University Physics, PHYS 227/232    Sample Midterm 2    Thu Feb 27, 2014

## Useful Equations

Definition of capacitance: $C \equiv \frac{Q}{V}$

Capacitance of a parallel plate capacitor: $C = \kappa \frac{A}{4\pi k d}$ ($\kappa$: dielectric constant)

Capacitors in parallel: $C_{\text{equiv}} = C_1 + C_2 + \ldots$

Capacitors in series: $\frac{1}{C_{\text{equiv}}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

Energy stored in capacitor: $U_{\text{stored}} = \frac{1}{2}CV^2$

Definition of current: $I \equiv \frac{dQ}{dt}$

Ohm's Law, voltage drop across a resistor: $V = IR$

Power dissipated by a resistor: $P = IV = I^2R$ (1 Watt = (1 Coulomb)(1 Volt))

Resistors in series: $R_{\text{equiv}} = R_1 + R_2 + \ldots$

Resistors in parallel: $\frac{1}{R_{\text{equiv}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

## Useful Geometry Equations

Circle circumference: $2\pi r$    Circle area: $\pi r^2$

Sphere surface area: $4\pi r^2$    Sphere volume: $\frac{4}{3}\pi r^3$

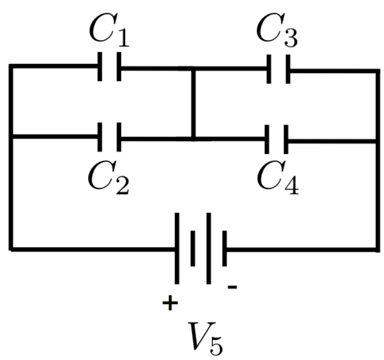
Cylinder surface area: $2\pi r^2$ (ends) $+ 2\pi r L$ (side)    Cylinder volume: $\pi r^2 L$

## Useful Constants

$k = 9.00 \times 10^9$ N m$^2$/C$^2$    $\epsilon_0 = \frac{1}{4\pi k} = 8.85 \times 10^{-12}$ C$^2$/N m$^2$

1 pF = $10^{-12}$ F    1 nF = $10^{-9}$ F    1 $\mu$F = $10^{-6}$ F    1 mF = $10^{-3}$ F

Electron charge: $e = -1.6 \times 10^{-19}$ C




1. The circuit shown above has capacitors $C_1 = 1.0\,\mu\text{F}$, $C_2 = 2.0\,\mu\text{F}$, $C_3 = 3.0\,\mu\text{F}$, and $C_4 = 4.0\,\mu\text{F}$ connected by perfectly conducting wires. The EMF $V_5$ has a voltage across its terminals of $V_5 = 12.0$ V, and the circuit is in a state where the capacitors are charged.

   (a) (3 points) Find the equivalent capacitance of the capacitors.

   (b) (3 points) Find the charges $Q_1$, $Q_2$, $Q_3$, and $Q_4$ of each capacitor.

   (c) (4 points) Find the voltages $V_1$, $V_2$, $V_3$, and $V_4$ across each capacitor. Are they consistent with the voltage across the EMF?

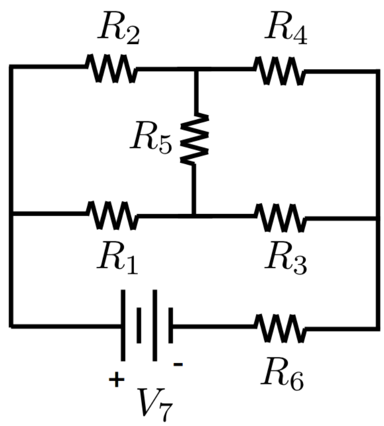
2. An incandescent light bulb has a resistance of $140\,\Omega$ when it is lit and $9.5\,\Omega$ when it is not lit. It is plugged into a DC power supply that provides a constant voltage of 120V.

   (a) (2 points) What current goes through the bulb just as it is plugged in, when it's not lit? What current goes through the bulb after it's lit?

   (b) (2 points) What power does the bulb draw in both cases?

   (c) (3 points) How many electrons pass through the bulb per second when it's lit?

   (d) (3 points) A second light bulb is connected in series with the first one. How much power do both bulbs draw now?




3. The circuit shown above has resistors $R_1 = 1.0\,\Omega$, $R_2 = 2.0\,\Omega$, $R_3 = 3.0\,\Omega$, $R_4 = 4.0\,\Omega$, $R_5 = 5.0\,\Omega$, and $R_6 = 6.0\,\Omega$ connected by perfectly conducting wires. The EMF $V_7$ has a voltage across its terminals of $V_7 = 12.0\,\text{V}$. This circuit cannot be reduced to just parallel and series capacitors; you have to use Kirchhoff's rules to evaluate it.

   (a) (2 points) Draw and label arrows for the six currents in the resistors in the diagram.

   (b) (4 points) There are four nodes in the above diagram. Select three of them and label them A, B, and C in the diagram. Using Kirchhoff's node rule and the currents you have drawn in part (a), write down the current equations for these three nodes.

   (c) (4 points) You need three more equations, so draw three Kirchhoff loops. Using Kirchhoff's loop rule, write down the three voltage equations for these loops.

   (d) (5 points) Solve the equations in parts (b) and (c) to find the currents in each of the resistors.