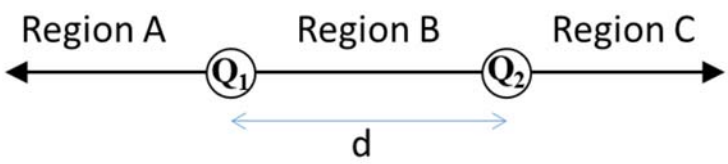
The next three questions pertain to the situation described below.

A positive and a negative charge have mass 0.4 kg and are fixed in position along the x-axis separated by a distance d=0.2 m as shown in below.



$Q1=8.2 \times 10^{-6}$ Coulombs
$Q2=-1.64 \times 10^{-5}$ Coulombs
d =0.2 m
m =0.4 kg

1) If charge Q2 is released from rest, how fast will it be moving when it is a distance d/4 from charge Q1?

$U_i = \frac{kQ_1Q_2}{d_i}$

$U_f = \frac{kQ_1Q_2}{d_f}$

$\Delta U = kQ_1Q_2\left(\frac{1}{d_f} - \frac{1}{d_i}\right)$

$= \frac{3kQ_1Q_2}{d}$

$|\Delta K| = |\Delta U|$

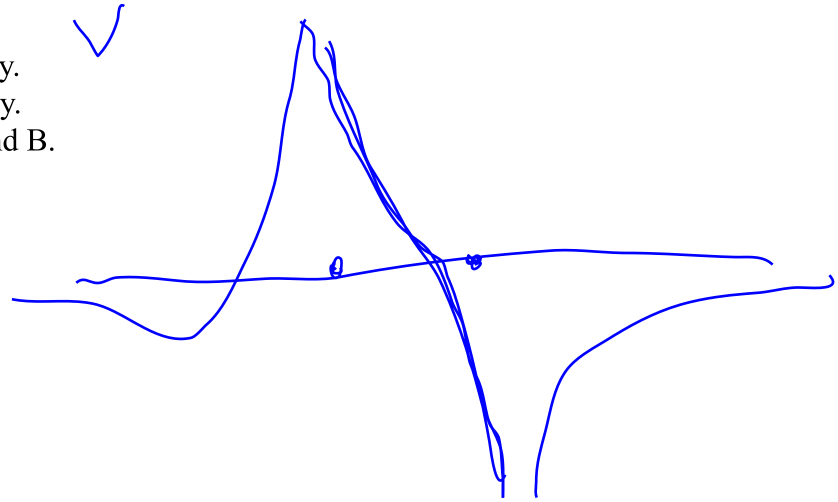
$\Rightarrow \frac{1}{2}mv_f^2 = 3\left|\frac{kQ_1Q_2}{d}\right|$

$v_f^2 = 6\left|\frac{kQ_1Q_2}{dm}\right|$

a. 11 m/s
b. 12.3 m/s
c. 5.5 m/s
d. 9.53 m/s
e. 0 m/s

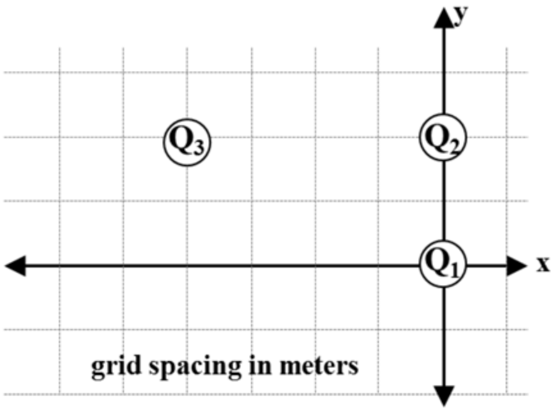
3) In which region(s) is there a point on the x-axis where the electric potential due to the two charges is zero?

a. Region B only.
b. Region A only.
c. Regions A and B.



The next three questions pertain to the situation described below.

Three charges are fixed in position as shown in below. Note, charges Q1 and Q3 are positive, charge Q2 is negative.



$Q1=2.4 \times 10^{-6}$ Coulombs
$Q2=-4.8 \times 10^{-6}$ Coulombs
$Q3=2.4 \times 10^{-6}$Coulombs

$$U_i = 0$$

$$U_f = \frac{kQ_1Q_2}{r_{12}} + \frac{kQ_1Q_3}{r_{13}} + \frac{kq_2q_3}{r_{23}}$$

$$= 9\times10^{9}\cdot10^{-12}\left[\frac{2.4\cdot(-4.8)}{2} + \frac{2.4\cdot2.4}{\sqrt{20}} + \frac{(-4.8)2.4}{4}\right]$$

$$= -0.066\text{ J}$$

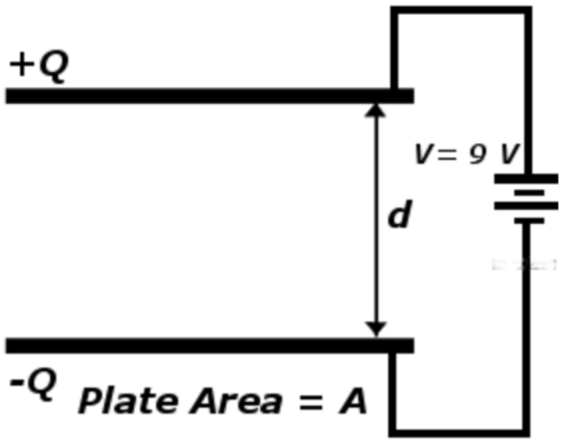
6) How much work does the **electric field** do,when the charges are brought from infinitely far away, to their location in the figure.

a. W_E = -0.0143 J
b. W_E = -0.0662 J
c. W_E = 0.0662 J
d. W_E = 0.0143 J
e. W_E = 0 J

$$W_E = -\Delta U$$

(like lowering a mass in g field)

The next three questions pertain to the situation described below.



$$C = \frac{\varepsilon_0 A}{d}$$

$$= \frac{8.85\times10^{-12} \cdot 542\times10^{-6}}{0.36\times10^{-3}}$$

$$= 1.33\times10^{-11}\ F$$

A parallel plate capacitor consists of two metal plates with an area $A = 542\ mm^2$ separated by a distance $d = 0.36\ mm$. The capacitor is connected to a 9 volt battery as shown above.

16) What is the charge Q on the capacitor?

$Q = CV$

$= 1.33\times10^{-11} \times 9$

$= 0.12 \times 10^{-9}\ C$

a. $Q = 0.539\ nC$
b. $Q = 1.08\ nC$
c. $Q = 120\ nC$
d. $Q = 0.12\ nC$
e. $Q = 1.2 \times 10^{-4}\ nC$

17) If the plates are pulled slightly further apart (increasing *d*) the magnitude of the *electric field* between the plates

fixed $V = Ed$

a. decreases.
b. remains the same.
c. increases.

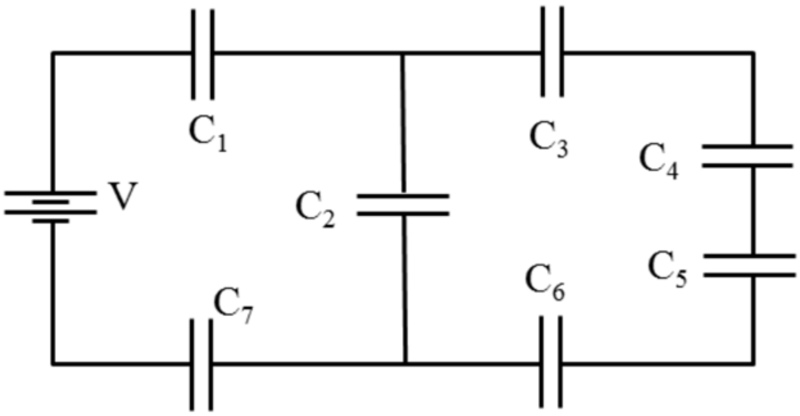
18) If a dielectric of dielectric strength κ is placed between the plates, how will the charge on the capacitor change?

$C = \kappa C_0$

$Q = CV$

a. *decrease by a factor of κ.*
b. *Stay the same.*
c. *Increase by a factor of κ.*

The next four questions pertain to the situation described below.



Seven identical capacitors with capacitance C = 8.5 nF are connected to a 12 Volt battery as shown in the figure above.

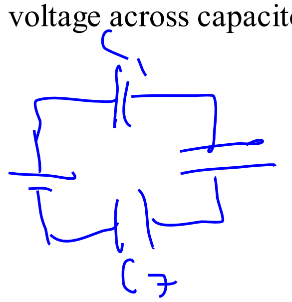
19) Capacitors C_3 and C_6 are connected

A single wire connects them

a. in parallel.
b. in series.
c. neither in series nor in parallel.

20) Compare the magnitude of the voltage across capacitor C_1 with the magnitude of the voltage across capacitor C_7

$Q_1 = Q_{23456} = Q_7$



$V = \frac{Q}{C}$

a. $V_1 = V_7$
b. $V_1 > V_7$
c. $V_1 < V_7$

21) What is the equivalent capacitance of the network of seven capacitors?

$C_{3456} = \frac{C}{4} \Rightarrow C_{23456} = \frac{5}{4}C$

$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_7} + \frac{1}{C_{23456}} = \frac{2.8}{C}$

a. $C_{eq} = 9.92$ nF
b. $C_{eq} = 9.07$ nF
c. $C_{eq} = 23.8$ nF
d. $C_{eq} = 3.04$ nF
e. $C_{eq} = 1.21$ nF

22) What is the voltage across capacitor C_2?

$Q = C_{eq}V = 3.64\times10^{-8}C$

a. $V_2 = 3.4$ Volts
b. $V_2 = 4$ Volts
c. $V_2 = 0.85$ Volts

$V_2 = \frac{Q_2}{C_2}$ $\quad V_{3456} = \frac{Q_{3456}}{C_{3456}}$

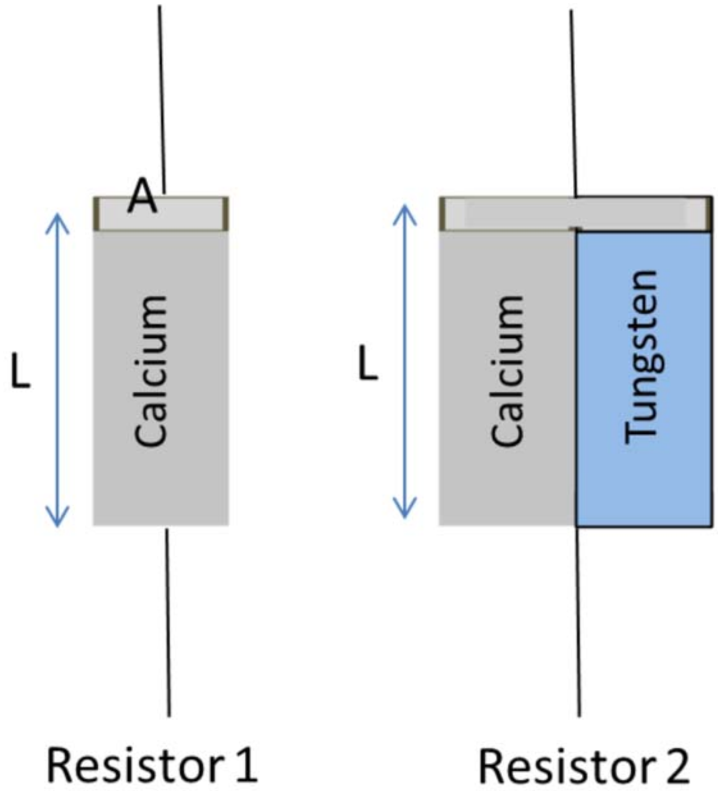
$V_2 = V_{3456} \Rightarrow Q_{3456} = \frac{C_{3456}Q_2}{C_2}$

$Q_1 = Q_2 + Q_{3456} = Q_2\left[1 + \frac{1}{4}\right]$

$Q_2 = \frac{4}{5}Q_1$

$V_2 = Q_2/C$

The next two questions pertain to the situation described below.



$R = \frac{\rho L}{A}$

A student decides to build some resistors using rectangular blocks of calcium ($\rho = 3.36 \times 10^{-8}$ Ω m) and tungsten ($\rho = 5.6 \times 10^{-8}$ Ω m). The dimensions of the blocks are identical with a length L = 0.12 m, and cross section A = 2.25×10^{-4} m^2. Resistor 1 is created from a single block of calcium. Resistor 2 is created by attaching a block of calcium to a block of tungston as shown in the figure above.

