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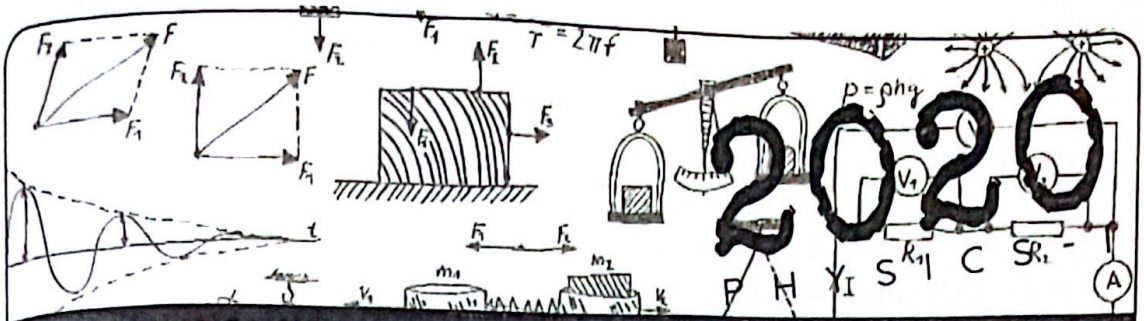
SDISCUSSIONGROUP



General Certificate of Education (Adv. Level) Examination

01. Dimensions of Planck's constant are,

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

Unit and Dimentions 01

The simplest equation with Planck's constant is E = hf. Therefore, you can get the dimensions of h from the division of dimensions of energy [M (mass) LT^{-2} (acceleration) L (distance)] by the dimensions of frequency (f = 1/T). So, the dimensions of Planck's constant are $ML^2T^{-2}T = ML^2T^{-1}$. If not, form the unit of h (Js) we can get its dimensions. Another easy method is to keep in mind that the dimensions of h and angular momentum are same. Angular momentum = $I\pi = mr^2\pi = mr^2 2\pi f = ML^2T^{-1}$.

What is the secret of having the same dimensions in Planck's constant and angular momentum?

The earth rotates around the sun. Therefore, it has an angular momentum. Likewise, the earth rotates around its own axis. Therefore, there is a spin for the earth too. Likewise, there is a spin for the fundamental particles. According to quantum mechanics, the numerical value of the spin of an electron is ½ $h/2\pi$. As $h/2\pi$ = Therefore, it is not a surprise that the dimensions of h becoming equal to the dimensions of angular momentum. Spin is considered as a specific characteristic or as an inherent angular momentum that the particle has. In 2013, the units of Planck's constant had been asked.

02. **Figure (a) shows the scale of a micrometer screw gauge when the spindle and the anvil touch each other. Figure (b) shows the scale when a metal sphere is properly placed between the spindle and the anvil. The pitch of the screw is 0.5 mm and the circular scale is divided into 50 equal divisions.**

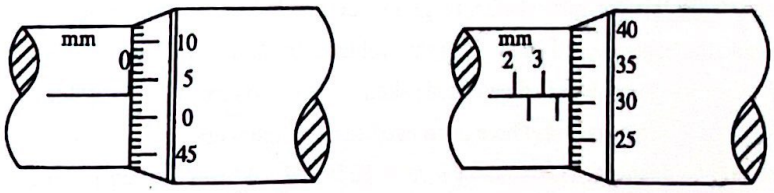


Figure (a)

What is the correct diameter of the metal sphere?

(1) 3·28 mm (2) 3·31 mm (3) 3·78 mm (4) 3·81 mm (5) 3·84mm

Measuring Instruments 01

Cannot you get the value from your memory? Actually, you can. Such students can score more than 40 correct answers easily. Many say that such papers are hard because the time runs out. It is not the difficulty in Physics. You need to get the answers quickly in a limited time. If you master this skill, then you should be able to solve the given questions in two hours. But you need to work hard to get the skill and the ability.

You need to think in a new way without doing the questions in the traditional way. If you try hard, then it is not unachievable. Why is this hard for quick sms sending and social media handling people like you? All you need is the need.

As soon as you see the figure (a), you can see directly that the zero error of the micrometer screw gauge is 0.03 mm. It has been given that the sleeve has been divided into 0.5 mm whereas the circular scale is divided into 50 parts. Actually, these points are not needed to be given. The micrometer screw gauges in the laboratories are divided in this way. Even though the least measurement of the vernier caliper can be changed (as some are 0.1 mm and some are 0.02mm), every micrometer screw gauge is made in this way. The least amount is 0.01 mm. In figure (a), you can just see zero of the main scale. It indicates that the circular scale has been rotated little bit more. However, the circular scale is rotated to 0, 5, 10 side. No to the other way (0, 45, ...). Therefore, to get the correct reading according to figure (a), you need to understand that the zero error should be reduced (as it is rotated more). Next, according to figure (b), it is clear that the reading is 3.81 mm (3.50 + 0.31).

It is clearly visible that 3.5 mm of the main scale has been passed but has not gone towards 4.00 mm. When 0.03 is reduced from 3.81, the answer is 3.78 mm. If you cannot do this from your memory (you can do it), then you only need to write (3.81-0.03) in your rough sheet. There are many such questions in the past papers (1996 and 2000). Do not use the zero error as positive and negative. What is important here is that the identification of the error as an addition or as a subtraction to the reading.

3. The threshold of hearing of a normal human ear is 10^{-12} W m^{-2}. This corresponds to a sound intensity level of

(1) 0 dB (2) 1 dB (3) 10 dB (4) 12 dB (5) 120 dB

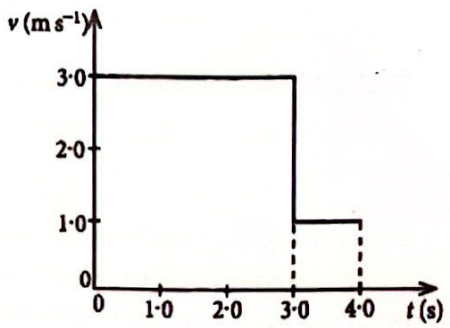
03 *Intensity of Sound*

There could have been many students who did not give the correct answer to this question. Look at the 2nd question in paper 2001. It was as follows. 'The sound intensity of 10^{-12} Wm^{-2} is interpreted as 0 decibel level. When the intensity is 10^{-8} Wm^{-2}, the sound intensity level will be...'. Children do many things in online mode. If possible, they go to classes. Or else they bring a teacher to home. They do many questions and even very complex questions. These are good things. But if a question related to a past paper is given, they get confused. You can ask "who is this? what does s/he do?" only.

The threshold level is 0 dB. It is doubtful whether by giving the threshold value as 10^{-12} Wm^{-2} was a question. The people who made the paper should have given this value to emphasize it as the threshold value. I feel that it is better, if it was not given. But as it had been asked in 2001, you cannot say anything against it too. You need to find the answer in a second. There is no need to do rough work here. For students who feel to do rough work can do like this way. The intensity level = 10 log I/I_0; When $I = I_0$, log 1 = 0 (as $10^0 = 1$)

4. The figure shows the velocity (v) - time (t) graph for an object moving along a straight line. What is the average velocity of the object from $t = 0$ to $t = 4$ s?

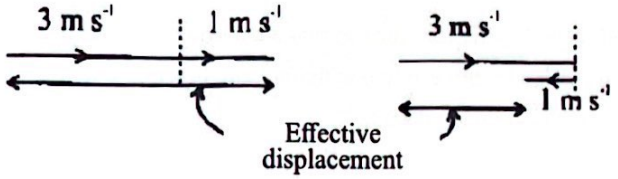
(1) 1·5 m s^{-1} (2) 2·0 m s^{-1}
(3) 2·5 m s^{-1} (4) 2·7 m s^{-1}
(5) 3·3 m s^{-1}



02 *Linear Motion*

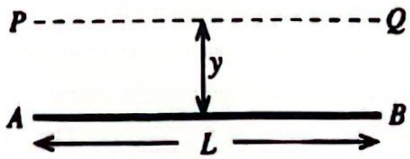
This can be done from the memory. If you think honestly without blaming anyone, then it is true. The interpretation of the normal velocity is the division of total displacement from the time taken for that displacement. From the area of a v-t curve with the time axis, you can get the displacement. You can find the area just by looking at the figure. For convenience, the people who made the paper has drawn dashed lines too. Area of the first square = 3 x 3 = 9; Area of the second square = 1 X 1 =1. Who cannot do this by memory? 3 by 3 is 9. 1 by 1 is 1. When 1 is added to 9, it is 10. How much is it when 10 is divided by the total time of 4 s? 10/4 =2.5. If needed, then you can write these on your rough paper. Should not we be ashamed as teachers of mathematics when the younger generation who quickly send sms, do WhatsApp and put comments on social media in a flip of a second cannot do division of 10 by 4?

Here both displacements take a positive value. Therefore, addition can be done quickly. To which occasion does such v-t graph is corresponding? An example for this motion can be an instance where an object travels at a uniform speed and goes to the same direction with a lower speed after it hit on an obstacle or entered an area of friction. If the direction of the velocity is reversed after the collision, then the direction of the velocity gets negative. Then the displacement also gets negative. In such an occasion, you need to consider the negative sign when considering the net displacement.



It is wrong to take 1.5 ms^{-1} which is the half of 3.0 ms^{-1} for the average velocity. In 3 s it has gone in 3.0 ms^{-1} where as in 1 s it has gone in 1.0 ms^{-1} velocity. Therefore, to find the average velocity, always use net displacement/ time taken. If average speed was asked, then you can consider the distance instead of the displacement. Displacement is a vector but distance is a scalar. Therefore, negative signs are not considered when taking distances.

5. The figure shows a thin uniform rod *AB* of length *L* and mass *M*. Moment of inertia of the rod about axis *PQ* parallel to the rod, situated at a distance y is,

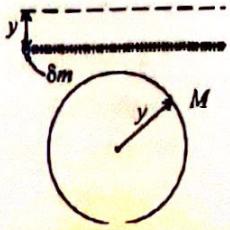


(1) My^2 (2) $M(L^2+y^2)$

(3) $\frac{1}{3}ML^2$ (4) $\frac{1}{2}M(L^2+y^2)$

(5) zero

There is nothing to think in this question. Some have mentioned that to solve this, you need parallel axis theorem which is not in the syllabus. The axis of PQ is parallel to rod AB. It is true. The distance to PQ from any place of AB rod is y. Therefore, is not the moment of inertia of the rod around PQ axis is My^2? If needed, then you can divide the rod into small parts of δm Each mass element is in equidistance with PQ. So, what else do you need?



You know that the moment of inertia of a thin ring with a radius y and a perpendicular axis across its centre is My^2. If you know this, then why cannot apply the same logic to the given rod? The distance from the centre to anywhere is equal. If needed, then make the ring straight by cutting it. But you also need to turn the axis parallelly to the rod.

06. The quark content of a proton (p) and a neutron (n) are respectively given by,

(1) ssd, sdd (2) udd, uus (3) ssd, uud

(4) uud, udd (5) udd, uud

11 Partial Physics

This question is asked from the newest part that was added into the syllabus. Only u and d quarks are needed to make p and n. The charge of a u quark is +2/3e. The charge of a d quark is -1/3. You should know these things. Use the following table to keep in mind.

$$u\,c\,t \rightarrow +\frac{2}{3}e$$
$$d\,s\,b \rightarrow -\frac{1}{3}e$$

To keep in mind about uct, us ethe three words of university Colombo teacher. The charge of the first row is +2/3e. The second row's charge is -1/3e. The charge of p is +e. To get it, the quark composition of p it should definitely be uud. (+2/3 +2/3-1/3) e = +e. As n is neutral, to get it, the quark composition should be udd. (+2/3-1/3-1/3) e =0.

If u quark is male and d quark is female, then to make a p you will need one female for two males. For n, two females for one male. Two males can live with one female without a problem, but I doubt whether two females can live with a male without a dispute.

07. Which of the following statements made regarding seismic waves is incorrect?

(1) all seismic waves are mechanical waves and require a medium to propagate.
(2) Primary (P) waves are longitudinal and secondary (S) waves are transverse.
(3) Speed of S - waves is less than that of P - waves.
(4) S - waves can travel through both liquid and solid media.
(5) P - waves can travel through both liquid and solid media.

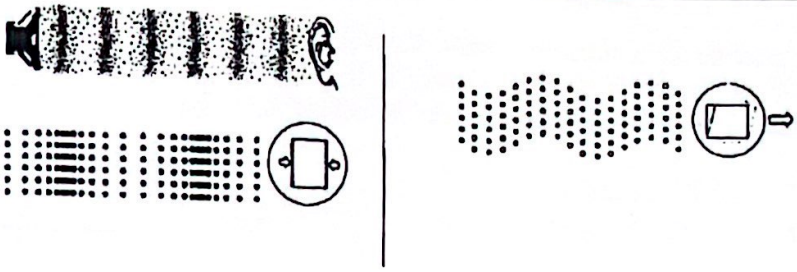
03 Wave Properties

If the 6th essay question paragraph of paper 2015 was studied properly, then the answer can be obtained very easily. Geo vibrational waves are mechanical waves. Geo vibrational waves are produced from the collisions inside the earth's core. Once the name of geo vibrational waves is mentioned, then spontaneously it is felt that they are mechanical vibrational waves. A medium is needed to have mechanical vibrations. Only electromagnetic waves do not need a medium for propagation. Therefore statement (1) is correct.

P waves are known as primary/ pressure/ push-pull waves whereas S waves are known as secondary/shear/ shake waves. If P waves are remembered as pressure waves as letter p in pressure waves, then it is easy to keep in mind.

It is clear that pressure waves are always longitudinal waves. Even sound waves are also pressure waves. Sound waves are longitudinal. As there are pressure variations, there are compressions and rarefactions. In a longitudinal wave, when one place is pulled, the other place is stretched.

S waves should be remembered as shear waves. (Letter s in shear) Shear is a change of shape. When longitudinal/pressure waves are transferred there is no change of shape in the medium. It is getting compressed and relaxed. But when a transverse wave is travelling the shape of the medium gets changed. Recall the transverse waves of a stretched string, the transverse waves on a water surface etc.

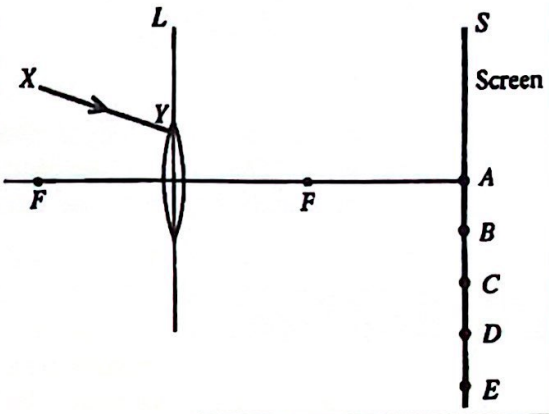


Therefore, P waves are longitudinal and S waves are transverse. The statement (2) is also correct.

