Physics 161, Homework 1

Due 12:00 pm, Monday, Feb 10; No Exceptions

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Short Answer Questions: S1, S2, S3 ,S4; Problems: P1 , P2, P3, P4, P5

Special Note: Please always:

1). PRINT your name and section number CLEARLY on the front page of your HW.

2). STAPLE all your pages. It is your responsibility to make sure that your hw gets submitted in one piece.

3). DO ALL THE PROBLEMS IN ORDER.

4). Show complete work and write logically consistent explanations for ALL PROBLEMS to receive credit.

5). Write units next to all dimensionful quantities.

Short Answer Questions

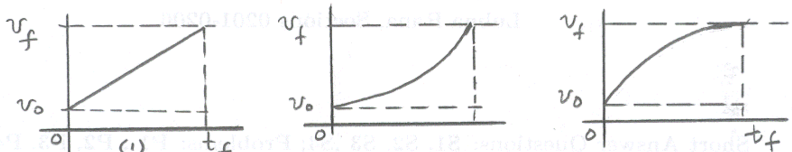
S1). Consider a car moving along a highway. Answer the following questions, giving an explanation of your answer in each case. Sketch at least one possible set of a versus t, v versus t, and x versus t graphs corresponding to your description in each case. a). If the acceleration of the car is zero, what are the possible values of velocity?

b). Under what circumstances is the acceleration in the opposite direction to the velocity?

c) How might you drive a car so that the acceleration would go through zero (from positive to negative) while the velocity remains positive?

d). How might you drive a car so that the velocity would go through zero (from negative to positive) while the acceleration remains positive?

S2). Consider the three different plots of velocity v versus clock reading t shown in the figure.

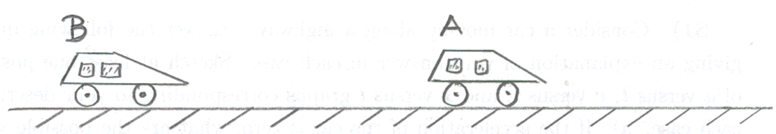


a). In case 1, argue that the average velocity $\bar{v}$ over the time interval between $t = 0$ and $t = t_f$ must be equal to $(v_0 + v_f)/2$. Explain your reasoning carefully. *Hint: Use the basic definition of average velocity and the fact that Δx is the area under the v vs t curve.*

b). In case 2 and 3, is $\bar{v}$ also equal to $(v_0 + v_f)/2$? Why or why not? If not, how does $\bar{v}$ compare with $(v_0 + v_f)/2$ in each instance? Is it greater or smaller? Explain your reasoning.

S3). A car starts from rest at position $x = 0$ and moves in the positive x direction. At position x_1 it is observed to have a velocity v_1. Some time later, at position $2x_1$ it is observed to have a velocity $2v_1$. At position $3x_1$, it has a velocity $3v_1$, etc.. Is the car accelerating? If it is accelerating, is the acceleration uniform, increasing or decreasing? Explain your reasoning.

S4). Consider a case in which two cars, A and B, are located one behind the other as shown.



a). Suppose car A starts from rest with uniform acceleration a at instant $t = 0$, moving in the positive direction (to the right) along the road. Car B starts somewhat later at $t = t_1$, with exactly the same acceleration. What will happen to the spacing between the cars as time goes by? Will they remain the same distance apart or will the spacing increase or decrease? Explain your reasoning both with relevant diagrams (x vs t graphs) and with an algebraic analysis. (*See Conceptual Example 2.9 for relevant discussion.*)

Problems

P1. The Hundred Meter Dash: A certain sprinter has a top speed of 11.0 m/s. If the sprinter starts from rest and accelerates at a constant rate, she is able to reach her top speed in a distance of $12.0m$. Suppose that she is able to maintain this top speed for the remainder of the $100m$ race.

a). What is her time for the $100m$ dash?

b). In order to decrease this time, the sprinter tries to decrease the distance required for her to reach this top speed. What must this distance if the sprinter is to decrease this time to 10.0 seconds?

