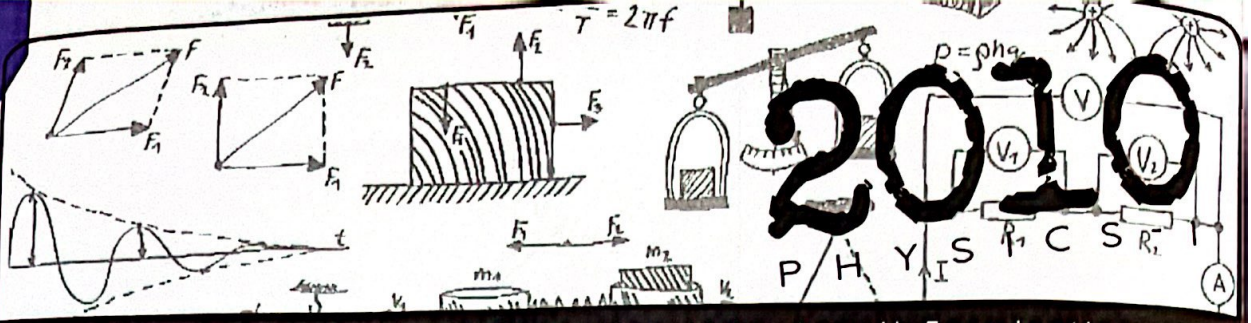


01. The dimensions of moment Inertia is

(1) ML^2 (2)ML (3) M (4) L (5) MLT^{-1}

01 Unit and Dimensions

You can find the answer as soon as you saw the question. The moment of inertia goes with the multiple of mass with the square of the distance. Therefore, the answer is (1). Like mass is there for translational motion, it is moment of inertia for rotational motion. It is like affection for love and desire for romance.

The desire or the laziness of an object for translational motion is measured from its mass. In rotational motion, it is measured as rotational inertia or moment of inertia. Here the word moment is connected because for rotational inertia, the mass as well as the distance are being related. But rotational inertia or the desire or the dislike towards the rotational motion cannot be measured by the multiple of mass and distance. Mass is a scalar quantity. Likewise, rotational inertia also should be a scalar. There is no direction for the desire or what you like. So, the mass should be multiplied by the square of the distance not distance.

02. SI unit of the quantity of heat is

(1) cal (2) W (3) K (4) J (5) cd

01 Unit and Dimensions

The answer is in your hand as soon as you saw the question. There is no waste of a second. The SI unit of any energy is J. The older unit for the amount of heat is calorie. The reason for this that the English word calorie was derived from Latin word of calor. The meaning of calor in Latin is heat. The unit of calorie was introduced by a French national Nicolas Clement in 1824. Even though the SI unit of the amount of heat is Joule, still calorie is being used to measure the energy values of foods. But according to the SI standard, the energy is measured in Joulefor any energy. Even there were students who chose K by mistake.

03. When white light passes through a glass prism, which of the following colours deviates the least?

(1) green (2) orange (3) blue (4) yellow (5) indigo

03 Refraction through Prisms

It is a question of year 8, 9. You all know about VIBGYOR. The colour red has the least deviation. But it is not found in the answers. The next one is orange.

04. The distance from the eye lens to the retina of a person is 1.7 cm. The focal length of the eye lens when the eye is in completely relaxed position is

(1) 0.85 cm (2)1.0 cm (3) 1.2 cm (4) 1.4 cm (5) 1.7 cm

Defect of Vision 03

It has been checked every day. When the eye is at rest without being tired means the situation when the eye is looking far away. Then the eye lens is at a relaxed state. The rays that are coming from far away are focused on the retina. That means the focal length of the eye lens is 1.7 cm. Even the eye lens cannot stay by doing nothing all the time when it is at rest. When you are reading, writing or engaged in a work, the ciliary muscles that are associated to the eye lens are not idling at all.

05. Consider the following statements made about a voltmeter and an ammeter.

(A) A voltmeter has a large internal resistance and an ammeter has a small internal resistance.

(B) A voltmeter is connected in series with a circuit component to measure the village across the component.

(C) An ammeter measures the charge per unit time that flows through it.

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

Moving coil Meters 08

When you are reading the sentences, the answer is created. There is no need of argument. Both (A) and (C) are correct whereas (B) is incorrect. It is clear that the voltmeter should be connected to the section parallelly when it is being mentioned as across the circuit part. An ammeter measures the current that flow across it. Current is the amount of charge that flows in a unit time.

06. Two guitar wires A and B identical in all respects except that the diameter of A is twice the diameter of B, and are subjected to same tension.

The ratic, $\frac{\text{fundamental frequency produced by A}}{\text{fundamental frequency produced by B}}$ is

Transverse Waves

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

Transverse Waves 03

You have done many questions like this. There is no need to do rough work. Except for the diameters of the wires, all the other things are equal. As the length of the wires is equal, the ratio of the fundamental frequencies is inversely proportional to the square root of mass per unit lengths of the wires. The mass per unit length can be obtained by the multiplication of the cross- sectional area and the density of the wire. There is no change in the density. The cross- sectional area is proportional to the square of the diameter. That means, the square root of cross-sectional area is proportional to the diameter. So, the answer is ½. If you want to write (please do not do) then, (please do not do) then, $\frac{f_A}{f_B} = \frac{v_A}{v_B} = \sqrt{\frac{m_B}{m_A}} = \sqrt{\frac{A_B}{A_A}} = \frac{d_B}{d_A}$

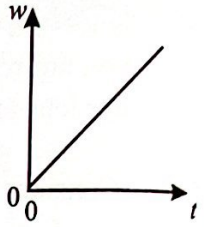
07. In order to double the root mean square speed of an ideal gas, the factor by which the absolute temperature of the gas to be increased is

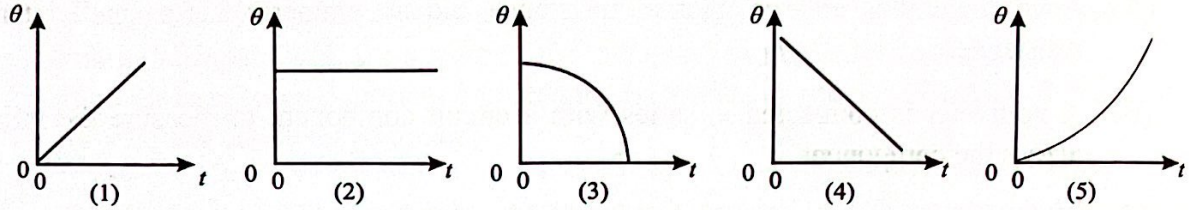
(1) $\sqrt{2}$ (2) 2 (3) 4 (4) 8 (5) 16

04 **Expansion of Gases**

It is just a simple question. Many similar questions have been solved. Root mean square speed is proportional to the square root of absolute temperature. So, if you need to double to speed then the absolute temperature must be increased by four times.

08. If the angular velocity (ω) of an object varies with time (t) as shown in the figure, the corresponding variation of angular displacement (θ) with time (t) is best represented by





02 **Rotational Motion**

A constant angular acceleration is indicated by a gradual increment of angular velocity with time. If there is an acceleration, the displacement variation with time cannot be linear. If so, then ω will be constant. If ω is constant, then the angular acceleration should be zero. You can instantly remove (1), (2) and (4) choices. As ω is represented as a positive quantity, the correct graph is (5).

The gradient of the drawn tangent at any place of a displacement-time curve gives the velocity. There is a positive gradient only in (5).

Instead of angular velocity and angular displacement, even there is no harm to the question if you consider as linear velocity and displacement. Remove (1), (2) and (4) quickly and then find the curve with positive gradient.

09. A major artery with a 1.0 cm^2 cross-sectional area carrying blood branches into 18 smaller arteries, each having a cross-sectional area of 0.4 cm^2 and carrying equal volumes of blood per unit time.

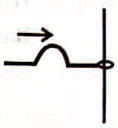
The ratio, $\frac{\text{speed of blood in the major artery}}{\text{speed of blood in the smaller artery}}$ is

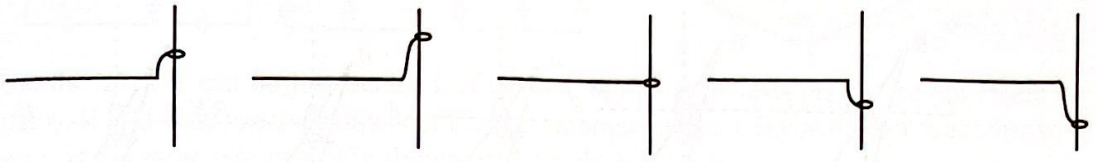
(1) 3.6 (2) 4.0 (3) 7.2 (4) 8.4 (5) 45

02 **Hydrodynamics**

You can solve from your memory. The blood volume needs to be continuous. The blood that is coming from the main artery is divided into 18 networks. $1\ v_1 = 18 \times 0.4\ v_2$; You will get v_1/v_2 as 7.2 quickly.

10. The figure shows a wave pulse traveling along a string towards its end which is connected to a small light ring that can move along a vertical wire. Which of the following figures best represents the shape of the wave pulse at instant when the peak of the pulse reaches the ring?

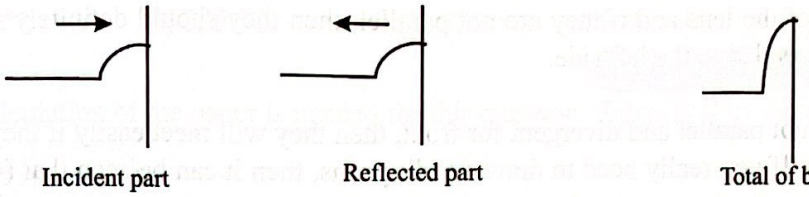




(1) (2) (3) (4) (5)

Wave Properties 03

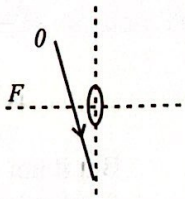
The same question was given for hard reflection in the year 2008 (19th question). So, if that question was studied correctly, will not this be an easy question? There is a smooth reflection here. Then there is no phase change in the reflected pulse. The ring also moves with the pulse. When the maximum of the pulse is reached to the ring, the front half will turn back as it is without being inverted and having a phase change. According to that, half and half will be added. The displacement of the ring will be double as the maximum but the width of the total pulse is half of the pulse.

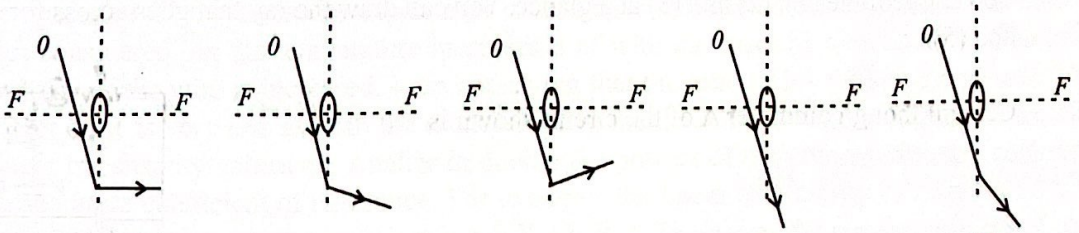


Incident part Reflected part Total of both

Therefore, the correct shape is (2).

11. A point object 0 is placed in front of a thin convex lens as shown in the figure. The refracted path of the incident ray shown is best represented by



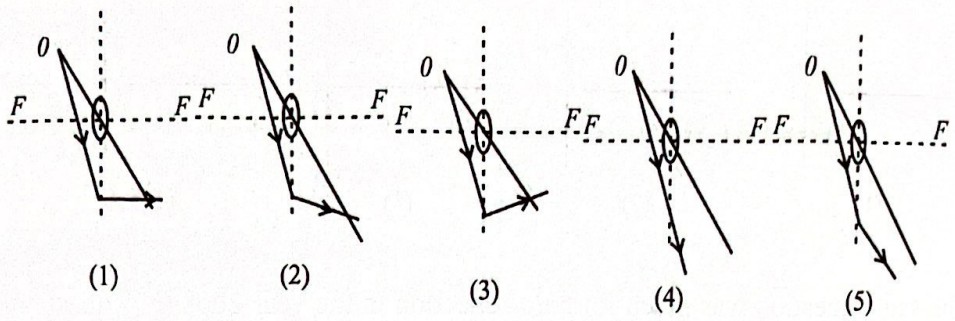


(1) (2) (3) (4) (5)

Refraction through lenses 03

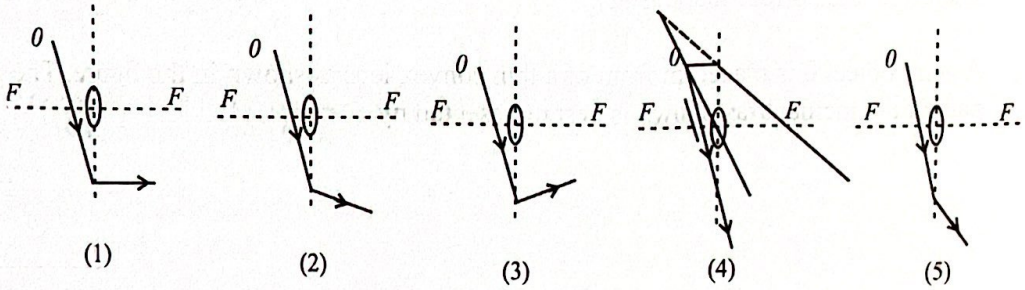
You can find the correct refracted path very easily without much drawing. The object is placed in between the focal point and the optic centre. Therefore, the image should be generated on the same side of the object, in front and to the left of it. So, the ray that starts from the point O

which goes across the optic centre and any refracted ray cannot meet on the right side of the lens. According to that, (1), (2) and (3) are just removed. I have drawn the rays that go across the optic centre for explanation. Look at the following figure.



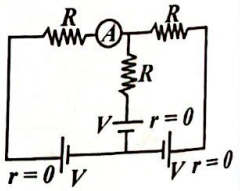
Actually, there is no need to draw. Even for (1), (2) and (3), there is no need to draw definitely. A person with eyes can see that the rays are cutting on the right side of the lens. It is ok to draw and see (4) and (5). When the rays are extended at (5), it can be seen that they are meeting on the right side of the lens. Only the rays at (4) do not get cut (divergent) on the right side of the lens. If the refracted ray and the ray that goes across the optic centre are not meeting on the right side of the lens and if they are not parallel, then they should definitely meet when the rays are extended to the left side.

If two are not parallel and divergent for front, then they will meet easily if they are extended backwards. If you really need to draw ray diagrams, then it can be seen that (4) is proven to be correct.



But it not necessary to draw the incident ray parallel to the main axis which goes across the focal point. According to the mentioned logic, you can get the answer without much trouble. You can remove (1), (2) and (3) at a glance. You can draw the ray that goes across for only (4) and (5).

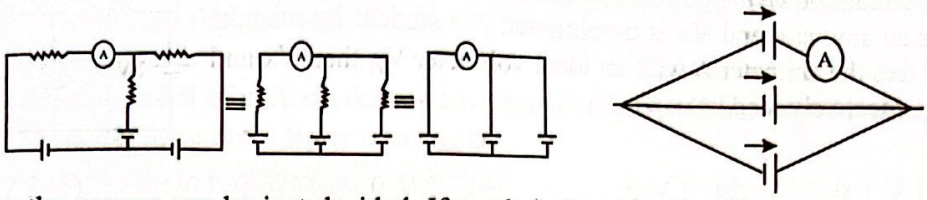
12. Current though ammeter A of the circuit shown is



(1) 0 (2) $\frac{V}{3R}$ (3) $\frac{3V}{2R}$ (4) $\frac{V}{R}$ (5) $\frac{3V}{R}$

103 **Kirchhoff's Law Combinations of cells**

You do not have to think far for this question. The given circuit can be considered according to the way that is shown below. There is no problem in it.



Now the answer can be just decided. If needed, the given R resistors can be put inside the battery. If you want, you can consider them as internal resistors. If you think it in another way, then it is the same circuit that is shown on the right-hand side.

It is clear that the current across the ammeter needs to be zero. When going around V and V get cancelled off. There is no need for calculation. Even the resistors R are included, there is no change in the argument. When it is going in a closed circuit, the algebraic sum of the e. m. f is zero.

13. A coil made of a platinum wire has a resistance of 50 Ω at 0 °C. When immersed in melting lead, the resistance of the coil increases to 115 Ω. If the temperature coefficient of resistivity of platinum is 4.0 X 10^{-3} $°C^{-1}$, the melting point of lead is

(1) 225 °C (2) 325 °C (3) 475 °C (4) 575 °C (5) 598 °C

First calculation of the paper is needed for this question. Simplify it by direct substitution.

