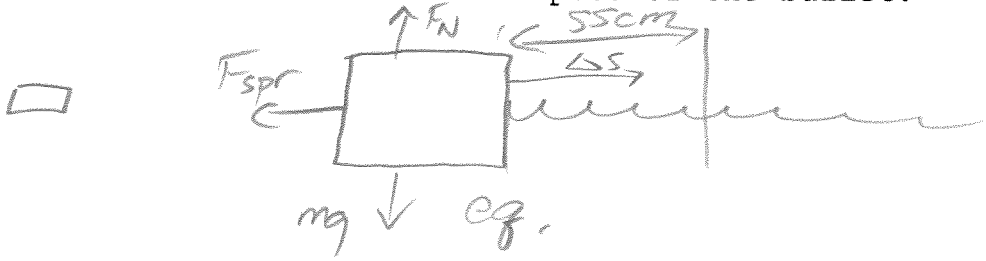
Physics 10154 - Exam #3c

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 8.0 gram projectile with an unknown speed is fired horizontally at a 220 gram block initially at rest on a frictionless, horizontal table. The block is connected to a spring, initially in its equilibrium state, with a spring constant k = 360 N/m. After the collision, the projectile rebounds with a speed of 45 m/s in the opposite direction while the block compresses the spring by a maximum amount of 55 cm. What was the initial speed of the bullet?



Collision: $(.008)v_{1i} + (.220)(0) = (.008)(-15) + (.220)v_{2f}$

Spring: $\Sigma W_F = W_N + W_{grav} + W_{spr} = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$

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

$\frac{1}{2}(360)(.055)^2 = \frac{1}{2}(.220)v_0^2$

$4.95 = v_0^2$

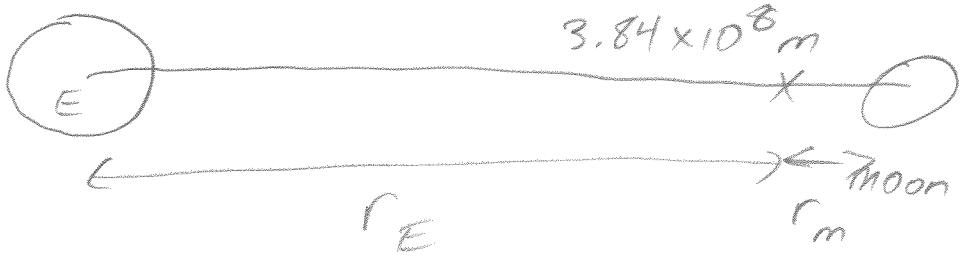
$2.22 = v_0$

$.008\,v_{1i} = (.008)(-15) + (.220)(2.22)$

$.008\,v_{1i} = -0.12 + .489$

$v_{1i} = \frac{.369}{.008} = 46\ m/s$

2. (30 pts) The mass of Earth's moon is 7.35×10^{22} kg. Suppose a spacecraft is positioned at a point in space between Earth and Moon at which the force of gravity is exactly balanced so that the net force experienced is zero. How far from the center of the Moon is the spacecraft? E-M distance = 384,000 km



$$F_{grav,E} = F_{grav,moon}$$

$$\frac{G M_E \cancel{m}}{r_E^2} = \frac{G M_M \cancel{m}}{r_m^2}$$

$$r_E + r_m = 3.84 \times 10^8$$

$$\frac{M_E}{M_{moon}} = \frac{r_E^2}{r_{moon}^2}$$

$$\frac{5.98 \times 10^{24}}{7.35 \times 10^{22}} = \frac{r_E^2}{r_m^2}$$

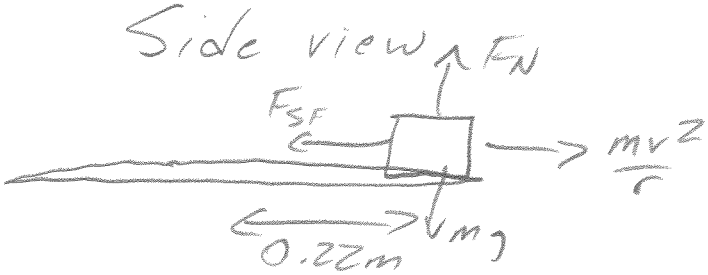
$$\sqrt{81.36} = \frac{3.84 \times 10^8 - r_m}{r_m}$$

$$9.02 r_m = 3.84 \times 10^8 - r_m$$

$$10.02 r_m = 3.84 \times 10^8$$

$$r_m = 3.8 \times 10^7 \text{ m} \quad \text{or} \quad 38{,}000 \text{ km}$$

3. (35 pts) A small block is placed on a turntable 22 cm away from the center of the turntable. Starting from rest, the turntable accelerates at a rate of 0.075 rad/sec^2. If the coefficient of static friction between the block and the turntable is 0.65, how many seconds elapse before the block begins to slide?



$\Sigma F_y: F_N - mg = 0$

$F_N = mg$

Block about to slide, so $F_{SF} = F_{SF,MAX} = \mu_s F_N$

or $\mu_s mg$

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

$$mr\omega^2 = \mu_s mg$$

$$\omega = \sqrt{\frac{\mu_s g}{r}} = 5.38 \text{ rad/s}$$

$\alpha = 0.075$

$\omega_0 = 0$

$$\omega = \omega_0 + \alpha t$$

$$5.38 = 0 + (.075)t$$

$t = 72$ s