

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

In General, remember to use units throughout. You should also substitute numbers in at the very end, because the symbols often cancel and simplify things. It also easier to interpret and is easier to work with than having a string of numbers to manipulate.

#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?
  - a. What lens might you use?
  - b. Why can you use this lens?
  - c. Using this lens, what would be your first step?

I would use an energy lens because I can see that potential energy is being converted to kinetic energy. Yes, there's also heat produced, but this is a small amount because I say that the hill is smooth. My first step would be to conserve energy from beginning to end. Show work, get 5 m.

- b) How could we calculate speed from looking at a cell phone video?
  - a. What lens might you use?
  - b. Why can you use this lens?
  - c. Using this lens, what would be your first step?

I would use a kinematic lens because with the changing positions we have in the video frames, we have our position as an explicit function of time. My first step would be to find  $dx$  and  $dt$  and use  $v = dx/dt$ .

- 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?
  - a. What lens might you use?
  - b. Why can you use this lens? Some people answered along the lines, "because you have mass and velocity." But to say "because I can calculate momentum" isn't enough... you could also calculate kinetic energy. The question is deeper: "what physics allows you to conserve momentum?"
  - c. Using this lens, what would be your first step?

would use a momentum lens because I know momentum is conserved in collisions because there is no outside force... yes, it's true that there are many other forces acting on us, but for the moment that we collide, these other forces are very small in comparison. My first step would be to conserve momentum. I can find my initial momentum just before hitting Tekuru, and know that it is the same as our final momentum after colliding. Show work, get 7 m/s.

- d) In a second attempt, I went down the same hill, but *started at the top* with a speed of 10 m/s. What was my final speed at the bottom this time?
  - a. What lens might you use?
  - b. Why can you use this lens?
  - c. Using this lens, what would be your first step?

I would use energy lens because my potential energy is being converted to kinetic energy. The difference between this and the first question is that NOW, I start with potential *and* kinetic energy that is all turned to kinetic energy. I would start by finding all the initial energies and setting them equal to all the final energies. Did you get about 14 m/s?

e) (If you have time for it) explain why it would be difficult to estimate speed from a video of a person *coming directly at you*.

It is easier to measure the change in position if they are moving perpendicular to your line of sight. If they are moving toward you or at an angle, you will only see the perpendicular motion.

Name \_\_\_\_\_