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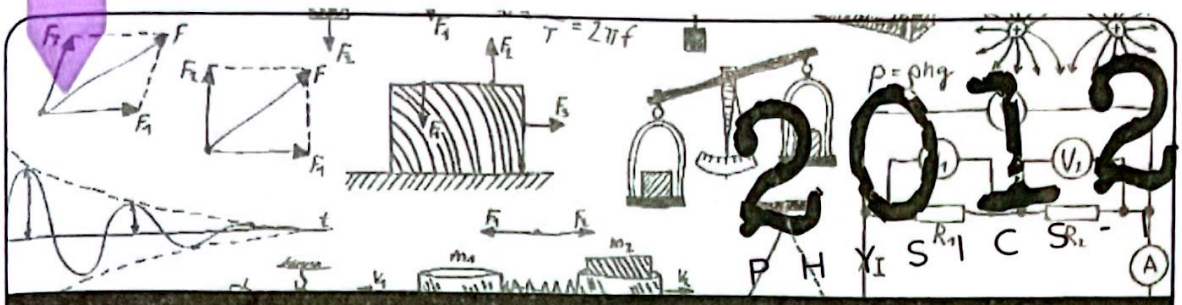
SDISCUSSIONGROUP



General Certificate of Education (Adv. Level) Examination

1. Which of the following **does not** represent a fundamental unit in the SI system?
(1) m (2) N (3) kg (4) s (5) K

Unit and Dimension 01

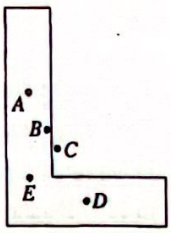
You can select the answer at a glance. There is no need to find the unit. Even there is no need to spend any time on this question. The basic units are m, kg, s and K. They are the basic units of length, mass, time and temperature respectively. Newton is the derived unit of the force. ($N = kg\ ms^{-2}$) If you know that there were persons who chose m as the answer, then how do you name such children?

2. If the distance between two masses is doubled the gravitational force between them will decrease by a factor of
(1) 2 (2) 4 (3) 6 (4) 8 (5) 12

Gravitational Force Field 05

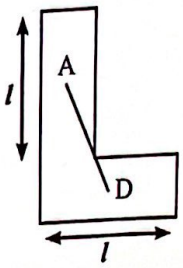
This is also a question that its answer can be obtained at a glance. The answer is (2). The gravitational force obeys the reciprocal square law. Some argue that the answer is ¼ not 4. If the varying factor has been asked, then ¼ is correct. There is the word reduced in the question. Therefore, the reducing factor is 4 not ¼. If you say that your love is reduced by 4 times (factor), then that indicates your love is reduced, not increased.

3. Figure shows a thin uniform L-shaped metal sheet. The centre of gravity of the sheet is most likely to be found at the point
(1) *A*
(2) *B*
(3) *C*
(4) *D*
(5) *E*



Centre of Gravity 02

You can get the answer very quickly for this. However, the points of A, E and D can be just removed. The shape of L is drawn as the two arms are with equal length according to the shown figure. The middle point of the vertical part is A whereas it is D in the horizontal part. Therefore, the centre of gravity lies in the middle of the line which joins the equal masses of A and D. That point is C. What else? The point B can be seen that it is not in the middle of A and D. Once you locate the middle points of vertical and horizontal parts as A and D, then the correct point can be found easily by yourself.



4. The minimum amount of work that has to be done in order to fix a light elastic string of initial length l_0 between two parallel walls separated by a distance d ($d > l_0$) with a tension T is

(1) $\frac{1}{2}T(d-l_0)$ (2) $\frac{Td}{l_0}$ (3) $T(d-l_0)$ (4) $\frac{1}{2}\frac{T}{(d-l_0)}$ (5) $\frac{1}{2}\frac{(d-l_0)^2}{T}$

Elasticity 10

If you get this wrong, then it can happen only due to the choices of (1) and (3). The other expressions are not correct even if you consider from dimensions. The initial tension of the string is zero. When there is an extension of (d-l_0), the tension is T. That means the tension has increased from zero to T. So, the average of the tension is T/2. The minimum work amount is ½ T (d-l_0). If you think in another way, a string with a spring constant k has faced an extension of x. Then the stored elastic potential energy of it is ½ kx^2. If the tension of the string for x extension is T, then T =kx. Accordingly, the stored elastic potential energy of the string is ½.T/x. x^2 =1/2 Tx. So, this is the minimum applied work. If this potential energy should be given to the string, then this amount of work has to be done.

5. A vessel contains an ideal gas at 27 °C. If the temperature of the gas is increased to 127 °C, the ratio, $\frac{\text{mean kinetic energy of the gas atoms at 127 °C}}{\text{mean kinetic energy of the gas atoms at 27 °C}}$ will become

(1) $\frac{127}{27}$ (2) $\frac{16}{9}$ (3) $\frac{4}{3}$ (4) $\frac{3}{4}$ (5) $\frac{27}{127}$

Expansion of Gauses 04

This can be done from the memory. The average kinetic energy is proportional to the absolute temperature. The temperatures of 127° C and 27° C are given to get a beautiful number when 273 is added. 300 is marked in our finger tips when 273 is added to 27 as we do Physics. Likewise, do not you get 400 when 273 is added to 127? Because compared to 27, 127 is increased by 100. Is not the answer 4/3? Is not the average kinetic energy at 127° C increased than the value at 27°C? Therefore, then answer is 4/3 as it cannot be ¾.

6. The mass of body A is twice that of body B. The specific heat capacity of the material of body A is three times that of body B. They are supplied with equal amounts of heat. If the body A experiences a temperature change of ΔT, then body B will experience a temperature change of

(1) $\frac{\Delta T}{2}$ (2) $\frac{2}{3}\Delta T$ (3) ΔT (4) $\frac{3}{2}\Delta T$ (5) $6\Delta T$

Calorimetry 04

This also can be done from the memory. $\Delta Q = mc\Delta\theta$. ΔQ is same. If m has been increased by double and c by triple, then should not $\Delta\theta$ be increased by six times? Do you need rough work? You can write if needed. 2m. 3c. $\Delta T = 6$ mc ΔT.

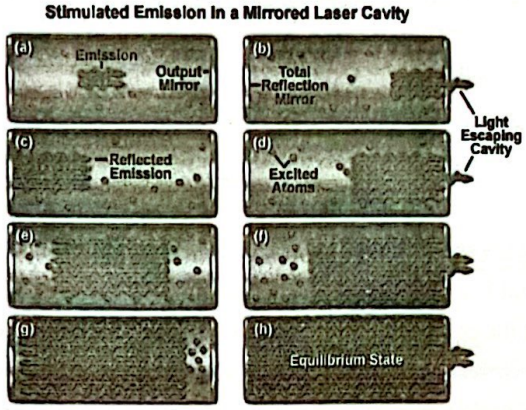
7. Consider the following statements made about laser light.
(A) The energy of a photon in a laser beam of certain frequency is higher than the energy of a photon of the same frequency in a normal light beam.
(B) A laser beam cannot be refracted by a glass prism.
(C) All the photons in a laser beam have the same energy, the same phase, and the same direction.

Of the above statements,

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

Electromagnetic Waves 03

The fundamental facts about laser light have been checked. There is light even it is laser. If the frequency is same, then the energy of a photon should be same even it is laser light or normal light. Laser is only an adjective for light. The laws of reflection and refraction are common to it. Statement (A) and (B) are not correct.



In the statement of (C), three special characteristics of a laser beam has been mentioned. Laser beam is monochromatic. That means the energy of all photons are same. The photons of laser are generated from an electron transfer of two specific energy levels. Each photon is in the same phase. It moves following one after the other one beautifully. That is why it is said as same phase (same art). Look at the figure. Another word for same phase is called coherent. The photons of the laser beam are a team that goes with a specific aim to a specified direction.

I would like to compare a laser beam to a group of soldiers in a march-past of a parade. They wear same clothes and simultaneously go forward in a same way (same phase). When one is lifting the left leg, then all the others are lifting their left legs. When one lifts left leg and the other lifts the right leg, then they are out of phase with each other. How beautiful when all are moving towards the same direction in a same style?

Most children learn a lot in vain about topics like laser, earthquakes etc. It is ok if learn for the desire. There is no need to by heart the things like laser production, materials, energy levels that are considered etc. In a paper of Physics, it is always check about your basic knowledge of Physics and the ability of solving non-complex problems. If something is asked beyond that, always you will be given aid.

8. A noisy workplace has a noise level of 90 dB. This was reduced to a less uncomfortable level of 70 dB.

The ratio $\frac{\text{new intensity of the noise}}{\text{old intensity of the noise}}$ is equal to

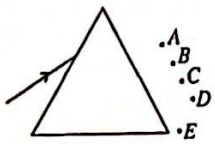
(1) 0.9 (2) 0.5 (3) 0.1 (4) 0.01 (5) 0.001

Intensity of Sound 03

Do you need rough work for this? If you have done similar questions in the previous papers with the correct logic, then you can get the answer very quickly. 20 dB has been reduced. So, the new intensity should be 10^{-2} times the old intensity. If you need to do it in a lengthy way, then $\beta_1 = 10 \log I_1/I_0$ and $\beta_2 = 10 \log I_2/I_0$. $\beta_2 - \beta_1 = 10 \log I_1/I_2$; If $\beta_2 - \beta_1 = 20$, then I_1/I_2 should be 10^2. It means $I_2/I_1 = 10^{-2} = 0.01$ Dear God! Do not do like this! Do you still need rough work for such questions?

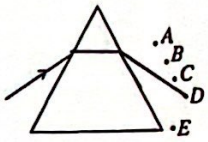
9. A monochromatic ray of light is incident on a glass prism and suffers minimum deviation while going through the prism. The emergent ray most likely will go through the point

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



Intensity of Sound 0

This is simple geometry. It is better to take a small ruler to the exam. Do not draw lines from the pen or pen clip. In this paper, the need of a ruler has been arisen in couple of questions (for example, 16, 26).

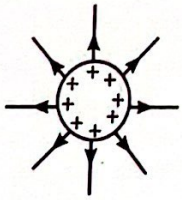


In the minimum deviation the ray should go symmetrically in the prism. If you design correctly (according to the eye sight), then point D is obtained as the correct answer. Some children have taken point C as the correct answer. However, the competition is between C and D. If you draw two lines across C and D, then you will see that D is the correct answer. You should see that the angle between the straight line across C and the refractive surface of the prism is greater than the angle between the incident ray and the incident surface of the prism.

10. Which of the following statements made about electric field lines is **false**?
(1) Electric field lines can be either straight or curved.
(2) Electric field lines can be parallel to one another.
(3) Electric field lines can form closed loops.
(4) Electric field lines begin on positive charges and end on negative charges.
(5) Electric field lines can never intersect with one another.

Electric Field Intensity 06

The problem is with the sentences of (3) and (4). Some say that electric field lines should start with positive charges and end with negative charges. Is this true? If an object is positively charged, then it is positively charged because some electrons are being removed from it. These removed electrons should be somewhere else. We draw the electric field lines emanating from a positively charged object like the figure below.

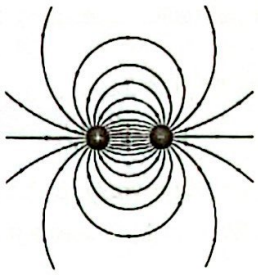


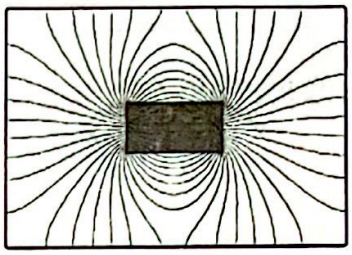
It is not visible that these lines end in negative charges. But these lines cannot be stopped abruptly as they need to be stopped at negative charges. The total charge of the universe should be conserved. Therefore, the negative charges related to positive charges should be at nearby or far away objects. Otherwise, it should end in infinity. The field lines are stopped in the middle due to convenience. This fact has been mentioned in Physics books that are written in English as well. For example, I will present the following sentence.

