# Average Acceleration

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## I. A Very Quick Review

The city of Berlin lies 700 miles due north of the city of Rome. A woman flies in a straight line from Berlin to Rome. The journey takes her four hours.

A. What is her total distance for this journey?
B. What is her total displacement for this journey?
C. What is her average speed for this journey?
D. What is her average velocity for this journey?

**HINT 1:** As always, draw a picture. It's easy to get tricked on this problem if you don't.
**HINT 2:** Your answers to ***B*** & ***D*** might be ***similar*** to your answers to ***A*** & ***C***, but they should ***not*** be ***exactly*** the same.

## II. Instantaneous Velocity.

NOTE: We have ***not yet*** established a method for COMPUTING ***instantaneous velocity***. The key point right now is that we believe that it exists and CAN be computed.

Sometimes you can compute it without thinking too hard--as long as you believe in it.

FOR EXAMPLE:
A car travels at ***constant*** velocity for 30 minutes. During that 30 minutes, it travels 40 miles. What is the car's ***instantaneous*** velocity at precisely the 18th minute, 42nd second?

I guarantee you ***can*** get this. And it's ***not*** a trick.
For harder ones, we need the concept of "Average Acceleration".

## III. Average Acceleration.

***Average Acceleration*** is DEFINED to be:

***the change in instantaneous velocity per time***

$$i.e. \qquad \bar{a} \equiv \frac{\Delta v}{\Delta t}$$

For a deeper understanding of what this means and how to apply it, do the assigned reading in ***YOUR TEXTBOOK*** (Halliday, Resnick & Walker): ***Sections 2.1, 2.2 and 2.3.***

Yaverbaum's 1975 Toyota Corolla could go 0 to 60 mph. Unfortunately, that took it 2 full minutes.
A) Expressed in miles per hour per minute, what was the average acceleration of my Toyota?
B) Expressed in miles per second per second, what was the average acceleration of my Toyota?

## IV. Acceleration & Direction 1

An Audi is driving east at 10 m/s. Over a period of 10 seconds, it speeds up to 50 m/s.
A Buick is driving west at 10 m/s. Over a period of 10 seconds, it speeds up to 50 m/s.
A Camry is driving east at 50 m/s. Over a period of 10 seconds, it slows down to 10 m/s.
A dirt bike is driving west at 50 m/s. Over a period of 10 seconds, it slows down to 10 m/s.

A) Choose which direction (east or west) will be positive and which will be negative. It's up to you.

B) Given the choice you made in part A, write down the initial & final velocity of each vehicle, using negative & positive signs. (By "initial" we mean at the beginning of the 10 seconds, and by "final" we mean at the end of the ten seconds.)

C) Calculate the average acceleration of each vehicle during these 10 seconds.
**HINT:** use the definition of average acceleration: $\bar{a} \equiv \Delta v / \Delta t$

D) In 2-3 sentences, discuss the relationship between speeding up, slowing down, and the sign (negative/positive) of the acceleration. There is a ***very*** common and tenacious ***mis***understanding on this question. Try to figure out what the common misunderstanding is and what the correct understanding is.

## V. Acceleration & Direction 2

A) A particle is moving at a velocity of -17 m/s. What is its speed?

B) What does the negative sign in the velocity indicate? What determines whether a velocity is negative or positive?

C) In some experiment, some hydrogen atom is found to have a ***positive acceleration*** for some segment of its motion. During that segment, is the hydrogen atom necessarily speeding up? Why or why not?
**HINT #1:** It's not particularly relevant that the atom is hydrogen or even that it's an atom.
**HINT #2:** The answer to this question is ***far from obvious***. Think carefully about the ***definition*** of average acceleration.

## VI. Averages & Midpoints.

A) Find the average of each set of numbers below:

i. 1, 2, 3, 4, 5, 6, 7
ii. 4, 5, 6, 7, 8, 9, 10
iii. 3, 5, 7, 9, 11, 13, 15
iv. 12, 17, 22, 27, 32, 37, 42
v. 8, 6, 10, 12, 14, 16
vi. 1, 4, 9, 16, 25, 36, 49

B) How is the sixth sequence above different from the others? What trick can be used to find the averages of the first five? In what situations *can* this trick be used and in what situations can it *not* be used? (Answer in 2-4 complete sentences.)

C) Stare at the fourth equation in the right hand column of the website. How does this exercise relate to that equation? Can you see the connection?