Advanced Level Examination 2022

Physics Seminar

Part A – Structured Essay

01. The figure shows a U - tube with water and an immiscible liquid in balance in the experiment for determining the relative density of a liquid. **XY is the initial horizontal common inter surface.**

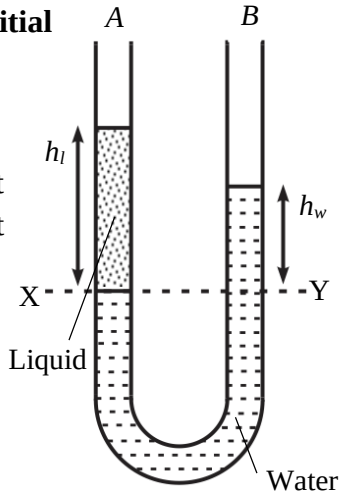

Figure (i)

(a) (i) Four liquids arranged in order of their densities from highest to lowest are aniline, water, coconut oil and alcohol. What liquid/ liquids cannot be used as the liquid labelled in this experiment?

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(ii) Give reasons

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(b) If the densities of the liquid and water are ρ_l and ρ_w, write $\frac{\rho_l}{\rho_w}$ in terms of h_l and h_w

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(c) You have to find $\frac{\rho_l}{\rho_w}$ by a graphical method. Draw the graph you expect by labelling axes.

(d) Initially h_l= 10 cm and h_w = 8 cm. What will be the new value of h_w if 10 cm^3 of the liquid is put into the arm A. Area of cross section of the tube is 2 cm^2.

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(e) In the experiment a student carries out two extra steps ahead **by reducing the height of the liquid back to 10 cm.** As shown in figure (ii), a smooth and light piston (area of cross section 2 cm^2) is inserted into the arm A and the liquid is compressed until the upper levels of the liquid and water come to the same level.

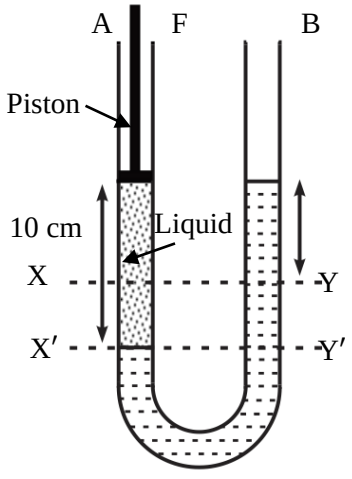

Figure (ii)

(i) What is the force (F) applied to the piston? (Density of water is 1000 kgm^{-3})

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(ii) What is the gap between xy and x′y′?

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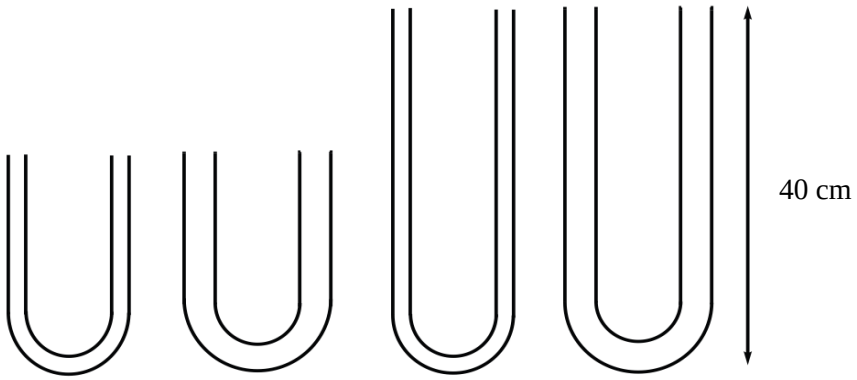
(f) Several U tubes with different cross section areas and different heights are given.



(i) What is the most suitable U tube for the above practical from the given list?

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(ii) Give two reasons for your answer.

(1) ……

(2) ……

(02) The following setup is used by a student to find the specific heat capacity of lead shot by the method of mixture in a school laboratory.

