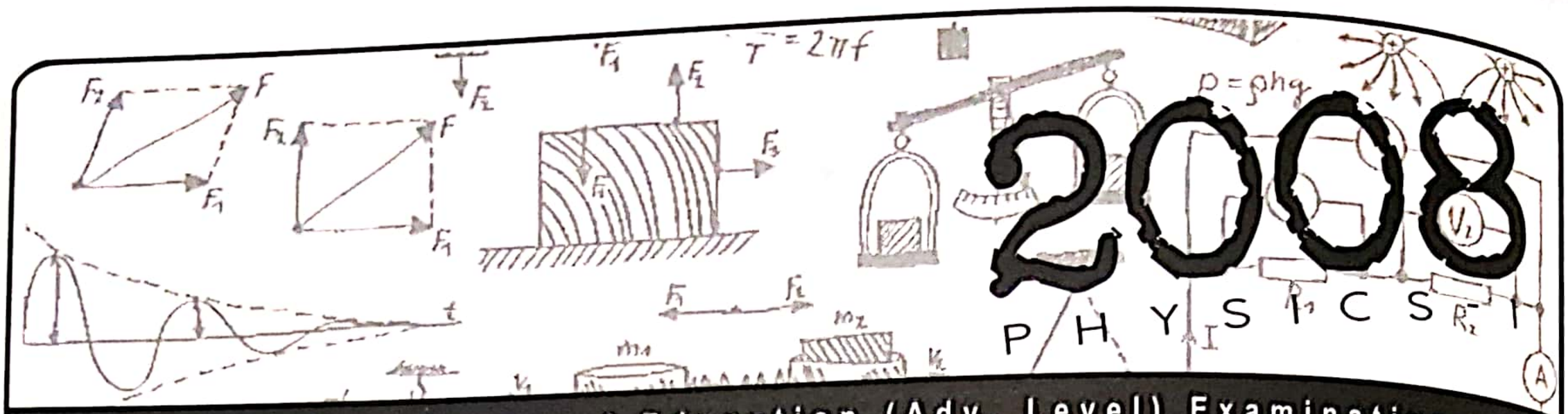


1 Dimensions of kilowatt-hour is

(1)$[M][L]^2[T]^{-2}$ (2) $[M][L][T]^{-1}$ (3) $[M][L]^2[T]^{-3}$ (4) $[T]$ (5) $[T]^{-1}$

01 ***Unit and Dimensions***

Kilowatt-hours has been given before. The energy is measured from kWh not power. To decide the dimensions of energy, I think the easiest method is to recall the expression of kinetic energy. There is no need of ½. According to mv^2 you will get $M(LT^{-1})^2$. Do you need rough work? Energy can be obtained by the multiplication of force x distance also. If you look at the choices, you can just remove the last two. The second represents mv.

2 Consider the following statements made regarding the action force and the reaction force.

(A) They are equal in magnitude.

(B) They act on the same object.

(C) They are opposite in direction to each other.

Of the above statements.

(1) only (A) is true. (2) only (A) and (B) are true.

(3) only (A) and (C) are true. (4) only (B) and (C) are true.

(5) All (A), (B) and (C) are true.

02 ***Newton's Law and Momentum***

Without an effort, you can get the answer very quickly. Once you read the sentences according to Newton's third law, you can get the answer. You can directly decide that both (A) and (C) are true whereas (B) is false. The action and the reaction are acted upon the two objects of interaction and not on a single object. If I hit my head on the wall, my action is felt to the wall. The reaction from the wall is felt to myself.

3 A parallel beam of light is incident on a prism as shown in the figure. The angle θ between the two reflected beams is equal to

(1) A/4 (2) A/2 (3) A (4) 2A
(5) 4A

03 ***Refraction through Prism***

There is no need to waste time. These questions are already seen questions before. Answer is 2A.

4 When the tension in a guitar string is doubled without changing its length the frequency of a given tone will

(1) increase by a factor of 2. (2) decrease by a factor of 2.

(3) increase by a factor of $\sqrt{2}$. (4) decrease by a factor of $\sqrt{2}$.

(5) be the same.

Transverse Waves 03

This is also a question that was seen before. No need of rough work. As the length of the wire is unchanged, the wavelength of a particular tone is not changed. Therefore, the frequency is dependent upon the speed of the wave. The transverse wave speed of a given wire is proportional to $\sqrt{T}$.

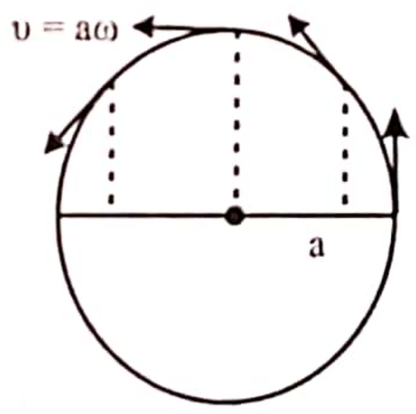
5 A mass attached to one end of a vertical spring whose other end is fixed to a ceiling, is made to execute simple harmonic motion with amplitude α and maximum speed v. When the amplitude of the motion is increased to 2α, the maximum speed will become

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

Simple harmonic Motion 03

Don't you know that $v \alpha a$? Cannot you recall $v = \omega a$?

A particle that is going around a circle with a uniform angular velocity of ω is engaged in a simple harmonic motion that can be projected on the diameter of the circle. Therefore, is not the maximum speed (at the middle) of the simple harmonic motion $a\omega$? So, when a gets double v also gets doubled (as ω is unchanged)



Even according to energy, we can come into this conclusion. Then the kinetic energy is going with V^2. The stored elastic energy of the spring is dependent upon a^2. So, is not v proportional to a?

Some questions in the paper can be shortened and then they should be given to the students is my idea. In many questions, the figures are given and even it is described again in the question. Cannot you shorten the question more like this? As a research study, shall we present this shortened version, and see?

Please let me know the feedback from the teachers and students who use this book. If shortening the question is not a problem to you, if it is not damaging the content of the question, if the question that is being asked is understandable, then I believe that we need to do a timely survey on that issue.

Especially, for the students who say that the time is not sufficient to answer the questions, it will be a relief if the questions are shorter. For the clever students of Physics, they can

understand that what is being asked as soon as they see the question. But medium level students tend to read each and every letter of the question. It takes some time. Throughout the review I will write the questions that can be shortened as I think. You read them and send me the +/- suggestions. Cannot this question be shortened like this?

In a simple harmonic motion, what is the changing factor of the maximum speed when the amplitude is doubled?

(1) 4 (2) 2 (3)1 (4)1/2 (5) ¼

Likewise, as the third structured question's figure is there, can the question be shortened by asking about θ? From the figure it is clear that A is the prism angle.

6 Two ideal gases A and B having same value for the ratio of principal specific heat capacities are kept at the same temperature. Mass of a molecule of gas A is four times of a molecule of gas B.The ratio $\frac{\text{velocity of sound in gas A}}{\text{velocity of sound in gas B}}$ is equal to

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

11 **Radiation**

As soon as you see the 4th power, even from the memory it hints that you need to take the square root. Therefore, the answer is ½ or 2. As the ratio of C_p and C_v is same in value, γ is not changed. That means if the temperature is constant, the sound speed of a gas is dependent on $v \propto \frac{1}{\sqrt{M}}$. The sound speed of the lighter gas should be greater. Is not it? Therefore, the

answer is ½ not 2.

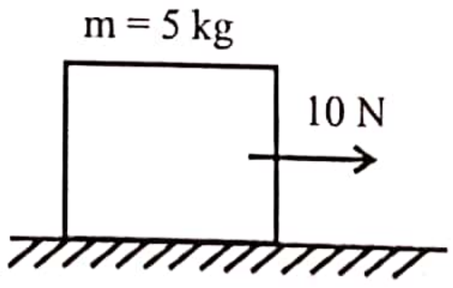
7 A box of mass 5 kg is placed on a horizontal surface. The coefficient of static friction between the box and the surface is 0.3. If a horizontal force of 10 N is applied to the box, the magnitude of the frictional force acting on the box will be

(1) 1.5 N (2) 3 N (3) 4.5 N (4) 10 N (5) 15 N

02 **Friction**

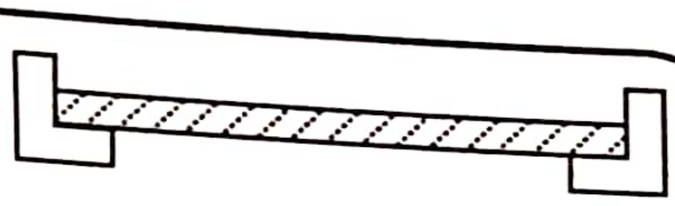
Cannot this be done from the memory? The limiting friction (μR) is 0.3 X 50 = 15 N. Is not it? As 10<15 is not the frictional force 10 N still? You can think that the answer is 15 N. You need to understand that, if the applied force is lesser than the limiting frictional force, then the frictional force is equal to the applied force.

Frictional force is like our testimony of the heart. If we think to do a wrong act, it tells us not to do it. If we think 'No, I want to do', thenit says no. But it has a limiting value. If we need to do the wrong thing, we will do it somehow by breaking all the barriers. Many wrong doers have this limiting force of testimony of the heart up to zero.



This question can be shortened by drawing a figure. If it ok? If μ =0.3, then the frictional force acting on the box is ……..

8 A steel (Young's modulus = E, linear expansivity = α) beam of cross-sectional area A is clamped between two concrete supports as shown in the figure. When the temperature of the beam rises by ΔT, the force that must be exerted by the concrete supports to each end of the beam, in order to keep the beam without expanding is given by



(1) $AE\,\alpha\Delta T$ (2) $\frac{AE}{\alpha\Delta T}$ (3) $\frac{AE\alpha}{\Delta T}$ (4) $\frac{AE\Delta T}{\alpha}$ (5) $E\alpha\Delta T$

Elasticity **10**

Even the description is long, this is a familiar question. The answer can be just recalled for the students who had done past papers.

$$E = \frac{F}{A}\frac{l}{\Delta l} = \frac{F}{A}\frac{L}{\alpha L\Delta T}$$

Even though equations are written, do you need to write them? It is clear that the answer is (1) according to the dimensions. The dimension of α is per degree. Therefore, αΔT does not have dimensions. To get dimensions of the force, you need to multiply Young modulus from the area

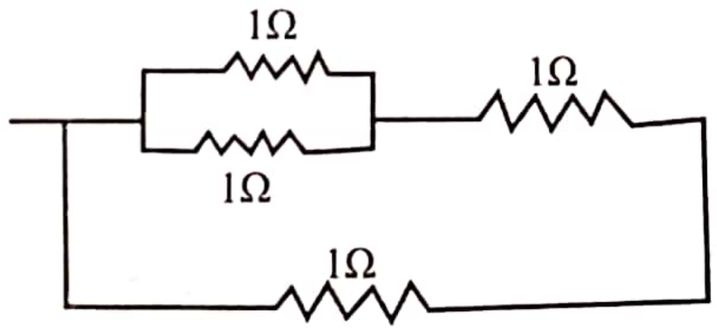
9 The two lowest values of the resistance that can be obtained by combining four 1Ω resistor are

(1) 0.25Ω and 1.0Ω (2) 0.25Ω and 1.33Ω (3) 1Ω and 2Ω

(4) 1.2Ω and 2.66Ω (5)1.33Ω and 2.5Ω

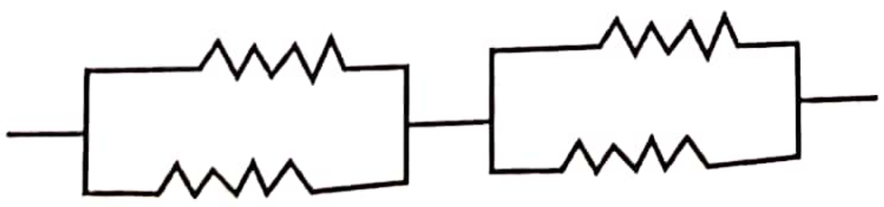
Combination of Resistances **08**

There is a mistake in the answer. The smallest resistance value can be obtained when all are connected in parallel. There is no problem in it. Once four resistors of one each are in parallel, you will get 0.25. You can get it from the memory. The next smallest is obtained for this which has a value of 0.6.



In a parallel configuration, the equivalent resistor should be lesser than the value of a resistor in a branch. So, the resistance of the above network should be less than 1.

If it was connected like this, then you will get 1 Ω.



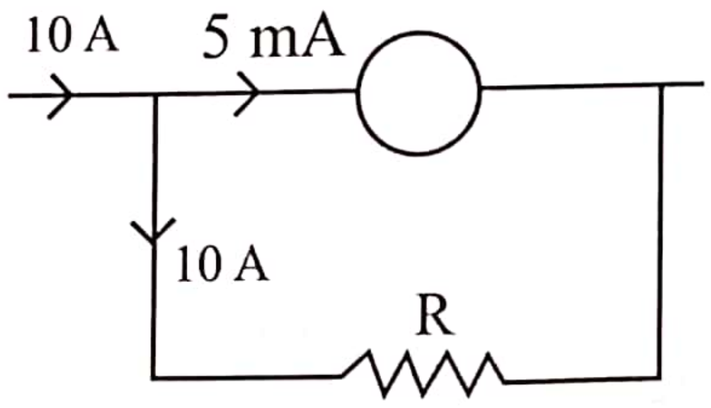
10 A galvanometer having an internal resistance of 200 Ω produce ful-scale deflection when a current of 5 mA passes through it. In order to use this galvanometer as an ammeter which gives a full-scale deflection for 10 A, the approximate value of the external resistance needed, and the way in which it should be connected with the galvanometer are

(1) 0.2Ω in series. (2) 0.2Ω in parallel. (3) 2.0Ω,in parallel.

(4) 0.1Ω in series. (5) 0.1Ω in parallel.

08 **Moving Coil Meters**

Even though this is a familiar question, if you subtract 5 mA from 10 A and do the question, it will take unnecessary time. The nearvalue of the resistor in the sub circuit is being asked in the question. Therefore, no need to subtract 5 mA from 10 A.



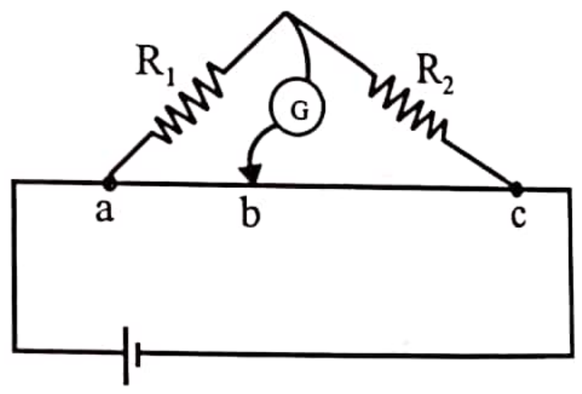
Actually, you need to subtract 5 mA from 10 A. But if 5 is subtracted from 10,000, then who will care about it? It is like reduction of petrol by Rs. 2!

$10\ R = 200\ X\ 5\ X\ 10^{-3}$ $R = 0.1\ \Omega$

Little calculation is needed. If you take as 9995 R = 200 X 5, then it will not solve easily. You need to understand that there is a subterfuge.

I feel that this question cannot be shortened.

11 In the circuits shown ac is a uniform resistive wire of length 1m. When the galvanometer reading is zero, the distance from point a to point b is 20 cm.



The ratio $\frac{R_1}{R_2}$ is,

(1) 5 (2) 4 (3) $\frac{1}{4}$ (4) $\frac{1}{5}$ (5) $\frac{1}{10}$

08 **Wheatstone Bridge and Meter Bridge**

You can do it from your memory. If ab is 20 cm, then bc is 80 cm. It is 1: 4. What else to think?

12 A heating element draws a current of 10 A when connected to 240 V power source. The wattage of the element is

(1) 2.4 W (2) 24 W (3) 240 W (4) 2.4 kW (5) 24 kW

08 **Heating Effect of Electric Current**

This is just a multiplication. As there is no 2400 W, the answer is 2.4 kW.

13 Blue and red light falling on a certain photocathode produce photoelectrons.

Which of the following statements is true?

(1) Maximum kinetic energy of the emitted photoelectrons is higher for blue light.

(2) Stopping potential is higher for red light.

(3) Work function of the material of the photocathode is higher for blue light.

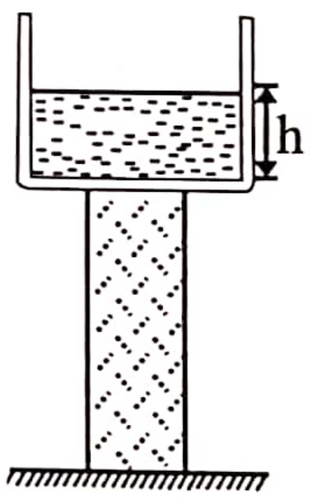
(4) Number of emitting photoelectrons is always higher for blue light.

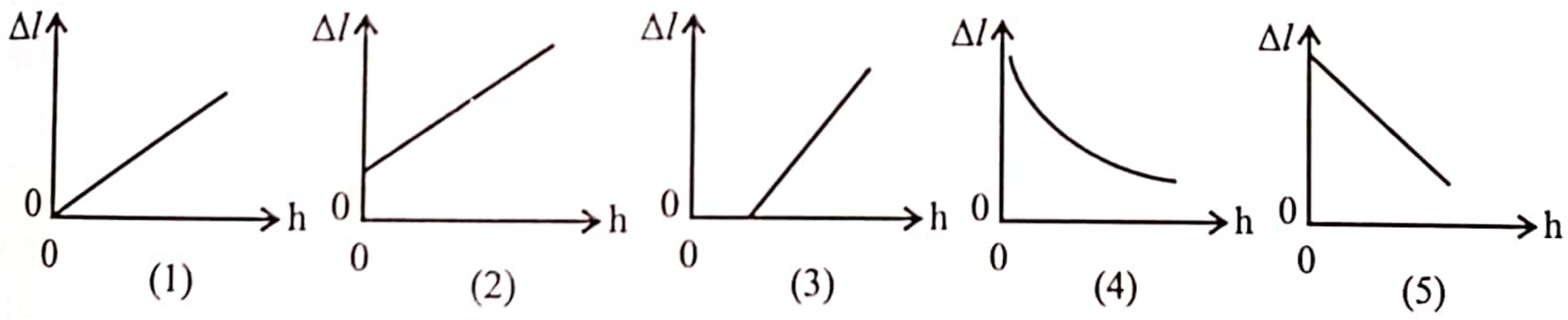
(5) Stopping potential is same for both colours.

Photoelectric Effect 11

You should know that the frequency of the blue light is greater than the frequency of the red light. When the frequency is increased the corresponding photon energy also gets increased. So, the kinetic energy of the emitting electrons is also higher. (1) is correct. If (1) is correct, then (2) cannot be true. The stopping potential also needs to be higher if the frequency is higher. The work function is dependent upon the material and the nature of the surface. It is not changed due to incident light. Emitted photo electrons are dependent upon the intensity of the incident light. It is not dependent on the frequency. If the intensity of the blue light is higher, then more electrons are emitted. If the intensity is higher in red light, then more electrons will emit from it. As the word 'always' is there, statement (4) is incorrect. If not, (4) could have been true as the intensity is not mentioned. Statement (5) is just wrong.

14 A water tank is construction on a steel pillar of original length l_0 and water is filled up to a height h as shown in figure. The variation of the compression (Δl) of the pillar from its original length with the height of water level h is best represented by





Elasticity 10

This is also familiar. Anybody knows that when h is increased, Δl should increase. (4) and (5) gets removed. For a certain h value,Δl is zero. This is not possible. Even though h is zero, the empty tank has a weight. So, at that instance, Δl should have some value. This is clearly there in the question. The steel pillar's length before making the tank is given as the initial length. So, even there is no water, there is a compression only from the tank for the initial length. Therefore, graph (1) is not correct.

15 A blood vessel of length 0.1 m has a radius of 1.0×10^{-3} m. Blood of viscosity 3.0×10^{-3} pa s flows through the vessel at a rate of $1.0 \times 10^{-7}\ m^3s^{-1}$. The pressure difference between the two ends of the vessel is (take π=3)

(1) 80Pa (2) 8Pa (3) 0.8Pa (4) 0.5Pa (5) 0.1Pa

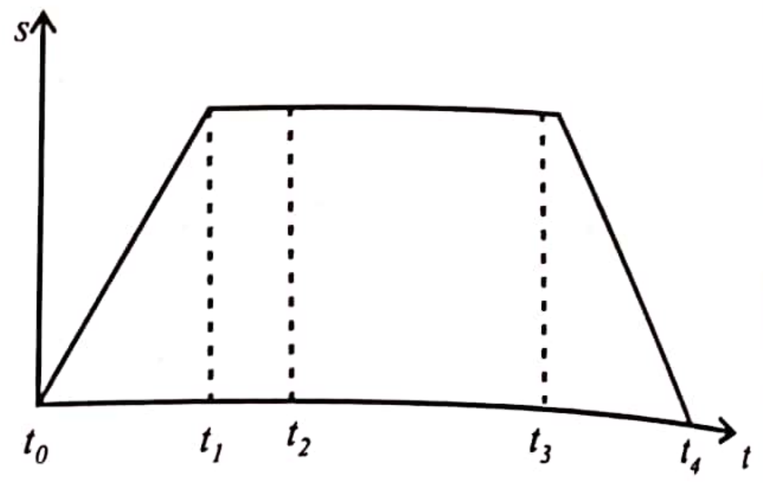
Viscosity 10

You need a calculation but it is a familiar calculation.

$$10^{-7} = \frac{\Delta P \times 3 \times (10^{-3})^4}{8 \times 3 \times 10^{-3} \times 0.1}$$

Simplifies easily. The work is quick as π is taken as 3. 3 is cut off by 3. The rest can be simplified by the powers of 10. ΔP=80 Pa

16 Figure shows displacement (s) versus time (t) curve for a motion of a particle. Consider the following statements made about its motion.



(A) During the time period t_0-t_1 the particle moves at a constant acceleration and during t_2-t_3, it moves at a constant velocity.

(B) Particle comes to rest at time t_4.

(C) During the time period t_0-t_4, the total distance travelled by the particle is equal to the area under the s-t curve.

Of the above statements,

(1) only (A) is true.

(2) only (A) and (B) are true.

(3) only (B) and (C) are true.

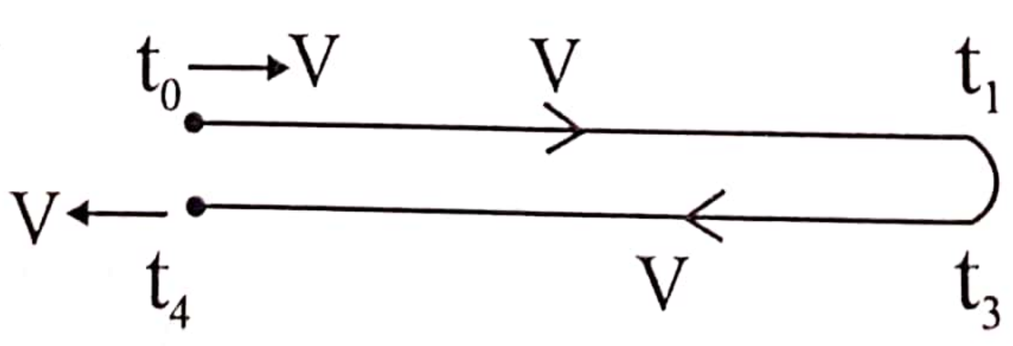
(4) only (A), (B) and (C) are true.

(5) All (A), (B) and (C) are false.

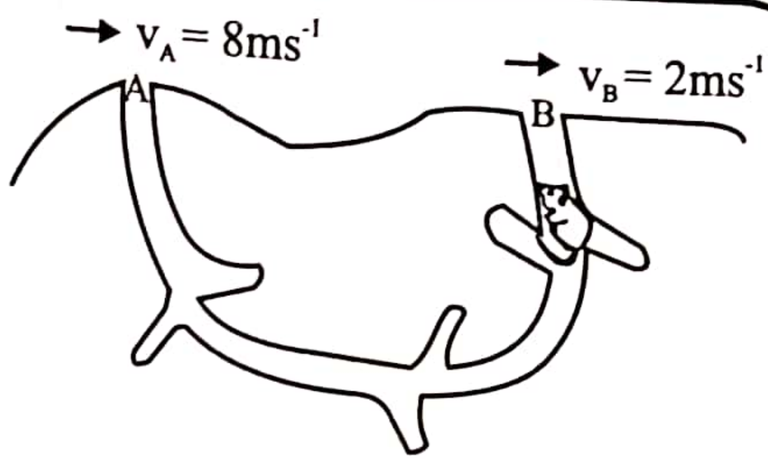
02 **Linear Motion**

It is a simple question that has been asked from a displacement-time curve. During the time t_0-t_1 the particle is moving at a uniform speed. Therefore, the acceleration is zero. From the time t_1-t_3, the particle is not moving. From the time t_3 to t_4, the particle turns back (the direction of the velocity becomes reversible) and comes to the same place in t4.

From a gradient of a displacement-time graph you get the velocity. Displacement is directly obtained. There is no connection with the area. Displacement is given from the area of a velocity-time graph. Do not get a feeling that at t_4 the particle is at rest. There is a velocity to the particle even at t_4. The motion after that is not shown in the graph. The motion of this particle can be represented from the shown figure.



17 Figure shows a burrow of some animals living underground. The animals maintain the shapes of two entrances A and B to the burrow different from each other and because of this, air (density 1.3 kg m^{-3}) blows past the openings at different speeds of 8 m s^{-1} and 2 m s^{-1} as shown in the figure. If the openings are at the same level, the difference in air pressure between the openings and the direction of the air-movement in the burrow are



(1) 78 Pa and from B to A.

(2) 78 Pa and from A to B.

(3) 39 Pa and from B to A.

(4) 39 Pa and from A to B.

(5) 3.9 Pa and from B to A.

Hydrodynamics 02

As soon as you see the question, you can decide that it is a question that should be solved from Bernoulli's theorem. There are velocities at points A and B. Those points are at the same level. Therefore, as $V_A > V_B$ then $P_A < P_B$. So, the air should be flowing from B to A inside the hole. As the points are in the same level, we can forget about the potential energy terms. So, simply, the pressure difference is obtained by the change of kinetic energy in a unit volume.

Therefore, $\Delta P = 1/2 \times 1.3 \times (64-4)$. You can write this as rough work.

