Name________________________

Oct. 30, 2003

Phys 2020 — Fall 2003
Exam #2

1.	____________	(10)
2.	____________	(7)
3.	____________	(12)
4.	____________	(7)
5.	____________	(18)
6.	____________	(8)
7.	____________	(11)
8.	____________	(7)
MC	____________	(20)
Total	____________	(100)

$$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \,\frac{\mathrm{N{\cdot}m^2}}{\mathrm{C^2}} \qquad \epsilon_0 = 8.85 \times 10^{-12} \,\frac{\mathrm{C^2}}{\mathrm{N{\cdot}m^2}} \qquad e = 1.602 \times 10^{-19}\,\mathrm{C}$$

$$A = \pi r^2 \qquad \mathbf{F} = m\mathbf{a} \qquad \mathrm{KE} = \tfrac{1}{2}mv^2 \qquad g = 9.80\,\tfrac{\mathrm{m}}{\mathrm{s^2}} \qquad m_{\mathrm{elec}} = 9.1094 \times 10^{-31}\,\mathrm{kg}$$

$$V = IR \qquad P = I^2R = \frac{V^2}{R} \qquad E = Pt \qquad \sum I_{\mathrm{in}} = \sum I_{\mathrm{out}} \qquad \sum_{\mathrm{loop}} V = 0$$

$$F = |qvB\sin\theta| \qquad \frac{mv}{r} = qB \qquad F = ILB\sin\theta \qquad \tau = NIAB\sin\phi \qquad m = \left(\frac{qr^2}{2V}\right)B^2$$

$$\mu_0 = 4\pi \times 10^{-7}\,\frac{\mathrm{T{\cdot}m}}{\mathrm{A}} \qquad B = \frac{\mu_0 I}{2\pi r} \qquad B_{\mathrm{loop}} = \frac{\mu_0 I}{2R} \qquad B_{\mathrm{sol}} = \mu_0 n I$$

$$\Phi = BA\cos\phi \qquad \mathcal{E} = -N\frac{\Delta\Phi}{\Delta t} \qquad \mathcal{E}_2 = -M_{21}\frac{\Delta I_1}{\Delta t} \qquad \mathcal{E} = -L\frac{\Delta I}{\Delta t} \qquad \mathcal{E} = NAB\omega\sin\omega t$$

$$\lambda f = c \qquad c = 2.998 \times 10^8\,\tfrac{\mathrm{m}}{\mathrm{s}} \qquad \overline{S} = \frac{c\epsilon_0}{2}E_0^2 = \frac{c}{2\mu_0}B_0^2 \qquad \overline{S}_{\mathrm{pol}} = \tfrac{1}{2}\overline{S}_{\mathrm{unpol}} \qquad \overline{S} = \cos^2\theta\,\overline{S}_0$$

Multiple Choice

Choose the best answer from among the four!

1. Another unit for the magnetic field, equal to 10^{-4} T is called the

a) Oersted.

b) Henry.

c) Statvolt.

d) Gauss.

2. If the magnetic field at a distance R from a long current–carrying wire has magnitude B then at a distance of $R/2$ the magnetic field has magnitude

a) $2B$

b) B

c) $B/2$

d) $B/4$

3. Two long parallel wires carry current in the same direction; they are shown at the right, in cross section, and the currents go into the page. Using the given coordinate system, in what direction is the force on wire 2?

a) $-x$

b) $-y$

c) $+z$

d) $+x$

4. A long wire carries a current, as shown. (Wire is in the plane of the page.) Using the given coordinate system, in which direction does the magnetic field point at P?

a) $-z$

b) $+x$

c) $-x$

d) $+z$

5. In general, a current–carrying loop in a uniform magnetic field experiences

a) A net force and a torque.

b) No net force, and a torque.

c) A net force, but no torque.

d) Neither a net force nor a torque.

6. Magnetic flux Φ is measured in webers. A weber is equal to:

a) $1\,\frac{\mathrm{V \cdot s}}{\mathrm{m^2}}$

b) $1\,\mathrm{T \cdot m^2}$

c) $1\,\frac{\mathrm{T \cdot m^2}}{\mathrm{s}}$

d) $1\,\mathrm{A \cdot m^2}$

7. The speed of light waves through materials like glass or water is

a) The same as the speed in vacuum.

b) Slower than the speed in vacuum.

c) Faster than the speed in vacuum.

d) Possibly slower or faster than the vacuum speed, depending on the type of material.

