Review Problems

from chapters

12-15

A uniform rigid rod having a mass of 50 kg and a length of 2.0 m rests on two supports *A* and *B* as shown in the Fig. 3. When a block of mass 60 kg is kept at point *C* at a distance of *x* from the center, the rod is about to be lifted off *A* (the normal force on the rod at *A* is zero). The value of *x* is:

A) 0.92 m
B) 1.2 m
C) 0.55 m
D) 1.7 m
E) 0.44 m

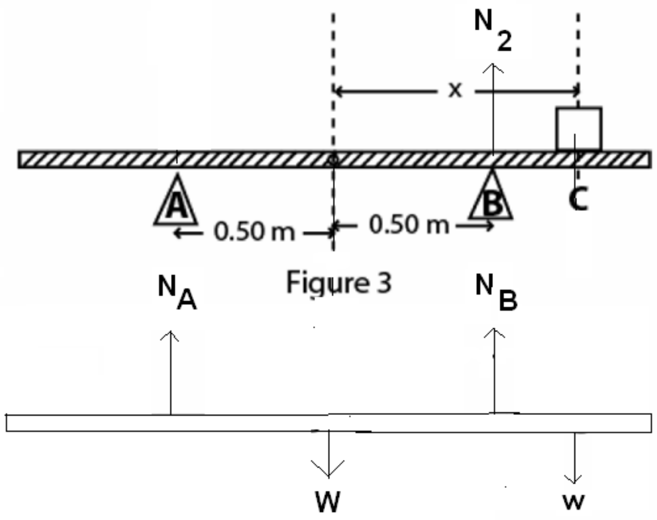


Figure 3

$$N_A = 0$$

take the torque around B

$$W \times 0.50 = w \times (x - 0.50)$$

$$x = ?$$

A uniform beam having a mass of 60 kg and a length of 2.8 m is held in place at its lower end by a pin (P). Its upper end leans against a vertical frictionless wall as shown in the Fig. 4. The force on the rod from the wall is:

A) 100 N
B) 390 N
C) 550 N
D) 780 N
E) 980 N

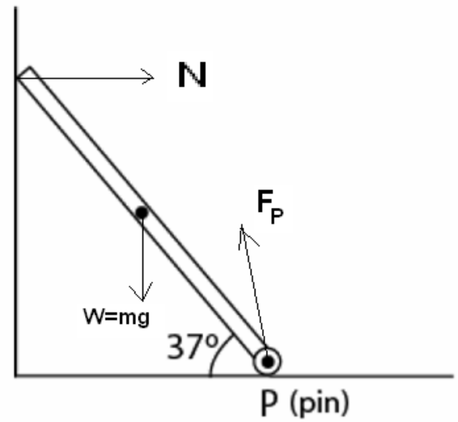


Figure 4

take torque around P

$$N \times L \times \sin(37^o) = W \times \frac{L}{2} \times \cos(37^o)$$

$$N = ?$$

A 20-m long steel wire (cross-sectional area 1.0 cm**2, Young's modulus 2.0 x 10**11 N/m), is subjected to a force of 25000 N. How much will the wire be stretched?

A1 2.5 cm
A2 0.25 cm
A3 12 cm
A4 25 cm
A5 1.2 cm

$$Young's\ Modulus = \frac{stress}{strain}$$

$$E = \frac{F/A}{\Delta L/L} = \quad 2.0\times 10^{11} = \frac{25000/A}{\Delta L/20} \qquad A = 1.0cm^2 \times \left(\frac{1m}{100}\right)^2 = 10^{-4}m^2$$

$$\Rightarrow \qquad \Delta L = 0.025\ m = 2.5\ cm$$

A cube of volume 8.0 cm^3 is made of material with a bulk modulus of 3.5×10^9 N/m^2. When it is subjected to a pressure of 3.0×10^5 Pa, the change in its volume ($|\Delta V|$) is:

A) 3.1×10^{-4} cm^3
B) 4.5×10^{-4} cm^3
C) 9.9×10^{-4} cm^3
D) 6.9×10^{-4} cm^3
E) 1.8×10^{-4} cm^3

$$B = \frac{p}{|\Delta V| / V}$$

Calculate the magnitude and direction of net gravitational force on particle of mass m due to two particles each of mass M, where m =1000 kg and M =10000 kg and are arranged as shown in the Fig. 5.

