# IIT-JEE-Physics–1998

**Time : Three Hours** **Max. Marks : 100**

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**Instructions**

1. This question paper is in two section and contains 8 pages. Section I has 40 objective type questions. Section II had 15 questions. There are no negative marks for wrong answers.
2. Answer section I only on the printed form on the third page of your answer book.
3. Answer problems of section II starting from page 4 of the answer book. All parts of a question must be answered sequentially at one place only.
4. Attempt all question/problems.
5. Answer must be written only in the language of your choice as shown in your admit card.
6. Use of logarithmic table is permitted.
7. Use of slide rule/calculate is not permitted.

**Useful data**
Acceleration due to gravity g = 10 m s–2
Speed of light in vacuum c = 3.0 × 108 ms–1
Planck's constant h = 6.63 × 10–34 J s
Elementary charge e = 1.60 × 10–19 C

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**SECTION I**

1. You must first transfer the code given here on top of this Section to your Answer Sheet In the appropriate box marked. Question Paper Code.
2. Answer Section I only on the printed form on the third page of your answer book by writing the appropriate letters (A), (B), (C) etc. against the question number in the table. Answers for Section I written in this space alone will be awarded marks.
3. Section I consists of 40 objective type questions.
4. This section should take about one hour to answer.
5. Each question in this section carries 2 marks.

**1.** A transistor is used in common emitter mode as an amplifier, then :
(A)the base emitter junction is forward biased
(B)the base emitter junction is reverse biased
(C)the input signal is connected in series with the voltage applied to bias the base emitter junction.
(D)the input signal is connected in series with the voltage applied to bias the base collector junction.

**2.** Water from a tap emerges vertically downwards with an initial speed of 1.0 m/s. The cross-sectional area of tap is $10^{-4}$ m2. Assume that the pressure is constant throughout the stream of water and that the flow is steady, the cross-sectional area of stream 0.15 m below the tap is :

(A) $5.0 \times 10^{-4}$ m2 (B) $1.0 \times 10^{-4}$ m2
(C) $5.0 \times 10^{-5}$ m2 (D) $2.0 \times 10^{-5}$ m2

**3.** A real image of a distant object is formed by a planoconvex lens on its principal axis. Spherical aberration:

(A) is absent
(B) is smaller if the curved surface of the lens faces the object
(C) is smaller if the plane surface of the lens faces the object
(D) is the same whichever side of the lens faces the object

**4.** Let v, vrms and vp respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then :

(A) no molecule can have a energy greater then √2 Vrms
(B) no molecule can have speed less thenVp/√2
(C) Vp < V < Vrms
(D) the average kinetic energy of a molecule is 3/4 mvp2

**5.** A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300K. The ratio of the average rotational kinetic energy per O2 molecule to per N2molecule is:

(A) 1 : 1
(B) 1 : 2
(C) 2 : 1
(D) depends on the moment of inertia of the two molecules.

**6.** A string of length 0.4 ma and mass $10^{-2}$ Kg is tightly clamped at its ends. The tension in the string is 1.6N. Identical wave pulses are produced at one end at equal intervals of time Dt. The minimum value of Dt, which allows constructive interference between successive pulses, is :

(A) 0.05 s (B) 0.10 s
(C) 0.20 s (D) 0.40 s

**7.** Two particles, each of mass m and charge q, are attached to the two ends of a light rigid rod of length 2R. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moment of the system and its angular momentum about the centre of the rod is :

(A) q/2m (B) q/m
(C) 2q/m (D) q/pm

**8.** A ray of light travelling in a transparent medium falls on a surface separating the medium from air at an angle of incidence 450. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible value(s) of n from the following :

(A) 1.3 (B) 1.4
(C) 1.5 (D) 1.6

**9.** Let mp be the mass of proton, mn the mass of neutron. M1 the mass of 20/10 Ne nucleus and M2 the mass of 40/20 Ca nucleus. Then :

(A) M2 = 2M1 (B) M2 > 2M1
(C) M2 < 2M1 (D) M1 < 10 (mn + mp)

**10.** A parallel monochromatic beam of light is incident normally on a narrow slit. A diffraction pattern is formed on a screen placed perpendicular to the direction of the incident beam. At the first minimum of the diffraction pattern, the phase difference between the rays coming from the two edges of the slit is:

