G. C. E (Advanced Level) Examination, August 2014

PHYSICS - I

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 care fully.*
- *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 (x) in accordance with the instructions given on the back of the answer sheet***

Use of calculators is not allowed.

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

01. As far as the units are concerned, which of the following quantities differs from the rest?
(1) Rotational kinetic energy
(2) Mechanical potential energy
(3) Internal energy
(4) Work
(5) Power

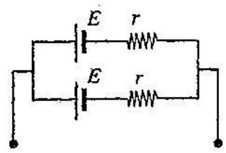
02. Which of the following quantities is / are dimensionless?
(A) Relative velocity
(B) Relative density
(C) Relative humidity
(1) A only. (2) A and B only.
(3) B and C only. (4) A and C only.
(5) All A, B and C.

03. Which of the following propagates in the form of longitudinal waves?
(1) Laser light (2) X-rays
(3) Ultrasonic waves (4) Microwaves
(5) Radio waves

04. When a guitar is played, it will produce
(1) longitudinal progressive waves on the strings and longitudinal progressive waves in air.
(2) transverse progressive waves on the strings and longitudinal progressive waves in air.
(3) longitudinal standing waves on the strings and transverse progressive waves in air.
(4) transverse standing waves on the strings and longitudinal progressive waves in air.
(5) transverse standing waves on the strings and transverse standing waves in air.

05. Which of the following statements is **not** true with regard to a compound microscope?
(1) It has two convex lenses.
(2) Image of the object formed by the objective is real.
(3) Separation of the lenses is much greater than the focal length of the objective or the eyepiece.
(4) Final image formed by the microscope is a virtual image.
(5) The object to be examined should be placed within the focal length of the objective.

06. Two cells, each having e.m.f. E and internal resistance r, connected as shown in figure are equivalent to a single cell with



(1) e. m.f. E and internal resistance r.
(2) e. m. f. 2E and internal resistance 2r.
(3) e.m.f 2E and internal resistance r.
(4) e.m.f. E and internal resistance r/2
(5) e.m.f. E and internal resistance 2r.

07. Two charged conducting spheres of radii $R_1 = r$ and $R_2 = 2r$ are connected by a thin conducting wire. After being connected, if the respective charges on the two spheres are Q_1 and Q_2 and, the corresponding surface charge densities on the two spheres are Q_1 and Q_2 respectively, then

(1) $\frac{Q_1}{Q_2} = \frac{\sigma_1}{\sigma_2} = \frac{1}{2}$ (2) $\frac{Q_1}{Q_2} = \frac{\sigma_1}{\sigma_2} = 2$

(3) $\frac{Q_1}{Q_2} = \frac{1}{2}, \frac{\sigma_1}{\sigma_2} = 2$ (4) $Q_1 = Q_2, \sigma_1 = \sigma_2$

(5) $\frac{Q_1}{Q_2} = 2, \frac{\sigma_1}{\sigma_2} = \frac{1}{2}$

08. Four particles each having a charge of +q are placed on four vertices of a regular pentagon as shown in figure. The distance from the centre O of the pentagon to a vertex is a. The electric fiel intensity at the centre of the pentagon is

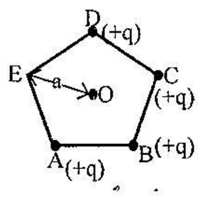
(1) $\frac{q}{4\pi\varepsilon_0 a^2}$ in the OE direction

(2) $\frac{q}{4\pi\varepsilon_0 a^2}$ in the EO direction.

(3) $\frac{q}{\pi\varepsilon_0 a^2}$ in the OE direction.

(4) $\frac{q}{\pi\varepsilon_0 a^2}$ in the EO direction.

(5) zero.



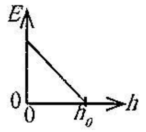
09. A thin ring of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre perpendicular to its plane with a constant angular velocity ω. Now if two small masses, each of mass m, are attached gently to the opposite ends of a diameter of the ring, the new angular velocity of the system is

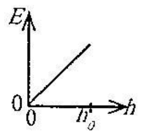
(1) $\frac{\omega M}{M+2m}$ (2) $\frac{\omega(M+2m)}{M}$

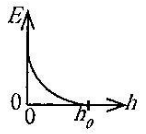
(3) $\frac{\omega M}{M+m}$ (4) $\frac{\omega(M-2m)}{M+2m}$

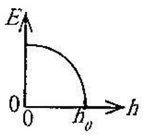
(5) $\frac{\omega(M+m)}{M}$

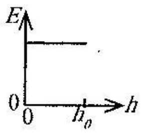
10. A particle of mass m is dropped freely from a location at a height h_0 from the ground. The variation of the kinetic energy (E) of the particle with height h as measured from ground is best represented by

(1) 

(2) 

(3) 

(4) 

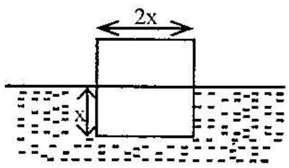
(5) 

11. A solid cube of plastic of mass M and side length 2x floats in water with half the side length submerged as shown in figure. If this cube is now converted into a hollow cube of mass M with external side length 8x, the depth to which it submerges in water will be

(1) $\frac{x}{2}$ (2) $\frac{x}{4}$

(3) $\frac{x}{8}$ (4) $\frac{x}{16}$

(5) $\frac{x}{32}$



12. A Gaussian surfacs S encloses a metal sphere carrying a charge of $+q$, three n-type semiconductor pieces each having a number of free electrons corresponding to charge of $-q$, and one p-type semiconductor piece having a number of holes corresponding to charge of +q as shown in figure.

Total electric flux through the surface can be made zero by

(A) removing one n-type semiconductor piece.

(B) adding one more p-type semiconductor piece with the same hole concentration.

(C) bringing a metal sphere carrying a charge of $-q$ from outside into the enclosed volume.

Of the above three methods

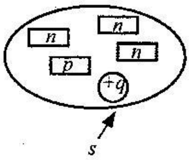
(1) only A is true.

(2) only C is true.

(3) only A and B are true.

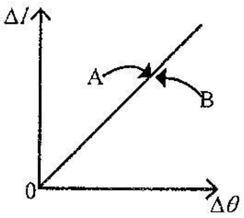
(4) only B and C are true.

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



13. When two metal rods A and B at room temperature are heated together and their expansions Δl are plotted with the incerase in temperature $\Delta\theta$, the two curves are found to coincide with each other as shown in figure.

This could happen only if



(1) the two rods are made of same material.

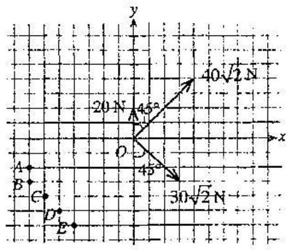
(2) length of A is same as the length of B.

(3) linear expansivity of A is same as that of B.

(4) the product 'linear expansivity x original length' is same for both rods.

(5) the two rods are heated together.

14. If three coplanar forecs of 20N, $40\sqrt{2}$ N and $30\sqrt{2}$ N act on a particle situated at the origin O of a x-y coordinate system as shown in figure, the vector that represents the force necessary to keep the particle stationary is

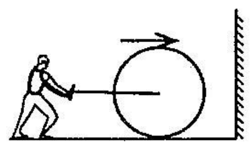


(1) OA (2) OB

(3) OC (4) OD

(5) OE

15. A heavy roller of mass 500kg, moving on a horizontal surface at a constant velocity of 1m s^{-1} as shown in figure is stopped in 0.5s on hitting a smooth vertical wall. The horizontal force exerted by the roller on the wall is



(1) 5 000 N

(2) 3 000 N

(3) 2 000 N

(4) 1 000 N

(5) 500 N

16. A traditional grain grinder consists of two flat stones. The upper stone is rotated on top of the lower stationary stone by applying a horizontal force of magnitude F to the handle H which is fixed at a distance of r from the axis of rotation as shown in figure. If the force is always applied parallel to the direction of motion of the handle, and the period of rotation is T, the power being expended is

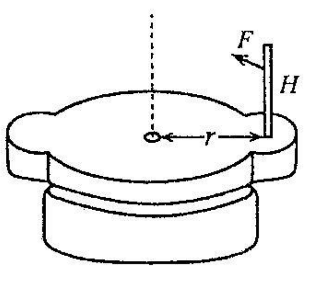
(1) $\frac{\pi rF}{T}$

(2) $\frac{2\pi rF}{T}$

(3) $\frac{rF}{T}$

(4) $\frac{F}{\pi r^2 T}$

(5) $\pi r^2 FT$



17. A radioactive material has a half life of 60 minutes. The percentage of the fraction of material that has **decayed** during a period of 3 hours is

(1) 8.75% (2) 12.5%
(3) 66.6 % (4) 78.3%
(5) 87.5%

18. Intensity of the noise generated by a machine is 10^{-2} Wm^{-2}. By employing a noise barrier, the intensity of noise is reduced to 10^{-6} W m^{-2}. What is the reduction in the noise intensity level?

(1) 160 dB (2) 100 dB
(3) 60 dB (4) 40 dB
(5) 25 dB

19. A convex lens is used to obtain a clear image of an object on a screen. The screen is located 30 cm away from the lens, and the object is at 20 cm from the lens. If the lens is now used to focus the image of a distant tree on the screen, the distance between the lens and the image of the tree is

(1) 12 cm (2) 24 cm
(3) 50 cm (4) 60 cm
(5) 90 cm

20. Which of the types of glass prisms shown in figure (2) can be used to bend a ray of light into all the forms given in figure (1)?

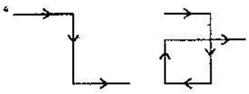


Figure (1)

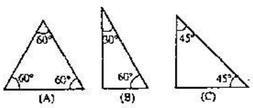
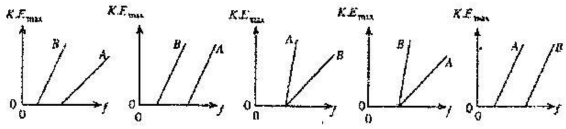


Figure (2)

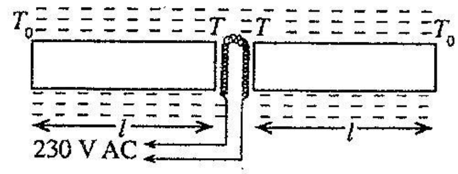
(1) Type A only. (2) Type B only.
(3) Type C only. (4) Types A and C only.
(5) Type B and C only.

21. The work functions corresponding to two metals A and B are W_1, and W_2 respectively, and $W_1 > W_2$. Two surfaces made of *A* and *B* are illuminated separately using a monochromatic beam of light of frequency *f*. Which of the following graphs correctly represents the variation of the maximum kinetic energy ($K.E_{max}$) of the emitted photoelectrons with the frequency (*f*) of the incident light beam, for the surfaces made of metals *A* and *B*?



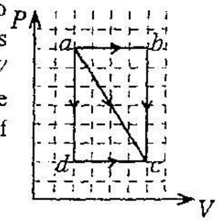
(1) (2) (3) (4) (5)

22. Two ends of two identical metal rods of uniform cross section are placed very close to each other, and those ends are heated using an electric heating element which supplies heat at a constant rate of *P* (Watts), as shown in figure. The rods are thermally well insulated as shown, and at the steady state, the temperature at free ends which are exposed to the surroundings is T_0. Assume that the entire heat energy generated by the element is absorbed equally by the two rods. If *l*, *A* and *k* respectively are the length, cross sectional area and the thermal conductivity of a rod, what is the temperature *T* of the ends close to the heating element at the steady state?



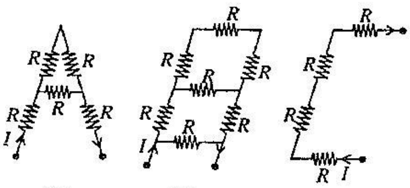
(1) $T = T_0 + \frac{Pl}{kA}$ (2) $T = T_0 + \frac{Pl}{2kA}$
(3) $T = T_0 + \frac{2Pl}{kA}$ (4) $T = 2T_0$
(5) $T = 2\left(T_0 + \frac{Pl}{kA}\right)$

23. An ideal gas can expand from state *a* to state *c* along three thermodynamic paths *adc*, *ac* and *abc* as given in the *P* - *V* diagram. Along which of the above paths would the highest exchange of heat occur?



(1) Path *adc*
(2) Path *ac*
(3) Path *abc*
(4) Path *adc* and *ac* equally
(5) Path *adc* and *abc* equally

24.



