2014

Section A *(alternatives are to be noted)*

Question: 1 [1x10=10]

a. When a car takes a circular turn on a level road, which force acts as the centripetal force?

Answer:
The frictional force acting on the wheels of car.
f_1=MR and f_2 = MR_2

Total force $f_1+f_2=\frac{mv^2}{r}$

b. Show that the angular momentum of a particle under the action of the force $\vec{f}=k\vec{r}$ is a constant quantity.

Answer:

If the external torque acting on a rotating body is zero if J=0 the $\frac{dL}{dt}$ =0 L = Constant.

OR

If the moment of inertia of a solid sphere of mass M and radius R is $\frac{2}{5}MR^2$, what will be the radius of gyration?

Answer:

The radius of gyration is $K=\sqrt{\frac{I}{M}}$

$$=\sqrt{\frac{\sum MR^2}{M}}$$

$$=\sqrt{\frac{215\not{M}R^2}{\not{M}}}$$

$$=\sqrt{215R^2}$$

c. Are sound waves longitudinal or transverse?

Answer:
Sound waves are transverse.

d. What is the phase difference between two points situated on a wave front?

Answer:

The phase different is $\frac{\pi}{2}$.

OR

Does the principle of conservation of energy always hold in case of superposition of two sound waves?

Answer:
Yes, principle of conservation energy hold in case of superposition of two sound wave.

e. Write down the name of the physical quantity whose unit is $\frac{\text{joule}}{\text{coulomb}}$

Answer:
Volt = $\frac{\text{Joule}}{\text{coulomb}}$ unit is volt (V)

OR

Does a stationary charge experience any force in a magnetic field?

Answer:
No.

f. Which of the following is the unit of magnetic flux?

i. Tesla

ii. $\frac{\text{Resla}}{\text{m}^2}$

iii. Tesla x m^2

iv. $\frac{\text{weber}}{\text{m}^2}$

Answer:
Tesla x m^2

g. Express 39 as a binary number

Answer:

2	39	1
2	19	1
2	9	1
2	4	0
2	2	0
2	1	1
	0	

$\therefore (39)_{10} = (100111)_2$

h. What will be the kinetic energy of emitted photo-electrons if light of threshold frequency falls on a metal?

Answer:
Zero

OR

What are the majority carriers in a p-type semiconductor?

Answer:
Hole are the majority carriers in a p-type semiconductor.

i. In which part of the electromagnetic spectrum do the spectral lines of hydrogen atom as a given by Balmer series occur?

Answer:
The spectral lines of hydrogen atom as a given by Balmer series occur in the visible range of the electromagnetic spectrum.

j. What type of semiconductor is produced if Germanium crystal is doped with Arsenic?

Answer:
n-type semiconductor is produced if germanium crystal is doped with arsenic.

Section B *(alternatives are to be noted)*

Question 2 [2x7=14]

a. If a gas expands adiabatically will its temperature increase of decrease? Use first law of thermodynamics to justify your answer.

Answer:

If the gas expand adiabatically there no exchange of heat between gas and surrounding.

$\therefore \Delta Q = 0$

The equation of adiabatic process is $PV\chi$= constant.

According first law of thermodynamic $\Delta Q = \Delta U + \Delta W$

or, $\Delta W = -\Delta U$

o = $\Delta U + \Delta W$

b. Four point charges +q +q, +q and –q are placed at the font corners of a square, length of each side of which is a. Find the magnitude of the intensity of the electric field at the center of the square.

Answer:

The point of intersection of the diagonal is equidistance t from four charges.

$\therefore OA = OB - OC = OD = \frac{a}{\sqrt{2}}$

Intensity at O due the charge at B = $\frac{q}{(\frac{a}{\sqrt{2}})^2}$ along $\overrightarrow{OD}$

Intensity O due the charge D = $\frac{q}{(\frac{a}{\sqrt{2}})^2}$ along $\overrightarrow{OD}$

Resultant Intensity at O = $\frac{q}{(\frac{a}{\sqrt{2}})^2} + \frac{q}{(\frac{a}{\sqrt{2}})^2}$

$= \frac{2q}{a^2} + \frac{2q}{a^2}$

$= \frac{4q}{a^2}$ along $\overrightarrow{OD}$

c. Determine how much work is to be done to move a line coulomb positive charge I m along the y axis in a uniform electric field $\vec{E} = 5(\hat{i} + \hat{j})Vm^{-1}$.

Answer:

Force acting on a charge q placed in a uniform electric field $\vec{E}$ is given by $\vec{F} = q\vec{E}$

= 10 x $5(\hat{i} + \hat{j})$ N

Displacement along y-axis $\vec{S} = 1\hat{j}m$

$\therefore$ Work done = $\vec{F}.\vec{S}$

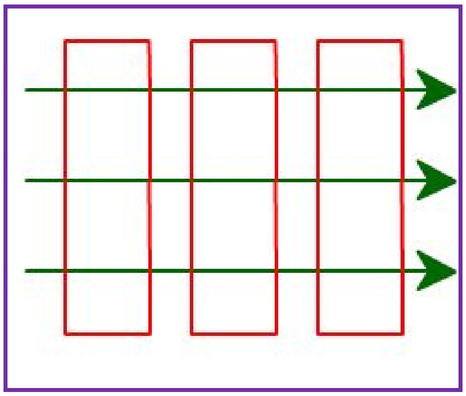
= 5o $(\hat{i} + \hat{j}).\hat{j}$

= 5o Joule.

OR

Show that the direction of electric field is normal to the equipotential surface.

