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** A negative ion is an atom that has gained electrons.

2. (2) **T F** A positive ion is an atom that has gained protons.

3. (2) **T F** A coulomb of charge corresponds to 6.24×10^{18} elementary charges of size $e = 1.602 \times 10^{-19}$ C.

4. (2) When two equal but opposite charges $q_1 = -q_2$ are separated by 1.00 cm, they exert a Coulomb force of magnitude F on each other. If each charge is doubled in magnitude, the force becomes

a. $F/4$ b. $F/2$ c. F d. $2F$ e. $4F$ f. some other value.

5. (2) The static electric field *inside* an object made from a conducting material is (check the best answer)

a. zero everywhere. b. constant in magnitude and direction, but not necessarily zero.
c. constant in magnitude only. d. greater than the electric field outside.

6. (12) A small balloon has been given some charge by rubbing it on a sweater. It is noticed that a dust particle 2.5 meters away, with a net charge of -3.6 nC, is repelled with a force of 6.5×10^{-7} N. Assume that the balloon is like a point charge.

a) (2) **T F** The electric field acting on the dust particle points away from the balloon.

b) (4) How strong is the electric field due to the balloon, acting on the dust particle (magnitude only)?

c) (6) Determine the electric charge on the balloon (sign and value).

7. (8) Three identical conducting spheres A, B and C carry initial charges $Q_A = Q$, $Q_B = 0$ and $Q_C = -Q$. Now A and B are touched togther and separated, and then B and C and touched together and separated.

a) (4) Determine the final charge on sphere A.

b) (4) Determine the final charge on sphere B.

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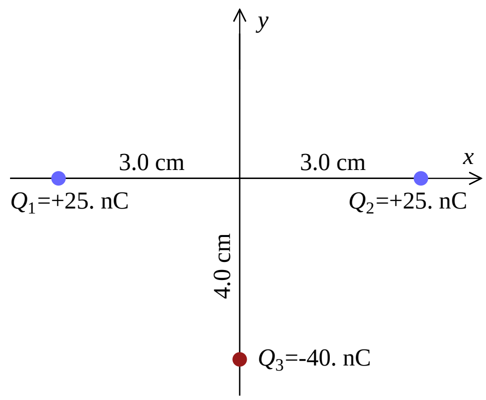
8. (10) Three charges are fixed in place as shown in the xy plane.



a) (4) Find the x-component of the net electric field at the origin.

b) (6) Find the y-component of the net electric field at the origin.

1. (2) **T F** In a vertically upward electric field, the electric potential increases with height.
2. (2) **T F** The equipotentials around an isolated positive point charge are spheres.
3. (2) **T F** The equipotentials between oppositely charged parallel plates are planes.
4. (2) **T F** A volt is the same as a newton·meter/coulomb.

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5. (2) The electric potential *inside* an object made from a conducting material is (check the best answer)

a. zero everywhere. b. constant, but not necessarily zero.
c. greatest at the surface of the object. d. greatest at the center of the object.

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6. (2) **T F** 2.0 μF and 4.0 μF capacitors in series have equal voltages between their plates.
7. (2) **T F** A capacitor that loses half its stored charge also loses half its stored energy.

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8. (12) A cell wall membrane is 8.0 nm thick. Excess negative charges are found just inside the cell, and excess positive charges are found just outside the wall membrane. When a Cl^- ion passes from outside the cell to inside the cell, the amount of work required is 7.0×10^{-21} J.

a) (6) If the electric potential is zero outside the cell, determine the electric potential inside the cell.

b) (6) Calculate the strength of the electric field, assumed constant, within the cell wall membrane.

9. (8) A proton ($q = +e$, mass=1.67×10^{-27} kg) is released from rest in vacuum and accelerated over a distance of 25 cm in a uniform electric field until its speed is 5.6×10^5 m/s. What change in kinetic energy did the proton experience, in electron volts (eV)?

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10. (6) You are given a 9.00-volt battery and five initially uncharged 25.0 μF capacitors. When you connect all five capacitors in series to the battery, how much charge flows out of its positive terminal while the capacitors are charging?

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

1. (2) **T F** Electric current always corresponds to a flow of electrons.

2. (2) **T F** In a battery that is charging, the electric current flows into the positive terminal.

3. (2) **T F** A 300 mA current through your chest will probably cause ventricular fibrillation.

4. (2) **T F** For alternating current, the peak value is twice the rms (root-mean-square) value.

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5. (2) 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.

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6. (12) During a biological process, 3900 K^+ ions pass through a channel in the phospholipid bilayer of a cell membrane in 680 μs.

   a) (6) What is the electric current through the channel during that time interval?

   b) (6) If the potential difference across the channel is 75 mV, what electric power is associated with the current?

7. (6) A circuit breaker in your house is rated to turn off at an rms current of 20.0 A. The circuit is operating at 120 V (rms). What is the minimum resistance that can be connected to the circuit before the breaker trips?

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8. (12) A 14.4-volt laptop battery is rated to store a charge of 4460 mA·H (milliamp-hours).

a) (6) Determine the total charge (in coulombs) the battery can supply before it needs to be recharged.

b) (6) For how long (in hours) could the battery power a laptop using an average power of 8.00 watts?

 Ch. 18 = ___________/40 Ch. 19 = ___________/40 Ch. 20 = ___________/40

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/$N_A = 1.6605 \times 10^{-27}$ 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:

$F = k\frac{Q_1Q_2}{r^2}, \quad k = 8.988 \times 10^9$ N·m^2/C^2, $\quad F = \frac{Q_1Q_2}{4\pi\epsilon_0 r^2}, \quad \epsilon_0 = \frac{1}{4\pi k} = 8.854$ 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.