

**MOTION FREE RESPONSE QUESTIONS**

**Work through each FRQ on a separate sheet of paper.**

**Motion FRQ #1 – Calculator Allowed**

A particle moves along the  $x$ -axis so that its velocity at time  $t$  is given by

$$v(t) = -(t + 1) \sin\left(\frac{t^2}{2}\right).$$

At time  $t = 0$ , the particle is at position  $x = 1$ .

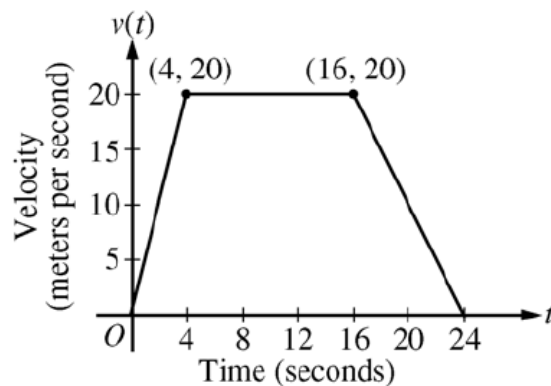
- Find the acceleration of the particle at time  $t = 2$ . Is the speed of the particle increasing at  $t = 2$ ? Why or why not?
- Find all times  $t$  in the open interval  $0 < t < 3$  when the particle changes direction. Justify your answer.
- Find the total distance traveled by the particle from time  $t = 0$  until time  $t = 3$ .
- During the time interval  $0 \leq t \leq 3$ , what is the greatest distance between the particle and the origin? Show the work that leads to your answer.

**Motion FRQ #2 – Calculator Allowed**

A particle moves along the  $y$ -axis so that its velocity  $v$  at time  $t \geq 0$  is given by  $v(t) = 1 - \tan^{-1}(e^t)$ . At time  $t = 0$ , the particle is at  $y = -1$ . (Note:  $\tan^{-1} x = \arctan x$ )

- Find the acceleration of the particle at time  $t = 2$ .
- Is the speed of the particle increasing or decreasing at time  $t = 2$ ? Give a reason for your answer.
- Find the time  $t \geq 0$  at which the particle reaches its highest point. Justify your answer.
- Find the position of the particle at time  $t = 2$ . Is the particle moving toward the origin or away from the origin at time  $t = 2$ ? Justify your answer.

### Motion FRQ #3 – NO Calculator



A car is traveling on a straight road. For  $0 \leq t \leq 24$  seconds, the car's velocity  $v(t)$ , in meters per second, is modeled by the piecewise-linear function defined by the graph above.

- Find  $\int_0^{24} v(t) dt$ . Using correct units, explain the meaning of  $\int_0^{24} v(t) dt$ .
- For each of  $v'(4)$  and  $v'(20)$ , find the value or explain why it does not exist. Indicate units of measure.
- Let  $a(t)$  be the car's acceleration at time  $t$ , in meters per second per second. For  $0 < t < 24$ , write a piecewise-defined function for  $a(t)$ .
- Find the average rate of change of  $v$  over the interval  $8 \leq t \leq 20$ . Does the Mean Value Theorem guarantee a value of  $c$ , for  $8 < c < 20$ , such that  $v'(c)$  is equal to this average rate of change? Why or why not?