AP CALCULUS AB/BC

Scoring Guidelines

Part A (AB or BC): Graphing Calculator Required

t (hours)	0	2	4	6	8	10	12
$R(t)$ (vehicles per hour)	2935	3653	3442	3010	3604	1986	2201

1. On a certain weekday, the rate at which vehicles cross a bridge is modeled by the differentiable function R for $0 \le t \le 12$, where $R(t)$ is measured in vehicles per hour and t is the number of hours since 7:00 A.M. ($t = 0$). Values of $R(t)$ for selected values of t are given in the table above.

   (a) Use the data in the table to approximate $R'(5)$. Show the computations that lead to your answer. Using correct units, explain the meaning of $R'(5)$ in the context of the problem.

   (b) Use a midpoint sum with three subintervals of equal length indicated by the data in the table to approximate the value of $\int_0^{12} R(t)dt$. Indicate units of measure.

   (c) On a certain weekend day, the rate at which vehicles cross the bridge is modeled by the function H defined by $H(t) = -t^3 - 3t^2 + 288t + 1300$ for $0 \le t \le 17$, where $H(t)$ is measured in vehicles per hour and t is the number of hours since 7:00 A.M. ($t = 0$). According to this model, what is the average number of vehicles crossing the bridge per hour on the weekend day for $0 \le t \le 12$?

   (d) For $12 < t < 17$, $L(t)$, the local linear approximation to the function H given in part (c) at $t = 12$, is a better model for the rate at which vehicles cross the bridge on the weekend day. Use $L(t)$ to find the time t, for $12 < t < 17$, at which the rate of vehicles crossing the bridge is 2000 vehicles per hour. Show the work that leads to your answer.

Part A (AB or BC): Graphing calculator required
Scoring Guidelines for Question 1

9 points

Learning Objectives: CHA-2.D CHA-3.A CHA-3.C CHA-3.F CHA-4.B LIM-5.A

(a) Use the data in the table to approximate $R'(5)$. Show the computations that lead to your answer. Using correct units, explain the meaning of $R'(5)$ in the context of the problem.

Model Solution	Scoring	
$R'(5) \approx \frac{R(6)-R(4)}{6-4} = \frac{3010-3442}{2} = -216$	Approximation using values from table	**1 point** 2.B
At time $t = 5$ hours (12 P.M.), the rate at which vehicles cross the bridge is decreasing at a rate of approximately 216 vehicles per hour per hour.	Interpretation with units	**1 point** 3.F 4.B
	Total for part (a)	**2 points**

(b) Use a midpoint sum with three subintervals of equal length indicated by the data in the table to approximate the value of $\int_0^{12} R(t)\,dt$. Indicate units of measure.

$\int_0^{12} R(t)\,dt \approx 4(R(2)+R(6)+R(10))$	Midpoint sum setup	**1 point** 1.E
$= 4(3653+3010+1986)$ $= 34{,}596$ vehicles	Approximation using values from the table with units	**1 point** 2.B 4.B
	Total for part (b)	**2 points**

(c) What is the average number of vehicles crossing the bridge per hour on the weekend day for $0 \le t \le 12$?

$\frac{1}{12-0}\boxed{\int_0^{12} H(t)\,dt} = 2452$ Definite integral — Answer	Definite integral	**1 point** 1.D 4.C
	Answer with supporting work	**1 point** 1.E
	Total for part (c)	**2 points**

(d) Use $L(t)$ to find the time t, for $12 \le t \le 17$, at which the rate of vehicles crossing the bridge is 2000 vehicles per hour. Show the work that leads to your answer.

$L(t) = H(12) - H'(12)(t-12)$ $H(12) = 2596,\ H'(12) = -216$	Slope	**1 point** 1.E 4.E
$L(t) = 2000$	$L(t) = 2000$	**1 point** 1.D
$\Rightarrow t = 14.759$	Answer with supporting work	**1 point** 1.E 4.E
	Total for part (d)	**3 points**
	Total for Question 1	**9 points**