Problem Set 9: Momentum and Collision Theory, Rigid Bodies, Kinematics

Design Engineering Challenge: "The Big Dig" 2.007 Contest Ball Pyramid breaking Concepts

***PROBLEM 1*:**

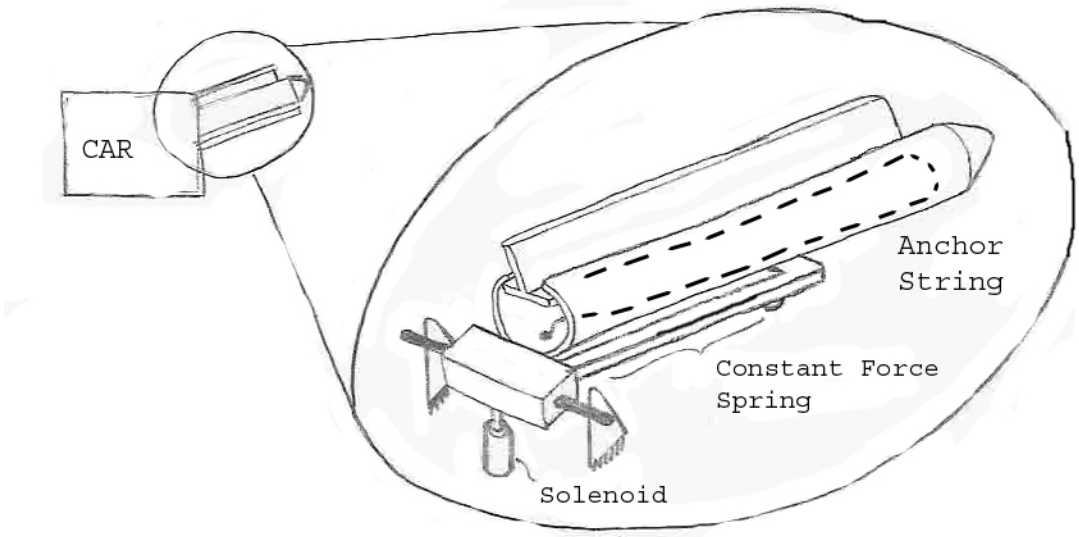


Figure 1: Projectile Mechanism

Not retractable. One shot, rapid deployment, little room for error, misalignment. Would be better if could rapidly retract, but is not feasible. Far from target.

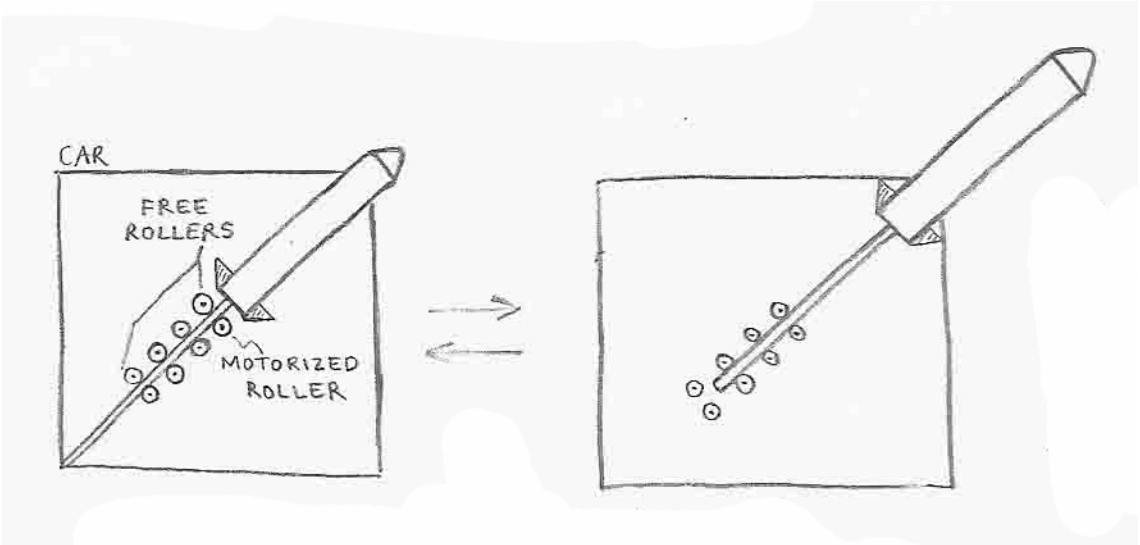


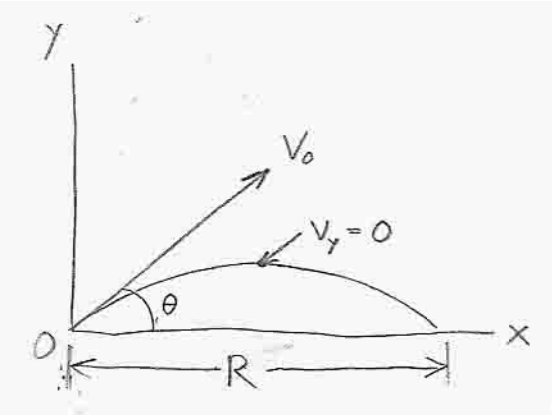
Figure 2: Telescope Mechanism

Retractable, multiple attempt fairly rapid deployment, room for error/ misalignment.

Can rapidly retract but not so important. Direct contact with target.

***PROBLEM 2*:**

Projectile:



$V_{ox} = V_o \cos q$
$V_{oy} = V_o \sin q$

At highest point,

$V_y = V_o \sin q - gt = 0$
$t = \frac{V_o \sin q}{g}$

at R, total time T=2t where T= time to target

$$R = (V_o \cos q)T = \frac{2V_o^2(\sin q \cos q)}{g} = \frac{V_o^2(2 \sin q \cos q)}{g} = \frac{V_o^2 \sin 2q}{g}$$

Telescope:

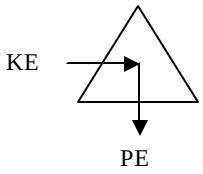
Rotational: $T = \frac{2p}{w}$ $C = 2pR$ where, ? = rpm of motor and R = radius of wheel.

Translational: $V = wR$ $t = \frac{L}{V} \Rightarrow t = \frac{L}{wR}$ prong extension

$T = \frac{D}{wR}$ time to target

***PROBLEM 3*:**

$$KE = \frac{1}{2}mV^2$$
$$PE = Mgh$$



Where, m: mass of car
M: mass of stack
h: height of center of mass of stack
V: velocity of car

To fully pierce,

Conservation of energy (negligible losses)

$$\frac{1}{2}mV^2 = Mgh \Rightarrow V = \sqrt{\frac{2Mgh}{m}}$$

Conservation of momentum (perfectly elastic)

$$mV_{car} = mV_{stack} \Rightarrow V_{car} = \frac{M}{m}V_{stack}$$

***PROBLEM 4*:**

An experiment can be observed to verify conversation of energy approach. Run car at calculated velocity and see if stack is fully pierced.