SCIENCE

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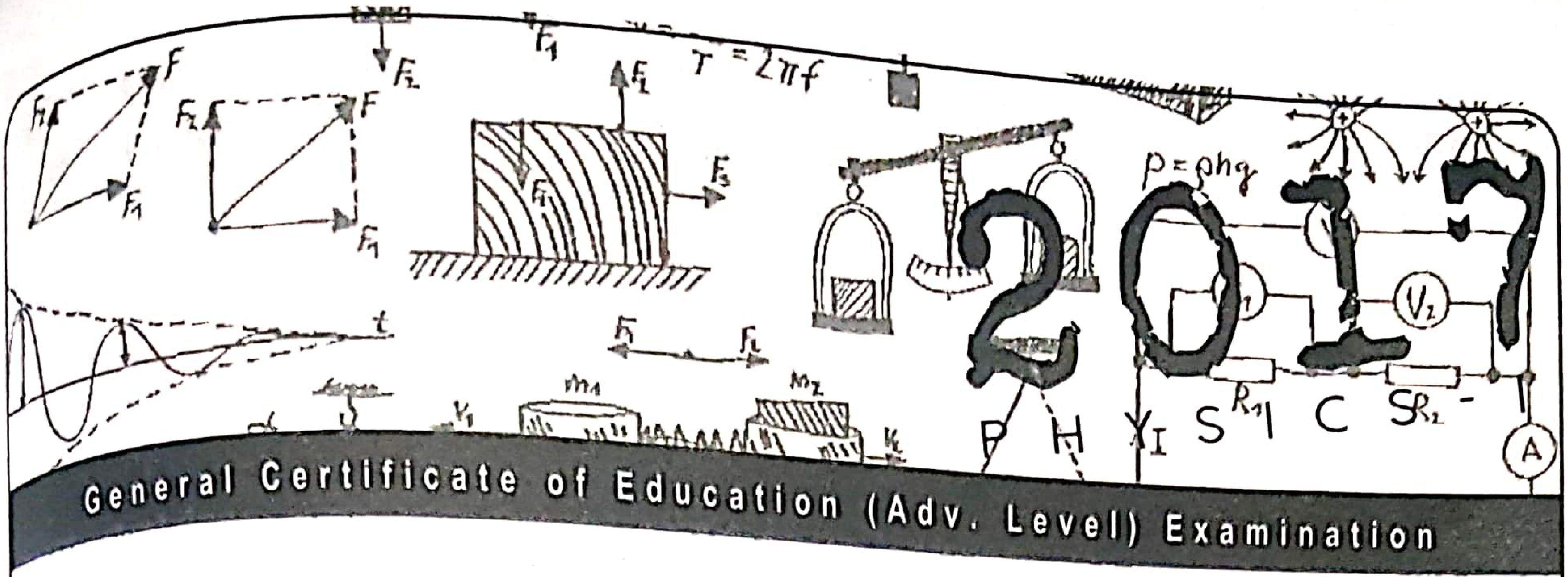
SDISCUSSIONGROUP

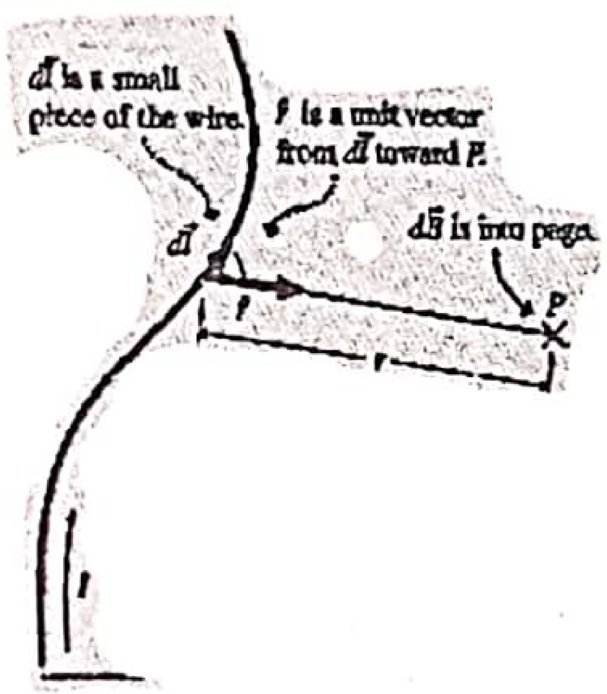


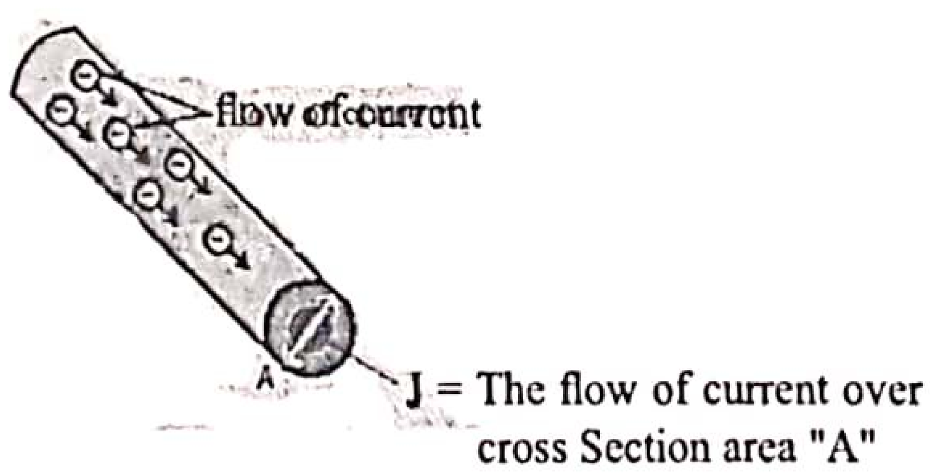
01. Unit of current density is

(1) A m^2 (2) A m^2 (3) A m-3 (4) A m^{-1} (5) A m

Unit and Dimentions **01**

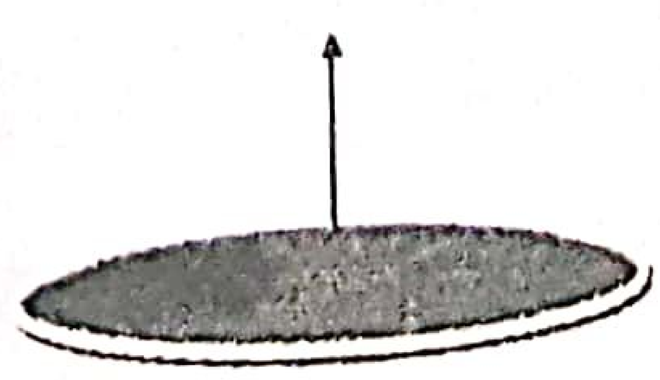
Is current (I) a vector quantity? Or a scalar quantity? Current has a magnitude and a direction but it is considered as a scalar quantity. Current element is a vector quantity. A current element is (iΔl). (Δl) is a part of a small length. In Bio-Savart law, you can find is a vector.



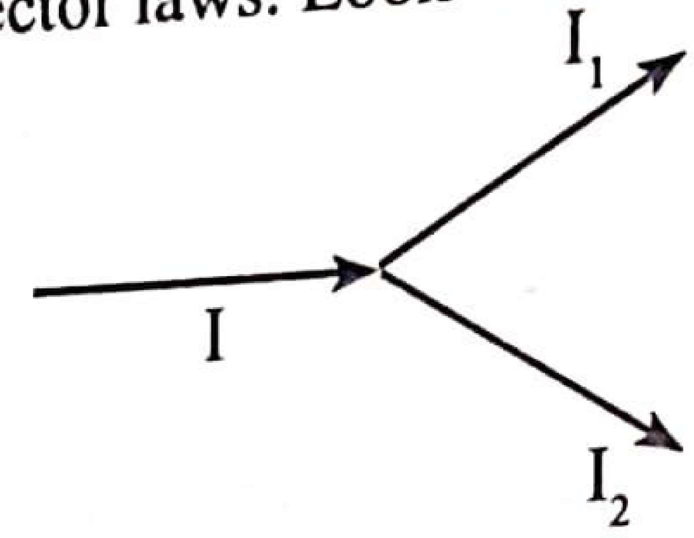


It is an infinite length of the wire that is measured to the current direction. As dl is a vector, idl is a vector. The equation that the drift velocity is there $I = neAv_d$ can be written as $J = I/A = nev_d$. That means the unit of the current density Am^{-2}. The current density is the current across a unit area. For an example, if a current I is flown across an area of A, then current density J is given by I/A.

The terms n and e in the above equation are scalars but v_d is a vector. So, there can be an argument that current should be a vector. But A should be considered as a vector. Even if you think area as a scalar, actually the area is a vector. The vector direction of A is the direction that is drawn perpendicular to the area. (There is a vector dot product between V_d and A. The dot product of two vectors is a scalar. Understanding of this concept is irrelevant to Bio students.)



When two currents are added, it does not obey the law of parallelogram. If it is a vector, then it should obey the law of parallelogram. The currents are being added or subtracted algebraically not by considering as vectors. The currents do not obey vector laws. Look at the following example.



If the currents obey vector laws (like forces) then you cannot write $I = I_1 + I_2$. Therefore, you can understand that considering currents as vectors is a joke.

02. o, b, c and d are physical quantities having different dimensions, and k is a dimensionless constant. Consider the following relationships.

(A) $H = b$ (B) $d = ac$ (C) $a = kb$

Of the above relationships

(1) only B is dimensionally valid.

(2) only C is dimensionally valid.

(3) only A and B are dimensionally valid.

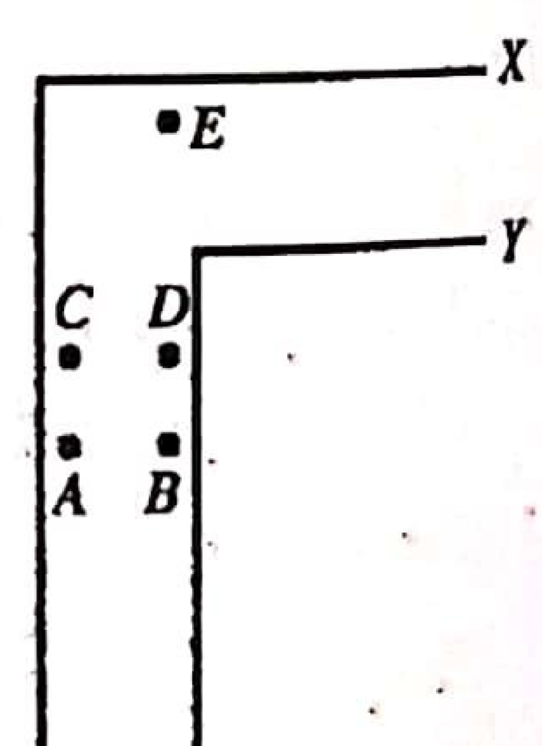
(4) only A and C are dimensionally valid.

(5) all A, B and C are dimensionally valid.

Unit and Dimention

Equations like $4/3\ \pi r^3 = V$ and $v = r\omega$ are known by yourself. But equations such as $r = 4/3\pi V$, will not be found in any day. A distance can be turned into a volume only in the dreams. There are different dimensions for r, V, v and ω units. When such a unit with dimensions is multiplied or divided by a dimensionless unit, the dimension of it cannot be changed in any day. Therefore, if the relation $r = 4/3\pi V$ is valid, then the dimensions of V and r should be equal.

03. A uniform thin wire is bent into a wire-frame with its two erids k and P kept opened as shown in the figure. The centre of gravity ct the wire- frame is most likely to be at the point,

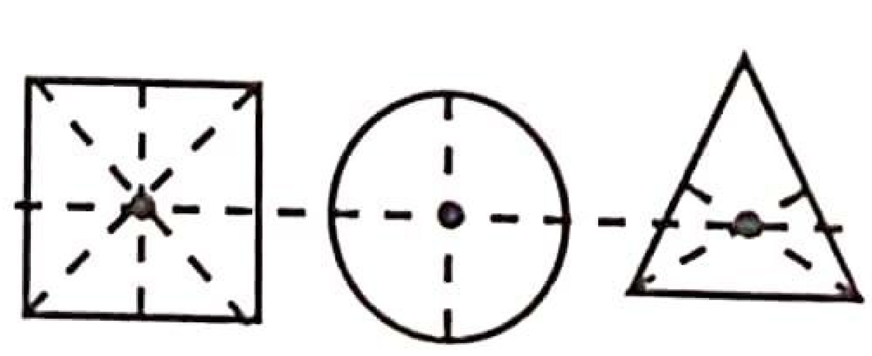


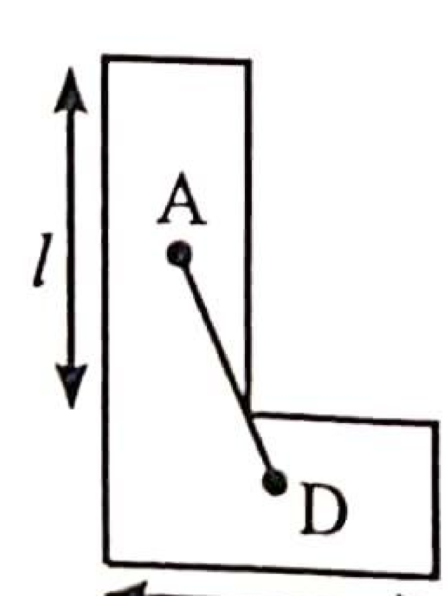
(1) A (2) B (3) C

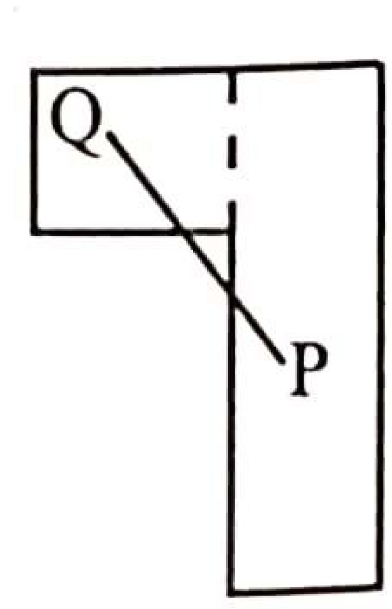
(4) D (5) E

We know the places of centre of gravity in different shapes.

Centre of Gravity







Let us consider a plane plate with a shape of L. The middle of the vertical section is A. The centre of the horizontal section is D. Therefore, these parts with equal masses should have the common centre of gravity in the middle of the line which connects the points of A and D. (3rd question of paper 2012)

Now consider a hard string that is kept according to the L shape as shown. The easiest method to find the centre of gravity of this arrangement is by completing the vertical parts into a rectangle (as shown in the dashed line). Look at the figure. When it is considered as a complete rectangle, its centre of gravity is located at the middle of the rectangle, which is at point P. There are two strings of equal length that is left out at the left-hand side. The centre of gravity of those two strings are located in the middle at Q. Now connect those two points. The combined centre of gravity is located at a point that is near to the line. The centre of gravity of the string arrangement will not locate at point which is not near to the line that connect the points.

There is no need to find the centre of gravity of each part of the string and find the combined centre of gravity. The time will be wasted from it. The centre of gravity cannot be placed exactly at the drawn line. Why? In the string arrangement, there is no part that we added at all (shown from the dashed line). Therefore, the combined centre of gravity should be away from the line and it will be biased towards the right-hand side. Actually, one leg is shorter than the other. If the right leg is shorter than the left leg, then the centre of gravity will be biased towards left side from the drawn line.

Once you consider piece by piece, it will consume some time. For completion, there is no wrong in inserting a small piece. I am not complete. Even I have found the most possible point where the centre of gravity can lie. Therefore, it is enough to get an approximation. Why do you need to work hard?

04. A tube with one end closed resonates at its fundamental frequency with a tuning fork of frequency / When the closed end is opened, the same length of the tube will resonate at its fundamental frequency with a tuning fork of frequency approximately equal to

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

In a tube which is closed from one side λ = 4l. If both ends are open, then λ = 2l. If v is same (as the temperature and other physical conditions are not changed), then the frequency will get doubled $v = f4l = f_1 2l$; $f_1 = 2f$. The tube can be initially opened and then be closed. A tube with both ends closed can be changed into a one end closed tube. Look at the 14th question of paper 1984. Then this will get reversed $f_1 = \frac{f}{2}$. As there is end correction of the tubes, the approximate value for frequencies is obtained.

05. A potentiometer is not used for

(1) comparing resistances.

(2) comparing e.m.f.s.

(3) measuring the internal resistance of a cell.

(4) measufing very small e.m.f.s.

(5) measuring varying voltages.

Potentiometer

Answer 05

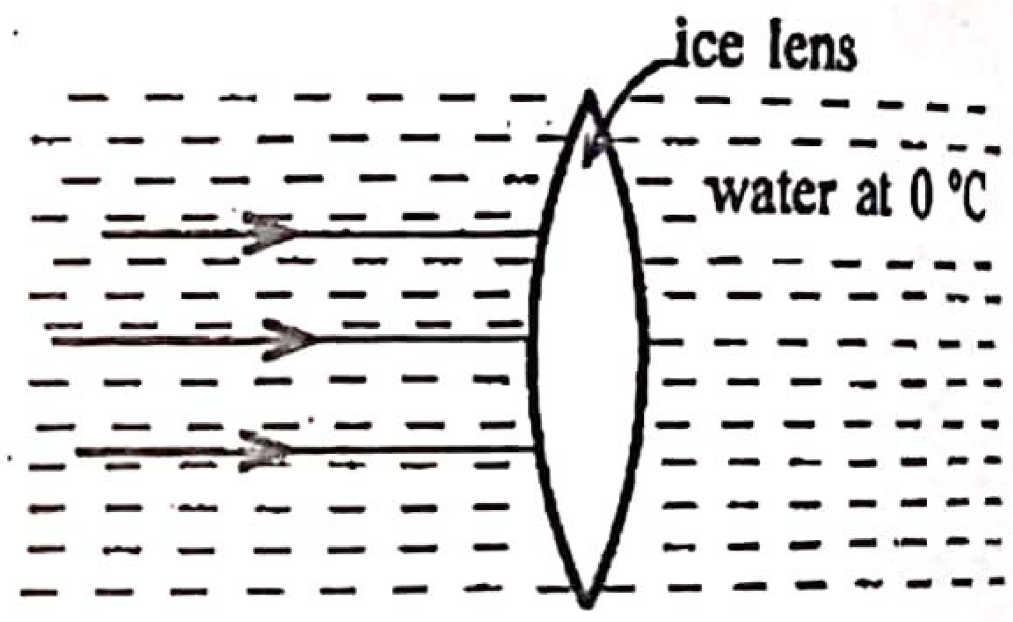
06. Two rods A and B are connected end to end. Sound wave travelling in rod A has a speed u. If it enters the rod B whose Young's modulus is four times that of A but having the same density as A, the speed of the sound wave in rod B will be

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

Wave Properties

The speed of longitudinal waves in a solid medium is $v = \sqrt{\frac{E}{\rho}}$. If ρ is ot changed, then $v \propto \sqrt{E}$. Therefore, if E is doubled, then v will be increased in a factor of $\sqrt{2}$. If E is increased by four times, then v gets doubled.

7. A thin transparent convex lens made of ice is immersed in water at 0 °C, and rays of parallel light are made to incident on the lens as shown in the figure. Refractive indices of ice and water relative to air are 1.31 and 1.33 respectively. Consider the following statements.



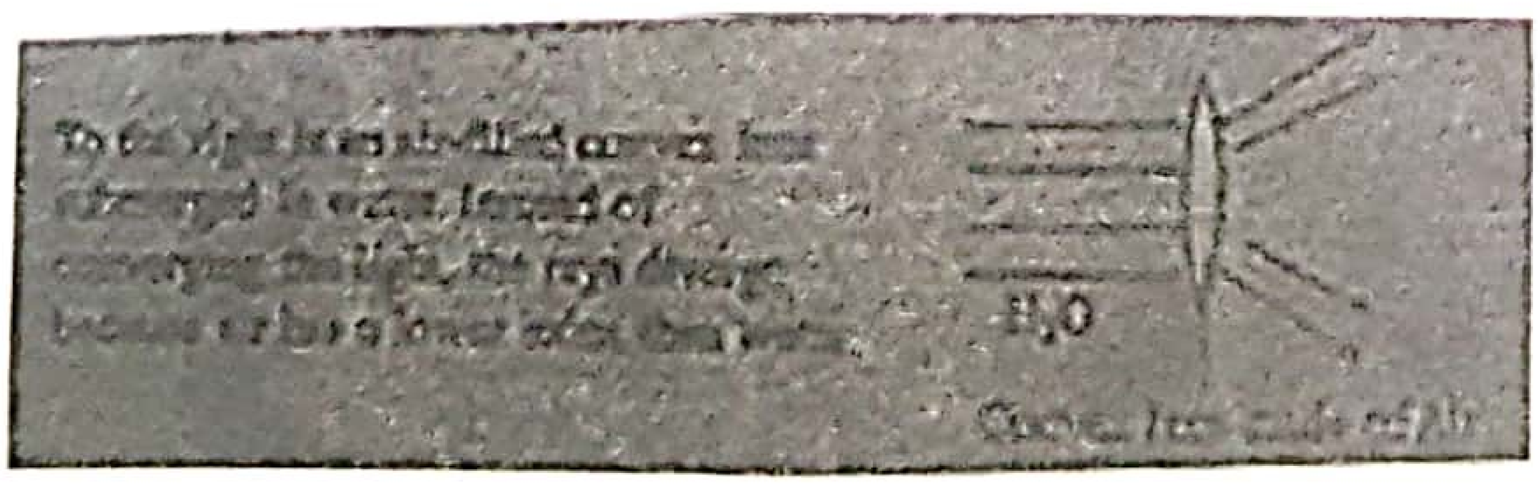
(A) Parallel light rays get converged to a point on the right side far away from the lens.
(B) Ice lens behaves as a diverging lens under this situation.
(C) Real images cannot be observed under this situation.

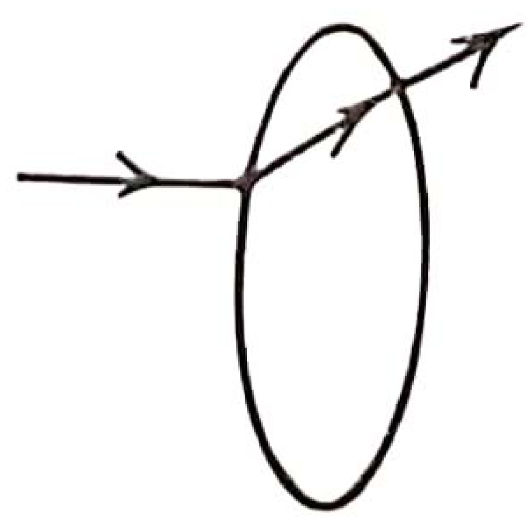
Of the above statements,

(1) only A is true. (2) only B is true. (3) only C is true.
(4) only A and C are true. (5) only B and C are true.

Refraction Through Lenses

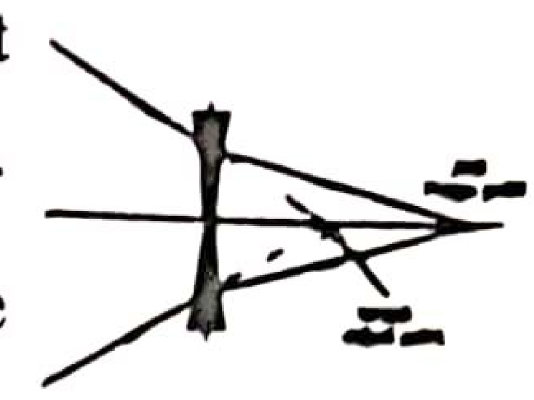
We will consider about a convex lens filled with air that is sunk in water. Even it is visible as a convex lens, the light rays are coming from a denser to a rarer medium not the other way around. Therefore, the path of a light ray which comes parallel to the main axis is as below.





So, the rays are diverging and the lens also acts as a diverging lens. If the lens is diverging, then the light rays that are coming parallel to the main axis cannot be convergent after the refraction from the lens. Likewise, under this condition, real images are not obtained from a diverging lens. All the sentences are associated with each other. They are not independent from each other. If the lens is diverging, then the refracted rays are not convergent. If the refracted rays are divergent, then you will not get real images. Look at the 52nd question of paper 1999. This logic is valid equally if the refractive index of the material of the convex lens is lesser than the refractive index of the medium.

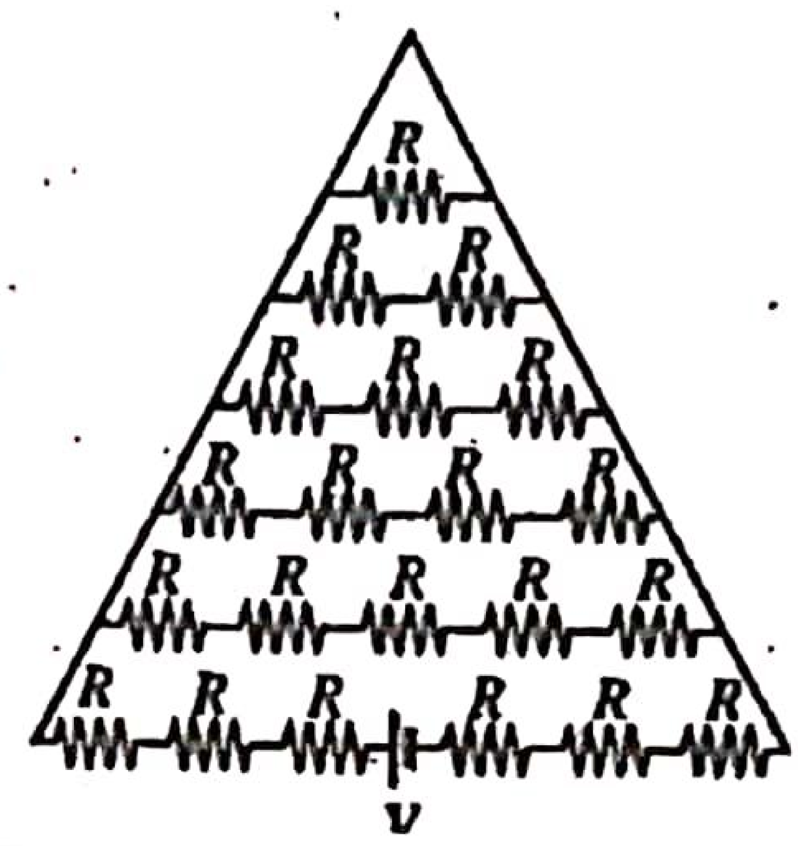
Cannot we get real images from a diverging lens? Actually, you can. This can happen under unreal object/ real image. Look at the figure. If we argue like this, a child may think that we can get real images. But if we consider according to the situation, it is not fair to think like that. This situation means for parallel light. To get real images from a diverging lens, the rays should be incident according to the given figure. From a beam of parallel light, you never cannot get a real image. The other arguments are broken from the specifically mentioned 'under this situation'. If we say that 'real images cannot be observed by this system', then this statement is wrong definitely. When we say under this condition, then everything should be treated like that way.

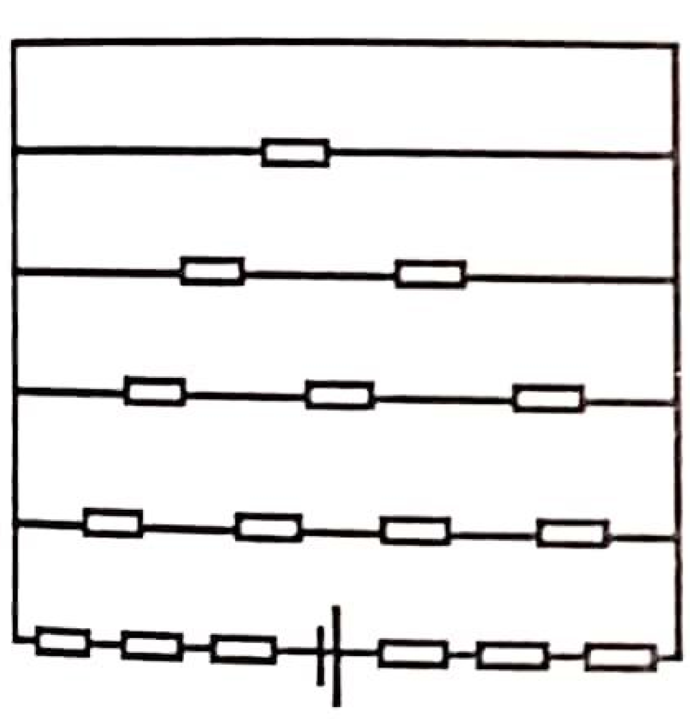


8. **Current drawn from the battery in the circuit shown is**

(1) $\frac{V}{6R}$ (2) $\frac{20V}{27R}$ (3) $\frac{V}{21R}$

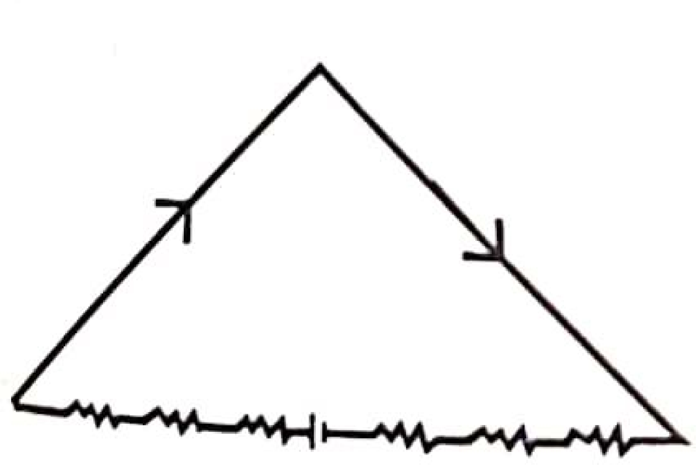
(4) $\frac{27V}{182R}$ (5) $\frac{137V}{882R}$





Consider this resistor network which is connected to a cell with an e. m. f of E. We will find the current in the network.

If you do not see around, then you will have to go for a longer calculation. In the rectangular resistor network, both sides of the legs are surrounded by a wire without a resistor. Therefore, the current from the cell will go across the wire and come back to the cell. So, there is no use from the rest of the resistors except the resistors in the rectangular base. Therefore, I = E/ 6R. The six R at the bottom are in series to each other.

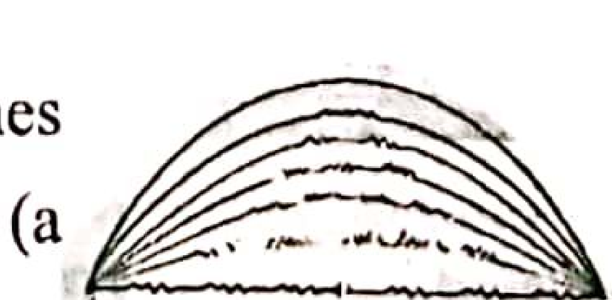


R R R R R R

If you did not see this, you can consider that 4R, 3R, 2R and R are parallel and do the calculation to add to 6R and then go in the wrong path. Why do you need to work so hard? The upper hat has the important part of the surrounding wire. Even if you think that, this part is not there (look at the figure below), then there is no option than going in the parallel method. Hats are very important! Both those who puts hats and who do not consider hats are important!

The above resistor network can be represented like this way too. Due to the upper wire part, A and B ends have become short-circuited. Therefore, resistors in the middle are not needed.

However, more time will be wasted if you consider the middle resistors as parallel ones and try to find the equivalent resistance.Therefore, in such problems, try to find a way (a trick) to go for a simple solution always. Do not try to go for longer methods.



09. In a compound microscope under normai adjustment,

(I) the object distance is less than the focal length of the objective.

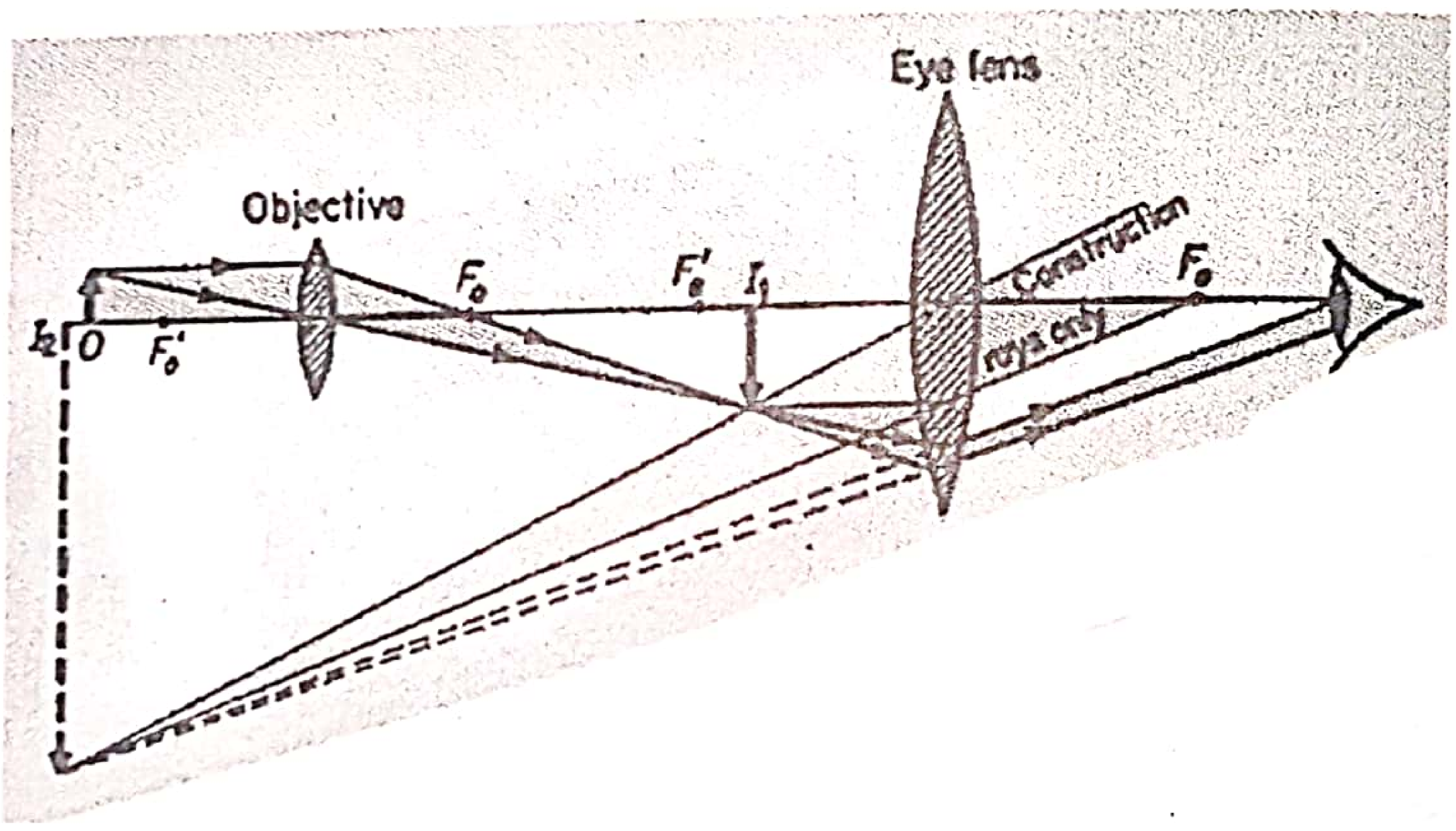
(2) the image formed by the objective is virtual.

