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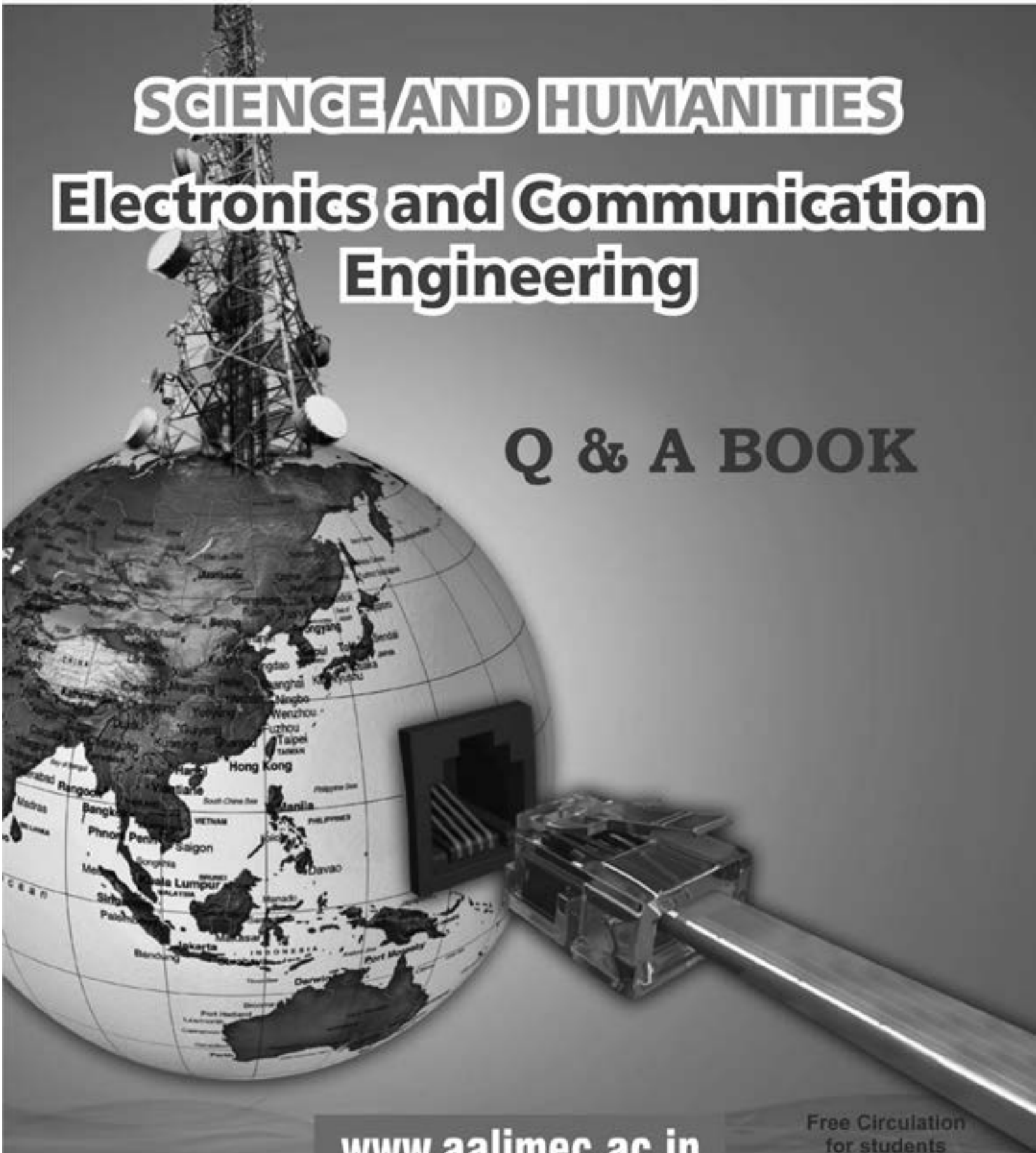
SCIENCE AND HUMANITIES

Electronics and Communication Engineering

Q & A BOOK



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HS6251/TECHNICAL ENGLISH – II

Part-A

1. Match the words in column "A" with their meanings in column "B":

a) Cramped	i) Take people into service on contract
b) Stagnant	ii) Variety; having differences
c) Recruit	iii) Confined within narrow limits
d)Diversity	iv) Not moving or changing
	v) A condition caused by magical powers

a) Mandatory	Make certain
b) Ascertain	Compulsory
c) Infrastructure	Feasibility
d) Viability	Building

a) Benevolent	Save
b) Regulations	Clear
c) Lucid	System
d) Redeem	Kind

a) Affluent	Deadly, danger
b) Uranium	Bring goods from foreign country
c) Fatal	Abundant: rich
d) Import	Metallic element

a) Amalgamation	Giving out rays
b) Chip	Man-made program
c) Radiation	Bring together
d) Depletion	Getting completely exhausted
	Device composed of silicon

a) Permeability	Not belonging to the earth.
b) Core	Abnormal accumulation of people
c) Extra terrestrial	Passing through
d) Congestion	An additional thing
	Inner most part

2. Fill in the blanks in following passage with suitable prepositions.

1. Very fast trains are safe compared _____ most other forms _____ motorized transport. For example, the TGV, which commenced operation ____ 1981 travels ____ 10 million passenger kilometers each year.

2. The boiler converts water ____ steam ____ the required temperature and pressure. The steam gets collected ____ the surface ____ the water.

3. Experiments have been carried out------ volunteers to see what happen when all sensations are stopped. This can be done ----- several ways. One method is----- put a man ----- a completely isolated room.

4. All the great developments----- the physical sciences, natural science and engineering technology have contributed ----- a more comfortable life. Efficiency------work is almost ensured. The human energy is saved ------- drudgery.

5. A Snowflake originates ____ countless water molecules that initially come together ____ small groups as a result ____ a weak force _____ oxygen and hydrogen atoms

6. You can see the entire information_____the screen which gives the details the arrival and departure_____trains.

7. What is the matter _____your car?Haven't you sent it_____servicing?

8. We do most _____our travelling_____summer,when our children are _____vacation.

9. Bhutan is a land _____soaring snowcapped peaks,alpine meadows and densely forested hills and ravines abounding _____exotic flora and fauna. _____May _____August the hills are covered with many flowers

10. Children have been playing_____toys_____ages. Infact,the very early. Toys are said _____be made _____2000 B.C.A toy is not simply an object _____amusement, it can be educative also.

11. In future,houses may be erected _____built-in computers controlling everything _____paying bills _____opening doors and regulating the entry _____people.

3. **Insert suitable adverbs in the blanks**:
   1. She danced _____ at the function.
   2. He speaks very _____.
   3. The fee structure is _____announced by the government.
   4. Prabha's ideas are _____ sound and acceptable.
   5. This essay is _____written.
   6. The bus broke down,_____I was late.
   7. My friend is expected to arrive _____.
   8. Your answer is _____right.
   9. Ram arrived _____in the morning.
   10. I looked for him _____.
   11. The _____help rendered by friends was very valuable.
   12. I _____expect to pass in the examination.
   13. I have done the problem as it was _____easy.

4. **Rewrite the following expressions using numerical adjectives:**
   1. A tank with a capacity of 2000 litres
   2. A committee of 6 members
   3. A project proposal for 10 crores
   4. An engine with 100cc power
   5. A weight of six quintals.

   6. A distance of three hundred miles.
   7. A dowry of six lakh rupees.
   8. A speed of five hundred miles
   9. A dam of twelve gates.
   10. A tour of two hundred days.
   11. A ship of four hundred meters.
   12. A compensation of five lakh rupees

5. **Rewrite the following pairs of sentences into one by using appropriate cause and effect expressions:**
   1. The price of petrol has gone up. The essential commodities have become costlier.
   2. A nail has pierced the tire. It has become flattened.
   3. Vertical boilers have been installed in the factory. Only a limited floor space is available.
   4. National criteria for handling wastes have not been fixed. Traders take full advantage of it.
   5. Recycling and disposal of wastes require sizable expenditure. In such situations, industries Preferred to export their wastes to other countries.
   6. The reprocessing units in our country are far below the standard of efficiency. The environmentalists suggest a blanket ban on the import of wastes.
   7. There is a considerable increase in the number of industries. The quantum of wastes has also increased.
   8. The earth's ice cover is melting at high rates. Polar regions are warming faster than the planet as a whole.
   9. Safety precautions were not observed. There were many accidents in the factory.
   10. Several new blocks of buildings have been built there. The huge canopy of trees has been cut.

6. **Combine the following sentences using the expressions to show the idea of purpose:**
   1. Safety instructions are given in symbols. People can quickly comprehend them.
   2. Pure feed water is used. This prevents the formation of deposits.
   3. Underground cable: carry electricity to towns.
   4. A telescope: view stars and other celestial bodies.
   5. CTS: conducted a three hour test.
   6. Internet browsing: Information is collected for many reasons.
   7. Tamil Nadu government: scrapped the entrance testto help rural boys and girls.
   8. Improvement examinations cancelled. Such students gain undue advantage.

7. **Insert articles wherever necessary:**
   1. He received ____ honorarium of Rs.1000/-
   2. Everyone needs ___ visa to go to the other countries.
   3. ____ Principal is on rounds.
   4. Raghul is ___ Engineer by profession.
   5. Mr. Smith studied in ___ European University.
   6. I saw ___ stranger who was wearing a red turban.
   7. An apple a day keeps ___ doctor away.
   8. ____ earth has many satellites.
   9. ____ Neither land is a delight full holiday sport.
   10. ____bird has a keen eye sight to catch his prey.

11. India is ___land of Pilgrims.
12. I like ___ color blue.
13. Every citizen has ___ duty to perform.
14. ____garnished food is always is a delightful sight.
15. _____ talented artist is always recognized.

8. Fill in the blanks with the suitable verbs given in brackets:

1. The Parliament _____(has/have) its speaker.
2. Every body _____(appreciate/ appreciates) Mr. Rahul Gandhi's speech.
3. Computer classroom and lab _____ (was/ were) closed.
4. The news _____ (are/is) not true.

9. GIVE EXTENDED DEFINITION FOR THE FOLLOWING:

1. Bacteria
2. Osmosis
3. Antibiotic
4. Triangle
5. Nuclear reactor
6. System software
7. Food processor
8. Hard disk
9. Laptop
10. Satellite
11. Rocket
12. Miller
13. Caterpillar
14. Electronics
15. Projector
16. Processor
17. Submarine
18. Pillar
19. Concrete
20. Miller

10. Punctuate the following passage:

Science fiction are one of the most popular form of literature it command a very wich reading public many writer of the word are trying to produse it without bambos the villagas cannot survive says M.N. Buch farmer forest seceretary of Madhya Pradesh the blooming bamboo of bastar yield 3000 to 4000 quintais of rare seedIn 1895 the oil rich countrees came to realise that if they acts together there oil deposits could be a source of great power and wealth and their action of increase the price of oil immedietely afterwards, almost hold the developed countries to ransom.

11. MAKE ANTONYMS OF THE FOLLOWING WORDS BY ADDING SUITABLE PREFIXES:-

a) -------- nutrition
b) -------- reconcilable
c) -------- accountable
d) -------- normal

a) -------- associate
b) ---------repairable
c) -------- typical
d) --------- aided

a) -------- structure
b) -----pass
c) -----confidence
d) ------division

a) ----tension
b) ---apply
c) -----scopic
d) -----form

a) ---lingual
b) ---assuring
c) ---critical
d) ----laterally

a) -----sales
b) ----write
c) -----cast
d) -----hold

a) --- moral
b) --- fortune
c) --- suitable
d) --- legal

PART – B

INSTRUCTION

1. Write a set of eight instructions that are to be followed by the studends in college library.
2. Write a set of eight important instructions that you would like to give a foreigner who wants to visit Chennai. Give your instructions related to food, stay, and travel. Etc.,
3. Write a set of eight important instructions that are to be followed by the lab assistants while handling sophisticated equipment.
4. Write a set of eight important instructions that are to be followed while constructing a shamiana.
5. Write a set of eight important instructions that you will give to a friend who is traveling at night.
6. Write a set of eight important instructions to ensure safety in nuclear plant.
7. Write a set of eight important instructions to prevent our environment.
8. Write a set of eight important safety instructions to be followed in the chemistry laboratory while doing experiments.
9. Write a set of eight important instructions that can be followed by the public to preserve the environment and keep it free from pollution. (air, water and land).
10. Write a set of eight instructions that people could follow to keep the College Campus clean.
11. Write a set of eight important instructions that will help to control noise pollution in cities.
12. Write a set of eight important instructions to be followed in a Chlorine plant.
13. Write a set of eight important instructions to protect the ozone layer.
14. Write a set of eight important instructions for maintaining houses in good condition.
15. Write instructions to impose strict punishment on poachers and illicit users of forest wealth.

RECOMMENDATIONS:

1. Write a set of eight important recommendations to a group of students from Europe who has come to spend their one month's vacation in India. The suggestions may be on the lines of food, travel, transport, climatic conditions etc. to make their stay comfortable and enjoyable.
2. Write a set of eight important recommendations to keep the city of Chennai clean and green.
3. Write a set of eight important recommendations to maintain your computer in good working condition.
4. Write a set of eight important recommendations to preserve underground water resources.
5. Write a set of eight important recommendations to be adopted for maintaining your two-wheeler in perfect condition.
6. Write a set of eight important recommendations for improving health services in Government hospitals.
7. Write a set of ten recommendations to your fellow mates not to indulge in ragging
8. Write a set of Eight recommendations to overcome the ENERGY CRISIS in India

Read the following advertisement. Write a job application letter with a resume. Assume suitable address and qualifications.

PMR Software Technology Pvt., Ltd.,
Anna Nagar,
Chennai- 600 040
Phone : 4350042\458998
Career Opportunities for Engineers/ Software Engineers
We are a fast growing company in the field of Software. We require qualified Engineers / Software Engineers in the following areas:-

- System Administration
- Web Server Administration
- C++,VC++, VB, CAD
- JAVA services, JAVA Swing etc.,

Required Qualifications:-

- B.E/B. Tech with at least 70% marks
- 3 years real time work experience preferred
- Excellent Communication Skills

CHECK LIST

1. Your family is about to leave for Ooty on a two-week holiday. Your father has asked you to prepare a checklist of things to be done before you leave the house. Prepare an eight-item checklist to give to your father. Remember to give a title to your checklist.
2. Imagine that you have to go New Delhi to appear for an interview. Make an eight- item checklist with a proper title for your reference.
3. Prepare a checklist that consists of ten items to be checked before you leave your house for a long tour.
4. Prepare a checklist before appearing for the University Examinations.
5. Prepare a checklist for applying education loan.
6. Prepare a checklist for applying for a passport.
7. Prepare a checklist for going abroad for higher education.

Paragraphs

1. Write two paragraphs comparing the newspaper and the television as media of mass communication. Each of the paragraphs should not exceed 200 words.
2. Write two paragraphs, one describing the benefits of technology the other describing the drawbacks of technology. Each paragraph should not exceed 200 words.
3. Imagine yourself to be in the year 2050 and you are in your early 70's. The fuel position is very bad. Describe how life was fifty years ago when fuel was easily available. Write this in about 170-200 words.
4. Describe in about 170-200 words the utility, function with advantages and disadvantages of a washing machine.
5. Imagine yourself to be living in the year 2050 and you are in your early 70's. The fuel position is very bad. Describe how life was fifty years ago when fuel was easily available. Write this for about 170- 200 words.
6. Write two paragraphs, one describing the advantages and disadvantages of Mass media.
7. Write a paragraph on Population explosion.
8. Write a paragraph on Information Technology in India.

Essay

1. Technology and science.
2. Engineers in Nation Building
3. Unemployment in India.
4. India in 2020.
5. Nuclear power.
6. Alternate Sources of energy.
7. Are computer better than human Brain.
8. Global warming.
9. English in Todays world.
10. Rainwater Harvesting.

COMPREHENSION:

Read the passage and answer the questions that follow:

1. Man has won his dominant position on this planet by his command of technology. Other animals have to take nature as they find her ; they must fit into the environment that she provides as best they can. Man alone changes the shape of this world. He moves things about; he alters them in a constant effort to create an environment more hospitable than that, which nature has thurst him into. Technology is the sum total of all different techniques by which man changes his environment.

   Technology is characteristic of all human societies, and it exits even among leas developed tribes and communities. Even the Eskimo uses a number of techniques to make life more comfortable for him. He makes clothes: he builds an igloo and a boat: he uses needles and knives: he gets food by means of fishing lines and harpoons. All these are techniques for changing his wild habitat into an environment that suits him better.

   More advanced civilizations have more complex technologies, but the basic pattern is always the same. There must be means to get food; so the hunter invents the spear , or the bow and arrow, or the boomerang; and the farmer invents the hoe or the plough. There must be means to move things about, so the community domesticates the ox or the horse and invents the boat or the wheel. There must be means to ward off the weather, so the community makes clothes and huts and invents the tools that are needed to make them. These and other tools need to be strong and durable, so civilizations gradually move on from stone to bronze, from bronze to iron, and so on. And when we think of our present age as the age of light metals, we see ourselves in the tradition of progress that began with stone, bronze, and iron.

   Our own technological progress, then, has been a natural continuation of earlier trends. When today we breed new stains of corn, we are following the same aims as the first farmers. And when we send a rocket above the atmosphere, we are following the line begun by the invention of the wheel.

   However, there is one respect in which our technology is markedly different. We have transformed the simple tools of the past into complex machines. For example, man has used such a tool as the hammer since long before historical records began. But it was only in historical times that he discovered that the hammer could be made into a trip hammer that is, could be made to deliver its blow again and again automatically, When a tool is

made to repeat the same mechanical action, it becomes a machine. Modern civilization is built on the use of machines in this way. However clever they may appear, all machines at bottom are as the water wheel they do nothing but save us from carrying out ourselves a fixed and repeated sequence of actions.

(i)Answer in a sentence or two:

1) What is technology?
2) What is the common feature between the technologies developed by advanced and less advanced civilizations?
3) In what respect is the modern technology different from that of the past?
4) What are the techniques used by the Eskimoes to better their life?

(ii) Say whether the following statement s are true or false:

1) Technology is typical of only a few societies.
2) Humans have used simple tools since time immemorial.
3) Other animals can modify their environment.
4) Eskimoes represents less developed society.

(iii) Complete the following appropriately:

1) Human beings have achieved a powerful position on earth because of their _____.
2) The spear or the bow and arrow are _____.
3) In this passage, the present age is referred to as the _____.
4) A tool becomes a machine _____.

(iv) Give the meanings of the following words:

1) Hospitable-
2) Dominant-
3) Durable-
4) Breed-

2. What is so common among highly successful people and organizations? It is their vision, the power to look beyond the present and to visualize the possibilities of the future. It is not only their vision, but their determination to transform their dreams into realities that have made them great. Thinking ahead is the **privilege** given to man alone. Man learns from the past experience, analyses the present and plans for the future. Management is defined as the art of getting things done through and with the people. Therefore, to be successful, a manager needs to do a lot of planning not only for himself but also for his people. Planning is an important management function.

   The planning process takes into account the following factors:

A. PEOPLE: who are going to carry out the plan? How many people do we need? What are the kinds of people required and how to involve them?
B. PRODUCTS: What are the products necessary for achieving the goal?
C. DEADLINE: What is the time-grace needed for achieving the gold?

Planning also takes into account the strengths, which are to be made use of an weaknesses which are to be avoided during the execution of any task. It considers how to capitalize on the available opportunities and how to **safeguard** against competitive developments and the changing scenario.

Planning is of different kinds depending on the planner and his objectives. For example, companies have 'Corporate Visions which stem from individual vision. To achieve these, they make short-term and long-term plans. A long term plan is derived from a long range vision of the organization's destiny.

It is involved in setting broad objectives and the procedures for achieving them. This is essential for the survival and future growth of any business. Senior Managers are involved in long-term planning, thinking of new products and services, and of new ways of obtaining resources. Short- term plans are drawn up to realize more immediate goals and take care of the step by step activities needed for achieving the over-all objectives of a long- term.

It is necessary that planning should be realistic. While planning, one must accept the reality and set objectives which can be **accomplished.** Whenever one develops a plan, it is important to devise back up actions and alternative plans, just in case something goes wrong. Flexibility is vital to any good business plan. After planning, clear communication to all concerned is the key to success. Then **implementation** within a time frame must follow Planning and monitoring must go together, because, planning cannot be really effective without regular monitoring and good control.

The prime advantage with planning is that it leads to systematic and methodical work. It ensures proper coordination; helps proper control and provides an overall picture of the operations. It brings about optimum input utilization, minimizes wastage and helps periodic evaluation and replanning it necessary. Due to lack of planning many projects have failed. So success in life requires both merely thinking big , but also planning in advance.

(i) Choose the response which best reflects the meaning of the text.

1. The vision of highly successful people has enabled them to
   a) see far beyond and foretell what might happen in time to come
   b) predict the future events that might affect humanity in one way or the other
   c) send warning signals to the people regarding the future
   d) dream about the happily life, they will lead in the future

2. Planning is
   a) thinking ahead
   b) examining the past
   c) the art of achieving one's objective
   d) devising a method following which the objective can be achieved

3. Good planning is
   a) realistic having set objectives
   b) fixed not permitting any change
   c) supported by back-up actions

   d) a failure when a mistake occurs in implementation

4. Successful planning
   a) helps management settle amicably labour unrest.
   b) takes to task those who waste raw material
   c) punishes those who are not systematic in their work
   d) ensures maximum input utilization, continuous monitoring and periodic evaluation.

ii) Decide whether the following statements are 'true' or 'false' :

1. The future growth of any business depends only on the procurement of resources by senior managers.
2. The success of planning depends on how well it is implemented with regular monitoring, within the time limit, securing the support of all concerned.
3. Short-term plans help not only to realize immediate goals, but also to monitor the step-by- step activities in achieving the over- all objectives of a long term plan.
4. Success in life depends on thinking big alone.

iii) Choose the most accurate definitions of the terms taken from the text:

1. Privilege
   (a) Special right or advantage
   (b) Special choice
   (c) Special prize
   (d) Special respect

2. Safeguard
   (a) to improve or better something
   (b) to violate something
   (c) to protect or guard something
   (d) to despise something

3. to accomplish
   (a) to master something
   (b) to complete successfully something
   (c) to help another to do something illegal
   (d) to fail to achieve something

4. Implementation
   (a) Division of labour
   (b) A tool or instrument
   (c) Involvement
   (d) Carrying out effectively.

3. It is everyone who agrees a difficult task that the child performs when he learns to speak, and the fact that he does so, in so short a period of time challenges explanation.
   Language learning begins with listening. Individual children vary greatly in the amount of listening they do before they start speaking and late starters are often long listeners. Most children will obey spoken instructions some time before they can speak, though the word 'obey' is hardly accurate as a description of the eager and delighted cooperation usually

shown by the child. Before they can speak, many children will also ask questions by gesture and by making questioning noises.

Any attempt to trace the development from the noises babies make to their first spoken words leads to considerable difficulties. It is agreed that they enjoy making noises and that during the first few months one or two noises sort themselves out as particularly indicative of delight, distress, sociability and so on. But since these cannot be said to show the baby's intention to communicate, they can hardly be regarded as early forms of language. It is agreed, too, that from about three months they play with sounds for enjoyment and that by six months they are able to add new sounds to their repertoire. This self-imitation leads to deliberate imitation of sounds made or words spoken to them by other people. The problem then arises as to the point at which one can say that these imitations can be considered as speech.

It is a problem we need not get our teeth into. The meaning of word depends on what a particular person means by it in a particular situation; and it is clear that what a child means by a word will change as he gains more experience of the world. Thus the use, at say seven months of 'mama' as a greeting for his mother cannot be dismissed as a meaningless sound simply because he also uses it at other times for his father, his dog, or anything else he likes.

Playful and apparently meaningless imitation of what other people say continuous after the child has begun to speak to itself. I doubt, however, whether anything is gained when parents cash in on this ability in an attempt to teach new sounds.

I. Choose the response which best reflects the meaning of the text:-

1. Children who start speaking late
   a) May have problems with their hearing.
   b) Probably do not hear enough language spoken around them.
   c) Usually pay close attention to what they hear.
   d) Often takes a long time in learning to listen properly.
2. A baby's first noises are
   a) a reflection of his models and feelings.
   b) an early form of language.
   c) a sign that he means to tell you something.
   d) an imitation of the speech of adults.
3. The problem of deciding at what point a baby's imitations can be considered as speech
   a) is important because words have different meanings for different people.
   b) is not especially important because the change over takes place gradually.
   c) is one that can never be properly understood because the meanings of words change with age.
   d) is one that should be completely ignored because children's use of words is often meaningless.
4. The writer implies that
   a) Parents can never hope to teach their children new sounds.
   b) Children no longer imitate people they begin to speak.
   c) Children who are good at imitating learn new sounds more quickly.
   d) Even after they learn to speak, children still enjoy imitating.

II. Write whether the following statements are 'True' or 'False':-

a) Before they begin to speak most children do about the same amount of listening.
b) Children can ask questions by making noises.
c) Children first imitate adults, and then themselves.

d) Children's first words are usually meaningless because they can apply to many different things.

III. Choose the most accurate definition of the terms taken from the text:

1) Vary
   a) Worry b) differ c) develop d) change
2) Sort themselves out
   a) Become evident b) are learnt c) are discovered d) take the place of others
3) It is agreed
   a) it has been proved b) it is generally accepted c) it is obvious d) it is most likely
4) Cash in on
   (d) a) Ignore b) exploit c) discourage d) praise

MA6251 MATHEMATICS II

Unit 1 VECTOR CALCULUS

Part – A

1. Find grad ϕ if $\phi = x^2 + y^2 + z^2$ at $(1,-1,1)$.

Solution: Given $\phi = x^2 + y^2 + z^2$

$$\nabla\phi = \vec{i}\frac{\partial}{\partial x}\left(x^2+y^2+z^2\right) + \vec{j}\frac{\partial}{\partial y}\left(x^2+y^2+z^2\right) + \vec{k}\frac{\partial}{\partial z}\left(x^2+y^2+z^2\right)$$

$$= 2x\vec{i} + 2y\vec{j} + 2z\vec{k}$$

$$\nabla\phi(1,-1,1) = 2\vec{i} - 2\vec{j} + 2\vec{k}$$

2. Prove that $\nabla r^2 = 2\vec{r}$.

Solution: Given $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$

$$\nabla r^2 = \vec{i}\frac{\partial r^2}{\partial x} + \vec{j}\frac{\partial r^2}{\partial y} + \vec{k}\frac{\partial r^2}{\partial z} = 2r\frac{\partial r}{\partial x}\vec{i} + 2r\frac{\partial r}{\partial y}\vec{j} + 2r\frac{\partial r}{\partial z}\vec{k}$$

$$= 2r\left(\frac{x}{r}\vec{i} + \frac{y}{r}\vec{j} + \frac{z}{r}\vec{k}\right) = 2r\left(\frac{x\vec{i}+y\vec{j}+z\vec{k}}{r}\right) = 2\vec{r}.$$

3. Find a unit normal vector to the surface $\phi = x^2y + 2xz - 4$ at the point $(2,-2,3)$.

Solution: Given $\phi = x^2y + 2xz - 4$

$$\nabla\phi = \left(\vec{i}\frac{\partial\varphi}{\partial x} + \vec{j}\frac{\partial\varphi}{\partial y} + \vec{k}\frac{\partial\varphi}{\partial z}\right) = \vec{i}(2xy+2z) + \vec{j}\left(x^2\right) + \vec{k}(2x)$$

$$\nabla\phi(2,-2,3) = -2\vec{i} + 4\vec{j} + 4\vec{k}$$

Unit vector normal $= \dfrac{\nabla\phi}{|\nabla\phi|} = \dfrac{-2\vec{i}+4\vec{j}+4\vec{k}}{\sqrt{4+16+16}} = \dfrac{-\vec{i}+2\vec{j}+2\vec{k}}{3}.$

4. Find the values of a, b, c so that the vector $\vec{F} = (x+y+az)\vec{i} + (bx+2y-z)\vec{j} + (-x+cy+2z)\vec{k}$ may be irrotational?

Solution: If $\vec{F}$ is irrotational then $\nabla\times\vec{F} = 0$

consider, $\nabla\times\vec{F} = 0$

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ x+y+az & bx+2y-z & -x+cy+2z \end{vmatrix} = 0$$

$$\Rightarrow \vec{i}(c+1) - \vec{j}(-1-a) + \vec{k}(b-1) = 0$$

$$\Rightarrow c+1 = 0, -1-a = 0, b-1 = 0$$

$$\Rightarrow c = -1, a = -1, b = 1.$$

5. Find the maximum directional derivative of $\phi = x^2yz + 4xz^2$ at the point $P(1,-2,1)$.

Solution: Given $\phi = x^2yz + 4xz^2$

$$\nabla\phi = (2xyz + 4z^2)\vec{i} + x^2z\vec{j} + (x^2y + 8xz)\vec{k}$$

$$(\nabla\phi)_{(1,-2,-1)} = \vec{j} + 6\vec{k}$$

Maximum directional derivative $= |grad\phi| = |\nabla\phi| = \sqrt{1^2+6^2} = \sqrt{37}.$

6. Find the Directional Derivative of $\phi = x^2yz+4xz^2$ at (1, -2, -1) in the direction of $2\vec{i} - \vec{j} - 2\vec{k}$. (A.U.A/M 2008)

Solution : Given $\phi = x^2yz + 4xz^2$, $\vec{a} = 2\vec{i} - \vec{j} - 2\vec{k}$, $|\vec{a}| = \sqrt{4+1+4} = 3$

$$\text{D.D.} = \nabla\phi.\frac{\vec{a}}{|\vec{a}|}$$

$$\nabla\phi = \left(2xyz + 4z^2\right)\vec{i} + x^2z\vec{j} + \left(x^2y + 8xz\right)\vec{k}, \quad (\nabla\phi)_{(1,-2,-1)} = 8\vec{i} - \vec{j} - 10\vec{k}$$

$$\text{D.D} = \nabla\phi.\frac{\vec{a}}{|\vec{a}|} = (8\vec{i} - \vec{j} - 10\vec{k}).\frac{2\vec{i} - \vec{j} - 2\vec{k}}{3} = \frac{37}{3}.$$

7. If the directional derivative of the function $\phi = xyz$ at (1, 1, 1) in the direction of $\alpha\vec{i} + \vec{j} + \vec{k}$ is $\sqrt{3}$ find α.