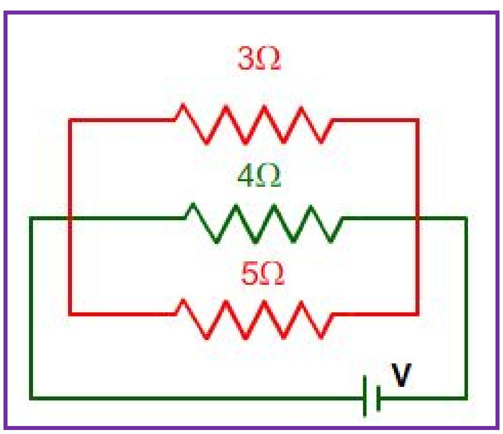
Answer:
A uniform electric is represented by parallel and equispaced field line. Equipotential surface in such a field would be normal to these field lines at every point in the field.



d. A parallel combination of three resistors 3Ω, 4Ω and 5Ω is connected across a battery. Find which resistor will consume more electrical per second.

Answer:
As the three resistance are connected in parallel. So the voltage drop across each of them while be samepower disspated in 3Ω resistance.

$P_1 = \frac{V^2}{3}$



Similarly, $P_2 = \frac{V^2}{4}$ and $P_3 = \frac{V^2}{5}$

So, the resistance 3Ω will consume more energy in 1 sec.

OR

Write down four differences between peltier effect and joule's effect,

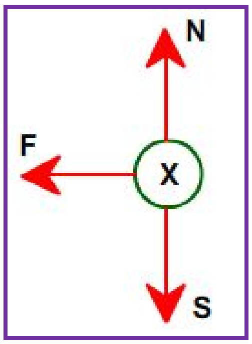
Answer:

Peltier effect	Joule's effect
1. It is reversible.	1. It is irreversible.
2. It depends upon direction of current	2. It is independents of direction of curvent.
3. It may be heating or cooling effect.	3. It is always heating effect.
4. It takes place only at the junction of two different metal.	4. It's occurs throughout the conductor.

e. A wire is kept horizontally at a place in the northern hemisphere of the earth. In what direction will force act on the wire due to the vertical component of the earth's magnetic field, if electric current flows through the wire from south to north?

Answer:

When a wire placed horizontally in the northern hemisphere and the current in it flow from south to north then according to Fleming's left hand rule, the direction of the force acting on the wire will be along the west. The vertical component of the earth's magnetic field in along ⊗ mark.



OR

A copper wire of length 1 meter is bent to form circular loop, If I amp current flows through the loop, find out the magnitude of magnetic moment of the loop.

Answer:

The length of copper wire = l, let the radius be R when the wire is bent to form a circular coil.

$\therefore$ $2\pi r = l$ or,

$$r = \frac{l}{2\pi}$$

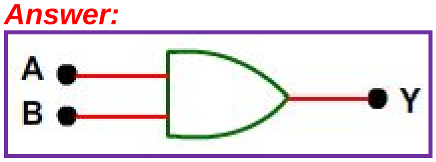
$\therefore$ Area of the circular coil,

$$A = \pi r^2 = \pi \times \frac{l^2}{4\pi 2} = \frac{l^2}{4\pi}$$

Magnetic moment of the circular wire = iA = $\frac{il^2}{4\pi}$.

f. Draw the symbol of an AND gate. And write its truth table.

Answer:



Truth table:

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

g. State de Broglie's hypothesis and write down the expression for the wavelength of matter waves.

Answer:

Matter also consists of waves. For a radiation of frequency f, the energy of photon E = hf

or, $E = h\frac{c}{\lambda}$ [$C= f\lambda$]

or, $\lambda = \frac{h}{\frac{E}{c}} = \frac{h}{p}$ where p is momentum of the photon. This known as de Broglie's hypothesis.

$\lambda = \frac{h}{p} = \frac{h}{mv}$ where m = mass of particle v = velocity of particle p = mv = momentum of the particle.

Section – C *(alternatives are to be noted)*

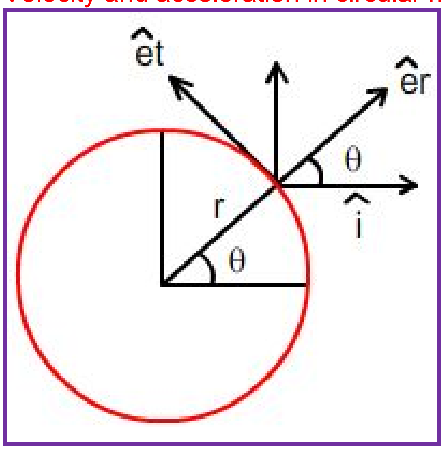
Question 3 [4x11=44]

a.

i. A particle is moving in a circle of radius r with constant angular velocity. At any point (r, θ) on its path, its position vector is $\vec{r} = \hat{i}\cos\theta + \hat{j}r\sin\theta$. Show that the velocity of the particle has no component along the radius.

Answer:

Velocity and acceleration in circular motion:



The above figure shows the rotation of some particle along a circle of radius "r" in the direction shown.

Let $\hat{e}r$ and $\hat{e}t$ be the unit vector along the radical and tangential direction. As per scheme shown

$\hat{e}r = \hat{i}\cos\theta + \hat{j}\sin\theta$ .... (i)

$\hat{e}t = -\hat{i}\sin\theta + \hat{j}\cos\theta$ .... (ii)

The location of the particle can be given as $\overrightarrow{OP} = \vec{r} = r_{\hat{e}r}$ ($\hat{e}r$ is defined radically outward)

$$\rightarrow \vec{V} = \frac{d\vec{r}}{dt}$$

$$= \frac{dr}{dt}\hat{e}r + r\frac{d\hat{e}r}{dt} \text{ .... (iii)}$$

From (i) $\hat{e}r = \hat{i}\cos\theta + J\sin\theta$

$$\rightarrow \frac{d\hat{e}r}{dt} = -\hat{i}\sin\theta\frac{d\theta}{dt} + J\cos\theta\frac{d\theta}{dt}$$

$$= -\hat{i}\sin\theta\omega + \hat{J}\cos\theta$$

$$= \omega(\hat{J}\cos\theta - \hat{i}\sin\theta)$$

$$= [\omega e - \hat{i}]$$

$\therefore (\vec{V} = r\omega\hat{e}t)$ .... (iv)

So, the linear velocity of a rotating particle is along the tangential direction corresponding to rotation. Then,

