Name: _____ Date: _____

1. When a certain truck stands on a level roadway, its front wheels support 1.11 kN, and its rear wheels support 18.9 kN. If the front and rear axles are 3.66 m apart, the horizontal distance between the rear axle and the center of gravity of the truck is approximately

A) 0.305 m
B) 0.610 m
C) 0.244 m
D) 0.229 m
E) 0.203 m

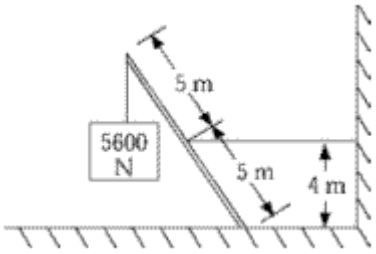
Ans: E

2. The center of gravity and the center of mass coincide if

A) the body is in rotational equilibrium.
B) the body is in translational equilibrium.
C) the acceleration due to gravity is constant over the body.
D) the body is in both translational and rotational equilibrium.
E) any forces accelerating the body are constant.

Ans: C

3. If the weight of the uniform boom shown in the figure is 2.00 kN, the tension in the horizontal guy wire supporting the boom and the 5.60-kN weight is

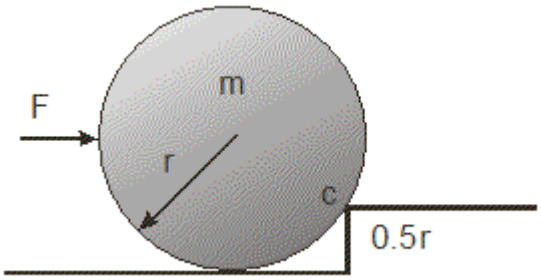


A) 13.2 kN
B) 9.90 kN
C) 9.20 kN
D) 6.90 kN
E) 3.00 kN

Ans: B

Use the following to answer questions 4-5.

A ball of mass *m* and radius *r* is placed next to a step of height ½ *r*.



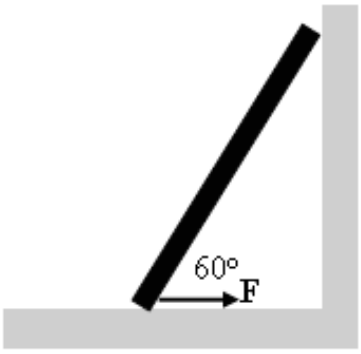
4. What is the force *F* needed to just lift the ball off the floor?
A) 0.5 mg
B) 1.41 mg
C) 1.73 mg
D) mg
E) None of these is correct.

Ans: C

5. What is the magnitude of the force the contact point c exerts on the ball when the applied force F just lifts the ball off the floor?
A) mg
B) 1.5 mg
C) 1.73 mg
D) 2 mg
E) 2.14 mg

Ans: D

6. A uniform beam of length $L = 3$ m and mass $M = 12$ kg is leaning against a frictionless vertical wall. The bottom of the beam makes an angle of 60° with the horizontal ground. Assuming the beam is in static equilibrium, what is the magnitude of the frictional force *F* between the beam and the ground?



A) F = 26 N
B) F = 37 N
C) F = 22 N
D) F = 120 N
E) F = 34 N

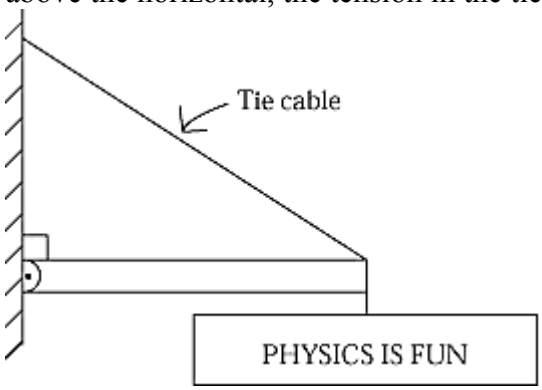
Ans: E

7. A 10-m long plank (of negligible mass) is supported at each end by vertical cables. A person of unknown weight sits on the plank between the cables. The tension in the left cable is 300 N, and in the right cable it is 200 N. How far is the person sitting from the left cable?

A) 2.0 m
B) 3.0 m
C) 4.0 m
D) 6.0 m
E) 7.0 m

Ans: C

8. The sign shown in the figure weighs 200 N. The boom is of uniform construction. If the force exerted by the hinge on the boom is 300 N and acts at an angle of 20º above the horizontal, the tension in the tie cable is



A) ~205 N
B) ~145 N
C) ~413 N
D) ~625 N
E) None of these is correct.