Solution: Directional derivative $= \nabla\phi \bullet \dfrac{\vec{n}}{|\vec{n}|}$

$$\nabla\phi = \left(\vec{i}\frac{\partial\varphi}{\partial x} + \vec{j}\frac{\partial\varphi}{\partial y} + \vec{k}\frac{\partial\varphi}{\partial z}\right) = \vec{i}(yz) + \vec{j}(xz) + \vec{k}(xy)$$

$$\nabla\phi(1,1,1) = \vec{i} + \vec{j} + \vec{k}$$

Given

$$D.D = \sqrt{3} = \left(\vec{i} + \vec{j} + \vec{k}\right) \bullet \frac{\left(\alpha\vec{i} + \vec{j} + \vec{k}\right)}{\sqrt{\alpha^2 + 2}}$$

$$\sqrt{3}\sqrt{\alpha^2 + 2} = \alpha + 2$$

$$3\left(\alpha^2 + 2\right) = (\alpha + 2)^2$$

$$3\alpha^2 + 6 = \alpha^2 + 4\alpha + 4$$

$$2\alpha^2 - 4\alpha + 2 = 0 \Rightarrow \alpha^2 - 2\alpha + 1 = 0$$

$$\alpha = 1.$$

8. Prove that $div\vec{r} = 3$ and $curl\vec{r} = 0$.

Solution: Given $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$

$$div\vec{r} = \nabla.\bullet\vec{r} = \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right) \bullet \left(x\vec{i} + y\vec{j} + z\vec{k}\right) = 1 + 1 + 1 = 3$$

$$curl\vec{r} = \nabla \times \vec{r} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix} = 0$$

9. If ϕ is a scalar point function prove that $curl(grad\phi) = 0$.

Solution: consider $curl\left(grad\phi\right) = \nabla \times (\nabla\phi)$

$$= \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right) \bullet \left(\vec{i}\frac{\partial\phi}{\partial x} + \vec{j}\frac{\partial\phi}{\partial y} + \vec{k}\frac{\partial\phi}{\partial z}\right)$$

$$= \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix}$$

$$= \vec{i}\left[\frac{\partial^2\phi}{\partial y\partial z} - \frac{\partial^2\phi}{\partial y\partial z}\right] - \vec{i}\left[\frac{\partial^2\phi}{\partial x\partial z} - \frac{\partial^2\phi}{\partial x\partial z}\right] + \vec{i}\left[\frac{\partial^2\phi}{\partial y\partial x} - \frac{\partial^2\phi}{\partial y\partial x}\right]$$

$$= 0.$$

10. Find the constant b such that $\vec{A} = (bx + 4y^2z)\vec{i} + (x^3\sin z - 3y)\vec{j} - (e^x + 4\cos x^2 y)\vec{k}$ is solenoidal.

Solution : If $\vec{A}$ is solenoidal then $\nabla.\bullet\vec{A} = 0$

$$\nabla.\bullet\vec{A} = \frac{\partial}{\partial x}(bx + 4y^2z) + \frac{\partial}{\partial y}(x^3\sin z - 3y) + \frac{\partial}{\partial z}(-e^x - 4\cos x^2 y)$$

$$0 = b - 3 + 0$$

$$b = 3.$$

11. Prove that *curl* of constant vector is zero.

Solution : Let $\vec{A} = a\vec{i} + b\vec{j} + c\vec{k}$, where a,b and c are constants.

$$curl\vec{A} = \nabla \times \vec{A} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ a & b & c \end{vmatrix} = 0$$

12. If $F = (3x^2 + 6y)\vec{i} - 14yz\vec{j} + 20xz^2\vec{k}$. Evaluate $\int_C \vec{F}.d\vec{r}$ from (0,0,0) to (1,1,1) along the curve x = t, y = t^2, z = t^3

Solution: The end points are (0,0,0) and (1,1,1)

These points correspond to t=0 and t=1.

$\therefore$ dx = dt, dy = 2t dt, dz = $3t^2$dt.

$$\int_C \vec{F}.d\vec{r} = \int_C \left(3x^2 + 6y\right)dx - 14yzdy + 20xz^2dz$$

$$= \int_0^1 \left(3t^2 + 6t^2\right)dt - 14t^5\left(2tdt\right) + 20t^7\left(3t^2\right)dt$$

$$= \int_0^1 \left(9t^2 - 28t^6 + 60t^9\right)dt$$

$$= \left[3t^3 - 4t^7 + 6t^{10}\right]_0^1$$

$$= \left[\left(3 - 4 + 6\right) - 0\right] = 5$$

13. Evaluate $\int_c \left(5y^2dx - 2x^2dy\right)$ along the parabola $y = x^2$ from (0,0) to (2,4).

Solution: Given $y = x^2 \Rightarrow dy = 2xdx$

$$\int_c \left(5y^2dx - 2x^2dy\right) = \int_0^2 \left(5x^4dx - 2x^2\left(2x\right)dx\right) = \int_0^2 \left(5x^4 - 4x^3\right)dx$$

$$= \left[\frac{5x^5}{5} - \frac{4x^4}{4}\right]_0^2 = 2^5 - 2^4 = 32 - 16 = 16.$$

14. Evaluate $\int_c \left(xdy - ydx\right)$ around the circle $x^2 + y^2 = 1$.

Solution: We Know that Area = $\frac{1}{2}\int_c \left(xdy - ydx\right)$

$$\therefore \int_c \left(xdy - ydx\right) = 2Area\left(circle\right) = 2\pi r^2 \left(radius = r = 1\right) = 2\pi\left(1\right)^2 = 2\pi.$$

15. If $F = ax\vec{i} + by\vec{j} + cz\vec{k}$, a, b, c are constants. Show that $\iint_S \vec{F}.\hat{n}ds = \frac{4\pi}{3}(a+b+c)$ where s is the surface of a unit sphere. (A.U. A/M2008)

Proof: W.K.T Gauss's divergence theorem

$$\iint_S \vec{F}.\hat{n}ds = \iiint_V \nabla.\vec{F}dv$$

$$= \iiint_V \left(\frac{\partial}{\partial x}(ax) + \frac{\partial}{\partial y}(by) + \frac{\partial}{\partial z}(cz)\right)dv$$

$$= \iiint_V (a+b+c)dV$$

$$= (a+b+c)V = (a+b+c)\frac{4}{3}\pi(1)^3$$

$$\iint_S \vec{F}.\hat{n}ds = \frac{4}{3}\pi(a+b+c)$$

PART –B

1. Verify stokes theorem for $\vec{F} = xy\vec{i} - 2yz\vec{j} - xz\vec{k}$ Where S is the surface of the rectangular parallelopiped by the planes *x = 0, x =1, y =0, y =2* and *z =3* above *xy* plane.
2. Verify stokes theorem for vector field define by $\vec{F} = (x^2 - y^2)\vec{i} + 2xy\vec{j}$ in rectangular region in the xy plane bounded by the lines x=0, x=a, y=0, y=b .
3. Prove that $\nabla.(\vec{u}\times\vec{v}) = \vec{v}.(\nabla\times\vec{u}) - \vec{u}.(\nabla\times\vec{v})$.
4. By applying Green's theorem prove that the area bounded by a simple closed curve C is given by $\frac{1}{2}\int_C (xdy - ydx)$. Hence find area of the ellipse x = a cos θ, y = b sin θ.
5. Find a and b such that the surfaces ax^2-byz=(a+2)x and $4x^2y+z^3=4$ cut orthogonally at (1, -1, 2) .
6. Prove that $\vec{F} = \left(6xy + z^3\right)\vec{i} + \left(3x^2 - z\right)\vec{j} + \left(3xz^2 - y\right)\vec{k}$ is irrotational vector and find the scalar potential such that $\vec{F} = \nabla\phi$.
7. If $\vec{F}$ is position vector of the *(x, y, z)* prove that $\nabla^2 r^n = n\left(n+1\right)r^{n-2}$ and hence deduce $\nabla^2\left(\frac{1}{r}\right)$.
8. Find the work done in moving a particle in the force field $\vec{F} = 3x^2\vec{i} + \left(2xz - y\right)\vec{j} + z\vec{k}$ along the curve defined by $x^2 = 4y$, $3x^3 = 8z$ from $x = 0$ to $x = 2$.
9. Verify Gauss Divergence theorem for $\vec{F} = \left(x^3 - yz\right)\vec{i} - 2x^2y\vec{j} + 2\vec{k}$ over the cube bounded by *x = 0, x =a, y =0, y =a* and *z =0,z = a.*
10. Verify Gauss Divergence theorem for $\vec{F} = \left(4xz - yz\right)\vec{i} - y^2\vec{j} + yz\vec{k}$ over the cube bounded by *x = 0, x =1, y =0, y =1* and *z =0,z = 1.*
11. Verify Green's theorem in the *xy* plane for $\int_c \left(3x^2 - 8y^2\right)dx + \left(4y - 6xy\right)dy$,where c is the boundary of the region defined by $x=y^2$, $y=x^2$.
12. Verify Green's theorem in the *xy* plane for $\int_c \left(3x^2 - 8y^2\right)dx + \left(4y - 6xy\right)dy$,where c is the boundary of the region defined by $x=0$, $x+y=1$.
13. Verify Green's theorem in the *xy* plane for $\int_c \left(xy + y^2\right)dx + x^2dy$, where c is the boundary of the region defined by $x=y$, $y=x^2$.

UNIT 2

ORDINARY DIFFERENTIAL EQUATIONS

PART – A

1. **Solve: $\frac{d^2y}{dx^2} + 5\frac{dy}{dx} + 6y = 0$**

Sol:

Denote D=$\frac{d}{dx}$, $(D^2 + 5D + 6)y = 0$

AE is m^2+5m+6=0

(m+2)(m+3)=0

m = -2, -3

$y = Ae^{-2x}+Be^{-3x}$

2. **Solve the equation** $\left(D^2 - 6D + 13\right)y = 0$ $[N/D\,2009]$

Sol: A.E is $m^2 - 6m + 13 = 0$, $m = 3 \pm 2i$ (The roots are imaginary and occur in conjugate pairs).The general solution $y = e^{3x}(A\cos 2x + B\sin 2x)$

3. **Solve: y"-6y'+9y = 0**

Sol:$(D^2 - 6D + 9)y = 0$

AE is m^2-6m+9=0,(m-3)(m-3)=0

m = 3, 3

$y = (Ax+B)e^{3x}$

4. **Solve $(D^2 + 4D + 13)y = 0$**

Sol: AE is m^2+4m+13=0

m = $-2\pm i3$

$y = e^{-2x}$(Acos3x+Bsin3x)

5.Solve $\left(D^4 - a^4\right)y = 0$ $[N/D\,2008]$

Sol:

The auxiliary equation is $m^4 - a^4 = 0$

$$m^4 = a^4$$
$$m^2 = \pm a^2$$
$$m^2 = a^2;\ m^2 = -a^2$$
$$m = \pm a;\ m = \pm ai$$

$\therefore$ The general solution is $y = Ae^{ax} + Be^{-ax} + (C\cos ax + D\sin ax)$

6. **Solve** $\left(D^2 + 1\right)^2 y = 0$ $[A/M\ 2008]$

Sol:

The auxiliary equation is $\left(m^2 + 1\right)^2 = 0$

$$m^2 + 1 = 0;\ m^2 = -1$$
$$m = \pm i \text{ (twice)}$$
$$m = i, i, -i, -i$$

$\therefore$ The general solution is $y = (Ax + B)\cos x + (Cx + D)\sin x$

7. **Reduce the differential equation (x^2D^2+4xD+2)y = x^2cos(logx) into that of constant coefficients.**

Sol:

Put z = logx (or) $x=e^z$ and $x^k=e^{kz}$

Put D=d/dx and θ=d/dz, We've

xD=θ, x^2D^2=θ(θ-1).

The given D.E becomes $(\theta^2+3\theta+2)\ y = e^{2z}$cosz.

8. **Solve: x^2y"-3xy'+4y=0**

Sol:

Put z = logx (or) $x=e^z$ and $x^k=e^{kz}$

Put D=d/dx and θ=d/dz, we've

xD=θ, x^2D^2=θ(θ-1).

The given D.E becomes $(\theta^2-4\theta+4)y = 0$

AE is m^2-4m+4 = 0

(m-2)(m-2) = 0

m = 2, 2

The solution is $y = (Az+B)e^{2z} = (Alogx+B)x^2$

9. **Solve** $x^2y'' - xy' + y = 0$ $[May\,2009]$

Soln.

Given $(x^2D^2 - xD + 1)y = 0$

put $x = e^z$ *or* $\log x = z$, $xD = D'$, $x^2D^2 = D'(D' - 1)$

the given o.d.e becomes $(D'^2 - 2D' + 1)y = 0$

then the A.E is $m^2 - 2m + 1 = 0\, i.e., (m-1)^2 = 0 \Rightarrow m = 1,1$

$\therefore y = (Az + B)e^z = (A\log x + B)e^{\log x} = (A\log x + B)x$

10. Solve $\frac{dx}{dt}-y=0,\frac{dy}{dt}+x=0$ **[A/M 2008]**

Sol:

Given $Dx-y=0$ .....(1)

$Dy+x=0$ .....(2)

$(1)\times D \Rightarrow D^2x-Dy=0$ .....(3)

$(3)+(2)\Rightarrow D^2x+x=0$

$(D^2+1)x=0$

A.E is $m^2+1=0; m^2=-1; m=\pm i$

$\therefore x=A\cos t+B\sin t$

$(2)\times D \Rightarrow D^2y+Dx=0$ .....(4)

$(4)-(1)\Rightarrow (D^2+1)y=0$

$\therefore y=C\cos t+D\sin t$

11. Eliminate y from $\frac{dx}{dt}-y=t,\frac{dy}{dt}+x=sint$

Sol:

Put D=d/dt

The given equation becomes,

Dx-y = t .....(1)

Dy+x = sint .....(2)

Eliminate (1) & (2) for y, we get,

(D^2+1) x = 1+sint

12. Eliminate x from $\frac{dx}{dt}+y=sint,\frac{dy}{dt}+x=e^{3t}$

Sol:

Put D=d/dt

The given equation becomes,

Dx+y = sint ..... (1)

x+Dy = e^{3t} ..... (2)

To eliminate x,

(2)xD $\Rightarrow$ Dx+D^2y = D(e^{3t})

$\Rightarrow$Dx+ D^2y = 3 e^{3t} ..... (3)

(3) – (1) $\Rightarrow$$D^2$y – y = 3 e^{3t} – sint

$\Rightarrow$(D^2 – 1) y = 3 e^{3t} – sint

13. Find the particular integral for $(D^3-1)\,y=e^{2x}$

Sol: Given $(D^3-1)\,y=e^{2x}$

$$PI=\frac{1}{(D^3-1)}(e^{2x})=\frac{e^{2x}}{(2^3-1)}=\frac{e^{2x}}{7}$$

14. Find the particular integral of $(D^2-2D+1)y=coshx$

Sol:

Given $(D^2-2D+1)y=coshx=\frac{1}{2}(e^x+e^{-x})$

$PI=\frac{1}{2}(PI_1+PI_2)$

$PI_1=\frac{1}{(D^2-2D+1)}(e^x)$

$=\frac{e^x}{1-2+1}$

$=\frac{e^x}{0}=\frac{x^2e^x}{2}$

$PI_2=\frac{1}{(D^2-2D+1)}(e^{-x})$

$=\frac{e^{-x}}{1+2+1}$

$=\frac{e^{-x}}{4}$

$PI=\frac{1}{2}\left(\frac{x^2e^x}{2}+\frac{e^{-x}}{4}\right)$

15. Solve: $(xD^2+D)y=0$

Sol: Given $(xD^2+D)y=0$

Multiply by 'x' $(x^2D^2+Dx)y=0$

put z = logx (or) $x=e^z$ and $x^k=e^{kz}$, D=d/dx and θ=d/dz, we've

$xD=\theta$, $x^2D^2=\theta(\theta-1)$.

The given D.E becomes $\theta^2y=0$, AE is $m^2=0$. m = 0, 0.

The solution is y = Az+B = Alogx+B

16. Find the particular integral of $(D^2+2D+1)y=e^{-x}cosx$ **[M/J 2009]**

Sol: The particular integral = $\frac{1}{(D^2+2D+1)}e^{-x}\cos x$

$=e^{-x}\frac{1}{((-1)^2+2(-1)+1)}cosx$

$=e^{-x}\frac{1}{0}cosx \qquad (dr=0)$

$=\frac{1}{(D+1)^2}\,e^{-x}\,cosx$

$=\frac{1}{(D-1+1)^2}e^{-x}cosx$ replace D by $D-1$

$=e^{-x}\frac{1}{D^2}cosx$

$=e^{-x}\frac{1}{-1}cosx$ by replacing D^2 by -1^2

$=-e^{-x}cosx$

17. Find the particular integral of $\frac{d^2y}{dx^2}-4y=3^x$ **[N/D 2007]**

Sol:

given $(D^2-4)y=3^x$

$=e^{\log 3^x}=e^{x(\log 3)}$

$$\text{P.I}=\frac{1}{D^2-4}e^{x(\log 3)}=\frac{1}{(\log 3)^2-4}e^{x(\log 3)}=\frac{3^x}{(\log 3)^2-4}$$

18. Find the particular integral of $\frac{d^2y}{dx^2}+4y=\sin 2x$ **[N/D2008]**

Sol:

given $(D^2+4)y=\sin 2x$

$$\text{P.I}=\frac{1}{D^2+4}\sin 2x=\frac{1}{-(2)^2+4}\sin 2x \qquad (by\ replacing\ D^2\ by -(2)^2)$$

$$=\frac{1}{0}\sin 2x \quad (dr=0)$$

$$=x\frac{1}{2D}\sin 2x=\frac{x}{2}\int \sin 2x\,dx=\frac{x}{2}\left(\frac{-\cos 2x}{2}\right)=\frac{-x\cos 2x}{4}$$

PART – B

1. Solve $(D^2-2D+1)\ y=(e^x+1)^2$
2. Solve the equation $(D^2+4)y=x^2\cos 2x$ [M/J 2009]
3. Solve $y''+3y'+2y=\sin 3x.\cos 2x$
4. Solve $(D^2+5D+6)\ y=e^{2x}\sin 3x$
5. Solve the equation $\left(x^2D^2+3xD+5\right)y=x\cos(\log x)$ [M/J 2009]
6. Solve $x^2\frac{d^2y}{dx^2}+3x\frac{dy}{dx}+y=\frac{\sin(\log x)}{x^2}$
7. Solve $x^2y''+xy'-9y=x^2\log x$
8. Solve $(2x+3)^2y''-(2x+3)y'-12y=6x$ [N/D 02, Jan 05]
9. Solve $\frac{dx}{dt}+4x+3y=t, \frac{dy}{dt}+2x+5y=e^{2t}$
10. Solve $\frac{dx}{dt}+y=\sin t, x+\frac{dy}{dt}=\cos t$ given that $x=2$ and $y=0$ at $t=0$ [M/J 2009]
11. Solve $Dx-(D-2)y=\cos 2t;\ (D-2)x+Dy=\sin 2t$ [A/M 2008]
12. Solve $\frac{dx}{dt}-y=t, x+\frac{dy}{dt}=sint$
13. Solve $\frac{d^2y}{dx^2}+a^2y=tanax$ by method of variation of parameter. [N/D 07,A/M 08]
14. Solve $\frac{d^2y}{dx^2}+a^2y=secax$ by method of variation of parameter. [A/M 2004]
15. Solve $\frac{d^2y}{dx^2}+a^2y=cosecax$ by method of variation of parameter.

UNIT-III

LAPLACE TRANSFORM

PART-A

1. Find L [$te^{-t}\sin 2t$] =F(s+1).

L [$te^{-t}\sin 2t$] = L [$e^{-}t\ (\sin 2t)$]

F(s) = L [$t\sin 2t$] = $-\frac{d}{ds}\left(\frac{2}{s^2+4}\right)=\frac{4s}{(s^2+4)^2}$

F(s+1) = $\frac{4(s+1)}{((s+1)^2+4)^2}$

∴ L [$te^{-t}\sin 2t$] =$\frac{4(s+1)}{((s+1)^2+4)^2}$

2. Find$L\left[\frac{sin\omega t}{t}\right]$.

$L\left[\frac{sin\omega t}{t}\right]=L\left[\frac{f(t)}{t}\right]=\int_s^\infty F(s)ds$

F(s) =L $[sin\omega t]=\frac{\omega}{s^2+\omega^2}$

$\int_s^\infty F(s)ds=\omega\int_s^\infty \frac{1}{s^2+\omega^2}ds=\omega\left[\frac{1}{\omega}tan^{-1}\frac{s}{\omega}\right]_s^\infty$

$=\left[tan^{-1}\infty-tan^{-1}\frac{s}{\omega}\right]=\left[\frac{\pi}{2}-tan^{-1}\frac{s}{\omega}\right]$

$L\left[\frac{sin\omega t}{t}\right]=tan^{-1}\frac{s}{\omega}\ orcot^{-1}\frac{s}{\omega}$

3. Find $L\left[\frac{cos2t-cos3t}{t}\right]$.

$L\left[\frac{cos\,2t-cos\,3t}{t}\right]=\int_s^\infty L[cos2t-cos3t]ds$

$=\int_s^\infty\left(\frac{s}{s^2+4}-\frac{s}{s^2+9}\right)ds$

$=\left[\frac{1}{2}log(s^2+4)-\frac{1}{2}log(s^2+9)\right]_s^\infty$

$= \frac{1}{2}\left[log\frac{s^2+4}{s^2+9}\right]_s^\infty = \frac{1}{2}\left[log\frac{s^2\left(1+\frac{4}{s^2}\right)}{s^2\left(1+\frac{9}{s^2}\right)}\right]_s^\infty$

$= \frac{1}{2}\left[log1 - log\left(\frac{1+\frac{4}{s^2}}{1+\frac{9}{s^2}}\right)\right]$

$= \frac{1}{2}\ log\left(\frac{s^2+9}{s^2+4}\right)$

4. If L [f (t)] = F(s), then L [f (at)] = $\frac{1}{a}$ F(s/a)

By definition L [f (at)] = $\int_0^\infty e^{-st} f(at)dt$

Put at = u; dt = du/a

When t = 0; u = 0, t = ∞

∴ L [f (at)] = $\frac{1}{a}\int_0^\infty e^{-\frac{s}{a}u} f(u)du = \frac{1}{a}$ F(s/a)

5. Evaluate L[e^{-t}sin3t]

Soln: L[e^{-t}sin3t] = L[e^{-at} f(t)] = F(s+a)

F(s) = L [f (t)] = L (sin 3t) = $\frac{3}{s^2+9}$

F(s+1) = $\frac{3}{(s+1)^2+9} = \frac{3}{s^2+2s+10}$

6. Find L[t^n e^{-at}]

Soln: L[t^n e^{-at}] = L[e^{-at} f(t)] = F(s+a)

F(s) = L[t^n] = $\frac{n!}{s^{n+1}}$

F(s+a) = $\frac{n!}{(s+a)^{n+1}}$

7. Find L[e^{-4t} cosh5t]

Soln: L[e^{-4t} cosh5t]=L$\left[e^{4t}\left(\frac{e^{5t}+e^{-5t}}{2}\right)\right]$

$= \frac{1}{2}L[e^{9t} + e^{-t}] = \frac{1}{2}\left[\frac{1}{s-9} + \frac{1}{s+1}\right]$

$= \frac{s-4}{s^2-8s-9}$

8. Find L[e^{-2t}(3sinh2t – 5cosh2t)]

Soln: L[e^{-2t}(3sinh2t – 5cosh2t)] = L $\left[3\text{sinh}2t - 5\text{cosh}2t)\right]_{s\to s+2}$

L [3sinh2t – 5cosh2t] = 3L [sinh2t] – 5L (cosh2t)

$= \frac{3}{2}L[e^{2t} - e^{-2t}] - \frac{5}{2}L[e^{2t} + e^{-2t}]$

$= \left[\frac{-1}{s-2} - \frac{4}{s+2}\right] = \frac{6-5s}{s^2-4}$

∴ L [e^{-2t} (3sinh2t – 5cosh2t)] = $\frac{6-5(s+2)}{(s+2)^2-4}$

9. Find L[cosh at cos at]

Soln: L[cosh at cos at]= L$\left[\left(\frac{e^{at}+e^{-at}}{2}\right)\cos at\right]$

$= \frac{1}{2}L[(e^{at}\cos at) + L(e^{-at}\cos at)]$

$= \frac{1}{2}[F(s-a) + F(s+a)]$

F(s) = L (cos at) = $\frac{s}{s^2-a^2}$

$= \frac{1}{2}\left[\frac{s-a}{(s-a)^2+a^2} + \frac{s+a}{(s+a)^2+a^2}\right]$

$= \frac{s^3}{s^4+4a^4}$

10. Find L[e^{-t} $\sin^2 t$]

Soln: L[e^{-t} $\sin^2$t] = L{$\sin^2$t}$_{s\to s+1}$

L ($\sin^2$t) = $\frac{1}{2}L[1 - cos2t] = \frac{1}{2}\left[\frac{1}{s} - \frac{s}{s^2+4}\right]$

L [e^{-t} $\sin^2$t] = $\frac{1}{2}\left[\frac{1}{s+1} - \frac{s+1}{(s+1)^2+4}\right]$

11. Find L[e^{-3t} $\cos^2$t]

Soln: L[e^{-3t} $\cos^2$t] = L{$\cos^2$t}$_{s\to s+3}$

L ($\cos^2$t) = $\frac{1}{2}L[1 + cos2t] = \frac{1}{2}\left[\frac{1}{s} + \frac{s}{s^2+4}\right]$

L $[e^{-3t}\cos^2 t] = \frac{1}{2}\left[\frac{1}{s+3} - \frac{s+3}{(s+3)^2+4}\right]$ L$[e^{-3t}\cos^2 t]$ = L$\{\cos^2 t\}_{s\to s+3}$

L $(\cos^2 t) = \frac{1}{2}L[1+cos2t] = \frac{1}{2}\left[\frac{1}{s} + \frac{s}{s^2+4}\right]$

L $[e^{-3t}\cos^2 t] = \frac{1}{2}\left[\frac{1}{s+3} - \frac{s+3}{(s+3)^2+4}\right]$

12. Find L$(1+te^{-t})^3$

Soln: L$(1+te^{-t})^3$ = L$(1 + t^3e^{-3t} + 3te^{-t} + 3t^2e^{-2t})$

= L(1) + L(t^3e^{-3t}) + 3L(te^{-t}) + 3L(t^2e^{-2t})

$= \frac{1}{s} + \frac{6}{(s+3)^2} + \frac{3}{(s+1)^2} + \frac{6}{(s+2)^2}$

13. Evaluate $\int_0^\infty e^{-2t}$t sin 3t dt

$\int_0^\infty e^{-2t}$t sin 3t dt = $\int_0^\infty e^{-st}$f(t) dt = F(s) at s = 2

Where F(s) = L [f (t)]

F(s) = L [t sin 3t]

$= \frac{-d}{ds}\left[\frac{3}{s^2+9}\right] = \frac{6s}{(s^2+9)^2}$

$\int_0^\infty e^{-2t}$t sin 3t dt = $[F(s)]_{s=2} = \frac{12}{4+9)^2}$

$= \frac{12}{169}$

14. Find $L^{-1}\left(tan^{-1}\left(\frac{2}{s}\right)\right)$

Soln: $L^{-1}\left(tan^{-1}\left(\frac{2}{s}\right)\right) = L^{-1}(F(s)) = \frac{-1}{t}L^{-1}(F'(s))$

F(s) = $tan^{-1}\left(\frac{2}{s}\right)$

$F'(s) = \frac{1}{1+\left(\frac{2}{s}\right)^2}\left(\frac{-2}{s^2}\right) = \frac{-2}{4+s^2}$

$L^{-1}(F'(s)) = L^{-1}\left(\frac{-2}{4+s^2}\right)$ = -sin2t

$L^{-1}(F(s)) = \frac{sin2t}{t}$

15. Find $L^{-1}\left[\frac{1}{s(s-a)}\right]$

$L^{-1}\left[\frac{1}{s(s-a)}\right] = L^{-1}\left[\frac{1}{s}.\frac{1}{(s-a)}\right] = L^{-1}\left[\frac{1}{s}F(s)\right]$

$= \int_0^t L^{-1}[F(s)]dt$

$= \int_0^t L^{-1}\left(\frac{1}{s-a}\right)dt = \int_0^t e^{at}\,dt$

$= \left[\frac{e^{at}}{a}\right]_0^t = \frac{1}{a}[e^{at} - 1]$

16. State convolution theorem.

If $L^{-1}[F_1(s)] = f_1(t)$ and $L^{-1}[F_2(s)] = f_2(t)$,
Then $L^{-1}[F_1(s)F_2(s)] = \int_0^t f_1(u)f_2(t-u)du$.

17. Find the laplace transform of f (t) =$cos^2 3t$

we know $\cos^2\theta = \frac{1+\cos 2\theta}{2}$

$\cos^2 3t = \frac{1+\cos 6t}{2}$

L $[\cos^2 3t] = L[\frac{1+\cos 6t}{2}]$

$= \frac{1}{2}[L(1) + L[6\cos 6t]]$

$= \frac{1}{2}[\frac{1}{s} + \frac{1}{s^2+36}]$

18. Find f (t) if L (f (t)) =$\frac{s}{(s+2)^2}$

Let F(s+2) = $\frac{s}{(s+2)^2}$

Replace s by s-2

F(s) = $\frac{s-2}{s^2}$

$L^{-1}[F(s)] = L^{-1}\left[\frac{1}{s} - \frac{2}{s^2}\right]$

f (t) = $e^{-2t}[1-2t]$

19. Find $L^{-1}\left[\frac{1}{s^2+4s+4}\right]$

$L^{-1}\left[\frac{1}{s^2+4s+4}\right] = L^{-1}\left[\frac{1}{(s+2)^2}\right]$

$= e^{-2t}L^{-1}\left(\frac{1}{s^2}\right)$

$= te^{-2t}$.

20. Find L[f(t)] where f(t) = $\begin{cases} sint & ,0 < t < \pi \\ 0 & t \geq \pi \end{cases}$

By definition L [f (t)] = $\int_0^\infty e^{-st}f(t)dt = \int_0^\pi e^{-st}sintdt$

$= \left[\frac{e^{-st}}{s^2+1}(-s\,sint - cost)\right]_0^\pi = \frac{e^{-s\pi}+1}{s^2+1}$

PART-B

1. Find the Laplace transform of f (t) = $\begin{cases} cost & ,0 < t < \pi \\ 0, & \pi < t < 2\pi \end{cases}$, f (t+2 π) =f (t).
2. Find the Laplace transform of f (t)= $\begin{cases} -E & ,0 < t < \pi \\ E, & \pi < t < 2\pi \end{cases}$ and f (t+2 π) =f (t).
3. Find the Laplace transform of the Triangular wave function .
4. Find the Laplace transform of f (t) = $\begin{cases} sint & ,0 < t < \pi \\ 0, & \pi < t < 2\pi \end{cases}$,and f(t) is periodic with period 2π.
5. State and prove initial and final value theorem.
6. Find $L^{-1}\left\{\frac{s}{(s^2+a^2)^2}\right\}$ *using convolution theorem.*(AU.N/D2007, A/M 2008)
7. Using convolution find $L^{-1}\left\{\frac{4}{(s^2+2s+5)^2}\right\}$
8. Using Laplace transform, solve $\frac{dy}{dt} - 3y = e^{2t}$ subject to y (0) =1.
9. Solve using Laplace transform $\frac{d^2y}{dt^2} - 4\frac{dy}{dt} + 3y = e^{-t}$ given y(0)=1 and $y'(0) = 0$.
10. Using Laplace Transforms solve $y'' + 5y' + 6y = 2, y'(0) = 0, y(0) = 0$
11. Verify the initial and final value for the function $f(t) = 1 + e^{-t}(sint + cost)$
12. Apply the convolution theorem to find $L^{-1}\left\{\frac{1}{s(s^2-a^2)}\right\}$
13. Solve the equations $\frac{dx}{dt} - y = e^t, \frac{dy}{dt} + x = \sin t$ given that x(0)=1 and y(0)=0 using Laplace Transforms.
14. Find $L^{-1}\left\{\frac{s^2}{(s^2+a^2)(s^2+b^2)}\right\}$ *using convolution theorem.*
15. Solve by using LT $(D^2+9)y = \cos 2t$ given that if y(0)=1 and Y(π/2) = -1

UNIT IV
ANALYTIC FUNCTIONS
PART A

1. Show that the function f (z) = $\bar{z}$ is no where differentiable. (Nov '01,jun '09)

Solution: Given u+iv = x-iy

u=x v=-y

u_x =1 v_x =-1

u_y =0 v_y =-1

$u_x \neq v_y$

∴ C-R equations are not satisfied.

