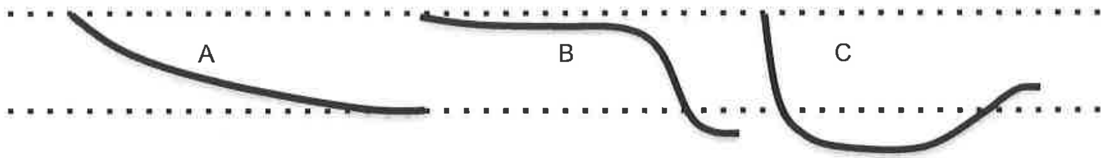
MT1, 141, Schwartz Name___________________

1. 10 pts. Shown are three frictionless tracks, *each is of equal length*, but bent differently. I drop a marble down each track.



a) We want to know which marbles come off with the highest speed. **Explain why using energy is the way to figure this out:**

We know $KE_0 = 0$ because $v_0 = 0$, so total $\Delta KE = -\Delta PE$ so $\frac{1}{2}mv^2 \propto \Delta h$, $v \propto \sqrt{\Delta h}$

b) Rank the tracks according to **final speed** when it goes off the track, from fastest to slowest, or state why they all come off with the same speed.

B_> A > C because B drops the most, C the least from beginning to end.

c) We want to know which marbles took the most time. **Explain why using energy is the way to figure this out:**

Using the same logic above, we see that the one that has the higest average v will have the shortest time.

d) Rank the tracks according to time taken to get to the end of the track, from shortest time to longest time, or state why they all take the same time.

C_< A < B

Eventhough ~~at the~~ track C ends the highest, and so has the lowest final speed, it spens the majority of the trip at the lowest ~~pt~~ elevation + so will have the highest average speed + lowest time.

2. Your Statements:

a) Please write and sign the following statement: "I will not communicate any information about this test until after 2:00 PM today."

*Signature*___________________

b) If you didn't use a calculator for this test and would like extra credit for it, please write and sign the following statement: "I didn't use a calculator on this test - *your signature*"

*Signature*___________________

3. (10 pts) You fire a 5g bullet into a 1 kg mass which embeds itself into the block. The bullet is well known to have a speed of 500 m/s. The mass slides 2.0 meters on a horizontal frictionless surface, and then compresses a spring as shown. The spring constant is 1000 N/m. We want to find the speed of the block immediately after the collision with the bullet and the compression of the spring.

a) For each step of this process, explicitly state what is conserved and not conserved. You may refer to any of the 4 concepts to describe what is happening. There's maybe 4 steps that you might consider, but two of them that you *must* consider:
   1 - the gunpowder exploding to get the bullet moving (optional)
   2 - The bullet hitting and embedding itself in the block
   3 - The block sliding down the frictionless surface (optional)
   4 - The compression of the spring

b) $\vec{v}_{Block}$ = ~2.5 m/s or 0.5% less

c) Δx_{Spring} = _~8cm_______

1) $\Delta\vec{P}_{gun} = -\Delta\vec{P}_{bullet}$ $PE_{chem} \Rightarrow KE_{Bullet} + Heat$

2) $\vec{p}$ is conserved, or $\Delta\vec{P}_{Block} = -\Delta\vec{P}_{Bullet}$

or $\vec{P}_{Block+Bullet} = \vec{P}_{Bullet\ before\ collision}$.

- $KE_{Bullet} \Rightarrow KE_{Block+Bullet}$ + Heat mechanical

energy is not conserved

3) $F = 0$, $W_f = 0$ $\Delta\vec{p} = F\,dt = 0$ $\Delta E = W = 0$

$\vec{p}$ + $E_{mechanical}$ are unchanged

4) $KE_{Bullet} \Rightarrow PE_s$ conserving $E_{mechanical}$

$\vec{P}_{Block+Bullet} \Rightarrow \vec{P}_{earth}$. The $\vec{p}$ of the block is imparted to earth

Step #2 $M_{Block+Bullet} \Rightarrow 200\,M_{Bullet}$ $V \Rightarrow \frac{1}{200} V_{Bullet}$

