# Physics 100: Homework Assignment #2
## Due Friday, February $2^{nd}$ at the Beginning of Class



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| **Instructor:** | Nathan Bramall | **Lecture:** | MWF 9:10 - 10:00 |
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*Note: you may use your own paper to write out your answers if there is not enough room on this hand-out (it was not designed for such a purpose). Remember also to show all of your work on any calculations!*

**Problem 1:**
As you read this, how fast are you moving relative to the chair you are sitting on? relative to the Sun?
*Review Questions #1, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Unless you have very odd sitting habits, your relative speed compared to the chair you're sitting on should be zero. Your speed relative to the Sun will be roughly 107,000 km/hr = 66,487 mph.*

**Problem 2:**
What kind of speed is registered by an automobile speedometer– average speed or instantaneous speed?
*Review Questions #3, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Ideally, instantaneous speed.*

**Problem 3:**
If a car moves with constant velocity, does it also move with a constant speed?
*Review Questions #8, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Not necessarily. If the car moved with constant speed AND in a constant direction, then yes, it does move with constant velocity. If the car moves with constant speed while changing direction (e.g. driving in a circle), then the velocity is not constant. This is because **velocity** is a measurement of both speed and direction of travel and for velocity to be constant both speed AND direction must remain a constant.*

**Problem 4:**
If a car is moving at 90 km/hr and it rounds a corner, also at 90 km/hr. Does it maintain a constant speed? A constant velocity?
*Review Questions #9, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *It maintains a constant speed as it is not changing its speed as it rounds the corner. It does not maintain a constant velocity as it rounds the corner as velocity is a measurement of speed and direction– as it rounds the corner, its direction changes.*

**Problem 5:**
(A) What is the acceleration of a car that maintains a constant velocity of 100 km/hr West? (B) What is the (average) acceleration of a car that increases its velocity from 0 to 100 km/hr North in a period of 10 seconds? (C) Is the acceleration of a car moving at constant speed around a corner zero?

*Review Questions #11 and #12 (slightly modified), Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt*, plus original question

> **Answer:** *(A) The acceleration of the car is zero as the velocity is not changing (acceleration is the rate of change of velocity). (B) The average acceleration of the car is given by:*
>
> $$Acceleration = \frac{Change\ of\ Velocity}{Time\ Interval\ of\ Change}$$
> $$Acceleration = \frac{100\ km/hr\ North}{10\ s}$$
> $$Acceleration = 10\ km/(hr \cdot s)\ North$$
>
> *(C) No, the acceleration of the car around the corner is not zero since the change of velocity around the corner is not zero (the car is changing direction.).*

**Problem 6:**
(A) What is the gain in speed of a freely falling object during one second (ignore air resistance)? (B) The gain in velocity in one second? (C) If an object is thrown upward, how much speed does it lose each second?

*Review Question #22, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt*, plus original question

> **Answer:** *(A) The speed increases 10 m/s every second (or 10 $m/s^2$, the same as g). (B) The velocity increases 10 m/s every second in the downward direction (or 10 $m/s^2$ downward, the same as **g**).(C) An object thrown upward loses speed at a rate of 10 m/s every second (or 10 $m/s^2$, the same as g).*

**Problem 7:**
(A) What is the distance fallen for a freely falling object 1 s after being dropped from a rest position? (B) What is it 4 s after? Ignore air resistance for this question.

*Review Questions #24, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

> **Answer:** *The distance traveled is given by:*
>
> $$Distance\ fallen = \frac{1}{2} \times (Acceleration\ due\ to\ Gravity) \times (Time\ of\ Fall)^2$$
>
> *For (A), the distance is equal to* $\frac{1}{2} \times (10\ m/s^2) \times (1\ s)^2 = \frac{1}{2} \times\ 10\ m =\ 5\ m$. *For (B), the distance is equal to* $\frac{1}{2} \times (10\ m/s^2) \times (4\ s)^2 = \frac{1}{2} \times\ 160\ m =\ 80\ m$.

**Problem 8:**
Consider these measurements: 10 m, 10 m/s, and 10 $m/s^2$. Which is a measure of distance, which of speed, and which of acceleration (the magnitude, without direction)?

*Review Questions #26, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *10 m is a measure of distance. 10 m/s is a measure of speed (the amount of distance (m) covered per unit of time (s)). 10 m/s2 is a measure of acceleration (the amount the speed (m/s) changes per unit of time (s)).*

**Problem 9:**
Practice as many of the "One-Step Calculations" (page 55 of the text book) you need to in order to feel comfortable in calculating different quantities. You do not need to turn in your work, this question is here just to bring to your attention that you should be able to problems like these on an exam.

*One-Step Calculations #1-22, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *The work done need not be turned in.*

**Problem 10:**
What is the impact speed when a car moving at 100 km/hr bumps into the rear of another car traveling in the same direction at 98 km/hr? What if the two cars were headed in opposite directions– a head-on collision?

*Exercises #1, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *As the two cars are traveling in the same direction, their relative speeds (to each other) is only 2 km/hr, despite their much higher speeds relative to the ground (100 km /hr and 98 km/hr).*

**Problem 11:**
Harry Hotshot can paddle a canoe in still water at 8 km/h. How successful will he be at canoing upstream (north) in a river that flows at 8 km/h (south)? How fast would he be moving, relative to a tree on the bank of the river, if he paddled downstream (south)?

