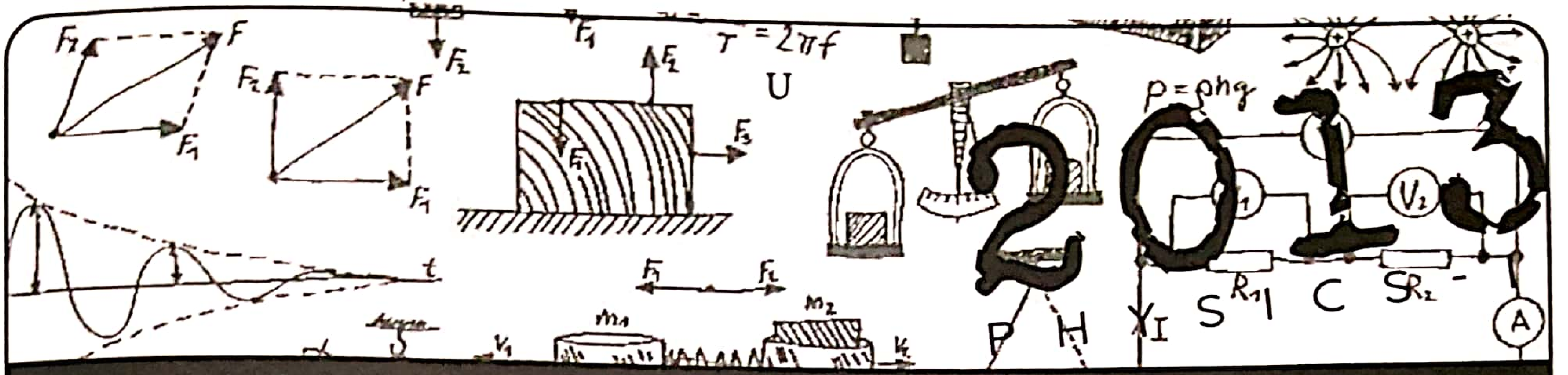
SCIENCE

@ALSCIENCESTUDENT
SDISCUSSIONGROUP



1. SI unit of Planck constant is
   (1) $J\,s^{-1}$ (2) $J\,s$ (3) $J\,K^{-1}$ (4) $J\,K$ (5) $J^{-1}\,s^{-1}$

Unit and Dimension **01**

There is nothing to look. It is enough if you could recall E = hf. E is measured from J and the unit of f is s^{-1}. Therefore, the unit of h is Js^{-1}. In everywhere of quantum physics which is used to study microscopic systems, Planck's constant is definitely coming into surface. If Planck's constant is zero, then there is no quantum physics. Fortunately, its value is very small. Therefore, there is no need to apply quantum physics for macroscopic systems. Planck's constant and the speed of light are considered as the basic constants. The unit of the angular momentum is same as Planck's constant. Just check that out.

2. Which of the following waves requires a physical medium for travelling?
   (1) Light waves (2) Radio waves (3) Sound waves (4) X-rays (5) Gamma rays

Wave Properties **03**

This is an ordinary level question. A medium is needed for the travelling of sound waves. The sound waves are mechanical waves. Therefore, a medium (molecules) is needed to transmit the energy. There should be something to shake to vibrate. Otherwise, how to take energy by shaking? In an electromagnetic wave, electric field and the magnetic field are being shaken. So, an electromagnetic wave can exist even in a vacuum.

3. Electromagnetic radiation of frequency f is incident on a photosensitive surface of which threshold frequency for emission of photoelectrons is f_0.
   Which of the following is **not** true?
   (1) No photoelectrons are emitted when $f < f_0$.
   (2) f_0 is a characteristic feature of the material of the photosensitive surface.
   (3) When $f > f_0$, the rate of the emission of photoelectrons increases as the intensity of incident radiation increases.
   (4) The stopping potential is directly proportional to f^2.
   (5) The stopping potential is independent of the intensity of the incident radiation.

Photoelectric Effect **11**

Everything is what you have known already. Even previous papers have also checked these facts. The false statement is being asked. Consider each statement one by one. If photoelectric effect has to happen then $f>f_0$. Therefore, (1) is true. The threshold frequency of f_0 is dependent upon the material that the surface was made, nature of the surface etc. So, (2) is true and (3) is also true. What is false is (4). The equation of stopping potential is $eV_s = hf - \varphi$. There is no f^2 in it. Even V_s is not proportional to f. There is $-\varphi$ on the right side of the equation. There is no relation between the stopping potential and the intensity of the incident radiation. This can be clearly seen just by looking at the above relationship.

In the photoelectric effect, the intensity of the radiation is measured by the number of photons that incident in a unit area per second. It is not measured from the energy that is incident in a unit area per second. The concept of photons is a particle theory. These two types of intensities should not be confused with each other. According to the wave model, the unit of the intensity is Wm^{-2}. It is correct. You cannot insert particle concept in the wave model. In the particle model, the unit of the intensity is photon $m^{-2}s^{-1}$. Both of these models are being used by ourselves interchangeably as per our convenience.

4. Consider the following statements made regarding the speed of sound.

(A) The speed of sound in air increases with the increase of temperature of air.

(B) At a given temperature the speed of sound in a metal is higher than that in air.

(C) The speed of sound depends on the frequency of the sound wave.

Of the above statements

(1) only (A) is true. **(2) only (C) is true.**

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

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

Velocity of Sound

These facts also you know by heart. How many times that the sentence (A) has been given? The following relation is valid for the speed of mechanical waves v.

$$v = \sqrt{\frac{\text{The restoring force that is used to apply for the equillibrium state of the system}}{\text{The inertia that resist for the equilibrium state}}}$$

For example, the speed of the transverse wave of a stretched string is $\sqrt{\frac{T}{m}}$. Here the tension T does the duty of the restoring force. The tension tries to bring the string back to the initial undisturbed state. If the tension is higher, then the restoring force is higher. It quickly comes to the initial equilibrium state. If the tension is less, then it will come to the initial undisturbed state very slowly. We know that without a tension, a transverse wave cannot be sent. If there is no tension, the string will break up. It cannot bear transverse displacements.

By the mass per unit length or the inertia corresponding to a unit length prevents the string to come back to its initial undisturbed equilibrium state. If m is greater, then the inertia will be greater. So, it slowly comes to its initial state. Therefore, when T is increased or m is decreased, the parts of the string quickly change transversely.

Now the restoring force in the denominator should be considered per unit area in the expression for longitudinal waves in a metal or solid material. The longitudinal waves are travelled into the material. Therefore, the force should be taken per unit area. If it is taken as Nm^{-2}, then it is the Young modulus of the material. As the numerator was multiplied by m^{-2}, the denominator also needed to be multiplied by m^{-2}. Then kgm^{-1} that we get for transverse waves becomes kgm^{-3}. That means the density of the material. So, the longitudinal wave speed v in a solid material is given by $v = \sqrt{\frac{E}{\rho}}$. The elastic characteristic is measured by E whereas the inertia characteristic is measured by ρ.

When a sound wave is travelled in a gas, the restoring force that is needed to be in the undisturbed state is provided by the pressure of the gas. When a sound wave is travelled in a gas, there are changes of pressure and volume from place to place. Newton has given an expression for the sound speed of air according to the above relationships as $v = \sqrt{\frac{P}{\rho}}$. But when the values are substituted, the value obtained for v is lesser than the experimental value. That means $\sqrt{\frac{1.01 \times 10^5}{1.3}} = 279\ ms^{-1}$.

After a century, when Laplace modified the above equation as $v = \sqrt{\frac{\gamma P}{\rho}}$, the correct experimental value was obtained. I tend to write about more because a letter sent by a teacher. His suggestion was even if the sound speed of the air is given by $\sqrt{\frac{\gamma P}{\rho}}$, when ultrasound waves are sent, their wave speed is given by $\sqrt{\frac{P}{\rho}}$. Even the equation for ultrasound waves is not in the syllabus, it is true that for ultrasound waves the equation is $\sqrt{\frac{P}{\rho}}$. The reason for this will be explained in a while.

The relevant query of his inquiry was whether sentence (C) is correct or wrong. Ultrasound waves are also a type of wave. His argument was that if there is one equation for normal waves and another equation for ultrasound waves, then why does the statement that sound speed depends upon the frequency is not correct? His argument is correct when sound waves and ultrasound waves are both taken together. But in A/Ls we take the waves that are in your auditory range when we mention as sound waves. The ultrasound waves are not included for this. Therefore, we consider statement (C) as wrong. Whatever the frequency of the sound waves that are in our auditory range, the speed of sound is given by $\sqrt{\frac{\gamma P}{\rho}}$.But it is true that the speed of ultrasound is given by $\sqrt{\frac{P}{\rho}}$.

What is the difference for this change? The frequency of the ultrasound waves are at a very higher value. When the frequency is increased, the wavelength is shortened. That means when an ultrasound wave is travelled, the distance between the compressions and rarefactions is very less among the air layers. We know that when the air is compressed it gets warm whereas it gets cold when it is relaxed with rarefactions. When an ultrasound wave is travelled in the air, then there can be heat transfers from the warm layers to the cold layers as the air layers of warm and cool are very near to each other. Therefore, ultrasound wave travelling is considered as an isothermal process. That means as there is possibility to heat transfer, there will not be any temperature increment or decrement in air layers. Therefore, in the equation of the speed of ultrasound waves only P is there in the numerator.

But the transmission of normal sound waves is considered as an adiabatic process. The frequency of the waves do not take a higher value like in the ultrsound waves. Therefore, the wavelengths are relatively greater. That means the distance between the air layers of compression and rarefacation are greater. Then there is less chance for the heat transmission. Even air is also an insulator. If there is no possibility for heat transmission, then such a process is adiabatic. In an adiabatic process, γ parameter is connected to our equations.

For an isothermal process PV = constant. For an adiabatic process, PV^{γ}= contant. (It is better if you just know the equation. The problem solving by its usage is not in the syllabus.)

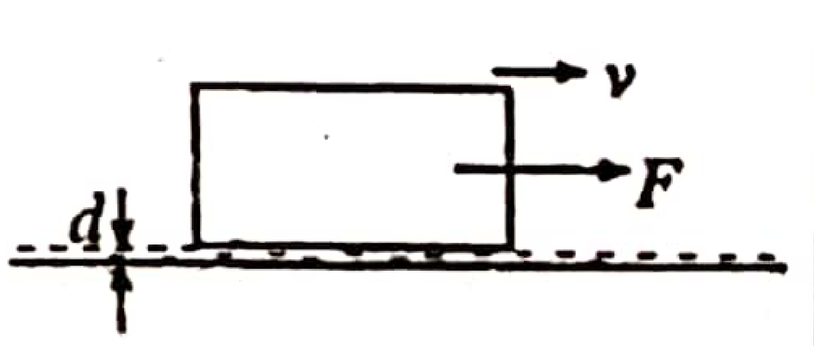
You may have understood that why there is γP in numerator of the equation of sound waves speed in air. The place where Newton got it wrong was corrected by Laplace by considering the sound transmission as an adiabatic process.

We know that the sound speed in a metal is higher than the value of it in the air. For example, for steel, E $=2 \times 10^{11}$ Pa and $\rho = 7.8 \times 10^3$ kgm^{-3}.

$$v = \sqrt{\frac{2 \times 10^{11}}{7.8 \times 10^{3}}} = 5064 \text{ ms}^{-1}$$

It has been given as the same temperature because the speed of sound of a gas changes with the temperature. There is not such an effect about the temperature variations of high or low for the sound speed of the metal. The density of a solid material does not vary much with temperature compared to a liquid and gas.

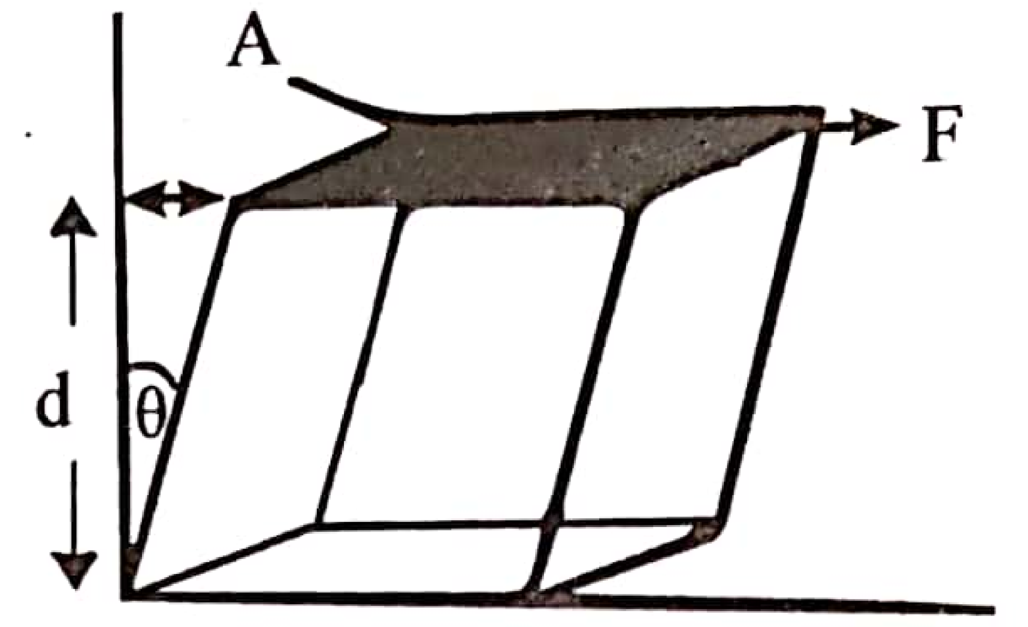
5. As shown in figure, a box is placed on an oil layer of viscosity η and thickness d. The area of the surface of the box in contact with the oil is A. What should be the horizontal force F to be applied on the box in order to move it at a constant velocity v?



(1) $F = \frac{\eta A d}{v}$ (2) $F = \frac{\eta A v}{d}$ (3) $F = \frac{\eta v}{dA}$ (4) $F = 6\pi\eta A v d$ (5) $F = 6\pi v A \eta$

From the interpretation you can get η. F = ηAv/d. Even it is not being discussed in advanced level, η is interpreted like this. Relative to the oil layer that is in touch with the ground, the oil layer that is in d distance has gone a distance of v forward. In Physics, it is considered as a shear. Young modulus (E) for a wire or metal rod is interpreted like this way. E = tensile stress/ tensile strain

Likewise, for shear it is interpreted as η = shear stress/ sheer strain = $\frac{F/A}{\tan\theta}$. (These are not in the syllabus. I present this information only to the students who love to learn more)



A shear is not a pull or a compression. It is a change of shape. It is like a rectangular box that has been pulled from a side. The shear stress is measured by a familiar way of F/A. The shear strain is measured from tan θ. If tan θ is greater, then it is being pulled more. Strain cannot have units. Even tan θ does not have a unit.

$\eta = \frac{F/A}{v/d} \rightarrow F = \frac{\eta A v}{d}$

6. A slow neutron is absorbed by a $^{235}_{92}U$ nucleus and results in a fission process as follows.

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{139}_{56}Ba + ^{94}_{36}Kr + x\,^{1}_{0}n$$

The value of x (number of neutrons produced) of the above fission process is

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

Radioactivity

When A (mass number) is conserved on both sides, you will just get the answer. The total of A on the left side is 236. Therefore, the total of A on the right side should be 236. 139 +94 = 233. That means the rest should be given by neutrons. So, x =3. There is no need to conserve Z number here. There is no charge in neutrons. Therefore, 92 = 56 + 36. You only have to look at those in such nuclear reactions. How easy are nuclear reactions compared to chemical reactions?

7. If the mean output pressure of the heart is 1.2×10^4 Pa and the mean blood flow rate is 5.0×10^{-3} m³ per minute, the mean output power of the heart is

(1) 0.5 W (2) 1.0 W (3) 1.5 W (4) 2.0 W (5) 2.5 W

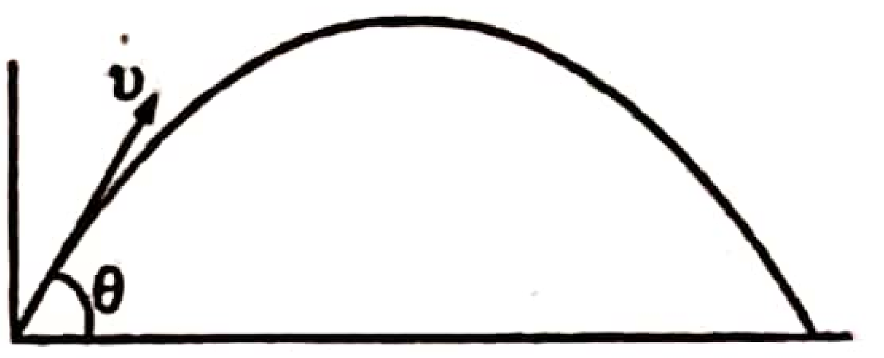
Work Power and Energy

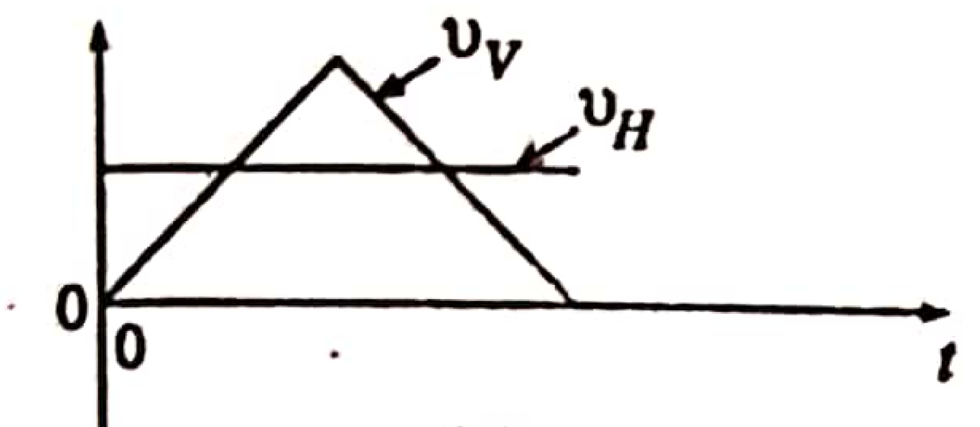
You need a simple calculation. Power P = Fv (where F = force and v = speed). P = F/A. AV (divide by A and multiply by A where A = area).

So, P = pressure X volume per second = $\frac{1.2\times10^4\times5\times10^{-3}}{60} = 1W.$

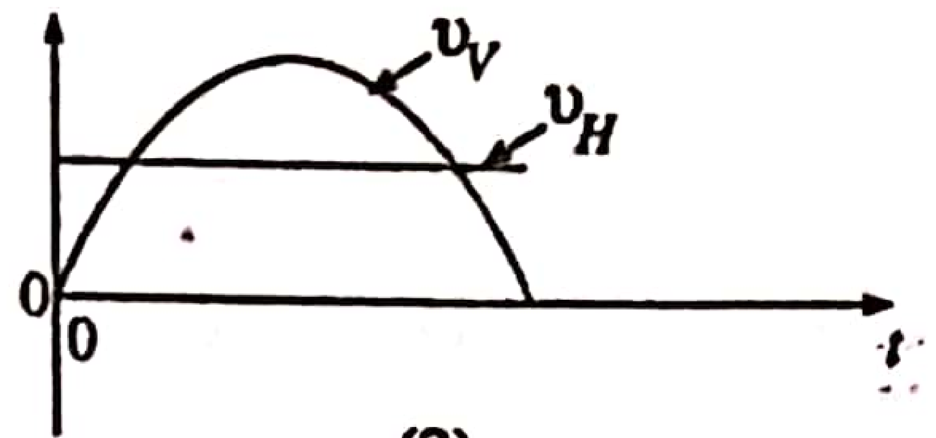
1.2 and 5 are given to get the multiple as 6. Even though it is thought as above, you know that the work is PΔV. When ΔV is taken as the volume change per second, power is given by PΔV.

8. **An object is projected under gravity with velocity υ, in a direction which makes an angle θ with the horizontal as shown in the figure. Which of the following graphs correctly indicates the variation of the horizontal (υ_H) and vertical (υ_V) components of the velocity of the object with time (t)?**





(1)



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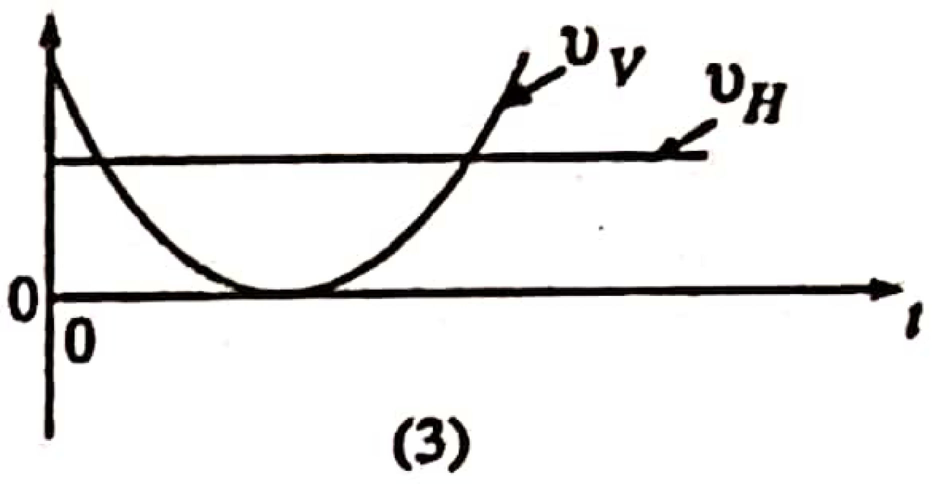
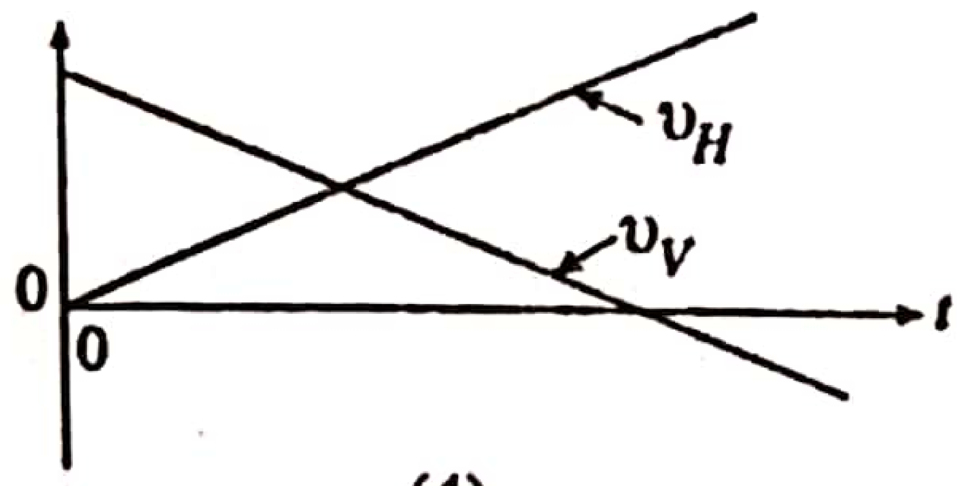
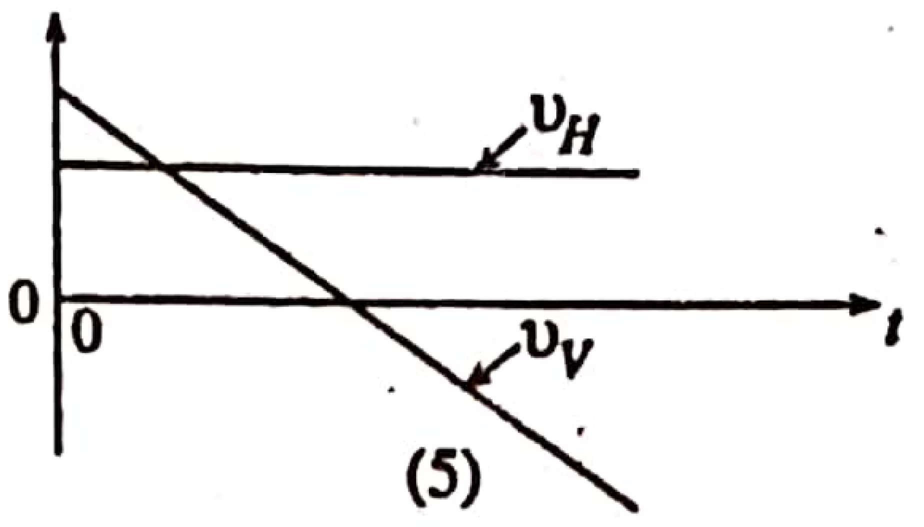


(3)



(4)



(5)

Linear Motion **02**

It is very simple. It has been checked before. V_H, is not changing with t. V_H is V cos θ. As there is no horizontal force, the velocity is a constant. The vertical component will gradually reduce and suddenly gets zero at the maximum height and then turn back afterwards. The direction gets reversed. Such a variation is shown in graph (5). The vertical upward acceleration is a constant. It is -g. Therefore, V_V should be a straight line with a negative gradient. When the object comes back to the ground, the net displacement to the vertical direction is zero. Therefore, the positive area bounded by V_V and t should be equal to the negative area.

9. **Two athletes run a 10 km race with constant speeds v_1 and v_2 in a circular track of radius 50 m. It has been observed that the athlete with speed v_1 completed 10 rounds when the other athlete completed 9 rounds. The ratio $\frac{v_1}{v_2}$ is**

(1) $\frac{10}{9}$ **(2)** $\frac{9\pi}{10}$ **(3)** $\frac{18\pi}{10}$ **(4)** $\frac{10\pi}{9}$ **(5)** 9

Circular Motion **02**

I doubt whether more time was spent on this question. Actually, there is no use from the radius of the locus or the distance that should be travelled. When the first athlete goes 10 rounds, the other athlete goes 9 rounds. That means the time spent is equal for both of them. So, $v_1 > v_2$. Likewise, $v_1/v_2 = 10/9$. If you, do it in a lengthy way as by taking the radius of the locus is r, then one round will be $2\pi r$. If so, then $2\pi r \times 10/v_1 = 2\pi r \times 9/v_2$ (as times are equal). Even if r is substituted, then it will be cut off. The length of one round in the locus $= 2\pi r \times 50 = 300$ m (when $\pi = 3$). Therefore, to go a distance of 10 km, you need to go 33.3 rounds. Round 10 and 9 are lesser than this value.

10. Two wheels A and B of a machine rotate about a common axis in the same direction with angular speeds ω_1 and ω_2, respectively. See figure (a). Moment of inertia of wheel A about the axis of rotation is I_1 and that of wheel B is I_2. At a certain instant, two wheels are pushed towards each other until they are firmly pressed and the system rotates with a common angular speed ω, without slipping. See figure (b). The value of ω is given by

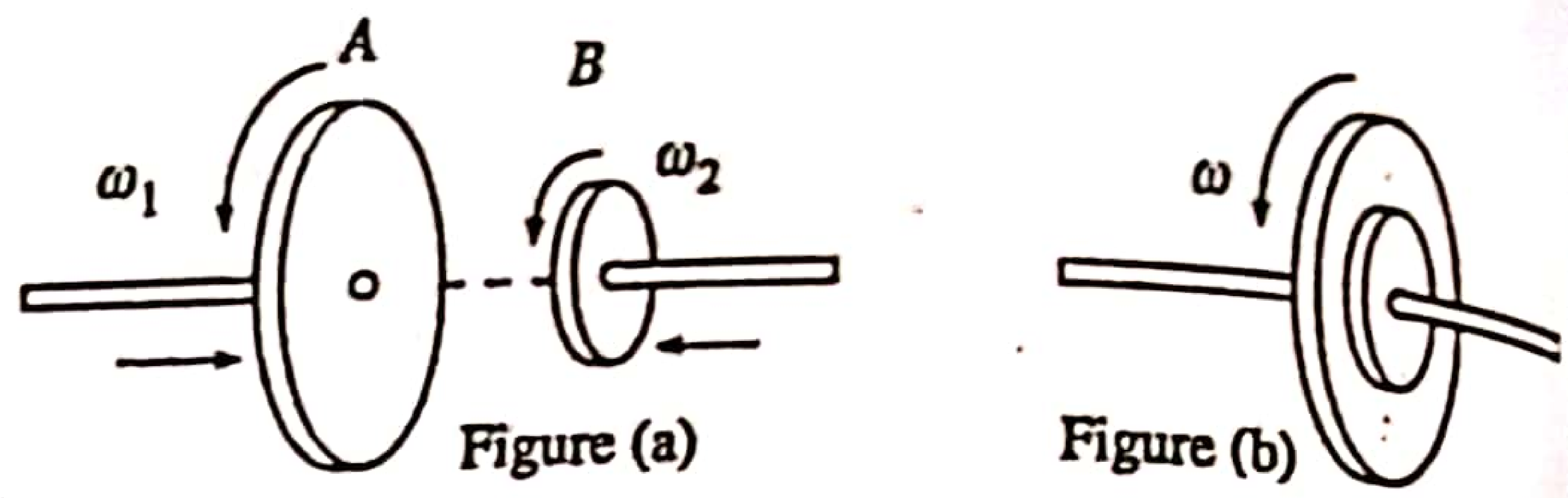


Figure (a) Figure (b)

(1) $\omega = \dfrac{\omega_1 + \omega_2}{2}$ (2) $\omega = \dfrac{I_1\omega_1 + I_2\omega_2}{I_1 - I_2}$ (3) $\omega = \sqrt{\omega_1\omega_2}$

(4) $\omega = \dfrac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}$ (5) $\omega = \dfrac{I_1\omega_1^2 + I_2\omega_2^2}{\omega_1^2 + \omega_2^2}$

Rotational Motion

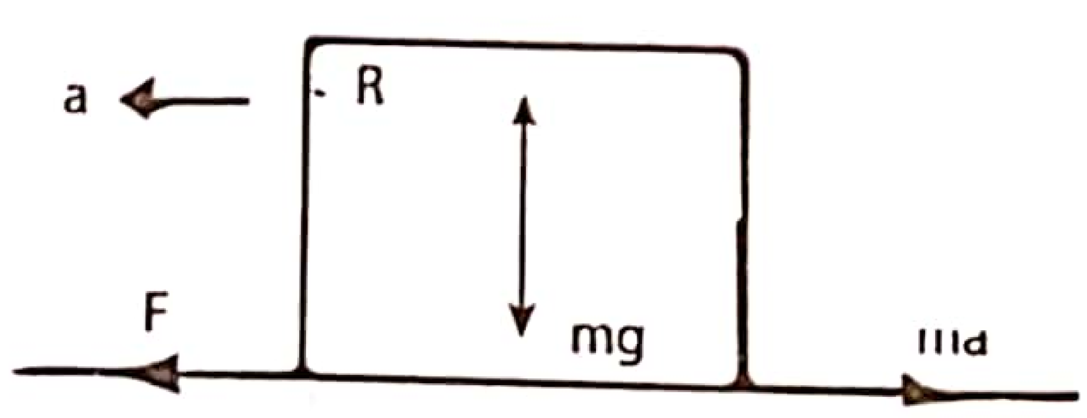
You can close the eyes and do this question. Even this was asked in 2011 as the 13th question. When you apply the conservation of angular momentum, you will get the answer effortlessly.