8. In an electromagnetic wave,

a) Both **E** and **B** point in the direction of propagation.

b) **E** points along the propagation direction but **B** is perpendicular to it.

c) **B** points along the propagation direction but **E** is perpendicular to it.

d) Both **E** and **B** are perpendicular to the propagation direction.

9. Of the following, the EM waves with the shortest wavelengths are

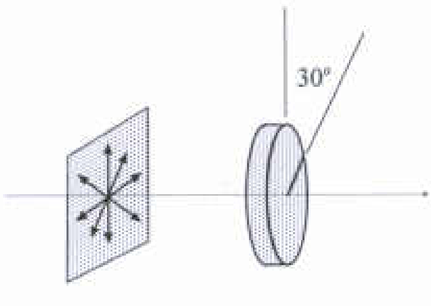
a) Radio waves.

b) Visible light.

c) X–rays.

d) Infra–red radiation.

10. If unpolarized light of intensity $1000\,\mathrm{W/m^2}$ passes through a polarizer with its transmission axis at 30° from the vertical, the intensity of the transmitted light is



a) $0\,\mathrm{W/m^2}$

b) $250\,\mathrm{W/m^2}$

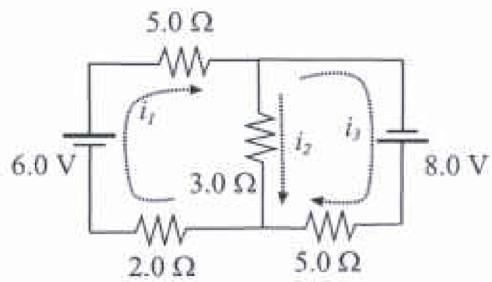
c) $500\,\mathrm{W/m^2}$

d) $750\,\mathrm{W/m^2}$

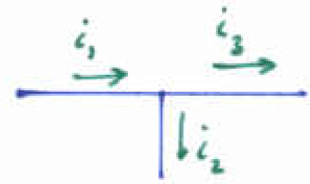
Problems

1. At the right is shown a multi–loop circuit with various resistances and two batteries. We would like to find the currents in all the branches.

In the figure, currents in the three branches (and their assigned directions) are shown. You don't need to solve for these currents. All I'd like you to do is to write down three equations which *can* be solved to give their values. Write the equations *clearly*, and say a word or two about how you got them. (10)



Recall that the large bar on the battery symbol is the positive terminal!



The junction rule applied at the upper junction (or the lower one!) gives

$$i_1 = i_2 + i_3 \qquad (1)$$

Considering the leftmost loop (the i_1 and i_2 branches) the Kirchhoff loop rule gives:

$$+6.0\,\mathrm{V} - i_1(5.0\,\Omega) - i_2(3.0\,\Omega) - i_1(2.0\,\Omega) = 0 \qquad (2)$$

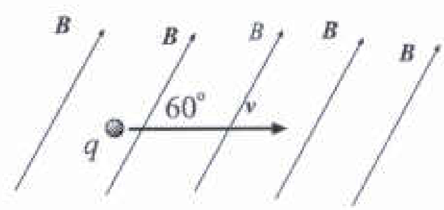
Considering the loop all around the outside (the i_1 & i_3 branches) loop rule gives:

$$+6.0\,\mathrm{V} - i_1(5.0\,\Omega) + 8.0\,\mathrm{V} - i_3(5.0\,\Omega) - i_1(2.0\,\Omega) = 0 \qquad (3)$$

These are three <u>independent</u> eqns which can be solved for i_1, i_2 and i_3.

2. A particle of charge 3.20×10^{-19} C moves with speed $3.00 \times 10^4\ \frac{\mathrm{m}}{\mathrm{s}}$ as shown (in the plane of the page) It moves in a uniform B field of magnitude 0.300 T which also lies in plane of the page but points at an angle of 60° from the velocity, as shown.