$\vec{a} = \frac{d\vec{y}}{dt} = r[\frac{dw}{dt}\hat{e}t + \omega\frac{d\hat{e}t}{dt}]$ .... (v)

From (ii) $e\hat{t} = -\hat{i}\sin\theta + \hat{J}\cos\theta$

$\therefore \frac{de\hat{t}}{dt} = \hat{i}\cos\theta\frac{d\theta}{dt} - \hat{J}\sin\frac{dv}{dt}$

$= -\omega(\hat{i}\cos\theta + \hat{J}\sin\theta)$

$= [-\omega\hat{e}_r]$........... (vi)

∴ Combining (v) and (vi) $[a = r\,\infty\,\hat{e}_t - \omega^e r\hat{e}_r]$

ii. Find an expression for the acceleration of the particle and hence indicate its direction. [2+2]

Answer:

a

→ $r\infty\hat{e}_t$

(Originate due to change in magnitude of velocity and absent uniform circular motion)

→ $-\omega^2 r\hat{e}_r$

$= -(\frac{u}{r})r\hat{e}_r$

$=(-\frac{V^2}{r}\hat{e}_r = ar)$

(Originate due to change in direction. It is called centripetal acceleration)

OR

i. A cyclist tilts to make an angle θ with level ground as he takes a circular turn of radius r. If the speed of the cycle is *v*, show that $\tan\theta = \frac{rg}{v^2}$.

Answer:

When a cyclist takes turn, he also requires some centripetal force. To calculate the angle of bending with vertical, let b

m = mass of cyclist

v = velocity of cyclist

r = radius of circular path

θ = angle of bending with vertical

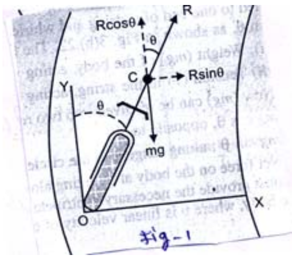
R can be resolved into two rectangular component Rcosθ along vertical upward direction, R sinθ along horizontal toward centre of the track. In equilibrium Rcosθ balance the weight of the cyclist

$R\cos\theta = mg \rightarrow$ (i) and R sin θ provides the necessary centripedal force $\rightarrow \frac{mv^2}{r}$

$\therefore R\sin\theta = \frac{mv^2}{r}$............(ii)

$\frac{(ii)}{(i)} \qquad \frac{R\sin\theta}{R\cos\theta} = \frac{mv^2}{rmg}$

$\therefore \tan\theta = \frac{v^2}{rg}$ (Proved)



ii. Show that for planetary motion around the sun, the orbital velocity of a planet is maximum and minimum at the nearest and furthest point respectively from the sun. [2+2]

Answer:

Deduction of Kepler's second law(Law of Areas)

It can be deduced from the knowledge of angular momentum. The geometrical interpretation the angular momentum is $\vec{L}$ mass of body $\rightarrow$ m areal velocity $\frac{d\vec{A}}{dt}$

$\therefore \vec{L} = 2m \times \frac{d\vec{A}}{dt}$

A planet revolves around the sun in the elliptical orbit under the influence of gravitational pull of the sun. the pull force $\vec{F}$ acting along line joining the centre of sun and planet. Here $\vec{r}$ is radius and angle between $\vec{r}$ and $\vec{F}$ is 1800. Now, Torque = $\vec{J} = \vec{r} \times \vec{F} = rF\sin\ 180^0 = 0$

As, $\vec{J} = \frac{d\vec{L}}{dt} = 0$

We have $2m\frac{d\vec{A}}{dt}$ = constant

or, $\frac{d\vec{A}}{dt}$ = constant (Proved)

b.

i. Define Gravitational potential.

Answer:

The **gravitational potential** (V) is the **gravitational potential** energy (U) per unit mass: U = m V, {displaystyle U=mV} where m is the mass of the object. **Potential** energy is equal (in magnitude, but negative) to the work done by the **gravitational** field moving a body to its given position in space from infinity.

ii. At what height above the surface of the earth is the gravitational potential energy of a body equal to that on the surface of the moon? Assume that the mass of the earth is 80 times that of the moon and the radius of the earth is 4 times that of the moon. Given, Radius of the earth= 6400km.

Answer:

According to the problem, gravitational potential energy= $\frac{GMm}{R}$

$\therefore \frac{GMe}{R} = \frac{GMmh}{R}$

$\therefore \frac{80Mm}{4R} = \frac{Mmh}{R}$

= 20 um = h

Height = 20 um

OR

i. State Kepler's laws of planetary motion. [3]

Answer:

Kepler' Law –

Law of orbit - Every planet revolves around the sun in an elliptical orbit. The sun is situated at one foci of the ellipse.

Law of Areas – The line joining a planet to sun sweeps out equal areas in equal interval of time i.e., the areal velocity of the planet around the sun is constant.

Law of periods – The square of the time period of revolution of planet around the sun is directly proportional to the cube of semi-major axis of its elliptical orbit.

$[T^2 \propto R^3]$

ii. Does the motion of a satellite obey Kepler's laws? [1]

Answer:

Yes, satellite obey Kepler's laws.

c. One mole of an ideal gas is compressed to half of its initial volume (**)

i. Isothermally

Answer:

ii. Adiabatically.

Draw the P-V diagram in each case and hence state with reason, in which case the done is less.

Answer:

OR

i. Write down the mathematical form of the first law of thermodynamics.