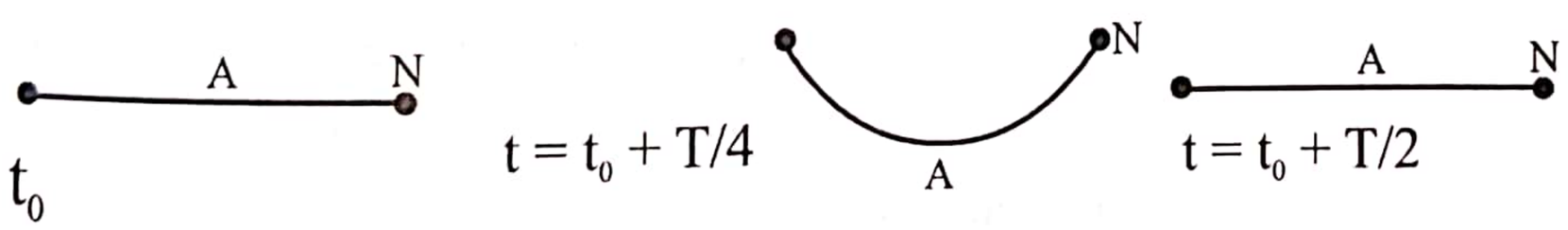
Cannot you do the rest from your memory? 64 and 4 is given to get 60. When 60 is divided by 2, it is 30. Look how marvelous is the nature? Animals living in holes need air the live. Even the animals are unaware of Bernoulli's theorem, they create an opening in convex shape and the other in flat shape. So, when the wind is passed among the portal, the speed of the air flowing from the convex portal is higher compared to the other. Think of an air current that is flowing across a wing of an airplane. Some animals make one of their portals at a higher level relative to the other in the hole. From that way also the requirement can be satisfied.

18 Both nodes and antinodes of a standing wave of period T have zero vertical displacements at time t_0. This will happen next at time

(1) $t_0 + \frac{T}{4}$ (2) $t_0 + \frac{T}{2}$ (3) $t_0 + \frac{3T}{4}$ (4) $t_0 + T$ (5) $t_0 + \frac{3T}{2}$

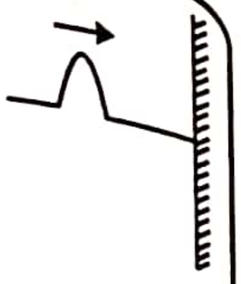
Transverse Waves 03

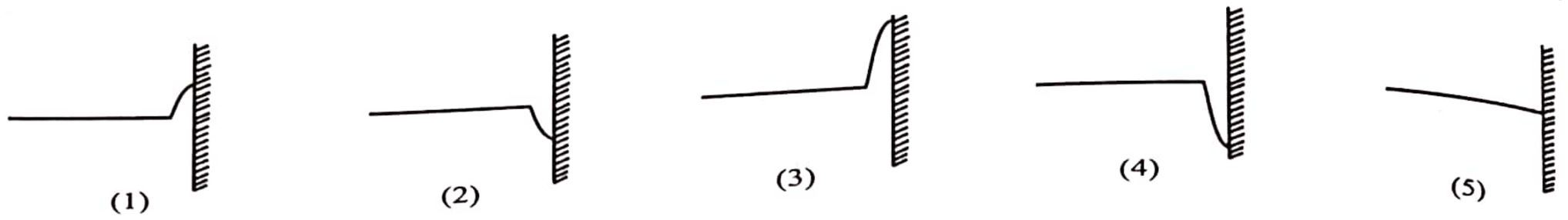
You can find the answer easily to this question. The displacement is already zero in a node.In half of a period does not the particle goes down and comes back to the same position?



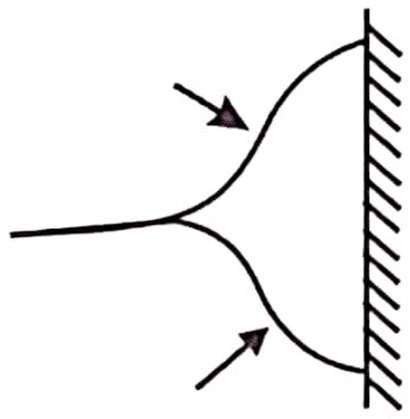
This argument is valid even if we think about a normal simple harmonic motion. To go on a complete circle, you need to pass four quarters. For a half way, it is two quarters. That means a half.

19 A symmetrical pulse shown in the figure is moving along a string towards a rigid boundary. Which of the following figures correctly shows the resultant pulse at the instant when exactly half of the pulse is reflected from the rigid boundary?





03 Wave Properties



Here why does not superposition (resultant) get zero? Therefore, is not (5) the correct figure? If the pulse is not symmetric, then half of each will not meet in opposite directions. The resultant of equal and opposite forces is zero.

20 A box rests on the floor of an elevator. If the magnitudes of the minimum force required to slide the box on the floor when the elevator is stationary, acceleration upward and accelerating downward are F_1, F_2 and F_3 respectively, then

(1) $F_2 > F_1 > F_3$ (2) $F_1 > F_2 > F_3$ (3) $F_3 > F_2 > F_1$

(5) $F_1 = F_2 = F_3$

02 Friction

You do not have to waste time by writing equations for this question. It is a well-known fact that when the lift is accelerating upwards, the normal reaction force from the floor on the box is increased whereas when the lift is accelerating downwards, it is reduced. So, is not the answer (1)? When normal reaction force is increased, the friction also gets increased with it. Even normal rection force has being asked, the relevant answer is $R_2 > R_1 > R_3$. It is a sin to write equations for this question.

21 The far point of a near sighted eye is 50 cm, in front of the eye. To see clearly objects at infinity a lens is worn 2 cm in front of the eye. The lens should be a

(1) converging lens with a focal length of 50 cm.

(2) converging lens with a focal length of 48 cm.

(3) diverging lens with a focal length of 52 cm.

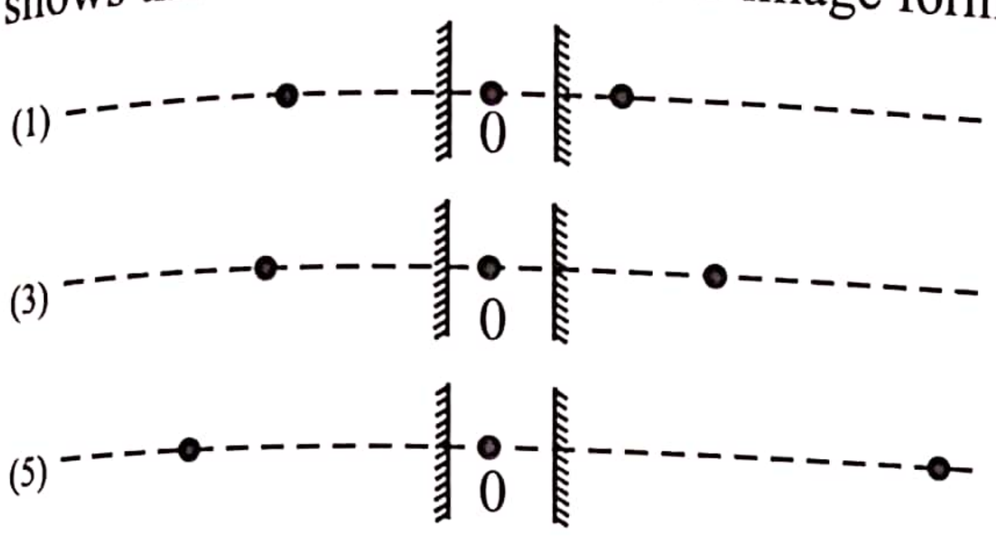
(4) diverging lens with a focal length of 50 cm.

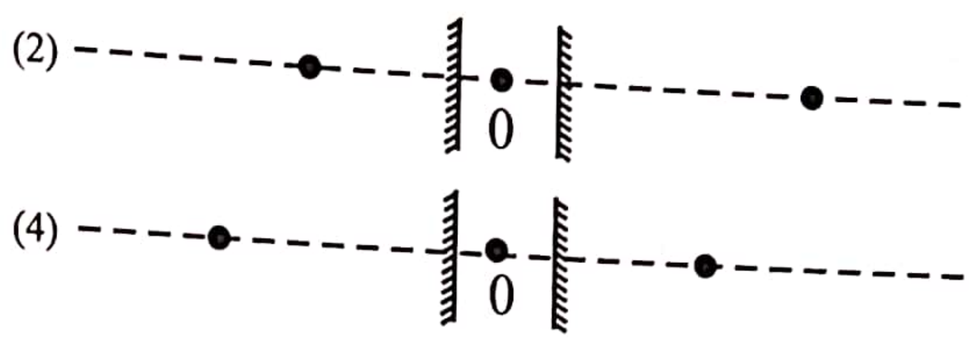
(5) diverging lens with a focal length of 48 cm.

03 Defects of Vision

This is also a very familiar question. The only difference is that, the distance from the eye to the lens is mentioned in it. Always we tend to forget it. The rays coming from the infinity should be seen as coming from 50. If we forget the distance from the eye to the lens, the needed focal length is 50 cm. As the distance is considered, the answer is 48 cm. A concave lens is needed. For short sightedness/ myopia, a concave(divergent) lens is needed.

22 A point object O is placed between two parallel plane mirrors. Which of the following diagrams shows the location of the second image formed by each mirror?

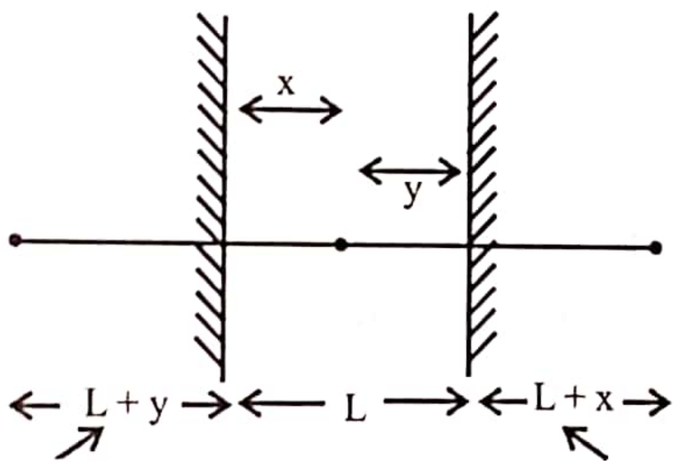




I feel that many children have wasted their time on this question. Some insult that the answer is not coming properly. There is no point in measuring the exact balance in such questions. These are MCQ. You need to select the correct and the most relevant answer. In this question it is not expected to get a ruler and measure. By guessing and method of elimination you can get the correct answer.

It is being asked about the second image from each mirror. That means the image from one mirror is acting as the object to the other. From the right dot, the second image from the right mirror and from the left dot, the second image from the left mirror should be represented.

As soon as you see the figure (1), it can be seen that it is not correct. Because the distance from O to the right mirror is seen equal or more than the distance of right mirror to the right dot. The right dot is like the first image of the right mirror.



The right dot of figure (2) is far away. In (1) it is too close. In (4), the left dot is far away. In (5), both dots are far away. Then what is left is (3). Do not measure them by using a ruler to the decimal point. This is not a question paper for the exam of surveyors. If you need to check in a different way, then look at the right-side diagram.

Do not decide (3) as the wrong answer by saying that it is not accurate to the decimal point of cm. The question is not expecting to measure from the ruler and get the answer. The secret is the usage of simple Physics knowledge and estimation.

In lot of saloons, there are such parallelly kept mirrors. If not, once the hair is cut, the barber will hold a mirror behind the head. Then you can see the behind of your head. You will feel sad by seeing that behind the head has gone bald!

In such questions, you do not get answers that are going near to each other. Clearly (3) is correct. There are no other answers that are nearly equal to it.

23 The planet mars subtends an angle of 8.0×10^{-5} rad at an unaided eye. When mars is viewed using an astronomical telescope in normal adjustment it subtends an angle of 2.4×10^{-3} rad at the eye. If the focal length of the eyepiece is 0.03 m, the focal length of the objective is

(1) 0.001 m (2) 0.01 m (3) 0.5 m (4) 0.9 m (5) 1.0 m

03 Opticle Instruments

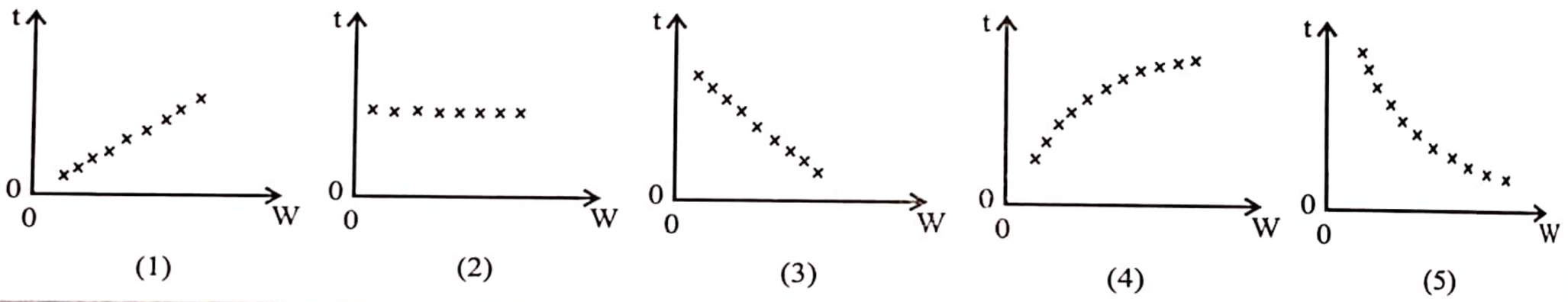
These are also common questions. According to the given angles, you can find angular magnification. You know by heart that the magnification of an astronomical telescope that is in normal adjustment is the ratio of focal length of objective to focal length of eyepiece.

$$\frac{F_o}{0.03} = \frac{2.4 \times 10^{-3}}{8 \times 10^{-5}} = \frac{240}{8} = 30$$

$$F_o = 0.9\ m$$

Even you can do the question from your memory. Some children can do like that. But there is no harm if you do the above calculation. Do not try to draw ray diagrams. Hope you have done plenty of questions in astronomical telescope.

24 A set of identical kettles are fitted with heating coils of different wattages. If the kettles are used to boil same amount of water, which of the following curves best represents the variation of the time (t) that is required to raise the temperature of water up to its boiling point, with wattage (W) of the coils.

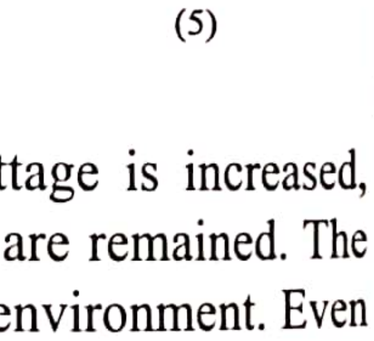


(1) (2) (3) (4) (5)

08 Heating Effect of Electric Current

This is a general knowledge question. Anybody knows that when wattage is increased, the needed time gets reduced. According to that only (3) and (5) graphs are remained. The variation cannot be linear. In whatever wattage there is a heat loss to the environment. Even if there is a linear variation, then at a finite wattage the time is zero. Theoretically the time will go towards zero when W is at a very large value. By that time, the kettle can be melted. Practically, the time cannot be zero. How can we get heat by time being zero? Therefore, the correct variation is (5). You do not even need to look at the graphs of (1), (2) and (4).

25 Consider a rubber balloon filled with air. Inside and outside pressures of the balloon are P_1 and P_2 respectively, and temperatures on either side remain the same. Which of the following statements is true?



(1) $P_1 = P_2$ as the temperatures on either side remain the same.

(2) $P_1 > P_2$ due to higher mean speeds of air molecules inside the balloon.

(3) $P_1 > P_2$ due to higher mean kinetic energy of air molecules inside the balloon.

(4) $P_1 > P_2$ due to higher rate of collision of air molecules inside with the wall of the balloon.

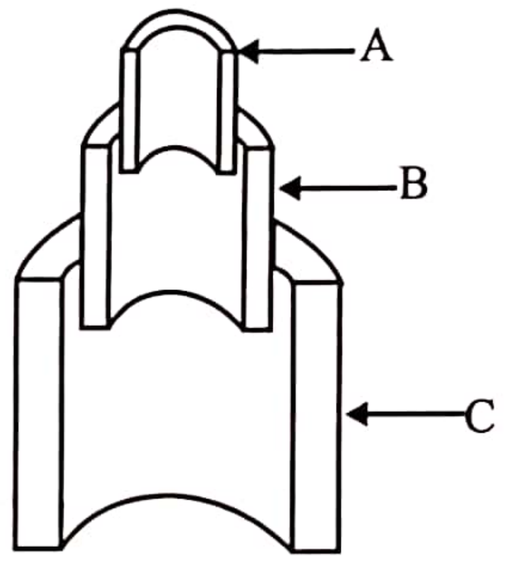
(5) $P_1 > P_2$ due to lower mean kinetic energy of air molecules inside the balloon.

04 Expansion of Gases

The pressure by a particle on a cover depends upon how fast that the particles hit on the cover as well as how many particles should hit per unit time. As the temperature is equal, the mean kinetic energy of both sides and mean speeds (as with same gas) are equal. Accordingly, as the temperature of both sides are equal, the choices of (2), (3) and (5) just get removed. Even an O/L child knows that when the balloon is filled with air, the pressure inside the balloon is greater than the outside atmosphere pressure. Once the mouth of the balloon is opened, that is why the air is gone out with a noise.

The distance of the gas molecules inside the balloon are less compared to the gas molecules in the air. As they are closer to each other, the number of gas molecules that hit on the wall of the balloon is higher per unit time. That is why the pressure inside the balloon is high. When many persons are closer together, do not they have many collisions when they move? The blood pressure of the colliding persons can also get high. As the temperature is high, once (2), (3) and (5) is removed, only (1) and (4) remain. We just know that (1) is not correct. So, without much argument, it is clear that the correct answer is (4).

26 Figure shows a cross-sectional view of three hollow cylinders A,B and C made from different materials, lead, brass and steel. They barely fit one another at room temperature. If the cylinders are heated the cylinder C falls off, while cylinder A becomes tightly wedged to cylinder B.



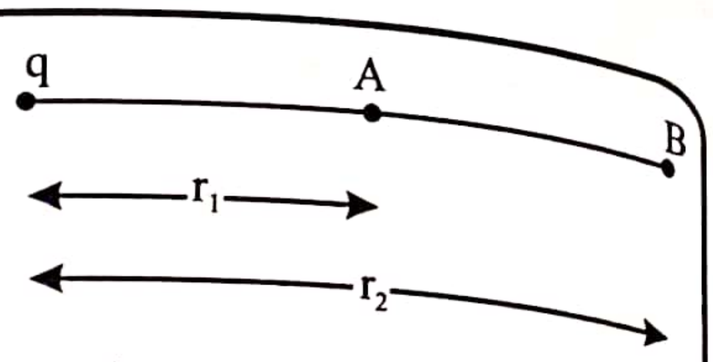
If $\alpha_{lead} > \alpha_{brass} > \alpha_{steel}$, A,B and C cylinders are likely to be made of

	A	B	C
(1)	brass	lead	steel
(2)	steel	lead	brass
(3)	brass	steel	lead
(4)	steel	brass	lead
(5)	lead	brass	steel

Once you argue, simply cannot you decide that less expansion occurs in the cylinder of the middle (B)? As C is falling, it cannot be steel. If C is made from steel and B can be of any material then as lead and brass expand more than steel C should be stuck. Likewise, as A is stuck with B, then A cannot be made from steel. If A was made from steel, as the expansion of other two materials are high, then B falls down even B was made from lead or brass. According to the given facts, only steel's place is B. There is only one answer with B as steel. That is (3). What needs to be decided is that the place of steel (less expansion) only. No matter if A and C were lead or brass. Therefore, the answer of A- lead B-steel and C- brass is also correct. So only one choice is there with B in steel. Even from a small mathematical work you can get the correct answer. Think that the respective linear expansions are represented in A, B and C.

As C falls, then C>B. As A is stuck in B then A>B. As C>B and A>B then B should be the least. Is not it? C is bigger than B. A is bigger than B. Therefore, B should be relatively smaller than A and C. Even if we cannot come into a correct conclusion about A and C, you can decide that B should be the smallest directly.

27 A point charge q_0 moves under the influence of the electric field created by another stationary point charge q. The change in the kinetic energy of q_0 when it moves from A to B is

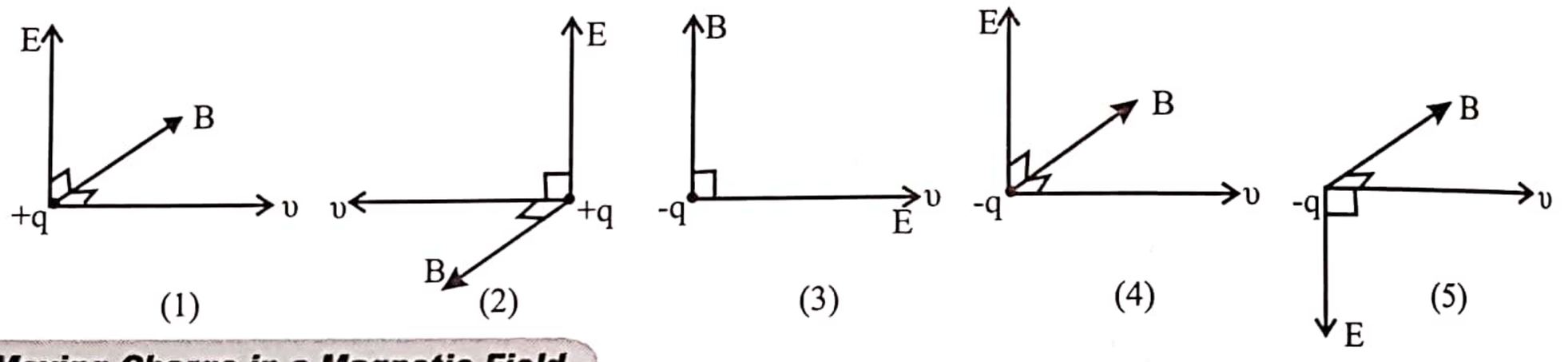


(1) $\frac{qq_0}{4\pi\varepsilon_0}\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$ (2) $\frac{qq_0}{4\pi\varepsilon_0}\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$ (3) $\frac{qq_0}{4\pi\varepsilon_0}(r_1+r_2)$ (4) $\frac{qq_0}{4\pi\varepsilon_0}\left(\frac{1}{r_1^2}-\frac{1}{r_2^2}\right)$ (5) $\frac{q_0^2}{4\pi\varepsilon_0}\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$

06 **Electrostatic Potential**

This is peanuts. The kinetic energy difference is equal to the corresponding potential energy difference. The only answer is (2). If you get wrong, then you can go in between (2) and (4). The potential and potential energy goes with 1/r not with $1/r^2$. As both are like charges, the kinetic energy is increased when moving from A to B. As $r_1<r_2$, then $1/r_1-1/r_2$ becomes a positive quantity. Only (2) has $1/r_1$ and $1/r_2$ terms and a minus in between them.

28 Diagrams below show situations where two charges +q and –q moving with a uniform velocity (v) and separately entering five regions having a uniform electric field (E) and a uniform magnetic field (B). Vectors E and B or parallel to E. Which of the following configurations may provide a possibility for charges to move across the region without changing their directions?



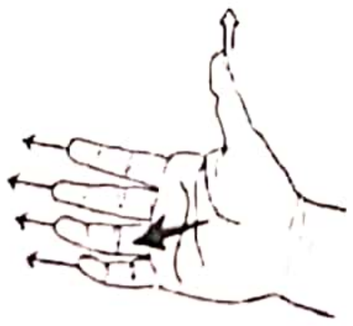
07 **Force on a Moving Charge in a Magnetic Field**

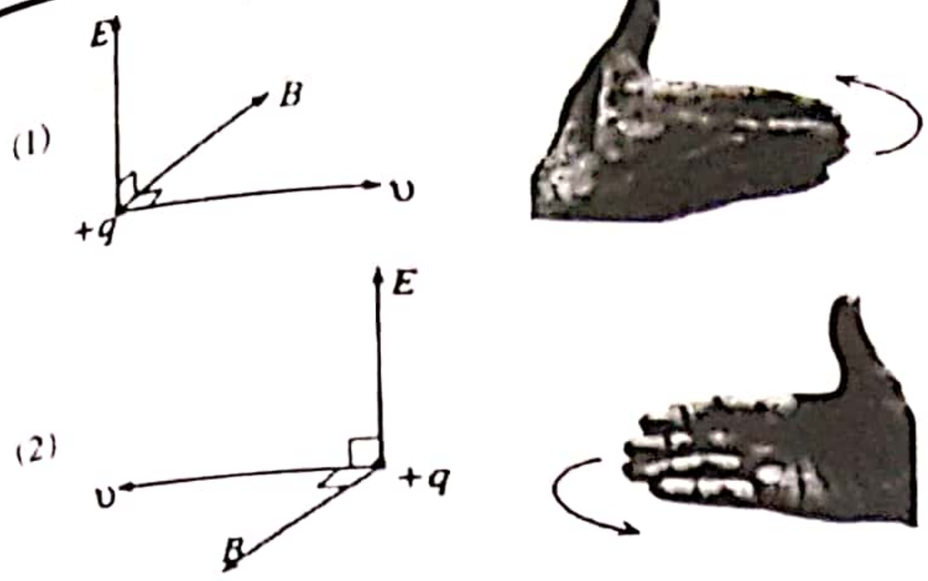
This is a question that can be shortened as I feel. As E, B, q and v are standard symbols do they have to be described again? Is the last sentence of the question enough?

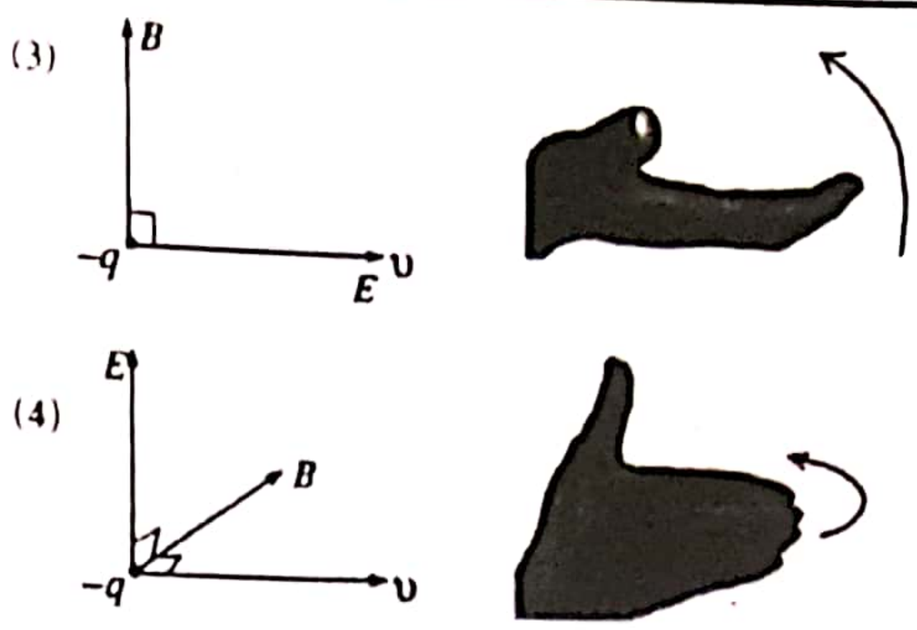
Here you only need to look whether the magnetic force on the charge is at opposite direction to the force due to the electric field. No need to think of the magnitude of the forces.

