AP® Physics C: Electricity and Magnetism
2003 Sample Student Responses

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E&M. 2.

In the laboratory, you connect a resistor and a capacitor with unknown values in series with a battery of emf $\mathcal{E}$ = 12 V . You include a switch in the circuit. When the switch is closed at time t = 0, the circuit is completed, and you measure the current through the resistor as a function of time as plotted below.

A data-fitting program finds that the current decays according to the equation $i(t) = \dfrac{\mathcal{E}}{R} e^{-t/4}$.

(a) Using common symbols for the battery, the resistor, the capacitor, and the switch, draw the circuit that you constructed. Show the circuit before the switch is closed and include whatever other devices you need to measure the current through the resistor to obtain the above plot. Label each component in your diagram.

R = resistor
C = capacitor
$\mathcal{E}$ = battery
A = ameter
S = switch

(b) Having obtained the curve shown above, determine the value of the resistor that you placed in this circuit.

$i(0) = .01$ A

$.01 = \dfrac{12}{R}$

$\boxed{R = 1200\ \Omega}$

(c) What capacitance did you insert in the circuit to give the result above?

$$RC = \tau = 4$$

$$1200 \cdot c = 4$$

$$\boxed{c = .0033 \ F}$$

You are now asked to reconnect the circuit with a new switch in such a way as to charge and discharge the capacitor. When the switch in the circuit is in position A, the capacitor is charging; and when the switch is in position B, the capacitor is discharging, as represented by the graph below of voltage V_C across the capacitor as a function of time.

(d) Draw a schematic diagram of the RC circuit that you constructed that would produce the graph above. Clearly indicate switch positions A and B on your circuit diagram and include whatever other devices you need to measure the voltage across the capacitor to obtain the above plot. Label each component in your diagram.
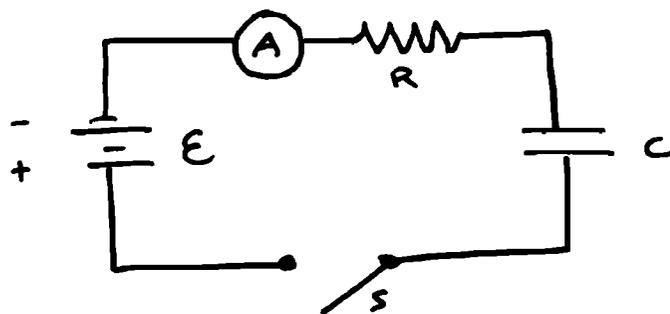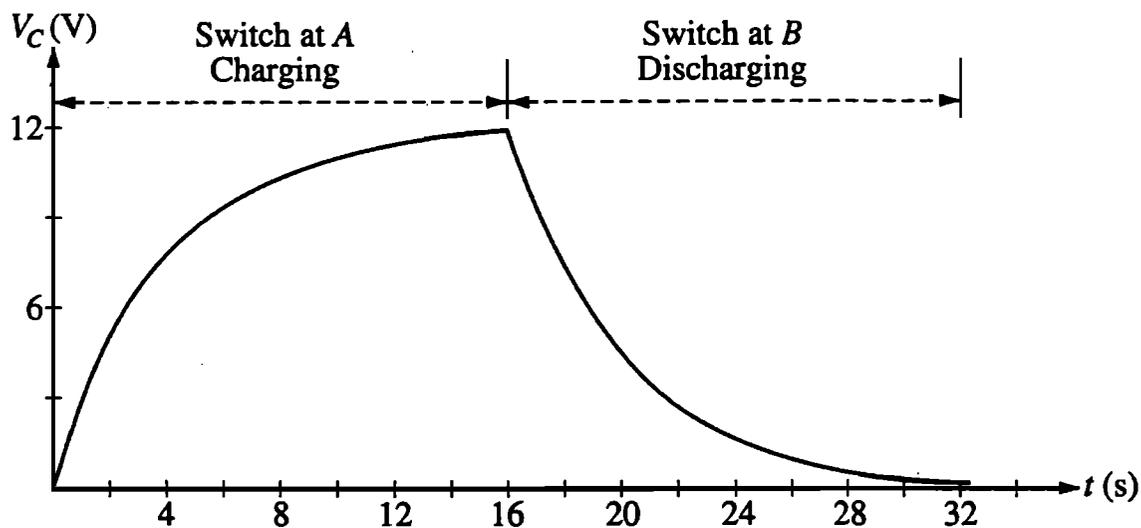

V = voltmeter

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(b) Having obtained the curve shown above, determine the value of the resistor that you placed in this circuit.