11. A block of mass m, kept on the horizontal truck-bed, is at rest with respect to the truck when it is moving horizontally with a constant acceleration a. The coefficient of static friction between the truck-bed and the mass is μ. The frictional force acting on the mass is given by

(1) ma (2) μma (3) $\mu m(g+a)$
(4) $\mu m(g-a)$ (5) mg

Friction

A similar question has been given as the 20th question of paper 2010. I have given a long description there. Most of the time children may consider μR = μmg as the answer. But that answer is not given. In 2010 review, the motion of the block relative to the lorry and ground have been described. Following diagram shows the acting forces on the block relative to the accelerated vehicle.



If the block needs to be accelerated with the vehicle to the left, then there should be a force to the left. That force can be obtained for the block only from the frictional force. If the block needs to be connected with the hood and go to the left, then the hood must find the frictional force on the block to the left. Here the frictional force helps us. If the block is at rest relative to the vehicle, then the imaginary 'ma' force is needed to be marked to the right side. Likewise, it should be F = ma. If the acceleration of the vehicle is gradually increased, then F also should get increased with ma. But there is a maximum value that F could take. It is μR. If ma increases than this value, then the connection between the block and the hood gets over and their relationship breaks down.

Therefore, if the block is at rest all the time, then the frictional force is equal to ma. If the maximum(limited) frictional force is asked, then the answer is μmg. If μmg was there in the choices, then it is correct. But as it is not in the answers, ma is fairly true always. At one instance only the frictional force is equal to μmg. That means at the limited stage. But if it was in the answers, then there would have be a confusion in selecting the correct answer. Some children have decided that the question is wrong as μmg is not in the answers. The question is asking about any common situation. The maximum acceleration is being asked in the question of paper 2010. Therefore, the maximum frictional force according to that instance is μmg.

12. **A simple pendulum is constructed by suspending a small metal bob with a fine wire of the same metal. The period of the pendulum at temperature θ_1 is T_1. When the pendulum operates at a higher temperature of θ_2 the period of the pendulum would be (Linear expansivity of the metal is α)**

(1) $T_1\sqrt{1+\alpha(\theta_2-\theta_1)}$
(2) $T_1\sqrt{\frac{1}{1+\alpha(\theta_2-\theta_1)}}$
(3) $\frac{T_1}{1+\alpha(\theta_2-\theta_1)}$
(4) $[1+\alpha(\theta_2-\theta_1)]\frac{1}{T_1}$
(5) $T_1\sqrt{\alpha(\theta_2-\theta_1)}$

Expansion of Solids **04**

This question is just simple as peanuts. The oscillation time is proportional to the square root of the length. Therefore, $T_1 \propto \sqrt{l_1}$ and $T_2 \propto \sqrt{l_1(1+\alpha(\theta_2-\theta_1))} \rightarrow \frac{T_2}{T_1} = \sqrt{1+\alpha(\theta_2-\theta_1)}$

These things are not needed to be written. As the temperature is increased, the length of the wire should be increased and the oscillation time should also be increased. Therefore, you can remove the choices of (2) and (3). There is no square root in (4). In (5), there is no 1+... term. We know the expression of $l_2 = l_1(1+\alpha(\theta_2-\theta_1))$ by heart.

13. The atoms of an ideal gas have a certain mean kinetic energy at 10 °C. Their mean kinetic energy will be twice at

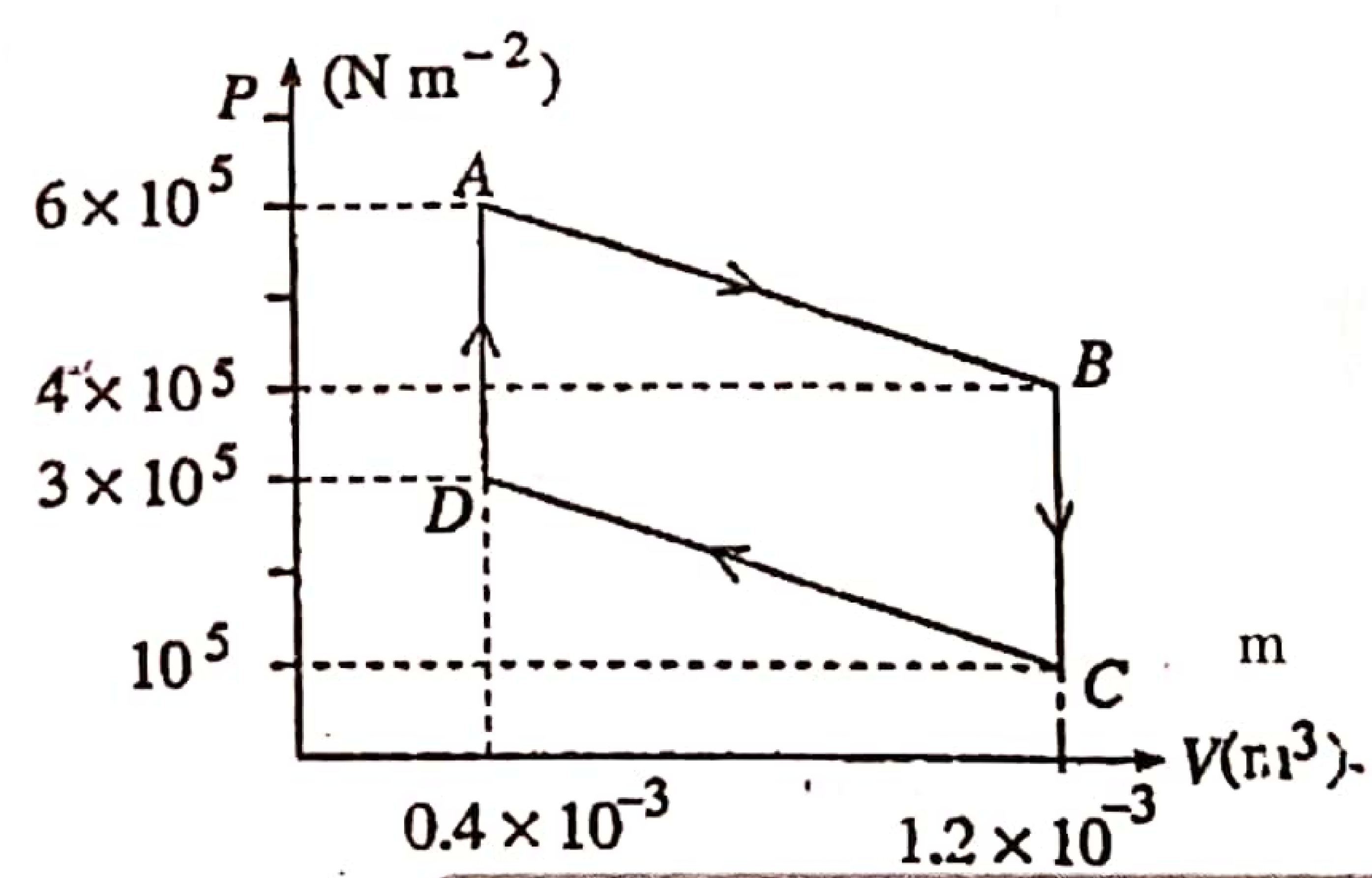
(1) 20 °C (2) 100 °C (3) 293 °C (4) 566 °C (5) 600 °C

Expansion of Gases **04**

How many times that such questions have been asked? The mean kinetic energy is proportional to absolute temperature. All the answers are given in °C. therefore, 566-273 = 293°C. You can do it from your memory. 273 + 10 = 283. The double of 283 is 566. When 273 is reduced from 566, it is 293.

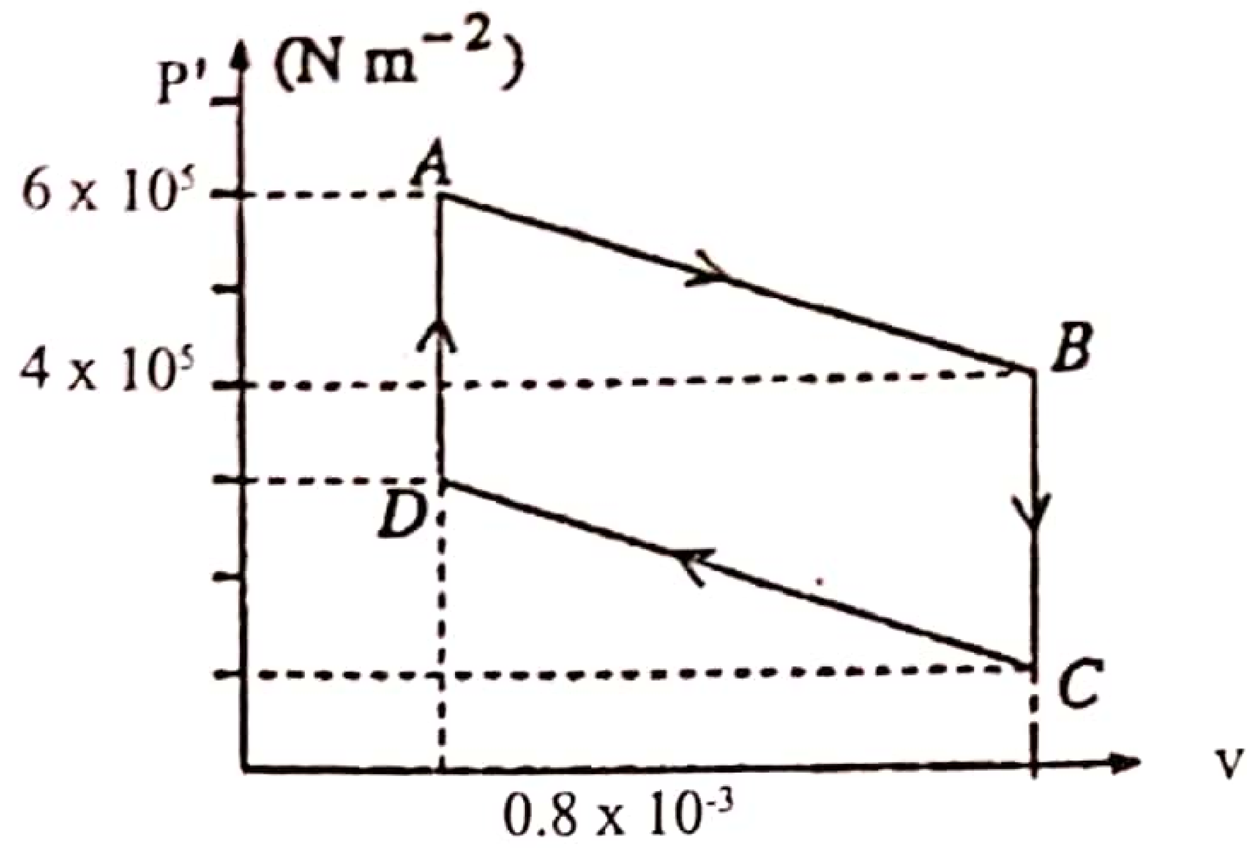
14. A system undergoes a cyclic process according to the *P–V* diagram shown in figure. The work done by the system from *A* to *B* and from *B* to *C*, respectively are

(1) 400 J, 0
(2) 400 J, 360 J
(3) 480 J, 360 J
(4) 480 J, 0
(5) 520 J, 0



Thermodynamic **04**

Simple mathematics is there. The work is zero from B to C. Why? Because there is no change in volume. You can directly remove choices (2) and (3). To find the work from A to B, we need to find the area between AB and volume axis. That means we need to find the area of the trapezium.



$$(6+4)10^5 \times \frac{0.8}{2} \times 10^{-3} = 4 \times 10^2 = 400J$$

Once the expression is written, you should do the simplification from the memory. 6+4 is 10.10 divide by 2 is 5. 5 X 0.8 is 4. When finding the work from A to B, you should not find the area of the parallelogram of ABCD. That area is equal to the work done in ABCD cycle.

15. A stretched string is vibrating with four loops. If the frequency of vibration is increased by a factor of 2, the number of loops formed would be
(1) 3 (2) 5 (3) 6 (4) 7 (5) 8

Transverse Waves

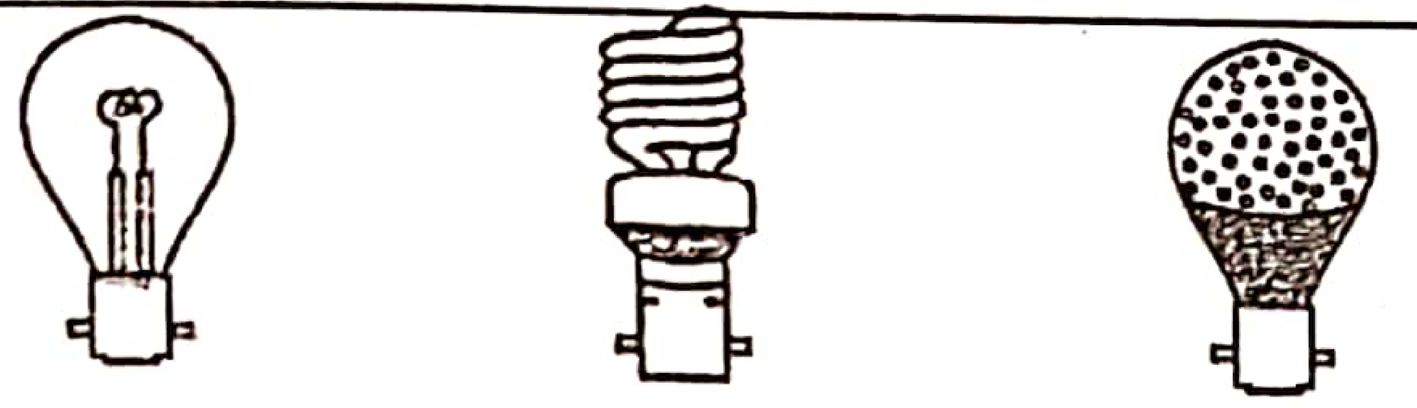
It is very easy. Four loops mean two wavelengths. As the tension of the string or the string are not changed, the speed of the transverse wave does not get changed. Therefore, when the frequency is doubled, the wavelength gets half from the previous value. When the wavelength is halved, the loops get doubled. The length of the string is not changed. If previously the string is set for four loops and now the wavelength is halved, then the number of loops created should be doubled. You can argue by drawing loops but it is a waste of time. From logic you can get the answer. If needed, then draw one loop only and try to get the answer. As the wavelength is halved (the wave is shrunk), the place where there was one loop should now have two loops.

16. Consider the following statements made about a compound microscope.
(A) The object should be placed just outside the focal point of the objective.
(B) The eyepiece acts as a simple magnifier.
(C) The angular magnification is independent of the focal length of the objective.
Of the above statements
(1) only (A) is true.
(2) only (A) and (B) are true.
(3) only (B) and (C) are true.
(4) only (A) and (C) are true.
(5) all (A), (B) and (C) are true.

Optical Instrument

This also contains facts that you already know. There is no complexity in the sentences. A combined microscope finally makes a large and unreal image by taking the image in between the focus and optical centre of the eyepiece using the large and real image that is created from the objective. The object should be placed in between C and F to get a large and real image. The image gets larger as long as it is nearing to F. Therefore, (A) is correct. When the object is placed just after F, you can get the largest real image as well as you can get the practical advantage of keeping the specimen near to the microscope. (B) is also true. The duty of the eyepiece is giving a large and unreal image as previously mentioned. What is happening in a simple microscope is the same. You can just see that (C) is wrong. There is f_0 even in the equation that gives the angular magnification. So, why do you have to bother about it?

17.



230 V, 60 W (A) Incandescent

230 V, 10 W (B) CFL

230 V, 5 W (C) LED

The figure shows three types of electric bulbs (A), (B) and (C) which produce the same brightness approximately. The consumptions of electric power by (B) and (C) when compared with (A) are approximately

(1) same as (A).

(2) $\frac{1}{10}$ and $\frac{1}{5}$ of (A), respectively.

(3) 10 times and 5 times of (A), respectively.

(4) $\frac{1}{6}$ and $\frac{1}{12}$ of (A), respectively.

(5) 6 times and 12 times of (A), respectively.

Heating Effects of Electric Current **08**

This is O/L. The voltages of the three batteries are same. So, 10 W is 1/6 of 60 W. 5 W is 1/12 of 60 W. Do you need to do calculations? Compared to a filament bulb, from the general knowledge you know that the electricity consumption is less in a CFL bulb, whereas a LED bulb has even lesser electricity consumption. These facts are only satisfied by the choice (4).

Bulbs are used to get the light. If equal amounts of light intensities are given to manage electricity, then it is economically profitable. There are LED bulbs in the market. Even their price is high, it will go down in the near future. A solid object is being heated in a filament bulb. From that, we can get the whole spectrum. From CFL and LED bulbs, you will not get the whole spectrum. But white LED that is being used in present days, has omitted the production of characteristic colours. Therefore, LED bulb usage will be very common in the near future is my feeling.

18. **Consider the following statements made regarding a transformer.**
(A) The core of the transformer is made out of laminated plates of soft iron.
(B) Both Joule heating and eddy currents contribute to the energy loss of a transformer.
(C) Power can be amplified using a transformer.

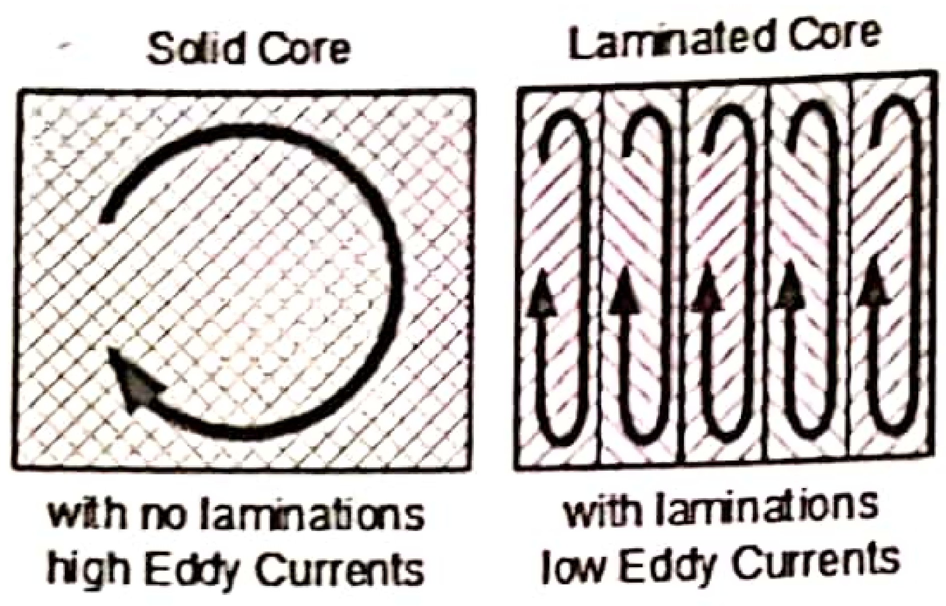
Of the above statements

(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.

Mutual Induction **08**

The facts in this question have been given by many times. These three sentences are in the past papers. Both (A) and (B) are correct whereas (C) is wrong. The core is made from soft iron to grasp the magnetic flux properly. Then the magnetic force lines will not anywhere and go across the soft iron. The permeability (μ) of soft iron is greater. Another advantage of the usage of soft iron is that it reduces the energy loss from the hysteresis losses. The hysteresis loop of soft iron is narrow. Even some teachers teach hysteresis, it is not in the syllabus. It can be laminated and apply a non-conducting material (natural film of oxide or insulating varnish type), we can minimize the generation of Eddy currents. Look at the following figure.

The first figure has shown the Eddy currents that are being induced in a non -laminated solid core. The second figure has shown the Eddy currents that are being induced in a laminated medium. The Eddy currents in the first medium moves in the whole volume of the core whereas the generated Eddy currents of the second is limited to the laminas. That means Eddy current paths are narrow.

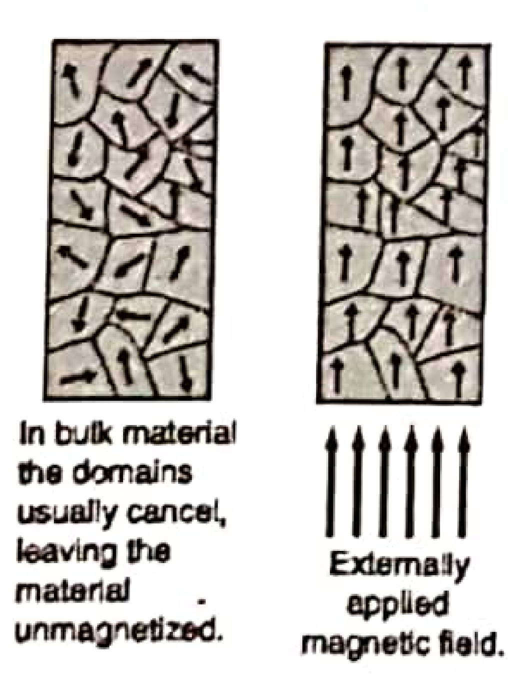


If you look at the second figure, it is true that the net length of paths of Eddy currents are greater than the first one. Therefore, there can be a dilemma about how can the energy loss is minimum in the second figure. Actually, once a teacher asked this from me.

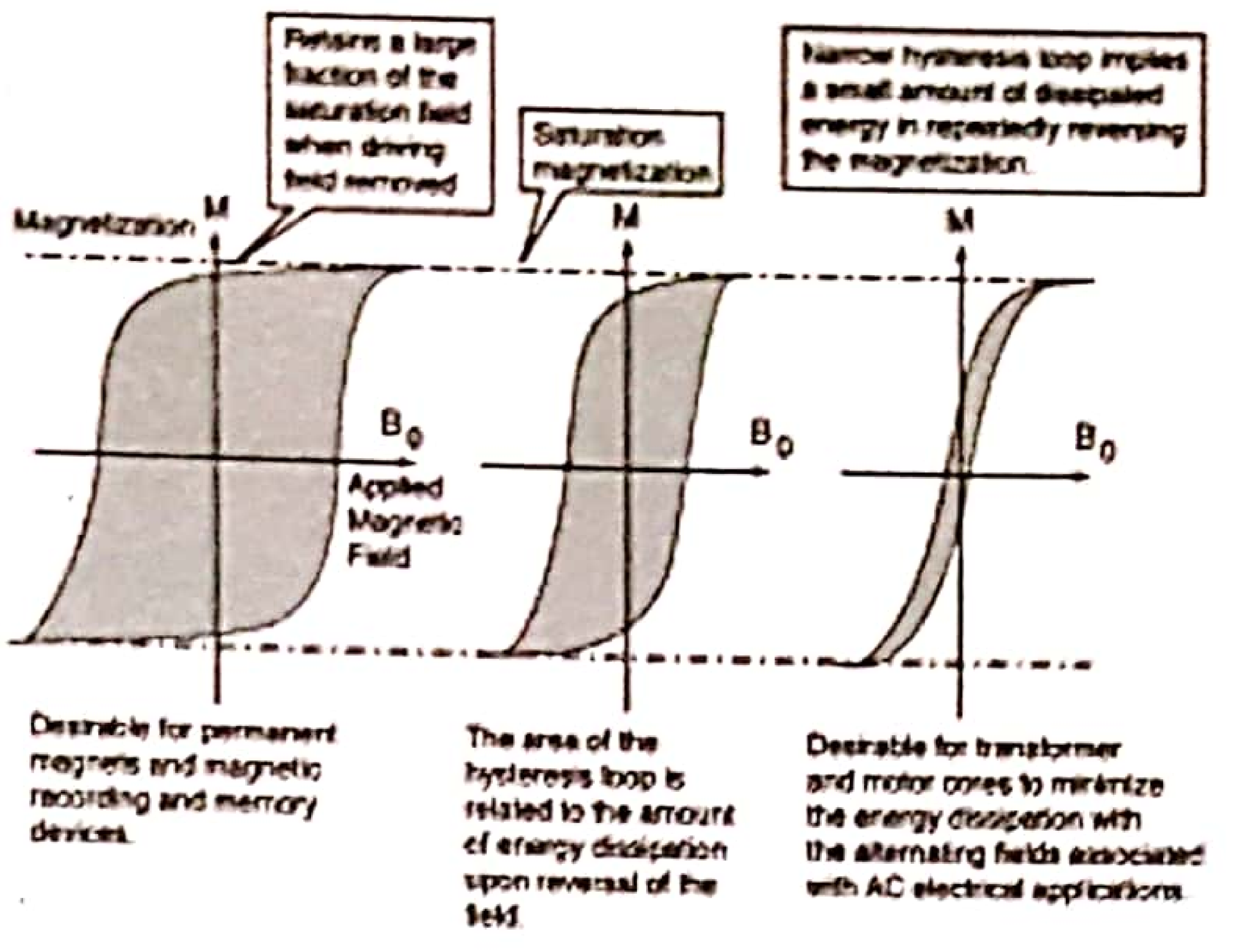
What is happening here is that as the area in between the plates are small and the magnitude of the rate of change of magnetic flux gets smaller across it ($\Delta B/\Delta t.\ A$). The value of A is smaller. The paths of Eddy currents are narrower. Therefore, the magnitude of the induced e. m. f is small. Therefore, the magnitude of the induced current is small. The energy loss goes with i^2R. So, the reduction of the value is affecting immensely to i^2. If the core is totally a solid, then the magnitude of the induced currents is greater. The paths of Eddy currents will be broad (A is greater). Then the values of i^2 is also greater. When it is laminated, even though there are many small paths, the magnitude of flowing current in them are greater. There is a saying that small family is golden (but the damage from this is not small. Even my family is small).

There is a small disadvantage in lamination. Due to the force created on the current carrying plates by the alternative magnetic field, they are being vibrated. From this, the characteristic 'hum' sound is heard from a transformer. This hum sound is heard from the bees too. Joule heating is known as the heat generation across a resistor when a current is flown. When there is current flow across the turns of the transformer, there are losses of i^2R. Here R is not the resistance of the wounded wires. It is the resistance of the Eddy current path. The power cannot be amplified by a transformer. Even energy cannot be created.

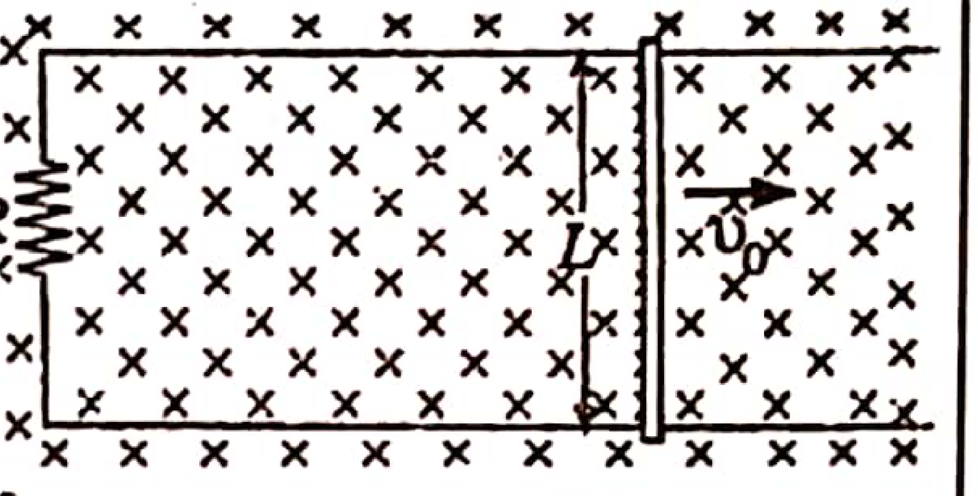
Even hysteresis is not in the syllabus, I guess it is valuable to write something because some children mention about it. Soft iron core belongs to ferromagnetic materials type. They have domains that are being magnetized. When there is no external magnetic field, these magnetic domains are directed to random directions (Look at the figure.). When an external magnetic field (B_0) is applied, the magnetic field tends to align with the applied magnetic field gradually. When this alignment is complete, the magnetization of the material (M, magnetization) gets to a maximum value. When the external magnetic field lessens M gets reduced but when B_0 is zero, M will not be zero. There is a leftover value for M.



