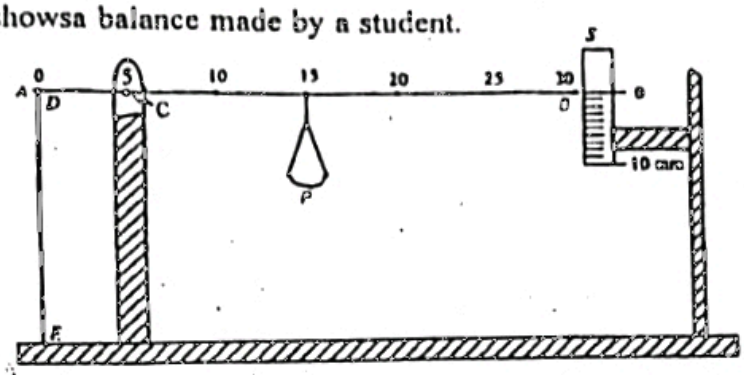
PAPER II PART A - STRUCTURED ESSAY

(1) Diagram showsa balance made by a student.



ACB - a 30 cm long thin beam having centre of gravity at the pivoted point C.
DE - a light rubber thread of circular cross section ; E is fixed and D is connected to the end A of the beam.
S - a mm scale.
P - a light pan which can be slid along CB.
The pointer at the end of the beam indicates zero on the scale S when the rubber thread is unstretched.

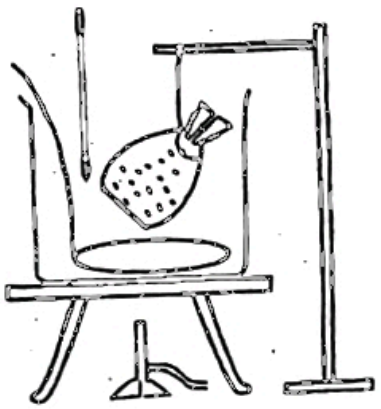
(a) When the pan P with a 10 gram weight on it is at the 15 cm mark, the reading on the scale S is 5 mm divisions. Assuming that the deflection of the beam is small and rubber obeys Hook's Law for small extensions, find
  (i) the extension of the rubber thread (in mm) *(Two lines)*
  (ii) the force on the rubber thread (in N). *(Two lines)*

(b) If the range of the soale S is 0 - 10 mm and the pan P can be moved between the 10 cm and the 25 cm marks only, find the maximum weight that can be measured using this balance . *(3 lines)*

(c) This arrangement can be used to obtain strees - strain relationship for rubber.
  (i) To calculater stress and strain in the rubber thread using values obtained in the part (a) what additional measurements do you need to make ?
  For stress :..... (X - say)
  For strain .....(Y - say)
  (ii) What are the most appropriate instruments that can be used to take these measurements ?
  X : ..... (state only one instrument)
  Y : .....(state only one instrument)
  (iii) Write down the corressponding stressand strainfor the case (a) using X and Y.
  Stress : .....
  Strain : .....

(d) If an identical second rubber thread is fixed along with the first one, what should be the position of the pan P in order to obtain the same reading of 5 mm divisions on S for the 10 g weight
.....
at .....cm mark

(2) Figure shows an experimental arrangement that can be used to determine the apparent vc of a given liquid.



(a) Mark clearly on the diagram upto what level the water should be filled in the water to perform the experiment accurately.
(b) What is the additional laboratory measuring instrument that you would require in this experiment. *(one line)*
(c) Why do you have to stir water during this experiment ? *(one line)*
(d) What are the initial measurements that you should take before heating the liquid ? *(3 measurements required, one line each)*
(e) What are the final measurements that you should take ?
(Two measurements required. one line each)
(f) State the precaution you would take before obtaining the measurements indicated in (e) *(4 lines)*
(g) Why is it necessary to have a bottle with a narrow opening in this experiment ? *(3 lines)*

(h) An expression for the apparent volume expansivity (γ_{ap}) of the liquid can be given as follows.

$$\gamma_{ap} = \frac{(X - Y)}{(Y - Z)\,(\text{temperature difference})}$$

Relate the symbols X, Y and Z in the above expression to the measurements taken under (*d*) and ( ). *(3 lines)*

(i) Suppose the above experiments is carried out with a similar bottle made of a metal, Will you obta the same value for γ_{ap} ? Explain your answer. *(3 lines)*

(3) A student has constructed an astronomical telescope using two convex lenses, A and B, of focal length 5 c and 100 cm respectively.