∴ f (z) = $\bar{z}$ is no where differentiable.

2. Show that f (z) =|z| is differentiable at z=0 but not analytic at z=0. (May'96)

Solution: Let z = x + iy, $\bar{z} = x - iy$

$|z|^2 = z\bar{z} = x^2 + y^2$

$u = x^2 + y^2$ v=0

u_x =2x v_x =0

u_y =2y v_y = 0

$u_x = v_y$ and $u_y = -v_x$ are not satisfied everywhere except at z=0

So f (z) may be differentiable only at z=0. Now u_x, v_x, u_y, v_y are continuous everywhere and in particular at (0,0).

3. Test the analyticity of the function w=sin z. (May '01)

Solution: w=f (z) =sin z

u+iv = sin(x+iy)

=sin x cosiy+ cos x siniy

= sin x coshy+i cos x sinhy

u= sin x cushy v= cos x sinhy

u_x = cosx cushy v_x = -sinx sinhy

u_y = sinx sinhy v_y = cosx cushy

$u_x = v_y$ and $u_y = -v_x$

∴ C-R equations are satisfied.

∴ The function is analytic.

4. Verify the function 2xy+i($x^2 - y^2$) is analytic or not . (May '02)

Solution: u=2xy v= $x^2 - y^2$

u_x = 2y v_x = 2x

u_y = 2x v_y = -2y

∴ $u_x \neq v_y$ and $u_y \neq -v_x$

∴ C-R equations are not satisfied.

∴ The function is not analytic.

5. Test the analyticity of the function f (z) =e^z. (May '01)

Solution: f (z) =e^z

u+iv = e^{x+iy} =$e^x e^{iy}$ = e^x(cosy+isiny)

u= e^xcosy v= e^xsiny

u_x = e^xcosy v_x = e^xsiny

u_y = $-e^x$siny v_y = e^xcosy

$u_x = v_y$ and $u_y = -v_x$

∴ The function is analytic.

6. If u+iv = is analytic, show that v-iu and –v+iu are also analytic.

Solution: Given u+iv is analytic.

∴ C-R equations are satisfied.

i.e. $u_x = v_y$ ---------- (1) and $u_y = -v_x$----------(2)

To prove v-iu and –v+iu are also analytic

For this, we have to show that

(i) $u_x = v_y$ and $-u_y = v_x$ (ii) $u_x = v_y$ and $u_y = -v_x$

These results follow directly from (1) & (2) by replacing u by v and –v and v –u and u respectively.

∴ v-iu and –v+iu are analytic.

7. Give an example such that u and v are harmonic but u+iv is not analytic. (Nov'05)

Solution: Consider the function w=$\bar{z}$ = x-iy

u=x v=-y $u_x = 1$ $u_y = 0$ $u_{xx} = 0$ $u_{yy} = 0$ $v_x = 0$ $v_y = -1$

$v_{xx} = 0$ $v_{yy} = 0$ $u_x \neq v_y$, ∴ The function f(z) is not analytic. But $u_{xx} + u_{yy} = 0$ and $v_{xx} + v_{yy} = 0$ gives u and v are harmonic.

8. If f (z) = u(x,y) +v(x,y) is an analytic function. Then the curves u(x,y) = c_1 and v(x,y) =c_2 where c_1 and c_2 are constants are orthogonal to each other.

Solution: If u(x,y) = c_1 , then du = 0 . But by total differential operator we have

du =$\frac{\partial u}{\partial x}\,dx + \frac{\partial u}{\partial y}\,dy$ ∴ $\frac{\partial u}{\partial x}\,dx + \frac{\partial u}{\partial y}\,dy = 0$ ⇒ $\frac{dy}{dx} = -\frac{\frac{\partial u}{\partial x}}{\frac{\partial u}{\partial y}} = m_1$ (Say)

Similarly, for the curve v(x,y) =c_2 we have

$\frac{dy}{dx} = -\frac{\frac{\partial v}{\partial x}}{\frac{\partial v}{\partial y}} = m_2$ (Say)

For any curve $\frac{dy}{dx}$ gives the slope, Now the product of the slopes is

$m_1 m_2 = \frac{u_x}{u_y} X \frac{v_x}{v_y} = -\frac{u_x}{v_y} X \frac{v_y}{u_x} = -1$

∴ *The curves* u(x,y) = c_1 and v(x,y) =c_2 intersect at right angles (i.e) they are orthogonal to each other.

9. Prove that w=z^2 is analytic and hence find $\frac{dw}{dz}$

Solution: Given w=z^2 =$(x+iy)^2$=$x^2 - y^2 + 2ixy$

u= $x^2 - y^2$ v= $2xy$

$u_x = 2x$ $v_x = 2y$

$u_y = -2y$ $v_y = 2x$

Now $u_x = v_y$ and $u_y = -v_x$

∴ w=z^2 is analytic

Now $\frac{dw}{dz} = f'(z) = u_x + i\,v_x = 2x + i2y$=2(x+iy) =2z

10. Find the analytic region of f (z) = $(x-y)^2 + 2i(x+y)$

Solution: Given f (z) = $(x-y)^2 + 2i(x+y)$

u= $(x-y)^2$ v= $2(x+y)$

$u_x = 2(x-y)$ $v_x = 2$

$u_y = 2(x-y)(-1)$ $v_y = 2$

Now $u_x = v_y$ and $u_y = -v_x$

⇒ $2(x-y) = 2$ $-2(x-y) = -2$

⇒ x-y=1 x-y=1

∴ Analytic region of f (z) is x-y=1

11. Find a function w such that w=u+iv is analytic, if u=$e^x siny$. (May '01)

Solution: Given u=$e^x siny$

$u_x = e^x siny$ $u_y = e^x cosy$

$u_x(z,0) = 0$ $u_y(z,0) = e^z$

$$\int f'(z)dz = \int u_x(z,0)\,dz - i\int u_y(z,0)\,dz$$

= 0-i$\int e^z dx$

f (z) = -i$e^z + c$

12. Prove that u= $x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$ satisfies Laplace's equation. (Jun'05)

Solution: Given u= $x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$

$\frac{\partial u}{\partial x} = 3x^2 - 3y^2 + 6x$

$\frac{\partial^2 u}{\partial x^2} = 6x + 6$ $\frac{\partial u}{\partial y} = 6xy - 6y$ $\frac{\partial^2 u}{\partial y^2} = -6x - 6$ $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$

∴ u satisfies Laplace's equation.

13. If u=log $(x^2 + y^2)$ find v and f (z) such that f (z) = u+iv is analytic. (Nov'05)

Solution: Given u=log $(x^2 + y^2)$

$u_x = \frac{2x}{x^2+y^2}$ $u_y = \frac{2y}{x^2+y^2}$

$u_x(z,0) = \frac{2}{z}$ $u_y(z,0) = 0$

$$\int f'(z)dz = \int u_x(z,0)\,dz - i\int u_y(z,0)\,dz$$

=$\int \frac{2}{z} dz + 0$

f (z) = 2log z +c

To find the conjugate harmonic v

We know that dv = $\frac{\partial v}{\partial x}dx + \frac{\partial v}{\partial y}dy$= - $\frac{\partial u}{\partial y}dx + \frac{\partial u}{\partial x}dy$ [by C – R equations]

dv = $\int -\frac{2y}{x^2+y^2}$ dx Integrating V = 2 $\tan^{-1}\frac{y}{x}$ +c

14. Find the critical points for the transformation $w^2 = (z-\alpha)(z-\beta)$

Solution: Given $w^2 = (z-\alpha)(z-\beta)$

2w $\frac{dw}{dz} = (z-\alpha)+(z-\beta) = 2z-(\alpha+\beta)$

∴ w $\frac{dw}{dz} = z - \frac{1}{2}(\alpha+\beta)$

Critical points occur at $\frac{dw}{dz} = 0$

∴ $z - \frac{1}{2}(\alpha+\beta) = 0$

$\Rightarrow z = \frac{1}{2}(\alpha+\beta)$

Also $\frac{dw}{dz} = \frac{w}{z-\frac{1}{2}(\alpha+\beta)}$

The critical points occur at $\frac{dw}{dz} = 0$

∴ $\frac{w}{z-\frac{1}{2}(\alpha+\beta)}$ =0

$\Rightarrow w = 0$

$\Rightarrow (z-\alpha)(z-\beta) = 0$

$\Rightarrow$ z = α and z = β

∴ The critical points occur at z = $\frac{1}{2}(\alpha+\beta)$, α and β.

15. Find the image of the circle $|z| = 2$ under the transformation w=3z.

Solution: w=3z

u+iv = 3(x+iy)

u=3x v=3y

$\Rightarrow$ x= $\frac{u}{3}$ y= $\frac{v}{3}$

Given $|z| = 2$

$\Rightarrow (x^2+y^2)^{\frac{1}{2}} = 2$

$\Rightarrow x^2 + y^2 = 4$

$\Rightarrow \left(\frac{u}{3}\right)^2 + \left(\frac{v}{3}\right)^2 = 4$

$\Rightarrow u^2 + v^2 = 36 = 6^2$.

∴ $|z| = 2$ maps to a circle in w- plane with centre at the origin and radius 6.

16. Find the fixed points for the following transformation w= $\frac{z-1}{z+1}$

Solution: Fixed points are obtained from

f (z) = z

z = $\frac{z-1}{z+1}$

$z^2 + z - z + 1 = 0$

$z^2 + 1 = 0$

Z = $\pm i$ are the fixed points.

17. Find the bilinear transformation that maps the points z = -1, 0, 1 into w=0, i, 3i respectively. (M/J '99, '06)

Solution: The bilinear transformations is given by

$\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)} = \frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$

$\frac{(w-0)(i-3i)}{(w-3i)(i-0)} = \frac{(z+1)(0-1)}{(z-1)(0+1)}$

$\frac{w(-2i)}{(w-3i)i} = \frac{-(z+1)}{(z-1)}$

2w (z-1) = (w-3i) (z+1)

w [2z-2-z-1] = (z+1)(-3i)

w = $\frac{-3i(z+1)}{z-3}$ is the required bilinear transformation.

18. Find the bilinear transformation that maps the points z = 0, 1, ∞ into the points w=-1,-2-i, i respectively.

Solution: The bilinear transformations is given by

$\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)} = \frac{(z-z_1)(z_2-z_3)}{(z-z_3)(z_2-z_1)}$

Since $z_3 = \infty$ the above relation becomes.

$\frac{(w-w_1)(w_2-w_3)}{(w-w_3)(w_2-w_1)} = \frac{(z-z_1)}{(z_2-z_1)}$

$\frac{(w+1)(-2-2i)}{(w-i)(-2-i+1)} = \frac{(z-0)}{(-1-0)}$

$\frac{(w+1)(2+2i)}{(w-i)(i+1)} = -z$

2w+2=-zw+iz

∴ W (z+2) = iz-2

w = $\frac{(iz-2)}{z+2}$ is the required bilinear transformation.

19. Prove that u = $\frac{1}{2}\log(x^2+y^2)$ is harmonic.

Solution: Given u = $\frac{1}{2}\log(x^2+y^2)$

Differentiating this w.r.to x and y partially, we get

$\frac{\partial u}{\partial x} = \frac{x}{x^2+y^2}$ $\frac{\partial u}{\partial y} = \frac{y}{x^2+y^2}$ $\frac{\partial^2 u}{x^2} = \frac{y^2-x^2}{(x^2+y^2)^2}$, $\frac{\partial^2 u}{\partial y^2} = \frac{x^2-y^2}{(x^2+y^2)^2}$

∴ $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = \frac{y^2-x^2+x^2-y^2}{(x^2+y^2)^2} = 0$ $\Rightarrow$ u is harmonic.

20. Find conjugate harmonic function of u = $\frac{1}{2}\log(x^2+y^2)$.

Solution: Let v (x,y) be the conjugate harmonic. Then w = u+iv is analytic.

By C-R equations, $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ and $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$

We have

dv = $\frac{\partial v}{\partial x}\,dx + \frac{\partial v}{\partial y}\,dy$

dv = $\frac{-\partial u}{\partial y}\,dx + \frac{\partial u}{\partial x}\,dy$

dv = $\frac{-y}{x^2+y^2}\,dx$

Integrating, we get

V = $\tan^{-1}\left(\frac{y}{x}\right) + c$ *where c is a constant.*

PART B

1. If u=$x^2 - y^2$, v=$\frac{-y}{x^2+y^2}$ prove that u and v are harmonic functions but u+iv is not an analytic function.
2. If f(z) is an analytic function of z, prove that

(i) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\{\log|f(z)|\} = 0$

(ii) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)|Re\, f(z)^2| = 2\,|f'(z)|^2$

(iii) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)|f(z)|^2 = 4\,|f'(z)|^2$

3. If w=f(z) is analytic, prove that (i) $\frac{dw}{dz} = \frac{\partial w}{\partial x} = -i\frac{\partial w}{\partial y}$ where w = u+iv (ii) $\frac{\partial^2 w}{\partial z\,\partial \bar{z}}$
4. Prove that the function u = $e^x(x\cos y - y\sin y)$ satisfies laplace's equation and find the corresponding analytic function f (z) = u+iv.
5. Prove that the function v = $e^{-x}(x\cos y + y\sin y)$ is harmonic and determine the corresponding analytic function of f(z).
6. Prove that the function u = $x^3 - 3xy^2 + 3x^2 - 3y^2$+1 satisfies laplace's equation and find the corresponding analytic function f (z) = u+iv.
7. If u= $\frac{\sin 2x}{\cosh 2y+\cos 2x}$ find the corresponding analytic function f(z) u+iv.
8. Determine the analytic function f(z)=u+iv such that u −v = $e^x(\cos y - \sin y)$

9. Find the analytic function f(z) = u+iv given that $2u + 3v = \frac{\sin 2x}{\cosh 2y+\cos 2x}$
10. Draw the image of the square whose vertices are at(0,0), (1,0), (1,1), (0,1) in the z-plane under the transformation w = (1+i)z. What has this transformation done to the original square?
11. Show that the transformation w = 1/z transforms circles and straight line in the z-plane into circles or straight lines in the w-plane.
12. Find the image of $|z - 2i| = 2$ under the transformation w = 1/z.
13. Find the bilinear transformation that maps the points z = 1, i, -1 into the points w=i, 0, -i respectively. Hence find the image of $|z| < 1$
14. Find the mobius transformation that maps the points z = 0, 1, ∞ into the points w=-5, -1, 3 respectively. What are the invariant points of the transformation?
15. Find the bilinear transformation that maps the points z = 0, 1,∞ into the points w=-1,-2-i, i respectively.

UNIT V
COMPLEX INTEGRATION
PART A

1. What do you mean by analytic part and principal part of the laurent's series of a function.

Ans: In laurent's series expansion , $\sum_{i=0}^{\infty} a_n (z-a)^n$ consisting of positive integral powers of (z-a) is called the analytic part of the laurent's series , while $\sum_{i=1}^{\infty} b_n (z-a)^{-n}$ consisting of negative powers of (z-a) is called the principal part of the laurent's series.

2. Find the Taylor series for sinz about z=$\frac{\pi}{4}$.

Ans: The Taylor series for f(z) about z=$\frac{\pi}{4}$ is

$f(z) = f(\frac{\pi}{4}) + (z-\frac{\pi}{4})\frac{f'(\frac{\pi}{4})}{1!} + \left(z-\frac{\pi}{4}\right)^2\frac{f''(\frac{\pi}{4})}{2!} + \left(z-\frac{\pi}{4}\right)^3\frac{f'''(\frac{\pi}{4})}{3!} + \left(z-\frac{\pi}{4}\right)^4\frac{f''''(\frac{\pi}{4})}{4!} + \dots$

$f(z) = \sin z$, $f(\frac{\pi}{4}) = \sin\frac{\pi}{4} = \frac{1}{\sqrt{2}}$

$f'(z) = \cos z$, , $f'(\frac{\pi}{4}) = \cos\frac{\pi}{4} = \frac{1}{\sqrt{2}}$

$f''(z) = -\sin z$, , $f''(\frac{\pi}{4}) = -\sin\frac{\pi}{4} = \frac{-1}{\sqrt{2}}$

$f'''(z) = -\cos z$, $f'''(\frac{\pi}{4}) = -\cos\frac{\pi}{4} = \frac{-1}{\sqrt{2}}$

$f''''(z) = \sin z$, etc. $f''''(\frac{\pi}{4}) = \sin\frac{\pi}{4} = \frac{1}{\sqrt{2}}$

$f(z) = \frac{1}{\sqrt{2}} + (z-\frac{\pi}{4})\frac{1}{\sqrt{2}} - \frac{1}{2\sqrt{2}}\left(z-\frac{\pi}{4}\right)^2 - \frac{1}{6\sqrt{2}}\left(z-\frac{\pi}{4}\right)^3 + \dots$

3. Evaluate $\int \frac{\sin 3z dz}{z+\frac{\pi}{2}}$ where C is the circle C : |z|=5.

Solution:Here C : |z|=5 represent the circle with centre 0 and radius 5.
$F(z) = \frac{\sin 3z}{z+\frac{\pi}{2}}$ => $z = -\frac{\pi}{2} = \frac{-3.14}{2} = -1.57$ **is** the singularity of the given function F(z) .
But z=-1.57 lies inside C : |z|=5. (By CAUCHY'S INTEGRAL FORMULA : If f(z) is analytic inside and on a simle closed curve C that encloses a simply connected region R and if 'a' is any point in R , then $f(a) = \frac{1}{2\pi i}\int_c \frac{f(z)}{z-a}dz$ **dz** , where C is described in the anticlockwise sense.)

Therefore $\int \frac{\sin 3z dz}{z+\frac{\pi}{2}} = 2\pi i f(-1.57)$. where f(-1.57) =-sin$\frac{3\pi}{2}$ =1 Ie., $\int \frac{\sin 3z dz}{z+\frac{\pi}{2}} = 2\pi i$.

4. Using Cauchy's integral formula evaluate $\int_c \frac{\cos \pi z^2}{(z-1)(z-2)}dz$ where c:|z| =3/2

Solution : $\int_c \frac{\cos \pi z^2}{(z-1)(z-2)}dz = \int_c \frac{\cos \pi z^2}{(z-1)}dz + \int_c \frac{\cos \pi z^2}{(z-2)}dz$ = - $2\pi i$f(1)+0
= -$2\pi i(-1) = 2\pi i$.
Since z=1 lies inside c:|z| =3/2. And z=2 lies outside c:|z| =3/2.

5. Evaluate $\int_c \frac{z}{(z-1)^3}$dz where c:|z| =2.

Solution : Cauchy's integral formula is $\int_c \frac{f(z)}{(z-1)^{n+1}}dz = \frac{2\pi i.}{n!}f^n(a)$.
z=1 is the singularity of f(z) =$\frac{z}{(z-1)^3}$ Z=1 is the pole of order 3 and also z=1 lies inside c:|z| =2. By Cauchy's integral formula $\int_c \frac{f(z)}{(z-1)^{n+1}}dz = \frac{2\pi i.}{2!}f^n(a)$, $\int_c \frac{zdz}{(z-1)^3}$
f(z) =2 z=1 lies inside |z| =2
Cauchy's integral formula $\int_C \frac{zdz}{(z-1)^3}dz = \frac{2\pi i.}{2!}f''(1)$ =0 .
Since f(z) =z => f'(z) = 1 => f''(z) =0=> f''(1) = 0.

6. Evaluate $\int_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)}$dz where C:IzI=3. (A / M '2000)

Solution: CAUCHY'S INTEGRAL FORMULA is $f(a) = \frac{1}{2\pi i}\int_c \frac{f(z)}{z-a}dz$ **dz**

Given $\int_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)}dz$ Here f(z) = $\sin \pi z^2 + \cos \pi z^2$ and a_1 = 1 lies inside C:IzI=3 , a_2 = 2 lies inside C:IzI=3 By using partial fraction $\frac{1}{(z-1)(z-2)} = \frac{-1}{(z-1)} + \frac{1}{(z-2)}$
Hence by formula

$\int_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)}dz = -\int_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)}dz + \int_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-2)}dz$
= - $2\pi i$f(1)+ $2\pi i$f(2) = $-2\pi i(-1) + 2\pi i(1)$
= $4\pi i$

7. Evaluate $\int \frac{zdz}{z-2}$ where C is the circle C : |z-2|=3/2.

Solution:Here C : |z-2|=1.5 represent the circle with centre (2,0) and radius 1.5
CAUCHY'S INTEGRAL FORMULA is $f(a) = \frac{1}{2\pi i}\int_c \frac{f(z)}{z-a}dz$ **dz** , $f(z) = \frac{z}{z-2}$=>
z=2 **is** the singularity of the given function f(z) . But z=2 lies inside C : |z-2|=1.5.
$\int \frac{zdz}{z-2} = 2\pi i f(2)$. where f(z) =z => f(2) =2. Therefore $\int \frac{zdz}{z-2} = 2\pi i(2) = 4\pi i$.

8. Evaluate $\int \frac{z^2+1}{z^2-1}dz$ over c If C: |z-1|=1, using cauchy's integral formula.

Solution : Given C: |z-1|=1 is a circle whose centre is 1 and radius 1 and

$\int \frac{z^2+1}{z^2-1}dz = \int \frac{z^2+1}{(z-1)(z+1)}dz$ 1 lies inside C, -1 lies outside C

$\int \frac{z^2+1}{z^2-1}dz = \int \frac{\left(\frac{z^2+1}{(z+1)}\right)}{(z-1)}dz$

Here f(z) = $\frac{z^2+1}{(z+1)}$ is analytic inside C.

Hence CAUCHY'S INTEGRAL FORMULA is

$2\pi i\, f(a) = \int_c \frac{f(z)}{z-a}dz$ => $\int \frac{\left(\frac{z^2+1}{(z+1)}\right)}{(z-1)}dz = 2\pi i\, f(1) = 2\pi i$ (Since f(1) =2/2 = 1)

9. Using cauchy's integral formula Evaluate $\int \frac{1}{z^2-1}dz$ over c If C is the circle centre 1 and radius 1.

Soluton : CAUCHY'S INTEGRAL FORMULA is $\boldsymbol{f(a) = \frac{1}{2\pi i}\int_c \frac{f(z)}{z-a}dz}$

Given $\int_C \frac{1}{z^2-1}dz = \int_C \frac{1}{(z+1)(z-1)}dz$ Here f(z) = 1 and $z=a_1$ =1 lies inside C:Iz-1I=1 ,

$z=a_2$ =-1 lies inside C:Iz-1I=1 By using partial fraction $\frac{1}{(z+1)(z-1)} = \frac{\left(\frac{-1}{2}\right)}{(z+1)} + \frac{\left(\frac{1}{2}\right)}{(z-1)}$

Hence by formula

$\int_C \frac{1}{(z+1)(z-1)}dz = -\frac{1}{2}\int_C \frac{1}{(z+1)}dz + \frac{1}{2}\int_C \frac{1}{(z-1)}dz$ = - πif(1)+ πif(-1) = -$\pi i + \pi i$ =0

(f(1) =1,f(-1) =1).

10. Evaluate $\int_C \frac{dz}{(z+1)^2(z-2)}$dz where C:IzI=3/2.

Solution: CAUCHY'S INTEGRAL FORMULA is $\boldsymbol{f(a) = \frac{1}{2\pi i}\int_c \frac{f(z)}{z-a}dz\ dz}$

Given C:IzI=3/2 is the circle centre 0 and radius 1.5 and $\int_C \frac{dz}{(z+1)^2(z-2)}$

By using partial fraction

$\frac{1}{(z+1)^2(z-2)} = \frac{Az+B}{(z+1)^2} + \frac{C}{(z-2)}$ => $\frac{1}{(z+1)^2(z-2)} = \frac{\left(\frac{-1}{9}\right)z+\left(\frac{-4}{3}\right)}{(z+1)^2} + \frac{\left(\frac{1}{9}\right)}{(z-2)}$

$\int_C \frac{dz}{(z+1)^2(z-2)} = \int_C \frac{\left(\frac{-1}{9}\right)z+\left(\frac{-4}{3}\right)}{(z+1)^2}dz + \frac{1}{9}\int_C \frac{dz}{(z-2)} = \frac{-1}{9}\int_C \frac{z+12}{(z+1)^2}dz + \frac{1}{9}\int_C \frac{dz}{(z-2)}$

$= \frac{-1}{9}2\pi i$f'(-1)+ 0 = $\frac{-2\pi i}{9}$

(Since z= -1 lies inside the circle and z = 2 lies outside the circle) where

$\int_C \frac{z+12}{(z+1)^2}dz$ = 2πif'(-1) where f(z) = z+12 , f'(z) = -1 => f'(-1) = -1 and

$\int_C \frac{dz}{(z-2)} = 0$ by Cauchy's Integral Theorem

11. Evaluate $\int_C \frac{(z+4)dz}{z^2+2z+5}$dz where C:IzI=1.

Solution: CAUCHY'S INTEGRAL FORMULA is $\boldsymbol{f(a) = \frac{1}{2\pi i}\int_c \frac{f(z)}{z-a}dz\ dz}$

Given C:IzI=1 is the circle centre 0 and radius 1 and $\int_C \frac{(z+4)dz}{z^2+2z+5}$

Here f(z) = $\frac{(z+4)}{z^2+2z+5}$ The singular points of f(z) are given by z^2+2z+5 =0 = >

z = $\frac{-2\pm\sqrt{4-20}}{2}$ =-1$\pm$2i

Let a = =-1+2i and b=-1- 2i then z^2+2z+5 = (z-a)(z-b) and clearly IaI<1 , IbI>1 .

Both the Singular points z=a and z = b lie outside C = > $\int_C \frac{(z+4)dz}{z^2+2z+5}$ = 0 by Cauchy's Integral Theorem(If f(z) is analytic and its derivative f'(z) is continuous at all points on and inside a simple closed curve C , then $\int_c f(z)dz = 0$)

12. Evaluate $\int_C \frac{(z+4)dz}{z^2-2z+5}$dz where C:Iz+1+iI=2.

Solution: Given C:Iz+1+iI=2 is the circle centre 0 and radius 1 and $\int_C \frac{(z+4)dz}{z^2-2z+5}$

Here f(z) = $\frac{(z+4)}{z^2-2z+5}$ The singular points of f(z) are given by

z^2-2z+5 =0 = > z = $\frac{-2\pm\sqrt{4-20}}{2}$ =-1$\pm$2i

Let a = -1+2i and b = -1- 2i then z^2+2z+5 = (z-a)(z-b)

when z = a , $|z+1+i| = |-1+2i+1+i| = |3i| > 2$ and

z = b , $|z+1+i| = |-1-2i+1+i| = |-i| = 1 < 2$ = > z = b lies inside C and z = a lies outside C $\int_C \frac{(z+4)dz}{z^2-2z+5} = \int_C \frac{(z+4)dz}{(z-b)(z-a)} = \int_C \frac{f(z)dz}{(z-b)}$ where f(z) = $\frac{z+4}{z-a}$

= 2πif(b) = $2\pi i\ \frac{b+4}{b-a}$ = $2\pi i\ \frac{-1-2i+4}{2i}$ = $\frac{\pi}{2}(2i-3)$

13. Evaluate $\int_c (z^2+2z)\,dz$ where C : |z|= 1.

Sol: f(z) = z^2+2z is analytic inside and on C. By CAUCHY'S INTEGRAL THEOREM : If f(z) is analytic and its derivative f'(z) is continuous at all points on and inside a simple closed curve C , then $\int_c f(z)dz = 0$)

Therefore $\int_c (z^2+2z)\,dz = 0$.

14. Evaluate $\int_c (z-3)^4\,dz$ where C : |z − 3|= 4.

Sol:Given $\int_c (z-3)^4\,dz$ => f(z) = $(z-3)^4$ is analytic everywhere inside and on C. By CAUCHY'S INTEGRAL THEOREM : If f(z) is analytic and its derivative f'(z) is continuous at all points on and inside a simple closed curve C , then $\int_c f(z)dz = 0$) Therefore $\int_c (z-3)^4\,dz = 0$.

15. what is the value of $\int e^z dz$ over C where C : $|z|= 1$

Solution: Given $\int e^z dz$ over C where C : $|z|= 1$ put $z = e^{i\theta}$, $dz = i\, e^{i\theta} d\theta$ => $\int e^z dz = \int_0^{2\pi} e^{i\theta}\, i\, e^{i\theta} d\theta$

Put $x=e^{i\theta}$, $dx = i\, e^{i\theta} d\theta$ when $\theta = 0$ => x=1 , $\theta = 2\pi$ => x=1

therefore $\int_1^1 e^x dx = 0$

16. Evaluate $\int_c \frac{dz}{(z-3)^3}$dz where c:$|z|$ =1.

Solution : Here z = 3 is the point lies outside c:$|z|$ =1 , => $\int_c \frac{dz}{(z-3)^3} = 0$.

17. Find the Laurent's series expansion of f(z) = $\frac{e^{2z}}{(z-1)^3}$ about z = 1.

Solution: f(z) = $\frac{e^{2z}}{(z-1)^3}$, z=1 is a pole of order 3. f(z) = $\frac{e^{2z}}{(z-1)^3} = \frac{e^{2z-2+2}}{(z-1)^3} = \frac{e^{2(z-1)+2}}{(z-1)^3}$

put z-1 = t

$f(z) = \frac{e^{2t+2}}{t^3} = \frac{e^2}{t^3}\left[1 + \frac{2t}{1!} + \frac{(2t)^2}{2!} + \frac{(2t)^3}{!} + \cdots\right] = \frac{e^2}{t^3} + \frac{2e^2}{t^2} + \frac{4e^2 t}{2!} + \ldots.$

$= \frac{e^2}{(z-1)^3} + \frac{2e^2}{(z-1)^2} + \frac{4e^2(z-1)}{2!} + \ldots = \frac{e^2}{(z-1)^3}\left[1 + \frac{2(z-1)}{1!} + \cdots\right]$

18. Find the residue of $z\, e^{1/z}$ at its singular point.

Solution: z = 0 is only singular point, Laurent's series of f(z) about z = 0

$f(z) = z\left[1 + \frac{1}{z} + \frac{1}{2!z^2} + \cdots.\right] = \left[z + 1 + \frac{1}{2!z} + \cdots.\right]$ $[Res\, f(z)]_{z=0}$ = coeff of 1/z in the expansion = ½.

