Physics 214 Test 1A

Section 1: Dr. Gladden, Feb. 26, 2009

NAME: Key **UM ID#:** _____

Conceptual Multiple Choice (*2 points each*): Clearly write the letter corresponding to the BEST possible answer in the space provided. You may also circle the answer to be sure.

1. A Materials in which the electrons are bound very tightly to the nuclei are referred to as
   A) insulators.
   B) conductors.
   C) semiconductors.
   D) superconductors.

2. B How can a negatively charged rod charge an electroscope positively?
   A) by conduction
   B) by induction
   C) by deduction
   D) It cannot.

3. C Two charged objects are separated by a distance d. The first charge is larger in magnitude than the second charge.
   A) The first charge exerts a larger force on the second charge.
   B) The second charge exerts a larger force on the first charge.
   C) The charges exert forces on each other equal in magnitude and opposite in direction.
   D) The charges exert forces on each other equal in magnitude and pointing in the same direction.

4. A An electron and a proton are separated by a distance of 1.0 m. What happens to the size of the force on the proton if the electron is moved 0.50 m closer to the proton?
   A) It increases to 4 times its original value.
   B) It increases to 2 times its original value.
   C) It decreases to one-half its original value.
   D) It decreases to one-fourth its original value.

5. D Can electric field lines intersect in free space?
   A) Yes, but only at the midpoint between two equal like charges.
   B) Yes, but only at the midpoint between a positive and a negative charge.
   C) Yes, but only at the centroid of an equilateral triangle with like charges at each corner.
   D) No.

6. B One joule per coulomb is a
   A) newton.

B) volt.
C) electron-volt.
D) farad.

7. C A surface on which all points are at the same potential is referred to as
A) a constant electric force surface.
B) a constant electric field surface.
C) an equipotential surface.
D) an equivoltage surface.

8. C If the electric field between the plates of a given capacitor is weakened, the capacitance of that capacitor
A) increases.
B) decreases.
C) does not change.
D) cannot be determined from the information given

9. C Two parallel-plate capacitors are identical in every respect except that one has twice the plate area of the other. If the smaller capacitor has capacitance C, the larger one has capacitance
A) C/2.
B) C.
C) 2C.
D) 4C.

10. B An equipotential surface must be
A) parallel to the electric field at any point.
B) perpendicular to the electric field at any point.
C) there is no connection between their orientation.

11. A The total amount of charge that passes through a wire's full cross section at any point per unit of time is referred to as
A) current.
B) electric potential.
C) voltage.
D) wattage.

12. C The *resistivity* of a wire depends on
A) its length.
B) its cross-sectional area.
C) the material out of which it is composed.
D) all of the given answers

13. C The length of a wire is doubled and the radius is doubled. By what factor does the resistance change?
A) four times as large
B) twice as large

C) half as large
D) quarter as large

14. A If the voltage across a circuit of constant resistance is doubled, the power dissipated by that circuit will
A) quadruple.
B) double.
C) decrease to one half.
D) decrease to one fourth.

15. B A current that is sinusoidal with respect to time is referred to as
A) a direct current.
B) an alternating current.

16. D When two or more resistors are connected in series to a battery
A) the total voltage across the combination is the algebraic sum of the voltages across the individual resistors.
B) the same current flows through each resistor.
C) the equivalent resistance of the combination is equal to the sum of the resistances of each resistor.
D) all of the given answers

17. B Kirchhoff's junction rule is an example of
A) conservation of energy.
B) conservation of charge.
C) conservation of momentum.
D) none of the given answers

