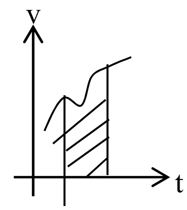
Q1.

The area under a velocity-time graph represents:



- A) displacement
- B) acceleration
- C) impulse
- D) work
- E) power

Ans:

$$v = \frac{dx}{dt}$$

$$\Rightarrow \Delta x = \int v dt$$

$$\Rightarrow area\ under\ (v - t) graph = displacement$$

Q2.

A particle is thrown upward from the ground into the air. If the particle returns back to the ground in 2.40 s, what was its initial speed? Ignore air resistance.

- A) 11.8 m/s
- B) 5.88 m/s
- C) 23.5 m/s
- D) 9.41 m/s
- E) 2.40 m/s

Ans:

From the ground $\longrightarrow$ up

$t = 1.2$ s

$$\overset{0}{\cancel{v}} = v_i - gt \Rightarrow v_i = gt = 9.8 \times 1.2 = 11.8 \text{ m/s}$$

Q3.

If $\vec{A} = 3\hat{i} - 4\hat{j}$ and $\vec{B} = 8\hat{i} - 6\hat{j}$, find $\dfrac{\vec{A}\times\vec{B}}{\vec{A}.\vec{B}}$.

A) $0.3\hat{k}$
B) $\hat{k}$
C) $3\hat{k}$
D) 3
E) zero

Ans:

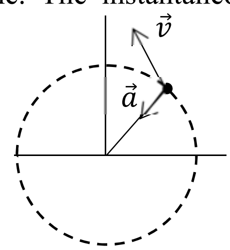
$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 3 & -4 & 0 \\ 8 & -6 & 0 \end{vmatrix} = (-18+32)\hat{k} = 14\,\hat{k}$$

$$\vec{A}\cdot\vec{B} = 24 + 24 = 48$$

$$\frac{\vec{A}\times\vec{B}}{\vec{A}\cdot\vec{B}} = \frac{14}{48}\hat{k} = 0.3\,\hat{k}$$

Q4.

A particle is in uniform circular motion in a horizontal plane. The instantaneous velocity and instantaneous acceleration are:



A) perpendicular to each other
B) both tangent to the circular path
C) opposite to each other
D) in the same direction
E) both perpendicular to the circular path

Ans:

A

Q5.

An airplane is flying horizontally at a height of 490 m above the surface of earth and at a speed of 200 m/s. How far from a target (horizontal distance) should it release a package to hit the target on the ground?

A) 2000 m
B) 1000 m
C) 490 m
D) 200 m
E) 980 m

Ans:

$$\cancelto{0}{y} - y_0 = \cancelto{0}{v_{y_0}} t - \frac{1}{2} g t^2$$

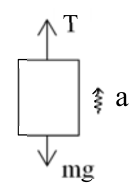
$$t = \sqrt{\frac{2y_0}{g}} = \sqrt{\frac{2 \times 490}{g}} = 10 \text{ s}$$

$$x = v_{x_0} \cdot t = 200 \times 10 = 2000 \text{ m}$$

Q6.

A body is hanging from a balance supported form the ceiling of an elevator. The balance reads 98.0 N when the elevator is stationary. If the elevator moves with an upward acceleration of 2.00 m/s^2, what will be the reading of the balance?

A) 118 N
B) 78.0 N
C) 156 N
D) 98.0 N
E) 49.0 N



Ans:

$$m = \frac{98}{9.8} = 10 \text{ kg}$$

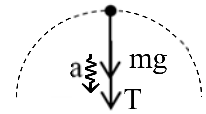
$$ma = T - mg$$

$$T = m(a + g) = (10)(2 + 9.8) = 118 \text{ N}$$

Q7.