(3) the image formed by the objective is located within the focal length of the eyepiece.

(4) the final image is real.

(5) overall angular magnification can be increased by using an objective having a larger focal length.

The ray diagram of a combined microscope in normal adjustment is shown in the figure. If the image distance is lesser than the focal length of the objective, then an unreal image will be produced by the objective on the side of the object. There is no usage from the eyepiece if the image from the objective is not real. The image from the objective is produced in between the eyepiece and its focal length. The final image is produced in front of the eye as an unreal image. If you need to increase the angular magnification, then the focal length of the objective should be smaller. If the focal length of the objective is bigger, then the object cannot be placed away from the focus. Look at the 4th question of paper 2011, the 16th question of paper 2013 and the 5th question of paper 2014. Look especially the 5th question of paper 2014.



Can the angular magnification be increased by having a less focal length to the objective? Or else does it reduce? There is an argument for this. Therefore, we will consider this matter.

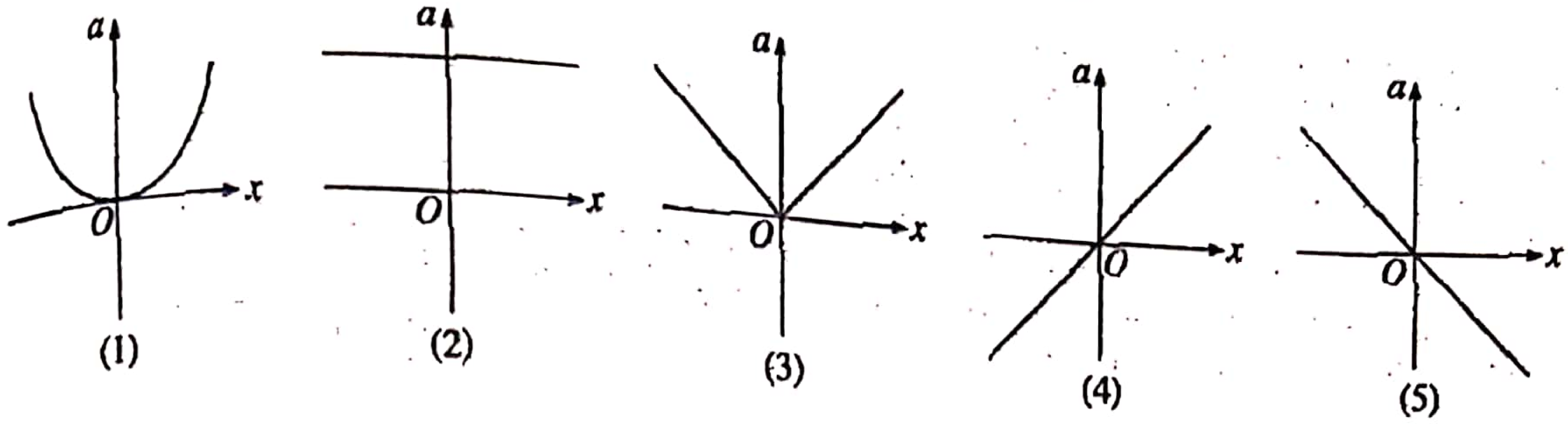
The angular magnification is given by the following expression in a combined microscope which is in normal adjustment. This can be derived easily.

$(v/f_0 - 1)(1 + D/f_e)$ Here v is the distance from the objective lens to the image of the objective. By looking at the expression, I think it is not fair to argue that angular magnification increases when f_0 is reduced. Why? When f_0 is changed v also change. When f_0 is reduced, if u is constant, then v is reduced. Then what will happen to v/f_0? We argue that angular magnification increases by considering that v is constant. Let us write v from u.

Apply lens formula to the objective. $-1/v - 1/u = -1/f_0 \rightarrow v = uf_0/u - f_0 = \frac{u}{\frac{u}{f_0} - 1}$

Practically, when f_0 is reduced u can be reduced. There is no advantage by keeping u at a higher value and reduce f_0 only. Always, the object is placed in a microscope near to the objective. Therefore, when f_0 is reduced practically u can be reduced accordingly. When the focal length of the objective is 6.0 mm, then u can be kept at 6.1 mm or 6.2 mm. The value of u will not be kept at a value like 10 mm. Therefore, when f_0 is reduced u will automatically be reduced. When u is reduced v is increased. So, v/f_0 ratio will be increased.

10. A body executes simple harmonic motion along the x-axis around the point 0. The variation of the acceleration (a) of the body with the displacement (z) from 0 is correctly represented in



Simple Harmonic Motion **03**

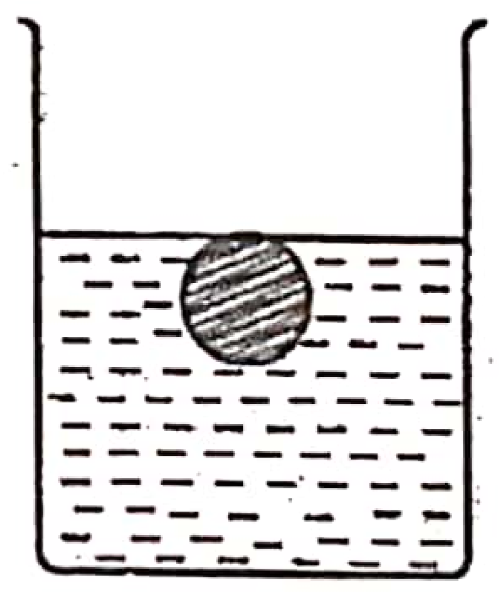
According to the equation of $a = -\omega^2 x$ in simple harmonic motion, the graph of x against a should be a straight line which goes across the origin with a negative gradient. Especially, look at the 12[th] question of paper 1997.

11. Which of the following statements is not true regarding progressive transverse waves in a stretched string?
   (1) Direction of the motion of particles in the string is normal to the direction of propagation of the wave.
   (2) Speed of the wave is inversely proportional to the square root of the mass per unit length of the string when the tension of the string is constant.
   (3) Energy carried by the wave depends on the amplitude of the wave.
   (4) Waves formed on the string cannot be reflected.
   (5) Two adjacent particles of the string do not move with the same speed at a given instant.

Answer 04

Wave Properties **03**

12. A solid sphere at θ°C with volume expansivity γ_s is completely immersed and floating in a liquid at θ°C as shown in the figure. Volume expansivity of the liquid is $\gamma_f (> \gamma_s)$. The entire sphere with the liquid is cooled down to a certain temperature.

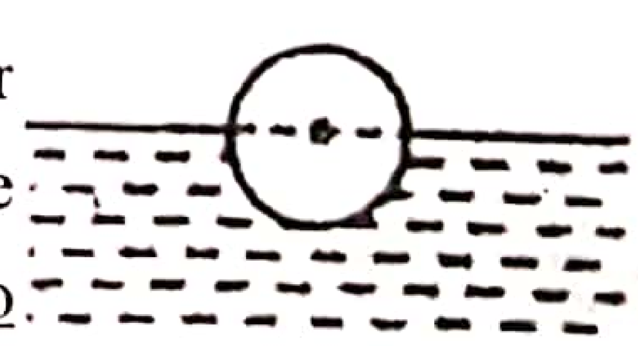


Consider the following statements.
   (A) A part of the sphere will be above the surface of the liquid after cooling.
   (B) The magnitude of the upthrust acting on the sphere will not change.
   (C) The density of the sphere will be greater than the liquid after cooling.

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.

Expention of Liquid **04**

Think of a sphere which floats in a liquid. As the sphere is floating, its weight should be equal to the upthrust from the liquid. The mass (weight) of the sphere will not be changed even it is heated or cooled. As the weight is unchanged and it remains floating, then there is no change in the magnitude of the upthrust on it.



Think that both the liquid and the sphere is heated. Look at the 49[th] question of paper 1988. Think that the volume expansivity of the liquid is greater than the value of the sphere. This is normally true. To judge what happens to the sphere, actually you do not have to think of the higher/lower density of the sphere. Compared to the sphere, the volume expansivity of the liquid is higher. Therefore, think only of the liquid.

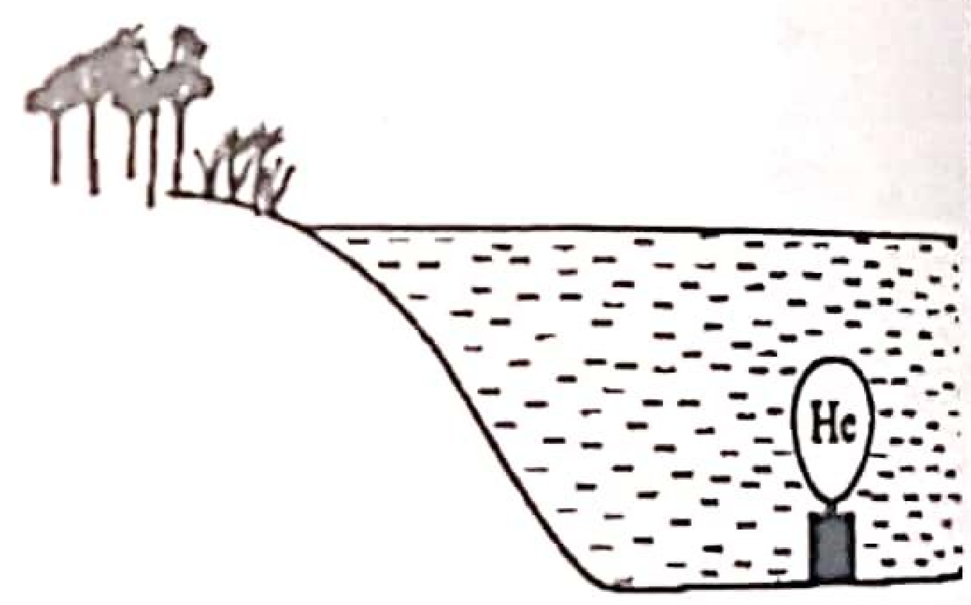
When it is heated, the density of the liquid gets reduced. Then the upthrust from the liquid is reduced. The mass (weight) of the sphere is unchanged. So, to give an upthrust which is equal to the weight, the centre of the sphere should go downwards. That means it should sink a little more. Likewise, think that the system was cooled. Then also think only about the liquid. Now the density of the liquid gets increased. So, to given an upthrust from the liquid which is equal to the weight, the centre of the sphere should go upwards. All you have to think only these things.

Even the process is same if the sphere is completely sunk in the liquid. As the density of the liquid is increased, the upthrust from the liquid gets increased. That means, now the sphere does not have to be sunk more in the liquid. As the sphere is completely sunk in the liquid, the density of the sphere is initially equal to the density of the liquid. This is true. What will happen if we heat the system? Think about it. As the volume expansivity of the liquid is greater than of the sphere, when the system is cooled, the density of the sphere cannot be greater than of the liquid. You can just decide this by comparing the volume expansivities.

When it is cooled, the volume of the sphere gets reduced to a certain extent. The density of the liquid as well as the sphere gets increased. If the volume of the sphere is reduced with unchanged density of the liquid, then as the upthrust on the sphere is reduced. As the sphere is completely sunk and floated, it cannot protect the previous upthrust of vdg. So, the sphere comes downwards. But the volume expansivity of the liquid is greater than the sphere, the increment of the density of the liquid is greater than the increment of the density of the sphere. Compared to the increment of the density of the sphere, the increment of the density of the liquid is greater. That is why it was mentioned that there is no need to consider about the increment of density of the sphere. As the density of the liquid is increased, the upthrust from the liquid gets increased. That means there is no need to sink more by the sphere than before. Even the sunk volume of the sphere is reduced by little, the previous upthrust can be provided by the liquid as the density of the liquid is increased. Do not write equations for these situations. It is a sin.

13. A solid block of metal of volume $1\,m^3$ and density 8×10^3 kg m^{-3} rests at the bottom of a lake. What is the volume of a helium filled balloon connected as shown in the figure to make the block just float at the bottom of the lake? Neglect the mass of the balloon with helium. (Density of water $= 1 \times 10^3\,kg\,m^{-3}$)

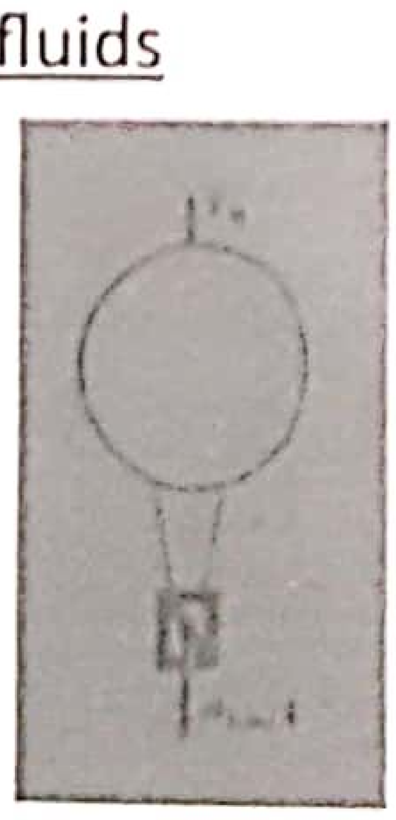
(1) $7\,m^3$ (2) $8\,m^3$ (3) $70\,m^3$
(4) $80\,m^3$ (5) $700\,m^3$



Hydrostatics

The figure shows a load connected to a balloon filled with Helium. What is the volume V of Helium that is needed if the balloon has to lift a load of volume 1 m^3 and mass of 800 kg?

https://www.slideshare.net/ibidorigin/14-fluids



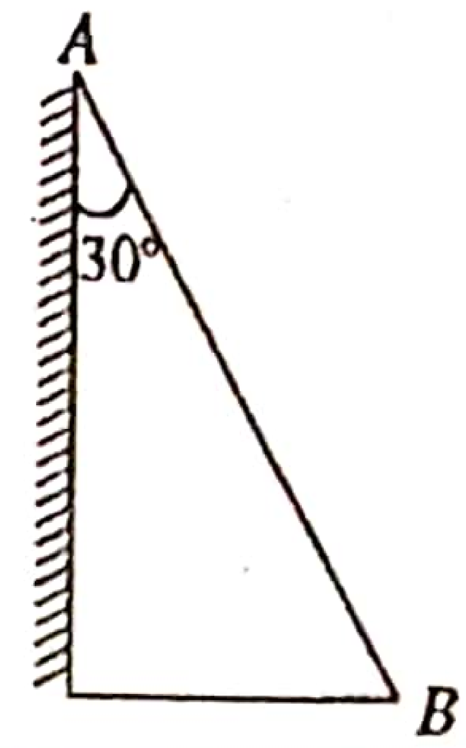
If the system is sunk and float in water, then the total weight should be equal to the upthrust from the water. If we neglect the mass of, He and the material of the balloon, then a small calculation is needed to find the volume V of the balloon.

$8 \times 10^3 \times 10 = (1 + V)\, 10^3 \times 10$; $V = 7\,m^3$. Without a simplification, you should see that $V = 7\,m^3$.

$7 + 1 = 8$.

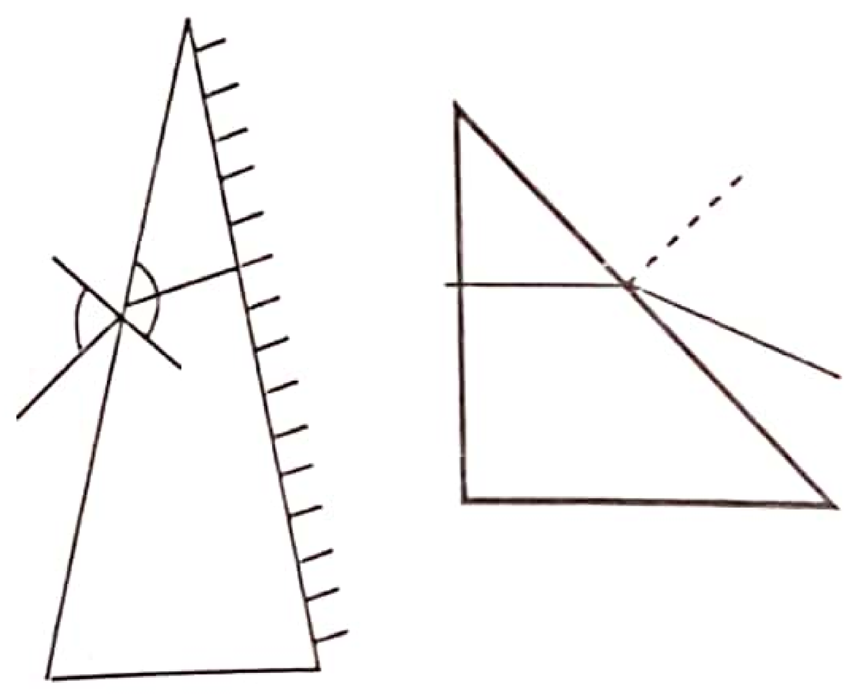
14. One of the surfaces of a glass prism of refractive index 1.5, is silvered as shown in the figure. A ray of light falling on the face AB with an angle of incidence θ gets reflected from the silvered surface and returns along the same path. Which one of the following values is closest to θ ?

(1) 37° (2) 41° (3) 49°
(4) 51° (5) 56°



Refraction **03**

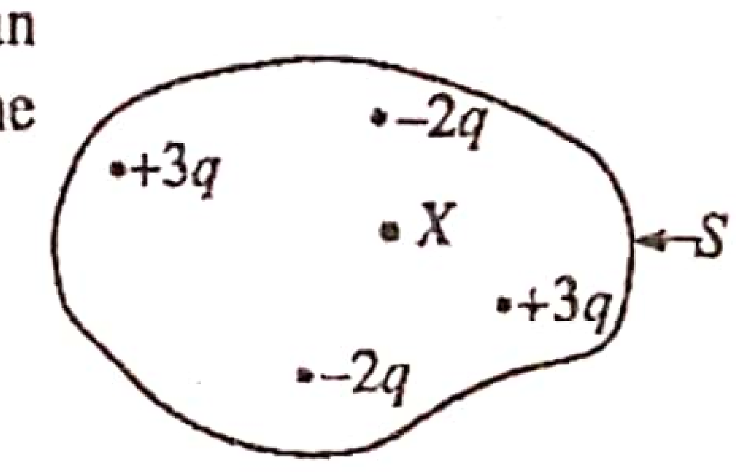
Consider a light ray which is incident on a prism of refractive index 3/2. A calculation is needed to find θ. $\frac{\sin\theta}{\sin 30^0} = \frac{3}{2}$; $\sin\theta = \frac{3}{4}$ (0.75)



To find θ, you need to use the tables. There is no other way. The value of θ = $\sin^{-1}$ (3/4) is equal to the critical angle of water-air interface. When the refractive index of water is taken as 4/3, then sin C = 3/4. You may know from memory that this critical angle is about 49^0. For the glass- air interface you know that the critical angle is about 42^0. If you do not know the value of θ which is equal to the critical angle of water-air interface and its value is the above value from your memory, then I do not know how to get the answer without tables.

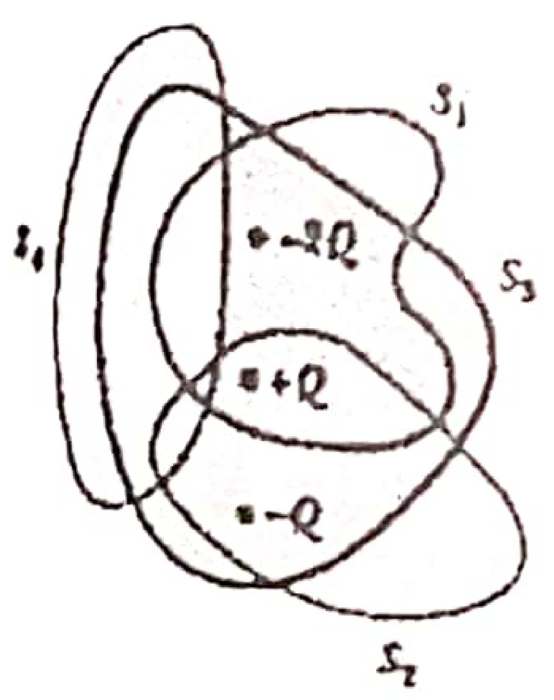
15. Figure shows a distribution of static electric charges enclosed by a Gaussian surface S. X is an unknown charge. If the net outward electric flux through the surface S is $\frac{-q}{\varepsilon_0}$, then charge X is

(1) $-3q$ (2) $-2q$ (3) $-q$
(4) $+q$ (5) $+2q$



Gauss Theorem **06**

The net electric flux from any closed surface is dependent upon the net charge that is inside the surface.

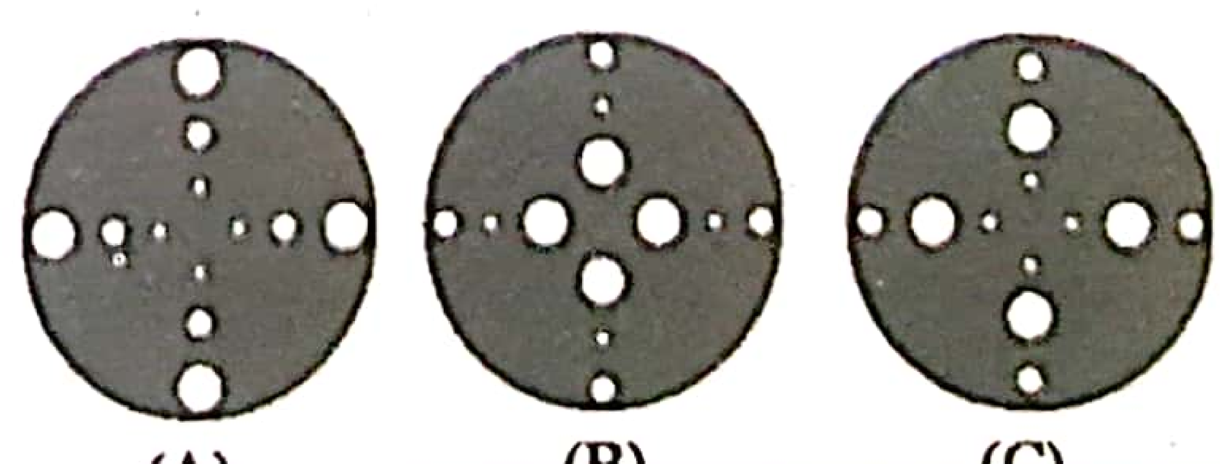


Try to add the charges algebraically on the area of S surface. It is numerical mathematics. For S_1 = -2 Q + Q, for S_2 = -Q + Q, for S_3 = -2Q + Q- Q.

If there are charges like this in a certain area, +4Q + 4Q- 3Q – 3Q= 2Q, then the extra charge that should be put is -3Q to get net result as -Q. -3+2 = -1. Even in the Practical Physics book of Prof. C. Dahanayake, the unit of electric flux has been taken as C.

16. Three identical uniform metal discs are perforated to form twelve holes in each disc with three different radii as shown in the figures (A), (B) and (C). The three discs A, B and C when arranged so that their moments of inertia, about an axis normal to the plane of the disc and passing through the centre, are in the ascending order, is

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



Rotational Motion **02**

The figure has shown three uniform plates where holes are cut at each place. How can you compare the moment of inertia in them? You can get it from logic. When the bigger holes away from the rotational axis, the moment of inertia gets into a minimum. According to that in (1), the material is being removed as it is further away. All four holes are far. In (2), the holes are removed near the rotational axis. All four holes are closer. In (3), two holes are far whereas two holes are nearby. This argument is valid even if the holes are cut exactly to the middle of the plate. Therefore, the minimum moment of inertia is in (1). (2) is has the highest moment of inertia. (3) is in the middle. 1, 3, 2. When the flesh is reduced from far away, the moment of inertia gets reduced. When there are bigger holes, which idiot looks into smaller holes?

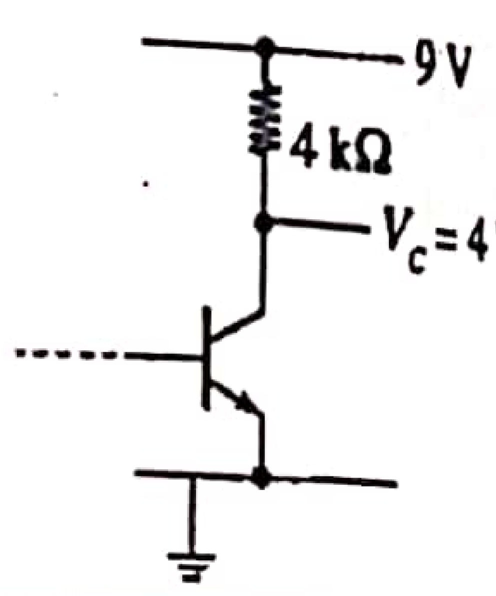
17. A person with surface body temperature 30 °C is in an environment of temperature 20 °C. The net rate of loss of heat due to radiation from the body is proportional to (Assume that the black body radiation-conditions can be applied.)

(1) $303^4 - 293^4$ (2) 293^4 (3) 10^4 (4) $303^4 + 293^4$ (5) $30^4 - 20^4$

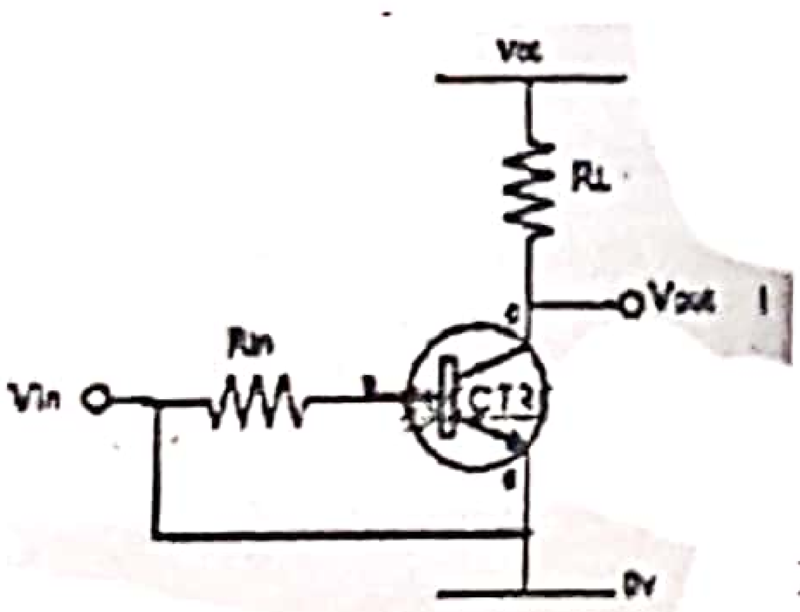
Radiation

The heat loss net rate from radiation is proportional to ($T_1^4 - T_2^4$). However, there should be difference. It cannot be there without a difference. The temperature should be taken in kelvin. It is wrong to take in ^{0}C.

18. When the transistor shown in the circuit is biased in the active mode, the collector current will be



(1) 0.60 mA (2) 0.80 mA (3) 1.25 mA
(4) 1.40 mA (5) 2.50 mA

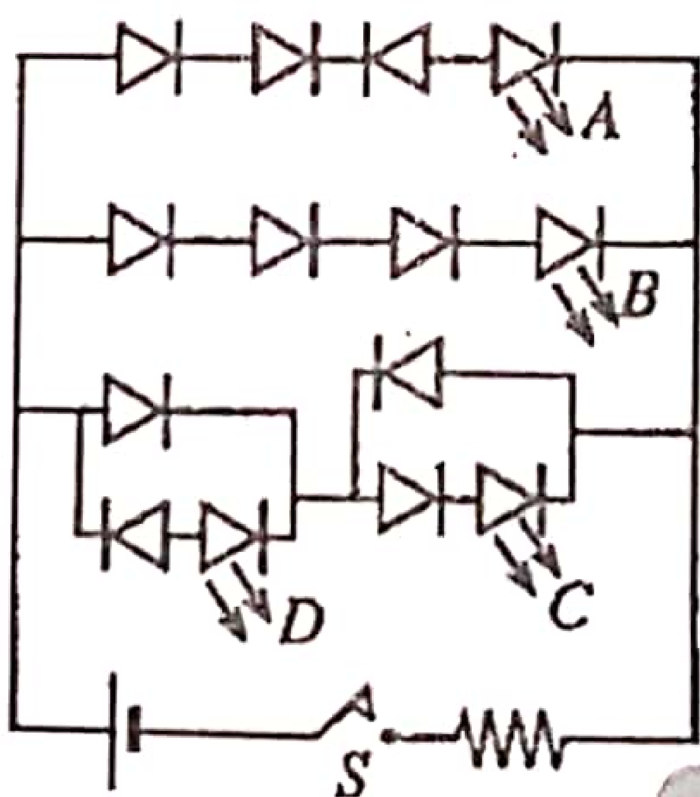


Transistors

and R_L values are given, then finding I_C is very easy. $I_C = (V_{CC} - V_C)/R_L$. When you resistor and the voltage difference, you can find the current across the resistor.

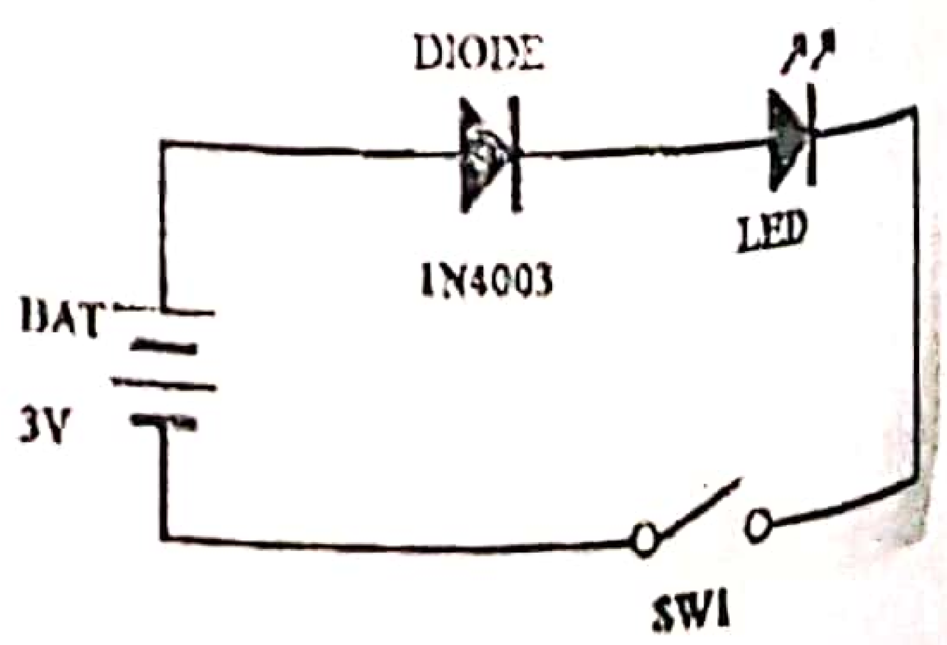
19. When the switch S is closed in the circuit shown,

(1) only A will glow.
(2) only B and C will glow.
(3) only B and D will glow.
(4) only B, C and D will glow.
(5) all A, B, C and D will glow.

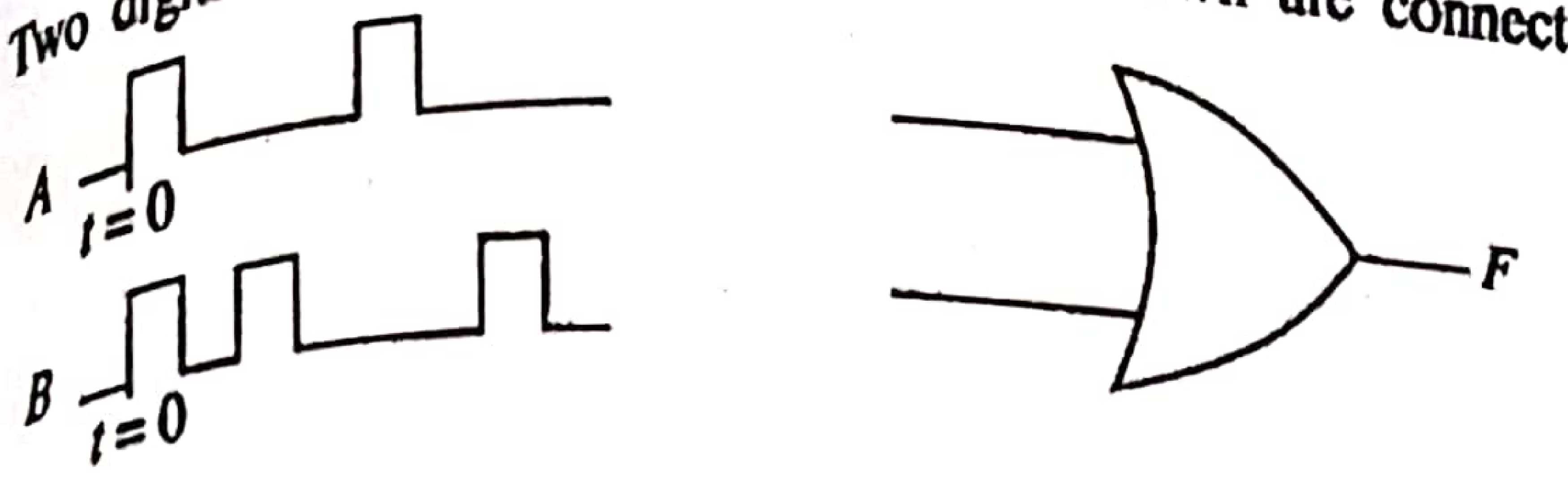


Semi Conductor Diodes

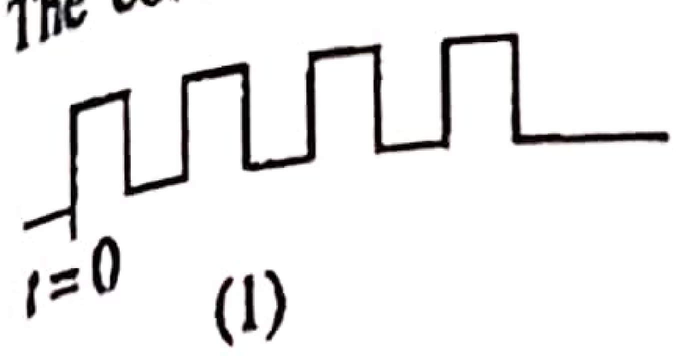
If one LED should be lit when SW1 is closed, then there cannot be a diode/s in the reverse biased mode at the branch of LED. If there is a reverse biased diode/s, then there is no current flow in that branch. It is ok if all the diodes are in forward biased mode. If there is even one reverse biased diode in the particular branch, then there is no current flow. Then LED in that branch will not be lit.



