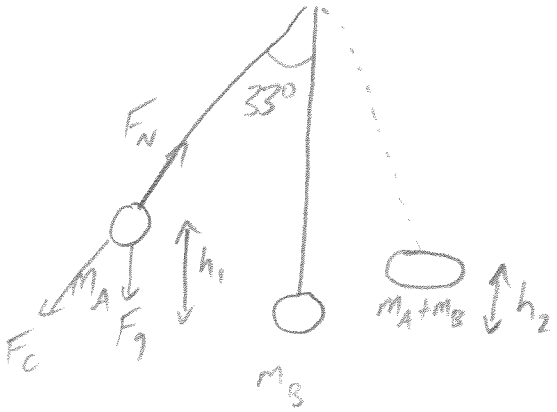
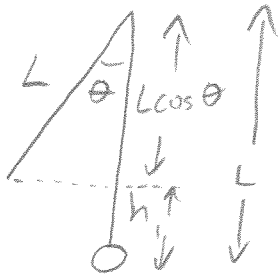
Physics 10154 - Exam #3b

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (35 pts) A 250 gram pendulum bob (mass A) is initially at rest, attached to a 1.5 meter string making a 33° angle with respect to the vertical. At the lowest point of its motion, mass A collides with 380 gram mass B, initially at rest. The two masses stick together after the collision and rise to what maximum height above the lowest point of the motion?



$$h_1 = L - L\cos\theta$$
$$= 1.5 - 1.5\cos 33^\circ$$
$$= 0.24\,m$$



Part 1: m_A falls from h_1 to lowest point

$W_N = 0$

$W_c = 0$

$W_g = mgh_1$

$$0 + 0 + mgh_1 = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 \quad (v_0 \to 0)$$
$$v = \sqrt{2gh_1} = 2.18\,m/s$$

Part 2: Collision $\quad m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

$v_{2i} = 0, \quad v_{1f} = v_{2f} = v_f$

$$m_1v_{1i} + 0 = (m_1 + m_2)v_f$$
$$(.250)(2.18) = (0.630)v_f \Rightarrow v_f = 0.864$$

Part 3: $m_A + m_B$ rise to max height h_2

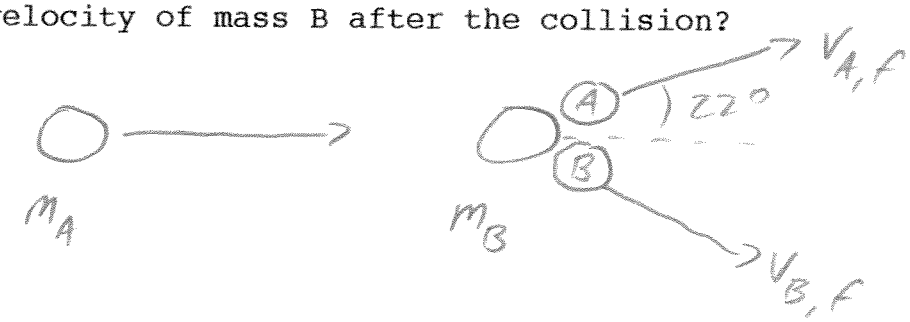
$W_N = 0$

$W_c = 0$

$W_g = -mgh_2$

$$0 + 0 - mgh_2 = \frac{1}{2}mv^2 \;(v \to 0) - \frac{1}{2}mv_0^2$$
$$h_2 = \frac{v_0^2}{2g} = \frac{(.864)^2}{2(9.8)} = .038\,m$$

2. (30 pts) Mass A is 2.5 times more massive than mass B. Mass A slides across a frictionless surface with a speed of 6.5 meters/sec in the +x direction, then strikes mass B, which is initially at rest. After the collision, mass A moves away at a speed of 4.5 meters/sec at an angle of 22° with respect to to the +x axis. What is the magnitude and direction of the velocity of mass B after the collision?



