AP Physics Fall 2013/Spring 2014

Test 18 – Magnetic Fields, Forces, and Induction

Name: Key

Multiple Choice	(Problems 1- 5)	_____	15 pts
Fill The Blank	(Problems 6-9)	_____	8 pts
Problem 10		_____	8 pts
Problem 11		_____	12 pts
Problem 12		_____	12 pts
Problem 13		_____	6 pts
Problem 14		_____	14 pts
Problem 15		_____	13 pts
Problem 16		_____	12 pts
Bonus		_____	18 pts
Total		_____	

Mass of electron = 9.11×10^{-31} kg

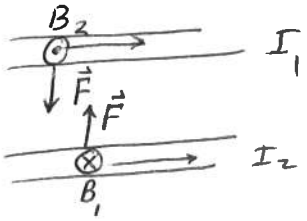
Charge on an electron = 1.6×10^{-19} C

Permeability of free space = $4\pi \times 10^{-7}$ Tm/A

Permittivity of free space = 8.85x10-12 $C^2/(Nm^2)$

Name: _____

1. Two long parallel wires are placed side-by-side on a horizontal table. If the wires carry current in the same direction,



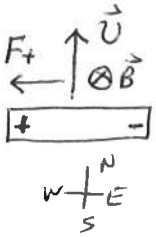
A. both wires are lifted slightly

(B.) the wires attract each other.

C. the wires repel each other.

D. one wire is lifted slightly as the other wire is forced against the table surface.

2. A horizontal rod (oriented in the east-west direction) is moved northward at constant velocity through a magnetic field that points straight down. Make a statement concerning the potential induced across the rod.



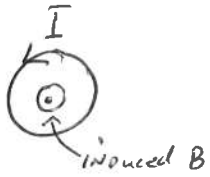
A. The bottom surface of the rod is at higher potential than the top surface.

B. The east end of the rod is at higher potential than the west end.

C. The top surface of the rod is higher potential than the bottom surface.

(D.) The west end of the rod is at higher potential than the east end.

3. A circular coil lies flat on a horizontal table. A bar magnet is held above its center with its north pole pointing downward, and released. As it approaches the coil, the falling magnet induces (when viewed from above)



A. no current

(B.) a counter clockwise current in the coil.

C. a clockwise current in the coil.

D. a current whose direction cannot be determined from the information provided.

Name: _____

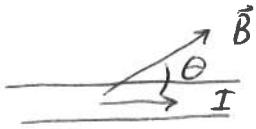
4. Consider two current-carrying circular loops. Both are made from one strand of wire and both carry the same current, but one has twice the radius of the other. Compared to the magnetic moment of the smaller loop, the magnetic moment of the larger loop is $\mu = IA = I\pi r^2$

(A.) 4 times stronger
B. 8 times stronger
C. 2 times stronger
D. 16 times stronger

$\frac{\mu_2}{\mu_1} = \left(\frac{r_2}{r_1}\right)^2 = (2)^2$

5. The force on a current carrying wire in a magnetic field is zero when

A. the current is at a 60 degree angle with respect to the field lines.
(B.) the current is parallel to the field lines.
C. the current is perpendicular to the field lines.
D. the current is at a 30 degree angle with respect to the field lines.



$F = I\ell B \sin\theta = 0$
$\Rightarrow \sin\theta = 0 \Rightarrow \theta = 0°$

6. The unit of inductance is Henry

7. The unit of magnetic flux is Weber or Tesla·(meter)^2

8. The unit of electromotive force is Volt

9. The unit of magnetic field is Tesla or Gauss

Name: _____

8 pts 10. You are designing a generator with a maximum emf of 8.0 V. If the generator coil has 200 turns and a cross-sectional area of 0.030 m^2, what would be the frequency in Hertz of the generator in a magnetic field of 0.0052 T?

$$\mathcal{E}_{MAX} = \omega N B A \quad (+2)$$

$$\text{But } \omega = 2\pi f \quad (+2)$$

$$\Rightarrow \mathcal{E}_{MAX} = 2\pi f N B A$$

$$f = \frac{\mathcal{E}_{MAX}}{2\pi N B A} \quad (+1)$$

$$f = \frac{8\ V}{2\pi (200 \text{turns})(0.0052\ T)(0.030\ m^2)}$$

$$f \cong \boxed{40.8\ Hz}$$

(+2) for Numerical Ans.