One end of a 0.800 m massless string is fixed, while the other end is attached to a 2.00 kg stone. The stone swings in a vertical circle, passing the highest point with a speed of 4.00 m/s. The magnitude of the tension in the string at the highest point is:

A) 20.4 N
B) 12.4 N
C) 10.1 N
D) 32.7 N
E) zero



Ans:

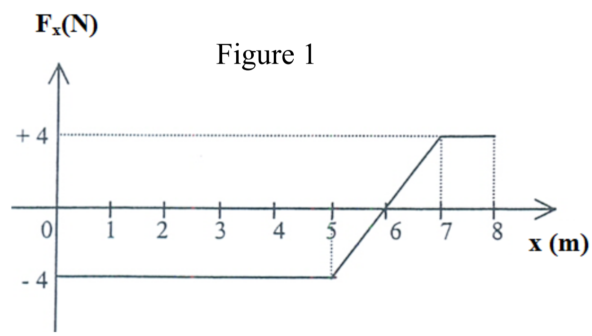
$$ma = mg + T$$

$$T = m(a - g) = m\left(\frac{v^2}{R} - g\right) = 20.4\text{ N}$$

Q8.

A body moving along the *x*-axis is acted on by a force that varies with *x* as shown in **Figure 1**. Find the work done by this force on the object as it moves from *x* = 0 to *x* = 8.0 m.

A) – 16 J
B) +34 J
C) – 18 J
D) +10 J
E) +18 J



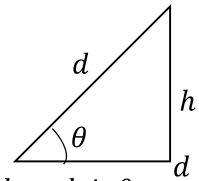
Ans:

After cancelling the positive area:
$W = -4 \times 4 = -16$ J

Q9.

A 2.0 kg block is projected down a rough inclined plane that makes an angle of 30° above the horizontal with an initial kinetic energy of 2.0 J. If the coefficient of kinetic friction between the block and the incline is 0.60, how far will the block slide down the incline before coming to rest?

A) 5.2 m
B) 1.8 m
C) 3.0 m
D) 1.0 m
E) 2.3 m



$$h = d\sin\theta = \frac{d}{2}$$

Ans:

$$\Delta K + \Delta U_g = W_{ext}$$

$$-K_i - mgh = -f_x \cdot d$$

$$-K_i - \frac{1}{2}mgd = -\mu_x\, mg\, cos30°\, d$$

$$(\mu_x\, cos30° - 0.5)\, mgd = K_i$$

$$0.384\, d = 2.0 \Rightarrow d = 5.2 \text{ m}$$

Q10.

A 2000 kg truck travelling north at 12 m/s turns and travels at 14 m/s east. What is the magnitude of the change of the linear momentum of the truck?

A) 3.7×10^4 N.s
B) 4.0×10^3 N.s
C) 5.2×10^4 N.s
D) 1.4×10^4 N.s
E) 2.9×10^4 N.s

Ans:

$$\vec{P}_i = m\vec{v}_i$$

$$= 2\times10^3 \times 12\hat{j} = 24\times10^3\hat{j}\ (\text{N}\cdot\text{s})$$

$$\vec{P}_f = m\vec{v}_f = 2\times10^3\times 14\,\hat{\imath} = 28\times10^3\,\hat{\imath}\ (\text{N}\cdot\text{s})$$

$$\Delta\vec{P} = \vec{P}_f - \vec{P}_i = 28\,\hat{\imath} - 24\,\hat{j}\ (\times 10^3\ \text{N}\cdot\text{s})$$

$$\Delta P = \sqrt{(28)^2+(24)^2}\times10^3 = 3.7\times10^4\ (\text{N}\cdot\text{s})$$

Q11.

In a completely inelastic collision, a bullet of mass 20.0 g strikes a ballistic pendulum whose block has a mass of 5.00 kg and is initially at rest. The (block + bullet) system is observed to rise a vertical distance of 5.00 cm before momentarily stopping. What was the initial speed of the bullet?

