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North Western Province

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Diagnostic Test -2024 -Grade 13

Physics -Part II

Name/Index No..... Time- 02 hours

Part -B Essay

Answer only four(04) questions

(5)

1. Write down the Archimedes' Principle
2. Explain the floatating of an object using the principle of floatation.
3. Explain why it is harder to float a uniform rod vertically than horizontally.
4. When the weight of an object was weighed with a spring balance, the reading was 15N . When fully immersed in water and liquid and weighed the readings were 10 N and 12 N respectively.
   (i) Find the relative density of the material the object is made of.
   (ii) Find the relative density of the liquid.
5. 60% of the boat was submerged when a fishing boat carrying six men weighing 50kg each was sailing. When two men jumped into the water at the same time the submerged volume of the boat was 50%. Find the mass and volume of the boat.
6. Find the mass of fish that can be loaded into the boat so that the boat does not sink.
7. The boat carrying the four men while sailing , suddenly entered a region where water is uniformly mixed with tiny air bubbles , causing 75% of the boat to sink.Find the effective density of water in that area.
8. If the volume of an air bubble is $1mm^3$, find the concentration of air bubbles in that area.
9. If the two men who had just jumped into the water got back into the boat in this area, would the boat have sunk? explain.
10. The engine of the boat stopped working due to a mechanical fault in the boat (in the air bubble - free region). The boat was pulled ashore by another boat with the help of a string. If the resistive force exerted by the water on the boat is $100Nkg^{-1}$find the minimum tension the string must be able to withstand to be pulled with an acceleration of $5ms^{-2}$. (The weight of the boat with fish is 650kg).

11. Find the work done required to drag the boat a distance of 500m.

(6)

a) Explain what is meant by the critical angle and the total internal reflection.

b) If the absolute refractive index of glass is 1.5 and that of water is $\frac{4}{3}$, calculate the critical angle for

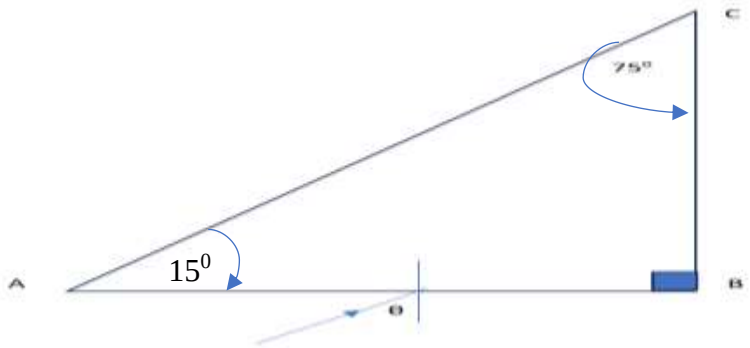
(i) glass - air interface

(ii) glass - water interface

c) Draw the ray diagrams to show the following angle of deviations of a ray incident on a suitable prism of refractive index 1.5.

1) 90^0 11) 180^0 111) 0^0

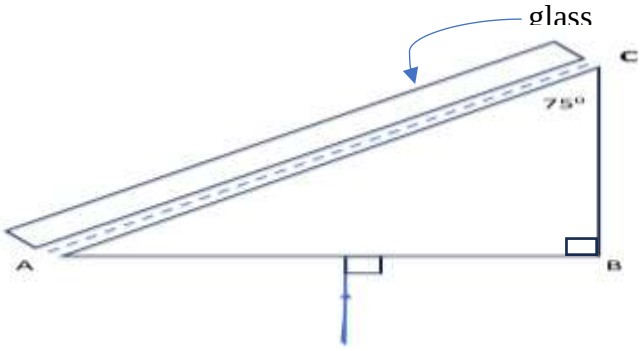
d) In the diagram it is shown a monochromatic ray of light incident on a transparent glass prism of reflective index 1.4. For this ray to undergo total internal reflection at the face AC, calculate the required minimum value of angle of incidence θ.