(+1) units

Name: _____

12 pts 11. A 150 W lamp is placed into a 120 Volt outlet.

4 pts A. What is the peak power delivered to the lamp?

$$\text{Peak Power} = 2\,P_{Average}$$ (+2)

$$\text{Peak Power} = 2(150\,W) = \boxed{300\,W}$$

(+1) # (+1) units

4 pts B. What is the rms current?

$$P_{AV} = I_{RMS}\,V_{RMS}$$ (+1)

(+1) $$I_{RMS} = \frac{P_{AV}}{V_{RMS}} = \frac{150\,W}{120\,V}$$

$$I_{RMS} = \boxed{1.25\,A}$$

(+1) # (+1) units

4 pts C. What peak current?

$$I_{peak} = \sqrt{2}\,I_{RMS}$$ (+2)

$$I_{peak} = \sqrt{2}\,(1.25\,A)$$

$$I_{peak} = \boxed{1.77\,A}$$

(+1) # (+1) units

Name: _____

12 pts 12. A proton travels through a potential of 1.0 kV and then moves into a magnetic field of 0.040 T. What is the radius of the proton's resulting orbit given that the mass of the proton is 1.67×10^{-27} kg?

(+2) $E = qV$

$E = (1e)(1.0\,kV) = 1.0\,keV = 1.6 \times 10^{-16}\,J$ (+1) (+1)

(+2) $E = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ ⇐ Either is good

$p = \sqrt{2mE}$

$p = \sqrt{2(1.67 \times 10^{-27}\,kg)(1.6 \times 10^{-16}\,J)}$

(+1) $p \cong 7.31 \times 10^{-22}\,kgm/s$

(+3) $R = \frac{p}{Bq}$ or $R = \frac{mv}{Bq}$ ⇐ Either is good

$R \cong \frac{7.31 \times 10^{-22}\,kg\,m/s}{(0.040T)(1.6 \times 10^{-19}C)}$

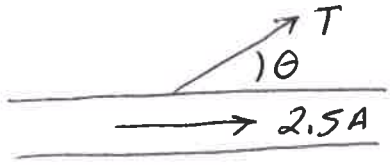
$R \cong \boxed{0.114\,m}$ or $11.4\,cm$

(+1) #

(+1) suitable unit

Name: _____

6 pts 13. A 3 meter long wire carrying 2.5 A is placed at an angle 30 degrees with respect to a magnetic field of 150 gauss. What is the force on the wire?



$$B = (150\ \text{Gauss})\left(\frac{1\ T}{10{,}000\ \text{Gauss}}\right) \cong 0.015\ T$$ +1

+3 $F = I \ell B \sin\theta$

$$F = (2.5A)(3m)(0.015T)\sin(30°)$$

$$F \cong \boxed{0.0563\ N}$$ +1 units

+1 #

Name: _____

14 pts 14. A long solenoid with 250 turns has a radius of 2 cm and a length of 40 cm.

6 pts A. What is the magnetic field in the solenoid when a current of 2 A is applied to it?

$$B = \frac{\mu_0 N I}{\ell} \quad (+3)$$

$$B = \frac{(4\pi \times 10^{-7}\ Tm/A)(250\ turns)(2A)}{0.4m}$$

$$B = \boxed{0.00157\ T} \text{ or } 1.57\ mT$$

(+2) for # (+1) for suitable unit

if they put it in Gauss it is ok.

