Name____________________________

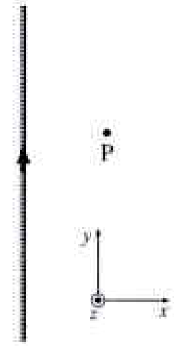
Apr. 8, 2004

Phys 2020 — Spring 2004
Exam #2

1.	________________	(8)
2.	________________	(8)
3.	________________	(8)
4.	________________	(8)
5.	________________	(6)
6.	________________	(13)
7.	________________	(3)
8.	________________	(3)
9.	________________	(6)
10.	________________	(6)
11.	________________	(11)
MC	________________	(20)
Total	________________	(100)

Multiple Choice *Choose the best answer from among the four!*

1. A long wire carries a current in the direction shown. (The wire is in the plane of the page.) Using the coordinate system shown, in what direction is the magnetic field at point P?



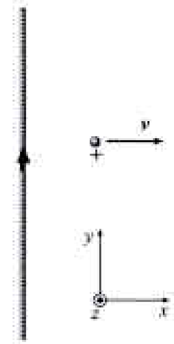
a) $+x$

b) $+y$

c) $-y$

d) $-z$

2. Again, a long wire carries a current as shown. If a particle with positive charge moves in the direction shown, in what direction is the magnetic force on the particle? (The answer to 1 may help here!)



a) $-x$

b) $+y$

c) $-y$

d) $+z$

3. A positively–charged particle moves in a uniform magnetic field, with its velocity perpendicular to the field direction. This is shown at the right; it moves in the plane of the page in the direction shown.

The direction of the magnetic field is

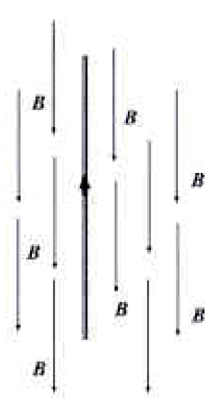
a) Radially inward, toward the center of the circle.

b) Radially outward from the center of the circle.

c) Into the page.

d) Out of the page.

4. A current in a long wire flows in the direction shown ("up"). The wire is in a uniform magnetic field, with the direction shown ("down"). The force on the wire is



a) Zero.

b) Into the page.

c) Out of the page.

d) "Up", i.e. in the direction of the current.

5. Magnetic flux (Φ) is measured in Webers. A Weber is equal to

a) $1\ \mathrm{T/m}$

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

c) $1\ \mathrm{T \cdot m}$

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

6. Two solenoid–type inductors A and B have the same length and radius, but inductor B has twice as many turns as A.

If A has inductance $100\,\text{mH}$, the inductance of B is

a) $25\,\text{mH}$

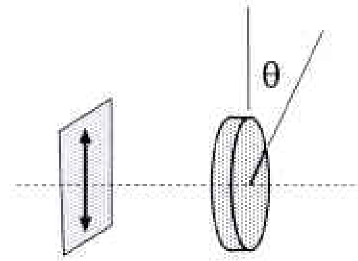
b) $50\,\text{mH}$

c) $200\,\text{mH}$

d) $400\,\text{mH}$

7. Light which is polarized vertically is incident on a polarizer whose axis is tilted at angle θ from the vertical.

If the intensity of the emerging light is 50% (0.50) of the original intensity, θ is



a) 30°

b) 45°

c) 60°

d) 90°

8. An electromagnetic wave moving through free space is

a) Always a transverse wave.

b) Always a longitudinal wave.

c) Can have either transverse or longitudinal components but not both.

d) Can have both transverse and longitudinal components.

9. Of the following, the type of electromagnetic radiation with the smallest *frequency* is:

a) Ultra-violet radiation.

b) Radio waves.

c) Visible Light.

d) Gamma rays.

10. An object sits in front of a spherical (non-planar) mirror. The image is upright.

a) The mirror must be concave.

