2015

Section A *(alternatives are to be noted)*

Question: 1 [2×5=10]

Establish the relation between drift velocity of electron and current density in metallic conductor.

Answer:

The electric current flowing through a conductor is proportional to the drift velocity of the electrons.

Consider a conductor XY having its 2 ends raised 2 potentials V_1 & V_2. the electrons get drifted from Y 2 X. (assume $V_1>V_2$)
any electron crossing section AB travels a distance '(Vd)t' upto section CD in time 't'. Thus all d electrons contained ion d cylinder ABCD have crossed AB in 't' secs.
If 'n' is no of free electrons per unit vol.of a conductor.
And d no 'N' of electrons crossing AB in 't' secs. is given by

N=n X vol. of ABCD cylinder.
=n X A X Vd X t
where 'A' is d area of cross section of d conductor. Also if 'e' is d charge on one electron d charge 'q' crossing in 't' seconds.

q = N X e
=>q = nA(Vd)te
=> q/t = nA(Vd)e.
As,i=q/t

So, i is directly proportional 2 Vd.(since n,A,e are const).

OR

Why is potentiometer preferred to voltmeter for the measurement of emf of a cell? Explain.

Answer:

The voltmeter measures the voltage across the terminals of a cell when the cell is in closed circuit.(that is when current is flowing through the cell.) This voltage is in general not equal to the "emf" of the cell. In fact it is equal tp the emf MINUS the potential drop across the internal resistance of the cell. Thus voltmeter reading, V = Emf - i*r, where r is the internal resistance.

In contrast, the voltage measured using potentiometer is the voltage across the terminals of the cell when current is not flowing through it. (Because at null point there is no current through the cell). This voltage is exactly the emf of the cell.

Further, the accuracy of a potentiometer can be increased to a great extent by increasing the length of the "potentiometer wire." The accuracy of a voltmeter cannot be increased beyond a limit.

Question: 2 [1+1]

How is a galvanometer converted into a voltmeter?

Answer:

Voltmeter is an instrument used to measure the potential difference between any two points in a circuit. It is always connected in parallel to the circuit across the component where we want know the potential difference and will not alter the current flowing through the circuit neither will it draw current from the main circuit.

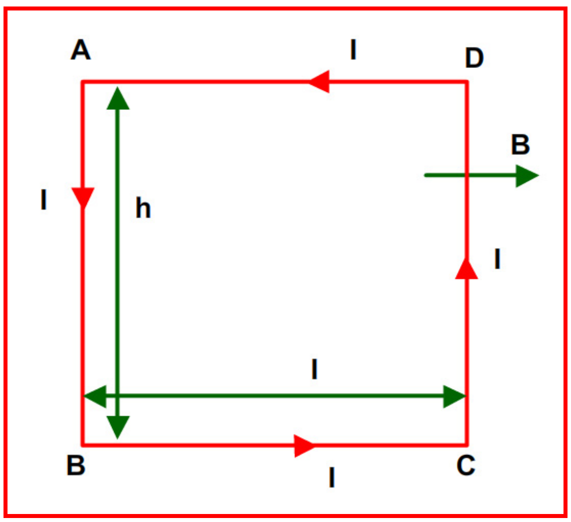
The current should be negligible through the voltmeters if the resistance of the voltmeter should be high. For an ideal voltmeter the resistance should be infinity which is impractical but. A galvanometer is the sensitive instrument used to measure small currents.

OR

The plane of a suspended current carrying rectangular coil makes an angle θ with the direction of uniform magnetic field. Calculate the torque acting on the coil.

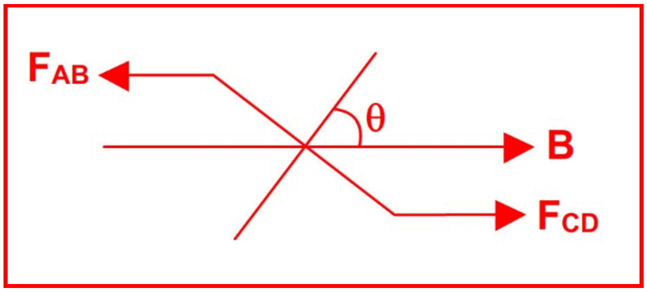
Answer:

Consider a rectangular loop ABCD being suspended in a uniform magnetic field B and direction of B is parallel to the plane of the coil as shown below in the figure



- Magnitude of force on side AM according to the equation(13) is
  F_{AB}=IhB (angle between **I** and B is 90^0)
  And direction of force as calculated from the right hand palm rule would be normal to the paper in the upwards direction
- Similarly magnitude of force on CD is
  F_{CD}=ihB
  and direction of F_{CD} is normal to the page but in the downwards direction going into the page
- The forces F_{AB} and F_{CD} are equal in magnitude and opposite in direction and hence they constitute a couple
- Torque τexerted by this couple on rectangular loop is
  τ=IhlB
  Since torque = one of the force * perpendicular distance between them
- No force acts on the side BC since current element makes an angle θ=0 with B due to which the product (**ILXB**) becomes equal to zero
- Similarly on the side DA ,no magnetic force acts since current element makes an angle θ=180^0 with **B**
- Thus total torque on rectangular current loop is
  τ=IhlB
  =IAB --(15)
  Where A=hl is the area of the loop
- If the coil having N rectangular loop is placed in magnetic field then torque is given by
  τ=NIAB ----(16)

