G.C.E. (A. L.) Support Seminar - 2014

Physics I

Two hours

Instructions :

∗ Answer **all** the questions.

∗ Select the correct or the most suitable answer.

$(g = 10\,\mathrm{N\,kg^{-1}})$

1. SI unit of Wein's constant is,

(1) mK (2) NK (3) WK (4) JK (5) kgK

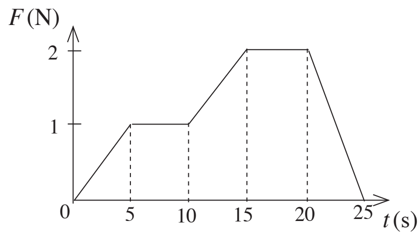
2. If C is the electrostatic capacitance and R is electric resistance, dimensions of CR is,

(1) M (2) T (3) L (4) $\mathrm{M^{-1}}$ (5) $\mathrm{T^{-1}}$

3. A particle of mass m is projected vertically upwards with velocity u. The resistance force F due to air motion is a constant value. The maximum height reached by the particle is,

(1) $\dfrac{mu^2}{4F}$ (2) $\dfrac{mu^2}{2F}$ (3) $\dfrac{mu^2}{2mg+F}$ (4) $\dfrac{u^2}{4g+F}$ (5) $\dfrac{mu^2}{2(mg+F)}$

4. The graph of a force F with time, created on an object of mass 2 kg at rest is shown in the figure. The momentum of the object after 25 s is,



(1) 5 Ns (2) 20 Ns (3) 25 Ns
(4) 30 Ns (5) 35 Ns

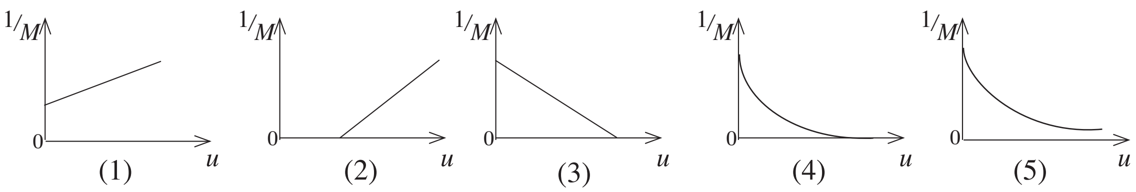
5. Which one of the following is **not** an instance at which the velocity of the source exceeds the velocity of the wave propagating through the medium?

(1) Hearing a distinctive sound when supersonic jets fly.
(2) Formation of white water waves at the tail of a fast moving boat on water.
(3) Observing of a white mist at the tail of an aeroplane flying high in the sky.
(4) Hearing a bursting sound when a whip is cracked.
(5) Observing asteroids moving towards earth, in blue colour.

6. Two large tuning forks A and B fixed to two wooden boxes are placed close to each other and when the tuning fork A is vibrated, the tuning fork B also vibrated with maximum intensity. If the prong of the tuning fork A is scraped and when they are vibrated together, 10 beats were heard during 5 s. Now when this tuning fork A is vibrated together with another tuning fork C of frequency 256 Hz, 20 beats were heard during 5 s. Frequency of tuning fork B could be,

(1) 254 Hz (2) 256 Hz (3) 258 Hz (4) 260 Hz (5) 264 Hz

7. If the magnification done by a convex lens when forming a real image of a real object is M, the graph that best represents the variation of $1/M$ with the object distance u is,



8. An Astronomical telescope is made by using two convex lenses of focal lengths 100 cm and 6 cm. When a person observes the image of a distant object forming at his near point using the telescope, is 105 cm. The least distance of the range at the distinct vision of this person is,
(1) 6 cm (2) 25 cm (3) 30 cm (4) 100 cm (5) 105 cm

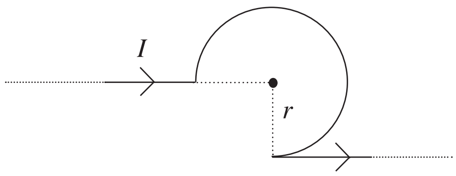
9. A closed vessel contains only water vapour. The pressure of water vapour is $\frac{P}{4}$, while the saturated vapour pressure of water vapour at this temperature is P. The percentage of the water vapour condensed, when the volume of the vessel is reduced to $\frac{1}{8}^{\text{th}}$ of the initial value is,

(1) 40% (2) 50% (3) 60% (4) 70% (5) 80%

10. A certain thermometer is incorrectly calibrated as 96 °C and −2 °C at the upper and lower fixed points, respectively. Its reading when it measures a temperature read indicated as 50°C in a correctly calibrated thermometer is,
(1) 46 °C (2) 47 °C (3) 48 °C (4) 49 °C (5) 50°C

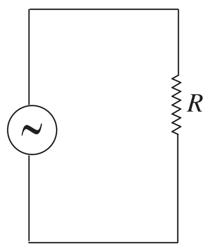
11. The radius and mean density of Earth are R and ρ respectively. Acceleration due to gravity at a point on Earth's surface is g. The acceleration due to gravity at a point on the surface of a planet with radius $\frac{R}{2}$ and mean density 3ρ is,
(1) $\frac{g}{3}$ (2) $\frac{g}{2}$ (3) g (4) $\frac{2g}{3}$ (5) $\frac{3g}{2}$

12. A long wire is folded to form a part of a circular loop of radius r as shown. Magnetic flux density at the center of the loop when a current I flows through the wire is,



(1) $\frac{\mu_o I}{8r}\left(3+\frac{2}{\pi}\right)$ (2) $\frac{\mu_o I}{4r}\left(3+\frac{1}{\pi}\right)$ (3) $\frac{\mu_o I}{8r}\left(3-\frac{2}{\pi}\right)$ (4) $\frac{\mu_o I}{4r}\left(3-\frac{1}{\pi}\right)$ (5) $\frac{\mu_o I}{8r}\left(\frac{3}{2}+\frac{1}{\pi}\right)$

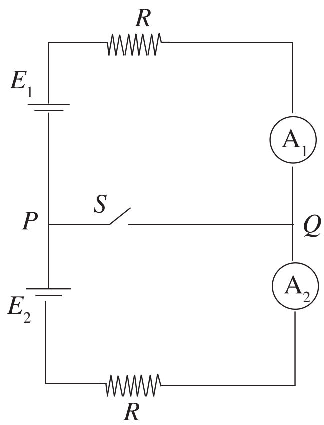
13. The peak current of the AC supply connected across the resistor R shown in the diagram is I_o. The mean dissipation of power in the resistor R is,



(1) $\frac{1}{2} I_o^2 R$ (2) $\frac{I_o^2 R}{\sqrt{2}}$ (3) $I_o^2 R$

(4) $\sqrt{2}\, I_o^2 R$ (5) $2I_o^2 R$

14. The internal resistances of the cells and ammeters in the circuit shown in the diagram are zero. If the switch is closed and P and Q are short circuited what can happen to the ammeter readings? ($E_1 > E_2$)



	Reading A_1	Reading A_2
(1)	Increases	Increases
(2)	Increases	Decreases
(3)	Decreases	Decreases
(4)	Decreases	Increases
(5)	Equal to A_2	Equal to A_1

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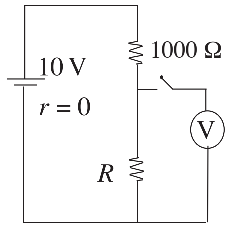
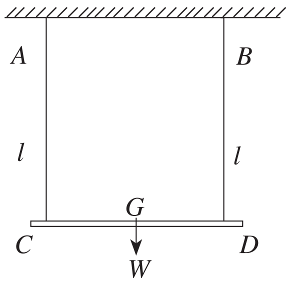
15. The internal resistance of the voltmeter shown in the circuit diagram is 1000 Ω. When the switch is closed, the voltmeter reads 4 V. Value of the resistor R is,