It is very easy to decide the force on the charge due to the electric field. If it is positive charge, then to the direction of E. If it is negative, then opposite to the direction of E.

The easiest way to find the direction of the magnetic force is to take you right hand and keep your thumb perpendicular to other fingers. Keep those fingers to the direction of velocity and then turn them point to the magnetic field intensity (B) direction. Once it is done, the direction of the magnetic force on a positive charge is given by the direction pointed by the thumb. If it is a negative force, reverse the previously mentioned direction.







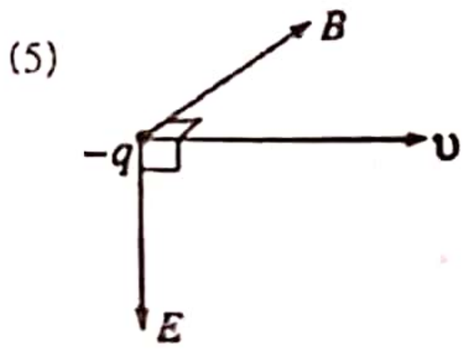
1. Magnetic force and electric force are towards the same direction.

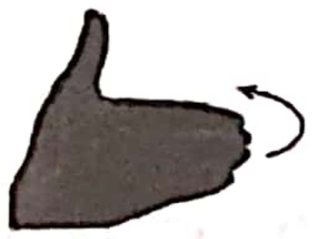
2. Magnetic force and electric force are towards the same direction.

3. Magnetic force and electric force are perpendicular to each other.

4. Magnetic force and electric force are towards the same direction.

When the fingers are rotated from v to B, the thumb is directed to upwards. As it is a negative charge, it should be reversed. That means to downwards. The electric force due to a negative charge also opposite to the direction of E. That means both forces are downwards.





5. This is correct. The magnetic force is downwards and the electric force is upwards.

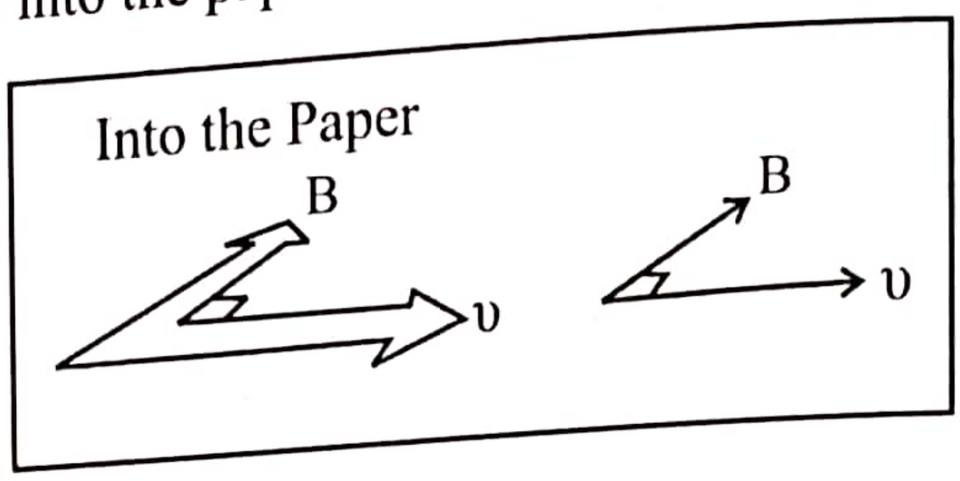
We can get the direction of the magnetic force from Fleming's law also by considering the flow of charge as a current. You must be familiar with it. There is no problem in it. If the rotation that I mentioned above is easy for you, then follow that. For me this method is easy. If you direct the fingers according to Fleming's law, then the palm has to be rotated here and there. You can solve this problem in a cunning way.

If (1) is wrong then definitely (2) is wrong. The direction of E and +q charge is the same. Both the directions of v and B are being reversed. When both v and B are reversed the respective direction of the magnetic field is not changed. In (1) the magnetic force is upwards. It should be in the same direction in (2) also. You can directly see that (3) is wrong. The magnetic force is perpendicular to E. Again if (1) is wrong, there are no two words about (4). Even (4) is wrong. Why? The only difference in (1) and (4) is the change of +q into -q. Then the direction of the two forces is changed. As both forces are upwards in (1), in (4) both of them act downwards. That means the forces are not in equilibrium.

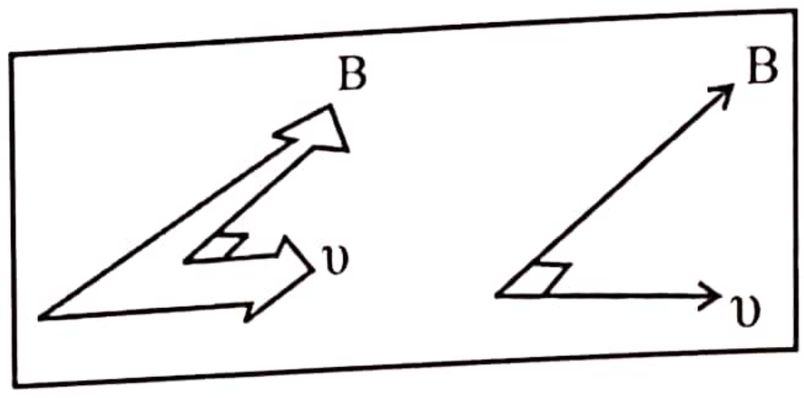
Then what is left is (5). If examiners are not wrong, (5) should be correct. If (4) is wrong, then definitely (5) should be correct. The only difference in (4) and (5) is the reversing of the direction of E. Then the direction of the force of E only changes.

As heard, some children have taken the perpendicular directions in the figures to the other side.

For example, this figure should be considered as the direction of B is inward to the paper. Not outward of the paper. Here vector v is drawn bigger than vector B. Then B should be considered as a vector into the paper.



If you need to consider the other way, it should be drawn like this. This is not a law. It is just the normal standard.



29 A spherical liquid drop has an electrical capacitance C_1 and another spherical drop made of the same liquid has a capacitance C_2 If these two liquid drops coalesce to form one spherical drop the capacitance C of that drop is given by

(1) $C = C_1 + C_2$ (2) $C = \frac{C_1 C_2}{C_1 + C_2}$ (3) $C = \left(C_1^3 + C_2^3 \right)^{\frac{1}{3}}$

(4) $C = \left(C_1^2 + C_2^2 \right)^{\frac{1}{2}}$ (5) $C = \left(C_1 C_2 \right)^{\frac{1}{2}}$

06 Electrostatic Potential

You do not have to do a big calculation. The capacitance of a sphere is dependent upon its radius. When the two liquid drops are attached, the total volume is a constant. The volume is dependent upon the third power of the radius. If the radii of two spheres are a_1 and a_2 with a as the radius of the single sphere, then $a^3 = a^3_1 + a^3_2$.

Even the capacitance goes like this. Actually, there is no need to write any of the above. When two spheres are connected, we need to apply the conservation of volume to find the radius of the single sphere. The volume is dependent upon the third power of the radius. Even the capacitance and the radius has a linear relationship. Only (3) has third power of C_1 and C_2. For a child who understands the question in a simple way can get this answer from memory.

30 Two audio systems A and B produce sounds with intensity levels of 90 dB and 95 dB respectively. If the corresponding sound intenties are I_A and I_B respectively, the ratio of I_B/I_A is equal to

(1) 500 (2) 100 (3) $\sqrt{50}$ (4) $\sqrt{10}$ (5) $\sqrt{5}$

03 Intensity of Sound

You should not do a big calculation for this question too. The ratio of intensity means the difference of the intensity level. This has been checked by many times.

$5 = 10 \log (I_B/I_A)$ Now you need to know about little mathematics.

If $\log (I_B/I_A) = ½$ then (I_B/I_A) should be $10^{1/2}$.

If you do not see this, then getting the answer will be hard. You are familiar to solve problems of the reciprocal. That means instances such as log 10^2 =2, log 10^3 =3. Likewise log $10^{½}$ = ½. Is not it? If your logarithmic knowledge is less, you will not be able to solve it.

31 When a ball of mass 0.1 kg is thrown vertically upward in a vacuum, it reaches a maximum height of 5.0 m. When the ball is thrown upward with the same velocity in air it reaches a maximum height of 2.0 m. The average resistive force exerted on the ball by the air is

(1) 1.5 N (2) 1.25 N (3) 1.0 N (4) 0.75 N (5) 0.5 N

It will take a long time if we go for a long calculation. Such questions can be done very easily from energy. As the ball is going to a height of 50m in a vacuum, the potential energy of the ball at that instance (even the initial kinetic energy) is 0.1 X 10 X5 = 5. Cannot you do it from your memory?

When it goes 2.0 m in the air, then the relveant potential energy is 0.1 X10 X2 = 2. Therefore, the lost energy 3J (5 -2) is used to stop the resistive force from the air. If the resistive force is F and the ball goes 2.0 m distance in air, then F X2 = 3. The work done from the resistive force should be equal to the spent energy. A child who caught this method can do it from the memory. To multiply 0.1 from 10 or 5 from 2, do you need rough work? If you really want, you can use rough work to subtract 5 by 2 and divide by 2. If you want to do in a lengthy way, ½ mv^2= mgh v= 10

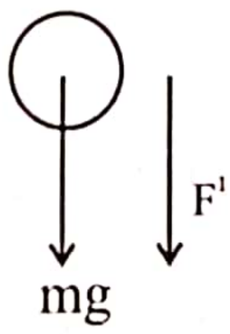
Applying conservation of energy for the second instance, ½ X 0.1 X 100 = (0.1 X10 X 2) + (F X 2)

If you apply equations of motion, then you will be in lot of trouble. It is totally wrong to take that ball is decelerating upwards in g. As there is a resistive force, if you apply equations of motion and take the deceleration of the second instance as a, then apply v^2= u^2 + 2 as upwards,

0 = 100 + (2aX 2) a = -25 ms^{-2}

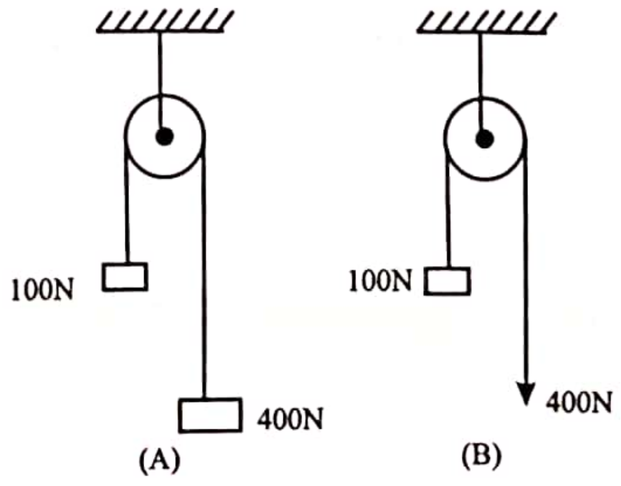
Now apply F =ma upwards

-0.1 X 10 – F'= 0.1 X(-25) F'= 1.5



Why do you have to work so hard? If you do it from the first method, then time will not finish when you are in 35-40 questions.

32 Figure (A) shows two blocks of weight 100 N and 400 N which are connected by a light strong that passes over a frictionless pulley. Figure (B) shows a situation where the heavier block in the system is removed and the string is pulled by a downward force of 400 N. The respective accelerations of the 100 N block in the two situations are given by



(1) 0.6 m s^{-2} and 3 m s^{-2} (2) 6 m s^{-2} and 6 m s^{-2}

(3) 10 m s^{-2} and 10 m s^{-2} (4) 6 m s^{-2} and 40 m s^{-2} (5) 6 m s^{-2} and 30 m s^{-2}

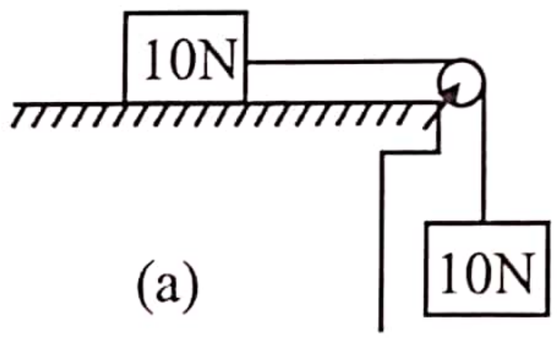
Even though it is a simple and familiar question, you should not waste time on this too. If you think traditionally, you will write equation for (A) like 400 -T = 40 a. Cannot we get the acceleration directly? Once we take the string as horizontal and expand the blocks, do not you see the figure below?

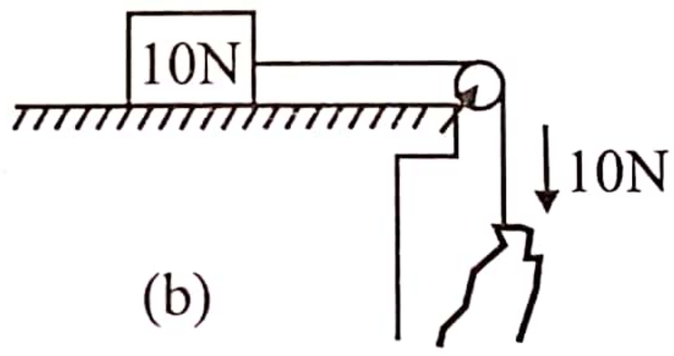
Now apply F= ma to the system. 400- 100 = 50 a a= 6

You can do it even using the memory.From 400 N, the system tends to accelerate downwards. From 100 N, it does not give a support but a resistance. 400 N is pulled for one side whereas 100 N is pulled for the other side. So the net force is 400-100. Both masses are in motion. Therefore, the total mass that is in motion is 50 kg. In such an instance, do not hesitate to write the equations without tensions. Traditionally if you put F =ma to one block and then add the two equations (to remove tensions) you will get the same answer. (B) is very simple. The tension of the string is 400 N. Therefore, for 100 N, 400-100 = 10a'→ a'= 30 ms^{-2}

Do you need rough work for this? Try to reduce the rough work to a minimum as possible.

The resultant of the two systems are in the same value (300 N). But from the force of (A) it accelerates two persons where as from (B) it accelerates one. Therefore, definitely in (B) the acceleration of the block of 100 N should be greater. If things are divided among two people, then it is unavoidable that one gets less. Look at the 47th question of paper 1989. It is the same logic.





33 Two voltmeters A and B having internal resistances 1500 Ω and 13500 Ω respectively are connected (a) in series, and (b) in parallel with an ideal battery of e.m.f. 10 V. Which of the following correctly indicates the voltages read by A and B?

	(*a*) when *A* and *B* are in series		(*b*) when *A* and *B* are parallel	
	reading of *A* (V)	reading of *B* (V)	reading of *A* (V)	reading of *B* (V)
(1)	10	10	10	10
(2)	1	9	10	10
(3)	10	10	9	10
(4)	9	10	1	9
(5)	1	9	9	10

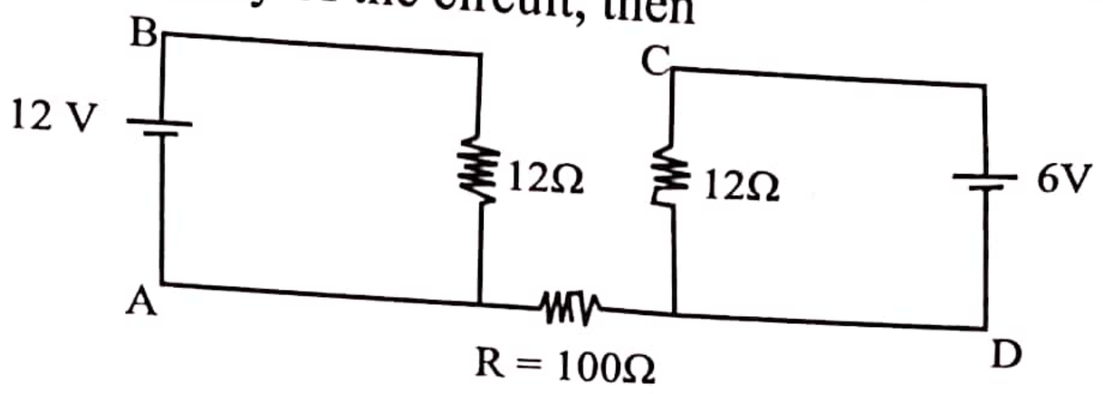
08 Moving Coil Meters

This is also a very easy question. It is a familiar question. When it is in series, 10 V is divided among the resistors according to the resistor ratio. 13,500 is 9 times of 1500. How hard is it to notice this? Therefore, the reading of A is 1 V and the reading of B is 9V. Do you really need rough work? As the internal resistance of the battery is zero, the work is really easy. When it is in parallel, both readings are in the same value. There is no voltage drop across the battery.

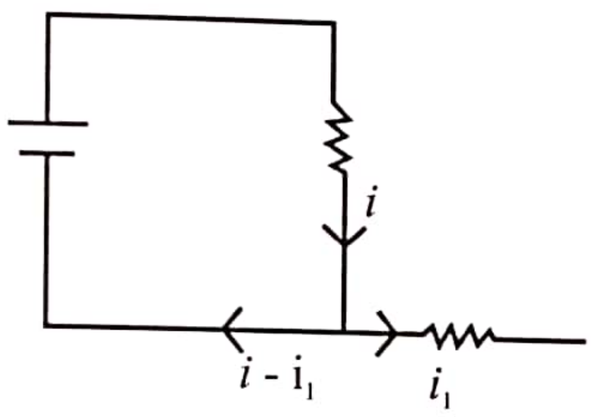
How many children are there who tries to find the current after finding the equaivalent resistance of the parallel state? When it is parallel, the readings of the voltmeters should be 10V. Then the correct choices are only (1) and (2). In (1), if both show 10 V in series combination, then the total voltage should be 20 V.The battery has 10 V. If you look from that point, (2) is correct. Is not it?

34 In the circuit shown the batteries have negligible internal resistances. If V_A, V_B, V_C and V_D represent potentials at points A,B,C and D respectively of the circuit, then

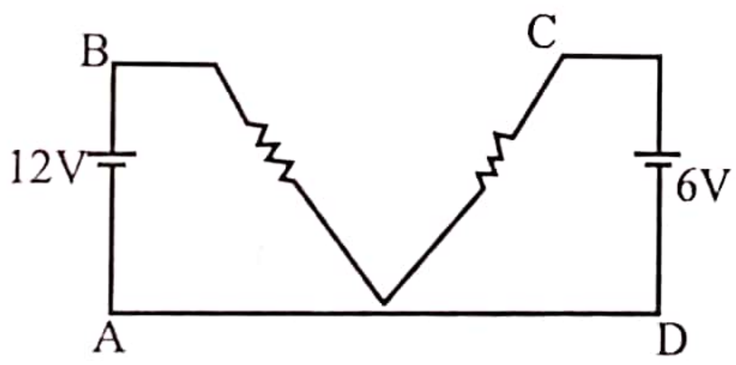
(1) $V_B - V_D = 10$ V
(2) $V_A \neq V_D$
(3) $V_B - V_C = \frac{6}{124}$ V
(4) $V_A - V_C = -6$V
(5) $V_A - V_D = 0$ only if $R = 0$



The trick of this question is the identification of no current flow across R = 100 Ω. As shown in the figure, when two circuits are connected only from two ends, the current cannot flow in that direction. If current is flown in such a direction, there is no coming back route. It is how the water is flown in a single drain. For an example, as shown below if the current is divided and if current i is gone from the battery, then i-i_1 current will be flown back. This cannot happen as charge is not conserved.



Therefore, for any the value of R, there is no current across R. If needed, the circuit in the question can be redrawn like this.



The potential is equal in the points of A and D. Or else V_A-V_D =0. From this you can remove (2) and (5).V_B - V_A(V_D) = 12. Therefore, (1) is wrong.

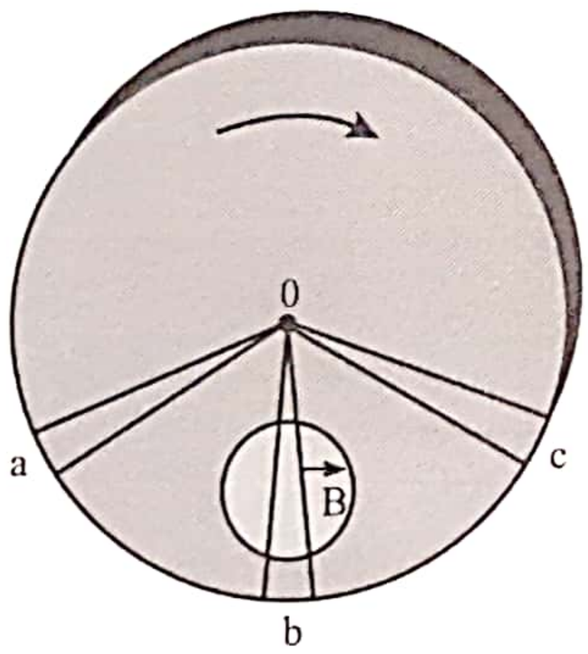
At a glance we can see that V_A(V_D) - V_C = -6 clearly. Try to avoid applying Kirchhoff's laws and writing equations. There is no use from 12 Ω. As the internal resistances are not considered, the voltage difference across the plates is equal to its e. m. f. If needed find V_B- V_C. I do not know from where did 124 come. An impossible answer is given to avoid looking at it as I guess. If you put your eye on the answers before doing the choices separately, then there is no reason that you cannot eye on (4) as the correct answer.

35 When a magnet is brought closer to three freely rotating discs A,B and C having same moment of inertia and same angular velocity, A is found to stop first followed by B, and C is found to rotate continuously. Which of the following is true?

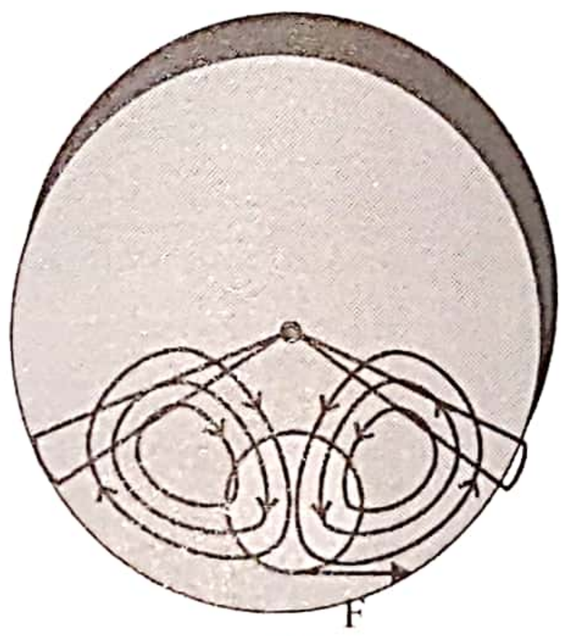
	Metal Disc	Laminated metal disc	Plastic disc
(1)	C	A	B
(2)	C	B	A
(3)	A	B	C
(4)	B	A	C
(5)	B	C	A

You can decide that C is the plastic disk by general knowledge. It is a fact that you learn in smaller grades that there is no interaction between a magnetic field and plastic. Then only (3) and (4) are left. Once you see the word lamina, you should remember about eddy currents and the core of a transformer. It is clear that (3) is correct.

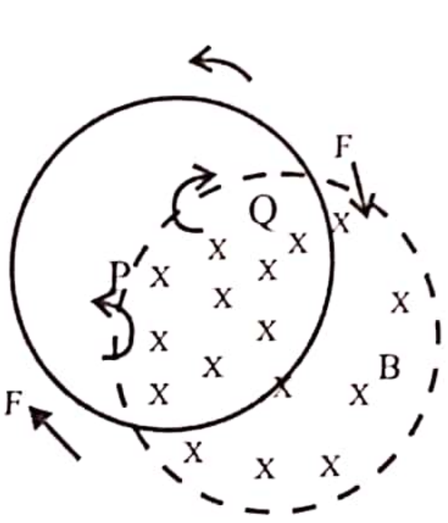
As the metal disk is rotating (moving) the magnetic flux density is changed across it. Then there will be generated eddy currents in the disk from electromagnetic induction. If the disk is made as a lamina, then there will be less induction of eddy currents to some extent.



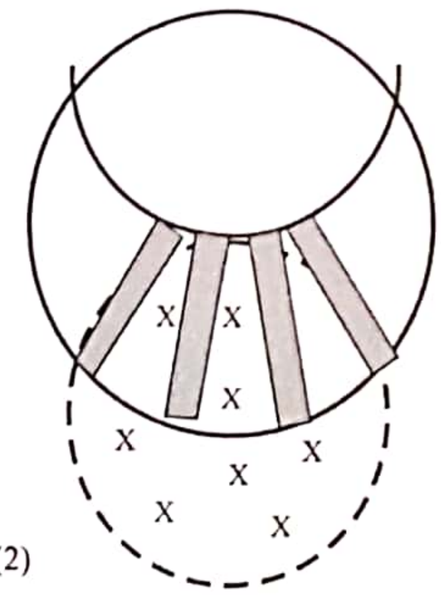
(a)



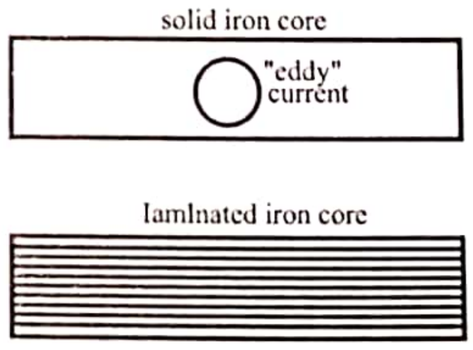
(b)



(1)

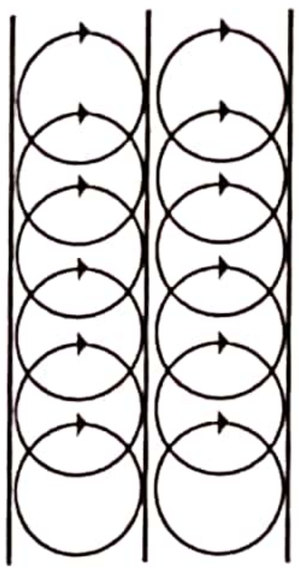


(2)

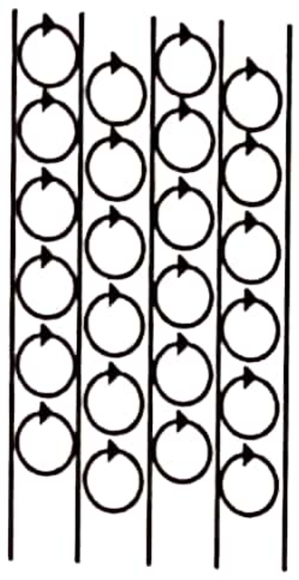


As shown in figure 1, think that the metal disk is rotating anti-clockwise. When the disk is entering to the field at P, eddy currents are being generated to the anti-clockwise direction. I leave up to you to decide the direction. When the disk is moving out of the field like in a place of Q, the eddy currents are being generated to clock wise direction. Due to these eddy currents, the mechanical energy of the disk is converted to heat. Therefore, the disk comes to rest quickly compared to the motion without a field. When we consider about the generated forces, the force acting on the disk when it enters and leaves the field are shown in the force diagram. It says do not come when it tries to enter and says do not leave when it leaves. This is the way of nature. Both instances are affecting the rotation of the disk.

