1. Multiple Choice (5pts each) Fill in the most correct answer on the bubble sheet, and circle the correct answer on this page for future reference.

1) Two currents run parallel to each other in the same direction, isolated from all other interactions. Current 1 is twice current 2, what is the direction and magnitude of the magnetic force they feel?
   a) $F_{12} > F_{21}$ and they are attracted
   b) $F_{12} = F_{21}$ and they are attracted
   c) $F_{12} > F_{21}$ and they are repelled
   d) $F_{12} = F_{21}$ and they are repelled
   e) No magnetic forces

2) Looking from above, a current flows in a loop in a clockwise direction. What is the direction of the magnetic field from the loop in the center of the loop?
   a) into the page
   b) out of the page
   c) no field

3) An electron moves in a magnetic field as shown in the picture. What is the direction of the magnetic force?
   a) Up
   b) Down
   c) Into page
   d) Out of page
   e) To the right

4) A proton in a magnetic field moves as shown below. If the magnetic field has a magnitude of 0.01T and the proton has an initial speed of 10m/s, what is the work done by the magnetic field on the proton after a distance of 1.5m?
   a) 253J
   b) 2.53J
   c) 2.53mJ
   d) 2.53microJ
   e) none

5) The current moving through a region of space is given in cylindrical coordinates by the function $J = \frac{A}{r^{1/2}}$. What are the units of $K$?
   a) $A/m$
   b) $A/m^{1/2}$
   c) $A/m^{3/2}$
   d) $A/m^{3/2}$
   e) $A/m^{1/2}$

6) From 5), what is the current flowing through a region of radius $R$?
   a) $\frac{2\pi KR^{3/2}}{5}$
   b) $\frac{4\pi KR^{3/2}}{5}$
   c) $\frac{4\pi KR^{3/2}}{5}$
   d) $\frac{4\pi KR^{3/2}}{5}$

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III. Written Solution: 30 Points. Be sure to show all of your work for full credit.

Current flows through a cylindrical region with a uniform current density \( J \) and a total current \( I_0 \). The region has a radius of \( R \). Your answers should be written as a function of \( r \), \( R \), \( J \), and \( I_0 \), but not necessarily all of them.

A. Find the current with a region of radius \( r \) within the cylinder that is coaxial with its center. Your solution should be expressed as a function of \( I_0 \), \( r \), and \( R \), but not \( J \).

\[
I = \int \vec{J} \cdot d\vec{a} = JA
\]

\[
= \frac{I_0}{\pi R^2} \cdot \pi r^2 = \frac{I_0 r^2}{R^2} = I(r)
\]

B. Draw on the diagrams above the amperian loop needed to calculate the B field inside the cylinder.

C. Find the magnetic field within the cylinder, for \( r < R \).

\[
\oint \vec{B} \cdot d\vec{e} = \mu_0 I_{nc}
\]

\[
B 2\pi r = \frac{\mu_0 I_0 r^2}{R^2}
\]

\[
B = \frac{\mu_0 I_0}{2\pi r}
\]

D. Draw the amperian loop needed to calculate the B field outside the cylinder.

E. Find the magnetic field outside of the cylinder, \( r > R \).

\[
\oint \vec{B} \cdot d\vec{e} = \mu_0 I_{nc}
\]

\[
B 2\pi r = \mu_0 I_0
\]

\[
B = \frac{\mu_0 I_0}{2\pi r}
\]