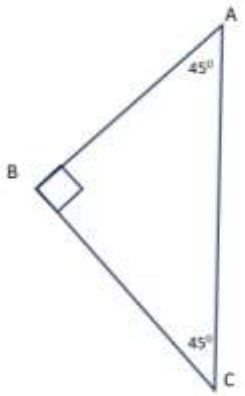
e) If the angle of incidence $\theta = 80^0$ find the angle at which the ray emerges to air.

f) As shown in the diagram below a layer of water of refractive index 4/3 is applied on face AC by a glass slide which has the same refractive index as the prism.

A ray is incident perpendicular to face AB. Find the angle at which this ray emerges to air

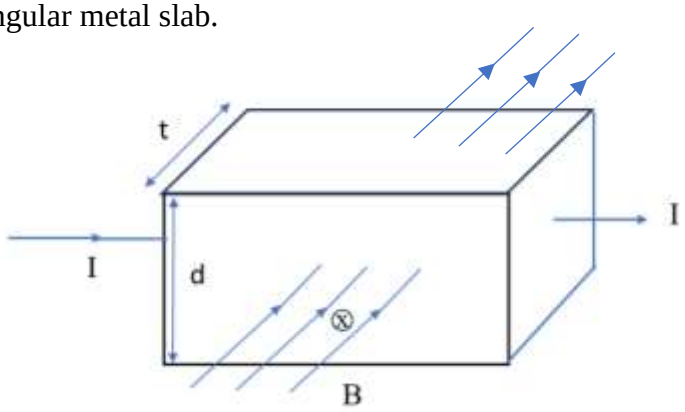


g) Copy the given figure on your answer sheet. Draw the image of letter F formed by the faces AB and BC when observed through the face AC.



7. A magnetic force acts on conduction electrons when a magnetic field is applied perpendicular to the moving direction of them. Electrons are pushed by the force producing an electric field within the conductor. At a certain steady state, a potential difference or voltage called Hall voltage is set up at the two ends of the electric field.

(a) A magnetic field (B) is applied perpendicular to the current I flowing through a rectangular metal slab.



(i) What is the moving direction of electrons when the current (I) flowing to the right through the conductor?

(ii) What is the direction of force acting on electrons when the magnetic field (B) is applied perpendicular to the I as shown?

(iii) What is the direction of electric field (E) then setup across the slab?

(iv) Write down an expression relating forces acting on the electrons when the hall voltage is setup.

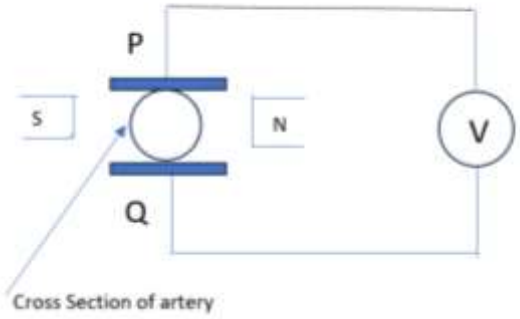
(v) Derive the equation for the hall voltage V_H,

$$V_H = \frac{BI}{net}$$

(vi) Identify the symbols in the above equation. A steady current of 80 A is flowing through the conductor. When a uniform magnetic field of strength 0.4T is applied

across the slab, a potential difference of $0.8\ x\ 10^{-6}$ V develops between the sides parallel to the field lines. The thickness (t) along the direction of B is $2\ x\ 10^{-3} m$, Calculate the number of free electrons per unit volume. (Charge of an electron = $1.6\ x\ 10^{-19}\ C$)

(b) As the blood contains charged ions, blood flow detectors based on the above principle can be used to find the speed of blood flow through arteries.



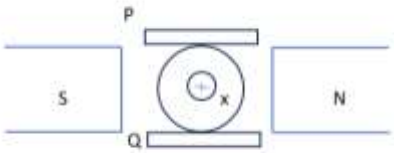
Sensitive Voltmeter

Here the two parallel plate electrodes P and Q are placed touching the walls of the artery as shown in the figure above, and blood flow speed is determined by measuring the voltage across electrodes at the steady state.

If the flux density of the applied magnetic field B=2T and the measured voltage across the electrodes is 0.7mV. The area of cross section of the artery is 1.5mm^2 and the separation between the electrodes is 1.4mm. (Assume that the internal diameter of the artery is also 1.4mm).