(A) 0 (B) p/2
(C) p (D) 2p

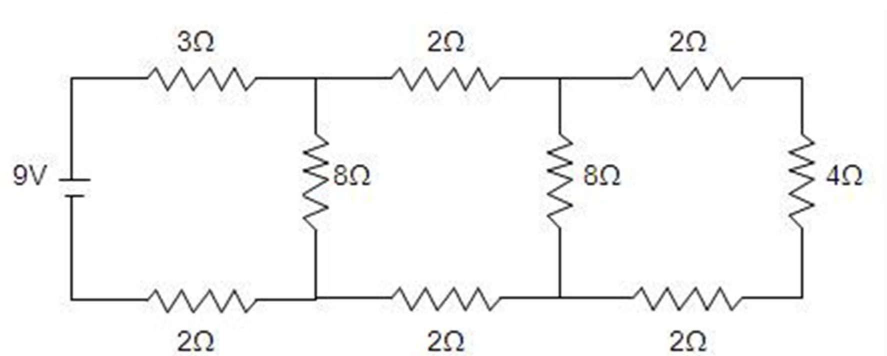
**11.** The electron in a hydrogen atom makes a transition n1 ®n2 where n1 and n2 are the principal quantum numbers of two states. Assume the Bohr model to be valid. The time period of the electron in the initial state is eight times that in the final state. The possible values of n1 and n2 are :

(A) n1 = 4, n2 = 2 (B)n1 = 8, n2 = 2
(C) n1 = 8, n2 = 1 (D) n1 = 6, n2 = 3

**12.** A stone tied to a string of length L is whirled in a vertical circle with the other end of the string at the centre. At a certain instant of time the stone is at its lowest position and has a speed u. The magnitude of the change in its velocity as it reaches a position, where the string is horizontal, is:

(A) √(u2-2gL) (B) √2gL
(C) √(u2-gL) (D) √2(u2- gL)

**13.** In the circuit shown in the figure, the current through:




(A) the 3W resistor is 0.50 A (B) the 3W resistor is 0.25 A
(C) the 4W resistor is 0.50 A (D) the 4W resistor is 0.25 A

**14.** A dielectric slab of thickness d is inserted in a parallel late capacitor whose negative plate is at x = 0 and positive plate is at x = 3d. The slab iis equidistant from the plates. The capacitor is given some charge. As x goes from 0 to 3d:
(A) the magnitude of the electric field remains the same
(B) the direction of the electric field remains the same
(C) the electric potential increases continuously
(D) the electric potential increases at first, then decreases and again increases.

**15.** The (x, y) coordinated of the corners of a square plate are (0, 0), (L, 0), (L, L) and (0, L). The edges of the plate are clamped and transverse standing waves re set up in it. If u (x, y) denotes the displacements of the plate at the point (x, y) at some instant of time, the possible expression (s) for u is (are) (a = positive constant):
(A) a cos (px/2L) cos (py/2L)
(B) a sin (px/L) sin (py/L)
(C) a sin (px/L) sin (2py/L)
(D) a cos (2px/L) sin (py/L)

**16.** A force F®= K(y î + x ĵ) (where K is a positive constant) acts on a particle moving in the xy plane. Starting from the origin, the particle is taken along the positive x-axis to the point (a, 0) and then parallel to the y-axis to the point (a, a). The total work done by the force F on the particle is:
(A) –2Ka2 (B) 2Ka2
(C) –Ka2 (D) Ka2

**17.** A small square loop of wire of side l is placed inside a large square loop of wire of side L(L >> l). The loops are coplanar and their centres coincide. The mutual inductance of the system is proportional to :
(A) l/L (B) I2/L
(C) L/l (D) L2/l.

