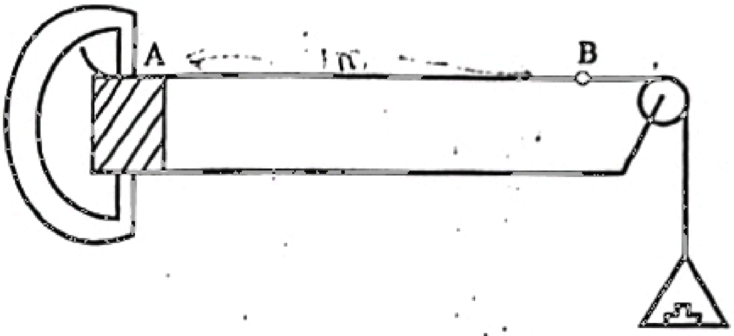
PAPER II PART A - STRUCTURED ESSAY

01. A uniform thin steel wire is fixed at A and passes over a smooth pully as shown in the figure. Section AB of the wire is horizontal and about 1 m in length. The tension in the wire is adjusted by keeping weights on the scale pan.



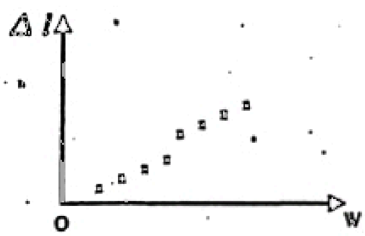
(a) In this experiment it is required to measure the extension Δl of the section AB of the wire due to a weight W placed on the scale pan. A fine mark is made at B on the wire for this purpose. State what would be the most suitable laboratory measuuing instrument that could be used to obtain this measurement. *(one line)*

(b) (i) To determine Young's modulus Y of the material of the wire what other additional measurements would you take ? Give suitable measuring instruments.

Measurement	Instrument
1	α (say) ....
2.	β (say) ....

(ii) Write down an expression for Y in terms of Δl, α β and W. *(one line)*

(c) A student measured extension Δl for increasing loads W and plotted Δl vs W. The points corresponding to his measurements are shown in the diagram.



(i) What would have happened to the wire, for the last four points to displace with respect to the first four points ? *(3 lines)*

(ii) Draw on the diagram in (c) above, the best graph through the point's that would enable you to obtain the best possibe value for Young's modulus Y of the material of the wire.

(d) Suppose that you want to calculate the speed of sound in this steel wire.

(i) In order to find this ; state what property, of the material of the wire you would require in addition to the property you have already found. *(one line)*

(ii) If you are provided with an additional piece of the same wire what measurements would you take in order to determine the above property ? *(2 lines)*

(e) Obtain an expression for the velocity of transverse waves in the wire in terms of Y. the density ρ of the material of the wire and the strain ε of the wire. *(one line)*

02. In an experiment to find the dew point of air in the school laboratory you are provided with the following .

(1) Small metal container with a well polished outer surface
(2) Sufficient amount of water and ice cubes
(3) Stirrer

(a) What else would you require to perform this experiment ? *(one line)*

(b) Draw a labelled diagram of the experimental setup. *(3 cm given)*

(c) What is the purpose of using a container with well polished outer surface ? *(2 lines)*

(d) What measurements would you take in this experiment and when do you take them ? *(3 lines)*

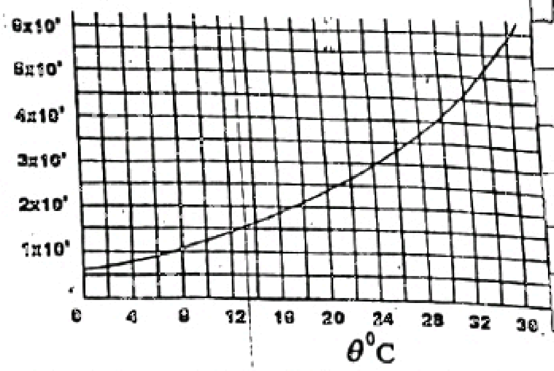
(e) In this experiment what is the advantage of adding small ice pieces one at a time ? *(2 lines)*

