1. Three 0.300 kg billiard balls are placed on a table at the corners of a right triangle as shown in the figure. Calculate the magnitude of the gravitational force on the cue ball resulting from the other two balls.

\[ \vec{F}_{net} = Gm^2 \left( \frac{1}{r_1^2} \hat{i} + \frac{1}{r_2^2} \hat{j} \right) \]

\[ |\vec{F}_{net}| = \]

\( a) \ 7.65 \times 10^{-11} N \)

\( b) \ 10.42 \times 10^{-11} N \)

\( c) \ 6.67 \times 10^{-11} N \)

\( d) \ 3.75 \times 10^{-11} N \)

\( e) \) It does not feel any gravitational force due to the other two balls.

\( r_2 = 0.400 m \)

\( r_1 = 0.300 m \)

2. The International Space Station (ISS) operates at an average altitude of \( h \approx 249 \) mi above the Earth’s surface. If an astronaut weighs 588.6 N at the surface of the Earth, what is her weight at the ISS?

\[ m_a \sin r = a) \ 522 N \]

\( b) \ 0.00 N \)

\( c) \ 588.6 N \)

\( d) \ 135 N \)

\( e) \ 236 N \)

\[ m_{astronaut} = 60 \ kg \]

\[ g_{ISS} = \frac{GM_e}{(r_e + h)^2} = 8.7 \ m/s^2 \]

3. A grinding wheel 0.500 m in diameter rotates at a rate of \( 8.00 \times 10^2 \) revolutions per minute. Find the magnitude of the acceleration of a speck of metal caught in the outer edge of the wheel.

\( a) \ 3510 \ m/s^2 \)

\( b) \ 20.9 \ m/s^2 \)

\( c) \ 8.00 \times 10^2 \ m/s^2 \)

\( d) \ 1580 \ m/s^2 \)

\( e) \ 1750 \ m/s^2 \)

\[ a = \frac{v^2}{r}, \quad v = \frac{8.00 \cdot 2 \cdot \pi \cdot r}{60} \]
4. If \( F = 5.0 \text{ N} \), what is the magnitude of the contact force that block 2 (right) exerts on block 1 (left) in the figure below? Assume there is no friction.

- a) 17 N
- b) 13 N
- c) 21 N
- d) 23 N
- e) 5.0 N

\[
\text{Net} = 25 \text{N} - F = 20 \text{N} \quad \Rightarrow \quad a = \frac{20 \text{N}}{5 \text{ kg}} = 4 \text{ m/s}^2
\]

\[
\begin{array}{c}
25 \text{ N} \\
\overbrace{\begin{array}{c}
2.0 \text{ kg} \\
3.0 \text{ kg}
\end{array}}^{F}
\end{array}
\]

\[
F_{\text{net}} = 3 \text{ kg} \cdot 4 \text{ m/s}^2 = 12 \text{ N} = F_{\text{12}} - F
\]
\[
\Rightarrow \quad F_{\text{12}} = 17 \text{ N}
\]

5. A block of mass 3 kg is pulled up a frictionless 30° incline by an applied force of 25 N in the direction parallel to the incline. What is the magnitude of the resulting acceleration of the block?

- a) 4.6 m/s²
- b) 2.3 m/s²
- c) 4.9 m/s²
- d) 2.9 m/s²
- e) 3.4 m/s²

\[
\begin{align*}
25 - m g \sin \theta &= m a \\
\Rightarrow \quad a &= \frac{25 - m g \sin \theta}{m}
\end{align*}
\]

6. The potential energy stored in a certain spring that is compressed 0.02 m from its equilibrium position is 50 J. What is the potential energy if the spring is compressed an additional 0.01 m?

- a) 75 J
- b) 40 J
- c) 50 J
- d) 100 J
- e) 112 J

\[
\begin{align*}
\frac{1}{2} k (0.02)^2 &= 50 \\
\Rightarrow \quad U_f &= 50 \left( \frac{0.02}{0.01} \right)^2
\end{align*}
\]

7. A pendulum is made by letting a 2.0 kg object swing at the end of a string of length 1.5 m. The maximum angle that the string makes with the vertical as the pendulum swings is 30°. What is the speed of the object as it goes through the lowest point on its trajectory?