Ans: C

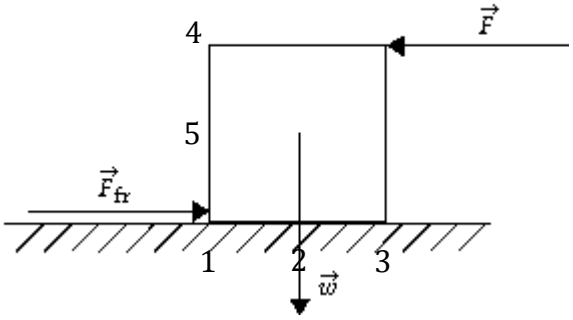
9. A ladder is extended to a length of 8 m. It rests against a smooth frictionless vertical wall at an angle of 55 degrees to the horizontal. The ladder has a mass of 30 kg, and its center of mass is three-eighths of the way up the ladder from the floor. If the coefficient of static friction between the ladder and the floor is 0.2, calculate how far a man of 80 kg can stand along the ladder without it slipping away at the floor.

A) 3.7 m
B) 6.3 m

C) all the way to the top
D) 5.4 m
E) none of the above

Ans: D

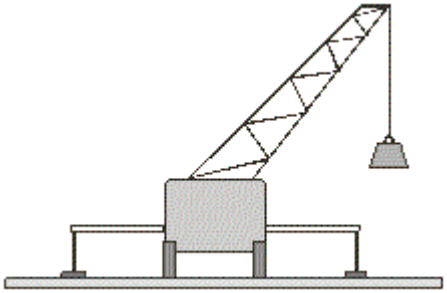
10. The object shown in the diagram is a cube of uniform density resting on a rough surface. The applied force $\vec{F}$ is balanced by the frictional force $\vec{F}_{fr}$. When the block is on the verge of tipping, the point of application of the normal force acting on the cube will be



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

Ans: A

11. Large cranes have stabilizers that extend beyond the wheels of the machines. If a crane has stabilizers that extend out by the width of the machine, by what factor can the load be increased before it tips over? Assume that the center of gravity of the crane without the load is in the middle of the crane.



A) 1

B) 2
C) 3
D) 4
E) 5

Ans: C

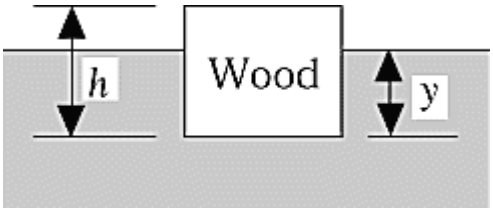
12. An 800-kg mass is hung from a 2-m steel wire with a cross-sectional area of 0.25 cm^2. Young's modulus for steel is 2.0×10^{11} N/m^2. How much does the wire stretch?
A) 2.56 mm
B) 2.97 mm
C) 3.14 mm
D) 3.86 mm
E) 4.13 mm

Ans: C

13. A 3-m long wire with a diameter of 1.5 mm has a Young's modulus of 9×10^{10} N/m^2. What mass hung from the wire would extend it by 3 mm?
A) 159 kg
B) 5.20 kg
C) 16.2 kg
D) 64.8 kg
E) None of the above

Ans: C

14.



A piece of wood is floating at the surface of some water as illustrated. The wood has a circular cross section and a height h = 3.0 cm. The density of the wood is 0.41 g/cm^3. The distance y from the surface of the water to the bottom of the wood is

A) impossible to determine because the area of the cross section is not given.
B) 0.81 cm
C) 3.2 cm
D) 1.2 cm
E) None of these is correct.

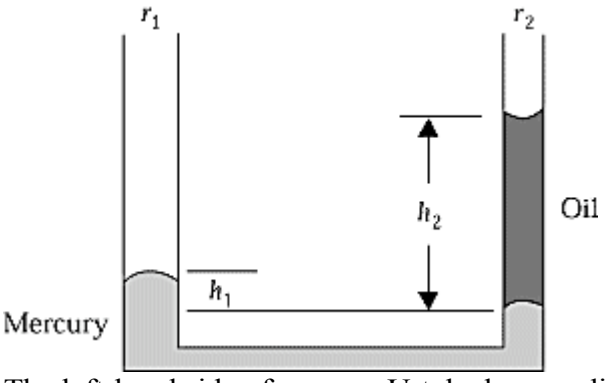
Ans: D

15. What is the gauge pressure at a depth of 6 cm in a glass filled with 4 cm of mercury and 4 cm of water? Water has a density of 1000 kg/m^3, and mercury has a density 13.6 times as great.