19. Evaluate $\int_c \frac{1}{2z-3} dz$ where c:$|z|$ =1.

Solution: $\int_c \frac{1}{2z-3} dz = \int_c \frac{1}{2(z-\frac{3}{2})} dz = 0$ (Since z = 3/2 lies outside c:$|z|$ =1.)

20. Evaluate $\int_c \frac{dz}{(z^2+4)^2}$ if C is the circle $|z - i| = 2$

Solution: Given $\frac{1}{(z^2+4)^2} = \frac{1}{(z+2i)^2(z-2i)^2}$ and $|z - i| = 2$ => centre (0,1) radius 2 => 2i ie.,(0,2) lies inside C and -2i ie., (0, -2) lies outside C

$\int_c \frac{dz}{(z^2+4)^2} = \int_c \frac{\left[\frac{1}{(z+2i)^2}\right]}{(z-2i)^2} dz$

$= \frac{2\pi i.}{1!} f'(2i)$

$= \frac{2\pi i.}{1!}\left(\frac{-i}{32}\right)$

$= \frac{\pi}{16}$

by cauchy's integral formula $\int_c \frac{f(z)}{(z-1)^{n+1}} dz = \frac{2\pi i.}{n!} f^n(a)$.

f(z) = $(z + 2i)^{-2}$ => f'(z) =-2 $(z + 2i)^{-3}$

=> f'(2i) =-2 $(2i + 2i)^{-3} = \left(\frac{-i}{32}\right)$

PART B

1. Evaluate $\int_c \frac{e^{2z}}{z-3} dz = 0$ where C : |z|=1
2. Evaluate $\int_c \frac{\cos \pi z^2}{(z-2)(z-5)} dz$ where C |z| =3
3. Evaluate $\int_c \frac{\cos \pi z^2 + \sin \pi z^2}{(z-1)^2(z-2)} dz$ where C |z| =3
4. Evaluate $\int_c \frac{z^2+1}{(z-2)(z-3)} dz$ where C : |z| = 1
5. Evaluate $\int_c \frac{e^z}{z-\pi} dz$ around |z-i| = 2.
6. Evaluate $\int_c e^z dz$ where C : |z| =1.
7. Evaluate $\int_c \frac{dz}{z-1}$ where C : |z| = 2.
8. Evaluate $\int_c \frac{\cos \pi z}{z-1} dz$ where C : |z| = 1.
9. Find the residue *of f(z)* = $\frac{z+2}{(z-2)(z+1)^2}$ about each singularity.

10. Evaluate $\int \frac{e^z dz}{(z^2+\pi^2)^2}$ over C where C is the circle IzI = 4 by using Cauchy's Residue theorem.

11. Evaluate $\int_0^{2\pi} \frac{d\theta}{\frac{5}{4}+sin\theta}$ using contour integration.

12. Evaluate $\int_0^{2\pi} \frac{d\theta}{13+5sin\theta}$ using contour integration.

13. Show that $\int_0^{2\pi} \frac{d\theta}{1-2pcos\theta+p^2} = \frac{2\pi}{1-p^2}$, $|p| < 1$ using contour integration.

14. Evaluate $\int_0^{2\pi} \frac{sin^2\theta\, d\theta}{a+bcos\theta}$,a>b>0 using contour integration.

15. Show that $\int_0^{2\pi} \frac{cos\ 3\theta\, d\theta}{5-4cos\theta} = \frac{\pi}{12}$, using contour integration.

16. From the $\int_C \frac{dz}{z+2}$ where C : |z| = 1 find the value $\int_0^{2\pi} \frac{(1+2cos\ \theta)\, d\theta}{5+4cos\theta}$ and $\int_0^{2\pi} \frac{sin\ \theta\, d\theta}{5+4cos\theta}$ using contour integration.

17. Evaluate $\int_0^{\infty} \frac{x^2 dx}{(x^2+a^2)(x^2+b^2)}$ by using contour integration.

18. Evaluate $\int_0^{\infty} \frac{dx}{(x^2+a^2)^2}$ by using contour integration.

19. Evaluate $\int_0^{\infty} \frac{\cos\ mx\, dx}{x^2+a^2}$ by using contour integration.

20. Evaluate $\int_0^{\infty} \frac{x\ \sin\ mx\, dx}{x^2+a^2}$, m >0 , a>0 by the method of residues.

ENGINEERING PHYSICS – II

UNIT - I

CONDUCTING MATERIALS

PART-A

1. **Define electrical conductivity?**
   The quantity of electrical charge (Q) flowing per unit time (t) across unit area (A) in the metal for unit applied electric filed (E) is called Electrical conductivity (σ)
   $\sigma = \frac{Q}{tAE} = \frac{J}{E}$ (unit : $\Omega^{-1}m^{-1}$)

2. **Define mobility of electrons?**
   Mobility of the electrons is given as ($\mu = V_d/E$). Therefore mobility (μ) is defined as the drift velocity (V_d) per unit electric field (E) applied to it.

   (unit: $m^2V^{-1}S^{-1}$)

3. **Define mean free path of electrons?**
   The average distance travelled by the free electrons between the successive collisions in the presence of an applied field is known as mean free path.

   $(\lambda) = V_d * \tau_c$

4. **Define drift velocity?**
   When an external field is applied, the free electrons are slowly drifting towards the positive potential. Therefore, the average velocity acquired by the free electrons in a particular direction after a steady state is reached by the external electric field is called drift velocity.

5. **State Widemann –Franz law?**
   The ratio between the thermal conductivity (K) and electrical conductivity (σ) of a metal is directly proportional to the absolute temperature (T) of the metal. This ratio is a constant for all metals at a given temperature.
   $\frac{K}{\sigma} = LT$

6. **What are the merits of classical free electron theory?**
   1. It is used to verify ohm's law.
   2. The electrical and thermal conductivities of metals can be explained by this theory.
   3. It is used to derive Widemann –Franz law.
   4. It is used to explain the optical properties of metals.

7. What are main drawbacks of classical free electron theory?

1. It is a macroscopic theory
2. It cannot explain the electrical conductivity of the semiconductors and insulators properly.
3. Dual nature is not explained
4. This theory cannot explain Compton Effect and Photo-electric effect.

8. What is Lorentz number?

The ratio between the thermal conductivity (K) to the product of electrical conductivity (σ) and absolute temperature (T) of the metal is a constant. This constant value is known as Lorentz number (L) and is given by

$$\frac{K}{\sigma T} = L$$

$$L = \frac{3}{2}(K/e)^2$$

9. Define Fermi energy?

Fermi energy is the energy of the state at which the probability of electron occupation is (1/2) at any temperature above 0 K. It is also the maximum energy filled states at 0 K.

10. Define Fermi level?

Fermi level is the state at which the probability of electron occupation is (1/2) at any temperature above 0K. It is also the highest energy level of the filled energy state at 0K.

11. What are the importance of Fermi energy?

1. It acts as a reference level which separates the vacant and filled states at 0 K.
2. It gives the information about the filled electrons states and the empty states.
3. At 0 K, below Fermi energy level, electrons is filled, and at above Fermi energy level, it will be empty.

12. Define density of states and its importance?

Density of states N(E)dE is defined as the number of available states present in a metal per unit volume in an energy interval E and E+dE.

$$N(E)dE = \frac{\text{number of energy states available between E and E+dE in a metal piece}}{\text{Volume of that metal}}$$

Importance: it is used for the Fermi energy calculation at any temperature.

13. Define Relaxation time?

The average time taken by the free electron to reach its equilibrium position from its disturbed position due to the application of external electric field is called relaxation time.

14. Define mean collision time?

The average time taken by a free electron between two successive collisions is known as collision time

$$\tau_c = \frac{\lambda}{Vd}.$$

15. How classical free electron theory failed to account for specific heat of solid?

According to classical free electron theory, the value of specific heat of solid is 4.5 R, but experimental is 3R. Where R is universal gas constant. The experimental and theoretical values of specific heat are not matched.

PART B

1. On the basis of free electron theory, derive an expression for electrical conductivity?
2. State and prove Widemann-Franz law?
3. Deduce a mathematical expression for electrical conductivity of a conducting material and hence obtain Widemann-Franz law?
4. Write Fermi-Dirac distribution. Explain how Fermi function varies with temperature?
5. Derive an expression for the density of states, and based on that calculate the carrier concentration in metals?

UNIT- II

SEMICONDUCTING MATERIALS

PART- A

1. **What are the properties of semiconductors?**
   The resistivity of a semiconductor is lesser than an insulator but more than a conductor.It is in the order of 10^{-4} to 0.5 ohm m

2. **Mention any two advantages of semiconducting materials.**
   - It behaves as insulators at 0k and as conductors at high temperature
   - It possess both the properties of conductors and Insulators.

3. **What are the differences between elemental and compound semiconductors?**

Elemental semiconductors	**Compound semiconductor**
They are made of single element Eg Ge,Si	They are made of compounds eg GaAs,GaP
Heat is produced during recombination	Photons are emitted during recombination

4. **Write an expression for the concentration of electrons and holes in intrinsic semiconductors.**

$$n = 2\ (2\pi m_e * kT / h^2)^{3/2}\ e^{(E_f - E_c)/kT}$$

$$p = 2\ (2\pi m_h * kT / h^2)^{3/2}\ e^{(E_v - E_f)/kT}$$

5. **Write the expression for the electrical conductivity of an intrinsic semiconductor.**

   Electrical conductivity $\sigma = n_i (\mu_e + \mu_h)$

6. **Distinguish between intrinsic and extrinsic semiconductors**.

Intrinsic semiconductor	**Extrinsic semiconductor**
Semiconductor in a pure form is called Intrinsic semiconductor	Semiconductor doped with impurity is called Extrinsic semiconductor
Charge carriers are produced only due to thermal agitation	Charge carriers are produced only due impurities

7. **Define Hall Effect and Hall voltage.**
   When a conductor carrying a current is placed in a transverse magnetic field a potential difference is produced inside the conductor in a direction normal to the direction of the current and magnetic field is known as Hall effect.and the generated voltage is known as Hall voltage.

8. **How is Hall Effect used in the identification of the nature of semiconductor?**
   If Hall coefficient is negative then the semiconductor is n type and if the Hall coefficient is positive then the semiconductor is p type.

9. **Mention some uses of Hall Effect.**
   - It is used to find type of semiconductor
   - It is used to find mobility of charge carrier
   - It is used to measure charge carrier concentration

10. **What are donor levels?**
    A pentavalent impurity when doped with an intrinsic semiconductor donates one electron which produces an energy level called donor energy level.

11. **What is an n-type and p-type semiconductor?**
    When a small amount of pentavalent impurity is added to a pure semiconductor it is known as n type semiconductor When a small amount of trivalent impurity is added to a pure semiconductor it is known as p type semiconductor.

12. **What is meant by doping?**

    Adding impurities to a pure semiconductor is called doping

PART – B

1. Derive an expression for the electrical conductivity of an intrinsic semiconductor.
2. Derive an expression for the carrier concentration of an electron and holes in intrinsic semiconductor.
3. Discuss the variation of Fermi level with temperature in intrinsic semiconductor.
4. How does the intrinsic semiconductor electrical conductivity vary with temperature? Describe a method of determining band gap of a semiconductor.
5. Obtain an expression for density of electrons in the conduction band of n-type and density of holes in the valence band of an p-type semiconductor.
6. What is Hall Coefficient? Explain with necessary theory the Hall Effect and the experimental method to determine the electrical conductivity of a semiconductor. Explain any four applications.

UNIT- III
MAGNETIC AND SUPERCONDUCTING MATERIALS
PART-A

1. **What is meant by magnetic materials? Give example.**
   The materials which can be easily magnetized by keeping it in an external magnetic field are called magnetic materials.
   Eg: Iron, Ferrites, etc

2. **Define Magnetic dipole moment.**
   A system having two opposite magnetic poles separated by a distance'd' is called as a magnetic dipole. If 'm' is the magnetic pole strength and 'l' is the length of the magnet, then its dipole moment is given by M=ml

3. **Define magnetic field intensity (H).**
   It is defined as the force experienced by a unit North Pole placed at the given point in a magnetic field.

4. **Define magnetization (or) Intensity of magnetization (I)**
   It is the process of converting a nonmagnetic material into a magnetic material. It is also defined as the magnetic moment per unit volume.

5. **Define magnetic flux density (or) magnetic induction**
   It is defined as the number of magnetic lines of force passing normally through unit area of cross section.

6. **Define magnetic permeability**
   It is defined as the ratio between magnetic flux density (B) and the magnetic field intensity (H). it is the measure of degree at which the lines of force can penetrate through the material.

7. **Define magnetic susceptibility**
   It is the measure of the ease with which the specimen can be magnetized by the magnetizing force. It is the ratio between I and H.

8. **What do you understand by the term magnetic domains?**
   Magnetic domains are small regions in a ferromagnetic material where all the dipoles are aligned in the same direction.

9. **What is Bohr magneton?**
   The orbital magnetic moment and spin magnetic moment of an electron in an atom can be expressed in terms of atomic unit of magnetic moment called Bohr magneton.
   1 Bohr magneton=eh/4πm=9.27x10-24 Am2

10. **Define hysteresis**
    When a ferromagnetic material is made to undergo a cycle of magnetization, the intensity of magnetization and the magnetic flux density lags behind the applied magnetic field. This process is known as hysteresis.

11. **What are the four types of energy involved in the growth of magnetic domains?**
    The four types of energies involved in the growth of magnetic domains are
    i) Exchange energy
    ii) Anisotropy energy
    iii) Domain wall energy
    iv) Magneto-strictive energy.

12. **What is meant by reversible and irreversible domains?**
    When the external magnetic field applied to a domain is increased, it starts expanding. Now when the external magnetic field is removed, if the domain returns to its original position it is called reversible domains and if the domain doesn't returns to its original position it is known as irreversible domains.

13. **On the basis of spin how the materials are classified as para,ferro,antiferro and ferri magnetic?**
    → paramagnetic materials have few unpaired electron spins of equal magnitudes.
    → ferromagnetic materials have many unpaired electon spins with equal magnitudes.
    → anti ferro magnetic materials have equal magnitude of spins but in anti parallel manner.
    → ferrimagnetic materials have spins in anti-parallel manner but with unequal magnitudes.

14. **What are soft and hard magnetic materials?**
    The materials which can be easily magnetized and demagnetized are called soft magnetic materials. The materials which are very difficult to magnetize and demagnetize are called hard magnetic materials.

15. **State the applications of ferrites?**
    →They are used in transformer cores for high frequencies upto microwaves.
    →They are used in radio receivers to increase the sensitivity and selectivity of the receivers.
    →ferrites are used in data processing circuits as magnetic storage elements.

16. **Define retentivity**
    Even when the applied field is zero(or)removed, the material still acquires some magnetic induction which is known as residual magnetism (or) retentivity

17. Define coercivity

To remove the residual magnetism in a magnetic material, the magnetic field strength has to be reversed during a hysteresis cycle and this phenomenon is known as coercivity.

18. Define hysteresis loss

It is the loss of energy in taking a ferromagnetic material through a complete cycle of magnetization and the area enclosed is called hysteresis loop.

19. Define critical magnetic field.

It is the minimum magnetic field that is required to destroy the superconducting property.

20. Define transition (or) critical temperature

The temperature at which a normal conductor loses its retentivity and becomes a super conductor is known as transition temperature or critical temperature.

21. Explain Meissner Effect.

When the superconducting material is placed in a magnetic field, under the condition that T ≤Tcand H ≤Hcthe flux lines are excluded from the material. Thus the material exhibits perfect diamagnetism. This phenomenon is known as Meissner effect.

22. Define critical current

The minimum current that can be passed in a sample without destroying its superconductivity is called critical current(ic). ic= 2πrHc

23. Define persistant current

When d.c current of large magnitude is once induced in a superconducting ring then the current persists in the ring even after the removal of the field. This is known as persistant current.

24. Define super conductivity

The process of conducting the electrical current with zero resistance is called super conductivity.

25. Give the applications of soft and hard magnetic materials

Soft magnetic materials

1. They are used in a wide variety of machines in daily uses such as power transformers, output transformers, motors, generators etc. electrical steel are used as core material for these machines.
2. Nickel iron alloy and soft ferrites are used in the magnetic amplifiers, saturable core devices, computers etc.
3. They are also used in switching circuits, micro wave isolaters and matrix storage of computers.

Hard Materials

1. They are mainly used to make permanent magnets.
2. They are used for the storage of information. Magnetic taps and discs for the storage and reproduction of audio, video and digital sequences.

26. Explain the properties of superconductors

(i) Electrical Resistance:

Electrical Resistance of a superconducting material is very less of the order of 10-5 ohm-cm.

(ii) Magnetic property:

When super conducting materials are subjected to very large value of magnetic field , super conducting property is destroyed. The field required to destroy super conductingproperty is called as critical magnetic field.

(iii) Dia magnetic property-Messiner effect

When the super conducting material is placed in a magnetic field of flux density B the magnetic lines of force penetrates through the material. When the material is cooled below it's transition temperature, the magnetic lines of force are expelled out from the material. This effect is called Meissner Effect.

(iv) Effect of electric current:

When a large value of AC current is applied to a super conducting material it induces some magnetic field in the material. And because of this magnetic field the super conducting property of the material is destroyed.

(v) Persistent Current

When DC current of large magnitude is once induced in the super conducting ring then the current persist in the ring even after the removal of the field. This is known as persistent current.

(vi) Thermal property:

1. The entropy and specific heat decreases at transition temperature.
2. The thermal conductivity of type I super conductor is low.
3. The thermo-electric effect disappears in the super conducting state.

(vii) Isotope Effect:

The transition temperature varies due to the presence of isotopes.

27. Explain about SQUID

SQUID is the acronym for the Superconducting Quantum Interference Device. It is an ultra sensitive instrument for the measurement of very weak magnetic fields of the order of 10^{-14} tesla.

Principle:

Small change in magnetic field produces variation in the flux quantum.

Explanation:

It consist of a super conducting ring which can have magnetic fields of quantum values (1, 2,3……..) of flux placed in between two josephson junction when the magnetic field is applied perpendicular to the plane of the ring current is induced at the two josephson junctions and produces interference pattern. The induced current flows around the ring so that the magnetic flux in the ring can have quantum values of flux which corresponds to the values of magnetic fields applied.

Therefore SQUIDS are used to detect the variation in very minute magnetic signals in terms of Quantum flux. They are used as the storage devices for magnetic flux.

28. What do you meant by magnetic levitation? Explain

We know that super conducting material exhibits meissner effect because of this nature super conducting materials strongly repel external magnets. It leads to a levitation effect. When a magnet is placed over a super conductor the magnet floats. This effect is known as magnetic levitation. Diamagnetic property of a super conductor namely rejection of magnetic flux lines is the basis of magnetic levitation. A super conducting material can be suspended in air against a repulsive force from a permanent magnet. This magnetic levitation effect can be used for high speed transportation such as super fast trains without frictional loss.

29. Give the applications of superconductors.

Engineering applications:

1. Since there is no loss in power (zero resistivity) super conductors can be used for the transmission of power over very large distances.
2. Since the super conducting property can be easily destroyed it can be used in switching Devices.
3. Since the variation in small voltages causes large constant current it can be used in very Sensitive electrical instruments.eggalvano meter.
4. Since the current in the super conducting ring can flow with out any change in its value (persistant current) it can be used as the memory or storage element in computers.
5. Since the size of the specimen can be reduced to about 10-4 cm it can be used to manufacture electrical generators and transformers in small sizes with high efficiency. Apart from this they are used to design cryotron, josephson devices, SQUID, magnetic levitated trains, modulators, rectifiers, commutators etc.

Medical Applications

1. super conducting materials are used in NMR imaging equipments which is used for scanning purposes.
2. They are applied in the detection of brain wave activity such as brain tumour, defective cells etc

30. Discuss about type I superconductors and type II superconductors

Type I super conductors:

When a super conductors is kept in the magnetic field and if the field is increased the super conductors becomes a normal conductor abruptly at critical magnetic field. His type of materials are named as type I super conductors. Below the critical field the specimen excludes all the magnetic line of forces and exhibit completemeissner effect. Hence they are perfect dia magnets. They have only one critical magnetic field. The maximum known critical field for type I super conductors is of the order of 0.1T.

Type II super conductors:

The material which looses super conducting property gradually due to increase in magnetic field are called Type II super conductors. They do not show complete meissner effect. They do not behave as perfect diamagnet. When the super conductor is kept in the magnetic field and if the field is increased below the lower critical field HC1 the material exhibit complete meissner effect, and above HC1 the magnetization decreases and hence the magnetic flux starts penetrating through the material. The specimen is said to be in a mixed state between HC1 and HC2. Above HC2 (upper critical field) it becomes a normal conductor.

Part-B

Magnetic materials

1. Briefly explain the different types of magnetic materials and their properties?
2. (i) What is Ferro magnetism?
   (ii) Explain the reason for the formation of domain structure in a ferro magnetic material?
3. (i) Classify the material on the basic of their spins?
   (ii) What are ferromagnetic domains?
   (iii) What are its merits and demerits?
4. Explain ferromagnetic domain theory?
5. Discuss the domain structures in ferromagnetic materials?
6. Explain the hysteresis on the basic of domain theory of ferromagnetism?
7. Briefly explain the different types of energy involved in domain growth?
8. Distinguish between antiferro and Ferro magnetic materials?
9. Distinguish between soft and hard magnetic materials?
10. Briefly explain the structure and application of ferrites?

Superconductors

1. Explain the superconducting phenomenon? What are its properties and applications?

2. (i) What are high Tc superconductors? Give examples.
   (ii) Explain meissner effect, type-1 and type-2 superconductors.

3. (i) What is superconductivity?
   (ii) Mention any four property changes that occur?
   (iii) Explain the effects of isotopes in superconductors?
   (iv) Explain type-1 and type-2 superconductors?
   (v) Mention two applications?
4. (i) explain meissner effect and magnetic levitation?
   (ii) Discuss the applications of superconductors?

UNIT-4
DIELECTRIC MATERIALS
PART-A

1. **Define dielectric constant**.
   It is the ratio between absolute permittivity of the medium (**ε**) and permittivity of the free space(**ε_0**)

   Dielectric constant (**ε_r**)= $\frac{\text{absolute permittivity } (\varepsilon)}{\text{Permittivity of free space } (\varepsilon_0)}$

2. **Define polarization of dielectric material.**
   The process of producing electrical dipoles inside the dielectric by the application of external electric field is called polarization in dielectrics.
   Induced dipole moment **$(\mu) = \alpha E$**
   Where
   E → Applied electric field
   α → Polarisability

3. **Name the four polarization mechanisms.**
   (i) Electronic polarization
   (ii) Ionic polarization
   (iii) Orientational polarization
   (iv) Space-charge polarization

4. **What is electronic polarisation?**
   Electronic polarisation means production of electric dipoles by the applied electric field. It is due to shifting of charges in the material by the applied electric field.

5. **What is ionic polarisation?**
   Ionic polarisation is due to the displacement of cations (negative ions) and anions (positive ions) in opposite direction due to the application of an electrical field. This occurs in an ionic solid.

6. **What is orientational polarisation?**
   When an electrical field is applied on the dielectric medium with polar molecules, the dipoles align themselves in the field direction and thereby increases electric dipole moment. Such a type of contribution to polarisation due to the orientation of permanent dipoles by the applied field is called orientational polarisation.

7. **What is space - charge polarisation?**
   In some materials containing two or more phases, the application of an electrical field causes the accumulation of charges at the interfaces between the phases or at the electrodes. As result of this, polarisation is produced. This type of polarisation is known as space charge polarisation.

8. What is meant by local field in a dielectric?

When a dielectric is kept in an external electric field (E), two fields are exerted due to (i) external field and (ii) dipole moment created. These long range coulomb forces which are created due the dipoles are called local field in dielectric.

It is given by

$$E_{int} = E + \frac{P}{\varepsilon_0}$$

Where

P —> polarization

ε_0—> permittivity in free space.

9. Define dielectric loss and loss tangent.

When a dielectric material is subjected to an A.C voltage, the electrical energy is absorbed by the material and is dissipated in the form of heat. This dissipation of energy is called dielectric loss. In a perfect insulator, polarisation is complete during each cycle and there is no consumption of energy and the charging current leads the applied voltage by 90°. But for commercial dielectric, this phase angle is less than 90° by an angle 5 and is called dielectric loss angle. Tan 5 is taken as measure of dielectric loss and is known as loss tangent.

10. Define dielectric breakdown and dielectric strength.

Whenever the electrical field strength applied to a dielectric exceeds a critical value, very large current flows through it. The dielectric loses its insulating property and becomes conducting. This phenomenon is known as dielectric breakdown. The electrical field strength at which dielectric breakdown occurs is known as dielectric strength.

11. Mention the various breakdown mechanisms.

(i) Intrinsic breakdown and avalanche breakdown
(ii) Thermal breakdown
(iii) Chemical and Electrochemical breakdown
(iv) Discharge breakdown
(V) Defect breakdown

12. What is intrinsic breakdown?

For a dielectric, the charge displacement increases with increasing electrical field strength. Beyond a critical value of electrical field strength, there is an electrical breakdown due to physical deterioration in the dielectric material.

13. What is thermal breakdown?

When an electrical field is applied to a dielectric material, some amount of heat is produced. This heat must be dissipated from the material. Due to excess of heat, the temperature inside the dielectric increases and may produce local melting in the dielectric material. This type of breakdown is known as thermal breakdown.

14. What is chemical and electrochemical breakdown?

Electrochemical breakdown is similar to thermal breakdown. When the temperature of a dielectric material increases, mobility of ions increases and hence the electrochemical reaction may take place. This leads to leakage current and energy loss in the material and finally dielectric breakdown occurs.

15. What is discharge breakdown?

Discharge breakdown occurs when a dielectric contains occluded gas bubbles. When this type of dielectric is subjected to electrical field, the gases present in the material will easily ionise and thus produce large ionisation current. The gaseous ions bombard the solid dielectric. This causes electrical deterioration and leads to dielectric breakdown.

16. What is defect breakdown?

The surface of the dielectric material may have defects such as cracks, porosity and blow holes, impurities like dust or moisture may collect at these discontinuities (defects). This will lead to a breakdown in a dielectric material.

17. Compare active and passive dielectrics.

Active dielectrics	**Passive dielectrics**
1. Dielectrics which can easily adapt itself to store the electrical energy in it is called active dielectrics	Dielectric which restricts the flow of electrical energy in it are called passive dielectrics.
2. Examples: Piezo electrics, Ferro electrics and Pyro electrics	Examples: glass, mica and plastics
3. It is used in the production of ultrasonics	It is used in the production of sheets, pipes etc.

18. What are the dielectrics?

Dielectrics are insulating materials, in which all the electrons are bound to their parent molecules and there are no free electrons. Even with normal voltage or thermal energy, electrons are not released.

19. What are the differences between the polar and non-polar molecules?

Polar molecules	Non-polar molecules
1. These molecules have permanent dipole moments even in the absence of an applied field.	These molecules do not have permanent dipole moments.
2. The polarization of polar molecules is highly temperature dependent.	The polarization of this kind of molecules is independent of temperature.
3. Examples: $CHCl_3$, H_2O, HCl	Examples: CCl_4, CO_2, H_2

20. What are requirements of good insulating materials?

The good insulating materials should have

- ❖ High electrical resistivity to reduce leakage current.
- ❖ High dielectrical strength to withstand higher voltage.
- ❖ Smaller dielectric loss
- ❖ Sufficient mechanical strength.

21. What are ferro-electric materials? Give examples.

Materials which exhibit electronic polarization even in the absence of the applied electrical field are known as ferro-electric materials.

Example: **Barium Titanate ($BaTiO_3$)**

Potassium Dihydrogen Phosphate (KH_2PO_4)

PART-B

1. Discuss the different types of polarization mechanism involved in a dielectric material.
2. Explain the effects of frequency and temperature on polarization of dielectrics.
3. What is meant by local field in a dielectric and how is it calculated for cubic structure. Deduce the Clausius-Mosotti relation.
4. Discuss in detail the various types of breakdown mechanisms in dielectric material.
5. What are ferro electric materials? Mention few example and explain properties and applications of ferro electric materials.

UNIT-V

ADVANCED ENGINEERING MATERIALS

PART-A

1. What are metallic glasses?

Metallic glasses are metal alloys which have non crystalline or amorphous structure and exhibit the property of both metals and glasses.

2. What you mean by the term Quenching?

Quenching is a technique used to form metallic glasses. Quenching means extremely rapid cooling of a molten liquid which results in the irregular arrangement of atom .

3. Give some properties of metallic glasses

(i) They have high corrosion resistance.

(ii)The ferromagnetic properties of metallic glasses have received a great deal of attention, probably because of the possibility that these materials can be used as transformer cores

(iii)High rupture, strength and toughness

(iv) Electrical resistivity is high in amorphous phase of metglasses

4. What is meant by glass transition temperature?

The temperature at which liquid like atomic configuration can be frozen into a solid is said to be glass transition temperature.

5. List out a few applications of metallic glasses.

i) Some of the met glasses can behave as superconductors.

ii) They are used in the cores of high power transformers

iii) As they have high corrosion resistance they are used in reactor vessels, marine cables, surgical clips, orthopaedical implants , etc.

iv) They are used to make computer memories, magneto-resistance sensors etc.

6. What are nano phase materials?

Materials with grain size of the order of 1-100 nm are known as nanophase materials.

7. What are methods of synthesizing nanophase materials?

i) top down approach where bulk materials are broken into nanosizes

ii) bottom-up approach in which nano materials are made by building atom by atom.

8. Mention some properties of nanomaterials

i) Size of grains controls the mechanical, electrical, optical, chemical, semiconducting and magnetic properties.

ii) These materials are very strong. the strength of the material is inversely proportional to the grain size.

iii) The melting point of nanophase material is reduced by reducing the grain size.

iv) Undergoes super elastic properties even at lower temperatures.

v) Magnetic moment is increased by decreasing its material size.

9. Give some uses of nanophase materials.

- used as ceramic capacitors to store elkectrical energy
- used in current controlling devices
- magnetic devices made from these materials are used in RAM,
- READ/WRITE head, sensors etc
- they are used to make semiconductor lasers.
- They are used in power generation

10. What are Shape memory alloys?

Shape memory alloys are metal alloys which have the ability to return back to their original shape when subjected to some appropriate thermal procedures.

11. What do you understand by "Martensite" and "Austenite" phases?

The crystal structure of SMA at lower temperature is said to be Martensite phase and the crystal structure of SMA at higher temperature is said to be Austenite phase.