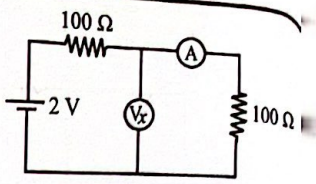
$$115 = 50\,(1 + 4 \times 10^{-3}\theta);\ \theta = \frac{65}{50\times4} \times 10^3 = \frac{65}{200} \times 10^3 = 325^0C$$

In this problem, some questioned whether there is a mistake as it has given the temperature coefficient of resistivity. There is no problem. In books also, normally α value is given for resistivity. That means thecoefficient of temperature of the given wire's resistance for a unit length and unit cross-sectional area (that is resistivity). It is more practical to mention like that.

That means, $\rho = \rho_0\,(1 + \alpha\theta)$ but $R = \rho l/A = \rho_0 l/A\,(1 + \alpha\theta)$. So, $R = R_0\,(1 + \alpha\theta)$

There is no change if you write α in R or ρ. It is true that l and A can be changed due to temperature. But even in the experiment of finding α, change of dimensions in the wire is not considered. As the temperature increases, l of wire increases as well as its A. The total volume of the wire is increased. I am not saying that the ratio of l/A will be a constant. The effect on R is very less as both the numerator and the denominator are increased. Normally linear expansivity values are smaller in double the powers of ten compared to the values of temperature coefficient of resistance. For example, the linear expansivity of copper is 1.7 X 10^{-5} $^0C^{-1}$. The temperature coefficient is 4.0 X 10^{-3} $^0C^{-1}$. Therefore, the temperature effect on l and A is 100 times less than the effect of temperature on the temperature coefficient. So, the difference between the temperature coefficient of resistivity and the temperature coefficient of resistance is very less.

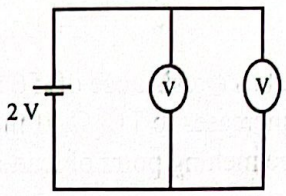
14. The circuit shown in figure is constructed using ideal components. A is an ammeter and Vx is a voltmeter. If a student by mistake replaces the ammeter A with an ideal voltmeter Vy, then Vx and Vy respectively read



(1) 1 V, 1 V (2) 1 V, 0 (3) 2 V, 0 (4) 0, 1 V (5) 2 V, 2 V

08 Moving coil Meters

There is no need for calculation. You can get the answer by simple logic. As the components are ideal, the voltmeters have infinite (large) internal resistances. There is no use from 100 Ω for such a voltmeter. They are like peanuts. Therefore, both voltmeter readings give the e. m. f value of the battery. When a voltmeter is replaced by an ammeter, you can also consider the circuit as below. Both gives 2 V as the reading.



15. In the nuclear reaction,

$$^{7}_{3}Li + ^{A}_{Z}X \rightarrow ^{A+6}_{Z+2}Y + a$$

Particle denoted by a is

(1) a proton (2) an electron (3) a neutron (4) an α particle (5) a positron

11 Radioactivity

You do not need rough work. You can get the answer by looking at the given reaction. In any reaction A (mass number or the number of protons + neutrons) should be conserved. Likewise, Z (atomic number or number of protons, that means charge) should be conserved.

The total A of left side is A+7. So, a of A should be 1 if the right side also needs to be A +7. Likewise, the total of Z of left side is Z+3. So, Z of a should be 1 if the right side also needs to be Z+3. If A=1 and Z=1, then definitely it should be a proton.

16. A small conducting sphere of mass m has a+Q charge. This sphere is hung from an insulating thread of length l in a region where there is an electric field of intensity E in vertically downward direction, (in addition to the gravitational field), and is allowed to oscillate as a simple pendulum. If the period of small oscillations of this simple pendulum is T, Then

(1) $T = 2\pi\sqrt{\frac{l}{g}}$ (2) $T = 2\pi\sqrt{\frac{l}{g+E}}$ (3) $T = 2\pi\sqrt{\frac{l}{g+QE}}$

(4) $T = 2\pi\sqrt{\frac{l}{g-\frac{QE}{m}}}$ (5) $T = 2\pi\sqrt{\frac{l}{g+\frac{QE}{m}}}$

06 Electric Field Intensity and coulomb's Law

It is a known familiar question. You do not have to write any equation. The electric force on the sphere is QE to downwards. The corresponding downward acceleration for that electric force is QE/m. The direction of g is to downwards. Therefore, the net acceleration is (g +

QE/m). The answer is (5). As this is a known past paper question, you should find the answer as soon as you see the question.

17. Two stars, A and B of uniform density have equal radii. Star A having twice the mass of star B is spinning three times faster than star B.

The ratio, $\frac{\text{angular momentum of star A}}{\text{angular momentum of star B}}$ is

(1) 1/6 (2) 2 (3) 3 (4) 6 (5) 18

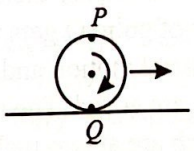
Rotational Motion 02

This also can be solved without any calculation. The angular momentum goes with Iω. I is dependent upon the multiple of mass and the square of distance (radius). You do not have to know the expression for the moment of inertia for an axis around the sphere. But from your sense you know that, it is a certain value of the multiple of mass and the square of radius. However, the given radii are equal in value. Therefore, I should be only proportional to the mass. A has double the mass of B and A is rotating in thrice the speed of B. M is double and ω is triple. Then is not the answer 6? Do not waste the time by writing equations for these.M is double and ω is triple. Radius is the same.

Why it has been given that stars have a uniform density? If not, the moment of inertia will not be obtained in a simple way. The moment of inertia is dependent upon the mass distribution. If the mass distribution of the two stars is different, then the ratio of I in two stars simply is not equal to the ratio of M.

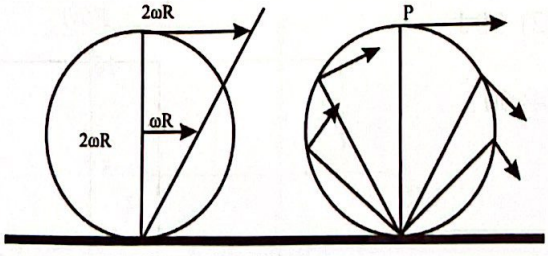
18. A circular disk of radius 0.5 m rolls with a uniform angular speed 12 rad s^{-1} on a horizontal surface without slipping. Two points P and Q are located on the perimeter of the disk. The speeds of the two points relative to the earth when they are at the positions shown in the figure, are

P	Q
(1) 6 m s^{-1}	6 m s^{-1}
(2) 6 m s^{-1}	3 m s^{-1}
(3) 6 m s^{-1}	0
(4) 12 m s^{-1}	6 m s^{-1}
(5) 12 m s^{-1}	0



Rotational Motion 02

This is an instance where you definitely study in rotational motion. This can be solved in two methods. If you consider the rotation of the disk around Q, then we get the following figure.

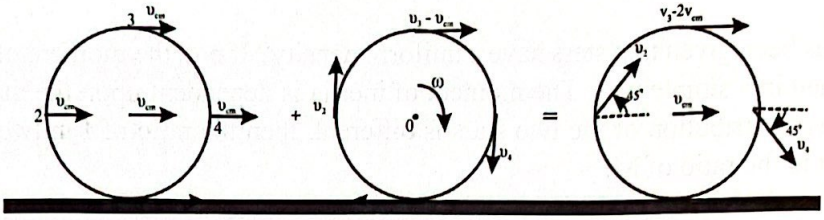


When the point Q is touched on the surface, its speed is zero. The rotation is occurring around Q. Therefore, for a moment that point is at rest. The speed of P relative to point Q is 2 Rω (2 X 0.5 X 12 =12).

The speed of a particular point is increased when it goes far from the rotational axis. The angular velocity is the same. But as the distance from the rotational axis increases, the linear speed is increased. The magnitude and the direction of the other points at the circumference of the disk have been shown in the figure. The direction of velocity of any point should be perpendicular to the distance between that point and the rotational axis. The magnitude of the velocity is the increment of the distance between those two points as ω.

When a wheel is rotated in a moving bicycle, the spokes that are near to the ground can be seen clearly but the spokes that are in the upper part of the wheel which are away from the ground are not seen clearly. This is due to the fact that the speeds of spokes at far away ends are higher compared to the speeds of spokes near to the ground.

Such a rolling without sliding can be studied according to the following figure.



The rotation of the disk around Q can be divided into two parts. They are the translational motion at the centre of mass of the disk and the rotational motion around the centre of mass of the disk. According to the translational motion, each point in the disk is translating in a velocity of vcm (Rω). According to rotational motion around the centre of the mass, the points in the circumference of the disk are rotating in a linear velocity of v_{cm}. If we add up these two motions, then we get the motion that was previously described. How the instant velocity of point Q gets zero is now clearly understood. The vector sum of forward v_{cm} due to translational motion and backward v_{cm} due to rotational motion is zero. At the highest point P, both v_{cm} are added. The net velocity of other points is obtained by the resultant of velocities of v_{cm} which are at two inclined angles.

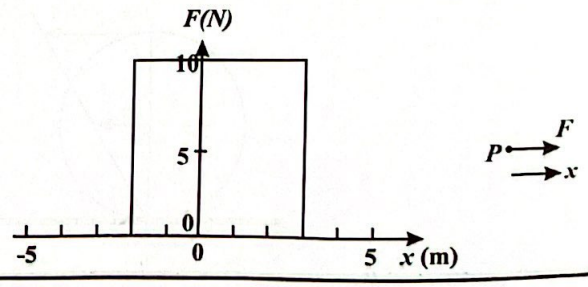
You know that from the general knowledge that the speed of point Q is zero. Then you have to choose either one from the choices (3) or (5). If you forget that the distance from Q to P is twice the radius, then you will pick (3).

19. The graph shows the variation of a force F exerted on an object P when it is moving along the X- axis fromx= -5 to x=5. The work done on the object by the force is

(01) 10 J (2) 30 J

(3) 40 J (4) 50 J

(5) 100 J



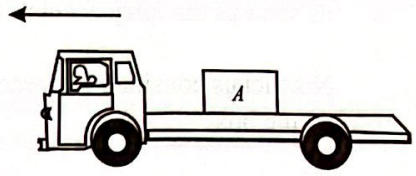
There is no need for any calculation. You can get the answer by the area of the square. The height is 10 and the width is 5. The answer is 50 J. Here the work done from the force is not getting negative even the value of x gets negative from x = - 2 m to x = 0. The force is always acting on the +x direction. Therefore, the work done from the force is always positive. Some values of x have become negative relative to the origin that we have taken. If needed the origin can be shifted to the place where x = -2m. Then there will not be a problem anyway. So, it is wrong to take the work done from the force as (10 X3) – (10 X2). It is (10 X5).

If you are doing without the area, then the work done from the force = F Δx

That means F $(x_f - x_i)$ = 10 X [3 – (-2)] = 10 X 5;

Where x_f = final value of x, x_i = initial value of x.From this also you get 50 J.

20. A box (A) of mass 50 kg is placed on the horizontal floor-bed of a lorry as shown in the figure. The coefficient of static friction between the box and the floor-bed is 0.8 and the lorry accelerates along a straight horizontal road. The maximum acceleration the lorry can have so that the box will not slide over the floor-bed is



(1) 2 m s^{-2} (2) 4 m s^{-2} (3) 8 m s^{-2} (4) 10 m s^{-2} (5) 12 m s^{-2}

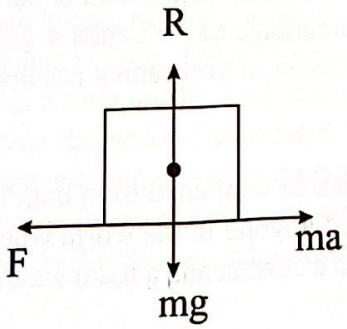
This can be done from the memory. The only horizontal force on the box is the frictional force. What other forces can occur here? The maximum frictional force that can be there is μR. The maximum acceleration that can be associated without sliding is connected with this force.

$$\mu mg = ma \rightarrow a = \mu g$$

The answer is 8 ms^{-2}. The weight of the box is not needed for the question.

Let us take a look at the motion of the box. The lorry is accelerated. If the box is needed to accelerate with the lorry, then there should be a force on the left side on the box. That force can only be obtained by the frictional force. The hood of the lorry is accelerating forward. If the box has to be connected with hood and needed to go to the left, then the box should be pressed to the right and get the frictional force from the hood to the left.

How to mark forces on the box relative to the lorry? The lorry belongs to a frame that accelerates. It is not an inertial frame. Therefore, when marking forces relative to an accelerating frame, we need to consider fictious forces as well as real forces. The forces that are acting on the box relative to the accelerating lorry has been shown below.

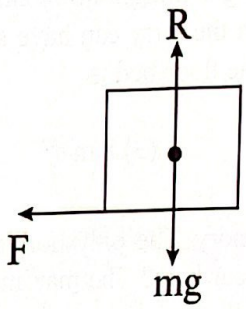


R, mg and F (frictional force) are the real forces we consider. But from the three forces, the motion of the box relative to the lorry cannot be described. We must put 'ma' force on the box. It belongs to the fictitious forces that was mentioned above. (Even centrifugal force belongs to this group.)

Now when the acceleration of the lorry is gradually increasing, force of ma is gradually increased. Accordingly, the frictional force also gets increased. But there is a maximum limit to the frictional force (μR). If ma exceeds that value, then the box definitely will slide towards right. Actually, this is what happens in reality. There is no doubt that you may have seen many such phenomena.

What happens to the box when it is kept on a frictionless surface? The box will throw backwards as soon as the lorry accelerates. There is no F (friction) to go against ma.

Now let us consider the forces acting on the box relative to the earth. Then there is no ma force on the box.



You can describe the motion of the box relative to the earth. If the box is not moving on the hood of the lorry relative to earth, then the box also accelerates with the lorry. Both are connected to each other. As the box is also accelerating to the left side relative to earth, there should be a net force to the left on the box to accelerate like that. It is supplied by the frictional force (F). Next, when the acceleration of the lorry gradually increases, the value of F should be increased if the box also needed to be with the lorry as one. If the multiple of ma is increased, then definitely the value of F is needed to increase.

But there is a maximum limit for the frictional force. Therefore, if the multiple of ma is increased than the maximum F value, the hood of the lorry will say bye and accelerate forward by neglecting the box. The lorry is accelerating forward. But there is no force to the box to accelerate forward with the lorry. What else to do? The lorry will move forward without considering the box. Finally, the hood of the lorry is moving forward whereas the box will fall down from the hood.

Our relationships are also like this. Both will stay together until both accelerate. If one person is going forward at a higher acceleration and the other person cannot join, then you need to get a divorce. Now the divorce percentage of Sri Lanka is getting higher. You better find a person who can accelerate with you! Even, if you cannot accelerate, then is not it enough if you can go with a uniform velocity!

So, what happens to the box can be explained from both frames relative to the lorry as well as to the earth. If you and me and anyone in the world who knows Physics can explain what is happening in the two frames in a correct and a lucid way, then there is no such Physics beyond that.

I am writing this much to give you a correct concept about the fictious/false forces. As I think, these are not suitable to be called as false forces (This is my opinion.). The word false has been used by scientists because such forces are not needed to consider relative to the inertial frame that is applied. But to describe the motion of the box from the frame of accelerating lorry by you and me and god (there is no reason that god does not know Physics), the force of ma should be definitely marked on the box to the right. So even it is thought as a false force, if it is needed to get the things done, is not it a real one? What is 'the truth' in this world? If everybody is accepting the 'lie' as the truth, then does not it belong to the truth? Is not this happening from the media?

On the other hand, what we consider as true forces are really true. Is that so? For example, is the gravitational force that we consider real force? What do we call as a real force? Newton saw how the apples fall and introduced gravitational force concept to explain the phenomena. From this gravitational force, we can explain the related things. After some time, Einstein explained the gravitational force not the way as Newton saw. He explained it from the curvature of space-time.

Is gravitational force a real force? I do not like to get this question for me. What is the truth? If everyone in this world can explain the gravitational force and related phenomena in a correct way, then what is the use of it even it is actually not there!

If a space colony is rotated in a specific angular speed, the inhabitants can be given a feeling that they are living on Earth by giving a gravitational field. What we experience as the truth is unreal acting. Is not it? I will stop by leaving you to think about something.

21. When a standing wave is setup on a string fixed at both ends,

(1) the number of nodes is equal to the number of antinodes.

(2) the wavelength of the wave is always equal to the value obtained when the length of the string is divided by an integer.

(3) the frequency of the wave is equal to the value of the number of nodes times the fundamental frequency.

(4) the frequency of the wave is equal to the value of the number of antinodes times the fundamental frequency.

(5) the shape of the string at the fundamental frequency is not symmetric about the mid-point of the string.

There is little bit of theory. Many children have mentioned that the questions are hard after question number 20. They might have said like that because till 20th question you can do the questions easily. If you can do first 20 questions in 15 minutes, then you are a clever person. Out of 20 questions rough work is only needed for the 13th question. When you read it, you will get to know that the first sentence is false. There are two nodes in the fundamental frequency with only one anti-node. If it is wrong for the fundamental frequency, then do not think about the rest of the overtones. Even the second statement is clearly wrong by considering the fundamental frequency. The wavelength of the fundamental frequency is double the length of the string. If it is not fitting for the fundamental frequency do not just think of other instances. As there is the word of 'always' in the choices, why do you consider about others if it is wrong for one?

