There are 20 equally-weighted questions on this test (two-part problems count as two separate questions). There is only one correct answer per question. Clearly circle your answer. The second to last page is blank for extra space if needed. The formulas are on the last page so you can separate it for easy access. The key will be posted online after all make-up tests are completed.

1. A 10 kg box is being pulled across a level surface by a 5.0 N horizontal force. A 3.0 N kinetic friction force opposes the motion. What is the acceleration of the box?

   a) 0.20 m/s²  b) 0.30 m/s²  c) 0.40 m/s²  d) 0.50 m/s²

   \[
   \begin{align*}
   m &= 10 \text{ kg} \\
   F_p &= 5.0 \text{ N} \\
   F_f &= -3.0 \text{ N} \\
   a &= \,? \\
   \Sigma F_x &= ma_x \\
   F_p - F_f &= ma_x \\
   5.0 \text{ N} - 3.0 \text{ N} &= 10 \text{ kg} \\
   a &= 0.2 \text{ m/s²}
   \end{align*}
   \]

2. Consider a block accelerating down a rough incline plane. Which one of the following statements is true?

   a) The kinetic friction force and the normal force add up to zero.
   b) The kinetic friction force > the component of the weight pointing down the incline.
   c) The kinetic friction force = the component of the weight pointing down the incline.
   d) The kinetic friction force < the component of the weight pointing down the incline.

   \[
   \begin{align*}
   \Sigma F_x &= ma_x \\
   mg \sin \theta - F_f &= ma_x \\
   \text{accelerating down plane} &\Rightarrow a_x > 0 \\
   mg \sin \theta - F_f &> 0 \\
   mg \sin \theta &> F_f
   \end{align*}
   \]
3. A box that weighs 300N is pulled across a level surface with a constant velocity. The rope makes an angle of 30.0 degrees above the horizontal and the tension in the rope is 100N. What is the normal force of the floor on the box?

\[ F_g = 300 \text{N} \quad \theta = 30.0^\circ \quad F_p = 100 \text{N} \quad n = ? \]

\[ \Sigma F_y = ma_y \]
\[ n + F_p \sin \theta - F_g = 0 \]
\[ n + 100 \text{N} \sin 30.0^\circ - 300 \text{N} = 0 \]
\[ n = 250 \text{N} \]

4. An object is on a frictionless inclined plane. The plane is inclined at an angle of 30° with the horizontal. What is the magnitude of the acceleration of the object?

\[ \theta = 30^\circ \quad a_x = ? \]

\[ \Sigma F_x = ma_x \]
\[ n \cdot g \sin \theta = ma_x \]
\[ (9.8 \text{ m/s}^2) \sin 30^\circ = a_x \]
\[ a_x = 4.9 \text{ m/s}^2 \]
5. A 4.00 kg block is at rest on a level floor. If a horizontal force of 12.0 N is applied to this block, it just starts to move. What answer is closest to the coefficient of static friction?

\[ F_f = \mu_s n \]
\[ m = 4.00 \text{ kg} \quad F_p = 12.0 \text{ N} \quad \mu_s = ? \]
\[ \Sigma F_x = m a_x \quad \Sigma F_y = m a_y \]
\[ F_p - F_f = 0 \quad n - mg = 0 \]
\[ F_p - \mu_s n = 0 \]
\[ 12.0 \text{ N} - \mu_s (39.2 \text{ N}) = 0 \]
\[ \mu_s = 0.31 \]

6. A car approaches a barrier at a speed of 30.0 m/s along a level road. The driver locks the brakes and begins skidding at a distance of 75 m from the barrier. What minimum coefficient of kinetic friction \( \mu_k \) is required to stop the car before it hits the barrier?