When the direction of the external field is reversed and repeated again, the variation of M is shown in this figure. The behaviour of M is known as hysteresis and the loops that are shown are known as hysteresis loops. These magnetic locations are continuously turn from side to side and the heat is generated. This is known as the hysteresis loss. If the area of the hysteresis loop is less, then the generated heat is less. Due to many external effects, even hysteresis loops are created in our minds. The happiness or sadness is decided by the area of the loop.



19. **A metal rod of mass M and length L is placed on a frictionless parallel horizontal rail in a magnetic field of flux density B directed into the paper as shown in figure. (The rail is a conductor and a resistor of value R is connected to the rail as shown.) If an initial velocity of v_0 is given to the rod and released as shown, it will begin to move in the direction of v_0, with an acceleration of**



(1) $-\dfrac{BLv_0^2}{MR}$ (2) $\dfrac{RB^2L^2v_0^2}{M}$ (3) $\dfrac{B^2Lv_0}{MR}$ (4) $-\dfrac{B^2L^2v_0}{MR}$ (5) $-\dfrac{MBLv_0}{R}$

Intensity of Sound **03**

Ample questions are there of similar nature in the past papers. An e. m. f of v_0LB is being induced across the rod. From that the current that flows across the rod is $i = v_0LB/R$. Due to this current there is a force of iLB which is created to the opposite direction of v_0. You will get the acceleration when you divide from the mass. – $(v_0LB/R)\ (LB/M)$. Actually, this is a retardation if it is from the direction of motion. The force iBL cannot be there for the direction of motion. If so, then the rod will be accelerated without any talk. This is against the nature (Lenz's law). If so, then it is enough to shake the rod a little at the beginning. Then it will go passing any barrier. However, there is no correct expression with a positive sign. Therefore, the work is easy.

20. **Sound that has an intensity level of 100 dB is how many times more intense than sound of intensity level 20 dB?**

(1) 5 (2) 8 (3) 10^3 (4) 10^5 (5) 10^8

Gravitational Force Fields **05**

The problems of Decibel have been many times in the past papers. These should be done without rough work. The dB level reduction from 100 dB to 20 dB is 80 dB. When you cut the zero of 80, then you will get the difference of the intensity level's power of 10.

$80 = 10 \log (I_1/I_2)$; $(I_1/I_2) = 10^8$. Is not it?

In every review, I have shown how to do these questions easily. The number change in dB is 80. But the change of intensity level is 10^8. It is the nature of the logarithmic limit. Logarithmic limit is not linear. Some may have lot of love but cannot be seen. They are like logarithmic limit. You can give decibel changes of 10, 20, 30, 40 etc. for a question. If the decibel change occurs in 15, you need to use logarithmic tables or calculators to get the answer.

21. **The minimum velocity υ that a particle should have in order to escape from a planet of mass M and radius R is given by**

(1) $\upsilon=\sqrt{\frac{2GM}{R}}$ (2) $\upsilon=2\sqrt{\frac{GM}{R}}$ (3) $\upsilon=4\sqrt{\frac{gM}{R}}$ (4) $\upsilon=\frac{GM}{R}$ (5) $\upsilon=\frac{2GM}{R}$

Doppler Effects

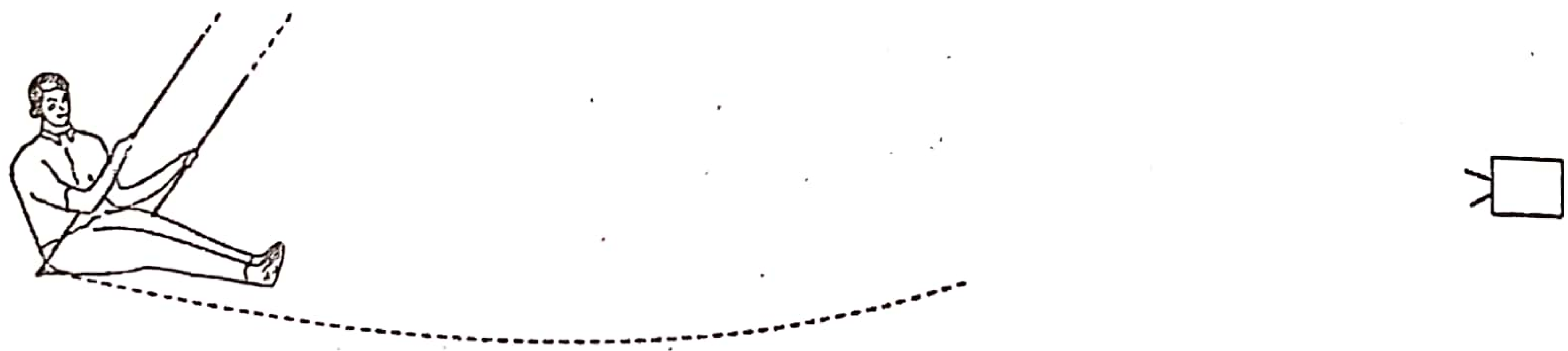
How many times has this been asked? The expression for the escape velocity can be obtained very quickly.

$\frac{1}{2} mv^2 = GMm/R \rightarrow v = \sqrt{\frac{2GM}{R}}$

The above expression is independent from the weight of the object that is needed to be escaped or the direction that it should be released. If you need to escape from our Earth, then the required velocity is 1.12 X 104 ms^{-1} (40, 200 kmh^{-1} = 25,000 mih^{-1}). For example, a spacecraft taking off from Florida should have a minimum of the above mentioned speed. Normally, such spacecrafts are released towards the east direction. The reason is due to the revolution of the Earth a velocity of 410 ms^{-1} is automatically obtained for the spacecraft. So, if you take off from the eastern side, then it is advantageus to get the free velocity from the Earth's revolution. Even though the escape velocity is independent from the mass of the object, the force that is needed to give that speed is not independent from the mass.

The most common element of the universe is Hydrogen but it is very less in our atmosphere. I hope you can explain the reason. Compare the escape velocity and the root mean suqare velocity of Hydrogen molecule.

22. **A child, swinging a swing, hears a sound from a stationary whistle located in the direction where he is facing as shown in figure. The minimum and maximum frequencies of the sound heard by him are 1314 Hz and 1326 Hz respectively. If the speed of sound in air is 330 m s^{-1} and air remains still, what is the wavelength of the sound emitted from the whistle?**

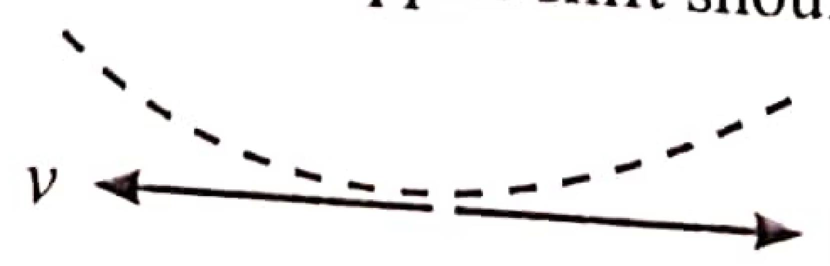


(1) 12.5 cm (2) 24.8 cm (3) 25.0 cm (4) 25.2 cm (5) 50.0 cm

Deflection of Vision

Children must have used Doppler's effect equations for this question. But it is not needed. Where do maximum and minium frequencies are heard? The source is still. The apparent frequancy is maximum when the observer is going near to the source at a higher speed. The minimum frequency is heard when the observer is getting away from the source at a higher speed. Therefore, this is happening in the lowest point of the child's path.

Actually, these things are not necessary when solving the problem. The true frequency should be in the middle of the maxiumumand the minimum. The magnitude of v is not changed. Therefore, $(f_{max} - f_0)$ value should be equal to $(f_0 - f_{min})$ value. That means the Doppler shift should be same.



Therefore, the frequency from the horn should be the middle value of 1326 Hz and 1314 hz. It is 1320 Hz which can be found from the memory. The difference between 1326 and 1314 is 12. When 12 is divided by 2, it is 6. 1314+6 or 1326-6 are equal to 1320. If you do it in another way, then $1326-f_0 = f_0-1314$; $f_0 = (1326 + 1314)/2 = 1320$ Hz. There is no need to apply to the equations of Doppler's effect. It will take time if you do with them. Now apply $v = f\lambda$. $= 330/1320 = 1/4 = 0.25$ m =25 cm.

1320 is obtained because it divides nicely with 330. The maximum and minimum frequencies are not heard at the top point of the locus. When it comes to the top, suddenly the speed gets zero. Then you will hear the true frequency. The problem is not with the distance of the source (whether it is near or far) to the frequency that is heard. It is affecting the loudness (intensity). Sometimes we entagle with two parameters of the frequency and the loudness together. The relative motion between the source and the observer affects the frequency change.

23. A person suffering from farsightedness has his near point located at 150 cm from the eyes. After wearing contact lenses, he could read clearly a book held at a distance of 25 cm. The used contact lenses are
(1) concave lenses with 21.7 cm focal length.
(2) convex lenses with 21.7 cm focal length.
(3) concave lenses with 30.0 cm focal length.
(4) convex lenses with 30.0 cm focal length.
(5) convex lenses with 60.0 cm focal length.

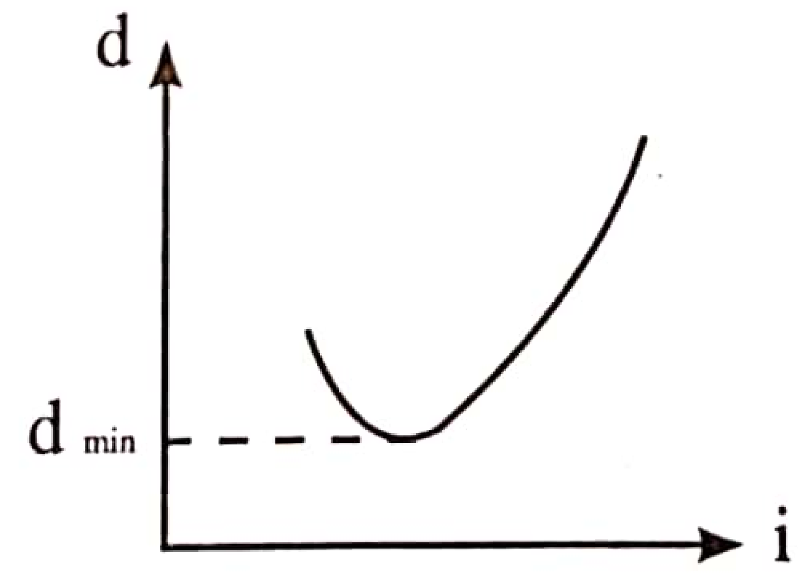
Refraction Through Prism **03**

Hope you have got exhausted by looking at such questions. 25 cm should be taken into 150 cm. $1/150 - 1/25 = 1/f$; $f = -30$ cm. We know that you need to wear convex lenses. Even if you do the calculation you will get a negative value for f.

24. A prism is placed on the prism table of a properly adjusted spectrometer and the refracted image of the illuminated collimator slit is observed while rotating the prism table starting from a large angle of incidence towards smaller angles. As the prism table rotates
(1) the image will move in a direction with continuously decreasing angle of deviation.
(2) the image will move in a direction with continuously increasing angle of deviation.
(3) the image will first move in a direction with increasing angle of deviation, turn back, and move in a direction with decreasing angle of deviation.
(4) the image will first move in a direction with decreasing angle of deviation, turn back, and move in a direction with increasing angle of deviation.
(5) the image will first move in a direction with decreasing angle of deviaiton and then stop.

Refraction Through Lenses **03**

A child has sent me a letter saying that the arrangement of the prism has not been mentioned in this question. He has kept the prism according to the way that which is kept to find the refractive angle. Then you will observe the images of reflection from the refractive surfaces.



As you read the question, you should realize that what is being asked in the question. Here, you should identify that deflection angle is being measured. If you have done this experiment, then what is being observed should be noted in your memory. Even in the experiment where you find prism angle, you do not rotate the prism table. You rotate the prism table to change the incident ray i. Even if you have not done the experiment, hope you have learnt the variation between i and d. According to that variation, (4) can be found as the correct answer. In the question it has been mentioned that the prism table is rotated from bigger incident angles towards smaller angles. So, even if you think that you take your eye along the i-d curve as in a dream, you can get the correct answer.

25. A lighted candle is placed in front of a convex lens as shown in figure (a).

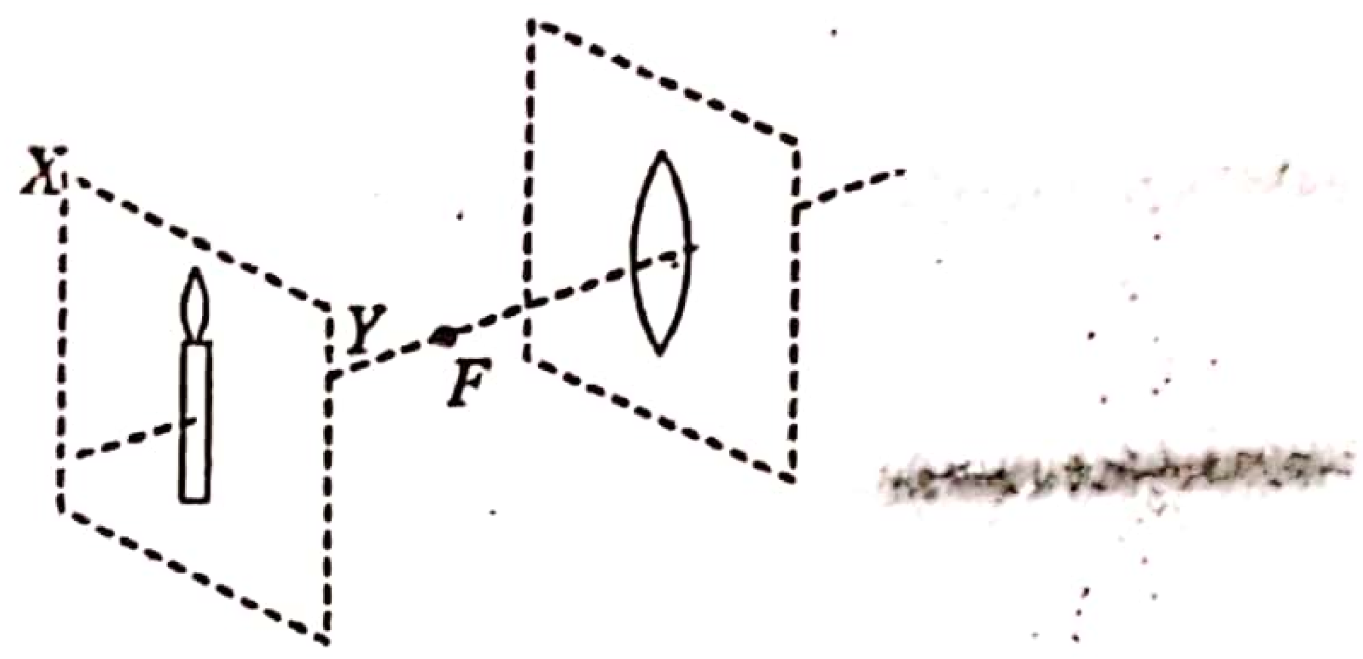


Figure (a)

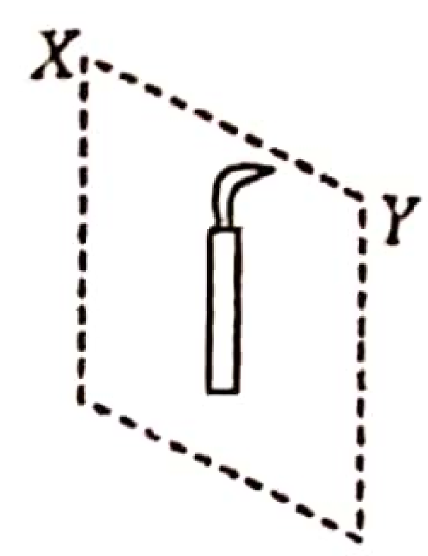
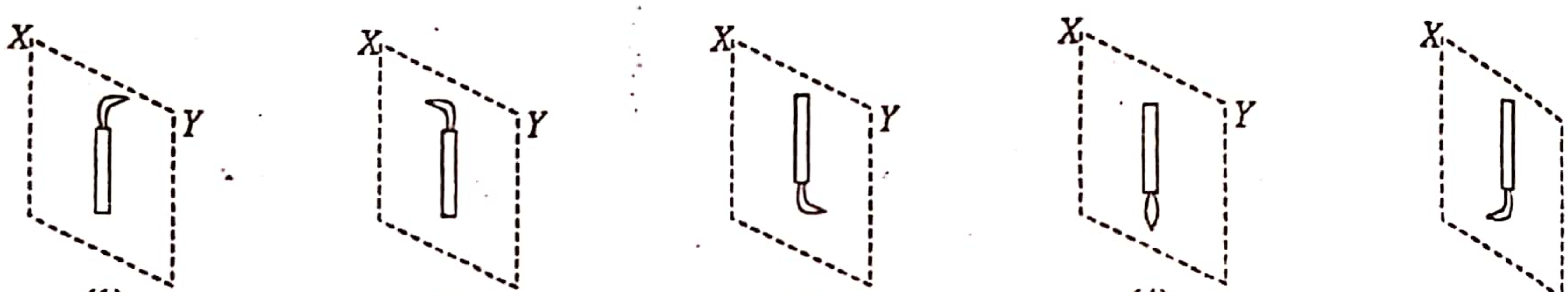


Figure (b)

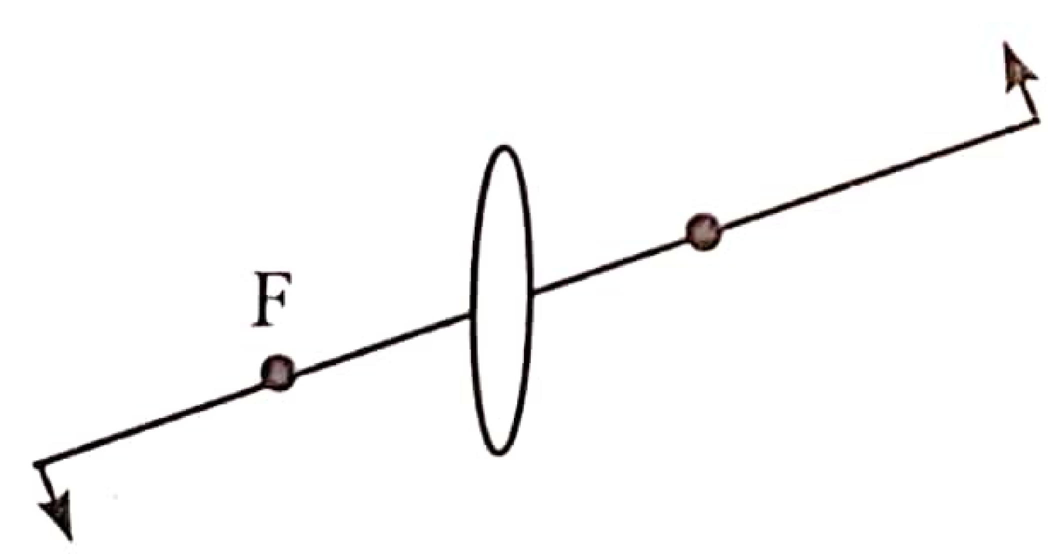
If the flame bends towards the direction Y due to wind as shown in figure (b) , which of the following shows the nature of the image of the candle and the flame?



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

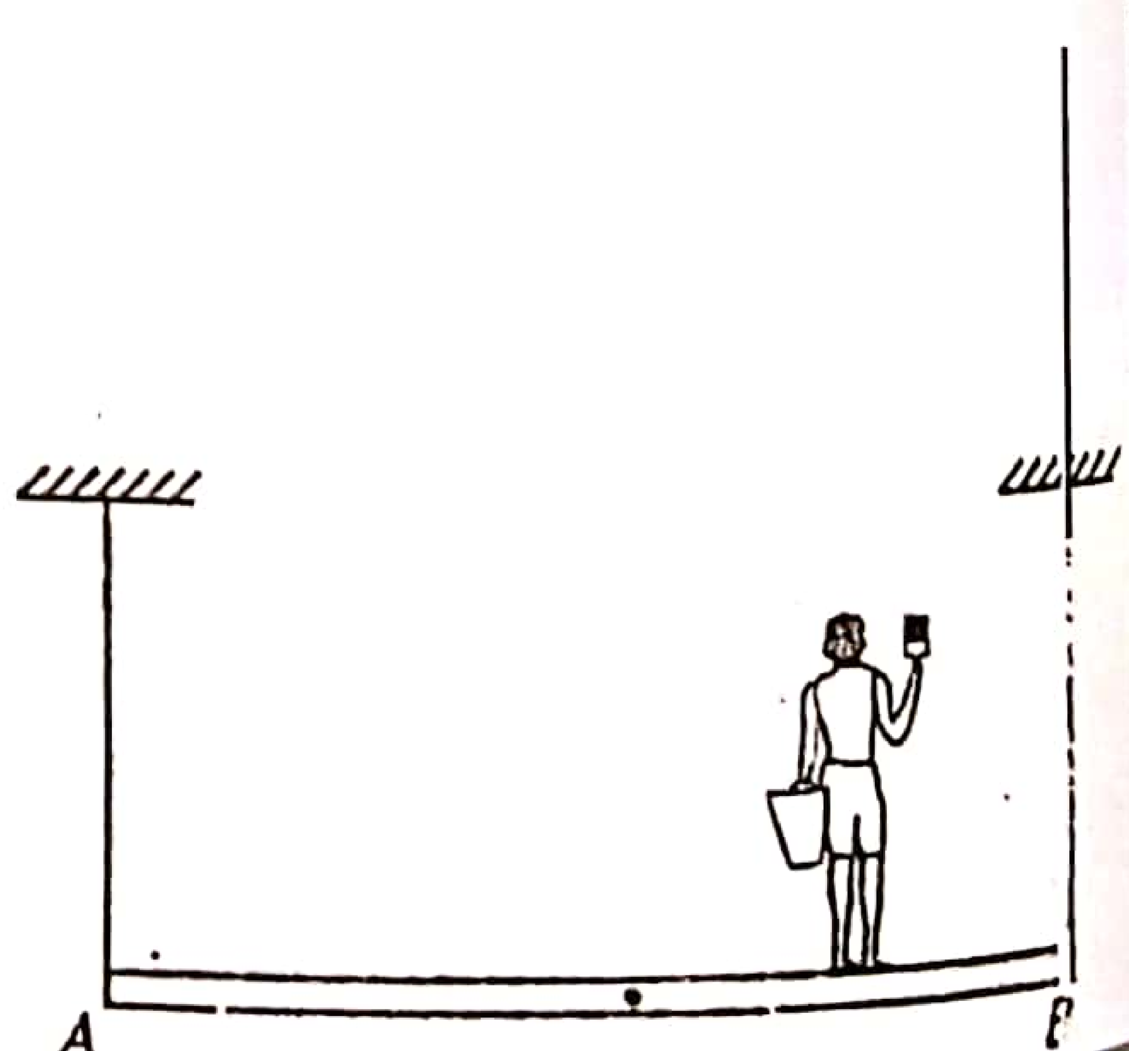
Equlibrium of Forces

Is not this an O /L question? The candle is kept in front of the F. Actually u as 2f. Therefore, there cannot be a magnification in the image. The image should be inverted. From that (1) and (2) figures are removed. (4) also can be removed. If the flame of the object is bent, then the image cannot be straight. If the flame of the object is bent to the right, then the flame in the image should be bent to the left. If the image is inverted, then the flame also needed to be inverted. If an object is placed as shown, then you can easily understand that its image should be as shown in the figure. Even if the object is slanted, the inverted nature of the image is as it is.



26. A man of mass 60 kg standing on a uniform wooden rafter hung horizontally by two identical ropes is painting a wall. The mass of the rafter is 20 kg. What is the **minimum** tension that should be withheld by each rope so that the man can move safely between A and B?

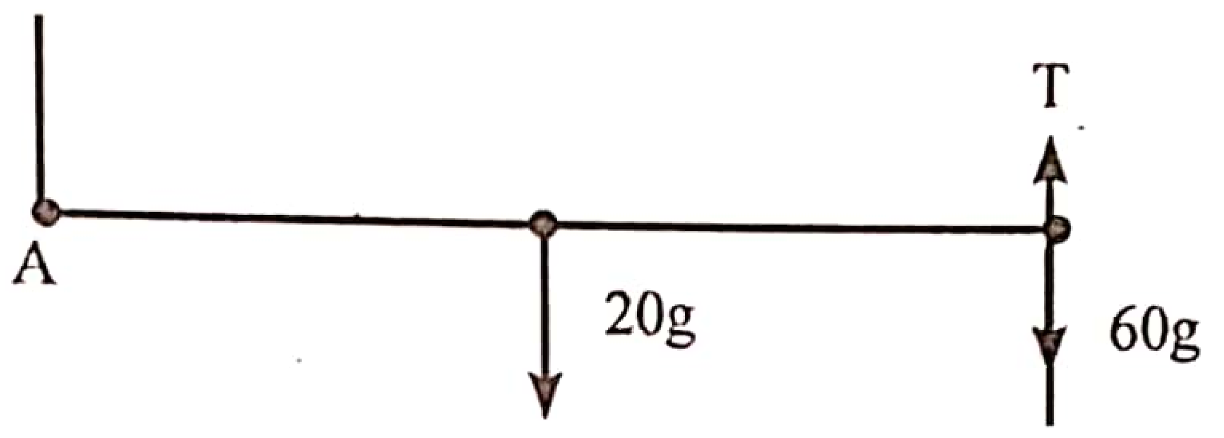
(1) 100 N (2) 400 N (3) 600 N
(4) 700 N (5) 800 N



Equlibrium of Forces

This question had many issues. The arguments were about the minimum. It is not asking about the minimum tension of a rope. It is being asked about the minimum tension that the rope should bear. The minimum exisitng tension and the minimum bearable tension are two different things. Not one. Even we get tension as humans. The minimum bearable tension means, if it exceeds then there can be upset moods. You can bear the minimum. There should be a maximum to be upset.

If the man needs to walk safely between A and B, then when he comes to the corners of A and B, the relevant rope should be able to hold the tension. Think that the man came to the end of B. Then the rope tension of the end of B is greater than the rope tension at the end of A. When the man comes to the other end, the reciprocal happens. The highest tension from both of these two tensions is the minimum bearable tension of the rope. Think that the man is at B.

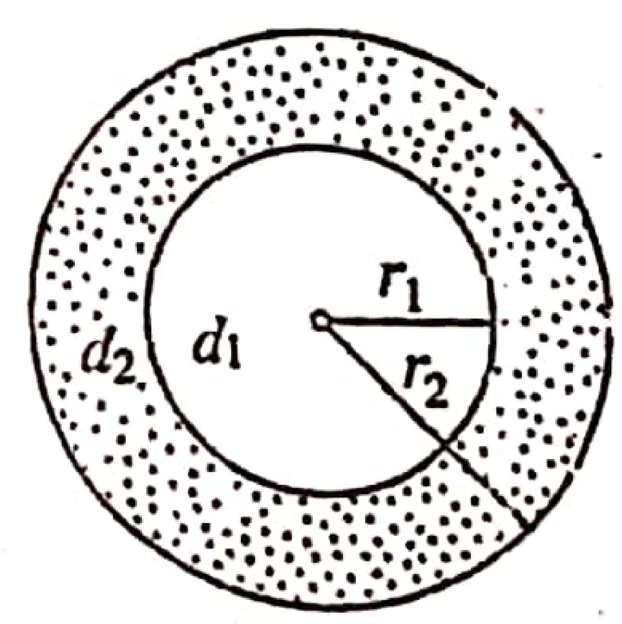


Now if T is the tension of the rope at B, then taking moments around A (the tension of rope A is not connected into the calculation).

↶A T X l = 600 X l + 200 X l/2;T= 700 N

This is the needed answer. At this moment the tension of rope A is 100 N. Many children have taken 100 N as the answer. Why? Because 100 is less than 700. That is their argument. But the question asks minimum bearable tension not the least tension. The minimum bearable is 700 not 100. If 100 is the minimum, then how can it bear 700? There is no problem if each rope can bear more thaan 700 N but atleast it should be able to bear a minimum of 700 N. This is the minimum clearly. There is no issue if the rope had any other maxumum value greater than 700 N.

