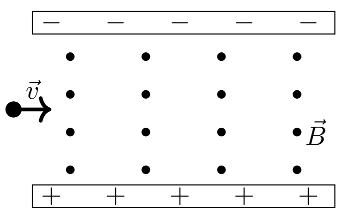
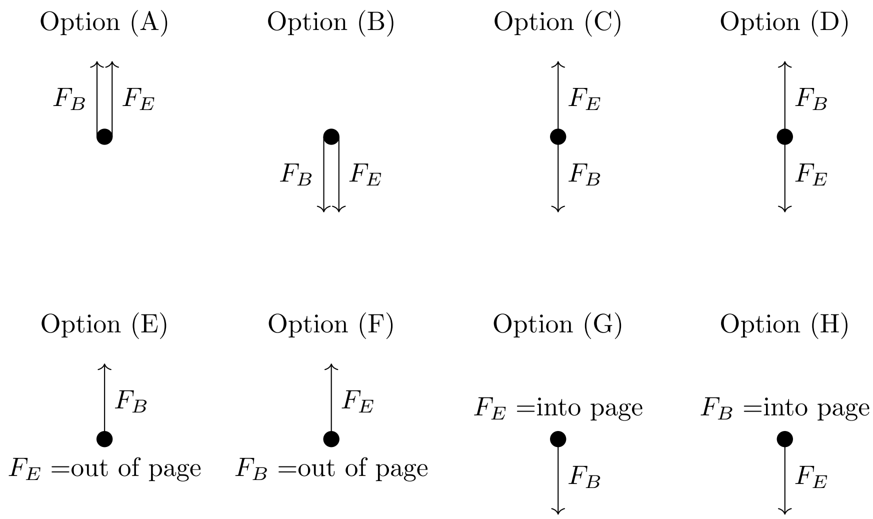
Make sure to fill out the grading sheet completely including your name, instructor, exam flavor and UIN. You are allowed to write, work on and keep this exam copy, but your answers must be bubbled in on the grading sheet to receive credit.

Physics 207 Exam 3 – Flavor 1

Problem 1: (4 Points) A positive charge passes through a velocity filter that is set up using two parallel plates where the bottom plate is positively charged and the top plate is negatively charged. There is also a magnetic field coming out of the page as shown by the points. Which of the following is the correct free body diagram acting on the charge as it passes through the filter? Let F_E be the electric force and F_B be the magnetic force.





Option C - 4 points
Option D - 2 points
Options A, B, F, G - 1 point

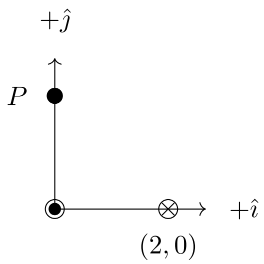
Problem 2: (4 Points) If the charge in the previous problem has a velocity greater than E/B, which direction will it be deflected?

(A) Upwards [2 points]
(B) Downwards [4 points]
(C) Left
(D) Right
(E) Out of the page
(F) Into the page
(G) There is no deflection for this velocity

Problem 3: (8 Points) A charge with a magnitude of 6.0 mC is moving in the presence of both an electric and a magnetic field. The electric field is $\vec{E} = 100\hat{x} - 200\hat{z}$ and the magnetic field is $\vec{B} = -8.0\hat{y}$. If the velocity of the charge is $\vec{v} = -120\hat{z}$, what is the magnitude of the net force vector acting on this charge?

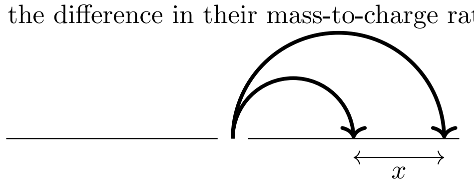
(A) 1.3 N [3 points]
(B) 2.2 N
(C) 4.5 N
(D) 5.3 N [8 points]
(E) 5.8 N [3 points]
(F) 6.8 N [6 points]
(G) 7.1 N [6 points]
(H) 7.8 N

Problem 4: (8 Points) Two long wires carry identical currents of 300 mA. The wire at the origin carries the current out of the page and the wire at $(2, 0)$ carries the current into the page. What is the net magnetic field at the point $P = (0, 2)$?