(i) Write down an expression for the force F acting on a charge Q moving through the artery with the blood at the same speed V and the same direction as the blood flow. The direction of V is perpendicular to B.

(ii) A positively charged ion , x moving through the artery travels into the plane of the paper as shown below. Show the direction of the force F on the charge and what is the polarity of the electrodes P and Q.



(iii)

i. Find the electric field intensity between P and Q

ii. If the charge of ion is 1.6x10^{-19} C , find the force acting on it by the electric field

(iv)

(1) Find the speed of the blood flow through the artery.(The magnetic force on the ions equals to the electric force between the electrodes)

(2) Using the result obtained in (iv)(1) and the data given ,calculate the rate of blood flow through the artery.

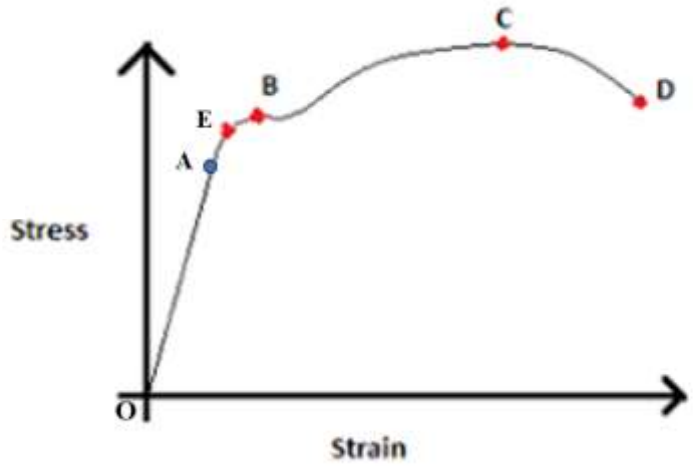
8.

(i)Write down the dimensions of following physical quantities

(a)Stress (b)Strain

(ii)Express the Young's modulus in terms of tensile stress and tensile strain

(iii)The tensile stress-strain curve for a certain metal wire is shown in the following figure below



(a) Identify the points A,E and D marked on the curve shown in figure above.

(b) Which physical quantity is represented by the gradient of the straight line OA

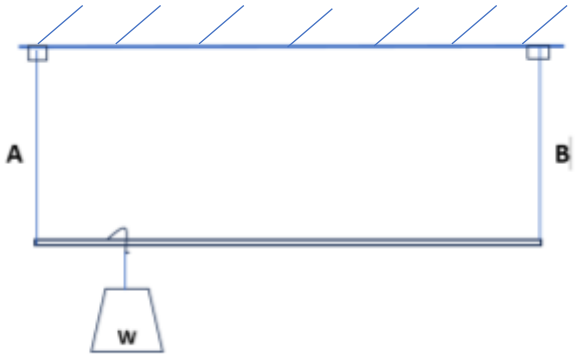
(c) Is stress propotional to strain at the part AE?

(d) If the metal wire is stretched beyond the point E , explain what happens to the internal atomic planes?

(iv)Table given below shows some physical quantities relevant to three wires.

Wire	**Initial length (l) (m)**	**Area of cross section A (X $10^{-6}m^2$)**	**Young's modulus E (X Pa)**
A	1.00	2.40	2.50
B	1.00	3.20	1.25
C	0.75	1.20	1.25

a)



A 1.05m long rod of negligible weight is supported at its ends by wires A and B.

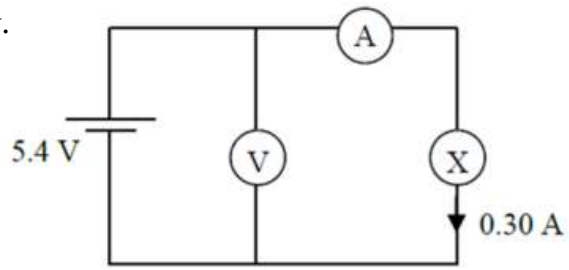
1) At what point along the rod should a weight W be suspended to produce equal stresses in A and B?
2) At what point along the rod should a weight W be suspended to produce equal strains in A and B?
3) If the weight W suspended is 1000N, calculate the total elastic potential energy stored in both wire considering the situation (2) above.

b) Now, the above rod is supported at its ends by wires A and C.

