



AP[®] Calculus BC

Free-Response Questions

Answer QUESTION 1 parts (a) and (b) on this page.

Response for question 1(a)

\int rate arrive = # arrive ... 😊

total # vehicles that arrive = $\int_1^5 A(t) dt$

1pt: answer

Response for question 1(b)

avg value of rate arrive ... avg value $A(t)$... 😊

avg value of the rate arrive = $\frac{1}{5-1} \int_1^5 A(t) dt$
 = 375.537

1pt: uses avg value formula

1pt: answer

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

Answer QUESTION 1 parts (c) and (d) on this page.

Response for question 1(c)

rate arrive inc or dec?
 $A(t)$ inc or dec?
 $A'(t) > 0$ or < 0 ? @ $t=1$? ☺

1pt: considers $A'(1)$

$$A'(1) = 148.947$$

The rate at which vehicles arrive @ $t=1$
is inc b/c $A'(1) > 0$

1pt: answer w/ reason

Response for question 1(d)

line forms when $A(t) \geq 400$

Greatest # vehicles \rightarrow does max candidate test ☺

$$A(t) = 400$$

$$A(t) - 400 = 0$$

$$t = \frac{1.496}{1.469}, t = 3.598$$

$$A(t) \geq 0 \text{ on } (1.469, 3.598)$$

↑
a

1pt: considers $N'(t) = 0$

1pt: $t = 1.469$
 $t = 3.598$
(crit #s)

$$N(t) = \int_{1.496}^t (A(x) - 400) dx$$

$$N(1.469) = 0$$

$$N(3.598) = 71.254$$

$$N(4) = 62.338$$

1pt: answer
1pt: justification

The greatest # of vehicles in line on $[1.469, 4]$
is 71.

Answer QUESTION 2 parts (a) and (b) on this page.

Response for question 2(a)

$\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$ ☺

$$\left. \frac{dy}{dx} \right|_{t=4} = \frac{\ln(2+4^2)}{\sqrt{1+4^2}}$$

← ok to stop here.

1pt: answer (must show set-up)

$$= 0.701$$

Response for question 2(b)

$$\text{speed} = |v(4)| = \sqrt{(x'(4))^2 + (y'(4))^2} = 5.035$$

1pt: speed @ t=4 (must show set-up)

$$a(4) = \langle x''(4), y''(4) \rangle = \langle 0.970, 0.444 \rangle$$

1pt: 1st component of a(4)
1pt: 2nd component of a(4) (must show set-up)



Answer QUESTION 2 parts (c) and (d) on this page.

Response for question 2(c)

final pos = initial pos + $\int v(t) dt$... 😊

$$\begin{aligned}
 y(6) &= y(4) + \int_4^6 y'(t) dt \\
 &= 5 + \int_4^6 y'(t) dt \\
 &= 11.571
 \end{aligned}$$

1pt: integrand
 1pt: uses y(4)
 1pt: answer

Response for question 2(d)

$$\begin{aligned}
 \text{total distance} &= \int_4^6 |v(t)| dt \\
 &= \int_4^6 \sqrt{(x'(t))^2 + (y'(t))^2} dt \\
 &= 12.136
 \end{aligned}$$

1pt: integrand
 1pt: answer

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

