Name: Key

Physics 2020 – Fall 2001

Exam #1 – Sept. 25, 2001

Grading

Multiple Choice (30): _____

Q1 (10): _____ Q2 (20): _____ TOTAL (100): _____

Q3 (20): _____ Q4 (20): _____

Part I: Multiple Choice (3 points each)

Circle the most suitable answer from among those given. If you do not agree with any of the answers write your own.

1. Two unknown resistances are connected in series. Which of these statements is correct?

a) The equivalent resistance is greater than either of the individual resistances.
b) The equivalent resistance is equal to the largest of the individual resistances.
c) The equivalent resistance is less than either of the individual resistances.
d) It is impossible to decide on a), b) or c) without knowing the values of the resistances.

2. Two unknown resistances are connected in parallel. Which of these statements is correct?

a) The equivalent resistance is greater than either of the individual resistances.
b) The equivalent resistance is equal to the smallest of the individual resistances.
c) The equivalent resistance is less than either of the individual resistances.
d) It is impossible to decide on a), b) or c) without knowing the values of the resistances.

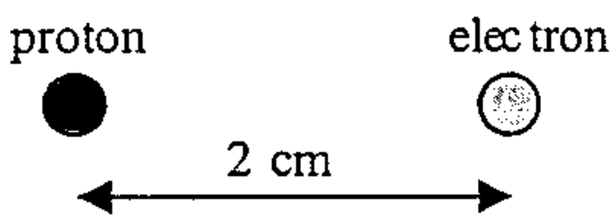
3. The magnitude of the electric field around a negative point charge

a) Gets stronger the further from the charge you move.
b) Is the same, no matter what the distance from the charge is.
c) Gets stronger, the closer to the charge you move.
d) Is zero everywhere.

4. The direction of the electric field around a negative point charge

a) Points tangentially to circles drawn around the charge.
b) Points radially outward from the charge.
c) Trick question. Electric fields have no direction.
(d) Points radially inward toward the charge.

5. A proton and an electron are separated by a distance of 2.0 cm. The total electric potential (V) at a point half-way between them is:



a) Positive, because the proton has a bigger charge than the electron.
b) Positive, because the proton has a bigger mass than the electron.
(c) Zero, because they have equal and opposite charges.
d) Negative, because the proton has no charge.

6. A proton and a neutron:

a) Attract each other because they have opposite charges.
b) Neither attract or repel, because neither are charged.
c) Repel each other because they have the same charge.
(d) Neither attract or repel, because only one of them is charged.

7. Which of the following is NOT a correct combination of units for electric field?

a) Volts per meter (V/m)
b) Ampere-ohms per meter (A.Ω/m)
c) Newtons per Coulomb (N/C).
(d) Coulombs per second (C/s).

8. A metal bar has a length of 1 m and a cross sectional area of 2 cm^2. The bar is then heated and stretched, such that (when it has cooled again) it is now 2 m long, but with a cross sectional area of only 1 cm^2. The electrical resistance of the new, stretched, bar is:

a) The same as before.
(b) More than before.
c) Cannot tell without knowing the resistivity of the material.
d) Less than before.

9. The hallway in a house has two light bulbs that operate in the same circuit. If one bulb 'blows' the other continues to work because:

a) The bulbs are wired in parallel.
b) The bulbs are wired in series.
c) Electricity continues to flow through the blown bulb, it just doesn't light.
d) None of the above.

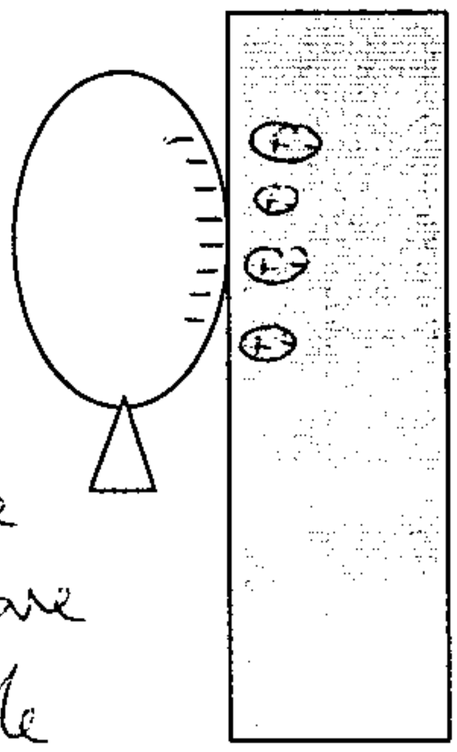
10. Sensitive electronic components are enclosed in metal boxes because:

a) The box shields the outside world from the effects of the strong electric fields created by the components in the box.
b) The box provides a conducting path for the electric circuits inside it.
c) The box shields the components from the effects of the strong electric fields created by other devices around it.
d) A metal box provides the strongest physical protection when the device is moved around.