A) 248 m/s
B) 192 m/s
C) 267 m/s
D) 120 m/s
E) 460 m/s

Ans:

$$Just\ after\ collision: V = \sqrt{2gh}$$

$$collision: mv = (m+M)V \left\{\begin{matrix} \left.\begin{matrix} m \\ v \end{matrix}\right\} bullet \\ M \longrightarrow block \end{matrix}\right\}$$

$$\Rightarrow v = \frac{m+M}{m}V$$

$$= \frac{0.02 + 5.0}{0.02} \times \sqrt{2 \times 9.8 \times 0.05} = 248\ \mathrm{m/s}$$

Q12.

A wheel, starting from rest, turns through 8.0 revolutions in a time interval of 12 s. Assuming constant angular acceleration, what is the angular speed of the wheel at the end of this time interval?

A) 8.4 rad/s
B) 5.9 rad/s
C) 3.0 rad/s
D) 1.7 rad/s
E) 3.8 rad/s

Ans:

$$\theta = \cancelto{0}{\omega_i} t + \frac{1}{2}\alpha t^2 \Rightarrow \alpha = \frac{2\theta}{t^2}$$

$$\omega = \cancelto{0}{\omega_i} t + \alpha t = \frac{2\theta}{t^2} \cdot t = \frac{2\theta}{t} = \frac{2 \times 8 \times 2\pi}{12} = 8.4\ \mathrm{rad/s}$$

Q13.

A uniform solid sphere (radius = 0.200 m, mass = 150 kg) is initially stationary. How much work is required to have it rolling without slipping on a horizontal surface with 50.0 rad/s?

A) 1.05×10^4 J
B) 3.00×10^3 J
C) 7.50×10^3 J
D) 1.75×10^4 J
E) 1.30×10^4 J

Ans:

$$W = K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{m}{2}\cdot R^2\omega^2 + \frac{1}{2}\times\frac{2}{5}mR^2\times\omega^2$$

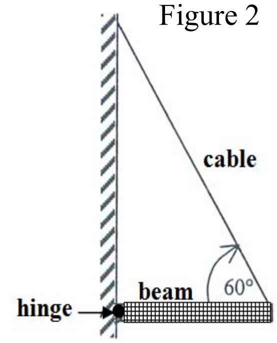
$$= 0.5\, mR^2\omega^2 + 0.2mR^2\omega^2 = 0.7\, mR^2\omega^2$$

$$= 0.7 \times (0.2)^2 \times 150 \times 2500 = 1.05 \times 10^4 \text{ J}$$

Q14.

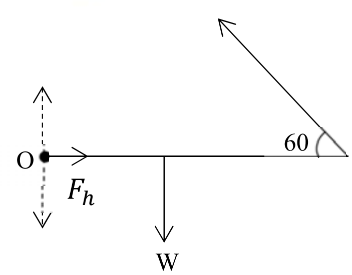
A uniform horizontal beam of weight W is supported by a hinge and a cable, as shown in **Figure 2**. The vertical component of the force by the hinge on the beam is:

Figure 2



A) $W/2$, up
B) W, down
C) W, up
D) $W/2$, down
E) zero

Ans:



$$\sum \tau_0 = 0:$$

$$-W\frac{\cancel{L}}{2} + T\cdot\cancel{L}\,sin60° = 0$$

$$\Rightarrow T = \frac{W}{2\,sin60°}$$

$$\sum F_y = 0:\ Tsin60° - W + F_y = 0$$

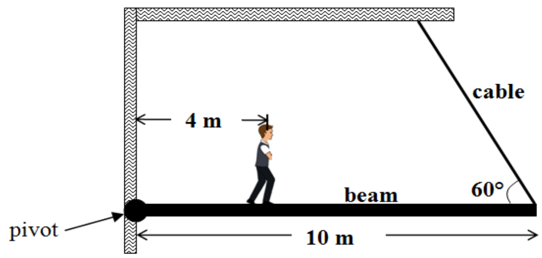
$$\Rightarrow\ F_y = W - T\,sin60° = W - \left(\frac{W}{2\,sin60°}\,sin60°\right) = \frac{W}{2}\ (+) \rightarrow up$$

Q15.