$$x: m_1 v_{1i,x} + m_2 v_{2i,x} = m_1 v_{1f,x} + m_2 v_{2f,x}$$

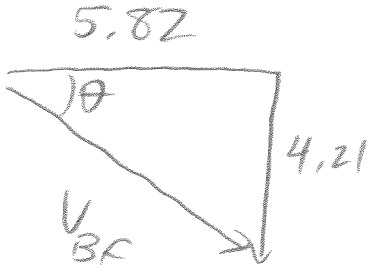
$$(2.5m)(6.5) + 0 = (2.5m)(4.5\cos 22°) + m\, v_{Bf,x}$$

$$16.25 = 10.43 + v_{Bf,x} \qquad v_{Bf,x} = 5.82\ m/s$$

$$y: m_1 v_{1i,y} + m_2 v_{2i,y} = m_1 v_{1f,y} + m_2 v_{2f,y}$$

$$0 + 0 = (2.5m)(4.5\sin 22°) + m\, v_{Bf,y}$$

$$0 = 4.21 + v_{Bf,y} \qquad v_{Bf,y} = -4.21\ m/s$$



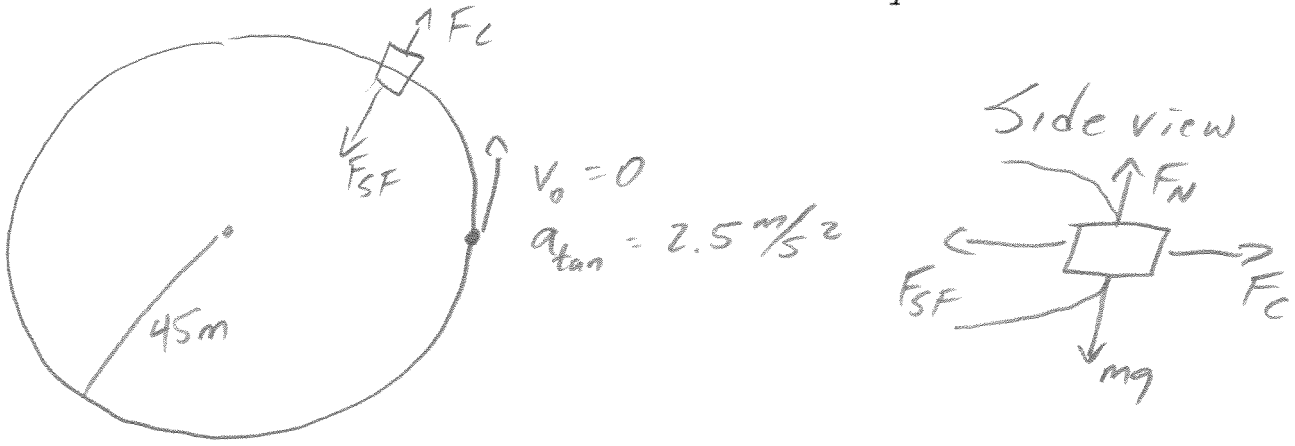
$$V_{Bf} = \sqrt{5.82^2 + 4.21^2}$$

$$= 7.19\ m/s$$

$$\theta = \tan^{-1}\left(\frac{4.21}{5.82}\right) = 35.9°$$

$V_{Bf} = 7.2\ m/s$, 36° below +x

3. (35 pts) A car on a circular track of radius 45 meters starts from rest and accelerates tangentially at a rate of 2.5 m/s^2. The coefficient of static friction between the car tires and the track is 0.75. For how many seconds does the car move until it skids off the track radially?



When car on verge of leaving track...

$$\Sigma F_{rad} = F_C - F_{SF,MAX} = 0$$

In this problem $F_N = mg$

$$\frac{mv^2}{r} - \mu_s F_N = 0$$

$$\frac{mv^2}{r} - \mu_s mg = 0$$

$$\frac{v^2}{r} = \mu_s g$$

$$v = \sqrt{\mu_s g r} = 18.19\ m/s$$

$\Delta s = ?$

$v_0 = 0$

$v = 18.19\ m/s$

$a = 2.5\ m/s^2$

$t =$

$v = v_0 + at$

$18.19 = 0 + 2.5t$

$t = 7.3\ s$