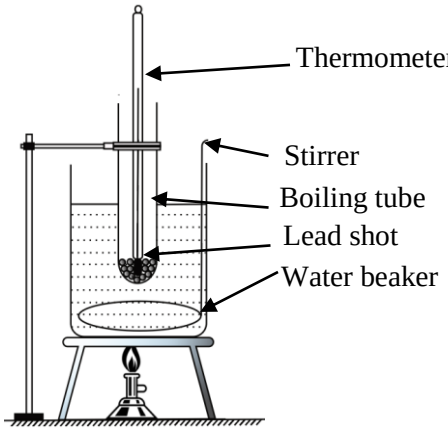

Figure 1

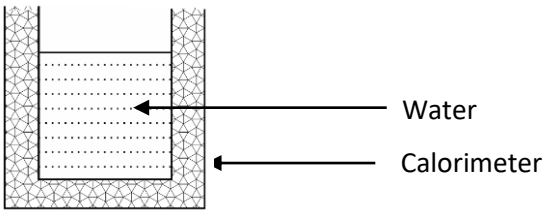

Figure 2

As shown in figure 1, the boiling tube with lead shot are heated up to 95°C by placing in a water bath. The heated lead shot are mixed to the water in the calorie meter.

(a) (i) How do you confirm that the lead shot in the boiling tube have reached 95°C?

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(ii) A student suggests that a tube made out of metal is more suitable than a boiling tube to heat the lead shot. Do you agree with this statement? give the reason why.

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(iii) Name two other apparatus required for this practical?

1. ..... 2. .....

(iv) What are the points that should be considered when adding heated lead shot to the calorimeter?

1) .....

2) .....

(b) (i) Write down the measurements taken by the student during the above experiment in correct order.

1) .....

2) .....

3) .....

4) .....

5) .....

(ii) The readings relevant to the measurements taken above are given in the below table in SI units.

Measurements	**reading**
(1)	100×10^{-3}
(2)	220×10^{-3}
(3)	30
(4)	40
(5)	720×10^{-3}

(Specific heat capacity of water is 4000 $Jkg^{-1} K^{-1}$, Specific heat capacity of the calorimeter is 400 $Jkg^{-1} K^{-1}$)

Calculate the specific heat capacity of lead.

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(c) In an experiment to find the specific capacity of a metal from the method of mixture is it suitable to use coconut oil instead of water? Justify your answer.

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03. A student has arranged a practical setup to find molar mass in the laboratory. He uses a tall glass beaker of water, a meter ruler, a resonance tube open at both ends and a signal generator for this practical.

(a) Obtain an expression for the velocity of sound (V) using the absolute temperature (T) of air in the tube and molar mass of air (M).

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(b) Describe the other physical quantities in the above expression.

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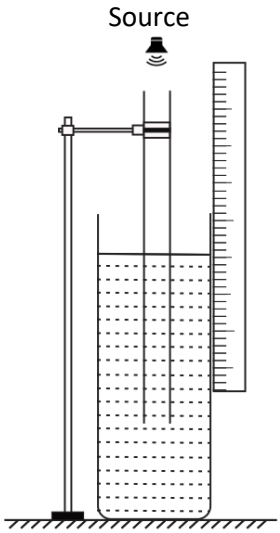

(c) The student has decided to do the practical in a room that the temperature can be changed and set up the apparatus as shown in the figure, and kept the vibrating signal generator just above the open end of the tube and obtained the fundamental resonance position. What is the correct method of obtaining the fundamental resonance?

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(d) If the fundamental resonance length is l, the end correction of the tube is e, and the frequency of the tube is f. Write an expression for the velocity (v) of sound in air.

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(e) It is required to find the molar mass (m) of air by drawing a graph. For this the student has taken the fundamental resonance lengths by considering room temperatures. The student has taken the gradient of the graph as 2.5×10^{-3} m^2 k^{-1} and γ = 1.4, R = 8.3 JK^{-1} mol^{-1}, 100Hz. Calculate the molar mass of air (**neglect the end correction of the tube**

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(f) To do the above practical accurately, two students have selected two different temperature ranges.

student A –15℃, 20℃, 25℃, 30℃, 35℃

student B –20℃, 30℃, 40℃, 50℃, 60℃

(i) What range would you select from the above two ranges.

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(ii) Give the reason why.

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(g) When the temperature of air is constant, value and humidity is increased. What will happen to the velocity of sound in air?

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04. (a) The figure (A) shows a solenoid connected to a centre zero galvanometer and the movement of the magnet

(i) What is the direction of the deflection of the galvanometer?