A) 3.1 kPa
B) 5.6 kPa
C) 5.8 kP
D) 310 kPa
E) 560 kPa

Ans: A

16.



The left-hand side of an open U-tube has a radius r_1 = 0.82 cm, and the right-hand side has a radius r_2 = 0.41 cm. Mercury and oil are poured into the U-tube. The density of mercury is 13.6 g/cm^3. The heights shown in the diagram are h_1 = 3.50 cm and h_2 = 57.3 cm. The density of the oil is approximately

A) 0.83 g/cm^3

B) 110 g/cm^3
C) 7.9 g/cm^3
D) 6.9 g/cm^3
E) 1.82 g/cm^3

Ans: A

17. A small sphere of wood with a density $\rho = 0.40$ g/cm^3 is held at rest well under the surface of a pool of water. The magnitude of the initial acceleration of the sphere when it is released is

A) 15 m/s^2
B) 9.8 m/s^2
C) 33 m/s^2
D) 23 m/s^2
E) 3.4 m/s^2

Ans: A

18. Two pistons of a hydraulic lift have radii of 2.67 cm and 20.0 cm. The downward force on the 2.67-cm piston that is required to lift a mass of 2000 kg supported by the 20-cm piston is

A) 350 N
B) 270 N
C) 36 N
D) 1.5×10^3 N
E) 2.6×10^3 N

Ans: A

19. A ball bearing that has a density of 5.16 g/cm^3 is held at rest under the surface of a liquid that has a density of 2.50 g/cm^3. The magnitude of the acceleration of the ball bearing just after it is released is

A) 5.0 m/s^2
B) 14 m/s^2
C) 10 m/s^2
D) 6.5 m/s^2
E) 1.6 m/s^2

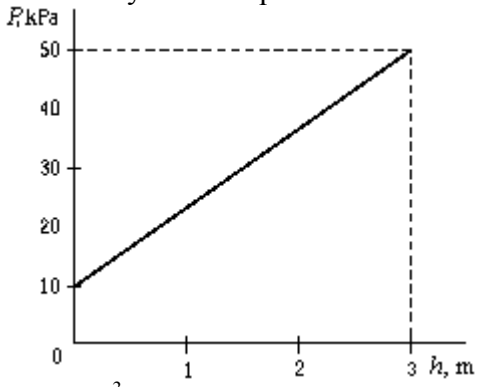
Ans: A

20. If a column of liquid 52 cm high supports a column of mercury (ρ = 13.6 g/cm^3) 10 cm high, the density of the liquid is

A) 6.0 g/cm^3
B) 2.6 g/cm^3
C) 3.8 g/cm^3
D) 4.9 g/cm^3
E) 5.0 g/cm^3

Ans: B

21. Pressure as a function of depth for a certain liquid is plotted on the graph. What is the density of the liquid?



A) 1.76 g/cm^3
B) 1.36 g/cm^3
C) 0.340 g/cm^3
D) 1.70 g/cm^3
E) 3.27 g/cm^3

Ans: B

22. A block of ice 30.5 cm thick floating in fresh water just supports a man weighing 801 N. If the specific gravity of ice is 0.917, the smallest area the block can have is

A) 3.25 m^2
B) 3.57 m^2
C) 2.88 m^2
D) 1.45 m^2
E) 0.269 m^2

Ans: A

23. A solid wooden sphere of volume 0.0100 m^3 floats freely exactly one-half submerged in a liquid of density 800 kg/m^3. A lightweight cord is now tied to the sphere and is used to pull the sphere under the surface and hold it completely submerged. What is the tension in the cord?

A) zero
B) 2.00 N
C) 39.2 N
D) 4.00 N
E) 78.4 N

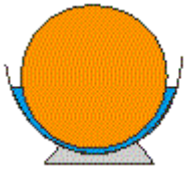
Ans: C

24. A block of wood of relative density 0.750 and dimensions 20.3 cm ∞ 30.5 cm ∞ 40.6 cm is tossed into a choppy freshwater lake. After a reasonable time, the approximate vertical dimension above the water will be

A) 2.54 cm
B) 5.08 cm
C) 7.62 cm
D) 10.2 cm
E) 12.7 cm

Ans: B

25. Is it possible to float an object that is less dense that water when the amount of the water is less than the weight of the object?