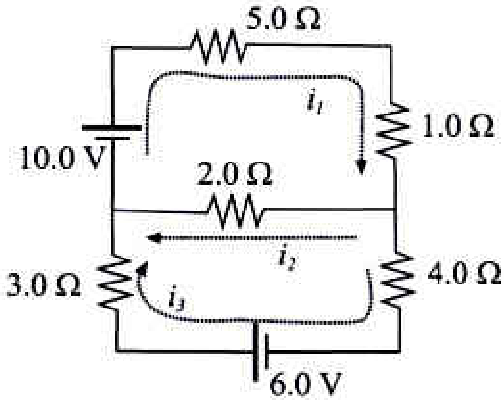
b) The mirror must be convex.

c) The mirror can be concave or convex.

d) None of the above; the mirror *must* be planar.

Problems

1. We would like to find the labelled currents i_1, i_2 and i_3 in the circuit at the right.



a) Write down three equations that will allow us to solve for these currents. **You don't need to find the solutions**, but your equations should allow you to find them, if you had the time. (8)

Use either junction and the Kirchhoff junction rule and get:

$$i_1 = i_2 + i_3$$

// current in = current out

Use the topmost loop and the Kirchhoff loop rule to get:

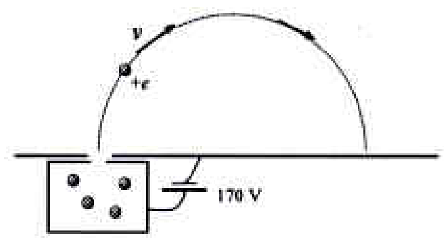
$$+10\,V - i_1(5\Omega) - i_1(1.0\Omega) - i_2(2.0\Omega) = 0$$

// Sum of changes in potential around loop is zero

Use the bottommost loop and the Kirchhoff loop rule to get:

$$+6.0\,V - i_3(3.0\Omega) + i_2(2.0\Omega) - i_3(4.0\Omega) = 0$$

2. An ion with charge $+e$ is accelerated through a potential of 170 V and then moves into a region where there is a uniform B field perpendicular to the motion; the B field has magnitude 0.100 T. In this region the ion moves in a circular path of radius 7.0 cm.



a) What is the kinetic energy of the ions after they are accelerated through the 170 V? (3)

The ions start from rest (that's implied!) so their KE is equal to the loss in potential energy,

$$KE = |\Delta EPE| = |q\Delta V| = (1.602\times10^{-19}\,C)(170\,V) = \boxed{2.72\times10^{-17}\,J}$$
$$= 170\text{ eV !}$$

b) What is the mass of the ions? (5)

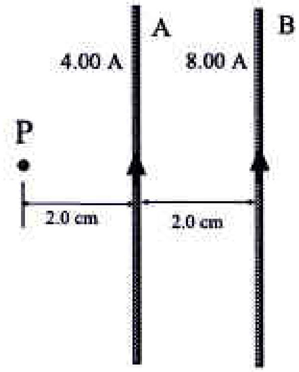
Formula relating mass, charge, accel voltage etc. is given on equation sheet: $m = \left(\frac{qr^2}{2V}\right)B^2$. Substitute given values and get:

$$m = \left(\frac{(1.602\times10^{-19}\,C)(0.070\,m)^2}{2\,(170\,V)}\right)(0.100\,T)^2 = \boxed{2.31\times10^{-26}\,kg}$$

3. Two long, parallel current–carrying wires are as shown at right, both in the plane of the page. Wire A carries a current of 4.00 A and wire B carries a current of 8.00 A. They are separated by 2.00 cm.

The point P is 2.00 cm from wire A and 4.00 cm from wire B.

Find the magnitude and direction of the magnetic field at point P. (8)



From RHR-2, the field at P due to A comes out of the page and has magnitude

$$B_A = \frac{\mu_0 I_A}{2\pi r_A} = \frac{(4\pi\times10^{-7})(4.00)}{2\pi\,(0.020)}\ \mathrm{T} = 4.0\times10^{-5}\,\mathrm{T}$$

and the field at P due to B also comes out of the page and has magnitude

$$B_B = \frac{\mu_0 I_B}{2\pi r_B} = \frac{(4\pi\times10^{-7})(8.00)}{2\pi\,(0.040)}\ \mathrm{T} = 4.0\times10^{-5}\,\mathrm{T}$$