**18.** The half life of 131I is 8 days. Given a sample of 131I at time t = 0, we can assert that:
(A) no nucleus will decay before t = 4 days
(B) no nucleus will decay before t = 8 days
(C) all nuclei will decay before t = 16 days
(D) a given nucleus may decay at any time after t = 0

**19.** Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of the gas in A is mA and that in B is mB. The gas in each cylinder is now allowed to expand isothermally to the same final volume 2V. The changes in the pressure in A and B are found to be DP and 1.5 DP respectively. Then :
(A) 4 mA = 9mB (B) 2mA = 3mB

(C) 3mA = 2mB (D) 9mA= 4mB

**20.** A given quantity of an ideal gas is at pressure P and absolute temperature T. The isothermal bulk modulus of the gas is:
(A) 2/3 P (B) P
(C) 3/2 P (D) 2P

**21.** A charge + q is fixed at each of the points x = x0, x = 3x0, x = 5x0 ….¥ on the x-axis and a charge – q is fixed at each of the points x = 2x0, x = 4x0, x = 6x0 …. ¥. Here x- is a positive constant. Take the electric potential at a point due to a charge Q at a distance r from it to be Q / 4p $Î_0$ r. Then the potential at the origin due to the above system of charges is :
(A) 0 (B) q / (8p $Î_0$ x0 In2)
(C) ¥ & (D) (q In2) / (4p $Î_0$ x0 )

**22.** Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle q with AB. The moment of inertia of the plate about the axis CD is then equal to :
(A) I (B) I $sin^2$q..
(C) I $cos^2$q (D) I $cos^2$(q/2)

**23.** Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of the gas in B is:
(A) 30 K (B) 18K
(C) 50 K (D) 42 K

**24.** A concave mirror is placed on a horizontal table with its axis directed vertically upwards. Let 0 be the pole of the mirror and C its centre of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be:
(A) real and will remain at C
(B) real and located at a point between C and µ
(C) virtual and located at a point between C and 0
(D) real and located at a point between C and 0

**25.** A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement (s) from the following :
(A) the entire rod is at the same electric potential
(B) there is an electric field in the rod
(C) the electric potential is highest at the centre of the rod and decreases towards its ends.

(D) the electric potential is lowest at the centre of the rod and increases towards its ends.

**26.** A positively charged thin metal ring of radius R is fixed in the xy plane with its centre at the origin O. A negatively charged particle P is released from rest at the point (0, 0, z0) where z0 < 0. Then the motion of P is :
(A) period for all values of z0 satisfying 0 < z0 < µ
(B) simple harmonic for all values of z0 satisfying 0 <  z0 < R
(C) approximately simple harmonic provided z0 < < R
(D) such that P crosses 0 and continues to move along the negative z-axis towards z = – µ.

**27.** A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small compared to the mass of the earth.
(A) The acceleration of S is always directed towards the centre of the earth.
(B) The angular momentum of S about the centre of the earth changes in direction, but its magnitude remain constant
(C) the total mechanical energy of S varies periodically with time
(D) The linear momentum of S remains constant in magnitude

**28.** The torque r® on a body about a given point is found to be equal to A® × L®  where A® is a constant vector and L® is the angular momentum of the body about that point. From this it follows that:
(A) (dL)®/dt is perpendicular to L® at all instants of time.
(B) the component of L® in the direction of A® does not change with time.
(C) the magnitude of L® does not change with time.
(D) L® does not change with time.

**29.** During the melting of a slab of ice at 273K at atmospheric pressure :
(A) positive work is done by the ice-water system on the atmosphere.
(B) positive work is done on the ice-water system by the atmosphere.
(C) the internal energy of the ice-water system increases.
(D) the internal energy of the ice-water system decreases.

**30.** In a p-n junction diode not connected to any circuit :
(A) the potential is the same everywhere
(B) the p-type side is at a higher potential than the n-type side
(C) there is an electric field at the junction directed from the n-side to the p-type side.
(D) there is an electric field at the junction directed from the p-type side to the n-type side.

**31.** A spherical surface of radius of curvature R, separates air) refractive index 1.0) from glass (refractive index 1.5). The centre of curvature is in the glass. A point object P placed in air is found to have a real image Q in the glass. The line PQ cuts the surface at a point O and PO = OQ. The distance PO is equal to :
(A) 5R (B) 3R

(C) 2R & (D) 1.5R

**32.** A non-conducting slid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre :

(A) increases as r increases for r < R

(B) decreases as r increases for 0 < r < µ

(C) decreases as r increases for R < r < µ

(D) is discontinuous at r = R

**33.** A transverse sinusoidal wave of amplitude a, wavelength l and frequency f is travelling on a stretched string. The maximum speed of any point on the string is v/10, where v is the speed of propagation of the wave. If a = $10^{-3}$ and m and v = 10 m/s, then l and f are given by :