*Exercises #2, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Harry's maximum speed, relative to the water, is 8 km/h. If he paddles upstream (in the opposite direction the water flows) at 8 km/h, his speed relative to the water will still be 8 km/h. However, since the water is moving southward at 8 km/h relative to the river bankf, Harry's northward speed relative to the river bank will be zero– he will not be moving as determined by onlookers on shore.*

**Problem 12:**
Can an automobile with a northward velocity simultaneously have a southward acceleration? Explain.

*Exercises #6, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Yes. Having an acceleration opposing one's velocity means that the speed (magnitude of velocity) is decreasing.*

**Problem 13:**
Acceleration is...

(A) How fast something changes velocity
(B) How fast something changes position
(C) Always in the same direction as the velocity
(D) How long it takes to travel 1 m

*Original problem*

**Answer:** *(A). Strictly speaking, it's the rate of change of velocity. How fast something changes position is speed. Acceleration need not be in the same direction as the velocity, such as when things slow down. How long it takes to travel 1 m isn't really anything but a measure to trip time.*

**Problem 14:**
(A) Starting from rest, one car accelerates to a speed of 50 km/hr, and another car accelerates to a speed of 60 km/hr. Can you say which car underwent the greater acceleration? Why or why not?
(B) Suppose the first car was a Honda Civic and the second car was a Lotus? Could you now say which underwent the greater acceleration?
*Exercises #13, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *(A) No, you can't determine which car underwent a greater acceleration because they did not say how long it took to reach those different speeds and acceleration is a measure of how fast velocity changes. For instance, the first car may have accelerated to 50 km/hr in only 4 s, while the second car may have taken three weeks. In this case the first car would have had a much bigger acceleration. (B) No, you still can't because you still don't know how long it took the cars to accelerate. As the Lotus is capable of accelerating much faster than the Honda, my money is on the Lotus. Keep in mind that this question did not ask which car could accelerate more– clearly that would be the Lotus.*

**Problem 15:**
If it were not for air resistance, why would it be dangerous to go outdoors on rainy days?
*Exercises #36, Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *The rain drops would be moving at nearly 320 mph (see Problem 16), which would be very unpleasant to be hit by. Hail would be downright horrible.*

**Problem 16:**
If there were no air drag, how fast would rain drops hit the ground after falling from a cloud 1 kilometer above the Earth's surface?
*Problems #9 Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Ignoring air resistance, we know that the speed of a free-falling object is given by:*

$$change\ in\ speed\ =\ (accelearation\ due\ to\ gravity) \times (time\ of\ fall)$$

*and that the distance fallen by an object dropped from rest is given by:*

$$distance\ fallen\ =\ \frac{1}{2} \times (accelearation\ due\ to\ gravity) \times (time\ of\ fall)^2$$

*To solve this problem, we only know the distance fallen. From this, we can figure out the time of the fall, and from that we can figure out the change in speed (starting from zero speed, the change in speed will be the final speed). Putting in 1,000 m in for the distance fallen and* $10\ m/s^2$ *in for the acceleration due to gravity, and calling the time of the free-fall t, we have:*

$$1{,}000\ m\ = \frac{1}{2} \times (10\ m/s^2) \times\ t^2$$

$$1{,}000\ m = 5\ m/s^2 \times\ t^2$$
$$1{,}000\ m \times \frac{1}{5m/s^2}\ =\ t^2$$
$$200\ s^2 =\ t^2$$
$$t = \sqrt{200}\ s$$

*now we plug this into the first equation:*

$$speed = (10\ m/s^2) \times (\sqrt{200}\ s) = 10\sqrt{200}\ m/s = 141\ m/s = 316\ mph$$

**Problem 17:**
Consider a vertically launched projectile when air drag is negligible. When is the acceleration due to gravity greater? When ascending, at the top, or when descending? Defend your answer.
*Exercises #35 Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *The acceleration due to gravity is the same for all cases. This is because, once the projectile has left the launcher, the only force acting on it is gravity. The speed may be changing all the time as the relative orientations between the object's velocity and acceleration change, but the acceleration never does.*

**Problem 18:**
A ball is thrown straight up with an initial speed of 30 m/s. How high does it go, and how long is it in the air (neglecting air resistance)?
*Problems #3 Chapter 3 of* Conceptual Physics, $10^{th}$ ed., *by Paul Hewitt.*

**Answer:** *Because we're ignoring air resistance, we know that the time it takes to go up is the time it takes to fall, the distance it goes up is the distance it falls (in all cases, regardless of air resistance), and the initial upward speed is equal to the final downward speed. Using this, we can figure out how long the object needs to fall to go from rest (at the top) to 30 m/s (downward). Using this time, we can calculate the distance fallen. This will be the distance it went up.*

*Ignoring air resistance, we know that the speed of a free-falling object is given by:*

$$\frac{change\ in\ speed}{accelearation\ due\ to\ gravity}\ =\ (time\ of\ fall)$$

*and that the distance fallen by an object dropped from rest is given by:*

$$distance\ fallen\ =\ \frac{1}{2} \times (accelearation\ due\ to\ gravity) \times (time\ of\ fall)^2$$

*In this case, the acceleration due to gravity is 10 m/s$^2$ (Earth's surface), and the change in speed is 30 m/s. Using this information, we find that the time of the fall is:*

$$\frac{30\ m/s}{10\ m/s^2} =\ time\ of\ fall\ = 3\ seconds$$

*Using the second equation, we find that*

$$distance\ fallen\ =\ \frac{1}{2} \times (10\ m/s^2) \times (3\ s)^2$$

$$distance\ fallen \ = \ \frac{1}{2} \times (10\ m/s^2) \times (9\ s^2)$$

$$distance\ fallen \ = \ \frac{1}{2} \times (90\ m)$$

$$distance\ fallen \ = \ 45\ m$$

*How long is it in the air? We know it falls for 3 seconds, so it must have taken 3 seconds to rise up. Therefore, it's in the air for a total of 6 seconds*