'Electric filed lines extend away from positive charge (where they originate) and toward negative charge (where they terminate).'

As the static electric filed lines originate from positive charges and end with negative charges, under static conditions these lines cannot turn and come back to the positive charge. That means it cannot end in a closed loop.

But closed loops are created by the magnetic field lines. Look at the following two figures. From the first, it has shown a positive and a negative charge (with same magnitude; di-pole) whereas from the second a bar magnet is shown.





Observe the behaviour of electric field lines and magnetic field lines properly. The electric field lines are always going away from the positive charge and towards to the negative charge. The magnetic field lines emanate from the north pole, go towards the south pole and again come to the north pole through the magnet. The logic is true even if you substitute a current carrying solenoid instead of the magnet. If you consider a Gaussian surface around a positive charge, there is a net positive flux across that surface. It should be like that that. The field lines are always going away from the positive charge.

Likewise, if a Gaussian surface was designed around the north pole, the net magnetic flux is zero. This is considered as the Gauss theorem for magnetic fields. This is not in the syllabus of G. C. E. (A/L). The net magnetic flux across any Gaussian surface should be zero. What is removed should come back again. To do so, the magnetic field lines should make closed loops. But this characteristic is not found in static electric field lines. The magnetic field lines come back as a boomerang.

Here many have asked a question. Their argument was that electric field lines should start from positive charges and should not end with negative charges. Also, they argue that electric fields make closed loops. How can this be resolved? Here the answer lies as the electric field can be possibly generated from two ways. The electric fields are created from the charges. We considered such an instance as above. Apart from that electric fields can be generated from the changing magnetic fields. Charges are not needed to generate such electric fields. When the magnetic field varies an electric field is generated even in the free space. This electric field is generated not from the charges. The base or the root of such electric fields are not the charges.

Therefore, for such electric fields, it is useless to mention that the relevant field lines should start from positive charges and end with negative charges. But such field lines are making closed loops. For example,

we can consider the induced eddy currents.

We can come into the following conclusions if we summarize everything as below.

For static electric fields generated from charges,

(1) The electric field lines start from positive charges and end from negative charges. This is correct.

(2) Closed loops are produced from the electric field lines. This is wrong.

For electric fields produced from the variations of magnetic fields (dynamic), (1) is wrong but (2) is correct.

Due to the conflict, both (3) and (4) have been considered as correct. The question mentioned about common electric fields. The question might have expected about the force lines under static conditions.

11. A spherical Gaussian surface surrounds a point charge q. The following changes were made to the system.
(A) The magnitude of the charge was tripled.
(B) The radius of the spherical Gaussian surface was doubled.
(C) The spherical Gaussian surface was changed to a surface of a cube.
(D) The charge was moved to another location inside the surface.
Of the changes mentioned above, the net electric flux through the surface is changed only in
(1) (A) (2) (A) and (B) (3) (C) and (D)
(4) (A), (B) and (D) (5) all (A), (B), (C) and (D).

Gauss Theorem 06

This is very simple. The net electric flux is dependent only upon the net charge inside the Gaussian surface. There is no effect from other changes on the net electric flux. Statement (A) is only true.

12. An ideal transformer operates at V_p = 12.0 kV ac on the primary side and supplies electricity to a number of nearby houses at V_s = 240 V, ac. The turns ratio, $\frac{\text{number of turns in the primary}}{\text{number of turns in the secondary}}$ of the transformer is
(1) 0.02 (2) 0.2 (3) 25 (4) 50 (5) 100

Mutual Induction 08

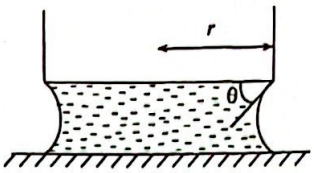
It is very simple. You can do it from the memory. The ratio of the turns is equal to the ratio of (primary voltage/ secondary voltage). That means 12,000/240 = 50. 12 kV should be converted to V. This is a step-down transformer. Therefore, the number of turns in the primary should be greater than the number of turns in the secondary.

13. Two copper wires have the same volume, but wire 2 is 20% longer than wire 1. The ratio, $\frac{\text{resistance of the wire 2}}{\text{resistance of the wire 1}}$ is
(1) 0.83 (2) 0.91 (3) 1.11 (4) 1.20 (5) 1.44

Ohm's Law Combinations of Resistances 08

This is the first question that I do rough work $R \propto \frac{l}{A}$. As the volume is same, in the proportionality, multiply l (length) on right and divide again., $R \propto \frac{l^2}{Al}$. Here Al is the volume. As the volumes are equal $R \propto l^2$ So, if the length of the first wire is 100 then the length of the second wire is 120. It is easy to take 20% increment like this way for the work. $R_2/R_1 = (120/100)^2 = 1.2^2 = 1.44$. You need a small calculation. If you take as $R \propto l^2$, then the calculation is very easy. As nothing is mentioned about the area (A), however it should be removed. The easiest way to do it is multiply A from l. Then as the volumes are equal, when taking the proportionality it will just cancel off.

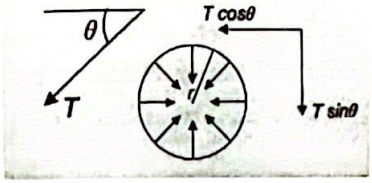
14. A water layer exists between the bottom of a cylindrical bottle and a glass plate as shown in the figure. The radius of the bottom of the bottle is r. When the bottle is raised slowly, at one instant the contact angle between water and the bottom of the bottle becomes θ. (see figure)
The magnitude of the force on the bottom of the bottle at that instant due to surface tension T of water, is



(1) $2\pi rT\sin\theta$ (2) $2\pi rT\cos\theta$ (3) $\pi r^2T\sin\theta$ (4) $\pi r^2T\cos\theta$ (5) $4\pi rT\sin\theta$

Surface Tension 10

It is very simple. If we consider the bottom of the bottle (the circle), the horizontal components of surface tensions are cancelled off with each other. Only the vertical components are left. To get the total surface tension force, you need to go a complete circle around the circumference of the bottom of the bottle. T sin θ is the vertical force per unit length. In a length of 2πr, there is 2πr T sin θ total force downwards. The figure has shown the horizontal components of surface tension forces.

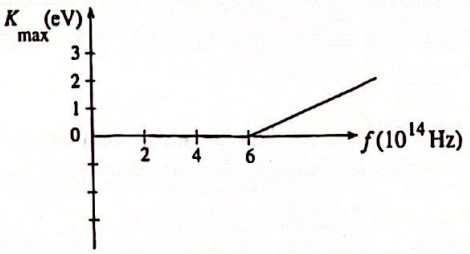


15. Which of the following is **not true** regarding the rate at which a body emits radiant energy?
(1) It is proportional to the surface area of the body.
(2) It is proportional to the 4th power of the absolute temperature of the body.
(3) It is proportional to the emissivity of the surface of the body.
(4) It depends on the temperature of the surrounding.
(5) It **does not** depend on the thermal capacity of the body.

Radiation 11

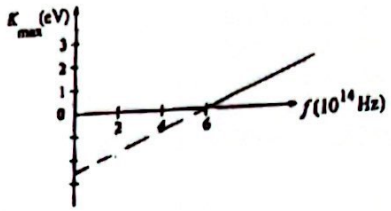
This is also very easy. The rate of emission of the radiation energy is not dependent upon the temperature of the environment. The rate of emission is equal to $e\sigma AT^4$. There are terms of e (emissivity), A (area) and T^4. If it is the net rate of emission, then it is equal to $e\sigma A\,(T_1^4 - T_2^4)$. There is the temperature of the environment in this expression. But there is the fourth power of the temperature of the environment.

16. The graph shows the variation of the maximum kinetic energy (K_{max}) of emitted photo-electrons from a metal with the frequency (f) of the incident radiation. The work function of the metal is
(1) 6.0 eV
(2) 4.0 eV
(3) 2.5 eV
(4) 2.0 eV
(5) 1.0 eV



Photoelectric Effect 11

The work is done, if you draw the straight line backwards and find the intercept. Some children have applied the Planck's constant from their memory and solve the equation to find the work function. It takes time. The examiners have given the graph with f versus K_{max} to find the work function directly from the intercept. $K_{max} = hf - \varphi$



Use a ruler and draw the straight line backwards. Estimate the value where it meets the K_{max} axis. It is exactly like 2.5 eV. If you solve numerically, then when K_{max} =0 then $hf_o = \varphi$

$\Phi = 6.6 \times 10^{-34} \times 6 \times 10^{14}$ J = $(6.6 \times 10^{-34} \times 6 \times 10^{14})/ 1.6 \times 10^{-19}$ eV = 2.475 eV. If you do like this, then it will consume time to simplify.

17. A radioactive isotope of iodine, $^{131}_{53}I$ decays to $^{131}_{54}Xe$. What type of particle is emitted in this decay?
(1) α (2) β^- (3) β^+ (4) p (5) n

Radioactivity

It is very simple. You can get the answer as soon as you see the question. In the decay, the value of A (131) has not been changed. Therefore, this is definitely a β decay. Next, look at the value of Z. Z value has been increased by one. That means a neutron has become a proton. If n has become a p, then it is a β^- decay. From the conservation of charge, you can decide this fact. $n \rightarrow p^+ + \beta^-$.

18. Consider the following statements made about the the information that can be obtained from dimensional analysis.
(A) Numerical values of constants of proportionality that may appear in a physical equation can be determined by dimensional analysis.
(B) Numerical signs of constants of proportionality that may appear in a physical equation can be determined by dimensional analysis.
(C) The units of constants of proportionality that may appear in a physical equation can be determined by dimensional analysis.
Of the above statements
(1) only (A) is true. (2) only (B) is true. (3) only (C) is true.
(4) only (B) and (C) are true. (5) all (A), (B) and (C) are true.

Unit and dimension

This is also very simple. From the dimension analysis, you already know that you cannot decide the numerical value or the sign of a constant. In the dimensional analysis, you equal the indices (powers) of the same dimension on both sides. When doing so, the value of the constant or the sign of the constant are not caught.

19. Equal masses of three liquids of densities d_1, d_2 and d_3 are added together. If the liquids mix together without causing any change, then the density of the composite liquid will be

(1) $\frac{d_1+d_2+d_3}{3}$ (2) $\frac{d_1d_2d_3}{3}$ (3) $\frac{3d_1d_2d_3}{d_1d_2+d_2d_3+d_3d_1}$

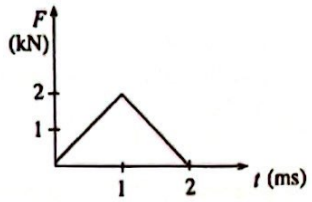
(4) $\frac{d_1d_2+d_2d_3+d_3d_1}{3}$ (5) $\frac{d_1d_2d_3}{d_1d_2+d_2d_3+d_3d_1}$

Hydrostatics

We will consider the equal mass as m. The density of the combined liquid is the division of total mass from the total volume. That means $\frac{3m}{\frac{m}{d_1}+\frac{m}{d_2}+\frac{m}{d_3}}$. As soon as you write this, you can see that the correct answer r is (3). You do not need to simplify further. Only (3) has three on the top.

20. A ball of mass 0.5 kg which is initially at rest, is struck by a bat. The variation of the force (F) on the ball with time (t) is shown in the figure. The speed of the ball when it leaves the bat is

(1) 10 m s^{-1} (2) 8 m s^{-1} (3) 6 m s^{-1}
(4) 4 m s^{-1} (5) 2 m s^{-1}

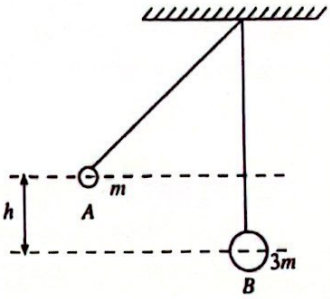


Newton's laws & momentum 02

There are plenty of such problems in previous past papers. F = m (v-u)/t; mv = Ft (as u= 0). Ft is the area of the triangle. 2 X 1 = 0.5 v; v = 4 ms^{-1}.

