Properties of Solids and Liquids

Question1

A Spherical ball of radius 1 mm and density 10.5g / cc is dropped in glycerine of coefficient of viscosity 9.8 poise and density 1.5g / cc. Viscous force on the ball when it attains constant velocity is 3696×10^{-x}N. The value of x is
(Given, $g = 9.8 m / s^2$ and $\pi = \frac{22}{7}$)
[24-Jan-2023 Shift 2]

Solution:

When the ball attain terminal velocity

$F_v = (mg - F_B)(\because a = 0)$

$= V\sigma . g - V\rho_\ell g$

$- \rho_\ell)$

$= \frac{4}{3}\pi(10^{-3})^3 \times 9.8(10.5 - 1.5) \times 10^3$

$= 3696 \times 10^{-7}N$

So, $x = 7$

Question2

A spherical drop of liquid splits into 1000 identical spherical drops. If u_i is the surface energy of the original drop and u_f is the total surface energy of the resulting drops, the (ignoring evaporation). $\frac{u_f}{u_i} = \left(\frac{10}{x}\right)$. Then value of x is _______:
[25-Jan-2023 Shift 2]

Answer: 1

Solution:

Surface Tension $= T$

R : Radius of bigger drop
r : Radius of smaller drop
Volume will remain same

$$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3$$

$R = 10r$

$u_i = T \cdot 4\pi R^2$

$u_f = T \cdot 4\pi r^2 \times 1000$

$$\frac{u_f}{u_i} = \frac{1000r^2}{R^2}$$

$$\frac{u_f}{u_i} = \frac{10}{1}$$

Question3

Surface tension of a soap bubble is $2.0 \times 10^{-2} Nm^{-1}$. Work done to increase the radius of soap bubble from 3.5 cm to 7 cm will be : [Take $\pi = \frac{22}{7}$]
[29-Jan-2023 Shift 1]

Options:

A. $0.72 \times 10^{-4} J$

B. $5.76 \times 10^{-4} J$

C. $18.48 \times 10^{-4} J$

D. $9.24 \times 10^{-4} J$

Answer: C

Solution:

Solution:
Surface area of soap bubble $= 2 \times 4\pi R^2$
Work done = change in surface energy $\times T_S$

$= T_S \times 8\pi \times (R_2{}^2 - R_1{}^2)$

$= 2 \times 10^{-2} \times 8 \times \frac{22}{7} \times 49 \times \frac{3}{4} \times 10^{-4}$

$= 18.48 \times 10^{-4} J$

Question4

A fully loaded boeing aircraft has a mass of 5.4×10^5 kg. Its total wing area is $500 m^2$. It is in level flight with a speed of 1080 km / h. If the density of air ρ is $1.2 kg m^{-3}$, the fractional increase in the speed of the air on the upper surface of the wing relative to the lower surface in percentage will be ($g = 10 m / s^2$)
[29-Jan-2023 Shift 2]

A. 16

B. 6

C. 8

D. 10

Answer: D

Solution:

Solution:

$P_2A - P_1A = 5.4 \times 10^5 \times g$

$P_2 - P_1 = \frac{5.4 \times 10^6}{500} = 5.4 \times 2 \times 10^2 \times 10$

$P_2 + 0 + \frac{1}{2}\rho V_2^{\,2} = P_1 + 0 + \frac{1}{2}\rho V_1^{\,2}$

$P_2 - P_1 = \frac{1}{2}\rho(V_1^{\,2} - V_2^{\,2}) = \frac{1}{2}\rho(V_1 - V_2)(V_1 + V_2)$

$10.8 \times 10^3 = \frac{1}{2} \times 1.2(V_1 - V_2) \times 2 \times 3 \times 10^2$

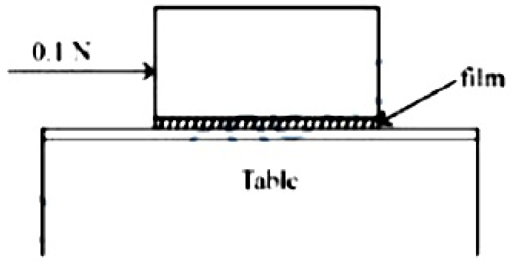
$10.8 \times 10 = 3.6(V_1 - V_2)$

$V_1 - V_2 = 30$

$\left(\frac{V_1 - V_2}{V}\right) \times 100 = \frac{30}{300} \times 100 = 10\%$

Question5

A metal block of base area $0.20m^2$ is placed on a table, as shown in figure. A liquid film of thickness 0.25 mm is inserted between the block and the table. The block is pushed by a horizontal force of 0.1N and moves with a constant speed. If the viscosity of the liquid is 5.0×10^{-3} Pl, the speed of block is _____ $\times 10^{-3}$m / s.



[29-Jan-2023 Shift 2]

Solution:

Solution:

$|F| = \eta A \frac{\Delta v}{\Delta h} : 0.1 = 5 \times 10^{-3} \times 0.2 \times \frac{v}{.25 \times 10^{-3}}$

$v = 0.025m / s$ or $v = 25 \times 10^{-3}m / s$

Question6

The height of liquid column raised in a capillary tube of certain radius when dipped in liquid A vertically is, 5 cm. If the tube is dipped in a similar manner in another liquid B of surface tension and density double the values of liquid A, the height of liquid column raised in liquid B would be _______ m.
[30-Jan-2023 Shift 1]

Options:

A. 0.20

B. 0.5

C. 0.05

D. 0.10

Answer: C

Solution:

Solution:

$$h = \frac{2S\cos\theta}{r\rho g}$$

$$\therefore \frac{h_1}{h_2} = \frac{S_1}{S_2}\frac{\rho_2}{\rho_1}$$

$$\frac{5}{h_2} = \left[\frac{1}{2}\right]\left[\frac{2}{1}\right] \Rightarrow h_2 = 5\,\text{cm} = 0.05\text{m}$$

\{Info about angle of contact not there so most appropriate is 3}

Question7

If 1000 droplets of water of surface tension 0.07N / m. having same radius 1 mm each, combine to from a single drop. In the process the released surface energy is-

(. Take $\pi = \frac{22}{7}$)

[31-Jan-2023 Shift 1]

Options:

A. 7.92×10^{-6}J

B. 7.92×10^{-4}J

C. 9.68×10^{-4}J

D. 8.8×10^{-5}J

Solution:

Solution:

$1000\times\frac{4\pi}{3}(1)^3=\frac{4\pi}{3}R^3$

$R=10\,mm$

$T\times1000\times4\pi(10^{-3})^2-T\times4\pi(10\times10^{-3})^2=\Delta E$

$\Delta E=4\times\pi\times7\times10^{-2}[1000-100]\times10^{-6}$

$\Delta E=7.92\times10^{-4}J$

Option 2.

Question8

A 100m long wire having cross-sectional area 6.25 $\times10^{-4}m^2$ and Young's modulus is $10^{10}Nm^{-2}$ is subjected to a load of 250N, then the elongation in the wire will be :
[24-Jan-2023 Shift 1]

Options:

A. $6.25\times10^{-3}m$

B. $4\times10^{-4}m$

C. $6.25\times10^{-6}m$

D. $4\times10^{-3}m$

Answer: D

Solution:

Solution:

Elongation in wire $\delta=\frac{F\ell}{AY}$

$\delta=\frac{250\times100}{6.25\times10^{-4}\times10^{10}}$

$\delta=4\times10^{-3}m$

Question9

Given below are two statements: one is labelled as
Assertion A and the other is labelled as Reason R
Assertion A: Steel is used in the construction of buildings and bridges.
Reason R: Steel is more elastic and its elastic limit is high.
In the light of above statements, choose the most appropriate answer from the options given below
[24-Jan-2023 Shift 2]

Options:

B. A is not correct but R is correct

C. Both A and R are correct and R is the correct explanation of A

D. A is correct but R is not correct

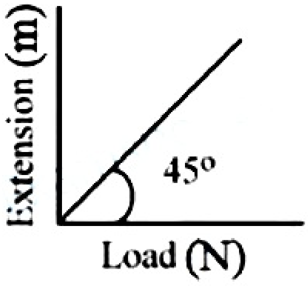
Answer: C

Solution:

Solution:
Concept based

Question10

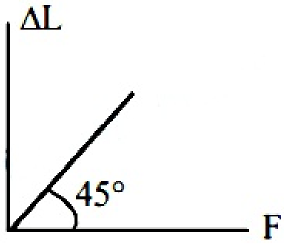
As shown in the figure, in an experiment to determine Young's modulus of a wire, the extension-load curve is plotted. The curve is a straight line passing through the origin and makes an angle of 45° with the load axis. The length of wire is 62.8 cm and its diameter is 4 mm. The Young's modulus is found to be $x \times 10^{4} Nm^{-2}$.
The value of x is ______.



[25-Jan-2023 Shift 1]

Solution:

Solution:



From graph:
$F = \Delta L$
$Y = \frac{FL}{A \Delta L}$
$Y = \frac{L}{A}$
$Y = \frac{62.8 \times 10^{-2}}{\pi (2 \times 10^{-3})^{2}}$

$Y = 5 \times 10^4 N / m^2$

Question11

An electric bulb is rated as 200W. What will be the peak magnetic field at 4m distance produced by the radiations coming from this bulb? Consider this bulb as a point source with 3.5% efficiency. [24-Jun-2022-Shift-2]

Options:

A. $1.19 \times 10^{-8} T$

B. $1.71 \times 10^{-8} T$

C. $0.84 \times 10^{-8} T$

D. $3.36 \times 10^{-8} T$

Answer: B

Solution:

Solution:

$200 \times \frac{1}{4\pi \times 16} \times \frac{3.5}{100} = \frac{B_0^2}{2\mu_0} C$

$\mu_0 = 4\pi \times 10^{-7} Tm / A$

$C = 3 \times 10^8 m / sec$

$\Rightarrow B_0 = 1.71 \times 10^{-8} T$

Question12

Choose the correct relationship between Poisson ratio (σ). bulk modulus (K) and modulus of rigidity (η) of a given solid object: [30-Jan-2023 Shift 1]

Options:

A. $\sigma = \frac{3K - 2\eta}{6K + 2\eta}$

B. $\sigma = \frac{6K + 2\eta}{3K - 2\eta}$

C. $\sigma = \frac{3K + 2\eta}{6K + 2\eta}$

D. $\sigma = \frac{6K - 2\eta}{3K - 2\eta}$

Answer: A

Solution:

$$Y = 3\eta(1+\sigma)$$
$$Y = 3K(1-\sigma)$$
$$\Rightarrow 2\eta(1+\sigma) = 3K(1-2\sigma)$$
$$\Rightarrow \sigma = \left(\frac{3K - 2\eta}{6K + 2\eta}\right)$$

Question13

A force is applied to a steel wire ' A ', rigidly clamped at one end. As a result elongation in the wire is 0.2 mm. If same force is applied to another steel wire ' B ' of double the length and a diameter 2.4 times that of the wire ' A ', the elongation in the wire ' B ' will be (wires having uniform circular cross sections)
[30-Jan-2023 Shift 2]

Options:

A. 6.06×10^{-2} mm

B. 2.77×10^{-2} mm

C. 3.0×10^{-2} mm

D. 6.9×10^{-2} mm

Answer: D

Solution:

Solution:

$$Y = \frac{F/A}{\frac{\Delta \ell}{\ell}}$$
$$\Rightarrow F = \frac{YA}{\ell}\Delta \ell$$
$$\left(\frac{A\Delta \ell}{\ell}\right)_1 = \left(\frac{A\Delta \ell}{\ell}\right)_2$$
$$\Rightarrow \frac{\Delta \ell_2}{\Delta \ell_1} = \frac{A_1}{A_2} \times \frac{\ell_2}{\ell_1}$$
$$\Rightarrow \frac{\Delta \ell_2}{0.2} = \frac{1}{2.4 \times 2.4} \times \frac{2}{1}$$
$$\Rightarrow \Delta \ell_2 = 6.9 \times 10^{-2} \text{ mm}$$

Question14

A thin rod having a length of 1m and area of cross-section $3 \times 10^{-6} m^2$ is suspended vertically from one end. The rod is cooled from 210°C to 160°C. After cooling, a mass M is attached at the lower end of the rod such that the length of rod again becomes 1m. Young's modulus and coefficient of linear expansion of the rod are $2 \times 10^{11} Nm^{-2}$ and $2 \times 10^{-5} K^{-1}$ respectively. The value of M is ______ kg. (Take

[31-Jan-2023 Shift 1]

Solution:

Solution:
If $\Delta\ell$ is decease in length of rod due to decease in temperature

$\Delta\ell = \ell\alpha\Delta T$
$\alpha = 2\times10^{-5}K^{-1}$, $\Delta T = (210-160)$
$= 50K$
$\Delta\ell = 1\times2\times10^{-5}\times50 = 10^{-3}m$
Young Modulus $= Y = \frac{F/A}{\Delta\ell/\ell}$ $A = 3\times10^{-6}m^2$
$2\times10^{11} = \frac{Mg/3\times10^{-6}}{10^{-3}/1}$
$Mg = 2\times10^{11}\times3\times10^{-9} = 6\times10^{-2}$
$M = 60\,kg$

Ans is 60 .

Question15

For a solid rod, the Young's modulus of elasticity is $3.2\times10^{11}Nm^{-2}$ and density is $8\times10^{3}\,kg\,m^{-3}$. The velocity of longitudinal wave in the rod will be.
[31-Jan-2023 Shift 2]

Options:

A. $145.75\times10^{3}ms^{-1}$

B. $3.65\times10^{3}ms^{-1}$

C. $18.96\times10^{3}ms^{-1}$

D. $6.32\times10^{3}ms^{-1}$

Answer: D

Solution:

Solution:

$= \sqrt{0.4 \times 10^8}$
$= \sqrt{40 \times 10^6}$
$= 6.32 \times 10^3 m / s$

Question16

Under the same load, wire A having length 5.0m and cross section $2.5 \times 10^{-5} m^2$ stretches uniformly by the same amount as another wire B of length 6.0m and a cross section of $3.0 \times 10^{-5} m^2$ stretches. The ratio of the Young's modulus of wire A to that of wire B will be:
[31-Jan-2023 Shift 2]

Options:

A. 1 : 4

B. 1 : 1

C. 1 : 10

D. 1 : 2

Answer: B

Solution:

Solution:

$\Delta \ell = \frac{F \ell}{SY}$

F is same for both wire and $\Delta \ell$ is also same

$\frac{\Delta \ell}{F} = \frac{\ell}{SY}$

$\Rightarrow \frac{\ell_A}{S_A Y_A} = \frac{\ell_B}{S_B Y_B}$

$\Rightarrow \frac{5}{2.5 \times Y_A} = \frac{6}{3 \times Y_B}$

$\Rightarrow \frac{Y_A}{Y_B} = 1$

Question17

A hole is drilled in a metal sheet. At $27^{\circ}C$, the diameter of hole is 5 cm. When the sheet is heated to $177^{\circ}C$, the change in the diameter of hole is $d \times 10^{-3}$ cm. The value of d will be ________ if coefficient of linear expansion of the metal is $1.6 \times 10^{-5} / {}^{\circ}C$.
[24-Jan-2023 Shift 1]

Solution:

d_0 at $27^\circ C$ & d_1 at $177^\circ C$
$d_1 = d_0(1 + \alpha \Delta T)$
$d_1 - d_0 = 5 \times 1.6 \times 10^{-5} \times 150\,\text{cm}$
$= 12 \times 10^{-3}\,\text{cm}$

Question18

A faulty thermometer reads $5^\circ C$ in melting ice and $95^\circ C$ in steam. The correct temperature on absolute scale will be ________ . K when the faulty thermometer reads $41^\circ C$.
[30-Jan-2023 Shift 2]

Answer: 313

Solution:

Solution:

$$\frac{41^\circ - 5^\circ}{95^\circ - 5^\circ} = \frac{C - 0^\circ}{100^\circ - 0^\circ}$$

$$\Rightarrow \quad C = \frac{36}{90} \times 100 = 40^\circ C = 313K$$

Question19

A water heater of power 2000W is used to heat water. The specific heat capacity of water is $4200J\ kg^{-1}K^{-1}$. The efficiency of heater is 70%. Time required to heat 2 kg of water from $10^\circ C$ to $60^\circ C$ is _______ s.
(Assume that the specific heat capacity of water remains constant over the temperature range of the water).
[31-Jan-2023 Shift 2]

Solution:

Solution:
The amount of heat energy required to raise the temperature of a substance can be calculated as:

in temperature.
The time required to heat a substance can be calculated as :

$t = \frac{Q}{P}$

where t is the time required, and P is the power of the heating device.
The actual power output of the heating device can be calculated as:

$P_{actual} = P_{input} \times \text{ efficiency}$

where P_input is the input power to the device and efficiency is the fraction of input power that is actually converted to useful power output.
Substituting the given values:

$Q = 2\,kg \times 4200J / kg / K \times (60 - 10) = 2\,kg \times 4200J / kg / K \times 50K = 4200 \times 50 \times 2J = 420,000J$

$P_{input} = 2000W = 2000J / s$

$P_{actual} = 2000 \times 0.7 = 1400J / s$

$t = \frac{Q}{P_{actual}} = \frac{420,000}{1400} J / s = 300\ s$

So, the time required to heat 2 kg of water from 10°C to 60°C is approximately 300 s.

Question20

A mercury drop of radius 10^{-3}m is broken into 125 equal size droplets. Surface tension of mercury is $0.45Nm^{-1}$. The gain in surface energy is: [1-Feb-2023 Shift 1]

Options:

A. $2.26 \times 10^{-5}J$

B. $28 \times 10^{-5}J$

C. $17.5 \times 10^{-5}J$

D. $5 \times 10^{-5}J$

Answer: A

Solution:

Solution:

Sol. Initial surface energy $= 0.45 \times 4\pi(10^{-3})^2$

$\frac{4}{3}\pi(10^{-3})^3 = 125 \times \frac{4\pi}{3} R_{new}^{\ 3}$

$\therefore 10^{-3} = 5R_{new}$

$\therefore R_{new} = \frac{10^{-3}}{5} m$

So, final surface energy $= 0.45 \times 125 \times 4\pi \left(\frac{10^{-3}}{5} \right)^2$

Increase in energy $= 0.45 \times 4\pi \times (10^{-3})^2 \left[\frac{125}{25} - 1 \right]$

$= 4 \times 0.45 \times 4\pi \times 10^{-6}$

$= 2.26 \times 10^{-5}J$

Question21

The surface of water in a water tank of cross section area $750cm^2$ on the top of a house is hm above the tap level. The speed of water coming out

through the tap of cross section area $500 mm^2$ is $30 cm/s$. At that instant, $\frac{dh}{dt}$ is $x \times 10^{-3} m/s$. The value of x will be ______.
[1-Feb-2023 Shift 2]

Solution:

$$A_1V_1 = A_2V_2$$
$$750 \times 10^{-4} V_1 = 500 \times 10^{-6} \times 0.3$$
$$\frac{3 \times 10^{-3}}{750} m/s$$
$$= 2 \times 10^{-3} m/s$$
$$\frac{dh}{dt} = -2 \times 10^{-3} m/s$$

Question22

A certain pressure 'P' is applied to 1 litre of water and 2 litre of a liquid separately. Water gets compressed to 0.01% whereas the liquid gets compressed to 0.03%. The ratio of Bulk modulus of water to that of the liquid is $\frac{3}{x}$. The value of x is ______.
[1-Feb-2023 Shift 1]

Answer: 1

$$B_{water} = \frac{-\Delta P}{\left(\frac{\Delta V}{V}\right)} = \frac{-\Delta P}{\frac{0.01}{100}}$$
$$B_{liquid} = \frac{-\Delta P}{\frac{0.03}{100}}$$
$$\frac{B_{water}}{B_{liquid}} = 3$$
$$x = 1$$

Question23

The Young's modulus of a steel wire of length 6m and cross-sectional

**area $3mm^2$, is $2 \times 11^{11} N / m^2$. The wire is suspended from its support on a given planet. A block of mass 4 kg is attached to the free end of the wire. The acceleration due to gravity on the planet is $\frac{1}{4}$ of its value on the earth. The elongation of wire is (Take g on the earth $= 10 \text{ m} / \text{s}^2$)
[1-Feb-2023 Shift 2]**

Options:

A. 1 cm

B. 1 mm

C. 0.1 mm

D. 0.1 cm

Answer: C

Solution:

Solution:
Tension $(F) = mg$

$= 4 \times \frac{10}{4} = 10N$

$\Delta L = \frac{FL}{AY}$

$= \frac{10 \times 6}{3 \times 10^{-6} \times 2 \times 10^{11}}$

$= 10^{-4} m = 0.1 \text{ mm}$

Question24

**A small ball of mass M and density ρ is dropped in a viscous liquid of density ρ_0. After some time, the ball falls with a constant velocity. What is the viscous force on the ball?
[6-Apr-2023 shift 1]**

Options:

A. $F = Mg\left(1 + \frac{\rho_0}{\rho}\right)$

B. $F = Mg\left(1 + \frac{\rho}{\rho_0}\right)$

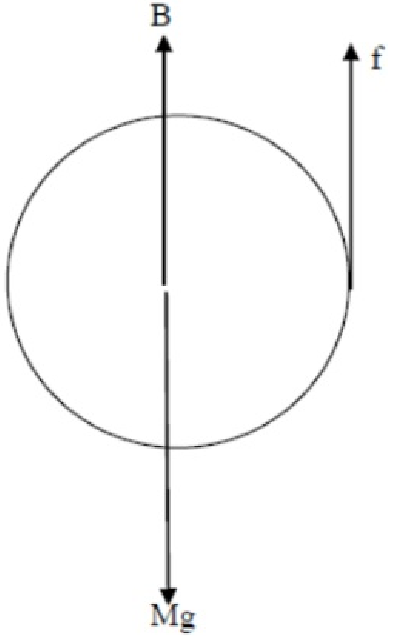
C. $F = Mg\left(1 - \frac{\rho_0}{\rho}\right)$

D. $F = Mg(1 \pm \rho\rho_0)$

Answer: C

Solution:

At terminal velocity, net force on the ball is Zero.



$Mg = f + B$

$\Rightarrow Mg = f + V_{ball}\,\rho_o g \quad \ldots (i)$

Volume of ball $= \frac{M}{\rho}$

From eq (i),

$Mg = f + \frac{M}{\rho}\rho_o g$

$\Rightarrow f = Mg - \frac{M}{\rho}\rho_o g$

$\Rightarrow f = Mg\left(1 - \frac{\rho_o}{\rho}\right)$

Question25

Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : When you squeeze one end of a tube to get toothpaste out from the other end. Pascal's principle is observed.
Reason R : A change in the pressure applied to an enclosed incompressible fluid is transmitted undiminished to every portion of the fluid and to the walls of its container.
In the light of the above statements, choose the most appropriate answer from the options given below
[6-Apr-2023 shift 2]

Options:

A. A is correct but R is not correct

B. Both A and R are correct and R is the correct explanation of A

C. A is not correct but R is correct

D. Both A and R are correct but R is NOT the correct explanation of A

Answer: B

As per pascal's law, when we apply pressure to an ideal liquid it is equally distributed in the entire liquid and to the walls as well.
Since due to applied pressure, every morning, the tooth paste does not get compressed and we can safely consider it on incompressible liquid.
Therefore both statements are true and R is correct explanation of A.

Question26

An air bubble of volume $1 cm^3$ rises from the bottom of a lake 40m deep to the surface at a temperature of $12^{\circ}C$. The atmospheric pressure is 1×10^5 Pa, the density of water is $1000 kg / m^3$ and $g = 10 m / s^2$. There is no difference of the temperature of water at the depth of 40m and on the surface. The volume of air bubble when it reaches the surface will be:
[8-Apr-2023 shift 1]

Options:

A. $3 cm^3$

B. $4 cm^3$

C. $2 cm^3$

D. $5 cm^3$

Answer: D

Solution:

Pressure at surface $= P_{atm} = 1 \times 10^5 Pa$
$= ?$
Pressure at $h = 40m$ depth
$P = P_{atm} + \rho gh$
$P = 10^5 + 10^3 \times 10 \times 40$
$P = 5 \times 10^5 Pa$
$V = 1 cm^3$
Temp. is constant
$P_1 V_1 = P_2 V_2$
$10^5 \times v = 5 \times 10^5 \times 1$
$v = 5 cm^3$

Question27

A hydraulic automobile lift is designed to lift vehicles of mass 5000 kg. The area of cross section of the cylinder carrying the load is $250 cm^2$. The maximum pressure the smaller piston would have to bear is [Assume $g = 10 m / s^2$] :
[8-Apr-2023 shift 2]

A. $2 \times 10^{+5}$ Pa

B. $20 \times 10^{+6}$ Pa

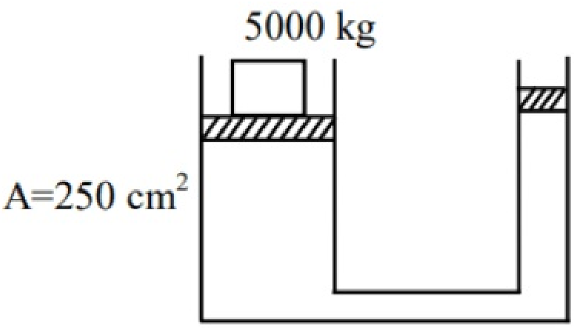
C. $200 \times 10^{+6}$ Pa

D. $2 \times 10^{+6}$ Pa

Answer: D

Solution:

Solution:



From pascal law same ΔP transmitted through out liquid

$$\Delta P = \frac{F}{A} = \frac{5000 \times 10}{250 \times 10^{-4}}$$

$= 2 \times 10^{6}$ Pa

Question28

Given below are two statements :
Statements I : Pressure in a reservoir of water is same at all points at the same level of water.
Statements II : The pressure applied to enclosed water is transmitted in all directions equally.
In the light of the above statements, choose the correct answer from the options given below :
[10-Apr-2023 shift 1]

Options:

A. Both Statements I and Statements II are false

B. Both Statements I and Statements II are true

C. Statements I is true but Statements II is false

D. Statements I is false but Statements II is true

Answer: B

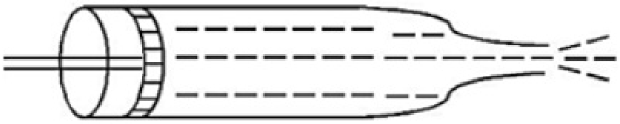
Solution:

Both Statements I and Statements II are true

By Pascal law, pressure is equally transmitted to in enclosed water in all direction.

Question29

Figure below shows a liquid being pushed out of the tube by a piston having area of cross section $2.0 cm^2$. The area of cross section at the outlet is $10 mm^2$. If the piston is pushed at a speed of $4 cm\ s^{-1}$, the speed of outgoing fluid is ______ $cm\ s^{-1}$



[10-Apr-2023 shift 2]

Solution:

By equation of continuity

$A_1V_1 = A_2V_2$

$(2cm^2)(4 cm/s) = (10 \times 10^{-2}cm^2)(v)$

$\frac{8cm^3}{s} = 10^{-1}cm^2(v)$

$V = 80 cm/s$

Question30

Eight equal drops of water are falling through air with a steady speed of 10 cm / s. If the drops collapse, the new velocity is :-
[11-Apr-2023 shift 2]

Options:

A. 10 cm / s

B. 40 cm / s

C. 16 cm / s

D. 5 cm / s

Answer: B

Solution:

Solution:

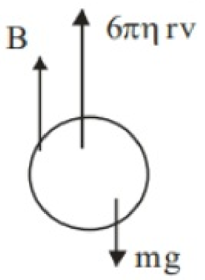
$8 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$R = 2r$

$V = \frac{2r^2}{9\eta}(\rho_b - \rho_{air})$

$V \propto r^2$

$\frac{V_1}{V_2} = \left(\frac{r}{R}\right)^2$



$V_2 = V_1 \times 4 = 10 \times 4 = 40\,km / s^{-1}$

Question31

The surface tension of soap solution is $3.5 \times 10^{-2} Nm^{-1}$. The amount of work done required to increase the radius of soap bubble from 10 cm to 20 cm is ________ $\times 10^{-4}$J. (take π = 22 / 7)
[11-Apr-2023 shift 2]

Solution:

$W = \Delta U$

$W = 25 \times (A_f - A_i)$

$= 2 \times 5 \times 4\pi(r_f^2 - r_i 2)$

$= 2 \times 3.5 \times 10^{-2} \times 4 \times \frac{22}{7} \times 10^{-4}(300)$

$= 264 \times 10^{-4} J$

Question32

64 identical drops each charged upto potential of 10 mV are combined to form a bigger drop. The potential of the bigger drop will be ______ mV.
[12-Apr-2023 shift 1]

Answer: 160

Solution:

We know $V = \frac{kq}{r}$, $q' = 64q$

Voulme remain const so

$\frac{4}{3}\pi r^3 \times 64 = \frac{4}{3}\pi R^3$

$R = 4r$

Now new potential $V' = \frac{K64q}{4r} = \frac{16\,kq}{r}$

$V' = 16 \,.\, V$ and $V = \frac{Kq}{r} = 10\,mV$

$V' = 16 \times 10 \times 10^{-3}$

$V' = 0.16V$

OR $V' = 160\,mV$

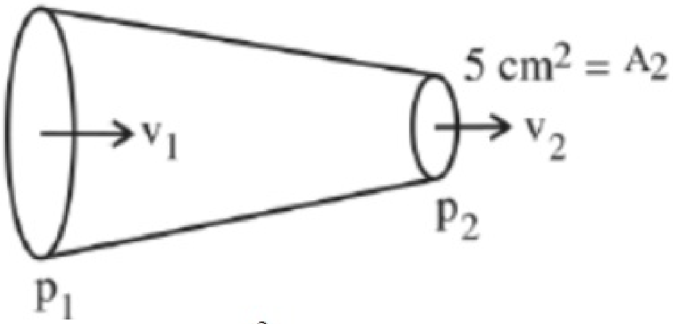
Question33

Glycerin of density $1.25 \times 10^3\,kg\,m^{-3}$ is flowing through the conical section of pipe. The area of cross-section of the pipe at its ends are $10cm^2$ and $5cm^2$ and pressure drop across its length is $3Nm^{-2}$. The rate of flow of glycerin through the pipe is $x \times 10^{-5}m^3\,s^{-1}$. The value of x is ______.

[12-Apr-2023 shift 1]

Solution:

$A_1 = 10cm^2$



$\Delta P = P_1 - P_2 = 3N/m^2$ (given)

By continuity equation

$A_1 v_1 = A_2 v_2$

$\therefore v_1 = \frac{A_2}{A_1} v_2 \,.\,.\,.\,.\,.\,(1)$

By bernoulli's equation

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2)$

$\Delta P = \frac{1}{2}\rho\left(v_2^2 - \frac{A_2^2}{A_1^2}v_2^2\right)$

$\Delta P = \frac{1}{2}\rho\left[1 - \left(\frac{A_2}{A_1}\right)^2\right]v_2^2$

$3 = \frac{1}{2} \times 1.25 \times 10^3 \left[1 - \frac{1}{4}\right] v_2^2$

$3 = \frac{1}{2} \times 1.25 \times 10^3 \times \frac{3}{4} v_2^2$

$\therefore v_2 = 8 \times 10^{-2} m / s$

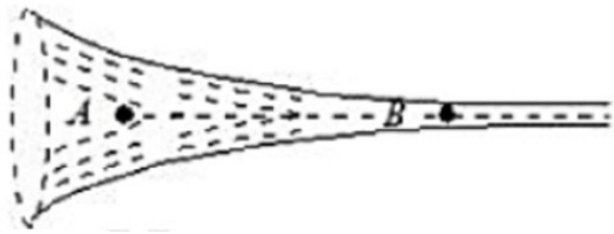
So discharge rate $= A_2 V_2$

$= 5 \times 10^{-4} \times 8 \times 10^{-2}$

$= 4 \times 10^{-5} m^3 / s$

Question34

The figure shows a liquid of given density flowing steadily in horizontal tube of varying cross - section. Cross sectional areas at A is $1.5 cm^2$, and B is $25 mm^2$, if the speed of liquid at B is $60 cm / s$ then $(P_A - P_B)$ is:
(Given P_A and P_B are liquid pressures at A and B points)
Density $\rho = 1000 kg m^{-3}$
A and B are on the axis of tube



[13-Apr-2023 shift 1]

Options:

A. 175 Pa

B. 36 Pa

C. 27 Pa

D. 135 Pa

Answer: A

Solution:

By equation of continuity,

$A_1 V_1 = A_2 V_2$

$(1.5 \times 10^{-4}) V_A = (25 \times 10^{-6}) 60 cm / s$

$V_A = 10 cm / s$

By Bernoulli's theorem.

$P_A + \frac{1}{2} \rho V_A^2 = P_B + \frac{1}{2} \rho V_B^2$

$P_A - P_B = \frac{\rho}{2} (V_B^2 - V_A^2)$

$P_A - P_B = \frac{1000}{2} (60^2 - 10^2) \times 10^{-4}$

$P_A - P_B = 175 Pa$

Question35

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : A spherical body of radius (5 ± 0.1) mm having a particular density is falling through a liquid of constant density. The percentage error in the calculation of its terminal velocity is 4%
Reason R : The terminal velocity of the spherical body falling through the liquid is inversely proportional to its radius.
In the light of the above statements, choose the correct answer from the options given below
[13-Apr-2023 shift 2]

Options:

A. Both A and R are true but R is NOT the correct explanation of A

B. Both A and R true and R is the correct explanation of A

C. A is false but R is true

D. A is true but R is false

Answer: D

on:

Terminal velocity of a spherical body in liquid

$V_t \propto r^2$

$$\frac{\Delta V_t}{V_t} = 2\frac{\Delta r}{r}$$

$$\frac{\Delta V_t}{V_t} \times 100\% = 2 \times \frac{0.1}{5} \times 100 = 4\%$$

Also, $V_t \propto r^2$

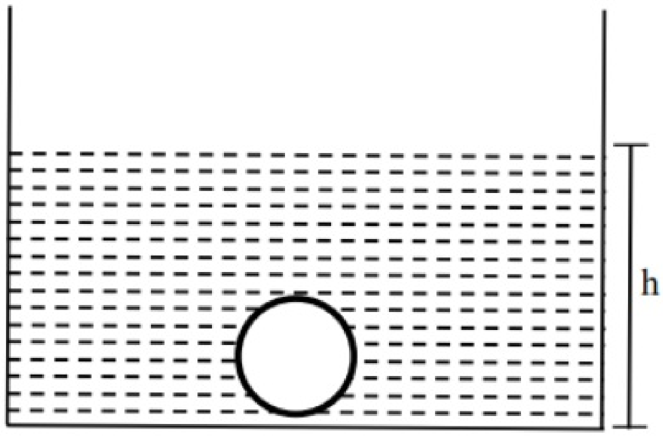
Reason (R) is false

Question36

There is an air bubble of radius 1.0 mm in a liquid of surface te
$^{-1}$ and density 1000 kg m^{-3} at a depth of 10 cm below t
e amount by which the pressure inside the bubble is
than the atmospheric pressure is _______ Pa$(g = 10ms^{-2})$
[15-Apr-2023 shift 1]

Answer: 1150

$P_{in} = P_0 + \rho gh + \frac{2T}{r}$



$P_{in} - P_0 = 1000 \times 10 \times 0.1 + \frac{2 \times 0.075}{0.001}$

$= 1000 + 150$

$P_{in} - P_0 = 1150\,Pa$

Question37

A metal block of mass m is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is $7 \times 10^5 Nm^{-2}$. The value of mass m is ______ kg.
(Take, $g = 9.8 ms^{-2}$ and $\pi = \frac{22}{7}$)
[6-Apr-2023 shift 2]

Solution:

Solution:

Using stress $= \frac{\text{force}}{\text{area}} = \frac{mg}{A}$

$\Rightarrow m = \frac{S \times A}{g} = \frac{7 \times 10^5 \times \pi R^2}{g}$

$= \frac{7 \times 10^5 \times \frac{22}{7} \times (7 \times 10^{-3})^2}{9.8}$ (Note: 14 mm is diameter)

$= 11\,kg$

Question38

An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10} N / m^2$ undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:
[8-Apr-2023 shift 1]

Options:

A. 5600

B. 2800

C. 11200

D. 8400

Answer: A

Solution:

rod Young's modulus

$10^{10} \frac{N}{m^2}$

strain 0.04%

$\text{strain} = \frac{0.04}{100}$

Energy per unit volume $= \frac{1}{2}$ stress × strain

$= \frac{1}{2} y \text{ strain } \times \text{ strain}$

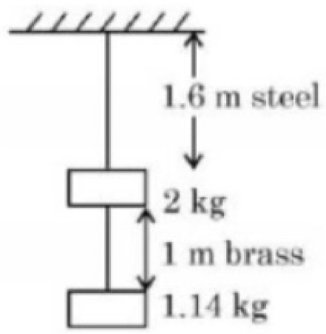
$= \frac{1}{2} y(\text{ strain })^2$

$= \frac{1}{2} \times 7 \times 10^{10} \times \left(\frac{0.04}{100}\right)^2$

Energy per unit volume $= 5600 \frac{J}{m^3}$

Question39

Two wires each of radius 0.2 cm and negligible mass, one made of steel and the other made of brass are loaded as shown in the figure. The elongation of the steel wire is ______ $\times 10^{-6}$ m. [Young's modulus for steel $= 2 \times 10^{11} Nm^{-2}$ and $g = 10 ms^{-2}$



[10-Apr-2023 shift 1]

Solution:

$T_2 = T_1 + 20 = 20 + 11.4$
$T_2 = 31.4$
∴ Elongation in steel wire

$$\Delta L = \frac{T_2 L}{AY}$$

$$= \frac{31.4 \times 1.6}{\pi(0.2 \times 10^{-2})^2 \times 2 \times 10^{11}}$$

$$= 2 \times 10^{-5}$$

$$\Delta L = 20 \times 10^{-6} \text{m}$$

Question40

Young's moduli of the material of wires A and B are in the ratio of 1 : 4, while its area of cross sections are in the ratio of 1 : 3. If the same amount of load is applied to both the wires, the amount of elongation produced in the wires A and B will be in the ratio of [Assume length of wires A and B are same]
[10-Apr-2023 shift 2]

Options:

A. 12 : 1

B. 1 : 36

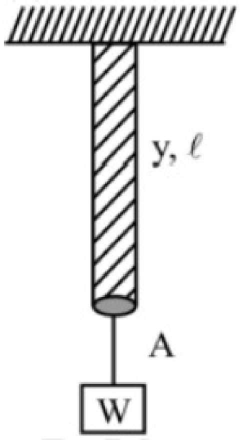
C. 1 : 12

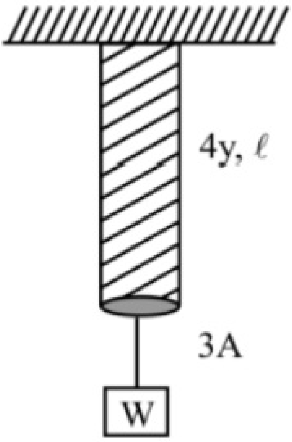
D. 36 : 1

Answer: A

Solution:

Solution:





$\frac{W}{A} = Y \cdot \frac{\Delta\ell_1}{\ell}$ $\frac{W}{3A} = 4Y \cdot \frac{\Delta\ell_2}{\ell}$

$\Delta l_1 = \frac{W\ell}{AY}$ $\Delta l_2 = \frac{W\ell}{12\,AY}$

$\frac{\Delta\ell_1}{\Delta\ell_2} = \frac{12}{1}$

Question41

The length of a wire becomes l_1 and l_2 when 100N and 120N tensions are applied respectively. If $10l_2 = 11l_1$, the natural length of wire will be $\frac{1}{x}l_1$. Here the value of x is _______.
[11-Apr-2023 shift 1]

Answer: 2

Solution:

ℓ_0 = natural length

$F = kx$

$F = \frac{yA}{\ell_0} \cdot x$.

Sol when $F = 100N$

$100 = k(\ell_1 - \ell_0)$ . . . (1)

When $F = 120N$

$120 = K((\ell_1 - \ell_0)$.

Given that

$10\ell_2 = 11\ell_1$

$\ell_2 = 1.1\ell_1$

So $120 = K(1.1\ell_1 - \ell_0)$ . . . (2)

Now (2) \(1)

$\frac{120}{100} = \frac{K(1.1\ell_1 - \ell_0)}{K(\ell_1 - \ell_0)}$

$1.2 = \frac{1.1\ell_1 - \ell_0}{\ell_1 - \ell_0}$

$1.2\ell_1 - 1.2\ell_0 = 1.1\ell_1 - \ell_0$

$0.1\ell_1 = 0.2\ell_0$

$\ell_0 = \frac{\ell_1}{2}$ So x = 2 Ans.