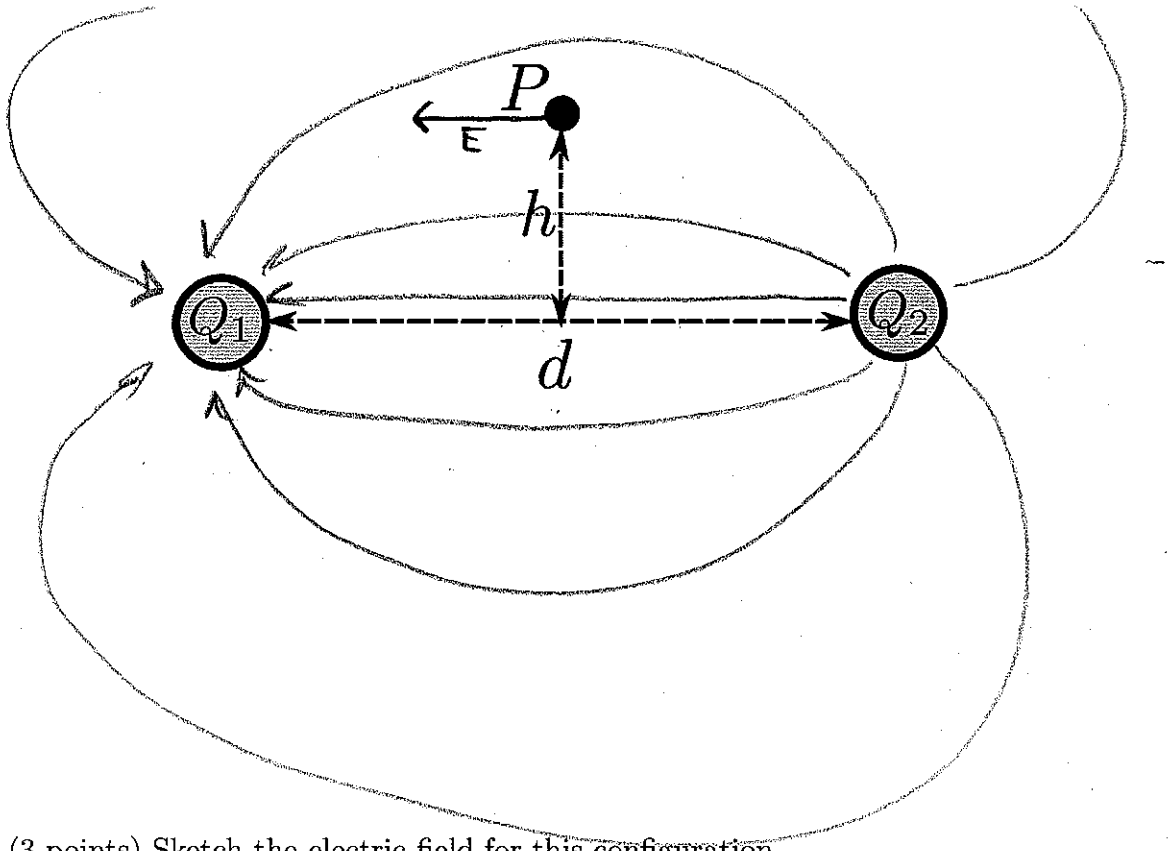
18. B When resistors are connected in parallel, we can be certain that A) the same current flows in each one.
B) the potential difference across each is the same.
C) the power dissipated in each is the same.
D) their equivalent resistance is greater than the resistance of any one of the individual resistances.

19. A As more resistors are added in parallel to a constant voltage source, the power supplied by the source
A) increases.
B) decreases.
C) does not change.
D) increases for a time and then starts to decrease.

20. A Kirchhoff's loop rule is an example of
A) conservation of energy.
B) conservation of charge.
C) conservation of momentum.
D) none of the given answers

Problems: Work each of the following problems. Make sure to **show your work** and put a box around your final answer.

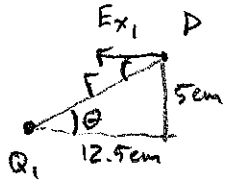
1. (*15 points*) The two charges shown below have the following magnitudes: Q_1 = -2.0 mC and Q_2 = + 2.0 mC. They are separated by a distance of d = 25 cm.



a) (3 points) Sketch the electric field for this configuration.

b) (6 points) Determine the electric field (magnitude and direction) at point P which is located midway between the charges and h = 5.0 cm above a line joining them.