\[ V_i = 30.0 \text{ m/s} \quad \Delta x = 75 \text{ m} \quad V_f = 0 \quad \mu_k = ? \]
\[ F_f = \mu_k n \]
\[ \Sigma F_y = m a_y \quad \Sigma F_x = m a_x \]
\[ n - mg = 0 \]
\[ n = mg \]
\[ -F_f = ma_x \]
\[ -\mu_k n = ma_x \]
\[ -\mu_k mg = ma_x \]
\[ v^2 = v_0^2 + 2a_x \Delta x \]
\[ 0 = (30.0 \text{ m/s})^2 + 2a_x (75 \text{ m}) \]
\[ a_x = -60 \text{ m/s}^2 \]
\[ -\mu_k (9.8 \text{ m/s}^2) = (-60 \text{ m/s}^2) \]
\[ \mu_k = 0.61 \]
7. A block is at rest on a wooden ramp with an angle of 25°. What is the coefficient of static friction between the block and the ramp?

a) 0.40  b) 0.47  c) 0.53  d) 0.76  e) 0.87

\[ \Sigma F_x = m a_x \]
\[ \Sigma F_y = m a_y \]
\[ m g \sin \theta - F_f = 0 \]
\[ n - m g \cos \theta = 0 \]
\[ m g \sin \theta - \mu_s n = 0 \]
\[ n = m g \cos \theta \]
\[ m g \sin \theta - \mu_s m g \cos \theta = 0 \]
\[ \sin 25^\circ = \mu_s \cos 25^\circ \]
\[ \mu_s = 0.47 \]

8. When an object slides down an incline, the work done by the normal force

a) is greater than zero
b) is less than zero
\[ \text{W} = F_{net} \Delta x \text{ the normal force is perpendicular to the motion} \]
c) is zero
d) increases as the speed increases
e) decreases as the speed increases

9. A wooden block is pulled 12 m across a frictionless surface using a rope. The tension in the rope is 30 N; and the net work done on the block is 291 J. What angle does the rope make with the horizontal?

a) 72°  b) 54°  c) 36°  d) 27°  e) 15°

\[ \Delta x = 12 \text{ m} \]
\[ T = 30 \text{ N} \]
\[ W_{net} = 291 \text{ J} \]
\[ \theta = ? \]

\[ W_{net} = F_{net} \Delta x \]
\[ 291 \text{ J} = F_{net} \Delta x (12 \text{ m}) \]
\[ F_{net} = 24.25 \text{ N} \]

\[ F_{net} \Sigma F_x = T \cos \theta \]
\[ 24.25 \text{ N} = 30 \text{ N} \cos \theta \]
\[ 0.808 = \cos \theta \]
\[ \theta = \cos^{-1}(0.808) = 36^\circ \]
10. At the top of a 15 m hill (vertical height), an 1800 kg car has a speed of 15 m/s. If the car's speed at the bottom is 20 m/s, how much energy is lost to nonconservative forces (such as air resistance)?

\[
y_i = 15 \text{ m} \quad v_i = 15 \text{ m/s} \quad m = 1800 \text{ kg} \quad y_f = 0 \quad v_f = 20 \text{ m/s}
\]

Energy lost = \( PE_i + KE_i - (PE_f + KE_f) \)

\[
= mgy_i + \frac{1}{2}mv_i^2 - mg y_f - \frac{1}{2}mv_f^2
\]

\[
= (1800 \text{ kg})(9.8 \text{ m/s}^2)(15 \text{ m}) + \frac{1}{2}(1800 \text{ kg})(15 \text{ m/s})^2 - 0 - \frac{1}{2}(1800 \text{ kg})(20 \text{ m/s})^2
\]

\[
= 107100 \text{ J}
\]

11. An elevator supported by a single cable descends a shaft at a constant speed. The only forces acting on the elevator are the tension in the cable and the gravitational force. Which one of the following statements is true?

a) The magnitude of the work done by the tension force is larger than that done by the gravitational force.
b) The magnitude of the work done by the gravitational force is larger than that done by the tension force.
c) The net work done by the two forces is zero joules.
d) The work done by the tension force is zero joules.
e) The work done by the gravitational force is zero joules

\[
W_{\text{net}} = \Delta KE
\]

\[
\text{constant speed } \Rightarrow \Delta KE = 0
\]

