1. A Blackhawk helicopter is winching up an injured soldier from a danger zone. The soldier and his kit have a mass of 150 kg and are pulled up 51 m in the air at a steady rate. If it takes 30 s to pull the soldier up, at what rate is the winch engine doing work?

(a) 2.5 kW  
(b) 2.1 kW  
(c) 2.7 kW  
(d) 1.0 kW  
(e) 1.63 kW

\[ P = F \cdot \Delta \, \text{m} = mg \cdot \Delta \, \text{m} = 150 \cdot 9.81 \cdot \frac{51}{30} \, \text{W} \]

2. An airplane travels 95 m/s as it makes a horizontal circular turn which has a 1.2-km radius. What is the magnitude of the net force on the 81-kg pilot of this airplane?

(a) 0.61 kN  
(b) 0.69 kN  
(c) 0.63 kN  
(d) 0.66 kN  
(e) 0.57 kN

\[ F = m \frac{v^2}{R} = 81 \frac{9.81^2}{1200} \, \text{N} \]

3. What is the angle between the vectors \(3\hat{i} + 2\hat{j}\) and \(\hat{i} + \hat{j} + \hat{k}\)?

(a) 30°  
(b) 53°  
(c) 60°  
(d) 37°  
(e) 45°

\[ \cos \theta = \frac{5}{\sqrt{3^2 + 2^2}} \]

4. A particle moves at constant speed in a circular path. The instantaneous velocity and instantaneous acceleration vectors are:

(a) opposite to each other  
(b) both tangent to the circular path  
(c) both perpendicular to the circular path  
(d) none of the above  
(e) perpendicular to each other

5. A truck has a box of mass \(m\) sitting on its horizontal bed. The coefficient of friction between the bed and the box is \(\mu_s = 0.2\). The maximum speed the truck can go around an unbanked curve of radius \(R\) without the box sliding is \(v\). If the speed is doubled and the mass of the box is doubled, what is the tightest curve the truck can round?

(a) \(2R\)  
(b) \(\frac{R}{2}\)  
(c) \(8R\)  
(d) \(4R\)  
(e) \(\frac{R}{4}\)

\[ \mu_s mg = m \frac{v^2}{R} \]

\[ 2\mu_s g = \frac{v^2}{R} \]

6. A 1000-kg elevator is rising and its speed is increasing at 3 m/s². Assume \(g = 10\text{m/s}^2\). The tension in the elevator cable is:

(a) 1000 N  
(b) 3000 N  
(c) 13,000 N  
(d) 10,000 N  
(e) 7000 N

\[ T = m \frac{v^2}{2} + mg \]

7. A 2.0 kg block moves down a plane that makes an angle of 20° with the horizontal with an initial kinetic energy of 2.0 J. If the coefficient of kinetic friction between the block and the plane is 0.40, how far will the block slide along the plane before coming to rest?

(a) 3.0 m  
(b) 1.3 m  
(c) 0.30 m  
(d) 1.0 m  
(e) 1.8 m

\[ \Delta E_{\text{kin}} = 0 - \frac{m v^2}{2} = W \]

\[ W = m g \sin \theta \cdot L - \mu_k m g \cos \theta \cdot \frac{L}{2} \]

\[ L = \frac{m v^2}{2 \mu_k (\mu_k \cos \theta - \sin \theta)} \]

\[ f = \mu_k m g \cos \theta \]
8. A 2.0-kg mass is projected from the edge of the top of a 20-m tall building with a velocity of 24 m/s at some unknown angle above the horizontal. Disregard air resistance and assume the ground is level. What is the kinetic energy of the mass just before it strikes the ground?

\[ \frac{1}{2} m v^2 + m g h = E_{k_{\text{fin}}}, \]

a) 400 J  
b) 180 J  
\[ \boxed{970 J} \]  
c) 890 J  
d) 260 J

9. Block A, with a mass of 10 kg, is placed on a 30° incline. The coefficient of kinetic friction is 0.20. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 8.0 kg, is attached to the dangling end of the string. The acceleration of A is:

a) 2.6 m/s², down the plane  
b) 0.69 m/s², up the plane  
c) 0.69 m/s², down the plane  
d) 2.6 m/s², up the plane  
e) 0

\[ f = \mu_{k} m g \cos \theta \]

11. A 1.5 kg object moving along the x-axis has a velocity of 4.0 m/s at the point \( x = 0 \). If the only force acting on the object is that shown in the figure, what is the kinetic energy of the object at the point \( x = 6 \) m?

