Physics 1403 - Exam II Solutions, Summer 2014

1. Conceptual Questions

a) Newton's 1st Law: One object at a time. An object in uniform motion (at constant velocity in a straight line) or an object at rest will remain in that state unless it is acted on by an unbalanced force.

b) Newton's 3rd Law: Two objects at a time. When two objects are interacting, object A exerts a force $F_A$ on object B, then object B exerts an equal and opposite force $F_B$ on object A.

c) The ball will land on the car. As far as the person in the car is concerned, the ball is in free fall since it is moving horizontally at the same constant velocity $V_{ox}$ as the car. So the ball will come back to the thrower. A person standing on the ground watching it will see a projectile in a parabolic path.

\[ \begin{align*}
  V_{oy} & = V_{ox} \\
  0 & = V_{ox}
\end{align*} \]
d) Hockey puck on frictionless ice.

\[ v = \text{Constant} \]

Free body diagram is Figure b).

Because \( v = \text{Constant} \), there can be no unbalanced forces horizontally as there is in Figures a) + c).

Figures a) & c) would imply that \( F = ma \), which would contradict the statement that \( v = \text{Constant} \).

2nd & 1st laws require Figure b).

\[ \Sigma F_y = 0 \]

Newton's 2nd Law in vertical direction gives \( \Sigma F_y = 0 \)

2nd Law! Not 3rd Law! There is only one mass! Both forces act on it.

4th Static Equilibrium is a condition where no mass is moving. This requires that each mass have (Newton's 3rd Law):

\[ \Sigma F_x = 0, \Sigma F_y = 0 \]

Sum of forces = 0
\[ F \rightarrow a \]

\[ \mu_k = 0.16, \ m = 38 \text{ kg}, \ \theta = 30^\circ, \ F = 48 \text{ N} \]

1) Free Body Diagram

Friction
\[ F_r \]
\[ F_n \]
\[ mg \]

2) Right 15 + x

\[ F_x = F \cos \theta = 48 \cos(30^\circ) = 41.58 \text{ N} \]

\[ F_y = -F \sin \theta = -48 \sin(30^\circ) = -24 \text{ N} \]

3) \[ mg = (38)(9.8) = 372.4 \text{ N} \]

Friction force \( F_n \) from Newton's 2nd Law in vertical direction.

\[ \sum F_y = 0 \]
\[ F_n - F \sin \theta - mg = 0 \]
\[ F_n = mg + F \sin \theta \]
\[ F_n = 372.4 + 24 \]
\[ F_n = 396.4 \text{ N} \]

4) Friction force

\[ F_r = \mu_k F_n = (0.16)(396.4) \]
\[ F_r = 63.4 \text{ N} \]

5) Newton's 2nd Law in \( x \) direction

\[ \sum F_x = ma \]
\[ F_x - F_r = ma \]
\[ a = \frac{41.58 - 63.4}{38} = -0.57 \text{ m/s}^2 \]
4) Freebody diagrams.

m_1:
- F_T - F_N = m_1a
- F_T = m_1a

m_2:
- \sum F_x = m_2a
- \sum F_y = m_2g - F_T = m_2a

5) Put 1 into 2:

m_2g - m_1a = m_2a

a = \frac{m_2g}{m_1 + m_2}

a = \frac{(24)(9.8)}{16 + 24} = 5.88 \text{ m/s}^2

F_T = m_1a

= \left[ \frac{16}{17.6} \right] (5.88)
= 94.0 \text{ N}

For m_2:

v = v_0 + at = 0 + (5.88)(3) = 17.6 \text{ m/s}

y = v_0t + \frac{1}{2}at^2

= \frac{1}{2}(5.88)(3)^2 = 26.5 \text{ m}

3) No friction.

m_1 = 16 \text{ kg}

m_2 = 24 \text{ kg}