- Again if the normal to the plane of coil makes an angle θ with the uniform magnetic field as shown below in the figure then



- τ=NIABsinθ
- We know that when an electric dipole is placed in external electric field then torque experienced by the dipole is
  τ=**P** X **E**=PEsinθ
  Where **P** is the electric dipole moment
- comparing expression for torque experienced by electric dipole with the expression for torque on a current loop i.e ,
  τ=(NIA)Bsinθ
  if we take NIA as magnetic dipole moment (m) analogues to electric dipole moment (p),we have
  m=NIA -- (18)
  then
  τ=**m** X **B** -- (19)
- The coil thus behaves as a magnetic dipole
- The direction of magnetic dipole moment lies along the axis of the loop
- This torque tends to rotate the coil about its own axis .Its value changes with angle between the plane of the coil and the direction of the magnetic field
- Unit of magnetic moment is Ampere.meter^2 (Am^2)
- Equation (18) and (19) are obtained by considering a rectangular loop but this equations are valid for plane loops of any shape

Question: 3 [1+1]

An electromagnetic wave of the frequency 25 MHz travels in free space alone x-direction. At a particular point in space and time. $\bar{E} = 6.3\,\hat{j}\,\frac{\text{volt}}{\text{meter}}$. What is the value and direction of $\bar{B}$ the wave at the point?

Answer:

Magnitude of magnetic field $\vec{B}$

$B = \frac{E}{C} = \frac{6.3}{3x10^8}$

$= 2.1 \times 10^{-8}$ wb.m^{-2}

Direction of wave propagation: x axis

Direction of $\vec{E}$: y axis (unit vector is directed along $\vec{J}$)

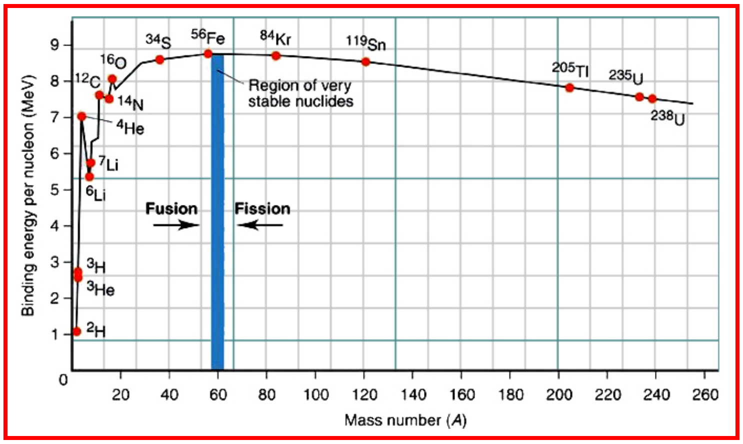
∴ $\vec{B}$ is directed along z-axis.

∴ $\vec{B} = (2.1 \times 10^{-8})\,\hat{u}$ wb.m^{-2}

Question: 4

Draw the variation of binding energy per nucleon with mass number of atoms and indicate the stable and unstable regions on the diagram. [1+1]

Answer:



The greater the binding energy per nucleon, the more stable the nuclide.
Nuclear Stability Two key factors determine the stability of a nuclide: - the number of neutrons (N), the number of protons (Z), and their ratio (N/Z), and - the total mass of the nuclide. A plot of number of neutrons vs. number of protons for all stable nuclides produces a band of stability that gradually curves above the line for N = Z. - Lighter nuclides are stable when N = Z. - As Z increases, the N/Z for stable nuclei gradually increases. - All nuclides with Z > 83 are unstable.

A plot of number of neutrons vs. number of protons for the stable nuclides. Fission is triggered by uranium absorbing a neutron, which renders the nucleus unstable. The result of the instability is the nucleus breaking up (in any one of many different ways), in the process producing more neutrons, which in turn hit more uranium atoms and make them unstable and so on. This chain reaction is the key to fission reactions, but it can lead to a runaway process, as in a nuclear bomb.

