global minimum of a function with several (possibly thousands) of local minima.
Tunneling algorithms are composed of a sequence of cycles, each having two phases. The first phase is the minimization phase, *i.e.* a local minimum is computed. The second phase is the tunneling phase, *i.e.* a new starting point for the minimization phase is computed.

Minimization phase

Given a point x_0, a local minimization, using any unconstrained optimization algorithm, is performed. This minimization yields a local minimum $x_0^\star$.

Tunneling phase

A point $x_1 \neq x_0^\star$ such that

$$f(x_1) = f(x_0^\star)$$

is determined. See Figure 4.3 for a geometrical interpretation.

In theory, tunneling methods generate a sequence $\{x_k^\star\}$ such that

$$f(x_{k+1}^\star) \leq f(x_k^\star)$$

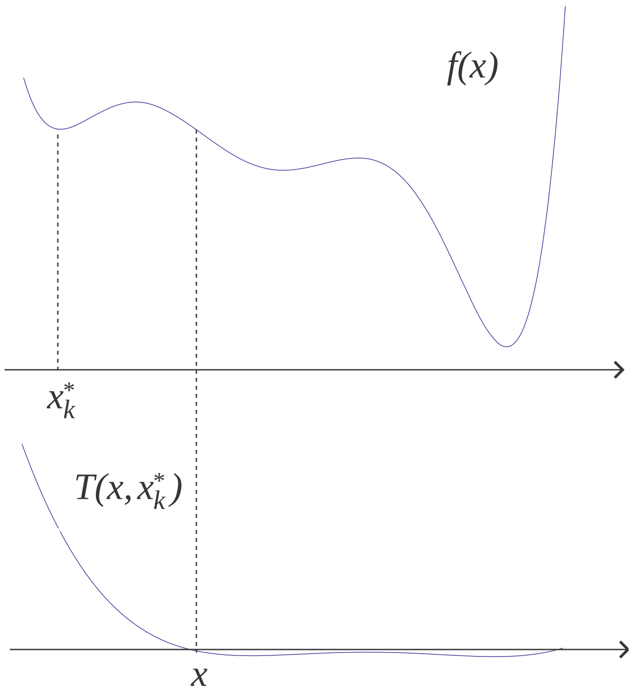


Figure 4.4: The functions $f(x)$ and $T(x, x_k^\star)$.

and the sequence $\{x_k^\star\}$ converges to the global minimum without *passing* through all local minima. This is the most important advantage of tunneling methods. The main disadvantage is the difficulty in performing the tunneling phase. In general, given a point $x_k^\star$ a point x such that $f(x) = f(x_k^\star)$ is constructed searching for a zero of the function (see Figure 4.4)

$$T(x, x_k^\star) = \frac{f(x) - f(x_k^\star)}{\|x - x_k^\star\|^{2\lambda}},$$

where the parameter $\lambda > 0$ has to be selected such that $T(x_k^\star, x_k^\star) > 0$.
Finally, it is worth noting that tunneling methods do not have a stopping criterion, *i.e.* the algorithm attempts to perform the tunneling phase even if the point $x_k^\star$ is a global minimum.

4.3 Probabilistic methods

4.3.1 Methods using random directions

In this class of algorithms at each iteration a randomly selected direction, having unity norm, is selected. The theoretical justification of such an algorithm rests on Gaviano theorem. This states that the sequence $\{x_k\}$ generated using the iteration

$$x_{k+1} = x_k + \alpha_k d_k,$$

where d_k is randomly selected on a unity norm sphere and α_k is such that

$$f(x_k + \alpha_k d_k) = \min_{\alpha} f(x_k + \alpha d_k),$$

is such that for any $\epsilon > 0$ the probability that

$$f(x_k) - f^\star < \epsilon,$$

where $f^\star$ is a global minimum of f, tends to one as $k \to \infty$.

4.3.2 Multistart methods

Multistart methods are based on the fact that for given sets D and A, with measures $m(D)$ and $m(A)$, and such that

$$1 \geq \frac{m(A)}{m(D)} = \alpha \geq 0,$$

the probability that, selecting N random points in D, one of these points is in A is

$$P(A,N) = 1 - (1-\alpha)^N.$$

As a result

$$\lim_{N\to\infty} P(A,N) = 1.$$

Therefore, if A is a neighborhood of a global minimum of f in D, we conclude that, selecting a sufficiently large number of random points in D, one of these will (almost surely) be close to the global minimum. Using these considerations it is possible to construct a whole class of algorithms, with similar properties, as detailed hereafter.

Step 0. Set $f^\star = \infty$.

Step 1. Select a random point $x_0 \in I\!R^n$.

Step 2. If $f(x_0) > f^\star$ go to **Step 1**.

Step 3. Perform a local minimization starting from x_0 and yielding a point $x_0^\star$. Set $f^\star = f(x_0^\star)$.

Step 4. Check if $x_0^\star$ satisfies a stopping criterion. If not, go to **Step 1**.

4.3.3 Stopping criteria

The main disadvantage of probabilistic algorithms is the lack of a theoretically sound stopping criterion. The most promising and used stopping criterion is based on the construction of a *probabilistic approximation* $\tilde{P}(w)$ of the function

$$P(w) = \frac{m(\{x \in D \mid f(x) \leq w\})}{m(D)}.$$

Once the function $\tilde{P}(w)$ is known, a point $x^\star$ is regarded as a good approximation of the global minimum of f if

$$\tilde{P}(f(x^\star)) \leq \epsilon \ll 1.$$

MAM SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Department of Mechatronics Engineering

Teacher Teach Teacher (TTT)

Academic year (2019-2020) Even semester

Date: 12.3.2020

Speaker: Mrs.P.Sudha

HOD – Mechatronics Engineering

Staff attended:

1. Dr.Punitha
2. Mr.M.Chandra sekar
3. Ms.M.Suba pradha
4. Mr.Arumugasamy
5. Mr.Ravichandran
6. Mr.Karthikeyan

Topic:

Blooms Taxonomy

Venue:

Smart class

Date & Time:

12th March 2020 & 2.00 P.M to 3.00 P.M

**enclosure: Report

13/3/20

HOD

PRINCIPAL

REPORT

The session was initiated by Mrs.P.Sudha HOD /Met, the topic for the Lecture is Blooms Taxonomy and discuss about the following topics

- Introduction
- Stages of Bloom's Taxonomy
- Bloom's verb charts
- Course level and lesson level objectives
- Steps towards writing effective learning objectives
- Uses of Bloom's Taxonomy

The session comes to an end with the explaining the overview Blooms Taxonomy

HOD

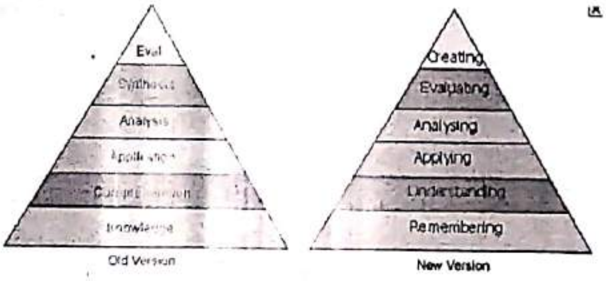
Scanned with CamScanner

Blooms Taxonomy

Introduction

- Bloom's Taxonomy is a popular and extremely helpful tool that is used by most teachers.
- **Bloom's Taxonomy** is a list of cognitive skills that is used by teachers to determine the level of thinking their students have achieved.
- The taxonomy ranks the cognitive skills on a continue from lower-order thinking to higher-order thinking.
- The taxonomy is often depicted by a pyramid that shows the hierarchy of cognitive skills.
- It was created by psychologist Benjamin Bloom and several of his colleagues in 1948.
- It was then updated in the 1990s by one of his students named Lorin Anderson.
- Anderson updated the names of the categories and swapped the top two elements on the pyramid.

Old and New version of Blooms Taxonomy



Old Version

New Version

Stages of Blooms Taxonomy

1.Remembering: Retrieving, recognizing,.and recalling relevant knowledge from long-term memory.

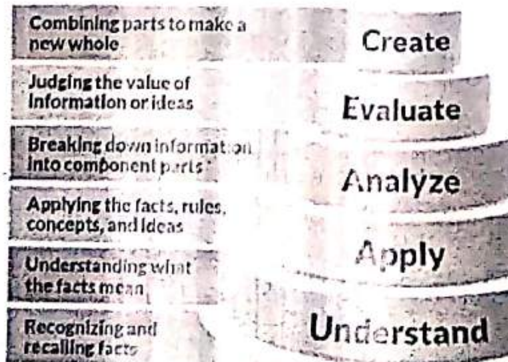
2.Understanding: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.

3.Applying: Carrying out or using a procedure for executing, or implementing.

4.Analyzing: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.

5.Evaluating: Making judgments based on criteria and standards through checking and critiquing.

6.Creating: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.



Contd..

- Like other taxonomies, Bloom's is hierarchical, meaning that learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels.
- Pyramid into a "cake-style" hierarchy to emphasize that each level is built on a foundation of the previous levels.

Scanned with CamScanner

How Bloom's can aid in course design

- Bloom's taxonomy is a powerful tool to help develop learning objectives because it explains the process of learning:
- Before you can ***understand*** a concept, you must ***remember*** it.
- To ***apply*** a concept you must first ***understand*** it.
- In order to ***evaluate*** a process, you must have ***analyzed*** it.
- To ***create*** an accurate conclusion, you must have completed a thorough ***evaluation***.

Bloom's verb charts

Bloom's Level	Key Verbs (keywords)	Example Learning Objective
Create	design, formulate, build, invent, create, compose, generate, derive, modify, develop.	By the end of this lesson, the student will be able to design an original homework problem dealing with the principle of conservation of energy.
Evaluate	choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.	By the end of this lesson, the student will be able to determine whether using conservation of energy or conservation of momentum would be more appropriate for solving a dynamics problem.
Analyze	classify, break down, categorize, analyze, diagram, illustrate, criticize, simplify, associate.	By the end of this lesson, the student will be able to differentiate between potential and kinetic energy.

Contd..

Bloom's Level	Key Verbs (keywords)	Example Learning Objective
Apply	calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform, present.	By the end of this lesson, the student will be able to calculate the kinetic energy of a projectile.
Understand	describe, explain, paraphrase, restate, give original examples of, summarize, contrast, interpret, discuss.	By the end of this lesson, the student will be able to describe Newton's three laws of motion to in her/his own words
Remember	list, recite, outline, define, name, match, quote, recall, identify, label, recognize.	By the end of this lesson, the student will be able to recite Newton's three laws of motion.

How Bloom's works with course level and lesson level objectives:

- Course level objectives are broad. You may only have 3-5 course level objectives.
- They would be difficult to measure directly because they overarch the topics of your entire course.
- Lesson level objectives are what we use to demonstrate that a student has mastery of the course level objectives.
- We do this by building lesson level objectives that build toward the course level objective.

Course level and lesson level objectives

- The biggest difference between course and lesson level objectives is that we don't directly assess course level objectives.
- Course level objectives are just too broad.
- Instead, several lesson level objectives are used to demonstrate mastery of one course level objective.
- To create good course level objectives, we need to ask ourselves: "what do I want the students to have mastery of at the end of the course?"
- Then, after finalize our course level objectives, we have to make sure that mastery of all of the lesson level objectives underneath confirm that a student has mastery of the course level objective
- In other words, if students can prove (through assessment) that they can do each and every one of the lesson level objectives in that section, then as an instructor agree they have mastery of the course level objective.

Steps towards writing effective learning objectives:

1. Make sure there is one measurable verb in each objective.
2. Each objective needs one verb. Either a student can master the objective, or they fail to master it. If an objective has two verbs (say, define and apply), what happens if a student can define, but not apply? Are they demonstrating mastery?
3. Ensure that the verbs in the course level objective are at least at the highest Bloom's Taxonomy as the highest lesson level objectives that support it. (Because we can't verify they can **evaluate** if our lessons only taught them (and assessed) to **define**.)
4. Strive to keep all your learning objectives measurable, clear and concise.

Scanned with CamScanner

COMPUTER NETWORKS

- UNIT I INTRODUCTION AND PHYSICAL LAYER
- UNIT II DATA-LINK LAYER & MEDIA ACCESS
- UNIT III NETWORK LAYER
- UNIT IV TRANSPORT LAYER
- UNIT V APPLICATION LAYER

Course Objective

- To discuss the protocol layers and physical level communication.
- To explain the functions of data link layer and connecting devices.
- To illustrate the functions of network layer in various routing protocols.
- To analyze the functions and protocols of the Transport layer.
- To evaluate the working of various application layer protocols.

019

USES OF BLOOMS TAXONOMY

- Create assessment
- Plan lessons
- Evaluate the complexity of assignments
- Design Curriculum gap
- Develop online courses
- Self assessment

Course Objective for current course Handling

THANK YOU

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

SIRUGANUR TRICHY

DEPARTMENT OF MECHATRONICS ENGINEERING

ACADEMIC YEAR 2019-2020 ODD SEMESTER

TEACHER TEACH TEACHERS (TTT) SCHEME

Date: 9.9.2019

Speaker : Mrs.Deepika
Assistant Professor
Mechatronics Engineering

Staff Attended : Mr.M.Chandrasekar
Mr.Ravichandran
Mr.Tamilarasan
Mr.Arumugasamy
Mr.Karthikeyan
Mr.S.Saravanan

Topic : 5G Technology

Venue : Smart Class

Date : 9.9.2019
Time : 2.30pm to 3.30pm

**Enclosure Report

10/9/19
HoD

10/9
Principal

Scanned with CamScanner

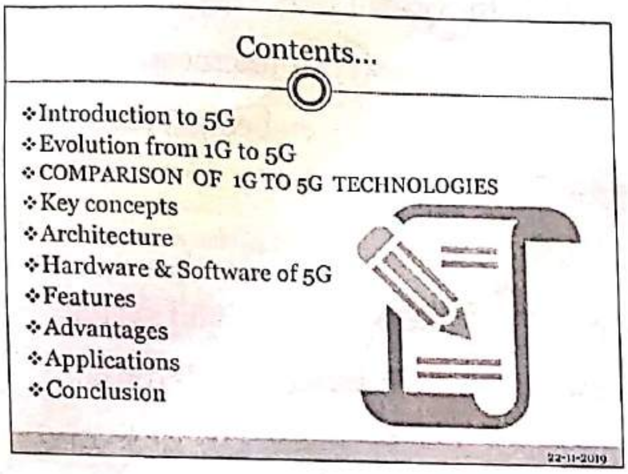
Scanned with CamScanner

5G TECHNOLOGY

Presented by,
J.Deepika
Assistant Professor
Mechatronics Engineering
MAM School of Engineering

Scanned with CamScanner

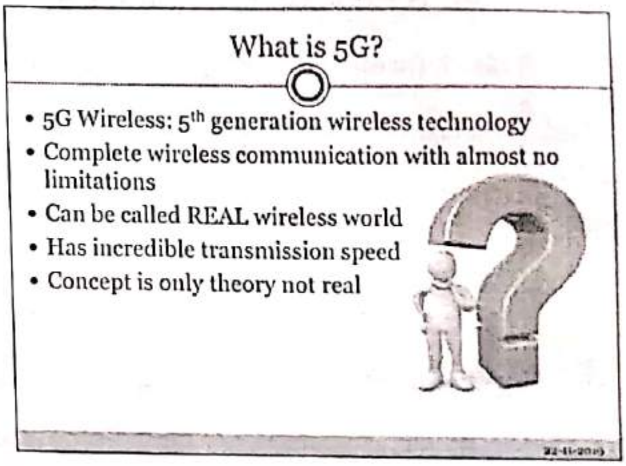
9.9.2019



Contents...

- ❖Introduction to 5G
- ❖Evolution from 1G to 5G
- ❖COMPARISON OF 1G TO 5G TECHNOLOGIES
- ❖Key concepts
- ❖Architecture
- ❖Hardware & Software of 5G
- ❖Features
- ❖Advantages
- ❖Applications
- ❖Conclusion

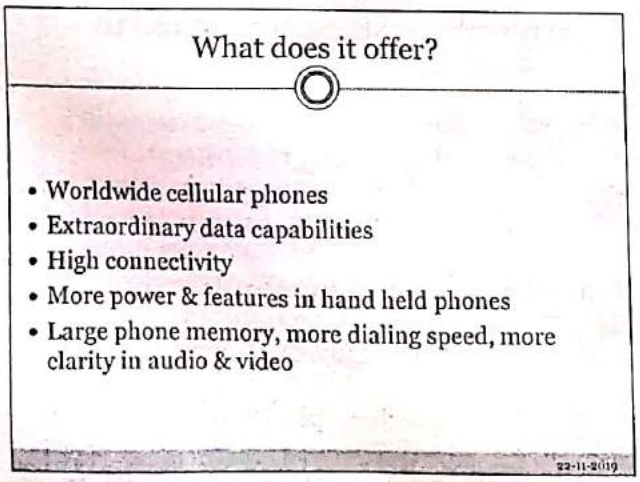
22-11-2019



What is 5G?

- 5G Wireless: 5th generation wireless technology
- Complete wireless communication with almost no limitations
- Can be called REAL wireless world
- Has incredible transmission speed
- Concept is only theory not real

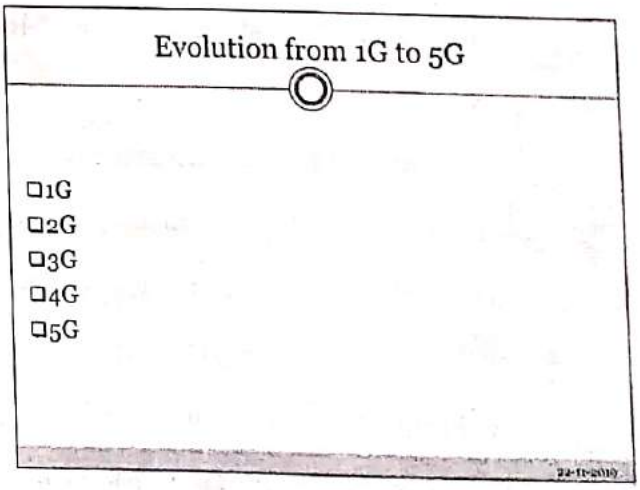
22-11-2019



What does it offer?

- Worldwide cellular phones
- Extraordinary data capabilities
- High connectivity
- More power & features in hand held phones
- Large phone memory, more dialing speed, more clarity in audio & video

22-11-2019

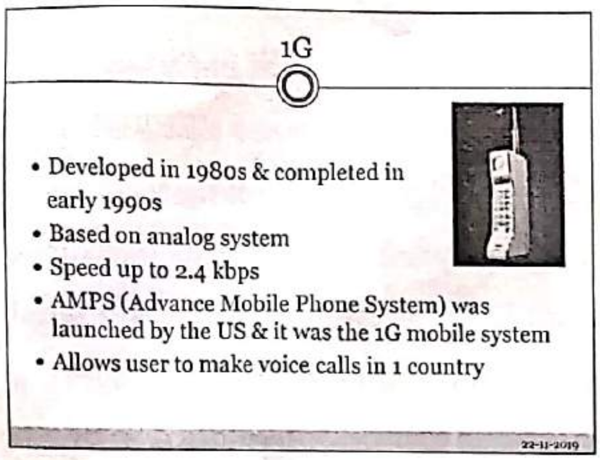


Evolution from 1G to 5G

☐1G
☐2G
☐3G
☐4G
☐5G

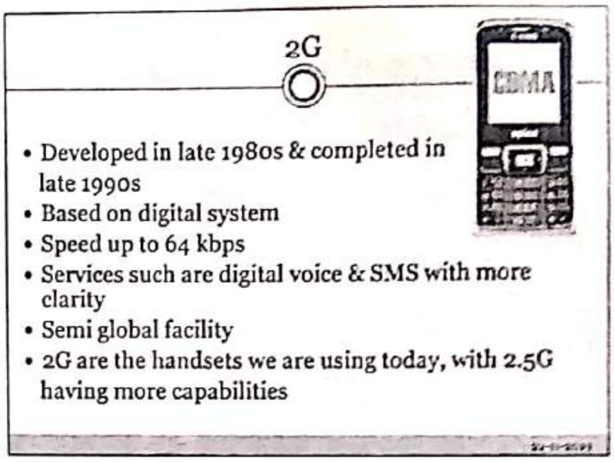
22-11-2019

Scanned with CamScanner



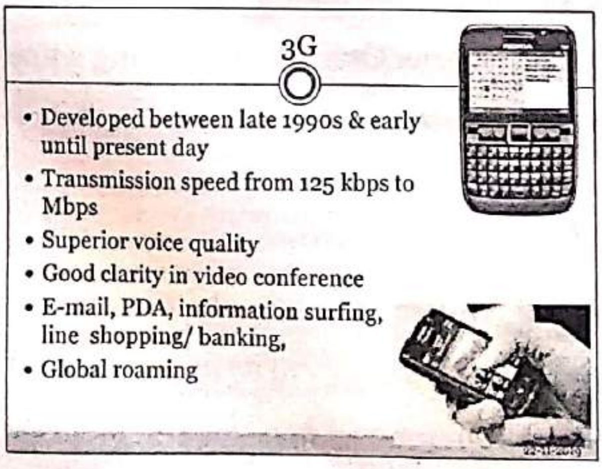
1G

- Developed in 1980s & completed in early 1990s
- Based on analog system
- Speed up to 2.4 kbps
- AMPS (Advance Mobile Phone System) was launched by the US & it was the 1G mobile system
- Allows user to make voice calls in 1 country



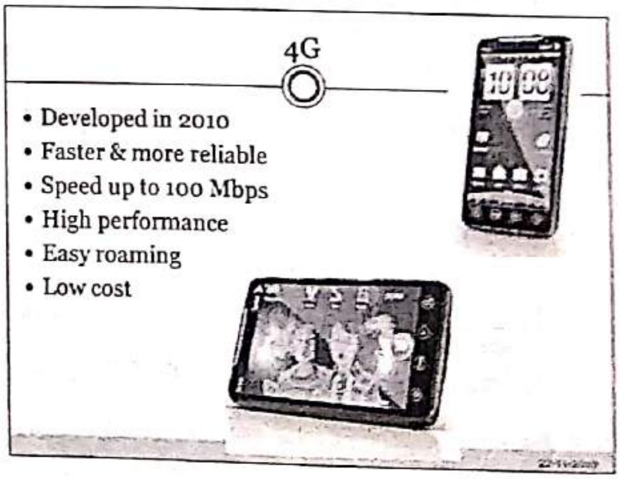
2G

- Developed in late 1980s & completed in late 1990s
- Based on digital system
- Speed up to 64 kbps
- Services such are digital voice & SMS with more clarity
- Semi global facility
- 2G are the handsets we are using today, with 2.5G having more capabilities



3G

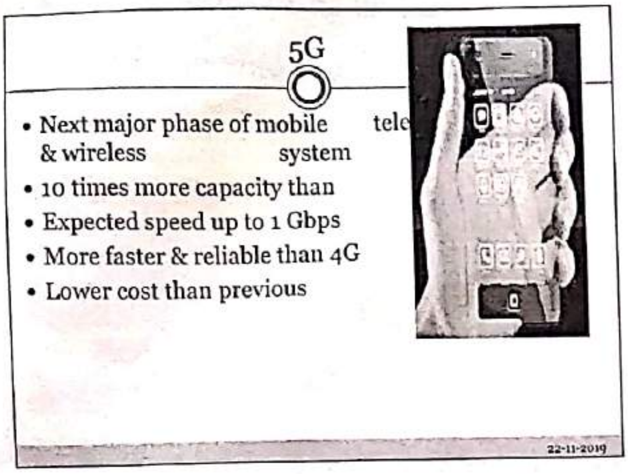
- Developed between late 1990s & early until present day
- Transmission speed from 125 kbps to Mbps
- Superior voice quality
- Good clarity in video conference
- E-mail, PDA, information surfing, line shopping/ banking,
- Global roaming



4G

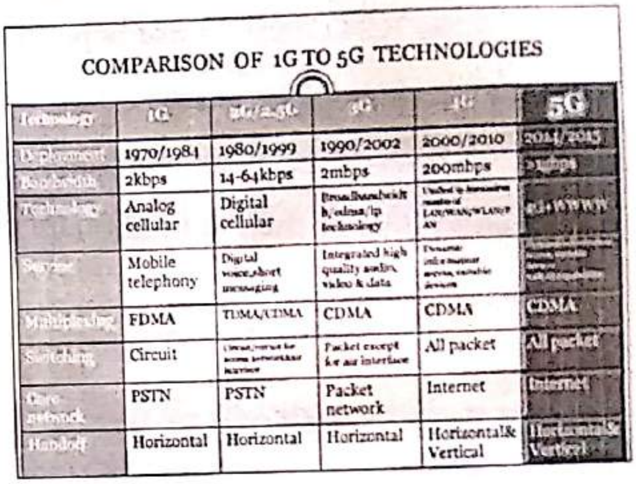
- Developed in 2010
- Faster & more reliable
- Speed up to 100 Mbps
- High performance
- Easy roaming
- Low cost

9.9.2019



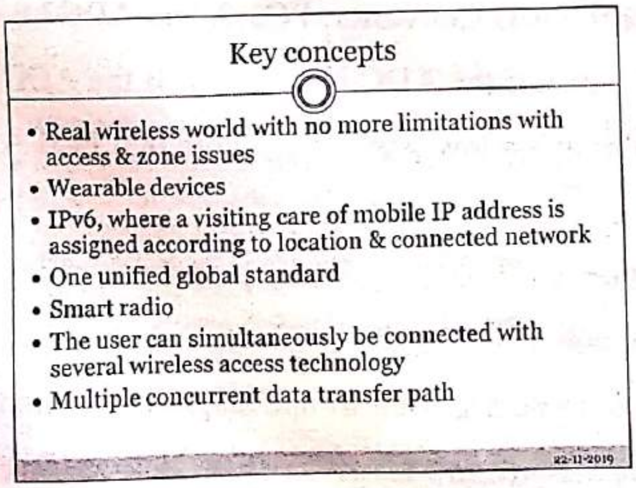
5G

- Next major phase of mobile tele
  & wireless system
- 10 times more capacity than
- Expected speed up to 1 Gbps
- More faster & reliable than 4G
- Lower cost than previous



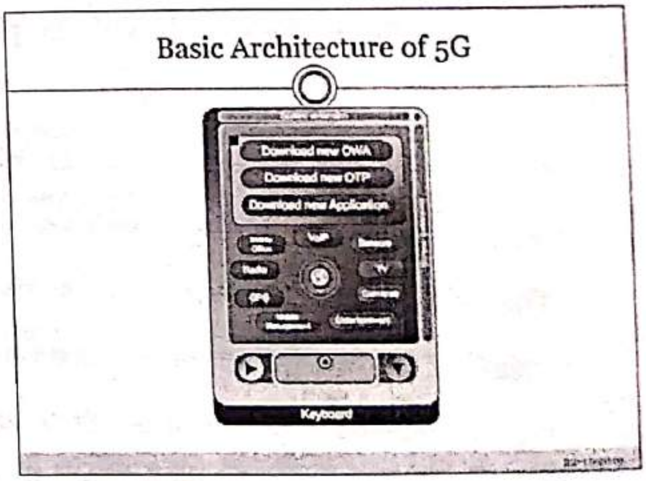
COMPARISON OF 1G TO 5G TECHNOLOGIES

Technology	1G	2G/2.5G	3G	4G	5G
Deployment	1970/1984	1980/1999	1990/2002	2000/2010	2014/2015
Bandwidth	2kbps	14-64kbps	2mbps	200mbps	[illegible]
Technology	Analog cellular	Digital cellular	Broadbandwidth/cdma/ip technology	[illegible] LAN/WAN/WLAN/PAN	4G+WWWW
Service	Mobile telephony	Digital voice,short messaging	Integrated high quality audio, video & data	[illegible]	[illegible]
Multiplexing	FDMA	TDMA/CDMA	CDMA	CDMA	CDMA
Switching	Circuit	[illegible]	Packet except for air interface	All packet	All packet
Core network	PSTN	PSTN	Packet network	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal	Horizontal& Vertical	Horizontal& Vertical



Key concepts

- Real wireless world with no more limitations with access & zone issues
- Wearable devices
- IPv6, where a visiting care of mobile IP address is assigned according to location & connected network
- One unified global standard
- Smart radio
- The user can simultaneously be connected with several wireless access technology
- Multiple concurrent data transfer path



Basic Architecture of 5G

Scanned with CamScanner

9.9.2019

Application Layer	Application(Service)
Presentation layer	
Session Layer	Open Transport Protocol (OTP)
Transport Layer	
Network Layer	Upper network layer Lower network layer
Datalink Layer	Open Wireless Architecture (OWA)
Physical Layer	

Open Wireless Architecture (OWA)

- OSI layer 1 & OSI layer 2 define the wireless technology
- For these two layers the 5G mobile network is likely to be based on Open Wireless Architecture (OWA)
- Physical layer + Data link layer = OWA

Network Layer

- All mobile networks will use mobile IP
- Each mobile terminal will be FA (Foreign Agent)
- A mobile can be attached to several mobiles or wireless networks at the same time
- The fixed IPv6 will be implemented in the mobile phones
- Separation of network layer into two sub-layers:
  (i) Lower network layer (for each interface)
  (ii) Upper network layer (for the mobile terminal)

Open Transport Protocol (OTP)

- Wireless network differs from wired network regarding the transport layer
- In all TCP versions the assumption is that lost segments are due to network congestion
- In wireless, the loss is due to higher bit error ratio in the radio interface
- 5G mobile terminals have transport layer that is possible to be downloaded & installed – Open Transport Protocol (OTP)
- Transport layer + Session layer = OTP

Scanned with CamScanner

9.9.2019

Application (service) Layer

- Provides intelligent QoS (Quality of Service) management over variety of networks
- Provides possibility for service quality testing & storage of measurement information in information database in the mobile terminal
- Select the best wireless connection for given services
- QoS parameters, such as, delay, losses, BW, reliability, will be stored in DB of 5G mobile
- Presentation layer + Application layer = Application

Hardware & Software of 5G

➢ 5G Hardware:

- Uses UWB (Ultra Wide Band) networks with higher BW at low energy levels
- BW is of 4000 Mbps, which is 400 times faster than today's wireless networks
- Uses smart antenna
- Uses CDMA (Code Division Multiple Access)

➢ 5G Software:

- 5G will be single unified standard of different wireless networks, including LAN technologies, LAN/WAN, WWWW- World Wide Wireless Web, unified IP & seamless combination of broadband
- Software defined radio, encryption, flexibility, Anti-Virus

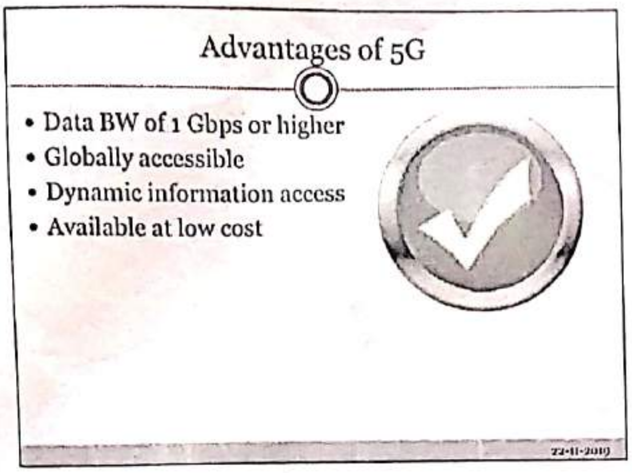
Features of 5G

- High resolution for crazy cell phone users
- Bi-directional large BW
- Less traffic
- 25 Mbps connectivity speed
- Enhanced & available connectivity just about the world
- Uploading & Downloading speed of 5G touching the peak (up to 1 Gbps)
- Better & fast solution

Features (Conti...)

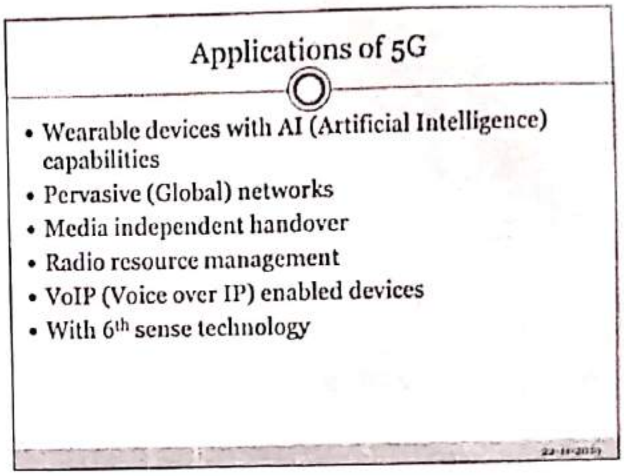
- High quality service based on policy to avoid error
- Support virtual private networks
- More attractive & effective
- Provides subscriber supervision tools for fast action

Scanned with CamScanner



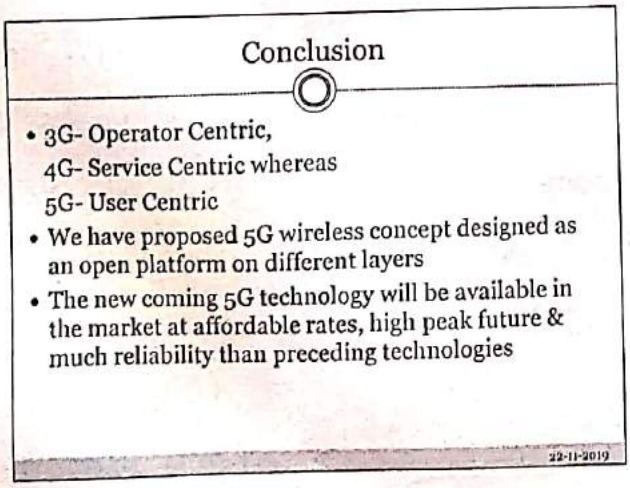
Advantages of 5G

- Data BW of 1 Gbps or higher
- Globally accessible
- Dynamic information access
- Available at low cost



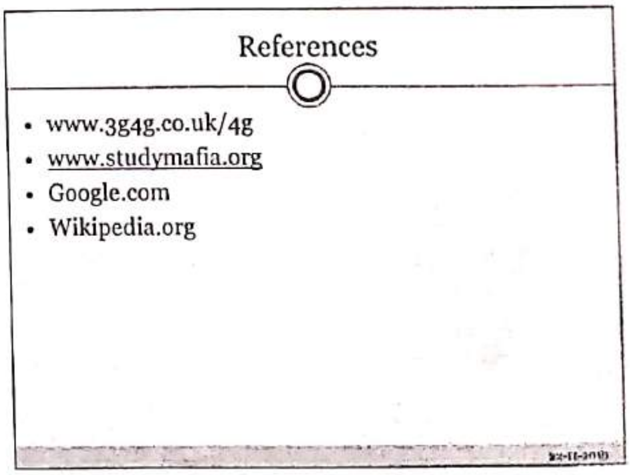
Applications of 5G

- Wearable devices with AI (Artificial Intelligence) capabilities
- Pervasive (Global) networks
- Media independent handover
- Radio resource management
- VoIP (Voice over IP) enabled devices
- With 6th sense technology



Conclusion

- 3G- Operator Centric,
  4G- Service Centric whereas
  5G- User Centric
- We have proposed 5G wireless concept designed as an open platform on different layers
- The new coming 5G technology will be available in the market at affordable rates, high peak future & much reliability than preceding technologies



References

- www.3g4g.co.uk/4g
- www.studymafia.org
- Google.com
- Wikipedia.org

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Department of Mechatronics Engineering

Teacher Teach Teacher (TTT)

Academic year (2019-2020) Even semester

Date: 21 .01.2020

Speaker: Mr.M.Arumugasamy

Assistant Professor – Mechanical Engineering

Staff attended:

1. Mr.M.Chandrasekar
2. Mr.Karthikeyan
3. Ms.M.Suba pradha
4. Mr.S.Ravichandran
5. Mr.S.Saravanan
6. Mrs.P.Sudha

Topic:

Entrepreneurship Development

Venue:

Smart class

Date & Time:

21st Jan 2020 & 1.30 P.M to 2.30 P.M

**enclosure: Report

22/1/20

HOD

PRINCIPAL

Scanned with CamScanner

REPORT

The session was initiated by Mr.M.Arumugasamy Assistant Professor/Mech, the topic for the Lecture is Entrepreneurship Development and discuss about the following topics

- Entrepreneur
- Intrapreneurship
- Employee satisfaction
- Motivation
- Entrepreneur types
- Characteristics of Entrepreneur

The session comes to an end with the explaining the overview of Entrepreneurship Development and its Types.

