General Physics II Exam 2 - Chs. 19–21 - Circuits, Magnetism, EM Induction - Sep. 29, 2016

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. (3) Kirchhoff's first rule or junction rule is based on what physical principle?

a. conservation of energy. b. Ohm's Law. c. conservation of charge. d. quantization of charge.

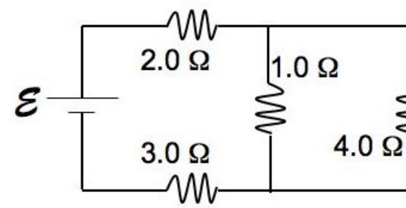
2. (3) Kirchhoff's second rule or loop rule is based on what physical principle?

a. conservation of energy. b. Ohm's Law. c. conservation of charge. d. quantization of charge.

3. (3) What is the same for three different resistors connected in series to a battery?

a. the voltage drops. b. the currents. c. the powers. d. the temperatures.

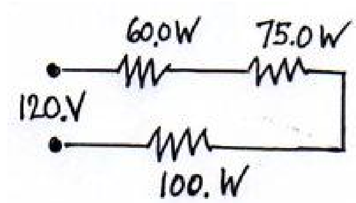
4. (10) Four resistors, 1.00 Ω, 2.00 Ω, 3.00 Ω and 4.0 Ω are connected to an ideal 12.0-volt battery in the circuit shown.



a) (6) Calculate the equivalent resistance for the circuit.

b) (4) How large is the current through the 2.00 Ω resistor, and in which direction?

5. (8) Three lightbulbs that each normally operate on 120 V (60 W, 75 W, and 100 W) are connected in series to a power supply of 120 V as shown.



a) (2) Which bulb has the highest resistance?

a. 60 W. b. 75 W. c. 100 W. d. All have the same resistance.

b) (2) Which bulb has the largest current?

a. 60 W. b. 75 W. c. 100 W. d. All have the same current.

c) (2) Which bulb has the largest voltage drop across it?

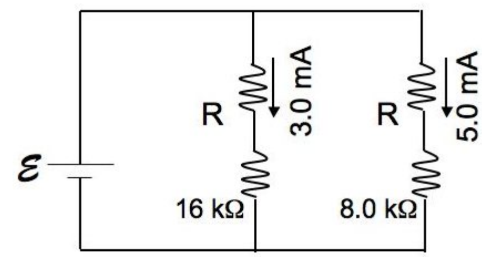
a. 60 W. b. 75 W. c. 100 W. d. All have the same voltage drop.

d) (2) Which bulb is the brightest?

a. 60 W. b. 75 W. c. 100 W. d. They all look equally bright.

6. (6) A spotlight in a police car uses 0.240 kW of power when supplied with 12.0 V. How large is its resistance?

7. (12) For this circuit, $\mathcal{E}$ is an ideal battery emf and R is a resistance.



a) (8) Find the value of resistance R (Kirchhoff's rules may help).

b) (4) Find the value of $\mathcal{E}$.

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8. (3) A bar magnet is placed as shown. The direction of the magnetic field at point P is

a. $\uparrow$ b. $\downarrow$ c. $\leftarrow$ d. $\rightarrow$ e. $\otimes$ f. $\odot$ g. $\vec{F} = 0$.

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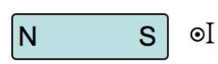
9. (3) A bar magnet is placed near a wire carrying a current as shown. The direction of the magnetic force on the wire is



a. $\uparrow$ b. $\downarrow$ c. $\leftarrow$ d. $\rightarrow$ e. $\otimes$ f. $\odot$ g. $\vec{F} = 0$.

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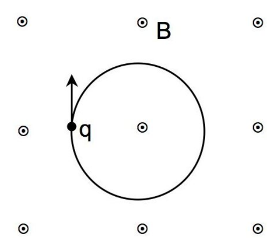
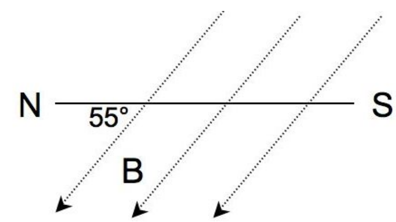
10. (12) A proton finds itself doing uniform circular motion of 1.20 cm radius due to a uniform 4.5-tesla magnetic field perpendicular to the plane of the circle.



a) (6) At what uniform speed is the proton moving?

b) (6) What is the frequency of its cyclotron motion, in hertz?