Answer:

Mathematical form of first law of thermodynamics is [dQ = dW+dU].

ii. The temperature of a fixed mass of an ideal gas is changed from T1k to t_2k ($T_2 < T_1$) Calculate the work done if the change is brought about (i) Constant pressure and (i) Constant volume. Hence find the first law of Thermodynamics, in which case heat absorbed will be greater. (**) [1+(1+1+1)]

Answer:

d.

i. Use kinetic theory of gases to show that the average kinetic energy of an ideal gas is directly proportional to the absolute temperature of the gas. [2]

Answer:
Kinetic interpretation of temperature
According to kinetic theory of gases the pressure P exerted by one mole of ideal gas is given by,

$$P=\frac{1}{3}ec^2=\frac{1}{3}\frac{M}{V}C^2$$

$$\text{or, } PV=\frac{1}{3}MC^2$$

$$\text{or, } \frac{1}{3}MC^2=RT\,[PV=RT]$$

$$\text{or, } C^2=\frac{3RT}{M}$$

$$\text{or, } C^2\propto T^2$$

$$\text{or, } C\propto\sqrt{T}$$

$$\text{or, } \sqrt{T}\propto C$$

Thus the square root of the absolute temperature of an Ideal gas is directly proportional to root mean square velocity of its molecules.

ii. What is 'mean free path' of a gas molecule? On what factors does it depend? [1+1]

Answer:
Mean free path of gas molecules as the average distance travelled by a molecule between two successive collisions.
It depends on –
i. Number of molecule density(n) and
ii. Area of the molecule

e.

i. Two waves are expressed as y_1 = asin $w_1(\frac{x}{e}$-t) and y_2=asin $W_2(\frac{x}{e}$-t). Find the resultant displacement due to superposition of the two waves.

Answer:
If the two wave are out of phase by a constant angle θ, their equation can be written as,
$y_1(u,t) = r \sin (wt – ku) \rightarrow$ (i)
$y_2(u,t) = r \sin (wt – kv+Q) \rightarrow$ (ii)
According to superposition, principal the net displacement of the result wave is
$y(u,t) = y_1(u_1,t) + y_2(u,t) = r \sin (wt – uv) + r \sin (wt – uv) + Q \rightarrow$ (iii)
being the trigonometrical relation,

$$\sin a+\sin b=2\cos\left(\frac{\alpha-\beta}{2}\right)\text{sjin}\left(\frac{\alpha+\beta}{2}\right)$$

$$y(u,t)=\left(2r\cos\frac{Q}{2}\right)\sin\left(wt-uv+\frac{Q}{2}\right)$$

This equation shows that the resultant wave is also a sinusoidal wave travelling the same positive direction of u-axis. However the phase angle of resultant wave is $\frac{Q}{2}$ w.r.t either wave and its amplitude is $R=2r\cos\frac{Q}{2}$

ii. Determine the amplitude of the resultant displacement at x=0

Answer:

If Q = 0, i.e., the two waves are in phase, then equation of the resultant wave is y(u,t) = 2rsin (wt – uv). The amplitude of the resultant wave is 2r.

Beat frequency = After superposition of two wave the maximum amplitude is given by the equation A = 2rcosr(U_1-U_2)x t

When cos r(U_1-U_2) x t = max = ± 1 = cos kr where k = 0,1,2,….

$$t = \frac{k}{(U_1 - U_2)} \text{ if } t = 0\ \frac{1}{U_1 - U_2} \cdot \frac{2}{U_1 - U_2} \cdot \frac{3}{U_1 - U_2}$$

iii. If the two frequencies are nearly equal, find the beat frequency.

Answer:

Frequency of maxima = (U_1-U_2). Again A will minimum when, cosr(U_1-U_2) x t = 0, then

$$\cos(2K+1)\frac{\pi}{2}$$

$$t = \frac{(2K+1)}{2(U_1 - U_2)}$$

$$\therefore = \frac{1}{2(U_1 - U_2)} \cdot \frac{2}{2(U_1 - U_2)} \cdot \frac{3}{2(U_1 - U_2)}$$

Frequency of minima = (U_1-U_2)

∴Beat frequency = (U_1-U_2)

OR

The equation of a travelling wave is y=20 sin (0.2π-59π), where x and y are in cm and t is in second. Find out the

i. Amplitude

Answer:

The equation wave is y = 20 sin (0.2rπ - 59π). Comparing with the standard equation of wave $y(u,t) = r\ \sin\left(\frac{2\pi}{\lambda} - \frac{2\pi}{T}\right)$, we get r = 20 cm.

ii. Wavelength

Answer:

$$\frac{2\pi}{\lambda} = 0.2$$

$$\text{or}, \lambda = \frac{2\pi}{0.2} = \frac{2 \times 3.14}{0.2} = 31.4\text{cm}$$

iii. Frequency and

Answer:

$$\frac{2\pi}{T} = 59\pi$$

$$\text{or}, \frac{1}{T} = 59$$

$U = \frac{1}{T} = 59\ H_2$

iv. Velocity of the wave. [1+1+1+1]

Answer:

$v = u \times \lambda$

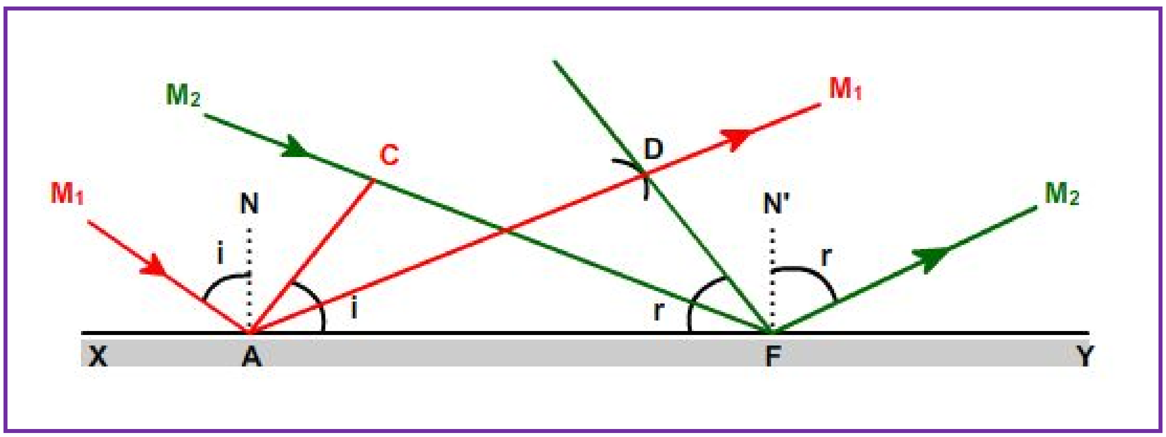
or, $v = 59 \times 31.4 = 1852.6$ cm.

f. State Huygen's principle for propagation of light wave. Use this principle to explain reflection of light by plane mirror. [1+3]

Answer:

Each point on a wave front act as a new source called secondary source. From these secondary source, secondary wave or wave lets generated and propagate in all direction at the same speed of the wave. The new wave front at a later stage is simply the common envelope or tangential plane to these wavelets.

