



PHYSICS

BOOKS - HC VERMA

SOME MECHANICAL PROPERTIES OF MATTER

Example

1. A load of 4.0 kg is suspended from a ceiling through a steel wire of radius 2.0 mm. Find the

tensile stress developed in the wire when equilibrium is achieved. Take $g = 3.1\pi \frac{m}{s^{-2}}$



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2. A load of 4.0 kg is suspended from a ceiling through a steel wire of length 20 m and radius 2.0 mm. It is found that the length of the wire increases by 0.031 mm as equilibrium is achieved. Find Young modulus of steel. Take $g = 3.1\pi m s^{-2}$



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3. A steel wire of length 2.0 m is stretched through 2.0 mm. The cross sectional area of the wire is 4.0 mm^2 . Calculate the elastic potential energy stored in the wire in the stretched condition. Young modulus of steel $= 2.0 \times 10^{11} \text{ Nm}^{-2}$



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4. Water is kept in a beaker of radius 5.0 cm. Consider a diameter of the beaker on the

surface of the water. Find the force by which the surface on one side of the diameter pulls the surface on the other side. Surface tension of water = $0.075Nm^{-1}$.



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5. A water drop of radius 10^{-2} m is broken into 1000 equal droplets. Calculate the gain in surface energy. Surface tension of water is $0.075Nm^{-1}$



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6. Find the excess pressure inside a mercury drop of radius 2.0 mm. The surface tension of mercury $0.464Nm^{-1}$.



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7. A 0.02 cm liquid column balances the excess pressure inside a soap bubble of radius 7.5 mm. Determine the density of the liquid. Surface tension of soap solution $0.03Nm^{-1}$.



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8. A capillary tube of radius 0.20 mm is dipped vertically in water. Find the height of the water column raised in the tube. Surface tension of water = 0.075 Nm^{-1} and density of water = 1000 kgm^{-3} . Take $g = 10 \text{ ms}^{-2}$.



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Worked Out Example

1. One end of a wire 2m long and 0.2 cm^2 in cross section is fixed in a ceiling and a load of 4.8 kg is attached to the free end. Find the extension of the wire. Young modulus of steel $= 2.0 \times 10^{11} \text{ Nm}^{-2}$. Take $g = 10 \text{ ms}^{-2}$.



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2. One end of a nylon rope of length 4.5 m and diameter 6 mm is fixed to a tree limb. A monkey weighing 100 N jumps to catch the

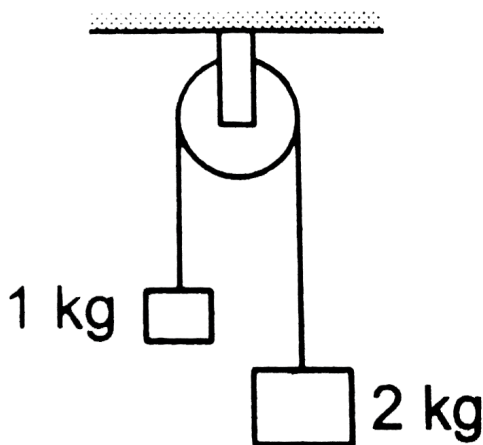
free end and stays there. Find the elongation of the rope and the corresponding change in the diameter. Young modulus of nylon = $4.8 \times 10^{11} Nm^{-2}$ and poisson ratio of nylon = 0.2.



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3. Two blocks of masses 1 kg and 2kg are connect by a metal wire going over a smooth pulley as shown in figure. The breaking stress of the metal is $2 \times 10^9 Nm^{-2}$. What should be

the minimum radius of the wire used if it is not to break? Take $g = 10\text{ms}^{-2}$



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4. Two wires of equal cross section but one made of steel and the other of copper, are joined end to end. When the combination is

kept under tension, the elongations in the two wires are found to be equal. Find the ratio of the lengths of the two wires. Young modulus of steel $= 2.0 \times 10^{11} Nm^{-2}$ and that of copper $= 1.1 \times 10^{11} Nm^{-2}$



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5. Find the decrease in the volume of a sample of water from the following data. Initial volume $= 1000cm^3$ initial pressure $= 10^5 Nm^{-2}$, final pressure $= 10^6 Nm^{-2}$,

compressibility

of

water

$$= 50 \times 10^{-11} m^2 N^{-1}.$$



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6. One end of a metal wire is fixed to a ceiling and a load of 2 kg hangs from the other end. A similar wire is attached to the bottom of the load and another load of 1 kg hangs from this lower wire. Find the longitudinal strain in both wires. Area of cross section of each wire is

