PAPER II PART A - STRUCTURED ESSAY

1. (a) What is the basic cause for surface tension phenomenon observed in liquids? *(one line)*

   (b) (i) If you are given a suitable capillary tube, what is the essential equipment needed to determine the surface tension of water using the capillary rise method? *(one line)*

   (ii) Write down an expression for the surface tension of water, T, in terms of the capillary rise, h, radius of the capillary, r, density of water, ρ, and the acceleration due to gravity, g. (Assume the angle of contact to be zero.) *(2 lines)*

   (iii) When this experiment was performed by students in a class using capillary tubes with same radius and identical set of apparatus, the heights h obtained by some students seemed to be very different. What is the main cause for this? *(one line)*

   (iv) To overcome this discrepancies certain experimental procedure should have been adopted correctly. Give the steps of this procedure. *(3 lines)*

   (c) In such an experiment when the capillary tube is withdrawn from water and held vertically, a small column of water is found to remain at the bottom of the tube. Will the radius of the lower miniscus of this water column be same as that of the upper miniscus ? Explain your answer. *(2 lines)*

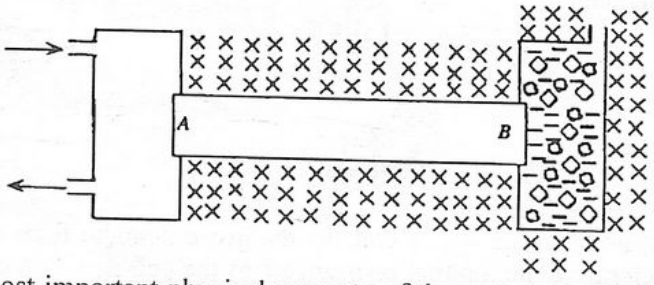
   (d) When the capillary tube is held horizontally and water from a constant pressure head is connected to one end of the tube, water is found to flow out of the other end very slowly.

   (i) What property of the water determines the rate of flow? *(one line)*

   (ii) To determine the above property of water, the radius of the tube has to be measured very accurately. What is the other reason for this, apart from radius being small? *(2 lines)*

   (iii) For the same reason as in d(ii) above the tube must be of uniform bore. How would you check whether the given tube is of uniform bore? *(3 lines)*

2. Figure shows a uniform metal rod AB of length 50 cm whose one end, A, is maintained at 100 ^{0}C and the other end, B, is in contact with a water-ice mixture at 0 ^{0}C. The cross-sectional area of the rod is 0.5 cm^2 and it is well lagged. You can assume that there is no heat transfer with the surroundings.



   (a) (i) What is the most important physical property of the material used for the lagging? *(one line)*
   (ii) Liquids are generally not used for lagging. What is the main reason for this? *(one line)*

   (b) Draw rough sketches of the temperature variations along the rod,
   (i) at any instant before reaching the steady state.
   (ii) in the steady state.

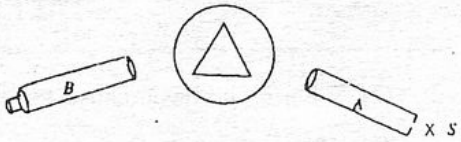
   (c) What is the temperature gradient along the rod, in the steady state? *(one line)*

   (d) If the rate of melting of ice in the steady state is 0.01 kg s^{-1} , find the rate of heat flow through the rod. (specific latent heat of fusion of ice = 3 x 10^5 J kg^{-1}) *(one line)*

   (e) Calculate the thermal conductivity of the material of the rod. *(2 lines)*

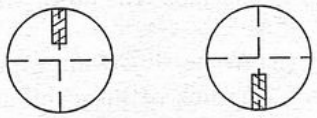
   (f) After sometime the ice gets completely melted. If you wait long enough will the water boil? Explain your answer. *(2 lines)*

3. Figure shows an experimental arrangement to produce a pure spectrum of the light from a source of white light S using a spectrometer.