Verification of the laws of reflection.



Point F is the reflector. In accordance with Huygen's principal all point from A to F on the reflecting plane in turn generate wavelets. Hence by the time the wavelets from C reached F, wavelets generated at A reaches D in the same medium. Centering the point A, an arc of radius CF drawn. Assuming C to be speed of light in the medium under consideration, we have CF=Ct. Tangent FD is drawn on the arc FD is the reflected wave front after time t.

The perpendicular M_1A and M_2F drawn on the incident wave front AC are the incident rays. Let AC, part of a plane wave front perpendicular to the plane paper be incident on the surface of a plane reflection XY. Note that the plane wave front and the plane paper intersect each other along line AC. The plane paper and plane of reflection are also perpendicular to each other.

According to Huygen's each point on wave front AC acts as a source of secondary wavelet. Let at time t = 0, one end of the wave front touches the reflecting surface at A. At the same time wavelets form each point on the wave front AC. These wavelets gradually reach the reflector. After a time t say wavelets from C reaches and the perpendicular M_1 and $F'M_2$ drawn on the reflected wavefront DF are the corresponding reflected rays, NA and N'F are the normal drawn at the point of incident on the surface.

$\angle M_1AN$ = angle of incident(i)

M'_2FN' = angle of reflection(r)

$\angle CAF = 90^0 - \angle NAC = \angle M_1AC - \angle MAC$

$= \angle M_1AN = i$

$\angle AFD = 90^0 - \angle N'FD = \angle M'_2FD - \angle N'FD = \angle M'_2FN = r$

Now, ΔACF and ΔAFD, $\angle ACF = \angle ADF = 90^0$

CF = AD = Ct and AF common side,

Hence, $\therefore \angle CAF = \angle AFD$ (Δ are congruent)

Angle of incident (i) = Angle of reflection (r)

OR

What is interference of light? State the conditions for interference. Does the interference phenomenon obey the principle of conservation of energy? [1+2+1]

Answer:

When two light wave of the same frequency and amplitude superpose in a certain region of a medium the intensity of the resultant light wave increase at some other point in that region. This phenomenon is unknown as interference of light.

Conditions for interference:

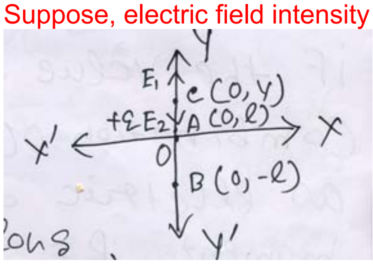
i. Two light source must be monochromatic and should emit waves of the wave length.
ii. Amplitude of the waves should be equal or nearly equal.

Yes, interface obey the principle of conservation energy.

g. On the x-y plane two point charges +q and –q are placed at positions (*o*,*l*) and (*o*,-l)respectively. Find an expression for the intensity of electric field at a point (o,y) where y>>l. Under what condition does the charge system behave as a dipole and hence express the electric field in terms of the dipole moment of the dipole so formed. [2+1+1]

Answer:

Suppose, electric field intensity at the point C due to the charge at A and B are E_1 and E_2



$$\therefore E_1 = \frac{1}{4\pi \Sigma_0} = \frac{q}{(y-l)^2} \text{along} \overrightarrow{CY}$$

$$E_2 = \frac{1}{4\pi \Sigma_0} = \frac{q}{(y+l)^2} \text{along} \overrightarrow{CA}$$

As E_1 and E_2 act opposite then $E_1 > E_2$.

$\therefore E_1 > E_2$.

$$\frac{1}{4\pi \Sigma_0} \cdot \frac{q}{(y-l)^2} - \frac{1}{4\pi \Sigma_0} - \frac{q}{(y+l)^2}$$

$$= \frac{q}{4\pi \Sigma_0} \cdot \left[\frac{1}{(y-l)^2} - \frac{1}{(y+l)^2} \right]$$

$$= \frac{q}{4\pi \Sigma_0} \frac{4yl}{(y^2 - l^2)^2}$$

$$= \frac{1}{4\pi q} \frac{4qyl}{(y^4)} [\because y >> l]$$

$$= \frac{1}{4\pi q} \frac{4yl}{(y^3)} \text{ along} \overline{CY}$$

If the value of l smell, the combination of charge behave as electric dipole with dipole moment P = $\Sigma \times 2l$.

In that case $E = \frac{q}{4\pi \Sigma_0} \frac{2P}{y^3} \text{ along} \overline{CY}$

OR

i. The capacitance of a capacitor is C. Find out how much work will have to be done to charge to capacitor with an amount of positive charge Q. [2]

Answer:

Let a conductor be charged with Q and let capacitance be C. The potential of conductor is V. we know Q = CV. When dq charge given work done dq against potential v, $dw = vdq = \frac{q}{c} dq$

$$Q = w = \int dw = \int_0^Q \frac{q}{c} dq = \frac{1}{2} \frac{Q^2}{C}$$

$$= \frac{1}{2} CV^2 = \frac{1}{2} QV$$

ii. Two capacitors of capacitances 5 μF are charged to 16 V and 10V respectively. Find what will be the common potential when they are connected in parallel to each other. [2]

Answer:

Initially, the charge on the first capacitor.

