Gen. Phys. II **Exam 1 - Chs. 18,19,20 - Electric Fields, Potential, Current** **Feb. 12, 2018**

Rec. Time **Name**

For full credit, make your work clear. Show formulas used, essential steps, and results with correct units and significant figures. Points shown in parenthesis. For TF and MC, choose the *best* answer.

OpenStax Ch. 18 - Electric Charges & Fields

1. (2) **T F** Good conductors are materials that have a lot of free charges.

2. (2) **T F** Insulators are materials that lack free charges.

3. (2) **T F** The electric force on an electrically neutral object is always zero.

4. (2) **T F** Electric field lines point towards positive charges and away from negative charges.

5. (2) **T F** A region of uniform electric field has parallel electric field lines.

6. (4) A tiny styrofoam ball is suspended on a thread. Tests show it gets attracted to a positively charged rod, and also attracted by a negatively charged rod. What can you can conclude about the tiny styrofoam ball?

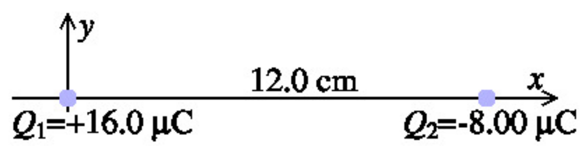
a. It has a negative net charge b. It has zero net charge.
c. It has positive net charge. d. Its net charge changes when then rods are placed near it.

7. (4) A balloon acquires a positive charge when rubbed on a sweater.

a) (2) As a result, the charge acquired by the sweater is a. negative b. zero c. positive.

b) (2) **T F** Electrons were lost by the sweater in the balloon charging process.

8. (12) Two charges, $Q_1 = +16.0\ \mu$C and $Q_2 = -8.00\ \mu$C are separated by 12.0 cm on the x-axis as shown. The charges produce an electric field in the surrounding region. Consider only the electric field along the x-axis.



a) (2) **T F** At any point between the charges, the net electric field points to the right.

b) (2) **T F** At any point to the left of Q_1, the net electric field points to the left.

c) (8) Determine the magnitude of the net electric field at the point midway between the charges.

9. (10) One day, there is a vertically downward electric field of 1800 N/C outside. The electric force on a 7.0 μg charged dust particle exactly balances its weight. What is its electric charge (sign and magnitude)?

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10. (10) Copper has a molar mass of 63.5 grams/mol. One electron from each atom is a "free" electron. Calculate the amount of free charge (in coulombs) in a 3.00-gram penny made of 100% copper.

OpenStax Ch. 19 - Electric Potential **Name**____________________________________

1. (2) **T F** Removing electrons from an object will raise its electric potential.

2. (2) **T F** All points of a conductor with static charges are at the same electric potential.

3. (2) **T F** Electric field lines point towards regions of higher electric potential.

4. (2) **T F** An electron-volt is the same as 1.602×10^{-19} volts.

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5. (2) **T F** Doubling the plate area will quadruple the capacitance of parallel plates.

6. (2) **T F** Combining two 5.0 μF capacitors in series makes a larger capacitance.

7. (2) **T F** When a capacitor discharges through a wire, no charges flow through its dielectric.

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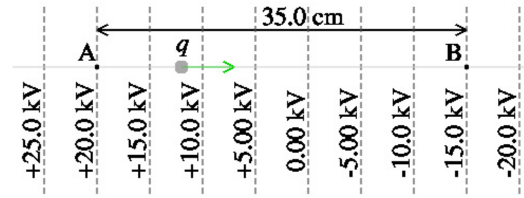
8. (12) The large conducting sphere of a van de Graaf generator has radius $R = 10.0$ cm. At a radius of 20.0 cm from the center of the sphere, the electric field is 250 kV/m pointing radially inward. Determine the electric potential of the sphere (relative to $V = 0$ at $r = \infty$).

9. (12) A proton ($q = +e$, mass=1.67×10^{-27} kg) is released from rest at point A and accelerates 35.0 cm to point B by moving through the equipotentials shown, that are caused by *other* charges.



a) (6) How much work (in J) did the electric field do on the proton?

b) (6) What change in kinetic energy did the proton experience, in electron-volts?

