සියලුම හිමිකම් ඇවිරිණි/முழுப் பதிப்புரிமையுடையது/All Rights Reserved]

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
இலங்கைப் பரீட்சைத் திணைக்களம்
Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2025
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2025
General Certificate of Education (Adv. Level) Examination, 2025

භෞතික විද්‍යාව I
பௌதிகவியல் I
Physics I

01 E I

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two hours

Instructions:

- *This question paper consists of* **50** *questions in* **10** *pages.*
- *Answer* ***all*** *the questions.*
- *Write your* ***Index Number*** *in the space provided in the answer sheet.*
- *Read the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives from* (1), (2), (3), (4), (5) *which is* ***correct*** *or* ***most appropriate*** *and* ***mark your response on the answer sheet with a cross*** (×) ***in accordance with the instructions given on the back of the answer sheet.***

Use of calculators is not allowed.

($g = 10\ m\ s^{-2}$)

1. Which one below **does not** represent the unit of energy?
(1) $kg\ m^2\ s^{-2}$ (2) $W\ s$ (3) $kW\ h$ (4) $V\ A\ s$ (5) $C\ V\ s^{-1}$

2. A student uses a stopwatch to measure the time for 10 oscillations of a simple pendulum and observes a reading of 20·0 s. If the least count of the stopwatch is 0·1 s, what is the percentage error of the period?
(1) 0·05% (2) 0·1% (3) 0·5% (4) 1% (5) 1·25%

3. A spring-mass system oscillates with period T. If the length of the spring is halved and the mass is reduced to half of its initial mass, what will be the new period?
(1) $\frac{T}{2}$ (2) $\frac{T}{\sqrt{2}}$ (3) T (4) $\sqrt{2}T$ (5) $2T$

4. Two identical transverse waves travelling in opposite directions in a string, superimpose to form a standing wave. If the distance between two adjacent nodes is 12 cm, what is the wavelength of the original waves?
(1) 3 cm (2) 6 cm (3) 12 cm (4) 24 cm (5) 48 cm

5. An object is projected with an initial velocity u at an angle θ to the horizontal. Neglect air resistance. Consider the following statements regarding the projectile.

(A) The kinetic energy of the object remains constant throughout the motion.
(B) The velocity of the object is zero at the highest point of the trajectory.
(C) The acceleration of the object is constant throughout the motion.

Of the above statements,
(1) only (A) is true. (2) only (B) is true.
(3) only (C) is true. (4) only (A) and (B) are true.
(5) all (A), (B) and (C) are true.

6. Three identical resistors, each of resistance R are provided. What are the respective minimum and maximum equivalent resistances that can be obtained from them?
(1) R and $3R$ (2) $\frac{R}{2}$ and $2R$ (3) $\frac{R}{2}$ and $3R$
(4) $\frac{R}{3}$ and R (5) $\frac{R}{3}$ and $3R$

[See page two

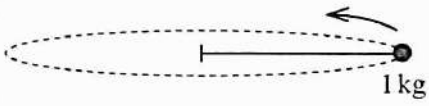
7. Consider the following statements about quarks.
(A) There are six types of quarks.
(B) The charge of a quark can either be $-\frac{2}{3}e$ or $+\frac{1}{3}e$, where e is the elementary charge.
(C) Quarks can exist in isolation.
Of the above statements,
(1) only (A) is true. (2) only (A) and (B) are true.
(3) only (A) and (C) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

8. An isolated point charge q is placed in a dielectric medium of dielectric constant k. What is the magnitude of the electric field intensity at a point inside the medium at distance r away from the point charge?
(1) 0 (2) $\frac{q}{4\pi k\varepsilon_0 r^2}$ (3) $\frac{q}{4\pi\varepsilon_0 r^2}$ (4) $\frac{kq}{4\pi\varepsilon_0 r^2}$ (5) $\frac{q}{k\varepsilon_0 r^2}$

9. A magnetic field is applied perpendicular to the plane of a circular coil of area 25 cm^2 and 200 turns. If the magnetic flux density is uniformly increased from 0·01 T to 0·05 T during a time interval of 0·2 s, what is the average induced e.m.f. in the coil?
(1) 0·01 V (2) 0·1 V (3) 1·0 V (4) 2·5 V (5) 4·0 V

10. A person can see objects clearly only up to 50 cm from his eyes. What is the type and the power (in diopters) of the lens needed to clearly see distant objects?
(1) Concave lens, –2·0 D (2) Concave lens, –1·33 D
(3) Convex lens, +1·33 D (4) Convex lens, +2·0 D
(5) Concave lens, –0·02 D

11. A mass of 1 kg is attached to a uniform wire of unstretched length 10 cm. The cross sectional area of the wire is 1 cm^2 and the Young modulus of the material of the wire is $1{\cdot}0\times10^{11}$ N m^{-2}. As shown in the figure the mass is allowed to move in a circle of approximate radius 10 cm with constant speed of 2 m s^{-1}. What is the extension of the wire?



(1) 0·04 μm (2) 0·40 μm (3) 4·0 μm (4) 40 μm (5) 400 μm

12. A four-wheel drive (power all four wheels by the engine) car starting from rest moves with uniform acceleration and attains a velocity of 72 km h^{-1} in 5·0 s on a horizontal straight road. Neglect air resistance. What is the minimum coefficient of static friction between the tyres and the road during acceleration period?
(1) 0·3 (2) 0·4 (3) 0·5 (4) 0·6 (5) 0·8

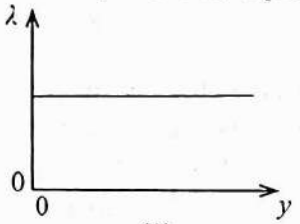
13. A uniform solid cylinder starts from rest and rolls on an inclined plane without slipping. The moment of inertia I of a solid cylinder of mass M and radius R rotating about the axis of the cylinder is $I=\frac{1}{2}MR^2$.
What is the ratio $\frac{\text{total kinetic energy of the cylinder}}{\text{rotational kinetic energy of the cylinder}}$?
(1) $\frac{4}{3}$ (2) $\frac{3}{2}$ (3) 2 (4) 3 (5) 4

14. A body is dropped freely from a height above the ground. At the same time another body is thrown horizontally from the same height. Assume that air resistance is negligible. Which of the following statements is true regarding the time of flight of the two bodies?
(1) Cannot answer without the value of the initial velocity of the thrown body.
(2) Cannot answer without the value of the height.
(3) The thrown body will take a longer time to hit the ground.
(4) The thrown body will hit the ground first.
(5) Both bodies will hit the ground at the same time.