Figure 3 shows a uniform horizontal beam (length 10.0 m, mass 25.0 kg) that is pivoted at the wall, with its far end supported by a cable that makes an angle of 60.0º with the horizontal. If a person, of mass 60.0 kg, stands 4.00 m from the pivot, what is the tension in the cable?

A) 413 N
B) 200 N
C) 830 N
D) 446 N
E) 390 N

Figure 3



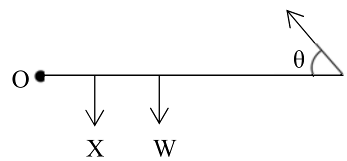
Ans:

$$\sum \tau_0 = 0$$

$$(-X)(4) - (W)(5) + (T)(10)\sin 60° = 0$$

$$\Rightarrow T = \frac{4X + 5W}{10 \cdot \sin 60°} = \frac{[(4 \times 60) + (5 \times 25)] \times 9.8}{10 \times \sin 60°}$$

$$= 413 \text{ N}$$



Q16.

A cylindrical wire stretches 1.0 cm when a force is applied to it (perpendicular to its cross section). The same force is applied to another cylindrical wire of the same material but that has twice the radius and twice the length of the first wire. The second wire stretches by:

A) 0.50 cm
B) 0.25 cm
C) 1.0 cm
D) 2.0 cm
E) 4.0 cm

Ans:

$$1st\ Wire: \frac{F}{A} = E \cdot \frac{\Delta l}{l} \quad \left\{A = \pi r^2 = \pi\left(\frac{D}{2}\right)^2 = \frac{\pi D^2}{4}\right\}$$

$$F = \frac{\pi \cdot E \cdot \Delta l \cdot d^2}{4l} \rightarrow (1)$$

$$2nd\ Wire: F = \frac{\pi \cdot E \cdot \Delta L \cdot D^2}{4L} \rightarrow (2)$$

$$Divide\ (2)\ by\ (1): 1 = \frac{\cancel{\pi} \cdot \cancel{E} \cdot \Delta L \cdot D^2}{\cancel{4}L} \cdot \frac{\cancel{4}l}{\cancel{\pi} \cdot \cancel{E} \cdot \Delta l \cdot d^2}$$

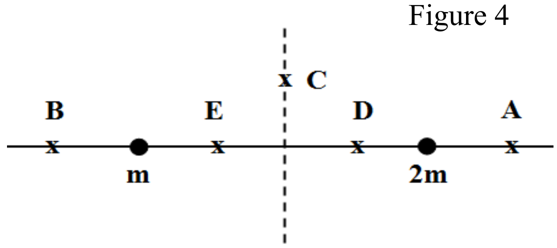
$$1 = \frac{\Delta L}{\Delta l} \cdot \left(\frac{D}{d}\right)^2 \cdot \frac{l}{L} \Longrightarrow 1 = \frac{\Delta L}{\Delta l} \cdot \left(\frac{2d}{d}\right)^2 \cdot \frac{l}{2l}$$

$$1 = \frac{\Delta L}{\Delta l} \times 4 \times \frac{1}{2} \Rightarrow \Delta l = 2\Delta L \Rightarrow \Delta L = \frac{\Delta l}{2} = \frac{1}{2}\ \text{cm}$$

Q17.

Two particles, of masses m and $2m$, are fixed in place on the x-axis, as shown in **Figure 4**. The net gravitational force, due to these two particles, on a third particle will possibly be zero when this particle is at point:

Figure 4



A) E
B) C
C) D
D) A
E) B

Ans:

The point of equilibrium has to be on the x-axis between the two particles closer to the lighter one $\Longrightarrow$ Point E

Q18.

An astronaut weighs 140 N on the surface of the Moon. If the astronaut is in a circular orbit about the Moon at an altitude that is equal to the radius of the Moon, what is his kinetic energy in the orbit? The radius of the Moon is 1.7×10^{6} m.