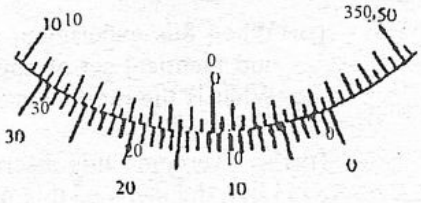
(a) (i) What kind of lamp is suitable for the white light source S ?
(ii) Name the components A and B. *(one line each)*

(b) When a student attempted to observe the images of the slit reflected from the two faces of the prism he observed the two images as shown below.



What was the reason for this appearence ? *(one line)*

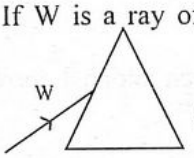
(c) The following figure shows the spectrometer scales for a certain setting.



What is the spectrometer reading indicated ? *(one line)*

(d)

(i) If W is a ray of white light incident on the prism as shown, draw the paths of the blue and red rays through the prism and subsequently through air.



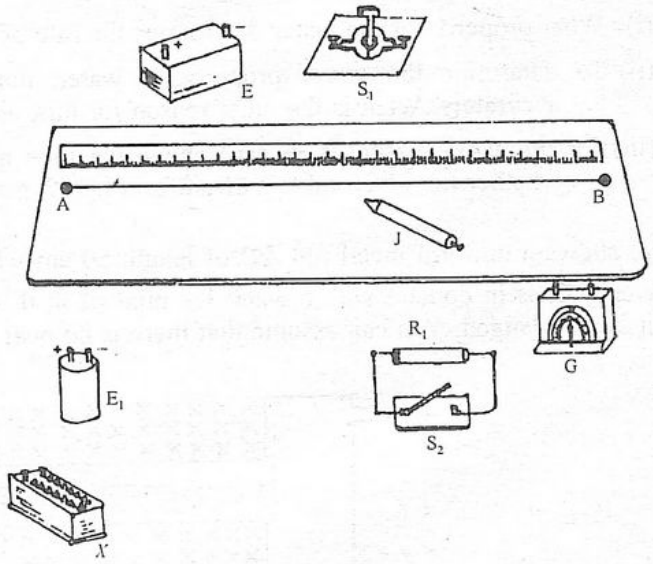
(ii) Which colour (blue or red) of light travels faster in glass ? *(one line)*

(e) To determine the refractive index of glass for red light, the white light source is replaced by a red light source . what measurements would you require ? *(2 lines)*

(f) (i) If the refractive index of glass for red light is 1.61 and the wavelength of red light in air is 6.44 x 10^{-7}m, find the corresponding wavelength of the light in glass. *(2 lines)*

(ii) Will there be a change in colour of the light in glass due to the above change of wavelength ? Justify your answer. *(3 lines)*

4. Diagram below shows the apparatus which can be used in an experiment to determine the value of the internal resistance r of a cell E_1.



AB - Potentiometer wire
G - centre zero galvanometer
E - accumulator
R_1 - 1 kΩ resistor
S_1 - plug key
S_2 - tap key
X - resistance box
J - sliding key

(a) In the above figure indicate how you would connect the given items to form a suitable electrical circuit, which enables you to determine the internal resistance r of the cell E_1

(b) Why is it advisable to use an accumulator for E ? *(one line)*

(c) What is the purpose of the resistor R_1 ? *(one line)*

(d) When do you close the key S_2? *(one line)*

(e) You are asked to plot a suitable graph in order to determine r. What measurements would you take for this? *(2 lines)*

(f) It is not advisable to connect the resistance box X to the circuit with all resistance plugs closed. Explain why? *(2 lines)*