(a) Which lens has to be used as the objective ? *(One line)*

(b) (i)Usually it is convenient to use a telescope in **normal adjustment** to view an object, state the reason f this. *(One line)*

(ii) When the telescope is used in normal adjustment position, where will the final image e formed ? *(One line)*

(iii) What is the magnifying power of the telescope in normal adjustment when viewing a dist object ? *(One line)*

(c) (i) Calculate the distance between the eye - piece and the best position of the eye to be placed, wh viewinga distant object through the above mentioned telescope in normal adjustment. *(3 lines)*

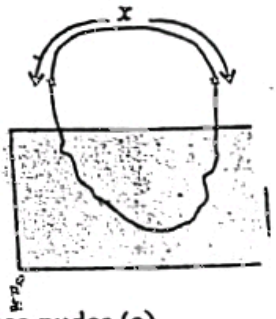
(ii) What is the advantage of placing the eye at the location mentioned in c (i) above? *(One line)*

(d) An illuminated metre scale shown in figure (A) below is placed in front of the objective of a cert astronomical telescope so that the 50 cm scale mark is perpendicular to the principal axis of the lenses. The enlarged scale (without the numbers) when viewed through the telescope is shown in fig (B)

(i) What is the linear magnification of the image ? *(one line)*

(ii) Indicate correctly on the fig. (B) how the number '50' appears in the image . (the number is required to be drawn to the correct magnification)

(4) A uniform resistive wire of total length L is joined end to end so as to form a loop. part ofthis loop is inside an insulating block and only a portion of the loop is seen outside the block as shown in the figure.



By measuring the effective resistance R between any two outside points of length x of the loop, it is intended to determine the totla length of the wire L and the resistivity of the material of the wire.

(a) State the usual laboratory method that can be used for the accurate determination of R. (Ohmmeter o multimeter will not be accepted as an answer). *(One line)*

(b) Draw a clear circuit diagram of the experimental arrangement which you would use nuder (a) *(5cm available)*

(c) Write down an expression for R in termsof the resistance per unit length of the wire k, L and x. *(3 line*

(d) (i) Re- arrange the variables of the above expression to get $\frac{R}{x}$ on the left hand side. *(2 lines)*

(ii) What quantities would you choose for the axes to obtain a straight line graph with the expres obtained in d (i) ?

For Y axis .....

For X axis .....

(e) (i) From the above graph, how would you obtain thevalues for k and L ?

k : .....

L : .....

(ii) After obtaining a value for k, what additional measurement is needed to calculate the resistivity material of the wire ? *(One line)*

(f) In such an experiment, when plotting the graph mentioned in d (ii), a student obtained a straigl parallel to the X axis. Give the reason for this. *(One line)*

1. Answer either part (a) or part (b).

(a) An ice skater A of total mass 65 Kg (including his helmet) slides freely on a frictionless frozen lake in a straight line with a velocity of 2 ms^{-1} .While moving. A throws his helmet weighing 5 kg horizontally with a velocity of 4 ms^{-1} in a direction perpendicular to his direction of motion.

(i) Find the magnitude of the resultant velocity of A after trowing the helmet.

(ii) Another skater B of mass 45 kg sliding freely in the opposite direction on a nearby parallel course with a velocity 1 m s^{-1} catches the helmet thrown by A. After catching the helmet, find the new velocity of B in.

(a) the original direction of motion of B.

(b) the direction perpendicular to the original direction of motion of B.

(iii) Calculate the total kinetc energy of the helmet and the skater B just before B catches the helmet.

(iv) Calculate also the total kinetic energy of the helmet and the skater B after B catches the helmet.

(v) Explain briefly why the two values calculated in (iii) and (iv) above are different.

(vi) After some time the helmet falls off freelyfrom the skater B, what will happen to the velocity of B ? Explain your answer.

(b) The average rate at which the solar energy falls on the surface of the earth is 1 kW m^{-2}

(i) Calculate the average power received by sri Lanka from the sun in MW.

Area of Sri Lanka = 65 000 km^2

(ii) Suppose, in an average, a home in a village uses five 40 W bulbs for 3 hours daily, and also consumes 1.4 kW-hours daily to operate other electrical appliances, Calculate the daily energy requirment for 100 such homes in a village.

(iii) A project is planned to use solar panels to generate the energy requirement calculated in (ii) , If solar panels convert sunlight to electricity with 10% efficiency, and the average power generation period of solar panels is 5 hours per day calculate the total area of the solar panels needed to fulfil the energy requirement of the village. Assume that the solar panels are placed parallel to the earth surface. and capable of delivering electrical energy to bulbs and other appliances with 80% efficiency.

(iv) At present the total electrical power generation capability in Sri Lanka stands at 1400 MW. If this value is to be increased to 2 000 MW using solar panel based power generators, calculate the total area of the solar panels needed for this purpose.