23) Compare the resistance of the two resistors.

a. $R_1 = R_2$
b. $R_1 > R_2$
c. $R_1 < R_2$

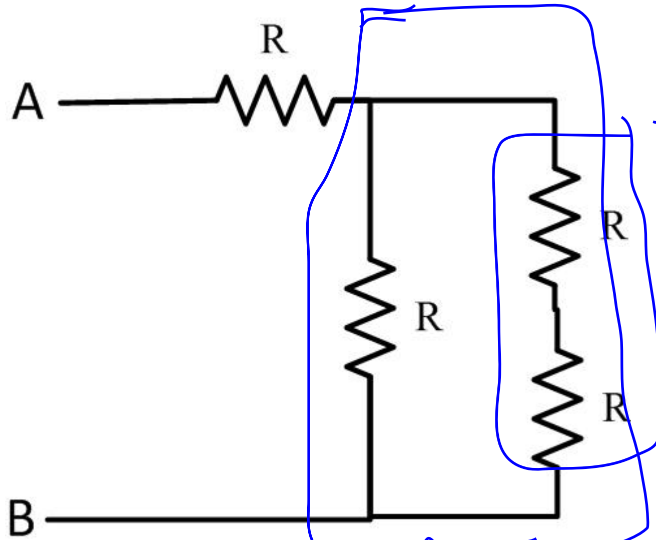
Basically 2 resistors in parallel

24) What is the resistance of resistor 2?

a. $R_2 = 1.12 \times 10^{-5}$ Ω
b. $R_2 = 4.78 \times 10^{-5}$ Ω
c. $R_2 = 2.39 \times 10^{-5}$ Ω

$$\frac{1}{R_2} = \frac{1}{R_{Ca}} + \frac{1}{R_W}$$
$$= \frac{A}{L}\left(\frac{1}{\rho_{Ca}} + \frac{1}{\rho_W}\right)$$

3. What is the resistance between points A and B of the resistor network shown in the diagram below? Each resistor in the network has resistance R.



2R

$$\frac{1}{\frac{1}{R} + \frac{1}{2R}} = \frac{2}{3}R$$

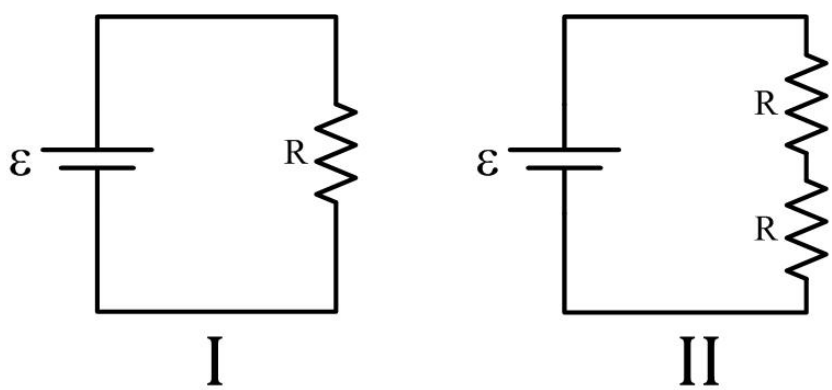
a. 5R/2
b. 3R/5
c. 5R/3
d. 4 R
e. R/4

4. Animal fat has a resistivity ρ=7 Ω·m. What is the resistance of a cylinder of animal fat that has a radius of 0.5 m and a length of 1 m?

$$R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2}$$

a. 0.79 Ω
b. 0.0079 Ω
c. 1.6 Ω
d. 12500 Ω
e. 8.9 Ω

12. Consider the two circuits, labeled I and II, in the circuit below. All resistors have the same resistance R, and the batteries both have the same emf ε.



2R

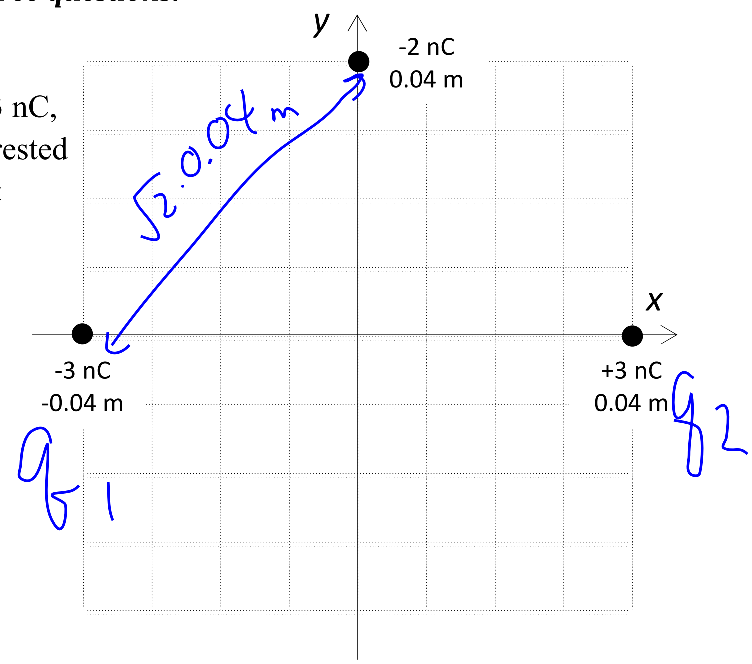
Which of the following statements is true regarding the power P_I supplied by the battery in circuit I compared with the power P_{II} supplied by the battery in circuit II?

a. $P_I=2\ P_{II}$
b. $P_I=0.5\ P_{II}$
c. $P_I=0.25\ P_{II}$
d. $P_I=4\ P_{II}$
e. $P_I= P_{II}$

$P = \frac{V^2}{R}$

The following situation pertains to the next three questions.

A positive charge, +3nC is placed at +0.04 m on the *x*-axis. A negative charge, -3 nC, is placed at -0.04 m on the x-axis. We are interested in the electric force on a -2 nC charge placed at +0.04 m on the *y*-axis.



15. What is the electric potential at the position of the -2 nC particle, due to the two charges on the *x*-axis? The electric potential is defined to be zero at infinity.

a. -955 V
b. -477 V
c. 0 V
d. 477 V
e. 955 V

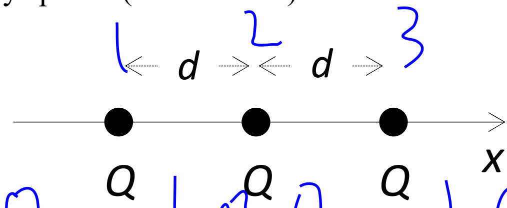
$$V = \frac{kq_1}{d_1} + \frac{kq_2}{d_2}$$

$$q_1 = -q_2, \; d_1 = d_2 \Rightarrow V = 0$$

The following two problems are related.

16. How much work must you do to assemble the charge configuration shown? All three charges have Q = -1.5 μC and are equally spaced (d = 0.035 m) on the x-axis.

a. 1.16 J
b. 1.45 J
c. 1.74 J
d. 9.64×10^5 J
e. 1.16×10^6 J



$$U = \frac{kQ_1Q_2}{d_{12}} + \frac{kQ_1Q_3}{d_{13}} + \frac{kQ_2Q_3}{d_{13}}$$

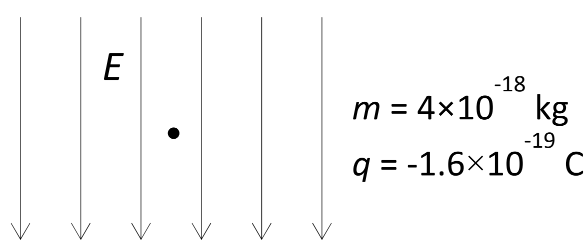
$$= kQ^2\left[\frac{1}{d} + \frac{1}{2d} \;\; \frac{1}{d}\right]$$

17. Suppose the charges in the previous problem all had Q = +1.5 μC. How would your answer change?

a. The work would become less positive (or more negative).
b. The work would not change.
c. The work would become more positive (or less negative).

18. A small particle of mass $m = 4\times10^{-18}$ kg has a charge of $q = -1.6\times10^{-19}$ C. It is placed in a vertical electric field, E, as shown. What must the magnitude of E be to suspend the particle against the force of gravity?

a. 0.04 N/C
b. 25 N/C
c. 245 N/C



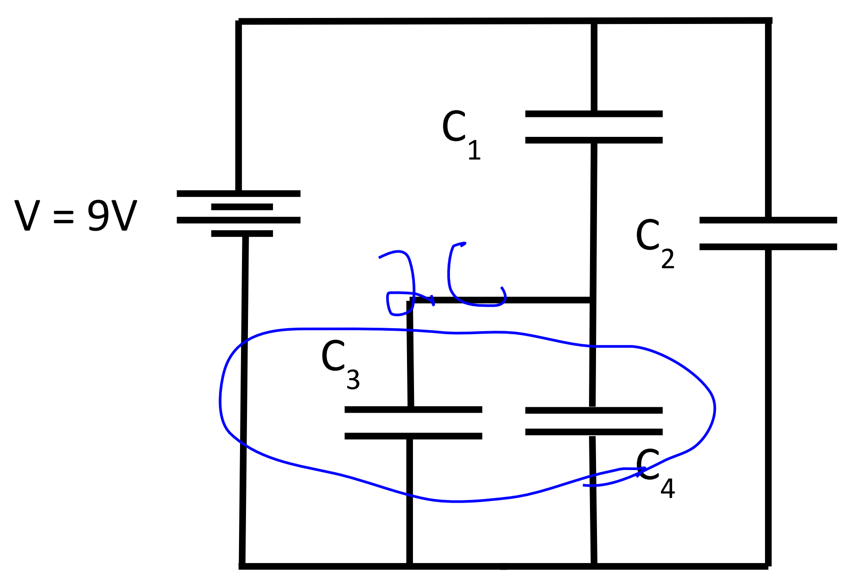
$$mg = qE$$

$$E = \frac{mg}{q} = \frac{4\times10^{-18}\cdot 9.8}{1.6\times10^{-19}} \left[\frac{kg\, m/s^2}{C}\right]$$

$$= 245 \text{ N/C}$$

The next two problems refer to the capacitor network shown below.

The circuit consists of 4 capacitors C_1, C_2, C_3 and C_4 and a battery with a voltage of 9 V. All capacitors have identical values $C = C_1 = C_2 = C_3 = C_4$.