The speed of longitudinal waves is greater than transverse waves. Push and pulls are quickly propagated. High and low twisted ones are being slowly propagated. In a queue where all are connected, when a person in one corner started pulling, the person in the other corner can feel that pull in a little time. When a person in a corner is being dragged for a certain direction, the person in the other end of the queue can feel it after some time. Therefore, the speed of S waves is slower than P waves.

It is a known fact that transverse waves cannot travel in liquids or gases (fluids). Therefore, statement (4) is false. Longitudinal waves (P waves) can travel across fluids. Transverse waves cannot be travelled across mediums without connections. Even there is a relation or not, it can be pulled. But when one person is removed from a set of people with no relation or with weak relations, the others will not feel anything. (Look at the essay paragraph question of 2015)

8. A narrow beam of monochromatic light *XY* falls on a converging lens *L* as shown in the figure. After refraction through the lens, the beam hits the screen *S* and makes a light spot. What would be the position of the light spot?

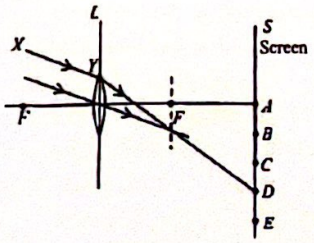


(1) *A* (2) *B*

(3) *C* (4) *D*

(5) *E*

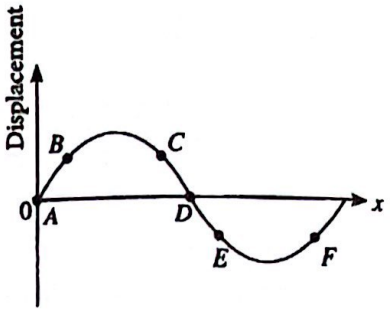
A small design should be done on the paper. Draw a line across the optical centre of the convex lens that is parallel to XY. The ray of XY should come to the place where the focal plane is intersected. When that line is lengthened till it cut the screen, you will get the required place. When parallel rays are incident inclined to the main axis, they should meet a certain point at the focal plane. This is a question that has been checked many times (11th question of paper 2004, 11th question of paper 2010).



The answer is D. There is a high chance to take C as the correct answer. These arguments have been mentioned many times before.

But how such questions are still be hard cannot be understood by the world controlling gods too.

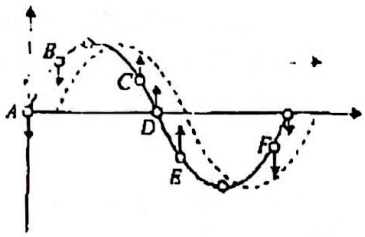
9. Positions of particles of a transverse wave travelling along $+x$ direction at a certain instance is shown in the figure. A pair of particles with same instantaneous velocities is,

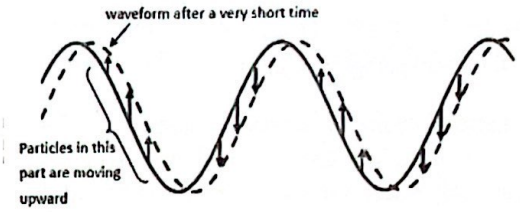


(1) *B* and *F* (2) *A* and *D*
(3) *B* and *C* (4) *C* and *F*
(5) *B* and *E*

03 *Wave Properties*

This question has been checked before (23rd question of paper 1985, 56th question of paper 1987, 22nd question of paper 1991, 22nd question of paper 1997). The easiest way to solve is to give a small displacement to +x direction. Look at the figure. To have equal velocities, not only the magnitude, the direction also should be equal. Here the points of A, B and F are moving downwards whereas the points C, D and E are moving upwards. According to the given pairs of the paper, only B and F are correct. If needed, then you can find more pairs and select. But those pairs are not in the paper.





10. A small instrument of mass 1·0 kg is placed on a planet. The mass of the planet is three times and radius is two times that of the earth. What would be the weight of the instrument on the surface of the planet? Neglect all the other effects except gravitation.

(1) $\frac{15}{4}$ N (2) $\frac{20}{3}$ N (3) $\frac{15}{2}$ N (4) 10 N (5) $\frac{45}{4}$ N

05 *Gravitational Force Fields*

This also can be done from the memory for a student with a normal brain. The mass of the planet is three times of the mass of Earth. But its radius is twice as Earth's radius. If so, then the gravitational acceleration on the planet should be ¾ times of the gravitational acceleration (10 ms^{-2}) of Earth ($g \propto M/R^2$).That means 30/4. As the mass of the apparatus is 1.0 kg, the mass will be this value. 30/4 is not in the answers. There is 15/2. The children who cannot do from the memory (those who do not try) do like this way.

For earth, $10 = GM_E/R^2$; for the planet, $g' = G(3M_E)/(2R)^2 \rightarrow g'/10 = 3/4$; $g' = 30/4$

As the mass is 1.0 kg weight = $mg' = 1 \times 30/4 = 15/2$ N

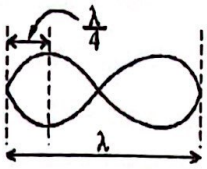
You can do it like this way. But once they come out when two hours are gone, they come by crying while cursing.

11. Two identical transverse waves of frequency 300 Hz and speed 30 m s^{-1} travelling in opposite directions along x-axis, superimpose with each other and produce a standing wave. The distance between a node and its adjacent anti-node is equal to,

(1) 2·5 cm (2) 5·0 cm (3) 10·0 cm (4) 15·0 cm (5) 20·0 cm

05 *Transverse Waves*

Cannot this be also done from the memory? If the speed is 30 ms^{-1} and the frequency is 300 Hz, then the wave length is equal to 30/300 = 0.1 m. That is 10 cm. The distance between a node and its adjacent anti-node is λ/4. Is not it? The answer is 2.5 cm. The children who think a lot are doing like this way. They even draw.

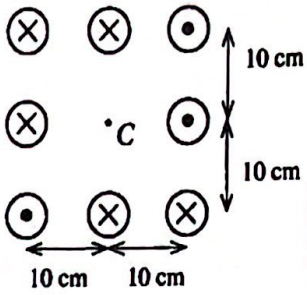


$V = f\lambda$; $30 = 300\lambda$; $\lambda = 0.1$ m = 10cm
Therefore, $\lambda/4 = 10/4 = 5/2 = 2.5$ cm

Two hours are gone when doing 30 questions for such children who do like this way. There is no other alternative than insulting the people who made the paper.

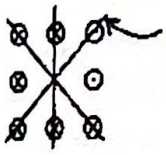
12. Very long eight parallel wires each carries a current of 10 A. The directions of the current in each wire are shown in the figure. The magnitude and the direction of the magnetic flux density produced at the centre (*C*) are,

($\frac{\mu_0}{4\pi} = 10^{-7}$ T m A^{-1} ; Neglect the effect of earth's magnetic field)

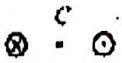


(1) 20 μT ↓ **(2) 20 μT ↑**
(3) 40 μT ↑ **(4) 40 μT ↓**
(5) 40 μT →

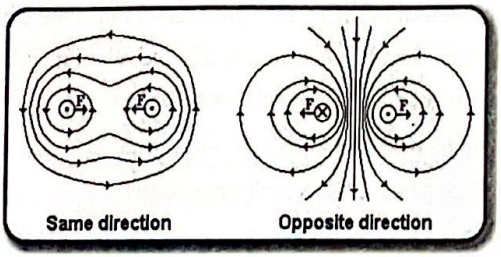
This is an imitation of the 17th question of paper 2019. In 2019, there is charge. In 2020, there are wires that carry currents instead of the charge. The same logic applies here. Except the two current carrying wires that are horizontal across point C, all the other wires are equidistant from each other (relative to point C) by carrying the current to the same direction. Therefore, the magnetic flux density created at point C by these corresponding pairs are cancelled off with each other. It is a known fact that there is a null point (where the magnetic field density is zero) in two equal current carrying straight wires in the same direction. So, in the given wire arrangement, you need to consider the following two wires according to the figure.



Remove all of these and you need to consider only these two wires.



The magnetic flux density at C due to one wire is $\mu_0 I/2\pi r$. The magnetic flux density from both of the wires is $2\mu_0 I/2\pi r$ (the magnetic flux density in the middle of two equally current carrying wires to different directions are being added). $(4 \times 10^{-7} \times 10)/ 10 \times 10^{-2} = 4 \times 10\text{-}5 = 4$ μT. The direction is ↓



Only this should be in the rough sheet. There could have been students who considered the magnetic flux densities at point C due to all the wires. May them be blessed! The unawareness of finding the magnetic flux densities by considering every wire will not be given to MCQ and it is equivalent to the unawareness of the tedious task to loving eight boys/girls simultaneously. They have not learnt from the 17th question of paper 2019.

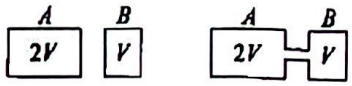
13. **Two adjacent rooms A and B at same temperature, connected by a closed door are initially at relative humidity (RH) 60% and 90% respectively. The volume of room A is twice that of room B. If the door is kept open for a long time at the same temperature, what would be the final relative humidity of the rooms?**

(1) 65% **(2) 70%** **(3) 75%** **(4) 80%** **(5) 85%**

04 **Hygrometry**

The method of traditional, non-creative people who blames the fathers of paper makers:

For this method, it is better to draw the rough sketches of before and after situation for two rooms.



Before After

Think that the mass of the water vapour in room A as m_1 and mass of water vapour as m_2 in room B before opening the door. As the temperatures are equal, if m is the water vapour mass needed to saturate room B, then 2m is needed as the water vapour mass to saturate room A. According to the interpretation of relative humidity, $60 = (m_1/2m) \times 100$; $90 = (m_2/m) \times 100$

Once the door is opened, the total water vapour mass is m_1+m_2. The needed water vapour mass is 3m to saturate both rooms.

New relative humidity $= (m_1+m_2/3m)100\% = [\{(60/100) \times 2m + (90/100) \times m\}\ 100\%]/3m = \{(120+90)/(3\times 100)\} \times 100\% = 210/3 = 70\%$

The method of students who love to think new and be creative:

They do not draw figures. There is no need to dream about a size of a room. As there is no temperature change, to saturate room A, you need double the mass of water vapour that is needed for room B. If we think simply, the water vapour mass needed to saturate is proportional to the volume.

It is like this way. If the volume of a tea cup is V and m is the mass of sugar that is needed to saturate tea, then for a volume of 2V at the same temperature you will need 2m mass of sugar. Likewise, to saturate a volume of 3V, you will need 3m mass of sugar.

The shortest method to find the answer is $\{(60 \times 2) + (90 \times 1)\}/3 = 210/3 = 70$

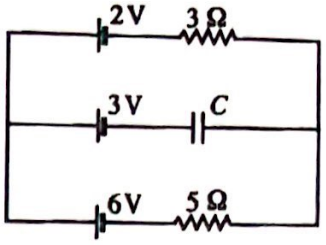
2 from 60 and 1 from 90 and when all are added, they are stored in 3. Such students do not take 100 for the calculation. However, 100 (percentage) is everywhere. A thing that is everywhere is ok to attach at the end.

This has become a MCQ because the temperature is constant in it. If the temperature is changed, then it will not be a MCQ. If a MCQ is not viewed as MCQ, then you cannot finish the paper in two hours.

If you think more on this question, then this question is like the relation $(P_1V_1 + P_2V_2)/(V_1 + V_2)$ where P refers to pressures and V refers to volumes. These relations can be written if the temperature is constant.

If needed, the above relation can be modified into $(R_1V_1 + R_2V_2)/(V_1 + V_2)$ for relative humidity where R is relative humidity. (35th question of paper 2007 is such a question.)

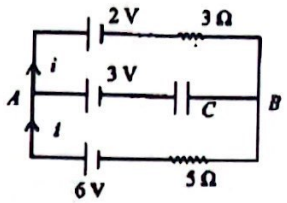
14. **All batteries shown in the circuit diagram have negligible internal resistances. If the capacitor C is ideal, what is the potential difference across C?**



(1) 0·5 V **(2)** 1·0 V
(3) 2·0 V **(4)** 2·5 V
(5) 3·5 V

Korchoff's Law - Combination of Cells 08

Such circuits can be seen in previous past papers. The nearest instance is the 53rd question of paper 2012 (old syllabus).



Once the steady state is reached, the network with capacitor does not flow any current. However, our syllabus has steady state circuits. That means the circuits are being completely charged. So, the current flows in the external circuit. Cannot you get the current in it from your memory? 6V is greater than 2V. Therefore, the current flows according to the direction that is shown in the figure.

Net e. m. f is 4V (6-2). Net resistance is 8 Ω (5 + 3). Therefore, the current = 4/8 =1/2 A.

Therefore, if we look from below, then V_{AB} = 6 - (½ x5) = 3.5 V. So, the potential difference across C is 3.5-3 =0.5 V. If you look from above, then V_{AB} =2 + ½ x 3 (E + ir) = 3.5 V

If you practice, then it is easy to do it from your memory. These are not tasks for our intelligent children who type text without looking at the keyboard. Are they? When 2 is subtracted from 6, it is 4. When 4 is divided by 8, it is ½. According to (E -ir), 6 - (½ x5) = 3.5 V (at the bottom). Out of it 3V belongs to the battery. The rest should be across C.

15. **Which of the following statement is incorrect?**

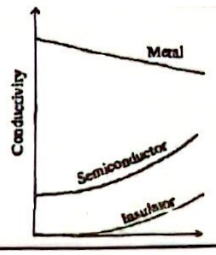
(1) The electrical conductivity of an intrinsic semiconductor increases with increasing temperature.
(2) A full-wave rectifier cannot produce a constant d.c. output voltage for a sinosoidal input.
(3) In a bipolar transistor, the emitter is heavily doped than that of the collector.
(4) Drain current (I_D) of a Junction Field Effect Transistor (JFET) is maximum when Gate to Source voltage is zero ($V_{GS} = 0$).
(5) When an op-amp is used as a voltage comparator, closed loop state is used.

Transistors 09

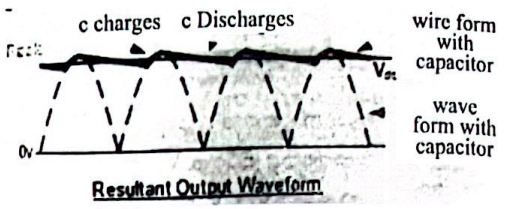
Whole syllabus of 'electronics' has been mentioned in this. Most of the time, statement (2) can be taken as false. But the false statement is (5). We will check the statements.

In a conductor, there are free electrons as we know. When the temperature goes higher, as these electrons have more collisions with the atomic lattice of the conductor, the resistivity goes higher and the electric conductivity gets reduced.

But when the temperature goes higher in semiconductors, more and more covalent bonds are broken and charge carriers (electrons and holes) are being released. When temperature is increased, even charge carriers have more collisions with the stationary lattice, the net electric conductivity is increased due to increment of the carriers by breaking bonds. Therefore, statement (1) is true.