(A) $+8.37 \times 10^{-8}\hat{\imath} - 8.37 \times 10^{-8}\hat{\jmath}$
(B) $-8.37 \times 10^{-8}\hat{\imath} + 8.37 \times 10^{-8}\hat{\jmath}$
(C) $-1.50 \times 10^{-8}\hat{\imath} - 4.50 \times 10^{-8}\hat{\jmath}$ [4 points]
(D) $+1.50 \times 10^{-8}\hat{\imath} + 4.50 \times 10^{-8}\hat{\jmath}$ [4 points]
(E) $+1.50 \times 10^{-8}\hat{\imath} - 1.50 \times 10^{-8}\hat{\jmath}$ [6 points]
(F) $-1.50 \times 10^{-8}\hat{\imath} + 1.50 \times 10^{-8}\hat{\jmath}$ [8 points]
(G) $+5.12 \times 10^{-8}\hat{\imath}$
(H) $-5.12 \times 10^{-8}\hat{\imath}$

Problem 5: (6 Points) When particles enter a mass spectrometer they follow circular paths like the ones below. You measure that the distance between where two particles hit on the detector is $x = 4.00$ cm. The magnetic field in the spectrometer is $B = 0.150$ T pointing out of the page towards you. We know the velocity of the particles is $v = 67500$ m/s. What is the difference in their mass-to-charge ratio?



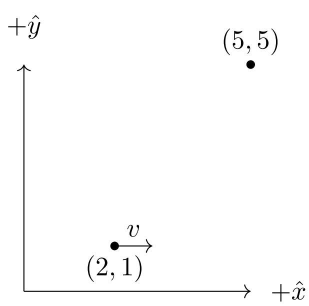
(A) 1.89×10^{-8} kg/C
(B) 2.39×10^{-8} kg/C
(C) 4.44×10^{-8} kg/C [6 points]
(D) 6.96×10^{-8} kg/C
(E) 8.89×10^{-8} kg/C [5 points]

Problem 6: (4 Points) A circular loop of wire with radius R is in the presence of a uniform magnetic field B that is pointing perpendicular to the loop. Rank the order of the magnitude of the emf induced in the loop for the following changes. Assume each change will take place in the same amount of time.

Change A: The magnitude of the magnetic field will double, but stay pointing in the same direction.
Change B: The magnitude of the magnetic field will stay the same, but the direction will rotate by 180 degrees.
Change C: The radius of the loop will increase by a factor of 2.

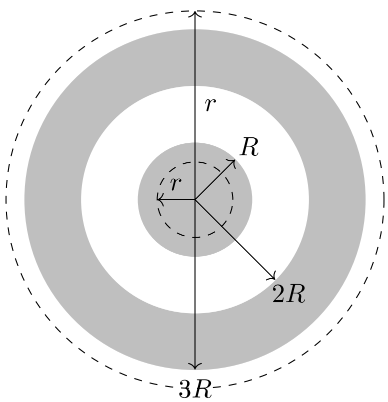
(A) $A > B > C$
(B) $A > C > B$
(C) $B > A > C$
(D) $B > C > A$
(E) $C > A > B$ [2 points]
(F) $C > B > A$ [4 points]

Problem 7: (8 Points) A proton is at the position $(2, 1)$ with a speed of 750,000 m/s and is moving in the positive x-direction. What is the magnitude of the magnetic field created by this proton at the position $(5, 5)$? All positions are given in SI units.



(A) 1.70×10^{-22} T [5 points]
(B) 3.84×10^{-22} T [8 points]
(C) 8.46×10^{-22} T
(D) 1.07×10^{-21} T [5 points]
(E) 1.20×10^{-21} T [3 points]
(F) 2.40×10^{-21} T [3 points]
(G) 5.01×10^{-21} T
(H) 7.47×10^{-21} T

Problem 8: (6 Points) The figure below shows a solid cylindrical conductor with radius R (the shaded circle) that carries a current I into the page. There is also a conducting, cylindrical shell (the shaded annulus) with inner radius $2R$ and outer radius $3R$ that carries a current $3I$ out of the page. What is the magnitude of the magnetic field at a distance r, where $r < R$?



(A) $B = \frac{\mu_0 I}{2\pi r}$ [2 points]

(B) $B = \frac{2\mu_0 I}{2\pi r}$

(C) $B = \frac{3\mu_0 I}{2\pi r}$

(D) $B = \frac{4\mu_0 I}{2\pi r}$

(E) $B = \frac{\mu_0 I}{2\pi R^2} r$ [6 points]

(F) $B = \frac{2\mu_0 I}{2\pi R^2} r$

(G) $B = \frac{3\mu_0 I}{2\pi R^2} r$ [3 points]

(H) $B = \frac{4\mu_0 I}{2\pi R^2} r$

Problem 9: (6 Points) What is the magnitude of the magnetic field in the previous problem at a distance $r > 3R$?