1) Draw a diagram to represent the above situation , if the rod is horizontally suspended using two vertical wires A and C.
2) At what point along the rod should the weight be suspended to produce equal strains in A and C.

Answer either Part (A) or Part (B) only.

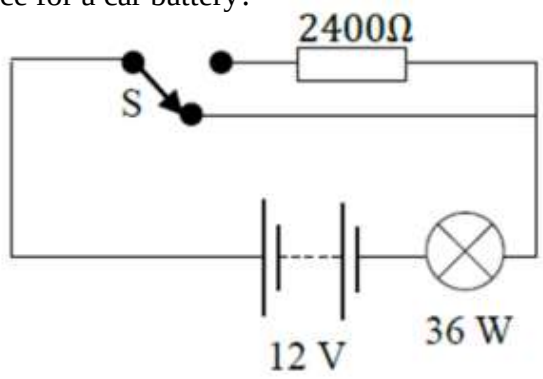
9. (A) (i)Electromotive force of a battery shown in the figure is 5.4V.When 0.3A current is passing through the bulb , reading of the voltmeter is 4.8V.Explain what is the reading of the voltmeter is less than the E.M.F of the battery.



(ii) (a)Find the internal resistance of the battery

(c) Find the energy dissipated by the bulb in 1 s.Write down two assumptions that you have made for this calculation.

(iii) A Car battery of 12V is shown in the following diagram.What is it more suitable to have very small internal resistance for a car battery?



(iv) In the above diagram ,a 12V car battery with a negligible internal resistance is connected to a 12V,36W filament bulb.

a)Find the current passing through the bulb, when only the bulb is connected to the battery.

b)Find the current passing through the bulb, when the bulb is connected to the circuit through the resistance.

c)When the switch "S" is moved at once to the circuit consisting battery , resistance and bulb, to set current through the circuit few seconds are taken.What is the reason for it.

(v) (a) After using the above battery ,it is required to charge. The internal resistance of the battery is found to be 0.5Ω .A 120V source of negligible and a resistance 15.5Ω are provided for you .Draw the circuit diagram required to charge the battery.

(b)Find the potential difference across the terminals of the battery during the charging.

(c)What is the reason of connecting a resistor of to the circuit.

(vi) A high voltage power pack used in school Laboratohas a high resistance. What is the advantage of it.

9. (B) (i)The diagram(1) shows an ideal op amp and connected circuit.

The inverting and non inverting inputs are V_1 & V_2 respectively.

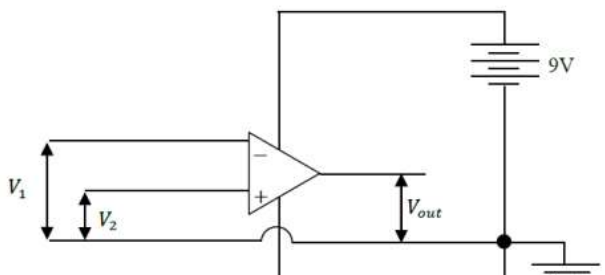


Diagram 1

when ,

(i) V1>V2

(ii) V2>V1

Draw a graph by using the values of output voltage.

(ii)

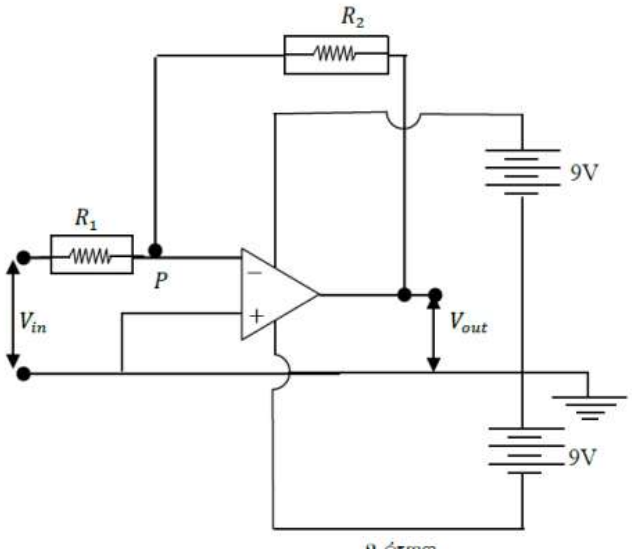


Diagram 2

(a)What is the name of the above amplifier circuit shown in diagram 2.

