1. A 0.60 kg toy car moving with an initial velocity of 0.15 m/s due East collides with a 0.80 kg toy truck moving with an initial velocity of 0.25 m/s due North. The collision is perfectly inelastic, so that the two toys stick together. What is their final speed?

\[ \vec{\hat{p}}_i = \vec{\hat{p}}_f \]

- a) 0.16 m/s
- b) 0.44 m/s
- c) 0.29 m/s
- d) 0.22 m/s
- e) 0.12 m/s

\[ m_i \vec{v}_i + m_j \vec{v}_j = (m_i + m_j) \vec{v}_f \]

\[ x : m_i v_i + 0 = (m_i + m_j) v_{xf} \Rightarrow v_{xf} = \frac{m_i v_i}{m_i + m_j} = 0.064 \text{m} / \text{s} \]

\[ y : \vec{v}_i + m_j v_j = (m_i + m_j) \vec{v}_f \Rightarrow v_{yf} = \frac{m_i v_i}{m_i + m_j} = 0.143 \text{m} / \text{s} \]

\[ v_f = \sqrt{v_{xf}^2 + v_{yf}^2} = 0.16 \text{m} / \text{s} \]

2. A roller coaster cart with a mass of 200 kg is at the top of a 30 m hill and is moving with a velocity of 4.0 m/s. The cart dives into a valley whose deepest point is at a height of 10 m and then climbs to the top of a 20 m hill. At the top of the 20 m hill, the cart has a velocity of 10 m/s. How much mechanical energy has been lost to heat?

- a) \( 4.9 \times 10^4 \text{ J} \)
- b) \( 2.0 \times 10^4 \text{ J} \)
- c) \( 2.0 \times 10^3 \text{ J} \)
- d) \( 1.1 \times 10^4 \text{ J} \)
- e) \( 6.0 \times 10^4 \text{ J} \)

\[ E_{lost} = E_i - E_f \]

\[ E_{lost} = (KE_i + PE_i) - (KE_f + PE_f) \]

\[ E_{lost} = \left( \frac{1}{2} m v_i^2 + mgh_i \right) - \left( \frac{1}{2} m v_f^2 + mgh_f \right) \]

\[ E_{lost} = 1.1 \times 10^4 \text{ J} \]

3. A billiard ball whose mass is 0.38 kg moves at 5.00 m/s in the positive x-direction. It strikes a stationary ball of the same mass. After the collision, the x-component of the first ball’s velocity is 3.75 m/s, and the y-component of its velocity is 2.16 m/s. What is the magnitude of the velocity of the struck ball after the collision? (Neglect friction and rotational motion.)

- a) 1.2 m/s
- b) 2.2 m/s
- c) 2.5 m/s
- d) 5.0 m/s
- e) 4.3 m/s

\[ \vec{\hat{p}}_i = \vec{\hat{p}}_f \]

\[ m_i \vec{v}_i + m_j \vec{v}_2 = m_i \vec{v}_{if} + m_j \vec{v}_{jf} \]

\[ x : v_i + 0 = v_{1,xf} + v_{2,xf} \Rightarrow v_{2,xf} = 5 - 3.75 = 1.25 \text{m} / \text{s} \]

\[ y : 0 + 0 = v_{1,yf} + v_{2,yf} \Rightarrow v_{2,yf} = -v_{1,yf} = -2.16 \text{m} / \text{s} \]

\[ v_f = \sqrt{v_{2,xf}^2 + v_{2,yf}^2} = 2.5 \text{m} / \text{s} \]

4. How much torque is required to bring a disk from rest up to the speed of 10 radians/s in 2.0 s? The moment of inertia of the disk is 0.060 kg-m².

- a) 0.30 N-m
- b) 0.60 N-m
- c) 2.0 N-m
- d) 1.0 N-m
- e) none of these

\[ \omega = \omega_0 + \alpha t \Rightarrow \alpha = \frac{\omega}{t} = 5 \text{rad} / \text{s}^2 \]

\[ \tau = I \alpha = 0.060 \times 5 = 0.30 \text{N} \cdot \text{m} \]
5. A block of mass 5.0 kg slides without friction around a loop-the-loop. If the block is released from rest from a height of 3.5 m, what is its speed at the top of the loop-the-loop which is 2 m high?

   a. 5.4 m/s   \[ KE_i + PE_i = KE_f + PE_f \]
   b. 29 m/s   \[ \frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f \]
   c. 8.3 m/s   \[ 0 + gh_i = \frac{1}{2}v_f^2 + gh_f \]
   d. 73 m/s
   e. 6.3 m/s   \[ v_f = \sqrt{2g(h_i - h_f)} = 5.4 \text{ m/s} \]

6. A 9.0-kg box of oranges slides from rest down a frictionless incline from a height of 5.0 m (see figure). A constant frictional force, introduced at point A, brings the block to rest at point B, 19 m to the right of point A. What is the coefficient of kinetic friction, \( \mu_k \), of the surface from A to B?