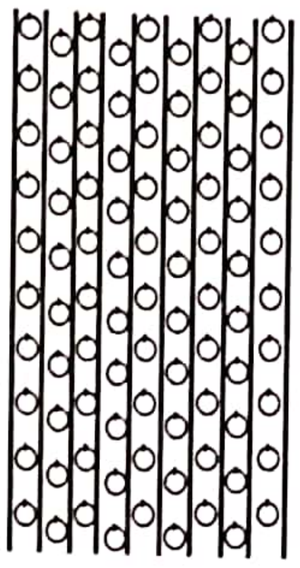
The laminated disk is shown in figure 2. Lamination means applying a non-conducting material in between the two metal layers. Then it prohibits the generation of eddy currents with long routes. Eddy currents are only being limited to each conducting layers. By this, the energy loss is minimized. The lamination should be done towards the direction of the field but not towards the axis of the disk.



Thick Laminations



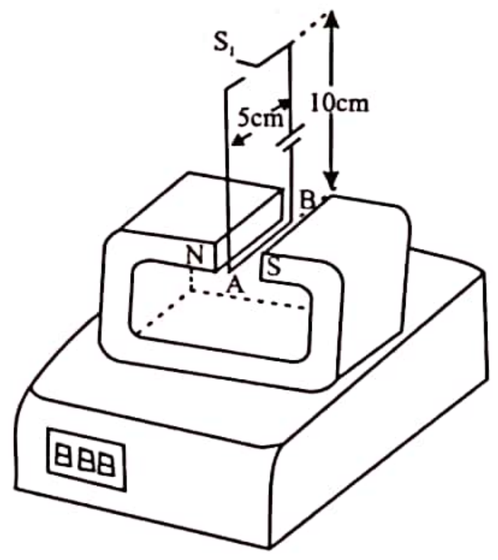
Medium Laminations



Thin Laminations

In the equipment like transformers, the eddy currents should be controlled but there are advantages from them too. The brake systems in tube trains and fast-moving vehicles are made from eddy currents to stop quickly and smoothly (gradually) and induction furnaces that are being used to melt metals are some of the usages of eddy currents. The temperature of induction furnaces is obtained by the generated heat of eddy currents of an alternative current (AC). Such furnaces do not need fuel to function.

36 A magnet with magnetic flux of 1.0 T between the poles is placed on an electronic balance. A rectangular wire loop of resistance 10 Ω, which is connected to a 40 V battery with zero internal resistance, is placed in between the poles of the magnet so that the side AB of the loop is completely inside the magnetic field and the plane of the loop is perpendicular to the magnetic field, as shown in the figure. The loop is firmly fixed to avoid any movement. When the switch S_1 is closed, the reading of the electronic balance



(1) will decrease by 200 grams. (2) will decrease by 20 grams.

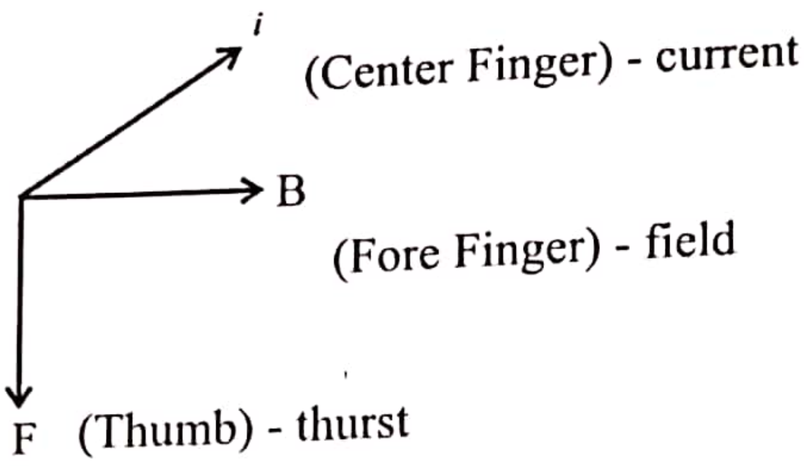
(3) will increase by 200 grams. (4) will increase by 20 grams.

(5) will not change.

There was a controversial situation in this question. There is no debate that ilB force is produced on the wire of AB. But does that force is felt as an opposite and equal force to the magnet? If so, then how does it feel about it? This has been inquired by many persons. So, I will present a descriptive review about it.

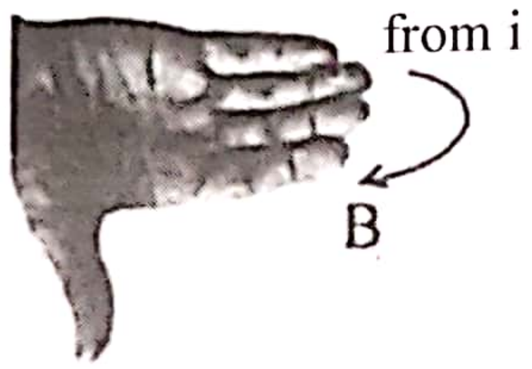
First, we will find the magnitude and the direction of the force acting on AB. When the circuit is complete, the current flows from A to B. Magnetic force = (40/10) X 5 X 10^{-2} X 1 = 0.2 N

The answers are given in grams. That is because the reading is shown in kg/g in a balance. 0.2 N is 0.02 kg. As 1000 g is 1 kg, the answer is 20g. The direction of the force can be found from Fleming's left-hand rule or the right-hand rule that I use.



I am taking everything from the right-hand rule.

As it has been mentioned in a previous question, the thumb of the right-hand is kept perpendicularly to the other fingers and the fingers are rotated from the direction of the current to the direction of the field. From the direction that should be pointed from the thumb gives the direction of the force.

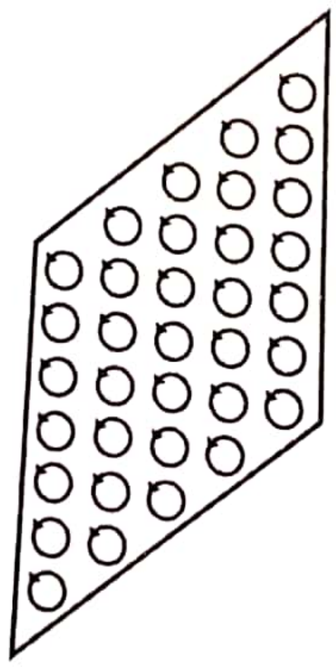


Now we know that the force on AB is downwards. Is this force is felt opposite and equal to the magnet? This is where the question lies. Most of them argued that, there will not be a change in the reading. This conclusion is not correct.

Here the opposite force that is acting on the magnet is not visible to us simultaneously. It is familiar to you that if there are two conducting wires with a current or magnet, according to Newton's third law, there are opposite and equal forces acting on each other separately. When a current carrying conductor and a magnet interact, we will now consider how the force is generated on the magnet or how the force is transmitted.

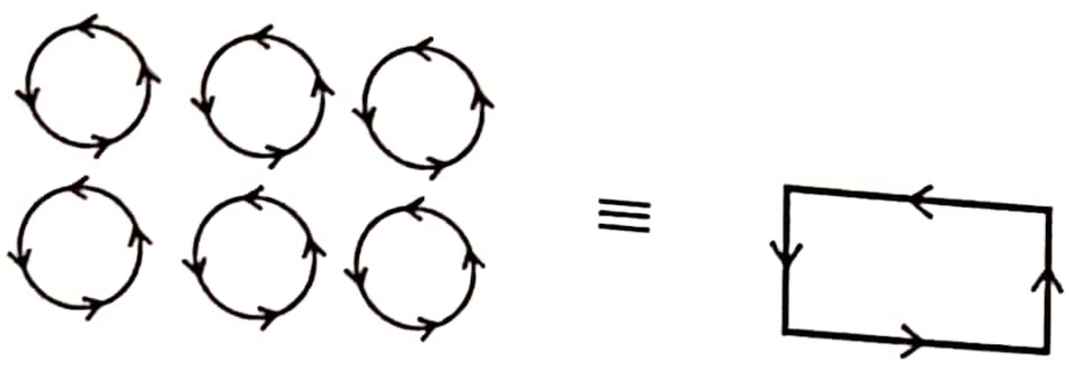
The forces cannot exist alone in nature(universe). If there is a force, it is unavoidable to have an opposite and equal force on the factor/agent that created the force.

If we help somebody, we get the happiness (merit). Likewise, if we hurt somebody, we get the results.



Actually, how does the magnetic field is created in a magnet? Even though we could not see, the magnetic field in a permanent magnet is created by the unpaired electrons that are grouped together. The contribution to the magnetic field is mainly from the spins of the unpaired electrons. The spins of the charge are equivalent to small current loops. Therefore, the magnetic field from the north pole in the magnet can be considered to get it from the current loops as shown.

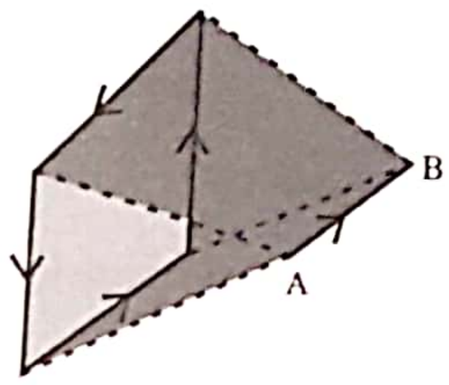
If we consider the nearby current loops,



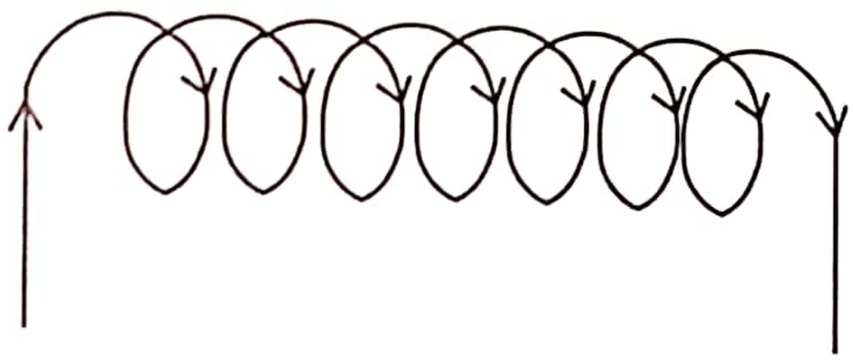
Can you observe that the current of the current loops that are nearby are flowing to the opposite directions? Therefore, cannot we take the total of them as an equivalent to a rectangular wire loop?

So, if you consider a current carrying wire loop instead of the north pole of the magnet, then a person is created who can get the opposite force.

I will not draw the forces between the wire loop and AB wire. If needed, the two planes are represented in the figure that is needed to draw the forces. If you want, then the same thing can be done to south pole too.



If we think in another way, then the permanent magnet can be equalized to a current carrying solenoid.



You know that the field is uniform inside a solenoid. It can be equalized to the magnetic field between N and S in a horse shoe magnet. If solenoid is used instead of the magnet, there is a readily seen person who is ready to take the equal and opposite force.

Most of them have picked up 'there is no change' because they think that there is nobody to be seen to take the equal and opposite force.

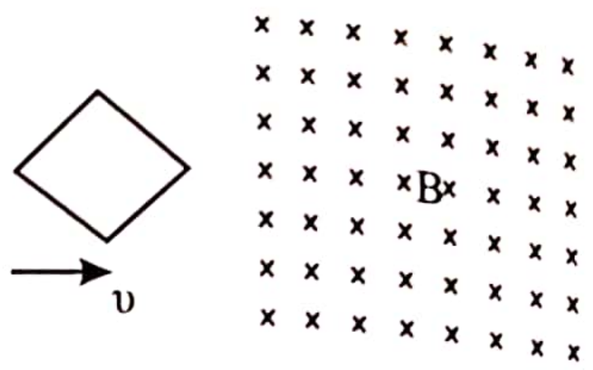
Finally, the magnetic field in the magnet is highlighted by the electrons. So, the action is created by the electron friends. Then the result also should be felt by them. On the other hand, the force on AB wire is felt by the electrons of AB.

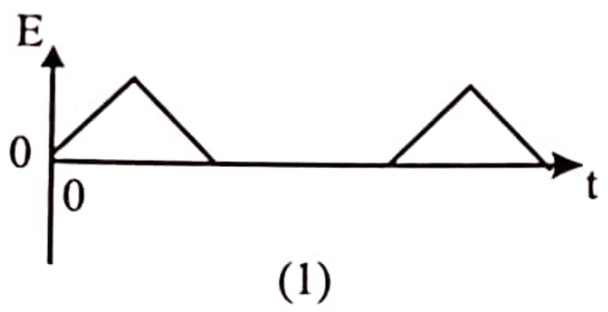
As the force is downwards in AB wire, the force on the current loops of the magnet should be equal and in the upward direction. It is felt by the magnet. If so, the reading of the balance should be reduced by 20 g.

From an arrangement like this you can study the magnetic force on a current carrying wire. The difference of the reading in the balance can be taken to measure the force. Accordingly,

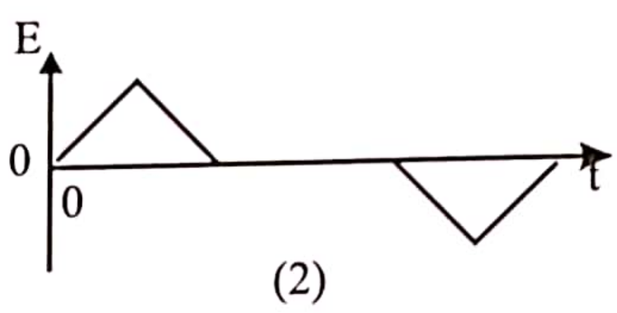
you can come into conclusions of F$\propto$ i, Fαl and F $\propto$ B. The force can be measured by increasing or decreasing the current. You can measure the force byby increasing or decreasing the length of AB. You can keep different magnets and study the variation of F. On the other hand, you can consider this as a current balance.

37 A conducting wire loop bent in the shape of a parallelogram enters a uniform magnetic field with a constant speed as shown in the figure. The variation of the induced e.m.f. (E) in the loop with time (t) is best represented by





(1)



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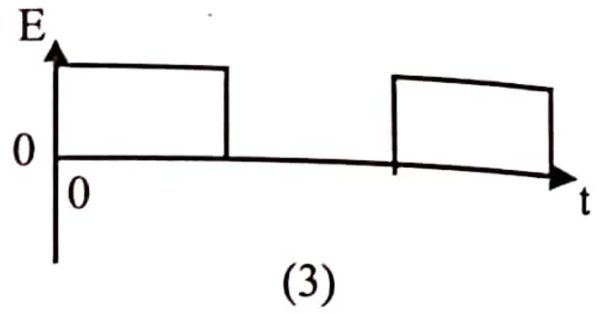
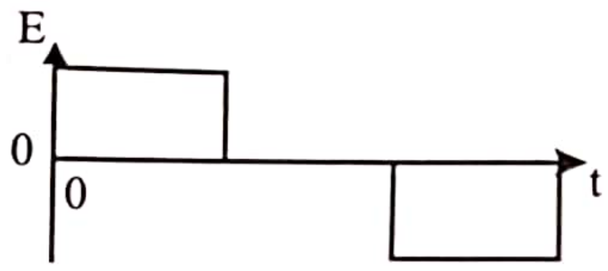
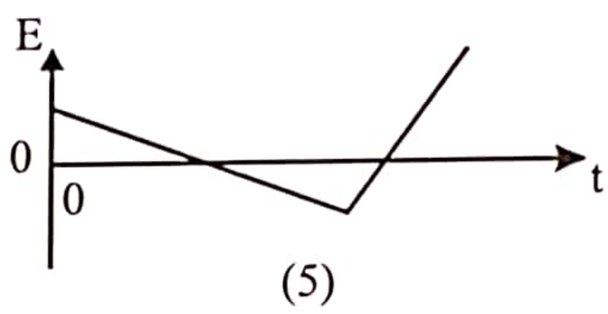


(3)



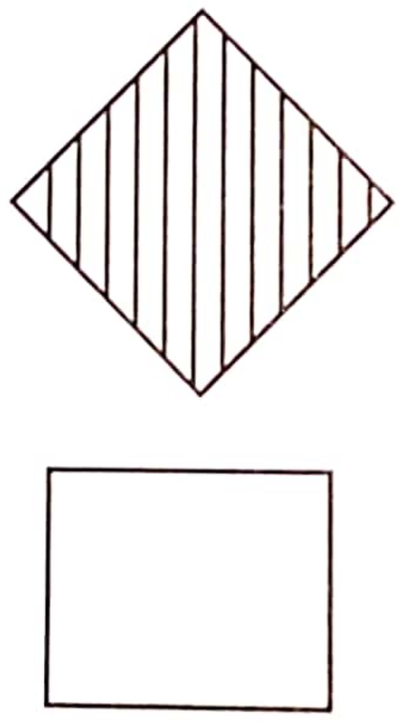
(4)



(5)

08 Electro Magnetic Induction

This is a familiar question. If the parallelogram is divided into horizontal rods, then the answer is in your hand.



B and v are constant. Therefore, the induced e. m. f across the rod is dependent upon its length (l). At a glance it can be decided that, the length of the rods is gradually increased and then gradually reduced. Therefore, the correct variation is (2). You can directly remove (3), (4) and (5).

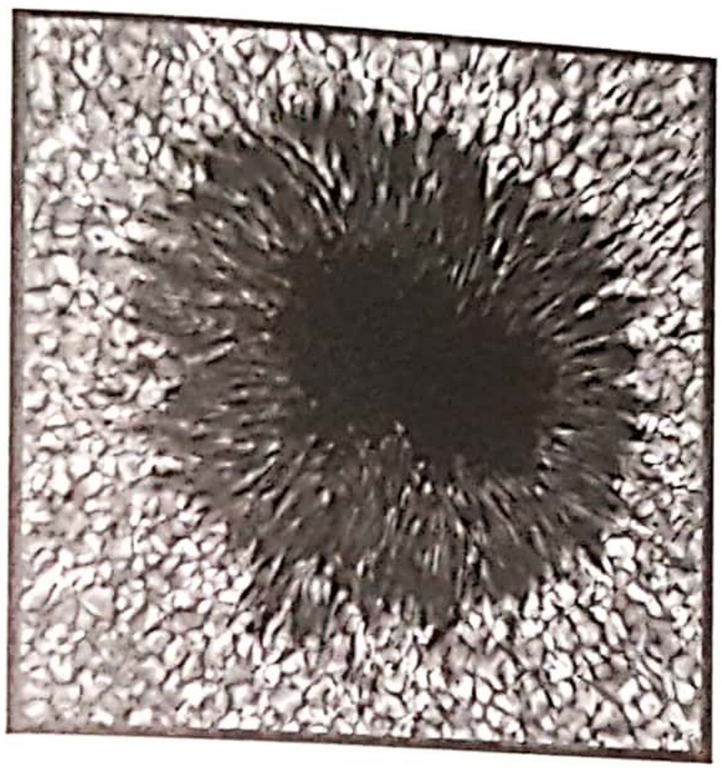
If there was a rectangle, then (4) is correct. The length of the rods is same. This has been asked before. Even though the parallelogram is divided into small strips, you can identify that the increment and decrement of the area of strips are uniform. It is a famous fact of yours that the direction of e. m. f changes when the loop is entering and leaving. You get what is not there when entering and lose what you have got when leaving.

38 The temperature of a sunspot is 4000 K while the surrounding solar surface is at 6000 K. The ratio $\frac{\text{The intensity of the sunspot}}{\text{The intensity of the surrounding solar surface}}$ is (assume that the surface emissivity is the same throughout the sun's surface.)

(1) $\frac{2}{3}$ (2) $\frac{1}{2}$ (3) $\frac{4}{9}$ (4) $\frac{8}{27}$ (5) $\frac{16}{81}$

Black Body Radiation 11

A simple calculation is enough. As soon as you see the question, you will remember black body radiation. The intensity is proportional to the fourth power of the absolute temperature. Therefore, the answer is $(4/6)^4$.



Do I need to write the zeros? It takes some time to write zeros. Is not it? Before getting the fourth power, 4/6 should be simplified to 2/3. Then the work is quick. Next 2^4 is 16 whereas 3^4 is 81. According to this, the intensity of a sun spot is lesser than five times of a normal place. Both temperatures are higher compared to ourselves. But as the intensity is proportional to the fourth power of temperature, the surrounding of a sun spot is seen relatively dark. It is seen darker not because there is no light. It is because the light is less than five times of the surroundings. White persons are seen as white not because they are white. Because black persons are there.

39 When an atom of a radioactive element emits a β^- particle, it is transformed into an atom of a different element. A different element is formed in this manner because,

(1) the nucleus of the radioactive element emits a proton.

(2) the nucleus of the radioactive element gains a neutron.

(3) a proton in the nucleus of the radioactive element changes into a neutron.

(4) a neutron in the nucleus of the radioactive element changes into a proton.

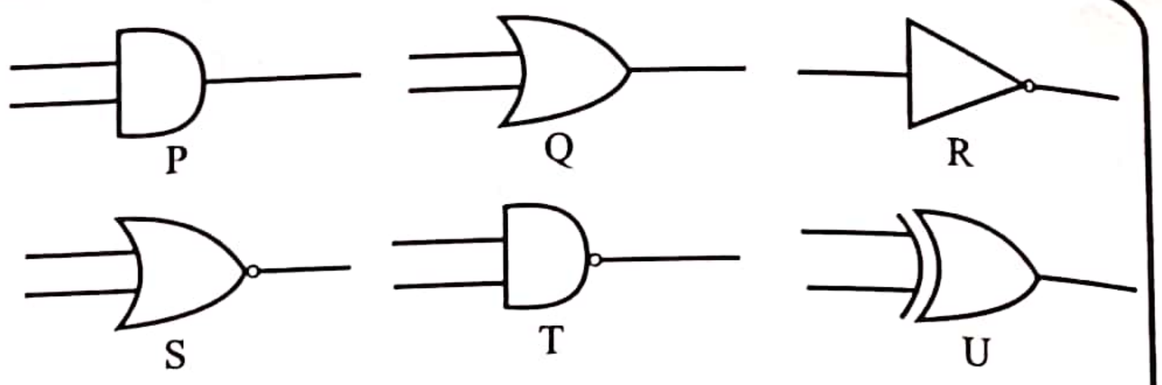
(5) the radioactive atom emits one of its electrons from an outer orbit.

Radioactivity 11

This is just a theoretical question. The charge should be conserved. As the charge of β^- particle is negative, in a β^- emission a neutron should be a proton. n $^{23}_{11}$ p+ β^-

The conservation of charge is needed to be checked. You have not heard that protons and neutrons are being emitted from radioactive nuclei. There is an ionization in (5). It is not a nuclear phenomenon.

40 Which of the two gates shown can be combined to construct a circuit in order to obtain a binary output of 1 for input binary digit combinations of 00 and 11 only?



(1) P and R (2) P and Q

(3) R and U (4) S and R (5) T and Q

09 **Logic Gates**

As you look at the answers, everyone has two gates in each. There are no single ones. Therefore, somehow you need to connect two gates. The shortest method is to identify that only XOR gate gives the same output to 00 and 11. All the six gates that you have learnt are seen here. As there are 00 and 11 combination, you need to consider only P, Q, R, T and U. R (NOT gate) is only needed to make 0 to 1 or 1 to 0.

If P is taken, 0 for 00 and 1 for 11. The outputs are not equal.

If Q is taken,0 for 00 and 1 for 11. The outputs are not equal.

If S is taken, 1 for 00 and 0 for 11. The outputs are not equal.

If T is taken, 1 for 00 and 0 for 11. The outputs are not equal.

There is no point in looking the other two if it is not suited to AND gate and OR gate.

If U is taken, 0 for 00 and 0 for 11. If NOT gate is connected, then both 0 become 1. The answer is (3). After U, R should be taken. But the order is not asked from the question.

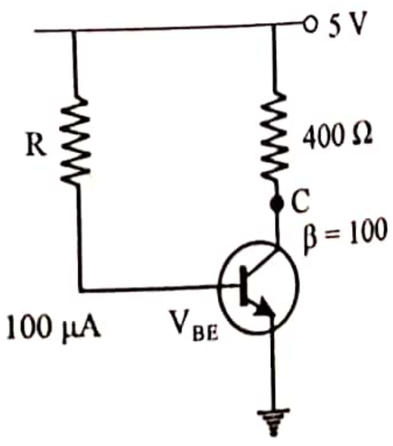
As there was a printing error in the Tamil medium paper, it became ALL. By looking at the answers separately also you can solve this question but takes some time.

There is another easy method. Both (2) and (5) can be removed. Why? A gate with two inputs gets one output. How can one output be connected again to a gate with two inputs? Therefore, it is a joke to connect two gates with two inputs one after the other (if there is no input to the second). Only (1), (3) and (4) are left out.

There is AND gate initially at (1). Then 0 for 00 and 1 for 11. If it goes across NOT gate, then 1 and 0. Incorrect.

(4) can be argued like that and only (3) will be left.When (2) and (5) are removed, R is there in the rest of the three. It means that if you want 1 to the end, then only 0 should be there as the input of NOT gate. 0 is obtained for both 00 and 11 from a XOR gate only. As the question contains two inputs each, you cannot consider NOT gate initially.

41 In the circuit shown base current to the transistor is 100μA, and V_{BE}=0.7 V. If the current gain of the transistor is 100, then the voltage at C is



(1) 0.1 V (2) 1 V (3) 2 V

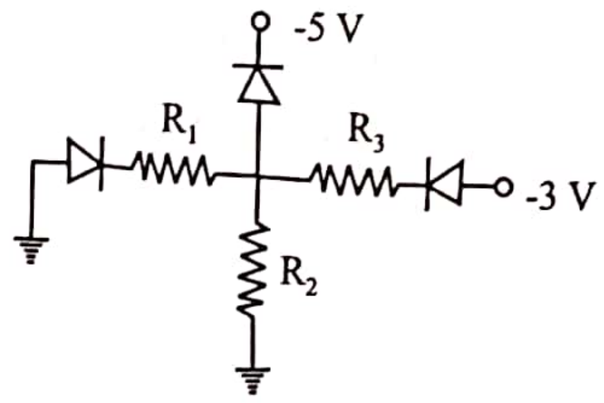
(4) 4 V (5) 5 V

09 **Transistors**

It is a simple calculation. If needed, you can do it from your memory. If you can find I_C, then it is correct. If you know the drop of voltage across 400 Ω, then it is very easy to find V_C. As β is given quickly you can find IC. ($\beta = I_C / I_B$).