$C_{134} = \frac{2}{3} C$

$C_{1234} = \frac{5C}{3}$

19. What is the equivalent capacitance C_{eq} of the circuit in terms of $C=C_1=C_2=C_3=C_4$?

a. C/3
b. 2C/3
c. 5C/3
d. 7C/3
e. 3C

20. If C = 15 mF, what is the electric charge Q_2 stored in capacitor C_2 ?

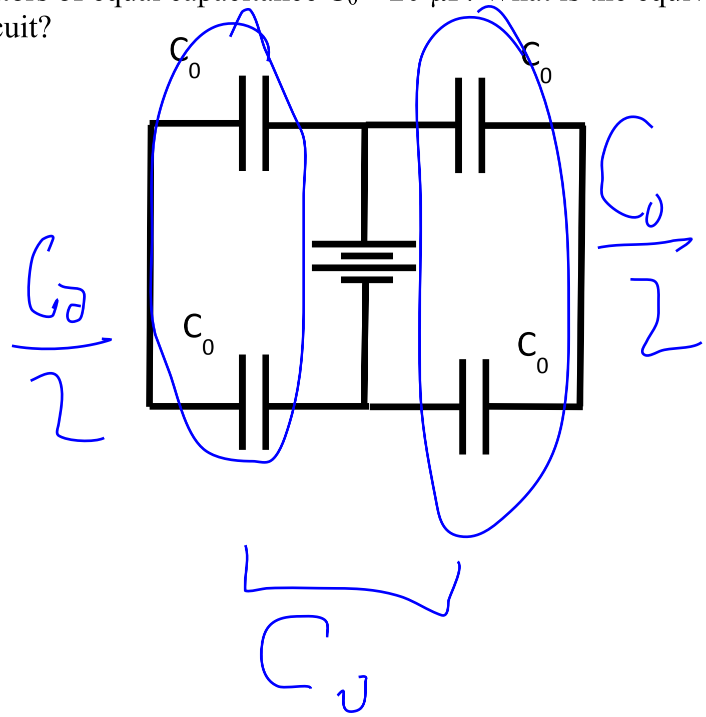
a. 0.045 C
b. 0.135 C
c. 0.225 C

C_2 connected to battery

$\Rightarrow V_2 = V = 9V$

$Q = C_2 V = 15 \times 10^{-3} (9)$ C

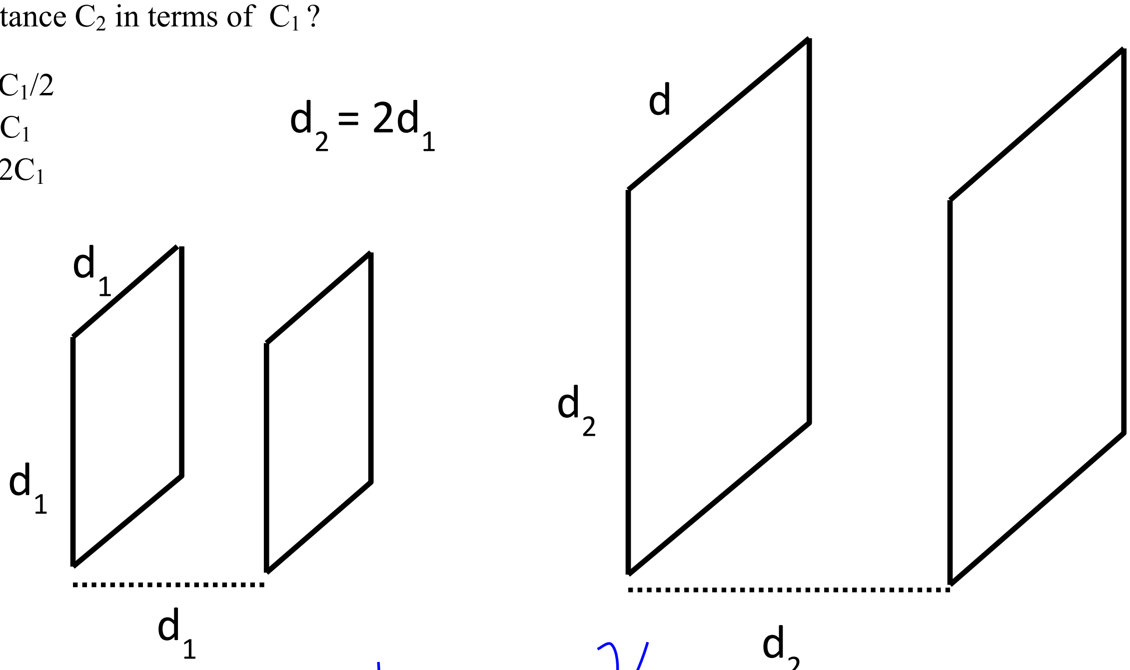
21. A circuit has 4 capacitors of equal capacitance $C_0 = 20\ \mu F$. What is the equivalent capacitance C_{eq} of the circuit?



a. $C_{eq} = 10\mu$ F
b. $C_{eq} = 20\mu$ F
c. $C_{eq} = 30\mu$ F
d. $C_{eq} = 40\mu$ F
e. $C_{eq} = 50\mu$ F

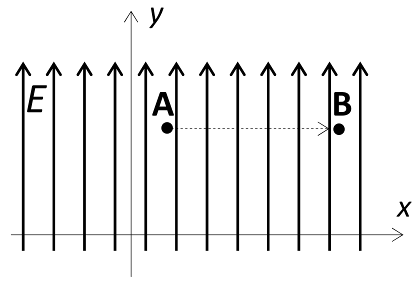
22. Two capacitors are made from two square sheets of copper plates. For each of the capacitors the length of the sides of the sheets is identical to the distance between the two plates. The distances between plates for the first capacitor with capacitance C_1 is d_1, and $d_2=2d_1$. What is the capacitance C_2 in terms of C_1?

a. $C_2=C_1/2$
b. $C_2=C_1$
c. $C_2=2C_1$



$$C = \frac{K_o A \varepsilon_o}{d} = \frac{K \varepsilon_o d^2}{\cancel{d}}$$

23. A charged particle (q = 0.5 μC) moves in a uniform electric field ($E = 1.2\times10^7$ N/C, in the +x direction) from **A** to **B** as shown. The starting point, **A**, is at (x=0.15 m, y=0.14 m), and the ending point, **B**, is at (x=0.215 m, y=0.14 m). How much work does the electric field do on the particle as it moves from **A** to **B**?



a. -1.2 J
b. 0 J
c. +1.2 J

$W = F \cdot d \underbrace{\cos\theta}_{=0}$

24. A collection of large capacitors connected in parallel is used in operating an accelerator in a radiation oncology practice. The total capacitance is C = 1F. Assuming the capacitors are operated with a voltage of V=110 V, how much energy can be stored?

a. 55 J
b. 305 J
c. 610 J
d. 6050 J
e. 12100 J

$U = \frac{1}{2} C V^2$

25. A naval rail gun has accelerated a projectile to 3km/s. The projectile has a kinetic energy of 490kJ. The energy for rail gun shots is stored in large capacitors. If the capacitance used is C_R=2F, how much charge was stored in the capacitor just before the shot was fired?

a. 70 C
b. 490 C
c. 700 C
d. 1400 C
e. 2800 C

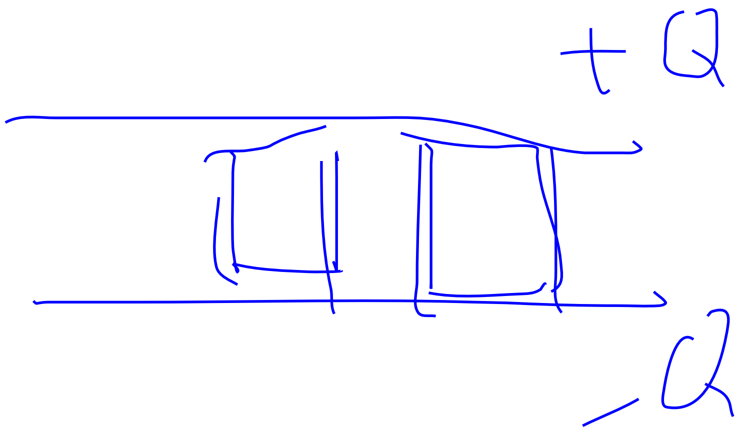
$U = \frac{1}{2}\frac{Q^2}{C}$; $U = 490$ kJ

$\Rightarrow Q^2 = 2 \cdot 2\,[490 \times 10^3]\,J$

C

26. Two large parallel aluminum plates are isolated and separated by an adjustable distance. A container of water (with dielectric constant ε=80) has been placed between the plates. Which change to the setup would increase the capacitance of the plates?

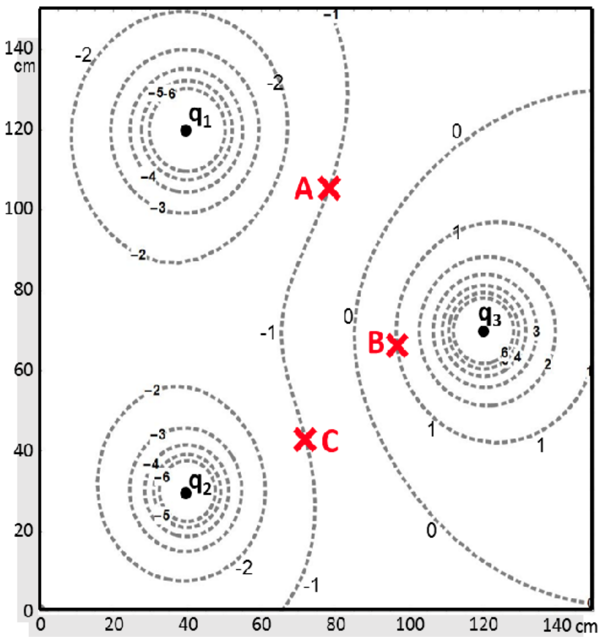
a. Increasing the distance between the two plates.
b. Removing the container of water.
c. Adding a second container of water between the plates while keeping the distance between them fixed.



Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

The next two questions pertain to the situation described below.

Given is a map of equal-potential lines (see figure). The potential is created by three charges in a plane (q_1, q_2, q_3). **Potential values are given in Volts** . Note the signs (+/-). Based on the map:



16) What is the sign (+/-) of the charge q_2?

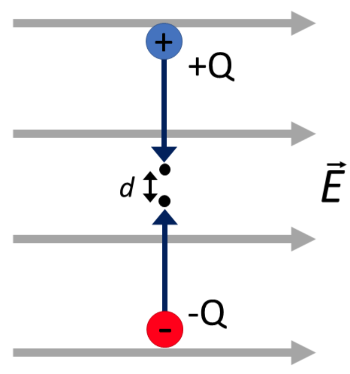
a. +
b. -
c. *0*

17) How much total work W by you is required to move a charge of *1 C* from point *A* to point *B*, and then from point *B* to point *C*?

a. $W = 0\ J$
b. $W = 4\ J$
c. $W = -2\ J$
d. $W = 2\ J$
e. $W = -4\ J$

A, C at same potential

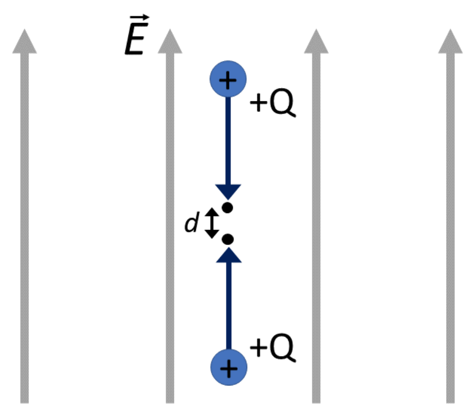
18) You move two charges closer towards each other by equal distances, until they are separated by a small distance *d*. They have equal masses and charges of equal magnitude and opposite sign, *Q* and -*Q*. The charges are exposed to a uniform electric field *E*, as shown in the diagram. Keeping in mind interactions between the two objects, which statement best describes the work done by you on the system of charges?



$\Delta U < 0$

a. *I am doing negative work on the system of charges.*
b. *I am doing positive work on the system of charges.*
c. *I am doing no work on the system of charges.*

19) Choose the statement that best describes the work done by you on the system shown. The objects have equal charge *Q*, and the direction of electric field is vertical.



$\Delta U > 0$

a. *I am doing positive work on the system of charges.*
b. *I am doing negative work on the system of charges.*
c. *I am doing no work on the system of charges.*

20) Consider the case of two identical charges, with equal mass $M = 0.7\ kg$ and equal charge $Q = +6\ C$, in the absence of an external electric field. The charges start at an infinitely far distance apart, and move in opposite directions directly towards one another, with velocities of $+5\ km/s$ and $-5\ km/s$, respectively. What is the closest distance d that the charges will get to one another?

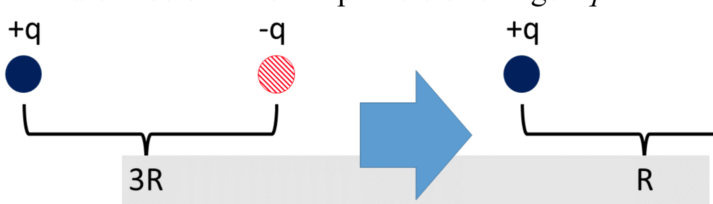
a. $d = 8700\ m$
b. $d = 58\ m$
c. $d = 2 \times 10^3\ m$
d. $d = 150\ km$
e. $d = 19\ km$

$K_i = 2 \cdot \frac{1}{2} m v^2 \qquad d_i = \infty$

$K_f = 0 \qquad U_f = \frac{k q_1 q_2}{d}$

$\Rightarrow d = \frac{k q^2}{m v^2} = 18.5\ km$

21) What is the change in potential energy of a particle of charge $+q$ that is brought from a distance of $3R$ to a distance of R from a particle of charge $-q$?

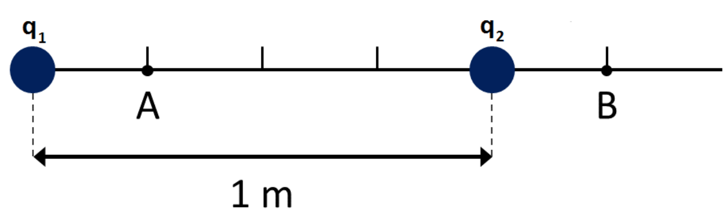


a. $U = -2kq^2/3R$
b. $U = -kq^2/4R^2$
c. $U = -2kq^2/R$
d. $U = kq^2/3R$
e. $U = kq^2/3R^2$

$U_f - U_i = \frac{k q(-q)}{R} - \frac{k(q)(-q)}{3R}$

$= -\frac{2}{3} \frac{k Q^2}{R}$

22) Two $2.9\ \mu C$ charges are held fixed at the positions shown in the figure. Note that both charges are positive. Calculate the change in potential energy $U(B)\text{-}U(A)$ of a $1.0\ \mu C$ charge that is moved from A to B. Note that the ruler lines shown in the figure are equally spaced.