OR

Write down different condition in connection with the hydrogen atom. What is the value of Bohr's radius in SI system? [1+1]

Answer:

According to de Broglie's hypothesis, if the mass of electron = m and its speed = u, then

$$\lambda = \frac{h}{mv} \left[h = \text{planck's constant}\right]$$

$$\text{So, } 2\pi r = h\frac{h}{mv} \quad [\text{where } h = 1,2,3...]$$

$$\text{or, } mvr = h\frac{h}{2\pi}$$

For different value of n, the value of r and u will be different, if these values are taken as r_n and v_n for definite value of n, then m

$$mu_n r_n = h\frac{h}{2\pi} \quad [\text{where } h = 1,2,3...]$$

This is Bohr's quantum condition.
First Bohr radius,

$r_0 = 0.53\ \mathring{A} = 0.053\ \text{nm} = 5.3 \times 10^{-11}\text{m}$

Question: 5

Write down different modes by which electromagnetic waves can propagate from transmitting to receiving antenna. Mention one important use of microwaves. [1+1]

Answer:

When the electromagnetic waves are propagated from the transmitter antenna, it travels in a free space, up to receiver antenna. The movement of theses electromagnetic waves took place by different ways. Each way of propagation is

- Ground waves
- Sky Waves
- Space Waves

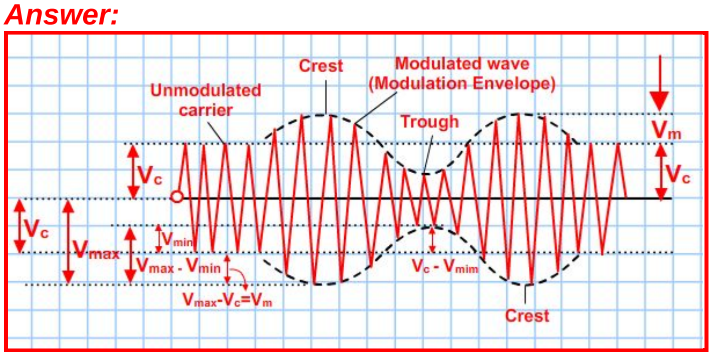
Microwaves are used in:

a. In microwave-ovens.
b. In radar systems.

OR

Draw a neat diagram of amplitude modulated waveform. Write down the expression of modulation index and show each term in the diagram. [1+1]

Answer:



Section B *(alternatives are to be noted)*

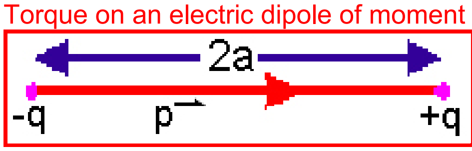
[3 × 9=27]

Question: 6

Define electric dipole moment. Find the torque acting on a dipole when it is placed in a uniform electric field $\bar{E}$. [1+2]

Answer:

In physics, the electric dipole moment is a measure of the separation of positive and negative electrical charges within a system, that is, a measure of the system's overall polarity. The electric field strength of the dipole is proportional to the magnitude of dipole moment.
Torque on an electric dipole of moment p when placed in a uniform electric field E is



That is the electric dipole moment is numerically equal to the torque acting on it when it is placed in a uniform electric field of strength $1NC_{\vec{p}} = q.2_{\vec{a}}$ with its dipole moment perpendicular to the direction of electric field.
Consider, an electric dipole consisting of charge –q at A and +q at B separated by a distance 2l. So, dipole moment $\vec{p} = q.2l$. Suppose, the dipole make an angle with the uniform electric field. $\vec{E}$ and force on charge qE, opposite to the direction of $\vec{E}$. This forces are equal and opposite in direction. Therefore net force on the dipole, $\vec{F}_{net} = q\vec{E} - q\vec{E} = 0$ net force on electric dipole in uniform electric field is zero. If the magnitude of the torque is j, then
J = other force $\times$ perpendicular distance
= qE $\times$ AC
= qE $\times$ 2l sinθ = q $\times$ 2l $\times$ Esinθ
J = PE sinθ (Proved).

OR

State Gauss's theorem in electrostatics. Find the electric flux through a surface of area $50m^2$ in plane in the electric field $\vec{E} = 3\hat{i} + 2\hat{j} + \hat{k}$ Vm^{-1}

Answer:
See topics on 'Gauss's theorem'.
Gauss's theorem: The net electric flux linked with a closed surface is $\frac{1}{\varepsilon}$ time the net charge within the surface.

$Q = \oint_S \vec{E}.d\vec{S} = \frac{q}{\varepsilon}$

The unit vector along the normal of the XY plane i.e. z axis is $\hat{u}$. So the area vector = $50\hat{u}m^2$

$\therefore$ Electric flux $= \int \vec{E}.d\vec{S}$

$= \int \left(3\hat{i} + 2\hat{J} + \hat{u}\right).d\vec{S}$

$= 3\hat{i} + 2\hat{J} + \hat{u} \int d\vec{S}$

$= \left(3\hat{i} + 2\hat{J} + \hat{u}\right).50\hat{u}$

= 50 v.m

Question: 7
What is understood by capacitance of a capacitor? A900 pF capacitor is charged to 100 V by a battery. How much energy is store in the capacitor?

Answer:
The capacitance or capacity of a conductor is defined as the charge required to rise its potential by unity.
Here, C = 900 pF $\times$ 10^{-12} F
= 9 x 10^{-10} F

$\therefore$ Stored energy = $\frac{1}{2}CV^2$

= $\frac{1}{2} \times (9 \times 10^{-10}) \times 100^2$

= 4.5 $\times$ 10^{-6} J.