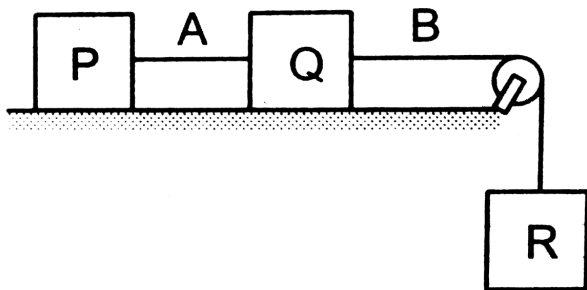
0.005cm^2 and Young modulus of the metal is $2.0 \times 10^{11}\text{Nm}^{-2}$. Take $g = 10\text{ms}^{-2}$



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7. Each of the three blocks P, Q and R shown in figure has a mass of 3 kg. Each of the wires A and B has cross sectional area 0.005cm^2 and Young modulus $2 \times 10^{11}\text{Nm}^{-2}$. Neglect friction. Find the longitudinal strain developed

in each of the wires. Take $g = 10\text{ms}^{-2}$



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8. A wire of area of cross section 3.0mm^2 and natural length 50 cm is fixed at one end and a mass of 2.1 kg is hung from the other end. Find the elastic potential energy stored in the wire in steady state. Young modulus of the material

of

the

wire

$$= 1.9 \times 10^{11} \text{ Nm}^{-2}. \text{ Take } g = 10 \text{ ms}^{-2}$$



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9. A block of weight 10 N is fastened to one end of a wire of cross sectional area 3mm^2 and is rotated in a vertical circle of radius 20 cm. The speed of the block at the bottom of the circle is 2ms^{-1} . Find the elongation of the wire when the block is at the bottom of the

circle. Young modulus of the material of the wire = $2 \times 10^{11} \text{ Nm}^{-2}$.



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10. A uniform heavy rod of weight W , cross sectional area a and length L is hanging from fixed support. Young modulus of the material of the rod is Y . Neglect the lateral contraction. Find the elongation of the rod.



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11. There is an air bubble of radius 1.0 mm in a liquid of surface tension $0.075Nm^{-1}$ and density $1000kgm^{-3}$. The bubble is at a depth of 10 cm below the free surface. By what amount is the pressure inside the bubble greater than the atmospheric pressure? Take $g = 9.8ms^{-2}$.

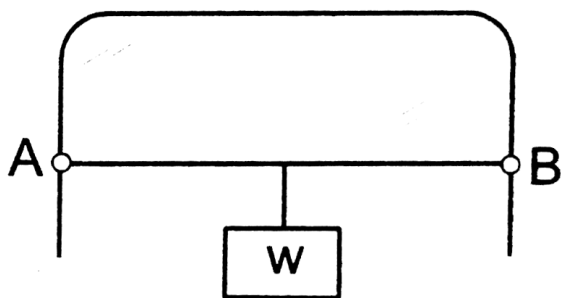


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12. A light wire AB of length 10 cm can slide on a vertical frame as shown in figure. There is a

film of soap solution trapped between the frame and the wire. Find the load W that should be suspended from the wire to keep it in equilibrium. Neglect friction. Surface tension of soap solution = 25 dyne cm^{-1} .

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



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13. The lower end of a capillary tube is dipped into water and it is seen that the water rises through 7.5 cm in the capillary. Find the radius of the capillary. Surface tension of water $= 7.5 \times 10^{-2} \text{Nm}^{-1}$. Contact angle between water and glass $= 0^\circ$. $Take g = 10 \text{ms}^{-2}$.



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14. Two mercury drops each of radius r merge to form a bigger drop. Calculate the surface

energy released.



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15. A large wooden plate of area $10m^2$ floating on the surface of river is made to move horizontally with a speed of $2ms^{-1}$ by applying a tangential force. If the river is 1m deep and the water in contact with the bed is stationary, find the tangential force needed to keep the plate moving. Coefficient of viscosity

of water at the temperature of the river
 $= 10^{-2} \text{poise}.$



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16. The velocity of water in a river is 18kmh^{-1} near the surface. If the river is 5 m deep, find the shearing stress between the horizontal layers of water. The coefficient of viscosity of water $= 10^{-2} \text{poise}.$



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17. Find the terminal velocity of a rain drop of radius 0.01 mm. The coefficient of viscosity of air is $1.8 \times 10^{-5} \text{ N} - \text{sm}^{-2}$ and its density is 1.2 kgm^{-3} . Density of water = 1000 kgm^{-3} .
 $Take g = 10 \text{ ms}^{-2}$



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Question For Short Anser

1. The ratio stress/strain remains constant for small deformation of a metal wire. When the

deformation is made larger, will this ratio increase or decrease ?



