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Provincial Department of Education - NWP

01 F I

Practice Test - Grade 13 - 2020 104 ***Enu***

Index No. .....

Physics I

2 hours

- **This paper consists of 50 questions and Answer all the questions.**
- **Use of calculator is not allowed.**
- **Write your index number in the space provided in the answer sheet.**
- **In each of the questions 1 to 50 pick one of the alternatives from (1),(2),(3),(4),(5) which is correct or most appropriate and mark your response on the answer sheet with a cross (x) in the answer sheet.**

01 If the units of velocity, acceleration and force are denoted by α, β and γ respectively, the units of momentum would be,

(1) $\alpha\beta\gamma$ (2) $\frac{\alpha\gamma}{\beta}$ (3) $\frac{\gamma\beta}{\alpha}$ (4) $\frac{\alpha\beta}{\gamma}$ (5) $\frac{\alpha^2\gamma}{\beta}$

02. Consider the statements made on zero error

(A) It depends on the measurement you make.

(B) It can be eliminated by repeating the measurement.

(C) It exists only in instrument in which a vernier scale is used.

of the above statements

(1) only (A) is true (2) only (A) and (B) are true (3) only (A) and (C) are true

(4) all (A), (B) and (C) are true (5) all (A), (B) and (C) are false.

03 Which of the following statement is not true for a gas?

(1) they diffuse readily. (2) they are highly compressible.

(3) they possess viscosity. (4) they are immiscible.

(5) gas molecules move here and there randomly

04. A steady current is flowing in a conductor of non-uniform cross-section. The charge passing through any cross-section per unit time is

(1) directly proportional to the area of cross-section

(2) inversely proportional to the area of cross-section

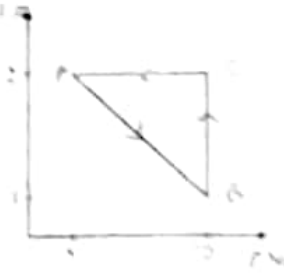
(3) proportional to square of the area of cross-section

(4) inversely proportional to thesquare of the area of cross-section

(5) independent of the area of cross-section

05. An ideal gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$ as shown in figure below. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process $C \rightarrow A$ is,

(1) -5 J (2) - 10 J (3) -15 J (4) – 20 J (5) -25 J

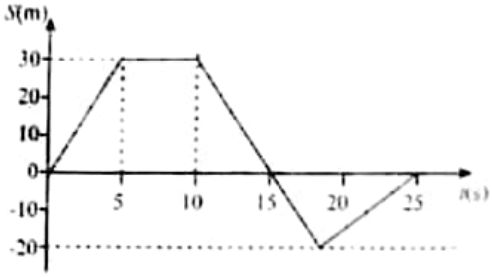


06. A primary cell has emf 2 V When short circuited it gives a current of 4 ampere. Its internal resistance in ohms will be
(1) 4 (2) 2 (3) 1 (4) 0 5 (5) 0 25

07 In which of the following cases can the principle of superposition be applied to two overlapping waves of the same nature?
(1) Only when the two waves travel in opposite directions.
(2) Only when the two waves have the same frequency.
(3) Only when the two waves have the same amplitude.
(4) Only when the two waves are coherent.
(5) It can be applied in all cases.

08. A piece of metal and a piece of wood are kept at a temperature of 45°C. On touching the two with hand, then
(1) both will appear equally hot
(2) the piece of wood will appear hotter than the piece of metal
(3) the piece of metal will appear hotter than the piece of wood
(4) the distinction in the hotness of wood will not be possible
(5) the distinction in the hotness of both will not be possible

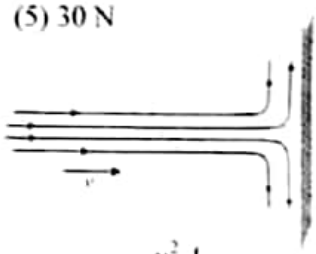
09. The displacement time (s - t) graph for a child riding a bicycle is shown in the figure. What is the average speed of the child for the given duration?



(1) 0.8 m s^{-1} (2) 2 m s^{-1} (3) 2.5 m s^{-1}
(4) 4 m s^{-1} (5) 5 m s^{-1}

10. A flat plate of area 0.1 m^2 is placed on a horizontal surface and is separated from it by an oil film 10^{-5} m thick If the coefficient of viscosity of oil is 1.5 kg m^{-1} s^{-1} , the force required to cause the plate to slide on the surface at a constant speed of 1 mm s^{-1} is
(1) 7.5 N (2) 10 N (3) 15 N (4) 12.5 N (5) 30 N

11. A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall that is perpendicular to the direction of the stream, as shown in the figure. The water then flows sideways across the wall. The force exerted by the stream on the wall is,



(1) $\frac{\rho v A}{2}$ (2) $\rho v^2 A$ (3) $\rho v A$ (4) $\frac{v^2 A}{\rho}$ (5) $\frac{v^2 A}{2\rho}$

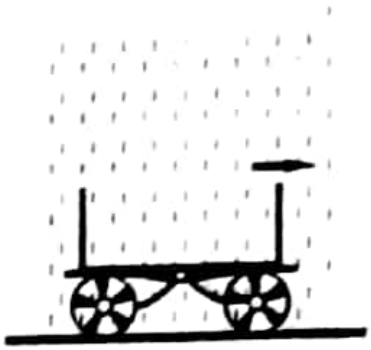
12. A particle of mass M is moving in a horizontal circle of radius R with a uniform speed V When it moves from one point to a diametrically opposite point, its
(1) kinetic energy changes by $\frac{MV^2}{4}$ (2) momentum does not change
(3) momentum changes by $2MV$ (4) kinetic energy changes by MV^2
(5) neither kinetic energy nor momentum change.

13. The amount of work done in forming a soap film of size 10 cm x 10 cm, (surface tension of soap = 3 x 10^{-2} N m^{-1}) is
(1) 6 x 10^{-4} J (2) 3 x 10^{-4} J (3) 4 x 10^{-4} J (4) 6 x 10^{-3} J (5) 3 x 10^{-3} J

14 Maximum and minimum magnitudes of the resultant of two vectors of magnitudes P and Q are in ratio 3:1. Which of the following relation is true?