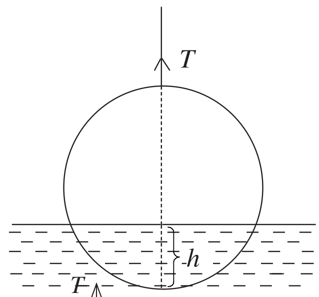
(1) 50 Ω (2) 200 Ω (3) 250 Ω
(4) 1 000 Ω (5) 2 000 Ω

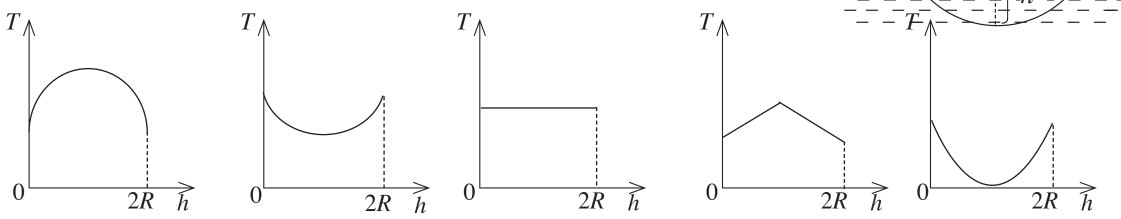
16. If the Young's modules of two wires A and B of equal length are Y_A and Y_B, respectively, the ratio $Y_A : Y_B = 3 : 2$. The ratio between the areas of cross - section of A and B, is 2 : 1. A light rod CD is attached horizontally to the lower ends of A and B. If the rod exists in equilibrium horizontally when a load W is hanged at a point G on the rod, the ratio $CG : GD$ is,



(1) 1 : 2 (2) 1 : 3 (3) 2 : 1
(4) 3 : 1 (5) 4 : 1

17. A thin circular metal plate of radius R is suspended from a string, and is immersed in water as shown in the diagram. The graph that the most accurately indicates the variation of the tension (T) of the string with the depth (h) the plate immersed is,





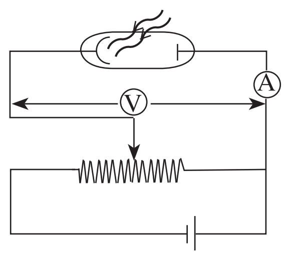
(1) (2) (3) (4) (5)

18. Given below is the decay of a radioactive carbon nucleus $\left({}^{14}_{6}\mathrm{C}\right)$

$${}^{14}_{6}\mathrm{C} \longrightarrow {}^{14}_{7}\mathrm{N} + \mathrm{X}$$

X could be,
(1) an α particle. (2) a β particle. (3) a γ photon. (4) a neutron. (5) a proton.

19. Shown in the diagram is an instance that the radiation of frequency being greater the than threshold frequency incident on the cathode of a photo cell:



Consider the following statements

(A) When the voltmeter reading is increased by the rheostat, the ammeter reading also increases.
(B) When the intensity of the incident radiation is increased, the ammeter reading also increases.
(C) The ammeter shows a reading even when the electric cell is removed.

Which of the above statement/s is/are true?

(1) (A) only (2) (B) only (3) (C) only
(4) (A) and (B) only (5) (B) and (C) only

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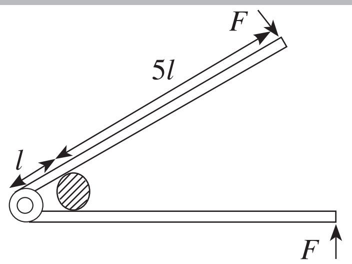
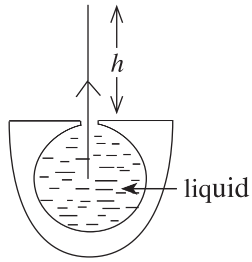
20. Shown in the diagram is how forces F are applied perpendicularly to the handles of a cracker when cutting an arecanut. If the equilibrium instance is given in the diagram, the force exerted on one side of the arecanut is,



(1) F (2) $2F$ (3) $4F$
(4) $5F$ (5) $6F$

21. When the king coconut is pierced at top as shown, the liquid of density ρ in it will rise to a maximum height h. If this liquid can be considered as a non viscose incompressible liquid, the excess pressure inside the king-coconut over the atmospheric pressure before it was pierced is,

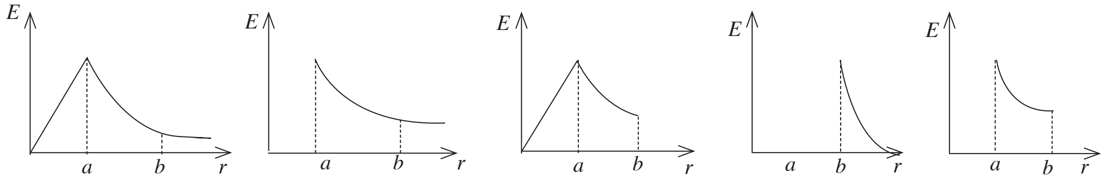


(1) $\sqrt{h\rho g}$ (2) $\sqrt{2h\rho g}$ (3) $\frac{1}{2}h\rho g$
(4) $h\rho g$ (5) $2h\rho g$

22. An object moves with a uniform acceleration on a smooth horizontal plane, starting from rest and obtain a velocity v during a time of n seconds. The displacement of the object within the time interval from $(n - 2)$ seconds to n seconds is,

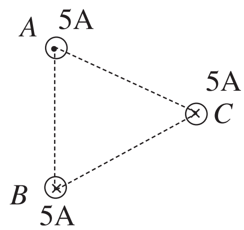
(1) $\frac{2nv}{(n+1)}$ (2) $\frac{2nv}{(n-1)}$ (3) $\frac{2v}{n}$ (4) $\frac{2v(n-1)}{n}$ (5) $\frac{v(n^2-1)}{2n}$

23. Two concentric conducting crusts of radii a and b $(b > a)$ are given respective charges $+Q$ and $-Q$. The graph that indicates the variation of the electric field intensity E with the distance r from the center is,



(1) (2) (3) (4) (5)

24. Three infinitely long straight conducting wires carrying 5A current in each, are placed across three vertices A, B, C of an equilateral triangle of side 5 cm as shown. The magnitude of the force per unit length of the wire kept at C and the direction are given by, $(\mu_0 = 4\pi \times 10^{-7}\,\text{Hm}^{-1})$



(1) $1 \times 10^{-6}\,\text{N m}^{-1} \uparrow$ (2) $1 \times 10^{-5}\,\text{N m}^{-1} \downarrow$ (3) $2 \times 10^{-5}\,\text{N m}^{-1} \downarrow$
(4) $2 \times 10^{-5}\,\text{N m}^{-1} \uparrow$ (5) $1 \times 10^{-4}\,\text{N m}^{-1} \downarrow$

25. 44 g of CO_2 gas and 64 g of O_2 gas at the same temperature contain separately in two identical containers. If the pressure created by the CO_2 gas is P, the total pressure inside the container when both gases are inserted into one of the two containers is,

(1) P (2) $1.5\,P$ (3) $2\,P$ (4) $2.5\,P$ (5) $3\,P$

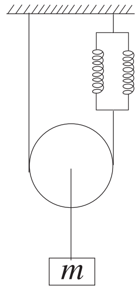
26. According to the equation $\Delta Q = \Delta U + \Delta W$ in thermodynamics, at the change of state of water to vapour,

(A) $\Delta U = 0$
(B) $\Delta W > 0$
(C) $\Delta Q > 0$

Which of the above statement/s is/are true?