(A) (B) (C)

The same current I is sent through resistor networks A, B and C as shown in above figure. If all the resistors in the networks are of equal magnitude, the maximum power is consumed by

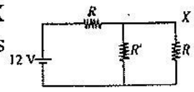
(1) the network A.
(2) the network B.
(3) the network C.
(4) the networks A and B equally.
(5) the networks B and C equally.

25. A 5W electronic device having a resistance of 5Ω is operated by receiving power from a 230V main supply through a transformer.

The ratio, $\frac{\text{Number of turns in the primary coil}}{\text{Number of turns in the secondary coil}}$ of the transformer is

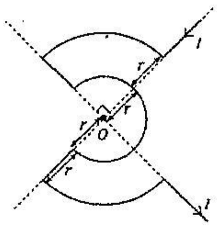
(1) 46 (2) 23
(3) $\frac{10}{23}$ (4) $\frac{1}{23}$
(5) $\frac{1}{46}$

26. In the circuit shown, the voltage at X is found to increase by 4 V when *R'* is removed. The resistance of *R'* is equal to



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

27. A piece of wire is bent into the form shown in figure and a current of I is passed in the direction shown. The magnitude of the magnetic flux density at the point O is



(1) $\frac{\mu_0 I}{4r}$ (2) $\frac{\mu_0 I}{8r}$

(3) $\frac{3\mu_0 I}{2r}$ (4) $\frac{\mu_0 I}{2r}$

(5) $\frac{3\mu_0 I}{8r}$

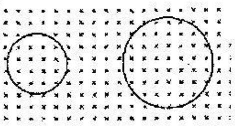
28. Two identical strings are separately subjected to a tension T. When plucked at the middle, each string produces waves of frequency f. Now, if the tension of only one string is reduced to 0.81 T and the strings are plucked at the middle simultaneously, five beats can be heard during one second. The value of f is

(1) 25 Hz (2) 50 Hz

(3) 75 Hz (4) 90 Hz

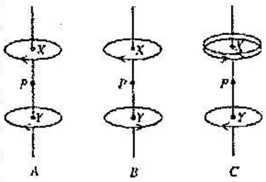
(5) 100 Hz

29. An electron and a proton travel with equal speeds around two circular paths shown in the diagram (drawn not to scale) under the influence of a uniform magnetic field. If the direction of magnetic field is perpendicular and into the plane of the paper,



(1) the electron travels clockwise around the small circular path and the proton travels counter - clockwise around the large circular path.
(2) the electron travels counter - clockwise around the small circular path and the proton travels clockwise around the large circular path.
(3) the electron travels clockwise around the large circular path and the proton travels counter-clockwise around the small circular path.
(4) the electron travels counter-clokwise around the large circular path and the proton travels clockwise around the small circular path.
(5) the electron travels counter-clockwise around the small circular path and the proton travels counter-clockwise around the large circular path.

30. Identical loops in the three arrangements A, B and C of circular loops centred around vertical axes, carry equal currents in the directions shown in figure. In the arrangement C there are two separate loops very close to each other with a common centre at X. In all three arrangements the loops are separated by the same distance XY and P is the mid-point of XY. If the magnitudes of the magnetic flux densities at P in the arrangements A, B and C are B_A, B_B and B_C respectively, then

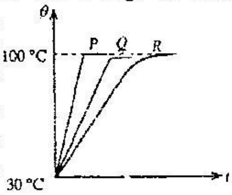


(1) $B_A > B_B > B_C$ (2) $B_A > B_C > B_B$

(3) $B_B > B_C > B_A$ (4) $B_C > B_B > B_A$

(5) $B_C > B_A > B_B$

31. Three different types of thermometers, P, Q and R having a temperature range of 0 -110°C, and kept at room temperature of 30°C were simultaneously dipped into a large oil bath, maintained at 100°C at time t = 0, and their readings (θ) were recorded with time (t). Curves in figure show the variation of θ with t for three thermometers. Consider the following conclusions made about the thermometers after analyzing the three curves.

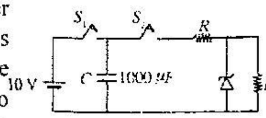


(A) P is the most sensitive thermometer.
(B) Thermometers P and R are accurate but not Q.
(C) The scale of thermometer R is not linear.

Of the above conclusions,

(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 ture.

32. Breakdown voltage of the zener diode in the circuit shown is 5V. R_L is a suitable resistor. The capacitor C is first charged to 10V by closing the switch S_1 and opening the switch S_2. Subsequently, S_1 is opened and S_2 is closed. Consider the following statements made about the functioning of the circuit after S_2 is closed.



(A) Voltage across R_L will be 5 V so long as the capacitor voltage is adequately above 5 V.
(B) Time period through which the voltage across R_L remains constant does not depend on the value of the capacitance.
(C) Potential drop across R gradually decreases with time.

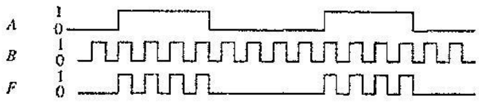
Of the above statements,

(1) Only A is true. (2) Only C is true.

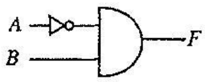
(3) Only A and B are true. (4) Only A and C are true.

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

33. A and B shown below represent the logical inputs applied to circuits (1) to (5) given below, and F represents the expected output from the circuit.

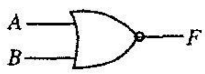


Which of the following circuits, (1) to (5), provides the expected output?

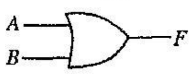


(1)

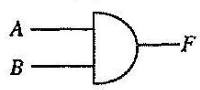
(2)



(3)



(4)



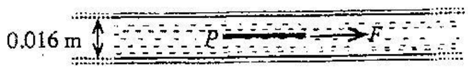
(5)

34. Which of the following is **not** true regarding an npn transistor and an n-channel junction field effect transistor (JFET)?

npn transistor	*n*-channel JFET
(1) Has two pn junctions.	Has only one pn junction.
(2) Base-emitter junction is forward biased when operating in the active mode.	Gate-source junction is reverse biased during the operation.
(3) An arrow is marked on the emitter of the transistor symbol.	An arrow is marked on the source of the transistor symbol.
(4) Both free electrons and holes participate in the operation of the transistor.	Only free electrons participate in the operation.
(5) Magnitude of the current through the collector depends on the base-emitter voltage.	Magnitude of the current through the channel depends on the gate-source voltage.

35. Figure shows a section of a long horizontal rectangular tube of height 0.016m having a large surface area, and filled with a lubricating oil of viscosity 0.072 Pas. What is the force F required to drag a very thin plate P of area $0.4 m^2$ with a velocity of $0.02 ms^{-1}$ along the middle plane between the top and bottom surfaces of the tube as shown in figure?

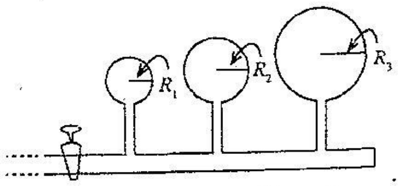
(1) $3.5\pi \times 10^{-3} N$ (2) $7.0\pi \times 10^{-3} N$



(3) $3.6 \times 10^{-2} N$ (4) $7.2 \times 10^{-2} N$

(5) $1.44 \times 10^{-1} N$

36. Three spherical liquid films of surface tensions T_1, T_2 and T_3 respectively are in equilibrium as shown in figure such that the corresponding radii $R_1 = r$, $R_2 = 2r$ and $R_3 = 3r$ Then,



(1) $T_1 = T_2 = T_3$ (2) $\frac{T_1}{3} = \frac{T_2}{2} = T_3$

(3) $\frac{T_1}{6} = \frac{T_2}{4} = T_3$ (4) $T_1 = \frac{T_2}{2} = \frac{T_3}{4}$

(5) $T_1 = \frac{T_2}{2} = \frac{T_3}{3}$

37. A cylindrical copper block of radius r and length l = 2r radiates energy as a black body at temperature T. If this copper block is cut and separated into N identical disks having the same radius r, the rate of the emission of radiant energy at the above temperature will increase by a factor of

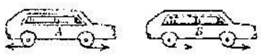
(1) $\frac{(N+3)}{3}$ (2) $\frac{(N+2)}{3}$

(3) $\frac{(N+1)}{3}$ (4) $\frac{N}{3}$

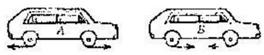
(5) N

38. Consider two motor vehicles, A and B. In motor vehicle A only the front wheels are coupled to the engine and rotated, and in vehicle B only the rear wheels are coupled to the engine and rotated. Which of the following diagrams correctly shows the **directions** of the frictional forces acting on the front and rear wheels of motor vehicles A and B by the ground, when they are travelling in the forward direction?

(1) 

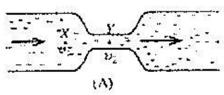
(2) 

(3) 

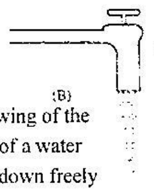
(4) 

(5) 

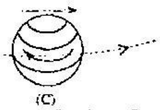
39. Consider the following physical phenomena.



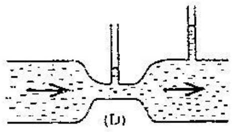
Water flowing through a tube having two different areas of cross-section; speed of water at Y (υ_2) > speed of water at X (υ_1).



Gradual narrowing of the cross section of a water column falling down freely from a tap.



Deflection of a cricket ball which is moving whille spinning.



Existence of a height difference in the liquid columns in vertical tubes.

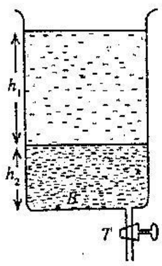
Which of the above phenomena can be explained using the Bernoulli's theorem?

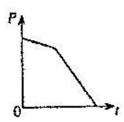
(1) A and D only. (2) B and D only.

(3) C and D only. (4) B, C and D only.

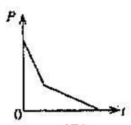
(5) All A, B, C and D.

40. A cylinder contains two immiscible liquids filled to heights h_1 and h_2 as shown in figure. If the tap T at the bottom is opened at time t = 0 and liquids are taken out slowly at a constant volume rate, the variation of pressure (P) due to liquids at the point B at the bottom of the cylinder with time (t) is best represented by

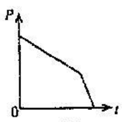




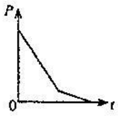
(1)



(2)



(3)



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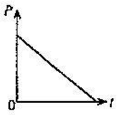
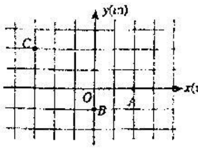


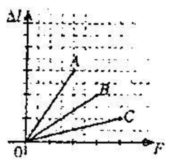
(5)

41. A small object is initially at rest at point O, and due to an internal explosion it breaks into three parts and move away. At a certain instant after the explosion, the location of three moving parts are shown by the points A, B and C in figure. If the mass of the part which is at point A is 6 grams, what is the mass of the object (in grams) before explosi on?



