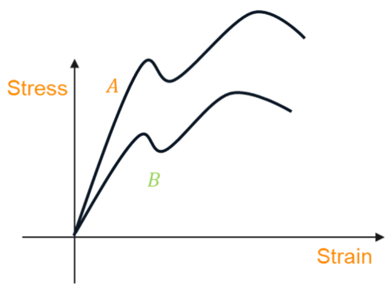
JEE Main Part Test 2

Subject: Physics　　　　　　　　　　　　Class: Standard XII

1. The stress-strain diagram for two materials A and B are shown here. Select the correct option.



A. 'A' has greater Young's modulus than 'B' ✔

B. 'B' has greater Young's modulus than 'A'

C. 'A' & 'B' has same Young's modulus

D. Cannot comment

Slope of stress - strain curve within the elastic limit gives the Young's modulus.
It can be clearly seen that
$(slope)_A > (slope)_B$
So, Young's modulus of A is greater than Young's modulus of B.

2. A brass rod of length 1 m is fixed to a vertical wall at one end, with the other end kept free to expand. When the temperature of the rod increases by 120°C, the length increases by 3 cm. What is the strain?

A. 0.5

B. 0.005

C. 0.05

D. 0 ✔

After the increase of 120°C, temperature remains constant.
$\therefore$ No tensile force and no internal force developed in the rod.

So, strain $= 0$.

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3. Stress generated in a wire when force F_1 acts on it as shown in the figure, is T. Initial cross sectional area of the wire is A_1. When force F_2 replaces F_1, cross-sectional area becomes A_2. Find $\left(\frac{A_2}{A_1}\right)$ if $F_2 = 6\text{ N}$.

[Consider stress generated in the wire to be the same]

A. 3

B. $1/2$

C. 4

D. $1/6$

Given,
Stress generated in the wire is same in both cases.
$\text{Stress generated when } F_1 \text{ acts} = \text{Stress generated when } F_2 \text{ acts}$

$$\Rightarrow \frac{F_1}{A_1} = \frac{F_2}{A_2}$$
$$\Rightarrow \frac{2}{A_1} = \frac{6}{A_2}$$
$$\Rightarrow \frac{A_2}{A_1} = \frac{6}{2} = 3$$

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4. Two cylindrical wires A and B are of the same material. Their lengths are in the ratio $1:2$ and the diameters are in the ratio $2:1$. If they are pulled by the same force, then increase in their respective lengths will be in the ratio

A. $2:1$

B. $1:4$

C. $1:8$ ✔

D. $8:1$

We know that Young's modulus

$Y=\frac{F}{A}\times\frac{L}{\Delta L}$

$\because A=\pi r^2$

$\Rightarrow Y=\frac{F}{\pi r^2}\times\frac{L}{\Delta L}$

Since Y, F are same for both the wires,

$Y_1=Y_2$

$\Rightarrow\frac{L_1}{\Delta L_1 r_1^2}=\frac{L_2}{\Delta L_2 r_2^2}$

$\Rightarrow\frac{\Delta L_1}{\Delta L_2}=\frac{r_2^2\times L_1}{r_1^2\times L_2}=\frac{\left(\frac{D_2}{2}\right)^2\times L_1}{\left(\frac{D_1}{2}\right)^2\times L_2}$

$\Rightarrow\frac{\Delta L_1}{\Delta L_2}=\frac{D_2^2\times L_1}{D_1^2\times L_2}=\frac{D_2^2}{(2D_2)^2}\times\frac{\left(\frac{L_2}{2}\right)}{L_2}=\frac{1}{8}$

$\therefore\frac{\Delta L_1}{\Delta L_2}=\frac{1}{8}$

$\Rightarrow\Delta L_1:\Delta L_2=1:8$

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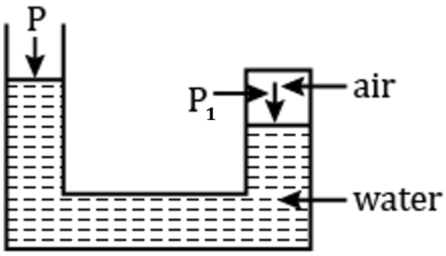
5. The pressure of the confined air in the right leg is P_1. If the atmospheric pressure is P, then

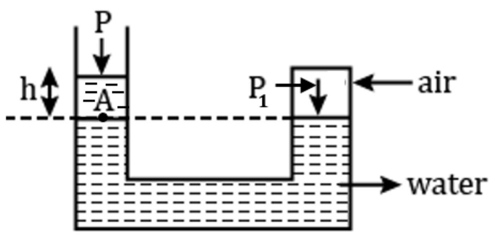


A. P is equal to P_1

B. P is less than P_1

C. P is greater than P_1

D. P may be less or greater than P_1 depending on the mass of the confined air



Pressure at point $A = P_1$ (Hydrostatic paradox)
and we know,
$P + \rho_w gh =$ pressure at $A = P_1$
$\Rightarrow P = P_1 - \rho_w gh$
So, $P < P_1$

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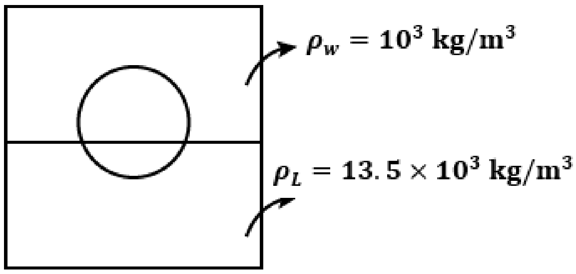
6. A metallic sphere floats in an immiscible mixture of water and a liquid such that its $\frac{4}{5}$th volume is in water and $\frac{1}{5}$th volume is in the liquid. Then, density of the metal is