The drop of voltage across 400 Ω is 400 X 100 X 10^{-6} X 100 = 4. There are exactly six zeros. That means 10^6. 10^6 X 10^{-6}= 1.If the drop of voltage across 400 Ω is 4 V, then V_C= 1V. Is not it? There is no need of V_{BE}. It has been given to show that the transistor is in the active region. The value of R should be taken to make V_B as 0.7 V.

42 In the circuit shown R_1, R_2 and R_3 are of the order of a few kilo ohms. An appreciable currents can be found



(1) only through R_1 and R_3 (2) only through R_2 and R_3

(3) only through R_1 and R_2 (4) through all R_1, R_2 and R_3

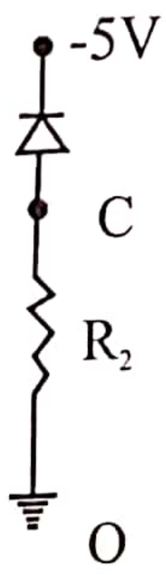
(5) through none of the resistor.

You need to think a bit. Considerable current means a current in mA range. That means you need to check whether the diodes of the circuit are in forward or reverse biased state. If the diodes are in reverse biased state, then μA range currents are flown. These μA range currents are not considered as considerable currents. We know that there are no currents of A range across the diodes. If so, the diodes get burnt. When taking diodes, considerable currents indicate the currents in mA range.

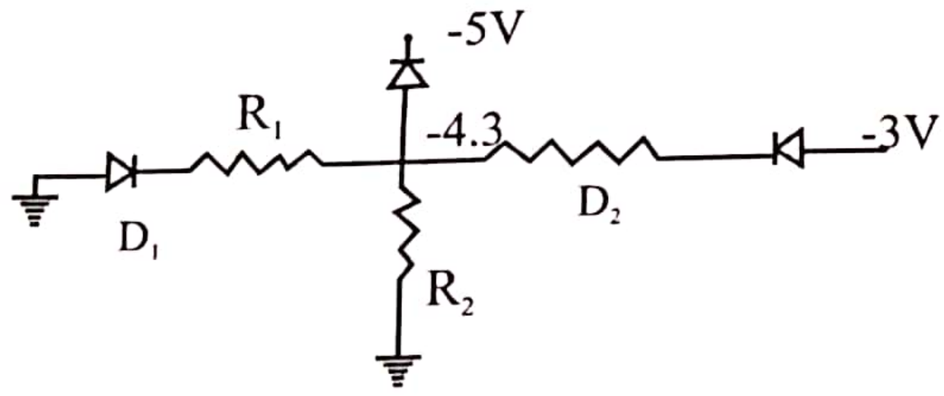
Actually, you do not need to find the values of currents in this question. Even you cannot find accurate currents. But the resistors are mentioned to be in kΩ range to emphasize that mA range currents flow if the diodes are forward biased.

As mentioned earlier, to find the answer, you need to check whether the diodes are in forward/ reverse biased state. Nothing much is needed further. If they are forward bias, then mA range currents are flown across the resistors.

If we guess the potential at the middle of the circuit (where it cuts), then the work is done. The method to get is by considering the part that goes vertical from the middle of the circuit.



As 0> -5, this diode is forward biased. Consider the diodes as Si. There is no effect on the question whether these diodes are Si or Ge. But to estimate the value of point C, we will take as Si diodes. Then the potential at C is -4.3 V. Is not it? V_C-(-5) = 0.7. Now the answer is in hand.



Now let us take a look at other diodes. As $0 > -4.3$, D_1 is forward biased. If you look at the right, then as $-3 > -4.3$ it is also forward biased. That means all diodes are forward biased. So, a considerable amount of current is flown across every resistor. You need to be careful about the negative values of the potential. -3 is bigger than -4.3.

Sometimes if children have gone far and estimated the values of the currents (it is not needed), then let us take the resistors as 1 kΩ.

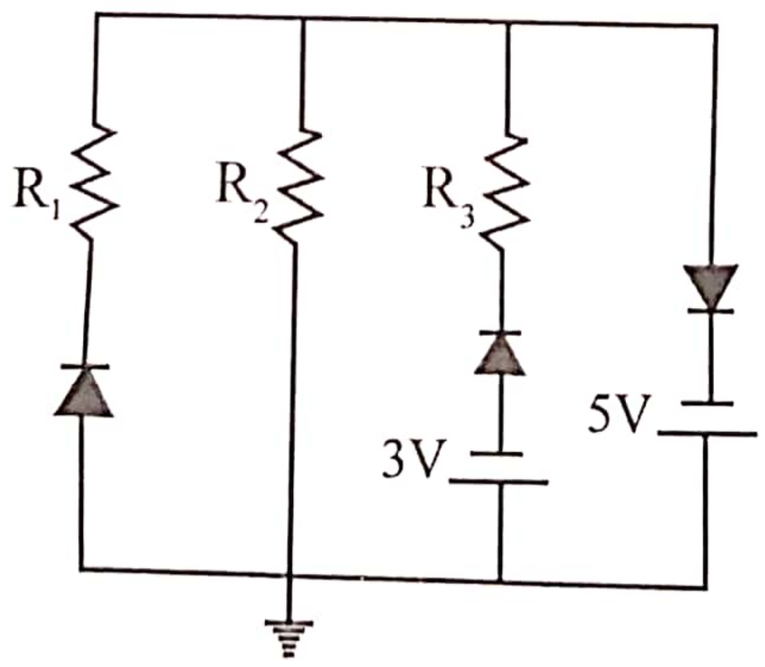
$$(R_1)\ i_1 = \frac{-0.7-(-4.3)}{10^3} = 3.6\ mA$$

$$(R_2)\ i_2 = \frac{0-(-4.3)}{10^3} = 4.3\ mA$$

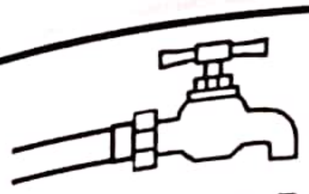
$$(R_3)\ i_3 = \frac{-3.7-(-4.3)}{10^3} = 0.6\ mA$$

If 0.6 mA is considered as small compared to 3.6 mA and 4.3 mA and if we neglect i_3 then (3) is bit correct. That is why (3) is also being selected as correct. But if you understand the question properly, then the correct answer is only (4). Some children might have not understood that what is meant by a considerable current. If the diodes are reverse biased, then very small μA range currents are flown. Therefore, the question cannot ask across which resistors does the current flow. Even they are in μA range, it is a current as one might argue. The question can ask what are the diodes that are forward biased. But then there is no thrill in the question.

Therefore, considerable amount of current flow means that the diodes are being forward biased. You need to start from the middle of the circuit to find the potential of point C. If you try from left or right, it cannot be done. If you catch the trick, then the rest is simple.



Some have argued that the circuit drawn in the paper is an open circuit and there cannot be currents across the resistors. Even if you are not familiar with this method of drawing circuits, this is an art of drawing circuits. Most of the time, electrical engineers draw circuits like this. If you draw from this method, then it is easy to study the circuit and do the calculations. Have a look if the circuit that has been drawn here is equivalent to the circuit of the paper.

43 

Water droplets drip at a constant rate from a tap as shown in the figure. The centre of gravity of the system of drops in the air is most likely to be found at

(1) P (2) Q (3) R (4)S (5) T

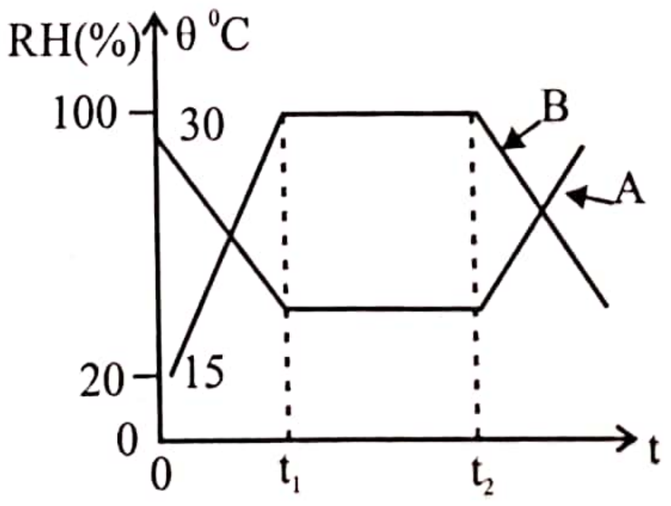
Centre of Gravity **02**

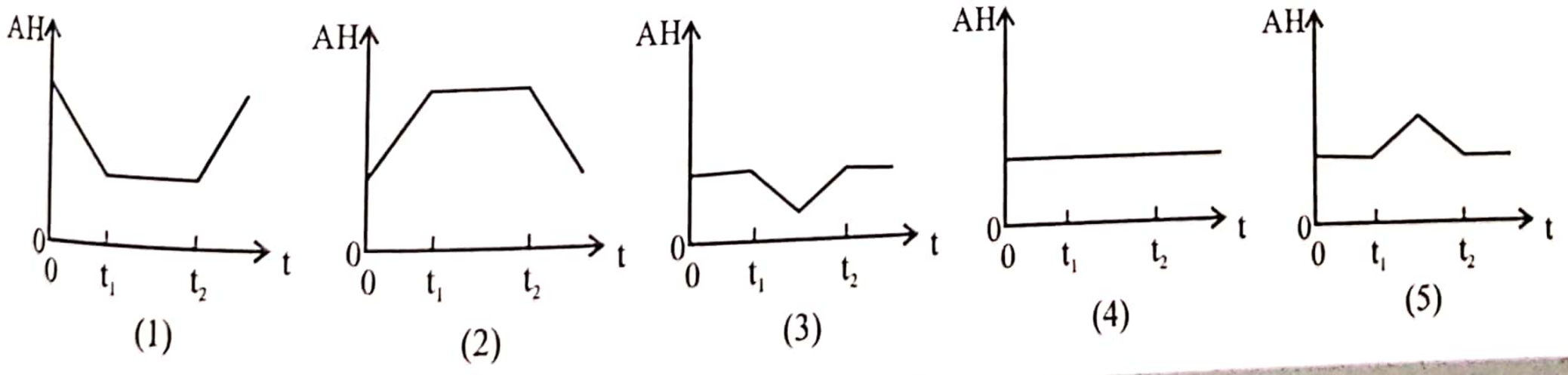
This is question like the mirror question (22) where the answer should be obtained from guessing. There is no need for a calculation. May you have the blessings of Sakvithi Sir if you measure the distance of water drops and take the moments. Even from general knowledge we know that, when the water drops fall, the distance between the later drops is greater compared withthe distance between the initial drops. The speed of the water drops increases due to gravity. It has been also shown in the figure. Therefore, the centre of gravity of the drops system should be at a higher place than the middle of the system. At an instance, the amount of water drops at the top is greater than the amount of water drops that are below. From that logic, you can remove points S and T. Both points of P and Q are drawn upwards. It is not physical. They are someone at below also. Then only R is left. Point R is the only point that is above the middle which closer to the answer.

Some take the moments and argue that the centre of gravity should be above R. It is true according to the water drops system that is shown. The splitting pattern of water drops is shown in the question. You do not need to find the centre of gravity exactly for the shown water drops.

Even there is no need for any calculation to get the answer for this question. It should not be done. You can get the answer quickly by the method of elimination. In such questions, it has been asked about the point where the centre of gravity can lie not the exact point of centre of gravity. First, you need to remove S and T. Even P and Q are drawn nearby and above just to omit them.

44 When the temperature (θ) of air inside a closed room is varied with time (t) according to the A shown in figure, its relative humidity (RH) is found to vary with time according to the curve (B).The corresponding variation of the absolute humidity (AH) of air inside the roon with time (t) is correctly represented by



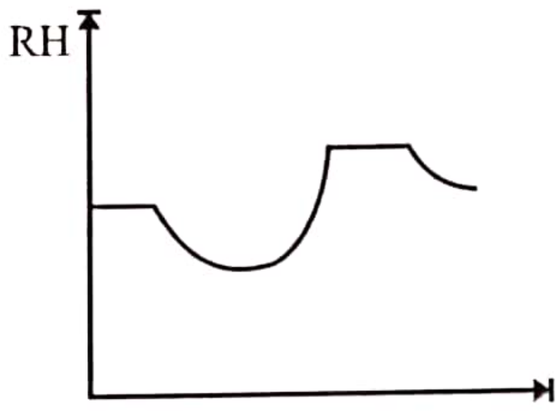


Hygrometry **04**

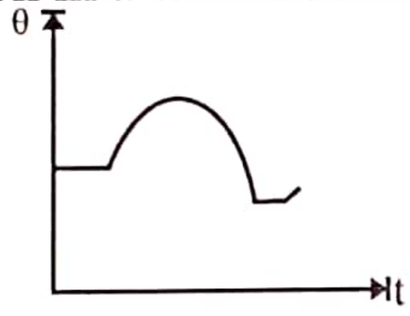
No doubt that you must have seen such questions. If the mass of water vapour in a unit volume (absolute humidity) of a closed room did not get condensed, then it should be a constant. Can

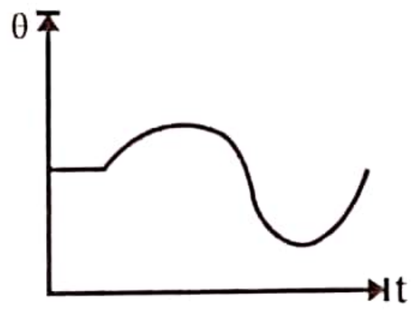
the mass of sugar in a tea cup be changed when the temperature is reduced?

When the temperature is reduced, the relative humidity goes up. It gets 100% at the dew point. It happens in t_1. At that instance the room temperature has reached the dew point. From t_1 to t_2 the room temperature has not reduced than the dew point. It was constant on that value without being changed. So, the water vapour was not condensed. If the temperature was lesser than the dew point, then the relative humidity is still 100%. But as the water vapour gets condensed (as dews are formed) the absolute humidity gets reduced. Look at 56th question of paper 1992.



The temperature variation in a closed room is shown withrelative humidity (RH) and time (t).

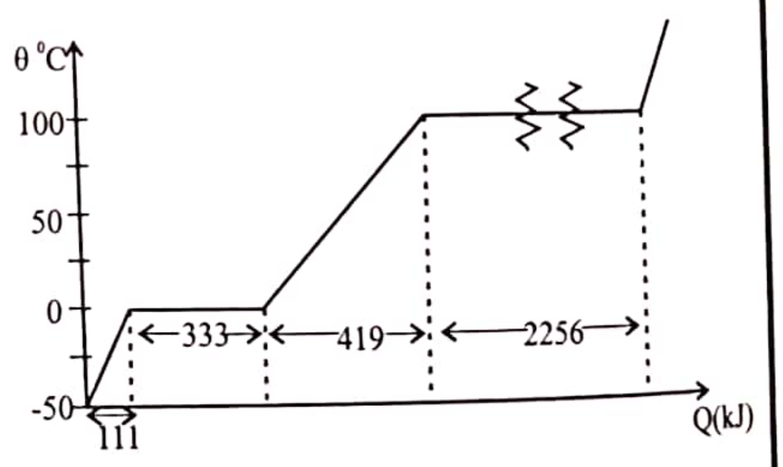




There are two ways that the temperature (θ) can vary inside the room. We cannot say which one is correct exactly.

First, if RH is constant then the temperature is constant. The reduction of RH means an increment of temperature. An increment of RH means a reduction of temperature. In a low temperature, RH is remaining at a higher constant value than before means either room temperature has come to the dew point and it is constant. Or else, the temperature even can be at a value lower than the dew point. RH is 100% even if it remains at the dew point or the temperature goes lower than that value. To catch the difference, you need to check the absolute humidity (AH). If RH remains at 100% and AH remains as a constant, then the temperature remains at the dew point. If RH remains at 100% and AH gets reduced then the temperature has gone lower than the dew point.

45 The figure shows the amounts of heat, Q, (in kJ) absorbed by 1 kg of ice under each of the states when it is heated from temperature-50^{0}C to 100 ^{0}C .



Which of the following statements is incorrect?

(1) Specific latent heat of fusion of ice is 333×10^3 J Kg^{-1}.

(2) Specific latent heat of vaporization of water is 2256×10^3 J Kg^{-1}.

(3) Specific heat capacity of ice is 1110 J Kg^{-1} ^{0}C^{-1}

(4) Specific heat capacity of ice is less than that of water

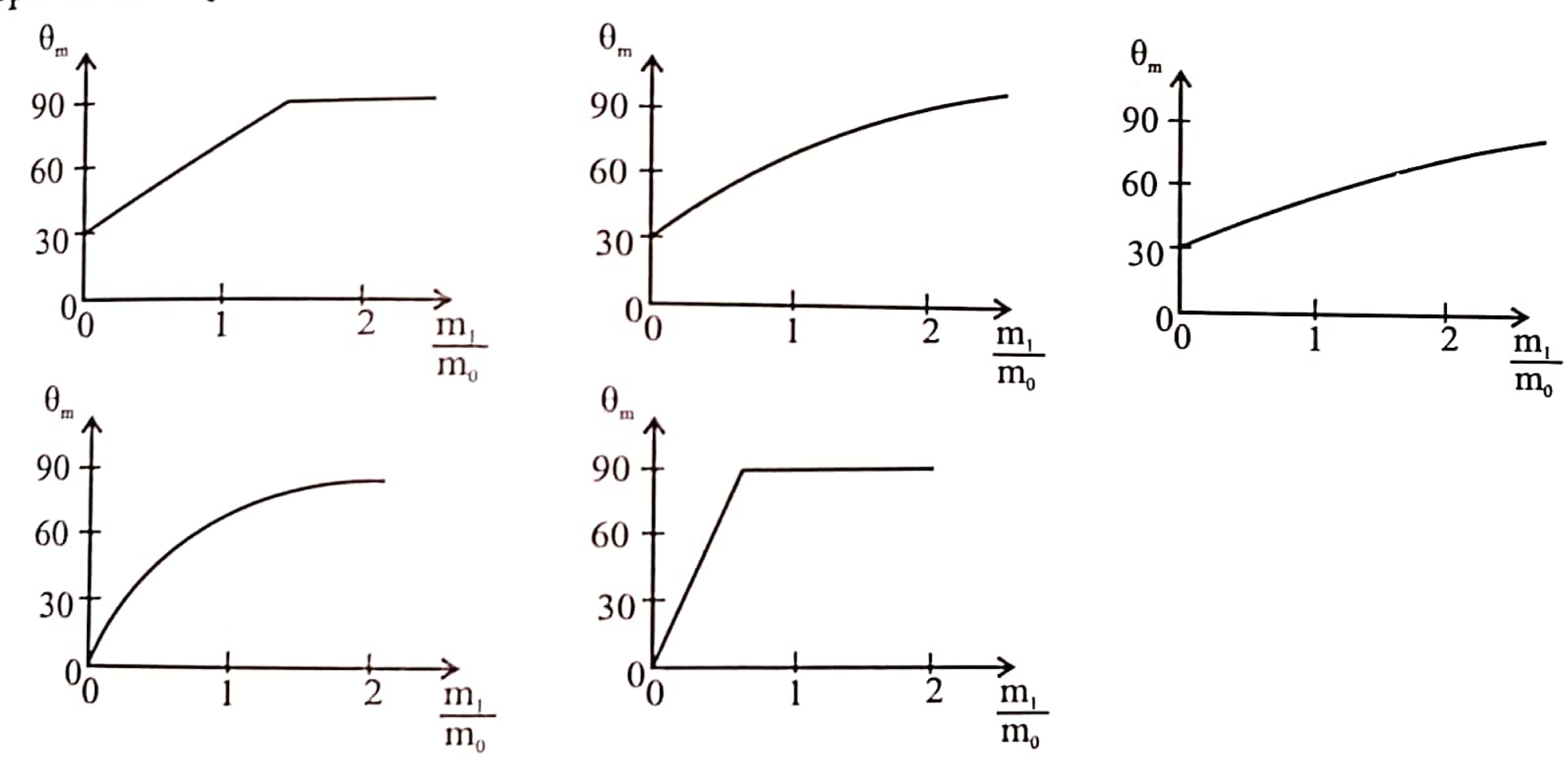
(5) Specific heat capacity of water is 4190 J Kg^{-1} ^{0}C^{-1}

This is also a very simple question. Looks very familiar. No doubt that you might have studied many of such questions with variations. As 1 kg has been used, from the supplied heat you just can get specific latent heat of fusion and vaporization. It can be directly seen that both (1) and (2) are correct. To find specific heat capacity, you need to get the temperature difference. $Q = ms(\theta_1 - \theta_2)$

If you just think 111 is correct, then kJ is converted to J and it should be $111 \times 10^3\ Jkg^{-1}\,{}^0C^{-1}$. It is wrong if you thought like that.

From general knowledge you get to know that (4) is correct. Ice quickly melts. Even the gradient of the straight line of ice is greater than the corresponding value of water. It means that, from a certain amount of heat, ice is increasing its temperature quickly compared to water. That means the specific heat capacity of ice is less. From the instinct you can get to know that (5) is correct. 4200 is normally a memorable quantity. No need to keep on doing calculations.

46 A vessel of negligible heat capacity contains water of mass m_0 at the room temperature of 30^0C.When a mass m_1 of water at 100 ^0C is added to the vessel, the maximum temperature of the mixture becomes θ_m (neglect heat losses). The variation of θ_m with m_1/m_0 is best represented by

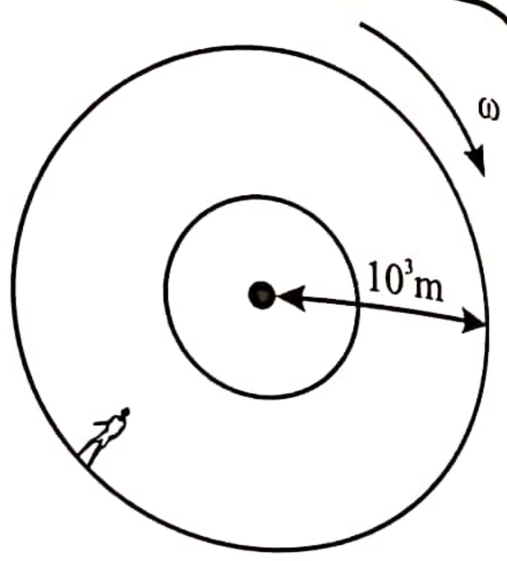


There is no doubt that examiners expected to find correct variations without doing calculations for this question also. $m_1/m_0 = 0$ means that $m_1 = 0$. That means there is no water in 100^0C. So, the temperature should start from 30. (4) and (5) are removed directly.$m_1/m_0 = 1$ means that $m_1 = m_0$. No need to do calculation to find the temperature of the mixture. If equal masses of water are used, then the maximum temperature of the mixture should be 65. Is not 65 the mid value of 100 and 30? When m_1/m_0 are going to big values (when m1 is greater), the maximum temperature should reach up to 100^0C. It cannot go beyond 100^0C. The examiners might only have expected that. Some children have found θm for $m_1/m_0 = 2$ too. Then you will get around 77^0C for θ_m.

Unfortunately, in the second curve, when $m_1/m_0 = 2$, θ_m is greater than 77 ^0C. It is nearly gotten in the third curve but when $m_1 = m_0$, you do not get 65^0C.

Only simple things are expected from such questions. As $m_1/m_0 = 2$ is marked, it is fair that children tend to calculate it also. Initially it is 30. When it is equal it is 65. As it is going far, it reaches 100. The examiners might have expected only those facts.

47 Figure shows the space colony of radius 10^3 m, rotating about its axis. At what angular speed (ω) must the space colony be rotated so that an astronaut standing on the floor of the colony experiences a push on his feet that equals his weight on the Earth?



(1) 0.1 rad s^{-1} (2) 1 rad s^{-1} (3) 2 rad s^{-1}
(4) 5 rad s^{-1} (5) 10 rad s^{-1}

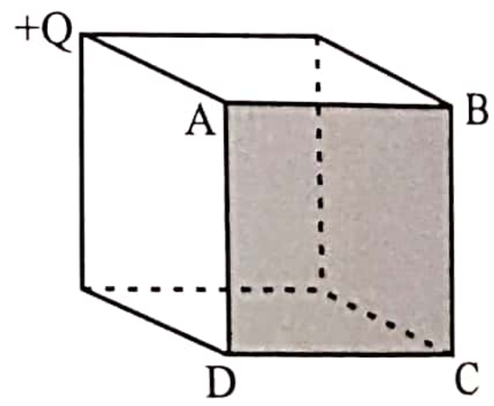
02 Circular Motion

Simple calculation is there. If the thrust has be equal to the weight on earth, the acceleration of the legs should be equal to g. $r\omega^2=g$ $\rightarrow 10^3\ \omega^2=10\rightarrow\omega=0.1$

If you are doing with the powers then R is the force felt on the legs. $R=mr\omega^2$ but $R=mg$. That means $g=r\omega^2$

If the colony with this radius is rotated with the above mentioned ω, then the man is like staying on the earth. The reaction he feels from the floor is equal to his weight. The gravity of a space colony is made to feel like this. It is not good to reduce the radius of the colony. If the radius is reduced, then ω should be increased. Then the inhabitants in the colonial tube (which is in the shape of donut/ ulundu wade) will feel uncomfortable.