$Q_1 = c_1 v_1 = (5 \times 10^{-6}) \times 16 = 80 \times 10^{-6}$ C

Charge on second capacitor,

$Q_2 = C_2 V_2 = (10 \times 10^{-6}) \times 10 = 100 \times 10^{-6}$ C

Net charge = Q = $Q_1 + Q_2 = 180 \times 10^{-6}$ C

Equivalent capacitance in parallel C = $C_1 + C_2$ = (5 + 10)mF = 15×10^{-6} F

The variation of field intensity with distance has been shown by curved line AB.

$\therefore$ Common potential

$$V = \frac{Q}{C} = \frac{180 \times 10^{-6}}{15 \times 10^{-6}} = 12V$$

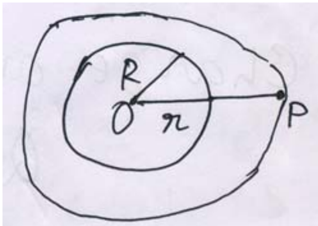
h.

i. A thin spherical shell of radius R is charged with +Q amount of charge. Use Gauss law to find out the magnitude of the intensity of the electric field at a distance r from center of the shell when r < R and r > R.

Answer:

Field intensity at a point due to a uniformly charged thin spherical shell.

Point outside the shell = suppose a thin spherical shell of radius R is charged uniformly with +q



Electric field intensity at point P to be calculated. Suppose, the distance of P from the centre O of shell is r. Imagine a Gaussian spherical shell of a radius r with centre at O.

We can say from symmetry that electric field intensity at each point on the surface of the spherical shell is equal and is directed along outward drawn normal.

Intensity at P is E. Flux linked with this surface E = $4\pi r^2$. Since the Gaussian surface enclosed the charge +q, the net flux is $\frac{q}{\Sigma_0}$

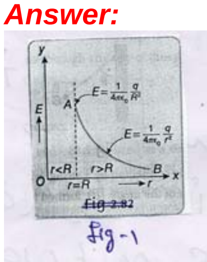
$$\therefore E.4\pi r^2 = \frac{q}{\Sigma_0}$$

$$\text{or}, E = \frac{1}{4\pi r^2}\frac{q}{\Sigma_0}$$

In vector form, $\vec{E} = \frac{1}{4\pi r^2}\frac{q}{q^2}\hat{r}$

ii. Show graphically how the magnitude of the intensity of the electric field changes with distance r from the center of the shell. [3+1]

Answer:



The variation of field intensify with distance has been shown by curved line AB.

OR

i. An electric field is expressed as $\vec{E} = 20\,\hat{i}$ Vm^{-1}. Find the electric flux passing through a surface 0.25 m^2 normal to the axis.

Answer:

The y-z plane per perpendicular to the x-axis, so the given area vector

$\vec{S} = 0.25\hat{i}m^2$

$Q = \vec{E}.\vec{S} = (20\hat{i}).0.25\hat{i} = 5V.m$

ii. The electric field strength at a point in an electric field is zero. Is electric potential also zero At that point? Answer with reason.(**) [2+2]

Answer:

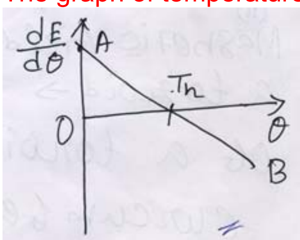
i.

i. What is thermos-e.m.f? Draw a graph to show the relation between this e.m.f and temperature. [1+2]

Answer:

Seebeck found that if wire of different metal connected say(Cu-Fe) and one end is heated and current flows to hot end to cold end in this junction and galvanometer connected shows deflection. This current called thermos current, this current due to some e.m.f called thermos e.m.f.

The graph of temperature vs thermos e.m.f



ii. To demonstrate See beck effect using micro voltmeter, Which one of the two thermos-couples Sb-Bi and Cu-Fe is preferred? [1]

Answer:

Cu-Fe thermocouple is preferred to demonstrate See beck effect.

j.

i. Write down the mathematical form of Ampere's circuital law related to magnetic field produced by electric current and state the meaning of the symbols used. [2]

Answer:

Mathematical form of Ampere's circuital law $\oint \vec{B}.d\vec{l} = \mu_o I$

where I = Net current

$\oint$ = closed loop

B = magnetic field

μ_o = permeability in free space

ii. Use Ampere's law to determine the intensity of magnetic field at a point on the axis of a toroid. [2]

Answer:

Magnetic field at a toroid → Let radius be = r of a toroid. N = no of turns circumference of circular axis = $2\pi r$.

No of turn per unit length $n = \frac{N}{2\pi}$

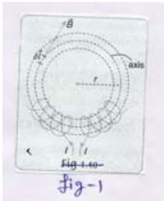
Magnitude of $\vec{B}$ is same every point. Hence, $\oint \vec{B}.dl = \oint Bdl\cos O^0 = B\oint dl$ = B. $2\pi r$.

Again the net current enclosed by the axis = current I through each of N turns = NI. So, Ampere's circuital law,

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

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

$B = \mu onI$



OR

i. An electron is moving with a velocity $\vec{v} = (\hat{i} + 2\hat{j})ms^{-1}$ in the magnetic field $\vec{B} = (2\hat{i} + 2\hat{j})Wbm^{-2}$, Determine the magnitude and direction of the force action on the electron. Charge of an electron is-1.6 x10^{-19} coulomb.

Answer:

The force acting on the electron $\vec{F} = q\left(\vec{V} \times \vec{B}\right) = 1.6 \times 10 - 19\left(\hat{i} \times 2\hat{j}\right) \times \left(2\hat{i} + 2\hat{j}\right)$

$= -3.2 \times 10 - 19\hat{u}N.$

So, magnitude of force = 3.2 × 10-19 N the direction is along negative Z-axis.

ii. Write Lenz's law in relation to electromagnetic induction. Explain the law from the principle of conservation of energy. [2+2]

Answer:

Lenz's law

In case of electromagnetic induction, the direction of the induced emf in such that, it always opposes the cause of generation of current in the circuit.

