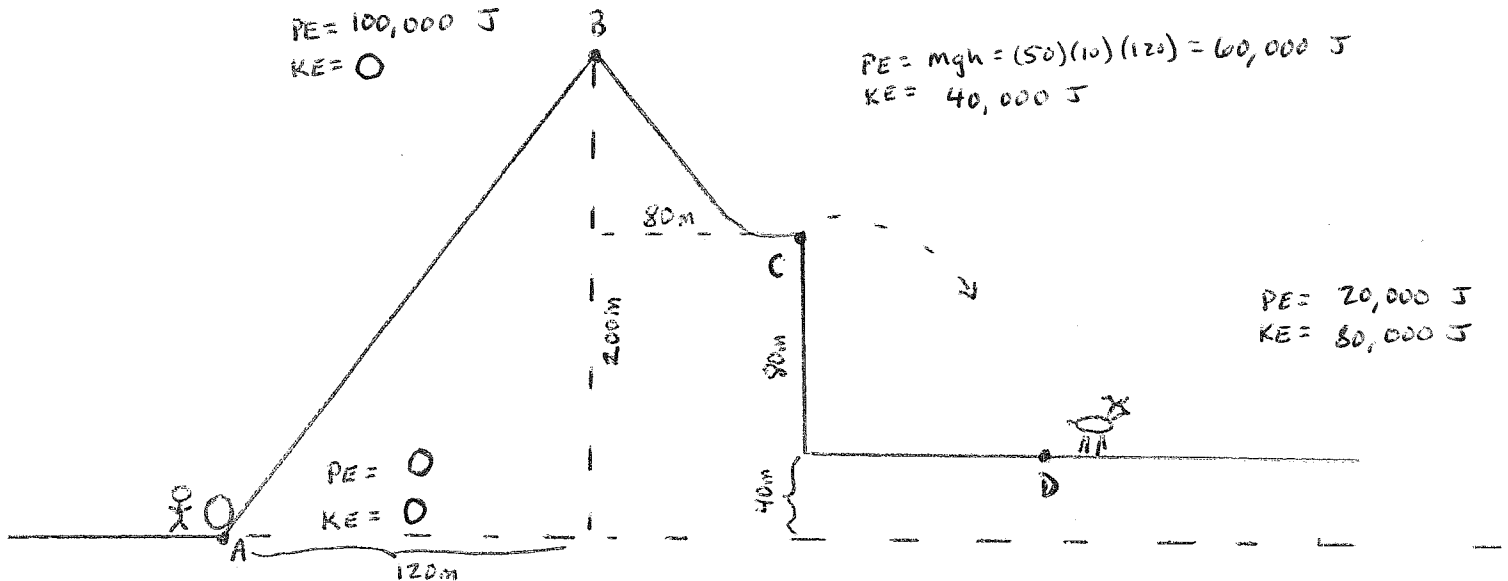


1. Mr. Caveman pushes a giant 50 kg boulder up the side of a hill and releases it down the other side so that it (frictionlessly) rolls down the slope until it flies horizontally off a cliff. It flies through the air to strike the ground below in an attempt to incapacitate a moose.



- Label the Potential Energy at points A, B, C and D. (6 pts)
- Label the Kinetic Energy at points A, B, C and D. (6 pts)
- How much work does Mr. Caveman do on the boulder? (3 pts)

$$\begin{aligned} \text{work} &= \Delta \text{energy from } A \rightarrow B \\ &= 100,000 \text{ J} \end{aligned}$$

- What is the boulder's velocity at point C? (3 pts)

$$\begin{aligned} KE &= \frac{1}{2}mv^2 = 40,000 \\ \frac{1}{2}(50)v^2 &= 40,000 \\ v &= 40 \text{ m/s} \end{aligned}$$

- How long will it take the boulder to hit the ground? (3 pts)  
 (when in the air)

$$\begin{aligned} d &= \frac{1}{2}at^2 \\ -80 &= \frac{1}{2}(-10)t^2 & t &= 4 \text{ sec.} \end{aligned}$$

- How far away from the base of the cliff will it land? (4 pts)

answer from (D) 40 m/s  
 answer from (E) 4 s

$$d = vt = (40)(4) = 160 \text{ m}$$

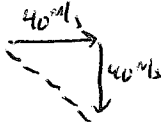
g) How fast is the boulder traveling vertically just before it strikes the ground? (2 pts)

$$a = \frac{\Delta v}{t} \quad \Delta v = (4)(10) = 40 \text{ m/s downwards}$$

h) How fast is the boulder traveling horizontally just before it strikes the ground? (2 pts)

$$40 \text{ m/s} \quad (\text{same as answer (d)})$$

i) How fast is the boulder traveling just before it strikes the ground? (2pts)



$$40^2 + 40^2 = v^2 \quad v = 56.6 \text{ m/s}$$

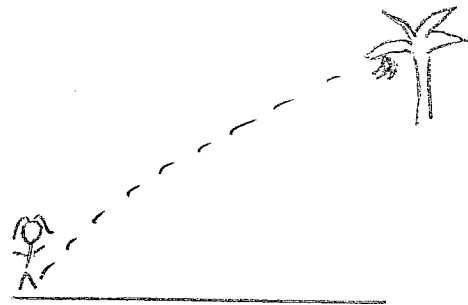
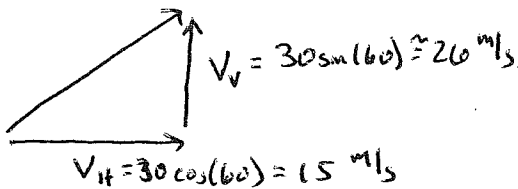
$$\text{also } KE = 80000 = \frac{1}{2}mv^2$$

$$v = 56.6$$

j) What can Mr. Caveman do so that the boulder strikes the moose on his next attempt? (3 pts)

More higher if possible to give it more PE or push it to give it more KE initially at point B.