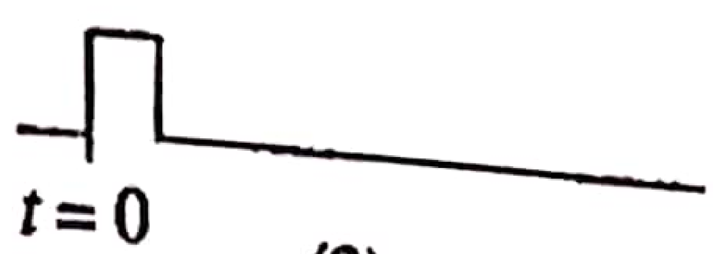
20. Two digital voltage waveforms A and B shown are connected to the two inputs of the gate shown.



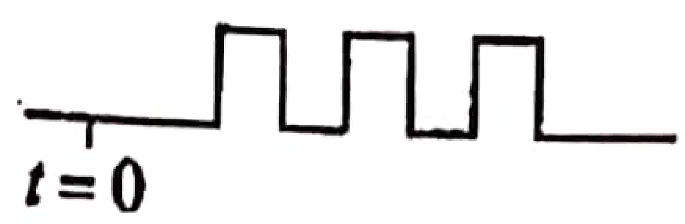
The correct output voltage waveform at F is



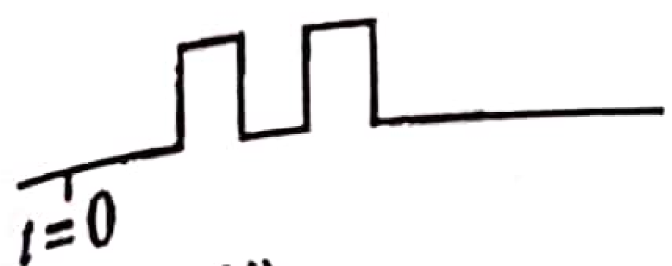
(1)



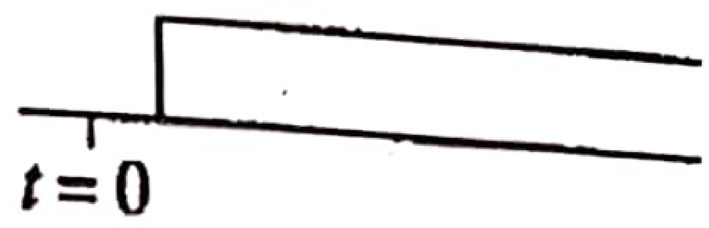
(2)



(3)

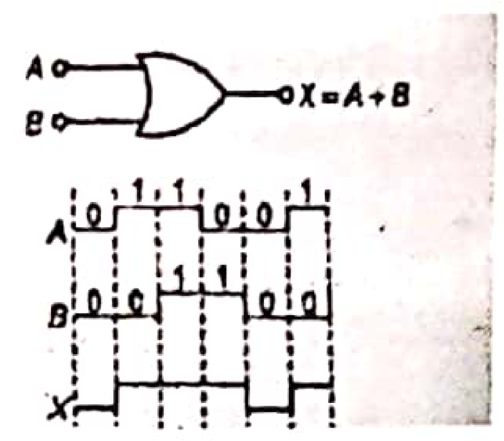


(4)



(5)

Logic Gates 09



Truth table

Inputs		Output
A	B	X = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Look at the wave model that has been applied to an OR gate. In an OR gate, there is no problem if either one of the two stays or both stay. Move your eye towards the wave model. Initially, both are not there. Then there is no output. Next, there is one. There is an output. Next, both A and B is 1. After that, there is no A. It does not matter for the output. The output becomes zero when both are not there.

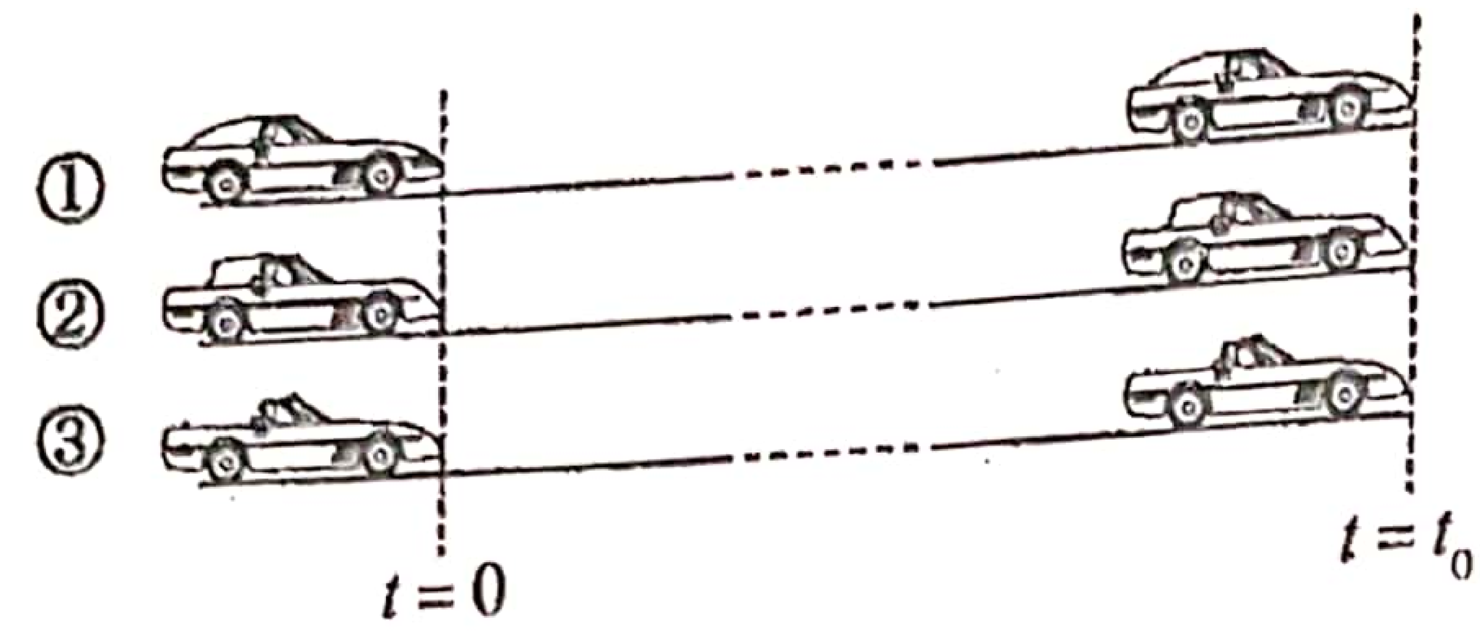
Initially, there is no issue when both are set with each other. What to do when there is one afterwards? You will have to stay alone always. Therefore, logic 1 should be in the output in a way that has one for both or one for each. At the beginning, both have one. Next, there are single ones. If there is one for both or three singles, then there should be four sections with upper parts.

21. A beam of monochromatic light is incident on a metal surface which is capable of producing photoelec If the frequency of the light is above the cut-off frequency of the metal, the number of photoele ejected from the metal surface is proportional to the
(1) reciprocal of the kinetic energy of a photoelectron.
(2) work function of the metal.
(3) frequency of the incident light.
(4) number of photons that hits the metal surface.
(5) energy of a single photon.

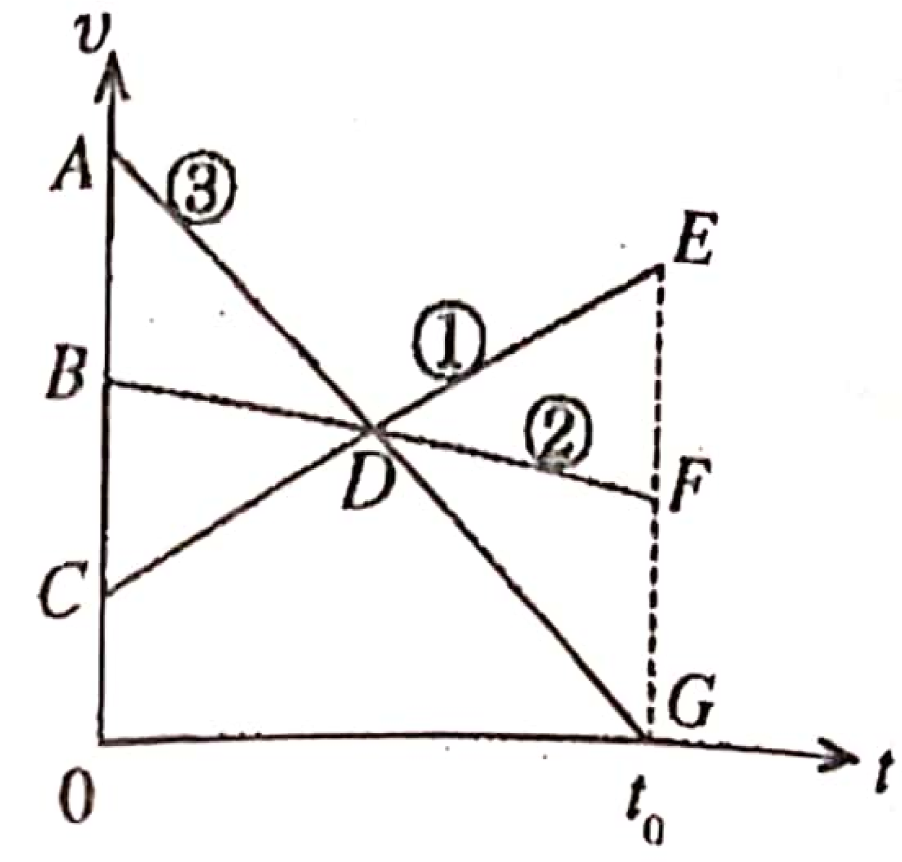
Photo Electric Effect 10

When the photo electric effect occurs, that means when the frequency of the incident wave is greater than the threshold frequency of the material, then the number of emitted photo electrons are dependent upon the number of photons that incident on the surface. If mangoes can be plucked from the thrown stones, then the fallen mangoes are dependent upon the number of stones that are thrown. But mangoes will not fall from each stone. Likewise, if the energy from incident photons is strong enough to remove electrons, then one lakh photons per second that are incident on the surface even will not be able to emit one lakh electrons. It is great if it can happen like that. Then the efficiency will be 100%. We all are not 100% efficient. (Look at the 26th question of paper 1998, the 33rd question of paper 2002 and the 18th question of paper 2016.)

22. Positions of three motor cars ①, ② and ③ travelling along three parallel straight lanes of a road at time $t = 0$, and $t = t_0$ are shown in figure (a), and their corresponding velocity (v)–time (t) graphs are shown in figure (b).



(a)



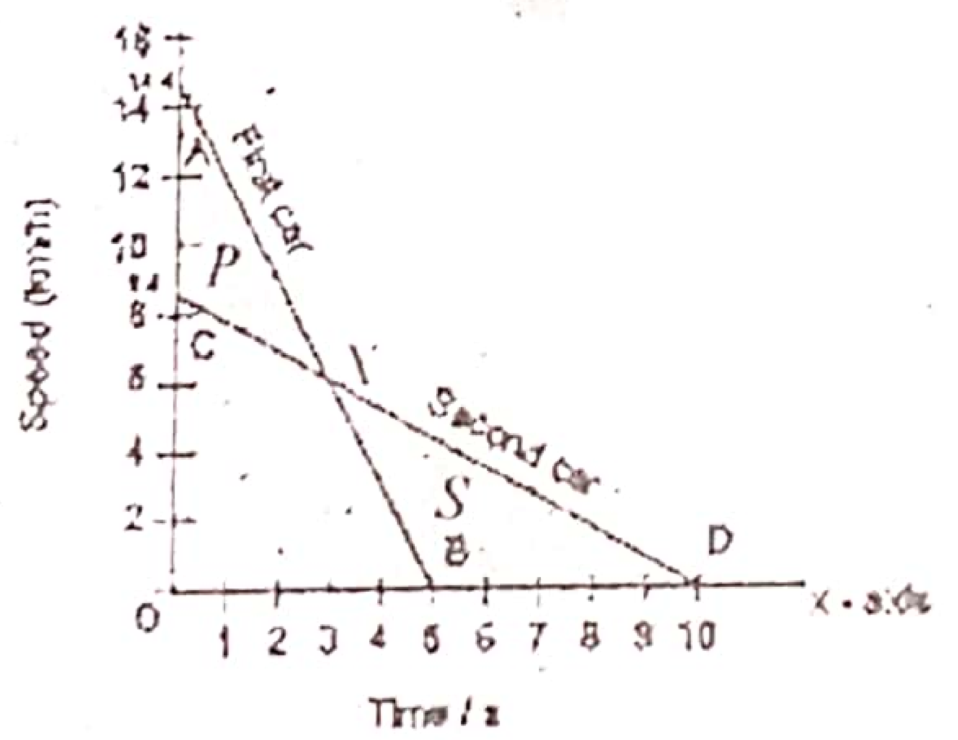
(b)

The situation shown in figure (a) could have happened only if the areas in the graphs satisfy the conditions

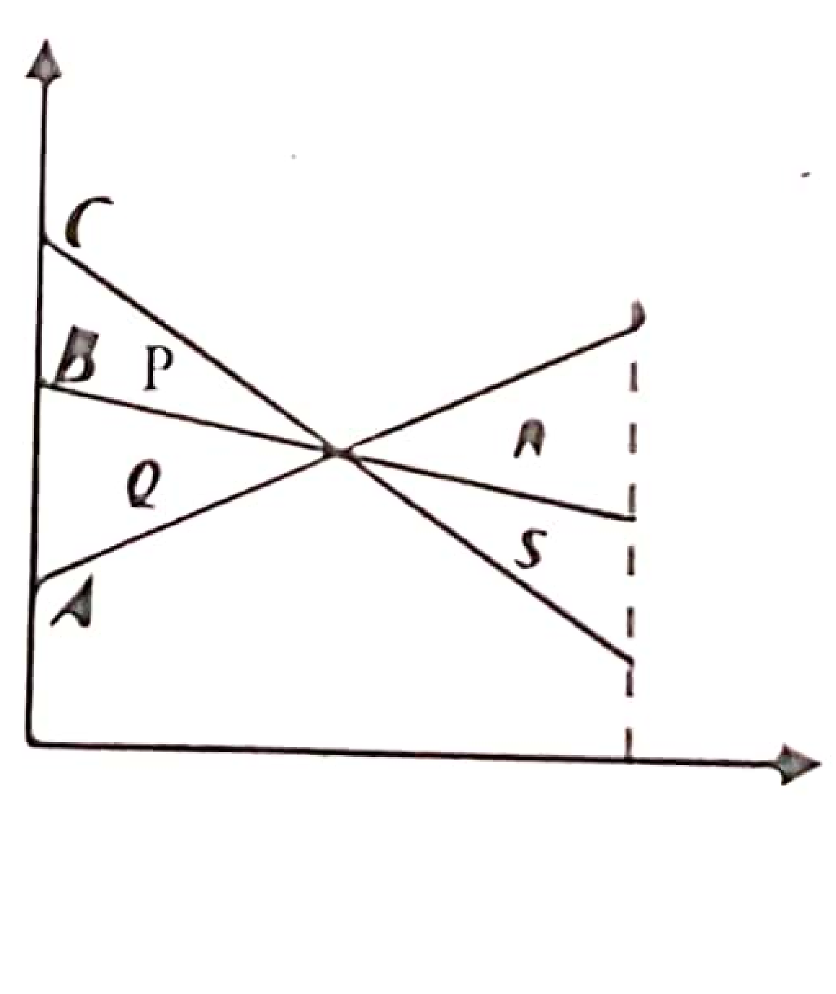
(1) $ABD = DEF$ and $ABD = DEG$
(2) $BCD = DEF$ and $ABD = DFG$
(3) $CDB = DEG$ and $ABD = DEF$
(4) $BCD = ABD$ and $DEF = DFG$
(5) $ACD = DFG$ and $BCD = DFG$

Linear Motion

As shown in the following figure, consider the velocity-time graphs of two motor vehicles. We know that displacement is given by the area bounded by the graph and t axis of a v-t graph. Therefore, if the displacements are equal in two vehicles, then the relevant areas of the v-t graphs should be equal to each other. By looking at them, the section (area) of OBXC is common to both of them. Therefore, you do not have to look at that area. So, to have equal areas, the areas of the triangles should be equal which are facing to each other. That means P should be equal to S.

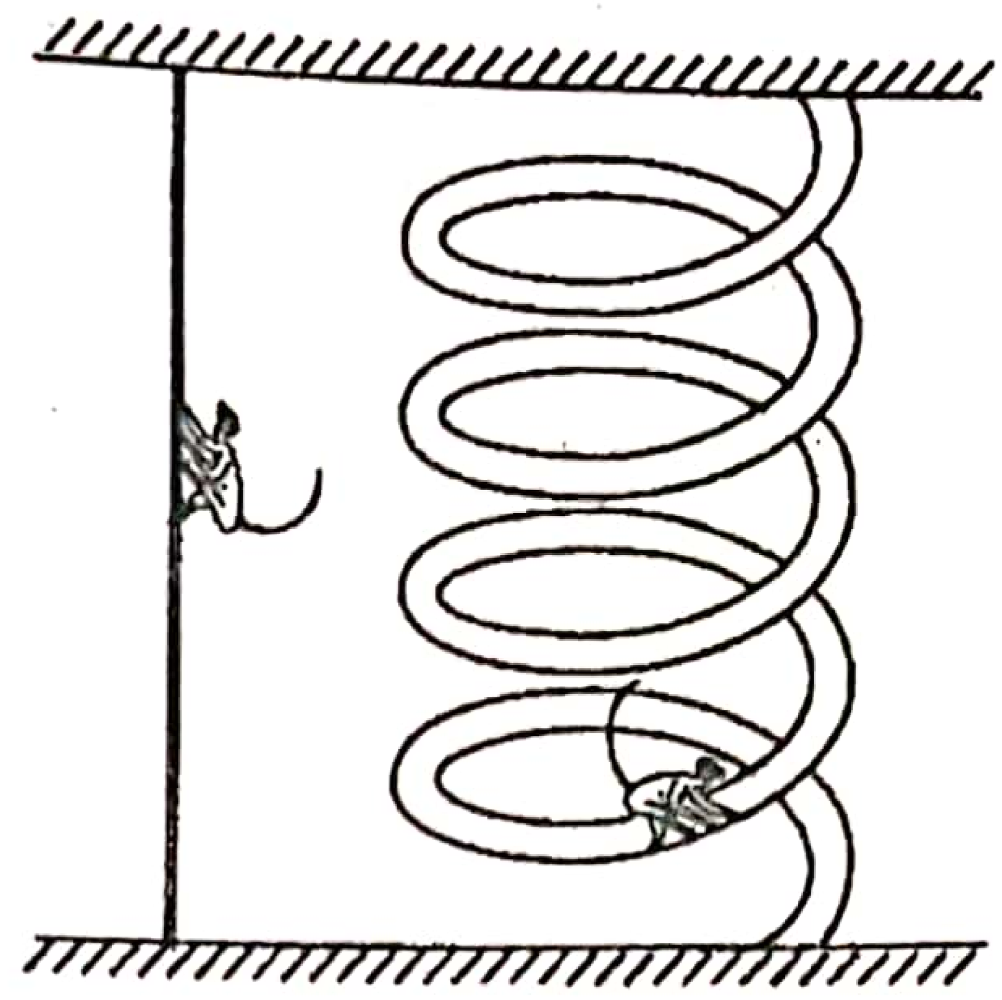


The same logic can be applied to three motor vehicles. The triangle parts are named as P, Q, R and S. You can do like that (for convenience). It is easy to call like that also. In graph A, there is R + S apart from the common section. In graph B, there is Q + S apart from the common section. So, to have equal areas R should be equal to Q. Likewise to have an equal area in graph C like in graph A and B, P should be equal to S. The areas of the triangles that are placed in front of each other should have equal areas. If Q = R in one place, then I will be delighted. That is because I do not have to look at others.



23. A monkey climbed a certain vertical height along a vertical rope with uniform speed in 30 seconds. (See figure.) Later the same monkey climbed the same **vertical** height along a spiral-path of 75 m path length with another uniform speed. If the monkey applied the same power throughout its motion in both cases, the speed with which the monkey has climbed the spiral path is

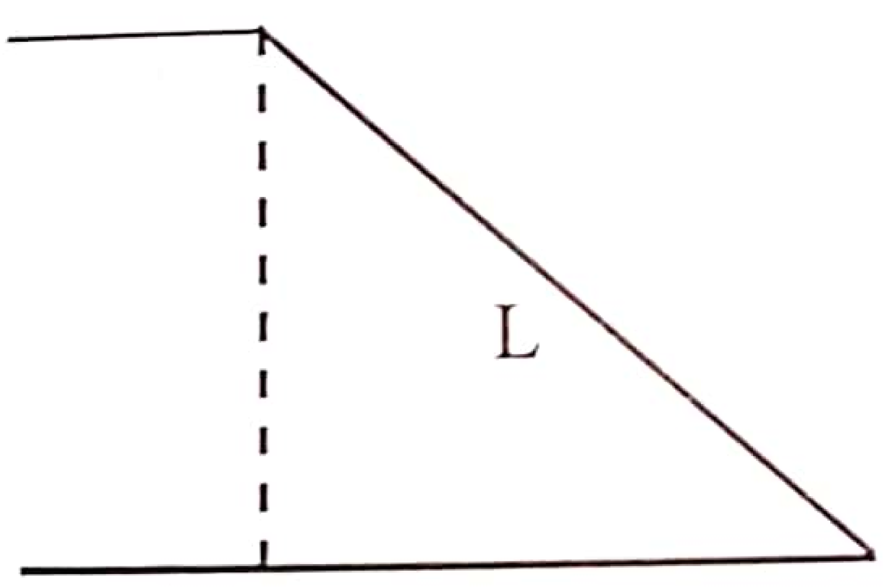
(1) $0.33\ m\ s^{-1}$ (2) $2.5\ m\ s^{-1}$ (3) $5\ m\ s^{-1}$
(4) $7.5\ m\ s^{-1}$ (5) $10\ m\ s^{-1}$



Newton's Law & Momentum **02**

There are different ways to climb a certain height. If possible, you can climb directly. Think that a person is climbing a vertical height in time t with a uniform speed. Secondly, he goes on a different way like a spiral as shown in the figure to climb the same vertical height with a uniform speed. Spiral paths cannot be horizontal in each place. There should be a vertical lift at each end or at each loop.

In the first instance, there is no change in the kinetic energy as he goes with a uniform speed. The work is done to increase the gravitational potential energy (mgh). In the second instance, his increment of energy is mgh even though he goes many rounds. The height slowly increases by going in spiral paths. The gravitational potential energy difference does not depend on the path that it travelled. It is dependent on the initial and final states only. The reason for that is the gravitational field is a conservative force field.

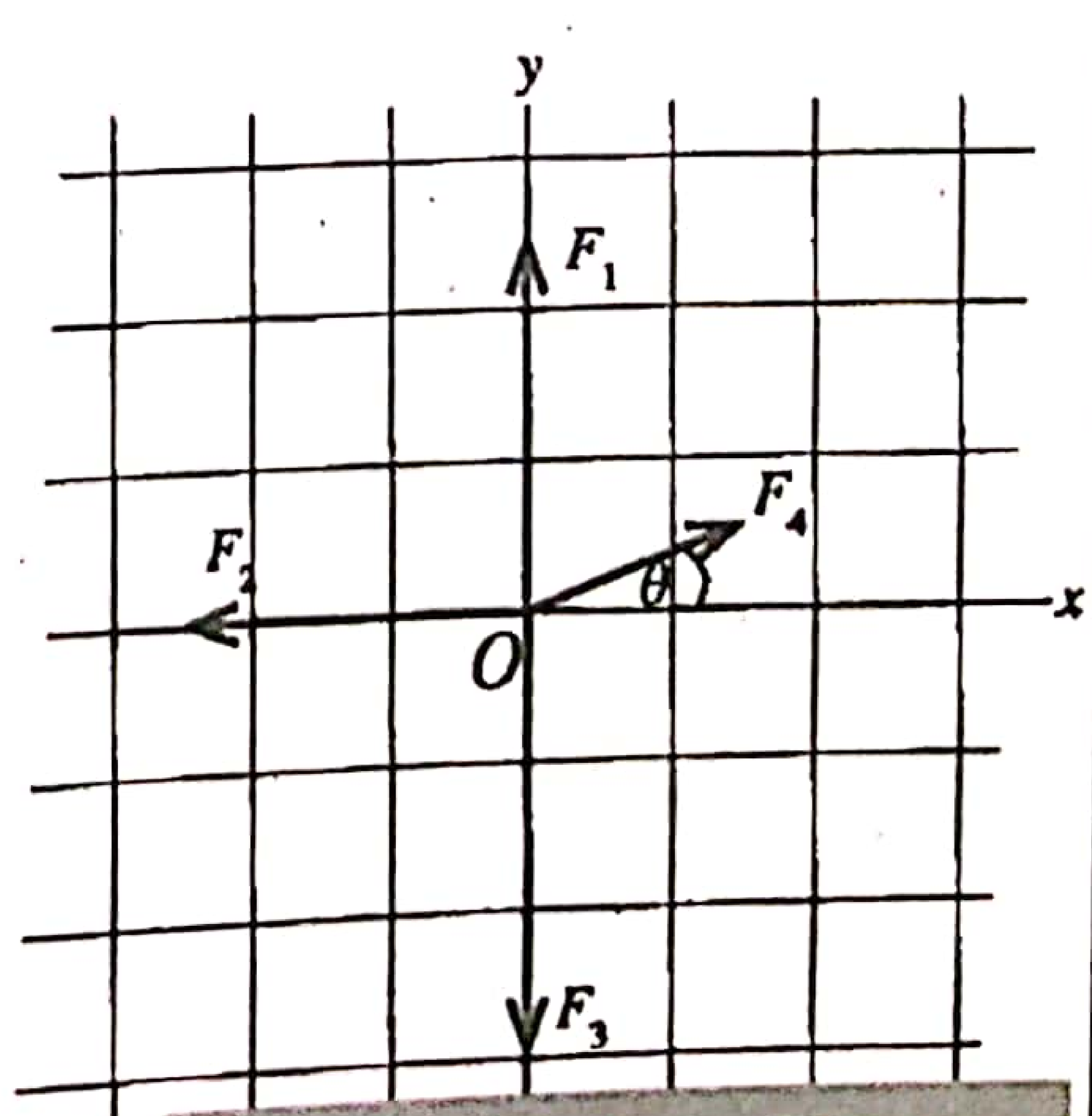


The easiest method to understand this is to think of an inclined plane which is equal in length of L of the spiral or any other path. You can find an inclined plane with a length L which can fit from top and bottom accurately.

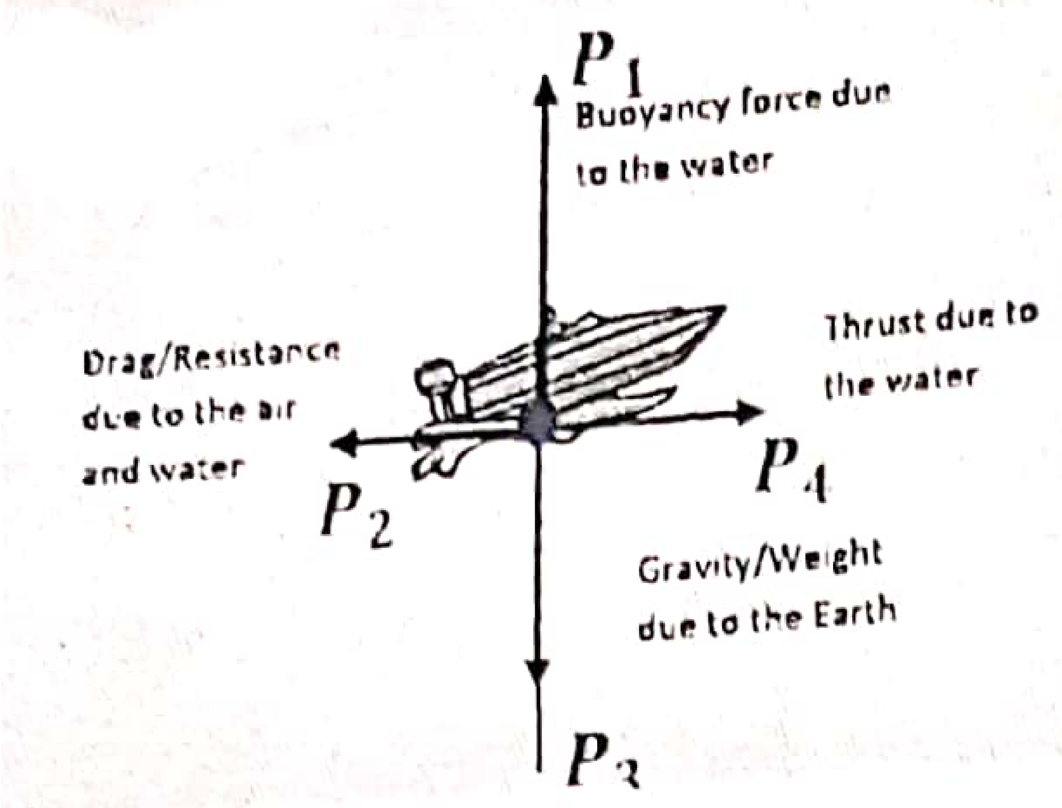
The work done against the gravity in running an inclined plane of length L and running a spiral path with the same length is same as the initial and final states are same. If we think that he applied same power (rate of doing work), then he should go L distance in t time. As the speed is uniform v =L/t. I have mentioned about one time and one length. Therefore, there is no other way to find the speed other than distance/ time. Even you can do the question easily without thinking too much, the logic of Physics behind this instance is important.

24. In the figure shown F_1, F_2 and F_3 represent fixed vectors of three forces acting at the point O in the x-y plane. F_4 is a vector representing a rotating force about the point O in the same x-y plane. Which of the following best represents the **direction** of the resultant vector, when the vector F_4 is at angles $\theta=0°$, 90°, and 180°?

	0°	90°	180°
(1)	→	←	→
(2)	←	←	←
(3)	←	→	→
(4)	→	←	←
(5)	←	→	←

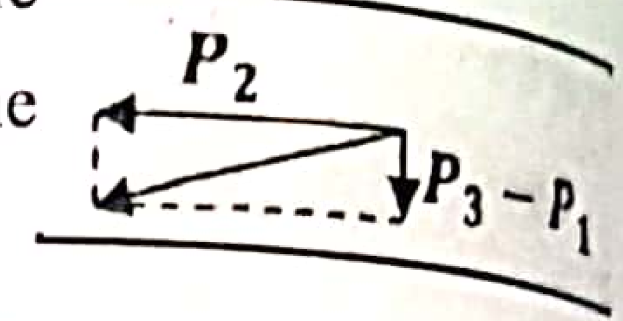


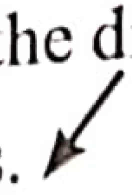
Equilibrium of Forces **02**



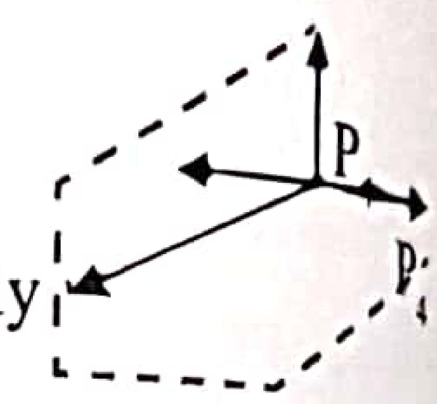
Consider the forces that act on a boat which moves in water. P_1 -The upthrust acted on the boat; P_2 -The resistive force from the water and the air; P_3 – The weight of the boat; P_4- The push from the water to the boat; The boat is moved forward from this push. The propeller blades of the boat pressurize the water. An equal and opposite force is obtained by the boat from the water. Think that the angle of the push (θ to the horizontal direction) can be changed.

Think that we need to decide the resultant force of the boat. First decide the net force of P_1 and P_3.P_3 is bit greater than P_1. As P_1 and P_3 are opposite to each other, The net force of P_1 and P_3 works vertically little bit downwards . Now get the resultant with this force and P_2 by completing the parallelogram of forces. Look at the figure.



It is the resultant of P_1, P_2 and P_3. Now decide the direction of the resultant of P_1, P_2 and P_3 and the horizontal P_4 ($\theta = 0^0$). It is directed to a direction like this. 

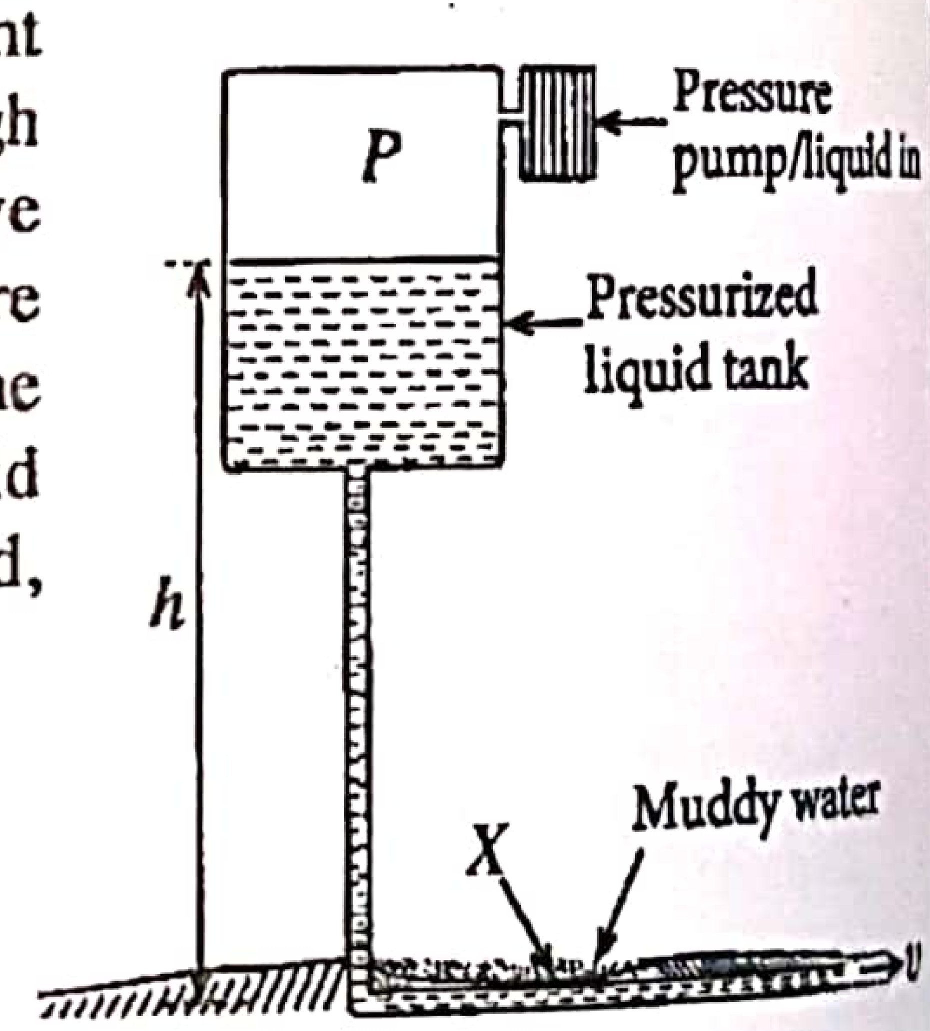
No need to consider about other directions. Consider about this direction.