$V_{Block} \approx \frac{500\ m/s}{200} = 2.5\ m/s$

Step #4: $KE_{Block+Bullet} = PE_s \Rightarrow \frac{1}{2}(M_{Block+Bullet})V_{Block}^2 = \frac{1}{2}kx^2$

$$\frac{1}{2} M_{B+B} V_{B+B}^2 = \frac{1}{2} K X^2$$

$$X = \sqrt{\frac{M_{B+B}}{K}}\, V_{B+B} = \sqrt{\frac{1.005\,kg}{1000\,N/m}}\, V_{B+B}$$

$N = kg\, m/s^2$

$$\approx \frac{1\,s}{31}\; 2.5\, m/s$$

$$\frac{kg}{N/m} = s^2$$

$$\approx 0.08\,m = 8\,cm$$

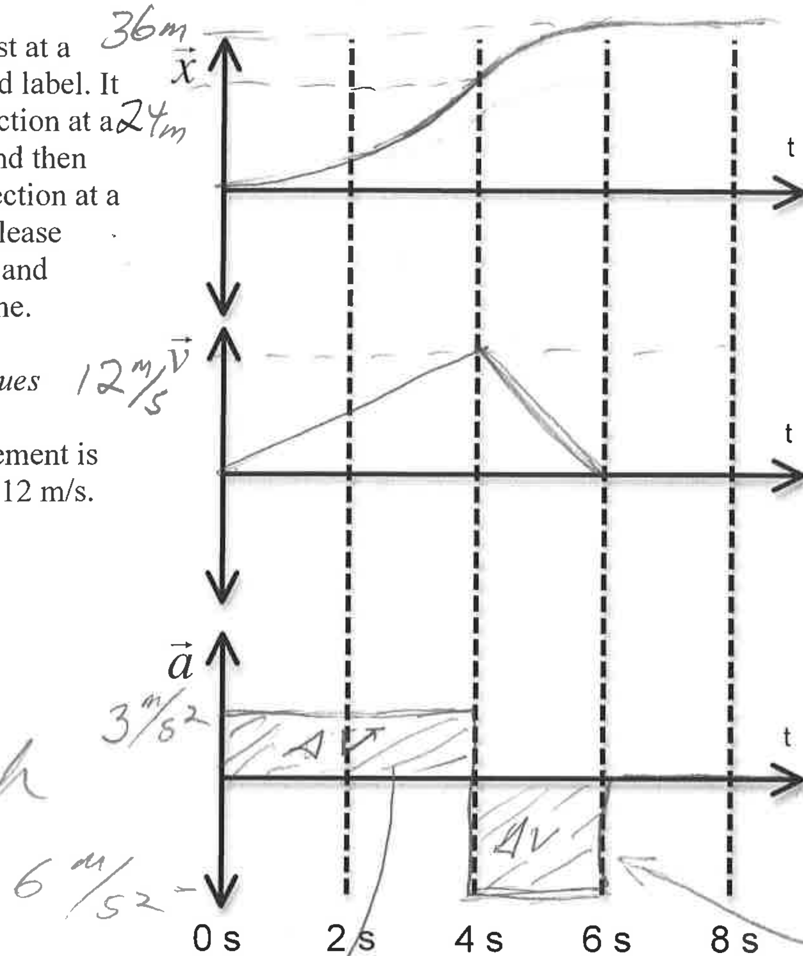
Some of you found an answer w/ this in it: $\sqrt{.0063}$ ... need a calculator?

try $\approx \sqrt{\frac{64}{10^4}\, m^2} = \frac{8}{10^2} = .08\,m$

4. (10 pts) An object starts from rest at a displacement you can choose and label. It accelerates in the positive x direction at a rate of 3 m/s^2 for four seconds and then accelerates in the *negative* x direction at a rate of 6 m/s^2 for two seconds. Please graph the acceleration, velocity, and displacement as a function of time.

Extra Credit: label axis with values

The maximum and final displacement is 36 m. The maximum velocity is 12 m/s.