Find the magnitude and direction of the force on the charge. (7)

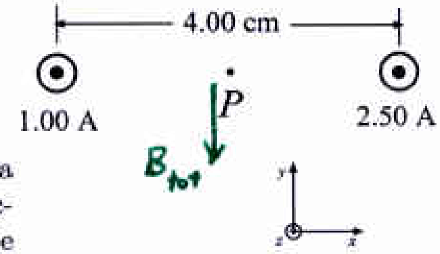


Magnitude of the force is

$$F = qvB\sin\theta = (3.20\times10^{-19}\,\mathrm{C})(3.00\times10^{4}\,\tfrac{\mathrm{m}}{\mathrm{s}})(0.300\,\mathrm{T})\sin 60^\circ$$
$$= \boxed{2.49\times10^{-15}\,\mathrm{N}}$$

<u>Direction</u> of the force, by RHR-1 is $\boxed{\text{out of the page}}$.

3. Two long parallel wires carry currents in the same direction, as shown at the right, in cross-section. One wire carries a current of 1.00 A and the other carries a current of 2.50 A. The wires are separated by 4.00 cm.



Find the magnitude and direction of the magnetic field at a point P midway between the wires. You can indicate the direction on the figure or else use the coordinate system given in the picture. (12)

The field from the left wire points in the +y dir and has magnitude

$$B_1 = \frac{\mu_0 I_1}{2\pi r_1} = \frac{(4\pi \times 10^{-7})(1.0)}{2\pi(0.0200)}\ \mathrm{T} = 1.0 \times 10^{-5}\ \mathrm{T}$$

The field from the right wire points in the −y dir and has magnitude

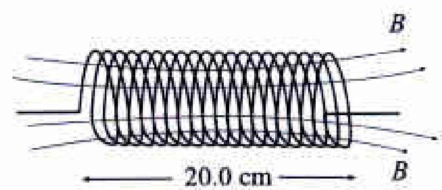
$$B_2 = \frac{\mu_0 I_2}{2\pi r_2} = \frac{(4\pi \times 10^{-7})(2.50)}{2\pi\ (0.0200)}\ \mathrm{T} = 2.5 \times 10^{-5}\ \mathrm{T}$$

Then the y component of the total $\vec{B}$ field at P is

$$B_{tot,y} = (1.0 \times 10^{-5}\mathrm{T}) - (2.5 \times 10^{-5}\mathrm{T}) = \boxed{-1.5 \times 10^{-5}\ \mathrm{T}}$$

(Dir of $\vec{B}_{tot}$ noted on the figure.)

4. A solenoid is made by wrapping 1000 turns of wire around a cylinder which is 20.0 cm in length. If the current in the wire is 0.500 A, what is the magnitude of magnetic field inside the solenoid? (7)



Use $B_{sol} = \mu_0 n I$. Here the # of turns per unit length is

$$n = \frac{1000}{0.200\ \mathrm{m}} = 5.00 \times 10^3\ \mathrm{m}^{-1}$$

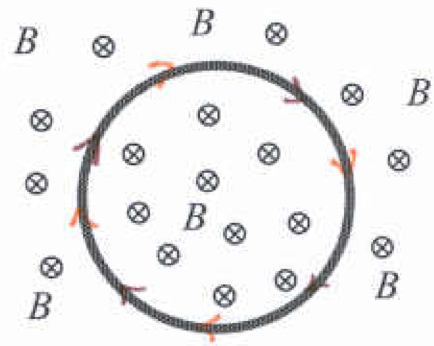
Then the field inside the solenoid is

$$B = \mu_0 n I = (4\pi \times 10^{-7}\ \tfrac{\mathrm{T \cdot m}}{\mathrm{A}})(5.00 \times 10^3\ \mathrm{m}^{-1})(0.500\ \mathrm{A})$$

$$= \boxed{3.14 \times 10^{-3}\ \mathrm{T}}$$

5. A circular coil of radius 2.00 cm and having 10 turns lies in a uniform B field which points perpendicular to the plane of the loop; As shown at the right, it points into the page. The coil has a resistance of $15\,\Omega$.

