G.C.E. (Advanced Level) Examination - August 2010

PHYSICS - I

Two hours

Important :

- This question paper includes **60** questions in **07** pages.
- Enter your **Index Number** in the space provided on the answer sheet.
- **Answer all the questions.**
- Instructions are given on the back of the answer sheet. Follow them carefully.
- In each of the questions **1** to **60**, pick one of the alternatives (1), (2), (3), (4), (5) which is **correct or most appropriate** and mark your response on the answer sheet **in accordance with the instructions given therein.**

Use of calculators is not allowed.

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

01. The dimensions of moment of inertia is

(1) ML^2 (2) ML (3) M (4) L (5) MLT^{-1}

02. SI unit of the quantity of heat is

(1) Cal (2) W (3) K (4) J (5) cd

03. When white light passes through a glass prism, which of the following colours deviates the **least?**

(1) green (2) orange (3) blue
(4) yellow (5) indigo

04. The distance from the eye lens to the retina of a person is 1.7 cm. The focal length of the eye lens when the eye is in completely relaxed position is

(1) 0.85cm (2) 1.0 cm (3) 1.2 cm
(4) 1.4 cm (5) 1.7 cm

05. Consider the following statements made about a voltmeter and an ammeter.

(A) A voltmeter has a large internal resistance and an ammeter has a small internal resistance.

(B) A voltmeter is connected in series with a circuit component to measure the voltage across the component.

(C) An ammeter measures the charge per unit time that flows through it.

Of the above statements

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

06. Two guitar wires *A* and *B* identical in all respects except that the diameter of *A* is twice the diameter of *B*, and are subjected to same tension.

The ratio, $\frac{\text{fundamental frequency produced by A}}{\text{fundamental frequency produced by B}}$ is

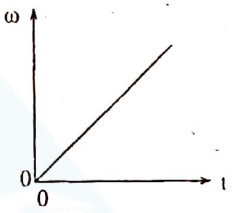
(1) $\frac{1}{4}$ (2) $\frac{1}{2}$ (3) $\frac{1}{\sqrt{2}}$

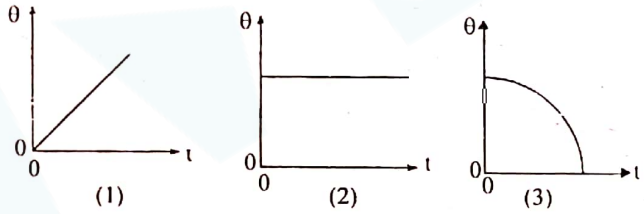
(4) $\sqrt{2}$ (5) 2

07. In order to double the root mean square speed of an ideal gas, the factor by which the absolute temperature of the gas to be in creased is

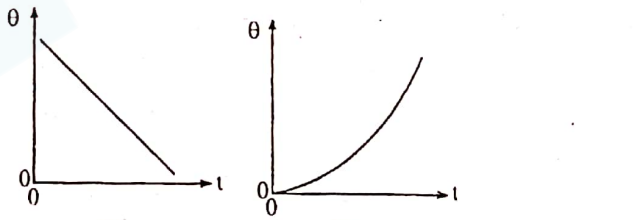
(1) $\sqrt{2}$ (2) 2 (3) 4
(4) 8 (5) 16

08. If the angular velocity (ω) an object varies with time (t) as shown in fig ure, the corresponding variation of angular displacement (θ) with time (t) is best represented by





(1) (2) (3)



(4) (5)

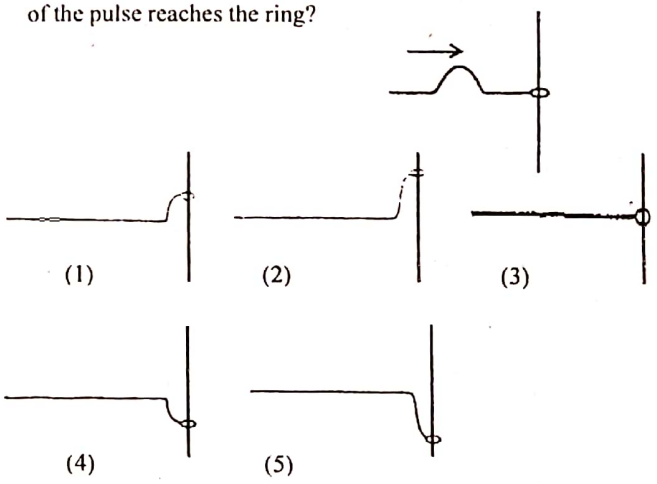
09. A major artery with a 1.0 cm^2 cross-sectional area carrying blood branches into 18 smaller arteries, each having a cross-sectional area of 0.4 cm^2 and carrying equal volumes of blood per unit time.

The ratio, $\frac{\text{speed of blood in the major artery}}{\text{speed of blood in a smaller artery}}$ is

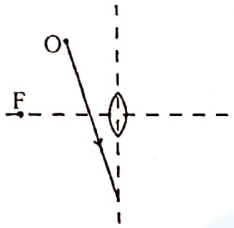
(1) 3.6 (2) 4.0 (3) 7.2
(4) 8.4 (5) 45

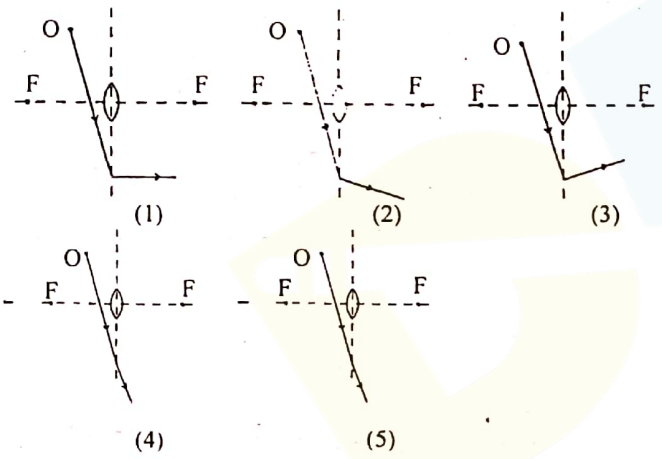
10. The figure shows a wave pulse travelling along a string towards its end which is connected to a small light ring that can move along a vertical wire. Which of the following figures best repre

sents the shape of the wave pulse at the instant when the peak of the pulse reaches the ring?

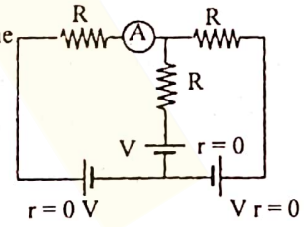


11. A point object O is placed in front of a thin convex lens as shown in the figure. The refracted path of the incident ray shown is best represented by





12. Current through ammeter A of the circuit shown is



(1) 0 (2) $\frac{V}{3R}$

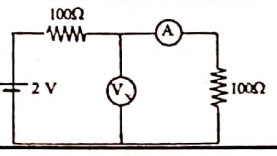
(3) $\frac{3V}{2R}$ (4) $\frac{V}{R}$

(5) $\frac{3V}{R}$

13. A coil made of a platinum wire has a resistance of 50 Ω at 0 °C. When immersed in melting lead, the resistance of the coil increases to 115 Ω. If the temperature coefficient of resistivity of platinum is 4.0×10^{-3} °C^{-1}, the melting point of lead is

(1) 225 °C (2) 325 °C (3) 475°C (4) 575 °C (5) 598 °C

14. The circuit shown in figure is constructed using ideal components. A is an ammeter and V is a voltmeter. If a Student by mistake replaces the ammeter A with an ideal voltmeter V_Y, then V_X and V_Y respectively read



(1) 1 V, 1V (2) 1V, 0

(3) 2V, 0 (4) 0, 1V

(5) 2V, 2V

15. In the nuclear reaction.

$$^{7}_{3}Li + ^{A}_{Z}X \longrightarrow ^{A+6}_{Z+2}Y + a$$

Particle denoted by a is

(1) a proton. (2) an electron. (3) a neutron.

(4) an α particle. (5) a positron.

16. A small conducting sphere of mass m has a + Q charge. This sphere is hung form an insulating thread of length l in a region where there is an electric field of intensity E in vertically down ward direction, (in addition to the gravitational field), and is allowed to oscillate as a simple pendulum. If the period of small oscillations of this simple pendulum is T, then

(1) $T = 2\pi\sqrt{\frac{l}{g}}$ (2) $T = 2\pi\sqrt{\frac{l}{g+E}}$ (3) $T = 2\pi\sqrt{\frac{l}{g+QE}}$

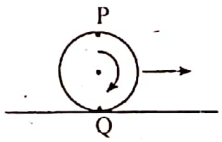
(4) $T = 2\pi\sqrt{\frac{l}{g-\frac{QE}{m}}}$ (5) $T = 2\pi\sqrt{\frac{l}{g+\frac{QE}{m}}}$

17. Two stars, A and B of uniform density have equal radii. Star A having twice the mass of star B is spinning three times faster than star B.

The ratio, $\frac{\text{angular momentum of star A}}{\text{angular momentum of star B}}$ is

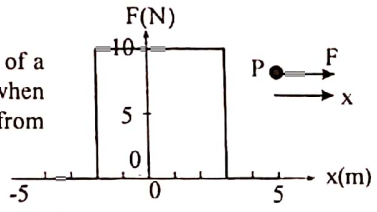
(1) $\frac{1}{6}$ (2) 2 (3) 3 (4) 6 (5) 18

18. A circular disk of radius 0.5 m rolls with a uniform angular speed 12rad s^{-1} on a horizontal surface without slipping. Two points *P* and *Q* are located on the perimeter of the disk. The speeds of the two points relative to the earth when they are at the positions shown in the figure, are



	P	Q
(1)	6 ms^{-1}	6 ms^{-1}
(2)	6 ms^{-1}	3 ms^{-1}
(3)	6 ms^{-1}	0
(4)	12 ms^{-1}	6 ms^{-1}
(5)	12 ms^{-1}	0 ms^{-1}

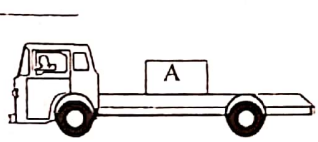
19. The graph shows the variation of a force *F* exerted on an object *P* when it is moving along the x-axis from x = -5 to x = 5.



The work done on the object by the force is

(1) 10 J (2) 30 J (3) 40 J (4) 50 J (5) 100 J

20. A box (A) of mass 50 kg is placed on the horizontal floor-bed of a lorry as shown in the figure. The coefficient of static friction between the box and the floor-bed is 0.8 and the lorry accelerates along a straight horizontal road.



The maximum acceleration the lorry can have so that the box will not slide over the floor-bed is

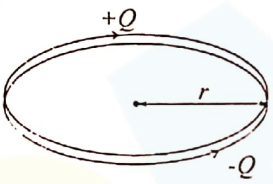
(1) 2 ms^{-2} (2) 4 ms^{-2} (3) 8 ms^{-2} (4) 10 ms^{-2} (5) 12 ms^{-2}

21. When a standing wave is setup on a string fixed at both ends,
(1) the number of nodes is equal to the number of antinodes.
(2) the wavelength of the wave is always equal to the value obtained when the length of the string is divided by an integer.
(3) the frequency of the wave is equal to the value of the number of nodes times the fundamental frequency.
(4) the frequency of the wave is equal to the value of the number of antinodes times the fundamental frequency.
(5) the shape of the string at the fundamental frequency is **not** symmetric about the mid point of the string.