(1) $PQ = 1$ (2) $P = Q$ (3) $3P = Q$ (4) $P = 2Q$ (5) non of these

15. The figure shows an open wagon moving with negligible resistance in vertically falling rain. An appreciable amount of rain falls into the wagon and accumulates there. What are the effects of the accumulating rain on the speed, momentum and kinetic energy of the wagon? (Ignore the effects of the raindrops hitting the front of the wagon.)



	speed	*momentum*	*kinetic energy*
(1)	decreased	unchanged	decreased
(2)	decreased	unchanged	unchanged
(3)	decreased	decreased	decreased
(4)	unchanged	unchanged	unchanged
(5)	unchanged	increased	increased

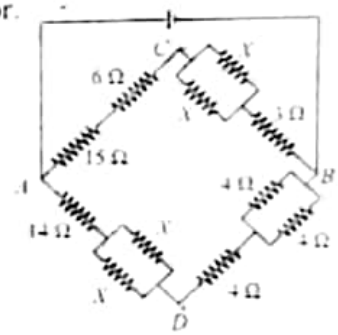
16 For the photoelectric effect, which of the following is the correct relationship between the energy E of a photon, the work function w of the surface which it strikes, and the maximum kinetic energy K of the emitted photoelectron?

(1) $E = w + K$ (2) $E = w - K$ (3) $E = K - w$ (4) $K = 2(w + E)$ (5) $w = \frac{1}{2}(K + E)$

17. In a controlled thermal fission reactor, the direct function of the moderators is to reduce

(1) the speed of the neutrons released on fission.
(2) the rate of production of the neutrons.
(3) the energy generated in the nuclear reactor.
(4) the amount of radioactive radiations produced in the nuclear reactor.
(5) the rate of disintegration of the ^{235}U nucleus

18. In the given circuit the value of resistance X so that the potential difference between C and D is zero is,



(1) 4 Ω (2) 6Ω (3) 8Ω
(4) 9Ω (5) 10Ω

19. In a surface tension experiment with a capillary tube, water rises up to 0.1 m. If the same experiment is repeated on an artificial satellite, which is revolving around the earth, water will rise in the capillary tube unto a height of

(1) 0.1 m (2) 0.2 m (3) 0.98 m (4) 0.05 m (5) full length of the capillary tube

20. One mole of an ideal gas of volume V_1 is at an initial pressure P_1 and temperature T_1. If the gas undergoes an isothermal expansion, so that its volume increases to V_2.

(A) there is no heat exchange between the gas and the surroundings.
(B) the external work done is equal to $P_1(V_2 - V_1)$
(C) the internal energy of the gas remains unchanged

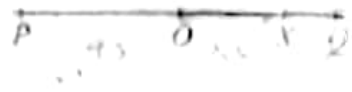
Which of the above is correct?

(1) (A) only (2) (C) only (3) (B) and (C) only
(4) (A) and (C) only (5) all (A), (B) and (C)

21 A person can see clearly between 1 m and 2 m only. His corrective lenses should be
(1) Bifocals with power -0.5 D and + 3.5 D (2) Bifocals with power -1.0 D and + 3.0 D
(3) Bifocals with power -3.5 D and + 0.5 D (4) Bifocals with power -2.0 D and + 1.0 D
(5) Bifocals with power -1.0 D and + 2.0 D

22 You are originally 1.0 m beneath the surface of a pool. If you dive to 2.0 m beneath the surface, what happens to the absolute pressure on you?
(1) It quadruples. (2) It more than doubles (3) It doubles.
(4) It less than doubles. (5) It does not change.

23 A particle performs simple harmonic motion along a straight line between P and Q as shown. The particle passes the equilibrium position O and travels to the right at time $t = 0$. It passes point X the first time after 3 s and it passes X the second time after a further 2 s. After what further time will the particle pass X the third time?



(1) 18 s (2) 16 s (3) 14 s (4) 12 s (5) 10 s

24 Which of the following graph best represent the variation of current through a tungsten filament bulb with the variation of voltage until the bulb light with full brightness?

(1) (2) (3) (4) (5)

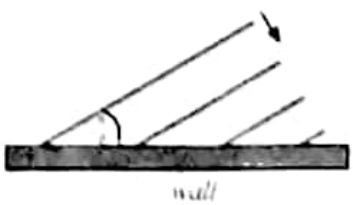
25. A beaker contains water of volume expansivity α_w and density ρ_w at temperature t. Another liquid of density ρ_L ($>\rho_w$) and volume expansivity at t is α_L ($>\alpha_w$) poured in to this container. The temperature at which this liquid starts to float in water is,

(1) $\dfrac{\rho_w - \rho_L}{\rho_L\alpha_w - \rho_w\alpha_L} + t$ (2) $\dfrac{(\rho_w - \rho_L) + t}{\rho_L\alpha_L + \rho_w\alpha_w}$ (3) $\dfrac{\rho_w - \rho_L}{\rho_L\alpha_w + \rho_w\alpha_L} + t$

(4) $\dfrac{(\rho_w + \rho_L)}{\rho_L\alpha_L + \rho_w\alpha_w} + t$ (5) $\dfrac{\rho_w - \rho_L}{\rho_w\alpha_L - \rho_L\alpha_w} + t$

26. An electrical heater is placed in the middle of a lump of ice and measures the time it takes to just melt all of the ice. The power of the electric heater and the initial mass of ice were measured and found to be 12 W and 0.10 kg, respectively. From these measurements, he calculates the specific latent heat of fusion of ice, but finds that his answer is lower than expected. This result is possibly due to the fact that,
(A) energy has been lost to the surroundings.
(B) the mass of ice is actually more than the measured value.
(C) the power of the heater is actually more than the measured value.
(1) (A) only (2) (B) only (3) (C) only (4) (A) and (B) only (5) (B) and (C) only

27. Water waves of frequency 4 Hz travelling with speed 8 m s^{-1} strike a straight wall. The parallel straight lines represent wave crests and they make an angle of $\dfrac{\pi}{6}$ with the wall as shown. What is the phase difference between the waves at two points 1 m apart along the wall?



(1) $\frac{\pi}{8}$ (2) $\frac{\pi}{6}$ (3) $\frac{\pi}{4}$ (4) $\frac{\pi}{3}$ (5) $\frac{\pi}{2}$

28. A microscope is focused on a mark on a table and then a glass slab of thickness 3 cm and refractive index 1.5 is placed over the mark. In order to get the mark again in focus, microscope should be moved

(1) 1 cm downward (2) 1 cm upward (3) 2 cm downward

(4) 2 cm upward (5) 3 cm upward

29. The diagram shows the path of an α-particle as it approaches a massive nucleus at N. At point P the α-particle is nearest to the nucleus. Which of the following statements is **incorrect**?

(A) At P the electric potential energy of the α-particle is at a minimum.