If f_0 is the fundamental frequency of a string that both ends are fixed, then the frequency of the first overtone is $2f_0$. You can draw the wave pattern in your mind. The frequency of the second overtone is thrice as the fundamental frequency. You need to draw the number of loops that the string makes in your mind. There is one loop in the fundamental frequency. There are two loops in the first overtone. There are three loops in the second overtone. The number of loops is equal to the number of anti-nodes. If there is one loop, then there is one anti-node. If there are two loops, then there are two anti-nodes. Therefore, the correct statement is (4).

Even if you think in a simple way, you should directly realize that only (3) and (4) are correct. (1) can be just seen as wrong. If you think of the fundamental frequency of (2), you will understand that it is wrong. Again (4) can be just seen as wrong. The shape of the string in the fundamental frequency is symmetric around the mid-point. Then what is left is (3) and (4). You need to think a bit for (3) and (4). Even without argument you can see that if (3) is correct, then (4) cannot be correct and vice versa.

Do not waste time by drawing each wave pattern on the rough work sheet. Cannot you see the simple patterns from your mind?

22. If the ratio of sound intensities and the corresponding difference in sound intensity levels (in dB) of two sound sources are numerically equal, then the ratio of sound intensities is

(1) 10 (2) 20 (3) 100 (4) 200 (5) 1000

03 Intensity of Sound

It is very difficult to solve using a mathematical equation. You know the relation between the difference of sound intensity levels and the corresponding ratio of sound intensity very well. Each year, there is a question out of this area. $\beta_1-\beta_2 = 10 \log (I_2/I_1)$

You should not write separate expressions for β_1 and β_2. Now this should be a familiar relation to you. According to the question, $\beta_1-\beta_2$ should be numerically equal to I_2/I_1. If we take that common value as x, then it should be $x = 10 \log x$. It is a difficult to solve directly. If you tempted to solve, then you will waste your time.

If you find a hard MCQ or if you feel that it is time consuming to solve and get the answer, then always stop the process there and look another side. Here the shortest method is by checking the answers and check whether you get what you want from each of them. According to that, if you consider the first answer of 10, then the answer is in your hand. You do not need to write equations for this. If we take I_2/I_1 as 10, then $\log 10 = 1$. Then the relevant change of decibels is 10. No need to do extra calculations. Examiners might have put the answer to (1) to make the question easy for you. The given requirement of the question is not fitting for any other ratio of intensity. $\Delta\beta$ gets 10 only when $I_2/I_1 = 10$.

This question may be hard for some children. Even if you feel it is hard, do not you think and try to use answers and come out of the question as there are numerical values in the answers? If you think to do it, then from the first try you will get successful results. Even answers such as 20 and 200 can be directly removed. To find log of them you need calculators or logarithmic tables. So, powers of ten is only matching for a question like this. If you think like this, the answer should only be the first power of 10. 10^2 gives 20 dB. 10^3 gives 30 dB.

23. A telescope having a magnifying power of 15 has an eyepiece of power 50 diopters. The length of the telescope, when it is in the normal adjustment is

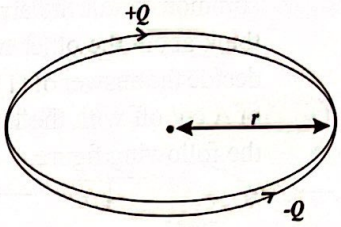
(1) 15 cm (2) 28 cm (3) 30 cm (4) 32 cm (5) 64 cm

Optical Instruments 03

This is a very familiar question to you. It can be seen in many past papers. The length of a telescope in normal adjustment is $f_o + f_e$. This fact you know by heart. The only difference in this question is that, the values of foand fe are not given separately. The power has been given instead of the focal length of the eyepiece. As the power is 50 D, then you should be able to get the corresponding focal length from your memory and save your valuable time. If the power is 50 D, then the focal length of the eyepiece is 1/50 m. To get this in cm, you need to multiply by 100. Then you will get 2 cm. Next, the magnification power is obtained by f_o / f_e. If fe is 2 cm, then foshould be 30 cm. Finally $(f_o + f_e)$ is 32 cm. Actually, all these can be done in your computer of brain. Children who have not mastered MCQ without determination and confidence do such questions in papers.

The multiplication of 100 by 1/50 is 2. 2X 15 is 30. 30 and 2 is 32. If you go on this process across the brain, then you can get the answer.

24. Two particles having charges +Q and -Q revolve in opposite directions with the same angular frequency ω along two circular paths of radius r, which are very close to each other has shown in the figure. Magnetics flux density at the Centre of the circular paths is



(1) zero (2) $\frac{\mu_o Q\omega}{4\pi r}$ (3) $\frac{\mu_o Q\omega}{2\pi r}$

(4) $\frac{\mu_o Q\omega}{2\pi^2 r}$ (5) $\frac{\mu_o Q\omega}{4r}$

Magnetic effect of Electric current 07

Many teachers told me that numerous questions were arisen about the angular frequency, ω of this question. Instead of ω, f should have been given if it was known that such a problem would come up. The number of revolutions/ oscillations per second is given by f. By ω, it converts to the amount of radian per second. $\omega = 2\pi f$

Even -Q charge is revolving to the opposite direction, the standard current flows to the other side. That means the rotation -Q charge to anti-clockwise direction is equivalent to the rotation of +Q charge rotation to the clockwise direction. Therefore, the given instance is equal to a rotation of current i to the same direction.

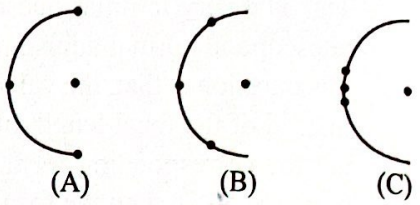
$$B = \frac{\mu_o 2i}{2r} = \frac{\mu_o Qf}{r} = \frac{\mu_o Q\omega}{2\pi r}$$

The correct answer is (3). The same situation is there in the particle accelerators of colliding beams. The particles and anti-particles are closely revolving in opposite directions in a very highly drawn tube.If the required conditions are satisfied, then at a particular location these rays are allowed to collide face to face by applying an electric field.

Some said that, there is no answer due to the confusion of ω. Because they have interpreted ω as f. The symbol ω is being used to angular velocity as well as angular frequency. Both are same. Especially when a particle is vibrating or when we write the displacement of a

wave by a relation of y=A sin ωt, ω is called as the angular frequency. According to that ω = 2πf is a very common relation. If ω is considered as linear frequency f, then you will get the answer without 1/2π. In such an occasion, do not think that there is a problem in the question and consider joining ω or 1/2π (ω = 2πf) into it.If there is a problem in the question, then everybody gets the related mark eventually.

25. Figure shown three arrangements (A, B and C) of four identical particles with three of them placed on a semi circle and the fourth placed at the Centre of the semi circle. If the respective magnitudes of the net gravitational force on the particle at the Centre due to the other three particles are represented by F_A, F_B and F_C then,

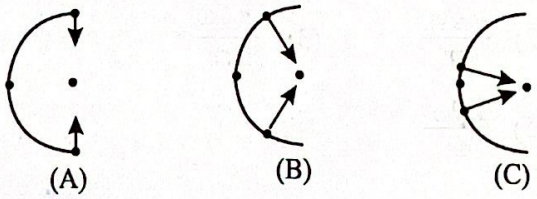


(1) $F_C > F_B > F_A$ (2) $F_B < F_C < F_A$ (3) $F_C < F_B < F_A$

(4) $F_C = F_B = F_A$ (5) $F_C = F_B > F_A$

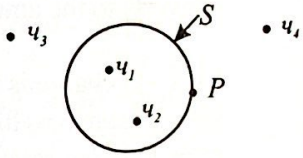
05 Grovitational force fields

It is a very easy question. The particle in the middle of the circumference of the half circle is common for all the arrangements. Therefore, you do not have to think about it. You need to think about the other two particles in the circumference. If you think like that, then you can decide the answer of (1) as $F_C > F_B > F_A$ is correct directly. The two particles in the circumference of A cut off with the forces of the particle at the centrewith each other(cancellation). Look at the following figure.



At (B), even though the vertical components of the forces are cancelled off, the horizontal components are added together.At (C),the vertical components of the forces are cancelled off again. But as the particles are located closer to each other, the strength of total horizontal components is higher.

26. Figure shows four point charges and a Gaussian surface S.



Consider the following statements.

(A) Net electric flux through the surface depends only on the fields produced by q_1 and q_2.

(B) The electric field intensity at point P depends only on the fields produced by q_1 and q_2.

(C) The electric field intensity at point P depends on the locations of the charges q_1, q_2, q_3 and q_4.

Of the above statements only

(1) (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.

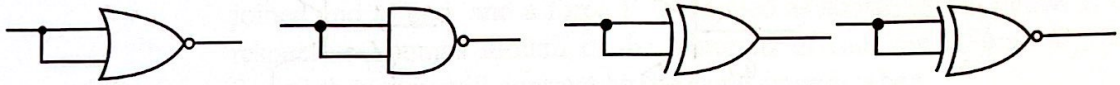
Gauss theorem 06

These are normal known theories. As you read, you get that (A) is correct. The net electric flux across a Gaussian surface is dependent upon the magnitude of the charges inside that surface. The flux from the charges that are outside enter to the surface and exit from the other side. Therefore, the net flux across the surface from them is zero.

But do not get confused with the field intensity of a point. If the point P is on the Gaussian surface, then the electric field intensity of that point is dependent upon everyone. Gaussian surface is a surface that we designed. It is ok to consider that there are no such surfacesfor statements of (B) and (C). If you think like that, then there is no doubt that you will decide that (B) is incorrect whereas (C) is correct.

There are four charges. Does the electric field strength of a point P in space dependent on the magnitude of the charges and their location (distance from point P)?

27. Which of the arrangements shown is/are equivalent to a NOT gate?



(P) (Q) (R) (S)

(1) P only

(2) Q only

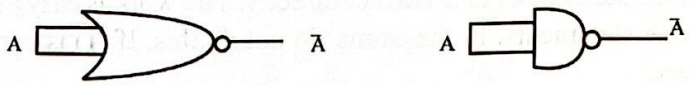
(3) P and Q only

(4) P,Q and S only

(5) all P,Q,R and S

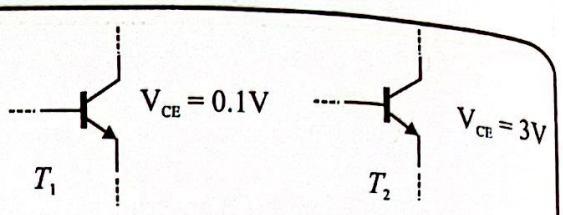
Logic Gates 09

It can be solved using Boolean expressions or logic levels (0 and 1). P is a NOR gate. Q is a NAND gate. As the inputs of these two are connected to each other, you will get a NOT gate from both of them.



Or else, if we argue from logic levels, then in (P), 0, 0 is 1 and 1, 1 is 0. (Q) is also similar to that. (R) is a XOR gate. In that, 0, 0 is 0 and 1, 1 is 0. It is not working as a NOT gate as we get 0 for 0, 0 even it is right for 1, 1. If (R) is not working then there is nothing to see in (S). Therefore, only P and Q are correct. It is easy for me to work with logic levels. As the two inputs are connected, all you have to do is check whether 1 comes for 0 and 0 comes for 1. In addition, NAND and NOR gates are commonly used in logic circuit construction because they can be used to construct NOT gates. It cannot be done from AND and OR gates.

28. Figure shows two silicon transistors T_1 and T_2 located in a circuit, which operate properly. If V_{CE} values of the transistors T_1 and T_2 are 0.1 V and 3 V respectively, which of the following is true?



(1) V_{BC} of T_1 is approximately 0.6 V, and the BC junction is forward biased.

(2) V_{BC} of T_2 is approximately 0.6 V, and the BC junction is forward biased.

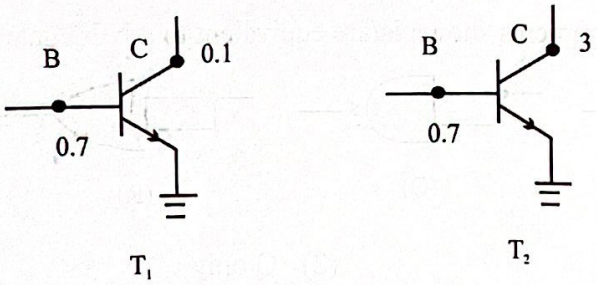
(3) V_{BC} of T_1 is approximately 0.6 V, and the BC junction is reverse biased.

(4) V_{BC} of T_2 is approximately 2.3 V, and the BC junction is forward biased.

(5) V_{BC} of T_1 is approximately 3 V, and the BC junction is reverse biased.

09 **Transistors**

This is a question that faced little bit of controversy. Many think that BC junction of a transistor should always be on reverse biased mode. This is an incorrect conclusion. At a glance we can see that T_1 is at the saturated region whereas T_2 is at the active region. We can mark the voltages of B and C in T_1 and T_2 states very easily as shown below. For our convenience we will earth E.



T_1 T_2

We know that as it is a Silicon transistor, $V_{BE}(V_B) = 0.7$ V. Now the answer can be just seen.

For T_1 $V_{BC} \approx 0.6$ V (0.7-0.1) For T_2 $V_{BC} \approx -2.3$ V (0.7-3)

($V_B > V_C$) ($V_C > V_B$)

You can see that the statement (1) is correct directly. The work is easy as (1) is correct. But let us look at the other statements. In the exam, do not do this. If (1) is correct, then why should you look at others?

(2) is wrong. $V_{BC} \approx -2.3$ V

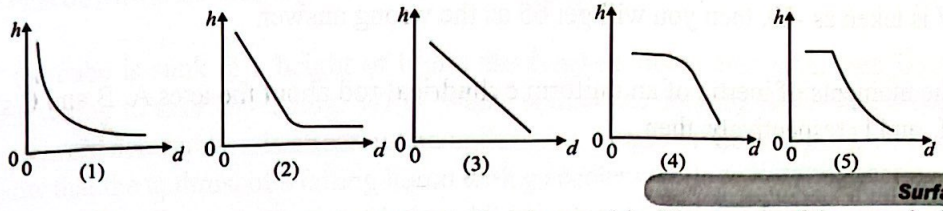
(3) is wrong. V_{BC} is correct but BC junction is forward biased. Even if (1) is correct, then (3) is automatically wrong.

(4) is very wrong. (5) is very wrong.

Commonly, the voltages of B, C and E of a npn transistor at different states are shown below.

State	Voltage	B-E junction	B-C junction
Active	$V_E < V_B < V_C$	Forward biased	Reverse biased
Saturated	$V_E < V_B > V_C$	Forward biased	Forward biased
Cut-off	$V_E > V_B < V_C$	Reverse biased	Reverse biased

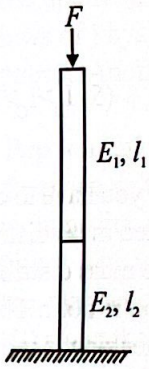
29. When a glass capillary tube of internal diameter d is immersed vertically in water, the water level inside the tube rises to a height of h. The variation of h with d is best represented by



Surface Tension 10

This is totally from past papers.h∝1/d. You just know this. The graph of d versus h should be a curve (like P-V curve). It cannot be a linear one. When d is reduced h is quickly increasing. The shape of (1) is correct.

30. Two light rods of initial l_1 and l_2, having equal areas of cross-section are joined and to end, and a force F is applied as shown in the figure. If the respective Young's moduli of the materials of rods are E_1 and E_2, (see figure) then they will contract by the same amount when



(1) $E_2 l_1 = E_1 l_2$ (2) $E_2 l_2 = E_1 l_1$

(3) $E_1^2 l_2 = E_2^2 l_1$ (4) $E_1 l_2^2 = E_2 l_1^2$

(5) $E_1^2 l_1 = E_2^2 l_2$

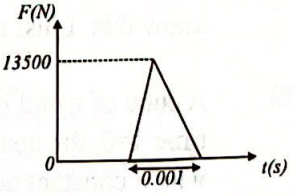
Elasticity 10

It is very easy. The force on the two rods is same. As the rods are light, there is no extra force from the upper rod to the lower rod. F is same. A is same. Therefore, contraction (Δl) is proportional to

$$\Delta l \propto \frac{l_1}{E_1} \propto \frac{l_2}{E_2} \quad \left[E = \frac{Fl}{A\Delta l}\right]$$

As Δl should be same, $\frac{l_1}{E_1} = \frac{l_2}{E_2}$ Answer of (1) is glittering.

31. A cricket bass of mass 0.15 kg travels with a speed of 20 m s^{-1} just before batted by a batsman. When he batted, the variation of the force(F)exerted by the bat on the ball with time (t) is shown in the graph. If the ball bounces back in the opposite direction the speed of the cricket ball just after batting is



(1) 20 m s^{-1} (2) 25 m s^{-1} (3) 65 m s^{-1} 4) 70 m s^{-1} (5) 110 m s^{-1}

Newton's Law and Momentum 02

It is a known logic. There are many questions in the past papers. You need to find the area of F-t curve. $F = m(v-u)/t$

The area of the triangular section = ½ X 0.001 X 13500. Do not try to simplify at this time.