(b) Explain the reasons , why does the point "P" consider as virtual ground point.

(C) If the open loop gain is A; obtain an expression for A in terms of R_1 & R_2

(d)Draw the graph V_{out} Vs V_{in}

(iii) Following circuit diagram 3 shows the above circuit diagram 2 modify by using a Light dependent resistor (LDR)

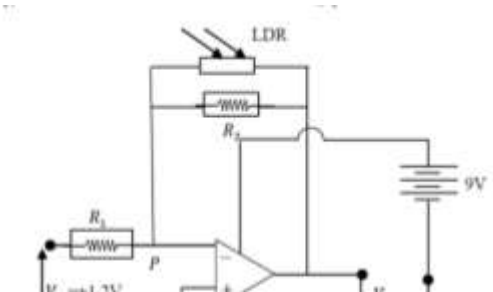


Diagram 3

The resistors R_1 and R_2 are 6kΩ and 60kΩ respectively.Vin=+1.2V, V_{out} is measured by using a high voltage meter.To control the intensity of light, LDR is used.

(a)When the light intensities relevant to 1000kΩ and 10KΩ are fallen on to the LDR , find the voltmeter reading for 1000kΩ and 10kΩ values of LDR.

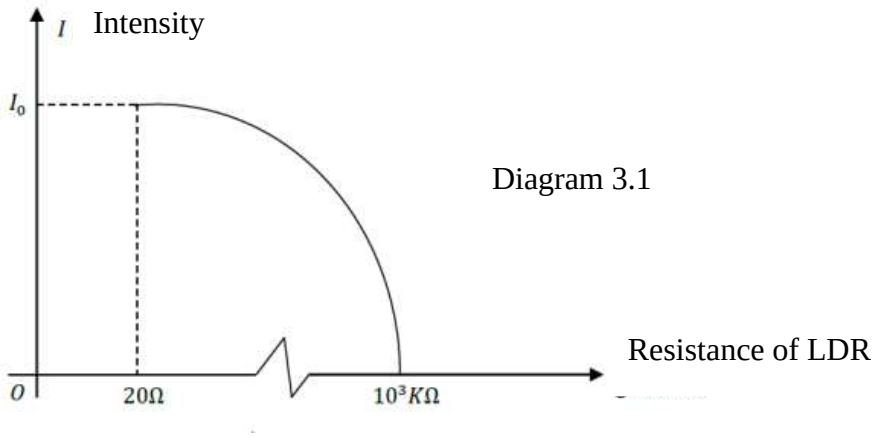
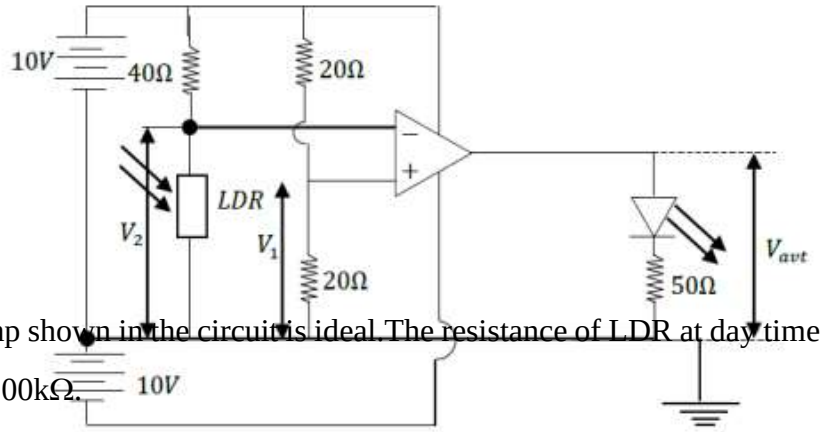


Diagram 3.1

(b)The resistance of LDR varies according to the intensity of light as the diagram 3.1.Draw the variation of V_{out} with the intensity of the light,

(iv)To light the LED bulb,circuit shown in the diagram3, is modified as shown in the following.



