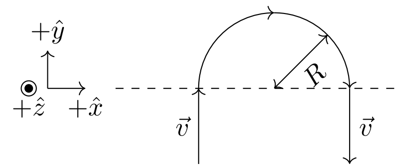
Make sure to fill out the grading sheet completely including your name, instructor, exam flavor and UIN. You are allowed to write, work on and keep this exam copy, but your answers must be bubbled in on the grading sheet to receive credit.

Physics 207 Exam 3 – Flavor 1

Problems 1-2: A beam of particles with charge $q = -3e$ and $M = 12m_p$ enters a region of space with a uniform magnetic field. The speed of the particles is $v = 3.15 \times 10^6$ m/s and the radius of their path when in the magnetic field is $R = 47.5$ cm. The picture to the right will show the trajectory of the particles and the coordinate system. The magnetic field exists only in the region of space above the dashed line.



Problem 1: (7 points) What is the magnitude of the magnetic field?
(A) 0.0231 T [4 points]
(B) 0.0692 T [2 points]
(C) 0.106 T
(D) 0.277 T [7 points]
(E) 0.831 T [4 points]
(F) 1.17 T

Problem 2: (3 points) What is the direction of the magnetic field?

(A) $+\hat{x}$
(B) $-\hat{x}$
(C) $+\hat{y}$
(D) $-\hat{y}$
(E) $+\hat{z}$ [2 points]
(F) $-\hat{z}$ [3 points]

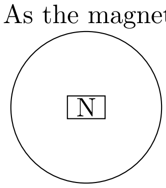
Problem 3: (9 points) What is the magnitude of the net force that acts on a particle with charge $q = 2$ C at the instant when it has a velocity vector $\vec{v} = -2000\hat{z}$ at a location in space with a magnetic field $\vec{B} = 0.55\hat{x} - 0.45\hat{z}$ and an electric field $\vec{E} = -400\hat{x} + 1400\hat{y}$? All vectors are given in SI units.

(A) 500 N [7 points]
(B) 1000 N [9 points]
(C) 2200 N [3 points]
(D) 2910 N [3 points]
(E) 3540 N
(F) 5060 N [7 points]
(G) 5110 N [5 points]
(H) 6800 N

Problem 4: (7 points) Niels Bohr created an early model of the atom where he predicted that the electron in the ground state of a Hydrogen atom moves with a speed of $c/137$ or 2.19×10^7 m/s with a circular radius of 5.29×10^{-11} m around the nucleus. Based on these predictions, what would be the magnitude of the magnetic field created by the electron at the center of its circular path?

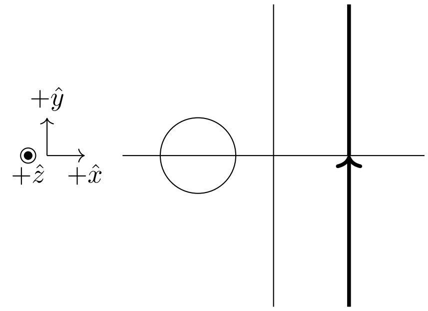
(A) 125 T [7 points]
(B) 237 T [4 points]
(C) 499 T
(D) 601 T
(E) 662 T [4 points]

Problem 5: (3 points) You are looking down at a loop and there is a magnet below the loop with the north pole facing you. As the magnet falls away from you, which way does the induced current flow in the loop?



(A) Clockwise
(B) Counterclockwise [3 points]
(C) The current will be zero.

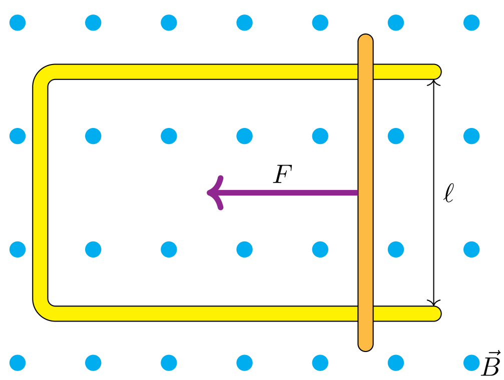
Problems 6-7: A long straight wire and a coil with N loops all exist in the xy-plane as shown below. The long straight wire carries $2500I$ in the $+y$-direction through the position $(0.6, 0)$. The coil of wire has a radius of 0.1 m, is centered at position $(-0.6, 0)$ and carries a magnitude of current, I. All answers below have been rounded to three significant figures.