12. Explain transformation temperature

Shape memory alloys have the ability to switch from a temporary shape to a parent shape above a certain temperature called as transformation temperature.

13. Define Pseudoelasticity.

Pseudoelasticity occurs in some types of SMA in which the change in its shape will occur even without change in its temperature.

14. What is meant by a biomaterial?

Any material that are brought into contact with the fluids, cells and tissues of living body is called bio materials.

15. How are SMA's classified

i) Materials which regain the shape only upon heating are referred to as one-way shape memory.

ii) Materials that take up their own shape not only upon heating but also upon cooling are referred as two way shape memory.

16. List out some properties of SMA.

(i) The transformation occurs over a range of temperature

(ii) They exhibit pseudoelastic or superplastic property

(iii) They exhibit hysteresis curve during cooling and heating process.

17. Mention some uses of shape memory alloys.

i) It is used as a blood-clot filter

ii) They are used to make glass frames

iii) They are used in the opening and closing of valves.

iv) They are used in controlling and preventing cracks

v) They are used to correct irregularities in the teeth

18. What are non-linear materials?

In some materials, optical properties may be affected when light of high intensity s allowed to pass through it. Such materials are called non-linear materials

19. What is meant by second harmonic generation?

Second harmonic generation represents the generation of new frequencies with help of the crystals such as quartz, KDP. Etc..

20. List out properties of NLO materials.

* NLO materials has high curie temperature and melting point

* They are synthetic ferro magnetic materials

* High electric polarizability and low optical transmission.

* Some act as conducting materials

21. What are the applications of NLO materials?

* Used as in electro optic modulators

* Act as a wave guides

* Used as a optical grating and electro optic wave guide switches.

PART-B

1. Give a detailed account on metallic glasses, their method of production, types, properties and applications.
2. What are nano materials? Discuss the methods of producing nano phase materials. What are the advantages of nano materials?
3. List out any four properties and applications of nano phase materials. What are shape memory alloys? Write down the characteristics. List out any four applications of shape memory alloys.
4. Write a note on pulsed laser deposition.
5. What is meant by NLO? List out some of the NLO materials, their properties and its applications.
6. What is meant by Kerr effect? Describe the phenomenon of second harmonic generation in KDP crystals.
7. What are Bio materials? Detail the classification of biomaterials and its applications.

CY6152 - ENGINEERING CHEMISTRY – I

UNIT – I WATER TECHNOLOGY

PART –A

1. Define hard water and soft water

Water which does not produce lather with soap solution but forms a white precipitate is called hard water. Water which produce lathers easily with soap solution is called soft water.

2. What are the salts responsible for carbonate and non-carbonate hardness of water?

Carbonate hardness : $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$

Non-carbonate hardness : $CaCl_2$, $CaSO_4$, $MgCl_2$ and $MgSO_4$

3. What is Sludge?

If the precipitate is loose and slimy it is called sludge. Sludges are formed by $MgCl_2$, $MgSO_4$, $MgCO_3$ and $CaCl_2$.

4. What is Scale?

If the precipitate forms hard and adherent coating on the inner walls of the boiler, it is called scale. Scales are formed by substances like $Ca(HCO_3)_2$, $CaSO_4$ and $MgCl_2$.

5. Distinguish between priming and foaming.

Priming is the process of production of wet steam during the process of steam production in boilers. During steam production certain water droplets also get into steam due to some dissolved solids in water, high steam velocity or irregular steam velocity.

Foaming is the production of persistent bubbles in the water which do not break easily due to the presence of oily or soapy substances.

6. What are boiler compounds? Give examples.

The chemicals added inside the boilers (during internal treatment of water) to remove scale forming substance are called boiler compounds.

Eg. Sodium phosphate, calgon.

7. What is calgon? What is its role in water treatment?

It is chemical added inside the boilers during internal treatment of water. Calgon is sodium hexa metaphosphate. $(NaPO_3)_6$ or $Na_2[Na_4(PO_3)_6$. It forms a highly soluble complex with Ca^{2+} ions of hard water and prevents the formation of scale in boilers.

8. What is desalination? Name few methods of converting sea water into fresh water?

Process of removal of extra common salt from sea water is described as desalination or desalting. The various desalination processes

- distillation
- freezing
- reverse osmosis
- electro dialysis

9. Define Temporary and permanent Hardness.

The hardness removed by boiling the water is called as temporary hardness and it is due to the presence of carbonate and bicarbonate of calcium and magnesium. The hardness due to the presence of sulphate and chlorides of calcium and Magnesium is called as permanent Hardness.

10. Name any two disadvantages of using hard water for domestic purpose.

- Hard water when used for drinking affects our digestive system and also leads to the formation of stones in kidney.
- Hard water when used for washing does not lather with soap easily and thereby causing wastage of soap.

11. What is meant by boiler corrosion? How is it prevented?

Boiler corrosion is due to the presence of dissolved gases such as O_2, CO_2 and easily hydrolysable salts like $MgCl_2$.Mechanical deaeration is a method used to remove dissolved gases such as O_2 and CO_2. The principles involved in this process are the solubility of a gas is directly proportional to pressure and inversely proportional to temperature.

12. What are the advantages of Reverse Osmosis?

- The life time of the membrane is high, and it can be replaced within few minutes.
- It removes ionic as well as non-ionic, colloidal impurities.
- Low capital cost, simplicity, low operating, this process is used for converting sea water in to drinking water.

PART- B

- Explain the principle, procedure, calculation involved in EDTA method?
- Write a note of boiler problems?
- What is ion exchange method? Explain the concept.
- What is reverse osmosis? Bring out the methodology behind it.
- What are boiler compounds? How are they used in internal water treatment?
- How is the internal conditioning of boiler feed water carried out using phosphate, carbonate and calgon conditioning.

UNIT – II ELECTROCHEMISTRY

PART –A

1. Differentiate metallic and electrolytic conductors.

S. No.	Metallic conductors	Electrolytic conductors
1.	It is due to the flow of electrons.	It is due to the flow of ions.
2.	It is not accompanied by decomposition of the substance. (Only physical changes occurs)	It is accompanied by decomposition of the substance. (Physical as well as chemical change occur)
3.	It does not involve transfer of matter.	It involves transfer of matter in the form of ions.
4.	Conductivity decreases with increase in temperature.	Conductivity increases with increases in temperature.

- Anode: Oxidation occurs: Negative sign; Anode disintegrates
- Cathode: Reduction occurs: Positive sign; Solid deposits on cathode.

2. State the functions of Salt bridge.

A U-tube containing saturated KCl or NH_4NO_3 in agar-agar gel is used as a salt bridge.

- It connects the 2 half cells and maintains internal electrical continuity
- It eliminates liquid junction potential.

3. Define single electrode potential (E).

It is the measure of tendency of a metallic electrode to lose or gain electrons, when it is in contact with a solution of its own salt.

4. Define standard electrode potential (E^0).

It is the measure of tendency of a metallic electrode to lose or gain electrons, when it is in contact with a solution of its own salt **of 1 molar concentration at 25^0c.**

5. What are reversible cells?

Reversible cells follow the two main conditions of ***thermodynamic reversibility***:

(i) The chemical reaction of the cell stops when an exactly equal opposing emf is applied.

(ii) The chemical reaction of the cell is reversed when the opposing emf is slightly greater than that of the cell.

Eg. Daniell cell (emf value 1.09 V). If an opposing emf exactly equal to 1.09 volt is applied to the cell, the cell reaction stops,

$$Zn + Cu^{2+} \longrightarrow Cu + Zn^{2+}$$

but if it is increased infinitesimally beyond 1.09 volt, the cell reaction is reversed.

$$Cu + Zn^{2+} \longrightarrow Zn + Cu^{2+}$$

6. What are reversible cells?

Those cells which **do not obey the thermodynamic reversibility** is called as ***irreversible cells***.

Eg. $Zn|H_2S0_4(aq)|Ag$

whose cell reaction is, $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$

It is irreversible because when the external emf is greater than the emf of the cell is applied, the reaction is not reversed but the cell reaction becomes

$$2Ag + 2H^+ \longrightarrow 2Ag^+ + H_2$$

7. Define EMF of a Cell.

The potential difference which causes the flow of current from higher potential electrode to lower potential electrode is called ***electromotive force*** **or** ***EMF*****.**

$E^o_{cell} = E^o_{reduction} + E^o_{oxidation}$ (or) $E^o_{cell} = E^o_{cat} - E^o_{an}$

8. What is a reference electrode or standard electrode? Give examples.

- The electrode whose potential is ***known or arbitrarily fixed as zero*** is called Reference or Standard electrode.
- The electrode potential of unknown electrode can be measured by coupling with the reference electrode.

Eg. Primary reference electrode – Standard Hydrogen Electrode (SHE)
Secondary reference electrode – Saturated Calomel Electrode (SCE)

9. What is electrochemical series or EMF series?

When various electrodes are arranged in the **order of their increasing values** of standard reduction potential $\mathbf{E^0}$ on the hydrogen scale, then the arrangement is called electrochemical series or emf series.

Electrode	Electrode reaction	E^0 (volts)	Nature
Li^+/Li	$Li^+ + e \rightleftharpoons Li$	-3.01	Anodic
Zn^{2+}/Zn	$Zn^{2+} + 2e \rightleftharpoons Zn$	-0.76	
H^+/H_2	$2H^+ + 2e \rightleftharpoons H_2$	0.00	Reference
Cu^{2+}/Cu	$Cu^{2+} + 2e \rightleftharpoons Cu$	+0.34	
$½\ F_2/F^-$	$½\ F_2 + e \rightleftharpoons F^-$	+2.87	Cathodic

10. Mention the limitations of Standard Hydrogen electrode.

1. It requires hydrogen gas and is difficult to set up and transport.
2. It requires considerable volume of test solution.
3. The solution may poison the surface of the platinum electrode.
4. The potential of the electrode is altered by changes in barometric pressure.

11. List the applications of Nernst Equations.

1. Nernst equation is used to calculate electrode potential of unknown metal.
2. Corrosion tendency of metal can be predicted.
3. Spontaneity of a given cell reaction can be predicted
4. It is used to calculate the emf of a given cell.

12. What are Ion Selective electrodes? Give an example.

The electrode having the ability to respond only to a particular ion in the solution and ignoring other ions is called Ion Selective Electrode (ISE). In other words, these electrodes generate the potential due to the presence of specific ions in the solution.
Example : **Glass Electrode** – Which is selective to H^+ ions in the solution.

13. What is a Glass electrode?

Glass electrode is an example of ion selective electrode. It is highly sensitive to H^+ ion concentration. The potential of glass electrode depends on the pH of the solution and it is used in pH measurements.

14. What are the applications of Ion Selective Electrodes?

1. ISE are used to determine :
   a. Concentration of cations like H^+, Li^+, Na^+, K^+, NH_4^+, Ag^+, Cu^{2+} etc.
   b. Concentration of anions like NO_3^-, CN^-, S^{2-}, halides etc.
   c. Hardness causing ions: Ca^{2+}, Mg^{2+}
2. pH of the solution can be determined using glass electrode.
3. Concentration of gas can be determined using gas-sensing electrode.
4. Solid state ISE are used to estimate the fluoride ions in water and tooth paste.

15. What are the limitations of glass electrode? (or) Why glass electrode cannot be use in high alkaline solution?

- It cannot be used in strongly alkaline solution (pH above 10) since the cations affects the glass membrane. In such cases special type of glass must be used.
- Electronic potentiometers are needed for the measurement since the resistance of glass membrane used in the bulb is very high.

16. What are Secondary reference electrodes? Give an example.

Secondary reference electrodes are electrodes whose electrode potential known. Since it is very difficult to set up a hydrogen electrode secondary reference electrodes are used.
Example: Saturated Calomel Electrode (E^o= +0.2422 V).

17. What is Poggendroff's compensation principle?

In Poggendroff's compensation principle the emf of the cell is just opposed or balanced by the external emf, so that no current flows in the circuit. This principle is used in the potentiometric measurement of emf of a cell.

18. Write the rules to represent the cell notation.

a. The anode should be written on the left hand side and cathode on the right hand side.
b. Anode: electrode metal followed by the electrolyte with a semicolon or a line.
c. Cathode: electrolyte followed by the electrode metal with a semicolon or a line.
d. The two half cells are seperated by a salt bridge indicated by a double vertical line.

eg. $Zn ; Zn^{2+}$ (1M) ‖ Cu^{2+} (1M) ; Cu

PART – B

1. Explain a redox reaction with an example.
2. Derive the Nernst equation for Single electrode potential
3. What are reference electrodes? Explain standard hydrogen electrode.
4. What are Secondary reference electrodes? Explain saturated calomel electrode.
5. What is Glass electrode? How it is used to determine the pH of the solution.
6. What is EMF or Electrochemical series? Explain its significance or applications.
7. Explain the reversible and irreversible cells with examples.

*****

UNIT-II CORROSION

PART – A

- **Define corrosion. Mention the different types of corrosion.**

Any process of deterioration (or destruction) and consequent loss of a solid metallic material, through a direct chemical or electrochemical attack by its environment, starting at its surface, is called corrosion, e.g., rusting of iron**.**

Based on the environment, corrosion can be classified in to two types,

- Dry or chemical corrosion
- Wet or electrochemical corrosion

- **What is Pilling- Bed worth ratio?**

It is the ratio of the volume of the metal oxide formed to the volume of the metal consumed.

$$PB\ Ratio = \frac{\text{Volumen of metal oxide}}{\text{Volume of metal consumed}}$$

- **What is the effect of H_2S gas when it comes in contact with Iron metal?**

When Fe metal comes in contact with H_2S at ordinary temperatures, atomic hydrogen is produced:

$$Fe + H_2S \longrightarrow FeS + 2H\ (atomic)$$

This atomic hydrogen diffuses readily into metal and collects in the voids, where it recombines to form molecular hydrogen.

$$H + H \longrightarrow H_2 \uparrow$$

Collections of these hydrogen gases in the voids develop very high pressure, which causes cracks and blisters on metals and this is called **hydrogen embrittlement**.

- **Explain Galvanic corrosion with an example.**

When two dissimilar metals are electrically connected and exposed to an electrolyte, the element with the more negative standard reduction potential in the electrochemical series undergoes corrosion. This type of corrosion is called galvanic corrosion.

In Zn-Fe bimetallic couple, zinc is more active than iron, hence, Zn acts as anode and suffers corrosion. In Fe-Cu bimetallic couple, Fe is more active than copper, hence, Fe acts as anode and undergoes corrosion.

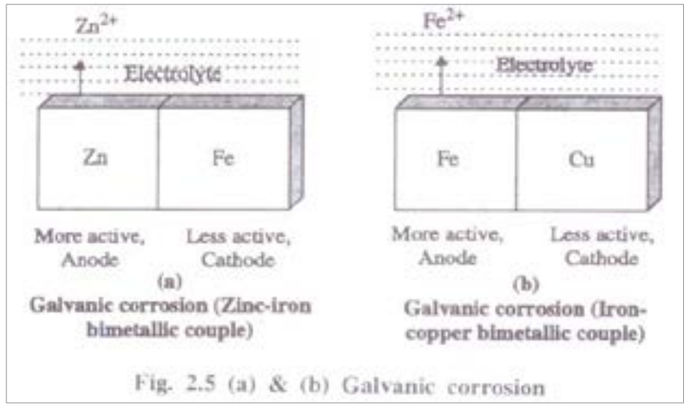

Fig. 2.5 (a) & (b) Galvanic corrosion

- **How galvanic corrosion can be minimized?(or) Bolt and nut made of the same metal is preferred in practice, Why?**

Galvanic corrosion can be minimized by,

- Providing an insulating material between two metals.
- Using metals closer together in the electrochemical (or galvanic) series
- Maximizing anodic area relative to the cathodic area

- **What are corrosion inhibitors?**

A corrosion inhibitor is a substance which when added in small quantities to the aqueous medium effectively decreases the corrosion of the metal by inhibiting corrosion in the anode and/or in the cathode.

- **What are organic inhibitors? What is the reason for the increase in the inhibiting power of aliphatic amines in the following order: $NH_3<RNH_2<R_2NH<R_3N$?**

Organic inhibitors are substances which reduce the corrosion of a metal, when it is added to the acid medium.
Corrosion is reduced by slowing down the diffusion of hydrated H^+ ions to the cathode. The diffusion of H^+ ion is considerably reduced by organic inhibitors which are capable of being adsorbed at the metal surface. Greater the electron density on the nitrogen atom in the amines and greater the size of the inhibitor, greater is the binding ability to the metal to be protected, and hence, greater inhibition.

- **What is the principle of cathodic protection? Mention the methods employed.**

The principle involved in cathodic protection method is to force the metal to behave like a cathode, thereby corrosion does not occur.
There are two types of cathodic protection
Sacrificial anodic protection
Impressed current cathodic protection

- **Using chemical equations , state the mechanism of corrosion of Iron in weakly alkaline solution.**

Anode : $Fe \longrightarrow Fe^{2+} + 2e^-$ (oxidation)

Cathode : $H_2O + \frac{1}{2} O_2 + 2e^- \longrightarrow 2OH^-$ (reduction)

$Fe + H_2O + \frac{1}{2} O_2 \longrightarrow Fe^{2+} + 2OH^- \square Fe(OH)_2$

If enough oxygen is present $Fe(OH)_2$ is readily oxidized to $Fe(OH)_3$

$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3$ □(rust)

- **Write any four differences between chemical and electrochemical corrosion.**

S.No	CHEMICAL CORROSION	ELECTROCHEMICAL CORROSION
1.	It occurs only in dry condition and is self-controlled	It occurs in presence of moisture or electrolyte and is a continuous process
2.	It is due to the direct chemical attack of the metal by the environment	It is due to the presence of large number of cathodic and anodic areas
3.	Even a homogenous metal surface gets corroded	Heterogeneous surface (or) bimetallic contact is required
4.	Corrosion products accumulate in the same place, where corrosion occurs	Corrosion occurs at the anode, while products formed else where

- **Using chemical equations , state the mechanism of corrosion of Iron in weakly alkaline solution.**

Anode : $Fe \longrightarrow Fe^{2+} + 2e^-$ (oxidation)

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$4Fe(OH)_2 + O_2 + 2H_2O \longrightarrow 4Fe(OH)_3$ □(rust)

- **What is Paint? Mention its constituents.**

Paint is a mechanical dispersion of mixture of one or more pigments in a vehicle. The vehicle is a liquid consisting of non–volatile film-forming material (drying oil), and a highly volatile solvent (thinner). The drying oil slowly oxidizes forming a dry pigmented polymeric crossing liking organic film.

Constituents of paint are,

1. Pigments
2. Vehicle
3. Thinner
4. Drier
5. Extender
6. Plasticizer
7. Anti skinning Agents

- **What is the principle of electro-deposition.**

Electroplating/Electro-deposition is the process by which the coat metal (noble metal) is deposited on the base metal by passing a direct current through an electrolytic solution containing the soluble salt of the coat metal. The coat metal is the anode and the object to be plated is the cathode. E.g., Electro deposition of nickel coat metal and iron base metal.

- **What are the factors affecting the quality of electroplating?**
  - Low metal ion concentration in the electrolyte
  - Current density
  - Optimum temperature

- **What are the objectives of electroplating?**

Objectives of electroplating

To increase the resistance to corrosion of the coated metal.
To improve the hardness and physical appearance of the article.
To increase the resistance to chemical attack and wear resistance.
To improve the surface properties.
To increase the decorative and commercial value of the metal.

- **What are vapour phase inhibitors?**

Vapour phase inhibitors are organic inhibitors which readily vaporize and form a protective layer on the metal surface. VPI are used in the protection of storage containers, packing materials, and shipping of sophisticated equipments, etc.
Eg: Dicyclohexyl ammonium nitrate, benzotriazole etc.

18. Mention the advantages of Electroless plating over Electroplating.

1. No electrical energy is required.
2. Metal can be coated on both conductors and non-conductors (plastics, .)
3. Better throwing power.
4. Even intricate parts can be uniformly coated.

19. Explain Differential aeration corrosion with example.

This type of corrosion occurs due to electrochemical attack on the metal surface, in the presence of an electrolyte and varying concentration of oxygen eg: Metals partially immersed in water (or) conducting solution.

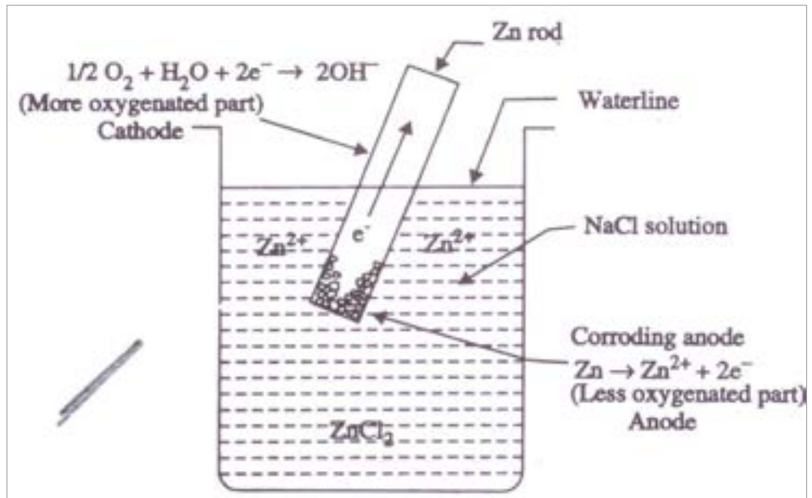


Fig 2.6 Differential aeration corrosion

20. Distinguish between Electroplating and Electroless plating.

S.No	Electroplating	Electroless plating
1.	It is carried out by passing electric current.	It is carried out by auto catalytic redox reaction.
2.	Anodic reaction is $M \longrightarrow M^{n+} + ne^-$	Anodic reaction is $R \longrightarrow O + ne^-$
3.	Separate anode is employed.	Catalytic surface of substrate acts as an anode.
4.	Cathodic reaction is $M^{n+} + ne^- \longrightarrow M$	Cathodic reaction is $M^{n+} + ne^- \longrightarrow M$

PART-B

1. Explain the mechanism of Dry or Chemical corrosion. Also explain the intensity of corrosion with the nature of the oxide layer formed over metal.
2. Write short notes on Hydrogen embrittlement and Decarburization.
3. When does the electrochemical corrosion occur? Describe the mechanism of electrochemical corrosion.
4. What are the factors which influence chemical and electrochemical corrosion?
5. Explain the Sacrificial anodic protection and Impressed current cathodic protection methods.
6. Describe the mechanism of Differential aeration corrosion taking pitting corrosion as an example.
7. What are corrosion inhibitors? Classify the different types of inhibitors with examples.
8. What is a paint? What are the constituents of paints and their functions? 9. What is electroless plating ? Write a short note on electroles nickel plating and discuss its applications?
10. Explain the process of electrodeposition with a suitable example.

UNIT III
ENERGY SOURCES

PART - A

1. What is nuclear chain reaction?

A fission reaction where the neutrons from the previous step continue to propogate and repeat the reaction is called nuclear chain reaction.

2. What is nuclear energy?

The energy released by the nuclear fission is called nuclear fission energy (or) nuclear energy.

3. What is light water nuclear – power plant?

Light-water nuclear power plant is the one, in which U^{235} fuel rods are submerged in water. Here the water acts as a coolant as well as a moderator.

4. What is super critical mass and sub-critical mass of U^{235}?

Super critical mass

If the mass of the fissionable material (U^{235}) is more than the critical mass, it is called super critical mass.

Sub-critical mass

If the mass of the fissionable material is smaller than the critical mass, it is called Sub-critical mass.

5. What is fissile nucleides and fertile nucleides?

The fissionable nucleides such as U^{235} & Pu^{239} are called fissile Nucleides.

The non-fissionable nucleides such as U^{238} & Th^{232} are called fertile nucleides.

6. What is thermal conversion?

Thermal conversion involves absorption of thermal energy in the form of IR radiation.

Solar energy is an important source for low-temperature heat (temperature below 100^0C),

which is useful for heating buildings, water and refrigeration.

7. What are the applications of H_2-O_2 fuel cell?

(a) H_2-O_2 fuel cells are used as auxiliary energy source in space vehicles, submarines or other military-vehicles.

(b) In case of H_2-O_2 fuel cells, the product of water is proved to be a valuable source of fresh water by the astronauts.

8. What are the advantages of alkaline battery over dry battery?

(i) Zinc does not dissolve readily in a basic medium.

(ii) The life of alkaline battery is longer than the dry battery, because there is no corrosion on Zn.

(iii) Alkaline battery maintains its voltage, as the current is drawn from it.

9. How is NICAD battery constructed?

Nickel cadmium cell consists of a cadmium anode and a metal grid containing a paste of NiO_2 acting as a cathode. The electrolyte in this cell is KOH.

10. Describe Lithium battery.

The lithium battery consists of a lithium anode and a TiS_2 cathode. A solid electrolyte, generally a polymer, is packed in between the electrodes. The electrolyte(polymer) permits the passage of ions but not that of electrons.

11. What are the important requirement of a battery?

A useful battery should fulfil the following requirements.

(i) It should be light and compact for easy transport.

(ii) It should have long life both when it is being used and when it is not used.

(iii) The voltage of the battery should not vary appreciably during its use.

12. Write the uses of lead storage battery.

i) Lead storage cell is used to supply current mainly in automobiles such as cars, buses, trucks etc.

ii) It is also used in gas engine ignition, telephone exchanges, hospitals, power station etc. iii) It is used for SLI system (Starting Lighting-Ignition) of road automobiles.

13. What is a fuel cell or flow battery?

A fuel cell is a device in which thermal energy is directly converted to electrical energy. In a conventional system, thermal energy is converted to mechanical energy and the mechanical energy into electrical energy.

PART - B

1. a) Write in brief about chain reaction and nuclear fission reactions.

   b) How is NICAD battery constructed? Explain with all reaction.

2. a) Sate the principle and application of solar batteries.

   b) Write briefly about the advantages and the limitations of the wind energy.

3. a)Discuss about principles and functions of an alkaline batteries

4. a) Explain the working of H_2-O_2 fuel cell.

   b)Write notes on lithium battery.

5. a)What is reversible battery? Describe the construction and working of lead acid storage battery with reaction occurring during charged and discharging cycles.

   b) Discuss about principles and functions of an Lithium batteries

UNIT – IV
ENGINEERING MATERIALS

1. What are abrasives?

Abrasives are the hard substances used for grinding, cutting, sharpening, polishing or drilling purposes. They are used in the form of granules or powder. They are characterized by high hardness, high melting point and chemical inertness.

2. What is abrasive power?

It is the strength of an abrasive to grind away other materials. It depends on hardness, toughness and refractoriness.

3. How is carborundum manufactured?

It is manufactured using a mixture containing sand (54%) , coke (34%) saw dust (10%) and common salt (2%). The mixture is heated in an electric furnace at 2000ºC for 36 hours.

$$SiO_2 + 3C \rightarrow SiC + 2CO$$

4. What are refractories ?

Refractories are any inorganic materials which can withstand high temperature without softening, melting or deformation in shape.

5. Name the stages in the manufacture of refractory.

1) Crushing
2) Grinding
3) Screening
4) Mixing
5) Moulding
6) Drying
7) Firing

6. What is hardness of an abrasive?

It is ability of an abrasive to grind or scratch away other materials. The harder the abrasive quicker will be its abrading action.

7. What is cement?

Cement is a bonding materials having adhesive and cohesive properties. It is capable of bonding the materials like stones, bricks, etc.,

8. What is Portland cement?

Portland cement is chemically defined as a finely powdered mixture of calcium aluminates and silicates.

9. What is white cement and mention their Applications?

It is white in colour due to the absence of iron, manganese, chromium, copper, vanadium, nickel etc., which gives colour to the Portland cement.

- ✓ It is used in decorative works
- ✓ It is used to produce white concrete
- ✓ It is used for repairing and joining the marble pillars and blocks
- ✓ It is used for the manufacturing of tiles and mosaics

10. What is glass?

Glass is an amorphous, hard, brittle, transparent and supercooled liquid of infinite viscosity which is obtained by fusing a mixture of number of metallic silicates.

11. What are the types of Glasses?

- ➢ Sodalime or Soft glass
- ➢ Lead glass or Flint glass
- ➢ Potash lime or Hard glass
- ➢ Borosilicate glass or Pyrex glass
- ➢ Alumino silicate glass
- ➢ Optical or Crookes glass
- ➢ Quartz glasses
- ➢ Opal glasses
- ➢ Glass wool

12. Mention the raw materials for Glass?

Name of the element	Source of the element	Name of the Glass Produced
Sodium (Na)	Na_2CO_3, Na_2SO_4	Soft Glass
Potassium (K)	Potash, K_2CO_3, KNO_3	Hard Glass
Calcium (Ca)	Lime, Limestone	
Barium (Ba)	$BaCO_3$	
Lead (Pb)	Litharge, Red Lead	Flint Glass

Zinc (Zn)	Zinc Oxide	Heat and Shock Proof Glass
Borate	Borax, Boric Acid	Heat and Shock Proof Glass
Silica	Sand, Quartz	
Colour 1.Yellow – Ferric Salt 2. Green – Ferrous and Chromium Salt 3. Blue – Cobalt Salt		

13. Define the thermal spalling?

Thermal Spalling is the property of breaking, cracking or peeling of a refractory material under high temperature.

14. What is Corundum?

It is a pure crystalline form of aluminium oxide (Alumina Al_2O_3). It is hardness on Moh's Scale is 9.

PART - B

1. Define refractoriness and explain thermal spalling and porosity of refractories.
2. a) What are the characteristics of a good refractory? Write a note on carborundum?
   b). Explain the manufacture of alumin and zirconia bricks?
3. a). What are abrasives? Give the preparation and properties of carborundum and alundum?
   b). Write shorts notes on the synthetic abrasives?
4. Explain the chemistry involved in setting and hardening of cement?
5. Describe the manufacture of Portland cement?
6. Explain the various types of glass and their properties and uses?

UNIT-V
FUELS AND COMBUSTION

PART A

- **What is Coalification? How do you classify the coal on the basis of rank?**

The process of conversion of vegetable matter to anthracite is called coalification or metamorphism of coal.

Coal is classified on the basis of its rank. The rank of coal indicates its degree of maturity. Various types of coal are as follows:

Wood ⟶ Peat ⟶ Lignite ⟶ Bituminous coal ⟶ Anthracite

- **Distinguish between proximate and ultimate analysis.**

S.No	Proximate analysis	Ultimate analysis
1.	It involves the determination of physical constituents like moisture, volatile, ash and fixed carbon content in coal.	It involves the determination of chemical constituents like carbon, hydrogen, nitrogen, sulphur and oxygen content in coal.
2.	It gives the approximate composition of the main constituents of coal.	It gives the exact composition of the elementary constituents of coal.

- **What is carbonisation of coal? (or) what is metallurgical coke?**

When bituminous coal is heated strongly in the absence of air, the volatile matter escapes out and the mass becomes hard, strong, porous and coherent which is called metallurgical coke. This process is carbonisation.

