Q1.

A car starts a trip from Dammam and travels 480 km in a straight line to Riyadh in 4 hours. Immediately, the car turns around, and returns to Dammam through the same straight road. If the average speed of the car for the entire trip is 96 km/h, find the time taken by the car to return from Riyadh to Dammam.

A) 6 hours
B) 4 hours
C) 3 hours
D) 8 hours
E) 9 hours

Ans:

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{480 + 480}{4 + t}$$

$$96(4 + t) = 960$$

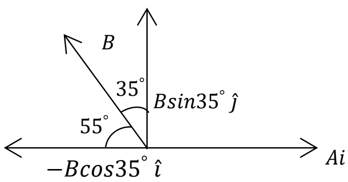
$$t = \frac{960}{96} - 4 = 6\ hours$$

Q2.

Vector $\vec{A}$ has a magnitude of 5.0 m and is directed east. Vector $\vec{B}$ has a magnitude of 4.0 m and is directed 35° west of due north. What is the magnitude of $\vec{B} - \vec{A}$?

A) 8.0 m
B) 6.0 m
C) 5.0 m
D) 4.0 m
E) 2.0 m

Ans:



$$\vec{B} - \vec{A} = -A\hat{\imath} - Bcos55\hat{\imath} + Bsin\,55\,\hat{\jmath}$$

$$\vec{B} - \vec{A} = -(A + Bcos55)\hat{\imath} + Bsin\,55\,\hat{\jmath}$$

$$\left|\vec{B} - \vec{A}\right| = \sqrt{(5 + 4cos55)^2 + (4sin55)^2} = 8.0 \text{ m}$$

Q3.

A particle has its position vector defined by, $\vec{r} = (2.0t - t^2)\hat{i} + (3.0 - 2.0t^2)\hat{j}$, with r and t are measured in SI units. At the time when x-component of the particle's velocity is zero, what is the magnitude of y-component of its velocity?

A) 4.0 m/s
B) 3.0 m/s
C) 2.0 m/s
D) 1.0 m/s
E) 5.0 m/s

Ans:

$\vec{r} = x\hat{\boldsymbol{i}} + y\hat{j}$

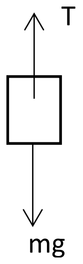
When $v_x = 0 \Longrightarrow 2 - 2t = 0 \Longrightarrow t = 1\ s$

$|v_y| = |-4t| = 4.0\ m/s$

Q4.

The tension in a massless string to which a 4.0-kg object is suspended (attached and hanged) in an elevator is equal to 44 N. What is the acceleration of the elevator?

A) 1.2 m/s^2
B) 3.5 m/s^2
C) 6.4 m/s^2
D) 2.3 m/s^2
E) 7.1 m/s^2



Ans:

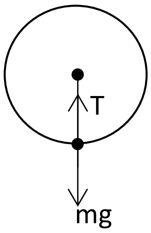
$T - mg = ma$

$$a = \frac{T - mg}{m} = \frac{44 - 4 \times 9.8}{4} = 1.2\ m/s^2$$

Q5.

A 0.50-kg mass attached to the end of a massless string swings in a vertical circle of radius 2.0 m. When the mass is at the lowest point on the circle, the speed of the mass is 12 m/s. What is the magnitude of the force of the string on the mass at this position? (Ignore air resistance)

A) 41 N
B) 13 N
C) 82 N
D) 56 N
E) 27 N



Ans:

$$T - mg = \frac{mv^2}{r}$$

$$T = mg + \frac{mv^2}{r} = m\left(g + \frac{v^2}{r}\right) = 0.5\left(9.8 + \frac{12^2}{2}\right) = 41\ N$$

Q6.

A projectile of mass 0.20 kg is fired with an initial speed *v* at an angle of 60° above the horizontal. If the kinetic energy of the projectile at the highest point is 10 J find the value of *v*. (Ignore air resistance)

A) 20 m/s
B) 10 m/s
C) 30 m/s
D) 40 m/s
E) 50 m/s

Ans:

$$\frac{1}{2}mv_{0x}^2 = 10\ \text{J}$$

$$v_{0x} = \sqrt{\frac{20}{0.2}}$$

$$v cos 60^{\circ} = \sqrt{100} = 10$$

$$v\,\frac{1}{2} = 10 \Rightarrow v = 20\ m/s$$

Q7.