(1) (A) only (2) (A) and (B) only (3) (A) and (C) only
(4) (B) and (C) only (5) All (A), (B) and (C)

27. A mass m is suspended to a light inextensible string, which passes around a smooth light pulley. The string is light and. It is attached to two identical springs of spring constant k each as shown in the diagram. The periodic time of the system is,



(1) $\pi\sqrt{\frac{m}{2k}}$ (2) $\pi\sqrt{\frac{m}{k}}$ (3) $2\pi\sqrt{\frac{m}{2k}}$

(4) $2\pi\sqrt{\frac{m}{k}}$ (5) $2\pi\sqrt{\frac{2m}{k}}$

28. A resonance pipe with end correction e is fully immersed in water, and is then gradually raised while vibrating a tuning fork at its open end. The difference in lengths of the first two resonating situations is L. If the speed of sound in air is V, the frequency of the tuning fork could be,

(1) $\frac{V}{2L+2e}$ (2) $\frac{V}{2L+e}$ (3) $\frac{V}{L+e}$ (4) $\frac{V}{L}$ (5) $\frac{V}{2L}$

29. When a weight is attached to a sonometer to provide a tension, the minimum length that resonates with a tuning fork is l_1. When this weight is fully immersed in water, the minimum length that resonates with the same tuning fork is l_2. The relative density of the substance of the weight is,

(1) $\frac{l_1}{l_2}$ (2) $\frac{l_1}{l_1 - l_2}$ (3) $\frac{l_1^2}{l_1^2 - l_2^2}$ (4) $\frac{l_2^2}{l_1^2}$ (5) $\frac{l_1^2}{l_2^2}$

30. A volume of a liquid of density ρ_1 and mass m_1, is mixed with an equal volume of a liquid of mass m_2 and density ρ_2. If the mixture volume is not reduced, the density of the mixture is,

(1) $\frac{\rho_1 - \rho_2}{2}$ (2) $\frac{\rho_2 - \rho_1}{2}$ (3) $\frac{\rho_1 + \rho_2}{2}$ (4) $\frac{2\rho_1 + \rho_2}{2}$ (5) $\frac{\rho_1 + 2\rho_2}{2}$

31. The weight of an object in air is 45 N. Its weight when fully immersed in a liquid is 44.58 N. When the temperature of the liquid is raised by 100°C, the weight of the object fully immersed in the liquid is 44.60 N. If the volume expansion of the object with increasing temperature is negligible, the co-efficient of volume expansion of the liquid is,

(1) $5 \times 10^{-5}\,K^{-1}$ (2) $5 \times 10^{-4}\,K^{-1}$ (3) $4.5 \times 10^{-3}\,K^{-1}$ (4) $5 \times 10^{-3}\,K^{-1}$ (5) $5.5 \times 10^{-3}\,K^{-1}$

32. The rod AB is suspended horizontally by two strings as shown in the diagram. If the center of gravity of the rod is G, the ratio $\frac{AG}{GB}$ is,

(1) 3 : 1
(2) $\sqrt{3}$: 1
(3) 1 : $\sqrt{3}$
(4) 1 : 1
(5) 1 : 3

33. Levels of intensity of two sounds which approach a certain place at two instances are 20 dB and 60 dB. If the intensities received due to these two sounds at this place are I_1 and I_2, respectively, the ratio $\frac{I_1}{I_2}$ is equal to,

(1) 10^{-6} (2) 10^{-4} (3) 10^{-2} (4) 10^{2} (5) 10^{4}

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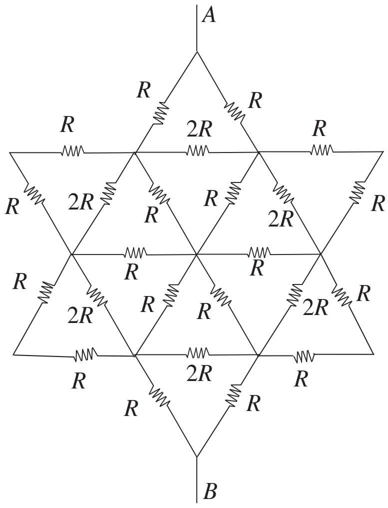
34. A ray of light in a medium of refractive index $\frac{4}{\sqrt{3}}$ travels into another medium of refractive index $\frac{4}{3}$ at an angle of incidence of 30°. Consider the following statements.

(A) Deviation of the ray is 30°.
(B) The ray is subjected to total internal reflection.
(C) Refracted ray is perpendicular to the partially reflected ray.

True statement/ statements is/are,

(1) (A) only (2) (B) only (3) (A) and (B) only
(4) (A) and (C) only (5) (B) and (C) only

35. The equivalent resistance of the resistor network between A and B in the diagram is,



(1) $\frac{R}{2}$

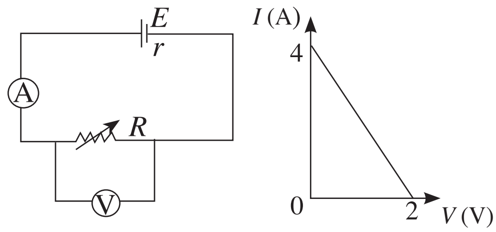
(2) R

(3) $\frac{3R}{2}$

(4) $2R$

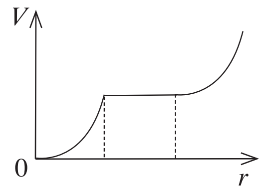
(5) $\frac{5R}{2}$

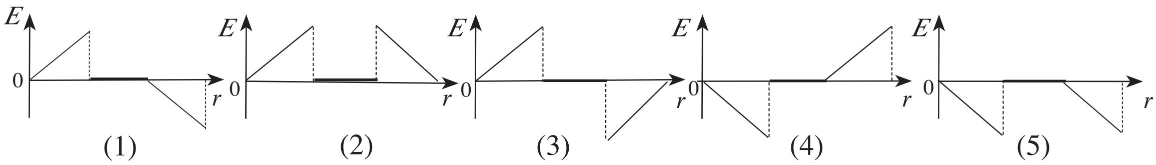
36. Shown in the graph is the variation of the ammeter reading with the voltmeter reading when the resistance R in the circuit is changed. The electromotive force and the internal resistance of the cell respectively,



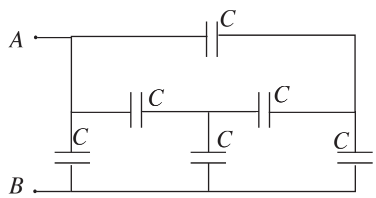
(1) 2 V, 0.5 Ω (2) 2 V, 1 Ω (3) 2 V, 2 Ω
(4) 4 V, 1 Ω (5) 4 V, 2 Ω

37. Shown in the graph is the variation of the electrostatic potential (V) with the distance (r) in an electrostatic field. The graph that best expresses the corresponding variation of the electrostatic field intensity (E) is,





38. The equivalent capacitance between A and B in the system shown, which consists of six identical capacitors each having a capacitance C is,



(1) $\frac{C}{6}$ (2) $\frac{C}{2}$ (3) C

(4) $2C$ (5) $6C$

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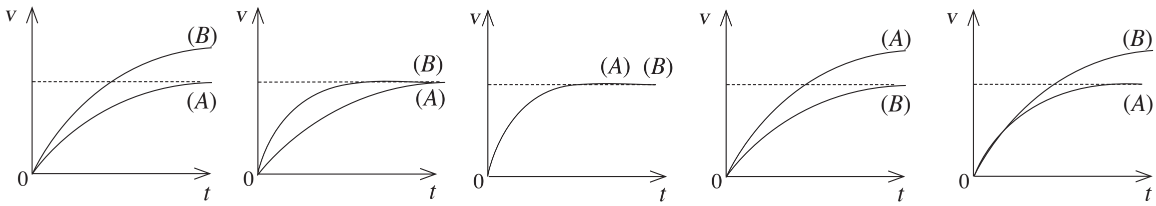
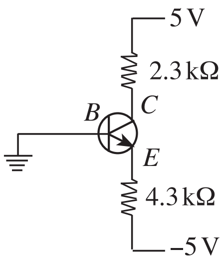
39. A wooden cube is released from rest at the top of a rough inclined plane of angle of inclination θ, over which a layer of oil is uniformly distributed. If the velocity- time curves for the motion of the cube corresponding to the situations $\theta = 35^\circ$ and $\theta = 45^\circ$ are represented by the curves (A) and (B), respectively, the most suitable graph that represents A and B curves is,



