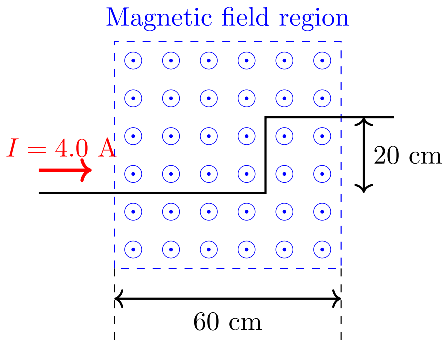
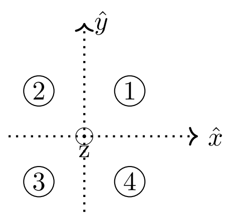
Make sure to fill out the grading sheet completely including your name, instructor, exam flavor and UIN. You are allowed to write and work on this exam copy, but your answers must be bubbled in on the grading sheet to receive credit. Your bubbled responses are the only responses that will be considered for the grade.

Physics 207 Exam 3 – Flavor 1

Problem 1 (7 points) A wire carying a current of $I = 4.0$ A is bent with two 90 degree turns as shown in the figure. The wires go through a region of constant magnetic field $B = 2.0$ T. Find the magnitude of the net force that the field exerts on the wire.





A) 1.6 N [3 points]

B) 2.8 N

C) 3.3 N

D) 4.8 N [3 points]

E) 5.1 N [7 points]

F) 5.7 N

G) 6.4 N [5 points]

H) 9.2 N

Problem 2 (2 points) What is the direction of the force on the wire in the previous problem?

A) $+\hat{x}$

B) In quadrant ①

C) $+\hat{y}$

D) In quadrant ②

E) $-\hat{x}$

F) In quadrant ③

G) $-\hat{y}$ [1 points]

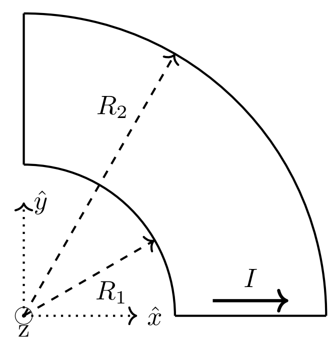
H) In quadrant ④ [2 points]

Problem 3 (8 points) A solid cylindrical wire of radius R carries a uniform current density j. Compute the magnitude of the magnetic field inside the wire at a distance r from its axis.

A) $B = \frac{\mu_0 j R}{2}$
B) $B = \frac{\mu_0 j}{2\pi r}$
C) $B = \frac{\mu_0 j}{2\pi R}$
D) $B = \frac{\mu_0 j r}{2}$ [8 points]
E) $B = \frac{\mu_0 j R^2}{2r}$ [4 points]
F) $B = \frac{\mu_0 j r^2}{2R}$ [3 points]
G) $B = \frac{\mu_0 j R^3}{2r^2}$
H) $B = \frac{\mu_0 j r^3}{2R^2}$

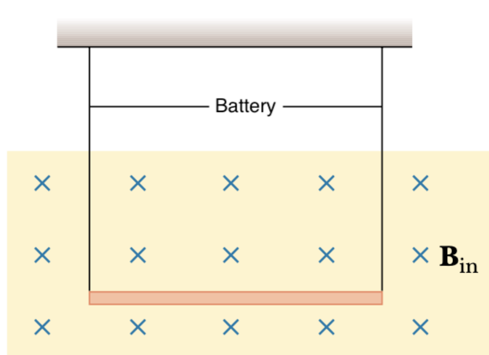
Problem 4 (7 points) A thin wire shaped as shown in the figure carries a current I. Find the magnetic field produced at the center of the coordinate system.

A) $\vec{B} = -\frac{\mu_0 I}{8}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\hat{z}$ [7 points]
B) $\vec{B} = +\frac{\mu_0 I}{8}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\hat{z}$ [5 points]
C) $\vec{B} = -\frac{\mu_0 I}{8}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)\hat{z}$
D) $\vec{B} = +\frac{\mu_0 I}{8}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)\hat{z}$
E) $\vec{B} = +\frac{\mu_0 I}{8}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)(\hat{x} + \hat{y})$



Problem 5 (7 points) A conductor suspended by two flexible wires as shown in the figure has a mass per unit length of 0.40 kg/m. What current must exist in the conductor for the tension forces in the supporting wires to be zero when the magnetic field is 2.0 T into the page? (Take $g = 10$ m/s^2).

A) left to right, 8.0 A [2 points]
B) right to left, 8.0 A
C) left to right, 4.0 A [2 points]
D) right to left, 4.0 A
E) left to right, 2.0 A [7 points]
F) right to left, 2.0 A [5 points]



Problem 6 (8 points) The loop in figure is completely embedded in a homogenous, exponentially decreasing, magnetic field pointing out of the page. The magnetic field has a time-dependance given by $B(t) = 12e^{-t/\tau}$ T, where $\tau = 6$ seconds. Find the current going through the resistor when $t = 2\tau$.