A. 3.5×10^3 kg/m^3

B. 1.5×10^3 kg/m^3

C. 4×10^3 kg/m^3

D. 2×10^3 kg/m^3

From Archimede's principle,
$\text{Total Buoyant force} = \text{Weight of displaced fluid}$
This buoyant force will balance weight of the sphere
$\therefore$ Weight of the ball $=$ Weight of displaced fluid
Buoyant force due to immersion in both liquids will balance the weight of sphere.

$$\rho_{metal} g V = \rho_w g \times \left(\frac{4}{5} V\right) + \rho_L g \times \left(\frac{1}{5} V\right)$$

[For sphere, $W = mg = \rho_{metal} g V$]

$$\Rightarrow \rho_{metal} = \frac{4}{5}\rho_w + \frac{1}{5}\rho_L$$

Substituting the given data,

$$\Rightarrow \rho_{metal} = \frac{4}{5} \times 10^3 + \frac{1}{5} \times 13.5 \times 10^3$$

$$\therefore \rho_{metal} = 3.5 \times 10^3 \text{ kg/m}^3$$

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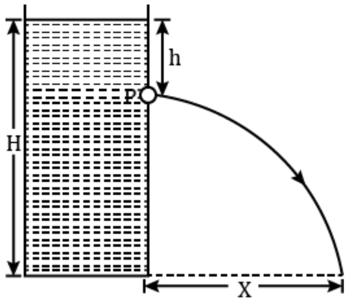
7. A tank is filled with water upto a height H. Water is allowed to come out of a hole P in one of the walls at a depth h below the surface of water (see figure). Express the horizontal distance X in terms of H and h.



A. $X = \sqrt{h(H-h)}$

B. $X = \sqrt{\frac{h}{2}(H-h)}$

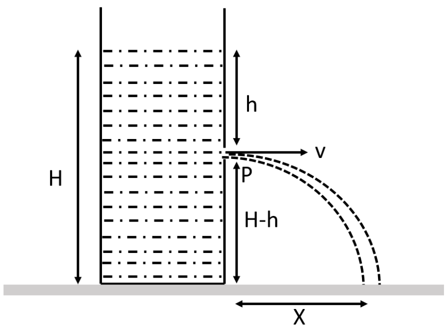
C. $X = 2\sqrt{h(H-h)}$ ✔

D. $X = 4\sqrt{h(H-h)}$

Along vertical -
Vertical distance covered by water before striking the ground $= (H-h)$
On applying $s = ut - \frac{1}{2}gt^2$ as motion of water along the vertical is uniformly accelerated motion under gravity.

$(H-h) = \frac{1}{2}gt^2$

$\Rightarrow t = \sqrt{\frac{2(H-h)}{g}}$ ....(1)



Along horizontal -
Horizontal velocity of water coming out of hole at P, $v = \sqrt{2gh}$
$\therefore$ Horizontal range, $X = vt$

$= \sqrt{2gh} \times \sqrt{\frac{2(H-h)}{g}}$ [from (1)]

$\Rightarrow X = 2\sqrt{h(H-h)}$

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8. If the excess pressure inside a soap bubble of radius $1 \mathrm{~cm}$ is balanced by an oil
$(\rho=0.8 \mathrm{~g} / \mathrm{cm}^3)$ column of height $2 \mathrm{~mm}$, then the surface tension of soap solution will be
[Take $g=10 \mathrm{~m} / \mathrm{s}^2$]

A. $0.02 \mathrm{~N} / \mathrm{m}$

B. $0.04 \mathrm{~N} / \mathrm{m}$

C. $0.09 \mathrm{~N} / \mathrm{m}$

D. $0.08 \mathrm{~N} / \mathrm{m}$

Given,
Radius of soap bubble, $R=1 \mathrm{~cm}=10^{-2} \mathrm{~m}$
Density of oil, $\rho=0.8 \mathrm{~g} / \mathrm{cm}^3=800 \mathrm{~kg} / \mathrm{m}^3$
Height of oil column, $h=2 \mathrm{~mm}=2 \times 10^{-3} \mathrm{~m}$
Let us suppose, surface tension of soap solution is T.
We know that, excess pressure inside soap bubble is given by
$\Delta P=\frac{4 T}{R}$
$=\frac{4 T}{10^{-2}}=400 T$ ....(1)
Pressure due to height of oil column,
$P=\rho g h$
$=800 \times 10 \times 2 \times 10^{-3}$
$=16 \mathrm{~N} / \mathrm{m}^2$ ....(2)
Given, pressure due to height of oil column is equal to excess pressure of soap bubble.
From (1) and (2)
$400 T=16$
$\Rightarrow T=0.04 \mathrm{~N} / \mathrm{m}$

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9. Water rises to a height h in a capillary tube of area of cross-section a. To what height will the water rise in a capillary tube of area of cross-section $4a$?

A. $\frac{h}{4}$

B. $\frac{h}{2}$

C. $2h$

D. $4h$

Area of cross-section $a = \pi r^2$.

$\Rightarrow r = \sqrt{\frac{a}{\pi}}$

The height to which a liquid rises in a capillary tube is given by,

$h = \frac{2T\cos\theta}{r\rho g} = \frac{2\sqrt{\pi}T\cos\theta}{\sqrt{a}\rho g}$

Keeping the liquid and material of tube to be fixed,

$\Rightarrow h \propto \frac{1}{\sqrt{a}}$

If a is increased 4 times,

$\Rightarrow \frac{a_2}{a_1} = 4$

From Eq.(i),

$\Rightarrow \frac{h_2}{h_1} = \sqrt{\frac{a_1}{a_2}}$

$\Rightarrow \frac{h_2}{h_1} = \frac{1}{2}$

$\because h_1 = h$, given

$\Rightarrow h_2 = \frac{h_1}{2}$

Hence, h will decrease by a factor of 2.

