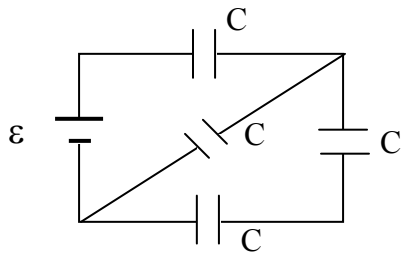
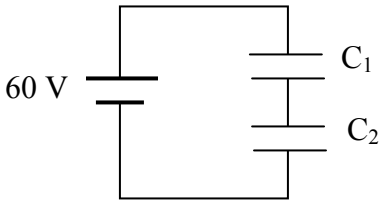
Solve the following 8 problems:

1.(2 marks) Four identical capacitors, each of capacitance 1μF, are connected to a source with emf **ε** as shown in the figure. Calculate the equivalent capacitance of the network.



$C_{eq} = 3C/5$

2.(5 marks) Two air-filled capacitors, $C_1 = 20\mu F$ and $C_2 = 10\mu F$, are connected to a 60 volt battery as shown in the figure. After the capacitors are fully charged, capacitor C_2 is filled with a dielectric material (dielectric constant K= 4). Calculate the change in energy stored in C_1, due to the addition of dielectric in C_2.



Before:

$Ceq = C_1C_2/(C_1+C_2) = 6.67\ \mu F$
$Q = C_{eq}V = 400\ \mu C$
$U_1 = 0.5\ Q^2/C_1 = 4\ mJ$

After :
$Ceq = 13.33\ \mu F$
$Q = C_{eq}V = 800\ \mu C$
$U_1 = 0.5\ Q^2/C_1 = 16\ mJ$
$\Delta U = 12\ mJ$

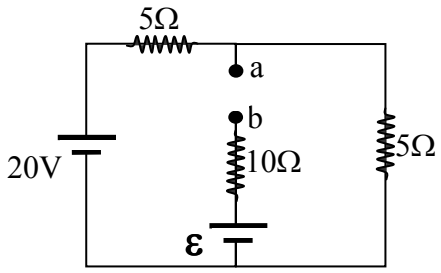
3.(2 marks) A copper wire carries a current of 2 A at 20°C. The temperature coefficient of resistance for Copper is $\alpha=0.004°C^{-1}$. Find the current in the wire when its temperature increases to 100 °C (Assume that the voltage supplied to the wire remains the same).

$I_1 = V/R_1$, $I_2 = V/R_2$ $R_2 = R_1(1+\alpha\Delta T)$

$I_1R_1 = I_2R_2$, $I_2 = I_1/(1+\alpha\Delta T)$

$I_2 = 1.5$ A

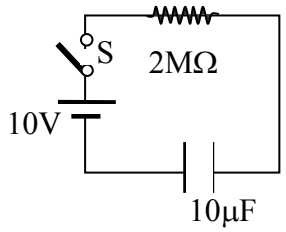
4.(3 marks) In the circuit shown $\boldsymbol{\varepsilon} = 8$V. Find the value of the potential difference $(V_a - V_b)$ between the points a and b.



I = 2A

Vab = 2V

5.(3 marks) In the circuit shown, the capacitor is initially uncharged. The switch S is closed at time t=0. Find the current in the circuit when the charge on the capacitor becomes 63 μC.

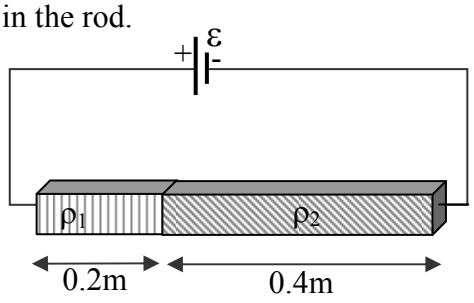


$Q = EC(1- e^{-t/RC})$, $e^{-t/RC} = 1-q/EC$

$e^{-t/RC} = 0.37$

$i = E/R\ e^{-t/RC} = 1.85\ \mu A$

6.(3 marks) A 0.2 m long rod with resistivity $\rho_1 = 4\times10^{-8}$ Ω.m and a 0.4 m long rod with resistivity $\rho_2 = 6\times10^{-8}$ Ω.m have equal and uniform cross sectional area. The two rods are joined to form a single rod which is connected to a 12 V battery. Calculate the current density in the rod.



