SPH4U Skill Builder: Motion Problems Name:

A: Skill Building Check-up

You have finished your first skill builder that focused on representations of motion. It's time to check on how you are progressing.

1. **Reflect.** Do you feel the skill builder exercises improved your understanding of representations of motion (graphs, motion diagram, vector diagram, descriptions)? Explain.

2. **Reflect.** Have you noticed any difference with your skills when you work on your regular homework? Explain.

Our main goal when we solve problems in physics is to build our physics understanding. This goal also helps us make sure we get the correct answer. Building our understanding requires careful thought with each question and our standard solution process helps us do this. This skill builder will help you practice the main parts of our solution process.

B: Pictorial Representation

The goal of the pictorial representation is to clarify the problem. This is important: if you rush through this step there is a good chance that you will not understand the problem well, or end up solving an incorrect version of the problem. The key parts of the pictorial representation are:

- **Sketch:** The sketch show what is happening at each important moment in time (each event labelled)
- **Coordinate system:** The coordinate system shows the origin and which direction is positive and negative. This helps you write down the given quantities with the correct sign. Choose the positive direction to reduce the number of negative quantities in your problem.
- **Describe events:** Events are the important things that happen in the problem and help define the intervals of time the problem is interested in. This is one of the most critical steps in solving any problem. An event is something that happens at one time and position in space.
- **Label givens and unknowns with symbols:** use physics symbols and event numbers for the important quantities in the problem.
- **Conversions:** Often it is convenient to do any conversions at the start of the problem. Check out the units of your important quantities and see if they match or need to be converted.

1. (a) **Represent.** Draw a simple sketch for each situation and indicate the coordinate system. Describe each important event. Label the given and unknown quantities. Don't check your answers yet.

The starting gun fires and a sprinter begins to run a 100-m race. She quickly crosses the finish line 10 seconds later. Find the acceleration of the sprinter.	Isaac is driving along a city street at 60 km/h. A traffic light turns red and he driver slams on the brakes. He slows down at a rate of 14.5 m/s^2 and stops just in time. Find the distance the car travels while braking.	Marie drops a ball from the top of a 3.7 m high building. Find the time for the ball to reach the ground.

(b) **Reason**. Each situation has a given quantity that was not explicitly mentioned in the description of the situation. What are those quantities?

(c) **Reason.** Albert says, "For the ball question I want to use $v_2 = 0$ to help find the time." Emmy says, "I don't think you should do that." Who do you agree with? Explain.

(d) **Reason.** Let's think about conversions. Do any of the situations have givens with mixed units, where you will need to make a conversion? Explain.

(e) **Evaluate.** Check your solutions for the three situations. Use a different colour pen to make any improvements or additions. Explain to yourself what you should keep in mind to improve your work on the pictorial representations.

C: Word Representation

We write a word representation to helps us explain to ourselves what is happening and why. This will help us focus on the right physics ideas and allow us to set up the mathematics correctly. The important parts of the word representation are:

- **Describe the motion:** Use words to describe the motion (we practiced this in the first skills builder package)
- **Explain why:** In our unit on motion, our explanations will be very simple. When our focus turns to forces and energy, we will provide more detail.
- **Assumptions:** We routinely (often without realizing it) make very important assumptions about the motion or forces in a situation. Without these assumptions, the problem would likely be too difficult to solve. An assumption is something that is not explicitly mentioned in the problem and is not 100% correct, but is close enough such that our result is still pretty reliable.

1. **Represent.** Complete a word representation for each of the three situations described in part B#1.

(a) The Sprinter	(b) The Car	(c) The Ball

2. **Evaluate.** Check your answers for question C#1. Write up advice to yourself on things to remember or improve for the future.

D: Mathematical Representation

The mathematical representation explains the process of the solution and comes up with a final answer to the problem. When writing, keep in mind a physics student from another school or a previous grade who might be reading your solution and might be having some difficulty following it. To help this imaginary person, the important steps of part D are:

- **Describe steps:** Explain using a simple statement (not symbols!) what the math work you are about to show is about to find. This outlines the logic of your solution process.
- **Complete equations:** Always start by writing the original equations using symbols (with appropriate subscripts for the events) so our reader can easily understand the starting point for your calculations.
- **Algebraically isolate:** Don't plug in numbers yet! Use algebra to isolate the quantity you want to find. The exception is if a quantity is zero, substitute that right away since it simplifies your work. This is a key skill for science work beyond high school where you are very often interested in an algebraic answer instead of a numeric answer.
- **Substitutions with units:** Only now should you plug in your given quantities, and don't forget the units! Compute an answer in your next step.
- **Final statement**: Use a sentence to interpret your mathematical result and answer the problem.