21. Two small spheres A and B of putty of mass m and $3m$ respectively are suspended from a ceiling by means of strings of equal length. Sphere A is drawn aside so that it is raised to a height h as shown, and then released. Sphere A collides with sphere B which is at rest, and they stick together. The maximum height to which the composite body swings is

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



Work Power & Energy 02

This is also a very familiar question. Everyone knows how to solve this. You need to use conservation of mechanical energy and conservation of linear momentum. There a shorter method instead of doing according to the traditional method. The normal way is to convert the initial potential energy of A into the kinetic energy of A and then use conservation of momentum for the collision. Finally, convert the total kinetic energy of A and B into gravitational potential energy.

Look at the way that I do. The momentum of the system is not changed. Therefore, you can write the kinetic energy as $p^2/2m$ instead of ½ mv^2 and save your time.

Applying conservation of energy for A, $mgh = p^2/2m$ ..... (1)

Once A and B are together, the common momentum of the system is p and it cannot be changed as it is conserved. If the maximum height of the system is h' then if we apply conservation of mechanical energy for the system (the total mass of the system is 4m), then

$4mgh' = p^2/2(4m)$ ..... (2)

Divide (2) by (1). You will get the answer and p just gets cut off. $4h'/h = ¼$; $h' = 1/16$ h.

22. A car of mass m manoeuvres a circular bend of radius of curvature r in a horizontal flat road with a speed v. If the car skids then (μ is the coefficient of friction between the road and a tyre).

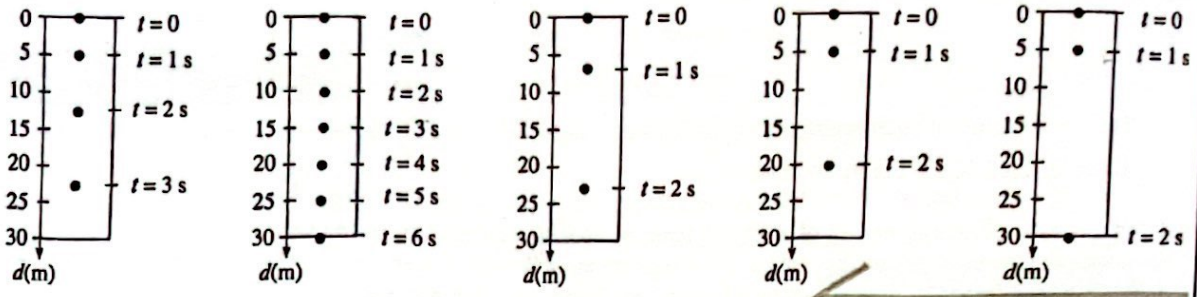
(1) $v > \sqrt{\mu rg}$ (2) $v < \sqrt{\frac{\mu rg}{4}}$ (3) $v > \sqrt{\frac{\mu rg}{m}}$ (4) $v < \sqrt{\mu rmg}$ (5) $v > \sqrt{\frac{\mu mg}{r}}$

Circular Motion 02

It is a question of peanuts. The road is flat $mv^2/r = \mu mg$. $v = \sqrt{\mu rg}$. Therefore, only the frictional force should provide the centripetal force that is needed to take the bend. If you need to go slightly by v speed

(without skidding), $mv^2/r = \mu mg$. . Therefore, if the vehicle is skidding, then v should be greater than $\sqrt{\mu r g}$. The frictional force is not able to provide the centripetal force at that moment. The correct answer is (1).

23. Photographs of an object that starts falling freely from rest at $t = 0$ are taken by a camera, first at $t = 0$, and thereafter at the end of each second. Which of the following diagrams correctly indicates the location of the object at the end of each second? The vertical axes of the diagrams represent the distance (d) travelled by the object.



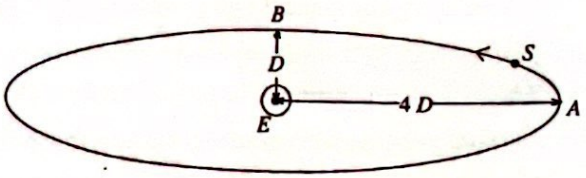
(1) (2) (3)

It is very simple. Most of the questions of this time seems to be simple. The travelled distance is proportional to t^2 (as u =0). So, if the travelled distance in the first second is 5 m, then after 2s it should travel 20m [5 x $(2)^2$] of distance. If you do calculations, then $5 \propto 1^2$; $d \propto 2^2$; d/5 = 4; d = 20m

There is no need to apply g and do the calculation. Even from the proportionality method, you can do from your memory. In all of (1), (2), (4) and (5), it has been drawn that the travelled distance as 5 m in the first second. Only in (3) it has been drawn more than 5. If you consider as 7, then 7 multiplied by 4 it should be 28. Therefore, (3) is wrong. Except for (3), the travelled distance is 5 m in t = 1 s in all choices. So, the work is easy. The correct answer is (4).

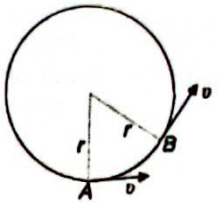
24. A satellite (S) moves in an elliptical orbit about the earth (E). If the speed of the satellite at point A is v, then its speed at point B will be

(1) $\frac{v}{8}$ (2) $\frac{v}{4}$
(3) v (4) $2v$
(5) $4v$



There was an unexpected problem in this question. Most children have solved using $mv^2/r = GMm/r^2$. According to this $v^2 \propto \frac{1}{r}$. If so, $v^2 \propto \frac{1}{4D}$; $v_1^2 \propto \frac{1}{D}$. Then you will get $v_1 = 2v$. But the correct answer is 4v. What is the reason for this?

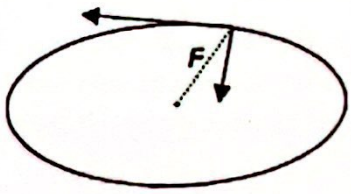
The locus of the satellite is elliptical. You can use v^2/r for a circular locus. If you need to use v^2/r, then r should be a constant. Many aksed cannot we apply v^2/r for one place (A and B). Acceleration is the rate of **change** of velocity with time. To have a change there should be two instances. If the locus is not circular, then the radius r may not be the same even if we take a very close instances. v^2/r is derived using the following figure (derivation is not in the syllabus).



When considering the points A and B, you get v^2/r only if r is constant. Therefore, this problem should be solved using conservation of angular momentum. The gravitational force is a centric force. Therefore, we can conserve the angular momentum around the centre. If m is the mass of the satellite, then mvr is always a constant. Then $v4D = v_1D$ and $v_1 = 4v$.

It is easy to get angular momentum from mvr instead of Iω. There is no problem in taking Iω as well. $I = mr^2$, $v = r\omega$ and from this also you get mvr. There is no isuue in considering the satellite as a point object here. Compared to the dimensions of the satellite the value of D is very large. So, compared to the centre of the earth there is no problem in considering the satellite as a point object. We see everything as small when they tend to go far away.

Some argue that this should be solved using Kepler's second law. Kepler's laws are not in the syllabus. Practically found second law of Kepler is associated with conservation of angular momentum. From the conservation of angular momentum, you can get Kepler's second law. Nobody knew about conservation of angular momentum during the time he found it experimentally with greatest difficulty. Newtonian mechanics was born after Kepler had found these laws.



There is a wrong assumption that we cannot apply conservation of angular momentum for this question. As the gravitiational force on the satellite which is directed towards the centre of the earth goes across the centre, there is no torque around the centre from this force what ever the location of the satellite. There is no argument about it. Some argure that this force F which is directed towards the centre can be resolved along the tangent (at the direction of the velocity) and to its perpendicular direction. Further they say that the force component across the tangent creates a moment around the centre. Why do they forget the moment from the other component? If the component along the tangent creates an anti-clockwise moment, then the perpendicular component to the tangent creates a clockwise moment across the centre. As these moments act in opposite directions they should be cancelled off with each other. There is no need to resolve the gravitational force that is directed towards the centre. Actually, the gravitational force is a definitely a central froce. Even our earth does not go on a circular path around the sun. That locus is elliptical. But if the forces acting on the earth from the other celestal objects can be neglected, then we can conserve the angular momentum of the earth around the sun.

25. Consider the following statements made about a particle of mass m attached to a light spring and performing simple harmonic motion as shown in the figure.

(A) The acceleration of the particle is always towards the centre of motion.
(B) The force on the particle is proportional to the square of the displacement from the centre.
(C) The period of oscillation depends on the mass of the particle.

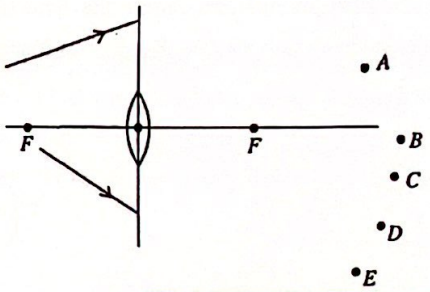
Of the above statements,

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

Simple Harmonic Motion 03

These are simple sentences that everybody knows. (A) is true. The acceleration of an object which undergoes simple harmonic motion is always directed towards the centre of the motion. The reason is that the active force is always directed towards the centre. If the force is directed only to the person of love, then is it a surprise that force revolves around that person? (B) is wrong. The force (F) is proportional to displacement (x) like this $F \propto (-x)$. (C) is correct. You will recall an equation like $T = 2\pi\sqrt{\frac{m}{k}}$. T is dependent upon m. T is proportional to $\sqrt{m}$. The correct answer is (4). There is no m in the period equation of simple pendulum. The reason is that the simple pendulum is only driven by a component of mg. When F = ma is applied, m is cut off. But when there is a spring, there is a force of kx on m. Then m is not cut off from both sides in the equation of F = ma.

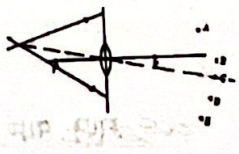
26. Consider two rays moving towards a thin converging lens as shown in the figure. After passing through the lens, the two rays are most likely to be met at the point



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

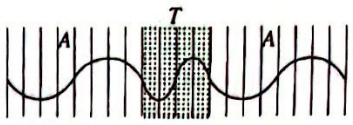
Refraction Through Lenses 03

You need to do a simple thing. The two incident rays should be drawn to the left side (backwards). So that they meet each other. Only point C is directly located with the point that rays meet and the optical centre. You do not need to draw the ray that goes across the optical centre. It is like you kept an object or a point object there. There is nothing wrong in considering like that way.



The most possible point where the two rays can meet after going across the lens is the place where the image of the object or the image of a point in an object is formed. From the point where two rays meet, the ray that is drawn parallel to the main axis should go across F and it should go across point C. Point C has been marked even to get that requirement correct. But you do not have to check whether it is right or wrong. Only the point C has been marked as the point where it is marked directly with the meeting point of the rays at left side and the optical centre. If there is another point in that straight line, then you need to draw the ray diagram that goes parallel to the main axis. But such extra work is not needed.

27. Figure shows the changes occurred to a waveform of a monochromatic ray of light travelling in air (A) when incident normally and transmitted through a transparent medium (T). The refractive index of the transparent medium is



(1) 1.5 (2) 2.0 (3) 2.5
(4) 3.0 (5) 3.5

Refraction 03

The refractive index of a transparent medium is the division of light speed in the air by the light speed in the medium. As the frequency of the light is not changed, this ratio is equal to the ratio of wavelengths. The change of wavelength of the wave has been clearly shown in the figure. The vertical lines are drawn in an equidistant way to decide the width of the wave (wavelength) conveniently. One wavelength has been drawn in the air. Its value is 8 vertical squares. In the medium also there is one wavelength and its value is 4 vertical squares. Therefore, the ratio of the wavelength of the air by medium is 2 (8/4). That means the refractive index is 2. If you take half or quarter from the wavelength, this ratio can be very easily decided. If quarter of a wavelength is taken, then its width is 2 stripes in the air. At the medium, it is reduced to one.