22. If the ratio of sound intensities and the corresponding difference in sound intensity levels (in dB) of two sound sources are numerically equal, then the ratio of sound intensities is
(1) 10 (2) 20 (3) 100 (4) 200 (5) 1000

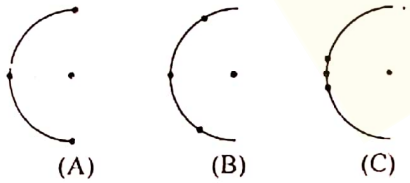
23. A telescope having a magnifying power of 15 has an eyepiece of power 50 diopters. The length of the telescope, when it is in the normal adjustment is
(1) 15cm (2) 28cm (3) 30cm (4) 32cm (5) 64cm

24. Two particles having charges $+Q$ and $-Q$ revolve in opposite directions with the same angular frequency ω along two circular paths of radius r, which are very close to each other as shown in the figure. Magnetic flux density at the centre of the circular paths is



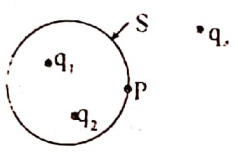
(1) zero (2) $\frac{\mu_0 Q\omega}{4\pi r}$ (3) $\frac{\mu_0 Q\omega}{2\pi r}$
(4) $\frac{\mu_0 Q\omega}{2\pi^2 r}$ (5) $\frac{\mu_0 Q\omega}{4r}$

25. Figure shows three arrangements (A, B and C) of four identical particles with three of them placed on a semi circle and fourth placed at the centre of the semi circle. If the respective magnitudes of the net gravitational force on the particle at the centre due to the other three particles are represented by F_A, F_B and F_C then



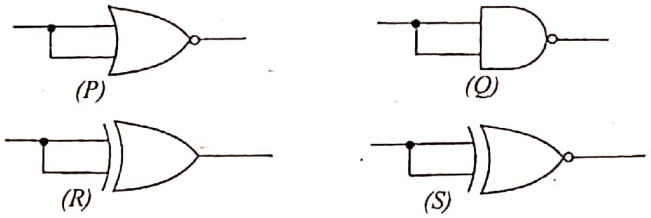
(1) $F_C > F_B > F_A$ (2) $F_B < F_C < F_A$ (3) $F_C < F_B < F_A$
(4) $F_C = F_B = F_A$ (5) $F_C = F_B > F_A$

26. Figure shows four point charges and a Gaussian surface S
Consider the following statements.
(A) Net electric flux through the surface depends only on the fields produced by q_1 and q_2
(B) The electric field intensity at point P depends only on the fields produced by q_1 and q_2
(C) The electric field intensity at point P depends on the locations of the charges q_1, q_2, q_3 and q_4.



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

27. Which of the arrangements shown is/are equivalent to a NOT gate?

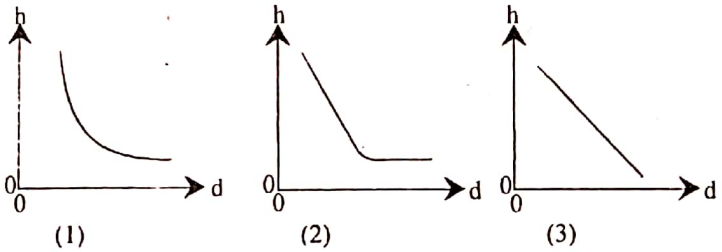


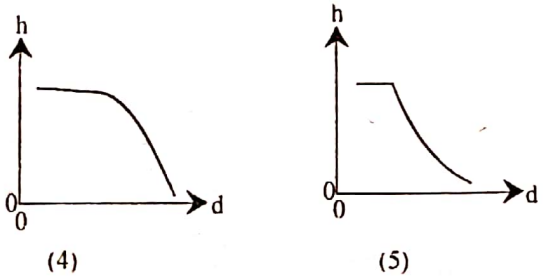
(1) P only (2) Q only (3) P and Q only
(4) P, Q and S only (5) all P, Q, R and S

28. Figure shows two silicon transistors T_1 and T_2 located in a circuit, which operate properly. If V_{CE} values of the transistors T_1 and T_2 are 0.1V and 3V respectively, which of the following is true?

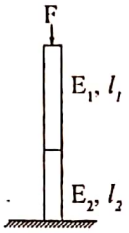
(1) V_{BC} of T_1 is approximately 0.6 V, and the BC junction is forward biased.
(2) V_{BC} of T_2 is approximately 0.6V, and the BC junction is forward biased.
(3) V_{BC} of T_1 is approximately 0.6V, and the BC junction is reverse biased.
(4) V_{BC} of T_2 is approximately 2.3V, and the BC junction is forward biased.
(5) V_{BC} of T_1 is approximately 3V, and the BC junction is reverse biased.

29. When a glass capillary tube of internal diameter d is immersed vertically in water, the water level inside the tube rises to a height of h. The variation of h with d is best represented by





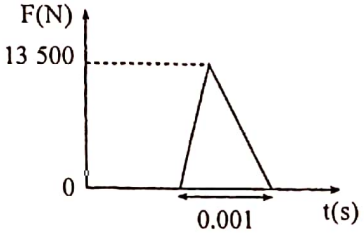
30. Two light rods of initial lengths l_1 and l_2, having equal areas of cross-section are joined end to end, and a force F is applied as shown in the figure.



If the respective Young's moduli of the materials of rods are E_1 and E_2, (see figure) then they will con tract by the same amount when

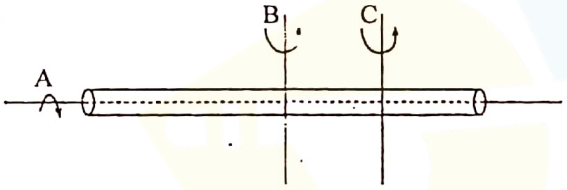
(1) $E_2l_1 = E_1l_2$ (2) $E_2l_2 = E_1l_1$ (3) $E_1^2l_2 = E_2^2l_1$
(4) $E_1l_2^2 = E_2l_1^2$ (5) $E_1^2l_1 = E_2^2l_2$

31. A cricket ball of mass 0.15kg travels with a speed of 20 ms^{-1} just before batted by a batsman. When he batted, the variation of the force (F) exerted by the bat on the ball with time (t) is shown in the graph. If the ball bounces back in the opposite direction the speed of the cricket ball just after batting is



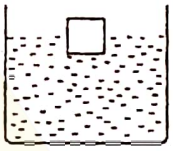
(1) 20ms-1 (2) 25 ms-1 (3) 65ms-1
(4) 70 ms-1 (5) 110ms-1

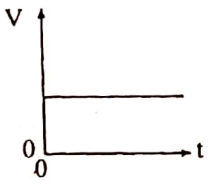
32. If the moments of inertia of an uniform cylindrical rod about the axes A, B and C shown are I_A, I_B and I_C respectively, then



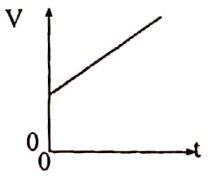
(1) $I_A > I_B > I_C$ (2) $I_A < I_B < I_C$ (3) $I_B = I_C > I_A$
(4) $I_A = I_B = I_C$ (5) $I_B > I_C > I_A$

33. A cube of wood is floating in a beaker of water as shown in the figure. At time t = 0, the beaker begins to move in the downward direction from rest with a constant acceleration. The variation of the volume V of the portion of the cube that is immersed in water, with time t is best represented by

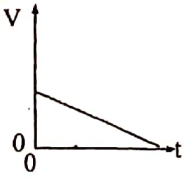




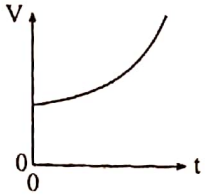
(1)



(2)



(3)



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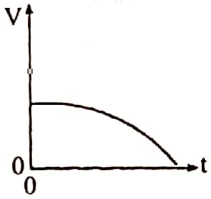
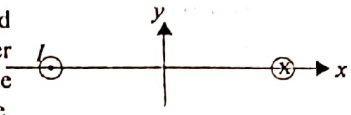
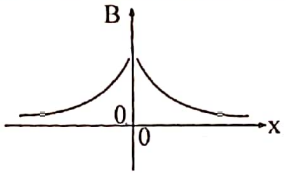


(5)

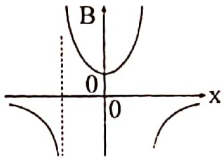
34. Two long parallel wires placed normal to the plane of the paper carry equal currents in opposite directions as shown in the figure.



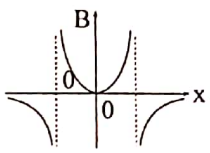
The variation of the component of the magnetic flux density in y direction (B) along the x axis is best represented by



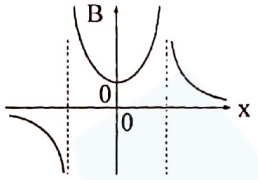
(1)



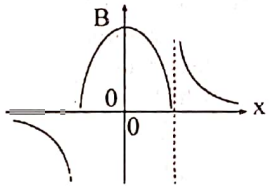
(2)



(3)



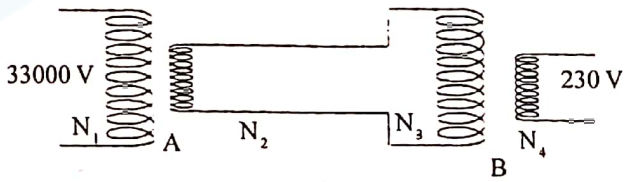
(4)



(5)

35. Sensitivity of a potentiometer can be increased by
(1) increasing the e.m.f. of the call connected across the wire.
(2) reducing the resistivity of the wire.
(3) connecting a resistance in series with the wire.
(4) reducing the diameter of the wire.
(5) maintaining the temperature of the wire at room temperature.

36. The figure shows two transformers A and B connected to power lines. The primary coil of A is connected to a voltage of 33000V ac and the secondary coil of B provides a voltage of 230V ac for domestic use. Transformer A has N_1 and N_2 turns in its primary and secondary respectively. Transformer B has N_3 and N_4 turns in its primary and secondary respectively.



If the power losses in the system are neglected, which of the following is true?

(1) $\frac{N_1}{N_4} = \frac{33000}{230}$ (2) $\frac{N_4}{N_1} = \frac{33000}{230}$ (3) $\frac{N_1N_3}{N_2N_4} = \frac{33000}{230}$

(4) $\frac{N_2N_4}{N_1N_3} = \frac{33000}{230}$ (5) $\frac{N_1N_4}{N_2N_3} = \frac{33000}{230}$

37. A fish in a lake releases an air bubble of volume $2.5 \times 10^{-7} m^3$. This bubble subsequently releases a volume of $10^{-6} m^3$ air into the atmosphere. If the atmospheric pressure is 10^5 Pa and the density of water is 10^3 kg m^{-3}, depth of the position of the fish is, (neglect the effects of surface tension)

(1) 30m (2) 40m (3)50m
(4) 60m (5) 80m

38. Air is rapidly pumped into a tyre by a bicycle pump. Which of the following is true for air **inside the pump** during the pumping process? (Here all the symbols have their usual meaning)

	ΔQ	ΔW	ΔU
(1)	0	negative	positive
(2)	positive	positive	positive
(3)	0	positive	negative
(4)	0	positive	positive
(5)	negative	negative	positive

39. An electric kettle requires 0.2k Wh to raise temperature of 2kg of water from 28 °C to the boiling point of 100°C. If the specific heat capacity of water is 4200J kg^{-1} K^{-1}, the efficiency with which the kettle works is

(1) 42% (2) 54% (3) 60%
(4) 72% (5) 84%

40. The variation of temperature (θ) with time (t) for two liquids P and Q of equal masses heated in identical manner are shown in the figure.

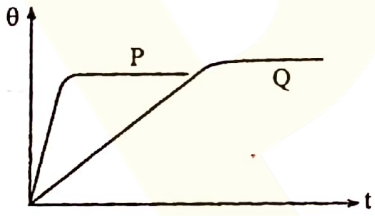
Consider the following statements.

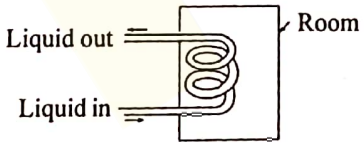
(A) Liquid Q is a better thermometric liquid than P to measure temperature variations in small quantities of liquids.

(B) Liquid Q is mors suitable than P to construct a constant temperature liquid bath.

(C) Liquid Q is better than liquid P for heating air in an enclosed room by sending through a spiralled pipe as shown.