HOD

Scanned with CamScanner

M.A.M. School of Engineering
Siruganur, Trichy 621105

MG 6071 Entrepreneurship Development

Presentation By
M.Arumugasamy
Dept of Mechatronics Engineering
M A M School of Engineering
Trichy -621105

Entrepreneurship

Overview

- What is an entrepreneur?
- Characteristics of an entrepreneur
- Planning to be an entrepreneur
- Growth pressures, managing a family business, and corporate intrapreneurship

Entrepreneurs V. Intrapreneurs

- Entrepreneurs are people that notice opportunities and take the initiative to mobilize resources to make new goods and services.
- Intrapreneurs also notice opportunities and take initiative to mobilize resources, however they work in large companies and contribute to the innovation of the firm.

- Intrapreneurs often become entrepreneurs.

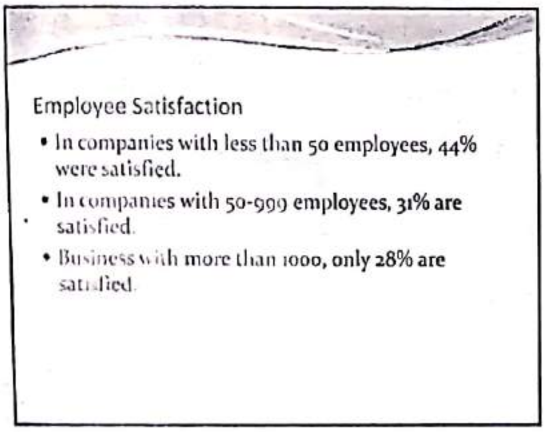
Intrapreneurship

- Learning organizations encourage intrapreneurship.
- Organizations want to form:
  - Product Champions: people who take ownership of a product from concept to market.
  - Skunkworks: a group of intrapreneurs kept separate from the rest of the organization.
  - New Venture Division: allows a division to act as its own smaller company.
  - Rewards for Innovation: link innovation by workers to valued rewards.

Small Business Owners

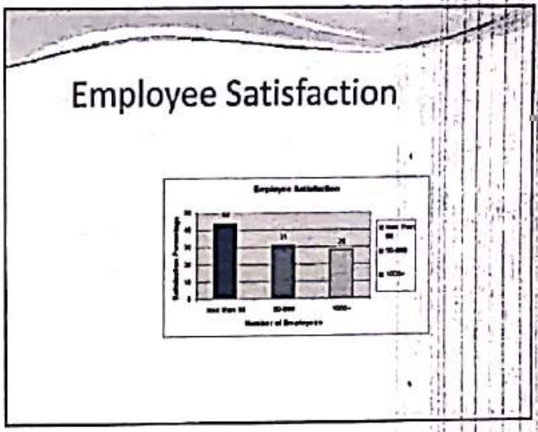
- Small business owners are people who own a major equity stake in a company with fewer than 500 employees.
- In 1997 there were 22.56 million small business in the United States.
- 47% of people are employed by a small business.

Scanned with CamScanner

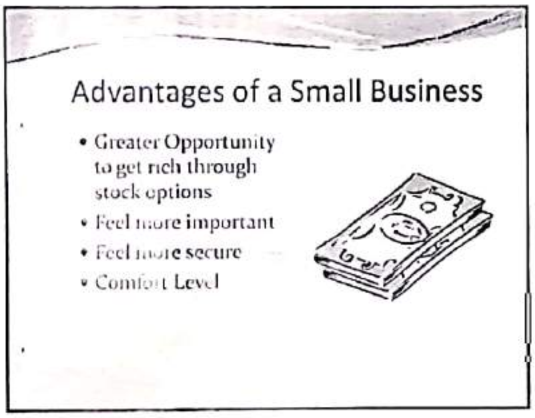


Employee Satisfaction

- In companies with less than 50 employees, 44% were satisfied.
- In companies with 50-999 employees, 31% are satisfied.
- Business with more than 1000, only 28% are satisfied.

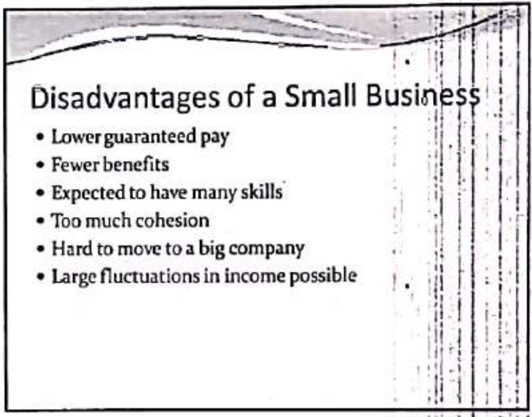


Employee Satisfaction



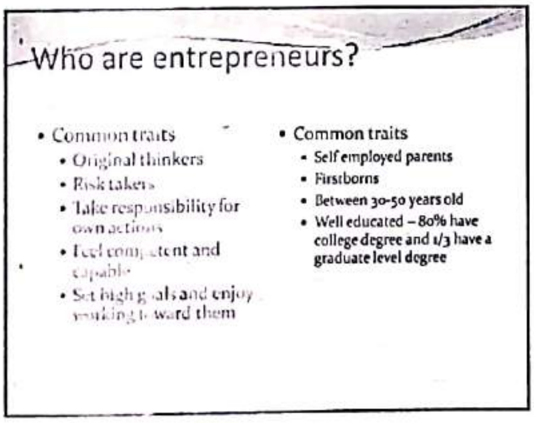
Advantages of a Small Business

- Greater Opportunity to get rich through stock options
- Feel more important
- Feel more secure
- Comfort Level



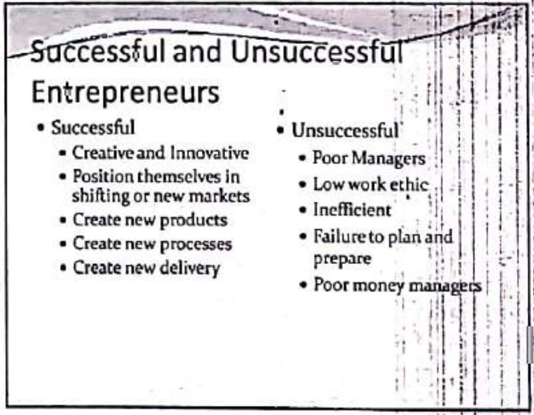
Disadvantages of a Small Business

- Lower guaranteed pay
- Fewer benefits
- Expected to have many skills
- Too much cohesion
- Hard to move to a big company
- Large fluctuations in income possible



Who are entrepreneurs?

- Common traits
  - Original thinkers
  - Risk takers
  - Take responsibility for own actions
  - Feel competent and capable
  - Set high goals and enjoy working toward them
- Common traits
  - Self employed parents
  - Firstborns
  - Between 30-50 years old
  - Well educated – 80% have college degree and 1/3 have a graduate level degree



Successful and Unsuccessful Entrepreneurs

- Successful
  - Creative and Innovative
  - Position themselves in shifting or new markets
  - Create new products
  - Create new processes
  - Create new delivery
- Unsuccessful
  - Poor Managers
  - Low work ethic
  - Inefficient
  - Failure to plan and prepare
  - Poor money managers

Scanned with CamScanner

Characteristics of Entrepreneurs

Key Personal Attributes

- Entrepreneurs are Made, Not Born!
    - Many of these key attributes are developed early in life, with the family environment playing an important role
    - Entrepreneurs tend to have had self employed parents who tend to support and encourage independence, achievement, and responsibility
    - Firstborns tend to have more entrepreneurial attributes because they receive more attention, have to forge their own way, thus creating higher self-confidence

Key Personal Attributes (cont.)

- Entrepreneurial Careers
    - The idea that entrepreneurial success leads to more entrepreneurial activity may explain why many entrepreneurs start multiple companies over the course of their career
    - *Corridor Principle* - Using one business to start or acquire others and then repeating the process
    - *Serial Entrepreneurs* - A person who founds and operates multiple companies during one career

Key Personal Attributes (cont.)

- Need for Achievement
    - A person's desire either for excellence or to succeed in competitive situations
    - High achievers take responsibility for attaining their goals, set moderately difficult goals, and want immediate feedback on their performance
    - Success is measured in terms of what those efforts have accomplished
    - McClelland's research

Key Personal Attributes (cont.)

- Desire for Independence
    - Entrepreneurs often seek independence from others
    - As a result, they generally aren't motivated to perform well in large, bureaucratic organizations
    - Entrepreneurs have internal drive, are confident in their own abilities, and possess a great deal of self-respect

Key Personal Attributes (cont.)

- Self-Confidence
    - Because of the high risks involved in running an entrepreneurial organization, having an "upbeat" and self-confident attitude is essential
    - A successful track record leads to improved self-confidence and self-esteem
    - Self-confidence enables that person to be optimistic in representing the firm to employees and customers alike

Scanned with CamScanner

Key Personal Attributes (cont.)

- Self-Sacrifice
  - Essential
  - Nothing worth having is free
  - Success has a high price, and entrepreneurs have to be willing to sacrifice certain things

Technical Proficiency

- Many entrepreneurs demonstrate strong technical skills, typically bringing some related experience to their business ventures
- For example, successful car dealers usually have lots of technical knowledge about selling and servicing automobiles before opening their dealerships
- Especially important in the computer industry
- NOT ALWAYS NECESSARY

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING
Siruganur, Tiruchirappalli – 621 105.

Department of Mechatronics Engineering

Teacher Teach Teacher (TTT)

Academic year (2019-2020) Odd semester

Date:8.8.2019

Speaker: Mr.Karthikeyan
Assistant Professor – Mechatronics Engineering

Staff attended:

1. Mr.M.Chandra sekar
2. Mr.S.Saravanan
3. Mr.Tamilarasan
4. Mr.Arumugasamy
5. Mr.Ravichandran
6. Mrs.Deepika

Topic:

Organic Light Emitting Diode Displays

Venue:

Smart class

Date & Time:

7th August 2019 & 1.30 P.M to 2.30 P.M

**enclosure: Report

8/8/19

HOD **PRINCIPAL**

REPORT

The session was initiated by Mr. S.Saravanan Assistant Professor/Mct, the opic for the Lecture is Organic Light Emitting Diode Displays and its Applications and discuss about the following topics

- Organic Electronics
- Organic Solar Cells
- Organic LED
- AMOLED
- OLED Types
- OLED Applications
- OLED Television

The session comes to an end with the explaining the overview of OLED and its Application.

HOD\

INTRODUCTION

For the past forty years inorganic silicon and gallium arsenide semiconductors, silicon dioxide insulators, and metals such as aluminum and copper have been the backbone of the semiconductor industry However, there has been a growing research effort in "organic electronics" to improve the semiconducting, conducting, and light-emitting properties of organics (polymers, oligomers) and hybrids (organic–inorganic composites) through novel synthesis and self-assembly techniques. Performance improvements, coupled with the ability to process these "active" materials at low temperatures over large areas on materials such as plastic or paper, may provide unique technologies and generate new applications and form factors to address the growing needs for pervasive computing and enhanced connectivity.

If we review the growth of the electronics industry, it is clear that innovative organic materials have been essential to the unparalleled performance increase in semiconductors, storage, and displays at the consistently lower costs that we see today However, the majorities of these organic materials are either used as sacrificial stencils (photoresists) or passive insulators and take no active role in the electronic functioning of a device. They do not conduct current to act as switches or wires, and they do not emit light.

The ability of chemists to optimize the properties of the organic materials described above has provided key contributions to the growth of the electronics industry. However, it is possible in the near future we may reach the limits of performance improvements in silicon devices, magnetic storage, and displays that can be provided at a reasonable cost. As in the past, basic research on materials may provide a path to new product form factors.

So nontraditional materials such as conjugated organic molecules, short-chain oligomers, longer-chain polymers, and organic–inorganic composites are being developed that emit light, conduct current, and act as semiconductors. The ability of these materials to transport charge (holes and electrons) due to the π-orbital overlap of neighboring molecules provides their semiconducting and conducting properties. In addition to their electronic and optical properties, many of these thin-film materials possess good mechanical properties (flexibility and toughness) and can be processed at low temperatures using techniques familiar to the semiconducting and printing industries, such as vacuum evaporation, solution casting, ink-jet printing, and stamping. These properties could lead to new form factors in which roll-to-roll manufacturing could be used to create products such as low- cost information displays on flexible plastic, and logic for smart cards and radio-frequency identification (RFID) tags.

Similar enhancements in performance have been seen in the development of organic light-emitting diodes (OLEDs). Pioneering work was done at Eastman Kodak in 1987 on evaporated small molecules and at Cambridge University in 1990 on solution-processed semiconducting polymers. Currently, the highest observed luminous efficiencies of derivatives of these materials exceed that of incandescent lightbulbs, thus eliminating the need for the backlight that is used in AMLCDs.

The electronic and optical properties of these "active" organic materials are now suitable for some low-performance, low-cost electronic products that can address the needs for lightweight portable devices for the 21st century.

ORGANIC ELECTRONICS

Organic electronics, or plastic electronics, is a branch of electronics that deals with conductive polymers, plastics, or small molecules. It is called 'organic' electronics because the polymers and small molecules are carbon-based, like the molecules of living things. This is as opposed to traditional electronics which relies on inorganic conductors such as copper or silicon.

The men principally credited for the discovery and development of highly-conductive organic polymers are Alan J. Heeger, Alan G. MacDiarmid, and Hideki Shirakawa, who were jointly awarded the Nobel Prize in Chemistry in 2000 for the 1977 discovery and development of oxidized, iodine-doped polyacetylene.

ORGANIC LIGHT EMITTING DIODE (OLED)

Abstract:

Organic light-emitting diodes (OLEDs) operate on the principle of converting electrical energy into light, a phenomenon known as electroluminescence. They consist of emissive electroluminescent layer comprised of a film of organic compunds (carbon, hydrogen and oxygen). In its simplest form, an OLED consists of a layer of luminescent material sandwiched between two electrodes. When an electric current is passed between the electrodes, through the organic layer, light is emitted with a color that depends on the particular material used.

When OLEDs are used as pixels in flat panel displays they have some advantages over backlit active-matrix LCD displays - greater viewing angle, lighter weight, and quicker response. Since only the part of the display that is actually lit up consumes power, the most efficient OLEDs available today use less power.

Based on these advantages, OLEDs have been proposed for a wide range of display applications including magnified micro displays, wearable, head-mounted computers, digital cameras, personal digital assistants, smart pagers, virtual reality games, and mobile phones as well as medical, automotive, and other industrial applications.

Key Words:

- **OLED:**

  An organic light-emitting diode (OLED), also Light Emitting Polymer (LEP) and Organic Electro-Luminescence (OEL), is any light-emitting diode (LED) whose emissive electroluminescent layer is comprised of a film of organic compounds. The layer usually contains a polymer substance that allows suitable organic compounds to be deposited. They are deposited in rows and columns onto a flat carrier by a simple "printing" process. The resulting matrix of pixels can emit light of different colors.
- **OLED Components**

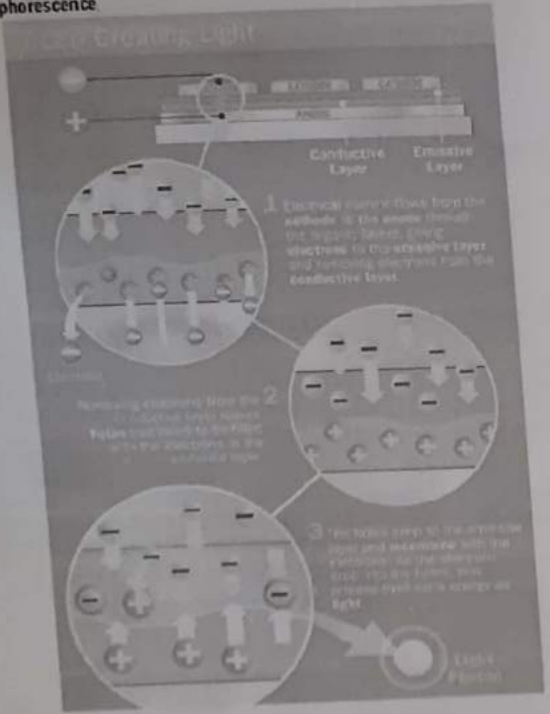
  Like an LED, an OLED is a solid-state semiconductor device that is 100 to 500 nanometers thick or about 200 times smaller than a human hair. OLEDs can have either two layers or three layers of organic material; in the latter design, the third layer helps transport electrons from the cathode to the emissive layer.

Conclusion: LED is gaining immense application in day to day . OLED is a miniaturized LED which will be used for extended visual applications.

Scanned with CamScanner

4.3 How do OLEDs Emit Light?

OLEDs emit light in a similar manner to LEDs, through a process called **electrophosphorescence**.



The process is as follows:

1. The battery or power supply of the device containing the OLED applies a voltage across the OLED.
2. An electrical current flows from the cathode to the anode through the organic layers (an electrical current is a flow of electrons).
   The cathode gives electrons to the emissive layer of organic molecules.
   The anode removes electrons from the conductive layer of organic molecules.
   (This is the equivalent to giving electron holes to the conductive layer.)
3. At the boundary between the emissive and the conductive layers, electrons find electron holes.
   When an electron finds an electron hole, the electron fills the hole (it falls into an energy level of the atom that's missing an electron).
   When this happens, the electron gives up energy in the form of a photon of light.
4. The OLED emits light.

Electronically, OLED is similar to old-fashioned LEDs – put a low voltage across them and they glow. Light-emitting diodes, based upon materials like Gallium Arsenide, Gallium Phosphide and, most recently, Gallium Nitride, have been around since the late '50s. They are mostly used as indicator lamps, although they were used in calculators before liquid crystals, and are used in large advertising signs, where they are valued for very long life and high brightness. Such crystalline LEDs are not inexpensive, and it is very difficult to integrate them into small high-resolution displays.

OLEDs can provide brighter, crisper displays on electronic devices and use less power than conventional light-emitting diode (LEDs) or liquid crystal displays (LCDs) used today.

4.2 OLED Components

Like an LED, an OLED is a solid-state semiconductor device that is 100 to 500 nanometers thick or about 200 times smaller than a human hair. OLEDs can have either two layers or three layers of organic material; in the latter design, the third layer helps transport electrons from the cathode to the emissive layer. In this article, we'll be focusing on the two-layer design.

An OLED consists of the following parts:

Substrate (clear plastic, glass, foil) - The substrate supports the OLED.

Anode (transparent) - The anode removes electrons (adds electron "holes") when a current flows through the device.

Organic layers - These layers are made of organic molecules or polymers.

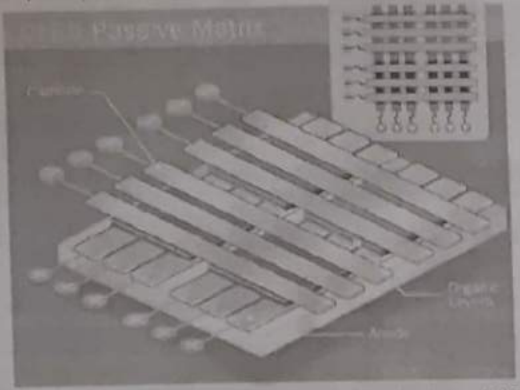
Conducting layer - This layer is made of organic plastic molecules that transport "holes" from the anode. One conducting polymer used in OLEDs is polyaniline.

Emissive layer - This layer is made of organic plastic molecules (different ones from the conducting layer) that transport electrons from the cathode; this is where light is made. One polymer used in the emissive layer is polyfluorene.

Cathode (may or may not be transparent depending on the type of OLED) - The cathode injects electrons when a current flows through the device.

Scanned with CamScanner

and cathode, determining which pixels get turned on and which pixels remain off. Again, the brightness of each pixel is proportional to the amount of applied current.



PMOLEDs are easy to make, but they consume more power than other types of OLED, mainly due to the power needed for the external circuitry. PMOLEDs are most efficient for text and icons and are best suited for small screens (2- to 3-inch diagonal) such as those you find in cell phones, PDAs and MP3 PLAYERS. Even with the external circuitry, passive-matrix OLEDs consume less battery power than the LCDs that currently power these devices.

Active-matrix OLED (AMOLED):

AMOLEDs have full layers of cathode, organic molecules and anode, but the anode layer overlays a thin film transistor (TFT) array that forms a matrix. The TFT array itself is the circuitry that determines which pixels get turned on to form an image.

AMOLEDs consume less power than PMOLEDs because the TFT array requires less power than external circuitry, so they are efficient for large displays. AMOLEDs also have faster refresh rates suitable for video. The best uses for AMOLEDs are computer monitors, large-screen TVs and electronic signs or billboards.

5. The color of the light depends on the type of organic molecule in the emissive layer. Manufacturers place several types of organic films on the same OLED to make color displays.
6. The intensity or brightness of the light depends on the amount of electrical current applied: the more current, the brighter the light.

4.4 Making OLEDs:

Laboratory set up of a high-precision inkjet printer for making polymer OLED displays

The biggest part of manufacturing OLEDs is applying the organic layers to the substrate. This can be done in three ways:

- Vacuum deposition or vacuum thermal evaporation (VTE) - In a vacuum chamber, the organic molecules are gently heated (evaporated) and allowed to condense as thin films onto cooled substrates. This process is expensive and inefficient.
- Organic vapor phase deposition (OVPD) - In a low-pressure, hot-walled reactor chamber, a carrier gas transports evaporated organic molecules onto cooled substrates, where they condense into thin films. Using a carrier gas increases the efficiency and reduces the cost of making OLEDs.
- Inkjet printing - With inkjet technology, OLEDs are sprayed onto substrates just like inks are sprayed onto paper during printing. Inkjet technology greatly reduces the cost of OLED manufacturing and allows OLEDs to be printed onto very large films for large displays like 80-inch TV screens or electronic billboards.

OLED TYPES

There are several types of OLEDs:

- Passive-matrix OLED
- Active-matrix OLED
- Transparent OLED
- Top-emitting OLED
- Foldable OLED
- White OLED

5.1 Passive and Active Matrix OLEDs:

Passive-matrix OLED (PMOLED):

PMOLEDs have strips of cathode, organic layers and strips of anode. The anode strips are arranged perpendicular to the cathode strips. The intersections of the cathode and anode make up the pixels where light is emitted. External circuitry applies current to selected strips of anode

Scanned with CamScanner

5. The color of the light depends on the type of organic molecule in the emissive layer. Manufacturers place several types of organic films on the same OLED to make color displays.
6. The intensity or brightness of the light depends on the amount of electrical current applied: the more current, the brighter the light.

4.4 Making OLEDs:

Laboratory set up of a high-precision inkjet printer for making polymer OLED displays

The biggest part of manufacturing OLEDs is applying the organic layers to the substrate. This can be done in three ways:

- Vacuum deposition or vacuum thermal evaporation (VTE) - In a vacuum chamber, the organic molecules are gently heated (evaporated) and allowed to condense as thin films onto cooled substrates. This process is expensive and inefficient.
- Organic vapor phase deposition (OVPD) - In a low-pressure, hot-walled reactor chamber, a carrier gas transports evaporated organic molecules onto cooled substrates, where they condense into thin films. Using a carrier gas increases the efficiency and reduces the cost of making OLEDs.
- Inkjet printing - With inkjet technology, OLEDs are sprayed onto substrates just like inks are sprayed onto paper during printing. Inkjet technology greatly reduces the cost of OLED manufacturing and allows OLEDs to be printed onto very large films for large displays like 80-inch TV screens or electronic billboards.

OLED TYPES

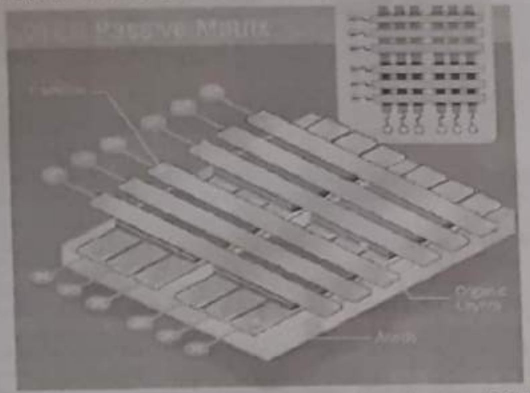
There are several types of OLEDs:

- Passive-matrix OLED
- Active-matrix OLED
- Transparent OLED
- Top-emitting OLED
- Foldable OLED
- White OLED

5.1 Passive and Active Matrix OLEDs:

Passive-matrix OLED (PMOLED):

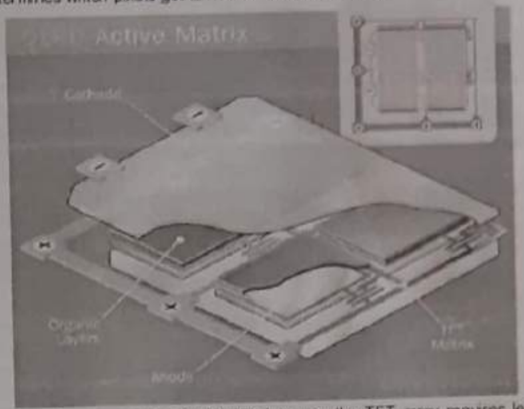
PMOLEDs have strips of cathode, organic layers and strips of anode. The anode strips are arranged perpendicular to the cathode strips. The intersections of the cathode and anode make up the pixels where light is emitted. External circuitry applies current to selected strips of anode and cathode, determining which pixels get turned on and which pixels remain off. Again, the brightness of each pixel is proportional to the amount of applied current.



PMOLEDs are easy to make, but they consume more power than other types of OLED, mainly due to the power needed for the external circuitry. PMOLEDs are most efficient for text and icons and are best suited for small screens (2- to 3-inch diagonal) such as those you find in cell phones, PDAs and MP3 PLAYERS. Even with the external circuitry, passive-matrix OLEDs consume less battery power than the LCDs that currently power these devices.

Active-matrix OLED (AMOLED):

AMOLEDs have full layers of cathode, organic molecules and anode, but the anode layer overlays a thin film transistor (TFT) array that forms a matrix. The TFT array itself is the circuitry that determines which pixels get turned on to form an image.



AMOLEDs consume less power than PMOLEDs because the TFT array requires less power than external circuitry, so they are efficient for large displays. AMOLEDs also have faster refresh rates suitable for video. The best uses for AMOLEDs are computer monitors, large-screen TVs and electronic signs or billboards.

Scanned with CamScanner

OLED APPLICATIONS

7.1 Current OLED Applications:

OLED technology is already used in some devices. Most of them are cellular phones or portable music players, but also other products use this new technology.

Cellular/mobile phones

There are many mobile phones that use OLED displays. Samsung has several models like the SGH-E700, E715 or E730. All these models use an external OLED screen with different resulutions (64 x 96, 96 x 96 pixels) and different color depths (either 256 colors or 65k colors). The Samsung SGH-X120 uses a main OLED screen with 128 x 128 pixels. The S88 phone from BenQ-Siemens uses a two inch active-matrix OLED display with about 262k colors and 176 x 220 pixels. LG Electronic offers several mobile phones with an OLED technology. LG LP4100 has an external display powered with the new technology. LG's model VX8300 has an organic light-emitting diode display with 262,000 colors and a resolution of 176 x 220 pixels.

Other mobile phone manufacturers like Motorola, Nokia, Panasonic or SonyEricsson are also using organic light emitting diodes for their external displays.

MP3 players

MobiBLU ships an mp3 player that features an OLED display, the DAH-1500i model. The popular Creative Zen Micro has also an organic LED display with 262k colors. The Sony NW-A3000 and NW-A1000 both have an OLED display. The Zen Sleek music player from Creative has a new 1.7 inch organic LED display. The Gigabeat audio player from Toshiba features also an OLED screen.

Digital cameras

The Kodak EasyShare LS633 is the world's first digital camera with an organic LED display. The Sanyo Xacti HD1 is a high definition camera that features an OLED display. Other digital cameras with an OLED screen are from Hasselblad (H2D-39 and 503CWD for example).

Photo Courtesy HowStuffWorks Shopper
Kodak LS633 EasyShare with OLED display

In September 2004, Sony Corporation announced that it was beginning mass production of OLED screens for its CLIE PEG-VZ90 model of personal-entertainment handhelds.

LCD means liquid crystal display and its technology is widely used in modern television screens or computer displays. LCDs are non-organic and non-emissive devices, that means they do not produce any form of light. They just pass or block light reflected from an external light source. This is called a backlighting system. Because of this backlighting system LCDs are consuming more power than OLED displays.

OLED displays consume much less power, simply because no backlighting is needed. In addition, they have a higher contrast and are brighter than LCDs. OLED allows thinner, lighter and more flexible designs, the viewing angle is wider (up to 160 degrees and above). This is because they produce there own light, whereas LCDs need a backlight.

CRT means cathode ray tube. It is the old traditional technology used in computer or television screens. A cathode ray tube is like an electronic vacuum tube employing a focused beam of electrons. Displays with CRT technology are cheap to produce and have a wide viewing angle. Manufacturing of LCDs is more cost-intensive than producing CRTs, but the power consumption is lower and the smaller design allows thinner products. LCDs are emitting fewer electromagnetic emissions than CRTs.

OLED seems to be the perfect technology, but there are also some disadvantages we want to mention. The lifetime is limited, especially those of blue organics. Manufacturing is at this time more cost-intensive than producing LCDs. Water can easily damage OLEDs, so complex sealing is necessary.

Despite these small disadvantages OLED is emerging the new technology for thin panel displays.

6.3 Drawbacks:

The biggest technical problem for OLEDs is the limited lifetime of the organic materials. In particular, blue OLEDs typically have lifetimes of around 5,000 hours when used for flat-panel displays, which is lower than typical lifetimes of LCD, LED technology – each currently rated for about 60,000 hours, depending on manufacturer and model. But in 2005 experiments found that it is possible to swap the chemical component for a phosphorescent one, if the subtle differences in energy transitions are accounted for, resulting in lifetimes of up to 20,000 hours for blue PHOLEDs.

The intrusion of water into displays can damage or destroy the organic materials. Therefore, improved sealing processes are important for practical manufacturing and may limit the longevity of more flexible displays.

Scanned with CamScanner

Photo courtesy Sony Corporation
OLED display for Sony Clie

Several companies have already built prototype computer monitors and large-screen TVs that use OLED technology. In May 2005, Samsung Electronics announced that it had developed a prototype 40-inch, OLED-based, ultra-slim TV, the first of its size.

Sony 11-inch XEL-1 OLED TV:

In October 2007, Sony announced that it would be the first to market with an OLED television. The XEL-1 will be available in December 2007 for customers in Japan. It lists for 200,000 Yen - - or about $1,700 U.S.

Front Back Left Side Remote Controller

Photo Courtesy Sony
the Sony 11-inch XEL-1 OLED TV.

Main Features of "XEL-1":

Thinness: Proposes new TV form factor measuring approximately 3mm thinness (at its thinnest point)
As OLEDs are light-emitting, there is no need for a separate light source such as a backlight system. Sony's "Organic Panel" consists of an organic material layer of just several hundred nanometers thickness, with two extremely thin glass panels aligned on either side of the organic material layer. This realizes a new TV form factor measuring approximately 3mm at its thinnest point.

High contrast: Reproduces realistic images using exquisite shades of black and flexible control of color tone and gradation
With its light-emitting structure, the OLED display can prevent light emission when reproducing shades of black, enabling "XEL-1" to reproduce very deep blacks (contrast ratio 1,000,000 1).

Furthermore, XEL-1 can control all the phases of light emission from zero to peak brightness, generating color expression and subtleties conventional displays cannot match.

High peak brightness: Faithfully reproduces picture glow
"Super Top Emission," a technology unique to Sony and incorporated in its "Organic Panel" has a high aperture ratio which allows for efficient light emission from the organic materials, realizing high peak brightness. This enables "XEL-1" to faithfully reproduce light flow such as reflections of sun light or camera flashlights through the image reproduced on the display.

Excellent color reproduction: Delivers pure and vivid colors in both dark and bright images
In order to use OLED to generate the full spectrum of Sony's TV color requirements, Sony developed its own proprietary organic materials, with bright coloration. In addition, the micro-cavity structure of "Super Top Emission" and the color extracting technology within its embedded color filter enable "XEL-1" to reproduce natural colors beautifully. As a result, the fresh colors of ripe fruit and shades of deep cobalt blue can be stunningly reproduced. The "Organic Panel" can also sustain its color reproduction capability in scenes of diminished brightness, enabling "XEL-1" to faithfully recreate even dark movie scenes using the colors that were originally intended.

Rapid response time: Smoothly reproduces fast moving images such as sports scenes
Since OLED can spontaneously turn the light emitted from the organic material layer on and off, OLED is capable of very rapid response times. Newly developed OLED drive circuits enable "XEL-1" to reproduce fast moving images such as sports scenes smoothly and naturally.

Low power consumption
OLED does not require a separate light source due to its light-emitting structure, therefore it can be powered using very low voltages. This means that OLED TVs consume extremely low levels of power compared with other display devices. The power consumption of "XEL-1" is as low as 45W.

7.2 Future Applications:

Research and development in the field of OLEDs is proceeding rapidly and may lead to future applications in heads-up displays, automotive dashboards, billboard-type displays, home and office lighting and flexible displays. Because OLEDs refresh faster than LCDs -- almost 1,000 times faster -- a device with an OLED display could change information almost in real time. Video images could be much more realistic and constantly updated.

Scanned with CamScanner

OLED keyboard

A Russian company has showed a prototype of an OLED keyboard. The keys are displayed with OLED technology. Thus the whole keyboard is highly configurable. The position, appearance and function of the keys are switchable. In addition, the keyboard looks awesome because of its LEDs.

The keys can display icons as well as regular symbols. Its possible to associate keys with mathematical functions, HTML codes or other special characters. It is also possible to configure a gaming keyboard layout for first-person shooters, strategy games or other purposes. There are preconfigured layouts for Quake, Photoshop and other mainstream games and applications.

Windows that light-up at dark:

It is true, this could be possible with OLED. This is because organic light emitting diodes can be transparent. A window could act as a normal window at day, but at night it can be used as a light resource. This vision can replace the boring old bulb in the middle of every room. It is getting even better: nearly every surface can become a lighting source. It does not matter if its curved or flat - OLED sheets are flexible and ultra-flat.

OLEDs can mimic a natural feeling of light in the dark. If turned off, they are transparent - an ideal precondition for windows. It is also imaginable that tables, cupboards or other furniture are used as a light source.

The problem is (as in general for OLED) the fast burnout of the blue component. Blue is one of the major colors needed to make white light. Physicist are working to resolve this problem.

The newspaper of the future might be an OLED display that refreshes with breaking news, and like a regular newspaper, you could fold it up when you're done reading it and stick it in your backpack or briefcase.

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

SIRUGANUR TRICHY

DEPARTMENT OF MECHATRONICS ENGINEERING

ACADEMIC YEAR 2019-2020 ODD SEMESTER

TEACHER TEACH TEACHERS (TTT) SCHEME

Date: 19.07.2019

Speaker : Mr.S.Saravanan
Assistant Professor
Mechatronics Engineering

Staff Attended : Mr.M.Chandrasekar
Mr.Karthikeyan
Mr.Tamilarasan
Mr.Arumugasamy
Mr.Ravichandran
Mrs.Deepika

Topic : Shape Memory Alloy (SMA) and its Applications

Venue : Smart Class

Date : 18.07.2019
Time : 2pm to 3pm

**Enclosure Report

20/7/19
HoD

Principal

Scanned with CamScanner

SHAPE MEMORY ALLOY

Presented by,

S.Saravanan

Assistant Professor

Mechatronics Engineering

MAM School of Engineering

Scanned with CamScanner

ABSTRACT

The aim of this seminar is an introduction to shape memory alloys, the materials that change shape on applying heat. This paper contains a brief history, description of general characteristics of the shape memory alloys and their advantages and limitations. At the end are mentioned groups of most widely used commercial applications.

