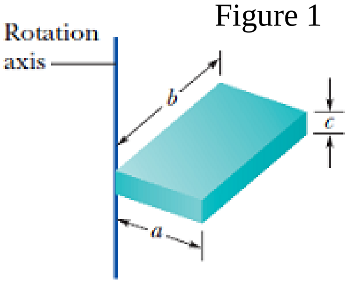
Q1.

The uniform solid block in **Figure 1** has mass 0.172 kg and edge lengths a = 3.5 cm, b = 8.4 cm, and c = 1.4 cm. Calculate its rotational inertia about an axis through one corner and perpendicular to the large faces.

Figure 1



A) 4.8×10^{-4} kg.m^2
B) 5.7×10^{-4} kg.m^2
C) 7.7×10^{-1} kg.m^2
D) $8.7\times10^{+1}$ kg.m^2
E) 9.7×10^{-4} kg.m^2

Ans:

$$I = I_{COM} + Md^2 = \frac{1}{12}M(a^2+b^2) + M\frac{1}{4}(a^2+b^2) = 4.8\times10^{-4} kg.m^2$$

Q2.

A man pushes a 500 kg block along the x axis by a constant force $\vec{F} = (100N)\hat{i} - (200N)\hat{j}$. Find the power required to maintain a speed of 5.00 m/s.

A) 500 W
B) 2500 W
C) 1000 W
D) 750 W
E) 300 W

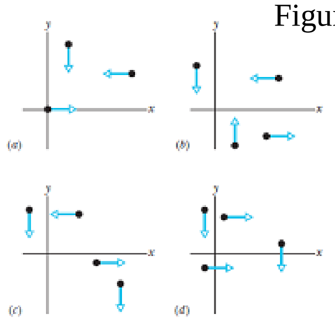
Ans:

$$P = \vec{F}.\vec{v} = 500\ W$$

Q3.

Figure 2 shows four groups of three or four identical particles that move parallel to either the x axis or the y axis, at identical speeds. Rank the groups according to center-of-mass speed, greatest first.

Figure 2



A) d, c, a, b
B) d, a, b, c
C) a, b, c, d
D) d, c, b, a
E) c, d, a, b

Ans:

A

Q4.

A block is sliding down on a rough inclined plane. A man applies a force to reduce the acceleration of the block. Let W_f be the work done by the friction force, W_m the work done by the man, and W_g the work done by the gravitational force. While the block is sliding down, which of the following is TRUE?

A) $W_f < 0, W_m < 0, W_g > 0$
B) $W_f < 0, W_m > 0, W_g < 0$
C) $W_f < 0, W_m < 0, W_g < 0$
D) $W_f < 0, W_m > 0, W_g > 0$
E) $W_f > 0, W_m > 0, W_g > 0$

Ans:

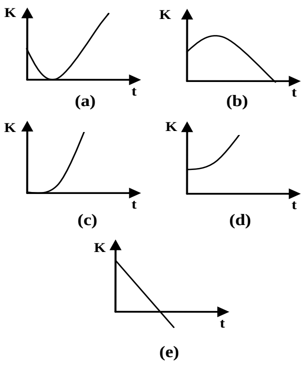
A

Q5.

A ball is launched upward from the edge of a cliff. Which of the graphs shown in **Figure 3** could possibly represent how the kinetic energy of the ball changes during its flight?

A) a
B) b
C) c
D) d
E) e

Figure 3



Ans:

A

Q6.

A 2.00 kg ball is thrown with an initial velocity of $\vec{v}_o = 18\hat{i} + 10\hat{j}$, where v_o is in m/s. What is the maximum change in the potential energy of the ball-Earth system during its flight?

A) 100 J
B) −100 J
C) 50 J
D) −50 J
E) zero

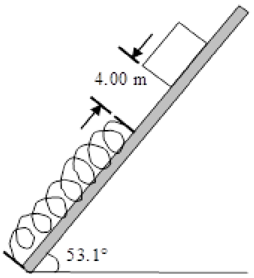
Ans:

$$\Delta K = \frac{1}{2}m(v^2 - v_0^2) = -\Delta U \rightarrow \Delta U = \frac{1}{2}m(v_0^2 - v^2) = \frac{1}{2}2(18^2 + 10^2 - 18^2) = 100\ J$$

Q7.