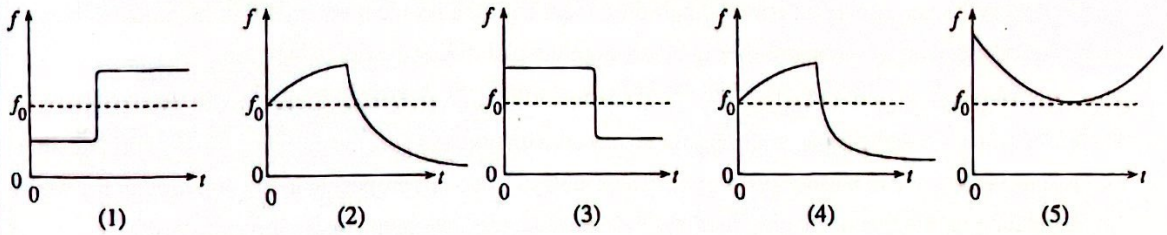
28. The human vocal tract (larynx) can be considered as a tube that is open at one end. If the length of this tube is 17 cm, the frequencies of the lowest two harmonics produced are given by (The speed of sound in air = 340 m s^{-1})

(1) 500 Hz, 1500 Hz (2) 500 Hz, 1000 Hz (3) 1000 Hz, 2000 Hz
(4) 1000 Hz, 3000 Hz (5) 1500 Hz, 2500 Hz

Longitudinal Waves 03

The lowest two harmonics are the fundamental and the first overtone. In the fundamental frequency, the wavelength (λ) is four times the length of the tube (l). This is a fact that you know it from your heart. When $v = f\lambda$ is applied, then $340 = f \times 4 \times 17 \times 10^{-2}$; $f = 340 \times 10^2 / (4 \times 17) = 500$. It simplifies very easily. Once you get this you know that the first overtone is triple the value of the fundamental frequency. There is no need to do calculations again. The beat frequencies of a tube with one end open are placed at 1: 3: 5: 7 (odd numbers) and likewise. If both ends are open, then the adjacent beat frequencies are placed at 1: 2: 3: 4 and likewise. The answer is (1).

29. A train travelling at a constant velocity while continuously sounding its horn with a frequency f_0 moves towards an observer standing on a platform and then moves away from him. The variation of the frequency (f) of the horn as heard by the observer with time (t) is best represented by



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

Doppler Effect 03

You can decide as soon as you see the question. When the source is coming towards the observer the heard frequency should be greater than f_o whereas when it is going away from the observer the heard frequency should be lesser than f_o. This variation is shown only in (3). (1) shows the reciprocal of it. (2) and (4) are nonsense whereas (5) is wrong. The heard frequency is not dependent upon the distance. However (5) shows only the values greater than f_o. When you look accurately from the equations, if f' is the heard frequency when it is coming towards and f'' is the heard frequency when it is going away, then the following expressions gives f' and f''.

$f' = v f_o/(v - v_s)$ and $f'' = v f_o/(v + v_s)$; According to that, one can argue that the increment of f' compared to f_o which is $(f' - f_o)$ is not equal to the decrement of f'' compared to f_o which is $(f_o - f'')$. In (3), these changes have been drawn equally. But what is expected in this question is to check only the increase of f' compared to f_o and decrease of f'' compared f_o, if you check this fact also, then the question gets complicated. Because we need to decide the magnitude of the differences of $(f' - f_o)$ and $(f_o - f'')$. This takes time. Even if we substitute normal values, then the differences between these two are not adequate enough to show in a graph.

$$f' - f_o = f_o\left(\frac{v}{v - v_s} - 1\right) = f_o\frac{v_s}{v - v_s} = \frac{f_o}{\frac{v}{v_s} - 1}$$

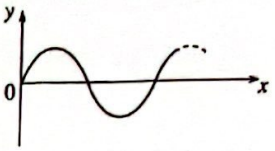
$$f_o - f'' = f_o\left(1 - \frac{v}{v + v_s}\right) = f_o\frac{v_s}{v + v_s} = \frac{f_o}{\frac{v}{v_s} + 1}$$

If we take $v = 340\ ms^{-1}$ and v_s (train) $= 20\ ms^{-1}$, then $f' - f_o = 0.0625\ f_o$; $f_o - f'' = 0.0556\ f_o$. It is true that, $(f' - f_o)$ than $(f_o - f'')$. But if you try to check that also, then you need to think more. From the given graphs, (3) is the most suitable graph.

30. The graph shows the variation of a quantity y with another quantity x. Consider the following statements.

(A) If the graph represents a wave travelling in a stretched string, along the x direction, y could be the displacement of a particle of the string in a direction perpendicular to the motion of the wave, at a given instant.

(B) If the graph represents a wave travelling in water, x could be the time and y could be the displacement of a water molecule along the direction of the wave.



(C) If the graph represents a vibration of a tuning fork, x could be the time and y could be the velocity of the tip of one prong of the fork.

Of the above statements,

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

There was some uncertainty in some sentences. Statement (A) says ab realize it once you read it. If we consider the displacement of a particle, then statement (A) is wrong. The graph shows the displacement of the particles not a particle. If we take a picture at an instance, that shape is shown by the graph. Once the shape is obtained the locations of the particles of the string are shown from the graph. Due to the confuse about particle/ particles, there can be a problem whether this statement is correct or wrong. The benefit of the doubt should be given to the plaintiff or the defendant?

If the statement (B) says about a longitudinal wave travelling in water, then (B) is correct. In a longitudinal wave, any water molecule is in simple harmonic motion with time towards the direction of wave propagation. If it is transverse wave in a water surface, the water molecules do not propagate to the direction of the wave. So, depending on the fact of longitudinal/ transverse wave, the statement (B) is correct or wrong.

Without an argument statement (C) is true. Some argue that a cosine curve should be drawn instead of a sine curve. There is no truth in this. We can start to measure time from anywhere. In this graph, the time has started to measure from the instance where the velocity is zero. That means the prong of the tuning fork has come to its amplitude. If the time is measured from the balanced arrangement of the prong, then it is true that a cos curve should be obtained. But it does not have to be like that. However, these three statements are independent from each other.

Instead of the displacement of particles there is a displacement of a particle. So, (A) is wrong. (B) can be

correct or incorrect. (B) is definitely correct if it was mentioned as in the water instead of the water. Anyway (C) is correct. Due to the dilemma, the choices of (2), (3), (4) and (5) were all considered as correct.

31. A planet is observed by an astronomical telescope in normal adjustment, having an objective of focal length 14 m and an eyepiece of focal length 2 cm. Consider the following statements.
(A) The distance between the objective and the eye piece is 1402 cm.
(B) Angular magnification of the planet is 700.
(C) The image of the planet is formed at the near point of the observer.
Of the above statements
(1) only (A) and (B) are true.
(2) only (A) and (C) are true.
(3) only (B) and (C) are true.
(4) only (B) is true.
(5) all (A), (B) and (C) are true.

Optical Instrument 03

This is just a question that everyone knows. If an astrlogical telescope is at normal adjustment, then the distance between the lenses is equal to the total of focal lengths of the lenses. Therefore, (A) is correct. You should not be cofused with cm and m. The angular magnification is equal to the ratio of focal length of the objective by the focal length of eyepiece. It is 1400/2 =700. The image is created at the infinity. These questions have been asked multiple times. Both (A) and (B) are correct.

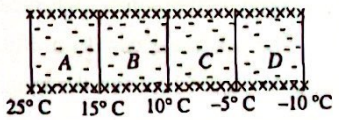
32. Consider a process where air is quickly leaking out of a balloon. Which of the following is true for this process?

	ΔQ	ΔW	ΔU
(1)	+	+	+
(2)	–	–	–
(3)	0	0	0
(4)	0	–	–
(5)	0	+	–

Thermodynamics 04

It is very simple. The air supplying process was asked in paper 2010. Once you see the word 'quickly', you should remember the word adiabatic. When it is happening quickly, it does not allow time to transfer heat. $\Delta Q = 0$. When air travels from the balloon to the environment, there is a volume expansion (increment). Then a work is done by the air. ΔV is positive. Therefore, ΔW is also positive. As $\Delta Q = 0$ and ΔW is positive, ΔU should be negative. $\Delta U = -\Delta W$. What is meant by negative ΔU is the reduction of the internal energy of the air. That means a reduction of the temperature. When air is released from a tyre to the environment, we know from experience that the nozzle of the tyre gets cooled. Even from that experience we can decide that ΔU of the air gets reduced (negative). We know that $\Delta Q = 0$, once we saw the word quickly. If ΔU get negative and $\Delta Q = 0$, then ΔW should be definitely be positive.

33. The figure indicates the face and interface temperatures of a lagged composite slab consisting of four materials *A*, *B*, *C* and *D* of identical thickness and surface area through which the heat transfer is steady. If k_A, k_B, k_C and k_D are the thermal conductivities of materials *A*, *B*, *C* and *D* respectively then



(1) $k_A > k_B > k_C > k_D$
(2) $k_A < k_B < k_C < k_D$
(3) $k_B = k_D > k_A > k_C$
(4) $k_B = k_D < k_A < k_C$
(5) $k_B = k_D = k_A > k_C$

Conductivity 04

It is enough if you could write down the temperature difference of adjacent interfaces in the question paper itself. As the area and thickness are equal in the adjacent interfaces, you can decide the thermal conductivity values by the temperature difference at the continuous state.

A B C D

25 15 10 -5 -10

10 5 15 5

You need to be careful when taking 10-(-5) and -5-(-10). We need the temperature difference. When the temperature is reduced from 10°C to -5°C, the difference is 15°C. Now the answer is in your hand. If the temperature differences are same, then the thermal conductivities are also same. If the temperature difference is greater, then the thermal conductivity is less. When heat flows across a greater thermal conductor, then the temperature difference between the adjacent interfaces is less. If it is a good insulator (with less thermal conductivity), then the temperature difference is bigger. If it is a good thermal conductor (with high thermal conductivity), then the temperature difference between adjacent interfaces is not with much value. Therefore, as soon as a temperature difference is seen, you can decide that $k_B = k_D > k_A > k_C$.

34. Consider the following statements made about the capability of a given thermometer to produce an accurate value for a temperature measurement.
(A) In situations where quick changes of temperature with time have to be measured, the given thermometer must be a one having large variation of the thermometric property with temperature.
(B) Thermal capacity of the thermometer must be negligible when compared to the thermal capacity of the environment of which the temperature is measured.
(C) Thermometric property must have a linear variation with the temperature.
Of the above statements
(1) only (B) is true.
(2) only (A) and (B) are true.
(3) only (B) and (C) are true.
(4) only (A) and (C) are true.
(5) all (A), (B) and (C) are true.

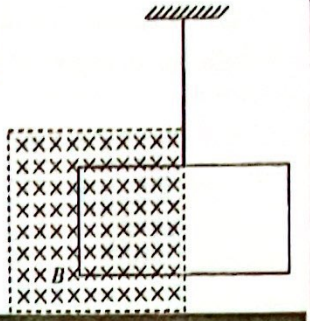
Thermometry

There were different views also for this question The important word is the correct value in the phrase of 'possibility of giving a **correct value** for a temperature measurement'. Statement (A) is correct and there is no debate about it. If the temperature changes quickly with time, then it is better if the thermometric characteristic also varies quickly. Then it has a good sensitivity of the thermometer. But you will not get a hint about accuracy from this statement. It can be accurate. Sensitivity and accuracy are two different characteristics. Sensitive people can be correct or not. Therefore, statement (A) cannot predict the accuracy of the thermometer even it is correct as a sentence.