$\therefore$The correct choice is (b)

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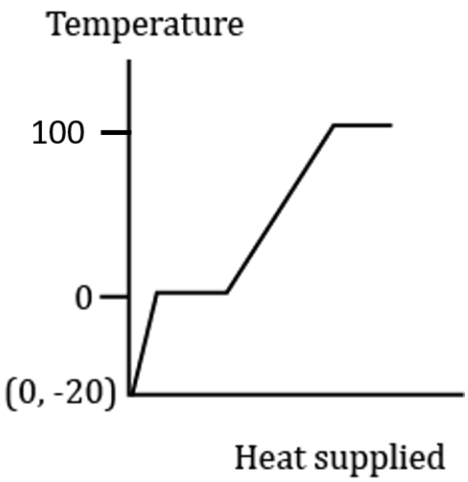
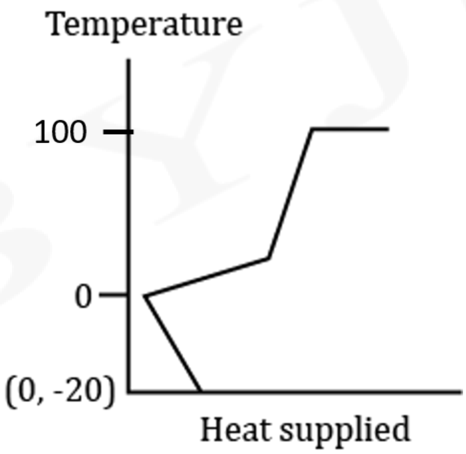
10. A block of ice at temperature $-20^\circ\mathrm{C}$ is slowly heated and converted to steam at $100^\circ\mathrm{C}$. Which of the following diagrams is most appropriate?

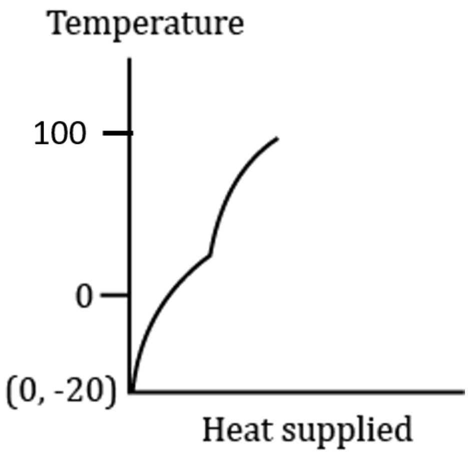
A.



B.



C.



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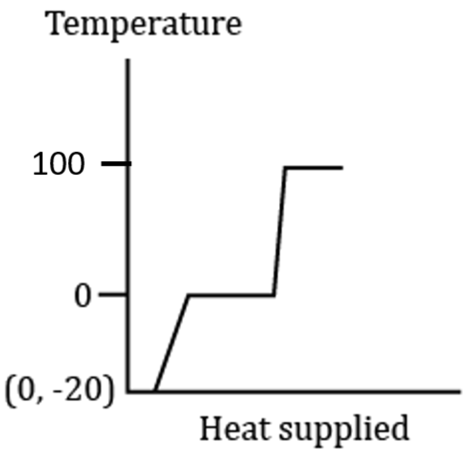
D.



First, the ice at $-20^{\circ}\mathrm{C}$ converts to ice at $0^{\circ}\mathrm{C}$, so there is constant increase in temperature. Thus, the graph will be a straight line starting from the origin, where the temperature is proportional to the Heat supplied.

At $0^{\circ}\mathrm{C}$, change of phase occurs, thus the temperature remains constant while the heat supplied kept on increasing.

Water at $0^{\circ}\mathrm{C}$ when heated increases it's temperature to become water at $100^{\circ}\mathrm{C}$. Thus, the graph will be a straight line where the temperature is proportional to the Heat supplied.

Finally, water at $100^{\circ}\mathrm{C}$ changes to steam at $100^{\circ}\mathrm{C}$, resulting in a change of phase. Thus the temperature remains constant while the heat supplied kept on increasing.

Thus, graph (a) is the most appropriate depiction.

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11. A hole is drilled in a copper sheet. The diameter of the hole is $4.24 \mathrm{~cm}$ at $27{ }^{\circ} \mathrm{C}$. What is the change in the diameter of the hole when the sheet is heated to $227{ }^{\circ} \mathrm{C}$?
$\left[\alpha=1.70 \times 10^{-5} /{ }^{\circ} \mathrm{C}\right]$.

A. $1.44 \times 10^{-2} \mathrm{~cm}$ ✔

B. $1.96 \times 10^{-2} \mathrm{~cm}$

C. $1.78 \times 10^{-2} \mathrm{~cm}$

D. $1.28 \times 10^{-2} \mathrm{~cm}$

Given:
Diameter of the hole, $d=4.24 \mathrm{~cm}$
Initial temperature, $T_1=27{ }^{\circ} \mathrm{C}$
Final temperature, $T_2=227{ }^{\circ} \mathrm{C}$
Co-efficient of linear expansion of copper, $\alpha=1.70 \times 10^{-5} /{ }^{\circ} \mathrm{C}$.
To find: Change in diameter, $\Delta d=?$
We know that change in linear dimension on heating is given by
$\Delta d=\alpha d \Delta T$
$\Rightarrow \Delta d=1.70 \times 10^{-5} \times 4.24 \times(227-27)$
$\Rightarrow \Delta d=1.44 \times 10^{-2} \mathrm{~cm}$

12. A uniform copper rod of length $50 \mathrm{~cm}$ and diameter $3 \mathrm{~mm}$ is kept on a frictionless horizontal surface at $20{ }^{\circ} \mathrm{C}$. The coefficient of linear expansion of copper is $2 \times 10^{-5}{ }^{\circ} \mathrm{C}^{-1}$ and Young's modulus is $1.2 \times 10^{11} \mathrm{~N} / \mathrm{m}^2$. The copper rod is heated to $100{ }^{\circ} \mathrm{C}$, Then, the tension developed in the copper rod is

A. $12 \times 10^3 \mathrm{~N}$

B. $36 \times 10^3 \mathrm{~N}$

C. $18 \times 10^3 \mathrm{~N}$

D. Zero ✔

As the rod is not bounded at the ends, therefore there is no stress to counter the expansion. Hence, no tension in the rod.

