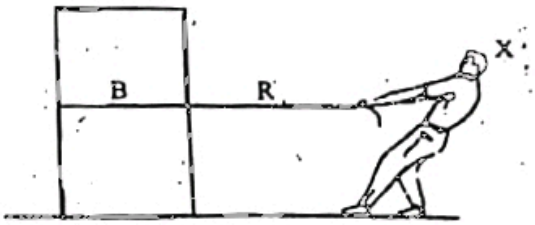
PAPER II PART A - STRUCTURED ESSAY

01. A man X pulls a wooden box B along a rough horizontal surface with a horizontal rope R attached to the box as shown in the figure.

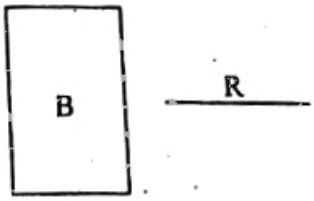


(a) (i) Indicate on the diagrams given on the next page, the horizontal forces acting on the box B and the rope R.
[Use the following notatioin to label each force
F_{RX} - the force exerted by the man on the rope
F_{RB} - the force exerted by the box on the rope
F_{BR} - the force exerted by the rope on the box
F - the frictional force acting on the box]

(ii) Which of the above forces can be considered as an action- reaction pair? *(one line)*

(b) When the man pulls the rope with a force of 100 N the box still continues to remain stationary What is the frictional force acting on the box the by the surface in this situation? *(one line)*

(c) (i) When the man pulls the rope with 150 N, the box is found to be on the verge of moving. In this instant what is the force exerted on the box by the rope? *(one line)*



(ii) If the mass of the box is 50 kg, calculate the coefficient of static friction between the box and the surface. *(2 lines)*

(d) (i) When the force exerted by the man is increased to 200 N, the box and the rope begin to move with a constant acceleration of 2 ms^{-2}. If the mass of the rope is 1 kg, calculate the force exerted on the box by the rope. *(2 lines)*

(ii) Calculate the frictional force acting on the box by the surface under this situation. *(2 lines)*

(iii) Determine the coefficient of kinetic friction between the box and the surface. *(2 lines)*

02. The figure shows an apparatus arranged by a student in the laboratory to generate steam. The tube B is used to take steam out.

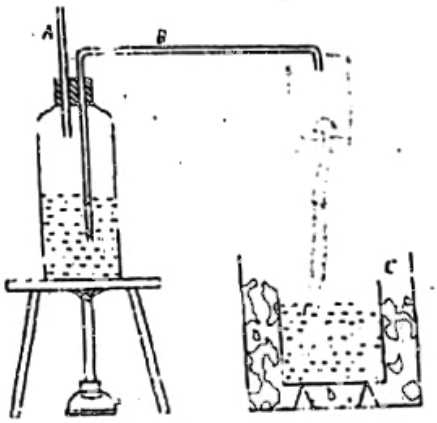
(a) In this setup the two tubes A and B are fixed incorrectly. State how you would arrange them properly.

(i) Tube A : .....

(ii) Tube B : .....

(b) What is the purpose of having the tube A? *(one line)*

(c) After making the changes mentioned in (a) the student decided to use the above setup to detemine the specific latent heat of vaporization of water by inserting the outlet of the tube B directly into the calorimeter C containing water. This procedure is not satisfactory.



(i) Explain why? *(2 lines)*

(ii) The correct procedure in this experiment would be to connect another piece of apparatus to the outlet of tube B, before passing steam into the calorimeter. Draw this piece of apparatus in the space between the tube B and the calorimeter.

(d) (i) In addition to the two relevant temperature measuraments what are the other measurements that you would take in this experiment. *(3 lines) (3 measurements)*

(ii) What additional data do you need for the computation of specific latent heat of vaporization of water? *(2 lines) (two datas)*

(e) What precautions would you take in order to improve the accuracy of the experiment? *(3 lines) (2 precautions)*

(f) When the above experiment was carried out in a hill-country school laboratory, the barometer reading was found to be 720mm of Hg. Explain how the student should take this factor into account in his calculation. *(2 lines)*

03. A student plans to carry out an experiment using a sonometer to determine the frequency (f) of a tuning fork

(a) Where should he place the sounded tuning fork in order to obtain resonance? *(one line)*

(b) What procedure must he follow in order to obtain the fundamental resonance length? *(2 lines)*