The magnitude of the B field changes from 0.500 T to 0.100 T in 0.500 s.



a) Find the magnitude of the (average) emf induced in the coil. (8)

From Faraday's Law, magnitude of induced emf has magnitude:

$$|\mathcal{E}| = \left|N \frac{\Delta\Phi}{\Delta t}\right| = \left|N \frac{A\,\Delta B}{\Delta t}\right| = 10 \cdot \frac{\pi(0.0200\,\text{m})^2(0.500\text{T} - 0.100\text{T})}{(0.500\,\text{s})}$$

$$= \boxed{1.01 \times 10^{-2}\,\text{V}}$$

b) Find the magnitude of the current induced in the coil. (2)

(Avg) current induced has magnitude

$$I = \frac{\mathcal{E}}{R} = \frac{(1.01 \times 10^{-2}\,\text{V})}{(15\,\Omega)} = \boxed{6.7 \times 10^{-4}\,\text{A}}$$

c) Find the energy dissipated in the coil during the changing of the B field. (4)

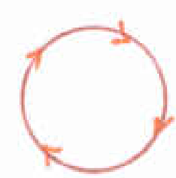
Dissipated power is $P = I^2 R = (6.7 \times 10^{-4}\,\text{A})^2 (15\,\Omega) = 6.7 \times 10^{-6}\,\text{W}$

Dissipated energy is $E = Pt = (6.7 \times 10^{-6}\,\text{W})(0.500\,\text{s}) = 3.4 \times 10^{-6}\,\text{J}$

d) Referring to the picture above, in what direction does the induced current flow? *(Note: The magnetic field goes into the page and it decreased...)* (4)

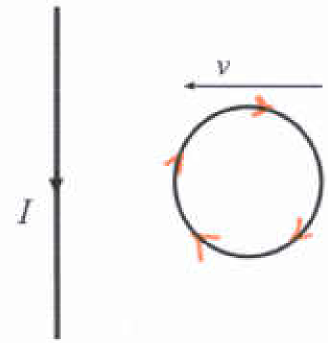
The magnetic field goes into the page and decreases. To oppose the change we need to make a flux directed into the page.

Such a flux is produced by a $\boxed{\text{clockwise}}$ current in the loop



6. A long wire carries a steady current in the direction shown. A conducting loop, in the same plane as the wire approaches the wire as shown.

On the figure (or in words) give the direction of the induced current in the loop and give the *reasoning* for your answer. (8)



From RHR-2 the magnetic field in the interior of the loop comes out of the page and since the ring is approaching the wire it is getting stronger.

To oppose this change in flux we want to make a flux going into the page from the induced current. If the current goes $\boxed{\text{clockwise}}$ it will produce such a flux.

7.a) A certain electromagnetic wave has a wavelength of 3.00 m. What is the frequency of this wave? (5)

$\lambda = 3.00\,\text{m}$ Use $\lambda f = c$, then:

$$f = \frac{c}{\lambda} = \frac{2.998 \times 10^8 \frac{m}{s}}{3.00\,m} = \boxed{1.00 \times 10^8\ Hz}$$

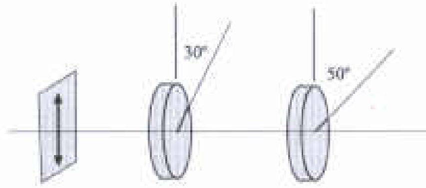
b) The amplitude of the B field in a certain EM wave is 5.00×10^{-6} T. What is the intensity (power per unit area) of this wave? (6)

Use $\bar{S} = \frac{c}{2\mu_0} B_0^2$. Then:

$$\bar{S} = \frac{(2.998 \times 10^8)}{2(4\pi \times 10^{-7})}(5.00 \times 10^{-6})^2\ \frac{W}{m^2}$$

$$= \boxed{2.98 \times 10^3\ \frac{W}{m^2}}$$

8. A beam of light which is polarized along the vertical axis encounters two polaroid sheets in succession. The first sheet has its polarizing axis at 30.0° from the vertical and the second has its axis at 50.0° from the vertical.



The intensity of the incoming beam is $1200\,\mathrm{W/m^2}$. What is the final intensity of the beam? (7)

After the first polarizer the beam is polarized at 30° from the vertical and its intensity is changed by a factor of $\cos^2 30°$.

The second polarizer is rotated by $(50° - 30°) = 20°$ from the polarization of the incoming light. So the light which it transmits is rotated by 50° from the vertical and the intensity is changed by a further factor of $\cos^2 20°$.

The final intensity is

$$1200\,\mathrm{W/m^2} \cdot \cos^2 30° \cdot \cos^2 20° = \boxed{795\,\mathrm{W/m^2}}$$