A) 6.0×10^{7} J
B) 2.4×10^{8} J
C) 1.2×10^{8} J
D) 1.5×10^{7} J
E) 2.8×10^{8} J

Ans:

On the surface: $\mathrm{F} = \dfrac{GmM}{R^2} = 140$

In the Orbit: $\mathrm{K} = \dfrac{GmM}{2r} = \dfrac{GmM}{(2)(2R)} = \dfrac{GmM}{4R}$

$$= \frac{R}{4}\cdot\frac{GmM}{R^2} = \frac{1.7\times10^{6}}{4}\times 140 = 6.0\times10^{7}\ \mathrm{J}$$

Q19.

An object is released from rest when it is at an altitude of 4.0×10^{6} m above the surface of a planet of mass 4.0×10^{24} kg and radius 5.0×10^{6} m. What is the speed of the object just before striking the surface of the planet? Neglect air resistance

A) 6.9 km/s
B) 7.8 km/s
C) 3.5 km/s
D) 5.4 km/s
E) 4.1 km/s

Ans:

$$\overset{0}{\cancel{\mathrm{K}_i}} + U_i = \mathrm{K}_f + U_f$$

$$\mathrm{K}_f = U_i - U_f$$

$$\frac{1}{2}\cancel{m}v^2 = -\frac{G\cancel{m}M}{r_i} + \frac{G\cancel{m}M}{R}$$

$$v^2 = 2GM\left(\frac{1}{R} - \frac{1}{R+h}\right)$$

$$= 2\times6.67\times10^{-11}\times4\times10^{24}\times\left[\frac{1}{5\times10^{6}} - \frac{1}{9\times10^{6}}\right]$$

$$\therefore v = 6887\ \mathrm{m/s} \longrightarrow 6.9\ \mathrm{km/s}$$

Q20.

A planet orbits with an angular momentum of 3.6×10^{45} kg.m^2/s about the Sun. The line drawn from the Sun to the planet sweeps area at a rate of 3.0×10^{20} m^2/s. The mass of the planet is:

A) 6.0×10^{24} kg
B) 1.9×10^{24} kg
C) 8.0×10^{24} kg
D) 3.4×10^{27} kg
E) 7.6×10^{35} kg

Ans:

Kepler's 2nd Law:

$$\frac{dA}{dt} = \frac{L}{2m} \Rightarrow m = \frac{L}{2\left(\frac{dA}{dt}\right)} = \frac{3.60\times10^{45}}{2\times3\times10^{20}} = 6.0\times10^{24}\ \text{kg}$$

Q21.

A rocket is fired vertically upward from Earth's surface with a speed that is half of the escape speed. If R is the radius of Earth, the highest altitude reached, measured from the surface, is:

A) $R/3$
B) $R/2$
C) $R/4$
D) R
E) $2R$

Ans:

$$v_{esc} = \sqrt{\frac{2GM}{R}} \longrightarrow v_i = \frac{v_{esc}}{2} = \sqrt{\frac{GM}{2R}}$$

$$i \rightarrow surface\ ;\ f \rightarrow maximum\ altitude$$

$$K_i + U_i = \overset{0}{\cancel{K_f}} + U_f$$

$$\frac{1}{2}\cancel{m}v_i^2 - \frac{G\cancel{m}M}{R} = -\frac{\cancel{G}mM}{r}$$

$$\frac{GM}{r} = \frac{GM}{R} - \left(\frac{1}{2}\times\frac{GM}{2R}\right) = \frac{GM}{R} - \frac{GM}{4R} = \frac{3GM}{4\,R}$$

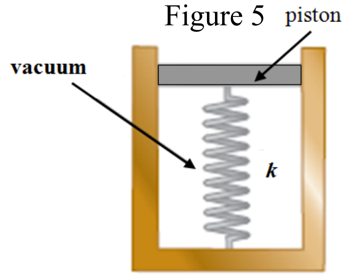
$$\Rightarrow r = \frac{4R}{3} \Rightarrow h = r - R = \frac{4R}{3} - R = \frac{R}{3}$$

Q22.