Question42

Under isothermal condition, the pressure of a gas is given by $P = aV^{-3}$, where a is a constant and V is the volume of the gas. The bulk modulus at constant temperature is equal to
[13-Apr-2023 shift 1]

Options:

A. $\frac{P}{2}$

B. 2P

C. P

D. 3P

Answer: D

Solution:

$\frac{}{dV} = -3aV^{-}$

Bulk modulus, $B = -V\frac{dP}{dV}$

$B = -V\left(\frac{-3a}{V^4}\right)$

$B = 3\frac{a}{V^3} = 3P$

Question43

The elastic potential energy stored in a steel wire of length 20m stretched through 2 cm is 80J. The cross sectional area of the wire is ________ (. Given, $y = 2.0 \times 10^{11} Nm^{-2}$) mm^2.
[13-Apr-2023 shift 1]

Answer: 40

Solution:

$$\text{Energy, } U = \frac{1}{2}kx^2$$
$$80 = \frac{1}{2}k(2 \times 10^{-2})^2$$
$$k = \frac{160}{4 \times 10^{-4}}$$
$$k = 4 \times 10^5 N/m$$
$$\frac{yA}{\ell} = 4 \times 10^5$$
$$A = \frac{4 \times 10^5 \times 20}{2 \times 10^{11}}$$
$$A = 40 \times 10^{-6} m^2$$
$$A = 40 mm^2$$

Question44

A wire of length ' L ' and radius ' r ' is clamped rigidly at one end. When the other end of the wire is pulled by a force f, its length increases by ' l '. Another wire of same material of length ' 2L ' and radius ' 2r ' is pulled by a force ' 2f. Then the increase in its length will be :
[15-Apr-2023 shift 1]

Options:

A. l / 2

B. 4l

C. l

D. 2l

Answer: C

Solution:

By hooke's law,
$$\gamma = \frac{Fl}{A \Delta l}$$
$$\Delta l \propto \frac{Fl}{A}$$
$$\frac{\Delta l_2}{\Delta l_1} = \frac{F_2 l_2}{F_1 l_1} \times \frac{A_1}{A_2}$$
$$= \frac{2f \times 2L}{f \times L} \times \frac{\pi(r)^2}{\pi(2r)^2}$$
$$\Delta l_1 = \Delta l_2$$
$$\Delta l_2 = 1$$

Question45

A body cools in 7 minutes from 60°C to 40°C. The temperature of the surrounding is 10°C. The temperature of the body after the next 7 minutes

Options:

A. 30°C

B. 34°C

C. 32°C

D. 28°C

Answer: D

Solution:

Method-1

cooling

$T - T_s = (T_0 - T_s)e^{-Kt}$

Case-I: $(40 - 10) = (60 - 10)e^{-7K}$

$30 = 50e^{-7K}$

Case-II: $(T - 10) = (40 - 10)e^{-7K}$ or $T - 10 = 30e^{-7K}$

Dividing (2) by (1)

$$\frac{T-10}{30} = \frac{30}{50}$$

$$\Rightarrow T - 10 = \frac{30 \times 30}{50} = 18$$

or $T = 28^\circ C$

Methode-2

Using newton's average law of cooling

$$\frac{T_i - T_f}{t} = k\left(\frac{T_i + T_f}{2} - T_s\right)$$

Case-I:- $\frac{60-40}{7} = R\left[\frac{60+40}{2} - 10\right] \Rightarrow \frac{20}{7} = k[40]\ldots$ (i)

Case-II:- $\frac{40-T}{7} = R\left[\frac{20+T}{2}\right]\ldots$ (2)

Dividing (2) by (1)

$$\frac{40-T}{20} = \frac{20+T}{80}$$

$160 - 4T = 20 + T$

$5T = 140$

$T = 28^\circ C$

Question46

A steel rod of length 1m and cross sectional area $10^{-4}m^2$ is heated from $0^\circ C$ to $200^\circ C$ without being allowed to extend or bend. The compressive tension produced in the rod is ________ of steel $= 2 \times 10^{11} Nm^{-2}$, coefficient of linear expansion $= 10^{-5}K^{-1}$) $\times 10^4 N$. (Given Young's modulus

[8-Apr-2023 shift 2]

Solution:

Thermal stress $= Y\alpha\,\Delta T$
$F = YA\alpha\,\Delta T$
$= 2 \times 10^{11} \times 10^{-4} \times 10^{-5} \times 200$
$= 4 \times 10^{4}$
$x = 4$

Question47

1 kg of water at 100°C is converted into steam at 100°C by boiling at atmospheric pressure. The volume of water changes from $1.00 \times 10^{-3} m^3$ as a liquid to $1.671 m^3$ as steam. The change in internal energy of the system during the process will be
(Given latent heat of vaporisation = 2257 kJ / kg, Atmospheric pressure = 1×10^5 Pa)
[11-Apr-2023 shift 1]

Options:

A. +2476 kJ

B. −2426 kJ

C. −2090 kJ

D. +2090 kJ

Answer: D

Solution:

Change in volume at constant pressure and temp →
$\Delta V = V_2 - V_1 = 1.671 - 0.001$
$\Delta V = 1.67 m^3$ ...... (1)
$\Delta Q = \Delta U + w$
$mL_v = \Delta U + (1.013 \times 10^5)(1.67)$
$\Delta U = (2257 - 170)10^3$
$\Delta U = 2090$ kJ (approx.) Ans. Option → 4

Question48

On a temperature scale ' X ', the boiling point of water is 65°X and the freezing point is −15°X. Assume that the X scale is linear. The equivalent temperature corresponding to −95°X on the Farenheit scale would be :
[11-Apr-2023 shift 1]

Options:

A. −63°F

C. $-48^{\circ}F$

D. $-112^{\circ}F$

Answer: C

Solution:

$$\frac{X - X_L}{X_H - X_L} = \frac{T_F - 32}{212 - 32}$$

$$\frac{-95^{\circ} - (-15^{\circ})}{65^{\circ} - (-15^{\circ})} = \frac{T_F - 32}{180}$$

$$\frac{-80^{\circ}}{80^{\circ}} = \frac{T_F - 32}{180^{\circ}}$$

$$-180 = T_F - 32$$

$$T_F = -180 + 32 = -148^{\circ}F$$

Ans. option → (2)

Question49

A body cools from $80^{\circ}C$ to $60^{\circ}C$ in 5 minutes. The temperature of the surrounding is $20^{\circ}C$. The time it takes to cool from $60^{\circ}C$ to $40^{\circ}C$ is: [12-Apr-2023 shift 1]

Options:

A. 450 s

B. 500 s

C. 420 s

D. $\frac{25}{3}$ s

Answer: B

Solution:

Body cools from $80^{\circ}C$ to $60^{\circ}C$ in 5 min

$T_{suroumding} = 20^{\circ}C$

Time taken to cool from $60^{\circ}C$ to $40^{\circ}C$?

we know newton's law of cooling is

$$-\frac{d\theta}{dt} = b(\theta - \theta_0)$$

surrounding temp.

We take approx value of v as $\frac{80 + 60}{2} = 70^{\circ}$

$$\frac{20}{5} = b[70 - 20]\ldots(1)$$

$$\frac{20}{t} = b[50 - 20]\ldots(2)$$

After solving $t = \frac{25}{3}\text{min}$

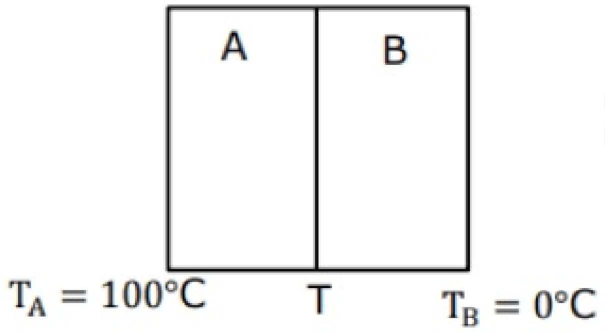
In second $t = \frac{25}{3} \times 60$

= 500 sec .

Question50

Two plates A and B have thermal conductivities $84 Wm^{-1}K^{-1}$ and $126 Wm^{-1}K^{-1}$ respectively. They have same surface area and same thickness. They are placed in contact along their surfaces. If the temperatures of the outer surfaces of A and B are kept at $100^{\circ}C$ and $0^{\circ}C$ respectively, then the temperature of the surface of contact in steady state is ______ $^{\circ}C$.
[13-Apr-2023 shift 2]

Solution:



Let the temperature of contact surface is T then,

$$\frac{K_A A(T_A - T)}{L} = \frac{K_B A(T - T_B)}{L}$$

$84(100 - T) = 126(T - 0)$

$T = 40^{\circ}C$

Question51

The terminal velocity (v_t) of the spherical rain drop depends on the radius (r) of the spherical rain drop as :
[25-Jun-2022-Shift-1]

Options:

A. $r^{1/2}$

B. r

C. r^2

D. r^3

Answer: C

Solution:

$(\rho - \sigma)g \Rightarrow v_t = Cr^2$ where C is a constant or $v_t \propto r^2$

Question52

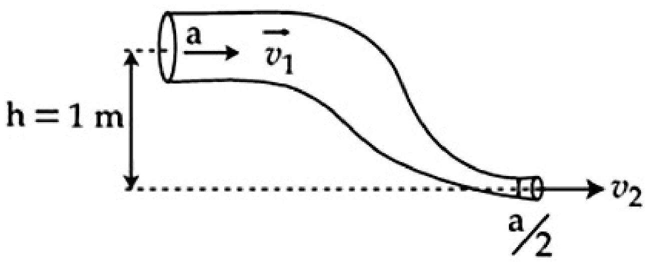
The velocity of upper layer of water in a river is $36 kmh^{-1}$. Shearing stress between horizontal layers of water is $10^{-3} Nm^{-2}$. Depth of the river is m. (Co-efficient of viscosity of water is _____ 10^{-2} Pa . s)
[25-Jun-2022-Shift-1]

Answer: 100

$$F = -\eta A \frac{du}{dx}$$
$$\Rightarrow 10^{-3} = 10^{-2} \times \frac{10}{h}$$
$$\Rightarrow h = \frac{10^{-1}}{10^{-3}} m = 100 m$$
$$\Rightarrow (100)$$

Question53

An ideal fluid of density $800 kgm^{-3}$, flows smoothly through a bent pipe (as shown in figure) that tapers in cross-sectional area from a to $\frac{a}{2}$. The pressure difference between the wide and narrow sections of pipe is 4100 Pa. At wider section, the velocity of fluid is $\frac{\sqrt{x}}{6} ms^{-1}$ for x = (Given $g = 10 ms^{-2}$)



[26-Jun-2022-Shift-1]

Answer: 363

Solution:

From Bernoulli's equation

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$P_1 - P_2 + \rho g(h_1 - h_2) = \frac{1}{2}\rho(v_2^2 - v_1^2) \ldots\ldots \text{ (i)}$$

Also, from equation of continuity

$$A_1 v_1 = A_2 v_2$$

$$A v_1 = \frac{A}{2} v_2$$

$$v_2 = 2v_1 \ldots\ldots \text{ (ii)}$$

put equation (ii) in (i),

$$4100 \times 800 \times 10 \times 1 = \frac{1}{2} \times 800 \times (4v_1^2 - v_1^2)$$

$$4100 + 8000 = 400 \times 3v_1^2$$

$$v_1^2 = \frac{12100}{3 \times 400} = \frac{121}{12}$$

$$v_1 = \sqrt{\frac{121}{12}}$$

Now, $\frac{\sqrt{x}}{6} = \sqrt{\frac{121}{12}}$

$$\frac{x}{36} = \frac{121}{12}$$

$$x = 121 \times 3 = 363$$

$$\therefore x = 363$$

Question54

If p is the density and η is coefficient of viscosity of fluid which flows with a speed v in the pipe of diameter d , the correct formula for Reynolds number R_e is :

[26-Jun-2022-Shift-2]

Options:

A. $R_e = \frac{\eta d}{\rho v}$

B. $R_e = \frac{\rho v}{\eta d}$

C. $R_e = \frac{\rho v d}{\eta}$

D. $R_e = \frac{\eta}{\rho v d}$

Answer: C

Solution:

$$R_e = \frac{\rho v d}{\eta}$$

d.

Question55

The velocity of a small ball of mass ' m ' and density d_1, when dropped in a container filled with glycerin, becomes constant after some time. If the density of glycerin is d_2, then the viscous force acting on the ball, will be :
[27-Jun-2022-Shift-1]

Options:

A. $mg\left(1-\frac{d_1}{d_2}\right)$

B. $mg\left(1-\frac{d_2}{d_1}\right)$

C. $mg\left(\frac{d_1}{d_2}-1\right)$

D. $mg\left(\frac{d_2}{d_1}-1\right)$

Answer: B

Solution:

Solution:
Viscous force acting on the ball will be equal and opposite to net of weight and buoyant force

$\Rightarrow F_0=\frac{4}{3}\pi r^3 d_1 g-\frac{4}{3}\pi r^3 d_2 g$

$=\frac{4}{3}\pi r^3 d_1 g\left(1-\frac{d_2}{d_1}\right)$

$=mg\left(1-\frac{d_2}{d_1}\right)$

Question56

The area of cross-section of a large tank is $0.5m^2$. It has a narrow opening near the bottom having area of cross-section 1 cm. A load of 25 kg is applied on the water at the top in the tank. Neglecting the speed of water in the tank, the velocity of the water, coming out of the opening at the time when the height of water level in the tank is 40 cm above the bottom, will be ____cms^{-1} · [. Take $g=10ms^{-2}$]
[27-Jun-2022-Shift-1]

Solution:

By Bernoulli's theorem:
$\frac{250}{0.5} + \rho gh = \frac{1}{2}\rho v^2$
$\Rightarrow v = 3m / s$
$\Rightarrow v = 300\,cm / s$

Question57

When a ball is dropped into a lake from a height 4.9m above the water level, it hits the water with a velocity v and then sinks to the bottom with the constant velocity v. It reaches the bottom of the lake 4.0s after it is dropped. The approximate depth of the lake is :
[27-Jun-2022-Shift-2]

Options:

A. 19.6m

B. 29.4m

C. 39.2m

D. 73.5m

Answer: B

Solution:

$t_1 = \sqrt{\frac{2h}{g}}$
$= \sqrt{\frac{2 \times 4.9}{9.8}} = 1\ s$
$\Delta t = 4 - 1 = 3\ s,$
$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 4.9} = 9.8m / s$
$\therefore$ depth $= 9.8 \times 3 = 29.4m$

Question58

Given below are two statements : One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.
Reason R : Coefficient of viscosity $= \frac{\text{Force}}{\text{Velocity gradient}}$
Choose the correct answer from the options given below :
[28-Jun-2022-Shift-1]

A. Both A and R are true, and R is the correct explanation of A.

B. Both A and R are true but R is NOT the correct explanation of A.

C. A is true but R is false.

D. A is false but R is true.

Answer: C

Solution:

$$\text{e][Time} \Big] = \Big[\frac{\text{Force}}{\text{Area}} \Big] \Big[\frac{\text{distance}}{\text{Area}} \Big]$$

$$[\text{Coefficient of viscosity} \Big] = \Big[\frac{\text{Force}}{\text{Area}} \Big] \Big[\frac{\text{distance}}{\text{Area}} \Big]$$

Statement ' A ' is true

But Statement ' R ' is false are coefficient of viscosity

$$= \frac{\text{Force}}{\text{Area} \times \text{Velocity gradient}}$$

Question59

A water drop of diameter 2 cm is broken into 64 equal droplets. The surface tension of water is 0.075N / m. In this process the gain in surface energy will be :
[28-Jun-2022-Shift-1]

Options:

A. $2.8 \times 10^{-4} J$

B. $1.5 \times 10^{-3} J$

C. $1.9 \times 10^{-4} J$

D. $9.4 \times 10^{-5} J$

Answer: A

Solution:

$r' = \frac{r}{4}$

$\Rightarrow \Delta E = T(\Delta S)$

$= T \times 4\pi(nr'^2 - r^2), n = 64$

$= T \times 4\pi \times (4 - 1)r^2$

$\Rightarrow \Delta E = 0.075 \times 4 \times 3.142(3) \times 10^{-4} J$

$= 2.8 \times 10^{-4} J$

A water drop of radius 1μm falls in a situation where the effect of buoyant force is negligible. Co-efficient of viscosity of air is $1.8 \times 10^{-5} Nsm^{-2}$ and its density is negligible as compared to that of water $10^6 gm^{-3}$. Terminal velocity of the water drop is (Take acceleration due to gravity $= 10ms^{-2}$)
[28-Jun-2022-Shift-2]

Options:

A. $145.4 \times 10^{-6} ms^{-1}$

B. $118.0 \times 10^{-6} ms^{-1}$

C. $132.6 \times 10^{-6} ms^{-1}$

D. $123.4 \times 10^{-6} ms^{-1}$

Answer: D

Solution:

$$6\pi\eta r v = \frac{4}{3}\pi r^3 \rho g$$

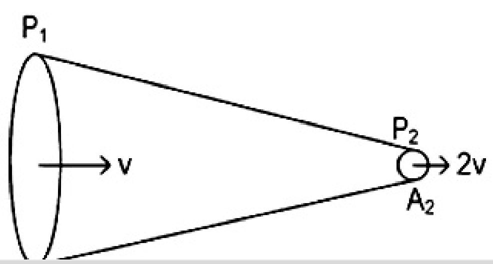
$$\text{or } v = \frac{2}{9}\frac{\rho r^2 g}{\eta} = \frac{2}{9} \times \frac{10^3 \times (10^{-6})^2 \times 10}{1.8 \times 10^{-5}}$$

$$= 123.4 \times 10^{-6} m / s$$

Question61

A liquid of density $750 kgm^{-3}$ flows smoothly through a horizontal pipe that tapers in cross-sectional area from $A_1 = 1.2 \times 10\ -2m^2$ to $A_2 = \frac{A_1}{2}$. The pressure difference between the wide and narrow sections of the pipe is 4500 Pa. The rate of flow of liquid is _____ $\times 10^{-3} m^3 s^{-1}$
[28-Jun-2022-Shift-2]

Solution:



Using Bernoulli's equation

$$P_1 + \frac{1}{2}\rho v^2 = P_2 + \frac{1}{2}\rho 4v^2$$

$$\frac{3}{2}\rho v^2 = P_1 - P_2$$

$$\Rightarrow v = \sqrt{\frac{2(P_1 - P_2)}{3\rho}}$$

$$= \sqrt{\frac{2 \times 4500}{3 \times 750}} = 2m / \ sec$$

So $Q = A_1 v = 24 \times 10^{-3} m^3 / \ sec$

Question62

A small spherical ball of radius 0.1 mm and density 10^4 kg m^{-3} falls freely under gravity through a distance h before entering a tank of water. If, after entering the water the velocity of ball does not change and it continue to fall with same constant velocity inside water, then the value of h will be _____m.
(Given $g = 10ms^{-2}$, viscosity of water $= 1.0 \times 10^{-5} N - sm^{-2}$).
[29-Jun-2022-Shift-2]

Answer: 20

Solution:

$$\sqrt{2gh} = \text{ terminal speed}$$

$$\Rightarrow \sqrt{2gh} = \frac{2}{9}\frac{r^2 g(\rho - \rho')}{\eta}$$

$$= \frac{2}{9} \times \frac{10^{-8} \times 10 \times 9000}{10^{-5}}$$

$$\Rightarrow h = \frac{400}{2g}$$

$$\Rightarrow h = 20m$$

Question63

The bulk modulus of a liquid is $3 \times 10^{10} Nm^{-2}$. The pressure required to reduce the volume of liquid by 2% is :
[24-Jun-2022-Shift-1]

Options:

A. $3 \times 10^{8} Nm^{-2}$

B. $9 \times 10^{8} Nm^{-2}$

C. $6 \times 10^{8} Nm^{-2}$

D. $12 \times 10^{8} Nm^{-2}$

Answer: C

Solution:

Solution:

$$\because B = \frac{\Delta P}{\left(-\frac{\Delta V}{V}\right)}$$

$$\Rightarrow \Delta P = 3 \times 10^{10} \times (0.02)$$

$$= 6 \times 10^{8} N / m^{2}$$

Question64

The elastic behaviour of material for linear stress and linear strain, is shown in the figure. The energy density for a linear strain of 5×10^{-4} is_____ kJ / m^{3}. Assume that material is elastic upto the linear strain of 5×10^{-4}.
[26-Jun-2022-Shift-1]

Solution:

slope of strain - stress curve given by $= \frac{10^{-10}}{20}$

for strain of 5×10^{-4} stress is given by

$5 \times 10^{-4} = \frac{10^{-10}}{20} \times$ stress

stress $= 10^{8} N / m^{2}$

Energy density $= \frac{1}{2} \times$ strain $\times$ stress

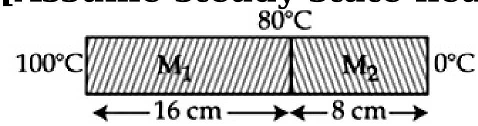
$= \frac{1}{2} \times 5 \times 10^{-4} \times 10^{8}$

$= 25000 J / m^{3}$

$= 25 kJ / m^{3}$

Question65

Two metallic blocks M $_1$ and M $_2$ of same area of cross-section are connected to each other (as shown in figure). If the thermal conductivity of M_2 is K then the thermal conductivity of M_1 will be :
[Assume steady state heat conduction]



[24-Jun-2022-Shift-1]

Options:

A. 10K

B. 8K

C. 12.5K

D. 2K

Answer: B

Solution:

Thermal current is same so

$$\frac{dQ}{dt} = \frac{\Delta T_1}{\frac{l_1}{K_1 A}} = \frac{\Delta T_2}{\frac{l_2}{K_2 A}}$$

$$\text{or } \frac{20}{16} \times K' = \frac{80}{8} \times K$$

$$\Rightarrow K' = 8K$$

Question66

A 100g of iron nail is hit by a 1.5 kg hammer striking at a velocity of $60 ms^{-1}$. What will be the rise in the temperature of the nail if one fourth of energy of the hammer goes into heating the nail?
[Specific heat capacity of iron $= 0.42 Jg^{-1} {}^{\circ}C^{-1}$]
[24-Jun-2022-Shift-2]

Options:

A. $675^{\circ}C$

B. $1600^{\circ}C$

C. $16.07^{\circ}C$

D. $6.75^{\circ}C$

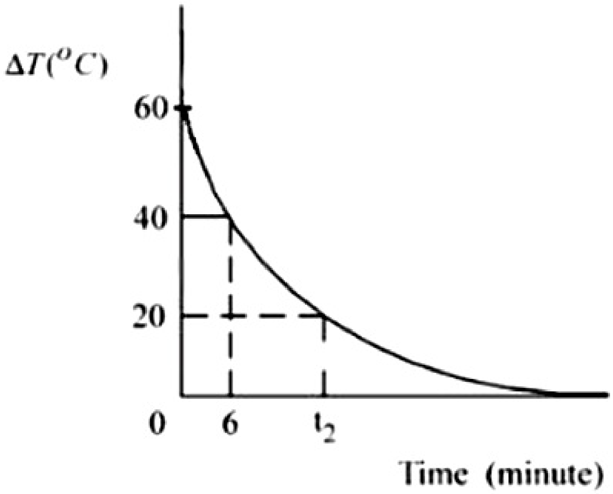
Answer: C

$$\frac{1}{2} \times 1.5 \times 60^2 \times \frac{1}{4} = 100 \times 0.42 \times \Delta T$$

$$\Delta T = \frac{1.5 \times 60^2}{8 \times 100 \times 0.42} = 16.07^\circ C$$

Question67

In an experiment to verify Newton's law of cooling, a graph is plotted between the temperature difference (ΔT) of the water and surroundings and time as shown in figure. The initial temperature of water is taken as 80°C. The value of t_2 as mentioned in the graph will be



[24-Jun-2022-Shift-2]

Solution:

Temperature of surrounding $= 20^\circ C$
For $0 \rightarrow 6$ minutes, average temp. $= 70^\circ C$
$\rightarrow$ Rate of cooling $\propto 70^\circ C - 20^\circ C = 50^\circ C$
For $6 \rightarrow t_2$ minutes, average temp. $= 50^\circ C$
$\rightarrow$ Rate of cooling $\propto 30^\circ C$
$\Rightarrow t_2 - 6 = \frac{5}{3}(6 \text{ minutes})$
$\Rightarrow t_2 = 16$ minutes

Question68

A steam engine intakes 50g of steam at 100°C per minute and cools it down to 20°C. If latent heat of vaporization of steam is 540 cal g^{-1}, then the heat rejected by the steam engine per minute is _____ $\times 10^3$ cal (Given : specific heat capacity of water : $1 \text{ cal g}^{-1}\,{}^\circ C^{-1}$)

[25-Jun-2022-Shift-1]

Answer: 31

Solution:

$\Delta Q_{rej} = 50 \times 540 + 50 \times 1 \times (100 - 20)$
$= 50 \times [540 + 80]$
$= 50 \times 620$
$= 31000\,\text{cal}$
$= 31 \times 10^3\,\text{cal}$

Question69

A solid metallic cube having total surface area 24m^2 is uniformly heated. If its temperature is increased by 10°C, calculate the increase in volume of the cube. (. Given .$\alpha = 5.0 \times 10^{-4\circ}\text{C}^{-1}$)
[25-Jun-2022-Shift-2]

Options:

A. $2.4 \times 10^6\text{cm}^3$

B. $1.2 \times 10^5\text{cm}^3$

C. $6.0 \times 10^4\text{cm}^3$

D. $4.8 \times 10^5\text{cm}^3$

Answer: B

Solution:

$6 \times l^2 = 24$
$\Rightarrow l = 2\text{m}$
$\therefore \frac{\Delta V}{V} = 3 \times \frac{\Delta l}{l}$
$\Rightarrow \Delta V = 3 \times (\alpha \Delta T) \times V$
$= 3 \times 5 \times 10^{-4} \times 10 \times (8)$
$= 120 \times 10^{-3}\text{m}^3$
$= 120 \times 10^{-3} \times 10^6\text{cm}^3$
$= 1.2 \times 10^5\text{cm}^3$

Question70

A copper block of mass 5.0 kg is heated to a temperature of 500°C and is placed on a large ice block. What is the maximum amount of ice that

can melt? [Specific heat of copper : $0.39 J g^{-1} {}^{\circ}C^{-1}$ and latent heat of fusion of water : $335 J g^{-1}$]
[25-Jun-2022-Shift-2]

Options:

A. 1.5 kg

B. 5.8 kg

C. 2.9 kg

D. 3.8 kg

Answer: C

Solution:

$$ms \Delta T$$
$$\Rightarrow m = \frac{0.39 \times 10^{3} \times 500}{335}$$
$$= 2.9 \text{ kg}$$

Question71

A geyser heats water flowing at a rate of 2.0 kg per minute from $30^{\circ}C$ to $70^{\circ}C$. If geyser operates on a gas burner, the rate of combustion of fuel will be _____ $g min^{-1}$
[Heat of combustion $= 8 \times 10^{3} J g^{-1}$, Specific heat of water $= 4.2 J g^{-1} {}^{\circ}C^{-1}$]
[26-Jun-2022-Shift-2]

Answer: 42

Solution:

$$Q = ms \Delta T$$
$$\frac{dQ}{dt} = \left(\frac{dm}{dt}\right)_{water} S \Delta T = \left(\frac{dm}{dt}\right)_{oil} C$$
$$\Rightarrow 2 \times 4.2 \times 10^{3} \times 40 = \left(\frac{dm}{dt}\right)_{oil} \times 8 \times 10^{6}$$
$$\Rightarrow \left(\frac{dm}{dt}\right)_{oil} = \frac{8 \times 4.2 \times 10^{4}}{8 \times 10^{6}} \text{kg / minute}$$
$$= 42 \text{g / min}$$

Question72

A lead bullet penetrates into a solid object and melts. Assuming that 40% of its kinetic energy is used to heat it, the initial speed of bullet is : (Given : initial temperature of the bullet = 127°C, Melting point of the bullet = 327°C, Latent heat of fusion of lead = $2.5 \times 10^4 J\ kg^{-1}$, Specific heat capacity of lead . = 125J / kg K)
[27-Jun-2022-Shift-2]

Options:

A. $125 ms^{-1}$

B. $500 ms^{-1}$

C. $250 ms^{-1}$

D. $600 ms^{-1}$

Answer: B

Solution:

Solution:

$\frac{2}{5} \times \frac{1}{2} mv^2 = mL + ms \Delta T$

$\Rightarrow \frac{v^2}{5} = 2.5 \times 10^4 + 125 + 200$

$\Rightarrow \frac{v^2}{5} = 5 \times 10^4$

$\Rightarrow v = 500 m / s$

Question73

Resistance of the wire is measured as 2Ω and 3Ω at 10°C and 30°C respectively. Temperature co-efficient of resistance of the material of the wire is :
[28-Jun-2022-Shift-2]

Options:

A. $0.033°C^{-1}$

B. $-0.033°C^{-1}$

C. $0.011°C^{-1}$

D. $0.055°C^{-1}$

Answer: A

Solution:

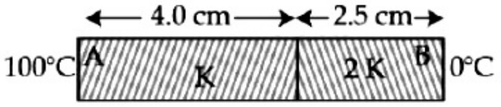
Solution:

$R_{10} = 2 = R_0(1 + \alpha \times 10)$

On solving
$\alpha = 0.033 / ^\circ C$

Question74

**As per the given figure, two plates A and B of thermal conductivity K and 2K are joined together to form a compound plate.
The thickness of plates are 4.0 cm and 2.5 cm respectively and the area of cross-section is $120 cm^2$ for each plate. The equivalent thermal conductivity of the compound plate is $\left(1 + \frac{5}{\alpha}\right)$K, then the value of α will be______**



[29-Jun-2022-Shift-1]

Answer: 21

$$\frac{L_1}{K_1A_1} + \frac{L_2}{K_2A_2} = \frac{L_1 + L_2}{K_{eff}A_{eff}}$$
$$\Rightarrow \frac{4}{K} + \frac{2.5}{2K} = \frac{6.5}{K_{eff}}$$
$$\Rightarrow \frac{10.5}{2K} = \frac{6.5}{K_{eff}}$$
$$\Rightarrow K_{eff} = \frac{13K}{10.5} = \left(1 + \frac{5}{21}\right)K$$
$$\Rightarrow \alpha = 21$$

Question75

**At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter 6.241 cm ? Both the diameters have been measured at room temperature (27°C).
(Given : coefficient of linear thermal expansion of gold
$\alpha_L = 1.4 \times 10^{-5} K^{-1}$)
[29-Jun-2022-Shift-2]**

Options:

A. 125.7°C

B. 91.7°C

C. 425.7°C

D. 152.7°C

Answer: D

Solution:

$$\Delta T = \frac{.011}{6.230 \times 1.4 \times 10^{-5}}$$

$= 126.11^\circ C$

$\Rightarrow T_f = T + \Delta T$

$= (27 + 126.11)^\circ C$

$= 153.11^\circ C$

Question76

A drop of liquid of density ρ is floating half immersed in a liquid of density boldsymbol σ and surface tension $7.5 \times 10^{-4} N\ cm^{-1}$. The radius of drop in cm will be :
$(g = 10 ms^{-2})$
[25-Jul-2022-Shift-2]

Options:

A. $\frac{15}{\sqrt{(2\rho - \sigma)}}$

B. $\frac{15}{\sqrt{(\rho - \sigma)}}$

C. $\frac{3}{2\sqrt{(\rho - \sigma)}}$

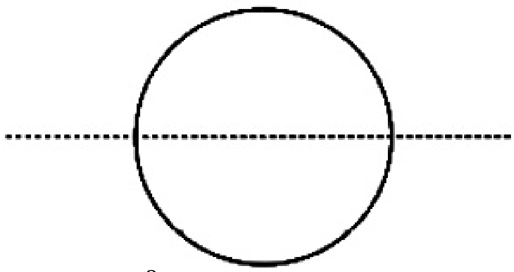
D. $\frac{3}{20\sqrt{(2\rho - \sigma)}}$

Answer: A

Solution:

Balancing the forces on drop

$$2\pi RT + \frac{4}{3}\pi R^3 \rho g = \frac{2}{3}\pi R^3 \sigma g$$



$$\Rightarrow 2T = \frac{2R^2}{3}(\sigma - 2\rho) \times 10$$

$$\Rightarrow \frac{15 \times 10^{-2} \times 3}{} = R^2$$

$R = \frac{3}{2 \times 10} \sqrt{\frac{1}{(\sigma - 2\rho)}}$

$= \frac{3}{20} \sqrt{\frac{1}{\sigma - 2\rho}} (\text{ in m })$

(R) in cm = $\frac{3 \times 100}{20} \sqrt{\frac{1}{\sigma - 2\rho}} = 15 \times \sqrt{\frac{1}{\sigma - 2\rho}}$

Now if $2\rho > \sigma (R_{\text{in cm}}) = \frac{15}{\sqrt{2\rho - \sigma}}$

Question77

A water drop of radius 1 cm is broken into 729 equal droplets. If surface tension of water is 75 dyne\/ cm, then the gain in surface energy upto first decimal place will be :
(Given π = 3.14)
[26-Jul-2022-Shift-1]

Options:

A. $8.5 \times 10^{-4} J$

B. $8.2 \times 10^{-4} J$

C. $7.5 \times 10^{-4} J$

D. $5.3 \times 10^{-4} J$

Answer: C

Solution:

Solution:

$729 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3$

$\Rightarrow R = 9r \ldots\ldots (1)$

$\Delta U = S \times \Delta A \ldots\ldots (2)$

$\Rightarrow \Delta U = S \times \{-4\pi R^2 + 729 \times 4\pi r^2\}$

$= S \times 4\pi \{729 r^2 - 81 r^2\}$

$= 7.5 \times 10^{-4} J$

Question78

Two cylindrical vessels of equal cross-sectional area $16 cm^2$ contain water upto heights 100 cm and 150 cm respectively. The vessels are interconnected so that the water levels in them become equal. The work done by the force of gravity during the process, is [Take, density of water $= 10^3 kg / m^3$ and .g = $10 ms^{-2}$] :
[27-Jul-2022-Shift-1]

Options:

A. 0.25J

B. 1J

C. 8J

D. 12J

Answer: B

Solution:

Solution:

$A = 16 \times 10^{-4} m^2$

$E_{in} = m_1 g \frac{H_1}{2} + m_2 g \frac{H_2}{2}$

$= \rho g \frac{A}{2}(H_1^2 + H_2^2) = \rho g \frac{A}{2}(1^2 + 1.5^2)$

$E_{fin} = \rho g \frac{A}{2}(2H^2) = \rho g \frac{A}{2}(2 \times 1.25^2)$

$W = \rho g \frac{A}{2}(3.25 - 3.125)$

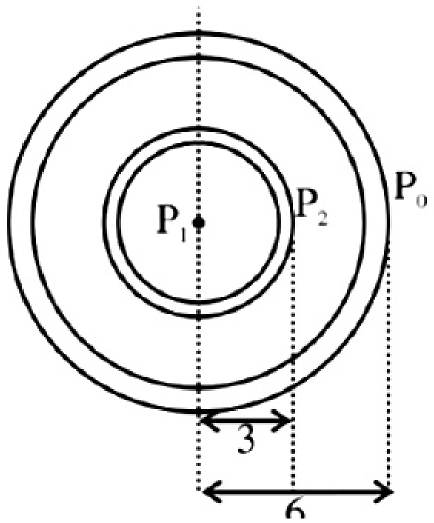
$= 1J$

Question79

A spherical soap bubble of radius 3 cm is formed inside another spherical soap bubble of radius 6 cm. If the internal pressure of the smaller bubble of radius 3 cm in the above system is equal to the internal pressure of the another single soap bubble of radius r cm. The value of r is ________.
[27-Jul-2022-Shift-2]

Solution:

Solution:



$P_2 - P_0 = \frac{4T}{6}$ & $P_1 - P_2 = \frac{4T}{3}$

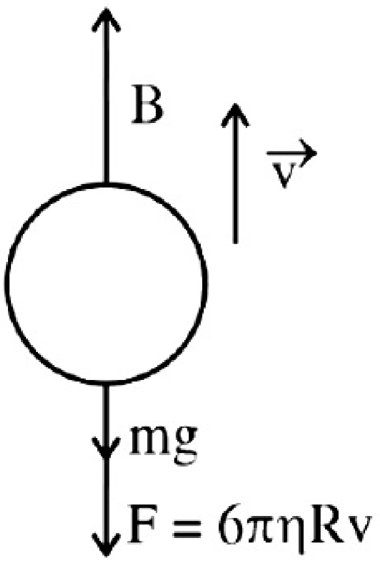
$\Rightarrow P_1 - P_0 = \frac{4T}{2} = 2$

Question80

The diameter of an air bubble which was initially 2 mm, rises steadily through a solution of density $1750\,kg\,m^{-3}$ at the rate of $0.35 cms^{-1}$. The coefficient of viscosity of the solution is ______ poise (in nearest integer). (the density of air is negligible).
[28-Jul-2022-Shift-1]

Solution:

As the bubble is rising steadily the net force acting on it will be zero



(Because of density of air the value of mg can be neglected)

So $B = F \Rightarrow \frac{4\pi}{3}R^3\rho g = 6\pi\eta Rv$

Putting $R = 1\,mm = 10^{-3}m$

$c\rho = 1.75 \times 10^3\,kg / m^3$

$g = 10m / s^2$

$v = 0.35 \times 10^{-2}m / s$

$\eta = \frac{10}{9} \simeq 1 \cdot 11$ SI unit $= 11$ poise (CGS)

Question81

A pressure-pump has a horizontal tube of cross sectional area $10cm^2$ for the outflow of water at a speed of $20m / s$. The force exerted on the vertical wall just in front of the tube which stops water horizontally flowing out of the tube, is :
[given: density of water $= 1000\,kg / m^3$]

[28-Jul-2022-Shift-2]

Options:

A. 300N

B. 500N

C. 250N

D. 400N

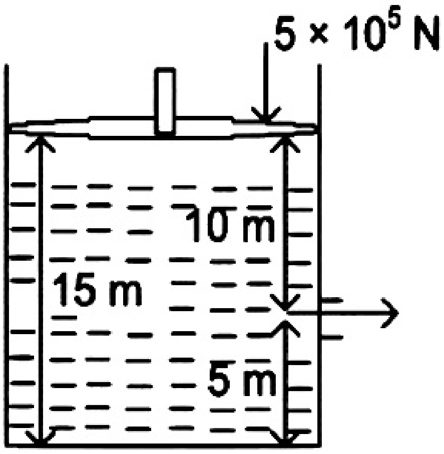
Answer: D

Solution:

$= 10^3 \times 10 \times 10^{-4} \times 20 \times 20$
$= 400\text{N}$

Question82

Consider a cylindrical tank of radius 1m is filled with water. The top surface of water is at 15m from the bottom of the cylinder. There is a hole on the wall of cylinder at a height of 5m from the bottom. A force of 5×10^5N is applied an the top surface of water using a piston. The speed of ifflux from the hole will be : (given atmospheric pressure $P_A = 1.01 \times 10^5$ Pa, density of water $\rho_W = 1000\,\text{kg} / \text{m}^3$ and gravitational acceleration $g = 10\text{m} / \text{s}^2$)



[28-Jul-2022-Shift-2]

Options:

A. 11.6m / s

B. 10.8m / s

C. 17.8m / s

D. 14.4m / s

Answer: C

Solution:

Solution:
By Bernoulli's theorem,

$$\frac{5\times10^5}{\pi(1)^2}+\rho g(10)=1.01\times10^5+\frac{1}{2}\rho(v)^2$$

$$\Rightarrow v^2=200+\frac{10^6}{1000\pi}-202$$

$$\Rightarrow v\simeq17.8m/\ s$$

Question83

Given below are two statements : One is labelled as Assertion (A) and the other is labelled as Reason (R)
Assertion (A): Clothes containing oil or grease stains cannot be cleaned by water wash.
Reason (R): Because the angle of contact between the oil/grease and water is obtuse.
In the light of the above statements, choose the correct answer from the option given below.
[29-Jul-2022-Shift-1]

Options:

A. Both (A) and (R) are true and (R) is the correct explanation of (A)

B. Both (A) and (R) are true but (R) is not the correct explanation of (A)

C. (A) is true but (R) is false

D. (A) is false but (R) is true

Answer: A

Solution:

Solution:
Due to obtuse angle of contact the water doesn't wet the oiled surface properly and cannot wash it also.
⇒ Assertion is correct and Reason given is a correct explanation.