A 2.00 kg package is released on a rough 53.1° incline at 4.00 m from a long spring of force constant 120 N/m. The spring is attached to the bottom of the incline as shown in **Figure 4**. If the maximum compression of the spring is d = 1.00 m, what is the work done by the friction force?

Figure 4



A) −18.4 J
B) +18.4 J
C) −60.0 J
D) +60.0 J
E) zero

Ans:

$$\Delta K + \Delta U = W_f$$

$$\Delta K = 0, \qquad \Delta U = \frac{1}{2}kd^2 - mg(h_1 + h_2)$$

$$\Rightarrow W_f = \frac{1}{2} \times 120 \times 1^2 - 2 \times 9.8 \times 5 \times sin(53.1^o) = -18.4\ J$$

Q8.

The only force acting on a particle is a conservative force $\vec{F}$. If the particle is at point A, the potential energy of the system associated with $\vec{F}$ and the particle is 80 J. If the particle moves from point A to point B, the work done on the particle by $\vec{F}$ is + 20 J. What is the potential energy of the system with the particle at B?

A) 60 J
B) 100 J
C) 20 J
D) 80 J
E) zero

Ans:

$$W = -\Delta U = -(U_B - U_A) \rightarrow U_B = U_A - W = 60\ J$$

Q9.

The force acting along the *x* axis on an 8 kg object varies as shown in **Figure 5**. The speed of the object at *x* = 0 is zero. The speed of the object at *x* = 5.0 m is

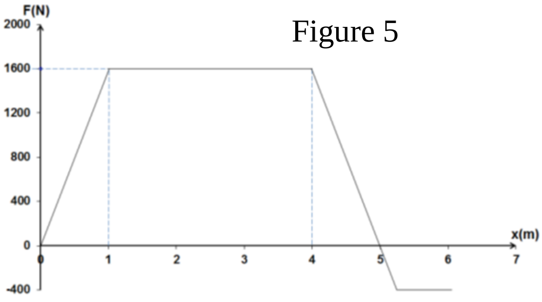


Figure 5

A) 40 m/s
B) 30 m/s
C) 160 m/s
D) 80 m/s
E) zero

Ans:

$$\Delta K = W = \int F dx \rightarrow \frac{1}{2}mv^2 = \frac{1}{2}(3+5)1600 \rightarrow v = 40\ m/s$$

Q10.

A dam is 170 m high. The electrical power output from generators at its base is approximately 2000 MW. How many cubic meters of water must fall from the top of the dam per second to produce this amount of power if 50% of the work done on the water by gravity is converted to electrical energy? (Density of water is 1000 kg/m^3)

A) 2.40×10^3 m^3/s
B) 3.40×10^1 m^3/s
C) 2.90×10^4 m^3/s
D) 4.80×10^3 m^3/s
E) 1.20×10^3 m^3/s

Ans:

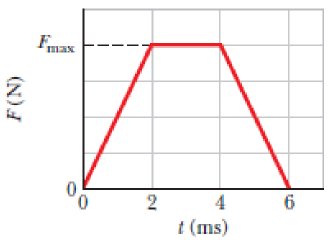
$$W = Mgh = \rho V g h$$

$$P = 0.5 \times \frac{dW}{dt} = 0.5 \times \rho g h \frac{dV}{dt} \rightarrow \frac{dV}{dt} = \frac{2P}{\rho g h} = 2.4 \times 10^3\ m^3/s$$

Q11.

Figure 6 shows an approximate plot of force magnitude *F* versus time *t* during the collision of a 58 g ball with a wall. The initial velocity of the ball is 34 m/s perpendicular to the wall; the ball rebounds directly back with approximately the same speed, also perpendicular to the wall. What is F_{max}, the maximum magnitude of the force on the ball from the wall during the collision?