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13. The root mean square speed of a gas molecule is $300 \mathrm{~m/s}$. What will be the root mean square speed of the molecules if the atomic mass is doubled and absolute temperature is halved?

A. $300 \mathrm{~m/s}$

B. $150 \mathrm{~m/s}$

C. $600 \mathrm{~m/s}$

D. $175 \mathrm{~m/s}$

Given:
Initial root mean square speed, $v_{rms} = 300 \mathrm{~m/s}$
To find:
Final root mean square speed when the atomic mass is doubled and absolute temperature is halved, $v'_{rms} = ?$

We know that,
$v_{rms} = \sqrt{\frac{3RT}{M}}$, where M is molar mass and T is absolute temperature.

$\Rightarrow 300 = \sqrt{\frac{3RT}{M}}$ ....(1)

Now, if molar mass is doubled and absolute temperature is halved, then

$v'_{rms} = \sqrt{\frac{3RT/2}{2M}} = \sqrt{\frac{3RT}{4M}} = \frac{1}{2}\sqrt{\frac{3RT}{M}}$

$\Rightarrow v'_{rms} = \frac{300}{2}$ [from (1)]

$\Rightarrow v'_{rms} = 150 \mathrm{~m/s}$

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14. The temperature of a gas at pressure P and volume V is $27^{\circ}\mathrm{C}$. Keeping its volume constant, if its temperature is raised to $927^{\circ}\mathrm{C}$, then its pressure will be -

A. $2P$

B. $3P$

C. $4P$ ✔

D. $6P$

The ideal gas equation states that,
$PV = nRT$
So, we can conclude from the data given in the question that,
$P \propto T$ (As V is constant)
Hence, $\dfrac{P_1}{P_2} = \dfrac{T_1}{T_2} \quad \ldots\ldots\ldots(1)$
Given, $T_1 = 300\ \mathrm{K}, T_2 = 1200\ \mathrm{K}, P_1 = P$
$\therefore$ From (1), we can write that
$$P_2 = \frac{P_1 T_2}{T_1}$$
$$\Rightarrow P_2 = \frac{P \times 1200}{300}$$
$\Rightarrow P_2 = 4P$
Thus, option (c) is the correct answer.

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15. A perfect gas goes from a state A to state B by absorbing 8×10^5 J and by doing 6.5×10^5 J of external work. It is taken from same initial state A to final state B in another process in which it absorbs 10^5 J of heat, then work done in the second process

A. on gas is 10^5 J

B. on gas is 0.5×10^5 J

C. by gas is 10^5 J

D. by gas is 0.5×10^5 J

Heat is absorbed by system {gas}, $\Delta Q = +8 \times 10^5$ J
work done by system, $\Delta W = +6.5 \times 10^5$ J
According to the 1^{st} law of thermodynamics
$\Delta Q = \Delta U + \Delta W$
$8 \times 10^5 = \Delta U + 6.5 \times 10^5$
$\Rightarrow \Delta U = +1.5 \times 10^5 \text{J} \quad \ldots\ldots\ldots (1)$
For the second process,
Heat absorbed by the system $\Delta Q' = +10^5$ J
Again using First law,$\Delta Q = \Delta U + \Delta W$
We write that,
$\Delta Q' = \Delta U + \Delta W'$
ΔU will stay the same as initial and final states of gas is same.
Now, From the data given in the question and (1)
$10^5 = 1.5 \times 10^5 + \Delta W'$
$\Delta W' = -0.5 \times 10^5$ J
(negative sign indicates work is being done on the gas).
Thus, option (b) is the correct answer.

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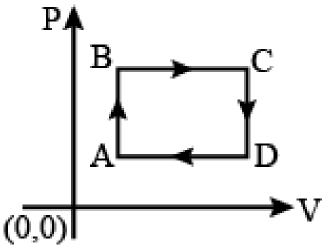
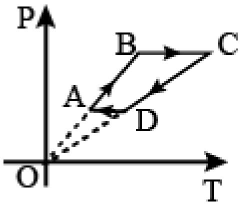
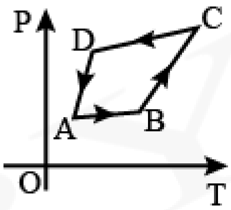
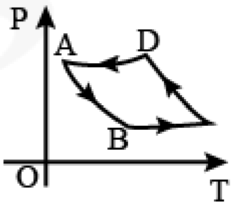
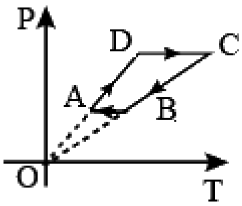
16. The figure shows the $P-V$ diagram of a thermodynamic cycle for an ideal gas. Which of the following graphs for the corresponding $P-T$ diagram is correct ?



A. 

B. 

C. 

D. 

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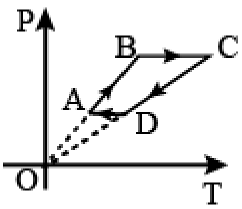
From the plot of $P-V$ graph,
It can be observed that AB and CD are isochoric processes.
i.e Volume is constant.
$V=$ constant
$\Rightarrow \dfrac{nRT}{P}=$ constant
Hence, P vs T graphs for AB and CD are straight lines passing through the origin.

Also, BC and DA are isobaric processes ($P=$ constant).
Hence, P vs T graphs for BC and DA are horizontal lines parallel to the temperature axis.



Thus, option (a) is the correct graph.