Question84

The velocity of a small ball of mass 0.3g and density 8g / cc when dropped in a container filled with glycerine becomes constant after some time. If the density of glycerine is 1.3g / cc, then the value of viscous force acting on the ball will be $x\times10^{-4}$N, The value of x is _______. [use $g=10m/s^2$]
[29-Jul-2022-Shift-2]

Answer: 25

Solution:

Solution:

$F_V + F_B = mg (v = \text{constant})$

$F_V = mg - F_B$

$= \rho_B Vg - \rho_L Vg$

$= (\rho_B - \rho_L) Vg$

$= (8 - 1.3) \times 10^{+3} \times \frac{0.3 \times 10^{-3}}{8 \times 10^3} \times 10$

$= \frac{6.7 \times 0.3}{8} \times 10^{-2}$ (g = 10)

$= \frac{67 \times 3}{8} \times 10^{-4} = 25.125 \times 10^{-4}$

Question85

A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force F , its length increases by 5cm. Another wire of the same material of length 4L and radius 4r is pulled by a force 4F under same conditions. The increase in length of this wire is cm
[25-Jul-2022-Shift-1]

Answer: 5

Solution:

Solution:

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

$\Rightarrow \Delta L = \frac{FL}{AY}$

$\frac{\Delta L_2}{\Delta L_1} = \left(\frac{F_2}{F_1}\right) \times \left(\frac{L_2}{L_1}\right) \times \left(\frac{A_1}{A_2}\right)$

$= 4 \times 4 \times \frac{1}{16} = 1$

$\Delta L_2 = \Delta L_1 = 5\text{cm}.$

Question86

In an experiment to determine the Young's modulus of wire of a length exactly 1m, the extension in the length of the wire is measured as 0.4 mm with an uncertainty of ±0.02 mm when a load of 1 kg is applied.

± 0.01 mm. The error in the measurement of Young's modulus (ΔY) is found to be $x \times 10^{10} Nm^{-2}$. The value of x is ________(. take .g = $10 ms^{-2}$)
[26-Jul-2022-Shift-1]

Answer: 2

Solution:

Solution:

$\frac{F / A}{l / L} = Y, A = \pi D^2$

$\frac{\Delta Y}{Y} = \frac{\Delta F}{F} + \frac{2 \Delta D}{D} + \frac{\Delta l}{e} + \frac{\Delta L}{L}$

$= 2 \times \frac{0.01}{0.4} + \frac{0.02}{0.4}$

$= \frac{0.04}{0.4} = \frac{1}{10}$

$Y = \frac{F l}{A \Delta l}$

$= \frac{10 \times 1}{\pi (0.1 mm)^2 \times 0.4 mm}$

$= 1.988 \times 10^{11}$

$\approx 2 \times 10^{11}$

$\frac{\Delta y}{y} = \frac{1}{10}$

$\Delta y = \frac{y}{10} = 2 \times 10^{10}$

Question87

The area of cross section of the rope used to lift a load by a crane is $2.5 \times 10^{-4} m^2$. The maximum lifting capacity of the crane is 10 metric tons. To increase the lifting capacity of the crane to 25 metric tons, the required area of cross section of the rope should be :
(. take .g = $10 ms^{-2}$)
[26-Jul-2022-Shift-2]

Options:

A. $6.25 \times 10^{-4} m^2$

B. $10 \times 10^{-4} m^2$

C. $1 \times 10^{-4} m^2$

D. $1.67 \times 10^{-4} m^2$

Answer: A

Solution:

Since breaking stress (Maximum lifting capacity) is the property of material so it will remain same.

$$\text{breaking stress} = \frac{\text{Maximum lifting capacity}}{\text{Area of cross section of rope}}$$

$$\frac{10}{2.5 \times 10^{-4}} = \frac{25}{A}$$

$$A = \quad = 625 \times 10^{-6}$$

$$= 6.25 \times 10^{-4} m^2$$

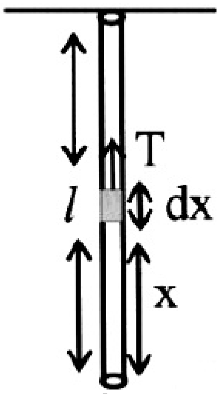
Question88

A uniform heavy rod of mass 20 kg, cross sectional area $0.4m^2$ and length 20m is hanging from a fixed support. Neglecting the lateral contraction, the elongation in the rod due to its own weight is $x \times 10^{-9}$m. The value of x is _______.
(Given, young modulus $Y = 2 \times 10^{11} Nm^{-2}$ and $g = 10 ms^{-2}$)
[26-Jul-2022-Shift-2]

Answer: 25

Solution:

Solution:



$$Y = \frac{T}{A} \frac{dx}{dy}$$

$m = 20 kg$

$A = mathbf 0 . 4 mathrm m^2$

$1 = 20m$

$$Y = \frac{\text{stress}}{\text{strain}}$$

$$Y = \frac{\frac{T}{A}}{\frac{dy}{dx}} = \frac{T}{A} \cdot \frac{dx}{dy}$$

$$dy = \frac{T\,dx}{AY}$$

Tension at a distance x from lower end $= \frac{mg}{\ell} x$

So. $\int_0^{\Delta l} dy = \int_0^{\ell} \frac{mg}{\ell} x \frac{dx}{AY}$

$$\Delta \ell = \frac{mg}{\ell AY} \left[\frac{x^2}{2} \right]_0^{\ell}$$

$$\Delta \ell = \frac{mg\ell}{2AY}$$

$$\Delta\ell = \frac{20 \times 10 \times 20}{2 \times 0.4 \times 2 \times 10^{11}}$$
2500×10^{-11}
$\Delta\ell = 25 \times 10^{-9}$
$= x \times 10^{-9}$
$x = 25$

Question89

A square aluminum (shear modulus is $25 \times 10^{9} Nm^{-2}$) slab of side 60 cm and thickness 15 cm is subjected to a shearing force (on its narrow face) of 18.0×10^{4}N. The lower edge is riveted to the floor. The displacement of the upper edge is _______ μm.
[27-Jul-2022-Shift-1]

Answer: 48

Solution:

Solution:
$\frac{F}{A} = \eta \frac{x}{\ell} \Rightarrow \frac{F\ell}{A\eta} = x$
$$\Rightarrow x = \frac{18 \times 10^{4} \times 60 \times 10^{-2}}{60 \times 10^{-2} \times 15 \times 10^{-2} \times 25 \times 10^{9}}$$
$= 48 \times 10^{-6} m = 48 \mu m$

Question90

A steel wire of length $3.2 m (Y_s = 2.0 \times 10^{11} Nm^{-2})$ and a copper wire of length $4.4 m (Y_c = 1.1 \times 10^{11} Nm^{-2})$, both of radius 1.4 mm are connected end to end. When stretched by a load, the net elongation is found to be 1.4 mm. The load applied, in Newton, will be: (Given .$\pi = \frac{22}{7}$)
[27-Jul-2022-Shift-2]

Options:

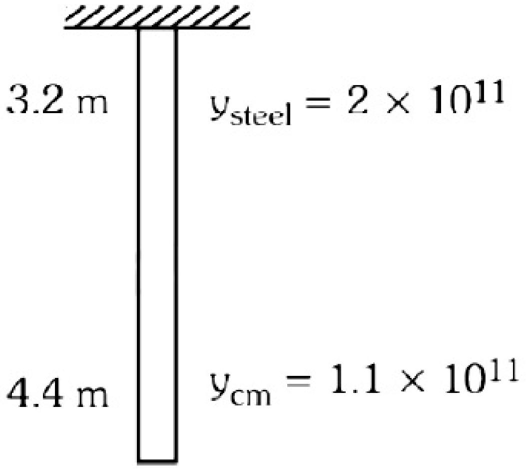
A. 360

B. 180

C. 1080

D. 154

Answer: D



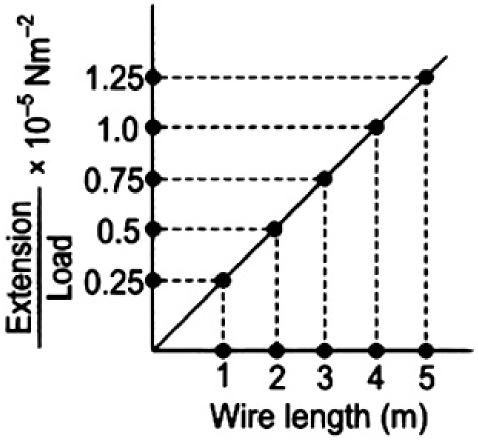
$\Delta \ell_1 + \Delta \ell_2 = \Delta \ell$

$\frac{F\ell_1}{A_1 y_1} + \frac{F\ell_2}{A_2 y_2} = \Delta \ell$

$F = \frac{\Delta \ell}{\frac{\ell_1}{A_1 y_1} + \frac{\ell_2}{A_2 y_2}} = 1.54 \times 10^2 = 154$

Question91

In an experiment to determine the Young's modulus, steel wires of five different lengths (1, 2, 3, 4, and 5m) but of same cross section ($2mm^2$) were taken and curves between extension and load were obtained. The slope (extension/load) of the curves were plotted with the wire length and the following graph is obtained. If the Young's modulus of given steel wires is $x \times 10^{11} Nm^{-2}$, then the value of x is ________.



[27-Jul-2022-Shift-2]

Solution:

Slope $= \frac{\Delta l / w}{L} = \frac{\Delta l / L}{W} = \frac{1}{YA}$

$\Rightarrow Y = \frac{1}{(\text{ slope })A}$

$Y = \frac{1}{2 \times 10^{-6}(0.25 \times 10^{-5})}$

$Y = 2 \times 10^{11} N / m^2$

Question92

The force required to stretch a wire of cross-section $1 cm^2$ to double its length will be : (Given Yong's modulus of the wire $-2 \times 10^{11} N / m^2$) [28-Jul-2022-Shift-1]

Options:

A. $1 \times 10^7 N$

B. $1.5 \times 10^7 N$

C. $2 \times 10^7 N$

D. $2.5 \times 10^7 N$

Answer: C

Solution:

Solution:

$F = \gamma A \frac{\Delta \ell}{\ell}$

$= 2 \times 10^{11} \times 10^{-4} \left(\frac{2\ell - \ell}{\ell} \right)$

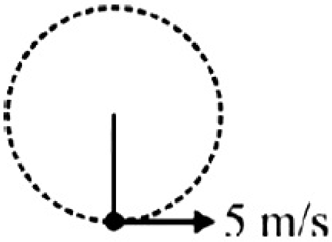
$= 2 \times 10^7 N$

Question93

A string of area of cross-section $4 mm^2$ and length 0.5m is connected with a rigid body of mass 2 kg. The body is rotated in a vertical circular path of radius 0.5m. The body acquires a speed of 5m / s at the bottom of the circular path. Strain produced in the string when the body is at the bottom of the circle is ____ $\times 10^{-5}$ (use Young's modulus $10^{11} N / m^2$ and $g = 10 m / s^2$) [28-Jul-2022-Shift-2]

Answer: 30

Solution:



Strain = F/AY

$$= \frac{mg + \frac{mv^2}{R}}{AY}$$

$$= \frac{20 + \frac{2(5)^2}{0.5}}{3 \times 10^{-6} \times 10^{11}} = 30 \times 10^{-5}$$

Question94

If the length of a wire is made double and radius is halved of its respective values. Then, the Young's modulus of the material of the wire will:
[29-Jul-2022-Shift-1]

Options:

A. remain same

B. become 8 times its initial value

C. become $\frac{1}{4}$ of its initial value

D. become 4 times its initial value

Answer: A

Solution:

Solution:
Young's modulus of matter depends on material of wire and is independent of the dimensions of the wire. As the material remains same so Young's modulus also remain same.

Question95

A metal wire of length 0.5m and cross-sectional area $10^{-4}m^2$ has breaking stress $5 \times 10^8 Nm^{-2}$. A block of 10 kg is attached at one end of the string and is rotating in a horizontal circle. The maximum linear velocity of block will be ______ ms^{-1}
[29-Jul-2022-Shift-2]

Solution:

$T=\frac{mv^2}{\ell}=\frac{10\times v^2}{0.5}=20v^2$
$T_{max}=$ Breaking stress $\times$ Area
$=5\times10^8\times10^{-4}=5\times10^4$
$20V^2=5\times10^4$
$V=\sqrt{\frac{1}{4}\times10^4}=50m/s$

Question96

A unit scale is to be prepared whose length does not change with temperature and remains 20cm, using a bimetallic strip made of brass and iron each of different length. The length of both components would change in such a way that difference between their lengths remains constant. If length of brass is 40cm and length of iron will be cm . ($\alpha_{iron}=1.2\times10^{-5}K^{-1}$ and $\alpha_{brass}=1.8\times10^{-5}K^{-1}$)
[25-Jul-2022-Shift-1]

Answer: 60

Solution:

Solution:
$\Delta L_1=\alpha_1L_1\Delta T$
$\Delta L_2=\alpha_2L_2\Delta T$
$\alpha_1L_1=\alpha_2L_2$
$1.2\times10^{-5}\times L_1=1.8\times10^{-5}\times L_2$
$L_1=\frac{1.8}{1.2}\times40=60cm$

Question97

A block of ice of mass 120g at temperature 0°C is put in 300g of water at 25°C. The ×g of ice melts as the temperature of the water reaches 0°C. The value of x is____
[Use specific heat capacity of water $=4200J\,kg^{-1}K^{-1}$, Latent heat of ice $=3.5\times10^5J\,kg^{-1}$]
[25-Jul-2022-Shift-2]

Answer: 90

Solution:

Solution:
Heat lost by water = Heat gained by ice
$0.3 \times 4200 \times 25 = x \times 3.5 \times 10^{5}$
$x = \frac{0.3 \times 4200 \times 25}{3.5 \times 10^{5}}$
$= 90 \times 100 \times 10^{5} \times 10^{3}\text{gram} = 90\text{gm}$

Question98

An ice cube of dimensions $60\,cm \times 50\,cm \times 20\,cm$ is placed in an insulation box of wall thickness $1\,cm$. The box keeping the ice cube at $0^{\circ}C$ of temperature is brought to a room of temperature $40^{\circ}C$ The rate of melting of ice is approximately :
(Latent heat of fusion of ice is $3.4 \times 10^{5} Jkg^{-1}$ and thermal conducting of insulation wall is $.0.05 Wm^{-1} {}^{\circ}C^{-1}$)
[26-Jul-2022-Shift-2]

Options:

A. $61 \times 10^{-3}\,kg\,s^{-1}$

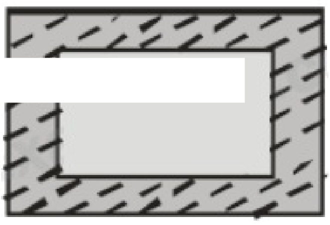
B. $61 \times 10^{-5}\,kg\,s^{-1}$

C. $208\,kg\,s^{-1}$

D. $30 \times 10^{-5}\,kg\,S^{-1}$

Answer: B

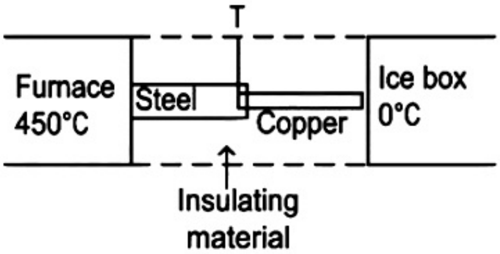
Solution:



$\frac{dQ}{dt} = \frac{KA\,\Delta T}{\ell}$
$A = 2(0.6 \times 0.5 + 0.5 \times 0.2 + 0.2 \times 0.6)$
$= 2(0.3 + 0.1 + 0.12)$
$= 2(0.4 + 0.12)$
$= 2(0.52)$
$= 1.04 m^{2}$
$R_{th} = \frac{\ell}{KA} \Rightarrow \frac{1 \times 10^{-2}}{0.05 \times 1.04} \Rightarrow \frac{10^{-2}}{0.052}$
$\frac{dQ}{dt} = \frac{\Delta T}{R_{th}} \Rightarrow \frac{40 \times 0.052}{10^{-2}} \Rightarrow 2.08 \times 10^{2} J/s$
$2.08 \times 10^{2} = m \times 3.4 \times 10^{5}$
$m = \frac{2.08}{3.4 \times 10^{3}} \Rightarrow 0.61 \times 10^{-3}\,kg/s$

Question99

If K_1 and K_2 are the thermal conductivities, L_1 and L_2 are the lengths and A_1 and A_2 are the cross sectional areas of steel and copper rods respectively such that $\frac{K_2}{K_1} = 9$, $\frac{A_1}{A_2} = 2$, $\frac{L_1}{L_2} = 2$. Then, for the arrangement as shown in the figure, the value of temperature T of the steel - copper junction in the steady state will be:



[27-Jul-2022-Shift-1]

Options:

A. 18°C

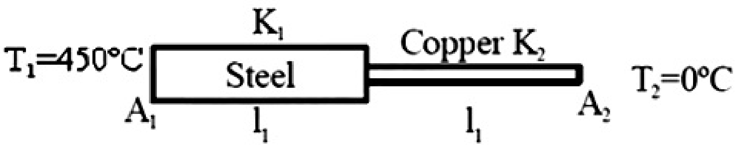
B. 14°C

C. 45°C

D. 150°C

Answer: C

Solution:



$$\frac{d\theta}{dt} = \frac{K_1A_1}{l_1}(T_1 - T) = \frac{K_2A_2}{l_2}(T - T_2)$$

$$\Rightarrow \frac{450 - T}{T - 0} = \frac{K_2A_2l_1}{K_1A_1l_2} = 9 \times \frac{1}{2} \times 2$$

$$\Rightarrow 450 - T = 9T \Rightarrow T = 45^{\circ}C$$

Question100

Read the following statements :

time by P and Q are in the ratio 1 : 1.15.
C. A Carnot Engine working between 100K and 400K has an efficiency of 75%.
D. When small temperature difference between a liquid and its surrounding is quadrupled, the rate of loss of heat of the liquid becomes twice.
Choose the correct answer from the options given below :
[27-Jul-2022-Shift-1]

Options:

A. A, B, C only

B. A, B only

C. A, C only

D. B, C, D only

Answer: A

Solution:

low of colling $\frac{d\theta}{dt} = \propto \Delta T$

B. $H = \frac{d\theta}{dt} = \sigma eATT^4 \Rightarrow \frac{H_P}{H_Q} = \left(\frac{T_P}{T_Q}\right)^4 = \left(\frac{283}{293}\right)^4$

$H_P : H_Q = 1(1.03)^4 = 1 : (1.03)^4 = 1 : 1.15$

$\Rightarrow$B is correct

C. $\eta = 1 - \frac{100}{400} = \frac{3}{4} = 75\%$

D. is wrong as $\frac{d\theta}{dt} \propto \Delta T$

Question101

Two metallic wires of identical dimensions are connected in series. If σ_1 and σ_2 are the conductivities of the these wires respectively, the effective conductivity of the combination is :
[29-Jul-2022-Shift-1]

Options:

A. $\frac{\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$

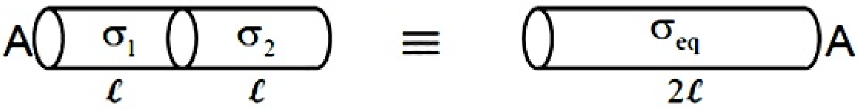
B. $\frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$

C. $\frac{\sigma_1 + \sigma_2}{2\sigma_1\sigma_2}$

Answer: B

Solution:

Solution:



Let length of wire be ' ℓ '
Area of wire as 'A'
For equivalent wire length $= 2\ell$& area will be A
Thermal resistance

$R_{eq} = R_1 + R_2$

$$\frac{2\ell}{\sigma_{eq}A} = \frac{\ell}{\sigma_1 A} + \frac{\ell}{\sigma_1 A}$$

$$\frac{2\ell}{\sigma_{eq}} = \frac{\ell}{\sigma_1} + \frac{\ell}{\sigma_2} \Rightarrow \sigma_{eq} = \frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

Question102

Nearly 10% of the power of a 110W light bulb is converted to visible radiation. The change in average intensities of visible radiation, at a distance of 1m from the bulb to a distance of 5m is a $\times 10^{-2}$W / m^2. The value of 'a' will be ________.
[29-Jul-2022-Shift-2]

Answer: 84

Solution:

Solution:

$P' = 10\%$ of 110W

$$= \frac{10}{100} \times 110W$$

$= 11W$

$$I_1 - I_2 = \frac{P'}{4\pi r_1^2} - \frac{P'}{4\pi r_2^2}$$

$$= \frac{11}{4\pi}\left[\frac{1}{1} - \frac{1}{25}\right]$$

$$= \frac{11}{4\pi} \times \frac{24}{25}$$

$$= \frac{264}{\pi} \times 10^{-2} = 84 \times 10^{-2} W / m^2$$

Question103

A uniform metallic wire is elongated by 0.04m when subjected to a linear force F. The elongation, if its length and diameter is doubled and

[24 Feb 2021 Shift 2]

Solution:

Solution:
Let initial length and diameter be l_1 and d_1,
whereas final length and diameter be I_2 and d_2.
Given, $I_2 = 2I_1$, $d_2 = 2d_1$, $\Delta I_1 = 0.04\text{m}$
By using formula of Young's modulus of elasticity,
$Y = \frac{F \cdot l}{A \Delta l}$
$\because Y_1 = Y_2$
$\Rightarrow \frac{F I_1}{A_1 \times \Delta I_1} = \frac{F I_2}{A_2 \times \Delta I_2}$
$\Rightarrow \frac{F I_1}{\pi(d_1 / 2)^2 \times 0.04} = \frac{F\, 2I_1}{\pi(2d_1 / 2)^2\, \Delta I_2}$
$\Rightarrow \frac{1}{1 / 4 \times 0.04} = \frac{2}{\Delta I_2}$
$\Rightarrow \Delta I_2 = 0.02\text{m} = 2\text{cm}$

Question104

The normal density of a material is ρ and its bulk modulus of elasticity is K. The magnitude of increase in density of material, when a pressure p is applied uniformly on all sides, will be
[26 Feb 2021 Shift 1]

Options:

A. $\frac{\rho K}{p}$

B. $\frac{\rho p}{K}$

C. $\frac{K}{\rho p}$

D. $\frac{pK}{\rho}$

Answer: B

Solution:

Solution:
Given, density of material $= \rho$
Bulk modulus of elasticity $= K$
and applied pressure $= p$
Let change in volume and density be ΔV and $\Delta\rho$ respectively and initial volume and density be V and ρ.

and density (ρ) = $\frac{\text{mass(m)}}{\text{volume (V)}}$

$\therefore \frac{\Delta\rho}{\rho} = -\frac{\Delta V}{V}$

Substituting it in Eq. (i), we get

$\frac{-\Delta V}{V} = \frac{p}{K} = \frac{\Delta\rho}{\rho}$

$\therefore \Delta\rho = \frac{p\rho}{K}$

Question105

The length of metallic wire is I_1 when tension in it is T_1. It is I_2 when the tension is T_2. The original length of the wire will be [26 Feb 2021 Shift 2]

Options:

A. $\frac{I_1 + I_2}{2}$

B. $\frac{T_2 I_1 + T_1 I_2}{T_1 + T_2}$

C. $\frac{T_2 I_1 - T_1 I_2}{T_2 - T_1}$

D. $\frac{T_1 l_1 - T_2 I_2}{T_2 - T_1}$

Answer: C

Solution:

Solution:

Let I_0 be the original length, A be the area of cross-section, α be the coefficient of linear expansion, Δl be the change in length and Y be the Young's modulus of elasticity.

As, $I_1 = I_0(1 + \alpha \Delta T)$

$\Rightarrow I_1 - I_0 = I_0 \alpha \Delta T \Rightarrow \Delta I = I_0 \alpha \Delta T$

Initially, $Y = \frac{\text{Stress}}{\text{Strain}} = \frac{T / A}{\Delta l / I_0}$

$\Rightarrow Y = \frac{T_1 / A}{(I_1 - I_0) / I_0}$ . . . (i)

Finally, $Y = \frac{T_2 / A}{(I_2 - I_0) / I_0}$ . . . (ii)

Now, from Eqs. (i) and (ii), we get

$\frac{T_1 / A}{(I_1 - I_0) / I_0} = \frac{T_2 / A}{(I_2 - I_0) / I_0}$

$\Rightarrow \frac{T_1}{I_1 - I_0} = \frac{T_2}{I_2 - I_0}$

$\Rightarrow T_1 I_2 - T_1 I_0 = T_2 I_1 - T_2 I_0$

$\Rightarrow T_1 I_2 - T_2 I_1 = (T_1 - T_2) I_0$

$\Rightarrow I_0 = \frac{T_1 I_2 - T_2 I_1}{T_1 - T_2}$

or $I_0 = \frac{T_2 I_1 - T_1 I_2}{T_2 - T_1}$

Question106

Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R.
Assertion (A) When a rod lying freely is heated, no thermal stress is developed in it.
Reason (R) On heating, the length of the rod increases.
In the light of the above statements, choose the correct answer from the options given below
[25 Feb 2021 Shift 1]

Options:

A. Both A and R are true but R is not the correct explanation of A.

B. A is false but R is true

C. A is true but R is false.

D. Both A and R are true and R is the correct explanation of A.

Answer: A

Solution:

Solution:
Thermal stress is defined as the stress, experienced by any rod on heating between two fixed rigid supports. On heating, the size of the rod increases but, if the two ends are free, rod will not experience any stress. i.e, there is no thermal stress will be produced in it.
Hence, option (a) is the correct.

Question107

A large number of water drops, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be
[26 Feb 2021 Shift 1]

Options:

A. $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

B. $\frac{2T}{r}$

C. $\frac{3T}{rJ}$

D. $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

Answer: D

Solution:

Given, radius of small drop $= r$
Radius of big drop $= R$
Surface tension $= T$
and mechanical equivalent of heat $= J$
As, small drops combine to form big drop.
$\therefore$ Volume of big drop $(V_B) = n \times$ Volume of small drop (V_S)

$$\Rightarrow \frac{4}{3}\pi R^3 = n \cdot \frac{4}{3}\pi r^3$$

$$\Rightarrow nr^3 = R^3$$

$$\Rightarrow r = \frac{R}{n^{1/3}} \quad \ldots \text{(i)}$$

Surface energy of small drop $(E_S) =$ Surface tension $(T) \times$ Area (A)

$$\Rightarrow E_S = n \times 4\pi r^2 T \text{ and } E_B = 4\pi R^2 T$$

Now, change in energy will be

$$\Delta E = E_B - E_S = 4\pi T(nr^2 - R^2)$$

$$\therefore \text{Heat energy per unit volume} = \frac{\Delta E}{V} = \frac{4\pi T(nr^2 - R^2)}{J \times \frac{4}{3}\pi R^3}$$

$$= \frac{3T}{J}\left(\frac{nr^2}{R^3} - \frac{1}{R}\right) = \frac{3T}{J}\left(n\frac{R^2}{n^{2/3}R^3} - \frac{1}{R}\right)$$

$$= \frac{3T}{J}\left[\frac{n^{1/3}}{R} - \frac{1}{R}\right] \text{ [from Eq. (i)]}$$

$$= \frac{3T}{J}\left[\frac{1}{r} - \frac{1}{R}\right]$$

Question108

If Y, K and η are the values of Young's modulus, bulk modulus and modulus of rigidity of any material respectively. Choose the correct relation for these parameters.
[24feb2021shift1]

Options:

A. $Y = \frac{9K\eta}{3K - \eta} N/m^2$

B. $\eta = \frac{3YK}{9K + Y} N/m^2$

C. $Y = \frac{9K\eta}{2\eta + 3K} N/m^2$

D. $K = \frac{Y\eta}{9\eta - 3Y} N/m^2$

Answer: D

Solution:

We know that $Y = 3K(1 - 2\sigma)$

σ = Poisson's ratio

$$\sigma = \frac{1}{2}\left(1 - \frac{Y}{3K}\right)$$

Also,

$$Y = 2\eta(1 + \sigma)$$

$$\sigma = \frac{Y}{2\eta} - 1$$

From equation (i) and (ii), we have

$\frac{1}{2}\left(1-\frac{Y}{3K}\right)=\frac{Y}{2\eta}-1$

$\Rightarrow 1-\frac{Y}{3K}=\frac{Y}{\eta}-2 \Rightarrow \frac{Y}{3K}=3-\frac{Y}{\eta}$

$\Rightarrow \frac{Y}{\eta-Y}$

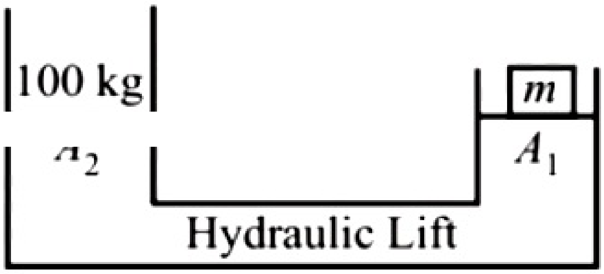
$\Rightarrow \frac{\eta Y}{3K}=3\eta-Y$

$\Rightarrow K=\frac{\eta Y}{9\eta-3Y}$

Question109

A hydraulic press can lift 100kg when a mass 'm' is placed on the smaller piston. It can lift kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass 'm' on the smaller piston.
[24feb2021shift1]

Solution:



$\frac{100\times g}{A_2}=\frac{mg}{A_1}$ ....(1)

Let m mass can lift M_0 in second case then

$\frac{M_0 g}{16A_2}=\frac{mg}{\frac{A_1}{16}}\left(\because A=\frac{\pi d^2}{4}\right)$

From equation (i) and (ii), we get

$\frac{M_0}{16\times100}=16$

$M_0=25600\text{kg}$

Question110

Each side of a box made of metal sheet in cubic shape is ' a ' at room temperature ' T ', the coefficient of linear expansion of the metal sheet is ' α '. The metal sheet is heated uniformly, by a small temperature ΔT, so that its new temperature is T + Δ T. Calculate the increase in the volume of the metal box.
[24feb2021shift1]

Options:

A. $3a^3\alpha\,\Delta T$

B. $4a^3\alpha\,\Delta T$

C. $3\pi a^3\alpha\,\Delta T$

D. $\frac{4}{3}\pi a^3\alpha\,\Delta T$

Answer: A

Solution:

Solution:
$\Delta V = V\gamma\,\Delta T$
Since, $V = a^3$ and $\gamma = 3\alpha$
$\therefore \Delta V = 3a^3\alpha\,\Delta T$

Question111

An object is located at 2km beneath the surface of the water. If the fractional compression $\frac{\Delta V}{V}$ is 1.36%, the ratio of hydraulic stress to the corresponding hydraulic strain will be ....
(Take, density of water is $1000 kgm^{-3}$ and $g = 9.81 ms^{-2}$)
[17 Mar 2021 Shift 2]

Options:

A. $1.96 \times 10^7 N\,m^{-2}$

B. $1.44 \times 10^7 N\,m^{-2}$

C. $2.26 \times 10^9 N\,m^{-2}$

D. $1.44 \times 10^9 N\,m^{-2}$

Answer: D

Solution:

Solution:
Given, The volumetric strain is $\frac{\Delta V}{V} = 1.36\%$
The depth beneath the water surface, $h = 2km$
The pressure inside the water surface up to $2km$,
$p = \rho gh$
Substituting the values in the above equation, we get
$p = 1000 \times 9.81 \times 2000$
$p = 19.62 \times 10^6 Pa$
The bulk modulus of the object,
$\beta = \frac{p}{\frac{\Delta V}{V}}$
Substituting the values in the above equation, we get

$\beta = \frac{19.62 \times 10^6}{\frac{1.36}{100}}$

$\beta = 1.44 \times 10^9 N / m^2$

Hence, the ratio of the hydraulic stress to the corresponding hydraulic strain will be $1.44 \times 10^9 N / m^2$.

Question112

Two separate wires A and B are stretched by 2mm and 4mm respectively, when they are subjected to a force of 2N . Assume that both the wires are made up of same material and the radius of wire B is 4 times that of the radius of wire A. The length of the wires A and B are in the ratio of a : b. Then, $\frac{a}{b}$ can be expressed as $\frac{1}{x}$, where x is

[18 Mar 2021 Shift 1]

Answer: 32

Solution:

Solution:

Given,

The change in the length of the wire A, $\Delta L_A = 2mm = 0.002m$

The change in the length of the wire B, $\Delta L_B = 4mm = 0.004m$

The force subjected to the wire, $F = 2N$

The radius of the wire B is 4 times the radius of the wire A, i.e., $\frac{r_B}{r_A} = \frac{4}{1}$

Since, the wire is made of the same material, so the Young's modulus of the elasticity of the wire is same.

$\Rightarrow Y_A = Y_B$

Using Hooke's law,

Stress $= Y$ (Strain)

$\frac{F}{A} = Y\left(\frac{\Delta L}{L}\right)$

$\Rightarrow L = \frac{Y \Delta LA}{F}$

$\Rightarrow \frac{L_A}{L_B} = \frac{Y_A}{Y_B} \times \frac{\Delta L_A}{\Delta L_B} \times \frac{A_A}{A_B} \times \frac{F_B}{F_A}$

$\Rightarrow \frac{L_A}{L_B} = \frac{Y_A}{Y_B} \times \frac{0.002}{0.004} \times \frac{\pi r_A^2}{\pi r_B^2} \times \frac{2}{2}$

$\Rightarrow \frac{L_A}{L_B} = \frac{0.002}{0.004} \times \frac{r_A^2}{16 r_A^2}$

$\Rightarrow \frac{L_A}{L_B} = \frac{a}{b} = \frac{1}{32}$

Comparing this equation with 1 / x, we get the value of the x is 32 .

Question113

The pressure acting on a submarine is 3×10^5Pa at a certain depth. If the depth is doubled, the percentage increase in the pressure acting on

$1 \times 10^5 Pa$, density of water is $10^3 kgm^{-3}$, $g = 10ms^{-2}$)
[16 Mar 2021 Shift 1]

Options:

A. $\frac{200}{3}\%$

B. $\frac{200}{5}\%$

C. $\frac{5}{200}\%$

D. $\frac{3}{200}\%$

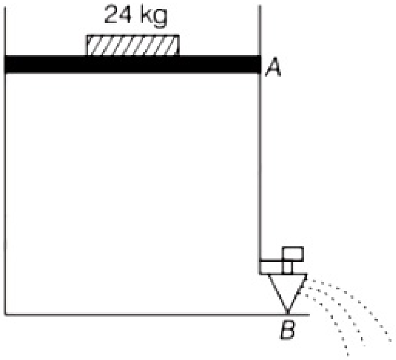
Answer: A

Solution:

Solution:
Given, pressure on submarine at a certain depth,
$p_i = 3 \times 10^5 Pa$
Since, we know that at a certain depth or below the surface of a liquid of density ρ, pressure is given as
$p_i = p_0 + \rho gh$
$\Rightarrow 3 \times 10^5 = p_0 + \rho gh$
$\Rightarrow 3 \times 10^5 = 1 \times 10^5 + \rho gh \quad (\because p_0 = 1 \times 10^5 Pa)$
$\Rightarrow 3 \times 10^5 - 1 \times 10^5 = \rho gh$
$\Rightarrow 2 \times 10^5 = \rho gh$....(i)
When the depth is doubled, then final pressure will be
$p_f = p_0 + \rho g 2h = 1 \times 10^5 + 2(\rho gh)$
$= 1 \times 10^5 + 2(2 \times 10^5)$ [using Eq. (i)]
$= 1 \times 10^5 + 4 \times 10^5$
$\Rightarrow p_f = 5 \times 10^5 Pa$
∴ Percentage increase in pressure
$= \frac{p_f - p_i}{p_i} \times 100 = \frac{(5-3) \times 10^5}{3 \times 10^5} \times 100 = \frac{200}{3}\%$

Question114

Consider a water tank as shown in the figure. It's cross-sectional area is $0.4m^2$. The tank has an opening B near the bottom whose cross-section area is $1cm^2$. A load of 24kg is applied on the water at the top when the height of the water level is 40cm above the bottom, the velocity of water coming out the opening B is vms^{-1}. The value of v, to the nearest integer, is (Take value of g to be $10ms^{-2}$)

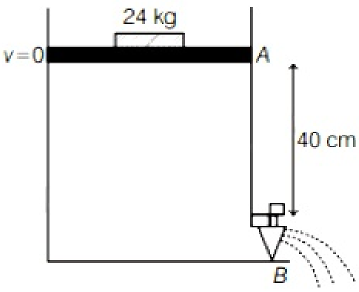


[18 Mar 2021 Shift 2]

Answer: 3

Solution:

Solution:
Given, cross-sectional area of the tank, $A = 0.4\text{m}^2$
Cross-sectional area of the opening at B,
$A = 4\text{cm}^2 = 1 \times 10^{-4}\text{m}^2$
Load applied on the top of the tank,
$m = 24\text{kg}$
Height of the water level, $h = 40\text{cm}$
From the figure,



Using the Bernoulli's principle equation,

$$p_0 + \frac{mg}{A} + \rho gh + \frac{\rho v_A{}^2}{2} = p_0 + \frac{\rho v_B{}^2}{2}$$

$$\Rightarrow 0 + \frac{(24)10}{0.4} + 1000 \times 10 \times 0.4 + \frac{\rho(0)^2}{2} = 0 + \frac{1000 \times v_B{}^2}{2}$$

$v_B = 3\text{m/s}$
Hence, the value of v to the nearest integer is 3 .

Question115

What will be the nature of flow of water from a circular tap, when its flow rate increased from 0.18L/min to 0.48L/min ? The radius of the tap and viscosity of water are 0.5cm and 10^{-3}Pa – s, respectively. (Density of water $= 10^3\text{kg/m}^3$)
[16 Mar 2021 Shift 2]

Options:

A. Unsteady to steady flow

B. Remains steady flow

C. Remains turbulent flow

D. Steady flow to unsteady flow

Answer: D

Solution:

Solution:
As we know that the nature of flow of water is determined by Reynold's number,
$R_e = \frac{\rho v D}{\eta}$
Here, $\rho = 10^3 kgm^{-3}$, $r = 0.5cm = 0.5 \times 10^{-2}m$
$D = 2r = 1 \times 10^{-2}m$
$\eta = 10^{-3}Pa - s$
$Q_1 = 0.18L/min = \frac{0.18 \times 10^{-3}}{60} m^3/s$
$Q_2 = 0.48L/min = \frac{0.48 \times 10^{-3}}{60} m^3/s$
Also, $v = \frac{Q}{\pi r^2} \therefore v_1 = \frac{Q_1}{\pi r^2}$
Also, $v = \frac{Q}{\pi r^2} \therefore v_1 = \frac{Q_1}{\pi r^2}$
$\therefore R_{e_{initial}} = \frac{\rho v_1 D}{\eta} = \frac{\rho Q_1 D}{\pi r^2 \eta}$
$= \frac{10^3 \times 0.18 \times 10^{-3}}{\pi \times (0.5 \times 10^{-2})^2 \times 60} \times \frac{1 \times 10^{-2}}{10^{-3}}$
$= 381.97 \sim eq382$
and $R_{e_{final}} = \frac{\rho v_2 D}{\eta} = \frac{\rho Q_2 D}{\pi r^2 \eta}$
$= \frac{10^3 \times 0.48 \times 10^{-3} \times 1 \times 10^{-2}}{\pi \times (0.5 \times 10^{-2})^2 \times 60 \times 10^{-3}}$
$= 1019.09$
We know that,
When $R_e < 1000$, the flow of water is considered to be steady.
When $1000 < R_e < 2000$, the flow of water becomes unsteady.
When $R_e > 2000$, the flow of water becomes turbulent.
As the $R_{e_{final}}$ value lies in between 1000 and 2000 and
$R_{e_{initial}}$ value is less than 1000 , so the nature of flow of water will be steady flow to the unsteady one.

Question116

When two soap bubbles of radii a and b(b > a) coalesce, the radius of curvature of common surface is [17 Mar 2021 Shift 1]

Options:

A. $\frac{ab}{b-a}$

B. $\frac{a+b}{ab}$

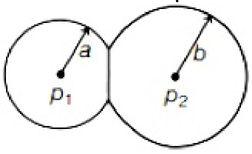
C. $\frac{b-a}{ab}$

D. $\frac{ab}{a+b}$

Answer: A

Solution:

Solution:
When two soap bubbles of radii a and $b(b > a)$ coalesce, it can be shown as follows



Pressure inside the bubble 1, $p_1 = p_0 + \frac{4T}{a}$
where, p_0 is the initial pressure,
T is the surface tension
and a is the radius of the bubble 1.
Similarly, pressure inside the bubble 2, $p_2 = p_0 + \frac{4T}{b}$
where, b is the radius of the bubble 2.
Excess pressure at common surface is given by
$p_{ex} = p_1 - p_2$
Let, r be the radius of common surface, then

$\Rightarrow \frac{4T}{r} = \left(p_0 + \frac{4T}{a}\right) - \left(p_0 + \frac{4T}{b}\right)$

$\Rightarrow \frac{4T}{r} = p_0 + \frac{4T}{a} - p_0 - \frac{4T}{b}$

$\Rightarrow \frac{4T}{r} = \frac{4T}{a} - \frac{4T}{b} \Rightarrow \frac{1}{r} = \frac{1}{a} - \frac{1}{b} \Rightarrow \frac{1}{r} = \frac{b-a}{ab}$

$\Rightarrow r = \frac{ab}{b-a}$, which is the required expression for radius of curvature at common surface.