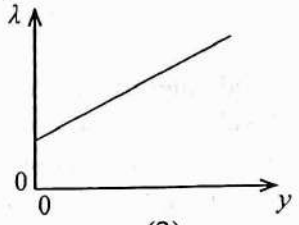
[See page three

15. A heavy uniform rope hangs vertically from a rigid support. A block of mass m is attached to the free end of the rope as shown in the figure. A transverse pulse is generated at the lower end of the rope. The variation of the wavelength λ of the pulse with distance y measured from the lower end of the rope is best represented by

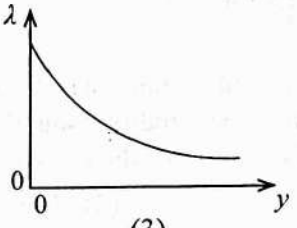




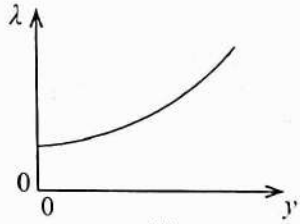
(1)



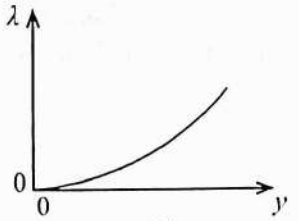
(2)



(3)



(4)

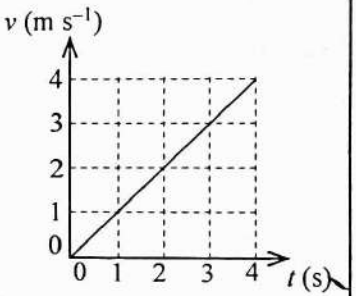


(5)

16. A blackbody (A) has its maximum radiant intensity at a wavelength of 200 nm. Another blackbody (B) has its maximum radiant intensity at 600 nm. What is the value of the ratio $\frac{\text{power emitted per unit surface area by } A}{\text{power emitted per unit surface area by } B}$?

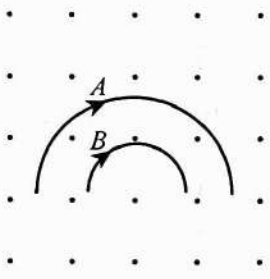
(1) $\frac{1}{81}$ (2) $\frac{1}{9}$ (3) 3 (4) 9 (5) 81

17. The velocity (v) - time (t) graph of an elevator moving vertically downwards is shown in the figure. A block of mass 1 kg is placed on the floor of the elevator. What is the apparent weight of the block?



(1) 1 N (2) 5 N (3) 9 N
(4) 10 N (5) 11 N

18. Two particles A and B of masses m_A and m_B respectively and having similar charges are moving perpendicular to a uniform magnetic field. The speeds of the particles are v_A and v_B respectively and the trajectories are as shown in the figure. Which of the following is true?



(1) $m_A v_A > m_B v_B$
(2) $m_A v_A < m_B v_B$
(3) $m_A < m_B$ and $v_A < v_B$
(4) $m_A = m_B$ and $v_A = v_B$
(5) $m_A = m_B$ and $v_A < v_B$

19. A pipe closed at one end and filled with helium (relative atomic mass = 4) gas has a fundamental frequency f. The pipe is then filled with neon (relative atomic mass = 20) gas at the same temperature. If both gases are ideal, what is the fundamental frequency of the neon filled pipe?

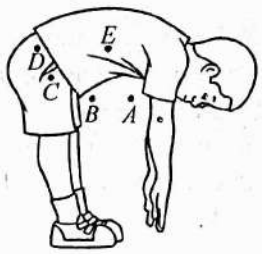
(1) $\frac{f}{5}$ (2) $\frac{f}{\sqrt{5}}$ (3) f (4) $\sqrt{5}f$ (5) $5f$

20. Water at 20 °C enters an electric water heater which heats water to 80 °C and supply at uniform rate of 0·3 kg min^{-1}. Assume that there is no heat loss from the system. The specific heat capacity of water is 4×10^3 J kg^{-1} °C^{-1}. What is the power of the heater?

(1) 800 W (2) 1200 W (3) 1440 W (4) 1600 W (5) 1920 W

[See page four

21. When an athlete bends as shown in the figure his centre of gravity is most likely to be found at



(1) A (2) B (3) C
(4) D (5) E

22. A radio emits sound which produces sound intensity level of 40 dB at a distance of 1·0 m from it. If the clear audible sound intensity level of a person is 20 dB, what is the maximum distance from the radio at which sound can be heard clearly? (Assume that sound waves spread spherically)

(1) 2 m (2) 4 m (3) 10 m (4) 20 m (5) 100 m

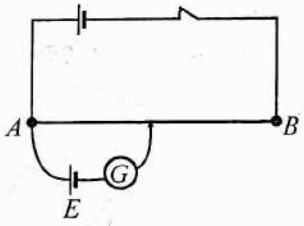
23. Consider the following statements regarding humidity.

(A) At below dew point temperatures relative humidity is constant.
(B) When relative humidity is higher absolute humidity is always higher.
(C) When absolute humidity is constant, relative humidity decreases with increase of temperature.

Of the above statements,

(1) only (A) is true.
(2) only (A) and (B) are true.
(3) only (A) and (C) are true.
(4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

24. The figure shows a potentiometer circuit. The balance length for a cell of e.m.f. E is found to be 120 cm. When a resistance of 4 Ω is connected parallel to this cell, the balance length becomes 60 cm. What is the internal resistance of the cell?

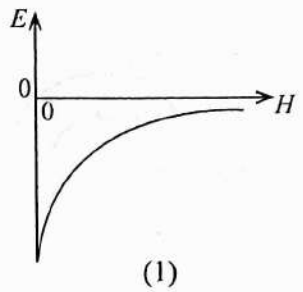


(1) 1 Ω (2) 2 Ω (3) 3 Ω
(4) 4 Ω (5) 5 Ω

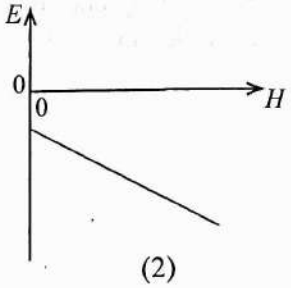
25. Which of the following statements is true regarding propagation of mechanical waves?

(1) Transverse waves cannot propagate on the surface of liquids.
(2) Longitudinal waves can propagate through solids only.
(3) Longitudinal waves can propagate through a vacuum.
(4) Transverse waves cannot propagate through gases.
(5) Longitudinal waves transmit both energy and matter.