48 point charge +Q is placed at one of the corners of a cube as shown in the figure. The electric flux through the surface ABCD of the cube due to the charge is



(1) $Q\left(\text{or}\frac{Q}{\varepsilon_0}\right)$ (2) $\frac{Q}{4}\left(\text{or}\frac{Q}{4\varepsilon_0}\right)$ (3) $\frac{Q}{6}\left(\text{or}\frac{Q}{6\varepsilon_0}\right)$

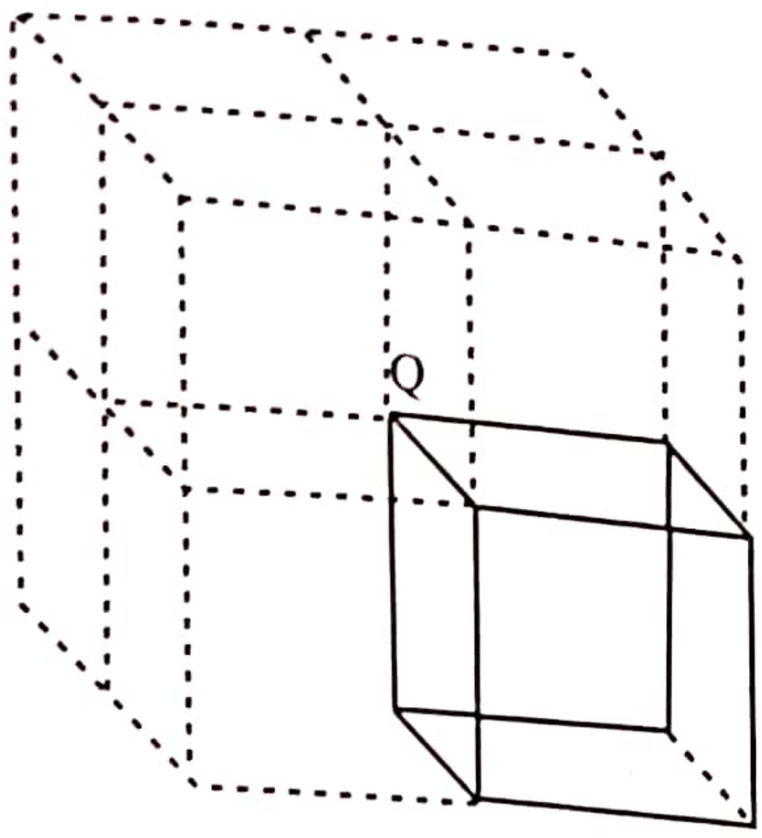
(4) $\frac{Q}{24}\left(\text{or}\frac{Q}{24\varepsilon_0}\right)$ (5) $\frac{Q}{36}\left(\text{or}\frac{Q}{36\varepsilon_0}\right)$

06 Gauss Theorem

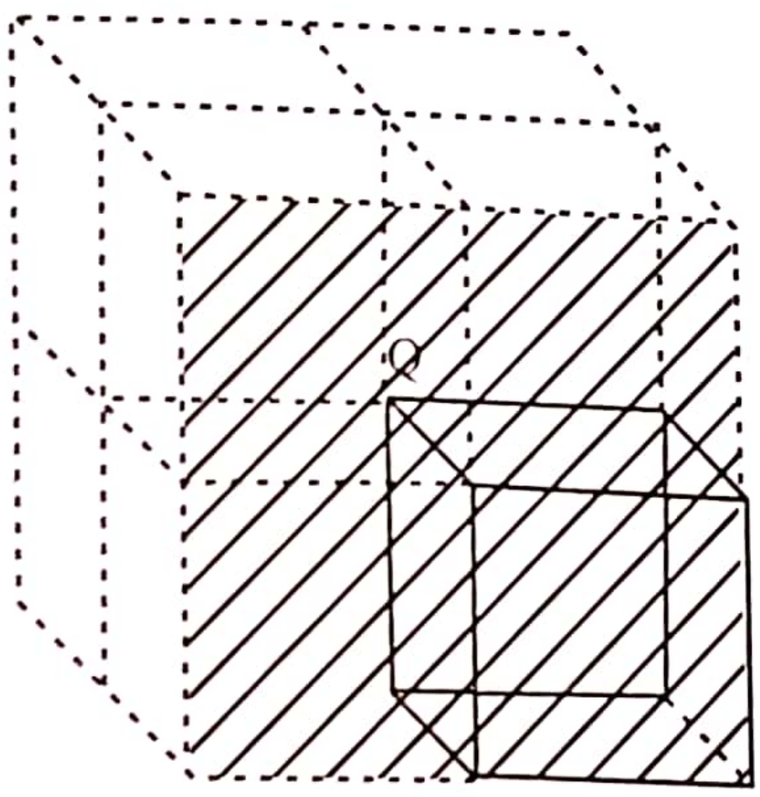
There is only one method to solve this question. If you did not see it, then you cannot solve even if your mother or great grand dad says. As you read the question, you will feel that this is a question that Gauss theorem should be applied. Sphere is the symmetrical surface that can be considered to cover a point charge. Here they have drawn a cube. Therefore, the electric flux cannot be found across ABCD as it is. You must design a closed surface using cubes by keeping the point charge in the middle. How to draw an imaginary closed surface with symmetry in the middle of Q which has a flux flowing surfaces like ABCD where Q is situated in the middle? Look at the following figure.

To design symmetric surfaces like ABCD which are equidistant with the point of charge in the middle, you need four packed cubes in front as well as four cubes behind. Then you will see four surfaces like ABCD together. To cover the whole charge of Q do not you see that you

need 24 such cubes? (4 X 6) This needs to be drawn in 3D at your mind. There are 4 cubes per a face and for all 6 faces it should be 24.



If such cubes are kept behind these four cubes, then Q is covered from all the sides beautifully. So, the electric flux going across ABCD surface is 1/24 of the total flux. There are two answers as you have been taught to write the electric flux in two methods. This is the beggar's wound of A/L Physics. Seems there is no solution.



How do you write Gauss theorem? Is it in Q or Q/ε_0? This is a compulsory question that I get when I go to a school. In Gauss's time it was written as Q/ε_0. But later on, according to the flux model, the electric flux is equal to Q. According to that the standard unit of electric flux is Coulomb. If you write in either way, there is no harm to the presentation power of the theorem.

The other fact that is relevant to these two methods is the identification of the difference between the electric lines of force and electric flux lines. Electric lines of force are E lines. Lines of forces do not have to be continuous. As we know from one medium to another medium E (electric field strength) can be changed. But flux lines must be continuous.

Gauss theorem is expressed by Q/ε_0 according to electric lines of force (according to E field). According to actual electric flux of electric flux lines Gauss theorem is expressed by only Q.

Gauss theorem is not a problem with a problem. If needed you can make it as a problem.

49 A radio is powered by six 1.5 V batteries, connected in series, whose internal resistance can be neglected. A single battery can provide a charge of 9600 C. If the batteries treat the radio as a resistance of 270 Ω at a certain sound level, the number of hours the radio can be operated at this sound level is

(1) 60. (2) 80. (3) 90. (4) 240. (5) 480.

08 **Heating Effect of Electric Current**

There is a simple calculation. It is a normal mathematical question. From 6 batteries of 1.5 V, you will get 9 V. Cannot you multiply 1.5 from 6 from your memory? So, the current flowing in the circuit is 9/270. If time is t, then it= Q

(9/270) t = 9600 $t = \frac{9600 \times 270}{9 \times 3600}$ (it must be divided by 3600 as we need in hours) = 80

Many argue that the correct answer is 480 (80 X 6). If 9600 C in one battery, then in six batteries we can think that there are 6 times of 9600 C. But we already have multiplied the e. m. f. Therefore, considering 6 of 9600 again is a double calculation.

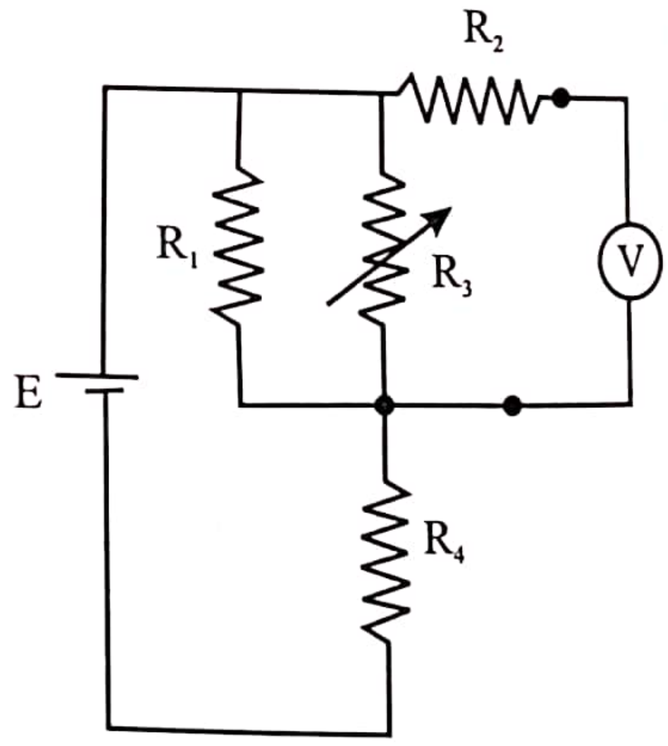
If we look from the stored energy of a battery, you can achieve this. The energy that is stored in a battery is 9600 X 1.5. (W = QV). It is six times in six batteries. No need to multiply by 6 again.

$$9600 \times 1.5 \times 6 = 1.5 \times 6 \times \frac{1.5 \times 6}{270} t$$

QV = Eit ($i^2Rt = E^2t/R$) From this also you can get the answer.

All the juice in six batteries should be over. When the batteries are connected in series, it is true that the current is getting increased. The current is increased as the equivalent e. m. f (pull) gets increased by the increment of flowing charges in a unit time. The power of the pump is increased and more water is pulled in a unit time.

50 In the circuit shown E represents the e.m.f. of a cell of negligible internal resistance. R_1, R_2 and R_4 are finite resistances. V is an ideal voltmeter connected across a variable resistance R_3. If the value of R_3 varies from zero to infinity, which of the following terms correctly predicts the readings of V when $R_3 = 0$and $R_3 \rightarrow \infty$?



	When $R_3 = 0$	When $R_3 \rightarrow \infty$
(1)	0	$\left(R_4 + \frac{R_1 R_2}{R_1 + R_2}\right)E$
(2)	$\left(\frac{R_1}{R_1 + R_4}\right)E$	$\left(\frac{R_4}{R_1 + R_4}\right)E$
(3)	0	$\left(\frac{R_1}{R_1 + R_4}\right)E$
(4)	$\left[\frac{R_1 + R_2}{R_1 + R_4}\right]E$	$\left(\frac{R_1}{R_1 + R_4}\right)E$
(5)	0	$\left(R_1 + \frac{R_4 R_2}{R_4 + R_2}\right)E$

08 **Ohm's Law combinations of resistance**

I feel that this question can be shortened with the description. If all devices are treated as ideal, then as the circuit is already given, can we ask what will be the reading of the voltmeter when $R_3 = 0$ and $R_3 = \infty$?

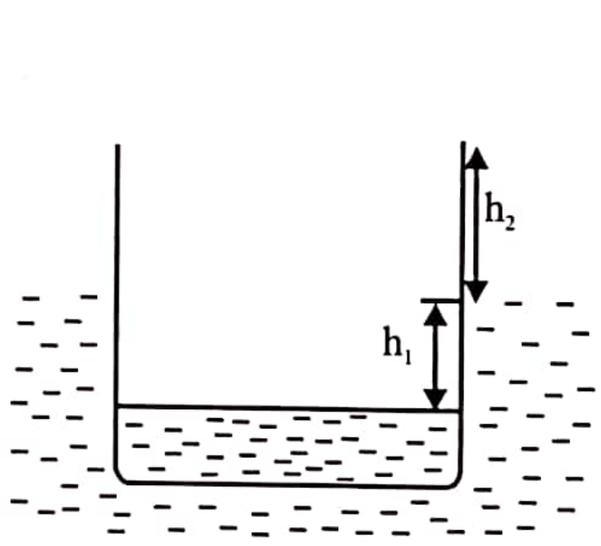
The problem is very simple. Even it is the 50th question, it can be quickly solved. When $R_3 = 0$, it can be considered as an instance where you have a wire with zero resistance. Then the joints get short circuited. There is no current across R_1. Why do you need to go in woods when there is a good and a convenient road? There is no use from the resistor R_2. The voltmeter is ideal. That means theoretically its resistance is very large (infinite). If a finite value is added to the infinity, then it is also an infinity.

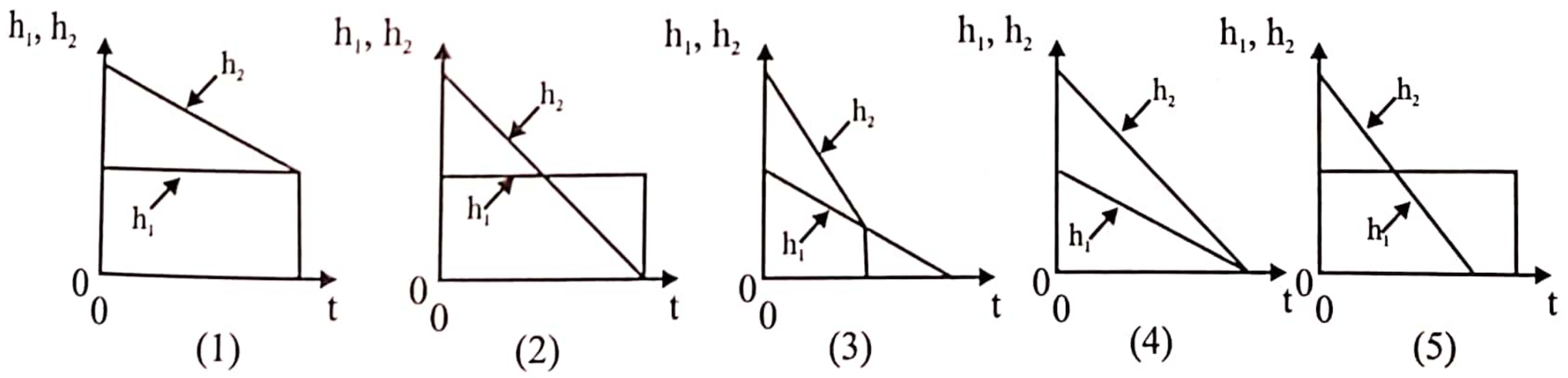
As $R_3 = 0$, there is no voltage difference between the ends of the voltmeter. Its reading is zero.

When $R_3 = \infty$ what is meant is the breaking of the connection. Normally people who tries to go to infinity breaks the relationships. Now R_3 does not have anything. The current is flown across R_1 and R_4. Then do you need to write equations to find the voltage difference across R_1? There is E across $R_1 + R_4$ (as the internal resistance is zero). Therefore, is not there across R_1? You can solve them by just finding the ratios. Do not try to apply $\left(\frac{R_1}{R_1+R_4}\, E\right)$

Kirchhoff's laws. You can effortlessly decide that as the ends of the voltmeter gets short circuited, the reading is zero when $R_3 = 0$. Then you can remove (2) and (4). R_2 is not any how connected to the question. If the voltmeter is ideal, then there is no use to draw another resistor in series. It is dangerous to lean on persons who think that they are ideal. There is R_2 in (1) and (5). So, only (3) is left.

51 A thin walled cylindrical vessel is floating in a lake. At time t=0, a small hole is made at the bottom of the vessel and water is allowed to flow into the vessel at a constant rate so that the vessel immerses with a constant velocity. If h_1 is the difference in heights of the water levels inside and outside the vessel and h_2 is the height of the brim above the outside water level at time t, which of the following curves best presents the variation of the heights h_1 and h_2 with time (t) until the vessel is fully immersed?



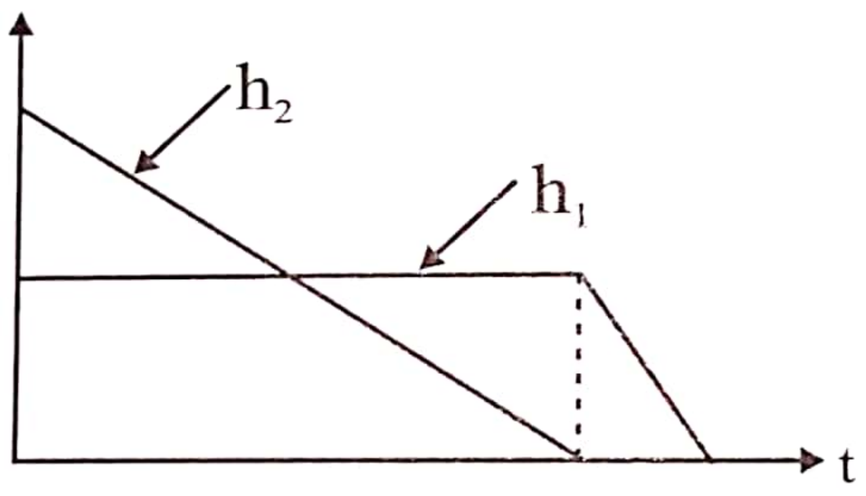


When the container is sunk, even a small child can say that h_2 gradually decreases and finally gets zero. Likewise, if you think a little, then h_1 should be at the same value till water is poured to the container. As shown in the figure, consider a moment where the container is floating. Is not the weight of the container is balanced due to the upthrust from the section of height h_1? Even water is entered, only the weight of the container will not be changed. Even if the container gets drowned, the weight of the container is same. It is very important to the question which mentions the fact that the container is made with thinner walls. If it was not

thinner, then when the container gets drowned the upthrust acting on the container is increased due to the volume of the walls.

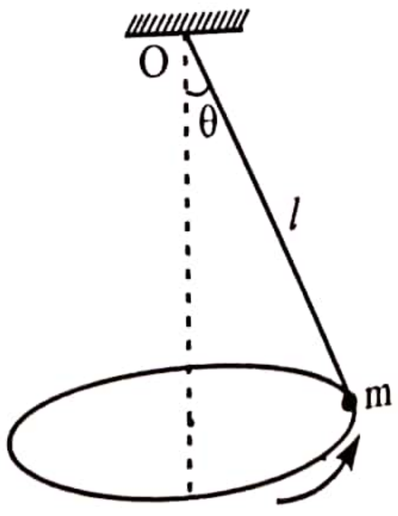
As the wall is thinner, it does not displace water. That means there is no corresponding upthrust for it. Even though water is filled, due to thinner walls, the filled volume of water and the respective displaced volume of water due to this volume are equal to each other. Therefore, what is left is the displaced water volume from the container with a respective height of h_1. The related upthrust is equal to the weight of the container. As it has been given that the container is sinking with a uniform velocity, there is no resultant force acting on the container. That means the weight that acts downwards always have to be equal with the upwards thrust in magnitude. The weight of water that goes into the container is equal to the upthrust from the water outside the container which is equivalent to this volume. Therefore, the net forces acting on the container are only its weight and the balanced upthrust (related to height of h_1). As the resultant force on the container should be zero, h_1 should be constant until the container sinks.

When the container is sunk to its mouth ($h_2 = 0$), water will flow into the container. You can neglect the time taken to fill the container as negligibly small due to a lake. It is true that a small time is taken to fill the container. Some children have taken (5) by considering this fact. Even in (5) there is a confusion when marking the relevant variations. For the same line h_1 and h_2 has been used. Without considering that issue, you can consider the gradually reducing line as h_2 and the other as h_1 according to other choices. But this choice is not correct (even the time delay was considered). If we consider that a small time is taken by h_1 to reach zero, then the correct variation is the following graph.



The height h_1 is getting reduced at the moment when h_2 is zero. In the 5th choice of the paper, h_2 was zero and h_1 was drawn as a constantfor some more time. This cannot happen. If it was drawn like this, then the better choice would have been that one. But as it is not seen, there is no other choice to select than (2). As mentioned previously, getting to know about gradual reduction of h_2 and reaching it to zero is a question of year 5 scholarship exam. According to that, (1) and (3) can be removed. If you understand that h_1 is constant, then (4) is removed. What is remained are choices of (2) and (5).

52 A small object of mass m is suspended by a string of length l, and is allowed to move in a horizontal circular path about the vertical axis passing through O, as shown in figure, If the air resistance can be neglected, the speed of the object will be given by



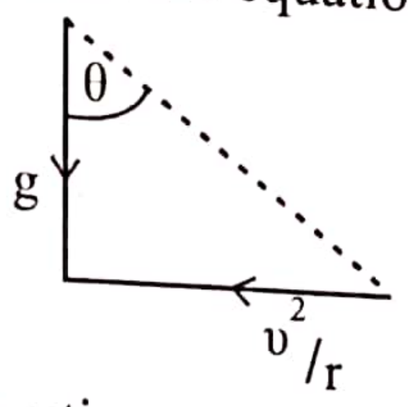
(1) $\sqrt{lg\sin\theta\tan\theta}$ (2) $\sqrt{lg\sin\theta\cos\theta}$ (3) $\sqrt{lg\tan\theta}$

(4) $\sqrt{lg\sin\theta}$ (5) $\sqrt{lg\cos\theta}$

It is a familiar question. You will be tempted to write the known equations.

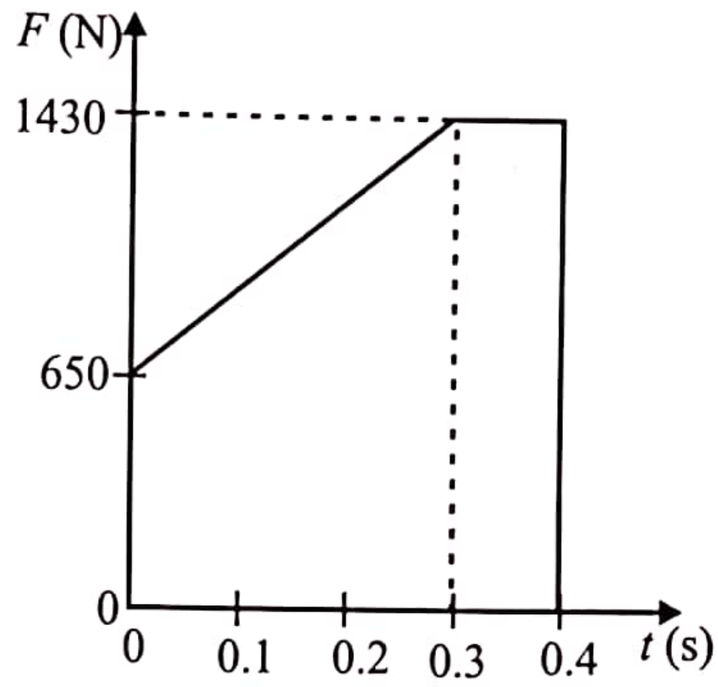
$T\sin\theta=(mv^2)/r$ ..... (1) $T\cos\theta=mg$..... (2)

If 1 is divided by 2 you will get the familiar equation $\tan\theta=v^2/rg$



Even without writing the two equations, we can get this directly. The direction of g is downwards ↓. v^2/r is towards ← . Therefore, is not $\tan\theta=v^2/rg$? $r=l\sin\theta$ and the correct answer is (1).

53 Figure shows the variation of the force (F) exerted by the floor on the feet with time (t) when a person jumps vertically upwards. The force (F) increases from a value which is equal to the person's normal weight of 650 N to 1430 N in 0.3 s, stays constant for 0.1 s, and then drops to zero as the feet lose contact with the floor. At what speed did the person leave the floor?

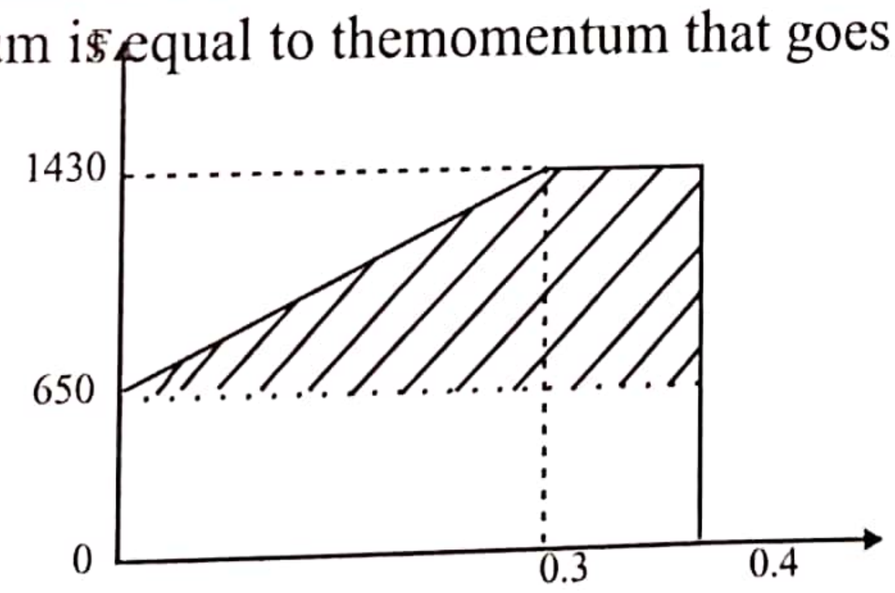


(1) 1 m s^{-1} (2) 1.5 m s^{-1} (3) 2 m s^{-1}
(4) 3 m s^{-1} (5) 10 m s^{-1}

This is a question that you can get wrong. The principle of this question has been asked many times. The area of F-t curve gives the change of momentum. By taking the whole area into the calculation can get you into wrong path.

If a person wants to jump up, then he should get a force more than the force from the weight. This should be achieved by pressing the floor from the muscles of the legs. There is already the normal weight of 650 N. So, for the change of momentum, you need to take the upward resultant force.

Therefore, the marked area is the area that should be calculated. The upward resultant force is given by a force more than 650 N. The area is a trapezium in shape. As it is started from rest, the change of momentum is equal to themomentum that goes upwards.



$$\frac{(0.4+0.1)}{2}\times 780 = 65\,v$$

$0.4 + 0.1 = 0.5$ (0.5 is a half. For 780, there are 12 of 65)

$$v=\frac{12}{4}=3$$

The upward force that this person can get by pulling the floor is 1430 N. At that instance, he can jump up. But he holds with this force for 0.1 s to increase the upward speed. When the active time of a resultant force is increased, the obtained momentum change also gets increased.

54 A source of sound (S), moving with velocity V_S, emits a sound wave of frequency f_0. An observer (O) moving with velocity V_0, as shown in the figure, determines the frequency of the sound as f'. Which of the following statements is true?

(1) If $V_S = 60\ m\ s^{-1}$ and $V_0 = 20\ m\ s^{-1}$ then $f' > f_0$

(2) If $V_S = 20\ m\ s^{-1}$ and $V_0 = 60\ m\ s^{-1}$ then $f' > f_0$

(3) If $V_S = -20\ m\ s^{-1}$ and $V_0 = -60\ m\ s^{-1}$ then $f' > f_0$

(4) If $V_S = -60\ m\ s^{-1}$ and $V_0 = -20\ m\ s^{-1}$ then $f' > f_0$

(5) If $V_S = 60\ m\ s^{-1}$ and $V_0 = -20\ m\ s^{-1}$ then $f' > f_0$

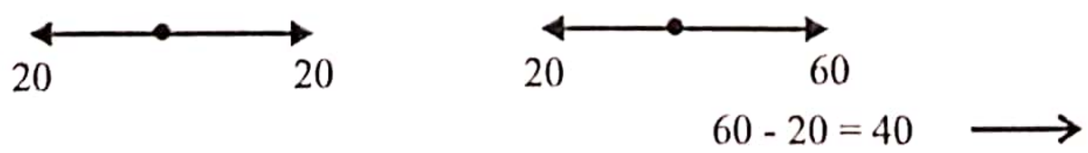
03 Doppler Effect

This is a question that got scolded. It got scolded due to the question. Even some teachers insulted by saying that, out of the syllabus things were given. It is true that the source and the observer both move here. But in the question, the observer's f' question is not being asked. The question only asks whether f' is lesser or greater than fo. You do not have to do calculations to decide that. May be 99% of children might have found the answer for this 54th question by applying equations step by step to check whether f' is lesser or greater than f_o.