CONTENTS

Scanned with CamScanner

1. INTRODUCTION

Metals are characterized by physical qualities as tensile strength, malleability and conductivity. In the case of shape memory alloys, we can add the anthropomorphic qualities of memory and trainability. Shape memory alloys exhibit what is called the shape memory effect. If such alloys are plastically deformed at one temperature, they will completely recover their original shape on being raised to a higher temperature. In recovering their shape the alloys can produce a displacement or a force as a function of temperature. In many alloys combination of both is possible. We can make metals change shape, change position, pull, compress, expand, bend or turn, with heat as the only activator.

Shape memory alloys have found use in everything from space missions (pathfinder and many more) to floral arrangement (animated butterflies, dragon flies and fairies), from bio-medical applications, to actuators for miniature robots and cell phone antennas and even eyeglasses use SMA wires for their extreme flexibility.

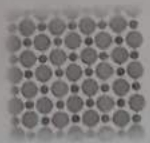
2. HISTORY

First observations of shape memory behaviour were in 1932 by Olander in his study of "rubber like effect" in samples of gold–cadmium and in 1938 by Greninger and Mooradian in their study of brass alloys (copper–zinc). Many years later (1951) Chang and Read first reported the term "shape recovery". They were also working on gold–cadmium alloys. In 1962 William J. Buehler and his co–workers at the Naval Ordnance Laboratory discovered shape memory effect in an alloy of nickel and titanium. He named it NiTiNOL (for Nickel–Titanium Naval Ordnance Laboratory).

3. DEFINITION OF A SHAPE MEMORY ALLOY

Shape memory alloys are a unique class of metal alloys that can recover apparent permanent strains when they are heated above a certain temperature. The shape memory alloys have two stable phases - the high–temperature phase, austenite and the low–temperature phase, martensite.

Austenite
- High temperature phase
- Cubic crystal structure



Scanned with CamScanner

4. TYPES OF SHAPE MEMORY EFFECTS

4.1 ONE WAY MEMORY EFFECT

If an alloy, which is in a state of self–accommodated martensite, is deformed by applying mechanical load and then unloaded, remains deformed. If the alloy is then reheated to a temperature above the austenite finish temperature, it recovers original macroscopic shape. This is so called one–way memory effect. During the one–way memory effect internal structural changes take place. When we apply load to the self–accommodated martensite, this structure becomes deformed through variant rearrangement, resulting in a net macroscopic shape change. If the alloy is now reheated to a temperature above the martensitic transformation range the original parent phase microstructure and macroscopic geometry is restored. This is possible because no matter what the post deformation distribution of martensite variants, there is only one reversion pathway to parent phase for each variant. If the alloy is cooled again under martensitic finish temperature, a self–accommodated martensite microstructure is formed and the original shape before deformation is retained. Thus one–way shape memory is achieved.

4.2 TWO WAY MEMORY EFFECT

In one–way memory effect there is only one shape "remembered" by the alloy. That is the parent phase shape (so-called hot shape). Shape memory alloys can be processed to remember both hot and cold shapes. They can be cycled between two different shapes without the need of external stress. Two–way shape memory changes rely entirely on micro-structural changes during martensitic transformation which occur under the influence of internal stress. Self–accommodation of the martensite microstructure is lost in the two-way effect due to the presence of these internal stresses. Internal stress may be introduced in a number of ways. Usually we talk about "training" of shape memory alloy. Internal stress is usually a result of irreversible defects which can be introduced through cyclic deformation between hot and cold shapes at a temperature above austenite finish temperature.

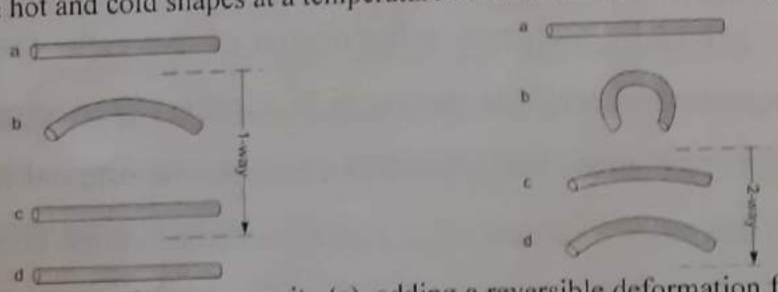


Figure 3: Starting from martensite (a), adding a reversible deformation for the one-way effect or severe deformation with an irreversible amount for the two-way (b), heating the sample (c) and cooling it again (d).

Scanned with CamScanner

5. PSEUDOELASTICITY OR SUPERELASTIC EFFECT

One of the commercial uses of shape-memory alloy exploits the pseudo-elastic properties of the metal during the high-temperature (austenitic) phase. The frames of reading glasses have been made of shape-memory alloy as they can undergo large deformations in their high-temperature state and then instantly revert back to their original shape when the stress is removed. This is the result of pseudo-elasticity; the martensitic phase is generated by stressing the metal in the austenitic state and this martensite phase is capable of large strains. With the removal of the load, the martensite transforms back into the austenite phase and resumes its original shape.

This allows the metal to be bent, twisted and pulled, before reforming its shape when released. This means the frames of shape-memory alloy glasses are claimed to be "nearly indestructible" because it appears that no amount of bending applied on it results in permanent plastic deformation.

6. ADVANTAGES AND DISADVANTAGES

Some of the main advantages of shape memory alloys include:

- Bio-compatibility
- Diverse Fields of Application
- Good Mechanical Properties (strong, corrosion resistant)

The use of NiTi as a biomaterial has severable possible advantages. Its shape memory property and super elasticity are unique characteristics and totally new in the medical field. The possibility to make self-locking, self expanding and self- compressing thermally activated implants is fascinating. As far as special properties and good bio compatibility are concerned, it is evident that NiTi has a potential to be a clinical success in several applications in future.

There are still some difficulties with shape memory alloys that must be overcome before they can live up to their full potential. These alloys are still relatively expensive to

Scanned with CamScanner

manufacture and machine compared to other materials such as steel and aluminum. Most SMA's have poor fatigue properties; this means that while under the same loading conditions (i.e. twisting, bending, compressing) a steel component may survive for more than one hundred times more cycles than an SMA element.

7. APPLICATIONS

- **AIRCRAFT MANEUVERABILITY**

The wire on the bottom of the wing is shortened through the shape memory effect, while the top wire is stretched bending the edge downwards, the opposite occurs when the wing must be bent upwards. The shape memory effect is induced in the wires simply by heating them with an electric current.

- **BONE PLATES**

Bone plates are surgical tools, which are used to assist in the healing of broken and fractured bones. The breaks are first set and then held in place using bone plates in situations where casts cannot be applied to the injured area. Bone plates are often applied to fractures occurring to facial areas such the nose, jaw or eye sockets. Bone plates can be fabricated using shape memory alloys.

- **MINIATURIZED WALKING ROBOT**

The implementation of SMA wires coupled with a

Scanned with CamScanner

simple DC control system can be used to drive small objects without the addition of relatively heavy motors, gears, or drive mechanisms.

- **ROBOTIC MUSCLE**

Shape memory alloys mimic human muscles and tendons very well. SMA's are strong and compact so that large groups of them can be used for creating a life-like movement unavailable in other systems.

8. CONCLUSION

The many uses and applications of shape memory alloys ensure a bright future for these metals. Research is currently carried out at many robotics departments and materials science departments. With the innovative ideas for applications of SMAs and the number of products on the market using SMAs continually growing, advances in the field of shape memory alloys for use in many different fields of study seem very promising.

There are many possible applications for SMAs. Future applications are envisioned to include engines in cars and airplanes and electrical generators utilizing the mechanical energy resulting from the shape transformations. Other possible automotive applications include using SMA springs in engine cooling, carburetor and engine lubrication controls.

9. REFERENCES

- "Materials Science and engineering" by William D.Callister, Jr.
- http://smart.tamu.edu
- Shape Memory Applications Inc._Shape Memory Alloys.
  http://www.sma-inc.com/SMAPaper.html
- Mechanical properties and reactive stresses of Ti-Ni shape memory alloys.
  N. N. Popov, T. I. Sysoeva, S. D. Prokoshkin, V. F. Lar'kin and I. I. Vedernikova.

Scanned with CamScanner

simple DC control system can be used to drive small objects without the addition of relatively heavy motors, gears, or drive mechanisms.

- **ROBOTIC MUSCLE**

Shape memory alloys mimic human muscles and tendons very well. SMA's are strong and compact so that large groups of them can be used for creating a life-like movement unavailable in other systems.

8. CONCLUSION

The many uses and applications of shape memory alloys ensure a bright future for these metals. Research is currently carried out at many robotics departments and materials science departments. With the innovative ideas for applications of SMAs and the number of products on the market using SMAs continually growing, advances in the field of shape memory alloys for use in many different fields of study seem very promising.

There are many possible applications for SMAs. Future applications are envisioned to include engines in cars and airplanes and electrical generators utilizing the mechanical energy resulting from the shape transformations. Other possible automotive applications include using SMA springs in engine cooling, carburetor and engine lubrication controls.

9. REFERENCES

- "Materials Science and engineering" by William D.Callister, Jr.
- http://smart.tamu.edu
- Shape Memory Applications Inc._Shape Memory Alloys.
  http://www.sma-inc.com/SMAPaper.html
- Mechanical properties and reactive stresses of Ti-Ni shape memory alloys.
  N. N. Popov, T. I. Sysoeva, S. D. Prokoshkin, V. F. Lar'kin and I. I. Vedernikova.

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

Siruganur, Tiruchirappalli – 621 105.

Department of Mechatronics Engineering

Teacher Teach Teacher (TTT)

Academic year (2019-2020) Even semester

Date: 10 .2.2020

Speaker: Ms.M.Suba pradha
Assistant Professor – Mechatronics Engineering

Staff attended:

1. Mr.M.Chandra sekar
2. Mr.S.Saravanan
3. Mr.S.Ravichandran
4. Mr.M.Arumugasamy
5. Mrs.P.Sudha
6. Mr.Karthikeyan

Topic:

Introduction To IPR and its needs

Venue:

Smart class

Date & Time:

10th February 2020 & 1.30 P.M to 2.30 P.M

**enclosure: Report

11/2/20

HOD **PRINCIPAL**

Scanned with CamScanner

REPORT

The session was initiated by Ms.M.Suba pradha Assistant Professor/Mct, the topic for the Lecture is Introduction To IPR and its needs and discuss about the following topics

- Intellectual property rights
- Infringement
- Patent
- Overview of patenting process using PCT
- Industrial Design
- Trademarks
- Copyrights

The session comes to an end with the explaining the overview of IPR and its needs.

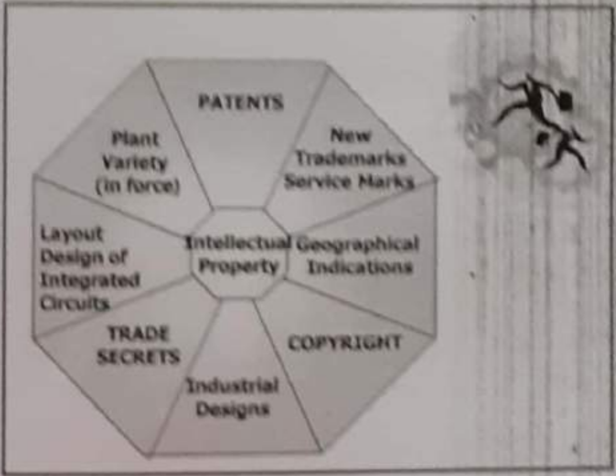
HOD

Scanned with CamScanner

DIPP
MINISTRY OF COMMERCE AND INDUSTRIES
GOVERNMENT OF INDIA

INTRODUCTION TO IPR AND ITS NEEDS

PRESENTED BY
SUBA PRADHA.M
ASSISTANT PROFESSOR
MECHATRONICS DEPARTMENT



PATENTS

New Trademarks Service Marks

Geographical Indications

COPYRIGHT

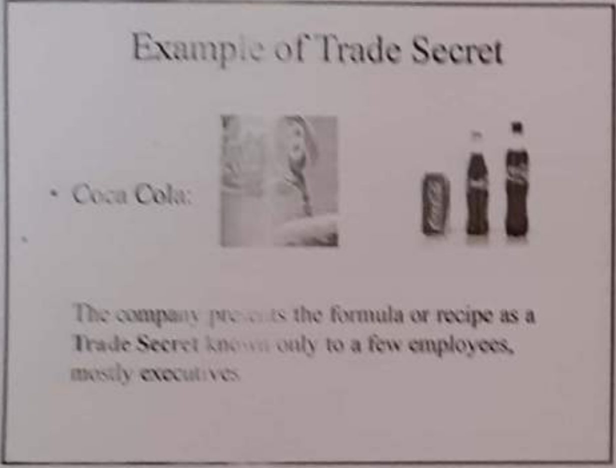
Industrial Designs

TRADE SECRETS

Layout Design of Integrated Circuits

Plant Variety (in force)

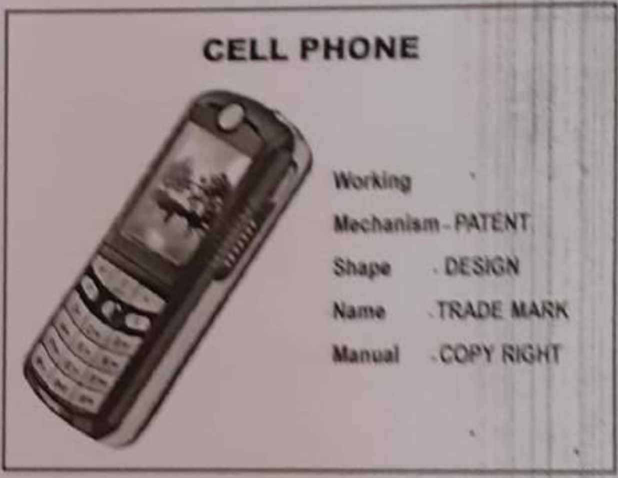
Intellectual Property



Example of Trade Secret

- Coca Cola:

The company protects the formula or recipe as a Trade Secret known only to a few employees, mostly executives



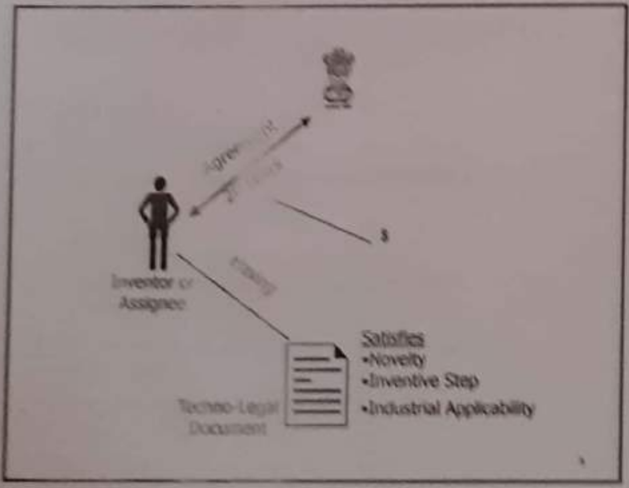
CELL PHONE

Working Mechanism - PATENT

Shape - DESIGN

Name - TRADE MARK

Manual - COPY RIGHT



Satisfies
- Novelty
- Inventive Step
- Industrial Applicability

INFRINGEMENT

- Nutrisciences innovation Ltd – New york based herbal medicine company – registered the name "jeevani" at USPTO.
- Great Earth Inc. (Great Earth), another New York based supplement and vitamin company-marketed an energy drink called "Jeevani Jolt 1000" that included the same ingredients as those in the original Jeevani.

Scanned with CamScanner

Research Commercialization at Universities through IPR cell

- Evaluate inventions for patenting
- University work closely with inventors
- Work with legal experts for obtaining and management of patents
- Identify and negotiate with a commercial partner for license or collaboration agreements
- Managing relationship with commercial partners

Criteria for Patentability

An invention must pass through all 3 doors of patentability:

Novelty - New

- The invention should not have been published in India or elsewhere.
- The invention should not have been in prior public knowledge or public use in India.
- Exception: display in public exhibition or paper presented before a learned society but within twelve months, patent application should be filed.

Inventive Step or Non-Obvious

- "Inventive step" means a feature of an invention that involves technical advancement as compared to the existing knowledge or having economic significance or both and that makes the invention not obvious to a person skilled in the art.
- The question, 'is there any inventive step?' arises only if there is novelty.

NON PATENTABLE INVENTIONS

Section 3(a)

- Frivolous inventions
- Inventions contrary to well established natural laws

Examples

- Machine producing mare than 100% performance.
- A machine alleged to give output without any input.
- Perpetual motion machines

NON PATENTABLE INVENTIONS

Section 3 (c)

- Mere Discovery of a Scientific Principle or
- formulation of an Abstract Theory or
- discovery of any living thing or
- discovery of non-living substance occurring in nature

Examples

- Newton's law.
- Darwin's theory.
- Discovery of an animal.
- Discovery of natural gas or a mineral.

Scanned with CamScanner

What are not Inventions?......

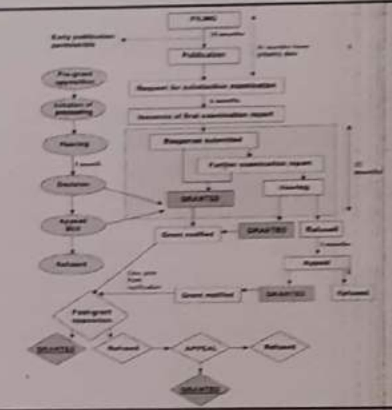
- Plants and animals in whole or any part thereof including seed varieties and species and essentially biological process for production or propagation of animals but other than *genetically modified micro-organisms (GMO)*
- *Eg. Clones and new varieties of plants.*
- *Sec. 3(j)*

Provisional Specification

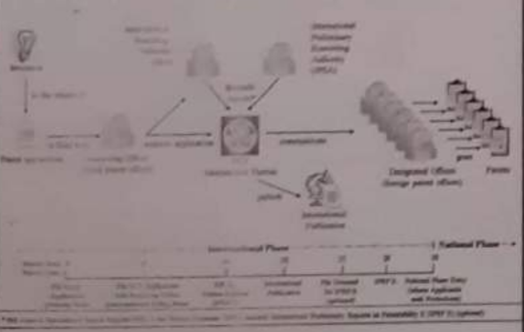
- Should contain title, Problem in the art and nature of the invention with probable solution.
- To claim the priority date of the invention
- Need not contain claims, drawings.
- Complete specification within 12 months

Complete Specification

- Title of the invention
- Field of Invention
- Uses of the invention
- Prior art
- Drawbacks of the prior art
- Comparison of prior art and the invention
- Summary of the invention
- Drawings
- Detailed description of the invention
- Claims.



Overview of the Patenting Process using the PCT System



Source: WIPO

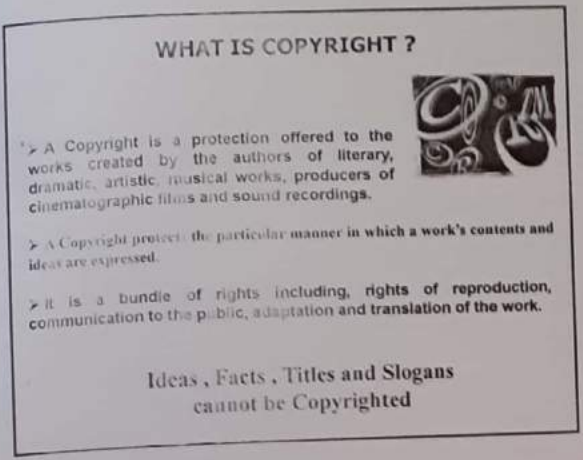
INDUSTRIAL DESIGNS

An Industrial design is that aspect of a useful article, which is ornamental or aesthetic. Two-dimensional features like patterns, lines, colors etc. and three-dimensional features like shape, surface of the article etc.

e.g. shape of a handle or body portion of a pressure cooker

A Design must be ***new or original and industrially reproducible*** in order to become eligible for protection under Industrial designs law. Protection of Industrial designs is territorial and there is only civil remedy available against its infringement.

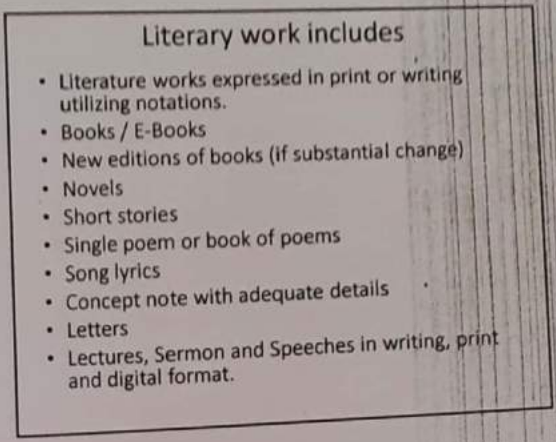
Scanned with CamScanner



WHAT IS COPYRIGHT ?

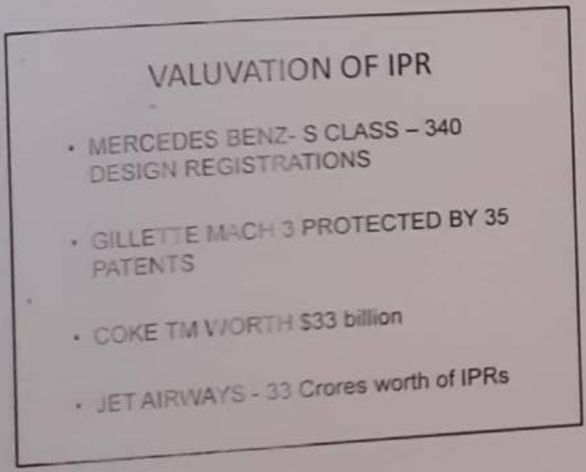
- A Copyright is a protection offered to the works created by the authors of literary, dramatic, artistic, musical works, producers of cinematographic films and sound recordings.
- A Copyright protects the particular manner in which a work's contents and ideas are expressed.
- It is a bundle of rights including, rights of reproduction, communication to the public, adaptation and translation of the work.

Ideas , Facts , Titles and Slogans
cannot be Copyrighted



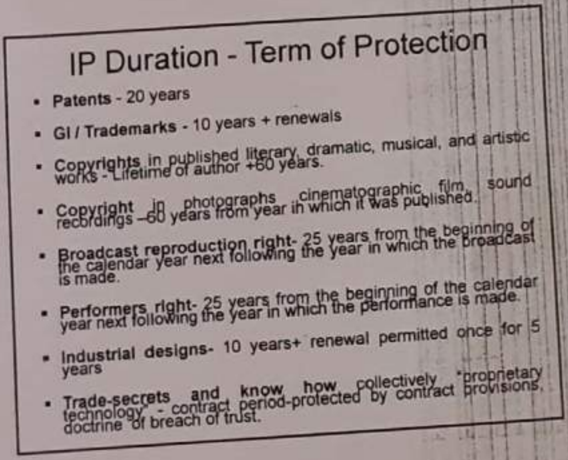
Literary work includes

- Literature works expressed in print or writing utilizing notations.
- Books / E-Books
- New editions of books (if substantial change)
- Novels
- Short stories
- Single poem or book of poems
- Song lyrics
- Concept note with adequate details
- Letters
- Lectures, Sermon and Speeches in writing, print and digital format.



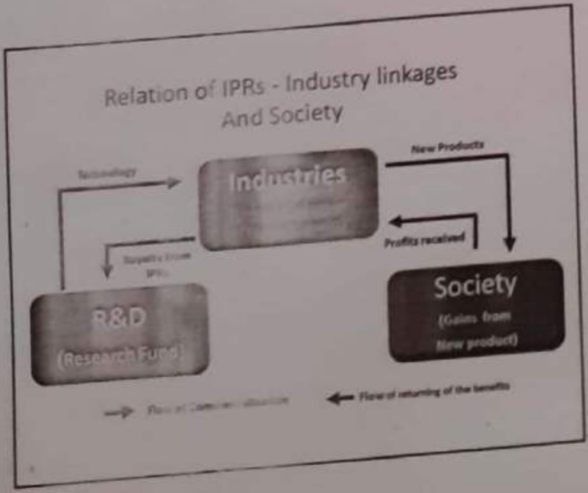
VALUVATION OF IPR

- MERCEDES BENZ- S CLASS – 340 DESIGN REGISTRATIONS
- GILLETTE MACH 3 PROTECTED BY 35 PATENTS
- COKE TM WORTH $33 billion
- JET AIRWAYS - 33 Crores worth of IPRs



IP Duration - Term of Protection

- **Patents** - 20 years
- **GI / Trademarks** - 10 years + renewals
- **Copyrights** in published literary, dramatic, musical, and artistic works - Lifetime of author +60 years.
- **Copyright** in photographs, cinematographic film, sound recordings –60 years from year in which it was published.
- **Broadcast reproduction right**- 25 years from the beginning of the calendar year next following the year in which the broadcast is made.
- **Performers right**- 25 years from the beginning of the calendar year next following the year in which the performance is made.
- **Industrial designs**- 10 years+ renewal permitted once for 5 years
- **Trade-secrets** and know how collectively "proprietary technology" - contract period-protected by contract provisions, doctrine of breach of trust.



Relation of IPRs - Industry linkages And Society

Technology
Industries
New Products
Profits received
Royalty from IPRs
R&D (Research Fund)
Society (Gains from New product)
Flow of Commercialization
Flow of returning of the benefits

THANK YOU...

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING
SIRUGANUR, TRICHY-621105
(Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai)
(An ISO 9001: 2008 Certified Institution)
(ACCREDITED BY NAAC)

DEPARTMENT OF MECHATRONICS ENGINEERING

WEBINAR

on

"MICRO FABRICATION TECHNIQUES FOR MEMS"

26.05.2020

2/6/20

H.O.D **PRINCIPAL**

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi I Affiliated to Anna University)
Siruganur, Trichy - 621 105

Department of Mechatronics
Organises

Webinar on
Micro Fabrication Techinques for MEMS

Resource person

zoom

Dr. L. Sujatha,

Head, Centre of Excellence in MEMS & Microfluidics
Rajalakshmi Engineering College, Chennai.

Date: 26/05/2020, Time: 11.00am.

For Registration Visit
www.mamse.in

Scanned with CamScanner

Resource Person Profile

Dr. L. Sujatha, Head, Centre of Excellence in MEMS & Microfluidics (CEMM) and Professor in the Department of Electronics & Communication Engineering, Rajalakshmi Engineering College (REC), Chennai has 30 years of experience in teaching and research. Graduating with an A.M.I.E. in Electronics & Communication Engineering from Institution of Engineers (INDIA) in 1991, she obtained her M.E. (Applied Electronics) from Bharathiar University in 1996. She has done her PhD and Post-Doctoral Research in the field of Micro Electro Mechanical Systems (MEMS) at Indian Institute of Technology Madras. She is a recognized supervisor under Anna University and guided 3 research scholars for their PhD degree. She has published two book chapters, 40 journal papers in refereed international journals, more than 60 International Conferences. She had received a "Best Woman Engineer" award from Pondicherry Engineering College in the year 2007 and received "Dr. A.P.J. Abdul Kalam Award' for Innovative Research" by Society for Engineering Education Enrichment (SEEE) in the year 2017. She is a Life Member of various technical societies such as IEI, ISSS, ISTE, IETE and SEEE. She had visited Singapore, European Countries and USA for presenting her research works. She has established a "Centre of Excellence in MEMS & Microfluidics" at Rajalakshmi Engineering College with sophisticated equipment and Clean Room facilities for in-house fabrication of microdevices. She fabricated many Micro Devices such as Micro Tweezers, Micro-heater, MEMS Gyroscope, Tri-axes Accelerometer, Digital Microfluidics etc. She has successfully completed 10 sponsored projects and received funding of Rs 7 Crores from various funding agencies such aş DRDO, DST, AERB etc. She is very passionate on research activities on microfabrication technologies and developing chemical and biosensors.

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING
Siruganur, Trichy-621105

Department of Mechatronics Engineering

Webinar on "Micro Fabrication techniques for MEMS"

(26th MAY, 2020)

Department of Mechatronics Engineering had the privilege of having webinar with Dr. L. Sujatha, Head - Centre of Excellence in MEMS & Micro fluidics, Rajalakshmi Engineering College, Chennai. on the topic of "Micro Fabrication techniques for MEMS".

The invitation for this program by the designer team of MAMSE and distributed through face book. The registration form for this program has created by Google form and published in our college website on 24th May 2020.

The link for the registration:
https://docs.google.com/forms/d/e/1FAIpQLSeavDtiSJmEbOqoD_LiquFQHWmbsOElhyX20igCYA4v-S4LpA/viewform

Totally 113 participant has register for this webinar. The session is started sharply by 11 am from welcome address and introduction given by Dr.Punitha, Professor, Mechatronics Engineering Department. After that the resource person starts the lecture with the introduction of MEMS. Later she gave the lecture with Different types of Fabrication methods and its process and etc. The event ended with vote of thanks given by P.Sudha Head of the Department, Mechatronics Engineering Department. Also the feedback for the participant was collected through Google form.

The link for the Feedback:
https://docs.google.com/forms/d/e/1FAIpQLSdB5SiXHH2Dr7YgEZigi-u21PvTX9cJ1yC-cHfjUdi_y5CwVA/viewform

Program Co-ordinator **HOD**

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING
DEPARTMENT OF MECHATRONICS
Feedback for the Webinar "Micro Fabrication techniques for MEMS"

Sl.No	Timestamp	Name	Institution	Department	At Present	Year	Email ID	What about the session?
1	2020/05/26 11:48:06 AM GMT+5:30	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	Not applicable	saravananknm@gmail.com	Excellent
2	2020/05/26 11:48:32 AM GMT+5:30	Gopi K	Periyar Centenary Polytechnic college	Mechanical	Faculty	Not applicable	gopiindian555@gmail.com	Good
3	2020/05/26 11:50:02 AM GMT+5:30	A.satheesh kumar	Mam school of engineering	Mechatronics	Student	II	satheshkumar4444@gmail.com	Excellent
4	2020/05/26 11:50:03 AM GMT+5:30	Vaitheeswari.V	Mam school of engineering	Mechatronics	Student	IV	vaitheeswarimechatronics@gmail.com	Excellent
5	2020/05/26 11:52:12 AM GMT+5:30	P. Palanisamy	M. A. M. SCHOOL OF ENGINEERING	Aeronautical	Student	III	Palaniaero35@gmail.com	Excellent
6	2020/05/26 11:52:43 AM GMT+5:30	K.KARTHIKEYAN	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	Not applicable	karthikcacet121@gmail.com	Excellent
7	2020/05/26 11:54:50 AM GMT+5:30	R Nirmal	Trichy engineering college	Electrical and Electronics	Faculty	Not applicable	nirmalpse@gmail.com	Good
8	2020/05/26 11:54:52 AM GMT+5:30	VIVEKNIJANTHAN L	Periyar Centenary Polytechnic College, Vallam, Thanjavur	Department of Mechanical Engineering	Faculty	Not applicable	vknijanthan96@gmail.com	Excellent
9	2020/05/26 12:03:04 PM GMT+5:30	N.Timple Rosni Augustina	M.A.M.school of engineering	CSE	Student	I	timplerosni@gmail.com	Excellent
10	2020/05/26 12:05:57 PM GMT+5:30	S . SRIRAM NIVAS	M. A. M. SCHOOL OF ENGINEERING	MECHATRONICS	Student	I	sriramnivas1104@gmail.com	Excellent
11	2020/05/26 12:06:48 PM GMT+5:30	Saravana Kumar K	Periyar centenary polytechnic college	Mechanical engineering	Faculty	Not applicable	saran07mech@gmail.com	Good
12	2020/05/26 12:07:39 PM GMT+5:30	RAJESHKUMAR	MAM SCHOOL OF ENGINEERING	CSE	Faculty	Not applicable	grkresearch@gmail.com	Excellent
13	2020/05/26 12:19:31 PM GMT+5:30	P.GRANAF	MAM SCHOOL OF ENGINEERING	CSE	Student	I	granafpaul@gmail.com	Excellent
14	2020/05/26 12:45:21 PM GMT+5:30	Elangathir	Mam school of engineering	Mechatronics	Student	IV	elangathirmamse@gmail.com	Average
15	2020/05/26 12:54:10 PM GMT+5:30	Dr. LILLY FLORENCE. P	M. A. M. School of Engineering	Chemistry	Faculty	Not applicable	mamseonlineclasses@gmail.com	Good
16	2020/05/26 12:55:49 PM GMT+5:30	MUTHUKUMARAN D	Periyar Centenary Polytechnic college.vallam	Mechanical engineering	Faculty	Not applicable	kumaranmuthu00@gmail.com	Excellent
17	2020/05/26 1:02:36 PM GMT+5:30	Sumathi Sivakumar	Mam school of engineering	Cse	Faculty	Not applicable	dsumihari@gmail.com	Good
18	2020/05/26 1:08:28 PM GMT+5:30	SUDHA P	M.A.M SCHOOL OF ENGINEERING	MECHATRONICS ENGINEERING	Faculty	Not applicable	suha1906@gmail.com	Excellent
19	2020/05/26 1:25:39 PM GMT+5:30	R. Arun Kumar	M. A. M school of engineering	Mechatronics	Student	IV	arunselvi141@gmail.com	Good
20	2020/05/26 2:44:37 PM GMT+5:30	Jenith Kumar.B	M.A.M School of Engineering	Mechatronics	Student	II	jenithbala07@gmail.com	Excellent
21	2020/05/26 3:25:59 PM GMT+5:30	LALUPRASHANTH-A	Mam school of engineering	Mechatronics	Student	II	aplalu2001@gmail.com	Excellent
22	2020/05/26 3:51:38 PM GMT+5:30	Prasanth.P	M.A.M school of engineering	MECHATRONICS	Student	IV	josephprasanth1999@gmail.com	Excellent
23	2020/05/26 5:15:58 PM GMT+5:30	M.SUBA PRADHA	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	Not applicable	cool.pradha@gmail.com	Excellent
24	2020/05/26 5:36:04 PM GMT+5:30	T. Varshini	M. A. M. School of engineering	Mechatronics	Student	III	Varshinithapasu@gmail.com	Good
25	2020/05/26 9:42:46 PM GMT+5:30	P.MANOJ KUMAR	MAM SCHOOL OF ENGINEERING	MECHATRONICS	Student	II	msmano3786@gmail.com	Excellent

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING

DEPARTMENT OF MECHATRONICS

List of Pasticipants Registration for the Webinar "Micro Fabrication techniques for MEMS"