11. (10) A power line carries a current of 25 A due north, while exposed to Earth's magnetic field of strength 0.45 gauss at 55° below due north (the magnetic declination is zero, but the dip is 55°).



a) (4) In which direction is the magnetic force on the wire? Show and label your answer on the diagram as an arrow or as one of the symbols $\odot$ for out of the page or $\otimes$ for into the page.

b) (6) Find the magnitude of the magnetic force on a 100.-m segment of the wire.

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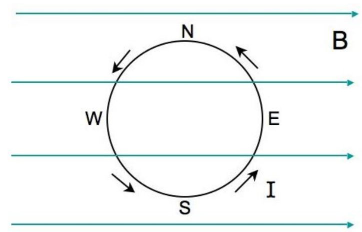
12. (6) Consider the horizontal coil shown with a counterclockwise current, in a magnetic field pointing east.



a) (3) In which direction does the coil's magnetic dipole moment $\vec{M}$ point?

a. N b. S c. E d. W e. $\odot$ f. $\otimes$.

b) (3) Which edge would move out of the page due to the torque on the loop?

a. N b. S c. E d. W e. The torque is zero.

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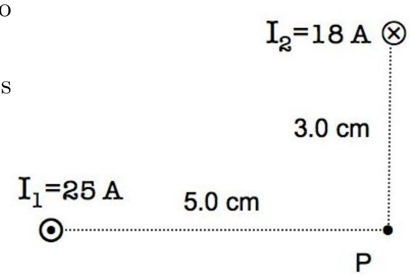
13. (18) Two long straight wires carry currents I_1 and I_2 perpendicular to the page as shown. For point P, determine



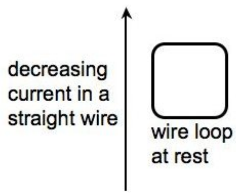
a) (6) the magnitude of magnetic field $\vec{B}_1$ produced by I_1 and show its direction as an arrow at point P,

b) (6) the magnitude of magnetic field $\vec{B}_2$ produced by I_2 and show its direction as an arrow at point P,

c) (6) the net magnetic field strength and direction at point P.

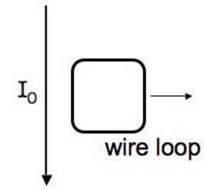
14. (3) For the situation shown here, the induced current in the wire loop is

a. zero. b. CW. c. CCW



15. (3) The wire loop moves away from a wire with a constant current I_0. The induced current in the wire loop is

a. zero. b. CW. c. CCW



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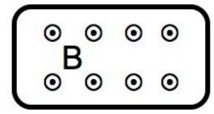
16. (12) A rectangular 30.0 cm × 20.0 cm coil has 250 turns and resistance of 0.25 Ω. Its leads are connected together to form a closed circuit. A magnetic field passing perpendidularly outward through the coil changes from 0.50 T to 2.50 T in 5.00 ms.



a) (6) While the magnetic field is increasing, what emf does the coil generate?

b) (6) What are the magnitude and direction of the current induced in the coil?

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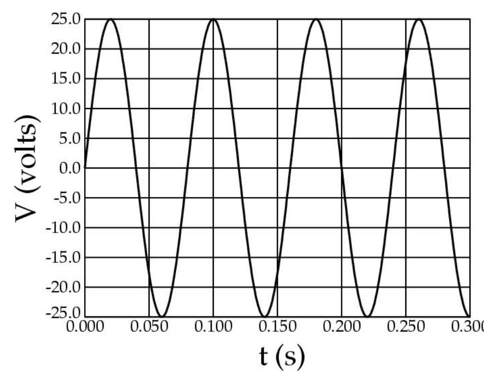
17. (16) The graph shows the voltage from an AC generator as a function of time. Using the graph, find values for



a) (4) the peak voltage,

b) (4) the root-mean-square (rms) voltage,

c) (4) the period of the oscillations,

d) (4) the frequency of the oscillations.

Score = ____________/131.

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 (Avogodro'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:

$F = k\frac{Q_1Q_2}{r^2}, \quad k = 8.988 \times 10^9$ 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 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.

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

Potential:

$\Delta V = \frac{\Delta\mathrm{PE}}{q}$ = 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.

$\mathrm{PE} = k\frac{Q_1Q_2}{r_{12}}$ = 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:

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

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

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

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

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

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.

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

$I_{\rm rms} = \sqrt{\overline{I^2}} = I_0/\sqrt{2}$ = root-mean-square current.

AC power in resistors:

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

$\overline{P} = I_{\rm rms}^2 R = V_{\rm rms}^2/R = I_{\rm rms} V_{\rm rms}$ = 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)

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

AC Circuits, Inductors, Capacitors, Reactance

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

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

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

$V_L = I X_L$ (inductor voltage)

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

$V_C = I X_C$ (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)

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

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