General Physics II Exam 1 - Chs. 18,19,20- Electric Fields, Potential, Current Feb. 10, 2020

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 charged Van de Graaff generator will not attract objects made from insulators.

2. (2) **T F** When a plastic rod is rubbed with fur, the plastic & fur get charges of opposite signs.

3. (2) **T F** It is impossible to give an insulator a net charge.

4. (2) **T F** In a metal like silver, all of the electrons are free electrons.

5. (12) A water droplet has a mass of 2.0 milligrams (molar masses: H=1.0 g/mole, O=16 g/mole).

a) (6) How many H_2O molecules does this droplet contain?

b) (6) What is the electric charge of the droplet if one electron has been removed from each H_2O molecule in it?

Questions about electrostatic fields.

6. (2) **T F** Electric field lines point out from positive charges and in towards negative charges.

7. (2) **T F** Electrostatic fields inside conductors are always zero.

8. (2) **T F** The electric field strength is higher where electric field lines are closer together.

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

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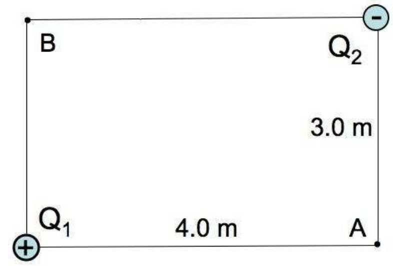
10. (12) Two charges, $Q_1 = +16.0$ nC and $Q_2 = -18.0$ nC occupy two corners of a rectangle as shown. These charges produce an electric field in the surrounding region.



a) (6) Find the x & y **components** of the electric field $\vec{E}$ at point A.

b) (6) Find the **magnitude** and **direction** of the electric field at point A.

Openstax Ch. 19 - Electric Potential **Name** ______________________________________

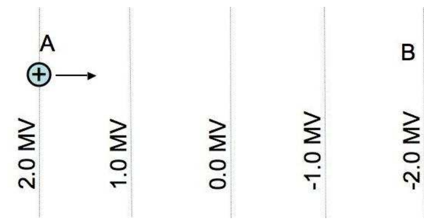
1. (2) **T F** Equipotential surfaces are perpendicular to electric field lines.

2. (2) **T F** Electric field lines point towards lower electric potential.

3. (2) **T F** The electron-volt is a unit of electric potential.

4. (2) **T F** When two charges of opposite signs get closer together their electric potential energy increases.

5. (14) A helium (He) nucleus ($q = +2e$, mass$=4u = 6.64 \times 10^{-27}$ kg) is released from rest at point A and moves to point B. It moves through equipotentials as shown, caused by *other* charges.



a) (4) How much work did the electric field do on the He nucleus, in electron-volts?

b) (4) What change in kinetic energy did the He nucleus experience, in joules?

c) (6) How fast is the He nucleus moving at B, in m/s?

6. (4) The electrostatic potential 2.50 cm away from a point charge is -56.0 V. What is the charge?

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7. (16) A capacitor stores +680 μC of charge on the positive plate when connected to a 20.0 volt battery. The separation of the plates is 2.0×10^{-6} m; the space between them is filled with a dielectric with $K = 12$ and dielectric strength 24×10^{6} V/m.

a) (6) How large is its capacitance?

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

c) (4) What is the maximum voltage that can be applied to this capacitor?

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

1. (4) In a metal wire carrying a current,

a) (2) the electric field is a. zero b. parallel to the current c. opposite to the current.

b) (2) the free electron velocity is a. zero b. parallel to the current c. opposite to the current.

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2. (2) **T F** Na^+ ions passing through a cell membrane do not constitute an electric current.

3. (2) **T F** The resistance of a wire is linearly proportional to its length.

4. (2) **T F** Very good conductors like copper, silver and gold have large values of resistivity.

5. (2) **T F** A current of 5 mA in the human body is the maximum allowed shock for safety reasons.

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6. (12) A 1.4-volt battery connected to a circuit produces a current where 5.0×10^{12} electrons leave its negative terminal each second.

a) (6) How large is the current, in amperes?

b) (6) What electrical power (in watts) is being supplied by the battery?

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7. (6) A flashlight has four 1.50-volt D-batteries wired in series to a lightbulb that uses a 450 mA current. What is the (hot) resistance of the lightbulb, in ohms?

8. (4) The voltage from a portable generator is $V(t) = 1.80 \times 10^2\ \sin(60.0\pi t)$, where V is in volts and t is in seconds. What is the frequency f in hertz?

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9. (8) A 75.0-watt lightbulb operates on 125 volts-rms AC at 60.0 Hz.

a) (4) Calculate the rms current through the lightbulb.

b) (4) Calculate the peak current through the lightbulb.

 Ch. 18 = __________/40 Ch. 19 = __________/42 Ch. 20 = __________/42

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

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

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

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:

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

Alternating current:

$V = V_0 \sin(2\pi f t)$ = time-dependent AC voltage. $I = I_0 \sin(2\pi f t)$ = 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:

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