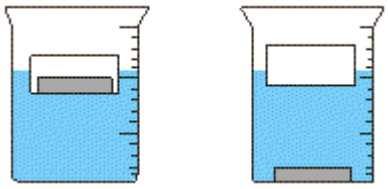


A) No, the weight of the water must at least equal the weight of the object.
B) Yes, as long as the container that holds the water allows the water to rise so that the volume of water displaced is equal to the weight of the object.
C) It is not possible to determine the answer.
D) It depends on the density of the object.
E) It depends on the mass of the object.

Ans: B

Use the following to answer questions 26-27.

A beaker is filled with water. A small plastic container contains a solid bar of aluminum, which has a mass of 40 g, and is placed on the water so that it floats. The water level reads 60 ml. Next, the bar of aluminum is taken out of the container and placed in the water so that it sinks to the bottom.



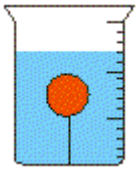
26. The water level in the beaker _____
A) drops.
B) stays unchanged.
C) rises.
D) depends on the type of container
E) unable to tell

Ans: A

27. By how much does the water level change? (density of Al is 2.7 g/cm^3)
A) 40 ml
B) 14.8 ml
C) 25.2 ml
D) 0 ml
E) 30 ml

Ans: C

28. A beaker is filled with water. A ball of mass m and density $\rho < \rho_{water}$ is tied to a string. The other end of the string is then tied to the bottom of the beaker so that the ball is completely submerged. What is the tension in the string?



A) $mg\left(\frac{\rho_{water}}{\rho} - 1\right)$

B) $mg\frac{\rho_{water}}{\rho}$

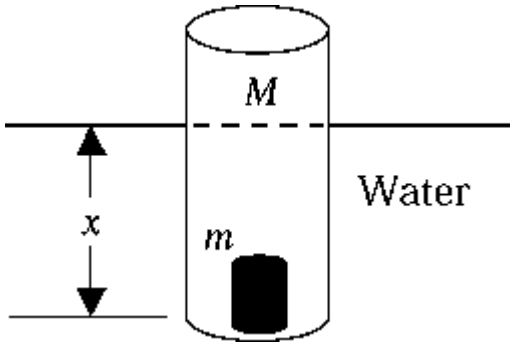
C) mg

D) $mg\left(1 - \frac{\rho}{\rho_{water}}\right)$

E) $mg\frac{\rho}{\rho_{water}}$

Ans: A

29.



A cylindrical piece of wood has a mass $M = 0.235$ kg. A small piece of lead with a mass $m = 0.021$ kg is fixed in the wood at the bottom of the cylinder so that the cylinder floats in water in a stable position, as shown. The radius of the cylinder is 1.65 cm. The depth x of the cylinder below the surface of the water is

A) 0.38 m
B) 0.57 m
C) 0.22 m
D) 0.42 m
E) None of these is correct.

Ans: E

30. A metal block suspended from a spring balance is submerged in water. You observe that the block displaces 55 cm^3 of water and that the balance reads 4.3 N. What is the density of the block?

A) 7.0 g/cm^3
B) 8.0 g/cm^3
C) 9.0 g/cm^3
D) 1.1 g/cm^3
E) 1.2 g/cm^3

Ans: C

31. A block of wood of mass 300 g and density 0.75 g/cm^3 is floating on the surface of a liquid of density 1.1 g/cm^3. What mass of lead (density = 11.3 g/cm^3) must be added to the block in order for the combination just to be submerged?

A) 440 g
B) 820 g
C) 140 g
D) 155 g
E) none of the above

Ans: D

32. A raft of density 700 kg/m^3 has a surface area of 7.0 m^2 and a volume of 0.7 m^3. What depth does it sink into water of density 1000 kg/m^3?

A) 10 cm
B) 0.7 cm
C) 0.7 m
D) 7 m
E) 7 cm

Ans: E

33. A large spherical air balloon is filled with helium. If the balloon is to lift three people, each approximately 80 kg, plus a basket and balloon outer covering material of mass 50 kg, calculate the minimum radius of the balloon. Assume values of the density of air and helium to be 1.29 kg/m^3 and 0.18 kg/m^3 respectively.