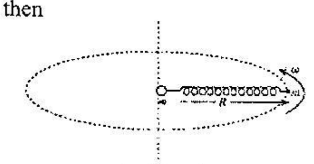
(1) 6 (2) 9
(3) 12 (4) 15
(5) 18

42. Figure shows the variation of the extensions (Δl) produced by three different metal rods A, B and C with the force when they are subjected to a tensile force F. If E_A, E_B and E_C are the corresponding energies stored in the rods due to extensions, then



(1) $E_A > E_B = E_C$
(2) $E_A = E_B > E_C$
(3) $E_A = E_B = E_C$
(4) $E_A > E_B > E_C$
(5) $E_A < E_B < E_C$

43. A light spiral spring has an unstretched length l and a spring constant k. A small object of mass m is attached to one end of the spring and the system is rotated about a vertical axis that passes through a small light ring attached to the other end of the spring as shown in figure. If the object travels along a circular path of radius R with constant angular speed ω, keeping the spring on a horizontal plane, then



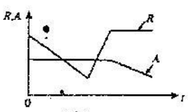
(1) $\omega = \sqrt{\frac{k}{m}\left(\frac{R-l}{R}\right)}$

(2) $\omega = \sqrt{\frac{k}{m}}$

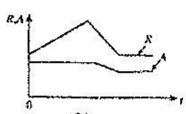
(3) $\omega = \sqrt{\frac{k}{m} \cdot \frac{l}{R}}$ (4) $\omega = \sqrt{\frac{k}{m}\left(1 - \frac{R}{l}\right)}$

(5) $\omega = \sqrt{\frac{k}{m} \cdot \frac{R}{l}}$

44. A certain volume of air, isolated from the atmosphere at 30°C, is first heated up to 80 °C and then cooled down to 15°C at uniform rates. Both heating and cooling are done at constant pressure. Dew point of the isolated air is 25°C. The variations of relative humidity (R) and absolute humidity (A) of the air volume with time (t) are best represented by



(1)



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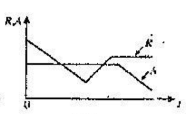

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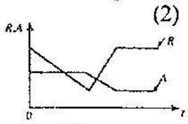

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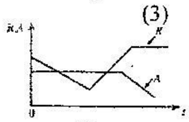
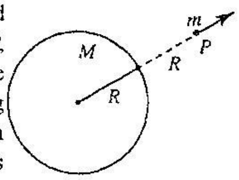


(5)

45. A particle of mass m is projected vertically upwards from a point P, which is at a distance of 2R from the centre of a spherical planet having a mass M and radius R as shown in figure. The escape velocity for this projectile is

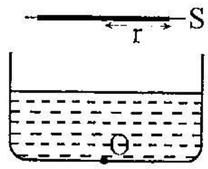


(1) $\upsilon = \sqrt{\frac{GM}{R}}$ (2) $\upsilon = \sqrt{\frac{2GM}{R}}$

(3) $\upsilon = \sqrt{\frac{2Gm}{R}}$ (4) $\upsilon = \sqrt{\frac{GM}{2R}}$

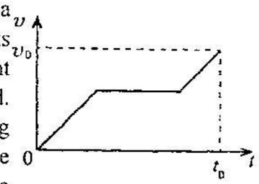
(5) $\upsilon = 2\sqrt{\frac{GM}{R}}$

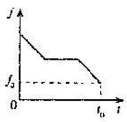
46. A point source of light O situated at the bottom of a water tank produces a circular patch of light of radius r on a horizontal screen S as shown in figure. C is the critical angle for the water-air interface. If the light source is moved vertically up by a distance d, the radius of the light patch will



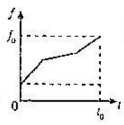
(1) increase to $r + d \sin C$.
(2) increase to $r + d \tan C$.
(3) remain unchanged.
(4) decrease to $r - d \sin C$.
(5) decrease to $r - d \tan C$.

47. An ambulance which emits a sound of frequency f_0 from its siren is travelling with constant velocity υ_0 along a straight road. A car starting from rest is moving behind the ambulance in the same direction, and the velocity-time graph of the car is shown in figure. The car approaches the velocity υ_0 of the ambulance at time t_0. The variation of the frequency (f) of the siren sound heard by a passenger in the car with time (t) is best represented by,

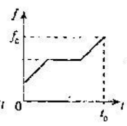




(1)



(2)



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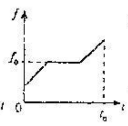

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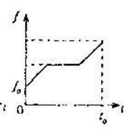
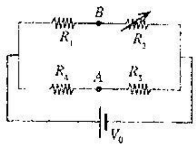


(5)

48. When the resistance R_2 in the circuit shown in figure is varied from zero to infinity, the potential at A relative to B will change from



(1) zero to zero

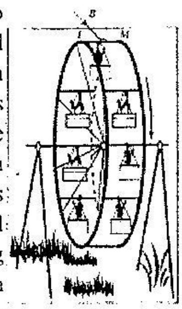
(2) $\frac{R_1}{R_4+R_1}V_0$ to zero

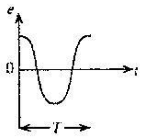
(3) $\frac{R_1}{R_4+R_1}V_0$ to $\frac{R_1}{R_4+R_1}V_0 - V_0$

(4) $\frac{R_3}{R_4+R_3}V_0$ to $\frac{R_3}{R_4+R_3}V_0 - V_0$

(5) $\frac{R_3}{R_4+R_3}V_0$ to $\frac{R_4}{R_4+R_3}V_0 - V_0$

49. A Ferris wheel which consists of two parallel large wooden wheels joined together with metal cross bars as shown in figure, is erected so that the planes of wheels are in the north-south direction, and the cross bars are perpendicular to the direction of the earth's magnetic field B which is horizontal at this location. The Ferris wheel rotates around the horizontal axis passing through the centres of the two wheels at a constant period of rotation T in the direction shown. LM is a metal cross bar which is at the highest position as shown when time t = 0. Variation of the induced electromotive force (e) at the end L of the cross bar with respect to the end M with time (t) is best represented by

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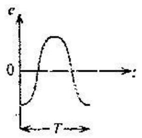
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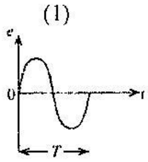
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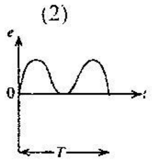
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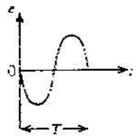
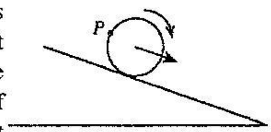
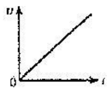
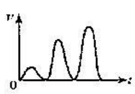

(5)

50. A wheel, startihg from rest, is allowed to roll down without slipping, along an inclined plane as shown in figure. Which of the following graphs best represents the variation of the magnitude (υ) of the velocity of a point P, locate on the perimeter of the wheel, relative to the earth with time (*t*)? (The point *P* touches the inclined plane at t = 0.)




(1)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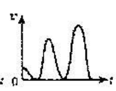
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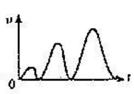
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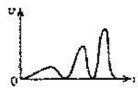
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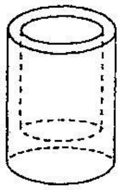
G. C. E (Advanced Level) Examination, August 2014

PHYSICS - II

Three hours

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

01. The following measuring instruments are given to determine the density of material of a small uniform cylindrical container of the form shown in figure.



(1) A vernier calliper
(2) An electronic balance

(a) Before using a vernier calliper for taking measurements, what is the first step that you should take?

....

(b) Write down an expression for the density d of material of the container in terms of volume of the material V and its mass M.

....

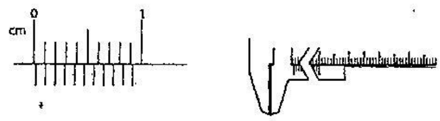
(c) In addition to the two measurements, the outer diameter and the inner diameter of the container, state the other measurements that you would take using the vernier calliper to determine the volume of the material.

(1) .... (2) ....
(3) ....

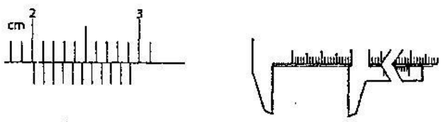
(d) The figures (i) to (v) below show all the relevant positions of the main and the vernier scales pertaining to one set of measurements that has been taken in order to determine the volume of the material of the container. Relevant jaws/ depth rod etc., that have been used to take each measurement are shown on the right hand side of the figure.

Nort : Height of the contairner is greater than its outer diameter.

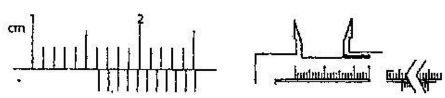
(i)



(ii)



(iii)



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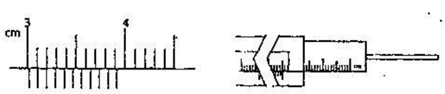
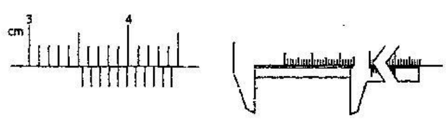


(v)



Identify the figures correctly and relate them to the measurements that have been indicated in (c), and fill in the table given below.

Figure	Reading of the vernier calliper	Corrected reading	Name of the measurement
(i)	....	[redacted]	....
(ii)	....	..........(say x_1)	....
(iii)	....	..........(say x_2)	....
(iv)	....	..........(say x_3)	....
(v)	....	..........(say x_4)	....

(e) (i) Write down an expression for the volume V of the material of the container in terms of the symbols (x_1, x_2, x_3, x_4) given in the table above.

....
....
....

(ii) Using the expression written under (e) (i) above and readings that have given in the above table in (d), calculate V (Take $\pi = 3$).

....
....
....

(f) According to the reading of the electronic balance, if the mass of the container is 9.60 grams, find the density of the material of the container and give your answer in $kg\ m^{-3}$.

....
....
....

02. An experiment is to be designed and carried out to find the specific latent heat of vaporization of water using an electric method. The labelled experimental arrangement of the items to be used for this purpose is shown in figure (1).

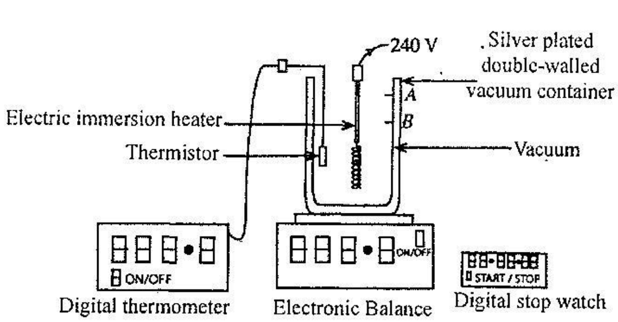


Figure (1)

Experimental Procedure:

(1) Add a sufficient quantity of water to the silver plated double-walled vacuum container which is kept on the electronic balanec.

(2) Switch on the electric immersion heater.

(3) After the water has started boiling thoroughly at the boiling point, start the digital stop watch at a certain instant (say at time t = 0) and also record the reading of the electronic balance (say M_0) at that instant.

(4) A fter a suitable time t, record the reading of the balance again (say M_1)

(5) If several readings for M_1 are needed, continue the experiment without stopping and record the successive readings of the balance at times $2t$, $3t$, $4t$, and $5t$.

(a) When the experiment is carried out according to the above procedure, suggest up to which level, A or B, marked on the diagram should the water be filled. Give **two** reasons for your choice. Assume that when boiling, water does not spill over from the container.

Level : ....

Reasons :

(i) ....

(ii) ....

(b) How does the silver plated double-walled vacuum container reduce the heat loss?

....

(c) Indicate which property of the thermistor is used to measure the temperature, and state how this property changes with the temperature.

....

(d) If P is the power of the electric heater in watts and t is the time through which the water has been boiled off as steam, write down an expression for the specific latent heat of vaporization L of water in terms of P, t and the measured quantities of M_0 and M_1 under the experimental procedure above.

(e) (i) If the least measurement of the electronic balance is 0.1 grams, what should be the minimum mass of water that has to be boiled off to ensure that the fractional error in the measured mass of water that had been boiled off as steam is $\frac{1}{100}$?

(ii) If P = 500W, calculate the minimum value for time t through which the water has to be boiled off in order to satisfy the requirement given in (e) (i) above. (For this calculation take the value of L as 2.3×10^6 J kg^{-1})

(f) A graph of mass m (in **grams**) of the vaporized water with time t (in **minutes**) was plotted using the data taken under the experimental procedure number (5) and the coordinates corresponding to two points on the graph were found to be (2, 26) and (8, 106). Determine the value of L.

....

....

....

....

03. You have been given a standard spectrometer, a glass prism, and a source of sodium light to determine the refractive index n of glass using a glass prism.

(a) Write down the two major components which can be rotated independent of each other, about the vertical axis passing through the centre of the prism table of the spectrometer.

(i) ....

(ii) ....

(b) Write down the major steps of the adjustments that you should do to the following items, before beginning to take measurements using the spectrometer.

(i) Eyepiece :

....

(ii) Telescope :

....

....

(iii) Collimator :

....

....

....

(c) You have been asked to use the prism PQR shown in figure 2 (a) for levelling the prism table.

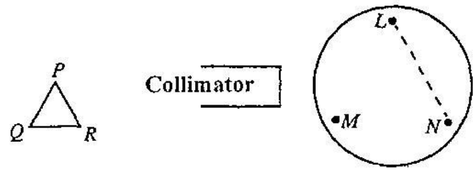


Figure 2 (a) Figure 2 (b)

Draw on the figure 2(b), the way you should place the prism PQR on the prism table in order to level the prism table. In figure 2(b), L, M, N indicate the positions of the levelling screws of the table.