27. The inner sphere of a composite solid spherical object is made of a material of density d_1 and the rest of the composite sphere is made of a material of density d_2 as shown in figure. The radius of the inner sphere is r_1 and the radius of the composite sphere is r_2. If the composite sphere floats fully immersed in a liquid of density d_3, then



(1) $r_2^3 d_3 = r_1^3 d_1 + r_2^3 d_2 - r_1^3 d_2$ (2) $r_1^3 d_1 = r_2^3 d_2 - r_2^3 d_3 + r_1^3 d_2$

(3) $r_2^2 d_2 = r_1^2 d_1 + r_2^2 d_1 - r_2^2 d_2$ (4) $r_2^2 d_3 = r_1^2 d_1 + r_2^2 d_2 - r_1^2 d_2$

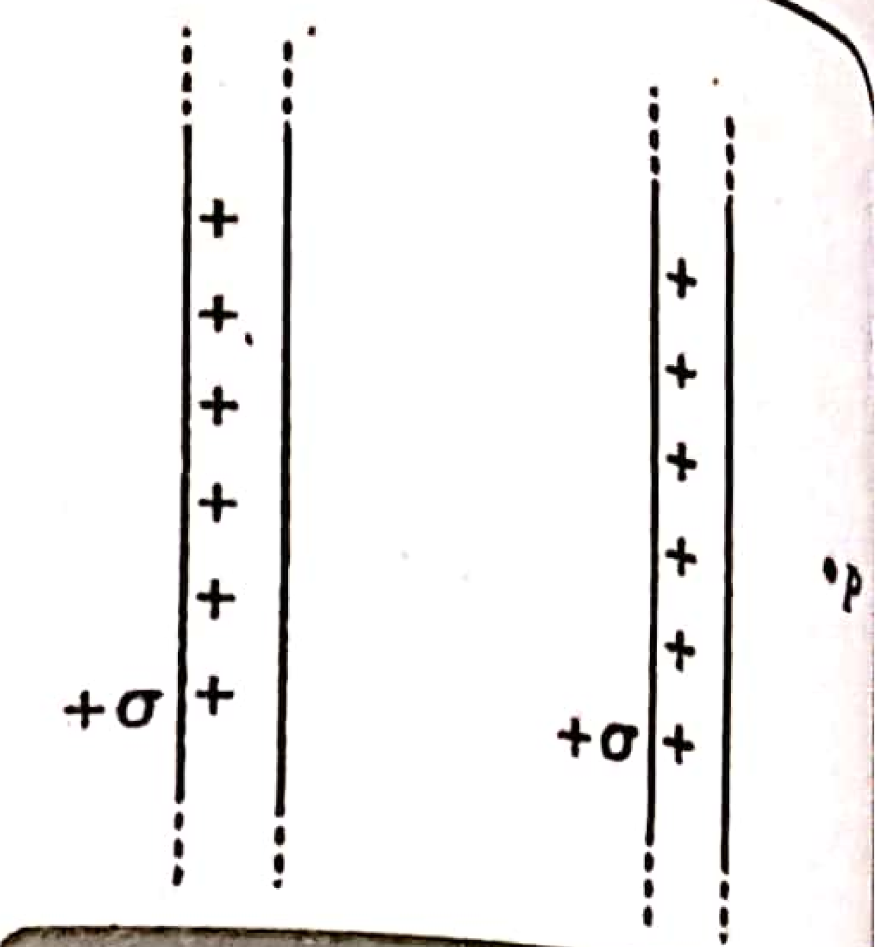
(5) $r_2^3 d_2 = r_1^3 d_1 + r_1^3 d_3 - r_1^3 d_2$

There is simple mathematics in this question. There is nothing to do even if you look into it. If it is floating, then the upthrust is equal to its weight. The upthrust is going with the multiplication of the cube of external radius with the density of the liquid. That means $r_2^3 d_3$. This $r_2^3 d_3$ is there at only one choice. As there is one term in the upthrust, you can realise that the left side of the expressions should have it. When finding the weight, the the weight of the internal sphere goes with $r_1^3 d_1$. To find the weight of the weight of the residual part, you need to subtract the volume of the external spehre with the internal sphere and then multiply with d_2. That means it is proportional to $(r_2^3 - r_1^3)d_2$. There is no need to write 4π/3. Even if you write it, then it will cut off. If you recognize $r_2^3 d_3$, then the answer is blown on your hand.

28. Two large non-conducting plane sheets, each having a uniform surface charge density $+\sigma$ on one side, are situated parallel to each other as shown. The electric field intensity at a point P is

(1) $\frac{2\sigma}{\varepsilon_0}$ (2) $\frac{\sigma}{\varepsilon_0}$ (3) $\frac{\sigma}{2\varepsilon_0}$

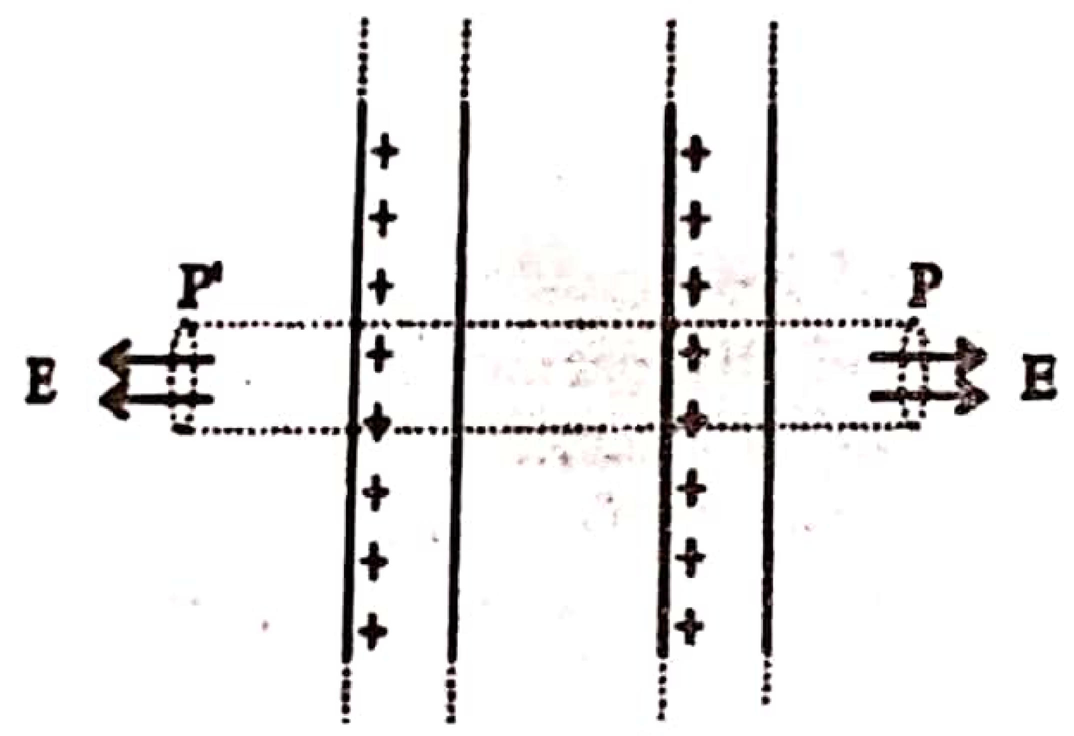
(4) $\frac{\sigma}{4\varepsilon_0}$ (5) 0



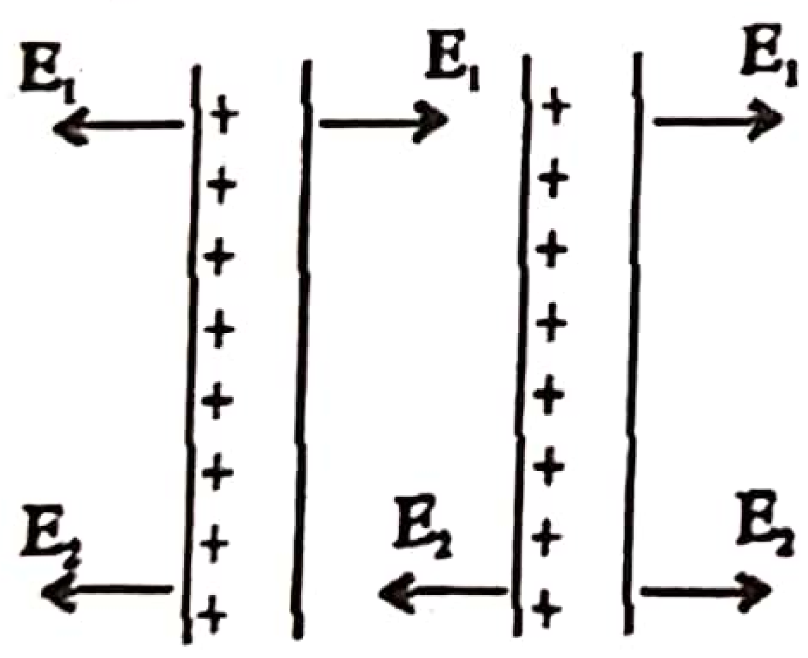
Gauss Theorem

As it is not a conductor, the charges can be there on one side of the plate. There is no issue on that. The charges cannot go here and there as they wish. There are two ways in getting the answer for this question. Create a Gauss surface taking both plates as the boarder. According to the symmetry, if the electric field intensity is E at point P, then the corresponding electric field intensity at point P' is also E. If the surface area of the Gaussian surface is A, then

EA + EA = $(\sigma A + \sigma A)/\varepsilon_0$; $2E = 2\sigma/\varepsilon_0$; $E = \sigma/\varepsilon_0$. Actually, there is no need to write A. It is enough if you consider a unit area. The net charge enclosed by the Gaussian surface is $2\sigma A$.

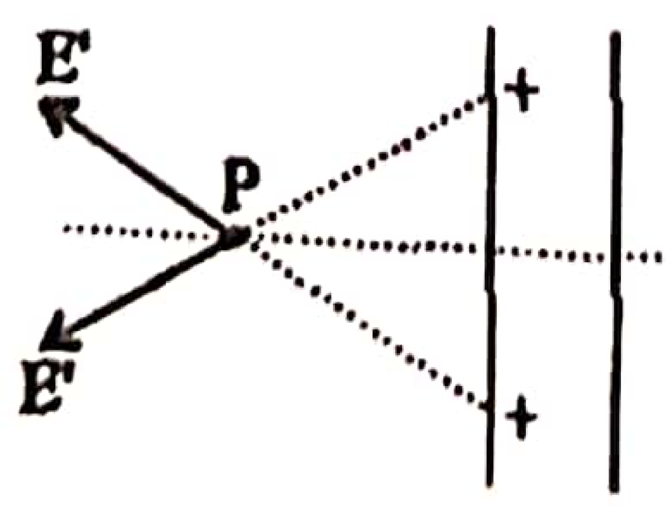


The other method (which is simpler) is the application of superposition principle. The outside E of a single plate is given by $\sigma/2\varepsilon_0$. Therefore, the outside E is obtained for both plates will be the addition of two $\sigma/2\varepsilon_0$.



The magnitude of E_1 and E_2 are equal. If the first plate was only there, then there wil be an electric field intensity of E_1 outside the plate. If the second plate was only there, then similarly there will be an electric field intensity of E_2 outside the plate (as it is a positive charge). Therefore, the net outside electric field intensity is $E_1 + E_2$. As the magnitudes are same (same σ), it will be 2 E. The electric field intensity in between the plates is zero. The direction of E_1 and E_2 are equal and opposite.

As an insulator is given, some argue that the electric field intensity does not act perpendicular to the plates. In a conductor, E should be always act perpendicular to the surface. There is no argument that E should not be perpendicular in an insulator. It can be perpendicular or not. In this arrangement E is perpenducular to the plates. Look at the figure.



From one positive charge from above, there will be E' field intensity at the point P. Likewise, from the symmetric positive charge at the bottom, the corresponding E' is there at P. The vertical components of these (two E') are cancelled off with each other. The net E is horizontal. That means it is perpendicular to the surface. There cannot be a component along the surface as charges can travel. There is no such a law for a material that it not a conductor. Even there is no law that it should <u>not be perpendicular</u>.

29. Consider the following statements made about electric fields and equipotential surfaces.

(A) Electric field lines and equipotential surfaces are always perpendicular to each other.

(B) The magnitude of the electric field intensity should be same at all points on an equipotential surface.

(C) The magnitude of the electric field intensity cannot be zero at a point on an equipotential surface.

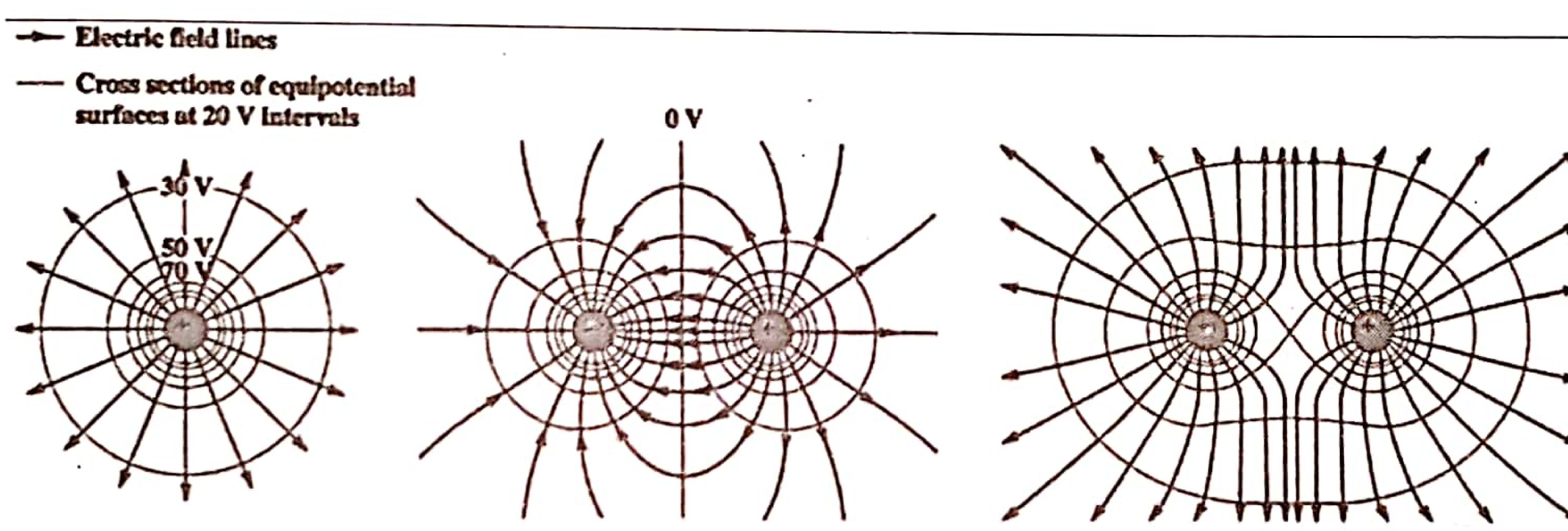
Of the above statements,

(1) only (A) is true. **(2) only (B) is true.**

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

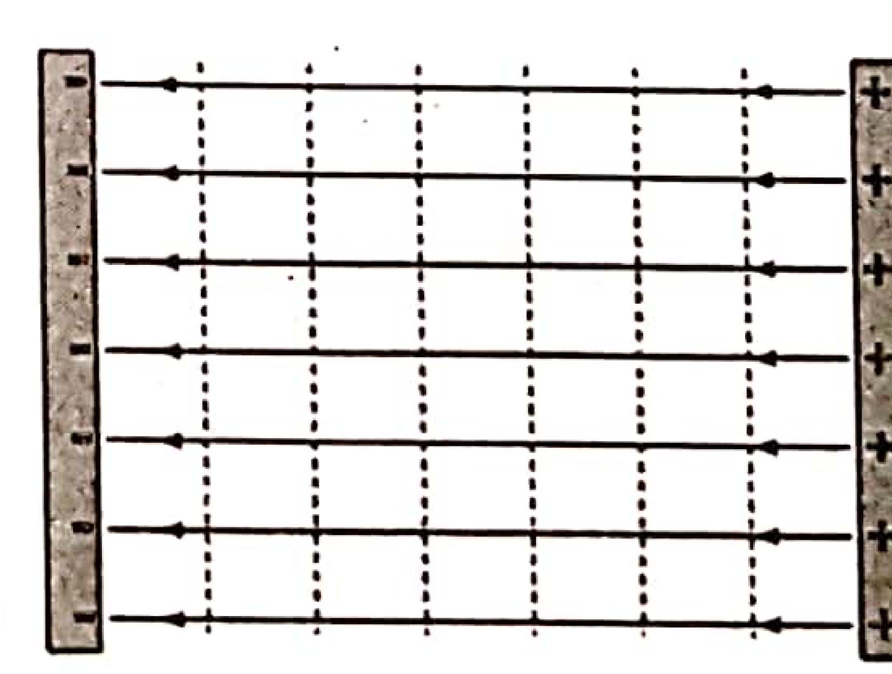
(5) all (A), (B) and (C) are true.

The equipotential surfaces that are related to the generated electric field of a uniform electric field, at a point charge, at two charges of positve and negative with same magnitude and at two positve charges with same magnitude are shown in the following figures.



(a) A single positive charge (b) An electric dipole (c) Two equal positive charges

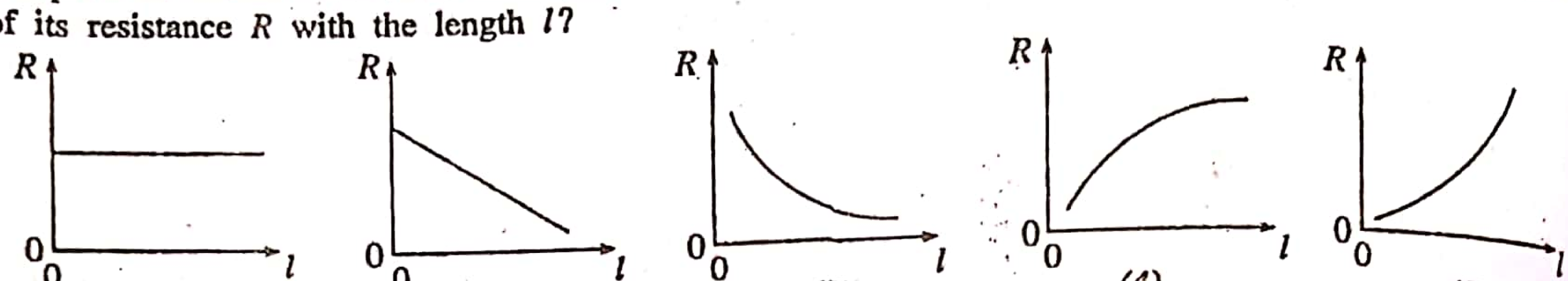
Sentence (A) is correct. Always the equipotential surfaces are drawn perpendicular to the electric field lines. Any place along an equipotential surface, there cannot be a potential difference. The potential difference is zero. That means if a point charge is taken along an equipotential surface, then there is no need to do any work against it even from the field. Therefore, the electric field lines should be perpendicular to the surface. If it gets inclined, then there will be a force on the charge that is placed on the equipotential surface. To do so, the electric field force lines should be perpendicular to the surface.



Sentence (B) is generally false. The statement (B) is true for a uniform electric field or single point charge. But in the two instances which is shown above, you will see that statement (B) is wrong. For a point charge, the equipotential surfaces are concentric spheres. Therefore, all the points in one equipotential surface has the same magnitude of electric field intensity. But if you look at the other two figures, you will see that the equipotential surfaces are not concntric spheres. The concentric nature is gone when there are two charges. In this equipotential surface, E value is not same from place to place. If you look at logically, then all you need is to get zero for E along the equipotential surface. There is no law which mentions that the values of E that are perpendicular to the surface should be same.

You can see from the 4th figure that (C) is not correct. As there are equal values, the electric potential is not zero in the middle of two positive charges. But electric field intensity is zero. The electric field intensity should not be there along the surface is the only characteristic that an equipotential should have. If there is a field, then you should do a positive or negative work on the charge when it moves along the surface. If a work is needed to be done, then the potential of the surface is not equal.

30. If a piece of uniform wire is stretched gradually, which of the following curves correctly indicates the variation of its resistance R with the length l?

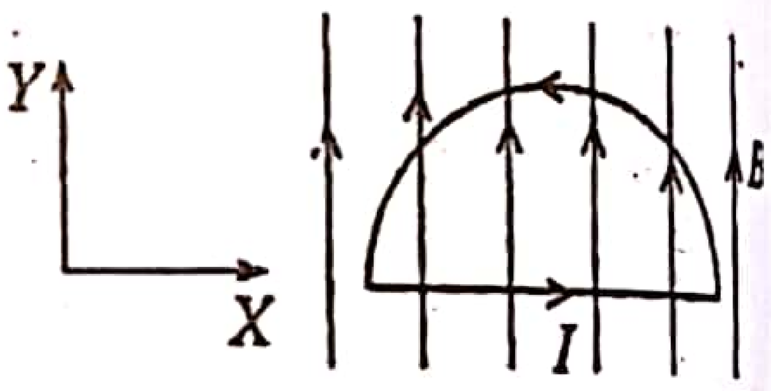


(1) (2) (3) (4) (5)

Ohm's Law Combination of resistance

If you have done the 13th question of paper 2012, then the answer is in your hand. $R \propto \frac{l}{A}$; Now multiply the numerator and the denominator from l. Then $R \propto \frac{l^2}{lA}$; Al is the volume of the wire. This is a constant. Therefore $R \propto l^2$ So, the graph between R and l cannot be a straight line. Form this (1) and (2) are removed. When l is increased R should increase. Then (3) is removed. R should rapidly increase with l. When l is increased, R cannot reach a constant value. Therefore, the correct variation is shown from (5).

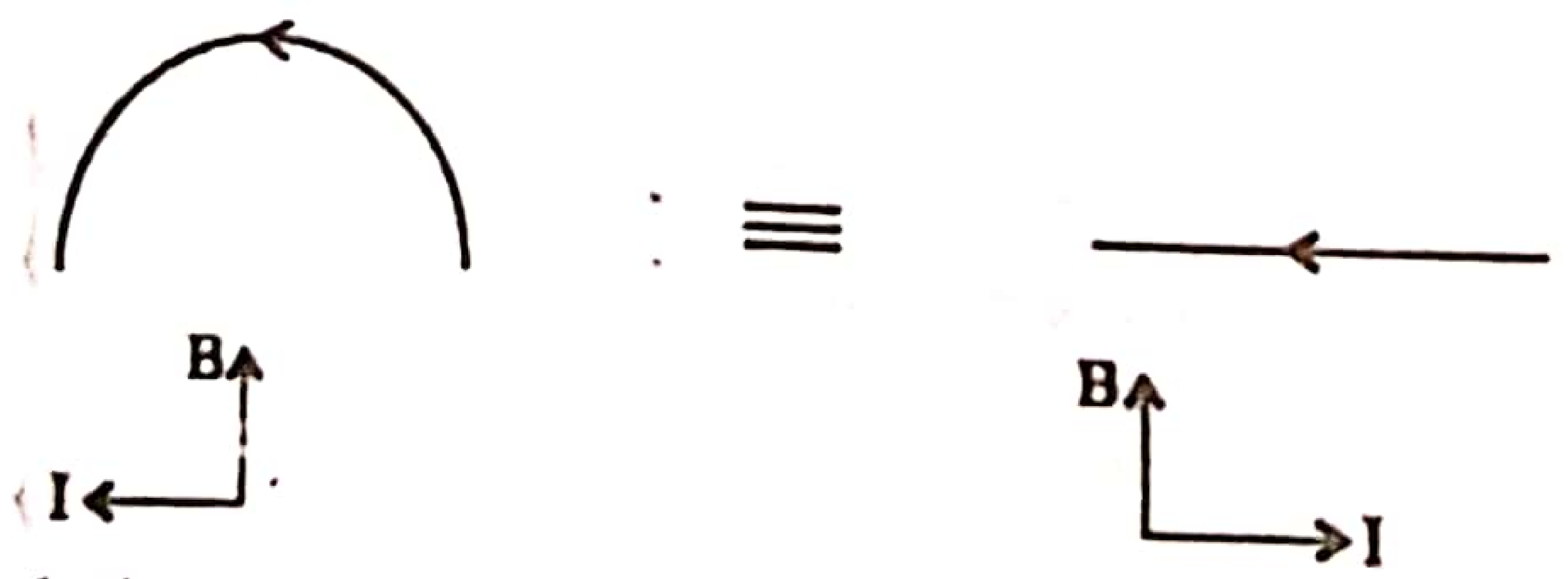
31. A wire bent into the shape of a semicircle forms a closed loop and carries a current I as shown in figure. The loop lies in the XY plane and a uniform magnetic field is present along the Y direction. Which of the following is true regarding the forces acting on the circular and the straight portions of the loop due to the magnetic field?



	Force on the circular portion	Force on the straight portion
(1)	zero	into the paper
(2)	zero	out of the paper
(3)	into the paper	into the paper
(4)	into the paper	out of the paper
(5)	out of the paper	into the paper

Magnetic Field

If you have considered the past papers correctly, then you will get the answer quickly. In the previous reviews it has been mentioned that, the force on a current carrying wire loop with any shape in a uniform magnetic field is equal to the force on a straight wire which connects two ends of the wire loop. Look at the 33rd question of old syllabus paper 2011. According to this, you can take the straight wire section that connects the ends instead of the semi circular wire with a current that flows to anticlockwise direction.



The force is towards the paper

The force is out of the paper.

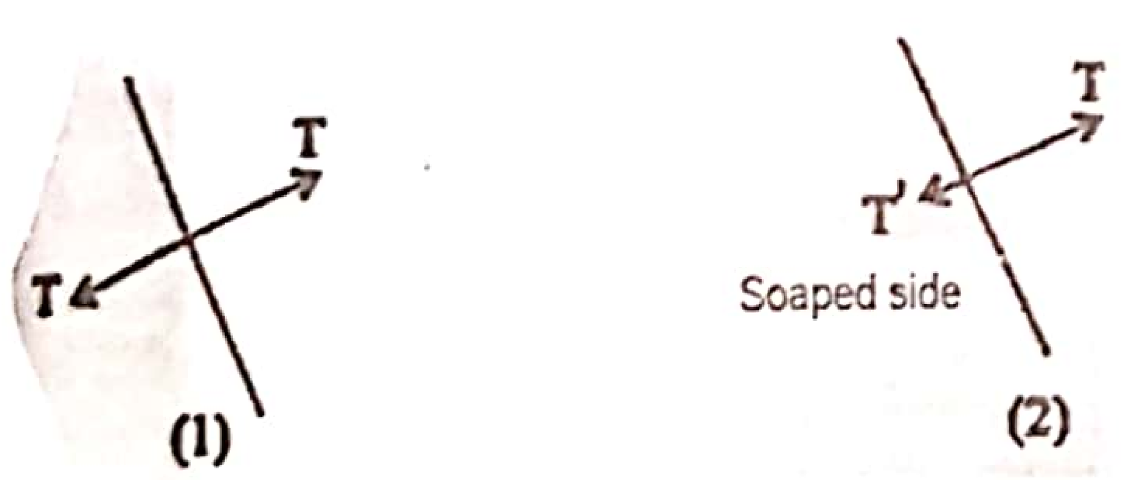
The circular section can be displaced with a straight wire. Now you have two straight wires with current flows in opposite directions.

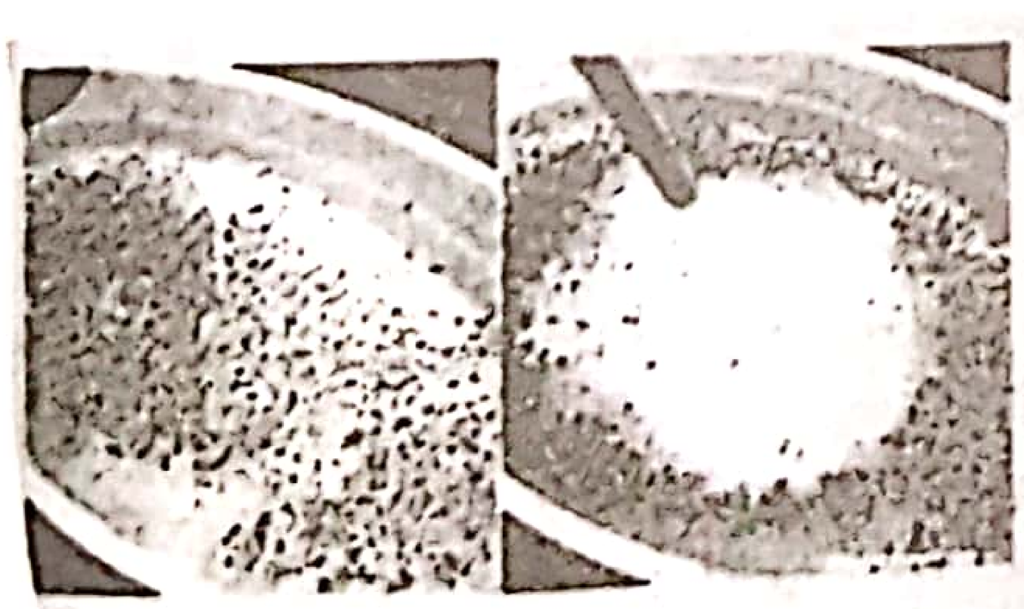
When the direction of the force on the straight part of the wire loop is decided, then the force on the circular section should be opposite to it. Instead of the circular wire part, the straight wire that we consider has a current flow to the other direction. So, the correct answer is (4).

