On capacitance

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Warm-up problems

1. Sketch graphs of the voltage, current and charge on a capacitor which is being discharged through a resistor.

2. Repeat question 1 for a capacitor in series with a resistor which is being charged by being connected to a battery.

3. What is meant by the *time constant* of a resistor-capacitor combination in charging / discharging? State the expression used to measure it, giving units.

Regular problems

4. Copy and complete the time constant table shown below

C	R	time constant
$1\,\mu F$	$1\,M\Omega$	
	$1\,k\Omega$	$1\,s$
$0.22\,\mu F$	$150\,k\Omega$	
$10\,\mu F$		$0.47\,s$

5. Design a circuit which could be used to investigate the charging and discharging of a capacitor, with appropriate meters for measurement of the relevant quantities.

6. Calculate the energy stored in

   (a) a capacitor with a charge of $2\,C$ and $9\,V$ across its plates,

   (b) a $1\,\mu F$ capacitor charged to $500\,V$.

7. A $1.5\,V$ battery is connected to a $1000\,\mu F$ capacitor in series with a $150\,\Omega$ resistor.

   (a) What is the maximum current which flows through the resistor during charging?

   (b) What is the maximum charge on the capacitor?

   (c) How long does the capacitor take to charge to $1.0\,V$?

8. A $5\,\mu F$ capacitor is charged up to a p.d. of $10\,V$. It is then removed from the charging circuit and connected across an uncharged $2\,\mu F$ capacitor. Calculate

   (a) the initial charge and energy stored in the $5\,\mu F$ capacitor

(b) the final p.d. across the combination

(c) the energy stored by the capacitors at the end. Why is this less than you started with?

9. A student measures the capacitance of a capacitor by placing it in a circuit in series with a 1 MΩ resistor and a 48 V battery. He observes, that 5 s after closing the switch, the voltage across the capacitor is 33 V. What is the capacitance?

Extension problems

10. A voltmeter has a range of 0 to 250 V and the smallest potential difference that can be estimated with is is 0.5 V. A 1.0 µF capacitor is charged to 200 V and then allowed to discharge through a 1.0 MΩ resistor. In what time will the capacitor be completely discharged as indicated by the voltmeter?

11. Two metal plates, each having area 0.05 m^2 are mounted 2 mm apart in a vacuum. This arrangement is found to have a capacitance of 220 pF. The plates are then given a charge of 0.1 µC.

    (a) What is the potential difference between the plates?

    (b) What is the electric field strength between the plates?

    (c) How much energy is stored in this system?

    (d) If the separation of the plates is now doubled, what is the effect on the field between the plates, the potential of the plates, the capacitance and the electrical stored energy? How can this change in energy be accounted for?