$$\frac{12}{R} = e^{-6/4}$$

$$R = \frac{12}{.223}$$

$$\boxed{R \approx .54\,\Omega}$$

$$T = RC$$
$$T = .37$$
$$T \approx 6\text{ sec}$$

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(c) What capacitance did you insert in the circuit to give the result above?
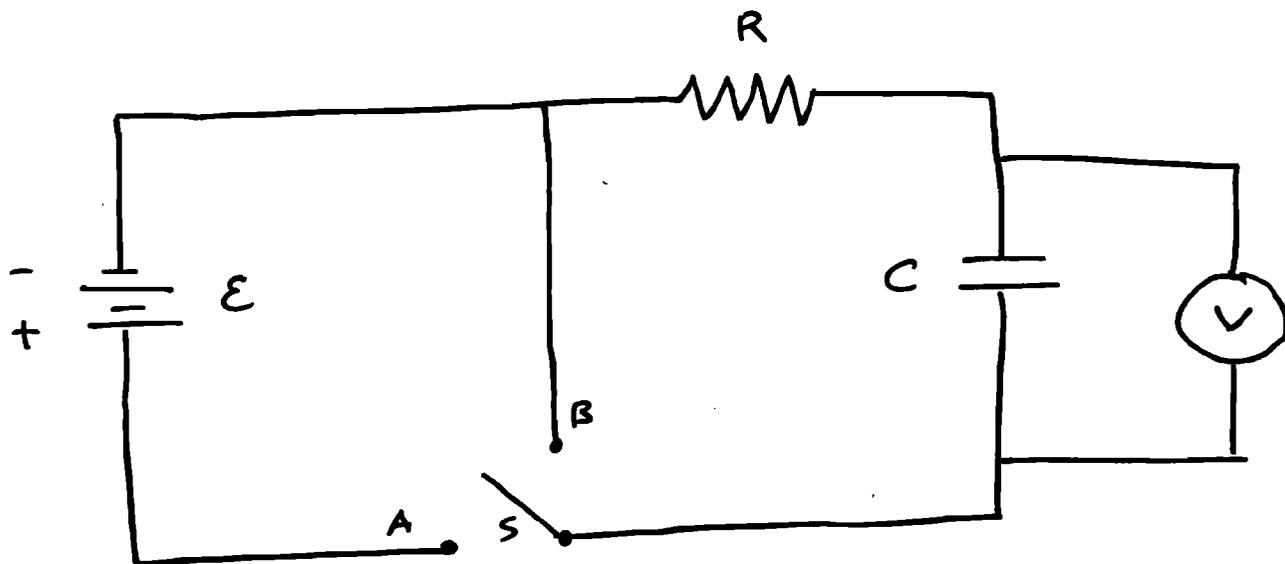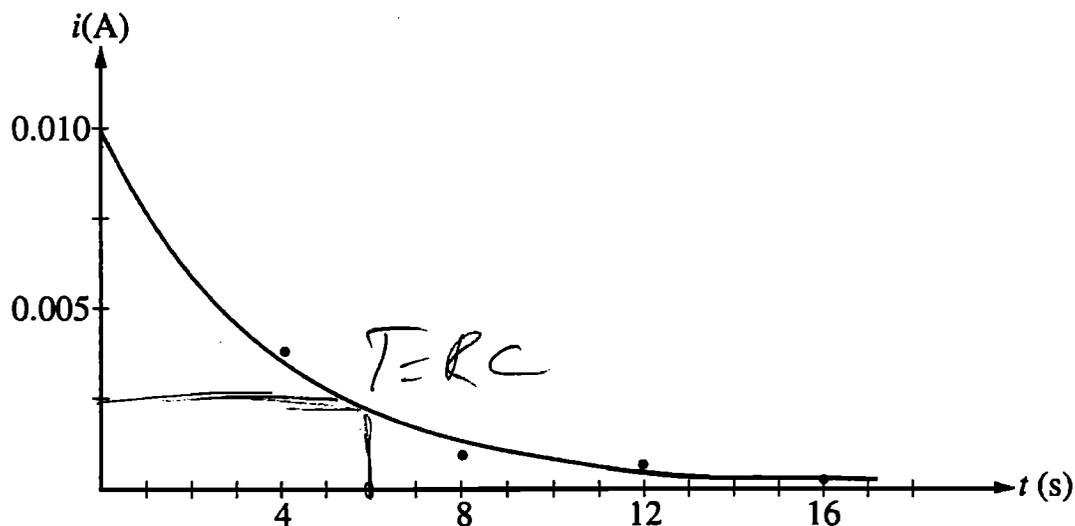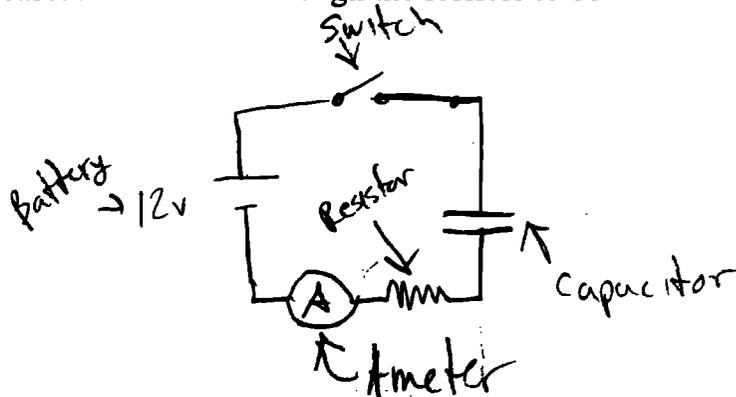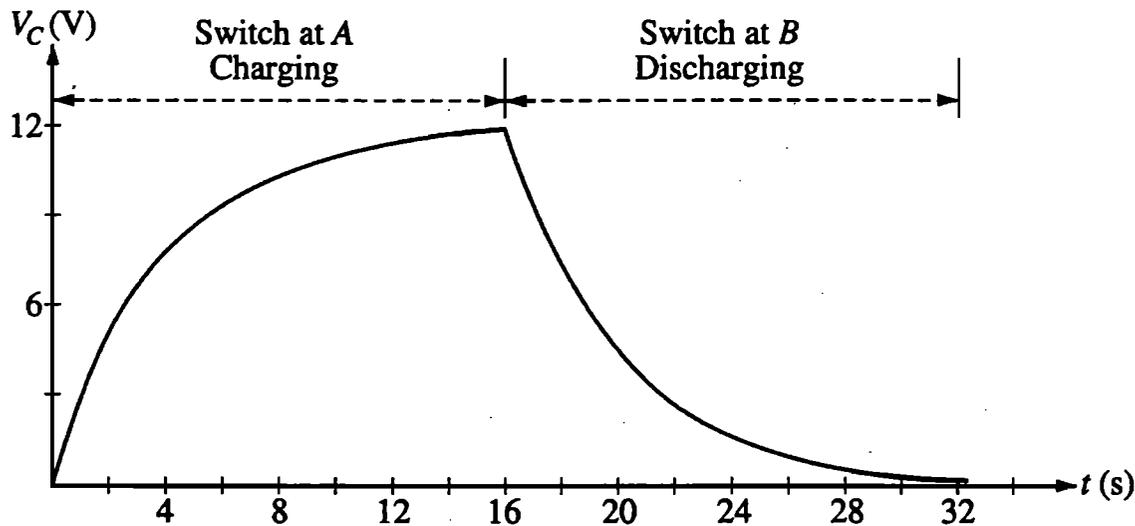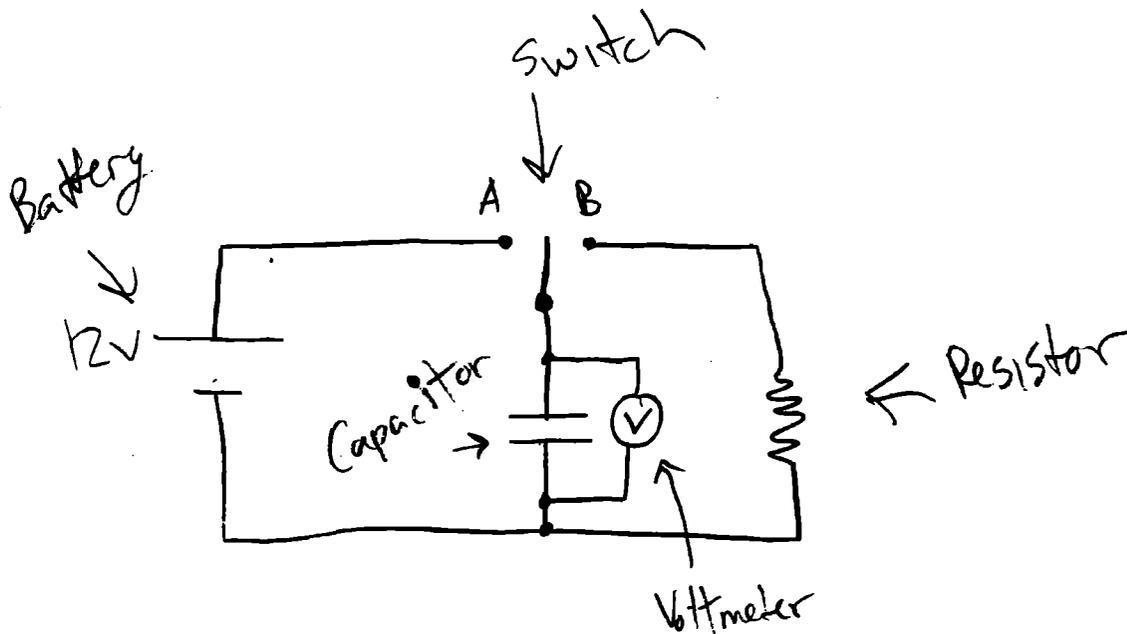
$$T = RC$$
$$6 = (54s)C$$
$$C = \frac{6}{54}$$
$$\boxed{C = .111 \mu F}$$

You are now asked to reconnect the circuit with a new switch in such a way as to charge and discharge the capacitor. When the switch in the circuit is in position A, the capacitor is charging; and when the switch is in position B, the capacitor is discharging, as represented by the graph below of voltage V_C across the capacitor as a function of time.

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