Question117

Two wires of same length and radius are joined end to end and loaded. The Young's modulii of the materials of the two wires are Y_1 and Y_2. The combination behaves as a single wire then its Young's modulus is : [25 Jul 2021 Shift 1]

Options:

A. $Y = \frac{2Y_1Y_2}{3(Y_1 + Y_2)}$

B. $Y = \frac{2Y_1Y_2}{Y_1 + Y_2}$

C. $Y = \frac{Y_1Y_2}{2(Y_1 + Y_2)}$

D. $Y = \frac{Y_1Y_2}{Y_1 + Y_2}$

Answer: B

Solution:

In series combination $\Delta l = l_1 + l_2$

$Y = \frac{F/A}{\Delta l / l} \Rightarrow \Delta l = \frac{Fl}{AY}$

$\Rightarrow \Delta l \propto \frac{l}{Y}$

Equivalent length of rod after joing is $= 2l$

As, lengths are same and force is also same in series

$\Delta l = \Delta l_1 + \Delta l_2$

$\frac{l_{cq}}{Y_{cq}} = \frac{l}{Y_1} + \frac{l}{Y_2} \Rightarrow \frac{2l}{Y} = \frac{l}{Y_1} + \frac{l}{Y_2}$

$\therefore Y = \frac{2Y_1Y_2}{Y_1 + Y_2}$

Question118

The length of a metal wire is l_1, when the tension in it is T_1 and is l_2 when the tension is T_2. The natural length of the wire is :
[20 Jul 2021 Shift 2]

Options:

A. $\sqrt{l_1 l_2}$

B. $\frac{l_1T_2 - l_2T_1}{T_2 - T_1}$

C. $\frac{l_1T_2 + l_2T_1}{T_2 + T_1}$

D. $\frac{l_1 + l_2}{2}$

Answer: B

Solution:

Solution:

$T_1 = k(l_1 - l_0)$

$T_2 = k(l_2 - l_0)$

$\frac{T_1}{T_2} = \frac{l_1 - l_0}{l_2 - l_0}$

$\frac{T_1l_2 - T_2l_1}{T_1 - T_2} = l_0$

Question119

The value of tension in a long thin metal wire has been changed from T_1 to T_2. The lengths of the metal wire at two different values of tension T_1 andT_2 are l_1 and l_2 respectively. The actual length of the metal wire is :

Options:

A. $\frac{T_1 l_2 - T_2 l_1}{T_1 - T_2}$

B. $\frac{T_1 l_1 - T_2 l_2}{T_1 - T_2}$

C. $\frac{l_1 + l_2}{2}$

D. $\sqrt{T_1 T_2 l_1 l_2}$

Answer: A

Solution:

Solution:

$Y = \frac{FL}{A\Delta L}$

$\Rightarrow Y = \frac{T_1 l_0}{A(l_1 - l_0)} = \frac{T_2 l_0}{A(l_2 - l_0)}$

$1 = \frac{T_1(l_2 - l_0)}{T_2(l_1 - l_0)}$

$T_2 l_1 - T_2 l_0 = T_1 l_2 - T_1 l_0$

$(T_1 - T_2) l_0 = T_1 l_2 - T_2 l_1$

$l_0 = \left(\frac{T_1 l_2 - T_2 l_1}{T_1 - T_2}\right)$

Question120

A stone of mass 20g is projected from a rubber catapult of length 0.1m and area of cross section $10^{-6} m^2$ stretched by an amount 0.04m. The velocity of the projected stone is __________ m / s
(Young's modulus of rubber $= 0.5 \times 10^9 N / m^2$)
[27 Jul 2021 Shift 1]

Solution:

By energy conservation

$\frac{1}{2} \cdot \frac{YA}{L} \cdot x^2 = \frac{1}{2} mv^2$

$\frac{0.5 \times 10^9 \times 10^{-6} \times (0.04)^2}{0.1} = \frac{20}{1000} v^2$

$\therefore v^2 = 400$

$v = 20 m / s$

Question121

The area of cross-section of a railway track is $0.01 m^2$. The temperature variation is 10°C. Coefficient of linear expansion of material of track is 10^{-5} / °C. The energy stored per meter in the track is ______ J / m. (Young's modulus of material of track is $10^{11} N m^{-2}$)
[22 Jul 2021 Shift 2]

Answer: 5

Solution:

Solution:

Elastic energy $= \frac{Y}{2}(\text{ strain })^2 \times$ Area × length

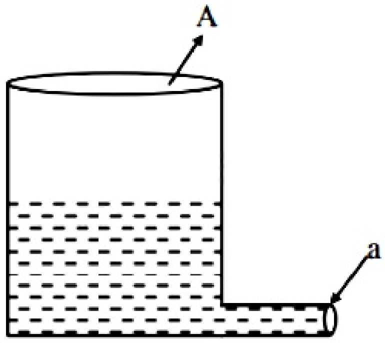
⇒ Elastic energy per unit length $= \frac{Y}{2}(\text{ strain})^2 \times$ Area

(strain $= \frac{\Delta l}{l} = \alpha \Delta T = 10^{-5} \times 10 = 10^{-4}$)

$= \frac{10^{11}}{2} \times (10^{-4})^2 \times 10^{-2} = 5 J / m$

Question122

A light cylindrical vessel is kept on a horizontal surface. Area of base is A. A hole of cross sectional area 'a' is made just at its bottom side. The minimum coefficient of friction necessary to prevent sliding the vessel due to the impact force of the emerging liquid is (a < < A) :



[27 Jul 2021 Shift 1]

Options:

A. $\frac{A}{2a}$

B. None of these

C. $\frac{2a}{A}$

D. $\frac{a}{...}$

Answer: C

Solution:

For no sliding

$f \geq \rho a v^2$

$\mu mg \geq \rho a v^2$

$\mu \rho A h g \geq \rho a 2gh$

$\mu \geq \frac{2a}{A}$

Option (3)

Question123

A raindrop with radius R = 0.2mm falls from a cloud at a height h = 2000m above the ground.
Assume that the drop is spherical throughout its fall and the force of buoyance may be neglected, then the terminal speed attained by the raindrop is :
[Density of water $f_w = 1000 kgm^{-3}$ and Density of air $f_a = 1.2 kgm^{-3}$, $g = 10 m/s^2$
Coefficient of viscosity of air $= 1.8 \times 10^{-5} N sm^{-2}$]
[27 Jul 2021 Shift 2]

Options:

A. $250.6 ms^{-1}$

B. $43.56 ms^{-1}$

C. $4.94 ms^{-1}$

D. $14.4 ms^{-1}$

Answer: C

Solution:

At terminal speed

$a = 0$

$F_{net} = 0$

$mg = F_v = 6\pi\eta R v$

$v = \frac{mg}{6\pi\eta R v}$

$v = \frac{\rho_w \frac{4\pi}{3} R^3 g}{6\pi\eta R}$

$= \frac{2\rho_w R^2 g}{9\eta} = \frac{400}{81} m/s$

$= 4.94 m/s$

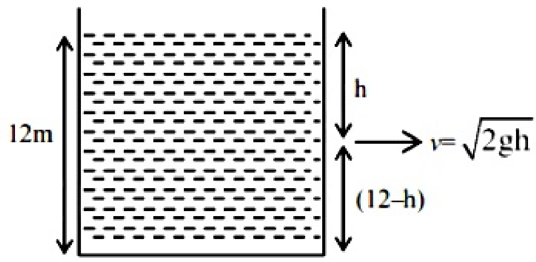
Question124

The water is filled upto height of 12 m in a tank having vertical sidewalls. A hole is made in one of the walls at a depth 'h' below the water level. The value of 'h' for which the emerging stream of water strikes the ground at the maximum range is ___ m.
[27 Jul 2021 Shift 2]

Answer: 6

Solution:

Solution:



$R = \sqrt{2gh} \times \sqrt{\frac{(12-h)\times 2}{g}}$

$\sqrt{4h(12-h)} = R$

For maximum R

$\frac{dR}{dh} = 0$

$\Rightarrow h = 6m$

Question125

Two spherical soap bubbles of radii r_1 and r_2 in vacuum combine under isothermal conditions. The resulting bubble has a radius equal to :
[25 Jul 2021 Shift 2]

Options:

A. $\frac{r_1 r_2}{r_1 + r_2}$

B. $\sqrt{r_1 r_2}$

C. $\sqrt{r_1^2 + r_2^2}$

D. $\frac{r_1 + r_2}{2}$

Solution:

no. of moles is conserved

$n_1 + n_2 = n_3$

$P_1V_1 + P_2V_2 = P_3V$

$\frac{4S}{r_1}\left(\frac{4}{3}\pi r_1^{\ 3}\right) + \frac{4S}{r_2}\left(\frac{4}{3}\pi r_2^{\ 3}\right) = \frac{4S}{r_3}\left(\frac{4}{3}\pi r_3^{\ 3}\right)$

$r_1^{\ 2} + r_2^{\ 2} = r_3^{\ 2}$

$r_3 = \sqrt{r_1^{\ 2} + r_2^{\ 2}}$

Question126

Two small drops of mercury each of radius R coalesce to form a single large drop. The ratio of total surface energy before and after the change is :
[20 Jul 2021 Shift 2]

Options:

A. $2^{\frac{1}{3}} : 1$

B. $1 : 2^{\frac{1}{3}}$

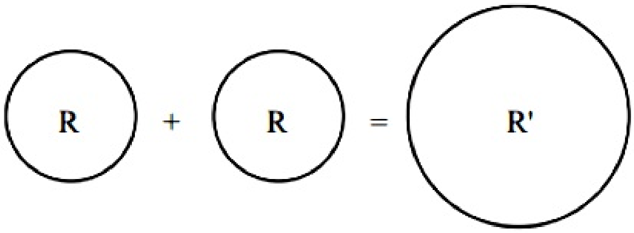
C. 2 : 1

D. 1 : 2

Answer: A

Solution:

Solution:



$\frac{4}{3}\pi R^3 + \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R^3$

$R' = 2^{\frac{1}{3}}R$ ....(i)

$A_i = 2[4\pi R^2]$

$A_f = 4\pi R'^2$

$\frac{U_i}{U_f} = \frac{A_i}{A_f} = \frac{2R^2}{2^{2/3}R^2} = 2^{1/3}$

Question127

A uniform heavy rod of weight $10\,\text{kg ms}^{-2}$, cross-sectional area 100cm^2 and length $20\,\text{cm}$ is hanging from a fixed support. Young's modulus of the material of the rod is $2 \times 10^{11}\text{Nm}^{-2}$. Neglecting the lateral contraction, find the elongation of rod due to its own weight.
[31 Aug 2021 Shift 1]

Options:

A. $2 \times 10^{-9}\text{m}$

B. $5 \times 10^{-8}\text{m}$

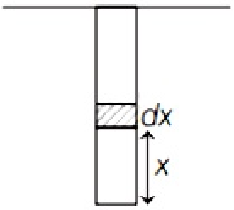
C. $4 \times 10^{-8}\text{m}$

D. $5 \times 10^{-10}\text{m}$

Answer: D

Solution:

Given, weight of rod, $w = 10\,\text{kg ms}^{-2}$
section, $A = 100\text{cm}^2 = 100 \times 10^{-4}\text{m}^2$
Length of rod, $l = 20\,\text{cm} = 20 \times 10^{-2}\text{m}$



Young's modulus $(Y) = 2 \times 10^{11}\text{Nm}^{-2}$
Let, elongation = Δl
Since, Young's modulus, $Y = \dfrac{dmgx}{A\Delta l}$

Mass of element dx at distance x, $dm = \dfrac{m}{l}dx$

$$\Rightarrow \Delta l = \frac{\left(\frac{mg}{l}\right)}{AY} x\,dx$$

$$\Rightarrow \Delta l = \frac{mg}{AlY}\frac{x^2}{2}\Big|_0^l$$

$$\Rightarrow \Delta l = \frac{mg}{AlY}\frac{l^2}{2}$$

$$= \frac{mgl}{2AY} = \frac{wl}{2AY}$$

$$= \frac{10 \times 20 \times 10^{-2}}{2 \times 100 \times 10^{-4} \times 2 \times 10^{11}}$$

$$= 5 \times 10^{-10}\text{m}$$

Question128

Section B : Numerical Type Questions
When a rubber ball is taken to a depth of ___ m in deep sea, its volume

decreases by 0.5%. (The bulk modulus of rubber $= 9.8 \times 10^8 Nm^{-2}$. Density of sea water $= 10^3 kg\, m^{-3}$, $g = 9.8 m / s^2$)
[31 Aug 2021 Shift 1]

Answer: 500

Solution:

Given, decrease in volume $(\Delta V / V) = -\frac{0.5}{100}$
Bulk modulus of rubber, $B = 9.8 \times 10^8 Nm^{-2}$
Density of sea water, $\rho = 10^3 kgm^{-3}$
Acceleration due to gravity, $g = 9.8 ms^{-2}$
Let h be the depth at which ball is dipped.
Since, $B = \frac{\Delta p}{-\Delta \frac{V}{V}}$
where, Δp is change in pressure $= \rho gh$
$\therefore \rho gh = -B\frac{\Delta V}{V}$
$\Rightarrow h = -\frac{1}{\rho g} B \frac{\Delta V}{V}$
$\Rightarrow h = -\frac{1}{10^3 \times 9.8} \times 9.8 \times 10^8 \times \left(-\frac{0.5}{100}\right)$
$= 0.5 \times 10^{8-3-2} = 0.5 \times 10^3 = 500 m$

Question129

Four identical hollow cylindrical columns of mild steel support a big structure of mass $50 \times 10^3 kg$. The inner and outer radii of each column are 50 cm and 100 cm, respectively. Assuming, uniform local distribution, calculate the compression strain of each column.
[Use, $Y = 2.0 \times 10^{11} Pa$, $g = 9.8 m / s^2$].
[31 Aug 2021 Shift 2]

Options:

A. 3.60×10^{-8}

B. 2.60×10^{-7}

C. 1.87×10^{-3}

D. 7.07×10^{-4}

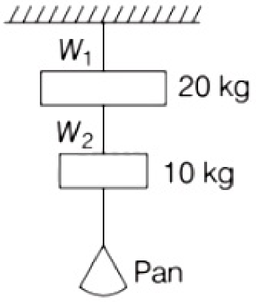
Answer: B

Solution:

Given that, $r = 50$ cm, $R = 100$ cm
Mass supported on four columns, $M = 50 \times 10^3$ kg
Mass supported on each column, $m = \frac{M}{4}$
$\Rightarrow m = \frac{50 \times 10^3}{4} = 12.5 \times 10^3$ kg
Now, weight, $w = mg = 12.5 \times 9.8 \times 10^3 N = 1225 \times 10^5 N$
Area of cross-section of each column
$A = \pi(R^2 - r^2)$
$= 3.14\{(100)^2 - (50)^2\} \times 10^{-4} m^2 = 2.35 m^2$
Young's modulus, $Y = 2.0 \times 10^{11}$ Pa
By using Hooke's law,
Stress = Y × Strain
$\therefore$ Compressive strain $= \frac{\text{Stress}}{Y} = \frac{W}{AY}$
Substituting the values, we get
Compressive strain $= \frac{1.225 \times 10^5}{2.35 \times 2.0 \times 10^{11}} = 2.60 \times 10^{-7}$

Question130

Wires W_1 and W_2 are made of same material having the breaking stress of $1.25 \times 10^9 N / m^2$. W_1 and W_2 have cross-sectional area of $8 \times 10^{-7} m^2$ and $4 \times 10^{-7} m^2$, respectively. Masses of 20 kg and 10 kg hang from them as shown in the figure. The maximum mass that can be placed in the pan without breaking the wires is .... kg.
(Use, $g = 10 m / s^2$)

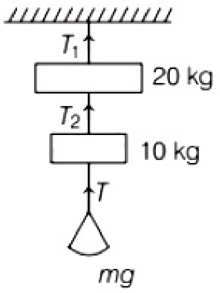


[27 Aug 2021 Shift 2]

Answer: 40

Solution:

Solution:
Given, breaking stress of wires 1 and 2 are $\sigma_1 = \sigma_2 = 1.25 \times 10^9 N / m^2$
Cross-sectional area of wire 1 ,
$A_1 = 8 \times 10^{-7} m^2$
Cross-sectional area of wire 2 ,
$A_2 = 4 \times 10^{-7} m^2$
Mass hanging from first wire, $m_1 = 20$kg Mass hanging from second wire,
$m_2 = 10$kg
Acceleration due to gravity, $g = 10 ms^{-2}$
Let m be the maximum mass placed in pan without breaking the wire.



Since, stress(σ) = $\frac{\text{Tension (T)}}{\text{Area(A)}}$

$\therefore\ T_1 = \sigma A_1$

$= 1.25 \times 10^9 \times 8 \times 10^{-7}$

$= 10.00 \times 10^2 = 1000\text{N}$

and $T_2 = \sigma A_2$

$= 1.25 \times 10^9 \times 4 \times 10^{-7}$

$= 5.00 \times 10^2 = 500\text{N}$

By using concept of tension in string

$T_2 = (10 + m)g$

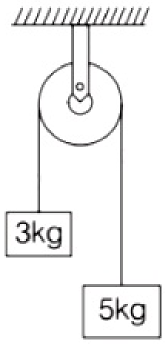
$\Rightarrow\ 500 = (10 + m)10$

$\Rightarrow\ m = 50 - 10 = 40\text{kg}$

Question131

Two blocks of masses 3 kg and 5 kg are connected by a metal wire going over a smooth pulley. The breaking stress of the metal is $\left(\frac{24}{\pi}\right) \times 10^2 \text{Nm}^{-2}$. What is the minimum radius of the wire?

(Take, $g = 10\text{ms}^{-2}$)



[26 Aug 2021 Shift 2]

Options:

A. 125 cm

B. 1250 cm

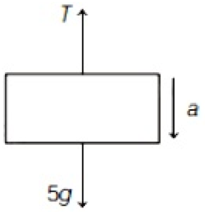
C. 12.5 cm

D. 1.25 cm

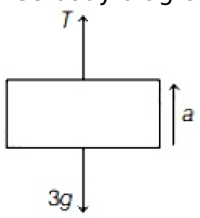
Answer: C

Solution:

Solution:



where, a is common acceleration.
Value of acceleration due to gravity, $g = 10 ms^{-2}$
From free body diagram of block of mass 5 kg
$5g - T = 5a$
$\Rightarrow 5 \times 10 - T = 5a$
$\Rightarrow 50 - T = 5a$ ...(i)
Free body diagram of 3 kg block is given as



From free body diagram of block of mass 3 kg,
$T - 3g = 3a$
$\Rightarrow T - 3 \times 10 = 3a$
$\Rightarrow T - 30 = 3a$ ...(ii)
Add Eqs. (i) and (ii), we get
$50 - T + T - 30 = 5a + 3a$
$\Rightarrow 20 = 8a$
$\Rightarrow a = 2.5 ms^{-2}$
Substituting the value of a in Eq. (i), we get
$50 - T = 5 \times 2.5$
$\Rightarrow T = 37.5$ N
Let us assume the minimum radius of wire is r.
The breaking stress is expressed as
$\sigma = \frac{T}{\pi r^2}$
$\frac{24}{\pi} \times 10^2 = \frac{37.5}{\pi r^2}$
$\Rightarrow r^2 = \frac{37.5}{24 \times 10^2} = \frac{1}{64}$
$\Rightarrow r = \frac{1}{8} m = \frac{100}{8} cm = 12.5 cm$
Thus, the minimum radius of wire should be 12.5 cm.

Question132

In Millikan's oil drop experiment, what is viscous force acting on an uncharged drop of radius 2.0×10^{-5}m and density $1.2 \times 10^{3} kgm^{-3}$? Take viscosity of liquid $= 1.8 \times 10^{-5} Nsm^{-2}$. (Neglect buoyancy due to air).
[27 Aug 2021 Shift 1]

Options:

A. 3.8×10^{-11}N

B. 3.9×10^{-10}N

C. 1.8×10^{-10}N

D. 5.8×10^{-10}N

Solution:

Solution:
Given, radius of oil drop, $r = 2.0 \times 10^{-5} m$
Density of oil drop, $\rho = 1.2 \times 10^{3} kgm^{-3}$
Viscosity of liquid, $\eta = 1.8 \times 10^{-5} Nsm^{-2}$
To neglect buoyancy, consider the density of air, ρa = 0
Viscous force acting on drop can be given as
$F = 6\pi\eta rV$ ...(i)
Here, v is terminal velocity.
The terminal velocity of drop can be given as
$$v = \frac{2r^2(\rho - \rho_a)g}{9\eta}$$
$$\Rightarrow v = \frac{2 \times (2.0 \times 10^{-5})^2(1.2 \times 10^3 - 0) \times 9.8}{9 \times 1.8 \times 10^{-5}}$$
$= 5.807 \times 10^{-2} ms^{-1}$
Substituting all values in Eq. (i), we get
$F = 6\pi \times 1.8 \times 10^{-5} \times 2.0 \times 10^{-5} \times 5.807 \times 10^{-2}$
$= 3.94 \times 10^{-10} N$
$\simeq 3.9 \times 10^{-10} N$

Question133

Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube.
[Take surface tension of water $T = 7.3 \times 10^{-2} Nm^{-1}$, angle of contact $= 0$, $g = 10 ms^{-2}$ and density of water $= 1.0 \times 10^{3} kg\,m^{-3}$]
[26 Aug 2021 Shift 1]

Options:

A. 3.62 mm

B. 2.19 mm

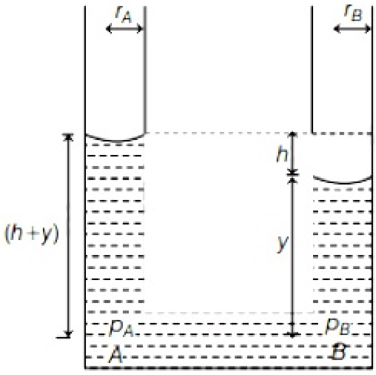
C. 5.34 mm

D. 4.97 mm

Answer: B

Solution:

Solution:
The given situation can be shown as below.



Points A and B are at same horizontal level.
So, the pressure at A and B will be equal
i.e. $p_A = p_B$.... (i)
If p_0 is the atmospheric pressure, then from Bernoulli's theorem,

$$p_A = p_0 - \frac{2T}{r_A} + (h+y)\rho g$$

$$p_B = p_0 - \frac{2T}{r_B} + \rho g y$$

Substituting the value of p_A and p_B in Eq. (i), we get

$$p_0 - \frac{2T}{r_A} + (h+y)\rho g = p_0 - \frac{2T}{r_B} + \rho g y$$

$$\Rightarrow 2T\left(\frac{1}{r_B} - \frac{1}{r_A}\right) = \rho g y - (h+y)\rho g$$

$$\Rightarrow 2T\left(\frac{1}{r_B} - \frac{1}{r_A}\right) = -\rho g h$$

$$\text{or} 2T\left(\frac{1}{r_A} - \frac{1}{r_B}\right) = cg h \text{ ...(ii)}$$

Here, $r_A = 2.5\,\text{mm} = 2.5 \times 10^{-3}\text{m}$,
and $T = 7.3 \times 10^{-2}\text{N} / \text{m}$,
$r_B = 4\,\text{mm} = 4 \times 10^{-3}\text{m}$, $g = 10\text{m} / \text{s}^2$ and $\rho = 1 \times 10^3\text{kgm}^{-3}$
Substituting the given value in Eq. (ii), we get

$$h = \frac{2 \times 7.3 \times 10^{-2}}{1 \times 10^3 \times 10}\left(\frac{1}{2.5 \times 10^{-3}} - \frac{1}{4 \times 10^{-3}}\right)$$

$$h = \frac{2 \times 7.3 \times 10^{-2}}{10^{-3} \times 10^4}\left(\frac{1}{2.5} - \frac{1}{4}\right)$$

$$h = 2.19 \times 10^{-3}\text{m} = 2.19\,\text{mm}$$

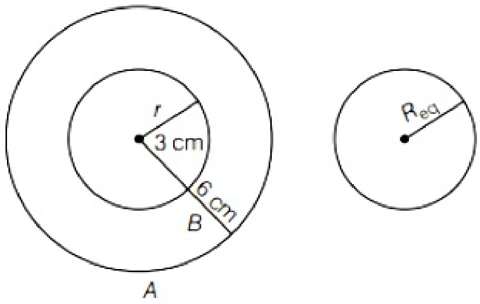
Question134

A soap bubble of radius 3 cm is formed inside the another soap bubble of radius 6 cm. The radius of an equivalent soap bubble which has the same excess pressure as inside the smaller bubble with respect to the atmospheric pressure is .... cm.
[26 Aug 2021 Shift 1]

Answer: 2

Solution:

Solution:
The given situation is shown below



$r_A = 6\,cm$
$r_B = 3\,cm$
Excess pressure inside the soap bubble is given by
$(\Delta p)_{excess} = \frac{4S}{r_A} + \frac{4S}{r_B}$
According to the given question,
$\frac{4S}{r_A} + \frac{4S}{r_B} = \frac{4S}{R_{eq}}$
$\Rightarrow \frac{1}{r_A} + \frac{1}{r_B} = \frac{1}{R_{eq}}$
$\Rightarrow \frac{1}{6} + \frac{1}{3} = \frac{1}{R_{eq}}$
$\Rightarrow \frac{1+2}{6} = \frac{1}{R_{eq}}$
$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{2}$
$\Rightarrow R_{eq} = 2\,cm$

Question135

**A steel rod with $Y = 2.0 \times 10^{11} Nm^{-2}$ and $\alpha = 10^{5}°C^{-1}$ of length 4m and area of cross-section $10cm^2$ is heated from 0°C to 400°C without being allowed to extend. The tension produced in the rod is $x \times 10^5 N$, where the value of x is ....
[1 Sep 2021 Shift 2]**

Answer: 8

Solution:

Solution:
Given, the Young's modulus of the steel rod, $Y = 2 \times 10^{11}$ Pa
Thermal coefficient of the steel rod, $\alpha = 10^{-5}$ºC
The length of the steel rod, l = 4 m
The area of the cross-section, $A = 10\ cm^2$
The temperature difference, $\Delta T = 400°C$
As we know that,
Thermal strain = $\alpha\ \Delta T$
Using the Hooke's law
Young's modulus (Y) $= \frac{\text{Thermal stress}}{\text{Thermal strain}} = \frac{\frac{F}{A}}{\alpha \Delta T}$
Thermal stress, $F = YA\ \alpha\ \Delta\ T$
Substitute the values in the above equation, we get
$F = 2 \times 10^{11} \times 10 \times 10^{-4} \times 10^{-5} \times (400)$

Comparing with, $F = x \times 10^5 N$
The value of the $x = 8$.

Question136

A body of mass m = 10kg is attached to one end of a wire of length 0.3m. The maximum angular speed (in rad s^{-1}) with which it can be rotated about its other end in space station is (Breaking stress of wire $= 4.8 \times 10^7 N\,m^{-2}$ and area of cross section of the wire $= 10^{-2} cm^2$) is ______.
[9 Jan 2020 I]

Answer: 4

Solution:

Solution:
Given : Wire length, $l = 0.3m$
Mass of the body, $m = 10kg$
Breaking stress $\sigma = 4.8 \times 10^7 N\,m^{-2}$
Area of cross-section, $a = 10^{-2} cm^2$
Maximum angular speed $\omega = ?$
$T = M l \omega^2$

$$\sigma = \frac{T}{A} = \frac{ml\,\omega^2}{A}$$

$$\frac{ml\,\omega^2}{A} \le 48 \times 10^7 \Rightarrow \omega^2 \le \frac{(48 \times 10^7)A}{ml}$$

$$\Rightarrow \omega^2 \le \frac{(48 \times 10^7)(10^{-6})}{10 \times 3} = 16 \Rightarrow \omega_{max} = 4\,rad / s$$

Question137

Two steel wires having same length are suspended from a ceiling under the same load. If the ratio of their energy stored per unit volume is 1 : 4, the ratio of their diameters is:
[9 Jan 2020 II]

Options:

A. $\sqrt{2} : 1$

B. 1: 2

C. 2: 1

D. $1 : \sqrt{2}$

Answer: A

Solution:
If force F acts along the length L of the wire of crosssection A, then energy stored in unit volume of wire is given by
Energy density $= \frac{1}{2}$ stress times strain
$= \frac{1}{2} \times \frac{F}{A} \times \frac{F}{AY}$ ($\because$ stress $= \frac{F}{A}$ and strain $= \frac{X}{AY}$)
$= \frac{1}{2}\frac{F^2}{A^2Y} = \frac{1}{2}\frac{F^2 \times 16}{(\pi d^2)^2 Y} = \frac{1}{2}\frac{F^2 \times 16}{\pi d^4 Y}$
If u_1 and u_2 are the densities of two wires, then $\frac{u_1}{u_2} = \left(\frac{d_2}{d_1}\right)^4 \Rightarrow \frac{d_1}{d_2} = (4)^{1/4} \Rightarrow \frac{d_1}{d_2} = \sqrt{2} : 1$

Question138

Three containers C_1, C_2 and C_3 have water at different temperatures. The table below shows the final temperature T when different amounts of water (given in liters) are taken from each container and mixed (assume no loss of heat during the process)

C_1	C_2	C_3	T
1*l*	2*l*	—	60°C
—	1*l*	2*l*	30°C
2*l*	—	1*l*	60°C
1*l*	1*l*	1*l*	θ

The value of θ (in °C to the nearest integer) is______.
[8 Jan. 2020 II]

Answer: 50

Solution:

Solution:
Let Q_1, Q_2, Q_3 be the temperatures of container C_1, C_2 and C_3 respectively.
Using principle of calorimetry in container C_1, we have $(\theta_1 - 60) = 2ms(60 - \theta)$
$\Rightarrow \theta_1 - 60 = 120 - 2\theta$
$\Rightarrow \theta_1 = 180 - 2\theta$ ......(i)
For container C_2
$ms(\theta_2 - 30) = 2ms(30 - \theta)$
$\Rightarrow \theta_2 = 90 - 2\theta 3$ ....(ii)
For container C_3
$2ms(\theta_1 - 60) = ms(60 - \theta)$
$\Rightarrow 2\theta_1 - 120 = 60 - \theta$
$\Rightarrow 2\theta_1 + \theta = 180$
.......(iii)
Also, $\theta_1 + \theta_2 + \theta_3 = 3\theta$ ....(iv)
Adding (i), (ii) and (iii)
$3\theta_1 + 3\theta_2 + 3\theta_3 = 450$

$\Rightarrow 3\theta = 150 \Rightarrow \theta = 50°C$

Question139

A leak proof cylinder of length 1m, made of a metal which has very low coefficient of expansion is floating vertically in water at 0°C such that its height above the water surface is 20cm. When the temperature of water is increased to 4°C, the height of the cylinder above the water surface becomes 21cm. The density of water at T = 4°C, relative to the density at T = 0°C is close to:
[8 Jan 2020 (I)]

Options:

A. 1.26

B. 1.04

C. 1.01

D. 1.03

Answer: C

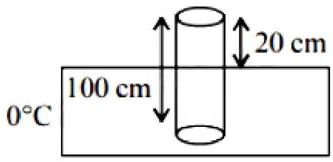
Solution:

Solution:

When cylinder is floating in water at $0°C$

Net thrust $= A(h_2 - h_1)\rho_{0°c}g$

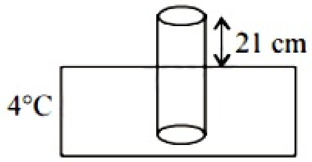
$= A(100-80)\rho_{0°c}g$



When cylinder is floating in water at $4°C$

Net thrust $= A(h_2 - h_1)\rho_{4°c}g$

$= A(100-21)\rho_{4°c}g$



$\therefore \frac{\rho_{4°c}}{\rho_{0°c}} = \frac{80}{79} = 1.01$

Question140

Consider a solid sphere of radius R and mass

density$\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right)$, $0 < r \le R$. The minimum density of a liquid in which it will float is:
[8 Jan 2020 (I)]

Options:

A. $\frac{\rho_0}{3}$

B. $\frac{\rho_0}{5}$

C. $\frac{2\rho_0}{5}$

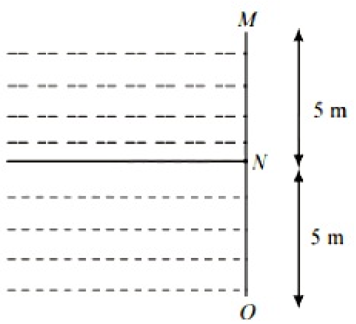
D. $\frac{2\rho_0}{3}$

Answer: C

Solution:

Solution:
For minimum density of liquid, solid sphere has to float (completely immersed) in the liquid.
$mg = F_B$(also $V_{immersed} = V_{total}$)
or $\int \rho d V = \frac{4}{3}\pi R^3 \rho_l$
$\left[\rho(r) = \rho_0\left(1 - \frac{r^2}{R^2}\right) 0 < r \le R \text{ given}\right]$
$\Rightarrow \int_0^R \rho_0 4\pi\left(1 - \frac{r^2}{R^2}\right) . r^2 d r = \frac{4}{3}\pi R^3 \rho_l$
$\Rightarrow 4\pi\rho_0\left[\frac{r^3}{3} - \frac{r^5}{5R^2}\right]_0^R = \frac{4}{3}\pi R^3 \rho_l$
$\frac{4\pi\rho_0 R^3}{3} \times \frac{2}{5} = \frac{4}{3}\pi R^3 \rho_l$
$\therefore \rho_l = \frac{2\rho_0}{5}$

Question141



Two liquids of densities ρ_1 and $\rho_2 (\rho_2 = 2\rho_1)$ are filled up behind a square wall of side 10m as shown in figure. Each liquid has a height of 5m. The ratio of the forces due to these liquids exerted on upper part M N to that at the lower part N O is (Assume that the liquids are not mixing):

Options:

A. 1 / 3

B. 2 / 3

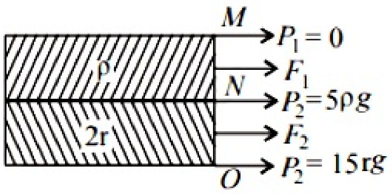
C. 1 / 2

D. 1 / 4

Answer: D

Solution:

Solution:



Let P_1, P_2 and P_3 be the pressure at points M , N and O respectively.
Pressure is given by $P = \rho g h$
Now, $P_1 = 0 (\because h = 0)$
$P_2 = \rho g(5) P_3 = \rho g(15)$
$= 15\rho g$

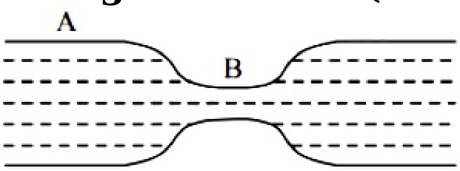
Force on upper part, $F_1 = \frac{(P_1 + P_2)}{2} A$

Force on lower part, $F_2 = \frac{(P_2 + P_3)}{2} A$

$\therefore \frac{F_1}{F_2} = \frac{5\rho g}{20\rho g} = \frac{5}{20} = \frac{1}{4}$

Question142

Water flows in a horizontal tube (see figure). The pressure of water changes by 700N m^{-2} between A and B where the area of cross section are 40cm^2 and 20cm^2, respectively. Find the rate of flow of water through the tube. (density of water $= 1000 \text{kgm}^{-3}$)



[9 Jan. 2020 (I)]

Options:

A. $3020 \text{cm}^3 / \text{s}$

B. $2720 \text{cm}^3 / \text{s}$

C. $2420 \text{cm}^3 / \text{s}$

D. $1810 \text{cm}^3 / \text{s}$

Solution:

Solution:
According to question, area of cross-section at A $aA = 40cm^2$ and at B, $aB = 20cm^2$
Let velocity of liquid flow at A, $= V_A$ and at B, $= V_B$
Using equation of continuity $a_A V_A = a_B V_B$
$40V_A = 20V_B$
$\Rightarrow 2V_A = V_B$
Now, using Bernoulli's equation
$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2 \Rightarrow P_A - P_B = \frac{1}{2}\rho(V_B^2 - V_A^2)$
$\Rightarrow \Delta P = \frac{1}{2}1000\left(V_B^2 - \frac{V_B^2}{4}\right) \Rightarrow \Delta P = 500 \times \frac{3V_B^2}{4}$
$\Rightarrow V_B = \sqrt{\frac{(\Delta P) \times 4}{1500}} = \sqrt{\frac{(700) \times 4}{1500}} m/s = 1.37 \times 10^2 cm/s$
Volume flow rate $Q = a_B \times v_B$
$= 20 \times 100 \times V_B = 2732 cm^3/s \approx 2720 cm^3/s$

Question143

An ideal fluid flows (laminar flow) through a pipe of nonuniform diameter. The maximum and minimum diameters of the pipes are 6.4cm and 4.8cm, respectively. The ratio of the minimum and the maximum velocities of fluid in this pipe is:
[7 Jan. 2020 (II)]

Options:

A. $\frac{9}{16}$

B. $\frac{\sqrt{3}}{2}$

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

D. $\frac{81}{256}$

Answer: A

Solution:

Solution:
From the equation of continuity
$A_1 v_1 = A_2 v_2$
Here, v_1 and v_2 are the velocities at two ends of pipe.
A_1 and A_2 are the area of pipe at two ends
$\Rightarrow \frac{v_1}{v_2} = \frac{A_2}{A_1} = \frac{\pi(4.8)^2}{\pi(6.4)^2} = \frac{9}{16}$

Question144

A small spherical droplet of density d is floating exactly halfimmersed in a liquid of density ρ and surface tension T. The radius of the droplet is (take note that the surface tension applies an upward force on the droplet):
[9 Jan. 2020 (II)]

Options:

A. $r = \sqrt{\frac{2T}{3(d+\rho)g}}$

B. $r = \sqrt{\frac{T}{(d-\rho)g}}$

C. $r = \sqrt{\frac{T}{(d+\rho)g}}$

D. $r = \sqrt{\frac{3T}{(2d-\rho)g}}$

Answer: D

Solution:

Solution:
For the drops to be in equilibrium upward force on drop = downward force on drop

$T.2\pi R = \frac{4}{3}\pi R^3 d\,g - \frac{2}{3}\pi R^3 \rho g$

$\Rightarrow T(2\pi R) = \frac{2}{3}\pi R^3(2d-\rho)g$

$\Rightarrow T = \frac{R^2}{3}(2d-\rho)g \Rightarrow R = \sqrt{\frac{3T}{(2d-\rho)g}}$

Question145

A non-isotropic solid metal cube has coefficients of linear expansion as: 5×10^{-5} / °C along the x-axis and 5×10^{-6} / °C along the y and the z-axis. If the coefficient of volume expansion of the solid is $C \times 10^{-6}$ / °C then the value of C is _______.
[NA 7 Jan. 2020 I]

Answer: 60

Solution:

Solution:
Volume, V = lbh

$\therefore \gamma = \frac{\Delta V}{V} = \frac{\Delta l}{l} + \frac{\Delta b}{b} + \frac{\Delta h}{h}$

$= 60 \times 10^{-6} / °C$
∴ Value of C = 60.00

Question146

M grams of steam at 100°C is mixed with 200 g of ice at its melting point in a thermally insulated container. If it produces liquid water at 40°C [heat of vaporization of water is 540 cal/ g and heat of fusion of ice is 80 cal/g], the value of M is _______.
[NA 7 Jan. 2020 II]

Answer: 40

Solution:

Solution:
Using the principal of calorimetry
$M_{ice} L_f + m_{ice}(40 - 0)C_w$
$= m_{stream} L_v + m_{stream}(100 - 40)C_w$
$\Rightarrow M(540) + M \times 1 \times (100 - 40)$
$= 200 \times 80 + 200 \times 1 \times 40$
$\Rightarrow 600M = 24000$
$\Rightarrow M = 40g$

Question147

If the potential energy between two molecules is given by $U = -\frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules, and the potential energy are:
[Sep. 06, 2020 (I)]

Options:

A. $\left(\frac{B}{2A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$

B. $\left(\frac{B}{A}\right)^{\frac{1}{6}}, 0$

C. $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{4B}$

D. $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\frac{A^2}{2B}$

Answer: C

Given: $U = \frac{-A}{r^6} + \frac{B}{r^{12}}$

For equilibrium,

$F = \frac{dU}{dr} = -(A(-6r^{-7})) + B(-12r^{-13}) = 0$

$\Rightarrow 0 = \frac{6A}{r^7} - \frac{12B}{r^{13}} \Rightarrow \frac{6A}{12B} = \frac{1}{r^6}$

∴ Separation between molecules, $r = \left(\frac{2B}{A}\right)^{1/6}$

Potential energy,

$U\left(r = \left(\frac{2B}{A}\right)^{1/6}\right) = -\frac{A}{2B/A} + \frac{B}{4B^2/A^2}$

$= \frac{-A^2}{2B} + \frac{A^2}{4B} = \frac{-A^2}{4B}$

Question148

A hollow spherical shell at outer radius R floats just submerged under the water surface. The inner radius of the shell is r. If the specific gravity of the shell material is $\frac{27}{8}$ w.r.t water, the value of r is:
[5 Sep. 2020 (I)]

Options:

A. $\frac{8}{9}R$

B. $\frac{4}{9}R$

C. $\frac{2}{3}R$

D. $\frac{1}{3}R$

Answer: A

Solution:

Solution:

In equilibrium, $mg = F_e$

$F_B = V\rho_0 g$ and mass = volume × density

$\frac{4}{3}\pi(R^3 - r^3)\rho_0 g = \frac{4}{3}\pi R^3 \rho_w g$

Given, relative density, $\frac{\rho_0}{\rho_w} = \frac{27}{8}$

$\Rightarrow \left[1 - \left(\frac{r}{R}\right)^3\right]\frac{27}{8}\rho_w = \rho_w$

$\Rightarrow 1 - \frac{r^3}{R^3} = \frac{9}{27} \Rightarrow 1 - \frac{1}{3} = \frac{r^3}{R^3} \Rightarrow \frac{2}{3} = \frac{r^3}{R^3}$

$\Rightarrow \frac{r}{R} = \left(\frac{2}{3}\right)^{1/3} \Rightarrow 1 - \frac{r^3}{R^3} = \frac{8}{27}$

$\Rightarrow \frac{r^3}{R^3} = 1 - \frac{8}{27} = \frac{19}{27}$

$\therefore r = 0.89R = \frac{8}{9}R$

Question149

An air bubble of radius 1cm in water has an upward acceleration $9.8 cms^{-2}$. The density of water is $1 gm\ cm^{-3}$ and water offers negligible drag force on the bubble. The mass of the bubble is $(g = 980 cm / s^2)$
[4 Sep. 2020 (I)]

Options:

A. 4.51gm

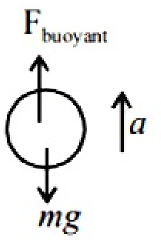
B. 3.15gm

C. 4.15gm

D. 1.52gm

Answer: C

Solution:



(c) Given:
Radius of air bubble $= 1 cm$,
Upward acceleration of bubble, $a = 9.8 cm / s^2$
$\rho_{water} = 1 gcm^{-3}$
Volume $V = \frac{4\pi}{3} r^3 = \frac{4\pi}{3} \times (1)^3 = 4.19 cm^3$

$F_{buoyant} - mg = ma \Rightarrow m = \frac{F_{buoyant}}{g + a}$

$\therefore m = \frac{(V \rho_\omega g)}{g + a} = \frac{V \rho_\omega}{1 + \frac{a}{g}} = \frac{(4.19) \times 1}{1 + \frac{9.8}{980}} = \frac{4.19}{1.01} = 4.15 g$

Question150

Two identical cylindrical vessels are kept on the ground and each contain the same liquid of density d . The area of the base of both vessels is S but the height of liquid in one vessel is x_1 and in the other, x_2. When both cylinders are connected through a pipe of negligible volume very close to the bottom, the liquid flows from one vessel to the other until it comes to equilibrium at a new height. The change in energy of the system in the process is:
[4 Sep. 2020 (II)]

Options:

A. $gd\,S(x_2{}^2 + x_1{}^2)$

B. $gd\,S(x_2 + x_1)^2$

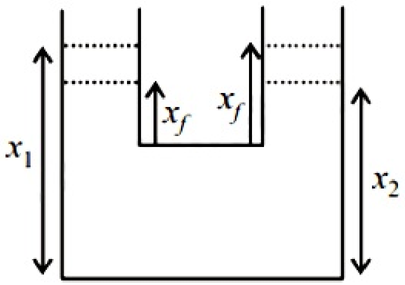
C. $\frac{3}{4}gd\,S(x_2 - x_1)^2$

D. $\frac{1}{4}gd\,S(x_2 - x_1)^2$

Answer: D

Solution:

Solution:



Initial potential energy,

$U_1 = (\rho S x_1)g \cdot \frac{x_1}{2} + (\rho S x_2)g \cdot \frac{x_2}{2}$

Final potential energy,

$U_f = (\rho S x_f)g \cdot \frac{x_f}{2} \times 2$

By volume conservation,

$Sx_1 + Sx_2 = S(2x_f)$

$x_f = \frac{x_1 + x_2}{2}$

When valve is opened loss in potentail energy occur till water level become same.