A spring, of force constant k =1250 N/m, is placed below a circular piston (radius 0.60 cm), as shown in **Figure 5**. As the piston is lowered into water, what change of depth causes the piston to compress the spring by 1.5 cm?

A) 17 m
B) 24 m
C) 13 m
D) 38 m
E) 79 m

Figure 5



Ans:

$$F = ky: \ pA = ky$$

$$\Rightarrow p = \frac{ky}{A} = \frac{1250 \times 1.5 \times 10^{-2}}{\pi \times 36 \times 10^{-6}} = 1.66 \times 10^{5} \text{ Pa}$$

$$\Delta p = \rho g h \rightarrow h = \frac{\Delta p}{\rho g} = \frac{1.66 \times 10^{5}}{10^{3} \times 9.8} = 17 \text{ m}$$

Q23.

An object, of density 7.9 g/cm^3, hangs from a balance. The balance reads 80 N when the object is in air, and 71 N when completely immersed in a liquid. What is the density of the liquid?

A) 0.89 g/cm^3
B) 8.8 g/cm^3
C) 0.010 g/cm^3
D) 1.5 g/cm^3
E) 0.58 g/cm^3

Ans:

$$In\ air: \ W_a = mg \longrightarrow m = \frac{W_a}{g}$$

$$m = \rho_0 V \rightarrow V = \frac{m}{\rho_0} = \frac{W_a}{\rho_0 g} \rightarrow Vg = \frac{W_a}{\rho_0}$$

$$In\ liquid: F_B = W_a - W_f$$

$$\rho_f V_g = W_a - W_f$$

$$\rho_f = \frac{W_a - W_f}{V_g} = \rho_0 \cdot \left(\frac{W_a - W_f}{W_a}\right)$$

$$= \rho_0 \cdot \left(1 - \frac{W_f}{W_a}\right) = (7.87)\left(1 - \frac{70.9}{80}\right) = 0.89 \ \text{g/cm}^3$$

Q24.

The rate of flow of water through a horizontal pipe is 2.0 m^3/minute. Determine the speed of flow at a point where the radius of the pipe is 4.0 cm.

A) 6.6 m/s
B) 400 m/s
C) 2.3 m/s
D) 0.84 m/s
E) 9.8 m/s

Ans:

$R_v = Av$

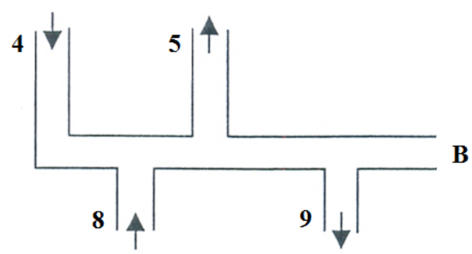
$$\Rightarrow v = \frac{R_v}{A} = \frac{R_v}{\pi r^2} = \frac{1}{\pi} \cdot 2.0\ \frac{m^3}{\cancel{min}} \cdot \frac{1\ \cancel{min}}{60\ s} \cdot \frac{1}{16 \times 10^{-4}}$$

$= 6.6\ \mathrm{m/s}$

Q25.

Figure 6 shows a pipe and gives the volume flow rate (in cm^3/s) and the direction of flow for all but one section (**B**). What are the volume flow rate and direction of flow in section **B**?