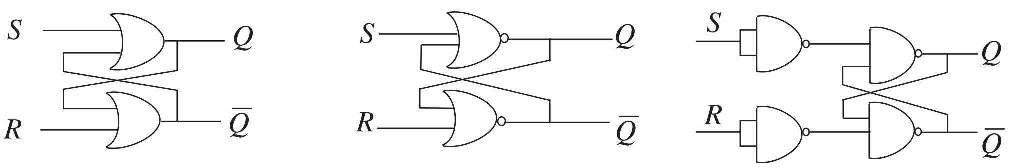
(1) (2) (3) (4) (5)

40. Shown in the diagram is a circuit with a Silicon transistor. The value of V_{CE} is approximately,



(1) 2.7 V
(2) 3.3 V
(3) 3.7 V
(4) 4.3 V
(5) 4.7 V

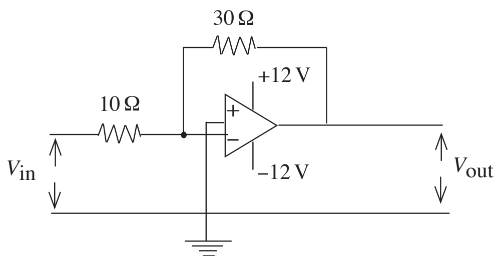
41. Among the gate circuits given below, which circuits give S - R flip flop.

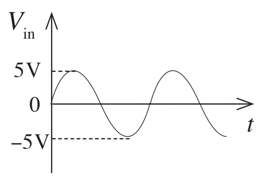


(A) (B) (C)

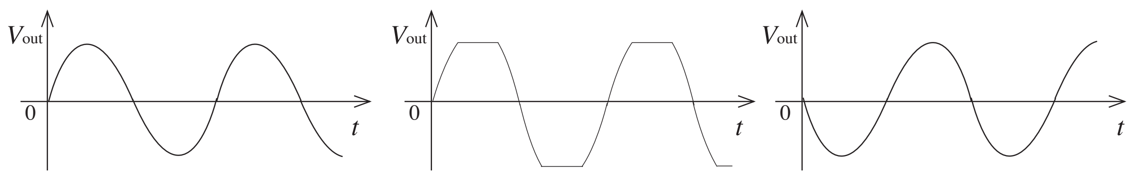
(1) (A) only
(2) (B) only
(3) (A) and (C) only
(4) (B) and (C) only
(5) All (A), (B) and (C)

42.

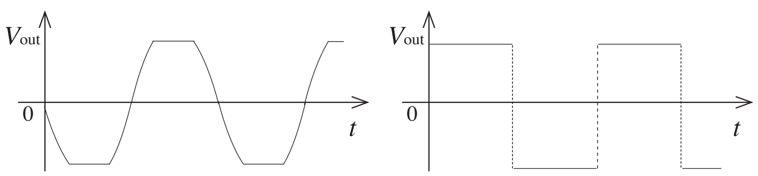




If the variation of the input voltage is as shown, the variation of the output voltage could be,

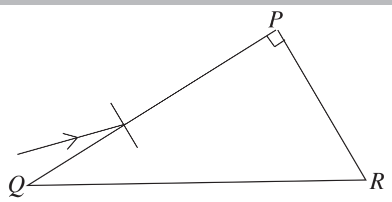


(1) (2) (3)



(4) (5)

43. A monochromatic light ray incident on the surface PQ of a prism of angle of prism 90°, refracts and incident on the surface PR at its critical angle. Refractive index of the prism substance is $\frac{2}{\sqrt{3}}$. Consider the following statements.

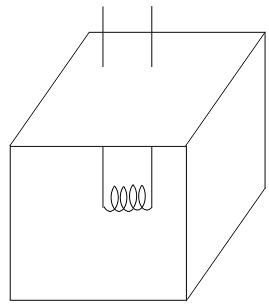


(A) Critical angle for glass is 60°
(B) Angle of incidence on $PQ > 30°$
(C) Angle of incidence is equal to the angle of deviation.

True statement/s is/are,

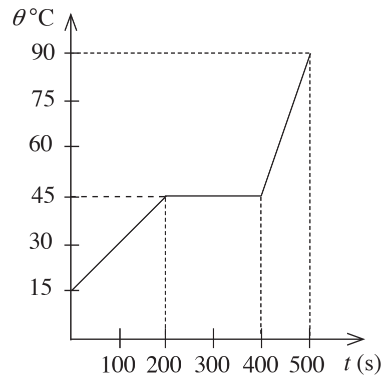
(1) (A) only (2) (A) and (B) only (3) (A) and (C) only
(4) (B) and (C) only (5) All (A), (B) and (C)

44. A heating coil of power 90 W is submerged in a metal block as shown and the block is suspended in a room of temperature 30°C. When the heating coil is switched on, the temperature of the block increases to 80°C and then become steady. Now when the heating coil is switched off, the metal block begins to cool down at a rate of $0.18\,°C\,s^{-1}$. Heat capacity of the metal block is,



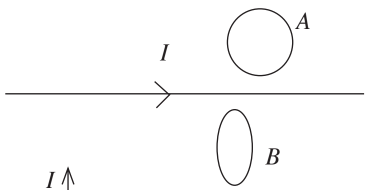
(1) $100\,J\,K^{-1}$ (2) $200\,J\,K^{-1}$ (3) $300\,J\,K^{-1}$
(4) $400\,J\,K^{-1}$ (5) $500\,J\,K^{-1}$

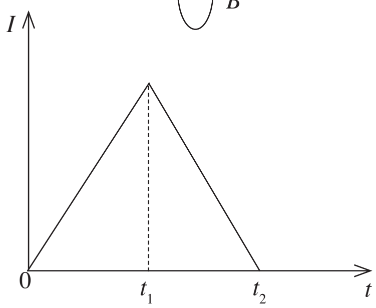
45. A solid substance kept inside a vessel of negligible heat capacity, is heated at a constant rate. The variation of its temperature with time is shown in the figure. If the specific heat capacity of the solid substance is $2100\,J\,kg^{-1}K^{-1}$, its specific heat capacity in the liquid state is,



(1) $600\,J\,kg^{-1}K^{-1}$ (2) $700\,J\,kg^{-1}K^{-1}$ (3) $800\,J\,kg^{-1}K^{-1}$
(4) $900\,J\,kg^{-1}K^{-1}$ (5) $1000\,J\,kg^{-1}K^{-1}$

46. Two circular conducting discs A and B are placed near a long straight wire as shown in the diagram. The wire is kept in the same plane of the disc A and this plane is perpendicular to the plane of disc B. If the current (I) flowing through the wire varies with time (t) is shown in the graph, which one of the following statements made about the electromotive forces induced in the discs A and B is correct?

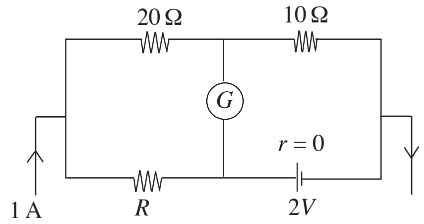




(1) During the period (0 - t_1), eddie current loops are created in disc A in the anti clockwise direction and in disc B in the clockwise direction.
(2) During the period (t_1- t_2) eddie current loops are created in disc A in the anti clockwise direction and in disc B in the clockwise direction.
(3) During the period (0 - t_1), eddie current loops are induced in disc A in the clockwise direction and in disc B in the anti clockwise direction.
(4) During the period period (0 - t_1), eddie current loops are induced in disc A in the clockwise direction and they are not induced in disc B.
(5) During the period (t_1 - t_2) eddie current loops are induced in disc A in the clockwise direction and are not induced in disc B.