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2. When a block of mass M is suspended by a long wire of length L , the elastic potential energy stored in the wire is $\frac{1}{2} \times \textit{stress} \times \textit{strain} \times \textit{volume}$. Show that it is equal to $\frac{1}{2}Mgl$ where l is the extension. The loss in gravitational potential energy of the mass

earth system is Mgl . Where does the remaining $\frac{1}{2}Mgl$ energy go ?



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3. When the skeleton of an elephant and the skeleton of a mouse are prepared in the same size, the bones of the elephant are shown thicker than those of the mouse. Explain why the bones of an elephant are thicker than proportionate. The bones are expected to with

stand the stress due to the weight of the animal.



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4. The yield point of a typical solid is about 1%. Suppose you are lying horizontally and two persons are pulling your hands and two persons are pulling your legs along your own length. How much will be the increase in your length if the strain is 1% ? Do you think your yield point is 1% or much less than that ?



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5. When rubber sheets are used in a shock absorber, what happens to the energy of vibration ?



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6. If a compressed spring is dissolved in acid, what happens to the elastic potential energy of the spring ?



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7. A steel blade placed gently on the surface of water floats on it. If the same blade is kept well inside the water, it sinks. Explain.



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8. The contact angle between pure water and pure silver is 90° . If a capillary tube made of silver is dipped at one end in pure water, will the water rise in the capillary?



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9. It is said that a liquid rises or is depressed in a capillary due to the surface tension. If a liquid neither rises nor depresses in a capillary, can we conclude that the surface tension of the liquid is zero ?



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10. Assertion :The contact angle between water and glass is acute.

Reason :The surface of water in the capillary is convex .



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11. A uniform vertical tube of circular cross section contains a liquid. The contact angle is 90° . Consider a diameter of the tube lying in the surface of the liquid. The surface of the right of this diameter pulls the surface on the left of it. What keeps the surface on the left in equilibrium?



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12. When a glass capillary tube is dipped at one end in water, water rises in the tube. The gravitational potential energy is thus increased. Is it a violation of conservation of energy?



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13. If a mosquito dipped into water and released it is not able to fly till it is dry again.

Explain.



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14. What happens to the pressure inside a soap bubble when air is blown into it ?



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15. When the size of a soap bubble is increased by pushing more air in it, the surface area increases. Does it mean that the average

separation between the surface molecules is increased?



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16. Frictional force between solids operates even when they do not move with respect to each other. Do we have viscous force acting between two layers even if there is no relative motion?



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17. Water near the bed of a deep river is quiet while that near the surface flows. Give reasons.



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18. If water in one flask and castor oil in other are violently shaken and kept on a table, which will come to rest earlier



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1. A rope 1 cm in diameter breaks if the tension in it exceeds 500 N. The maximum tension that may be given to a similar rope of diameter 2 cm is

A. 500N

B. 250 N

C. 1000 N

D. 2000N

Answer:



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2. The breaking stress of a wire depends upon

..... .

- A. material of the wire
- B. length of the wire
- C. radius of the wire
- D. shape of the cross section

Answer:



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3. A wire can sustain the weight of 20 kg before breaking. If the wire is cut into two equal parts each part can sustain a weight of

A. 10 kg

B. 20 kg

C. 40 kg

D. 80 kg

Answer:



4. Two wires A and B are made of same material. The wire A has a length l and diameter r while the wire B has a length $2l$ and diameter $r/2$. If the two wires are stretched by the same force the elongation in A divided by the elongation in B is

A. $1/8$

B. $1/4$

C. 4

D. 8

Answer:



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5. A wire elongates by 1.0 mm when a load W is hanged from it. If this wire goes over a pulley and two weights W each are hung at the two ends the elongation of the wire will be

A. 0.5 m

B. 1.0 mn

C. 2.0 mn

D. 4.0 mm

Answer:



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6. A heavy uniform rod is hanging vertically from a fixed support. It is stretched by its own weight. The diameter of the rod is

A. smallest at the top and gradually

increases down the rod

B. largest at the top and gradually

decreases down the rod

C. uniform everywhere

D. maximum in the middle

Answer:



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7. When metal wire is stretched by a load the fractional change in its volume $\left(\frac{\Delta V}{V}\right)$ is proportional to

A. $\frac{\Delta l}{l}$

B. $\left(\frac{\Delta l}{l}\right)^2$

C. $\sqrt{\frac{\Delta l}{l}}$

D. none of these

Answer:



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8. 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

A. a) $\frac{l_1 + l_2}{2}$

B. b) $\sqrt{l_1 l_2}$

C. c) $\frac{l_1 T_2 - l_2 T_1}{T_2 - T_1}$

D. d) $\frac{l_1 T_2 + l_2 T_1}{T_2 + T_1}$

Answer:



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9. A heavy mass is attached to a thin wire and is whirled in a vertical circle. The wire is most likely to break

A. a) when the mass is at the highest point

B. b) when the mass is at the lowest point

C. c) when the wire is horizontal

D. d) at an angle of $\cos^{-1}\left(\frac{1}{3}\right)$ from the upward vertical.

Answer:



10. When a metal wire elongates by hanging a load on it, the gravitational potential energy is decreased. What does that mean?