Question: 8

Define angle of dip at a place. What will be the value of the angle at the poles and at the equator of the earth? At what place on the earth's surface will be horizontal component if the earth's magnetic field and its vertical component be equal? [1+1+1]

Answer:

Angle of dip: The angle made by the intensity of earth's magnetic field with horizontal at any place on the earth is called dip or angle of dip at that place.

Angle of dip at any of the pole = 900.

Angle of dip at the equator = 00.

Now, $\tan\theta = \frac{V}{H}[\theta = \text{Angle of dip}]$

For V =H

$\tan\theta = 1 = 45^0$

$\theta = 45^0$

OR

State Amper's circuital law. Using this law obtain an expression for the intensity of the magnetic field on the axis of a torodal solenoid for a current of i ampere. [1+2]

Answer:

Amper's circuital law:

The line integral of the magnetic field vector along a closed path in magnetic field is equal to the product of the net current enclosed by the closed path and the permeability of vacuum.

Mathematically $\oint \vec{B}.d\vec{l} = \text{MoI}$

I = Net current enclosed by the closed path

Magnetic field of a toroid : Let radius of the ring of toroid = r . number of turn = N circumference of circular axis = $2\pi r$

Number of turns per unit n = $\frac{N}{2\pi r}$

Current passing in toroid = I if any part $S\vec{l}$ is taken as axis then magnetic field $\vec{B}$.

According Ampere's law,

$\oint B.d\vec{l} = \oint B.dl\cos 0^0$

$= B\oint dl = B.2\pi r$

Net current = NI [N = No of turn]

$B.2\pi r = \mu o\ NI$

$B = \mu o \frac{N}{2\pi r} I$

Or, $B = \mu o\ NI$

Question: 9

What are coherent sources? Green light of wavelength 5100 $\overset{0}{A}$ incident on a double slit. If the overall separation of 10 fringes in a screen 200 cm away from the slits is 2 cm, find the distance between the slits. [1+2]

Answer:

Coherent source:

There must be a constant phase difference between the two waves. With the change in phase of any wave there should be a simultaneous change in the other to the same extent. Such pair of source are called coherent source.

Here λ = 5100 $\overset{0}{A}$

Distance between the screen and the double slit,

D = 200 cm
Distance between 10 fringes 10x = 2cm
Distance between slits = d

Now, $x = \frac{D}{d}\lambda$

$10x = 10\frac{D}{d}\lambda$

or, $d = 10\frac{D}{10x}\lambda$

$= 10 \times \frac{200}{2}(5.1 \times 10)$

$= 5.1 \times 10^{-2}$ cm
= 0.051 cm

OR

What is understood by diffraction of light? In a single slit experiment, if the width of the slit increases, what will be the change of angular width of the central maxima? State Brewster's law. [1+1+1]

Answer:

Diffraction of light: Light rays, while passing round the edges of an obstacle or aperture, instead of travelling in a straight line, bend to some extent.

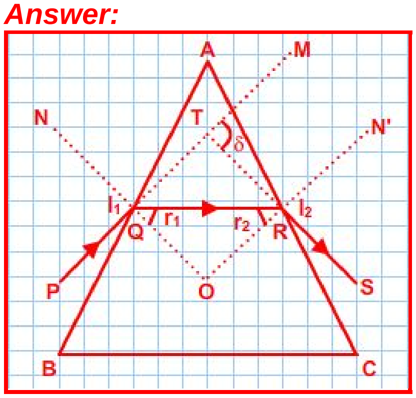
We know, $2\theta = \frac{2\lambda}{a}$

The angular width decreases in the same ratio at which the width of a slit increases.
SEE TOPICS ON 'BREWSTER'S LAW.

Question: 10 [2+1]

The refracting angle of an equilateral prism is A. Derive an expression for the angle of deviation for a ray of light incident on the refracting surface if the prism. Draw a neat curve to show the variation of deviation with angle of incident ray.

Answer:



Expression for angle of deviation:

Let the angle of the prism = ∠BAC = A. For refraction on the face AB, angle of incident = ∠PQN = i_1, and angle of refraction = ∠RQO = r_1 and for refraction on face AC, the angle of incident of QR = ∠QRO = r_2 and angle of refraction ∠N'RS = i_2.

Now, we get from ΔQRT, angle of deviation,

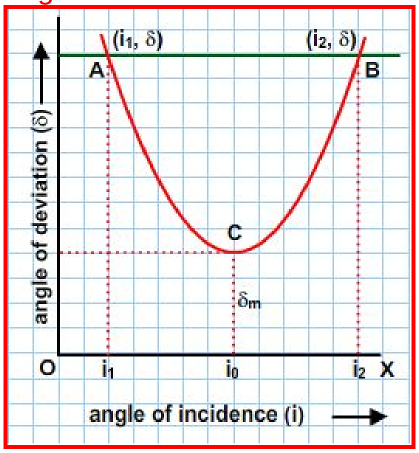
S = ∠MTR = ∠TQR + ∠TRQ = $\angle(i_1 - r_1) + (i_2 - r_1) = i_1 + i_2 - (r_1 - r_2)$

Now, from the quadrilateral AQOR as NO and N'O are normal on AB and AC.

