2008

Part: I

Question: 1 [20]

Answer all questions briefly and to the point.

a. Write Coulomb's Law in vector form.

Answer:
See topics on 'Coulomb's law'.

b. How much kinetic energy is gained by an electron, initially at rest, when it moves through a potential difference of 1000 v? Leave your answer in Joule. (**)

c. A wire of resistivity is stretched uniformly so that its length becomes four times. What is its new resistivity? (Assume temperature of the wire remains constant during stretching of the wire.) (**)

d. Show graphically how electric resistance of a piece of Silicon on Germanium varies when its temperature is varied. (**)

e. A circular coil having 50 turns, each with an area of $0.01m^2$, carries a currency of 2A. Calculate its magnetic dipole moment. (**)

f. How the electric vector $\bar{E}$, the magnetic vector $\bar{B}$ and velocity vector $\bar{C}$ oriented in an electromagnetic wave? (**)

g. State two conditions which must be satisfied in order to apply Tangent Law in magnetism.

Answer:
Two conditions which must be satisfied in order to apply tangent law in magnetism are:
- There must be two magnetic fields present at that place.
- The two magnetic fields must be in a horizontal plane and perpendicular to each other.

h. A straight conductor of length 0.4 m is moved with a speed of $7ms^{-1}$along the direction of a uniform magnetic field. What will be the emf induced, if any across its end?

Answer:
Given,
l = 0.4 m,
v = 7 m / sec
emf induced,
E = Bvl
= Bvl sin θ
= 0
Since the rod moves along the field, so $\theta = 0$
So, E = Bvl sin $\theta = 0$

i. An alternating current of frequency f is flowing through an idea choke coil of self inductance L. If Vo and Io be the peak value of the voltage and current, find the average power consumed, if any, by the choke coil.

Answer:
Average power

= E_{rms} x irms x cosϕ

= $\frac{v_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}}$ x 0 (ideal choke coil has cosϕ = 0)

= 0

j. What type of wave front is generated from a line source of light?

Answer:

From a line source of light cylindrical wave front arises.

k. What will be the effect, if any, on the fringe width in Young's double slit experiment if red light is used in place of violate light?

Answer:

We know, $\omega = \frac{D\lambda}{d}$

As wavelength increases fringe width increases.

l. How will you identify experimentally whether a given beam of light is plane polarized or unpolarized?

Answer:

The light which is to be tested is passed through a Polaroid. Then Polaroid is rotated in its own plane and intensity of emergent light is observed. If the intensity becomes twice the maximum and twice the minimum then the incident light is plane polarized and if the intensity of emergent light does not changes at all, then the incident light is an un-polarized light.

m. An intensity of illumination of 5 lux is required at a distance of 10 m from an electric lamp. What must be the luminous intensity of the lamp?

Answer:

Given, E = 5 lux., r = 10 m

We know,

$E = \frac{I}{r^2}$

$5 = \frac{I}{10^2}$

I = 100 x 5

= 500 candela

n. What is the main reason for axial chromatic aberration in the formation of images by a lens?

Answer:

Main reason for axial chromatic aberration in the formation of image by a lens is that the focal length of the lens is different for different colours of light.

o. What is the angle of refraction made by a ray of light inside a regular i.e., an equilateral glass prism in the deviation case?

Answer:
Angle of refraction inside a regular equilateral prism in the case of minimum deviation will be as, r + r' = $\angle$A and, in the case of minimum deviation, r = r'
So, $2r = 60^0$
$R = 30^0$

p. Photo electric threshold frequency of an alkali metal is $5.0X\ 10^{14}$ Hz. Calculate the work function of this metal.

Answer:
Given, $v_0 = 5 \times 10^{14}$ nz

Work function,
$\omega = 6.6 \times 10^{-34} \times 5 \times 10^{14}$
= 3.3 x 10-19 J
= 2.062 eV

q. What conclusion can be drawn from G.P Thomason's experiment?

Answer:
G.P Thomson's experiment confirmed wave like behavior of electrons.

r. Half life of a certain radioactive substance is 13.86 days. What is the value of its disintegration constant?

Answer:
T = 13.86 days

We know, $T = \frac{0.6931}{\lambda}$

$13.86 = \frac{0.6931}{\lambda}$

λ = 0.050 per day

s. What is the source of energy of star?

Answer:
Nuclear fusion is the source of energy of stars. Energy produced due to fusion of very light nucleus is called stellar energy.

t. Identify the logic gate whose truth table is given below and draw its logic symbol.

A	B	Y
O	O	1
O	1	1
1	O	1
1	1	O

Answer:
See topics on 'NAND'.

