

**AP<sup>®</sup> CALCULUS AB**  
**2016 SCORING GUIDELINES**

**Question 2**

For  $t \geq 0$ , a particle moves along the  $x$ -axis. The velocity of the particle at time  $t$  is given by

$$v(t) = 1 + 2\sin\left(\frac{t^2}{2}\right). \text{ The particle is at position } x = 2 \text{ at time } t = 4.$$

- (a) At time  $t = 4$ , is the particle speeding up or slowing down?  
 (b) Find all times  $t$  in the interval  $0 < t < 3$  when the particle changes direction. Justify your answer.  
 (c) Find the position of the particle at time  $t = 0$ .  
 (d) Find the total distance the particle travels from time  $t = 0$  to time  $t = 3$ .

(a)  $v(4) = 2.978716 > 0$   
 $v'(4) = -1.164000 < 0$

The particle is slowing down since the velocity and acceleration have different signs.

(b)  $v(t) = 0 \Rightarrow t = 2.707468$

$v(t)$  changes from positive to negative at  $t = 2.707$ .  
 Therefore, the particle changes direction at this time.

(c)  $x(0) = x(4) + \int_4^0 v(t) dt$   
 $= 2 + (-5.815027) = -3.815$

(d) Distance  $= \int_0^3 |v(t)| dt = 5.301$

2 : conclusion with reason

2 :  $\begin{cases} 1 : t = 2.707 \\ 1 : \text{justification} \end{cases}$

3 :  $\begin{cases} 1 : \text{integral} \\ 1 : \text{uses initial condition} \\ 1 : \text{answer} \end{cases}$

2 :  $\begin{cases} 1 : \text{integral} \\ 1 : \text{answer} \end{cases}$