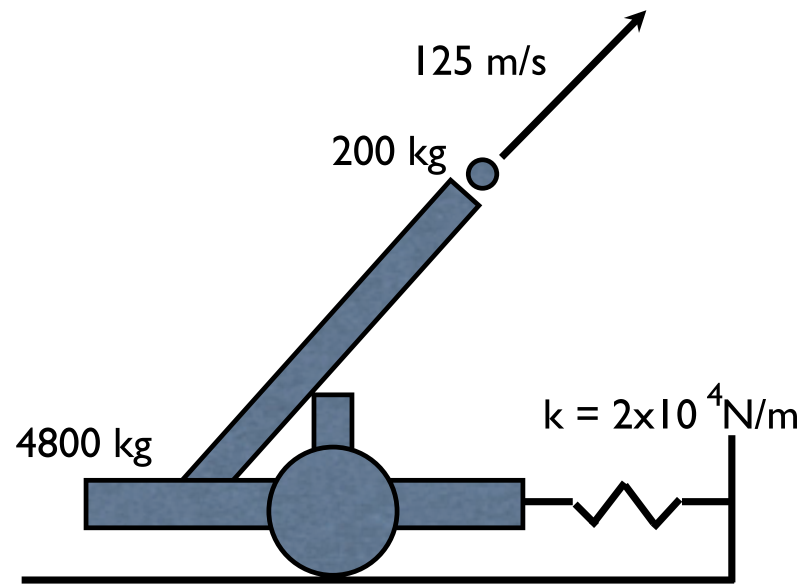
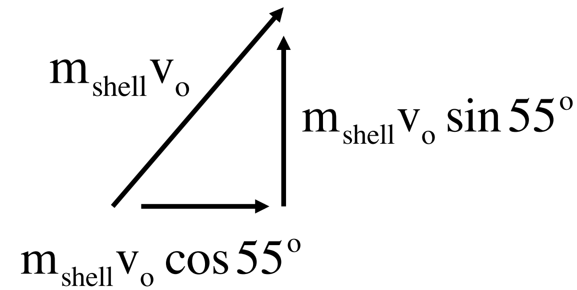
a.) Determine the recoil speed of the carriage is the cannon is angled at 55°.



b.) Determine the maximum extension of the spring.

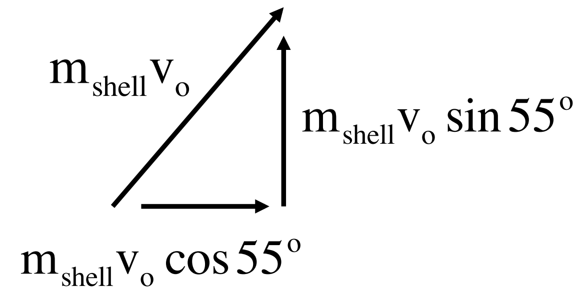
c.) Determine the maximum force exerted on the carriage by the spring.

a.) Momentum in the "y" direction is not conserved as the ground provides an enormous external impulse. In the "x" direction, there are no external impulses through the collision (the spring hasn't elongated yet) so momentum is conserved in that direction. The problem is, we need to break the shell's momentum into components, then use the "x" component of the shell in conjunction with the momentum of the carriage. Writing this out, we get:



$$
\begin{aligned}
\sum p_{1,x} + \sum F_{ext,x} \Delta t &= \sum p_{2,x} \\
0 + 0 &= m_{shell} v_o \cos 55^o - m_{carriage} v_c \\
\Rightarrow \quad 0 &= (200\ \text{kg})(126\ \text{m/s}) \cos 55^o - (4800\ \text{kg}) v_c \\
\Rightarrow \quad v_c &= 3\ \text{m/s}
\end{aligned}
$$

b.) Energy is not conserved as the shell is being fired (we started with no KE and all of a sudden, shazam, motion all over the place). AFTER the shell leaves the muzzle, though, the CARRIAGE has initial kinetic energy which turns into spring potential energy, and energy IS conserved for the carriage from just after the shell leaves the muzzle on. Ignoring the shell, then, and focusing solely on the carriage, we can write:



$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$\frac{1}{2} m_{carriage} v_c^2 + 0 + 0 = 0 + \frac{1}{2} k x^2$$

$$\frac{1}{2}(4800 \text{ kg})(3 \text{ m/s})^2 + 0 + 0 = 0 + \frac{1}{2}(2x10^4 \text{ N/m})x^2$$

$$\Rightarrow \quad x = 1.47 \text{ m}$$

c.) The maximum force exerted on the carriage happens when the spring is as compressed as it every will be (i.e., we just solved that problem in part b). That force is:

$$\begin{aligned} F &= -kx \\ &= -\left(2x10^4 \text{ N/m}\right)\left(1.47 \text{ m}\right) \\ &= -2.94x10^4 \text{ N} \end{aligned}$$