(B) At P the total energy of the α-particle is the minimum.

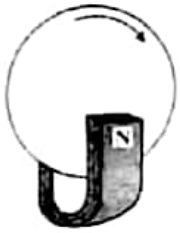
(C) If the atomic number of the nucleus was greater, the distance between P and N would be larger.

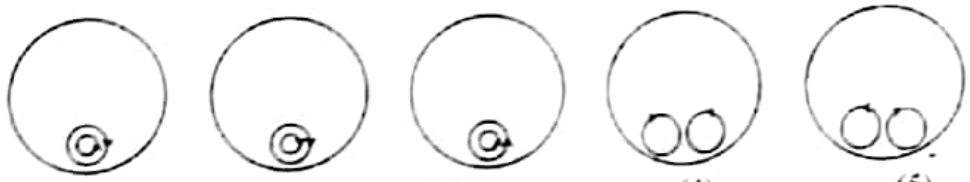
(1) only A (2) only B (3) only C (4) only A and B (5) only A and C

30. A mercury barometer is made of a tube of length 90 cm and cross-section 1.5 cm^2. Mercury stands at a height of 76.3 cm. The room temperature is 27 °C. A small amount of nitrogen is introduced into the evacuated space above the mercury and the column drops to a height of 68.0 cm. The amount of nitrogen introduced is (Molar mass of N_2 = 28)

(1) 11.12 mg (2) 41.89 mg (3) 40.48 mg (4) 8.96 mg (5) 13.44 mg

31. A large aluminium disc mounted on a horizontal axle is spun in the clockwise direction between the poles of a powerful horseshoe magnet. Which of the following diagrams shows how the eddy currents flow in the disc?



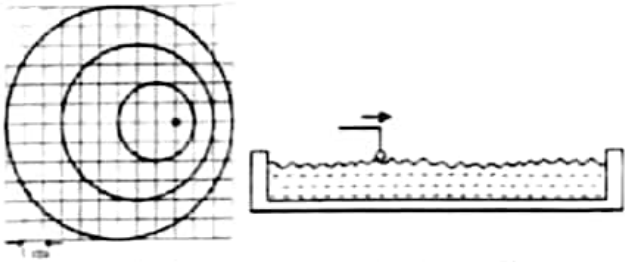


(1) (2) (3) (4) (5)

32. A prism, having refractive index $\sqrt{2}$ and refracting angle 30°, has one of the refracting surfaces silvered. A beam of light incident on the other refracting surface will retrace its path if the angle of incidence is

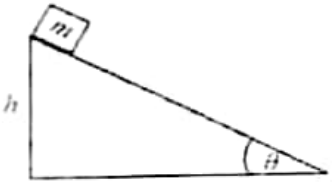
(1) 0 (2) 15° (3) 30° (4) 45° (5) 60°

33. A vibrating point is moving across the surface of water in a ripple tank with a steady speed as shown. The figure represents the water surface showing the pattern of the water waves against a background of centimetre squares. The speed of the water waves is 20 cm s^{-1}. What is the speed of the vibrator?



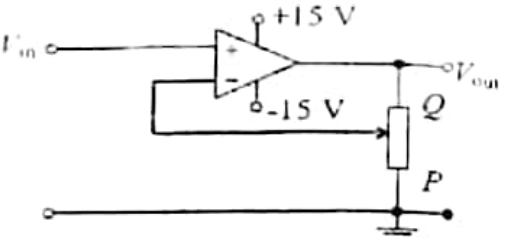
(1) 10 cm s^{-1} (2) 8 cm s^{-1} (3) 5 cm s^{-1} (4) 4 cm s^{-1} (5) 2 cm s^{-1}

34. A block of mass m sliding down an incline at constant speed is initially at a height h above the ground, as shown in the figure. The coefficient of kinetic friction between the mass and the incline is μ. If the mass continues to slide down the incline at a constant speed, how much energy is dissipated by friction by the time the mass reaches the bottom of the incline?



(1) mgh (2) $\frac{mgh}{\mu}$ (3) $\frac{\mu mgh}{\sin\theta}$ (4) $mgh \sin\theta$ (5) zero

35. In the operational amplifier circuit shown the feedback is provided by a potentiometer PQ. The gain of the amplifier circuit is,



(A) zero when the sliding contact is at P.
(B) one when the sliding contact is at Q.
(C) independent of the resistance value of the potentiometer PQ.

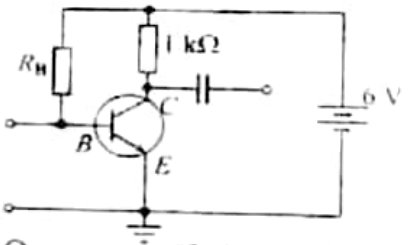
Which of the above statement/s is/are correct?

(1) (A) only (2) (B) only (3) (B) and (C) only
(4) all (A), (B) and (C) (5) all (A), (B) and (C) are **false**

36. The loss of mass in a nuclear reaction is Δm. This energy is capable of keeping a machine of power p work for (number of hours) (C speed of light)

(1) $\frac{\Delta mc^2}{p}$ (2) $\frac{\Delta mc^2}{60p}$ (3) $\frac{\Delta mc^2}{3600p}$ (4) $\frac{3600p}{\Delta mc^2}$ (5) $\frac{\Delta mc}{60p}$

37. The figure shows a transistor in a simple voltage-amplifier circuit operating satisfactorily such that the collector-emitter voltage is half the voltage of the battery connected. The base-emitter junction voltage V_{BE} is **+0.6 V** and the transistor d.c. current gain is 50. Find the resistance value of the base-bias resistor R_B if the load is 1 kΩ.

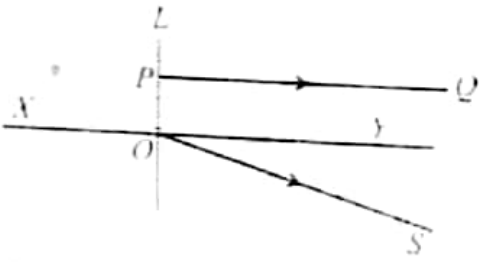


(1) 45 kΩ (2)50 kΩ (3) 60 kΩ (4) 90 kΩ (5) 110 kΩ

38. The activity of a freshly prepared sample of ^{60}Co is 1.0×10^6 Bq. The half-life of ^{60}Co is 5.3 years. Estimate the number of ^{60}Co nuclei in the sample that decay in the first day.

