**CALCULUS AB**

**SECTION II, Part A**

**Time—30 minutes**

**Number of questions—2**

**A GRAPHING CALCULATOR IS REQUIRED FOR THESE QUESTIONS.**

1. People enter a line for an escalator at a rate modeled by the function $r$ given by

$$r(t) = \begin{cases} 44\left(\frac{t}{100}\right)^3\left(1 - \frac{t}{300}\right)^7 & \text{for } 0 \le t \le 300 \\ 0 & \text{for } t > 300, \end{cases}$$

where $r(t)$ is measured in people per second and $t$ is measured in seconds. As people get on the escalator, they exit the line at a constant rate of 0.7 person per second. There are 20 people in line at time $t = 0$.

(a) How many people enter the line for the escalator during the time interval $0 \le t \le 300$ ?

(b) During the time interval $0 \le t \le 300$, there are always people in line for the escalator. How many people are in line at time $t = 300$ ?

(c) For $t > 300$, what is the first time $t$ that there are no people in line for the escalator?

(d) For $0 \le t \le 300$, at what time $t$ is the number of people in line a minimum? To the nearest whole number, find the number of people in line at this time. Justify your answer.

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2. A particle moves along the $x$-axis with velocity given by $v(t) = \dfrac{10\sin\left(0.4t^2\right)}{t^2 - t + 3}$ for time $0 \le t \le 3.5$.

The particle is at position $x = -5$ at time $t = 0$.

(a) Find the acceleration of the particle at time $t = 3$.

(b) Find the position of the particle at time $t = 3$.

(c) Evaluate $\int_0^{3.5} v(t)\,dt$, and evaluate $\int_0^{3.5} |v(t)|\,dt$. Interpret the meaning of each integral in the context of the problem.

(d) A second particle moves along the $x$-axis with position given by $x_2(t) = t^2 - t$ for $0 \le t \le 3.5$. At what time $t$ are the two particles moving with the same velocity?

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**END OF PART A OF SECTION II**

# AP® CALCULUS AB/CALCULUS BC
# 2018 SCORING GUIDELINES

## Question 1

(a) $\int_0^{300} r(t)\,dt = 270$

According to the model, 270 people enter the line for the escalator during the time interval $0 \le t \le 300$.

2 : { 1 : integral; 1 : answer }

(b) $20 + \int_0^{300} (r(t) - 0.7)\,dt = 20 + \int_0^{300} r(t)\,dt - 0.7 \cdot 300 = 80$

According to the model, 80 people are in line at time $t = 300$.

2 : { 1 : considers rate out; 1 : answer }

(c) Based on part (b), the number of people in line at time $t = 300$ is 80.

The first time $t$ that there are no people in line is $300 + \frac{80}{0.7} = 414.286$ (or 414.285) seconds.

1 : answer

(d) The total number of people in line at time $t$, $0 \le t \le 300$, is modeled by $20 + \int_0^t r(x)\,dx - 0.7t$.

$r(t) - 0.7 = 0 \Rightarrow t_1 = 33.013298,\ t_2 = 166.574719$

| $t$ | People in line for escalator |
|---|---|
| 0 | 20 |
| $t_1$ | 3.803 |
| $t_2$ | 158.070 |
| 300 | 80 |

The number of people in line is a minimum at time $t = 33.013$ seconds, when there are 4 people in line.

4 : { 1 : considers $r(t) - 0.7 = 0$; 1 : identifies $t = 33.013$; 1 : answers; 1 : justification }