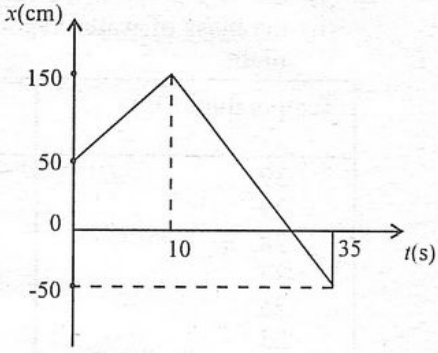
(g) After making all the connections correctly, a student observes that the dependent variable mentioned in (e) above stays at the same value when the resistance plugs are being removed one by one. What is the most probable reason for the above observation ? *(one line)*

(h) A student says that in order to perform this experiment the e.m.f. of the cell E_1 has to be always less than that of E. Is the above statement true? Give reasons for your answer. *(2 lines)*

PAPER II PART B - ESSAY

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

(a) Figure shows a displacement (x) - time (t) curve of an object which moves in a straight line on a horizontal table. Mass of the object is 0.5 Kg.



(i) Find the initial and the final velocities of the object.

(ii) (a) Draw the corresponding velocity- time curve for the whole journey of the object.

(b) Determine the total distance travelled by the object.

(c) Explain what happens to the motion of the object at t=10 s. Give a practical example where similar changes that occur at t = 10 s can be observed.

(iii) Suppose the object experiences a constant frictional force exerted by the table after 35 s, and it comes to rest in further 2 s.

(a) What is the magnitude of the frictional force acting on the object ?

(b) Calculate the coefficient of kinetic friction between the object and the table.

(b) The present electrical energy consumption in Sri Lanka is 3.0×10^9 kWh per year.

(i) Calculate the above energy consumption per year in Joules.

(ii) Calculate the minimum mass of water needed per year to generate the above amount of electricity in a hydro-power plant, if the water falls from a vertical height of 200 m. State clearly the assumption that you have made to arrive at the answer.

(iii) Taking the rate of flow of water to be constant throughout the year, determine the force exerted by falling water on a turbine blade in the generator. Assume that the water strikes the blade perpendicular to its surface and then flows along the surface without any recoil.

(iv) The Ceylon Electricity Board estimates that the energy demand for electrical power will increase to 7.5×10^9 kWh per year in the year 2000. The Board plans to meet this increase in energy demand by operating coal powered thermal power stations. Calculate the mass of coal needed per year to generate the extra amount of electrical energy. Assume that a coal power station operates with an overall efficiency of 40%.

(1 Kg of coal on burning gives 4.5×10^5 kJ of energy.)

2. Distinguish between the elastic limit and the proportional limit of a given material.

Two uniform steel wires of equal lengths of 0.5 m and cross-sectional area of 0.5 cm^2 and 0.2 cm^2, respectively, are connected together to form a compound wire of length 1 m.

The Young`s modulus and the proportional limit of steel are 2.0×10^{11} N m^{-2} and 2.5×10^8 N m^{-2} respectively.

(i) What is the maximum mass that can be hunged by the compound wire so that the proportional limit is not exceeded? Calculate the total elongation of the compound wire in this situation.

(ii) If the two wires are joined at the ends so that they are parallel to each other and forms a compound wire of length 0.5 m, what is the maximum mass that can be hunged by the compound wire so that the proportional limit is not exceeded ?

3. Compare the advantages and disadvantages of the following three methods used in determining the specific heat capacity of water :

(A) Joule`s electrical calorimeter method

(B) The method of mixtures

(C) The continuous flow method

An ice cube of mass 100 g kept at a temperature of - 40 ^{0}C is dropped into a large amount of water in a container which is at 0 ^{0}C. Assume that no heat is transferred with the surroundings.

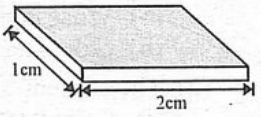
(i) Calculate the mass of water that will freeze to form ice. Where will this ice settle?