(f) If the temperature of water had dropped much below the dew point when adding ice you might face a difficulty in taking one of the measurements. Explain why ? *(3 lines)*

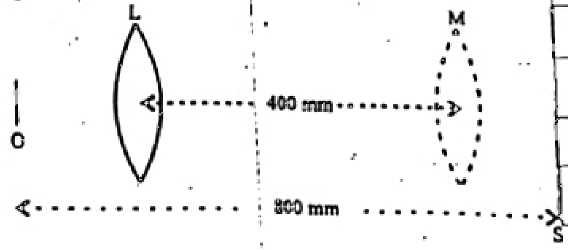
(g) The dew point of the laboratory was found to be 24^0C when its room temperature was 30^0C. The graph given below shown the variation of saturated water vapour pressure (P) in air with temperature (θ).

(i) What is the saturated water vapour pressure of air at the dew point? *(one line)*

(ii) Calculate the relative humidity of air in the laboratory. *(one line)*



03. An object O and a screen S are placed 800 mm apart. A converging lens is moved between them until a clear image of the object is obtained on the screen. The position of the lens is then changed until another clear image is obtained on the screen. These two positions L and M of the lens are 400 mm apart.



(a) Suggest a suitable object for this experiment. *(one line)*

(b) State with reasons which of the positions of the lens gives a larger image? *(2 lines)*

(c) Which of the lens positions gives a brighter image? *(one line)*

(d) Calculate the focal length (f_0) of the converging lens. *(10 lines)*

(e) What is the minimum distance between the object and the screen for this experiment to be possible? *(one line)*

(f) You are provided with a diverging lens of focal length (f_d) larger in magnitude than that of the convex lens.

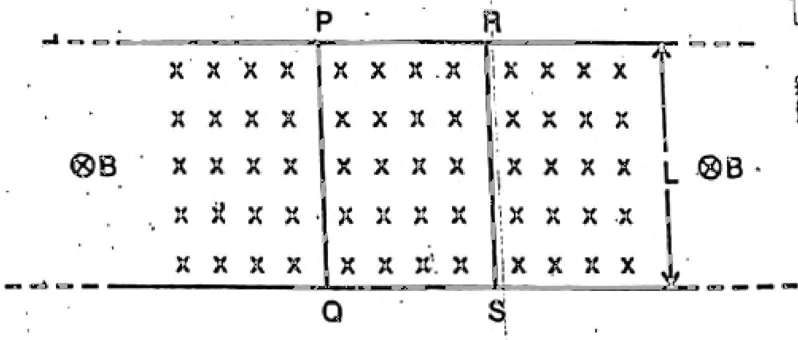
(i) Draw in the space given below a complete diagram of the arrangement that you would use in order to find its focal length using the above method. (You may change the distance between O and S to a new value.) (3cm given)

(ii) What measurements do you take to determine f_d? *(2 lines)*

(iii) Write the additional equation that you need to calcutate the focal length of the diverging lens. (Identify all the additional symbols that you have used in the equation) *(2 lines)*

(g) This method cannot be used with diverging lenses having focal lengths less than that of the convex lens. Explain this. *(2 lines)*

04. Two conducting wires PQ and RS each having length L and resistance r make contact with two smooth parallel conducting rails of negligible resistance. The plane of the wire is normal to a uniform magnetic field of flux density B as shown in the figure. The wire PQ is pulled with a uniform velocity V to the left.



(a) (i) Show in the figure given, the direction of the induced current in PQ.