(A) l = 2π × 10–2 m (B) l = $10^{-3}$ m

(C) f = $(10^{3})/2\pi$ Hz (D) f = $10^{4}$ Hz

**34.** A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is $U_1$, between 999 nm and 1000 nm is $U_2$ and between 1499 nm and 1500 nm is $U_3$. The Wein constant, b = 2.88 × 106 nm–K. Then :

(A) $U_1 = 0$ (B) $U_3 = 0$

(C) $U_1 > U_2$ (D) $U_2 > U_1$

**35.** Let [Î$_0$] denote the dimensional formula of the permittivity of the vacuum and [m$_0$] that of the permeability of the vacuum. If M = mass, L = length, T = time and I = electric current :

(A) [Î$_0$] = [M–1 L–3 T–2I] (B) [Î$_0$] = [M–1 L–3 T4I2]

(C) [m$_0$] = [MLT–2I–2] (D) [m$_0$] = [ML–2 T–1I]

**36.** The SI unit of the inductance, the henry can be written as:

(A) Weber/ampere (B) Volt-second/ampere

(C) Joule/(ampere)2 (D) ohm-second]

**37.** Two very long straight parallel wires carry steady currents I and –I respectively. The distance between the wires is d. At a certain instant of time, a point charge q is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity v® is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is :

(A) (µ0 Iqv) / 2πd (B) (µ0 Iqv) / πd

(C) (2µ0 Iqv) / πd (D) 0

**38.** X-rays are produced in an X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-rays has values from :

(A) 0 to ¥
(B) $I_{min}$ to ¥ where $I_{min}$ > 0
(C) 0 to $I_{max}$ where $I_{max}$ < ¥
(D) $I_{min}$ to $I_{max}$ where 0 < $I_{min}$ < $I_{max}$ < ¥

**39.** A particle of mass m is executing oscillations about the origin on the x-axis. Its potential energy is U(x) = k |x|3 where k is a positive constant. If the amplitude of oscillation is a, then its time period T is :
(A) proportional to 1/√a
(B) proportional of a
(C) proportional to √a
(D) proportional to a3/2

**40.** The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately:
(A) 540 nm (B) 400 nm
(C) 310 nm (D) 220 nm

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## SECTION II

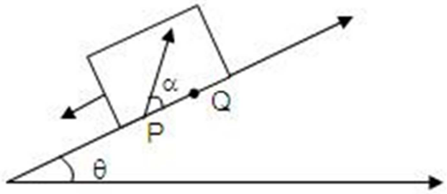
**Instructions**
**1.** There are 15 questions in this section. Each question carries 8 marks.
**2.** At the end of the answer to a question, leave 3 cm blank space, draw a horizontal line and start the answer to the next question. The corresponding question number must be written in the left margin. Answer all parts of a question at one place only.
**3.** The use of only Arabic numerals (0, 1, ….., 9) is allowed in answering the questions irrespective of the language in which you answer.

**1.** A particle of mass 10–2 Kg is moving along the positive x-axis under the influence of a force F(x) = – k/2x2 where k = 10–2 Nm2. At time t = 0 it is at x = 1.0 m and its velocity is v = 0:

(a) Find its velocity when it reaches x = 0.5 m

(b) Find the time at which it reaches x = 0.25 m

**2.** A large heavy box is sliding without friction down a smooth plane of inclination q. From a point P on the bottom of the box, a particle is projected inside the box. The initial speed of the particle with respect to the box is u and the direction of projection makes an angle q with the bottom as shown in the figure :

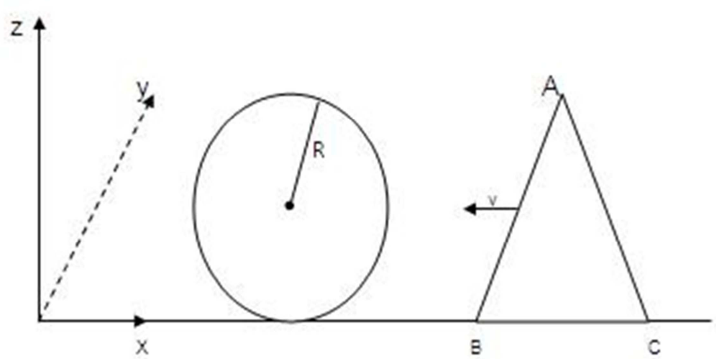



(A) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands (Assume that the particle does not hit any other surface of the box. Neglect air resistance).