(d) To determine the angle of minimum deviation of a ray of light through the prism, it is necessary to take two measurements.

(i) After placing the prism on the prism table and adjusting the spectrometer to obtain the minimum deviation position, draw a ray diagram on figure (3) to show the deviation of the ray through the prism. Draw also the position of the telescope.

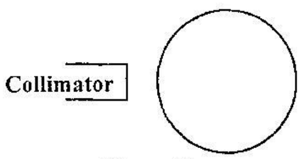


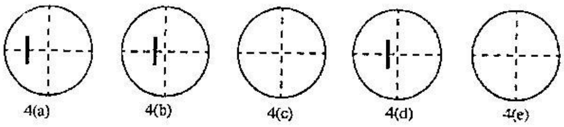
Figure (3)

(ii) If corresponding readings of one scale for the two measurements mentioned above for sodium light are 143°29' and 183°15' (Assume that the scale did not pass through 360° mark when taking the measurements.), find the angle of minimum deviation.

....

....

(e) Once you have identified and fixed the angle of minimum deviation position on the cross wires, in order to reconfirm it, you have been asked to rotate the prism table starting with a smaller angle of incidence until it passes through the minimum deviation position, while continuously observing the image of the slit. Figures 4(a), 4(b) and 4(d) show **three** of the five consecutive positions where image of the slit could be observed during this rotation.



On figure 4(c) and figure 4(e), draw the images of the slit at the position where you expect to see them.

(*f*) If *A* is the angle of the prism and *D* is the angle of minimum deviation for sodium light, write down as expression for the refractive index *n* of glass for the sodium light in terms of *A* and *D*.

....

....

(*g*) If $A = 60°$, find the value of *n*.

....

....

04. You are asked to determine the correct resistance (*R*) of a resistor of unknown value by measuring currents (*I*) and voltages (*V*) across it, and plotting a suitable graph. The resistance *R* of the unknown resistor is known to have a value around 500 Ω.

(a) A section of the circuit digaram of the electrical circuit that you would set up for this purpose is drawn in figure (1). X is a rheostat connected between points *A* and *B*.

(i) Complete the circuit diagram using circuit symbols of other components shown below. All the symbols have their usual meaning.

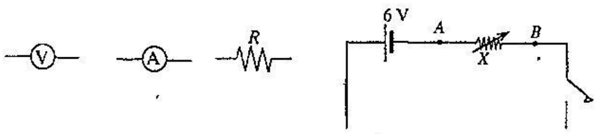


Figure (1)

(ii) Correctly mark the + and - signs on either side of circuit symbols of voltmeter and ammeter on the section of the circuit drawn by you.

(b) You have been given the rheostat shown in figure (2) to be used in this experiment. Mark the points *A* and *B*, mentioned in (a) above, at the appropriate terminals of the rheostat shown in figure (2).

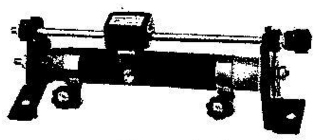


Figure (2)

(c) Following specifications are given for the rheostat.
Total resistance = 2000 Ω
Maximum current = 0.5A
When this rheostat is used in the completed circuit drawn in part (a) (i), estimate the maximum and the minimum currents that you can obtain..

Maximum current : ....

Minimum current : ....

(*d*) If you are asked to select a suitable ammeter from a collection of ammeters having full scale deflections of 0.5 mA, 15mA, 20mA, 100mA and 1 A, what would be your choice? Give reason for the choice.

Choice : ....

Reason : ....

(e) You are asked to take five different pairs of readings for *I* and *V*.

(i) Deflection of the indicator of the voltmeter corresponding to one such voltmeter reading is shown in figure (3).

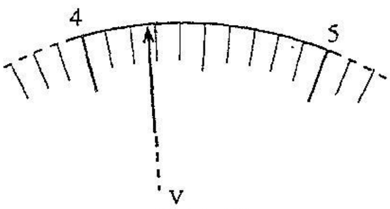


Figure (3)

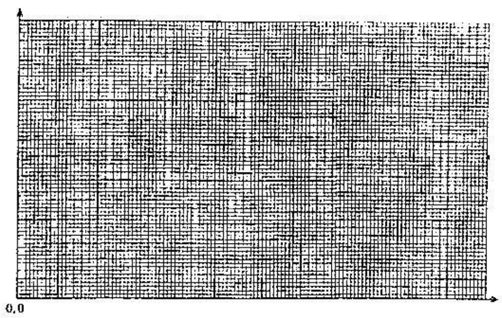
(1) Write down the value of this reading :

....

(2) What is the maximum estimated error in that measurement?

....

(ii) When this experiment was performed using the circuit completed in (*a*) (*i*) above, the corresponding voltmeter readings obtained for ammeter readings of 3 mA, 5 mA, 7 mA, 9 mA and 11 mA were 1.4V, 2.4V, 3.4V, 4.3V and 5.3V respectively. Considering the current as the independent variable mark the data points, on the grid provided, in a suitable manner to determine *R*.



(f) After plotting a suitable graph, suppose you have determined the value of the unknown resistance R as 480 Ω. The internal resistance (R_i) of the voltmeter that you have used in this experiment is 5000 Ω. Calculate the value you would expect from this experiment for *R* is R_i was infinitely large.

....

....

....

PART B - Essay

Answer four questions only. **($g = 10N\,kg^{-1}$)**

05. (a) When a person is changing steps while walking, at one instant the entire body weight of the person is borne only by a single leg as shown in figure (1). Front view of the relevant bone structure of this leg is shown in figure (2), and the corresponding simplified free-body diagram indicating all the forces acting on the leg is shown in figure (3). All the forces indicated in figure (3) and the weight of the body are acting in one vertical plane and the frictional force between the leg and the ground is negligible for this situation.

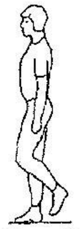


Figure (1)

Here, F_M = Resultant force acting on the leg by the group of muscles M

F_S = Force exerted by the hip socket (S) on the leg

W_L = Weight of the leg

R = Reaction force acting on the leg by the ground

Figure (2)

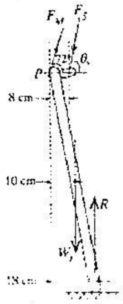


Figure (3)

(i) If the weight of the person is W, express the reaction force R in terms of W

(ii) Generally, $W_L = 0.2W$. By taking the moments aroud the point P or otherwise obtain a relationship between F_S, θ_S and W.

(iii) Find F_M in terms of W. (Take sin 72° = 0.9 and cos 72° = 0.3)

(iv) Find the value of θ_S.

(v) Find F_S in terms of W. (Only for this calculation, you may take $\sin\theta_S = 1$)

(b) When a person with an injured hip joint is walking, he tends to limp by leaning towards the injured side as he steps on the foot attached to the injured joint [see figure (4)]. As a result, the centre of gravity of the body shifts to the side of injured hip joint and F_M acts in the vertical upward direction. The free body diagram for the leg for this case is shown in figure (5)and corresponding forces of F_M and F_S are indicated as F'_M and F'_S respectively.

Figure (4)

(i) Find the force F'_S for this situation, in terms of W.

(ii) Calculate, as a percentage, the reduction in the magnitude of force F_S as result of the limping of the person for the reason described in (b) above.

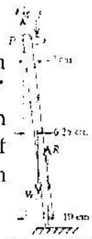


Figure (5)

(c) In the process of walking, while one leg rests on the ground the other leg moves around the hip joint. This motion can be considered as an oscillatory motion of a rod which is freely pivoted at one end as shown in figure (6). Here the leg is considered as a uniform rod of length l.

(i) If I is the moment of inertia of the rod around the axis of rotation through the point Q, obtain an expression for the angular acceleration α in terms of , θ, W_L and I, for the position indicated in figure (6).

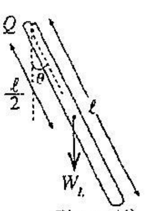


Figure (6)

(ii) The period of oscillations of the rod, T, can be obtained from $T = 2\pi\sqrt{\frac{\theta}{\alpha}}$ and it can be shown that $T = 2\pi\sqrt{\frac{2\ell}{3g}}$ for a uniform rod of length ℓ.
Clculate the value of T corresponding to a person whose length of a leg is 0.9 m. Take = 3 and $\sqrt{0.06} = 0.25$

(iii) The most effortless speed of walking for a person is the speed where his legs oscillate with period obtained in (c) (ii) above. When a person with 0.9 m long legs is walking, the distance between two successive positions where one of his legs touches the ground is 0.9m. Calculate the most effortless walking speed for him.

06. (a) Draw in **four** separate diagrams the standing wave patterns of fundamental mode and first three overtones produced by a tube of length L open at both ends. Mark nodes as N and antinodes as A in the diagram corresponding to the fundamental mode. Obtain expressions for frequencies f of these waves in terms of L and the speed of sound υ, inside the tube. Neglect end corrections.

(b) Figure 1 (a) shows a standard 6 hole-flute. According to a simple model, this flute can be considered equivalent to a set of tubes open at both ends. Figure 1(b) shows the corresponding effective lengths of open tubes equivalent to the flute. When all the hole of the flute are opened it is equivalent to an open tube of length L_0 as shown in figure (2). When the first hole of the flute is closed the equivalent length of the tube becomes L_1 and when the first 2 holes are closed at the **same time** the equivalent length becomes L_2 and so on [see figure (2)] L_6 is the equivalent length when all 6 holes are closed. These effective lengths are generally larger than the actual lengths of the flute due to the effects of ends and holes.

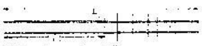


Figure 1 (b)

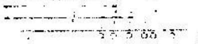


Figure 1(a)

Figure (2)

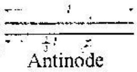


Figure (3)

Table (1) shows how the holes are closed with fingers to obtain two notes, n_1 and n_2 of the flute and their correspond ing fundamental frequencies. The speed of sound in the tube is 340 ms^{-1}. Calculate the effective lengths L_6 and L_2.

(c) Certain flutes have a few small holes in addition to the standard holes. Such a small hole, when open, will produce an antinode at the location of that hole in the flute. Having such a small hole in the flute will not alter the effective length of the equivalent open tube, but produces an antinode at an appropri -ae location in the equiv- alent tube ther by mod-

Table (1)

Note	Closed holes ⊗	Fundamental frequency Hz
n_1	⊗ ⊗ ⊗ ⊗⊗ ⊗	262.0
n_2	⊗ ⊗ O OO O	392.0

ifying the wave pattern accordinglyand produces a standing wave. If such an open small hole on the flute produces an antinode at the centre of the equivalent open tube of length L_6 when all other holes are closed, draw the first **two** new standing wave patterns produced in the tube and obtain expressions for their frequencies f in terms of υ and L_6.

(d) (i) Write down the frequencies of first four standing wave patterns in part (c) in terms of υ and L_6.
(ii) Assuming that the length L6 is equal to the length L of the open tube mentioned in (a) above, compare the frequecies that you obtain in (d) (i) with the frequencies obtained in part (a), and thereby comment on the effect of having a small hole as mentioned in part (c).

(e) An antinode is produced at a distance of $\frac{2}{3}$ L_2 in the equivalent open tube due to an open small hole located at the left of the first standard hole of the flute as shown in figure (3). Draw the wave pattern of the first standing wave in the equivalent open tube (corresponding to the lowest frequency) and calculate its frequency, when the flute is played with the small hole opened.

07. Read the passage below and answer the questions given.

The magnitude of the contact angle of water depends on the nature of the surfae with which water is in contact.

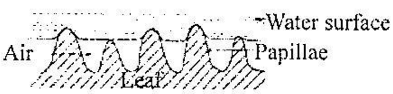


Figure (1)

Water drops can settle on certain ideally flat surfaces so that the angle of contact is less than 90°. Such

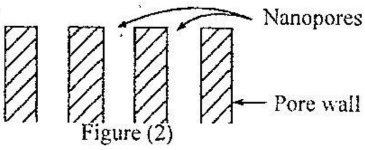
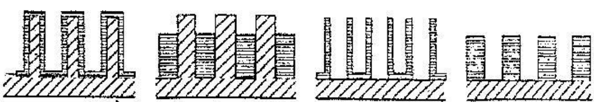


Figure (2)

a surface is known to have been wetted by water and acts as a hydrophilic surface.

However, some surfaces consisting of rough structure at micro/nano scale can act as hydrophobic surfaces showing non-wetting properties.