Sl.No	Timestamp	Name	Institution	Department	At Present	Designation	Year	Gender	Email ID	Mobile Number
1	2020/05/25 6:41:26 PM GMT+5:30	Rajeshkumar	MAM School of Engineering	CSE	Faculty	Assistant Professor	Not applicable	Male	[illegible]@gmail.com	9677787134
2	2020/05/25 7:21:24 PM GMT+5:30	Sivamalar P	MAM school of Engineering	CSE	Faculty	Assistant Professor	Not applicable	Female	sivamalarp23@gmail.com	9944419074
3	2020/05/25 7:21:33 PM GMT+5:30	SATHISH KUMAR K	MAM SCHOOL OF ENGINEERING	CSE	Faculty	Assistant Professor	IV	Male	ksk2mohan@gmail.com	7530050947
4	2020/05/25 7:24:37 PM GMT+5:30	A satheesh kumar	Mam school of engineering	Mechatronics	Student	Not applicable	II	Male	satheeshkumar4444@gmail.com	7558103874
5	2020/05/25 7:25:23 PM GMT+5:30	M.SUBA PRADHA	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	Assistant Professor	Not applicable	Female	cool pradha@gmail.com	9791802917
6	2020/05/25 7:25:25 PM GMT+5:30	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	Assistant Professor	Not applicable	Male	saravanankom@gmail.com	9843042115
7	2020/05/25 7:25:44 PM GMT+5:30	Dhanalakshmi D	M.A.M.School of Engineering	EEE	Faculty	Assistant Professor	Not applicable	Female	dhanalakshmi28011996@gmail.com	8110955171
8	2020/05/25 7:25:50 PM GMT+5:30	Jenith Kumar. B	M.A.M School of Engineering	Mechatronics	Student	Not applicable	II	Male	jenithbala07@gmail.com	9047132812
9	2020/05/25 7:27:07 PM GMT+5:30	Vidhya V	M.A.M. School of Engineering	CSE	Faculty	Assistant Professor		Female	vidhyavfbe@gmail.com	9486890998
10	2020/05/25 7:29:17 PM GMT+5:30	Vaitheeswari.V	Mam school of engineering	Mechatronics	Student	Not applicable	IV	Female	vaitheeswarimechatronics@gmail.com	9361140549
11	2020/05/25 7:29:55 PM GMT+5:30	S.Praveenkumar	MAM school of engineering	Mechatronics	Student	Not applicable	II	Male	monsterbubloo0@gmail.com	8946075031
12	2020/05/25 7:31:23 PM GMT+5:30	M.Muralidharan	MAMSE	Mechatronics	Student	Assistant Professor	IV	Male	muralikutty117@gmail.com	9751477824
13	2020/05/25 7:31:36 PM GMT+5:30	Sowndarya.L	M.A.M school of engineering	Mechatronics engineering	Student	Not applicable	III	Female	sowndaryalakshmanansowndarya@gmail.com	6385303622
14	2020/05/25 7:34:08 PM GMT+5:30	Kishore.R	Coimbatore Institute of Technology	ECE	Student	Not applicable	I	Male	kishore1207india@gmail.com	9789728800
15	2020/05/25 7:34:38 PM GMT+5:30	K.KOWSALYA	M.S.M SCHOOL OF ENGINEERING	MECHATRONICS	Student	Not applicable	IV	Female	kowsi0371@gmail.com	9384974457
16	2020/05/25 7:35:05 PM GMT+5:30	Vishnu.E	MAMSchool Of Engineering	Mechatronics	Student	Not applicable	II	Male	Vishnuraja19v@ail.com	9943593647
17	2020/05/25 7:37:55 PM GMT+5:30	VIVEKNIJANTHAN.L	Periyar Centenary Polytechnic College, Vallam, Thanjavur	Department of Mechanical Engineering	Faculty			Male	vknijanthan96@gmail.com	8760086370
18	2020/05/25 7:38:01 PM GMT+5:30	R. Arun Kumar	M. A. M school of engineering	Mechatronics	Student	Not applicable	IV	Male	arunselvi141@gmail.com	8610145268
19	2020/05/25 7:38:44 PM GMT+5:30	MURUGAVALLI SANGILIMUTHU	M. A. M SCHOOL OF ENGINEERING	CSE	Faculty	Associate Professor	Not applicable	Female	vallisangilimuthu2012@gmail.com	8220912297
20	2020/05/25 7:39:48 PM GMT+5:30	Praveen S	M.A.M School of Engineering	Mechatronics	Student	Not applicable	III	Male	spraveen1617@gmail.com	6380108060
21	2020/05/25 7:41:47 PM GMT+5:30	Rajkumar D	Periyar centenary polytechnic college	Mechanical	Faculty	Professor	IV	Male	sathushkavi@gmail.com	8973868633
22	2020/05/25 7:45:04 PM GMT+5:30	M. Manisha	MAM school of engineering	Mechatronics	Student	Not applicable	IV	Female	manishamuthu199@gmail.com	7397128708
23	2020/05/25 7:47:59 PM GMT+5:30	MUGESH KUMAR. B	MAM SCHOOL OF ENGINEERING	MECHATRTONICS	Student	Not applicable	IV	Male	plamugesh144@gmail.com	6385601333
24	2020/05/25 7:48:27 PM GMT+5:30	Aswin	Mam school of engineering	Mechatronics	Student		II	Male	aswin2periyasamy@gmail.com	8.12118E+11
25	2020/05/25 7:49:32 PM GMT+5:30	B sankar	M.A.M . school of engineering	Mechatronics	Student	Not applicable	IV	Male	bsankarbala534@gmail.com	8870335042
26	2020/05/25 7:50:15 PM GMT+5:30	P.MANOJ KUMAR	MAM SCHOOL OF ENGINEERING	MECHATRONICS	Student	Not applicable	II	Male	mmano3786@gmail.com	6374853895
27	2020/05/25 7:51:25 PM GMT+5:30	Prasanth P	MAM School of Engineering	Mechatronics	Student	Not applicable	IV	Male	josephprasanth1999@gmail.com	8525018372
28	2020/05/25 7:53:38 PM GMT+5:30	Nitheesh M	MAM School of Engineering	Mechatronics	Student	Not applicable	IV	Male	nitheeshmechz2020@gmail.com	9787634007

Scanned with CamScanner

29	2020/05/25 7:57:28 PM GMT+5:30	Kowsalya R	Mam school of engineering	Cse	Student	Not applicable	III	Female	[illegible]@gmail.com	[illegible]
30	2020/05/25 8:23:07 PM GMT+5:30	RAVICHANDRAN S	M A M School of Engineering Trichy	Mechanical Engineering	Faculty	Assistant Professor	Not applicable	Male	[illegible]@gmail.com	[illegible]
31	2020/05/25 8:29:26 PM GMT+5:30	R Sanjai	M.A.M SCHOOL OF ENGINEERING	MECHATRONICS	Student	Not applicable	II	Male	[illegible]@gmail.com	[illegible]
32	2020/05/25 8:30:06 PM GMT+5:30	LALUPRASHANTH-A	MAM school of engineering	Mechatronics	Student		II	Male	aplalu2001@gmail.com	9629724975
33	2020/05/25 8:42:27 PM GMT+5:30	VIJAYAKUMAR.K	M. A. M. SCHOOL OF ENGINEERING	MECHATRONICS	Student	Not applicable	IV	Male	k.vijay.kvs.0207@gmail.com	9159582190
34	2020/05/25 9:04:12 PM GMT+5:30	Ramachandran	M. A. M school of engineering	Mechatronics	Student	Not applicable	IV	Male	ramc2852@gmail.com	9789368294
35	2020/05/25 9:05:59 PM GMT+5:30	J Eviganas Banu	Roever engineering college	Computer science and engineering	Student	Not applicable	I	Female	eviganasbanu@gmail.com	8220858971
36	2020/05/25 9:07:44 PM GMT+5:30	Gopi K	Periyar centenary polytechnic college	Mechanical	Faculty	Not applicable	Not applicable	Male	gopiindian555@gmail.com	8870723732
37	2020/05/25 9:16:09 PM GMT+5:30	Dr. S.Rooban	Kl university	ECE	Faculty	Associate Professor	Not applicable	Male	rooban@kluniversity.in	9944043430
38	2020/05/25 9:27:30 PM GMT+5:30	Ajay.A	MAM school of engineering	Mechatronics	Student	Not applicable	II	Male	ajayzion875@gmail.com	6380883205
39	2020/05/25 9:28:17 PM GMT+5:30	K.KARTHIKEYAN	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	Assistant Professor	Not applicable	Male	karthikcacet121@gmail.com	9159683577
40	2020/05/25 9:36:40 PM GMT+5:30	A Ahamed Faisal	MAM school of engineering	Mechatronics	Student		II	Male	ahmedfaisal4171@gmail.com	7639566212
41	2020/05/25 9:42:45 PM GMT+5:30	Thiruneelan	Mam school of the	Mechatronics	Student	Not applicable	III	Male	thiruneelan4@gmail.com	7824985474
42	2020/05/25 9:47:44 PM GMT+5:30	Kavimani	M.A.M.School Of Engineering	CSE	Student	Professor	I	Male	kavimanikavimani85@gmail	8870541455
43	2020/05/25 9:47:59 PM GMT+5:30	S.Akash	MAM School Of Engineering	Mechanical	Student	Not applicable	IV	Male	akash30051999@gmail.com	9677794143
44	2020/05/25 9:53:23 PM GMT+5:30	Berbeth Mary S	MAM School of Engineering, Trichy	Physics	Faculty	Assistant Professor		Female	berbethmary@gmail.com	9715633325
45	2020/05/25 10:15:58 PM GMT+5:30	Balamurugan.G	MAM School of engineering	Mechatronics	Student	Not applicable	IV	Male	balamurugabala75@gmail.com	9790315983
46	2020/05/25 10:43:26 PM GMT+5:30	Prasanth.P	M.A.M scool of engineering	Mechatronics	Student	Not applicable	IV	Male	josephprasanth1999@gmail.com	8525018372
47	2020/05/25 10:46:34 PM GMT+5:30	Dr. P. Lilly Florence	MAM School of Engineering, Trichy	Chemistry	Faculty	Professor	Not applicable	Female	mamseonlineclasses@gmail.com	9345690431
48	2020/05/25 10:52:51 PM GMT+5:30	Elangathir	Mam school of engineering	Mechatronics	Student	Not applicable	Not applicable	Male	Elangathirmamse@gmail.coM	8838022463
49	2020/05/25 11:08:04 PM GMT+5:30	M.MUTHUKUMAR	M.A.M SCHOOL OF ENGINEERING	Mechanical engineering	Student		IV	Male	muthukumar.manikcam@gmail.com	9965375496
50	2020/05/26 12:55:10 AM GMT+5:30	Abinas Kumar	MAMSE	Mechatronics	Student	Not applicable	IV	Male	abinas9199@gmail.com	7339173553
51	2020/05/26 5:53:26 AM GMT+5:30	VIGNESH WARAN	M.A.M SCHOOL OF ENGINEERING	MECHANICAL	Student	Not applicable	II	Male	vw60239@gmail.com	9092280912
52	2020/05/26 6:27:41 AM GMT+5:30	K.Kaviya	M.A.M SCHOOL OF ENGINEERING	CSE	Student	Not applicable	I	Female	aa2984230@gmail.com	9150802546
53	2020/05/26 6:52:33 AM GMT+5:30	B.Bharathi raja	Mam school of engineering	Mechanical	Student	Professor	II	Male	bharathi272001@gmail.com	9626999644
54	2020/05/26 7:34:08 AM GMT+5:30	Kaviya	M.A.M.School of Engineering	ECE	Student	Not applicable	III	Female	ramkaviya1999@gmail.com	8870445972
55	2020/05/26 7:47:04 AM GMT+5:30	Thamilselvan K	M. A. M SCHOOL of ENGINEERING	Mechatronics	Student	Not applicable	IV	Male	tamilamar22@gmail.com	9787752132
56	2020/05/26 7:48:53 AM GMT+5:30	S senthurNivas	Mam school of engineering	Mechanical	Student	Not applicable	II	Male	natpunivas2000@gmail.com	9384288519
57	2020/05/26 7:50:50 AM GMT+5:30	R.VIJAYAKUMAR	MAM school of Engineering	Mechanical Engineering	Faculty	Assistant Professor		Male	Vijayakumarecm@gmail.com	9600262823
58	2020/05/26 7:51:24 AM GMT+5:30	K. Ganesh kannan	M. A. M school of engineering	Mechanical	Student	Not Applicable	II	Male	Siragu 238@gmail.cdm	9600987494
59	2020/05/26 8:06:21 AM GMT+5:30	N.KARTHIK	MAM SCHOOL OF ENGINEERING	MECHANICAL	Student	Not applicable	II	Male	Karthikn.be2018@gmail.com	9087147332
60	2020/05/26 8:38:44 AM GMT+5:30	PRIYADHARSHINI V	M.A.M School of Engineering	Aeronautical	Faculty	Assistant Professor		Female	priyadharshini10896@gmail.com	9688796543
61	2020/05/26 8:40:01 AM GMT+5:30	Shakil	MAMSE	Mechatronics	Student	Not applicable	I	Male	shakilshafa007@gmail.com	7867811500

Scanned with CamScanner

62	2020/05/26 8:41:39 AM GMT+5:30	P Anand	Mam school of engineering	Mechatronics	Student	Not applicable	II	Male	Vijayanand[illegible]	
63	2020/05/26 8:42:17 AM GMT+5:30	V Sivasankar	M.A.M School Of Engineering	Mechanical	Student	Not applicable	II	Male	sivamechboy212@gmail.com	6381759353
64	2020/05/26 8:48:30 AM GMT+5:30	ABDUL RAHMAN K	M.A.M. SCHOOL OF ENGINEERING	AERONAUTICAL ENGINEERING	Student	Not applicable	III	Male	aerosafty100@gmail.com	9965720628
65	2020/05/26 8:54:55 AM GMT+5:30	R NIRMAL	Trichy engineering college	Electrical and Electronics	Faculty	Assistant Professor	Not applicable	Male	nirmalpse@gmail.com	9894181238
66	2020/05/26 8:57:42 AM GMT+5:30	M Murugan	MAM SCHOOL OF ENGINEERING	Mechanical	Student	Not applicable	II	Male	murugesankallai1959@gmail.com	9361770076
67	2020/05/26 8:57:51 AM GMT+5:30	R. Rajkumar	MAM	Mechanical	Student	Associate Professor	II	Male	ravirajkutty143@gmail.com	9791464602
68	2020/05/26 8:58:15 AM GMT+5:30	P JACKVIN JANDRO	M.A.M school of enginnering	Aeronautical engineering	Student	Not applicable	I	Male	jackwinjandro@gmail.com	8778923737
69	2020/05/26 9:01:16 AM GMT+5:30	Vishali M	M.A.M School of Engineering	Aeronautical	Student	Not applicable	IV	Female	vishali aero27@gmail.com	9786422512
70	2020/05/26 9:03:08 AM GMT+5:30	S SRIRAM NIVAS	M. A. M. SCHOOL OF ENGINEERING	MECHATRONICS	Student	Not applicable	I	Male	sriramnivas1104@gmail.com	8925347424
71	2020/05/26 9:03:44 AM GMT+5:30	Gopinath A	Surya college of engineering	Electrical and electronics engineering	Faculty	Assistant Professor	IV	Male	gopinathmec2011@gmail.com	9003177604
72	2020/05/26 9:04:34 AM GMT+5:30	Anupriya C	MAM SCHOOL OF ENGINEERING	Aeronautical	Student	Not applicable	II	Female	hasinivani97@gmail.com	9944862487
73	2020/05/26 9:05:08 AM GMT+5:30	Anjana J G	Nitc	Ece	Research Scholar	Not applicable	II	Female	Jganjana@gmail.com	9746927627
74	2020/05/26 9:07:36 AM GMT+5:30	P Granaf	M.A.M school of engineering	Cse	Student	Not applicable	I	Female	granafpaul@gmail.com	9344329747
75	2020/05/26 9:07:39 AM GMT+5:30	Balamurugan R	M.A.M School Of Engineering	Aeronautical	Student	Not applicable	III	Male	rbnivash1990@gmail.com	6369911208
76	2020/05/26 9:09:15 AM GMT+5:30	T Kirubasree	Trichy Engineering College	EEE	Faculty	Assistant Professor	Not applicable	Female	kirubasree25@gmail.com	9486162460
77	2020/05/26 9:11:11 AM GMT+5:30	Blessingam V	M. A. M School of Engineering	Aeronautical	Student	Not applicable	IV	Male	Wintercrux7@gmail.com	7305424495
78	2020/05/26 9:11:20 AM GMT+5:30	P PALANISAMY	M. A. M. SCHOOL OF ENGINEERING	Aeronautical	Student	Not applicable	III	Male	Palaniaero35@gmail.com	9952575992
79	2020/05/26 9:18:39 AM GMT+5:30	POOJA V	M.A.M School of engineering	IV/Aeronautical	Student	Not applicable	IV	Female	poojamarypooja@gmail.com	8825695611
80	2020/05/26 9:23:13 AM GMT+5:30	Soundharya S	Cms college of engineering	ECE	Student	Not applicable	IV	Female	soundharyarajan1999@gmail.com	6381879853
81	2020/05/26 9:24:19 AM GMT+5:30	K ezhilarasi	Saranathan college of engineering	Instrumentation and control engineering	Faculty	Assistant Professor	II	Female	ezhil.harii@gmail.com	9629305667
82	2020/05/26 9:24:55 AM GMT+5:30	Gautham raj	M.A.M.SCHOOL OF ENGINEERING	Mechanical engineering	Student	Not applicable	II	Male	gauthamraj8344@gmail.com	8344321707
83	2020/05/26 9:25:08 AM GMT+5:30	S.A. Nizar Ahamed	M.A.M School of Engineering	Aeronautical Engineering	Student	Not applicable	II	Male	na0852492@gmail.com	6369058714
84	2020/05/26 9:32:14 AM GMT+5:30	P selvabharathi	M.A.M.school of engineering	B.E mechanical	Student	Not applicable	II	Male	selva2bharathi@gmail.com	6383981587
85	2020/05/26 9:32:18 AM GMT+5:30	Mariyaljosephdurai	MAM School of engineering	Aeronautical	Student	Not applicable	IV	Female	jmariyal1999@gmail	6379169705
86	2020/05/26 9:34:18 AM GMT+5:30	G. Petchiyammal	MAM school of engineering	Electronics and communication engineering	Student	Not applicable	I	Female	gopipetchi123@gmail.com	9361754756
87	2020/05/26 9:39:50 AM GMT+5:30	Nithya.M	Mam school of engineering	Aeronautical engineering	Student	Not applicable	IV	Female	nithyamurugan0303@gmail.com	8508198531
88	2020/05/26 9:41:05 AM GMT+5:30	Ajith kumar	MAM School of engineering	Aeronautical	Student	Not applicable	III	Male	Ajithtony16@gmail.com	9965069921
89	2020/05/26 9:41:51 AM GMT+5:30	I.Sasikumar	MAM SCHOOL OF ENGINEERING	Mechanical	Student	Not applicable	II	Male	sasi84016@gmail.com	9585053680
90	2020/05/26 9:46:25 AM GMT+5:30	Abirami.M	MAM School of engineering	Aeronautical	Student	Not applicable	III	Female	Abiaero22@gmail.com	9790196308
91	2020/05/26 9:48:52 AM GMT+5:30	THURAP MOHIDEEN T M	Periyar centenary polytechnic college	Mechanical	Faculty	Assistant Professor	I	Male	thuraptma@gmail.com	9791808815
92	2020/05/26 9:49:51 AM GMT+5:30	Mohammed bathusha	MAM SCHOOL OF ENGINEERING	Mechanical	Student	Not applicable	II	Male	mohammedbathusha2001@gmail.com	7538816875
93	2020/05/26 9:52:40 AM GMT+5:30	JEEVA D	M.A.M SCHOOL OF ENGINEERING	MECHANICAL	Student	Not applicable	II	Male	jeevadu2001@gmail.com	6385430032
94	2020/05/26 9:53:26 AM GMT+5:30	MOHAMED IZATHUL IQRAM	MAM SCHOOL OF ENGINEERING	MECHANICAL	Student		II	Male	mohamediqram14@gmail.com	6374746534

Scanned with CamScanner

[illegible]	[illegible]	[illegible]	[illegible]							
96	2020/05/26 9:58:14 AM GMT+5:30	Harishchand Nishad	National centre for Nanoscience and Nanotechnology, University of Mumbai	Nanoscience and Nanotechnology	Research Scholar	Not applicable	I	Male	[illegible]	[illegible]
97	2020/05/26 10:04:22 AM GMT+5:30	Monica Gnanaselvam	Trichy Engineering College	EEE	Faculty	Assistant Professor	Not applicable	Female	[illegible]	[illegible]
98	2020/05/26 10:11:53 AM GMT+5:30	SUDHA P	M.A.M SCHOOL OF ENGINEERING	MECHATRONICS ENGINEERING	Faculty	Assistant Professor	Not applicable	Female	[illegible]	[illegible]
99	2020/05/26 10:12:27 AM GMT+5:30	P.Divya	MAM school of engineering	Aeronautical engineering	Student	Not applicable	III	Female	[illegible]	[illegible]
100	2020/05/26 10:17:44 AM GMT+5:30	R.Selvamani	M.A.M.School of engineering	B.E MECHANICAL ENGINEERING	Student	Not applicable	II	Male	[illegible]	[illegible]
101	2020/05/26 10:19:43 AM GMT+5:30	KARTHIK R	Alagappa University	Botany	Research Scholar		II	Male	[illegible]	[illegible]
102	2020/05/26 10:20:49 AM GMT+5:30	Kaviya	MAM SCHOOL OF ENGINEERING	Aeronautical	Student	Not applicable	III	Female	[illegible]	[illegible]
103	2020/05/26 10:22:38 AM GMT+5:30	Asfaq Meeran.K	M.A.M School of Engineering	Aeronautical Engineering	Student	Not applicable	IV	Male	[illegible]	[illegible]
104	2020/05/26 10:34:24 AM GMT+5:30	Manika	Gujarat Forensic Sciences University	Forensic Chemistry	Research Scholar	Not applicable	II	Female	[illegible]	[illegible]
105	2020/05/26 10:34:39 AM GMT+5:30	v kowsalya	MAM school of engineering	aeronautical engineering	Student	Not applicable	IV	Female	[illegible]	[illegible]
106	2020/05/26 10:35:08 AM GMT+5:30	Arumugasamy M	M A M SCHOOL OF ENGINEERING, TRICHY	Mechanical engineering	Faculty	Assistant Professor	Not applicable	Male	[illegible]	[illegible]
107	2020/05/26 10:36:57 AM GMT+5:30	R. Yuvashri	M. A. M school of engineering	Aeronautical	Student	Not applicable	III	Female	[illegible]	[illegible]
108	2020/05/26 10:45:40 AM GMT+5:30	Pawn kumar	MAM school of engineering school	Mechatronics	Student	Not applicable	II	Male	[illegible]	[illegible]
109	2020/05/26 10:47:11 AM GMT+5:30	M.Madhumitha	M.A.M School of Engineering	Electronics and Communication Engineering	Student	Not applicable	IV	Female	[illegible]	[illegible]
110	2020/05/26 10:50:24 AM GMT+5:30	K.Jayasudha	Trichy Engineering College	Electrical and Electronics Engineering	Faculty	Associate Professor	Not applicable	Female	[illegible]	[illegible]
111	2020/05/26 10:50:50 AM GMT+5:30	Mohamed yasar s	M.A.M School of engineering	Computer science and engineering	Student	Not applicable	III	Male	[illegible]	[illegible]
112	2020/05/26 10:59:13 AM GMT+5:30	SUJITHA	AVC COLLEGE AUTONOMOUS	MICROBILOGY	Student	Not applicable	II	Female	[illegible]	[illegible]
113	2020/05/26 11:00:08 AM GMT+5:30	M. R. MOHAMMED HUSSAIN	MAM SCHOOL OF ENGNEERING	Mechatronics	Student	Not applicable	III	Male	[illegible]	[illegible]

Total No of Registrations : 113

HOD

PRINCIPAL

Scanned with CamScanner


11:16

◂ WhatsApp

Close

Participants (50)

Search

Suba Pradha (me)

Punitha a (Host)

Sujatha L

A.Bhuvaneswari

A.p. Lalu

ABDULRAHMAN K

Abirami25

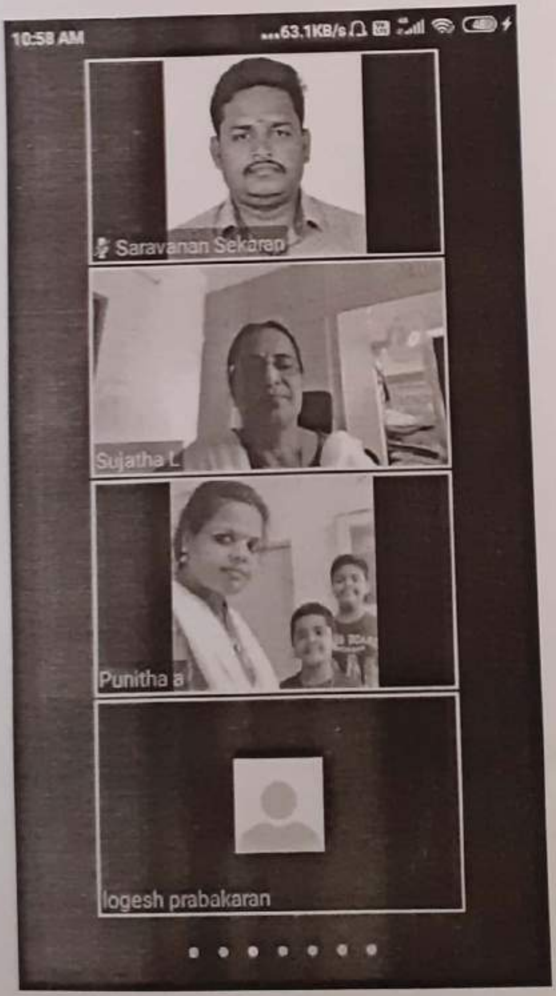
amsavalli M

anbarasan s

Asfaq Meeran.K

Berbeth Mary S

Invite


10:58 AM

63.1KB/s

Saravanan Sekaran

Sujatha L

Punitha a

logesh prabakaran

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING
Siruganur, Trichy-621105

Department of Mechatronics Engineering

Webinar on "Arduino with Thinkercad Simulator"

1st June 2020.

5/6/20

HOD

PRINCIPAL

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi I Affiliated to Anna University)
Siruganur, Trichy - 621 105

Department of Mechatronics Engineering
Organises

Webinar on
Arduino with Tinkercad Simulator

Resource person

Prof. Kanagaraj Venusamy,
Industry and Academic Expert,
Al musanna College of Technology,
Sultanate of Oman, Muscat.

Date: 01/06/2020, Time: 3.00 pm - 4.00pm.

For Registration Visit
www.mamse.in

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

(ACCREDITED BY NAAC)

Approved by AICTE, New Delhi | Affiliated to Anna University
Siruganur, Tiruchirapalli - 621 1

Department of Mechatronics Engineering Organises

Webinar on
Arduino withTinkercad Simulator

Resourse Person

Mr. Kanagaraj Venusamy, B.E., M.E., M.B.A., (P.hD)
Industry and Academic Expert,
Al musanna College of Technology,
Sultanate of Oman, Muscat.

oin us on: Tuesday, 2nd June, 2020

Time: 3.00 p.m to 4.00 pm, IST

For Registration Visit : www.mamse.in

zoom

E-Certificate will be provided to all participants

Scanned with CamScanner

CURRICULUM VITAE

Personal Profile

Name: Kanagaraj Venusamy

Nationality: Indian

Date of Birth: 19.03.1982

Passport Number: L2303315

Languages speak: Tamil, Telungu & English

Communication Address:

Al Musanna College of Technology.
Directorate of Technological Education,
Sultanate of Oman -Muscat
E.Mail :rajkanagaraj1983@gmail.com
Mobile: 00968 91327801

Objective

To merge my enthusiasm and talent for learning and teaching with students in order to develop professional skills and attitudes.

Academic Qualification

PhD in Management (Pursuing under Bharthidhasan University)

M.E in Mechatronics Engineering (Rajas college of Technology)

M.B.A in Production (Manonmanium sundaranar University)-May 2011.

B.E. in Electronics & Communication Engineering from Srinivasa Institute of Engg. Technology, Tamil Nadu. (Anna University, Chennai), April 2005.

Diploma in Project Planning Management from CADD CENTRE, Dec 2009.

Scanned with CamScanner

Area of Interest

- INDUSTRAIL AUTOMATION (PLC)
- MATLAB/SIMULINK
- ARDUINO
- VEX ROBOTICS
- ENTREPRENEURSHIP
- INDUSTRY-INSTITUTION INTERACTION CENTRE ACTIVITY

I hereby inform you that all the statements are made above true the best of my knowledge and belief.

Kanagaraj V

Scanned with CamScanner

Proposal for online webinar

Title: Introduction to Arduino and Programming

How: Using Real Time open Source Software Tinkercad

Organizer:

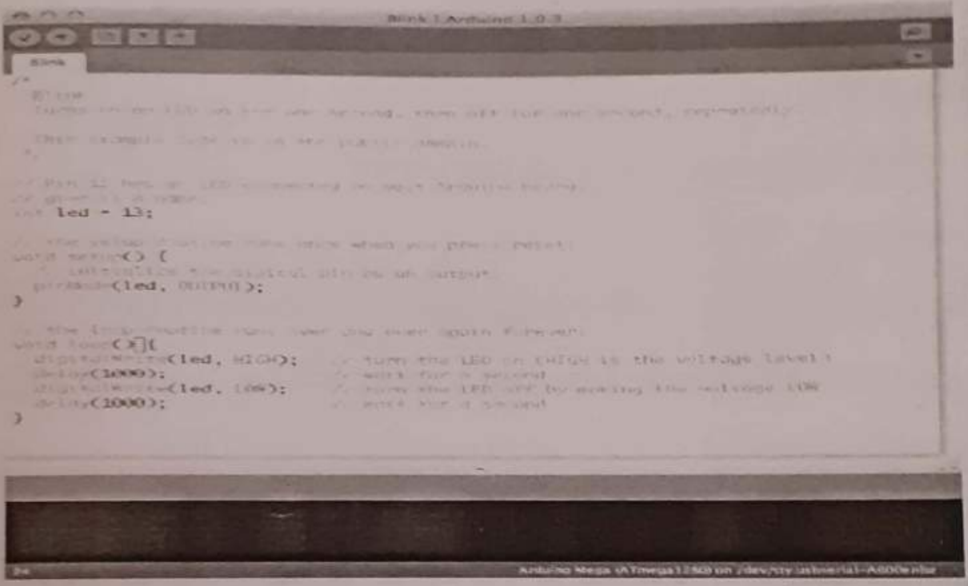
Speaker/Presenter: Kanagaraj Venusamy B.E, M.B.A, M.E, (Ph.D)

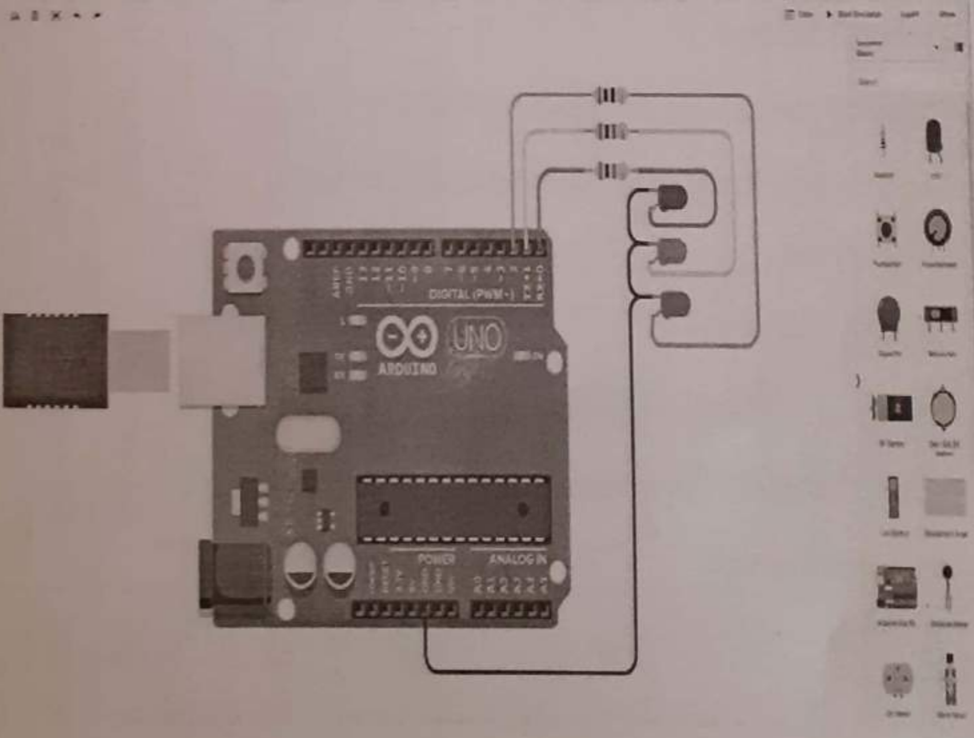
When: yet to plan

Where: Online Webinar

Target Audience: Computer science and Electronics discipline students and faculty but globally Arduino is used by grade4 level to any discipline people.

Interdisciplinary Arduino: Programming, Electronics, Mechanical, hobbyist...