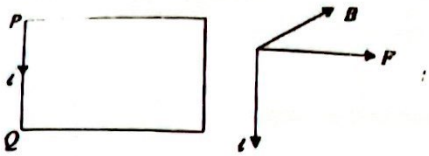
Statement (B) directly affects the accuracy of the measuring temperature. According to (B), the heat transfer from the system to the thermometer is very less. Then the measured temperature is close to the real temperature. That means the measured value is accurate. (C) is not a compulsory factor. It is good to have a linear variation. But it is not a compulsory and an essential factor. If it is calliberated correctly, there is no need for the thermometric characteristic to vary linearly with the temperature. For example, we can consider the thermo electric couple. Let us think that the expansion of mercury is not linearly varying with the temperature. Let us thenink that the expansion for high temperatures for a degree is greater compared to the lower temperatures. If so, in high temperatures you can increase the distance between two adjacent marks and construct the thermometer. Therefore, the variation of being linear or not affecting the accuracy. Such sentences have been given in previous papers too. In the 6th question of paper 1994, it has been checked that for a thermometric liquid it is not essential to have a charateristic which linearly increases with the temperature. All you need is a characteristic which varies with the temperature. In the 38th question of year 2008, there are three sentences about the sensitivity and accuracy of themometers. The 57th question of paper 2007 is also related to this question. It has mentioned that what is meant by accuracy. It is the meaurment of the temperature with its value as much as possible. So, statement (B) is only correct.

35. A light, conducting loop is suspended freely, and a half of the loop is inserted into a magnetic field as shown in the figure. If the magnetic field begins to increase rapidly in strength,

(1) the loop begins to move in the direction of the magnetic field.
(2) the loop begins to move against the direction of the magnetic field.
(3) the loop begins to move (to the left) into the field.
(4) the loop begins to move (to the right) out of the field.
(5) the loop **does not** move at all.

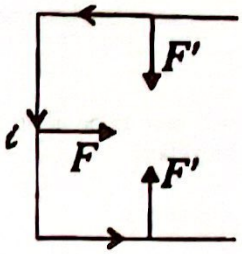


This is very simple. As the magnetic field strength is increased into the loop, according to Lenz law (accroding to nature), there should be an induced current in the loop which can reduce the increment of the magentic field. The nature resists for changes. So are we. To decrease the increment into the loop, the direction of the generated magentic field should be out of the loop due to the induced current. That means the induced current should flow downwards in PQ wire section.



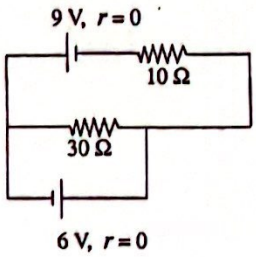
Then the induced magnetic field acts outside the loop perpendicularly to it. If the current of PQ section flows from Q to P, then the magnetic field inside the loop will be increased more to inward. Now ilB force is acting to the right side on PQ.

So, the loop goes away from the field. The horizontal wire parts of the loop which stays inside the field are not needed to be considered. Even there are forces acting on those parts, these forces are equal and opposite (F' = il'B). They cancel off with each other.



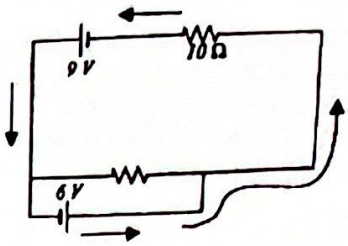
36. Current through the 10 Ω resistor is

(1) 0
(2) 1.5 A
(3) 3.0 A
(4) 5.0 A
(5) 6.0 A



This is very simple. There is no use from 30 Ω. Just do not hold 30 Ω and take your eye around. You can

get the answer from your memory. 9 and 6 are added together. When 15 is divided by 10 it is 1.5 A. The 39th question of paper 2009 is also like this question.



37. A metal wire has resistances R_1 and R_2 at temperatures θ_1 and θ_2 respectively. The temperature coefficient of resistivity of the metal, is given by

(1) $\frac{(\theta_1-\theta_2)}{(R_1-R_2)}$ (2) $\frac{(R_1-R_2)}{(\theta_1-\theta_2)}$ (3) $\frac{(R_1-R_2)}{(\theta_1-\theta_2)(R_1+R_2)}$

(4) $\frac{(R_1-R_2)}{(R_2\theta_1-R_1\theta_2)}$ (5) $\frac{(R_2\theta_1-R_1\theta_2)}{(R_1-R_2)}$

Ohm's Law Combinations of Resistance

You need a simplify but the question is simple.

$R_1 = R_o(1+\alpha\theta_1)$ ..... (1)

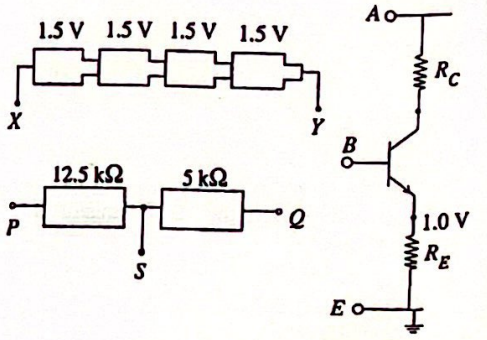
$R_2 = R_o(1+\alpha\theta_2)$ ..... (2)

As there is R_1-R_2 in the answers, you can be tempted to subtract 1 from 2. But you cannot remove R_o from it. So, you need to divide 2 by 1. $R_1/R_2 = (1+\alpha\theta_1)/(1+\alpha\theta_2)$

Once you do cross multiplication, $R_1 + R_1\,\alpha\theta_2 = R_2 + R_2\,\alpha\theta_1$ you will realize that (4) is the answer. If you simplify more, you can get the correct expression for α. The unit of α should be $^0C^{-1}$. Even if you look from that way, the correct answer should be either (3) or (4). The dimensions/units are wrong in other expressions. It is true that you do not think like this way. But at some occasions, you can remove many choices from dimension/unit analysis.

38. Which of the following connections will have to be made in order to operate the transistor (Si) circuit given in the figure as a common emitter amplifier?

(1) *XE, YB, AP, BQ, SE*
(2) *PA, YE, XP, BS, QE*
(3) *SB, YA, AQ, BQ, SE*
(4) *XE, YB, AQ, BP, SA*
(5) *YA, XE, AP, BS, QE*

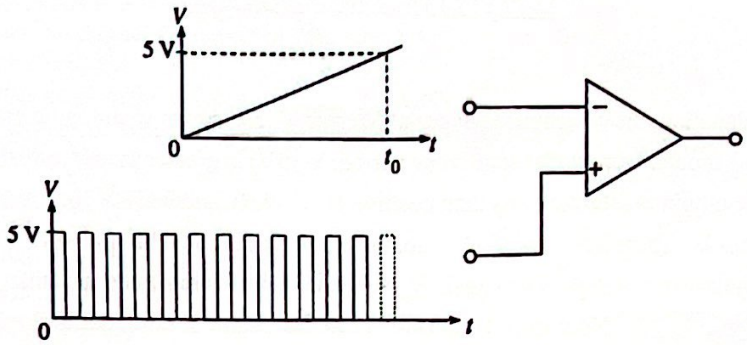


Transistors

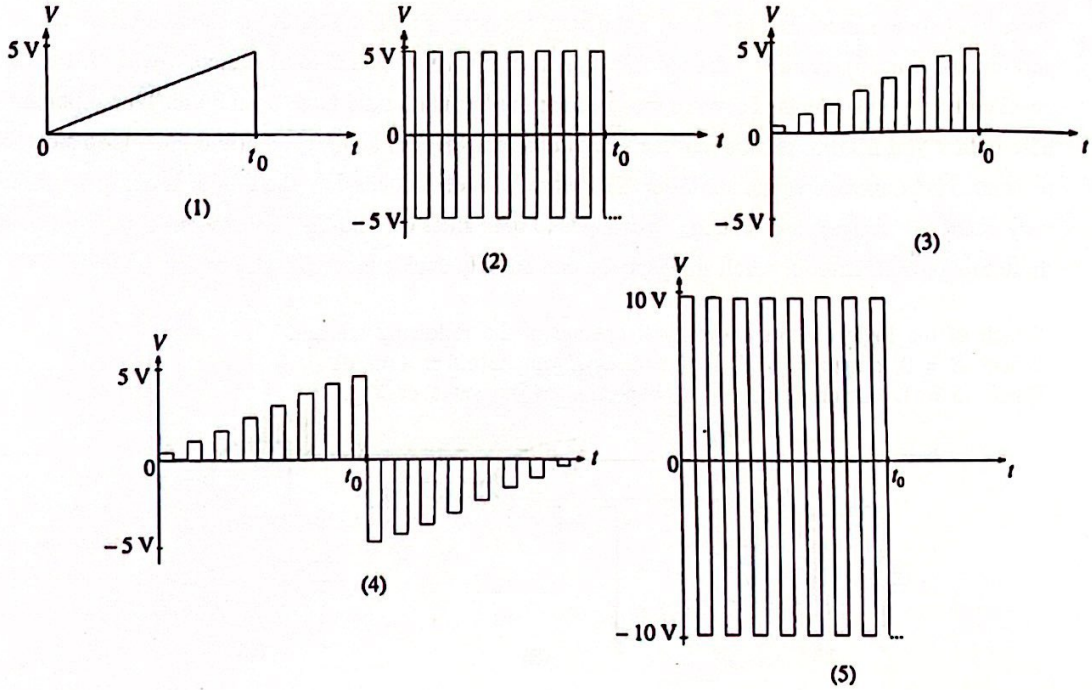
You can decide the answer even without thinking more. You clearly know that the voltage should be applied in between A and E. Therefore, the positive end of cells row Y should be connected to A whereas negative

end X to E. YA and XE connections are shown only in (5). Any other choice does not mention these two relations correctly. How great is that? You can finish it by without looking at the other relations. If you look at the other relations, then here is the logic. The transistor is Silicon. If it is in active mode, the voltage drop is 0.7 V across the base and the emitter junction. Therefore, the voltage drop across B and E ends (earthed) should be 1.7 V. The voltage of the emitter is given as 1 V. So, 6 V (1.5 X 4) which is in between A and E (earthed) ends should be dropped more in between A and B. To do that, the bigger resistance (12.5 kΩ) should be connected in between A and B. There is no need to find the values as there is no requirement. 6V should be dropped more in between A and B. If you need to do calculations, then do like this way. The voltage drop that should be across AB = 6 -1.7 = 4.3 V; The voltage drop across BE = 1.7 V; The ratio of these two values = 4.3/1.7 = 2.53; 12.5/5 =2.5. So, the work is done. But this calculation is unnecessary. If you can finish the work initially in the land, why do you go into the mud?

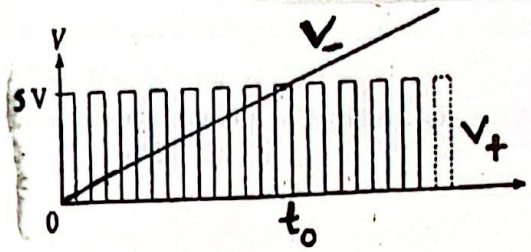
39.



The inverting input of a 741 operational amplifier operating with ±10 V power supply voltages is provided with a voltage signal which increases linearly with time (t) as shown in the figure.
The non-inverting input is provided with a rectangular voltage waveform of amplitude 5 V as shown. The output waveform of the operational amplifier is best represented by



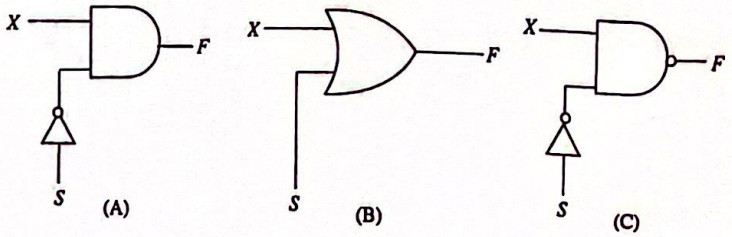
I feel that this question was bit hard. There is an open loop operational amplifier here. You know that if th non-inverting input voltage is V_+ and the inverting input voltage is V_-, then the output voltage $V_o = A(V_+ - V$ A is the open loop voltage gain of the amplifier. As the value of A is large (10^5-10^6), even for a very sma voltage change (μV range), the output voltage is saturated. But the value of V_o cannot increase the supplie voltage of and practically V_o is stable (saturated) little lower than 10 V. Even if you only consider this point you can decide that the correct choice is (5). Why? Because in any other graph, the positive value of V_o i not drawn lesser than +10 V or the negative value of V_o is not drawn bit higher than -10 V.