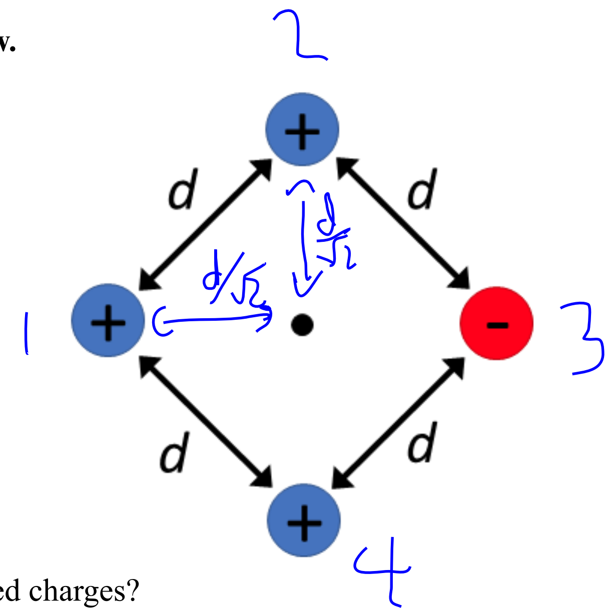
a. $U = -0.014\ J$
b. $U = -0.042\ J$
c. $U = 0\ J$
d. $U = 0.042\ J$
e. $U = 0.014\ J$

$U_A = \frac{k q q_1}{\frac{1}{4}(1\ m)} + \frac{k q q_2}{\frac{3}{4}(1\ m)} = k q q_1 \left(\frac{4^2}{3\ m}\right)$

$U_B = \frac{k q q_1}{(\frac{5}{4})\ m} + \frac{k q q_2}{(1\ m)(\frac{1}{4})} = k q q_1 \left(\frac{24}{5\ m}\right)$

The next three questions pertain to the situation described below.

Four point charges are equally spaced by a distance $d = 4.69\ mm$ at the corners of a square, as shown in the figure. Three of the charges are positive, with $q = 2.9\ \mu C$, while one is negative with charge $q = -2.9\ \mu C$.



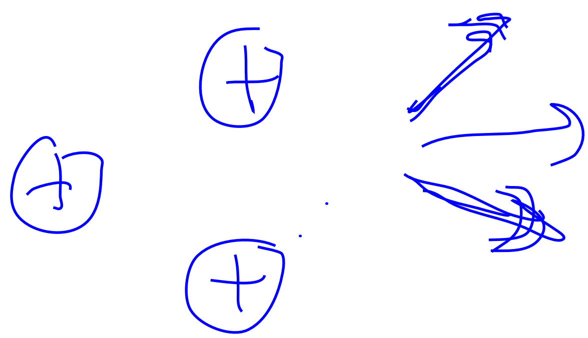
23) What is the electric potential at the center point between the fixed charges?

a. $V = -1.6 \times 10^{7}\ V$
b. $V = 1.6 \times 10^{7}\ V$
c. $V = 2.2 \times 10^{7}\ V$
d. $V = -1.1 \times 10^{7}\ V$
e. $V = 1.1 \times 10^{7}\ V$

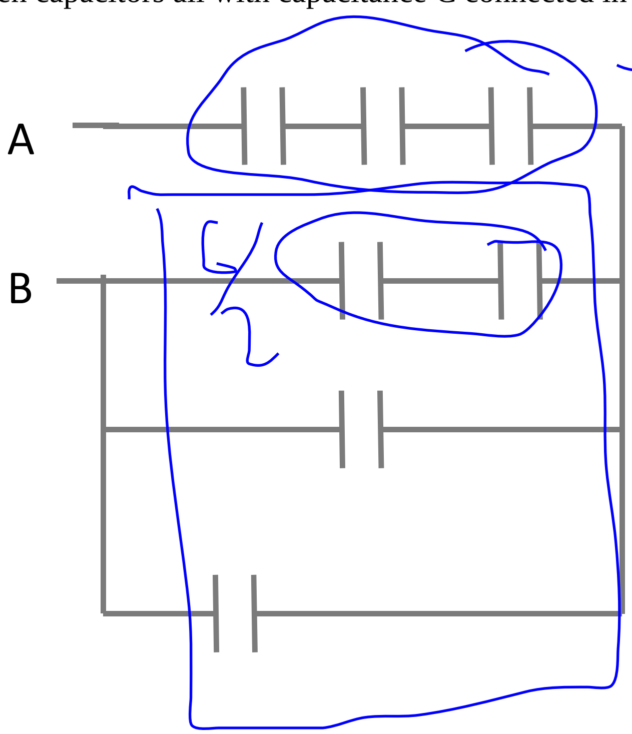
$$V = V_1 + V_2 + V_3 + V_4$$

$$= \frac{kq}{d/\sqrt{2}} + \frac{kq}{d/\sqrt{2}} - \frac{kq}{d/\sqrt{2}} + \frac{kq}{d/\sqrt{2}}$$

$$= 2\sqrt{2}\, kq/d$$



1. There are seven capacitors all with capacitance C connected in the network indicated below.



$= \frac{C}{3}$

$= \frac{5}{2} C$

What is the equivalent capacitance of this network between points A and B?

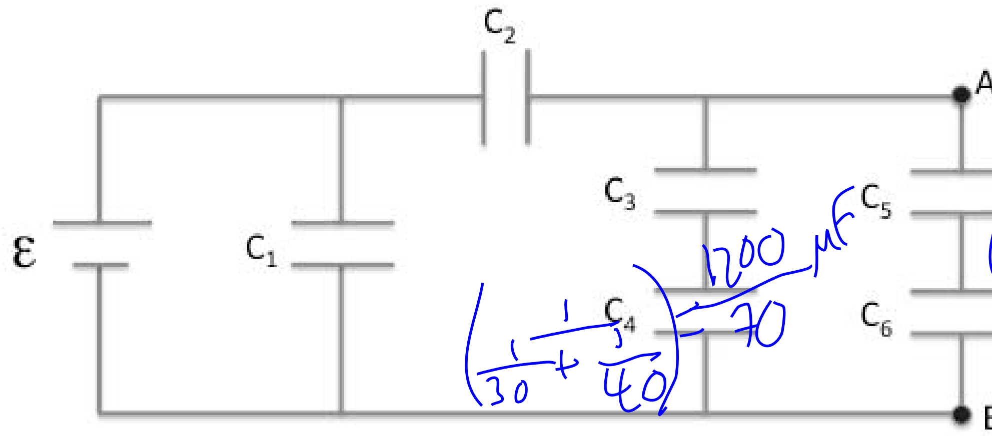
a. 5/6 C
b. 2/3 C
c. 5/17 C
d. 20/5 C
e. 42/7 C

$$\frac{1}{C_{eq}} = \frac{1}{\left(\frac{C}{3}\right)} + \frac{1}{\left(\frac{5}{2}C\right)}$$

$$= \frac{1}{C}\left[3 + \frac{2}{5}\right] = \frac{17}{5C}$$

The following situation pertains to the next three questions:

A network of fully charged capacitors and a battery is drawn below. The components have the following values: $C_1 = 10\ \mu F$, $C_2 = 20\ \mu F$, $C_3 = 30\ \mu F$, $C_4 = 40\ \mu F$, $C_5 = 50\ \mu F$, $C_6 = 60\ \mu F$, and $\mathcal{E} = 12$ Volts. The points A and B are labeled on the diagram.



$\left(\frac{1}{\frac{1}{30}+\frac{1}{40}}\right) = \frac{1200}{70}\ \mu F$

$\left(\frac{1}{\frac{1}{50}+\frac{1}{60}}\right) = \frac{3000}{110}\ \mu F$

2. What is the equivalent capacitance of this entire network?

a. $C_{eq} = 23.8\ \mu F$
b. $C_{eq} = 123.5 \mu F$
c. $C_{eq} = 52.8\ \mu F$
d. $C_{eq} = 100.1\ \mu F$
e. $C_{eq} = 65.9\ \mu F$

$C_{3456} = 44.4\ \mu F$

$\frac{1}{C_{23456}} = \frac{1}{20\mu F} + \frac{1}{44.4\mu F}$

$C_{23456} = 13.8\ \mu F$

$C_{eq} = C_1 + C_{23456}$

3. What is the electric charge stored on capacitor C_1 ?

a. $Q_2 = 95.1\ \mu C$
b. $Q_2 = 120.0\ \mu C$
c. $Q_2 = 131.0\ \mu C$
d. $Q_2 = 85.3\ \mu C$
e. $Q_2 = 201.3\ \mu C$

$V_1 = \mathcal{E}$

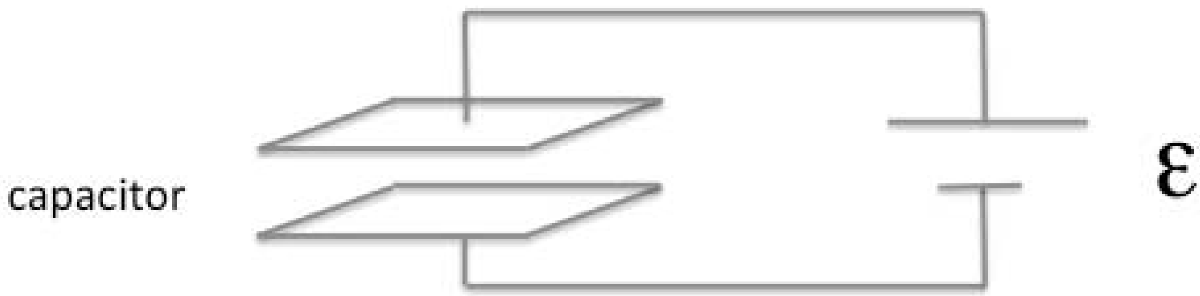
$Q_1 = C_1 V_1 = C_1 \mathcal{E}$

4. Suppose the branch from point A to point B, including capacitors C_5 and C_6, were removed from the circuit. The charge stored on C_1 would

a. increase.
b. decrease.
c. stay the same.

The next three questions pertain to the following situation:

A capacitor is in a circuit with a battery as shown. This capacitor has square plates with sides s = 2.2 cm and has no dielectric between the plates. Each plate has a charge of magnitude Q = 10 pC.

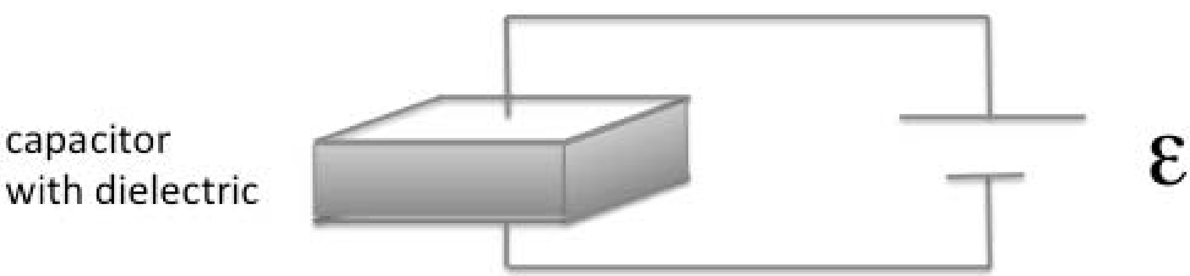


5. What is the electric field, E, between the plates?

$$E = \frac{Q}{\varepsilon_0 A} = \frac{10 \times 10^{-12}\,C}{\varepsilon_0 (0.022m)^2}$$

a. $E = 2.33 \times 10^3$ N/C
b. $E = 1.54 \times 10^3$ N/C
c. $E = 3.14 \times 10^4$ N/C
d. $E = 5.98 \times 10^3$ N/C
e. $E = 6.79 \times 10^4$ N/C

6. The capacitor has a stored energy, U_1, without any dielectric between the plates. Now a slab of dielectric material with dielectric constant K = 2.0 is placed between the plates, with the same width as the plate separation.