17. A thermodynamic cycle is comprised of four processes $1 \to 2$, $2 \to 3$, $3 \to 4$ and $4 \to 1$. Heat & work interactions of these processes are given as

Process	Heat transfer (J)	Work done (J)
1-2	0	150 (by the gas)
2-3	100 (from the gas)	0
3-4	0	50 (on the gas)
4-1	200 (to the gas)	0

The thermal efficiency of the cycle is -

A. $20\ \%$

B. $30\ \%$

C. $40\ \%$

D. $50\ \%$

From the given data, we can find the efficiency of the cyclic process by using

$$\eta=\frac{\text{Work output}}{\text{Heat input}}=1-\left(\frac{\text{Heat rejected}}{\text{Heat added}}\right)$$

From the data given in the question,

$$\eta=1-\frac{100}{200}=\ 50\ \%$$

Thus, option (d) is the correct answer.

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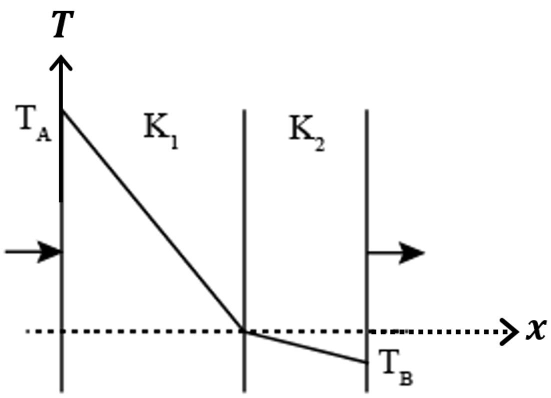
18. Temperature variation under steady state heat conduction across a composite slab of two materials with thermal conductivities K_1 and K_2 having same cross sectional area is shown in figure. Choose the correct statement.



A. $K_1 > K_2$

B. $K_1 = K_2$

C. $K_1 = 0$

D. $K_1 < K_2$

We know that, rate of heat conduction $\frac{dQ}{dT} = KA\frac{dT}{dx}$
So, for a constant heat flow, we can say that:
$\frac{dT}{dx} \propto \frac{1}{K}$
where $\frac{dT}{dx}$ is the temperature gradient (slope of the lines in the figure)
[As cross sectional area A is constant]

So, by observing the slopes for both slabs, we can say that
$K_1 < K_2$
Thus, option (d) is the correct answer.

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19. Two spheres A and B having radii $3 \mathrm{~cm}$ and $5 \mathrm{~cm}$ respectively are coated with carbon black on their outer surface. The wavelengths of maximum intensity of emission of radiation are $300 \mathrm{~nm}$ and $500 \mathrm{~nm}$ respectively. The respective powers radiated by them are in the ratio of :

A. $\sqrt{\frac{5}{3}}$

B. $\frac{5}{3}$

C. $\left(\frac{5}{3}\right)^2$

D. $\left(\frac{5}{3}\right)^4$

The bodies behave as black bodies.

Using Wien's displacement law :
$\lambda_m T=b \Rightarrow T=\frac{b}{\lambda_m} \ldots(i)$

Using Stefan's law, power radiated by a black body at temperature T
$P=\sigma A T^4 \quad \ldots(i)$

Using (i) and (ii)
$P=\sigma A\left(\frac{b}{\lambda_m}\right)^4=\frac{\sigma b^4 A}{\lambda_m^4}$

Area of sphere $=4 \pi r^2$
$\Rightarrow P=\frac{\sigma b^4\left(4 \pi r^2\right)}{\lambda_m^4}$
$\Rightarrow P \propto \frac{r^2}{\lambda_m^4}$
$\Rightarrow \frac{P_1}{P_2}=\frac{r_1^2\left(\lambda_{m 2}\right)^4}{r_2^2\left(\lambda_{m 1}\right)^4}$
$\Rightarrow \frac{P_1}{P_2}=\left(\frac{3}{5}\right)^2\left(\frac{500}{300}\right)^4$
$\Rightarrow \frac{P_1}{P_2}=\left(\frac{5}{3}\right)^2$
is the ratio of powers radiated.

Thus, option (c) is the correct answer.

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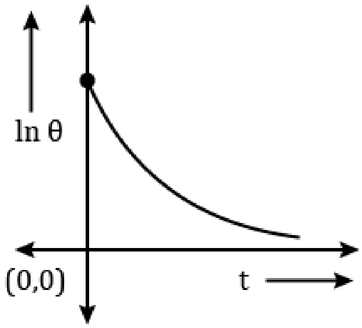
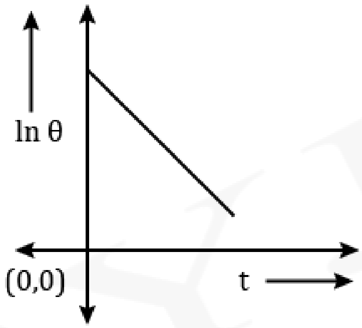
20. Instantaneous temperature difference between a cooling body and the surroundings, obeying Newton's law of cooling, is θ. Which of the following represents the variation of ln θ with time t?

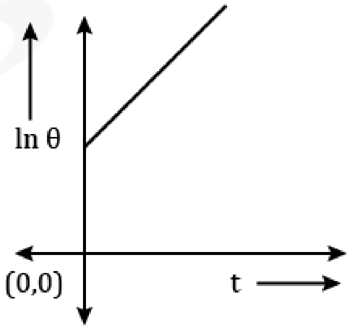
A.



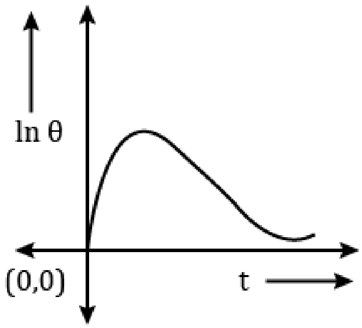
B.