c). A cheetah can go from a complete standstill to 45 miles/hr in 2.5 seconds! Suppose that it maintains a speed of 45 mi/hr (although, it can go faster) for the rest of the time, what will be the cheetah's time if it participated in the Olympics 100 meter sprint? *Caution: Watch out for units!*

P2. A car moves along a straight road with a constant speed v_0 when the driver sees a roadblock a distance L away and wants to stop. It takes the driver a time T_r (her reaction time) before she can actually put her foot on the brake pedal. During this time the car continues moving with its previous speed v_0. After the brakes are applied, the car decelerates, with an acceleration of constant magnitude a_0, until it comes to rest a time T_a later.

a). Draw a x vs t plot of the motion of the car. Carefully label the axes and mark all significant times and positions.

b). Are the equations given in Table 2.2 valid for the entire time interval from $t = 0$ to $t = T_r + T_a$? If not then point out the time intervals for which those equations are valid.

c). Find the acceleration a_0 in terms of v_0, L, and T_r. Once you have that expression, use $v_0 = 20m/s$, $L = 120m$, $T_r = .70s$ and find the numerical value of a_0.

d). What is the average velocity of the car over the entire time period $t = 0$ to $t = T_r + T_a$? You can't use Eq. 2.10. Why not? What *can* you use?

P3. Car catching up with a truck:

A stationary car is initially behind a stationary truck. The truck moves with a constant acceleration of $a_T = 1.2m/s^2$ and the car with a constant acceleration of $a_c = 1.8m/^2s$. The car overtakes the truck after the latter has moved $48m$.

a). Plot the positions of the car (x_c) and the truck (x_T) on the same x vs t plot. On this plot, circle the point which indicates the instant when the two vehicles are abreast.

b). How long a time does it take for the car to overtake the truck?

c). How far behind the truck was the car initially?

d). What is the speed of each vehicle when they are abreast?

P4. Ball Thrown Vertically Upward: A person throws a ball vertically upward. The ball is observed to remain in the air during a time T before it lands back in the person's hand. Express the answers to the following questions in terms of T and g.

a). With what speed did the person throw the ball into the air?

b). How long a time elapsed before the ball reached its maximum height h?

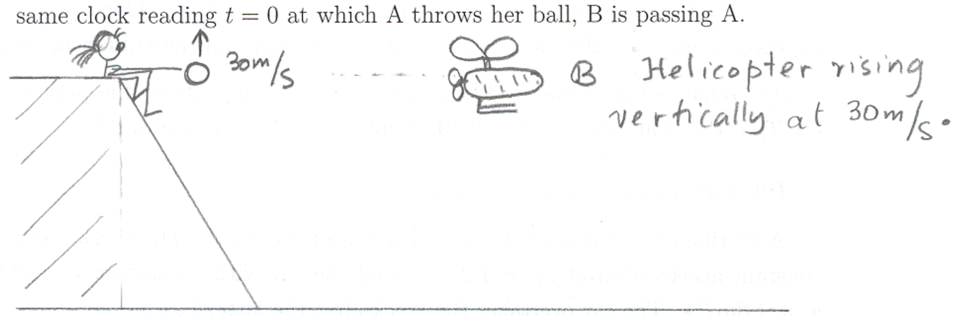
c). How high above the person's hand did the ball rise?

d). The time to go up is equal to the time to go down. Is the time to reach $h/2$ equal to the time to go from $h/2$ to h? Explain.

e). Suppose the ball, instead of being thrown upward, is instead dropped overboard by a hot-air balloonist rising vertically upward with speed v_b. Draw the trajectory of the ball.

P5). A Thought Experiment: Consider a thought experiment to show that a freely falling tennis ball is accelerating even when its instantaneous velocity is zero at the peak of its flight:

At $t = 0$, observer A at the edge of a cliff throws a ball vertically upward with an initial velocity of $30m/s$. Observer B is located in the helicopter, which started at the base of the cliff and is rising vertically at the constant velocity of $30m/s$. At the same clock reading $t = 0$ at which A throws her ball, B is passing A.



a). Describe how observer B perceives the motion of the ball, not relative to the ground but relative to B's own frame of reference in the rising helicopter.