A 2.0-kg block with an initial velocity of $\vec{v} = 3.0\hat{i} - 4.0\hat{j}$ (m/s) slides on a horizontal xy- rough surface with coefficient of kinetic friction μ_k = 0.12. Find the total distance traveled by the block before it comes to rest.

A) 11 m
B) 17 m
C) 25 m
D) 30 m
E) 47 m

Ans:

$$\Delta K + \Delta U_g = W_f$$

$$K - K_0 = \mu_k F_N d\cos 180°$$

$$0 - \frac{1}{2}mv^2 = -\mu_k mgd$$

$$\Rightarrow d = \frac{v^2}{2\mu_k g} = \frac{5^2}{2 \times 0.12 \times 9.8} = 10.6\ \approx 11\ m$$

Q8.

A 2.0-kg object moving at 5.0 m/s collides with and sticks to an 8.0-kg object initially at rest. Determine the kinetic energy lost by the system as a result of this collision.

A) 20 J
B) 10 J
C) 15 J
D) 25 J
E) 30 J

Ans:

$$K_0 = \frac{1}{2} \times 2 \times 5^2 = 25\ \text{J}$$

$$2 \times 5 = (2+8)v \qquad \Rightarrow v = 1.0\ m/s$$

$$K = \frac{1}{2} \times (2+8)v^2 = 5\ \text{J}$$

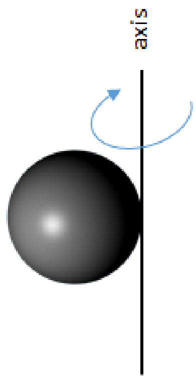
$$\Delta K = K - K_0 = -20\ \text{J}$$

Q9.

A uniform solid sphere, of radius R = 1.0 m and mass M = 5.0 kg, rotates freely with a constant angular speed ω = 2.0 rad/s about a vertical axis tangent to the surface of the sphere, as shown in **Figure 1**. Find the rotational kinetic energy of the sphere.

A) 14 J
B) 10 J
C) 22 J
D) 28 J
E) 36 J

Figure 1



Ans:

$$K = \frac{1}{2} I\omega^2 = \frac{1}{2}\left(\frac{2}{5}\, mR^2 + mR^2\right)\omega^2$$

$$= \frac{1}{2}\left(\frac{7}{5}\, mR^2\right)\omega^2 = \frac{7}{10} \times 5 \times 1^2 \times 2^2 = 14\ \text{J}$$

Q10.

A horizontal disc of radius 2.0 m rotates with a constant angular speed of 3.0 rev/s about a vertical axis through its center. Find the magnitude of the radial acceleration at a point on the rim of the disc.

Ans:

$$a_r = \omega^2 r = (3 \times 2\pi)^2 \times 2 = 710\ m/s^2$$

A) 710 m/s^2

B) zero

C) 430 m/s^2

D) 560 m/s^2

E) 370 m/s^2

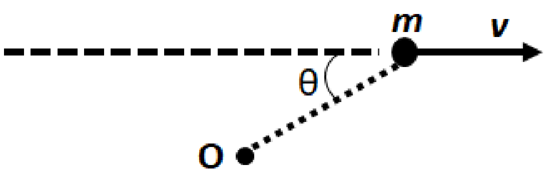
Ans:

Q11.

A particle of mass m = 0.20 kg moves with constant speed v = 2.0 m/s along a straight line as shown in **Figure 2**. When angle θ = 30°, the distance between the particle and point O is 2.0 m. Find the magnitude of its angular momentum with respect to point O.