V=0 at t=0, so slope of X↔t graph = 0

max slope of x-t graph is at 4s

ΔV = area = 3 m/s² · 4s = 12 m/s

ΔV = −12 m/s

<u>Δx is area under</u> V-t graph

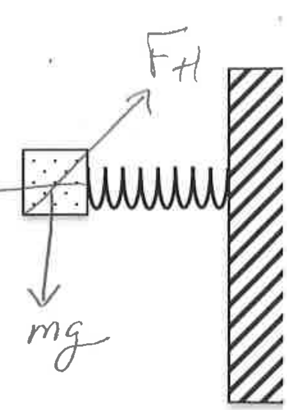
Area @ 4s = ½ bh

= ½ 4s 12 m/s = 24m

Total area at 6s = 36m

I choose to start at $x_0 = 0$, but you don't have to.

5. (10 pts) At right you see a 3 kg mass that would just flop downward and hang from the wall on a spring except for the fact that it is being held at rest by my hand, which you cannot see because I didn't draw it. ~~Additionally,~~ The mass is attached to a spring of spring constant 100 N/m and is compressed (not stretched) 40 cm. We want to find the force that my hand is exerting in holding the mass in place.



a) Please start this problem stating why you know it's a dynamics problem and then

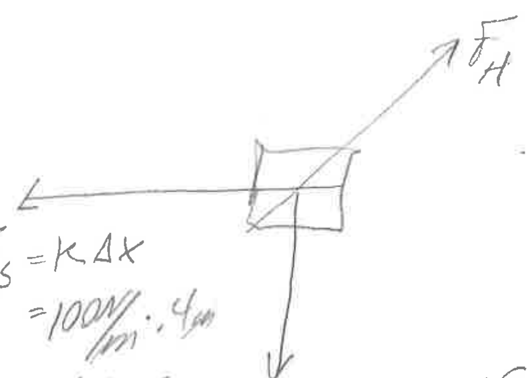
b) Follow the protocol introduced in class to find the force provided by my hand. The force should have a magnitude and direction (angle).

The answer should involve 50 N and a 37 degree angle.

a) I know some forces + the $\vec{a}$ + I want to find 1 other forces: Perfect for $\sum \vec{F} = m\vec{a}$

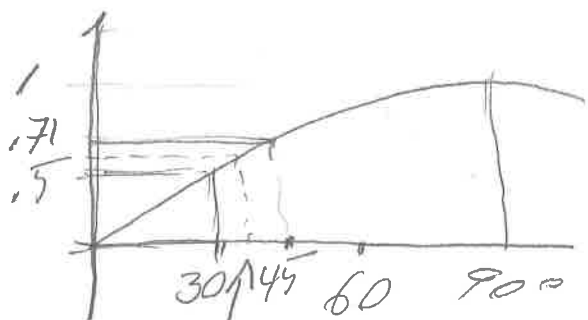
b) Dynamics - no formula

$\sum \vec{F} = m\vec{a}$

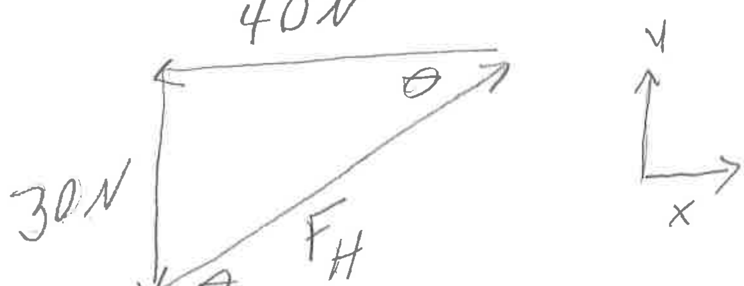


$F_s = k\Delta x = 100 N/m \cdot .4m = 40N$

$mg = 30N$



~37°



$F_H = 40N\hat{x} + 30N\hat{y}$

$= 50N \quad \theta = 37°$ (above horizon)

$(30N)^2 + (40N)^2 = (50N)^2$

$\theta = \sin^{-1}\frac{30N}{50N} = \sin^{-1}(0.6)$