A) 62 m
B) 8.0 m
C) 4.0 m
D) 20 m

E) 5.0 m

Ans: C

34. Water from a tap is flowing at a uniform rate of 24 cm^3/s into a cylindrical container. An exit tube is mounted on the side of the container at height $h/2$ from the base. The height h of the water remains constant. The volume flow at which the water leaves the container is

A) 12 cm^3/s
B) 24 cm^3/s
C) 36 cm^3/s
D) 48 cm^3/s
E) 72 cm^3/s

Ans: B

35. The drag force on a plane is proportional to the density of the air. By what factor does the drag force change if a plane goes from an altitude 5.5 km to 11 km? The atmospheric pressure goes from $\frac{1}{2}$ to $\frac{1}{4}$ atm in going from 5.5 km to 11 km. Assume that the plane is at level flight and flies at the same speed.

A) $\frac{1}{4}$
B) $\frac{1}{2}$
C) $\frac{3}{4}$
D) 1
E) 2

Ans: B

36. Water flows at speed v in a pipe of radius r. Neglecting viscosity, at what speed does the water flow through a constriction in which the radius of the pipe is $r/3$?

A) $v/9$
B) $v/3$
C) v
D) $3v$
E) $9v$

Ans: E

37. Sea water of density 1.03×10^3 kg/m^3 is in streamline flow through a Venturi meter. The pressure difference between the main pipe and the constriction is 20.7 kPa, and the flow velocity in the constriction is 7.32 m/s. The flow velocity in the main pipe is

A) 2.44 m/s
B) 3.66 m/s
C) 7.32 m/s
D) 14.6 m/s
E) 29.3 m/s

Ans: B

38. Cities across the U.S. supply fresh water to the residents at constant pressure by the use of water towers. If the diameter, d_2, of the pipe coming out of the tower is 25 cm, and the diameter, d_1, of the pipe at your home is 2.0 cm, what is the ratio of the velocity of the water at d_1 compared to d_2? Assume that all the taps are off except yours.

A) 12.5
B) 156
C) 0.0064
D) 0.08
E) 25

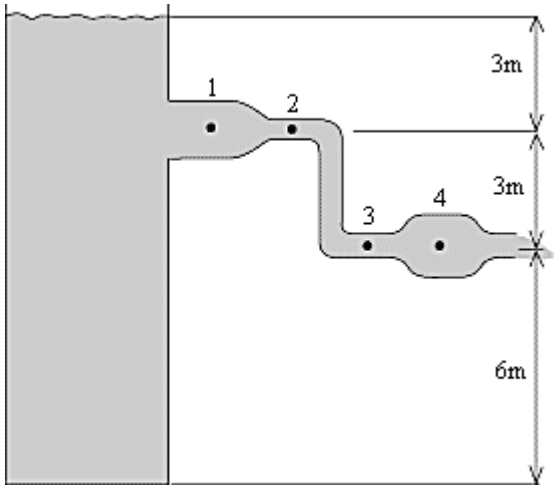
Ans: B

39. A pipe of 2.54 cm inside diameter has a constriction in which the inside diameter is 1.27 cm. If water is flowing through this pipe with a velocity of 1.22 m/s in the main section, the velocity in the constricted section is

A) 0.305 m/s
B) 0.610 m/s
C) 2.44 m/s
D) 1.22 m/s
E) 4.88 m/s

Ans: E

40.

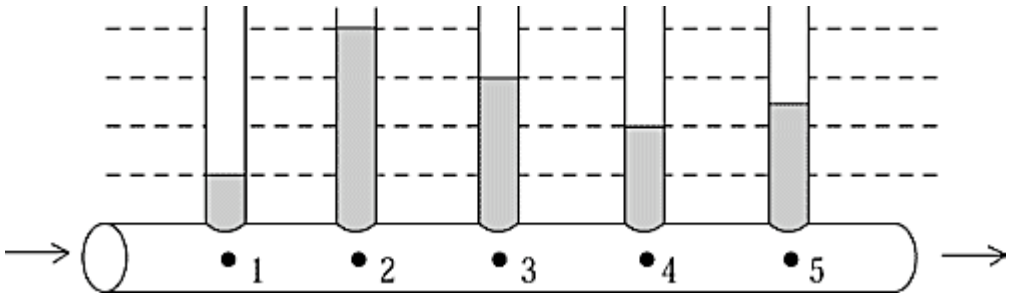


Water is discharged from the tank in the manner shown. At which point is the pressure the least?

A) 1
B) 2
C) 3
D) 4
E) The pressure is the same at all points.

Ans: B

41.