$\theta = \tan^{-1}\left(\frac{5}{12.5}\right) = 22°$



By Symmetry $E_{y_1} = -E_{y_2}$ so they Cancel and only the x components need to be Calculated

also, $E_{x_1} = E_{x_2}$ and $\vec{E} = \vec{E}_{x_1} + \vec{E}_{x_2} = 2E_{x_1}$

Now $|E_1| = k\frac{Q_1}{r^2} = 9\times10^9 \frac{2\times10^{-3}}{[(12.5)^2+(0.05)^2]} = 9.9\times10^8 \frac{N}{C}$

and $E_{x_1} = |E_1|\cos\theta = 9.2\times10^8 N/C$

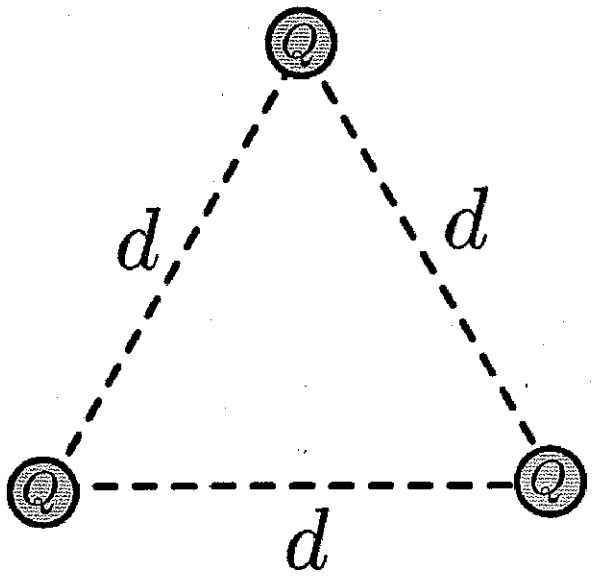
so $\vec{E} = 1.8\times10^9 \frac{N}{C}$ to the left

c) (6 points) If a third charge of Q_3= +1 mC were placed at point P, what force would it experience (magnitude and direction)?

$F_3 = Q_3 E$

$= 1.8\times10^6 N$ to the left

2. (*15 points*) How much work had to be done to assemble the three charges shown below? All charges are +8 mC and they are positioned at the corners of an equilateral triangle of side length 10 cm.



First charge is for free (no work required) : $W_1 = 0$

2nd charge

$W_2 = Q V_1$, where V_1 is potential due to presence of 1st charge

$= Q \, k \frac{Q}{d}$

$= k \frac{Q^2}{d}$

3rd charge

$W_3 = Q V_{12}$, where V_{12} is potential due to the presence of 1st two charges

$= Qk\left[\frac{Q}{d} + \frac{Q}{d}\right]$

$= 2\frac{kQ^2}{d}$

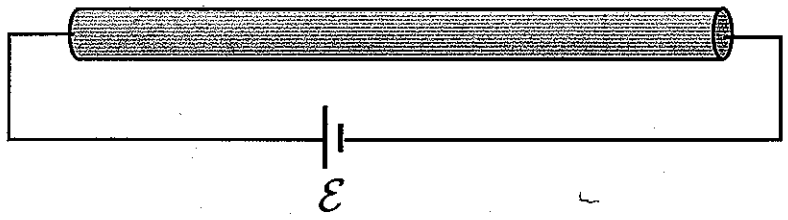
So total work is

$W = W_1 + W_2 + W_3$

$= 3 \, k \frac{Q^2}{d}$

$= 1.73 \times 10^{7}$ J

3. (*15 points*) A section of steel wire with radius 1.5 mm, length 2.5.m is connected across a 1.5 V battery. The resistivity of steel is about 2.5 $\times 10^{-7} \Omega \cdot$m. Assume the system is Ohmic.



a) (5 points) What is the resistance of the wire?

$$R = \rho \frac{L}{A} = \rho \frac{L}{\pi r^2} = 2.5 \times 10^{-7}\,\Omega\cdot m \; \frac{2.5\,m}{\pi (0.0015\,m)^2}$$

$$= 0.089\,\Omega$$

b) (5 points) What current is flowing through the wire?