   a. 0.11  \[ W_{fr} = W_{gr} = \Delta KE + \Delta PE \]
   b. 0.33
   c. 0.52  \[ W_{fr} = \left( \frac{1}{2}mv_f^2 + mgh_f \right) - \left( \frac{1}{2}mv_i^2 + mgh_i \right) \]
   d. 0.26
   e. 0.47  \[ f_d \cos(180) = -mgh \]
   \[ f_d = \mu_k F_N = \mu_k mg \]
   \[ \Rightarrow \mu_k mgd(-1) = -mgh \Rightarrow \mu_k = \frac{h}{d} = 0.26 \]

7. A conical pendulum (see figure) is set in horizontal circular motion about the vertical axis with a constant speed of 6.05 m/s. The radius of the circle is 2.16 m. The angle that the string makes with the vertical axis is:

   \[ \sum F = ma \]
   \[ x : T \sin \theta = \frac{mv^2}{r} \]

   a. 48°
   b. 80°  \[ y : T \cos \theta - mg = 0 \Rightarrow T \cos \theta = mg \]
   c. 71°
   d. 75°
   e. 60°  \[ \tan \theta = \frac{v^2}{rg} \Rightarrow \theta = 60° \]

8. A man, with his arms at his sides, is spinning on a light frictionless turntable. When he extends his arms:

   a) his angular velocity remains the same
   b) his moment of inertia decreases
   c) his angular velocity increases
   d) his angular velocity decreases
   e) his rotational kinetic energy increases

Angular momentum is conserved

\[ I_1 \omega_1 = I_2 \omega_2 \]

When the man extends his arms, his moment of inertia (I) increases.
Therefore the angular velocity (\( \omega \)) decreases
9. A 200 N uniform scaffold is held up by a wire at each end. The scaffold is 18 m long. A 650 N box sits 3.0 m from the left end as shown. What is the tension in each wire?
   a. Left wire = 520 N; right wire = 130 N
   b. Left wire = 642 N; right wire = 208 N
   c. Left wire = 195 N; right wire = 975 N
   d. Left wire = 295 N; right wire = 1000 N
   e. Left wire = 395 N; right wire = 800 N

   \[ \sum \vec{F} = 0 \]
   \[ \vec{T}_L + \vec{T}_R + \vec{T}_w = 0 \]
   \[ +T_1 \times (18) - W_B \times (15) - W_s \times (9) = 0 \]
   \[ \Rightarrow T_1 = 642N \]
   \[ \sum \vec{F} = 0 \]
   \[ T_1 + T_2 - W_B - W_s = 0 \]
   \[ \Rightarrow T_2 = 208N \]

10. Which statement is correct?
   a) In an elastic collision, momentum is conserved but some heat may be produced.
   b) In an inelastic collision, the total energy is conserved but momentum is not.
   c) In an elastic collision momentum and mechanical energy are conserved.
   d) In an inelastic collision, momentum and mechanical energy are conserved.
   e) In an elastic collision, the total energy is conserved but momentum is not.

11. If a turntable slows from 10 rev/s to 2 rev/s in 20 seconds at constant acceleration, how many revolutions are done during this time?
   a) 120
   b) 150
   c) 60
   d) 100
   e) 80

   \[ \theta = \frac{1}{2} (\omega + \omega_0) t \]
   \[ \theta = 120 \text{rev} \]

12. A solid sphere \( (I = \frac{2}{5}mr^2) \), a solid disk \( (I = \frac{1}{2}mr^2) \) and a hoop \( (I = mr^2) \) are released simultaneously from the top of a frictionless inclined plane. Which answer is the best answer?
   a) The sphere arrives first
   b) All three arrive at the same time
   c) The hoop arrives first
   d) the disk arrives first
   e) The sphere arrives first but the disk is a close second

   The inclined plane is frictionless \( \Rightarrow \) All objects will slide and not roll
   All three arrive at the same time.
13. A mass $M$ is located at the origin and a second mass $m$ ($< M$) is located at $x = 2$. The center of mass of the two particle system is located

a) at $1 < x < 2$

b) at $0 < x < 1$  \[\text{The center of mass is closer to the bigger mass.}\]

c) along the negative x-axis

d) at $2 < x < 3$

e) at the origin

14. A 1 kg block slides along a horizontal frictionless surface at 2 m/s. It is brought to rest by compressing a long spring of spring constant 200 N/m. The maximum spring compression is:

a) 0.20 m  \[KE_i + PE_i = KE_f + PE_f\]

b) 0.01 m  \[\frac{1}{2}mv_i^2 + 0 = 0 + \frac{1}{2}kx^2\]

c) 0.03 m  \[\Rightarrow x = \sqrt{\frac{mv_i^2}{k}} = 0.14m\]

d) 0.05 m

e) 0.14 m

15. In simple harmonic motion

a) the amplitude is maximum when the velocity is maximum

b) the displacement is minimum when the acceleration is maximum

c) the velocity and the acceleration are always in the opposite direction

d) the acceleration is minimum when the displacement is minimum

e) the force is proportional to the square of the displacement