So, A + ∠QOR = 180^0

Again, from the triangle QOR, ∠QOR + r_1 + r_2 and S = i_1 + i_2 – A

Angle of minimum deviation:



So, for every prism there is a fixed angle of incidence for which the deviation suffered by a ray of light traversing the prism becomes minimum. This minimum angle is called the angle of minimum deviation of a prism. The position of the prism in which the value of the deviation becomes minimum is called the position of minimum deviation of the prism. This position of the prism is unique, i.e., for only one position of the particular prism, the deviation becomes minimum.

OR

Calculate the speed of light in a medium whose critical angle is 45^0. Mention two practical applications of optical fibre. [2+1]

Answer:

If θc is the critical angle of any medium with respect to vacuum or air and M is the refractive Index of the medium,

$$\sin \theta_c = \frac{1}{m}$$

According to the question,

$$m = \frac{1}{\sin \theta_c} = \frac{1}{\sin 45^0} = \frac{1}{\frac{1}{\sqrt{2}}} = \sqrt{2}$$

Velocity of light C = 3 x 10^8 m/s

Application of obtical fibre:

i. Optical fibre are extensively used in medical sciences and communication system.

ii. It can be used to transmit high intensity laser eight inside the body for medical purpose.

Question: 11

What is meant by stopping potential in photoelectric emission? Does the stopping potential depend on?

i. The intensity

Answer:

Stopping potential does not depend on the intensity of the incident light.

ii. The frequency of the incident light? Explain.

Answer:
Stopping potential is directly proportional to the frequency of the incident light.
Stopping potential:
The minimum negative potential of anode with respect to photocathode, for which photoelectric current became zero, called stopping potential.

OR

What conclusion is drawn from Davission- Gremer experiment? Are matter waves electromagnetic waves? Explain. [1+2]

Answer:
Davisson-German experiment proved the existence of matter wave. It can be concluded form the experiment that any stream of particles behave as waves.
No, matter wave is not an electromagnetic wave, because the matter wave not associated with periodic wave vibrations of the electric and magnetic field.
∴ velocity of light in medium

$$v = \frac{c}{m} = \frac{3\times 10^8}{\sqrt{2}} m/s$$

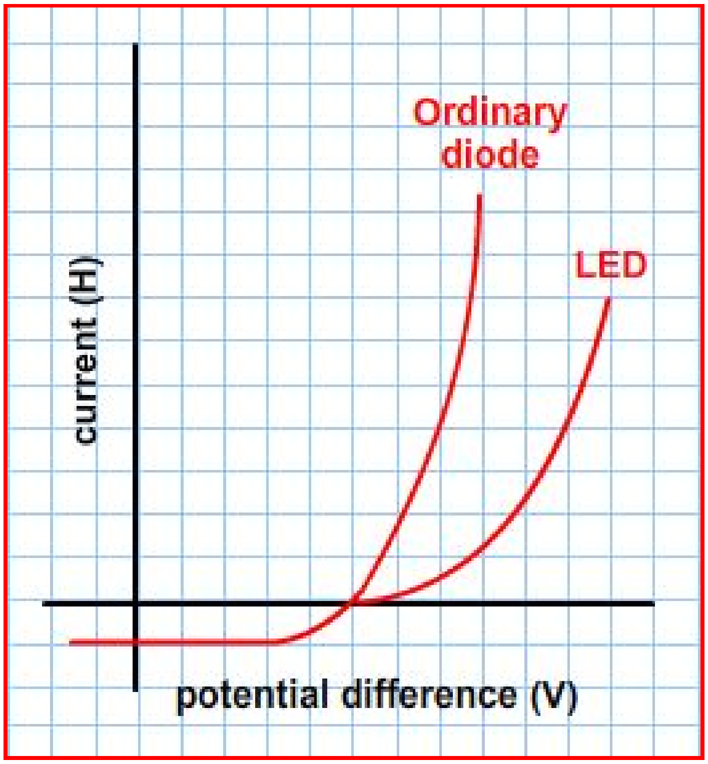
Question: 12
State radioactive decay law. Write down the relation between radius of the nucleus and mass number of an atom. What is isotone? Give an example. [1+1+1]

Answer:
Radioactive decay law:
This law states that the number of nuclei undergoing decay per unit time at any instant is proportional to the total number of nuclei in the sample at that instant.

Isotone:
Atoms having the same number of neutrons in their nucleus are isotone. Example: C^{14} and O^{16}.

Question: 13
Draw the I-V characteristics of a light emitting diode (LED) and explain its working principle. [1+2]

Answer:
See topics on 'Light emitting diode (LED)'.
I-V characteristic curve given below:



Working:

Principle:

When a p-n junction diode is forward-biased, both the electron and hole move towards the junction. As they cross the junction recombination of a few electron in the form of light. Actually photons are emitted from the p-n junction. The colour of emitted light depends on the energy of the photons. From the principle of conservation of momentum, it is found that a photon can be emitted only when an electron hole combine with equal and opposite momentum. This condition fulfilled in some crystal like GaP or SiC but not in Ge-Si. In the later, the released energy of electron-hole pair is converted into heat energy which only make the crystal heated. For this GaP or siC are used to construct LED.