Now draw P_4 vertically upwards ($\theta = 90^0$). Now the resultant of P_1, P_2 and P_3 and vertically upwards P_4 is considered, we can see that the final resultant is more towards upwards. 

Now if we consider this direction and $\theta = 0^0$, then you will be just happy. Do you need to see that $\theta = 180^0$? Actually, the direction of the resultant when P_4 is at 180^0 is not the same when the direction of final resultant when P_4 is at 0^0 position. But as $\theta = 180^0$, there is no need to look. Angle at $\theta = 180^0$ means an opposition to the push from the water to the boat. That means the boat goes to the opposite side. It cannot happen. If so, then the direction of P_2 will be changed.

25. A pipe line laid horizontally carries a liquid of density d at a constant speed v from a pressurized large over-head tank. Pipe line passes through a shallow region of muddy water as shown in the figure. Pressure above the liquid surface in the over-head tank is P and the atmospheric pressure is P_0. Suppose a small crack has been developed on the pipe at X. The condition for muddy water to seep into the pipe is (Assume that the liquid level in the tank is maintained at a constant height h from the ground, and that the seeping of muddy water does not change the speed v.)



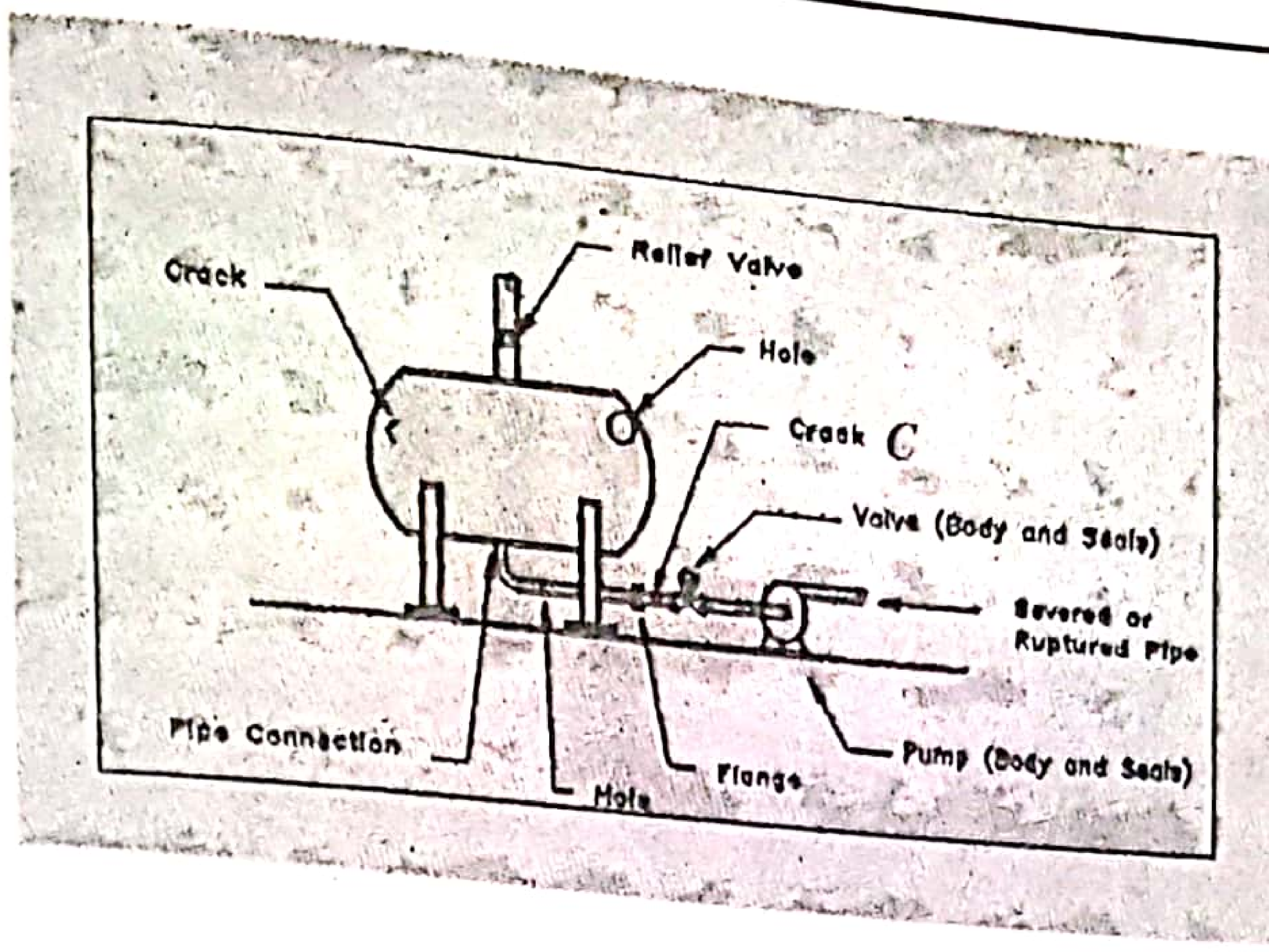
(1) $P + P_0 < hdg + \frac{1}{2}dv^2$ (2) $hdg - \frac{1}{2}dv^2 < P_0$

(3) $P + hdg - \frac{1}{2}dv^2 < P_0$ (4) $P + \frac{1}{2}dv^2 + hdg < P_0$

(5) $P + hdg < P_0$

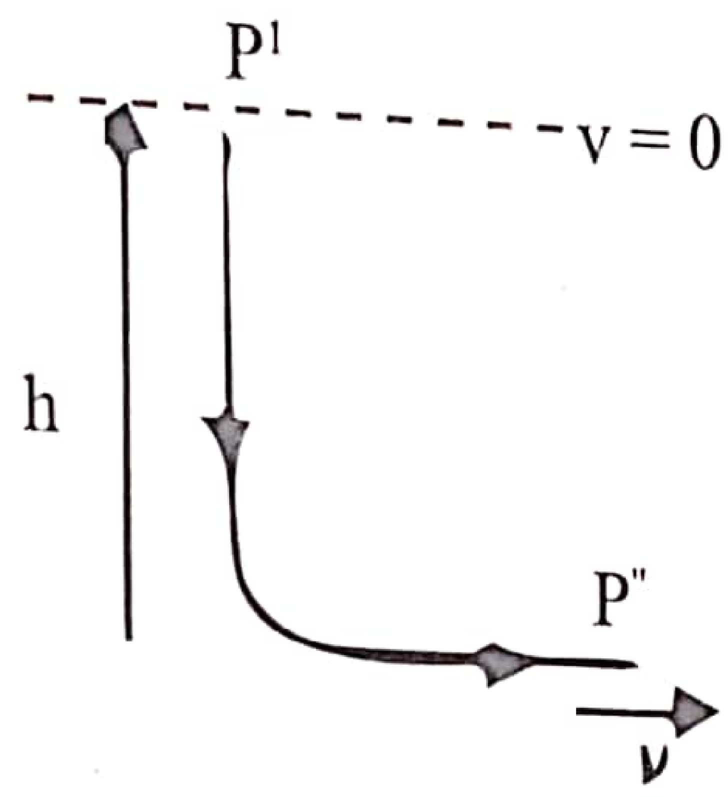
Hydrodynamic

Think that there is small crack at point C in the tube that flows the liquid outside of a big barrel which is filled with a liquid of density ρ. If you see such a thing, then you should remember Bernoulli's theorem. We will apply Bernoulli theorem to a stream line that goes towards a near point of the liquid in the crack at point C from a point in the liquid surface of the barrel. As it is a big barrel, we can consider that the speed of the liquid surface which goes down as zero (as it is a small value). However, we do this assumption in Bernoulli problems. The pressure above the liquid surface is P' and the potential energy term is $h\rho g$. If the streamline near the crack of C has a pressure P'', then when Bernoulli's equation is applied P'' can be written like this way.



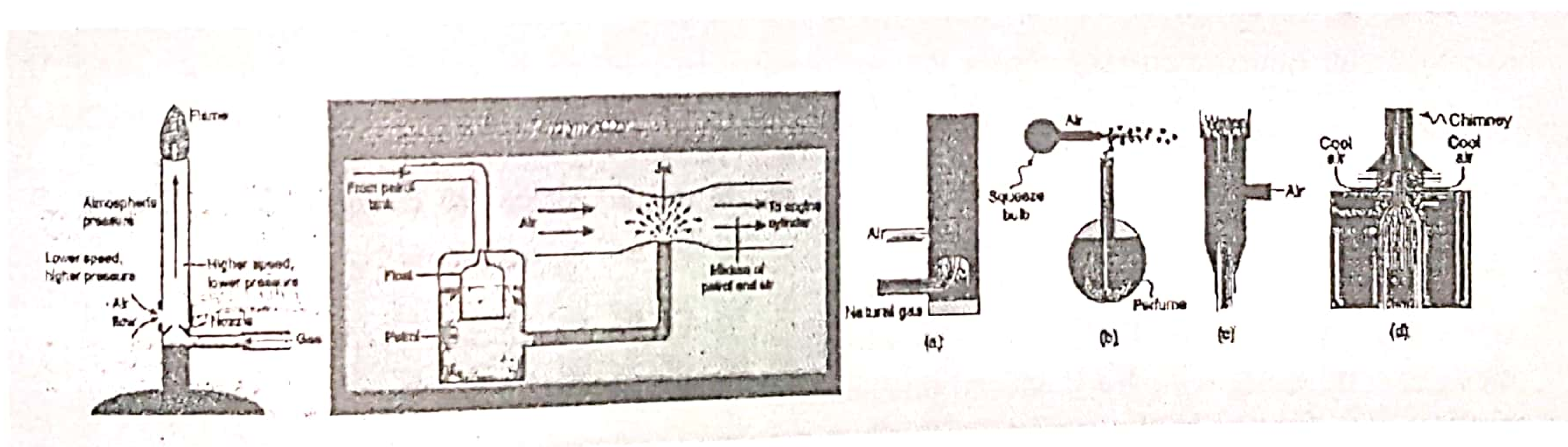
$p' + h\rho g + 0 = P'' + \frac{1}{2}\rho v^2 \rightarrow P'' = P' + h\rho g - \frac{1}{2}\rho v^2$

You can consider the outside pressure of the crack as the atmosphere pressure π. Therefore, if the air from the atmosphere is coming inside of the tube, then $P'' < \pi$.

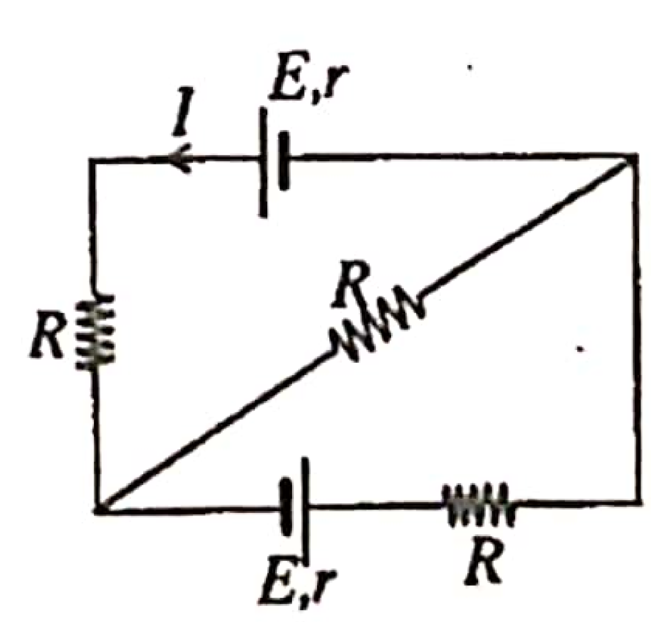


When such cracks are occurred in underground water flowing tubes, the outside things like mud water, bacteria etc. come into the tube. As there is water flow in the tubes, the pressure of water can be lesser than the atmospheric pressure. Then what happens is, what is outside will come to the inside of the tube. Therefore, small cracks are dangerous than bigger cracks. We repair bigger cracks as water come out in them. But nobody cares about smaller cracks.

The smaller cracks in the heart also hurt more than the bigger cracks. The dirty water is outside the crack. As it is a thin layer which is at rest, the pressure outside the crack can be considered as the atmospheric pressure, π.



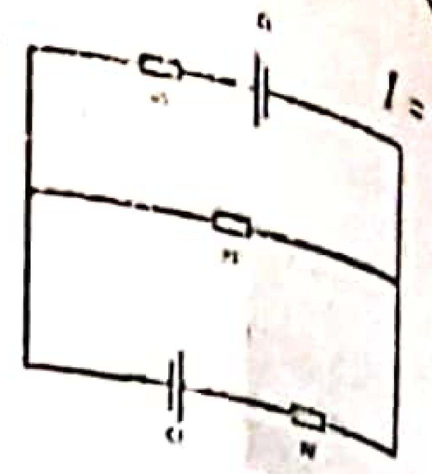
26. In the circuit shown, each cell has e.m.f. E and internal resistance r. Current I is given by



(1) $\frac{2E}{R+r}$ (2) $\frac{2E}{4R+r}$ (3) $\frac{E}{2(R+r)}$

(4) $\frac{E}{R+r}$ (5) 0

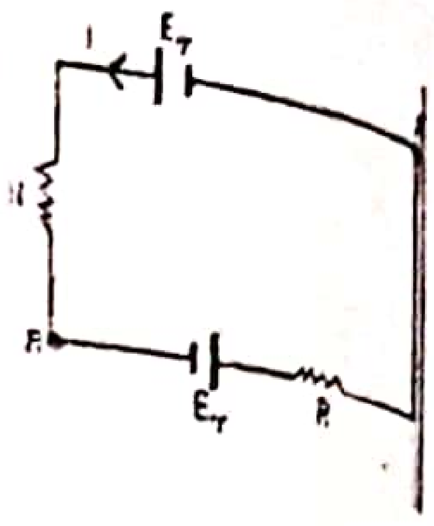
Think that we need to find the current across the cell in the following circuit. The calculation is simple if you see that there is no current flow in the middle resistor. Then that resistor can be removed and consider the circuit again. That circuit is shown on the right side.



If I is the current across the circuit, then

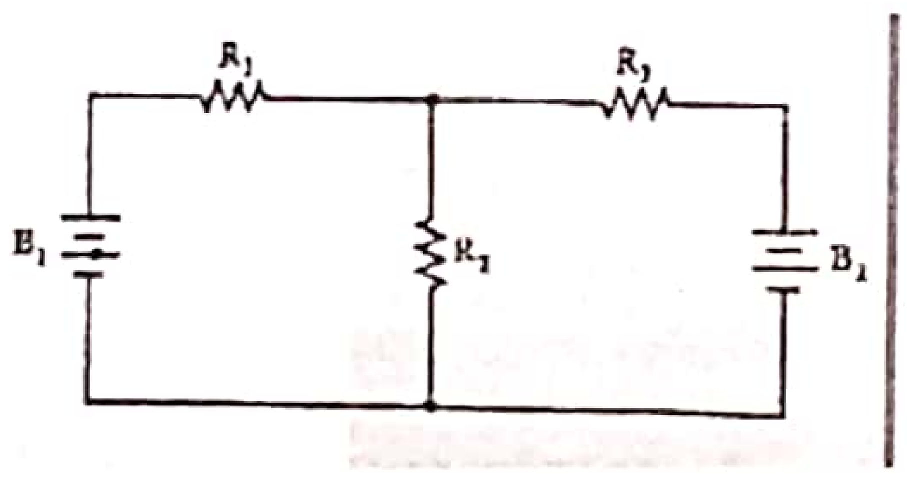
$I = 2E/2(R + r) = E/(R + r)$

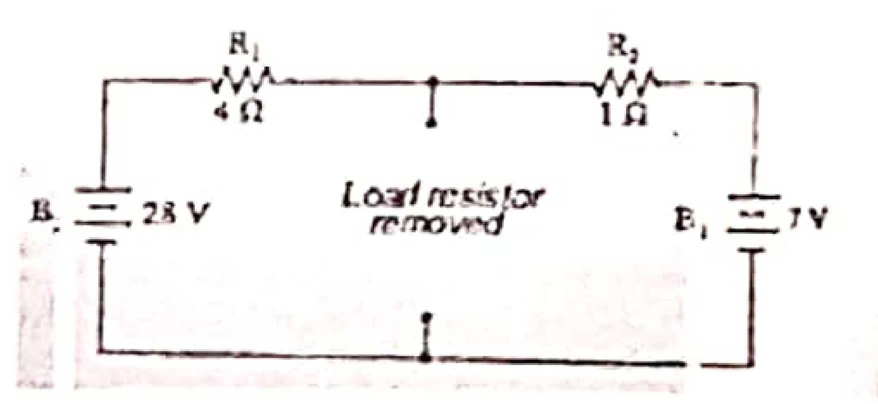
The potential difference between A and B $= V_{AB} = E - I(R + r) = E - E/(R + r).(R + r) = 0$



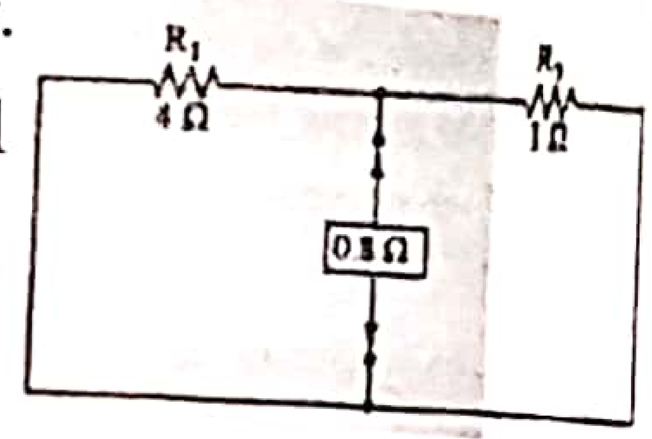
Therefore, when a resistor is connected across A and B points, there will not be a current flow. However, if we think that there is a current flow in the middle R, then you need to write two equations using Kirchhoff's second law and then find I. It will take some time to find I as a result. So, in such questions you need to think out of the traditional way. Another fact that you can check is that the given circuit is symmetrical around AB line. If so, then there is no current in the resistor that is across the symmetric axis.

A removal of a necessary resistor and solve the circuit questions is done according to a certain method. It is called as Thevenin Theorem. Even though this system is not in the syllabus, it is not a difficult method. Think that we need to find the current across R_2 in the circuit. First, you need to remove R_2 and consider the circuit. It is shown on the right side.

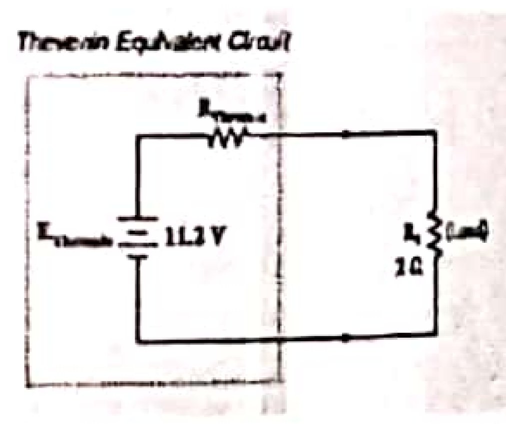




Now let us find the potential difference between the two ends of removed resistor. It is known s $E_{Thevenin}$. $E_{Thevenin} = 28 - \{(28 - 7)/(4 + 1).4\} = 11.2$ V. Next, remove all the cells and find the equivalent resistance acorss the ends of the removed resistor. Then the circuit will look like this way.

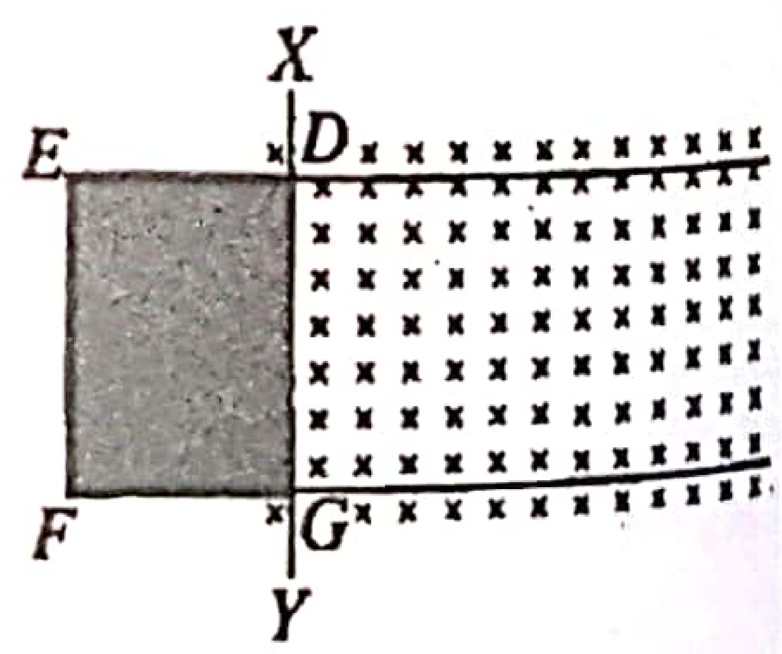


This is equivalent resistance is known as $R_{Thevenin}$. $R_{Thevenin} = (4 \times 1)/(4 + 1) = 0.8\ \Omega$.
Now we will complete the circuit using $E_{Thevenin}$ and $R_{Thevenin}$.



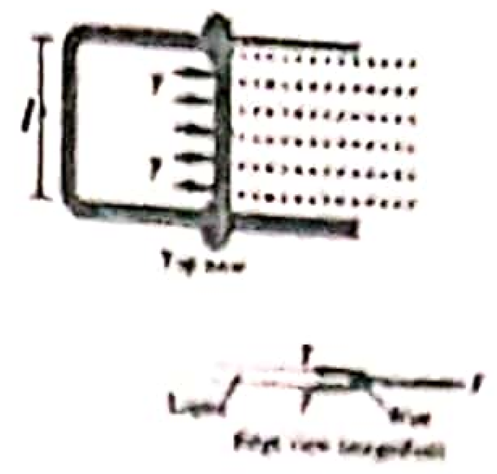
Now you can find the current across R_2 very easily. In the previous question, I have found $E_{Thevenin}$ by removing the middle R. As it is zero, when the middle R is added to the Thevenin equivalent resistance, the current across it also has become zero.

27. The part of a smooth horizontal loop *CDEFGH* in the figure consists of a non-conducting part *DEFG* and two conducting rails *CD* and *GH*. A thin straight conducting wire *XY* is placed on the rails and a soap film of surface tension *T* is formed in the region *DEFGD*. A magnetic field of flux density *B* is applied in the direction shown. The magnitude and the direction of the current needed to setup through *DG* in order to hold the soap film stationary is



(1) $\frac{T}{2B}$ in the direction of $D \rightarrow G$.
(2) $\frac{2T}{B}$ in the direction of $G \rightarrow D$.
(3) $\frac{2T}{B}$ in the direction of $D \rightarrow G$.
(4) $\frac{4T}{B}$ in the direction of $G \rightarrow D$.
(5) $\frac{4T}{B}$ in the direction of $D \rightarrow G$.

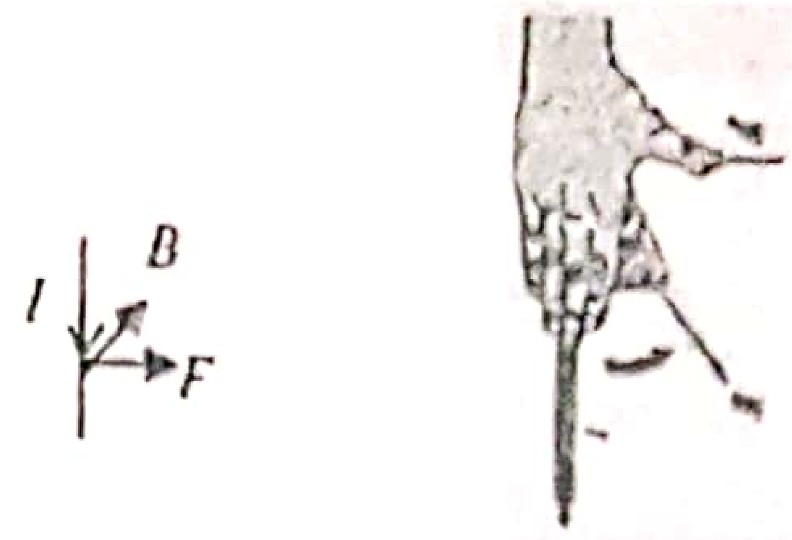
To the wire part of length l, the surface tension force is acted by the soap film to the left side. It is 2γl. There 2 as there are two free surfaces to the soap film. To keep the wire at rest, IlB force should be acted to the right side. As the magnetic field is directed into the paper, the current should flow downwards on the wire, when IlB force is needed to be acted on the right side.



Keep the thumb of right hand perpendicular to the other fingers and rotate those fingers from I to B. Then the thumb is directed to the right side.

$2\gamma l = IlB \rightarrow I = 2\gamma/B$

If the rest of the part surrounded by the film is conducting, then the current can flow across that part too. The 55[th] question of paper 2007 is also a question like this. Here the rest of the part surrounded by the film is a conductor. Therefore, the current flows across that part too.

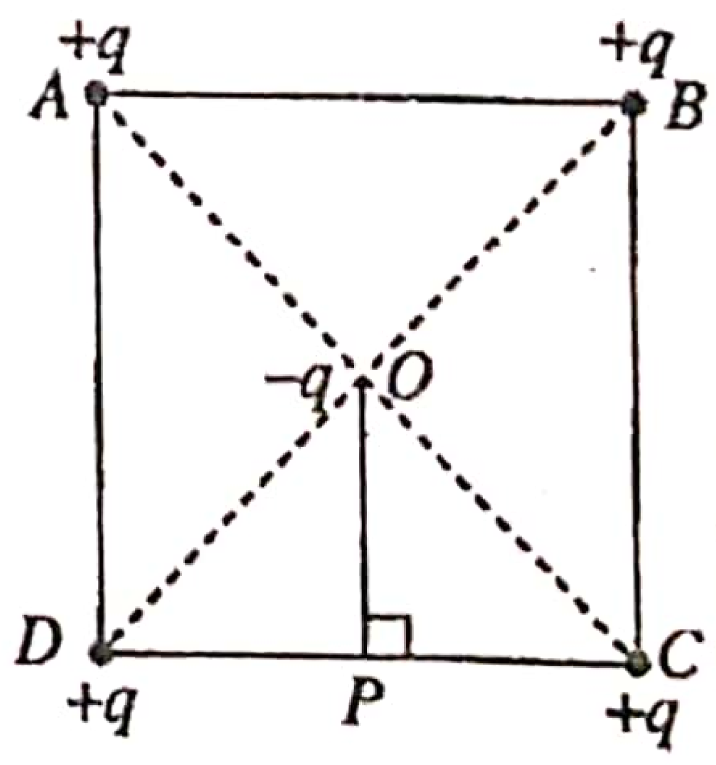


28. If the coefficient of viscosity of all fluids is reduced below the existing value without reaching the condition for turbulence, which of the following is **not** true?
   (1) Liquid flow rates in narrow tubes will be higher.
   (2) Heart may have to do less work to pump blood.
   (3) Sucking cool drinks using a straw is easier.
   (4) Resistance due to air drag on moving motor cars will decrease.
   (5) Terminal speeds acquired by rain drops will become smaller.

Viscosity **10**

When the viscosity is reduced, the liquid flow rate in narrow tubes gets increased ($\frac{Q}{t} \propto \frac{1}{\eta}$). You can think this from your general knowledge also. When the viscosity is reduced, the flow is very easy. Can you suck kithul treacle from a straw? Treacle has a high viscosity. When the treacle is heated, the viscosity is reduced. When η is reduced the produced resistant forces from the viscous forces are reduced. When rain drops fall, they acquire terminal speed when the weight of a rain drop is equal to the total of its upthrust and viscous force. Therefore, when the viscosity is reduced, it takes time to acquire terminal speed. That means the acquired terminal speed is a bigger value.

29. Four charges each of $+q$ are fixed at the vertices of a square $ABCD$ as shown in the figure. A movable particle with charge $-q$ is placed at the centre O of the square. If the two charges at A and B are vanished simultaneously, which of the following is **not true** regarding the movement of the particle with charge $-q$? (Neglect the gravitational effects and the air resistance on the particle.)



   (1) It will begin to accelerate in the direction OP.
   (2) Speed of the particle becomes maximum at P.
   (3) Once it arrives at P from O, it will move a further distance of magnitude OP along OP direction.
   (4) It will always have maximum acceleration at P.
   (5) It will again return to O.

Electric Field Intensity coloumbu's Law **04**

Consider three charges which are kept at the three corners of a triangle. The figure has shown the forces that act on the -q charge. The resultant of two forces is directed towards AP. The horizontal components are cancelled off with each other. Therefore, if the charge can go freely, it will accelerate towards AP. When it passes P, the resultant of forces acts vertically upwards. Therefore, when the maximum velocity is obtained at P by the charge it will be subjected to deceleration. Initially, the velocity of the charge was downwards.

When it passes P, the resultant force is opposite to the direction of the velocity.

The motion of the charge indicates a simple harmonic motion. It is enough if you understand that. In a simple harmonic motion, the acceleration is not maximum at the middle position. The acceleration is maximum at the ends (amplitudes). When P is passed due to deceleration, the velocity is reduced and when a distance of AP is gone downwards, the velocity suddenly gets zero. The charge again starts to travel upwards. If you understand the motion of the charge as a simple harmonic motion, then everything can be seen easily.

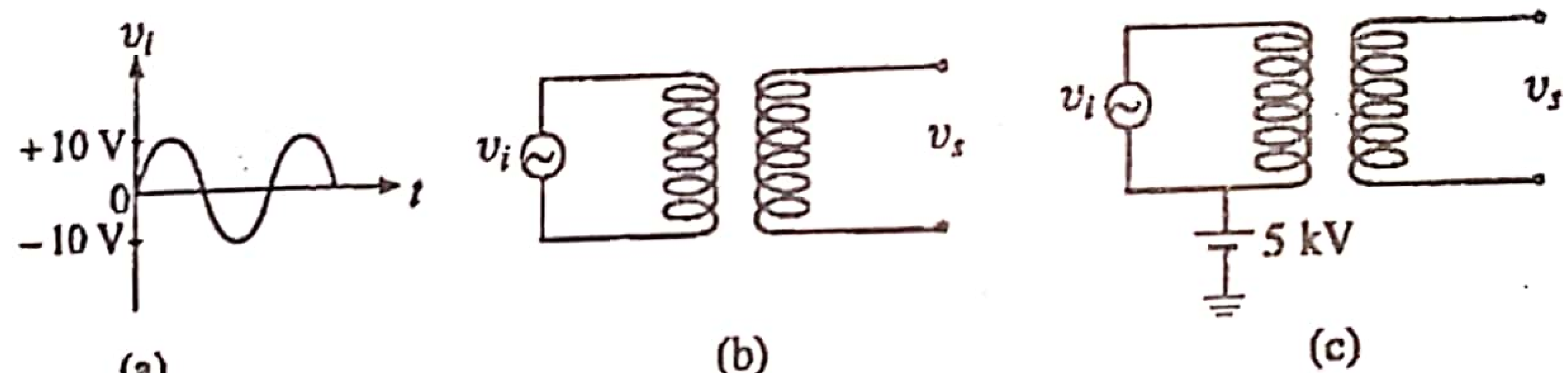
Even though equations are unnecessary, we will write them. The forces are acting like this if the charge is at x distance from P (↑)

If we apply F =ma downwards, then 2 F cosθ = - ma (x is measured from bottom to top. The resultant force is downwards.)

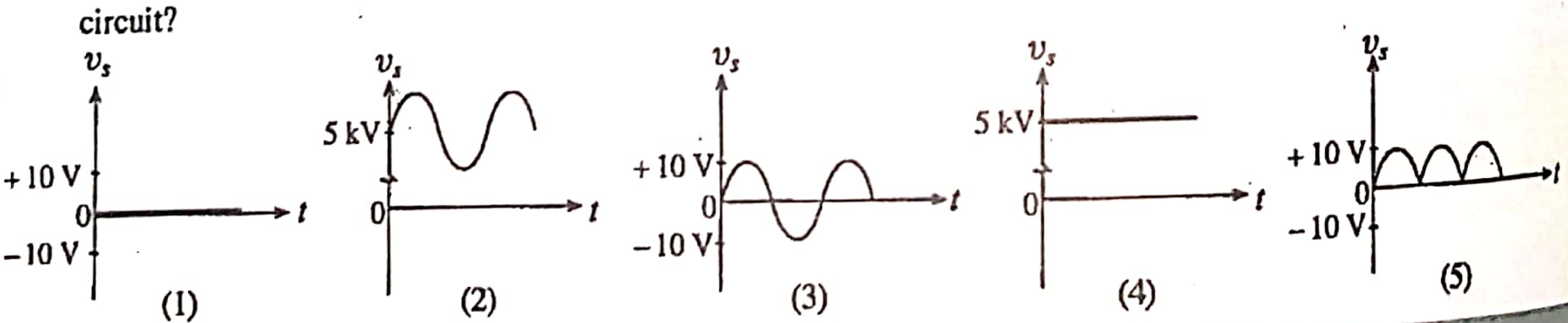
$$2.\frac{1}{4\pi\varepsilon_0}.\frac{q^2}{(d^2+x^2)}.\frac{x}{\sqrt{(d^2+x^2)}} = -ma$$

Even though it is not simple harmonic (as it is not like $a = -\omega^2 x$), it is harmonic. When x =0, a =0. At P, the acceleration of the charge is zero

30. As shown in the figure (b), an alternating voltage source v_i producing the voltage waveform shown in figure (a) is connected to the primary circuit of a transformer. The primary circuit is now connected to a dc potential of 5 kV as shown in figure (c). Assume that the primary coil is well insulated electrically from the secondary coil.



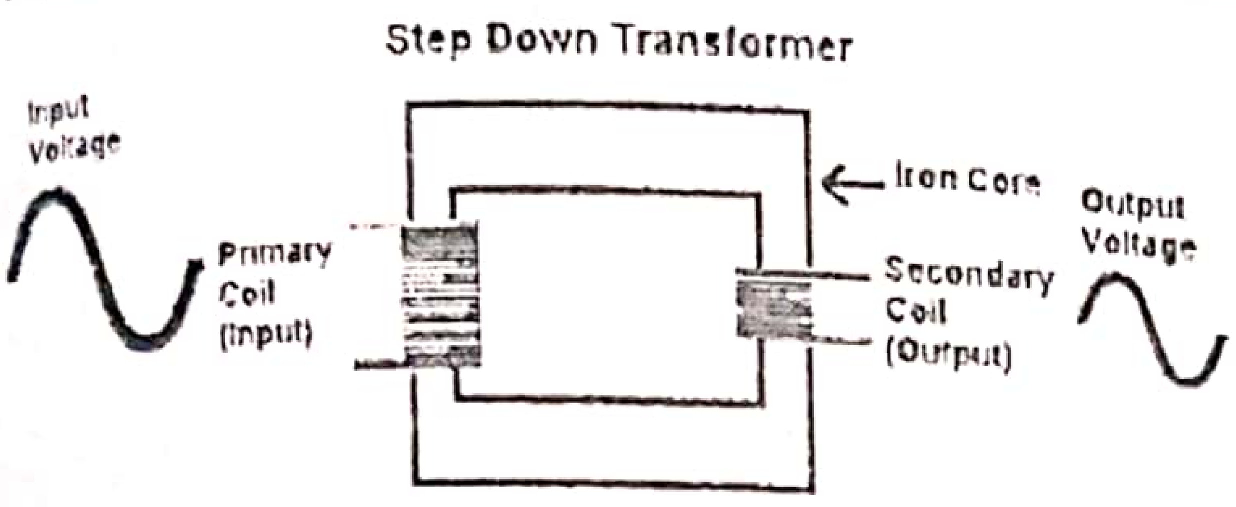
Which of the following figures correctly represents the voltage waveform v_s in figure (c) of the secondary circuit?



