Physics 114
Exam 3 Spring 2025

Name: Key

For grading purposes (do not write here):

Question	Problem
1.	1.
2.	2.
3.	3.

Sign here indicating you have followed the honor code and not cheated on this exam.

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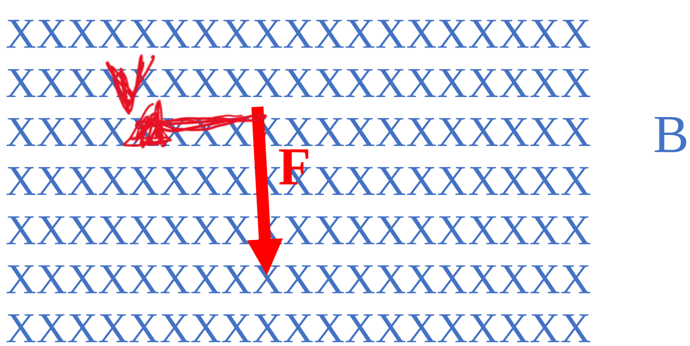
Answer each of the following questions and each of the problems. Points for each question and problem are indicated in red with the amount being spread equally among parts (a,b,c etc). Be sure to show all your work.
Use the back of the pages if necessary.

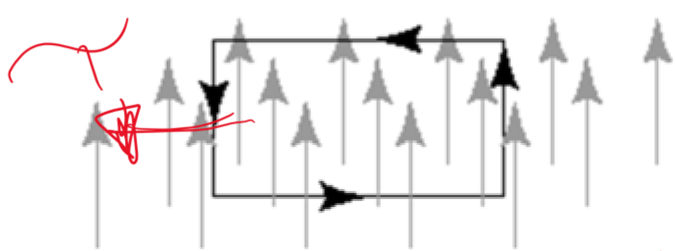
Question 1. (10 points) (a) Determine the direction of the force on a moving positive charge with velocity v as shown below in a magnetic field into the page. Draw the force clearly in the diagram

(b) A positively charged particle is moving perpendicular to a magnetic field that is into the page and experiences an downward force as shown below. What is the direction of the velocity? Draw it clearly on the diagram.



(c) A rectangular loop is placed in a uniform magnetic field with the plane of the loop parallel to the direction of the field. If a current is made to flow through the loop in the sense shown by the arrows. Does the field exert a net force on the loop? Does it exert a torque on the loop? If it does exert either one, what is the direction of the net force or torque (clearly draw it on the picture).

No, never

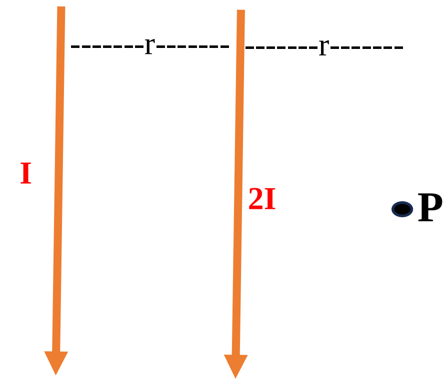


Yes

$\vec{\mu}$ out of page

$\vec{\tau} = \vec{\mu} \times \vec{B}$ to left

Question 2. (10 points) (a) If the magnetic field a distance r away from a long current carrying wire is 20 T, what will be the net magnetic field at 2r if another long wire is placed a distance r from the original wire and has a current twice as strong flowing in the same direction. In other words, Find the net magnetic field at point P which is a distance r from the wire carrying 2I and a distance of 2r from the wire carrying I.



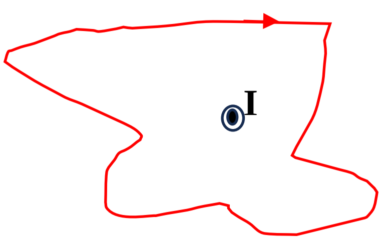
The B fields are both out of the page - they add

$B = \frac{\mu_0 I}{2\pi r}$ - 1st wire has 10 T

2nd wire has 40 T

Total is $\boxed{50\text{ T}}$

(b) There is a long wire carrying a current of 2 A out of the page as shown below. (i) what is the magnitude of the sum (path integral) $\oint \vec{B}.d\vec{s}$ for the magnetic field produced by the wire around the path shown in red?