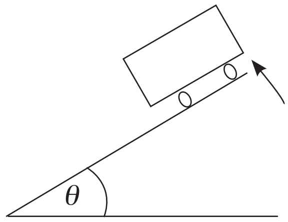
[See page 9

47. If the galvanometer reading in the circuit shown is zero, the value of R is,



(1) 2 Ω (2) 3 Ω (3) 4 Ω
(4) 5 Ω (5) 6 Ω

48. A motor vehicle of mass M moves on a banked track of inclination θ, performing a horizontal circular motion in a path of radius r, with a maximum velocity V, without skidding off the track. If R is the normal reaction, between the vehicle and the track. F is the maximum frictional force and μ is the co-efficient of static friction, consider the following statements,



(A) $R\cos\theta - F\sin\theta = Mg$

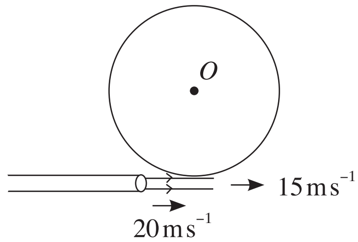
(B) $R\sin\theta - F\cos\theta = \dfrac{MV^2}{r}$

(C) $F = \mu R$

True statement/ statements are,

(1) (A) only (2) (A) and (B) only (3) (A) and (C) only
(4) (C) only (5) All (A), (B) and (C)

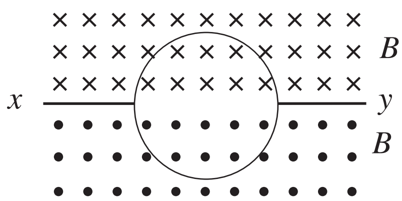
49. A uniform disc of mass 10 kg and radius 10 cm can perform a free rotation about its center O. A narrow column of water spirts at a speed of 20 m s^{-1} from a horizontal pipe with a cross section of 10 mm^2, strikes the circumference of the disc tangentially and leaves the disc with a speed of 15 m s^{-1} as shown. The angular acceleration obtained by the disc, due to the strike of the water column is,

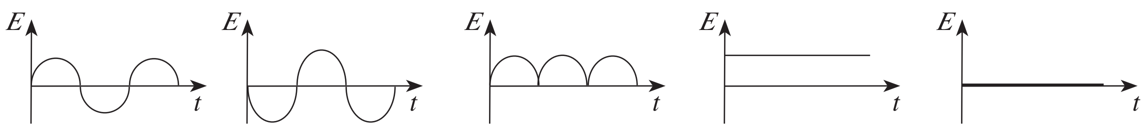


(Moment of inertia I of a uniform disc of mass m and radius r is given by $I = \frac{1}{2}mr^2$, density of water $\rho = 1000\,\text{kg m}^{-3}$ and ignore the gravitational forces)

(1) 0.001 rad s^{-2} (2) 0.01 rad s^{-2} (3) 0.1 rad s^{-2} (4) 0.5 rad s^{-2} (5) 5 rad s^{-2}

50. A circular wire loop is placed symmetrically to two magnetic fields of equal magnitudes B and opposite directions as shown in the diagram. If the loop is rotated with a constant angular velocity about the axis xy, the graph that repesents the most accurate variation of the electromotive force E induced in the loop with time t is,





(1) (2) (3) (4) (5)

* * *

G.C.E.(A. L.) Support Seminar - 2014

Physics II | *Three hours*

Instructions :

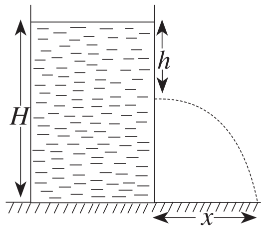
* **Part A :** Answer **all** the questions.

* **Part B :** Answer **only four** questions.

Part A - Structured Essay

($g = 10\,\mathrm{N\,kg^{-1}}$)

1. A cylindrical vessel filled with water to a height H, is placed on a horizontal surface as shown. A small hole is pierced on its curved surface at a depth h from the water surface.



(*a*) (i) Obtain an expression for the velocity v of water ejected from the hole, in terms of h and gravitational acceleration g.

....

....

....

(ii) State the principle you used to obtain this expression.

....

....

(iii) State the conditions under which this principle is valid.

....

(*b*) Water ejected from the hole is incident on the horizontal surface at a distance x from the foot of the cylinder.

(i) Obtain an expression for the time t consumed by a drop of water ejected from the hole to incident on the surface, in terms of H, h and g.

....

....

....

(ii) Obtain an expression for x in terms of H and h.

....

....

....

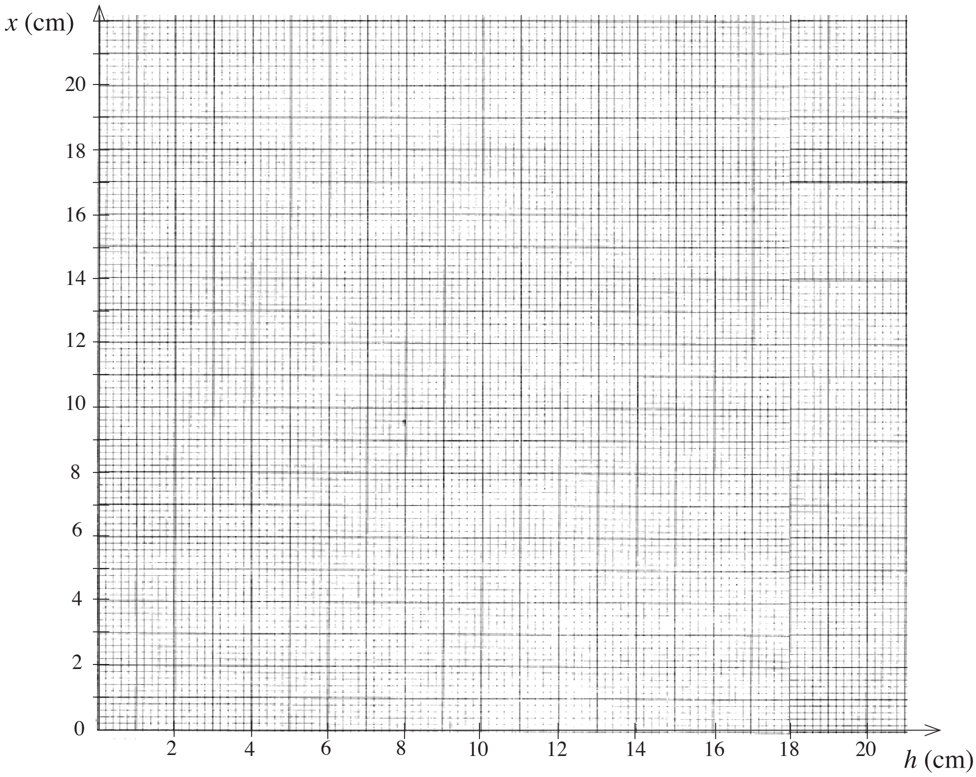
....

[See page 2

(*c*) (i) If H = 20 cm find the values of x corresponding to the values given for h in the table.

h (cm)	0	2	4	10	16	18	20
x (cm)							

(ii) Using the values obtained in part (*c*) (i), draw the rough sketch of the graph to express the variation of x with h.



(iii) State a conclusion that can be made about the value of x, using this graph.

(*d*) If this cylinder filled with water is allowed to fall under gravity starting from rest, from a certain height, having its axis vertical, what can you comment about the velocity of flow of water from the hole?