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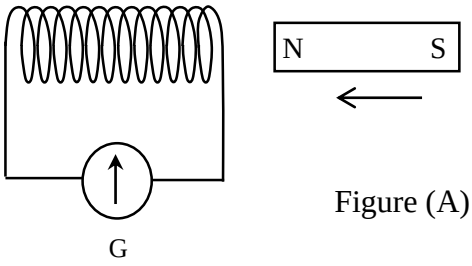

Figure (A)

(b) The figure (B) shows a conducting rod AB of length l moving perpendicular to a uniform magnetic field of flux density B with velocity v.

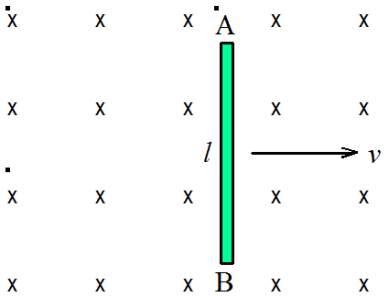

Figure (B)

(i) Write an expression for the electromotive force induced on the conductor.

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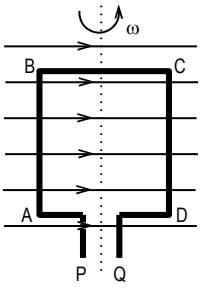
(ii) Mark the polarity of the EMF in the rod in the given figure (B)

c) A wire frame of cross sectional area A and number of turns N rotates in a magnetic field with uniform angular velocity ω. The axis of rotation is perpendicular to the field. Two positions of the frame are shown in figure (C) & (D). In the figure (C) the frame is parallel to the field and in the figure (D) the frame is inclined at angle θ to the field.

Figure (C)



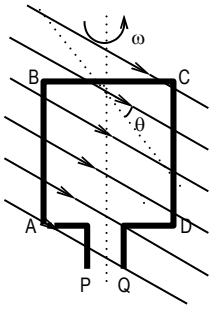


Figure (D)

(i) Write expressions for the EMF at each position.

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(ii) Show the changes necessary to the figure (C) & (D) to convert them to a D. C. generator and an A.C. generator respectively.

(ii) The cross section area of the frame is 100 cm^2, the number of turns is 300, magnetic flux density is 0.2 and the frequency of rotation is 50 Hz. Calculate the root mean square EMF induced across P and Q (π = 3)

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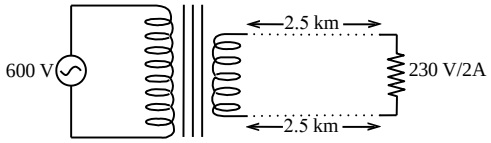
f) A. C. voltage produced by a dynamo is 600 V. It is required to supply 230 V and 2A to a factory which is at a distance 2.5 km from the dynamo. A transformer is used for this purpose. Linear resistance of the transmission cables is $10^{-3}\ \Omega\ m^{-1}$



(i) What type of transformer is used for this?

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(ii) Find the ratio of the number of turns between the primary and secondary coils.

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(iii) The efficiency of the transformer is 60%. Calculate the current through the primary coil.

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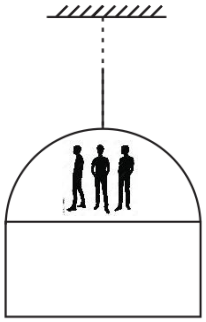
Part B
Essay Questions

05. Figure shows a diving chamber which is used to collect ruins of a ship sunk in the bed of the sea. If consists of half of a hollow sphere of radius 2 m and a hollow cylinder of 2 m height. When considering the volume of the chamber, the volume of the metal can be neglected. Mass of the diving chamber is 20000 kg and the total mass of 3 divers is 200 kg. (π = 3)



(a) When the diving chamber is in water, how much volume of the chamber is inside the water? (Density of sea water is 1200 kgm^{-1})

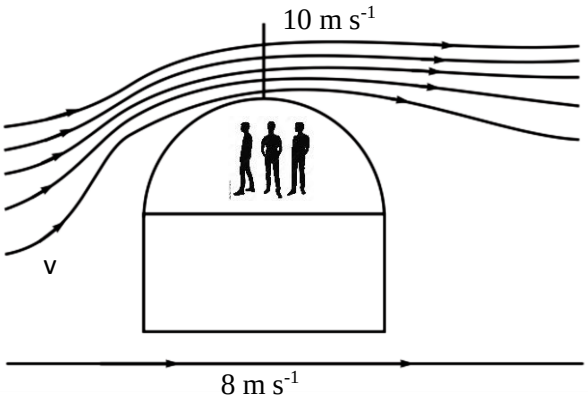
(b) Find the upthrust when the diving chamber is completely immersed in water.