C.



D.



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From Newtons law of cooling,
$\ln\left(\frac{T_1 - T_0}{T_2 - T_0}\right) = kt$
Let θ_i be the initial temperature of body and θ_s be the temperature of the surroundings.
Suppose θ is the instantaneous temperature differerence between the body and surroundings.
Then, $\ln\left(\frac{\theta_i - \theta_s}{\theta}\right) = kt$
$\Rightarrow \ln(\theta_i - \theta_s) - \ln\theta = kt$
$\Rightarrow \ln\theta = -kt + \ln(\theta_i - \theta_0)$
Comparing to $y = mx + C$, option (b) is correct.

21. A particle executes SHM with a time period of $4\ \mathrm{s}$. Find the time taken by the particle to go directly from its mean position to half of its amplitude.

A. $\frac{1}{6}\mathrm{s}$

B. $\frac{1}{3}\mathrm{s}$ ✔

C. $\frac{1}{2}\mathrm{s}$

D. $\frac{2}{5}\mathrm{s}$

$\because$ Particle is executing SHM, so we can write equation of motion as
$x = A\sin(\omega t + \phi) \quad ....(1)$
At $t = 0, x = 0$ [assuming the particle starts from mean position]
$\therefore \phi = 0$
From the data given in the question, let us suppose the particle is moving towards positive extreme position, So, from equation (1),
$\frac{A}{2} = A\sin\omega t \Rightarrow \sin\omega t = \frac{1}{2} \Rightarrow \omega t = \frac{\pi}{6} \text{or} \frac{5\pi}{6}$
Differentiating (1) with respect to time we get,
$v = A\omega\cos(\omega t + \phi)$
Since the particle is moving towards the positive extreme position, velocity is positive.
$\Rightarrow A\omega\cos\omega t > 0 \Rightarrow \cos\omega t > 0 \Rightarrow \omega t = \frac{\pi}{6}$
We know that, $\omega = \frac{2\pi}{T}$
$\Rightarrow \frac{2\pi}{T}t = \frac{\pi}{6} \Rightarrow t = \frac{T}{12}\mathrm{s}$
Given, Time period $(T) = 4\ \mathrm{s}$
$\therefore t = \frac{1}{3}\mathrm{s}$
Thus, option (b) is the correct answer.

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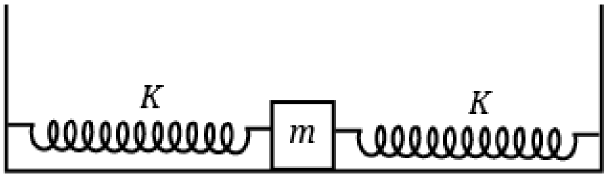
22. In the given figure, the block is displaced slightly and released. Then, the time period of oscillation is:



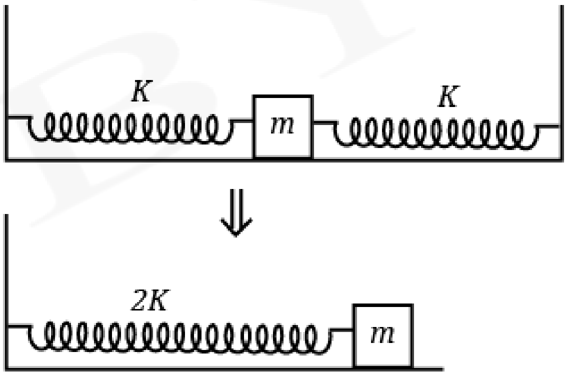
A. $T = 2\pi\sqrt{\frac{2m}{K}}$

B. $T = 2\pi\sqrt{\frac{m}{K}}$

C. $T = 2\pi\sqrt{\frac{m}{2K}}$

D. $T = 2\pi\sqrt{\frac{m}{3K}}$

If we displace the block on either side of the mean position, we observe that the displacement of each spring is the same. So, it's a parallel combination.



In a parallel combination, the equivalent spring constant is given by,
$K_{\text{eq}} = K_1 + K_2 = 2K$
Then,
Time period of oscillation
$T = 2\pi\sqrt{\frac{m}{K_{eq}}} = 2\pi\sqrt{\frac{m}{2K}}$
Thus, option (c) is the correct answer.

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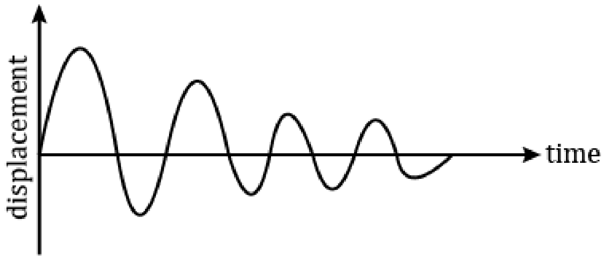
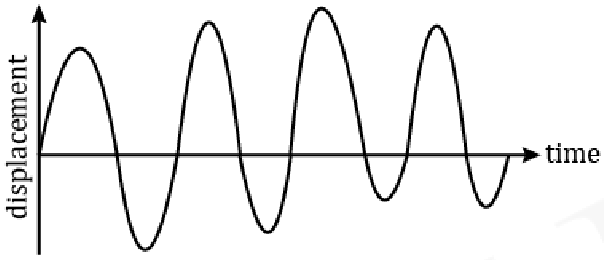
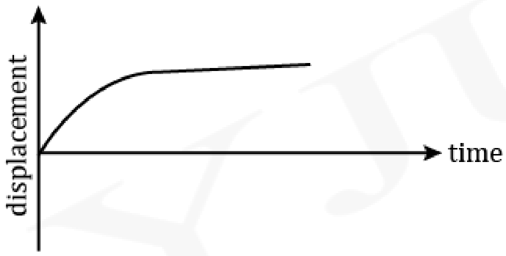
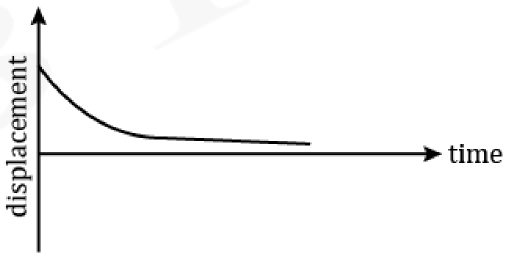
23. Which of the following figures represents damped harmonic motion?