(1) 5.2×10^2 (2) 5.2×10^{10} (3) 3.2×10^8 (4) 8.6×10^{10} (5) 8.6×10^6

39. In the figure, XY is the principal axis of a lens L. PQ and OS are two refracted rays from L which originate from a point object placed on the left side of L. Which of the following deductions is/are correct?



(A) The lens L must be a concave lens.
(B) The point object must lie along the line OS.
(C) The image of the point object must be virtual

(1) (A)only (2) (B) only
(4) (A) and (C)only (5) (B) and (C)only (3) (A) and (B) only

40. The figure (2) shows a bridge rectifier circuit in which all the diodes are assumed to be ideal. The source is a sinusoidal a.c. supply as shown in the figure 1. Which of the following traces ((A), (B) or (C)) would be displayed respectively on a CRO connected across the load resistor R if

(1) the diode D were reversed in the circuit,
(2) the diode D were removed leaving a break in the circuit?

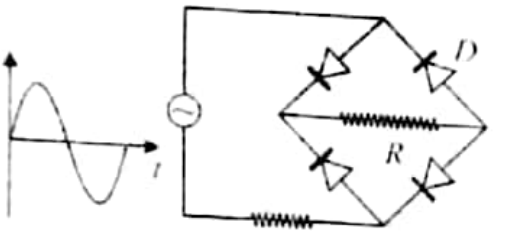
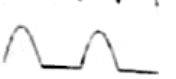
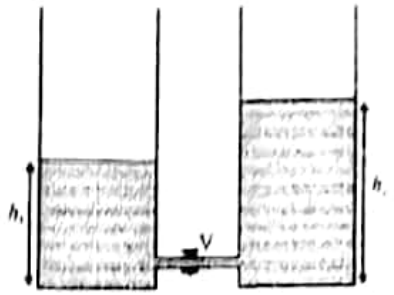


Fig (1) Figure (2)

(1) (A), (B) (2) (B), (B) (3) (B), (C)
(4) (C), (B) (5) (C), (C)

(A) 
(B) 
(C)

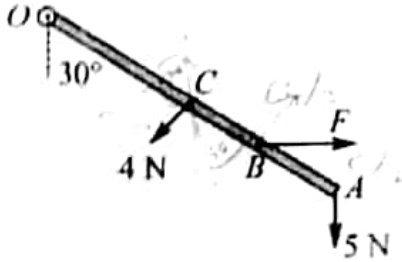
41 There are two identical cylindrical vessels with their bases at the same level as shown in figure. Each contains a liquid of density ρ. The height of the liquid column in one vessel is h_1 and that in the other is h_2. The area of their bases is A. the work done by gravity in equalizing the liquid levels when the valve V is opened.



(1) $A\rho g\left(\frac{h_2-h_1}{2}\right)$ (2) $A\rho g\left(\frac{h_2-h_1}{2}\right)^2$ (3) $A\rho g\left(\frac{h_2-h_1}{4}\right)$

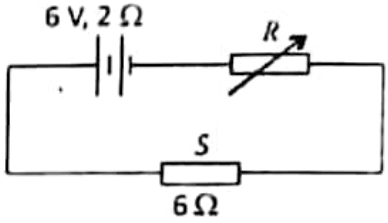
(4) $A\rho g\left(\frac{h_2-h_1}{4}\right)^2$ (5) $A\rho g\left(\frac{h_1+h_2}{4}\right)^2$

42 A light rod OA is smoothly pivoted at O as shown in the figure. It makes 30° with the vertical. It is held at the position shown in the figure by three forces 5 N (vertical), 4 N (perpendicular to the rod), and F (horizontal). $AB = BC = \frac{CO}{2}$. The magnitude of F is,



(1) $12\sqrt{3}$ (2) $\frac{12}{3\sqrt{3}}$ (3) $\frac{18}{\sqrt{3}}$ (4) $4\sqrt{3}$ (5) $\frac{4}{\sqrt{3}}$

43 In the circuit the battery has an e.m.f. of 6 V and internal resistance 2 Ω. S is a standard load resistor of 6 Ω and R is a rheostat. What will the value of R be if the power delivered by the battery to the load resistor S is at a maximum?



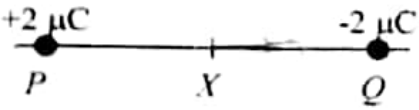
(1) 0 (2) 2 Ω (3) 4 Ω (4) 6 Ω (5) 8 Ω

44. The speeds of an object in simple harmonic motion when the displacements from the center are x_1 and x_2 are v_1 and v_2 respectively. The period of oscillation of the object will be,

(1) $2\pi\sqrt{\frac{x_1^2+x_2^2}{v_1^2+v_2^2}}$ (2) $2\pi\sqrt{\frac{v_1^2+v_2^2}{x_1^2+x_2^2}}$ (3) $2\pi\sqrt{\frac{v_2^2-v_1^2}{x_2^2-x_1^2}}$

(4) $2\pi\sqrt{\frac{x_1^2-x_2^2}{v_2^2-v_1^2}}$ (5) $2\pi\sqrt{\frac{x_1^2-x_2^2}{v_2^2+v_1^2}}$

45 Charges +2 μC and -2 μC are situated at points P and Q respectively. X is the mid-point of PQ. Consider the following statements about this system (The electric potential at infinity is taken to be zero.)



(A) The electric field at X is pointing towards Q.

(B) The electric potential at X is zero.

(C) The electric field strength at X is the strongest among any point between P and Q.

Which of the above conclusions is/are correct?

(1) (A) only (2) (A) and (B)only (3) (A) and (C)only

(4) (B) and (C) only (5) all are **incorrect**.

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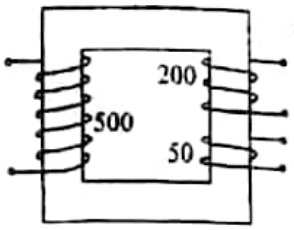
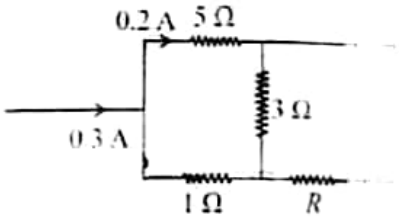
46. In the figure, the ideal transformer has a primary coil of 500 turns and **two** secondary coils of 200 turns and 50 turns. If an a.c. voltage of 240 V is applied to the primary, which of the following voltages can be obtained from the secondary using **different connections** of the secondary coils?



