General Physics II Exam 2 - Chs. 18B–21 - Circuits, Magnetism, EM Induction - Oct. 3, 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. (6) Current enters a resistor at terminal a and leaves at terminal b.

a) (2) **T F** The current at terminal b is less than the current at terminal a.
b) (2) **T F** The electric potential at terminal b is less than the electric potential at terminal a.
c) (2) **T F** The direction of electron flow in the resistor is from a to b.

2. (3) Three resistors $R_A > R_B > R_C$ are wired in series in some circuit. Their respective currents, I_a, I_b, I_c,

a. are all equal: $I_a = I_b = I_c$. b. are related by $I_a > I_b > I_c$. c. are related by $I_a < I_b < I_c$.

3. (3) Three resistors $R_A > R_B > R_C$ are wired in parallel in some circuit. Their respective currents, I_a, I_b, I_c,

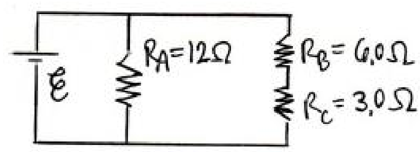
a. are all equal: $I_a = I_b = I_c$. b. are related by $I_a > I_b > I_c$. c. are related by $I_a < I_b < I_c$.

4. (2) **T F** The sum of the voltage changes around any loop of a circuit is zero.

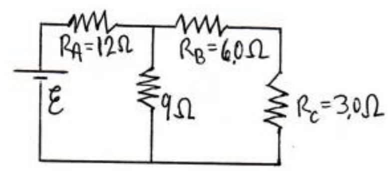
5. (2) **T F** The sum of currents entering a node of a circuit equal those leaving that node.

6. (2) **T F** A real battery's terminal voltage can be greater than its emf $\mathcal{E}$.

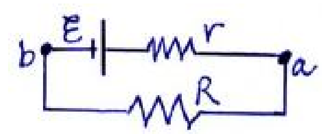
7. (6) Consider the circuit here with resistors R_A, R_B and R_C. Rank the resistors according to the currents I_A, I_B, I_C that flow through them, from largest to smallest (like $I_C > I_B > I_A$ or use "=" sign if two are the same).



8. (6) Consider the circuit here with resistors R_A, R_B and R_C. Rank the resistors according to the voltage drops V_A, V_B, V_C across them, from largest to smallest (like $V_A > V_B > V_C$ or use "=" sign if two are the same).



9. (12) In the circuit shown, the resistor $R = 44.0\ \Omega$ is using 2.50 W of electrical power. The resistance $r = 0.320\ \Omega$ is the internal resistance of the $\mathcal{E}$-volt battery.

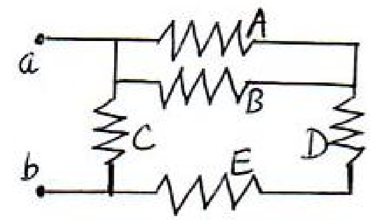


a) (4) How large is the current through the battery?

b) (4) How large is the terminal voltage of the battery?

c) (4) How large is the emf of the battery?

10. (12) In the diagram, each resistor is 1.0 kΩ.



a) (2) What pair of resistors is in series?

a. A & B. b. B & C. c. C & D. d. D & E. e. no pair is in series.

b) (2) What pair of resistors is in parallel?

a. A & B. b. B & C. c. C & D. d. D & E. e. no pair is in parallel.

c) (8) Calculate the equivalent resistance between the terminals a and b.

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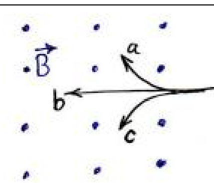
11. (6) A uniform magnetic field points out of the page as shown. Three particles shot into the region curve as shown. For each particle, indicate whether it has negative (-), zero (0), or positive (+) electric charge:



particle a:____ particle b:____ particle c:____

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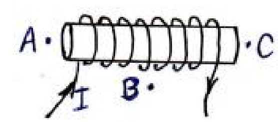
12. (6) A solenoid carries a current as shown.



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. ⊙

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

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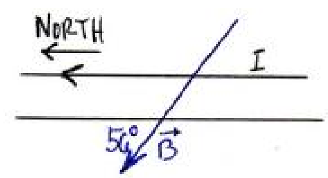
13. (8) A 120.0-meter long straight wire carries a current of 5.00 A towards the north. The Earth's 0.550-gauss magnetic field points north but 56.0° below horizontal.

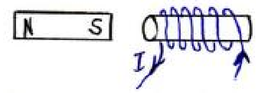


a) (2) In what direction is the force $\vec{F}$ on the wire? Draw and label $\vec{F}$ on the diagram, or use ⊙ or ⊗ if $\vec{F}$ is out-of-the-page or into-the-page.

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

14. (3) A bar magnet is set close to a current-carrying coil as shown. The force between bar magnet and coil is

a. zero. b. attractive. c. repulsive.