At a glance, you can see that statement (2) is false. There can be question that why a full wave rectifier cannot give a direct voltage output. The logic here is that from the full wave rectifier part alone is unable to give a direct voltage output. The output from the rectifier should be smoothened.



Resultant Output Waveform

The output from the full wave rectification alone is shown in figure 1 by dashed lines. What happens there is making of the negative part of the alternative input into positive only. The complete circuit that gives a direct voltage from a sinusoidal input is shown in figure 2.

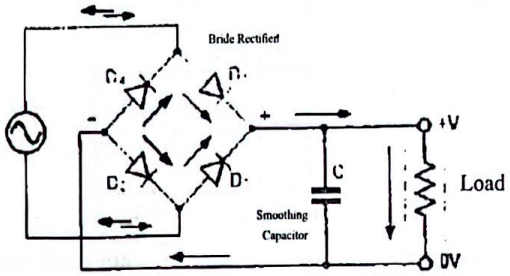
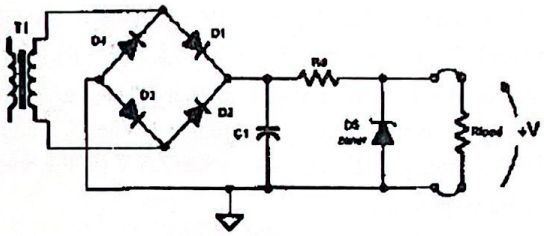


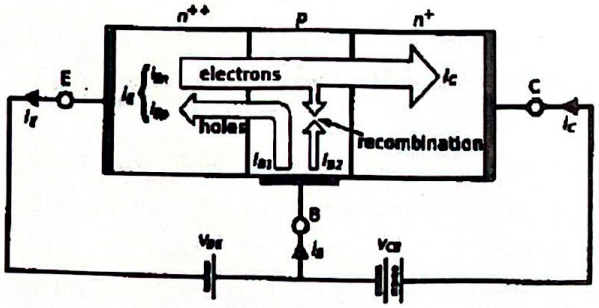
figure 01

If you need a more constant and stable dc output, then a Zener diode has to be used (figure 3). These are things that you learn. In essay 9 (B) question of paper 2013, these circuits are being described in detail.

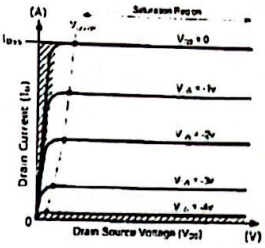


(figure 3)

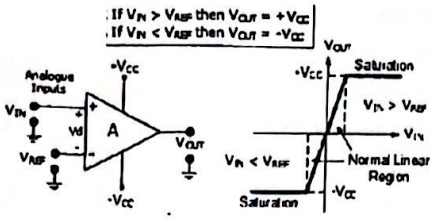
Statement (2) is true. This can get wrong. If so, then for this it can be forgiven.
The main duty of an emitter in a transistor is to emit/ inject the electrons/ charge carriers across the base. The collector is given its name as it collects the electrons from the base. There should be goods to emit in the emitter. A small amount of emitted charge carriers is given to the base and then given to the collector that collects the rest of all. Therefore, statement (3) is true.



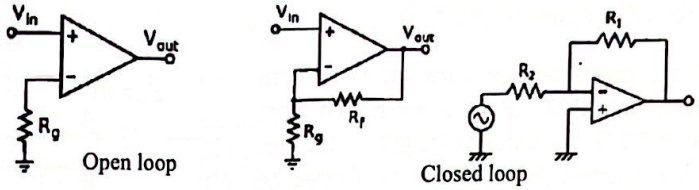
The gate current (I_D) is maximum when $V_{GS} = 0$. When the gate is opened, everybody can go. In a JFET, always $V_{GS} < 0$. To make V_{GS} negative, the gate is closed. $V_{GS} = 0$ means the gate is completely opened.



The figure has shown how an operational amplifier can be used as a voltage comparator.



A comparator is used to compare voltages. When $V_+ > V_-$, then V_{out} gets positive. When $V_+ < V_-$, then V_{out} gets negative. It compares the difference of V_+ and V_-, then changes V_{out} accordingly. Here the op-amp is working on the open loop state not at the closed loop state. The states of open loop and closed loop are shown in these two figures.



If simply said, then the two modes that op-amp functions can be explained like this way.

Open -loop: The output is only active in the two output instances of + VCC or -VCC. That means op-amp is working on as a switch (switch on-off) comparator only. Open loop means that it does not connect with a resistor with negative feedback. The op-amp is open. Open as it is not covered with a resistor.

Closed -loop: Here always the amplifier is working under negative feedback. As shown in the above circuits, the op-amp has been closed by a resistor of R_f/ R_1. The output of this never reaches the saturated state and the circuit behaves linearly in the meantime. Do not get confused with this and the essay question of 9(B). The question of 9(B) has a differential amplifier not a comparator. It works on closed loop state. The false statement is (5).

16. A particle of mass *m* performs a simple harmonic motion. If the maximum velocity and the maximum acceleration of the particle are *V* and *a* respectively, the angular frequency (ω) of the particle is given by,

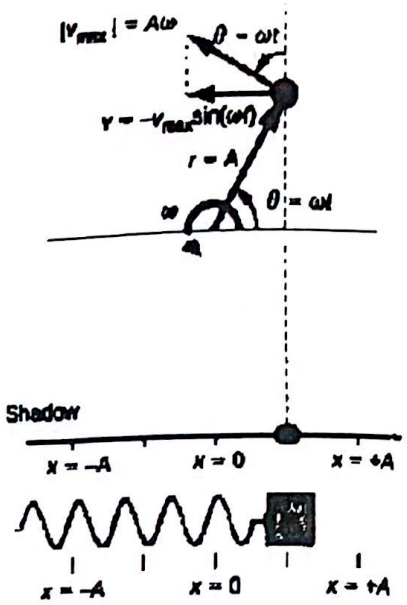
(1) $\frac{V}{ma}$ (2) $\frac{2\pi V}{a}$ (3) $\frac{2\pi a}{V}$ (4) $\frac{a}{V}$ (5) $\frac{V}{a}$

Simple Harmonic Motion 03

Maximum velocity V of simple harmonic motion is obtained by $V = A\omega$. A is the amplitude of the motion. The expression that gives the maximum acceleration numerically is $a = \omega^2 A$. When the second is divided from the first, you will get $a/V = \omega^2 A / A\omega = \omega$. $a/V = \omega$. The main relation that decides the simple harmonic motion is acceleration = - constant X displacement. The constant is represented by ω^2. Maximum acceleration is obtained when there is maximum displacement (amplitude).

Even without using these equations, you can get the correct expression in a cunning way. The unit of ω is s^{-1}. That unit is obtained by a/V. $ms^{-2}/ms^{-1} = s^{-1}$. a/V is only there in 2πa/V (3rd choice) and a/V (4th choice). There is no term of 2π for ω.

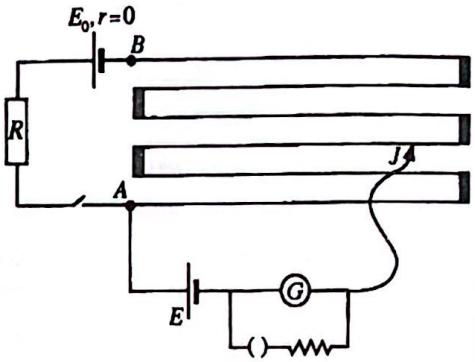
Is there a difference between angular frequency and angular velocity? The projected motion is in simple harmonic motion along the diameter in a circle when a particle travels in a uniform velocity around a circle. This is the easiest way to learn the simple harmonic motion mathematically. Look at the figure. When the particle undergoes the circular motion, its angular velocity is ω. The projected motion on the diameter has an angular frequency. Or else a linear frequency which is given by $f = \omega/2\pi$. If by mistake if you find f, then the term 2π should be there as 1/2π. That means f = 1/2π. a/V. This expression is not in the answers. Therefore, numerically same angular velocity and angular frequency are inter-related with each other.



When the simple harmonic motion and the circular motion are taken into consideration, it can be just seen that the maximum velocity of simple harmonic motion is Aω. You have learnt that the maximum acceleration is $\omega^2 A$ (look at the 17th question of paper 2018).

17. The length of the potentiometer wire *AB* is 600 cm and its resistance is 10 Ω. *R* is a resistance box. When *R* is set to 70 Ω the balance length is 280 cm. What will be the distance that sliding key *J* must be moved from the previous position to balance again if *R* is changed to 80 Ω?

(1) 45 cm (2) 40 cm
(3) 35 cm (4) 30 cm
(5) 25 cm



You must have consumed more time for this. Solving of this problem can be expanded from the shortest method to the time-consuming methods.

Very shortest method:

The wire is same on both occasions. Same E is being balanced. Only R value is being changed. When R is changed, the current across the wire is changed. When R is increased, the flown current gets reduced. When the current is reduced, the balanced length will be greater. Therefore, the balanced length should be proportional to (value of R + the resistance of the wire). The current across the wire varies according to the series addition of the resistance of the wire and the value of R. E_0 is unchanged.

Therefore, new balanced length = (280/80) X 90= 315 cm. If 80 is for 280, then how much for 90?

So, the distance that the sliding key should travel = (315 -280) cm = 35 cm

How easy to do like this way?

Longest method:

E =kl; here, k is the potential drop per unit length. The current across the wire in the first instance (i)= E_0/ (70+10) = E_0/80

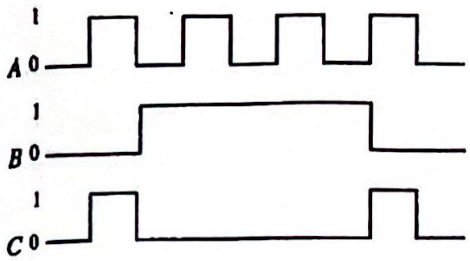
The potential drop per unit length = (i X 10)/600 = (E_0/80) x (10/600)

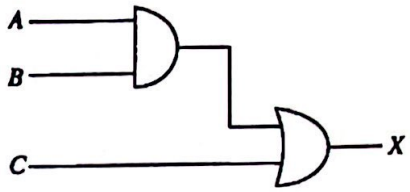
Likewise, the potential drop per unit length in the second instance = E_0/(80+10) X 10/600 = (E_0/90) x (10/600)

Now if l' is the new length, then E ={10 E_0/(80 X 600)} x 280= {10 E_0/(90 x 600)} l'→ l'=(280/80) x 90

You will get the previous answer. Actually, the length of the wire is not needed to be given. There can be longer methods than this one.

18. Logical inputs *A*, *B* and *C* of the given circuit is shown below.





The shape of the correct output (*X*) is,

(1)

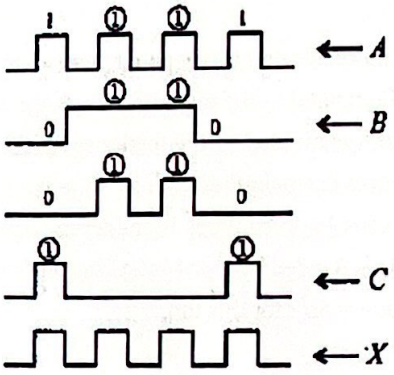
(2)

(3)

(4)

(5)

No need to take more time. 1 comes from AND gate only when both inputs are given 1. According to that both of the input of A and B get 1 only in two occasions.

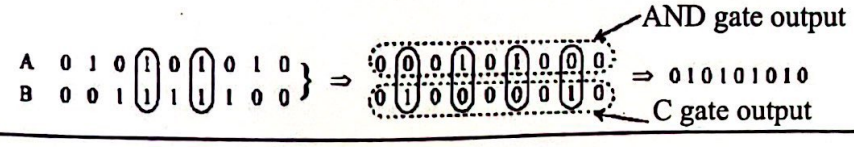


The output of AND

For OR gate, only one is enough to get 1.

The output gets zero when both inputs get zero. So, the output of X is equal to the input of A.

If you write 0 and 1 sequentially in the rough sheet, you can get the answer. But it takes time.



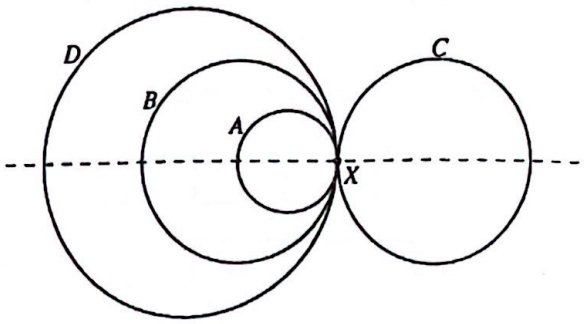
If you think in a simple way, then the middle two of A is there when going across the A gate. The input of C gives back the disappeared two (33rd question of paper 2014).

19. The combined object, illustrated in the figure is formed by joining four metallic rings A, B, C and D of radii r, $2r$, $2r$ and $3r$ respectively made out of same uniform wire. The distance to the centre of gravity of the combined object from point X is,

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

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

(5) zero

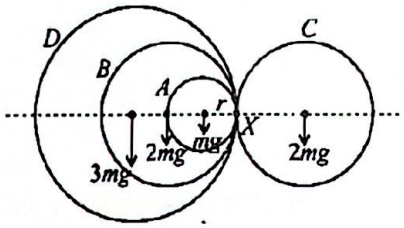


02 *Centre of Gravity*

The method that blames the mothers of the paper maker:

If the weight of the smallest wire is mg, then mark the weight of other wires in the figure. The total weight of the wires is 8mg. If the distance from X to the centrre of gravity is x, then taking moments around X, 8 mgx = 3mg x 3r + 2mg x 2r +mg x r -2mg x 2r

The moments from the wires to the left side of X are anti-clockwise whereas the wire that is to the right creates a moment that is clockwise. 8x =9r +r =10r; x =10r/8 = 5r/4



The method of children who believe that they can solve it quickly:

The combined centre of gravity of B and C wires are at X. Therefore, we will forget about them when taking moments (even they are being cut off if moments are taken). Compared to the mass of wire A, the mass of wire B(C) is double. In D, it is triple. When the total of moments is divided by the total mass of the wires, then the required answer is obtained. Such children's rough sheet has only these things. (3 x 3r+ 1 x r)/8. Even this is not needed. This is enough. 10r/8 (3x3 is 9 and 1x1 is 1). Even wires B and C are forgotten to take for moments, they should be added to the total mass. If 10 r is divided by 6 or 4 by saying that moments are forgotten, then the answer is wrong. There is an answer 10r/4 = 5r/2 for this too.

20. Water and coconut oil are poured into the two limbs of a U-tube as shown in the figure. Assume that the water - oil interface is at the middle of the tube and it is vertical. (ρ_w = density of water, ρ_o = density of coconut oil) Consider the following expressions about this situation.