Mutual Induction

Transformers work on alternative voltages. The variation of the primary is only being used to induce the secondary. The secondary reacts to a change not to stable things. Many people also react most of the time to the changes of the environment. The secondary does not know if a direct current voltage is applied to the primary. If you think like this, then you can understand this in a simple way. Think that the primary is not connected to an alternating voltage. Then will the connecting direct current source is felt by the secondary? As both are not touched how can it feel? How can you feel a direct current source without being touched? Males and females react even if they are not touched. That is because we have feelings.

If we consider that the number of turns is equal in the primary and the secondary, then the variation of the primary is induced in the secondary as it is. According to the number of turns ratio, if it is a step-up transformer, then the voltage is increased in the secondary. If it is a step- down transformer, then it is reduced. If there is no such an increment or a reduction, then you need to take the number of turns ratio as 1. If the primary coil is not touched by the secondary coil and it is insulated properly with the secondary coil, then the direct current source



Consider a step-down transformer. When an alternating voltage is applied, we know that there will be less alternating voltage which will be induced in the secondary.

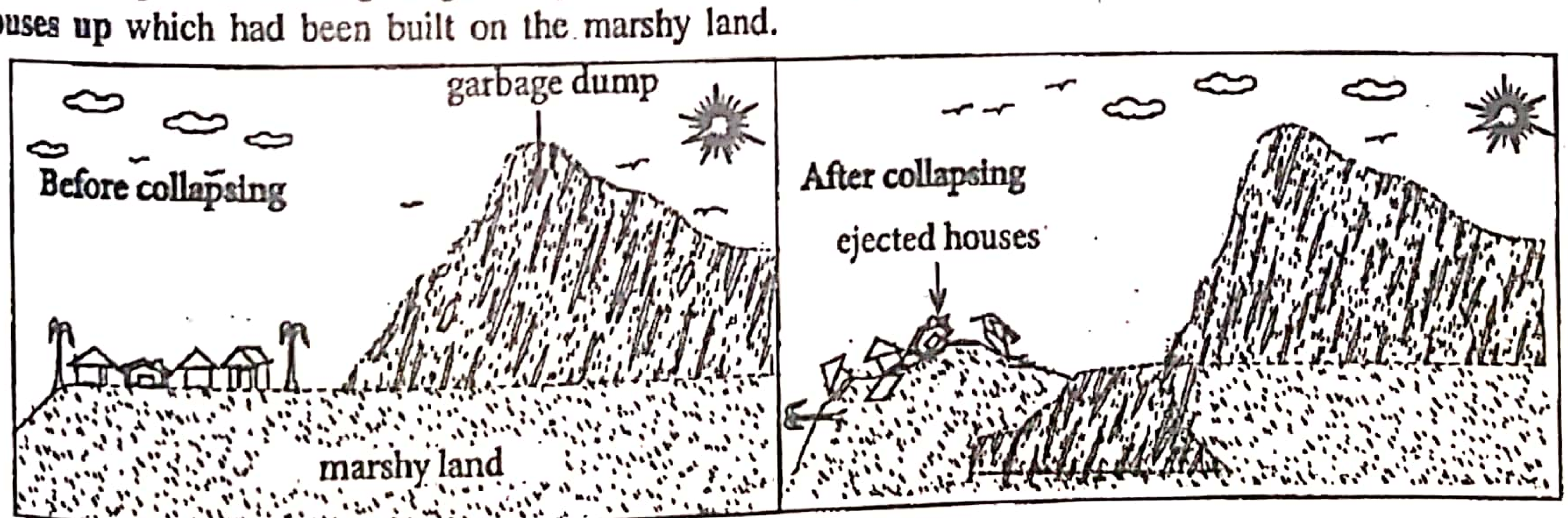
Now think that there are two plates instead of two coils. When there are plates, you will feel as an abnormal question. Even there are plates instead of coils, does not the secondary pick the primary a little? The difference is that there is a very good flux bond between the coils and the transformer core.

If there are plates instead of coils, then as the left plate is connected to the alternating voltage source, the magnetic flux around the plate will vary with time. If there is a second plate in the area of magnetic flux variation, then there will be an induced alternative voltage on it.

The magnitude of the induced voltage is reduced. But it is induced. Even though the answer is simple, the arguing can be unfamiliar. If a capacitor is given instead of two plates, then you will be tempted to think in a complex way. If needed, then you can forget about the word capacitor. It is enough to consider two plates that are closer to each other. If you consider as just two plates, then thinking is easier.

Clearly, a less voltage is induced in the secondary plate compared to the primary plate. But if the magnitudes are not needed to be shown, then you do not have to worry about it.

31. **Part of a huge man-made garbage dump on a large marshy land suddenly collapsed and sank ejecting nearby houses up which had been built on the marshy land.**



Which of the following physics principles that you have learnt is most suitable to understand the ejecting the houses up?

(1) Principle of flotation
(2) Principle of conservation of momentum
(3) Archimedes' principle
(4) Pascal's principle
(5) Principle of moments

On 19th February 2018, part of a mountain of garbage in Mozambique was collapsed and killed people. In Sri Lanka, such a thing cannot happen forever. The pressure created by the collapse of the garbage mountain has transmitted to the neighborhood houses in the marshy land. The most suitable principle to describe this phenomenon is Pascal principle. As it is not a closed and uncompressed fluid, the generated pressure difference will not be equally transmitted. It is true. But there is some pressure transmission.

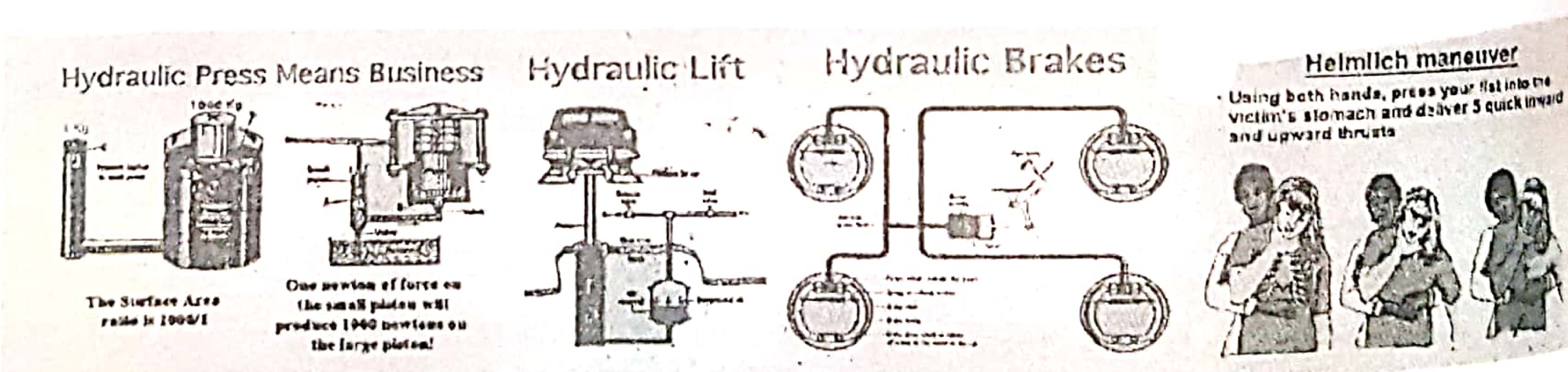
Therefore, the most suitable answer is Pascal principle. As there is no need of a calculation, the consideration of unequal pressure transmission is not necessary. Many people suspect about Archimedes principle but it cannot explain why other parts are risen when a part is pulled from one side. When a part of the mountain is collapsed and sunk in the marshy land, the marshy land can be risen from another place. If an object is drowned in the water of a closed container, then it is natural to see that the water level is rising. But the foundation of this phenomenon, which is the rising of the houses occurs due to the sudden pressure.

All you need to know is why these houses are risen like that. Rise of water due to the partial collapse of the mountain can happen by the rise of water only through the houses. In a big marshy land, the rise of water to a greater height cannot happen.

Pascal principle can be applied only for a closed system. There can be an argument that whether it can be applied on a marshy land (as it is not an uncompressed fluid). The above argument is valid when applying calculations, but to explain this phenomenon Pascal principle is the most suitable one. There is no argument in it. It can be thought that there can be a contribution from the principle moments to a certain amount but I cannot find an axis to rotate. The floating principle is needed for floating objects.

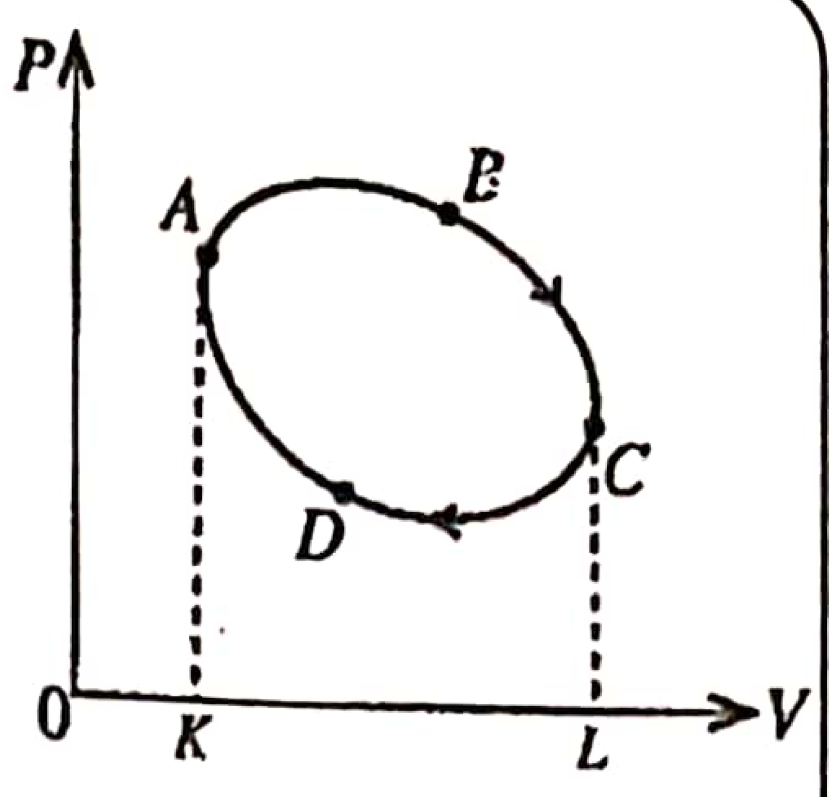
The conservation of momentum is not relevant for this what so ever. Due to a partial collapse, the stones or solid materials that are hit with that part can be thrown away. They cannot be thrown away opposite to the direction of the collapse.

There are many instances where Pascal principle is applied such as hydraulic press, hydraulic lift, hydraulic breaks



Finally, it is shown that when something is stuck in the throat or esophagus, how some sudden thrusts are given to the stomach. This is called as Heimlich maneuver. Heimlich was a throat surgeon. Pascal principle is really responsible of hitting the back when something is stuck in the throat and spread of toothpaste from the top when it is squeezed from the bottom.

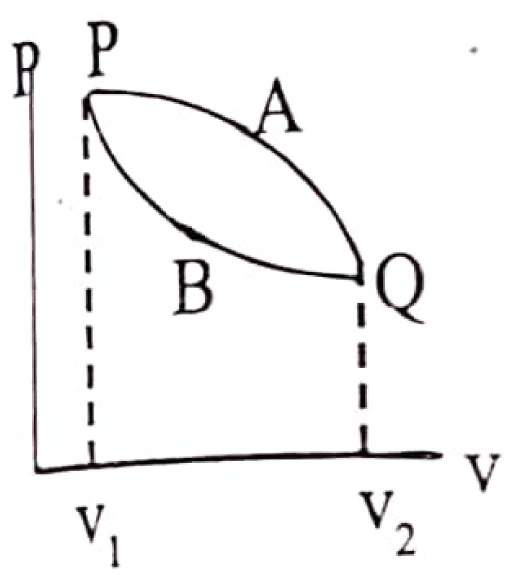
32. A certain mass of an ideal gas is taken from A through a cyclic process $ABCDA$ as shown in the P–V diagram. Which of the following is **not** true?



(1) Work done by the gas through the section of the path ABC is equal to the area $ABCLKA$.
(2) Net heat absorbed by the gas after completing the cycle is zero.
(3) Net work done by the gas after completing the cycle is equal to the area $ABCDA$.
(4) Net change in internal energy of the gas after completing the cycle is zero.
(5) Net change in temperature of the gas after completing the cycle is zero.

Thermodynamics **04**

Such cyclic processes can be seen in many books. Look at the 29th question of paper 2000 and the 53rd question of paper 2001. Simply, you need to look into this fact. As PAQBP has a net non-zero area according to the cyclic process (ΔW has a net value), ΔQ cannot be zero anytime for the cyclic process. If so, then ΔU cannot be zero for the cyclic process. There is a net work in the cyclic process. A positive work has been done. The arrow of the process is in clockwise direction. When going across the section of PAQ, the work done by the gas is equal to the area of $PAQV_2V_1P$.



ΔW_1 is positive. When going across QBP section, the work done by the gas is given by the area QV_2V_1PBQ. ΔW_2 is negative. As $\Delta W_1 > \Delta W_2$, the net work is positive. By the end of the cyclic process, we know that the net internal energy difference is zero. This fact has been checked many times. $\Delta U = 0$. Then according to $\Delta U = \Delta Q - \Delta W$, if $\Delta U = 0$ and ΔW is positive, then for ΔU to be zero, then ΔQ cannot be zero. ΔQ should be positive. That means net heat absorption should be there. The net heat cannot be zero at any time.

Can you tell something about the temperatures of points P and Q? That cannot be said exactly. If the pressure and the volume of P is P_P and V_P respectively, and the pressure and volume of Q is P_Q and V_Q respectively, when $P_PV_P = P_QV_Q (=nRT)$, then the temperatures of P and Q becomes equal. That means points P and Q should be placed in an isothermal curve (PV curve). But if it starts from point P and comes back to point P, then there cannot be a temperature change. The internal energy of an ideal gas depends upon on temperature only.

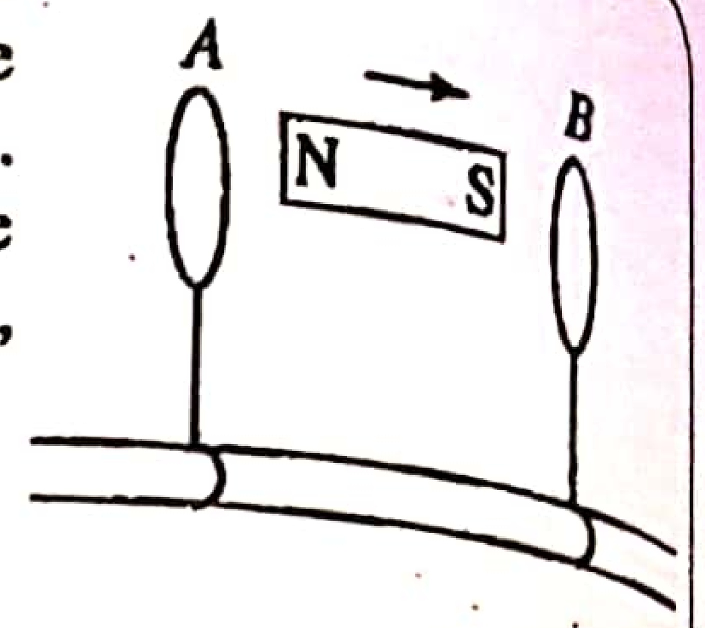
33. A flute maker produces a flute in a location where the speed of sound in air is $330\ ms^{-1}$ so that when the note A is played, it occurs exactly at 440 Hz. A flutist plays note A with this flute in a different location where the speed of sound in air is $333\ ms^{-1}$. If a tuning fork of 440 Hz is sounded simultaneously with the note A of this flute, at the new location, how many beats per second will the flutist hear?
(1) 2 (2) 4 (3) 8 (4) 10 (5) 12

Wave Properties **03**

Two identical flutes produce fundamental notes of frequency 440 Hz at 27°C. If the temperature of air in one flute is increased to 32°C, determine the number of beats heard per second. (The speed of sound in air at 27°C is $330\ ms^{-1}$.)

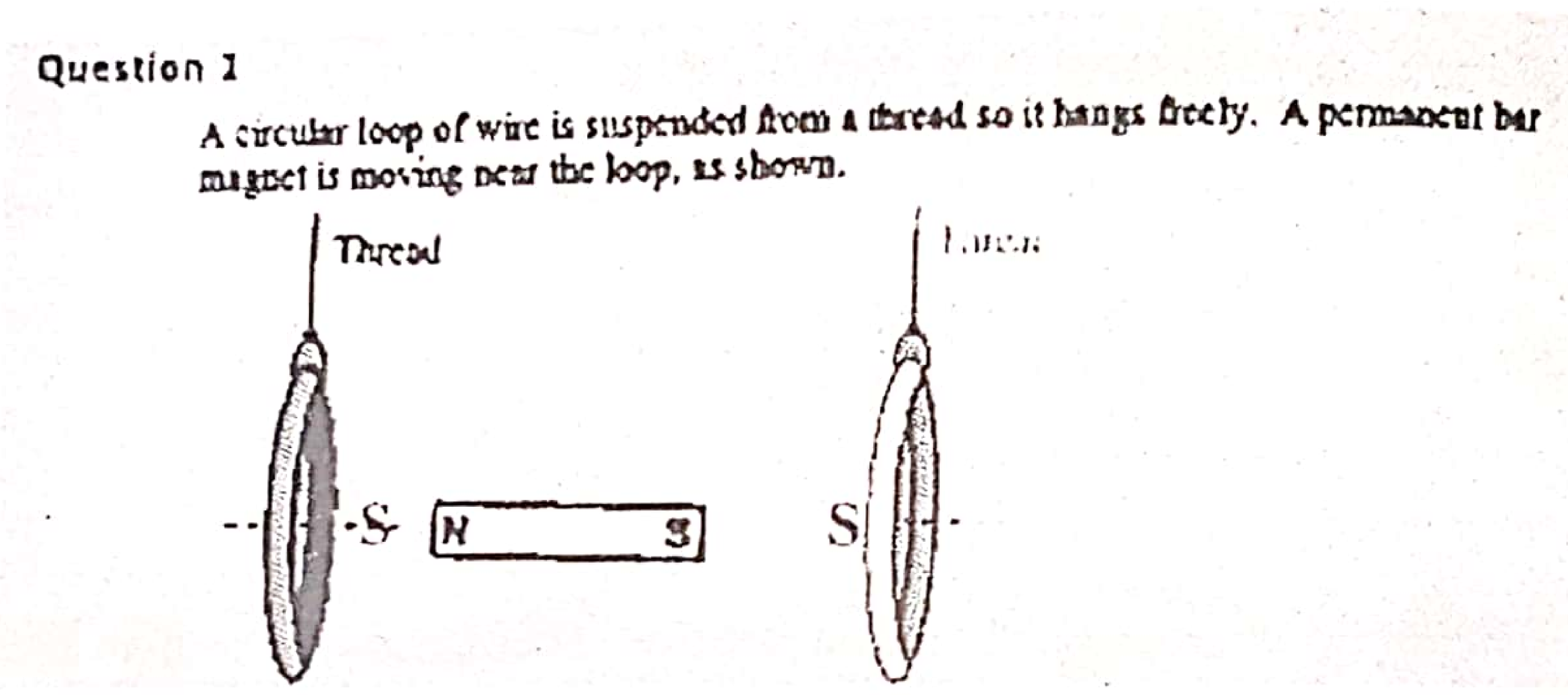
Do not go for longer calculations. Try to solve from the proportionality method. When the temperature of the air is increased, the speed of the air, v is increased As $v \propto \sqrt{T}$, $v_{305}/v_{300} = \sqrt{\frac{305}{300}}$; $v_{305} = 300\sqrt{\frac{305}{300}}$. Once this is simplified, you will get an approximate value for v_{305} as $333ms^{-1}$. The length of the flute (the net length for the note) has not been changed. Therefore $v \propto f$. So, $333/330 = f/440$. Simplify this directly. Zero to zero will be cut off. 11 by 3 is 33 and 11 by 4 is 44. 333 divided by 3 is 111 and 111 multiplied by 4 is 444. Therefore, the beat frequency with 440 Hz will be (444-440) Hz = 4 Hz. The calculation is simple. If the speed of air at 32°C has been given as $333\ ms^{-1}$, then the calculation will become easier.

34. Two conducting loops *A* and *B*, made of a material that is not attracted to magnets are placed on a frictionless insulated rail as shown in the figure. The loops are free to move along the rail, and the planes of the loops are perpendicular to the rail. The two loops and the bar magnet kept between the loops are initially at rest. The bar magnet is then suddenly moved to the right as shown in the figure. As a result,



(1) both loops *A* and *B* move towards right.
(2) both loops *A* and *B* move towards left.
(3) loops *A* and *B* move towards each other.
(4) loops *A* and *B* move away from each other.
(5) both loops *A* and *B* will remain at rest.

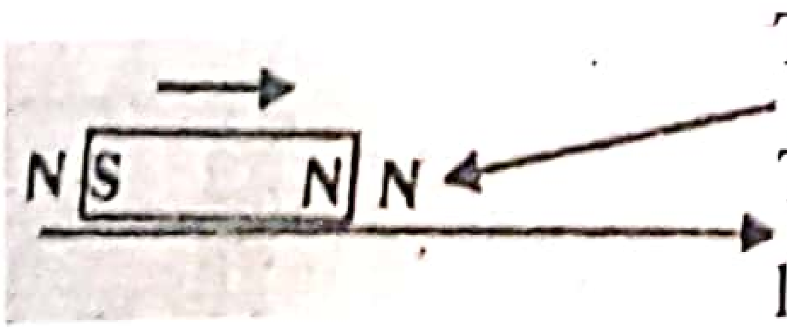
Consider a bar magnet which is placed in between the freely hanging two loops which are made from Al. When the magnet is moved to the right, what will happen to the loops? You can think of what is happening based on the phenomena of saying 'do not come' when it is coming closer and saying 'do not go' when it is trying to go. Look at the 39th question of paper 2015.


Question 1

A circular loop of wire is suspended from a thread so it hangs freely. A permanent bar magnet is moving near the loop, as shown.

When the bar magnet is travelled to the right side, a south pole (S) will be induced on the left side of the right loop. If a north pole (N) is induced, then as N and S poles are attractive, the magnet will be welcomed by saying please come. This is contradictory to Lens law. Likewise, the north pole N of the magnet is away from the loop of left side, a south pole S will be induced in the right side of the left loop. It tries to get closer to the person who goes away. It does not pull away the person who tries to go by saying 'you go'. Therefore, according to the figure mark the poles that are induced on the left side of the right loop and the right side of the left loop. Then both loops tend to go towards right due to the repulsion of S, S and the attraction of S, N.

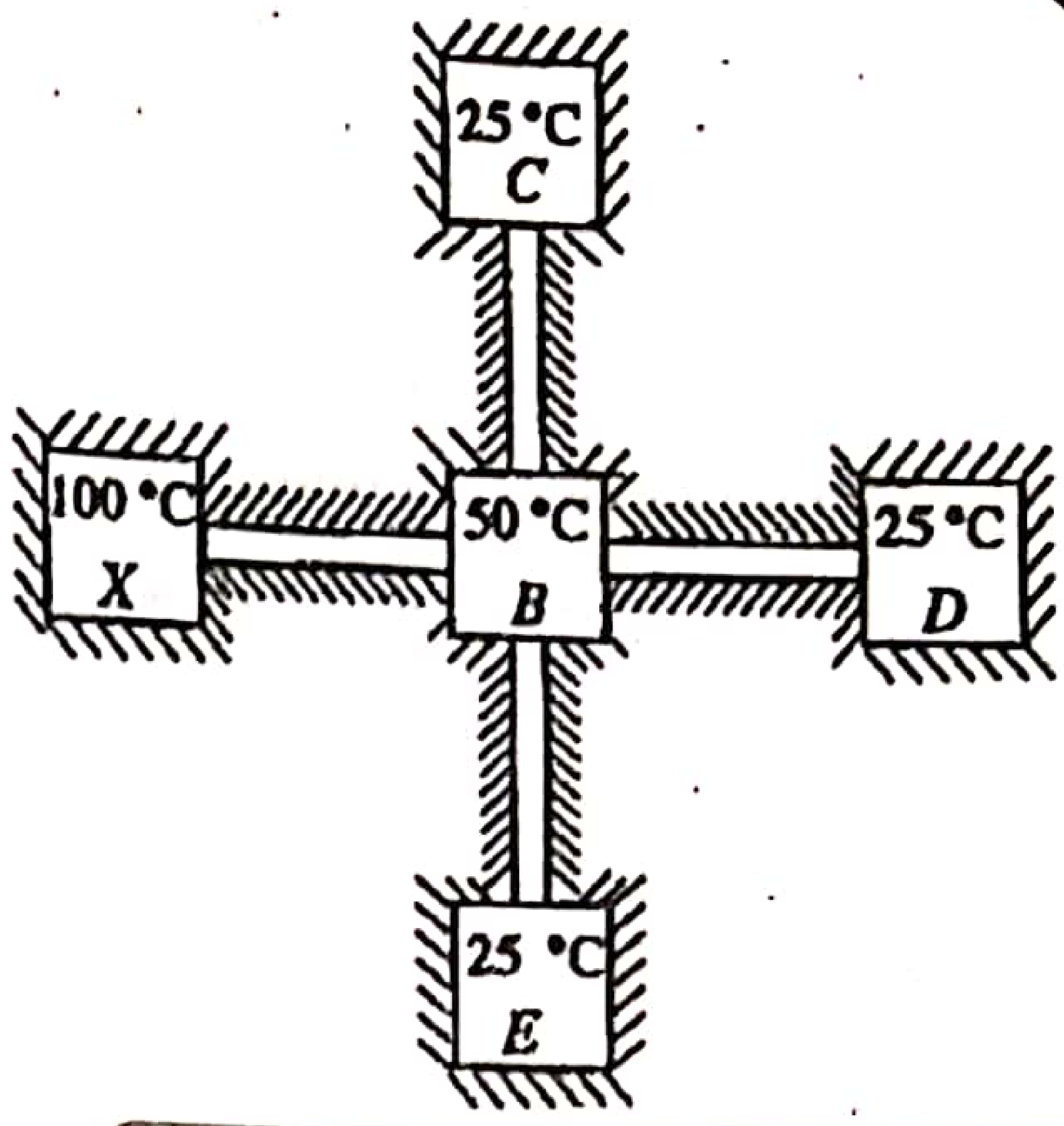
Even if you do not think much, according to the getting closer and getting away theory, the right loop is going away. The left loop tries to get closer. When it tries to get closer, the other loop gets away. When it is trying to get away, the other loop tries to get closer. What to do? This is the nature of samsara. That means both goes to the right side. Even same thing happens if the poles of the magnet is changed. The loops should be made from a material which is not attracted by the magnets. If not, then the loops will be just attracted to the magnet. But the loops should be a conductor. Then there will be induced currents in it. As there is induction, there will be magnetic properties.



Tries to throw away the person who comes closer

Tries to keep the person who goes. So, there is repulsion between N, N (on the loop) → and attraction between N, S (on the loop) ←

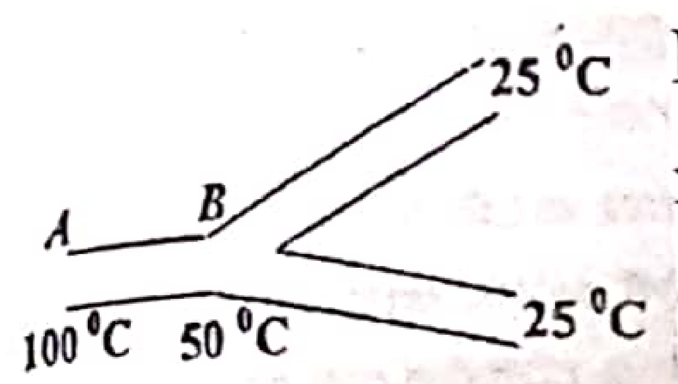
35. Figure shows an insulated network of heat reservoirs X, B, C, D and E of which C, D and E are identical. The reservoir X operating at 100 °C supplies heat and maintains the four other reservoirs B, C, D and E at the temperatures shown. Heat is supplied by connecting the reservoirs with insulated heat conducting rods of same material and having identical areas of cross-section. Lengths of the rods are not drawn to the scale. If the length of the conducting rod between X and B is L, the length of the conducting rod between B and D will be



(1) $2L$ (2) $\frac{3L}{2}$ (3) L

(4) $\frac{2L}{3}$ (5) $\frac{L}{2}$

Conductivity **04**



Look at the 48th question of paper 2005. Think that the heat is divided into two roads (two rods) from the heat supplying rod. Do not go for long calculations. The rods are made from the same material. Even the cross-sectional area is same. Therefore, the rate of heat flow is proportional only to the temperature gradient. If the rate of heat flow is Q from A to B, then $Q \propto \frac{50}{L}$. As the temperature differences of the branches are same (25°C) with same material and cross-sectional area, the lengths of the rods should be equal to each other (L'). They are identical in every way. So, Q that flows through AB should be divided into two equal parts after B. If the rods are divided into three, then Q that flows through AB should be divided into three equal parts after B. If the rods are divided into four, then Q that flows through AB should be divided into four equal parts after B. Therefore, for a divided one rod, $\frac{Q}{3} \propto \frac{25}{L'}$. When the above relation is divided from this, then 3= 50/L X L'/25; L' = 3L/2. Try to minimize the rough work.

36. In an experiment to determine the specific latent heat of fusion (L) of ice using method of mixtures, a student obtained a value for L which is less than the standard value. Reasons for the lower value for L have been explained by the student with following statements.

(A) It may have been due to the dew being formed on the outer surface of the calorimeter while doing the experiment.
(B) Water on the pieces of ice may have not been properly wiped out before adding to the calorimeter.
(C) Temperature of the ice used may have been lower than 0 °C.

Of the above statements,

(1) only A can be accepted. (2) only B can be accepted.
(3) only A and B can be accepted. (4) only B and C can be accepted.
(5) all A, B and C can be accepted.

Calorimatry **04**

I hope children have done the experiment which finds L of ice. The content of the experiment can be argued by studying the relation of emitted heat equals to the obtained heat. The heat is emitted from the calorimeter and the water. The heat is obtained by the ice. It is (the absorbed heat when ice melts + the absorbed heat of 0°C water when it heats till the maximum temperature of the water). If Q_1 is the heat that was absorbed by 0°C water when it heats till the maximum temperature of the water, and if the emitted heat from the water and the calorimeter is Q_2, then we write the relation as $mL + Q_1 = Q_2$

If dew is formed in the outer surface of the calorimeter, then there will be an extra heat given to the calorimeter from that process. When the water vapour turns into water droplets, the heat is removed. If so, then a certain amount of heat should be added to the right side of the equation. It should be considered in the calculation. But if I do not take that extra heat into the calculation, the right-side value of the equation will experience a reduced value. As the emitted heat is not considered when forming dews, the right-side value of the equation is less than the real value. If the right side is reduced, then the left side is also reduced. That means you will get a lower value for L.

If water is remained on ice pieces, then that water has already taken the latent heat. Therefore, actually you need to take a lower value of m compared to the m value which is used for calculation in mL term. But from my mistake, a bit higher value than the real value is substituted for m in mL term (ice + ice which turned into water). When m is taken a higher value, you will get a lower value for L. Even when finding L, it should be divided by m and when m is unnecessarily increased then L is reduced.

If the used ice is remained in a value less than 00C, then another term should be added to the left side of the above equation. For example, if ice was at -50C, then to reach towards 00C, heat amount of $mc_{ice}[0-(-5)] = mc_{ice}5$ should be absorbed. So, this term also should be added to the left side of the equation. But I do not consider that. Therefore, the left side is reduced. When the left side is reduced, you will get a higher value for L. If a term on the left side is ignored, then to balance the equation the value of L should be greater.

What will happen if all these three happen? Then can you talk accurately about the obtained value of L (more/less)? From two phenomena L is reduced. From the other one L gets increased. If you have luck, probably you will get a correct value for L. Therefore, these statements should be considered differently and independently with each other.

Look at the 56th question of paper 1991. All these are true here. If more time is consumed to melt the ice, then there can be heat from the surroundings which can be obtained by the calorimeter. If so, then a certain amount of heat should be added to the right side of the equation. It should be also considered in the calculation. But as I do not add that extra heat for the calculation, the right-side value of the above equation will experience a reduction. That means you will get a lower value for L.

37. A person wearing sweated clothes of temperature 35 °C has to enter to one of the three large closed rooms *X*, *Y* and *Z* which are maintained at 40 °C, 35 °C and 20 °C, respectively. Assume that all the rooms are saturated with water vapour. Consider the following statements.

(A) If the person enters the room *X*, initially some of the sweat will begin to evaporate.
(B) If the person enters the room *Y*, sweat will not evaporate.
(C) If the person enters the room *Z*, initially some of the sweat will begin to evaporate.

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.

Hydrometry 04

If tea water in a tea cup is saturated with sugar, then more sugar can be dissolved by heating the tea water. Or else by adding more tea water. If you like to drink sugar, then you need to dissolve sugar in hot tea water. Likewise, in a certain temperature if a closed volume is saturated with water vapour, then addition of more water vapour can be done by increasing the temperature of the room (as if the volume of the room cannot be expanded).

Let us consider that the temperature of the wet clothes as θ_1. Each room is saturated with water vapour. This fact is the most relevant factor here. By increasing the temperature, you can increase the absolute humidity of air (water vapour mass in a unit volume) if needed. When clothes in θ_1 temperature are brought to a temperature of θ_2, if $\theta_2 > \theta_1$, then the temperature around the clothes will not go beyond θ_2. For a little time, the temperature around the clothes will be greater than θ_1 but it will be less than θ_2. In the temperature of θ_2, the room is saturated with water vapour. The room or the nearby air of clothes will not be unsaturated even if the temperature around the clothes is less than θ_2. If you think in another way, then the relative humidity of all three rooms is 100%.

Therefore, even if the temperature of rooms gets reduced, the relative humidity remains in the value of 100%. The relative humidity can be reduced by increasing the temperature.

The surrounding s filled with water vapour (100%). Therefore, more water vapour can be added if the temperature is increased.

When clothes in θ_1 comes to the room of temperature θ_1, there is no change in the temperature. When clothes in θ_1 comes to the room of temperature θ_3, if $\theta_3 < \theta_1$, then θ_1 clothes around the temperature which is for a little time, gets increased than θ_3. It is less than θ_1 and greater than θ_3. Therefore, the air around the clothes gets unsaturated for a small time. The room is saturated at θ_3. So, when the temperature is increased, more water vapour can be added. This can be thought like this way. If little bit of 30°C water is added to a tea cup that is saturated with sugar at 50°C, then still the tea cup is saturated with sugar as the temperature of the mixture will be less than 50°C. Little bit of water was added to keep the volume of tea water unchanged.