(B) If the horizontal displacement of the particle as seen by an observer on the ground is zero, find the speed of the box with respect to the ground at the instant when the particle was projected.

**3.** A wedge of mass m and triangular cross-section (AB = BC = CA = 2R) is moving with a constant velocity – vî towards a sphere of radius R fixed on a smooth horizontal table as shown in the figure. The wedge makes an elastic collision with the fixed sphere and returns along the same path without any rotation. Neglect all friction and suppose that the wedge remains in contact with the sphere for a very short time Dt during which the sphere exerts a constant force F® on the wedge.

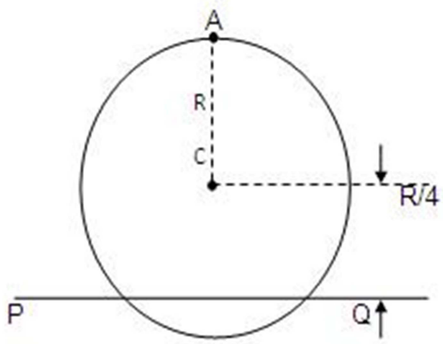
(A) Find the force F® and also the normal force N® exerted by the table on the wedge during the time Dt.




(B) Let h denote the perpendicular distance between the centre of mass of the wedge and the line of action of F. Find the magnitude of the torque due to the normal force N® about the centre of the wedge during the interval Dt.

**4.** A uniform circular disc has radius R and mass m. A particle, also of mass m, is fixed t a point A on the edge of the disc as shown in the figure. The disc can rotate freely about a fixed horizontal chord PQ that is at a distance R/4 from the centre C of the disc. The line AC is perpendicular to PQ.

Initially the disc is held vertical with the point A at its highest position. It is the then allowed to fall so that it starts rotating about PQ. Find the linear speed of the particle as it reaches its lowest position.




**5.** The air column in a pipe closed at one end is made to vibrate in its second overtone by tuning fork of frequency 440Hz The speed of sound in air is 330 m/s. End corrections may be neglected. Let P0 denote the mean pressure at any point in the pipe, and DP0 the maximum amplitude of pressure variation.

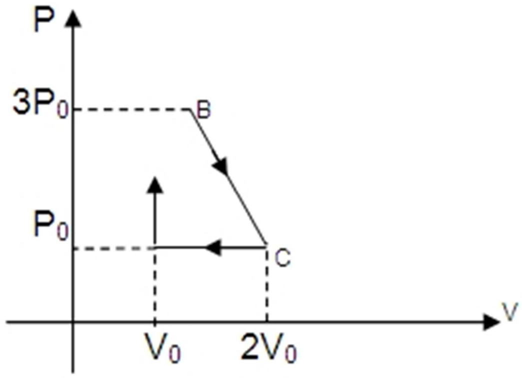
(a) Find the length L of the air column.

(b) What is the amplitude of pressure variation at the middle of the column?

(c) What are the maximum and minimum pressures at the open end of the pipe?

(d) What are the maximum and minimum pressures at the closed end of the pipe?

**6.** One mole of an ideal monoatomic gas is atomic round the cyclic process ABCA as shown in figure. Calculate :



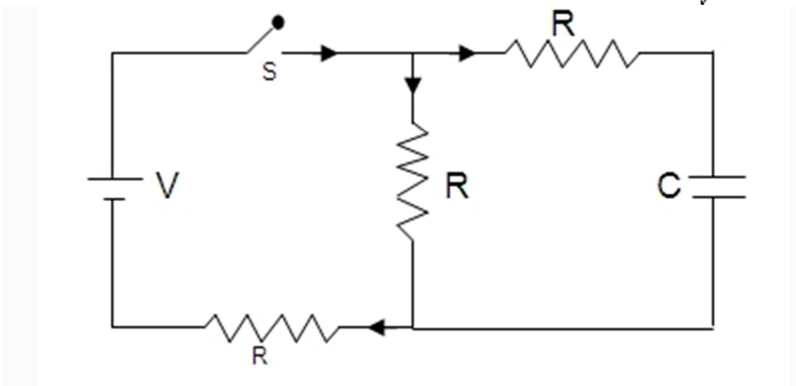

(a) the work done by the gas
(b) the heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB.
(c) the net absorbed by the gas in the path BC.
(d) the maximum temperature attained by the gas during the cycle.