(c) To immerse the diving chamber completely, sea water is filled in to the cylindrical part of the air chamber. If the cylindrical chamber is filled completely, find the tension of the string to keep the chamber stationary and completely immersed in water.

(d) If the string is not taut, find the acceleration of the chamber in the downwards direction.

(e) The chamber is kept at rest at a position where the bottom of the chamber will be at 100m depth from the sea surface. At that time there is no tension on the string. Find the force exerted on the curved surface of the diving chamber due to the water pressure and mark the directions.

(f) When the chamber is at 100 m depth it is affected by a sea current. Because of that, the velocity of water above the chamber is 10 ms^{-1} and velocity of water below the chamber is 8 ms^{-1} Find the resultant upwards force due to the pressure difference 0.48×10^5 Pa (Consider the flow is laminar and steady.)



(g) If at that time the string is 60° to the vertical, what is the horizontal force acting on the diving chamber due to the collision with water?

(h) At 120 m depth, the diving chamber comes to rest on the seabed and there is no water layer between the seabed and the chamber. A diver collects objects of 4000 kg mass into the chamber. Find the minimum volume of water needed to be removed from the cylindrical part to lift diving chamber.

06. (a) The Simple or compound microscopes are used to magnify and observe tiny objects.

(i) When an object is being moved towards the eye, its magnification seems to increase. State the reason for this.

(ii) Draw two ray diagrams to show that the image becomes larger and smaller respectively when an object is at two positions at close proximity and far away from the eye.

(iii What is meant by the normal adjustment of the microscope ?

(iv) What is the reason for selecting the normal adjustment?

(v) What is meant by angular magnification of a microscope?

(b) Two lenses having focal lengths of 5 cm and 2 cm have been used as the eye piece and the objective piece respectively in a compound microscope. This microscope is used to observe objects at 3cm away from the objective lens.

(i) If the final image is formed 25 cm away from the eye piece. Draw the ray diagram for this situation.

(ii) Calculate the angular magnification of this compound microscope.

(iii) Find the distance between the two lenses.

(c) (i) Generally, compound microscopes form inverted images. In order to obtain an "erect magnified final image", the eye piece of the above compound microscope is replaced by a concave lens of focal length 3 cm, and it was adjusted so that the final image is formed at 25 cm away from the eye piece. Draw the ray diagram for the newly adjusted compound microscope.

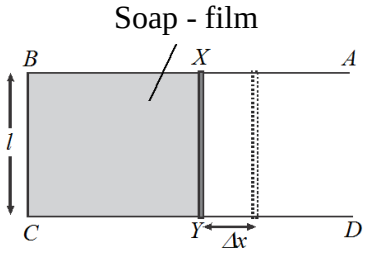
(ii) Find the distance between two lenses.

(iii) In order to obtain an "erect magnified final image", a student decided to introduce another convex lens to the compound microscope mentioned in (b) (i) without using a concave lens as in (c) (i), but another student says that, the method in (c) (i) is more suitable. What is your decision on this? Explain with reasons.

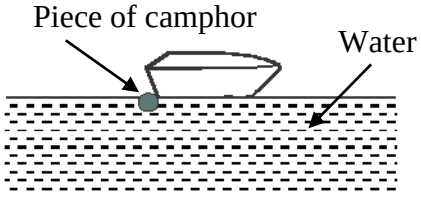
07. (a) (i) Write the dimensions of the co-efficient of surface tension.

(ii) What is meant by the surface energy?

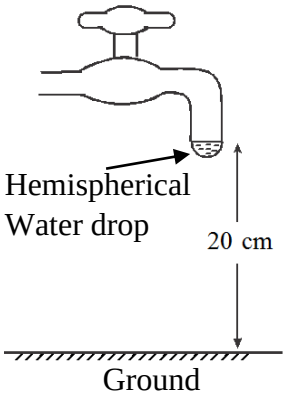
(iii) ABCD is a wire frame consisting of a thin soap-film which is kept horizontally. XY is a rod connected to the soap-film which can slide along the AB and CD arms. The co-efficient of surface tension of soap is 'T'. Obtain a relation between the work done on the rod and the additional energy stored in the soap-film, when the rod is moved by ΔX distance. (Neglect the frictional forces)



