USEFUL INFORMATION

For two point particles
\[
\vec{F} = \frac{1}{4\pi\varepsilon_0} \frac{q_1q_2}{r^2} \hat{r}
\]

\[
d\vec{r} = \frac{dx}{dt} \hat{x} + \frac{dy}{dt} \hat{y} = \frac{dr}{dt} \hat{r} + r \frac{d\theta}{dt} \hat{\phi}
\]

\[
V(\vec{r}_2) - V(\vec{r}_1) = -\int_{\vec{r}_1}^{\vec{r}_2} \vec{E} \cdot d\vec{r}
\]

\[
C = \frac{Q}{V} \quad R = \rho \frac{l}{A}
\]

\[
\oint \vec{E} \cdot d\vec{S} = \frac{Q_{\text{inside}}}{\varepsilon_0}
\]

\[
V = iR \quad \vec{E} = \rho \vec{j}
\]

For parallel plates \( C = \frac{A\varepsilon_0}{d} \)

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**WARNING:** In any circuit problem, failure to indicate the direction of currents and/or the failure to indicate where charge is located on capacitors will result in no credit being given.

1. 
2. 
3. 
4. 
1. (25 points) In the circuit below, all the $R'$s, and $V'$s are known. Obtain enough equations so that you could find the currents in each resistor if the circuit was put together a long time ago. You must clearly indicate what you are doing or you will receive no credit!

Laws or Definitions

Application

2 points  Result: Find each current if $R_1 = 3\Omega$, $R_2 = 6\Omega$, $R_3 = 4\Omega$, and $V = 6$ volts.
2. (25 points) In the circuit below, all the $R/s$, $C/s$ and $V/s$ are known. Obtain enough equations so that you could find the currents in each resistor and the charges on each capacitor if the circuit was put together a long time ago. You must clearly indicate what you are doing or you will receive no credit!

![Circuit Diagram]

Laws or Definitions

Application

2 points Result: Find all charges and currents if $R_1 = R_4 = 3\Omega$, $R_2 = R_3 = 6\Omega$, $C_1 = C_2 = 4\mu f$, $C_3 = 6\mu f$ and $V_1 = 6\text{volts and } V_2 = 12\text{volts}$
3. (25 points) A very, very long, hollow cylinder has inner radius $A$, outer radius $B$. It has a known uniform charge per unit volume $\rho$.

Find the difference in the electric potential between a point on the axis and a point a distance $A+D$ from the axis of the cylinder, where $A+D < B$.

Laws or Definitions

Application

Result: Find the difference in electrical potential if $D = A$. 
4. (25 points) A spherical shell is made of material with constant resistivity \( \rho_0 \). The shell has inner radius \( A \) and outer radius \( B \). It is inside a second spherical shell that has inner radius \( B \) and outer radius \( G \). The second spherical shell is made of material with resistivity that varies with the distance from the center of the spheres, \( r \), according to \( \rho(r) = \rho_0 \frac{r^2}{G^2} \). The plus terminal of a battery is connected to the inner surface at \( A \). Find the current that would flow if the minus terminal of the battery is connected to a point on the surface at \( B \). Find the current that would flow if the minus terminal of the battery is instead connected to a point on the surface at \( G \).

\[ \text{Laws or Definitions} \]

\[ \text{Application} \]

\[ \text{Result: Find each current if } B = 2A \text{ and } G = 4A. \]