8 pts B. What is the solenoid's inductance?

$$L = \frac{N\Phi_B}{I} \quad (+2)$$

$$\Phi_B = BA \quad (+2)$$

$$A = \pi r^2 = \pi(0.02m)^2 \cong 1.257\times10^{-4} m^2 \quad (+1)$$ (+1)

$$L \cong \frac{(250\ turns)(1.57\times10^{-3}\ T)(1.257\times10^{-4} m^2)}{2A}$$

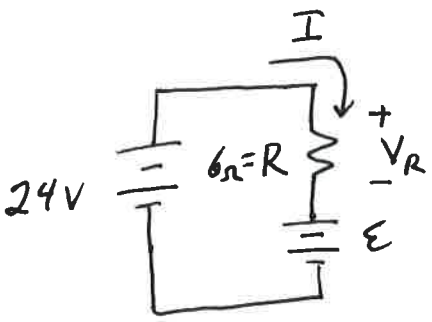
$$L \cong \boxed{2.47\times10^{-5}\ H} \quad (+2) \text{ or } 24.7\ \mu H$$

students can also use $L = \frac{\pi r^2 \mu_0 N^2}{\ell} = \pi r^2 \mu_0 n^2 \ell$

Name: _____

13 pts 15. A DC motor of internal resistance 6.0 Ω is connected to a 24 V power supply. The operating current is 1.2 A when the motor is operating at full speed.

5 pts A. What is the back emf when the motor is at full speed?



$V_R = IR$ (+1)

$V_R = (1.2\,A)(6\,\Omega)$

$V_R = 7.2\,V$ (+1)

$\varepsilon = 24\,V - 7.2\,V$ (+1)

$\varepsilon = \boxed{16.8\,V}$ (+1) units

(+1) #

4 pts B. What is the back emf when the motor is operating at half speed?

$\varepsilon_{MAX} = \omega N B A$ (+1)

$\frac{\varepsilon_H}{\varepsilon_F} = \frac{\omega_H}{\omega_F} = \frac{1}{2}$ (+1)

$\varepsilon_H = \frac{1}{2}\varepsilon_F$

$\varepsilon_H = \frac{1}{2}(16.8\,V)$

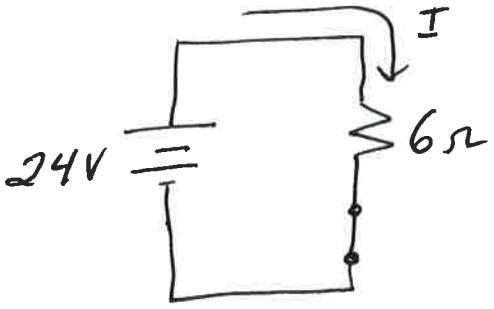
$\varepsilon_H = \boxed{8.4\,V}$ (+1) units

(+1) #

Name: _____

4 pts C. What is the motor's startup current (i.e. the current when the motor is initially turned on)?

$\mathcal{E}_{mf} = 0$



$$I = \frac{V}{R}$$ (+1)

$$I = \frac{24\,V}{6\,\Omega}$$ (+1)

$$I = \boxed{4\,A}$$ (+1 units) (+1 #)

Name: _____

12 pts 16. When the current in a 10-H coil of one turn is equal to 2.5 A and is increasing at 40 A/S, find

4 pts A) the magnetic flux through the coil.

$$L = \frac{\Phi_B}{I}$$ (+2)

$$\Phi_B = LI$$

$$\Phi_B = (10\,H)(2.5\,A) = \boxed{25\,Wb}$$ (+1) # (+1) units

4 pts B) the energy stored in the magnetic field.

$$U = \frac{1}{2} L I^2$$ (+2)

$$U = \frac{1}{2} (10\,H)(2.5\,A)^2$$

$$U = \boxed{31.3\,J}$$ (+1) # (+1) units

4 pts C) the induced emf in the coil.