A pipe that appears to be of uniform size has constrictions on the inside. When a liquid flows through the pipe, the pressures at various points are indicated by the heights of the columns in the manometer tubes. If fluid friction is negligible, at which point is the diameter greatest?

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

Ans: B

42. A horizontal pipe of 30 cm^2 cross-sectional area carries water at a speed of 2.5 m/s. This pipe feeds a smaller pipe of cross section 10 cm^2. Find the speed of water flow in the smaller pipe.

A) 3.5 m/s
B) 0.8 m/s
C) 2.5 m/s
D) 7.5 m/s
E) 23 m/s

Ans: D

43. As part of a science project you investigate the effect of punching holes in a plastic container of water and observing the flow of liquid out of the different holes. If the container has a water level 20 cm above the base and you punch a hole in the side 12 cm high, calculate the speed at which water will initially flow out of the hole.

A) 1.25 m/s
B) 15.3 m/s
C) 12.5 m/s
D) 1.50 m/s
E) 2.25 m/s

Ans: A

44. A hypodermic needle can be thought of as a large area pipe leading to a small area pipe that opens into the vein. The diameter of the plunger is 1.2 cm and the needle diameter is 0.15 cm. If the gauge pressure in the vein is 25 mmHg, what minimum force is needed on the plunger in order for a fluid flow into the vein to occur?

A) 0.38 N
B) 0.19 N
C) 0.0060 N
D) 31 N
E) 0.12 N

Ans: A

45. A pump is used to circulate oil in an engine. If the diameter of the tube connecting the pump to the engine is increase by a factor of 2, the resulting pressure drop at the end of the tube changes by a factor of

A) 1/32
B) 1/16
C) 1/8
D) 1/2
E) 1/4

Ans: B

46. In simple harmonic motion, the displacement $x = A \cos \omega t$ and the acceleration $a = -\omega^2 x$. If $A = 0.25$ m and the period is 0.32 s, the acceleration when $t = 0.12$ s is

A) zero
B) +3.9 m/s^2
C) –3.9 m/s^2
D) +6.8 m/s^2
E) –6.8 m/s^2

Ans: E

48. The acceleration of a particle moving with simple harmonic motion is given by

$$a = -16.0x,$$

where x is in meters and a is in meters per second squared. The period of the motion is
A) 0.25 s
B) 0.392 s
C) 1.57 s
D) 4.0 s
E) 25.2 s

Ans: C

49. A 2.50-kg object is attached to a spring of force constant k = 4.50 kN/m. The spring is stretched 10.0 cm from equilibrium and released. What is the maximum kinetic energy of this system?
A) 45.0 J
B) 22.5 J
C) 56.0 J
D) 2.25×10^5 J
E) 4.50 J

Ans: B

50. The force constant for a simple harmonic motion is k and the amplitude of the motion is A. The maximum value of the potential energy of a mass m oscillating with simple harmonic motion is
A) $2\sqrt{m/k}$
B) $\frac{1}{2}kA^2$
C) kA^2
D) kA
E) None of these is correct.

Ans: B

51. A 1.81-kg block slides on a horizontal frictionless table with a speed of 1.22 m/s. It is brought to rest by compressing a spring in its path. If the spring has a force constant of 7.30 N/m, it is compressed

A) 6.89 m
B) 1.22 m
C) 1.71 m
D) 0.305 m
E) by none of these amounts

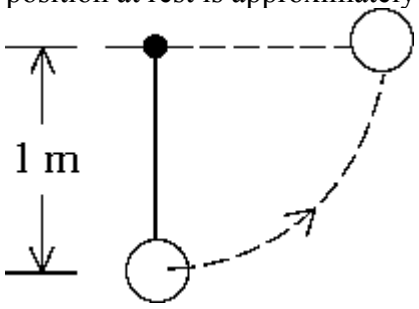
Ans: E

52. A 10-kg block starts from rest at a vertical height of 1 m on a 30º frictionless inclined plane. If the block slides down the incline and then 20 m along a frictionless horizontal surface into a fixed spring with a force constant of 100 N/m, the spring is compressed approximately

A) 1.4 m
B) 2.0 m
C) 0.33 m
D) 0.98 m
E) 2.5 m

Ans: A

53. A simple pendulum has a mass of 10 kg. The length of the pendulum is 1.0 m. The work required to move the pendulum from its vertical position at rest to a horizontal position at rest is approximately