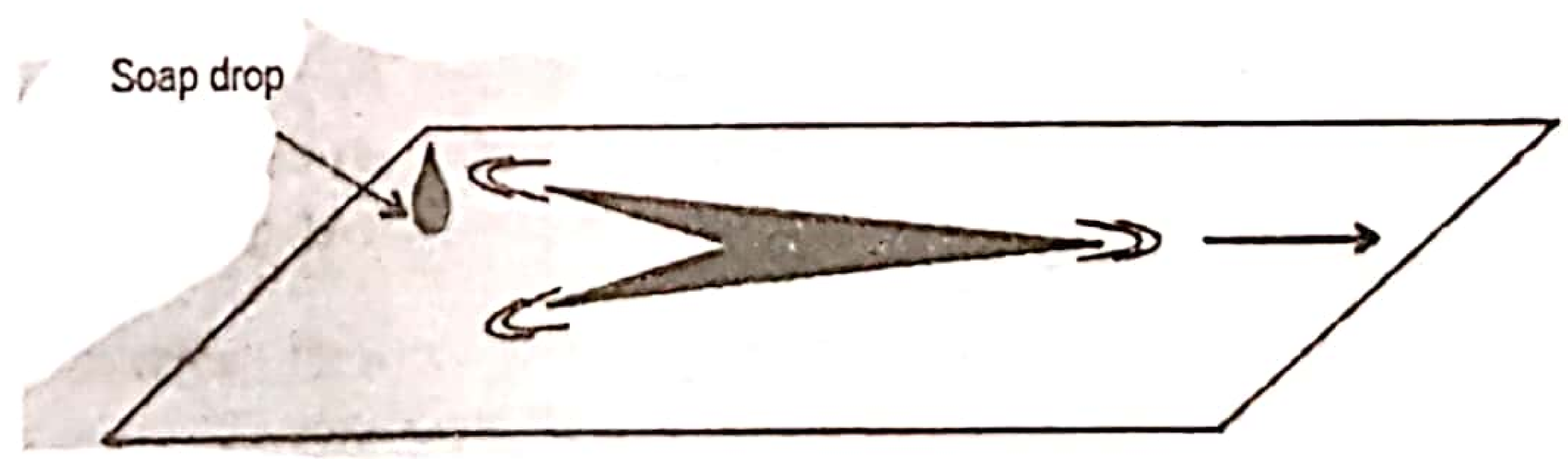
32. Small amount of powdered pepper was sprinkled on the surface of water in a cup and the water surface was touched with a clean dry finger tip. Then the finger tip was rubbed with a little soap and the same process was repeated. Which of the following observation is likely to be seen in the above processes?

	Cleaned and dried finger tip	Soapy finger tip
(1)	Pepper powder tend to move away from the finger tip.	into the paper
(2)	Pepper powder tend to move away from the finger tip.	Pepper powder tend to move away from the finger tip.
(3)	Nothing happens to the distribution of pepper powder.	Pepper powder tend to flock around the finger tip.
(4)	Nothing happens to the distribution of pepper powder.	Pepper powder tend to move away from the finger tip
(5)	Pepper powder tend to flock around the finger tip.	Pepper powder tend to flock around the finger tip.

This is a question that was subjected to a discussion. Many have tested this phenomenon after going home. Many children have chosen (3) not (4). But the correct choice is (4). W0 hy does the pepper powder go out of the fingers? Draw a fictious line on the water. If same water is on both sides, then the acting surface tension forces to both sides of this line is same (figure 1). Now according to figure 2, insert some soap to the left side of the surface. Then the surface tension of water on that side quickly get reduced. Now there is a resultant force on the line to the right side (T-T'). Think that there is pepper powder on this line. Then pepper powder goes to the other side which is not to the side that inserted soap. This effect can be demonstrated in different ways.

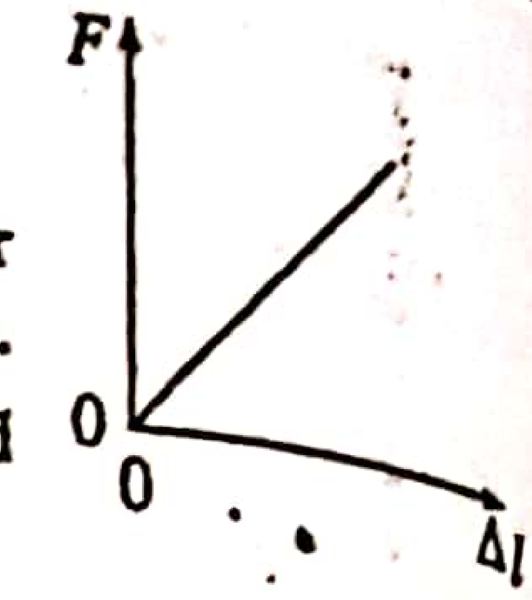






When soap water drop is applied to a thin plate as shown in the figure, the plate is removed to the other side quickly. If you float a toy boat in water and add a soap piece to its behind, the boat will move forward slowly (to the opposite side of the attached soap) as the soap dissolves.

33. The applied force F and extension Δl curve for a metal wire is shown in figure. Consider the following statements.



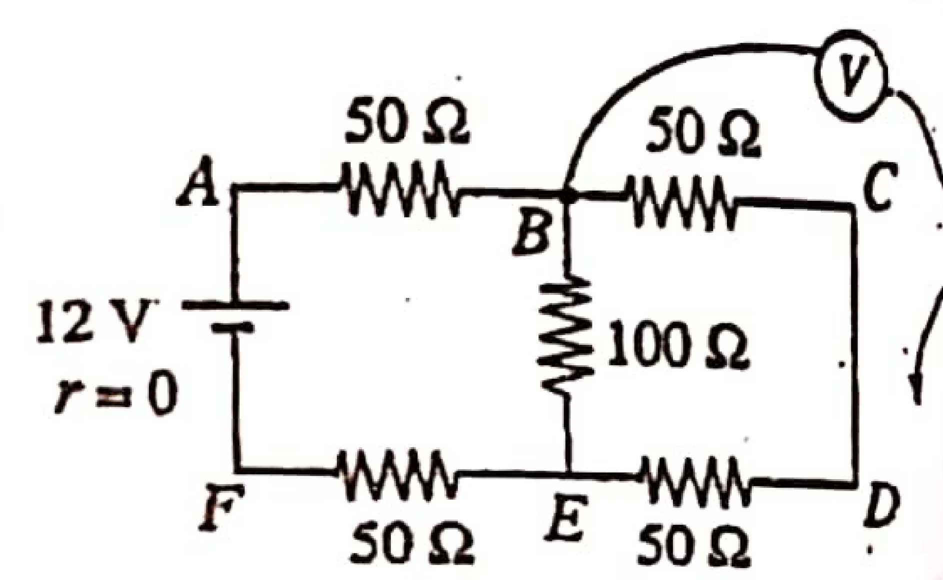
(A) If another wire of lower cross-sectional area is used without changing other parameters, the corresponding curve would fall above the curve shown in figure.
(B) If a wire having identical parameters but with a larger Young's Modulus is used then the corresponding curve would fall below the curve shown in figure.
(C) If a longer wire is used without changing the other parameters the corresponding curve would fall below the curve shown in figure.

Of the above statements
(1) only (A) is true.
(2) only (C) is true.
(3) only (A) and (B) are true.
(4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

Elastisity

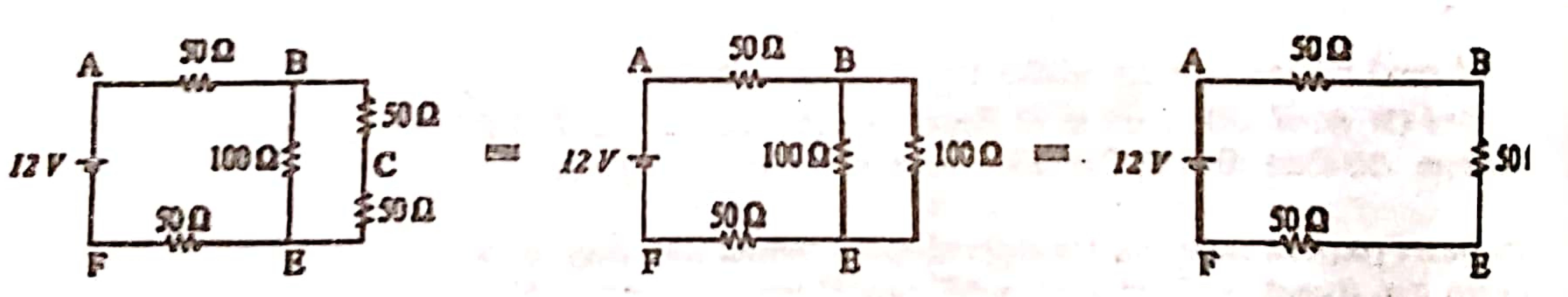
There is a need to do a parameter check for the equation of Young Modulus. $E = \frac{F\,L}{A\,\Delta l} \rightarrow F = \frac{EA\Delta l}{L}$ By looking at this expression, you can unentangle the question. The gradient of the graph between F and Δl is EA/L. When E and L is kept constant and A is reduced, then the gradient will get reduced. As the gradient is reduced, it should fall below the given straight line. Therefore, (A) is wrong. When E is increased by keeping A and L constant, then the gradient gets increased. That means it should fall above the given straight line. (B) is also wrong. When E and A is kept constant and L is increased, then the gradient is reduced. Therefore, (C) is correct. All you need to check is the same thing.

34. One terminal of the voltmeter V shown in figure is connected to the point B. When the voltages of all the other points labelled with English letters are measured by connecting the free terminal of the voltmeter to these points, the magnitudes of the possible values of the readings indicated by the voltmeter would be



(1) 0, 2 V, 8 V
(2) 4 V, 6 V, 8 V, 12 V
(3) 2 V, 4 V, 8 V
(4) 0, 6 V, 8 V
(5) 4 V, 8 V, 12 V

Ohm's Law Combination of Resistance

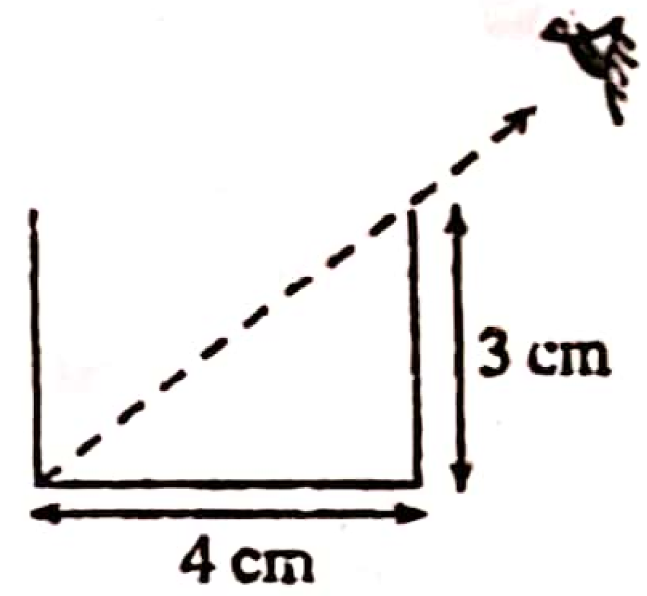


It takes time. The given circuit is equivalent to the following circuits.

50 and 50 are in series. Once they are added, it is 100. 100 and 100 are in parallel. The equivalent resistance is 50 Ω. 12 V is divided into three between 50 Ω. In the third circuit, the potential difference across each 50 Ω is 4 V.

Therefore, the potential difference across AB is 4 V. Potential difference across BC is 2 V (half of 4). Both C and D points are same. Again, the potential difference between B and E is 4 V. The potential difference between B and F is 8 V (two 4 V). Therefore, the correct answer is (3). The values are not asked in order. Only the reading that the voltmeter can have is being asked. There cannot be 0 or 12 V. You get 12 V in between the ends of the battery. From that also, you can remove choices of (1), (2), (4) and (5).

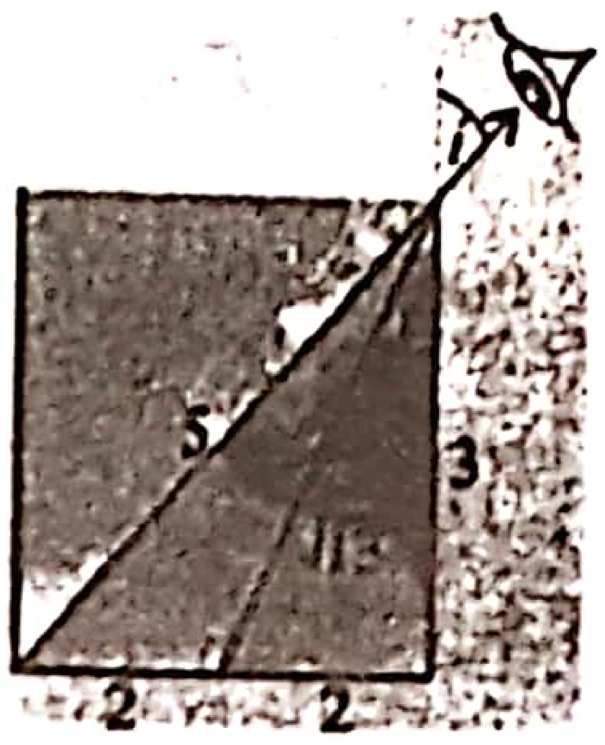
35. **By looking at an empty glass vessel along the path shown by the broken line in figure, a person could see the left corner of the bottom of the glass vessel. After the glass vessel is filled with a clear liquid the person could see the middle of the bottom of the glass vessel when looking along the same path. The refractive index of the liquid is (Take $\sqrt{13} = 3.6$)**



(1) 1.11 (2) 1.22 (3) 1.33
(4) 1.44 (5) 1.55

Refraction **03**

This question has been given in 2000 as the 53rd question. The answers of that question were in symbols. Here, there are in numbers. If the middle of the bottom can be seen once the container is filled with the liquid, then a light ray that is coming from the middle should refract from the liquid-air surface and go along the dashed line.



He is looking at the left side of the bottom of the container. But the middle of the bottom can be seen. There is simple geometry. The value of is given. Therefore, you can get the answer very quickly.

As this is done before, how can you get it wrong? $n = \sin i / \sin r = \frac{4/5}{2/\sqrt{13}} = \frac{4 \times 3.6}{5 \times 2} = \frac{7.2}{5} = 1.44.$

36. **The initial relative humidity of a closed room of volume V at room temperature θ_0 is $X\%$. The temperature and the relative humidity of the room are then reduced to θ_1 and $Y\%$ respectively using an airconditioner. If the absolute humidities of air at corresponding dew points of θ_0 and θ_1 are A_0 and A_1 respectively then the mass of water vapour that has been removed by the airconditioner is**

(1) $\left(\frac{XA_0V - YA_1V}{100}\right)$ (2) $\left(\frac{XA_0}{V} - \frac{YA_0}{V}\right)100$ (3) $\left(\frac{X}{A_0V} - \frac{Y}{A_1V}\right)\frac{1}{100}$

(4) $\left(\frac{XV}{A_0} - \frac{YV}{A_1}\right)100$ (5) $\left(\frac{A_0V}{X} - \frac{A_1V}{Y}\right)100$

Hygrometry **04**

The interpretation is needed to apply here. Some have got confused with this question. The relative humidity according to a certain temperature is the ratio of the mass of water vapour in the room with the mass of water vapour needed to saturate the room.

Many had a problem regarding the phrase 'at the relevant dew points for θ_0 and θ_1'. The absolute humidity A_0 of the relevant dew point of θ_0 means that a mass of water vapour A_0 is needed to saturate a unit volume in the temperature of θ_0.

It can be confusing about relevant dew points for θ_0 and θ_1. This does not mean different temperatures apart from the temperatures of θ_0 and θ_1. For example, we will think that $\theta_0 = 30^0$C. When 30^0C is equal to the dew point, this means that there is A_0 mass of water vapour in a unit volume in the air. I doubt that when the relevant dew points for θ_0 and θ_1 are mentioned, the idea of two temperatures that are different (or changed) than θ_0 and θ_1 was born in the minds most of the people. Both θ_0 and θ_1 are not dew points. They give temperatures of two instances of room temperature. In those temperatures, the room is not saturated with water vapour. Therefore, we do not know the mass of water vapour in a unit volume. In the tables, the absolute humidity relevant to θ_0 is marked as the mass of water vapour that is needed to saturate a unit volume in that specific temperature.

At the relevant dew points for θ_0 and θ_1 indicates the assumption if θ_0 and θ_1 becomes the dew points. You cannot write whether θ_0 and θ_1 are relevant to dew points. Because θ_0 and θ_1 are not the dew points. I feel it is better if the dew point word was not mentioned. But water vapour is being saturated at the dew point. Therefore, the phrase in the question should be read like this. 'At the relevant dew points of the air, for θ_0 and θ_1...... If it was read as relevant to θ_0 and θ_1, then it indicates two different temperatures.

However, we cannot solve the question without considering A_0 and A_1 as the absolute humidity of the air with saturated water vapour of corresponding temperatures. As the volume of the room is V, the mass of water vapour needed to saturate is A_0V at the temperature of θ_0. The other one is also same. If m_1 and m_2 are the real masses of the water vapour in the room at two instances, then from the interpretation,

$X/100 = m_1/A_0V$; $Y/100 = m_2/A_0V$

The mass that is being removed is m_1-m_2. That expression can be seen as soon as looking at the above two expressions. $m_1 - m_2 = (XA_0V - YA_0V)/100$

37. When a uniform rod of known length and area of cross-section was lagged, and the rate of flow of heat and the temperature gradient were measured, it was found that the value of the thermal conductivity calculated using those quantities, is smaller than the expected value of the thermal conductivity for the material of the rod. This could occur if

(A) the measured value of the rate of flow of heat through the rod is lower than the expected value.
(B) lagging of the rod is poor.
(C) the measured value of the temperature gradient is larger than the expected value.

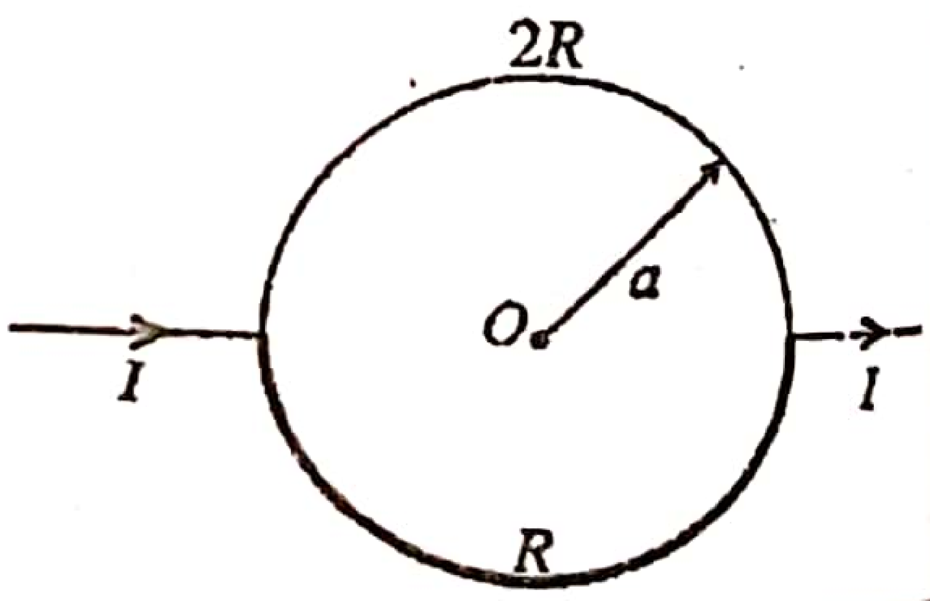
Of the reasons given above

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

Conductivity

The answer can be obtained from the heat conductivity equation. $\frac{Q}{t} = KGA$; $G = \frac{\theta_1 - \theta_2}{l}$. If Q/t is If Q/t is measured less, then there will be a lesser value for K. It is a simple argument. Statement (B) is not independent from statement (A). If the insulation is weak, then Q/t is measured less. If G is measured more as a mistake, then K gets reduced from it. These are simple logics. All three statements are correct.

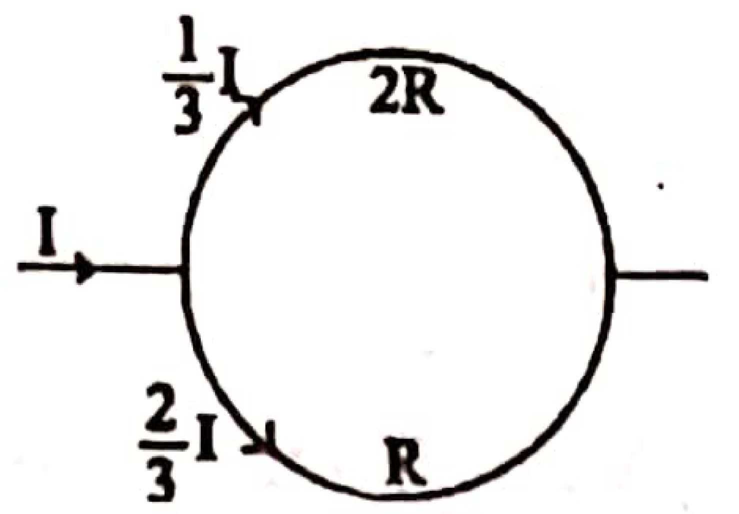
38. Lower half of the circular wire loop of radius a, shown in figure is made of a wire of resistance R and the upper half with a wire of resistance $2R$. The magnetic flux density at the center (O) of the wire loop is given by



(1) $\frac{\mu_0 I}{4a}$ (2) $\frac{\mu_0 I}{6a}$ (3) $\frac{\mu_0 I}{12a}$
(4) $\frac{\mu_0 I}{16a}$ (5) $\frac{\mu_0 I}{18a}$

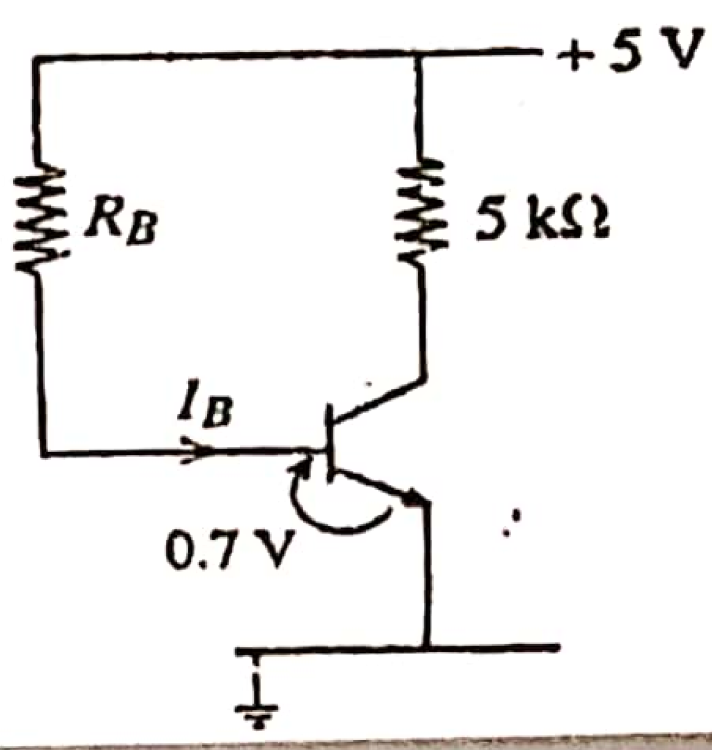
Magnetic Effect of Electric Current

You need to take the current across the upper half as I/3 and the current across the lower half as 2I/3 from your memory. I should be divided into the ratio of 1:2. We know that B is $\frac{\mu_0 I}{2a}$ at the centre of a circular loop that carries a current of I. For a half circle, this should be divided by 2. The other fact that you need to know is the current across the two loops are not flowing in the same direction. The current in the upper half flows clockwise whereas the current in the lower half flows anti-clockwise. Therefore, the direction of B in the centre are in opposite direction to each other.



$B = \left(\frac{\mu_0}{4a} \times \frac{2I}{3}\right) - \left(\frac{\mu_0}{4a} \times \frac{I}{3}\right) = \frac{\mu_0 I}{12a}$, It will be stuck if you add them together. Then you will get (1) as the answer.

39. In the circuit shown I_B = 500 μA and the transistor has a current gain, β of 100. Current through the 5 kΩ resistor is approximately
(1) 0.5 mA (2) 1.0 mA (3) 2.0 mA
(4) 5.0 mA (5) 50.0 mA



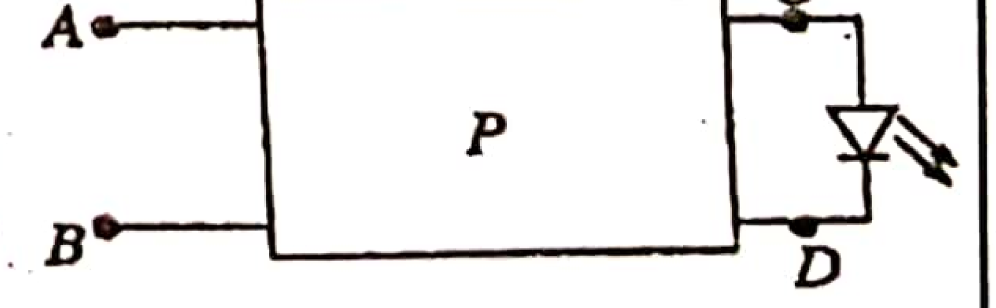
Transistors 09

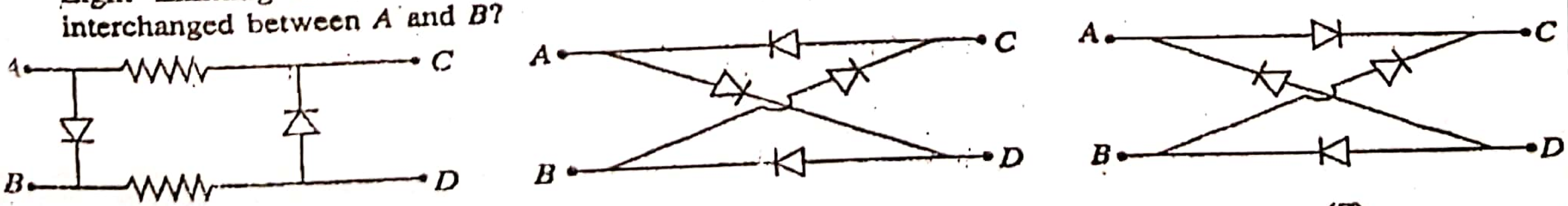
This is a problem that everyone got it wrong. Directly they have put I_C/I_B =100 and found I_C. I_C = 500 X 10^{-6} X100 = 50 mA. You do not get that this answer is wrong. To find that I_C = 50 mA is wrong, let us find the voltage across 5 kΩ. It is 5 X 10^{-2}X 5 X10^3 = 250 V. This cannot happen as only 5 V is applied to the transistor. Then how can 250 V be applied across 5 kΩ? I know that you will not check this. Directly you will find I_C and choose 50 mA as it is available in the answers. The method that you can argue is identifying that transistor is not in the active state when I_B = 500 μA. At this moment, the transistor is at the saturated state. Then $V_{CE} \approx 0$. As E is earthed, $V_C \approx 0$. Therefore, the current across 5 kΩ = 5/5 X 10^3 = 10^{-3} A = 1 mA

In such a question, it is better to decide the existing state of a transistor first. As V_{BE} = 0.7 V, there is no need to consider the cut off state. Consider when V_{CE} = 0 (saturated state). Then according to the above calculation, I_C = 1mA. If this was thought as the end point of the active state and apply $\beta = I_C/I_B$, then you will get I_B as 1/100 =10^{-2} mA = 10 μA.

So, if this transistor needs to be in the active state, then I_B should be less than 10 μA. 500 μA is too high! Therefore, I_B = 500 μA cannot be applied to the relation of $\beta = I_C/I_B$. If I_B is 5 μA, then I_C can be found from the above relation. Then the voltage drop across 5 kΩ is 2.5 V and V_{CE} = 2.5 V (as the total should be 5V). Now the transistor is at the active state.

40. The box P shown contains a circuit and when a battery is connected between A and B, the Light Emitting Diode (LED) connected to the circuit is lit. Which of the following circuit/circuits inside the box P enables/enable the Light Emitting Diode to be lit even when the battery terminals are interchanged between A and B?