- **Define the terms (a) cracking (b) knocking.**

Cracking:

Cracking is defined as the " process of decomposition of higher molecular weight hydrocarbon into lower molecular weight hydrocarbon".

$$\underset{\text{decane}}{C_{10}H_{22}} \longrightarrow \underset{\text{n-pentane}}{C_5H_{12}} + \underset{\text{pentene}}{C_5H_{10}}$$

Knocking:

Due to the presence of impurities in the petrol. The rate of combustion of fuel increases which producing an explosive sound in an IC engine is known as knocking. Knocking is rectified by

Addition of anti-knock compounds like TEL

Low octane petrol is blended with high octane compounds like alcohol (straight – run petrol is mixed with reformed petrol, benzol and alcohol).

- **Define cetane number.**

The cetane number is defined as the % of cetane present in the cetane and α – methyl naphthalene mixture which have the same ignition delay of the diesel under test. It can be improves by the addition of ethyl nitrate.

- **What is octane number?**

Octane number is defined as the percentage of isooctane present in the mixture of n-heptane and isooctane which has the same knocking characteristics of the petrol undr the same set of conditions.

It can be improved by the addition of tetra ethyl lead.

- **What is hydrogenation of coal?**

If coal is heated with hydrogen to high temperature and high pressure, it is converted to gasoline. The preparation liquis fuel from solid fuel is called hydrogenation od coal.

- **How is water gas superior to producer gas?**
  - Its calorific value is higher than producer gas.
  - It has very less amount of N_2 than producer gas.
  - It is used for the manufacture of power alcohol.

Hence, water gas is superior to producer gas.

- **What are the advantages of compressed natural gas (CNG)?**
  - CNG is the cheapest, cleanest and least environmentally vehicle impacting alternative fuel.
  - Vehicles powered by CNG produce less carbon monoxide and hydrocarbon (HC) emission.
  - It is less expensive than and diesel.
  - The ignition temperature of CNG is about 55ċ.
  - CNG requires more air for ignition.
  - CNG is used to run an automotive vehicle just like LPG.
  - CNG mixes better with air than LPG.
  - Leakages of CNG should not be risky than LPG.
  - It should not emits the any harmful pollutants.
  - It is used for power generation while LPG is used as a domestic fuel.

- **What is the composition of producer gas?**

It is a mixture of CO&N_2 with small *amount* of H_2. Its average composition is as follows.

Constituents	Percentage (%)
CO	30
N_2	51-56
H_2	10-15
CO_2+CH_4	rest

- **Write the composition of water gas.**

  It is mixture of CO and H_2 with small amount of N_2. The average composition of water gas is as follows.

Constituents	Percentage(%)
CO	41
H_2	51
N_2	4
CO_2+CH_4	rest

- **Arrange LPG, water gas, biogas and producer gas in increasing order of their calorific values.**

  Producer gas (1300 Kcal/m^3) < water gas (2800 Kcal/m^3) < biogas (5300 Kcal/m^3) < LPG (25,000 Kcal/m^3).

- **What is calorific value?**
  The calorific value of a fuel is defined as the total amount of heat liberated, when a unit mass of fuel is burnt completely.

- **What is GCV?**
  It is the total amount of heat produced, when a unit quantity of the fuel is completely burnt and the products of combustion are cooled at room temperature.

- **Define Net Calorific Value (NCV).**
  It is the net heat produced when a unit quantity of fuel is completely burnt and the products of combustion are allowed to escape.

  NCV = GCV – Latent heat of water vapour followed

  NCV = GCV – Mass of H_2 X 9 X Latent heat of condensation of water vapour.

  NCV = GCV – 0.09 H X 587 Kcal/kg (where H is % of H_2 in the fuel).

PART B

1. How is Proximate Analysis of coal carried out? What are its significance?
2. Describe the Otto – Hoffmann method of coke manufacture is the recovery of various by products?
3. Explain the moving bed catalytic cracking process in detail?
4. What is mean by catalytic cracking ? Discuss on fixed bed catalytic cracking?
5. What is hydrogenation of coal? Write the Fischer – Tropsh process of manufacture of liquid fuel from solid fuel?
6. What is synthetic petrol? How is it manufactured by Bergius Process?
7. Write the preparation and use of producer gas?
8. Write the preparation and use of Water Gas?
9. What is flue gas? How do you analyze flue gas? What are the significances of flue gas analysis?
10. Calculate the gross and net calorific values of coal having the following composition, carbon = 85%, hydrogen = 8%, sulphur = 1%, nitrogen = 2%, ash = 4%, latent heat of steam = 587cal/gm.
11. A sample of coal was found to contain the following, C = 81%, H = 4%, O = 2%, N = 10%, S = 2% and the remaining being ash. Estimate the quantity of minimum air required for the complete combustion of 3 kg of the sample.

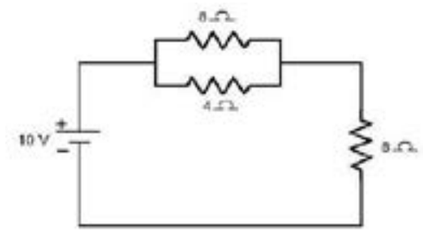
EE 6201 – CIRCUIT THEORY

QUESTION BANK

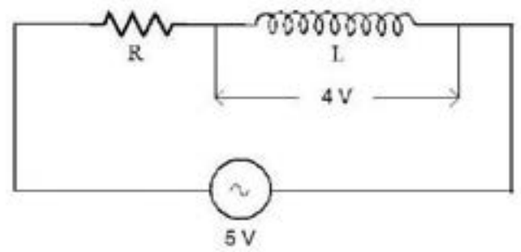
UNIT – I

PART – A (2-MARKS)

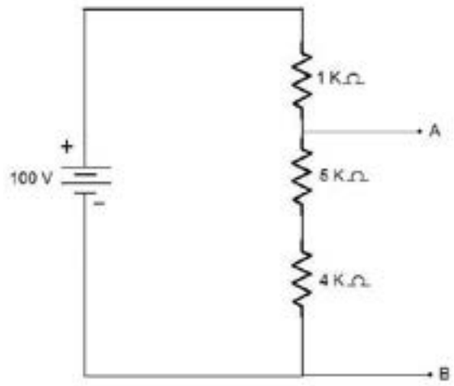
1. State Ohm's law and its limitations.
2. State Kirchhoff's voltage law.
3. State Kirchhoff's Current law.
4. Name different network elements.
5. What is meant by Electric Circuits?
6. Write Kirchhoff's law mathematically.
7. State two salient points of a series combination of resistance.
8. State two salient points of a parallel combination of resistance.
9. Give two applications of both series and parallel combination.
10. A bulb is as rated 230V, 230W. Find the rated current, resistance of the filament and the energy consumed when it is operated for 10 hours.
11. At a node there are 3 live conductors joining. The currents flowing in two conductors towards the node are 1A and 2A. What is the direction and magnitude of the current in the third conductor?
12. In a closed loop the algebraic sun of the electric motive forces is 10V. What is the voltage drop across resistors in that loop?
13. Define an ideal voltage source.
14. Define an ideal current source.
15. Draw the symbolic representation of the voltage source and current source.
16. Explain how voltage source with a source resistance can be converted into an equivalent current source.
17. Find the equivalent current source for a voltage source of 100 V with series resistance of 2 ohm.
18. Define the dependent source of a circuit.
19. A 10A current source has a source resistance of 100 ohm. What will be the equivalent voltage source?
20. Define the current division rule.
21. Draw the V-I relationship of an ideal voltage source.
22. Find the current in 4 ohm resistor.



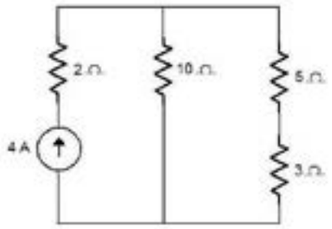
23. Calculate the voltage across resistor R.



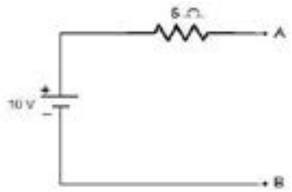
24. Find the voltage between A and B in the circuit given.(Dec 2004, June 2007)



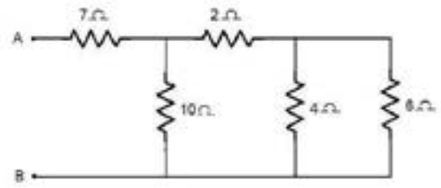
25. Find the current through 10 ohm resistor for the following circuit. (Dec 2004)



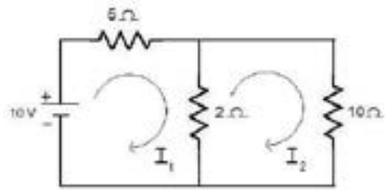
26. What are ideal sources?
27. Give the expressions for star to delta transformation.
28. Define Kirchhoff' laws.
29. Convert the voltage source into a current source for the Circuit given below.



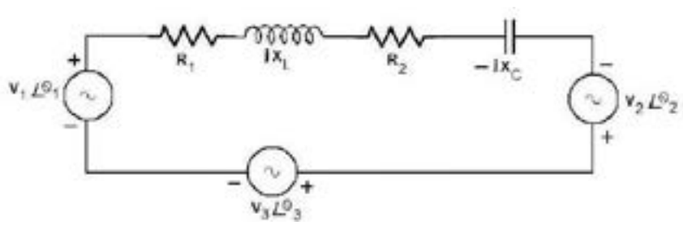
30. Find resistance across AB.



31. Name the four different types of dependent sources in electric circuits.
32. Write the voltage division rule.
33. Define R.M.S value.
34. State the advantages of sinusoidal alternating quantity.
35. What is a phasor?
36. Write the mesh equations for the circuit shown in figure below. (May 2007)

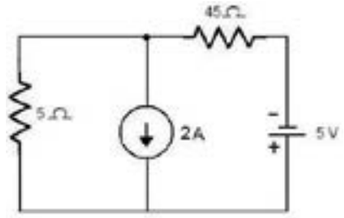


32. Write the mesh equations for the following circuit. (May 2006)



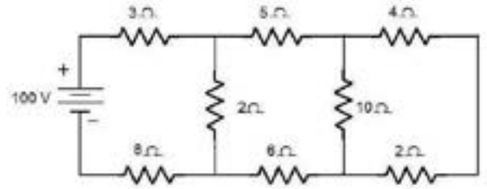
33. Give the algorithm of loop current analysis.

34. Write the node equations at A.

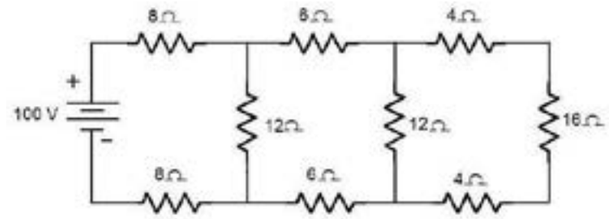


PART – B

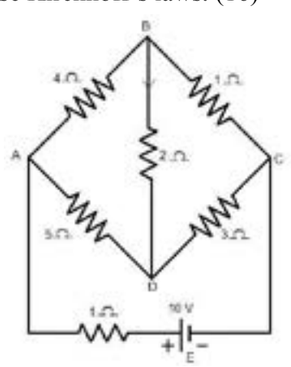
1. Find the current through each branch by network reduction technique. (16)



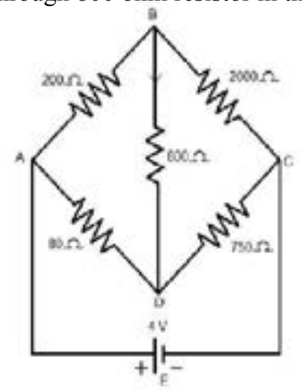
2. Calculate a) the equivalent resistances across the terminals of the supply,
b) total current supplied by the source and
c) power delivered to 16 ohm resistor in the circuit shown in figure. (16)



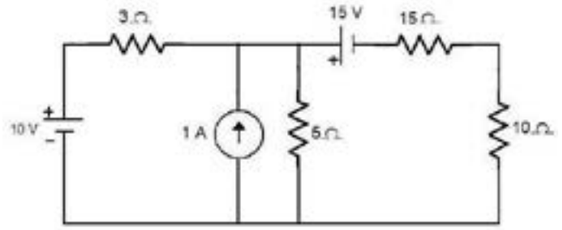
3. In the circuit shown, determine the current through the 2 ohm resistor and the total current delivered by the battery. Use Kirchhoff's laws. (16)



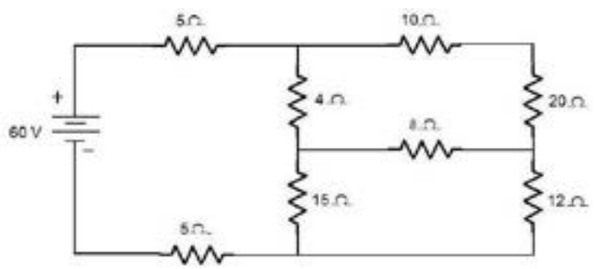
4. (i) Determine the current through 800 ohm resistor in the network shown in figure. (8)



(ii) Find the power dissipated in 10 ohm resistor for the circuit shown in figure. (8)



5. (i) In the network shown below, find the current delivered by the battery. (10)

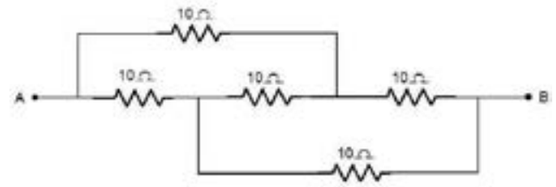


(ii) Discuss about voltage and current division principles. (6)

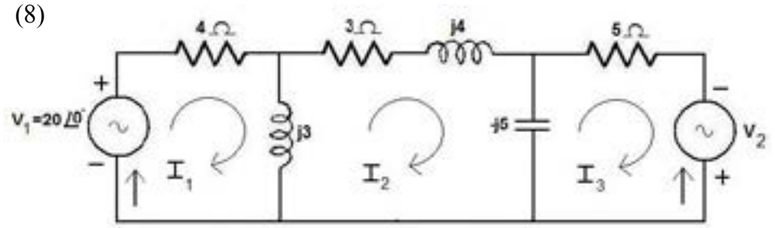
6. (i) Explain :

a) Kirchoff laws (4)
b) Dependent sources (2)
c) Source transformations with relevant diagrams (2)
d) Voltage division and current division rule (4)

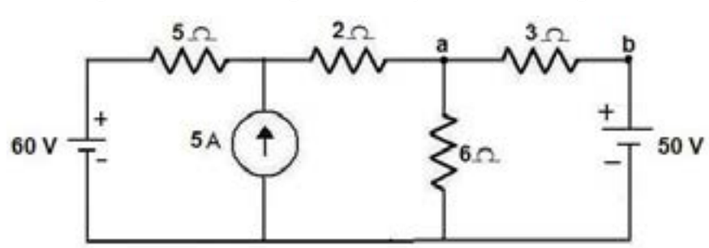
(ii) Calculate the resistance between the terminals A – B. (4)



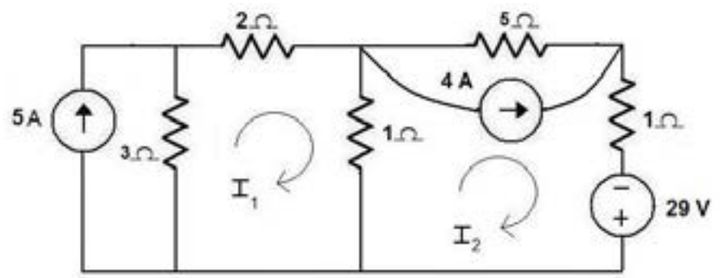
7. i) Determine the value of V2 such that the current through the impedance (3+j4) ohm is zero. (8)



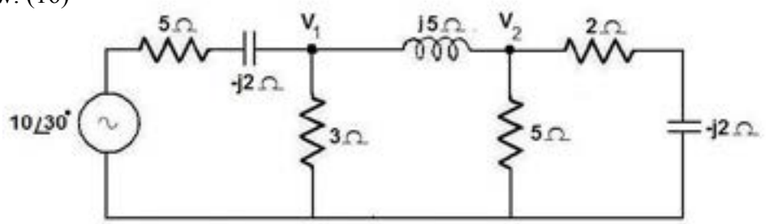
ii) Find the current through branch a-b using mesh analysis shown in figure below. (8)



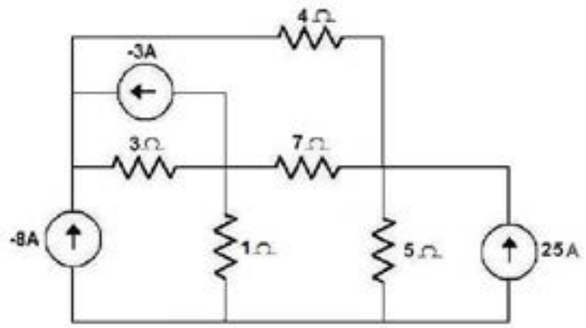
8. Determine the mesh currents I1 and I2 for the given circuit shown below. (16)



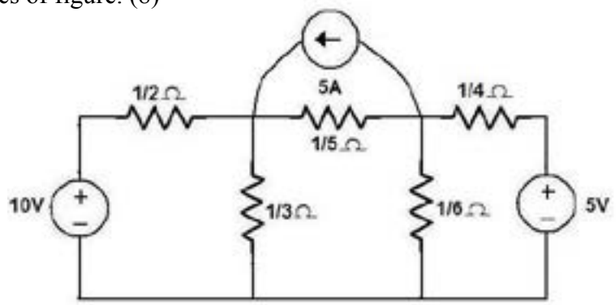
9. Find the node voltages V1 and V2 and also the current supplied by the source for the circuit shown below. (16)



10. Find the nodal voltages in the circuit of figure. (16)

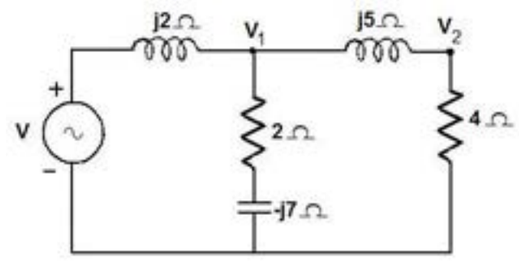


11. i) Using the node voltage analysis, find all the node voltages and currents in 1/3 ohm and 1/5 ohm resistances of figure. (8)

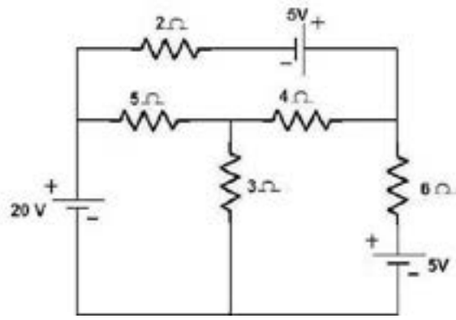


ii) For the mesh-current analysis, explain the rules for constructing mesh impedance matrix and solving the matrix equation [Z]I = V. (8)

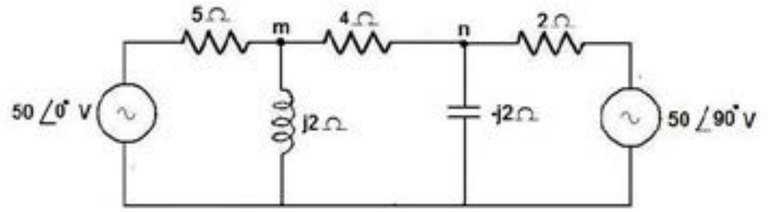
12. Solve for V1 and V2 using nodal method. Let V = 100V (16)



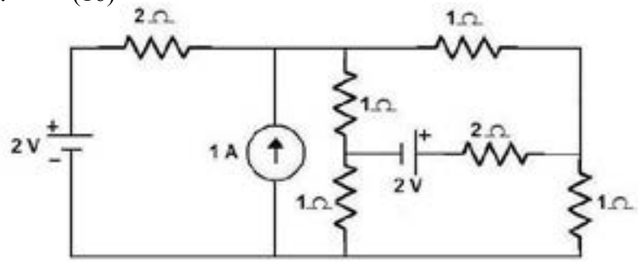
13. Using Mesh analysis, find current through 4 ohm resistor. (16)



14. Use Nodal Voltage method to find the voltages of nodes ‘m’ and ‘n’ and currents through j2 ohm and –j2 ohm reactance in the network shown below. (16)



15. For the circuit shown find the current I flowing through 2 ohm resistance using loop analysis. (16)



UNIT – II

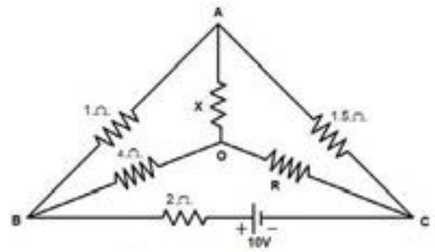
PART – A (2-MARKS)

1. State Superposition theorem.
2. State Thevenin's theorem.
3. State Norton's theorem.
4. State Maximum Power Transfer Theorem.
5. State reciprocity theorem.
6. Write some applications of Maximum Power Transfer Theorem.
7. The power delivered is maximum if the load impedance is equal to the supply circuit impedance – True or False.
8. What is the condition for Maximum Power Transfer?

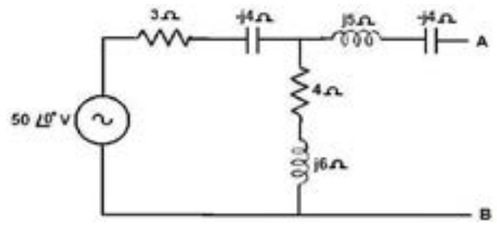
9. A voltage source has internal impedance (4+j5) ohm. Find the load impedance for maximum power transfer
10. Given that the resistors Ra, Rb and Rc are connected electrically in star. Write the equations for resistors in equivalent delta.
11. Three equal resistors each of R ohms are connected in star. Find the value of resistors in the equivalent delta.
12. Three resistors R_{AB}, R_{BC} and R_{CA} are connected in delta. Write the expression for resistors in equivalent star.
13. Three resistors, each of value R ohms are connected in delta. Find the value of resistors in its equivalent star.
28. Write the expression for converting delta connected resistances into an equivalent star connected resistances.
29. Each of the three arms of a delta connected network has resistance of 3ohm. Find the equivalent star connected network.
14. A Y-connected resistive network consists of 2 ohm in each arm. Draw the equivalent delta-connected network and insert the values
15. Give the expressions for star to delta transformation.

PART – B

1. (i) Find the value of R and the current flowing through it in the circuit shown when the current in the branch OA is zero. (8)

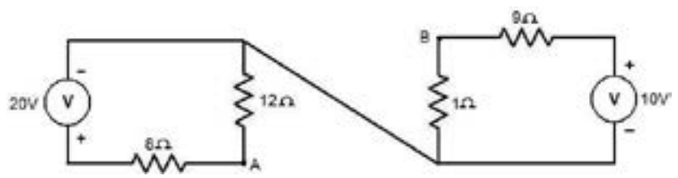


ii) Determine the Thevenin's equivalent for the figure (8)

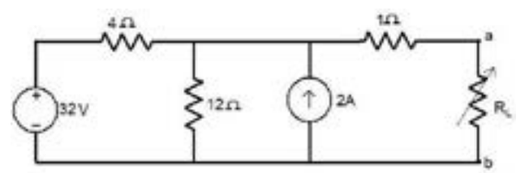


2. Derive expressions for star connected arms in terms of delta connected arms and delta connected arms in terms of star connected arms. (16)

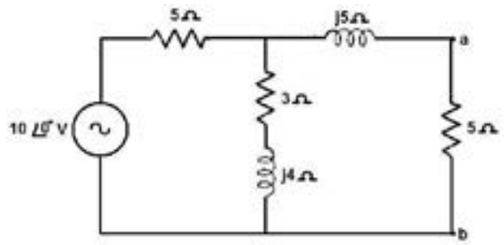
3. Determine Thevenin's equivalent across the terminals AB for the circuit shown in figure below. (16)



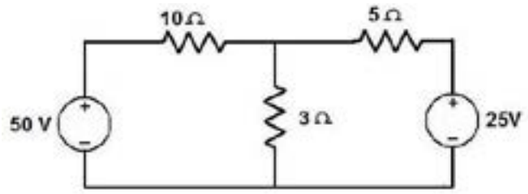
4. Find the Thevenins's equivalent circuit of the circuit shown below, to left of the terminals ab. Then find the current through RL = 16 ohm and 36 ohm. (16)



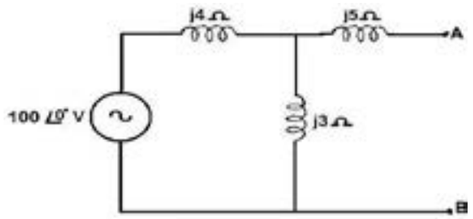
5. i) Find the current through branch a-b network using Thevenin's theorem. (8)



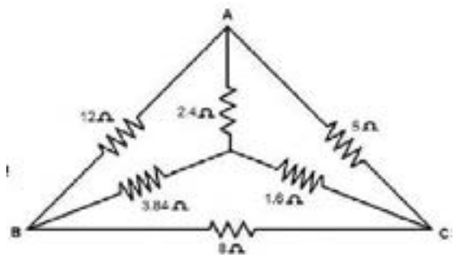
ii) Find the current in each resistor using superposition principle of figure. (8)



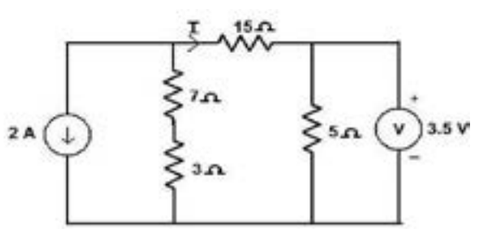
6. i) Determine the Thevenin's equivalent circuit. (8)



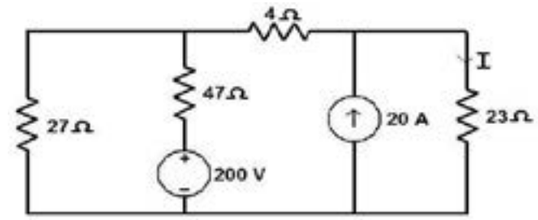
(ii) Determine the equivalent resistance across AB of the circuit shown in the figure below. (8)



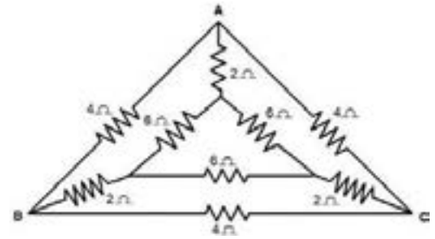
7. For the circuit shown, use superposition theorem to compute current I. (16)



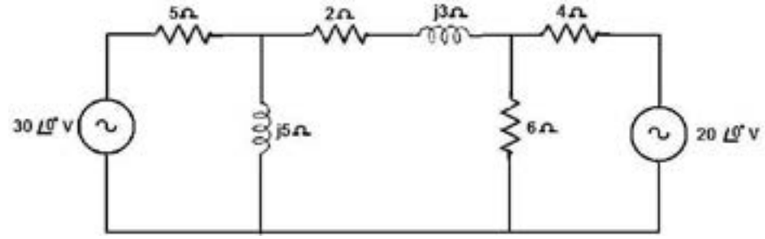
8. (i) Compute the current in 23 ohm resistor using super position theorem for the circuit shown below. (8)



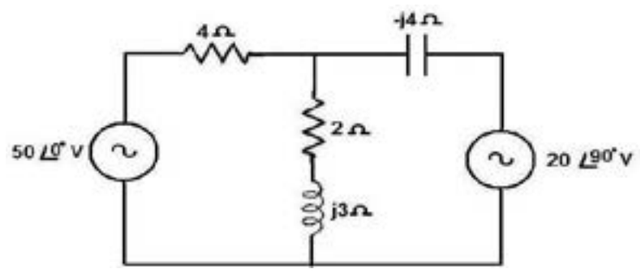
(ii) Find the equivalent resistance between B and C in figure. (8)



9. Using Superposition Theorem calculate current through (2+j3) ohm impedance branch of the circuit shown. (16)

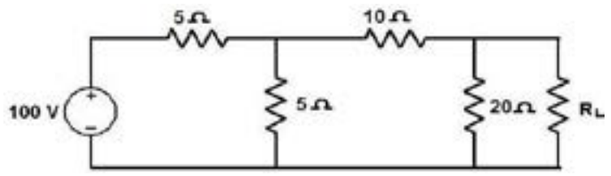


10. i) For the circuit shown, determine the current in (2+j3) ohm by using Superposition Theorem. (8)



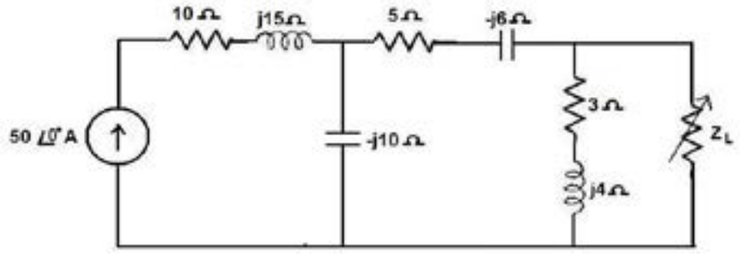
ii) State and prove Norton's theorem. (8)

11. i) Find the value of RL so that maximum power is delivered to the load resistance shown in figure. (8)

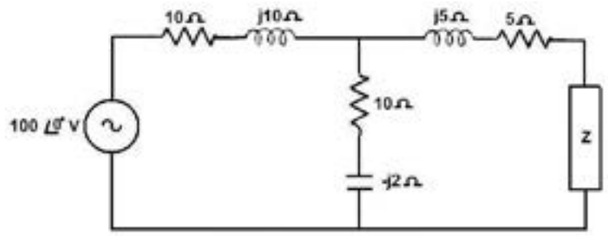


ii) State and prove compensation theorem. (8)

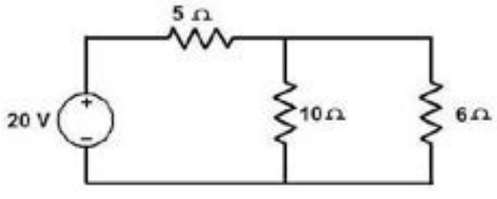
12. Determine the maximum power delivered to the load in the circuit. (16)



13. Find the value of impedance Z so that maximum power will be transferred from source to load for the circuit shown. (16)



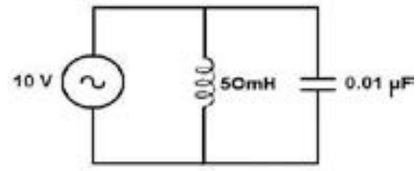
14. i) State and explain maximum power transfer theorem for variable Pure resistive load. (8)
ii) Using Norton's theorem, find current through 6 ohm resistance shown in figure. (8)



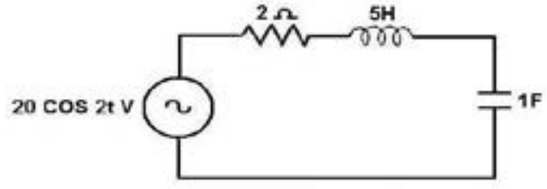
UNIT – III

PART – A (2-MARKS)

1. For the purely resistive circuit excited by sinusoidal varying voltage, what are the phase angle and p.f?
2. For the purely inductive circuit supplied by sinusoidal varying voltage, what is the phase relation between current and applied voltage. How are applied voltage and induced emf?
3. For purely capacitive circuit, excited by sinusoidal voltage, find the phase relation between applied voltage and current.
4. How are the following affected by change of frequency?
   a. Resistance b. Inductive reactance c. Capacitive reactance
5. Define quality factor of series resonant circuit.
6. What is the dynamic impedance and what is its expression?
7. Define bandwidth.
8. What are the half power frequencies?
9. What is resonance?
10. What do you understand by series and parallel resonance?
11. A voltage of $v(t) = 100 \sin\omega t$ is applied to a circuit. The current flowing through the circuit is $i(t) = 15 \sin(\omega t - 30^\circ)$. Determine the average power delivered to the circuit.
12. Derive resonant frequency for series RLC circuit.
13. Write the expression for resonant frequency and current at resonance of a RLC series circuit.
14. Define Q-factor of a coil.
15. Define bandwidth of a resonant circuit.
16. Find the resonant frequency in the ideal parallel LC circuit shown below



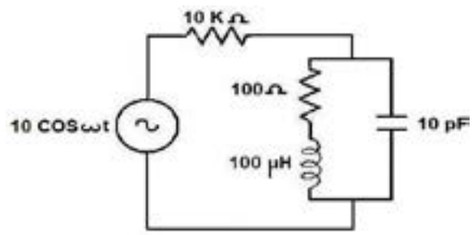
17. Find the impedance offered to the source by the load.