(ii) What would you expect to happen if the container initially contained only 20 g of water ? Determine the final temperature attained by the ice cube in this situation. Neglect the heat capacity of the container. (specific heat capacity of ice = 2.1×10^3 J kg^{-1} K^{-1}; specific latent heat of fusion of ice = 3.36×10^5 J kg^{-1})

4. On a day when the relative humidity of the atmosphere is 85% a certain room of capacity 50 m^3 was completly closed and isolated from the rest of the atmosphere. The room temperature was found to be 30^0C at the time of closure. Use the above data and the table given below to calculate,
   (i) the dew point of the room'
   (ii) the mass of water vapour condensed inside the room when the temperature drops to 24C during the night.

Temperature (^{0}C)	Mass (g) of water vapour required to saturate 1m^3 of air
39	30.01
29	28.45
28	26.93
27	25.51
26	24.11
25	22.80
24	21.51
23	20.35

(iiii) Assume that 0.01% of the mass calculated in (ii) above is deposited over the upper surface of a rectangular plate made of carbon, forming a uniform film of water on it. This plate is shown in the figure and it`s width and length are 1 cm and 2 cm respectively. Calculate the thickness of the water film formed on the plate.
(density of water = 10^3 kg m^{-3})

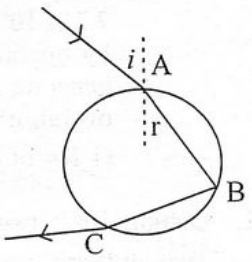


(iv) The plate has an electrical resistance of 30Ω along its length. Due to the formation of the water film. the effective resistance of the plate along its length will change. Calculate this change in the resistance as a percentage (resistivity of water = 10^{-3} Ω m)

(v) For better performance some electronic equipment are usually kept in air - conditioned rooms. What is the major reason for this ?

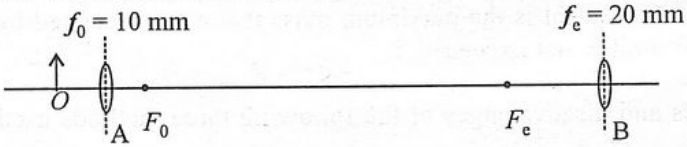
5. Answer **either** part (a) **or** part (b)

(a) Why does the refractive index vary from medium to medium ?
As shown in the figure a monochromatic ray of light in air is incident on the surface of a spherical water drop at A, with an angle of incidence i. The ray is refracted into the water with a refractive angle r. Reaching the opposite side of the drop at B, the ray is partly reflected back and emerges into air at C.



(i) What is the value of the angle of emergence ?
(ii) Derive an expression for the total deviation of the ray in terms of i and r.
(iii) if i=30^0, and the ray is fully deviated by an angle of 156^0, calculate the refractive index of water for the given colour.
(iv) Can the ray suffer total internal reflection at the opposite side for some values of i? Justify your answer.

(b) The diagram shows two converging lenses arranged as a compound microscope.



The focal length of the objective lens. A, is 10 mm and that of the eye piece lens, B is 20 mm, If the final image of an object placed at O, 12 mm from the objective lens is formed at infinity, trace the paths of two rays coming from the head of the object through the microscope to the eye. Calculate the angular magnification (magnifying power) of the microscope.

The separation of the lenses is changed keeping the object distance fixed until the angular magnification of the microscope attains its maximum value. what is the position of the final image in this situation ? Calculate the new lens separation and the angular magnification of the microscope. (The least distance of distinct vision is 25 cm).

6. Distinguish clearly between a progressive wave and a stationary wave set up along a string considering the following :

(A) the energy transmitted along the string (B) the amplitude of the points on the string

(C) the frequency of the points on the string

Give the essential steps of a laboratory method in determining the speed of sound in air.

A variable frequency source emitting a pure note is placed just above the open end of a uniform vertical tube 0.5 m long. The lower end of the tube is closed. If the frequency of the note emitted by the source is gradually raised from 150 Hz, at what frequencies will resonance occur ? The speed of sound in air is 330 $m\ s^{-1}$, at the room temperatrre, 27 ^{0}C.(You can neglect the end correction of the tube.)