M.A.M School of Engineering
Siruganur - 621 105

List of Participant Register for the webinar "Arduino with Thinkercad Simulator"

S.No	Timestamp	Name	Institution	Department	At Present	Designation	Year	Gender	Email ID	Mobile Number
1	2020/05/30 7:48:58 AM GMT+5:30	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	Assistant Professor	NA	Male	saravananknm@gmail.com	9841041315
2	2020/05/30 8:41:07 AM GMT+5:30	J Eviganas Banu	Roever engineering college	CSE	Student	Not applicable	I	Female	eviganasbanu@gmail.com	8220858971
3	2020/05/30 8:47:35 AM GMT+5:30	VIVEKNIJANTHAN L	Periyar Centenary Polytechnic College, Vallam, Thanjavur	MECH	Faculty	Not applicable	NA	Male	vknijanthan96@gmail.com	8760086370
4	2020/05/30 9:57:54 AM GMT+5:30	THURAP MOHIDEEN T M	Periyar centenary polytechnic college	Mechanical	Faculty	Assistant Professor	I	Male	thuraptma@gmail.com	9791808815
5	2020/05/30 11:44:49 AM GMT+5:30	R VIJAYAKUMAR	M. A. M School of Engineering	Mechanical Engineering	Faculty	Assistant Professor	NA	Male	vijayakumarecm@gmail.com	9600262823
6	2020/05/30 11:55:09 AM GMT+5:30	R.Selvamani	M.A.M School of engineering	Mechanical engineering	Student	Not applicable	II	Male	rmsmani786@gmail.com	8525953608
7	2020/05/30 11:59:38 AM GMT+5:30	K. Ganesh kannan	M. A. M school of engineering	Mechanical	Student	Not applicable	II	Male	Siragu238@gmail.com	9600987494
8	2020/05/30 12:17:03 PM GMT+5:30	S Aravind	MAMSE	Mechanical	Student	Not applicable	II	Male	s8069936@gmail.com	9.16383E+11
9	2020/05/30 12:30:28 PM GMT+5:30	SJ.Balamurugan	M.A.M SCHOOL OF ENGINEERING	Mechanical engineering	Student	Not applicable	III	Male	balasj5747@gmail.com	9786574759
10	2020/05/30 5:47:07 PM GMT+5:30	Sudha P	M.A.M School of Engineering	Mechatronics Engineering	Faculty	Assistant Professor	NA	Female	suha1906@gmail.com	9003674127
11	2020/05/30 8:14:10 PM GMT+5:30	B.vasanthan	M.A.M SCHOOL OF ENGINEERING	MECHANICAL	Student	Not applicable	II	Male	manimanimaran276@gmail.com	9159573019
12	2020/05/30 9:23:19 PM GMT+5:30	Jency elakkiya	M. A. M school of engineering	ECE	Student	Not applicable	III	Female	jencyelakkiya9@gmail.com	7639511354
13	2020/05/30 9:25:25 PM GMT+5:30	Mr. RAVICHANDRAN. S	M A M School of Engineering Trichy	Mechanical Engineering	Faculty	Assistant Professor	NA	Male	ravi.thuraiyur0791@gmail.com	9486583988
14	2020/05/30 9:30:48 PM GMT+5:30	Arumugasamy M	M A M SCHOOL OF ENGINEERING, TRICHY	Mechanical engineering	Faculty	Assistant Professor	NA	Male	jas18091996@gmail.com	9787269963
15	2020/05/30 9:36:01 PM GMT+5:30	M.SUBA PRADHA	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	Assistant Professor	NA	Female	cool.pradha@gmail.con	9791892917
16	2020/05/30 9:47:38 PM GMT+5:30	BIKRAM MANNA	Calcutta Institute of Technology	ECE	Student	Not applicable	II	Male	bikrammanna41@gmail.com	9007207207
17	2020/05/30 9:47:52 PM GMT+5:30	Sharmila	Krishna engineering college	Ece	Faculty	Assistant Professor	NA	Female	r.sharmila@krishnacollege.ac.in	7042560309
18	2020/05/30 9:49:13 PM GMT+5:30	AHMED RIFATH	M.A.M.School of Engineering	MECHATRONICS ENGINEERING	Student	Not applicable	III	Male	rifath142@gmail.com	9943058148
19	2020/05/30 9:53:10 PM GMT+5:30	VIKRAM GAJULA	ST.MARTINS ENGINEERING COLLEGE	ECE	Faculty	Assistant Professor	NA	Male	vikramece@smec.ac.in	9866900791
20	2020/05/30 10:08:46 PM GMT+5:30	Asraf Banu,A	Mamse	English	Faculty	Assistant Professor		Female	asraf71073@gmail.com	9443213411
21	2020/05/30 10:11:18 PM GMT+5:30	MALARVIZHI A	Vinayaka Missionâ€™s Kirupananda Variyar Engineering College	ECE	Faculty	Assistant Professor	NA	Female	malar.ece06@gmail.com	8220446846
22	2020/05/30 10:13:23 PM GMT+5:30	S VALARMATHY	Vinayaka Mission's Kirupananda Variyar Engineering College	ECE	Faculty	Associate Professor		Female	valarmathysr@gmail.com	9944949866
23	2020/05/30 10:17:17 PM GMT+5:30	Ajay.A	MAM school of engineering	Mechatronics	Student	Not applicable	II	Male	ajayzion875@gmail.com	6380883205
24	2020/05/30 10:21:07 PM GMT+5:30	Priya Shaw	Calcutta institute of technology	ECE	Student	Not applicable	II	Female	pinkyshaw561@gmail.com	9051032310
25	2020/05/30 10:23:45 PM GMT+5:30	Jenith Kumar.B	M.A.M School of Engineering	Mechatronics	Student	Not applicable	II	Male	jenithbala07@gmail.com	9047132832
26	2020/05/30 10:44:37 PM GMT+5:30	Kartik Mathur	Swami keshvanand institute of technology	EC	Student	Not applicable	III	Male	Mathurkartik1234@gmail.com	9587823004
27	2020/05/30 11:44:19 PM GMT+5:30	Kuldeep Sharma	CGC-CEC Landran	ECE	Faculty	Assistant Professor	NA	Male	Kuldeep.4455@cgc.edu.in	9501364443
28	2020/05/30 11:46:32 PM GMT+5:30	Priyansh Kumar	Chandigarh Engineering College,Landran	ECE	Student	Not applicable	I	Male	kpriyansh391@gmail.com	6209887342

Scanned with CamScanner

29	2020/05/30 11:46:34 PM GMT+5:30	AKSHAY VERMA	CHANDIGARH ENGINEERING COLLEGE	ECE	Student	Not applicable	I	Male	[illegible]	[illegible]
30	2020/05/30 11:46:35 PM GMT+5:30	Navya sharma	Chandigarh group of colleges	Ece	Student	Not applicable	I	Female	navyasharma307@gmail.com	7056296097
31	2020/05/30 11:46:39 PM GMT+5:30	Palak	Chandigarh engineering college	Batchelor of technology	Student	Not applicable	I	Female	palakrai90749@gmail.com	6394952023
2	2020/05/30 11:46:47 PM GMT+5:30	MOHIT KUMAR GUPTA	CHANDIGARH GROUP OF COLLEGES	ECE	Student		I	Male	mohitgupta17042000@gmail.com	9.18394E+11
	2020/05/30 11:47:21 PM GMT+5:30	Nitish Tiwari	Chandigarh Group of Collage	B.Tech ECE	Student	Not applicable	I	Male	Nitishtiwari23456@gmail.com	8697846179
	2020/05/30 11:47:33 PM GMT+5:30	TANAV	Cgc landran	ECE	Student	Not applicable	I	Male	tanavgarg4@gmail.com	8284020544
	2020/05/30 11:47:36 PM GMT+5:30	SAURAV JHA	CHANDIGARH ENGINEERING COLLEGE	ECE	Student	Not applicable	I	Male	Jha.123sj@gmail.com	9914608086
	2020/05/30 11:47:41 PM GMT+5:30	Raman Sharma	Chandigarh engineering college	B tech	Student	Not applicable	I	Male	sharmarahi63163@gmail.com	9805563163
	2020/05/30 11:49:36 PM GMT+5:30	Utkarsh Singh	Chandigarh engineering college	ECE	Student	Not applicable	I	Male	utparshdecfeb11@gmail.com	7069242277
	2020/05/30 11:51:49 PM GMT+5:30	Rahul Kumar	Chandigarh Engineering College	ECE	Student	Not applicable	II	Male	iamrahulll4@gmail.com	7004246472
	2020/05/30 11:53:13 PM GMT+5:30	Swarnim Swaraj	Laxmi Narayan College Of Technology and Science	CSE	Student		I	Male	swarnimswaraj712@gmail.com	9.18521E+11
	2020/05/30 11:53:39 PM GMT+5:30	Nikhil Raj	CEC	ECE	Student	Not applicable	I	Male	nraj9141@gmail.com	7870183241
	2020/05/31 12:03:24 AM GMT+5:30	RAHUL POONIA	Chandigarh group of college	ECE	Student	Not applicable	I	Male	rahulpoonia0638@gmail.com	7056807465
	2020/05/31 12:09:49 AM GMT+5:30	SUDEEP DAS	CHANDIGARH GROUP OF COLLEGES	ECE	Student	Not applicable	I	Male	sudeep1098@gmail.com	9350248220
	2020/05/31 12:15:07 AM GMT+5:30	Pranjal amrit	Chandigarh engineering college landran	Ece	Student	Not applicable	I	Female	pranjalamrit2303@gmail.com	6205269355
	2020/05/31 12:22:28 AM GMT+5:30	Sumit	Chandigarh Engineering College	ECE	Student		I	Male	sumittaggarh786st@gmail.com	8568010810
	2020/05/31 12:23:45 AM GMT+5:30	Bishvender singh	Chandigarh engineering college, landran	ECE	Student	Not applicable	I	Male	sbishvender26@gmail.com	8237657556
	2020/05/31 12:26:01 AM GMT+5:30	Nisha Rani	Chandigarh group of colleges, landran	ECE	Student		I	Female	angelnishu3121@gmail.com	9780128714
	2020/05/31 12:27:35 AM GMT+5:30	Ankit Agarwal	Swami Keshvanand Institute of Technology, Management & Gramothan	ECE	Faculty	Assistant Professor	NA	Male	Ankitsagarwal@gmail.com	7877556914
	2020/05/31 12:41:11 AM GMT+5:30	Parul Sinha	Swami Keshvanand Institute of technology, Management and Gramothan	ECE	Student	Not applicable	III	Female	2308parulsinha@gmail.com	7732990073
9	2020/05/31 1:00:29 AM GMT+5:30	Rahul Kumar	Cgc	Ece	Student	Not applicable		Male	rahulshandilya81840@gmail.com	8969698174
50	2020/05/31 1:04:47 AM GMT+5:30	MOZAHID HUSSAIN	Chandigarh group of colleges, landran	ECE	Student	Not applicable	II	Male	mozahidh7763@gmail.com	8210632752
51	2020/05/31 1:14:42 AM GMT+5:30	TIRTHA JYOTI BOL	Chandigarh Engineering College	ECE	Student	Not applicable	I	Male	tjstyles555@gmail.com	9706923488
52	2020/05/31 1:22:23 AM GMT+5:30	Mahesh kumar	CHANDIGARH GROUP OF COLLEGE LANDRAN	ECE	Student	Not applicable	II	Male	maheshkumar25587600@gmail.com	7696312558
53	2020/05/31 1:24:43 AM GMT+5:30	Rajan Verma	Chandigarh college of engineering	Engineering	Student	Not applicable	I	Male	Rajanverma5410@gmail.com	9729622331
54	2020/05/31 2:02:16 AM GMT+5:30	Prema Sahay	Chandigarh Engineering College, Landran	Applied Science (ECE)	Student	Not applicable	I	Female	prema.sahay.atc@gmail.com	9102133762
55	2020/05/31 5:04:18 AM GMT+5:30	AROCKIARAJ S	Mepco Schlenk Engineering College, Sivakasi	EEE	Faculty	Assistant Professor	NA	Male	keerthanajose4@gmail.com	6381681395
56	2020/05/31 5:12:23 AM GMT+5:30	Mithilesh Kumar yadav	Chandigarh group of college landran	ECE	Student		IV	Male	mithilesh29568@gmail.com	8562870085
57	2020/05/31 5:34:47 AM GMT+5:30	Neetu	Cgc	Ece	Student	Not applicable	I	Male	Shneetu9878@gmail.com	7710403338
58	2020/05/31 5:53:24 AM GMT+5:30	YALLA RAMESH	Chandigarh Group Of Colleges	ECE	Student	Not applicable	I	Male	yallaramesh42@gmail.com	9.19866E+11
59.	2020/05/31 6:24:20 AM GMT+5:30	Vrinda Singhal	Chandigarh group of colleges , Landran	ECE	Student	Not applicable	I	Female	vrindasinghal1606@gmail.com	7505897009
60	2020/05/31 6:27:24 AM GMT+5:30	Parveen kumar	Chandigarh Group of colleges,landran	B. Tech	Student	Not applicable	I	Male	K876793@gmail.com	7710525714
61	2020/05/31 6:29:01 AM GMT+5:30	Rajan Tiwari	Chandigarh group of colleges	ECE	Student	Not applicable	II	Male	tiwari.rajan2002@gmail.com	8360290538
62	2020/05/31 6:35:37 AM GMT+5:30	Akshay Sharma	Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur	ECE	Student	Not applicable	III	Male	sharmaakshay3414@gmail.com	7737587180
63	2020/05/31 6:47:43 AM GMT+5:30	Pankaj	Chandigarh group of college	ECE	Student		I	Male	Pankajdeswal146@gmail.com	8168735898
64	2020/05/31 6:57:39 AM GMT+5:30	Muskan	Cgc landran	Ece	Student	Not applicable	I	Female	Muskankamboj05609@gmail.com	9050052999
65	2020/05/31 6:58:15 AM GMT+5:30	Yogeshwaran N	Perumal Manimekalai College of Engineering, Hos	BE.Mechatronics	Student	Not applicable ·	III	Male	nyogeshwaran5@gmail.com	9791273054
66	2020/05/31 7:04:44 AM GMT+5:30	Mohit dagar	CEC LANDRAN	B.TECH ECE	Student	Not applicable	I	Male	mohitdager4567@gmail.com	9306232508
67	2020/05/31 7:37:57 AM GMT+5:30	Piyush Vashisht	CGC landran	ECE	Student	Not applicable	I	Male	piyushsharmaccs@gmail.com	7669518613
68	2020/05/31 8:06:26 AM GMT+5:30	Vivek kumar	Chandigarh group of colleges	ECE	Student		I	Male	Vivekkumarp1p2p3@gmail.com	8809250956
69	2020/05/31 8:21:48 AM GMT+5:30	Prakhar dwivedi	Chandigarh engineering college	ECE	Student	Not applicable	I	Male	prakhardwivedi22@gmail.com	9872646993
70	2020/05/31 8:36:26 AM GMT+5:30	RAJPUT SAURAV	CGC,LANDRAN	ECE	Student	Not applicable	I	Male	sauravrajput703@gmail.com	9998180703
71	2020/05/31 8:47:22 AM GMT+5:30	Nitika.rj224@gmail.com	Chandigarh group of colleges landran	ECE	Student	Not applicable	I	Female	Nitika.rj224@gmail.com	8437675218
72	2020/05/31 8:47:56 AM GMT+5:30	Naman Tanwar	CGC LANDRAN	ECE	Student			Male	namantanwar886@gmail.com	6230991484
73	2020/05/31 8:49:12 AM GMT+5:30	Raghav Sahni	CEC LANDRAN	Btech ECE	Student	Not applicable	II	Male	raghavsahni02@gmail.com	7528990160
74	2020/05/31 8:50:09 AM GMT+5:30	Sunder Newar	Chandigarh Engineering College, Landran	ECE	Student	Not applicable	I	Male	newarsunder@gmail.com	6284108576
75	2020/05/31 8:50:35 AM GMT+5:30	Nitish kumar	Chandigarh groups of college,mohali	ECE	Student	Not applicable	I	Male	nitishkchd@gmail.com	7986315897
76	2020/05/31 8:53:04 AM GMT+5:30	B. Dilip kumar	Er. Perumal Manimekalai College of Engineering	Mechatronics	Student	Not applicable	II	Male	dilipboopathi15@gmail.com	9514814295
77	2020/05/31 8:55:25 AM GMT+5:30	Pushpjeet kaur	Chandigarh group of college	ECE	Student	Not applicable	I	Female	pushpjeetkaur2003@gmail.com	7888318337
77	2020/05/31 8:55:25 AM GMT+5:30	Mehak	Chandigarh group of colleges	Ece	Student	Not applicable	I	Female	mehakjangra44@gmail.com	9996150171
78	2020/05/31 9:00:48 AM GMT+5:30	Emmanuel paulraja.J	CSI POLYTECHNIC COLLEGE	EEE	Faculty	Not applicable	NA	Male	immanuel1234@rediffmail.com	9443441519
79	2020/05/31 9:05:03 AM GMT+5:30	Lalita rani	Cgc landran	b.tech ece	Student	Not applicable	II	Female	dollythakur716@gmail.com	6239229780
80	2020/05/31 9:09:32 AM GMT+5:30	Mohit Jaiswal	CGC college of engineering	ECE	Student	Not applicable	I	Male	mohitjaiswalji169@gmail.com	8979758308
81	2020/05/31 9:13:57 AM GMT+5:30	Manshi	Chandigarh group of colleges landran	Ece	Student	Not applicable	I	Female	Singhankita3112@gmail.com	6239111903
82	2020/05/31 9:19:03 AM GMT+5:30	MOHAN P	M.A.M.SCHOOL OF ENGINEERING	CSE	Student	Not applicable	I	Male	mohanss073@gmail.com	6384091017
83	2020/05/31 9:21:31 AM GMT+5:30	Vivek yadav	Chandigarh Engineering college	ECE	Student	Not applicable	I	Male	vivek734706@gmail.com	7347063116
84	2020/05/31 9:21:56 AM GMT+5:30	Sindhu	Chandigarh group of colleges	ECE	Student	Not applicable	NA	Female	sindhumfp@gmail.com	9334592188
85	2020/05/31 9:26:03 AM GMT+5:30	VIVEK KUMAR	Chandigarh Engineering college	ECE	Student	Not applicable	I	Female	Kvivek5003@gmail.com	8107022508
86	2020/05/31 10:04:29 AM GMT+5:30	Vibhuti goyal	Chandigarh engineering college	ECE	Student	Not applicable	I	Female	Vibhuti1807@gmail.com	9779952140
87	2020/05/31 10:05:09 AM GMT+5:30	Balakrishnan.H	MAMSE	MECHANICAL	Student	Not applicable	III	Male	lovelymilky544@gmail.com	8870533443
88	2020/05/31 10:17:03 AM GMT+5:30	Priya	Chandigarh group of colleges, landran	ECE	Student	Not applicable	I	Female	priyapriya557766@gmail.com	8295582410
89	2020/05/31 10:17:23 AM GMT+5:30	Tarun Singhal	Chandigarh engineering college	Ece	Faculty	Assistant Professor	NA	Male	Tarun.sgl@gmail.com	9802445302
90	2020/05/31 10:40:10 AM GMT+5:30	Reetika	Cgc landran mohali	ECE	Student	Not applicable	I	Female	reetika.062006@gmail.com	6005262929
91	2020/05/31 11:20:32 AM GMT+5:30	Nancy	Chandigarh group of colleges	ECE	Student	Not applicable	I	Female	Nancyrke777@gmail.com	8958152001
92	2020/05/31 11:22:36 AM GMT+5:30	TUSHAR BALI	CGC LANDRAN	ECE	Student	Not applicable	I	Male	balisuman25@gmail.com	7082071949
93	2020/05/31 11:42:35 AM GMT+5:30	VIJAYAKUMAR.K	M. A. M. SCHOOL OF ENGINEERING	MECHT	Student	Not applicable	IV	Male	k.vijayakumar0201@gmail.com	9159582190
94	2020/05/31 11:52:17 AM GMT+5:30	M.Madhumitha	M.A.M School of Engineering	ECE	Student	Not applicable	IV	Female	madhumurugesan12@gmail.com	9080255309
95	2020/05/31 11:56:25 AM GMT+5:30	Manisha. M	MAM school of engineering	Mechatronics	Student	Not applicable	IV	Female	manishamuthu199@gmail.com	7397128708
96	2020/05/31 12:01:16 PM GMT+5:30	MUGESH KUMAR. B	MAM SCHOOL OF ENGINEERING	MECHT	Student	Not applicable	IV	Male	plsmugesh144@gmail.com	6385601335
97	2020/05/31 12:04:07 PM GMT+5:30	Elangathir	Mam school of engineering	Mechatronics	Student	Not applicable	IV	Male	Elangathirmamse@gmail.com	6838022463
98	2020/05/31 12:07:01 PM GMT+5:30	neetu	cgc	ece	Student	Not applicable	I	Male	shneetu9878@gmail.com	7710403338
99	2020/05/31 12:12:34 PM GMT+5:30	Vaitheeswari.V	Mam school of engineering	Mechatronics	Student	Not applicable	IV	Female	vaitheeswarimechatronics@gmail.com	9361140549
100	2020/05/31 12:14:25 PM GMT+5:30	Kaviya.R	M.A.M School of Engineering	ECE	Student	Not applicable	III	Female	ramkaviya1999@gmail.com	8870445972
101	2020/05/31 12:28:11 PM GMT+5:30	SATHISH KUMAR K	MAM SCHOOL OF ENGINEEIRNG	CSE	Faculty	Assistant Professor	NA	Male	ksk2mohan@gmail.com	7530050947
102	2020/05/31 12:35:40 PM GMT+5:30	Vivek Kumar Poddar	Chandigarh Engineering College	Btech (ECE)	Student	Not applicable	I	Male	10.vivekpoddar@gmail.com	7808726515
103	2020/05/31 12:39:50 PM GMT+5:30	KANCHAN	Chandigarh Engineering College	ECE	Student	Not applicable	I	Female	kan3122001@gmail.com	7876166817

105	2020/05/31 12:44:12 PM GMT+5:30	B.Bhuvaneshwari	Sri bharathi engineering college for women,pudukkottai	B.E(ECE)	Student	Not applicable	III	Female	bbhuvana46883@gmail.com	8056906216
106	2020/05/31 12:44:41 PM GMT+5:30	Mukund Shukla	Chandigarh Group of colleges, Landran	Applied science	Student	Not applicable	I	Male	mukundshukla000@gmail.com	9119964642
107	2020/05/31 1:04:43 PM GMT+5:30	Abdul Latif S	MAM School of Engineering	Mechatronics	Student		II	Male	lamuya.tnj@gmail.com	9940803798
108	2020/05/31 1:06:33 PM GMT+5:30	A. Satheesh Kumar	MAM school of engineering	Mechatronics	Student	Not applicable	II	Male	satheshkumar4444@gmail.com	7558103874
109	2020/05/31 1:09:12 PM GMT+5:30	P.MANOJ KUMAR	MAM SCHOOL OF ENGINEERING	Mechatronics	Student	Not applicable	II	Male	msmano3786@gmail.com	6374855895
110	2020/05/31 1:11:51 PM GMT+5:30	LALUPRASHANTH-A	MAM school of engineering	Mechatronics	Student	Not applicable	II	Male	aplalu2001@gmail.com	9629724975
111	2020/05/31 1:26:32 PM GMT+5:30	K.KOWSALYA	M.A.M SCHOOL OF ENGINEERING	Mechatronics	Student	Not applicable	IV	Female	kowsi0371@gmail.com	9384974457
112	2020/05/31 1:47:16 PM GMT+5:30	Prasanth P	M.A.M school of engineering	Mechatronics	Student	Not applicable	IV	Male	josephprasanth1999@gmail.com	8525018372
113	2020/05/31 3:24:01 PM GMT+5:30	Selvakumar M	Er Perumal Manimekalai Polytechnic College	ECE	Faculty	Professor	III	Female	selvakumari.sundaram@gmail.com	9789856578
114	2020/05/31 4:01:54 PM GMT+5:30	Yukta Wadhwa	Chandigarh engineering college	ECE	Student	Not applicable	I	Female	yuktawadhwa23@gmail.com	8059704050
115	2020/05/31 4:14:08 PM GMT+5:30	Navraj Singh	Chandigarh Engineering College Landran	ECE	Student	Not applicable	I	Male	navrajsingh2300@gmail.com	7696007990
116	2020/05/31 4:35:35 PM GMT+5:30	BAVADHARANI.A	Sri bharathi engineering college for women	B.E(ECE)	Student	Not applicable	III	Female	bavaakbh@gmail.com	7806941832
117	2020/05/31 6:05:25 PM GMT+5:30	Aswin	Mam school of engineering	Mechatronics	Student		II	Male	aswin2periyasamy@gmail.com	8838635672
118	2020/05/31 6:22:56 PM GMT+5:30	E.sankar	M.A.M school of engineering	Mechatronics	Student	Not applicable	IV	Male	bsankarbala534@gmail.com	8870335042
119	2020/05/31 6:38:53 PM GMT+5:30	S.Praveenkumar	MAM school of engineering	Mechatronics	Student	Not applicable	II	Male	monsterbubloo0@gmail.com	8946075031
120	2020/05/31 7:39:16 PM GMT+5:30	Ahamed Faisal A	MAM School of engineering	Mechatronics	Student		II	Male	ahmedfaisal4171@gmail.com	7639566212
121	2020/05/31 9:11:35 PM GMT+5:30	P.M.Santhiya	M.A.M.School of engineering	Ece	Student	Not applicable	IV	Female	Sandypugal1999@gmail.com	8124852601
122	2020/05/31 9:33:35 PM GMT+5:30	Anbarasan.S	Mam school of engineering	Mechatronics	Student	Not applicable	II	Male	Anbarasan2801@gmail.com	6385331468
123	2020/05/31 9:57:08 PM GMT+5:30	Muskan kumari	Chandigarh group of colleges landran,mohali	Applied sx	Student	Not applicable	I	Female	musku09kum@gmail.com	9306848438
124	2020/05/31 10:42:13 PM GMT+5:30	Mudit Rakheja	Chandigarh group of colleges	ECE	Student	Not applicable	I	Male	Muditrakheja01@gmail.com	9992324124
125	2020/05/31 11:17:55 PM GMT+5:30	G.S. SANTHAVENKATESH	K. L. N. COLLEGE OF ENGINEERING	Automobile Engineering	Faculty	Assistant Professor	NA	Male	santhavenkatesh2000@gmail.com	9750346058
126	2020/05/31 11:36:30 PM GMT+5:30	G.Purushothaman	M.A.M. School of Engineering	EEE	Faculty	Assistant Professor	NA	Male	eeemamse@gmail.com	9600269887
127	2020/06/01 5:49:11 AM GMT+5:30	Suruthi.s	Mam school of Engineering	EEE	Student	Not applicable	II	Female	suruthiselva01@gmail.com	9150365571
128	2020/06/01 6:38:06 AM GMT+5:30	K.Karthikeyan	M.A.M School of Engineering	ECE	Faculty	Assistant Professor	NA	Male	karthikcacet121@gmail.com	9159683577
129	2020/06/01 7:15:11 AM GMT+5:30	Manash Pratim Ghosh	CGC LANDRAN	ECE	Student	Not applicable	I	Male	manashpghosh2000@gmail.com	6000020673
130	2020/06/01 7:16:56 AM GMT+5:30	RAJESHKUMAR	MAM SCHOOL OF ENGINEERING	CSE	Faculty	Assistant Professor	NA	Male	grkresearch@gmail.com	9677787134
131	2020/06/01 7:54:05 AM GMT+5:30	DR.DIMPLE V.PAUL	DNYANPRASSARAK MANDAL'S COLLEGE AND RESEARCH CENTRE (GOA UNIVERSITY)	COMPUTER SCIENCE	Faculty	Assistant Professor	NA	Female	dimplevpaul@gmail.com	9422643263
132	2020/06/01 8:06:53 AM GMT+5:30	Ismail	Mam school of engg	Eee	Faculty	Assistant Professor	II	Male	Dazlingsammi@gmail.com	9524384044
133	2020/06/01 8:11:32 AM GMT+5:30	Senthamarai Kannan A	M.A.M. SCHOOL OF ENGINEERING	ECE	Faculty	Associate Professor	NA	Male	ersenthamarai@gmail.com	9786611813
134	2020/06/01 9:04:18 AM GMT+5:30	Reka X	M.A.M School of Engineering	Computer science	Student	Not applicable	IV	Female	rekaxavier98@gmail.com	8870812810
135	2020/06/01 9:08:29 AM GMT+5:30	M.sowmiya	M.A.M school of engineering	Cse	Student	Not applicable	III	Female	Creamydoll172@gmail.com	6384294387
136	2020/06/01 9:13:14 AM GMT+5:30	Priyanka K	M.A.M SCHOOL OF ENGINEERING	CSE	Student	Not applicable	II	Female	priyankaaero2000@gmail.com	6380316515
137	2020/06/01 9:20:34 AM GMT+5:30	MOHAMED SHAFVAN	MAM SCHOOL OF ENGINEERING	Computer science	Student	Professor		Male	shafvansha4136@gmail.com	6382712534
138	2020/06/01 9:43:17 AM GMT+5:30	S. Arikaran	M. A. M. School of engineering	Cse	Student	Not applicable	II	Male	arikaran0401s@gmail.com	6385412853
139	2020/06/01 9:43:21 AM GMT+5:30	M.Manjula	M.A.M SCHOOL OF ENGINEERING	CSE	Student	Not applicable	III	Female	manjumanjula5700@gmail.com	6369282419
140	2020/06/01 10:00:26 AM GMT+5:30	vinitha v	MAM school of engineering	CSE	Student	Not applicable	II	Female	vinitha7475@gmail.com	6383808606
141	2020/06/01 10:13:04 AM GMT+5:30	N.Firthose Banu	MAMSE	CSE	Student	Not applicable	IV	Female	banufir61@gmail.com	7871244007
142	2020/06/01 10:20:02 AM GMT+5:30	RANJITHKUMAR R	M.A.M.SCHOOL OF ENGINEERING	CSE	Student	Not applicable	II	Male	smartranjith7475@gmail.com	9629690559
143	2020/06/01 10:21:26 AM GMT+5:30	S MURUGAVALLI	M. A. M School of Engineering	CSE	Faculty	Associate Professor	NA	Female	vallisanglimuthu2012@gmail.com	8220912257
144	2020/06/01 10:26:43 AM GMT+5:30	T. Thenmozhi	M. A. M. School of Engineering, Tiruchi.	ECE	Student	Not applicable	II	Female	honeythean001@gmail.com	8940855332
145	2020/06/01 10:28:48 AM GMT+5:30	Preethika	MAM School Of Engineering	CSE	Student	Not applicable	II	Female	preethi.selvam2732000@gmail.com	8344906957
146	2020/06/01 10:41:49 AM GMT+5:30	Sivamalar. P	MAM school of EngineÃ©ring	CSE	Faculty	Assistant Professor	NA	Female	sivamalarp23@gmail.com	9944419074
147	2020/06/01 10:50:51 AM GMT+5:30	PANDI.P	M.A.M.SCHOOL OF ENGINEERING	CSE	Student	Not applicable	II	Male	pandibepandi@gmail.com	7548820677
148	2020/06/01 11:00:35 AM GMT+5:30	S. Kamali	MAM school of Engineering	EEE	Student	Not applicable	II	Female	senthivel12@gmail.com	6382368727
149	2020/06/01 11:13:45 AM GMT+5:30	K.UMARANI	M.A.M.SCHOOL OF ENGINEERING	Ece	Faculty	Associate Professor	NA	Female	umaranikece@gmail.com	9597939569
150	2020/06/01 11:56:39 AM GMT+5:30	Nisha verma	Chandigarh group of colleges	ECE engineering	Student	Not applicable	NA	Female	nishaverm19@gmail.com	8360355871
151	2020/06/01 11:57:06 AM GMT+5:30	Vidhya V	M.A.M. School of Engineering	CSE	Faculty	Assistant Professor		Female	vidhyavibs@gmail.com	9486896998
152	2020/06/01 12:26:07 PM GMT+5:30	Pooja	M.A.M school of engineering	CSE	Student	Not applicable	II	Female	gspooja2001@gmail.com	6385751382
153	2020/06/01 12:27:03 PM GMT+5:30	Balaji Viswanathan N	Thiagarajar Polytechnic College, Salem	Mechanical Engineering	Faculty	Associate Professor	NA	Male	viswasanjit@gmail.com	9487208995
154	2020/06/01 12:36:01 PM GMT+5:30	Rejina Devi.R	Mam school of engineering	Cse	Student	Not applicable	II	Female	rejina1405@gmail.com	8098156483
155	2020/06/01 12:37:33 PM GMT+5:30	M.Thangam	M.A.M school Of Engineering	Cse	Student	Not applicable	III	Male	karthikthangam62155@gmail.com	8220423293
156	2020/06/01 1:32:39 PM GMT+5:30	NITIN TEJASWI	Chandigarh group of colleges	ECE	Student	Not applicable	I	Male	nitintejaswi123@gmail.com	9834057132
157	2020/06/01 2:34:23 PM GMT+5:30	Dr.P.LILLY FLORENCE	M.A.M.SCHOOL OF ENGINEERING	Chemistry	Faculty	Professor	NA	Female	mamseonlineclasses@gmail.com	9345690431

Total No. of Registration: 157

HOD

PRINCIPAL

Scanned with CamScanner

M.A.M School of Engineering

Siruganur - 621 105

List of Participants who attended the webinar on "Arduino with Thinkercad"

Meeting ID : 861 2219 4266
Topic : MAM-Arduino Interface with Tinkercad
User Email : rajkanagaraj1983@gmail.com
Duration (Minutes) : 92
Start Time : 06/01/2020 14:40:48
End Time : 06/01/2020 16:12:17

Name (Original Name)	User Email	Total Duration (Minutes)
chandrasekar M	mchandrasekar1983@gmail.com	88
A.p. Lalu		43
Rosy kanna		73
vivo 1713		20
Sumathi Sivakumar	dsumihari@gmail.com	72
Akshay Verma 1903220 E2	vermaakshay80@gmail.com	6
Senthamarai Kannan	ersenthamarai@gmail.com	84
Nitish kumar(1902459)		2
P. Palanisamy		4
Kvijaya Kumar		78
RAVICHANDRAN S	ravi.thuraiyur0791@gmail.com	59
umarani		57
A.karthick Kumar	kumar.akarthick783@gmail.com	8
Kanagaraj Venusamy	rajkanagaraj1983@gmail.com	92
Vidhyaraj		3
Sumit Taggarh	taggarhsumit00@gmail.com	79
Priyansh Kumar 1902474	kumarpriyansh620@gmail.com	14
Yukta Wadhwa 1902587 E1		5
Karthik Keyan	karthikcacet121@gmail.com	75
Parul Sinha		2
vivo 1906		5
Punitha a	sweetpunitha@gmail.com	61
Rajeshkumar Gunasekaran		51
Abirami25		57
Bishvender 1903226 E2	sbishvender28@gmail.com	61
Yogeshwaran N		80
Selvakumari M		71
Training and Placement MAMSE	mamseplacement@gmail.com	45
Arockiaraj S	keerthanajose4@gmail.com	16
S.Deepa		27
Jenith Balu	jenithbala07@gmail.com	82
Saravanan Sekaran	saravananknm@gmail.com	82
Kaviya		14
Navraj Singh 1903238	navrajsingh2300@gmail.com	3
Sudha P	suha1906@gmail.com	53
Ahmed Faisal	ahmedfaisal4171@gmail.com	62
Yukta Wadhwa 1902587 E1	yuktawadhwa23@gmail.com	14
Sowndarya		58
Dimple V. Paul		31
Abdul Latiff S	lamuya.tnj@gmail.com	36
ARASHDEEP RIAT 1903222	arashriat3151@gmail.com	4
Hussain		28
Kavitha P	kaviakshya@gmail.com	46
Sounthar Pandian		2
Ajay Arun	ajayzion875@gmail.com	77
Mohit_ Dagar(1902438)	mohitdager4567@gmail.com	78
V		80

Scanned with CamScanner

Vivek yadav 1902584 E1	vivek734706@gmail.com	52
k.chandra Sekaran	kchandrusekaran1984@gmail.com	33
K Sathish Kumar	ksk2mohan@gmail.com	53
BALAJI VISWANATHAN N	viswasanjit@gmail.com	14
Bubloo ..	monsterbubloo0@gmail.com	35
wb		22
Dr. P. Lilly Florence	mamseonlineclasses@gmail.com	78
Sanjai.R		69
B. Dilip kumar		71
Tirtha 1902568	tjstyles555@gmail.com	1
VIVEKNIJANTHAN L	vknijanthan96@gmail.com	41
Jeba Priyadarshini J	jebachristinal1995@gmail.com	76
Sudeep das 1903246 E2	sudeep1098@gmail.com	39
Purushothaman G	eeemamse@gmail.com	45
1fLCtOpsflh4xF0sK_901SAAAAABFBbmRyb2lkU2hhcmVfNTgx		11
Emmanuel paulraja		34
Manisha Manisha	manishamuthu199@gmail.com	76
Vibhuti Goyal 1902573 E1	vibhuti1807@gmail.com	45
Murugavalli S	vallisangilimuthu2012@gmail.com	60
Dhanalakshmi D	dhanalakshmi28031996@gmail.com	3
Suba Pradha	cool.pradha@gmail.com	88
S.kulanthaivel		8
Pankaj 1902462		8
Ramanathan R	srnathan2000@gmail.com	24
Kutty Vasanth8	kutty5645@gmail.com	59
Ranjithkumar P	ranjjith@gmail.com	57
Divya		6
A.Bhuvaneswari		36
Asraf Banu	asraf71073@gmail.com	7
T. Varshini		33
Navya (1902448)	navyasharma307@gmail.com	25
Manoj Kumar	msmano3786@gmail.com	48
P.jackvin jandro		17
Yukesh		5
Akshay Verma 1903220 E2		78
Ithyas		67
S Valarmathy	valarmathysr@gmail.com	5

Total No. of Participants: 84

HOD **PRINCIPAL**

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING
Siruganur, Trichy-621105

Department of Mechatronics Engineering

Webinar on "Arduino with Thinkercad Simulator"

(1st June, 2020)

Department of Mechantronics Engineering had the privilege of having webinar with Mr. V. Kanagaraj, Industry and Academic Expert, Al Musanna College of Technology, Sultanate of Omen, Muscat on the topic of "Arduino with Thinkercad Simulator".

The invitation for this program by the designer team of MAMSE and distributed through face book. The registration form for this program has created by Google form and published in our college website on 30th May 2020.

The link for the registration:
https://docs.google.com/forms/d/e/1FAIpQLSdgIAqikZgN03dtyuvCSXfjBBqagLDDvogaUYV7AFCE8BBGcg/viewform

Totally 157 participant has register for this webinar. The session is started sharply by 3.00 pm from welcome address and introduction given by M.Chandrasekar, Assistant Professor, Mechatronics Engineering Department. After that the resource person starts the lecture with the introduction of Thinkercad simulator. Later he given the lecture with demonstration of how to connect LED with Arduino, servomotor interface with Arduino and etc. The event ended with vote of thanks given by M.Suba pradha, Assistant Professor, Mechatronics Department. Also the feedback for the participant was collected through Google form.

The link for the Feedback:
https://docs.google.com/forms/d/e/1FAIpQLSde7sm1YTLhkKYPKlgmItghjgczOpSr-H0nYb1ODxIepr16yQ/viewform

6/6/20.

Program Co-ordinator **HOD**

Scanned with CamScanner

M.A.M School of Engineering
Siruganur - 621 105.

