General Physics II Exam 2 - Chs. 19–21 - Circuits, Magnetism, EM Induction - Mar. 4, 2013

Name Rec. Instr. Rec. Time

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.

1. (2) What quantity is being used up when current flows through a resistor R?

a. voltage across R. b. current through R. c. potential energy of charges.

2. (3) When three resistors R_A, R_B, and R_C are wired in series to an ideal battery,

a. they have the same currents. b. they have currents inversely proportional to their resistances.
c. they have the same voltage drops. d. they use equal amounts of power.

3. (3) When three resistors R_A, R_B, and R_C are wired in parallel and connected to an ideal battery,

a. they have the same currents. b. they have voltage drops proportional to their resistances.
c. they have the same voltage drops. d. they use equal amounts of power.

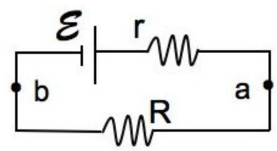
4. (2) **T F** A standard 100-watt incandescent lightbulb use 100 watts of power for any applied voltage.

5. (2) **T F** A standard 100-watt lightbulb has greater resistance than a standard 50-watt lightbulb.

6. (2) **T F** A kilowatt-hour is a unit of electric energy.

7. (2) **T F** An ampere-hour is a unit of charge.

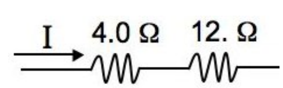
8. (10) The terminal voltage of a real 12.0-volt battery drops to only 11.2 volts when sending current into a load with a resistance $R = 1.50\ \Omega$.



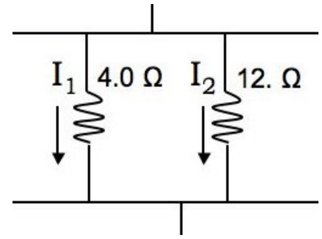
a) (5) What current is flowing through the load?

b) (5) What is the internal resistance of the battery?

9. (8) Two resistors are connected as shown in a larger circuit. There is nothing else connected between them. If the voltage across the 4.0 Ω resistor is 6.0 V, how large is the voltage across the 12 Ω resistor?



10. (8) Two resistors are connected as shown in a larger circuit. If the current through the 4.0 Ω resistor is 6.0 A, how large is the current through the 12 Ω resistor?



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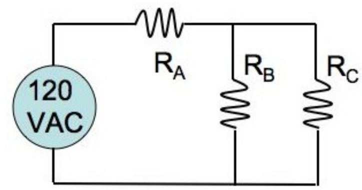
11. (18) Resistor R_A is a standard 120 VAC, 50-watt lightbulb. Resistors $R_B = R_C = 144\ \Omega$ are standard 120 VAC, 100-watt lightbulbs. The rms-voltage supplied to the circuit is 120 VAC at frequency 60 Hz.



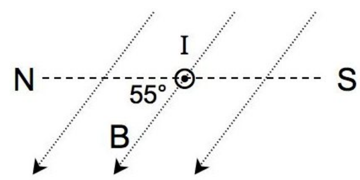
a) (4) What is the resistance of lightbulb A?

b) (6) How large is the equivalent resistance connected to the 120 VAC power supply?

c) (6) How much rms-current flows through lightbulb A?

d) (2) Which lightbulb glows the brightest? a. A. b. B. c. C. d. B & C tie. e. all three tie.

12. (10) A 40.0-meter long straight wire carries a 75.0 A current towards the west. Earth's 0.45-gauss magnetic field there points north but 55.0° below horizontal.



a) (4) In what direction is the magnetic force $\vec{F}$ on the wire? Draw and label $\vec{F}$ on the diagram or use $\odot$ to show that $\vec{F}$ is out-of-the-page or $\otimes$ to show that $\vec{F}$ is into-the-page.

b) (6) Calculate the magnitude of the magnetic force on the wire.

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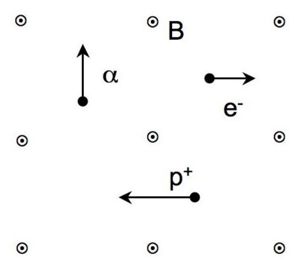
13. (6) A uniform magnetic field points out of the page. The diagram shows the instantaneous velocities of a proton (p), an electron (e) , and an alpha-particle (α, He^{2+} ion).



a) (2) The magnetic force on the proton points
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

b) (2) The magnetic force on the electron points
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

c) (2) The magnetic force on the alpha-particle points
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

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14. (2) A bar magnet is set as shown. Which is closest to the direction of its magnetic field at point P?
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

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15. (2) A wire carries a current I as shown. Which is closest to the direction of its magnetic field at point P?
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