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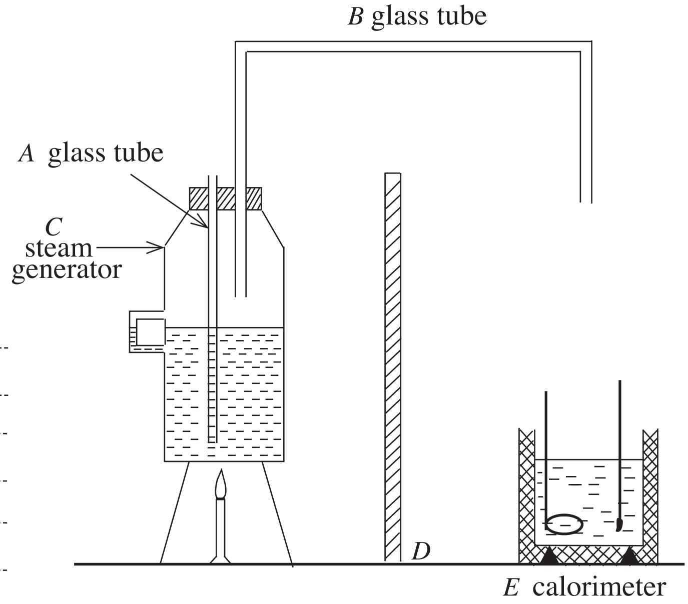
2. Shown in the diagram is an incomplete apparatus designed by a student to determine specific latent heat of vaporization of water.



(*a*) (i) State the practical difficulty faced when tube *A* is used as shown in the diagram.

....

....

....

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....

....

(ii) What is the requirement fulfilled in the experiment, by placing the tube *A* accurately?

....

....

(iii) Draw and label the part that must be attached to the end of tube *B*, in order to carry out the experiment accurately.

(*b*) Name the part *D* and state the use of it,

....

....

....

(*c*) If the calorimeter is well insulated from heat, what is the precaution that should be taken to further improve the accuracy of the experiment?

....

....

....

(*d*) (i) State the measurements taken in the order of proceeding the experiment using the usual symbols.

1. ....
2. ....
3. ....
4. ....
5. ....

[See page 4

(ii) Write an expression to determine the specific latent heat of vaporization L of water in terms of the symbols used in part (d) (i) above.
(Specific heat capacity of calorimeter and stirrer is C and specific heat capacity of water is C_w)

(e) Why is it important to get a very accurate value for the mass of vapour?

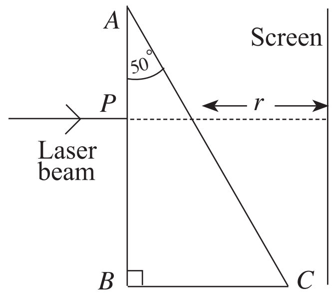
----

3. Laser rays are significantly used in various fields.

(a) (i) Write **two** properties of Laser rays.

(ii) State **two** instances where laser rays are used practically.

Shown below is a set-up used to study refraction of light using laser rays. ABC is a right - angled prism made of plastic of refractive index $\sqrt{2}$ (=1.414). When a laser ray is incident at right angles on surface AB, a light spot forms at Y on the screen when the prism is kept as shown while a light spot forms at X on the screen when the prism is removed.



(b) (i) Complete the path of the ray given, on the diagram.

(ii) Mark the positions of X and Y on the screen.

(c) If the distance between X and Y is s, obtain an expression including the angle of deviation d in terms of r and s.

(d) If the prism is slowly rotated in the clockwise direction about the point P, the light spot will disappear at one instance.

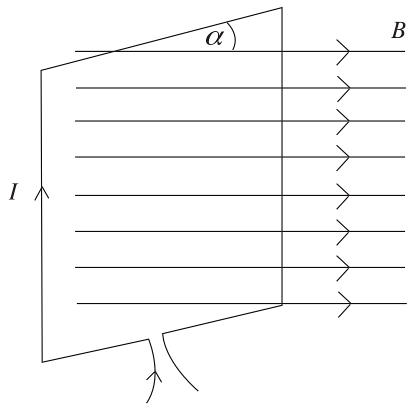
(i) What is the reason for this?

(ii) Find the angle at which the laser ray must incident on the surface *AC*, at the disappearance of the light spot as mentioned in *d*(i) above.

(iii) Find the angle of refraction of the ray at the surface *AB* at this instance.

(iv) If the prism must be rotated by an angle α to obtain the above instance, write an expression relating α and the angle of refraction at surface *AB*. (Simplification is not required).

4. Shown in the diagram is a coil of wire consisting *N* number of turns carrying a current *I*, placed in a uniform magnetic field of flux density *B*. Area of cross section of the coil is *A*.



(*a*) Write an expression using given symbols for the torque τ that exerts on the coil when the plane of the coil incline by an angle α to the uniform magnetic field.

(*b*) Draw a rough sketch of a graph to express the variation of τ with α.

[See page 6

(*c*) The moving coil galvanometer is an instrument made using a certain mechanism in order to maintain a constant value for τ at any position of the coil.

(i) State this mechanism.

(ii) If the torsion constant of the spring pivoted to the coil of wire is C and the angle of rotation of the coil is θ, write an expression for I using the answer in part (*a*).

(iii) State how the following factors must be adjusted in order to increase the sensitivity of the instrument.

Factor	Adjustment
N	
A	
C	
B	

(*d*) The internal resistance of a moving coil galvanometer which shows a full scale deflection for a current of 100 mA is 10 Ω.

(i) State how this instrument should be modified to measure a maximum current of 1 A.

(ii) What two other items should be connected to the above moving coil galvanometer in order to convert it to an ohmmeter?

1

2

(iii) State a special feature that you observe in the scale when the instrument is used as an ohmmeter.

(iv) Plot a graph for the variation of the deflection of the ohmmeter with the resistance measured by the ohmmeter.

* *

[See page 7

Part B - Essay

($g = 10\,\mathrm{N\,kg^{-1}}$)

* Answer **only four** Questions.

5. Read the paragraph given below and answer the questions.

Importance of using alternative sources of power as a solution for the existing power crisis have been now confirmed. One such alternative method identified is to improve usage of windmills to convert wind power to electric power. Wind energy is solar energy. A small percentage of the solar radiation approaching the earth is absorbed by the atmosphere. As a result of this irregular heating in the atmosphere, patterns of air circulation occur. It is important to study how such stored energy in wind can be utilized economically and ecologically. Since Sri Lanka is an island this wasted wind energy can be used by installing wind mills near coastal areas of Sri Lanka. Wind mills convert kinetic energy of wind to electrical energy. The blades of the mill is connected to current generators through a gear system using belts. The section with blades in the mill is called the turbine.

A majority of this power requirement is fulfilled by hydro power. But hydro power alone is no longer sufficient as the power consumption in Sri Lanka has increased. Therefore, mineral oil, coal and solar energy are also used, as alternative sources of power to generate electricity.

When deciding an alternative source of power, the factors such as the durability, the economical benefit of the methodology, the ability for easy access to the source, minimum environmental pollution and a minimum initial capital are also considered.

(*a*) (i) Name **two** alternative sources of power in addition to hydro power and wind mills, that can be used in Sri Lanka.

(ii) Write **three** factors that must be considered when using alternative sources of power.

(*b*) If the radius of a blade in a wind mill is r, the density of air is ρ and it can be considered that wind blows with an average velocity of v perpendicular to the plane of rotation of the blades in the mills,

(i) Write an expression for the mass of air cut - off by a blade during a second.

(ii) Write an expression for the kinetic energy stored in this mass of air, in terms of r, ρ and v.

(iii) Considering that 80% of the wind energy is extracted by the blades, write an expression for the rate of transfer of energy from wind to the mill using the above symbols.