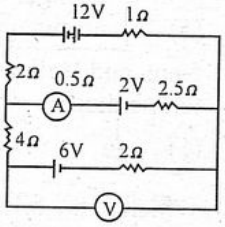
The air temperature is now changed. It is found that as the frequency of the note emitted by the source is increased, resonance first occurs at a frequency of 168 Hz. If the experiment is repeated with the lower end of the tube open the corresponding situation occurs at a frequency of 335 Hz. Calculate,

(i) the end correction of the tube. (ii) the speed of sound in air at the new temperature.

(iii) the value of the new temperature.

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

(a) In the circuit shown, all the batteries have negligible internal resistances, ammeter A has a resistance of 0.5Ω and V is a voltmeter with infinite resistance.



(i) Find (a) the readings in the ammeter A and voltmeter V.

(b) the energy supplied by the 12 V battery in 2 s.

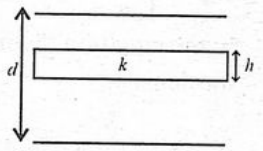
(c) the total heat dissipated in the circuit in the 2 s duration.

(ii) What is the reason for the difference in your answers to parts (i)(b) and (i)(c) ?

(iii) When A and V are interchanged in the above circuit, find the new readings of A and V.

(b) A parallel plate capacitor having plate area A carries a charge Q. If the capacitor is placed in air derive an expression for the electric field intensity E across the plates.

A parallel plate capacitor placed in air has a plate area A and a plate separation d. It is charged to charge Q by connecting a constant voltage source across the plates. The voltage source is then disconnected and a slab of dielectric constant k and thickness h is inserted between the plates as shown in the figure.



(i) write down expressions for the electric field intensity :

(a) in the gap between the upper plate and the dielectric slab.

(b) in the dielectric slab.

(c) in the gap between the dielectric and the lower plate.

(ii) Derive an expression for the potential difference across the plates of the capacitor.

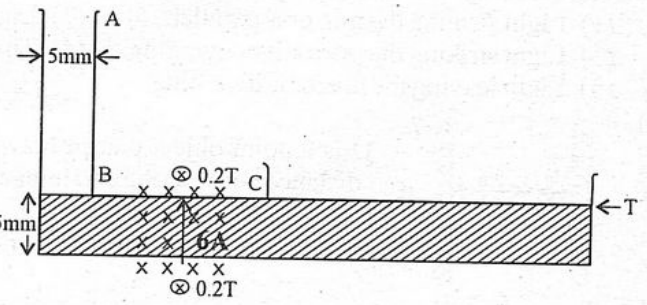
(iii) Hence or otherwise show that the effective capacitance of the capacitor is given by

$$\frac{k\,\varepsilon_0\,A}{Kd-h(k-1)}$$

(iv) If the dielectric slab is inserted without disconnecting the voltage source what will be the final charge on the capacitor ?

(v) In which situation it is easier to insert the dielectric slab? Explain your answer without doing any calculations.

8. An L - shaped tube ABC of square cross - section of side 5 mm is connected to a large tank T containing a conducting liquid as shown in the diagram. A uniform magnetic field of flux denisity 0.2 T is acting in the direction indicated across the horizontial arm of the tube BC. A current of 6 A is passed vertically upwards along an entire coross - section of the liquid.



(i) Find the magnitude and direction of the force acting across the cross-section of the liquid.

(ii) Find the pressure developed across the cross-section of the liquid due to the above force.

(iii) If the denisity of the liquid is 1.2 x 10^3 Kg m^{-3} how hogh will the liquid level rise in the vertical arm AB due to this pressure ? (Assume that the change in level of liquid in the tank is negligibly small.)

(iv) If the vertical arm AB of the tube is not there, what is the flow speed of the liquid?