(ii) Write down an expression for the induced current. *(2 lines)*

(b) Give the magnitude of the force which is required to keep the wire in motion in terms of the symbols given. *(one line)*

(c) (i) If the wire RS is also moved with the same velocity V to the left what will be the induced current in the loop PQSR? *(one line)*

(ii) Explain your answer. *(2 lines)*

(iii) What is the magnitude of the total force required to maintain the motion of the wires. *(one line)*

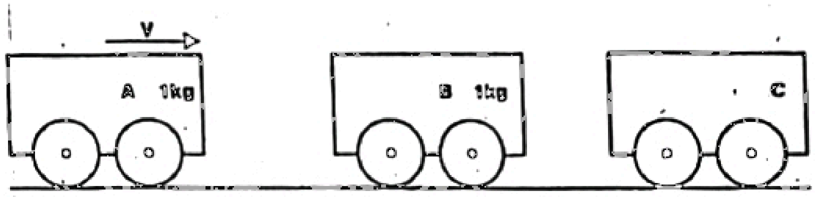
(d) (i) If RS is now moved to the right with uniform velocity V in addition to the motion of PQ as stated above what will be the induced current in the loop PQSR? *(2 lines)*

(ii) Write down an expression for the total mechanical power required to maintain the wires in motion *(one line)*

(iii) In what form this power finally appears in the system. *(one line)*

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

(a) Distinguish between elastic and inelastic collisions between two bodies. Give an example for a completely inelastic collision.



Three trolleys A,B and C of mass 1Kg, 1 Kg and M respectively are kept at rest on frictionless horizontal rails, As shown in the figure the trolley A is projected with a velocity V towards the trolley B. Assuming all collision taking place to be elastic.

(i). Show that when the trolley A collides with B,A becomes stationary and B takes off with velocity V.

(ii) State how many subsequent collisions will occur and find the final velocities of all trolleys in terms of V if M = ½ kg.

(iii) State what happens if M=2kg and find the final velocities of all trolleys in terms of V.

(iv) If instead the rails have friction are the conservation laws that you have used still valid ? Explain your answer.

(b) Draw a labelled diagram of the apparatus used to determine the surface tension of a liquid using the jaeger's method. Give the essential steps of this experiment. write down the equation which would enable you to determine the surface tension, indicating clearly the quantities involved. what are the advantages of this method?

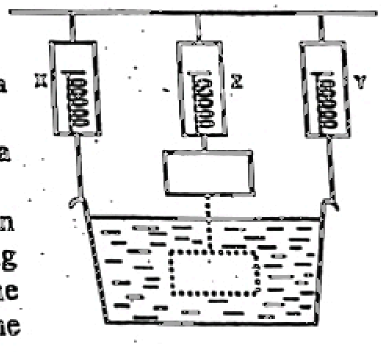
A bucket with a flat base has a small circular hole of radius 0.1 mm at its base and contains 5 cm of oil of density 800 kg m^{-3} and surface tension 0.03 N m^{-1} show that the oil will not flow out of the hole.

If this bucket without any oil is now pushed vertically down into water. at what depth will the water start to flow into the bucket through the hole. The surface tension of water is 0.075 Nm^{-1} and its density is 10^3 kgm^{-3}.

02. State Archimede's principle.

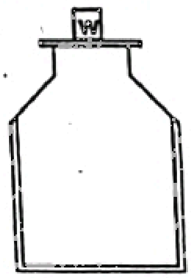
Explain why it is easier to float a uniform cylindrical body horizontally in a liquid than vertically. How can this cylinder be made to float vertically ?

Describe how such a cylinder can be used to determine the relative density of a liquid.



A pan of water is suspended from two spring balances. X and Y as shown in the figure. A block of brass is suspended from a third balance Z. X and Y read 1 kg each and Z reads 1.2 kg. when the block is gradually lowered by increasing the length of the string so that it is completely immersed in water as shown by the dashed lines, the balance Z reads 0.80 kg. Find the new readings of X and Y.

If the brass is made of copper and zinc of densities 9×10^3 kg m^{-3} and 7×10^3 kg m^{-3} respectively, find the mass of zinc in the block. The density of water is 10^3 kg m^{-3}



03. An ideal gas at 27^0C is trapped in a vessel at atmospheric pressure by placing a light lid on the mouth of the vessel as shown. The area of cross section of the mouth of the vessel is 1 cm^2 and the atmosperic pressure is 1.0×10^5 Pa.

(i) The temperature of the gas in the vessel is raised while keeping a weight W on the lid to prevent gas escaping from the vessel, Find the minimum value of W required to keep the gas in the vessel at 127^0C.