(iv) Explain the following incident using surface tension. "A toy boat is staying at rest on the surface of a stagnant body of water, as shown in figure. When a piece of camphor is connected to the back side of the boat so that it contacts with water, it proceeds to move forward"



(b) The figure shows an incident which happens after closing a tap. The water remaining in the vertical portion of the tube gets collected at the open end and the collected amount increased with the time, forming a hemispherical water drop, and then it gets released from the tap and falls under gravity. Assume, it falls as a spherical water drop, having a constant radius. The diameter of the open end of the tap is 9.2 mm. The density of water is 1000 kgm^{-3}. (π-3)



(i) Find the maximum amount of water mass that can be collected in the drop under the above conditions.

(ii) Calculate the coefficient of surface tension of water.

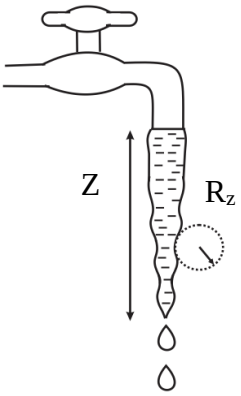
(iii) Find the radius of the water drop which falls under gravity (Consider $2^{4/3} = 2.5$)

(iv) The water drop then hits on the ground and breaks into 100 identical water droplets with equal kinetic energies. The energy dissipations on the collision is negligible.

(I) Find the radius of one droplet after collision on the ground. (consider $10^{8/3} \sim 500$)

(II) Is the total maximum kinetic energy gained by small droplets equal to the initial kinetic energy of the water drop? (consider surface energy is negligible)

(c) When the tap opens smoothly the water falls downward as a thin stream as shown in the figure. At the beginning the shape is linear and later it forms sinusoidal pattern. The radius of the curvature of a wave is R_Z , given by the following equation. At a certain value of R_Z the stream breaks into water drops.



$R_Z = R_O + A_K \text{ Cos } (k \times z)$

Where,

R_O = radius of the tube of the steam

A_k = the amplitude of a loop of a wave

$_k$ = wave number (the number of Crests and troughs per centimeter)

$_z$ = the distance from the mouth of the tap to the point of breaking. (In meters)

When AK = $\frac{R_O}{Z}$ and $R_Z = 1.25\ R_O$, it begins to break. At this time the number of crests and troughs which appear within 10 cm is 100.

(i) Find the wave number (k) of the water stream.

(ii) Find the distance from mouth to the point when the stream starts to break.

8. (a) (i) Write Newton's law of gravitation.
(ii) Define the gravitational potential at a point in a gravitational field.
(iii) Write an expression for gravitational potential V at a point at distance r from the centre of an object of mass M in terms of G, M and r. Where G is the universal gravitational constant.
(iv) Draw a rough graph to show how the gravitational potential V, varies with distance r.
(v) Why is the gravitational potential always a negative value?

(b) When a mass falls towards earth, its potential energy will be lost. Explain what happens to this energy lost under each of the following scenarios.

(i) When the mass free falls above the atmosphere

(ii) When the mass is moving with uniform velocity through the atmosphere

(c) An object of mass 1 kg is projected upward with a kinetic energy of 32 MJ from earth's surface.

(i) Calculate the velocity of the object.

(ii) Obtain an expression for the escape velocity of an object on earth's surface in terms of G, M and R. Where, M and R are the mass of earth and radius of earth respectively.

(iii) If the mass and radius of earth are 6×10^{24} kg and 6400 km respectively, and G = 6.67×10^{-11} N m^2 kg^{-2}, calculate the escape velocity of the object at earth's surface and hence show that the object does not leave the gravitational field.

(iv) How much kinetic energy must be imparted to the object at earth's surface so that it just leaves the gravitational field?

(v) If the mass of moon is 7.5×10^{22} kg and the distance between the centres of earth and moon is 4.0×10^{5} km, calculate the minimum velocity required to project a planetary object of mass 400 kg into infinity from the mid-point of the distance between earth and moon.

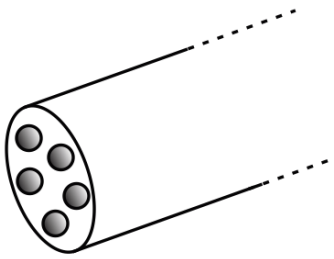
(**Hint: consider the mass of moon with compared to earth is negligible for this calculation**)

(vi) What will happen to the velocity of the planetary object if its mass is doubled?