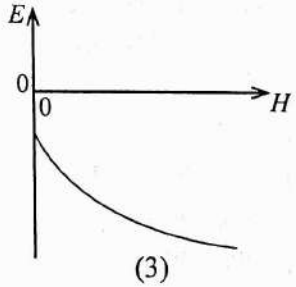
26. A satellite is moving in a circular orbit around the earth. The variation of total mechanical energy E of the satellite with the height H from the earth surface is best represented by



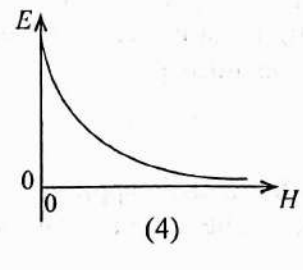
(1)



(2)



(3)



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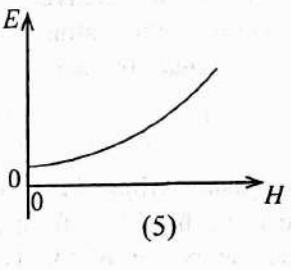
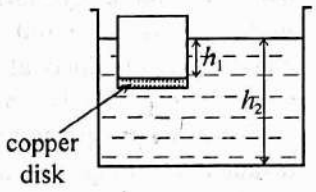


(5)

[See page five

27. A wooden block, with a copper disk pasted on its bottom, floats in a beaker of water as shown in the figure. The heights h_1 and h_2 are shown in the figure. After some time the disk is detached and falls into the water. Then

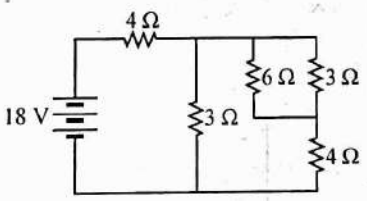


(1) h_1 decreases and h_2 increases.
(2) h_1 remains the same but h_2 decreases.
(3) both h_1 and h_2 increase.
(4) both h_1 and h_2 decrease.
(5) both h_1 and h_2 remain the same.

28. When an object is placed on the principal axis of a convex lens of focal length 10 cm the lens forms an image of the same size as that of the object. If the lens is replaced by another convex lens an erect image is formed. If the focal length of the second lens is f_2 (cm), which of the following is true?

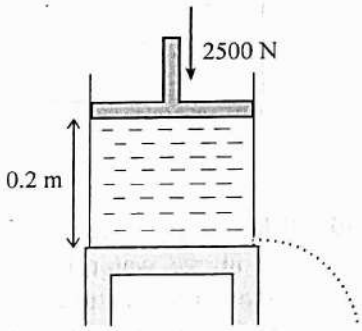
(1) $f_2 < 10$ (2) $f_2 = 10$ (3) $10 < f_2 < 20$ (4) $f_2 = 20$ (5) $f_2 > 20$

29. Consider the circuit diagram shown in the figure. The 18 V battery has no internal resistance. What is the potential drop across 6 Ω resistor?



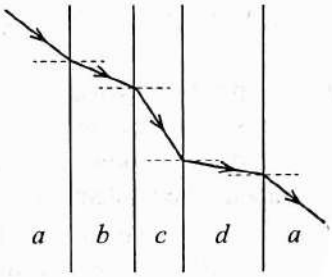
(1) 2 V (2) 3 V (3) 4 V
(4) 6 V (5) 9 V

30. The inner cross-sectional area of a cylindrical tank is 1 m^2. It is filled with water and a frictionless piston covers its entire water surface as shown in the figure. A uniformly distributed force of 2500 N is applied on the piston from top. A small hole is situated close to the bottom of the tank. What is the speed of water coming out of the hole, when the height of water level is 0·2 m? Density of water is 10^3 kg m^{-3}.



(1) 1·0 m s^{-1} (2) 1·5 m s^{-1} (3) 2·0 m s^{-1}
(4) 2·5 m s^{-1} (5) 3·0 m s^{-1}

31. The figure shows the path of a monochromatic ray of light passing through transparent media a, b, c, d and a with surfaces parallel to each other. If the refractive indices of media a, b, c and d are n_a, n_b, n_c and n_d respectively which of the following relationships is correct?

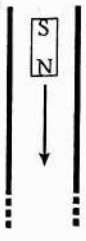


(1) $n_d > n_b > n_a > n_c$ (2) $n_d > n_a > n_b > n_c$
(3) $n_d > n_b > n_c > n_a$ (4) $n_b > n_d > n_a > n_c$
(5) $n_c > n_b > n_a > n_d$

32. A conducting circular loop of radius r carries a constant current I. It is placed in a uniform magnetic field of flux density B such that the field is perpendicular to the plane of the loop. What is the net magnetic force acting on the loop?

(1) zero (2) IrB (3) $2IrB$ (4) $I\pi rB$ (5) $2I\pi rB$

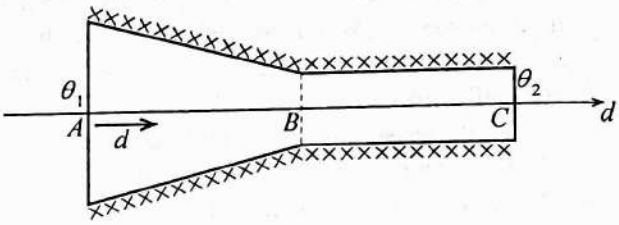
33. Starting from rest a short magnet is allowed to fall along the axis of a thick-walled long vertical aluminium tube as shown in the figure. Neglect air resistance. The distance the magnet falls in the initial second can be

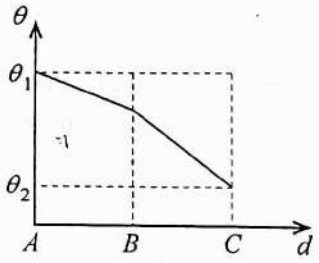


(1) 1 m (2) 5 m (3) 6 m
(4) 7 m (5) 8 m

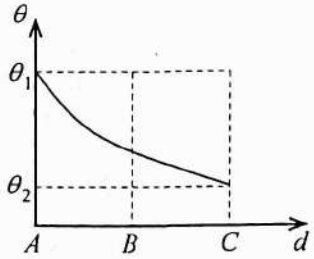
[See page six

34. A combined metal rod consists of a tapered part AB and a cylindrical part BC as shown in the figure. The rod is fully lagged and the ends are maintained at temperatures θ_1 and θ_2 ($\theta_1 > \theta_2$) respectively. At the steady state, the variation of temperature θ of the rod with the distance d along the axis of the rod is best represented by

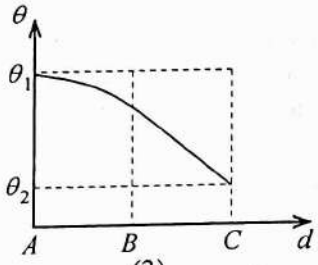




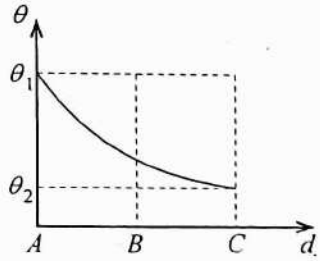
(1)