All you need to check is, either the source is moving away relative to the observer or coming towards relative to the observer. If the source is moving away relative to the observer, then $f' < f_o$. If it is getting closer, then $f' > f_o$. So, is this hard to notice?

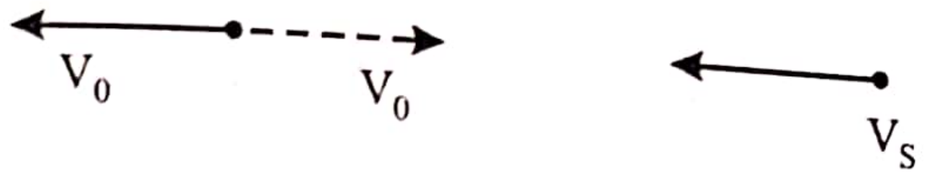
When the observer and the source go to the right as shown and if the velocity of the observer is smaller than the velocity of the source (1st choice), then the source is still moving away from the observer. This is general knowledge. That means $f' < f_o$. So, (1) is wrong. If this cannot be decided by normal intelligence, then the students can think of the method that is mentioned below.

To think relative to the observer, the observer should be at rest. You need to be good before criticizing others. To keep the observer at rest, then 20 should be applied to the left. What ever you are doing should be done to the source also.



Actually, such things are not needed to be done. You can solve everything by the logic. In (2). Both velocities are to the right. But the observer's velocity is greater than the source. That means the observer is moving towards the source. So, $f' > f_0$. It is also wrong. If (1) is wrong, then (2) should also be wrong. In (2), the velocities of (1) are swapped. Therefore, as in (1),

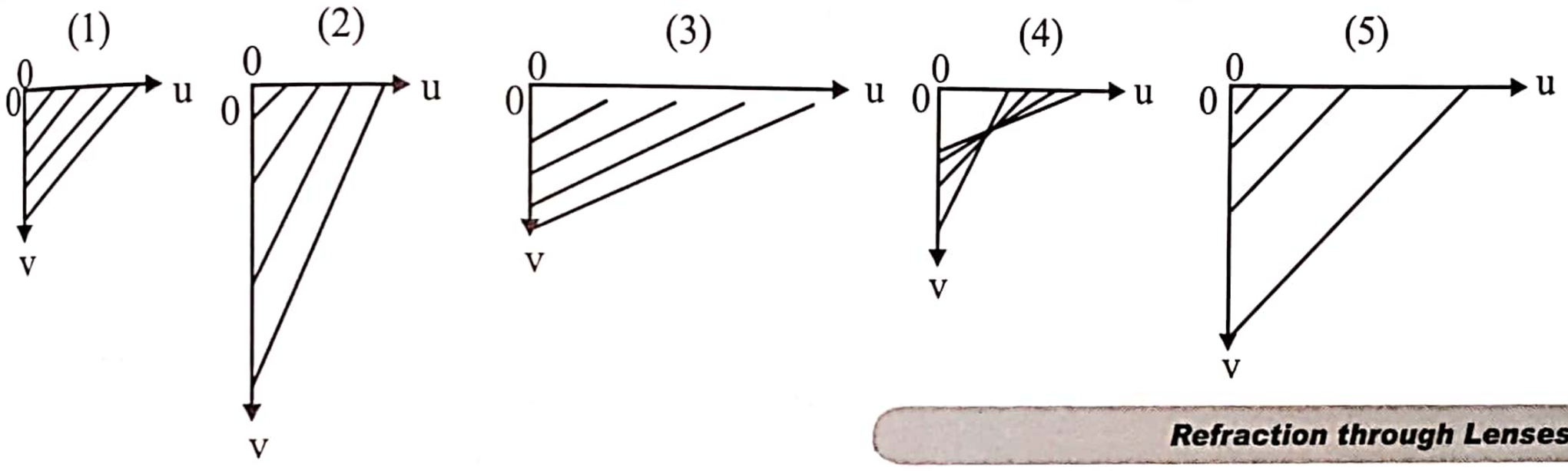
if $f' > f_0$ was kept unchanged, then (2) should be correct. In (3) both velocities are to the other side.



If taken to the other side, you can omit neglect sign. As $V_o > V_s$, the source is moving away relative to the observer. That means $f' < f_o$. (3) is wrong. In (4), $V_o > V_s$. That means the source is getting closer.So, $f' > f_o$. It is correct. Now you do not need to look at (5). If you want, just find out.

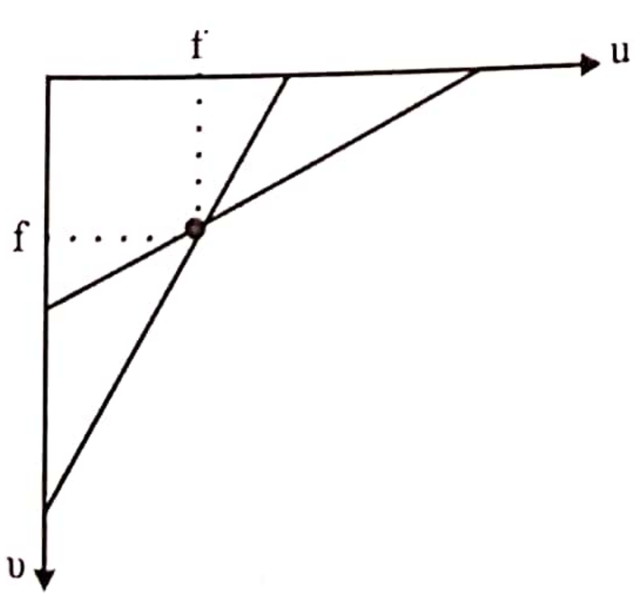
Really if (1) is wrong then (4) should be correct. Think about it. If that was seen, all you have to do is decide that (1) is wrong. It is true that you do not think like this. But such questions are not changed in a bigger way. All of the choices have the two numbers of 20 and 60 only. Therefore, is not the logic easy?

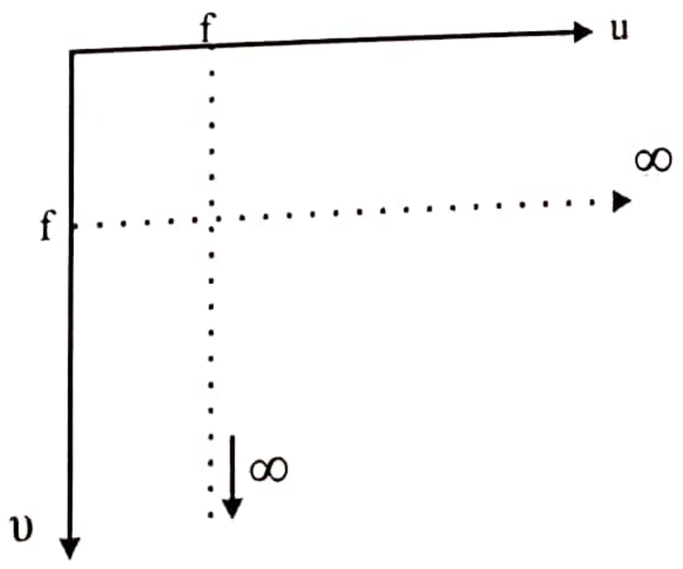
55 For real images produced by a convex lens, value of object distance (u) and image distance (v) are marked on the u-axis respectively. Which of the following best represents the correct pattern when the corresponding u and v points are connected by straight lines?



For real images in convex lenses, when the values of u are increased, numerically the values of v should be decreased. When the object is nearing, the real image is going further from the other side. When the object is moving away from the lens, the real image is getting closer to the lens from the other side. If you look at this fact, (4) is the only correct pattern. When u is increased, v is increased more or less in the other choices. Drawing these patterns is an easy method of finding the focal length of a lens.

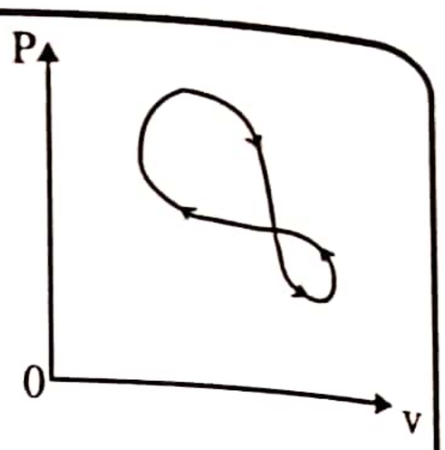
The lines are being cut at one place is shown only in (4). These lines are not familiar u-v graphs. If v is drawn in front of u, then you will get a curve. What has been done here is that mark u values in u axis and the corresponding v values in v axis. As mentioned before, for a small u value, a big v value and for a big u value, a small v value were represented in only (4).





We know that if u = f then v⟶ ∞. Therefore, the corresponding point of v for u = f cannot be marked. The corresponding point of v is going far away towards the axis of v. Even when u is in infinity, v = f.

56 An ideal gas undergoes a cyclic process as shown in the figure. Consider the following statements.



(A) Over a complete cycle a net work is done by the gas.

(B) Over a complete cycle a net heat goes out of the gas.

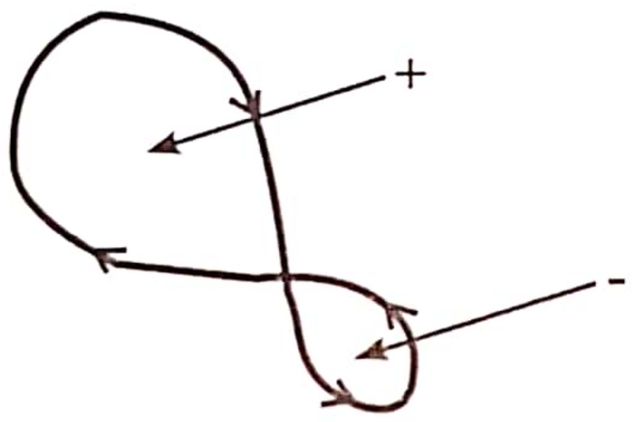
(C) The temperature of the gas remains unchanged throughout the cycle.

Of the above statements,

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

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

Such questions should be familiar to you by now. If the arrow is in clockwise direction, then the work is positive. That means work is done by the gas. If the arrow is in anti-clockwise direction, then the work is negative. That means work is done on the gas.

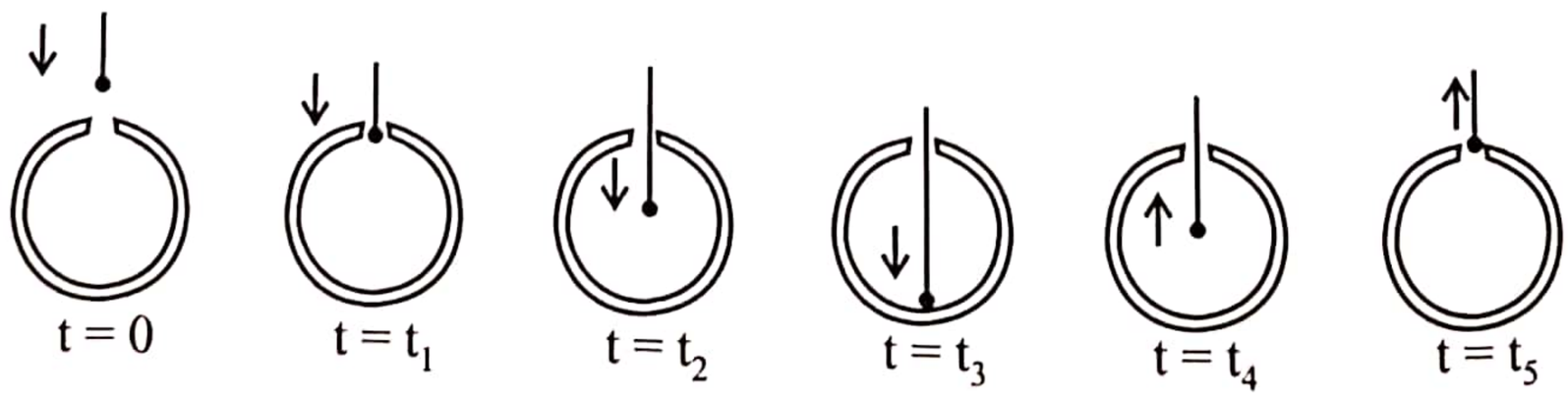


At a glance you can see that clockwise direction is bigger than the anti-clockwise direction. Therefore, (A) is true. For the cyclic process, ΔW is positive. That means net work is done by the gas. If ΔW gets negative, then the net work is done on the gas.

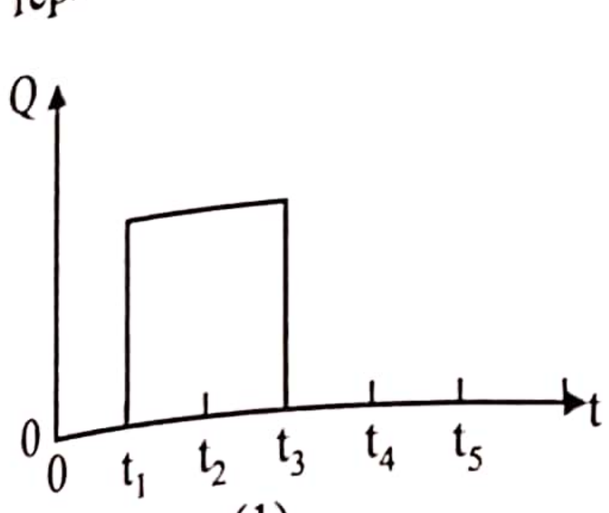
For any cyclic process of an ideal gas, $\Delta U = 0$. It has come back to the starting point. Therefore, according to $\Delta U = \Delta Q - \Delta W$, $\Delta Q = \Delta W$. That means if ΔW is positive, then ΔQ is also positive. It indicates that a net heat is supplied to the gas. Ina cyclic process, this is always true. Without giving a net of something, you cannot get the work done. By giving a net heat, it does a net work in a simple manner. So, (B) is wrong.

As soon as you see, you can decide that (C) is a big fat lie. Can you keep T constant when P and V are varying? Even if you do not know (A) and (B) statements, you should know that (C) is false. Then what is remained will be (1), (2) and (3). If you are making the answer as a blind shot, then the probability of being correct increases by 13%.

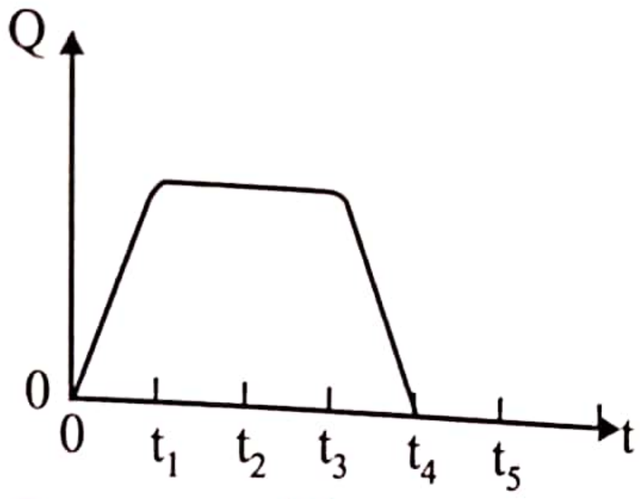
57 A small metal ball, suspended by a insulating thread and carrying a charge q is inserted gradually into an uncharged, conducting hollow sphere through a small hole until it touches the bottom and then it is removed in the same manner. Positions of the metal ball at different times t=0, t_1, t_2, t_3, t_4 and t_5 are shown in the figure.



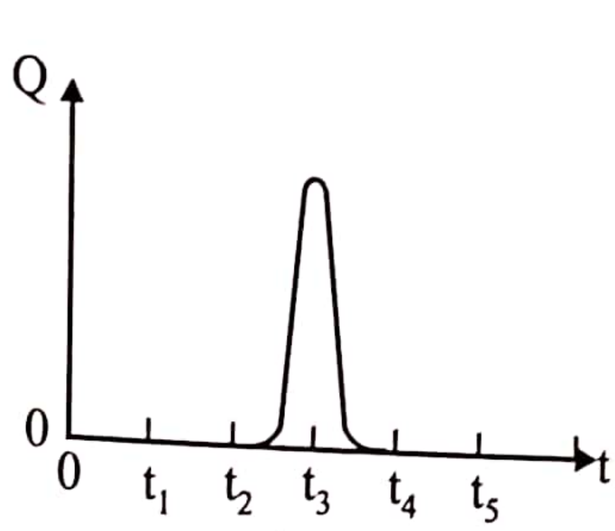
Variation of the charge (Q) on the outer surface of the hollow sphere with time (t) is best represented by



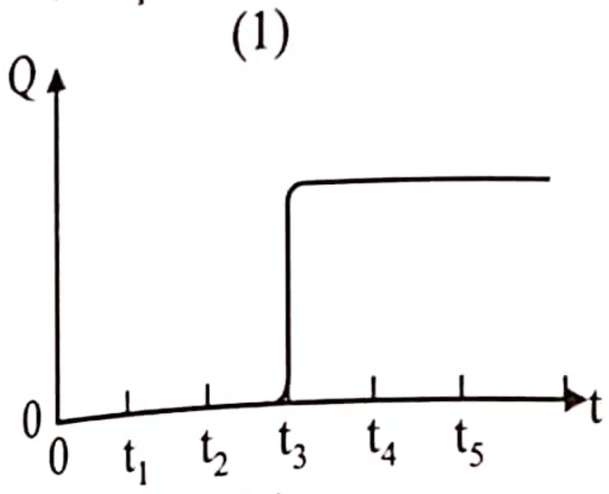
(1)



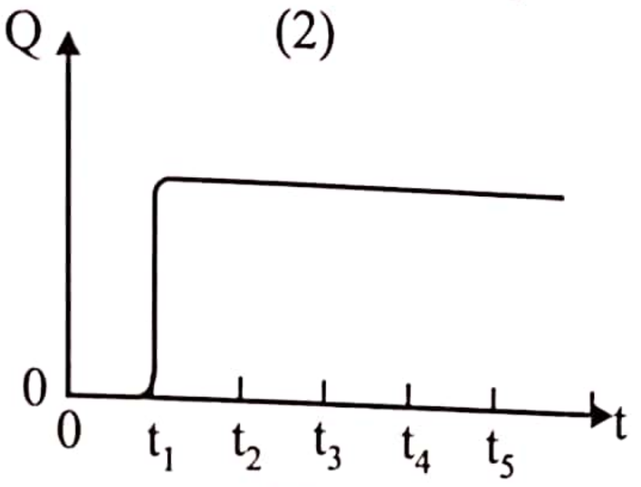
(2)



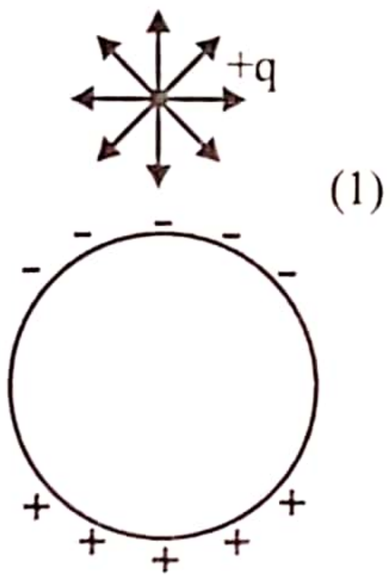
(3)



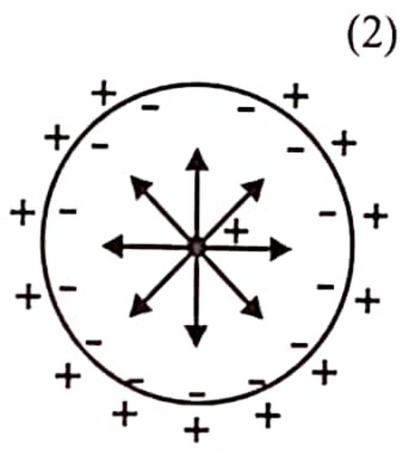
(4)



(5)



(1)

(2)


1)When the charge is outside

2) When the charge is inside

This is simple theory that you have learnt.

The charge distribution of the charged sphere when the charged ball is outside and inside of the sphere are shown by figure (1) and (2) respectively.

The charge of the ball is taken as positive. When there is a positive charge outside, normally negative charges are induced near the positive charges and positive charges are induced far from the sphere. Therefore, the net charge of the sphere is zero. Negative and positive signs are being cancelled off. But it is wrong to take the induced charges of the sphere as +q and -q. All of the force lines emanating from the +q charged ballis not covered by the sphere. Some force lines are going away into different directions. Therefore, the consideration of the induced charge of the sphere as +q and -q is incorrect. But can take as -q' and +q' (q'<q).

However, there is no net induced charge when the ball is outside.

When the ball is inside the sphere, there will be an induced negative charge in the inner surface and an induced positive charge on the outside. Here as a snake who protects a gem, the sphere is covering the ball. As the hole of the sphere is small, it does not allow any force line to go outside. So, now the induced charge in the inner surface can be taken as -q and the induced charge in the outer surface can be taken as +q.

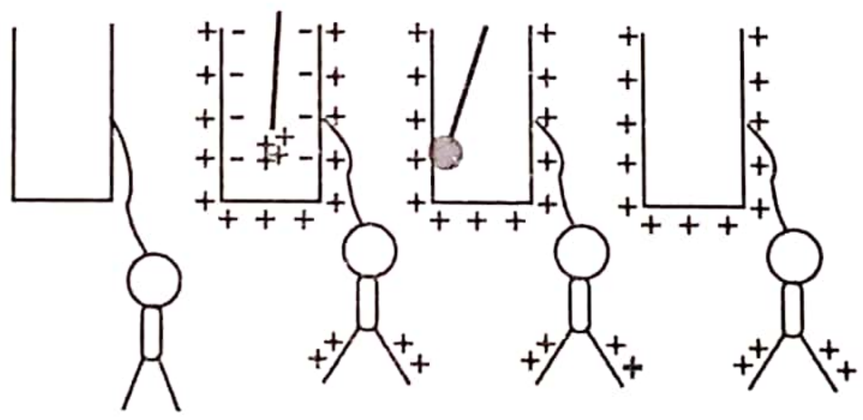
This is not dependent on the location of the ball inside the sphere. If it is covered, then who cares about the location of the thing that is inside!

The induced charge density can be changed depending on the location of the ball inside the sphere. What it means is that, if the ball is closer to a certain place in the inner surface, then number of induced charges in a unit area on that area is higher than a far away place. But where ever the ball that is inside the sphere, can the induced total charge be changed? If a water injector to all the directions is completely shut, then the water amount that is received in a particular place at a particular time is more or less is dependent on the place of the injector. But the total amount of water that is injected is not dependent upon the place of the injector. Therefore, when the ball is inside the sphere, the charge of the inner surface is -q where as the charge of the outer surface is +q.

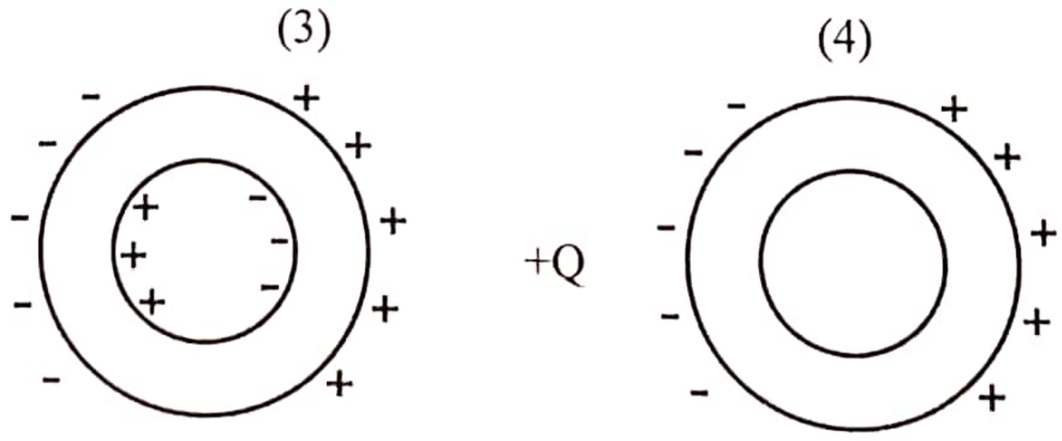
Next, when the sphere is touched by the ball, +q and -q gets cancelled off. There is +q in the ball. The inner surface of the sphere has -q. When +q is added with-q, do not you get zero? When this happens, the charge of the ball gets zero.

It is like +q of what you had was given to the outer surface of the sphere. The ball goes happily after giving the alms.

The question is being asked about the outer surface charge of the sphere. If we simply take it, as long as the ball is outside the sphere, it is zero where one side is negative and the other side is positive. Once it is inside, Q is a constant. It is equal to +q. Therefore, the correct shape is (5). This is equivalent to faraday's ice pail experiment. He took a tall container relative to its cross section which was used to put ice and not a hollow sphere. Such a container was taken to stop the electric force lines going out of it as much as possible. Then the induced charge is nearly equal to the person who is being charged. Some try to cover the person that he/she loves may be to stop the induced charges going out to the other people. The ice pail experiment of Faraday is shown below.

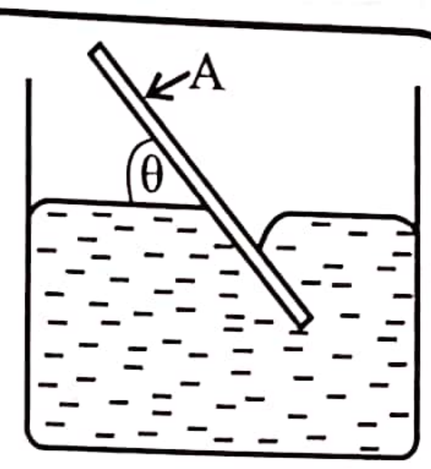


I feel it is valuable to mention one more thing. How can the charges be induced if a charge is kept outside a hollow conductor with thick walls? Look at the following two figures.



Out of these what is correct? Is it (3) or (4)? The correct one is (4). Negative charges (electrons) should be near to +Q as much as possible whereas the induced positive charges should be far away from +Q as much as possible. As it is a conductor, there is no barrier to separate as much as possible as well.