A) 0.40 $kg.m^2/s$
B) 0.80 $kg.m^2/s$
C) 0.20 $kg.m^2/s$
D) 0.60 $kg.m^2/s$
E) 0.10 $kg.m^2/s$

Figure 2



Ans:

$$r sin\theta m v = \vec{L}$$

$$\vec{L} = m v r sin\theta$$

$$= 0.2 \times 2 \times 2 sin 30°$$

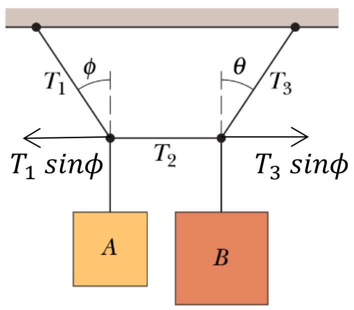
$$= 0.2 \times 2 \times 2 \times \frac{1}{2}$$

$$= 0.40\ kg \cdot m^2/s$$

Q12.

The system in **Figure 3** is in static equilibrium, with the string in the center exactly horizontal. Block A weighs 35 N, block B weighs 45 N, and angle ϕ is 35°. Find the magnitude of the tension (T_2) in the horizontal section of the string.

Figure 3



A) 25 N
B) 30 N
C) 15 N
D) 10 N
E) 35 N

Ans:

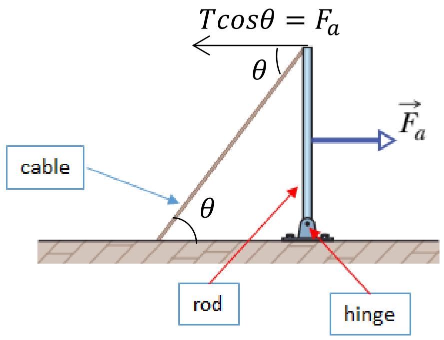
$$\frac{T_1 sin\phi}{T_1 cos\phi} = \frac{T_2}{35}$$

$$T_2 = 35tan\phi = 35 \times tan35° = 25\ N$$

Q13.

In **Figure 4**, a vertical rod is hinged at its lower end and attached to a cable at its upper end. A constant horizontal force ($\vec{F}_a$) is to be applied to the rod as shown. Assuming the rod remains in its vertical position, if the point at which the force is applied is moved up the rod, the tension in the cable:

Figure 4



A) increases
B) decreases
C) remains constant
D) first increases then decreases
E) first decreases then increases

Ans:

$Tcos\theta = F_a$

$rF_a = Tcos\theta L$

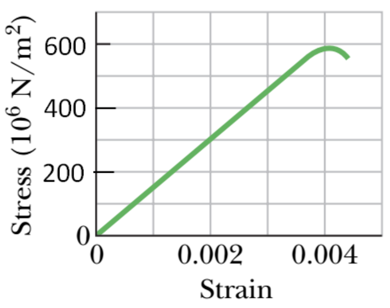
If r goes up it has to be balanced by T as $\theta,\ L$ and F_a are constant.

Q14.

Figure 5 shows the stress–strain curve for a material. What is the Young's modulus of the material?

A) 1.5×10^{11} N/m^2
B) 6.0×10^{4} N/m^2
C) 1.5×10^{5} N/m^2
D) 2.4×10^{11} N/m^2
E) 2.4×10^{5} N/m^2

Figure 5



Ans:

$$Y = \frac{Stress}{Strain}$$

$$= \frac{600\ \times 10^6 - 0}{0.004 - 0}$$

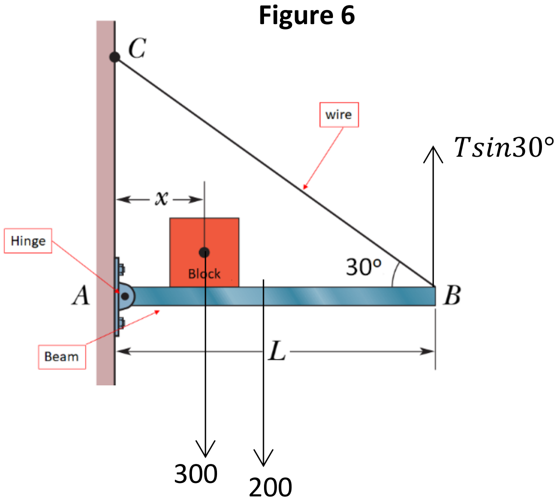
$$Y = 1.5 \times 10^{11}\ N/m^2$$

Q15.