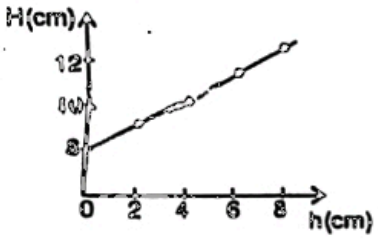
2. A vertical narrow tube carriesa soap bubble of radius 0.1 cm at its lower end, and the air inside the bubble is trapped by a column of the soap solution of length 1 cm as show in the figure.

Take density of the soap solution as 1000 kg m^{-3}

(i) If the angle of contact at both menisci of the liquid column is zero, calculate the surface tension of the soap solution.

(ii) When the soap bubble is broken it was found that the maximum length of the column of the soap solution that can be kept inside the vertical tube without falling is 3 cm. Calculate the internal radius of the tube.

(iii) Now the soap column is removed and the tube is partially dipped in a liquid so that its lower end is at a depth h below the liquid surface. when the air pressure inside the tube is then gradually increased, and measured with a manometer it is found that the maximum level difference of the manometer liquid, that can be achieved is H. If the variation of H with h is as shown in the figure, calculate the surface tension of the liquid.



Density of the manometer liquid = 6.0 x 10^2 kg m^{-3}

3. A cylindrical steam boiler made of a material of thermal conductivity 2.1×10^3 m^{-1} k^{-1} has a flat circul bottom of thickness 1 cm and cross- sectional area 10^2 cm^2. The bottom of the boiler is heated uniform by a gas burner. At the steady state the boiler generates steam (at 100°C) at a rate of 40 g s^{-1} Heat loss to the surroundingscan be neglected.

(i) Calculate the temperature of the flame of the burner assuming that it is the same as the temperature the outer surface of the bottom of the boiler.

Specific latent heat of vaporization of water = 2.27×10^6 J kg^{-1}

(ii) After a long usage of the boiler a thin uniform material layer is formed on the inner surface of tl bottom and as a result, steam generation rate is reduced to 20 g s^{-1} . If th thickness of the material layer is 0.1 cm , calculate its thermal conductivity. (Use only standard formulae in the calculation)

(iii) Suppose the steam boiler, after removing the above mentioned material layer, is to be converted into hot water generator. Hot water at 60 °C is to be taken out continuously from this boiler at a constant rate while feeding in cold water at 30 °C at the same rate. Calculate the maximum rate at which the h water at 60 °C can be taken out from the boiler.

Specific heat capacity of water = 4.18×10^3 J kg^{-1} k^{-1}

4. A cylinder of volume 0.01 m^3 contains helium gas (relative atomic mass = 4) at a pressure of 1.5×10^6 N m^{-2} and it is used to fill small balloons made of unstretchable thin plastic material. The balloons are collapsible and each has a maximum volume of 2×10^{-3} m^3.

(i) Suppose such a balloon is filled with helium gas upto its maximum volume at a pressure equal to tl atmospheric pressure, ie. 1×10^5 N m^{-2} . If the temperature of the gas is 27 °C , calculate the mass of the gas in the balloon.

(ii) Calculate how many balloon can be filled properly with the gas cylinder at 27 °C.

(iii) One of the gas filled balloons is now exposed to an atmosphere with cooler climatic conditions having a temperature of 2°C. Calculate the volume of the balloon at 2°C, Assume that the pressure inside th balloon remains constant, and is equal to the above mentioned atmospheric pressure.

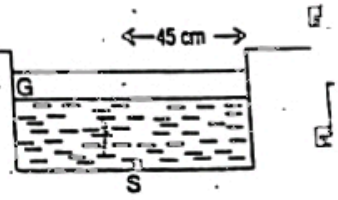
(iv) If the mass of the material of the balloon is 1.5 g show that the balloon will rise up when it is released in an atmosphere mentioned in (iii)

R = 8.3 J mol^{-1} K^{-1}

density of air at 2°C = 1.3 Kg m^{-3}

5. Answer either part (a) part (b)

(a) Figure shows a vertical cross section of a shallow circular pond covered with a thick glass plate (G) of thickness 4 cm and refractive index 3 /2. The pond contains water upto the lower surface of the glass plate, and a point source of light S is placed at the bottom of the pond as shown. Depth of water in the pond is 30 cm and the refractive index ofwater is 4/ 3.



(i) A person when looking at the pond from above sees a circular patch of light. Explain briefly how a circular patch of light is formed.

(ii) Using only the standard laws of refraction and geometry calculate the radius of the circular light patch seen on the glass plate.

(iii) What will happen to the diameter of the circular patch of light when another layer of water i placed on the glass plate ? Briefly explain your answer.

(iv) If the radius of the pond is 45 cm calculate the minimum thickness of a water layer needed in (iii) to make sure that the light patch covers its entire top surface.