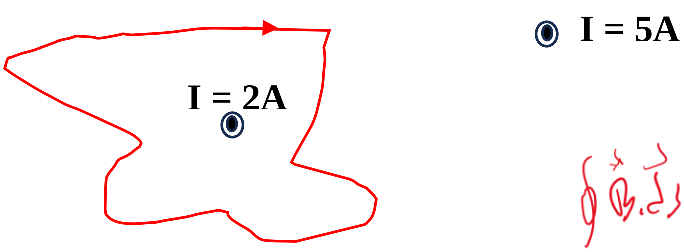
$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{encl}$

$= (4\pi \times 10^{-7})(2) = 8\pi \times 10^{-7}$ T-m

$= 2.5 \times 10^{-6}$ (T-m = N/A)

(ii) Now suppose another wire carrying a current of 5 A out of the page is added as shown below. What is the magnitude of the sum (path integral) $\oint \vec{B}.d\vec{s}$ along the same path as before.

the path shown in red? Note the 2nd current is outside the path.



Same as above

$\oint \vec{B}\cdot d\vec{s} = 2.5 \times 10^{-6}$ N/A

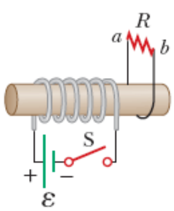
Question 3. (10 points)

(a) A long wire carries a steady current below a metal ring as shown in the figure below. (i) Is there a magnetic field through the ring? If so, what is the direction of that magnetic field? (ii) If the diameter of the ring suddenly begins to increase at a steady rate, will there be a current induced in the ring? If so, what will the direction of that current be? Draw it clearly on the loop if there is a current.

i) field into page

2) I into page increasing. Counter it w/ a CCW current

(b) What is the direction of the current induced in the resistor R (i) immediately after the switch is closed in the diagram below? Is it a to b, b to a, or is no current induced. (ii) What about after the switch has been closed for a long time. Is it a to b, b to a, or is no there no current?



i) Flux increases to right counter flux created by I going from $\boxed{\text{b to a}}$

ii) No current, No change in flux

(c) In an AC generator, a coil with *N* turns of wire spins in a magnetic field. Of the following choices, which will not cause an increase in the emf generated in the coil? Write yes or no next to each.

-replacing the coil wire with one of lower resistance No increase
-spinning the coil faster yes, increase
-increasing the magnetic field yes, increase
-increasing the number of turns of wire on the coil yes increase

Problem 1. (15 points) A magnetic field is given by $\vec{B} = (3\hat{\imath} + 3\hat{k})T$. (a) A particle with a charge of 3 C is traveling through the field with a velocity given by $\vec{v} = (2\hat{\imath} + 3\hat{\jmath})$ m/s. What is the force on the particle. (b) Another particle with a charge of 2 C is travelling in the x-y plane in this same field and it experience a magnetic force of $\vec{F} = (6\hat{\imath} - 6\hat{k})$ N. Determine the velocity of this particle – what are its x and y components ($v_z = 0$) and if one of these is undetermined state so.

$\hat{\jmath}\hat{k}$ $\hat{\imath}\hat{k}$

a) $\vec{F} = q\vec{v} \times \vec{B} = 3(2\hat{\imath} + 3\hat{\jmath}) \times (3\hat{\imath} + 3\hat{k})$

$= 3(6\hat{\imath}\times\hat{\imath} + 6\hat{\imath}\times\hat{k} + 9\hat{\jmath}\times\hat{\imath} + 9\hat{\jmath}\times\hat{k})$