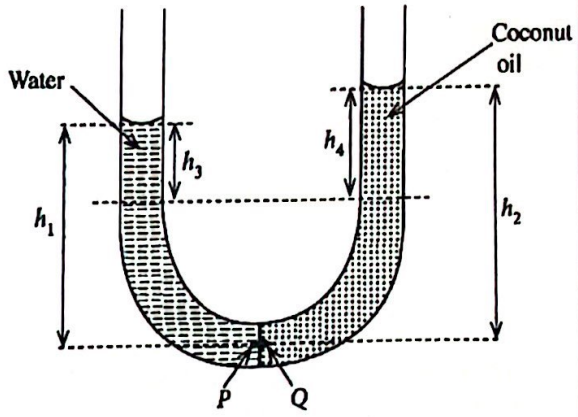
(A) Pressure at point P = Pressure at point Q

(B) $h_1\rho_w = h_2\rho_o$

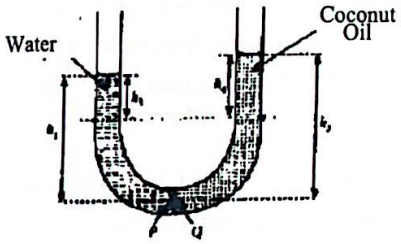
(C) $h_3\rho_w = h_4\rho_o$

Of the above expressions,

(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.

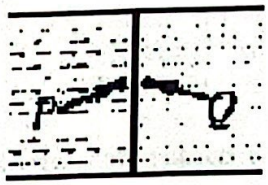


There is nothing in this question. The interface is in equilibrium. There is a logic which says that the interface cannot exist. It is not true. If such an opportunity is not obtained every time, then can be obtained if needed. There is no point in thinking about surface tension forces in such problems of U tubes. There is no mention about it.



So, if the pressure of point P is equal to the pressure of point Q, then obviously $h_1\rho_w = h_2\rho_o$. Likewise, it is evident that it cannot be $h_3\rho_w = h_4\rho_o$. The horizontal reference level is not there for the same liquid. This argument is not valid for points P and Q. The interface that the two liquids are there vertically as mentioned in the question. If the pressure of point P is greater than the pressure of point Q, then point P tries to go to the and right tries to equalize the pressures. If not, then the interface will move towards the vertical arms of U tube.

As P and Q points are not in the same liquid, there can be a problem that how can the pressure of those points be equal. If we consider the horizontal liquid part of P and Q points, then the weight of the liquid part is not affecting the liquid pressure. Therefore, as the liquid part is at rest, according to the figure the pressure of the two sides of the interface should be equal. But for vertical arms this argument cannot be applied. There is a pressure due to the weight of the liquid. So, the pressures in two different liquids from the same horizontal level cannot be made equal.

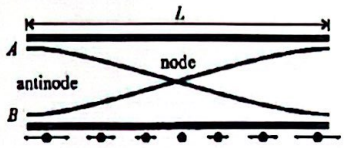


21. **Two identical opened pipes each of length 50 cm are sounded with their fundamental notes at 15 °C. The variation of velocity of sound v ($m\,s^{-1}$) in air with temperature is given by $v = 331 + 0{\cdot}6\theta$, where θ is in °C. If the temperature of one pipe is raised to 30 °C, what would be the number of beats produced per second?**

(1) 4 **(2) 6** **(3) 9** **(4) 12** **(5) 14**

03 *Velocity of Sound*

The method in which the mothers and fathers of the paper makers get insulted: Such children will definitely draw a figure like this way.



As the length of the tube is 50 cm, $\lambda = 2l = 1$m.

Sound speed at 15°C $v_1 = 331 + (0.6 \times 15) = 340$

Sound speed at 30°C $v_2 = 331 + (0.6 \times 30) = 349$

By applying $v = f\lambda$, $340 = f_1 \times 1$; $349 = f_2 \times 1$; $f_2 - f_1 = 9$ Hz

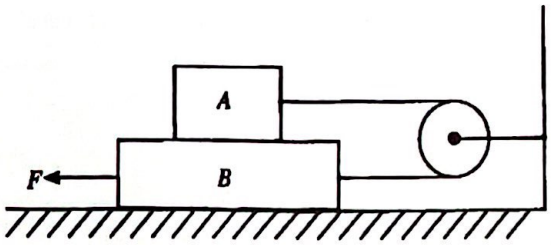
The children who can present logic and like to win challenges while having persistence do this from his/her memory. They think like this way.

When the tube is open with both ends, λ of the fundamental tone is double the length of the tube. Such facts are in their memory store. As the length of the tube is 50 cm, $\lambda = 100$ cm or 1 m. L =50 cm is given to simplify the calculation. As $\lambda = 1$m, the difference of frequencies (beat frequency) is equal to the difference of the velocities. In the expression given for velocity, you do not have to consider 331. Why? When you take the difference of the velocities, 331 will be cancelled off. Therefore, the difference between the velocities is 0.6 X temperature difference. The temperature difference is 15°C (30-15). So, the answer is 0.6 x 15. That means 9. All you have to argue to multiply 0.6 from 15. Can there be children who are unable to get it from memory?

There is a criticism that the end correction is not asked to neglect. There is a truth in it. But the paper makers have not mentioned may be because the question can be lengthy. In such questions, if there is no sign about end correction, then the normal tradition is to neglect it. Even if we consider the end correction, then the calculation cannot be done. Still there are criticisms that how do children know to neglect the change of length and the tube vibrate in the fundamental tone, when the temperature is increased. It is very good to criticize the questions and show the weak points.

When the temperature is increased by 150C, the change of length of the tube is negligible. If we take the copper tubes, then the change of length = $50 \times 17 \times 10^{-6} \times 15 = 0.01$ cm. By the increment of this tiny amount, there is no transfer from the fundamental tone to an overtone. This is not a respectable criticism.

22. **Two blocks *A* and *B* of mass 0·5 kg and 1·0 kg respectively are connected by a massless inextensible string which goes over a massless, smooth pulley as shown in the figure. The coefficient of dynamic friction between all contact surfaces is 0·25. What is the force *F* needed to drag the block *B* to the left with a constant speed?**



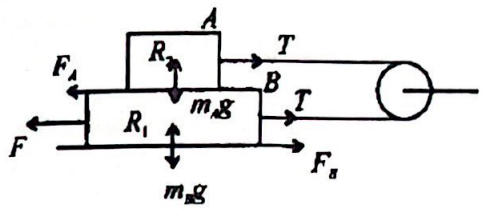
(1) 2·50 N **(2) 3·75 N** **(3) 5·00 N** **(4) 6·25 N** **(5) 7·50 N**

02 *Newton's Law and Momentum*

Even though this is a familiar question, this can be solved quickly or consuming more time. It should be decided by yourself not anyone else (46th question of paper 1989).

If you need to consume time, then you can mark all the forces like this way. But it is not necessary. Now apply ← F = ma to the blocks of A and B (to the system)

As it is moving at a uniform speed, a = 0. When you consider the system, the frictional forces from A to B and from B to A in the surfaces of A and B are being cancelled off with each other. What is left from the horizontal forces are the frictional force from the horizontal surface on B and 2T. The frictional force is μR.

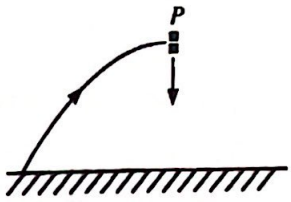


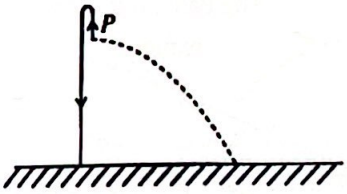
For R, you need to consider the weight of both blocks. The weight of both blocks is 15 N {(0.5 +1)10}. For convenience we will take μ =1/4. Then ←F = (¼ x15) + 2 T. T is equal to the frictional force in between the blocks. Its value is equal to ¼ X 5. Therefore, if you are a child who loves to do calculations quickly, then you should only have these on your rough sheet.

$F = (¼ X 15) + 2T = (¼ X 15) + (2 X ¼ X 5) = 25/4 = 6.25$ N.

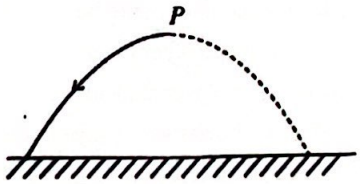
You can do it this way. All you need is the belief that you can do and the practice for it.

23. A projectile suddenly explodes into two fragments with equal masses at the highest point (*P*) of its trajectory. If one fragment falls vertically downwards with an initial velocity as shown, which of the following diagrams best represents the path of the other fragment?
(Neglect air resistance. The broken line represents the path of the projectile if there was no explosion.)

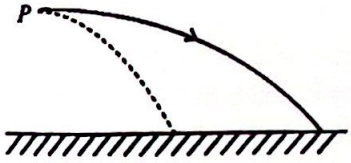




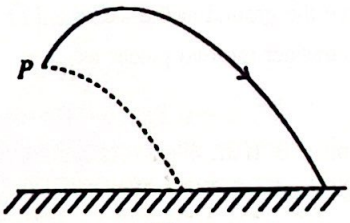
(1)



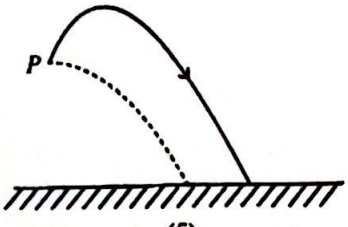
(2)



(3)



(4)



(5)

Once you see this question, you should remember the 53rd question of paper 2010. If you are a user of past papers, then you should remember that you have seen this question somewhere. There are two arguments in this question. The explosion happens at the highest point of the path. A moment before explosion the momentum of the projectile is acting towards the horizontal direction. After the explosion, one piece is fallen down vertically. Therefore, for linear momentum to be conserved, the other piece should have a component of momentum vertically upwards and another component of momentum to horizontally to the right-side. Otherwise, you cannot equal the momentum before and after explosion.

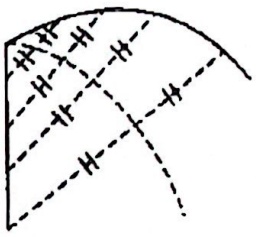
After explosion it cannot be like this way.

Then we cannot balance the horizontal momentum before explosion. Likewise, after the explosion, it cannot be like this way.

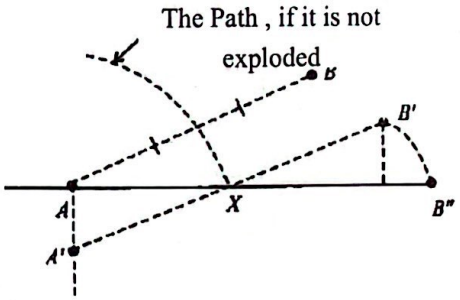
Then once after the explosion, the momentum of a piece in direction cannot be balanced. So, after the explosion, the other piece should go to a direction like this way.

It has been satisfied by only (4) and (5). You can remove (1), (2) and (3).

Next argument is that the explosion occurs due to an internal activity. The external forces are not affecting this explosion. In such an instance, the motion of the centre of mass of the system does not get affected. The internal forces are cancelled off with each other. The mass centre tends to go on the previous path. As the masses are equal in the broken pieces, their mass centre is located in the middle of their paths. We know the path of a piece. It is vertically downwards. We know the path of the projectile if there was no explosion.

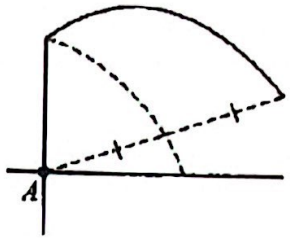


Therefore, the path of the dashed line should be just in the middle of the other two paths. As shown in the figure, the distance from the vertical piece to the dashed line should be equal to the distance from the dashed line to the other piece. It is clearly shown in (4). Some teachers and clever students have shown an issue that is not correct in the answer. They should be praised if they look at the question critically and show the weakness if there is any. The argument is built when the two pieces do not arrive the ground at the same time after the explosion. Let us consider the two pieces as A and B.



Piece A comes to ground before piece B. If the piece A is continuously moved from the moment that it hits the ground and if the projectile is not exploded, then the place where it hit will be X. At that moment, if the placement of A is A', then A'X = XB'. Therefore, the argument is that AX and XB'' does not have a possibility to be equal. It should be XB''> AX. But figure (4) has been drawn as AX = XB''. Therefore, we can think that there is no correct answer to the question.

But there is another point to remind. When the piece A is hit on the ground, there is an external force acting on it (the reaction from the ground). Therefore, after that our argument is broken which is at a moment the centre of mass should be placed at the point where the centre of mass places if there is no explosion. So, A'X=XB' is not accurately correct.

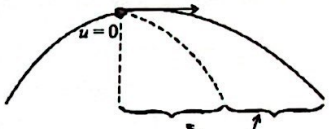


When piece A hit the ground, it is better if the path of piece B is stopped from drawing. That means if a figure like this is given, then the answer is very correct. According to the given answers, it is clear that the very correct answer is (4). From the conservation of energy choices (1), (2) and (3) are removed and out of the remaining (4) and (5), in (5) the place where piece B touches the ground is very close to the place of the ground when it hits if there is no explosion. In (5), the distances are not equal before as well. If two choices are given with equal distances of reaching the ground and B reaching as far away, then children will not be able to find the correct choice. Therefore, the better answer is (4).

Such questions in the books and Internet always give as the pieces reaches the ground at the same time. Then there will not be a breakdown of our common argument.

For example, after exploding at the highest point at the projectile, if the piece which falls vertically starts the initial velocity freely from zero, then the two pieces reach the ground at the same time. You better check whether this argument is correct.

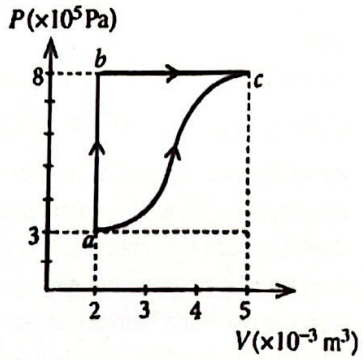
As the downward falling piece in our question had an initial velocity in downward direction, the initial velocity of the second piece cannot be in the horizontal direction if the momentum has to be conserved. Definitely there should be a vertical component of that velocity.



The distances are equal

The space shuttle which took off from Florida point in USA on 28th of January 1986 exploded after 73 s from take-off. The image of that explosion is shown here. Look as if the linear momentum had been conserved. All of the seven pilots who travelled were killed at an instant.

24. **Two thermodynamic processes ($a \rightarrow b \rightarrow c$ and $a \rightarrow c$) of a closed system of an ideal gas are shown in the figure. In the process *abc*, 6·0 kJ heat is absorbed by the system to go from *a* to *b* and 1·8 kJ heat is absorbed from *b* to *c*. What is the change in internal energy in the process *ac*?**



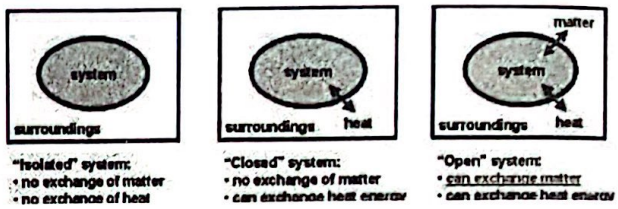
(1) 4·2 kJ (2) 5·4 kJ

(3) 6·3 kJ (4) 6·7 kJ

(5) 10·2 kJ

This has been asked many times. The nearest year is the previous year (30th question of paper 2019). The internal energy difference change is dependent upon the initial state and the final state only. It does not depend on the travelled path. Therefore, ΔU in the process of a→c, is equal to the total of ΔU of two processes a→b and b→c.