**7.** A solid body X of heat capacity C is kept in a an atmosphere whose temperature is TA = 300 K. At time t = 0, the temperature of X is T0 = 400 K. It cools according to Newton's law of cooling. At time t1 its temperature is found to be 350 K.

At this time (t1) the body X is connected to a large body Y at atmospheric temperature TA through a conducting rod of length L, cross-sectional area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross-sectional area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time t = 3t1.

**8.** A conducting sphere S1 of radius r is attached to an insulating handle. Another conducting sphere S2 of radius R is mounted on an insulating stand S2 is initially uncharged.
S1 is given a charge Q brought into contact with S2 and removed. S1 is contact with S2 and removed. This procedure is repeated n times.
(A) Find the electrostatic energy of S2after n such contacts with S1.
(B) What is the limiting valve of this energy as n ® ¥ ?

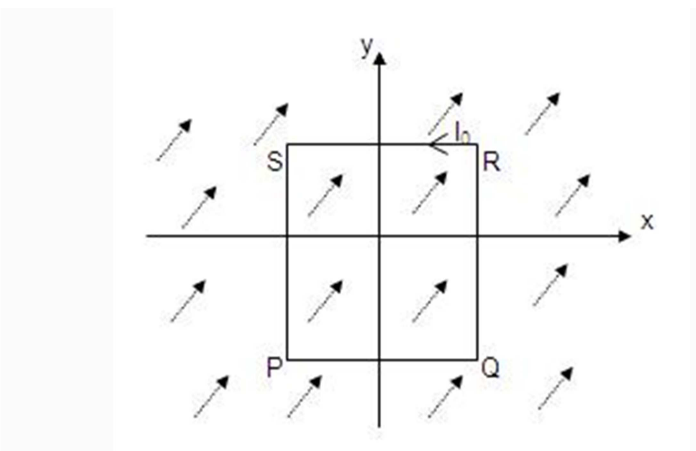
**9.** In the circuit shown in figure, the battery is an ideal one with emf V. The capacitor is initially uncharged. The switch S is closed at time t = 0.




(A) Find the charge Q on the capacitor at time t.
(B) Find the current in AB at time t. What is its limiting value as t ® ¥ ?

**10.** A particle of mass m and charge q is moving in a region where uniform constant electric and magnetic fields E® and B® are present. E® and B® are parallel to each other. At time t = 0, the velocity v0 of the particle is perpendicular to E® (Assume that its speed is always << c, the speed of light in vacuum). Find the velocity v of the particle at time t. You must express your answer in terms of t, q, m, the vectors v0, E® an B® and their magnitudes v0, E® and B®.

**11.** A uniform constant magnetic field B® is directed at an angle of 450 to the x-axis in xy plane. PQRS is a rigid square wire frame carrying a steady current I0, with its centre at the origin O. At time t = 0, the frame is at rest in the position shown in the figure with its sides parallel to x and y axes. Each side of the frame is of mass M and length L :




(a) What is the torque τ® about O acting on the frame due to the magnetic field?
(b) Find the angle by which the frame rotates under the action of this torque in a short interval of time Dt, and the axis about which this rotation occurs (Dt is so short that any

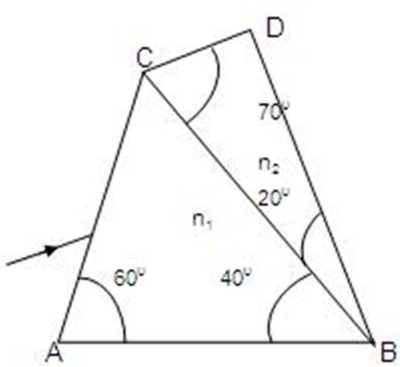
variation in the torque during this interval may be neglected). Given : the moment of inertia of the frame about an axis through its centre perpendicular to its plane is 4/3 ML2.