A.


B.


C.


D.


The oscillations in which the amplitude decreases gradually with the passage of time are called damped oscillations.

Equation of a damped oscillation is given by $y = A_0 e^{-\gamma t} \sin(\omega' t + \phi)$
This equation will be satisfied by the graph in option (a).

Graph in option (b) represents motion of a particle with variations in amplitude, but the amplitude of oscillations doesn't continuously decrease with time. So, option (b) is a wrong answer.

Graph in option (c) represents a particle whose amplitude increases with time and becomes constant at steady state. So, option (c) is also wrong.

Graph in option (d) represents a particle whose amplitude decreases with time exponentially but has no oscillatory motion. Hence, option (d) is also wrong.
Thus, option (a) is the correct answer.

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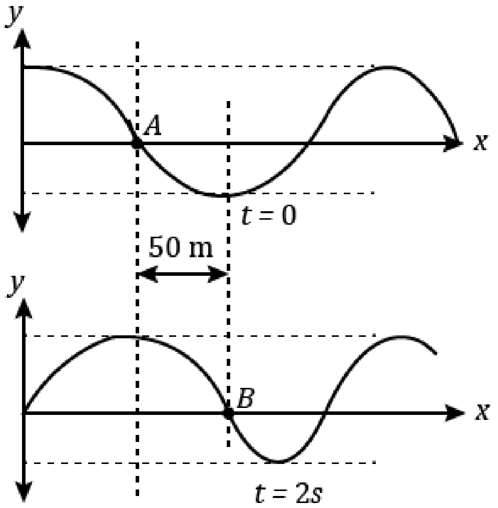
24. Find the phase velocity of the wave whose $y-x$ graph is shown at two instants.



A. $10\ \mathrm{m/s}$

B. $15\ \mathrm{m/s}$

C. $25\ \mathrm{m/s}$

D. $20\ \mathrm{m/s}$

From figure, we can deduce that, the wave is travelling in the positive $x-$ direction .
From the two graphs, phase difference between points A and B is given by
$\Delta x - v\Delta t = 0$
From the data given in the diagram,
$\Delta x = 50\ \mathrm{m}$ and $\Delta t = 2s$
$\therefore$ Phase velocity, $v = \dfrac{\Delta x}{\Delta t}$
$\Rightarrow v = \dfrac{50}{2} = 25\ \mathrm{m/s}$
Thus, option (c) is the correct answer.

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25. Choose the correct option for the given assertion and reason.

Assertion : When a wave travels from a denser medium to rarer medium, its amplitude of oscillation increases.

Reason : In denser medium, speed of wave is less compared to that in rarer medium.

A. Assertion and Reason both are true and the Reason is correct explanation of the Assertion. ✔

B. Assertion and Reason both are true, but Reason is not the correct explantion of Assertion. ✘

C. Assertion is true, but Reason is false ✘

D. Assertion is false, but Reason is true. ✘

Velocity of a wave on a string is given as $(v) = \sqrt{\frac{T}{\mu}}$

where $T \rightarrow$ Tension in the string
$\mu \rightarrow$ Linear density of the medium.

i.e $v \propto \frac{1}{\sqrt{\mu}} \quad \ldots\ldots.(1)$

Let the linear density of the denser medium be μ_1 and of the rarer medium be μ_2.
$\therefore$ From (1), we can conclude that, $v_1 < v_2$
$v_1 \rightarrow$ velocity of wave in denser medium
$v_2 \rightarrow$ velocity of wave in rarer medium

Now, if amplitude of the transmitted wave is A_t,
$A_t = \left(\frac{2v_2}{v_1 + v_2}\right) A_i$
$v_1 < v_2 \Rightarrow v_1 + v_2 < 2v_2$
so, $A_t > A_i$

Hence option (a) is the correct answer.

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26. A $1\ \mathrm{m}$ long horizontal rope, having a mass of $40\ \mathrm{g}$, is fixed at one end and is tied to a light string at the other end. The tension in the rope is $400\ \mathrm{N}$. What will be the wavelengths (in metres) in the first and second overtone ?

A. $\frac{3}{4}, \frac{3}{4}$

B. $\frac{4}{3}, \frac{4}{5}$

C. $\frac{5}{4}, \frac{5}{3}$

D. $\frac{4}{5}, \frac{4}{3}$

Given,
Length of rope, $L = 1\ \mathrm{m}$
Mass, $M = 40\ \mathrm{g}$ or $0.04\ \mathrm{kg}$
Mass per unit length, $\mu = \frac{M}{L} = 0.04\ \mathrm{kg/m}$
Tension in the rope, $T = 400\ \mathrm{N}$

It behaves like a string fixed at one end.
$\therefore$ wave speed on the stretched string, $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{400}{0.04}} = 100\ \mathrm{m/sec}$

Fundamental frequency, f_0 on a string fixed at one end is given by
$$f_0 = \frac{v}{4L}$$
$$\Rightarrow f_0 = \frac{100}{4} = 25\ \mathrm{Hz}$$

Frequency of the first overtone on the string fixed at one end
$$f_1 = \frac{3v}{4L}$$
$\Rightarrow$ Wavelength of first overtone $\lambda_1 = \frac{v}{f_1} = \frac{4L}{3}$
From the given data,
$$\lambda_1 = \frac{4 \times 1}{3} = \frac{4}{3}\mathrm{m}$$

Frequency of the second overtone, f_2 on the string,
$$f_2 = \frac{5v}{4L}$$
$\Rightarrow$ Wavelength of second overtone $\lambda_2 = \frac{v}{f_2} = \frac{4L}{5}$
From the given data,
$$\lambda_2 = \frac{4 \times 1}{5} = \frac{4}{5}\mathrm{m}$$

Thus, option (b) is the correct answer.