The lotus leaf, compared to other natural leaves, shows **superhydrophobic** properties with a contact angle of water greater than 150° and remains clean in muddy, dirty ponds and tanks. When rain drops fall on the surfaces of lotus leaves, instead of wetting the leaf, they immediately bead up like shiny spherical balls and roll off the surface even at the slightest disturbance, collecting dirt and debris away. This water repellent self cleaning property of lotus leaf is known as the 'Lotus effect'.


3(a) 3(b) 3(c) 3(d)

The lotus effect arises due to the dual scale micro/nano structures present in the lotus leaf. Covering its surface, the lotus leaf has a series of protrusions (parts that stick out like bumps) called papillae that are nearly 10μm in height. Each papilla is covered with a nano-metre scale thick superhydrophobic waxy layer. The roughness introduced by papillae allows air to be trapped under water drops as shown in figure (1) contributing to the non-wetting behaviour of the leaf. Using the lotus effect, a variety of surfaces has been patterned to produce roughened hydrophobic surfaces with high contact angles of water necessary for water repellent window glasses, self cleaning clothes and paints, and low-drag (show low resistance by water against motion) marine vessels, etc.

Wettability of a surface also depends on the nature of the liquid. some liquids wet roughened surfaces whereas, some liquids show non-wetting properties. Property of wetting of roughened surfaces by liquids is used to fabricate nano-structures such as nanotubes and nanorods by means of the techique known as 'template wetting nano fabrication'. This technique uses a solid template that contains an array of nanopores as shown in figure(2).

A non-wetting liquid does not penetrate the pores and settles on the protrusions of the template whereas, a wetting liquid penetrates into pores by wetting walls and filling the pores. When nanopores are filled with a wetting solvent that contains a desired solid and the template is heated, due to evaporation of the solvent, the solid is left behind on the Pore walls or in the nanopores asshown in figures 3(a) and 3 (d) respectively. Removal of pore walls of the template by a chemical treatment known as etching will leave behind structures with nano-tubes or nanorods as shown in figures 3(c) and 3(d), respectively.

(a) Write down **three** applications of artificially fabricated hydrophobic surfaces.
(b) How does the lotus effect help to remove dirt from the surface of a lotus leaf?
(c) How do you categorise hydrophilic, hydrophobic and superhydrophobic surfaces in terms of the contact angle of water?
(d) Show using a diagram how a wetting liquid and a nono-wetting liquid settles on an ideally flat solid surface.
(e) By copying the rough surface in figure (2) draw diagrams to show how a wetting liquid and non-wetting liquid settles on it.
(f) When dew begins to form, do you expect water molecules to condense in the pores on the surface of a lotus leaf? Give reasons for your answer.
(g) State the effect of employing roughened hydrophobic surfaces on low-drag marine vessels.
(h) Mention **two** nano-structures that can be fabricated using the technique 'template wetting nano fabrication'.
(i) Consider a parallel gold plate capacitor having plates consisting of gold nanorods of diameter of 100 nm and height of 50 μm with 10^{13} nanorods per square meter. Assuming that the capacitance of this capacitor increases due to the increase in the effective surface area, calculate by what factor would the capacitance increase compared to a gold plate capacitor without nanorods, but has identical dimensions. Assume that the separation between capacitor plates is much greater than the height of a nanorod.

08. Two identical planar eletrodes are placed paralle to each other with a separation of d as shown in figure (1). A magnetic field of flux density B can be established between the electrodes in the direction shown in the figure.

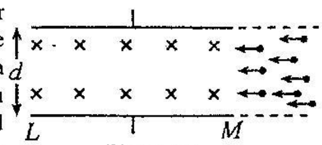


Figure (1)

A beam of ions enters the magnetic field region with speed υ parallel to LM as indicated in figure (1). Each ion has mass m and charge +q. The magnetic field is turned on at time $t = t_0$. Assume that the motion of the ions will not be affected by the medium through which they travel.

(a) Obtain an expression for the radius R of the circular path followed by an ion which enters the magnetic field at time $t = t_0$ in terms of υ, B, and q.

(b) Consider three ions which enter the magnetic field simultane -ously at time $t = t_0$ from positions P (very close to the electrode), Q and R as indicated in the figure (2).

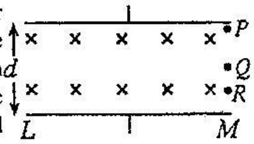


Figure (2)

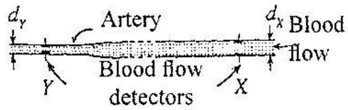
(c) Assume that the ions hitting the electrode LM get gradually and uniformly accumulated on the surface of the electrude.

(i) As the ions get accumulated on the electrode LM, what is the direction of the electric field being developed between the electrodes due to accumulated ions? Assume that the electric field is confined only to the space between the two electrodes.

(ii) Once the accumulation of the ions on the electrode has begun, the path for the ions entering the field region is not a part of a circle. What is the reason for this?

(iii) After a certain period of time has elapsed, the ions entering the field region tends to travel along a straight line without deviation. If V_0 is the the voltage across the electrodes once this state (steady state) has been reached, obtain an expression for υ in terms of V_0, B and d.

(d) As the blood contains charged ions, blood flow detectors based on the above principle can be used to find the speed of blood flow through arteries. Here the two parallel plate electrodes are placed touching the walls of the artery as shown in figure (3), and blood flow speed is determined by measuring the voltage across electrodes at the steady state.



Figure(3)

(i) If the flux density of the applied magnetic field at a certain location X of an artery is $B_x = 0.08$ T and the measured voltage across the electrodes at X is $V_x = 2.16 \times 10^{-4}$ V, determine the speed of blood flow at X using the expression obtained in (c) (iii). The internal diameter of the artery at X is $d_x = 3 \times 10^{-3}$m.

(ii) In order to investigate the possible change in diameter of the artey at another location Y, a similar device is placed at Y. When the magnetic field applied at Y is set to $B_y = 0.05$ T, the measured voltage across the electrodes at Y is $V_Y = 1.80 \times 10^{-4}$V. Find the internal diameter d_Y of the artery at Y.

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

(A) (a) A potential divider AB of total resistance R_0 is used to provide a variable voltage to a load resistance R_L. The potential divider is connected to a power supply of voltage V as shown in figure (1).

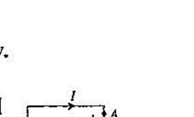


Figure (1)

(i) When the resistance of the section of the potential divider between the points B and the sliding contact (wiper) W is R_1, derive an expression for the equivalent resistance between A and B.

(ii) Through argumentation or otherwise, show that the minimum and the maximum resistances that can exist between A nd B are $\frac{R_0 R_L}{R_0 + R_L}$ and R_0 respectively.

(iii) If $R_0 = 5$ kΩ, calculate the minimum value of R_L which will permit only up to a 1% of variation in the current I of the circuit when slider W is moved from A to B.

(b) Terminals 1-9 of the potential divider shown in figure (2) are used to provide currents to 9 electrodes (not shown in the figure) of a certain device. Values of the resistors R_1, R_2 and R_3 are selected so that when electrodes are not connected to the potential divider, and a voltage (V_0) is applied to the potential divider, the voltage appearing across the resistor R_1 is 4 times that appearing across each and every R_2 resistor, and the voltage appearing across R_3 is 3 times that across R_2.

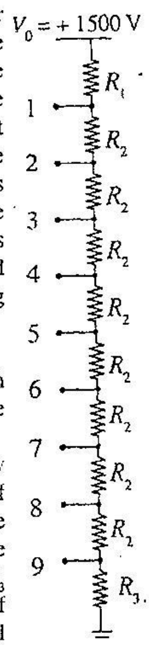


figure (2)

(i) If $V_0 = 1500$V and the current through the potential divider is 1 mA, calculate R_1, R_2 and R_3.

(ii) Consider a situation where only terminal 9 has to provide a current of 5 μA for a period of 1 μs to the electrode to which it is connected. Calculate the voltage drop appearing across R_3 during this period due to the supply of the above current from the potential divider. Assume that the current through the potential divider from terminal 1 to terminal 9 remains undhanged at 1 mA.

(iii) In situations where curents are drawn for short periods of time as in (b)(ii), the drop created in terminal voltage can be minimized by providing this current from the charges stored in the capacitor connected across R_3 as ahown in figure (3).

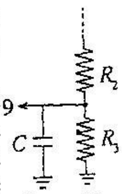


figure (3)

(1) Calculate the amount of charge ΔQ carried by 5 μA current during the period of 1 μs.

(2) If this amount of charge ΔQ is provided by the capacitor of capacitance C shown in figure (3), write down an expression for the drop in voltage ΔV across the capacitor in terms of ΔQ and C.

(3) If this drop in voltage is to be limited to 0.05V, find the value of the capacitor that has to be connected across R_3.

(B) (a) Draw the input-output voltage characterictic for a 741 operational ampilfier and label the linear and saturation regions.

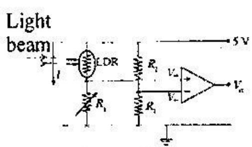


figure (1)

(b) A circuit is to be designed to detect an intruder I entering a premises at night. A part of a circuit that can be used for this purpose is shown in figure (1).

A narrow beam of light is set to incident continuously on the Light Dependent Resistor (LDR) as shown in figure (1). The operational amplifier is to operate with V_0 at its saturation voltages of ±10V.

(i) If the voltage at the inverting input (V_-) is set at 3.5V, calculate the value of R_2, Take the value of R_3 as 7000 Ω.

(ii) When light falls continuously on the LDR, it is decided to maintain a voltage difference of 0.5V between the inverting input (V-) and the non inverting input (V+). What should be the value of R_1 in order to achieve a value of +10 V at the output V_0 under this condition? Assume that the resistance of the LDR when light falls on it is 500 Ω.

(iii) If the light beam gets obstructed due to the movement of the intruder, what will be the value of V_0 during the period of interruption? Give reasons to your answer. Take the resistance of the LDR under this condition as 10^5Ω.

(c) Suppose the output of the circuit given in figure (1) is now connected to the circuit shown in figure (2).

(i) When V_0 = +10V, calculate a suitable value for R_B to provide a base current of 50μA. Take $V_D = V_{BE}$ = 0.7V.

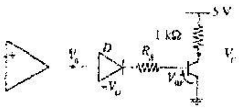


Figure (2)

(ii) If the current gain of the transistor is 100, find the value of the collector voltage V_C under the situation given in (c)(i).

(iii) When V_0 = -10V,

(1) What will be the potential difference across the diode? (Assume that the reverse breakdown voltage of the diode is 25V.)

(2) what will be the collector voltage V_C under this condition?

(d) (i) If the transistor output V_C is connected to a S-R flip-flop as shown in figure (3), write down the input logic levels of *S* and *R* when light falls on the LDR, and when the intruder crosses the light beam.

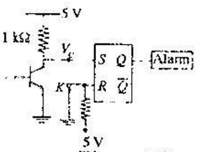


Figure (3)

(ii) If the alarm operates when Q = 1, state whether the alarm sounds continuously even after the intruder has crossed the light beam and moved away. Explain your answer. (K is a grounded switch.)

10. **Answer either part (A) or part (B) only.**

(A) Figure 1(a) shows a parabolic disc type solar energy collector having a circular aperture which extracts and converts solar energy to heat. Solar energy flux is concentrated to a cavity reseiver placed at the focus of the parabolic disc as shown in figure 1(a). An oil passing continuously through a spiralled metal tube fixed to the inner wall of the cavity extracts the heat absorbed by the cavity. Parabolic disc is moved so that the solar flux always falls normal to the disc as shown in figure 1(b). Aperture diameter, *d* of the disc is 20 m and the intensity of the solar flux striking the earth surface is 1000W m^{-2}.

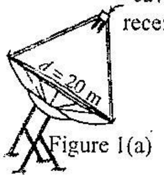


Figure 1(a)

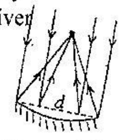


Figure 1(b)

(*a*) Calculate the rate at which solar energy is incident on the parabolic disc (Take π =3).

(b) Assuming that sunshine is available for 6 hours a bay and 60% of the incident solar energy is absorbed by the oil, calculate the thermal energy stored in oil per day.

When answering the parts (c) and (d) take the thrmal energy stored in oil per day as 5 x 10^9J.

(c) It is planned to store this heated oil in an insulated tank so that it can be used even during night. A cubical tank, insulated with two layers of materials of thickness d_1 (inner) and d_2 (outer) having thermal conductivities k_1 and K_2 respectively is used for this purpose [see figure 2]. Such a storage of thermal energy is called a thermal battery.