Figure 6 shows a uniform beam hinged to a wall and it is supported by a wire. Suppose the length L of the beam is 3.00 m and its weight is 200 N. A block of weight 300 N is placed on the beam at distance *x* from the wall. If the wire can withstand a maximum tension of 500 N what is the maximum possible distance *x* before the wire breaks?

A) 1.50 m
B) 2.00 m
C) 2.50 m
D) 3.00 m
E) 3.50 m

Figure 6



Ans:

$$Tsin30°L = 300x + 200\frac{L}{2}$$

$$300x = 500 \times \frac{1}{2} \times 3 - 200 \times \frac{3}{2}$$

$$x = 2.5 - 1 = 1.5\ m$$

Q16.

Assume that the Earth is a uniform solid sphere. What is the magnitude of the gravitational acceleration (a_g) at a height, $h = R_E/3$ above the surface of the earth, where R_E is the radius of the Earth?

A) 5.5 m/s^2
B) 4.9 m/s^2
C) 3.2 m/s^2
D) 9.8 m/s^2
E) 8.9 m/s^2

Ans:

$$a_g = \frac{GM}{\left(R_E + \frac{R_E}{3}\right)^2} = \frac{9GM}{16R_E^2} = \frac{9}{16} \times 9.8 = 5.5\ m/s^2$$

Q17.

Find the speed of a satellite which is rotating in a circular path at a distance of $2R_E$ from the center of the earth, where, R_E is the radius of the earth.

A) 5.59×10^3 m/s
B) 3.24×10^3 m/s
C) 1.60×10^3 m/s
D) 6.75×10^3 m/s
E) 7.68×10^3 m/s

Ans:

$$\frac{mv^2}{2R_E} = \frac{GMm}{(2R_E)^2}$$

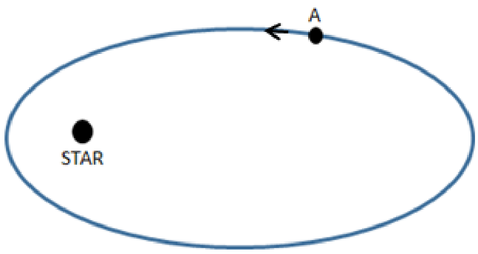
$$\frac{v^2}{2R_E} = \frac{GMm}{4(R_E)^2}$$

$$v = \sqrt{\frac{g}{2}R_E} = 5.59 \times 10^3\ m/s$$

Q18.

Figure 7 shows a planet traveling in a counterclockwise direction in an elliptical path around a star located at one focus of the ellipse. When the planet passes through point A

Figure 7



A) its speed is increasing.
B) its speed is constant.
C) its speed is decreasing.
D) its speed is maximum.
E) its speed is minimum.

Ans:

$mvr = constant, \quad \Rightarrow r\ decreasing\ so\ v\ must\ increase$

Q19.

An object is released from rest when it is at a height *h* above the surface of a planet of mass *M* and radius *R*. What is the speed of the object just before striking the surface of the planet? Neglect any air resistance. Let $h = 4.0 \times 10^6$ m, $R = 5.0 \times 10^6$ m, and $M = 4.0 \times 10^{24}$ kg.

A) 6.9 km/s
B) 4.2 km/s
C) 2.5 km/s
D) 1.3 km/s
E) 5.7 km/s

Ans:

$$\Delta K + \Delta U_g = 0$$

$$K - \cancel{K_0}^{\,0} + U - U_g = 0$$

$$\frac{1}{2}mv^2 - \frac{GMm}{R} + \frac{GMm}{R+h} = 0$$

$$v = \sqrt{2GM\left(\frac{1}{R} - \frac{1}{R+h}\right)} = 6.9\ km/s$$

Q20.

The potential energy of a rocket on the surface of the earth $U_o = -6.24\times10^{10}$ J. Find the amount of work required to take the rocket to an **altitude** equal to half of the radius of the earth. (Assume the rocket is at rest both at the initial and final positions).

