Phys 112
Spring 2019

General Physics: Class Exam II

27 March 2019

Name: Solution **Total:** /70

Instructions

- There are 8 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

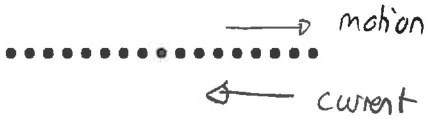
$$e = 1.61 \times 10^{-19}\,\mathrm{C} \qquad q_{\text{electron}} = -e \qquad q_{\text{proton}} = +e$$

$$m_{\text{electron}} = 9.11 \times 10^{-31}\,\mathrm{kg} \qquad m_{\text{proton}} = 1.67 \times 10^{-27}\,\mathrm{kg}$$

$$k = 8.99 \times 10^{9}\,\mathrm{Nm^2/C^2} \qquad \mu_0 = 4\pi \times 10^{-7}\,\mathrm{T\ m/A}$$

Question 1

Electrons travel from left to right in a straight line as illustrated. The number of electrons that passes any one point in 5.00 s is 6×10^{15}. Determine the magnitude and direction of the current associated with the electron beam.



+2

For negative charges current is opposite to direction of motion

$$I = \frac{\Delta q}{\Delta t} \quad +1$$

$$\Delta q = 6\times10^{15} \times e = 6\times10^{15}\times1.6\times10^{-19}\mathrm{C} = 9.6\times10^{-4}\mathrm{C}. \quad +2$$

$$I = \frac{9.6\times10^{-4}\mathrm{C}}{5.00\mathrm{s}} = 1.92\times10^{-4}\mathrm{A} \quad +2$$

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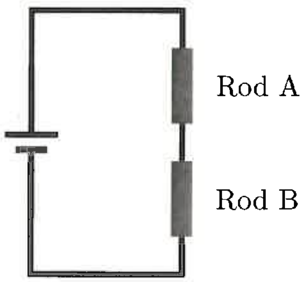
Question 2

Two metal rods are connected to a battery as illustrated. The resistance of rod A is five times that of rod B. Which of the following (choose one) is true regarding the currents through the rods?



[✓ i)] $I_{\text{in A}} = I_{\text{in B}}$

ii) $I_{\text{in A}} = 25\, I_{\text{in B}}$

iii) $I_{\text{in A}} = 5\, I_{\text{in B}}$

iv) $I_{\text{in A}} = \frac{1}{5}\, I_{\text{in B}}$

Current does not split in such a circuit.

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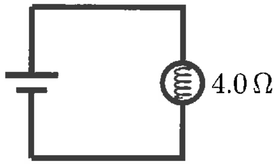
Question 3

A bulb, which can be regarded as a 8.0 Ω resistor, is connected to a battery.



a) Determine the power output by the bulb if the battery provides a 2.0 V potential difference.

+1 [$\Delta V = IR$

$2.0\text{V} = I\, 8.0\Omega$

$\Rightarrow \quad I = \frac{2.0\text{V}}{8.0\Omega}$

$= 0.25\text{ A}$] +2

$P = I\Delta V$] +1

$= 0.25\text{A} \times 2.0\text{V}$

$P = 0.50\text{W}$] +2

b) The battery is replaced by one with twice the voltage. By what factor (i.e. by how many times) does the power output change?

The current will be twice as much

$\Delta V = IR$

twice twice same

+1 +1

Then power will be 4 times

+2

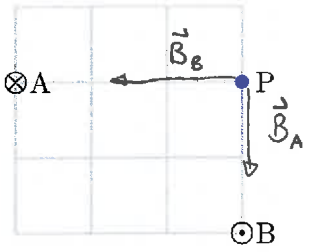
$P = I\Delta V$

twice twice

/10

Question 4

Two infinitely long wires are perpendicular to the page and carry identical currents with magnitudes 30 A in the indicated directions. They are situated as illustrated; the grid blocks are each 0.010 m wide.



a) Determine the magnetic field produced by wire A at location P.

$$B = \underbrace{\frac{\mu_0 I}{2\pi r}}_{(+1)} = \frac{4\pi\times10^{-7}\,Tm/A \times 30A}{2\pi \times 0.030m}$$

$r = 3\times0.010m = 0.030m$

$$= 2.0\times10^{-4}T \;](+3)$$

Direction (by r.h.rule) ↓](+2)

b) Determine the magnetic field produced by wire B at location P.

$$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}\,Tm/A\times30A}{2\pi \times 0.020m}$$

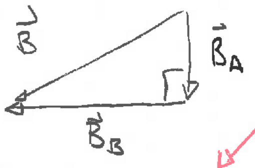
$r = 2\times0.010m = 0.020m$

$$= 3.0\times10^{-4}T \;](+3)$$

Direction (by r.h.rule) ←](+2)

c) Determine the magnitude of the net magnetic field at location P.

$\vec{B} = \vec{B}_A + \vec{B}_B$



(+2)

or similar *

~~4~~*

$$B = \sqrt{B_A^2 + B_B^2}$$

$$= \sqrt{(2.0\times10^{-4}T)^2 + (3.0\times10^{-4}T)^2}$$

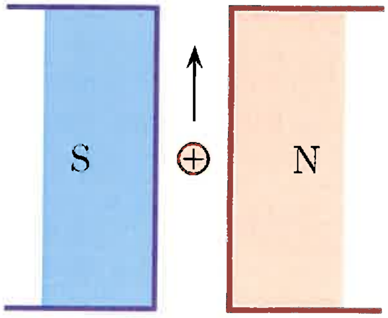
$$= 3.6\times10^{-4}T$$

(+2)

/15

Question 5

At one instant, a proton moves as illustrated between the poles of two closely spaced magnets as illustrated. Which of the following (choose one) represents the direction of the force exerted by the magnetic field produced by the magnets on the proton?