Feedback Reprot for a Webinar - Arduino with Thinkercad

.No	Timestamp	Name	Institution	Department	At Present	Email ID	What about the session?
1	2020/06/01 3:57:53 PM GMT+5:3	SUDEEP DAS	Chandigarh group of colleges landran	ECE	Student	sudeep1098@gmail.com	Excellent
2	2020/06/01 3:58:02 PM GMT+5:3	P.MANOJ KUMAR	MAM SCHOOL OF ENGINEERING	MECHATRONICS	Student	msmano3786@gmail.com	Excellent
3	2020/06/01 3:58:23 PM GMT+5:3	Mohit dagar	CEC LANDRAN	B.TECH ECE	Student	mohitdager4567@gmail.com	Excellent
4	2020/06/01 3:58:37 PM GMT+5:3	AKSHAY VERMA	CHANDIGARH ENGINEERING COLLEGE	ECE	Student	vermaakshay80@gmail.com	Excellent
5	2020/06/01 3:59:00 PM GMT+5:3	Ajay.A	MAM school of engineering	Mechatronics	Student	ajayzion875@gmail.com	Good
6	2020/06/01 3:59:16 PM GMT+5:3	Jenith kumar.B	M.A.M School of Engineering	Mechatronics	Student	jenithbala07@gmail.com	Excellent
7	2020/06/01 3:59:41 PM GMT+5:3	K.Nageswari Rosy	M.A.M School of engineering	Mathematics	Faculty	krosy.kanna@gmail.com	Excellent
8	2020/06/01 3:59:41 PM GMT+5:3	Rajeshkumar	MAM School of Engineering	CSE	Faculty	grkresearch@gmail.com	Excellent
9	2020/06/01 3:59:42 PM GMT+5:3	Prof.S.Arockiaraj	Mepco Schlenk Engineering College, Sivakasi.	EEE	Faculty	keerthanajose4@gmail.com	Excellent
10	2020/06/01 3:59:44 PM GMT+5:3	Vivek yadav	Chandigarh Engineering College	ECE	Student	vivek734706@gmail.com	Excellent
11	2020/06/01 3:59:51 PM GMT+5:3	SELVAKUMARI M	Er.Perumal Manimekalai Polytechnic College	ECE	Faculty	selvakumari.sundaram@gmail.com	Excellent
12	2020/06/01 4:00:53 PM GMT+5:3	Sumit	Chandigarh Engineering College	ECE	Student	sumittaggarh786st@gmail.com	Good
13	2020/06/01 4:01:06 PM GMT+5:3	B. Dilip kumar	Er. Perumal Manimekalai College of Engineering	Mechatronics	Student	dilipboopathi15@gmail.com	Excellent
14	2020/06/01 4:01:45 PM GMT+5:3	Pankaj	CEC LANDRAN	B.TECH ECE	Student	Pankajdeswal146@gmail.com	Good
15	2020/06/01 4:02:09 PM GMT+5:3	Dr. P. LILLY FLORENCE	M. A. M. School of Engineering	Chemistry	Faculty	mamseonlineclasses@gmail.com	Good
16	2020/06/01 4:02:55 PM GMT+5:3	S.Deepa	MAM school of engineering	Cse	Student	deepakarambayam@gmail.com	Good
17	2020/06/01 4:03:08 PM GMT+5:3	VIJAYAKUMAR. K	M. A. M. SCHOOL OF ENGINEERING	MECHATRONICS	Student	k.vijayakumar0201@gmail.com	Excellent
18	2020/06/01 4:03:51 PM GMT+5:3	ARASHDEEP RIAT	CHANDIGARH ENGINEERING COLLEGE, LANDRAN	ECE	Student	Arashriat3151@gmail.com	Excellent
19	2020/06/01 4:08:04 PM GMT+5:3	Gowtham	Nehru memorial collage	Bsc.Chemistry	Student	Gowtham2603msd@gmail.com	Good
20	2020/06/01 4:09:06 PM GMT+5:3	K.KARTHIKEYAN	M.A.M School of Engineering	ECE	Faculty	karthikcacet121@gmail.com	Good

Scanned with CamScanner

21	2020/06/01 4:11:19 PM GMT+5:3	DR.DIMPLE V.PAUL	DNYANPRASSARAK MANDAL'S COLLEGE AND RESEARCH CENTRE (GOA UNIVERSITY)	COMPUTER SCIENCE	Faculty	dimplevpaul@gmail.com	Excellent
22	2020/06/01 4:11:19 PM GMT+5:3	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	saravananknm@gmail.com	Excellent
23	2020/06/01 4:11:20 PM GMT+5:3	Abdul Latiff S	MAM School of Engineering	Mechatronics	Student	lamuya.tnj@gmail.com	Excellent
24	2020/06/01 4:17:55 PM GMT+5:3	Yogeshwaran N	Er. Perumal Manimekalai College of Engineering, Hosur.	BE.Mechatronics	Student	nyogeshwaran5gmail.com	Excellent
25	2020/06/01 4:18:29 PM GMT+5:3	SUBA PRADHA M	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	cool.pradha@gmail.com	Excellent
26	2020/06/01 4:18:54 PM GMT+5:3	R. Arun Kumar	M. A. M school of engineering	Mechatronics	Student	arunselvi141@gmail.com	Good
27	2020/06/01 4:20:59 PM GMT+5:3	Vaitheeswari.V	Mam school of engineering	Mechatronics	Student	vaitheeswarimechatronics@gmail.com	Excellent
28	2020/06/01 4:22:36 PM GMT+5:3	MUGESH KUMAR. B	MAM SCHOOL OF ENGINEERING	MECHATRTONICS	Student	plsmugesh144@gmail.com	Good
29	2020/06/01 4:24:15 PM GMT+5:3	Sanjai	M.A.M SCHOOL OF ENGINEERING	MECHATRONICS	Student	Sanjai1332000s@gmail.com	Good
30	2020/06/01 4:26:41 PM GMT+5:3	Pankaj	Chandigarh group of college	ECE	Student	Pankajdeswal146@gmail.com	Excellent
31	2020/06/01 4:28:22 PM GMT+5:3	S.praveenkumar	MAM school of engineering	Mechatronics	Student	monsterbubloo0@gmail.com	Good
32	2020/06/01 4:38:37 PM GMT+5:3	RAVICHANDRAN S	M A M School of Engineering Trichy	Mechanical Engineering	Faculty	ravi.thuraiyur0791@gmail.com	Good
33	2020/06/01 4:38:53 PM GMT+5:3	SENTHAMARAI KANNAN	M.A.M. SCHOOL OF ENGINEERING	ECE	Faculty	ersenthamarai@gmail.com	Excellent
34	2020/06/01 4:41:24 PM GMT+5:3	M. R. MOHAMMED HUSS	MAM SCHOOL OF ENGNEERING	Mechatronics	Student	msdhussain514655@gmail.com	Good
35	2020/06/01 4:55:51 PM GMT+5:3	AHMED RIFATH	M.A.M.School of Engineering	Mechatronics	Student	rifath142@gmail.com	Good
36	2020/06/01 5:25:41 PM GMT+5:3	Sowndarya.L	M.A.M school of engineering	Mechatronics engineering	Student	sowndaryalakshmanansowndarya@gmail.com	Good
37	2020/06/01 5:45:25 PM GMT+5:3	T. Varshini	M. A. M. School of engineering	Mechatronics	Student	Varshinithapasu@gmail.com	Good
38	2020/06/01 7:37:54 PM GMT+5:3	Elangathir	Mam school of engineering	Mechatronics	Student	Elangathirmamse@gmail .com	Good
39	2020/06/01 8:32:53 PM GMT+5:3	M. Manisha	MAM school of engineering	Mechatronics	Student	manishamuthu199@gmail.com	Good
40	2020/06/01 9:34:14 PM GMT+5:3	Prasanth.P	M.A.M school of engineering	Mechatronics	Student	josephprasanth1999@gmail.com	Excellent

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

SIRUGANUR, TRICHY-621105
(Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai)
(An ISO 9001: 2008 Certified Institution)
(ACCREDITED BY NAAC)

TÜV SÜD

DEPARTMENT OF MECHATRONICS ENGINEERING

WEBINAR

on

"PRINCIPLES OF ROBOTICS AND ITS APPLICATIONS"

18.05.2020

2/6/20

H.O.D

PRINCIPAL

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi I Affiliated to Anna University)
Siruganur, Trichy 621 105

Department of Mechatronics Engineering
Organises

Webinar on
Principles of Robotics and its Applications

Resource person

zoom

Dr.Sheeja.V.Francis M.S., Ph.D

Prof & Head,
Department of Biomedical Engineering,
Jerusalem College of Engineering,
Chennai.

Date: 18.5.2020, Time:3.00pm - 4.00pm

For Registration Visit
www.mamse.in

ACADEMIC PROFILE

Dr. SHEEJA V FRANCIS B.E., M.S.,Ph.D.
Professor & Head
Department of Biomedical Engineering
Jerusalem College of Engineering
Pallikaranai, Chennai- 600 100
Mobile No : + 91 9941218230
E mail : sheejavf@gmail.com

Dr. Sheeja V Francis, who is currently, Prof & Head, Dept of Biomedical Engineering, Jerusalem College of Engineering, Chennai started her career as a lecturer in Electronics & Communication Engineering, after acquiring her B.E. Degreein 1995. With great passion towards the teaching profession, she has been mentoring and educating hundreds of future engineers over the last **25 years at UG and PG levels.** Of the numerous academic courses handled, **Electronic Circuits, Signals & Systems, Digital Signal Processing, Bio Signal Processing, Digital Image Processing,Medical Image Processing and Roboticsare** her forte. She has constantly upgraded and shared her knowledge in these areas through several **seminars, workshops and NPTEL Courses.** She has been constantly motivating students to further their knowledge beyond text books and to find solutions to needs of the society through **innovative projects.** She has guided student projects every year leading to conference presentations.

She firmly believes that 'Today's research is the key to tomorrow's technological advancements'. Being attracted by the immense contributions made by engineers to the field of health and medicine, she pursued research at **the Centre for Medical Electronics, Anna University, Chennai,** where she acquired her **M.S and Ph.D degrees.** She has explored the possibilities of using non-ionising radiations in diagnostics instead of the bio-hazardous X-rays currently in use. She has extensively studied the scope of using Near Infra red light for detecting hematomas in the brain and thermal imaging for detecting breast cancer, which presently use CT scan and Mammography respectively. **She has presented her works at several National and International Seminars & Conferences and published several research papers in reputed International Journals.**

She serves as a **member of review panels** of reputed international journals with leading publishers such as **Elsevier, Springer, Taylor & Francis,** etc.,. She has received the **'Award of Recognition for Outstanding Contribution in Reviewing'** from **Elsevier Journals, The Netherlands** in May 2015. She has contributed a chapter to a book titled **'Applications of Infrared to Biomedical Sciences'**,a prestigious venture by **Nanyang Technological University, Singapore,** published by **Springer Nature,** Singapore in 2017.She is committed to the cause of furtheringquality research and is a **recognized supervisor for guiding M.S / Ph.D scholars with Anna University, Chennai.**

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING
Siruganur, Trichy-621105

Department of Mechatronics Engineering

Webinar on "Principles of Robotics and its Applications"
(18th MAY, 2020)

Department of Mechantronics Engineering had the privilege of having webinar with Dr.Sheeja.V.Francis, M.S., Ph.D Prof & Head Department of Bio Medical Engineering, Jerusalem College of Engineering, Chennai, on the topic of "Principles of Robotics and its Applications".

The invitation for this program by the designer team of MAMSE and distributed through face book. The registration form for this program has created by Google form and published in our college website on 16th May 2020.

The link for the registration:
www.mamse.in

Totally 316 participant has register for this webinar. The session is started sharply by 3.00 pm from welcome address and introduction given by Dr.Punitha, Professor, Mechatronics Engineering Department. After that the resource person starts the lecture with the basics of Robot configurations, after that she extended lecture session with kinematics of Robotics, Industrial Robots Applications, Manipulator Controls, etc. The event ended with vote of thanks given by M.Suba pradha, Assistant Professor, Mechatronics Department. Also the feedback for the participant was collected through Google form.

Program Co-ordinator **HOD**

Scanned with CamScanner

MAM SCHOOL OF ENGINEERING
DEPARTMENT OF MECHATRONICS
Participants Registration for the Webinar "Principles of Robotics and its Applications"

Sl.No	Timestamp	Name	Institution	Department	Gender	Email ID	Mobile Number
1	2020/05/16 7:17:49 PM GMT+5:30	RAVICHANDRAN. S	M A M School of Engineering Trichy	Mechatronics Engineering	Male	ravi.thuraiyur0791@gmail.com	9486583988
2	2020/05/16 7:20:23 PM GMT+5:30	Abdul Latiff S	MAM School of Engineering	Mechatronics	Male	lamuya.tnj@gmail.com	9940803798
3	2020/05/16 7:27:35 PM GMT+5:30	M.Arumugasamy	M A M SCHOOL OF ENGINEERING, TRICHY	MECHANICAL ENGINEERING	Male	jas18091996@gmail.com	9787269963
4	2020/05/16 7:53:15 PM GMT+5:30	Dr T Rammohan	Karpagam college of engineering	EEE	Male	profdrrammohan@gmail.com	9486876972
5	2020/05/16 7:53:44 PM GMT+5;30	C.SHANMUGA RAJA	AAA College of Engineering and Technology	ECE	Male	shanmugaraja0683@gmail.com	8056826592
6	2020/05/16 7:53:48 PM GMT+5:30	G. Vinothkumar	M. A. M college of engineering	Mechanical department	Male	vinothnadhi@gmail.com	8610448615
7	2020/05/16 8:01:11 PM GMT+5:30	K.UTHAYASURIYAN	SRI MANAKULA VINAYAGAR ENGINEERING COLLEGE PONDICHERRY	ELECTRONICS AND COMMUNICATION ENGINEERING	Male	kuthaya.29@gmail.com	8754618855
8	2020/05/16 8:01:40 PM GMT+5:30	L. R. Akshaya	Kongu Arts and Science College (Autonomous)	English	Female	akshayakavitha26@gmail.com	9524599767
9	2020/05/16 8:04:19 PM GMT+5:30	Ms.A.THENMOZHI	Sri G.V.G Visalakshi College for Women, Udumalpet	Commerce with e-Commerce	Female	thenmozhigvg15@gmail.com	7010747926
10	2020/05/16 8:04:40 PM GMT+5:30	VENKATA RAMANA BANDA	Sri venkateswara college of engineering and technology	Computer science and engineering	Male	bvramana2005@gmail.com	8790445444
11	2020/05/16 8:05:20 PM GMT+5:30	M.A.SESHAIAH	Meenakshi Sundararajan engineering college	ECE	Male	maseshaiah@gmail.com	9884539420
12	2020/05/16 8:05:46 PM GMT+5:30	JAYADEVAN N M	KARPAGAM COLLEGE OF ENGINEERING	ELECTRONICS AND COMMUNICATION ENGINEERING	Male	jayadevannamangalam@gmail.com	7907949799
13	2020/05/16 8:06:26 PM GMT+5:30	Jyotshna	Meenakshi sundararajan engineering college	Electronics and communication	Female	jyotshnajha4292@gmail.com	9003163738
14	2020/05/16 8:06:41 PM GMT+5:30	Dr. Bharat Bhushan Sharma	Banasthali Vidyapith Rajasthan	School of Automation	Male	mbbs.sharma@gmail.com	9953051587
15	2020/05/16 8:06:57 PM GMT+5:30	Vasupradha S	Meenakshi Sundararajan Engineering College	Electronics and Communication Engineering	Female	vasupradha17@gmail.com	9840774426
16	2020/05/16 8:07:34 PM GMT+5:30	LALUPRASHANTH-A	MAM school of engineering	Mechatronics	Male	aplalu2001@gmail.com	9629724975
17	2020/05/16 8:07:46 PM GMT+5:30	RAMDAS KAPILA	NSRIT	CSE	Male	kramdas.cse@nsrit.edu.in	8897897765
18	2020/05/16 8:07:57 PM GMT+5:30	Vydarsi Sita Rama Prasad	Vignan's Institute of Engineering For Women	Computer Science and Engineering	Male	vsrprasad45@gmail.com	8500372822
19	2020/05/16 8:08:45 PM GMT+5:30	P. Thirumagal	Kings college of engineering	Electronics and communication engineering	Female	thirumagaal@gmail.com	9944883713
20	2020/05/16 8:09:00 PM GMT+5:30	Akhila Patnaikuni	SRI VENKATESWARA COLLEGE OF ENGINEERING AND TECHNOLOGY	CSE	Female	akhilapatnaik2000@gmail.com	7989618378
21	2020/05/16 8:09:14 PM GMT+5:30	K. Kodeeswari .	Excel engineering college	ECE	Female	kodees26@gmail.com	9678627770
22	2020/05/16 8:09:45 PM GMT+5:30	bhaskar sanapala@gmail.com	Sri Venkateswara College of Engineering and Technology, Srikakulam	Computer Science & Engineering	Male	bhaskar sanapala@gmail.com	8328319274

23	2020/05/16 8:11:35 PM GMT+5:30	[illegible] Sheerin	M.M.S Government College [illegible]	Commerce and Management	Female	[illegible]@gmail.com	[illegible]
24	2020/05/16 8:11:28 PM GMT+5:30	K KOWSALYA	M.A.M SCHOOL OF ENGINEERING	MECHATRONICS	Female	[illegible]@gmail.com	[illegible]
25	2020/05/16 8:11:50 PM GMT+5:30	A.Mary joy kind	Sathyabama institute of science and technology	Electronics and communication engineering	Female	[illegible]@Gmail.com	[illegible]
26	2020/05/16 8:12:11 PM GMT+5:30	C John Selvaraj	King's college of engineering	EEE	Male	[illegible]@gmail.com	[illegible]
27	2020/05/16 8:13:58 PM GMT+5:30	Sajitha	Dhaanish ahmed college of engineering	ECE	Female	[illegible]@gmail.com	[illegible]
28	2020/05/16 8:14:01 PM GMT+5:30	MAJITHA T	DHAANISH AHMED COLLEGE OF ENGINEERING	ECE	Female	majitha4300@gmail.com	7358238616
29	2020/05/16 8:14:25 PM GMT+5:30	M. R. MOHAMMED HUSSAIN	MAM SCHOOL OF ENGINEERING	Mechatronics	Male	[illegible]hussain514655@gmail.com	7550300157
30	2020/05/16 8:18:28 PM GMT+5:30	K.PADMAPRIYA	AAA COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Female	padmapriya@aaacet.ac.in	8531822334
31	2020/05/16 8:19:29 PM GMT+5:30	Parshuram Nandu Shingote	Amrutvahini College of Engineering Sangamner	Computer Engineering	Male	parshuramshingote5751@gmail.com	8605643209
32	2020/05/16 8:19:34 PM GMT+5:30	Bhimavarapu Usha Rani	KL University	Cse	Female	ushareddy vja@gmail com	8465034028
33	2020/05/16 8:21:12 PM GMT+5:30	Vasanthamma H	ProudhaDevaraya Institute of technology Hosapete Karnataka	Computer Science Engineering	Female	gvasreddy@gmail.com	9886639986
34	2020/05/16 8:25:43 PM GMT+5:30	BALASUBRAMANYAM N	SV UNIVERSITY COLLEGE OF ENGINEERING-TIRUPATI	Mechanical Engineering	Male	er nmbalu@gmail.com	9989366203
35	2020/05/16 8:30:46 PM GMT+5:30	JANANI J	Meenakshi Sundararajan engineering college	ECE	Female	janani j211@gmail.com	9941192673
36	2020/05/16 8:33:29 PM GMT+5:30	VIKRAM GAJULA	St.Martin's Engineering College	ECE	Male	vikramece@smec.ac.in	9866900791
37	2020/05/16 8:33:47 PM GMT+5:30	Vijay Mohan	Banasthali Vidyapith	Automation	Male	vijay13787@gmail.com	9968790714
38	2020/05/16 8:35:43 PM GMT+5:30	SUSHEEL S	SASTRA DEEMED TO BE UNIVERSITY	Mechanical	Male	123009238@sastra.ac.in	6381558122
39	2020/05/16 8:36:34 PM GMT+5:30	Ankur Singh Rana	National Institute of Technology, Tiruchirappalli	Electrical & Electronics Engineering	Male	ankurranag@gmail.com	9910478111
40	2020/05/16 8:47:48 PM GMT+5:30	ARCHANA VIJAYAN	DHAANISH AHMED COLLEGE OF ENGINEERING	ECE	Female	varcha2312@gmail.com	9944200611
41	2020/05/16 8:48:19 PM GMT+5:30	K. Umarani	M.A.M.SCHOOL OF ENGINEERING	Ece	Female	umaranikece@gmail.com	9597939569
42	2020/05/16 8:49:37 PM GMT+5:30	GandhiGeerthana M	DHAANISH AHMED COLLEGE OF ENGINEERING	EEE	Female	manoharangeerthana@gmail.com	7449187760
43	2020/05/16 8:51:59 PM GMT+5:30	THENMOEZHILN	AAA COLLEGE OF ENGINEERING AND TECHNOLOGY	ECE	Female	thenmoezhi@aaacet.ac.in	9688449326
44	2020/05/16 8:53:47 PM GMT+5:30	Gattadi Vinatha	St.Martin's Engineering College,Dhulapally,Secunderabad-500100	Electronics and Communication Engineering	Female	vinnu251@gmail.com	8985045735
45	2020/05/16 8:55:25 PM GMT+5:30	SUGANYA.P	Kings college of Engineering, Punalkulam	Mathematics	Female	suganyap.1983@gmail.com	7010473878
46	2020/05/16 8:56:48 PM GMT+5:30	Jakir Hussain G K	KPR Institute of Engineering and Technology	Electronics and Communication Engineering	Male	gkjakirhussain1@gmail.com	9600548540
47	2020/05/16 8:59:03 PM GMT+5:30	Bazani Shaik	MTIET-JNTUA	Mechanical Engineering	Male	bazanijntua@gmail.com	9966786948
48	2020/05/16 8:59:32 PM GMT+5:30	Kamal Kumar Gola	Faculty of Engineering, TMU, Moradabad	Computer Science and Engineering	Male	kkgolaa1503@gmail.com	9.19457E+11

Scanned with CamScanner

49	2020/09/16 9:00:01 PM GMT+5:30	PREETHI M	KPR Institute of engineering and technology	Electronics and communication engineering	Female	preethikala2000@gmail.com	9842225863
50	2020/09/16 9:01:24 PM GMT+5:30	Sasi Rekha R	KPR Institute of Engineering and technology	ELECTRONIC AND COMMUNICATION ENGINEERING	Female	18ec119@kpriet.ac.in	6383933935
51	2020/09/16 9:02:14 PM GMT+5:30	THARANI K S	KPR Institute of Engineering and Technology	Electronic and Communication	Female	tharanikannappan130@gmail.com	8754015463
52	2020/09/16 9:02:52 PM GMT+5:30	ARUN RAJ S R	U B D T COLLEGE OF ENGINEERING	ELECTRONICS AND COMMUNICATION	Male	arunrajsr5@gmail.com	9164483260
53	2020/09/16 9:05:30 PM GMT+5:30	Dr. S Roshan	KL university	ECE	Male	roshan@kluniversity.in	9944043430
54	2020/09/16 9:08:17 PM GMT+5:30	Abhishek Guru	Gurukul College Pathalgaon	Computer Science Department	Male	abhishekguru0703@gmail.com	9630113386
55	2020/09/16 9:08:31 PM GMT+5:30	Pramoda Patro	Annamacharya college of engineering_tanguturu	Computer engineering	Male	pramoda.mtech09@gmail.com	7709333379
56	2020/09/16 9:09:45 PM GMT+5:30	R. N. Mary	Meenakshi sundararajan engineering college	ECE	Female	marymaresh1301@gmail.com	9840244541
57	2020/09/16 9:20:51 PM GMT+5:30	Dr. Asha Ambhaikar	Kalinga University, Naya Raipur (CG)	Computer Science and Engineering	Female	dr.asha.ambhaikar@gmail.com	9229635211
58	2020/09/16 [illegible] PM GMT+5:30	R RAJENDRAN	KRISHNASAMY COLLEGE OF ENGINEERING AND TECHNOLOGY	ECE	Male	rajendran.tesla@gmail.com	9894048771
59	2020/09/16 [illegible] PM GMT+5:30	SAKTHIVEL M	KINGS COLLEGE OF ENGINEERING	MECHANICAL	Male	sakthi.mech[illegible]@gmail.com	9791521437
60	2020/09/16 [illegible] PM GMT+5:30	R. Ravi	Krishnasamy college of engineering technology cuddalore	ECE	Male	[illegible]@gmail.com	9626417647
61	2020/09/16 [illegible] PM GMT+5:30	NITHILA SHERIN A	KPR INSTITUTE OF ENGINEERING AND TECHNOLOGY	ECE	Female	[illegible]@gmail.com	[illegible]
62	2020/09/16 [illegible] PM GMT+5:30	Franklin George Johns	Lord Jegannath College of Engineering and Technology	Electronics and Communication Engineering	Male	franklingj@gmail.com	[illegible]
63	[illegible]	[illegible]	M. A. M SCHOOL OF ENGINEERING	ECE	Female	[illegible]@gmail.com	[illegible]
64	[illegible]	[illegible]	KPR INSTITUTE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Female	[illegible]	[illegible]
65	[illegible]	[illegible]	[illegible] College of Arts and Science	Computer Science	Male	[illegible]@gmail.com	[illegible]
66	[illegible]	[illegible]	M. A. M school of engineering	[illegible] engineering	Female	[illegible]	[illegible]
67	[illegible]	[illegible]	KPR Institute of Engineering and Technology	Electronics and communication Engineering	Male	[illegible]@gmail.com	[illegible]
68	[illegible]	[illegible]	[illegible] SCHOOL OF ENGINEERING	[illegible]	Male	[illegible]@gmail.com	[illegible]
69	[illegible]	[illegible]	M. A. M School of Engineering	[illegible]	Male	[illegible]@gmail.com	[illegible]
70	[illegible]	[illegible]	[illegible]	Mechanical	Male	[illegible]@gmail.com	[illegible]
71	[illegible]	[illegible]	[illegible]	[illegible]	Male	[illegible]@gmail.com	[illegible]
72	[illegible]	[illegible]	[illegible]	[illegible]	Female	[illegible]@gmail.com	[illegible]
73	[illegible]	[illegible]	[illegible] Institute of Technology	[illegible]	Male	[illegible]@gmail.com	[illegible]
74	[illegible]	[illegible]	[illegible]	[illegible]	Female	[illegible]@gmail.com	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Female	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Engineering	Male	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Male	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] college of Engineering	Electronics and communication Engineering	Female	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] college of Engineering	Electrical and Electronics Engineering	Male	[illegible]@gmail.com	[illegible]
80	[illegible]	[illegible]	[illegible] institute of engineering and technology	[illegible]	Male	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Electronics and communication engineering	Male	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] institute of engineering and technology	[illegible]	Female	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible] institute of Engineering and technology	Electronics and communication Engineering	Female	[illegible]@gmail.com	[illegible]
84	[illegible]	[illegible]	M.A.M school of engineering	EEE	Male	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	Mohamed [illegible]	M.A.M SCHOOL OF ENGINEERING	Mechatronics Engineering	Male	[illegible]@gmail.com	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Chemistry	Male	[illegible]@gmail.com	[illegible]
87	[illegible]	[illegible]	[illegible]	EEE	Male	[illegible]@gmail.com	[illegible]
88	[illegible]	[illegible]	[illegible] Institute of Engineering and Technology	Electronics and Communication Engineering	Male	[illegible]@gmail.com	[illegible]
89	[illegible]	[illegible]	MAM School of Engineering	EEE	Male	[illegible]@gmail.com	[illegible]
90	2020/05/16 9:56:26 PM GMT+5:30	M. Mamdia	MAM school of engineering	Mechatronics	Female	[illegible]@gmail.com	[illegible]
91	2020/05/16 9:57:31 PM GMT+5:30	[illegible]	M.A.M school of engineering	[illegible]	Male	[illegible]@gmail.com	[illegible]
92	2020/05/16 9:57:40 PM GMT+5:30	[illegible]	Mam	[illegible]	Male	[illegible]@gmail.com	[illegible]
93	2020/05/16 9:58:59 PM GMT+5:30	[illegible]	[illegible] College of Engineering	Computer Engineering	Male	[illegible]@gmail.com	[illegible]
94	2020/05/16 10:00:15 PM GMT+5:30	[illegible]	M.A.M school of engineering	EEE	Female	[illegible]@gmail.com	[illegible]
95	2020/05/16 10:00:41 PM GMT+5:30	[illegible]@gmail.com	Kpr institute of engineering and technology	Electronic and communication engineering	Female	[illegible]@gmail.com	[illegible]
96	2020/05/16 10:07:08 PM GMT+5:30	P. Mugil [illegible]	M. A. M School of Engineering	EEE	Female	[illegible]@gmail.com	[illegible]
97	2020/05/16 10:07:24 PM GMT+5:30	Kaustubh Kumar Shukla	Vinayaka Mission's Research Foundation, Salem	ECE	Male	[illegible]@gmail.com	[illegible]
98	2020/05/16 10:07:44 PM GMT+5:30	Kannan S	Vinayaka Mission's Kirupananda Variyar Engineering College	Bio Medical Engineering	Male	[illegible]@gmail.com	[illegible]
99	2020/05/16 10:08:57 PM GMT+5:30	Yuvasri R	MAM school of engineering	EEE	Female	[illegible]@gmail.com	[illegible]
100	2020/05/16 10:11:53 PM GMT+5:30	Berbera Mary S	MAM School of Engineering, Trichy	Physics	Female	[illegible]@gmail.com	[illegible]

101	2020/05/16 10:15:40 PM GMT+5:30	Malarvizhi A	Vinayaka Missionâ€™s Kirupananda Variyar Engineering College	ECE	Female	malar.ece06@gmail.com	8220446846
102	2020/05/16 10:17:31 PM GMT+5:30	N Gunasekhar Reddy	S V Engineering College	ECE	Male	gunasekhar2008@gmail com	9959154521
103	2020/05/16 10:18:41 PM GMT+5:30	S VALARMATHY	Vinayaka Mission's Kirupananda Variyar Engineering College, Salem	Electronics and Communication Engineering	Female	valarmathysr@gmail.com	9944949866
104	2020/05/16 10:24:35 PM GMT+5:30	S.Vaishnodevi	Vinayaka Mission's Kirupananda Variyar Engineering College	Biomedical Engineering	Female	vaishnosathees@gmail.com	9710161468
105	2020/05/16 10:25:40 PM GMT+5:30	Pooja walunj	Amrutvahini College of engineering sangamner	Computer Engineering	Female	pooja.walunj31@gmail.com	9561951485
106	2020/05/16 10:26:48 PM GMT+5:30	Dr. T. Sheela	Vinayaka Mission's Kirupananda Variyar Engineering College	ECE	Female	sheelamuthu@gmail.com	9443860350
107	2020/05/16 10:29:24 PM GMT+5:30	Arockuaraj s	Mepco schlenk engg college	EEE	Male	Arockiarocks@gmail.com	9626044699
108	2020/05/16 10:32:06 PM GMT+5:30	M.Muthukumar	M.A.M.SCHOOL OF ENGINEERING	Mechanical engineering	Male	muthukumar.manikcam@gmail.com	9965375496
109	2020/05/16 10:34:20 PM GMT+5:30	R.Ramani	VINAYAKA MISSION'S KIRUPANADA VARIYAR ENGINEERING COLLEGE	ECE	Male	ramaniapece@gmail.com	9944870878
110	2020/05/16 10:38:36 PM GMT+5:30	Subashini R	Dhaanish ahmed college of engineering	ECE	Female	subashinirajendiran1999@gmail.com	7339507830
111	2020/05/16 10:44:35 PM GMT+5:30	A. Vembathurajesh	Nadar Saraswathi College of Engineering and Technology Theni	Mechanical Engineering	Male	avr.krj@gmail.com	9976412468
112	2020/05/16 10:51:09 PM GMT+5:30	SABITA PAL	S'O'A	ECE	Female	sabitapal@soa.ac.in	9937664824
113	2020/05/16 10:55:33 PM GMT+5:30	Menaka	M. A. M school of engineering, trichy	Electrical and electronics engineering	Female	menaka2000ashokan@gmail.com	9384126738
114	2020/05/16 11:12:55 PM GMT+5:30	Abu backer siddique	Mamse	Eee	Male	Abub49803@gmail.com	8144679552
115	2020/05/16 11:31:07 PM GMT+5:30	Ilayaraja M	MAM school of engineering	EEE	Male	ilayaraja7305@gmail.com	6380488324
116	2020/05/16 11:57:17 PM GMT+5:30	Sabita Mali	ITER, SOA deemed to be University	EIE	Female	sabitamali@soa ac in	9861375535
117	2020/05/17 12:32:16 AM GMT+5:30	Gautham raj J	M.A.M school of engineering	Mechanical engineering	Male	gauthamraj8344@gmail com	8344321707
118	2020/05/17 4:34:30 AM GMT+5:30	Mohamed thowfeek Rahman S	MAM School of engg	BE-EEE	Male	thowfeekrahman4646@gmail com	8056675131
119	2020/05/17 5:23:56 AM GMT+5:30	Suruthi.s	Mam school of Engineering	EEE	Female	suruthiselva01@gmail.com	9150365371
120	2020/05/17 5:28:26 AM GMT+5:30	G Ramachandran	Vinayaka Mission's Kirupananda Variyar Engineering College	ECE	Male	sriramachandrang@gmail com	9843396844
121	2020/05/17 6:26:57 AM GMT+5:30	Raghu	M A M school of engineering	EEE	Male	raghusaran18@gmail com	9786293430
122	2020/05/17 7:40:14 AM GMT+5:30	Asuntha A	SRMIST	EIE	Female	asunthaa@srmist edu in	9551925514
123	2020/05/17 7:52:58 AM GMT+5:30	Maheshwari M	KCET	ECE	Female	mahe mahima@gmail com	6380749603
124	2020/05/17 8:08:25 AM GMT+5:30	GANAPRIYA S	KPR INSTITUTE OF ENGINEERING AND TECHNOLOGY	Electronic and Communication Engineering	Female	sshanmugam8726@gmail.com	[illegible]
125	2020/05/17 8:23:06 AM GMT+5:30	A Balaji	M A M school of engineering trichy	Mechatronics	Male	Alagarbalaji1999@gmail com	8056965791
126	2020/05/17 9:23:42 AM GMT+5:30	B vasanthan	M A M SCHOOL OF ENGINEERING	MECHANICAL	Male	[illegible]	9159573059

