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. <u>Clearly indicate your answer with a circle or box</u> and remember to include correct <u>units</u> and <u>significant figures</u>.

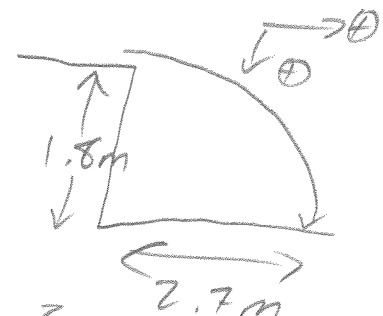
1. (35 pts) A 55 gram mass A slides across a horizontal, frictionless table to have a collision with 1.2 kg mass B, initially at rest at the edge of the table. After the collision, mass A bounces back with a speed of 15 m/s, and mass B flies horizontally off the 1.8 meter high table, landing 2.7 meters away horizontally from the base of the table. What was the initial velocity of mass A?

Part 1: Collision

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

$(.055) v_{1i} + 0 = (.055)(-15) + (1.2) v_{2f}$

Part 2: Ballistic motion



x	y
$\Delta x = 2.7$	$\Delta y = 1.8$
$v_{0x} = ?$	$v_{0y} = 0$ (horizontal)
$v_x = ?$	$v_y = ?$
$a_x = 0$	$a_y = 9.8$
$t = ?$	$t = ?$

$\Delta y = v_{0y} t + \frac{1}{2} a_y t^2$

$1.8 = \frac{1}{2}(9.8) t^2 \Rightarrow t = 0.606$

$\Delta x = v_0 t + \frac{1}{2} a_x t^2$

$2.7 = v_0 (.606) \Rightarrow v_0 = 4.45 \text{ m/s}$

Use as v_{2f} for part 1

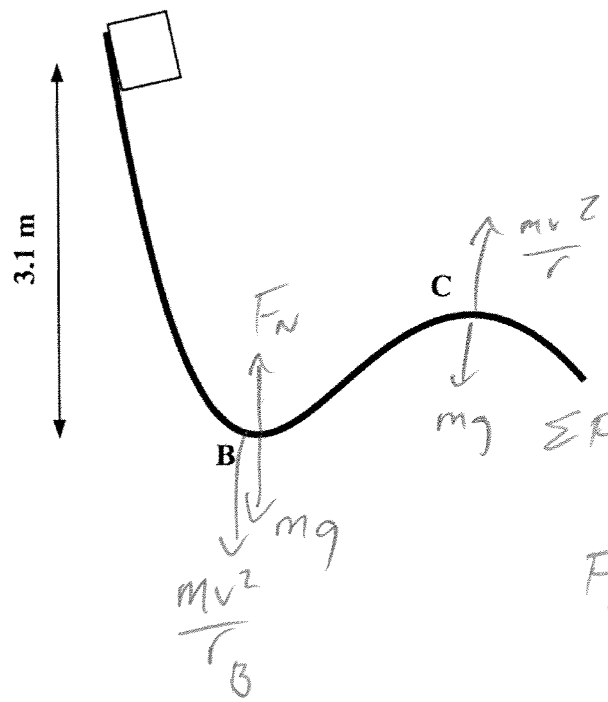
$(.055) v_{1i} = (.055)(-15) + (1.2)(4.45)$

$v_{1i} = \frac{4.52}{.055} = 82 \text{ m/s}$

2. (35 pts) A 560 gram mass starts from rest and slides down a frictionless ramp as shown below.

a) At point B, the lowest point of the curve, 3.1 meters below the starting point, the radius of curvature of the ramp is ~~38 cm~~ 1.5 m. What is the normal force exerted by the ramp on the sliding mass?

b) Point C is at the top of the right-hand side of the ramp, where the ramp has a radius of curvature of ~~68 cm~~ 2.2 m. What is the maximum possible speed for the sliding mass here for which it will still remain on the ramp and not fly off?



a) $\Sigma W_F = W_{grav} = \frac{1}{2}mv^2 - 0$

$mgh = \frac{1}{2}mv^2$

$v_B = \sqrt{2gh} = 7.795\ m/s$

$\Sigma F_{rad} = +mg + \frac{mv^2}{r_B} - F_N = 0$

$F_N = mg + \frac{mv_B^2}{r_B}$

$= (.560)(9.8) + (.560)(40.5)$

$= \boxed{28\ N}$

b) Max speed means $F_N = 0$

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

$\frac{v^2}{r} = g \Rightarrow v = \sqrt{rg} = 4.6\ m/s$

3. (30 pts) A satellite in geosynchronous orbit will appear to hover over a particular spot on Earth. This happens if the period of the satellite is 23 hours and 56 minutes.

a) How far away is the satellite from the center of the Earth?
b) What is the orbital velocity of the satellite?

a) $T = 23h\ 56m = 86160\,s$

$$T^2 = \left(\frac{4\pi^2}{GM}\right) r^3$$

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$$= \frac{(6.67\times10^{-11})(5.98\times10^{24})(86160)^2}{4\pi^2}$$

$$= \frac{2.96\times10^{24}}{4\pi^2} = 7.50\times10^{22}$$

$$r = 4.22\times10^{7}\,m = 6.6\,R_E$$

b) $$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{(6.67\times10^{-11})(5.98\times10^{24})}{4.22\times10^{7}}}$$

$$= \sqrt{9.45\times10^{6}}$$

$$= 3100\ m/s$$