$\Delta U = U_i - U_f$

$\Delta U = \rho S g\left[\left(\frac{x_1{}^2}{2} + \frac{x_2{}^2}{2}\right) - x_f{}^2\right]$

$= \rho S g\left[\frac{x_1{}^2}{2} + \frac{x_2{}^2}{2} - \left(\frac{x_1 + x_2}{2}\right)^2\right]$

$= \frac{\rho S g}{2}\left[\frac{x_1{}^2}{2} + \frac{x_2{}^2}{2} - x_1 x_2\right] = \frac{\rho S g}{4}(x_1 - x_2)^2$

Question151

A fluid is flowing through a horizontal pipe of varying crosssection, with speed $v\,ms^{-1}$ at a point where the pressure is P Pascal. At another point where pressure is $\frac{P}{2}$ Pascal its speed is $V\,ms^{-1}$. If the density of the fluid is $\rho\,kgm^{-3}$ and the flow is streamline, then V is equal to :
[6 Sep. 2020 (II)]

Options:

A. $\sqrt{\frac{P}{\rho} + v}$

B. $\sqrt{\frac{2P}{\rho} + v^2}$

C. $\sqrt{\frac{P}{2\rho} + v^2}$

D. $\sqrt{\frac{P}{\rho} + v^2}$

Answer: D

Solution:

Solution:
Using Bernoulli's equation
$P_1 + 12\rho {v_1}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho {v_2}^2 + \rho g h_2$
For horizontal pipe, $h_1 = 0$ and $h_2 = 0$ and taking
$P_1 = P, P_2 = \frac{P}{2}$, we get
$\Rightarrow P + \frac{1}{2}\rho v^2 = \frac{P}{2} + \frac{1}{2}\rho V^2$
$\Rightarrow \frac{P}{2} + \frac{1}{2}\rho v^2 = \frac{1}{2}\rho V^2$
$\Rightarrow V = \sqrt{v^2 + \frac{P}{\rho}}$

Question152

In an experiment to verify Stokes law, a small spherical ball of radius r and density ρ falls under gravity through a distance h in air before entering a tank of water. If the terminal velocity of the ball inside water is same as its velocity just before entering the water surface, then the value of h is proportional to :
(ignore viscosity of air)
[5 Sep. 2020 (II)]

Options:

A. r^4

B. r

C. r^3

D. r^2

Answer: A

Solution:

Using, $v^2 - u^2 = 2gh$
$\Rightarrow v^2 - 0^2 = 2gh \Rightarrow v = \sqrt{2gh}$
Terminal velocity,

$V_T = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$

After falling through h the velocity should be equal to terminal velocity $\therefore \sqrt{2gh} = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$

$\Rightarrow 2gh = \frac{4}{81}\frac{r^4 g^2(\rho - \sigma)^2}{\eta^2}$

$\Rightarrow h = \frac{2r^4 g(\rho - \sigma)^2}{81 eta^2} \Rightarrow h \propto r^4$

Question153

When a long glass capillary tube of radius 0.015cm is dipped in a liquid, the liquid rises to a height of 15cm within it. If the contact angle between the liquid and glass to close to 0°, the surface tension of the liquid, in milli Newton m^{-1}, is [$\rho_{(liquid)} = 900 kgm^{-3}$, $g = 10 ms^{-2}$] (Give answer in closest integer) ______.
[NA 3 Sep. 2020 (I)]

Solution:

Given : Radius of capillary tube,
$r = 0.015cm = 15 \times 10^{-5} mm$
$h = 15cm = 15 \times 10^{-2} mm$
Using, $h = \frac{2T\cos\theta}{\rho g r} [\cos\theta = \cos 0° = 1]$
Surface tension,
$T = \frac{rh\rho g}{2} = \frac{15 \times 10^{-5} \times 15 \times 10^{-2} \times 900 \times 10}{2} = 101$ milli newton m^{-1}

Question154

Pressure inside two soap bubbles are 1.01 and 1.02 atmosphere, respectively. The ratio of their volumes is :
[3 Sep. 2020 (I)]

Options:

A. 4 : 1

B. 0.8 : 1

C. 8 : 1

D. 2 : 1

Answer: C

Solution:

Solution:
According to question, pressure inside, 1 st soap bubble,

$\Delta P_1 = P_1 - P_0 = 0.01 = \frac{4T}{R_1}$ ......(i)

And $\Delta P_2 = P_2 - P_0 = 0.02 = \frac{4T}{R_2}$ ....(ii)

Dividing, equation (ii) by (i),

$\frac{1}{2} = \frac{R_2}{R_1} \Rightarrow R_1 = 2R_2$

Volume $V = \frac{4}{3} \leq \pi R^3$

$\therefore \frac{V_1}{V_2} = \frac{R_1^3}{R_2^3} = \frac{8R_2^3}{R_2^3} = \frac{8}{1}$

Question155

A capillary tube made of glass of radius 0.15mm is dipped vertically in a beaker filled with methylene iodide (surface tension $= 0.05 \mathrm{N\,m^{-1}}$, density left. $= 667 \mathrm{kgm^{-3}}$) which rises to height h in the tube . It is observed that the two tangents drawn from liquid-glass interfaces (from opp. sides of the capillary) make an angle of 60° with one another. Then h is close to ($g = 10 \mathrm{ms^{-2}}$).
[2 Sep. 2020 (II)]

Options:

A. 0.049m

B. 0.087m

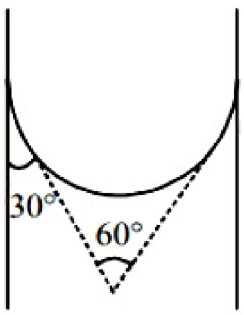
C. 0.137m

D. 0.172m

Answer: B

Solution:

Given, Angle of contact $\theta = 30°$
...sion, $T = 0.05 \mathrm{N\,m^{-1}}$
Radius of capillary tube, $r = 0.15 \mathrm{mm} = 0.15 \times 10^{-3} \mathrm{m}$
Density of methylene iodide, $\rho = 667 \mathrm{kgm^{-3}}$



Capillaryrise, $h = \frac{2T\cos\theta}{\rho g r}$

$$= \frac{2 \times 0.05 \times \frac{\sqrt{3}}{2}}{667 \times 10 \times 0.15 \times 10^{-3}} = 0.087\text{m}$$

Question156

Two different wires having lengths L_1 and L_2, and respective temperature coefficient of linear expansion α_1 and α_2, are joined end-to-end. Then the effective temperature coefficient of linear expansion is : [Sep. 05,2020 (II)]

Options:

A. $\frac{\alpha_1 L_1 + \alpha_2 L_2}{L_1 + L_2}$

B. $2\sqrt{\alpha_1 \alpha_2}$

C. $\frac{\alpha_1 + \alpha_2}{2}$

D. $4\frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2} \frac{L_2 L_1}{(L_2 + L_1)^2}$

Answer: A

Solution:

Solution:

Let L'_1 and L'_2 be the lengths of the wire when temperature is changed by ΔT °C.

At T °C $L_{eq} = L_1 + L_2$

At T + Δ°C

$L_{eq}' = L_1' + L_2'$

$\therefore L_{eq}(1 + \alpha_{eq}\Delta T) = L_1(1 + \alpha_1 \Delta T) + L_2(1 + \alpha_2 \Delta T) \quad \because L' = L(1 + \alpha \Delta T)]$

$\Rightarrow (L_1 + L_2)(1 + \alpha_{eq}\Delta T) = L_1 + L_2 + L_1\alpha_1\Delta T + L_2\alpha_2\Delta T$

$\Rightarrow \alpha_{eq} = \frac{\alpha_1 L_1 + \alpha_2 L_2}{L_1 + L_2}$

Question157

A bakelite beaker has volume capacity of 500cc at 30°C. When it is partially filled with V_m volume (at 30°C) of mercury, it is found that the unfilled volume of the beaker remains constant as temperature is varied. If $\gamma_{(beaker)} = 6 \times 10^{-6} °C^{-1}$ and $\gamma_{(mercury)} = 1.5 \times 10^{-4} °C^{-1}$, where gamma is the coefficient of volume expansion, then V_m (in cc) is close to __________.
[NA Sep. 03,2020 (I)]

Answer: 20

Solution:

Solution:
Volume capacity of beaker, $V_0 = 500cc$
$V_b = V_0 + V_0\gamma_{beaker}\Delta T$
When beaker is partially filled with V_m volume of mercury,
$V_b^1 = V_m + V_m\gamma_m\Delta T$
Unfilled volume $(V_0 - V_m) = (V_b - V_m^1)$
$\Rightarrow V_0\gamma_{beaker} = V_m\gamma_M$
$\therefore V_m = \frac{V_0\gamma_{beaker}}{\gamma_M}$
or, $V_m = \frac{500 \times 6 \times 10^{-6}}{1.5 \times 10^{-4}} = 20cc.$

Question158

When the temperature of a metal wire is increased from 0°C to 10°C, its length increased by 0.02%. The percentage change in its mass density will be closest to :
[Sep. 02, 2020 (II)]

Options:

A. 0.06

B. 2.3

C. 0.008

D. 0.8

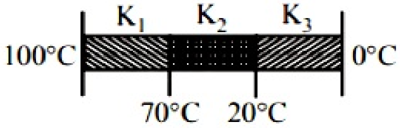
Answer: A

Solution:

Solution:
Change in length of the metal wire (Δl) when its temperature is changed by ΔT is given by
$\Delta l = l\alpha\Delta T$
Here, $\alpha =$ Coefficient of linear expansion
Here, $\Delta l = 0.02\%$, $\Delta T = 10°C$
$\therefore \alpha = \frac{\Delta l}{l\,\Delta T} = \frac{0.02}{100 \times 10}$
$\Rightarrow \alpha = 2 \times 10^{-5}$
Volume coefficient of expansion, $\gamma = 3\alpha = 6 \times 10^{-5}$
$\because \rho = \frac{M}{V}$
$\frac{\Delta V}{V} \times 100 = \gamma\Delta T = (6 \times 10^{-5} \times 10 \times 100) = 6 \times 10^{-2}$
Volume increase by 0.06% therefore density decrease by 0.06%.

Question159

Three rods of identical cross-section and lengths are made of three different materials of thermal conductivity K_1, K_2 and K_3, respectively. They are joined together at their ends to make a long rod (see figure). One end of the long rod is maintained at 100°C and the other at 0°C (see figure). If the joints of the rod are at 70°C and 20°C in steady state and there is no loss of energy from the surface of the rod, the correct relationship between K_1, K_2 and K_3 is:



[Sep. 06, 2020 (II)]

Options:

A. $K_1 : K_3 = 2 : 3, K_1 < K_3 = 2 : 5$

B. $K_1 < K_2 < K_3$

C. $K_1 : K_2 = 5 : 2, K_1 : K_3 = 3 : 5$

D. $K_1 > K_2 > K_3$

Answer: A

Solution:

Solution:
As the rods are identical, so they have same length (l) and area of cross-section (A). They are connected in series.
So, heat current will be same for all rods.

Heat current $= \left(\frac{\Delta Q}{\Delta t}\right)_{AB} = \left(\frac{\Delta Q}{\Delta t}\right)_{BC} = \left(\frac{\Delta Q}{\Delta t}\right)_{CD}$

$\Rightarrow \frac{(100-70)K_1A}{l} = \frac{(70-20)K_2A}{l} = \frac{(20-0)K_3A}{l}$

$\Rightarrow K_1(100-70) = K_2(70-20) = K_3(20-0)$

$\Rightarrow K_1(30) = K_2(50) = K_3(20)$

$\Rightarrow \frac{K_1}{10} = \frac{K_2}{6} = \frac{K_3}{15}$

$\Rightarrow K_1 : K_2 : K_3 = 10 : 6 : 15$

$\Rightarrow K_1 : K_3 = 2 : 3$

Question160

A bullet of mass 5 g, travelling with a speed of 210 m/s, strikes a fixed wooden target. One half of its kinetics energy is converted into heat in the bullet while the other half is converted into heat in the wood. The rise of temperature of the bullet if the specific heat of its material is 0.030 cal/(g - ºC) (1 cal = 4.2×10^7 ergs) close to :
[Sep. 05, 2020 (I)]

Options:

B. 83.3ºC

C. 119.2ºC

D. 38.4ºC

Answer: A

Solution:

Solution:
According to question, one half of its kinetic energy is converted into heat in the wood.

$$\frac{1}{2}mv^2 \times \frac{1}{2} = ms\Delta T$$

$$\Rightarrow \Delta T = \frac{v^2}{4 \times s} = \frac{210 \times 210}{4 \times 4.2 \times 0.3 \times 1000} = 87.5°C$$

Question161

The specific heat of water $= 4200 J\,kg^{-1}K^{-1}$ and the latent heat of ice $= 3.4 \times 10^5 J\,kg^{-1}$.100 grams of ice at 0°C is placed in 200g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams):
[Sep. 04, 2020 (I)]

Options:

A. 61.7

B. 63.8

C. 69.3

D. 64.6

Answer: A

Solution:

Solution:
Here ice melts due to water.
Let the amount of ice melts $= m_{ice}$

$$m_w s_w \Delta\theta = m_{ice} L_{ice}$$

$$\therefore m_{ice} = \frac{m_w s_w \Delta\theta}{L_{ice}}$$

$$= \frac{0.2 \times 4200 \times 25}{3.4 \times 10^5} = 0.0617kg = 61.7g$$

Question162

A calorimter of water equivalent 20g contains 180g of water at 25°C. ' m ' grams of steam at 100°C is mixed in it till the temperature of the

= 540 cal g^{-1}, specific heat of water = 1 cal $g^{-1}{}^{\circ}C^{-1}$)
[Sep. 03, 2020 (II)]

Options:

A. 2

B. 4

C. 3.2

D. 2.6

Answer: A

Solution:

Heat given by water $= m_w C_w (T_{mix} - T_w)$
$\times (31 - 25)$
Heat taken by steam $= mL_{stem} + mC_w (T_s - T_{mix})$
$= m \times 540 + m(1) \times (100 - 31)$
$= m \times 540 + m(1) \times (69)$
From the principal of calorimeter,
Heat lost = Heat gained
$\therefore (200)(31 - 25) = m \times 540 + m(1)(69)$
$\Rightarrow 1200 = m(609) \Rightarrow m \approx 2$

Question163

A metallic sphere cools from 50°C to 40°C in 300 s. If atmospheric temperature around is 20°C, then the sphere's temperature after the next 5 minutes will be close to :
[Sep. 03, 2020 (II)]

Options:

A. 31°C

B. 33°C

C. 28°C

D. 35°C

Answer: B

Solution:

Solution:
From Newton's Law of cooling,
$T_1 - T_2 t = K\left[\frac{T_1 + T_2}{2} - T_0\right]$
Here, $T_1 = 50°C$, $T_2 = 40°C$
and $T_o = 20°C$, $t = 600S = 5$ minutes

Let T be the temperature of sphere after next 5 minutes.
Then
$\frac{40 - T}{5} = K\left(\frac{40 + T}{2} - 20\right)$ ......(ii)
Dividing eqn. (ii) by (i), we get
$\frac{40 - T}{10} = \frac{40 + T - 40}{50 + 40 - 40} = \frac{T}{50}$
$\Rightarrow 40 - T = \frac{T}{5} \Rightarrow 200 - 5T = T$
$\therefore T = \frac{200}{6} = 33.3°C$

Question164

A load of mass M kg is suspended from a steel wire of length 2m and radius 1.0mm in Searle's apparatus experiment. The increase in length produced in the wire is 4.0mm. Now the load is fully immersed in a liquid of relative density 2 . The relative density of the material of load is 8 . The new value of increase in length of the steel wire is :
[12 Jan. 2019 (II)]

Options:

A. 3.0mm

B. 4.0mm

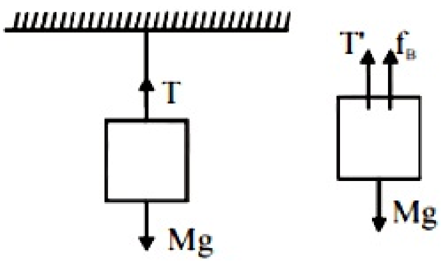
C. 5.0mm

D. Zero

Answer: A

Solution:

Using $\frac{F}{A} = Y \cdot \frac{\Delta l}{l}$



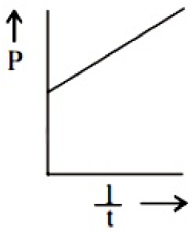
$\Rightarrow \Delta l \text{ propto } F$ ......(i)
$T = Mg$
$T = Mg - f_B = Mg - \frac{M}{\rho_b} \cdot \rho_l \cdot g$
$= \left(1 - \frac{\rho_l}{\rho_b}\right) Mg = \left(1 - \frac{2}{8}\right) Mg$
$T = \frac{3}{4} Mg$
From eqn (i)
$\frac{\Delta l'}{\Delta l} = \frac{T'}{T} = \frac{3}{4}$ [Given: $\Delta l = 4mm$]
$\therefore \Delta l' = \frac{3}{4} \cdot \Delta l = \frac{3}{4} \times 4 = 3mm$

Question165

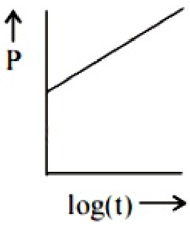
A soap bubble, blown by a mechanical pump at the mouth of a tube, increases in volume, with time, at a constant rate. The graph that correctly depicts the time dependence of pressure inside the bubble is given by:
[12 Jan. 2019 (II)]

Options:

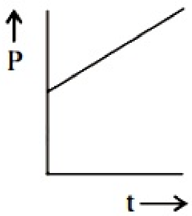
A.



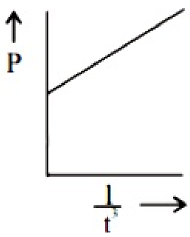
B.



C.



D.



Answer: D

Solution:

Solution:

$V = ct$ or , $\frac{4}{3}\pi r^3 = ct$

$\Rightarrow r = kt^{\frac{1}{3}}$

$P = P_0 + c\left(\frac{1}{t^{1/3}}\right)$

Question166

A liquid of density ρ is coming out of a hose pipe of radius a with horizontal speed v and hits a mesh. 50% of the liquid passes through the mesh unaffected. 25% looses all of its momentum and 25% comes back with the
[11 Jan. 2019 (I)]

Options:

A. $\frac{1}{4}\rho v^2$

B. $\frac{3}{4}\rho v^2$

C. $\frac{1}{2}\rho v^2$

D. ρv^2

Answer: B

Solution:

Solution:
Mass per unit time of the liquid = ρav
Momentum per second carried by liquid = \ρav ×v
Net force due to bounced back liquid,

$F_1 = 2 \times \left[\frac{1}{4}\rho a v^2\right]$

Net force due to stopped liquid, $F_2 = \frac{1}{4}\rho a v^2$

Total force,

$F = F_1 + F_2 = \frac{1}{2}\rho a v^2 + \frac{1}{4}\rho a v^2 = \frac{3}{4}\rho a v^2$

Net pressure $= \frac{3}{4}\rho v^2$

Question167

Water flows into a large tank with flat bottom at the rate of $10^{-4} m^3 s^{-(1)}$ Water is also leaking out of a hole of area $1 cm^2$ at its bottom. If the height of the water in the tank remains steady, then this height is:
[10 Jan. 2019 I]

Options:

A. 5.1cm

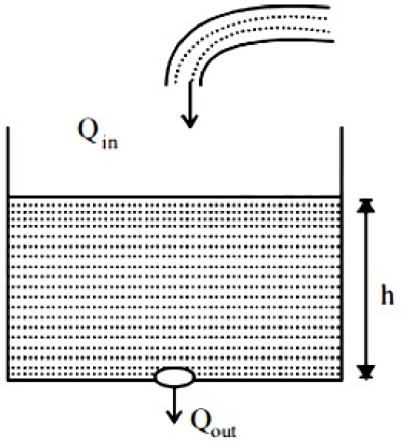
B. 7cm

D. 9cm

Answer: A

Solution:

Solution:



Since height of water column is constant therefore, water inflow rate (Q_{in})
= water outflow rate

$Q_{in} = 10^{-4} m^3 s^{-1}$

$Q_{out} = Au = 10^{-4} \times \sqrt{2gh}$

$\therefore 10^4 = 10^{-4} \times \sqrt{20 \times h}$

$\therefore h = \frac{1}{20} m = 5cm$

Question168

The top of a water tank is open to air and its water lavel is maintained. It is giving out $0.74m^3$ water per minute through a circular opening of 2 cm radius in its wall. The depth of the centre of the opening from the level of water in the tank is close to:
[9 Jan. 2019 (II)]

Options:

A. 6.0 m

B. 4.8 m

C. 9.6 m

D. 2.9 m

Answer: B

Solution:

Solution:
Here, volume tric flow rate

$= \frac{0.74}{60} = \pi r^2 v = (\pi \times 4 \times 10^{-4}) \times \sqrt{2gh}$

$\Rightarrow \sqrt{2gh} = \frac{74 \times 100}{\ldots} \Rightarrow \sqrt{2gh} = \frac{740}{\ldots}$

$\Rightarrow 2gh = \frac{740 \times 740}{24 \times 24 \times 10} (\because \pi^2 = 10)$
$\Rightarrow h = \frac{74 \times 74}{2 \times 24 \times 24} \approx 4.8 m$
i.e., The depth of the centre of the opening from the level of water in the tank is close to 4.8 m

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Question169

Two rods A and B of identical dimensions are at temperature 30°C. If A is heated upto 180°C and B upto T°C, then the new lengths are the same. If the ratio of the coefficients of linear expansion of A and B is 4 : 3, then the value of T is :
[11 Jan. 2019 II]

Options:

A. 230°C

B. 270°C

C. 200°C

D. 250°C

Answer: A

Solution:

Solution:
Change in length in both rods are same i.e.
$\Delta l_1 = \Delta l_2$
$l\alpha_1 \Delta\theta_1 = l\alpha_2 \Delta\theta_2$
$\frac{\alpha_1}{\alpha_2} = \frac{\Delta\theta_2}{\Delta\theta_1} \quad \left[\because \frac{\alpha_1}{\alpha_2} = \frac{4}{3}\right]$
$\frac{4}{3} = \frac{\theta - 30}{180 - 30}$
$[\theta = 230°C]$

Question170

A thermometer graduated according to a linear scale reads a value x_0 when in contact with boiling water, and $x_0 / 3$ when in contact with ice. What is the temperature of an object in °C, if this thermometer in the contact with the object reads $x_0 / 2$?
[11 Jan. 2019 II]

Options:

A. 25

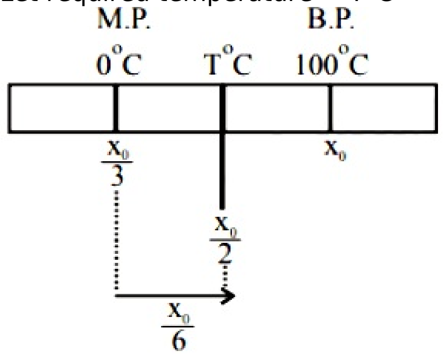
B. 60

D. 35

Answer: A

Solution:

Solution:
Let required temperature = T°C



$\Rightarrow T\,°C = \frac{x_0}{2} - \frac{x_0}{3} = \frac{x_0}{6}$

$\& \left(x_0 - \frac{x_0}{3} \right) = (100 - 0°C)$

$\Rightarrow \frac{2x_0}{3} = 100 \Rightarrow x_0 = \frac{300}{2}$

$\Rightarrow T\,°C = \frac{x_0}{6} = \frac{150}{6} = 25°C$

Question171

A rod, of length L at room temperature and uniform area of cross section A, is made of a metal having coefficient of linear expansion α / °C. It is observed that an external compressive force F , is applied on each of its ends, prevents any change in the length of the rod, when its temperature rises by ΔT K . Young's modulus, Y , for this metal is: [9 Jan. 2019 I]

Options:

A. $\frac{F}{A\alpha\Delta T}$

B. $\frac{F}{A\alpha(\Delta T - 273)}$

C. $\frac{F}{2A\alpha\Delta T}$

D. $\frac{2F}{A\alpha\Delta T}$

Answer: A

Solution:

Solution:
Young's modulus Y = stress ... F / A

$\alpha = \frac{\Delta l}{l\Delta T} \Rightarrow \frac{\Delta l}{l} = \alpha\Delta T$

$\therefore Y = \frac{F}{A(\alpha\Delta T)}$

Question172

A cylinder of radius R is surrounded by a cylindrical shell of inner radius R and outer radius 2R. The thermal conductivity of the material of the inner cylinder is K_1 and that of the outer cylinder is K_2. Assuming no loss of heat, the effective thermal conductivity of the system for heat flowing along the length of the cylinder is:
[12 Jan. 2019 I]

Options:

A. $\frac{K_1 + K_2}{2}$

B. $K_1 + K_2$

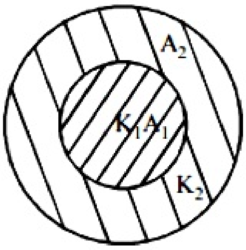
C. $\frac{2K_1 + 3K_2}{5}$

D. $\frac{K_1 + 3K_2}{4}$

Answer: D

Solution:

Solution:



Effective thermal conductivity of system

$$K_{eq} = \frac{K_1A_1 + K_2A_2}{A_1 + A_2}$$

$$= \frac{K_1\pi R^2 + K_2[\pi(2R)^2 - \pi R^2]}{\pi(2R)^2}$$

$$= \frac{K_1(\pi R^2) + K_2(3\pi R^2)}{4\pi R^2} = \frac{K_1 + 3K_2}{4}$$

Question173

Ice at –20°C is added to 50 g of water at 40°C, When the temperature of the mixture reaches 0°C, it is found that 20 g of ice is still unmelted. The amount of ice added to the water was close to

Specific heat of Ice = 2.1 J/g/°C
Heat of fusion of water at 0°C = 334J/g)
[11 Jan. 2019 I]

Options:

A. 50g

B. 100 g

C. 60 g

D. 40 g

Answer: D

Solution:

Solution:
Let m gram of ice is added.
From principal of calorimeter
heat gained (by ice) = heat lost (by water)
$\therefore 20 \times 2.1 \times m + (m - 20) \times 334$
$= 50 \times 4.2 \times 40$
$376m = 8400 + 6680$
$m = 40.1$

Question174

When 100 g of a liquid A at 100°C is added to 50 g of a liquid B at temperature 75°C, the temperature of the mixture becomes 90°C. The temperature of the mixture, if 100 g of liquid A at 100°C is added to 50 g of liquid B at 50°C, will be :
[11 Jan. 2019 II]

Options:

A. 85°C

B. 60°C

C. 80°C

D. 70°C

Answer: C

Solution:

Solution:
Heat loss = Heat gain $= mS\Delta\theta$
So, $m_A S_A \Delta\theta_A = m_B S_B \Delta\theta_B$
$\Rightarrow 100 \times S_A \times (100 - 90) = 50 \times S_B \times (90 - 75)$
$2S_A = 1.5S_B \Rightarrow S_A = \frac{3}{4}S_B$
Now, $100 \times S_A \times (100 - \theta) = 50 \times S_B \times (\theta - 50)$

$2 \times \left(\frac{3}{4}\right) \times (100 - \theta) = (\theta - 50)$
$300 - 3\theta = 2\theta - 100$
$400 = 5\theta \Rightarrow \theta = 80°C$

Question175

A metal ball of mass 0.1 kg is heated upto 500°C and dropped into a vessel of heat capacity 800 JK^{-1} and containing 0.5 kg water. The initial temperature of water and vessel is 30°C. What is the approximate percentage increment in the temperature of the water? [Specific Heat Capacities of water and metal are, respectively, 4200 $Jkg^{-1}K^{-1}$ and 400 $Jkg^{-1}K^{-1}$]
[11 Jan. 2019 II]

Options:

A. 15%

B. 30%

C. 25%

D. 20%

Answer: D

Solution:

Assume final temperature $= T\,°C$
= Heat gain $= ms\Delta T$
$\Rightarrow m_B s_B \Delta T_B = m_w s_w \Delta T_w$
$0.1 \times 400 \times (500 - T)$
$= 0.5 \times 4200 \times (T - 30) + 800(T - 30)$
$\Rightarrow 40(500 - T) = (T - 30)(2100 + 800)$
$\Rightarrow 20000 - 40T = 2900T - 30 \times 2900$
$\Rightarrow 20000 + 30 \times 2900 = T(2940)$
$T = 30.4°C$
$\frac{\Delta T}{T} \times 100 = \frac{6.4}{30} \times 100 = 21\%$
so the closest answer is 20%.

Question176

A heat source at $T = 10^3 K$ is connected to another heat reservoir at $T = 10^2 K$ by a copper slab which is 1m thick. Given that the thermal conductivity of copper is $0.1 W K^{-1} m^{-1}$, the energy flux through it in the steady state is:
[10 Jan. 2019 I]

Options:

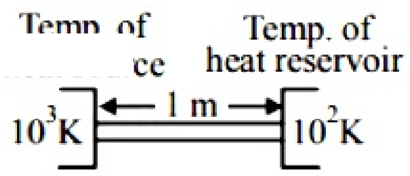
B. $120 W m^{-2}$

C. $65 W m^{-2}$

D. $200 W m^{-2}$

Answer: A

Solution:



$$\left(\frac{dQ}{dt}\right) = \frac{kA\Delta T}{l}$$

Energy flux, $\frac{1}{A}\left(\frac{dQ}{dt}\right) = \frac{k\Delta T}{l}$

$$= \frac{(0.1)(900)}{1} = 90 W / m^2$$

Question177

An unknown metal of mass 192 g heated to a temperature of 100°C was immersed into a brass calorimeter of mass 128 g containing 240 g of water at a temperature of 8.4°C.Calculate the specific heat of the unknown metal if water temperature stablizes at 21.5°C. (Specific heat of brass is $394 J kg^{-1} K^{-1}$)
[10 Jan. 2019 II]

Options:

A. $458 J kg^{-1} K^{-1}$

B. $1232 J kg^{-1} K^{-1}$

C. $916 J kg^{-1} K^{-1}$

D. $654 J kg^{-1} K^{-1}$

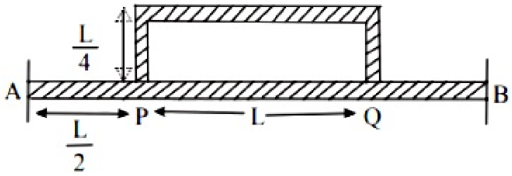
Answer: C

Solution:

Solution:
Let specific heat of unknown metal be ‘s’ According to principle of calorimetry, Heat lost
$= $ Heat gain $m \times s\Delta\theta = m_1 s_{brass} (\Delta\theta_1 + m_2 S_{water} + \Delta\theta_2)$
$\Rightarrow 192 \times S \times (100 - 21.5)$
$= 128 \times 394 \times (21.5 - 8.4)$
Solving we get, $+240 \times 4200 \times (21.5 - 8.4)$
$S = 916 J kg^{-1} k^{-1}$

Question178

Temperature difference of 120°C is maintained between two ends of a uniform rod AB of length 2L. Another bent rod PQ, of same cross-section as AB and length $\frac{3L}{2}$, is connected across AB (See figure). In steady state, temperature difference between P and Q will be close to:



[9 Jan. 2019 I]

Options:

A. 45°C

B. 75°C

C. 60°C

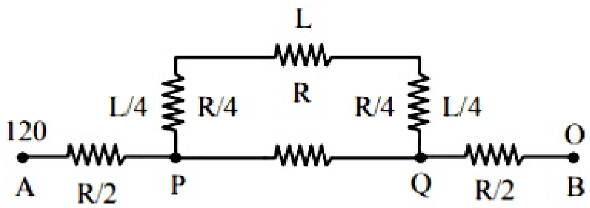
D. 35°C

Answer: A

Solution:

Solution:

$\frac{\Delta T_{AB}}{R_{AB}} = \frac{120}{85R} = \frac{120 \times 5}{8R}$



In steady state temperature difference between P and Q,

$\Delta T_{PQ} = \frac{120 \times 5}{8R} \times \frac{3}{5}R = \frac{360}{8} = 45°C$

Question179

A uniform cylindrical rod of length L and radius r, is made from a material whose Young's modulus of Elasticity equals Y. When this ı heated by temperature T and simultaneously subjected to a net longitudinal compressional force F, its length remains unchanged. coefficient of volume expansion, of the material of the rod, is (near equal to :

[12 April 2019 II]

B. $6F / (\pi r^2 Y T)$

C. $3F / (\pi r^2 Y T)$

D. $F / (3\pi r^2 Y T)$

Answer: C

Solution:

Solution:

$\Delta_{temp} = \Delta_{force}$

or $L\alpha(\Delta T) = \frac{F L}{AY} \therefore \alpha = \frac{F L}{AY T} = \frac{F}{\pi r^2 Y T}$

Coefficient of volume expression

$r = 3\alpha = \frac{3F}{\pi r^2 Y T}$.

Question180

In an environment, brass and steel wires of length 1m each with areas of cross section 1mm^2 are used. The wires are connected in series and one end of the combined wire is connected to a rigid support and other end is subjected to elongation. The stress required to produce a net elongation of 0.2mm is,
[Given, the Young's modulus for steel and brass are, respectively, $120 \times 10^9 N / m^2$ and $60 \times 10^9 N m^2$]
[10 April 2019 II]

Options:

A. $1.2 \times 10^6 N / m^2$

B. $4.0 \times 10^6 N / m^2$

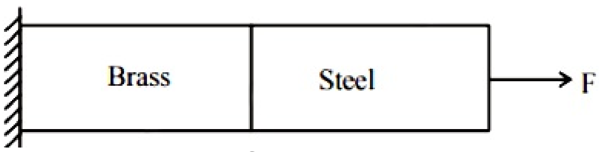
C. $1.8 \times 10^6 N / m^2$

D. $8 \times 10^6 N / m^2$

Answer: D

Solution:

Solution:



Young modulus, Y $= \frac{\text{Stress}}{\left(\frac{\Delta l}{L}\right)}$

Let σ be the stress

Total elongation Δl = σL_1 + σL_2

$\Delta l_{net} = \sigma\left[\frac{1}{Y_1} + \frac{1}{Y_2}\right][\because L_1 = L_2 = 1m]$

$\sigma = \Delta l\left(\frac{Y_1 Y_2}{Y_1 + Y_2}\right)$

$= 0.2 \times 10^{-3} \times \left(\frac{120 \times 60}{180}\right) \times 10^9 = 8 \times 10^6 \frac{N}{m^2}$

Question181

The elastic limit of brass is 379 MPa. What should be the minimum diameter of a brass rod if it is to support a 400 N load without exceeding its elastic limit? [10 April 2019 II]

Options:

A. 1.00 mm

B. 1.16 mm

C. 0.90 mm

D. 1.36 mm

Answer: B

Solution:

Solution:

Stress $= \frac{F}{A} = \frac{400 \times 4}{\pi d^2} = 379 \times 10^6 N / m^2$

$\Rightarrow d^2 = 400 \times 4379 \times 10^6 \pi$

$d = 1.15mm$

Question182

A steel wire having a radius of 2.0mm, carrying a load of 4kg, is hanging from a ceiling. Given that g = 3.1Ams^{-2}, what will be the tensile stress that would be developed in the wire? [9 April 2019 I]

Options:

A. $6.2 \times 10^6 N m^{-2}$

B. $5.2 \times 10^6 N m^{-2}$

C. $3.1 \times 10^6 N m^{-2}$

D. $4.8 \times 10^6 N m^{-2}$

Answer: C

Solution:

Solution:
Given,
Radius of wire, $r = 2mm$
Mass of the load $m = 4kg$
Stress $= \frac{F}{A} = \frac{mg}{\pi(r)^2}$
$= \frac{4 \times 3.1\pi}{\pi \times (2 \times 10^{-3})^2} = 3.1 \times 10^6 N / m^2$

Question183

A steel wire having a radius of 2.0mm, carrying a load of 4kg, is hanging from a ceiling. Given that $g = 3.1A ms^{-2}$, what will be the tensile stress that would be developed in the wire?
[8 April 2019 I]

Options:

A. $6.2 \times 10^6 N m^{-2}$

B. $5.2 \times 10^6 N m^{-2}$

C. $3.1 \times 10^6 N m^{-2}$

D. $4.8 \times 10^6 N m^{-2}$

Answer: C

Solution:

Solution:
Given,
Radius of wire, $r = 2mm$
Mass of the load $m = 4kg$
Stress $= \frac{F}{A} = \frac{mg}{\pi(r)^2} = \frac{4 \times 3.1\pi}{\pi \times (2 \times 10^{-3})^2} = 3.1 \times 10^6 N / m^2$

Question184

Young's moduli of two wires A and B are in the ratio 7 : 4.
Wire A is 2 m long and has radius R. Wire B is 1.5 m long and has radius 2 mm. If the two wires stretch by the same length for a given load, then the value of R is close to :
[8 April 2019 II]

Options:

A. 1.5 mm

C. 1.7 mm

D. 1.3 mm

Answer: C

Solution:

Solution:
$\Delta_1 = \Delta_2$

or $\frac{F l_1}{\pi r_1^2 y_1} = \frac{F l_2}{\pi r_2^2 y_2}$ or $\frac{2}{R^2 \times 7} = \frac{1.5}{2^2 \times 4}$

$\therefore R = 1.75mm$

Question185

A boy's catapult is made of rubber cord which is 42 cm long, with 6 mm diameter of cross-section and of negligible mass. The boy keeps a stone weighing 0.02 kg on it and stretches the cord by 20 cm by applying a constant force.
When released, the stone flies off with a velocity of 20 ms^{-1} . Neglect the change in the area of cross-section of the cord while stretched. The Young's modulus of rubber is closest to :
[8 April 2019 I]

Options:

A. $10^6 N / m^{-2}$

B. $10^4 N / m^{-2}$

C. $10^8 N / m^{-2}$

D. $10^3 N / m^{-2}$

Answer: A

Solution:

When a catapult is stretched up to length l, then the stored energy in it $= \Delta k.E \Rightarrow$

$(\Delta I)^2 = \frac{1}{2}mv^2 \Rightarrow y = \frac{mv^2 L}{\Delta(\Delta l)^2}$

$m = 0.02kg$
$v = 20ms^{-1}$
$L = 0.42m$
$A = (\pi d^2) / (4)$
$d = 6 \times 10^{-3}m$
$\Delta l = 0.2m$
$y = \frac{0.02 \times 400 \times 0.42 \times 4}{\pi \times 36 \times 10^{-6} \times 0.04} = 2.3 \times 10^6 N / m^2$
So, order is 10^6.