To ease the explanation, the two input voltages of V+ and V- are drawn in the same graph. First look at the rectangular wave model. During that small time period, V_+(5V) is greater than V_- (small value). That means $V_+ > V_-$. Then the output is saturated less than positive 10 V. Next, suddenly V_+ becomes zero. Then there is a certain value for V_-. Therefore, now $V_- > V_+$. So, the output is saturated bit higher than negative 10 V. Now the next rectangular strip arrives. Then again $V_+ > V_-$. The output is saturated less than positive 10 V. Next when V_+ gets zero, $V_- > V_+$. Now truly V_+ is zero. Then the output is saturated bit higher than negative 10 V. Cannot you see that this process is being carried out for 8 strips? One after the other $V_+ > V_-$ whereas one in between after the other is $V_- > V_+(0)$. Therefore, the output also goes up (less than +10 V) and down (little more than -10 V) interchangeably.

What will happen after 8 strips? Afterwards it is $V_- > V_+$. Even V_+ is changed between 5 V and zero time to time, V_- is always increased than 5 V. Then what happens is that, the output is saturated little above -10 V continuously. In (5), there is a dashed line after t_o (near -10 V) is due to this. Actually, such a thing is not checked from the students. To make the question harder, that could have been done. The important factor here is that you need to realize that the operational amplifier is being used at the open loop situation. No resistance is connected to the amplifier. Therefore, at such an occasion, the output is being saturated for a very small (μV range) input change. It changes to both sides depending on $V_+ > V_-$ or $V_- > V_+$. If you know these things, then without much analysis you can directly decide that (5) is the correct choice.

40. Which of the logic circuits shown will operate in the following manner?
When $S = 0$, output $F = X$ (value of X can be either 1 or 0)
When $S = 1$, output $F = 0$ (irrespective of the value of X)



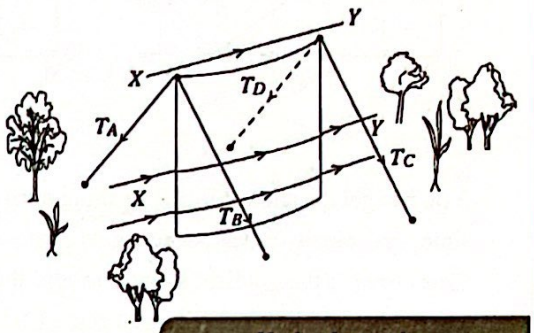
(1) (A) only.
(2) (B) only
(3) (C) only.
(4) (A) and (B) only
(5) (B) and (C) only.

Logic Gates

The easiest way is to write the Boolean expression. S becomes $\bar{S}$ Then Boolean expression for (A) is $F = X\,\bar{S}$ Now check the data that has been given. When S = 0, $\bar{S}$ =1 Then F =X. When S =1 $\bar{S}$ =0. Then F =0 for whatever the value of X. Circuit (A) is correct. The Boolean expression for (B) is F = X+S (OR gate). Then when S =0, F =X. It is correct but when S =1, F =1. This is not going to work (because X+1 =1; 0+1 =1; 1+1 =1). As (A) is correct, you do not have to look into (C). The only difference between (A) and (C) is instead of AND in (A), there is NAND in (C). Therefore, if (A) is correct, then (C) cannot be correct. Without writing Boolean expressions, you can apply values for S and get the answer without any rough work too. That system may be easy for many children. Once (A) is correct, a clever child can see that the others are just not working. (B) has a normal OR gate. From simple intelligence it can be see that it will not work according to the given way. As (A) is correct, why do you need to look at (C)? If (A) is boy/girl then (C) is girl/boy.

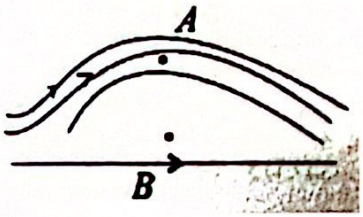
41. A large metal sheet **bent into the shape** shown in the figure is kept upright on the ground by means of four stretched ropes fixed to the ground.
Magnitudes of the tensions in all ropes, T_A, T_B, T_C, and T_D in still air are equal. When wind blows through the sheet in the direction XY

(1) $T_A < T_B$ and $T_D < T_C$
(2) $T_A > T_B$ and $T_D > T_C$
(3) $T_A = T_B$ and $T_C = T_D$
(4) $T_A > T_B$ and $T_C > T_D$
(5) $T_A < T_B$ and $T_C < T_D$

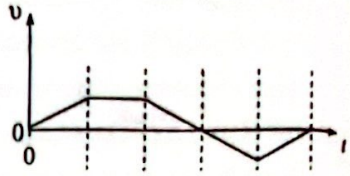


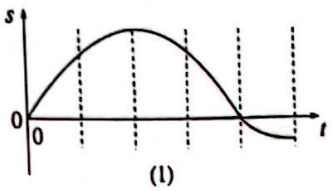
It is very simple. It is a plate that has been folded like a wing of an airplane. There nothing to write equations in the questions. As $V_A > V_B$, you know that $P_B > P_A$. Therefore, the plate tends to pull from the high-pressure side to the low-pressure side. Then the rope that is on high-pressure side tends to stretch more whereas the rope in the low- pressure side tends to release a bit. This is general knowledge. All you need to think this much. The correct answer is (2).

You cannot say anything about T_A and T_D or T_B and T_C. T_A can be bigger, smaller or equal to T_D. Nothing cannot be said about them. All you can say is that the tension of the side as a bay is greater than the tension of the side as a stomach. The plate tends to stretch from the side as a bay to the side as a stomach. This is what happen to us when we grow old. As shown, the word bent has been bold to emphasize the folded shape to you.

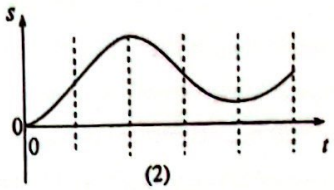


42. The variation of the velocity (υ) with time (t) of a particle is shown in the figure. The corresponding displacement (s) - time (t) curve is best represented by

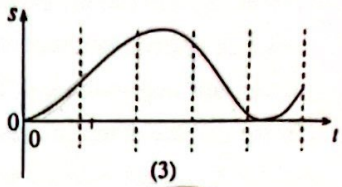




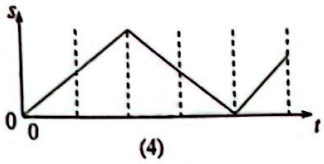
(1)



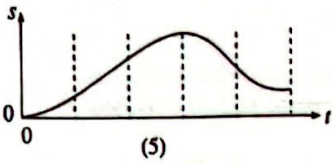
(2)



(3)



(4)



(5)

Linear Motion

You can get the answer from one thing even if you do not see any other facts. In the end of the third period of time, the velocity of the particle gets zero. At that moment, the curve should be parallel in the displacement-time curve as the gradient should be zero there. This point has been satisfied only at the graph of (5). Again, finally the particle's velocity gets zero. That is being correctly represented only in graphs (1) and (5). But (1) has many mistakes. Another point that should be checked is the net displacement. It should be at a positive value once the motion of the particle is over. In a velocity-time graph, the area gives the displacement. According to velocity-time graph, the positive area is greater than the negative area. Therefore, the net area is positive. When the particle is stopped, s should have a positive value. It is also satisfied in (5). If you look part by part continuously, then the particle accelerates initially (the gradient of s-t graph is a gradually increasing curve). Next, it goes in a uniform velocity (s-t graph is a straight line). Afterwards, it decelerates (the slope of s-t graph is a gradually decreasing curve but still the gradient should be positive). Next, the particle comes to a sudden rest, turn back (v gets negative) and gets accelerated. Then it gets decelerated and come to a rest. The particle stops before coming to the initial point.

Such graphs can be checked at one or more palces and reach for the correct shape in less amount of time. There is no issue in selection by checking only the special places.

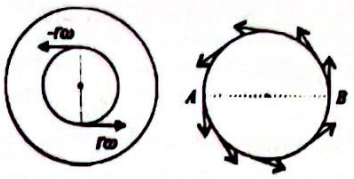
43. A grain of sand is stuck to a tyre of a vehicle at a distance r from its centre. The radius of the tyre is R. When the tyre is rotating at an angular speed of ω, the sand grain detaches suddenly from the tyre. If the air resistance is neglected, the **horizontal component** of the velocity of the grain **relative to the vehicle** immediately after detachment could have a value between

(1) 0 and $(R - r)\omega$.
(2) 0 and $(r + R)\omega$.
(3) 0 and $r\omega$.
(4) $-r\omega$ and $r\omega$.
(5) $(R - r)\omega$ and $(r + R)\omega$.

Rotational Motion

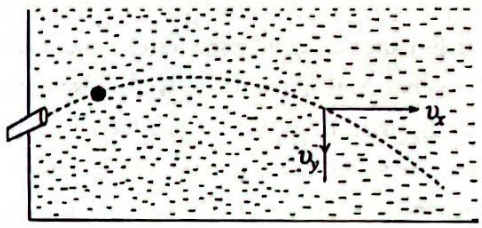
To get the answer without a mistake, the words relative to the vehicle and horizontal component have been bold. As it is asking relative to the vehicle, it is enough to consider rotation of the wheel around its centre. You do not have to consider about the forward motion of the wheel. If it was asked relative to the ground, then that motion also should be taken into consideration. Consider a sand piece which moves in a radius of r in a circle with ω angular velocity. If the right side is considered as positive, the maximum horizontal velocity that the sand piece can have is rω. Likewise, the minimum horozontal velocity to the left side is -rω.

At the points of A and B, the velocity to the horizontal is zero. At any other point the horizontal cmponent of the velocity lies between -rω and rω. Relative to the vehicle means you do not consider the translational motion here in the question.



44. A lead ball of radius a is fired from a toy gun in water in a large swimming pool as shown in the figure. The densities of water and lead are ρ_w and ρ_{pb} respectively and the viscosity of water is η. If the x and y components of the velocity of the ball at a certain instant are v_x and v_y respectively then the magnitudes of the corresponding acceleration components at that instant would be

	x (horizontal)	y (vertical)
(1)	$\frac{9\eta v_x}{2a^2\rho_{pb}}$	$\left(1-\frac{\rho_w}{\rho_{pb}}\right)g-\frac{9\eta v_y}{2a^2\rho_{pb}}$
(2)	0	$\left(1-\frac{\rho_w}{\rho_{pb}}\right)g-\frac{9\eta v_y}{2a^2\rho_{pb}}$
(3)	$\frac{9\eta v_x}{2a^2\rho_{pb}}$	$\left(1-\frac{\rho_w}{\rho_{pb}}\right)g$
(4)	$\frac{9\eta v_x}{2a^2\rho_{pb}}$	g
(5)	0	$\left(1-\frac{\rho_w}{\rho_{pb}}\right)g$



You need to write an equation for this. First consider the horizontal component. The weight of the steel ball and the upthrust are not being acted if we consider the horizontal direction. The only force to the horizontal is the viscous force that acts against the motion. It is wrong if we consider that there is no viscous force to the horizontal direction. There is a velocity to the horizontal direction. Therefore, due to that velocity component v_x, $6\pi\eta a v_x$ force is acting against the motion. Applying then

$\rightarrow F = ma$ then $-6\pi\eta a v_x = \frac{4}{3}\pi a^3 \rho_{Pb} a_x \rightarrow a_x = -\frac{9\eta v_x}{2a^2\rho_{Pb}}$

Actually, there is a retardation. But we can forget about the negative sign as the magnitude of the acceleration has been asked. According to that, the correct choice can be either (1), (3) or (4) as (2) and (5) can be removed. If we do not consider the viscous force to the horizontal direction, the acceleration will be zero to that direction.

