Time allowed : 3 Hours

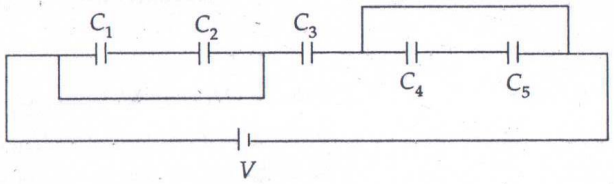
Physics

Max. Marks : 70

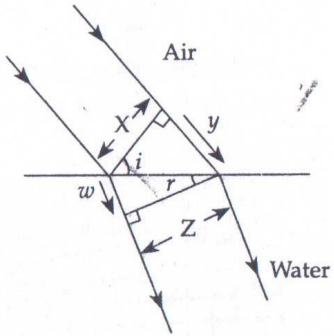
Prof. Tarsem Mahajan's Heights Academy

SECTION-A

1. What is the equivalent capacitance, C, of the five capacitors, connected as shown in figure given below?



2. A plane wavefront, of width X, is incident on an air-water interface and the corresponding refracted wavefront has a width Z as shown alongside. Express the refractive index of air with respect to water, in terms of the dimensions shown.



3. A device X can convert one form of energy into another. Another device Y can be regarded as a combination of transmitter and a receiver. Name the devices X and Y.
4. The maximum velocity of electrons, emitted from a metal surface of negligible work function, is 'v', when frequency of light falling on its is 'f'. What will be the maximum velocity when the incident light frequency is made '$4f$'?
5. A plane electromagnetic wave, of angular frequency ω, is propagating with velocity c along the Z-axis. Write the vector equations, of oscillating electric magnetic fields, and show these fields diagramatically.

SECTION-B

6. Justify that the electrostatic potential is constant throughout the volume of a charged conductor and has the same value on its surface as inside it.

(a)

disconnecting the battery. What will be the change in

(a) charge stored in the capacitor?

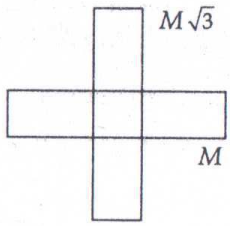
(b) energy stored in the capacitor?

(c) potential difference across the plates of the capacitor?

(d) electric field between the plates of the capacitor?

7. Draw the current versus potential difference characteristics for a cell. How can the internal resistance of the cell be determined from this graph?

8. Two magnets of magnetic moments M and $M\sqrt{3}$ are joined to form a cross. The combination is suspended in a uniform magnetic field B. Find the value of θ of $M\sqrt{3}$ with magnetic field.

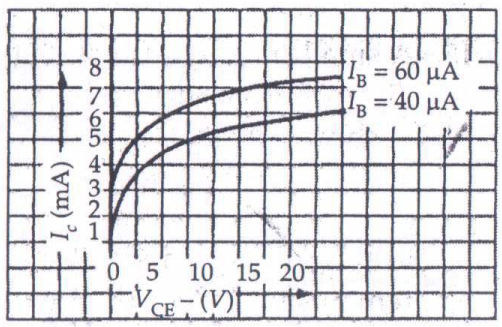


9. A luminescent object is placed at a depth 'd' in a (optically) denser medium of refractive index 'μ'. Prove that radius r, of the base of the cone of light, from the object, that can emerge out from the surface is $r = \dfrac{d}{\sqrt{\mu^2 - 1}}$.

10. A certain n-p-n transistor has the common emitter output characteristics as shown below:

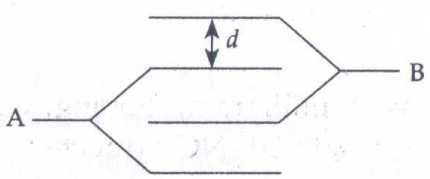
(a) Find the emitter current at V_{CE} = 10 V and I_B = 60 μA.

(b) Find β at this point.

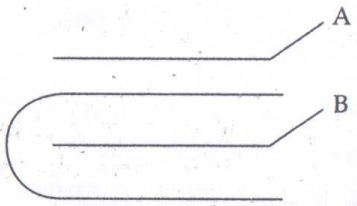


SECTION-C

11. Four identical horizontal square metal plates each of area A are placed at a distance d apart in air and connected to terminals A and B as shown in figure (*a*) and (*b*). Find effective capacitance between the terminals A and B in each case.