Part II – Short Answers and Problems

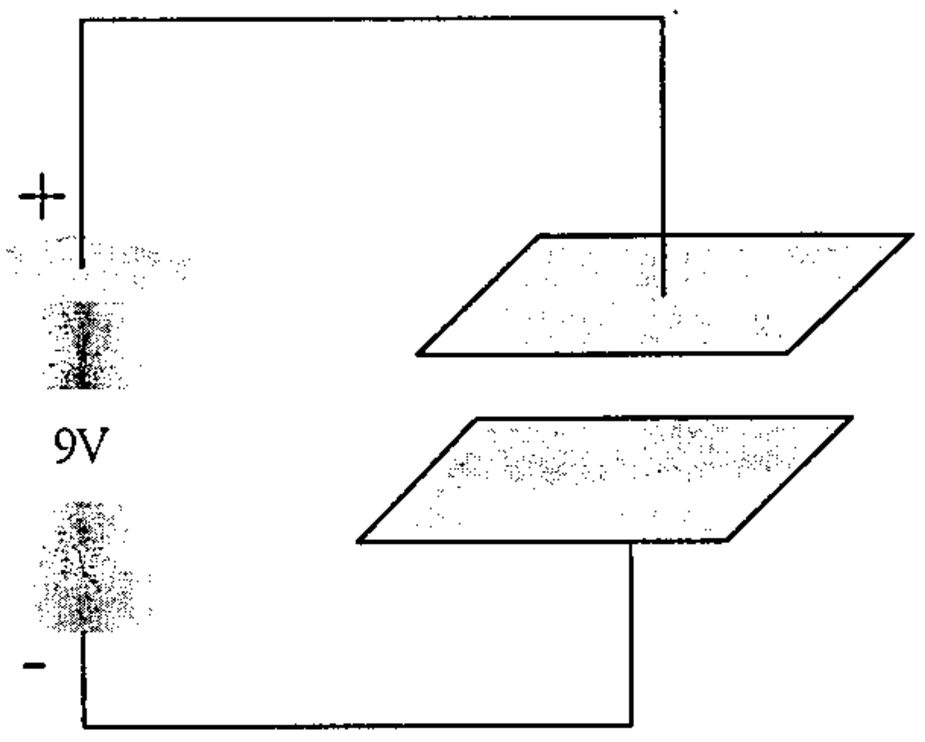
You must show your working and/or explain your answers in order to receive full credit.

1. An inflated rubber balloon is charged (negatively) by rubbing it on a woolen cloth. Explain why the balloon now sticks to the wall. (10 points)



When the negatively charged balloon is brought near to the wall the atoms/molecules in the wall become polarized. This means the + charges are slightly closer to the balloon than the - charges, so the attractive force is stronger than the repulsive force. Therefore the balloon sticks to the wall.

2. A parallel plate capacitor consists of two square flat metal plates, each side being 10 cm long. The plates are separated by a distance of 1 mm, and no dielectric material is placed between them.



a) What is the capacitance of this device? (5 points)

$$C = \frac{\varepsilon_0 A}{d} = \frac{8.85\times10^{-12}\ C^2/N\,m^2 \times (0.10\,m)^2}{0.001\,m}$$

$$= 8.85\times10^{-11}\ F$$

b) If this device is charged up, using a 9 V battery, as shown, what will be the magnitude of the charges on the two plates? (5 points)

$$q = CV = 8.85\times10^{-11}\ F \cdot 9V$$

$$= 7.97\times10^{-10}\ C$$

c) When fully charged, how much energy will be stored in the capacitor? (5 points)

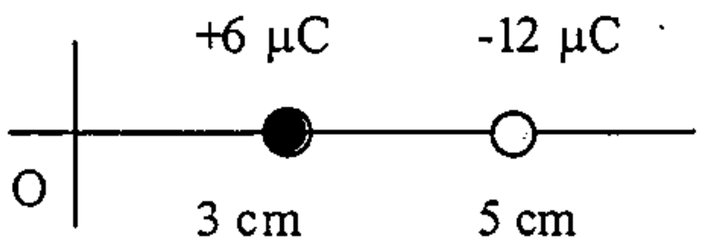
$$E = \frac{1}{2}CV^2 = \frac{1}{2}\times 8.85\times10^{-11}\ F \cdot 9V^2$$

$$= 3.58\times10^{-9}\ J$$

d) When fully charged, what will the magnitude of the electric field between the plates be? (5 points)

$$E = \frac{V}{d} = \frac{9V}{0.001\,m} = 9000\ V/m$$

3. Two charges are placed on the x-axis as shown. A +6 μC charge is placed at x = 3 cm, and a –12 μC charge is placed at x = 5 cm.



a) Determine the magnitude and direction of the force on the + 6 μC charge. (4 points)

$F = \frac{kq_1q_2}{r^2} = 8.99\times10^9\ N m^2/C^2\ \frac{6\times10^{-6}C \times 12\times10^{-6}C}{(0.02m)^2}$