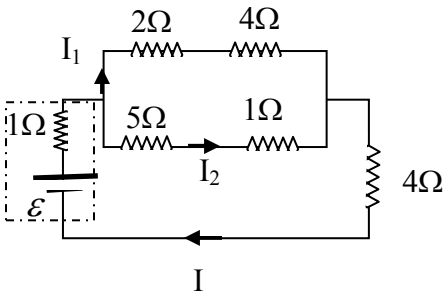
$J = I/A = V/RA$,

$R = (\rho_1 l_1 + \rho_2 l_2)/A$

$J = V/(\rho_1 l_1 + \rho_2 l_2) = 3.75 \times 10^8\ A/m^2$

7.(3 marks) In the circuit shown the battery has an emf of 12 V and an internal resistance of 1 Ω.

Find the power dissipated in the 2 Ω resistor.

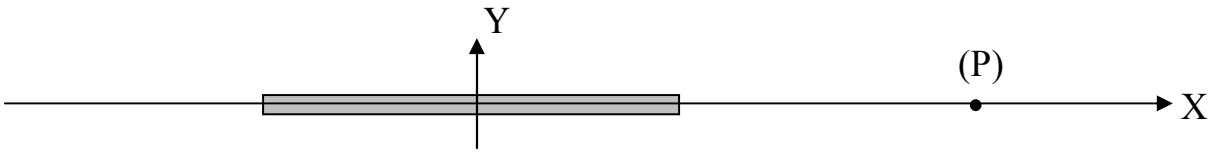


$I = \varepsilon/R_{eq} = 1.5$ A

$I_1 = I_2 = I/2 = 0.75$ A

$P = RI_1^2 = 1.125$ W

8.(3 marks) A 1 m long straight wire has a uniform linear charge density of 6 nC/m. It is placed on the X – axis with its center at the origin. Find the electric potential at the point P where $x_p = 0.8$ m. (Take V= 0 at infinity).



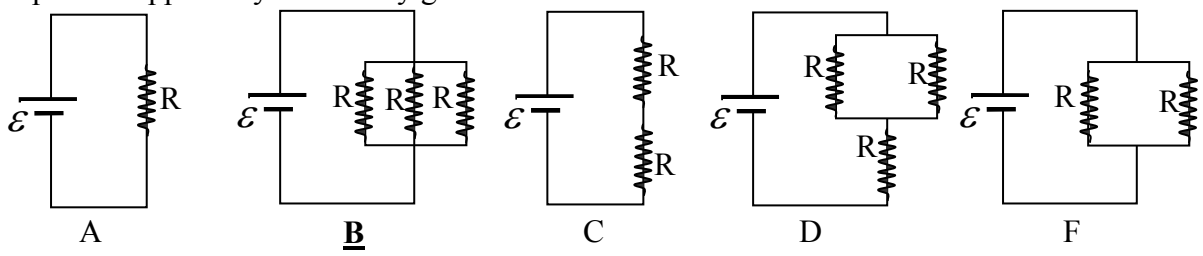
$V = \int kdq/r = \int k\lambda dx/(0.8-x)$ (2)

$= 79$ V (1)

Conceptual questions: (one mark for each question)

Circle the right answer:

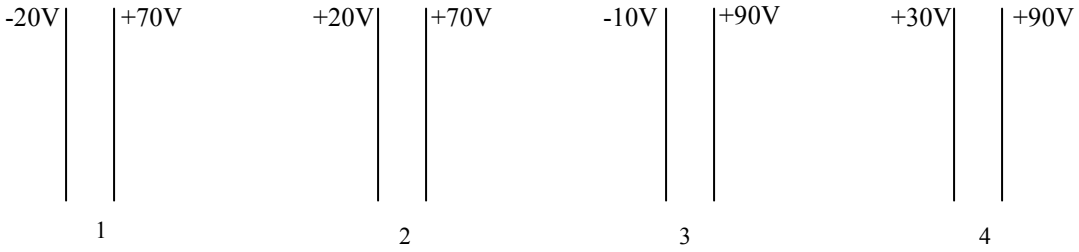
1. In the circuits shown, all batteries have the same emf ($\mathcal{E}$) and all resistors are equal. In which circuit is the power supplied by the battery greatest?