Once you find a_x, you can find the answer without finding a_y. In (4) g is there as a_y. This cannot happen. The ball is not an object which falls freely under the gravity. In (3) there is no part with η for a_y. It also cannot happen. Then what is left is (1). If you want, you can do the calculation. By applying then,

$$\frac{4}{3}\pi a^3 \rho_{Pb} g - 6\pi\eta a v_y - \frac{4}{3}\pi a^3 \rho_w g = \frac{4}{3}\pi a^3 \rho_{Pb} a_y$$

↑ weight ↑ viscous force ↑ upthrust

If the whole equation is divided by, $\frac{4}{3}\pi a^3 \rho_{Pb}$, then you will get the expression in (1). There is no problem if you can get the answer in a cunning way without finding for a_y.

45. Water is found to condense on the outer surface of a cooled glass bottle of soft drink when kept in the atmosphere. The total amount of water condensed before it reaches the atmospheric temperature will not depend on
(1) initial temperature of the cooled bottle of soft drink.
(2) thermal capacity of the bottle of soft drink.
(3) rate of increase of temperature of the bottle of soft drink.
(4) dew point of the atmosphere.
(5) the thermal conductivity of glass.

This is a problem which had many arguments. Undoubtedly the total water amount that get condensed is depending upon the choices of (1) and (4). The problem was created between (3) and (5). Due to the cool drink bottle, the air around the surrounding gets cooled. The heat transferred from the air to the bottle. If the air is cooled up to the dew point and the temperature goes even below that, then we know that dew is formed. However, in the question it has been mentioned that water is being condensed. So, definitely the temperature of air has gone further below the dew point. If the dew point of the atmosphere was at a higher value and if the cool drink bottle initially was at a lower temperature value, then the condensed water amount would be greater. Think that the dew point and the room temperature is equal. Then from the start the water gets condensed. We know from our experience that, if the bottle gets more cooler (with low temperature initially), then the condensed water amount is high. All of these are dependent upon the total absorbed heat of the cool drink bottle. If the bottle absorbed more heat, then water will be condensed more. $\Delta Q = W \Delta\theta$. What is meant by W here is that the heat capacity of the cool drink bottle. For a certain $\Delta\theta$ change with a large W value, ΔQ is greater. The increment of ΔQ means more water condensation. This also we have experienced. Compared to a small cool drink bottle, a big cool drink bottle condensed more water.

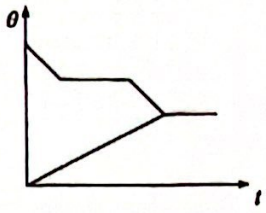
Now the problem is between (3) and (5). If the increment of temperature is high, then water gets more condensed. For example, if the initial temperature of the drink bottle is 10^0C when the dew point is 25^0C, then the amount of water that condenses is greater than the amount of water it condenses if the bottle has an initial temperature of 20^0C. If water gets more condensed when the temperature range is increased, then does the amount of water condensation depends upon the rate of temperature increment? The rate means the temperature increment divided by the time. If we think in another way, $\Delta\theta/\Delta t$ is proportional to the excess temperature. If the excess temperature is high, then the rate of temperature increment is also high. The excess temperature here is (temperature of the environment – temperature of the cool drink bottle).

Finally, there is the heat conductivity of the glass. If we consider glass as ideal heat insulator, then heat from the surrounding will not enter the bottle. Then it is true that there is no room to cool the air around the bottle. At that moment, there will be no water condensation. In the question it has been mentioned that the water gets condensed. Therefore, we cannot think of ideal heat insulator situation here. It is true that the heat conductivity of glass is less compared to a metal like copper. Therefore, there is a temperature difference between the inner surface of the bottle wall and the outside surface. But this fact does not have an effect on the <u>total</u> condensed water amount. For example, we will think that the glass material of the bottle has a less heat conductivity than normal glass. Then the bottle takes more time to come into the room temperature. But this fact does not change the <u>total</u> condensed water amount. Here the word total is very important. That is why it is in the question.

If the glass has a high heat conductivity, then the temperature increment of the bottle happens very quickly. If the heat conductivity is at a lower value, then the temperature increment happens very slowly. But the amount of condensed water for a certain temperature difference cannot be changed whether it occurs slowly or quickly. If the temperature is increased quickly, then water condenses quickly. The time taken for that is less. If the temperature is increased slowly, then the water also condenses slowly but with more time.

Finally, condensed water amount should be same. This is like modern time race of the rabbit and the tortoise. The rabbit runs quickly. The tortoise runs slowly with a more time. I mentioned as a modern race because nowadays the rabbits will not sleep in the middle of a race.

46. Small amounts of water and ice of identical masses are placed in a thermally insulated container and allowed to come to thermal equilibrium. The variations of the temperature (θ) of water and ice are recorded with time (t) and are shown in the same graph. Which of the following conclusions can be drawn about the behaviour of water and ice from the given graph?



(1) Water has fully frozen and no ice has melted.
(2) Water has partly frozen and no ice has melted.
(3) Water has partly frozen and ice has fully melted.
(4) Water has fully frozen and ice has fully melted.

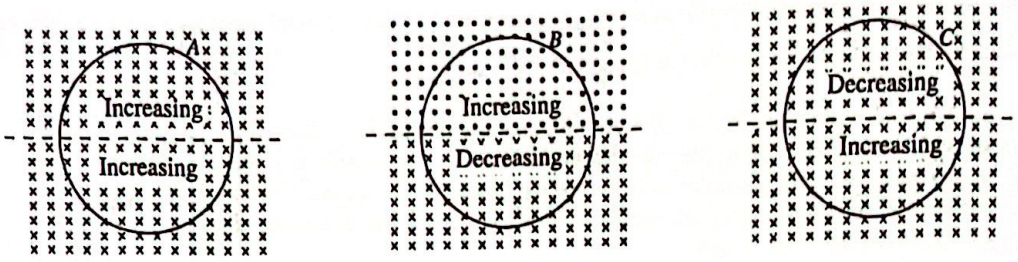
The drawn straight lines are not named. Likewise, the values of the temperature axis are not marked. If they were done like that, then the question gets very easy. I am not telling that the problem is hard without that. From the observation you can decide that the top straight line represents the temperature of the water. The temperature should be less in water. The heat transfer from water to ice. If the temperature of the water gets reduced and the total water amount has been turned to ice, then the temperature of the ice made from that way has also been reduced. The heat has been obtained by the ice in the container and their temperature has risen where they come into a common balanced temperature with the ice which was made from water melting. The correct choice is (1).

Practically, this can happen if the ice in the container has an initial temperature which is very less than 0°C. The initial ice remains as ice even after melting the water and till the ice from it goes to a value less than 0°C. The second horizontal line shows that both have come to a common temperature. It is not the melting of initial ice into water. The initial water has become ice and those ice has gone a temperature value less than 0°C. Therefore, there is no room for the initial ice to undergo state transformations. The common temperature of the mixture is at a value less than 0°C.

Why it has been mentioned that there are little amount of water and ice? The temperatures of water and ice should be checked separately. Practically, this can be done using two thermo electric couples. Especially, if there is lot of water, then there will be issues regarding the place (whether it is near or far to the ice piece) where the temperature of the water is measured. To control that it is better to use little amount of water.

If there are no equal masses, then you cannot do the comparison. For example, if there are big water mass and small ice piece, then the temperature reduction of the water can be negligibly smaller. If there are equal masses, the temperature variations of both can be measured (can be plotted) from the transferred heat. To avoid the heat transfer from any other place, it has been kept in an insulator container. The acquired heat for ice comes only from the water.

47.

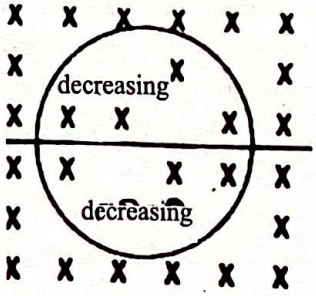


Three identical wire loops *A*, *B* and *C* are placed in uniform magnetic fields as shown in figures. Magnetic fields are either increasing or decreasing in magnitude at the same rate. If i_1, i_2, and i_3 are the magnitudes of the induced currents in loops *A*, *B*, and *C* respectively then

(1) $i_1 > i_2 > i_3$ (2) $i_1 < i_2 < i_3$ (3) $i_1 = i_2 = i_3$

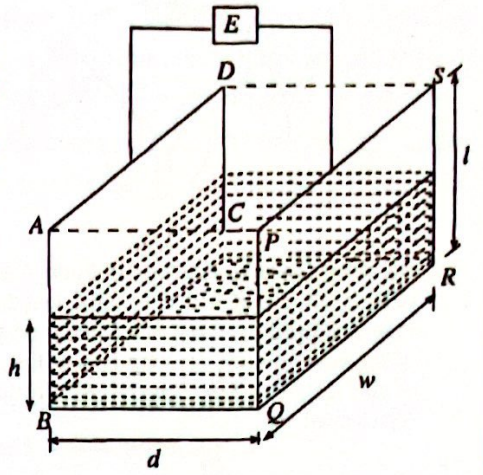
(4) $i_1 = i_2$; $i_3 = 0$ (5) $i_1 = i_2 = i_3 = 0$

You can get the answer by very simple logic without writing equations. Throughout the loop of A the magnetic field is increased to inside. Definitely there is an induced current in the loop. There is nothing to think. In loop B, the magnetic field is increased out of the paper in its top half. An outside increment means a reduction of inside. If you see this, then it will be very easy to get the answer. Therefore, what is happening in loop B can be also thought like this way. This instance is the reciprocal of A. In loop A, throughout the loop the field is increased inwardly. Throughout the loop B, the field is decreased inwardly. Therefore, the induced current is same in magnitude in both instances but opposite in direction.



The problem asks only about the magnitude. The current flows in anti-clockwise direction at loop A. He is trying to reduce the increment to the inside. If the current flows in clockwise direction, then the field is increased more. The nature does not like it. The nature wants to control what is increased and not to give more. Humans are different from nature due to this reason. Accordingly, the current flows in clockwise direction at loop B. But the magnitude of the currents should be same. As soon as you see, you can decide that the induced current is zero in C. In one half, it is decreased to its inside and the other half it is increased to its inside. The currents get cancelled off. What is happened from a piece is happened equally and opposite from the other piece. The answer is (4).