(iv) If the radius of a blades is $1.4\,\mathrm{m}$, density of air is $1.2\,\mathrm{kg\,m^{-3}}$ and the velocity of the wind is $36\,\mathrm{km\,h^{-1}}$, calculate the rate mentioned in part (*b*) (iii) above.

(*c*) If the angular velocity of the blades increased to $10\,\mathrm{rad\,s^{-1}}$ from zero during 10s, calculate the following considering that the friction due to rotation of blades is negligible:

(i) The moment of inertia of the blades about its axis of rotation.

(ii) The angular acceleration of the rotational system.

(iii) The torque created by wind on the system.

(*d*) If the friction on the blades is considerable, calculate the following:

(i) The new angular acceleration of the system, if frictional torque is $443.52\,\mathrm{N\,m}$.

(ii) The angular velocity of the blades obtain after 100 s, when they rotate with this acceleration starting from rest.

(iii) If the wind stops now, the number of cycles that the system rotates, when it comes to rest under the frictional torque above. (Express the answers to the nearest integer.)

[See page 8

6. (*a*) Write an equation for the speed (V) of a transverse wave propagating through a stretched wire. Introduce the symbols used.

(*b*)

A straight steel wire of length 0.5 m is attached to two fixed points horizontally at both ends, and a source of veritable frequency is attached at one end as shown. The frequency of the source varies from 300 Hz to 1000 Hz. Density of steel is 8000 $kg\,m^{-3}$, velocity of transverse wave of the wire is 350 $m\,s^{-1}$ and the tension of the wire is 0.15 N.

Consider the length of the wire is constant:

(i) Find the corresponding frequencies at which the wire can resonate with the source.

(ii) Find the maximum tension of the wire in order to observe the next overtone within the given range of frequencies.

(*c*) If the length of the wire mentioned above in part (*b*) (i), extends by 0.49% of it's original length:

(i) Find the young's modulus of the substance of the wire.

(ii) Now the source is removed from the wire and the end *A* is clamped, and the wire is rubbed in parallel to the wire using a resin spreaded cloth, while keeping the end *B* free. Find the velocity of the wave that sending across the wire when rubbed.

(iii) Calculate the frequencies corresponding to the fundamental and the first overtone in part *(c)* (ii) above.

7. (*a*) (i) Write an expression for the capillary rise h of water, through a clean glass capillary tube of internal radius r, when the tube is kept vertically in water, in terms of T, ρ, g and r. Consider that the angle of contact for water and glass is zero.

(ii) When another capillary tube identical to the one above is placed vertically in air, the height of the water column that can be maintained inside is h^1 and the radius of curvature of the water meniscus at the lower end is r^1. Draw the shape of the water meniscus at the lower end corresponding to each situation stated below.

(I) $h^1 = h$

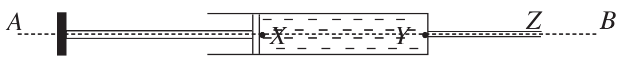
(II) $h^1 < h$

(III) $h^1 > h$

(iii) Find the maximum value of h^1 in terms of h.

(iv) Plot a graph for the variation of r^1 with h^1.

(*b*) Shown is the diagram of a syringe made by combining a uniform plastic pipe of diameter of cross section 10 mm with a narrow metal pipe *YZ* having a uniform cavity of diameter 1mm.



The syringe is kept horizontally along *AB*, filled with a liquid of a surface tension $7\times10^{-2}\,N\,m^{-1}$. A force is applied on the piston, to spray the liquid from the narrow pipe, in order to test the performance of the syringe. Atmospheric pressure = $1 \times 10^5\,N\,m^{-2}$ (Consider that the angle of contact between the narrow pipe and the liquid is zero.)

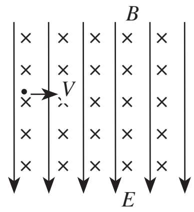
(i) Consider that the liquid is about to spray from *Z* and find the pressure inside the liquid at *Z*.

(ii) Find the pressure of the liquid at the points *Y* and *X*.

(iii) Plot a graph for the variation of pressure with the distance from *X* to *B*.

(iv) Find the minimum force that must be applied on the piston for the liquid to spray at *Z*.

8. A positively charged particle carrying a charge q, enters perpendicularly to a uniform electric field of field intensity E with a velocity V as shown in the diagram. A magnetic field of flux density B is created from the moving charge, perpendicular to its direction of motion.



(*a*) (i) Write an expression for the force F_E created on the charged particle by the electric field.

(ii) Write an expression for the magnetic force F_B created on the charged particle.

(iii) Clearly mark the forces acting on the moving charge q (Ignore gravitational forces).

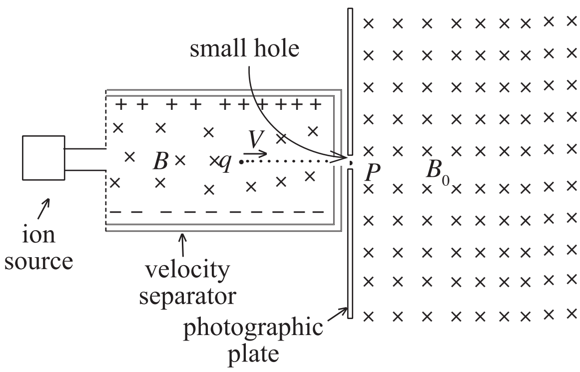
(iv) Clearly draw the paths of the charge when $F_E > F_B$, $F_E < F_B$ and $F_E = F_B$.

(*b*) The mass spectrometer is an important instrument used in atomic physics, which is based on forces acting on charged particles moving in electric and magnetic fields.
It consists of three main parts.

(1) Ion source - Emits ions with different velocities.

(2) Velocity Separator - Ions which move at different velocities are sent through a uniform electric field of field intensity E and a uniform magnetic field of flux density B perpendicular to each other, and hence ions which move with a definite velocity are taken out from the hole P.

(3) Photographic Plate - This is placed in a uniform magnetic field of flux density B_0. The ions that enter in to this field incident on the photographic plate. and create sensations.



A charge q ejected from the ion source enters the velocity separator with a velocity V. Obtain the requirements fulfilled, for the charge to leave or to not to leave from the hole P. Used the results obtained in part (*a*)(iv) above.

(*c*) Now consider a charge q of mass m enters perpendicularly to the uniform magnetic field B_0 with a velocity V.

(i) What kind of a motion (a path) will this charge show in the magnetic field B_0?

(ii) What is the reason for this nature (path) of motion?

(iii) If this charge q incident at a place at a distance d from P on the photographic plate, obtain an expression for the ratio m/q in terms of d, B_0, E and B.

(*d*) The charges which enter the field B_0 from the velocity separator, incident at various places on the photographic plate. What is the reason for this? (Assume that the charge q on the particles is constant.)

(*e*) How can the above process be used in atomic physics for the separation of isotopes?

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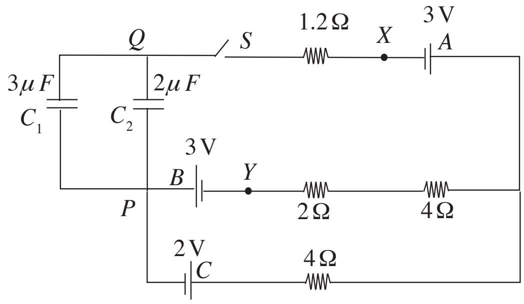
9. Answer only part (A) or (B)

(A) Shown in the diagram is a circuit that consists of three cells with negligible internal resistances.



(*a*) When the switch *S* is closed,

(i) Calculate the current that flows through each cell.

(ii) Find the charge stored in each capacitor.

(iii) If the points *X* and *Y* are joined together with a wire of negligible resistance, will the charge stored in capacitors vary? Explain your answer.