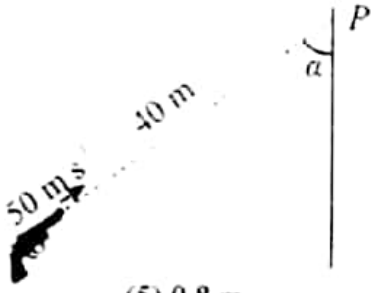
(1) 96 V and 24 V only (2) 96 V and 120 V only (3) 24 V and 120 V only
(4) 24 V , 96 V and 120 V only (5) 24 V , 96 V, 72 V and 120 V only

47. The figure shows some of the resistors in a network of resistors. The magnitudes and directions of some of the currents are marked as shown. Find the magnitude and direction of the current passing through the resistor R.



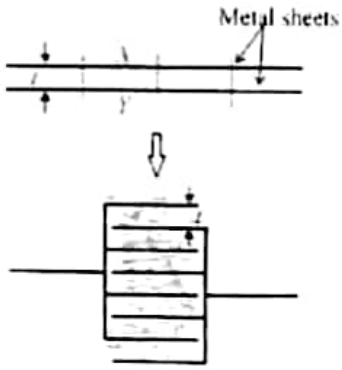
(1) 0.2 A from right to left (2) 0.2 A from left to right
(3) 0.3 A from right to left (4) 0.4 A from left to right
(5) It cannot be determined without the value of R

48. The figure shows a gun that aims directly at a point P 40 m from the muzzle of the gun. The barrel makes an angle α with the vertical.
If the speed of the bullet is 50 m s^{-1} when it leaves the gun, calculate the separation between the point where the bullet hit on vertical line through P and point P.
(Neglect air resistance.)



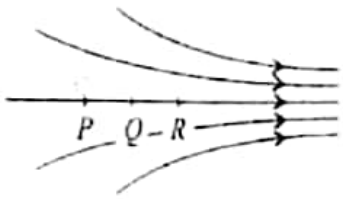
(1) 7 8 m (2) 6.8 m (3) 3.2 m (4) 1.6 m (5) 0.8 m

49. A capacitor made from two thin metal sheets X and Y separated by a small thickness t of insulating material has a capacitance of 8 μF. Each metal sheet is then cut into four identical sheets (across dotted lines) and they are joined together to form another capacitor as shown. The same thickness t of insulating material is used between the interleaved sheets, which overlap completely. Neglecting the edge effects, the capacitance of this capacitor is approximately.



(1) 4 μF (2) 14 μF (3) 16 μF
(4) 28 μF (5) 64 μF

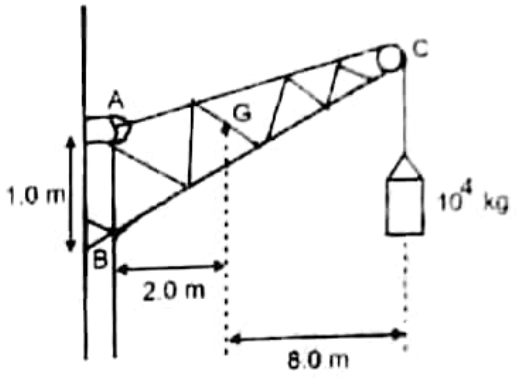
50. The figure shows a pattern of electric field lines in which P, Q and R are points marked on one of the field lines with $PQ = QR$. If the potential at P is 0 V, which of the following can give the possible potentials at Q and at R?



	Potential at Q	Potential at R
(1)	-200 V	-450 V
(2)	-200 V	-400 V
(3)	-200 V	-350 V
(4)	+200 V	+350 V
(5)	+200 V	+450 V

- **Answer only four questions.**

05. The total mass of the arm with the pulley of a crane shown in the figure is 4000 kg and G is the center of gravity of the system. The arm of the crane is smoothly pivoted at A and it is in contact with a smooth support at B. A mass of 10^4 kg hanging from the free end of the massless cable passing through the pulley is in equilibrium. The centre of gravity G and the cable are at horizontal distances 2.0m and 8.0m from the vertical plane across AB.



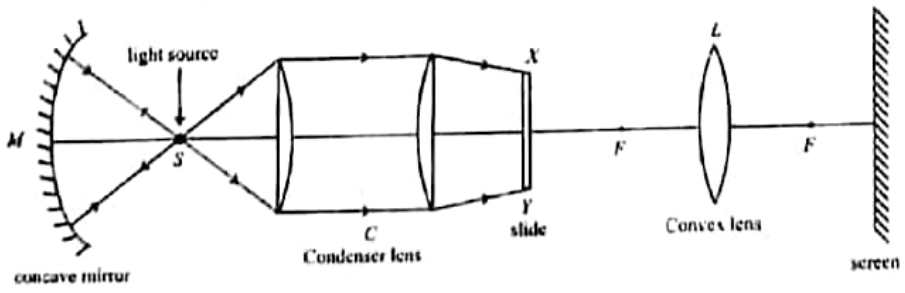
a) i) Draw a freebody diagram of the body of crane. Mark the forces acting on the crane at A, B, G and C. Mark the contact force at B as R and the horizontal and vertical components of the reaction at A as X and Y.
   ii) Find the magnitude of R.
   iii) Find X and Y. Calculate the magnitude of the reaction at A.

b) The pulley of radius 20 cm operated by a motor with a power of 3500 kw raises the mass of 10^4 kg at a constant speed of $10\ ms^{-1}$.
   i) Find the torque exerted by the motor on the pulley.
   ii) What should be the tension of the cable?
   iii) Find the torque on the pulley exerted by the cable.
   iv) Find the frictional torque on the pulley.

c) i) What should be the tension of the cable to pull the mass of $10^4\ kg$ upwards with an acceleration of $2\ ms^{-2}$.
   ii) Find the torque acting on the pulley due to the tension of the cable.
   iii) If the frictional torque is constant, find the torque on the pulley exerted by the motor.

d) The mass of $10^4\ kg$ starts its motion with $10\ ms^{-1}$ and moves upwards with an acceleration of $2\ ms^{-2}$. After $2s$, without any energy loss, the cable is broken.
   i) Find the further distance that the mass of $10^4\ kg$ rises after the cable is broken.
   ii) What is the tension of the cable after broken.
   iii) Describe the motion of the pulley.

6. a) Derive the lens formula with a geometrical method.



b) Above figure shows a schematic diagram of a slide projector. S is the light source. M and I represent a concave mirror and a convex lens respectively. F is the focal point of the lens L. C is called the condenser lens. O is the slide to be projected. The screen is situated behind the lens.

i) Copy the above diagram into your answer script and construct the final image.

ii) Explain how a concave mirror is useful in the slide projector.

