Answer on Question 67136, Physics, Mechanics, Relativity

Question:

1) A child pulls a loaded wagon with a total mass of $100\ kg$ by applying a force of $120\ N$ at an angle of 30° above the horizontal. If the coefficient of static friction is 0.25, determine the net force and acceleration of the wagon.

2) A $50.0\ kg$ skier coasts along the surface of a snowy hill (assume no friction) tilted at an angle of 25°. Find the normal force acting on her, the force pulling her down the hill, and the acceleration. If there was a coefficient of kinetic friction of 0.18, what would her acceleration be?

Solution:

1) Let's apply the Newton's Second Law of Motion:

$$F_{net} = ma,$$

$$F_{net} = F_{appl}cos30^{\circ} - F_{fr} = ma.$$

Let's find the friction force:

$$\sum F_y = ma_y = 0,$$

$$N + F_{appl}sin30^{\circ} - mg = 0,$$

$$N = mg - F_{appl}sin30^{\circ},$$

$$F_{fr} = \mu_s N = \mu_s\left(mg - F_{appl}sin30^{\circ}\right).$$

Then, we can find the net force acting on the wagon:

$$F_{net} = F_{appl}cos30^{\circ} - F_{fr} = F_{appl}cos30^{\circ} - \mu_s\left(mg - F_{appl}sin30^{\circ}\right) =$$
$$= 120\ N \cdot cos30^{\circ} - 0.25 \cdot \left(100\ kg \cdot 9.8\ \frac{m}{s^2} - 120\ N \cdot sin30^{\circ}\right) =$$
$$= -126\ N.$$

The sign minus indicates that the net force is directed in the opposite direction to the motion of the wagon.

Finally, we can find the acceleration of the wagon:

$$F_{net} = ma,$$

$$a = \frac{F_{net}}{m} = \frac{-126\ N}{100\ kg} = -1.26\ \frac{m}{s^2}.$$

2)

a) Let's apply the Newton's Second Law of Motion and project the forces on x and y axis:

$$\sum F_x = ma_x,$$

$$F_{pull} = ma,$$

$$F_{pull} = mgsin\theta = ma.$$

$$\sum F_y = ma_y = 0,$$

$$N - mgcos\theta = 0,$$

$$N = mgcos\theta.$$

Then, we can find the normal force acting on the skier:

$$N = mgcos\theta = 50.0\ kg \cdot 9.8\ \frac{m}{s^2} \cdot cos25^\circ = 444\ N.$$

The force pulling the skier down the hill:

$$F_{pull} = mgsin\theta = 50.0\ kg \cdot 9.8\ \frac{m}{s^2} \cdot sin25^\circ = 207\ N.$$

Finally, we can find the acceleration:

$$a = gsin\theta = 9.8\ \frac{m}{s^2} \cdot sin25^\circ = 4.14\ \frac{m}{s^2}.$$

b) If there is a friction force, applying the Newton's Second Law of Motion, we get:

$$\sum F_x = ma_x,$$

$$mgsin\theta - F_{fr} = ma,$$

$$mgsin\theta - \mu_k N = ma,$$

$$mgsin\theta - \mu_k mgcos\theta = ma,$$

$$a = g(sin\theta - \mu_k cos\theta) = 9.8\ \frac{m}{s^2} \cdot (sin25^\circ - 0.18 \cdot cos25^\circ) = 2.54\ \frac{m}{s^2}.$$

Answer:

1) $F_{net} = -126\ N$, $a = -1.26\ \frac{m}{s^2}$.

2) a) $N = 444\ N$, $F_{pull} = 207\ N$, $a = 4.14\ \frac{m}{s^2}$.

b) $a = 2.54\ \frac{m}{s^2}$.