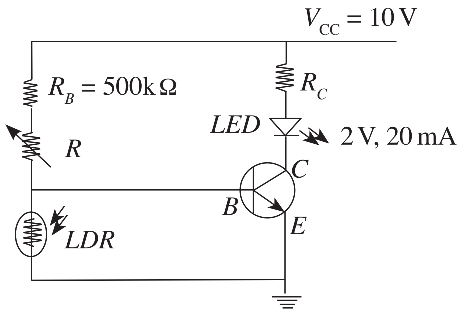
(*b*) When the switch *S* is opened, what will happen to the charges stored in the capacitors? Explain without any calculation.

(*c*) Now the system of capacitors removed and a resistor *R* is connected between *P* and *Q*. Then the switch *S* is closed. A potentiometer and a voltmeter with a finite resistance are provided to measure potential difference across this resistor. The given potentiometer is made with a uniform wire of length 1m and a driving cell of e.m.f 2V with a negligible internal resistance.

(i) If the balanced length obtained when the potentiometer is used is 60 cm, what will be the value of the resistor *R*?

(ii) If the value of *R* is calculated using the reading taken from the above voltmeter, instead of the potentiometer, will you get the same answer as in part (*c*) (i)? Explain your answer.

(B) (*a*) Shown in the diagram is a circuit designed by a student using a Silicon transistor to illuminate a *LED* bulb only at night using a light dependent resistor (*LDR*). The value of the resistance of the *LDR* becomes very small during day time and increases to a large value of a few MΩ during night. The *LED* requires a potential difference of 2V for proper illumination at which a current of 20 mA flows through it. The transistor becomes saturated when the *LED* bulb illuminates.



(i) When the *LED* bulb illuminates properly,

(I) Find approximately the potential at *C*.

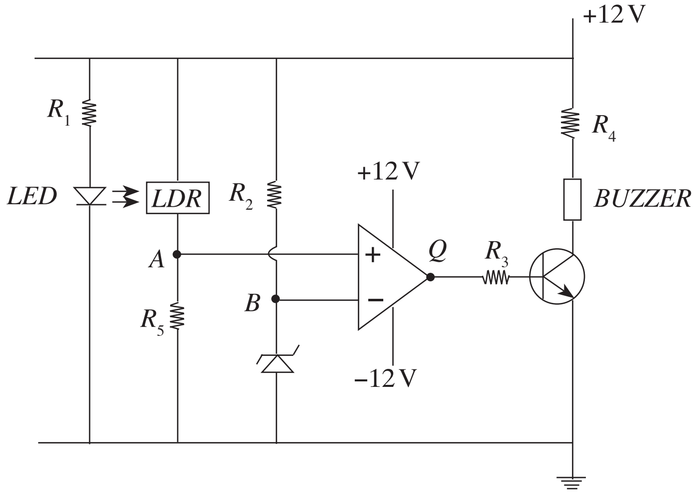
(II) Find approximately the value of R_C.

(ii) The *LED* bulb will illuminate properly, only in dark when $R = R_1$ and only in slight darkness when $R = R_2$.

(I) Compare R_1 and R_2 .

(II) State reasons for your answer.

(*b*) Shown below is a circuit of a security system that can be used to inform the residents when the gate of a house is open. Then the buzzer (bell) fixed in the house is ringing.



Light emitted from the *LED* will completely incident on the light dependent resistor (*LDR*) when the gate is closed. When the *LDR* is exposed only to the light of the *LED*, its resistance become low and a potential drop of 6 V will then build up across it. When the *LDR* is not exposed to light, its resistance become high and a potential drop of 9V will then build up across it. A Zener diode is used to give a constant voltage (V_B) to the inverting input of the op-amp. It acts as a voltage comparator with the voltage (V_A) of the non-inverting input.

(i) If the current and the potential drop across the *LED* when it is illuminated are 10 mA and 2 V, respectively, find the value of the resistor R_1.

(ii) Find the potential at *A* when the light emitted by the *LED* is not incident on the *LDR*.

(iii) Write the magnitude and the polarity of the voltage at *Q* when,
(I) $V_A > V_B$,
(II) $V_A < V_B$.

(iv) (I) Which one of the conditions mentioned in part (iii) above must be fulfilled for the buzzer in the circuit to ring?
(II) Explain your answer.

(v) (I) Which one of Zener diodes with the Zener voltages 2.7 V, 2.48 V and 6.8 V should be selected in order to fulfill the action expected from the circuit?
(II) State the reason for your selection.

(vi) If the power of the Zener diode selected in part (v)(I) above is 0.5 W,
(I) Find the maximum current that can be sent through it.
(II) Find the value of R_2.

10. Answer only (A) or (B)

(A) (*a*) State Newton's law of cooling. State the conditions under which it is valid.

(*b*) A student designs an experiment to demonstrate the physical properties of wax using the above law. Solid wax was heated uniformly and its temperature was measured with time, until the state just before it begins to vaporize. Draw the expected graph of its temperature with time.

(*c*) The student obtained these readings by heating 100 g of wax in a calorimeter of heat capacity 60 J kg^{-1}, using a heating element of 100 W . The details obtained by the graph are as follows. (Temperature of the environment is 30°C)

- The gradient of the tangent drawn to the graph just before wax begins to melt is 3·6°C min^{-1}
- The constant temperature obtained by wax is 62°C
- The time that the temperature of wax remains constant is 20 min.
- The gradient of the tangent drawn to the graph just after wax completely melts is 4·8°C min^{-1}

Specific heat capacity of solid wax used above is 1800 J $kg^{-1}K^{-1}$.

(i) Find the melting point of wax.

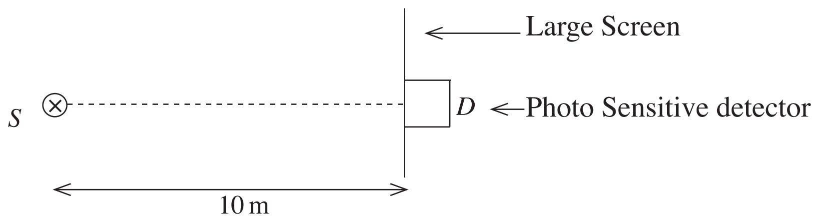
(ii) Find the rate of absorption of heat by the calorimeter and wax, just before wax begin to melt.

(iii) Find the rate of loss of heat to the environment at that moment.

(iv) Calculate the specific heat capacity of liquid wax and the specific latent heat of fusion of wax.

(v) When heat is supplied continuously to liquid wax, he observed that after a certain situation wax remains as a liquid and its temperature does not increase. Explain the reason for this and calculate this steady temperature.

(B)



S is a monochromatic point source. The wavelength and the power of the waves radiated by this are 6000°A and 10 W, respectively. A detector of surface area of 0·4 cm^2 is kept at the center of the screen as shown.

Charge of an electron = $1{\cdot}6 \times 10^{-19}$ C
Plank's constant = $6{\cdot}63 \times 10^{-34}$ J s
Valocity of light = 3×10^{8} m s^{-1}
Consider π = 3

(*a*) (i) Find the number of photons incident on unit area at the center of the photo screen during 1 s. (Express your answer to one decimal point)

(ii) Calculate the number of photons incident on the entire area of the detector during 1s.

(iii) If the efficiency of the photo detector is 0·9, find the number of photo electrons emitted from the detector during 1s.

(iv) Calculate the photo current.

(*b*) If a certain laser light of wave length 490 nm and of power 0.1 W is used instead of the monochromatic point source *S*,

(i) Calculate the number of photons emitted by the laser source during 1 s. (Express your answer to one decimal point).

(ii) When this light is incident on the Cesium cathode of a photo cell, electrons are released only from 20% of the photons of the beam, calculate the current flowing out from the photocell.

(iii) If the threshold frequency is $5{\cdot}2 \times 10^{14}$ Hz, determine the stopping potential for these emitted electrons.

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