(c) The student measured the fundamental resonance lengths (l) corresponding to different tensions (sonometer wire using different weights (Mg). Write down an expression relating M. l. f. and the ma unit length m of the sonometer wire. *(2 lines)*

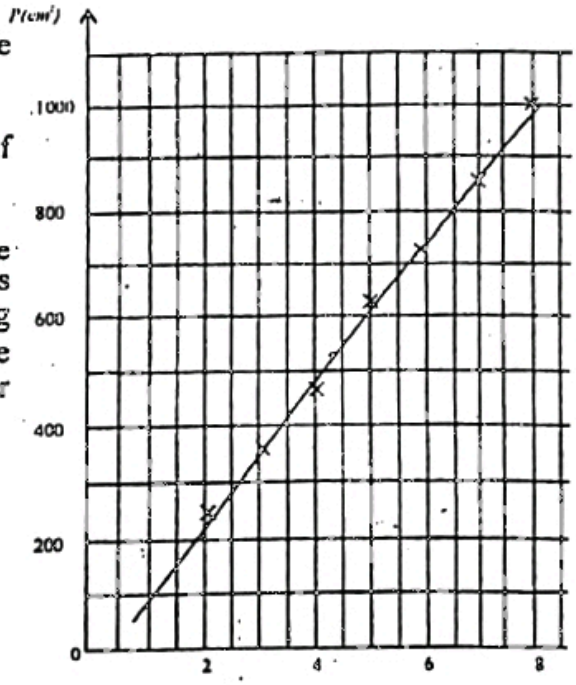
(d) (i) Which of this experimental 'l' values is considered to have the highest accuracy? *(one li*

(ii) Give the reason. *(2 lines)*

(e) In this experiment the graph plotted by the student is shown in the figure.

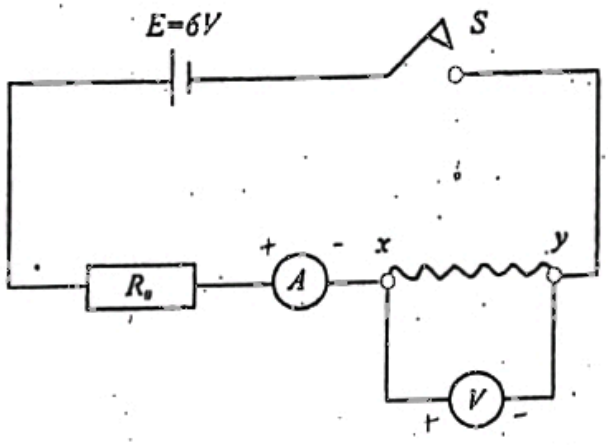
(i) Mark with arrows, two suitable points on the graph. which you would use to find its gradient.

(ii) Find the gradient of the graph. *(2 lines)*



(f). If the value of m is 8×10^{-4} kg m^{-1}, find the frequency of the tuning fork. *(3 lines)*

04. Figure shows a simple experimental arrangement to find the resistivity of a nichrome wire XY. Resistance of the wire is found to be in the order of 100Ω A is a micro ammeter having a full scale deflection of 100 μA. E is a 6V cell with negligible intemal resistance. R_0 is a fixed resistor. and V is a voltmeter (Both A and V can be considered as ideal instuments).



(a) Write down an expression relating the length l, redius r and resistivity p of the wire XY to its resistance R. *(one line)*

(b) In order to measure the resistance of the wire XY using the above arrangement, it is required to s curient in the order of 50 UA through XY. If you are provided with a bunch of resistors with values 1kΩ, 10kΩ, 100kΩ, 1MΩ and 10 MΩ what value would you choose for R_0? Show your calcul (Avoid lengthy calculations.) *(2 lines)*

(c) Voltmeters with the following full scale deflections are available for you to measure the voltage XY.

50μV. 100μV. 1 mV. 10 mV. and 100 mV

State the most suitable full seale deflection for the voltmeter. Show relevant calculations. *(2 lines)*

(d) Indicatc by marking '+' and '-' signs on either side of A and V symbols in the circuit above, the terminal connections of the ammeter and the voltmeter.

(e) Is there any advantage of using a low current in this experiment? Explain your answer. *(2 lines)*

(f) In this experiment following results were obtained by a student.