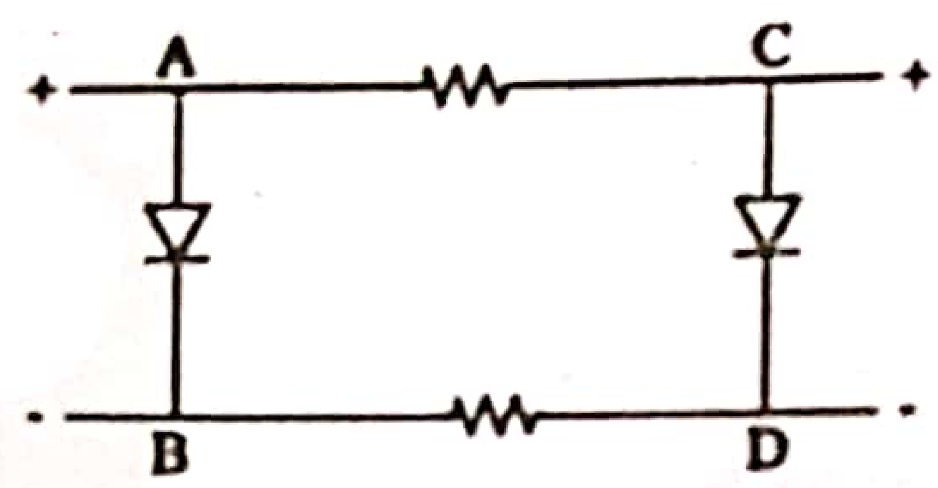


(X) (Y) (Z)

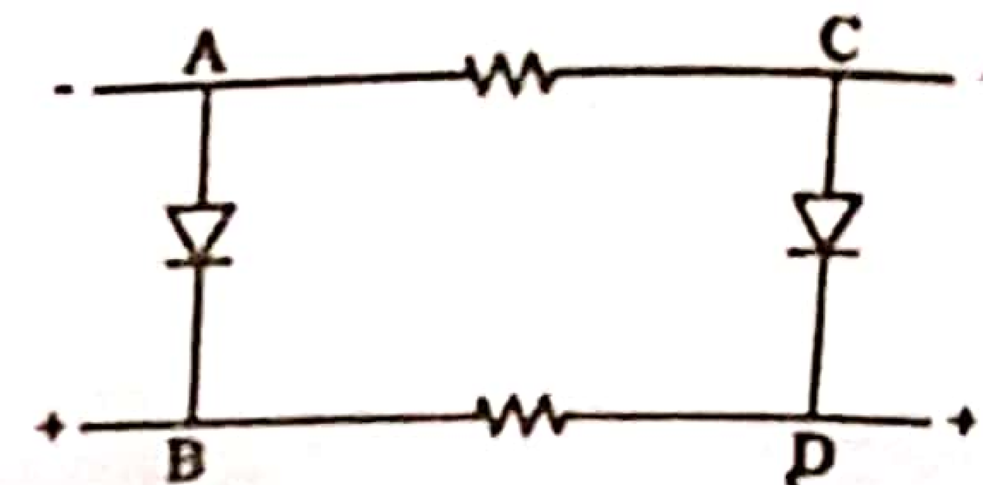
(1) Only X and Y (2) Only Y and Z
(3) Only X and Z (4) Only Y
(5) Only Z

Semi Conductior Diodes 09

If you wanted to light the LED, C terminal should be more positive than D terminal. Therefore, irrespective of the ways in which the terminals of the battery are connected, always C end should be connected to the positive end whereas D end should be connected to the negative end. All you need is to look into this matter. This is not happening from the circuit of X. When the terminals of the battery are interchanged, the polarity of the ends of C and D gets changed. Here there is no duty from the diodes. Directly A is connected to C end whereas B is connected to D end. There are no diodes in the way of AC or BD.

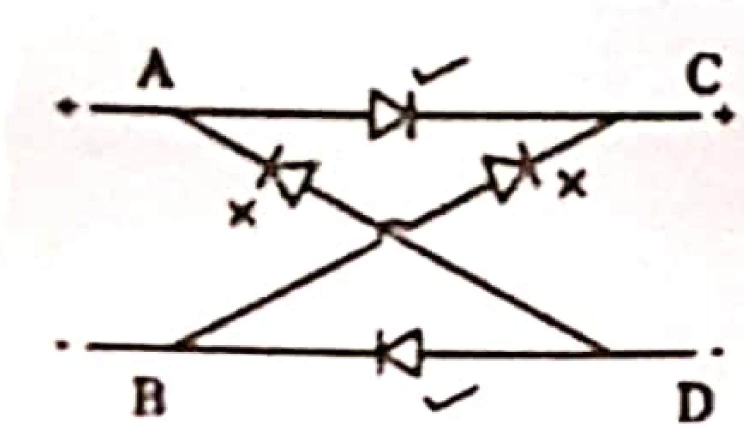


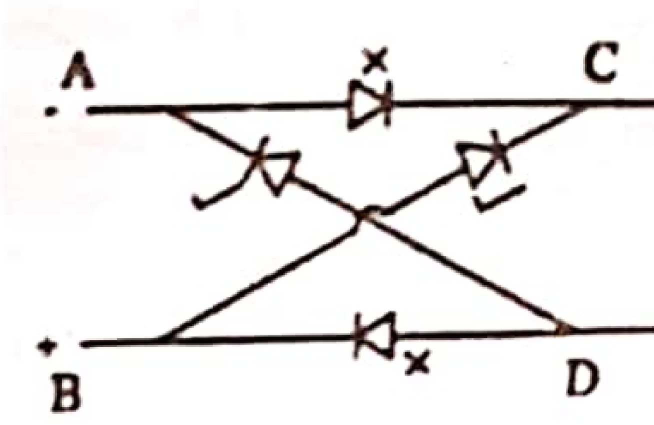
LED Lights up



LED Lights down

Next, look at the circuit (Y). As soon as you see, you get that it is wrong. When A is positive the road of AC gets closed. Why? Because the diode in between A and C gets reverse biased. But the road of AD is opened. Then D end gets positive. So, LED will not lit. Now (Z) should be correct. Otherwise, the question is wrong.





From the circuit of (Z), the work is done. When A is positive C gets positive. The road of AD is closed. As B end is negative, the road of BC is closed. D end gets negative. The polarities of C and D remain unchanged even when the polarities are changed in A and B.

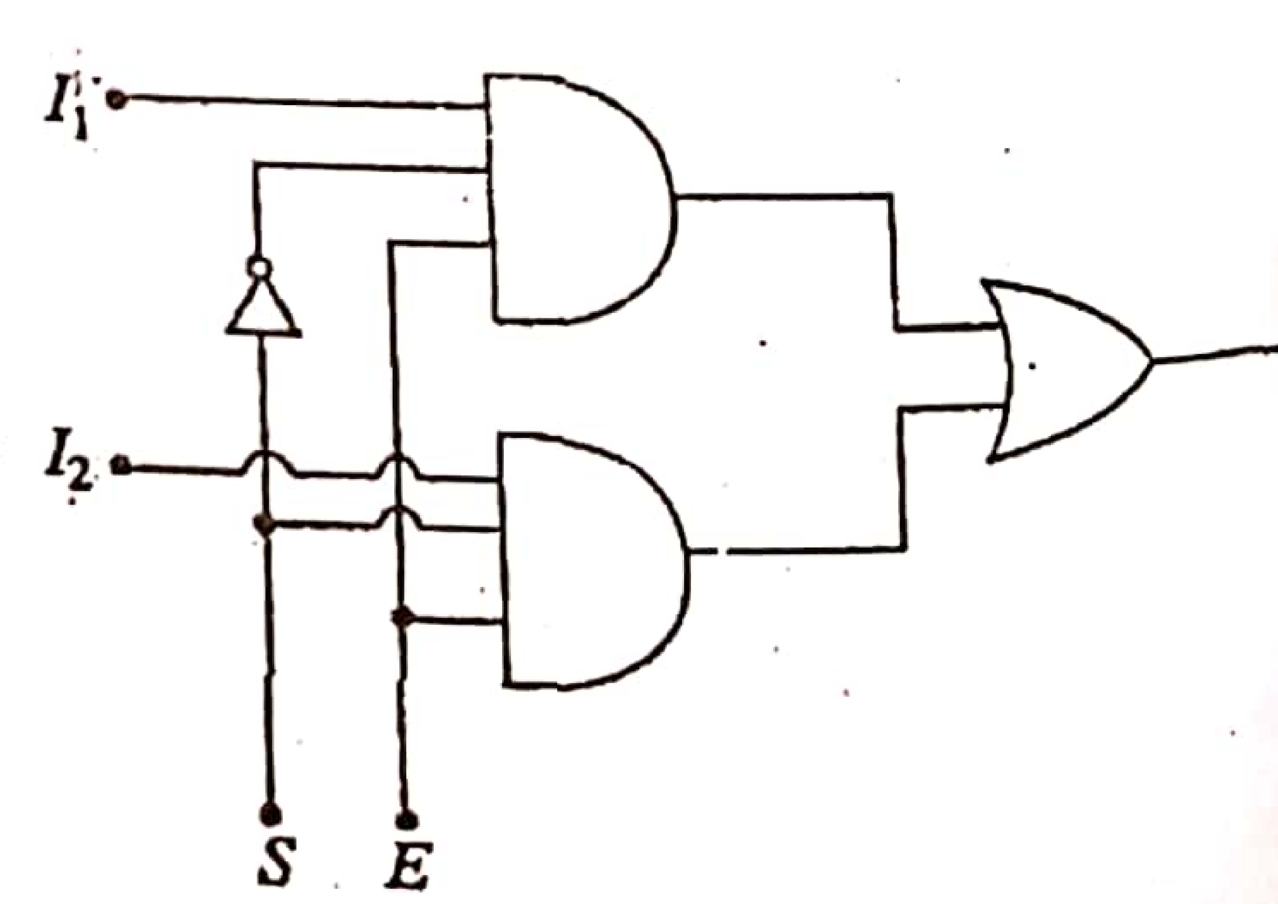
✓ Road is opened. The diodes are in forward biased state.

X Road is closed. The diodes are in reverse biased state.

As soon as you see the circuit (X), you can remove it. The diodes are not connected on the roads that are needed. They are being connected at somewhere else. Next when it comes to circuit (Y), you can clearly see that when A is positive, C does not get positive. When A is positive, D gets positive there. So, from that you can remove circuit (Y). There is no need to change the sides of the batteries. Next, circuit (Z) should be correct. Otherwise, the question is wrong.

Once the terminals are changed, check whether C end is positive. That is all you need to do. So, there should be a forward biased diode from A to C and B to C. Only (Z) has that requirement.

41. Consider following statements made about the circuit shown in figure.
(A) When $E = 1$ and $S = 0$, the output $F = I_1$
(B) When $E = 1$ and $S = 1$ the output $F = I_2$
(C) When $E = 0$ the output $F = 0$ irrespective of the values of S, I_1, and I_2.



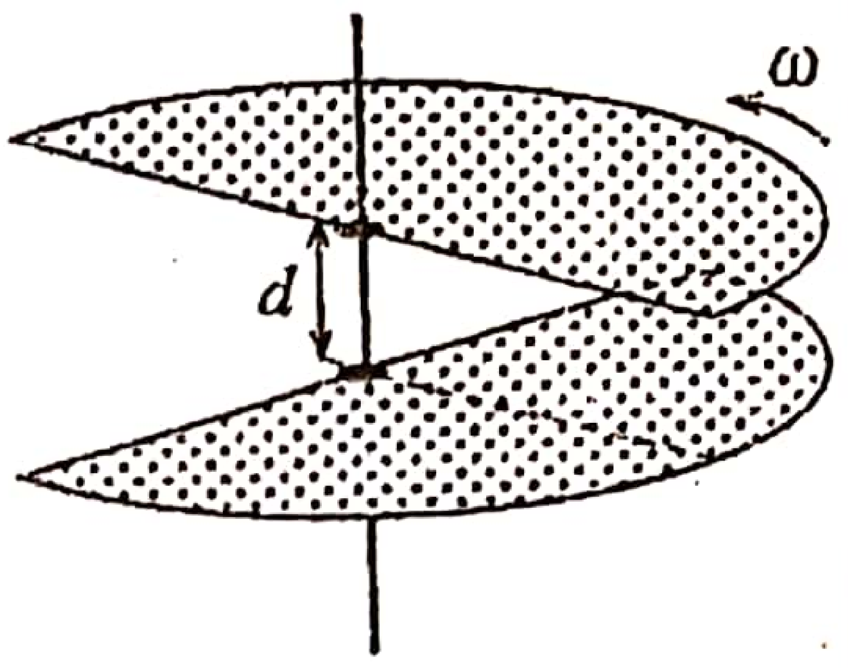
Of the above statements
(1) only (C) is true.
(2) only (A) and (B) are true.
(3) only (B) and (C) are true.
(4) only (A) and (C) are true.
(5) all (A), (B) and (C) are true.

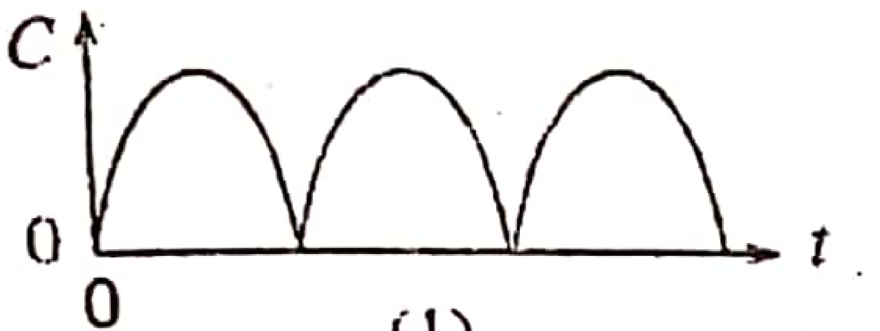
Logic Gates

Can you remember this circuit was there in the essay question of 5 (B) in paper 2012? When S = 0, the input of the first AND gate is 1. As E =1, the output of the first AND gate is I_1. That means if I_1 = 1, then the output is 1 (all the inputs are 1). If I_1 =0, then the output is 0. As the input of S is zero in the second AND gate, irrespective of the inputs from others, the output of that gate is zero. Then $F = I_1$ ($F = I_1 + 0$). The other side is mentioned in the statement (B). As S = 1, one input of the first AND gate is 0. Then its output gets 0. As S and E both are 1 in the second AND gate, its output is I2. Then $F = I_2$.

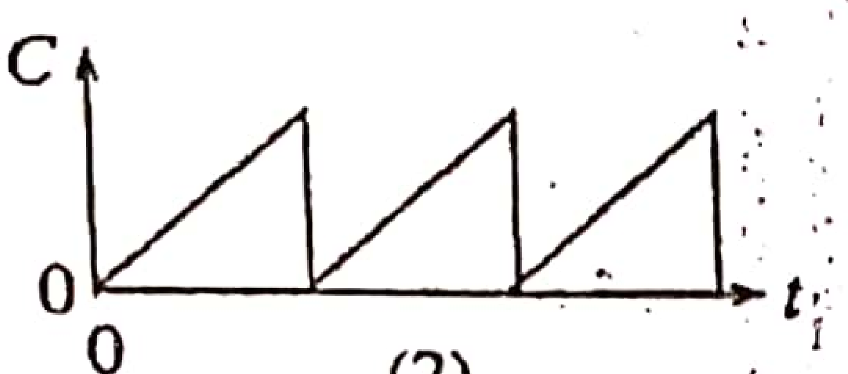
If E =0, then irrespective of the others the output of both AND gates will be 0. Then F = 0. All statements are true.

42. A variable parallel plate capacitor is made of two identical semi-circular metal plates that can be rotated about the common axis passing through the centres of each plate and perpendicular to them, as shown in the figure. If one plate rotates with constant angular speed ω, relative to the other, the variation of the capacitance C of the capacitor with time t is best represented by

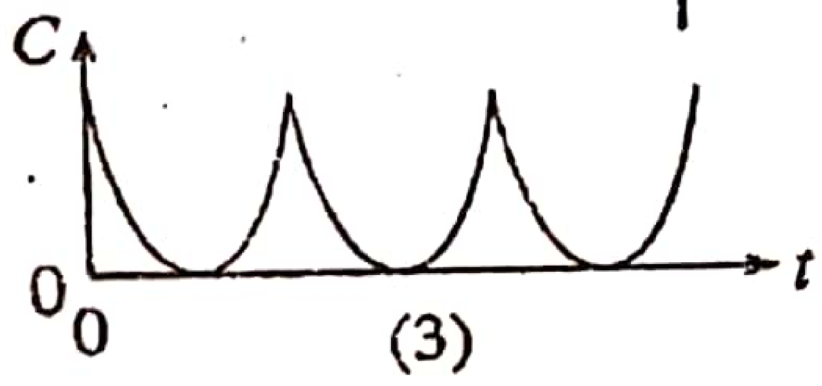




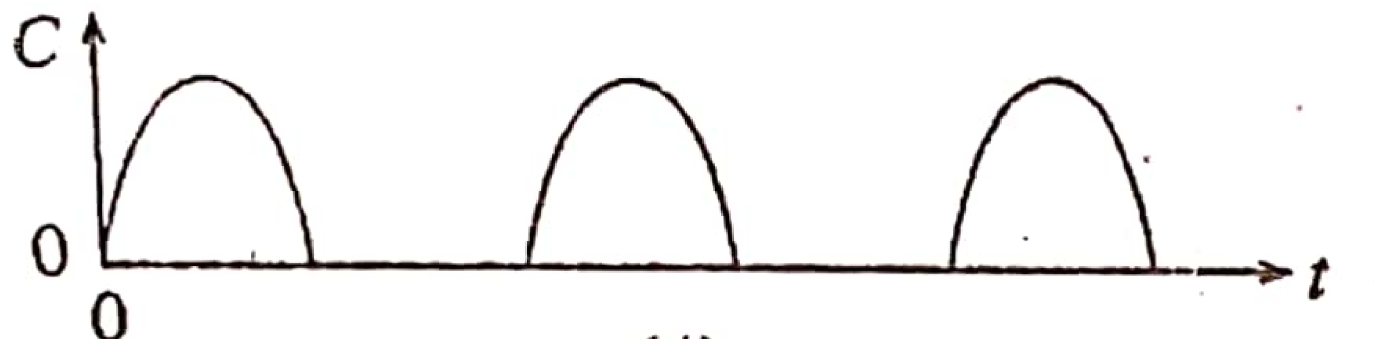
(1)



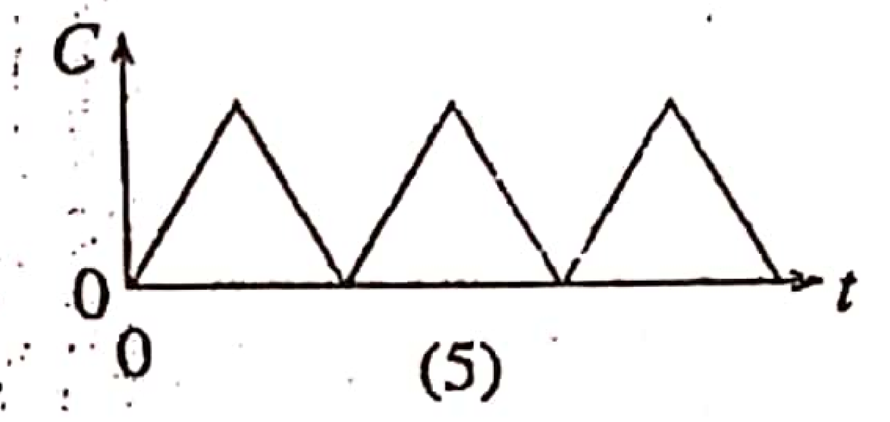
(2)



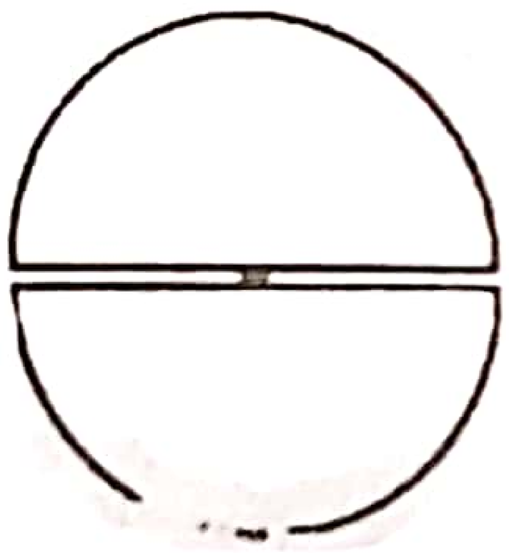
(3)



(4)



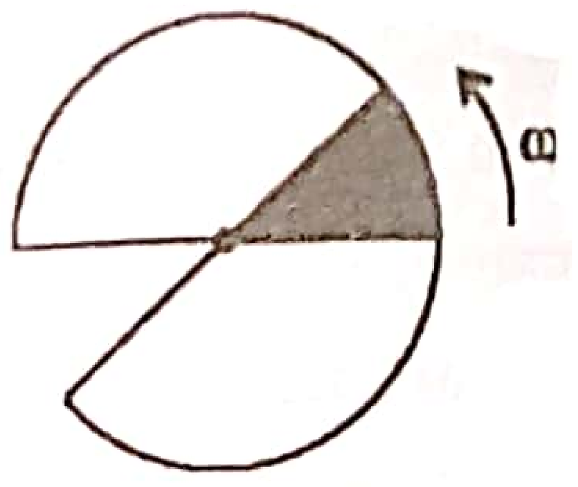
(5)



These two plates are drawn in 3D. The distance between the plates should be shown. If there is no distance between the plates, then it is not a capacitor. As the distance between the plates are constant, the capacitance of the capacitor is changed only due to the area that plates overlap. As one plate is rotated at a constant angular velocity relative to the other plate, the rate of overlapping area in a unit time is same. This can be understood even if the plate is rotated on a plate. Forget the distance between the plates.

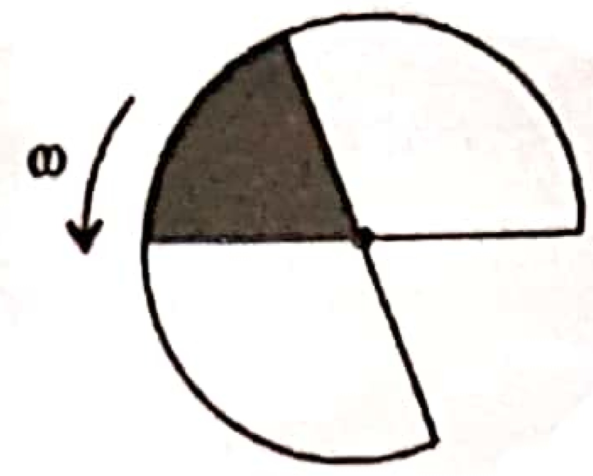
The area overlap is zero and the capacitance is zero.

The area that the plates overlap gradually increases. As ω is constant, the rate of area increment should be uniform. That means C should be increased uniformly.



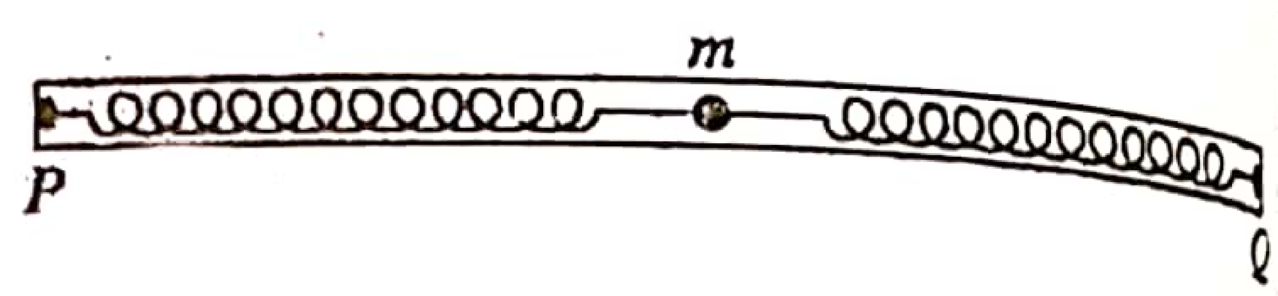
It is like those two plates are fallen on each other. There is maximum overlapping. C is maximum.

Now the rotating plate is getting away from the other. The area that the plates overlap gradually decreases.



Such variation is shown in (5). As ω is constant, the rate of area overlapping should be constant. If you understand this, then you can remove curve shapes. Choices of (2) and (5) are left out. As it is shown, C is gone to the maximum and then suddenly C cannot be zero. You need to exit as the way you entered. Then only (5) is left.

43. **One end each of two identical, stretched springs are fixed to the two ends of a closed tube and the other ends of the springs are attached to a mass m, as shown in the figure. Which of the following motion/s of the system results in a displacement of mass m towards P from the centre of the tube?**

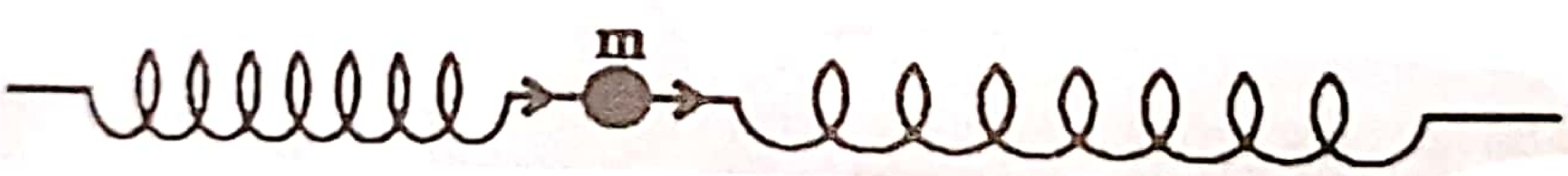


(A) Uniform acceleration of the tube in the direction of PQ, keeping the tube horizontal.
(B) Rotation of the tube around a vertical axis passing through Q, keeping the tube in a horizontal plane.
(C) Vertical motion of the tube under gravity keeping Q below P.

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

Circular Motion

You can get the answer form the general knowledge. Hope everybody who has gone in a bus has experienced that when it is accelerated to PQ direction, m should be displaced backwards. When accelerated forward, you will be pulled backwards. If you think according to Physics, then there should be a net force on m to the direction of PQ if it needs to be accelerated to that direction. To do so, the spring on the right side should be stretched and the spring on the left side should be compressed. If m is stretched left side to a certain distance, then the length of the right spring gets increased. That means a tension is created. Likewise, the left spring has a compression. Therefore, the directions of the two forces that act on m are towards right (PQ direction).



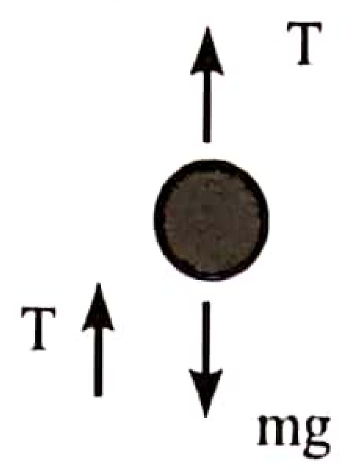
The spring on the right side is stretched. Again, it says to go back to the initial position of m. The spring on the left side is compressed. It tries to throw m to the previous position. Due to stretching and compressing there are forces on m that are acting on the same side. If both springs are stretched (this cannot happen) both will be tensions. Then m will have forces that are acting on opposite directions.

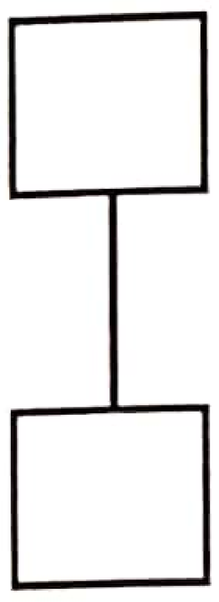
The work from (B) is similar to the work from (A). When Q is rotated in a more vertical axis, there is an acceleration on mass m to Q direction (centripetal acceleration). We know that when rotated, such a mass is tried to move outwards. When a vertical axis around Q is accelerated, m should have a net force which is directed towards Q (towards the centre). To do so, as previously mentioned m should be pushed towards P side. Actually, if (A) is correct, then (B) is also correct.

It has been mentioned as Q below P because when the tube is set vertical, a certain amount of m is pushed towards Q due to the weight of mass m. From that you can see that (C) is wrong. But when the tube is falling vertically downwards, then the tension or the compression of the springs should be zero.

When the tube is set to vertical direction (before the release)

2 T = mg (the bottom spring is compressed. The top spring is stretched)

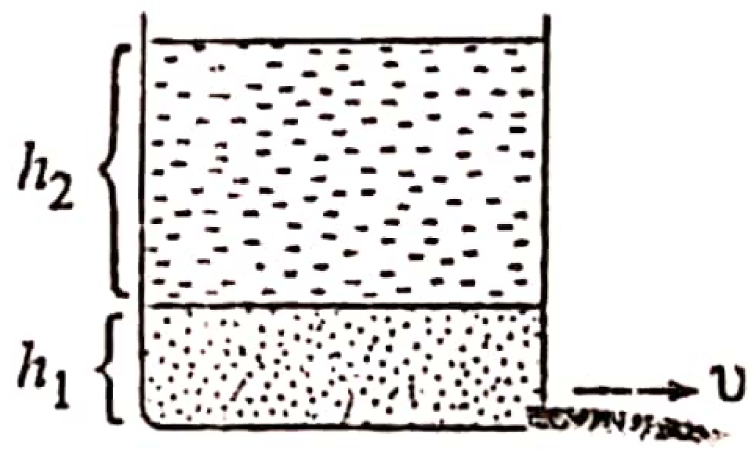




But when it is fallen freely at an acceleration of g, apply F = ma. Then mg – 2T = mg; T =0

We know about this fact. This has been checked many times in the past papers. When two mases as connected by a string as shown and released downwards to fall freely, does not the tension of the string get zero?