The above op amp shown in the circuit is ideal.The resistance of LDR at day time is 400Ω and at night time is 200kΩ.

(a)Find the potential difference V_1

(b)Find the potential difference V_2 separately when the LDR resistance is day time and night time.

(c)Find V_{out} of LED at dark(night) and V_{out} of LDR at day time.

(d) At what time , the LED be light.

(e)Apply the method to protect the LED from high voltag and Draw the circuit diagram for it.

Answer either part (A) or part (B) only

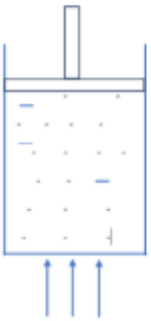
10. (A)

a) State the first low of thermodynamics.

b) What is the amount of work done when the volume of a certain mass of gas is increased from V_1 to V_2 at constant pressure P ?

c) Explain the isothermal and adiabatic process.

d) As shown in the figure, gas is enclosed in a thermally insulated cylinder by a smooth piston. The cross-sectional area of the cylinder is uniform and is equal to $8\ x10^{-3}m^2$. The cylinder is filled with helium gas at a temperature of 25^0C. The atmospheric pressure 1X 10^5 Nm^{-2} length of the gas column is 30cm. The mass of the piston ,the thermal capacities of the piston and the cylinder are all negligible.



(i) Find the number of moles of Helium gas in the cylinder (The molar mass of Helium gas = 4gmol^{-1} , R = 8.0 $Jmol^{-1}K^{-1}$

(ii) Find the root - mean - square speed of the gas molecules in the cylinder.

(iii)Find the pressure of the gas in the cylinder when a mass of 80kg is placed on the piston.

(iv)When the mass placed on the piston, the piston gradually moved down. Find the distance moved by the piston.

(v) When heat is supplied to the system at a constant rate for 10 seconds the air column moved up to 60cm and attained a steady temperature .Calculate the steady temperature.

(vi)Calculate the work done by the gas

(vii) Calculate the increase in internal energy.

(viii) Calculate the rate at which the heat was supplied.

10. B (a) (i)State the Boyle's law and the Charles law.

(ii)Derive the equation of state ,PV/T=k using the above laws.

(iii)Obtain the ideal gas equation.

(b) Divers are carrying "Scuba tanks" containing air needed to inhale them when in mid water.An rigid aluminum scuba tank contains 8.31 l(litre) of air at 27^0 C and 1 atm.Air is about 78% nitrogen in mass , 21% oxygen and 1% miscellaneous; its average molar mass is 28 $gmol^{-1}$ 1atm=$1x10^5$ pa.R=8.31 $Jmol^{-1}K^{-1}$.

(i) Calculate the number of moles of air and mass of air(m_1) present inside the tank at the beginning.

(ii) When the tank is filled rapidly from a compressor, the air temperature is 37^0C and the pressure is $3.1x10^7$Pa ,Neglecting the volume expansion of the tank, calculate the number of moles of air and mass of air (m_2) present inside the tank at the end

(iii)What mass of air (Δm) was added to the tank?

(c) The air inside the tank is not inhaled directly by the diver. This would be dangerous. Instead the air is inhaled through a valve with a pressure controlling mechanism.

(i) If at a certain depth in water , the diver with inhaled air inside the lungs at a pressure of $3x10^5$ Pa comes to the water surface. At constant temperature , the volume of the lungs increases by 10%.What would be is the excess pressure inside the lungs?

(d) (i)At what depth does the total pressure in the water become $3x10^5$Pa? (The density of water 1000kgm^{-3})

(ii) An exhaled air bubble at a depth of 20m rises to the water surface. Sketch a graph to show the variation of volume of the bubble with the depth from the water surface.

(ii) This amount of pressure difference relative to the environment is life threatening.What do divers do while they are ascending to the surface from deep underwater?