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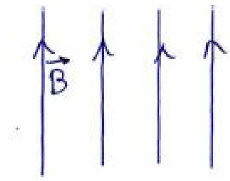
15. (6) A region has a uniform magnetic field pointing vertically on the page as shown.



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

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

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

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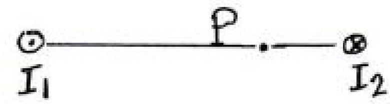
16. (16) A doubly charged helium ion (an alpha particle, mass $m = 6.64 \times 10^{-27}$ kg) has been accelerated through a potential difference of -1250 V. It is projected into a region of uniform magnetic field and then performs uniform circular motion with a period of 0.108 μs in a plane perpendicular to the field.

a) (4) How large is its kinetic energy, in eV?

b) (6) Find the speed of the helium ion in m/s.

c) (6) Calculate the strength of the magnetic field it is moving in, in tesla. (Hint: Apply Newton's 2nd Law.)

17. (10) Two long straight wires separated by 3.00 m carry 25.0 A currents. I_1 is out of the page and I_2 is into the page.



a) (8) Determine the magnitude of the net magnetic field produced at point P, between the two wires and 2.00 m from I_1 and 1.00 m from I_2.

b) (2) What is the direction of the net magnetic field at P?

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18. (3) Imagine you take the south pole of a bar magnet and move it towards a square loop of wire facing you. The induced current in the wire loop is

a. zero. b. clockwise. c. counterclockwise.

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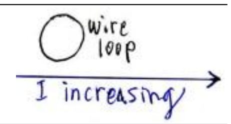
19. (3) A wire loop is near a current as shown. The induced current in the wire loop is



a. zero. b. clockwise. c. counterclockwise.

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20. (10) The magnetic field perpendicular to a circular wire loop of diameter 4.0 cm and resistance 0.040 Ω changes from +0.68 T to −0.32 T in a time of 55 ms, where + means the field points away from the observer and − means towards the observer.

a) (2) For the observer, in what direction is the induced current? a. clockwise. b. counterclockwise.

b) (8) Calculate the magnitude of the induced emf, according to Faraday's Law of Induction.

21. (12) The AC power from a small generator running on gasoline comes out at 50.0 Hz, with 48.0 volts rms. The output of the generator is connected directly to a light bulb whose resistance is 12.0 Ω.

a) (4) How large is the rms current through the lightbulb?

b) (4) How large is the peak voltage across the lightbulb?

c) (4) What average electrical power is the lightbulb using?

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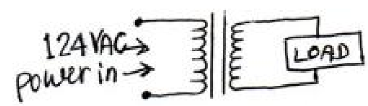
22. (14) An ideal transformer has 2.00×10^3 turns on the primary side and 1.00×10^2 turns on the secondary side. The rms current of the primary side is 1.20 A while connected to 124 VAC, 60.0 Hz power. A load is connected to the secondary side.



a) (2) This transformer is connected as? a. step-up. b. step-down.

a) (6) How large is the rms voltage across the secondary side of the transformer?

b) (6) How large is the rms current through the secondary side of the transformer?

Score = ___________/151.

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

Vectors

Written $\vec{V}$ or **V**, described by magnitude=V, direction=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{V_y}{V_x}$. 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

$\sin\theta = \frac{\text{(opp)}}{\text{(hyp)}}$, $\cos\theta = \frac{\text{(adj)}}{\text{(hyp)}}$, $\tan\theta = \frac{\text{(opp)}}{\text{(adj)}}$, $\text{(opp)}^2 + \text{(adj)}^2 = \text{(hyp)}^2$.
$\sin\theta = \sin(180^\circ - \theta)$, $\cos\theta = \cos(-\theta)$, $\tan\theta = \tan(180^\circ + \theta)$, $\sin^2\theta + \cos^2\theta = 1$.

Chapter 16 Equations

Charges:
$Q = \pm Ne$, $\Delta Q_1 + \Delta Q_2 = 0$, $e = 1.602 \times 10^{-19}$ C.
Electric Force:
$F = k\frac{Q_1 Q_2}{r^2}$, $k = 8.988 \times 10^9$ N·m^2/C^2, $F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$, $\epsilon_0 = \frac{1}{4\pi k} = 8.854$ 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: $\Delta\text{PE} = -W_{ba}$.
$\Delta KE + \Delta PE = 0$, or, $\Delta KE = -\Delta PE = -q\Delta V$, principle of conservation of mechanical energy.
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.

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

$\mathrm{PE} = k\frac{Q_1 Q_2}{r_{12}}$ = 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.

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

P = instantaneous work/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.

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

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

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

Chapter 19 Equations

Resistor Combinations

$R_{\mathrm{eq}} = R_1 + R_2 + R_3 + \ldots$ (series)

$\frac{1}{R_{\mathrm{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ (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)

$F/l = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{d}$ (between currents)

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

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

$v = \omega r = 2\pi f r = 2\pi r/T$ (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)

$I_P V_P = I_S V_S$ (power in = power out)