(a)



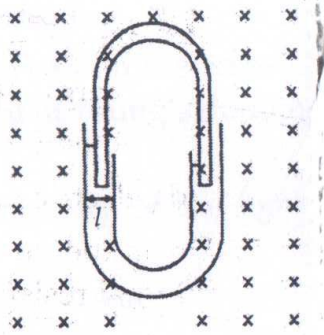
(b)

Or

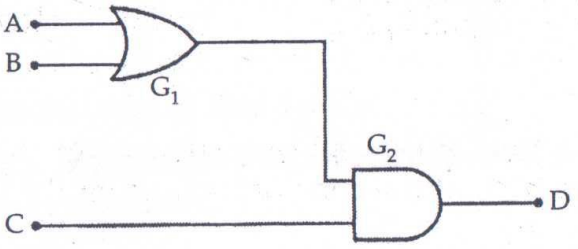
Define an electric field line. Draw the pattern of the field lines around a system of two equal positive charges separated by a distance.

10 A in one direction to 10 A in opposite direction in 0.40 second. Find the coefficient of self induction of the coil.

13. Define motional emf. A conducting U-tube can slide inside another U-tube maintaining electric contact between the tubes. The magnetic field is perpendicular to the plane of paper and is directed inward. Each tube moves towards the other at a constant speed v. Find the magnitude of induced emf across the ends of the tubes in terms of magnetic field B, velocity v and width of the tube.

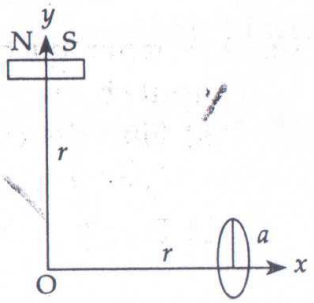


14. For the given combination of gates, find the values of outputs Y_1 and Y_2 in the table given below. Identify the gates G_1 and G_2.

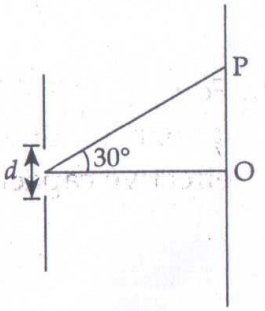


A	B	C	D
0	0	0	Y_1
1	1	0	Y_2

15. A small magnet, of magnetic moment M, is placed at a distance from the origin O with its axis parallel to x-axis as shown. A small coil, of one turn, is placed on the x-axis, at the same distance from the origin, with the axis of the coil coinciding with x-axis. For what value of current in the coil does a small magnetic needle, kept at origin, remains undeflected? What is the direction of current in the coil?



16. A slit of width 'd' is illuminated by white light. For what value of 'd' is the first minimum, for red light of $\lambda = 650$ nm, located at point P? For what value of the wavelength of light will the first diffraction maxima also fall at P?



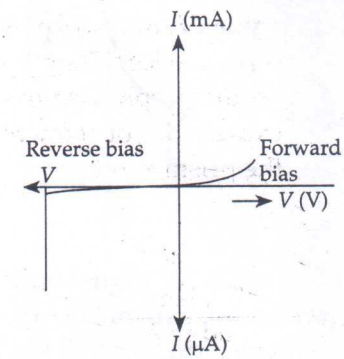
17. A charged particle of charge 2 μC and mass 10 milligram, moving, with a velocity of 1000 m/s enters a uniform electric field of strength 10^3 NC^{-1} directed perpendicular to its direction of motion. Find the velocity and displacement of the particle after 10 s.

18. What reasoning led de-Broglie to put forward the concept of matter waves? The wavelength, l, of a photon, and the de-Broglie wavelength associated with a particle of mass 'm' has the same value, say λ. Show that the energy of photon is $\frac{2\lambda mc}{h}$ times the kinetic energy of the particle.

(iii) If ... to the ground state from the third excited state ...

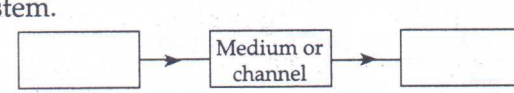
19. Give reason for each of the following observations:
    (i) The resultant intensity at any point on the screen varies between zero and four times the intensity, due to one slit, in Young's double slit experiment.
    (ii) A few coloured fringes, around a central white region, are observed on the screen, when the source of monochromatic light is replaced by white light in Young's double slit experiment.
    (iii) The intensity of light transmitted by a polaroid is half the intensity of the light incident on it.

20. The adjoining figure shows the *V-I* characteristics of a semiconductor device.
    (i) Identify the semiconductor device used here.
    (ii) Draw the circuit diagram to obtain the given characteristics of this device.
    (iii) Briefly explain how this device is used as a voltage regulator.