Problem 6: (8 points) How many turns/loops does the coil have if the net magnetic field at the center of the coil is exactly zero?
(A) 66.3 [8 points]
(B) 133 [6 points]
(C) 398
(D) 796 [2 points]
(E) 2840
(F) 4770 [3 points]
(G) 5690
(H) 9550 [5 points]

Problem 7: (3 points) What direction is the current in the coil if the net magnetic field is exactly zero at the center of the coil?
(A) Clockwise [3 points]
(B) Counterclockwise

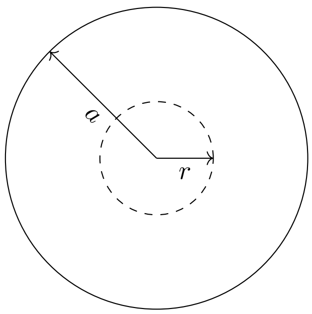
Problem 8: (8 points) A rectangular, conductive loop is created with width ℓ and a conducting bar with mass m. A uniform magnetic field $\vec{B}$ is directed perpendicular to the plane of the loop out of the plane of the figure. The bar is pushed with constant force F to the left. Assume that friction is negligible in this system, the resistance in the bar is R and the resistance of the rest of the loop is negligible. If the bar is in equilibrium, what is the constant speed with which it moves?



(A) $\dfrac{B\ell}{F}$
(B) $\dfrac{F}{B\ell}$
(C) $\dfrac{B\ell}{FR}$
(D) $\dfrac{FR}{B\ell}$ [4 points]
(E) $\dfrac{F\ell^2}{B^2R}$
(F) $\dfrac{FR^2}{B\ell}$
(G) $\dfrac{B^2\ell^2}{FR}$ [5 points]
(H) $\dfrac{FR}{B^2\ell^2}$ [8 points]

Problem 9: (3 points) Which end of the bar has the higher potential?
(A) Top [3 points]
(B) Bottom
(C) The potential is the same at both ends.

Problem 10: (8 points) A long, straight, solid wire is carrying a uniform current I out of the page as in the figure below. The wire has a radius a. What is the magnetic field in the region of space where $r < a$?



(A) $\frac{\mu_0 I}{2\pi}\frac{1}{a}$ [4 points]

(B) $\frac{\mu_0 I}{\pi}\frac{1}{a^2}$ [5 points]

(C) $\frac{\mu_0 I}{2\pi}\frac{r}{a^2}$ [8 points]

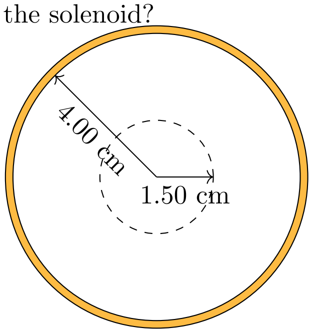
(D) $\frac{\mu_0 I}{2\pi}\frac{r^2}{a^3}$ [5 points]

(E) $\frac{\mu_0 I}{2\pi}\frac{1}{r}$ [6 points]

(F) $\frac{\mu_0 I}{\pi}\frac{1}{r^2}$

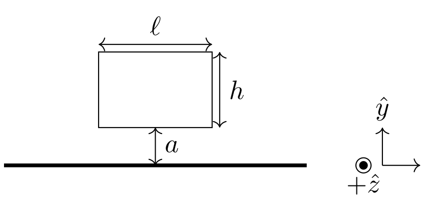
(G) $\frac{\mu_0 I}{2\pi}\frac{a}{r^2}$

Problem 11: (8 points) A long, thin solenoid has 200 turns per meter and radius 4.00 cm. The current in the solenoid is decreasing at a uniform rate of 30.0 A/s. What is the magnitude of the induced electric field at a point 1.50 cm from the axis of the solenoid?



(A) 8.67×10^{-2} N/C
(B) 7.54×10^{-3} N/C [6 points]
(C) 1.51×10^{-4} N/C [5 points]
(D) 4.02×10^{-4} N/C [4 points]
(E) 2.12×10^{-5} N/C [3 points]
(F) 5.65×10^{-5} N/C [8 points]
(G) 3.84×10^{-6} N/C

Problem 12: (8 points) In the system below there is a wire carrying a current of the form $I(t) = I_0 \cos(\omega t)$. The rectangular loop has dimensions ℓ and h as shown. The closest part of the loop is a away from the wire. Both the wire and the loop are in the xy-plane. Which of the following integrals represents the flux as a function of time through the loop due to the wire?



(A) $\int_0^{\ell} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi x} h dx$

(B) $\int_0^{\ell} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi x} y dx$

(C) $\int_0^{h} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi y} x dy$ [3 points]

(D) $\int_0^{h} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi y} \ell dy$ [5 points]

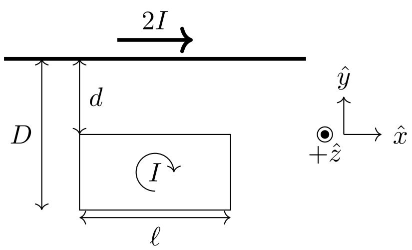
(E) $\int_a^{a+\ell} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi x} h dx$

(F) $\int_a^{a+\ell} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi x} y dx$

(G) $\int_a^{a+h} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi y} \ell dy$ [8 points]

(H) $\int_a^{a+h} \frac{\mu_0 I_0 \cos(\omega t)}{2\pi y} x dy$ [6 points]

Problem 13: (8 points) A long, straight wire carries a current, $2I$ to the right as shown below. The loop carries a current I clockwise also as shown. What is the net magnetic force vector on the entire loop due to the long, straight wire?