A) 0
B) 10 J
C) 16 J
D) 98 J
E) 1.6 kJ

Ans: D

54. A body moves with simple harmonic motion according to the equation

$$x = (2/\pi) \sin(4\pi t + \pi/3),$$

where the units are SI. At $t = 2$ s, the speed of the body is
A) 1/3 m/s
B) $1/\pi$ m/s
C) $\sqrt{3}/\pi$ m/s
D) 4 m/s
E) $4\sqrt{3}$ m/s

Ans: D

55. A body oscillates with simple harmonic motion according to the equation

$$x = 6.0 \cos(3t + \pi/3)$$

where the units are SI. The speed of the body when it has a displacement of 3 m is
A) $6\pi\sqrt{3}$ m/s
B) 6π m/s
C) 9π m/s
D) $9\pi\sqrt{3}$ m/s
E) 18π m/s

Ans: D

56. A body of mass 5.0 kg moves in simple harmonic motion according to the equation

$$x = 0.040 \sin(30t + \pi/6)$$

where the units are SI. The period of this motion is
A) 1/30 s
B) $\pi/15$ s
C) $\pi/6$ s
D) $15/\pi$ s
E) 30 s

Ans: B

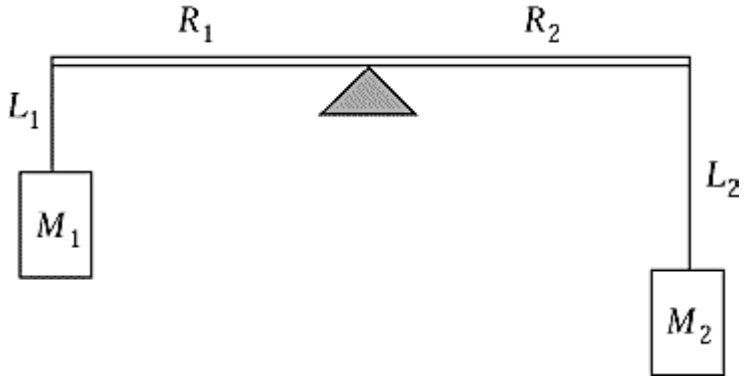
57. The equation of a body in simple harmonic motion is

$$y = 8.0\cos(20t + \frac{1}{4}\pi)$$

where y is in centimeters and t is in seconds. The frequency of the oscillations is
A) π/10 Hz
B) π/4 Hz
C) 10/π Hz
D) 8 Hz
E) 20 Hz

Ans: C

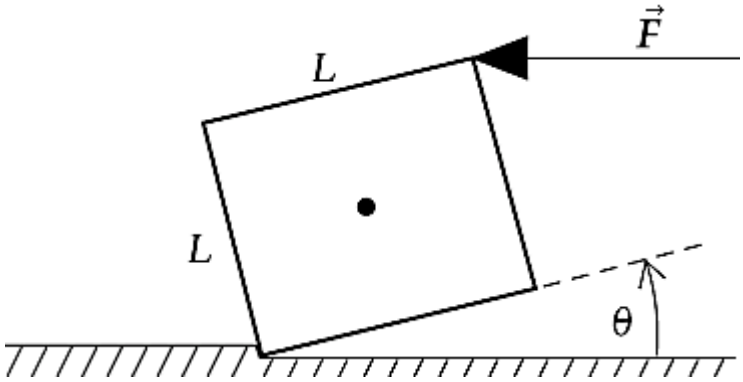
58. The horizontal bar in the figure will remain horizontal if



A) $L_1 = L_2$ and $R_1 = R_2$
B) $L_1 = L_2$ and $M_1 = M_2$
C) $R_1 = R_2$ and $M_1 = M_2$
D) $L_1M_1 = L_2M_2$
E) $R_1L_1 = R_2L_2$

→ C

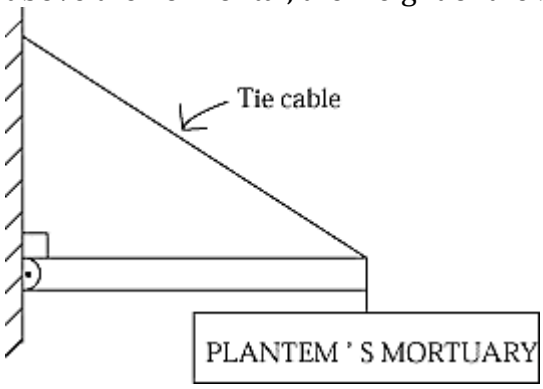
59. A box rests on a horizontal surface with one edge against a small ridge as shown. If the force $\vec{F}$ is 840 N and the bottom right edge of the box is just slightly off the ground, what is the weight of the box? (Hint: With the right edge slightly off the ground, the forces applied by the floor and the ridge must be at the bottom left corner of the box, and the angle can be taken to be negligibly small.)