(A) $B = \frac{\mu_0 I}{2\pi r}$ [2 points]

(B) $B = \frac{2\mu_0 I}{2\pi r}$ [6 points]

(C) $B = \frac{3\mu_0 I}{2\pi r}$ [3 points]

(D) $B = \frac{4\mu_0 I}{2\pi r}$ [2 points]

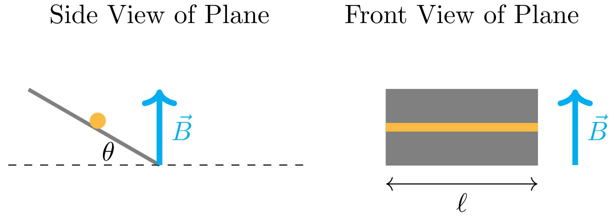
(E) $B = \frac{\mu_0 I}{2\pi R^2} r$

(F) $B = \frac{2\mu_0 I}{2\pi R^2} r$

(G) $B = \frac{3\mu_0 I}{2\pi R^2} r$

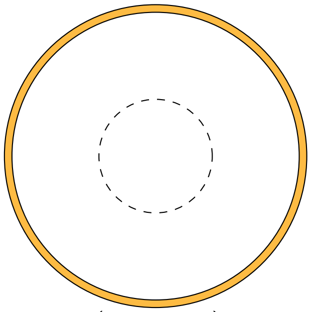
(H) $B = \frac{4\mu_0 I}{2\pi R^2} r$

Problem 10: (8 Points) A straight piece of conducting wire with mass $m = 250$ g and length $\ell = 20$ cm is placed on a frictionless incline tilted at an angle $\theta = 40$ degrees from the horizontal. There is a uniform magnetic field $B = 3.00$ T at all points in the figure. To keep the wire from sliding down the incline, a voltage source is attached to the ends of the wire. When just the right amount of current flows through the wire, the wire remains at rest. Determine the magnitude of the current in the wire that will cause the wire to remain at rest.



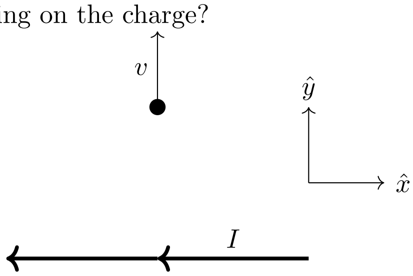
(A) 2.62 A [5 points]
(B) 3.13 A [5 points]
(C) 3.43 A [8 points]
(D) 4.08 A [4 points]
(E) 4.92 A
(F) 5.87 A

Problem 11: (4 points) A long, thin solenoid is carrying a current in the clockwise direction from the point of view in the figure below. The current in the solenoid is increasing at a uniform rate. What is the direction of the induced electric field along the dashed line shown in the figure?



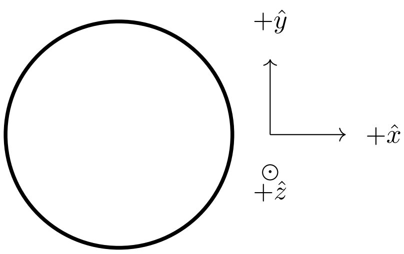
(A) Clockwise
(B) Counterclockwise [4 points]
(C) No electric field is induced.

Problem 12: (4 Points) In the figure below, there is a long wire carrying current I in the $-\hat{x}$ direction. There is a negative charge with a velocity in the $+\hat{y}$ direction. If the wire and the charge are in the xy-plane, what is the direction of the force acting on the charge?



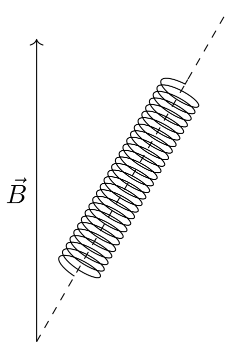
(A) $+\hat{x}$ [4 points]
(B) $+\hat{y}$
(C) $+\hat{z}$
(D) $-\hat{x}$ [2 points]
(E) $-\hat{y}$
(F) $-\hat{z}$
(G) The force is zero.

Problem 13: (4 Points) In the figure below, there is a loop of wire in the xy-plane. There is a uniform magnetic field in this region of space that is pointing in the $-\hat{y}$ direction. The magnetic field rotates to be pointing in the $+\hat{x}$ direction while keeping its magnitude constant. What is the sense of the average induced current in the loop during this change?