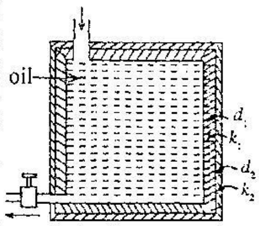


Figure (2)

(i) If the effective total surface area of cross-section of the inner and outer insulation layers are A_1 and A_2 respectively, write down expressions for the rate of flow of heat through the insulation layers, $\left(\frac{\Delta Q}{\Delta t}\right)$, at the steady state in terms of d_1, d_2, k_1, k_2, A_1, A_2, θ_1, θ_2, and θ_3, where θ_1 = temperature of the oil; θ_2 = temperature at the interface between the two layers; θ_3 = room temperature. Assume that the tank is completely filled with oil and heat flow is normal to the surfaces every where.

(ii) Find the thickness d_2 that the outer insulation layer must have in order to limit the heat loss from oil to the environment in a period of 10 hours to 1 % of the total thermal energy stored per day. Perform your calculation **assuming** that the temperature of oil, remains at θ_1 = 330 °C during the 10 hour period. Take k_1 = 0.2J m^{-1} K^{-1}; k_2 = 0.03J m^{-1} K^{-1}; A_1 = 16m^2; A_2 = 17m^2; d_1 = 0.2m; θ_3 = 30°C.

(iii) If the d_2 value calculated under the assumption in part (c) (ii) above is used to construct the thermal battery, will the heat from the battery be less than or greater than the planned limit of 1%? Explain your answer.

(d) 25% of the thermal energy stored per day in the thermal battery is to be used to produce distilled water by sending water at 30 °C through a metallic spiral tube dipped in the tank as shown in figure (3) and producing steam at 100°C. The steam is condensed using a heat exchanger. Calculate the number of litres of distilled water that can be produced per bay if the efficiency of this process is 50%. Specific latent heat of vaporization of water is 2.25× 106 Jkg^{-1}. Specific

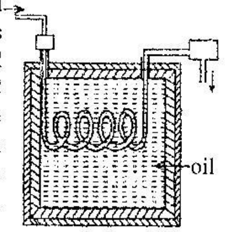


Figure (3)

heat capacity of water is 4200 J kg^{-1} K^{-1}
(1 kg of water ≅ 1 liter)

(B) Write down the expression for the Stefan-Boltzmann law of blackbody radiation. Identify each quantity of the above expression.

(a) (i) The sun behaves like an idealized black body. The distance from the Sun to the surface of the earth is 1.5×10^8 km. If the intensity of solar radiation flux received on the earth from the Sun is 1000 W m^{-2}, find the temperature of the Sun's surface. Neglect the temperature of the earth compared to the surface temperature of the Sun. Take the mean radius of the Sun as 7.0×10^5 km. Stefan - Boltzmann constant is 5.67×10^{-8} W m^{-2} K^{-4}.

(ii) Hence, calculate the wavelength of the peak emission of radiation from the Sun at the above temperature. The Wien's displacement constant is 2.9×10^{-3} m K.

(iii) A satellite orbiting the earth found that the more accurate temperature of the surface of the Sun to be 5800 K. Explain briefly the reason for the deviation of your answer from this value.

(b) The sunspots are irregularly shaped small dark regions of the surface of the Sun. The dark centre of a sunspot is known as the umbra and it emits 30% of radiation compared to an equal area without sunspots on the surface of the Sun.

(i) Assuming that a sunspot also behaves as an idealized black body, calculate the temperature of the umbra of a sunspot.

(ii) Calculate the shift in the wavelength of the peak emission of radiation from the umbra compared to the wavelength of peak emission of radiation from the normal surface of the Sun.

(c) What changes in appearance would you expect to observe in the Sun if the number of sunspots per unit area of the Sun's surface increases **significantly?** Explain your answer using the blackbody radiation spectrum.

Provision al Scheme of Marking

2014 - Answers

Question	Answer	Question	Answer
01	5	26	4
02	3	27	1
03	3	28	2
04	4	29	1
05	5	30	2
06	4	31	2
07	3	32	4
08	1	33	5
09	1	34	3
10	1	35	5
11	4	36	5
12	2	37	2
13	4	38	4
14	2	39	3
15	4	40	2
16	2	41	5
17	5	42	2
18	4	43	1
19	1	44	1, 2, 3, 4, 5
20	3	45	1
21	2	46	1, 2, 3, 4, 5
22	2	47	3
23	3	48	4
24	3	49	3
25	1	50	5

G. C. E (Advanced Level) Examination, August 2014

PHYSICS - I

Provision al Scheme of Marking

A - PART

1. (a) Check Whether there is a zero error in the vernier calliper.
OR
Move the external Jaws until they touch each other to see. Whether the zero mark of the two scales are on the same line.
OR
Determine the value of the least count
ony one (01)

(b) $d = \frac{M}{V}$ OR density $= \frac{\text{mass}}{\text{Volume}}$ (01)

(c) 1- Zero error
2- Height (external / outer length of container)
All (01)

(d)

Figum	Reading of the venier calliper	Correct reading	Name of the measurement
(i)	0.02 / 0.2mm	[redacted]	Zero error
(ii)	2.02 / 20.2mm	2.00 /20.0mm (x_1)	Outer diameter
(iii)	1.62/ 16.2 mm	1.60/16.0mm (x_2)	inner diameter
(iv)	3.02/ 30.2mm	3.00/30.2mm (x_3)	depth
(v)	3.54 / 35.4 mm	3.52/35.2mm (x_3)	height

correct complete tabale (04)

(e) (i) $V = \pi\left[\left(\frac{X_1}{2}\right)^2 X_4 - \left(\frac{X_2}{2}\right)^2 X_3\right]$ OR

$$V = \pi\left[\left(\frac{X_1}{2}\right)^2 - \left(\frac{X_2}{2}\right)^2\right]X_3 + \pi\left(\frac{X_1}{2}\right)^2 (X_4 - X_3)$$

$$V = \pi\left[\left(\frac{X_1}{2}\right)^2 - \left(\frac{X_2}{2}\right)^2\right]X_4 + \pi\left(\frac{X_2}{2}\right)^2 (X_4 - X_3)$$

(01)

(ii) $V = \frac{\pi}{4}\left[(2.0)^2 \times 3.52 - (1.6)^2 \times 3.0\right]$ OR

$$V = \pi\left[\left(\frac{2.00}{2}\right)^2 - \left(\frac{1.60}{2}\right)^2\right] 3.00 + \pi\left(\frac{2.00}{2}\right)^2 (3.52 - 3.00)$$
OR
$$V = \pi\left[\left(\frac{2.00}{2}\right)^2 - \left(\frac{1.60}{2}\right)^2\right] 3.52 + \pi\left(\frac{1.60}{2}\right)^2 (3.52 - 3.00)$$

$V = 4.8\ cm^3$ OR $4.8 \times 10^3\ mm^3$ OR $4.8 \times 10^{-6}\ m^3$
OR (01)

$V = 4.76 cm^3$, $4.76 \times 10^3 mm^3$ $4.76 \times 10^{-6}\ m^3$

(f) $d = \frac{9.6}{4.8}\ 9\ cm^{-3}$ OR $\frac{9.6}{4.76}\ g\ cm^{-3}$

$d = 2000\ kg\ m^{-3}$ (2010 - 2020) $Kg\ m^{-3}$ (01)

2. (a) level : A (01)

Reasons :
(i) To minimize the candensation of water vapour on the inner wall of the container OR
To reduce the exposed area of the container to air.
(ii) Readings Can be taken over a longer period of time.
(iii) To make sure that the heating element is submerged throughout the experiment.
(iv) To have a higher accaracy in the measurement of mass of vapour any two (01)

(b) By reducing the heat loss due to radiation, convection and Conduction.

(c) Resistance/ Resistivity, decreases with temperature.
Resistance / Resistivity, has negative temperature coefficient electrical Conductivity /Conduetance, increases with temperature any onw (01)

(d) $Q = mL$
$Pt = (M_0 - M_1)\ L$
$L = \frac{Pt}{(M_0 - M_1)}$ (01)

(e) (i) $\frac{0.1}{M_0 - M_1} = \frac{1}{100}$

Minimum mass of $(M_0 - M_1) = 10\ g$ (01)
$(10^{-2} kg)$

(ii) $Pt = (M_0 - M_1)_{min} \times L$

$$t = \frac{(m_0 - m_1)_{min} \times L}{P}$$

$$t = \frac{(10 \times 10^{-3}) \times 2.3 \times 10^6}{500}$$ (01)

$t = 46\ s$ (01)

(f) $m = (M_0 - M_1) = (P/L)\ t$

Gradient $= \frac{(106 - 26)\ 10^{-3}}{(8 - 2) \times 60}$ OR $\frac{100 - 26}{8 - 2}$ (01)

$$= \frac{40 \times 10^{-3}}{3 \times 60}$$

$$\therefore\ P/L = \frac{40 \times 10^{-3}}{3 \times 60}$$

$$L = \frac{3 \times 60 \times 500}{40 \times 10^{-3}}$$

$L = 2.25 \times 10^6 J\ kg^{-1}$ (01)

3. (a) (i) Telescope
(ii) Prism table (01)

(b) (i) Eyepiece:

The eye piece should be moved in and out adjusted until the cross wires are seen clearly. (01)

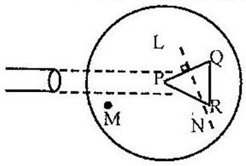
(ii) Telescope

Ajust the telescope to obtain a clear image of a distant object. (01)

(iii) Collimator

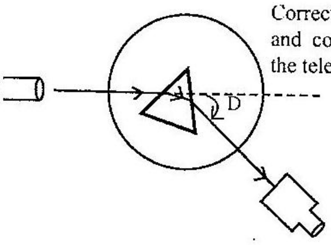
The telescope is brought in line with the collimator and the collima for is adjusted while looking through the telescope (or cross wires) Until a clear image of the slit is seen on the cross wires. (01)

(c)



PQ, (or QR or RP) is Perpendicular to the LN P (cor Q or R) Should be the prism table. (01)

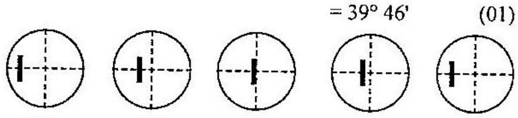
(d) (i)



Correct Ray diagram and correct position of the telescope. (01)

(ii) Angle of minimum deviation D = 183° 15' - 143° 29'
= 39° 46' (01)

(e)



if both positions are correct (01)

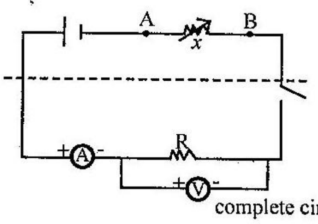
(f) $n = \dfrac{\text{Sin}\left(\frac{A+D}{2}\right)}{\text{Sin}\,A/2}$ (01)

(g) $n = \dfrac{\text{Sin}\left(\frac{60 + 39^\circ 46'}{2}\right)}{\text{Sin}\,60/2}$

$= \dfrac{Sin\,49^0\,53^1}{Sin\,30^0}$

$= 1.529\ (1.52 - 1.53)$ (01)

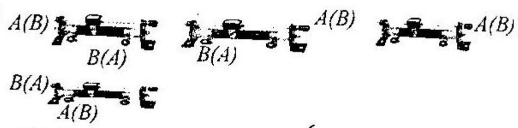
4. (a) (i)



complete circuit diagram (01)

(ii) + and - signs marked as shown across both the Ammeter and voltmeter terminals. (01)

(b)



(c) Maximum Current : $I_{max} = \dfrac{6}{500}$

$= 12\text{ mA}$ OR 0.012 A (01)

minimum current $I_{min} = \dfrac{6}{2500 + 500} = \dfrac{6}{2500}$

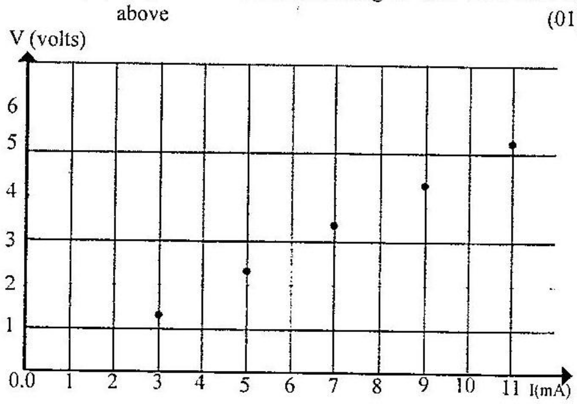
$= 2.4\text{ mA}$ OR 0.0024 A (01)