But if little bit of 35°C water is added to a tea cup that is saturated with sugar at 20°C, then bit more sugar can be dissolved as the temperature of the mixture will be little higher than 20°C.

If you think in a simpler way, then you need to think like this way. As the rooms are saturated with water vapour, a part of a room should be made unsaturated with vapour if you need to vaporize even a little bit sweat. To do so, the temperature of that place is needed to increase even for a small time.

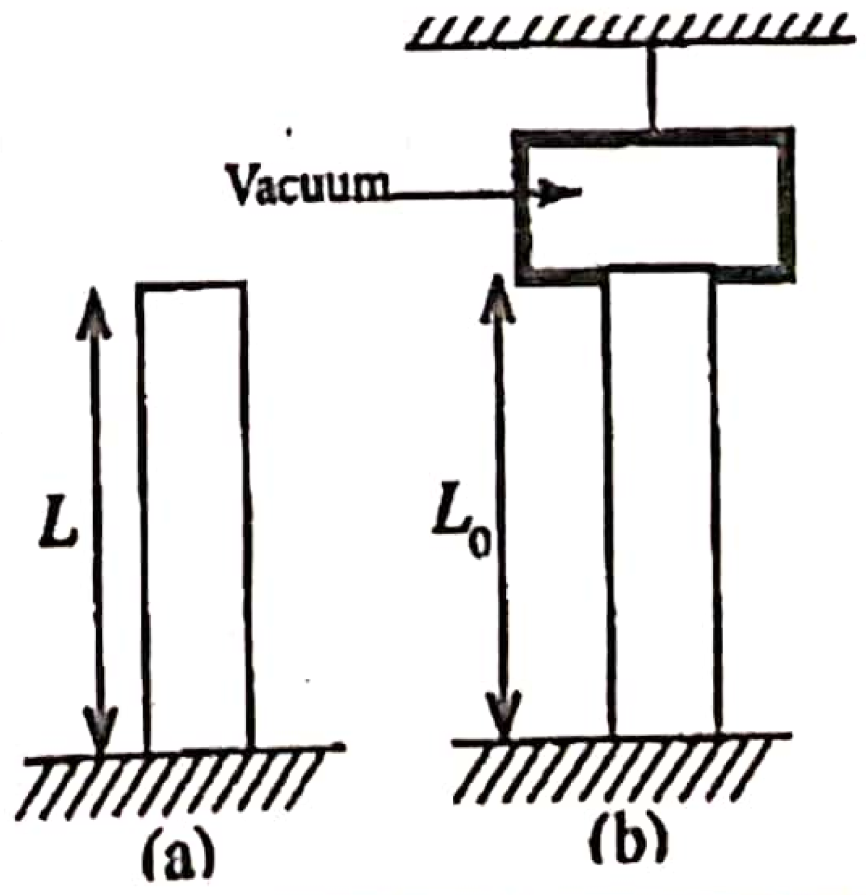
When a person comes to a room with high temperature, you can think that the sweat will be vaporized as the temperature is high. This is a wrong conclusion. The humidity of the environment affects the vaporization of our sweat. If the surrounding is saturated with water vapour, then the sweat will not be vaporized. The temperature affects the production of sweat. When the temperature of the environment is high, then more sweat will be produced. The sweat is produced to control the body temperature. We are endotherms.

But the humidity of the air affects to vaporize the sweat. If the water vapour concentration is less in air, then the produced sweat will be vaporized even if the temperature is high. If the temperature is high and the relative humidity is 100%, then there is no place for produced sweat to go.

A person wears clothes with sweat in θ_1 temperature and comes to the room of θ_3, if $\theta_3 < \theta_1$, then the temperature will be increased around a small area of him as the room is large. So, little bit of sweat will be vaporized. Quickly the room comes back to almost θ_3. If the room is small, then the final temperature of the room will be changed (increased) once the person arrives.

As there is a temperature control, the body temperature can differ from the temperature of clothes. That is why we talk of clothes instead of the body.

38. The height of a vertical uniform rod, when one end is firmly fixed to a horizontal surface in air as shown in figure (a) is L. Then the other end of the rod is kept in a vacuum chamber hung from the roof as shown in figure (b). Assume that the chamber does not exert any force at contact points with the rod. Y is the Young's modulus of the material of the rod and P_0 is the atmospheric pressure. If L_0 is the height of the rod in figure (b), then the ratio $\frac{L}{L_0}$ is given by



(1) $1-\frac{P_0}{Y}$ (2) $\left(1-\frac{P_0}{Y}\right)^{-1}$ (3) $\frac{P_0}{Y}-1$

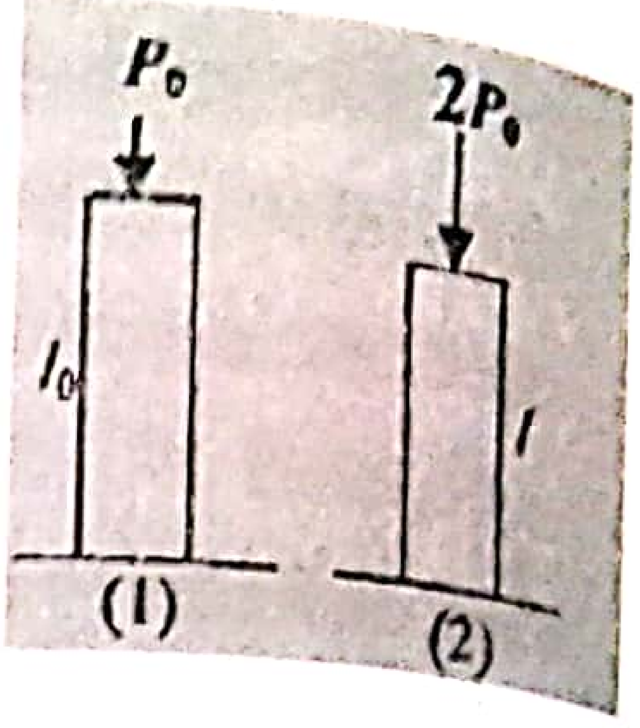
(4) $\frac{P_0}{Y}+1$ (5) $1-\frac{Y}{P_0}$

Elastisity 10

Consider a vertical pillar with length l_0 (figure 1) in the atmosphere (the atmospheric pressure is P_0). If the pressure on its top end was made $2P_0$ (figure 2), then we will find the contraction of the pillar. Here you need to consider the contraction due to the increment of atmospheric pressure. In the pillar shown figure 2, the pressure difference at the top is P_0. The initial length of the pillar is l_0. When the top end is subjected to an extra pressure of P_0, the pillar gets shortened due to the thrust. That means the contraction of the pillar is l_0-l.

According to Young modulus relation,

Young Modulus = Stress/ Strain; $Y = P_0 l_0/(l_0-l) \rightarrow (l_0-l)/l_0 = P_0/Y \rightarrow l/l_0 = 1-(P_0/Y)$



Stress (the force per a unit area- pressure) is P_0.

Then answer for l/l_0 is obtained. If this problem is solved in another way, that means a pillar of l is stretched by l_0 (when pressure is removed), then you will get like this way.

$Y = P_0 l/(l_0-l) \rightarrow (l_0-l)/l = P_0/Y \rightarrow l/l_0 = (1+P_0/Y)^{-1}$

The above answer and this answer are different. Out of them, the first one is the most correct one. Here we consider about the change in pillar length due to the changes of atmospheric pressure. As the initial length, you need to consider an instance where atmospheric pressure is applied on the top. Therefore, the initial natural length of the pillar is l_0 not l. So, the strain of the pillar is $(l_0-l)/l_0$ not $(l_0-l)/l$

Now think that there is a vacuum on the top end and then take l_0 as the length. Next, if the top of the pillar is opened for atmospheric pressure, then the force applied on the pillar is given from the atmospheric pressure. Therefore, even without that force the natural length of the pillar is l_0, not l. When there is no atmospheric pressure (no external force) the length of the pillar should be considered as l_0. When the length of the pillar when it is not subjected to an external stress or tension or compression, should be taken as the initial length. Therefore, the strain of the pillar is $(l_0-l)/l_0$ not $(l_0-l)/l$

Normally, in such problems we neglect the effect of the atmospheric pressure and take the initial length as l. If an external weight of W is kept on the top, then the pillar will be contracted from l to a certain extent. Then we take l as the initial length. There is no problem in that. If the effect from the atmosphere is neglected, the natural length is l when there is no external compression or tension. When the weight of W is kept, its natural length is contracted.

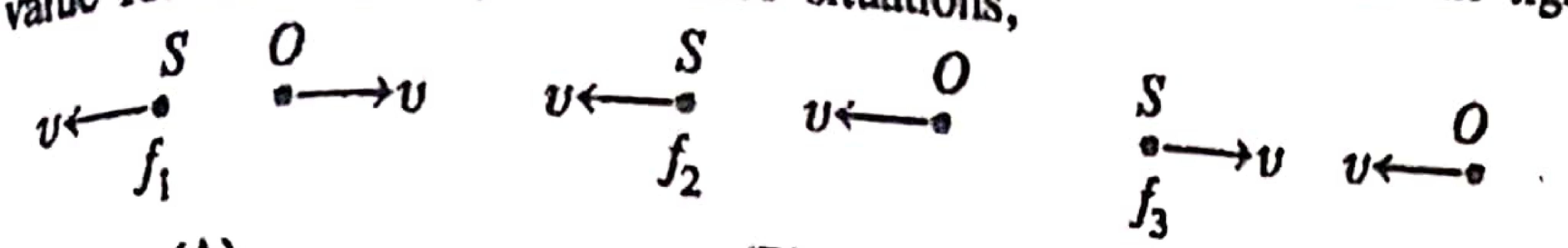
In such problems, the length of the pillar when there is no agent that produce the relevant result according to the problem, should be taken as the initial length. That means the length which it has when the external effect is being cancelled. As we neglect the effects from the atmosphere in the normal problems we solve, we take the initial length as the length when the external pull or compression is not applied. But as we consider the effect of the atmosphere, the initial length of the pillar has to be taken as the free length of the pillar which is not subjected to strain. It has been taken as l_0 symbolically, as it is needed to be taken as the initial length. Even in human things, you need to consider an instance without external effect/external compression as the natural (initial) dimension.

However, if you do it in the other way, then you will get the answer as $l/l_0 = (1+P_0/Y)^{-1}$.

If you know some mathematics and you expand the term $(1+P_0/Y)^{-1}$, then you will understand that it is nearly equal to $(1-P_0/Y)$. If x is small, then you know that $(1+x)^{-1} = 1-x$.

Actually, if we consider the weight of the pillar, then l_0 is not its natural length. Due to the weight of the pillar also it gets contracted (Look at the 46th question of paper 2016). If we neglect the effect from the atmosphere, then the real natural length of the pillar is obtained when it is kept horizontally.

39. The figures (A), (B) and (C) show a moving sound source S producing different frequencies f_1, f_2 and f_3 at three different situations. O is an observer carrying a sound frequency detector. Speed and the direction of motion of the source and the observer in each situation are shown in the figures. If the detector detects the same value for the frequency in all three situations,

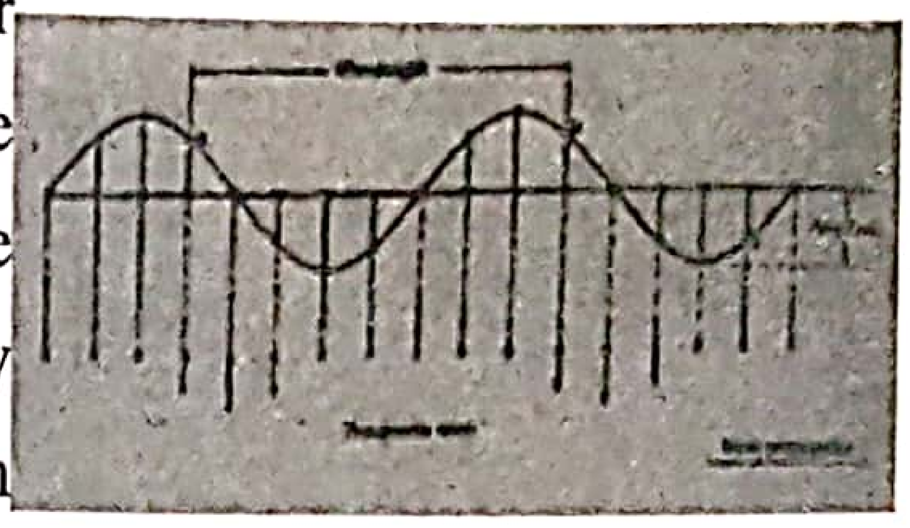


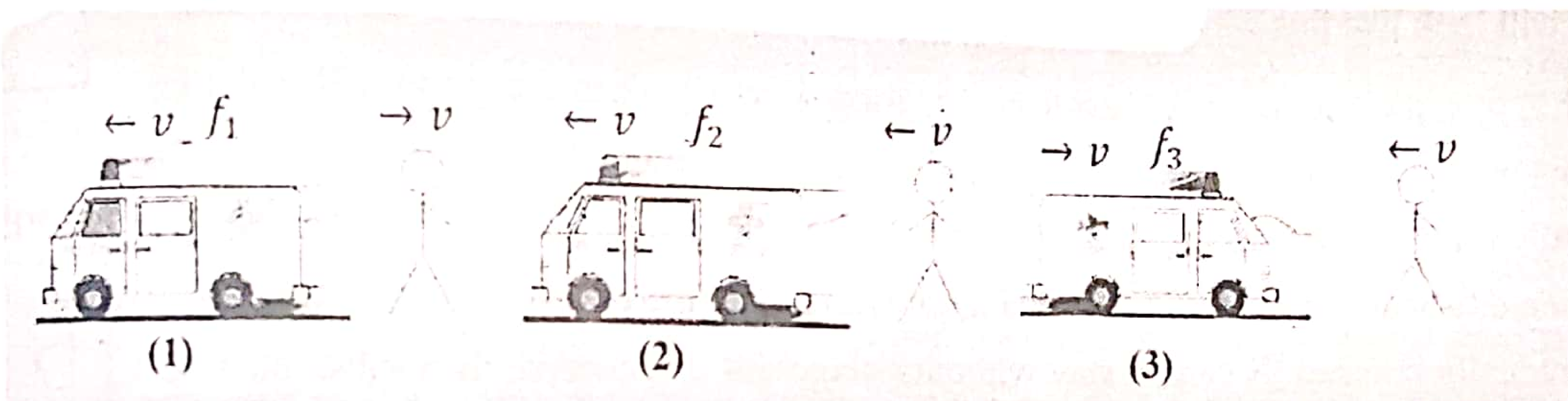
(A) (B) (C)

the frequencies produced by the sound source when arranged in the ascending order is

(1) f_1, f_2, f_3 (2) f_3, f_2, f_1 (3) f_1, f_3, f_2 (4) f_2, f_3, f_1 (5) f_2, f_1, f_3

In a progressive transverse wave, the particles in the string are perpendicular to the direction of propagation. It is a characteristic of a transverse wave. The energy of a wave is proportional to the square of the amplitude. Any wave can be reflected. According to $v = \sqrt{\frac{T}{m}}$, $v \propto \frac{1}{\sqrt{m}}$. The The velocity profile of the particles in a transverse progressive wave is shown here. It can be clearly seen that two adjacent particles do not travel in the same speed.





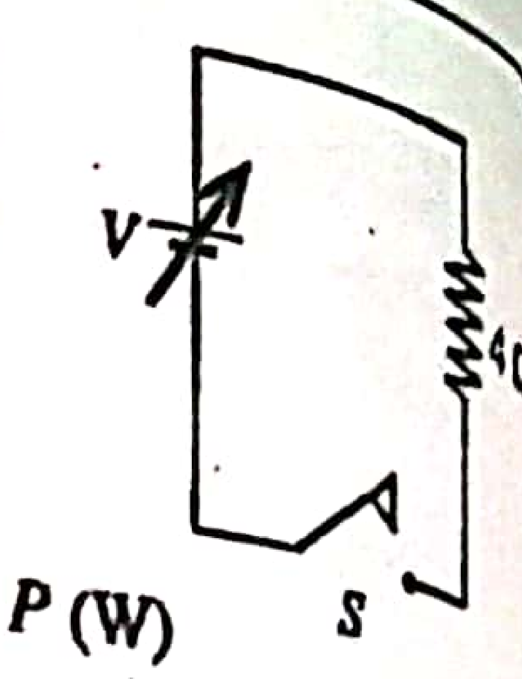
(1) (2) (3)

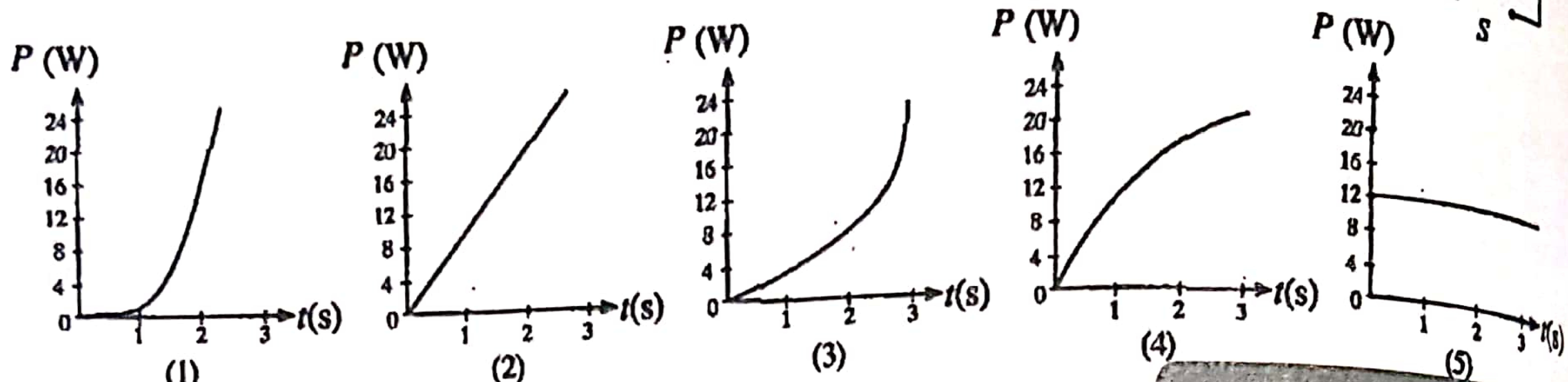
When applying Doppler's effect, always you need to consider the relative motion between the source and the observer. (Look at the 54th question of paper 2008.) If not, then once you see the figure (1), you can clearly see that the observer and the source are moving away from each other. If you think from the relative motion, then the source is going in 2v speed away from the observer. Therefore, the apparent frequency should be lesser than f_1. In figure (2), there is no relative motion between the source and the observer. Both go to the same direction with a same speed. Therefore, the apparent frequency is f_2.

In figure (3), the source and the observer are moving towards each other. Relative to the observer, the source is moving at 2v speed towards the observer. Therefore, the apparent frequency should be greater than f_3. But if the apparent frequencies are equal in all three instances, then the initial value of the lesser apparent frequency should be greater. The initial value of the higher apparent frequency should be lesser. That means $f_3 < f_2 < f_1$. According to the apparent frequencies, it should be 1<2<3. This relation can be written by just looking at it. In (1), it gets away. In (3), it gets closer and in (2), it is in the same place. If 3 and 1 are changed in the inequality, you will get the required thing.

If you feel the love of the current and the previous lover in equal terms, then the previous lover has loved you more.

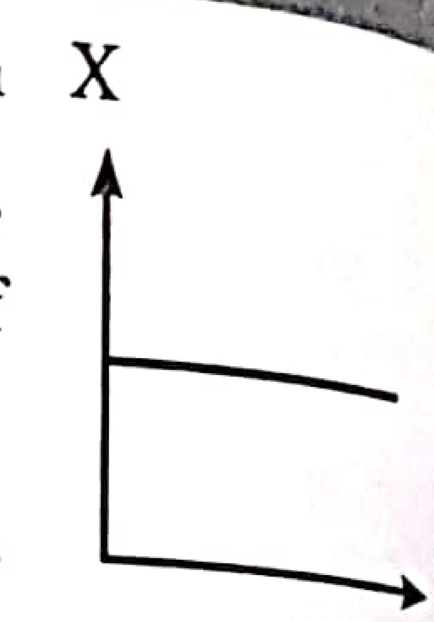
40. When the switch S in the circuit is closed at time $t = 0$, the voltage V of the power supply varies with time (t) according to the equation $V = Kt^2$, where the magnitude of K is 2. The variation of the power dissipation (P) in the 4 Ω resistor with time (t) is best represented by



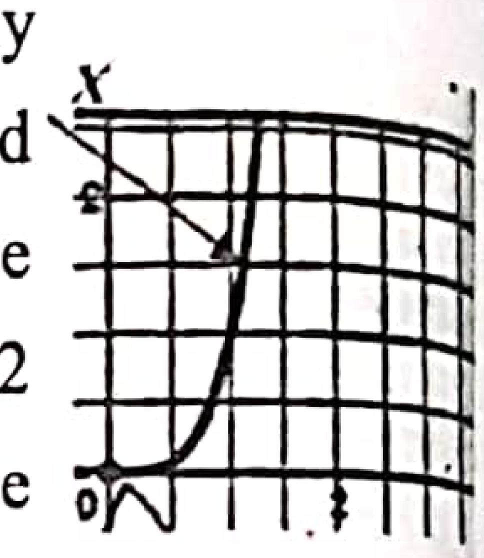


Heating Effects of Electric Current

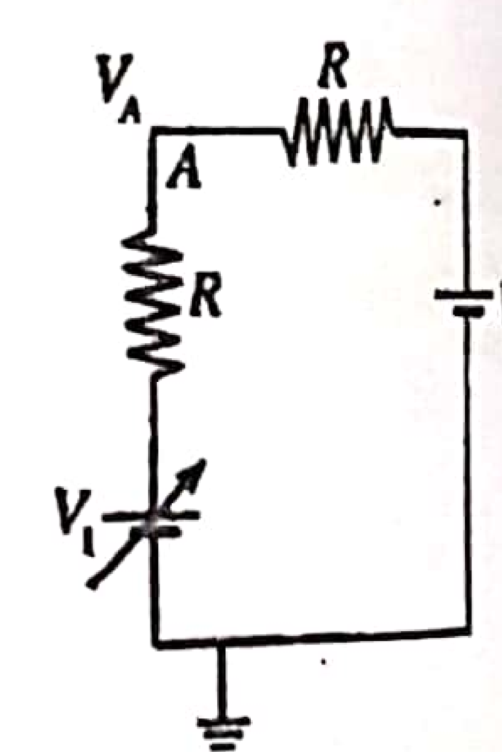
If a potential difference of V is applied across a resistor R, then the power generation X is equal to V^2/R. When R is constant, then $X \propto V^2$. If V is not changing with time, then X also does not change with time. X is unchanged with time t. Then the graph of it will look like this way.

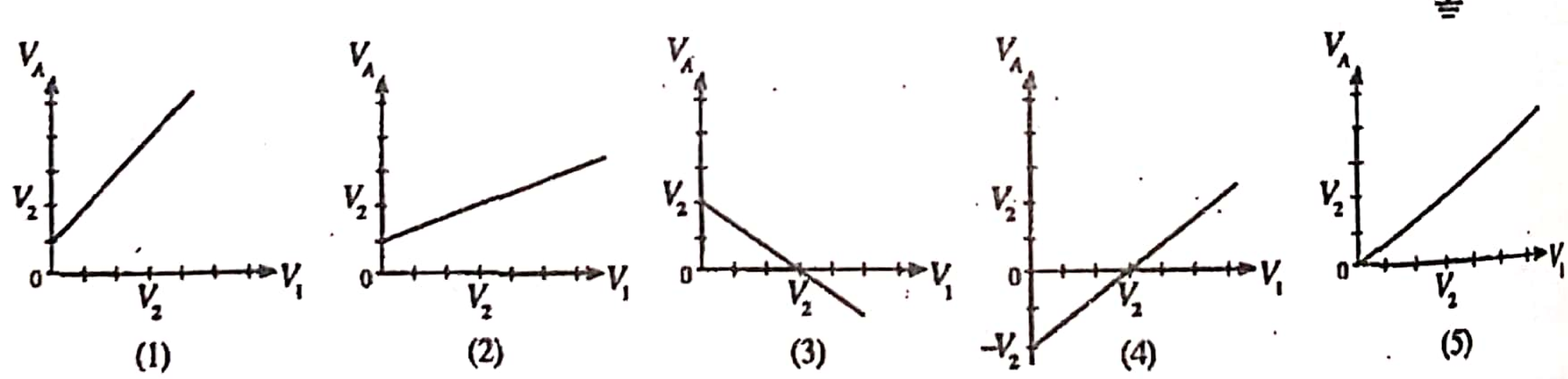


If $V \propto t$, then $X \propto t^2$. When $V \propto t^2$, then $X \propto t^4$. Then the graph will look like this way. X is proportional to t^4. X rapidly increases with t. X is increased drastically with t. X cannot be uniformly increased with t. X cannot uniformly increased with t and then drastically increase. If X is increased with t, then the rate of increment cannot be gradually reduced. X cannot stay without rising with t. If needed, then substitute t = 2 s. When t = 2 s, then X should be 16 W. But it is not needed. You can decide the shape of the curve from the eye.



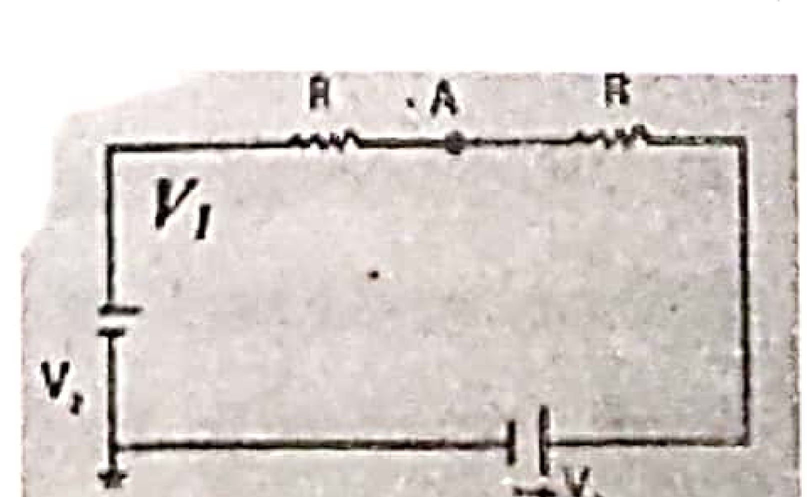
41. In the circuit shown V_1 is a variable voltage provided by a battery. Variation of the potential V_A at point A with respect to the earth, with V_1 is best represented by (Neglect the internal resistances of both power supplies.)



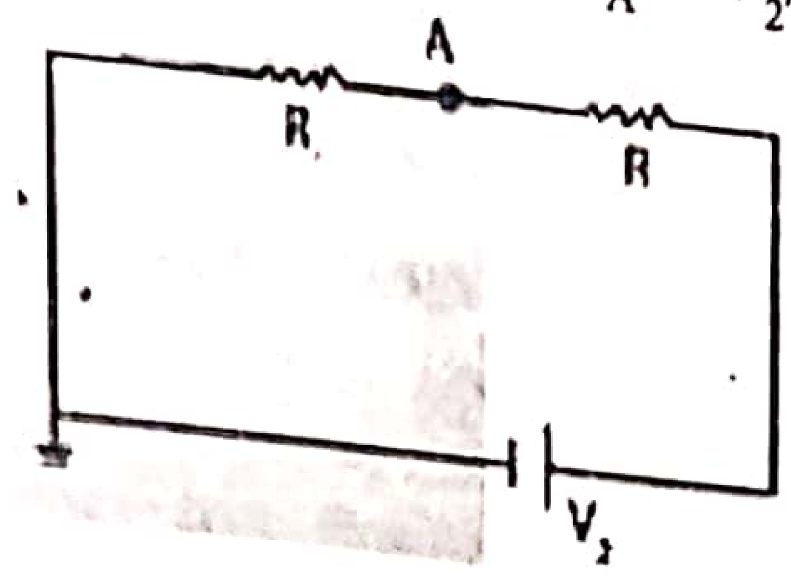


Korchoff's Law Combinations of Cells

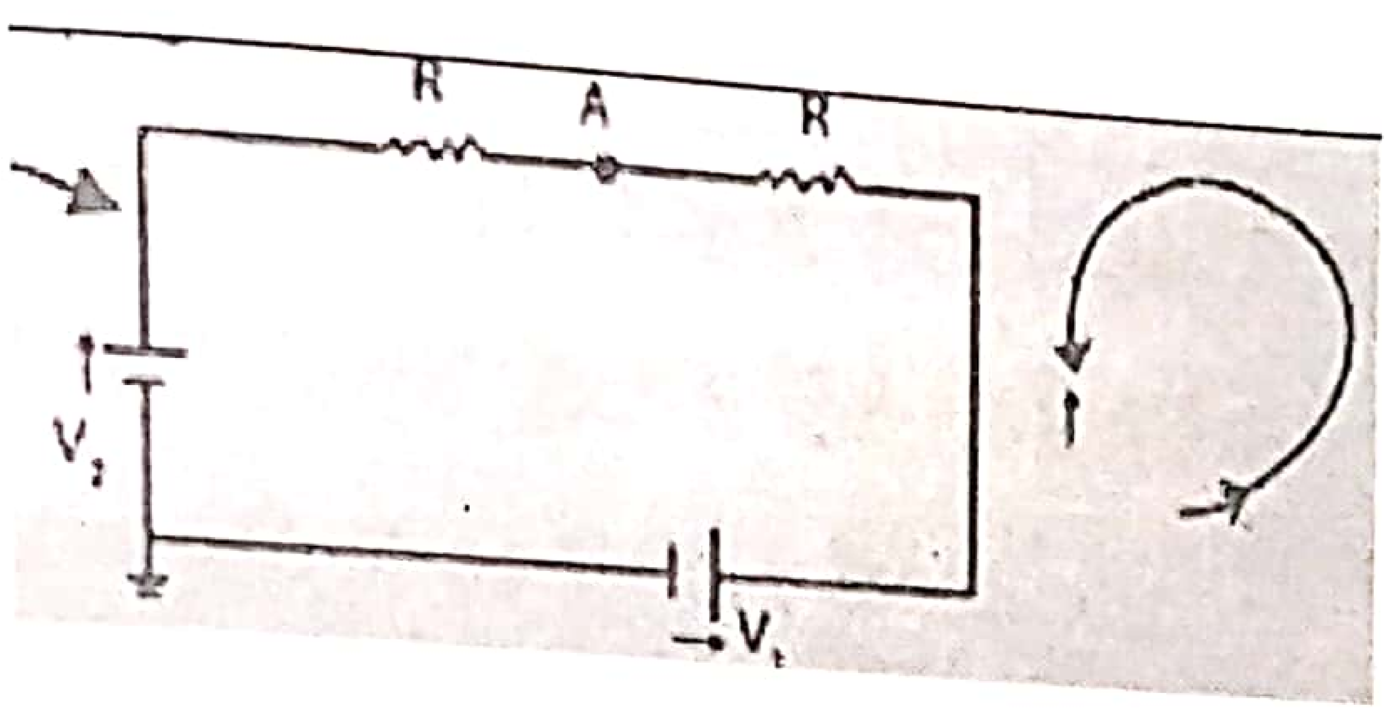
Let us consider this circuit.



Think that V_1 can be changed. From a trick (but from Physics) you can get the correct thing. Try to zero V_1. V_1 getting zero means that there is no voltage there. You have the wire only. Then V_2 voltage is divided equally with two Rs. Do you need equations? That means $V_A = V_2/2$. Is not it? Then the circuit will be like this way (there is no need to draw).

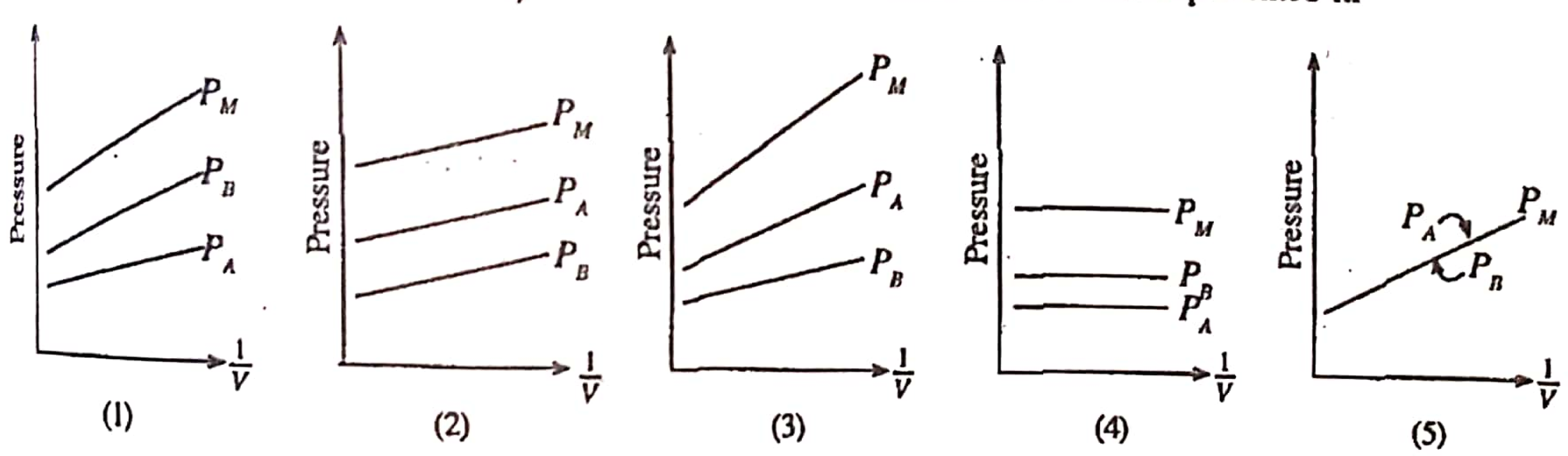


When $V_1 = 0$ then you can start to draw a variation as $V_A = V_2/2$. There is no point in drawing other variations. Now take $V_1 = V_2$. Then does not the current flow in the circuit is zero? V_1 and V_2 are equal and opposite to each other. Now the circuit will look like this way (there is no need to draw).



If the current in the circuit is zero, then is not $V_A = V_2$? As there is no current flow, there is no potential difference across R. So, $V_A = V_2$. When $V_1 = V_2$, $V_A = V_2$. Mark this point also in the variation you started. Cannot you do this question without any rough work?