The process of a→b is a constant volume process. For that ΔW is zero. The process of b→c is a constant pressure process. $\Delta W = P\ \Delta V = 8 \times 10^5 \times 3 \times 10^{-3} = 2.4$ kJ. The examiners might have done a→b→c process by directly applying $\Delta U = \Delta Q - \Delta W$. Then according to the given data, from a→b and b→c, heat is being absorbed for both processes. Therefore, both are positive. So, $\Delta U = 6.0 + 1.8 - 2.4 = 5.4$ kJ. There is an answer. But there is an issue with the given data. The issue can be seen when we try to find ΔU separately. $\Delta U_{a\to b} = 6.0$ kJ ($\Delta W = 0$) No problem. $\Delta U_{b\to c} = 1.8 - 2.4 = -0.6$ kJ; $\Delta U_{b\to c}$ is negative. When going from b→c, ΔU cannot be $\Delta U < 0$. When the volume is increased at a constant pressure, the temperature should be increased. Therefore, ΔU should be $\Delta U > 0$. If a higher value than 2.4 was given instead of 1.8, then this issue will not be arisen. As mentioned early, when the two paths are not considered separately and $\Delta U = \Delta Q - \Delta W$ is applied, then this problem will not be noticed. You will get a positive value for ΔU. When we try to apply shorter methods, rarely we encounter some issues. Here there is no need to give a certain mass/ number of moles. The closed term meant in the thermodynamics is that the energy transfer can occur into the system and out of the system but materials/ matter transfer cannot occur here. The interpretations of open, closed and isolated terms that are being used in thermodynamics are shown here (look at 56th question of paper 2007).

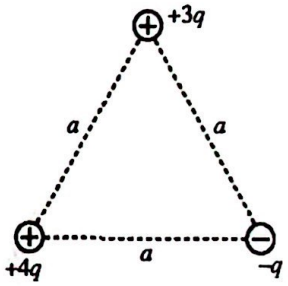


25. Three point charges $+4q$, $+3q$ and $-q$ are placed at vertices of an equilateral triangle of side a as shown in the figure. The electric potential energy of the system is given by,

(1) $\frac{5q^2}{4\pi\varepsilon_0 a}$ (2) $\frac{3q^2}{2\pi\varepsilon_0 a}$

(3) $\frac{7q^2}{4\pi\varepsilon_0 a}$ (4) $\frac{2q^2}{\pi\varepsilon_0 a}$

(5) $\frac{19q^2}{4\pi\varepsilon_0 a}$



06 Elastrostatic Potential

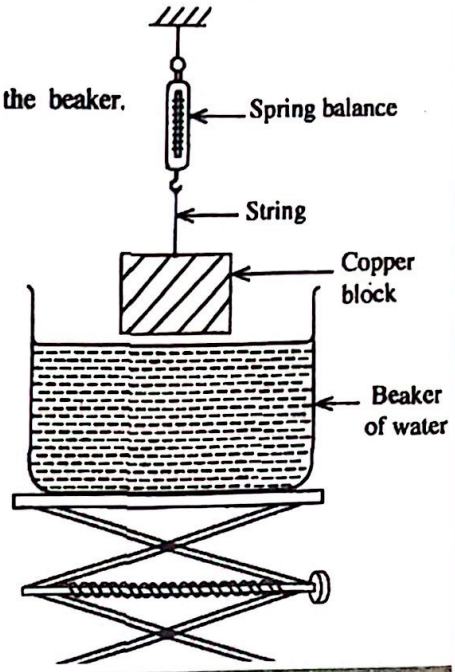
The potential energy of two charges q_1 and q_2 is given by $1/4\pi\varepsilon_0 \cdot q_1 q_2/r$. So, you can just get the answer from your memory. The distance between every two charges is equal. Therefore, keep $q^2/4\pi\varepsilon_0 a$ aside and get the multiplication in between the charges.

$q^2/4\pi\varepsilon_0 a\ [4 \times 3 - 3 \times 1 - 4 \times 1] = 5q^2/4\pi\varepsilon_0 a$

Actually, you can get the answer from the memory. 4 by 3 is 12.3 by 1 is 3. 4 by 1 is 4. Final two multiples are negative. When 7 is subtracted from 12, it is 5. There are only three charges. Only one potential energy is there between two charges. It is wrong to multiply by 2 saying there are two charges. If one charge is there, then there is no potential energy. At least you need two charges (if there is no external field). Do not you? There is one bond between father and mother. One energy is obtained from the bond between two persons. If you think in another way, then there is no need to do any work when a charge is brought from infinity. When one is brought, you need to do work to bring the others. There is no issue to bring the first one. The problems arise to bring the second as the second id brought when the first one is there. When third is brought, you need to consider both of the first and the second one. Can a third party be brought secretly to mother and father?

26. A copper block is hung over a beaker of water by a spring balance as shown in the figure. Consider the following positions while the beaker of water is slowly raising upward.

Position 1 : The block is partially submerged.
Position 2 : The block is completely submerged.
Position 3 : The block is on the bottom surface of the beaker.



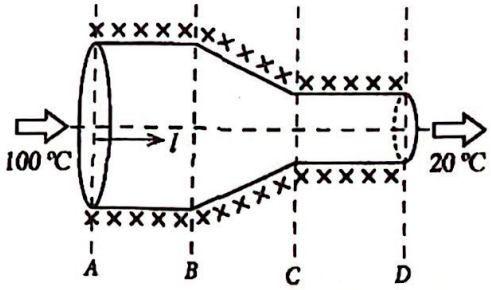
The buoyant forces and the readings of the balance with respect to positions 1, 2 and 3 are given by B_1, B_2, B_3 and W_1, W_2, W_3 respectively. Which of the following is correct?

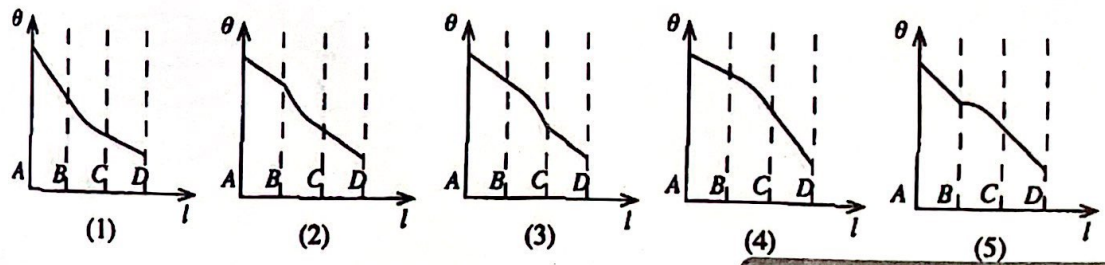
	Buoyant Force	Reading of the balance
(1)	$B_1 < B_2 < B_3$	$W_1 > W_2 > W_3$
(2)	$B_1 = B_2 < B_3$	$W_1 = W_2 > W_3$
(3)	$B_1 = B_2 < B_3$	$W_1 > W_2 = W_3$
(4)	$B_1 < B_2 = B_3$	$W_1 > W_2 = W_3$
(5)	$B_1 < B_2 = B_3$	$W_1 > W_2 > W_3$

This is a O/L question even it is a lengthy question. When the bloc k is sunk completely, the buoyancy force should be greater when compared to a block that is sunk half way. This is general knowledge. When the block is sunk completely, the buoyancy force or the upthrust is constant as it is completely sunk. This has been satisfied in (4) and (5). The reading of the spring balance should be gradually reduced when the block is sunk in the water beaker. When the block is sunk completely, the reading of the spring balance is constant. But when the string is contracted when the block is at the bottom of the water beaker, then the reading of the spring balance gets zero. However, the reading of the spring balance gets reduced when the block touches the bottom of the beaker. The correct choice is (5). This is also general knowledge.

The buoyance force does not get zero when the block is kept at the bottom of the beaker. Between the block and the bottom of the beaker there is a thin layer of water (Look at 52nd question in paper2005, 50th question in paper 2015). But there is an extra reaction from the bottom of the beaker to the block in upward direction.

27. The cross-sectional area of a uniform cylindrical metal rod is gradually reduced in part *BC* to form an object as shown in the figure. The object is perfectly lagged and the two ends of the object are maintained at temperature of 100 °C and 20 °C. At the steady state, the variation of temperature (θ) along the axis (l) of the object is best represented by,





It is simple. The area of the rod in the section of AB is constant. Therefore, temperature gradient should be a constant. That means it should be a straight line.

$\Delta Q/\Delta t = KA\,\Delta\theta/\Delta l$

If A is constant, then $\Delta\theta/\Delta l$ is a constant.

In the section of BC, the area of the rod (A) is gradually decreased. Then $\Delta\theta/\Delta l$ should be gradually increased. Therefore, the gradient of $\theta - l$ should be gradually increased. That means the shape of the variation should be this way and not this way.

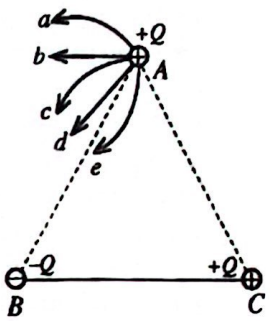
From this, (1) and (2) are removed.

Again, when we consider the section DC, the area is uniform but the value of it is lesser than of section AB. Therefore, even a straight line is relevant to this section, its gradient is should be greater than the gradient of section AB. All these are being satisfied by (4). The gradients of the straight lines of Ab and CD cannot be equal. That means they cannot be parallel. Here another point that has to be taken into consideration is that, the boundaries at which the areas are changed, the graph should be changed/transferred from one smooth place to another.

For example, this cannot be like this way.

If so, then there will be two changed gradients at the transferring point. It cannot be like this way. If we look at that way, then only graph (4) shows the smooth and co-operative transfer with each other in the boundaries. If we tell in another way, then the graphs cannot be subjected to be broken in the changing places.

28. Three small conducting spheres carrying charges $+Q$, $-Q$ and $+Q$ are located at the vertices of an equilateral triangle ABC situated on a frictionless horizontal surface as shown in the figure. Spheres at B and C are fixed and the sphere at A is free to move. The possible path of the sphere at A is best represented by



(1) a **(2) b**

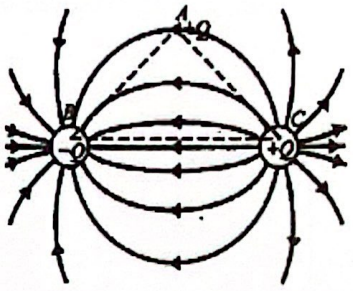
(3) c **(4) d**

(5) e

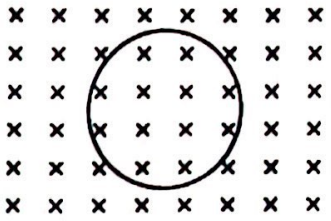
06 *Electrostatic Force Field*

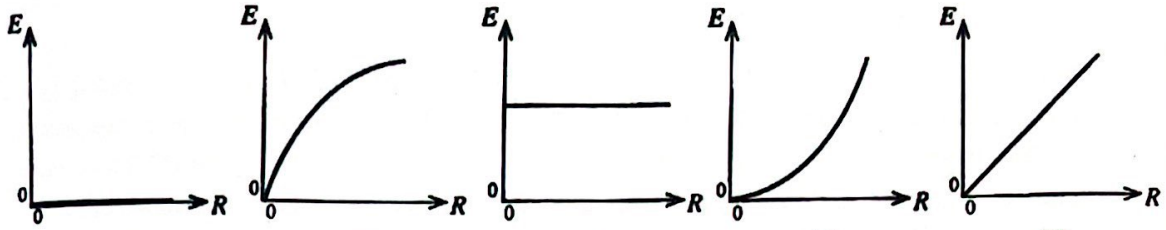
It is a very easy question. A is kept in the field of B and C. The electric filed lines from -Q and +Q charges are shown in the figure.

So, cannot you understand the locus of +Q charge which is kept above the perpendicular bisector? Is not is (c)? If the direction of the force is acted upon +Q, then it is acted upon the tangent of a field line. But the direction of the locus is being asked not the direction of the force. However, according to the nature of force lines, it is very clear that the locus cannot be a straight line. Only (c) is drawn towards this side from +Q to -Q at A.

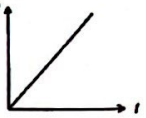


29. **As shown in the figure a conducting loop is placed perpendicular to a uniformly increasing magnetic field. Which of the following graphs best represents the variation of the magnitude of induced e.m.f. (E) in the loop with the rate of change of the magnetic flux density (R)?**





It is easy-peasy. The magnitude of the induced e. m. f is equal to the rate of change of flux. So, what else? $|E| = R$ ($E = -d\varphi/dt$). The graph of R against E is a straight line with a positive gradient (with 45^0 with the axes). Is not it? The correct choice is (5). We are not drawing the graph of time (t) against E. When R is increased, E is also gets increased. Some have got confused with this simple question. If magnetic flux (φ) is varied with time (t) like this way, then the induced e. m. f will be a constant. The way that rate of change of magnetic flux density varies with E has been directly asked in this question. It is not the variation of E with time. As the magnitude of E has only been asked, we do not have to consider the negative sign.



30. **An object of mass m stationary at time $t = 0$ is subjected to a force F, directed along a straight line, that varies with time t as shown in the graph. Select the correct statement from the followings.**

After the motion has started, the velocity of the object becomes zero,

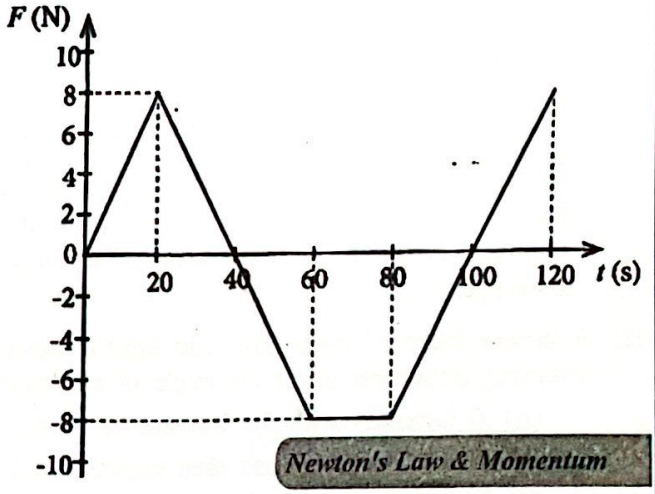
(1) **at $t = 40$ s only.**

(2) **at $t = 70$ s only.**

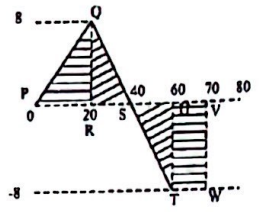
(3) **at $t = 40$ s and $t = 100$ s.**

(4) **at $t = 70$ s and $t = 120$ s.**

(5) **during the time interval from $t = 60$ s to $t = 80$ s.**



These have been checked before (24th question of paper 1996). The momentum is obtained from the area of F -t curve. $F = m(v-u)/t \rightarrow Ft = m(v-u)$. As the object is starting from the rest ($u = 0$), Ft multiple should be zero if the velocity (u) is needed to be zero again. That means the area of F-t curves should be cancelled of with each other.



