# Physics 10154 - Summer 2013 - Exam #3B

**Instructions:** Be sure to SHOW ALL WORK and clearly indicate your answers. I will not give full credit if I cannot logically follow how you got your answer, even if the answer is correct. Partial credit will be given provided you are solving parts of the problem correctly. Clearly indicate your final answer, including correct units and significant figures.

1. (35 pts) A 22-gram bullet ~~with a mass of 12 grams~~ strikes a 360 gram block, initially at rest on the edge of a 1.4 meter high table. After the collision, the bullet is embedded in the block, and the combined mass slides horizontally off the table, landing 2.3 meters away from the base of the table as measured along the ground horizontally. Find $v_i$ of bullet.

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

$0.022\, v_{1i} + 0 = 0.382\, v_f$

Ballistic-Motion:

| x | y |
|---|---|
| $\Delta x = 2.3$ | $\Delta y = 1.4$ |
| $v_{0x} = ?$ | $v_{0y} = 0$ |
| $v_x = ?$ | $v_y = ?$ |
| $a_x = 0$ | $a_y = 9.8$ |
| $t = ?$ | $t = ?$ |

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

$1.4 = 0 + 4.9 t^2$

$t = 0.535\ s$

$x: \Delta x = v_{0x} t$

$2.3 = v_{0x} (.535)$

$v_{0x} = 4.3\ m/s$

Use as $v_f$ for part 1

$v_{1i} = \frac{0.382}{0.022} v_f = 75\ m/s$

**2.** (30 pts) A 3.5 kg ball initially at rest is dropped from a height of 2.1 meters. The ball is in contact with the floor for 0.050 seconds. It rebounds to a maximum height of 1.7 meters. What is the magnitude and direction of the average force exerted by the floor on the ball during the bounce?

Falling

$\Delta y = -2.1$

$v_{oy} = 0$

$v_y = ?$

$a_y = -9.8$

$t = ?$

$v_y^2 = v_{oy}^2 + 2a_y\Delta y$

$v_y^2 = 2(-9.8)(-2.1)$

$v_y = -6.416 \text{ m/s}$

Rising

$\Delta y = 1.7 \text{ m}$

$v_{oy} = ?$

$v_y = 0$

$a_y = 9.8 \text{ m/s}^2$

$t = ?$

$v_y^2 = v_{oy}^2 + 2a_y\Delta y$

$0 = v_{oy}^2 + 2(9.8)(1.7)$

$v_{oy} = 5.772 \text{ m/s}$

$\bar{F} = \frac{\Delta p}{\Delta t} = \frac{mv - mv_0}{\Delta t}$ $v = v_{oy}$ for rising motion

$v_0 = v_y$ for falling motion

$= \frac{(3.5)(5.772-(-6.416))}{.050}$

$= 850 \text{ N}$

**3.** (35 pts) A remote-controlled toy car on a horizontal, circular track of radius 1.3 meters starts from rest and accelerates uniformly at a rate of 5.6 $m/s^2$.

**a)** When the car's tangential acceleration is equal to its centripetal acceleration in magnitude, how many laps (or revolutions) has the car completed?

**b)** If the coefficient of static friction between the car and the surface is 0.91, how many seconds elapse from the beginning of the car's motion until it slides radially off the track?

**c)** What is the car's angular speed the instant before it slides off the track?

a) $\frac{v^2}{r} = 5.6\ m/s^2$

$v = \sqrt{(1.3)(5.6)} = 2.70\ m/s$

$v^2 = v_0^2 + 2a\Delta s$

$2.70^2 = 0 + 2(5.6)\Delta s$

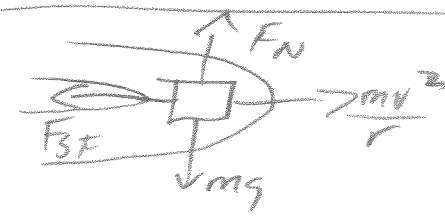
$\Delta s = 0.65\ m$

$\Delta\theta = \frac{\Delta s}{r}$

$= 0.500\ rad$

$= 0.080\ rev$

b)




$F_N = mg$ $\quad F_{SF} = \mu_s F_N = \mu_s mg$

limiting case

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

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

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

$v = \sqrt{\mu_s g r} = 3.4\ m/s$

$v = v_0 + at$

$3.4 = 0 + 5.6t$ $\quad t = 0.61\ s$

$v = 3.4\ m/s$ $\quad \omega = \frac{v}{r} = 2.6\ rad/s$