Measured value of the resistance of the wire = 105Ω

Length of the wire = 1.0m

Redius of the wire = 5×10^{-5} m

Calculate the resistivity of the material of the wire. *(3 lines)*

(g) If you are planning to obtain the resistivity of this wire by means of a graph, what modification wo suggest to the above experimental arrangement in order to obtain a set of readings. *(2 lines)*

PAPER II PART B - ESSAY

01. (i) Wind blows along a horizontal direction in an open space at a constant velocity v. If the density of air is ρ write down an expression for the kinetic energy (E) per unit volume of a moving column of air.

(ii) The Kinetic energy carried by the wind can be extracted through the rotating blades of a wind mill. and subsequently converted to useful energy. Consider a situation where the wind is blowing normal to the plane of rotation of the blades of a wind mill. The area swept out by a rotating blade is A. Assuming that all the kinetic energy of the wind blowing through a cross-sectional area A could be extracted by the blades. show that the rate at which the wind energy is transferred to the wind mill is $\frac{1}{2}\rho A v^3$

(iii) When a certain wind mill is in the free running state (i.e. when it is not coupled to any other device such as a water pump) the blades are found to be rotating at a constant angular speed of 30 revolutions per minute. When the wind suddenly stops the blades come to rest after 2 minutes due to frictional forces. If the moment of inertia of the system of rotating blades about its axis of rotation is 10,000 kg m^2 calculate the average frictional torque acting on the system.

(iv) Hence calculate the rate at which the wind energy is extracted by the rotating blades of the wind mill

(v) If the velocity of the wind is 10ms^{-1}. area swept out by a blade is 30m^2. and the density of air is 1.3 kgm^{-3} find the efficiency of the wind mill when it is in the free running state.

02. The near point of a far-sighted person is at 100 cm. and that for a normal person is at 25 cm.

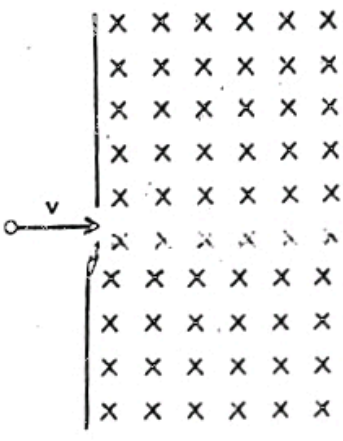
(i) Sketch two separate ray diagrams, one for the defective eye, and other for a normal eye to illustrate where the image of an object which is at a distance of 25 cm. is focused by the eye lenses.

(ii) What is the focal length and the type of the lens of the eye glass that the person should wear in order to correct his near point to 25 cm?
State clearly the sign convention you used.

(iii) Considering that the lens of the eye glass and the eye lens are in contact. calculate the focal length of the eye lens when an object at a distance of 25 cm is focused. The distance to the retina from the eye lens is 2.5 cm.

(iv) When an object at infinity is focused on the retina by the eye without the eye glass. What is the power of the eye lens?

A proton enters perpendicular to a uniform magnetic field of flux density 0.017 T with a velocity of 8.0×10^5 m s^{-1} as shown in the diagram where the magnetic field is directed into the paper. The charge and the mass of the proton are 1.6×10^{-19} C and 1.7×10^{-27} kg respectively.



(i) (a) Explain why the path of the proton in the magnetic field is circular. Find the radius of the path. Copy the given diagram and draw a rough sketch of the path of the proton on it.

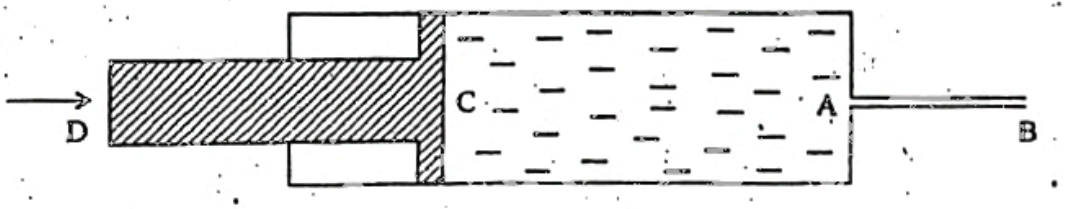
(b) If instead an electron enters with the same velocity in a similar manner how does its pa from the path of the proton?

(ii) Daduce the radius of the orbit of an a particle entering this magnetic field with the same velo similar manner.