12. Two objects have the same momentum but different masses. Which of the following statements about them is correct?

a) The one with less mass has more kinetic energy.
b) Both objects have the same kinetic energy.
c) The one with more mass has more kinetic energy.

\[
m_1v_1 = m_2v_2 \quad \Rightarrow \quad \text{if } m_1 < m_2 \quad \text{then} \quad v_1 > v_2
\]

\[
KE_1 = \frac{1}{2}m_1v_1^2 = \frac{1}{2}(m_1v_1)v_1 = \frac{1}{2}(m_2v_2)v_1
\]

\[
KE_2 = \frac{1}{2}m_2v_2^2 = \frac{1}{2}(m_2v_2)v_2
\]

Since \( v_1 > v_2 \) \( \Rightarrow \) \( KE_1 > KE_2 \)
13. A 15 kg object is moved from a height of 7 m above the floor to a height of 12 m above the floor. What is the increase in its gravitational potential energy?

\[ m = 15 \text{ kg} \quad y_i = 7 \text{ m} \quad y_f = 12 \text{ m} \quad \Delta GPE = ? \]

\[ \Delta GPE = mg y_f - mg y_i \]

\[ = (15 \text{ kg})(9.8 \text{ m/s}^2)(12 \text{ m}) - (15 \text{ kg})(9.8 \text{ m/s}^2)(7 \text{ m}) \]

\[ = 735 \text{ J} \]

14. A 0.16 kg hockey puck is initially at rest on the ice. When the puck is struck by a hockey stick, the average force exerted on the puck is 250 N. If the puck’s speed after being struck is 12 m/s, how long was the stick in contact with the puck?

\[ m = 0.16 \text{ kg} \quad v_i = 0 \quad F = 250 \text{ N} \quad v_f = 12 \text{ m/s} \quad \Delta t = ? \]

\[ I = \Delta p = F \Delta t \]

\[ mv_f - mv_i = F \Delta t \]

\[ (0.16 \text{ kg})(12 \text{ m/s}) - 0 = 250 \text{ N} \Delta t \]

\[ \Delta t = 0.008 \text{ s} \]
15. A ball is thrown by an Italian physicist from the top of the leaning tower of Pisa at a speed of 8 m/s, and falls to the ground in a parabolic motion, landing some distance from the base of the tower. Just before it reaches the ground, the ball’s speed is 34 m/s. Neglect air resistance and determine the height of the leaning tower of Pisa.

\[ V_i = 8 \text{ m/s} \quad V_f = 34 \text{ m/s} \quad y_f = 0 \quad y_i = \ ? \]

\[ PE_i + KE_i = PE_f + KE_f \]

\[ mg y_i + \frac{1}{2} \rho m v_i^2 = mg y_f + \frac{1}{2} \rho m v_f^2 \]

\[ (9.8 \text{ m/s}^2) y_i + \frac{1}{2} (8 \text{ m/s})^2 = (9.8 \text{ m/s}^2) (0) + \frac{1}{2} (34 \text{ m/s})^2 \]

\[ y_i = 56 \text{ m} \]

16. Consider a roller coaster car. It passes point 1 with a speed of 10.00 m/s and moves to point 2 (which is lower than point 1). The change in vertical position between point 1 and point 2 is 5.0 m. Ignoring air resistance and friction, the speed of the car when it reaches point 2 is closest to which answer?

\[ V_i = 10.00 \text{ m/s} \quad y_i = 5.0 \text{ m} \quad y_f = 0 \text{ m} \quad V_f = \ ? \]

\[ PE_i + KE_i = PE_f + KE_f \]

\[ mg y_i + \frac{1}{2} m v_i^2 = mg y_f + \frac{1}{2} m v_f^2 \]

\[ (9.8 \text{ m/s}^2) (5.0 \text{ m}) + \frac{1}{2} (10.00 \text{ m/s})^2 = 0 + \frac{1}{2} V_f^2 \]

\[ V_f = 14 \text{ m/s} \]
17. A basketball falling directly down impacts the ground at a speed of 6.0 m/s and rebounds directly up at a speed of 5.0 m/s. If the basketball has a mass of 0.60 kg and is in contact with the ground for 0.10 s what is the magnitude of the average net force exerted on the ball during this impact?