(ii) Suppose a small quantity of water is present in the vessel at 27^0C and at atmospheric pressure. Find the corresponding minimum value of W assuming that some of the water still remains in the liquid form at 127^0C. The saturated vapour pressure of water at 27^0C and 127^0C are 3.7×10^3 Pa and 2.5×10^5 Pa respectively.

(iii) State why water can remain in liquid form at 127^0C.

(iv) At 27°C and at atmospheric pressure if the vessel contains only air and saturated water vapour without any water in liquid form, what will be the final pressure inside the vessel at 127°C ? If this value is different from the corresponding value in (ii) give reasons for the existance of such a difference. (You may assume that unsaturated water vapour behaves as an ideal gas.)

04. In some heat experiments, in addition to the usual precautions taken to minimize heat losses to surroundings certain experimental procedures are adopted to minimize or eliminate, heat losses. Give two such experiment procedures.

When an ice cube of mass 30 g at 0°C is allowed to dissolve at a constant rate in a certain amount of water contained in a calorimeter, the temperature of water is found to drop from 35°C to 25°C. The room temperature is 30°C.

(i) If the same experiment is repeated with water having the initial temperature at 42°C, the temperature of water is seen to drop to 31°C when the ice cube is completely dissolved. Calculate the amount heat lost to the surroundings.

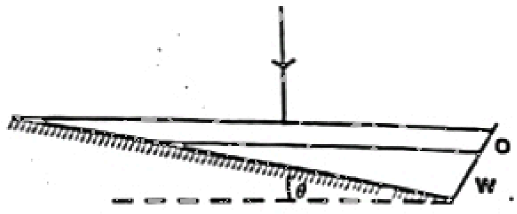
(ii) In (i) above if the dissolving rate of ice is doubled what will be the amount of heat lost to surroundings. Explain how you arrived at the answer.

Specific latent heat of fusion of ice = $3 \times 10^5 \, J \, kg^{-1}$

Specific heat capacity of water = $4200 \, J \, kg^{-1} \, k^{-1}$

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

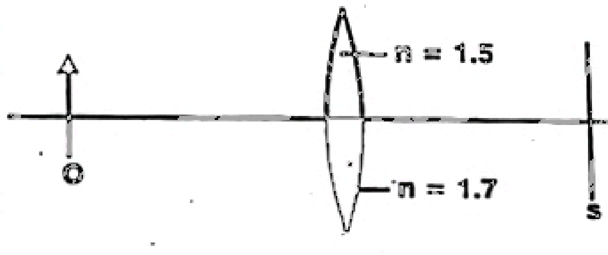
(a) State the conditions necessary for total internal reflection of ligh to occur. Describe a method of determining the refractive index of the material of a glass prism using the critical angle method with pins.



A layer of clear oil (O) is contained over some water (W) in a wide rectangular dish tilted at an angle θ. The bottom of this dish is silvered like a plane mirror.

A ray of monochromatic light is incident on the surface of oil normal to it. If the refractive indices of water and oil are $\frac{4}{3}$ and $\frac{7}{5}$ respectively. determine the maximum value of θ for which light after travelling through the liquids emerges from the oil-air interface.

(b) A thin equi-convex lens has surfaces with radius of curvature 28 cm each. Its upper half and lower half are made of two different types of glass materials of refractive indices 1.5and 1.7 respectively. An illuminated object. O of height 4cm is placed 60 cm away from the lens in such a way that oe half of its height is located above the principal axis of the lens as shown in the figure.



(i) As a screen S is moved away from the lens how many images of the object can be seen on S? Draw ray diagrams to show where the images are formed.

(ii) Find image distances and heights of images.

(iii) If the lens is made of one material, how does the nature of the image formed by this lens differ from the corresponding image/images formed in (i) above ?

06. Velocity of sound (v) in a given by the equation $V = \sqrt{\frac{YP}{\rho}}$. Identify the symbols and show that the equation is dimensionally correct.

Use the above equation to derive an expression for velocity of sound in an ideal gas of molecular weight M. at temperature T.

Two men A and B 209 m apart, both see a lightning flash along the extension of line joining them. Man A hears the thunder 2 s after the flash while B hears it 2.6 s after the flash.

