Force practice

Name _____

Show all work. Keep the units. Take g = 9.8 m/s^2. Right is positive.

A 15 kg crate is already sliding to the right at 0.80 m/s across a level floor. A rope pulls the crate and stays at one angle the whole time. Along the rope, every 4 m of horizontal run comes with 3 m of rise. The tension is 60 N. The coefficient of kinetic friction between the crate and the floor is 0.30. The rope pulls for 1.8 s. Then it goes slack, and the crate slides until it stops.

A. While the rope is pulling, draw a free body diagram of the forces on the crate. For each force, name the type of force, the object the force is on, and the object that exerts it.

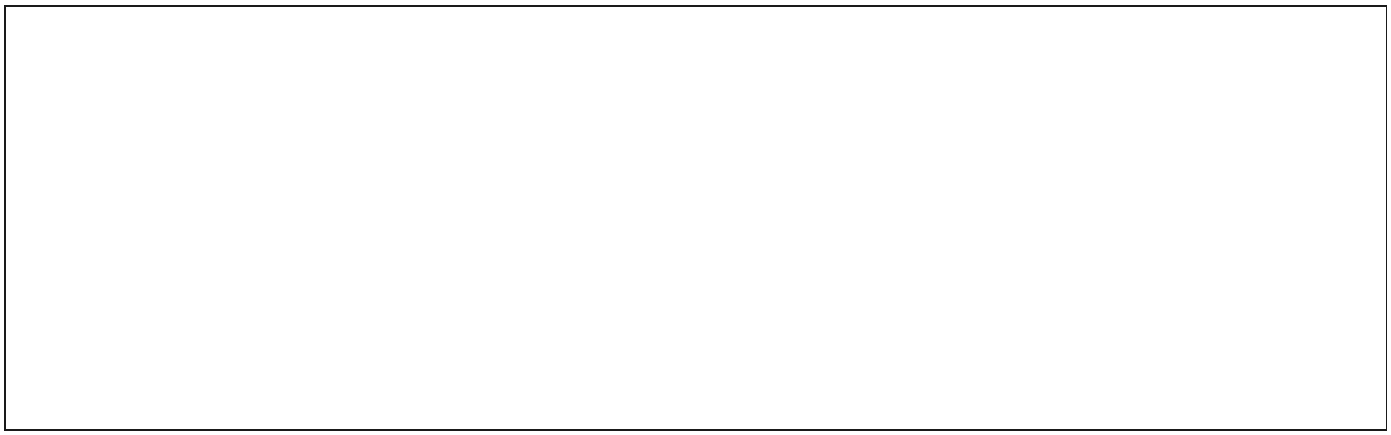
B. While the rope is pulling, is the normal force greater than the crate's weight, less than the weight, or equal to the weight? Say why.

C. Find the magnitude of the kinetic friction force while the rope is pulling.

D. Find the acceleration of the crate while the rope is pulling. Give the magnitude and the direction. Say whether the crate is speeding up or slowing down, and why.

E. Find the velocity of the crate at the instant the rope goes slack.

F. After the rope goes slack, draw a free body diagram of the forces on the crate. Use the same three labels on each force.



G. Find the distance the crate slides after the rope goes slack, before it stops.

H. Find the total distance the crate travels from the start of this description until it stops.

Answers

The rope is a 3-4-5. Horizontal part of the tension is (4/5)(60 N) = 48 N right. Vertical part is (3/5)(60 N) = 36 N up.

A. On the crate, while the rope pulls. Gravity, by Earth, 147 N down. Normal, by the floor, 111 N up. Kinetic friction, by the floor, 33.3 N left. Tension, by the rope, 60 N up along the rope.

B. Less than the weight. The rope pulls up, so the floor does not have to hold the whole weight. Normal = 147 N − 36 N = 111 N.

C. 33.3 N. Friction is 0.30 times the normal force, and the normal force is 111 N, not the weight.

D. 0.980 m/s^2 to the right. Net force is 48 N − 33.3 N = 14.7 N right, and 14.7 N / 15 kg = 0.980 m/s^2. The crate speeds up. The net force points the same way as the velocity.

E. 2.56 m/s to the right. 0.80 m/s + (0.980 m/s^2)(1.8 s) = 2.564 m/s. Keep 2.564 m/s into the next part, then round.

F. On the crate, after the rope goes slack. Gravity, by Earth, 147 N down. Normal, by the floor, 147 N up. Kinetic friction, by the floor, 44.1 N left. No tension.

G. 1.12 m. Normal is the full weight now, so friction is 0.30 × 147 N = 44.1 N left. Acceleration is 44.1 N / 15 kg = 2.94 m/s^2 to the left. Stopping distance is $(2.564\ m/s)^2$ / (2 × 2.94 m/s^2) = 1.12 m.

H. 4.15 m. While the rope pulls, the crate moves $0.80(1.8) + \frac{1}{2}(0.980)(1.8)^2$ = 3.03 m. Add the 1.12 m after the rope goes slack.