- i) ↑
- ii) ↓
- iii) ←
- iv) →
- v) Into the page
- [✓ vi) Out of the page]

Briefly explain your answer.

The field is $\overset{\vec{B}}{\longleftarrow}$ and velocity $\uparrow \vec{v}$

By r.h. rule using $\vec{v}, \vec{B}$ $\longrightarrow$ middle finger out

and charge is positive

so $\vec{F}$ is out of page.

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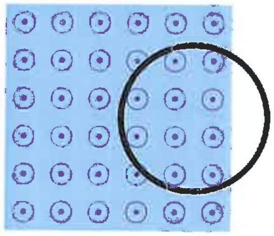
Question 6

Various magnets produce a uniform magnetic field over the illustrated shaded region. A loop, initially partly in this region as illustrated, is given a quick sharp tug to the right. Which of the following (choose one) is true immediately after the loop starts to move?



- i) There is no current in the loop.
- ii) There is a clockwise current (from the illustrated viewpoint) in the loop.
- [✓ iii) There is a counter-clockwise current (from the illustrated viewpoint) in the loop.]

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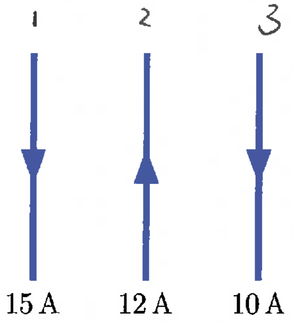
Flux is out + decreasing $\Rightarrow$ Induced field compensates in <u>outward</u> direction

$\Rightarrow$ Induced current c.c.w.

Question 7

Three wires each carry different currents as illustrated. The length of each wire is 2.5 m and the distance between adjacent wires is 0.0050 m. Determine the net force on the wire on the right (that with current 10 A).



$$F_{1on3} = \frac{\overbrace{\mu_0 I_1 I_3 L}^{+1}}{2\pi d}$$

← +1

direction

$$= \frac{4\pi\times10^{-7}\,\mathrm{Tm/A} \times 15\,\mathrm{A}\times 10\,\mathrm{A}\times 2.5\,\mathrm{m}}{2\pi\times 0.010\,\mathrm{m}} = \left.0.75\times10^{-2}\,\mathrm{N}\right] \quad +2$$

$$F_{2on3} = \frac{\mu_0 I_2 I_3 L}{2\pi d} = \frac{4\pi\times10^{-7}\,\mathrm{Tm/A}\times 12\,\mathrm{A}\times 10\,\mathrm{A}\times 2.5\,\mathrm{m}}{2\pi\times 0.0050\,\mathrm{m}} = \left.1.2\times10^{-2}\,\mathrm{N}\right] \quad +2$$

→ +1

direction

The net force is $\overbrace{\rightarrow}^{+1}$ and has magnitude

$$F_{2on3} - F_{1on3} = 1.2\times10^{-2}\,\mathrm{N} - 0.75\times10^{-2}\,\mathrm{N}$$

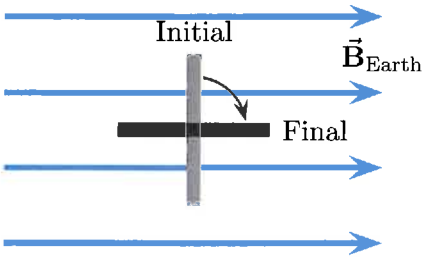
$$= 0.45\times10^{-2}\,\mathrm{N}$$

~~+3~~ +2

/10

Question 8

A circular loop whose radius is 0.080 m is in a region where the Earth's magnetic field is uniform and has strength 5.2×10^{-5} T. The loop is initially perpendicular to the magnetic field and is rotated so that it is finally parallel to the Earth's magnetic field. This is illustrated as viewed from the side of the loop.



a) Determine the change in flux through the loop.

$$\overbrace{\Phi_i = BA\cos\theta_i}^{+1}$$

$$= 5.2\times10^{-5}\,T\ \underbrace{\pi r^2}_{+1}\ \overbrace{\cos 0°}^{+1} = 5.2\times10^{-5}\,T\ \pi\times(0.080m)^2$$

$$= 1.04\times10^{-6}\ Wb$$

$$\Phi_f = BA\cos\theta_f^{=90°} = 0. \quad] \ +1$$

$$\underbrace{\Delta\Phi = \Phi_f - \Phi_i = -1.04\times10^{-6}\ Wb}_{3}$$

~~+3~~ +3

b) Determine the time taken for the loop to rotate so that the EMF is 15 V.

$$\underbrace{\mathcal{E} = \left|\frac{\Delta\Phi}{\Delta t}\right|}_{+1} \Rightarrow \quad 1.5V = \frac{1.04\times10^{-6}\,Wb}{\Delta t}$$

$$\Rightarrow \quad \Delta t = \frac{1.04\times10^{-6}\,Wb}{1.5V}$$

$$\Delta t = 7.0\times10^{-7}s$$

~~+3~~ +2

/10