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10. (12) A 58.0 μF capacitor is charged by connecting it to a 12.0 volt battery. The separation of the plates is 0.020 mm. The space between them is filled with pyrex glass, whose dielectric constant is $\kappa = 5.60$.

a) (6) How much charge flowed through the battery while charging the capacitor?

b) (6) How much electric potential energy is now stored in the capacitor?

OpenStax Ch. 20 - Electric Current **Name**____

1. (2) **T F** The electric field inside a current-carrying conductor is non-zero.

2. (2) **T F** A wire's resistance is inversely proportional to its length.

3. (4) When Ohm's Law, $V = IR$, is applied to a resistor R, the "V" refers to the potential ...

   a. where the current enters the resistor.
   b. where the current exits the resistor.
   c. in the middle of the resistor.
   d. difference between the ends of the resistor.

4. (3) What is the lowest current through the human body that would cause ventricular fibrillation?

   a. 1 mA. b. 5 mA. c. 20 mA. d. 100 mA. e. 6.0 A.

5. (3) What is the highest current through the human body that would be considered harmless?

   a. 1 mA. b. 5 mA. c. 20 mA. d. 100 mA. e. 6.0 A.

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6. (12) A particle accelerator produces a beam of He^{++} ions (α-particles) with a current of 0.250 mA.

   a) (6) How many He^{++} ions per second pass by an arbitrary point in the beam?

   b) (6) How long does it take for 1.00 C of charge to pass by?

7. (12) A 1200-watt hair dryer operates on 125 volts-rms AC at 60.0 Hz.

a) (6) Calculate the rms current through the hair dryer.

b) (6) How large is the electrical resistance inside the hair dryer?

8. (12) A particular 12.6-volt car battery is able to supply an electrical power of 1.68 kW to a motor during a time of 2.80 hours until it needs recharging.

a) (6) Determine the total energy that the battery can supply to a device, in kilowatt-hours.

b) (6) For how long could the battery power a 18.0-watt lightbulb that operates on 12.6 V?

Ch. 18 = __________/50 Ch. 19 = __________/50 Ch. 20 = __________/50

Prefixes

a=10^{-18}, f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^3, M=10^6, G=10^9, T=10^{12}, P=10^{15}

Physical Constants

$k = 1/4\pi\epsilon_0 = 8.988$ GN·m^2/C^2 (Coulomb's Law)

$\epsilon_0 = 1/4\pi k = 8.854$ pF/m (permittivity of space)

$e = 1.602 \times 10^{-19}$ C (proton charge)

$m_e = 9.11 \times 10^{-31}$ kg (electron mass)

$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units

$N_A = 6.02 \times 10^{23}$/mole (Avagodro's #)

1 u = 1 g/N_A = 1.6605×10^{-27} kg (mass unit)

1.0 eV = 1.602×10^{-19} J (electron-volt)

1 V = 1 J/C = 1 volt = 1 joule/coulomb

1 F = 1 C/V = 1 farad = 1 C^2/J

1 A = 1 C/s = 1 ampere = 1 coulomb/second

1 Ω = 1 V/A = 1 ohm = 1 J·s/C^2

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).

$V_x = V\cos\theta, \quad V_y = V\sin\theta,$

$V = \sqrt{V_x^2 + V_y^2}, \quad \tan\theta = \frac{V_y}{V_x}.$ θ is the angle from $\vec{V}$ to $+x$-axis.

Addition: $\mathbf{A} + \mathbf{B}$, head to tail. Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $-\mathbf{B}$ is $\mathbf{B}$ reversed.

Trig summary

$\sin\theta = \frac{\text{(opp)}}{\text{(hyp)}}, \quad \cos\theta = \frac{\text{(adj)}}{\text{(hyp)}}, \quad \tan\theta = \frac{\text{(opp)}}{\text{(adj)}}, \quad \text{(opp)}^2 + \text{(adj)}^2 = \text{(hyp)}^2.$

$\sin\theta = \sin(180^\circ - \theta), \quad \cos\theta = \cos(-\theta), \quad \tan\theta = \tan(180^\circ + \theta), \quad \sin^2\theta + \cos^2\theta = 1.$

OpenStax Chapter 18 Equations

Charges:

$Q = \pm Ne, \quad \Delta Q_1 + \Delta Q_2 = 0, \quad e = 1.602 \times 10^{-19}$ C.