- a) 2.0 m/s
- b) 2.2 m/s
- c) 2.5 m/s
- d) 2.7 m/s
- e) 3.1 m/s

\[
h = (1.5 - 1.5 \cos 30°) \text{ m}
\]

\[
m g h = \frac{1}{2} m v^2
\]

\[
v = \sqrt{2 g h}
\]
8. The blocks shown below are released from rest with the spring in its unstretched equilibrium position. The pulley and the horizontal surface are frictionless. If the spring constant is 400 N/m and \( M = 4.5 \text{ kg} \), what is the maximum amount that the spring will be stretched?

\[
\frac{1}{2}kx^2 = Mgx
\]

\[
x = \frac{2Mg}{k}
\]

a) 11 cm  
b) 66 cm  
c) 22 cm  
d) 33 cm  
e) 55 cm

9. A pendulum bob that weighs 1 N is held at an angle \( \theta \) from the vertical by a 2 N horizontal force \( F \) as shown. The tension in the string supporting the pendulum bob is:

\[
\cos \theta N
\]

\[
\frac{2}{\cos \theta} N
\]

\[
\sqrt{5} N
\]

\[
1 \text{ N}
\]

\[
2 \text{ N}
\]

\[
T = \sqrt{5} N
\]

a) \( \cos \theta \) N  
b) \( \frac{2}{\cos \theta} \) N  
c) \( \sqrt{5} \) N  
d) 1 N  
e) 2 N

10. Identical guns fire identical bullets horizontally at the same speed from the same height above level planes, one on the earth and one on the moon. Which of the following three statements is/are true?

- I. The horizontal distance traveled by the bullet is greater for the moon.
- II. The flight time is less for the bullet on the earth.
- III. The velocity of the bullets at impact are the same.

a) III only  
b) I and II only  
c) I and III only  
d) II and III only  
e) I, II, III
11. How much work is done by a person lifting a 2.0-kg object from the bottom of a well at a constant speed of 2.0 m/s for 5.0 s?
   a) 0.15 kJ  (b) 0.20 kJ  c) 0.25 kJ  d) 0.30 kJ  e) 0.35 kJ

12. A baseball outfielder throws a baseball of mass 0.15 kg at a speed of 40 m/s and initial angle of 30° above horizontal. What is the kinetic energy of the baseball at the highest point of the trajectory?
   a) 6.0 J  b) 240 J  c) 90 J  d) 5.25 J  e) 120 J

\[ V_{x} = 20 \text{ m/s}, \quad V_{y0} = 0, \quad mgh = \frac{mV_{x}^{2}}{2} \]

\[ 120 T = K_{T0} + mgh \]

13. A block of mass \( m \) is hung from a vertical spring of spring constant \( k \), which is hung in turn from another identical spring. In equilibrium, the amount by which each spring stretches is \( x \). The total elastic potential energy of the system in this situation is:
   a) \( \frac{1}{2} mgx \)  (b) \( mgx \)  c) \( 2mgx \)  d) \( \frac{1}{2} \frac{m^{2}g^{2}}{k} \)  e) \( \frac{2m^{2}g^{2}}{k} \)

\[ K_{el} = K_{el} \]

14. A mass of 3 kg is placed on an 8 kg mass which lies on a horizontal, frictionless table, as shown. What is the maximum acceleration, that can be achieved due to force \( F \) applied horizontally to the 3 kg mass so that the whole system accelerates without the 3 kg mass sliding on the 8 kg mass? The coefficient of static friction between them is 0.5.
   a) 1.3 m/s²  b) 1.5 m/s²  c) 1.8 m/s²  d) 1.1 m/s²  e) 0.9 m/s²

\[ a = \frac{m_{1}m_{2}g}{m_{1} + m_{2}} \]

\[ m_{1} > m_{2} \]

\[ F \]

\[ \text{3.0 kg} \]

\[ \text{8.0 kg} \]
15. A cougar accelerates from rest up to 27 m/s in 3.0 s. Assuming constant acceleration, how far does it travel during this 3.0 s?