A. a) This energy completely appears as the increased kinetic energy of the block

B. b) This energy completely appears as the increased elastic potential energy of the wire.

C. c) This energy completely appears as
heat

D. d) none of these

Answer:



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11. By a surface of a liquid we mean

A. a geometrical plane like $x=0$

B. all molecules exposed to the atmosphere

C. a layer of thickness of the order of 10^{-8} m

D. a layer of thickness of the order of 10^{-4} m

Answer:



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12. An ice cube is suspended in a vacuum in gravity free hall. As the ice melts it

- A. will retain its cubical shape
- B. will change its shape to spherical
- C. will fall down on the floor of the hall
- D. will fly up

Answer:



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13. When water droplets merge to form a bigger drop

A. energy is liberated

B. energy is absorbed

C. energy may either be liberated nor absorbed

D. energy may either be liberated or absorbed depending on the nature of the liquid

Answer:



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14. The dimensions $ML^{-1}T^{-2}$ may correspond to

- A. moment of a force
- B. surface tension
- C. modulus of elasticity
- D. coefficient of viscosity

Answer:



15. Air is pushed into a soap bubble of radius r to double its radius, of the surface tension of the soap solution is S , the work done in process is

A. $8\pi r^2 S$

B. $12\pi r^2 S$

C. $16\pi r^2 S$

D. $24\pi r^2 S$

Answer:



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16. If more air is pushed in a soap bubble, the pressure in it will

- A. decreases
- B. increases
- C. remains same
- D. becomes zero

Answer:



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17. If two soap bubbles of different radii are connected by a tube, then

A. air flows from bigger bubble to the smaller bubble till the sizes become equal

B. air flows from bigger bubble to the smaller bubble till the sizes are interchanged

C. air flows from the smaller bubble to the bigger

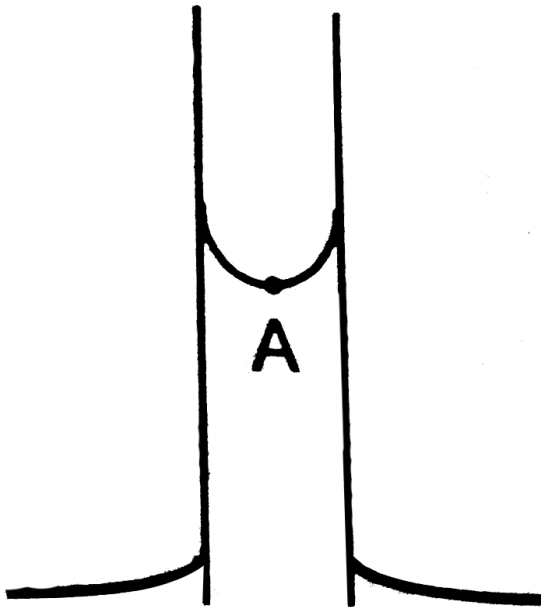
D. there is no flow of air

Answer:



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18. Figure shows a capillary tube of radius r dipped into water. If the atmosphere pressure is P_0 , the pressure at point A is



A. P_0

B. $P_0 + \frac{2S}{r}$

$$\text{C. } P_0 - \frac{2S}{r}$$

$$\text{D. } P_0 - \frac{4S}{r}$$

Answer:



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19. The excess pressure inside a soap bubble is twice the excess pressure inside a second soap bubble, the volume of the first bubble is n times the volume of the second where n is

A. 4

B. 2

C. 1

D. 0.125

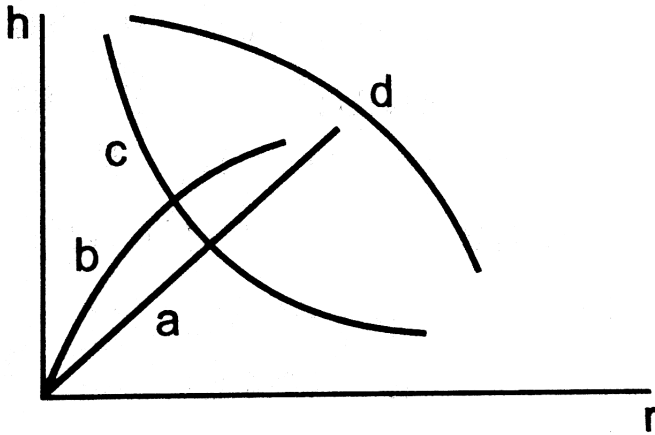
Answer:



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20. Which of the following graphs may represent the relation between the capillary

rise h and the radius r of the capillary?