(iii) If a neutron enters the magnetic field in the similar manner. show its path on the diagram drawn i Lable the path.

(iv) If a suitable uniform electric field is now applied in addition to the magnetic field the defle particles due to the magnetic field can be nullified. Find the magnitude and direction of this elect for a proton. Will there be any change of the velocity of the particles in this situation? Give the re your answer.

04. Write down the Poiseuille's equation for a stream line flow of a viscous fluid through a tube. identifyin symbols.
Draw a labelled diagram of an experimental set up used in a school laboratory to find the coefficient of v of water using the above equation.



Briefly state the procedures that should be adopted to enhance the accuracy of the final result.
Figure shows a rough sketch of a syringe that can be used to inject liquid drugs into blood veins. Th inside the tube is slowly pushed out through the needle AB by applying a constant force on D.
Length of the needle is 2 cm and it had bore of radius 0.02cm. Assume that the velocity of the liquid in wider tube is negligibly small under this situation.

(i) Draw the variation of the pressure inside the liquid along the axis of the syringe from C to

(ii) When the end B of the needle is exposed to the atmosphere the time taken to push 1 cm liquid through the needle is 10 s. If the coefficient of viscosity of the liquid is 1×10^{-3} N calculate the pressure difference across AB

(iii) Assuming that the averadge excess blood pressure over the atmospheric pressure is 100 Hg, calculate the additional force to be applied on D in order to inject 1 cm^3 of the liqui blood vein in 10 s.

Density of Hg $= 13.6 \times 10^3 kg\,m^{-3}$. Cross-sectional area of the piston $C = 0.75\ cm^2$.

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

(a) A 60 W light bulb is connected to a 12V voltage source using a copper wire. The bulb lights with brightness.

(i) Calculate the current through the wire.

(ii) Considering that each copper atom contributes one electron to the conduction process. Calcutate the number of conduction electrons in $1m^3$ of copper.

[Relative atomic mass of copper = 63; Density of copper = $9.0 \times 10^3 kgm^{-3}$

Take avogrado's number as 6.0×10^{23} atoms per gram mole.]

(iii) If the radius of the copper wire is 0.7 mm, calculate the drift velocity (v_d) of conduction electrons in copper (Electronic charge = 1.6×10^{-19} C.)

(iv) Assuming that the conduction electrons act like molecules in a perfect gas determine the root mean square velocity (v_{rms}) of elecctrons at 27 C.(Boltzmann's constant = $1.4 \times 10^{-23} Jk^{-1}$; Mass of the electron = 9.1×10^{-31} kg) Explain why there is a vast diffirence of magnitudes between V_d and V_{rms}?

(v) If the length of wire is 1 m. what is the time taken by an electron to travel from one end of the wire to the other ? in reality, however, the bulb will light as soon as the switch is closed. Explain this.

(b) Draw the circuit symbol of an operational amplifier, clearly identifying the non inverting in put (v_1) inverting input (v_2) and the output (v_0)
If A is the open loop .gain of the operational amplifier, write down an expression relating the inputs v_1, v_2 and the output v_0.

(i) A 741 operational amplifier has an open loop gain of 10^5, and it is powered with supply voltages of ± 15v . if voltages . $v_1 = -3$ mV and $v_2 = -5$ mV, are applied to the operational amplifier inputs, what would be the polarity and the approximate magnitude of the expected of the expected output voltage v_0?

(ii) (a) You are provided with two resistors R_1 and R_2 draw a circuit diagram of a non-inverting amplifier, clearly showing its input and output.

(b) In an experiment the voltages produced by a thermocouple in the range of 0 - 10mV are to be measured with a voltmeter having a full scale deflection of 1 V draw a circuit diagram to show how the non inverting amplifier given in (ii) (a) is inserted between the thermocouple and the voltmeter in order to obtain a full scale deflection from the voltmeter for 10mV thermocouple output.

(c) Of the two resistors R_1 and R_2 if the smaller resistor has the value 1 kΩ. what should be the value of the other resistor in order to achieve the full scale deflection in (ii) (b)?

(iii) If you are provided with another resistor R_3 and a two - way key, how would you modify the circuit given in (ii) (b) so that it can be used to measure voltages in two ranges 0-10 mV and 0-100 mV separately with the same voltmeter giving full scale deflections in either range the two - way key is used to select the required range. Find a suitable value for R_3