\[ \Delta E_{k_{\text{fin}}} = E_{k_{\text{ini}}} - \frac{1}{2} m v^2 \]

a) 92 J  
b) 24 J  
c) 10 J  
d) 12 J  
e) 160 J

\[ W = \text{area} = 12 J \]

\[ E_{k_{\text{fin}}} = 12 J \]

\[ E_{k_{\text{ini}}} = \frac{1}{2} \cdot 1.5 \cdot u^2 + 12 = 24 J \]

12. A 6.0-kg block slides along a horizontal surface. If \( \mu_k = 0.20 \) for the block and surface, at what rate is the friction force doing work on the block at an instant when its speed is 4.0 m/s?

\[ \begin{array}{l}
\text{a)} -47 W \\
\text{b)} +71 W \\
\text{c)} -71 W \\
\text{d)} -59 W \\
\text{e)} -82 W \\
\end{array} \]

\[ P = F v = \mu_k m g v = 0.2 \cdot 6 \cdot 4 \]

Two blocks are connected by a string and pulley as shown. Assume \( g = 10 \text{m/s}^2 \). Assuming that the string and pulley are massless, the acceleration of each block has a magnitude of:

\[ a = \frac{m_2 - m_1}{m_1 + m_2} \]

a) 0.1 m/s²  
b) 2.0 m/s²  
c) 5.0 m/s²  
d) 1.0 m/s²  
e) 10.0 m/s²
13. An iceboat is traveling clockwise in a horizontal circle on the ice. Exactly at the most Northern part of the circle, the sail and the steering mechanism fall off the boat. Assume friction is absent, and neglect the mass of the sail and steering mechanism. Which statement is correct?

a) The boat will move straight East on a line tangent to the circle at the Northernmost point because there is a force on it perpendicular to the boat directed to the outside of the circle.

b) The boat will continue traveling in the circle because there is no friction.

c) The boat will continue to travel in the circle because its velocity exerts a force on it.

d) The boat will move straight East on a line tangent to the circle at the Northernmost point because there is no horizontal force on it.

e) The boat will move straight North on a line directly away from the center of the circle since a force directed to the outside of the circle always acts on the boat.

14. In a contest, two different tractors pull two identical blocks of stone the same distance over identical surfaces. However, block A is moving twice as fast as block B when it crosses the finish line. Which statement is correct?

a) Block A has twice as much kinetic energy as block B.

b) No energy is lost to friction because the ground has no displacement.

c) Both blocks have had equal losses of energy to friction.

d) Block B has lost four times as much kinetic energy to friction as block A.

e) Block B has lost twice as much kinetic energy to friction as block A.

\[ W = \int \vec{F} \cdot d\vec{L} \quad \text{equal} \]

15. A traffic light that weighs 40 N is suspended by two wires as shown. What is the tension in the cable AC?

\[ 36.9^\circ \quad \text{B} \quad 53.1^\circ \quad \text{AC} \quad \text{T}_1 \quad \text{T}_2 \quad \text{A} \quad \text{C} \]

\[ T_1 = T_2 \cos 36.9^\circ + T_1 \cos 53.1^\circ \]

\[ T_1 (\cos 53.1^\circ + \cos 36.9^\circ) = W \]

\[ T_1 \left( \frac{s_i}{s_1} \right) = W \]

\[ T_1 \left( \frac{s_i}{s_1} \right) = W \]

a) 32 N

b) 24 N
c) 40 N
d) 37 N
e) 56 N

16. Two identical carts, A and B, are initially at rest on parallel frictionless tracks. (They are NOT connected to each other.) Equal constant forces are used to accelerate them. The force is applied to cart A twice as long as it is applied to cart B. The work the force does on A is \( W_A \); that on B is \( W_B \). Which statement is correct?

a) \( W_A = 2W_B \)

b) \( W_B = 2W_A \)

c) \( W_A = W_B \)

d) \( W_A = 4W_B \)

e) \( W_A = \sqrt{2}W_B \)

17. If \( F = 8.0 \text{ N} \) and \( M = 1.0 \text{ kg} \), what is the tension in the connecting string? The pulley and all surfaces are frictionless.

\[ a) 3.5 \text{ N} \]

\[ b) 4.8 \text{ N} \]

c) 4.1 N
d) 3.1 N
e) 3.8 N

\[ \text{All: } F - Mg \sin \theta = 3Ma \quad \Rightarrow \quad a = \frac{F}{3M} - \frac{g}{3} \sin \theta \]

\[ \text{Left: } 2Ma = F - T \]

\[ T = F - 2Ma = \frac{1}{2}(F + 2Mg \sin \theta) \]