21. If nuclei, with lower binding energy per nucleon, transform to nuclei with greater binding energy per nucleon, would the reaction be exothermic or endothermic? Justify your answer and write two examples to support your answer.

22. Complete the following block diagram depicting the essential elements of a basic communication system.



Name the two basic modes of communication. Which of these modes is used for telephonic communication?

Is it necessary for the transmitting antenna and the receiving antenna to be of the same height for line of sight communication? Find an expression for maximum line of sight distance d_m between these two antennas of heights h_r and h_R.

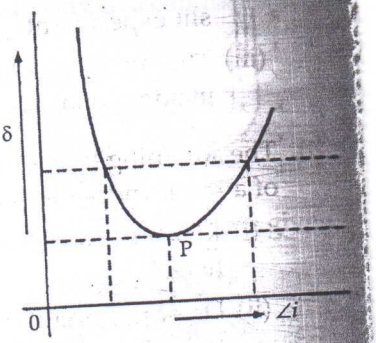
SECTION-D

23. Rutherford and his team performed the Gold foil experiment that provided a new insight into the structure of an atom. Their findings were not recognized by the scientific community in that period of time. Still this did not deter them from making further path breaking discoveries in the field of Physics.
    (i) What were the qualities that can be imbibed by us from Rutherford and his team?
    (ii) The ground state energy of hydrogen atom is –13.6 eV.
    What are the potential and kinetic energy of an electron in the 3rd excited state?

(iii) If the electron jumps to the ground state from the third excited state, calculate the frequency of the photon emitted.

SECTION-E

24. A plot, between the angle of deviation (δ) and angle of incidence (i), for a triangular prism is shown alongside. Explain why any given value of 'δ' corresponds to two values of angle of incidence? State the significance of point 'P' on the graph. Use this information to derive an expression for refractive index of the material of the prism.

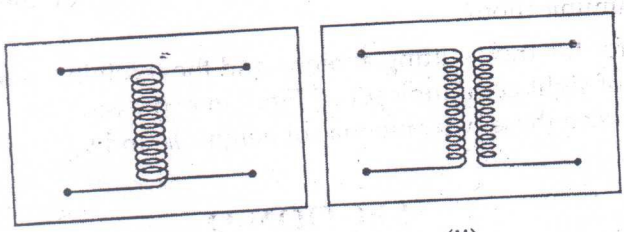


Or

A thin lens, made of a material of refractive index μ, has a focal length 'f'. If the lens is placed in a transparent medium of refractive index 'n' ($n < \mu$), obtain an expression for the change in the focal length of the lens. Use the result to show that the focal length of a lens of the glass ($\mu = \mu_g$) becomes $\frac{\mu_w(\mu_g - 1)}{(\mu_g - \mu_w)}$ times its focal length in air, when it is placed in water ($\mu = \mu_w$).

What happens when $n > \mu$. Explain using appropriate ray diagram.

25. (a) Out of the two arrangements, given below, for winding of primary and secondary coil in a transformer, which arrangement do you think will have higher efficiency, and why?



(i) (ii)

(b) Show that in an ideal transformer, when the voltage is stepped up by a certain factor, the current gets stepped down by the same factor.

(c) State any two causes of energy loss in a transformer.

Or

(a) In a series LCR as circuit, is the applied instantaneous voltage equal to the algebraic sum of the instantaneous voltages across the series elements of the circuit? Is the same true for r.m.s. voltages?

(b) Prove that in a series LCR circuit, the power dissipated depends not only on the voltage and current but also on the cosine of the phase angle ϕ between these two.

26. Is current density a vector or a scalar quantity? Deduce the relation between current density and potential difference across a current carrying conductor of length l, area of cross-section A and number density of free electrons n. How does the current density, in a conductor vary with

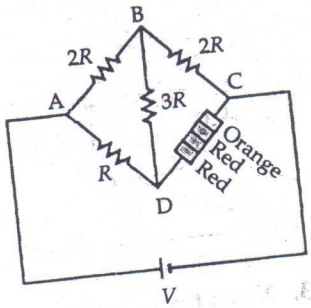
(a) increase in potential gradient? (b) increase in temperature?

(c) increase in length? (d) increase in area of cross-section?

(Assume that the other factor constant in each case.)

Or

Write the condition of balance in a Wheatstone bridge. In the given Wheatstone bridge, the current in the resistor 3R, is zero. Find the value of R, if the carbon resistor, connected in one arm of the bridge, has the colour sequence of red, red and orange.



The resistances of BC and CD arms, are now interchanged and another carbon resistance is connected in place of R so that the current through the arm BD is again zero. Write the sequence of colour bands of this carbon resistor. Also find the value of current through it.