Of the above statements

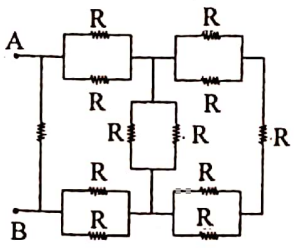




(1) only (A) is true.
(2) only (B) is true.
(3) only (A) and (B) are true.
(4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

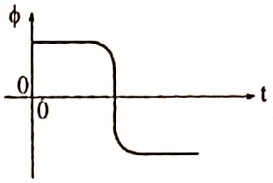
41. The equivalent resistance across points A and B of the resistor network shown is

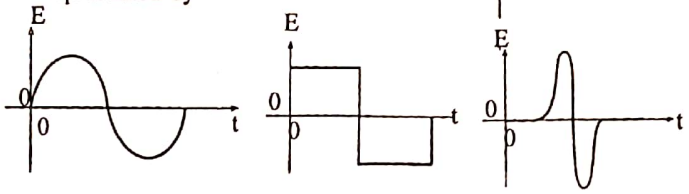
(1) $\frac{1}{3}$R (2) $\frac{1}{2}$R
(3) $\frac{7}{12}$R (4) $\frac{3}{4}$R
(5) R



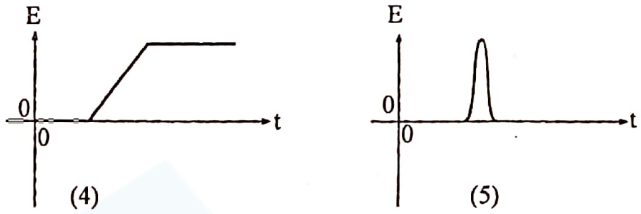
42. The graph shown the variation of a magnetic flux (ϕ) through a coil with time (t).

The variation of the corresponding induced e.m.f. (E) with time (t) is best represented by



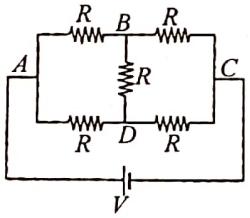


(1) (2) (3)



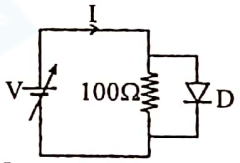
(4) (5)

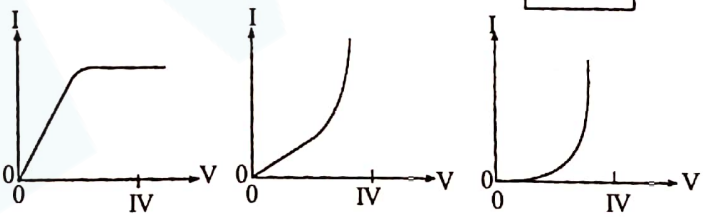
43. The respective effective resistances **'seen by'** the voltage source V across AC and BD are



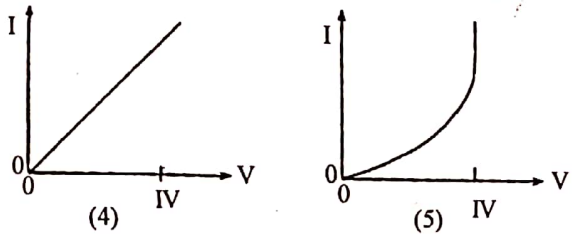
(1) $\frac{5R}{2}$ and R (2) R and 0
(3) $\frac{5R}{2}$ and ∞ (4) R and 3R (5) R and ∞

44. In the circuit shown, D is a silicon diode. The voltage source provides a variable voltage V. Which of the following curves best represents the variation of I with V?



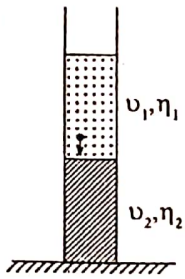


(1) (2) (3)



(4) (5)

45. A small sphere falls through two columns of immiscible liquids in a deep container as shown in the figure. If η_1 and η_2 are the viscosities of the two liquids, and υ_1 and υ_2 are the crresponding terminal velocities of the sphere respectively, then

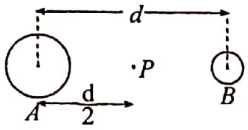


(1) $\eta_1\upsilon_1 = \eta_2\upsilon_2$ (2) $\eta_1\upsilon_1 > \eta_2\upsilon_2$ (3) $\eta_1\upsilon_1 < \eta_2\upsilon_2$
(4) $\eta_1\upsilon_2 > \eta_2\upsilon_1$ (5) $\eta_1\upsilon_2 = \eta_2\upsilon_1$

46. A and B are two conducting spheres having radii R and $\frac{R}{2}$, respectively, and each carrying a charge $+Q$. When the two spheres are separated by a distance d (>> R), as shown in the figure, the electric potential at point P is V_0. When these two spheres are connected using a very thin metal wire, the electric potential at P will become

(1) zero. (2) $\frac{V_0}{2}$ (3) $\frac{3V_0}{4}$

(4) V_0 (5) $2V_0$



47. A particle having an electric charge is travelling along a circular path under the influence of a uniform magnetic field. Consider the following statements.

(A) Direction of the velocity of the particle is always perpendicular to the direction of the magnetic field.

(B) Time required for the particle to make one revolution is independent of the radius of the circular path.

(C) Speed of the particle is directly proportional to its $\frac{\text{mass}}{\text{charge}}$ ratio.

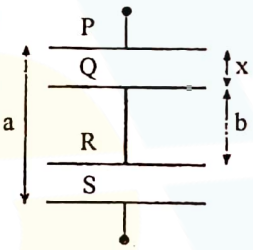
Of the above statements

(1) only (A) is true (2) only (B) and (C) are true

(3) only (A) and (B) are true. (4) only (A) and (C) are true.

(5) all (A), (B) and (C) are true.

48. P, Q, R and S are four parallel conducting plates each of area A, and P and S are fixed plates. Plates Q and R are connected by a rigid conductor as shown in the figure so that they could be moved up and down together. The equivalent capacitance of the sys tem is given by



(1) $\frac{\varepsilon_0 A}{\alpha}$ (2) $\frac{\varepsilon_0 A}{\alpha - x}$ (3) $\frac{\varepsilon_0 A}{\alpha + b - x}$

(4) $\frac{\varepsilon_0 A}{\alpha + b + x}$ (5) $\frac{\varepsilon_0 A}{\alpha - b}$

49. When a free particle with kinetic energy K and de Broglie wavelength λ enters a certain region its potential energy becomes V. The particle's new de Broglie wavelength is given by

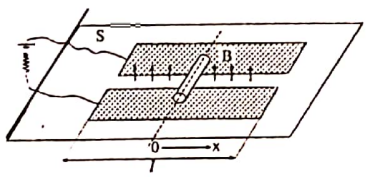
(1) $\lambda\sqrt{\frac{V}{V-K}}$ (2) $\lambda\sqrt{\frac{K}{K-V}}$ (3) $\lambda\left[1+\frac{K}{V}\right]$

(4) $\lambda\left[1-\frac{K}{V}\right]$ (5) $\lambda\sqrt{\frac{K}{V+K}}$

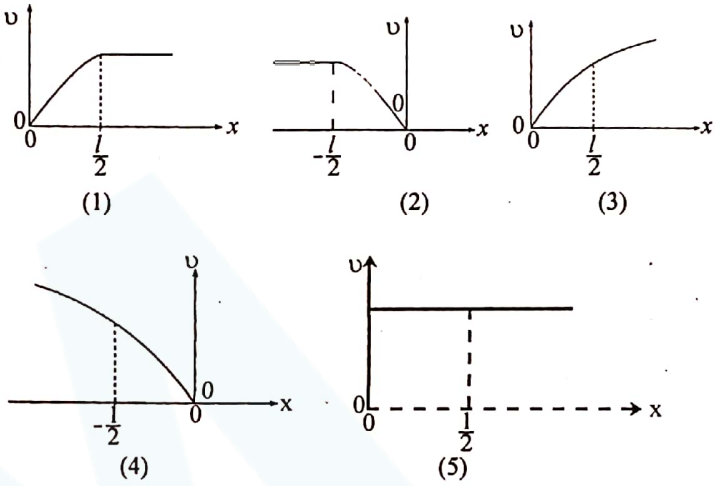
50. Two empty boxes of volumes 0.1 m^3 and 0.3m^3 filled with air at room temperature of 30°C are sealed and stored in a refrigerator. A packet of moisture absorbing silica gel has been inserted into the 0.3m^3 box just before sealing. Later it was found that the relative humidity of air inside the small box reached 100% at 15°C and relative humidity of air inside the large box reached the 100% at 5°C. If the absolute humidities of air at the dew points of 5°C and 15°C are 6.8gm^{-3} and 12.7gm^{-3} respectively, then the amount of water vapour absorbed by the gel is

(1) 1.77g (2) 2.04g (3) 3.81g (4) 6.80g (5) 12.70g

51. The diagram shows two thin smooth strips of aluminium of length l pasted on a flat smooth horizontal wooden surface S. Strips are connected to a battery at one end. A uniform upward magnetic



field is setup, perpendicular to the surface, throughout the region between the aluminium strips. When a steel rod is placed on the two aluminium strips as shown, the rod starts to move. The variation of the velocity (υ) of the rod with distance along the x axis is best represented by



52. A 110 W immersion heater is placed in a metal container of teat capacity 200JK^{-1}, containing 1kg of water. It is found that although the heater is kept switched on for a long time the temperature of water rises **only** upto 90°C. The temperature of water 10s after turning off the heater, is closest to, (specific heat capacity of water = 4200 J kg^{-1} K^{-1})

(1) 89.50 °C (2) 89.68 °C (3) 89.70 °C

(4) 89.73 °C (5) 89.75 °C

53. An artillery gun is positioned on a horizontal ground and an artillery shell is fired from it so that the shell would land at a target, which is located at a distance 2000m from the position of the gun. Accidentally, the shell explodes into two pieces A and B at a certain point of its trajectory. The mass of A is twice that of B, and both pieces land at the **same moment,** after travelling in the same vertical plane. If A lands at a distance 1800 m in the direction of the target from the gun, the distance to the landing point of B from the gun is

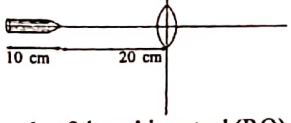
(1) 1600m (2) 2200m (3) 2400m

(4) 2600m (5) 2800m

54. A 10 cm long pencil is placed along the optical axis of a convex lens as shown in the figure. If the length of the image of the pencil is also 10cm, the value of the focal length of the lens is

(1) 4cm (2) 8cm (3) 10cm

(4) 12cm (5) 20cm



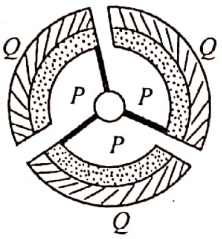
55. The wheel shown in the figure is made of three bi-meteal (P,Q) strips attached to the axis using radial metal parts. This can be setup to oscillate about an axis perpendicular to the plane of the wheel and passing through the centre. The wheel is designed

such that the oscillating period of the wheel remains the same regardless of the changes of the surrounding temperature. Consider the following statements,

(A) The moment of inertia of the wheel should not change with the temperature.

(B) The shape of the wheel should not change with temperature.

(C) The linear expansivily of metal P should be greater than that of *Q*.



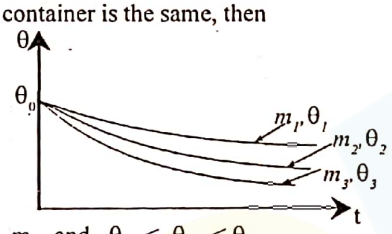
Of the above statements,

(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

56. Three masses m_1, m_2 and m_3 of hot water at temperatures θ_1, θ_2 and θ_3 respectively are added to three identical containers each having mass m of water to achieve the same final temperature θ_0. Then the containers are allowed to cool. The cooling curves for the three containers are shown in the figure. If the rate of loss of heat form each container is the same, then



(1) $m_1 < m_2 < m_3$ and $\theta_1 < \theta_2 < \theta_3$

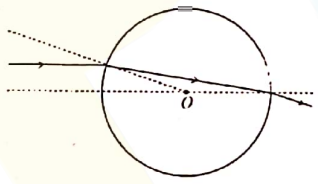
(2) $m_1 < m_2 < m_3$ and $\theta_1 > \theta_2 > \theta_3$

(3) $m_1 > m_2 > m_3$ and $\theta_1 < \theta_2 < \theta_3$

(4) $m_1 > m_2 > m_3$ and $\theta_1 > \theta_2 > \theta_3$

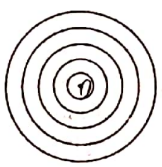
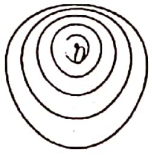
(5) $m_1 = m_2 = m_3$ and $\theta_1 = \theta_2 = \theta_3$

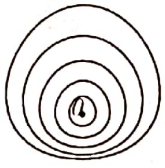
57. A monochromatic ray of light is incident close and parallel to a diameter of a transparent plastic sphere with centre *O* and refracted as shown in the figure. The refractive index of the plastic is closest to (take $\sin\theta \approx \theta$ for small θ angles)



(1) 1.2 (2) 1.3 (3) 1.5 (4) 2.0 (5) 2.5

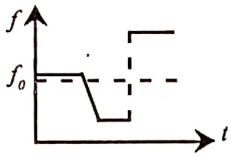
58. A source of sound is located at a point *O* above the earth surface. In the daytime, the air temperature decreases gradually when moving upwards from the earth surface. Which of the following figures best represents the way in which the wave fronts of the sound emitted from the source are propagated?

