

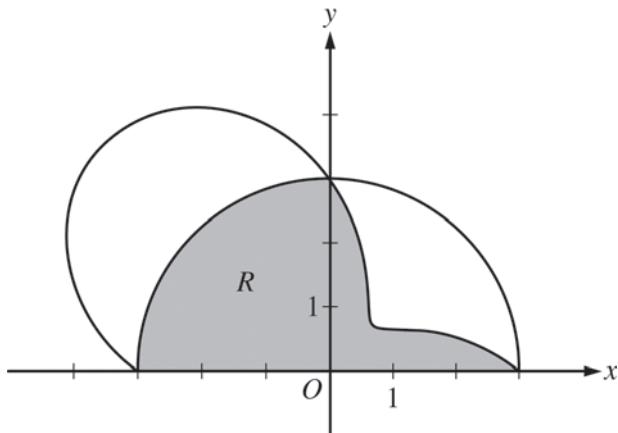
**2014 AP® CALCULUS BC FREE-RESPONSE QUESTIONS**

**CALCULUS BC  
SECTION II, Part A  
Time—30 minutes  
Number of problems—2**

**A graphing calculator is required for these problems.**

1. Grass clippings are placed in a bin, where they decompose. For  $0 \leq t \leq 30$ , the amount of grass clippings remaining in the bin is modeled by  $A(t) = 6.687(0.931)^t$ , where  $A(t)$  is measured in pounds and  $t$  is measured in days.
    - (a) Find the average rate of change of  $A(t)$  over the interval  $0 \leq t \leq 30$ . Indicate units of measure.
    - (b) Find the value of  $A'(15)$ . Using correct units, interpret the meaning of the value in the context of the problem.
    - (c) Find the time  $t$  for which the amount of grass clippings in the bin is equal to the average amount of grass clippings in the bin over the interval  $0 \leq t \leq 30$ .
    - (d) For  $t > 30$ ,  $L(t)$ , the linear approximation to  $A$  at  $t = 30$ , is a better model for the amount of grass clippings remaining in the bin. Use  $L(t)$  to predict the time at which there will be 0.5 pound of grass clippings remaining in the bin. Show the work that leads to your answer.
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2. The graphs of the polar curves  $r = 3$  and  $r = 3 - 2\sin(2\theta)$  are shown in the figure above for  $0 \leq \theta \leq \pi$ .
- Let  $R$  be the shaded region that is inside the graph of  $r = 3$  and inside the graph of  $r = 3 - 2\sin(2\theta)$ . Find the area of  $R$ .
  - For the curve  $r = 3 - 2\sin(2\theta)$ , find the value of  $\frac{dx}{d\theta}$  at  $\theta = \frac{\pi}{6}$ .
  - The distance between the two curves changes for  $0 < \theta < \frac{\pi}{2}$ . Find the rate at which the distance between the two curves is changing with respect to  $\theta$  when  $\theta = \frac{\pi}{3}$ .
  - A particle is moving along the curve  $r = 3 - 2\sin(2\theta)$  so that  $\frac{d\theta}{dt} = 3$  for all times  $t \geq 0$ . Find the value of  $\frac{dr}{dt}$  at  $\theta = \frac{\pi}{6}$ .
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**END OF PART A OF SECTION II**

**AP<sup>®</sup> CALCULUS AB/CALCULUS BC  
2014 SCORING GUIDELINES**

**Question 1**

Grass clippings are placed in a bin, where they decompose. For  $0 \leq t \leq 30$ , the amount of grass clippings remaining in the bin is modeled by  $A(t) = 6.687(0.931)^t$ , where  $A(t)$  is measured in pounds and  $t$  is measured in days.

- (a) Find the average rate of change of  $A(t)$  over the interval  $0 \leq t \leq 30$ . Indicate units of measure.
- (b) Find the value of  $A'(15)$ . Using correct units, interpret the meaning of the value in the context of the problem.
- (c) Find the time  $t$  for which the amount of grass clippings in the bin is equal to the average amount of grass clippings in the bin over the interval  $0 \leq t \leq 30$ .
- (d) For  $t > 30$ ,  $L(t)$ , the linear approximation to  $A$  at  $t = 30$ , is a better model for the amount of grass clippings remaining in the bin. Use  $L(t)$  to predict the time at which there will be 0.5 pound of grass clippings remaining in the bin. Show the work that leads to your answer.

(a)  $\frac{A(30) - A(0)}{30 - 0} = -0.197$  (or  $-0.196$ ) lbs/day

1 : answer with units

(b)  $A'(15) = -0.164$  (or  $-0.163$ )

2 :  $\begin{cases} 1 : A'(15) \\ 1 : \text{interpretation} \end{cases}$

The amount of grass clippings in the bin is decreasing at a rate of 0.164 (or 0.163) lbs/day at time  $t = 15$  days.

(c)  $A(t) = \frac{1}{30} \int_0^{30} A(t) dt \Rightarrow t = 12.415$  (or 12.414)

2 :  $\begin{cases} 1 : \frac{1}{30} \int_0^{30} A(t) dt \\ 1 : \text{answer} \end{cases}$

(d)  $L(t) = A(30) + A'(30) \cdot (t - 30)$

4 :  $\begin{cases} 2 : \text{expression for } L(t) \\ 1 : L(t) = 0.5 \\ 1 : \text{answer} \end{cases}$

$A'(30) = -0.055976$

$A(30) = 0.782928$

$L(t) = 0.5 \Rightarrow t = 35.054$