A) 4.3×10^{-5} N directed along positive x-axis
B) 4.3×10^{-5} N directed along negative x-axis
C) 2.2×10^{-5} N directed along positive x-axis
D) 2.2×10^{-5} N directed along negative x-axis
E) 8.3×10^{-5} N directed along positive x-axis

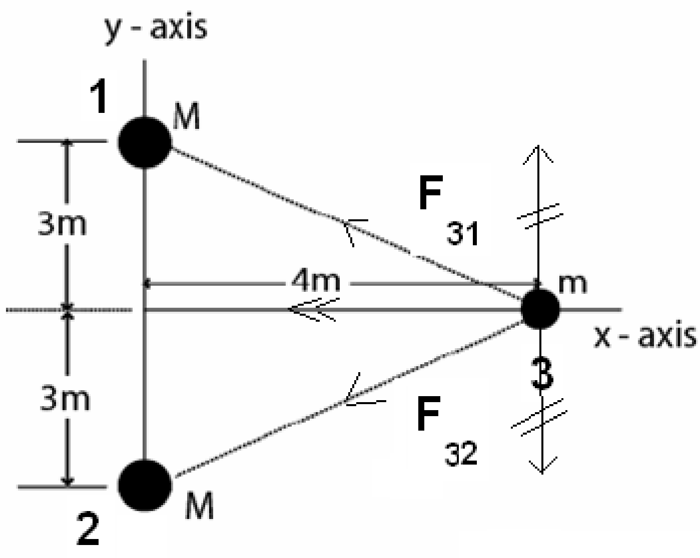


Figure 5

$$F_{31} = F_{32} = G\frac{Mm}{R^2} \quad (R = 5m)$$

$$F = 2 \times G\frac{Mm}{R^2} \times \frac{4}{5}$$

One of the moons of planet Mars completes one revolution around Mars in 1.26 Earth days. If the distance between Mars and the moon is 23460 km, calculate the mass of Mars.

A) 3.22×10^{23} kg
B) 7.45×10^{23} kg
→C) 6.45×10^{23} kg
D) 5.34×10^{23} kg
E) 1.45×10^{23} kg

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

A satellite circles a planet (mass M = 5.0x10**24 kg) every 98 min. What is the radius of the orbit?

A1 6.6 x 10**6 m
A2 7.8 x 10**6 m
A3 7.4 x 10**6 m
A4 1.3 x 10**7 m
A5 8.1 x 10**6 m

$$T = 98 \times 60 = 5880\ s$$

Use third Kepler Law:

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

$$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$$

A projectile was fired straight upward from Earth's surface with an initial speed v_i such that it reaches a maximum height of $2R_E$ above the Earth surface (Mass of the Earth = 5.96 x 10^{24} kg and radius of the Earth, R_E = 6.37 x 10^6 m). The initial speed v_i is:

A) 9.12 km/s
B) 11.2 km/s
C) 3.72 km/s
D) 2.85 km/s
E) 4.43 km/s

$$E_i = E_f$$

$$\frac{1}{2}mv_i^2 - G\frac{Mm}{R_E} = 0 - G\frac{Mm}{3R_E}$$

$$v_i = ?$$

A rocket is fired vertically from the surface of a planet (mass = M, radius = R). What is the initial speed of the rocket if its maximum height above the surface of the planet is 2R ? (Assume there is no air resistance)

A1 SQRT(4GM/3R)
A2 SQRT(8GM/5R)
A3 SQRT(3GM/2R)
A4 SQRT(5GM/3R)
A5 SQRT(GM/3R)

$$E_i = E_f$$

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv^2{}_0 - G\frac{Mm}{R_E} = 0 - G\frac{Mm}{3R}$$

$$\frac{1}{2}v^2{}_0 = 2G\frac{Mm}{3R}$$

$$v_0 = \sqrt{\frac{4GM}{3R}}$$

A satellite is moving in a circular orbit around a planet. If the kinetic energy of the satellite in its orbit is 1.87×10^9 J, what is the mechanical energy of the orbiting satellite?