(1)  (2)  (3) 

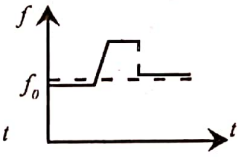
(4)  (5) 

59. 

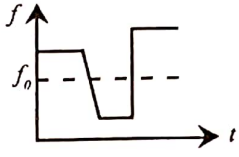
Two cars are moving along a road at constant speeds as shown in the figure. The driver of *A* is sounding the horn of his car of frequency f_0 continuously. Initially the car *B* is moving faster than *A*. Suddenly B slows down and stops. *A* continues to move at the same speed B which is stopped. The graph that best represents the variation of frequency (*f*) of sound heard by the driver of *B* with time (*t*) is



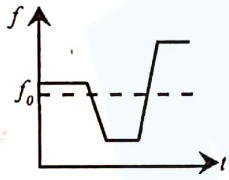
(1)



(2)



(3)



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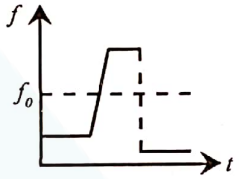
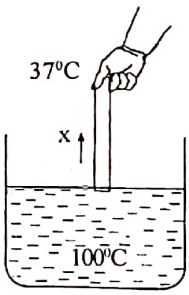
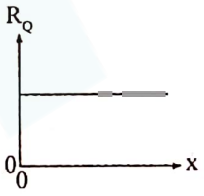


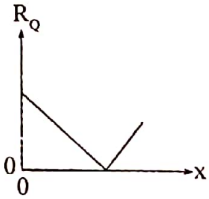
(5)

60. A metal rod is initially at 0 °C. New one end of this rod is immersed in boiling water and the other end is held by fingers as shown in the figure. The temperature of the fingers is 37 °C. Which of the following curve correctly represents the variation of the rate of flow of heat (P_Q) along the rod with *x* at a certain instant?

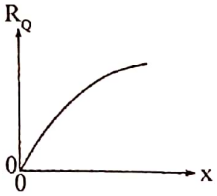




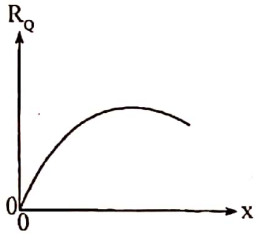
(1)



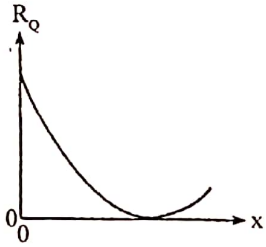
(2)



(3)



(4)



(5)

G.C.E. (Advanced Level) Examination - August 2010

PHYSICS - II

Three hours

Answer all four questions. **PART A - Structured Essay** [$g = 10\ N\ kg^{-1}$]

01. A student has designed an experiment to find out the spring constant k of a spring attached to a ball launcher. He placed the ball launcher in a horizontal table and connected it to a frictionless curved ramp as shown in figure 1.

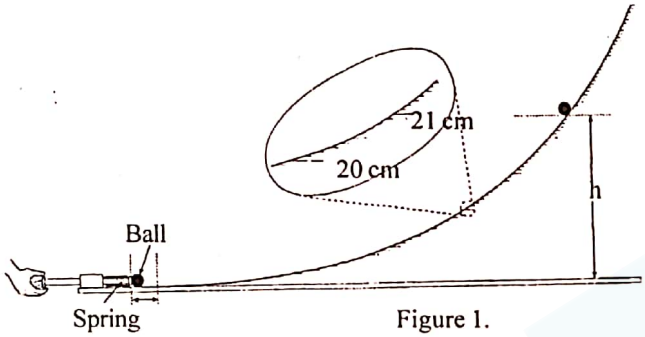


Figure 1.

The student compressed the spring by a distance x from ist natural length and placed a ball of mass M as shown in the figure. He subsequently ejected the ball by releasing the spring so that the ball climbs along the ramp to a maximum vertical height h without tolling.

To measure the vertical height h, student has used a properly calibrated scale marked along the ramp as shown in the figure.

(a) Write down the least count of the scale marked on the ramp.

.....

(b) When the spring is compressed by a distance x, write down an expression for the stored energy (E) in the spring in terms of k and x.

.....

(c) Write down an expression for the gravitational potential energy (U) that the ball will gain when it reached the height h after the spring is released.

.....

(d) Using your expressions in (b) and (c) obtain an expression for the height h, in terms of M, x, k and acceleration due to gravity g. (Assume that the entire stored energy in the spring is transferred to the ball.)

.....

.....

(e) Name the principle that you have used to obtain the expression in (d).

.....

(f) To find the spring constant k, the student has plotted a graph of h vs x2 as shown in figure 2.

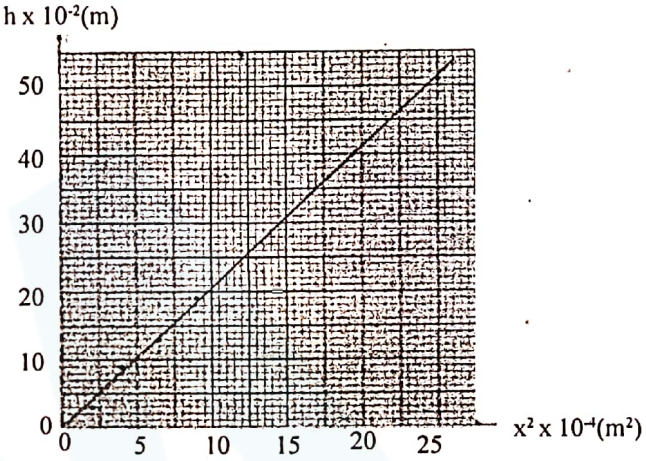


Figure 2.

(i) The teacher says that the graph is unsatisfactory. Why do you think it is unsatisfactory?

.....

.....

(ii) What measure would you take in this experiment to improve the graph?

.....

.....

(g) If the gradient obtained from the improved graph is 200m-1 and the value of M is 0.125kg find the spring constant k.

.....

.....

.....

(h) In this experiment the student measures the compression x and the corresponding height h. Which one of these tow measurements has to be taken more accurately than the other?What is the reason for this?

.....

.....

02. The variation of saturated vapour pressure of water with temperature can be investigated using a narrow glass tube with one end closed, and having a column of air trapped between the closed end and a thread of water.

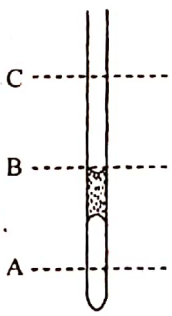


Figure 1.

(a) In this experiment, the tube is mounted in a beaker of water. Figure 1 shows **three** possible positions A, B and C for the water level of the beaker.

(i) Which one of these should be the correct position at the begining of the experiment?

.....

(ii) Give the reason for your choice.

.....

.....

(b) An incomplete diagram of the expeimental setup is shown is figure 2. Complete the diagram and label the items inside the beaker.

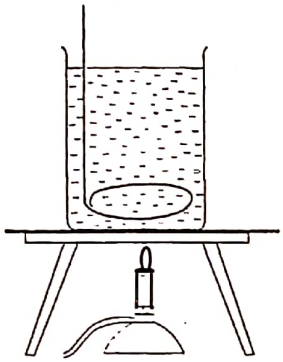


Figure 2

(c) Write down the measurements that you would take after properly setting up the apparatus.

.....

.....

(d) A student carried out this experiment with an air column of length 3cm at 27^{0}C temperature and 100 kPa atmospheric pressure. Saturated vapour pressure of water at 27 ^{0}C is 5 kPa.

(i) Using the above data, obtain an equation relating the length of the air column l (cm) and the saturated vapour pressure of water p (kPa) at temperature θ (^{0}C). (Assume that the pressure due to the water thread is negligible.)

.....

.....

.....

(ii) Assuming that the water thread was 1cm long, calculate the pressure exerted by the water thread and show that its effect on the results of the experiment is negligible.

(Density of water = 10^3 kg m^{-3})

.....

.....

.....

(e) Another student did this experiment with the same apparetus, but used a small volume of mercury and a small water thread to trap air as shown in figure 3.

When this student plotted the measured length l of the air column with temperature θ, he obtained a curve with the shape shown in figure 4.

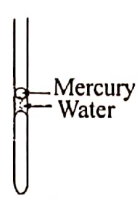


Figure 3

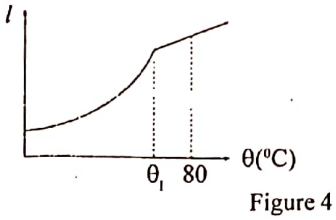


Figure 4

What could be the reason for the change in shape of the graph at θ_1?

.....

.....

03.

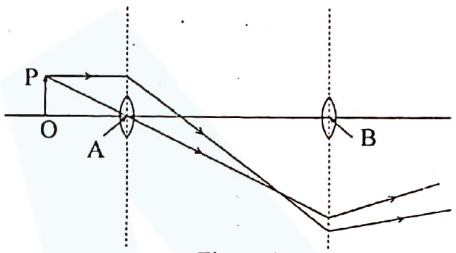


Figure 1

Figure 1 shows the paths of two rays from the object *OP* placed in front of a compound microcope at normal adjustment. The least distance of distinct vision of the observer is 25cm.

(a) Draw the image formed by the objective lens on the diagram and label it as *O'P'*

(b) Draw the final image formed by the microscope and label it as *O'' P''*.

(c) (i) Mark the location (f_1) of the focus of the objective lens on the object side.

(ii) What is the reason for selecting the object distance in such a way as shown is the figure?

.....

.....

(d) Assume that the eye is kept very close to the eyepiece. The focal length of the eyepiece is 5 cm.

(i) What should be the distance to the final image From the eyepiece (*BO''*)?

.....

(ii) Calculate the pbject distance (*BO'*) to the eyepiece.

.....

.....

.....

(iii) A student argues that, if the eyepiece is moved together with the eye towards *O'P'* the final image should be closer to the observer and larger. But the student says that when he does that, the image gets blurred.

(1) Why does the image get blurred?

.....

.....

(2) Is the student's argument correct?

.....

(e) Give a reason for selecting an objective lens of short focal length in the compound microscope.

.....

.....

(f) Figure 2 shows the way a square ruled paper can be seen when a **simple microscope** is placed close to it. What is the magnifying power of the lens?

.....

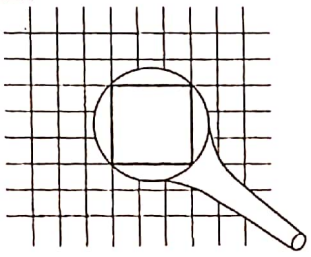


Figure 2

04. You are asked to investigate the cariation of the resistance of a coil of a metal wire with temperature, and to determine the temperature coefficient of resistance. The coil is formed by winding the wire on a wooden rod in such a way that no two turns touch each other. A Wheatstone bridge is to be used to measure the resistance of the coil.

(a) Resistance of the wire at a given temperature is given by the equation

$R_\theta = R_0 (1 + \alpha\theta)$

All the symbols have their usual meaning. Identify all the symbols.

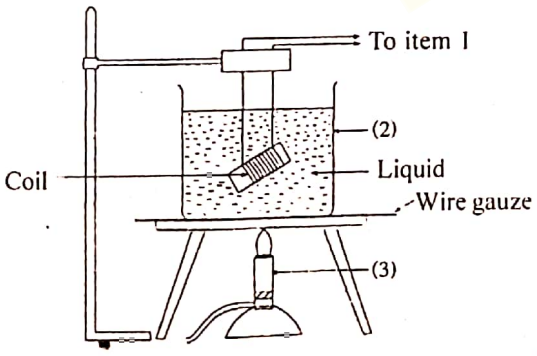
R_θ ≡ .....

