



AP[®] Physics C: Electricity and Magnetism 2004 Sample Student Responses

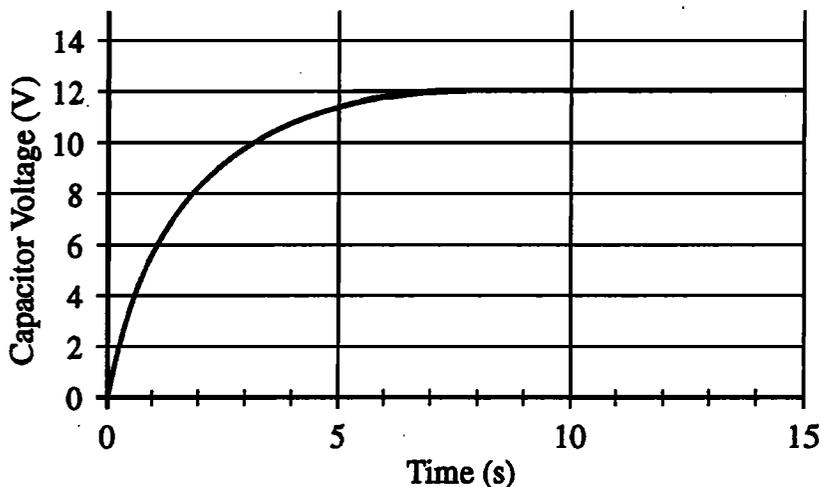
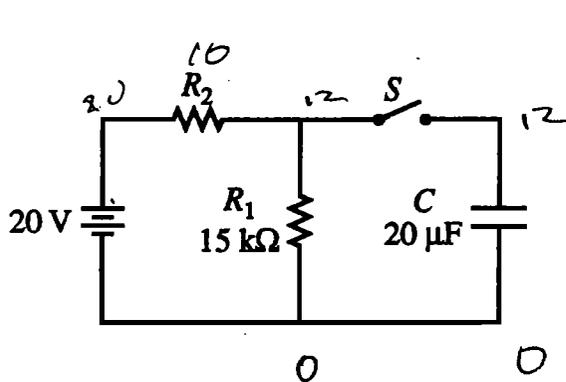
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E&M. 2.

In the circuit shown above left, the switch S is initially in the open position and the capacitor C is initially uncharged. A voltage probe and a computer (not shown) are used to measure the potential difference across the capacitor as a function of time after the switch is closed. The graph produced by the computer is shown above right. The battery has an emf of 20 V and negligible internal resistance. Resistor R_1 has a resistance of $15\text{ k}\Omega$ and the capacitor C has a capacitance of $20\text{ }\mu\text{F}$.

(a) Determine the voltage across resistor R_2 immediately after the switch is closed.

20 V, since no current will go through R_1

(b) Determine the voltage across resistor R_2 a long time after the switch is closed.

$20 - 12 = 8\text{ V}$, since voltage across C is 12 V , and voltage across R_1 is 12 V

$V = IR$

(c) Calculate the value of the resistor R_2 .

$$\frac{8}{20} = \frac{R_2}{15 + R_2}$$

$$8(R_2 + 15) = 20R_2$$

$$8R_2 + 120 = 20R_2$$

$$12R_2 = 120$$

$$R_2 = 10\text{ k}\Omega$$

(d) Calculate the energy stored in the capacitor a long time after the switch is closed.

$$E = \frac{1}{2} CV^2$$

$$= \frac{1}{2} (20\text{ }\mu\text{F})(12\text{ V})^2$$

$$= \frac{1}{2} (20 \times 10^{-6})(144)$$

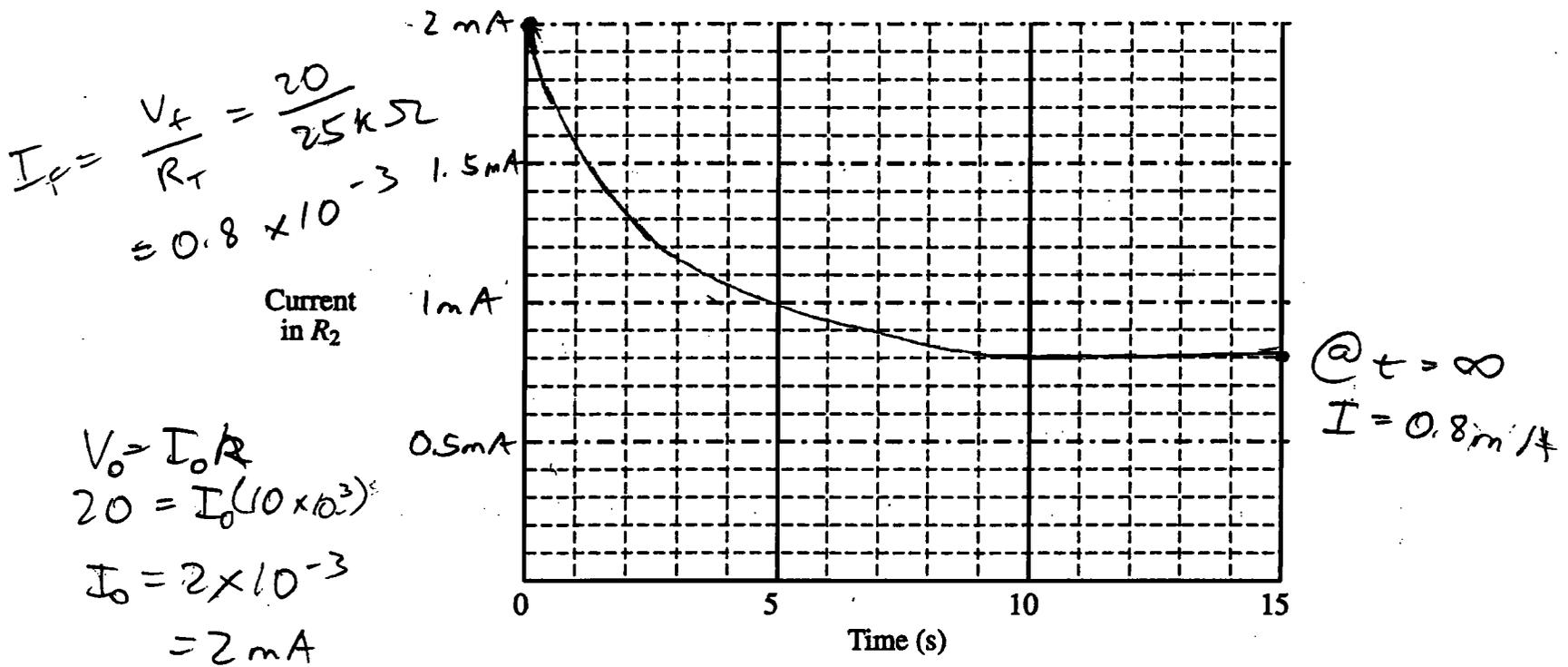
$$= 1.44 \times 10^{-3}\text{ J}$$

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A2

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(e) On the axes below, graph the current in R_2 as a function of time from 0 to 15 s. Label the vertical axis with appropriate values.



Resistor R_2 is removed and replaced with another resistor of lesser resistance. Switch S remains closed for a long time.

(f) Indicate below whether the energy stored in the capacitor is greater than, less than, or the same as it was with resistor R_2 in the circuit.

Greater than Less than The same as

Explain your reasoning.

If R_2 is replaced with a resistor of smaller resistance, the voltage drop across the new resistor will be smaller and thus the voltage drop across the capacitor will be greater, leading to a larger stored energy, since $E = \frac{1}{2} C V^2$

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