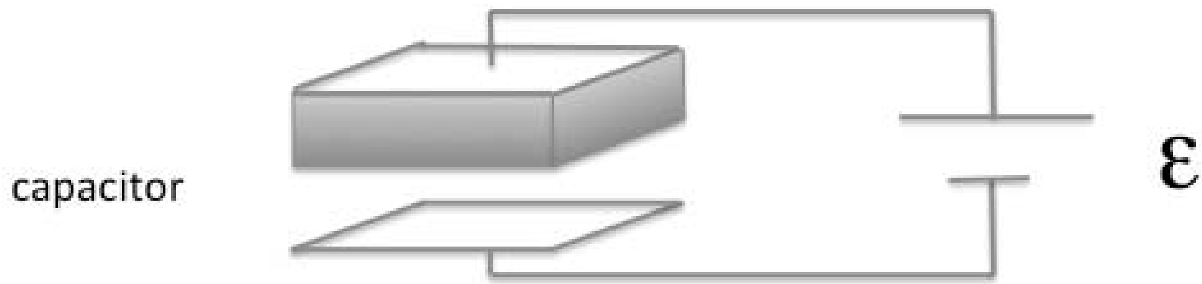
The new stored energy of the capacitor U_2 is

$$U = \frac{1}{2}CV^2 \; ; \; C = KC_0$$

a. the same as U_1.
b. less than U_1.
c. larger than U_1.

The next question continues from the previous page.

7. A conducting slab replaces the dielectric, and the distance between the plates is doubled. The stored energy is now U_3.

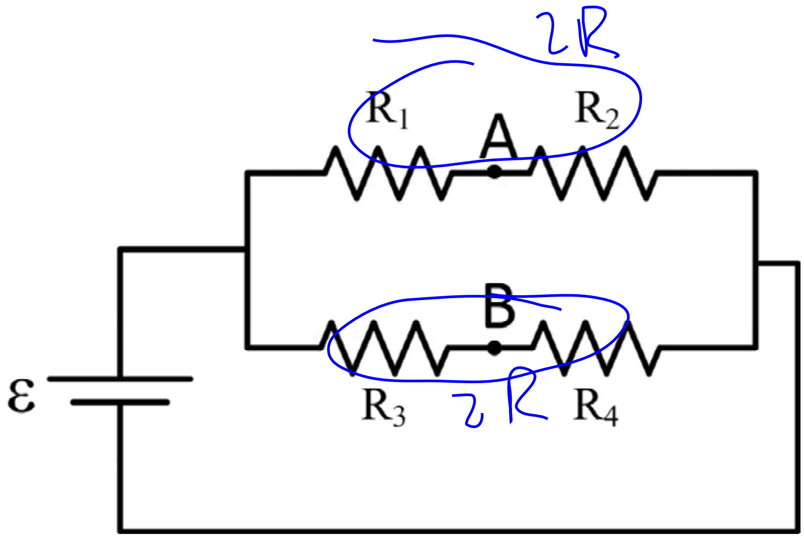


Compare this stored energy U_3 with the original stored energy U_1.

a. $U_3 = 3/2\ U_1$
b. $U_3 = 4\ U_1$
c. $U_3 = U_1$
d. $U_3 = 1/4\ U_1$
e. $U_3 = 2/3\ U_1$

distance between bottom of conducting slab is what matters now

The next four questions refer to the following circuit:



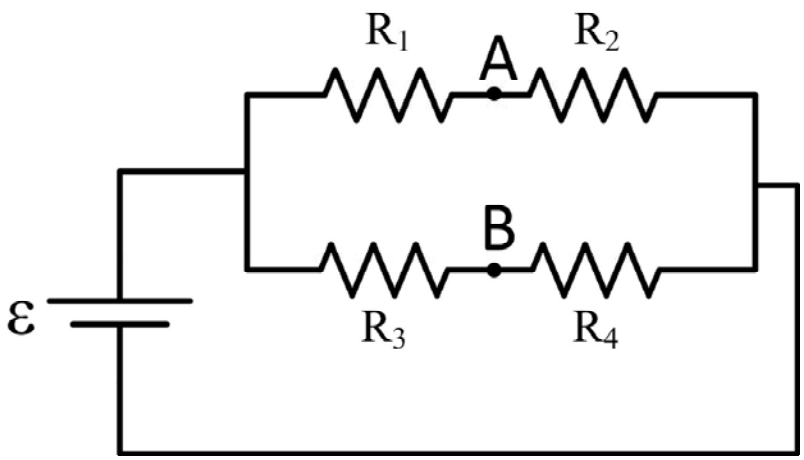
8. If all four resistors have resistance R, what is the total equivalent resistance for this circuit?

a. 4R
b. 2R
c. R
d. R/4
e. R/2

9. What is the current supplied by the battery if each resistor has resistance R?

a. ε / R
b. 2 R / ε
c. ε / 3R
d. 2 ε / R
e. ε / 4R

The next two questions continue from the previous page:



10. How much power is dissipated in this circuit if each resistor has resistance R?

a. ε^2 / R
b. $2\,\varepsilon^2 / R$
c. $R / 2\,\varepsilon^2$
d. $\varepsilon^2 / 4R$
e. ε^2/R

$$P = \frac{V^2}{R_{eq}} \qquad = R$$

11. What is the electric potential difference V_A-V_B if ε=10 V, R_1=R_2=10 Ω, and R_3=R_4=5 Ω?

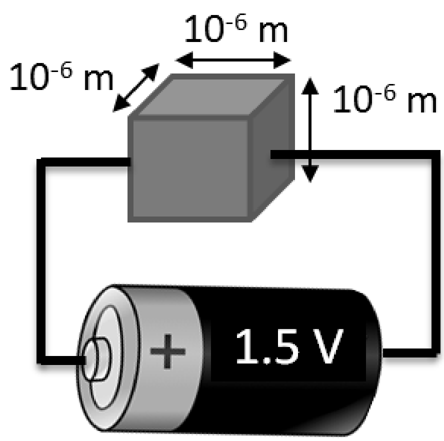
$$V_A - V_B = V_3 - V_1 = I_3 R_3 - I_1 R_1$$

a. 0.2 V
b. 5 V
c. 10 V
d. 0 V
e. 0.25 V

$$\boxed{I_3 = \frac{\varepsilon}{R_3 + R_4}} \qquad = \frac{\varepsilon R_3}{R_3 + R_4} - \frac{\varepsilon R_1}{R_1 + R_2}$$

$$\boxed{I_1 = \frac{\varepsilon}{R_1 + R_2}} \qquad = 0$$

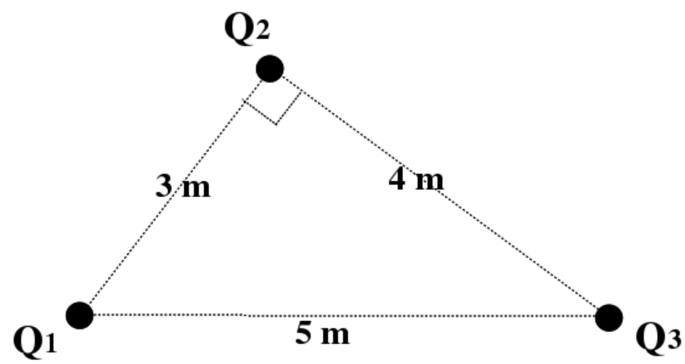
17. A resistor is created using a cube of carbon. The resistivity of carbon is $3.5 \times 10^{-5}\ \Omega$ m. The length of each side of the cube is 10^{-6} m. The cube is hooked up to a 1.5 V battery as shown below. How much current flows through the cube?



a. 4.3×10^{10} A
b. 0.043 A
c. 23.3 A
d. 0.1 A
e. 1.5 A

The next question pertains to the following situation:

Three charges are arranged in a right triangle, as shown. The three charges are $Q_1 = -3.4\ \mu C$, $Q_2 = +5.6\ \mu C$, and $Q_3 = -1.2\ \mu C$.

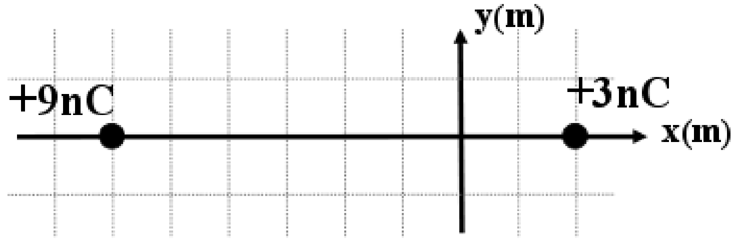


21. How much work was needed by an external force to assemble the three charges into the configuration above, assuming they started infinitely far away from each other?

a. $W = -4.6 \times 10^{-2}$ J
b. $W = -6.5 \times 10^{-2}$ J
d. $W = +6.5 \times 10^{-2}$ J
c. $W = +4.6 \times 10^{-2}$ J
e. $W = +9.1 \times 10^{-2}$ J

The next two questions pertain to the following situation:

Two charges are located on the x-axis at positions –6 m and +2 m respectively. Each grid spacing is 1 meter.



22. What is the net electric field at the origin due to the two charges?

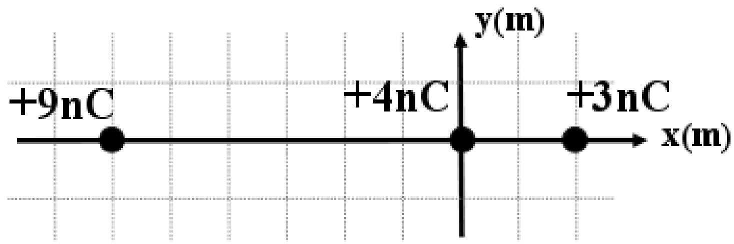
a. –4.50 V/m
b. –2.25 V/m
c. +9.00 V/m

23. Calculate the electric potential at the origin due to the two charges.

a. 3.9 V
b. 4.6 V
c. 12 V
d. 27 V
e. 32 V

The next two questions continue from the previous page:

Another charge with mass m = 4.3 x 10^{-17} kg is added to the configuration at the origin. The +9nC and +3nC charges are held stationary, while the 4nC charge is free to move.



25. What is the speed of the 4nC charge after it is released and has traveled infinitely far away?

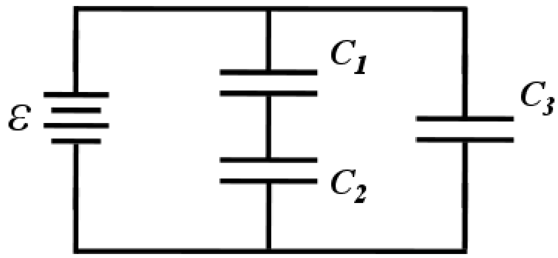
a. v = 9.3 x 10^3 m/s
b. v = 1.8 x 10^4 m/s
c. v = 3.7 x 10^4 m/s
d. v = 7.1 x 10^4 m/s
e. v = 8.5 x 10^4 m/s

KEY
Exam 1 – Spring 2012

1. c
2. a
3. b
4. c
5. a
6. c
7. c
8. c
9. a
10. ae
11. d
12. a
13. b
14. b
15. c
16. a
17. b
18. abcde
19. d
20. c
21. b
22. a
23. d
24. b
25. d
26. b

The next three questions pertain to the following situation:

A system of capacitors, all of equal capacitance $C_1 = C_2 = C_3 = C$, is connected to an ideal battery of voltage $\mathcal{E}$ = 24 V.



3. Calculate C given that the charge on capacitor C_2 is measured to be Q_2 = 98 nC.

a. C = 43.9 nF
b. C = 2.7 nF
c. C = 312 nF
d. C = 8.2 nF
e. C = 126 nF

For the next two questions, assume that all of the capacitors have capacitance C = 25 μF **and that their charges are unknown.**

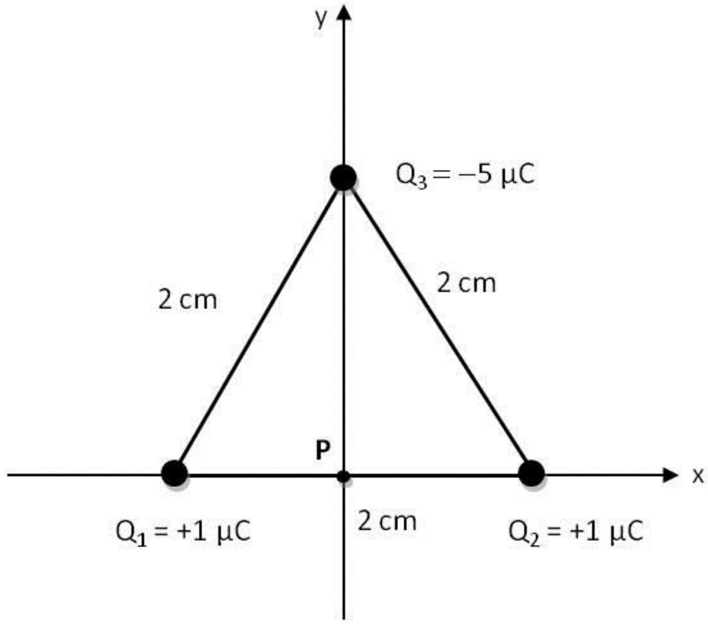
4. What is Q_3, the amount of charge collected on the capacitor C_3?

a. Q_3 = 150 μC
b. Q_3 = 300 μC
c. Q_3 = 600 μC

5. How much energy U_{total} is stored in the capacitor network?

a. U_{total} = 0.9 mJ
b. U_{total} = 3.2 mJ
c. U_{total} = 10.8 mJ
d. U_{total} = 58.2 mJ
e. U_{total} = 36.8 mJ

The next two questions continue from the previous page.