Law of conservation of energy from Lenz's law:

According to Lenz's law, the direction of the Induced emf is such that, this induced emf can oppose the cause of generation of electric current in the circuit. It means that, if we gradually bring a magnet near the coil, the induced emf will oppose the forward motion, and when the magnet is taken away from the coil, it opposes the receding motion. As a result, to generate relative motion between the magnet and the coil, some work must be done against this opposing force and this work done will induce electromotive force. Obeying the principle of conservation of energy. Hence, the principle of conservation of energy can be obtained from Lenz's law.

k.

iii. The energy of a hydrogen atom in a given orbit is -3.4eV. Find the radius of the orbit. [Given, e = -1.6x10^{-19}C. m_e = 9.11x10^{-31} kg.

$\frac{h}{2\pi}$ =1.055x10^{-34} J.s, $\frac{1}{4}\pi\varepsilon_0$ = 9x10^{9} Nm^2C^{-2}]

Answer:

We know, $E_n \propto \frac{1}{n^2}$

$\frac{E_1}{E_2} = \frac{h_2^2}{h_1^2}$ or, $\frac{-13.6}{-3.4} = \frac{h_2^2}{1}$

Again $r_n = \frac{\sum oh^2h^2}{\pi me^2}$

$r_2 = \frac{8.85 \times 10^{-12} \times 4 \times (6.63 \times 10^{-34})^2}{\pi \times 9.11 \times 10^{-31} \times (1.6 \times 10^{-19})^2}$

$$= \frac{1.56 \times 10^{-77}}{7.33 \times 10^{-68}}$$

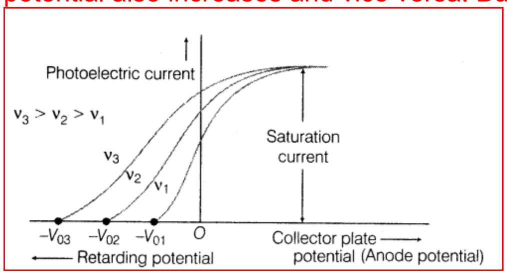
2.13×10^{-10} m.

$= 2.13 \overset{0}{A}$

iv. Draw a graph to how the dependence of stopping potential on the frequency of incident light in case of photoelectric effect. Indicate the threshold frequency in the graph. [3+1]

Answer:

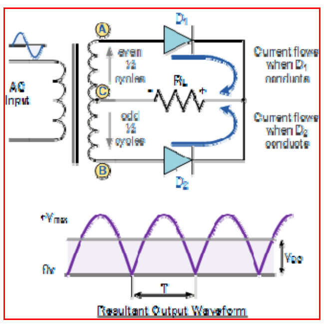
In this case, as the frequency of incident light on photocathode increases value of stopping potential also increases and vice versa. But saturation current is independent of frequency light.



OR

Draw the circuit diagram of a full wave rectifier using p-n junction diode and explain its operation. To which factor is the pulsating nature of the output due? [3+1]

Answer:



Full wave rectification

The required circuit diagram for full-wave rectification and input-output wave forms are shown in the figure. A full wave can be rectified by using two p-n junction. For one half-cycle of the a.c current the diode D_1 gets forward biased but D_2 gets reverse biased. As a result current flows only through the diode D_1 in this case. For the next half-cycle, the diode D_2 gets forward but the diode D_1 gets reverse biased. As a result current flow only through the diode D_2. Note that, for both the half-cycles of a complete cycle, the current through the load resistance is unidirectifed by this arrangements, so it is called full-wave rectification.

In this case, the number of ripple became double the number of wave crests of A.C input. Hence, if the frequency of the A.C input be so Hz, the frequency of the ripple will be 100 Hz.

Section– D (alternatives are to be noted)

Question 4 [6x2=12]

a.

i. State the laws of transverse vibration of a string.

Answer:

Law of length

If T and m are constant, then $U \propto \frac{1}{L}$. This is law of length.

Law of tension

If L and m are constant, then $U \propto \sqrt{T}$. This is law of tension.

Law of mass

If L and T are constant, then $U \propto \frac{1}{\sqrt{m}}$. This is law of mass.

These three laws combined and from the fundamental frequency by this equation $U = \frac{1}{2L}\sqrt{\frac{T}{m}}$

ii. How are stationary waves formed in a transversely vibrating stretched string? (**)

Answer:

ii. The ratio of the lengths of two uniform wires of the same material of equal diameter is 2:3. If the frequency of the fundamental note emitted by the longer wire, find the ratio of the tensions in the wires. (**) [3+1+2]

Answer:

OR

i. Describe Young's double slit experiment. State the nature of the distribution of intensity of light on the screen. What happens to the distribution of intensity if one of the slits is covered? [2+1+1]

Answer:

Young's experimental arrangement is as follows. Two narrow slits A and B are made in close in each other on an obstacle O placed in front of a source of a monochromatic light M. Being placed symmetrically about source M, slits A and B act as a pair of coherent source when illuminated by source. If laboratory is sufficiently dark, alternative bright and dark line can be seen on the screen placed behind O. These dark and bright line are called interference fringes.

Increase in intensity of light is due to constructive interference and decrease in intensity is due to destructive interference.

ii. The width of an interference fringe is 1.5mm. What would be the width of the fringe if the separation between the slits is made twice the original value? [2]

Answer:

When one of the slits is covered with an opaque screen, the interference fringes would disappear and the screen would appear to be illuminated uniformly.

In the first case $y = \frac{D}{2d}\lambda = 1.5\text{mm}$ where 2d = distance between the slits

In second case, the distance between the slits = $2 \times (2d)$

$$\therefore y' = \frac{D}{2\times 2d}\lambda = \frac{1}{2}\left(\frac{D}{2d}\lambda\right) = \frac{1}{2}\times 1.5 = 0.75\text{mm}$$

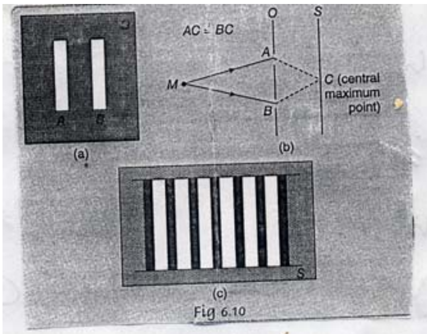


Fig 6.10

b.

i. Compare paramagnetic, diamagnetic and ferro-magnetic substances on the basis of magnetic permeability and magnetic susceptibility.