2. Mrs. Caveman is throwing rocks at a bunch of bananas hanging 18 m up in a tree in order to knock them down. If she throws rocks at 30 m/s a 60° angle above horizontal, how far away should she stand from the spot directly under the bananas? (8 pts)



$$d = vt + \frac{1}{2}at^2$$

$$18 = 26t - 5t^2$$

$$t = \frac{26 \pm \sqrt{676 - 360}}{10} = \frac{26 \pm 19.8}{10}$$

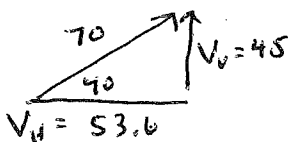
$$t = 0.82 \text{ or } 4.38 \text{ seconds}$$

$$d = (15)(0.82) = 12.3 \text{ m}$$

OR

$$d = (15)(4.38) = 65.7 \text{ m}$$

3. Caveman Jr. is practicing shooting his bow and arrow on level ground at 70 m/s at a 40° above horizontal. How far away are his arrows landing? (6 pts)



$$\text{time up} = \frac{45}{10} = 4.5$$

$$\text{total time} = 9 \text{ sec}$$

$$d_H = (53.6)(9) = 482.6 \text{ m}$$

4. A bullet with mass 0.0036 kg is shot at 990 m/s straight up. How much work does a gun have to do on the bullet? (5 pts)

$$\begin{aligned} W &= \Delta E_{\text{mgye}} \\ &= \Delta KE \\ &= 0 \rightarrow \frac{1}{2} (0.0036) (990)^2 = 1764 \text{ J} \end{aligned}$$

b) Assuming no air resistance, how high up will it go? (4 pts)

$$\begin{aligned} KE &\rightarrow PE \\ 1764 &= mgh \\ &= (0.0036)(10)h = 49005 \text{ m} \end{aligned}$$

c) Assuming air resistance this time, it is observed that the bullet only goes up 5 miles (1 mi = 1600m). How much work was done on the bullet on the way up by the air? (4 pts)

work done to slow bullet so it  
doesn't go as high ...  
energy at 8000m =  $(0.0036)(10)(8000) = 288 \text{ J}$

$$\text{work done} = 1764 - 288 = 1476 \text{ J}$$

5. Assuming I weigh 198 lbs (90 kg), do I do more work if I run up 4.6 vertical meters worth of stairs in 3 seconds or if I carry a friend of equal weight up the stairs in 8 seconds? Or is it the same? Explain. (5 pts)

Carrying friend, you'll weigh more (have more mass)  
so there is greater force of gravity.  
 $W = F \cdot d$  since distance is the same.

More work when carrying friend.

6. Assuming I weigh 198 lbs (90 kg), do I generate more power if I run up 4.6 vertical meters worth of stairs in 3 seconds or if I carry a friend of equal weight up the stairs in 8 seconds? Or is it the same? Explain. (5 pts)

	by myself	w/ friend
$W = F \cdot d$		
$P = \frac{W}{t}$	$P_{\text{me}} = \frac{(900 \text{ N})(4.6)}{3}$	$P = \frac{(1800 \text{ N})(4.6)}{8}$
	$= 1380 \text{ Watts}$	$= 1035 \text{ Watts}$

More Power by myself.

7. Pulling a 2500 kg trailer behind my car for 10 miles (1 mi = 1600m) on a horizontal road requires how much work if the coefficient of friction between the tires and the road is  $\mu = 0.6$ ? (6 pts)

$$F_{\perp} = 25000 \text{ N}$$

$$F_{\text{fr}} = \mu F_{\perp} = 15000 \text{ N}$$

$$W = (15000)(16000 \text{ m}) = 240,000,000 \text{ J}$$

\*Bonus\* Assume that the road is at a  $5^{\circ}$  incline and you still travel 10 miles, how much work will you need to do on the trailer now? This means you go up about 1394.5m and only travel 15939.1m horizontally.

Work against friction

$$F_{\perp} = 25000 (\cos(5^{\circ}))$$

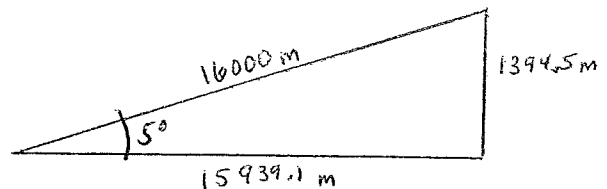
$$= 24904 \text{ N}$$

$$F_{\text{fr}} = (.6)(24904) = 14942 \text{ N}$$

$$W = (14942)(16000) = 239,086,727 \text{ J}$$

Work against gravity

$$= (25000)(1394.5) = 34,862,500 \text{ J}$$



total

$$273,949,227 \text{ J}$$