(2)



(3)



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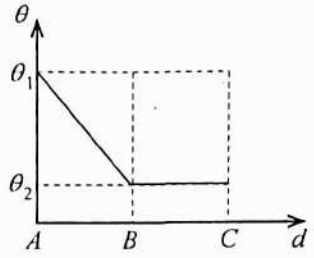
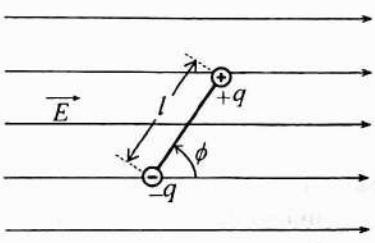


(5)

35. When a glass capillary tube is partially immersed vertically into water to a depth l, the capillary rise above water is h. Here $l < h$. Then the lower end of the tube is closed inside water using a finger and the tube is taken out of water. If the finger is released now keeping the tube vertical what is the height of the water column remaining in the tube? (Assume that the angle of contact between water and glass is zero)

(1) $h+l$ (2) $2h$ (3) h (4) l (5) $h-l$

36. A positive charge $+q$ and a negative charge $-q$ connected by a massless insulating rod of length l are placed in a uniform electric field E as shown in the figure. Consider the following statements about the system of two charges.

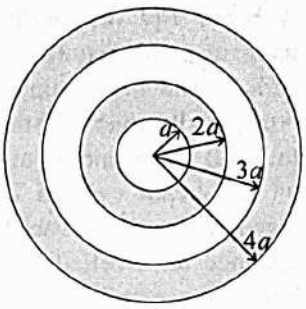


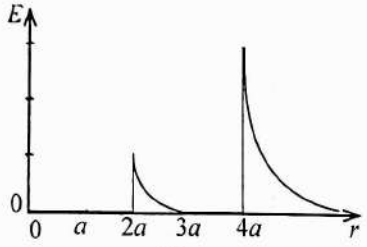
(A) The net electric force acting on the system is non-zero.
(B) The net torque acting on the system is non-zero.
(C) When $\phi = 180^\circ$ the system is in unstable equilibrium.

Of the above statements,
(1) only (A) is true.
(2) only (A) and (B) are true.
(3) only (A) and (C) are true.
(4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

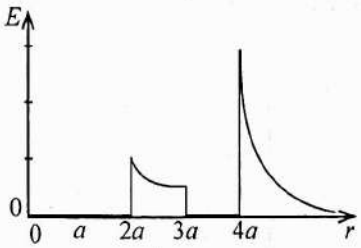
[See page seven

37. As shown in the figure a small conducting spherical shell with inner radius a and outer radius $2a$ is concentric with a larger conducting spherical shell with inner radius $3a$ and outer radius $4a$. The net charge of inner and outer shells are $+2q$ and $+4q$ respectively. The variation of electric field intensity E with the radial distance r from the common center is best represented by





(1)



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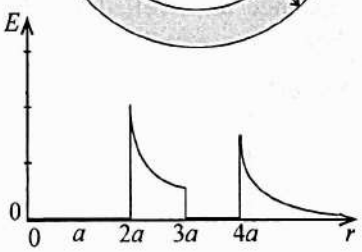

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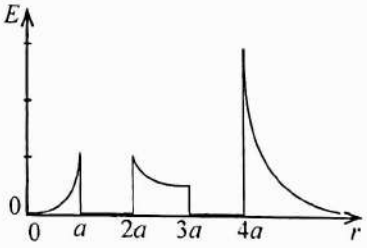

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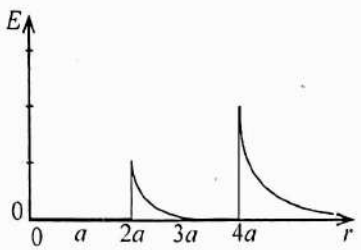
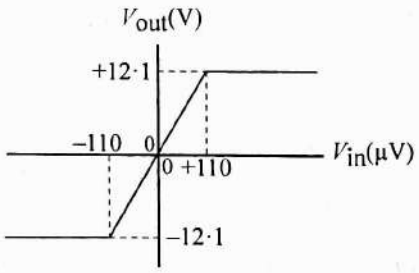


(5)

38. The density of the material of a small sphere is 1200 kg m^{-3}. If the sphere is placed on the surface of water in a tall measuring cylinder and released, it reaches a terminal velocity of 24 cm s^{-1}. The density of water is 1000 kg m^{-3} and coefficient of viscosity is 1×10^{-3} Pa s. If the cylinder is filled with isopropanol having density 800 kg m^{-3} and coefficient of viscosity 2×10^{-3} Pa s and the same sphere is then placed on the isopropanol surface and released, what will be its terminal velocity?

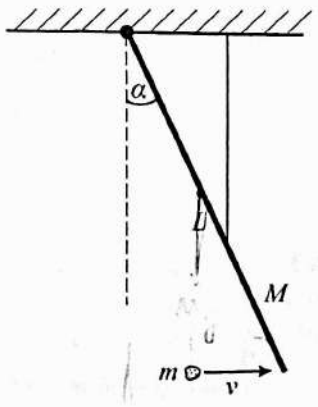
(1) 6 cm s^{-1} (2) 12 cm s^{-1} (3) 24 cm s^{-1} (4) 48 cm s^{-1} (5) 96 cm s^{-1}

39. The figure shows the input-output characteristics of an operational amplifier (Op-amp) circuit. What is the maximum voltage gain of the circuit?



(1) 11 (2) 55 000 (3) 100 000
(4) 110 000 (5) 220 000

40. A uniform rod of length L and mass M is freely pivoted to a point in a ceiling and suspended at an angle α from the vertical using a light string as shown in the figure. A small lump of clay of mass m moving horizontally at velocity v hits the free end of the rod and sticks together. Assume that the lump of clay is a point mass. What is the angular velocity of the system just after the collision? The moment of inertia I of a uniform rod of mass M and length L about one end and perpendicular to the rod is $I = \frac{1}{3}ML^2$.