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21. Water rises in a vertical capillary tube upto a length of 10 cm if the tube is inclined at 45° , the length of water risen will be

A. 10 cm

B. $10\sqrt{2}$ cm

C. $\frac{10}{\sqrt{2}}$ cm

D. none of these

Answer:



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22. A 20 cm long capillary tube is dipped in water. The water rises up to 8 cm. If the entire arrangement is put in a freely falling elevator,

the length of water column in the capillary tube will be

A. 8 cm

B. 6 cm

C. 10 cm

D. 20 cm

Answer:



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23. Viscosity is a property of

A. liquids only

B. solids only

C. solids and liquids only

D. liquids and gases only

Answer:



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24. The force of viscosity is

A. electromagnetic

B. gravitational

C. nuclear

D. weak

Answer:



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25. The viscous force acting between 2 layers of a liquid is given by $\frac{F}{A} = \eta \frac{dv}{dz}$ = This F/A may be called

- A. pressure
- B. longitudinal stress
- C. tangential stress
- D. volume stress

Answer:



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26. A raindrop falls near the surface of the earth with almost uniform velocity because

A. its weight is negligible

B. the force of surface tension balances its weight

C. the force of viscosity of air balances its weight

D. the drops are charged and atmospheric electric field balances its weight

Answer:



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27. A piece of wood is taken deep inside a long column of water & released it will move up.

- A. with a constant upward acceleration
- B. with a decreasing upward acceleration
- C. with a deceleration
- D. with a uniform velocity

Answer:



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28. A solid sphere falls with a terminal velocity of 20ms^{-1} in air. If it is allowed to fall in vacuum

A. terminal velocity will be 20ms^{-1}

B. terminal velocity will be less than

20ms^{-1}

C. terminal velocity will be more than

$$20\text{ms}^{-1}$$

D. there will be no terminal velocity

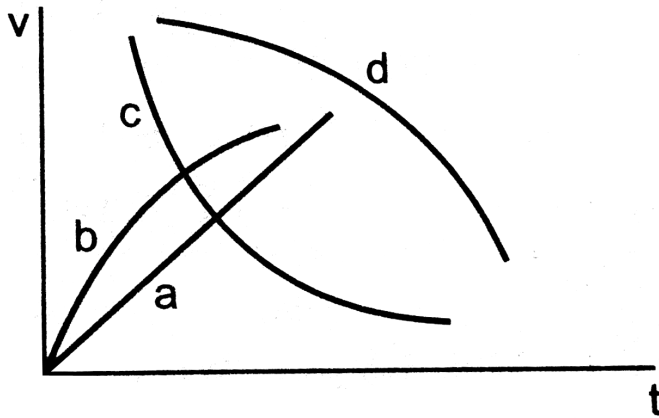
Answer:



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29. A spherical ball is dropped in a long column of a viscous liquid. The speed of the ball as a function of time may be best

represented by the graph



A. A

B. B

C. C

D. D

Answer:



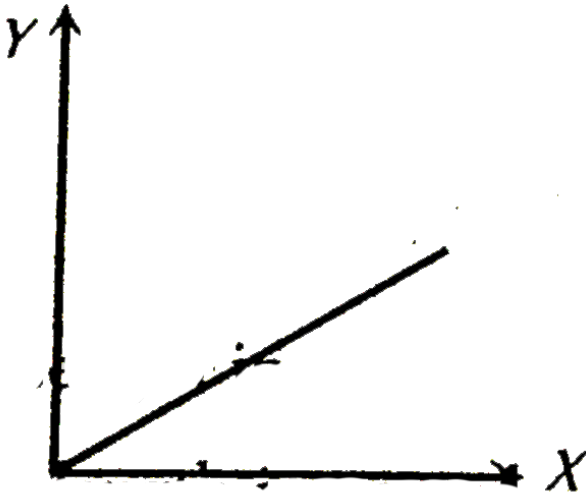


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Objective 2

1. A student plots a graph from his reading on the determination of Young's modulus of a metal wire but forgets to label. The quantities

on X and Y may be respectively.



- A. weight hung and length increased
- B. stress applied and length increased
- C. stress applied and strain developed
- D. length increased and the weight hung.