A) 420 N
B) 590 N
C) 840 N
D) 1.7×10^3 N
E) 2.4×10^3 N

→ D

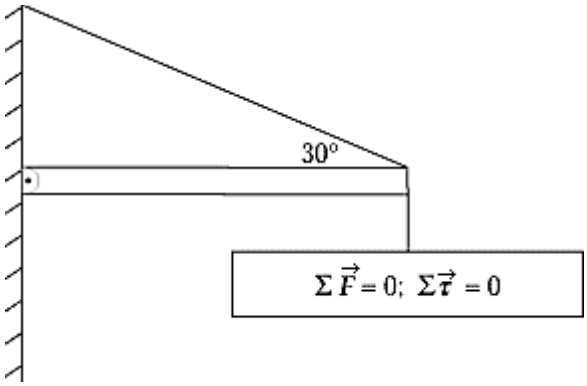
60. The sign in the figure weighs 200 N. The boom is of uniform construction. If the force exerted by the hinge on the boom is 300 N and acts at an angle of 20º above the horizontal, the weight of the boom is



A) ~250 N
B) ~540 N
C) ~460 N
D) ~413 N
E) None of these is correct.

→ E

Use the following to answer question 4.



61. The horizontal boom supporting the sign is of uniform construction and weighs 50 N. If the sign weighs 150 N, the tension in the supporting cable is
A) ~350 N
B) ~303 N
C) ~25 N
D) ~550 N
E) None of these is correct.

→ A

62. A ladder is extended to a length of 8 m. It rests against a smooth frictionless vertical wall at an angle of 55 degrees to the horizontal. The ladder has a mass of 30 kg, and its center of mass is three-eighths of the way up the ladder from the floor. Calculate the magnitude of the resultant of the horizontal and vertical forces at the bottom of the ladder and the floor.
A) 371 N
B) 294 N
C) 77.0 N
D) 304 N
E) 284 N

→ D

63. Which of the following could not have units of N/m^2?
A) Young's modulus
B) shear modulus
C) bulk modulus
D) stress
E) strain

→E

64. A wire of length L and cross-sectional area A is stretched an amount ΔL by a

force F. The strain is

A) ΔL
B) $\Delta L/L$
C) F
D) F/A
E) $FL/(A\,\Delta L)$

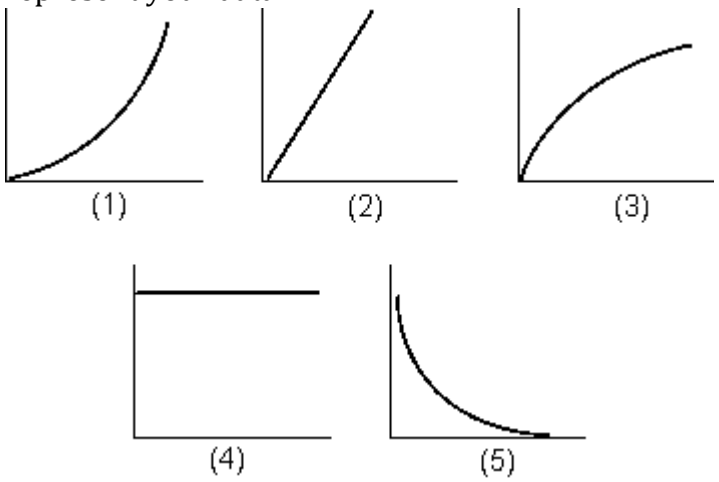
→ B

65. A wire of circular cross section of diameter d and length L is stretched an amount ΔL by a steady force F. An equal force would produce how much stretch in a similar wire of diameter $2d$ and length $2L$?

A) $\Delta L/8$
B) $\Delta L/4$
C) $\Delta L/2$
D) $2\Delta L$
E) $4\Delta L$

→C

66. If you measure the force required to stretch a typical laboratory spring as a function of the amount of stretch, which of the graphs shown below would best represent your data?



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

→ B

67. A 3-m long wire with a diameter of 1.5 mm has a Young's modulus of $9 \infty 10^{10}$

N/m^2. What mass hung from the wire would extend it by 3 mm?

A) 159 kg
B) 5.20 kg
C) 16.2 kg
D) 64.8 kg
E) None of the above

→C