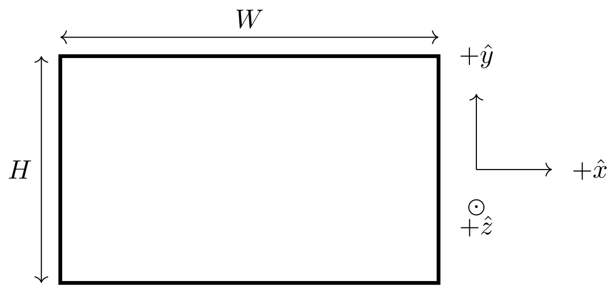
(A) The average induced current will be clockwise.
(B) The average induced current will be zero. [4 points]
(C) The average induced current will be counterclockwise.

Problem 14: (6 Points) A solenoid is 30.0 cm long, has a radius of 1.00 cm, has 650 turns and is carrying 0.750 A of current. There is a magnetic field with a magnitude of 0.900 T that is pointing vertically as shown in the figure. If the solenoid feels a magnitude of torque equal to 0.0380 Nm, what is the angle between the axis of the solenoid (the dashed line) and horizontal?



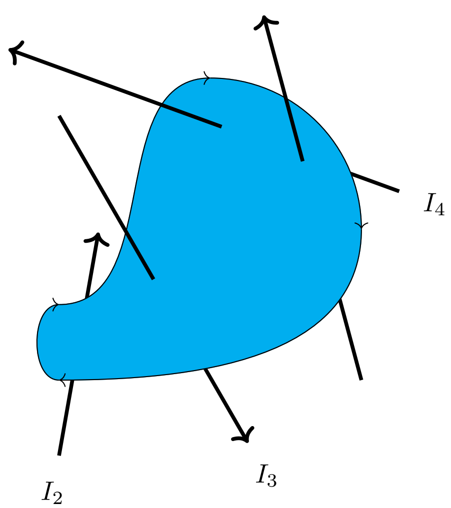
(A) 4 degrees
(B) 16 degrees [5 points]
(C) 30 degrees
(D) 38 degrees
(E) 52 degrees
(F) 60 degrees
(G) 74 degrees [6 points]
(H) 86 degrees

Problem 15: (8 Points) In the figure below, there is a rectangular loop of wire in the xy-plane that has sides that are $W = 25.0$ cm and $H = 15.0$ cm long. There is time dependent magnetic field in this region of space that is is given by $\vec{B}(t) = (0.0320t^2)\hat{z}$. What is the magnitude of the emf at $t = 0.650$ s



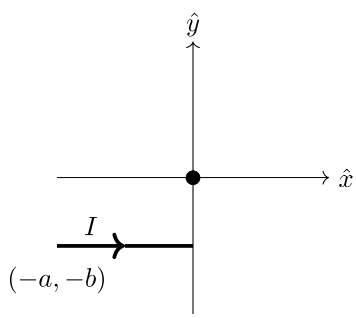
(A) 15.6 V [6 points]
(B) 5.07 V [2 points]
(C) 2.62 V
(D) 1.49 V
(E) 0.149 mV
(F) 0.262 mV
(G) 0.507 mV [4 points]
(H) 1.56 mV [8 points]

Problem 16: (4 Points) Find the value of the line integral of the magnetic field around a closed curve in the presence of six electric currents as shown in the figure: with $I_1 = 3$ A, $I_2 = 5$ A, $I_3 = 7$ A and $I_4 = 9$ A. The shaded region represents a flat region of space. Make sure to note the direction of the line integral.



(A) $+24\mu_0$
(B) $+19\mu_0$
(C) $+10\mu_0$ [1 points]
(D) $+5\mu_0$ [3 points]
(E) $-5\mu_0$ [4 points]
(F) $-10\mu_0$ [2 points]
(G) $-19\mu_0$
(H) $-24\mu_0$

Problem 17: (8 Points) A straight wire carries current I to the right. Which integral below represents the magnetic field at the origin due to only the segment of wire shown in the figure?



(A) $\frac{\mu_0 I}{4\pi} \int_{-a}^{0} \frac{b dx}{(x^2 + b^2)^2} \hat{z}$ [5 points]

(B) $\frac{\mu_0 I}{4\pi} \int_{-a}^{0} \frac{a dx}{(x^2 + a^2)^2} \hat{z}$

(C) $\frac{\mu_0 I}{4\pi} \int_{-a}^{0} \frac{b dx}{(a^2 + b^2)^2} \hat{z}$ [2 points]

(D) $\frac{\mu_0 I}{4\pi} \int_{-a}^{0} \frac{b dx}{(x^2 + b^2)^{3/2}} \hat{z}$ [8 points]

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

(F) $\frac{\mu_0 I}{4\pi} \int_{-a}^{0} \frac{b dx}{(a^2 + b^2)^{3/2}} \hat{z}$ [5 points]