R_0 ≡ .....

α ≡ .....

θ ≡ .....

(b) The figure shows a rough sketch of an incomplete setup that can be used for this experiment.



(i) What are the items marked as 1, 2 and 3?

1 .....

2 .....

3. .....

(ii) What is the main purpose of using a wire gauze when heating the liquid?

.....

(iii) Apart from the Wheatstone bridge arrangement and stands, two other items which are not shown in the above figure are necessary to perform this experiment. What are they?

(1) .....

(2) .....

(c) It has been decided to use coconut oil instead of water as the liquid in this experiment. Give **two** scientific reasons for this decision.

(1) .....

(2) .....

(d) A student argues that when using a Wheatstone bridge arrangement a current has to be setup through the coil, and that current may affect the accuracy of the measurements. Would you agree with this argument? (Yes / No)

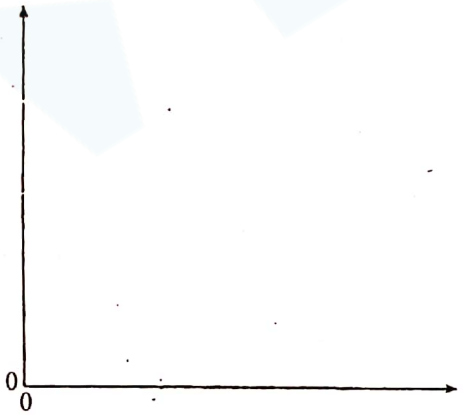
.....

Explain your answre.

.....

.....

(e) Draw a rough sketch of a graph that shown the expected variation of the resistance of the coil with temperature. Label the axes with appropriate symbols identified in (a) above.



(f) Write down an expression for the temperature coefficient of resistance in terms of the quantities that can be **extracted from the graph** above.

.....

.....

PART B

Answer all four questions on this paper itself.

$[g = 10\ N\ kg^{-1}]$

01.

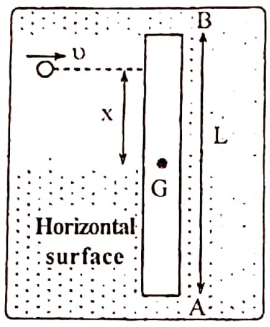


Figure 1

A uniform rod, AB, of square cross section, mass M and length L rests on a horizontal frictionless surface as shown in figure 1. The moment of inertia of the rod about as axis perpendicular to the surface and passing through its centre of gravity, G is I.

The rod is struck by a ball of mass m travelling along the surface without spinning, with a velocity perpendicular to the rod. The motion of the rod due to the impact of the ball can be studied in terms of the linear motion of the centre of gravity of the rod and the rotation about its centre of gravity. Assume that the rod does not topple. After the impact the ball recoils in the opposite direction with the same speed. First consider the linear motion of the rod that occurs due to the impact of the ball.

(a) (i) Write down an expression for the linear momentum of the ball before the impact.

(ii) Considering **only** the linear motion of the rod, obtain an expression for the velocity, V, of the rod after the impact.

(b) Now consider the rotational motion of the rod around its centre of gravity.

(i) If the ball strikes the rod at a distance x from its centre of gravity, write down an expression for the angular momentum of the ball about the centre of gravity of the rod before the impact.

(ii) considering **only** the rotational motion of the rod about its centre of gravity, obtain an expression for the angular velocity, ω of the rod about its centre of gravity after the impact.

(c) (i) Using the expression obtained in (*b*) (*ii*) above, write down an expression for the linear velocity, υ′ of the end A of the rod due to the rotational motion of the rod.

(ii) Are the directions of V and υ′ same or opposite?

(iii) For a certain value x_s of x the end A of the rod remains at rest as the rod begins to move. Derive an expression for x_s.

(d) The moment of inertia, I, of the rod about its centre of gravity is given by

$$I = \frac{1}{12}ML^2$$

If L = 0.6m, determine the value for x_s obtained in (*c*) (iii) above.

(e) Consider a player holding a tennis racket at the end of its handle (see figure 2). When the ball is struck at the special point at distance x_s from the centre of gravity of the racket, no force is produced on the palm of the player and it minimizes the 'sting' the player experiences on the palm. Indicate on your answer script, by drawing an arrow, the direction of the force on the palm experienced by the player when

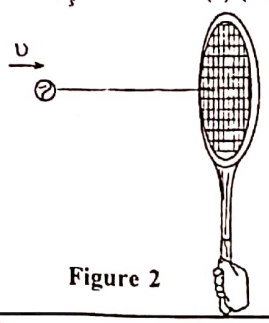


Figure 2

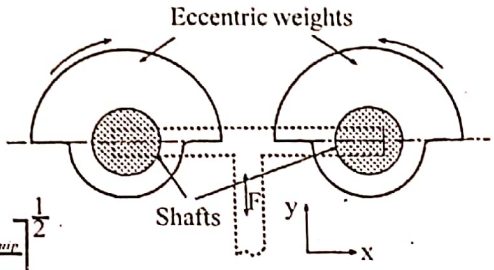
(i) $x > x_s$ (ii) $x < x_s$

02. Read the following passage and answer the questions below.

Activities used in construction such as blasting generate ground vibration. If its amplitudes are sufficiently large, ground vibration has the capability of damaging structures such as buildings, monuments and ruins, cause cosmetic damage such as cracking of plaster, or disrupt the operation of vibration sensitive equipment such as electron microscopes. Pile driving using pile drivers, demolition activity and blasting are some of the primary sources of vibration. Traffic, including heavy trucks traveling on a highways which are in good condition rarely generates vibration amplitudes high enough to cause structural or cosmetic damage. However, there have been cases in which heavy trucks traveling over potholes or other discontinuties on the road have caused vibrations high enough to result in complaints from nearby residents. In describing vibrations in the ground and in structures, the motion of a particle (i.e. a point in or on the ground or structure) is used. The concept of particle displacement, velocity, and acceleration are used to describe how the ground or structure respond to excitation. Although displacement is generally, easier to understand than velocity or acceleration, it is rarely used to describe ground and structureborne vibration because most transducers used to measure vibration directly measure velocity or acceleration, not displacement. Accordingly vibratory motion is commonly described by identifying the peak particle Velocity (*PPV*) or Peak Particle Acceleration (*PPA*). *PPV* is generally accepted as the most appropriate descriptor for evaluating the potential for building damage. To determine human response, however, an average of vibration amplitudes is more appropriate because it takes time for the human body to respond to the excitation (the human body respond to an average of vibration amplitudes, not a peak amplitude.) However as the average particle velocity over time is zero, the root-mean- square (r.m.s.) of the velocity amplitude is typically used to assess human response. Displacement is generally measured in millimeters (mm). Velocity is measured in mm s^{-1}.

One of the methods to assess the potential to damage structures by vibration is to estimate or predict the PPV from various sources at various distances. One such vibratory source is a vibratory pile driver. Pile driving has potential to damage surface and buried structures even at greater distances. Vibratory pile driver is a machine that installs piling into the ground by applying an alternating force. This force is generally generated by a pair of identical eccentric weights rotating about shafts. The figure shows the basic setup for the rotating eccentric weights used in modern vibratory pile equipment. Each rotating weights produces a force acting in a single plane and directed toward the axis of the shaft. However, when a pair of identical eccentric weights are used the resultant force F will act along ty direction.

Vibration amplitudes produced by vibrating pile drivers can be estimated by the following equation.



$$PPV = PPV_{Ref}\left[\frac{10}{D}\right]\left[\frac{E_{Equip}}{E_{Ref}}\right]^{\frac{1}{2}}$$

Where PPV_{Ref} represents PPV value for a reference pile driver at 10m from the driver

D = distance from pile driver to the structure in m.

E_{Equip} = Rated energy of the pile driver;

E_{Ref} = Rated energy of a reference pile driver

To assess the damage potential from ground vibration produced by a vibratory pile driver, the criteria given in following table can be used.

Maximum PPV (mms^{-1})	Structure and condition
2	Extremely fragile historic buildings, ruins, ancient monuments
2.5	Fragile Buildings
6.5	Historic and some old buoldings
7.5	Old residential structures
12.5	New residential structures, Modern industrial buildings

(a) Write down **three** sources of vibrations which can cause damage to historic monuments.

(b) Write down a physical parameter associated with vibrations which causes damage to structures.

(c) Write down **three** structures most vulnerable to ground vibrations.

(d) State a reason why heavy trucks travelling over potholes can cause more damage to structures then heavy trucks travelling in highways which are in good condition.

(e) State the reason for using the velocity to describe ground vibrations instead of displacement.

(f) Draw a rough sketch of a velocity (υa) - tine (t) curve for a particle executing simple harmonic motion and mark its PPV value.

(g) Give a reason for using the average value of the vibration amplitude to describe the human response to vibration.

(h) (i) Direction of the resultant force F created by a rotating pair of identical eccentric weights on the shafts is along the $\pm y$ direction. Give the reason for this.

(ii) Draw a rough sketch to show haw F varies with time (t).

(i) A vibratory pile driver (E_{Ewuip} = 112.5kN) will be operated at 30m from a new office complex and 30m from an ancient monument known to be very fragile. Assess the potential for damage

(i) to the office complex,

(ii) to the ancient monument.

Take PPV_{Ref} = 12.5mm s^{-1} for a reference pile driver at 10m. (E_{Ref} = 50kN)

(j) The pile driver mentioned in (i) above has to be used in a construction of a new building close to an ancient and fragile monument at Polonnaruwa. Calculate the minimum separation that has to be maintained between the monument and the new building.

03. (a) Radii of water droplets in low-lying rain clouds is in the range of 10 μm to 60 μm. Under certain conditions smaller water droplets coalesce to form larger water drops and these water drops are released from clouds as rain. How many water droplets, each having a radius of 10 μm, must coalesce to form a water droplet of radius 40 μm?

(b) When a water drop is falling through air, a drag force is acting on the drop, in addition to the other two forces, weight and the upthrust. Only if the radius of the water droplet is less than 50 μm, the water droplet retains its spherical shape and the drag force is due to the viscosity of air which is given by Stokes' law. Consider a water droplet of radius 40μm, released from a rain cloud located at an altitude of 2 km.

(i) Assuming that the air remains at rest and the upthrust on the water droplet can be neglected, calculate the terminal velocity (υ_t) of the water droplet of radius 40 μm.

(Viscosity of air = 1.6 x 10^{-5} Pa s, Density of water = ρ_w = 10^3 kgm^{-3})

(ii) It has been found that, in general, a water droplet of radius 40 μm would evaporate completely within a period of 600s. As the radius of this droplet decreases due to evaporation, the terminal velocity also decreases, and the mean velocity of the droplet for its entire motion can be considered to be $\frac{\upsilon_t}{2}$. Show that this water droplet will evaporate completely before reaching the ground.

(c) When the radius of the raindrop is larger (greater than about 100μm) the shape of the raindrop tends to deviate appreciably from spherical shape. Now, consider a raindrop which has a vertical length h (> 100μm) and is falling vertically through air at a **constant speed**. Assume that the atmospheric pressure (II) and the density of air remain constant. Take the radius of courvature of the drop as R_1 at the upper end of the drop and R_2 at the lower end.

(i) If the pressure at a point just below the upper end of the water drop is p_1 (> II), write down an expression for (P_1 - II) in terms of R_1 and the surface tension of water (γ).

(ii) What is the pressure at a point just above the lower end of the raindrop? Express your answer in terms of P_1, h, the density of water (ρ_w) a nd acceleration due to gravity g.

(iii) Show that $R_1 > R_2$.

(iv) Calculate the value of (R_1 - R_2) for a raindrop of vertical length h = 4mm. Take R_1R_2 = 4 x 10^{-6} m^2 for this case. surface tension of water is 7.5 x 10^{-2} Nm^{-1}

(d) When the maximum hydrostatic pressure inside the raindrop becomes greater than the pressure difference due to surface tension at the lower surface of the raindrop. the raindrop

becomes unstable and breaks into ... droplets. Assuming $h = 2R_2$, calculate the maximum value of vertical length h_{max} a raindrop can have. Take $\sqrt{7.5} = 2.7$

04. A uniform magnetic field of flux density B exists in a certain region of space. As shown in figure 1 an electron of mass m and charge e is projected with velocity υ perpendicular to the field. The electron moves along a circle of radius R.