(A) $\dfrac{\mu_0 I^2 (D-d)}{\pi}\left(\dfrac{1}{\ell}\right)\hat{y}$

(B) $\dfrac{\mu_0 I^2 (d-D)}{\pi}\left(\dfrac{1}{\ell}\right)\hat{y}$

(C) $\dfrac{\mu_0 I^2 \ell}{\pi}\left(\dfrac{1}{D}-\dfrac{1}{d}\right)\hat{y}$ [6 points]

(D) $\dfrac{\mu_0 I^2 \ell}{\pi}\left(\dfrac{1}{d}-\dfrac{1}{D}\right)\hat{y}$ [8 points]

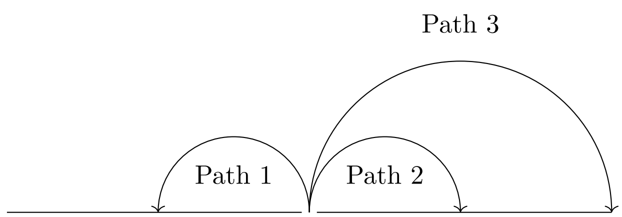
(E) $\dfrac{\mu_0 I^2 (D-d)}{\pi}\left(\dfrac{1}{\ell}\right)\hat{z}$

(F) $\dfrac{\mu_0 I^2 (d-D)}{\pi}\left(\dfrac{1}{\ell}\right)\hat{z}$

(G) $\dfrac{\mu_0 I^2 \ell}{\pi}\left(\dfrac{1}{D}-\dfrac{1}{d}\right)\hat{z}$ [2 points]

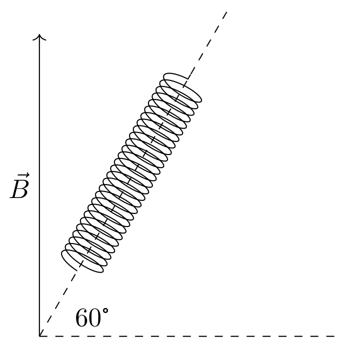
(H) $\dfrac{\mu_0 I^2 \ell}{\pi}\left(\dfrac{1}{d}-\dfrac{1}{D}\right)\hat{z}$ [3 points]

Problem 14: (6 points) A mass spectrometer and velocity selector are set up so that only particles of a speed v pass through the slit shown in the figure. The particles then follow paths like what are shown below. The three types of particles are positively charged hydrogen (H^+, $m = m_p$ and $q = +e$), negatively charged hydrogen (H^-, $m = m_p$ and $q = -e$) and doubly ionized helium (He^{2+}, $m = 4m_p$ and $q = +2e$). Which option below correctly pairs all three particles with the path numbers?



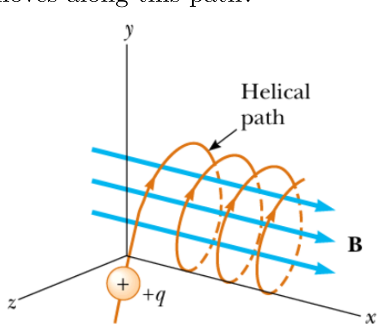
	Path 1	Path 2	Path 3
(A)	H^+	H^-	He^{2+} [2 points]
(B)	H^+	He^{2+}	H^-
(C)	H^-	H^+	He^{2+} [6 points]
(D)	H^-	He^{2+}	H^+ [2 points]
(E)	He^{2+}	H^+	H^- [2 points]
(F)	He^{2+}	H^-	H^+

Problem 15: (8 points) A solenoid is 30.0 cm long, has a radius of 1.00 cm and has 400 turns. There is a magnetic field with a magnitude of 0.250 T that is pointing vertically as shown in the figure. The axis of the solenoid is 60 degrees away from the horizontal. If the solenoid feels a magnitude of torque equal to 0.0175 Nm, what is the current in the solenoid?



(A) 0.169 A
(B) 0.334 A [4 points]
(C) 0.564 A
(D) 0.643 A [6 points]
(E) 1.11 A [8 points]
(F) 1.44 A
(G) 1.83 A
(H) 2.84 A

Problem 16: (3 points) A charged particle is moving in a helical path due to a magnetic field that is not perpendicular to the velocity of the particle. The charge is not under the influence of any other force. What happens to the speed of the particle as it moves along this path?



(A) The speed increases.
(B) The speed decreases.
(C) The speed stays constant. [3 points]
(D) The speed oscillates between increasing and decreasing.
(E) It is impossible to tell.