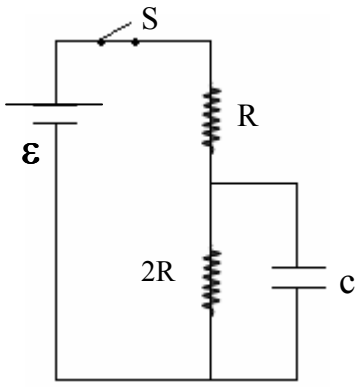
A **B** C D F

2. The diagram shows four pairs of large parallel conducting plates. The value of the electric potential is given for each plate. Rank the pairs according to the magnitude of the electric field between the plates, least to greatest.

a) 1, 2, 3, 4 b) 4, 3, 2, 1 c) 2, 3, 1, 4 **d) 2, 4, 1, 3** e) 3, 2, 4, 1



3. In the circuit shown, the switch S is closed for a long time. The Charge on the capacitor is:



a) $Q=\frac{2\varepsilon}{3}C$ √

b) $Q=\frac{\varepsilon}{3}C$

c) $Q=\frac{3\varepsilon}{2}C$

d) $Q=\frac{\varepsilon}{2}C$

e) $Q=\frac{2\varepsilon}{5}C$

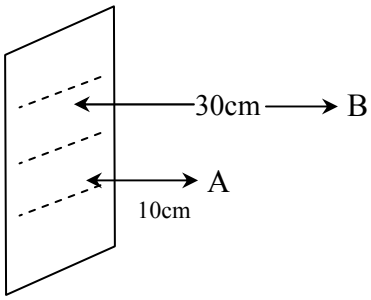
4. If the plate is negatively charged then:

a) $V_A > V_B$

b) $V_A = V_B$

c.) $V_A < V_B$

d) $V_A = 3V_B$



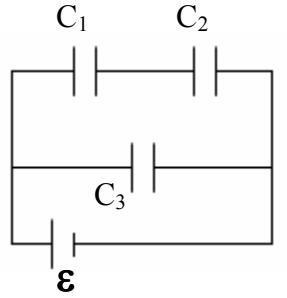
5. In the circuit shown If $C_1 = C_2 = C_3 = C$, then:

a) $Q_1 = 2Q_3$, $Q_1 = Q_2$

b) $Q_3 = 2Q_1$, $Q_1 = Q_2$

c) $Q_1 = Q_2 = Q_3$

d) $Q_1 = Q_2 = 0$, $Q_3 = C\varepsilon$



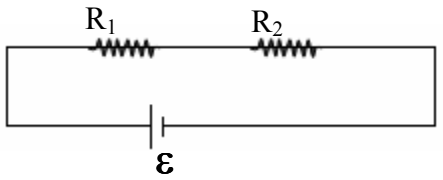
6. In the circuit shown $R_1 > R_2$. If V_1 is the voltage across R_1 and V_2 is the voltage across R_2, then:

a.) $V_1 = V_2 = \varepsilon$

b) $V_1 < V_2$, $V_1 + V_2 = \varepsilon$

c) $V_1 > V_2$, $V_1 + V_2 = \varepsilon$

d) $V_1 > V_2$, $V_1 + V_2 = 0$



7. Four wires, with equal diameters, are connected in turn to the same power supply. Which wire has the largest rate of electrical energy dissipation if their resistivities and lengths are:

a) ρ and 1.2 L

b) 1.2 ρ and L

c) ρ and L

d) 1.2 ρ and 1.2 L

8. If a charged and isolated parallel plate capacitor is filled with a dielectric, then, which of the following physical quantities remains unchanged?

a) The electrical field between the plates

b) The capacitance

c) The stored energy

d) The charge on the plates