09.A. The electric energy generated in power stations is distributed to distant villages using high voltage transmission. In this method the electric energy generated in the power station is converted in to a very high voltage and low current using a step-up transformer for transmission and at the sub stations a stepdown transformer is used to reduce the voltage and distribute it to factories and houses.

(a) Transmission of electric energy is done using a low current at high voltage. Explain the reason for this.

(b) Five parallel wires bundled together as a single cable as shown in the figure is used to transmit electricity to 40 km distance. Each wire is at room temperature (20°C), having resistivity 2 x 10^{-8} Ωm^{-1} and cross-sectional area 2 cm^2. During transmission the current flowing is 0.5 A.



(i) Find the resistance of the transmission cable.

(ii) Find the potential difference between the two ends of the transmission cable.

(iii) Find the power loss during electricity transmission.

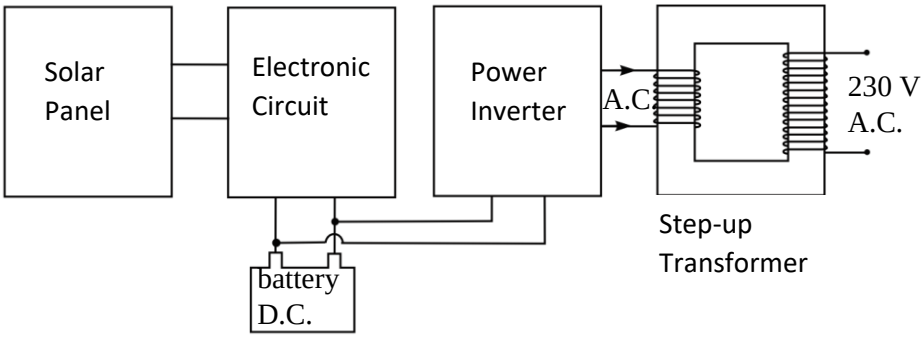
(iv) When a 0.4A current is transferred during a period of one hour, the potential difference between the 2 points of transfer is constant. The temperature of the wire also remains at a constant 40°C. Find the thermal coefficient of resistance.

c) (i) A DC motor is run by passing alternating current through a 12V full wave rectification. The maximum safe current flow through the motor coil is 2A. The resistance of the motor coil is 2Ω, calculate the resistance to be connected in series when operating the motor.

(ii) Calculate the back EMF when the motor is running at the maximum power and find the efficiency.

(d) If the motor rotates at a speed of 600 revolutions per minute and the area of the coil is 40 cm^2 and the number of turns of the coil is 100, find the magnetic flux density of the field acting on the coil.

(e) A certain country has implemented rolling blackouts in order to conserve energy. In order to provide basic lighting during the blackouts, Power inverters are used in many households. Below is a basic schematic of such a power inverter. A power inverter operates by converting a DC voltage source to an AC current and passing it through a step up transformer to output mains power. The batteries are energised by solar power during the day and the charge thus stored is used to drive the inverter.



A certain house uses a power inverter of output power 1000W at 230 Volts to operate the following apparatus. The battery supplied is 12V and 90Ah capacity.

Apparatus	**Quantity**	**Power (W)**
Bulb (LED)	04	5
Electric fan	01	40

(i) If all the apparatus are used at the same time, what is the operating time of the inverter?

(ii) If a refrigerator of power 750W is used with the above apparatus. What is the operating time of the inverter?

(iii) For the above inverter, what is the output power through a load resistor of 10 Ω?

09.B (a) Draw the characteristic curve of a diode

(b) Explain the action of a Zener diode.

(c) In the circuit given, a Zener diode of voltage 12 V is used. The resistances R_S and R_L are 120 Ω and 200 Ω respectively, supply voltage V_{in} = 25 V

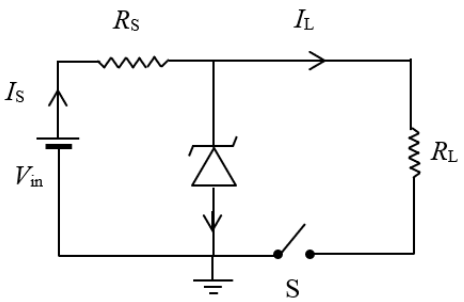


Figure (1)

(i) Calculate the currents through R_S, R_L and the zener diode, I_s, I_L and I_Z respectively.

