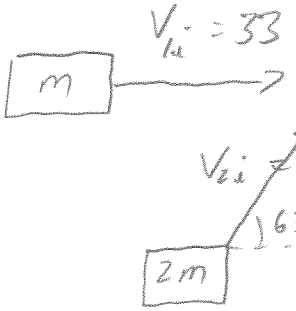
Physics 10154 - Exam #3a

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. (40 pts) A car moving East at 33 m/s collides with a truck (that is twice as massive) moving 63° North of East with a speed of 26 m/s. The car and the truck stick together after the collision. Answer both parts with 2 SF.

a) What is the magnitude and direction of the velocity of the combined mass after the collision?

b) Calculate the fraction of the initial kinetic energy of the system divided by the final kinetic energy of the system.



$x: m(33) + 2m(26\cos 63°) = 3m\,V_{f,x}$

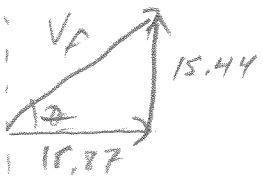
$33 + 23.61 = 3V_{f,x}$

$V_{f,x} = 18.87$ m/s

$y: m(0) + 2m(26\sin 63°) = 3m\,V_{f,y}$

$0 + 46.33 = 3V_{f,y}$

$V_{f,y} = 15.44$



$|V_f| = \sqrt{18.87^2 + 15.44^2} = 24$ m/s

$\theta = \tan^{-1}\left(\frac{15.44}{18.87}\right) = 39°$ N of E

b) $V_f = 24.38$

$K_i = \frac{1}{2}(m)(33)^2 + \frac{1}{2}(2m)(26)^2 =$

$= 544.5m + 676m$

$= 1220.5m$

$K_f = \frac{1}{2}(3m)(24.38)^2 = 891.58m$

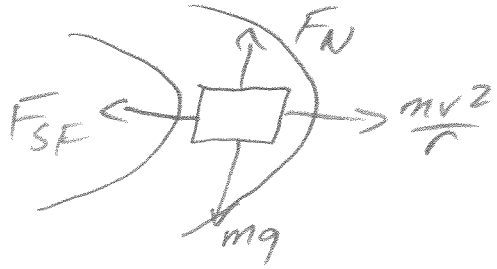
$\frac{K_i}{K_f} = \frac{1220.5}{891.6}$

$= 1.4$

2. (40 pts) A car drives on a flat road around a curve of radius 85 meters and can barely stay on the road with a speed of 55 miles/hour.

a) What is the coefficient of static friction between the car and the road?

b) What is the maximum speed for the same car if it goes around a curve with a radius of only 45 meters? Answer in miles/hour.



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

$F_{SF} = \mu_s F_N$ ← "barely stay on road"

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

$\Sigma F_y : F_N - mg = 0$

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

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

$v = 55 \frac{mi}{hr} = 24.58 \, m/s$

$\mu_s = \frac{v^2}{rg} = \frac{(24.58)^2}{(85)(9.8)} = 0.73$

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

$v = \sqrt{\mu_s g r}$

$= \sqrt{(.73)(9.8)(45)} = 17.9 \, m/s$

$= 40 \, mi/hr$

3. (20 pts) A satellite moves in a circular orbit around the Earth with a speed of 5600 m/s. Determine:

a) The satellite's altitude above the surface (in miles).

b) The satellite's orbital period (in hours).

a) $v = \sqrt{\frac{GM}{r}}$

$v^2 = \frac{GM}{r}$

$r = \frac{GM}{v^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})}{(5600)^2}$

$= 1.27\times10^7 m$

$h = r - R_E$

$= 1.27\times10^7 - 6.38\times10^6$

$= 6.34\times10^6 m$

$=$ 3900 miles

b) $T = \frac{2\pi r}{v} = \frac{2\pi(1.27\times10^7)}{5600} =$

$= 1.425\times10^4 s$

$= 3.96$ or 4.0 hrs