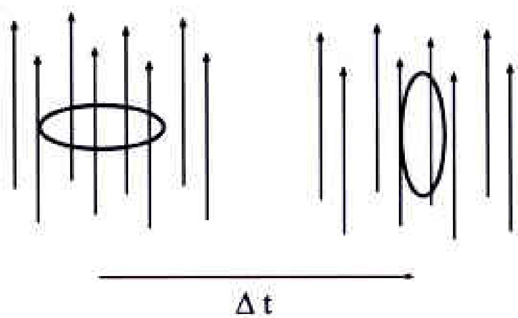
So the (total) mag. field at P points $\boxed{\text{out of the page}}$ and has magnitude

$$B = +B_A + B_B = \boxed{8.0\times10^{-5}\,\mathrm{T}}$$

4. A small circular coil of radius 1.00 cm with 10 turns of wire sits in a uniform magnetic field of magnitude $2.00\times10^{-3}\,\mathrm{T}$

At first, it is oriented so that the normal to its plane is along the B field direction. Then in a short time Δt it is flipped so that the normal is perpendicular to the field. Since the magnetic flux changes in this time, an emf is generated in the coil.

If the (average) emf generated is $1.00\times10^{-3}\,\mathrm{V}$, what is Δt? (8)



Here the flux changes from its initial value of

$$\Phi = BA\cdot1 = (2.00\times10^{-3}\mathrm{T})(\pi)(0.0100\,\mathrm{m})^2 = 6.283\times10^{-7}\ \mathrm{Wb}$$

to zero so $|\Delta\Phi| = 6.28\times10^{-7}\,\mathrm{Wb}$. Using:

$$|\mathcal{E}_{avg}| = \left|N\frac{\Delta\Phi}{\Delta t}\right|,$$ then:

$$\Delta t = \left|\frac{N\,\Delta\Phi}{\mathcal{E}_{avg}}\right| = \frac{(10)(6.28\times10^{-7}\,\mathrm{Wb})}{(1.00\times10^{-3}\,\mathrm{V})} = 6.28\times10^{-3}\,\mathrm{s}$$

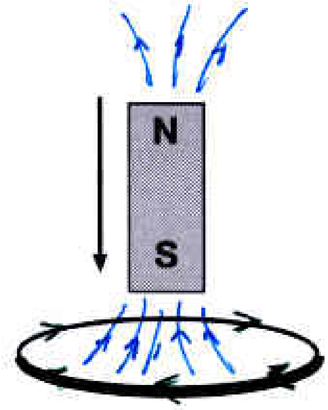
$$= 6.3\ \mathrm{ms}$$

5. A conducting loop lies in a plane which comes out of the page. Directly above this loop, a bar magnet is descending with the South pole going first toward the loop.

(I've tried to draw this as well as I can at the right.)

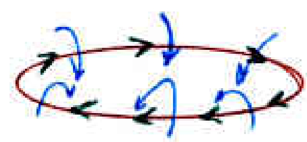
The motion of the magnet induces a current in the loop.

On the figure, *clearly* indicate the direction of the induced current and explain *completely and clearly* why you made this choice. (6)



Since magnetic field lines go toward a South magnetic pole then inside the loop the field is upward and increasing in magnitude. To oppose this change we need to induce a downward flux.

If the current goes as shown (clockwise as seen from the top) we will induce a downward flux.



6. A solenoid of radius 3.00 cm has 400 turns and a length of 10.0 cm.

a) Find its inductance. (5)

With $n = \frac{N}{\ell} = \frac{400}{0.100\,\text{m}} = 4.00 \times 10^3 /\text{m}$, we get:

$$L = \mu_0 n^2 A \ell = (4\pi \times 10^{-7})(4.00 \times 10^3)^2 \pi (0.0300)^2 (0.100)\ \text{H}$$

$$= \boxed{5.68 \times 10^{-3}\ \text{H}} = 5.68\ \text{mH}$$

b) Find the rate at which the current must change through it to produce an emf of 0.010 V. (5)