(b) Write down the main advantage of viewingan object with both eyes.

A certain far sighted person cannot see objects closer than 275 cm from his eyes clearly.

(i) What type of spectacle lens will bring objects situated at 25 cm from his eyes into focus ? Find th focal length of these lenses.

(ii) If the distance between the eye lens and the retina is 2.5 cm , what is the focal length of the eye lens when viewing the object mentioned in (i) with the spectacles on .

(iii) Later, the person decides to remove his eye lenses and replace them with artificial lenses. Fc proper vision of distant objects what should be the focal length of the implanted artificial lenses ?

(iv) Does he have to wear spectacles for normal reading even after the above mentioned implantation ? Explain your answer.

(v) If the answer is 'yes' to part (iv) above, what type of spectacle lens does he have to wear, for a reading distance of 30 cm ? Find the focal length of these lenses.

6 Write down an expression for the velocity of sound in a material in terms of the young's modulus E and the density d of the material.

A sonometer wire is stretched over two bridges separated by 1 m by hanging a weight W, and it is found that the resulting strain in the wire is 0.25 % . If the wire is struck so as to form 2 loops between the two bridges, it makes 4 beats per second with a tuning fork vibrating at a frequency 256 Hz. It is also found that when the weight W is gradually immersed in water the beat ferquency is diminished .

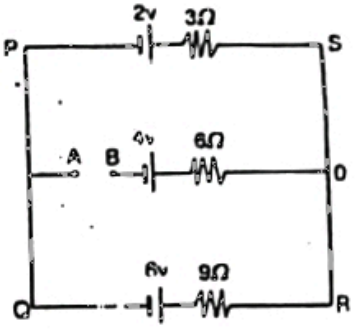
(i) What is the frequency of the transverse waves produced in the wire ?

(ii) Calculate the speed of sound in the material of the wire.

7 Answer either part (a) or part (b)

(a) State Kirchhoff' s Laws.

In the circuit shown all the cells have negligible internal resistance.



(i) Calculate the potential at the point B with respect to the point A in the circuit.

(ii) Calculate the voltemeter reading. If a voltemeter having an internal resistance of 100Ω is connected across AB.

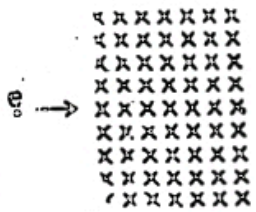
(iii) Is it correct to connect a voltmeter across AB as mentioned in (ii) to measure the potential difference between A and B ? Explain your answer

(b) An electron is accelerated through a potential difference of 18.2 kV. The charge (q) and the mass of the electron are 1.6×10^{-19} C and 9.1×19^{-31} kg respectively.

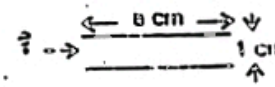
(i) Find the work done on the electron bythe potential difference.

(ii) Assuming that the electron started from rest, calculate the speed (v) of the electron after accelerating through the potential difference.

(iii) The electron then enters a region in which there is a uniform magnetic field of flux density. B = 0.2 T acting normal to the initial direction of motion of the electron as shown in the diagram. Calculate the force (F) on the electron due to the magnetic field and indication (Here F = qvB). Find the magnitude of an electric field that will make the electron move without any diviation. Indicate on a diagram the direction in which this electric field should be applied.



(iv) The undeviated electron is then allowed to travel between two horizontal parallel plates, each 8 cm long and separated by 1 cm as shown, If the potential difference between the plates is 200 V. find the vertical deflection of the electron as it leaves the plates.



8. An electrostatic instrument has a hollow metallic spherical shell of radius 0.9 m mounted on an insulating support Electrical breakdown will occur in the air outside the spherical shell when the electric field intensity at the surface of the shell exceeds 1.2×10^{6} V m^{-1}.

(i) What is the maximum potential to which the sphere can be charged without occuring an electrical breakdown ? Calculate the charge and the electrical energy stored on the sphere under this situation.

(ii) When the sphere is at its maximum potential. it is found that charge leaks off the sphere at a constant rate of 8×10^{-4} C per second. Briefly describe a process by which the charge leaks off the sphere.

(iii) In order to maintain the maximum charge on the sphere at the value calculated in (i). charge has to be supplied continuously to the sphere at the above mentioned rate. This is done by bringing source of charge inside the sphere and allowing it to touch the inner surface of the sphere. state the

[illegible]

(iv) Calculate the rate at which the electrical energy is supplied to the sphere under this situation

$$\left[\frac{1}{4\pi} = 9 \times 10^{9}\ \text{Nm}^{2}\ \text{C}^{-2}\right]$$