(d) Choice : 15 mA

reasons : It provides the maximum accuracy for measurement
OR error / fractinonal error will be small
OR the readings will be accurate
OR it use the major part of the scale
OR If is the most sensitive ammeter. (01)

(e) (i) Value of the readry : 4.3V [4.25 - 4.30v] (01)
Maximum estimated error in the measurement : 0.05V

(ii) Preper selection and labeling of axes with units as above (01)



making all the date points correctly (01)

(f) $\dfrac{RR_i}{R + R_i} = 480$ OR $\dfrac{5000R}{R + 5000} = 480$ (01)

$5000R = 480R + 5000 \times 480$

$4520R = 5000 \times 480$

$R = \dfrac{5000 \times 480}{4520}$

$R = 531\,\Omega$

$(530 - 532\,\Omega)$

PART - B

5. (a) (i) R = W (01)
(ii) $P \circlearrowleft 10W_L + 8F_s \sin\theta_s - 18R = 0$ (01)
Substituting R = W and $W_L = 0.2$ W
$2W + 8F_s \sin\theta_s - 18W = 0$
$F_s \text{Sin}\,\theta_s = 2W$ (01)

$\left[\text{OR } F_S = \frac{0.8W}{Sin\theta_S - 3Cos\theta_S}\right]$

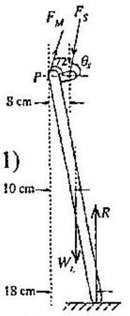


diagram (3)

(iii) $\uparrow y = o$

$F_M \text{ Sin } 72° + R - F_S \text{ Sin } \theta_S - W_L = 0$ (01)

$F_M \text{ Sin } 72° + W - 2W - 0.2W = 0$

$F_M \text{ Sin } 72° = 1.2W$

$F_M = \frac{1.2W}{0.9}$

$F_M = \frac{4W}{3}$ OR $F_M = 1.33W$ (01)

(iv) $\rightarrow X = 0$

$F_S \text{ Cos } 72° = F_S \text{ Cos } \theta_S$ (01)

$\frac{F_S Sinqs}{F_S Cosqs} = \frac{2W}{F_M Cos 72^\circ}$

$\tan\ \theta_S = \frac{2W}{\frac{4W}{3}} \times 0.3$

$\tan\ \theta_S = 5$

$\theta_S = \tan^{-1}(5)$

$\theta_S = 78^\circ\ 41' \left(78^\circ\ 40' - 78^\circ\ 42'\right)$ (01)

(v) $F_S\ \text{Sin}\ \theta_S = 2W$

$F_S\ \text{ Sin } 78°\ 41' = 2W$

$F_S = {}^{2W}/_{1}$

$F_S = 2W$ (01)

$(1.96W - 2.00W)$

(b) (i) P ↻ $7F_S' + 6.25\ W_L - 10\ R = 0$ (01)

$7Fs' = 10W - 6.25 \times 0.2W$

$F_S' = \frac{10W - 1.25W}{7}$

$F_S^1 = \frac{8.75}{7} W$

$F_S' = 1.25W$ (01)

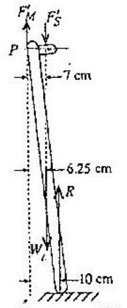


diagram (5)

(ii) Percentage reduction of the magnitude of Fs,

$= \frac{2W - 1.25W}{2W} \times 100\%$

$= \frac{0.75}{2} \times 100\ \%$

$= 37.5\%$ (01)

(C) (i) $\tau = I\alpha$; $\tau = F \times r$

$\tau = W_L \times {}^{\ell}/_{2}\ \text{Sin}\theta$

$W_L {}^{\ell}/_{2} \text{Sin}\theta = I\ \alpha$

$\alpha = \frac{W_L \ell Sin\theta}{2I}$ OR $\alpha = \frac{0.1W\ell.Sin\theta}{I}$

(01)

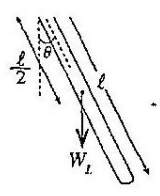


diagram (5)

(ii) $T = 2\pi\sqrt{{}^{2\ell}/_{3g}} = 2\pi\sqrt{\frac{2 \times 0.9}{3 \times 10}} = 2 \times 3 = \sqrt{0.06}$ s

T = 1.5 S (π =3.14 ; T = 1.575) (01)

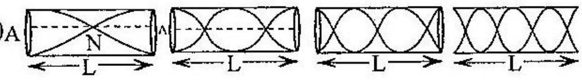
(iii) most effortless speed for the person $= \frac{0.9}{T}$ (01)

$= \frac{0.9}{1.5}$

$= 0.6\ ms^{-1}$ (01)

(If π is taken 3.14 the An swer 0.575 ms^{-1})

6. (a)



←L→ ←L→ ←L→ ←L→

$L = {}^{\lambda}/_{2}$ $\quad L = \lambda$ $\quad L = \frac{3\lambda}{2}$ $\quad L = \frac{4\lambda}{2}$

$f_0 = \frac{V}{2L}$ $\quad f_1 = \frac{V}{L}$ $\quad f_2 = \frac{3V}{2L}$ $\quad f_3 = \frac{4V}{2L}$

Drawing correct standing wave patterns & identifying the node (N) and the antinode (A) in the fundamental mode (01)

Correct standing wave patterns for three overtones (01)

Correct expressions for frequencies (01)

(b) $f_0 = {}^{V}/_{2L}$ (01)

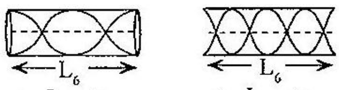
$L_6 = \frac{340}{2 \times 262}$

$= 0.6489m = (6.49 \pm 0.01)10^{-1} m$ OR 0.65 m (01)

$L_2 = \frac{340}{2 \times 392}$

$L_2 = 0.4337m = (4.34 \pm 0.01)10^{-1} m$ OR 0.43 m (01)

(c)



←L_6→ ←L_6→ (02)

$L_6 = \lambda$ $\quad L_6 = 2\lambda$

$f' = {}^{V}/_{L_6}$ $\quad f'' = \frac{2V}{L_6}$ (02)

(d) (i) Frequencies of first four standing wave patterns is in part (C)

$\frac{V}{L_6}, \frac{2V}{L_6}, \frac{3V}{L_6}, \frac{4V}{L_6}$

(01)

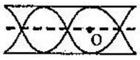
(ii) Frequencies of first four standing wave patterns in part (a)

$\frac{V}{2L_6}, \frac{2V}{2L_6}, \frac{3V}{2L_6}, \frac{4V}{2L_6}$

frequencing of part (c) is always equel to 2 x frequencies part (a)

OR

Inclusion of a small hole has removed 1st, 3rd, 5th... (or oda) harmonics of the open tube. (01)

(e) 

(01)

$L_2 = \frac{3\lambda}{2}$

$\lambda = \frac{2L_2}{3}$

$V = f\lambda$

$f_2 = \frac{3V}{2L_2}$

$f_2 = \frac{3 \times 340}{2 \times 0.4337}$

$= 1175.9\text{Hz}\ (1172 - 1178\,Hz)$ (01)

7\. (a) (i) Water repellent window glasses.
(ii) Self cleaning paints.
(iii) Self cleaning cloths / shoes.
(iv) low - drag marine vessels any three (01)

(b) Spherical water bubbles/ drops are formed due to non - wetting (water repellent) property of the surface. (01)

They roll of the surface at the slightest disturbance collecting dirt and dust. (01)

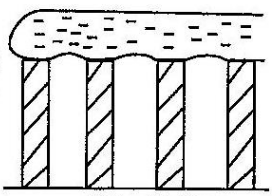
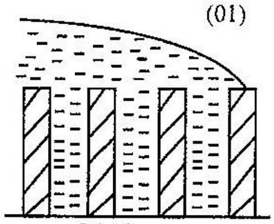
(c) Contact angle of water, $\theta < 90$ hydrophilic
$90° < \theta < 150°$ hydro phobic
$150° < \theta$ Super - hydrophobic

(01)

(d)  

Wetting angle of contaet < 90 Non - Wetting angle of contact > 90°

(01)

(e)  

Nan - Wetting Wetting

liquid should not be in pores. (01)
Angle contact should be as shown above (01)

liquid should fill the pores (01)

(f) Yes

Compared to the size of the pores the water molecules are very small in size and thus can condense in the pores. (01)

(g) Non - Wetting water repellent nature reduces. the adhesirity (sticky nature) of water to the surface. (01)

There fore, the friction against the motion of the vessel in water is reduced. (01)

(h) nanorods, nanotubes, nonowires. any two (01)

(j) $C_n = \frac{A_n \varepsilon_o}{d}$ —— ①

$C = \frac{A \varepsilon_o}{d}$ —— ②

$\frac{C_n}{C} = \frac{A_n}{A} = \frac{x + x \times 10^{13} \times \pi d\ell}{x}$

$\frac{C_n}{C} = 1 + 10^{13} \times \pi \times 100 \times 10^{-9} \times 50 \times 10^{-6}$ (01)

$\therefore \frac{C_n}{C} = 1 + 50\pi$

$= 151\ (\pi = 3)$ OR $158\ (\pi = 22/7)$ (01)

$(158 - 158.2)$

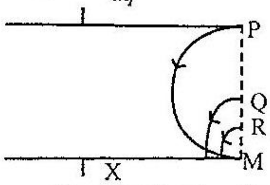
8\. (a) $\frac{mV^2}{R} = BqV$ $\left[F = m\frac{v^2}{r} \quad Bqv = m\frac{v^2}{R} \right]$ (01)

$R = \frac{mV}{Bq}$

(b) $R = d/2$

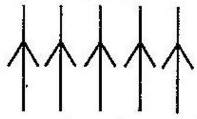
$\therefore \frac{d}{2} = \frac{mV}{Bq}$ (01)

$B = \frac{2mV}{dq}$ (01)



For correct paths of ions entering from P and Q (01)
For Correct path of ion entering from R (01)

(c) (i) Direction of the electric field ↑
OR vertically upward (01)

OR  drawn in the diagram .

(ii) Because there is an additional force acting on the ions due to the electric field and the resultant force is not always perpendicular to the velocity of the ions. (01)

(iii) E - electric field
$F = qE$ $[F = Bqv]$
$\therefore BqV = qE$ (01)
$V_0 = Ed$ (01)
$\therefore V = \frac{V_0}{Bb}$ $\left[E = \frac{V_0}{d} \right]$ (01)

(d) (i) Speed of blood flow at X ; $v_x = \frac{2.16 \times 10^{-4}}{0.08 \times 3 \times 10^{-3}}$ (01)

$V_x = 0.09\ ms^{-1}$ (01)

(ii) Applying the eq. of Continuity
$A_1 V_1 = A_2 V_2$

$$\pi \frac{d_x^2}{4} \times V_x = \pi \frac{d_y^2}{4} = V_y \quad (01)$$

$$\frac{V_x}{V_y} = \frac{d_y^2}{d_x^2} = \frac{V_x}{B_x d_x} \times \frac{B_y d_y}{V_y}$$

$$dy = \frac{V_x B_y}{V_y B_x} \times d_x$$

$$\upsilon_y = \frac{V_y}{B_y d_y}$$

$$dy = \frac{d_x^2 B_y \upsilon_x}{V_y}$$

$$dy = \frac{\left(3 \times 10^{-3}\right)^2 \times 0.9 \times 0.05}{1.80 \times 10^{-4}}$$

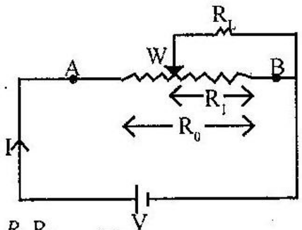
$dy = 2.25 \times 10^{-3} m$ (01)

OR 2.25 mm (01)

$$dy = \frac{2.16 \times 10^{-4} \times 0.05}{1.80 \times 10^{-4} \times 0.08} \times 3 \times 10^{-3} \quad (01)$$

$dy = 2.25 \times 10^{-1} m$ OR dy = 2.25mm (01)

