PHYS 1320 (Spring 2024) Sonnenfeld #8 Magnetism Review and Ampere

Problem 1: Please answer the following questions about magnetic fields.
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Part (a) Which of the following statements about magnetic fields are true?
MultipleChoice :

1) There are no magnetic field lines unless iron filings are present.
2) None of these.
3) There are no magnetic field lines outside the magnet.
4) Magnetic field lines point in towards the north pole of a magnet.
5) Magnetic field lines point outward from the north pole of a magnet.
6) Magnetic field lines point outward from the south pole of a magnet.

Part (b) What is an acceptable ending to the following sentence: “Magnetic field lines…”
MultipleChoice :

1) Are not present without iron filings.
2) Form closed loops.
3) All of the above.
4) Can cross each other.
5) Originate from monopoles.
6) None of these.

Part (c) Which of the following arrangements produces an attractive force?
MultipleChoice :

1) None of these.
2) Magnets never attract each other, only iron filings.
3) All of these.
4) North Pole to North Pole.
5) South Pole to South Pole.
6) South Pole to North Pole.

Problem 2: A charged particle moves in some area and does not experience any magnetic force.
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We can conclude that:
MultipleChoice :

1) There is no magnetic field in this area.
2) There is no magnetic field in the area or there is magnetic field whose lines are parallel to particle's velocity.
3) There is magnetic field which is parallel to the particle's velocity.
4) There is magnetic field which is perpendicular to particle's velocity.
5) There is no magnetic field in this area or there is magnetic field which lines are perpendicular to the particle's velocity.

Problem 3: A power line carries a DC current of $I = 23$ A in a direction $\phi = 23°$ east of magnetic north through an open field, in a location where the Earth's magnetic field is horizontal and its strength is $B = 0.61$ G.

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Part (a) Calculate the magnitude of the magnetic force per unit length, F/l, in newtons per meter, exerted on the wire due to the Earth's magnetic field.
Numeric : A numeric value is expected and not an expression.
F/l = ____ N/m

Part (b) In what direction does the force on the wire act? Be aware that the magnetic field of the Earth actually behaves in the opposite manner you would expect from a physical magnet. The Earth's magnetic field lines point from the Earth's south pole towards the Earth's north pole.
MultipleChoice :

1) East of North
2) Up
3) There is no magnetic force on the wire
4) West of South
5) East of South
6) There is a magnetic force acting on the wire, but in a direction not listed.
7) West of North
8) Down

Part (c) You decide to re-orient the wire to minimize the magnetic force acting on the wire. In which direction(s) could the current flow to get the minimum possible magnetic force on the wire?
MultipleSelect :

1) Up
2) The magnetic force does not depend on the orientation of the wire.
3) East
4) South
5) Down
6) West
7) North
8) The wire should be oriented in a direction not listed.

Part (d) In what direction(s) could you orient the current flow to maximize the magnetic force acting on the wire?
MultipleSelect :

1) South
2) North
3) There is not enough information to determine.
4) West
5) East
6) Anything but North or South

Part (e) In which of the directions that correctly answer part (d) is the magnetic force on the wire directed upward?
MultipleChoice :

1) Down
2) South
3) It is not possible to orient the current so that the magnetic force acts upwards.
4) East
5) West
6) North
7) Up

Part (f) If the wire is oriented so that the current flows in the direction you chose for part (e), what would the mass per unit length of the wire, μ, need to be for the magnetic force to balance the weight of the wire? Give you answer in units of grams per meter.
Numeric : A numeric value is expected and not an expression.
μ = ____ g/m

Problem 4: An infinitely long wire carries a current of *I* = *180* A.

Randomized Variables

I = *180* A

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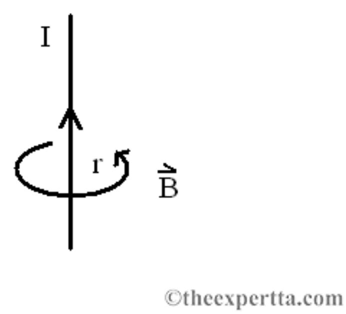

Part (a) Consider a circle with a radius *r* and centered on the wire. Determine the magnitude of the magnetic field B at points along the circle in terms of *I* and *r*.
Expression :
B = ____

Select from the variables below to write your expression. Note that all variables may not be required.
α, β, μ_0, π, θ, d, g, h, I, j, k, m, P, r, t

Part (b) If *r* = *0.24* m, calculate the numerical value of B in tesla.
Numeric : A numeric value is expected and not an expression.
B = ____

Problem 5: The hot and neutral wires supplying DC power to a light rail commuter train carry 800 A and are separated by 75.0 cm.