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27. Rahul is playing the drums. An increase in which of the following properties of the sound produced would result in an increase in loudness?

A. Amplitude ✔

B. Speed ✘

C. Pitch ✘

D. Quality ✘

The intensity or loudness of sound depends on the extent to which the sounding body vibrates, i.e. the amplitude of vibration. A sound is louder when the amplitude of vibration is greater. Loudness is measured in a unit called decibels (dB).

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28. The first overtone frequency of a closed organ pipe P_1 is equal to the fundamental frequency of an open organ pipe P_2. If the length of the pipe P_1 is $60\ \text{cm}$, what will be the length of P_2?

A. $20\ \text{cm}$

B. $40\ \text{cm}$

C. $60\ \text{cm}$

D. $80\ \text{cm}$

Modes of vibration of air column in a closed organ pipe are given by

$$f_n = \frac{(2n-1)v}{4l}$$

First overtone of a closed organ pipe is obtained for $n = 2$

$$f_2 = \frac{3v}{4l_1}$$

where l_1 is the length of the closed organ pipe.

Modes of vibration of air column in an open organ pipe is given by

$$f_n = \frac{nv}{2l}$$

Fundamental frequency of an open organ pipe is obtained for $n = 1$

$$f_1 = \frac{v}{2l_2}$$

where l_2 is the length of the open organ pipe.

From the data given in the question, $f_1 = f_2$

From this, $\frac{3v}{4l_1} = \frac{v}{2l_2} \Rightarrow l_2 = \frac{2}{3} l_1$

Given, $l_1 = 60\ \text{cm}$

$\therefore l_2 = \frac{2}{3} \times 60 = 40\ \text{cm}$

Thus, option (b) is the correct answer.

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29. A tuning fork vibrating at frequency $1000\ \mathrm{Hz}$ produces resonance in a resonance column tube. The upper end is open and the lower end is closed by the water whose height can be varied. The successive resonances are observed at lengths $10\ \mathrm{cm}$ and $27\ \mathrm{cm}$. Then, the speed of sound in air is [neglect end corrections]

A. $340\ \mathrm{m/s}$ ✔

B. $330\ \mathrm{m/s}$

C. $343\ \mathrm{m/s}$

D. $353\ \mathrm{m/s}$

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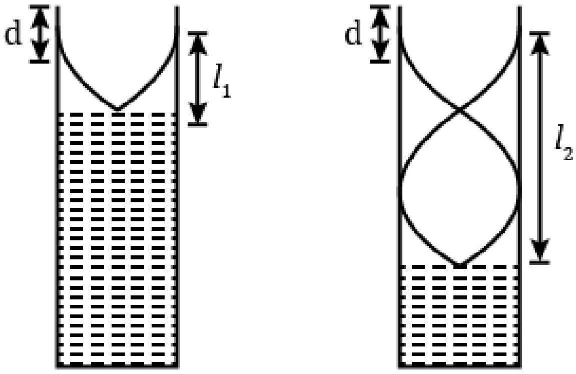
Given that,
Frequency of tuning fork $(f) = 1000\ \text{Hz}$



The column filled with water behaves as a closed organ pipe.

Modes of vibration of an air column in a closed organ pipe are given by

$f_c = (2n+1)\frac{v}{4l}$ where $n = 0, 1, 2...$
or
$l = \frac{(2n+1)v}{4f_c}$

For first resonance
$l_1 = \frac{v}{4f_c}...(n=0)$

For second resonance
$l_2 = \frac{3v}{4f_c}...(n=1)$

$\Rightarrow l_2 - l_1 = \frac{v}{2f_c}$

From the data given in the question,

$(27-10)\times 10^{-2} = \frac{v}{2\times 1000}$

$[f_c = f = 1000\ \text{Hz}]$

$\Rightarrow v = 17\times 10^{-2}\times 2000 \Rightarrow v = 340\ \text{m/s}$

Thus, option (a) is the correct answer.

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30. A train moves towards a stationary observer with a speed $34 \mathrm{~m/s}$. The train sounds a whistle and its frequency registered by the observer is f_1. If the speed of the train is reduced to $17 \mathrm{~m/s}$, the frequency registered is f_2. If the speed of sound is $340 \mathrm{~m/s}$, then the ratio $\frac{f_1}{f_2}$ is

[Assume, medium is stationary]

A. $\frac{18}{19}$

B. $\frac{1}{2}$

C. 2

D. $\frac{19}{18}$ ✔

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Let f_0 be the frequency of sound heard by the observer, when both the source of sound and observer are at rest.
Let v be the velocity of sound in the stationary medium and v_s be the velocity of the source of sound.

When a source is moving towards a stationary observer, the frequency heard by the observer is given by

$$f_{app} = f_0 \left(\frac{v}{v - v_s}\right) \quad .....(1)$$

From the data given in the question,

Case -1 :

When the speed of train is $v_s = 34 \text{ m/s}$,

Using (1), we get

$$f_1 = f_0 \left(\frac{340}{340 - 34}\right) = \frac{340}{306} f_0 \quad .....(2)$$

Case -2:

When the speed of train is $v_s = 17 \text{ m/s}$
Using (1), we get

$$f_2 = f_0 \left(\frac{340}{340 - 17}\right) = \frac{340}{323} f_0 \quad ......(3)$$

From (2) and (3), we get

$$\frac{f_1}{f_2} = \frac{323}{306} \Rightarrow \frac{f_1}{f_2} = \frac{19}{18}$$

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