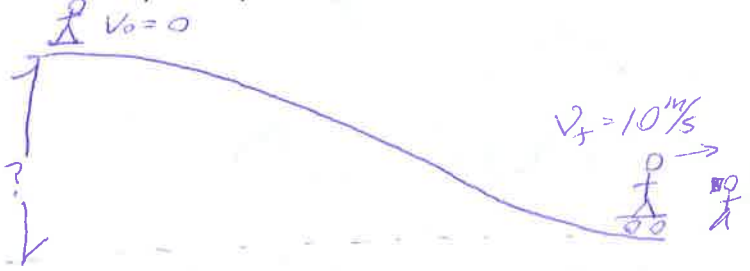
Big Exam #1 Use both sides. Put your name at the end

#1: I have a super smooth hill that I love to drop into on my skateboard. I have a mass of 70 kg. My daughter, Tekuru (30 kg) uses my cell phone to take a video of me as (starting from rest) I drop down this hill. From the video, we're able to measure my speed at the bottom at 10 m/s!

a) What is the change in elevation between the top and bottom of the hill?
b) How could we calculate speed from looking at a cell phone video?
c) Unfortunately, Tekuru took the video from the bottom of the hill on the flat part, and **BAM** I smacked right into her, but managed to grab her onto the skateboard with me. What was our speed after I hit her?
d) In a second attempt, I went down the same hill, but *started at the top* with a speed of 10 m/s! Tekuru took the video from the side this time. What was my final speed at the bottom this time?

a) Use Energy lens because

$E_g \Rightarrow E_K + E_{th}$ (small)



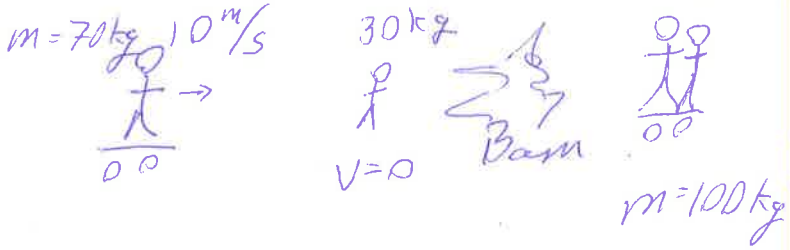
$$mgh_0 = \frac{1}{2}mv_f^2$$

$$h_0 = \frac{\frac{1}{2}v_f^2}{g} = \frac{\frac{1}{2}(10\ m/s)^2}{10\ m/s^2} = \frac{\frac{1}{2}\cdot 100\ m^2/s^2}{10\ m/s^2} = 5\ m$$

b) Use kinematic lens because video provides complete information of position as an explicit function of time: $v_f = \frac{dx}{dt} = \frac{\Delta x}{\Delta t}$ data are taken near bottom

c) Use $\vec{p}$ lens because during collision outside forces on the system are very small $\vec{F} = \frac{d\vec{p}}{dt}$, so

$\Delta \vec{p}_{system} = F_{outside} \cdot dt \sim 0$, so $\vec{p}_0 = \vec{p}_f$



$$\vec{p}_0 = m_p v_0 = 70\ kg\ 10\ m/s = 700\ kg\ m/s = p_f = m_f v_f$$

$$= 100\ kg\ v_f$$

$$v_f = \frac{700\ kg\ m/s}{100\ kg} = 7\ m/s$$ ... Pete slows down a little

d) Use energy lens again because very little energy is lost as heat, and

$E_p \Rightarrow E_K$

$$E_0 = E_f$$

$$E_{K_0} + mgh = E_{Kf}$$

$$\frac{1}{2}mV_0^2 + mgh = \frac{1}{2}mV_f^2$$

$$V_f^2 = V_0^2 + 2gh$$

$$= \left(10\ m/s\right)^2 + 2 \cdot 10\ m/s^2 \cdot 5\ m$$

$$V_f^2 = 200\ m^2/s^2$$

$$V_f = \sqrt{200}\ m/s = \sqrt{2}\left(10\ m/s\right) \approx 14\ m/s$$

you can't have answer in incomplete form. You need to estimate numerical answer to get full credit.

Name _____