11. How much work W is required ***by you*** to assemble the three charges to this configuration?

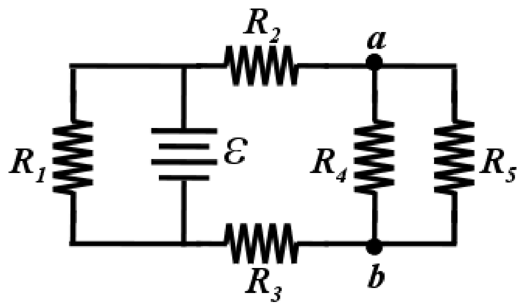
a. $W = -0.0405$ J
b. $W = -4.05$ J
c. $W = 4.05$ J
d. $W = -202.3$ J
e. $W = 202.3$ J

12. What is the electric potential V due to the three charges at origin, **P**?

a. $V = -202.3$ V
b. $V = -2.34$ V
c. $V = 1.35$ V
d. $V = -1.35\times10^5$ V
e. $V = -7.98\times10^5$ V

The next three questions pertain to the following situation:

An ideal battery of voltage $\mathcal{E}$ = 12 V is connected to a circuit of resistors.



13. Assume all of the resistors have resistance R. What is the equivalent resistance, R_{eq}, for the circuit?

a. $R_{eq} = 3R/2$
b. $R_{eq} = 5R$
c. $R_{eq} = 5R/7$
d. $R_{eq} = 4R/3$
e. $R_{eq} = 13R/9$

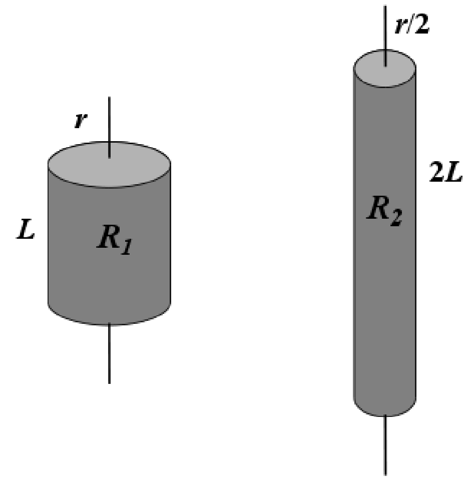
14. If the resistance of each resistor R = 75 Ω, what is P_1, the power dissipated by resistor R_1?

a. P_1 = 1.9 W
b. P_1 = 9.0 W
c. P_1 = 5.7 W

15. What is the voltage V_{ab} difference between points ***a*** and ***b***, as labeled on the circuit?

a. V_{ab} = 2.4 V
b. V_{ab} = 18.2 V
c. V_{ab} = 6.0 V
d. V_{ab} = 12.0 V
e. V_{ab} = 4.8 V

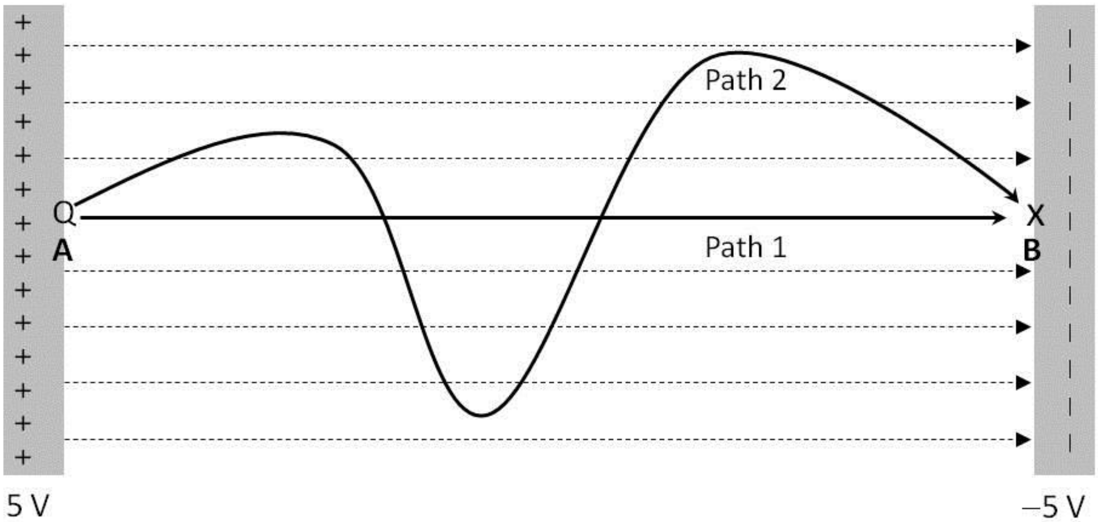
16. Two resistors are created using copper, which has resistivity $\rho = 1.72 \times 10^{-8}\ \Omega\cdot$m. The first resistor has radius r and length L. The second resistor has radius $r/2$ and length $2L$. What is the ratio of the second resistor's resistance R_2 to that of the first resistor's resistance R_1?



a. $R_2/R_1 = 1/4$
b. $R_2/R_1 = 1/2$
c. $R_2/R_1 = 2$
d. $R_2/R_1 = 8$
e. $R_2/R_1 = 16$

The next two questions pertain to the following situation.

A uniform electric field is generated by two parallel plate electrodes, positive and negative, respectively, as shown. The dashed lines indicate the electric field. The electric potential at the positive and the negative electrode is 5 V and −5 V, respectively. Consider a charge $Q = +3$ mC with mass of 1 mg.



17. Imagine that you move the charge Q from point **A** to point **B** along the two paths shown. Let W_1 and W_2 be the work done ***by the electric field*** following Path 1 and Path 2, respectively. What is the relationship between W_1 and W_2?

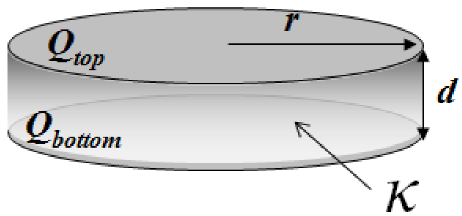
a. $W_1 > W_2$
b. $W_1 < W_2$
c. $W_1 = W_2$

18. If the charge Q is released freely at **A**, what is its speed, v, when arriving at **B**?

a. Not enough information is given.
b. $v = 7.75$ m/s
c. $v = 5.48$ m/s
d. $v = 173$ m/s
e. $v = 245$ m/s

The next two questions pertain to the following situation:

A capacitor is created by placing two circular metal plates of radius 2 mm a distance 5 μm apart. A material of dielectric constant $\kappa = 2.5$ is placed between the plates. The capacitor is then charged by placing a charge $Q_{top} = +3$ nC on the top plate and $Q_{bottom} = -3$ nC on the bottom plate. After charging, the capacitor is disconnected from all other elements, such as wires or a battery.



19. What is the voltage difference V measured between the two plates of this capacitor?

a. $V = 15$ V
b. $V = 54$ V
c. $V = 95$ V
d. $V = 65$ V
e. $V = 225$ V

20. The plates are then pulled apart so that the distance between them is increased from 5 μm to 20 μm. How does the new charge on the top plate $Q_{top,new}$ compare to the original charge on the top plate Q_{top}?

a. $Q_{top,new} < Q_{top}$
b. $Q_{top,new} > Q_{top}$
c. $Q_{top,new} = Q_{top}$

KEY
Exam 1 – Spring 2013

1. b
2. a
3. d
4. c
5. c
6. c
7. c
8. c
9. a
10. c
11. b
12. e
13. c
14. a
15. a
16. d
17. c
18. e
19. b
20. c
21. c
22. e
23. b
24. a
25. c
26. b
27. b

The next three questions pertain to the situation described below.

Consider the following circuit: $R_1 = 10\ \Omega$, $R_2 = 8\ \Omega$, $R_3 = 3\ \Omega$, $\varepsilon_1 = 17\ V$ and $\varepsilon_2 = 8\ V$. Initially the switch is <u>open</u>.

$-I_2 R_2 = V_2 = 4V$

$-\mathcal{E}_2 = -8V$

12) You connect a voltmeter at points A and B in the circuit. What is the electric potential difference, $\Delta V_{AB} = V_A - V_B$, measured between those points?

a. $\Delta V_{AB} = 12\ V$
b. $\Delta V_{AB} = 17\ V$
c. $\Delta V_{AB} = 9\ V$

$+\mathcal{E}_1 - I_1 R_1 - I_2 R_2 - \mathcal{E}_2 = 0; \quad I_1 = I_2$

$\Rightarrow I = \frac{\mathcal{E}_1 - \mathcal{E}_2}{R_1 + R_2} = 0.5A\ ; \quad V_2 = IR_2 = 4V$

13) Now the switch is <u>closed</u>. Using the same voltmeter as above, you measure the electric potential difference $\Delta V_{AB} = V_A - V_B = 3.33\ V$. In which direction does the current flow through resistor R_3?

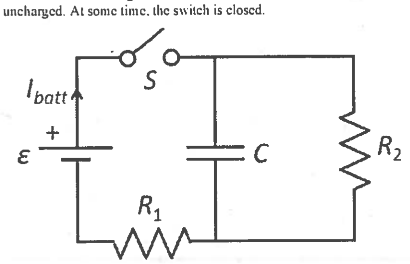
a. *no current flows*
b. *up*
c. *down*

14) What is the current I_1 through resistor R_1 after the switch is <u>closed</u>?

a. $I_1 = 0.8\ A$
b. $I_1 = 1.7\ A$
c. $I_1 = 1.4\ A$

The next three questions pertain to the situation described below.

Consider the following RC circuit: $R_1 = 3\ k\Omega$, $R_2 = 6\ k\Omega$, $C = 0.4\ \mu F$, and $\varepsilon = 9\ V$. Initially the capacitor is uncharged. At some time, the switch is closed.



15) What is the current out of the battery, I_{batt}, immediately after the switch is closed?

a. $I_{batt} = 1\ mA$
b. $I_{batt} = 3\ mA$
c. $I_{batt} = 1.5\ mA$
d. $I_{batt} = 0\ mA$
e. $I_{batt} = 22\ mA$

C acts like a wire
$\Rightarrow$ no current through R_2

$$I = \frac{\varepsilon}{R_1} = \frac{9V}{3\times10^{+3}} = 3\ mA$$

16) What is the current out of the battery, I_{batt}, a long time after the switch is closed?

a. $I_{batt} = 1.5\ mA$
b. $I_{batt} = 22\ mA$
c. $I_{batt} = 0\ mA$
d. $I_{batt} = 3\ mA$
e. $I_{batt} = 1\ mA$

C acts like open switch
$\Rightarrow$ current through $R_2 + R_1$

$$I = \frac{\varepsilon}{R_1+R_2} = \frac{9V}{9\times10^3\Omega} = 1\ mA$$

17) How much time does it take for the charge Q to decrease to 50% of its initial value after the switch is re-opened?

a. $t_{50\%} = 1.7\ ms$
b. $t_{50\%} = 0.83\ ms$
c. $t_{50\%} = 2.5\ ms$

$$Q = Q_0 e^{-t/RC}$$

After opening switch, just C & R_2 in the circuit

$$\frac{Q}{Q_0} = \frac{1}{2} \Rightarrow e^{-t/RC} = 0.5$$

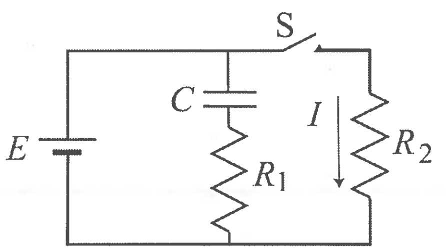
$$t/RC = \ln(2)$$

$$t = RC\ln(2)$$

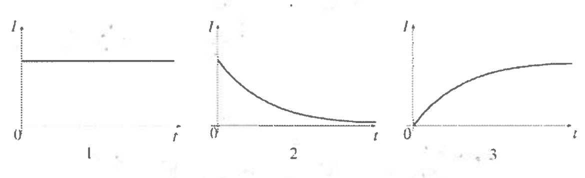
$6\times10^3\Omega$

$0.4\times10^{-6}F$

10) In the following RC circuit with a switch S, two resistors R_1 and R_2 have the same resistance $R = 20\ \Omega$, C denotes a capacitor of capacitance $15\ \mu F$, and E denotes a 12 V battery.