Question186

A cubical block of side 0.5m floats on water with 30% of its volume under water. What is the maximum weight that can be put on the block without fully submerging it under water? [Take, density of water left. = $10^3 kg / m^3$]
[10 April 2019(II)]

Options:

A. 46.3kg

B. 87.5kg

C. 65.4kg

D. 30.1kg

Answer: B

Solution:

Solution:
When a body floats then the weight of the body =upthrust
$\therefore (50)^3 \times \frac{30}{100} \times (1) \times g = M_{cube} g$
Let m mass should be placed, then
$(50)^3 \times (1) \times g = (M_{cube} + m)g$ ......(ii)
Subtracting equation (i) from equation (ii), we get
$\Rightarrow mg = (50)^3 \times g(1 - 0.3) = 125 \times 0.7 \times 10^3 g$
$\Rightarrow m = 87.5kg$

Question187

A submarine experiences a pressure of $5.05 \times 10^6 Pa$ at depth of d_1 in a sea. When it goes further to a depth of d_2, it experiences a pressure of 8.08 times 10^6 Pa. Then $d_1 - d_1$ is approximately (density of water $= 10^3 kg / m^3$ and acceleration due to gravity $= 10 ms^{-2}$):
[10 April 2019 (II)]

Options:

A. 300m

B. 400m

C. 600m

D. 500m

Answer: A

Solution:

Solution:
$P_1 = P_0 + \rho g d_1$
$P_2 = P_0 + \rho g d_2$
$\Delta P = P_2 - P_1 = \rho g \Delta d$
$3.03 \times 10^6 = 10^3 \times 10 \times \Delta d$
$\Rightarrow \Delta d \simeq 300 m$

Question188

A wooden block floating in a bucket of water has $\frac{4}{5}$ of its volume submerged. When certain amount of an oil poured into the bucket, it is found that the block is just under the oil surface with half of its volume under water and half in oil. The density of oil relative to that of water is: [9 April 2019 (II)]

Options:

A. 0.5

B. 0.8

C. 0.6

D. 0.7

Answer: C

Solution:

Solution:
$M g = \left(\frac{4V}{5}\right) \rho \omega g$
or $\left(\frac{M}{V}\right) = \frac{4\rho\omega}{5}$ or $\rho = \frac{4\rho\omega}{5}$
When block floats fully in water and oil, then
$M g = F_{b_1} + F_{b_2}$
$(\rho V) g = \left(\frac{V}{2}\right) \rho_{oil} g + \frac{V}{2} \rho \omega g$
or $\rho_{oil} = \frac{3}{5} \rho \omega = 0.6 \rho \omega$

Question189

**Water from a tap emerges vertically downwards with an initial speed of $1.0 ms^{-1}$. The cross-sectional area of the tap is $10^{-4} m^2$. Assume that the pressure is constant throughout the stream of water and that the flow is streamlined. The cross-sectional area of the stream, 0.15m below the tap would be : [Take $g = 10 ms^{-2}$)]
[10 April 2019 (II)]**

Options:

B. $5 \times 10^{-5} m^2$

C. $5 \times 10^{-4} m^2$

D. $1 \times 10^{-5} m^2$

Answer: B

Solution:

Solution:
Using Bernoullie's equation
$P + \frac{1}{2}(v_1^2 - v_2^2) + \rho gh = P$
$\Rightarrow v_2^2 = v_1^2 + 2gh$
$\Rightarrow v_2 = \sqrt{v_1^2 + 2gh}$
Equation of continuity
$A_1 v_1 = A_2 v_2$
$(1cm^2)(1m / s) = (A_2)\left(\sqrt{(1)^2 + 2 \times 10 \times \frac{15}{100}}\right)$
$10^{-4} \times 1 = A_2 \times 2$
$\therefore A_2 = \frac{10^{-4}}{2} = 5 \times 10^{-5} m^2$

Question190

Water from a pipe is coming at a rate of 100 liters per minute. If the radius of the pipe is 5cm, the Reynolds number for the flow is of the order of: (density of water = $1000 kg / m^3$, coefficient of viscosity of water = 1mPas)
[8 April 2019 I]

Options:

A. 10^3

B. 10^4

C. 10^2

D. 10^6

Answer: B

Solution:

Solution:
Rate of flow of water (V) = 100 lit / min
$= \frac{100 \times 10^{-3}}{60} \times \frac{5}{3} \times 10^{-3} m^3$
$\therefore$ Velocity of flow of water (v) $= \frac{V}{A} = \frac{5 \times 10^{-3}}{3 \times (5 \times 10^{-2})^2}$
$= \frac{10}{15\pi} = \frac{2}{3\pi} m / s$

∴ Reynold number $(N_R) = \frac{Dv\rho}{\eta}$

$$= \frac{(10 \times 10^{-2}) \times \frac{2}{3\pi} \times 1000}{1} = 2 \times 10^4$$

Order of $N_R = 10^4$

Question191

A solid sphere, of radius R acquires a terminal velocity v when falling (due to gravity) through a viscous fluid having a coefficient of viscosity η. The sphere is broken into 27 identical solid spheres. If each of these spheres acquires a terminal velocity, v_2, when falling through the same fluid, the ratio (v_1 / v_2) equals:
[12 April 2019 (II)]

Options:

A. 9

B. 1/27

C. 1/9

D. 27

Answer: A

Solution:

$27 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi r^3$

or $r = R / 3.$

Terminal velocity, $v \propto r^2$

$$\therefore \frac{v_1}{v_2} = \frac{{r_1}^2}{{r_2}^2}$$

$$\text{or } v_2 = \left(\frac{r_2}{r_1}\right)^2 v_1 = \left(\frac{R/3}{R}\right)^2 v_1 = \frac{1}{9}$$

$$\text{or } \frac{v_1}{v_2} = 9$$

Question192

The ratio of surface tensions of mercury and water is given to be 7.5 while the ratio of their densities is 13.6 . Their contact angles, with glass, are close to 135° and 0°, respectively. It is observed that mercury gets depressed by an amount h in a capillary tube of radius r_1, while water rises by the same amount h in a capillary tube of radius r_2. The ratio, (r_1 / r_2), is then close to :

Options:

A. 4 / 5

B. 2 / 5

C. 3 / 5

D. 2 / 3

Answer: B

Solution:

Solution:
As we know that
$\frac{2T\cos\theta}{r\rho g} = R_h$
$\frac{T_{Hg}}{T_{Water}} = 7.5$
$\frac{\rho_{Hg}}{\rho_W} = 13.6$ & $\frac{\cos\theta_{Hg}}{\cos\theta_W} = \frac{\cos 135°}{\cos 0°} = \frac{1}{\sqrt{2}}$
$\frac{R_{Hg}}{R_{Water}} = \left(\frac{T_{Hg}}{T_W}\right)\left(\frac{\rho_W}{\rho_{Hg}}\right)\left(\frac{\cos\theta_{Hg}}{\cos\theta_W}\right)$
$= 7.5 \times \frac{1}{13.6} \times \frac{1}{\sqrt{2}} = 0.4 = \frac{2}{5}$

Question193

If ' M ' is the mass of water that rises in a capillary tube of radius 'r', then mass of water which will rise in a capillary tube of radius '2r' is: [9 April 2019 I]

Options:

A. M

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

C. 4M

D. 2M

Answer: D

Solution:

Solution:
We have, $h = \frac{2T\cos\theta}{r\rho g}$
Mass of the water in the capillary
$m = \rho V = \rho \times \pi r^2 h = \rho \times \pi r^2 \times \frac{2T\cos\theta}{r\rho g}$
$\Rightarrow m \propto r$
$\therefore \frac{m_1}{m_2} = \frac{r}{2r}$

Question194

At 40°C, a brass wire of 1 mm radius is hung from the ceiling. A small mass, M is hung from the free end of the wire. When the wire is cooled down from 40°C to 20°C it regains its original length of 0.2 m. The value of M is close to:
(Coefficient of linear expansion and Young's modulus of brass are 10^{-5} / °C and 10^{11}N / m^2, respectively ;g = $10ms^{-2}$)
[12 April 2019 I]

Options:

A. 9 kg

B. 6.28 kg

C. 1.5 kg

D. 0.9 kg

Answer: B

Solution:

Solution:
$\Delta_{temp} = \Delta_{load}$ and $A = \pi r^2 = \pi(10^{-3})^2 = \pi \times 10^{-6}$
$L \propto \Delta T = \frac{F L}{AY}$
or $0.2 \times 10^{-5} \times 20 = \frac{F \times 0.2}{(\pi \times 10^{-6}) \times 10^{11}}$
$F = 20\pi N \therefore m = \frac{f}{g} = 2\pi = 6.28kg$

Question195

When M_1 gram of ice at −10°C (Specific heat = 0.5 cal $g^{-10}C^{-1}$) is added to M_2 gram of water at 50°C, finally no ice is left and the water is at 0°C. The value of latent heat of ice, in cal g^{-1} is:
[12 April 2019 I]

Options:

A. $\frac{50M_2}{M_1} - 5$

B. $\frac{5M_1}{M_2} - 50$

C. $\frac{50M_2}{M_1}$

D. $\frac{5M_2}{M_1} - 5$

Answer: A

Solution:

Solution:
$M_1 C_{ice} \times (10) + M_1 L = M_2 C_{\omega}(50)$
or $M_1 \times C_{ice}(= 0.5) \times 10 + M_1 L = M_2 \times 1 \times 50$
$\Rightarrow L = \frac{50M_2}{M_1} - 5$

Question196

A massless spring (K = 800N / m), attached with a mass (500g) is completely immersed in 1kg of water. The spring is stretched by 2cm and released so that it starts vibrating. What would be the order of magnitude of the change in the temperature of water when the vibrations stop completely? (Assume that the water container and spring receive negligible heat and specific heat of mass = 400J / kgK specific heat of water = 4184J / kgK)
[9 April 2019 II]

Options:

A. 10^{-4}K

B. 10^{-5}K

C. 10^{-1}K

D. 10^{-3}K

Answer: B

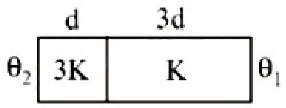
Solution:

Solution:
$\frac{1}{2} . kx^2 = mC(\Delta T) + m_{\omega} C_{\omega} \Delta T$
or $\frac{1}{2} \times 800 \times 0.02^2 = 0.5 \times 400 \times \Delta T + 1 \times 4184 \times \Delta T$
$\therefore \Delta T = 1 \times 10^{-5}$K

Question197

Two materials having coefficients of thermal conductivity 3K ' and ' K ' and thickness ' d ' and ' 3d ', respectively, are joined to form a slab as shown in the figure. The temperatures of the outer surfaces are ' θ_2 '

and ' θ_1 ' respectively, ($\theta_2 > \theta_1$). The temperature at the interface is:



[9 April 2019 II]

Options:

A. $\frac{\theta_1}{10} + \frac{9\theta_2}{10}$

B. $\frac{\theta_2 + \theta_1}{2}$

C. $\frac{\theta_1}{6} + \frac{5\theta_2}{6}$

D. $\frac{\theta_1}{3} + \frac{2\theta_2}{3}$

Answer: A

Solution:

Solution:
$H_1 = H_2$

or $(3k)A\left(\frac{\theta_2 - \theta}{d}\right) = kA\left(\frac{\theta - \theta_1}{3d}\right)$

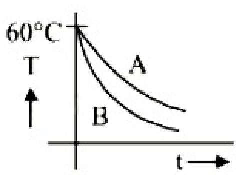
or $\theta = \left(\frac{\theta_1 + 9\theta_2}{10}\right)$

Question198

Two identical beakers A and B contain equal volumes of two different liquids at 60°C each and left to cool down.
Liquid in A has density of 8×10^2 kg/m^3 and specific heat of 2000 J kg^{-1} K^{-1} while liquid in B has density of 10^3 kg m^{-3}and specific heat of 4000 J kg^{-1} K^{-1}. Which of the following best describes their temperature versus time graph schematically ? (assume the emissivity of both the beakers to be the same)
[8 April 2019 I]

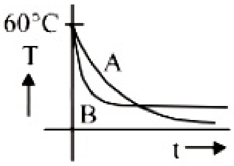
Options:

A.

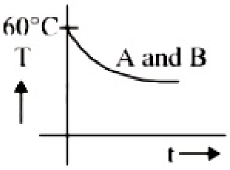


B.

C.



D.



Answer: B

Solution:

Solution:

Rate of Heat loss $= mS\left(\frac{dT}{dt}\right) = e\sigma AT^4$

$-\frac{dT}{dt} = \frac{e\sigma \times A \times T^4}{\rho \times Vol. \times S} \Rightarrow -\frac{dT}{dt} \propto \frac{1}{\rho S}$

$\frac{\left(-\frac{dT}{dt}\right)_A}{\left(-\frac{dT}{dt}\right)_B} = \frac{\rho_B}{\rho_A} \times \frac{S_B}{S_A} = \frac{10^3}{8 \times 10^2} \times \frac{4000}{2000}$

$\Rightarrow \left(-\frac{dT}{dt}\right)_A > \left(-\frac{dT}{dt}\right)_B$

So, A cools down at faster rate

Question199

A body takes 10 minutes to cool from 60°C to 50°C. The temperature of surroundings is constant at 25°C. Then, the temperature of the body after next 10 minutes will be approximately
[Online April 15, 2018]

Options:

A. 43°C

B. 47°C

C. 41°C

D. 45°C

Answer: A

According to Newton's law of cooling,

$$\left(\frac{\theta_1-\theta_2}{t}\right)=K\left(\frac{\theta_1+\theta_2}{2}-\theta_0\right)$$

$$\left(\frac{60-50}{10}\right)=K\left(\frac{60+50}{2}-25\right)\text{ ....(i)}$$

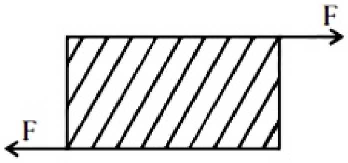
and, $\left(\frac{50-\theta}{10}\right)=K\left(\frac{50+\theta}{2}-25\right)$ ....(ii)

Dividing eq. (i) by (ii),

$$\frac{10}{(50-\theta)}=\frac{60}{\theta}\Rightarrow\theta=42.85°C\cong 43°C$$

Question200

As shown in the figure, forces of 10^5N each are applied in opposite directions, on the upper and lower faces of a cube of side 10cm, shifting the upper face parallel to itself by 0.5cm. If the side of another cube of the same material is, 20cm, then under similar conditions as above, the displacement will be:



[Online April 15, 2018]

Options:

A. 1.00cm

B. 0.25cm

C. 0.37cm

D. 0.75cm

Answer: B

Solution:

Solution:

For same material the ratio of stress to strain is same For first cube Stress $_1=\frac{\text{force }_1}{\text{area}_1}=\frac{10^5}{(0.1^2)}$

Strain $_1=\frac{\text{change in length }_1}{\text{original length }_1}=\frac{0.5\times10^{-2}}{0.1}$

For second block,

stress $_2=\frac{\text{force }_2}{\text{area }_2}=\frac{10^5}{(0.2^2)}$

$\text{strain}_2=\frac{\text{change in length }_2}{\text{original length }_2}=\frac{x}{0.2}$

x is the displacement for second block.

For same material, $\frac{\text{stress}_1}{\text{strain }_1}=\frac{\text{stress}_2}{\text{strain}_2}$

or, $\frac{\frac{10.5}{(0.1)^2}}{\frac{0.5\times10^{-2}}{0.1}}=\frac{\frac{10^5}{(0.2)^2}}{\frac{x}{0.2}}$

Question201

A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area a floats on the surface of the liquid, covering entire cross-section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere $\left(\frac{dr}{r}\right)$, is:

[2018]

Options:

A. $\frac{Ka}{mg}$

B. $\frac{Ka}{3mg}$

C. $\frac{mg}{3Ka}$

D. $\frac{mg}{Ka}$

Answer: C

Solution:

Solution:

Bulk modulus, $K = \frac{\text{volumetric stress}}{\text{volumetric strain}}$

$K = \frac{mg}{a\left(\frac{dV}{V}\right)}$

$\Rightarrow \frac{dV}{V} = \frac{mg}{Ka}$........(i)

volume of sphere, $V = \frac{4}{3}\pi R^3$

Fractional change in volume $\frac{dV}{V} = \frac{3dr}{r}$ ....(ii)

Using eq. (i) &(ii)

$\frac{3dr}{r} = \frac{mg}{Ka}$

$\therefore \frac{dr}{r} = \frac{mg}{3Ka}$ (fractional decrement in radius)

Question202

A thin uniform tube is bent into a circle of radius r in the vertical plane. Equal volumes of two immiscible liquids, whose densities are ρ_1 and $\rho_1(\rho_1 > \rho_2)$ fill half the circle. The angle θ between the radius vector passing through the common interface and the vertical is

[Online April 15, 2018]

Options:

A. $\theta = \tan^{-1}\left[\frac{\pi}{2}\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right)\right]$

B. $\theta = \tan^{-1}\frac{\pi}{2}\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right)$

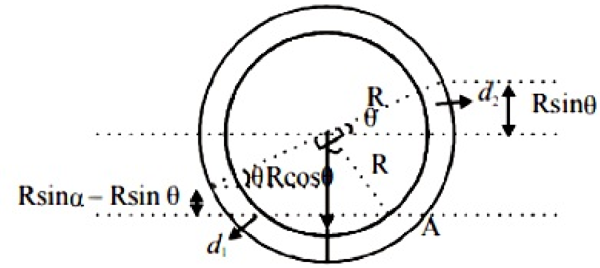
C. $\theta = \tan^{-1}\pi\left(\frac{\rho_1}{\rho_2}\right)$

D. None of above

Answer: D

Solution:

Solution:
Pressure at interface A must be same from both the sides to be in equilibrium.



$\therefore (R\cos\theta + R\sin\theta)\rho_2 g = (R\cos\theta - R\sin\theta)\rho_1 g$

$\Rightarrow \frac{d_1}{d_2} = \frac{\cos\theta + \sin\theta}{\cos\theta - \sin\theta} = \frac{1 + \tan\theta}{1 - \tan\theta}$

$\Rightarrow \rho_1 - \rho_1\tan\theta = \rho_2 + \rho_2\tan\theta$

$\Rightarrow (\rho_1 + \rho_2)\tan\theta = \rho_1 - \rho_2$

$\therefore \theta = \tan^{-1}\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right)$

Question203

When an air bubble of radius r rises from the bottom to the surface of a lake, its radius becomes $\frac{5r}{4}$. Taking the atmospheric pressure to be equal to 10m height of water column, the depth of the lake would approximately be (ignore the surface tension and the effect of temperature):
[Online April 15, 2018]

Options:

A. 10.5m

B. 8.7m

C. 11.2m

D. 9.5m

Solution:

Solution:
Using $P_1V_1 = P_2V_2$
$(P_1)\frac{4}{3}\pi r^3 = (P_2)\frac{4}{3}\pi\frac{125r^3}{64}$
$\frac{\rho g(10) + \rho gh}{\rho g(10)} = \frac{125}{64}$
$640 + 64h = 1250$
On solving we get $h = 9.5m$

Question204

Two tubes of radii r_1 and r_2, and lengths l_1 and l_2, respectively, are connected in series and a liquid flows through each of them in streamline conditions. P_1 and P_2 are pressure differences across the two tubes. If P_2 is $4P_1$ and l_2 is $\frac{l_1}{4}$, then the radius r_2 will be equal to: [Online April 9, 2017]

Options:

A. r_1

B. $2r_1$

C. $4r_1$

D. $\frac{r_1}{2}$

Answer: D

Solution:

The volume of liquid flowing through both the tubes i.e., rate of flow of liquid is same.
$\therefore V = V_1 = V_2$
i.e., $\frac{\pi P_1 r_1^4}{8\eta l_1} = \frac{\pi P_2 r_2^4}{8\eta l_2}$
Or $\frac{P_1 r_1^4}{l_1} = \frac{P_2 r_2^4}{l_2}$
$\because P_2 = 4P_1$ and $l_2 = l_1 / 4$
$\frac{P_1 r_1^4}{l_1} = \frac{4P_1 r_2^4}{l_1 / 4} \Rightarrow r_2^4 = \frac{r_1^4}{16}$
$r_2 = r_1 / 2$

Question205

An external pressure P is applied on a cube at 0°C so that it is equally compressed from all sides. K is the bulk modulus of the material of the

cube and alpha is its coefficient of linear expansion. Suppose we want to bring the cube to its original size by heating. The temperature should be raised by:
[2017]

Options:

A. $\frac{3\alpha}{PK}$

B. $3PK\alpha$

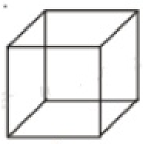
C. $\frac{P}{3\alpha K}$

D. $\frac{P}{\alpha K}$

Answer: C

Solution:

Solution:



As we know, Bulk modulus

$$K = \frac{\Delta P}{\left(\frac{-\Delta V}{V}\right)} \Rightarrow \frac{\Delta V}{V} = \frac{P}{K}$$

$$V = V_0(1 + \gamma\Delta t)$$

$$\frac{\Delta V}{V_0} = \gamma\Delta t$$

$$\therefore \frac{P}{K} = \gamma\Delta t \Rightarrow \Delta t = \frac{P}{\gamma K} = \frac{P}{3\alpha K}$$

Question206

A steel rail of length 5m and area of cross-section 40 cm^2 is prevented from expanding along its length while the temperature rises by 10°C. If coefficient of linear expansion and Young's modulus of steel are $1.2 \times 10^{-5} K^{-1}$ and $2 \times 10^{11} N\,m^{-2}$ respectively, the force developed in the rail is approximately:
[Online April 9,2017]

Options:

A. $2 \times 10^7 N$

B. $1 \times 10^5 N$

C. $2 \times 10^9 N$

D. $3 \times 10^{-5} N$

Answer: B

Solution:

Solution:

Young's modulus $= \frac{\text{Thermal stress}}{\text{Strain}} = \frac{F / A}{\Delta L / L}$

$Y = \frac{F}{A \cdot \alpha \cdot \Delta\theta} \left(Q \frac{\Delta L}{L} = \alpha \Delta\theta \right)$

Force developed in the rail $F = Y A \alpha \Delta t$

$= 2 \times 10^{11} \times 40 \times 10^{-4} \times 1.2 \times 10^{-5} \times 10$

$= 9.6 \times 10^{4} = 1 \times 10^{5} N$

Question207

A compressive force, F is applied at the two ends of a long thin steel rod. It is heated, simultaneously, such that its temperature increases by ΔT. The net change in its length is zero. Let l be the length of the rod, A its area of cross-section, Y its Young's modulus, and α its coefficient of linear expansion. Then, F is equal to :
[Online April 8,2017]

Options:

A. $l^{2} Y \alpha \Delta T$

B. $l A Y \alpha \Delta T$

C. $A Y \alpha \Delta T$

D. $\frac{AY}{\alpha \Delta T}$

Answer: C

Solution:

Solution:
Due to thermal exp., change in length $(\Delta l) = l \alpha \Delta T$ ......(i)

Young's modulus (Y) $= \frac{\text{Normal stress}}{\text{Longitudinal strain}}$

$Y = \frac{F / A}{\Delta l / l} \Rightarrow \frac{\Delta l}{l} = \frac{F}{AY}$

$\Delta l = \frac{F l}{AY}$

From eq $^{n}(i)$, $\frac{F l}{AY} = l \alpha \Delta T$

$F = AY \alpha \Delta T$

Question208

A copper ball of mass 100 gm is at a temperature T. It is dropped in a copper calorimeter of mass 100 gm, filled with 170 gm of water at room

be 75°C. T is given by (Given : room temperature = 30° C, specific heat of copper = 0.1 cal/gm°C
[2017]

Options:

A. 1250°C

B. 825°C

C. 800°C

D. 885° C

Answer: D

Solution:

Solution:
According to principle of calorimetry,
Heat lost = Heat gain
$100 \times 0.1(T - 75) = 100 \times 0.1 \times 45 + 170 \times 1 \times 45$
$10T - 750 = 450 + 7650 = 8100$
$\Rightarrow T - 75 = 810$
$T = 885°C$

Question209

In an experiment a sphere of aluminium of mass 0.20 kg is heated upto 150°C. Immediately, it is put into water of volume 150 cc at 27°C kept in a calorimeter of water equivalent to 0.025 kg. Final temperature of the system is 40°C. The specific heat of aluminium is :
(take 4.2 Joule=1 calorie)
[Online April 8, 2017]

Options:

A. 378 J/kg – °C

B. 315 J/kg – °C

C. 476 J/kg – °C

D. 434 J/kg – °C

Answer: D

Solution:

Solution:
According to principle of calorimetry,
$Q_{given} = Q_{used}$
$0.2 \times S \times (150 - 40) = 150 \times 1 \times (40 - 27) + 25 \times (40 - 27)$
$0.2 \times S \times 110 = 150 \times 13 + 25 \times 13$
Specific heat of aluminium

Question210

A thin 1m long rod has a radius of 5mm. A force of $50\pi kN$ is applied at one end to determine its Young's modulus. Assume that the force is exactly known. If the least count in the measurement of all lengths is 0.01mm, which of the following statements is false ?
[Online April 10, 2016]

Options:

A. The maximum value of Y that can be determined is $2 \times 10^{14} N / m^2$

B. $\frac{\Delta Y}{Y}$ gets minimum contribution from the uncertainty in the length

C. $\frac{\Delta Y}{Y}$ gets its maximum contribution from the uncertainty in strain

D. The figure of merit is the largest for the length of the rod.

Answer: A

Solution:

Solution:

Young's modulus $Y = \frac{F}{A} / \frac{\Delta l}{l}$

$Y = \frac{F l}{\pi r^2 \Delta l}$

Given, radius $r = 5mm$, force $F = 50\pi kN$,

$\frac{l}{\Delta l} = 0.01mm$

$\therefore Y = \frac{F}{\pi r^2} \frac{l}{\Delta l} = 2 \times 10^{14} N / m^2$

Question211

A uniformly tapering conical wire is made from a material of Young's modulus Y and has a normal, unextended length L. The radii, at the upper and lower ends of this conical wire, have values R and 3R, respectively. The upper end of the wire is fixed to a rigid support and a mass M is suspended from its lower end. The equilibrium extended length, of this wire, would equal :
[Online April 9, 2016]

Options:

A. $L\left(1 + \frac{2}{9} \frac{M g}{\pi Y R^2}\right)$

B. $L\left(1 + \frac{1}{9} \frac{M g}{\pi Y R^2}\right)$

C. $L\left(1+\frac{1}{3}\frac{Mg}{\pi Y R^2}\right)$

D. $L\left(1+\frac{2}{3}\frac{Mg}{\pi Y R^2}\right)$

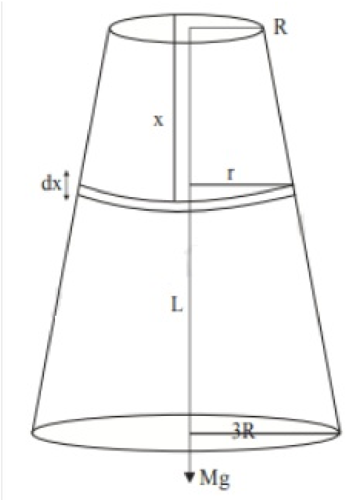
Answer: C

Solution:

Solution:

Consider a small element dx of radius r,

$r = \frac{2R}{L}x + R$



At equilibrium change in length of the wire

$\int_0^1 dL = \int \frac{Mgdx}{\pi\left[\frac{2R}{L}x+R\right]^2 y}$

Taking limit from 0 to L

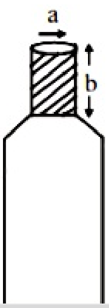
$\Delta L = \frac{Mg}{\pi y}\left[-\frac{1}{\left[\frac{2Rx}{L}+R\right]_0^L} \times \frac{L}{2R}\right] = \frac{MgL}{3\pi R^2 y}$

The equilibrium extended length of wire $= L + \Delta L$

$= L + \frac{MgL}{3\pi R^2 Y} = L\left(1+\frac{1}{3}\frac{Mg}{\pi Y R^2}\right)$

Question212

A bottle has an opening of radius a and length b. A cork of length b and radius (a + Δa) where (Δa < < a) is compressed to fit into the opening completely (see figure). If the bulk modulus of cork is B and frictional coefficient between the bottle and cork is m then the force needed to push the cork into the bottle is :



Options:

A. $(\pi\mu Bb)a$

B. $(2\pi\mu Bb)\Delta a$

C. $(\pi\mu Bb)\Delta a$

D. $(4\pi\mu Bb)\Delta a$

Answer: D

Solution:

Solution:

Stress $= \frac{\text{Normal force}}{\text{Area}} = N\,A = \frac{N}{(2\pi a)b}$

Stress $= B \times$ strain

$\frac{N}{(2\pi a)b} = B\frac{2\pi a\Delta a \times b}{\pi a^2 b}$

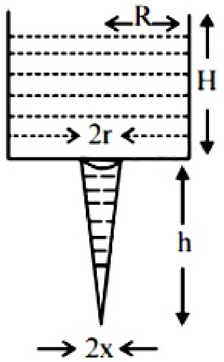
$\Rightarrow N = B\frac{(2\pi a)^2 \Delta a b^2}{\pi a^2 b}$

Force needed to push the cork.

$f = \mu N = \mu 4\pi b\Delta a B = (4\pi\mu Bb)\Delta a$

Question213

Consider a water jar of radius R that has water filled up to height H and is kept on a stand of height h (see figure). Through a hole of radius r (r < < R) at its bottom, the water leaks out and the stream of water coming down towards the ground has a shape like a funnel as shown in the figure. If the radius of the cross-section of water stream when it hits the ground is x. Then :



[Online April 9, 2016]

Options:

A. $x = r\left(\frac{H}{H+h}\right)^{\frac{1}{4}}$

B. $x = r\left(\frac{H}{H+h}\right)$

C. $x = r\left(\frac{H}{H+h}\right)^2$

D. $x = r\left(\frac{H}{H+h}\right)^{\frac{1}{2}}$

Answer: A

Solution:

Solution:
According to Bernoulli's Principle,
$\frac{1}{2}\rho v_1^{\,2} + \rho gh = \frac{1}{2}\rho v_2^{\,2}$
$v_1^{\,2} + 2gh = v_2^{\,2}$
$2gH + 2gh = v_2^{\,2}$ ......(i)
$a_1 v_1 = a_2 v_2$
$\pi r^2\sqrt{2gh} = \pi x^2 v_2$
$\frac{r^2}{x^2}\sqrt{2gh} = v_2$
Substituting the value of v_2 in equation (i)
$2gH + 2gh = \frac{r^4}{x^4}2gh$ or, $x = r\left[\frac{H}{H+h}\right]^{\frac{1}{4}}$

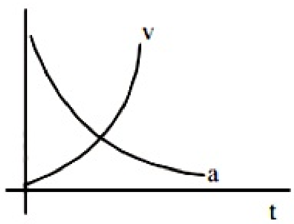
Question214

Which of the following option correctly describes the variation of the speed v and acceleration 'a' of a point mass falling vertically in a viscous medium that applies a force F = –kv, where 'k' is a constant, on the body? (Graphs are schematic and not drawn to scale)
[Online April 9, 2016]

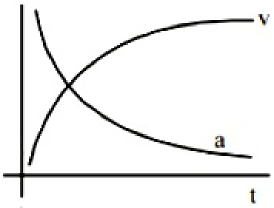
Options:

A.

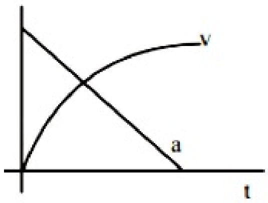
B.



C.



D.



Answer: C

Solution:

Solution:
When a point mass is falling vertically in a viscous medium, the medium or viscous fluid exerts drag force on the body to oppose its motion and at one stage body falling with constant terminal velocity.

Question215

If it takes 5 minutes to fill a 15 litre bucket from a water tap of diameter $\frac{2}{\sqrt{\pi}}$cm then the Reynolds number for the flow is (density of water $= 10^3 kg / m^3$) and viscosity of water $= 10^{-3}$ Pa.s) close to: [Online April 10, 2015]

Options:

A. 11,000

B. 1100

C. 550

D. 5500

Answer: D

Solution:

Solution:
Given: Diameter of water tap $= \frac{2}{\sqrt{\pi}} cm$

$\therefore$ Radius, $r = \frac{1}{\sqrt{\pi}} \times 10^{-2} m$

$\frac{dm}{dt} = \rho AV$

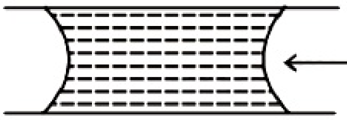
$\frac{15}{5 \times 60} = 10^3 \times \pi \left(\frac{1}{\sqrt{\pi}}\right)^2 \times 10^{-4} V$

$\Rightarrow V = 0.05 m / s$

$$= \frac{10^3 \times 0.5 \times \frac{2}{\sqrt{\pi}} 10^{-2}}{10^{-3}} \cong 5500$$

Question216

If two glass plates have water between them and are separated by very small distance (see figure), it is very difficult to pull them apart. It is because the water in between forms cylindrical surface on the side that gives rise to lower pressure in the water in comparison to atmosphere. If the radius of the cylindrical surface is R and surface tension of water is T then the pressure in water between the plates is lower by:



[Online April 10, 2015]

Options:

A. $\frac{2T}{R}$

B. $\frac{4T}{R}$

C. $\frac{T}{4R}$

D. $\frac{T}{R}$

Answer: D

Solution:

Solution:

Here excess pressure, $P_{excess} = \frac{T}{r_1} + \frac{T}{r_2}$

$P_{excess} = \frac{T}{R} \because \begin{pmatrix} r_1 = R \\ r_2 = O \end{pmatrix}$

Question217

An experiment takes 10 minutes to raise the temperature of water in a container from 0ºC to 100ºC and another 55 minutes to convert it totally into steam by a heater supplying heat at a uniform rate. Neglecting the specific heat of the container and taking specific heat of water to be 1 cal / g ºC, the heat of vapourization according to this experiment will come out to be :
[Online April 11, 2015]

A. 560 cal/ g

B. 550 cal/ g

C. 540 cal/ g

D. 530 cal/ g

Answer: B

Solution:

Solution:
As $Pt = mC\Delta T$
So, $P \times 10 \times 60 = mC100$ ......(i)
and $P \times 55 \times 60 = mL$ ....(ii)
Dividing equation (i) by (ii) we get
$\frac{10}{55} = \frac{C \times 100}{L}$
$\therefore L = 550$ cal./g.

Question218

The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100ºC is:
(For steel Young's modulus is $2 \times 10^{11} N\ m^{-2}$ and coefficient of thermal expansion is $1.1 \times 10^{-5} K^{-1}$)
[2014]

Options:

A. $2.2 \times 10^{8} Pa$

B. $2.2 \times 10^{9} Pa$

C. $2.2 \times 10^{7} Pa$

D. $2.2 \times 10^{6} Pa$

Answer: A

Solution:

Solution:
Young's modulus $Y = \frac{\text{stress}}{\text{strain}}$
stress $= Y \times$ strain
Stress in steel wire = Applied pressure
Pressure = stress $= Y \times$ strain
Strain $= \frac{\Delta L}{L} = \alpha \Delta T$
(As length is constant)
$= 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100 = 2.2 \times 10^{8} Pa$

Question219

Steel ruptures when a shear of $3.5 \times 10^8 \mathrm{N\,m^{-2}}$ is applied. The force needed to punch a 1cm diameter hole in a steel sheet 0.3cm thick is nearly:
[Online April 12, 2014]

Options:

A. $1.4 \times 10^4 \mathrm{N}$

B. $2.7 \times 10^4 \mathrm{N}$

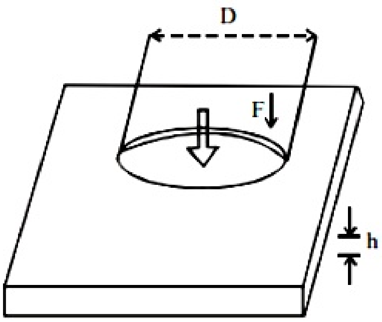
C. $3.3 \times 10^4 \mathrm{N}$

D. $1.1 \times 10^4 \mathrm{N}$

Answer: C

Solution:

Solution:



Shearing strain is created along the side surface of the punched disk. Note that the forces exerted on the disk are exerted along the circumference of the disk, and the total force exerted on its center only.
Let us assume that the shearing stress along the side surface of the disk is uniform, then

$$F = \int_{\text{surface}} dF_{\max} = \int_{\text{surface}} \sigma_{\max} dA = \sigma_{\max} \int_{\text{surface}} dA$$

$$= \int \sigma_{\max} . A = \sigma_{\max} . 2\pi \left(\frac{D}{2}\right) h$$

$$= 3.5 \times 10^8 \times \left(\frac{1}{2} \times 10^{-2}\right) \times 0.3 \times 10^{-2} \times 2\pi$$

$$= 3.297 \times 10^4 \simeq 3.3 \times 10^4 \mathrm{N}$$

Question220

The bulk moduli of ethanol, mercury and water are given as 0.9,25 and 2.2 respectively in units of $10^9 \mathrm{N\,m^{-2}}$. For a given value of pressure, the fractional compression in volume is $\frac{\Delta V}{V}$. Which of the following statements about $\frac{\Delta V}{V}$ for these three liquids is correct?
[Online April 11, 2014]

Options:

A. Ethanol > Water > Mercury

C. Mercury > Ethanol > Water

D. Ethanol > Mercury > Water

Answer: A

Solution:

Solution:

Compressibility $= \frac{1}{\text{Bulk modulus}}$

As bulk modulus is least for ethanol (0.9) and maximum for mercury (25) among ehtanol, mercury and water. Hence compression in volume $\frac{\Delta V}{V}$

Ethanol > Water > Mercury

Question221

In materials like aluminium and copper, the correct order of magnitude of various elastic modului is:
[Online April 9, 2014]

Options:

A. Young's modulus < shear modulus < bulk modulus.

B. Bulk modulus < shear modulus < Young's modulus

C. Shear modulus < Young's modulus < bulk modulus.

D. Bulk modulus < Young's modulus < shear modulus.

Answer: C

Solution:

Solution:

Poisson's ratio, $\sigma = \frac{\text{lateral strain } (\beta)}{\text{longitudinal strain } (\alpha)}$

For material like copper, $\sigma = 0.33$ And, $Y = 3k(1 - 2\sigma)$

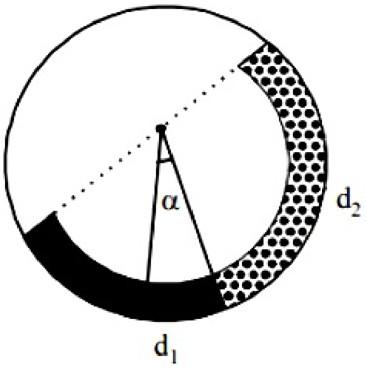
Also, $\frac{9}{Y} = \frac{1}{k} + \frac{3}{\eta}$

$Y = 2\eta(1 + \sigma)$

Hence, $\eta < Y < k$

Question222

There is a circular tube in a vertical plane. Two liquids which do not mix and of densities d_1 and d_2 are filled in the tube. Each liquid subtends 90° angle at centre. Radius joining their interface makes an angle α with vertical. Ratio $\frac{d_1}{d_2}$ is:



[2014]

Options:

A. $\frac{1+\sin\alpha}{1-\sin\alpha}$

B. $\frac{1+\cos\alpha}{1-\cos\alpha}$

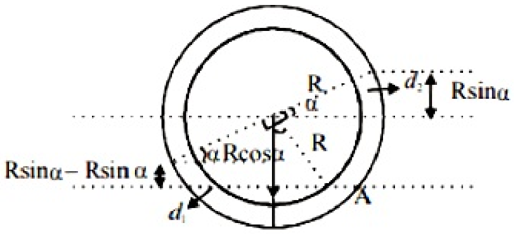
C. $\frac{1+\tan\alpha}{1-\tan\alpha}$

D. $\frac{1+\sin\alpha}{1-\cos\alpha}$

Answer: C

Solution:

Solution:
Pressure at interface A must be same from both the sides to be in equilibrium.