**12.** An inductor of inductance 2.0 mH is connected across a charged capacitor of capacitance 5.0 mF and the resulting LC circuit is set oscillating at its natural frequency. Let Q denote the instantaneous charge on the capacitor and I the current in the circuit. It is found that the maximum value of Q is 200 mC.
(A) When Q = 100 mC, what is the value of |dI / dt|?
(B) When Q = 200 mC, what is the value of I?
(C) Find the maximum value of I.
(D) When I is equal to one-half its maximum value, what is the value of |Q|?

**13.** A prism of refractive index n1 and another prism of refractive index n2 are stuck together with a gap as shown in the figure. The angles of the prism are as shown. n1and n2 depend on l, the wavelength of light according to:

n1 = 1.20 + (10.8 × 104)/l2 and

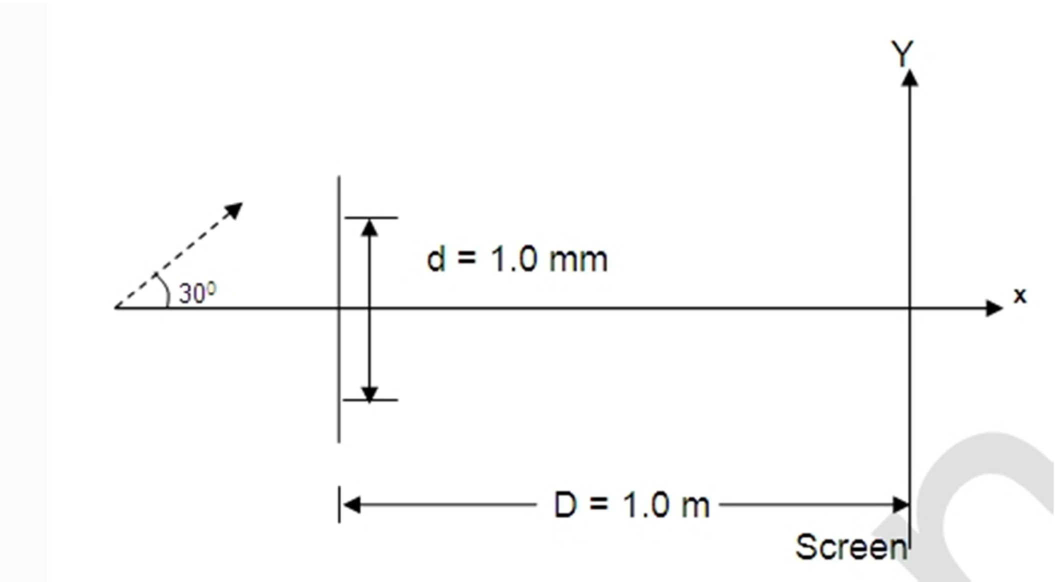
n2 = 1.45 + (1.80 ×104)/l2 where l is in nm.




(A) Calculate the wavelength l0 for which rays incident at any angle on the interface BC pass through without bending at that interface.
(B) For light of wavelength l0, find the angle of incidence i on the face AC such that the deviation produced by the combination of prisms is minimum.

**14.** A coherent parallel beam of microwaves of wavelength l = 0.5 mm falls on a Young's double slit apparatus. The separation between the slits is 1.0 mm. The intensity of microwaves is measured on a screen placed parallel to the plane of the slits at a distance of

1.0 m from it as shown in the figure.




(A) If the incident beam falls normally on the double slit apparatus, find the y-coordinates of all the interference minima of the screen.
(B) If the incident beam makes an angle of 300 with the x-axis (as in the dotted arrow shown in figure), the find the y-coordinates of the first minima on either side of the central maximum.

**15.** Nuclei of a radioactive element A are being produced at a constant rate a. The element has a decay constant l. At time t = 0, there are N0 nuclei of the element.

(A) Calculate the number N of nuclei of A at time t.
(B) If a = 2N0l, calculate the number of nuclei of A after one half life of A, and also the limiting value of N as t ® μ.