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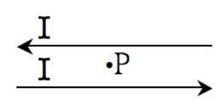
16. (2) Two parallel wires carry opposite but equal currents as shown. The magnetic field at a point halfway them has which direction (or choose $B = 0$ if appropriate)?
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙ g. $B = 0$



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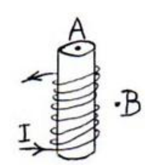
17. (4) A solenoid carries a current as shown.



a) (2) The direction of its magnetic field at point A is closest to
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

b) (2) The direction of its magnetic field at point B is closest to
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

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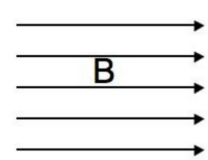
18. (6) A region has a uniform magnetic field pointing horizontally to the right as shown.



a) (2) The north pole of a compass needle placed in this magnetic field points:
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

b) (2) The magnetic force on a proton instantaneously moving into the page points:
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

c) (2) The magnetic force on a wire carrying a currrent downwards on the page points:
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙

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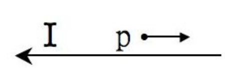
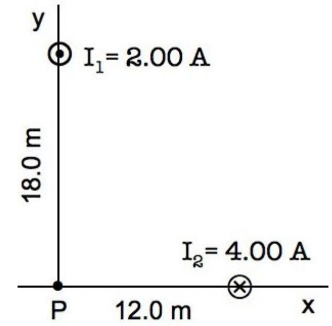
19. (2) A wire carries a current I. Which is closest to the direction of the force on a proton (p) moving as shown?
a. ↑ b. ↓ c. ← d. → e. ⊗ f. ⊙



20. (12) Two long straight wires carry currents perpendicular to the page as shown. Determine the x and y components of the net magnetic field produced at point P.



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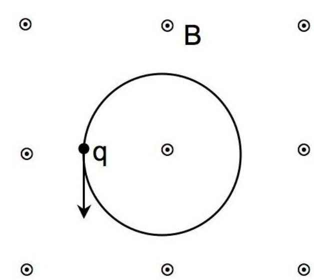
21. (14) A fluorine ion ($q = +4e,\ m = 3.15 \times 10^{-26}$ kg) that was accelerated through a potential difference of 48.0 kV moves in circular motion in a uniform 0.850-tesla magnetic field, see diagram.



a) (2) **T F** The diagram shows the correct direction of its motion.

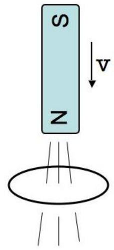
b) (6) Calculate the speed of the fluorine ion.

c) (6) Calculate the radius of its cyclotron orbit.

22. (3) The north pole of a bar magnet is moved towards a loop of wire. Viewed from above, the induced current in the wire loop is

a. zero. b. clockwise.

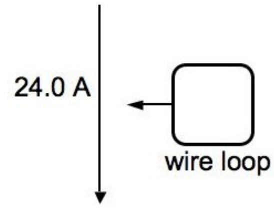
c. counterclockwise.



23. (3) A wire loop is pushed towards a long straight wire carrying a constant current. The induced current in the wire loop is

a. zero. b. clockwise.

c. counterclockwise.



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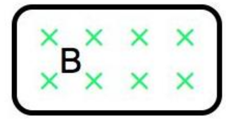
24. (10) A magnetic field points perpendicularly into a 2.0 cm × 4.0 cm rectangular coil with 120 turns and 0.25 Ω total resistance. At a certain instant, the magnetic field strength is 0.22 T and it is increasing at a rate of 2.5 T/s.



a) (2) The induced current in the coil is a. clockwise. b. counterclockwise.

b) (8) Calculate the instantaneous induced current in the coil.

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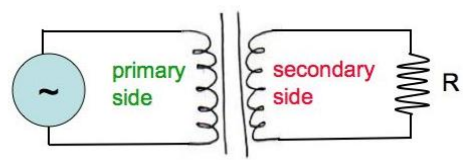
25. (10) An ideal transformer has 48.0 turns on the primary side and 960 turns on the secondary side. The secondary side is connected to a stereo using 12.0 watts average power at 124 volts rms, 60.0 Hz.



a) (5) How large is the rms voltage across the primary side of the transformer?

b) (5) How large is the rms current through the primary side of the transformer?

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

$k = 1/4\pi\epsilon_0 = 8.988$ GNm^2/C^2 (Coulomb's Law)
$e = 1.602 \times 10^{-19}$ C (proton charge)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$\epsilon_0 = 1/4\pi k = 8.854$ pF/m (permittivity of space)
$\mu_0 = 4\pi \times 10^{-7}$ T·m/A (permeability of space)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units

$N_A = 6.02 \times 10^{23}$/mole (Avogadro's #)
1.0 eV = 1.602×10^{-19} J (electron-volt)
1 F = 1 C/V = 1 farad = 1 C^2/J
1 A = 1 C/s = 1 ampere = 1 coulomb/second
1 T = 1 N/A·m = 1 tesla = 1 newton/ampere·meter
1 u = 1 g/N_A = 1.6605×10^{-27} kg (mass unit)
1 V = 1 J/C = 1 volt = 1 joule/coulomb
1 H = 1 V·s/A = 1 henry = 1 J/A^2
1 Ω = 1 V/A = 1 ohm = 1 J·s/C^2
1 G = 10^{-4} T = 1 gauss = 10^{-4} tesla

Chapter 16 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 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.