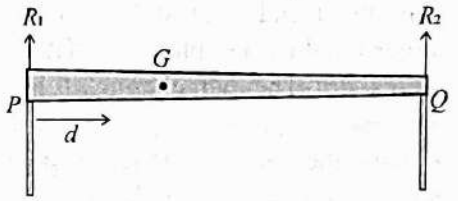


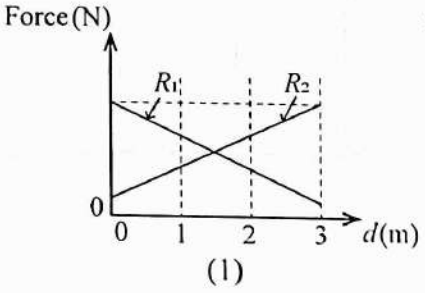
(1) $\frac{mv\cos\alpha}{(M+m)L}$ (2) $\frac{3mv\cos\alpha}{(M+m)L}$ (3) $\frac{3mv\cos\alpha}{(M+3m)L}$

(4) $\frac{3mv}{(M+3m)L}$ (5) $\frac{3mv}{mL}$

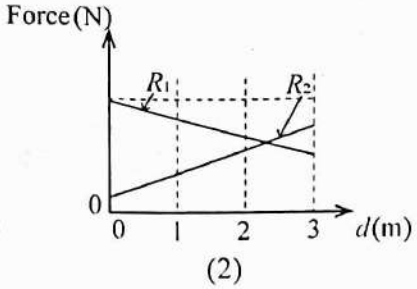
[See page eight

41. A beam PQ of length 3·0 m and mass 80 kg has its centre of gravity (G) at a distance 1·0 m from end P. The beam supported by two pillars is placed horizontally over a canal. A man of mass 60 kg starts to walk from end P to the other end Q. The forces on the beam exerted by the pillars are R_1 and R_2, respectively. The variation of R_1 and R_2 with the distance d travelled by the man from the end P is best represented by





(1)



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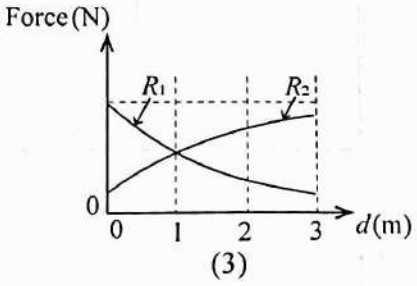

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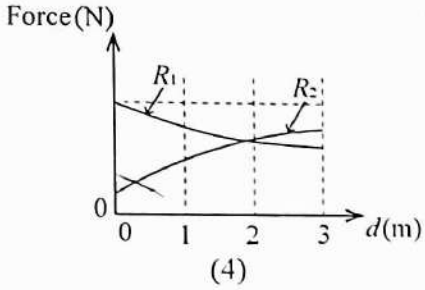

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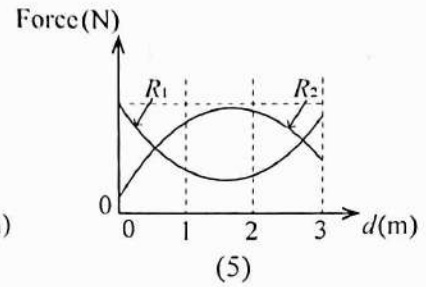


(5)

42. The diameter of an iron ball is 5·00 cm, which is 0·001 cm larger than the diameter of a hole in a brass plate when both are at a temperature of 30 °C. What is the temperature of the system at which the ball just passes through the hole? The linear expansivity of iron and brass are $1{\cdot}2\times10^{-5}\ °C^{-1}$ and $2{\cdot}0\times10^{-5}\ °C^{-1}$, respectively.

(1) 40 °C (2) 47 °C (3) 55 °C (4) 80 °C (5) 85 °C

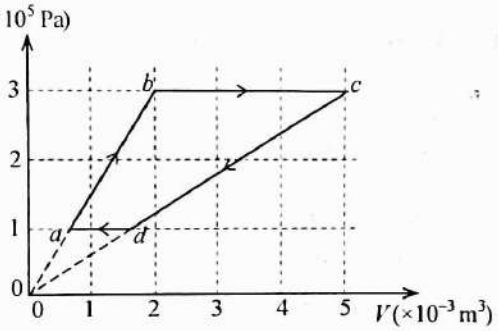
43. A parallel plate capacitor of capacitance C is charged to a voltage V. Another identical capacitor is charged to a voltage $\frac{V}{2}$. After disconnecting capacitors from the voltage supplies, the plates of the capacitors with opposite charges are connected together. What is the final energy stored in the capacitor system?

(1) 0 (2) $\frac{1}{16}CV^2$ (3) $\frac{1}{8}CV^2$ (4) $\frac{1}{2}CV^2$ (5) CV^2

44. The p-V diagram shown in the graph represents the thermodynamic cycle *abcda* of an ideal gas. What is the net work done by the gas in one cycle?

(1) 200 J (2) 350 J (3) 400 J

(4) 450 J (5) 800 J

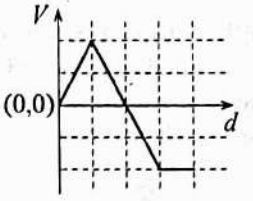


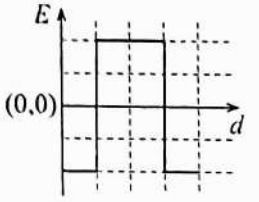
45. A block of mass m moving with velocity v on a frictionless horizontal surface collides with a heavier block of mass $3m$ at rest on the surface. If the two blocks stick together after the collision, they move with velocity V_1. If instead the collision is perfectly elastic, the lighter-block bounces back in the opposite direction and the heavier block moves with velocity V_2. What is the ratio of $\frac{V_2}{V_1}$?

(1) $\frac{1}{4}$ (2) $\frac{1}{2}$ (3) 1 (4) $\frac{3}{2}$ (5) 2

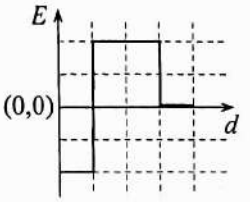
[See page nine

46. The variation of electric potential V with the distance d in a region is shown in the figure. The variation of electric field intensity E with d is best represented by





(1)



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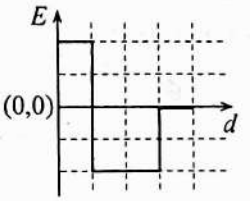

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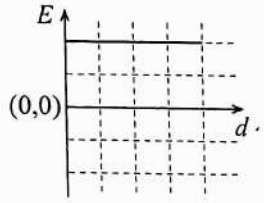

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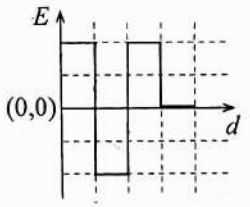
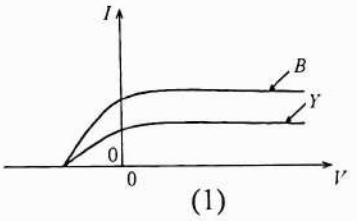
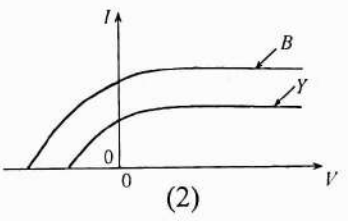


(5)

47. In a photoelectric experimental setup, the cathode is coated with sodium (work function 2·3 eV). The Planck constant $h = 4 \times 10^{-15}$ eV s and the speed of light $c = 3 \times 10^{8}$ m s^{-1}. Which graph best represents the current (I) - voltage (V) curves when the cathode is separately illuminated with blue-$B(\lambda = 400$ nm) or yellow-$Y(\lambda = 600$ nm) light?