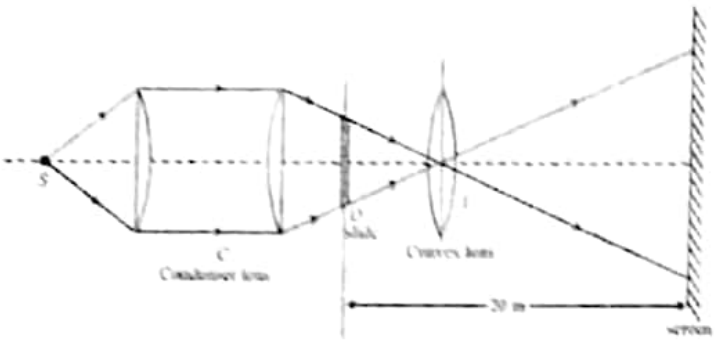
iii) What is the use of condenser lens C

iv) Dimensions of a slide in this slide projector is 5 cm x 5 cm. the projector projected an image of dimensions 3 m x 3 m on the screen placed 24 m from the lens L

1. How far from L should the slide be placed to obtain the above image?

2 Calculate the focal length of the lens L.

3. The lence L is now repleased with a new lense as shown in the figure



This is used to project a square slide of area 25 cm^2 to a screen and got an image of area 1 m^2. If the distance between the slide O and screen is 20 m, then find the focal length of the lens L

07. State the Hooke's law. Write down an expression for the Young's modulus for the material of a wire. The Young's modulus for the material of a uniform wire of length 2m and cross sectional area 2 mm^2 is $2 \times 10^{11}\ Nm^{-2}$. The breaking stress of the wire is $1 \times 10^{8}\ Nm^{-2}$. Assume that the wire obeys the Hooke's law until it breaks.

a) i) Find the maximum load that can be hung from the wire without breaking it.

ii) Find the increase in length of the wire when it breaks.

iii) What is the elastic potential energy stored in the above wire when break.

b) The above wire is fixed at one end to the ceiling and a small object is attached to the other end. Now the object is raised to a vertical height more than 1.5m from its equilibrium position and released from rest. At this situation the wire breaks.

i) What is the maximum mass the object can take?

ii) Find the extension of the wire when the object is attached to the lower end.

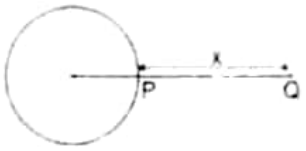
c) The breaking stress of a second wire with Young's modulus $1 \times 10^{11}\ Nm^{-2}$ having same dimensions as the first wire mentioned above is $1.5 \times 10^{8}\ Nm^{-2}$. Two wires are hung from the same point on the ceiling parallel to each other to make a compound wire. Calculate the maximum mass of the object that can be hung from the free end of the compound wire. Find the extension of the compound wire.

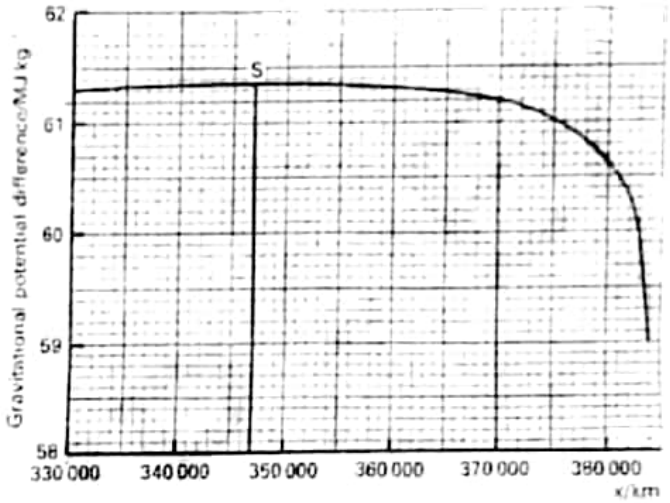
08 a) Define the gravitational potential at a point in a gravitational field. Write down an expression for the gravitational potential at a point distant r from the centre of the earth. Introduce the symbols you used.

b) Write down an expression for the gravitational potential difference between a point P on the Earth's surface and a distant point Q as shown below

Show that if r is **slightly** greater than R, the gravitional potential difference becomes $g(r - R)$ where g is the gravitational field strength on the earth's surface

c) The graph shows how the gravitational potential difference between a point on the earth's surface and a distant point, distance x from the earth's surface, changes near to the Moon's surface. The Moon's surface is 384000 km from the Earth's surface.





The graph shows the gravitational potential difference first increasing then achieving a maximum value and finally decreasing to a smaller value on the Moon's surface.

i) Use the graph to determine the amount of potential energy released as a mass of 200kg falls to the surface of the moon from a height of 14000 km. At what speed will it hit the surface?

ii) a. What feature of the graph justifies the assumption that the potential energy of a body measured with respect to the Moon's surface is proportional to its height above that surface

b. Obtain from the graph the height to which this assumption is true.

iii) The net force acting on a body moving from Earth's surface to the surface of the Moon is the resultant of two components, one due to the attraction of the body towards the Earth and the other due to its affraction towards the Moon.

1. What is the value of the net force at the point S where the gravitational potential difference is a maximum? Give a reason for your answer.
2. Explain why the gravitational potential difference is a maximum at the point S.

3. Is it possible to use parachute to reduce the velocity of the body falling on to the Moon's surface.

d) In practice, a satellite is carried by a rocket to the height of the orbit and then gives an impulse, by firing jets, to deflect it in a direction parallel to the tangent of the orbit

A satellite is to be put in to orbit 500 km above the earth's surface. If it's vertical velocity after launching is 2000 ms^{-1} at this height, calculate the magnitude and direction of the impluse required to put the satellite directly in to orbit, if its mass is 50 kg.

Radius of the earth $R_E = 6400\ km$

$g = 10\ ms^{-2}$

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

A) a) i) Write down an expression for the resistance R of a conducting wire of length l and cross sectional area A made of a material of specific resistivity ρ

ii) Define the specific resistivity.

b) Consider the given circuit where a battery of internal resistance r and e.m.f E is connected to a resistor R.