18. State the condition for resonance in RLC series circuit.
19. A resistance 5 ohms, inductance 0.02H and capacitor 5 microfarads are connected in series. Find the resonance frequency and the power factor at resonance.
20. Two capacitances C1 and C2 of values 10μF and 5μF are connected in series. What is the equivalent capacitance of this combination?

PART – B

1. (i) Derive bandwidth for a series RLC circuit as a function of resonant frequency.(16)
2. (i) For the circuit below, find the value of ω so that current and source emf are in phase. Also find the current at this frequency. (8)



(ii) Discuss the characteristics of parallel resonance of a circuit having G, L and C. (8)

3. (i) A Pure resistor, a pure capacitor and a pure inductor are connected in parallel across a 50Hz supply; find the impedance of the circuit as seen by the supply. Also find the resonant frequency. (8)
(ii) When connected to a 230V, 50Hz single phase supply, a coil takes 10kVA and 8kVAR. For this coil calculate resistance, inductance of coil and power consumed. (8)

4. (i) In an RLC series circuit if ω1 and ω2 are two frequencies at which the magnitude of the current is the same and if ωr is the resonant frequency, prove that $\omega^2 r = \omega 1 \omega 2$. (8)

(ii) A series RLC circuit has Q = 75 and a pass band (between half power frequencies) of 160 Hz. Calculate the resonant frequency and the upper and lower frequencies of the pass band. (8)

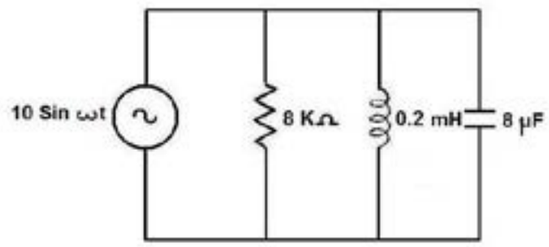
5. (i) Explain and derive the relationships for bandwidth and half power frequencies of RLC series circuit. (8)
(ii) Determine the quality factor of a coil R = 10 ohm, L = 0.1H and C = 10Mf (8)

6. A series RLC circuit has R=20 ohm, L=0.005H and C = 0.2 x 10^{-6} F. It is fed from a 100V

variable frequency source. Find i) frequency at which current is maximum ii) impedance at this frequency and iii) voltage across inductance at this frequency. (16)

7. A series RLC circuit consists of R=100 ohm, L = 0.02 H and C = 0.02 microfarad. Calculate frequency of resonance. A variable frequency sinusoidal voltage of constant RMS value of 50V is applied to the circuit. Find the frequency at which voltage across L and C is maximum. Also calculate voltage across L and C is maximum. Also calculate voltages across L and C at frequency of resonance. Find maximum current in the circuit. (16)

8. In the parallel RLC circuit, calculate resonant frequency, bandwidth, Q-factor and power dissipated at half power frequencies. (16)



UNIT – IV

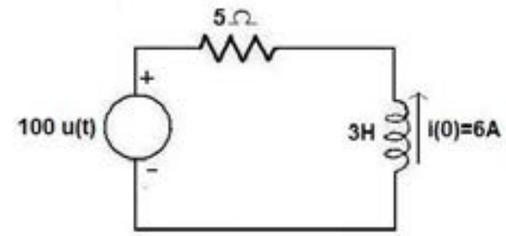
TRANSIENT RESPONSE OF DC AND AC CIRCUITS

PART – A (2-MARKS)

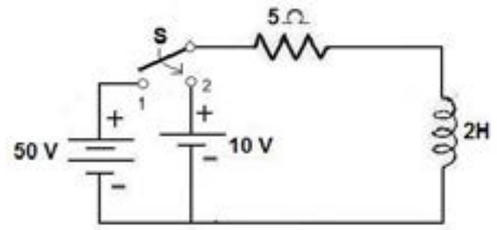
1. The transients are due to the presence of energy storing elements in the circuit – True or false.
2. What is a step function?
3. What is an initial condition?
4. What is a transient?
5. What is the steady state value?
6. Write the transient current equation when RL series circuit is connected to a step voltage of volts.
7. A DC voltage of 100 volts is applied to a series RL circuits with R = 25 ohm what will be the current in the circuit in the circuits at twice the time constant?
8. Sketch the current given by $I(t) = 5 - 4e^{-20t}$
9. Distinguish between free and forced response.
10. Draw the equivalent circuit for inductor and capacitor at t = 0+ when there is no initial energy.
11. Define a time constant of a RL circuit.
12. Draw the equivalent circuits for the inductor and capacitor at t=0+ with presence of initial energy.
13. Distinguish between the steady state and the transient response of an electrical circuit.
14. Define a time constant of a RC circuit.
15. Draw the equivalent circuit at t = 0+ for a capacitor with initial charge of q 0.
16. Sketch the response of RC network for a unit step input.
17. What are the periodic inputs?
18. What are critical frequencies? Why are they so called?
19. Draw the transient response of R-L circuits for step input.
20. Define the time constant of a transient response.
21. Find the time constant of RL circuits having R = 10 ohm and L = 0.1 mH.
22. What is meant by critical damping?

PART – B

1. In the circuit of the figure shown below, find the expression for the transient current and the initial rate of growth of the transient current (16)



2. In the circuit shown in figure, switch S is in position 1 for a long time and brought to position 2 at time t=0. Determine the circuit current. (16)

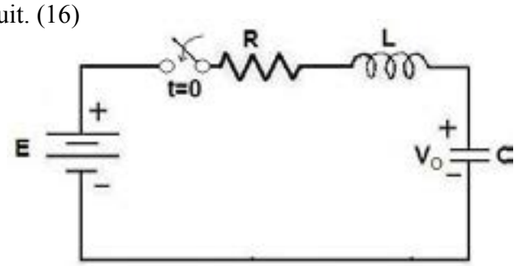


3. A resistance R and 2 microfarad capacitor are connected in series across a 200V direct supply. Across the capacitor is a neon lamp that strikes at 120V. Calculate R to make the lamp strike 5 sec after the switch has been closed. If R = 5Megohm, how long will it take the lamp to strike? (16)

4. A Series RLC circuits has R=50 ohm, L= 0.2H, and C = 50 microfarad. Constant voltage of 100V is impressed upon the circuit at t=0. Find the expression for the transient current assuming initially relaxed conditions. (16)

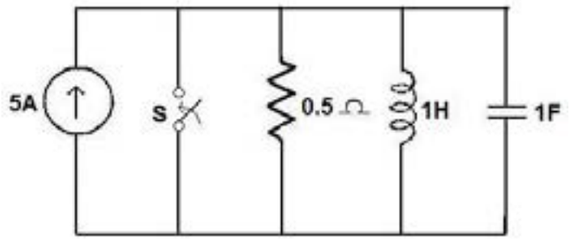
5. A Series RLC circuits with R=300 ohm, L=1H and C=100x10^{-6} F has a constant voltage of 50V applied to it at t= 0. Find the maximum value of current (Assume zero initial conditions) (16)

6. A step voltage V(t) = 100 u(t) is applied to a series RLC circuit with L=10H, R=2ohm and C= 5F. The initial current in the circuit is zero but there is an initial voltage of 50V on the capacitor in a direction which opposes the applied source. Find the expression for the current in the circuit. (16)

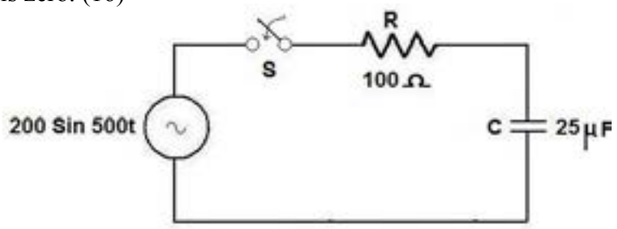


7. For a source free RLC series circuit, the initial voltage across C is 10V and the initial current through L is zero. If L = 20mH, C=0.5 microfarad and R=100 ohm. Evaluate i(t). (16)

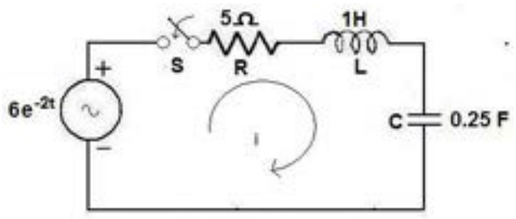
8. For the circuit shown in figure, find the voltage across the resistor 0.5 ohm when the switch, S is opened at t=0. Assume that there is no charge on the capacitor and no current in the inductor before switching. (16)



9. In the circuit shown in figure, find the current i. Assume that initial charge across the capacitor is zero. (16)



10. In the circuit shown in figure, the switch is closed at time t=0. Obtain i(t). Assume zero current through inductor L and zero charge across C before closing the switch. (16)



11. Derive an expression for current response of RLC series circuit transient. (16)

UNIT – V

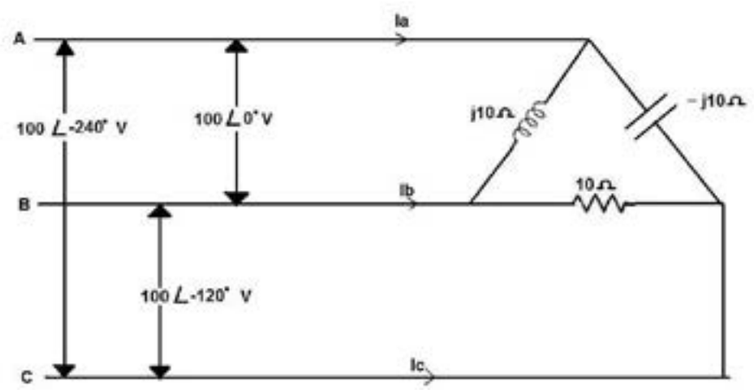
PART – A (2-MARKS)

1. Give the relation between apparent power, average power and reactive power.
2. What is P.F and what is reactive power?
3. In a three phase circuit, what do you mean by balanced load and unbalanced load?
4. Draw the circuit for two wattmeter method of measurement of three-phase power.
5. Write the relations between phase and line values in a delta and star connected loads.
6. Write the expressions for the power factor in a balanced three phase circuit.
7. Write the expression for total power in a three phase balanced circuit defining each quantity.
8. Write the expression for the wattmeter readings connected to measure the total power in a three phase balanced circuit.
9. Give the three phase power expressions in terms of phase values.
10. Give the relation between V_{ph} and V_L, I_{ph} and I_L for a star circuit.
11. An inductive load consumes 1000W power and draw 10A current when connected to a 25V, 25Hz supply. Determine the resistance and inductance of the load.
12. Write the expressions for calculating real, reactive and apparent power of a three phase system.

PART – B

1. With a neat circuit and phasor diagram explain the three phase power measurement by two wattmeter method. (16)
2. (i) A symmetrical three phase 400V system supplies a balanced delta connected load. The current in each branch circuit is 20A and phase angle 40° (lag) calculate the line current and total power. (8)
   (ii) A three phase delta connected load has Zab = (100+j0) ohms, Zbc = (-j100) ohms and Zca = (70.7-j70.7) ohms is connected to a balanced 3 phase 400V supply. Determine the line currents Ia,Ib and Ic. Assume the phase sequence abc. (8)
3. (i) A balanced three phase star connected load with impedance 8+j6 ohm per phase is connected across a symmetrical 400V three phase 50Hz supply. Determine the line current, power factor of the load and total power. (8)
   (ii) An alternating current is expressed as i=14.14 sin 314t. Determine rms current, frequency and instantaneous current at t =0.02ms. (8)
4. (i) A balanced star connected load of 4+j3 ohm per phase is connected to a 400V, 3 phase, 50Hz supply. Find the line current, power factor, power, reactive volt ampere and total volt ampere. (8)
   (ii) A Voltage source 100V with resistance of 10 ohms and inductance 50 mH, a capacitor 50 microfarad are connected in series. Calculate the impedance when the frequency is (i) 50HZ (ii) 500Hz (iii) the power factor at 100Hz. (8)

5. (i) Three impedances Z1 = 3∟45° ohm, Z2 = 10√2∟45° ohm, Z3 = 5∟-90° ohm are connected in series. Calculate applied voltage if voltage across Z1 = 27∟-10° V. (8)
(ii) A delta connected load as shown in figure is connected across 3 phase 100 volt supply. Determine all line currents. (8)



EC6201 – ELECTRONIC DEVICES
UNIT I SEMICONDUCTOR DIODE
PART A

1. **Give the value of Charge, Mass of an electron.**
Charge of an electron – 1.6 x 10 -19 coloumbs
Mass of an electron - 9.11 x 10 -31 Kgs

2. **Define Potential.**
A potential of V volts at point B with respect to point A, is defined as the work done in taking unit positive charge from A to B , against the electric field.

3. **Give the expression for Equation of motion.**
Y = e x ϵ x t2/ 2m

4. **What is Transit time? Give the expression for it.**
It is the time taken by the electron to travel a distance " d" between the plates.
τ= (2 x m / e x v) ½ x d

5. **What is the Force experienced by an electron in Magnetic field?**
Fm = B x e x V Newton's

6. **Define Current density.**
It is defined as the current per unit area of the conducting medium. J = I / A

7. **Define Electron volts.**
If an electron falls through a potential of one volt then its energy is 1 electron volt. 1eV = 1.6 x 10 -19 joules

8. **What is Electrostatic deflection sensitivity?**
Electrostatic deflection sensitivity of a pair of deflecting plates of a cathode ray Oscilloscope (CRO) is defined as the amount of deflection of electron spot produced when a voltage of 1 Volt DC is applied between the corresponding plates.

9. **Give the expression for Electrostatic deflection sensitivity?**
SE = l x D \ 2 x S x Va where l – length of the plates , D – distance between the centre of the plate and screen , S – distance between the plates , Va - anode potential.

10. **What is Cyclotron?**
Cyclotron is a device that imparts very high energies to positive ions. These higher energy positive ions are then allowed to bombard some substances, which become radioactive and generally disintegrate.

11. **Give the expression for frequency of Cyclotron?**
f = e x B / 2 x π x m Hz

12. What is Magnetic deflection sensitivity?

Magnetic deflection sensitivity of a cathode ray oscilloscope (CRO) is defined as the amount of deflection of electron spot produced when a magnetic flux density of 1 Wb/m2 is applied.SM = (e / m)1\2 x 1\ (2V0) 1\2 x l x L

13. What is atomic number?

The number of protons or electrons in an atom is atomic number.

14. What is the relation for the maximum number of electrons in each shell?

Ans: $2n^2$

15. What are valence electrons?

Electron in the outermost shell of an atom is called valence electron.

16. What is forbidden energy gap?

The space between the valence and conduction band is said to be forbidden energy gap.

17. What are conductors? Give examples?

Conductors are materials in which the valence and conduction band overlap each other so there is a swift movement of electrons which leads to conduction. Ex: Copper, silver.

18. What are insulators? Give examples?

Insulators are materials in which the valence and conduction band are far away from each other. So no movement of free electrons and thus no conduction. Ex glass, plastic.

19. Give the energy band structure of Insulator.

In Insulators there is a wide forbidden energy gap. So movement of valence electron from valence to conduction band is not possible

20. Give the energy band structure of Semi conductor.

In Semiconductors there is a small forbidden energy gap. So movement of valence electron from valence to conduction band is possible if the valence electrons are supplied with some energy.

21. Give the energy band structure of conductor.

In conductors there is no forbidden energy gap, valence band and conduction and overlap each other. so there is a heavy movement of valence electrons.

22. What are semiconductors? Give examples?

The materials whose electrical property lies between those of conductors and insulators are known as Semiconductors. Ex germanium, silicon.
It has two types.
1. Intrinsic Semiconductor 2. Extrinsic Semiconductor

23. Differentiate between intrinsic and extrinsic semiconductor

Pure form of semiconductors are said to be intrinsic semiconductor.
Ex: germanium, silicon.
It has poor conductivity

If certain amount of impurity atom is added to intrinsic semiconductor the resulting semiconductor is Extrinsic or impure Semiconductor
It has good conductivity.

24. Define Mass – action law.

Under thermal equilibrium the product of free electron concentration (n) and hole concentration (p) is constant regardless of the individual magnitude.
$n.p = ni^2$

25. What are the types of Extrinsic Semiconductor?

1.P-type Semiconductor 2. N- Type Semiconductor.

26. What is P-type Semiconductor?

The Semiconductor which are obtained by introducing pentavalent impurity atom (phosphorous, antimony) are known as P-type Semiconductor.

27. What is N-type Semiconductor?

The Semiconductor which is obtained by introducing trivalent impurity atom (gallium, indium) are known as N-type Semiconductor.

28. What is doping?

Process of adding impurity to a intrinsic semiconductor atom is doping. The impurity is called dopant.

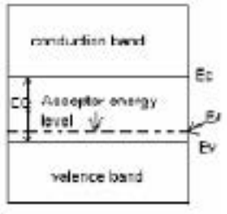
29. Which charge carriers is majority and minority carrier in N-type Semiconductor?

Majority carrier: electron and minority carrier: holes.

30. Which charge carriers is majority and minority carrier in P-type Semiconductor?

Majority carrier: holes and minority carrier: electron

31. Give the energy band structure of P- type semiconductor.



32. Why n - type or penta-valent impurities are called as Donor impurities?

n- type impurities will donate the excess negative charge carriers (Electrons) and therefore they are referred to as donor impurities.

33. Why P – type or trivalent impurities are called as acceptor impurity?

p- type impurities make available positive carriers because they create holes which can accept electron, so these impurities are said to be as acceptor impurity.

34. Give the law of electrical neutrality?

Law of electrical neutrality states Since the semiconductor is always electrically neutral, the magnitude of positive charge density must equal that of the negative charge density.

$ND + p = NA + n$

35. Give the relation for concentration of holes in the n- type material?

$pn = ni2 /ND$

Where

pn - concentration of holes in the n – type semiconductor

ND - concentration of donor atoms in the n – type semiconductor

36. Give the relation for concentration of electrons in the p - type material?

$np = ni2 /NA$

Where

np - concentration of electrons in p- type semiconductor

ND - concentration of acceptor atoms in the p – type semiconductor

37. Give the expression for the Fermi level energy in n – type semiconductor.

$EF = EC – kT \ln NC/ ND$

Where,

EF - Fermi level energy

EC – Conduction band energy K – Boltzmann constant

T – Temperature

NC – dimension of concentration in n - type ND - concentration of donor atoms

38. Give the expression for the Fermi level energy in n – type semiconductor.

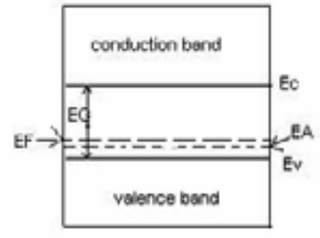
$EF = EV – kT \ln NV/ NA$

Where,

EF - Fermi level energy EV – valence band energy K – Boltzmann constant T – Temperature

NV - dimension of concentration in p - type NA - concentration of acceptor atoms

39. Show the position of the Fermi level in the case of n – type semiconductor using energy band diagram.



40. What is mobility? What is its unit?

Mobility of the charge carrier is defines as the average drift velocity per unit electric field.

Its unit is meters per volt – seconds.

$\mu = v / E$

Where μ – mobility v – Drift velocity E – applied electric field

41. Define Conductivity.

Conductivity is defined as the current density per unit applied electric field.

Its unit is mho per meter

$\sigma = J / E$

Where σ – Conductivity J- Current density E - applied electric field

42. Give the relationship between mobility and conductivity.

$\sigma = q n \mu$

Where σ – Conductivity

q- charge of electron

n- concentration of electron

μ-mobility

43. Define drift current?

When an electric field is applied across the semiconductor, the holes move towards the negative terminal of the battery and electron move towards the positive terminal of the battery. This drift movement of charge carriers will result in a current termed as drift current.

44. Give the expression for drift current density

Drift current density due to electrons

$$J_n = q\, n\, \mu_n E$$

Where,

Jn - drift current density due to electron

q- Charge of electron

μn - Mobility of electron

E - applied electric fieldDrift current density due to holes**.**

$$J_p = q\, p\, \mu_p E$$

Where,Jp - drift current density due to holes q - Charge of holes

μp - Mobility of holes

E - applied electric field

45. Define the term diffusion current?

A concentration gradient exists, if the number of either electrons or holes is greater in one region of a semiconductor as compared to the rest of the region. The holes and electron tend to move from region of higher concentration to the region of lower concentration. This process in called diffusion and the current produced due this movement is diffusion current.

46. Give the expression for diffusion current density

Diffusion current density due to electrons

$$J_n = q\ Dn\ dn / dx$$

Where

Jn - diffusion current density due to electron

q - Charge of an electron

Dn – diffusion constant for electron

dn / dx – concentration gradient

Diffusion current density due to holes

$$J_p = - q\, Dp\, dp / dx$$

Where

Jp - diffusion current density due to holes

q - Charge of a hole

Dp – diffusion constant for hole

dn / dx – concentration gradient

47. Differentiate between drift and diffusion currents.

Drift current

1. It is developed due to potential gradient.
2. This phenomenon is found both in metals and semiconductors

Diffusion current

1. It is developed due to charge concentration gradient.
2. This phenomenon is found only in metals

48. Define mean life time of a hole or and electron.

The electron hole pair created due to thermal agitation will disappear as a result of recombination. Thus an average time for which a hole or an electron exist before recombination can be said as the mean life time of a hole or electron.

49. What is the other name of continuity equation? What does it indicate?

The other name of continuity equation is equation of conservation of charge. This equation indicates that the rate at which holes are generated thermally just equals the rate at which holes are lost because of recombination under equilibrium conditions.

50. Give the expression for continuity equation?

$dp / dt = - (p-p0)/\tau p + Dp\ d2p / dx2 - \mu p\ d(pE) / dx$ Where

Dp – diffusion constant for hole μp – mobility of holes

51. Define Hall effect?

If a metal or semiconductor carrying current I is placed in a transverse magnetic field B ,an electric field E is induced in the direction perpendicular to both I and B, This phenomenon is known as Hall effect.

52. Give the expression for Hall voltage.

$V_H = BI / \rho w$

Where

VH – Hall voltage

w – width of the semiconductor B - transverse magnetic field

I – Current across the specimen

53. Give the expression for Hall coefficient.

$R_H = 1/ \rho = V_H w/ BI$

Where

RH - Hall coefficient VH – Hall voltage

w – width of the semiconductor B - transverse magnetic field

I – Current across the specimen

54. Give the expression for mobility in terms of Hall coefficient.

$\mu = \sigma R_H$

Where

RH - Hall coefficient μ – mobility

σ – conductivity

55. Give some application of Hall Effect.

i. Hall effect can be used to measure the strength of a magnetic field in terms of electrical voltage.
ii. it is used to determine whether the semiconductor is p – type or n- type material
iii. it is used to determine the carrier concentration
iv. it is used to determine the mobility.

56. What is depletion region in PN junction?

The region around the junction from which the mobile charge carriers (electrons and holes) are depleted is called as depletion region. Since this region has immobile ions, which are electrically charged, the depletion region is also known as space charge region.

57. What is barrier potential?

Because of the oppositely charged ions present on both sides of PN junction an electric potential is established across the junction even without any external voltage source which is termed as barrier potential.

58. Give the other names of depletion region?

i. space charge region
ii. Transition region

59. What is meant by biasing a PN junction?

Connecting a PN junction to an external voltage source is biasing a PN junction.

60. What are the types of biasing a PN junction?

1. Forward bias
2. Reverse bias.

61. What is forward bias in a PN junction?

When positive terminal of the external supply is connected to P region and negative terminal to N region ,the PN junction is said to be forward biased. under forward biased condition the PN region offers a very low resistance and a large amount of current flows through it.

62. What is reverse bias in a PN junction?

When positive terminal of the external supply is connected to N type and negative terminal to P type then the PN junction is said to be in reverse bias. Under reverse biased condition the PN region offers a very high resistance and a small amount of current flows through it.

63. Why a contact difference of potential exist in PN junction?

when a pn junction is formed by placing a p-type and n-type material in intimate contact, the Fermi level throughout the newly formed specimen is not constant at equilibrium. There will be transfer of electron and energy until Fermi levels in the two side did line up. But the valence and conduction band in pside cannot be at the at the same level as in n side .this shift in energy level results in contact difference of potential .

64. Give the expression of contact difference of potential?

$E0 = kT \ln ND\ NA / ni2$

Where

E0 - contact difference of potential K – Boltzmann constant

T – Temperature

ND - concentration of donor atoms NA - concentration of acceptor atoms ni – intrinsic

65. What is Reverse saturation current?

The current due to the minority carriers in reverse bias is said to be reverse saturation current. This current is independent of the value of the reverse bias voltage.

66. What is the total current at the junction of pn junction diode?

The total in the junction is due to the hole current entering the n material and the electron current entering the p material. Total current is given by

$I = Ipn(0) + np(0)$

Where,

I – Total current

Ipn(0) - hole current entering the n material Inp(0) - electron current entering the p material.

67. What is the diffusion length for holes (Lp)?

Diffusion length of holes can be said as the mean distance of travel of hole before recombination.

$Lp = (Dp\ \tau p)1/2$

68. State the law of junction relating the boundary value of injected minority carrier concentration with applied voltage?

The law of junction gives the density of minority carriers injected into a material across the junction. In a pn junction diode, concentration of holes injected in to the n region is given by

$$Pn(0) = pno\ e^{v/v_T}$$

69. Give the diode current equation?

The diode current equation relating the voltage V and current I is given by

$$I = I_o\,[e^{(V/\eta V_T)} - 1]$$

where

I – diode current

I_o – diode reverse saturation current at room temperature

V – external voltage applied to the diode
ɳ - a constant, 1 for Ge and 2 for Si

$V_T = kT/q = T/11600$, thermal voltage

K – Boltzmann's constant (1.38066x10^-23 J/K)

q – charge of electron (1.6x10^-19 C)
T – temperature of the diode junction

70. What is recovery time? Give its types.

When a diode has its state changed from one type of bias to other a transient accompanies the diode response, i.e., the diode reaches steady state only after an interval of time " tr" called as recovery time. The recovery time can be divided in to two types such as

(i) forward recovery time
(ii) reverse recovery time

71. Define storage time.

The interval time for the stored minority charge to become zero is called storage time. It is represented as t_s.

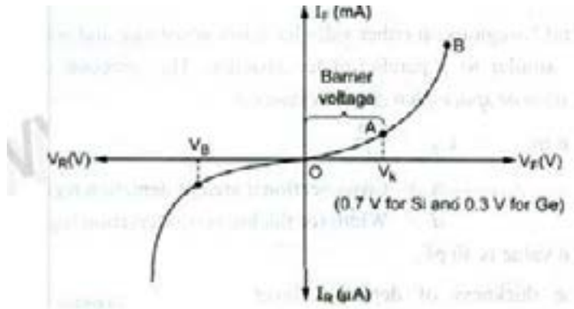
72. Define transition time.

The time when the diode has normally recovered and the diode reverse current reaches reverse saturation current Io is called as transition time. It is represented as t_t

73. Define PIV.

Peak inverse voltage is the maximum reverse voltage that can be applied to the PN junction without damage to the junction.

74. Draw V-I characteristics of pn diode



75. Write the application of pn diode

- Can be used as rectifier in DC Power Supplies.
- In Demodulation or Detector Circuits.
- In clamping networks used as DC Restorers
- In clipping circuits used for waveform generation.
- As switches in digital logic circuits.
- In demodulation circuits.

PART B

1. Explain the drift and diffusion currents for PN diode. (8)
2. Derive the quantitative theory of PN diode currents. (16)
3. Give diode current equation (6)
4. Explain the operation of PN junction under forward bias condition with its characteristics. (10)
5. Explain the operation of PN junction under reverse bias condition with its characteristics. (10)
6. Explain details about the switching characteristics on PN diode with neat Sketch. (12)

UNIT II
BIPOLAR JUNCTION
PART A

1. Why an ordinary transistor is called bipolar?

The operation of the transistor depends on both majority and minority carriers. So it is called bipolar device.

2. Collector region of transistor is larger than emitter. Why?

Collector is made physically larger than emitter and base because collector is to dissipate much power.

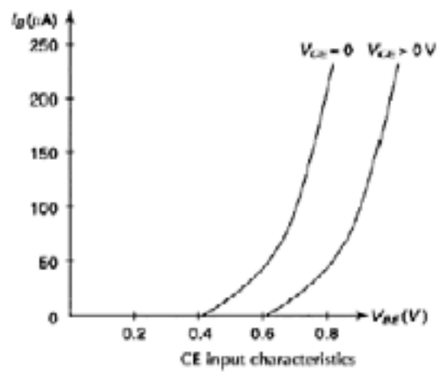
3. Why is BJT is called current controlled device?

The output voltage, current, or power is controlled by the input current in a transistor. So it is called the current controlled device.

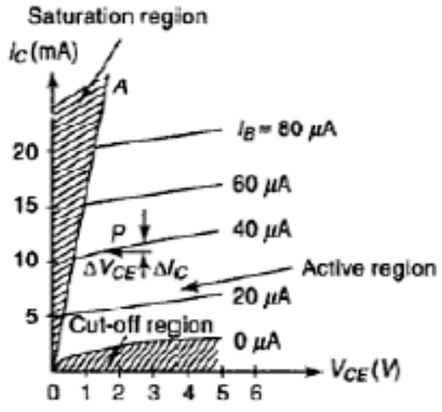
4. Define Early Effect.