Figure 6



A) 9.9×10^2 N
B) 1.8×10^2 N
C) 7.7×10^2 N
D) 3.9×10^2 N
E) 9.0×10^1 N

Ans:

$$\Delta p = 2Mv = \int F dt = F_{max} \frac{1}{2}(2+6)\times10^{-3}$$

$$\Rightarrow F_{max} = \frac{2Mv}{\frac{1}{2}(2+6)\times10^{-3}} = 9.9\times10^2\ \text{N}$$

Q12.

A 2100 kg truck traveling north at 41 km/h turns east and accelerates to 51 km/h. What are the magnitude and direction of the change in its momentum?

A) 3.8×10^{4} kg.m/s, 39^{o} South of East
B) 1.8×10^{2} kg.m/s, 39^{o} South of West
C) 3.1×10^{3} kg.m/s, 39^{o} South of East
D) 3.8×10^{4} kg.m/s, 39^{o} North of East
E) 7.8×10^{7} kg.m/s, 39^{o} South of East

Ans:

$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 2100\ kg \times (+51\hat{\imath} - 41\hat{\jmath})km/h$$

$$\Delta p = 2100 \times \frac{10^3\sqrt{51^2+41^2}}{3600} = 3.8\times10^4\ kg.m/s$$

$$tan(\theta) = \frac{-41}{51} \to \theta = 39^o\ South\ of\ East$$

Q13.

Two bodies, *A* and *B*, each with 2.0 kg mass collide. The velocities before the collision are $\vec{v}_A = (15\hat{i} + 30\hat{j})$ m/s and $\vec{v}_B = (-10\hat{i} + 5\hat{j})$ m/s. After the collision, $\vec{v}'_A = (-5\hat{i} + 20\hat{j})$ m/s, what is the final velocity of *B*?

A) $\vec{v}'_B = (10\hat{i} + 15\hat{j})$
B) $\vec{v}'_B = 10\hat{i}$
C) $\vec{v}'_B = 15\hat{j}$
D) $\vec{v}'_B = (-15\hat{i} - 30\hat{j})$
E) $\vec{v}'_B = (10\hat{i} - 5\hat{j})$

Ans:

$$m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}'_A + m_B\vec{v}'_B$$

$$m_A = m_B \to \vec{v}'_B = \vec{v}_A - \vec{v}'_A + \vec{v}_B = 10\hat{\imath} + 15\hat{\jmath}$$

Q14.

Figure 7 shows a graph of a torque applied to a rotating body as a function of time. What is the change in angular momentum of the rotating body between time $t = 0$ and $t = 6$ s?

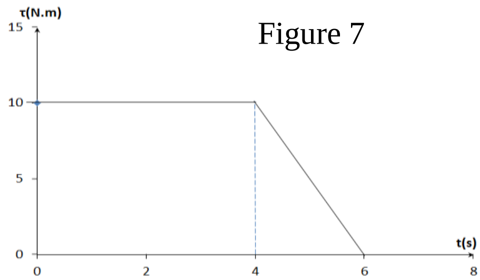


Figure 7

A) 50.0 $kg.m^2/s$
B) 10.0 $kg.m^2/s$
C) 20.0 $kg.m^2/s$
D) 30.0 $kg.m^2/s$
E) 40.0 $kg.m^2/s$

Ans:

$$\frac{dL}{dt} = \tau \to \Delta L = \int_0^6 \tau(t)dt = \frac{1}{2}(4+6)10 = 50\ kgm^2/s$$

Q15.

A diver makes 2.5 revolutions on the way from a 10 m high platform to the water. Assuming zero initial vertical velocity, find the average angular velocity during the dive.

A) 11 rad/s
B) 15 rad/s
C) 51 rad/s
D) 13 rad/s
E) 21 rad/s

Ans:

$$\Delta t = \sqrt{\frac{2h}{g}}; \ \Delta\theta = 2.5 \times 2\pi$$

$$\omega = \frac{\Delta\theta}{\Delta t} = 11\ rad/s$$

Q16.