A) 2.08×10^{10} J
B) 3.12×10^{10} J
C) 6.24×10^{10} J
D) 1.58×10^{10} J
E) 4.16×10^{10} J

Ans:

$$W_a = \Delta U = U - U_0$$

$$= \frac{-GMm}{\left(R_E + \frac{R_E}{2}\right)} - U_0$$

$$\frac{2U_0}{3} - U_0 = -\frac{U_0}{3} = 2.08 \times 10^{10}\text{ J}$$

Q21.

The magnitude of the gravitational force between two isolated particles of masses 5.2 kg and 2.4 kg, which are separated by distance *r*, is 2.3×10^{-12} N. What is the gravitational potential energy of the two-particle system?

A) -4.4×10^{-11} J
B) $+4.4\times10^{-11}$ J
C) -6.2×10^{-11} J
D) $+6.2\times10^{-11}$ J
E) -8.5×10^{-11} J

Ans:

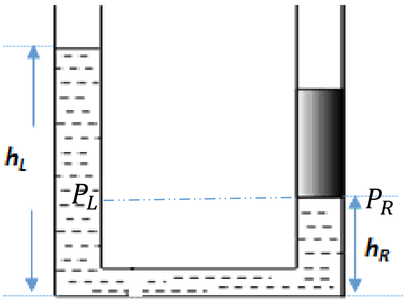
$$F = \frac{GMm}{r^2} \qquad \Rightarrow r = \sqrt{\frac{GMm}{F}}$$

$$U = -rF = -4.4 \times 10^2\ J$$

Q22.

Figure 8 shows a U-tube with uniform cross-sectional area A = 5.0×10^{-3} m^2 and partially filled with water. A solid cylinder, which fits the tube tightly but can slide without friction, is placed in the right arm. When the water-cylinder system is in equilibrium, the water levels in the left arm and right arm are h_L = 0.50 m and h_R = 0.20 m, respectively. Find the mass of the cylinder.

Figure 8



A) 1.5 kg
B) 2.0 kg
C) 2.5 kg
D) 3.0 kg
E) 3.5 kg

Ans:

$$P_L = P_R$$

$$\rho_w g(h_L - h_R) = \frac{mg}{A}$$

$$m = \rho_w(h_L - h_R)A = 1.5\ kg$$

Q23.

A wooden cube with edge length 0.843 m has density 6.00×10^2 kg/m^3. When the cube is placed in fresh water, to what depth will it be submerged?

A) 0.506 m
B) 0.419 m
C) 0.370 m
D) 0.218 m
E) 0.183 m

Ans:

$$mg = \rho_w g V_w = \rho_w g A h$$

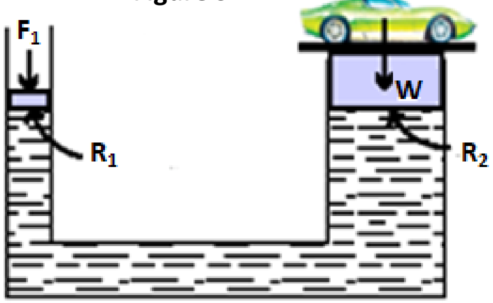
$$h = \frac{m}{\rho_w L^2} = 0.506\ m$$

Q24.

Figure 9 shows a hydraulic press in which a piston of radius R_1 = 5.00 cm is used to exert a force $F_1 = 1.20\times10^3$ N on the enclosed liquid to raise a car of weight W = 1.92×10^4 N. Find the radius of the larger piston R_2.

A) 20 cm
B) 30 cm
C) 40 cm
D) 50 cm
E) 10 cm

Figure 9



Ans:

$$P_1 = P_2$$

$$\frac{F_1}{\pi {R_1}^2} = \frac{F_2}{\pi {R_2}^2}$$

$$R_2 = \sqrt{\frac{F_2}{F_1}} R_1 = 20\ cm$$

Q25.

At one point in a pipeline, the water's speed is 3.00 m/s and the pressure is 5.00×10^4 Pa. Find the pressure at a second point in the line, 11.0 m lower than the first, if the pipe diameter at the second point is twice that at the first.