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What is the magnitude of the force (in N) between ***25*** m of these wires?
Numeric : A numeric value is expected and not an expression.
F = ____

Problem 6: Two very long, parallel wires are separated by d = ***0.095*** m. The first wire carries a current of I_1 = ***0.55*** A. The second wire carries a current of I_2 = ***0.85*** A.

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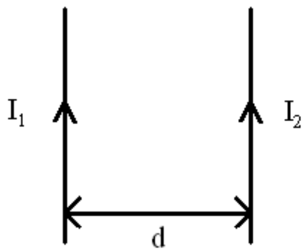

Part (a) Express the magnitude of the force between the wires per unit length, f, in terms of I_1, I_2, and d.
Expression :
f = ____

Select from the variables below to write your expression. Note that all variables may not be required.
α, β, μ_0, π, θ, d, g, h, I_1, I_2, ln(2), m, P, t, x

Part (b) Calculate the numerical value of f in N/m.
Numeric : A numeric value is expected and not an expression.
f = ____

Part (c) Is the force repulsive or attractive?
MultipleChoice :

1) Attractive.
2) Repulsive.

Part (d) Express the minimal work per unit length needed to separate the two wires from d to $2d$.
Expression :
w = ____

Select from the variables below to write your expression. Note that all variables may not be required.
α, β, μ_0, π, θ, d, g, h, I_1, I_2, ln(2), m, P, t, x

Part (e) Calculate the numerical value of w in J/m.
Numeric : A numeric value is expected and not an expression.
w = ____

Problem 7: A rectangular loop with L_1 = *0.75* m and L_2 = *0.55* m is sitting in a magnetic field B = *0.45* T as shown in the figure. There is a counterclockwise current I = *0.45* A in the loop.

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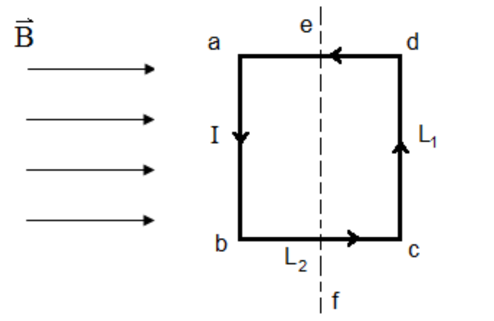

Calculate the numerical value of the total torque in N·m.

Numeric : A numeric value is expected and not an expression.

τ = ____

Problem 8: The lengthwise cross-section of a cylindrical coil of wire carrying a current of 8.11 A is shown. The coil has n evenly-spaced turns per unit length.

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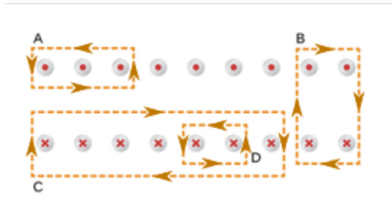

Part (a) Determine the value, in microtesla meters, of the line integral of $\vec{B} \cdot d\vec{\ell}$ for path A.

Numeric : A numeric value is expected and not an expression.

$\oint_A \vec{B} \cdot d\vec{\ell}$ = ____ μT · m

Part (b) Determine the value, in microtesla meters, of the line integral of $\vec{B} \cdot d\vec{\ell}$ for path B.

Numeric : A numeric value is expected and not an expression.

$\oint_B \vec{B} \cdot d\vec{\ell}$ = ____ μT · m

Part (c) Determine the value, in microtesla meters, of the line integral of $\vec{B} \cdot d\vec{\ell}$ for path C.

Numeric : A numeric value is expected and not an expression.

$\oint_C \vec{B} \cdot d\vec{\ell}$ = ____ μT · m

Part (d) Determine the value, in microtesla meters, of the line integral of $\vec{B} \cdot d\vec{\ell}$ for path D.