(1)



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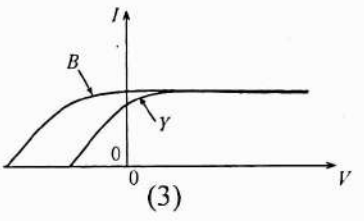

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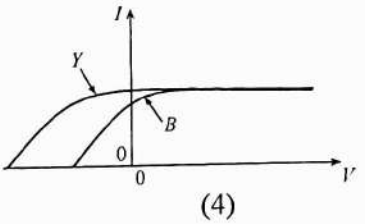

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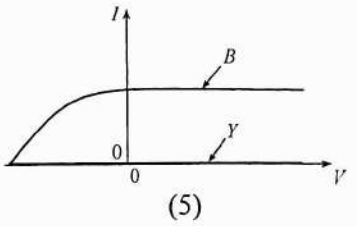
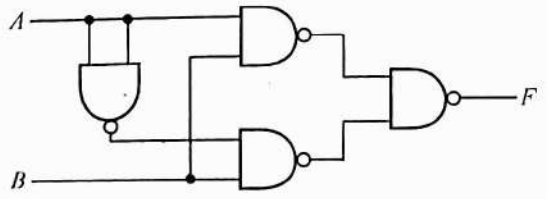


(5)

48. Consider the logic gate circuit made of NAND gates only.



What is the correct truth table of the circuit?

A	B	F
0	0	1
0	1	0
1	0	1
1	1	0

(1)

A	B	F
0	0	0
0	1	1
1	0	0
1	1	1

(2)

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

(3)

A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

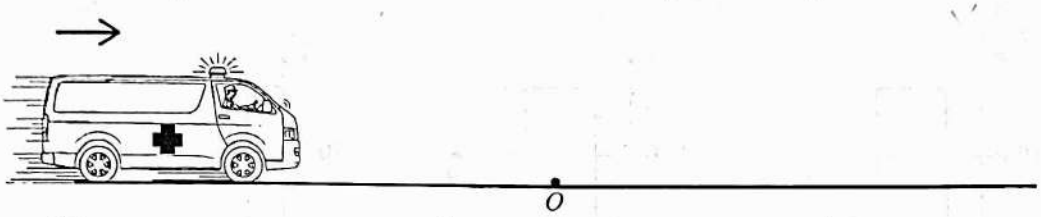
(4)

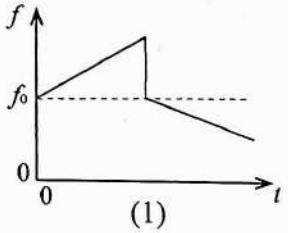
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

(5)

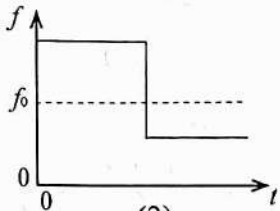
[See page ten

49. Starting from rest an ambulance travels with uniform acceleration along a horizontal road sounding its siren at a constant frequency f_0 as shown in the figure. It goes past a stationary observer O standing by the side of the road. The variation of the frequency f of the sound generated by the siren as heard by the observer with time t is best represented by





(1)



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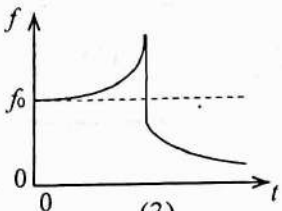

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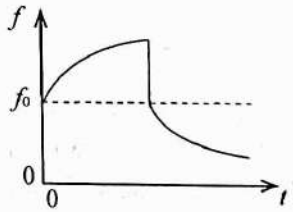

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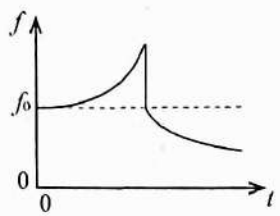
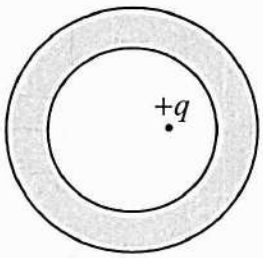
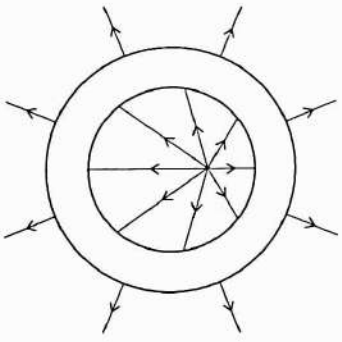


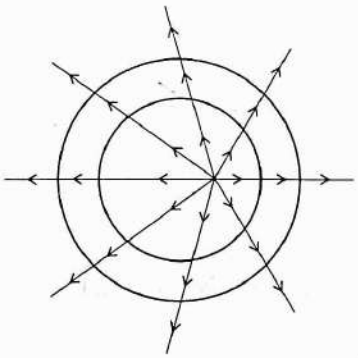
(5)

50. A point charge $+q$ is placed at a point inside the cavity of thick metallic shell as shown in the figure. Which diagram best represents the lines of the electric field?





(1)



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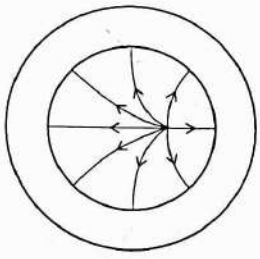

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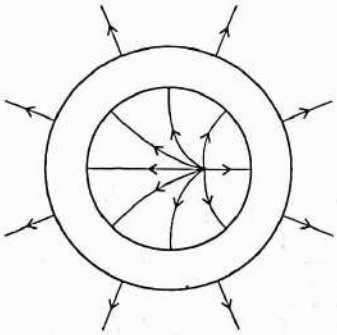

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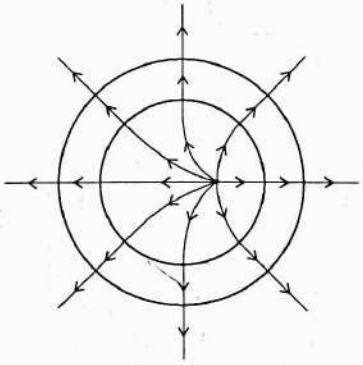

(5)

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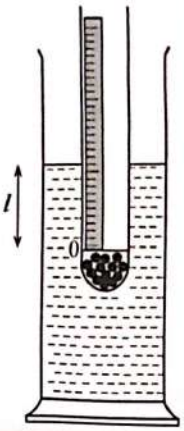
PART A — Structured Essay

*Answer **all four** questions on this **paper itself**.*

($g = 10\ m\ s^{-2}$)

1. You are asked to determine the density of a transparent liquid using a weighted boiling tube. A boiling tube, a tall jar containing the liquid, a sufficient number of 2 g weights, a paper strip marked in millimetres, lead shots and a small quantity of wax are provided.