The two areas that are being marked as this way are being cancelled off with each other. ≡

The area of QRS Δ = the area of TSU Δ

The area of PQR Δ = ½ X 20 X 8 = 80. To be equal to this 80, the rectangle TUVW area should be 80. To do so, t should be equal to t=70. That means from 60s you need to go 10 s forward. The correct answer is (2). The corresponding areas are not getting cancelled off beyond that. Check for yourself. So, the velocity of the object gets zero again in only t = 70 s. Some argue that it is correct during the period of t = 60 s to t = 80 s. But as there is a choice mentioning only t =70 s, where (5) is not suitable. When it is during the period, it can be of any place. It is true that 70 is in between 60 and 80. But when it is said at 70 s, the answer is exactly certain.

31. Identical small spherical droplets of mercury are charged so that each droplet has the same electric potential of 0·01 V. If one million (10^6) such droplets are combined to form a large spherical drop, what would be the electric potential of the large drop?

(1) 0·01 V (2) 1·0 V (3) 10 V (4) 100 V (5) 1000 V

06 *Electrostatic Potential*

A simple calculation is needed. But do not make this a complex one. The potential V is proportional to q/r where q is the charge of a droplet and r is the radius of a droplet. We need to find the radius of the drop (R) when 10^6 droplets are added. The volume of 10^6 droplets should be there in the created drop. The volume is proportional to the third power of the radius of the droplet. You have done surface tension questions like this way. The charge of the created drop is 10^6q. Actually, 10^6 droplets are given to get the root of 3 quickly. According to the given facts, your rough sheet should be like this way.

$0.01 \propto \frac{q}{r}$; $10^6 r^3 = R \rightarrow R = 10^2 r$; $V \propto \frac{10^6 q}{R} \propto \frac{10^6 q}{10^2 r}$.

By dividing the two proportional terms, V/ 0.01 = $10^4 \rightarrow$ V =10^2 (100 V)

Do not write 1/ $4\pi\varepsilon_0$ and $4\pi/3$. There is no point in writing them. The charge of the created drop can be forgotten that it is 10^6 times of a droplet. The charges are added together. When it is taken as $V \propto \frac{q}{r}$, tthe answer gets wrong.

32. A narrow beam of monochromatic light is passing through a prism placed in air. Consider the following statements about the angle of minimum deviation *D*.

(A) *D* increases with the increase of refractive index of the material of prism.

(B) *D* first decreases and then increases with gradual increasing of the angle of incidence.

(C) *D* increases with the increase of the angle of prism.

Of the above statements,

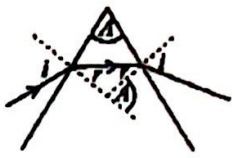
(1) only (A) is true. (2) only (A) and (B) are true.

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

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

03 *Refraction Through Prism*

The problem has mentioned about the least deflection angle. The word 'least' has been given in bold. Better if they are given as D and D_{min}. Sometimes there could have been a confusion between D and D_{min}. As soon as you read, you can see that statement (A) is correct. According to $n = \frac{Sin(\frac{A+D_m}{2})}{Sin\frac{A}{2}}$, when n is increased it can be seen that D_m gets increased. A sin value of an angle is increased with the



increment of the angle. Statement (B) can get wrong. It can be wrong not due to Physics but due to the difference between the deflection angle and the least deflection angle. The least deflection angle is a single value. Therefore, it cannot be changed with the incident angle.

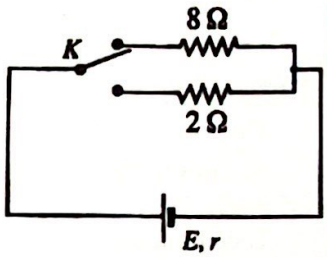
The deflection angle initially gets reduced and then it gets increased later on when the incident angle is increased. The variation of i-deflection angle is familiar to you. You need the language skill as well as Physics skill to your life. If the minimum deposit money is Rs. 1000, then you cannot change that minimum value. If you can, then you can deposit more than that. Statement (B) is wrong. It is hard to decide whether statement (C) is right or wrong. It is difficult to argue by looking at the above formula. A is there both in the numerator and the demnominator. For this, argue like this way. In the least deflection moment, the ray travels insdie the prism in a symmetrc way. Look at the figure.

We know that $D_m = 2i - 2r$. Likewise, $2r = A$. So, when A is increased, r gets increased. When r is increased, then also gets increased. But the increment of is greater relative to the increment of r. Always $i > r$. As $n = \sin i / \sin r \rightarrow \sin i = r \sin r$, compared to an increment of r (that means of A), increment of is greater than the corresponding increment of r. Therefore, when r(A) is increased in $D_m = 2(i-r)$, then the value of D_m gets increased.

If we take as $D_m = 2i - A$, then when A is increased, it is not correct to argue that D_m gets decreased. Why? When A is changed, is also changed accordingly. Instantly, you tend to argue like this way. Even the examiners might have thought like this way. So, the argument should be built from $D_m = 2(i-r)$

When A is increased, then r is increased. When r is increased, then however is increased. The increment of is greater than the increment of r. Therefore, when A is increased, D_m gets increased. (C) is correct. Only (B) is wrong.

33. Using a two-way key *K*, a cell of e.m.f. *E* and internal resistance *r* can be connected in series either with resistor of resistance 8 Ω or 2 Ω as shown in the figure. If power dissipation of each resistor is the same, what would be the value of the internal resistance *r*?



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

It is an easy question. When a current of is flown across a resistor of R, then the power generation is i^2R. i^2R of the two occasions should be equal. You need to reduce the calculations (rough work) to a minimum level. Write only this in your rough sheet. $(\frac{1}{r+8})^2 8 = (\frac{1}{r+2})^2 2$.

When 8 is divided by 2, it is 4. The data are given to get 4 to take the square root quickly. The square root of 4 is 2. When the square root of both sides are taken, then ; $\frac{1}{r+8}.2 = \frac{1}{r+2}$;

$2r + 4 = r + 8 \rightarrow r = 4$.

34. A hot object hung in a room at 30 °C takes 5 min to cool from 60 °C to 50 °C. What is the time taken by the object to cool further from 44 °C to 36 °C under same conditions?

(1) 10 min (2) 12·5 min (3) 15 min (4) 20 min (5) 25 min

04 **Convection**

This has been given for several years (36th question of paper 1999). You need to get the answer from the proportionality method with less rough work. The temperature lowering rate is proportional to the excess temeprature. Before trying to do lot of rough work, many calculations can be done from the memory. From 60°C to 50°C the difference is 10°C. The cooling rate is 10/5. The starting excess temperature =60-30 = 30. The final excess temeprature = 50-30 =20. The mean excess temperature =25 (in between 20 and 30). All these things can be done from your memory.

$\frac{10}{5} \propto 25$; Likewise, take the second instnace. $\frac{18}{t} \propto 10\ [\frac{(44-30)+(36-30)}{2}]$

When these two proportionalities are divided, 8/ (t x 2) =10/25; 10t =100 → t =10 s

The two proportional terms can be marked by this way too.

$$\frac{10}{5} \propto [\frac{(60+50)}{2} - 30] \propto 25$$

$$\frac{8}{t} \propto [\frac{(44+36)}{2} - 30] \propto 10$$

All the numbers are given to simplify easily. Some argues that it is better if it was mentioned as the heat loss has occurred only due to convection. It is not needed. For small temperature differences, even the heat loss due to radiation can be taken proportional to the environmental temperature difference. There is no wrong in it. $T^4-T^4_0 = (T^2-T^2_0)(T^2+T^2_0) = (T-T_0)(T+T_0)(T^2+T^2_0)$. Throughout the history, this question has been given this way.

35. What is the maximum mass of ice at –5 °C that can be completely dissolved in 1 kg of water at 35 °C in a container with negligible heat capacity?

Let the specific heat capacities of ice and water be $2{\cdot}0 \times 10^3$ J kg^{-1} °C^{-1} and $4{\cdot}0 \times 10^3$ J kg^{-1} °C^{-1} respectively, and the specific latent heat of fusion of ice be $3{\cdot}4 \times 10^5$ J kg^{-1}. Assume there is no exchange of heat with the surrounding.

(1) 200 g (2) 240 g (3) 300 g (4) 360 g (5) 400 g

04 **Calorimetry**

This is a very familiar question to you. The issue is there as the children consume unnecessary time to get the answer. The relvant Physics is simple.

The maximum mass that can be melted means that the temperature of the mixture should come to 0°C. This must be caught. Initially as ice is in -5°C, if we put more ice, then the temperature of the mixture can be less than 0°C. If we put less ice, then ice can quickly melt and the temperature of the mixture can reach to a value higher than 0°C like 20°C , 10°C. Therefore, more or less if we put the maximum mass that can melt ice completely, then the temperature of the mixture should come to 0°C. If the temeprature of the mixture is less than 0°C, then more ice has been put. If the temperature of the mixture is more than 0°C, then less ice has been put. Here the heat is not absorbed from the surroundings. The heat should be obtained for ice melting only from the water. If heat is absorbed from the surrounding, then enough amount of ice can be melted. Build the equation of relation at once. Ice should reach from -5°C to 0°C. Then all should be melted.

Water gives heat to all of these. It has been mentioned that to neglect the heat capacity of the container.

$$10\ m + 340\ m = 140;\ m = 140/350 = 0.4 = 400\ g$$

It simplifies very easily. The numbers are given to prove it. You need to improve the quick simplification ability. Cut 10^3 from the whole equation. Then the simplification gets easy. 340 + 10 = 350

There is a criticism that the melting point of water that is 0^0C or the atmospheric condition of the system is not mentioned. These are obviously famous things. Therefore, there is no need to mention that. If it is mentioned, then the question will be longer.

36. Magnifying power of a compound microscope in normal adjustment is 100. The focal length of the objective lens is 2·5 cm and the object distance is 2·6 cm. What is the magnification of the eyepiece?

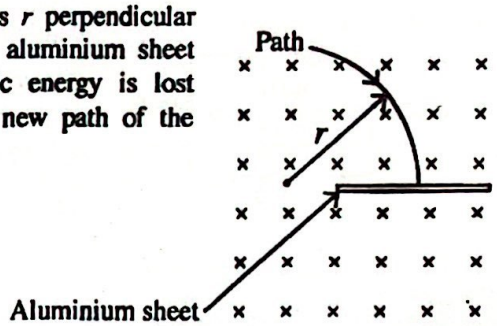
(1) 4 **(2) 5** **(3) 10** **(4) 20** **(5) 25**

Opticle Instrument 03

The magnification power of a combined microscope is equal to the magnification of objective and eyepiece. This has been checked before (39th question of paper 1991). Therefore, as the magnification power of the combined mircoscope is given, if we can find the magnification of the objective, then we can find the magnification of the eye piece. For objective, apply 1/V -1/U = 1/f.

-1/V- 1/2.6 = -1/2.5. The magnification is equal to V/U. But we do not know V. So, the above equation should be multiplied by U(2.6). Then, 2.6/V +1 = 2.6/2.5; 2.6/V = 26/25 -1 =1/25. The magnification of the objective which is V/2.6 (V/U) is equal to the reciprocal of 1/25 which is 25. Now the magnificaton of the eyepiece = 100/25 = 4

37. A charged particle moving in a circular path of radius r perpendicular to a uniform magnetic field penetrates through a thin aluminium sheet as shown in the figure. If half of the initial kinetic energy is lost due to penetration, what would be the radius of the new path of the particle?



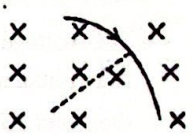
(1) $\frac{r}{2}$ **(2)** $\frac{r}{\sqrt{2}}$

(3) r **(4)** $\sqrt{2}r$

(5) $2r$

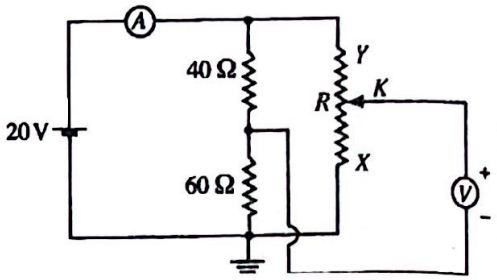
Force on a Moving Charge in Magnetic Field 07

It is an easy problem. For a charged particle that travels uniformly in a magnetic field, the relation of $mv^2/r = qvB$ is a familiar equation. According to this, $v \propto r$ (if m, q and B are constant). If the kinetic energy is reduced by half, then the speed should be $1/\sqrt{2}$ from the initial value ($k \propto v^2$). If the speed is from the initial value, then the radius also should be $1/\sqrt{2}$ from the initial value $r/\sqrt{2}$. This can be β (e) particle. If it is an α particle, then it should be stopped inside the aluminum plate whereas a γ ray conveniently penetrates across aluminum.



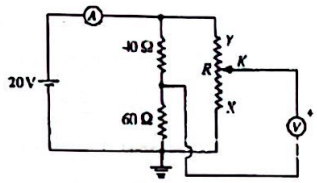
38. The electrical circuit shown in the figure has ideal centre-zero voltmeter and ammeter. The 20 V battery has negligible internal resistance. The value of the variable resistor R can be changed from 0 to 100 Ω. What are the ammeter (A) and voltmeter (V) readings when the sliding key K is at X and at Y?

	K is at X		K is at Y	
	(A)	(V)	(A)	(V)
(1)	200 mA	0	200 mA	+20 V
(2)	400 mA	0	400 mA	+20 V
(3)	200 mA	-12 V	200 mA	+8 V
(4)	400 mA	+12 V	400 mA	-8 V
(5)	400 mA	-12 V	400 mA	+8 V

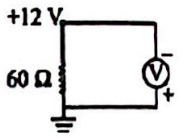


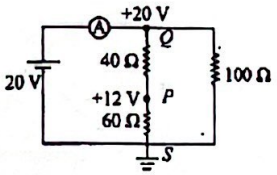
04 Moving Coil Meters

Half of the problem is solved if you see that the circuit current does not change even the voltmeter is connected to any place. As the voltmeter is ideal, there is no current flow in it. Therefore, the current in the circuit (ammeter reading) is unchanged even if the key K is kept anywhere. How much is it?

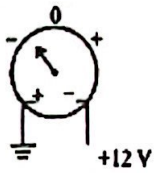


60 +40 =100 Ω. 100 Ω is parallel to 100 Ω. The equivalent resistance is 50 Ω. The current = 20/50 = 0.4 A = 400 mA.