1. **Represent.** Complete part D for the three situations you have been working with.

   (a) The sprinter:

   (b) The car:

   (c) The ball:

E: Evaluation

As a thinking human being, you should develop the skill of evaluating the final results for a problem and deciding if they seem right. You should evaluate the:

- **Size**: based on the situation or your experiences does the size of your final result seem OK or out of place?
- **Direction**: often we find vector quantities and it is helpful to double check whether the direction or sign of the answer makes sense with the problem.
- **Units**: does your final result have appropriate units?

1. **Evaluate.** Complete the evaluation step for the car question.

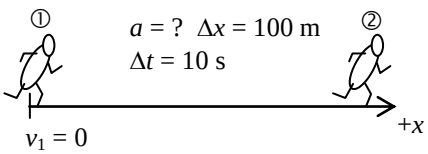
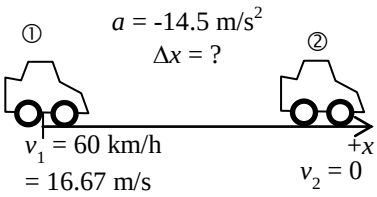
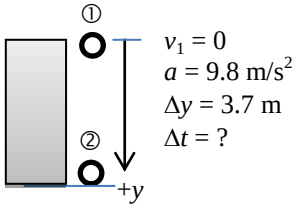
Answers

Question B#1(b): *For the sprinter, I used $v_1 = 0$ since she starts from rest. For the car, I used $v_2 = 0$ since the car stops at the light. For the ball, I used $v_1 = 0$ since the ball is just dropped (let go) and not thrown.*

Question B#1(c): *Albert should not use $v_2 = 0$ to find the time. We are interested in the interval of time when the ball is falling (freefall). When the ball contacts the ground, the forces and acceleration change, so we cannot use $v_2 = 0$. The velocity at moment 2 (when it reaches the bottom) is actually very large.*

Question B#1(d): *The car example has a velocity with units of km/h, while the acceleration is m/s^2. So, both km and h need to be converted to match the acceleration.*

Answers for question B#1(a)

Event 1: The sprinter begins to run. Event 2: The sprinter reaches the finish line. 	Event 1: The car begins to brake. Event 2: The car stops. 	Event 1: Marie releases the ball. Event 2: The ball reaches the ground. 

Question C#1:
(a) *The sprinter starts from rest and begins to run in the positive direction. She has a positive acceleration and speeds up due to the force the ground exerts on her. Assume her acceleration is constant.*
(b) *The car is traveling quickly in the positive direction and begins to slow down with a negative acceleration due to the brakes of the car. Assume the car's acceleration is constant.*
(c) *The ball is dropped, so we assume its initial velocity is zero. It experiences free fall (constant downward acceleration due to gravity) and speeds up until it reaches the ground. Assume air resistance is negligible.*

Question D#1:

(a) The Sprinter: Find the acceleration of the sprinter during the race. $\Delta x = v_1\Delta t + ½a\Delta t^2$ $\therefore\ a = \frac{2\Delta x}{\Delta t^2}$, since $v_1 = 0$ $= \frac{2(100m)}{(10s)^2}$ $= 2$ m/s^2 Her acceleration is 2 m/s^2.	(b) The Car: Find the displacement the car travels while it is slowing down. $v_2^2 = v_1^2 + 2a\Delta x$ $\therefore \Delta x = - v_1^2/2a$, since $v_2 = 0$ $= - (16.67 \text{ m/s})^2/2(-14.5 \text{ m/s}^2)$ $= 9.582$ m The car travels 9.58 m forward while it is stopping.
(c) The Ball: Find the time for the ball to reach the ground. $\Delta y = v_1\Delta t + ½a\Delta t^2$ $\therefore \Delta t = \sqrt{\frac{2\Delta y}{a}}$, since $v_1 = 0$ $= \sqrt{\frac{2(3.7\ m)}{9.8\ m/s^2}}$ $= 0.8690$ s The ball takes 0.869 s to reach the ground.	

Question E#1:
The size seems reasonable for a short stopping distance: it is about the length of a classroom. The sign was positive, which means the forwards direction. The units are *m* which are appropriate for a distance.