½ X 0.001 X 13500 = 0.15 [V-(-20)] { →u change of momentum m[V-(-u)] ←V}

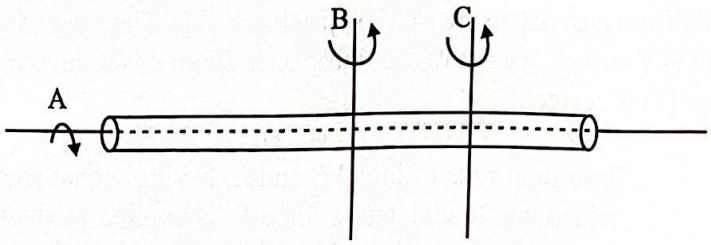
Actually, you need to write the following expression in your rough work.

½ X 10^{-3} X 13500 = 0.15 (V+20); 135 is divided by 15 as 9.

V + 20 =45; V =25

If V is taken as -20, then you will get 65 as the wrong answer.

32. If the moments of inertia of an uniform cylindrical rod about the axes A, B and C shown are I_A, I_B and I_C respectively, then



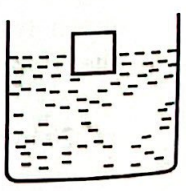
(1) $I_A > I_B > I_C$ (2) $I_A < I_B < I_C$ (3) $I_B = I_C > I_A$ (4) $I_A = I_B = I_C$ (5) $I_B > I_C > I_A$

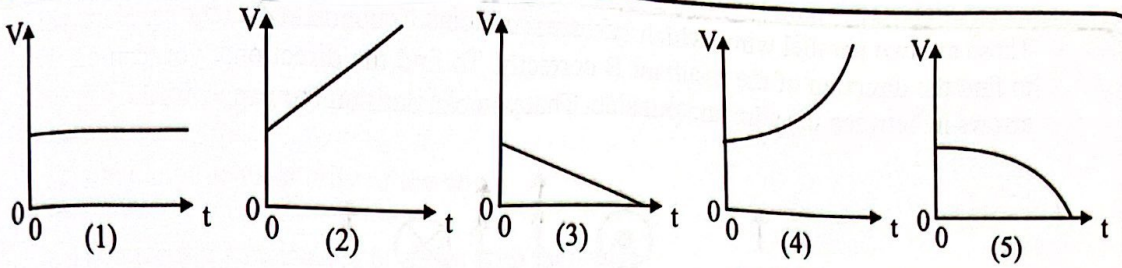
These are just simple logic questions. There is no need of an equation. All you have to consider is the mass distribution on related axis. Across A there is no such expanded mass distribution. Then I_A should be a minimum. The mass distribution of B is equal but the mass distribution of C is biased for one side. Recall that moment of inertia is dependent upon r^2 not r. Therefore, moment of inertia will not be cancelled off if one side is less and the other side is more.

The correct answer is (2). If you consider the axis of B and C, then the minimum moment of inertia is there across an axis of B which goes across the centre of mass. The moment of inertia is greater when it is moving away and away from the centre of mass. A uniform rod is difficult to rotate from one end instead from the middle. If you know the moment of inertia across the centre of mass, then there is a theorem to get the moment of inertia of any parallel axis. It is known as parallel axis theorem. For example, it can be written as $I_C = I_B + ml^2$.

The mass of the rod is m and l is the distance between C axis and B axis. You do not have to know this. I just mentioned.

33. A cube of wood is floating in a beaker of water as shown in the figure. At time t=0, the beaker begins to move in the downward direction from rest with a constant acceleration. The variation of the volume V of the portion of the cube that is immersed in water, with time t is best represented by



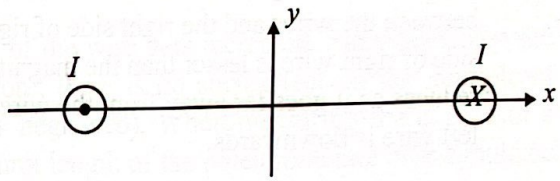


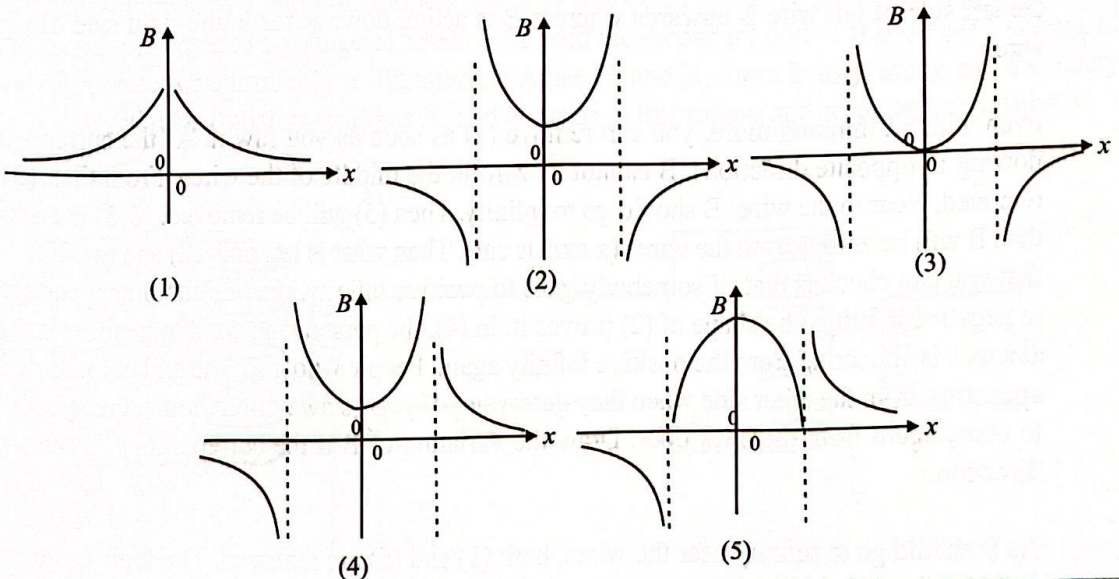
This is there in a past paper. The 50th question of year 2000 is same as this question. The only difference is, what is asked in words on that paper has been represented in a graph by this question. The change in apparent weight is affecting equally to the weight of the cube as well as the weight of the displaced water volume. If the upthrust on the cube is U and if we apply F =ma downwards, then mg - U = ma. U = m (g-a)

If the cube is sunk to a height of h and the cross-sectional area is A, then U = Ahd (g-a). It is wrong to take U = Ahdg. Why? Water is also accelerating downwards. Therefore, the downward acceleration is affecting the upthrust or weight of the displaced water volume. We know that the upthrust of a falling liquid with g acceleration is zero. If so, when a=g, U should be zero. Now if we substitute to U, then Ahd (g-a) = m (g-a). h= m/Ad

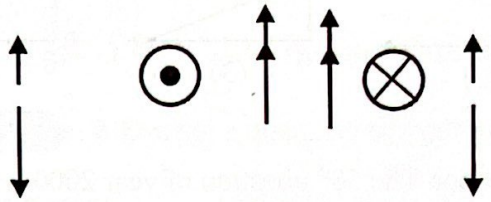
Even though it has been explained in this manner, you do not have work hard like this. As it is a previously seen question, this should be your logic. The acceleration is affecting the weight of the cube. Likewise, it is affecting equally to the weight of the displaced volume or the upthrust.There is no reason against this issue. One is not favourable than the other. The laws of Physics are equal to all. But laws of humans are not same for everyone. One rule for patriot. Another rule for traitor.

34. Two long parallel wires placed normal to the plane of the paper carry equal currents in opposite directions as shown in the figure. The variation of the component of the magnetic flux density in y direction (B) along the x axis is best represented by





These are two parallel wires which has equal currents to opposite directions. Here you need to find the direction of the resultant B correctly. To find the directions, you can easily draw arrows in between the wire and out side. That you can do it on the paper itself.



Two arrows are drawn separately for the two wires. The resultant B in between the wires is towards the same direction (upwards). The resultant B outside the wire is downwards (on both sides). From these facts you can understand that the correct graph is (2).

Near to the wires B should go towards infinity (as $r \rightarrow 0$). So, (1) is just removed. Even at a glance, you can decide from the normal intelligence that (1) is not correct. Only (2) and (3) in the left side of the left wire and the right side of the right wirehave drawn B to the same direction. In (4) and (5),in the outside of the wires the direction of B has changed. As B is added in between the wires, B cannot be zero in the middle of the wires. So, (3) cannot be correct. Finally, what is left is only (2).

I am using the right palm to decide the directions of B. Keep the thumb perpendicular to the other fingers and direct the thumb towards the direction of the current. Then the direction of B is given from the direction of the fingertips of the other fingers.

The dot means that the current is flowing outside the paper. When the thumb is directed outside the paper, the fingers rotate on the anti-clockwise direction. That means the direction of B in between the wires and the right side of right wire is upwards. The magnitude of B on theright side of right wire is lesser than the magnitude of B in between the wires. The magnitude of B reduces as it goes far away from the wire. Likewise, the direction of B on the left side of the left wire is downwards.

If you need to show the current into the paper, then the thumb should be towards the paper. The fingers rotate in clockwise direction. So, the direction of B in between the wires and the left side of left wire is upwards whereas B is acting downwards in the right side of right wire.

Even without thinking more, you can remove (1) as soon as you saw it. As the currents are flowing in opposite directions, B cannot be zero in the middle of the wires. From that, (3) is removed. Near to the wires B should go to infinity. Then (5) will be removed. If (5) is correct, then B will be zero near to the wires (x axis is cut). Then what is left only (2) and (4). The fact that you can check is that, if somebody goes to positive infinity, then he should appear again in negative infinity. The shape of (2) proves it. In (4), the person who went to positive infinity at x axis is appearing from the positive infinity again. People who go to the end of one side are appearing from the other side when they get wrong. If you go away from home, then you have to come again from the back door. Draw the variation of B if the currents flow to the same direction.

As B should go to infinity near the wires, both (1) and (5) are removed. The logic of positive and negative infinity, (4) is removed. As B cannot be zero in the middle, (3) is removed.

35. Sensitivity of a potentiometer can be increased by

(1) increasing the e.m.f. of the cell connected across the wire

(2) reducing the resistivity of the wire

(3) connecting a resistance in series with then wire

(4) reducing the diameter of the wire

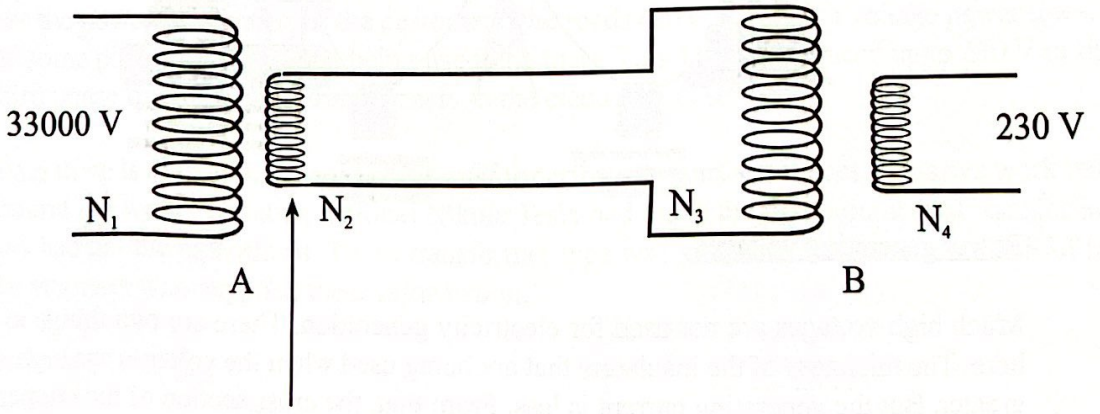
(5) maintaining the temperature of the wire at room temperature.

This is a very old question. This question has been asked from the time of MCQ introduction. To increase the sensitivity of the potentiometer, the voltage drop per unit length of the wire should be reduced. Then the balanced lengths are not closer to each other when balancing the corresponding very close potentials. There will be a considerable amount of change in length. If we react to a very small change, then we are sensitive.

By increasing the e. m. f of the cell, the voltage drop per unit length wil not be reduced. It get increased. When a resistor is connected in series with the wire, there will be voltage drop across the resistor also. So, the voltage drop across the wire gets reduced than before. Even the resistivity or the diameter of the wire is changed, the e. m. f of the cell is dropped across the same wire. Therefore, it does not affect the voltage drop per unit length of the wire (even the internal resistance of the cell is neglected). Part of the e. m. f of the cell should be given to another to reduce the voltage drop acorss the wire. That work is done by the resistance in series. Sensitive people like to share most of the time.

If the resistivity is reduced, then the current of the wire gets increased. Simultaneously, the resistane per unit length is reduced. Therefore, there is no such effect on the multiple of iR(even the internal resistance of the cell is neglected). When measuring the e. m. f of a thermo-electric couple, the voltage drop per unit length of the potentiomenter wire should be greatly reduced. It is done by connecting resistors in series with the wire.

36. The figure shows two transformers A and B connected to power lines. The primar y coil of A is connected to a voltage of 33000 V ac and the secondary coil of B provides a voltage of 230 V ac for domestic use. Transformer A has N_1 and N_2 turns in its primary and secondary respectively. Transformer B has N_3 and N_4 turns in its primary and secondary respectively.



If the power losses in the system are neglected, which of the following is true?

(1) $\frac{N_1}{N_4}=\frac{33000}{230}$ (2) $\frac{N_4}{N_2}=\frac{33000}{230}$ (3) $\frac{N_1N_3}{N_2N_4}=\frac{33000}{230}$

(4) $\frac{N_2N_4}{N_1N_3}=\frac{33000}{230}$ (5) $\frac{N_1N_4}{N_2N_3}=\frac{33000}{230}$

The relation of the ratio for the turns with related voltages of an ideal transformer should be written twice.

$N_1/N_2 = 33000/V$; $N_3/N_4 = V/230$

The easiest way to remove V is by only multiplying the two equations with each other. If you write the above two relations in your rough sheet, then try to multiply them from your heart. You will get the relation of (3). Try to avoid writing that in the rough paper. Why do you have to waste even a smaller time like that? Here what is drawn are the symbols of transformers. Therefore, no need to draw exactly with the number of turns to be seen. While giving high power 33,000 V to homes with 230 V, there are two types of transformers in practical usage.

Transformer usage for electricity consumption in Sri Lanka

Very expensive transformers are highly used in power transmission and distribution process. In any country, the electricity system is three folded.

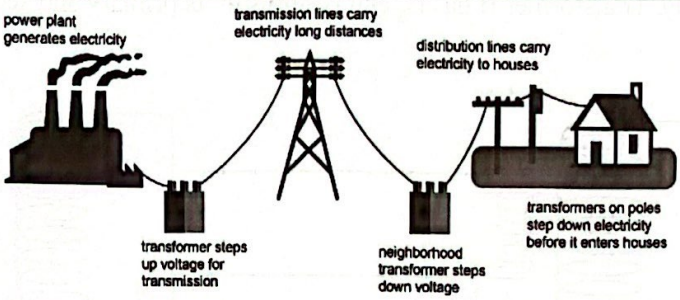
1) power generation

2) power transmission

3) power distribution

High voltages are used to do power transmission of distant cities. From that the power can be transmitted using lesser currents. It reduces the energy loss and gradient of power lines. Even though it is theoretically seen that it is better to use high voltages, suitable voltages are chosen by considering the economic feasibility according to the distance, power transmission.

Electricity generation, transmission, and distribution



Power generating voltages

Much high voltages are not used for electricity generation. There are two things to consider here. The thickness of the insulators that are being used when the voltages are high should be greater. But the generating current is less. From that, the cross section of the copper wires in

the coils can be reduced. When the generated voltage is less, the current is greater. The cross section of copper wires is higher. But the thickness of the insulators is less. According to the power of the machine, the other factors and considering the economic benefits, the machine manufacturer uniquely decides the generating voltage.

In the usage of high voltages, the people who are working in generating stations can be unsafe (if there is a weakness in the insulation). The other fact is that, there can be sparks inside the machines from high voltages.

Few generating voltages that are being used in Sri Lanka

11 kV by Wimalasurendra, Old Lakshapana, Kelanitissa gas turbines, Kerawalapitiya

12.5 kV by Polpitiya, Kaniyon, New Lakshapana, Victoria, Randenigala, Rantembe

13.8 kV by Kotmale

15 kV by Kelanitissa

10.5 kV by SamanalaWewa

20 kV by Norochcholai coal power plant

Transmission

You know that high voltages are being used. After the generator, the voltage is increased by using step-up transformers. There are two transmitting voltages in Sri Lanka. It is either 220 kV or 132 kV. The generating electricity is increased up to 220 kV in Kotmale, Victoria, Randenigala, Rantambe in Mahaweli zone as well as Keralwalapitiya and Norochcholai. It is increased up to 132 kV in other power plants.

