

**Easy Particle Problem Revisited SOLUTIONS**  
(Everything you've ever wanted to know about the graph of velocity )

**Answers to EASY PARTICLE PROBLEM:**

1. "Y" Position on graph of  $v(t)$  at  $t = 8 \rightarrow 0 \frac{ft}{sec}$
2.  $a(7) \rightarrow$  slope of  $v(t)$  at 7  $\rightarrow$  between (6,3)& (8,0) are on  $v(t) \rightarrow \frac{0-3}{8-6} \rightarrow \frac{-3}{2} \frac{ft}{sec^2}$
3. Position =  $s(0)$  + displacement  $\int v(t)dt \rightarrow 3$  + area from 0 to 2 - area from 2 to 5  $\rightarrow 3 + 2.5 - 4 \rightarrow 1.5 ft$
4. To the right when  $v(t)$  is above the x-axis  $\rightarrow [0,2), (5,8), (11,12)$
5. To the left when  $v(t)$  is below the x-axis  $\rightarrow (2,5), (8,11)$
6. particle changes direction when  $v(t)$  changes signs  $\rightarrow 4 \text{ times}$
7. "Speed" =  $|v(t)|$ : "speeds up" when  $|v(t)|$  has a positive slope  $\rightarrow (0,1) \wedge (2,3) \wedge (5,6) \wedge (8,9) \wedge (11,12)$   
This is also where  $v(t)$  and  $a(t)$  have the same sign
8. "Speed" =  $|v(t)|$ : "slows down" when  $|v(t)|$  has a negative slope  $\rightarrow (1,2) \wedge (4,5) \wedge (6,8) \wedge (9,11)$   
This is also where  $v(t)$  and  $a(t)$  have different signs
9. At rest when  $v(t) = 0 \rightarrow$  at  $t = 2, t = 5, t = 8, t = 11$
10. **Never**, its velocity is only zero at 4 points only (for an instant)
11.  $a(t) > 0$  when the slope of  $v(t)$  is positive  $\rightarrow (0,1) \wedge (4,5) \wedge (5,6) \wedge (9,12)$
12.  $a(t) < 0$  when the slope of  $v(t)$  is negative  $\rightarrow (1,3) \wedge (6,8) \wedge (8,9)$
13.  $a(t) = 0$  when the slope of  $v(t)$  is zero  $\rightarrow (3,4)$
14. largest positive slope of  $v(t) = 3 \frac{ft}{sec^2}$  on (5,6)
15. Total Distance =  $\int |v(t)| dt$  add areas under curves as positive values  $\rightarrow 2.5 + 4 + 4.5 + 3 + .5 \rightarrow 14.5 ft$
16. Position = initial point + left movement + right movement (4 & 5 above)  $\rightarrow t = 8$  seconds  
(Note that  $s(0) = 3, s(2) = 5.5, s(5) = 1.5, s(8) = 6, s(11) = 3, s(12) = 3.5$ )
17. Find position at  $s(8)$  from above  $\rightarrow 3(s(0)) + 2.5 - 4 + 4.5 \rightarrow 6 ft$
18. Check at the end of left movement  $s(5)$  and  $s(11)$  because it started in a positive position  $\{s(0)=3\}$ ,  
 $s(5) = 3 + 2.5 - 4 = 1.5; s(11) = 1.5 \{ \text{from } s(5) \} 4.5 - 3 = 3$  therefore **NEVER** since on  $[0,12]$  there was never a negative position
19. Given a velocity graph the average acceleration can be found by finding the slope using the given interval:  
thus  $\frac{v(12) - v(0)}{12 - 0} = \frac{1 - 1}{12} \rightarrow 0$  OR use the formula  $\frac{1}{12 - 0} \int_0^{12} a(t) dt = \frac{1}{12} (v(12) - v(0)) = \frac{1 - 1}{12 - 0} = 0$
20. Using the average(mean) value theorem:  $\frac{1}{12 - 0} \int_0^{12} v(t) dt = \frac{1}{12} [2.5 - 4 + 4.5 - 3 + .5] = \frac{1}{12} \left[ \frac{1}{2} \right] \rightarrow \frac{1}{24} \frac{ft}{sec}$