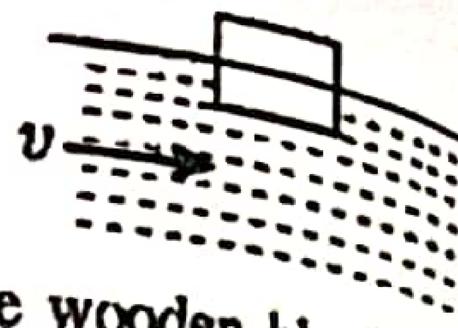
42. A volume V of a mixture of ideal gases contains n_A moles of gas A and $n_B(<n_A)$ moles of gas B at a constant temperature. The variation of the partial pressures P_A and P_B of the gases A and B respectively, and the overall pressure P_M of the mixture with $\frac{1}{V}$ at the above constant temperature is best represented in



Expansion of Gases **04**

If the temperature is constant in an ideal gas, then its pressure: $P \propto n\frac{1}{v}$. Therefore, the gradient of graphs of 1/v against P should be proportional to the number of moles in the gas. If there are ideal gases more than one, then the gradient should be greater in the gas with more moles. When the gases are added, as the moles in the mixture (total of the moles) are increased, the gradient of the relevant graph should be greater as well. The gradients cannot be equal or same at any time. Even if such graphs are given, then do not have a look at them. You can just remove them. Look at the gradients only. When the moles are increased, the gradient also gets increased accordingly. When selecting others, do not look at only gradients. Those gradients change with time.

43. A river flows steadily at a constant velocity v. A rectangular block of wood having density less than that of water is first held above the surface of water so that it is stationary with respect to the riverbank, and then slowly lowered to the water until the floating condition is achieved and then released it, as shown in figure. Assume that the initial speed of the wooden block in the direction of v is zero. During the subsequent motion of the block, which of the following is true for magnitudes of the impulsive force acting on the block, the viscous force acting on the block by water, and the momentum of the block? (Neglect effect due to air drag.)



	Impulsive force	Viscous force	Momentum
(1)	Decreases from a higher value to zero	Increases and becomes constant	Decreases from a higher value to zero
(2)	Increases and becomes constant	Decreases from a higher value to zero	Increases and becomes constant
(3)	Decreases from a higher value to zero	Increases and becomes constant	Increases and becomes constant
(4)	Increases and becomes constant	Increases and becomes constant	Decreases from a higher value to zero
(5)	Decreases from a higher value to zero	Decreases from a higher value to zero	Increases and becomes constant

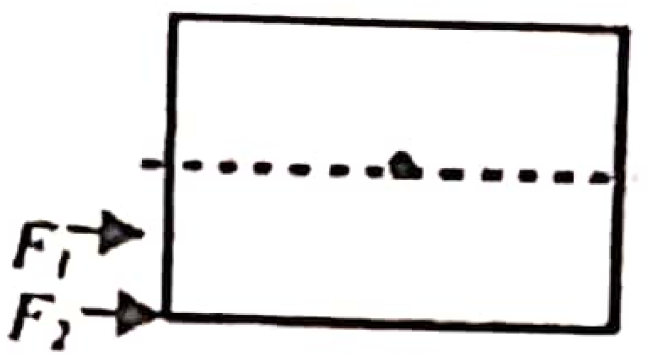
Newton's Law & Momentum

Consider an instance where a soap box has fallen suddenly on a water flow which moves in horizontal direction in uniform v velocity. This is similar to the motion of a fall of box which is released vertically to a belt which carries goods in a uniform v velocity (the 45th question of paper 1996). Which side does the friction apply on the box? The belt tries to carry the box. The box tries to reduce the motion of the belt. Therefore, the frictional force by the belt on the box is towards to the right. Here the frictional force helps to increase the velocity of the box till v. The figure has shown the resultant of the frictional force of the box and the perpendicular reaction. Think of the relative motion in between the belt and the box always. The frictional force is applied to the box. As the soap box is fallen to water, there is a viscous force on the box by the water. However, it is known from the general knowledge that after sometime, the box acquires the velocity of the water. Therefore, the velocity (momentum) should get increased and be a constant.

Compared to earth, the final momentum (velocity) of the box cannot be zero. The viscous force that acts on the box is dependent upon the relative motion of the box and the water. When the velocity of the box is constant, there is no relative motion between the box and the water. It is zero. Then the viscous force gets zero. When two people are moving to the same direction at the same speed, then there is no friction or viscosity. Both of them are not angry with each other. There is maximum support. The force by the water on the box should be zero when the velocity of the box gets v. The speed cannot be constant if the force is constant. As the viscous force is zero when the speed of the box is constant, if the force is constant from the water, then the box should accelerate as there is a resultant force on the box. You can even decide that this cannot happen from your general knowledge.

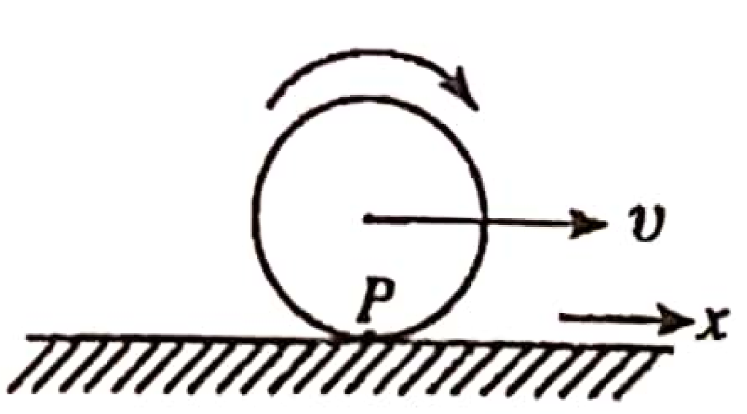
If somebody mentions that all the parameters are increased or mentions that from an increased amount, then remove those parts. Those parts are common to all. Therefore, by looking at those two parts you do not have to find the correct thing. Always you need to look into parts of reduced till zero and get constant.

According to that, the impulsive force is reduced up to zero (as the block is not accelerated). The viscous force also gets reduced till zero (as there is no relative motion between the box and the water). Likewise, the momentum (velocity, the mass of the box is however constant) comes to a constant value. However, anybody can understand that the box should come to a constant speed (speed of the water flow) relative to earth. Therefore, it is easy to start with known momentum. When it reaches a constant speed, the viscous force gets zero. The impulsive force also gets zero. If the velocity is constant, then there cannot be a resultant force.

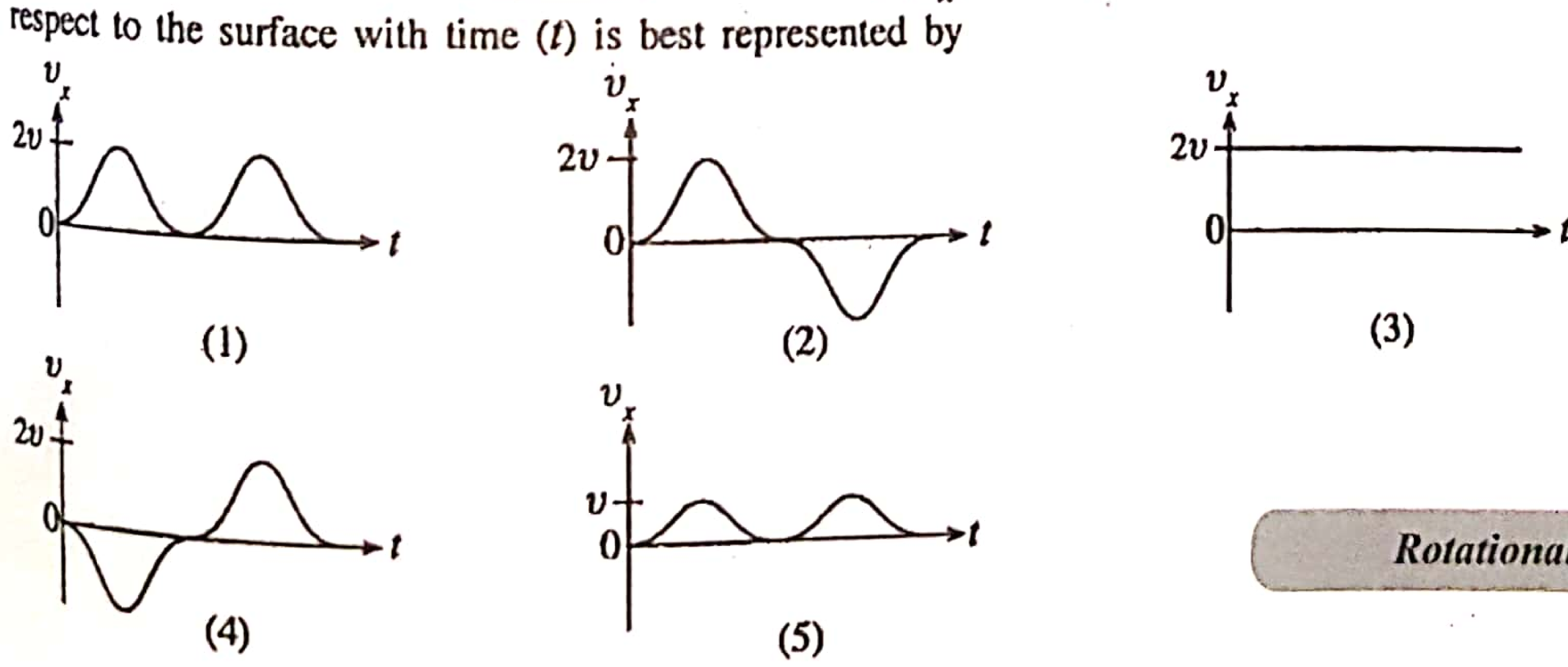


How the force has become an impulsive force here? The box is floating on water. Only a part of the box is sunk here. A part of the box is connected with water. Before the box acquires the velocity of water flow, the velocity of the water relative to the box is towards right side. Therefore, force given from the flowing water to the box (F_1) is applied only to the vertical left surface which is sunk in water. The water flow thrusts the sunk vertical left surface. It forces by saying 'please come with me'. The sunk vertical right side is not getting thrusted by the water. The water velocity of that side is greater than the velocity of the box. There is no force on yourself from the people who moves faster than you ahead. The force is felt from the people who pokes from behind. When the box acquires the velocity of water flow, F_1 gets zero. There will be a torque around the centre of mass due that force F_1. So, the box moves across the water by wiggling. On which side does the viscous force on the box (F_2) act? Is it opposite to F_1? No. F_2 is acting on the same side of F_1. Before the box acquires the velocity of water, the viscous force from the water is acted to the right side on the bottom surface of the box. It is to the right side by the water on the box; to the left side by the box on the water. Water tries to take away the box. The box tries to reduce the flow of water. Always think of the relative motion between the box and the water. The difference between the previously mentioned vertically released box to a belt and the fallen soap box to the water is that, there is nobody to poke from behind to the box that is fallen to the belt. These forces are acted for a small time. It is not there continuously. Even the box is not moved across the water flow in a stable manner. Little unstable nature can be created.

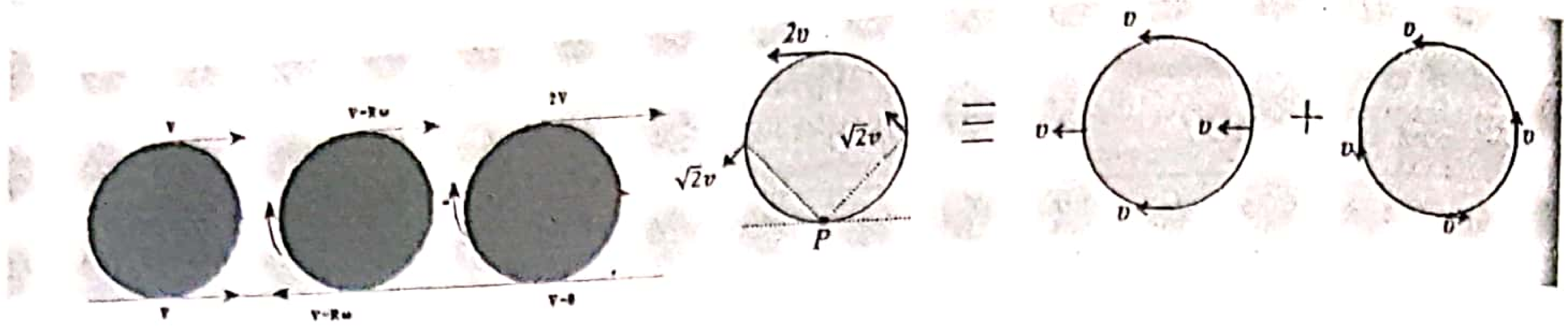
44. A uniform solid wheel rolls along a flat surface at a uniform velocity v without slipping as shown in the figure. P is a point on the circumference of the wheel. Location of the point P at $t = 0$ is also shown in the figure.



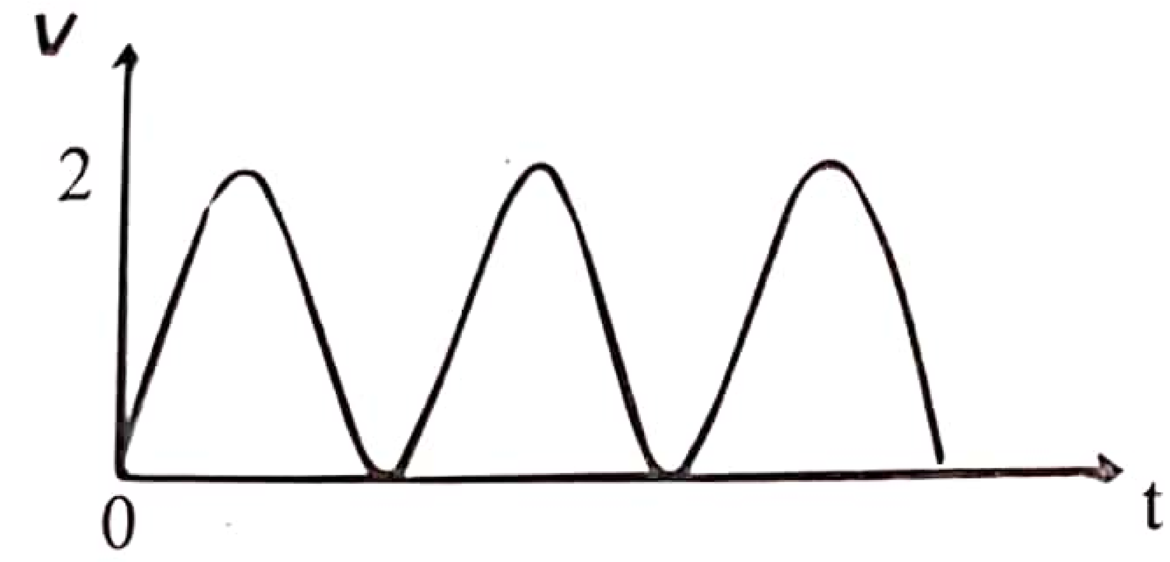
Variation of the horizontal component of the velocity (v_x) of the point P with respect to the surface with time (t) is best represented by

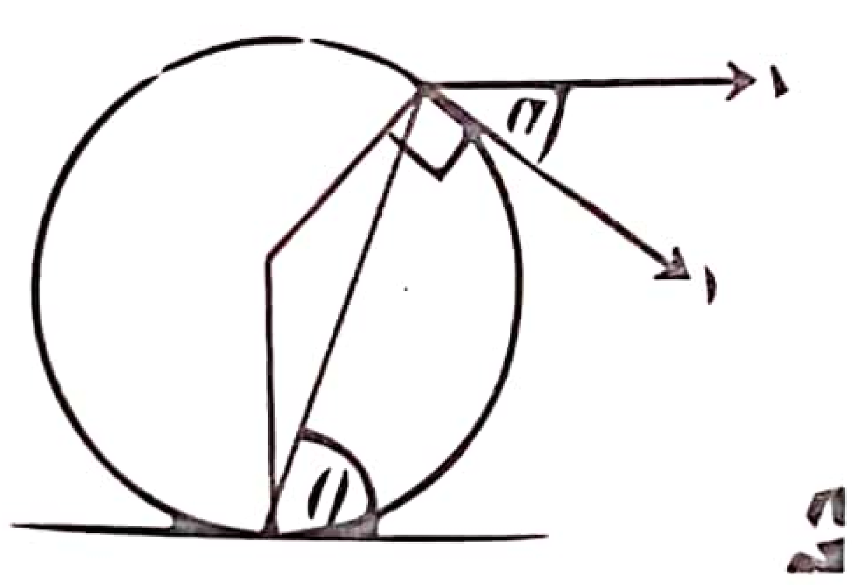


There is no doubt that you have learnt about the instances where such a wheel is rolled in the horizontal ground. Look at the 50th question of paper 2014, the 18th question of paper 2010 and the 57th question of paper 2012.



Compared to the ground, the magnitude of the velocity of point P oscillate from zero to 2v. When it touches the ground, the velocity of point P is zero. When point P is gone to the top of the locus, then the velocity gets 2v. In all the other points the velocity is less than2v. Therefore, the speed relative to the ground (V) in point P with time (t) of a rolling wheel on a horizontal ground is shown in the figure. The maximum magnitude of velocity (amplitude of velocity) is not changed. It is 2v.





The direction of the velocity of point P changes instantaneously. Some questions have given about the magnitude of the velocity. It is a scalar quantity. The direction of the horizontal component of the velocity of point P is certain and the direction of it does not change. Therefore, the direction of the horizontal component cannot be changed as positive or negative. The minimum is zero. The maximum is 2v. If you need it as an expression, then the horizontal component of the velocity is, $v_x = v + v \cos \alpha = v + v \cos (180^0 - 2\theta)$

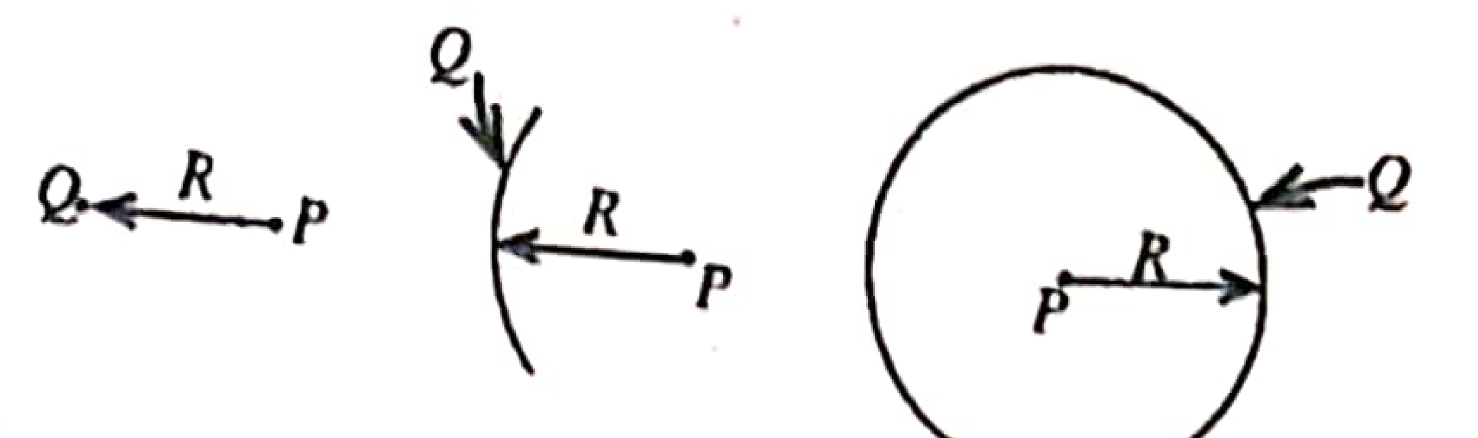
When $\theta = 0^0$, $\cos 180^0 = -1$ then $v_x = 0$

When $\theta = 90^0$, $\cos 0^0 = 1$ then $v_x = 2v$

When $\theta = 45^0$, $\cos 90^0 = 0$ $v_x = v$

45. Figures (A), (B) and (C) show distributions of a positive charge Q in three situations. In figure (A), charge Q exists as a point charge placed at a distance R from point P. In figure (B), the charge Q is uniformly distributed in the form of a thin circular arc of radius R with its centre located at point P. In figure (C), charge Q is uniformly distributed in the form of a thin ring of radius R, with its centre at point P. If the potentials, and the magnitudes of the intensity of the electric fields at points P in the situations (A), (B) and (C) are V_A, V_B, V_C, and E_A, E_B, E_C respectively, which of the answers given is true?

	Potentials at points P	Magnitudes of the intensity of the electric fields at points P
(1)	$V_A > V_B > V_C$	$E_A > E_B > E_C$
(2)	$V_A > V_B > V_C$	$E_C > E_B > E_A$
(3)	$V_A = V_B = V_C$	$E_A = E_B = E_C$
(4)	$V_A = V_B = V_C$	$E_A = E_C > E_B$
(5)	$V_A = V_B = V_C$	$E_A > E_B > E_C$

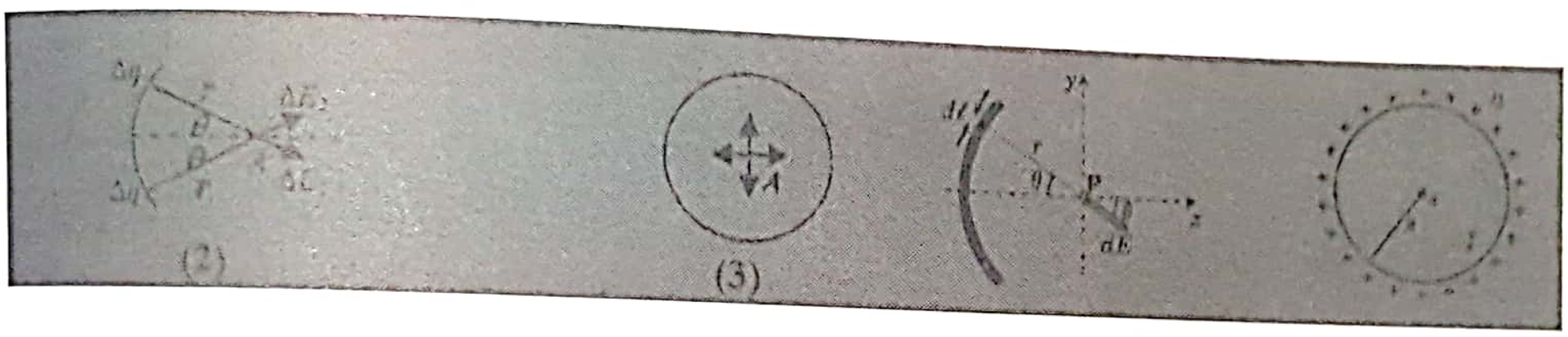


(A) (B) (C)

Electrostatic Potential

06

How do you find the electric field intensity at point A from the part of charged circular arc? There is a question under the gravitational field as the 60th question in paper 2008. That logic is relevant to this problem. Look at the following figures.

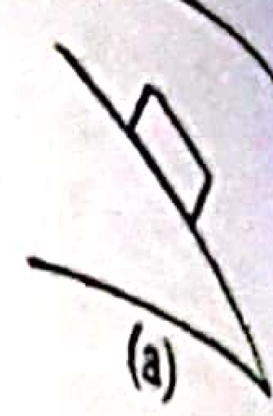


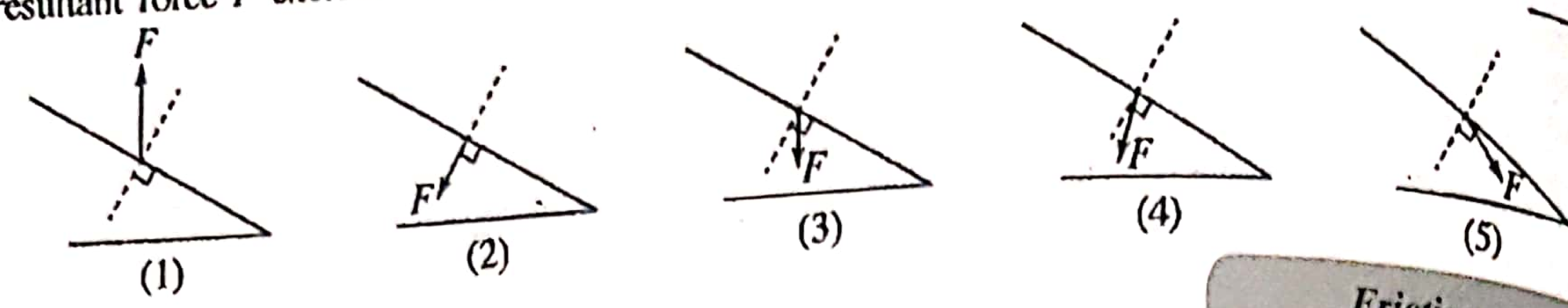
We know that the electric field intensity E_1 from a point charge of Q from a distance r is $\frac{1}{4\pi\varepsilon_0}.\frac{q}{(r^2)}$. If the circular arc is divided into small parts, then the electric field intensity ΔE_2 from one of the two symmetric small Δq part will be $\frac{1}{4\pi\varepsilon_0}.\frac{\Delta q}{(r^2)}$. The vertical components of ΔE_2 are cancelled off with each other. The total of horizontal components is $2.\frac{1}{4\pi\varepsilon_0}.\frac{\Delta q}{(r^2)}\cos\theta$. To find the resultant electric field intensity, the above expression should be integrated. For every charge element θ is not constant.

The electric field intensity of the point A of (3) is zero. It can be decided very easily. Again, if the circular loop is divided into smaller parts according to the figure, there is an opposite charge element for each charge element. So, the electric field intensity from them is cancelled off with each other. As $E_1 = \frac{1}{4\pi\varepsilon_0}.\frac{Q}{(r^2)}$ and $E_3 = 0$, it can be decided that E_2 should be in between these two values. Even finding the magnitude of E_2 is difficult, it is not difficult to come into a decision. In the 16th question of paper 1994, it is mentioned that the gravitational field intensity of a uniform loop with a radius r is zero. When you divide the power you have to the others, your power will be zero. $E_1 > E_2 > E_3$. Actually, $E_3 = 0$.

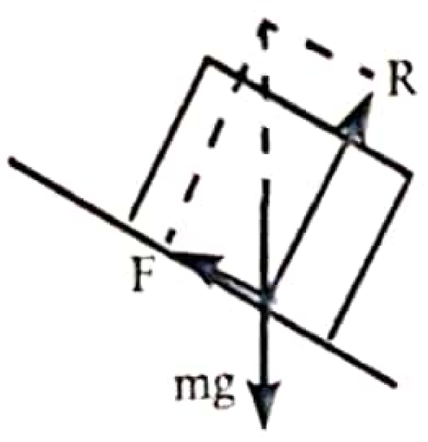
The distribution is not a problem for the potential. We know that $V_1 = \frac{1}{4\pi\varepsilon_0}.\frac{Q}{r}$. In (2), the potential of point A from Δq is $dV_2 = \frac{1}{4\pi\varepsilon_0}.\frac{\Delta q}{r}$. As potential is a scalar, there is no direction. So, the total potential of point A = $V_2 = \sum\frac{1}{4\pi\varepsilon_0}.\frac{\Delta q}{r} = \frac{1}{4\pi\varepsilon_0}.\frac{1}{r}\sum\Delta q$. The total of Δq is Q. It is same for (3). So, $V_1 = V_2 = V_3$

46. A rectangular block rests on an inclined plane as shown in figure (a). The direction of the resultant force F exerted on the inclined plane by the block is best represented by

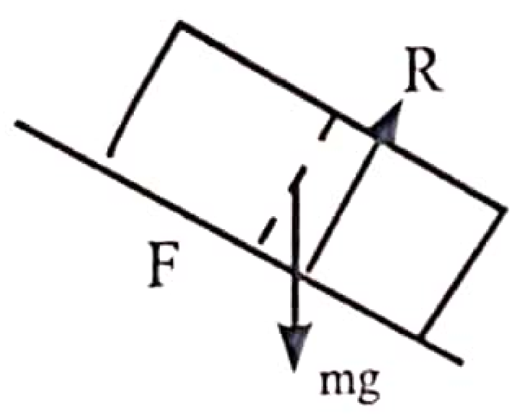




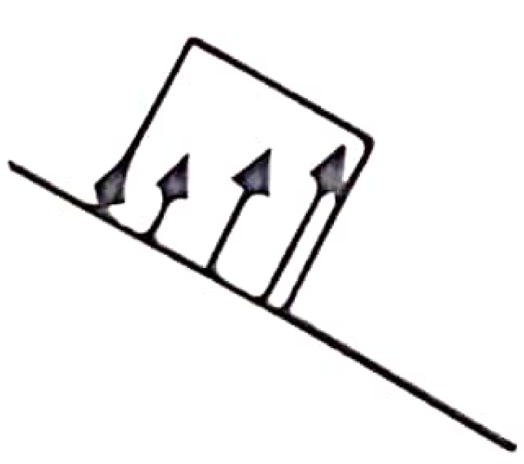
Friction



Consider a wooden block which is at rest in an inclined plane. Let us consider the forces acting on the block. The resultant of the perpendicular reaction (R) which acted on the block from the inclined plane and the frictional force (F) should be equal and opposite to mg. The resultant force from the inclined plane on the block means the resultant of the perpendicular reaction and the frictional force. As the block is in equilibrium, the resultant of R and F should be equal and opposite to mg. Therefore resultant force on the block by the inclined plane is acting vertically upwards. The resultant force on the inclined plane by the block should act vertically downwards (equal and opposite forces).

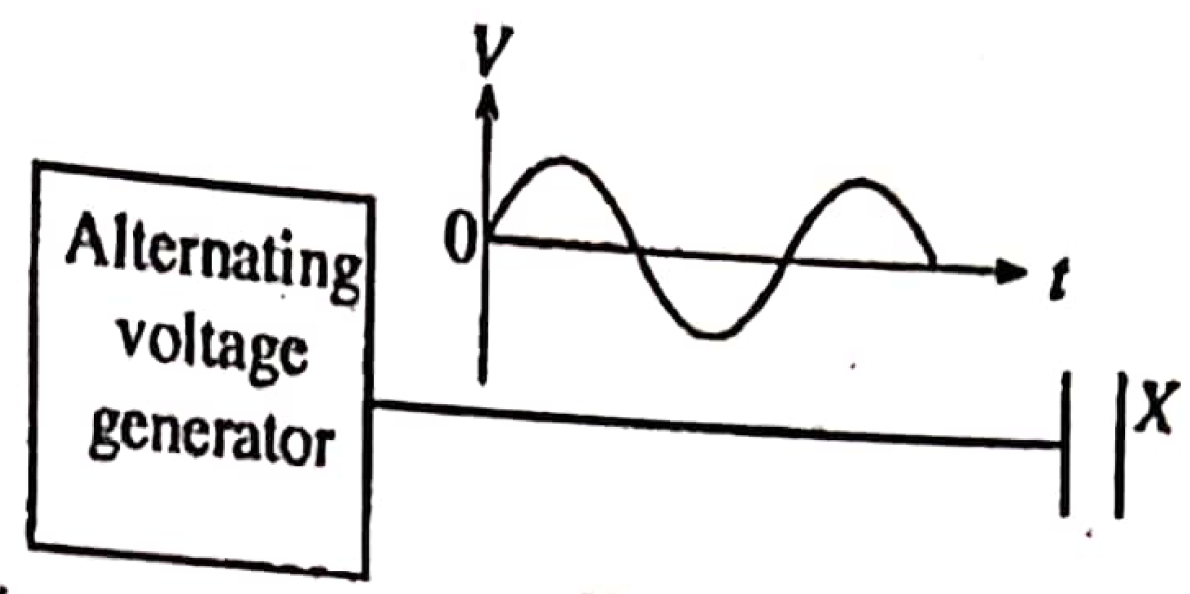


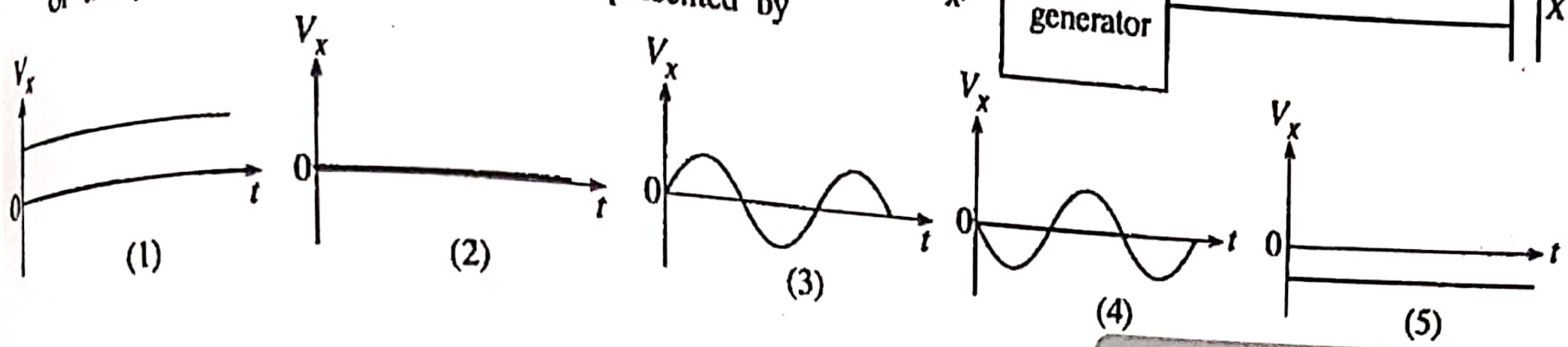
Actually, a single force is acted on the block by the inclined plane. For our convenience, we will resolve as the perpendicular reaction and the frictional force over the plane. If there is no frictional force, then the block will not be in equilibrium. If there are no frictional forces, then the block will slide towards the inclined plane. If we think that the block is uniform, then cannot you see that the perpendicular reaction cannot act from the middle of the lower surface of the block? As the block is at rest, R, F and mg should meet at one point. F is acted upon the surface. Therefore, R should act on the point where F and mg intersects. R cannot act across the dashed line which goes towards the centre of gravity of the block.



If the block is at a horizontal surface and it is uniform, then R is acting exactly across the centre of gravity vertically upwards. But when the block is at an inclined plane, the bottom surface of the block presses the inclined plane than the upper surface. If the block is broken into small parts, then the group of reactions on the block by the inclined plane has been shown in the figure. When it comes down, the magnitude of the perpendicular reactions gradually increases. Therefore, the resultant of those group of forces are not in the middle. The resultant is biased into downward direction.