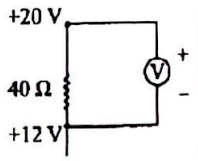
Now to find the voltmeter reading, decide the voltage of the places shown below. The potential of point S is zero. 20 V should be divided in between 40 Ω and 60 Ω. The voltage difference l V {(20/100) x 60 =12}. If not, then as the current t Ω is 0.2 A, the voltage difference across it = 0.2 x 6



Now when the sliding key is at X, the voltmeter relation will look like this way.

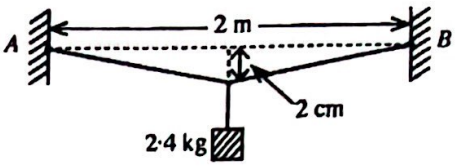
The + end of the voltmeter is earthed and the - end of the voltmeter is connected to +12 V. As the voltmeter is a centre zero voltmeter, the reading is shown as -12 V. The indicator goes to the negative side (12> 0).

Next, when the sliding key is brought to Y, then the voltmeter relation is like this way. Now the voltage of positive side is greater than the negative side. $V_+ > V_-$.



The voltage reading = 8 V (20-12). The correct answer is (5). The current can be found instantly. To decide the voltmeter reading, mark the potentials of the points in the paper as shown. To find the voltage difference across 60 Ω and 40 Ω, 20 V should be divided into the ratio of 3;2. However, the drop of voltage across 60 Ω should be greater than the drop of voltage across 40 Ω. You need to keep in mind that the voltage is a centre zero voltmeter. In such an equipment, if $V_+ > V_-$, then the indicator goes to the positive side. If $V_- > V_+$, then the indicator goes to the negative side.

39. A metal wire of length 2 m and cross-sectional area 5 mm^2 is rigidly clamped at two points A and B which are 2 m apart in the same horizontal plane. Then a block of mass 2·4 kg is hung from the mid point of the wire as shown in the figure. The mid point of the wire sags 2·0 cm from the initial position and the total extension of the wire is 0·04 cm. What will be the approximate value of Young's modulus of the metal?

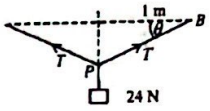


(1) 2×10^{11} N m^{-2} (2) 3×10^{11} N m^{-2} (3) 4×10^{11} N m^{-2}

(4) 6×10^{11} N m^{-2} (5) 12×10^{11} N m^{-2}

Elasticity 10

You need to do a calculation. If the tension of the wire is T, then 2T sin θ = 24; T =12/ sin θ.



Here the value of Young modulus is being asked to the nearest value. Therefore, it is not wrong to take the length of PB wire as 100 cm (1 m). If the real value is needed, then the length of PB is equal to 100. 02 cm. There is no problem in taking sin θ = 2/100. T = 12/2 X 100 = 600 N. Now we will apply Young modulus equation.

E = (600/ 5 X 10^{-6}) (200/0.04) = (force/ area) (initial length/ extension) = (6 X 2 X 10^4)/ 2 X 10^{-7} = 6 X 10^{11}

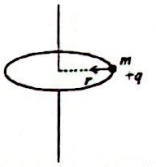
According to the given numbers, there is 6 in the answer. There is no such answer with 6. Even though it not right to think like this way, if the time is running out, you can apply such strategies. Once T is found, all you need to do is apply Young modulus relation. When finding T, the needed sin θ can be found by taking the length of PB as 100 cm. Even if 100.02 is taken instead of 100, the answer is asked to the near value. So, you need to be intelligent to take 100 instead of 100.02. If not, as θ is small, sin θ can be taken as sin θtan θ. Even the extension of the wire is given to make the calculation convenient. If not, it can be found from Pythagoras theorem.

40. An infinitely long thin straight wire which is located on the z-axis has a linear charge density of $-\lambda$. A small positive charge $+q$ of mass m is allowed to move in the xy-plane in a circular path of radius r about the wire. The periodic time of the charge is given by,

(1) $\sqrt{\frac{8\pi^3 r^2 m\varepsilon_0}{\lambda q}}$ (2) $\sqrt{\frac{4\pi^2 r^3 m\varepsilon_0}{\lambda q}}$ (3) $\sqrt{\frac{\lambda q}{8\pi^3 r^2 m\varepsilon_0}}$ (4) $\sqrt{\frac{\lambda q}{4\pi^2 r^3 m\varepsilon_0}}$ (5) $\sqrt{\frac{8r^2 m\lambda}{\varepsilon_0 q}}$

Gauss Theorem 06

Even though it is seen as hard, you need to write only two equations. If the electric field intensity is E on the charge q, then to move in a circular path qE = mv^2/r. The electric field intensity at a distance r of a wire with charge density of -λ can be obtained from applying Gauss theorem.



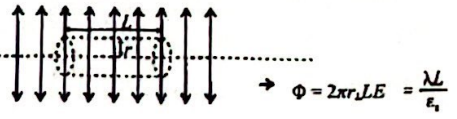
E. 2πr = λ/ ε_0. If E is substituted for E of the previous equation, then

$v^2 = qrE/m = q/m.\ (r\lambda / 2\pi r\ \varepsilon_0) = q\lambda / 2\pi r\varepsilon_0 m$

Period = $2\pi r/v = 2\pi r\sqrt{\frac{2\pi\varepsilon_0 m}{q\lambda}}$. When 2πr is absorbed into the square root, it becomes $4\pi^2 r^2$.

Period = $\sqrt{\frac{8\pi^3 r^2 \varepsilon_0 m}{q\lambda}}$

The charge on the wire should be negative. Then the force on +q charge will be towards the centre. If not, then it cannot go on a circular path. When finding E, you do not need to put -λ. All you need is the numerical value of E. When applying Gauss theorem, apply it for a unit length. Or else apply it for a length of L.

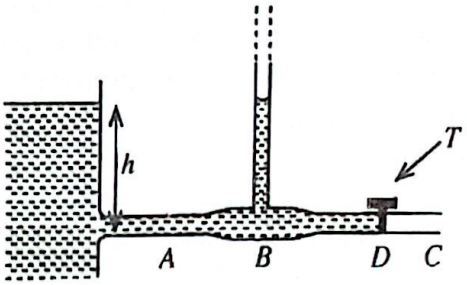


41. As shown in the figure a horizontal pipe *ABC* is connected to a water tank with a large cross-sectional area. The internal cross-sectional area of the pipe at *B* is twice that of at *C*. Initially a water tap (*T*) located at *D* is closed. Once the tap is opened what would be the height of water level in the vertical tube located at *B*? (Assume that the water flow is steady and streamline; Neglect the viscosity of water.)

(1) $\frac{1}{4}h$ (2) $\frac{1}{2}h$

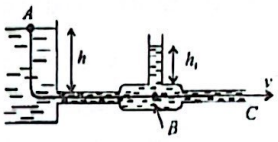
(3) $\frac{3}{4}h$ (4) h

(5) $\frac{4}{3}h$



02 **Hydrodynamics**

When initially the tap is opened, we need to find the speed of water flow from the end C. If Bernoulli's Theorem is applied to the points A and C, $P_0 + h\rho g = P_0 + \frac{1}{2}\rho v^2$; $v^2 = 2hg$

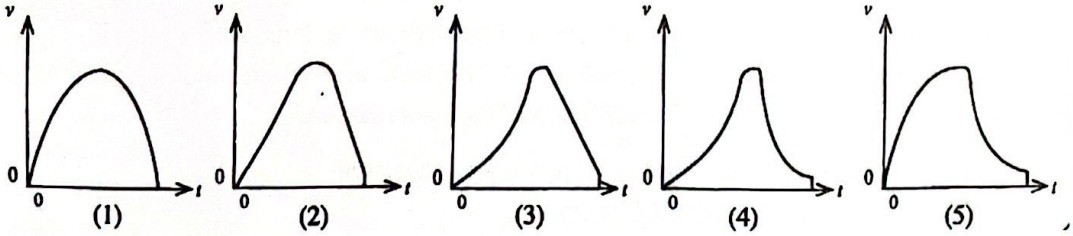


As it is a big tank, the speed of water at A is considered as zero. This is a familiar relation to you. As the areas are double, then the speed of water at B gets ½ v. Again, when Bernoulli's Theorem is applied to the points A and B, $P_0 + h\rho g = P_1 + \frac{1}{2}\rho(v/4)^2$; $P_0 - P_1 = h\rho g - \frac{1}{2}\rho(2hg/4) = \frac{3}{4}h\rho g$

The height that the water rises = ¾ h

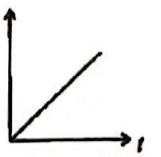
Without finding the speed of water at C, we cannot find the speed of water at b. You cannot get the answer just be applying Bernoulli's Theorem to the points A and B. the speed of water at B is unknown. Even the pressure of that point is unknown.

42. A parachutist bails out from a helicopter at time $t=0$. After a certain time he opens his parachute and then reaches the ground. Which of the following graph best represents the variation of the vertical component of the velocity (v) of the parachutist with time (t)?



10 **Viscosity**

The correct variation can be seen at a glance as (5). Before opening the parachute, the parachute man does not fall freely. He also undergoes a resistive force from the air. Such resistive forces are proportional to v^2. If he falls under gravitational acceleration g, then the velocity-time graph should have a shape like this way. It should never have a gradual increment of acceleration. According to that, (3) and (4) can be removed automatically.



The driving force is acted upon by the cloth of the parachute. Its confronting area is large as it touches the air. Due to this driving force, the parachute man under goes a deceleration.

It should be a gradually reducing deceleration (when the speed is reduced, then the driving force gets reduced). It touched the ground and instantly the speed gets zero. These points are satisfied only in (5). Even if we argue that the initial variation of (2) is correct (nearly), then the lateral part shows a uniform deceleration. In (1) of the second part also has a gradually rising deceleration.

Sometimes, a choice like below can also be correct. The terminal velocity could have been acquired before reaching the ground.

43. Consider the following statements about the half-life ($T_{½}$) of radioactive atoms in a sample.

(A) $T_{½}$ changes with the number of radioactive atoms present in the sample

(B) $T_{½}$ changes with the date and time of the prepared sample.

(C) $T_{½}$ does not change even if the radioactive atoms are ionized.

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.**

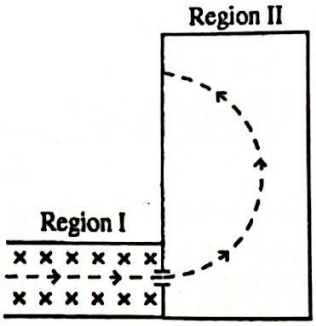
(5) only (B) and (C) are true.

Radioactivity 11

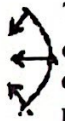
Three statements have been asked from the basic principles about the half-life in radioactivity. The value of $T_{1/2}$ is not dependent upon the number of radioactive atoms. It is a constant that belongs to a certain radioactivity. There is no such effect what so ever on $T_{1/2}$ with the number of atoms either they are with more or less amount. Likewise, $T_{1/2}$ value of a radioactive sample does not change depending upon the date that the sample was prepared using a radioactive element or the time frames of the preparation. If it was made/ kept today or it was made/kept million years ago, then the $T_{1/2}$ value is same for that sample. Even whether the radioactive atom is a positive or a negative ion is not an issue to radioactivity. The radioactivity is a work of a nucleus. The electrons in the nucleus does not know the inner work of the nucleus. Radioactivity is solely due to the emissions of the nucleus. Therefore, radioactivity is not a chemical emission. Only statement (C) is correct.

44. An electron moves in the plane of the paper through two regions along the path shown in th figure by broken line. Uniform Magnetic fields B_1 and B_2 exist in regions I and II respectivel; A uniform electric field exists only in region I directed into the plane of the paper as denote by crosses (×). Which of the following gives the correct directions of magnetic fields in region I and II?

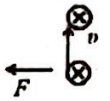
	B_1	B_2
(1)	↑	⊗
(2)	↑	⊙
(3)	⊙	⊗
(4)	⊗	⊙
(5)	↓	⊙



Magnetic Field 07

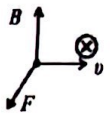


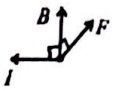
The direction of B can be decided quickly in region ii. It goes in a circular path in anti-clockwise direction. The force on the electrons should be towards the centre as to the shown direction.



If a positive charge is moving, then according to the right-hand rule, the magnetic field should be towards the paper.

When the fingers are rotated to the direction from v to B by keeping the right thumb perpendicularly to the other fingers, the direction of F is obtained by the direction that the thumb points. As the charge of the electron is negative, the direction of B should be away from the paper. The direction of B can be also obtained according to Fleming's left-hand rule that you use. If an electron moves ↑ means that the current flow is ↓



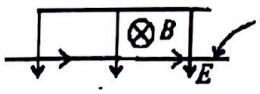


Region i can be confusing. Normally, cross and dot are used to show the directions of the magnetic fields.

⊗ ⊙

Here, the direction of the electric field is shown with the cross. The electric field is acting towards the paper. If there is only electric field, then the electrons will deflect away from the paper. The force on a negative charge is opposite to the direction of E. To cancel the outward force on electrons from E, then the force created from the magnetic field should be towards the paper. Again, if we think that a positive charge is going towards → and B is towards ↑ then the force will be acted away from the paper. If it is a negative charge, then the force is acted towards the paper. According to Fleming's left-hand rule, when the current flows ← direction, then the force should act towards ⊙

Therefore, the correct directions are ↑ and dot. ⊙



The region i is known as a velocity selector. This is a fact that you know. But normally such regions are marked like this way.

The electron beam is deflected by E towards this direction. ↗

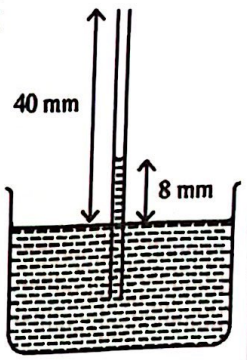
B that is towards the paper can cancel that force. Then eE =evB. That means, v = E/B. This has been checked in essay question of paper 2019. These are known as cross fields.

45. Figure shows a capillary tube dipped vertically in a container of water with a large cross-sectional area. The system is fixed in an elevator at rest. The open end of the capillary is 40 mm above the water level of the container and the capillary rise is 8 mm.
If the elevator is,

(I) moving downwards with an acceleration of 5 m s^{-2}

(II) falling freely

what would be the respective capillary rise?

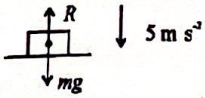


(1) 4 mm, 0 **(2) 16 mm, 0**
(3) 4 mm, 8 mm **(4) 16 mm, 32 mm**
(5) 16 mm, 40 mm

10 **Surface Tension**

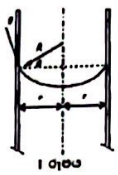
When a capillary tube is immersed in a water container, there is a capillary rise. This is a fact that we know. Compared to cohesive forces, as the adhesive forces in between water and glass are stronger, the water is risen above. These forces are (static) electric forces. When the inter molecular forces from this is equal to the mass of the rising water column, the rise stops. If this is shown from an equation (that you know), T. $2\pi r = \pi r^2 hdg$; $h = 2\ T/rdg$

When the value of g is changed, you can clearly see that the value of h changes by looking at the above expression. Under g =10 ms^{-2}, h is given as 8 mm. If the life is going down in an acceleration of 5 ms^{-2}, then the g value experienced in a lift is 10-5 =5 ms^{-2}.