48. A fuel-gauge in a vehicle uses a parallel plate capacitor made of two rectangular metal plates to determine the height of the fuel level in the tank. Each of the metal plates (*ABCD* and *PQRS*) has a width w and a height l. The height of the fuel level between the plates is h. (see figure) Appropriate electronic circuitry E determines the effective capacitance of the combined air and fuel capacitors. The effective capacitance of this system is given by (k = dielectric constant of fuel)



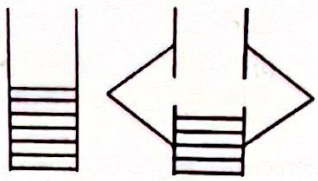
(1) $\frac{w\varepsilon_0}{d}[l+h(k-1)]$ (2) $\frac{(l-h)kh\varepsilon_0 w}{d[l+h(k-1)]}$

(3) $\frac{w\varepsilon_0}{2d}[l+h(k-1)]$ (4) $\frac{(l-h)kh\varepsilon_0 w}{2d[l+h(k-1)]}$

(5) $\frac{k\varepsilon_0 lw}{d}$

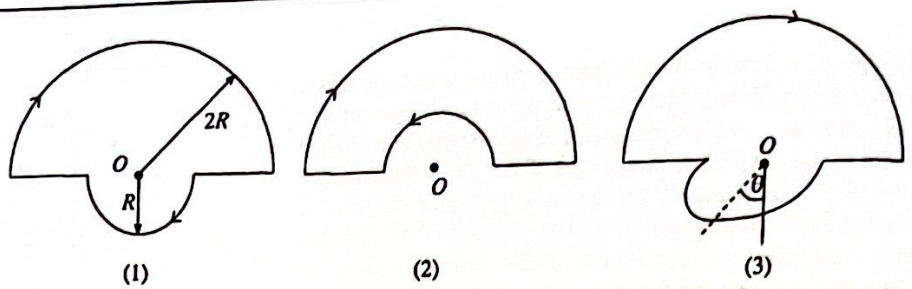
It is very important to decide the fuel amount in a fuel tank of a vehicle. In many vehicles, this is done by a floater. It goes up or down according to the fuel level. The other hand of the floater which has been connected to a variable resistor changes the flowing current. The modern vehicles, use the capacitor system mentioned in the question. The floater arrangement can be deactivated due to various reasons with time. This has to be considered as two parallel plate capacitors. If you get this, then the answer is in your hand. The capacitance of the capacitor which is filled with fuel is $k\varepsilon_o hw/d$. The plate area of the capacitor is shown as hw. The capacitance of the capacitor part that is in air is ε_o (l-h) w/d. The length of the capacitor plate filled with air is (l-h). Therefore, these two have to be added to find the net capacitance.

$$\frac{\varepsilon_o w}{d}[kh+l-h] = \frac{\varepsilon_o w}{d}[l+h(k-1)]$$



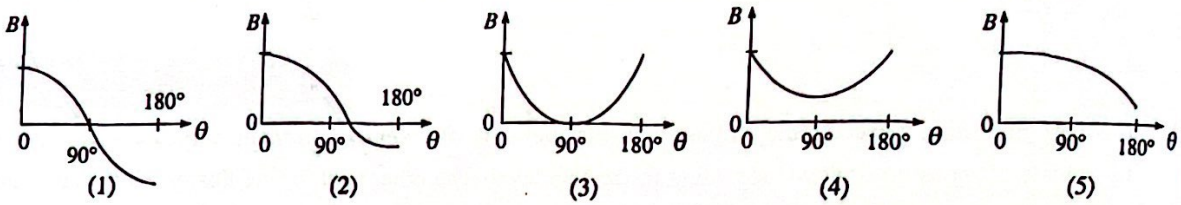
If k =1, then there is no fuel as all has been filled with the air. Then is not the capacitance of the capacitor $\frac{\varepsilon_o wl}{d}$? This is obtained only from (1). If you look like that, then you can just get the answer.

49.

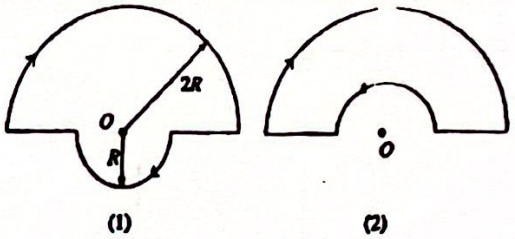


(1) (2) (3)

A current carrying wire loop in figure (1) lies in the plane of the paper and consists of two concentric semicircles of radii $2R$ and R and two radial lengths. The smaller semicircle is bent out of the plane gradually until the loop is flipped over and lies entirely on the same plane again as shown in figure (2). An intermediate situation of the system when the loop is bent through an angle θ is shown in figure (3). The variation of the component of the magnetic flux density (B) directed into the page at the center (O) of the loop with angle θ is best represented by



If you consider only the situations of (1) and (2), then 5 choices can be reduced to 2. At the first instance it is clear that the direction of the magnetic flux density of O is directed into the paper. Both magnetic flux densities generated from the sections of radius 2R and R, are added together.



If the thumb of the right hand is kept perpendicularly to the other fingers and the rest of the four fingers are taken around the direction of the current, then the thumb is directed towards the paper.

When the small loop is rotated by 180^0 and come to the situation (2), the current flows in clockwise direction at the bigger loop whereas the current flows in anti-clockwise direction at the smaller loop. Therefore, due to the current that flows in the smaller loop, the direction of the magnetic field generated at point O is outside the paper. This also can be found from the previously mentioned finger rotation. As the smaller loop is near to the centre, the magnitude of the magnetic flux density is greater. Therefore, at the second situation the net flux density at O is out of the paper.

What is clear from this is that, the magnetic flux density which is directed towards the paper at the first situation is directed out of the paper at the second situation. That means the direction of the flux density has been changed. A direction change (from + to -) is represented only in the variations of (1) and (2). (3), (4) and (5) can be removed instantly.

Now, how can we select the correct choice out of (1) and (2)? In (1), there is a symmetric variation. When θ

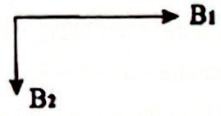
= 0^0 and $\theta = 180^0$, the magnitude of B is same. This cannot happen. In (1), both fluxes are added together. In (2), they are subtracted from each other. Then how can these two values get equal? It cannot never happen. In (2), the resultant should be a smaller value. It is shown by choice (2). There is no need to do any calculations. From the above two arguments, you can get the correct answer. As the direction change should be there, you can remove choices of (3), (4) and (5). As the addition of two values are greater than subtraction, you can remove (1).

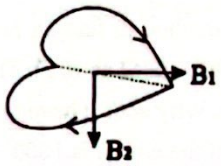
If you think of values, then we will consider B_1 as the flux density from loop of 2R and B_2 as the flux density from loop of R.

For the first situation, $B = B_1 + B_2$ (into the paper); In the second situation $B = B_2 - B_1$ (out of the paper). Actually, $B_2 = 2B_1$. The radius of the bigger loop is twice as the radius of the smaller loop. Therefore, for the first situation, $B = 3B_1$(+ direction); for the second situation $B = B_1$(- direction).

So, the magnitude of B at $\theta = 0^0$ should be thrice the magnitude of B at $\theta = 180^0$. Check whether it is correct.

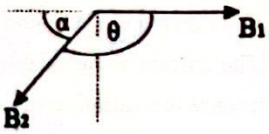
Even though it is not needed, we can do more analysis on this variation. In the variation, there is an instance where B =0. What is the θ value it occurs? For whatever the value of θ, the magnitude of B_1 and B_2 do not change. Actually, B_1 does not change in direction. The loop of 2R is still. As the small loop is rotated, the direction of B_2 rotates perpendicularly to the plane of semi-circle. We will consider the instance where $\theta = 90^0$. Then the direction of B_2 is perpendicular to B_1.





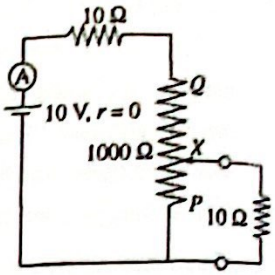
According to this also, it can be seen that choice (1) is wrong. At this moment, the net flux density into the paper is only B_1. It cannot be zero. True net flux density is $\sqrt{B_1^2 + B_2^2}$.

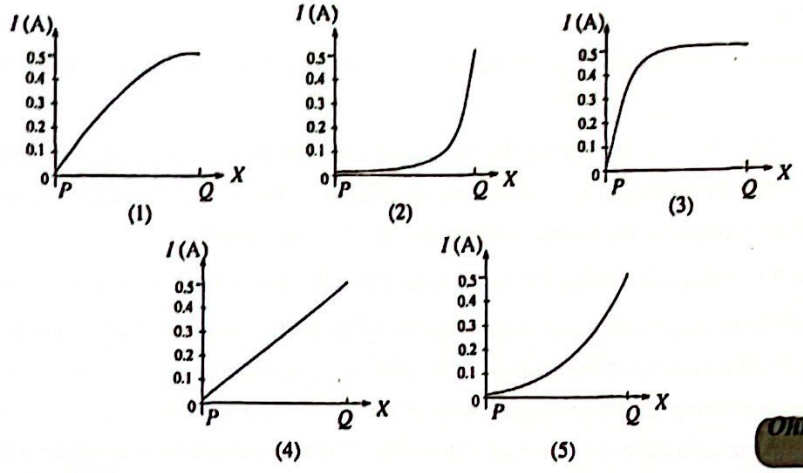
Now let us rotate the smaller loop more. According to that the direction of B_2 is also rotated to the left side. At a certain θ value ($\theta > 90^0$), the direction of B_2 is situated as shown below.



To get zero net flux inside the paper, then $B_1 = B_2 \cos\alpha$. As $B_2 = 2\ B_1$, $\cos\alpha = 60^0$. That means $\theta = 120^0$. This fact is satisfied by the variation of (2). But this is not being checked. If the question is intended to make harder, then this fact can also be checked. Look how sweet are the examiners! The value (magnitude) of B at $\theta = 90^0$ and at $\theta = 180^0$ should be same. Check whether it is correct. As I always say, do not try to check the shape of the graphs completely. All you need is logic. Hold two ends. Then many choices can be removed. Then focus on a special place or a characteristic.

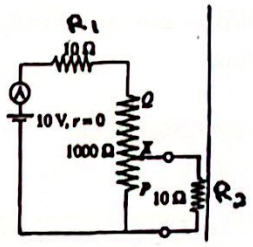
50. In the circuit shown PQ is a variable resistor of 1000 Ω, and the resistance between the terminals P and X varies linearly as terminal X moves from P to Q. As the terminal X moves from P to Q the variation of the ammeter reading (I) is best represented by





Ohm's Law combinations of Resistances

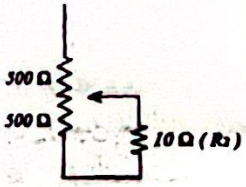
Use the normal method in finding circuit variants here. First bring the X end to P. Then there is no usage from R_2 where I have used as 10 Ω. The current from the battery is directly going across the connecting wires without resistors. Why does it have to go across 10 Ω as there is a road without resistors? At that moment, the total resistance of the circuit is 1000 +10(R_1). But neglect this 10 also. Why do you need to add 10 to 1000? Now the current that flows in the circuit is 10/1000 A. That means 0.01 A. It is 1/10 of 0.1 A. The I value of each choice has been started from a near value of this value. Therefore, you cannot remove any choice by looking only at this value.



Next, take X to Q. Then there is no use of 1000 Ω as mainly all the current flows across R_2. Now I = 10/20 = 0.5 A (nearly). All these values are almost correct.

But the variations of (3) and (1) can be removed. I = 0.5 A when X comes to Q. The current is not stable in 0. 5 A. At a glance you can remove (4). Because the variation of I cannot be linear. The competition is between (2) and (5).

Now what should be done? You need to look at another point. What to do? Without looking at another, shall we select the middle? Then 500 Ω and 10 Ω at the bottom of 1000 Ω are parallel to each other. When 500 Ω and 10 Ω are in parallel, the equivalent resistance is nearly 10 Ω. We need a near value for I, not the exact value. Therefore, do not try to find the equivalent resistance of 500 Ω and 10 Ω. It will be 9.8 Ω if you find it. Is not it nearly 10 Ω? Now,

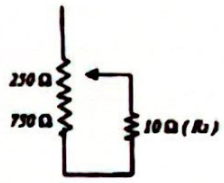


$$I = \frac{10}{10(R_1) + 500 + 10}$$

↑ upper 500

Here also we will forget about the 20 that should be added to 500. Then the near value of I = 10/500 = 0.02 A. If you add 20, then you will get 0.019 A. Is not this 0.02 A? Now look at the variations of (2) and (5).

I value gets nearly 0.02 A at the middle of PQ in only (2). When X is at P I value is around 0.01 A. When it comes to middle, there is not a significant increment. It has been only increased from 0.01 to 0.02. I value has not been even 0.1 A. At (5), I value gets around 0.1 A in the middle of PQ. Therefore, the variation of (5) is wrong.



If the X end is taken ¾ from P, then the current is still less than 0.1 A. The near value of I is 10/250 = 0.04 A As the point X goes upwards, the equivalent resistance below X is getting closer to 10 Ω. Instantly the current increases when X is coming near to Q.