Numeric : A numeric value is expected and not an expression.

$\oint_D \vec{B} \cdot d\vec{\ell}$ = ____ μT · m

Problem 9: The diagram to the right represents four different oriented Amperian loops that are located in the plane of the image. Electric currents that pass through the plane of the image are indicated.

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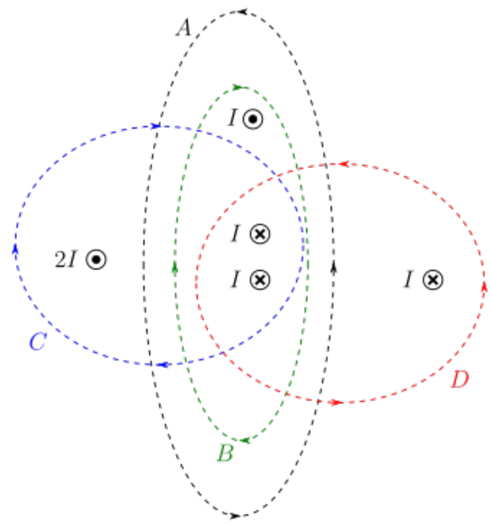

By dragging the images to the area at the top, rank them from the most negative value to the most positive value of $\oint \vec{B} \cdot d\vec{\ell}$.

DragNDrop :

= ____

Problem 10: Four current carrying wires are arranged in the corners of a square as shown in the picture.

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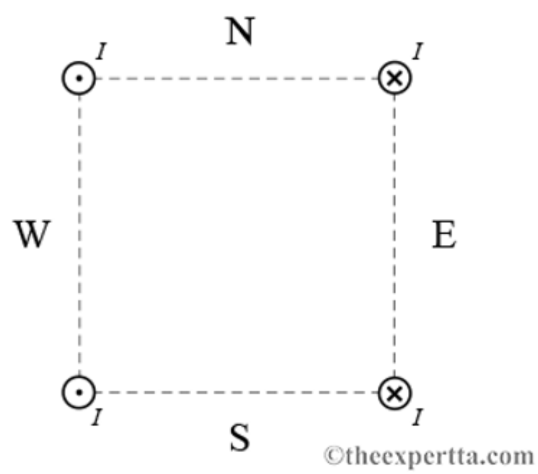

The magnetic field in the center of the square is directed towards:

MultipleChoice :

1) Zero.
2) West
3) East
4) North
5) South

Problem 11: A very long, straight, and solid cylindrical conductor with a radius $a = 4.87$ cm carries a current $I = 56.8$ A uniformly distributed through its interior.

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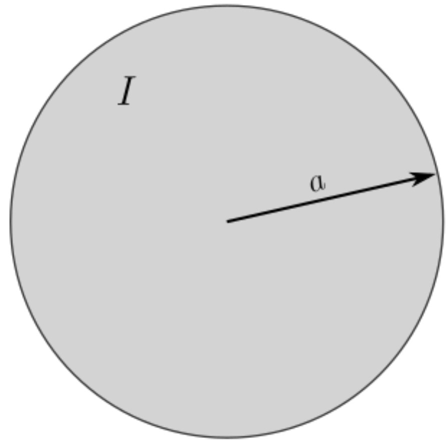

Part (a) Which of the following best describes the functional relationship between the magnetic field strength, B, and the radial distance, r, for distances less than the radius of the cylindrical conductor, a?

MultipleChoice :

1)

$$B \propto \frac{1}{r^3}$$

2)

$$B \propto \frac{1}{r}$$

3)

$$B \propto r$$

4)

$$B \propto r^3$$

5)

$$B \propto r^2$$

6)

$$B \propto \frac{1}{r^2}$$

Part (b) Which of the following best describes the functional relationship between the magnetic field strength, B, and the radial distance, r, for distances greater than the radius of the cylindrical conductor, a?