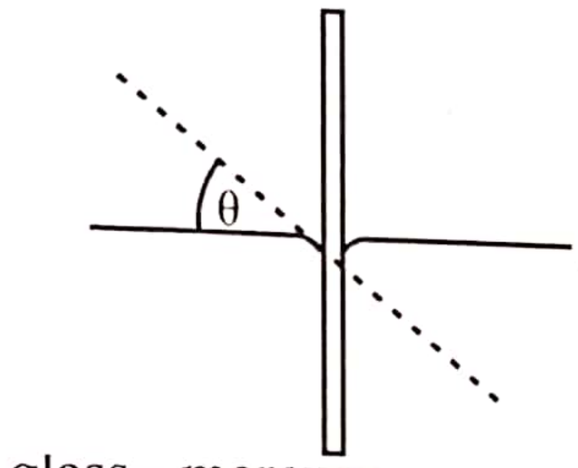
58 Figure shows a glass plate A dipped in a liquid. If the glass plate makes an angle θ with the horizontal, the angle of contact of the liquid with glass is



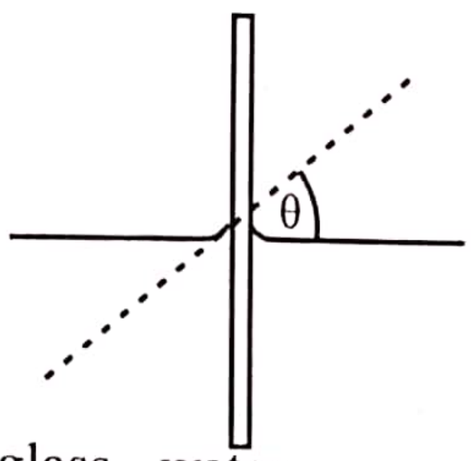
(1) 0 (2) θ (3) 90°- θ

(4) 180°- θ (5) 90°+ θ

This is a simple method of finding the angle of contact measured through the liquid with the solid medium. A vertical glass plate immersed both in mercury and water is shown below. You really know the fact of the shape of the meniscus of glass-mercury and glass-water interface.



glass - mercury

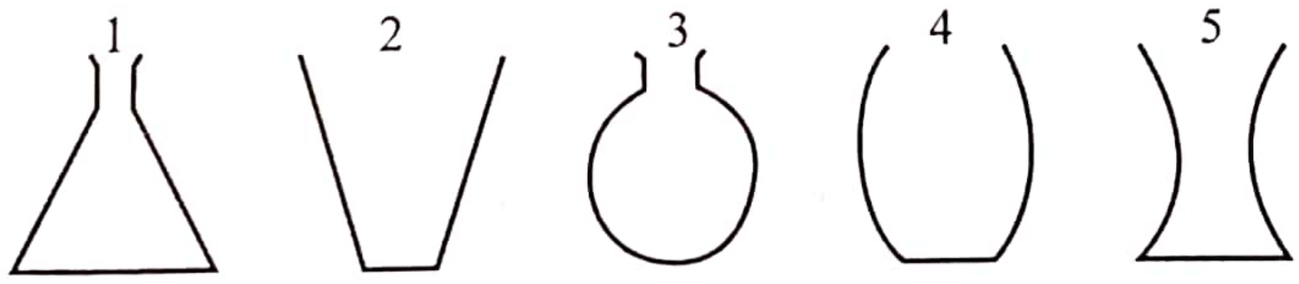


glass - water

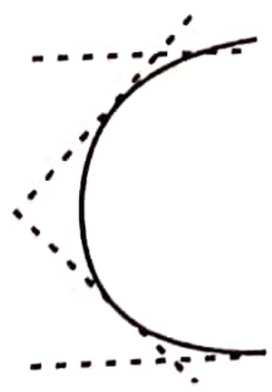
If the glass plate is tilted to the shown direction from dashed line in both instances, then can the relevant meniscus be seen horizontally from that side? This is the easiest method of finding contact angles. In both instances (the tilted glass plate to the left and right) if the marked angle is θ, then for glass-mercury interface 180-θ. For glass-water it is θ. At a glance, the figure has shown a liquid like mercury. As the contact angle of mercury is an obtuse angle, the possible answers can be only (4) and (5). Even this is the 58th question, no time is consumed for any calculation or logic.

Many children ask how much time they should spend on one question. There is no stable answer. According to the nature of the question, the time can differ from a range of seconds to minutes.

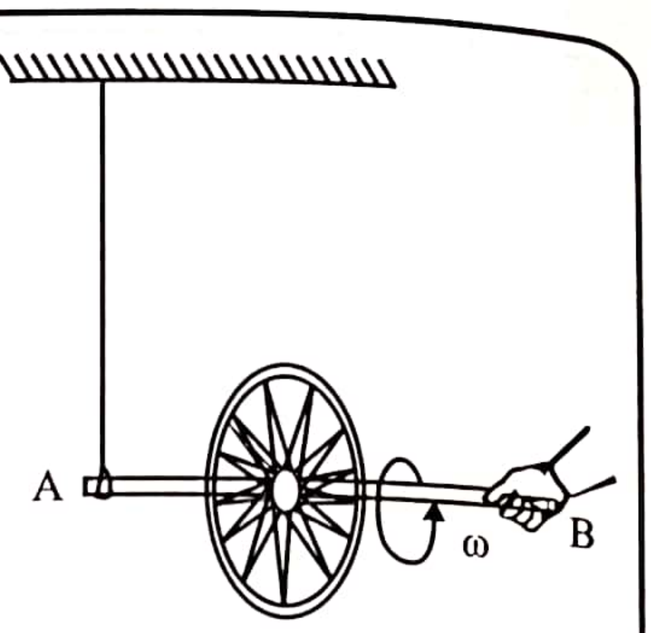
When I see this question, I remember the 50th question of paper 1993. If any liquid is filled to a particular height, then out of the given containers, which container below shows a liquid surface that is flat till the wall of the container?



Here it is clear that the correct container is (3). The logic of the question of paper 2008 and this question is same. The glass plate can be tilted to a correct direction and you can get the angles from acute to obtuse angles. Only (3) has the surface that can be tilted to both sides and can get all of the angles. (1) and (2) are just out. As the bottom is flat is (4) and (5), some angles cannot be obtained.



59 The figure shows a bicycle wheel, which is rotating with large angular velocity ω about the axle AB, hung from a string connected to the and A and holding from end B. If it is released from end B,



(1) the end B will fall down and the axle AB becomes vertical.

(2) the direction of AB remains unchanged.

(3) the axle will rotate about the vertical axis through A, while AB remains approximately horizontal.

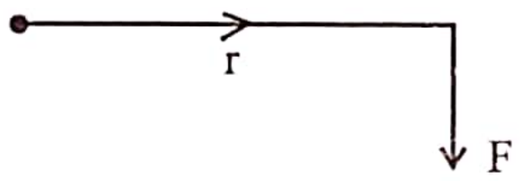
(4) the end B will fall down and the wheel will start to oscillate like a pendulum.

(5) the end B will move upward first and then fall down and will start to oscillate like a pendulum.

This question and the 60th question were controversial questions. Most of the time, children with more than 55 answers correct might have not done these two questions correctly. No doubt that most children picked up (2) as the answer. Except for (2) and (3), it is not difficult to decide that the other given answers cannot be the correct answer.

As the wheel is rotating, there is an angular momentum. The wheel likes to keep it unchanged but that happens when there is no external torque only.

When the wheel is released from B, there will be a moment of a force on the wheel which is not balanced by the weight of the wheel. How to find the direction of the moment of a force is the question for many people. We will check out about it.



When we think of the direction of the moment of a force, most of the time we take as clockwise and anti-clockwise directions. For an example, in the shown figure we take the moment across O due to the force F as clockwise. Most of the time we use symbols also like this. ↻

There is no wrong in it. But clockwise and anti-clockwise are not the scientifical directions. These directions can also be changed due to the way we observe. A clockwise rotation for one person can be an anti-clockwise to another person.

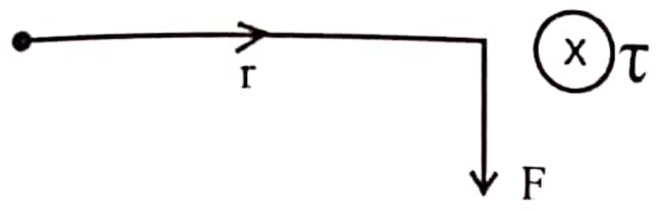
Moment is a vector. It should have a proper direction.

It does not imply a vector direction from ↻

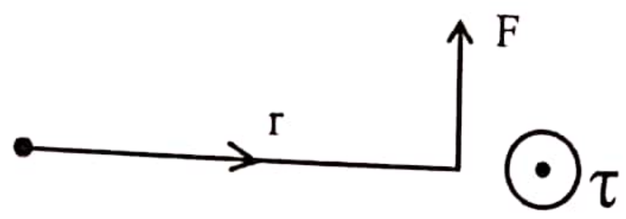
The direction of the moment is perpendicular to the plane made from vector r and vector F like in angular velocity and angular momentum. You can get the direction of the moment from the right-hand rule. If the right thumb is kept perpendicularly to the other fingers and if the fingers are rotated from the vector r to the direction of F (force), then the direction pointed from the thumb gives the direction of the moment.

a) Direction of the moment is inside of the paper

b) Direction of the moment is outside of the paper

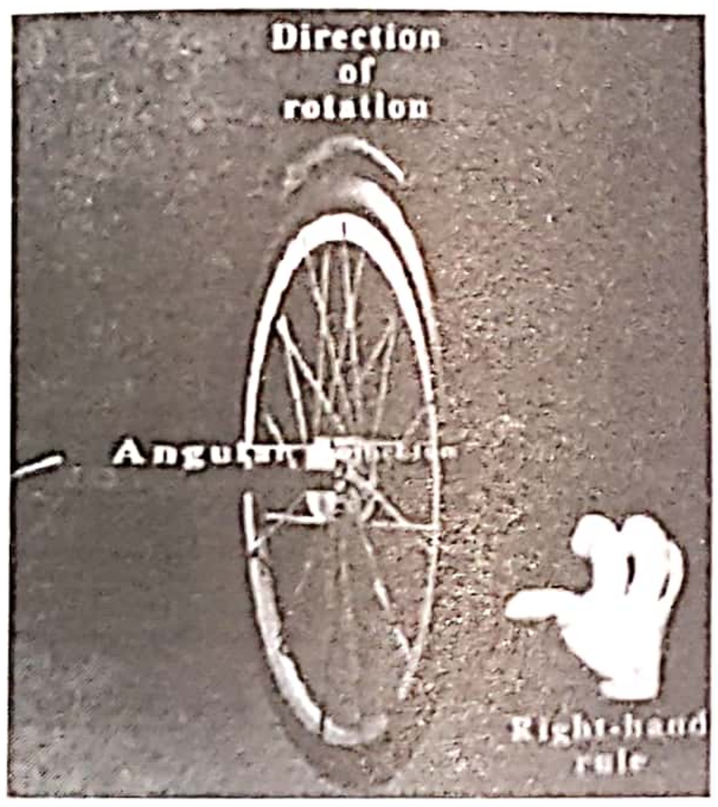


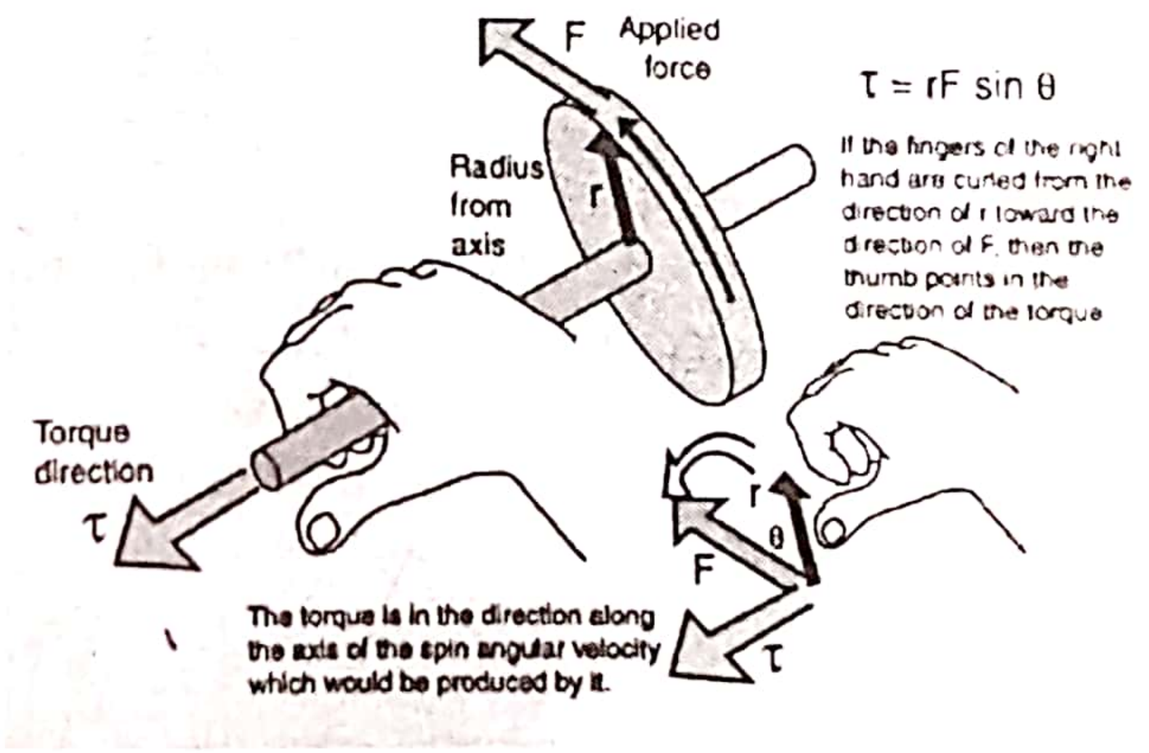
(a)



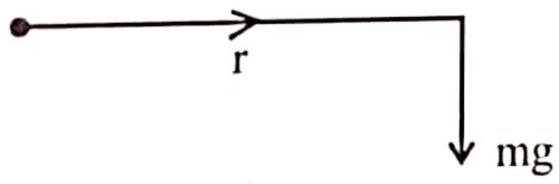
(b)

Directions of inside and outside the paper means certain directions. In such an occasion, we tend to subtract from one another to find the resultant moment due to this reason. By taking the direction of the moment as clockwise and anticlockwise is wrong. Depending on r and F directions, the direction of the moments (τ) of more diagrams are shown in the figures below.



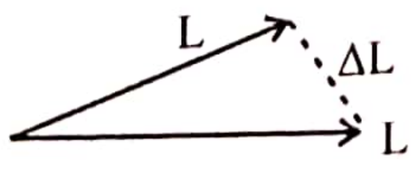


Now let us turn to the question, When the wheel is released, there is a moment around A due to the weight of the wheel. As mentioned above, it is towards the paper.

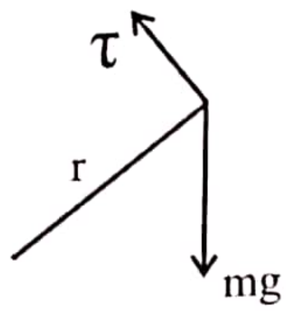


Now if there is a non-zero moment in the wheel, then according to $\tau = \Delta L/\Delta t$, there should be a ΔL. As there is a change of linear momentum to the direction of the resultant force, there should be change of angular momentum to the direction of resultant moment. That means ΔL should be there to the direction of τ. As the direction of τ is towards the paper, ΔL also should be into the paper. How can we create a ΔL towards the paper? The only way is by changing the rotating plane of the wheel. L is also a vector. We cannot get this done by changing the magnitude of L in more or less values. Then ΔL will be directed towards the direction of L or to the opposite direction of it.

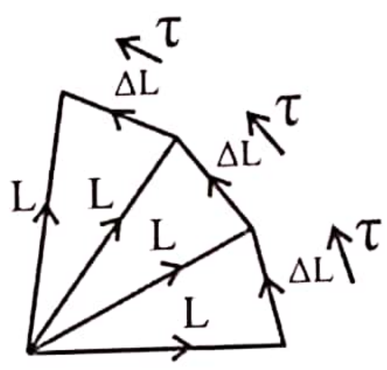
ΔL can be directed towards the paper by changing the direction of L only.



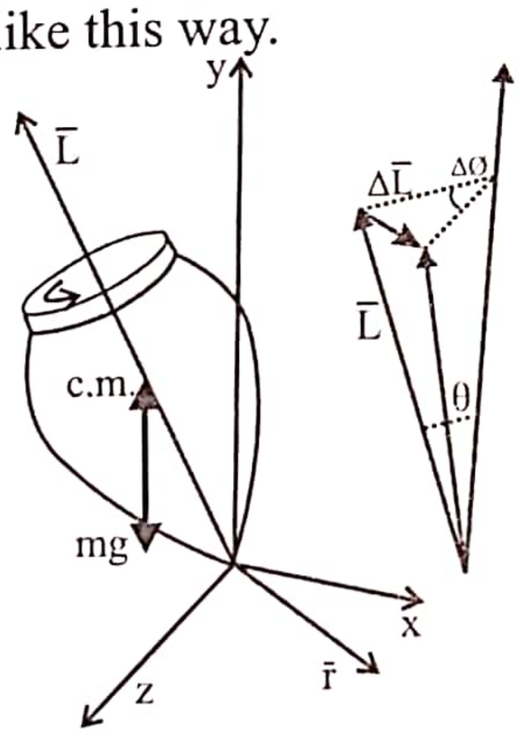
Therefore, while the wheel is rotating, it is revolving around an axis across A. Such a motion is known as precession. Have not you seen such a demonstration in science exhibitions? When the revolving plane is changed in the wheel, the direction of the moment also changes along with it. The direction of the moment should be always perpendicular to the plane of AB and the action line of weight.



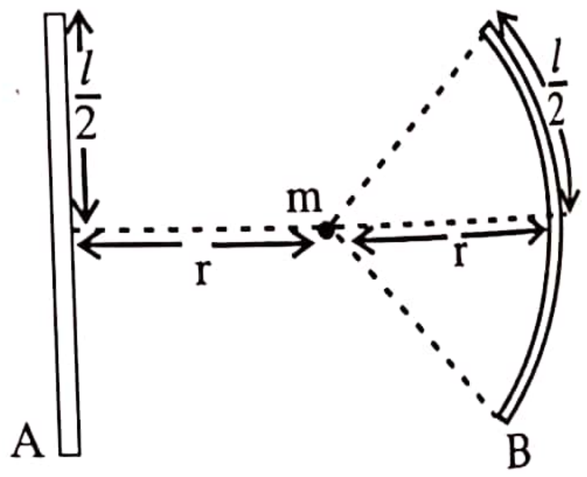
Always ΔL should be placed to the side of τ. If it is viewed from above vertically downwards, this process looks like below.



Shown in the figure is the information related to spinning and precession motion of a spinning top. In a spinning top, it rotates about its axis as well as has a precession around a vertical axis. Its motion can also be studied like this way.



60 A is a uniform metal rod of length l and mass M. The rod B is formed by bending another rod, which is identical to A, to form an arc of a circle of radius r. A point mass m has been placed in between A and B as shown in the figure.



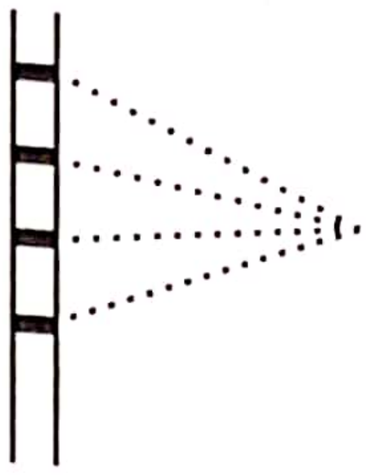
If F_A is the magnitude of the gravitational force on m by A, and

F_B is the magnitude of the gravitational force on m by B, then

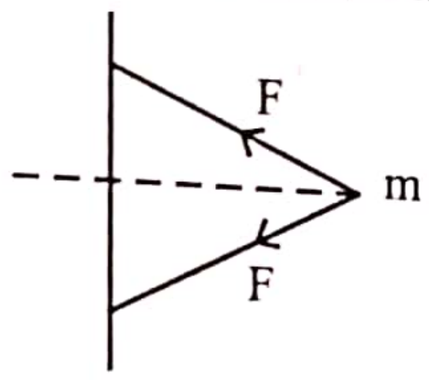
(1) $F_A = F_B = \frac{GMm}{r^2}$ (2) $F_B < F_A = \frac{GMm}{r^2}$ (3) $F_A < F_B = \frac{GMm}{r^2}$

(4) $F_A < F_B < \frac{GMm}{r^2}$ (5) $F_B < F_A < \frac{GMm}{r^2}$

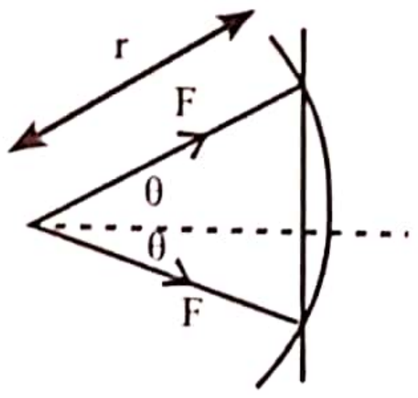
This is also a question that can get wrong. To find the gravitational force with m, it is wrong to take the total weight of the rod its centre of gravity. Centre of gravity is the point where the resultant of the parallel forces acting on the infinite masses (small parts) of an object is directed in a uniform gravitational field. To find the gravitational force between m and the rod, the rod should be broken into small parts and need to take the resultant of the forces in between these infinite masses and m. The equation of $F = Gm_1m_2/r^2$ can be applied to point or infinite masses.



It can be clearly observed that the distance from the mass parts to m gets reduced when it is going far away. You cannot find the magnitude of F_A. You need integration to do that. But you can decide that the magnitude of F_A should be smaller than $F = GMm/r^2$. Because M is not a point weight at r distance as it is distributed across a length of l.



As seen in the figure, there are two symmetric infinite masses at the top and below of the horizontal dashed line. They are equidistant from m. Therefore, the vertical components of F cancel off with each other. What is left are the total of two horizontal components. Now we will apply the solution to this arc also.



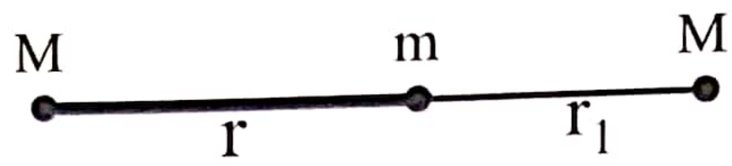
As the previous way, if the arc is divided into small parts, each infinite mass is away at a same distance of r. But that is not equal to $F = GMm/r^2$. As earlier, the vertical components of F cancel off with each other. But when the horizontal components are added, there is a term of $\cos\theta$. $(2F \cos\theta)$

Therefore, if this also considered as a point mass by taking the total mass of the arc put to the middle, then what is obtained should be lesser than$F = GMm/r^2$.

Now we have decided that both F_A and F_B are smaller than $F = GMm/r^2$. Next who is smaller from F_A and F_B? It should be $F_A < F_B$. Why?

Even both rods have the same length, A is kept vertically. Therefore, the infinite masses are further getting far away from m. B is bent towards m. The distance of the infinite masses and m is same. The infinite masses of B are closer to m than of A. Even we need to take the components in each case, it should be $F_A < F_B$as B is always near to m at the same distance and A is getting further away from m. So, the correct answer is (4).

This has to be solved from concepts and logic without any calculation. If you try calculation, then you are trouble. Everyone mentioned that there is no answer for this question. Here is their argument. You will get a figure like this if the total mass of A is put to the middle of A and total mass of B is put to the centre of gravity of the arc.

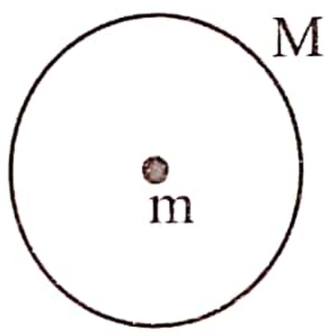


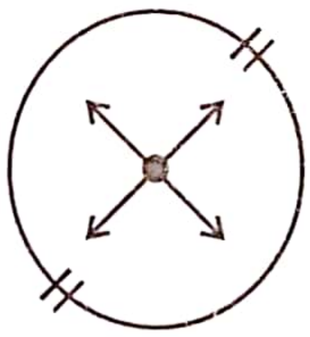
The centre of gravity of the arc is in r_1 distance from m. It is smaller than r. If this is correct, then the answer is $F_B > F_A = F = GMm/r^2$. This answer is not there. This argument is wrong. Another example which shows that this logic is wrong.

A uniform ring with mass M has a point mass m in its centre. How much is the gravitational force between the m and the ring? If the mass distribution of the ring is put to its centre of gravity, m and M are clashing with each other. Then the gravitational force between m and M is infinite. Actually, the gravitational force of m due to M is zero.

If the ring is divided into small parts and consider the forces on m by each of them, then it can be clearly seen that the resultant is zero. This is the 16th question of paper 1994.

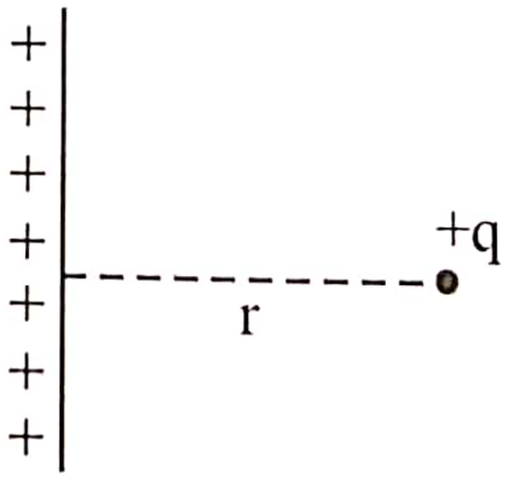
Not only gravitational force, can you take the charge of a wire to its middle when finding the electric force between a charged wire and a point q charge?





If the total charge of the wire is +Q, then does the electric force on +q is equal to $\frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$?

It is not. The wire should be broken into small infinite charges and follow the same procedure like we did to find the gravitational force.



As mentioned before, the centre of gravity is the point where the resultant of the forces of infinite masses of an object is acted upon in an external gravitational field. The gravitational field is considered as uniform. Actually, if a long rod is kept vertically, then its gravitational field intensity reduces when it goes up. So, taking the centre of the gravity of the vertical rod

to its middle is not exactly correct. But the reduction of the gravitational field intensity is minimal and hence we do not consider this effect.

What I am trying to say is this. When you need to find the gravitational force of two objects, it is wrong to consider them as point masses by concentrating the total mass into their centres of gravity. This can be done at instances with circular symmetry (eg: two spheres) due to the symmetry.

By taking everything to the middle of the rod is fair when relating to the uniform gravitational field (earth field). But the gravitational field on M from m is not uniform. If we get everything equally and uniformly, then we will work with equanimity. But if it not like that, then it is normal that we tend to bend towards the side that we get more.