Distribution

When the generated voltage is increased up to 220 kV or 132 kV, the power transmission is done by the grid sub-stations at the cities. These voltages should be kept far away from the people. In the first phase, the grid sub-station is reducing the voltage up to 33 kV by using step-down transformers. Some customers are taking the electricity of 33 kV. They are bigger factories. 33 kV power lines are then going to primary sub-stations. In the second phase, it is reduced up to 11 kVby using step-down transformers.

For the power distribution of the customers, the roads carry 11 kV high voltage power lines. (At some places, 33 kV is also being used like that). This 11 kV is reduced up to 230 V in the third phase by using small transformers to the electricity customers.

Even there is a small thing inside the transformerfrom the surface, it does a massive work load around the world. Croatian national Nikola Tesla had made the first commercial transformer and had got the patentfor it. Those transformer type was known as Concar. I am thankful for the engineer who supplied these information.

37. A fish in a lake releases an air bubble of volume 2.5 x $10^{-7}m^3$. This bubble subsequently releases a volume of 10^{-6} m^3 air into the atmosphere. If the atmosphere pressure is 10^5pa and the density of water is 10^3 kg m^{-3}, depth of the position of the fish is, (neglect the effects of surface tension)

(1) 30 m (2) 40 m (3) 50 m (4) 60 m (5) 80 m

04 **Expansion of Gases**

This is a familiar question to you. You need a simple calculation. You need to apply Boyle's law to the air that exists.

$(10^5 + h \times 10^3 \times 10) 2.5 \times 10^{-7} = 10^5 \times 10^{-6}$

$10^5 + h \times 10^4 = 10^{-1}/2.5 \times 10^{-7} = 1/2.5\ 10^6$; $10^5 + h \times 10^4 = 4 \times 10^5$

$h = 30$

Try to get the answer efficiently when trying to simplify. This can be also solved from the logic without writing the equations. Look at this logic.

The volume of the released air bubble is 2.5 X 10^{-7} m^3. The volume on the surface is 10^{-6} m^3. 10^{-6}, is 4 times of 2.5 X 10^{-7}. That means when coming into the surface the volume of the air has been increased by 4 times. Then the pressure inside the pond should be 4 times higher than the surface pressure. Only the atmospheric pressure is there on the surface. The pressure inside the pond should be (the atmospheric pressure + the pressure from the water). If the pressure inside the pond is 4 times of the atmospheric pressure, then the pressure from the water has to be 3 atm. So, h = 30 m. hρg = 30 X 10^3 X 10 = 3 X 10^5 (three times of the atmospheric pressure)

I do not know if there is anybody who did the question in this way. Even though more is written, if you use this logic, then you can even get the answer from your memory. The volume increment is 4. Therefore, the pressure decrement should be 4 times. (4:1) As the atmospheric pressure is there to the both sides, the pressure from water should be 3 atm. The equivalent length for 3 atm should be 30 m. 10 m of water is equal to a pressure of one atm.

38. Air is rapidly pumped into a tyre by a bicycle pump. Which of the following is true for air inside the pump during the pumping process? (Here all the symbols have their usual meaning)

ΔQ	ΔW	ΔU
0	negative	positive
positive	positive	positive
0	positive	negative
0	positive	positive
negative	negative	positive

04 **Thermodynamics**

This is also an easy question. It is clearly evident that this is an adiabatic process as the air is very quickly pumped. That means ΔQ = 0. Now the rest is simple. We are pumping the air. That means we are doing work on the system (air). According to the sign convention ΔW

is negative. It can be argued that ΔW is getting negative in another way. The final volume of the air is lesser than the initial volume. We put the outside air into the tyre. The air gets contractional. That means ΔW is negative. Now $\Delta U = \Delta Q - \Delta W$.

As $\Delta Q = 0$ and ΔW is negative, ΔU gets positive. Even if we do not argue like this, we can decide that ΔU is positive as the air gets hot. In an adiabatic contraction, the temperature of the air gets increased. That means the internal energy gets increased. In an adiabatic expansion, the air gets cooled. That means ΔU gets negative. ΔW gets positive. When the air is released to the environment from the valve of the air-filled tyre, the valve gets cooled.

As soon you saw the word very quickly, you should realize that this is an adiabatic process. Therefore, you need to draw your attention to the answers only with $\Delta Q = 0$.

39. An electric kettle requires 0.2 kWh to raise the temperature of 2 kg of water from 28 °C to the boiling point of 100 °C. If the specific heat capacity of water is 4200 J kg^{-1} K^{-1} , the efficiency with which the kettle work is

(1) 42% (2) 54% (3) 60% (4) 72% (5)84%

You do not need an abnormal logic or new thinking for this question. You only need a calculation. There is no need to argue for such questions. The heat required to increase upto the boiling point of water = 2 X 4200 X 72. Do the reduction of 28 from 100 from your memory. Do you have to write the reduction of 28 from 100? When 30 is dedcuted from 100 is 70. 28 is two less than 30. Therefore, if 28 is deducted from 100 is 72.

Do not try to simplify the intermediate number is any question like this nature. It is a waste of time. When the simplificaction is done at last, most of the numbers get simplified very easily. The energy spent by the kettle is 0.2 kWh. It is an energy. You need to multiply by 10^3 X 3600 to convert kWh to J. To convert kW to W, you need to multiply by 10^3. To convert hours into seconds, you need to multiply by 3600. The efficiency is,

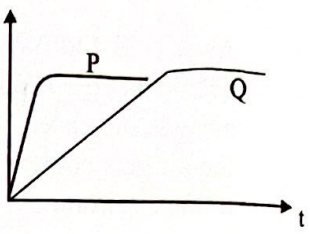
$$\frac{2 \times 4200 \times 72}{0.2 \times 10^3 \times 3600} \times 100 = 84\%$$

You need to write only this much in your rough work. Directly write the calculation only needed for efficiency in your rough work. The temperature difference is given as 72 because 72 is divided by 36.

You can do the simplification very quickly in your rough work sheet. The efficiency is (output/ input) X 100.

The water needs an energy of (2 X 4200 X 72) J. But in that time, the kettle has spent an energy of (0.2 X 10^3 X 3600) J. Actually, this much was spent but the water has taken only that much. The rest is wasted. When the childrent take 3 Fs, the parents also say these things. We worked this much. Spent this much. But all in vain. If you get 3F by working properly, then do not get discouraged. Your skill is on another side. Go on that road. Then you will be successful.

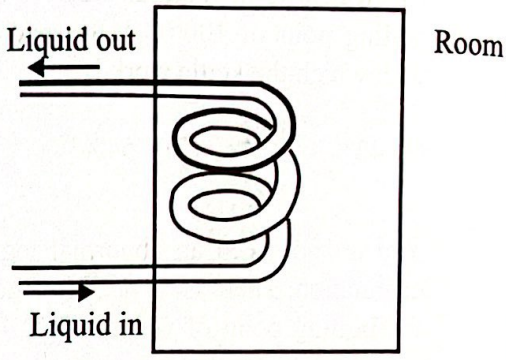
40. The variation of temperature (θ) with time (t) for two liquids P and Q of equal masses heated in identical manner are shown in the figure. Consider the following statements.



(A) Liquid Q is a better thermometric liquid than P to measure temperature variations in small quantities of liquids.

(B) Liquid Q is more suitable than P to construct a constant temperature liquid bath.

(C) Liquid Q is better than liquid P for heating air in an enclosed room by sending through a spiraled pipe as shown.



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 specific heat capacities of the two liquids are checked here. The temperature of liquid P has gradually increased. The gradient of the straight line is higher. If the temperature is rising quickly, then that means the specific heat capacity of that liquid is less. This is a conclusion that can be drawn from simple logic.

Therefore, specific heat capacity of liquid P < specific heat capacity of liquid Q. According to the given variations, you can only decide this fact. The boiling point of P and Q liquids are same. From that data the effect that can occur to the question has been removed. (see later)

To measure the temperature of a small liquid volume, the liquid of the thermometer should have a less specific heat capacity. The absorption heat from the liquid that the temperature is measured should be less. This characteristic should be there for any liquid of a thermometer. If the temperature is measured in a small liquid volume, then this characteristic is affecting seriously. A liquid with a high specific heat capacity should absorb more heat from the thing that it measures the temperature for a certain temperature increment. If you want to have something, then you should not absorb more. You need to take nectar from the flower without damaging it. Therefore, statement (A) is not correct. Liquid P is better than liquid Q.

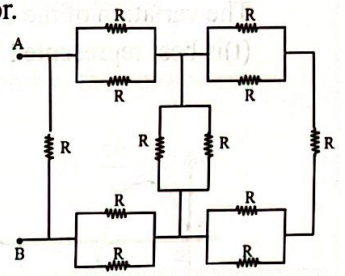
A constant heat container does not change its temperature even it absorbs little amount of heat. Even there are many problems, it does not care and not showing any change. What if some water goes to the sea? Does it change the water level? What is suitable here is a liquid with high specific heat capacity. If the specific heat capacity is high, then considerable amount of heat should be absorbed for a certain temperature increment. Therefore, statement (B) is correct.

From the same logic, it can be proven that statement (C) is also correct. If the room is needed to get hot, then the person who is heating the room should have ample heat. How to give something to somebody that you do not have? That means the liquid should have a high specific heat capacity. If you have something more, then only you will have a certain amount even after giving it to somebody. Therefore, statement (C) is correct. The main reason for the usage of water is due to its higher specific heat capacity in hot water (water vapour) for heating and water is also used to remove heat from an engine.

A liquid with less specific heat capacity has less heat amount in a unit mass. Therefore, when they come to the middle of the spiral tube, they have already given their heat.

The boiling points of the two liquids are drawn to be equal, to remove the change in boiling point from the question. If not one can argue about it also. For example, if the boiling point of liquid P is less than liquid Q, then one can argue that P is not suitable for a thermometer liquid. That is liquid P easily gets vapourized. Or else, if the boiling point of liquid Q is less than liquid P then one can argue that it is not suitable for constant temperature liquid container. That is because liquid Q easily gets vapourized. But as the liquids are in same boiling point, they are not subjected to that argument. The only valid argument is the difference of the specific heat capacities of the two liquids. If you can see that in the question, then you can get over from the question. If not, you need to argue here and there. You will not see a correct path.

41. The equivalent resistance across points A and B of the resistor.

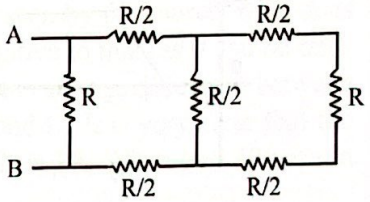


(1) $\frac{1}{3}R$ (2) $\frac{1}{2}R$

(3) $\frac{7}{12}R$ (4) $\frac{3}{4}R$

(5) R

Here there is no abnormal trick. Most of the time, children check whether they can remove a certain resistor from such resistor networks. In this network (as we consider A and B) such a thing cannot be done. Two Rs are parallel in five places.



Now if we start from the right side, then you can go to AB. In each place, try to reduce calculations and try to do it from memory.

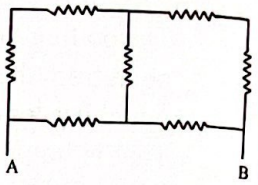
Let us start from the right side. R/2, R and R/2 are in series. The sum of these can be done from your memory. R/2, R/2 is R. R and R is 2R.

Now 2R is parallel to R/2 in the middle. The reciprocal of 2 is 1/2 and the reciprocal of ½ is 2. So, the sum of 2 and ½ is 2 ½. That means 5/2. The equivalent resistance is the reciprocal of 5R/2. That is 2R/5. However, the parallel equivalence of 2R and R/2 cannot be 5R/2.the parallel equivalence of 2R and R/2 should be lesser than both of them. Now this 2R/5 is in series with two R/2 resistors. Once they are added, it is 7R/5 (2/5 +1). Finally, 7R/5 is parallel to R. The reciprocal of 7/5 is 5/7. The reciprocal of 1 is 1. When 5/7 is added to 1 it is 12/7 (5/7 +1). The reciprocal of it is 7R/12.

There is little bit of mathematics here. Add the resistors in series from your memory. To find the parallel equivalence, take the reciprocal value of the resistor separately and add them. Finally take the reciprocal again. Then you can get the answer very quickly without writing equations.

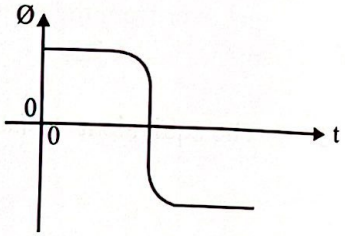
In addition, consider only the numbers without writing R when doing rough work. Writing R in every place also consumes some time. Is not that so? As the final answer should have R, there is no need of writing R continuously.

Here it is wrong to neglect the middle parallel two resistors of R by considering as a Wheatstone bridge. The resistor network is not behaving like a Wheatstone bridge relaltive topoints A and B. That conclusion is valid relative to the following points.

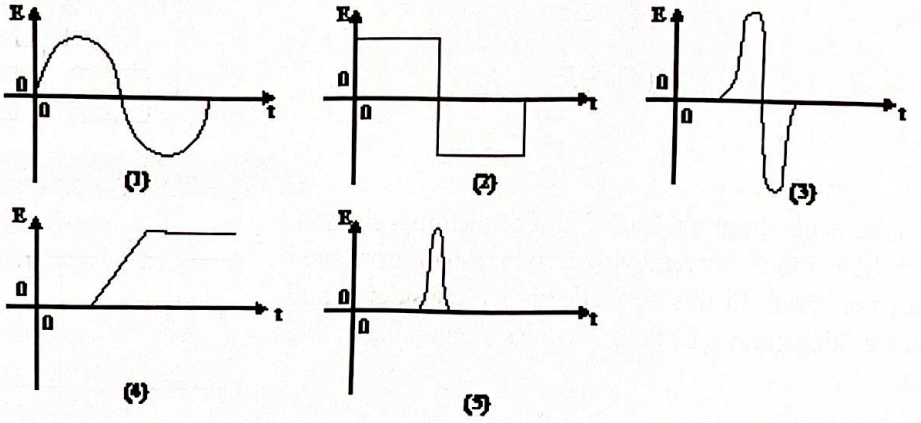


Therefore, you need to correctly understand whether there is a symmetry relative to the given two points when considering such circuit networks. There is no symmetry of the network corresponding to the points A and B in the question.

42. The graph shows the variation of a magnetic flux (Ø) through a coil with time (t).



The variation of the corresponding induced e.m.f(E) with time (t)is best represented by

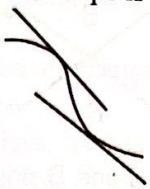


The magnetic flux is kept constant and suddenly it changed and again comes to a constant.

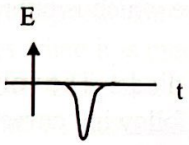
$E = -\Delta\varphi/\Delta t$

If φ is constant, then E is constant. If φ is suddenly changed and again gets constant, then E should suddenly be created and disappear. Such a variation is shown in (5). In the graph of φ-t, E can be obtained by the negative gradient of φ variation. According to φ variation, the gradient ($\Delta\varphi/\Delta t$) of the part that φ is constant and gets varied has a negative value.

As E is equal to negative rate of change of flux, if $\Delta\varphi/\Delta t$ is negative, then E is positive. The variation of φ is being enlarged and the shape is shown with tangents before and after.

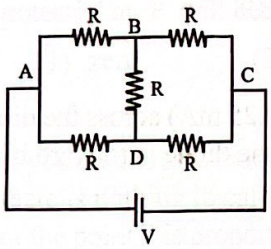


In both occasions, the gradient is negative. But initially, the gradient is gradually increased, then the gradient is gradually reduced. So, the value of E is positive but initially it should get increased and then it should be reduced. However, there is no such a choice in the answers according to the figure. Therefore, there is no need to decide whether the value of E is either positive or negative.



As initially φ is constant, then E should be zero at the beginning. According to that (1) and (2) can be removed. After the change of φ, it becomes constant again. Therefore, on that instant also E should be zero. According to that (4) can be removed. Then what is left is only (3) and (5). In (3), E gets zero in the middle. If E gets zero, then φ should be a constant for an instance. But in between the two constants φ is varying continuously. It is not constant in the middle. So, we can remove (3). Even the method of elimination gives very good results.

43.