OR

Draw the output characteristics of an n-p-n transistor in common emitter configuration for five base currents. What is an oscillator? [2+1]

Answer:

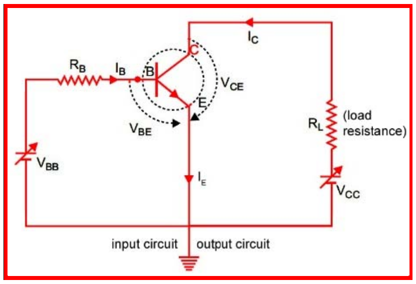
Oscillator:

The system which can convert a dc or unregulated ac signal to ac signal of a certain frequency is called an oscillator.

Three kinds of circuit can be constructed using transistors:

1. Common-base(CB)
2. Common-emitter (CE) and
3. Common-collector (CC).

Among these, common-emitter or CE circuit is widely used as amplifier circuit.



In the above diagram CE circuit is shown using an n-p-n transistor. In this case,

1. The circuit connecting the base and the emitter (left side circuit in the figure) is used as input circuit and
2. The circuit connecting the collector and the emitter (right side circuit in the figure) is used as output circuit. Hence, in both the circuits, the emitter is common. In an alternating current (ac) circuit this emitter is grounded. So it is called grounded emitter circuit.

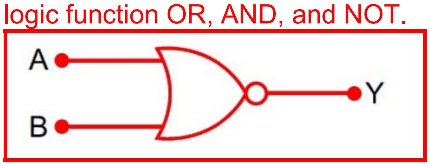
Question: 14

What is NOR gate? Prepare its Truth Table. Why is it called Universal gate? [1+1+1]

Answer:

See topics on 'NOR'.

Nor gate is called universal gate because NOR can gate obtain all the possible gates by using it as a basic building. This is why it is called universal gate. It may be used to realise the basic logic function OR, AND, and NOT.



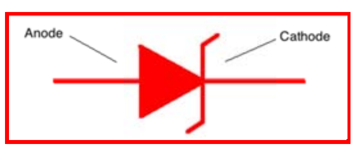
OR

What is Zener diode? Draw its voltage vs current characteristics in the reverse bias and indicate the breakdown voltage on the characteristics. Mention one important use of this diode. [1+1+1]

Answer:

Zener diode:

The tolerance of some specially prepared semiconductor diodes is increased in such way that at reverse bias, even due to flow of high reverse current, the diode is not damaged. This type of diode is called Zener diode:



Zener diode is used in voltage regulator.

Section C *(alternatives are to be noted)*

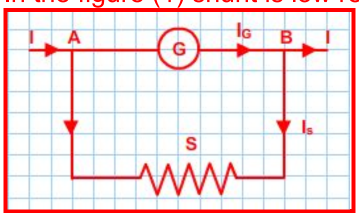
Question: 15 [5x3=15]

a. With the help of a circuit diagram explain the function of a shunt used in a galvanometer. [2]

Answer:

For every electrical instrument the current flowing through it has a maximum permissible limit. If the current exceeds the limit, there is a possibility of damage to the instrument. To protect sensitive instruments like galvanometer and ammeters against possible damage due to heavy current passing through them, an alternative passage is provided as an inbuilt device within these instrument such that a major part of the main current in the circuit passes through the alternative route and a very small part through the instrument. This alternative passage which is heating but low resistance connected in parallel with the instrument is called shunt.

In the figure (1) shunt is low resistance (s) connected in the parallel with galvanometer (G).



b. State Kirchhoff's laws in a network of conductors carrying current. State which law obeys the principle of conservation of energy. [1+2]

Answer:

Kirchhoff's First law:

In an electrical circuit (or net of wires) the algebraic sum of current through the conductor meeting at a point is zero. $\Sigma i = 0$.

Kirchhoff's Second law:

The algebraic sum of the product of the current and resistance in any closed loop of a circuit is equal to the algebraic sum of electromotive force acting in that loop.

$\Sigma_{ir} = \Sigma_{e}$.

Conservation of energy:

We know that inside a source of electricity other forms of energy are converted into electrical energy and in external circuit, electrical energy is converted into electrical energy and in external circuit, electrical energy is converted into other forms of energy. The amount of electrical energy developed inside a source of electricity to send one coulomb charge in a circuit is the electromotive force of the source. Again the amount of electrical energy spent in an external circuit due to the flow of one coulomb charge is the potential difference of the external circuit. According to second law of Kirchhoff,

$\Sigma_{ir} = \Sigma_{e}$, $\Sigma_{e} = \Sigma v$ [P.d $\rightarrow$ $v = i_r$]

Electrical energy developed in any circuit due charge = electrical energy spent in circuit. So, Kirchhoff's second law obeys of conservation of energy.