Use $|\mathcal{E}| = L \left|\frac{\Delta I}{\Delta t}\right|$, then the rate of change of the current is

$$\left|\frac{\Delta I}{\Delta t}\right| = \frac{\mathcal{E}}{L} = \frac{0.010\,\text{V}}{5.68 \times 10^{-3}\,\text{H}} = \boxed{1.76\ \frac{\text{A}}{\text{s}}}$$

7. Find the frequency of electromagnetic waves which have a wavelength of 12.5 cm. (3)

Use $\lambda f = c$, then:

$$f = \frac{c}{\lambda} = \frac{2.998\times10^{8}\ \frac{m}{s}}{0.125\ m} = \boxed{2.40\times10^{9}\ Hz} = 2.40\ GHz$$

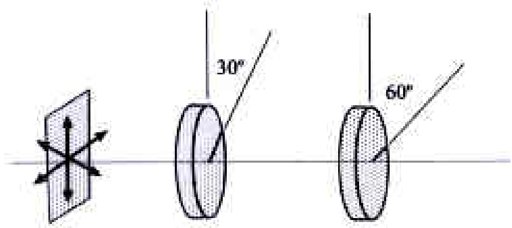
8. Identify (name) a common use for polaroid sheets. (3)

Displays for calculators & watches.

Glare-reducing sunglasses

9. Unpolarized light is incident on a polaroid sheet whose axis is oriented at 30.0° from the vertical direction. It then passes through another polaroid whose acis is 60.0° from the vertical.

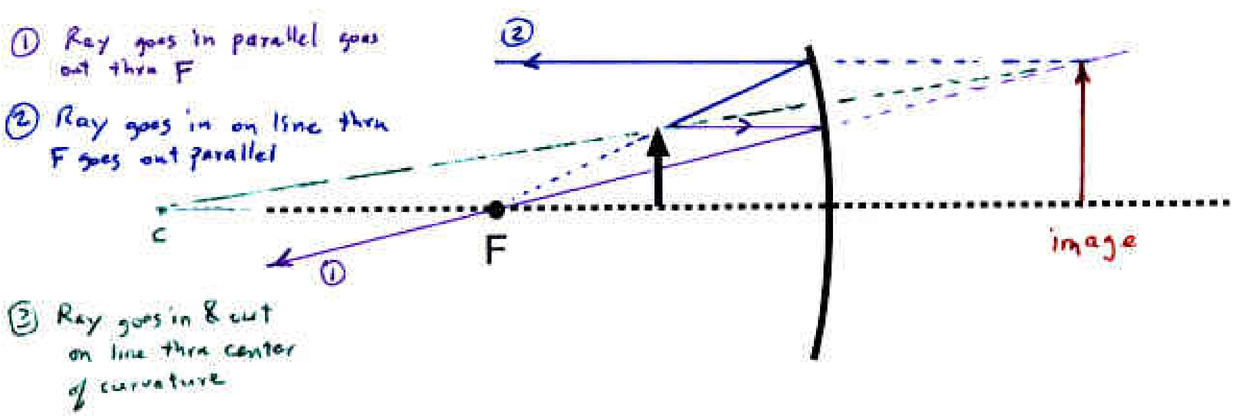
If the original intensity of the light is $85.0\,\frac{\mathrm{W}}{\mathrm{m}^2}$, what is the intensity of the light which passes through both polaroids? (6)



After the first polaroid the light is polarized at 30° from the vertical and the intensity is $\frac{1}{2}$ of the original intensity. After the second polaroid the light is polarized at 60° from the vertical and its intensity is reduced by a factor of $\cos^2(60°-30°) = \cos^2(30°) = 0.75$. So the final intensity is

$$S = (85.0\,\tfrac{W}{m^2})\,\tfrac{1}{2}\,(0.75) = \boxed{31.9\ \tfrac{W}{m^2}}$$

10. The figure below shows a concave mirror and its focal point along an axis. An object is indicated by the arrow.



By tracing rays, find the location and orientation of the image. (6)