A) 0 A

B) 0.36 A

C) 0.54 A

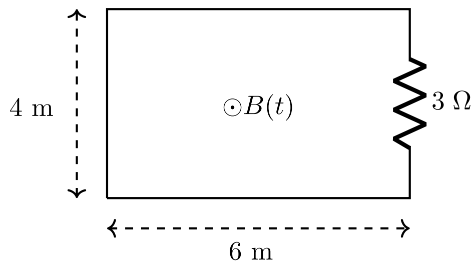
D) 1.57 A

E) 2.17 A [8 points]

F) 6.50 A [6 points]

G) 8.29 A

H) 13.0 A [4 points]



Problem 7 (3 points) What is the direction of the induced current in the previous problem at that same time $t = 2\tau$?

A) Clockwise

B) Counterclockwise [3 points]

C) The current is zero.

Problem 8 (7 points) Consider the hemispherical closed surface that has radius $R = 1.6$ m in Figure below. If the hemisphere is in a uniform magnetic field $B = 2.0$ T that makes an angle $\theta = 60$ degrees with the vertical, calculate the magnetic flux through the hemispherical surface S_2.

A) -18 Wb

B) -16 Wb [1 points]

C) -14 Wb [2 points]

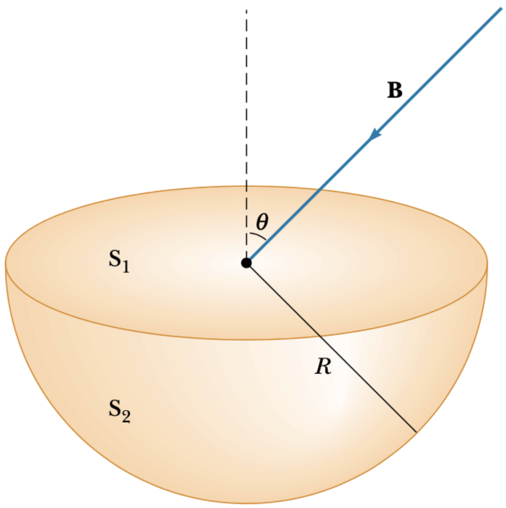
D) -8 Wb [5 points]

E) +8 Wb [7 points]

F) +14 Wb [4 points]

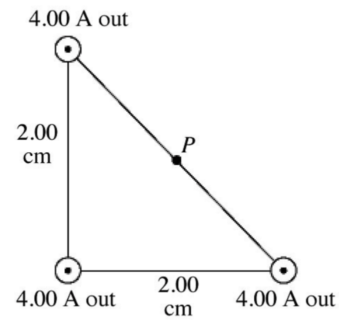
G) +16 Wb [3 points]

H) +18 Wb



Problem 9 (7 points) Three very long, straight, parallel wires each carry currents of 4.00 A, directed out of the page as shown in the figure. The wires pass through the vertices of a right isosceles triangle of side 2.00 cm. What is the magnitude of the magnetic field at point P at the midpoint of the hypotenuse of the triangle?

A) 4.42×10^{-6} T
B) 1.77×10^{-5} T
C) 5.66×10^{-5} T [7 points]
D) 1.26×10^{-4} T [4 points]
E) 1.69×10^{-4} T [2 points]



Problem 10 (7 points) Which of the following represents the well-defined integral for the net magnetic field at the point $(0, -a)$ due to the current carrying wire below? The wire extends from $x = -\infty$ along the x-axis, turns at the origin and extends to $y = +\infty$. Let the current in the wire be I.

A) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{0} \frac{dx}{(x^2 + a^2)^{3/2}} \hat{k}$ [7 points]

B) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{0} \frac{dx}{(x^2 + a^2)^{3/2}} \hat{k} + \frac{\mu_0 I a}{4\pi} \int_{0}^{+\infty} \frac{dy}{(y^2 + a^2)^{3/2}} \hat{k}$ [4 points]

C) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{0} \frac{dx}{x^2 + a^2} \hat{k}$ [2 points]

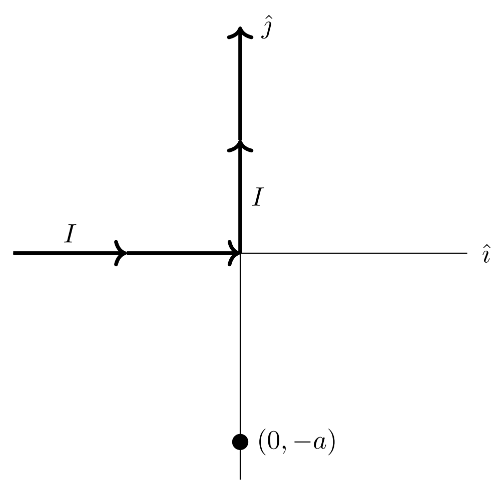
D) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{0} \frac{dx}{x^2 + a^2} \hat{k} - \frac{\mu_0 I a}{4\pi} \int_{0}^{+\infty} \frac{dy}{y^2 + a^2} \hat{k}$

E) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{+\infty} \frac{dx}{(x^2 + y^2)^{3/2}} \hat{k}$

F) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{+\infty} \frac{dy}{(x^2 + y^2)^{3/2}} \hat{k}$

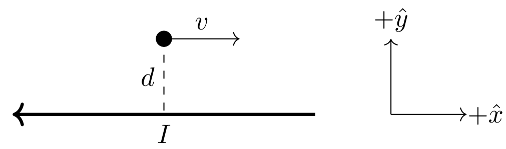
G) $-\frac{\mu_0 I a}{4\pi} \int_{-\infty}^{+\infty} \frac{dx}{(x^2 + y^2)^{3/2}} \hat{k} - \frac{\mu_0 I a}{4\pi} \int_{-\infty}^{+\infty} \frac{dy}{(x^2 + y^2)^{3/2}} \hat{k}$

H) 0



Problem 11 (5 points) An electron is traveling in the $+\hat{x}$ direction with a velocity $v = 3.70 \times 10^5$ m/s. Beneath the electron a distance $d = 1.50$ cm away, a very long wire is carrying a current of 10.0 A in the $-\hat{x}$ direction once a switch is flipped. If the electron is already over the wire when the switch is turned on, what is the magnitude of force felt by the electron the instant the switch is flipped? Assume the current reaches maximum instantly.

A) 3.51×10^{-18} N
B) 7.89×10^{-18} N [5 points]
C) 1.58×10^{-17} N
D) 6.11×10^{-17} N



Problem 12 (3 points) What is the direction of the force on the electron in the previous problem?
A) $+\hat{x}$
B) $-\hat{x}$
C) $+\hat{y}$ [1 points]
D) $-\hat{y}$ [3 points]
E) $+\hat{z}$
F) $-\hat{z}$

Problem 13 (8 points) An alpha particle ($m = 4m_p$ and $q = +2e$) enters a mass spectrometer after passing through a velocity filter. If the magnetic field in the velocity selector and the spectrometer are both 0.30 T, what is the electric field strength that gives the alpha particle's path a diameter of 14 cm in the detector?

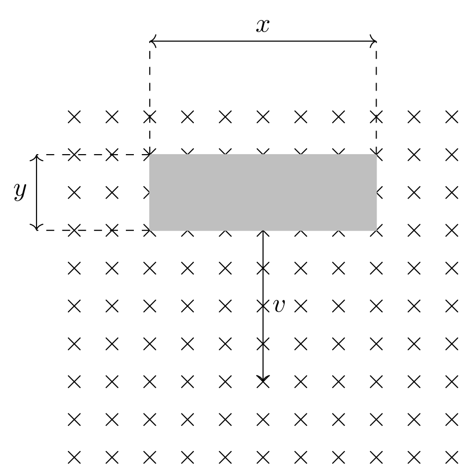
A) 4.6×10^9 N/C
B) 1.1×10^9 N/C
C) 7.9×10^6 N/C
D) 2.3×10^6 N/C
E) 1.0×10^6 N/C
F) 6.0×10^5 N/C [6 points]
G) 3.0×10^5 N/C [8 points]
H) 1.5×10^5 N/C [5 points]

Problem 14 (8 points) A 20-turn circular coil of wire with radius 10.0 cm is in the xy-plane. The wire has a resistance of 15.0 Ω. There is a uniform magnetic field $\vec{B}_0 = 0.250\hat{z}$. During a 40.0 ms time span, the magnetic field changes to $\vec{B}_f = 0.150\cos(30)\hat{x} - 0.150\sin(30)\hat{z}$. What is the average induced current in the wire during this change? Both magnetic field vectors in this problem are given in SI units.

A) 0.105 A [3 points]
B) 0.183 A [5 points]
C) 0.340 A [8 points]
D) 0.601 A
E) 0.938 A
F) 1.36 A
G) 5.11 A [6 points]

Problem 15 (5 points) A solid, conducting block with dimensions x by y is moving with a velocity v in a direction perpendicular (downward) to a uniform magnetic field B as shown in the figure below. What is the magnitude of the induced motional emf in the block and which direction is the induced electric field pointing in the block?

A) Bvx left [4 points]
B) Bvx right [5 points]
C) Bvx up [3 points]
D) Bvx down [3 points]
E) Bvy left [1 points]
F) Bvy right [2 points]
G) Bvy up
H) Bvy down



Problem 16 (8 points) At one instant, a proton has a velocity vector $\vec{v} = 300\hat{x} + 400\hat{y}$. The magnetic field and electric field at the same location of the proton are $\vec{B} = 0.250\hat{z}$ and $\vec{E} = 200\hat{y}$. What is the magnitude of the net force acting on the proton at this location? All vectors in this problem are given in SI units.

A) 9.77×10^{-17} N
B) 8.54×10^{-17} N
C) 6.51×10^{-17} N
D) 5.20×10^{-17} N [4 points]
E) 4.68×10^{-17} N [6 points]
F) 3.20×10^{-17} N [2 points]
G) 2.56×10^{-17} N [8 points]
H) 2.00×10^{-17} N [2 points]