\[ V_i = -6.0 \, \text{m/s} \quad V_f = 5.0 \, \text{m/s} \quad m = 0.60 \, \text{kg} \quad \Delta t = 0.10 \, \text{s} \quad F = ? \]

\[ I = \Delta p = F \Delta t \]
\[ mV_f - mV_i = F \Delta t \]
\[ (0.60 \, \text{kg})(5.0 \, \text{m/s}) - (0.60 \, \text{kg})(-6.0 \, \text{m/s}) = F(0.10 \, \text{s}) \]
\[ F = 66 \, \text{N} \]

18. A 1200 kg car traveling East at 25.0 m/s crashes into a 9000 kg truck traveling West at 20.0 m/s. After the crash, the truck is moving West at 12.0 m/s and the car is moving

a) 12.0 m/s to the West.

b) 35 m/s to the East.

c) 35 m/s to the West.

d) 85 m/s to the East.

e) 215 m/s to the West.

**take East to be positive direction**
\[ m_1 = 1200 \, \text{kg} \quad V_{i1} = 25.0 \, \text{m/s} \quad m_2 = 9000 \, \text{kg} \quad V_{i2} = -20.0 \, \text{m/s} \]
\[ V_{f1} = ? \quad V_{f2} = -12.0 \, \text{m/s} \]

\[ m_1V_{i1} + m_2V_{i2} = m_1V_{f1} + m_2V_{f2} \]
\[ (1200 \, \text{kg})(25.0 \, \text{m/s}) + (9000 \, \text{kg})(-20.0 \, \text{m/s}) = (1200 \, \text{kg})V_{f1} + (9000 \, \text{kg})(-12.0 \, \text{m/s}) \]
\[ V_{f1} = -35 \, \text{m/s} \]
\[ \text{negative} \Rightarrow \text{West} \]
19. An open cart is rolling to the left at a constant speed on a horizontal surface. A package slides down a chute and lands in the cart. Which quantities have the same value just before and just after the package lands in the cart?

a) The horizontal component of total momentum
b) The vertical component of total momentum
c) Both a and b
d) None of the above

20. Two asteroids are drifting in space with trajectories shown. Assuming the collision at point between them is completely inelastic, at what angle from its original direction is the larger asteroid deflected?

a) 37° above the +x axis
b) 21° above the +x axis
c) 15° above the +x axis
d) 19° above the +x axis
e) 29° above the +x axis

\[ m_1 = 1.0 \times 10^5 \text{ kg} \quad v_{1ix} = 100 \text{ m/s} \cos 40° \quad v_{1iy} = 100 \text{ m/s} \sin 40° \]
\[ m_2 = 2.0 \times 10^5 \text{ kg} \quad v_{2ix} = 20 \text{ m/s} \quad v_{2iy} = 0 \]
\[ m_1 v_{1ix} + m_2 v_{2ix} = (m_1 + m_2) v_f\]
X-component: \((1.0 \times 10^5 \text{ kg})(100 \text{ m/s} \cos 40°) + (2.0 \times 10^5 \text{ kg})(20 \text{ m/s}) = (3.0 \times 10^5 \text{ kg}) v_{fx} \)
\[ v_{fx} = 38.868 \text{ m/s} \]
Y-component: \( (1.0 \times 10^5 \text{ kg})(100 \text{ m/s} \sin 40°) + 0 = (3.0 \times 10^5 \text{ kg}) v_{fy} \)
\[ v_{fy} = 21.432 \text{ m/s} \]
\[ \tan \Theta = \frac{v_{fy}}{v_{fx}} \Rightarrow \Theta = \tan^{-1} \left( \frac{v_{fy}}{v_{fx}} \right) = \tan^{-1} \left( \frac{21.432}{38.868} \right) = 28.9° \Rightarrow 29° \]