A) 1.87×10^9 J
B) 3.74×10^9 J
C) -3.74×10^9 J
→ D) -1.87×10^9 J
E) -0.93×10^9 J

$$E = -K \ (circular\ orbit)$$

A spaceship (mass = m) orbits a planet (mass = M) in a circular orbit (radius = R). What is the minimum energy required to make the spaceship escape the gravitational force of the planet?

A1 GmM/(2R)
A2 GmM/R
A3 GmM/(3R)
A4 2GmM/(5R)
A5 GmM/(4R)

$$E = -K \; (circular\ orbit)$$
$$= -GMm/2R$$

$$hence\ we\ have\ to\ give\ it\ G\frac{Mm}{2R}\ of\ energy$$

$$to\ let\ it\ escape$$

Several cans of different sizes and shapes are all filled with the same liquid to the same height h (See Fig. 6). Then:

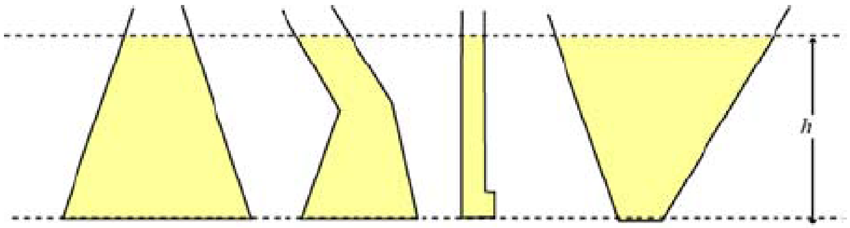
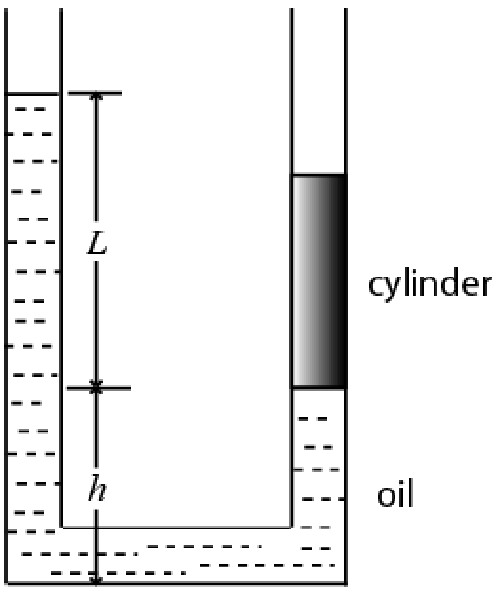


Figure 6

A) the weight of the liquid is the same for all cans
B) the force of the liquid on the bottom of each can is the same
C) the least pressure is at the bottom of the can with the largest bottom area
D) the greatest pressure is at the bottom of the can with the largest bottom area
E) the pressure on the bottom of each can is the same

Fig. 7 shows a U-tube with cross-sectional area A and partially filled with oil of density ρ. A solid cylinder, which fits the tube tightly but can slide without friction, is placed in the right arm. The system is in equilibrium. The weight of the cylinder is:



$$W = PA = (\rho g L)A$$

Figure 7

A) $AL\rho g$
B) $L^3\rho g$
C) $A\rho(L+h)g$
D) $A\rho(L-h)g$
E) none of the others