The bottom of the boiling tube is filled with lead shots and sealed with wax. The marked strip is pasted inside the tube so that the zero mark of the strip be on the cylindrical part of the tube as shown in the figure. During the experiment, weights are inserted one by one into the tube immersing it further in the liquid. The length l of the immersed cylindrical part of the tube from the zero mark of the strip is shown in the figure.



(*a*) (i) What is the purpose of using lead shots in this experiment?

.....

.....

(ii) Why should the zero mark of the strip be on the cylindrical part of the tube?

.....

.....

(*b*) (i) Let M be the mass of the boiling tube together with the lead shots and wax. Write down an expression for the upthrust U acting on the tube when floating.

$U =$ .....

(ii) To calculate the cross-sectional area of the immersed cylindrical portion of the tube, another measurement has to be taken. What is the measurement and the appropriate instrument for this purpose?

I. Measurement :.....

II. Instrument :.....

(iii) You have to add a weight of mass m into the boiling tube and record the corresponding length l during the experiment. If A is the relevant cross-sectional area of the cylindrical part of the tube and V_0 is the relevant volume of the tube below zero mark of the strip, obtain an expression for the density of the liquid ρ in terms of m, M, A, l and V_0.

.....

.....

.....

(iv) Rearrange the expression you obtained in (*b*) (iii) above to plot the appropriate straight line graph.

.....

.....

.....

.....

[*see page three*

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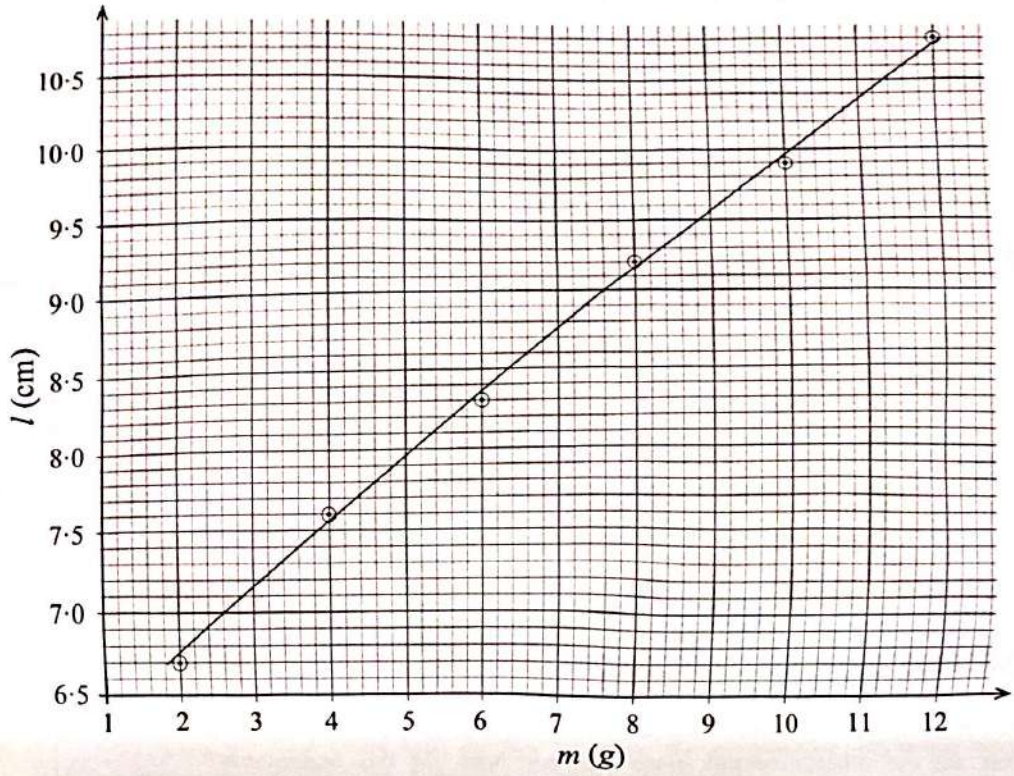
(c) The corresponding graph of l against m is shown below.



(i) Find the gradient of the graph.

.....

.....

.....

.....

(ii) If the measurement obtained in (*b*) (ii) above is 2·00 cm, calculate the density of the liquid (ρ) using the gradient of the above graph. Take $\pi = 3$. Give your answer to the nearest integer.

.....

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(*d*) Give **one** disadvantage of using fine sand instead of lead shots in this experiment.

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.....

(*e*) State **two** disadvantages of using a test tube with cross-sectional area $\frac{1}{4}$ of that of the boiling tube mentioned above in this experiment?

(1) .....

(2) .....

[see page four

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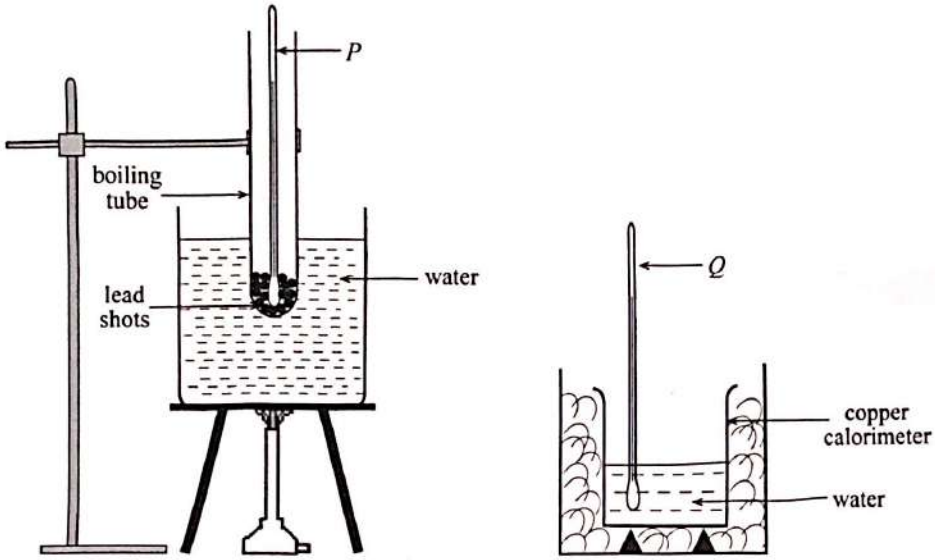
2. Following figure shows an experimental set-up used in a school laboratory to determine the specific heat capacity of lead given in the form of lead shots using the method of mixtures.