Answer:

Properties	Ferromagnetic substance	Paramagnetic substance	Diamagnetic substance
State	They are solid.	They may be solid, liquid or gas.	They may be solid, liquid and gas.
Effect of magnet	Strongly attracted by a magnet.	Feebly attracted by a magnet	Feebly repelled by a magnet
Behaviour of non-uniform field	Movement from low high field region	Movement from low to high field region	Movement from high to low field region
Behaviour in external magnetic field (lines of induction	The density of lines of induction in the material is larger than the density of the lines of magnetic intensity	The density of lines of induction is a little larger than that of the lines of magnetic intensity	The density of lines of induction is a little less than that of the lines of magnetic intensity
Effects of temperature	Above curie point, a ferromagnetic substance becomes paramagnetic	With the rise of temperature a paramagnetic substance becomes a diamagnetic.	No effects on a diamagnetic substance.
Permeability	Very high	A little greater than unity.	A little less than unit.
Susceptibility	Very high and positive	A little greater than unity and positive.	A little less than unity and negative.

ii. Suppose that the source of earth's magnetism is a magnetic dipole placed at the center of the earth. Find the moment of the magnetic dipole of the earth if the strength of the earth's magnetic field at the equator is $4\text{x}10^{-5}$T Given radius of the earth = $6.4\text{x } 10^{6}$m and

$$\frac{\mu o}{4\pi} = 10^{-7}\ \text{TmA}^{-1}$$

Answer:

The strength of earth's magnetic field at equation = $4\text{x}10^{-5}$T

Radius of earth = $6.4\text{x } 10^{6}$m

$\therefore B = \frac{M_o}{4\pi} \cdot \frac{P_m}{R^3}$ [P_m = the moment of the magnetic dipole of the earth]

$4 \times 10^{-5} T = 10^{-7} \cdot \frac{P_m}{(6.4 \times 10^6)}$

or $P_m = \frac{4 \times 10^{-5} (6.4 \times 10^6)}{10^{-7}}$

$= 1.05 \times 10^{23}$ A.m^2

OR

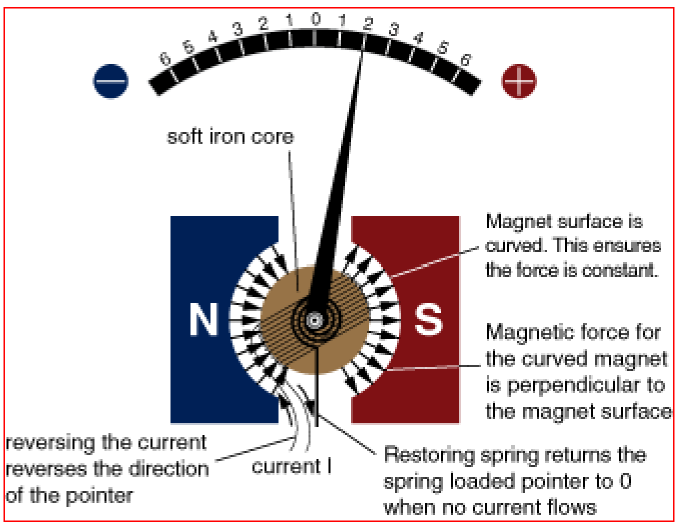
i. The number of turns of the coil of a moving coil galvanometer is n. the area enclosed by the coil is A and the magnetic field is B. Find how much torque will act on the coil if a current of strength flows through that coil. [3]

Answer:

Let the number of rectangular coil = N, area of its surface = A magnetic field parallel to the coil = B and current through coil = I

$\therefore$ Torque acting on coil J = B N I A.

Due to this torque, the coil rotates from its equilibrium position. On other hand, the phosphor-bronze thread in a suspended spring in a table galvanometer always tries to return the coil to its equilibrium position by the virtue of their elastic property. The value of this restoring torque J' is directly proportional to the angle of deflection of the coil.



[MOVING COILD GALVANOMETER]

So if the coil comes to rest at an angular displacement θ, J = J' or B N I A = Kθ

Or, $I = \frac{K}{B N A} . \theta$

Here K = restoring torque per unit twist = constant.

ii. If the torsional rigidity per unit angle of twist of the suspension of the coil is k. find out an expression for the current sensitivity of the galvanometer. [2]

Answer:

Current sensitivity = From the equation $\frac{\theta}{I}=\frac{BNA}{K}$. So, for given current I, to get greater deflection θ, the value of $\frac{BNA}{K}$ should be greater.

1. Used powerful magnet the value of B increased.
2. A rectangular coil of multiple turns(N).
3. Coil area (A) should be very large.
4. The suspension thread is chosen for which K is sufficiently small.

iii. Draw a circuit diagram to show how to convert a galvanometer into a voltmeter. [1]

Answer:

Galvanometer into voltmeter conversion

In this case, a high resistance R is connected in series with the galvanometer. The two points A and B are connected with the external circuit. So, if the current in the external circuit be IG, galvanometer current will also be IG and as a result, the pointer gives full-scale deflection. Hence, in this condition, the potential difference (VA-VB) between the two points A and B will show full-scale deflection of the pointer. So, the galvanometer will then be effectively converted into a voltmeter. Due to the series combination of G and R, the equivalent resistance of the voltmeter becomes sufficiently large.

Calculation:

$V_A - V_B = V = IG(G+R)$

Or, $G+B = \frac{V}{I_G}$

$\therefore R=\frac{V}{I_G}-G$

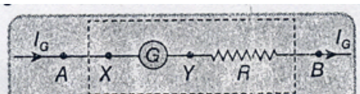


Fig 1.65