$\therefore (R\cos\alpha + R\sin\alpha)d_2 g = (R\cos\alpha - R\sin\alpha)d_1 g$

$\Rightarrow \frac{d_1}{d_2} = \frac{\cos\alpha + \sin\alpha}{\cos\alpha - \sin\alpha} = \frac{1+\tan\alpha}{1-\tan\alpha}$

Question223

An open glass tube is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now?
(Atmospheric pressure = 76 cm of Hg)
[2014]

Options:

A. 16 cm

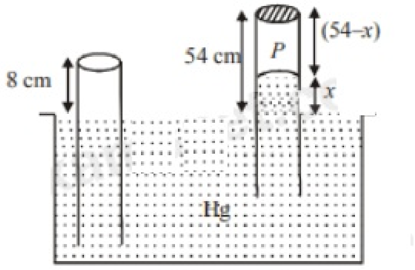
C. 38 cm

D. 6 cm

Answer: A

Solution:

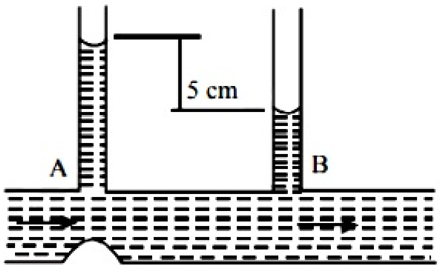
Solution:



Length of the air column above mercury in the tube is,
$P + x = P_0$
$\Rightarrow P = (76 - x)$
$\Rightarrow 8 \times A \times 76 = (76 - x) \times A \times (54 - x)$
$\therefore x = 38$
Thus, length of air column
$= 54 - 38 = 16\text{cm}$

Question224

In the diagram shown, the difference in the two tubes of the manometer is 5cm, the cross section of the tube at A and B is $6mm^2$ and $10mm^2$ respectively. The rate at which water flows through the tube is ($g = 10ms^{-2}$)



[Online April 19, 2014]

Options:

A. 7.5 cc/s

B. 8.0 cc/s

C. 10.0 cc/s

D. 12.5 cc/s

Answer: A

Solution:

According to Bernoulli's theorem,

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$\therefore v_2^2 - v_1^2 = 2gh$ ....(1)

According to the equation of continuity

$A_1v_1 = A_2v_2$ ......(2)

$\frac{A_1}{A_2} = \frac{6mm^2}{10mm^2}$

From equation(2) , $\frac{A_1}{A_2} = \frac{v_2}{v_1} = \frac{6}{10}$

or, $v_2 = \frac{6}{10}v_1$

Putting this value of v_2 in equation (1)

$\left(\frac{6}{10}v_1\right)^2 - (v_1)^2 = 2 \times 10^3 \times 5$

$[\because g = 10m/s^2 = 10^3 cm/s^2 \text{ and } h = 5cm]$

Solving we get $v_1 = \frac{10}{8}$

Therefore the rate at which water flows through the tube $= A_1v_1 = A_2v_2 = \frac{6 \times 10}{8} = 7.5cc/s$

Question225

A cylindrical vessel of cross-section A contains water to a height h. There is a hole in the bottom of radius ‘a’. The time in which it will be emptied is:
[Online April 12, 2014]

Options:

A. $\frac{2A}{\pi a^2}\sqrt{\frac{h}{g}}$

B. $\frac{\sqrt{2}A}{\pi a^2}\sqrt{\frac{h}{g}}$

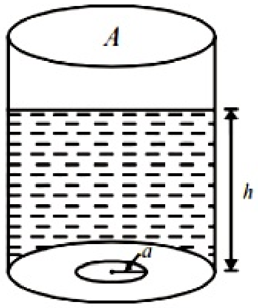
C. $\frac{2\sqrt{2}A}{\pi a^2}\sqrt{\frac{h}{g}}$

D. $\frac{A}{\sqrt{2}\pi a^2}\sqrt{\frac{h}{g}}$

Answer: B

Solution:

Solution:



Initially at $t = 0; h = h$
$t = t; h = 0$

Then, $A\left(-\frac{dh}{dt}\right) = \pi a^2 . v$

$dt = -\frac{A}{\pi a^2\sqrt{2gh}} dh$ [∵ velocity of efflux of liquid $v = \sqrt{2gh}$]

Integrating both sides

$\int_0^t dt = -\frac{A}{\sqrt{2g}\pi a^2}\int_h^0 h^{-1/2} dh$

$[t]_0^t = -\frac{A}{\sqrt{2g}\pi a^2} \cdot \left[\frac{h^{1/2}}{1/2}\right]_h^0$

$t = \frac{\sqrt{2}A}{\pi a^2}\sqrt{\frac{h}{g}}$

Question226

Water is flowing at a speed of $1.5 ms^{-1}$ through horizontal tube of cross-sectional area $10^{-2} m^2$ and you are trying to stop the flow by your palm. Assuming that the water stops immediately after hitting the palm, the minimum force that you must exert should be
(density of water $= 10^3 kgm^{-3}$)
[Online April 9, 2014]

Options:

A. 15 N

B. 22.5 N

C. 33.7 N

D. 45 N

Answer: A

Solution:

Solution:
For 1m length of horizontal tube
Mass of water M = density times volume
$= 10^3 \times$ area $\times$ length
$= 10^3 \times 10^{-2} \times 1 = 10 kg$
Therefore minimum force $= \frac{\Delta p}{\Delta t}$ (rate of change of momentum)
$= 10 \times 1.5 = 15 N$

Question227

The velocity of water in a river is 18km/ hr near the surface. If the river is 5m deep, find the shearing stress between the horizontal layers of water. The co-efficient of viscosity of water $= 10^{-2}$ poise.
[Online April 19, 2014]

Options:

A. $10^{-1} N / m^2$

B. $10^{-2} N / m^2$

C. $10^{-3} N / m^2$

D. $10^{-4} N / m^2$

Answer: B

Solution:

Solution:
$\eta = 10^{-2}$ poise
$v = 18 km / h = \frac{18000}{3600} = 5 m / s$
$l = 5 m$
Strain rate $= \frac{v}{l}$
Coefficient of viscosity, $\eta = \frac{\text{shearing stress}}{\text{strain rate}}$
∴ Shearing stress $= \eta \times$ strain rate
$= 10^{-2} \times \frac{5}{5} = 10^{-2} N m^{-2}$

Question228

The average mass of rain drops is 3.0×10^{-5} kg and their avarage terminal velocity is 9m / s. Calculate the energy transferred by rain to each square metre of the surface at a place which receives 100cm of rain in a year.
[Online April 11, 2014]

Options:

A. $3.5 \times 10^5 J$

B. $4.05 \times 10^4 J$

C. $3.0 \times 10^5 J$

D. $9.0 \times 10^4 J$

Answer: B

Solution:

Solution:
Total volume of rain drops, received 100 cm in a year by area $1 m_2$
$= 1 m^2 \times \frac{100}{100} m = 1 m^3$
As we know, density of water,
$d = 10^3 kg / m^3$
Therefore, mass of this volumeof water

v = 9m / s (given)
Therefore, energy transferred by rain,

$E = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 10^3 \times (9)^2$

$= \frac{1}{2} \times 10^3 \times 81 = 4.05 \times 10^4 J$

Question229

A tank with a small hole at the bottom has been filled with water and kerosene (specific gravity 0.8). The height of water is 3m and that of kerosene 2m. When the hole is opened the velocity of fluid coming out from it is nearly:
(take $g = 10ms^{-2}$ and density of water $= 10^3 kgm^{-3}$)
[Online April 11, 2014]

Options:

A. $10.7ms^{-1}$

B. $9.6ms^{-1}$

C. $8.5ms^{-1}$

D. $7.6ms^{-1}$

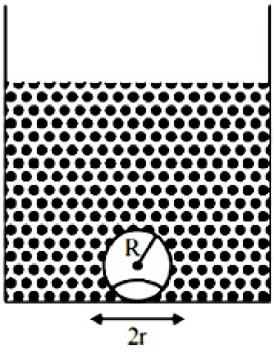
Answer: B

Solution:

Solution:
According to Toricelli's theorem,
Velocity of efflex,
$V_{eff} = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 5} \cong 9.8ms^{-1}$

Question230

On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If $r << R$ and the surface tension of water is T , value of r just before bubbles detach is: (density of water is ρ_w)



[2014]

Options:

A. $R^2\sqrt{\frac{2\rho_w g}{3T}}$

B. $R^2\sqrt{\frac{\rho_w g}{6T}}$

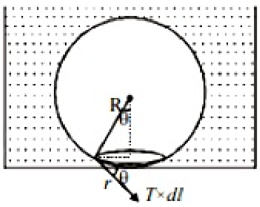
C. $R^2\sqrt{\frac{\rho_w g}{T}}$

D. $R^2\sqrt{\frac{3\rho_w g}{T}}$

Answer: A

Solution:

Solution:
When the bubble gets detached,
Buoyant force = force due to surface tension



Force due to excess pressure = upthrust
Access pressure in air bubble $= \frac{2T}{R}$

$\frac{2T}{R}(\pi r^2) = \frac{4\pi R^3}{3T}\rho o_w g$

$\Rightarrow r^2 = \frac{2R^4\rho_w g}{3T} \Rightarrow r = R^2\sqrt{\frac{2\rho_w g}{3T}}$

Question231

Two soap bubbles coalesce to form a single bubble. If V is the subsequent change in volume of contained air and S change in total surface area, T is the surface tension and P atmospheric pressure, then which of the following relation is correct?
[Online April 12, 2014]

Options:

A. $4PV + 3ST = 0$

B. $3PV + 4ST = 0$

C. $2PV + 3ST = 0$

D. $3PV + 2ST = 0$

Answer: B

Solution:

Solution:

Question232

An air bubble of radius 0.1cm is in a liquid having surface tension $0.06N / m$ and density $10^3 kg / m^3$. The pressure inside the bubble is $1100 N m^{-2}$ greater than the atmospheric pressure. At what depth is the bubble below the surface of the liquid? ($g = 9.8 ms^{-2}$)
[Online April 11, 2014]

Options:

A. 0.1m

B. 0.15m

C. 0.20m

D. 0.25m

Answer: A

Solution:

Solution:
Given: Radius of air bubble,
$r = 0.1cm = 10^{-3} m$
Surface tension of liquid,
$S = 0.06N / m = 6 \times 10^{-2} N / m$
Density of liquid,
$\rho = 10^3 kg / m^3$
Excess pressure inside the bubble,
$\rho_{exe} = 1100 N m^{-2}$
Depth of bubble below the liquid surface,
$h = ?$
As we know,
$\rho_{Excess} = h\rho g + \frac{2s}{r}$
$\Rightarrow 1100 = h \times 10^3 \times 9.8 + \frac{2 \times 6 \times 10^{-2}}{10^{-3}}$
$\Rightarrow 1100 = 9800h + 120$
$\Rightarrow 9800h = 1100 - 120$

Question233

A capillary tube is immersed vertically in water and the height of the water column is x. When this arrangement is taken into a mine of depth d, the height of the water column is y. If R is the radius of earth, the ratio $\frac{x}{y}$ is:
[Online April 9, 2014]

Options:

A. $\left(1-\frac{d}{R}\right)$

B. $\left(1-\frac{2d}{R}\right)$

C. $\left(\frac{R-d}{R+d}\right)$

D. $\left(\frac{R+d}{R-d}\right)$

Answer: A

Solution:

Solution:
Acceleration due to gravity changes with the depth,
$g' = g\left(1-\frac{d}{R}\right)$
Pressure, $P = \rho gh$
Hence ratio, $\frac{x}{y}$ is $\left(1-\frac{d}{R}\right)$

Question234

Three rods of Copper, Brass and Steel are welded together to form a Y shaped structure. Area of cross - section of each rod = 4 cm^2 . End of copper rod is maintained at 100ºC where as ends of brass and steel are kept at 0ºC. Lengths of the copper, brass and steel rods are 46, 13 and 12 cms respectively. The rods are thermally insulated from surroundings excepts at ends. Thermal conductivities of copper, brass and steel are 0.92, 0.26 and 0.12 CGS units respectively. Rate of heat flow through copper rod is:
[2014]

Options:

A. 1.2 cal/s

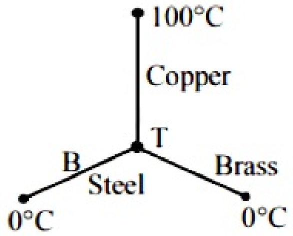
C. 4.8 cal/s

D. 6.0 cal/s

Answer: C

Solution:

Solution:
Rate of heat flow is given by,
$Q = \frac{KA(\theta_1 - \theta_2)}{l}$
Where, K = coefficient of thermal conductivity
l = length of rod and A = area of cross-section of rod



If the junction temperature is T, then
$Q_{Copper} = Q_{Brass} + Q_{Steel}$
$\frac{0.92 \times 4(100 - T)}{46}$
$= \frac{0.26 \times 4 \times (T - 0)}{13} + \frac{0.12 \times 4 \times (T - 0)}{12}$
$\Rightarrow 200 - 2T = 2T + T$
$\Rightarrow T = 40°C$
$\therefore Q_{Copper} = \frac{0.92 \times 4 \times 60}{46} = 4.8 cal / s$

Question235

A black coloured solid sphere of radius R and mass M is inside a cavity with vacuum inside. The walls of the cavity are maintained at temperature T_0. The initial temperature of the sphere is $3T_0$. If the specific heat of the material of the sphere varies as αT^3 per unit mass with the temperature T of the sphere, where α is a constant, then the time taken for the sphere to cool down to temperature $2T_0$ will be (σ is Stefan Boltzmann constant)
[Online April 19,2014]

Options:

A. $\frac{M\alpha}{4\pi R^2 \sigma} In\left(\frac{3}{2}\right)$

B. $\frac{M\alpha}{4\pi R^2 \sigma} In\left(\frac{16}{3}\right)$

C. $\frac{M\alpha}{16\pi R^2 \sigma} In\left(\frac{16}{3}\right)$

D. $\frac{M\alpha}{...} In\left(\frac{3}{...}\right)$

Answer: C

Solution:

Solution:
In the given problem, fall in temperature of sphere,
$dT = (3T_0 - 2T_0) = T_0$
Temperature of surrounding, $T_{surr} = T_0$
Initial temperature of sphere, $T_{initial} = 3T_0$
Specific heat of the material of the sphere varies as,
$c = \alpha T^3$ per unit mass ($\alpha =$ a constant)
Applying formula,

$$\frac{dT}{dt} = \frac{\sigma A}{McJ}(T^4 - T_{surr}^4)$$

$$\Rightarrow \frac{T_0}{dt} = \frac{\sigma 4\pi R^2}{M\alpha(3T_0)^3 J}[(3T_0)^4 - (T_0)^4]$$

$$\Rightarrow dt = \frac{M\alpha 27T_0^4 J}{\sigma 4\pi R^2 \times 80T_0^4}$$

Solving we get,
Time taken for the sphere to cool down temperature $2T_0$,

$$T = \frac{M\alpha}{16\pi R^2 \sigma} In\left(\frac{16}{3}\right)$$

Question236

Water of volume 2 L in a closed container is heated with a coil of 1 kW. While water is heated, the container loses energy at a rate of 160 J/s. In how much time will the temperature of water rise from 27°C to 77°C? (Specific heat of water is 4.2 kJ/kg and that of the container is negligible).
[Online April 9, 2014]

Options:

A. 8 min 20 s

B. 6 min 2 s

C. 7 min

D. 14 min

Answer: A

Solution:

Solution:
From question,
In 1 sec heat gained by water
= 1 KW – 160 J/s
= 1000 J/s – 160 J/s
= 840 J/s
Total heat required to raise the temperature of water (volume 2L) from 27°c to 77°c
$= m_{water} \times sp.ht \times \Delta\theta$
$= 2 \times 10^3 \times 4.2 \times 50$[∵ mass = density × volume]

or, $t = \frac{2 \times 10^3 \times 4.2 \times 50}{840}$
$= 500$ s $= 8$ min 20s

Question237

Hot water cools from 60°C to 50°C in the first 10 minutes and to 42°C in the next 10 minutes. The temperature of the surroundings is:
[Online April 12, 2014]

Options:

A. 25°C

B. 10°C

C. 15°C

D. 20°C

Answer: B

Solution:

Solution:
By Newton's law of cooling
$$\frac{\theta_1 - \theta_2}{t} = -K\left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$$
where theta_0 is the temperature of surrounding.
Now, hot water cools from 60°C to 50°C in 10 minutes,
$$\frac{60 - 50}{10} = -K\left[\frac{60 + 50}{2} - \theta_0\right] \text{.......(i)}$$
Again, it cools from 50°C to 42°C in next 10 minutes.
$$\frac{50 - 42}{10} = -K\left[\frac{50 + 42}{2} - \theta_0\right] \text{.......(ii)}$$
Dividing equations (i) by (ii) we get
$$\frac{1}{0.8} = \frac{55 - \theta_0}{46 - \theta_0}$$
$$\frac{10}{8} = \frac{55 - \theta_0}{46 - \theta_0}$$
$$460 - 10\theta_0 = 440 - 8\theta_0$$
$$2\theta_0 = 20$$
$$\theta_0 = 10°C$$

Question238

A hot body, obeying Newton's law of cooling is cooling down from its peak value 80°C to an ambient temperature of 30°C. It takes 5 minutes in cooling down from 80°C to 40°C. How much time will it take to cool down from 62°C to 32°C?
(Given In 2 = 0.693, In 5 = 1.609)
[Online April 11, 2014]

A. 3.75 minutes

B. 8.6 minutes

C. 9.6 minutes

D. 6.5 minutes

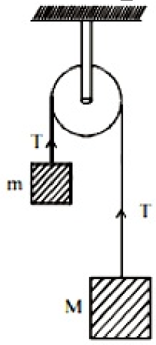
Answer: B

Solution:

Solution:
From Newton's law of cooling,
$t = \frac{1}{k}\log_e\left(\frac{\theta_2 - \theta_0}{\theta_1 - \theta_0}\right)$
From question and above equation,
$5 = \frac{1}{k}\log_e\frac{(40-30)}{(80-30)}$ ....(1)
And, $t = \frac{1}{k}\log_e\frac{(32-30)}{(62-30)}$ ......(2)
Dividing equation (2) by (1),
$\frac{t}{5} = \frac{\frac{1}{k}\log_e\frac{(32-30)}{(62-30)}}{\frac{1}{k}\log_e\frac{(40-30)}{(80-30)}}$
On solving we get, time taken to cool down from 62°C to 32°C, t = 8.6 minutes.

Question239

Two blocks of masses m and M are connected by means of a metal wire of cross-sectional area A passing over a frictionless fixed pulley as shown in the figure. The system is then released. If M = 2 m, then the stress produced in the wire is :



[Online April 25, 2013]

Options:

A. $\frac{2mg}{3A}$

B. $\frac{4mg}{3A}$

C. $\frac{mg}{A}$

D. $\frac{3mg}{4A}$

Answer: B

Solution:

Solution:

Tension in the wire, $T = \left(\frac{2mM}{m+M}\right)g$

Stress $= \frac{\text{Force / Tension}}{\text{Area}} = \frac{2mM}{A(m+M)}g$

$= \frac{2(m \times 2m)g}{A(m+2m)}(M = 2m \text{ given })$

$= \frac{4m^2}{3mA}g = \frac{4mg}{3A}$

Question240

A copper wire of length 1.0m and a steel wire of length 0.5m having equal cross-sectional areas are joined end to end. The composite wire is stretched by a certain load which stretches the copper wire by 1mm. If the Young's modulii of copper and steel are respectively $1.0 \times 10^{11} N\,m^{-2}$ and $2.0 \times 10^{11} N\,m^{-2}$, the total extension of the composite wire is : [Online April 23, 2013]

Options:

A. 1.75 mm

B. 2.0 mm

C. 1.50 mm

D. 1.25 mm

Answer: D

Solution:

Solution:

$Y_c \times (\Delta L_c / L_c) = Y_s \times (\Delta L_S / L_S)$

$\Rightarrow 1 \times 10^{11} \times \left(\frac{1 \times 10^{-3}}{1}\right) = 2 \times 10^{11} \times \left(\frac{\Delta L_s}{0.5}\right)$

$\therefore \Delta L_s = \frac{0.5 \times 10^{-3}}{2} = 0.25mm$

Therefore, total extension of the composite wire

$= \Delta L_c + \Delta L_s$

$= 1mm + 0.25m = 1.25m$

Question241

A uniform wire (Young's modulus $2 \times 10^{11} N\,m^{-2}$) is subjected to longitudinal tensile stress of $5 \times 10^{7} N\,m^{-2}$. If the overall volume change

close to :
[Online April 22, 2013]

Options:

A. 1.0×10^{-4}

B. 1.5×10^{-4}

C. 0.25×10^{-4}

D. 5×10^{-4}

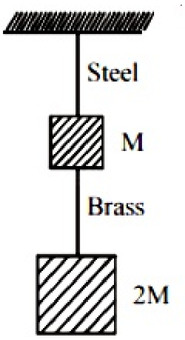
Answer: C

Solution:

Solution:
Given, $y = 2 \times 10^{11} \mathrm{N\,m^{-2}}$
Stress $\left(\frac{F}{A}\right) = 5 \times 10^{7} \mathrm{N\,m^{-2}}$
$\Delta V = 0.02\% = 2 \times 10^{-4} \mathrm{m^3}$
$\frac{\Delta r}{r} = ?$
$\gamma = \frac{\text{stress}}{\text{strain}} \Rightarrow \text{strain}\left(\frac{\Delta l}{l_0}\right) = \frac{\gamma}{\text{stress}}$ ......(i)
$\Delta V = 2\pi r l_0 \Delta r - \pi r^2 \Delta l$ ......(ii)
From eqns (i) and (ii) putting the value of Δl, l_0 and ΔV and solving we get
$\frac{\Delta r}{r} = 0.25 \times 10^{-4}$

Question242

If the ratio of lengths, radii and Young's moduli of steel and brass wires in the figure are a, b and c respectively, then the corresponding ratio of increase in their lengths is :



[Online April 9, 2013]

Options:

A. $\frac{3c}{2ab^2}$

B. $\frac{2a^2c}{b}$

C. $\frac{3a}{\ldots}$

D. $\frac{2ac}{b^2}$

Answer: C

Solution:

Solution:
According to questions,
$\frac{l_s}{l_b} = a, \frac{r_s}{r_b} = b, \frac{y_s}{y_b} = c, \frac{\Delta l_s}{\Delta l_b} = ?$
As, $y = \frac{F\,l}{A\Delta l} \Rightarrow \Delta l = \frac{F\,l}{Ay}$
$\Delta l_s = \frac{3mgl_s}{\pi r_s^2 \cdot y_s} [\because F_s = (M + 2M)g]$
$\Delta l_b = \frac{2M\,gl_b}{\pi r_b^2 \cdot y_b} [\because F_b = 2M\,g]$
$\therefore \frac{\Delta l_s}{\Delta l_b} = \frac{\frac{3M\,gl_s}{\pi r_s^2 \cdot y_s}}{\frac{2M\,g \cdot l_b}{\pi r_b^2 \cdot y_b}} = \frac{3a}{2b^2C}$

Question243

A uniform cylinder of length L and mass M having cross sectional area A is suspended, with its length vertical, from a fixed point by a massless spring such that it is half submerged in a liquid of density sigma at equilibrium position. The extension x_0 of the spring when it is in equilibrium is:
[2013]

Options:

A. $\frac{M\,g}{k}$

B. $\frac{M\,g}{k}\left(1 - \frac{LA\sigma}{M}\right)$

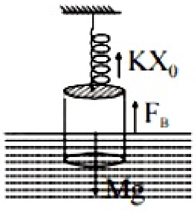
C. $\frac{M\,g}{k}\left(1 - \frac{LA\sigma}{2M}\right)$

D. $\frac{M\,g}{k}\left(1 + \frac{LA\sigma}{M}\right)$

Answer: C

Solution:

Solution:
From figure, $kx_0 + F_B = M\,g$



$kx_0 + \sigma\frac{L}{2}Ag = M g$

[∵ mass = density × volume]

$\Rightarrow kx_0 = M g - \sigma\frac{L}{2}Ag$

$\Rightarrow x_0 = \frac{M g - \frac{\sigma LAg}{2}}{k} = \frac{M g}{k}\left(1 - \frac{LA\sigma}{2M}\right)$

Hence, extension of the spring when it is in equilibrium is, $x_0 = \frac{M g}{k}\left(1 - \frac{LA\sigma}{2M}\right)$

Question244

Air of density $1.2 kgm^{-3}$ is blowing across the horizontal wings of an aeroplane in such a way that its speeds above and below the wings are $150 ms^{-1}$ and $100 ms^{-1}$, respectively. The pressure difference between the upper and lower sides of the wings, is:
[Online April 22, 2013]

Options:

A. $60 N m^{-2}$

B. $180 N m^{-2}$

C. $7500 N m^{-2}$

D. $12500 N m^{-2}$

Answer: C

Solution:

Solution:
Pressure difference

$P_2 - P_1 = \frac{1}{2}\rho(v_2{}^2 - v_1{}^2)$

$= \frac{1}{2} \times 1.2((150)^2 - (100)^2)$

$= \frac{1}{2} \times 1.2(22500 - 10000)$

$= 7500 N m^{-2}$

Question245

In an experiment, a small steel ball falls through a liquid at a constant speed of 10 cm/s. If the steel ball is pulled upward with a force equal to twice its effective weight, how fast will it move upward ?

Options:

A. 5 cm/s

B. Zero

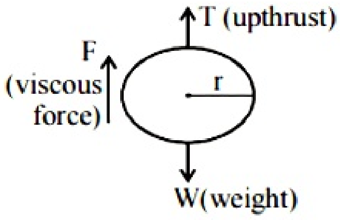
C. 10 cm/s

D. 20 cm/s

Answer: C

Solution:

Solution:



Weight of the body

$W = mg = \frac{4}{3}\pi r^3 \rho g$

$T = \frac{4}{3}\pi r^3 \sigma g$

and $F = 6\pi\eta vr$

When the body attains terminal velocity net force acting on the body is zero. i.e.

$W - T - F = 0$

And terminal velocity $v = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$

As in case of upward motion upward force is twice its effective weight, therefore, it will move with same speed $10 cm$ / s

---

Question246

Wax is coated on the inner wall of a capillary tube and the tube is then dipped in water. Then, compared to the unwaxed capillary, the angle of contact θ and the height h upto which water rises change. These changes are :
[Online April 23, 2013]

Options:

A. θ increases and h also increases

B. θ decreases and h also decreases

C. θ increases and h decreases

D. θ decreases and h increases

Answer: C

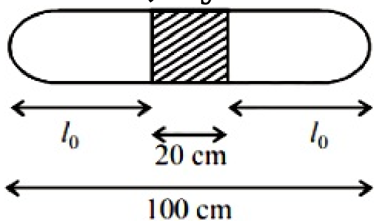
Solution:

Solution:

$\cos\theta = \frac{T_{SA} - T_{SL}}{T_{LA}}$
when water is on a waxy or oily surface
$T_{SA} < T_{SL}$ $\cos\theta$ is negative i.e.
$90° < \theta < 180°$
i.e., angle of contact θ increases
And for $\theta > 90°$ liquid level in capillary tube fall.
i.e., h decreases

Question247

A thin tube sealed at both ends is 100cm long. It lies horizontally, the middle 20cm containing mercury and two equal ends containing air at standard atmospheric pressure. If the tube is now turned to a vertical position, by what amount will the mercury be displaced?



(Given : cross-section of the tube can be assumed to be uniform) [Online April 23, 2013]

Options:

A. 2.95cm

B. 5.18cm

C. 8.65cm

D. 0.0cm

Answer: B

Solution:

Solution:

Question248

This question has Statement- 1 and Statement-2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement-1: A capillary is dipped in a liquid and liquid rises to a height h in it. As the temperature of the liquid is raised, the height h increases (if the density of the liquid and the angle of contact remain the same).
Statement-2: Surface tension of a liquid decreases with the rise in its temperature.
[Online April 9, 2013]

Options:

A. Statement- 1 is true, Statement- 2 is true; Statement- 2 is not the correct explanation for Statement-1.

B. Statement- 1 is false, Statement- 2 is true.

C. Statement- 1 is true, Statement- 2 is false.

D. Statement- 1 is true, Statement- 2 is true; Statement- 2 is the correct explanation for Statement-1.

Answer: B

Solution:

Solution:
Surface tension of a liquid decreases with the rise in temperture. At the boiling point of liquid, surface tension is zero.
Capillary rise $h = \frac{2T \cos\theta}{rd\,g}$
As surface tension T decreases with rise in temperature hence capillary rise also decreases.

Question249

The ratio of the coefficient of volume expansion of a glass container to that of a viscous liquid kept inside the container is 1 : 4. What fraction of the inner volume of the container should the liquid occupy so that the volume of the remaining vacant space will be same at all temperatures ? [Online April 23, 2013]

Options:

A. 2 : 5

B. 1 : 4

C. 1 : 64

D. 1 : 8

Answer: B

Solution:

Solution:
When there is no change in liquid level in vessel then $\gamma'_{real} = \gamma'_{vessel}$
Change in volume in liquid relative to vessel
$\Delta V_{app} = V\gamma'_{app}\Delta\theta = V(\gamma'_{real} - \gamma'_{vessel})$

Question250

On a linear temperature scale Y, water freezes at – 160° Y and boils at –

freezes at 273 K and boils at 373 K)
[Online April 9, 2013]

Options:

A. – 73.7° Y

B. – 233.7° Y

C. – 86.3° Y

D. – 106.3° Y

Answer: C

Solution:

$$\frac{\text{n any scale} - \text{LFP}}{\text{JFP - LFP}} = \text{constant for all scales}$$

$$\frac{340-273}{373-273} = \frac{°Y - (-160)}{-50-(-160)}$$

$$\Rightarrow \frac{67}{100} = \frac{y+160}{110}$$

$$\therefore Y = -86.3°Y$$

Question251

Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged. What should be the minimum radius of the drop for this to be possible? The surface tension is T, density of liquid is ρ and L is its latent heat of vaporization.
[2013]

Options:

A. $\rho L/T$

B. $\sqrt{T / \rho L}$

C. $T/\rho L$

D. $2T/\rho L$

Answer: D

Solution:

Solution:
When radius is decrease by ΔR,

$$4\pi R^2 \Delta R \rho L = 4\pi T\,[R^2 - (R-\Delta R)^2]$$

$$\Rightarrow \rho R^2 \Delta R L = T\,[R^2 - R^2 + 2R\Delta R - \Delta R^2]$$

$$\Rightarrow \rho R^2 \Delta R L = T\, 2R\Delta R \quad [\,\Delta R \text{ is very small}\,]$$

$$\Rightarrow R = \frac{2T}{\rho L}$$

Question252

A mass of 50g of water in a closed vessel, with surroundings at a constant temperature takes 2 minutes to cool from 30°C to 25°C. A mass of 100g of another liquid in an identical vessel with identical surroundings takes the same time to cool from 30° C to 25° C. The specific heat of the liquid is :
(The water equivalent of the vessel is 30g.)
[Online April 25, 2013]

Options:

A. 2.0 kcal/kg

B. 7 kcal/kg

C. 3 kcal/kg

D. 0.5 kcal/kg

Answer: D

Solution:

Solution:
As the surrounding is identical, vessel is identical time taken to cool both water and liquid (from 30°C to 25°C) is same 2 minutes, therefore

$$\left(\frac{dQ}{dt}\right)_{water} = \left(\frac{dQ}{dt}\right)_{liquid}$$

or, $\frac{(m_W C_W + W)\Delta T}{t} = \frac{(m_L C_L + W)\Delta T}{t}$

(W = water equivalent of the vessel)

or ,$m_w C_w = m_L C_L$

∴ Specific heat of liquid ,$C_L = \frac{m_W C_W}{m_L}$

$= \frac{50 \times 1}{100} = 0.5 \text{kcal} / \text{kg}$

Question253

500 g of water and 100 g of ice at 0°C are in a calorimeter whose water equivalent is 40 g. 10 g of steam at 100°C is added to it. Then water in the calorimeter is : (Latent heat of ice = 80 cal/g, Latent heat of steam = 540 cal/ g)
[Online April 23, 2013]

Options:

A. 580 g

B. 590 g

C. 600 g

D. 610 g

Answer: B

Solution:

Solution:
As 1g of steam at 100°C melts 8g of ice at 0°C.
10 g of steam will melt 8× 10 g of ice at 0°C
Water in calorimeter = 500 + 80 + 10g = 590g

Question254

Given that 1 g of water in liquid phase has volume 1 cm^3 and in vapour phase 1671 cm^3 at atmospheric pressure and the latent heat of vaporization of water is 2256 J/g; the change in the internal energy in joules for 1 g of water at 373 K when it changes from liquid phase to vapour phase at the same temperature is :
[Online April 22, 2013]

Options:

A. 2256

B. 167

C. 2089

D. 1

Answer: C

Solution:

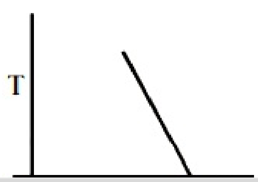
Solution:

Question255

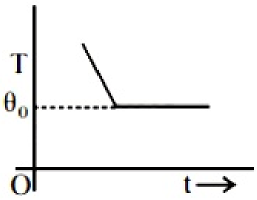
If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature θ_0 , the graph between the temperature T of the metal and time twill be closest to
[2013]

Options:

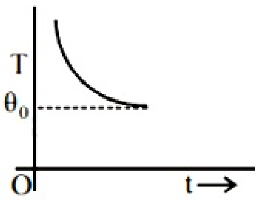
A.



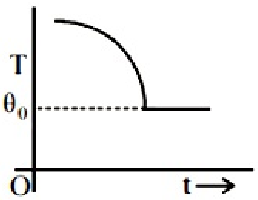
B.



C.



D.



Answer: C

Solution:

Solution:
According to Newton's law of cooling, the temperature goes on decreasing with time non-linearly.

Question256

A steel wire can sustain 100 kg weight without breaking. If the wire is cut into two equal parts, each part can sustain a weight of [Online May 19, 2012]

Options:

A. 50 kg

B. 400 kg

C. 100 kg

D. 200 kg

Answer: C

Solution:

Solution:

Question257

A structural steel rod has a radius of 10 mm and length of 1.0 m. A 100 kN force stretches it along its length. Young's modulus of structural steel is $2 \times 10^{11} N\,m^{-2}$. The percentage strain is about
[Online May 7, 2012]

Options:

A. 0.16%

B. 0.32%

C. 0.08%

D. 0.24%

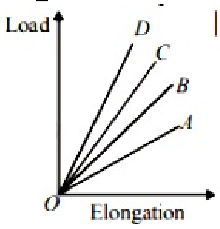
Answer: A

Solution:

Solution:
Given: $F = 100kN = 10^5 N$
$Y = 2 \times 10^{11} N\,m^{-2}$
$l_0 = 1.0m$
radius $r = 10mm = 10^{-2}m$
From formula, $Y = \frac{\text{Stress}}{\text{Strain}}$
$\Rightarrow$ Strain $= \frac{\text{Stress}}{Y} = \frac{F}{AY}$
$= \frac{10^5}{\pi r^2 Y} = \frac{10^5}{3.14 \times 10^{-4} \times 2 \times 10^{11}} = \frac{1}{628}$
Therefore % strain $= \frac{1}{628} \times 100 = 0.16\%$

Question258

The load versus elongation graphs for four wires of same length and made of the same material are shown in the figure. The thinnest wire is represented by the line



[Online May 7, 2012]

Options:

A. OA

C. OD

D. OB

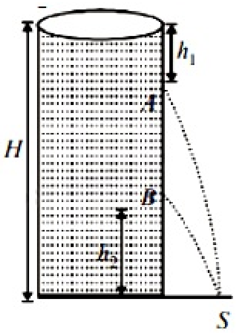
Answer: A

Solution:

Solution:
From the graph, it is clear that for the same value of load, elongation is maximum for wire OA . Hence OA is the thinnest wire among the four wires.