\[
\begin{align*}
\text{a) } 40.5 \text{ m} & \quad \alpha = \frac{2 \cdot 27 \text{ m/s}^2}{3 \text{ s}} = 9 \text{ m/s}^2 \\
\text{b) } 81 \text{ m} & \quad x(3 \text{ s}) = \frac{1}{2} \left( 9 \text{ m/s}^2 \right) (3 \text{ s})^2 \\
\text{c) } 27 \text{ m} & \\
\text{d) } 9.0 \text{ m} & \\
\text{e) } 20.25 \text{ m} &
\end{align*}
\]

16. The horizontal surface on which the objects slide is frictionless. If \( M = 2.0 \) kg, the tension in string 1 is 12 N. Determine \( F \).

\[
\begin{align*}
\text{a) } 25 \text{ N} & \quad L = 3Mq = q = \frac{y}{L} \\
\text{b) } 20 \text{ N} & \\
\text{c) } 12 \text{ N} & \\
\text{d) } 35 \text{ N} & \\
\text{e) } 24 \text{ N} & \quad \begin{array}{c}
\text{2N} \\
\text{2M} \\
\text{1} \\
\text{2M} \\
\end{array}
\end{align*}
\]

17. In the figure, if the tension in string 1 is 23 N, what is the mass of the object shown?

\[
\begin{align*}
\text{a) } 3.8 \text{ kg} & \\
\text{b) } 3.4 \text{ kg} & \\
\text{c) } 3.0 \text{ kg} & \quad T_1 \cos 30^\circ + T_2 \cos 50^\circ = M g \\
\text{d) } 4.2 \text{ kg} & \quad T_1 \sin 30^\circ - T_2 \sin 50^\circ = 0 \\
\text{e) } 5.0 \text{ kg} & \quad \begin{array}{c}
\text{1} \\
\text{30}^\circ \\
\text{50}^\circ \\
\text{2} \\
\end{array}
\end{align*}
\]

\[
M = \frac{1}{9} \left( \frac{\cos 30^\circ \cos 50^\circ}{\sin 30^\circ} + \frac{\sin 30^\circ}{\cos 50^\circ} \right)
\]

18. A particle moving along the x axis has a position given by \( x = Bt - Ct^3 \), where \( B = 24 \) m/s, \( C = 2.0 \) m/s³. What is the magnitude of the acceleration of the particle at the instant when its velocity is zero?

\[
\begin{align*}
\text{a) } 24 \text{ m/s}^2 & \\
\text{b) } \text{zero} & \quad \chi(t) = 24 t - 2 t^3 \\
\text{c) } 12 \text{ m/s}^2 & \quad v(t) = 24 t - 6 t^2 = 0 \quad t = \sqrt{\frac{24}{6}} = 2 \text{ s} \\
\text{d) } 48 \text{ m/s}^2 & \quad v(t) = 24 \quad a(t) = -12 t \\
\text{e) } 36 \text{ m/s}^2 & \quad \left| a(t) \right| = 24 \text{ m/s}^2
\end{align*}
\]
19. An astronaut lands on an earthlike planet and drops a small lead ball with a mass of 76.5 g from the top of her spaceship. The point of release is 18 m above the surface of the planet and the ball takes 2.5 s to reach the ground. The astronaut's mass is 68.5 kg. Her weight on the planet is
\[ \Delta y = \frac{1}{2} g_p \Delta t^2 \Rightarrow g_p = \frac{2 \Delta y}{\Delta t^2} \]
\[ W = 68.5 \cdot g_p \]
\[ a) \ 69.0 \text{ N} \]
\[ b) \ 395 \text{ N} \]
\[ c) \ 670 \text{ N} \]
\[ d) \ 990 \text{ N} \]
\[ e) \ 1.02 \text{ kN} \]

20. A 3.0-kg and a 2.0-kg cart approach each other on a horizontal air track in such a way that their center of mass has a speed of 4.0 m/s. They collide and stick together. After the collision their total kinetic energy is:
\[ U_{cm_i} = U_{cm_f} \]
\[ K = \frac{1}{2} (3 + 2) (4)^2 \]
\[ a) \ 16 \text{ J} \]
\[ b) \ 2.0 \text{ J} \]
\[ c) \ 24 \text{ J} \]
\[ d) \ 40 \text{ J} \]
\[ e) \ \text{can't tell from the given data} \]