Part: II

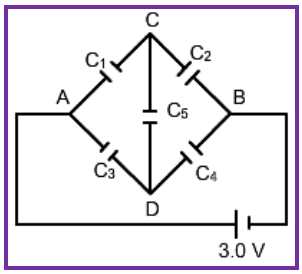
Section: A

Question: 2

a. Obtain an expression for the electric potential at a point which is at a distance r from the point charge.(**) [3]

b. Find the equivalent capacitance of the alongside given circuit between the junction A and B; given, $C_1 = C_2 = C_3 = C_4 = 10\mu$ F and $C_5 = 5$ μF. (**) [2]

c.



A galvanometer with a coil of resistance 100 Ω and a scale having 100 division has a current sensitivity of 25μA/division. How will you convert it into an ammeter of range 0 to 5A? [4]

Answer:

Resistance of coil: 100 ohm
Current sensitivity: 25μA/division
Total 100 divisions,

We know, $S = \frac{i_g G}{i - i_g}$

and
i_g = 25μA x 100
= 2500 μA
= 2.50 x 10-3 amp

$$S = \frac{i_g G}{i - i_g}$$

$$= \frac{2.50 \text{ x } 10 - 3 \text{ x } 100}{5 - 2.50 \text{ x } 10^{-3}}$$

0.05 ohm

So, 0.05 ohm resistance should be connected in parallel to the given galvanometer to convert it into an ammeter of given range.

Question: 3

a. The emf 'E' of a thermocouple varies with the temperature θ (in degree C) of the hot junction (cold junction at 0^0C) as $E=15\theta - 0.05\theta^2$. Determine the neutral temperature. [3]

Answer:

Given, $E=15\theta - 0.05\theta^2$

Differentiating E w.r.t. θ

$$\frac{dE}{d\theta} = 15 - 2 \times 0.05\theta$$

$$\frac{dE}{d\theta} = 15 - 0.1\theta$$

At neutral temperature,

$\theta = \theta_n$ and $\frac{dE}{d\theta} = 0$

$0 = 15 - 0.1\ \theta_n$

So, $0.1\ \theta_n = 15$

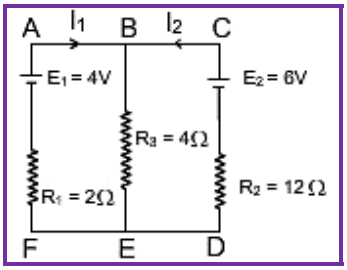
$$\theta_n = \frac{15}{0.1} = 150^0C$$

b. Using either deflection magnetometer or vibration magnetometer, explain how you will compare magnetic moments of two given bar magnets. [2]

Answer:

See topics on 'Magnetometers'.

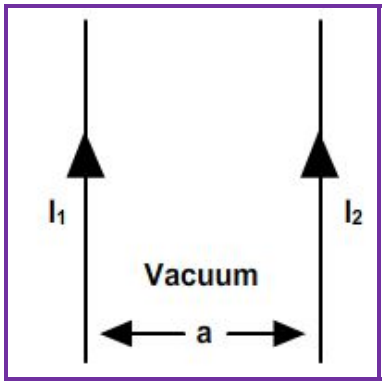
c.



In the circuit given along side, E_1 and E_2 are two cells of emfs 4V and 6V respectively, having negligible internal resistance. Applying Kirchhoff's laws of electrical networks, find the value of I_1 and I_2. (**) [4]

Question: 4

a.



Two very long straight parallel conductors carrying currents I1 and I2 in vacuum are separated by a distance 'a'. Write an expression for the force experienced per unit length by one wire due to current through the order wire and hence define the fundamental unit of current, i.e., an ampere. [3]

Answer:

Given two straight parallel conductors carrying currents I_1 and I_2.

Distance of separation = a

Force experienced per unit length by one wire due to current flowing through other wire is given by,

$$\frac{F}{l} = \frac{\mu 0 I_1 I_2}{2\pi a}$$

If $I_1 = I_2 = 1$, then, $\frac{F}{l} = \frac{\mu 0 I^2}{2\pi a}$

Definition of 1 ampere:

1 ampere is the current which when flowing in each of the two infinitely long parallel conductors 1 meter apart in vacuum produces between them a force of exactly 2×10^{-7} Newton per meter of length.

b. When the primary of a transformer is connected to 120VAC mains, the current in the primary is 18.5 mA. Find the voltage across the secondary when it delivers 1.5mA current through it, assuming the transformer to be an ideal one. State any one type of energy loss in a transformer. (**) [2]

c. A 30μF capacitor,0.2 H inductor and a 50 Ω resistor are conducted in series to an A.C. source whose emf is given by E= 310 sin(314t) where E is in volt and t is in second. Calculate, (**) [4]

i. The impedance of the circuit.
ii. Peak value of current in the circuit

Section: B

Question: 5

a. Draw a simple ray diagram showing the formation of a primary rainbow. [2]