Initially, switch S is open for a long time. After $t = 0$ switch S is closed. Choose the best figure from below describing the time-dependence of the current I through R_2. Do not forget that the battery E is still connected.

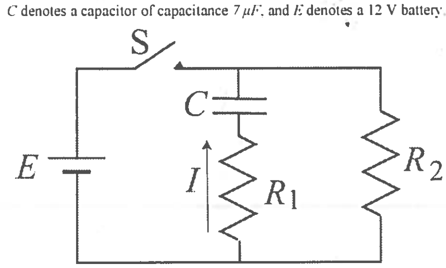


a. 3
b. 2
c. 1

use loop around outside

The next two questions pertain to the situation described below.

In the following RC circuit with a switch S, two resistors R_1 and R_2 have the same resistance $R = 29\ \Omega$. C denotes a capacitor of capacitance $7\ \mu F$, and E denotes a 12 V battery.



11) Switch S has been closed for a long time. What is the current I through R_1 immediately after S is opened? Pay attention to the direction of the current arrow in the figure.

a. $I = 0.41\ A$
b. $I = -0.21\ A$
c. $I = -0.21\ A$
d. $I = 0\ A$
e. $I = -0.41\ A$

When C is full $I_1 = 0$ (S is closed)

$\Rightarrow V_c = E$ to start

$I = \frac{V_c}{R_1 + R_2} = 12V / 59\Omega$

12) What is the voltage V_2 across resistor R_2 at a time of 0.5 ms after switch S is opened?

a. $V_2 = 3.2\ V$
b. $V_2 = 0.51\ V$
c. $V_2 = 1.8\ V$

$V_c = \frac{Q(t)}{C} = \frac{Q_0}{C} e^{-t/RC}$

$\Rightarrow V_c(t) = V_c(0) e^{-t/RC}$

$R_1 = R_2$, so each resistor sees $\frac{1}{2}$ of total voltage drop around circuit

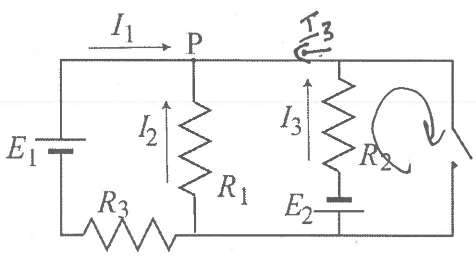
$\Rightarrow V(R_2) = \frac{V_c(0)}{2} e^{-t/RC}$

$RC = (58\Omega)(7 \times 10^{-6}\ F)$, $t = 0.5\ ms$

$V_c(0) = 12\ V$

The next two questions pertain to the situation described below.

In the following figure, $E_1 = 12\ V$, $E_2 = 4\ V$, $R_1 = 7\ \Omega$, $R_2 = 12\ \Omega$, and $R_3 = 4\ \Omega$. Initially, the switch S is open.



13) At junction P three currents I_1, I_2, and I_3 meet. Choose the correct relation among them from below.

a. $I_1 + I_2 + I_3 = 0$
b. $I_1 - I_2 - I_3 = 0$
c. $-I_1 + I_2 - I_3 = 0$
d. $I_1 - I_2 + I_3 = 0$
e. $I_1 + I_2 - I_3 = 0$

with switch open, I_3 flows in to P

14) When the switch S is closed, what is the current I_3?

a. $I_3 = 0\ A$
b. $I_3 = -0.57\ A$
c. $I_3 = -0.75\ A$
d. $I_3 = -0.33\ A$
e. $I_3 = -0.7\ A$

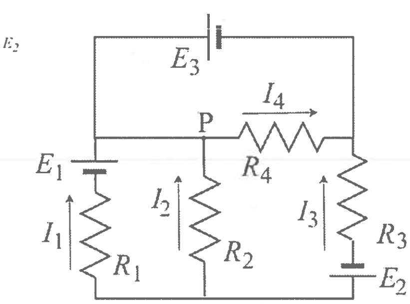
$-E_2 - I_3 R_2 = 0$ 4 V

$\Rightarrow I_3 = -\dfrac{E_2}{R_2}$

12Ω

The next three questions pertain to the situation described below.

In the following figure, $E_1 = 12\ V$, $E_3 = 7\ V$, $R_1 = R_2 = R_3 = R_4 = 3\ \Omega$, E_2 is not known.



15) Choose the correct formula exhibiting Kirchhoff's loop law from the following formulas.

a. $I_2R_2 + I_4R_4 - I_3R_3 - E_2 = 0$
b. $I_2R_2 - I_4R_4 - I_3R_3 + E_2 = 0$
c. $I_2R_2 + I_4R_4 - I_3R_3 + E_2 = 0$
d. $I_2R_2 + I_4R_4 + I_3R_3 - E_2 = 0$
e. $I_2R_2 + I_4R_4 + I_3R_3 + E_2 = 0$

16) What is the current I_4? Pay attention to the direction of the current arrow in the figure.

a. $I_4 = 0\ A$
b. $I_4 = +1.2\ A$
c. $I_4 = -2.3\ A$
d. $I_4 = +2.3\ A$
e. $I_4 = -1.2\ A$

$E_3 - I_4 R_4 = 0$ 7 V

$I_4 = \dfrac{E_3}{R_4}$

3Ω

17) The current I_2 is measured to be $-1.5\ A$. What is the current I_1? Again, pay attention to the direction of the current arrow in the figure.

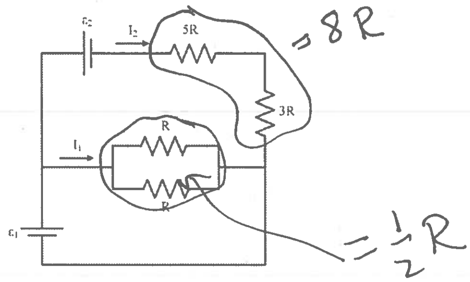
a. $I_1 = +2.5\ A$
b. $I_1 = -2.5\ A$
c. $I_1 = -5.5\ A$
d. $I_1 = +5.5\ A$
e. $I_1 = 0\ A$

$-I_1R_1 + E_1 + I_2R_2 = 0$

$I_1 = \dfrac{E_1 + I_2R_2}{R_1}$

3Ω

12V 3Ω $-1.5A$



$= 8R$

$= \frac{1}{2}R$

21. Which of the equations below correctly describe the circuit above?

I. $\varepsilon_1 - 8I_2R - \varepsilon_2 = 0$

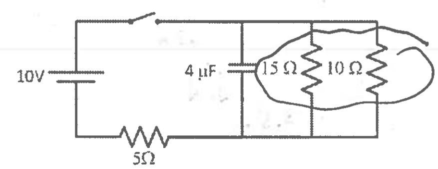
II. $\varepsilon_1 - \frac{1}{2}I_1R = 0$

III. $\varepsilon_2 + 8I_2R - \frac{1}{2}I_1R = 0$

a. I and II
b. II and III
c. I and III
d. I, II and III
e. None of the above.

The next three questions pertain to the following situation:

The switch in the circuit shown below has been open for a long time so that the capacitor is initially uncharged.



$\frac{1}{R_{eq}} = \frac{1}{15\Omega} + \frac{1}{10\Omega}$

$\Rightarrow R_{eq} = 6\Omega$

25. What is the current through the 5 Ω resistor immediately after the switch is closed?

a. 2.0 A
b. 0.9 A
c. 0 A

Initially, C acts like a bare wire

$\Rightarrow +10V - I_5R_5 = 0 \Rightarrow I_5 = \frac{10V}{5\Omega}$

26. What is the voltage across the capacitor after the switch has been closed for a long time?

a. 4.55 V
b. 5.45 V
c. 7.5 V
d. 8.2 V
e. 10 V

After a long time, no current through C

$\Rightarrow R_{eq}^{tot} = 6\Omega + 5\Omega = 11\Omega \Rightarrow I = 0.91\ A$

$+10V - V_c - I(5\Omega) = 0 \Rightarrow V_c = 5.45\ V$

27. The after the switch has been closed for a long time, it is then opened again. What is the current through the 15Ω after the switch has been open for 30µs?

a. 0.260 A
b. 0.257 A
c. 0.220 A
d. 0.104 A
e. 0.156 A

C $R_{eq} = 6\Omega$ $\Rightarrow RC = 6\Omega \cdot 4\times10^{-6} F$

$= 2.4\times10^{-5}\ s$

Do a Loop: $V_c - I_{15}(15\Omega) = 0 \Rightarrow I_{15} = \frac{V_c}{15\Omega}$

Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

$V_c = 5.45V \cdot e^{-t/RC}$

$= 1.56V$

$= 0.104\ A$

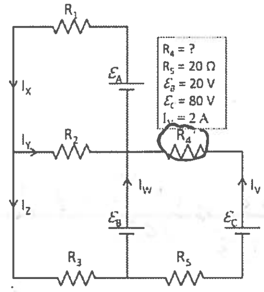
KEY

Exam 1 – Fall 2011

1. c
2. b or c
3. d
4. b
5. a
6. b
7. d
8. d
9. d
10. c
11. a
12. d
13. b
14. c
15. b
16. b
17. d
18. a
19. c
20. c
21. d
22. a
23. d
24. a
25. a
26. b
27. d

The next three questions pertain to the situation described below.

Consider the circuit shown below.



9) What is the resistance of resistor R_4?

$$+\mathcal{E}_C - I_V R_4 - \mathcal{E}_B - I_V R_5 = 0$$

$$\frac{\mathcal{E}_C - \mathcal{E}_B}{R_4 + R_5} = I_V$$

$$\Rightarrow R_4 + R_5 = \frac{60\,V}{2\,A} = 30\,\Omega$$

$$\Rightarrow R_4 = 10\,\Omega$$

a. $R_4 = 5\ \Omega$
b. $R_4 = 10\ \Omega$
c. There is no value of R_4 for which $I_V = 2$ A.
d. $R_4 = 20\ \Omega$
e. $R_4 = 2\ \Omega$

10) Which of the following equations is a valid application of Kirchhoff's current law?

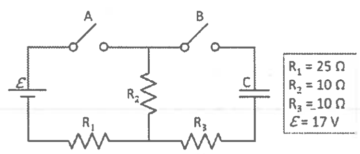
a. $I_X + I_Y = I_Z$
b. $I_Z = I_W - I_V$
c. $I_Y + I_W + I_V - I_X = 0$

11) Which of the following equations is NOT a valid application of Kirchhoff's voltage law?

a. $\varepsilon_A + \varepsilon_B - I_X R_1 - I_Z R_3 = 0$
b. $\varepsilon_B - I_Y R_2 - I_Z R_3 = 0$
c. $\varepsilon_A - I_X R_1 - I_Y R_2 = 0$

The next four questions pertain to the situation described below.

Consider the circuit shown below. Initially, both switches are open and the capacitor has been charged to 10 Volts.



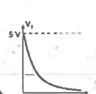
At time t=0 switch B is closed (switch A remains open).

12) What is the current through resister R_3 just after the switch B is closed?

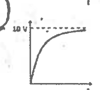
a. $I_3 = 1.5$ A.
b. $I_3 = 0.5$ A.
c. $I_3 = 2.5$ A.

$I = \frac{V_c}{R_2 + R_3} = \frac{10\text{ V}}{20\Omega} = 2\text{ A}$

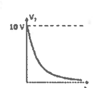
13) Which of the following plots best represents the voltage V_2 across resistor 2 starting just after switch B is closed? (Be careful image is above answer choice)



a.



b.

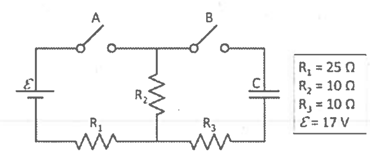


c.

Voltage drops across EACH RESISTOR

14) Figure repeated from previous page

Consider the circuit shown below. Initially, both switches are open and the capacitor has been charged to 10 Volts. At time t=0 switch B is closed (switch A remains open).