What is the linear speed of a point on Earth's surface at latitude 40^{o} North? (Radius of Earth = 6.4×10^{3} km)

A) 3.6×10^{2} m/s
B) 7.0×10^{2} m/s
C) 1.8×10^{2} m/s
D) 6.4×10^{2} m/s
E) 4.9×10^{5} m/s

Ans:

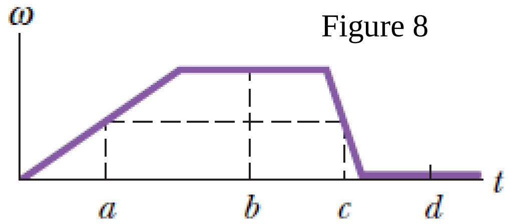
$$v = r\omega = 6.4 \times 10^{3} cos(40^{o}) \times \frac{2\pi}{24 \times 3600} \frac{km}{s} = 3.6 \times 10^{2}\ km/s$$

Q17.

Figure 8 is a graph of the angular velocity versus time for a disk rotating like a merry-go-around. For a point on the disk rim, rank the instants a, b, c, and d according to the magnitude of the radial acceleration, greatest first.

A) b, a & c tie, d
B) c, a, b & d tie
C) a & c tie, b & d tie
D) b & d tie, a & c tie
E) a, b, c, d

Figure 8



Ans:

A $\{(a_R = R^2\omega) \Rightarrow$ b, a & c tie, d$\}$

Q18.

A force $\vec{F} = (-8.0N)\hat{i} + (6.0N)\hat{j}$ acts on a particle with position vector $\vec{r} = (3.0m)\hat{i} + (4.0m)\hat{j}$. What is the torque on the particle about a point on the y axis with
y = 4 m?

A) (18 N.m) $\hat{k}$
B) (20 N.m) $\hat{k}$
C) (16 N.m) $\hat{k}$
D) (21 N.m) $\hat{k}$
E) (27 N.m) $\hat{k}$

Ans:

$$\vec{\tau} = (\vec{r} - \vec{r}_0) \times \vec{F} = \left(3\hat{\imath} + 4\hat{\jmath} - 4\hat{\jmath}\right) \times \left(-8\hat{\imath} + 6\hat{\jmath}\right) = 18\ N.m\ \hat{k}$$

Q19.

A student of mass M stands on the rim of a frictionless merry-go-around (rotating disk) of radius R and rotational inertia I that is not moving. He throws a rock of mass m with speed v in a direction that is tangent to the outer edge of the merry-go-around. What is the angular speed of the student & merry-go-around afterward?

A) $\omega = \frac{mR}{I + MR^2} v$
B) $\omega = \frac{MR}{I + mR^2} v$
C) $\omega = \frac{2mR}{I + MR^2} v$
D) $\omega = \frac{mR}{2I + MR^2} v$
E) $\omega = \frac{m}{I + MR^2} v$

Ans:

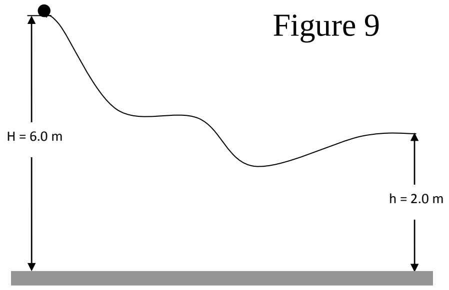
$$MvR = (I + MR^2)\omega \Longrightarrow \omega = \frac{MRv}{I + MR^2}$$

Q20.

Figure 9 shows a solid ball that rolls smoothly from rest at height H = 6.0 m until it leaves the horizontal section at the end of the track, at height h = 2.0 m. With what horizontal velocity will the ball leave the track?

A) 7.48 m/s
B) 9.38 m/s
C) 5.98 m/s
D) 2.18 m/s
E) 7.11 m/s

Figure 9



Ans:

$$v = R\omega;\ I = \frac{2}{5}MR^2 + MR^2 = \frac{7}{5}MR^2$$

$$K = \frac{1}{2}I\omega^2 = \frac{7}{10}Mv^2 = Mg\Delta h \rightarrow v = \sqrt{\frac{10}{7}g\Delta h} = 7.48\,m/s$$