OR

a. Establish the balanced condition of Wheatstone's bridge by applying Kirchhoff's laws. [3]

Answer:

Proof:

In balanced condition, Wheatstone's bridge $\rightarrow \frac{P}{Q} = \frac{R}{S}$

In null condition I_G = O. so, the potential difference between the two ends of the galvanometer,
$V_B - V_D = I_G.G = O$ [G = Resistance of galvanometer]
For, I_G = O, suppose current in resistance. P = current in resistance Q = I_1
Current in resistance R = current in resistance S = I_2
$\therefore V_A - V_B = I_1P$
$V_A = V_D = I_2S$
Now since $V_B = V_D$
$\therefore I_1P = I_2P$ ……...(ii)
$I_2Q = I_2S$ …………..(iii)
Now (ii) / (iii) we have
$$\frac{P}{Q} = \frac{R}{S}$$

b. Length, diameter and specific resistance of two wires of different materials are each in the ratio 2:1. One of the wires has a resistance of 10 ohm. Find the resistance of the other wire. [2]

Answer:

$$R = \rho\frac{l}{A} = \rho\frac{l}{\pi r^2 14}$$

$$\frac{R_1}{R_2} = \frac{\rho_1}{\rho_2}\frac{l1(d_2)^2}{l2(d_1)} = \frac{2}{1}x\frac{2}{1}\left(\frac{1}{2}\right)^2 = 1\Omega$$

Hence, if one of the wire has resistance of 10Ω the resistance of other wire must be 1Ω.

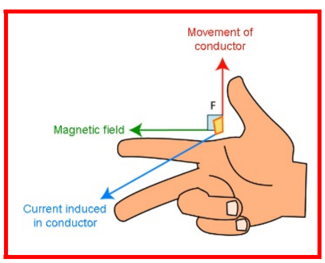
Question: 16 [1+1+1]

a. State Fleming's right hand rule. Define self- inductance of a coil. Explain non-inductive coil with diagram.

Answer:

Fleming's right hand rule

The thumb, the forefinger and the middle finger of the right hand are stretched per perpendicular to each other, if the forefinger points in the direction of the magnetic field and the thumb in the direction of the motion of the conductor, then the middle finger will point in the direction of induced current. This rule is also called dynamo rule.



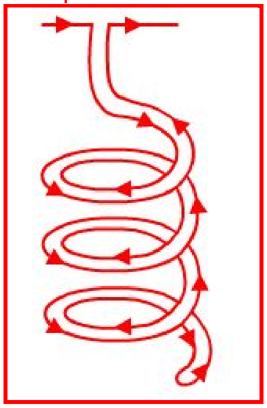
Self-Inductance

For unit current flowing through a coil, the magnetic flux linked with the coils is called self-Inductance.

Non-inductive coil:

Self-induction creates disturbances in many electrical circuits. A coils of finite resistance but of zero self-inductance is often required. Such a coil is called a non-inductive coil.
A long insulated conducting wire is given a fold and then coiled up. The free ends of the coil are now on the same side. This kind of winding is called non-inductive winding. Hence antiparallel

current flows through any part of the adjacent wires of the coil. So, the resultant magnetic flux then produced becomes zero. So, in this coil, no electromagnetic induction takes place.



b. A metallic disc of radius 10cm is rotating uniformly about a horizontal axis passing through its center with angular velocity 10 revolution per second. A uniform magnetic field of intensity 10^{-2} tesla acts along the axis of the disc. Find the potential difference induced between the center and the rim of the disc. [2]

Answer:

Any diameter of the disc generated a spherical plane of radius 10cm or 0.1 m during each rotation.

Area of the spherical plane $A = \pi \times (0.1)^2 = 0.01\ \pi m^2$

Now, magnetic field $B = 10^{-2}$

Number of rotation per second n = 10

$\therefore$ The value of induced potential difference between the end point and the centre of the metallic disc = change of magnetic flux per second = $nAB = 10 \times 0.01\pi \times 10^{-2} = 3.14 \times 10^{-3}$ v = 3.14mV

OR

a. The instantaneous voltage from an ac source is given by e=200 sin 314t volt. Find the rms voltage. What is the frequency of the source? [2]

Answer:

Peak voltage = 200V

Then, rms voltage = $\frac{200}{\sqrt{2}} = 141.4$V

Angular frequency w = 3.14 Hz

$\therefore$ The frequency of the source = $\frac{\omega}{2\pi} = \frac{314}{2 \times 3.14} = 50$Hz

b. State the condition under which the phenomenon of resonance occurs in series LCR circuit when ac voltage is applied. In a series LCR circuit, the current is in same phase with voltage. Calculate the value of self- inductance if the capacitor used is 20 μF and resistance used is 10 ohm with the ac source of frequency 50 Hz. [1+2]

Answer:

Condition of resonance in a series LCR circuit, $\omega L = \frac{\omega}{\omega C}$

where ω = angular frequency of source

L = self inductance of coil
C = capacitance
In question, current and emf in same phase in LCR circuit,
$\omega = 2\pi \times 50 = 2 \times 3.14 \times 50 = 314$ Hz
$C = 20$ MF $= 20 \times 10^{-6}$ F $= 2 \times 10^{-5}$ F

Now, $\omega L = \frac{1}{\omega C}$

$L = \frac{1}{\omega^2 C}$

$= \frac{1}{(314)^2 \times (2 \times 10^{-5})}$

= 0.507 Hz.