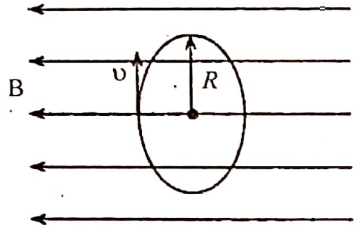


Figure 1

(a) (i) Derive an expression for R.

(ii) Obtain an expression for the number of revolutions, f, per unit time that the electron makes.

(b) When a charged particle like an electron moves along a circle it emits electromagnetic waves with a frequency which is equal to its own frequency, f, of revolution. Microwaves in a microwave oven are produced by allowing electrons to move in circular paths in a magnetic field as described above. The unit which produces microwaves in a microwave oven is known as a magnetron.

(i) A magnetron in a microwave oven emits microwaves with frequency 2450 MHz. Determine the magnetic flux density, B, needed to produce such microwaves. ($m = 9.0 \times 10^{-31}$kg, $e = 1.6 \times 10^{-19}$ C) Round off your answer to the second decimal place.

(ii) Such a uniform magnetic field could be produced inside a current carrying solenoid.

(1) Long, closely wound solenoid with n turns per unit length carries a current I. Write down an expression for the magnetic flux density B in the solenoid along its axis.

(2) For a current of $I = 10$A; what should be the value of n in order to produce B calculated in (b) (i) above. (Take $\mu_0 = 10^{-6}$ T m A^{-1})

(3) Calculate the diameter of the wire used to wind the solenoid.

(4) Sketch the magnetic flux lines in and around such a solenoid.

(c) If the direction of the initial velocity of the projected electron in (a) above makes an angle θ to the direction of the uniform magnetic field, the path of the electron is a helix as shown in figure (2).

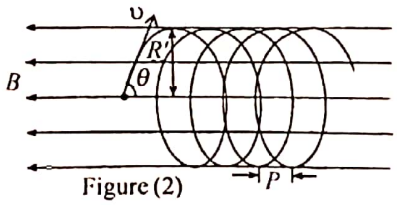


Figure (2)

(i) Build arguments to prove that the path of the electron is a helix.

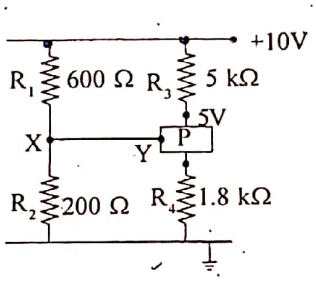
(ii) Deduce an expression for the radius R' of the helical path.

(iii) as shown in the figure the distance travelled by the electron along the axis of the helix per revolution is called the pitch p of the helix. Obtain an expression for p.

(iv) Show that the ratio $\frac{R'}{P}$ depends only on 0.

05. Answer either part (A) or part (B) only.

(A) (a) Write down an expression for the power dissipated by a resistor of resistance R when subjected to a potential difference of V.



(b) The circuit shown is powered by a battery of e.m.f. 10. V. P is a three-terminal element.

[Assume that the internal resistance of the battery is negligible when answering the parts (i), (ii) and (iii)].

(i) Calculate the power dissipated by the resistors R_1, R_2, R_3 and R_4 separately. Give your answers to the nearest integer in mW. Assume that the current through the path XY is negligible.

(ii) Resistors are available with different power ratings, and the price of resistors go up with the power rating value. Some of the standard ratings for resistors are 0.125W, 0.25W, 0.5W, 1W, 2w, etc Considering the above information indicate suitable power ratings for R_1, R_2, R_3 and R_4.

(iii) Find the total power consumed by the circuit. You may assume P also as a purely resistive element.

(iv) If the entire circuit is constructed in IC form in a small piece of silicon of mass 0.9 mg and there is no heat dissipation to surroundings, find the temperature of the circuit 5 minutes after connecting the power supply. Take the room temperature as 30°C. Specific heat capacity of silicon is 600 J kg^{-1} K^{-1}.

(v) When 5 such circuits are connected to a battery of e.m.f. 10V it is found that the terminal voltage drops to 9.9 V. Calculate the internal resistance of the battery.

05. (B) (a) In the circuit shown in figure 1, A and B are two identical light dependent resistors (LDR). The resistance of each LDR at complete darkness is 50MΩ. The operational amplifier has saturation voltages of ±5V and an open loop voltage gain of 10^5.

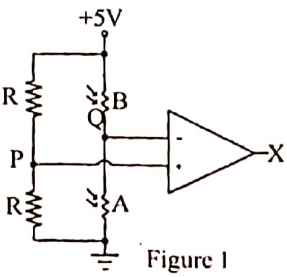


Figure 1

(i) Calculate the minimum voltage difference between P and Q that would saturate the operational amplifier at +5V

(ii) What would be the voltage V_x at X when both LDRs are at complete darkness?

(iii) When both LDRs are in a place where the ambient light level causes the resistance of each LDR to drop to 200Ω, what would be the value of V_x?

(iv) When both LDRs are kept in the place mentioned in (iii) above, light from a small light source is allowed to fall on A only. This reduces the resistance of A to 50Ω. Calculate the new V_x value.

(v) If this circuit is used for detecting an external light source, is there an advantage of using an *LDR* for *B*, without using of a fixed resistor? Explain the reason for your answer.

(b) Figure 2 shows three different positions of an opaque piece of cardboard with a hole, placed near the two LDRs. S is a light source. The cardboard is moved slowly at a constant speed starting from position

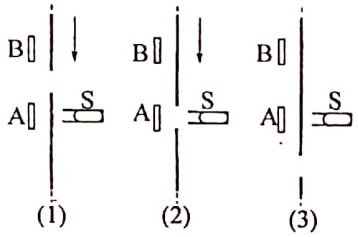


Figure 2

(1) until it reaches position (3) via position (2). The resistance of A when it receives light through the hole is 50Ω. At other positions, due to ambient light, its resistance is 200Ω. Resistance of B remains at 200Ω in all positions.

(i) Sketch the variation of V_x with time (t), when the cardboard is moving.

(ii) Sketch the variation of the V_x with time (t), when the speed of the cardboard is doubled.

(c) An 'optical encoder' which is used to determine the position of a moving part of a device such as a robot is based on the above principle. Figure 3 shows a robot arm that moves back and forth and a metal plate with two rows of holes, attached to it. The metal plate is moving between light sources and LDRs as shown in the figure. The two LDRs *B* and *B'* (not shown in the figure) are kept away from the light sources and they only receive the same ambient light as A and A'. The two LDRs *A* and *B* are connected to the circuit shown in figure 1 while LDRs *A'* and *B'* connected to another identical circuit which has output *Y*. Assume that one of the four section (1 -4) of the metal plate is always between the LDRs and the light sources.

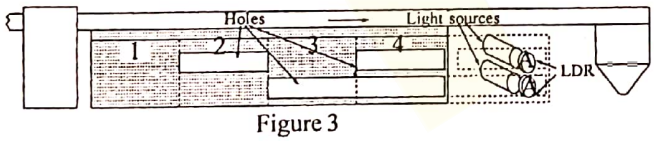


Figure 3

(i) Assuming that the light levels received by the LDRs are identical to those mentioned in part (*b*) above, draw a rough sketch of a graph to show the variations of voltage at the outputs *X* and *Y* with time (t) when the metal plate is moving from section 4 to section 1 at a constant speed past *A* and *A'*. Draw the variation of *Y* underneath that of *X* on the same time axis.

(ii) If the outputs of *X* and *Y* are interpreted as logic signals, write down the binary numbers obtained from *X* and *Y*, when each of the four sections of the metal plate are facing *A* and *A'*.

06. Answer either part (A) or part (B) only.

(A) A helium filled gas balloon, which carries an instrument, has been placed at a certain altitude of the earth surface fora research purpose. The atmospheric conditions at the said altitude are as follows.

Temperature (T) = 240 K, the pressure (P) = 420 Pa and density (ρ_A) = 58.4×10^{-4} kg m^{-3}.

Assume that the pressure inside and outside the balloon are the same. Derive any formulae you may use, starting from the equation of state for an ideal gas, when answering the following questions. Assume that helium behaves as an ideal gas.

(a) Calculate the density of the helium gas inside the balloon. Mass of a helium atom is 6.64×10^{-27} kg Avogadro number $N_A = 6 \times 10^{23}$ mol^{-1} and universal gas constant $R = 8.3$ JK^{-1} mol^{-1}

(b) If V_B is the volume of he balloon and P is the density of the helium inside the balloon at the said altitude, show that, to keep the balloon at the altitude

$$V_B = \frac{M}{\rho_A - \rho}$$ where M is the total mass of the empty balloon and instrument.

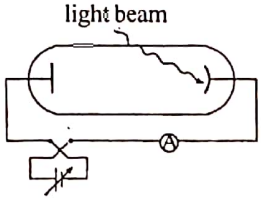
(c) If M is 10kg using (*a*) and (*b*) calculate the volume of the balloon V_B.

(d) Also determine the number of helium atoms inside the balloon.

(e) Calculate the volume of the balloon before it is released from the earth surface. The atmospheric pressure and temperature of the earth surface are 10^5 Pa and 300K respectively.

(f) If the atmospheric temperature at the said altitude decreases, what effect would you expect on the balloon's altitude? Explain your answer.

06. (B) The apparatus shown in the figure can be used to compare the intensities of the radiation corresponding to colours of green (frequency $f_G = 5.6 \times 10^{14}$ Hz) and violet (frequency $f_V = 7.2 \times 10^{14}$Hz) in the electromagnetic spectrum of the Sun, incident on the Earth. The two monochromatic light beams corresponding to the two frequencies are frequencies are obtained using filters. Each beam has a cross-sectional area of 5×10^{-5} m^2 and is allowed to incident normally on the photocathode, one beam at a time.



(a) (i) When the beam of violet light was incident on the photocathode, the stopping potential was found to be 0.05 V. Calculate the work function of the photocathode material. Take Planck's constant h = 6.6×10^{-34} Js and the magnitude of the electronic charge, e = 1.6×10^{-19}C.

(ii) Show that there will be no current in the circuit when green light is incident on the photocathode described in (*a*) (*i*) above.

(b) (i) Three other photocathodes A, B and C made of materials with work functions 3.4×10^{-19}J, 5.1×10^{-19}J, and 7.2×10^{-19}J, respectively, are available. If it is desirable to use only one photocathode to compare both green and violet light beams, which photocathode must be selected? Give reasons for your choice.

(ii) For the photocathode you selected in (b) (i) above, which colour produces photoelectrons with higher maximum kinetic energy? Calculate that value of maximum kinetic energy of photoelectrons.

(c) When photons are incident on the photocathode, only a part of the incident photons contributes for the emission of photoelectrons. Assume that only 10% and 15% of incident photons emit photoelectrons for green light and violet light, respectively.

(i) The maximum currents observed in the circuit for green and violet light beams are 400μA and 240μA, respectively. Taking N_G and N_V to be the number of photons incident on the photocathode per second for green and violet colours, respectively, calculate the ratio $\frac{N_G}{N_V}$.

(ii) Draw a sketch to indicate the variation of photoelectric current (I) with the applied potential difference (V), For both green colour and violet colour light, in the same graph.

(iii) The average value of the energy of the solar radiation incident per unit time per unit area on the surface of the Earth is 1200Wm^{-2} during the day time. Calculate the percentage of this energy which is due to the photons corresponding to green colour.