Answer:

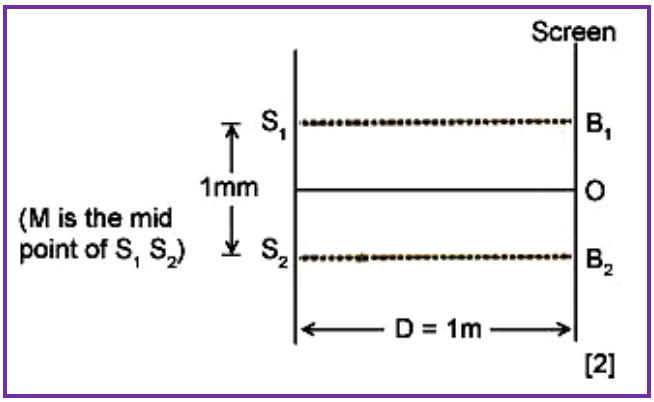
See topics on 'Rainbow formation'.

b. Using Huygens's principle, prove the laws of refraction of light. [3]

Answer:

See topics on 'Huygens' principle'.

c. The figure below shows the positions of the first bright fringes B_1 and B_2 on either side of the bright fringe O in Young's double slit experiment. Find the wavelength of monochromatic light used. [3]



Answer:

Given D = 1m

D = 1 x 10^{-3} m

Width of a fringe = $\frac{D\lambda}{d}$

We know, $\frac{mD\lambda}{d}$

Putting the value in the formula:

$0.5 \times 10 - 3 = \frac{1 \times 1 \times \lambda}{1 \times 10^{-3}}$

λ = 5 x 10-7 m

= 5000 $\mathring{A}$

Question: 6

a. Draw a labeled diagram of Michelson's method to determine the speed of light in air. [2]

Answer:

See topics on 'Michelson's method'.

b. What is the essential difference between polarized light and unpolarized light? Find Brewster's angle for water having refractive index n=1.33. [3]

Answer:

Essential difference between polarized light and unpolarized light is that in polarized light vibrations of electric vector are confined to one direction only whereas in an unpolarised light vibrations of electric vector are in all possible directions.

By Brewster's law:

n = tan ip

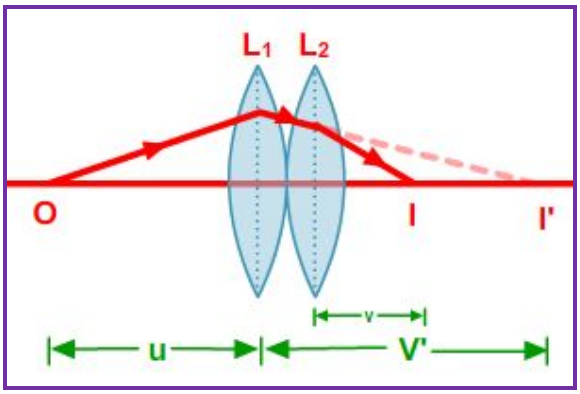
Given, n = 1.33

1.33 = tan ip

ip = $\tan^{-1}$ (1.33) = 53.06

c. When two thin lenses of focal lengths f_1 and f_2 are kept in contact, prove that their combined focal length 'f' is given by, $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$. [3]

Answer:



Suppose two thin convex lenses L_1 and L_2 of focal lengths f_1 and f_2 are placed in contact in air having a common principal axis. A point object O is placed on the principal axis at a distance u from the first lens L_1. Its image would be formed by the lens L_1 alone at I', distant v' from L_1.

Then from the lens formula, we have

$$\frac{1}{v'} - \frac{1}{u} = \frac{1}{f_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{(i)}$$

I' serves as a virtual object for the second lens L_2 which forms a final image I at a distance v from it.

Then, we have

$$\frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}$$

Adding equation (i) an d(ii) we get,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{(iii)}$$

If we replace these two lenses by a single lens which forms the image of an object distant u form it at a distance v, then the focal length f of this equivalent lens would be given by,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{(iv)}$$

From equation (iii) and (iv), we get

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{(v)}$$

Question: 7

a. Draw a labeled ray diagram of an image of a distant object formed by a refracting astronomical telescope in normal adjustment. Write (do not derive) an expression for its magnifying power. [3]

Answer:

See topics on 'telescope'.

b. In a compound microscope consisting of two convex lenses of local lengths 1.5 cm and 10 cm, the object is 2 cm from objective and the final image is formed at the least distance of distinct victim(D=25 cm). Find the distance of separation of the two lenses. [2]

Answer:

Given,
$f_0 = 1.5$ cm,
$f_e = 10$cm,
$u_0 = 2$ cm
$L = v_0 + u_e$

We know, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

In case of objective lens,

$$\frac{1}{f_0} = \frac{1}{v_0} + \frac{1}{u_0}$$

$$\frac{1}{1.5} = \frac{1}{v_0} + \frac{1}{2}$$

$$\frac{1}{v_0} = \frac{2 - 1.5}{1.5 \times 2}$$

$$= \frac{0.5}{3}$$

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e}$$

$$\frac{1}{10} = \frac{1}{-25} + \frac{1}{u_e}$$

$$\frac{1}{u_e} = \frac{1}{10} + \frac{1}{25}$$

$$\frac{1}{u_e} = \frac{5 + 2}{50}$$

$$= \frac{7}{50}$$

$$\frac{50}{7} \text{ - } 7.14 \text{ cm}$$

Distance of separation of two lenses,
$= v_0 + u_e$
$= 6 + 7.14$
$= 13.14$ cm

c. A parallel beam of monochromatic light of wavelength 500mm is incident normally on a rectangular slit. The angular width of the centre bright fringe of Fraunhofer diffraction is found to be 60^0. Find the width of the slit in meter. [3]

Answer:

Given,
$\lambda = 500$ nm
$= 500 \times 10\text{-}9$ m

$2\theta = 60^0$
$0 = 30^0$

We know,

$e \sin\theta = n\lambda$

$$e = \frac{n\lambda}{\sin\theta}$$

$$e = \frac{1 \times 500 \times 10^{-9}}{\sin 30^0}$$

$= 1 \times 10^{-6}$ m

Section: C

Question: 8

a. An electron beam passes through crossed electric and magnetic fields of 3.4×10^4 Vm^{-1} and $2X\ 10^{-3}$ Wbm^{-2} respectively. If the path of the beam remains un-deviated, calculate the speed of the electrons. [2]

Answer:
Given,
E = 3.4 x 104 V/m
B = 2 x 10-3 Wb/m^2

We know, $v = \frac{E}{B} = \frac{3.4 \times 10^4}{2 \times 10^{-3}}$

Radius of circular path described by the electrons is given by, $r = \frac{mv}{eB}$

Given mass of electron: 9.1×10^{-31} kg

Charge of electron: 1.6×10^{-19} C

So, $r = \frac{9.1 \times 10^{-31} \times 1.70 \times 10^7}{1.6 \times 10^{-19} \times 2 \times 10^{-3}}$

b. Draw the energy level diagram of a hydrogen atom; and draw arrows to show transitions responsible for:

i. Absorption line of Lyman series.

Answer:
See topics on 'Hydrogen atom'.

ii. Emission lines of Balmer series [3]

Answer:
See topics on 'Hydrogen atom'.

c. Explain in brief the Compton Effect. [3]

Answer:
See topics on 'Compton Scattering'.

Question: 9

a. IN photo electric effect, what is meant by the terms: [3]

i. Work function of the metal

Answer:
The minimum energy required for the emission of photoelectron from a metal is called the work function of that metal.

ii. Stopping potential.

Answer:
It is that energy required applied to the anode which completely stops the photoelectric current.

b. Alpha particles having kinetic energy of 1.8 MeV each are incident on a thin gold foil, from a large distance. Applying the principle of conservation of energy, find the closest distance of approach of the alpha particle from the gold nucleus.(Atomic number of gold =79) (**) [3]

Answer:
K.E of alpha particles = 1.8 MeV

Atomic number of gold = 79

We know,

$$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{2ze^2}{k}$$

$$= \frac{9 \times 10^9 \times 2 \times 79 \times (1.6 \times 10^{-19})^2}{1.8 \times 10^6 \times 10^{-19}}$$

$= 1.264 \times 10^{-13}$ m

c. Calculate the minimum wave length of X-ray tube operating at a tube potential of 40kv. How will this wave length change if target is made of another metal? [2]

Answer:
Given, Tube potential = 40 KV
We know,

$$eV = \frac{hC}{\lambda_{min}}$$

$$\lambda_{min} = \frac{hC}{eV}$$

$$\frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 40 \times 10^3}$$

= 3.09 x 10-11 m
= 0.309 x 10-10 m

$= 0.309$ Å

Question: 10

a. Draw a rough sketch showing the variation of binding energy per nucleon with mass number of various nuclei. Label the graph and state the region where the nuclei are most stable. [2]

Answer:
See topics on 'Figure 2: Variation of nuclear binding energy with mass number'.

b. Draw the labeled circuit diagram of a N-P-N transistor in a common-emitter configuration to study its characteristics. [4]

Answer:
See topics on 'Transistor'.

c. Why a NAND gate is called universal gate? Show how an AND gate can be obtained using one or more NAND gates. [2]

Answer:
See topics on 'NAND'.

(**) Currently out of syllabus. Answer can be provided up on request.