$$\mathcal{E} = L \frac{\Delta I}{\Delta t}$$ (+2)

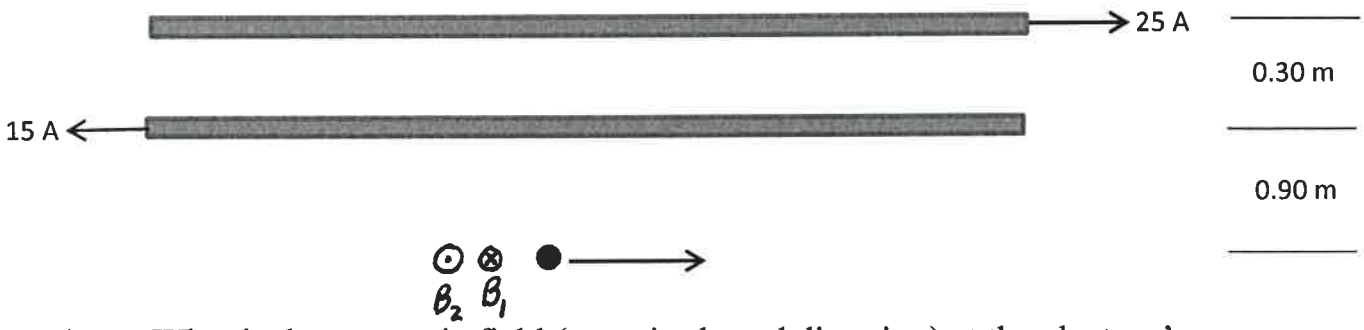
$$\mathcal{E} = (10\,H)\left(\frac{40\,A}{s}\right)$$

$$\mathcal{E} = \boxed{400\,V}$$ (+1) # (+1) units

Name: _____

Bonus

Two long parallel wires carry currents of 25 A and 15 A in opposite directions and are separated by 0.30 m as shown. An electron located 0.90 m below the bottom wire is traveling parallel to the wires at a speed of 2.5×10^5 m/s.



10 pts A. What is the magnetic field (magnitude and direction) at the electron's location?

$B_1 = \dfrac{\mu_0 I_1}{2\pi r_1}$ (+1)

$B_1 = \left(\dfrac{4\pi \times 10^{-7}\ Tm/A}{2\pi}\right)\left(\dfrac{25\ A}{(0.3m + 0.9m)}\right)$ (+1) find r_1

$B_1 = 4.1667 \times 10^{-6}\ T \cong 4.167\ \mu T$ (+1)

B_1 is into the page (+1)

$B_2 = \dfrac{\mu_0 I_2}{2\pi r_2}$ (+1)

$B_2 = \left(\dfrac{4\pi \times 10^{-7}\ Tm/A}{2\pi}\right)\left(\dfrac{15\ A}{0.90m}\right)$ (+1) find r_2

$B_2 \cong 3.3333 \times 10^{-6}\ T \cong 3.333\ \mu T$ (+1)

B_2 is out of the page (+1)

$B = B_1 - B = 8.33 \times 10^{-7}\ T$ or $0.833\ \mu T$ (+1) into page (+1)

Name: _____

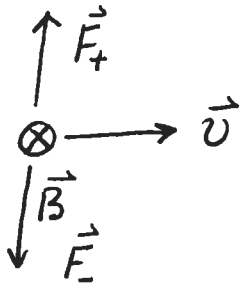
8 pts B. What is the magnetic force (magnitude & direction) the electron experiences?

(+3) $F = |q| v B$

$F \cong (1.6 \times 10^{-19} C)(2.5 \times 10^{5} m/s)(8.33 \times 10^{-7} T)$

$F \cong \boxed{3.33 \times 10^{-20} N}$ (+1) #

(+1) units



(+1) if they used RHR

By Right-Hand-Rule, the force is

$\boxed{\text{downward}}$

(+2) Direction