Figure 6



A) 2 cm^3/s , to the left
B) 9 cm^3/s , to the righ
C) 3 cm^3/s , to the right
D) 8 cm^3/s , to the left
E) 4 cm^3/s , to the left

Ans:

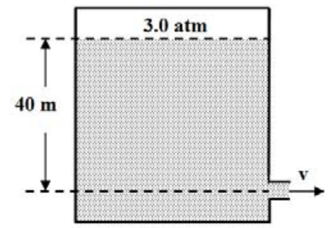
A

$$\begin{array}{cccc} 4\downarrow & \underset{\rightarrow}{12} & \uparrow 5 & \underset{\leftarrow}{2} \\ 8\uparrow & & \overset{\rightarrow}{7} & \downarrow 9 \end{array}$$

Q26.

A large gasoline tank is closed, and is under an absolute pressure of 3.0 atm (see **Figure 7**). A small hole is made 40 m below the surface of the gasoline. At what speed does the gasoline leave the hole? (Density of gasoline = 660 kg/m^3)

Figure 7



A) 37 m/s
B) 41 m/s
C) 98 m/s
D) 21 m/s
E) 34 m/s

Ans:

$$p_t + \cancel{\frac{1}{2}\rho v_t^2}^{\,0} + \rho g y_t = p_0 + \frac{1}{2}\rho v^2 + \rho g y_b$$

$$(p_t - p_0) + \rho g(y_t - y_b) = \frac{1}{2}\rho v^2$$

$$(2 \times 1.013 \times 10^5) + (660 \times 9.8 \times 40) = 330\, v^2$$

$$\Rightarrow v = 37 \text{ m/s}$$

Q27.

A 0.25 kg block oscillates on a frictionless surface at the end of a spring that has a spring constant of 200 N/m. If the system has a total energy of 6.0 J, then the amplitude of oscillation is:

A) 0.24 m
B) 0.060 m
C) 0.17 m
D) 4.9 m
E) 1.2 m

Ans:

$$E = \frac{1}{2}kx_m^2$$

$$x_m = \sqrt{\frac{2E}{k}} = \sqrt{\frac{2 \times 6}{200}} = 0.24 \text{ m}$$

Q28.

A 0.50 kg box connected to a light spring, of force constant 20 N/m, oscillates on a horizontal frictionless surface. The amplitude of the motion is 3.0 cm. Find the speed of the box when its displacement is 2.5 cm.

A) 0.10 m/s
B) 0.30 m/s
C) 1.2 m/s
D) 1.5 m/s
E) 2.0 m/s

Ans:

$$E = \frac{1}{2}kx_m^2 = \frac{1}{2} \times 20 \times 9.0 \times 10^{-4} = 0.009 \text{ J}$$

$$E = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = E - \frac{1}{2}kx^2$$

$$v^2 = \frac{2}{m}\left(E - \frac{1}{2}kx^2\right)$$

$$= \left(\frac{2}{0.5}\right)\left[0.009 - \left(\frac{1}{2} \times 20 \times 2.55^2 \times 10^{-4}\right)\right]$$

$$\Rightarrow v = 0.0999 = 0.10 \text{ m/s}$$

Q29.

The displacement of a particle moving in simple harmonic motion is given by the equation: $x(t) = 2.0\ cos(6.0t)$, where x is in meters and t is in seconds. What is the maximum acceleration of the particle and where does it occur?

A) 72 m/s^2 at maximum negative displacement
B) 72 m/s^2 at maximum positive displacement
C) 12 m/s^2 at maximum negative displacement
D) 12 m/s^2 at maximum positive displacement
E) 2.0 m/s^2 at zero displacement

Ans:

$$a_{max} = \omega^2 x_m = (36)(2.0) = 72\ m/s^2$$

It occurs at the negative extreme of the motion.

Q30.

A simple pendulum has length L and period T. If the length of the pendulum is reduced to $L/4$, then the period becomes

A) $T/2$
B) $2T$
C) $T/4$
D) $4T$
E) T

Ans:

$$T = 2\pi\sqrt{\frac{L}{g}} \rightarrow T' = 2\pi\sqrt{\frac{L}{4g}} = \frac{1}{2}\left[2\pi\sqrt{\frac{L}{g}}\right] = \frac{T}{2}$$