21. A 1000.0 kg car approaches an intersection traveling north at 20.0 m/s. A 1200.0 kg approaches the same intersection traveling east at 22.0 m/s. The two cars collide at the intersection and lock together. Ignoring any external forces that act on the cars during the collision, what is the velocity of the cars immediately after the collision?
\[ v_{cm} = \frac{1000 \cdot 20 + 1200 \cdot 22}{2200} \]
\[ a) \ 29.7 \text{ m/s, 47.7° east of north} \]
\[ b) \ 21.1 \text{ m/s, 47.7° west of south} \]
\[ c) \ 15.1 \text{ m/s, 52.8° east of north} \]
\[ d) \ 21.1 \text{ m/s, 52.8° east of north} \]
\[ e) \ 21.1 \text{ m/s, 47.7° east of north} \]

22. An electric car with mass 800 kg has a motor which can deliver 15 kW of power. What is the maximum angle of incline of a hill that the car can climb while maintaining a constant speed of 80 km/h, ignoring air resistance and internal friction of the motor and drive train?
\[ a) \ 5° \]
\[ b) \ 10° \]
\[ c) \ 15° \]
\[ d) \ 20° \]
\[ e) \ 25° \]
\[ P_{max} = mg \cdot v \sin \theta \]
\[ \theta = \arcsin \left( \frac{15 \text{ kW}}{800 \text{ kg} \cdot 2.2 \text{ m/s}} \right) \]
23. A 1.2-kg ball falling vertically hits the floor with a speed of 2.5 m/s and rebounds with a speed of 1.5 m/s. What is the magnitude of the impulse exerted on the ball by the floor?

a) 9.6 Ns  
(b) 4.8 Ns  
c) 6.4 Ns  
d) 1.6 Ns  
e) 1.2 Ns

\[ \Delta \vec{p} = m \Delta \vec{v} \quad |\Delta \vec{v}| = 4 \text{ m/s} \]

24. A 20-g bullet is fired into a 2.0-kg block of wood placed on a horizontal surface. The bullet stops in the block. The impact moves the block (+ bullet) a distance of 5.0 m before it comes to rest. If the coefficient of kinetic friction between the block and surface is 0.25, calculate the speed of the block (+ bullet) system immediately after impact.

a) 20 m/s  
b) 3.5 m/s  
c) 25 m/s  
d) 5.0 m/s  
e) 2.2 m/s

\[ \mathcal{E}_i + \mathcal{W}_f = \mathcal{E}_f, \quad \frac{1}{2} M v^2 - \mu M g \Delta x = 0 \]

\[ v = \sqrt{\frac{2 \mu M g \Delta x}{M}} \]

25. How many significant figures in 0.00023?

a) 2  
b) 3  
c) 4  
d) 5  
e) 6

26. A small car locks with a large truck in a head-on collision. Which statement is true concerning the magnitude of the average collision force?

a) The truck experiences the greater average force.  
b) The small car experiences the greater average force.  
c) The small car and the truck experience the same average force.  
d) The actual masses of the vehicles are needed to determine this.  
e) The velocities of the vehicles are needed to make a determination.
27. An elastic collision of two objects is characterized by the following.

- I. Total momentum of the system is conserved.
- II. Total energy of the system remains constant.
- III. Total kinetic energy of the system remains constant.

a) I  
b) II  
c) III  
d) Only I and II are true.  
e) I, II, and III are all true.

28. Which of the graphs illustrates Hooke’s Law? \( F = -kx \)

a) graph a  
b) graph b  
c) graph c  
d) graph d  
e) none of these

29. A stunt woman jumps off the roof of a tall building, but is not hurt because she lands on a large, air-filled bag. Which one of the following best describes why she is not injured?

a) The bag provides the necessary force to stop her.  
b) The bag increases the amount of time during which the momentum is changing and reduces the average force on her.  
c) The bag reduces the impulse on her.  
d) The bag increases the amount of time the force acts on her and reduces the change in momentum.  
e) The bag decreases the amount of time during which the momentum occurs and reduces the average force on her.
30. A packing crate slides down an incline ramp at constant velocity. Thus we can deduce that
   (a) a frictional force is acting on it.
   (b) a net downward force is acting on it.
   (c) a net upward force is acting on it.
   (d) it is not acted on by appreciable normal force.
   (e) it is not acted on by appreciable gravitational force.