Electric Force:

$F = k\frac{Q_1 Q_2}{r^2}, \quad k = 8.988 \times 10^9$ N·m^2/C^2, $\quad F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}, \quad \epsilon_0 = \frac{1}{4\pi k} = 8.854$ pF/m.

$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + ...$ superposition of many forces.

$F_x = F_{1x} + F_{2x} + F_{3x} + ...$ superposition of x-components of many forces.

$F_y = F_{1y} + F_{2y} + F_{3y} + ...$ superposition of y-components of many forces.

Electric Field:

$\vec{E} = \frac{\vec{F}}{q}$, q= test charge. Or: $\vec{F} = q\vec{E}$.

$|\vec{E}| = E = k\frac{Q}{r^2} = \frac{Q}{4\pi\epsilon_0 r^2}$, due to point charge. Negative Q makes inward $\vec{E}$, positive Q makes outward $\vec{E}$.

$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ...$ superposition of many electric fields.

$E_x = E_{1x} + E_{2x} + E_{3x} + ...$ superposition of x-components of many electric fields.

$E_y = E_{1y} + E_{2y} + E_{3y} + ...$ superposition of y-components of many electric fields.

$E = k\frac{Q}{r^2}$ = electric field around a point charge or *outside* a spherical charge distribution.

OpenStax Chapter 19 Equations

Potential Energy and Work:

$W_{ba} = F_E d \cos\theta =$ work done by electric force F_E on test charge, in displacement d from a to b.

$W_{ba} = -q\Delta V = -q(V_b - V_a) =$ work done by electric force on a test charge, moved from a to b.

$\Delta\text{PE} = q\Delta V = q(V_b - V_a) =$ change in electric potential energy of the system. Also: $\Delta\text{PE} = -W_{ba}$.

$\Delta KE + \Delta PE = 0$, or, $\Delta KE = -\Delta PE = -q\Delta V$, principle of conservation of mechanical energy.

$\Delta KE + \Delta PE = W_{\text{nc}}$, change in mechanical energy when nonconservative forces are present.

Potential:

$\Delta V = \frac{\Delta\text{PE}}{q} =$ definition of change in electric potential.

$\Delta V = Ed =$ potential change in a uniform electric field.

$V = k\frac{Q}{r} =$ potential produced by a point charge or *outside* a spherical charge distribution.

$\text{PE} = qV =$ potential energy for a test charge at a point in a field.

$\text{PE} = k\frac{Q_1 Q_2}{r_{12}} =$ potential energy of a pair of charges.

Capacitance:

$Q = CV$, $C = \kappa\epsilon_0\frac{A}{d}$, $E = V/d$, capacitor equations.

$U = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} =$ stored energy.

$E = \frac{Q/A}{\epsilon_0} =$ electric field strength very near a charged conductor.

OpenStax Chapter 20 Equations

Electric current:

$I = \frac{\Delta Q}{\Delta t}$, or $\Delta Q = I\Delta t$, definition of current.

$V = IR$, or $I = V/R$, Ohm's law.

$R = \rho\frac{L}{A} =$ calculation of resistance.

$\rho_T = \rho_0[1 + \alpha(T - T_0)] =$ temperature-dependent resistivity.

Electric power:

$P = IV$, $P = I^2R$, $P = V^2/R$, $P =$ instantaneous energy/time.

Alternating current:

$V = V_0\sin(2\pi ft) =$ time-dependent AC voltage. $I = I_0\sin(2\pi ft) =$ time-dependent AC current.

$V_{\text{rms}} = \sqrt{\overline{V^2}} = V_0/\sqrt{2} =$ root-mean-square voltage. $I_{\text{rms}} = \sqrt{\overline{I^2}} = I_0/\sqrt{2} =$ root-mean-square current.

AC power in resistors:

$\overline{P} = \frac{1}{2}I_0^2R = \frac{1}{2}V_0^2/R = \frac{1}{2}I_0V_0 =$ average power. $\overline{P} = I_{\text{rms}}^2R = V_{\text{rms}}^2/R = I_{\text{rms}}V_{\text{rms}} =$ average power.