Scanned with CamScanner

127	[illegible]	[illegible]	M. A. M. School of Engineering	Mechanical Engineering	Male	[illegible]	[illegible]
128	2020/05/17 9:28:42 AM GMT+5:30	Aravindhan k	M.A.M	Mechanical	Male	[illegible]	[illegible]
129	2020/05/17 9:33:52 AM GMT+5:30	Santha dhandapani	Mam school of engineering	EEE	Female	[illegible]	[illegible]
130	2020/05/17 9:36:20 AM GMT+5:30	K. Ganesh kumar	M. A. M school of engineering	Mechanical	Male	[illegible]	[illegible]
131	2020/05/17 9:37:31 AM GMT+5:30	M Murugan	MAM SCHOOL OF ENGINEERING	Mechanical	Male	[illegible]	[illegible]
132	2020/05/17 9:40:35 AM GMT+5:30	R Selvamani	M A M School of engineering	Mechanical engineering	Male	[illegible]	[illegible]
133	2020/05/17 9:44:00 AM GMT+5:30	Mrs S SENTHAZHAI	KRISHNASAMY COLLEGE OF ENGINEERING & TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Female	[illegible]	9791597357
134	2020/05/17 9:47:17 AM GMT+5:30	ANANDBABU P	MAM SCHOOL OF ENGINEERING	B.E(EEE)	Male	anandbala250@gmail.com	7708769506
135	2020/05/17 10:05:32 AM GMT+5:30	Guru Kailash S	KPR INSTITUTE OF ENGINEERING AND TECHNOLOGY	Electronics and communication engineering	Male	[illegible]	6381297738
136	2020/05/17 10:07:33 AM GMT+5:30	Sandhya S	M. A. M school of engineering	EEE	Female	[illegible]	8110058759
137	2020/05/17 10:09:09 AM GMT+5:30	P.selvabharathi	M.A.M school of engineering	Mechanical	Male	Selva2bharathi@gmail.com	6383981587
138	2020/05/17 10:11:43 AM GMT+5:30	PRAVEEN KUMAR V	DHAANISH AHEMD COLLEGE OF ENGINEERING	Eee	Male	praveenvaradhan123@gmail.com	9787414250
139	2020/05/17 10:13:04 AM GMT+5:30	A Mohan Kumar	MAM School of Engineering	Mechanical	Male	mohankumarayyasamy@gmail.com	9655973559
140	2020/05/17 10:14:07 AM GMT+5:30	I.Sasikumar	MAM school of engineering	Mechanical	Male	sasi84016@gmail.com	9585053680
141	2020/05/17 10:21:46 AM GMT+5:30	R. Rajkumar	MAM	Mechanical	Male	ravirajkutty143@gmail.com	9791464602
142	2020/05/17 10:21:48 AM GMT+5:30	Banisha Gandhimathi.P	M A M SCHOOL OF ENGINEERING	Electrical and electronics engineering	Female	banisha5006@gmail.com	9655758259
143	2020/05/17 10:29:14 AM GMT+5:30	S.senthurNivas	Mam school of Engineering	Mechanical	Male	natpunivas2000@gmail.com	9384288519
144	2020/05/17 10:33:18 AM GMT+5:30	raj Kumar	MAM school of engineering	Mechatronics	Male	rajkumar1822000@gmail.com	8220529005
145	2020/05/17 10:33:35 AM GMT+5:30	M.UMAIYASARAVANAN	M.A.M.School Of Engineering	Mechanical	Male	umaiyasaravanan8776@gmail.com	6379326511
146	2020/05/17 10:41:20 AM GMT+5:30	V. Sivasankar	M.A.M School Of Engineering	Mechanical	Male	sivamechboy212@gmail.com	6381759353
147	2020/05/17 10:44:10 AM GMT+5:30	SRINIVASAN.N	Chaitanya Bharathi Institute of technology	CSE	Male	sri.mtech04@gmail.com	9989482547
148	2020/05/17 10:44:17 AM GMT+5:30	Milindkumar Vaidya	AVCOE Sangamner	Computer	Male	milind.vaidya@avcoe.org	9420484165
149	2020/05/17 10:56:58 AM GMT+5:30	DIPIKA DIGDARSHINI PRADHAN	JSPM NARHE TECHNICAL CAMPUS	Electronics and Telecommunication	Female	deepika01513@gmail.com	8275597442
150	2020/05/17 11:01:59 AM GMT+5:30	Sri dhanusha S K	KPR institute of engineering and technology	Electronics and communication engineering	Female	sksridhanusha2000@gmail.com	9566851615
151	2020/05/17 11:15:00 AM GMT+5:30	B.BHARATHI RAJA	MAM SCHOOL OF ENGINEERING	MECHANICAL	Male	bharathi272001@gmail.com	9626999644
152	2020/05/17 12:22:07 PM GMT+5:30	RAAGAVI S	KPR Institute of Engineering and Technology	Electronics and Communication Engineering	Female	18ec101@kprier.ac.in	9080195109

153	2020/05/17 12:36:39 PM GMT+5:30	DHISHALINI R R	KPR INSTITUTE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Female	dhishaliniravichandran@gmail.com	9384394469
154	2020/05/17 12:59:13 PM GMT+5:30	S Aravind	MAMSE	Mechanical	Male	s8060936@gmail.com	9.16383E+11
155	2020/05/17 1:46:34 PM GMT+5:30	Vishal B	Meenakshi Sundararajan engineering college	ECE	Male	vishalbala20@gmail.com	8825755856
156	2020/05/17 2:43:47 PM GMT+5:30	S Purnima	Jerusalem College of Engineering	Biomedical Engineering	Female	purnima27bme@gmail.com	9884162307
157	2020/05/17 2:58:03 PM GMT+5:30	Dhamotharan P	Kamban college of arts and science	Computer science	Male	dhamotharanbca@gmail.com	9600481470
158	2020/05/17 4:05:01 PM GMT+5:30	Neeta Rajeev Kadam	JSPM Narhe Technical Campus, Pune	E&TC	Female	nkadam2006@gmail.com	9822594353
159	2020/05/17 4:27:51 PM GMT+5:30	Dr.C.Arunkumar Madhuvappan	Vinayaka Mission's Kirupananda Variyar Engineering College	Electronics and Communication Engineering	Male	carunmadhu@gmail.com	9345339000
160	2020/05/17 4:35:14 PM GMT+5:30	Dr.R.THAMILSELVI	Bharathiar University Arts and Science College Pollachi	Commerce	Female	tamilselvi9976@gmail.com	9976978695
161	2020/05/17 4:36:52 PM GMT+5:30	RITHIK KRISNA M	KPR Institute of Engineering and Technology	ECE	Male	rithikkrisna0@gmail.com	9944373236
162	2020/05/17 4:37:39 PM GMT+5:30	Monisha	Mamse	Eee	Female	monishachinnaiya4@gmail.com	9655953249
163	2020/05/17 4:40:41 PM GMT+5:30	A. ANTONY DAVID	Sureya College of engineering, Trichy	Electrical and Electronic engineering	Male	david73raj@gmail.com	8072511551
164	2020/05/17 4:48:27 PM GMT+5:30	Dinesh	Mam school of engineering	EEE	Male	dineshviji703@gmail.com	9655723816
165	2020/05/17 4:52:45 PM GMT+5:30	ujeyamalar@gmail.com	Kings College of Engineering	ECE	Female	ujeyamalar@gmail.com	9791468414
166	2020/05/17 4:57:03 PM GMT+5;30	J jothilakshmi	M.A.M school of engineering	EEE	Female	jjothi5010@gmail com	7397095357
167	2020/05/17 5:02:04 PM GMT+5:30	RAMAKRISHNA ACHARYA . N	OPJS University	Management sciences	Male	ramdas saphr@gmail com	7036703616
168	2020/05/17 5:11:05 PM GMT+5:30	P.Hema	Jerusalem college of Engineering	Biomedical	Female	divyahema63@gmail.com	7358265320
169	2020/05/17 5:11:27 PM GMT+5:30	Dhivya V	M.A.M SCHOOL OF ENGINEERING	EEE	Female	dhivyadevam28@gmail.com	9585259152
170	2020/05/17 5:16:18 PM GMT+5:30	Known student	M.A.M school of engineering	EEE	Male	ashifmd2820@gmail com	8056604449
171	2020/05/17 5.18.42 PM GMT+5.30	S zarina banu	Jerusalem college of engineering	Biomedical engineering	Female	zaribanu05561@gmail com	9840924827
172	2020/05/87 5:24:40 PM GMT+5:30	Raghul B	Jerusalem College of Engineering	Biomedical	Male	rahulbaskaranrp@gmail.com	9.19551E+11
173	2020/05/17 5:28:46 PM GMT+5:30	Priyanka B	Jerusalem College Of Engineering	Biomedical	Female	priyankabaskaranrr@gmail.com	9841524888
174	2020/05/17 5:30:12 PM GMT+5:30	L arun	m. a. m school of engineering	EEE	Male	akashakash54202@gmail.com	6381362300
175	2020/05/17 5:30:26 PM GMT+5:30	Prianka Mitha C	Jerusalem College of Engineering	Bio Medical Engineering	Female	priyankamitha2000@gmail.com	6380897552
176	2020/05/17 5:31:41 PM GMT+5:30	VISWA THARANI L	Jerusalem college of engineering	Biomedical engineering	Female	lsvn delb@gmail com	9150728935
177	2020/05/17 5:31:45 PM GMT+5:30	Bismu J H	Jerusalem college of engineering	BME	Female	bismibenadit@gmail com	9940191490
178	2020/05/17 5:32:34 PM GMT+5:30	Shubhankar S	Jerusalem college of engineering	Biomedical	Male	[illegible]@gmail com	[illegible]

Scanned with CamScanner

179	2020/05/17 5:32:42 PM GMT+5:30	Naveen A	jerusalemâ€™s college of engg	Bio medical	Male	naveenvenkat30699@gmail.com	9962921717
180	2020/05/17 5:32:45 PM GMT+5:30	M Radhika	Jerusalem College of Engineering	Biomedical Engineering	Female	radhimurugesan2000@gmail.com	9790829361
181	2020/05/17 5:32:51 PM GMT+5:30	BHARATH.S	Jerusalem college of engineering	BME	Male	bharath14112000@gmail.com	8270453099
182	2020/05/17 5:32:57 PM GMT+5:30	Srikanth.S	Jerusalem college of engineering	Bio-medical engineering	Male	srikanthsk11750@gmail.com	9941679115
183	2020/05/17 5:34:53 PM GMT+5:30	V.Shankari	Jerusalem college of engineering	Biomedical engineering	Female	shankari21bme@jerusalemengg.ac.in	7358430293
184	2020/05/17 5:35:11 PM GMT+5:30	Raksha G	Jerusalem college of engineering	Biomedical engineering	Female	rakshagrajan@gmail.com	9840425220
185	2020/05/17 5:35:31 PM GMT+5:30	Muthulakshmi A	Jerusalem college of engineering	Biomedical engineering	Female	muthulakshmi6mugam@gmail.com	9962156118
186	2020/05/17 5:36:55 PM GMT+5:30	Jesintha Rani. D	Jerusalem College of Engineering	Biomedical Engineering	Female	jsrani98@gmail.com	9884192418
187	2020/05/17 5:37:30 PM GMT+5:30	S.Swetha	Jerusalem college of engineering	Bio medical engineering	Female	swethasuresh1008@gmail.com	7358047964
188	2020/05/17 5:40:45 PM GMT+5:30	Dhanush k	Jerusalem college of engineering	Biomedical engineering	Male	dhanushk289@gmail.com	9087999574
189	2020/05/17 5:41:30 PM GMT+5:30	Pavithra.k	Jerusalem college of engineering	BME	Female	pavithramoorthipavithra@gmail.com	6379013246
190	2020/05/17 5:42:36 PM GMT+5:30	V.Dhanalakshmi	Jerusalem college of engineering	BE-BME	Female	dhanalakshmi24611@gmail.com	8122630660
191	2020/05/17 5:44:01 PM GMT+5:30	M. Subha	Jerusalem College of Engineering	Biomedical engineering	Female	subhamuthuram8@gmail.com	9176071483
192	2020/05/17 5:45:17 PM GMT+5:30	A.keerthiga	Jerusalem college of engineering	BE biomedical	Female	keerthu2510@gmail.com	9361563093
193	2020/05/17 5:45:54 PM GMT+5:30	M. Nagasai Gayathri	jerusalem college of engineering	biomedical engineering	Female	nagasaigayathri07@gmail.com	9944067776
194	2020/05/17 5:53:29 PM GMT+5:30	K.Prabhakaran	Jerusalem college of engineering	Biomedical engineering	Male	kk492413@gmail.com	8608445648
195	2020/05/17 5:57:41 PM GMT+5:30	Rijo JacksonTom	CMR Institute of Technology	CSE	Male	rijojackson@gmail.com	9500191494
196	2020/05/17 5:57:42 PM GMT+5:30	B.ANANDHI	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Female	anandhi132000@gmail.com	9003189490
197	2020/05/17 5:58:26 PM GMT+5:30	Sudharsanam.k	Jerusalem college of Engineering	Biomedical Engineering	Male	Ks06112k@gmail.com	9445706562
198	2020/05/17 6:02:22 PM GMT+5:30	Santhiya. K	Jerusalem college of engineering	Biomedical	Female	santhiyakannan1804@gmail.com	7358381149
199	2020/05/17 6:02:50 PM GMT+5:30	R.Kishore	Jerusalem college of engineering	BE-BME	Male	kishorekutty24611@gmail.com	9962142380
200	2020/05/17 6:10:51 PM GMT+5:30	YUVA SHAKTHI RAJESH	JERUSALEM CLG OF ENG	BIOMEDICAL ENGINEERING	Female	yuvashakthi0602@gmail.com	9176515896
201	2020/05/17 6:11:04 PM GMT+5:30	KEERTHANA. R	Jerusalem college of engineering	Biomedical	Female	rkeerthana197@gmail.com	9840122868
202	2020/05/17 6:18:53 PM GMT+5:30	S.V.Naveen	Jerusalem College Of Engineering	BME	Male	naveensv@jerusalemengg.ac.in	9701963431
203	2020/05/17 6:20:12 PM GMT+5:30	RAMYA K	Jerusalem college of engineering	Bio-Medical engineering	Female	ramyakasinathan1@gmail.com	8248866352
204	2020/05/17 6:22:33 PM GMT+5:30	S.A.SREE VISHWA	JERUSALEM COLLEGE OF ENGINEERING	B.E.BIOMEDICAL ENGINEERING	Female	sreevishwa.sa@gmail.com	9962014335

Scanned with CamScanner

205	2020/05/17 6:33:33 PM GMT+5:30	GS Nanditha	Jerusalem college of engineering	Bio medical engineering	Female	gsnanditha2000@gmail.com	9445541637
206	2020/05/17 6:33:34 PM GMT+5:30	Thebez Veda Jeyaraj .T	Jerusalem College of Engineering	Bio-Medical Engineering	Male	thebez1999@gmail.com	9789913346
207	2020/05/17 6:34:48 PM GMT+5:30	Janes Percy J	Jerusalem engineering college	BME	Female	janespercy7@gmail.com	9677297993
208	2020/05/17 6:36.00 PM GMT+5:30	M.Raga sakthi akshayaa	Jerusalem college of engineering	Biomedical engineering	Female	akshayaprakash24@gmail.com	7401221111
209	2020/05/17 6:36:41 PM GMT+5:30	Devi Lakshmi A	Jerusalem college of engineering	Biomedical engineering	Female	devilakshmi186@gmail.com	7871759514
210	2020/05/17 6:37:29 PM GMT+5:30	U.JATHURSHA	JERUSALEM COLLEGE OF ENGINEERING	B.E.BIOMEDICAL	Female	jathu.uruthira@gmail.com	6379164726
211	2020/05/17 6:37:55 PM GMT+5:30	Niharika	Jerusalem college of engineering	Bio medical engineering	Female	niharikaramdas26@gmail.com	9150873296
212	2020/05/17 6:40:05 PM GMT+5:30	P.MADHUMITHA	Jerusalem college of engineering	Biomedical engineering	Female	madhumithap2208@gmail.com	8667441809
213	2020/05/17 6:41:02 PM GMT+5:30	Kalaichezhiyan K S	Jerusalem college of engineering	BME-bio medical	Male	sekarkalai2001@gmail.com	6379067727
214	2020/05/17 6:41:17 PM GMT+5:30	Pallabi Ghosh	Jerusalem College of Engineering	Biomedical Engineering	Female	gpallabi24@gmail.com	9434270276
215	2020/05/17 6:45:44 PM GMT+5:30	M.Madhumitha	M.A.M School of Engineering	Electronics and Communication Engineering	Female	madhumurugesan12@gmail.com	9080255309
216	2020/05/17 6:56:41 PM GMT+5:30	AVESHA R	Jerusalem college of engineering	Biomedical engineering	Female	avesha2405@gmail.com	7448931657
217	2020/05/17 6:58:20 PM GMT+5:30	M.Vimenthani	Jerusalem college of Engineering	Biomedical	Female	vimenthani.vimey@gmail.com	9840650017
218	2020/05/17 7:05:17 PM GMT+5:30	P.Mohanram	Jerusalem college of engineering	BME	Male	mohanrammohanram921@gmail.com	9498553986
219	2020/05/17 7:10:51 PM GMT+5:30	D GAMALIEL SAM JOSHUAH	JERUSALEM COLLEGE OF ENGINEERING	Bio Medical ENGINEERING	Male	dgsjoshuah28@gmail.com	8220195209
220	2020/05/17 7:33:23 PM GMT+5:30	SUDHA P	M. A.M school of Engineering	Mechatronics Engineering	Female	suba1906@gmail.com	9003674127
221	2020/05/17 7:33:43 PM GMT+5:30	MOHANAPRIYA S	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Female	priya4122549@gmail.com	9677204940
222	2020/05/17 7:38:01 PM GMT+5:30	D.Daphne Pearl	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Female	d.daphnepearl@gmail.com	8939413410
223	2020/05/17 7:40:02 PM GMT+5:30	Rabin	MAMSE	EEE	Male	rabinpeter0143@gmail.com	9626056898
224	2020/05/17 7:42:14 PM GMT+5:30	Bharathi R	MAM SCHOOL OF ENGINEERING	EEE	Female	bharathbharathi2020@gmail.com	6385575033
225	2020/05/17 7:50:02 PM GMT+5:30	Naveen kumar k	MAM school of engineering	Electrical and electronics engineering	Male	naveen15eee@gmail.com	8725334909
226	2020/05/17 7:51:15 PM GMT+5:30	Syed kader Ajmal	Jerusalem College of Engineering	Biomedical engineering	Male	syedkaderajmal@yahoo.com	9884166063
227	2020/05/17 7:54:24 PM GMT+5:30	Poornima	Jerusalem college of engineering	Biomedical engineering	Female	poornideshkan@gmail.com	7904885216
228	2020/05/17 7:56:32 PM GMT+5:30	Priyanka. P	Jerusalem college of engineering	Bio medical	Female	pushkaranperiyanka@gmail.com	8870948347
229	2020/05/17 [illegible] PM GMT+5:30	Dhanalakshmi D	M A M school of Engineering	EEE	Female	dhanalakshmi24031996@gmail.com	8310965173
230	2020/05/17 8:17:58 PM GMT+5:30	Mohamed Farzik	Jerusalem College of engineering	Biomedical	Male	mfarzik15@gmail.com	[illegible]

Scanned with CamScanner

231	2020/05/17 8:[illegible] PM GMT+5:30	[illegible]	[illegible] UNIVERSITY	[illegible]	Male	[illegible]	[illegible]
232	2020/05/17 8:[illegible] PM GMT+5:30	S Divyabharathi	Jerusalem college of engineering	B.E(Biomedical)	Female	[illegible]@gmail.com	[illegible]
233	2020/05/17 8:20:34 PM GMT+5:30	[illegible]	[illegible] University	Political Science	Male	[illegible]@gmail.com	[illegible]
234	2020/05/17 8:24:23 PM GMT+5:30	Balaji Thiru	[illegible] tech university	Mechanical	Male	[illegible] edu.in	[illegible]
235	2020/05/17 8:28:46 PM GMT+5:30	PREETHA V	Jerusalem college of engineering	Biomedical engineering	Female	[illegible]@gmail.com	[illegible]
236	2020/05/17 8:33:34 PM GMT+5:30	SRINIVASA S	GFGC CHICKABALLAPUR	PHYSICS	Male	[illegible]@gmail.com	[illegible]
237	2020/05/17 8:35:12 PM GMT+5:30	J THAMEEM AFSARA BANU	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Female	[illegible]@gmail.com	[illegible]
238	2020/05/17 8:37:43 PM GMT+5:30	Sandhya S	MAM SCHOOL OF ENGINEERING TRICHY	EEE	Female	[illegible]@gmail.com	[illegible]
239	2020/05/17 8:38:48 PM GMT+5:30	Dr. G. Arockia sahaya sheela	Holy cross college	CS	Female	[illegible]	[illegible]
240	2020/05/17 8:46:19 PM GMT+5:30	Dr. Rishi Pal	Chaudhary Bansi Lal University Bhiwani 127021	Department of Physics	Male	[illegible]@gmail.com	[illegible]
241	2020/05/17 8:47:04 PM GMT+5:30	K.R.Martin	St Joseph's college	CS	Male	[illegible]@gmail.com	[illegible]
242	2020/05/17 8:52:35 PM GMT+5:30	Sowmya.m	Jerusalem college of engineering	BME	Female	sowmyadharani1302@gmail.com	[illegible]
243	2020/05/17 9:02:09 PM GMT+5:30	Sethuraman S	Jerusalem college of engineering	Biomedical engineering	Male	[illegible]@gmail.com	[illegible]
244	2020/05/17 9:19:04 PM GMT+5:30	Swarnambika. J	Jerusalem college of engineering	Biomedical	Female	Swarnambika99@gmail.com	[illegible]
245	2020/05/17 9:36:48 PM GMT+5:30	v.shankari	jerusalem college of engineering	biomedical engineering	Female	shanka130799@gmail.com	7358430293
246	2020/05/17 10:12:31 PM GMT+5:30	Gomathinayaham	Jerusalem College of engineering	Bio medical Engineering	Male	nayaham gomathi@gmail.com	9629130716
247	2020/05/17 10:25:32 PM GMT+5:30	Arvindhan M	GU	CSE	Male	5025hems@gmail.com	7904534200
248	2020/05/17 10:32:16 PM GMT+5:30	Dr R.Sudhakar	Dr Mahalingam College of Engineering and Technology	Electronics and Communication Engineering	Male	sudhakar rudhakrishnan@gmail.com	9443566095
249	2020/05/17 10:53:14 PM GMT+5:30	THURAP MOHIDEEN T M	Periyar centenary polytechnic college	Mechanical	Male	thuraptma@gmail.com	9791808815
250	2020/05/17 11:05:55 PM GMT+5:30	MANDAL K	R M D Engineering College	Department of Computer Science and Engineering	Male	mka.cse@rmd.ac.in	9994116836
251	2020/05/17 11:10:57 PM GMT+5:30	NISHA SHREE.T.R	Jerusalem college of engineering	Bio Medical Engineering	Female	nishashreetr@gmail.com	9094674349
252	2020/05/17 11:46:30 PM GMT+5:30	A.Tamizh Selvi	Jerusalam college of engineering	Biomedical engineering	Female	thamizhselvi2143@gmail.com	8939506310
253	2020/05/18 1:07:00 AM GMT+5:30	M.MUTHU KRISHNA KUMAR	ANNAI VAILANKANNI ARTS AND SCIENCE COLLEGE,THANJAVUR	MANAGEMENT	Male	muthukrishh.1985@gmail.com	9952444407
254	2020/05/18 6:41:59 AM GMT+5:30	Anandaraj E	Jerusalem college of engineering	Bio medical engineering	Male	anandaraj.elumalai@gmail.com	8870984910
255	2020/05/18 6:25:35 AM GMT+5:30	Muneeswaran R	Solamalai College of Engineering	Mechanical engineering	Male	munis1978@gmail.com	9444209558
256	2020/05/18 7:37:42 AM GMT+5:30	N Mageshwaran	MAM school of engineering	Mechatronics	Male	mageshn6460@gmail.com	9080642910

257	2020/05/18 8:53:00 AM GMT+5:30	Tuhina Sheryl Abraham	Jerusalem college of engineering	Biomedical engineering	Female	tuhinaabraham99@gmail.com	8300260720
258	2020/05/18 8:56:02 AM GMT+5:30	Swetha	Jerusalem College of Engg	Biomedical	Female	swetha1118@gmail.con	9962201275
259	2020/05/18 9:07:27 AM GMT+5:30	Kousik.R	Jerusalem college of engineering	Biomedical engineering	Male	kousikrajendrannn@gmail.com	9884346213
260	2020/05/18 9:11:07 AM GMT+5:30	VIVEKNIJANTHAN L	Periyar Centenary Polytechnic College, Vallam, Thanjavur.	Department of Mechanical Engineering	Male	vknijanthan96@gmail.com	8760086370
261	2020/05/18 9:14:46 AM GMT+5:30	Mr. C.BALAKUMAR	St.MICHAEL COLLEGE OF ENGINEERING & TECHNOLOGY	ECE	Male	bala6100@gmail.com	9791421025
262	2020/05/18 9:28:36 AM GMT+5:30	pawan tiwari	S.U.S.Govt College Sunam	Computer	Male	pawan.paw@gmail.com	8968949300
263	2020/05/18 9:34:47 AM GMT+5:30	Jeganathan.N	Solamalai college of engineering	Civil engineering	Male	resikjegan000@gmail.com	9.19944E+11
264	2020/05/18 9:40:52 AM GMT+5:30	VIJAYAKANTH K	Srinivasan engineering college	ECE	Male	k.vijayakanth85@gmail.com	9994964632
265	2020/05/18 9:46:15 AM GMT+5:30	Thamaraiselvan P	Kongunadu college of engineering and technology	Electronic and communication engineering	Male	arjunvijayece2018@gmail.com	6369219537
266	2020/05/18 10:03:12 AM GMT+5:30	S.PAVITHRA SREE	Kongunadu college of engineering and technology	Ece	Female	Pavithrasreesp@gmail.com	8903353472
267	2020/05/18 10:05:45 AM GMT+5:30	K.KARTHIKEYAN	M.A.M SCHOOL OF ENGINEERING	ECE	Male	karthikcacet121@gmail.com	9159683577
268	2020/05/18 10:09:46 AM GMT+5:30	Dr. T. Balakrishnan	SIVET college	Department of Library and Information science	Male	Vishalbala2310@gmail.com	9445671961
269	2020/05/18 10:25:04 AM GMT+5:30	varun prabu	Working	Mechanical Engineering	Male	varunprabu0110@gmail.com	9653429866
270	2020/05/18 10:35:37 AM GMT+5:30	J. Saranya Devi	Jerusalem College of Engineering	Biomedical Engineering	Female	saranyadevi2503@gmail.com	9003162223
271	2020/05/18 10:54:45 AM GMT+5:30	K.shineka	Jerusalem college of engineering	Bio medical engineering	Female	Shinekashree24@gmail.com	6369491058
272	2020/05/18 10:55:50 AM GMT+5:30	S.Ishwarya	Jerusalem college of engineering	B.E. Biomedical Engineering	Female	ishwaryashanmugam05@gmail.com	9962686546
273	2020/05/18 11:02:52 AM GMT+5:30	Gopi K	Periyar centenary polytechnic college	Mech	Male	gopiindian555@gmail.com	8870723732
274	2020/05/18 11:12:15 AM GMT+5:30	R.SOUNDARYA	Kongunadu College of engineering and technology	ECE	Female	soundaryatamilarasi2001@gmail.com	6374841718
275	2020/05/18 11:13:22 AM GMT+5:30	B. MAHABHARATHI	kongunadu college of engineering and technology thotiyam	ECE	Female	Mahabharathi242@gmail.com	7811899117
276	2020/05/18 11:14:08 AM GMT+5:30	Chandra Mohan.M	Bharath institute of science and Technology,BIHER,Chennai.	Mechatronics	Male	indiranimohan1993@gmail.com	9600880154
277	2020/05/18 11:17:48 AM GMT+5:30	R.Abinaya	Jerusalem college of engineering	Biomedical engineering	Female	abinayaramaiyan@gmail.com	6383809875
278	2020/05/18 11:21:59 AM GMT+5:30	Nirmal R	Trichy Engineering college	Electrical and Electronics	Male	nirmalpse@gmail.com	9894181238
279	2020/05/18 11:23:26 AM GMT+5:30	CHANDRESHKUMAR D. BHAMBHI	Department of Law	HNGU Patan Gujarat	Male	Chandresh24@gmail.com	9978949998
280	2020/05/18 11:28:43 AM GMT+5:30	BASKAR R	KONGUNADU COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Male	baskars3010@gmail.com	9715486916
281	2020/05/18 11:31:51 AM GMT+5:30	Dr. girish N. Patel	Smt. J. P. Shroff Arts College, Valsad	Dept. of Home Science	Male	patelgirish784@gmail.com	9429346707
282	2020/05/18 11:35:24 AM GMT+5:30	M.SUKANYA	JAYA COLLEGE OF ENGINEERING AND TECHNOLOGY	ECE	Female	Sukanya20sweety@gmail.com	8939407481

Scanned with CamScanner

283	2020/05/18 11:37:28 AM GMT+5:30	Senthil kumar velusamy	Paavai Engineering College,Namakkal	Mechanical	Male	[illegible]@gmail.com	9659968245
284	2020/05/18 11:38:24 AM GMT+5:30	T. Kirubasree	Trichy Engineering College	EEE	Female	kirubasree25@gmail.com	9486162460
285	2020/05/18 11:41:38 AM GMT+5:30	Monica G	Trichy Engineering College	EEE	Female	gmonica1996@gmail.com	8526259301
286	2020/05/18 11:42:21 AM GMT+5:30	Gopinath A	Surya college of engineering	Electrical and electronics engineering	Male	gopinathmec2011@gmail.com	9003377604
287	2020/05/18 11:42:43 AM GMT+5:30	PATEL NITABEN GIRISHKUMAR	Smt J P Shroff Arts College ,Valsad	Economics	Female	patel.nita.valsad@gmail.com	9429118310
288	2020/05/18 12:09:23 PM GMT+5:30	Sumathi D	MAM SCHOOL OF ENGINEERING	Computer science and engineering	Female	dsumihari@gmail.com	8825842068
289	2020/05/18 12:22:13 PM GMT+5:30	P Shalini	Kongunadu college of engineering and technology	ECE	Female	shaliniperiyasamy2001@gmail.com	9585061248
290	2020/05/18 12:23:58 PM GMT+5:30	Jency elakkiya	M A M school of engineering	Electronics and communication engineering	Female	jencyelakkiya9@gmail.com	7639511334
291	2020/05/18 12:26:53 PM GMT+5:30	Kaviya	M A M school of engineering	ECE	Female	ramkaviya1999@gmail.com	8870445972
292	2020/05/18 12:27:03 PM GMT+5:30	S Dinesh Aravinth	Kongunadu College of Engineering and technology	ECE	Male	kadinesh2001@gmail.com	8110034270
293	2020/05/18 12:27:25 PM GMT+5:30	R SABARI GANESH	Kongunadu College of engineering and technology	Electronic and communication engineering	Male	sabariramalingam19@gmail.com	8072690048
294	2020/05/18 12:28:42 PM GMT+5:30	THIRULOGACHANDAR M	MAM College of Engineering	Mechanical Engineering	Male	thirulogachandar.thiru@gmail.com	8903494540
295	2020/05/18 12:29:02 PM GMT+5:30	BALAKRISHNAN G	MAHENDRA INSTITUTE OF ENGINEERING AND TECHNOLOGY	MECHANICAL ENGINEERING	Male	balakrishnanmech1989@gmail.com	9500520105
296	2020/05/18 12:29:09 PM GMT+5:30	S priyadharshini	M.A.M school of engineering	ECE	Female	Priyaece2806@gmail.com	8778392843
297	2020/05/18 12:32:13 PM GMT+5:30	arunadevi1004@gmail.com	Mam school of engineering	Ece	Female	arunadevi1004@gmail.com	8489474627
298	2020/05/18 12:32:42 PM GMT+5:30	SENTHAMARAI KANNAN A	M.A.M. SCHOOL OF ENGINEERING	ELECTRICAL AND ELECTRONICS ENGINEERING	Male	ersenthamarai@gmail.com	9786611813
299	2020/05/18 12:33:53 PM GMT+5:30	Chella pandian M	M.A.M College of Engineering	Mechanical	Male	chellapandian.cmr@gmail.com	8012478898
300	2020/05/18 12:34:00 PM GMT+5:30	SARATHKUMAR P	M.A.M COLLEGE OF ENGINEERING	MECHANICAL ENGINEERING	Male	sarathmech09@gmail.com	8015429315
301	2020/05/18 12:48:44 PM GMT+5:30	M. Sandhiya	Mam school of engineering	ECE	Female	Sandhiyaece8@gmail.com	9597004669
302	2020/05/18 12:49:00 PM GMT+5:30	Najma Abdulrauf Shaikh	ZBTI	English	Female	najju1967@yahoo.com	9825839134
303	2020/05/18 12:49:53 PM GMT+5:30	A Mohana Priya	M A M School of Engineering	ECE	Female	mohanaece10@gmail.com	9566403796
304	2020/05/18 12:51:56 PM GMT+5:30	S.sangeetha	M.A M school of engineering	ECE	Female	hagooibu27@gmail.com	7639847216
305	2020/05/18 12:56:31 PM GMT+5:30	G.Rajavel	M A School of engineering	ECE	Male	rajavelrajavel037@gmail.com	9047727355
306	2020/05/18 12:58:09 PM GMT+5:30	Kasthuri s	M A M school of engineering	Electronics and communication engineering	Female	kasthuriias54@gmail.com	9344051635
307	2020/05/18 12:58:14 PM GMT+5:30	Gunavathi A	MAM School of engineering	ECE	Female	ak guna2299@gmail.com	9842160255
308	2020/05/18 1:00:47 PM GMT+5:30	M.S Dhanasekar	Kongunadu college of engineering and technology	ECE	Male	dhanasekars0402@gmail.com	9486639528

Scanned with CamScanner

309	2020/05/18 1:09:45 PM GMT+5:30	MOHAN P	M.A.M.SCHOOL OF ENGINEERING	CSE	Male	mohanss073@gmail.com	6384091017
310	2020/05/18 1:28:58 PM GMT+5:30	K.JAYASUDHA	TRICHY ENGINEERING COLLEGE	ELECTRICAL AND ELECTRONICS ENGINEERING	Female	jayasudha676@gmail.com	8870135098
311	2020/05/18 1:32:12 PM GMT+5:30	S.Sudha	Jayaram college of engineering and technology, Trichy	Electrical and electronics engineering	Female	logon2sudha@gmail.com	9677475049
312	2020/05/18 1:43:05 PM GMT+5:30	L.Swetha	M.A.M school of engineering	Electronics and communication engineering	Female	Swethalawrence28@gmail.com	9629493481
313	2020/05/18 1:54:23 PM GMT+5:30	S bharathi	The kavery college of engineering	ECE	Male	sbharathi@kavery.org.in	9994011412
314	2020/05/18 2:13:50 PM GMT+5:30	S. Pavithra	MAMSE	ECE	Female	pavi37729@gmail.com	7305415697
315	2020/05/18 2:24:56 PM GMT+5:30	D.Jegadheesan	Kongunadu college of engineering and technology	ECE	Male	jegadheesands@gmail.com	9095048808
316	2020/05/18 2:31:30 PM GMT+5:30	Santhiya	Jerusalem college of engineering	Cse	Female	kesanthiya@gmail.com	8778700391

Total No of Registration: 316

HOD

Principal

MAM SCHOOL OF ENGINEERING
DEPARTMENT OF MECHATRONICS
Feedback for the Webinar "Principles of Robotics and its Applications"