47. Variation of the output potential (V) with time (t) of an alternating voltage generator connected to one plate of an uncharged parallel plate capacitor is shown in the figure. The other plate X of the capacitor is kept unconnected. The variation of the potential (V_X) of the plate X with time (t) is best represented by





Capacitance and Capacitors **06**

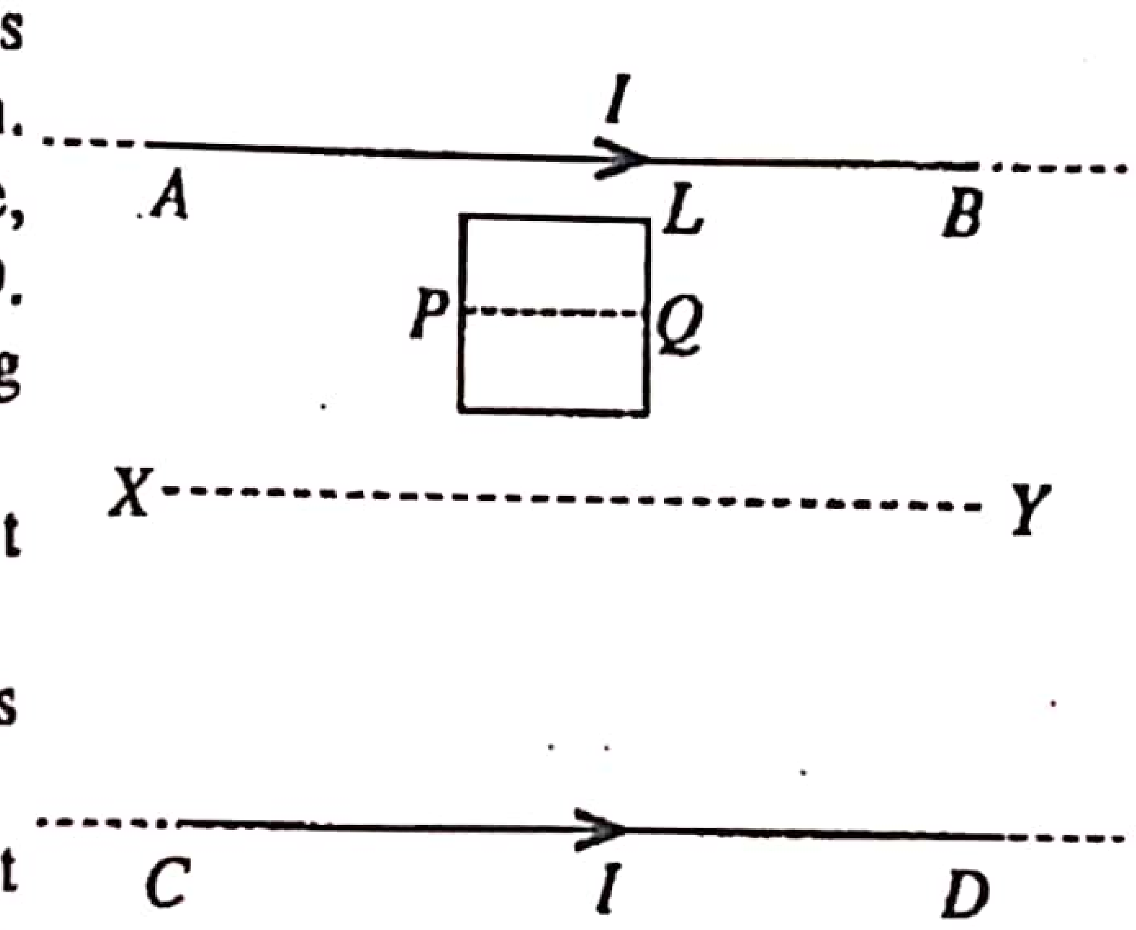
The four experiments that should be done in the laboratory using the potentiometer has been mentioned in the syllabus. They are comparing e. m. f, comparing resistors, measuring a small e. m. f and measuring the internal resistance of a cell. According to the new syllabus (from year 2019) there are only comparison of e. m. f and finding the internal resistance of a cell in the experiment list. A voltage which varies with time cannot be measured by a potentiometer. You should have to stay by moving the touch key continuously here and there.

48. AB and CD represent two parallel straight long conducting wires fixed to a horizontal plane and carrying current I in each of them. L is a conducting square loop placed on the same horizontal plane, as shown in the figure. XY is the centre line between AB and CD. Consider the following statements made when the loop L is moving towards CD on the same plane at a constant speed.

(A) The induced current in the loop gradually increases as it moves toward XY.

(B) The direction of the induced current in the loop is always clock-wise.

(C) The induced current in the loop is zero at the instant when the centre line PQ of the loop passes through the line XY.



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.

Electromagnetic of Induction **08**

We will consider a single wire and a loop. We know about the nature of the created magnetic field intensity due to current I of the wire. The magnetic field intensity inside the loop is not uniform. It changes with the distance of the wire. The magnetic flux inside the loop is perpendicular to the loop and flows inside the loop (perpendicular to the paper plane). When the loop is away from the wire, the magnitude of the magnetic flux which goes towards the loop gradually decreases. Gradually it is reduced. Then according to Lenz law, the current is induced to build up the magnetic flux which diminishes with time. If so, then the current in the loop should flow in clockwise direction.

The magnetic flux inside the loop (due to current in the wire) is reduced gradually into the loop. If you need to oppose the change, then the created magnetic field from the induced current should be directed inwards to the loop.

Every time, the nature has resistance for a change. It does not allow to reduce to the reducing things. It tries to build up again. It tries to reduce when it tries to increase. The actions of humans can be contradictory to this way.

When the loop goes away from the wire, due to current I, the magnetic flux that flows inside gets gradually reduced.

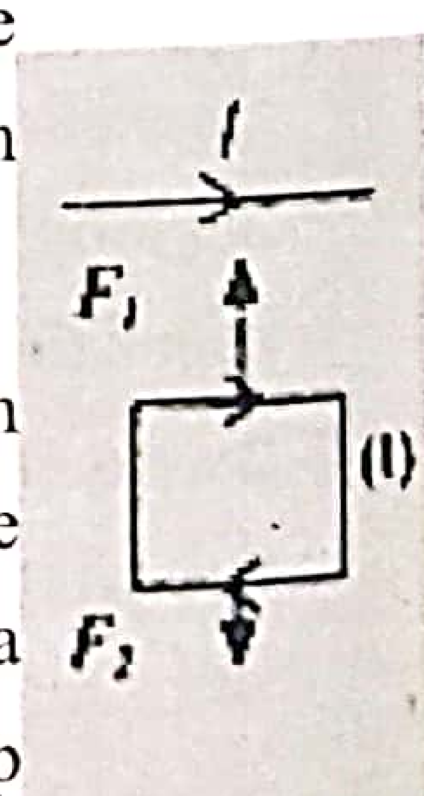
That means the rate of flux reduction is gradually reduced. Therefore, the induced current cannot be gradually increased. The induced e. m. f is equal t the rate of change of flux. However, things should be reduced when they try to go away. So, the induced current of the loop gradually decreases.

Now we will consider two wires. Consider the first position of the loop. Due to the current in the top wire, the magnetic flux flows towards the loop in an inward way. Due to the current of the bottom wire, the magnetic flux inside the loop flows outwards the loop. But as the loop is closer to the top wire, the inward flux is greater in magnitude than the outward flux. That means the resultant flux is towards inwards. So, the argument presented above is valid for this instance.

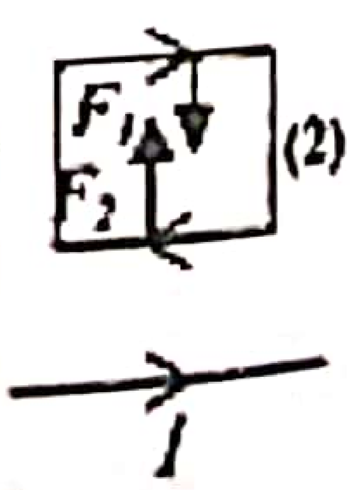
In the second position, as the loop is closer to the bottom wire the net flux inside the loop flow outwards. As the loop is closer to the bottom wire, the net outward flux gets increased. Now according to Lenz law, the induced current is induced to stop the rate of outward flux increment. So, the flux from the induced current should flow inwards to the loop. If it occurs outwards, then it encourages the gradual increment of the outward flux.

In the first position, the net flux towards the loop gets gradually reduced. The loop is closer to the top wire than the bottom wire. The flux from the induced current flows inwards the loop by saying "please do not try to get decreased inwards". In the second position, the net outward flux gradually gets increased as the loop is closer to the bottom wire than the top wire. Now the nature says like this. "Do not try to move more. I will not allow the outward flux to increase gradually". Therefore, in this instance also the flux from the induced current should be towards the loop. So, the direction of the induced current is always in clockwise direction.

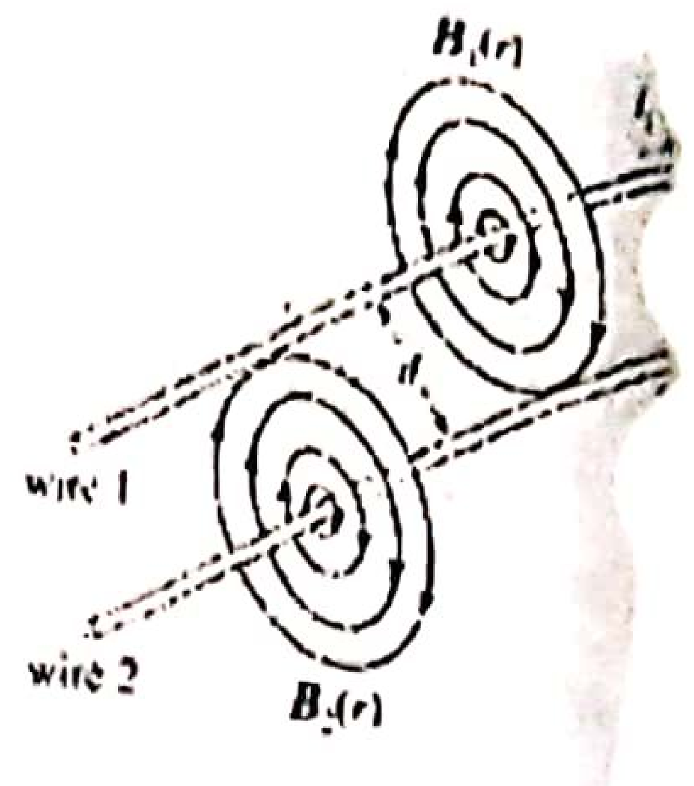
This can be studied in another way. As the loop is brought down, the net force created on the loop due to the interaction of currents should be always upwards. If is become downwards, then it encourages moving downwards. This is contradictory to conservation of energy. The net force created in the loop should be opposite to the pulling direction. Now we will consider the acting forces on the loop.



We know that the currents towards same direction are attracted whereas the currents in opposite directions are repelled. The top wire of the loop is closer to the current I than the bottom wire of the loop. Therefore, in the first position, $F_1 > F_2$ (F_1 is an attraction, F_2 is a repulsion). Therefore, the net force of the loop is upwards. So, the current inside the loop should be definitely in clockwise direction. Now we will consider the second position. Now the net force on the loop is acting upwards if $F_2 > F_1$. This requirement can be satisfied by the clockwise current flow in the loop. The bottom wire is closer to current I than the top wire. Now the repulsion is greater than the attraction. In both instances, the fair law of 'I (the nature) do not like you (the loop) to come' is applied.



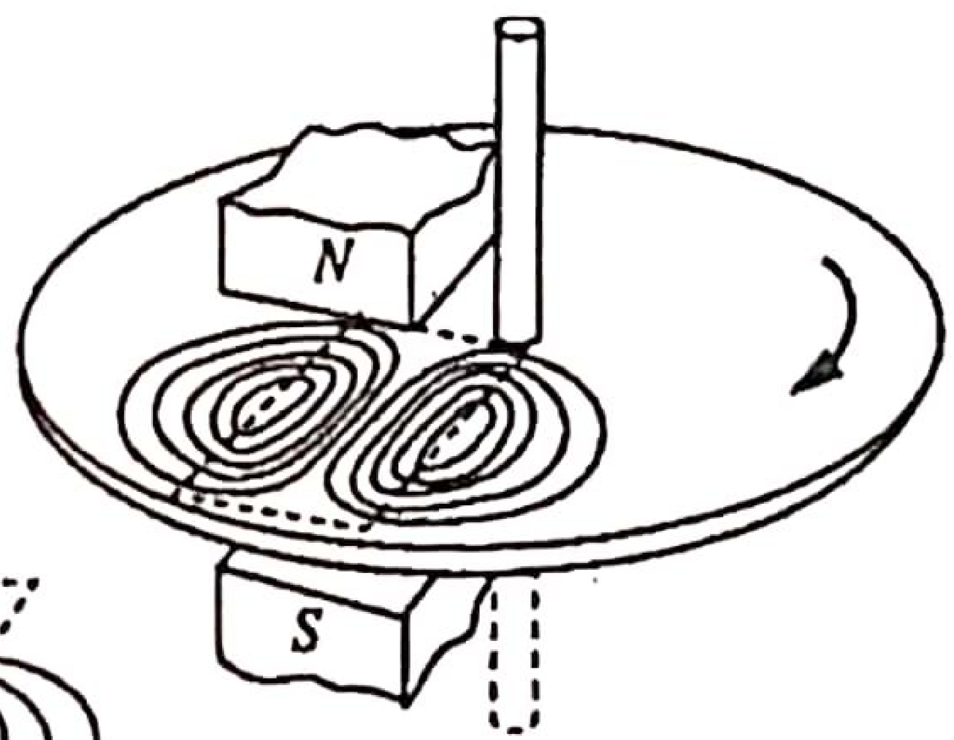
When the loop is moving in between the wires, does the induced current increase all the time? Or does it reduce? Before the loop comes to the middle of two wires, the inward flux of the loop gets reduced. Therefore, in that part of motion, the magnitude of the induced current is gradually reduced. It cannot gradually increase. To stop a person who tries to reduce should be given less. But as the loop tries to get closer to the bottom wire after the middle position, the outward flux of the loop gradually increases. Therefore, in that part of the motion, the induced current is gradually increased.

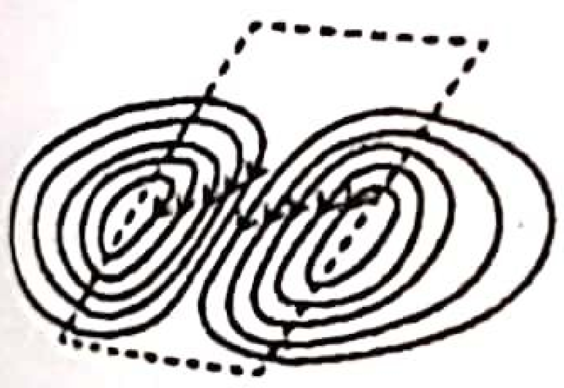


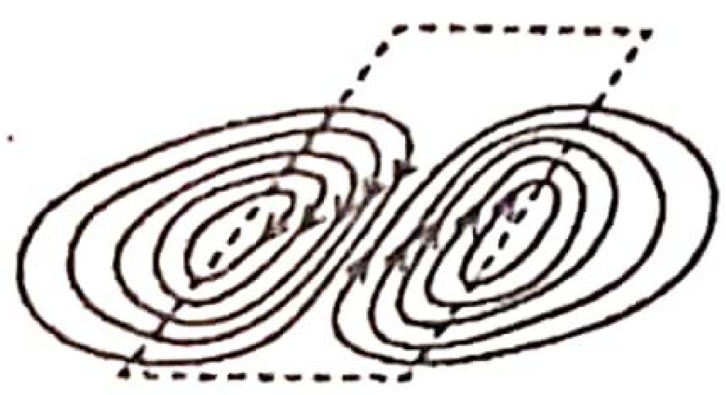
To stop the person who tries to increase, you need to give more medicine. But whatever the position, the direction of the induced current does not change 'always'. When it goes towards the middle, the induced current is gradually reduced. Once it passes the middle, the induced current is gradually increased. The difference of two wires compared to one wire is shown in this situation. When the middle line of the loop is at the middle of two wires, the net flux across the loop gets zero. At this instance, the loop is placed symmetrically to the current carrying wires. Therefore, the inward flux from the top wire gets opposite and equal with the outward flux from the bottom wire at this moment. Therefore, the flux of the loop suddenly gets a zero value. Does this indicate that the induced e. m. f is zero? No. The induced e. m. f is equal to the rate of change of flux. Even the flux is zero for a moment, the rate of change of flux will not be zero. To get the change, there should be two instances.

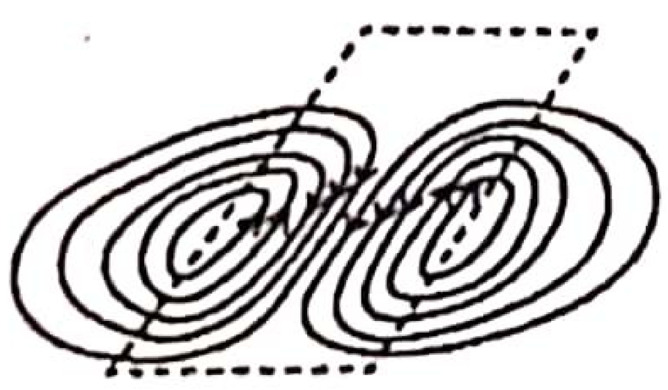
$E = -d\varphi/dt$; As $\varphi = 0$, E does not get zero. E should be zero when $d\varphi/dt = 0$. If the velocity is zero, then does acceleration get zero? Acceleration is the rate of change of velocity. The velocity at the highest point of an object that is thrown upwards gets suddenly zero. But the acceleration is not zero there. Acceleration is a constant. If the current always flow in clockwise direction, then it indicates that there is an induced current always. If so, then the current cannot be zero at a moment. That means the statement of 'current is zero for a certain moment' is false however. Even it is excluded from Physics, this statement can be decided as false. If a current is flown always, then it cannot be zero for a moment. But we need to think according to Physics.

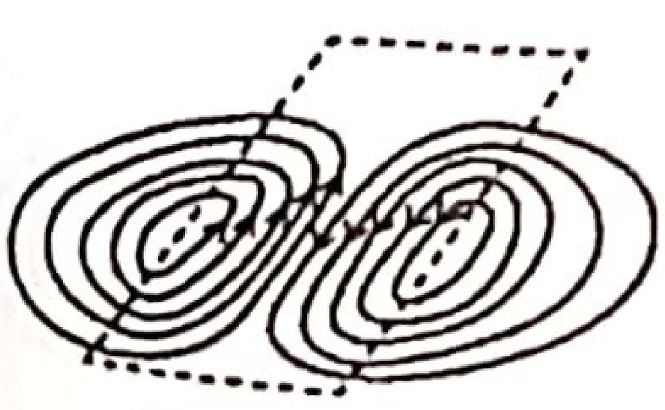
0. A metal disc rotates in the clock-wise direction between north and south poles of a magnet as shown in the figure. The magnet produces a magnetic flux confined to a small region shown with dotted lines. Magnetic field produced is perpendicular to the plane of the disc. Which of the following figures shows the correct direction of the current in the eddy-current loops which are produced in this situation?

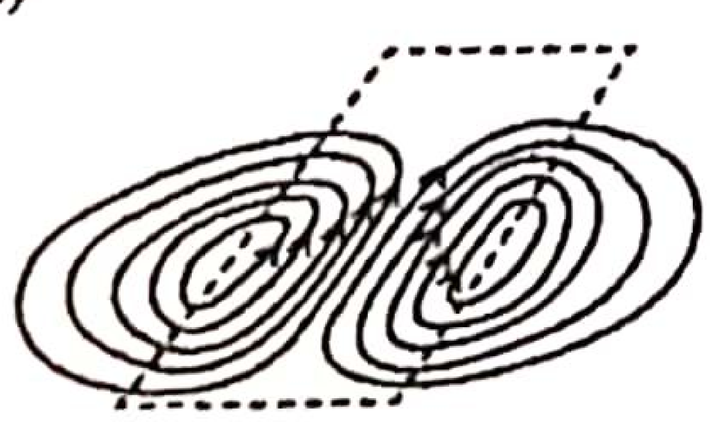



(1)

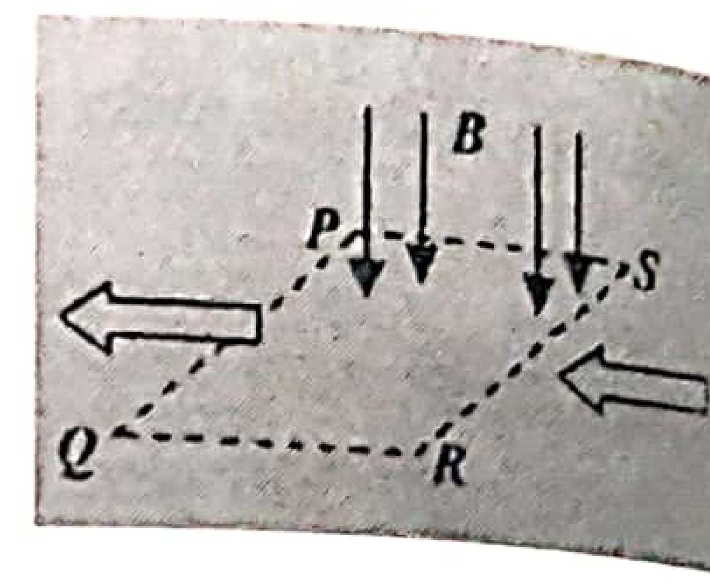

(2)


(3)


(4)

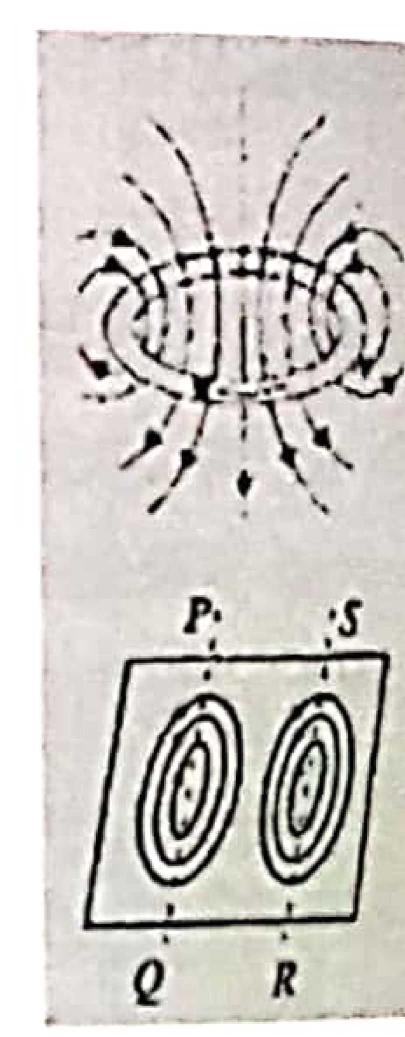

(5)

The figure has shown the induced eddy current pattens when a metal disk is rotated or pulled according to the given direction across a magnetic field which acts vertically downwards. It is another instance where induction laws are being applied. This question is equivalent to the 60th question of paper 1999. The metal disk was at rest there whereas the magnet was being moved. Here the magnetic field is static whereas the disk moves. But the same argument is there for both instances. If you have studies the question of 1999 very well, then the same argument can be applied to this question. The magnetic field is built across the disk is from top to bottom. The parts of the disk that is caught by the magnetic field is shown in dashed lines.



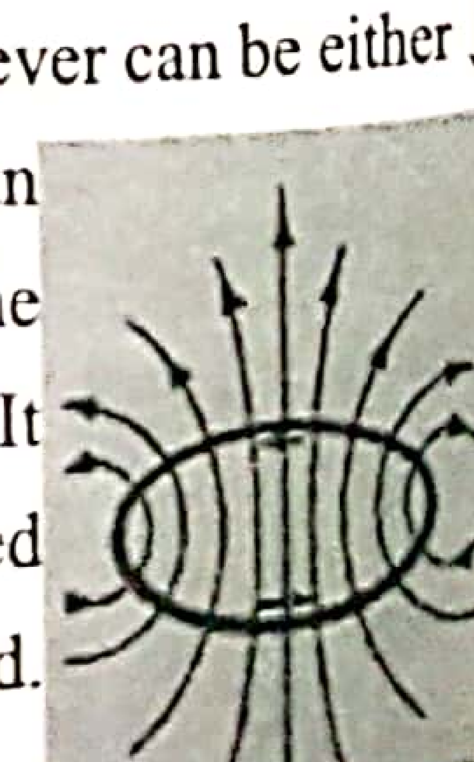
Think that the disk is rotating (in clockwise direction). When the disk is rotated, the left side of the disk (PQ) from the area that is marked from dashed lines is removed. That means that area of the disk is going away from the magnetic field. When it tries to go away, the magnetic field from the induced eddy currents tries to fill the gap from going away. The magnetic field from the magnetic poles act vertically downwards. When the disk goes away from line PQ, the magnetic field acting downwards from the magnetic poles suddenly vanishes. Therefore, eddy currents are produced to stop that loss. It says 'I do not like you to go'. To cover the loss of the downward magnetic field, then the created magnetic field also from eddy currents should be directed downwards. So, the direction of the eddy currents should be in clockwise direction. The eddy currents should be drawn in clockwise direction around PQ line.

Near the line of SR, the opposite thing should be happened. The disk is entered suddenly from a place without a field to a magnetic field that acts downwards. Suddenly it acquires something that already did not possess. Now the sentence is like this way. 'I do not like you to come'. The eddy currents are together to oppose the downward magnetic flux. That means the magnetic field from the eddy currents should act vertically upwards. If so, then the direction of the eddy current in that place should be in anti-clockwise direction.

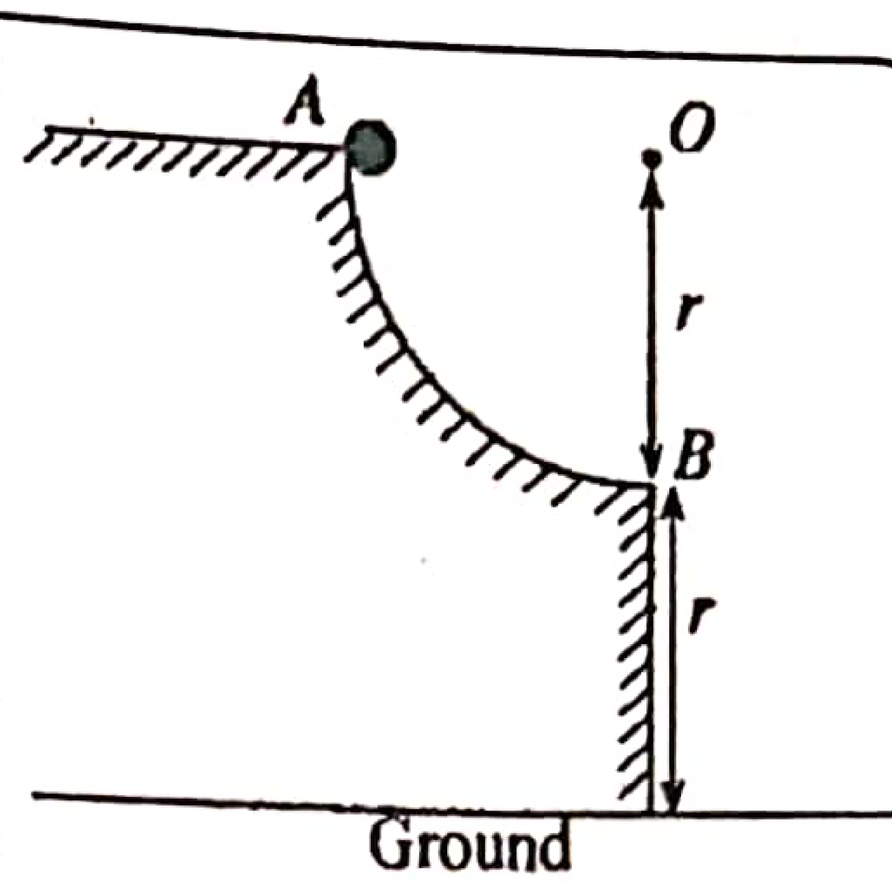


It is the way of the nature. When it tries to come, it says 'do not come'. When it comes, it says 'do not go'. If we look at the pattern, then it can be viewed that the direction of eddy currents is drawn to the same direction. It is an illusion if you see like that. The eddy currents that are in left side are in clockwise direction whereas the eddy currents in right side are in anti-clockwise direction. On one side there is a sudden arrival to an unknown place. On the other side, there is a departure from the known place. Even we as humans feel the same sensation on both of these occasions. We are bit reluctant to go to an unknown place. We work opposite to that. Even we do not like to go away from the known place. We work opposite to that also.

The other fact that you can notice is that eddy currents are subjected to attraction of each other. Therefore, the directions of the eddy currents are either ↓↓ or ↑↑. The directions of the eddy currents never can be either ↓↑ or ↑↓. The attraction occurs in currents of same direction. According to Lenz law, we can remove the pattern of ↑↑ (according to the above arguments). If the disk is rotated to the other side, then do you get that the pattern ↑↑ is correct? (Look at the top most figure) It says do not come to the front part and says do not go to the rear part. If the disk is rotated to the other side, then the front and rear sides are interchanged.

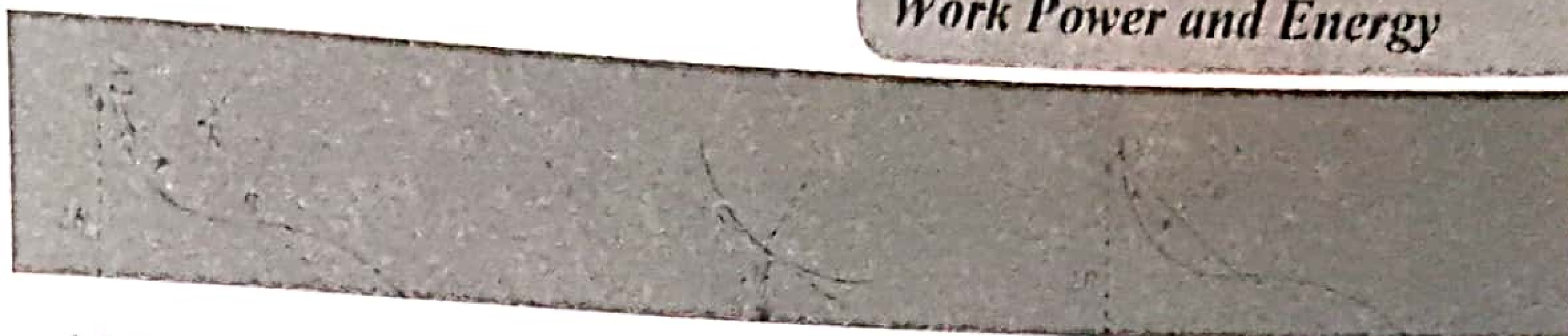


50. A small sphere is released from rest from point A in a firmly fixed frictionless track, which is a quarter of a circular path of centre O and radius r as shown in the figure. The sphere leaves the track horizontally at point B and falls under gravity until it hits the ground at a certain point C (C not shown). If the times taken and the distances travelled by the sphere from A to B and B to C are t_{AB}, t_{BC} and S_{AB}, S_{BC} respectively, which of the following is true?



(1) $t_{AB} > t_{BC}$ and $S_{AB} < S_{BC}$
(2) $t_{AB} > t_{BC}$ and $S_{AB} > S_{BC}$
(3) $t_{AB} = t_{BC}$ and $S_{AB} < S_{BC}$
(4) $t_{AB} < t_{BC}$ and $S_{AB} = S_{BC}$
(5) $t_{AB} = t_{BC}$ and $S_{AB} = S_{BC}$

Finding the inequality of time



Consider the motion of an object which is released from the top end of a curved surface without friction. When it is freed from the curved surface, the object is fallen under gravity. As it is frictionless, the object slides on the curved surface. There is no rotational motion. It will be complicated if you try to write equations. The easiest way which can be done from logic is shown below.

From A to B and from B to C the object moves an equal distance of R vertically. The acceleration of the object at point A (at that moment) is ↓□. At point B, the velocity of the object is towards horizontal direction →.

Let us consider a fair moment that the object is on the curved surface. At such a moment, the acceleration of the object towards the tangent of the curved surface is g sin θ. Even the variation of the acceleration is not uniform, the mean acceleration should be less than g in the motion of the object from A to B. This is true.

When the object goes away from B, the downwards acceleration of the object is ↓□ over the total motion. In both occasions, the vertical distance of motion is same (R). Therefore, tAB> tBC. The object passes B and falls down in constant acceleration of g. In the motion from A to B, the downwards acceleration of the object is not constant. It varies. The mean acceleration is less than g. The initial vertical velocities are zero on both instances. Therefore, to fall the same vertical distance of R, it should consume more time for the motion from A to B.

If it is simply said, then it will be like this way. From A to B: The initial vertical velocity is zero. The vertical distance that it travels is R. The downward acceleration is less than g.

From B to C: The initial vertical velocity is zero. The vertical distance that it travels is also R. The downward acceleration is g. Therefore, it should be tAB> tBC.

The vertical distance that the object travel from A to B and from B to C is same. Therefore, for the inequality of distance, you need to consider the horizontal distance that the object travel. At point A, the horizontal velocity of the sphere is zero. At B, if it is v, then according to the previous logic, then the mean horizontal velocity cannot be v in the motion of the object from A to B. It should be less than v. But when the object

Finding the inequality of distance

The vertical distance that the object travel from A to B and from B to C is same. Therefore, for the inequality of distance, you need to consider the horizontal distance that the object travel. At point A, the horizontal velocity of the sphere is zero. At B, if it is v, then according to the previous logic, then the mean horizontal velocity cannot be v in the motion of the object from A to B. It should be less than v. But when the object is gone from the curved surface (point B), its horizontal velocity is continuously →*v*. The object is pulled to the right side with horizontal v velocity. In the motion from A to B, the distance that the object goes horizontally is R (as it is a circular locus). But in the motion from B to C, it should be greater than R when the object is horizontally pulled. That means SAB< SBC. We can get this in a simpler way. The motion of the object from A to B occurs in a curved surface. It is one fourth of a locus of a circle.

The motion from B to C is a parabolic (look at the figure). The distance of a parabolic path is greater than a circular path. The parabolic path is stretched like the intestine. From this way also you can see that $S_{BC} > S_{AB}$.

From A to B: The initial horizontal velocity is zero. The horizontal distance that it travels is R.

From B to C: The horizontal velocity is continuously $\rightarrow v$. Therefore, the horizontal distance from B to C is definitely greater than R.

The time for the motion from A to B cannot be found from a simple equation because the acceleration of the object is not uniform. Therefore, we cannot apply the equations that we know. But if we design an inclined plane (third figure), then we can find the time for the object from A to B. Then the length of the inclined plane = $\sqrt{2}R$; The incline of the inclined plane = 45^0. The constant acceleration ↘ = $g \sin 45^0$; By applying ↘ $s = ut + \frac{1}{2} gt^2$ (the initial velocity of the object is zero), $\sqrt{2}R = \frac{1}{2} g \sin 45^0 \, t^2{}_{AB} \rightarrow t_{AB} = 2\sqrt{R/g}$

For the motion from B to C applying ↓ $h = ut + \frac{1}{2} gt^2$, $R = \frac{1}{2} g t_{BC}^2 \rightarrow t_{BC} = \sqrt{2R/g}$

Clearly it can be seen that $t_{AB} > t_{BC}$. The time taken to the object to come in the curved surface should be greater than the time taken to the object to come in the inclined plane. Therefore, the above inequality is more valid. If needed, then you can get inequality for the travelled distances by the equations too.

The horizontal distance that the object travelled in the motion from A to B = R

If the horizontal velocity at B is v, then the horizontal distance of BC path $s = vt_{BC} = v\sqrt{2R/g}$

From the conservation of energy $\frac{1}{2} mv^2 = mgR \rightarrow v = \sqrt{2gR}$

Therefore, the horizontal distance = $s = \sqrt{2gR}.\sqrt{2R/g} = 2R$;

As $2R > R$, clearly $S_{BC} > S_{AB}$.

From A to B and from B to C the object vertically travels a same distance of R. But from B to C, the horizontal distance that the object travels (2R) is greater than the horizontal distance that the object travels (R) from A to B. If so, then definitely the total distance which the object travels from B to C is greater than the total distance which the object travels from A to B.