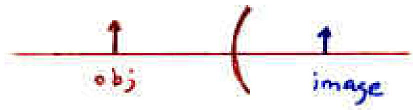
Rays traced as shown. Image is $\boxed{\text{behind the mirror}}$ (virtual) and is $\boxed{\text{upright.}}$

11. An object 6.0 cm high is placed 15.0 cm in front of a convex mirror with a focal length of −10.0 cm

a) Find the location of the image. Is it in front of the mirror or behind it? (5)

Here, $d_o = 15.0\text{ cm}$ and $f = -10.0\text{ cm}$ then

using $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$, get



$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{-1}{10\text{cm}} - \frac{1}{15\text{cm}} = -0.167\text{ cm}^{-1}$$

$\rightarrow d_i = \boxed{-6.0\text{ cm}}$ Image is behind the mirror (from neg. d_i)
so it is "virtual"

b) Find the height of the image. (3)

Since $m = -\frac{d_i}{d_o} = -\frac{(-6.0\text{ cm})}{(15.0\text{ cm})} = 0.40$ (image is upright since $m > 0$;
smaller since $|m| < 1$)

Then $h_i = m\,h_o = (0.40)(6.0\text{ cm}) = \boxed{2.4\text{ cm}}$

c) State whether the image is **Real** or **Virtual**; **Upright** or **Inverted**; **Smaller** or **Larger** than the object. (3)

As shown above, image is

$\boxed{\text{Virtual, Upright and Smaller}}$

$$e = 1.602 \times 10^{-19}\,\mathrm{C} \qquad \epsilon_0 = 8.85 \times 10^{-12}\,\frac{\mathrm{C}^2}{\mathrm{N{\cdot}m}^2} \qquad \mu_0 = 4\pi \times 10^{-7}\,\frac{\mathrm{T{\cdot}m}}{\mathrm{A}} \qquad c = 2.998 \times 10^{8}\,\frac{\mathrm{m}}{\mathrm{s}}$$

$$1\,\mathrm{eV} = 1.602 \times 10^{-19}\,\mathrm{J} \qquad \mathbf{F} = m\mathbf{a} \qquad \mathrm{KE} = \tfrac{1}{2}mv^2 \qquad \mathbf{F} = q\mathbf{E} \qquad \Delta\mathrm{EPE} = q\Delta V \qquad E_x = -\frac{\Delta V}{\Delta x}$$

$$V = IR \qquad R_{\mathrm{ser}} = R_1 + R_2 + \dots \qquad \frac{1}{R_{\mathrm{par}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \qquad P = VI = I^2R$$

Sum of currents entering junction = 0 Sum of voltages around a loop = 0

$$F = qvB\sin\theta \qquad \frac{mv}{r} = qB \qquad m = \left(\frac{qr^2}{2V}\right)B^2 \qquad F = LIB\sin\theta \qquad 1\,\mathrm{gauss} = 10^{-4}\,\mathrm{T}$$

$$B_{\mathrm{wire}} = \frac{\mu_0 I}{2\pi r} \qquad B_{\mathrm{loop}} = \frac{\mu_0 I}{2R} \qquad B_{\mathrm{sol}} = \mu_0 n I$$

$$\mathcal{E} = vBL \qquad \Phi = BA\cos\phi \qquad \mathcal{E} = -N\frac{\Delta\Phi}{\Delta t} \qquad \mathcal{E} = -L\frac{\Delta I}{\Delta t} \qquad L_{\mathrm{sol}} = \mu_0 n^2 A\ell$$

$$\lambda f = c \qquad E_0 = cB_0 \qquad \overline{S} = \frac{c\epsilon_0}{2}E_0^2 = \frac{c}{2\mu_0}B_0^2 \qquad \overline{S} = \tfrac{1}{2}\overline{S}_{\mathrm{unpol}} \qquad \overline{S} = \overline{S}_0\cos^2\theta$$

$$|f| = R/2 \qquad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$C = 2\pi R \qquad A = \pi R^2 \qquad \mathrm{c} = 10^{-2} \qquad \mathrm{k} = 10^3 \qquad \mathrm{M} = 10^6$$