The respective effective resistances 'seen by' the voltage source V across AC and BD are

1) $\frac{5R}{2}$ and R (2) R and 0 (3) $\frac{5R}{2}$ and ∞

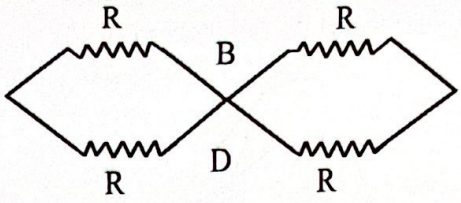
(4) R and $3R$ (5) R and ∞

Here 'seeing' the voltage source word is a new experience for A/L s as I know. What is indicated from 'seeing' is the ability of the source to see. If it seen by the source, what does the source see? The source is outside the resistor network. Relative to that (as it can be felt), the resistor network is a Wheatstone bridge circuit. Therefore, the voltage difference between B and D is zero. There is no current across R in between B and D. It is very clear that the equivalent resistance across AC is R. (The addition of R and R is 2R. When two 2Rs are in parallel, the equivalent resistance is R)

What is the equivalent resistance that the resource sees across BD? The source is not capable to send a current across BD. Therefore, the source thinks that the road BD is closed. If the road is closed (there is not current flow), then the resistance should be infinite.

However, the correct answer is oscillating with (2) and (5). We know that the equivalent resistance across AC is R. There is no problem in it. Even if the source sees or not, however the equivalent resistance across AC is R. If we do not talk about the resource and ask, what is the equivalent resistance across AC in the Wheatstone circuit? Then the value is R.

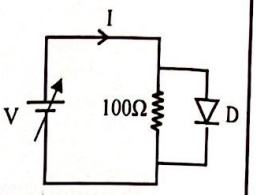
Actually, what is the net resistance across BD if we do not talk about the source? If we ask like that, then it cannot be answered. B and D points are in a same potential. Therefore, the given circuit can be presented as below.

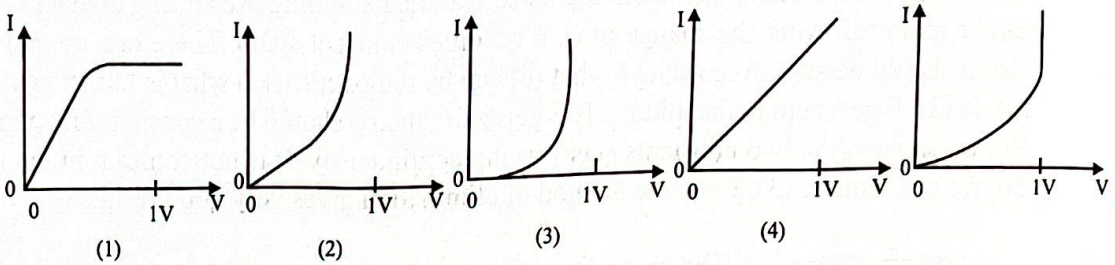


If we stay on the point B, then both B and D points are same relative to us. So, there is no point in talking an equivalent resistance across B and D. But an outsider sees as there is no path (road) called BD. The resistance is infinite in a non-existing road. It is not zero. If the resistance is zero, then there is a road with no resistance.

If two hearts are together, it is one heart relative to both of the hearts. But an outside villain sees this as a bond with infinite love which is unbreakable.

44. In the circuit shown, D is a silicon diode. The voltage source provides a variable voltage V. Whichof the following curves best represents the variation of I with V?



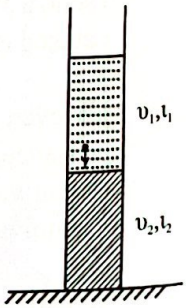


09 Semi Conductor Diodes

This is a very simple question. There is a small current flow (~0.25 mA) across the diode until it becomes forward biased. If you think from another way, till the diode is forward biased, its resistance is on a higher value (in kΩ).

Therefore, till V is 0.7 V, the current is flowing across 100 Ω. The I-V curve across a pure resistor is linear. The initial variation is drawn as linear only in (2). From that you can decide that (2) the answer. When V is 0.7 V, the diode goes into forward biased state and when the voltage difference is increased, the current across the diode is gradually rising. This is the I-V characteristic of a known diode by yourself. If there was no 100 Ω, then I-V variation is directly like the forward biased characteristic of a Silicon diode. As 100 Ω is parallel to the diode, a secret path is being designed. Therefore, until the diode goes into the conductive state, the current goes from the secret way. Until the work is succeeding, it goes on the secret road like a thief. Once it succeeds, it goes on the correct road like a gangster.

45. A small sphere falls through two columns of immiscible liquids in a deep container as shown in the figure. If η_1 and η_2 are the viscosities of the two liquids, and v_1 and v_2 are the corresponding terminal velocities of the sphere respectively, then



(1) $\eta_1 v_1 = \eta_2 v_2$ (2) $\eta_1 v_1 > \eta_2 v_2$ (3) $\eta_1 v_1 < \eta_2 v_2$
(4) $\eta_1 v_2 > \eta_2 v_1$ (5) $\eta_1 v_2 = \eta_2 v_1$

10 Viscosity

You do not have to write lot of equations for this question. The terminal speeds of the liquids are given. You can decide that the density of the top liquid is lesser than

the density of the lower liquid. If the mass of the sphere is m and the upthrust from the liquid is u, then the terminal speed v is proportional to (mg-u)/η (mg = 6πηav + u).

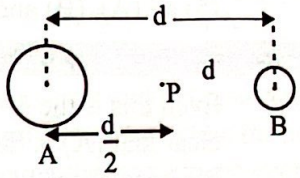
If you can write this directly, then the other argument is very simple.

As the density of the top liquid is less, its u is less. When u is less, (mg-u) gets increased. When (mg-u) gets increased, the multiple of ηv gets increased. This is the only logic. No need to write lengthy equations. If you write the above proportionality in your rough sheet, then it is enough.

$u_1 < u_2$ therefore, $mg - u_1 > mg - u_2$. So, $\eta_1 v_1 > \eta_2 v_2$.

We cannot decide only about terminal speeds. But we can find inequality about the multiple of ηv. We get a hint about the densities when it is mentioned as non-mixing liquids. The density of the liquid goes with the upthrust of the sphere. We cannot say anything about the viscosity of the liquids ($\eta_1 > \eta_2$ or $\eta_1 < \eta_2$). There is no need that the liquid on the top has to have less viscosity.

46. A and B are two conducing sphere having radii R and R/2, respectively, and each carrying a charge +Q. When the two sphere are separated by a distance d (>>R), as shown in the figure, the electric potential at pointP is V_0. When these two spheres are connected using a very thin metal wire, the electric potential at P will become



(1) zero (2) $\frac{V_0}{2}$ (3) $\frac{3V_0}{4}$ (4) V_0 (5) $2V_0$

If you do this also from the logic, then there is nothing to calculate. As point P is in the middle, there is nothing to calculate. As the distance from A and B to P is equal, the electric potential of the point P is proportional to the total charge of two spheres. Even they are being connected by a thin metal wire, the total charge of the two spheres is not changed. So, the potential of point P is not changed. Therefore, the answer is V_0.

$$V_o \propto 2Q \left[V_o = \frac{1}{4\pi\varepsilon_o}\frac{Q}{\frac{d}{2}} + \frac{1}{4\pi\varepsilon_o}\frac{Q}{\frac{d}{2}}\right]$$

If the potential of P is V after the wire connection, then

$$V \propto (Q_1 + Q_2) \left[V = \frac{1}{4\pi\varepsilon_o}\frac{Q_1}{\frac{d}{2}} + \frac{1}{4\pi\varepsilon_o}\frac{Q_2}{\frac{d}{2}}\right]$$

Q_1 and Q_2 are the stored charge of spheres A and B respectively. But $Q_1 + Q_2 = Q$.

Therefore, $V = V_o$

If you get the logic correctly, you can get the answer without any rough work. As point P is equidistant from the spheres, its potential is proportional to the total charges. Even the charges are divided, the total is the same. So, V_o is V_o.

99% of the children might have found the charges of the spheres after the connection of wire. If the point P is given at another point instead of middle, then you cannot apply the above logic. As the distances from the spheres are different, you cannot take it as one quantity in a common way. To eliminate the effect of the charge distribution from one sphere to another, it

has been mentioned as d >> R. If the charge distribution is asymmetric, you cannot consic the charges on the spherical surfaces as in their centres.

47. A particle having an electric charge is travelling along a circular path under the influence o uniform magnetic field. Consider the following statements.

A. Direction of the velocity of the particle is always perpendicular to the direction of t magnetic field.

B. Time required for the particle to make one revolution is independent of the radius of th circular path.

C. Speed of the particle is directly proportional to its mass/charge ratio.

Of the above statements

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

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

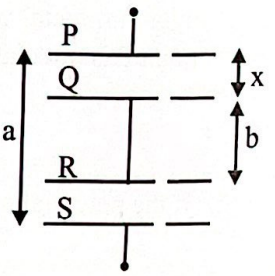
(5) all (A), (B) and (C) are true.

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

Even this is the 47th question, it is very simple. It is not worthy for the 47th question. It is very clear that (A) is true. It has been checked throughout the past papers. Even the statement (B) has been checked several times. It is also true. $\frac{mv^2}{r} = qvB\,; v = q\frac{Br}{m}$

(C) is wrong. In the correct statement, the charge is on the numerator. The mass is on the denominator. If you do not know about the statement (B), from the above statement also you can check about its true or false nature. The time for a revolution is proportional to $\frac{r}{v}\left(\frac{2\pi r}{v}\right)$ Once you saw the above expression you will definitely see that r/v is independent from r.

48. P,Q,R and S are four parallel conducting plates each of area A, and P and Sare fixed plates. Plates Q and R are connected by a rigid conductor as shown in the figure so that they could be moved up and down together. The equivalent capacitance of the system is given by



(1) $\frac{\varepsilon_0 A}{a}$ (2) $\frac{\varepsilon_0 A}{a-x}$ (3) $\frac{\varepsilon_0 A}{a+b-x}$

(4) $\frac{\varepsilon_0 A}{a+b+x}$ (5) $\frac{\varepsilon_0 A}{a-b}$

06 **Electrostatic Potential**

You need to write an expression. Here you have got two capacitors that are in series with each other. It can be seen at a glance. It is clearly evident from the conductor that the middle plate is being connected. As the capacitors are in series, $1/C = 1/C_1 + 1/C_2$. You do not have to write this. Because the capacitor equation of a capacitor you know by heart. Write the reciprocal of it directly like this.

$$\frac{1}{C} = \frac{x}{\varepsilon_0 A} + \frac{a-(b+x)}{\varepsilon_0 A}$$

Once you see this expression, do not try to simplify more. The denominators are same. So, once the numerators are added, x is cut off. $C = \frac{\varepsilon_0 A}{a-b}$.

According to my knowledge, you should write only $\frac{x}{\varepsilon_0 A} + \frac{a-(b+x)}{\varepsilon_0 A}$. The rest, I can do it from my memory. If I can do it, then why cannot you do it? According to the position of the middle plates, the equivalent capacity of the system does not change. If you stay away from one, then the other gets closer. Therefore, the net value of series combination is not affected by that motion.

49. When afree particle with kinetic energy K and de Broglie wavelength λ enters a certain region its potential energy become V. The particle's new de Broglie wavelength is given by

(1) $\lambda\sqrt{\frac{V}{V-K}}$ (2) $\lambda\sqrt{\frac{K}{K-V}}$ (3) $\lambda\left(1+\frac{K}{V}\right)$ (4) $\lambda\left(1-\frac{K}{V}\right)$ (5) $\lambda\sqrt{\frac{K}{V-K}}$

Particles and Waves 11

What is meant by a free particle is that its potential energy is zero. It does not have an energy due to its position or an energy due to another external effect (potential energy). This fact must be realized initially. Even though if you do not know this,it has been indicated that there was no potential energy before entering as it has been mentioned about the potential energy as V when the particle enters into a particular place.

You get a potential energy due to a connection. There is no potential energy without connection and affection. It is a free bird. To find the new De Broglie wavelength, you need to get the new kinetic energy of the particle. From the conservation of energy, we get the new kinetic energy as K-V [K + 0 = K' +V]. De Broglie wavelength λ of a particle with kinetic energy K is

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}};\ k = \frac{p^2}{2m}$$

If the new De Broglie wavelength is λ', then $\lambda' \propto \frac{1}{\sqrt{K-V}}$ but $\lambda \propto \frac{1}{\sqrt{K}}$

So, $\lambda' = \lambda\sqrt{\frac{K}{K-V}}$

When De Broglie wavelength is expressed in kinetic energy, there is a square root definitely. Therefore, (3) and (4) are removed. As the new kinetic energy is K-V, the answer should be (2).

50. Two empty boxes of volumes 0.1 m^3 and 0.3 m^3 filled with air at room temperature of 30°C are sealed and stored in a refrigerator. A packet of moisture absorbing silica gel has been inserted into the 0.3 m^3 box must before sealing. Later it was found that the relative humidity of air inside the small box reached 100% at 15 °C and relative humidity of air inside the large box reached the 100% at 5 °C. If the absolute humidities O air at the dew points of 5 °Cand 15 °C are 6.8 g m^{-3} and 12.7 g m^{-3} respectively, then the amount of water vapour absorbed by the gel is

(1) 1.77 g (2) 2.04 g (3) 3.81 g (4) 6.80 g (5) 12.70 g

Hygrometry 04

You need to read the question continuously. I admit that it takes some time. You need to save time from the other questions that can be done quickly.

This is the easiest way to solve the question. If gel was not put to the box of 0.3 m^3, then that also get 100% realtivve humidity at 15 °C (attains the dew point). If so, the water vapour mass should have been in box of 0.3 m^3 is 12.7 X 0.3 = 3.81 g. Why? At 15 °C, the volume is

saturated with water vapour. The absolute humidity at 15 °C means the mass of water vapour in one cubic meter (12.7 gm^{-3}). At 15 °C, the volume is saturated when cooling because that amount of water vapour mass was inside the box. Otherwise, from where should it come? The water vapour mass cannot be changed even it is cooled. At 30 °C also (before the insertion of gel) 3.81 g of water vapour was there inside the box of 0.3 m^3. As there was this mass, when it is cooling, the air in the box is saturated exactly at 15 °C. If there were more than that, then saturation occur before 15 °C. If there were less than that, then it should be cooled more to get saturated.

But when the gel was inserted to the box of 0.3 m^3, the amount of water vapour in the air is reduced because a certain amount of water vapour is absorbed by the gel. That is why the temperature has to be cooled to 5 °C for saturation. At 5 °C, there is 6.8 g of water vapour per one cubic meter. So, the amount of water vapour in the box with gel should be 6.8 X 0.3 = 2.04g. That means the water vapour mass that was absorbed by the gel is 3.81 – 2.04 = 1.77g.

You do not have to do this much. If gel was not inserted to the big box, then there should be 12.7 g of water vapour in one cubic meter. As the gel was inserted, now it has 6.8 g of water vapour in one cubic meter. Therefore, change per one cubic meter is 12.7 - 6.8. Then how much should it be for 0.3 m^3?

The rough work is only this. (12.7 -6.8) 0.3 =5.9 X 0.3 = 1.77

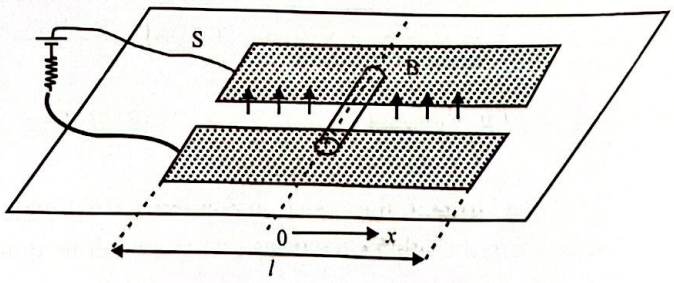
Actually, there is no use from the vloume of the smaller box. Even there is no use from the smaller box. Cannot this question be given like this?

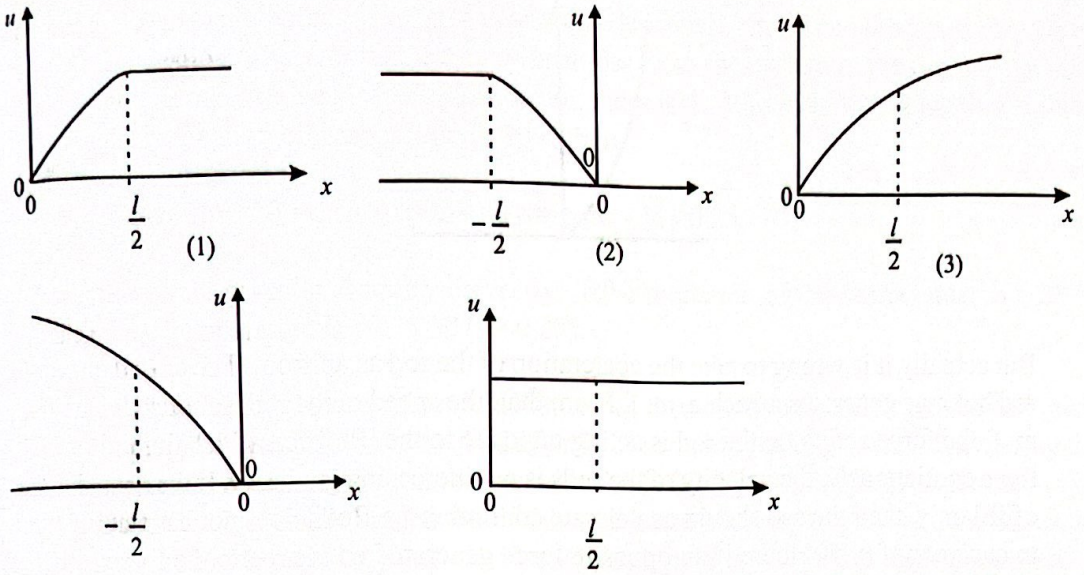
An empty box of volume 0.3 m^3 is filled with air in room temperature and kept in a refrigerator after sealing. It was found out that at 15 °C, the relative humidity inside the box was 100%. If two sillica gel packets which absorbes the moisture were insertrd into the box before sealing, then it was found that the relative humidity gets 100% at at 5 °C. If the absolute humidity of air at at 5 °C and 15 °C are 6.8 gm^{-3} and 12.7 gm^{-3} respectively, then the mass of water vapour that was absorbed by gel is…

The answer is same even the question was asked like this. There is 12.7gm^{-3} if gel is not there. Due to gel it has been reduced to 6.8 gm^{-3}. The difference is 12.7 - 6.8. That is for one cubic meter. Then how much will it be for 0.3 m^3?