9. (A) a (i) $\frac{1}{R_W} = \frac{1}{R_1} + \frac{1}{R_L}$



$$\frac{1}{R_W} = \frac{R_1 + R_L}{R_1 R_L}$$

$$R_W = \frac{R_1 R_L}{R_1 + R_L}$$

$$\therefore R_{AB} = R_0 - R_1 + \frac{R_1 R_L}{R_1 + R_L} \quad Ⓐ \quad (01)$$

(ii) $R_{AB} = R_0 - R_1\left(1 - \frac{R_L}{R_1 + R_L}\right)$

maximum R_{AB} ; When $R_1 = 0$

$= R_{max} = R_0$ (01)

minimum R_{AB} ; When $R_1 = R_0$

[Second term in the expression in maximum]

$$R_{min} = \frac{R_0 R_L}{R_0 + R_L} \quad (01)$$

OR effect of having R_L in parallel with R_1 is reduce the effective value of R_1. There fore when R_L is not in the circuit the potentional divider has its maximum resistance across AB which is equal to R_0 (01)

This effect is maximum When $R_1 = R_0$ and the effective resistance has its minimum value

$$R\min = \frac{R_O R_L}{R_O + R_V} \quad (01)$$

(iii) (01)

$$\frac{\frac{R_0 R_L}{R_0 + R_L}}{R_0} = \frac{99}{100} \quad \text{OR} \quad \frac{R_L}{R_0 + R_L} = \frac{99}{100}$$

$100R_L = 99R_L + 99 \times 5000$

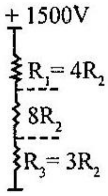
$R_L = 495$ KΩ (01)

(b) (i) $V_{R_2} = V$, then

4V + 8V + 3V = 1500 (01)

15V = 1500

V = 100 V



V = IR

$100 = 1 \times 10^{-3} \times R_2$

$R_2 = 100$ kΩ (01)

$R_1 = 400$ kΩ (01)

$R_3 = 300$ kΩ (01)

(ii) When the electrode is connected, the current through $R_3 = 995\mu A$ (01)

$\therefore$ Change (ΔV) in the voltage drop across R_3 is given by

$\Delta V - IR = V$

$\Delta V \quad - 995 \times 10^{-6} \times 300 \times 10^3 = 300$ (01)

$\Delta V \quad = (300 - 298.5)$ V

$\Delta V \quad = 1.5$V (01)

OR $\Delta V \quad = \Delta I \times R$ (01)

$= 5 \times 10^{-6} \times 300 \times 10^{+3}$ (01)

$\Delta V \quad = 1.5$V (01)

(c) (1) Q $= cV$

$\Delta Q = 5 \times 10^{-6} \times 1 \times 10^{-6}$

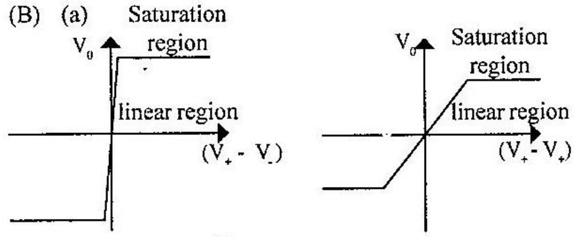
$= 5 \times 10^{-12}$ C (01)

(2) $\Delta V = \frac{\Delta Q}{C}$ (01)

(3) $= \frac{5 \times 10^{12}}{0.05}$

$= 10^{10}$F (100PF) (01)

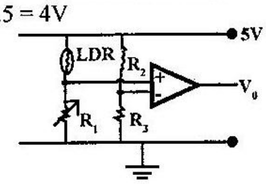
(B) (a)



(b) (i) $\frac{R_2}{R_3} = \frac{V_{R_2}}{V_{R_2}}$ OR $R_2 = \frac{1.5 \times 7000}{3.5}$ (01)

$\therefore R_2 = 3000\Omega$ (01)

(ii) In order to achieve +10V at the output V_0, Voltage at V+ input should be equal to 3.5 + 0.5 = 4V (01)



$$\therefore \frac{R_1}{R_{LDR}} = \frac{4}{1} \text{ OR } R_1 = 4 \times 500$$

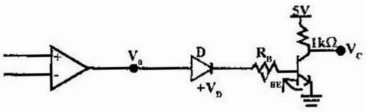
$R_1 = 2000\Omega$ (01)

(iii) $R_{LDR} = 10^5\Omega$ (Very large)

the voltage V_+ becomes smaller than 3.5V (Or V_-)

There fore $V_0 = -10$V (01)

(c)



(i) $V_0 = V_D + I_B R_B + V_{BE}$

$10 = 0.7 + 50 \times 10^{-6} \times R_B + 0.7$ (01)

$R_B = \frac{8.6}{50\times10^{-6}}$

$R_B = 1.72 \times 10^5 \Omega$ (01)

(ii) $I_C = \beta I_B$

$I_C = 100 \times 50 \times 10^{-6}$

$I_C = 5$ mA (01)

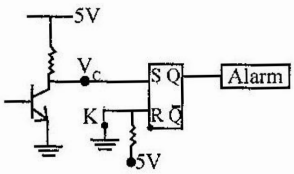
$V_C = 5 - I_C R_C$

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

$V_C = 0$ (01)

(iii) (1) Potential difference across the diode = 10 V (01)
(2) Collector Voltage under this condition = 5V (01)

(d)



(i) Input logic levels when light fall on LDR S = 0 , R = 0
Input logic levels when intruder crosses the beam
S = 1, R = 0
(01)

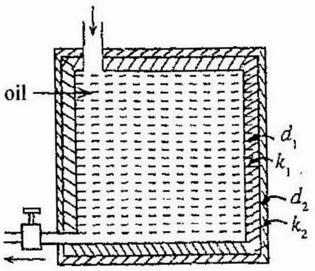
(ii) Alarm sounds continuously since it does not recieve a reset signal (S = 0 and R = 1) to reset the Alarm **OR** Conect truth table. (01)

10.(A) (a) Rate at which solar energy is incident on the dise $= \pi r^2 \times E$ (01)
$= 3 \times 100 \times 1000$
$= 3 \times 10^5$ W (01)

(b) Energy stoered in oil per day

$= 3 \times 10^5 \times 6 \times 60 \times 60 \times \frac{60}{100}$ (01)
$= 3.89 \times 10^9$ J (01)

(c)



(i) $\frac{\Delta Q}{\Delta t} = K_1 A_1 \frac{(\theta_1 - \theta_2)}{d_1}$ —(A) (01)

$= K_2 A_2 \frac{(\theta_2 - \theta_3)}{d_2}$ —(B) (01)

(ii) $\frac{\Delta Q}{\Delta t} = \frac{5 \times 10^9}{10 \times 60 \times 60} \times \frac{1}{100}$ (01)

$= 1.39 \times 10^3$W

(A) and (B)

$\theta_1 - \theta_2 = \frac{\Delta Q}{\Delta t} \cdot \frac{d_1}{K_1 A_1}$ —(1)

$\theta_2 - \theta_3 = \frac{\Delta Q}{\Delta t} \cdot \frac{d_2}{K_2 A_2}$ —(2) (01)

(1)+(2)

$\theta_1 - \theta_3 = \frac{\Delta Q}{\Delta t}\left[\frac{d_1}{K_1 A_1} + \frac{d_2}{K_2 A_2}\right]$ (01)

$300 = 1.39 \times 10^3 \left[\frac{0.2}{0..2\times16} + \frac{d_2}{0.03\times17}\right]$ (01)

$d_2 = 0.078$ m $(7.8\ cm)$

$(7.80 - 7.83\ cm)$ (01)

OR (A) $\Rightarrow 1.39\times10^3 = 0.2 \times 16 \frac{(330 - \theta_2)}{0.2}$ 01 $330 - \theta_2 = 86.88$ $\theta_2 = 243.12$ °C 01 (B) $\Rightarrow \frac{\Delta Q}{\Delta t} = K_2 A_2 \frac{(\theta_2 - \theta_3)}{d_2}$ $1.39 \times 10^3 = 0.03 \times 17 \times \frac{(243.12-30)}{d_2}$ (01) $d_2 = \frac{0.03 \times 17 \times 213.12}{1.39 \times 10^3}$ $d_2 = 0.078$m (01)

(iii) Heat loss from the battery will be less then the planned value becaues, the temperature of oil decreases with time, and the rate of heat loss becomes smaller. (01)

(d) M - mass of the distilled water produced per day

$5 \times 10^9 \times \frac{25}{100} \times \frac{50}{100} = M\left(2.25 \times 10^6 + 4200 \times 70\right)$

$6.25 \times 10^8 = M \times 2.544 \times 10^6$ LHS (01) RHS (01)

$\therefore$ M $= 245.68$ kg

$= 245.7\ell$

$(245 - 246.5)$ (01)

(B) $E = \sigma T^4$ **OR** $E_t = \sigma A T^4$ (01)

E = Total radiated power per unit Surface area of black body
σ = Stefan (-Boltzmann) Constant
T = Surface temperature in kelvins (K)

E_t = Total radiated power
A - Surface Area (01)

(a) (i) If the radius of the sun is r, the total power radiated from the surface of the sun

$\sigma = 4\pi r^2 \times T^4$

$= 5.67 \times 10^{-8} \times 4\pi \times (7.0 \times 10^8)^2 \times T^4$ (01)

If the distance from the sun to the surface of the earth is d, the intensity of the solar radiation flux at earth surface

$$= \frac{\sigma 4\pi r^2 T^4}{4\pi d^2}$$

$$1000 = \frac{5.67 \times 10^{-8} \times 4\pi \left(7.0 \times 10^8\right)^2 \times T^4}{4\pi \left(1.5 \times 10^{11}\right)^2} \quad (02)$$

$$\therefore T^4 = 1000 \times \left(\frac{1.5 \times 10^3}{7}\right)^2 \times \frac{1}{5.67 \times 10^{-8}}$$

$$= \left(\frac{0.3}{1.4}\right)^2 \times \frac{1}{5.67} \times 10^{17}$$

$$\therefore T = \left[\frac{1}{196} \times \frac{1}{0.63}\right]^{1/4} \times 10^{16}$$

$= 5334.5\ K$ (01)

(ii) From wein's law $\lambda_m T = C = 2.9 \times 10^{-3}$ (01)

$$\therefore \lambda_m = \frac{2.9 \times 10^{-3}}{5335}$$

$\therefore \lambda_m = 5.44 \times 10^{-7} m$ (01)

$(5.43 - 5.44)$

(iii) Calculated temperature is lower because the radiated power loss due to earth atmospheric absorption has not been considered in the Calculation (01)

(b) (i) If the temperature of the umbra of a sunspot is Tu Comparring with an equal area. A of normal Surface.

$$\frac{\sigma A T_u^4}{\sigma A T^4} = \frac{30}{100} \quad (01)$$

$T_u^4 = 0.3 \times 5335^4$

$T_u = 0.3^{1/4} \times 5335$

$T_u = 3948\ K$ $(3947\text{-}3949)$

(ii) $\lambda_{mu} T_u = \lambda_m T$ (01)

$$\frac{\lambda_{mu}}{\lambda_m} - 1 = \frac{T}{T_u} - 1$$

$$\Delta\lambda m = \left(T/T_u - 1\right)\lambda m \left(\frac{5335}{3948} - 1\right) \times 5.44 \times 10^{-7}$$

$\Delta\lambda = 1.91 \times 10^{-7} m$ (01)

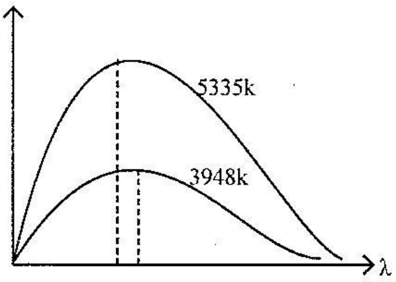
$\lambda_{mu} - \lambda_m = \frac{C}{T_{mu}} - \frac{C}{T_m}$ (01)

$$= 2.9 \times 10^{-7} \left(\frac{T_m - T_{mu}}{T_{mu} T}\right)$$

$$= 2.9 \times 10^{-7} \frac{(5334 - 3948)}{5334 \times 5948}$$

$= 1.91 \times 10^{-7} m$ (01)

(c)



Correet Two Curves (01)

Significant increase in sunspot per unit area causes λ_m **OR** red region making the sun appear reddish
Peak emission of radiation of shift more towards longer wavelengths. (01)