(ii) What is the power of the diode?

(iii) What is the possible maximum power of the diode?

(iv) What should be the minimum power rating of the diode used for proper operation of the circuit?

(d) The transistor shown in the circuit is biased to cut off region, and saturated region respectively by applying input voltages 0V and 5V respectively. Transfer characteristic (I_C vs I_B) of the transistor is shown in the graph. The dc current gain, β of the transistor is 100.

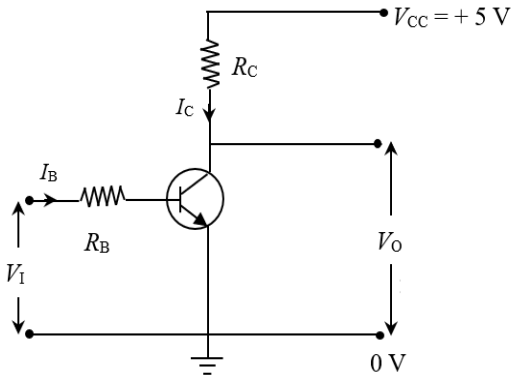


Figure (2)

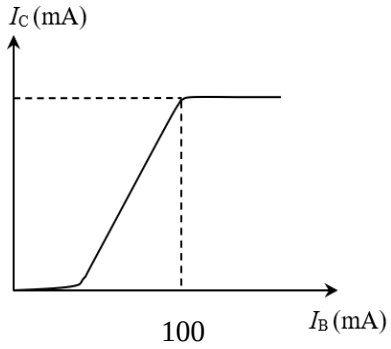


Figure (3)

(i) Calculate the maximum current of the I_c

(ii) Calculate the maximum resistance for R_B.

(iii) Calculate the resistance the R_C

(iv) Copy the table below and complete it giving the outputs for input 0 V and 5 V.

Input (A)	**Output (F)**
0 V	
5 V	

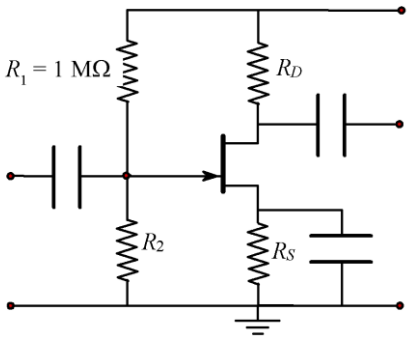
(v) What is the equivalent logic gate which gives the same output and give its truth table.

(e) (i) Draw the characteristic curve for V_{DS} vs I_D for a junction field effect transistor (JFET) for 3 different constant values of one parameter.

Mark the cut-off region, saturated region, and the Ohmic region.

(ii)Explain why the V_{DS}- I_D graph has a linear variation for small values of V_{DS} in the Ohmic region.

(iii) Draw the variation of V_{DS} against I_D when V_{GS}=0 and mark the pinch-off point, pinch off voltage (V_P) on the graph.



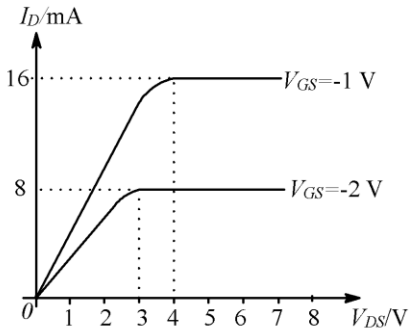
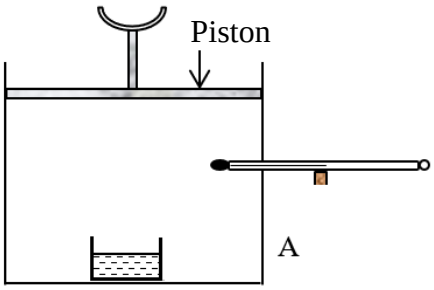


Figure shows a JFET amplifier and I_D vs V_{DS} graph.

(i) Find the minimum V_{DS} for the device to operate in pinch –off
(ii) Find the Gate current when V_{GS}=-2V and when V_{DS} =5V
(iii) If V_G=5V, I_D=4mA, V_D=8V and V_{GS}=-2V find the values of R_2,R_D,R_S

10. A. By moving the piston, the volume in the cylinder can be changed. A small quantity of water is placed inside.



(a) When the volume inside is slowly increased by moving the piston, water in vessel completely evaporated. The volume is further increased.
Draw a rough sketch to show the variation of vapour pressure with volume when the volume is increased by keeping the temperature constant.

