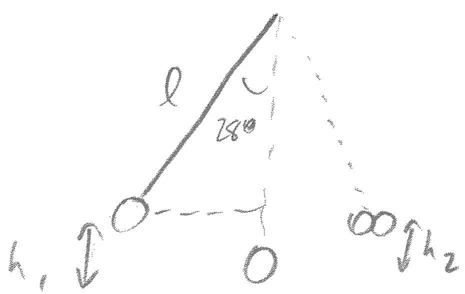
# Physics 10154 - Exam #3a

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) Mass A is initially at rest, connected to a 2.5 meter long string initially at an angle of 28° with respect to the vertical. Mass A is released, and at the bottom of its motion, it collides with and sticks to mass B, initially at rest. Mass A is three times more massive than mass B. After the collision, to what maximum height do the combined masses rise?




$h_1 = l - l\cos 28° = 0.2926\text{ m}$

Part 1

$\Sigma W_F = W_{grav} = \Delta K$

$+mgh_1 = \frac{1}{2}mv^2 - 0$

$v = \sqrt{2gh_1} = 2.395\text{ m/s}$

Part 2

$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$

$3m(2.395) + \sout{3m(0)} = 4m v_f$

$v_f = \frac{3(2.395)}{4} = 1.796\text{ m/s}$

Part 3

$W_{grav} = \Delta K$

$-mgh_2 = 0 - \frac{1}{2}mv_0^2$

$h_2 = \frac{v_0^2}{2g} = 0.1646\text{ m}$

$= \boxed{0.16\text{ m}}$

$.1646 = 2.5(1 - \cos\theta)$

$.0658 = 1 - \cos\theta$

$\cos\theta = 0.934$

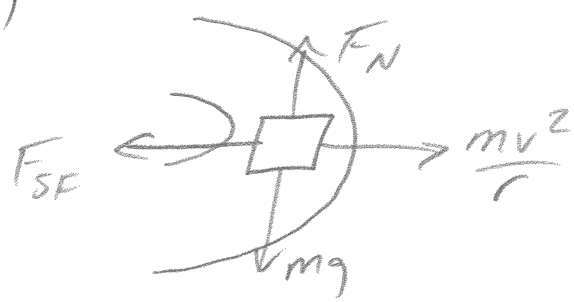
$\boxed{\theta = 21°}$

2. (30 pts) A car is moving at a constant speed around a curve on a flat road with radius of curvature 58 meters. The top speed the car can go without slipping is 38 miles/hour.

a) What is the coefficient of static friction that prevents the car from slipping radially as it moves around the curve?

b) If the road is icy and the coefficient of static friction is reduced to 0.13, what will be the car's speed around the same curve, in miles per hour?

a) Side view




$$\Sigma F_{rad} = \frac{mv^2}{r} - F_{SF} = 0$$

"top speed" $\Rightarrow F_{SF} = F_{SF,MAX}$

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

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

$v = 38 \frac{mi}{hr}$

$= 16.98\ m/s$

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

$$\mu_s = \frac{v^2}{rg} = \boxed{0.51}$$

b) $v^2 = \mu_s g r$

$$v = \sqrt{(.13)(9.8)(58)} = 8.60\ m/s$$

or $\boxed{19\ mi/hr}$

3. (35 pts) A projectile is launched vertically from Earth's surface and given some initial velocity. After launch, the only force acting on the projectile is gravity. The projectile reaches a maximum altitude of 1500 miles above Earth's surface. What was the initial launch velocity?

1500 miles $= 2.41 \times 10^6 m$

$r_f = R_E + h = 6.38 \times 10^6 + 2.41 \times 10^6$

$= 8.79 \times 10^6$

Only gravity does work, so energy conserved

$U_i + K_i = U_f + K_f$

$U_i = -\frac{G M_E m}{R_E} = -(6.25 \times 10^7) m$

on surface of Earth

$K_i = \frac{1}{2} m v_0^2$

$U_f = -\frac{G M_E m}{r_f} = -(4.54 \times 10^7) m$

$K_f = 0$ (at max height)

$-(6.25 \times 10^7) \cancel{m} + \frac{1}{2} \cancel{m} v_0^2 = -(4.54 \times 10^7) \cancel{m}$

$\frac{1}{2} v_0^2 = 1.71 \times 10^7$

$\Rightarrow v_0 = 5850 \, m/s$