44. A cylindrical tank having a very large diameter contains two immiscible liquids of densities d_1 and d_2 ($d_1 > d_2$). The tank has a small hole closer to the bottom (see figure). If the heights of the liquids at a certain instant, are h_1 and h_2 what will be the speed v of the liquid ejecting out of the tank at that instant? Neglect the surface tension effects and assume that the liquids are non-viscous.



(1) $v = \sqrt{2gh_1}$

(2) $v = \sqrt{\dfrac{2gh_1 d_1}{d_2}}$

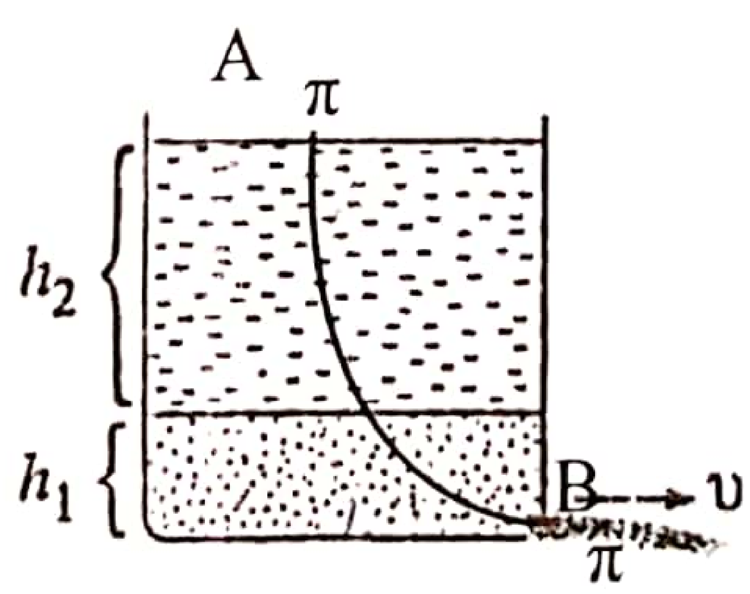
(3) $v = \sqrt{2g(h_1 + h_2)}$

(4) $v = \sqrt{2g\left(\dfrac{d_1}{d_2}h_1 + h_2\right)}$

(5) $v = \sqrt{2g\left(h_1 + \dfrac{d_2}{d_1}h_2\right)}$

Hydrodynamics 02

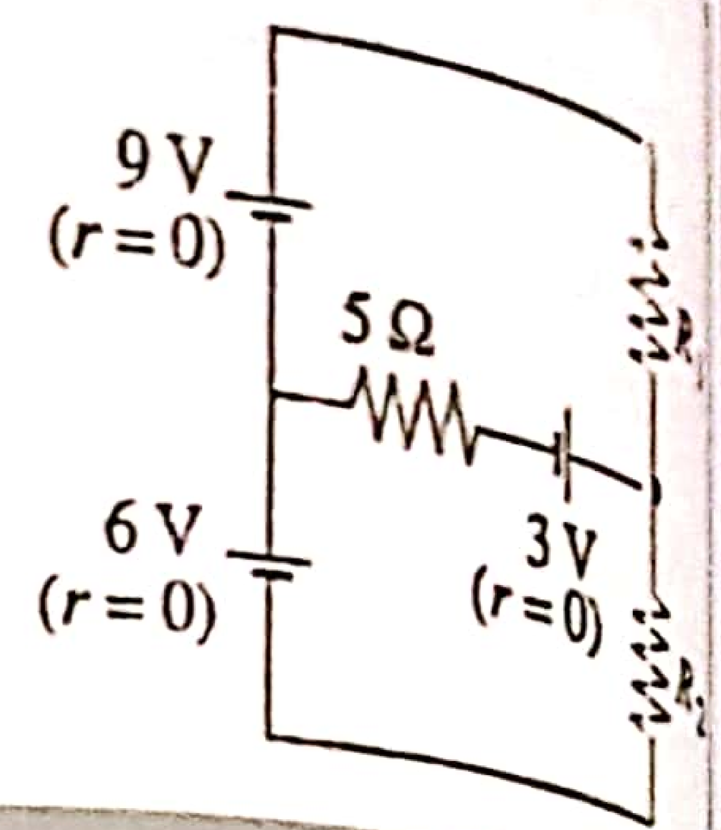
As soon as you see the figure, it is clear that you need to apply Bernoulli's theorem. The surface pressure of the tank is atmospheric pressure. As the exit point of the liquid is also open for the atmosphere, the pressure there is also the atmospheric pressure. As there is a huge diameter to the tank, you can consider the water flow speed from the surface as zero. If you apply Bernoulli's theorem to point A and B of the shown flow line, then $\pi + 0 + h_2 d_2 g + h_1 d_1 g = \pi + \frac{1}{2} d_1 v^2 + 0$



$\frac{1}{2} d_1 v^2 = (h_2 d_2 + h_1 d_1) g$; $v = \sqrt{2g\left(h_1 + \frac{d_2}{d_1}h_2\right)}$

You have done such questions using one liquid only. Even they have been given in previous papers. The only difference is that there are two liquids. Then there will be another potential energy term for the equation

45. If no current flows through the 5 Ω resistor in the circuit shown, what is the value of ratio $\left(\frac{R_1}{R_2}\right)$?

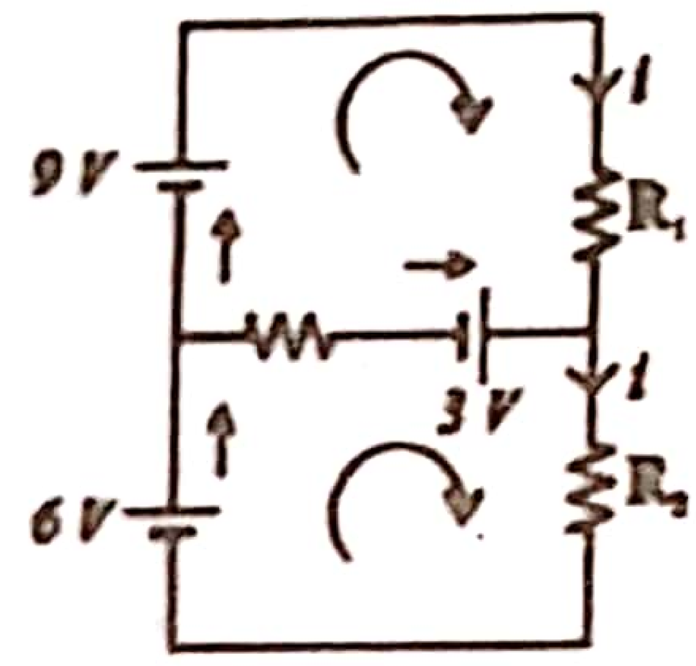


(1) $\frac{2}{5}$ (2) $\frac{3}{5}$ (3) $\frac{2}{3}$

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

Kerchoff's Law

There is nothing in this question. It is not worth to give as the 45th question. If there is no current flow across 5Ω, then same current flows across R_1 and R_2.

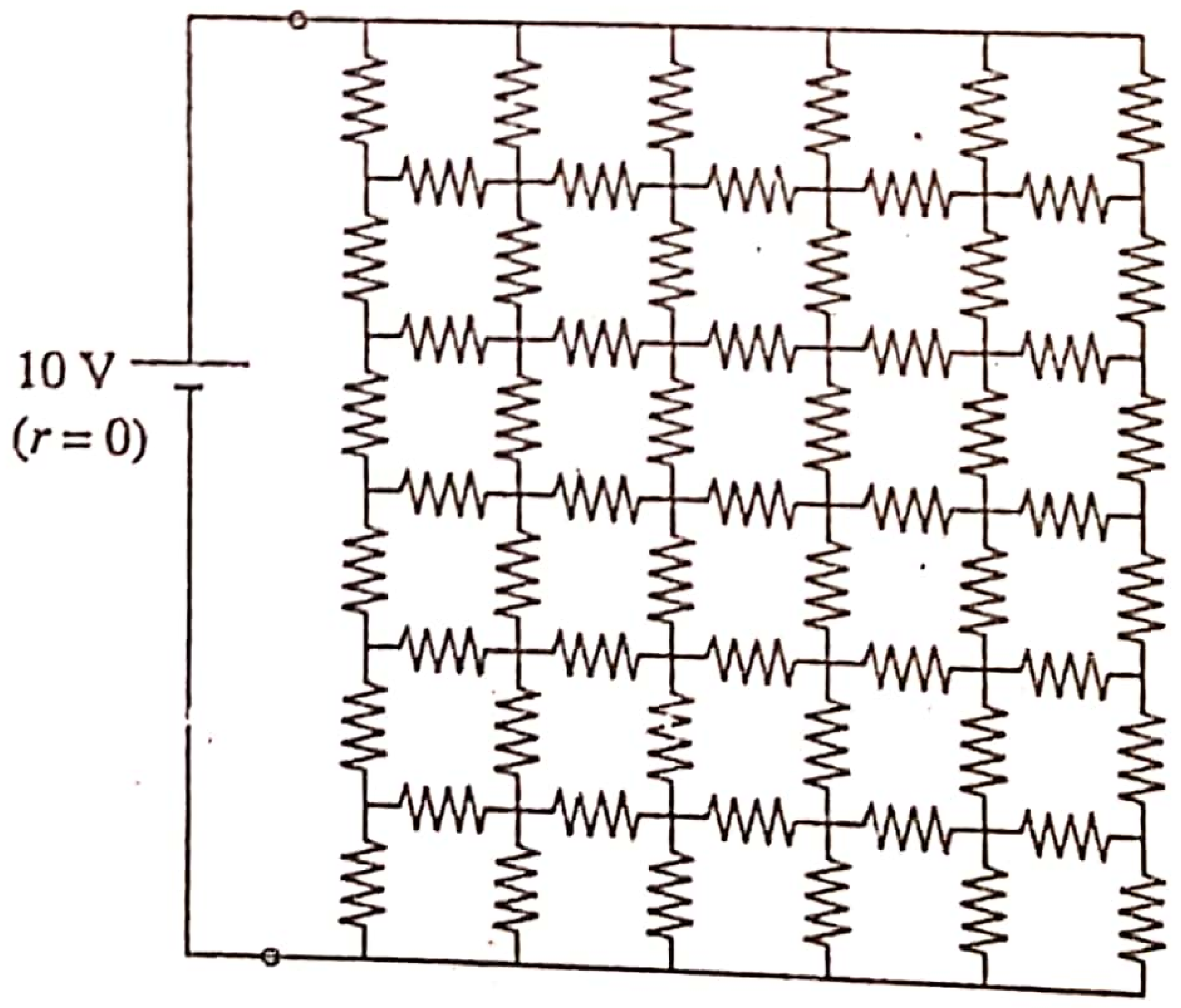


Considering the upper half, (9-3)6 = iR_1

Considering the lower half, (6+3) 9 -iR_2

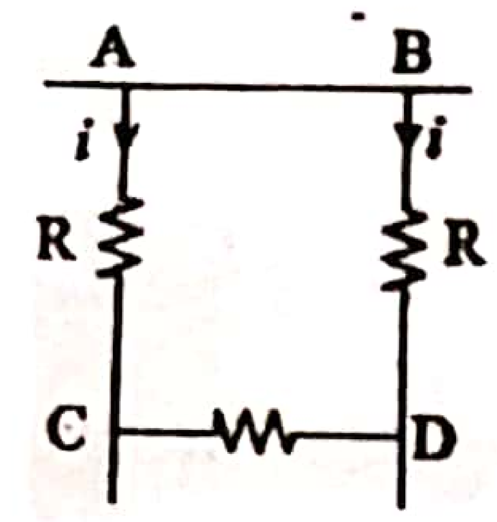
R_1/R_2 =2/3

46. The network shown in figure consists of identical resistors each having magnitude R. If R is 50 Ω, the current drawn from the cell is

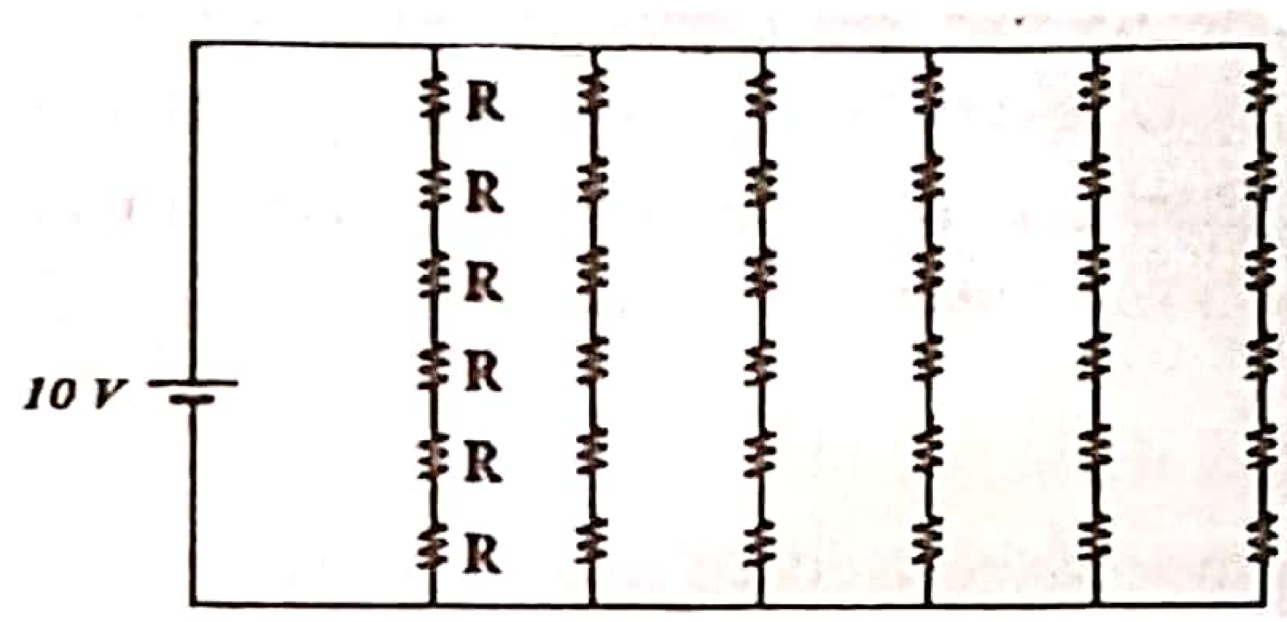


(1) 0.01 A (2) 0.1 A (3) 0.2 A (4) 0.5 A (5) 1.0 A

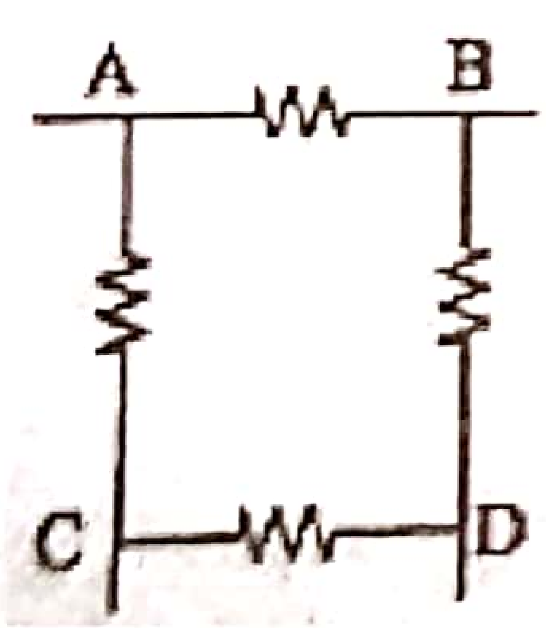
As soon as you see such a question, you need to realize that parts of the circuits are needed to be removed. Otherwise, there is no way. So, what are the parts that should be removed? All the horizontally drawn resistors can be removed. Consider a square at the top.



There is no resistor across AB. Therefore, when current comes to A, the currents that flow down from A and B should be equal. Actually, A and B are not two points. They are one. The potential of points A and B are same. In addition, $V_{AC} = V_{BD} = iR$. Therefore, $V_C = V_D$. So, there is no current flow across C and D. This argument is valid to the bottom. Even for other branches, this argument is valid. Therefore, we can remove all the horizontally drawn resistors as there is no current flow across them. Now the drawn resistor network can be minimized to the following shown network.



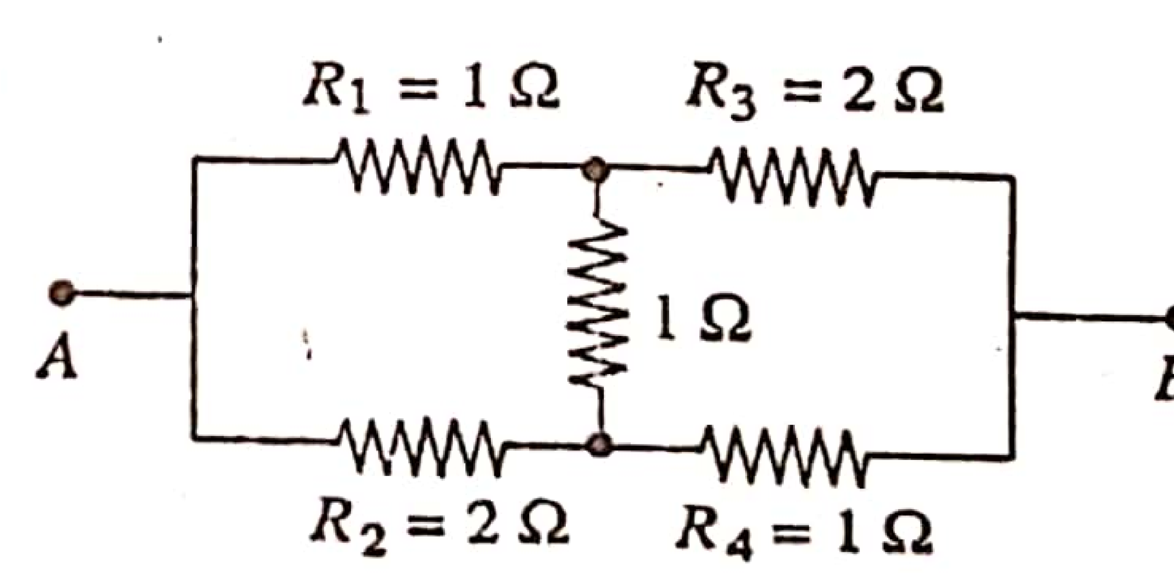
Now the answer is in your hand. Six Rs are in series. Their equivalent resistance is 6R. Six of 6R are parallel. That means the equivalent resistance is R. These things have to be done from the memory. Six vertical branches are given truly to get the final answer as R. $i = \frac{10}{R} = \frac{10}{50} = 0.2\,A$



If R resistors were connected across AB or up and/or down, then you cannot do the work like this way.

If so, then the potentials of A and B do not get equal. The currents that flow across AC and BD will not be same. If it was like this, then the problem gets more complex. Then this question will not be a MCQ. When such big networks are given, however you need to find a symmetry. In this network, you cannot remove vertical resistors. Then the network will be broken. All you can remove are the horizontal resistors.

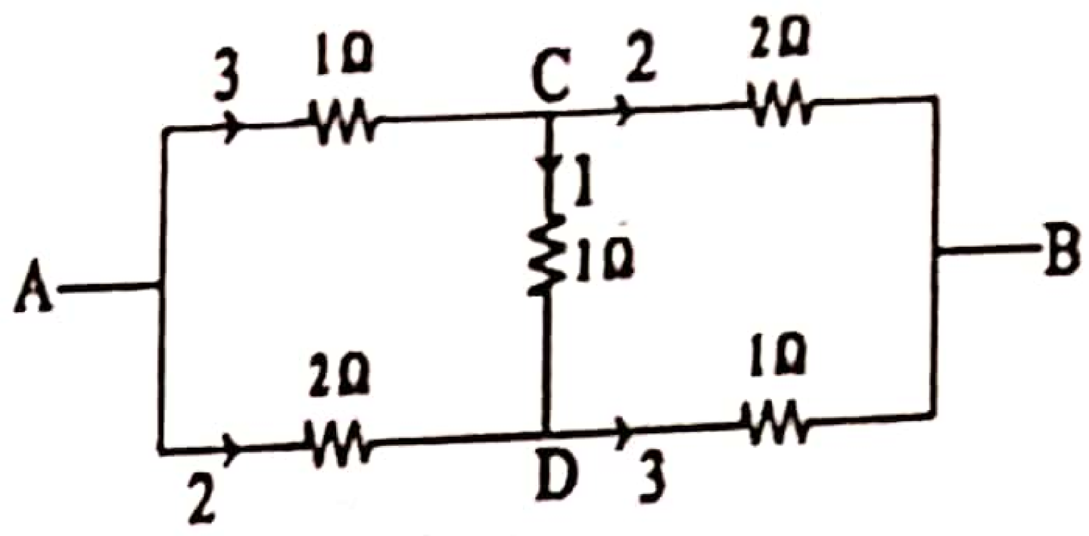
47. If a certain potential difference V is applied between A and B, a current of 3 A flows through R_1 and a current of 2 A flows through R_2. What is the equivalent resistance between A and B?

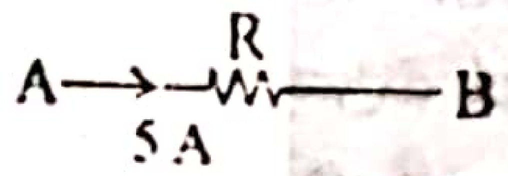


(1) $\frac{4}{3}\,\Omega$ (2) $\frac{7}{5}\,\Omega$ (3) $\frac{3}{2}\,\Omega$
(4) $6\,\Omega$ (5) $7\,\Omega$

Ohm's Law - Cobinationa of resistance **08**

It is very simple. As the currents are given, do not try to use the normal methods that you use to find the equivalent resistances in a resistor network. You cannot find a series or parallel arrangement in this. You cannot find any opportunity from this situation. Even this is not a Wheatstone bridge circuit. $R_1/R_2 \neq R_3/R_4$ Even if this is a Wheatstone bridge circuit, it will not be given for the 47th question. This can be solved considering the currents in the branches.





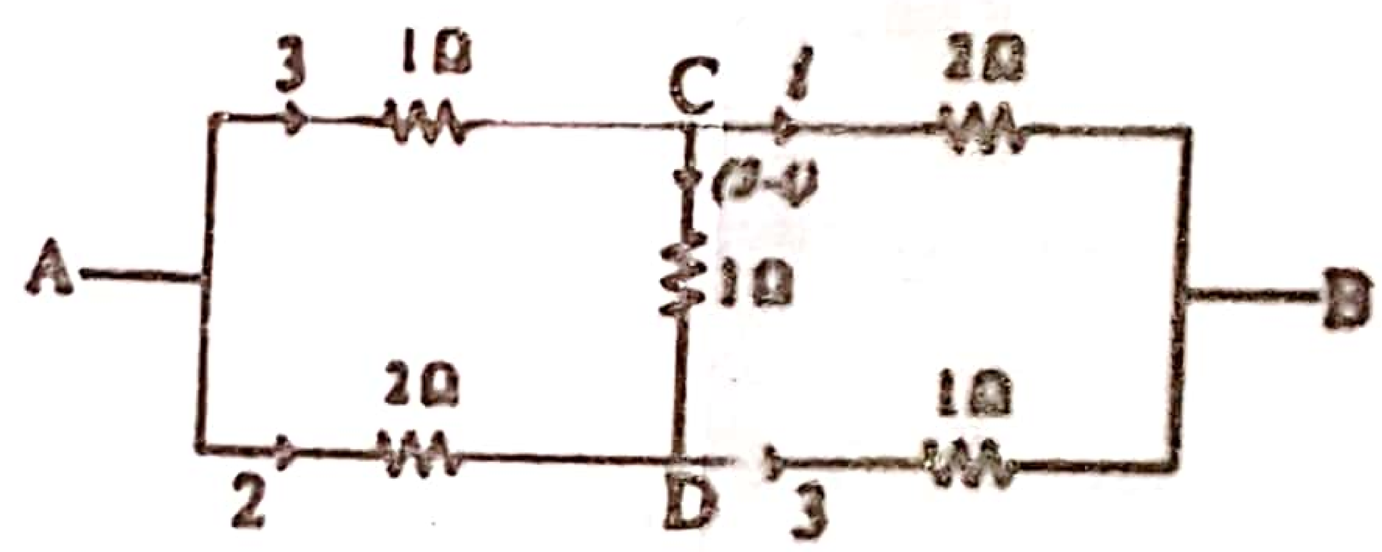
If 1Ω of top left side has a current of 3 A, then 1Ω of bottom right should have the same 3A current across it. Likewise, if 2Ω of bottom left has a current of 2 A, then 2Ω of top right should also have the same 2A across it. If so, 1A flows across 1Ω in the middle.

Now if the equivalent resistance is R, then total 5 A should flow across R.

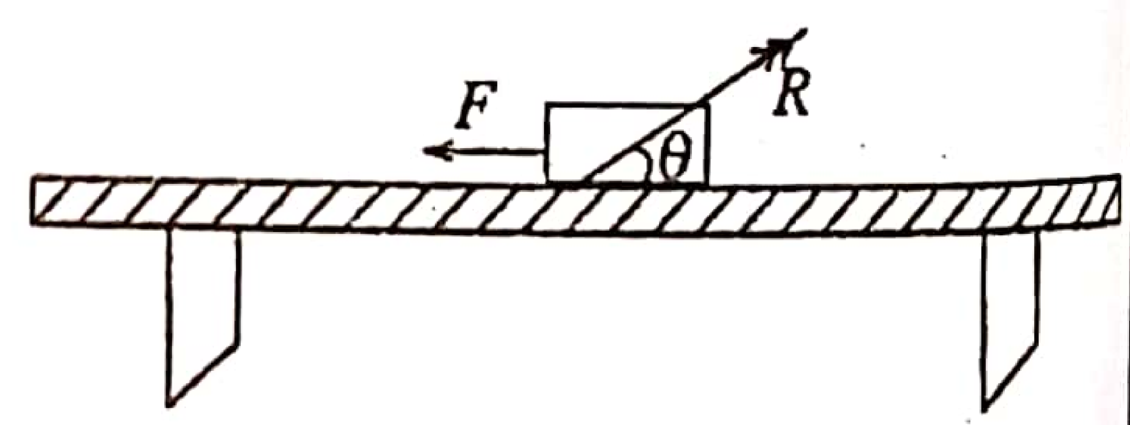
VAB = 5R =$V_{AC} + V_{CB}$ = 3 X 1 + 2 X 2 = 7; R = 7/5 Ω

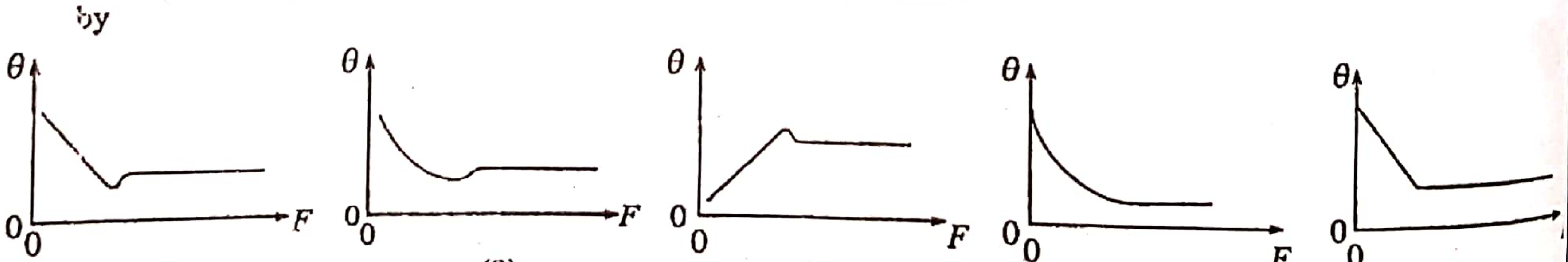
Even it was written in length for the explanation, it can be done from the memory if the method was identified. Take your eye across A→C→B or A→D→B. Add while you go. 3 + 4 =7. The total current across the circuit is 5A. Therefore, 5 should be in the denominator of the equivalent resistor. There is one choice where 5 is there as the denominator. Actually, you do not need to find the current that flows across 1Ω in the middle. It is needed, if you consider $V_{AB} = V_{AC} + V_{CD} + V_{DB}$. If so, then you will get 3 X 1 + 1X1 + 3 X 1 =7. If you continue to solve, then consider ACDA circuit.