Question: 17 [2]

a. Focal lengths of two lenses kept in contact are f_1 and f_2. Prove that their equivalent focal length f is given by $\frac{1}{f} = \frac{1}{f_1} = \frac{1}{f_2}$.

Answer:
Both the census are convex. Let C_1, C_2 be the optical centre of two thing convex lenses L_1 and L_2 held co-axially in contact with each other in air. Suppose f1 and f2 are their respective focal lengths.
Let a point object O be placed at a distance $OC_1 = u$. the lens L1 alone would form its image at where $C_1I' = V'$ from the lens formula,

$\frac{1}{V'} = \frac{1}{u} = \frac{1}{f_1}$......(1)

I' would serve as virtual object for lens L_2, which form a final image I at distance $C_2I = V$. As the lenses are thin, therefore for the lens $L_2 u = C_2 I' = C_1 I'$

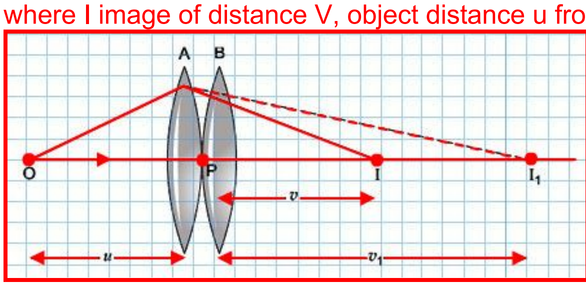
From the lens formula for $L_2 \rightarrow -\frac{1}{u} - \frac{1}{V'} = \frac{1}{f_2}$......(2)

Adding (1) and (2) we get $\frac{1}{V} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$

Let two lens be replaced of focal length F, then $\frac{1}{V} - \frac{1}{u} = \frac{1}{F}$

$\therefore \frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

where I image of distance V, object distance u from lens.



b. The refracting angle of a prism is 60^0 and the refractive index of its material is $\sqrt{\frac{7}{3}}$. Find the minimum angle of the prism such that the emerging ray will graze the other refracting face.

[3]

Answer:

Here $i_1 = \sin^{-1}$ [sin A $\sqrt{M^2 - 1}$ - cos A]

Here $M = \sqrt{\frac{7}{3}}$ or, $M^2 - 1 = \frac{4}{3}$

or, $\sqrt{M^2 - 1} = \frac{4}{3} = \frac{2}{\sqrt{3}}$

Given that A = 600

or, $\sin A = \frac{\sqrt{3}}{A}$

$\therefore \cos A = \frac{1}{2}$

Hence, $i_1 = \sin^{-1}\left[\frac{\sqrt{3}}{2} \times \frac{2}{\sqrt{3}} - \frac{1}{2}\right]$

$= \sin^{-1}\left(\frac{1}{2}\right) = 30^0$

OR

a. The object and the image are at distances x and y respectively from the focus of a concave mirror. Establish the relation between x, y and the focal length f of the mirror. (**) [2]

Answer:

b. Light from a point source placed at the bottom of a rectangular glass slab of thickness 5 cm is internally reflected by the upper surface and a circle of radius 8 cm is formed at the bottom. Find the R.I. of glass. [3]

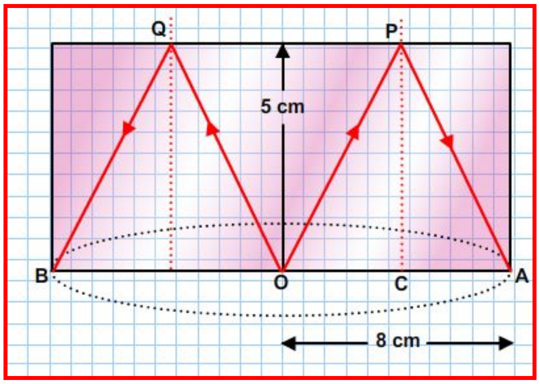
Answer:

Let O be a bright point at the bottom face of the rectangular slab. Light rays starting from O return to the bottom face after total reflection from the upper face of the slab. As a result, a circle of light of radius OA = OB = 8cm is formed on the bottom face. So angle of incident on the upper face θc = critical angle.

According to the figure, $OP = \sqrt{OC^2 + PC^2} = \sqrt{(4)^2 + (5)^2} = \sqrt{41}$ cm

$\therefore$ Refractive Index,

$M = \frac{1}{\sin\theta_c} = \frac{1}{\frac{OC}{OP}} = \frac{OP}{OC} = \frac{\sqrt{41}}{4} = 1.6$


Q
P
5 cm
B
O
C
A
8 cm