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

Chapter 17 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: $\Delta\text{PE} = -W_{ba}$.

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.

PE = qV = potential energy for a test charge at a point in a field.

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

Capacitance:

$Q = CV, \quad C = K\epsilon_0\frac{A}{d}$ = 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.

Chapter 18 Equations

Electric current and power:

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

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

$R = \rho L/A$ calculation of resistance.

$\rho = \rho_0[1 + \alpha(T - T_0)]$ resistivity changes.

$P = IV, \quad P = I^2R, \quad P = V^2/R.$

$P =$ instantaneous work/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.

$V_{\rm rms} = \sqrt{\overline{V^2}} = V_0/\sqrt{2} =$ root-mean-square voltage.

$I_{\rm rms} = \sqrt{\overline{I^2}} = I_0/\sqrt{2} =$ 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.

$\overline{P} = I_{\rm rms}^2R = V_{\rm rms}^2/R = I_{\rm rms}V_{\rm rms} =$ average power.

Chapter 19 Equations

Resistor Combinations

$R_{\rm eq} = R_1 + R_2 + R_3 + ...$ (series)

$\frac{1}{R_{\rm eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$ (parallel)

Real batteries

$V_{ab} = \mathcal{E} - Ir$ (terminal voltage)

$V_{ab} = IR$ (connected to load R)

Kirchhoff's Rules

$\sum \Delta V = 0$ (loop rule, energy conservation)

$\sum I = 0$ (node rule, charge conservation)

Chapter 20 Equations

Magnetic forces, torque

$F = IlB \sin\theta$ (on a current)

$F = qvB \sin\theta$ (on a moving charge)

$F/l = \frac{\mu_0}{2\pi}\frac{I_1I_2}{d}$ (between currents)

$F = qvB = mv^2/r$ (during cyclotron motion)

$\tau = NBAI \sin\theta$ (torque on a coil)

$v = \omega r = 2\pi fr = 2\pi r/T$ (circular motion)

Magnetic Fields

$B = \frac{\mu_0}{2\pi}\frac{I}{r}$ (due to long straight wire)

$B = \mu_0 IN/l$ (inside a solenoid)

Right Hand Rules

Force (thumb) = [I (4 fingers)] × [magnetic field (palm)] (force on a current)

Force (thumb) = [qv (4 fingers)] × [magnetic field (palm)] (force on a moving charge)

Current (thumb) $\Longleftrightarrow$ [magnetic field (4 fingers)] (magnetic field around a wire)

Current (4 fingers) $\Longleftrightarrow$ [magnetic field (thumb)] (magnetic field inside a current loop)

Chapter 21 Equations

Faraday's Induced EMF

$\Phi_B = BA\cos\theta$ (magnetic flux)

$\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t}$ (induced emf)

$\mathcal{E} = Blv$ (moving conductor)

$\mathcal{E} = NBA\omega \sin\omega t$ (AC generator)

$V - \mathcal{E} = IR$ (motor's counter-emf)

$\mathcal{E}_1 = -M\frac{\Delta I_2}{\Delta t}$ (mutual inductance emf)

$V_S/V_P = N_S/N_P$ (transformer equation)

$I_PV_P = I_SV_S$ (power in = power out)

AC Circuits, Inductors, Capacitors, Reactance

$\mathcal{E} = -L\frac{\Delta I}{\Delta t}$ (self-inductance emf)

$U = \frac{1}{2}LI^2$ (stored magnetic energy)

$X_L = 2\pi fL = \omega L$ (inductive reactance)

$V_L = IX_L$ (inductor voltage)

$X_C = 1/(2\pi fC) = 1/(\omega C)$ (capacitive reactance)

$V_C = IX_C$ (capacitor voltage)

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ (series RLC impedance)

$V_{\rm gen} = \sqrt{V_R^2 + (V_L - V_C)^2}$ (series RLC)

$\omega_0 = 1/\sqrt{LC}, \quad f_0 = \frac{\omega_0}{2\pi}$ (LC resonance)

$\tan\phi = (X_L - X_C)/R$ (series RLC phase)

$\overline{P} = I_{\rm rms}V_{\rm rms}\cos\phi$ (AC average power)

$\overline{P} = I_{\rm rms}V_{\rm rms}\cos\phi = I_{\rm rms}^2R$ (series RLC)