Answer:



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2. The properties of a surface are different from those of the bulk liquid because the surface molecules are

A. are smaller than other molecules

B. acquire charge due to collision from air molecules

C. find different type of molecules in their range of influence

D. feel a net force in one direction

Answer:



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3. The rise of a liquid in a capillary tube depends on

A. the material

B. the length

C. the outer radius

D. the inner radius of the tube

Answer:



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4. The contact angle between a solid & a liquid is a property of

A. the material of the solid

B. the material of the liquid

C. the shape of the solid

D. the mass of the solid

Answer:



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5. A liquid is contained in a vertical tube a semicircular cross section the contact angle is zero. The force of surface tension on the curved part & on the flat part are in ratio

A. 1 : 1

B. 1 : 2

C. π : 2

D. 2 : π

Answer:



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6. When a capillary tube is dipped into a liquid the liquid neither rises nor falls in the capillary

- A. the surface tension of the liquid must be zero
- B. the contact angle must be 90°
- C. the surface tension may be zero
- D. the contact angle may be 90°

Answer:



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7. A solid sphere moves at a terminal velocity of 20ms^{-1} in air at a place where $g = 9.8\text{ms}^{-2}$. The sphere is taken in a gravity free hall having air at the same pressure and pushed down at a speed of 20ms^{-1}

A. its initial acceleration will be 9.8ms^{-2}
downward

B. its initial acceleration will be 9.8ms^{-2}
upward

C. The magnitude of acceleration will decrease as the time passes.

D. It will eventually stop

Answer:



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Exercises

1. A load of 10 kg is suspended by a metal wire 3 m long and having a cross sectional area

4mm^2 . Find a. the stress b. the strain and c. the elongation. Young modulus of the metal is $2.0 \times 10^{11} \text{Nm}^{-2}$



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2. A vertical metal cylinder of radius 2 cm and length 2 m is fixed at the lower end and a load of 100 kg is put on it. find a. the stress b. the strain and c. the compression of the cylinder.

Young modulus of the metal
 $= 2 \times 10^{11} \text{Nm}^{-2}$



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3. The elastic limit of steel is $8 \times 10^8 Nm^{-2}$ and its Young modulus $2 \times 10^{11} Nm^{-2}$. Find the maximum elongation of a half meter steel wire that can be given without exceeding the elastic limit.



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4. A steel wire and a copper wire of equal length and equal cross sectional area are

joined end to end and the combination is subjected to a tension. Find the ratio of a. The stresses developed in the two wire and b. the strains developed.

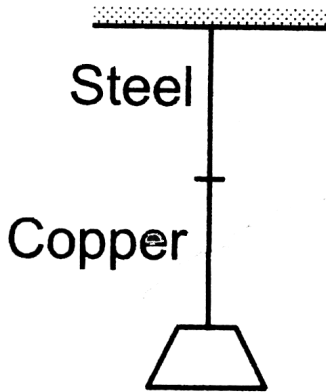
Y of steel
 $= 2 \times 10^{11} Nm^{-2}$. Y of copper
 $= 1.3 \times 10^{11} Nm^{-2}$.



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5. In figure the upper wire is made of steel and the lower of copper. The wires have equal cross section. Find the ratio of the

longitudinal strains developed in the two wires.

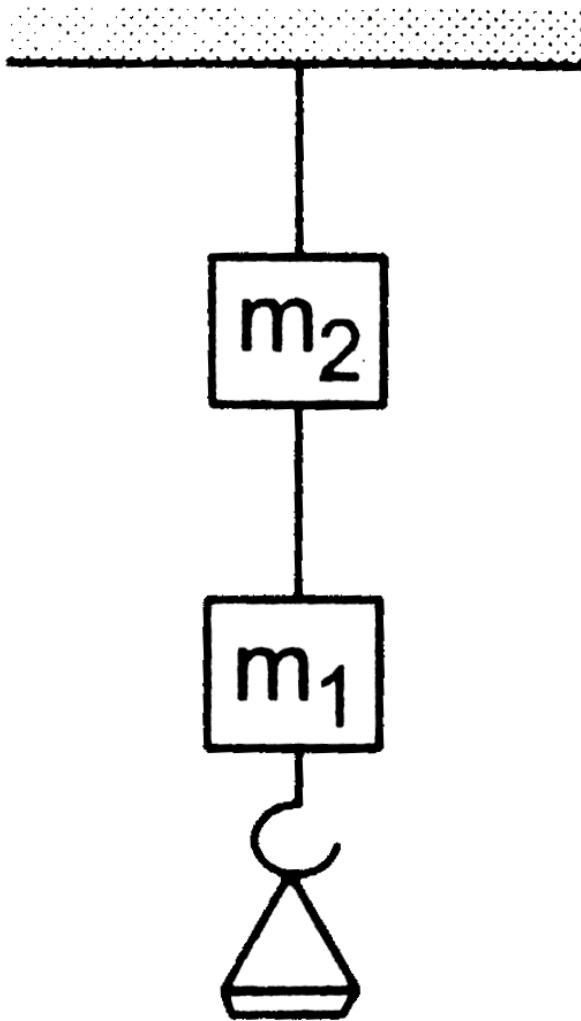


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6. The two wires shown in figure are made of the same material which has a breaking stress

of $8 \times 10^8 \text{ Nm}^{-2}$. The area of cross section of the upper wire is 0.006 cm^2 and that of the lower wire is 0.003 cm^2 . The mass $m_1 = 10 \text{ kg}$, $m_2 = 20 \text{ kg}$ and the hanger is light. a. Find the maximum load that can be put on the hanger without breaking a wire. Which wire will break first if the load is increased? b. Repeat the

above part $m_1 = 10\text{kg}$ and $m_2 = 36\text{kg}$.