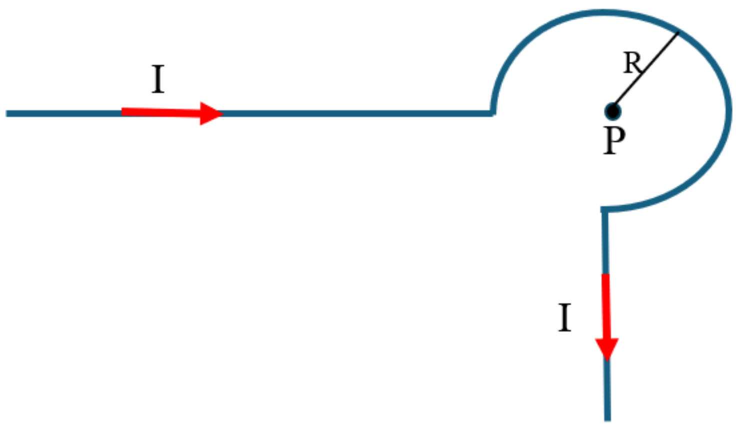
$= 3(-6\hat{\jmath} - 9\hat{k} + 9\hat{\imath}) = 27\hat{\imath} - 18\hat{\jmath} - 27\hat{k}$ N

b) $\vec{F} = q\vec{v} \times \vec{B}$ $\quad 6\hat{\imath} - 6\hat{k} = 2(v_x\hat{\imath} + v_y\hat{\jmath}) \times (3\hat{\imath} + 3\hat{k})$

$6\hat{\imath} - 6\hat{k} = 2(-3v_x\hat{\jmath} - 3v_y\hat{k} + 3v_y\hat{\imath})$

$v_x = 0, \quad v_y = 1$

Problem 2. (15 points). A long wire with a ¾ circular diversion as shown below carries a current of 2 A. The ¾ circle has a radius of 2 m. (a) (5 points Can Ampere's law be used to calculate the magnetic field at point P (at the center of the semi-circle)? (b) (10 points) Calculate the magnetic field at that point P by any means necessary. Include the direction.



a) No, not high-symmetry

b) $\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times \hat{r}}{r^2}$

$d\vec{s} \times \hat{r}$ is zero for the two straight parts. Thus they do not contribute. For the 3/4 circle,

$|\vec{B}| = \frac{\mu_0 I}{4\pi} \frac{1}{R^2} \int ds = \frac{\mu_0 I}{4\pi} \frac{1}{R^2} \frac{3}{4} 2\pi R$

$= \frac{\mu_0 I \, 6}{16 R} = 4.7 \times 10^{-7}\ T$

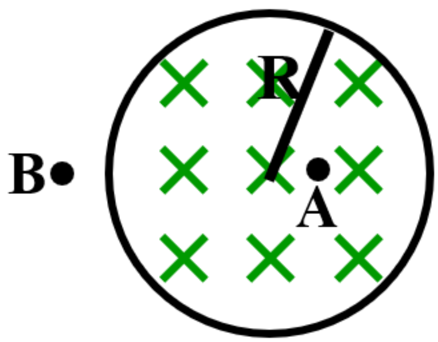
into page

Problem 3. (15 points) Within the black circle of radius R = 1 m shown in the figure below, the magnetic field decreases at a constant rate of 4 Teslas/second (so the field is like that of an ideal solenoid pointing into the page).

(a) (4 points) Calculate the electric field at point A which is 0.3 m from the center of the circle. (1 point) What is the direction of this electric field?

(b) (4 points) Calculate the electric field at point B which is 1.5 m from the center of circle. (1 point) What is the direction of this electric field?

(c) (4 points) If a circular wire of radius 1.5 m were placed concentrically with the field so that it intersects point B and the wire had a resistance of 10 Ω, what would be the current in the wire? (1 point) What would the direction of the current be (clockwise or counterclockwise.



a) $\oint \vec{E}\cdot d\vec{s} = -d\Phi/dt$

$E\,2\pi r = \pi r^2\, dB/dt$

$E = r/2\; dB/dt = (0.15)\,4$

$= 0.6$ N/c

Flux decreasing into page. Want to put it back in

E is CW - down

b) The solution from (a) is modified by the area used $E\,2\pi r = \pi R^2\, dB/dt$