By Ohm's Law

$$I = \frac{V}{R} = \frac{1.5\,V}{0.089\,\Omega} = 17.0\,A$$

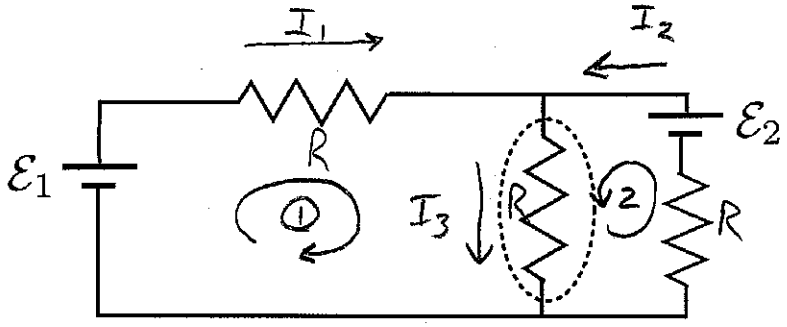
c) (5 points) After 1 minute of this current flowing, how much heat energy has been dissipated?

$$P = IV = \frac{\text{Energy}}{\text{time}}$$

$$\text{So Energy} = IVt = 17.0\,A\,(1.5\,V)(60\,\text{sec})$$

$$= 1.53 \times 10^{3}\,J$$

4. (*15 points*) For the circuit below, all resistors are equivalent: $R = 100\Omega$, $\mathcal{E}_1 = 12V$, and $\mathcal{E}_2 = 6V$.



a) (10 points) Determine the current through the circled resistor. Need I_3

Junction: $I_1 + I_2 = I_3$

Loops: ① $+\mathcal{E}_1 - I_1R - I_3R = 0$ } add ① + ②

② $+\mathcal{E}_2 - I_3R - I_2R = 0$ }

$\mathcal{E}_1 + \mathcal{E}_2 - R(I_1 + I_2 + 2I_3) = 0$, but $I_1 + I_2 = I_3$

So $\frac{\mathcal{E}_1 + \mathcal{E}_2}{R} = 3I_3 \Rightarrow I_3 = \frac{\mathcal{E}_1 + \mathcal{E}_2}{3R} = \frac{12+6}{3(100\,\Omega)} = 0.06\,A = 60\,mA$

b) (5 points) If your answer for a current comes out to negative, what does that mean?

You picked the wrong direction for the current during the set up.

Extra Credit(+5 points)
In problem 2, say a fourth charge of + 20 mC and mass 0.25 kg were placed in the center of the equilateral triangle of charges (or perhaps just barely off center) with an initial velocity of 0. What would it's speed be after it had gotten very far from the triangle of charges? (HINT: the distance to the center from any corner of an equilateral triangle of side length d is $\frac{\sqrt{3}}{3}d$ - but you already knew that!)

Use Conservation of energy

$E_{before} = E_{after}$

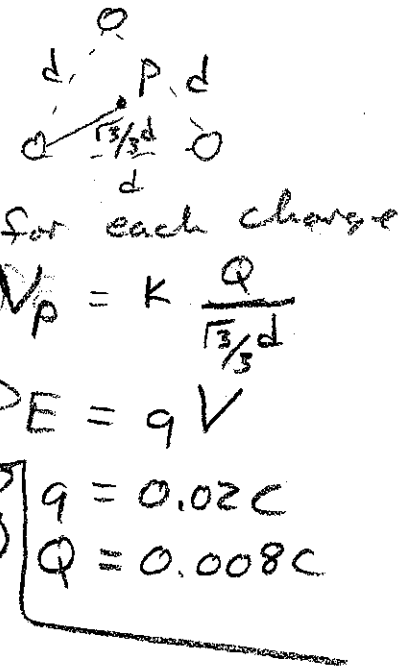
$\Sigma PE_e = KE$

$4k\frac{Qq}{\frac{\sqrt{3}}{3}d} = \frac{1}{2}mv^2$

$v = \sqrt{\frac{24}{\sqrt{3}}k\frac{Qq}{dm}} = \sqrt{\frac{24}{\sqrt{3}}(9\times10^9)\frac{(0.008)(0.02)}{(0.1)(0.25)}}$

$= 2.8\times10^4$ m/s

or 28 $\frac{km}{s}$



Constants:
$k = 1/(4\pi\varepsilon_0) = 9 \times 10^9$ Nm^2/C^2
$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(Nm^2)
Charge of an electron / proton: $e = \pm 1.60 \times 10^{-19}$ C

Test 1 B
MC Key

1. C	11. C
2. A	12. A
3. B	13. B
4. D	14. B
5. B	15. B
6. C	16. C
7. C	17. A
8. C	18. D
9. B	19. A
10. A	20. A