Question259

In a cylindrical water tank, there are two small holes A and B on the wall at a depth of h_1, from the surface of water and at a height of h_2 from the bottom of water tank. Surface of water is at heigh H from the bottom of water tank. Water coming out from both holes strikes the ground at the same point S. Find the ratio of h_1 and h_2



[Online May 26, 2012]

Options:

A. Depends on H

B. 1 : 1

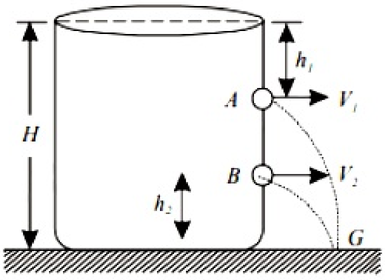
C. 2 : 2

D. 1 : 2

Answer: B

Solution:

Solution:



or, $v_1t_1 = v_2t_2$ ......(i)
Where $v_1 =$ velocity of efflux at $A = \sqrt{(2gh_1)}$ and
$v_2 =$ velocity of efflux at $B = \sqrt{(2g(H - h_2)}$
$t_1 =$ time of fall water stream through $A = \sqrt{\left(\frac{2(H - h_1}{g}\right)}$
$t_2 =$ time of fall of the water stream through $B = \sqrt{\frac{2h_2}{g}}$
Putting these values is eqn (i) we get
$(H - h_1)h_1 = (H - h_2)h_2$
or $[H - (h_1 + h_2)][h_1 - h_2] = 0$
Here, $H = h_1 + h_2$ is irrelevant because the holes are at two different heights. Hence $h_1 = h_2$ or, $\frac{h_1}{h_2} = 1$

Question260

Water is flowing through a horizontal tube having cross sectional areas of its two ends being A and A′ such that the ratio A / A′ is 5 . If the pressure difference of water between the two ends is $3 \times 10^5 N\ m^{-2}$, the velocity of water with which it enters the tube will be (neglect gravity effects)
[Online May 12, 2012]

Options:

A. $5ms^{-1}$

B. $10ms^{-1}$

C. $25ms^{-1}$

D. $50\sqrt{10}ms^{-1}$

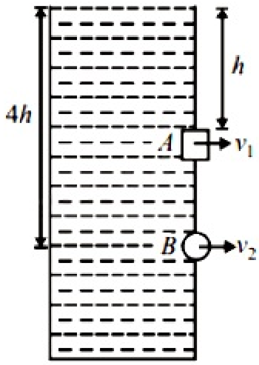
Answer: A

Solution:

Solution:
According to Bernoulli's theorem
$P_1 + \frac{1}{2}\rho v_1{}^2 = P_2 + \frac{1}{2}\rho v_2{}^2$ .....(i)
From question,
$P_1 - P_2 = 3 \times 10^5, \frac{A_1}{A_2} = 5$
According to equation of continuity
$A_1v_1 = A_2v_2$
or, $\frac{A_1}{A_2} = \frac{v_2}{v_1} = 5$
$\Rightarrow v_2 = 5v_1$
From equation (i)
$P_1 - P_2 = \frac{1}{2}\rho(v_2{}^2 - v_1{}^2)$
or $3 \times 10^5 = \frac{1}{2} \times 1000(5v_1{}^2 - v_1{}^2)$
$\Rightarrow 600 = 6v_1 \times 4v_1$
$\Rightarrow v_1{}^2 = 25$
$\therefore v_1 = 5m / s$

Question261

A square hole of side length l is made at a depth of h and a circular hole of radius r is made at a depth of 4h from the surface of water in a water tank kept on a horizontal surface.
If l < < h, r < < h and the rate of water flow from the holes is the same, then r is equal to



[May 7, 2012]

Options:

A. $\frac{l}{\sqrt{2\pi}}$

B. $\frac{l}{\sqrt{3\pi}}$

C. $\frac{l}{3\pi}$

D. $\frac{l}{2\pi}$

Answer: A

Solution:

Solution:
As $A_1v_1 = A_2v_2$ (Principle of continuity)
or, $l^2\sqrt{2gh} = \pi r^2\sqrt{2g \times 4h}$ (Efflux velocity $= \sqrt{2gh}$)
$\therefore r^2 = \frac{l^2}{2\pi}$ or $r = \sqrt{\frac{l^2}{2\pi}} = \frac{l}{\sqrt{2\pi}}$

Question262

The terminal velocity of a small sphere of radius a in a viscous liquid is proportional to
[Online May 26, 2012]

Options:

A. a^2

C. a

D. a^{-1}

Answer: A

Solution:

Solution:
Terminal velocity in a viscous medium is given by :
$V_T = \frac{2a^2(\rho - \sigma)g}{9\eta}$
$\therefore V_T \propto a^2$

Question263

A large number of liquid drops each of radius r coalesce to from a single drop of radius R. The energy released in the process is converted into kinetic energy of the big drop so formed. The speed of the big drop is (given, surface tension of liquid T , density ρ)
[Online April 19, 2014, 2012]

Options:

A. $\sqrt{\frac{T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)}$

B. $\sqrt{\frac{2T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)}$

C. $\sqrt{\frac{4T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)}$

D. $\sqrt{\frac{6T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)}$

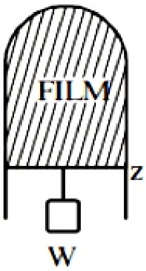
Answer: D

Solution:

Solution:
When drops combine to form a single drop of radius R. Then energy released, $E = 4\pi T R^3\left[\frac{1}{r} - \frac{1}{R}\right]$
If this energy is converted into kinetic energy then
$\frac{1}{2}mv^2 = 4\pi R^3 T\left[\frac{1}{r} - \frac{1}{R}\right]$
$\frac{1}{2} \times \left[\frac{4}{3}\pi R^3 \rho\right]v^2 = 4\pi R^3 T\left[\frac{1}{r} - \frac{1}{R}\right]$
$v^2 = \frac{6T}{\rho}\left[\frac{1}{r} - \frac{1}{R}\right]$
$v = \sqrt{\frac{6T}{\rho}\left[\frac{1}{r} - \frac{1}{R}\right]}$

Question264

A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2}N (see figure). The length of the slider is 30cm and its weight is negligible. The surface tension of the liquid film is



[2012]

Options:

A. $0.0125 \mathrm{N\,m}^{-1}$

B. $0.1 \mathrm{N\,m}^{-1}$

C. $0.05 \mathrm{N\,m}^{-1}$

D. $0.025 \mathrm{N\,m}^{-1}$

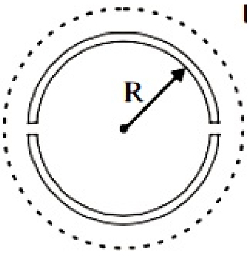
Answer: D

Solution:

Solution:
Let T is the force due to surface tension per unit length, then
$F = 2lT$
$l =$ length of the slider.
At equilibrium, $F = W$
$\therefore 2Tl = mg$
$\Rightarrow T = \frac{mg}{2l} = \frac{1.5 \times 10^{-2}}{2 \times 30 \times 10^{-2}} = \frac{1.5}{60} = 0.025 \mathrm{N\,m}^{-1}$

Question265

A wooden wheel of radius R is made of two semicircular part (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and length L. L is slightly less than 2πR. To fit the ring on the wheel, it is heated so that its temperature rises by ΔT and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semicircular parts together. If the coefficient of linear expansion of the metal is α, and its Young's modulus is Y , the force that one part of the wheel applies on the other part is:



[2012]

Options:

A. $2\pi SY\alpha\Delta T$

B. $SY\alpha\Delta T$

C. $\pi SY\alpha\Delta T$

D. $2SY\alpha\Delta T$

Answer: D

Solution:

Solution:
The Young modulus is given as
$Y = \frac{\{stress}{strain} = \frac{F / S}{\Delta L / L}$
Here ,$\Delta L = 2\pi\Delta R L = 2\pi R$
$Y = \frac{F}{S 2\pi\Delta R} \times 2\pi R$
$\Rightarrow Y = \frac{F R}{S . \Delta R}$ ......(i)
The coefficient of linear expansion $\alpha = \frac{\Delta R}{R\Delta T}$
$\Rightarrow \frac{\Delta R}{R} = \alpha . \Delta T \Rightarrow \frac{R}{\Delta R} = \frac{1}{\alpha\Delta T}$ ....(ii)
From equation (i) and (ii)
$Y = \frac{F}{S . \alpha\Delta T} \Rightarrow F = Y . S . \alpha\Delta T$
∴ The ring is pressing the wheel from both sides, Thus
$F_{net} = 2F = 2Y S\alpha\Delta T$

Question266

A large cylindrical rod of length L is made by joining two identical rods of copper and steel of length $\left(\frac{1}{2}\right)$ each.
The rods are completely insulated from the surroundings. If the free end of copper rod is maintained at 100°C and that of steel at 0°C then the temperature of junction is (Thermal conductivity of copper is 9 times that of steel)
[Online May 19, 2012]

Options:

A. 90°C

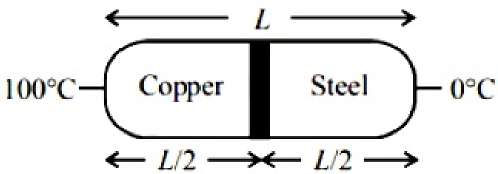
C. 10°C

D. 67°C

Answer: A

Solution:

Solution:



Let conductivity of steel $K_{steel} = k$ then from question
Conductivity of copper $K_{copper} = 9k$
$\theta_{copper} = 100°C$
$\theta_{steel} = 0°C$
$l_{steel} = l_{copper} = \frac{L}{2}$
From formula temperature of junction;
$$\theta = \frac{K_{copper}\theta_{copper}l_{steel} + K_{steel}\theta_{steel}l_{copper}}{K_{copper}l_{steel} + K_{steel}l_{copper}}$$
$$= \frac{9k \times 100 \times \frac{L}{2} + k \times 0 \times \frac{L}{2}}{9k \times \frac{L}{2} + k \times \frac{L}{2}}$$
$$= \frac{\frac{900}{2}kL}{\frac{10kL}{2}} = 90°C$$

Question267

The heat radiated per unit area in 1 hour by a furnace whose temperature is 3000 K is (s = 5.7×10^{-8} W $m^{-2}K^{-4}$) [Online May 7, 2012]

Options:

A. 1.7×10^{10} J

B. 1.1×10^{12} J

C. 2.8×10^{8} J

D. 4.6×10^{6} J

Answer: A

Solution:

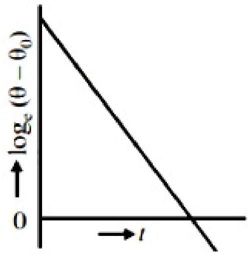
Solution:
According to Stefan's law
$E = \sigma T^4$
Heat radiated per unit area in 1 hour (3600 s) is

Question268

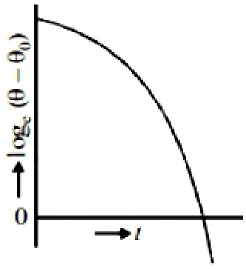
A liquid in a beaker has temperature $\theta(t)$ at time t and θ_0 is temperature of surroundings, then according to Newton's law of cooling the correct graph between $\log_e(\theta - \theta_0)$ and t is :
[2012]

Options:

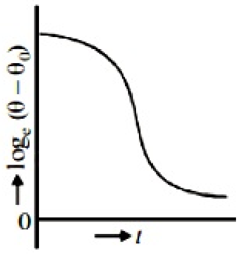
A.



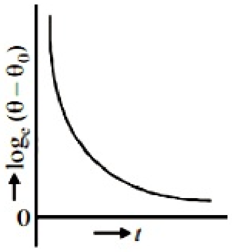
B.



C.



D.



Answer: A

Solution:

According to newton's law of cooling

$\frac{d\theta}{dt} = -k(\theta - \theta_0)$

$\Rightarrow \frac{d\theta}{(\theta - \theta_0)} = -k\,dt$

$\Rightarrow \int_{\theta_0}^{\theta} \frac{d\theta}{(\theta - \theta_0)} = -k \int_{\theta}^{t} dt$

$\Rightarrow \log(\theta - \theta_0) = -kt + c$

Which represents an equation of straight line.
Thus the option (a) is correct.

Question269

Water is flowing continuously from a tap having an internal diameter 8×10^{-3}m. The water velocity as it leaves the tap is $0.4 ms^{-1}$. The diameter of the water stream at a distance 2×10^{-1}m below the tap is close to:
[2011]

Options:

A. 7.5×10^{-3}m

B. 9.6×10^{-3}m

C. 3.6×10^{-3}m

D. 5.0×10^{-3}m

Answer: C

Solution:

Solution:
Using Bernoulli's theorem, for horizontal flow

$P_0 + \frac{1}{2}\rho v_1^2 + \rho g h = P_0 + \frac{1}{2}\rho v_2^2 + 0$

$v_2 = \sqrt{v_1^2 + 2gh} = \sqrt{0.16 + 2 \times 10 \times 0.2} = 2.03 m/s$

According to equation of continuity

$A_2 v_2 = A_1 v_1$

$\pi \frac{D_2^2}{4} \times v_2 = \pi \frac{D_1^2}{4} v_1$

$\Rightarrow D_2 = D_1 \sqrt{\frac{v_1}{v_2}} = 3.55 \times 10^{-3}$m

---

Question270

If a ball of steel (density $\rho = 7.8 gcm^{-3}$) attains a terminal velocity of $10 cms^{-1}$ when falling in water (Coefficient of viscosity $\eta_{water} = 8.5 \times 10^{-4}$Pa . s), then, its terminal velocity in glycerine ($\rho = 1.2 gcm^{-3}$, $\eta = 13.2$Pa . s) would be, nearly

Options:

A. $6.25 \times 10^{-4} cms^{-1}$

B. $6.45 \times 10^{-4} cms^{-1}$

C. $1.5 \times 10^{-5} cms^{-1}$

D. $1.6 \times 10^{-5} cms^{-1}$

Answer: A

Solution:

Solution:
When the ball attains terminal velocity
Weight of the ball = viscous force + buoyant force
$\therefore V \rho g = 6\pi\eta r v + V \rho_l g$
$\Rightarrow V g(\rho - \rho_l) = 6\pi\eta r v$
Also $V g(\rho - \rho_i{}') = 6\pi\eta v'$
$\therefore v'\eta' = \frac{(\rho - \rho_l{}')}{(\rho - \rho_l)} \times v\eta$
$\Rightarrow v' = \frac{(\rho - \rho_l{}')}{(\rho - \rho_l)} \times \frac{v\eta}{\eta'}$
$= \frac{(7.8 - 1.2)}{(7.8 - 1)} \times \frac{10 \times 8.5 \times 10^{-4}}{13.2}$
$\therefore v' = 6.25 \times 10^{-4} cm / s$

Question271

Work done in increasing the size of a soap bubble from a radius of 3cm to 5cm is nearly (Surface tension of soap solution $= 0.03 N m^{-1}$) [2011]

Options:

A. $0.2\pi mJ$

B. $2\pi mJ$

C. $0.4\pi mJ$

D. $4\pi mJ$

Answer: C

Solution:

Solution:
Work done = increasing in surface area × surface tension
$\Rightarrow W = 2T\, 4\pi[(5^2) - (3)^2] \times 10^{-4}$
$= 2 \times 0.03 \times 4\pi[25 - 9] \times 10^{-4} J$
$= 0.4\pi \times 10^{-3} J = 0.4\pi mJ$

Question272

**Two mercury drops (each of radius ' r ') merge to form bigger drop. The surface energy of the bigger drop, if T is the surface tension, is :
[2011 RS]**

Options:

A. $4\pi r^2 T$

B. $2\pi r^2 T$

C. $2^{8/3}\pi r^2 T$

D. $2^{5/3}\pi r^2 T$

Answer: C

Solution:

Solution:
As volume remains constant
∴ Sum of volumes of 2 smaller drops
= Volume of the bigger drop
$2 \cdot \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \Rightarrow R = 2^{1/3} r$
Surface energy = Surface tension times Surface area $= T \cdot 4\pi R^2$
$= T\, 4\pi 2^{2/3} r^2 = T \cdot 2^{8/3}\pi r^2$

Question273

**100g of water is heated from 30°C to 50°C. Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J/kg/K):
[2011]**

Options:

A. 8.4 kJ

B. 84 kJ

C. 2.1 kJ

D. 4.2 kJ

Answer: A

Solution:

Solution:
$\Delta U = \Delta Q = mc\Delta T$
$= \frac{100}{1000} \times 4184(50 - 30) \approx 8.4\text{kJ}$

Question274

The specific heat capacity of a metal at low temperature(T) is given as
$C_p(\text{kJ K}^{-1}\text{kg}^{-1}) = 32\left(\frac{T}{400}\right)^3$
A 100 gram vessel of this metal is to be cooled from 20ºK to 4ºK by a special refrigerator operating at room temperature (27°C). The amount of work required to cool the vessel is
[2011 RS]

Options:

A. greater than 0.148 kJ

B. between 0.148 kJ and 0.028 kJ

C. less than 0.028 kJ

D. equal to 0.002 kJ

Answer: D

Solution:

Solution:
Required work = energy released
Here, $Q = \int mc\,dT$

$$= \int_{20}^{4} 0.1 \times 32 \times \left(\frac{T^3}{400^3}\right) dT = \int_{20}^{4} \frac{3.2}{64 \times 10^6} T^3 dT$$

$$= 5 \times 10^{-8} \int_{20}^{4} T^3 dT = 0.002\text{kJ}$$

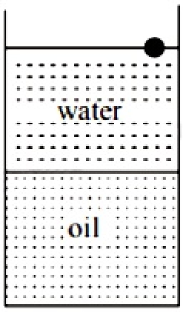
Therefore, required work $= 0.002\text{kJ}$

Question275

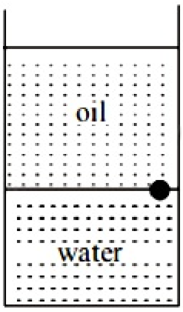
A ball is made of a material of density rho where $\rho_{oil} < \rho < \rho_{water}$ with ρ_{oil} and ρ_{water} represe-nting the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium position?
[2010]

Options:

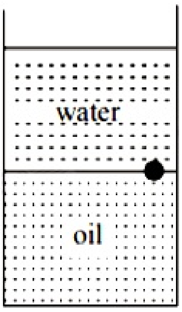
A.



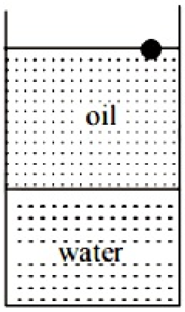
B.



C.



D.



Answer: B

Solution:

Solution:
Oil will float on water so, (b) or (d) is the correct option. But density of ball is more than that of oil,, hence it will sink in oil.

Question276

Two identical charged spheres are suspended by strings of equal

suspended in a liquid of density $0.8 gcm^{-3}$, the angle remains the same. If density of the material of the sphere is $1.6 gcm^{-3}$, the dielectric constant of the liquid is
[2010]

Options:

A. 4

B. 3

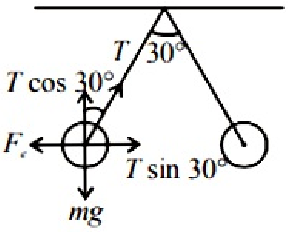
C. 2

D. 1

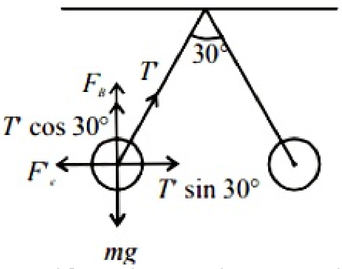
Answer: C

Solution:

Solution:



$F_e = T \sin 30°$
$mg = T \cos 30°$
$\Rightarrow \tan 30° = \frac{F_e}{mg}$ ......(i)
In liquid,
$F'_e = T' \sin 30°$ .....(A)
$mg = F_B + T' \cos 30°$
But $F_B =$ Buoyant force



$= V(d - \rho)g = V(1.6 - 0.8)g = 0.8Vg$
$= 0.8\frac{m}{d}g = \frac{0.8mg}{1.6} = \frac{mg}{2}$
$\therefore mg = \frac{mg}{2} + T' \cos 30°$
$\Rightarrow \frac{mg}{2} = T' \cos 30°$ ......(B)
From (A) and (B), $\tan 30° = \frac{2F'_e}{mg}$
From (1) and (2)
$\frac{F_e}{mg} = \frac{2F'_e}{mg}$ ....(2)
$\Rightarrow F_e = 2F'_e$
If K be the dielectric constant, then
$F'_e = \frac{F_e}{K}$
$\therefore F_e = \frac{2F_e}{K} \Rightarrow K = 2$

Question277

**Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area 3A. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount?
[2009]**

Options:

A. 4 F

B. 6 F

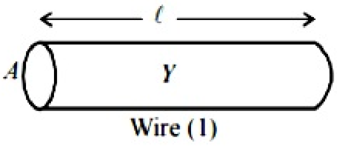
C. 9 F

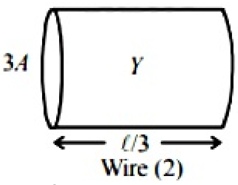
D. F

Answer: C

Solution:

Solution:





For wire 1
Length, $L_1 = l$
Area, $A_1 = A$
For wire 2
Length, $L_2 = \frac{l}{3}$
Area, $A_2 = 3A$
As the wires are made of same material, so they will have same young's modulus.
For wire 1
$Y = \frac{F / A}{\Delta x / l}$ ....(i)
For wire 2 ,
$Y = \frac{F' / 3A}{\Delta \frac{x}{(l / 3)}}$ ....(ii)
From (i) and (ii) we get,
$\frac{F}{A} \times \frac{l}{\Delta x} = \frac{F'}{3A} \times \frac{l}{3\Delta x} \Rightarrow F' = 9F$

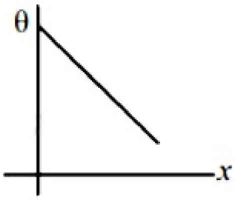
Question278

A long metallic bar is carrying heat from one of its ends to the other end

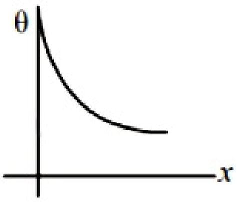
the bar from its hot end is best described by which of the following figures?
[2009]

Options:

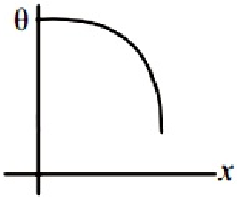
A.



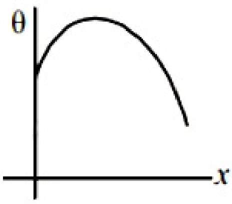
B.



C.



D.



Answer: A

Solution:

Solution:
Let Q be the temperature at a distance x from hot end of bar. Let Q is the temperature of hot end.
The heat flow rate is given by

$$\frac{dQ}{dt} = \frac{kA(\theta_1 - \theta)}{x}$$

$$\Rightarrow \theta_1 - \theta = \frac{x}{kA}\frac{dQ}{dt}$$

$$\Rightarrow \theta = \theta_1 - \frac{x}{kA}\frac{dQ}{dt}$$

Thus, the graph of Q versus x is a straight line with a positive intercept and a negative slope.
The above equation can be graphically represented by option (a).

Question279

A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and, ρ_2 respectively. A solid ball, made of a material of density rho$_3$, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_2 and ρ_3 ?
[2008]

Options:

A. $\rho_3 < \rho_1 < \rho_2$

B. $\rho_1 > \rho_3 > \rho_2$

C. $\rho_1 < \rho_2 < \rho_3$

D. $\rho_1 < \rho_3 < \rho_2$

Answer: D

Solution:

Solution:
As liquid 1 floats over liquid 2 . The lighter liquid floats over heavier liquid. So, $\rho_1 < \rho_2$
Also $\rho_3 < \rho_2$ because the ball of density rho_3 does not sink to the bottom of the jar.
Also $\rho_3 > \rho_1$ otherwise the ball would have floated in liquid 1 . we conclude that
$\rho_1 < \rho_3 < \rho_2$

Question280

A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density $\rho_1(\rho_2 < \rho_1)$. Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = -kv^2 (k > 0)$. The terminal speed of the ball is
[2008]

Options:

A. $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$

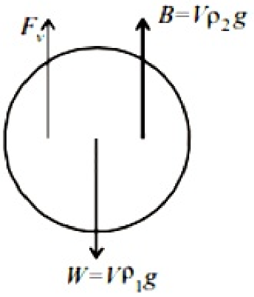
B. $\frac{Vg\rho_1}{k}$

C. $\sqrt{\frac{Vg\rho_1}{k}}$

D. $\frac{Vg(\rho_1 - \rho_2)}{k}$

Solution:

Solution:
When the ball attains terminal velocity
Weight of the ball = Buoyant force + Viscous force



$\therefore V\rho_1 g = V\rho_2 g + kv_t^2 \Rightarrow Vg(\rho_1 - \rho_2)g = kv_t^2$

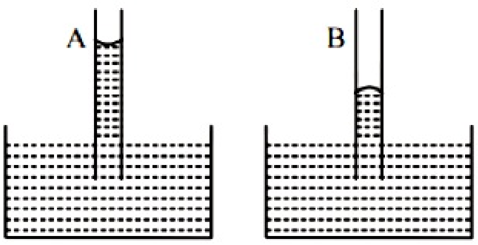
$\Rightarrow v_t = \sqrt{\dfrac{Vg(\rho_1 - \rho_2)}{k}}$

Question281

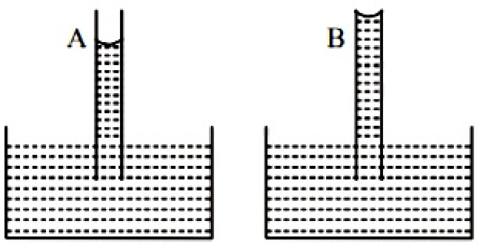
A capillary tube (A) is dipped in water. Another identical tube (B) is dipped in a soap-water solution. Which of the following shows the relative nature of the liquid columns in the two tubes?
[2008]

Options:

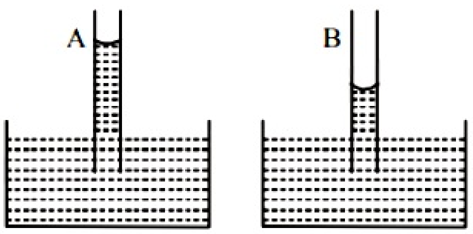
A.

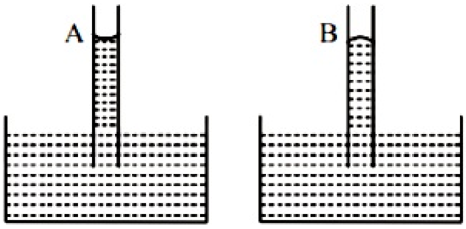


B.



C.





Answer: C

Solution:

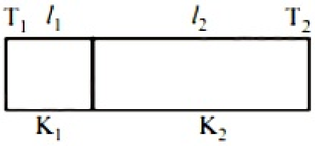
Solution:

In case of water, the meniscus shape is concave upwards. From ascent formula $h = \frac{2\sigma\cos\theta}{r\rho g}$

The surface tension (σ) of soap solution is less than water. Therefore height of capillary rise for soap solution should be less as compared to water. As in the case of water, the meniscus shape of soap solution is also concave upwards.

Question282

One end of a thermally insulated rod is kept at a temperature T_1 and the other at T_2. The rod is composed of two sections of length l_1 and l_2 and thermal conductivities K_1 and K_2 respectively. The temperature at the interface of the two section is



[2007]

Options:

A. $\frac{(K_1 l_1 T_1 + K_2 l_2 T_2)}{(K_1 l_1 + K_2 l_2)}$

B. $\frac{(K_2 l_2 T_1 + K_1 l_1 T_2)}{(K_1 l_1 + K_2 l_2)}$

C. $\frac{(K_2 l_1 T_1 + K_1 l_2 T_2)}{(K_2 l_1 + K_1 l_2)}$

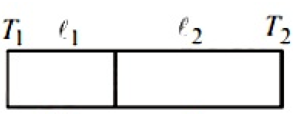
D. $\frac{(K_1 l_2 T_1 + K_2 l_1 T_2)}{(K_1 l_2 + K_2 l_1)}$

Answer: D

Solution:

Solution:

Let T be the temperature of the interface. In the steady state, $Q_1 = Q_2$



$\therefore \frac{K_1A(T_1 - T)}{l_1} = \frac{K_2A(T - T_2)}{l_2}$
where A is the area of cross-section.
$\Rightarrow K_1A(T_1 - T)l_2 = K_2A(T - T_2)l_1$
$\Rightarrow K_1T_1l_2 - K_1Tl_2 = K_2Tl_1 - K_2T_2l_1$
$\Rightarrow (K_2l_1 + K_1l_2)T = K_1T_1l_2 + K_2T_2l_1$
$\Rightarrow T = \frac{K_1T_1l_2 + K_2T_2l_1}{K_2l_1 + K_1l_2}$
$= \frac{K_1l_2T_1 + K_2l_1T_2}{K_1l_2 + K_2l_1}$

Question283

A wire elongates by l mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm)
[2006]

Options:

A. l

B. 2l

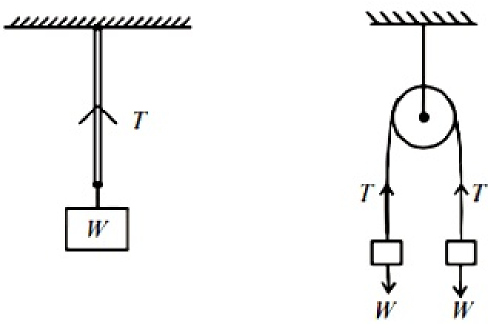
C. zero

D. l/2

Answer: A

Solution:

Solution:
Case (i)



At equilibrium, $T = W$
Young's modules, $Y = \frac{W / A}{l / L}$ ....(i)
Elongation, $l = \frac{W}{A} \times \frac{L}{Y}$
Case (ii) At equilibrium $T = W$
$\therefore$ Young's moduls, $Y = \frac{W / A}{\frac{l / 2}{L / 2}}$
$\Rightarrow Y = \frac{W / A}{l / L} \Rightarrow l = \frac{W}{A} \times \frac{L}{Y}$
$\Rightarrow$ Elongation is the same.

Question284

If the terminal speed of a sphere of gold (density $= 19.5 kg / m^3$) is 0.2m / s in a viscous liquid (density $= 1.5 kg / m^3$), find the terminal speed of a sphere of silver (density $= 10.5 kg / m^3$) of the same size in the same liquid
[2006]

Options:

A. 0.4 m/s

B. 0.133 m/s

C. 0.1 m/s

D. 0.2 m/s

Answer: C

Solution:

Solution:
Given,
Density of gold, $\rho_G = 19.5 kg / m^3$
Density of silver, $rho_5 = 10.5 kg / m^3$
Density of liquid, $\sigma = 1.5 kg / m^3$
Terminal velocity, $v_T = \frac{2r^2(\rho - \sigma)g}{9\eta}$
$\therefore \frac{v_{T_2}}{0.2} = \frac{(10.5 - 1.5)}{(19.5 - 1.5)} \Rightarrow v_{T_2} = 0.2 \times \frac{9}{18}$
$\therefore v_{T_2} = 0.1 m / s$

Question285

Assuming the Sun to be a spherical body of radius R at a temperature of T K , evaluate the total radiant powered incident of Earth at a distance r from the Sun
[2006]

Options:

A. $4\pi r_0{}^2 R^2 \sigma \frac{T^4}{r^2}$

B. $\pi r_0{}^2 R^2 \sigma \frac{T^4}{r^2}$

C. $r_0{}^2 R^2 \sigma \frac{T^4}{4\pi r^2}$

D. $R^2 \sigma \frac{T^4}{r^2}$

Solution:

Solution:
From stefan's law, total power radiated by operatorname Sun, $E = \sigma T^4 \times 4\pi R^2$
The intensity of power Per unit area incident on earth's surface
$= \frac{\sigma T^4 \times 4\pi R^2}{4\pi r^2}$
Total power received by Earth
$E' = \frac{E}{4\pi r^2} \times$ Cross − Section area of earth facing the sun $= \frac{\sigma T^4 R^2}{r^2}(\pi r_0{}^2)$

Question286

Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while Box contains one mole of helium at temperature $\left(\frac{7}{3}\right)T_0$. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature (ignore the heat capacity of boxes). Then, the final temperature of the gases, T_f in terms of T_0 is
[2006]

Options:

A. $T_f = \frac{3}{7}T_0$

B. $T_f = \frac{7}{3}T_0$

C. $T_f = \frac{3}{2}T_0$

D. $T_f = \frac{5}{2}T_0$

Answer: C

Solution:

Solution:
When two gases are mixed to gether then
Heat lost by He gas = Heat gained by N_2 gas
$n_1 C_{v_1} \Delta T_1 = n_2 C_{v_2} \Delta T_2$
$\frac{3}{2}R\left[\frac{7}{3}T_0 - T_f\right] = \frac{5}{2}R[T_f - T_0]$
$7T_0 - 3T_f = 5T_f - 5T_0$
$\Rightarrow 12T_0 = 8T_f \Rightarrow T_f = \frac{12}{8}T_0$
$\Rightarrow T_f = \frac{3}{2}T_0 ..$

Question287

If 'S' is stress and 'Y' is young's modulus of material of a wire, the energy stored in the wire per unit volume is
[2005]

Options:

A. $\frac{S^2}{2Y}$

B. $2S^2Y$

C. $\frac{S}{2Y}$

D. $\frac{2Y}{S^2}$

Answer: A

Solution:

Solution:
Energystored in the wire per unit volume,
$E = \frac{1}{2} \times \text{stress} \times \text{strain}$ ....(i)
We know that,
$Y = \frac{\text{stress}}{\text{strain}}$
$\Rightarrow \text{strain} = \frac{\text{stress}}{Y}$
On substituting the expression of strain in equation (i) we get
$E = \frac{1}{2} \times \text{stress} \times \frac{\text{stress}}{Y} = \frac{1}{2} \cdot \frac{S^2}{Y}$

Question288

A 20cm long capillary tube is dipped in water. The water rises up to 8cm. If the entire arrangement is put in a freely falling elevator the length of water column in the capillary tube will be
[2005]

Options:

A. 10cm

B. 8cm

C. 20cm

D. 4cm

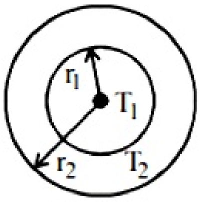
Answer: C

Solution:

Solution:
Water fills the tube entirely in gravityless condition i.e., 20 cm.

Question289

The figure shows a system of two concentric spheres of radii r_1 and r_2 are kept at temperatures T_1 and T_2, respectively. The radial rate of flow of heat in a substance between the two concentric spheres is proportional to



[2005]

Options:

A. $\ln\left(\frac{r_2}{n}\right)$

B. $\frac{(r_2 - r_1)}{(r_1 r_2)}$

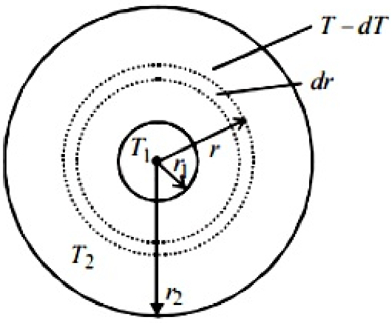
C. $(r_2 - r_1)$

D. $\frac{r_1 r_2}{(r_2 - r_1)}$

Answer: D

Solution:

Solution:



Consider a thin concentric shell of thickness (dr) and of radius (r) and let the temperature of inner and outer surfaces of this shell be T and (T – dT) respectively.
The radial rate of flow of heat through this elementary shell will be

$$\frac{dQ}{dt} = \frac{KA[(T - dT) - T]}{dr} = \frac{-KAdT}{dr}$$

$$= -4\pi K r^2 \frac{dT}{dr} \quad (\because A = 4\pi r^2)$$

Since the area of the surface through which heat will flow is not constant. Integrating both sides between the limits of radii and temperatures of the two shells, we get

$$\left(\frac{dQ}{dt}\right) \int_{r_1}^{r_2} \frac{1}{r^2} dr = -4\pi K \int_{T_1}^{T_2} dT$$

$$\left(\frac{dQ}{dt}\right)\int_{r_1}^{r_2} r^{-2}dr = -4\pi K\int_{T_1}^{T_2} dT$$

$$\frac{dQ}{dt}\left[\frac{1}{r_1}-\frac{1}{r_2}\right] = -4\pi K\,[T_2 - T_1]$$

or $\frac{dQ}{dt} = \frac{-4\pi K\, r_1 r_2 (T_2 - T_1)}{(r_2 - r_1)}$

$\therefore \frac{dQ}{dt} \propto \frac{r_1 r_2}{(r_2 - r_1)}$

Question290

A wire fixed at the upper end stretches by length l by applying a force F. The work done in stretching is [2004]

Options:

A. $2Fl$

B. Fl

C. $\frac{F}{2l}$

D. $\frac{Fl}{2}$

Answer: D

Solution:

Solution:
Let A and L be the area and length of the wire. Work done by constant force in displacing the wire by a distance l = change in potential energy

$= \frac{1}{2} \times$ stress $\times$ strain $\times$ volume

$= \frac{1}{2} \times \frac{F}{A} \times \frac{l}{L} \times A \times L = \frac{Fl}{2}$

Question291

Spherical balls of radius ‘R’ are falling in a viscous fluid of viscosity ‘η’ with a velocity ‘v’. The retarding viscous force acting on the spherical ball is [2004]

Options:

A. inversely proportional to both radius ‘R’ and velocity ‘v’

B. directly proportional to both radius ‘R’ and velocity ‘v’

C. directly proportional to ‘R’ but inversely proportional to ‘v’

Answer: B

Solution:

Solution:
From Stoke's law, force of viscosity acting on a spherical body is $F = 6\pi\eta rv$
hence F is directly proportional to radius & velocity.

Question292

If two soap bubbles of different radii are connected by a tube [2004]

Options:

A. air flows from the smaller bubble to the bigger

B. air flows from bigger bubble to the smaller bubble till the sizes are interchanged

C. air flows from the bigger bubble to the smaller bubble till the sizes become equal

D. there is no flow of air.

Answer: A

Solution:

Solution:
Let pressure outside be P_0 and r and R be the radius of smaller bubble and bigger bubble respectively.
$\therefore$ Pressure P_1 For smaller bubble $= P_0 + \frac{2T}{r}$
P_2 For bigger bubble $= P_0 + \frac{2T}{R}(R > r)$
$\therefore P_1 > P_2$
hence air moves from smaller bubble to bigger bubble.

Question293

If the temperature of the sun were to increase from T to 2T and its radius from R to 2R, then the ratio of the radiant energy received on earth to what it was previously will be [2004]

Options:

A. 32

B. 16

C. 4

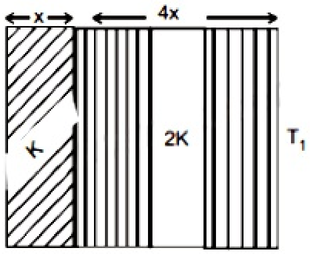
D. 64

Solution:

Solution:
From stefan's law, energy radiated by sun per second
$E = \sigma A T^4$
$\therefore A \propto R^2$
$\therefore E \propto R^2 T^4$
$\therefore \frac{E_2}{E_1} = \frac{R_2^{\,2} T_2^{\,4}}{R_1^{\,2} T_1^{\,4}}$
put $R_2 = 2R$, $R_1 = R$; $T_2 = 2T$, $T_1 = T$
$\Rightarrow \frac{E_2}{E_1} = \frac{(2R)^2(2T)^4}{R^2 T^4} = 64$

Question294

The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and $2K$ and thickness x and 4x,respectively, are T_2 and $T_1 (T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right) f$, with f equal to



[2004]

Options:

A. $\frac{2}{3}$

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

C. 1

D. $\frac{1}{3}$

Answer: D

Solution:

Solution:
The thermal resistance is given by
$\frac{x}{KA} + \frac{4x}{2KA} = \frac{x}{KA} + \frac{2x}{KA} = \frac{3x}{KA}$
Amount of heat flow per second,
$\frac{dQ}{dt} = \frac{\Delta T}{3x} = \frac{(T_2 - T_1)KA}{3x}$

$= \frac{1}{3}\left\{\frac{A(T_2 - T_1)K}{x}\right\} \therefore f = \frac{1}{3}$

Question295

The earth radiates in the infra-red region of the spectrum. The spectrum is correctly given by [2003]

Options:

A. Rayleigh Jeans law

B. Planck's law of radiation

C. Stefan's law of radiation

D. Wien's law

Answer: D

Solution:

Solution:
Wein's law correctly explains the spectrum

Question296

According to Newton's law of cooling, the rate of cooling of a body is proportional to $(\Delta\theta)^n$, where $\Delta\theta$ is the difference of the temperature of the body and the surroundings, and n is equal to [2003]

Options:

A. two

B. three

C. four

D. one

Answer: D

Solution:

Solution:
From Newton's law of cooling $-\frac{dQ}{dt} \propto (\Delta\theta)$

Question297

A cylinder of height 20 m is completely filled with water. The velocity of efflux of water (in ms^{-1}) through a small hole on the side wall of the cylinder near its bottom is [2002]

Options:

A. 10

B. 20

C. 25.5

D. 5

Answer: B

Solution:

Solution:
Given, Height of cylinder, $h = 20cm$ Acceleration due to gravity, $g = 10ms^{-2}$
Velocity of efflux $v = \sqrt{2gh}$
Where h is the height of the free surface of liquid from the hole
$\Rightarrow v = \sqrt{2 \times 10 \times 20} = 20m / s$

Question298

Heat given to a body which raises its temperature by 1°C is [2002]

Options:

A. water equivalent

B. thermal capacity

C. specific heat

D. temperature gradient

Answer: B

Solution:

Solution:
Heat required for raising the temperature of a body through 1ºC is called its thermal capacity.

Question299

[2002]

Options:

A. spectrometer

B. pyrometer

C. nanometer

D. photometer

Answer: B

Solution:

Solution:
Pyrometer is used to detect infra-red radiation

Question300

Which of the following is more close to a black body?
[2002]

Options:

A. black board paint

B. green leaves

C. black holes

D. red roses

Answer: A

Solution:

Solution:
Black body is one which absorb all incident radiation.
Black board paint is quite approximately equal to black bodies.

Question301

If mass-energy equivalence is taken into account, when water is cooled to form ice, the mass of water should
[2002]

Options:

A. increase

C. decrease

D. first increase then decrease

Answer: C

Solution:

Solution:
When water is cooled at 0°C to form ice, energy is released from water in the form of heat. As energy is equivalent to mass, therefore, when water is cooled to ice, its mass decreases.

Question302

Two spheres of the same material have radii 1 m and 4 m and temperatures 4000 K and 2000 K respectively. The ratio of the energy radiated per second by the first sphereto that by the second is [2002]

Options:

A. 1 : 1

B. 16 : 1

C. 4 : 1

D. 1 : 9

Answer: A

Solution:

From stefan's law, the energy radiated per second is given by $E = e\sigma T^4 A$
Here, T = temperature of the body
A = surface area of the body For same material e is same. σ is stefan's constant
Let T_1 and T_2 be the temperature of two spheres. A_1 and A_2 be the area of two spheres.

$$\therefore \frac{E_1}{E_2} = \frac{T_1^4 A_1}{T_2^4 A_2} = \frac{T_1^4 4\pi r_1^2}{T_2^4 4\pi r_2^2}$$

$$= \frac{(4000)^4 \times 1^2}{(2000)^4 \times 4^2} = \frac{1}{1}$$