$E = \frac{R^2}{2r}\, dB/dt = \frac{1}{3}\,4 = 1.33$ N/c , CW, up

c) $\mathcal{E} = d\Phi/dt = \pi R^2\, dB/dt = \pi 4 = 12.6$ V

$I = \frac{12.6\,V}{10\,\Omega} = 1.26$ A , CW

Possibly Useful Information

$$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$$

$e = 1.6 \text{ X } 10^{-19}$ C

$$E = \frac{|q|}{4\pi\varepsilon_0 r^2},\ E = \sigma/\varepsilon_0$$

$\Delta U = U_f - U_i = -W$

$\Delta V = V_f - V_i = -W/q_0 = \Delta U/q_0$

$$V_f - V_i = -\int_i^f \vec{E}.d\vec{s}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$U_f + K_f = U_i + K_i$

$K = ½ mv^2$

$$E = \frac{\Delta V}{\Delta s}$$

$Q = CV$

$$\frac{1}{C_{eq}} = \sum \frac{1}{C_j} \text{ (series)}$$

$u = ½\varepsilon_0 E^2$

$I = dQ/dt$

$\rho = 1/\sigma$

$R = \rho L/A$

$P = IV$

$P_{emf} = I\varepsilon$

$$\frac{1}{R_{eq}} = \sum \frac{1}{R_j} \text{ (parallel)}$$

$I = (\varepsilon/R)e^{-t/RC}$

$I = (Q/RC)e^{-t/RC},\ I_0 = (Q/RC)$

$\varepsilon_0 = 8.85 \text{ X } 10^{-12} (C^2 / N - m^2)$

$$\vec{E} = \vec{F}/q_0$$

$$\varepsilon_0 \Phi = \varepsilon_0 \oint \vec{E}.d\vec{A} = q_{enc}$$

$U = -W_\infty$

$V = -W_\infty/q_0$

$$V = -\int_i^f \vec{E}.d\vec{s}$$

$$V = \sum_{i=1}^{n} V_i = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_i}$$

$$V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r}$$

$$U = -W = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$C_{eq} = \sum C_j \text{ (parallel)}$$

$$U = \frac{Q^2}{2C} = ½ CV^2$$

$C = \kappa C_0$

$\Delta V = \varepsilon - Ir$

$V = IR$

$P = I^2R = V^2/R$

$$I = \varepsilon/(R + r)$$

$$R_{eq} = \sum R_j \text{ (series)}$$

$q(t) = Q(1 - e^{-t/RC})$

$q(t) = Qe^{t/RC}$

$\lambda = Q/L,\ \sigma = Q/A,\ \rho = Q/V$

$E = \sigma/\varepsilon_o$

$\vec{F} = q\vec{v} \times \vec{B}$

$$\left|\vec{F}\right| = qvB\sin(\theta)$$

$r = mv/qB$, $\omega = qB/m$

$d\vec{F} = Id\vec{s} \times \vec{B}$

$\vec{\mu} = NI\vec{A}$

$$\mathbf{B} = \frac{\mu_0 I}{4\pi}\int \frac{d\mathbf{s}\times\hat{\mathbf{r}}}{r^2}$$

$B = \mu_0 I/2\pi r$

$F/l = (\mu_0 I_1 I_2)/2\pi a$

$$\varepsilon = \oint \vec{E}.d\vec{s} = -\frac{d\Phi_B}{dt}$$

$\varepsilon = Blv$

$$\varepsilon = N\omega BA\sin(\omega t)$$

$\vec{F} = I\vec{L} \times \vec{B}$

$\tau = \vec{\mu} \times \vec{B}$

$U = -\vec{\mu}\bullet\vec{B}$

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{s} \times \vec{r}}{r^3}$, $\mu_0 = 4\pi \times 10^{-7}$ T.m/A

$$B = \frac{\mu_0 I}{4\pi a}\left(\cos\theta_1 + \cos\theta_2\right)$$

$B = \mu_0 nI$ (solenoid)

$\oint \vec{B}.d\vec{s} = \mu_0 I_{enc}$

$\Phi_B = \int \vec{B}.d\vec{A}$

$$\Phi_B = \oint \vec{B}.d\vec{A} = 0$$