Physics 211 / Spring 2009 **Name: Answer Key**
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Review Worksheet 1

(1) A baseball-player friend of yours wants to determine his pitching speed. You have him stand on a ledge and throw the ball horizontally from an elevation $4.0\,m$ above the ground. The ball lands $25\,m$ away. (a) At what speed was the ball pitched? (b) What is the magnitude and direction of the ball's velocity the instant before it strikes the ground?

The time to fall is,

$$y_f = y_i + v_{yi}\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$
$$0 = 4.0 + 0 - 4.9(\Delta t)^2$$
$$\Delta t = 0.904\,s$$

The displacement is,

$$x_f = x_i + v_{xi}\Delta t$$
$$x_f = v_{xi}\Delta t$$
$$25\,m = v_{xi}(0.904\,s)$$

(a) $v_{xi} = 27.65\,m/s = \boxed{28\,m/s}$

The *y*-component of the velocity is,

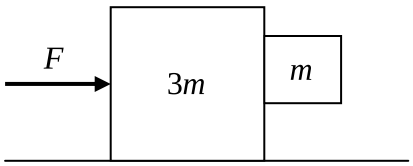
$$v_{yf} = v_{yi} + a_y(\Delta t)$$
$$v_{yf} = 0 - 9.8(0.904)$$
$$v_{yf} = -8.86\,m/s$$

$$v = \sqrt{v_{xf}^2 + v_{yf}^2} = \sqrt{28^2 + (-8.86)^2} = 29\,m/s$$

$$\theta = \tan^{-1}\left(\frac{-8.86}{27.65}\right) = -17.8^\circ$$

(b) $\vec{v}_f = \boxed{29\,m/s\ @ -18^\circ}$

(2) You push a pair of masses as shown ($m = 2.0\ kg$). The coefficient of static friction between the two masses is 0.89. Consider the floor to be frictionless. (a) What minimum value must F have so the small mass does not slide down the face of the large mass? (b) What force acts on the small mass?



For the small mass to stay put, the weight must be balanced by static friction,

$$mg = \mu_s n \qquad [1]$$

The acceleration of the system is given by the 2nd law,

$$F = (4m)a \quad \Rightarrow \quad a = \frac{F}{4m}$$

Applying the 2nd law to the large mass only, we can determine the normal force,

$$F - n = (3m)a$$
$$n = F - 3\cancel{m}\left(\frac{F}{4\cancel{m}}\right)$$
$$n = 0.25F$$

Plugging this back into [1] we have,

$$mg = \mu_s(0.25F)$$

(a) $F = \dfrac{mg}{0.25\mu_s} = \dfrac{4(2.0\ kg)(9.8\ m/s^2)}{0.89} = \boxed{88\ N}$

(b) $n = 0.25F = \boxed{22\ N}$

(3) Held in place, a $2.0\ kg$ mass compresses a spring of constant $k = 1250\ N/m$, a distance of $8.0\ cm$. When released, the mass travels across $20\ cm$ of level, rough surface with $\mu_K = 0.35$ and then up a frictionless incline of angle $\theta = 30^\circ$. Use the Work-Energy relation to determine how far up the incline the mass goes before stopping.

$$E_i = \tfrac{1}{2}(1250\ N/m)(0.08\ m)^2 = 4.0\ J$$
$$E_f = (2.0\ kg)(9.8\ m/s^2)(\Delta x)\sin(30^\circ) = 9.8(\Delta x)\ J$$
$$W_{nc} = -(0.35)(2.0\ kg)(9.8\ m/s^2)(0.2\ m) = -1.372\ J$$

$$W_{nc} = \Delta E$$
$$-1.372\ J = 9.8(\Delta x) - 4.0\ J$$
$$2.628\ J = 9.8(\Delta x)$$
$$\Delta x = \boxed{0.268\ m}$$

(4) A 1000 kg – car traveling east at 15 m/s collides with a 2000 kg – car traveling north at 20 m/s. The two cars lock up, moving together after the collision. (a) What is the velocity (magnitude and direction) just after the collision? (b) What fraction of the initial kinetic energy was lost during the collision? (c) How much work is done by friction in bringing the cars to rest *after* the collision?

The initial momentum of the system is: $\vec{p}_i = (1.5\times10^4\ kg\cdot m/s, 4.0\times10^4\ kg\cdot m/s)$

The final momentum is: $\vec{p}_f = [(3000\ kg)v_{xf}, (3000\ kg)v_{yf}]$

Momentum conservation requires,

$$(3000\ kg)v_{xf} = 1.5\times10^4\ kg\cdot m/s \qquad (3000\ kg)v_{yf} = 4.0\times10^4\ kg\cdot m/s$$

$$v_{xf} = 5.0\ m/s \qquad v_{yf} = 13.3\ m/s$$

$$v = \sqrt{v_{xf}^2 + v_{yf}^2} = \sqrt{(5.0\ m/s) + (13.3\ m/s)^2} = 14.2\ m/s$$

$$\theta = \tan^{-1}\left(\frac{13.3}{5.0}\right) = 69.4^\circ$$

(a) Thus: $\vec{v}_f = \boxed{14\ m/s\ @\ 69^\circ\ N\ of\ E}$

$$K_i = \tfrac{1}{2}(1000\ kg)(15\ m/s)^2 + \tfrac{1}{2}(2000\ kg)(20\ m/s)^2 = 5.13\times10^5\ J$$

$$K_f = \tfrac{1}{2}(3000\ kg)(14\ m/s)^2 = 3.02\times10^5\ J$$

(b) $\frac{\Delta K}{K_i} = \boxed{-0.41}$

$$W_{nc} = \Delta K + \Delta U = -3.02\times10^5\ J + 0$$

(c) $W_f = \boxed{-3.02\times10^5\ J}$