An incompressible liquid flows along the pipe as shown in Fig. 8 with $A_1=2A_2$. The ratio of the mass flow rate R_2/R_1 is:

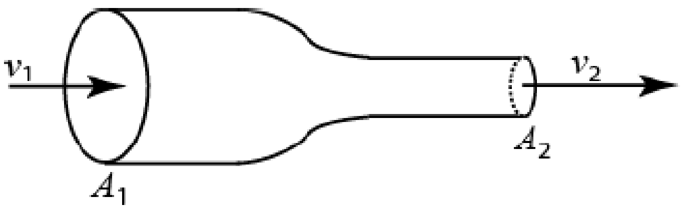


Figure 8

A) 1
B) 2
C) 1/2
D) 4
E) 1/4

$$R_1 = R_2$$

An object hangs from a spring balance. The balance indicates 30 N in air and 20 N when the object is submerged in water. What does the balance indicate when the object is submersed in a liquid with a density that is half that of water?

A) 20 N
B) 25 N
C) 30 N
D) 35 N
E) 40 N

$$W = 30N \,, W_{a,lwater} = W - B_{water} = 20$$

$$\Rightarrow B_{water} = 10N = \rho_{water} V g$$

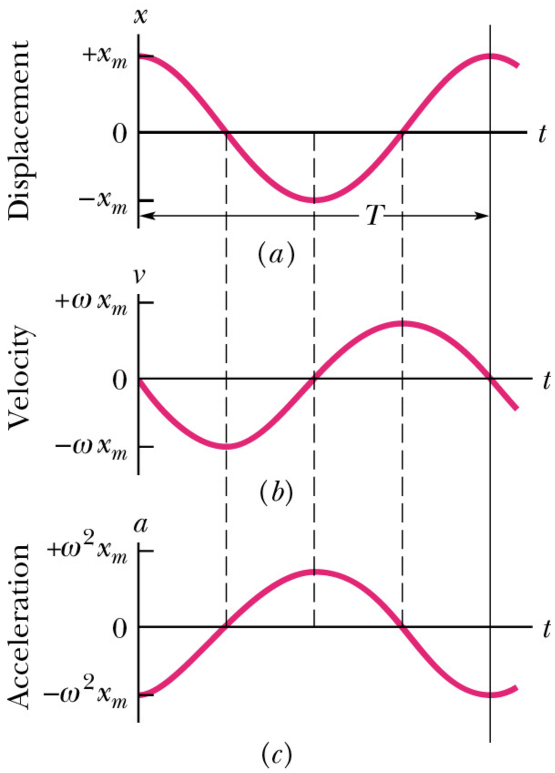
$$B_{liquid} = \rho_{liquid} V g = \frac{1}{2}\rho_{water} V g = \frac{1}{2} B_{water} = 5$$

$$W_{a,liquid} = W - B_{liquid} = 30 - 5 = 25N$$

In simple harmonic motion, the magnitude of the acceleration is greatest when:

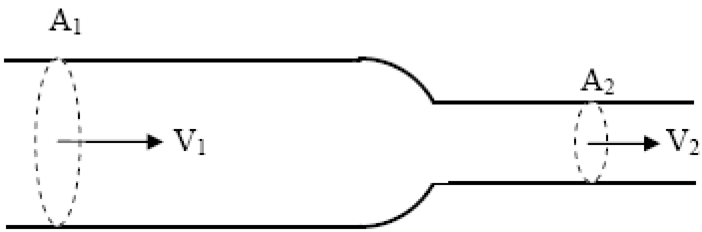
A) the displacement is zero
B) the displacement is maximum
C) the speed is maximum
D) the force is zero
E) the speed is between zero and its maximum

$$a(t) = -\omega^2 x(t)$$



An incompressible ideal liquid flows along the pipe as shown in Fig. The ratio of the speeds v2/v1 is:

A1 A1/A2
A2 A2/A1
A3 (A1/A2)**2
A4 (A1/A2)**0.5
A5 v1/v2

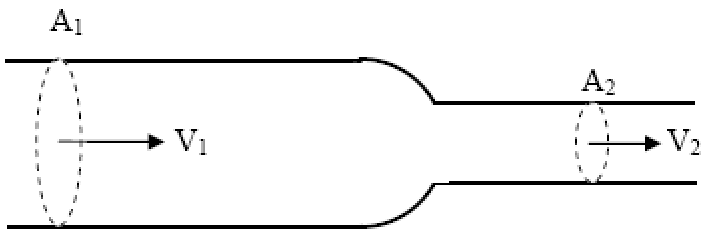


Av=constant

$A_1 v_1 = A_2 v_2$

A liquid of density 791 kg/m**3 flows smoothly through a horizontal pipe (see Fig.). The area A2 equals A1/2. The pressure difference between the wide and the narrow sections of the pipe (P1-P2) is 4120 Pa. What is the speed v1?

A1 1.86 m/s
A2 2.91 m/s
A3 4.50 m/s
A4 5.21 m/s
A5 0.19 m/s



$$A_1 v_1 = A_2 v_2 \Rightarrow A_1 v_1 = (A_1/2) v_2 \Rightarrow v_2 = 2v_1$$

$$P_1 + \rho g y_1 + \frac{1}{2}\rho v^2{}_1 = P_2 + \rho g y_2 + \frac{1}{2}\rho v^2{}_2$$

$$P_1 + \frac{1}{2}\rho v^2{}_1 = P_2 + \frac{1}{2}\rho v^2{}_2$$

$$P_1 - P_2 = \frac{1}{2}\rho (v^2{}_2 - v_1{}^2) = \frac{1}{2}\rho (3v^2{}_1)$$

$$v_1 = \sqrt{\frac{2(P_1 - P_2)}{3\rho}}$$

Bernoulli's equation can be derived from the conservation of:

A1 energy
A2 mass
A3 angular momentum
A4 volume
A5 pressure

A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. When t=0, the position and velocity of the block are x=0.15 m and v=3.0 m/s. What is the maximum speed of the block?

A1 5.2 m/s
A2 0.18 m/s
A3 3.7 m/s
A4 0.13 m/s
A5 13 m/s

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{200}{0.25}} = 28.3\ rad/s$$

$$x = x_m \cos(\omega t + \phi)$$

$$v = -x_m \omega \sin(\omega t + \phi)$$

$$at\ t = 0, \quad 0.15 = x_m \cos(\phi) \quad (1)$$

$$and \quad 3.0 = -x_m \times 28.3 \times \sin(\phi) \quad (2)$$

divide (2) *by* (1)

$$\frac{3.0}{0.15} = -28.3 \tan\phi$$

$$\tan\phi = -0.707 \quad \Rightarrow \phi = -0.615\ rad$$

$$from\ (1)\ x_m = \frac{0.15}{\cos(-0.615)} = 0.18\ m$$

$$v_m = x_m \omega = 0.184 \times 28.3 \approx 5.2\ m/s$$

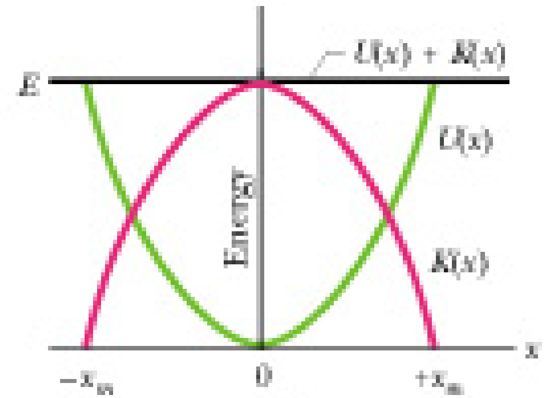
A particle is in simple harmonic motion along the x axis. The amplitude of the motion is x_m. At one point in its motion its kinetic energy is $K = 5$ J and its potential energy (measured with $U = 0$ at x = 0) is $U = 3$ J. When it is at $x = x_m$, the kinetic and potential energies are:

A) $K = 5$ J and $U = 3$J
B) $K = 5$ J and $U = -3$J
C) $K = 8$ J and $U = 0$
D) $K = 0$ and $U = 8$J
E) $K = 0$ and $U = -8$J

$$U(x) = \frac{1}{2}kx^2$$

$$K(x) = \frac{1}{2}k\left(x_m^{\ 2} - x^2\right)$$

$$E = U + K = \frac{1}{2}kx_m^{\ 2}$$



A 0.25-kg block oscillates at the end of the spring with a spring constant of 200 N/m. If the system has a mechanical energy of 6.0 J, then the amplitude of the oscillation is:

A) 0.06m
B) 0.17m
C) 0.24m
D) 4.9m
E) 6.9m

$$E = \frac{1}{2} k x_m^2$$

A simple pendulum has length L and period T. As it passes through its equilibrium position, the string is suddenly clamped (fixed) at its midpoint (See Fig. 9). The period then becomes:

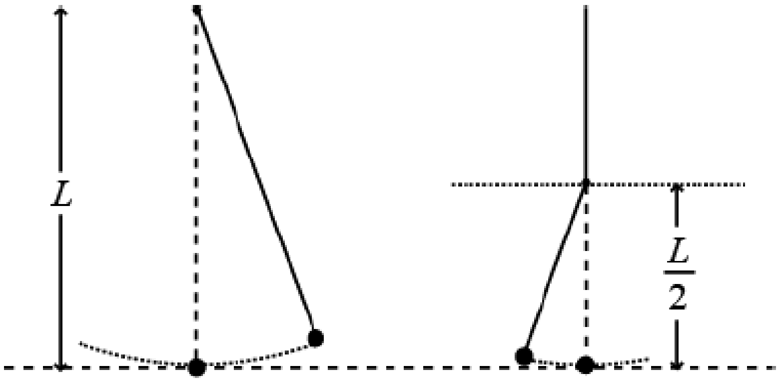


Figure 9

A) $\dfrac{T}{\sqrt{2}}$
B) 2 T
C) $T/2$
D) $4T$
E) $T/4$

$$T = 2\pi\sqrt{\frac{L}{g}};$$

A 3-kg block, attached to a spring, executes simple harmonic motion according to x = 2*cos(50*t) where x is in meters and t is in seconds. The spring constant of the spring is:

A1 7500 N/m
A2 100 N/m
A3 150 N/m
A4 1.0 N/m
A5 2100 N/m

compare:

$$x = x_m \cos(\omega t + \phi)$$

$$x = 2\cos(50t)$$

$$\Rightarrow x_m = 2\ m, \omega = 50\ rad/s$$

$$k = \omega^2 m = 2500 * 3 = 7500\ N/m$$

Mass m oscillating on the end of a spring with spring constant k has amplitude A. Its maximum speed is:

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A1 A*SQRT(k/m)
A2 (A**2)*k/m
A3 A*SQRT(m/k)
A4 A*m/k
A5 (A**2)*m/k
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$$v_m = x_m \omega = A\sqrt{\frac{k}{m}}$$

$$as\ x_m = A\ and\ \omega = \sqrt{\frac{k}{m}}$$

An object undergoing simple harmonic motion takes 0.25 s to travel from one point of zero velocity to the next such point. The distance between those points is 40 cm. The amplitude and frequency of the motion are:

A1 20 cm, 2 Hz
A2 40 cm, 2 Hz
A3 30 cm, 2 Hz
A4 30 cm, 4 Hz
A5 20 cm, 4 Hz

$$T = 2 \times 0.25 = 0.50\ s$$

$$f = \frac{1}{T} = 2\ Hz$$

$$x_m = \frac{40}{2} = 20\ cm$$