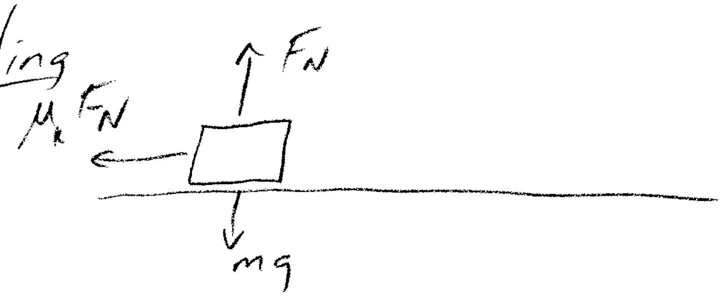
Physics 10154 - Exam #3b

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. (30 pts) A 2.5 gram steel bullet bounces elastically off of a 125 gram steel block initially at rest. After the collision, the steel block slides a distance of 65 cm over a rough horizontal surface with a coefficient of kinetic friction of 0.77. What was the velocity of the bullet prior to the collision?

Sliding



$$\Sigma W_F = W_{kF} = 0 - \frac{1}{2} m v_0^2$$

$$-\mu_k m g \Delta s = -\frac{1}{2} m v_0^2$$

$$v_0 = \sqrt{2\mu_k g \Delta s} = 3.13 \text{ m/s}$$

Use as v_{2f} for collision

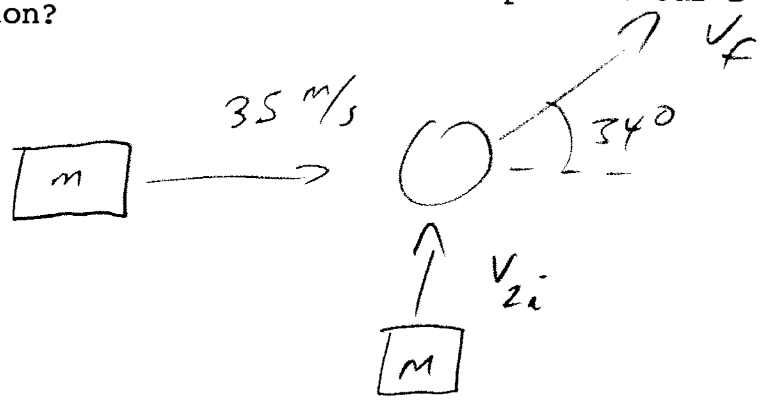
Collision

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

$$3.13 = \frac{2(2.5)}{127.5} v_{1i}$$

$$\boxed{v_{1i} = 80 \text{ m/s}}$$

2. (30 pts) Car A is travelling East with a speed of 35 m/s, and car B is travelling North with an unknown speed. After the collision, the two cars stick together and move as one at an angle 34° North of East. What was the speed of car B prior to the collision?



$$y: \; mV_{1i,y} + mV_{2i,y} = 2mV_f \sin 34°$$

$$0 + V_{2i} = 2V_f \sin 34°$$

$$x: \; mV_{1i,x} + mV_{2i,x} = 2mV_f \cos 34°$$

$$m(35) + 0 = 2mV_f \cos 34°$$

$$35 = 2V_f \cos 34°$$

$$V_f = 21.1 \text{ m/s}$$

$$V_{2i} = 2(21.1)\sin 34°$$

$$= 23.6 \text{ or } \boxed{24 \text{ m/s}}$$

3. (40 pts) A 400-kg satellite orbits the Earth at an altitude of 1100 miles above the surface. Assume the orbit is circular.

a) (8) What is the acceleration due to gravity at this altitude?

b) (6) What is the satellite's orbital velocity (in miles/hour)?

c) (6) What is the satellite's orbital period (in hours)?

d) (20) Suppose we want to accelerate the satellite from this altitude to a speed that would allow the satellite to escape. What minimum kinetic energy would the satellite need at this altitude to enable it to escape from the Earth's gravity?

$r = R_E + h \qquad h = 1100\,mi = 1.77 \times 10^6$

a) $= 6.38 \times 10^6 + 1.77 \times 10^6 = 8.15 \times 10^6\,m$

$$\text{"}g\text{"} = \frac{GM_E}{r^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})}{(8.15\times10^6)^2}$$

$$= \boxed{6.0\ m/s^2}$$

b) $$V = \sqrt{\frac{GM}{r}} = \sqrt{\frac{(6.67\times10^{-11})(5.98\times10^{24})}{8.15\times10^6}}$$

$$= \boxed{7000\ m/s} = \boxed{15{,}600\ mi/hr}$$

c) $$T = \frac{2\pi r}{v} = \frac{2\pi(8.15\times10^6)}{7000} = 7320\,s$$

$$= \boxed{2.0\ hr}$$

d) $W_{grav} = -\Delta U_{grav} = \Delta K$

$U_i - U_f = K_f - K_i$

$$-\frac{GM_E m}{r} - 0 = 0 - \frac{1}{2}mv_0^2$$

$$V_0 = \sqrt{\frac{2GM_E}{r}} = 9900\ m/s$$

$$K = \frac{1}{2}mv_0^2 = \boxed{1.96\times10^{10}\ J}$$