Assignment III, PHYS 101 (Introductory Physics I)
Fall 2020
Due via pdf upload to OAKS prior to Thursday, September 10th at 9:25 AM

General instructions:
For this, and all other homework assignments, please turn in your solutions with all supporting work; answers without supporting work will not earn credit. You do not need to upload the sheet with the questions on it, but please clearly number your problems and circle or box your final answers. I encourage you to collaborate with classmates to discuss how to approach a particular question, but the mathematical steps to generate your final answer on your submitted work should be your own. If I see the same simple mistake on multiple homework assignments, I will take off more points for that error than I normally would. Please include *words* in your answers. When you get answer keys back from me, you'll see that there are explanations, ideas, commentary, and thought processes included – not just a set of equations one after another. Finally, please ensure that all numerical answers have units. As always, if you have questions feel free to email me or send me a DM in the slack.

1. Consider the following vectors. All angles are measured counter-clockwise from the $+x$ axis (the standard way).

$$\vec{A} = 71.0 \text{ m/s at an angle } 130^\circ$$
$$\vec{B} = 92.3 \text{ m/s at an angle } 205^\circ$$
$$\vec{C} = 134.2 \text{ m/s at an angle } -62^\circ$$

   a) What is $\vec{A} + 2\vec{B}$? Leave your answer in component form.
   b) What is $-2\vec{A} - 3\vec{C}$? Leave your answer in magnitude-direction form (aka in the same form that the vectors above are defined).
   c) Find $\vec{D}$ if $\vec{A} + 3\vec{C} + 2\vec{D}$ combine to form a vector of magnitude 37.6 m/s at an angle of 42°. You may leave your answer in component form.

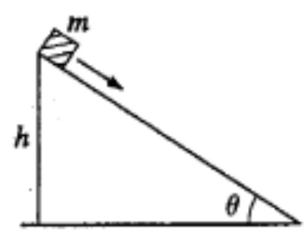
2. A rocket starts from rest and undergoes constant acceleration.
   a) If we wants the rocket to travel a total distance of 2.5×10^{11} meters in less than one (Earth) week, what would be the magnitude of its minimum required acceleration?
   b) If the rocket had the constant acceleration computed in part (a), what would the (instantaneous) velocity of the rocket be at the end of the week?

3. A block slides down a triangular wedge of height $h = 13.4$ m. The acceleration of the block is 3.94 m/s^2 and the "wedge-angle" (marked θ on the figure) is 35.0°.

    a) Assuming the block starts from rest at the top of the wedge, how long does it take for the block to reach the bottom of the triangular wedge?

    b) What is the magnitude of the velocity (aka how fast is the block moving) when it reaches the bottom of the triangular wedge?

    c) What is the magnitude of the velocity (aka how fast is the block moving) when it is halfway down the wedge?



4. A sprinter starts from rest and runs a 100-meter long race. The sprinter accelerates at 2.8 m/s^2 for the first 4.3 seconds and then stays at the velocity achieved at the end of that acceleration for the rest of the race.

    a) How far from the starting line is the runner when they reach their maximum velocity?

    b) How long does it take the runner to finish the race?

    c) Let's say the person wants to race against my dog Groot that also starts from rest and can accelerate at 4.2 m/s^2 for the first 5.0 seconds and then stays at the velocity achieved at the end of that acceleration for the rest of the race. Groot would beat the sprinter in a fair race, but you could try to set-up an exciting photo-finish if you gave the human a head-start, so you set it up that the human starts the race and some time later you let Groot start. How long should you wait after the human starts to let Groot start?

5. A super high-powered gun is shot straight up into the air. The bullet eventually reaches a peak height of 51.8 km. Assume that there is no air resistance.

   a) What was the speed of the bullet coming out of the gun?

   b) The troposphere (the bottom layer of the atmosphere) is about 12 km high; above the troposphere is the stratosphere. If we let the time the bullet leaves the gun be defined as $t = 0$, at what *two* times does the bullet intersect the troposphere/stratosphere boundary? (Hint....You'll need to solve the quadratic equation).

   c) What was the bullet's average velocity for the first 10.0 seconds after the gun was fired?

6. Recall the "moving man" PhET first shown in class on Tuesday, 9/1. For this problem, we will use that coordinate system shown on that applet (the right half of the screen has positive position, movement to the right corresponding to a positive velocity, movement to the left corresponding to a negative velocity, etc). For each of the following, indicate if the described motion is possible. If it is, describe a scenario that gives the specified scenario. If it is not possible, explain why not. [I will do one for you first, so you can get the picture of what I'm asking for].

   Example Question: Is it possible for a position to be positive and the velocity be negative?

   Example Answer: Yes. If the man is on the right side of the computer screen while moving to the left.

   a) Is it possible for a position to be negative and the velocity be positive?

   b) Is it possible for the position to be negative and the velocity be negative?

   c) Is it possible for the acceleration to be positive while the velocity is negative?

   d) Is it possible for the acceleration to be negative while the position is positive?

7. A ball is thrown straight upward (on Earth). What is its acceleration when it is at its highest point?

8. Living out your Mario Kart fantasies, you decide to attach a rocket engine to a bicycle. Assume the rocket engine can generate a constant acceleration of 23.0 m/s^2.

   a) The speed of sound is about 343 m/s. Assuming you started at rest, how far would you have ridden the rocket before you reached the speed of sound?

   b) Not enjoying the prospects of passing the sound barrier on a bicycle, you decide the next rider should use much less fuel in the rocket. This time, you only have enough fuel to get the acceleration for 4.0 seconds. If this second rider starts from rest, accelerates at 23 m/s^2 for 4.0 seconds, and then – immediately after the rocket burn finishes – hits the brakes to decelerate at -3.0 m/s^2 until the bike stops, how far was the whole trip from start to stop?

   c) What was the average velocity in the scenario outlined in part (b) above?