$= 1.62\times10^3 N$

to the right (attracted to - charge)

$E = \frac{kq}{r^2}$

b) Determine the total electric field (magnitude and direction) at the origin. (8 points)

$E_{6\mu C} = 8.99\times10^9\ N m^2/C^2\ \frac{6\times10^{-6}C}{(0.03m)^2} = 6.0\times10^7\ N/C$ to left

$E_{-12\mu C} = 8.99\times10^9\ N m^2/C^2\ \frac{12\times10^{-6}C}{(0.05m)^2} = 4.3\times10^7\ N/C$ to right

$\sum E = 4.3\times10^7\ N/C - 6.0\times10^7\ N/C = -1.7\times10^7\ N/C$

(to left)

c) At what point on the x-axis would the total electric potential V be zero? (8 points)

$V = \frac{kq}{r}$ need $V_{6\mu C} + V_{-12\mu C} = 0$

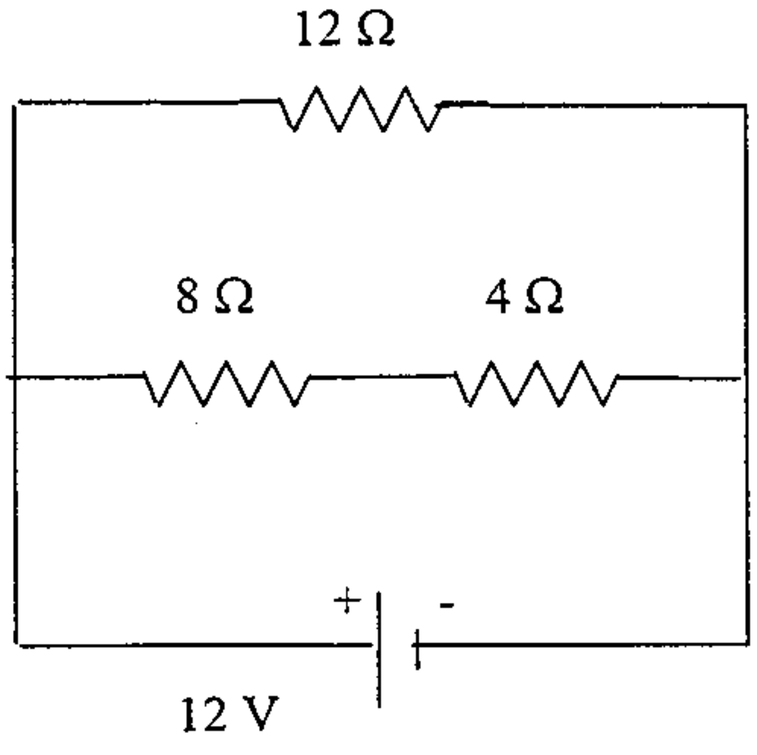
$\frac{k\,6\mu C}{x-3} = \frac{k\,12\mu C}{x-5}$

$\frac{1}{x-3} = \frac{2}{x-5}$

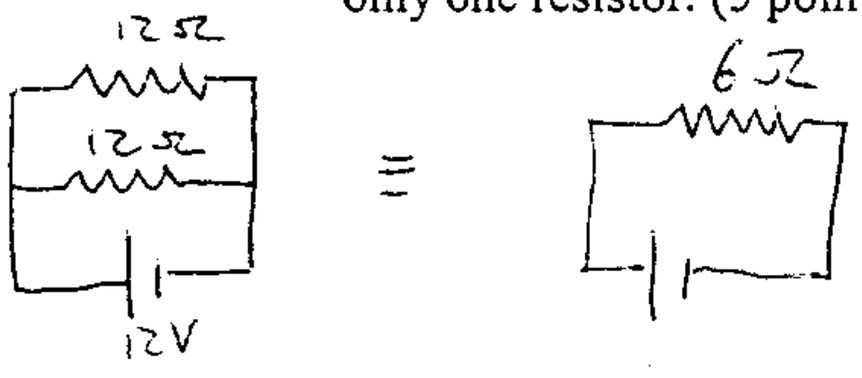
$x - 5 = 2x - 6$

$x = 1$ cm

4. Three resistors and a 12 V battery are connected in a circuit as shown.



a) Determine an equivalent circuit containing only one resistor. (5 points)



b) Determine the total current delivered by the battery. (5 points)

$$V = IR \quad \Rightarrow \quad I = \frac{V}{R} = \frac{12V}{6\Omega} = 2A$$

c) Determine the current through, and potential difference across, the 4 Ω resistor. (10 points)

$$\text{Pick. } V_{12\Omega} = 12V \quad \Rightarrow \quad I_{12\Omega} = \frac{12V}{12\Omega} = 1A$$

$$\Rightarrow I_{4\Omega} = 1A \quad \Rightarrow \quad V_{4\Omega} = 1A \times 4\Omega = 4V$$