(a) (i) What is the other essential measuring instrument that you need for this experiment?

.....

(ii) What are the other essential **items** that you need for this experiment?

(1) .....

(2) .....

(b) Three thermometers A, B and C are available for the experiment.

The range of thermometer A, –10 °C to 250 °C

The range of thermometer B, –10 °C to 110 °C

The range of thermometer C, –10 °C to 60 °C

(i) Which one of the above must be used for thermometer P?

.....

(ii) Which one of the above must be used for thermometer Q?

.....

(c) What are the mass measurements that you take in this experiment? Give them in the order of measurements.

(i) ..... (m_1)

(ii) ..... (m_2)

(iii) ..... (m_3)

(d) (i) What experimental steps would you take to measure the initial temperature (θ_1) of lead shots?

.....

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[see page five

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(ii) What are the temperature measurements that you take using thermometer Q? Give them in the order of measurements.

(1) ..... (θ_1)

(2) ..... (θ_2)

(iii) What are the experimental steps that you would take to measure temperature θ_1 given above?

(1) .....

(2) .....

(c) (i) If the specific heat capacities of water and copper are c_w and c_c respectively, write down an expression for the specific heat capacity c of lead in terms of the above mentioned measurements, c_w and c_c. Assume that there is no heat exchange with the surroundings.

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(ii) Using the following data and neglecting the heat capacity of the calorimeter calculate the mass of lead shots (m_l) needed to raise the temperature of water by 10 °C. Assume that there is no heat loss to the surroundings.

Mass of water used = 50 g; Temperature drop of lead shots = 70 °C; specific heat capacity of lead = 127 J kg^{-1} K^{-1}; specific heat capacity of water = 4200 J kg^{-1} K^{-1}

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(iii) Calculate the volume of lead shots used in (c)(ii) above.
(Density of lead = 12 × 10^3 kg m^{-3})

.....

.....

(iv) Giving reasons state whether 100 cm^3 calorimeter is suitable or not to perform this experiment. (Density of water = 10^3 kg m^{-3})

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[see page six

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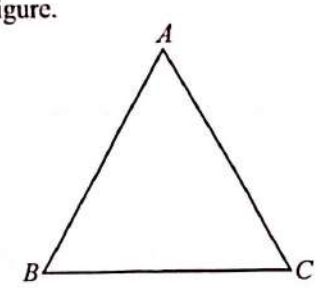
3. You are asked to determine the refractive index of the material of a prism using the critical angle method. You are provided with an equilateral glass prism, a drawing board, drawing pins, a white sheet of paper, three optical pins, a protractor, a setsquare and a ruler. The prism ABC is shown in the figure.



(*a*) (i) Mark the location of the optical pin P_1 on the face AB which is used to obtain a ray of light through the prism using a cross (×).

(ii) Give **two** reasons for selecting the above location for P_1.

(1) .....

(2) .....

(*b*) (i) How do you experimentally observe and locate (using optical pins P_2 and P_3) the path of the emerging ray of light from face BC which falls on face AC at critical angle of incidence?

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(ii) Drawing the ray diagram with the construction lines in the above figure, give the steps needed in the correct order to construct the ray diagram to identify the critical angle.

(1) .....

.....

(2) .....

.....

(3) .....

.....

(4) .....

.....

(iii) How do you determine the critical angle c?

.....

.....

[see page seven

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(iv) I. Write down an expression for the refractive index n of glass in terms of c.

n = ...

II. If $c = 40°$, calculate n. Give your answer to two decimal places. (Take $\sin 40° = 0{\cdot}64$)

.....

.....

(*c*) (i) If a thin layer of water is formed on the face *AC*, what will happen to the emerging ray from face *BC*? Underline the correct answer.

Will move towards *B* / Will not change / Will move towards *C*.

(ii) If the above water layer is replaced by a thin layer of liquid which has a refractive index higher than that of glass, giving reasons state what will happen to the ray emerged from face *BC* in (*b*) (i) above.

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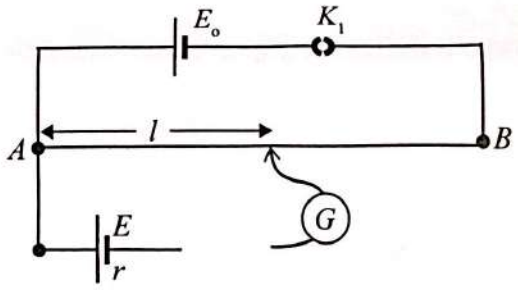
4. To determine the internal resistance (r) of a dry cell with e.m.f. E, a student uses a potentiometer and his incomplete circuit diagram is given in the figure. The following items are available to complete the circuit.



R_1 = 1 kΩ resistor

K_2 = plug key

R_2 = (0-50) Ω resistance box

K_3 = tap key

(*a*) Complete the circuit diagram using R_1, R_2, K_2 and K_3 in appropriate places.

(*b*) Write down the type and the e.m.f. of a cell suitable for obtaining E_o.

Type of the cell: .....

Value of E_o: .....

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(c) (i) Write down an expression for current I through the cell with e.m.f. E at the balance position when all keys are closed in terms of E, r and the resistance value R of the resistance box.

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(ii) Let k be the potential drop per metre in the wire AB. If the balance length of the potentiometer wire is l, write down an expression for the current I through R in terms of k, l and R at the balance position.

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(iii) Using the expressions in (c) (i) and (c) (ii) above obtain an expression to determine the internal resistance (r) of the cell by plotting an appropriate straight line graph.

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(d) In the graph identify the following.

(i) The independent variable: .....

(ii) The dependent variable: .....

(e) The student plots a straight line graph and the following values are extracted.

The gradient = 0·80 (in *SI units*)

The intercept = 0·40 (in SI units)

(i) Calculate the internal resistance (r) of the dry cell.

.....

.....

(ii) If $k = 0{\cdot}60\ \text{V m}^{-1}$, calculate the e.m.f. E of the dry cell.

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(f) Without changing the value of E_o, if a Li-ion cell is used instead of the dry cell in the above setup it is not possible to measure the e.m.f. of it. What is the reason for this?

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[see page nine