Dynamics Problems with Non-collinear Forces (no friction) – Answer Key

1. A mule pulls a frictionless 500.0 kg cart with a constant force of 460 N, exerted at an angle of 30° above horizontal.
   a) Draw the free-body diagram of the cart, with all forces labeled and calculated.
   b) What is the acceleration of the cart?

   \[ \sum F = ma \]

   \[ a = \frac{F_{Ax}}{m} = \frac{398 N}{500 kg} = 0.80 \frac{m}{s^2} \]

2. Bif and Hap both want the 12.0 kg file cabinet. Bif pulls to the left with a force of 200 N. Hap exerts a force of 200 N to the right, at an angle of 30° above horizontal.
   a) Draw the free-body diagram of the cabinet, with all forces labeled and calculated.
   b) What is the speed and direction of the cabinet 2.0 s after they both start pulling?

3. A worker pushes a 110 kg box, initially at rest, across a frictionless floor. She exerts a 400 N force on the box, at an angle of 45° below horizontal. How long does it take for the box to slide 5.0 meters?

4. A 1.0 kg cart, initially at rest, slides down a frictionless 30.0° ramp which is 5.0 m long. How fast is the cart going at the bottom of the ramp?
5. A 2.0 kg ball is returning up a 45° ramp at the bowling alley. The ramp is 1.3 m long.
   a) Draw the free-body diagram of the ball, with all forces labeled and calculated.
   b) What was the initial velocity of the ball if it came to a complete stop at the top?

\[
\sum F = ma \\
a = \frac{-13.9 N}{2 \text{kg}} = -6.9 \text{ m/s}^2 \\
V_f = V_i^2 + 2a(X_f - X_i) \\
V_i = 4.2 \frac{m}{s}
\]

6. A 0.50 kg frictionless puck is shot up a ramp at time \( t = 0 \) seconds. It travels 6.0 m up
   along the ramp, then slides back down to the starting point. The entire event lasts 3.6 s.
   a) From kinematics, determine the acceleration of the puck.
   b) Draw the free-body diagram of the puck, with all forces labeled and calculated.
   c) What was the ramp angle?

\[
X_f = X_i + V_i t + \frac{1}{2} a t^2 \\
a = \frac{2X_f}{t^2} = \frac{2(-6.0 \text{m})}{(1.8 \text{s})^2} = -3.7 \text{ m/s}^2
\]

\[
a = \frac{-F_{gx}}{m} \quad F_{gx} = 0.50 \text{kg}(-3.7 \text{ m/s}^2) = -1.85 \text{N}
\]

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\]

\[
F_{gx} = F_g \sin \theta \quad \theta = \sin^{-1}\left(\frac{-1.85 \text{N}}{4.9 \text{N}}\right) = 22^\circ
\]

7. A frictionless chute is set at a 15° angle. A 9.0 kg trunk is accelerated down the chute by
   a force of \( F_A = 20.0 \text{N} \) applied to the trunk handle, and acting parallel to the ramp
   surface. The trunk slides down the chute in 1.0 second. How long is the chute?

\[
a = \frac{42.8 \text{N}}{9 \text{kg}} = 4.75 \text{ m/s}^2
\]

\[
X_f = X_i + V_i t + \frac{1}{2} a t^2 \\
X_f = 2.4 \text{m}
\]