A smaller box has been given may be as a control arrangement. Or else to make the question more beautiful. Even it is more beautiful to have two instead of one.

51. The diagram shows two thin smooth stripsof aluminium of length l pasted on a flat smooth horizontal wooden surface S Strips are connected to a battery at one end. A uniform upward magnetic field is setup, perpendicular to the surface, throughout the region between the aluminium strips. When a steel rod is placed on the two aluminium strips as shown, the rod starts to move. The variation of the velocity v of the rod with distance along the x axis is best represented by

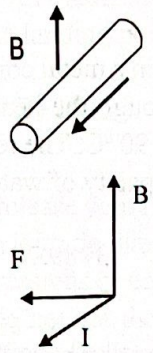




(1) (2) (3)

(4) (5)

This is a very easy question. If you do not think the problems after this (except 56 and 58), then it will be difficult. When you decide which way does the steel rod starts its journey, you can remove 3 out of 5 graphs.

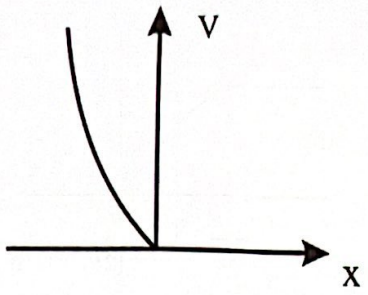


Finding the current direction of the steel rod can be done even to a child in year 6. The magnetic field is acting upwards. Therefore, the force on the rod (iBl) is generated to the left side. If the thumb of the right hand is kept perpendicular to the other fingers, and these fingers are rotated from the direction from I to B, then the thumb is directed to left side.

The steel rod is moving towards to -x direction. Once it is decided, only (2) and (4) will be left out. When the rod gets out from the two aluminium plates, there is no current across it. Therefore, the magnetic force on the rod is zero. As the wooden surface is smooth, the velocity of the rod should be unifrom after x = - l/2. It is shown by only (2). Even if you think these two points, you can decide quickly and conveniently that the correct vairation is (2).

When the rod is gone out from the plates, a child may see that the connecting wires are touched by the rod in the circuit. But even there is current, as the magnetic field lies only among the plates, the iBl force acting upon the rod is zero.

The graph of v is drawn with the distance. However, the velocity variation with distanceof an object with uniform acclereation is not linear ($v^2=2ax$). A curve of v-t is not given. If so, then one can argue that v-x curve should be like this.



But actually it is wrong to take the accleration of the rod as unifrom. The closed circuit that the rod belongs generates a back e. m. f. From that, the speed of the rod is reduced. Due to back e. m. f, the force acting on the rod is acting opposite to the iBl force. If the aluminium plates are there continuously, the velocity of the rods is not increasing gradually. If we consider the force of iBl only, then the rod should acclelerate continuously. But it does not happen like that. Due to back e.m. f (vlB), there is an opposite force generated on the rod to the force of iBl. When these two forces are equal, the velocity of the rod is uniform however. Like in the terminal velocity.

But you do not have to think all these. The rod is moving towards left isde. When the rod is out of the plates, there is no space to change the velocity. It is enough if you consider only these two facts.

52. A 110 W immersion heater is placed in a metal container of heat capacity 200 J K^{-1}, containing 1 kg of water. It is found that although the heater is kept switched on for a long time the temperature of water rises only upto 90 ^{0}C. The temperature of water 10s after turning off the heater, is closest to, (specific heat capacity of water = 4200 J kg^{-1} K^{-1})

(1) 89.50 ^{0}C (2) 89.68 ^{0}C (3) 89.70 ^{0}C (4) 89.73 ^{0}C (5)89.75 ^{0}C

04 Calorimetry

This is a question where many have talked about. The 53rd question is also like that. If you do not recognize the logic, then you will not be able to solve this in the life time. It has been mentioned that the temperature of the water rises till 90 ^{0}C only. What can you decide from that? The rate of heat supplied to the system is equal to the rate of heat loss to the surounding from the system. When these two are balanced, the temperature does not rise. It remains in the same value. This instance has been checked by many times. There is no problem in that.

Next, this is the most important logic. The rate of heat loss from the container and water at 90 ^{0}C is 110 W. What is meant by opening the switch is that the supplying heat is stopped. After that, the heat is lost from the system not supplied to it.

To solve this problem, we need to build a hypothesis that during the 10 s of the switch opening, 110 W is the heat loss from the system. It has not been mentioned in the question that to build a hypothesis. If it was mentioned, then there is no attractive nature in the question. But even if it was asked build a hypothesis, then there is no attractiveness in the question. But the factors that are tempting to build a hypothesis are mentioned in the question. The temperature of the water is being asked after closing the switch for a small time of 10s only. If this time was bigger, thenthe rate of heat loss cannot be taken as 110 W. As the temperature is decreasing graudally, the rate of heat loss to the surrounding also gets reduced as the extra temperature is reduced.

The other hint of the question is that the temperature is asked to the nearest value. That means as we do the above hypothesis we get a near value. However, there is no other way that we can solve this question. That means the rate of heat loss from the system in the first 10 s of small time should be taken as 110 W definitely. If not, there is no other way to resolve this problem. If $\Delta\theta$ is the reducation of temperature in 10 s, then

$(200 + 1X\ 4200)\Delta\theta/10 = 110;\ 4400\Delta\theta = 1100;\ \Delta\theta = ¼ = 0.25$

The numbers are given to simplify correctly. If the reduction of the temperature is 0.25 ^{0}C, then the new temperature is 89.75 ^{0}C (90-0.25).

If the time is reduced by more value (less than 10 s), then our hypothesis is getiing very good. For example, if the etmperature was aked after 1s of switching off the switch, then during that 1s, the reduction of temperature in that peiod is 0.025 ^{0}C. That means the temperature of the water is 89.975 ^{0}C. It can be argued that if this was asked it is very good. It is true. But aksing the temperature after 1s is not practical. Even that temperature is hard to measure as well.

53. An artillery gun is positioned on a horizontal ground and an artillery shell is fired from it so that the shell would land at a target, which is located at a distance 2000 m from the position of the gun. Accidentally, the Snell explodes into two pieces A and B at a certain point of its trajectory. The mass of A is twice that of B and both pieces land at the **same moment**, after travelling in the same vertical plane. If A lands at a distance 1800 m in the direction of the target from the gun, the distance to the landing point of B from the gun is

(1) 1600 m (2) 2200 m (3) 2400 m (4) 2600 m (5)2800 m

This is a question that will rotate and release you. If you apply equations and start to do, then it will go towards the world's end. Even if yo do like that, you will not be able to get the answer. There are no data given to apply expressions or equations. In such a question, what you need to do is neglect the question if you do not see the path to solve the question. Or else pick a blind shot. Do not waste time by writing equations continously and drowning more and more in the question.

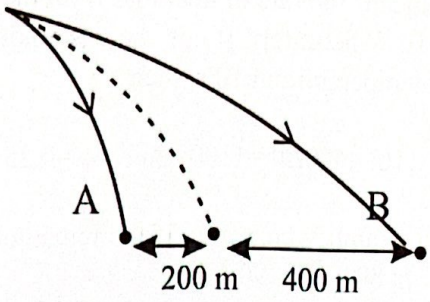
There is a simple logic here also. Once you know the logic, the question is very easy. If you do not see the logic, it will be the world's hardest question.

The explosion is due to an internal procedure. There is no external factor which encouraged it. If you consider the whole system, all internal forces get cancel off with each other. The external forces that act on the bullet and the exploded parts are gravitational forces (if we neglect the air resistance).

Therefore, if the bullet did not explode, the centre of gravity of the exploded two parts should move on the path it was supposed to go. Only an external force can change the net path of a system.

Think of a person who does acrobats. Even if he keeps his body stern or move his limbs in a certain way (by moving near or far to the body) his path in the centre of gravity cannot be changed. It will be changed if he collides with somebody. It is occuring due to an external force. Even all of our paths are changed due to someone.

You need to be musician or a dancer from your internal forces of yourself. But your parents want you to become a male or femal doctor. I will draw the diagram for your convenience.



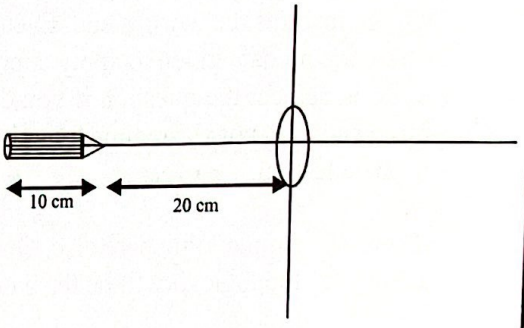
The dashed line shows the actual path of a bullet. The distance is 200 m from that point to point A (2000-1800). The mass of A is double the mass of B. Therefore, if the distance between the place where the centre of gravity of the system falls and the point A where it falls is 200 m, then the distance from the place where the centre of gravity falls to the point B where it falls should be 400 m. The ratio is 1:2. The centre of gravity must be near to the place with more weight and stay away from the lesser weight. If we take the moments around the centre of gravity, then it will be correct. Even if it is not necessary, you can do it if needed.

$2m \times 200 = m \times x$

Therefore, the distance from the gun to the place where B falls is 2400 m (2000 + 400 or 1800 + 600).

If you identify the logic, then you can do it from your memory. If not, there is nothing to do other than scolding.

54. A 10 cm long pencil is placed along the optical axis of a convex lens as shown in the figure. If the length of the image of the pencil is also 10 cm, the value of the focal length of the less is



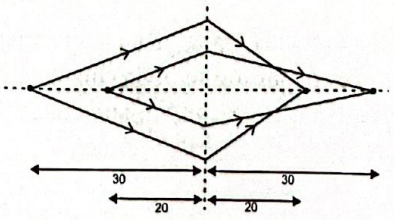
(1) 4 cm (2) 8 cm

(3) 10 cm (4) 12 cm

(5) 20 cm

03 Refraction through Lenses

Do not go to solve in the longest method. As the length of the object and the image is same, the object distance and the image distance should be reversible. That means the related image distance to object distance of the tip of the pencil (20 cm) should be equal to 30 cm which is the object distance of the pencil. So, the related image distance is 30 cm for u= 20 cm. Like wise, the image distance should be 20cm for u = 30 cm. The following ray diagram has been drawn for clarification.



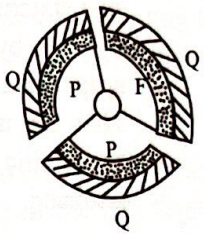
In other words, according to the reversible law of light, if u = 20 and v = 30, then when u = 30, v should be 20. Now the lens equation has to be substituted only once.

$$-\frac{1}{30}-\frac{1}{20}=\frac{1}{f}$$

$$f=-\frac{30\times 20}{50}=-12$$

You will consume a lot of time if you try to substitute to the lens equation twice and simplify as v_1 when u = 20 and v2 when u = 30.

55. The wheel shown in the figure is made of three bi-metal (P,Q) strips attached to the axis using radial metal parts. This can be setup to oscillate about an axis perpendicular to the plane of the wheel and passing through the centre. The wheel is designed such that the oscillating period of the wheel remains the same regardless of the charges of the surrounding temperature. Consider the following statements,



(A) The moment of inertia of the wheel should not change with the temperature.

(B) The shape of the wheel should not change with temperature.

(C) The linear expansivity of metalP should be greater than that of Q.

Of the above statements,

(1) only (A) is true.

(2) only (B) is true.

(3) only (C) is true.

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

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

This is not a question with deep logic. The requirement is clearly mentioned in the question. The oscillatory period of the wheel should be unchanged. Such wheels can be found in mechanical watches or in equipment which measures time. Such wheels help the measurement of time by oscillating to both sides from time to time.

When the temperature is fluctuated, the oscillatory period has to be unchanged. If so, the moment of inertia of the wheel should not be changed. So, there is no logic to understand that statement (A)is correct.

Think that the temperature was increased. Then the radial metal parts get expanded. Due to that the radius of the wheel is increased. Once the radius is increased, then the moment of inertia gets increased. The mass distribution goes far away from the rotational axis. To damage control the increment of radius the strips should be bent inwards. From that the mass distribution gets near to the rotational axis. The strips are made from bi-metal and there is a space in between them to allow bending (towards the centre) when the temperature increases. If the strips are not made with bi-metals, then the length of the strips will get increased but not bend. To rectify the damage from the increment of moment of inertia from the separation

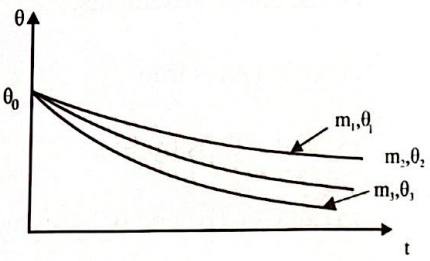
of radial parts, partial mass of the wheel should be near to the radius side. When one is going far, the other gets close by.

When the bi-metallic strip is bent, there is a change in the shape. It is unavoidable. Therefore, statement (B) is wrong. Many got confused with this. They argue that the shape is needed to be unchanged if you are in need to keep the moment of inertia unchanged. They argue that statement (B) is correct. This logic is not correct. The moment of inertia cannot be kept constant by keeping the shape of the wheel unchanged. When the temperature is increased, the strips should be bent inwards. If the temperature is decreased, the radial parts are contracted. Then the moment of inertia is reduced. So, to keep the moment of inertia unchanged, the bi-metallic strips should be bent outwards. Even though the shape of the wheel is little bit distorted.

If the strips have to be bent inward when the temperature is increased, then the expansivity of the outer metal must be higher than the expansivity of the inner metal. That means the expansivity of metal Q should be higher than the value of metal P. Therefore, statement (C) is also wrong.

So, only statement (A) is true.

56. Three masses m_1, m_2,and m_3, of hot water at temperatures θ_1, θ_2, and θ_3, respectively are added to three Identical containers each having mass m of water to achieve the same final temperature θ_0. Then the containers are allowed to cool.



The cooling curves for the three containers are shown in the figure. If the rate of loss of heat from each container is the same, then

(1) $m_1 < m_2 < m_3$ and $\theta_1 < \theta_2 < \theta_3$
(2) $m_1 < m_2 < m_3$ and $\theta_1 > \theta_2 > \theta_3$
(3) $m_1 > m_2 > m_3$ and $\theta_1 < \theta_2 < \theta_3$
(4) $m_1 > m_2 > m_3$ and $\theta_1 > \theta_2 > \theta_3$
(5) $m_1 = m_2 = m_3$ and $\theta_1 = \theta_2 = \theta_3$

04 Convection

Even though it is seen as a difficult question, if you think it in a simple way, then it will be very easy. It is about general knowledge. If the temperature is quickly decreased, the mass of the water should be reduced. Is not it? If there is more water weight in the container, then the reduction of temperature happens slowly.

So, do you need to think more to find that $m_1 > m_2 > m_3$? If you use equations, then

$\Delta Q/\Delta t = (ms + W)\, \Delta\theta/\Delta t$ where W is the heat capacity of the container. So, if m is less, then does not $\Delta\theta/\Delta t$ should be increased? Actually, there is no need to write equations. You can

argue from the general knowledge. If there is little water, then the temperature drops quickly. Is not it? If more tea is put to a cup, then does it temperature drop quickly or slowly?

Now, the next step is also general knowledge. As it is mixed with the same amount of water, to reach the same final temperature, does not the initial temperature should be higher in the poured smaller water mass? Does the initial temperature of the bigger mass should be lesser? If not, then how can the final temperature be same?

So, if $m_1 > m_2 > m_3$ then $\theta_1 < \theta_2 < \theta_3$. Is not it? Think that one person has Rs. 100. If Rs. 50 was given to a person without money, then both have same amount of money (each with Rs. 50). Two persons got together and give money to the person without money. If all three should have Rs. 50 eachfinally, then then first two initially should have Rs. 75 with each other. So, both gives by Rs. 25 to the person without money and all get Rs. 50 each. So according to this, if more persons are there to give money, then the money that one person should have gets lesser.