Sl.No	Timestamp	Name	Institution	Department	At Present	Email ID	What about the session?
1	2020/05/18 3:46:47 PM GMT+5:30	Jeganathan.N	Solamalai college of engineering	Civil enguneering	Faculty	resikjegan000@gmail.com	Excellent
2	2020/05/18 3:46:57 PM GMT+5:30	P.Hema	Jerusalem college of Engineering	Biomedical	Student	divyahema63@gmail.com	Excellent
3	2020/05/18 3:46:59 PM GMT+5:30	B.ANANDHI	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Student	anandhi132000@gmail.com	Good
4	2020/05/18 3:47:01 PM GMT+5:30	Thamaraiselvan P	Kongunadu college of engineering and technology	Electronic and communication engineering	Student	arjunvijayece2018@gmail.com	Excellent
5	2020/05/18 3:47:02 PM GMT+5:30	J.AROKIARAJ	Kings college of Engineering	Electrical and Electronics Engineering	Faculty	jasonjaraj@gmail.com	Excellent
6	2020/05/18 3:47:07 PM GMT+5:30	VIVEKNIJANTHAN L	Periyar Centenary Polytechnic College, Vallam, Thanjavur	Department of Mechanical Engineering	Faculty	vknijanthan96@gmail.com	Excellent
7	2020/05/18 3:47:09 PM GMT+5:30	Senthil kannan Velasamy	Paavai Engineering college, Namkkal	Mechanical	Faculty	vsktgp@gmail.com	Excellent
8	2020/05/18 3:47:19 PM GMT+5:30	RAMDAS KAPILA	NADIMPALLI SATYANARAYANARAJU INSTITUTE OF TECHNOLOGY	Computer Science and Engineering	Faculty	kramdas.cse@nsrit.edu.in	Excellent
9	2020/05/18 3:47:26 PM GMT+5:30	T.MOHAMMED SYED JAFFAR	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Student	msjaffar1999@gmail.com	Excellent
10	2020/05/18 3:47:27 PM GMT+5:30	Dr.R.Sudhakar	Dr.Mahalingam College of Engineering and Technology	Electronics and Communication Engineering	Faculty	sudhakar.radhakrishnan@gmail.com	Average
11	2020/05/18 3:47:33 PM GMT+5:30	Pallabi Ghosh	Jerusalem College of Engineering	Biomedical Engineering	Student	gpallabi24@gmail.com	Good
12	2020/05/18 3:47:39 PM GMT+5:30	A.Mohana Priya	M.A.M School of Engineering	ECE	Student	mohanaece10@gmail.com	Good
13	2020/05/18 3:47:44 PM GMT+5:30	EJAZ AHMED. J	Meenakshi Sundararajan Engineering College	ECE	Student	ejazahmed4688@gmail.com	Good
14	2020/05/18 3:47:44 PM GMT+5:30	Tuhina Sheryl Abraham	Jerusalem college of engineering	Biomedical engineering	Student	tuhinaabraham99@gmail.com	Good
15	2020/05/18 3:47:49 PM GMT+5:30	Kannan S	Vinayaka Mission's Kirupananda Variyar Engineering College	Bio Medical Engineering	Faculty	kanname79@gmail.com	Excellent
16	2020/05/18 3:47:53 PM GMT+5:30	Chella pandian M	M.A.M College of Engineering	Mechanical	Faculty	chellapandian.cmr@gmail.com	Good
17	2020/05/18 3:48:05 PM GMT+5:30	ARUN RAJ S R	U.B.D.T COLLEGE OF ENGINEERING	ELECTRONICS AND COMMUNICATION	Faculty	arunrajsr5@gmail.com	Excellent
18	2020/05/18 3:48:08 PM GMT+5:30	N.DIVYAA SHREE	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Student	ndivyaa18@gmail.com	Excellent
19	2020/05/18 3:48:15 PM GMT+5:30	THANGAMARI D	SOLAMALAI COLLEGE OF ENGINEERING	COMPUTER SCIENCE AND ENGINEERING	Faculty	Dsmari2003@gmail.com	Excellent
20	2020/05/18 3:48:16 PM GMT+5:30	M.SUKANYA	JAYA COLLEGE OF ENGINEERING AND TECHNOLOGY	ECE.	Faculty	Sukanya20sweety@gmail.com	Good
21	2020/05/18 3:48:21 PM GMT+5:30	KEERTHANA.K.P	MEENAKSHI SUNDARARAJAN ENGINEERING COLLEGE	ECE	Student	kpkeerthana03@gmail.com	Excellent
22	2020/05/18 3:48:22 PM GMT+5:30	BALAKRISHNAN G	MAHENDRA INSTITUTE OF ENGINEERING AND TECHNOLOGY	MECHANICAL ENGINEERING	Faculty	balakrishnanmech1989@gmail.com	Good
23	2020/05/18 3:48:27 PM GMT+5:30	YUVA SHAKTHI RAJESH	JERUSALEM CLG OF ENG	BIO MEDICAL ENG	Student	yuvashakthi0602@gmail.com	Good

Scanned with CamScanner

24	2020/05/18 3:48:29 PM GMT+5:30	P.MADHUMITHA	Jerusalem college of engineering	Biomedical engineering	Student	madhumithap2208@gmail.com	Excellent
25	2020/05/18 3:48:47 PM GMT+5:30	B. N. Manya	Meenakshi sundararajan engineering college	ECE	Student	manyanaresh1301@gmail.com	Excellent
26	2020/05/18 3:49:34 PM GMT+5:30	RAMYA K	Jerusalem college of engineering	Bio medical engineering	Student	ramyakanirathan1@gmail.com	Excellent
27	2020/05/18 3:49:52 PM GMT+5:30	G Purushothaman	M.A.M. School of Engineering	EEE	Research S	gpurushg@gmail.com	Excellent
28	2020/05/18 3:50:18 PM GMT+5:30	Sakthivel S	Kings College of Engineering	EEE	Faculty	sakthimekings@gmail.com	Excellent
29	2020/05/18 3:50:46 PM GMT+5:30	S V Naveen	Jerusalem College Of Engineering	BME	Student	naveensv@jerusalemengg.ac.in	Good
30	2020/05/18 3:50:51 PM GMT+5:30	SABITA PAL	ITER, SOA	EICE	Faculty	sabitapal@soa.ac.in	Excellent
31	2020/05/18 3:51:05 PM GMT+5:30	S Swetha	Jerusalem college of engineering	Bio medical engineering	Student	swethasuresh1008@gmail.com	Excellent
32	2020/05/18 3:51:06 PM GMT+5:30	VIJAYA KANTH K	SRINIVASAN ENGINEERING COLLEGE	ECE	Faculty	k.vijayakanth85@gmail.com	Good
33	2020/05/18 3:51:18 PM GMT+5:30	S sarina banu	Jerusalem college of engineering	Biomedical engineering	Student	caribanu05361@gmail.com	Good
34	2020/05/18 3:51:23 PM GMT+5:30	BHARATH S	Jerusalem college of engineering	BME	Student	bharath14112000@gmail.com	Excellent
35	2020/05/18 3:51:28 PM GMT+5:30	D Daphne Pearl	JERUSALEM COLLEGE OF ENGINEERING	BIOMEDICAL ENGINEERING	Student	d.daphnepearl@gmail.com	Excellent
36	2020/05/18 3:51:32 PM GMT+5:30	V Preethi	Jerusalem college of engineering	Biomedical engineering	Student	preethisathy21199412@gmail.com	Excellent
37	[illegible]	Abdul Latiff S	M.A.M School of Engineering	Mechatronics	Student	[illegible]@gmail.com	Good
38	[illegible]	RAJASEKAR P	Selvamani College of Engineering	EEE	Faculty	[illegible]@gmail.com	Good
39	[illegible]	S Radha	Jayaram college of engineering and technology, Trichy	Electrical and electronics engineering	Faculty	[illegible]@gmail.com	Good
40	[illegible]	S Bharathi	The kavery college of engineering	ECE	Faculty	[illegible]@kavery.org.in	Excellent
41	[illegible]	[illegible] M	M.A.M College of Engineering	Mechanical engineering	Faculty	[illegible]@gmail.com	Good
42	[illegible]	[illegible]	M.A.M. School of Engineering	EEE	Faculty	[illegible]@gmail.com	Good
43	[illegible]	S Mohan Kumar	M.A.M School of Engineering	Mechanical	Faculty	[illegible]@gmail.com	Good
44	[illegible]	[illegible]	Jerusalem College of Engineering	Biomedical Engineering	Student	[illegible]@gmail.com	Good
45	[illegible]	[illegible]	[illegible] Saraswathi College of Engineering and Technology, Trichy	Mechanical Engineering	Faculty	[illegible]@gmail.com	Excellent
46	[illegible]	[illegible]	[illegible] Institute of Technology	CSE	Faculty	[illegible]@gmail.com	Good
47	[illegible]	[illegible]	Jerusalem college of engineering	Biomedical engineering	Student	[illegible]	Excellent
48	[illegible]	[illegible]	Jerusalem college of engineering	Biomedical	Student	[illegible]	Excellent
49	[illegible]	[illegible]	[illegible] college of engineering and technology	[illegible]	Student	[illegible]	Excellent
50	[illegible]	[illegible]	[illegible] College of Engineering and Technology	[illegible] and communication Engineering	Student	[illegible]	Excellent

51	2020/05/18 3:53:20 PM GMT+5:30	R. Prem kumar	M. A. M. School of Engineering	Mechanical	Faculty	Mechanical. Prem@gmail.com	Excellent
52	2020/05/18 3:53:24 PM GMT+5:30	V.Shankari	Jerusalem college of engineering	Biomedical engineering	Student	shanku130799@gmail.com	Excellent
53	2020/05/18 3:53:25 PM GMT+5:30	pawan kumar tiwari	S.U.S.Govt College Sunam	Computers	Research S	Pawan.paw@gmail.com	Good
54	2020/05/18 3:53:33 PM GMT+5:30	Devi Lakshmi A	Jerusalem college of engineering	Biomedical engineering	Student	devilakshmi186@gmail.com	Good
55	2020/05/18 3:54:19 PM GMT+5:30	Dhivya V	M.A.M SCHOOL OF ENGINEERING	EEE	Student	dhivyadeivam28@gmail.com	Good
56	2020/05/18 3:54:22 PM GMT+5:30	Vimenthani	Jerusalem college of Engineering	Biomedical	Student	vimenthani.vimey@gmail.com	Good
57	2020/05/18 3:54:23 PM GMT+5:30	U.JATHURSHA	JERUSALEM COLLEGE OF ENGINEERING	B.E . BIOMEDICAL	Student	jathu.uruthira@gmail.com	Good
58	2020/05/18 3:54:26 PM GMT+5:30	S.A.SREE VISHWA	JERUSALEM COLLEGE OF ENGINEERING	B.E.BIOMEDICAL ENGINEERING	Student	sreevishwa.sa@gmail.com	Excellent
59	2020/05/18 3:54:36 PM GMT+5:30	Gopi K	Periyar centenary polytechnic college	Mechanical	Faculty	gopiindian555@gmail.com	Good
60	2020/05/18 3:55:02 PM GMT+5:30	Dr. G. Arockia Sahaya Sheela	Holy Cross College (Autonomous)	CS	Faculty	gsr_sheeba@yahoo.co.in	Excellent
61	2020/05/18 3:55:05 PM GMT+5:30	M.Madhumitha	M.A.M School of Engineering	Electronics and Communication Engineering	Student	madhumurugesan12@gmail.com	Excellent
62	2020/05/18 3:55:05 PM GMT+5:30	P.Shalini	Kongunadu college of engineering and technology	ECE	Student	shaliniperiyasamy2001@gmail.com	Good
63	2020/05/18 3:55:12 PM GMT+5:30	Swetha	Jerusalem college of engg	Biomedical	Student	swetha1118@gmail.com	Excellent
64	2020/05/18 3:55:21 PM GMT+5:30	R.KUBENDRAN	SOLAMALAI COLLEGE OF ENGINEERING	ECE	Faculty	kubendran.scemdu@gmail.com	Excellent
65	2020/05/18 3:55:31 PM GMT+5:30	Dr. S.Rooban	kl university - AP	ECE	Faculty	yes.rooban@gmail.com	Excellent
66	2020/05/18 3:55:58 PM GMT+5:30	SUDHA P	M.A.M School of Engineering	Mechatronics Engineering	Faculty	suha1906@gmail.com	Good
67	2020/05/18 3:56:43 PM GMT+5:30	M VIJAYAKUMAR	SACET TRICHY	MECHANICAL	Faculty	viattur@gmail.com	Excellent
68	2020/05/18 3:56:50 PM GMT+5:30	Neeta Rajeev Kadam	JSPM Narhe Technical Campus	Electronics and Telecommunications Engg.	Faculty	nkadam2006@gmail.com	Good
69	2020/05/18 3:56:52 PM GMT+5:30	Arockiaraj	Mepco schlenk engg college	EEE	Faculty	Arockiarocks@gmail.com	Excellent
70	2020/05/18 3:57:01 PM GMT+5:30	JANANI J	MEENAKSHI SUNDARARAJAN ENGINEERING COLLEGE	ECE	Student	janani.j211@gmail.com	Good
71	2020/05/18 3:57:18 PM GMT+5:30	M.SUBA PRADHA	M.A.M SCHOOL OF ENGINEERING	ECE	Faculty	cool.pradha@gmail.com	Excellent
72	2020/05/18 3:57:38 PM GMT+5:30	N.S.DHANASEKAR	Kongunadu college of engineering and technology	Electronics and communication engineering	Student	Dhanasekars0204@gmail.com	Good
73	2020/05/18 3:58:38 PM GMT+5:30	SUDHARSANAM K	Jerusalem college of Engineering	Biomedical Engineering	Student	ks06112k@gmail.com	Excellent
74	2020/05/18 4:00:14 PM GMT+5:30	Jenith kumar. B	M.A.M School of Engineering	Mechatronics	Student	jenithbala07@gmail.com	Excellent
75	2020/05/18 4:15:21 PM GMT+5:30	SAM CHARLES DEVAPRASAD J	Mahendra institute of engineering and technology	Mechanical engineering	Faculty	samcharlesj@miet.asia	Excellent
76	2020/05/18 4:29:41 PM GMT+5:30	NISHA SHREE T.R	JERUSALEM COLLEGE OF ENGINEERING	BIO MEDICAL ENGINEERING	Student	nishashreetr@gmail.com	Excellent
77	2020/05/18 5:17:46 PM GMT+5:30	K.prabhakaran	Jerusalem college of engineering	Biomedical engineering	Student	kk192413@gmail.com	Good

Scanned with CamScanner

78	2020/05/18 5:31:03 PM GMT+5:30	Srikanth.S	Jerusalem college of engineering	Bio-medical engineering	Student	srikanthsk11750@gmail.com	Excellent
79	2020/05/18 5:36:02 PM GMT+5:30	N. Sivasangari	Jerusalem college of engg	Bme	Student	sivasangarinamasivayam@gmail.com	Average
80	2020/05/19 1:55:32 PM GMT+5:30	S.priyadharshini	M.A.M School of engineering	ECE	Student	Priyaece2806@gmail.com	Excellent
81	2020/05/19 2:06:11 PM GMT+5:30	Dr. T. Balakrishnan	S.I.V.E.T. College Chennai	Department of Library and Information science	Faculty	Vishalbala2310@gmail.com	Excellent
82	2020/05/19 2:19:51 PM GMT+5:30	Chandra Mohan M	Bharath Institute of Science and Technology, BIHER, Chennai.	Mechatronics	Faculty	indiranimohan1993@gmail.com	Excellent
83	2020/05/19 2:37:05 PM GMT+5:30	A.Asuntha	SRM Institute of Science & Technology	EIE	Faculty	asunthaa@srmist.edu.in	Excellent
84	2020/05/19 3:01:12 PM GMT+5:30	Er. R. Ravi	Krishnasamy college of engineering and technology	ECE	Faculty	ifetravi@gmail.com	Good
85	2020/05/19 4:23:38 PM GMT+5:30	Dr.R.Thamilselvi	Bharathiar University Arts and Science College Pollachi	Commerce	Faculty	tamilselvi9976@gmail.com	Excellent

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING
ISO 9001 : 2008 Certified Institution
Approved by AICTE, New Delhi. Afflicated to Anna University, Chennai
Trichy - chennai Trunk Road, Siruganur, Tiruchirappalli - 621 105, India

DEPARTMENT OF MECHATRONICS ENGINEERING

Webinar

On

"Role of Microcontrollers in Mechatronics Systems"

09.06.2020

19/6/2020

H.O.D

PRINCIPAL

Scanned with CamScanner

M.A.M. SCHOOL OF ENGINEERING

(Accredited by NAAC)
(Approved by AICTE, New Delhi | Affiliated to Anna University)
Siruganur, Trichy - 621 105

Department of Mechatronics
Organises

Webinar On
Role of Microcontrollers in Mechatronics Systems

Resource person

DATE: 09-06-2020
TIME: 11.30 AM.

Dr. S. Mohanalakshmi,
Prof & Head / ECE,
Rohini college of Engineering and Technology
kanyakumari.

E - Certificate will be provided forthe participants

For Registration Visit
www.mamse.in

Scanned with CamScanner

Resource Person Profile

Dr. S. Mohanalakshmi is an educator and researcher with 23 years of experience in teaching and research. She received her Ph.D under the faculty of Information and Communication Engineering from CEG, Anna University, Chennai and Masters in Applied Electronics from Sathyabama University, Chennai. Her area of interest includes Signal and Image processing, IoT, Embedded Systems and Biomedical Engineering. She holds 25 publications to her credit which includes Journals and Conference Proceedings. She is part of the Reviewer Board of the Journal Biomedical Engineering/Biomedizinische Technik, Germany and life member of IETE. She currently serves as Professor and Head of the Dept./ ECE in Rohini college of Engineering and Technology, Kanyakumari, TN.

Scanned with CamScanner

M.A.M SCHOOL OF ENGINEERING

Siruganur, Trichy-621105

Department of Mechatronics Engineering

Webinar on "Role of Microcontrollers in Mechatronics Systems"

(9th June, 2020)

Department of Mechatronics Engineering had the privilege of having webinar with Dr.S.Mohanalakshmi, Professor and Head/ECE, Rohini college of Engineering and Technology, Kanyakumari on the topic of "Role of Microcontrollers in mechatronics systems".

The invitation for this program by the designer team of MAMSE and distributed through face book. The registration form for this program has created by Google form and published in our college website on 8th June 2020.

The link for the registration:

https://docs.google.com/forms/d/e/1FAIpQLScNHcW7mn1DeolZ1V_4mJLJLVIsYOhnlg71HaLseLd4HmRhKA/viewform

Totally 48 participant has register for this webinar. The session is started sharply by 11.30 Am from welcome address and introduction given by P.Sudha, Assistant Professor, Mechatronics Engineering Department. After that the resource person starts the lecture with the introduction of microcontrollers. Later she given the lecture with demonstration of how microcontrollers are featured with Mechatronics design, challenging controls of the microcontrollers in various parameter etc. The event ended with vote of thanks given by M.Suba pradha, Assistant Professor, Mechatronics Department. Also the feedback for the participant was collected through Google form.

19/6/2020

HOD

PRINCIPAL

Scanned with CamScanner

M.A.M School of Engineering
Siruganur - 621 105

List of Participant Register for the webinar "Role of Microcontrollers in mechatronics systems "

Timestamp	Name	Institution	Department	At Present	Designation	Year	Gender	Email ID	Mobile Number
2020/06/07 10:41:26 AM GMT+5:30	DIPSHIKA MK	AMRITA COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Student	Not applicable	II	Female	dipshikamk@gmail.com	7339108315
2020/06/07 11:03:51 AM GMT+5:30	B.Fazila Fathima	MAM School Of Engineering	Electronics And Communication Engineering	Student	Not applicable	I	Female	fazilafathima.b28062002@gmail.com	8925354195
2020/06/07 2:09:53 PM GMT+5:30	M.MUTHUKUMAR	M.A.M.SCHOOL OF ENGINEERING	MECHANICAL ENGINEERING	Student	Not applicable	IV	Male	muthukumar.manikcam@gmail.com	9965375496
2020/06/07 3:50:38 PM GMT+5:30	SATHISH KUMAR K	MAM SCHOOL OF ENGINEERING	CSE	Faculty	Assistant Professor	Not applicable	Male	ksk2mohan@gmail.com	7530050947
2020/06/08 9:56:26 AM GMT+5:30	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	Assistant Professor	Not applicable	Male	saravanankm@gmail.com	9841041315
2020/06/08 10:35:57 AM GMT+5:30	D.Dhanalakshmi	M.A.M.School of Engineering	EEE	Faculty	Assistant Professor	Not applicable	Female	dhanalakshmi28031996@gmail.com	8110955171
2020/06/08 2:08:24 PM GMT+5:30	Sudha P	M. A. M school of Engineering	Mechatronics Engineering	Faculty	Assistant Professor	Not applicable	Female	suha1906@gmail.com	9003674127
2020/06/08 2:42:10 PM GMT+5:30	D.Shiny Priya	Rohini college of engineering and technology	Electronics and communication engineering	Student	Not applicable	IV	Female	shinypriya35@gmail.com	9445848107
2020/06/08 8:02:02 PM GMT+5:30	J Evignas Banu	Roever engineering college	Computer science and engineering	Student	Not applicable	I	Female	eviganasbanu@gmail.com	8220858971
2020/06/08 8:04:50 PM GMT+5:30	Nivya K Suresh	Rohini College of Engineering and Technology	ECE	Faculty	Assistant Professor	Not applicable	Female	nivya227@gmail.com	9487083556
2020/06/08 8:51:20 PM GMT+5:30	ISHA.C	Rohini College Of Engineering And Technology	Electronics And Communication Engineering	Student	Not applicable	III	Female	ishacci@gmail.com	7871481144
2020/06/08 10:01:44 PM GMT+5:30	C.BAVITHRA	Rohini college of engineering and technology	Electronics and Communication engineering	Student		III	Female	bavithrac2000@gmail.com	9943754006
2020/06/08 10:26:51 PM GMT+5:30	Adlin Mahiba. B	Rohini college of engineering and technology	ECE	Student	Not applicable	II	Female	adlinmahiba74654@gmail.com	7339691221
2020/06/08 10:28:14 PM GMT+5:30	M. Aziha	Rohini college of engineering and technology	ECE	Student	Not applicable	II	Female	azihamohan2001@gmail.com	6369414706
2020/06/08 10:46:30 PM GMT+5:30	S V Nivedhitha	Rohini college of engineering and technology	Electronics and communication	Student	Not applicable	II	Female	nivedhitha237@gmail.com	8248554553
2020/06/08 10:46:41 PM GMT+5:30	N.K.Priyankaa	Rohini College Of Engineering And Technology	Electronics and communication engineering	Student	Not applicable	II	Female	priyankaakannan11@gmail.com	6374556890
2020/06/08 10:50:20 PM GMT+5:30	ISHWARYA.V	PSNA COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRICAL AND ELECTRONICS ENGINEERING	Student	Not applicable	II	Female	ishwaryavelmurugan1208@gmail.com	8754197038
2020/06/08 10:50:52 PM GMT+5:30	N. AISHWARYAA LAKSHMI	Government college of engineering	EEE	Student	Not applicable	III	Female	shanmathynagarajan@gmail.com	9952825128
2020/06/08 10:51:57 PM GMT+5:30	PRAKASH V	Institute of road and transport technology	Mechanical Engineering	Student	Not applicable	I	Male	prakashveerarasu@gmail.com	9150525120
2020/06/08 10:53:25 PM GMT+5:30	R Kamalaveni	Thiagarajar Polytechnic College, Salem	EEE	Faculty	Not applicable		Female	arulmuthamil@gmail.com	9443029262
2020/06/08 10:55:53 PM GMT+5:30	Mr.VENKATESAN.R	SRI VENKATESWARA COLLEGE OF ENGINEERING AND TECHNOLOGY (SVCET)	ELECTRICAL AND ELECTRONICS ENGINEERING (EEE)	Student	Not applicable	II	Male	venkateshappu1812@gmail.com	9176122457
2020/06/08 10:58:16 PM GMT+5:30	K. HARI HARA VASAN	Kalasalingam university	Commerce	Student	Not applicable	II	Male	hariharavasan2001k@gmail.com	8124124190
2020/06/08 11:04:58 PM GMT+5:30	PRASANTH S	Nandha Engineering College	Electronics And Communication Engineering	Student		I	Male	romanprasad890@gmail.com	9360499623
2020/06/08 11:09:14 PM GMT+5:30	ESSAKKI RAJA.S	ST.MOTHER THERESA ENGINEERING COLLEGE	Mechanical Engineering	Student	Not applicable	III	Male	azhaguraja8888@gmail.com	8870866136
2020/06/08 11:10:15 PM GMT+5:30	JOTHEESHWARAN.B	Government College of engineering sengipatti-Thanjavore	Electrical and electronics engineering	Student	Not applicable	I	Male	jotheesh82@gmail.com	6380714598
2020/06/08 11:11:03 PM GMT+5:30	G.GNANASUGIRTHAN	ST.MOTHER THERESA ENGINEERING COLLEGE	MECHANICAL ENGINEERING	Student	Not applicable	III	Male	sugirth.g5@gmail.com	9600756492
2020/06/08 11:36:16 PM GMT+5:30	M. BALA VIGNESH	ST. XAVIERS COLLEGE (AUTONOMOUS) PALAYAMKOTTAI	MCA	Student	Not applicable	I	Male	balav1011@gmail.com	6380998577
2020/06/08 11:41:50 PM GMT+5:30	Magi Sahulin.C	Rohini college of engineering and technology	Electronics and communication engineering	Student	Not applicable	IV	Female	magisahulin@gmail.com	9.18E+11
2020/06/08 11:49:24 PM GMT+5:30	APARNA N	Government College of Engineering, Thanjavur	EEE	Student		IV	Female	aparnaapril10@gmail.com	8940670649
2020/06/08 11:50:39 PM GMT+5:30	Mr. M. Vimalraj	Adhiparashakthi College, Kalaval, Ranipet district	Electrical and Electronics Engineering	Faculty		Not applicable	Male	vimalrajmp@yahoo.com	9789599868
2020/06/08 11:52:25 PM GMT+5:30	Sruthi Messia J	Francis Xavier Engineering College	Information Technology	Student	Not applicable	II	Female	Sruthy1206@gmail.com	9498195187
2020/06/08 11:57:14 PM GMT+5:30	R.Kottaimalai	Sree Sowdambika College of Engineering	ECE	Faculty	Assistant Professor	Not applicable	Male	rkottai@gmail.com	8807880278
2020/06/08 11:58:34 PM GMT+5:30	SOBAN S	ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Faculty	Assistant Professor	Not applicable	Male	sobancross@gmail.com	9943436897
2020/06/09 12:35:30 AM GMT+5:30	BALASANKARI.M	FRANCIS XAVIER ENGINEERING COLLEGE	ECE	Student	Not applicable	III	Female	balasankaribalasankari@gmail.com	8610422156
2020/06/09 12:54:42 AM GMT+5:30	JAYAKUMAR .N	THE OXFORD COLLEGE OF ENGINEERING	EEE	Faculty	Associate Professor	Not applicable	Male	njktry78@gmail.com	8050837275
2020/06/09 1:52:25 AM GMT+5:30	drsanjay@biet.ac.in	Bharat Institute of Engineering and Technology ,	ECE	Faculty	Professor	Not applicable	Male	prof.dr.sanjaykumarsuman@gmail.com	9003828131
2020/06/09 5:16:51 AM GMT+5:30	Ranjitha	Rohini collage of Engineering and technology	ECE	Student	Not applicable	II	Female	ranjitha5122000@gmail.com	6384562078
2020/06/09 5:19:42 AM GMT+5:30	C.M.Nivetha	Rohini college of Engineering and Technology	ECE	Student	Not applicable	II	Female	cmnivetha186@gmail.com	9498843750
2020/06/09 6:03:36 AM GMT+5:30	M.SAKTHIVEL	EXCEL COLLEGE OF ENGINEERING AND TECHNOLOGY	EEE	Student	Not applicable	III	Male	sakthivelm8973@gmail.com	8903792748
2020/06/09 6:16:39 AM GMT+5:30	rajkumar.ece39@gmail.com	Sree Arumugham Polytechnic College	ECE	Faculty	Assistant Professor		Male	rajkumar.ece39@gmail.com	9488900235
2020/06/09 6:23:12 AM GMT+5:30	TAEJAS	CPAT-TVS	Mechanical engineering	Student	Not applicable	III	Male	taejas.d@gmail.com	7397247692
2020/06/09 6:24:41 AM GMT+5:30	Dr.H.Vennila	Noorul Islam Centre for Higher Education	EEE	Faculty	Associate Professor	Not applicable	Female	vennilarajesh@yahoo.co.in	9994273837
2020/06/09 6:49:01 AM GMT+5:30	MANOJKUMAR M	The Institution of Engineers (India), Kolkata	Electrical Engineering	Faculty	Not applicable	Not applicable	Male	manojeee2015@gmail.com	9.19E+11
2020/06/09 6:54:10 AM GMT+5:30	L.vanishmuthu	Francis Xavier Engineering college	EEE	Student	Not applicable	II	Female	vanimuthu267@gmail.com	9360340259
2020/06/09 6:55:18 AM GMT+5:30	L.VARATHA RAJAN	NATIONAL ENGINEERING COLLEGE	EEE	Student	Not applicable	II	Male	varathan2002a@gmail.com	9360340259
2020/06/09 7:04:34 AM GMT+5:30	Vaishnavi R	Rohini college of engineering and technology	Electronics and communications engineering	Student	Not applicable	II	Female	vaishnaviramaswamy22@gmail.com	8056651401
2020/06/09 7:20:23 AM GMT+5:30	Balamurugan.G	MAM SCHOOL OF ENGINEERING	Mechatronics	Student	Not applicable	IV	Male	balamurugabala75@gmail.com	9790315983
2020/06/09 7:27:13 AM GMT+5:30	RAJESHKUMAR G	MAM SCHOOL OF ENGINEERING	CSE	Faculty	Assistant Professor	Not applicable	Male	grkresearch@gmail.com	9677787134

HOD
19/6/2020

PRINCIPAL

Scanned with CamScanner

M.A.M School of Engineering
Siruganur - 621 105.

Feedback Repret for a Webinar - Role of microcontrollers in mechatronics systems

S.No	Timestamp	Name	Institution	Department	At Present	Email ID	What about the session?
1	2020/06/09 1:57:53 PM GMT+5	DIPSHIKA MK	AMRITA COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Student	dipshikamk@gmail.com	Excellent
2	2020/06/09 1:58:02 PM GMT+5	B.Fazila Fathima	MAM School Of Engineering	Electronics And Communication Engineering	Student	fazilafathima.b28062002@gmail.con	Excellent
3	2020/06/09 1:58:23 PM GMT+5	M.MUTHUKUMA	M.A.M.SCHOOL OF ENGINEERING	MECHANICAL ENGINEERING	Student	muthukumar.manikcam@gmail.com	Excellent
4	2020/06/09 1:58:37 PM GMT+5	SATHISH KUMAR	MAM SCHOOL OF ENGINEERING	CSE	Faculty	ksk2mohan@gmail.com	Excellent
5	2020/06/09 1:59:00 PM GMT+5	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	saravananknm@gmail.com	Good
6	2020/06/09 1:59:16 PM GMT+5	D.Dhanalakshmi	M.A.M.School of Engineering	EEE	Faculty	dhanalakshmi28031996@gmail.com	Excellent
7	2020/06/09 1:59:41 PM GMT+5	Sudha P	M. A. M school of Engineering	Mechatronics Engineering	Faculty	suha1906@gmail.com	Excellent
8	2020/06/09 1:59:41 PM GMT+5	D.Shiny Priya	Rohini college of engineering and technology	Electronics and communication engineering	Student	shinypriya35@gmail.com	Excellent
9	2020/06/09 1:59:42 PM GMT+5	J Eviganas Banu	Roever engineering college	Computer science and engineering	Student	eviganasbanu@gmail.com	Excellent
10	2020/06/09 1:59:44 PM GMT+5	Nivya K Suresh	Rohini College of Engineering and Technology	ECE	Faculty	nivya227@gmail.com	Excellent
11	2020/06/09 1:59:51 PM GMT+5	APARNA N	Government College of Engineering, Thanjavur	EEE	Student	aparnaapril10@gmail.com	Excellent
12	2020/06/09 1:00:53 PM GMT+5	Mr. M. Vimalraj	Adhiparashakthi College, Kalavai, Ranipet district	Electrical and Electronics Engineering	Faculty	vimalrajmp@yahoo.com	Good
13	2020/06/09 1:01:06 PM GMT+5	Sruthi Messia J	Francis Xavier Engineering College	Information Technology	Student	Sruthy1206@gmail.com	Excellent
14	2020/06/09 1:01:45 PM GMT+5	R.Kottaimalai	Sree Sowdambika College of Engineering	ECE	Faculty	rkottai@gmail.com	Good
15	2020/06/09 1:02:09 PM GMT+5	SOBAN S	ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Faculty	sobancross@gmail.com	Good
16	2020/06/09 1:02:55 PM GMT+5	BALASANKARI.M	FRANCIS XAVIER ENGINEERING COLLEGE	ECE	Student	balasankaribalasankari@gmail.com	Good
17	2020/06/09 1:03:08 PM GMT+5	JAYAKUMAR .N	THE OXFORD COLLEGE OF ENGINEERING	EEE	Faculty	njktry78@gmail.com	Excellent
18	2020/06/09 1:03:51 PM GMT+5	SANJAY	Bharat Institute of Engineering and Technology , Hydera	ECE	Faculty	prof.dr.sanjaykumarsuman@gmail.c	Excellent
19	2020/06/09 1:08:04 PM GMT+5	Ranjitha	Rohini collage of Engineering and technology	ECE	Student	ranjitha5122000@gmail.com	Good
20	2020/06/09 1:09:06 PM GMT+5	C.M.Nivetha	Rohini college of Engineering and Technology	ECE	Student	cmnivetha186@gmail.com	Good
21	2020/06/09 1:11:19 PM GMT+5	M.SAKTHIVEL	EXCEL COLLEGE OF ENGINEERING AND TECHNOLOGY	EEE	Student	sakthivelm8973@gmail.com	Excellent
22	2020/06/09 1:11:19 PM GMT+5	RAJKUMAR	Sree Arumugham Polytechnic College	ECE	Faculty	rajkumar.ece39@gmail.com	Excellent
23	2020/06/09 1:11:20 PM GMT+5	TAEJAS	CPAT-TVS	Mechanical engineering	Student	taejas.d@gmail.com	Excellent
24	2020/06/09 1:17:55 PM GMT+5	Dr.H.Vennila	Noorul Islam Centre for Higher Education	EEE	Faculty	vennilarajesh@yahoo.co.in	Excellent
25	2020/06/09 1:18:29 PM GMT+5	MANOJKUMAR M	The Institution of Engineers (India), Kolkata	Electrical Engineering	Faculty	manojeee2015@gmail.com	Excellent
26	2020/06/09 1:18:54 PM GMT+5	L.vanishmuthu	Francis Xavier Engineering college	EEE	Student	vanimuthu267@gmail.com	Good
27	2020/06/09 1:20:59 PM GMT+5	L.VARATHA RAJA	NATIONAL ENGINEERING COLLEGE	EEE	Student	varathan2002a@gmail.com	Excellent
28	2020/06/09 1:22:36 PM GMT+5	Vaishnavi R	Rohini college of engineering and technology	Electronics and communications engineering	Student	vaishnaviramaswamy22@gmail.com	Good
29	2020/06/09 1:24:15 PM GMT+5	Balamurugan.G	MAM SCHOOL OF ENGINEERING	Mechatronics	Student	balamurugabala75@gmail.com	Good
30	2020/06/09 1:26:41 PM GMT+5	RAJESHKUMAR G	MAM SCHOOL OF ENGINEERING	CSE	Faculty	grkresearch@gmail.com	Excellent
31	2020/06/09 1:57:53 PM GMT+5	DIPSHIKA MK	AMRITA COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Student	dipshikamk@gmail.com	Excellent
32	2020/06/09 1:58:02 PM GMT+5	B.Fazila Fathima	MAM School Of Engineering	Electronics And Communication Engineering	Student	fazilafathima.b28062002@gmail.con	Excellent
33	2020/06/09 1:58:23 PM GMT+5	M.MUTHUKUMA	M.A.M.SCHOOL OF ENGINEERING	MECHANICAL ENGINEERING	Student	muthukumar.manikcam@gmail.com	Excellent
34	2020/06/09 1:58:37 PM GMT+5	SATHISH KUMAR	MAM SCHOOL OF ENGINEERING	CSE	Faculty	ksk2mohan@gmail.com	Excellent
35	2020/06/09 1:59:00 PM GMT+5	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	saravananknm@gmail.com	Good
36	2020/06/09 1:57:53 PM GMT+5	DIPSHIKA MK	AMRITA COLLEGE OF ENGINEERING AND TECHNOLOGY	ELECTRONICS AND COMMUNICATION ENGINEERING	Student	dipshikamk@gmail.com	Excellent
37	2020/06/09 1:58:02 PM GMT+5	B.Fazila Fathima	MAM School Of Engineering	Electronics And Communication Engineering	Student	fazilafathima.b28062002@gmail.con	Excellent
38	2020/06/09 1:58:23 PM GMT+5	M.MUTHUKUMA	M.A.M.SCHOOL OF ENGINEERING	MECHANICAL ENGINEERING	Student	muthukumar.manikcam@gmail.com	Excellent
39	2020/06/09 1:58:37 PM GMT+5	SATHISH KUMAR	MAM SCHOOL OF ENGINEERING	CSE	Faculty	ksk2mohan@gmail.com	Excellent
40	2020/06/09 1:59:00 PM GMT+5	Saravanan S	MAM School of Engineering	Mechatronics	Faculty	saravananknm@gmail.com	Good

19/6/2020

PRINCIPAL

Scanned with CamScanner