2018-2019 Term 2

PHYS1001 Essential Physics

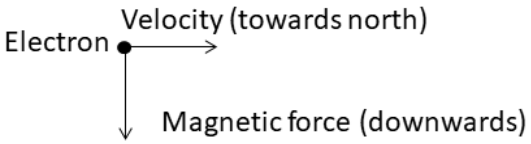
Assignment 9

Due date: 16th April, 2019 by 6:00 pm

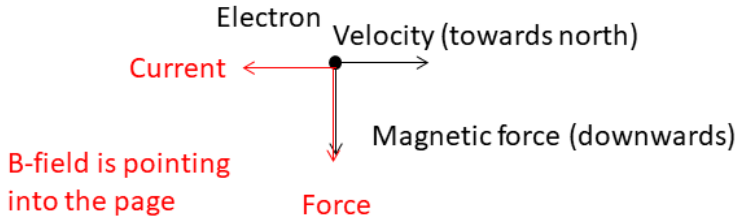
(Please leave your homework in the box with the label "PHYS 1001" outside room 213 in Science Centre North Block)

Please answer **all** five questions

1. An electron experiences the largest force when it travels at a speed 2.5×10^6m/s in a magnetic field when it is moving northward. The magnetic force is vertically upward and of magnitude 6.3×10^{-13} N.



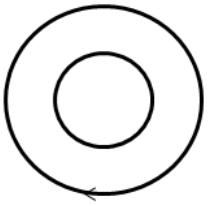
(a) What is the direction of the magnetic field?
(b) What is the magnitude of the magnetic field?
Answer:
(a) By Fleming's left hand rule, the magnetic field is pointing into the page.



(b)
$$|F| = |qvB|$$
$$6.3 \times 10^{-13} = |(1.6 \times 10^{-19})(2.5 \times 10^6)B|$$
$$B = 1.58 \text{ T}$$

2. A square loop (the length of each side is 10 cm) is perpendicular to a magnetic field of 0.5 T. The field is reduced to 0.1 T in 2 s.
(a) Calculate the average induced EMF in the coil.
(b) If the resistance of the square loop is 4×10^{-3} Ω, calculate the value of the induced current.
Answer:
(a)
$$E.M.F. = \frac{(0.5)(0.1)(0.1) - (0.1)(0.1)(0.1)}{2} = 2 \times 10^{-3} V$$
(b) $V = IR$
$$2 \times 10^{-3} = (4 \times 10^{-3})I$$
$$I = 0.5 \text{ A}$$

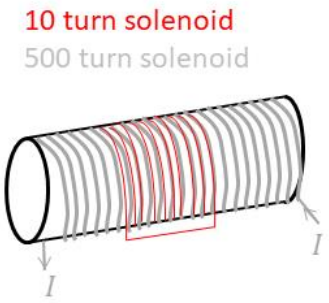
3. A metal ring with a smaller diameter is placed in a larger metal ring as shown in the figure below. Suddenly the large ring is connected to a battery, current flows in the large ring in the clockwise direction as shown below. What is the direction of the induced current in the small ring? Explain your answer.



Answer:

The direction of the induced current in the small ring should be anticlockwise. According to right hand grip rule, the magnetic field due to the current in the big ring is pointing into the page. According to Lenz's law, the magnetic field of the induced current tries to counteract the change of the magnetic field change. The current in the small ring should be anticlockwise so that the magnetic field due to the induced current points out of the page.

4. A 500 turn solenoid, 20 cm long, has a diameter of 2.5 cm. A 10 turn coil is wound tightly around the centre of the solenoid as shown in the figure below.



(a) Calculate the magnetic field in the solenoid when the current in the longer coil is 5.0 A.

(b) If the current in the solenoid increases uniformly from 0 to 5.0 A in 0.5 s, calculate the induced EMF in the 10 turn coil during this time.

(a) $$B = \mu_0 nI$$

$$B = (4\pi \times 10^{-7})\frac{500}{0.2}(5)$$

$$B = 0.0157\text{T}$$

(b) $\frac{\Delta\Phi}{\Delta t} = E.M.F.$

$$E.M.F. = N\frac{\Delta(\pi R^2 B)}{\Delta t}$$

$$E.M.F. = N\frac{\Delta(\pi R^2 \mu_0 nI)}{\Delta t}$$

$$E.M.F. = N\pi R^2 \mu_0 n\frac{\Delta(I)}{\Delta t}$$

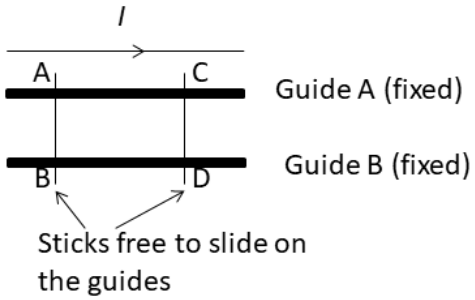
$$E.M.F. = (10)(3.14)\left(\frac{0.025}{2}\right)^2 (4\pi \times 10^{-7})(\frac{500}{0.2})\frac{5}{0.5}$$

$$E.M.F. = 1.54 \times 10^{-4}\ \text{V}$$

5. As shown in the figure below, two parallel smooth guides 1 and 2 are fixed near the current-carrying straight wire. The guides are parallel to the straight wire and in the same horizontal plane. Two conducting cylindrical sticks AB and CD are free to slide on the guide rail. The current in the current-carrying straight wire increases gradually.

(a) What is the direction of the induced current in the loop ABCD? Explain your answer.

(b) Using the results in (a), what is the direction of magnetic force on stick AB? What is the magnetic force on stick CD? Describe the subsequent motion of the two sticks AB and CD. Explain your answer.



Answer:

(a) When the current increases, the magnitude magnetic field (and hence the magnetic flux) in the loop ABCD increases. The direction of the induced current is into the page. According to Lenz's law, the induced current in ABCD flows in the counterclockwise direction (induced current flows in the direction which opposes the original effect that produces the change).

(b) The current flows in the counter-clockwise direction in the loop. According to Fleming's left hand rule, the magnetic force on stick AB points to the right while the magnetic force on stick CD points to the left. Therefore, the two sticks move towards each other.