(b) Keeping the volume constant, the temperature inside the cylinder is gradually increased until all the water in the vessel is evaporated. Now the temperature is further increased. Draw a rough sketch to show the variation of vapour pressure with temperature θ measured in ^{0}C.

(c) The water vessel is removed from the cylinder. Then the relative humidity of air becomes 60% when the volume is 0.2 m^3 and the temperature is 27 ^{0}C.

(i) Calculate the partial pressure of water vapour. (Saturated vapour pressure at 27 ^{0}C is 27 Hg mm).

(ii) Calculate the absolute humidity inside the cylinder. Molar mass of the water is 18 g, density of mercury 13600 kg m^{-3}, R = 8 J K^{-1} mol^{-1})

(iii) By how much must the volume in the cylinder be decreased to start condensing the water?

(iv) Variation of density of saturated water vapour with temperature is given below. Calculate the dew point.

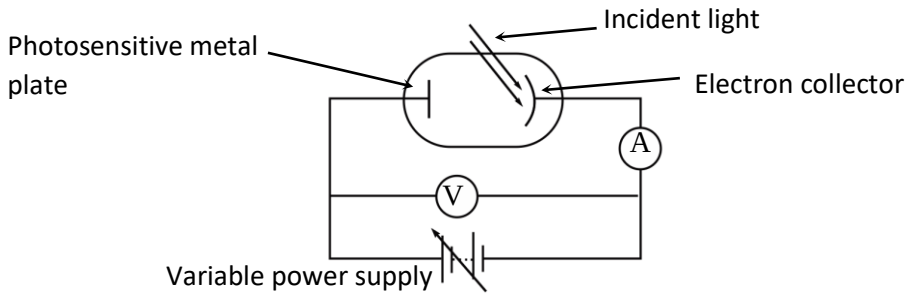
Temperature (^{0}C)	14	16	18	20	22
Density of saturated water vapour (g m^{-3})	12.00	13.50	15.30	17.10	19.20

(v) Calculate the saturated vapour pressure of water at the dew point.

(d) There is another cylinder (B) similar to the former one (A). Relative humidity inside B is 80% when the volume is 0.2 m^3 and at temperature is 7 ^{0}C.
Now A and B are connected by a tube of negligible volume. In what direction will water vapour flow? (Saturated vapour pressure at 7 ^{0}C is 7.5 Hg mm)

(e) Calculate the relative humidity of B after they come to equilibrium. (Temperature of the system at the equilibrium is 22 ^{0}C).

10) B. An apparatus used to study the photoelectric effect is shown in the diagram below. When light falls onto the photosensitive metal plate, electrons are ejected.



(a) Describe how the apparatus can be used to determine the maximum kinetic energy of ejected electrons for a given metal and a particular wavelength of light.

(b) Light of wave length 5.14×10^{-7} m is incident on the photosensitive metal plate. The work function of the metal plate is 2.14 eV. Calculate the minimum potential difference required to stop all the ejected electrons in the apparatus.

(c) (i) Sketch a graph of stopping voltage (Vs) against frequency (1), showing typical results of an experiment using the apparatus. Label this graph A.

(ii) Using the axes in part (i), sketch a graph showing the results for a different photosensitive metal of higher work function, label this graph as B.

(d) Explain how you could use the apparatus above to determine Plank's constant. You have the ability to change the frequency of the incident light.

(e) When sunlight ejects electrons from the silver coating on the outer surface of a satellite, the satellite can become charged by the photoelectric effect. Assume the outer surface is initially uncharged.

(i) Calculate the longest wave length of sunlight that can eject an electron from the satellite's outer surface. The work function of silver is 3.83 eV.

(ii) Explain why a satellites with a platinum coating charges more slowly than one with a silver coating. The work function of platinum is 5.32 eV.

(f) Production of X rays can be considered to be the inverse of the photoelectric effect. The accelerating potential applied across an X rays tube is $3x\ 10^4$ V.

(i) Calculate both the kinetic energy and speed of electrons just before it hits the target.

(ii) Calculate the De Broglie wave length associate with an electron just before it hits the target.

(iii) Calculate the maximum frequency of the X radiation emitted ($h = 6.63 \times 10^{-34}$Js)