3 X 1 + (3-i)1 – 2X2 = 0; 6- i-4 =0; From this you get i = 2A



48. A box, which is placed on a rough, horizontal surface of a table is pulled by a variable, horizontal force of magnitude F. For a given value of F the resultant force R exerted by the surface on the box makes an angle θ with the horizontal direction as shown in the figure. The variation of θ with F is best represented by

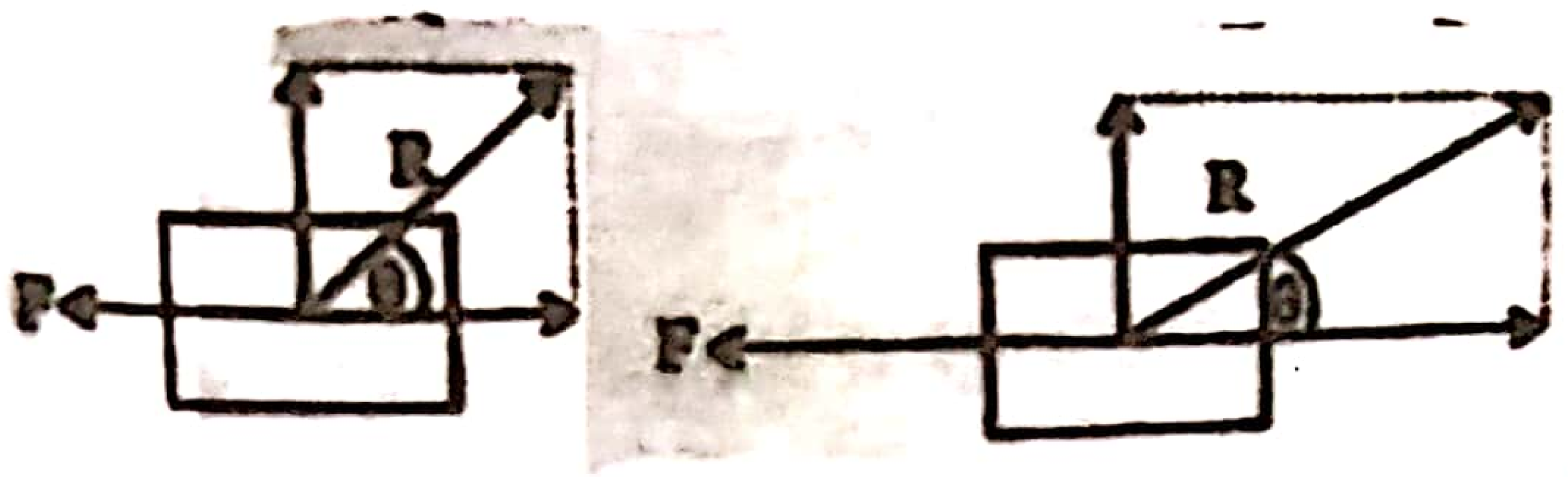




(1) (2) (3) (4) (5)

Kerchoff's Law - Cobinationa of Cells

When the box is kept on the table, (if F = 0) then only the perpendicular reaction is acted on the box by the table. The frictional force is also starting to act when F force is started to apply. When F is gradually increased, then the frictional force also gradually gets increased. But the perpendicular reaction does not change. As the frictional force is gradually increased, the resultant of the perpendicular reaction and the frictional force is more inclined to the side of the table. Therefore, when F increases, θ should gradually decrease.



But according to what we know, there is a maximum limit to static frictional force (static frictional force). Even if F is increased after it attained this maximum limit, then the frictional force will be little less (dynamic frictional force). Therefore, gradually decreased θ value should now be increased a little. Afterwards the frictional force does not change for any value of F. It will be a constant. Then θ value also should be unchanged.

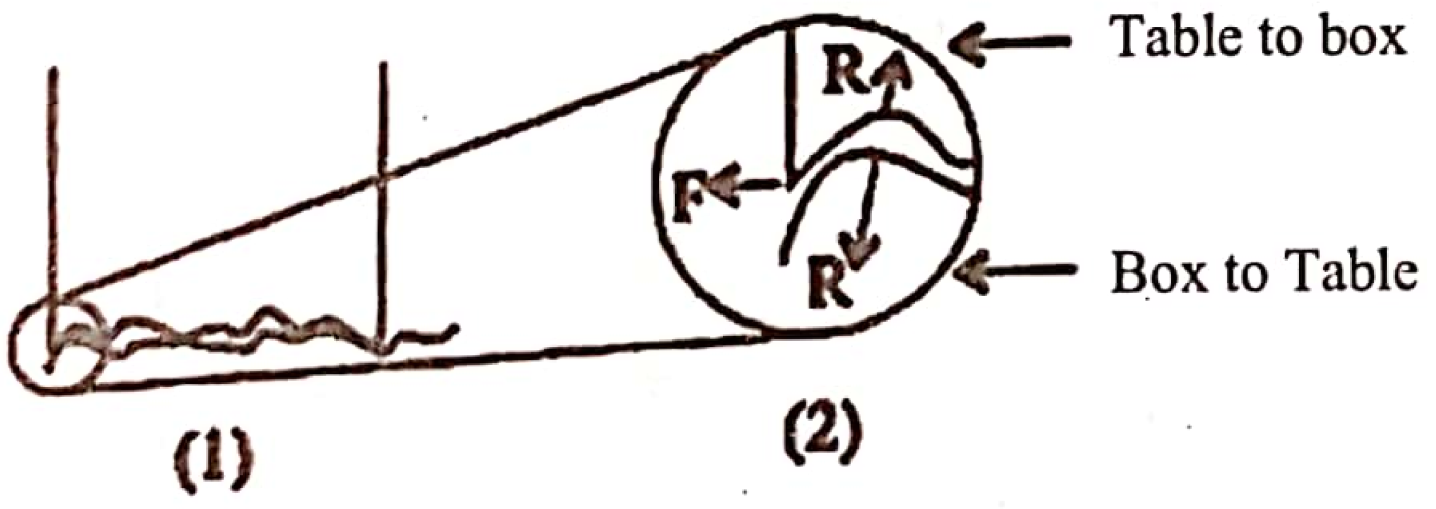
These facts are demonstrated in the graphs of (1) and (2) where (3) will be just removed. When F is increased θ cannot be increased. In (4) and (5), the small change of θ is not shown when the static frictional force changes to dynamic frictional force.

Does θ is reduced linearly or in a curved way? To have a linear variation F should be proportional to θ. It cannot happen as it can be proved from the simple knowledge. You should realize that there should be trigonometric relation between F and θ. So, the correct choice is (2) not (1). You can write the equations and see.

$F = R\cos\theta$; $R\sin\theta = mg$; Therefore, $F = mg\cot\theta$. $F \propto \cot\theta$

So, the variation of F with θ is not linear. If $F = 0$ then $\theta = 90^0$ ($\cot 90^0 = 0$). You do not have to think about cot curves. All you have to consider is only whether the variation is linear or curvy.

Most of the time we have misconceptions about the frictional force. If you look at the microscopic view of the surface that the box touches the table and the table surface, then there are bumps and damages. Look at the following figure 1.

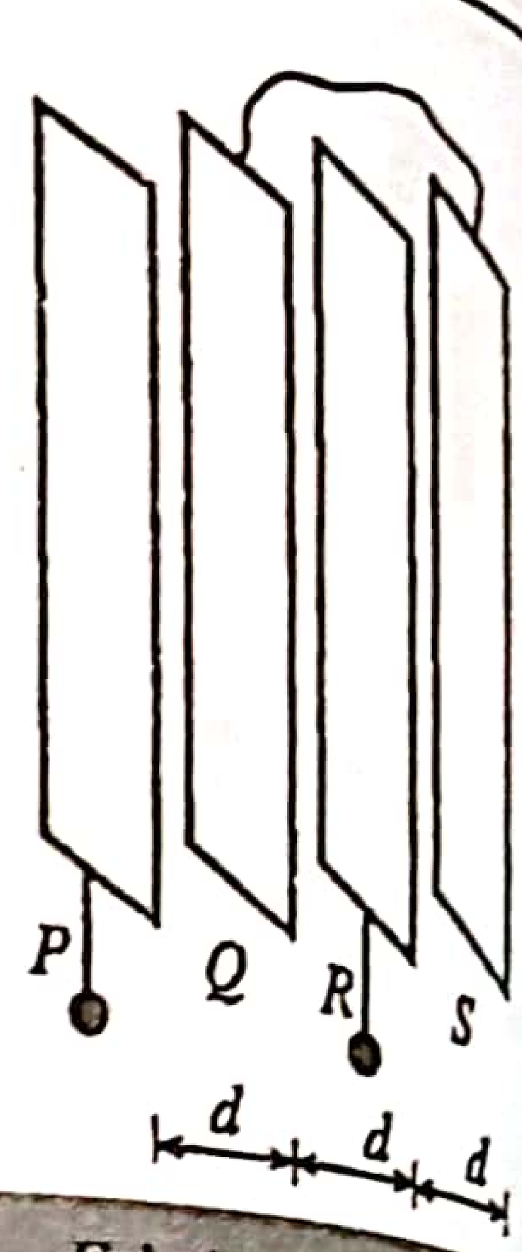


From the second figure it has shown the magnification of a small hill and a plateau which collide with each other. When the box is pulled to the left, these hills and plateaus are rubbed/pushed together and have a force from the box to the table. There is an opposite equal force from the table to the box. The horizontal component of R force (R cos θ) is called as the frictional force. The vertical force (R sin θ) is known as the perpendicular reaction. Actually, there are no two forces of frictional force and perpendicular reaction on the box by the table. There is only one acting force. That is known as R and we resolve it. When F is increased, the hills and plateaus are pushed together. But at a certain instance, where these connections are broken and the box will move forward. When the bonds are broken, the journey is easier. It is the nature of the world.

49. **Four identical rectangular metal plates, P, Q, R and S have been arranged parallel to each other so that the distance between two successive plates is d. Area of each plate is A. If the plates Q and S are connected by a thin metal wire, what will be the capacitance between plates P and R?**

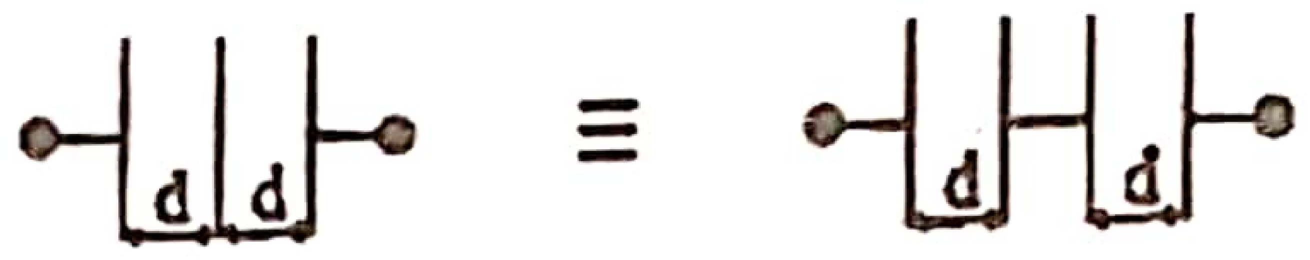
(1) $\frac{\varepsilon_0 A}{3d}$ (2) $\frac{2\varepsilon_0 A}{3d}$ (3) $\frac{3\varepsilon_0 A}{2d}$

(4) $\frac{2\varepsilon_0 A}{d}$ (5) $\frac{3\varepsilon_0 A}{d}$



Friction

It is a question that many have spoken about. This also had many views and thy are still there. To get the answer for this, the figure should be recreated. Consider the following plate arrangement.

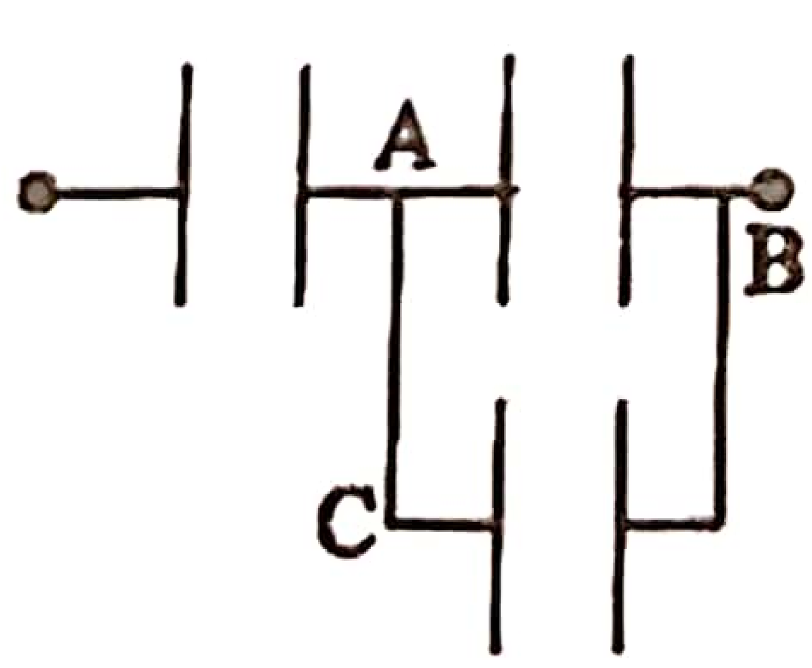


(1) **(2)**

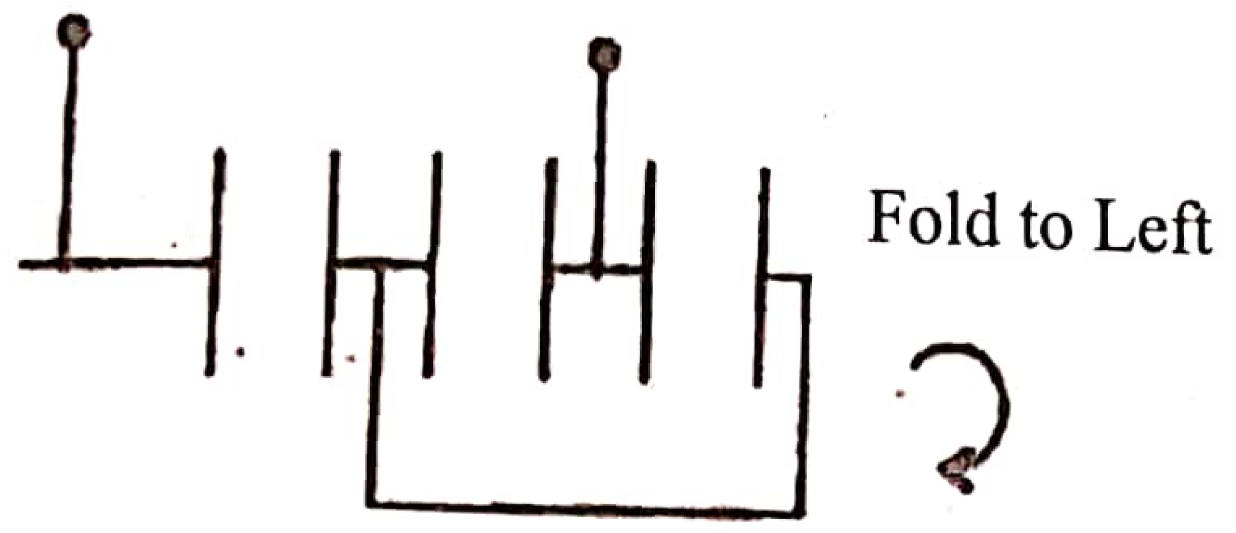
Here both (1) and (2) figures are equivalent to each other. It is like the middle plate has been split into two. Even if the middle plate is split and consider them as two capacitors or consider the 1st arrangement, both have the same equivalent capacitance. The capacitance of the first arrangement = $\varepsilon_0 A/2d$. For the capacitance of the second arrangement, we have to capacitors with capacitance of $\varepsilon_0 A/d$ in series. Its equivalent capacitance is $\varepsilon_0 A/2d$. If you think in another way, then the capacitance is not changed when a thin plate is inserted in between the parallel plate capacitor. Now do this for the arrangement of the question too.

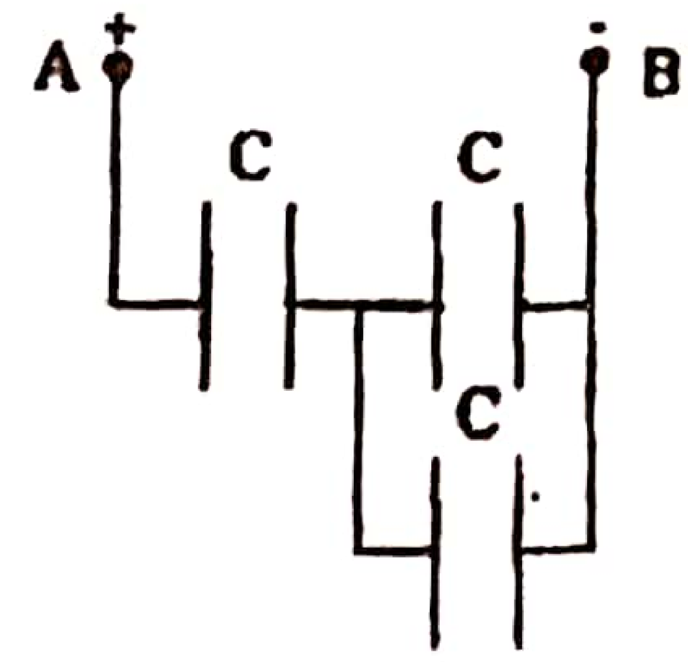
(1) **(2)**

Do not you think that (1) and (2) are equivalent to each other? The second and the third plates in the first figure have been split in length and the split plates are being distanced apart. Now cannot we draw the second figure like this?



As the second and the fourth plates are connected with each other, the potentials are equal in points A and C. Point B is however common. If the connectors of voltage are drawn above and if the connecting wire is drawn as below in the bottom, then you will properly understand that two capacitors are parallel and the other one is in series.

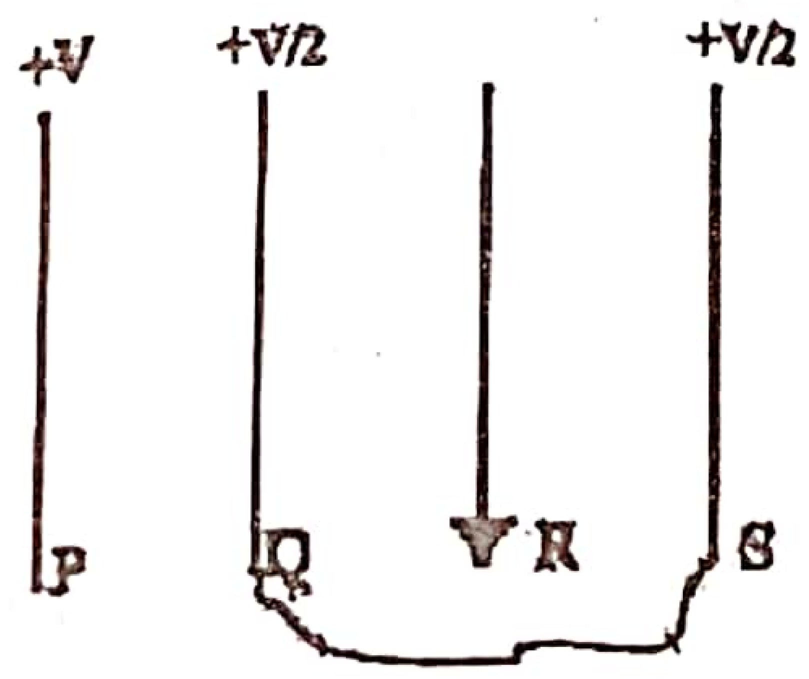




2 C is the equivalent of C and C parallel combination whereas 2C and C are in series. Then the equivalent capacitance is 2/3 C. $C = \varepsilon_0 A/d$. The equivalent capacitance of C and 2C in series should be lesser than C. Therefore, it cannot be 3/2 C. Apply these arguments all the time.

I know that the solving is easy when the plate is split. According to the way it is drawn in the paper, you cannot decide what is in series or parallel. So, what to do? Nobody can blame what was done above. It is correct. The MCQ paper of Physics is like our life. There are direct things that can be seen. Even there are unseen things. There are things to remove and add as well. There are small cunning methods and good tricks. There are things to be pulled and tightened.

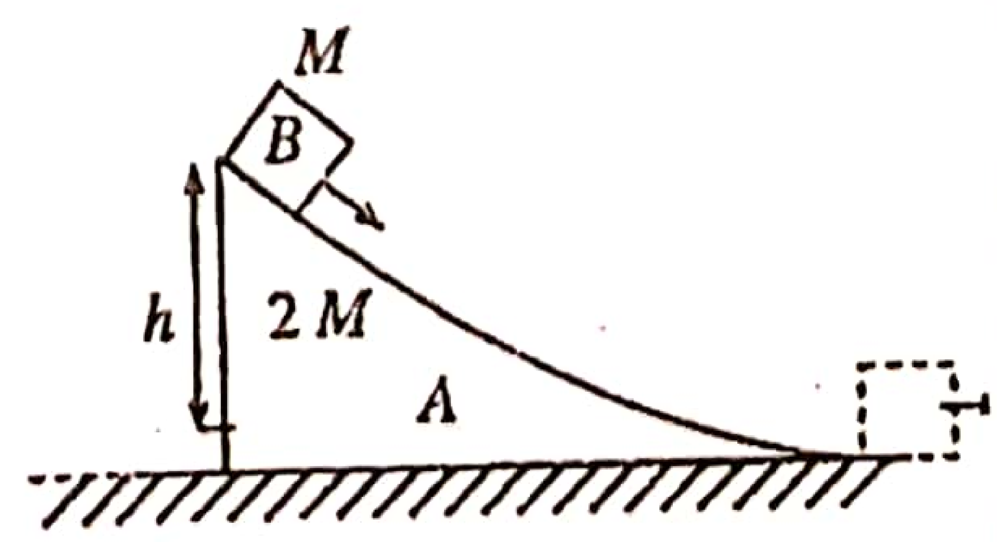
When a voltage is applied across A and B, many argue that the fourth plate which is in the outside cannot have charges. The fourth plate is not an isolated plate. It has been connected to the second plate. If there was no connection between the second and the fourth plate, then the above argument is correct. Then there cannot be a chance to have charges in the fourth plate. But as they are connected here, there is a charge leak to the fourth plate too. That plate also has a potential.



Consider R plate is earthed and there is an applied voltage of +V to the plate P.

As Q is located in between P and R, the potential of Q is +V/2. As Q and S are being connected, the potential of S is also V/2. If you look like this, then there comes a hint that QR and RS are parallel. You can get the answer very conveniently if you think like this way.

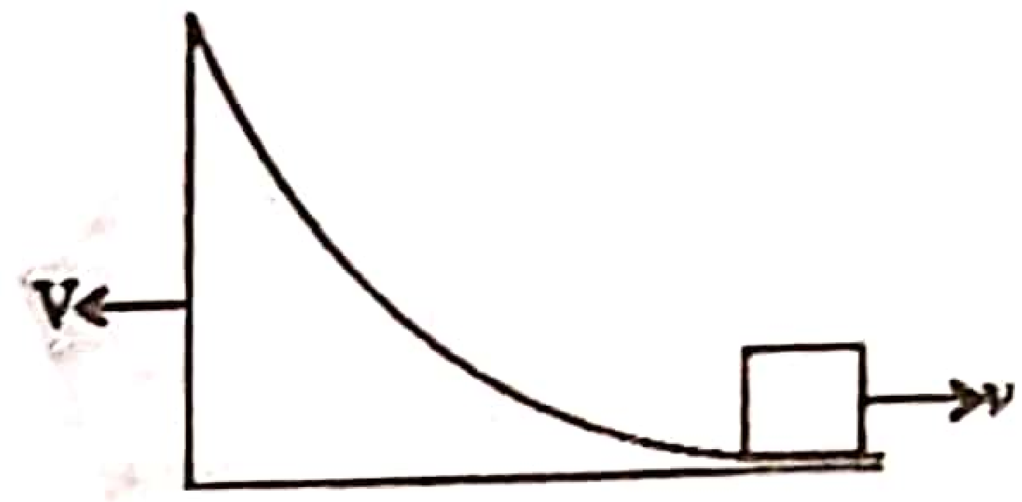
50. A body A of mass $2M$ shown in figure is placed on a smooth horizontal surface, and a small block B of mass M is placed at the top of the body. Starting from rest, block B slides down on the smooth surface of A. At the instant when block B leaves A the speed υ of A is given by



(1) $\upsilon = \sqrt{2gh}$ (2) $\upsilon = \sqrt{gh}$ (3) $\upsilon = \sqrt{\frac{gh}{2}}$

(4) $\upsilon = \sqrt{\frac{gh}{3}}$ (5) $\upsilon = \sqrt{\frac{gh}{5}}$

You need to apply conservation of energy as well as conservation of momentum. When B is sliding down A goes backwards. There is no friction between A and the horizontal surface. Let us take v as the speed when B is going away from A and V as the speed of A.

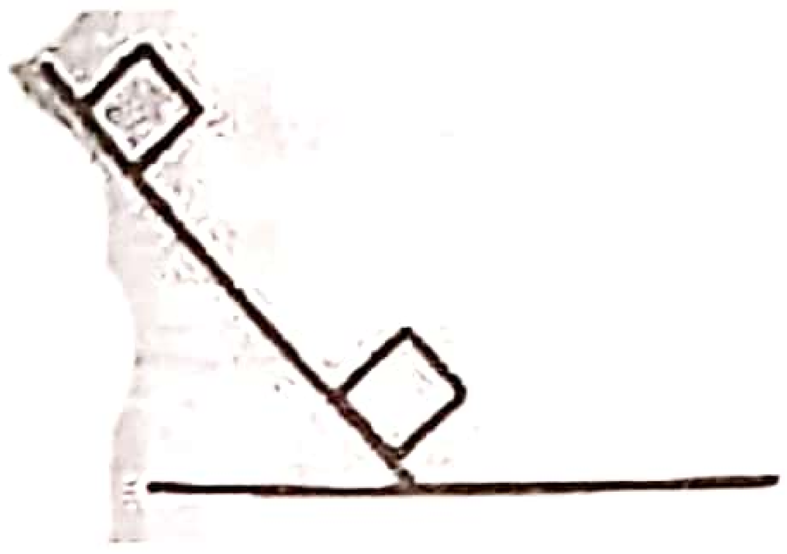


From the conservation of momentum, 2 MV = Mv; v =2V

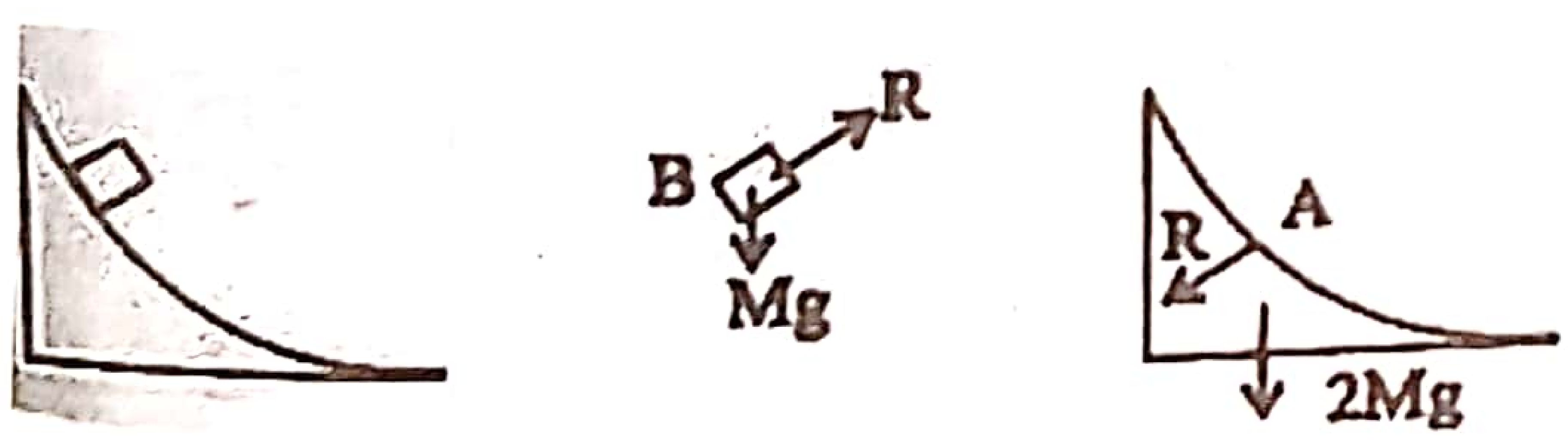
From the conservation of energy, Mgh = ½ X 2MV² + ½ Mv²

Both got the kinetic energy from the stored gravitational potential energy of B. There is no one to supply any energy. Substitute the second equation to v. $gh = V^2 + \frac{1}{2}4V^2 = 3\,V^2; V = \sqrt{\frac{gh}{3}}$

You will get it wrong when it was written like Mgh = ½ Mv². This is true when A was kept at rest.



The inclined plane is drawn as a curve to promote smooth movement when B is going away from A without hurting. When the inclined plane is drawn like this, the change of B surface to horizontal plane will not happen smoothly. There will be a collision with the horizontal plane. There can be an energy loss from that.



Why does a goes backwards when B comes down? Let us consider the forces that are acting on B and A.

A goes backwards due to the horizontal component of R that is acting on it. When B comes to the bottom, the speed of A is asked because at that instance v and V are acting on opposite directions. However, V is acting horizontally to the left. But v gets accurately horizontal when B is going away from A. if you find v at this moment, then $v = 2\sqrt{\frac{gh}{3}}$. If A is kept still, then we know that $v = \sqrt{2gh}$. As A moves, the speed of it which is v should be lesser than $\sqrt{2gh}$. Why? Because part of the potential energy is spent for the motion of A.