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7. Two person pull a rope towards themselves. Each person exerts a force of 100 N on the rope. Find the Young modulus of the material of the rope if it extends in length by 1 cm. Original length of the rope=2 m and the area of cross section = 2cm^2 .



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8. A steel rod of cross sectional area 4cm^2 and length 2m shrinks by 0.1cm as the

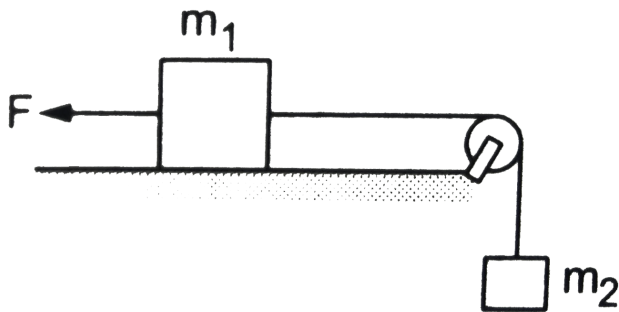
temperature decreases in night. If the rod is clamped at both ends during the day hours, find the tension developed in it during night hours. Young modulus of steel $= 1.9 \times 10^{11} Nm^{-2}$



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9. Consider the situation shown in figure. The force F is equal to the $\frac{m_2 g}{2}$. If the area of cross section of the string is A and its Young modulus Y , find the strain developed in it. The

string is light and there is no friction anywhere.



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10. A sphere of mass 20 kg is suspended by a metal wire of unstretched length 4 m and diameter 1 mm. When in equilibrium there is a

clear gap of 2 mm between the sphere and the floor. The sphere is gently pushed aside so that the wire makes an angle θ with the vertical and is released. Find the maximum value of θ so that the sphere does not rub the floor. young's modulus of the metal of the wire is $2.0 \times 10^{11} \text{ Nm}^{-2}$. Make appropriate approximation.



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11. A steel wire of original length $1m$ and cross-sectional area $4.00mm^2$ is clamped at the two ends so that it lies horizontally and without tension. If a load of $2.16kg$ is suspended from the middle point of the wire, what would be its vertical depression ?

Y of the steel $= 2.0 \times 10^{11} Nm^{-2}$. Take $g = 10ms^{-2}$



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12. A copper wire of cross sectional area 0.01cm^2 is under a tension of 20N . Find the decrease in the cross sectional area. Young modulus of copper $= 1.1 \times 10^{11}\text{Nm}^{-2}$ and Poisson ratio 0.32.



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13. Find the increase in pressure required to decrease the volume of a water sample of

0.01%. Bulk modulus of water

$$= 2.1 \times 10^9 \text{ Nm}^{-2}.$$



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14. Calculate the approximate change in density of water in a lake at a depth of 400m below the surface. The density of water at the surface is $1030\text{kg}/\text{m}^3$ and bulk modulus of water is $2 \times 10^9 \text{ N}/\text{m}^2$.



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15. A steel plate of face area 4cm^2 and thickness 0.5cm is fixed rigidly at the lower surface. A tangential force of 10N is applied on the upper surface. Find the lateral displacement of the upper surface with respect to the lower surface. Rigidity modulus of steel $= 8.4 \times 10^{10} \text{Nm}^{-2}$.



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16. Water is kept in a beaker of radius 5.0 cm . Consider a diameter of the beaker on the

surface of the water. Find the force by which the surface on one side of the diameter pulls the surface on the other side. Surface tension of water = 0.075 Nm^{-1} .



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17. Find the excess pressure inside (a) a drop of mercury of radius 2 mm (b) a soap bubble of radius 4 mm and (c) an air bubble of radius 4 mm formed inside a tank of water. Surface tension of mercury, soap solution and water

are

$0.465Nm^{-1}$, $0.03Nm^{-1}$ and $0.076Nm^{-1}$

respectively.



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18. Consider a small surface area of $1mm^2$ at the top of a mercury drop of radius 4.0 mm.

Find the force exerted on this area (a) by the air above it (b) by the mercury below it and (c) by the mercury surface in contact with it.