MultipleChoice :

1)

$$B \propto \frac{1}{r^3}$$

2)

$$B \propto r$$

3)

$$B \propto \frac{1}{r}$$

4)

$$B \propto \frac{1}{r^2}$$

5)

$$B \propto r^2$$

6)

$$B \propto r^3$$

Part (c) Determine the magnitude of the magnetic field in, microtesla, at a point located a distance $1.709\ \text{cm}$ from the center of the cylinder.
Numeric : A numeric value is expected and not an expression.
$B(1.709\ \text{cm})$ = ____ μT

Problem 12: The magnetic dipole moment of the iron atom is about $2.1 \times 10^{-23}\ \text{A} \cdot \text{m}^2$.
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Part (a) Calculate the *maximum* magnetic dipole moment of a domain consisting of 7.39×10^{19} iron atoms.
Numeric : A numeric value is expected and not an expression.
μ_{max} = ____ $\text{A} \cdot \text{m}^2$

Part (b) What current, in amperes, flowing through a single circular loop of wire of diameter $2.37\ \text{cm}$ would produce the magnetic dipole moment that was the answer to step (a)?
Numeric : A numeric value is expected and not an expression.
I = ____ A

Problem 13: Consider a long, closely wound solenoid with 10,000 turns per meter.
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What current, in amperes, is needed in the solenoid to produce a magnetic field inside the solenoid, near its center, that is 10^4 times the Earth's magnetic field of ***4.8*** $\times 10^{-5}$ T?

Numeric : A numeric value is expected and not an expression.

I = ____

Problem 14: A solenoid is producing a magnetic field of B = ***4.5*** x 10^{-3} T. It has N = ***1100*** turns uniformly over a length of d = ***0.25*** m.

Randomized Variables

B = ***4.5*** x 10^{-3} T
N = ***1100*** turns
d = ***0.25*** m

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Part (a) Express the current I in terms of B, N and d.

Expression :

I = ____

Select from the variables below to write your expression. Note that all variables may not be required.

α, γ, μ_0, θ, B, d, g, h, i, j, k, m, N, P, t

Part (b) Calculate the numerical value of I in amps.

Numeric : A numeric value is expected and not an expression.

I = ____

Problem 15: Consider the loop and coils depicted in the figure.

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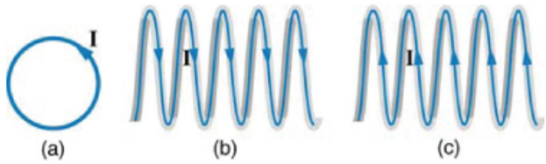

Part (a) What is the direction of the magnetic field in the center of the loop in (a)?
MultipleChoice :

1) Out of the page
2) To the Left
3) Up
4) Down
5) To the right
6) Into the page

Part (b) What is the direction of the magnetic field in the center of the coil in (b)? The current is going out of the page at the top of the loop.
MultipleChoice :

1) Down
2) To the right
3) Out of the page
4) Up
5) To the left
6) Into the page

Part (c) What is the direction of the magnetic field in the center of the coil in (c)? The current is going into the page at the top of the loop.
MultipleChoice :

1) Into the page
2) To the left
3) Down
4) Up
5) To the right
6) Out of the page

Problem 16: A solenoid has a ferromagnetic core and ***1275*** turns per meter.
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If the field in the solenoid core is 1.75 T when the current is 7.02 A, then what is the magnetic susceptibility for the core material?
Numeric : A numeric value is expected and not an expression.
χ = ____

Problem 17: You are looking at a current carrying loop of wire laying flat on the table. As viewed from above, the current is moving in the clockwise direction.
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Part (a) Magnetic field in the center of this loop is directed:
MultipleChoice :

1) Up
2) To the right part of loop
3) Zero.
4) To the left part of loop
5) Down

Part (b) The magnetic field outside (say, to the right) of this loop is directed:
MultipleChoice :

1) Down
2) Up
3) Away from the loop
4) Is zero
5) Towards the loop

Problem 18: The magnetic field of a proton is approximately like that of a circular current loop 0.650×10^{-15} m in radius carrying 1.05×10^{4} A. An MRI machine needs to be able to manipulate these fields.
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Part (a) To see why an MRI utilizes iron to increase the magnetic field created by a coil, calculate the current needed in a 400 loop-per-meter circular coil 0.660 m in radius to create a 1.20 T field (typical of an MRI instrument) at its center with no iron insert.
Numeric : A numeric value is expected and not an expression.
I = ____

Part (b) What is the field at the center of a proton? Notice how it compares to the field we used in the previous calculation.
Numeric : A numeric value is expected and not an expression.
B = ____