A) 1.62×10^5 Pa
B) 1.32×10^6 Pa
C) 1.35×10^5 Pa
D) 1.35×10^6 Pa
E) 2.02×10^5 Pa

Ans:

$$\pi {R_1}^2 v_1 = \pi (2R_1)^2 v_2 \qquad \Rightarrow v_2 = v_1/4$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g \cancel{h_2}^{\,0}$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho \frac{v_1^2}{16}$$

$$P_2 = P_1 + \frac{1}{2}\rho v_1^2 \times \frac{15}{16} + \rho g h_1 = 1.62 \times 10^5 Pa$$

Q26.

A uniform tube delivers 1550 kg of water per second. If the flow speed of the water in the tube is 31.6 m/s, find the radius of the tube.

A) 0.125 m
B) 0.270 m
C) 0.310 m
D) 0.835 m
E) 0.565 m

Ans:

$$\frac{m}{t} = \rho \frac{V}{t} = \rho A v = \rho \pi r^2 v$$

$$r = \sqrt{\frac{m/t}{\pi \rho v}} = \sqrt{\frac{1550}{3.14 \times 1000 \times 31.6}} = 0.125\, m$$

Q27.

A body oscillates without friction in a simple harmonic motion along the x axis. Its displacement varies with time according to the equation x = 5.0 sin (πt + π/3), provided *x* and *t* are in SI units. Find the maximum acceleration of the body.

A) 49 m/s^2
B) 25 m/s^2
C) 68 m/s^2
D) 76 m/s^2
E) 14 m/s^2

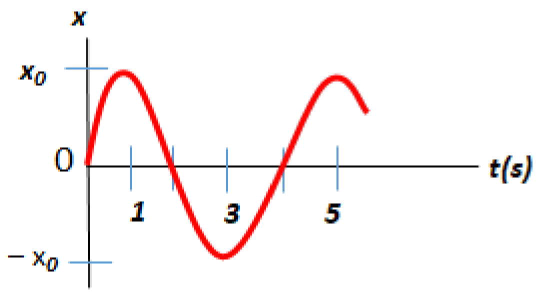
Ans:

$$\boldsymbol{a_m = \omega^2 x_m = \pi^2 \times 5 = 49\ m/s^2}$$

Q28.

Figure 10 shows the displacement-time graph of a particle in a simple harmonic motion. Which one of the following statements is **TRUE**?

Figure 10



A) At time, t = 0, 2, and 4 s, the particle has maximum speed.

B) At time, t = 0, 2, and 4 s, the particle is momentarily at rest.

C) At time, t = 0, 2, and 4 s, the particle has maximum acceleration.

D) At time, t = 1, 3, and 5 s, the particle has maximum speed.

E) At time, t = 1, 3, and 5 s, the particle has no acceleration

Ans:

Maximum speed happens at the mean position

Q29.

A block–spring system oscillate on a horizontal frictionless surface has a mechanical energy of 2.0 J and amplitude 10 cm. Find the maximum kinetic energy of the block.

A) 2.0 J
B) 1.0 J
C) 1.5 J
D) zero
E) 2.5 J

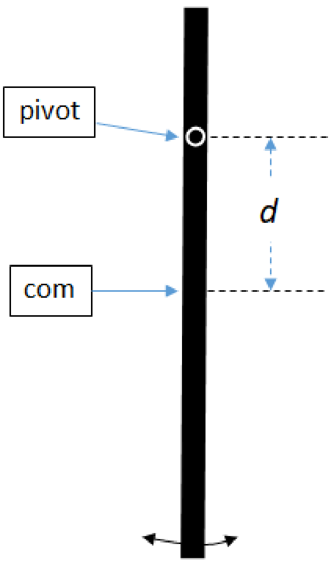
Ans:

Maximum Kinetic energy = total mechnaical energy

Q30.

Figure 11 shows a uniform rod (length L = 1.0 m, mass = 2.0 kg) suspended from a pivot a distance d = 0.25 m above its center of mass. The angular frequency (in rad/s) for small oscillations is

Figure 11



A) 4.1
B) 2.6
C) 5.0
D) 1.2
E) 3.6

Ans:

$$\omega = \sqrt{\frac{mgh}{I}} = \sqrt{\frac{mg\frac{L}{4}}{\frac{1}{12}mL^2 + md^2}} = 4.1\, rad/s$$