Atmospheric pressure = $1.0 \times 10^5 Pa$ and

surface tension of mercury $= 0.465 \text{Nm}^{-1}$.

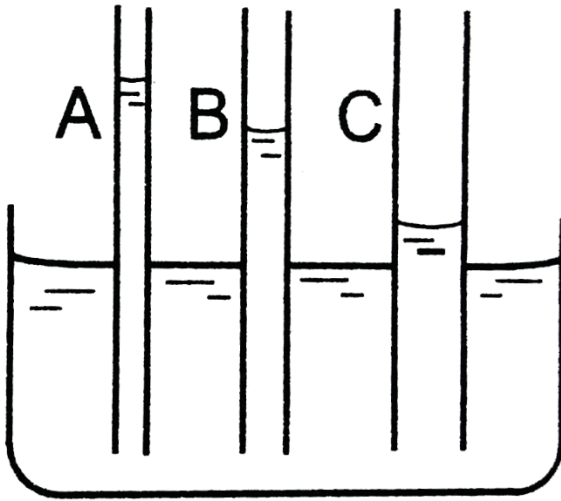
Neglect the effect of gravity. Assume all numbers to be exact.



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19. The capillaries shown in figure have inner radii 0.5 mm, 1.0 mm and 1.5 mm respectively. The liquid in the beaker is water. Find the heights of water level in the capillaries. The

surface tension of water is $7.5 \times 10^{-2} \text{ Nm}^{-1}$.



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20. The lower end of a capillary tube is immersed in mercury. The level of mercury in the tube is found to be 2 cm below the outer

level. If the same tube is immersed in water, up to what height will the water rise in the capillary ?



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21. A barometer is constructed with its tube having radius 1.0 mm. Assume that the surface of mercury in the tube is spherical in shape. If the atmospheric pressure is equal to 76 cm of mercury, what will be the height raised in the barometer tube? The contact angle of mercury

with glass 135° and surface tension of mercury

$= 0.466 Nm^{-1}$. Density of mercury

$= 13600 kgm^{-3}$.



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22. A capillary tube of radius 0.50 mm is dipped vertically in a pot of water. Find the difference between the pressure of the water in the tube 5.0 cm below the surface and the atmospheric pressure. Surface tension of water $= 0.075 Nm^{-1}$



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23. Find the surface energy of water kept in a cylindrical vessel of radius 6.0 cm. Surface tension of water $= 0.075 \text{ Jm}^{-2}$.



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24. A drop of mercury of radius 2 mm is split into 8 identical droplets. Find the increase in surface energy. Surface tension of mercury $= 0.465 \text{ Jm}^{-2}$



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25. A capillary tube of radius 1 mm is kept vertical with the lower end in water. (a) Find the height of water raised in the capillary. (b) If the length of the capillary tube is half the answer of part (a), find the angle θ made by the water surface in the capillary with the wall.



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26. The lower end of a capillary tube of radius 1 mm is dipped vertically into mercury. (a) Find the depression of mercury column in the capillary. (b) If the length dipped inside is half the answer of part (a), find the angle made by the mercury surface at the end of the capillary with the vertical. Surface tension of mercury $= 0.465 \text{ Nm}^{-1}$ and the contact angle of mercury with glass $= 135^\circ$.



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27. Two large glass plates are placed vertically and parallel to each other inside a tank of water with separation between the plates equal to 1 mm. Find the rise of water in the space between the plates. Surface tension of water = $0.075Nm^{-1}$.



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28. Consider an ice cube of edge 1.0 cm kept in a gravity-free hall. Find the surface area of the

water when the ice melts. Neglect the difference in densities of ice and water.



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29. A wire forming a loop is dipped into soap solution and taken out so that a film of soap solution is formed. A loop of 6.28 cm long thread is gently put on the film and the film is pricked with a needle inside the loop. The thread loop takes the shape of a circle. Find

the tension in the thread. Surface tension of soap solution = $0.030Nm^{-1}$.



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30. A metal sphere of radius 1 mm and mass 50 mg falls vertically in glycerine. Find the viscous force exerted by the glycerine on the sphere when the speed of the sphere is $1cms^{-1}$, Density of glycerine = $1260kgm^{-3}$ and its coefficient of viscosity at room temperature = 8.0 poise.



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31. Estimate the speed of vertically falling rain drops from the following data. Radius of the drops = 0.02 cm, viscosity of air = 1.8×10^{-4} poise, $g = 9.9 \text{ ms}^{-2}$ and density of water = 1000 kgm^{-3} .



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32. Water flows at a speed of 6 cms^{-1} through a tube of radius 1 cm. coefficient of

viscosity of water at room temperature is 0.01 poise. Calculate the Reynolds number. Is it a steady flow.



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