

~~1.8 Astronomical Distances~~ page 23, problem 29.

~~<http://einstein.stcloudstate.edu/Dome/clicks/au.html>~~

~~1.9 Mean Density of Stars~~ page 24, problems 37 and 38.

~~<http://search.yahoo.com/bin/search?p=neutron+stars>~~

1.10 *Position, Velocity, Speed, and Acceleration.*

The position,  $x$  (in m), of an object that moves along a straight line is changing with time,  $t$  (in sec), as follows:

$$x = +16 - 12t + 2t^2$$

- Make a plot of the position  $x$  vs. time from  $t = 0$  to  $t = +6$ .
- Make a plot of the velocity,  $v$  (in m/sec), vs. time from  $t = 0$  to  $t = +6$ .
- Make a plot of the acceleration,  $a$  (in m/sec<sup>2</sup>), vs. time from  $t = 0$  to  $t = +6$ .
- What is the velocity at  $t = 0$ ,  $+2$ , and  $+4$ ?
- What is the acceleration at  $t = 0$ ,  $+2$ , and  $+4$ ?
- When is the velocity zero, and what then is the  $x$  position of the object?
- What is the average velocity between  $t = -1$  and  $t = +3$ ?
- What is the average velocity between  $t = 0$  and  $t = +6$ ?
- What is the average speed between  $t = 0$  and  $t = +6$ ?
- At what time does the object reverse its direction?

~~1.11 Car Crash and Seat Belts~~ page 49, problem 35.

~~1.12 Brain Teaser - Returning to the same Point on Earth.~~

~~A person starts walking at point A on earth. She walks 10 km to the south, stops, then walks 10 km to the east, stops, then 10 km to the north, and she is back at point A where she started. Find all points on the surface of the earth that will meet this condition. Don't miss any, there are an infinite number of them!~~

~~1.13 Human Femur.~~

~~Look at <http://www.wcape.school.za/subject/biology/skeleton/femur.htm>. You will see a human femur on a scale roughly 2:1.~~

- ~~What is the ratio  $d/l$  as defined in class (look at our plot on the 8.01 home page)? The ratio  $d/l$  is independent of the scale. You will not be able to measure the average value of  $d$  as defined in class. This, however would make a difference of at most 10%.~~
- ~~What is the average value of  $d/l$  of the data in our plot? This value is substantially higher than the value under a).~~
- ~~Can you come up with reasons why that may be the case. Frankly, I am somewhat at a loss. Since humans walk on two legs, I had expected the value of  $d/l$  for humans, if anything, to be higher, not lower, than the average value for the mammals in our plot as they walk on four legs.~~

**REMEMBER!**

~~8.01 Home Page <http://www.mit.edu/~8.01/Fall99/>~~

~~There are 26 recitation sections. If you want to change, for whatever reason, please go to the physics education office (4-352).~~

**Problem 1.10** (*Position, Velocity, and Acceleration*)

- a)  $x(t) = 16 - 12t + 2t^2$  (see plot)
- b) By differentiating,  $v(t) = -12 + 4t$  (see plot)
- c) Another differentiation yields  $a(t) = 4$  (see plot)
- d) Using the equation in part b):  
 $v(0) = -12 \text{ m/s}$ ,  $v(2) = -4 \text{ m/s}$ ,  
 $v(4) = 4 \text{ m/s}$
- e) Using the equation in part c):  $a(0) = 4 \text{ m/s}^2$ ,  
 $a(2) = 4 \text{ m/s}^2$ ,  $a(4) = 4 \text{ m/s}^2$
- f) Set  $v(t) = -12 + 4t = 0$  to find that  $t = 3 \text{ s}$ .  
 Now, plug this  $t$  into the equation for  $x(t)$  to  
 find the position of the object when the velocity  
 is 0. To summarize  $x(3) = -2 \text{ m}$ ,  $v(3) =$   
 $0 \text{ m/s}$ , and of course  $a(3) = 4 \text{ m/s}^2$ .

- g) The average velocity between two times is de-  
 fined as

$$\bar{v}_{t_1, t_2} \equiv \frac{x(t_2) - x(t_1)}{t_2 - t_1}$$

$$\rightarrow \bar{v}_{-1, 3} = \frac{x(3) - x(-1)}{3 - (-1)} = \frac{-2 - 30}{4} = -8 \text{ m/s}$$

- h) We use the same formula

$$\bar{v}_{0, 6} = \frac{x(6) - x(0)}{6 - 0} = \frac{16 - 16}{6} = 0 \text{ m/s}$$

- i) The average speed  $s$  is the total distance trav-  
 eled over the time taken. The total distance is  
 found by adding up each one-way segment of  
 the complete journey. Looking at the plot, we  
 can see that the object traveled from  $x = 16 \text{ m}$   
 to  $x = -2 \text{ m}$  and back to  $x = 16 \text{ m}$  (this is  
 why plots are useful). The total distance is  $36$   
 $\text{m}$  and the time taken is  $6 \text{ s}$ . Therefore, the  
 average speed is  $s = (36 \text{ m})/(6 \text{ s}) = 6 \text{ m/s}$ .
- j) What does it mean to reverse direction? Of course, it means that you're going one way,  
 and then you turn around and go the other way. If you're going in the negative direction,  
 you then start going in the positive direction and vice versa. In other words, your velocity  
 changes sign. The point at which this happens is at zero (this is an important concept).  
 You can also think about it in terms of the calculus. If you reverse direction, then your  
 position will be a local minimum or maximum at that point. To find where this happens,  
 you take the derivative of position and set it equal to zero. This is exactly the same as  
 setting velocity equal to zero since *velocity is the derivative of position*!
- ¿From part f), we know that  $v(3) = 0$  so the object reverses direction at  $t = 3 \text{ s}$ .