If it takes 12 μs for the charge on the capacitor to drop the 1/2 of its initial value, what is the capacitance of the capacitor C?

a. C = 1631 nF
b. C = 493 nF
c. C = 3370 nF
d. C = 866 nF
e. C = 215 nF

$R_{eq} = R_2 + R_3 = 20\Omega$

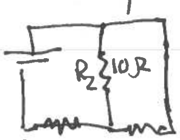
$e^{-t/RC} = \frac{1}{2} \Rightarrow t = R_{eq} C \ln 2$

$C = \frac{t}{R_{eq} \ln 2}$

15) After a very long time, switch A is closed. Switch B remains closed. What is the magnitude of the current I_1 through resistor R_1 immediately after switch A is closed?

a. $I_1 = 0.567$ A
b. $I_1 = 0.165$ A
c. $I_1 = 0.202$ A
d. $I_1 = 0.446$ A
e. $I_1 = 0.930$ A

Immediately after:



C acts like a wire

$R_{23} = 5\Omega$

$R_{123} = 30\Omega$

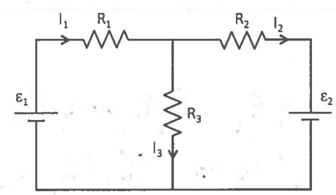
$\Rightarrow I_{123} = \frac{17\text{ V}}{30\Omega} = 0.567$

$I_1 = I_{123}$

Physics 102 Exam 1 –
Spring 2014

1. d
2. a
3. c
4. c
5. e
6. c
7. b
8. c
9. b
10. c
11. b
12. b
13. a
14. d
15. a
16. cd
17. a
18. c
19. b
20. a
21. d
22. a
23. b
24. a

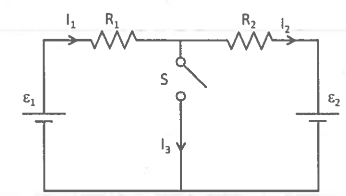
7. Consider the circuit below. Which of the following equations is ***incorrect***?



a. $\varepsilon_1 - \varepsilon_2 - I_1R_1 - I_2R_2 = 0$
b. $\varepsilon_1 - I_1R_1 - I_3R_3 = 0$
c. $\varepsilon_2 - I_2R_2 - I_3R_3 = 0$

The next three questions pertain to the following situation:

Consider the circuit below. $\mathcal{E}_1 = 15$ V, $\mathcal{E}_2 = 5$ V, $R_1 = 1\ \Omega$, $R_2 = 2\ \Omega$. Initially the switch S is *open*.



21. What is the current I_1 in resistor R_1?

a. $I_1 = 0$ A
b. $I_1 = 6.25$ A
c. $I_1 = 3.33$ A
d. $I_1 = 1.50$ A
e. $I_1 = 17.5$ A

$+\mathcal{E}_1 - I_1R_1 - I_2R_2 - \mathcal{E}_2 = 0$

$I_1 = I_2 \Rightarrow I_1(R_1 + R_2) = \mathcal{E}_1 - \mathcal{E}_2$

$I_1 = \dfrac{\mathcal{E}_1 - \mathcal{E}_2}{R_1 + R_2}$

22. Now the switch S is *closed*. What is the current I_3?

a. $I_3 = 0$ A
b. $I_3 = 6.25$ A
c. $I_3 = 3.33$ A
d. $I_3 = 1.50$ A
e. $I_3 = 17.5$ A

$+\mathcal{E}_1 - I_1R_1 = 0$

$\Rightarrow I_1 = 15$ A

$+\mathcal{E}_2 + I_2R_2 = 0$

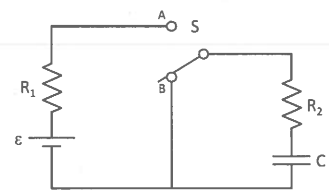
$\Rightarrow I_2 = -2.5$ A

$I_1 = I_2 + I_3$

$I_3 = I_1 - I_2 = 15 - (-2.5) = 17.5$ A

The next five questions pertain to the following situation:

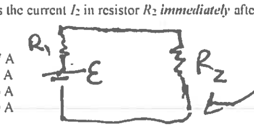
Consider the circuit below. $\mathcal{E} = 5$ V, $R_1 = 2\ \Omega$, $R_2 = 1\ \Omega$, and $C = 15\ \mu$F. Initially the switch S is at position B and the capacitor C is fully discharged.



At $t = 0$, the switch S is flipped to position A.

23. What is the current I_2 in resistor R_2 *immediately* after setting the switch to A?

a. $I_2 = 0$ A
b. $I_2 = 1.67$ A
c. $I_2 = 12.5$ A
d. $I_2 = 6.33$ A
e. $I_2 = 5.00$ A



C acts like a wire

$I = \dfrac{\mathcal{E}}{R_1 + R_2} = 1.67$ A

24. At some time $t > 0$ later, the current through R_2 is found to be $I_2 = 1.0$ A. What is the charge Q on the capacitor C at that precise time?

a. $Q = 30\ \mu$C
b. $Q = 250\ \mu$C
c. $Q = 75\ \mu$C

$+\mathcal{E} - IR_1 - IR_2 - V_c = 0$

$\Rightarrow V_c = 5\text{V} - 1\text{A}(3\Omega) = 2\text{V}$

$Q = CV_c = 15\times10^{-6}\ \text{F}\cdot 2\text{V} = 30\ \mu\text{C}$

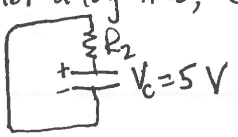
The next three questions continue from the previous page:

After a long time, the switch S is reset to position B. The next three questions pertain to this situation.

25. What is the magnitude of the current I_2 in resistor R_2 ***immediately*** after resetting the switch to B?

After a long time, C fully charged, $V_c = \mathcal{E}$

a. $I_2 = 0$ A
b. $I_2 = 6.67$ A
c. $I_2 = 5.00$ A
d. $I_2 = 12.5$ A
e. $I_2 = 1.33$ A



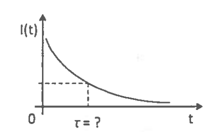
$V_c - IR_2 = 0$

$I = \dfrac{V_c}{R_2}$

26. In what direction around the circuit does the current I flow immediately after resetting the switch?

a. Clockwise
b. Counterclockwise

27. Eventually, the current decays gradually to zero as shown in the figure below. Which formula best represents the time constant τ for this decay?



a. $\tau = R_1C$
b. $\tau = R_2C$
c. $\tau = (R_1 + R_2)C$

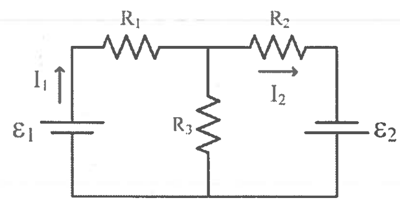
Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

KEY
Exam 1 – Spring 2013

1. b
2. a
3. d
4. c
5. c
6. c
7. c
8. c
9. a
10. c
11. b
12. c
13. c
14. a
15. a
16. d
17. c
18. c
19. b
20. c
21. c
22. c
23. b
24. a
25. c
26. b
27. b

The following situation pertains to the next two questions:

As shown in the diagram below, a circuit is constructed consisting of two batteries with emf ε_1 and ε_2 and resistors with resistance R_1, R_2, and R_3. Two currents I_1 and I_2 are labeled on the diagram.



1. Which equation is a correct application of Kirchhoff's laws?

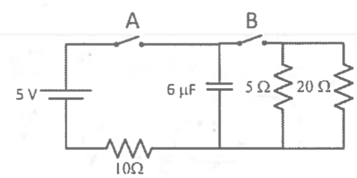
a. $\varepsilon_1 - I_1R_1 - I_2R_2 + \varepsilon_2 = 0$
b. $\varepsilon_1 + I_1R_1 + I_2R_2 + \varepsilon_2 = 0$
c. $\varepsilon_1 + I_1R_1 - I_2R_2 = 0$

2. Which equation is another correct application of Kirchhoff's laws?

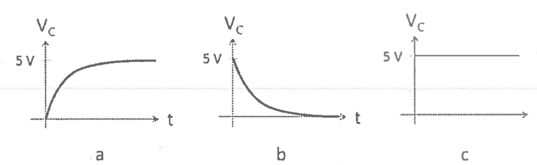
a. $\varepsilon_2 - (I_1 - I_2)R_3 = 0$
b. $\varepsilon_1 - I_1R_1 - (I_1 - I_2)R_3 = 0$
c. $\varepsilon_1 - I_1R_1 - (I_1 + I_2)R_3 = 0$
d. $\varepsilon_2 + (I_1 - I_2)R_3 + I_2R_2 = 0$
e. $\varepsilon_2 + (I_1 + I_2)R_3 + I_2R_2 = 0$

The following situation pertains to the next four questions:

The circuit in the diagram below consists of a 5V battery, a 6 μF capacitor, and a 5Ω, 20 Ω, and 10 Ω resistor. The switches A and B are initially open, and the capacitor is initially uncharged.



5. Switch A is closed at time t=0 and switch B is left open. Which graph shown below best represents how the voltage V_C across the capacitor changes with time t?



a. a
b. b
c. c

6. After closing switch A and waiting a long time, what is the charge on the capacitor?

a. 0 C
b. 1.2 μC
c. 30 μC

$Q = CV$

After a long time $V_c = 5V$

$\Rightarrow Q = 6 \times 10^{-6} F \cdot 5V$

$= 30\ \mu C$

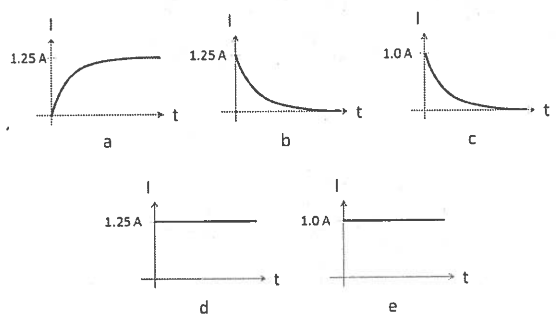
The next two questions refer to the diagram on the previous page:

7. After closing switch A and waiting a long time, what is the current through the 10 Ω resistor?

a. 0.5 A
b. 0 A
c. 2 A

C acts like an open switch after a long time

8. After switch A has been closed for a long time, switch A is opened and switch B is closed. Which graph best represents how the current I through the 5 Ω resistor changes with time after switch B is closed?



a. a
b. b
c. c
d. d
e. e

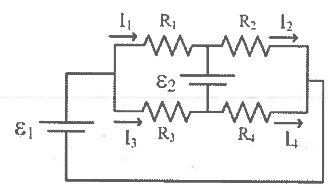
Initially, $V_c = 5\,V$

$\Rightarrow I = \frac{5V}{5\Omega} = 1\,A$

(0.25 A goes through 20Ω resistor, so total $I_{tot} = 1.25\,A$

KEY
Exam 1 – Fall 2012

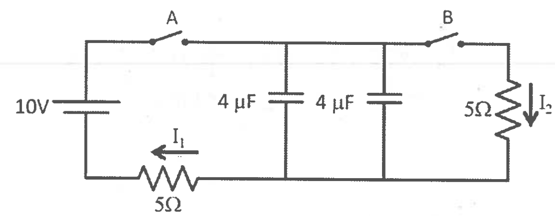
1. a
2. b
3. c
4. c
5. a
6. c
7. b
8. c
9. c
10. a
11. a
12. a
13. a
14. d
15. c
16. b
17. b
18. c
19. c
20. b
21. b
22. c
23. b
24. d
25. d
26. c
27. c



14. What is a valid Kirchhoff loop rule for the circuit shown above?

a. $\varepsilon_1 + I_1 R_1 - I_2 R_2 = 0$
b. $I_4 R_4 + I_3 R_3 - I_1 R_1 - I_2 R_2 = 0$
c. $-\varepsilon_2 - I_2 R_2 + I_4 R_4 = 0$

The next two questions pertain to the circuit shown below:



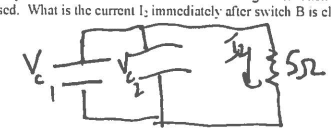
15. Switch B is opened. What is the current I_1 if switch A is left closed for a long time?

a. 2 A
b. 0.5 A
c. 0 A

After a long time, both capacitors are fully charged

16. Switch B is opened and switch A is left closed for a long time. Then switch A is opened and switch B is closed. What is the current I_2 immediately after switch B is closed?

a. 2 A
b. 0.5 A
c. 0 A



Initially $V_{c_1} = V_{c_2} = 10V$

$\Rightarrow$ 10 V across resistor I_2

$I = \frac{V}{R} = \frac{10V}{5\Omega} = 2A$

KEY
Exam 1 – Spring 2012

1. c
2. a
3. b
4. c
5. a
6. c
7. c
8. c
9. a
10. ac
11. d
12. a
13. b
14. b
15. c
16. a
17. b
18. abcde
19. d
20. c
21. b
22. a
23. d
24. b
25. d
26. b