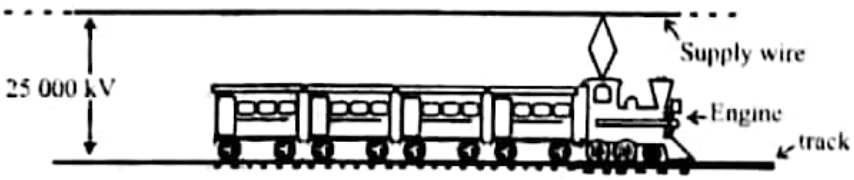
i) Get an expression for the power of heat dissipation through the resistor R.

ii) Find the efficiency of the battery in this circuit.

iii) What is the magnitude of R (in terms of r) through which the power dissipation become maximum?

iv) Find the efficiency of the battery when the power dissipation through R is maximum. Is this the maximum efficiency of the battery?

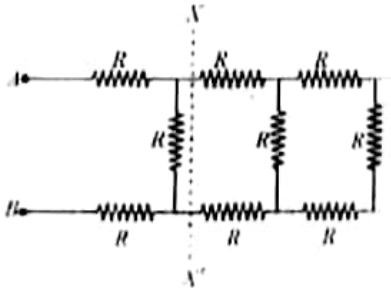
c) Elecrric train is powered by an overhead wire of cross section 1 cm^2 as shown in the figure. resistivity of the wire $\rho = 2.25 \times 10^{-8}\ \Omega\ m$



i) Find the resistance of 10 km long part of the above wire.

ii) When the train is very close to the power supply, the power of the motor is found to be 80 kW. If there is no power loss from motor, determine the resistance of the motor. Show that the resistance of the wire is negligible in comparison to the resistance of the motor.

d) Following figure shows an arrangement suggested to use in case of distance effect of resistance is significant. This is called the infinite resistance ladder.



It consists of ladder of equal resistors consists of 3 resistor units. Show that the equivalent resistance between A and B is independent of number of 3 resistor units in the ladder. (Hint: consider the equivalent resistance of right of the line XX' and left of XX' separately.)

B) a) i) Draw the output characteristic curve for a npn transistor and identify cutoff region, saturated region and active region.

ii) The figure shows a silicon transistor circuit which can be used as a switch. Find the collector current when.

a) the transistor is in the cut off region

b) the transistor is in the saturated region

iii) Explain the importance of keeping the transistor around the middle of active region when it is to be used as an amplifier.

iv) Find the input voltage that makes the transistor just saturate. (Assume that the current gain of the transistor is 200, $V_{BE} = 0.7$ V and $R = 100$ kΩ)

v) Following voltage variation is given to the output of the above transistor. Copy the input wave form and draw the output wave form with respect to the input wave form.

b) An air craft is equipped with a quality control system with sensors that functions in accordance with temperature of engine, pressure and rotation speed of shaft.

A warning bulb in pilots' cabin must be on when there is a risk and the risk levels are given below.

- When internal temperature is above 400 °C. **and**
- Internal pressure is above 1.5MPa **or** rotation speed of the shaft is less than 4000 rpm.

In a dangerous situation,

Three sensors A, B and C send signals regarding the internal temperature of the engine, internal pressure and the rotation speed of the shaft as follows

sensor	Condition/process	Boolean value
A	Internal temperature is above 400 °C.	1
	Internal temperature is below 400 °C.	0
B	Internal pressure is above 1.5 MPa	1
	Internal pressure is below 1.5 MPa	0
C	Rotation speed of the shaft is greater than 4000 rpm.	1
	Rotation speed of the shaft is less than 4000 rpm.	0

i) Construct a truth table to represent the functionality of the above circuit.

ii) Design the circuit by using a combination of only AND, OR, NOT gates to implement the above control system. (assume that the warning bulb is on by the Boolean value 1)

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

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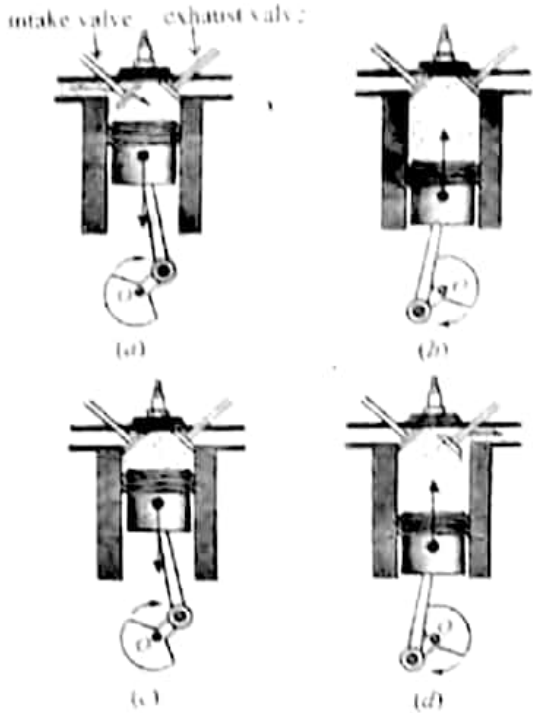
(A) The four-stroke internal combustion engine

A practical internal combustion engine working on a petrol-air mixture can be produced using a cylinder containing a piston and a pair of vales. The process involves four strokes which are the up-and-down movements of the piston that turn the crankshaft to provide the required drive. Although the cycle involves these four strokes, there are six identifiable stages to the cycle, which in a real engine is carried out by a set of cylinders that will be at different stages of the cycle.

1. **Intake stroke:** The drive provided by another cylinder in the engine rotates the crankshaft which pulls the piston down (as figure (*a*)). This reduces the pressure in the cylinder by an amount sufficient to cause the fuel-air mixture to be forced into the cylinder by the external atmospheric pressure when the intake valve opens.



2. **Compression stroke:** The rotation of the crankshaft which can rotate around a horizontal axis through *O* now drives the piston back up, (as in figure (*b*)) compressing the fuel-air mixture to a much higher pressure and temperature. Here the piston moves from Bottom Dead center (BDC) to Top Dead Center (TDC), extreme positions of the piston. Friction and conduction of heat through the cylinder walls restrict the efficiency of this process.
3. **Explosion:** An electrical spark provided by a spark plug ignites the fuel-air mixture, causing a rapid rise in temperature and pressure. This is timed to take place little before the piston reaches the TDC, so that by the time combustion has been completely established the piston has come to rest at TDC and ready for the power stroke.
4. **Power stroke:** The hot gasses expand rapidly, forcing the piston down, (as in figure (*c*)) and in the process their temperature and pressure drop. Friction and conduction again limit efficiency. This is the part of the cycle that produces useful work.
5. **Exhaust:** The exhaust gasses in the cylinder are still at a higher temperature and pressure than the surroundings, so that they start flow out of the cylinder when the exhaust valve opens.
6. **Exhaust stroke:** Crankshaft rotation forces the piston up, (as in figure (*d*)) expelling any remaining exhaust gasses into the surroundings.