If there is an object in the lift, then when ↓ F = ma is applied, mg-R =m x 5; R = m (10-5) =mg'

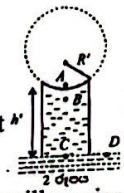
Where g' is the apparent g that is experienced in the lift. Likewise, when the value of g is reduced by half, then the value of h gets doubled (according to the above expression). Therefore, in the first instance the capillary rise 8 x 2 =16 mm. If the lift is freely falling, then the gravitational acceleration inside the lift gets zero. That means the mass of the water column will not be there. On such an instance, there is no gravitational downward force to stop the surface tension forces.



Therefore, the water column rises along the tube. The electric forces cannot be zero. That means the capillary rise is equal to the length of the tube. That is 40 mm. The correct answer is 16 mm and 40 mm.

According to the above equation, if g =0, then h.→ ∞ Here the infinity means the limit of the tube. A container with a large cross-section has been given as there is no change in the water level even though water went upwards towards the tube. Otherwise, there can be issues regarding the calculation of the length of the water column.

What will happen to water after is goes up? Can it over flow from the tube?



To understand this, we will look what happens if a shorter length tube compared to the height rise was put into water under normal g.

Figure (1) has shown an instance when the length of the tube is greater than the length of the capillary rise. For this situation, we know that, h = (2T/r). (cos θ/ dg) and cos θ can be written as cos θ =r/R where r = the radius of the tube and R = radius of the meniscus. $h = \frac{2T}{rdg}.\frac{r}{R} = \frac{2T}{dg}.\frac{1}{R}$ ....(1)

Now let us look at the second figure. The length of the tube h' is lesser than h. Then we will consider R' as the radius of the meniscus at that time. Similarly, $P_A - P_B = 2T/R$; $P_C = P_B + h'dg$; According to $P_C = P_v = P_A$, $2T/R' = h'dg$; $h' = \frac{2T}{dg}.\frac{1}{R'}$ ....(2)

By comparing (1) and (2), we get the relation as hR =h'R'. As h'<h, R'>R. That means the radius of the meniscus has been increased. If we argue in another way, , $h' \propto \frac{1}{R'}$.

If h' =0, then R' can take only infinity. Being R' infinite means the flattening of the meniscus. Always, according to h', R' is made so that the multiple of h'R' is equal to hR. Therefore, water/liquid does not overflow from the tube. If it over flows, then it is contradictory to the conservation of energy. If water started to over flow, then we can have a water fountain without using any external energy. This is what happens according to the question. The water does not over flow. We can study this instance in the tube more.

When it falls in g acceleration, there is no mass of the water column. Therefore, there is no pressure from the water column. $P_B = P_C = \pi$. That means there is no pressure difference in between the meniscus. That means the meniscus is plane (horizontal). The contact angle at this instance is 90°. Cos 90° =0. There is no vertical surface tensional force along the tube. So, there is no upward pulling afterwards. This argument cannot be used when the water is rising upwards. At that time, the water is not in a static situation. It is in a dynamic (moving) situation.

Such an incident can be taken as a wonder. But there is an incident in the practical world. How the coffee rises in a coffee cup at the international space station due to capillary rise is shown in the figure. Find how the coffee is drunk by thinning the side of a plastic container by going to YouTube on https://www.deathwishcoffee.com/blogs/news/don-petit-zerog-coffee-cup.

Coffee will go towards the top of the cup and stop. If you suck like a butterfly, then you can suck continuously. This cup is known as the zero-g-coffee-cup. Can you understand why this cup is made like this way?

46. Two vertical glass tubes (T_1 and T_2) filled with a liquid are connected at their lower ends by a horizontal capillary tube. One tube (T_1) is surrounded by a mixture of ice and water at 0 °C, and the other (T_2) by water kept at constant temperature 40 °C. The difference in the heights of the liquid in the two columns is 1·6 cm and the height of the liquid column at 0 °C is 80 cm as shown in the figure (drawn not to a scale). The real volume expansivity of the liquid is,

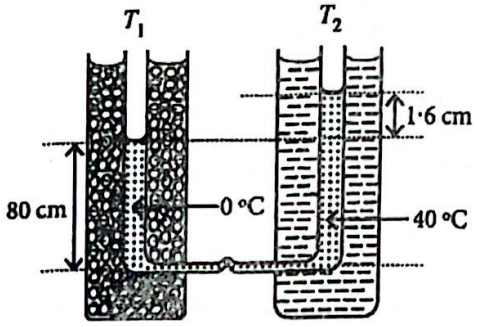
(1) $2{\cdot}5 \times 10^{-4}\,°C^{-1}$

(2) $5{\cdot}0 \times 10^{-4}\,°C^{-1}$

(3) $6{\cdot}0 \times 10^{-4}\,°C^{-1}$

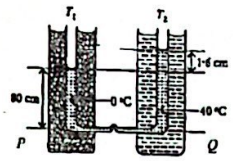
(4) $1{\cdot}0 \times 10^{-3}\,°C^{-1}$

(5) $1{\cdot}2 \times 10^{-3}\,°C^{-1}$



04 *Expansion of Liquids*

There is a long and a short method to solve this question.



Long Method:

Relative to the horizontal level of PQ, taking the both sides of pressures as equal,

$80\,\rho_0 = (80 + 1.6)\,\rho_{40}$; $80\,\rho_0 = 81.6\,\rho_{40}$..... (1)

$\rho_{40} = \rho_0/(1 + \gamma\,(40\text{-}0))$ ..... (2)

From (1) and (2), $81.6/80 = 1 + 40\,\gamma$; $40\,\gamma = 81.6/80 - 1 = 1.6/80$; $\gamma = 1.6/(40 \times 80) = 5 \times 10^{-4}$

Short Method:

$\gamma = \frac{\Delta V}{\Delta V_0 \times \Delta\theta}$ [increased volume/ (initial volume X increased temperature)] = 1.6/ (80 x40) = 5 X 10^{-4}

If the temperature of both sides is equal, then the liquid on the right- hand tube should also be there for 80 cm height. But as the temperature of the right-side liquid is greater, it has been expanded to a length of 1.6 cm. If we consider as a length, the expansion of 80 cm length is 1.6 cm length. One can argue that the first method is more accurate. There we do not consider the (tube) container expansion for the calculation. That is why we get the true expansion of the liquid by this method.

In the second method, when trying to find the volume, we need the cross-sectional area of the tube. There the difference of the expansion of glass tubes has been neglected. If we think on the other hand, if we need to find the true expansion, then we need to consider that the container has never undergone expansion. If we consider the tubal expansion, then we will get the apparent expansion of the liquid. So, one can argue that it is not wrong to do in the second method. Actually, this method is called Dulong-Petit (name of scientists) method which finds the true expansion of a liquid.

Here the horizontal tube that connects the two tubes should be thinner and it has an obstacle in the middle. The setup is made by creating an air bubble in this obstacle. It is done so to minimize the heat flow from the heated liquid to the cooler liquid side. Everything will be out of order if liquid parts are being mixed.

47. **Figure shows an infinite ladder network of 1 Ω resistors. If the equivalent resistance of this network between points *A* and *B* is *R*, which of the following is true?**

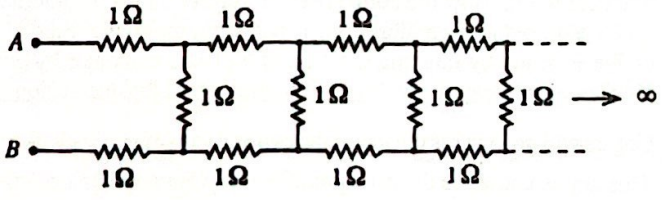
(1) $R < 2\,\Omega$

(2) $R = 2\,\Omega$

(3) $R > 3\,\Omega$

(4) $R = 3\,\Omega$

(5) $2\,\Omega < R < 3\,\Omega$

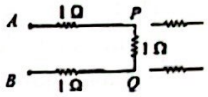


08 *Ohm's law combinations of Resistance*

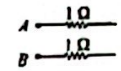
There were people who have scolded seven generations of paper makers in good Sinhala. Actually, they have thought that the equivalent resistance has to be found here. If so, then this is not a multiple question. It takes some time. Even you need to solve a quadratic equation. There is a simple logic in the question.

If you remove the circuit network from the shown two places and forget that part, then the equivalent resistance of the rest is 3 Ω. On the other hand, the shown two resistors of 1 Ω are added to the calculation when finding the equivalent resistance across AB.

There is no freedom from those two resistors. Next, the rest of resistors that are on the right side are connected to 1 Ω across PQ in a parallel way. Therefore, the equivalent resistance from 1 Ω across PQ and the rest of resistors on the right hand should be lesser than 1 Ω. Can you remember the rule that is applied to a parallel structure? In a parallel arrangement, the equivalent resistance should be lesser than the value of its smallest resistor.

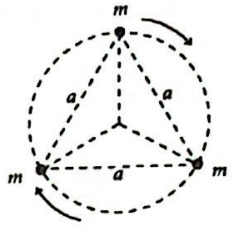


Therefore, the equivalent resistance between points AB should be greater than 2 Ω but lesser than 3 Ω. The correct answer is (5).



The contribution from all of the parallel resistors is lesser than 1 Ω. Do not ever think of solving this continuously even in your dreams.

48. Three stars each of mass *m* are at the vertices of an equilateral triangle of side *a* as shown in the figure. Suppose, these three stars rotate in a circular path about the centroid of the triangle while retaining the initial distances among the stars. If only the mutual gravitational forces are acting among the stars, the periodic time of the system is given by,



(1) $2\pi\sqrt{\frac{a^3}{2GM}}$ (2) $2\pi\sqrt{\frac{a^3}{3GM}}$

(3) $2\pi\sqrt{\frac{3a^3}{GM}}$ (4) $2\pi\sqrt{\frac{2a^3}{GM}}$

(5) $2\pi\sqrt{\frac{3a^3}{2GM}}$

Gravitational Force Field 05

Select one mass. There will be gravitational forces for it from the other two. If one force is F, then the resultant force that is towards the centre of the triangle is $2F\cos 30^0$ for mass m. From the shown rectangular triangle $\cos 30^0 = a/2r$; $r = a/2\cos 30^0$

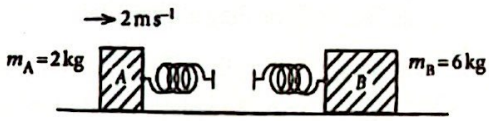
Directly for the circular motion of mass m around the centre, apply $F = ma$. $2F\cos 30^0 = mr\omega^2$ (where r = the distance from the centre to mass m, ω = the angular velocity of m)

$2Gmm\cos 30^0/a^2 = m.(a/2\cos 30^0).\omega^2$; $\omega^2 = 4Gm(\cos 30^0)^2/a^3$; $\omega^2 = 3Gm/a^3$

$$\omega = \sqrt{\frac{3Gm}{a^3}}; T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{a^3}{3Gm}}$$

There are simple geometry and calculation. Write centripetal acceleration as $r\omega^2$. Once ω is found, it is easy to find T. All you need is to select one mass and apply F = ma. When it is applied to one m, the others are also the same.

49. Block *A* of mass 2 kg and block *B* of mass 6 kg are placed on a frictionless horizontal surface. Two identical springs of negligible mass are fixed to the blocks as shown in the figure. Block *A* is projected with speed 2 m s^{-1} towards block *B* which is at rest. What is the maximum energy that the two springs could attain?



(1) 0 (2) 1 J

(3) 2 J (4) 3 J

(5) 4 J

Linear Momentum 05

The maximum energy of the springs is stored when the spring is contracted to its maximum amount. The strings are contracted in the maximum level when the two blocks are hit instantly and moves together. Next, the blocks are separated again. When the blocks are separated, again the springs acquire their natural lengths.

When the blocks are joined, let V be their common velocity. According to conservation of momentum, 2 x 2 = 8 V; V = ½ ms^{-1}

The maximum energy that two springs can acquire = initial kinetic energy – the kinetic energy of the combined system = ½ x 2x 4 -1/2 x 8x ¼ = 4 - 1 = 3 J

As the mass of the springs are not being considered, they are not connected to the kinetic energy calculations. There is no need of spring constant. If they are not stuck after collision, then they are being compressed to the maximum level as they are being collided. Are not they? After a moment of collision, both are separated. It is the nature of the world.

The initial kinetic energy of the bocks = 4 J (B is at rest)

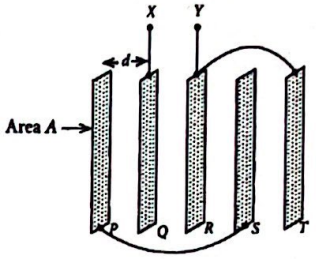
Kinetic energy of the blocks when they are moving together = 1 J

Who gets the difference? There is nobody unless the spring.

50. Five thin flat metal plates, each of area *A* are kept parallely in vacuum with an equal gap *d*. If plate *P* is connected to *S* and plate *R* is connected to *T* using conducting wires as shown in the figure, the equivalent capacitance between terminals *X* and *Y* is given by,

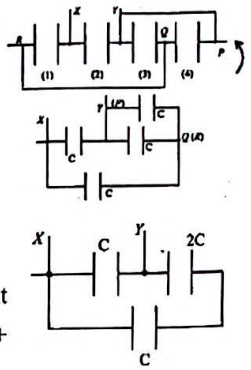
(1) $\frac{2\varepsilon_0 A}{d}$ (2) $\frac{5\varepsilon_0 A}{3d}$

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



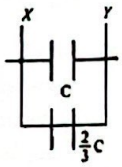
08 **Capacitants and Capacitors**

The logic of this problem has been discussed in 49th question of paper 2013. Draw the capacitors separately by dividing the middle plates. The four capacitors are shown by darkening. The potential of Y is equal to the potential of point P. So, (3) and (4) capacitors are parallel to each other. Why? Point Q is however common. Both points P and Y are nearby. Next, the potential of R is equal to the point of Q. Fold the fourth capacitor to upwards and first capacitor to downwards. The work is finished and the rest is simple.



By folding the first capacitor, R can be taken to Q. C and C are parallel. The equivalent capacitance is 2C. 2C and C series equivalent capacitance is 2C/3 (1/C' = 1//2C + 1/C). The equivalent capacitance should be lesser than C.

Finally, these two are in parallel. Therefore, final equivalnet capacitnace = C + 2C/3 = 5C/3 = $5\varepsilon_0 A/3d$



Even these diagrams are drawn for explaination, you should stop from the second figure and do the rest from your memory. C and C is 2C. When 2C and C are in series, then 2C/3. When 2C/3 is added to C (as they are parallel), then 5C/3.

A thin plate means theoretically a one without a thickness. Therefore, there is no meaning in giving the area of a side plate as A. The plates are divided into two for our convenience. Once the plates are divided, it is wrong to take the area of a plate as A/2. The area A of the thin plate is common to both sides.