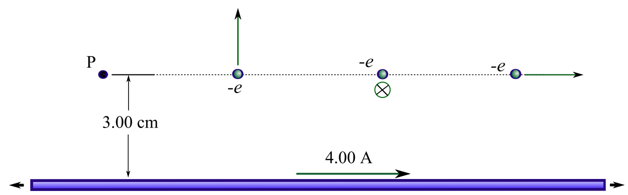
Name________________________________

Oct. 29, 2012

Quiz #3 — Fall 2012

Phys 2120 – Sec 4

1. Refer to the following picture for all parts:



A current of 4.00 A flows to the right in the (very long) wire. The point P is a distance of 3.00 cm from the wire, in the plane of the page.

a) Give the magnitude and direction of the magnetic field at point P. (Ignore the Earth's field!)

The magnitude is given by the formula for the magnetic field around a long wire:

$$B = \frac{\mu_o I}{2\pi r} = \frac{(4\pi \times 10^{-7}\ \frac{\mathrm{T\cdot m}}{\mathrm{A}})(4.00\ \mathrm{A})}{2\pi(3.00 \times 10^{-2}\ \mathrm{m})} = \boxed{2.67 \times 10^{-5}\ \mathrm{T}}$$

Use the right-hand rule for the B field around a straight wire: With thumb in direction of current fingers at P point outward! The direction of the field is $\boxed{\text{out of the page}}$.

b) Near the wire, also at a distance of 3.00 cm away are three electrons. The first electron has a speed of $2.00 \times 10^5 \frac{\mathrm{m}}{\mathrm{s}}$ and moves in the plane of the page, away from the wire. Find the magnitude and direction of the force on this electron.

The velocity of this electron is perpendicular to the field direction (found in (a)) so the magnitude of the force is

$$F = qvB = (1.602 \times 10^{-19})(2.00 \times 10^5 \tfrac{\mathrm{m}}{\mathrm{s}})(2.67 \times 10^{-5}\ \mathrm{T}) = 8.54 \times 10^{-19}\ \mathrm{N}$$

While the direction of $\mathbf{v} \times \mathbf{B}$ is to the right, the minus sign of the charge makes the force point $\boxed{\text{to the left}}$.

c) The next electron has the same speed but its velocity is into the page. Find the force on this electron.

The velocity of this electron is anti-parallel to the field and so from the $\mathbf{v} \times \mathbf{B}$ factor in the force law, the force on it is $\boxed{\text{zero}}$.

d) The next electron has the same speed but its velocity is to the right. Find the force on this electron.

The velocity of this electron is perpendicular to the field direction so the magnitude of the force is again

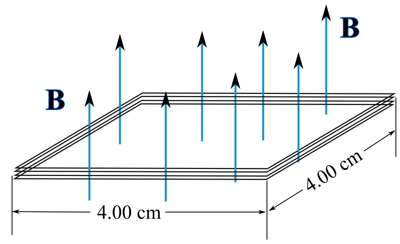
$$F = \boxed{8.54 \times 10^{-19}\ \mathrm{N}}\ .$$

The direction of $\mathbf{v} \times \mathbf{B}$ is down (toward the wire) but from the minus sign of the charge, the force is $\boxed{\text{up}}$ (away from the wire).

2. A square conducting coil of side 4.00 cm and 20 turns of wire sits in a region of space where the magnetic field B is normal to the plane of the loop and whose magnitude is given by

$$B = \left(0.500\,\tfrac{\mathrm{T}}{\mathrm{s}}\right) t$$

Find the magnitude of the emf induced in the loop.

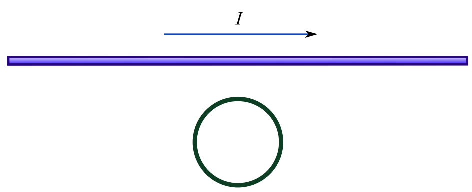


Here the flux is changing but only due to the changing B field. As we have $dB_z/dt = 0.500\,\frac{\mathrm{T}}{\mathrm{s}}$, Faraday's law gives the magnitude of the induced emf as

$$|\mathcal{E}| = \left| N\frac{d\Phi_B}{dt} \right| = NA\frac{dB_z}{dt} = (20)(4.00\times10^{-2}\ \mathrm{m})^2(0.500\,\tfrac{\mathrm{T}}{\mathrm{s}}) = \boxed{1.60\times10^{-2}\ \mathrm{V}}$$

3. Refer to the picture at the right; the long wire and conducting loop lie in the plane of the page.

If the current in the wire flows in the direction shown but it is *decreasing*; an emf and a current are thus induced in the loop.



State whether this current is clockwise or counter-clockwise and **give a complete explanation for your answer**.

From the right-hand rule for the field around a wire, in the interior of the ring the magnetic field goes *into* the page but the problem tells you that it is *decreasing*. The system will *oppose* this by producing a magnetic field in the ring's interior going *into the page*. Using the right-hand-rule for a current loop this would arise for a current in the loop which goes $\boxed{\text{clockwise}}$.

You must show all your work and include the right units with your answers!

$e = 1.60\times10^{-19}\ \mathrm{C}$ $\quad \mu_0 = 4\pi\times10^{-7}\,\frac{\mathrm{T\cdot m}}{\mathrm{A}}$ $\quad \mathbf{F} = q\mathbf{v}\times\mathbf{B}$ $\quad \mathbf{F} = I\mathbf{l}\times\mathbf{B}$ $\quad B_{\mathrm{wire}} = \dfrac{\mu_0 I}{2\pi r}$ $\quad B_{\mathrm{loop}} = \dfrac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}}$

$\mathbf{B} = \dfrac{\mu_0}{4\pi}\displaystyle\int \dfrac{I\,d\mathbf{l}\times\hat{\mathbf{r}}}{r^2}$ $\quad \boldsymbol{\mu} = NI\mathbf{A}$ $\quad \boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$ $\quad U = -\boldsymbol{\mu}\cdot\mathbf{B}$ $\quad \displaystyle\oint \mathbf{B}\cdot d\mathbf{r} = \mu_0 I_{\mathrm{enc}}$

$\Phi_B = \displaystyle\int \mathbf{B}\cdot d\mathbf{A}$ $\quad \mathcal{E} = -N\dfrac{d\Phi_B}{dt}$ $\quad \mathcal{E}_L = -L\dfrac{dI}{dt}$ $\quad I = \dfrac{\mathcal{E}_0}{R}(1-e^{-Rt/L})$ $\quad u_B = \dfrac{B^2}{2\mu_0}$