A full analysis of the process going on this cycle is extremely complex and impossible to carry out in mathematical detail. A simplified idea can be gained by considering the idealized cycle, which was first put into practice by N. Otto in 1876. To do this, it is necessary to assume that the working substance, air is behaving as an ideal gas and that there is no friction in the system. Consequently, the theoretical output power (indicated power) of the engine can be written as

$$\text{indicated power} = \left(\begin{matrix}\text{work done by}\\ \text{a piston in a cycle}\end{matrix}\right) \times (\text{no. of cylinders}) \times (\text{no. of cycles per second})$$

When frictional forces **inside the engine** are taken into consideration, actual (output) power of the engine (this is called *brake power*) is less than the indicated power. As there are power losses in the engine.

$$(\text{Brake power}) = (\text{Indicated power}) - (\text{Power lost overcoming friction})$$

a) State why this engine is called **four stroke** engine.

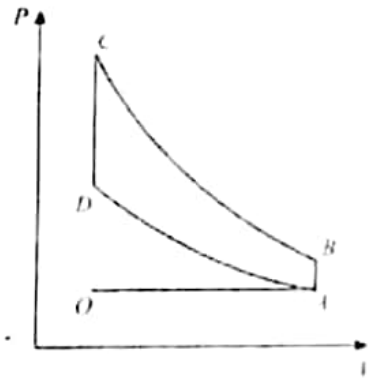
b) Identify the strokes involve in a cycle.

c) If idealized conditions are assumed,

i) Is the process undertake during the compression stroke adiabatic or isothermal? Compression or expansion?

ii) Is the process undertake during the power stroke adiabatic or isothermal? Compression or expansion?

d) The idealized *P-V* diagram for the cycle is given here. Relate the 6 process described in the paragraph to the paths of the cycle.



(*i*) O→A
(*ii*) A→ D
(*iii*) D→ C
(*iv*) C→ B
(*v*) B→ A
(*vi*) A → O

e) i) The area of the *P-V* cycle for a certain four cylinder engine of a car is 156 .25 cm^2. Calculate the indicated power of the engine when it is running at 6000 rpm. (Assume that the scale of the *P-V* cylcle is such that 1 cm represents 1 Pa and 1 m^3 on *y* and *x* axes respectively.)

ii) When this car is running on a horizontal straight road with a uniform velocity of 20 m s^{-1}, the air resistance is found to be 2500 N. If the engine speed at this velocity is 6000 rpm , Find the power loss due to friction in the engine. (assume there is no other losses)

iii) If the rate of fuel consumption at this speed (20 m s^{-1}), is 0.0025 *l* s^{-1}, find the efficiency of the engine. (Calorific value of petrol is 4 x 10^7 J l^{-1})

f) Who put forward the idea of idealized cycle for the petrol engine?

10 B) a) What is called photoelectric effect.

b) If ultraviolet light is fallen on to a clean zinc plate connected to a negatively charged gold - leaf electroscope, it is observed that the leaf slowly collapses. Explain this.

c) Write down the Einstein's photoelectric equation and introduce all the terms.

d) Explain the following observations.

i) Photo electrons are not emitted if the frequency of incident light is less than a certain minimum value.

ii) The maximum kinetic energy of photo electrons is independent of the intensity of the incident light. But depend on the frequency of the incident light.

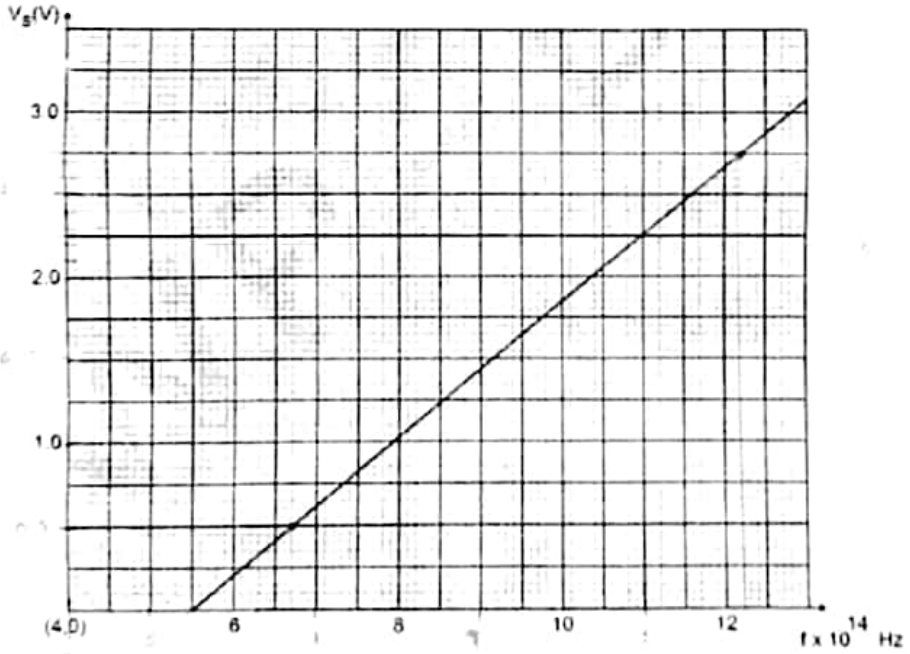
iii) Photoelectric current produced by light of frequency above the threshold value, is proportional to the intensity of the incident light.

e) Draw rough sketches for the following situations.

i) The intensity of the light incident on the photo cathode is doubled by keeping its frequency constant. The graph of photoelectric current (I) against potential difference (v) between anode and cathode.

ii) Two monochromatic light beams, green and red colours with same intensities measured in Wm^{-2} are allowed to incident on photo cathode, one beam at a time. The frequencies of the light beams are higher than the threshold frequency of the material made of cathode. Draw a rough sketch to indicate the variation of I with V for both green and red colours in the same graph. Assume that the same percentage of incident green and red colour photons emit photoelectrons.

f) The graph shows the variation of the stopping potential (V_s), as a function of the frequency (f) of the incident light for a sodium target (photo cathode)



i) What is the characteristic equation of the above graph. Introduce the symbols you use.

ii) Find the gradient (m) of the graph.

iii) Determine the Planck constant (h) (Electronic charge (e) = 1.6×10^{-19} C)

iv) What is the threshold frequency of the metal.

v) Calculate the work function of Sodium.

vi) Copy the shape of the above graph on your paper and draw a rough sketch for the target metal potassium (K) on the same graph.