Even this is the 56th question, you should be able to solve with your instinct. For 52nd and 53rd questions, I agree that you need specific logics. They are called out of the box logics. It indicates that it is beyond what is known. But to solve the 56th question, you do not need specific logics.

If the water mass of the containers is not equal, then the water volumes are not equal. Some argue that, then how can the rate of heat losses be equal. For example, in the experiment of finding the specific heat capacity of a liquid from Newton's cooling law, we take equal volumes of water and the liquid. The rate of heat loss is dependent upon the extra temperature, external surface area and the nature of the surface. Therefore, when equal volumes of water and the liquid are cooled in a same calorimeter with same temperature limits, the rate of heat loss will also be same. In such an experiment, if the cooling time takes time from t_1 to t_2 to go from a temperature of θ_1 to θ_2, then the familiar equation of yours is,

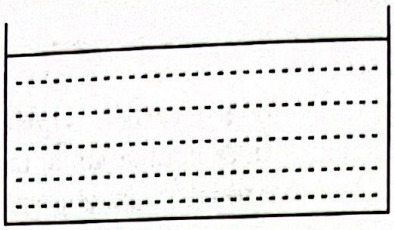
$$\frac{W + Mc_1}{t_1} = \frac{W + mc_2}{t_2}$$

Where W = the heat capacity of the calorimeter, M = mass of water, C_1 = the specific heat capacity of water, m =the mass of the liquid and C_2 = the specific heat capacity of the liquid.

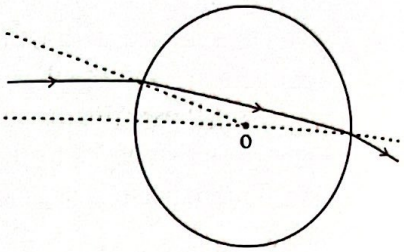
In this question you have only water. Therefore, $C_1 = C_2$. If so, definitely the masses should be changed. Then there cannot be equal volumes in the containers. But it has been mentioned to take the rate of heat loss as equal in the question. Therefore, some argue that this is a wrong question that cannot occur.

But this can happen practically. If there are containers with big cross-section, then it is not a thing that cannot be happened. If the cross- section is large, then water can be there nearly to a same height in the containers. But the mass of the water volume can be changed.

If the height of the water is changed by 1 mm in such a container, there is no change in the surface area that the water is filled. But the change of mass has be considered. The area goes with the radius of the cross-section (r). The mass goes with r_2. Therefore, in such an instance, there is no wrong in taking the rate of heat loss is same even the masses are different. So, the hypothesis mentioned in the question has no problem.



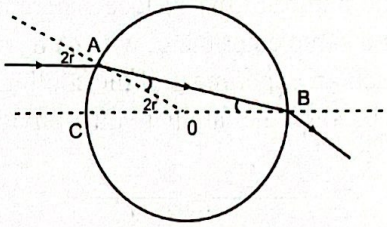
57. A monochromatic ray of light is incident close and parallel to a diameter of a transparent plastic sphere with centre O and refracted as shown in the figure. The refractive index of the plastic is closest to (take sin θ≈θ for small θ angles)



(1) 1.2 (2) 1.3 (3)1.5
(4) 2.0 (5)2.5

03 Refraction

If you forget the geometry that you learnt in O/Ls, then you cannot get the answer. Physics in here is easy. But if you do not know geometry, you will be stuck without getting the answer. Look at the figure. The path of a ray has been given. We know that n = sin i/sin r. You should think like this. In the question nothing has been given instead of taking sin θ as θ for small θ angles. Therefore, if we do not find a relation between i and r, then you cannot go forward. There is no other alternative of abandoning the question or cross any choice if you do not see that i=2r from the given figure.



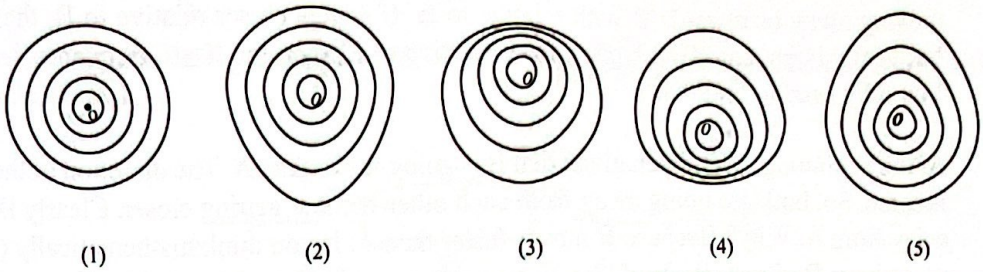
Let us take the refracting angle as r. Then as AO = OB, the angle ABO is also r. In the triangle of OAB, the angle AOC is 2r when BO is extended to the outside. The value of the exterior angle by extending a side of a triangle is equal to the sum of the opposite and non-adjacent interior angles is the geometric theorem that we use here. If you do not know that, then it is not hard to get as AOB angle is 180 -2r and AOC angle is 2r. Now from the theorem of alternate angles, you should get i=2r. If you cannot do this much, then you will not get the answer.

One can argue that there is more mathematics than Physics here in the question. It is true. But Physics and mathematics are inter-related to each other. Like male and female. Males cannot live without females. I believe it so to vice versa as well.

$n = \sin 2r / \sin r = 2[\sin 2r \approx 2r, \sin r \approx r]$

It has been mentioned that the ray is incident near to the diameter because to make sure to consider the angle as a small angle.

58. A source of sound is located at a point O above the earth surface. In the daytime, the air temperature decreases gradually when moving upwards from the earth surface. Which of the following figures best represents the way in which the wave fronts of the sound emitted from the source are propagated?

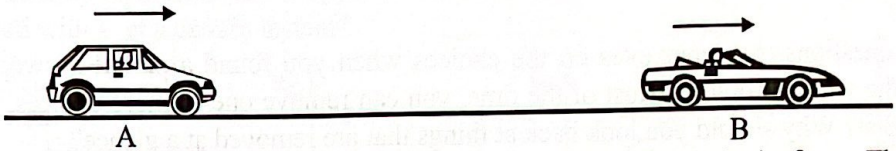


(1) (2) (3) (4) (5)

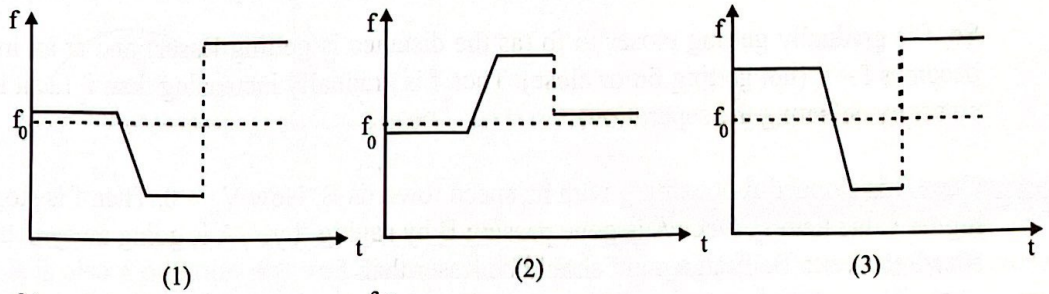
Velocity of Sound 03

Even though it is the 58th question, there is nothing in it. During day time, it has been given that the temperature of the air gradually reduces when it goes up from the earth surface. The air near the earth surface gets hotter as the earth is heated. We know that when the temperature increases, the speed of sound in air also increases. All you need to know are those facts. As the sound source is above the earth surface, when it is coming down towards the earth surface, the temperature is increased. As the temperature is increased, the sound speed also increases and the distance between the wave fronts should gradually increase to downward direction. Likewise, the distance between the adjacent wave fronts should get reduced when going into upward direction. This nature is only shown in (3). Along with that, the distance between the wave fronts of the horizontal direction from the source should not be changed. Because we do not expect a temperature change on the same horizontal level.

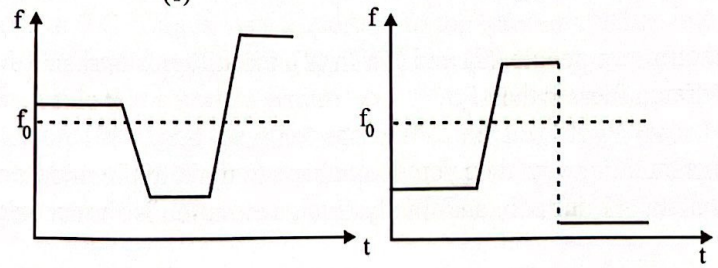
59.



Two cars are moving along a road at constant speeds as shown in the figure.The driver of A is sounding the horn of his car of frequency f_0 continuously. Initially the car B is moving faster than A. Suddenly B slows down and stops. Acontinues to move at the same speed and passes B which is stopped. The graph that best represents the variation of frequency (f) of sound heard by the driver of B with time (t) is



(1) (2) (3)



(4) (5)

Doppler Effect 03

The concept of the problem is familiar to you. But as there are many parts, this can be jumbled to you. If you use the beautiful cunning nature, then you can find the answer very quickly.

It is enough if you consider the speed of A relative to B. All you need to find is whether A is moving away or towards B with relative to B. If A gets closer relative to B, then the heard frequency is increased. If A goes away relative to B, then the heard frequency is decreased. You only need to find that.

At the beginning, it has been given that B is going faster than A. The direction of the velocities is same. So, both are going away from each other without getting closer. Clearly B is moving away from A. Why? Because B moves faster than A. If you think mathematically (no need of it), to keep B at rest, B should be given a velocity of VB to the left side. That same velocity should be given to A also.

As $V_B > V_A$, A is getting away relative to B. If so, the heard frequency of the horn to B should be less than f_o (as both are going farther apart). However, the frequency is less heard when moving away.

That means in the initial variation, f should be lesser than f_o. From that, you can kick three choices of (1), (3) and (4) out. How great is that? At the beginning of the solving process 5 choices are reduced to 2.

In such questions, run your eyes on the choices when you found a partial answer before solving the whole problem. Most of the time, you can remove one or more choices. What a relief is that? Why should you look back at things that are removed at a glance?

Next, vehicle B reduces the speed and stop. When the speed is initially reduced, getting away from B is gradually reduced from A. At a certain point the speed of B is equal to A. At that moment, the relative velocity of them is zero ($V_A = V_B$). After the speeds are equal, as the speed of B is getting reduced now a situation occurs where A is moving towards B ($V_A > V_B$).

So, f is gradually getting closer to fo (as the distance is getting lesser) and at an instance it becomes $f = f_o$ (not getting far or close). Then f is gradually increasing than f_o (as it is getting closer by defeating the separation).

Once B is stopped A is coming with its speed towards B. Now $V_B = 0$. Then f is stopped at a higher value than f_o. Once A is gone passing B by saying 'bye', A is going away in a uniform speedrelative to B. Then again f should be lesser than f_o.

Now we need to look at only two people. (2) and (5). In (2), f is still greater than f_o even A has passed B. Only (5) has drawn f lesser than f_o.

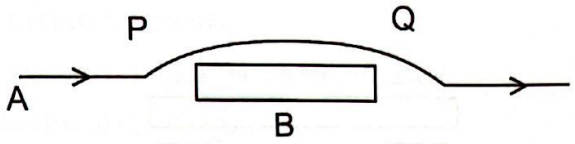
Actually, if you think in a cunning way, then you do not have to think of the middle variation. From logic you can get that $f < f_o$ initially and finally. Such a variation is shown only at (5).

The variation has been drawn to have more difference of fo-f at the end compared to the initial difference of f_o-f. Initially the relative velocity is V_B-V_A. Finally, as B is at rest, the speed of A

moving away from B is directly V_A relative to B. we cannot actually say that which is bigger either V_A or V_B-V_A. However, a variation is not given to look and decide about it.

If $V_A = 3ms^{-1}$ and $V_B = 5\ ms^{-1}$ then $V_A > V_B - V_A$.

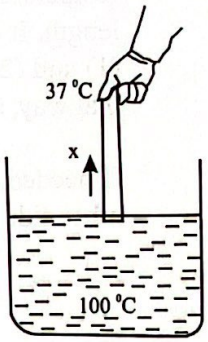
How f is changed during the time when vehicle A passes B is not considered here. Following is the path of A.

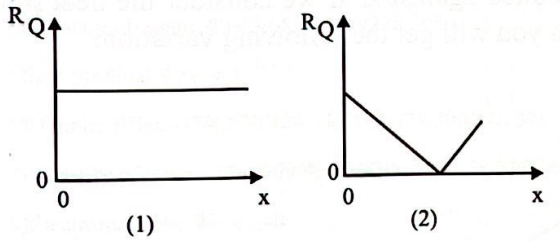


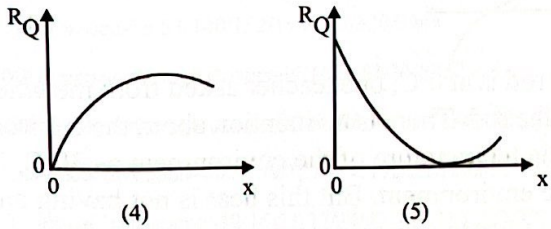
When the path is curved, you need to consider the velocity component of A towards the direction of B. Next, when the vehicle is parallel to B (at PQ section), the velocity component of A gets zero that is towards B. Then the apparent frequency is equal to the real frequency. The problem gets complicated if you start to consider these facts. You will not be tempted to get the answer only by checking the initial and final section of the question.

But there is no wrong in removing the wrong choices by looking at the first part. Luckily, you can remove three choices directly in this question.

60. A metal rod is initially at 0 °C. Now one end of this rod is immersed in boiling water and the other end is held by fingers as shown in the figure. The temperature of he fingers is 37 °C . Which of the following curve correctly represents the variation of the rate of flow of heat (R_Q) along the rod with x at a certain instant?







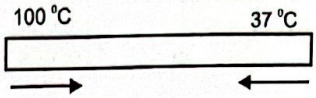
This is also a question that was discussed more. It is a strange question. Initially the metal rod is at 0°C. This is very important to the question. When one end of the rod in 0°C is kept at 100°C and the other end at 37°C, the rod will get confused. The rod must decide from which side that it should absorb heat. Normally when one end of the rod in room temperature is keptat 100°C and the other end at 0°C, the heat flows from 100°C to 0°C side. There is no problem in that. If the room temperature is taken as 30°C, then 30°C is less than 100°C and greater than 0°C. Therefore, the heat flows to one side. It is from 100°C to 0°C.

Here the rod is at 0°C. Both ends are greater than 0°C. Therefore, initially heat is flowing to both sides. This can be seen practically. If we take a rod with melted ice and keep one end

at 100°C and the other end with fingers, then does not ice melting occur on both sides? The melting of ice is happening very fast on the side of 100°C. But also, at the side with fingers ice melts to a certain extent.

The rod at 0°C is looking at both of them. It is true that 100 °C is stronger than 37 °C. So, there should be more space for 100. Even it is not so like 100, 37 also should be given space to enter.

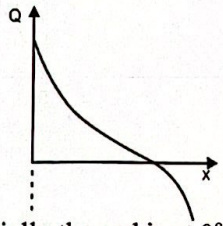
If we consider the heat flow in the rod, initially the heat flows to both directions.



The direction of the heat flow cannot be interpreted as positive or negative. Heat is a form of energy. Energy is a scalar quantity. Whatever the direction may be, the rate of heat flow is a positive quantity.

The rod is not covered. Therefore, the heat is lost from the surface area of the rod. So, however RQ cannot be a constant. Even R_Q cannot have a linear shape. When the heat is lost from the rod, the heat loss is not occurring in equal amounts. At a place where there is a higher temperature in the rod, the rate of heat loss is greater.The loss is less at a place with lower temperature. If R_Q is reduced linearly, then the rate of heat loss should be same per a unit length. It is unnatural for R_Q to increase with distance. Who provides the heat continuously? (1) and (2) cannot happen and (3) and (4) are non-physical. It cannot happen. If you look at that way, then only (5) is left out.

If needed, the flow of heat (Q) can be plotted against x. If we consider the heat flow to the other side as negative for a moment, then you will get the following variation.



As the rod is not covered and initially the rod is at 0°C, one teacher asked from me whether the heat from the surrounding is absorbed to the rod. There is no mention about the environmental temperature in the question. If we take the temperature of the environment as 30°C, it is true that the heat will flow to the rod from the environment. But this heat is not having an impact on the axial heat flow that much. The heat from the environment is entering to the rod from its curved surface. That means radially. The axial heat flow is asked from the question.

Even the question asks about the heat flow of a moment. That moment can be the starting moment also. As the rod is there, a variation like (5) is very justifiable and fair.

This question is given is not to find answers but to eliminate the variations which are not possible. R_Q cannot be a constant and cannot be linear (as it is not covered). It cannot increase with x. Even if we consider the heat absorbed from the environment, then it cannot increase with x. Only (5) is left. The 60th question is given to find out the eliminating choices.