(i) Find the velocity of sound in air.

(ii) Find the temperature of air. (Assume that the temperature of air is constant.)

(iii) If the value of Y for air is 1.403, calculate the average molecular weight of air. You may assume air as an ideal gas.

(iv) If the atmosphere contains certain amount of water vapour, would you expect the same value for the velocity of sound ? Explain your answer.

(universal gas constant $R = 8.3\ J\,k^{-1}\,mol^{-1}$: velocity of sound in air at $0^{\circ}C = 330\ ms^{-1}$)

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

(a) Three electrical appliances A, B and C rated 6 W, 6 V : 2 W, 0.5 A and 27 W , 9 V respectively are to be connected in parallel with a cell of e.m.f 10 V and internal resistance 0.5Ω.

(i) What is the total current that should be supplied by the cell for proper operation of the above appliances connected in a circuit as stated above.

(ii) Show that a single cell of the given type is unable to supply the necessary current to satisfactorily operate all the appliances us stated above.

(iii) What is the minimum number of such cells that should be connected in parallel to overcome the difficulty encountered in (ii) above.

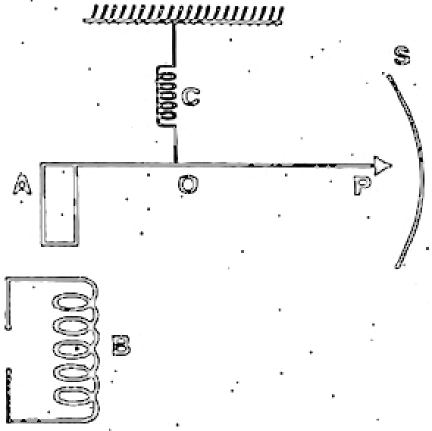
(iv) If you are supplied with a sufficient number of suitable resistors show in a diagram how you would connect all the appliances to the pack of cells as stated above.

(v) Calculate the values of resistors needed for the circuit.

(b) The diagram shows a sketch of a device that can be used to measure current with the following components ;

A - soft iron. B - fixed coil C - compensating spring

S - scale P - pointer pivoted at O.



Explain why the needle deflects when a steady current flows through the coil. Do you expect the pointer to deflect in the opposide direction if the current is reversed ? Explain your answer. why is that a piece of steel cannot be used in place of the soft iron A ?

If the coil has a resistance of 0.5Ω and the instrument gives a full scale deflection for a cuuent of 500 mA. explain how this instrument can be modified.

(i) to read currents up to 5 A.

(ii) to read voltages up to 5 V.

Explain with a diagram how this instrument can be used as a simple ohm meter. (Assume that the deflection of the pointer is proportional to the current in the coil)

8. What are the similarities and differences berween gravitational forces and electrostatic forces ?

Two protons P and Q of mass 1.67×10^{-27} kg and charge $+ 1.6 \times 10^{-19}$ C are placed 1 cm apart as shown in the figure. Show that the gravitational force acting between them is negligibly small when compared to the electrostatic force acting between them.

(universal constant of gravitation $G = 6.67 \times 10^{-11}\ N\,m^2\,kg^{-2}$; $\frac{1}{4\pi\epsilon_0} = 9 \times 10^{9}\ N\,m^2\,C^{-2}$)

Suppose the proton Q moves around the proton P which is at rest in a circle of radius 1 cm in the clockwise direction.

(i) Calculate the magnitude of the electric field intensity experienced by the proton P.

(ii) If the proton Q makes F number of revolutions per sec. the effective current I flowing around the circumference of the circle can be written as

$I = ef$, where e is the proton charge.

Determine the magnitude and direction of the magnetic flux density produced by this current at the centre when $f = 10^{3}$ Hz. ($\frac{\mu_0}{4\pi} = 10^{-7}\ Tm\,A^{-1}$)

(iii) Is there a force on the proton P due to this magnetic field ? Explain your answer.

(iv) If the moving proton Q is replaced by a thin circular loop of wire carrying the same current I. repeat the calculations (i) and (ii) above.