A variation of the base-collector voltage results in a variation of the quasi-neutral width in the base. The gradient of the minority-carrier density in the base therefore changes, yielding an increased collector current as the collector-base current is increased. This effect is referred to as the Early effect.

5. Draw the characteristics of CE configuration.



CE input characteristics



6. Among CE, CB, CC which one is most popular. Why?

CE is most popular among the three because it has high gain compared to base and collector configuration. It has the gain about to 500 that finds excellent usage in audio frequency applications.

7. Compare CE, CB, CC.

Property	*CB*	*CE*	*CC*
Input resistance	Low (about 100 Ω)	Moderate (about 750 Ω)	High (about 750 kΩ)
Output resistance	High (about 450 kΩ)	Moderate (about 45 kΩ)	Low (about 25 Ω)
Current gain	1	High	High
Voltage gain	About 150	About 500	Less than 1
Phase shift between input & output voltages	0 or 360°	180°	0 or 360°
Applications	for high frequency circuits	for audio frequency circuits	for impedance matching

8. Why h parameter model is important for BJT

It is important because:

1. its values are used on specification sheets
2. it is one model that may be used to analyze circuit behavior
3. it may be used to form the basis of a more accurate transistor model

9. Define current amplification factor

In a transistor amplifier with a.c. input signal, the ratio of change in output current to be the change in input current is known as the current amplification factor.

In the CB configuration the current amplification factor, $\alpha = \frac{\Delta I_C}{\Delta I_E}$

In the CE configuration the current amplification factor, $\beta = \frac{\Delta I_C}{\Delta I_B}$

In the CC configuration the current amplification factor, $\gamma = \frac{\Delta I_E}{\Delta I_B}$

10. Why h parameter model is important for BJT

It is important because:

1. its values are used on specification sheets
2. it is one model that may be used to analyze circuit behavior
3. it may be used to form the basis of a more accurate transistor model

11. What do you meant by multi emitter transistor.

Transistor–transistor logic (**TTL**) is a class of digital circuits built from bipolar junction transistors (BJT) and resistors. It is called *transistor–transistor logic* because both the logic gating function (e.g., AND) and the amplifying function are performed by transistors.

TTL is notable for being a widespread integrated circuit (IC) family used in many applications such as computers, industrial controls, test equipment and instrumentation, consumer electronics, synthesizers, etc.

12. In a CR connection, the value of I_E is 6.28 mA and the collector current Ic is 6.20 mA. Determine d.c. current gain.

Given: $I_E = 6.28$ mA and $I_C = 6.20$ mA

We know that common-base d.c. current gain,

$$\alpha = \frac{I_C}{I_E} = \frac{6.20 \times 10^{-3}}{6.28 \times 10^{-3}} = 0.987$$

13. The transistor has I_E = 10 mA and α = 0.98. Find the value of base and collector currents.

Solution:

Given: $I_E = 10$ mA and $\alpha = 0.98$

The common-base d.c. current gain, $\alpha = \frac{I_C}{I_E}$

i.e. $0.98 = \frac{I_C}{10}$

Therefore $I_C = 0.98 \times 10 = 9.8$ mA

The emitter current $I_E = I_B + I_C$

i.e. $10 = I_B + 9.8$

Therefore, $I_B = 0.2$ mA

14. If a transistor has a α of 0.97 find the value of β. If β=200, find the value of α.

Solution:

If $\alpha = 0.97, \beta = \frac{\alpha}{1-\alpha} = \frac{0.97}{1-0.97} = 32.33$

If $\beta = 200, \alpha = \frac{\beta}{\beta+1} = \frac{200}{200+1} = 0.995$

15. Give some applications of BJT.

The BJT remains a device that excels in some applications, such as discrete circuit design, due to the very wide selection of BJT types available, and because of its high transconductance and output resistance compared to MOSFETs.

The BJT is also the choice for demanding analog circuits, especially for very-high-frequency applications, such as radio-frequency circuits for wireless systems.

Bipolar transistors can be combined with MOSFETs in an integrated circuit by using a Bi CMOS process of wafer fabrication to create circuits that take advantage of the application strengths of both types of transistor.

PART B

1. Explain the operation of NPN and PNP transistors (8)
2. Explain the input and output characteristics of a transistor in CB configuration. (10)
3. Draw the circuit diagram of a NPN transistor CE configuration and the input and output characteristics. Also define its operating regions. (12)
4. Explain the input and output characteristics of a transistor in CC configuration. (10)
5. Give the comparison of CE,CB, CC configuration. (6)
6. Give the relationship between α, β and γ of a transistor (6)
7. Explain briefly about the Gummel Poon model (10)
8. How multi emitter transistor is working? Explain it with neat diagram. (12)
9. Explain details about the Ebers Moll model. (8)

UNIT III

FIELD EFFECT TRANSISTORS

PART A

1. Why it is called field effect transistor?

The drain current I_D of the transistor is controlled by the electric field that extends into the channel due to reverse biased voltage applied to the gate, hence this device has been given the name Field Effect Transistor.

2. Why FET is called voltage controlled device.

FET the value of the current depends upon the value of the voltage applied at the gate and drain. So it is *known as voltage controlled device*.

3. Define the term threshold voltage.

The **threshold voltage**, commonly abbreviated as $\mathbf{V_{th}}$, of a field-effect transistor (FET) is the value of the gate–source voltage when the conducting channel just begins to connect the source and drain contacts of the transistor, allowing significant current.

The threshold voltage of a junction field-effect transistor is often called **pinch-off voltage** instead, which is somewhat confusing since "pinch off" for an insulated-gate field-effect transistor is used to refer to the channel pinching that leads to current saturation behaviour under high source–drain bias, even though the current is never off. The term "threshold voltage" is unambiguous and refers to the same concept in any field-effect transistor.

4. What is channel length modulation.

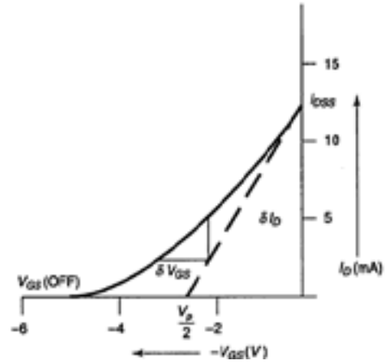
One of several short-channel effects in MOSFET scaling, **channel length modulation** (**CLM**) is a shortening of the length of the inverted channel region with increase in drain bias for large drain biases.

As the drain voltage increases, its control over the current extends further toward the source, so the uninverted region expands toward the source, shortening the length of the channel region, the effect called *channel-length modulation*.

5. Compare JFET with BJT.

1. FET operation depends only on the flow of majority carriers-holes for P-channel FETs and electrons for N-channel FETs. Therefore, they are called Unipolar devices. Bipolar transistor (BJT) operation depends on both minority and majority current carriers.
2. As FET has no junctions and the conduction is through an N-type or P-type semiconductor material, FET is less noisy than BJT.
3. As the input circuit of FET is reverse biased, FET exhibits a much higher input impedance (in the order of 100 M Ω) and lower output impedance and there will be a high degree of isolation between input and output. So, FET can act as an excellent buffer amplifier but the BJT has low input impedance because its input circuit is forward biased.
4. FET is a voltage controlled device, i.e. voltage at the input terminal controls the output current, whereas BJT is a current controlled device, i.e. the input current controls the output current.
5. FETs are much easier to fabricate and are particularly suitable for ICs because they occupy less space than BJTs.

6. Draw the transfer characteristics curve for JFET.



7. Differentiate between N and P channel FETs

1. In an N channel JFET the current carriers are electrons, whereas the current carriers are holes in a P channel JFET.
2. Mobility of electrons is large in N channel JFET; Mobility of holes is poor in P channel JFET.
3. The input noise is less in N channel JFET than that of P channel JFET.
4. The transconductance is larger in N channel JFET than that of P channel JFET.

8. Write some applications for JFET.

1. FET is used as a buffer in measuring instruments, receivers since it has high input impedance and low output impedance.
2. FETs are used in RF amplifiers in FM tuners and communication equipment for the low noise level.
3. Since the input capacitance is low, FETs are used in cascade amplifiers in measuring and test equipments.
4. Since the device is voltage controlled, it is used as a voltage variable resistor in operational amplifiers and tone controls.
5. FETs are used in mixer circuits in FM and TV receivers, and communication equipment because inter modulation distortion is low.

9. Compare MOSFET with JFET.

1. In enhancement and depletion types of MOSFET, the transverse electric field induced across an insulating layer deposited on the semiconductor material controls the conductivity of the channel. In the JFET the transverse electric field across the reverse biased PN junction controls the conductivity of the channel.
2. The gate leakage current in a MOSFET is of the order of 10^{-12} A. Hence the input resistance of a MOSFET is very high in the order of 10^{10} to $10^{15}\ \Omega$. The gate leakage current of a JFET is of the order of 10^{-9} A and its input resistance is of the order of $10^{8}\ \Omega$.
3. The output characteristics of the JFET are flatter than those of the MOSFET and hence, the drain resistance of a JFET (0.1 to 1 MΩ) is much higher than that of a MOSFET (1 to 50 kΩ).
4. JFETs are operated only in the depletion mode. The depletion type MOSFET may be operated in both depletion and enhancement mode.
5. Comparing to JFET, MOSFETs are easier to fabricate.

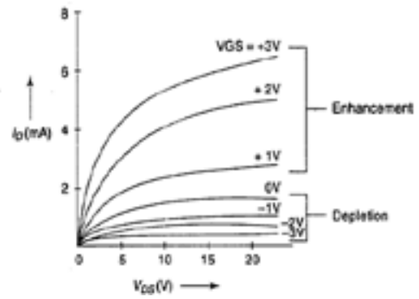
10. Compare N channel MOSFET with P channel MOSFET.

1. The P-channel enhancement MOSFET is very popular because it is much easier and cheaper to produce than the N-channel device.
2. The hole mobility is nearly 2.5 times lower than the electron mobility. Thus, a P-channel MOSFET occupies a larger area than an N-channel MOSFET having the same I_D rating.
3. The drain resistance of P-channel MOSFET is three times higher than that for an identical N-channel MOSFET.
4. The N-channel MOSFET has the higher packing density which makes it faster in switching applications due to the smaller junction areas and lower inherent capacitances.
5. The N-channel MOSFET is smaller for the same complexity than P-channel device.

11. Differentiate between current voltage relationships of the N channel and P channel MOSFET

N-Channel MOSFET	*P-Channel MOSFET*
Saturation region ($V_{DS} > V_{DS}$(sat)) $I_D = K_N(V_{GS} - V_{TN})^2$	Saturation region ($V_{SD} > V_{SD}$ (sat)) $I_D = K_P(V_{SG} + V_{TP})^2$
Non saturation region ($V_{DS} < V_{DS}$(sat)) $I_D = K_N[2(V_{GS} - V_{TN})V_{DS} - V_{DS}^2]$	Non saturation region ($V_{SD} < V_{SD}$(sat)) $I_D = K_P[2(V_{SG} + V_{TP})V_{SD} - V_{DS}^2]$
Transition point $V_{DS}(\text{sat}) = V_{GS} - V_{TN}$	Transition point $V_{SD}(\text{sat}) = V_{SG} + V_{TP}$
Enhancement mode $V_{TN} > 0$	Enhancement mode $V_{TP} < 0$
Depletion mode $V_{TN} < 0$	Depletion mode $V_{TP} > 0$

12. Draw the V-I characteristics curve of MOSFET.



PART B

1. Explain the operation of JFET and derive the drain and transfer characteristics. (16)
2. With neat diagram explain the operation of MOSFET in Depletion mode and derive its current equations (16)
3. With neat diagram explain the operation of MOSFET in Enhancement mode and derive its current equations (16)
4. Give some characteristics of MOSFET. (8)
5. Explain the operation of dual gate MOSFET (8)

UNIT IV
SPECIAL SEMICONDUCTOR DEVICES
PART A

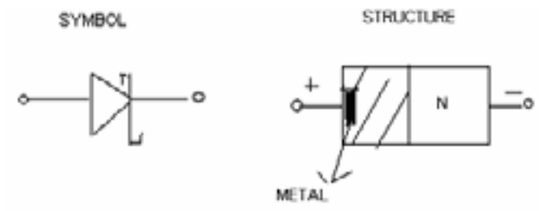
1. What is a metal semiconductor contact?

A metal semiconductor contact is a contact between a metal and a semiconductor which according to the doping level and requirement may act as a rectifying diode or just a simple contact between a semiconductor device and the outside world.

2. Define contact potential in metal semiconductor contact.

The difference of potential between the work function of metal and the work function of semiconductor in a metal semiconductor contact is termed as contact potential.

3. Give the symbol and structure of schottky diode.



4. Give the applications of schottky diode.

1. It can switch off faster than bipolar diodes
2. It is used to rectify very high frequency signals (>10 MHZ)
3. as a switching device in digital computers.
4. It is used in clipping and clamping circuits.
5. It is used in communication systems such as frequency mixers, modulators and detectors.

5. Compare between schottky diode and conventional diode.

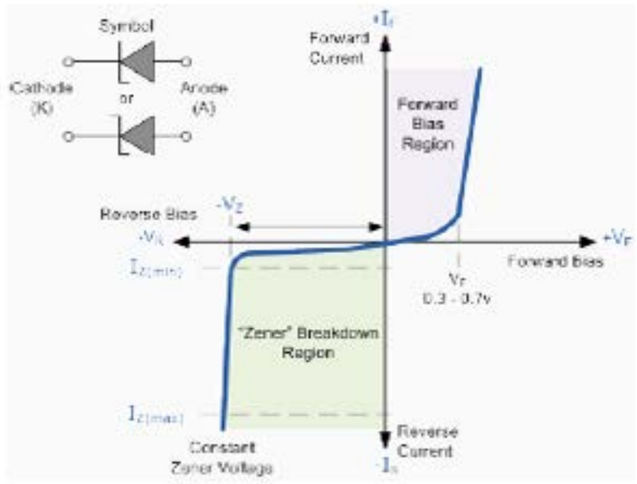
PN junction diode	Schottky
1. Here the contact is established between two semiconductors	1. Here the contact is established between the semiconductor and metal
2. current conduction is due to both majority and minority carriers	2. current conduction is only due to majority carriers
3. large reverse recovery time	3. Small reverse recovery time
4. barrier potential is high about 0.7 V	4. Barrier potential is low about 0.25 V
5. switching speed is less	5. switching speed is high
6. cannot operate at high frequency	6. can operate at very high frequency (> 300MHz)

6. Why zener diode is often preferred than PN diode.

When the reverse voltage reaches breakdown voltage in normal PN junction diode the current through the junction and the power dissipated at the junction will high. Such an operation is destructive and the diode gets damaged.

Whereas diode can be designed with adequate power dissipation capabilities to operate in breakdown region. That diode is known as zener diode. It is heavily doped than ordinary diode.

7. Draw the V-I characteristics curve for zener diode.



8. What is zener breakdown?

Zener break down takes place when both sides of the junction are very heavily doped and Consequently the depletion layer is thin and consequently the depletion layer is tin. When a small value of reverse bias voltage is applied , a very strong electric field is set up across the thin depletion layer. This electric field is enough to break the covalent bonds. Now extremely large number of free charge carriers are produced which constitute the zener current. This process is known as zener break down.

9. What is avalanche break down?

When bias is applied, thermally generated carriers which are already present in the diode acquire sufficient energy from the applied potential to produce new carriers by removing valence electron from their bonds. These newly generated additional carriers acquire more energy from the potential and they strike the lattice and create more number of free electrons and holes. This process goes on as long as bias is increased and the number of free carriers gets multiplied. This process is termed as avalanche multiplication. Thus the breaks down which occur in the junction resulting in heavy flow of current is termed as avalanche break down.

10. What is tunneling phenomenon?

The phenomenon of penetration of the charge carriers directly though the potential barrier instead of climbing over it is called as tunneling.

11. Give the application of tunnel diode.

As logic memory storage device

- As microwave oscillator
- In relaxation oscillator circuit
- As an amplifier
- As an ultra-high speed switch

12. Give the advantages and disadvantages of tunnel diode

Advantages

- Low noise
- Ease of operation
- High speed
- Low power

Disadvantages

- Voltage range over which it can be operated is 1 V less.
- Being a two terminal device there is no isolation between the input and output circuit.

13. What is backward diode?

The backward diode is a diode in which the doping level is moderate. The forward current in this case is very small, very much similar to that of the reverse current in the conventional diode.

14. How does the avalanche breakdown voltage vary with temperature?

In lightly doped diode an increase in temperature increases the probability of collision of electrons and thus increases the depletion width. Thus the electrons and holes needs a high Voltage to cross the junction. Thus the avalanche voltage is increased with increased temperature.

15. How does the zener breakdown voltage vary with temperature?

In heavily doped diodes, an increase in temperature increases the energies of valence electrons, and hence makes it easier for these electrons to escape from covalent bonds. Thus less voltage is sufficient to knock or pull these electrons from their position in the crystal and convert them in to conduction electrons. Thus zener break down voltage decreases with temperature.

16. What is a tunnel diode?

The tunnel diode is a pn junction diode in which the impurity concentration is greatly increased about 1000 times higher than a conventional PN junction diode thus yielding a very thin depletion layer. This diode utilizes a phenomenon called tunneling and hence the diode is referred as tunnel diode.

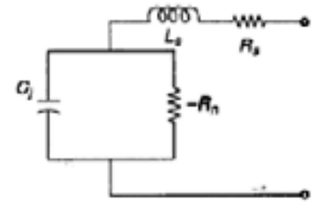
17. What is tunneling phenomenon?

The phenomenon of penetration of the charge carriers directly though the potential barrier instead of climbing over it is called as tunneling.

18. What is a LED?

A PN junction diode which emits light when forward biased is known as Light emitting diode (LED).

19. Draw equivalent circuit of tunnel diode



Equivalent circuit of tunnel diode

- This is the equivalent circuit of tunnel diode when biased in negative resistance region.
- At higher frequencies the series R and L can be ignored.
- Hence equivalent circuit can be reduced to parallel combination of junction capacitance and negative resistance.

20. What is varactor diode?

A varactor diode is best explained as a variable capacitor. Think of the depletion region as a variable dielectric. The diode is placed in reverse bias. The dielectric is "adjusted" by reverse bias voltage changes.

- Junction capacitance is present in all reverse biased diodes because of the depletion region.
- Junction capacitance is optimized in a varactor diode and is used for high frequencies and switching applications.
- Varactor diodes are often used for electronic tuning applications in FM radios and televisions.

PART B

1. Explain about the ohmic contact of metal semiconductor junction (8)
2. Explain the operation of zener diode and how it is used as a voltage regulator. (12)
3. Explain the operation of tunnel diode and draw its equivalent circuit. (12)
4. With neat diagram give the working principle of LASER diode (8)
5. Explain the operation of varactor diode (8)
6. With neat diagram explain about varactor diode. (8)

UNIT V
POWER DEVICES AND DISPLAY DEVICES
PART A

1. What is intrinsic stand- off ratio of an UJT?

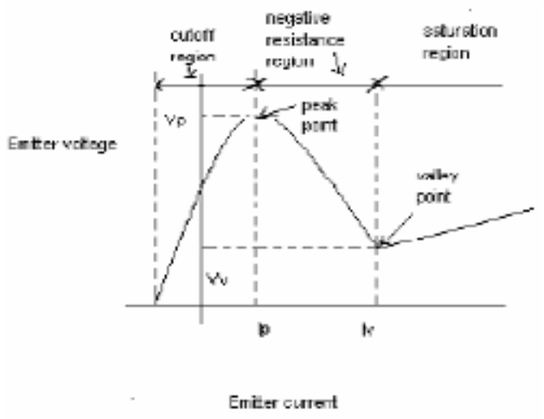
If a voltage V_{BB} is applied between the bases with emitter open the circuit will behave as a potential divider. Thus the voltage V_{BB} will be divided across R_{B1} and R_{B2}

Voltage across resistance R_{B1},

$$V_1 = \frac{R_{B1}}{R_{B1}+R_{B2}} * V_{BB} = \frac{R_{B1}}{R_{BB}} * V_{BB} = \eta * V_{BB}$$

The resistance ratio $\eta = R_{B1} / R_{BB}$ is known as intrinsic stand -off ratio.

2. Give the V-I Characteristics of UJT.



3. What are the regions in the VI characteristics of UJT?

1. Cut-off region
2. Negative resistance region.
3. Saturation region

4. What is meant by negative resistance region of UJT?

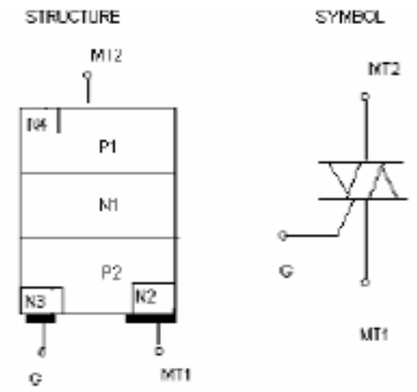
In a UJT when the emitter voltage reaches the peak point voltage, emitter current starts flowing. After the peak point any effort to increase in emitter voltage further leads to sudden increase in the emitter current with corresponding decrease in emitter voltage, exhibiting negative resistance. This takes place until the valley point is reached. This region between the peak point and valley point is called negative resistance region.

5. Mention the applications of UJT.

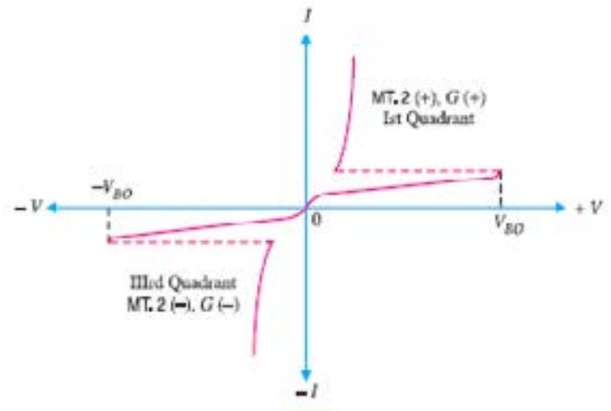
1. It is used in timing circuits
2. It is used in switching circuits
3. It is used in phase control circuits
4. It can be used as trigger device for SCR and triac.
5. It is used in saw tooth generator.
6. It is used for pulse generation

7. What is a TRIAC? Give the symbol and structure of TRIAC.

TRIAC is a three terminal bidirectional semiconductor switching device. It can conduct in both the directions for any desired period. In operation it it is equivalent to two SCR's connected in antiparallel.



8. Draw the V-I characteristics for TRIAC.

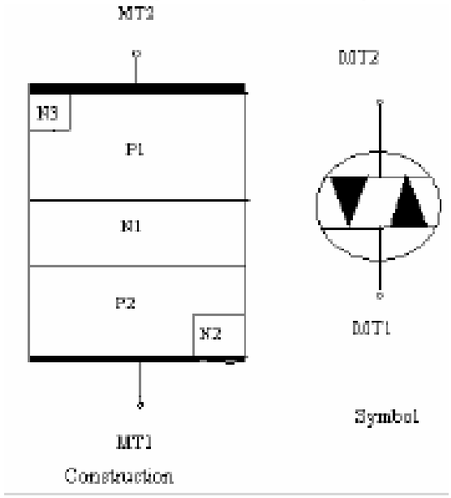


9. Give the application of TRIAC.

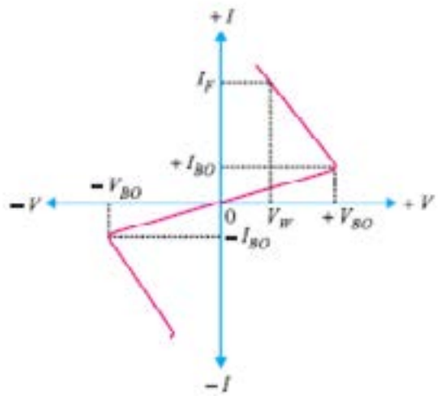
1. Heater control
2. Motor speed control
3. Phase control
4. Static switches

10. What is a DIAC? Give the basic construction and symbol of DIAC.

DIAC is a two terminal bidirectional semiconductor switching device. . It can conduct in either direction depending upon the polarity of the voltage applied across its main terminals. In operation DIAC is equivalent to two 4 layer diodes connected in antiparallel.



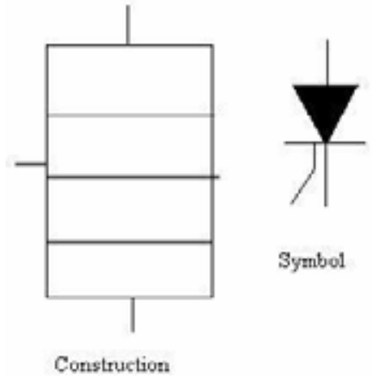
11. Draw the V-I curve for DIAC



12. Give some applications of DIAC.

1. To trigger TRIAC
2. Motor speed control
3. Heat control
4. Light dimmer circuits

13. Give the basic construction and symbol of SCR.



14. What is a SCR?

A silicon controller rectifier (SCR) is a three terminal, three junction semiconductor device that acts as a true electronic switch. It is a unidirectional device. It converts alternating current into direct current and controls the amount of power fed to the load.

15. Define break over voltage of SCR.

Break over voltage is defined as the minimum forward voltage with gate open at which the SCR starts conducting heavily.

16. Why SCR cannot be used as a bidirectional switch.

SCR can do conduction only when anode is positive with respect to cathode with proper gate current. Therefore, SCR operates only in one direction and cannot be used as bidirectional switch.

17. How turning ON of SCR is done?

1. By increasing the voltage across SCR above forward break over voltage.
2. By applying a small positive voltage at gate.
3. By rapidly increasing the anode to cathode voltage.
4. By irradiating SCR with light.

18. How turning OFF of SCR is done?

1. By reversing the polarity of anode to cathode voltage.
2. By reducing the current through the SCR below holding current.
3. By interrupting anode current by means of momentarily series or parallel switching

19. Define holding current in a SCR.

Holding current is defined as the minimum value of anode current to keep the SCR ON.

20. List the advantages of SCR.

1. SCR can handle and control large currents.
2. Its switching speed is very high
3. It has no moving parts, therefore it gives noiseless operation.
4. Its operating efficiency is high.

21. List the application of SCR.

1. It can be used as a speed controller in DC and AC motors.
2. It can be used as an inverter.
3. It can be used as a converter
4. It is used in battery chargers.
5. It is used for phase control and heater control.
6. It is used in light dimming control circuits

22. What is meant by latching.

The ability of SCR to remain conducting even when the gate signal is removed is called as latching.

23. Define forward current rating of a SCR.

Forward current rating of a SCR is the maximum anode current that it can handle without Destruction

24. List the important ratings of SCR.

1. Forward break over voltage
2.Holding current
3.Gate trigger current
4.Average forward current
5.Reverse break down voltage.

25. Compare SCR with TRIAC

SCR	TRIAC
1. unidirectional current	1. bidirectional current
2. triggered by positive pulse at gate	2. triggered by pulse of positive or negative at gate
3. fast turn off time	3,. Longer turn off time
4. large current ratings	4. lower current ratings

26. Differentiate BJT and UJT.

BJT	UJT
1. It has two PN junctions	1. It has only one PN junctions
2. three terminals present are emitter, base, collector	2. three terminals present are emitter, base1,base2
3. basically a amplifying device	3. basically a switching device

27. What is Shockley diode (PNPN diode)?

Shockley diode is a four layered PNPN silicon diode. It is a low- current SCR without a gate. This device is switched ON when the anode to cathode voltage is increased to forward switching voltageVS which is equivalent to SCR forward break over voltage.

28. What is a thyristor?

Thyristor is a semiconductor device having three or more junctions .Such a device acts as a switch without any bias and can be fabricated to have voltage ratings of several hundred and current ratings from a few amperes to almost thousand amperes.

29. What are the types of thyristors?

1. Unidirectional thyristors
2. Bidirectional thyristors
3. Low-power thyristors

30. Give the various triggering devices for thyristors.

1. SCR
2. UJT
3. DIAC
4. TRIAC

31. State the principle of operation of an LED

When a free electron from the higher energy level gets recombined with the hole, it gives the light output. Here in case of LEDs, the supply of higher level electrons is provided by the battery connection.

32. Give the advantages of LED

1. They are small in size
2. Light in weight
3. Mechanically Rugged
4. Low Operating Temperature
5. Switch on time is very small
6. Available in different colours
7. They have longer life compared to lamps
8. Linearity is better
9. Compatible with IC
10. Low Cost

33. State some disadvantages of LED

- Output power gets affected by the temperature radiation.
- Quantum efficiency is low.
- Gets damaged due to over –voltage and over-current.

34. List the applications of LED

- They are used in various types of displays.
- They are used as source in opto-couplers.
- Used in infrared remote controls.
- Used as indicator lamps.
- Used as indicators in measuring devices.

35. Give some advantages and disadvantages for LCD

Advantages of LCD

- Low power is required
- Good contrast
- Low cost

Disadvantages of LCD

- Speed of operation is slow
- LCD occupy a large area
- LCD life span is quite small, when used on d.c. Therefore, they are used with a.c. suppliers.

36. Give applications of LCD

- Used as numerical counters for counting production items.
- Analog quantities can also be displayed as a number on a suitable device. (e.g.) Digital multimeter.
- Used for solid state video displays.
- Used for image sensing circuits.
- Used for numerical display in pocket calculators.

37. Compare LEDs and LCDs.

LEDs	LCDs
1. More power is required.	1. Less power is required.
2. Fastest displays	2. Slowest displays.
3. More life.	3. Less life.
4. LED is light source.	4. LCD is not light source. It is a light reflector.
5. More temperature range.	5. Less temperature range
6. Mounting is easy	6. Mounting is difficult.

38. Give some notes on CCD.

A **charge-coupled device** (**CCD**) is a device for the movement of electrical charge, usually from within the device to an area where the charge can be manipulated, for example conversion into a digital value. This is achieved by "shifting" the signals between stages within the device one at a time. CCDs move charge between capacitive *bins* in the device, with the shift allowing for the transfer of charge between bins. The CCD is a major piece of technology in digital imaging. In a CCD image sensor, pixels are represented by p-doped MOS capacitors.

PART B

1. Explain the construction, operation, V-I characteristics and application of SCR and explain its two transistor model. (16)
2. Explain the construction, operation, equivalent circuit V-I characteristics and application of UJT (16)
3. Explain the construction, operation, equivalent circuit V-I characteristics and application of TRIAC (16)
4. Explain the construction, operation, equivalent circuit V-I characteristics and application of DIAC (16)
5. Explain: (a) DMOS (8) (b) VMOS (8)
6. Explain the operation of Photo transistor (8)
7. With neat diagram explain the operation of Solar cell. (8).
8. Explain: (a) Power BJT (8) (b) Power MOSFET (8)