G.C.E. (Advanced Level) Examination - August 2010

PHYSICS - I

Provisional Scheme of Marking

2010 - Answers

01	✗	2	3	4	5	21	1	2	3	✗	5	41	1	2	✗	4	5
02	1	2	3	✗	5	22	✗	2	3	4	5	42	1	2	3	4	✗
03	1	✗	3	4	5	23	1	2	3	✗	5	43	1	2	3	4	✗
04	1	2	3	4	✗	24	1	2	✗	4	5	44	1	✗	3	4	5
05	1	2	3	✗	5	25	✗	2	3	4	5	45	1	✗	3	4	5
06	1	✗	3	4	5	26	1	2	3	✗	5	46	1	2	3	✗	5
07	1	2	✗	4	5	27	1	2	✗	4	5	47	1	2	✗	4	5
08	1	2	3	4	✗	28	✗	2	3	4	5	48	1	2	3	4	✗
09	1	2	✗	4	5	29	✗	2	3	4	5	49	1	✗	3	4	5
10	1	✗	3	4	5	30	✗	2	3	4	5	50	✗	2	3	4	5
11	1	2	3	✗	5	31	1	✗	3	4	5	51	1	✗	3	4	5
12	✗	2	3	4	5	32	1	✗	3	4	5	52	1	2	3	4	✗
13	1	✗	3	4	5	33	✗	2	3	4	5	53	1	2	✗	4	5
14	1	2	3	4	✗	34	1	✗	3	4	5	54	1	2	3	✗	5
15	✗	2	3	4	5	35	1	2	✗	4	5	55	✗	2	3	4	5
16	1	2	3	4	✗	36	1	2	✗	4	5	56	1	2	✗	4	5
17	1	2	3	✗	5	37	✗	2	3	4	5	57	1	2	3	✗	5
18	1	2	3	4	✗	38	✗	2	3	4	5	58	1	2	✗	4	5
19	1	2	3	✗	5	39	1	2	3	4	✗	59	1	2	3	4	✗
20	1	2	✗	4	5	40	1	2	3	✗	5	60	1	2	3	4	✗

G.C.E. (Advanced Level) Examination - August 2010

PHYSICS - II

Provisional Scheme of Marking

A - PART

(1) (a) 0.1 cm OR 1 mm 01

(b) $E = \frac{1}{2} kx^2$ 01

(c) $U = Mgh$ 01

(d) $\frac{1}{2} kx^2 = Mgh$

$h = \left(\frac{K}{2Mg}\right) x^2$ 01

(e) conservation of (Mechanical) energy 01

(f) (i) Data Point are not spread out uniformly OR Data has not been taken between $x^2 = 9 \times 10^{-4} m^2$ and $x^2 = 25 \times 10^{-4} m^2$ Or Data has not been taken between last two data points OR Data is missing in the middle region. 01

(ii) Need to choose x so that x^2 can spread out uniformly in the entire range. 01

(g) $200 = \frac{K}{2Mg}$

$K = 200 \times 2Mg$

$K = 200 \times 2 \times 0.125 \times 10 Nm^{-1}$

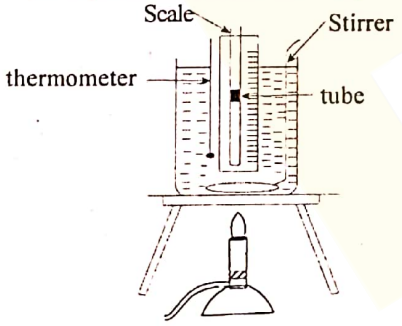
$K = 500 Nm^{-1}$ 01

(h) Mesurement x is smaller than h, OR since x^2 appears in the plot equation x has to be mesured accurately OR to reduce the fractional (percentage) error in x^2 01

02. (a) (i) C 01

(ii) To keep the air volume below the water level throughout the experiment (OR all the time) 01

(b)



(the tube, scale and thermomter, scale must be as shown or very close to the tube, thermometer should be immersed in the water to a reasonable depth) 01

labels (any three) 01

(c) Temperature 01

length of the air column 01

(d) (i) $\frac{P_1 V_1}{T_1} = \frac{P_2 V_1}{T_1}$

$\frac{(100 - P) \times l}{273 + \theta} = \frac{(100 - 5) \times 3}{300}$

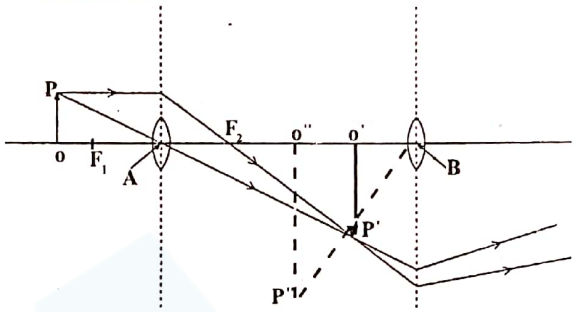
(ii) Pressure due to water thread $= 10^{-2} \times 10^3 \times 10$

$= 10^2 Pa$

This pressure is much smaller than the atmospherlc Pressure ($10^5 pa$)

(e) Water has completely evaporated or Air volume has become unsaturated.

03.



(a) Drawing the image O'P' 01

(b) Drawing the image O" P"

(any two lines should have been drawn in order to determine the position of the image) 01

(c) (i) Making F_1 ($AF_1 = AF_2$) 01

(ii) To form a real image by the objective.

OR The image formed by the objective should fall in between the objective and the eyepiece.

OR The image formed by the objective should be in the right side of the objective.

OR To obtain a higher magnification 01

(d) (i) 25cn OR least distance of distinct vision 01

(ii) $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{25} - \frac{1}{u} = -\frac{1}{5}$

$u = 4.17$ cm [(4.16 - 4.17)cm OR4.2 cm] 01

(iii) The image will be formed behind the retina,

OR The image will not be focused on the retina,

OR The image will not be formed on the retina,

OR The distance from the eye (OR BO") to the final image is less than 25cm 01

2 Argument is incorrect 01

3 (e)The object could be placed near the objective.

or More light from the object will enter the objective.

or The length of the microscope will be small 01

(f) Magnifying power = 3

04. (a) R_0 = Resistance of the at temperature θ

R_0 = Resistance of the at 0°C

α = Temperature Coefficient of resistance

θ = Temperature difference

All four Correct 01

(b) (i) (1) Wheatstone Bridge OR meter bridge

(2) Beaker

(3) Bunsen burner All three correct 01

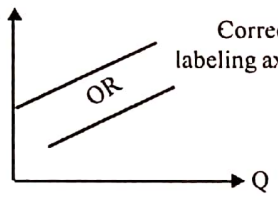
(ii) Provide a uniform temperature throughout the bottom surface OR Provide uniform heating throughout the bottom surface. 01

(iii) (1) thermometer

(2) Stirrer 01

(c) (i) coconut oil has lower electrcial conductivity OR To have a lower electrical conductivity OR
With water the turns of the coil will get short circuited.
(ii) To have a higher Temperature range for the experiment OR Coconut oil has a higher boiling point. 01

(b) yes
Temperature inside the wire can be higher than the measured Temparatune OR
There can be a temperature qradient inside the wire even at the steady state or
The current may heat the wire 01

(e) 

Correct shape 01
labeling axes correctly 01

(f) $x = \frac{\text{gradient}}{\text{intercept}}$ 01

PART B

01. (a) (i) linear momentum of the ball = mV 01
(ii) By Applying $m_1v_1 = m_2 V_2$ (OR Conservation of linear momentum)
$MV = 2m\upsilon$ 01
$V = \frac{2m\upsilon}{M}$ 01

(b) (i) Angular momentum of the ball = $m\upsilon x$ 01
(ii) By Applying Conservation of the Angular momentum
$I\omega = 2mvx$
$\omega = \frac{2mvx}{I}$ 01

(c) (i) linear Velocity at end A
$\upsilon' = L/2\ \omega \qquad [V = r\omega]$ 01
$\upsilon' = \frac{L}{2} \times \frac{2m\upsilon x}{I} \left(\text{Or } \frac{Lm\upsilon x}{I}\right)$ 01

(ii) V and V' are opposite in direction 01
(iii) For the end A to be at rest
$\upsilon' = V.$
$\frac{L}{2} \frac{2m\upsilon x_s}{I} = \frac{2m\upsilon}{M}$ 01
$X_s = \frac{2I}{ML}$ 01

(d) $X_s = \frac{2}{ML} \times \frac{I}{12} ML^2$
$X_s = L/6$ 01
$X_s = 0.1$ m 01

(e) (i) $x > x_s$; the direction of the force ← or ⟵
(ii) $x < x_s$; the direction of the force is → or ⟶

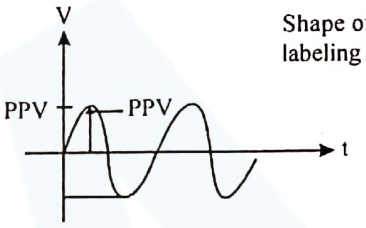
02. (a) Earth quakes
Blasting (Bomb, Blasting of Rocks)
Pile driving with pile drivers
Heavy trucks travelling over potholes or discontinuities
Huge thunders
Demolition any three 01

(b) Amplitude of vibration
Displacement
Velocity OR peak particle velocity, (PPV)
Acceleration (PPA) any one 01

(c) Ruins
historic buildings
Ancient monuments All three 01

(d) Heavy trucks travelling over potholes Produce higher Vibration amplitudes

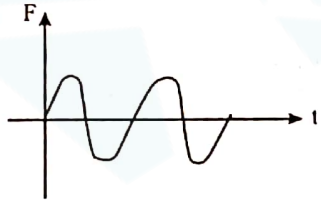
(e) This is because fronsducers measure velocities (and not displacements)

(f) 

Shape of the curve 01
labeling PPV 01

(g) This is because it take s time for the human body to respond to the excitation 01

(h) (i) As the two eccentric weights rotate in opposite directions horizontal components of the two forces cancel off 01

(ii) 

01

(I) (i) $PPV = PPV_{Ref}\left(\frac{10}{D}\right)\left[\frac{E_{EqusP}}{E_{Ref}}\right]^{1/2}$
$= 12.5\left(\frac{10}{30}\right)\left(\frac{112.5}{50}\right)^{1/2}$
$= \frac{12.5}{3} \times 1.5$ 01
$= 6.25\ mms^{-1}$
$(6.17 - 6.25\ mms^{-1})$

(ii) This value is less than 12.5 mms^{-1} and therefore the office complex is safe 01

(ii) The above PPV value is greater than 2mms^{-1} and therefore the ancient monument will be damaged 01

(j) PPVmax for ancient monument is 2mms^{-1}
$D = \frac{12.5 \times 10 \times 1.5}{2}$
$D = 93.75$ m 01

03. (a) if n is the number of smaller droplets
$n \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\therefore n = \left(R/r\right)^3 = \left(\frac{40 \times 10^{-6}}{10 \times 10^{-6}}\right)^3$

$n = 64$ -01

(b) (i) $6\pi a\eta V_t = \frac{4}{3}\pi a^3 \rho_w g$ -01

$V_t = \frac{2a^2\rho_w g}{9\eta}$

$V_t = \frac{2 \times (40 \times 10^{-6})^2 \times 10^3 \times 10}{9 \times 1.6 \times 10^{-5}}$ -01

$V_t = 0.22\ ms^{-1}$
$(0.20 - 0.22\ ms^{-1})$ -01

(ii) Mean Velocity of the Waler drop $\left(Vt/2\right) = \left(\frac{0.22}{2}\right) = 0.11\ ms^{-1}$

Time for the water drop to reach ground ; if it moves with the averge velocity

$= \frac{2000}{0.11}$ S OR $\frac{2000}{0.10}$ S 01

$= 18182$ S.

The time is much greatar than 10 minutes and therefore the water drop would evaporate before reaching qround. 01

Alternative method
Distance traveled during a period of 600s if the water droplet moves with the mean velocity $= 0.11 \times 600m$
$= 0.10 \times 600m$ -01
$= 66$ m.

This distance is much smaller than 2km. and therefore the water drop would evaporate before reaching ground. -01

(c) (i) $P_i - \pi = \frac{2r}{R_1}$ -01

(ii) Pressure at a point just above the lower end of the raindrop $= (p_1 + h\rho_w g)$ -01

(iii) For the lower surface
$(P_1 + h\rho_w g - \pi) = 2\gamma/R_2$ -01

Compar equation (i) and (iii) = $\frac{2\gamma}{R_1} < \frac{2\gamma}{R_2}$

There fore $R_1 > R_2$ -01

(iv) $\frac{2\gamma}{R_2} - \frac{2\gamma}{R_1} = 2\gamma\left(\frac{R_1 - R_2}{R_1 R_2}\right) = h\rho_w g$

$\therefore R_1 - R_2 = \frac{h\rho_w g \times R_1 R_2}{2\gamma}$

$= \frac{(4 \times 10^{-3} \times 10^3 \times 10)(4 \times 10^{-6})}{2 \times 7.5 \times 10^{-2}}$

$= 1.07 \times 10^{-3}$ m $= 1.07$ mm
(1.00 mm - 1.1 mm)

(d) Maximum hydrostatic pressure occurs just above the lower surface of the raindrop and is given by $h\rho_w g$ The drop becomes unstables and breaks into small droplets when $h\rho_w g > \frac{2\gamma}{R_2}$

Therefore the maximum vertical length of a raidrop is given by

$h_{max} = \frac{2\gamma}{\rho_w R_2 g}$ -01

$= \frac{4\gamma}{\rho_w h_{max} g}$

$\therefore h^2_{max} = \frac{4\gamma}{\rho_w g}$

$h^2_{max} = \frac{4 \times 7.5 \times 10^{-2}}{10^4}$ -01

$h_{max} = 2 \times \sqrt{7.5}$ mm $= 2 \times 2.7$ mm

$= 5.4 \times 10^{-3}$m $= 5.4$ mm -01
$= (5.4$ mm - 5.6 mm)

04. (a) (i) $\frac{mV^2}{R} = evB$

$R = \frac{mv}{eB}$

(ii) $f = \frac{v}{2\pi R}$ OR $f = \frac{eB}{2\pi m}$

(b) (i) $B = \frac{2\pi mf}{e}$

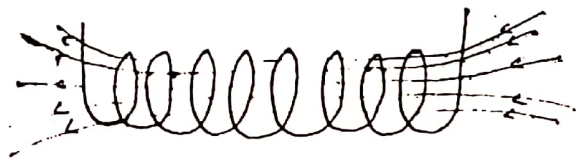
$B = 2 \times \frac{22}{7} \times \frac{2450 \times 10^6 \times 9 \times 10^{-31}}{1.6 \times 10^{-19}}$

$B = 0.09$ T
$(0.0865 - 0.0866)$

(ii) (1) $B = \mu_0 nI$
(2) $0.009 = 10^{-6} \times n \times 10$
$n = 9 \times 10^3\ (865 - 866 \times 10^3)$ turns m^{-1} -01

(3) $d = \frac{1}{9000}$
$d = 1.1 \times 10^{-4}$m (OR 0.11mm)
$[(1.1 - 1.2) \times 10^{-4}$m, $(0.11 - 0.12)$mm]

(4)



-01

(c) (i) Vsinθ Component :-
Magnetic ficld acts only on the velocity Component Perpendicular to the field (Vsinθ) and it makes the electron to travel in Circle 01

Vcos θ component :-
Magnetic field does not act on the velocity Compo nent Parallel to the field (VCoSθ) but it make. the electron to trarel parallel to the field direction 01

(ii) $R^1 = \frac{mv\sin\theta}{eB}$

(iii) Period of revolution $= \frac{2\pi m}{eB}$

(iv) $P = V\cos\theta \cdot \frac{2\pi m}{eB}$ $\left(or\ P = \frac{2\pi R^1}{\tan\theta}\right)$

$\frac{R^1}{P} = \frac{1}{2\pi}\tan\theta$ OR $\frac{R^1}{P} = \frac{\sin\theta}{2\pi\cos\theta}$

Therefore $\frac{R^1}{P}$ ratio depends only θ

05. (A) (a) $P = \frac{V^2}{R}$ 01

(b) (i) $P_{R_1} = \left(\frac{10}{800}\right)^2 \times 600$ OR $\frac{7.5^2}{600}$ 01

$= 0.094$ W OR 94 mW 01

$P_{R_2} = \frac{P_{R_1}}{3}$

$\therefore P_{R_2} = 0.031$ W OR 31mW 01

$P_{R_2} = \left(\frac{10}{800}\right)^2 \times 200$

$P_{R_2} = 0.031$ W OR 31 mW

$P_{R_3} = \frac{V^2}{R}$

$= \frac{25}{5 \times 10^3}$

$= 0.005$W OR5 mW

$P_{R_4} = I^2R$

$= \left(\frac{5}{5 \times 10^3}\right)^2 \times 1.8 \times 10^3$

$= 0.0018$ W

2mW OR 0.002 W 01

(ii) Rating of all resistors should be 0.125W 01

(iii) Power Consumed by the element $P = VI$

$= (5 - 1.8) \times 1 \times 10^{-3}$ 01

$= 3.2$mw OR 0.003W

Total power Consumed by the circuit = 94 + 31 + 5 + 2 + 3 mw

=135 mw OR 0.135W 01

Total current drawn from the power supply $= I = \frac{10}{800} + 0.001$

$= 13.5$ mA OR 0.0135A 01

Power Consumed by the circuit $= VI$

$= 10 \times 13.5 \times 10^{-3}$

$= 135$ mW OR 0.135 W

(134.5 - 135.5)mW 01

(iv) Heat generated by the circuit in 5min

$= 135 \times 10^{-3} \times 5 \times 60$ 01

Heat absorbed by the piece of silicon

$= 0.9 \times 10^{-6} \times 600 \times (\theta - 30)$ 01

$135 \times 10^{-3} \times 5 \times 60 = 0.9 \times 10^{-6} \times 600 \times (\theta - 30)$ 01

(v) Equivalent resistance (r_{eq}) of the circuit = $\frac{V}{I}$

[V - supply voltage, I - current drawn from the supply]

$V_{eq} = \frac{10}{13.5 \times 10^{-3}}$ OR $\frac{10^2}{135 \times 10^{-3}}$

$V_{eq} = 740\ \Omega$

Equivalent resistance when fire such circuits are conneeted in parallel

$= \frac{740}{5}$

$= 148\ \Omega$

$\frac{R_{Eq}}{r} = \frac{9.9}{0.1}$

r is the internal resistance of the bettery

$r = 1.5\Omega$ $(1.4 - 1.5\Omega)$ 01

05. B (a) (i) $V_O = (V_1 - V_2)A$ 01

$V_P - V_Q = 5 \times 10^{-5}$ V

(ii) $V_y = O$

(iii) $V_x = O$

(iv) $V_P = 2.5$ V

$V_Q = 50 \times \frac{5}{250}$

$= 1$ V 01

$V_P - V_Q = 1.5V > 5 \times 10^{-5}$ V 01

Therefore the op amp will saturate at 5v OR

$V_y = 5V$ 01

(v) yes, there is an advantage.

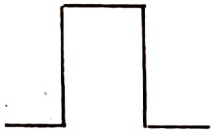
Output of the circuit will be in saturation all the time. Hence it cannot be used to detect (arbitray) light levels.

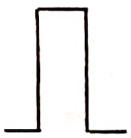
OR

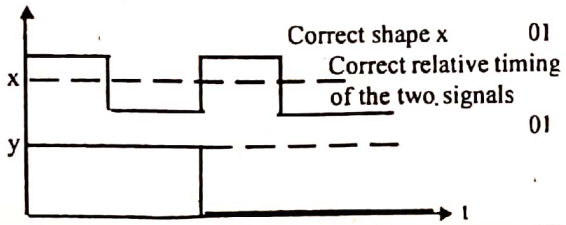
with a fixed resistor, if ambient light level changes, op amp will Saturate even without the external light source.

OR

with an LDR the circuit always compensates for ambi ent light 01

(b) (i)  01

(ii)  01

(c) (i) 

Correct shape x 01

Correct relative timing of the two signals 01

(ii)

	x	y
1	0	0
2	1	0
3	0	1
4	1	1

two correct 01
all correct 02

06(A) (a) $PV = nRT$ 01

$$P = \frac{PN_A m}{RT}$$

$$= \frac{420 \times 6 \times 10^{23} \times 6.64 \times 10^{-27}}{8.3 \times 240}$$

$= 8.4 \times 10^{-4}\ Kgm^{-3}$ 01

(b) $Mg + V_B \rho g = V_B \rho_A g$ 01

$$V_B = \left(\frac{M}{\rho_A - \rho}\right)$$

(c) $$V_B = \left(\frac{10}{58.4 \times 10^{-4} - 8.4 \times 10^{-4}}\right)^{m^3}$$ 01

$= 2 \times 10^3\ m^3$ 01

(d) Namher of the atoms $= \frac{PVN_A}{RT}$ 01

$$= \frac{420 \times 2 \times 10^3 \times 6 \times 10^{23}}{8.3 \times 240}$$ 01

$= 2.5 \times 10^{26}$ 01

(e) Number of the atoms inside the balloon does not change

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{P_EV_E}{T_E} = \frac{PV}{T}$$

$$V_E = \left(\frac{420}{10^5}\right)\left(\frac{300}{240}\right) \times 2 \times 10^3$$

$= 10.5\ m^3$

(f) Balloon will sink
When Temperature decreases and the gas inside the balloon cools down and contracts and cause the balloon to sink
OR
When the temperature decreases and of the effect due to decrease in the volume is larger than that due to the increase in the density of the atmosphere then balloon will sink.

ballon goes up
when the temperature decrease and it the effect due to decrease in the Volume is less than that due to increase in the density of the atmosphere then balloon goes up.
(OR if the above mentioned two effects are equal the balloon will stay stationary.)

6.(B) (a) (i) Work function $= hf - eV_{stop}$ 01

$\varnothing = 6.6 \times 10^{-34} \times 7.2 \times 10^{14} - 1.6 \times 10^{-19} \times 0.05$

$= 4.67 \times 10^{-19}$ J 01

$(4.6 - 4.8 \times 10^{-19}$ J)

(ii) Energy of a Photon of green colour radiation

$= 6.6 \times 10^{-34} \times 5.6 \times 10^{14}$ J 01

$= 3.7 \times 10^{-19}$ J

In order to remove electrons from the surface of the photocathode each incident photon must have energy of at least 4.67×10^{-19}J, But the energy of photons of green colour is 3.7×10^{-19}J. Therefore there will not be any current for green colour. 01

(b) (i) Photocathode A must be selected. It has the work function which is less than the energy of photons of green colour radiation.

(ii) Violet colour produces photoetectrons with maximum kintic ehergy 01

$K_{max} = hf - \varnothing$

$= 6.6 \times 10^{-34} \times 7.2 \times 10^{14} - 3.4 \times 10^{-19}$

$= 1.35 \times 10^{-19}$J 01

(1.3 - 1.4)

(c) (i) number of photoeleetrons emitted per second for

$$\text{green light} = n_G = \frac{i_G}{e} = \frac{400 \times 10^{-6}}{e}$$

where i_G is the current in the circuit for green colour light
Number of photons of green light incident per second on the photocathode

$$n_G = \frac{n_G}{0.1} = \frac{i_G}{0.1e} \quad \text{——— (1)}$$

Similarly, for Photons of violet colour radiation

$$N_V = \frac{n_V}{0.15} = \frac{i_V}{0.15e}$$

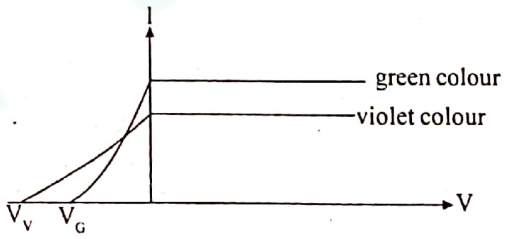
The ratio $\frac{N_G}{N_V} = \left(\frac{0.15}{0.1}\right)\frac{i_G}{i_V}$

$= \frac{3 \times 400}{2 \times 240}$

$= 5/2$

$= 2.5$

(ii)



(iii) let E_G be the energy incident per unit time per unit Area on the earth is surface due to photons of grecn colour light

$$E_a = \left(\frac{hf_G}{A}\right)\left(\frac{N_G}{0.1}\right) \text{OR } E_G = \left(\frac{hf_G}{A}\right)N_G$$

$$= \left(\frac{hf_G}{A}\right)\left(\frac{i_G}{0.1e}\right)$$

A is the cross sectional area of the light beam

$$= \left(\frac{6.6 \times 10^{-34} \times 5.6 \times 10^{14}}{5 \times 10^{-4}}\right)\left(\frac{400 \times 10^{-6}}{0.1 \times 1.6 \times 10^{-19}}\right)$$

$= 184.8\ Wm^{-2}$

Percentage of energy due to green photons $\frac{184.8}{1200} \times 100\%$

$= 15.4\%$ 01

$= (15 - 16\%)$