Useful constants: \( e=1.6\times10^{-19} \text{ C} \), \( m_e=9.1\times10^{-31} \text{ kg} \), \( m_p=1.67\times10^{-27} \text{ kg} \), \( \varepsilon_0=8.85\times10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2 \), \( k_e=8.99\times10^9 \text{ N}\cdot\text{m}^2/\text{C}^2 \), \( \mu_0=4\pi\times10^{-7} \text{ Wb}/\text{A}\cdot\text{m} \)

**Problem 1** Consider the mass spectrometer shown in the figure. The magnitude of the electric field between the plates of the velocity selector is \( E \), and the magnetic field in the velocity selector has a magnitude of \( B_{in} \). The magnitude of magnetic field in the deflection chamber is \( B_0 \). If the radius of the path for a singly charged particle is \( r \), what is the mass of the particle?

A) \( eE^2/(rB_{in}B_0) \)
B) \( erB_{in}(B_0E) \)
C) \( rB_{in}(eE) \)
D) \( erB_{in}B_0/E \)
E) \( Er/(eB_0^2) \)

**Problem 2** A current of 26 mA is maintained in a single circular loop of 3.1 m circumference. A magnetic field of 0.71 T is directed parallel to the plane of the loop. What is the magnitude of the torque exerted by the magnetic field on the loop?

A) 14.1 mN\(\cdot\)m
B) 24.9 mN\(\cdot\)m
C) 11.3 mN\(\cdot\)m
D) 33.3 mN\(\cdot\)m
E) 29.3 mN\(\cdot\)m

**Problem 3, 4** The center conductor of a coaxial cable is surrounded by a rubber layer, an outer conductor, and another rubber layer. In a particular application, the current in the inner conductor is \( I_1=1.16 \text{ A} \) out of the page and the current in the outer conductor is \( I_2=2.94 \text{ A} \) into the page. Assuming the distance \( d=1.00 \text{ mm} \). What is the magnitude of the magnetic field at point \( b \)?

A) 123 \( \mu \text{T} \)
B) 222 \( \mu \text{T} \)
C) 324 \( \mu \text{T} \)
D) 98 \( \mu \text{T} \)
E) 119 \( \mu \text{T} \)

What is the direction of the magnetic field at point \( a \)?

A) Left
B) Right
C) Upward
D) Downward
E) Into the page
**Problem 5** A long segment of wire has the shape shown in the figure and carries a current $I$. What is the magnitude of the magnetic field at point $P$?

A) $\frac{\mu_0 I}{4r} \left( \pi + \frac{1}{\pi} \right)$

B) $\frac{\mu_0 I}{4r}$

C) $\frac{\mu_0 I}{2r} \left( 1 + \frac{1}{\pi} \right)$

D) $\frac{\mu_0 I}{2\pi r}$

E) $\frac{\mu_0 I}{2r}$

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**Problem 6, 7** A rectangular loop of width $w$ and length $h$ located a distance $d$ from a long straight wire carrying a current $I$, as shown in the figure. The wire is parallel to the long side of the loop. What is the total magnetic flux through the loop?

A) $\frac{\mu_0 Ih}{4\pi} \ln \left( \frac{w}{d} \right)$

B) $\frac{\mu_0 Ih}{2\pi} \ln \left( \frac{d + w}{d} \right)$

C) $\frac{\mu_0 Ih}{4\pi} \ln \left( \frac{d + w}{d} \right)$

D) $\frac{\mu_0 Ih}{4} \ln \left( \frac{d + w}{2d} \right)$

E) $\frac{\mu_0 Ih}{\pi} \ln \left( \frac{d + w}{d - w} \right)$

Assume that the current in the long wire is decreasing, what is the direction of the induced current in the rectangular loop?

A) No induced current

B) Downward

C) Counterclockwise

D) Clockwise

E) None of above
**Problem 8** A circular coil lying in the plane of this paper has an area of 80 cm² and is made of 200 turns of copper, resulting in a resistance of 2.0 Ω. A uniform magnetic field of 0.085 T points perpendicularly outward through the coil towards you and decreases uniformly to zero in 0.45s. What is the current in the coil while the field decreases?

A) 1.15 A  
B) 0.32 A  
C) 0.77 A  
D) 2.34 A  
E) 0.15 A

**Problem 9, 10** A 140 mH inductor and a 4.6 Ω resistor are connected with a switch to a 6V battery as shown in the figure. After the switch is thrown to “a” for a very long time, what is the current in the inductor?

A) 1.3 A  
B) 2.8 A  
C) 3.5 A  
D) 1.9 A  
E) 0.8 A

Now the switch is quickly thrown from “a” to “b”. What time interval elapses before the current in the inductor falls to 200 mA?

A) 12 ms  
B) 24 ms  
C) 57 ms  
D) 63 ms  
E) 72 ms

**Problem 11** In the circuit shown, the switch is connected to position a for a long time, then thrown to position b. Find the maximum current in the inductor.

A) 27.7 mA  
B) 12.9 mA  
C) 20.8 mA  
D) 33.1 mA  
E) 13.9 mA
**Problem 12** The primary coil of a transformer is connected to a 12 volts DC battery and a manual switch as shown. The secondary coil is connected to a light bulb. Determine which of the following statements is corrected.

A) The light bulb will remain on, as long as the switch is closed.
B) The light bulb will never be on, because a transformer only works with AC voltage.
C) 12 volts DC is not high enough, 120 volts may turn the bulb on continuously.
D) The bulb can blink briefly, when the switch is either closed or opened quickly.
E) The bulb will never be on, because the primary coil and the second coil are not electrically connected.

**Problem 13** Magnetic force on a moving charged particle provides acceleration to the particle. Thus, it also changes the kinetic energy of the particle.
(A) True (B) False

**Problem 14** The magnetic force acting on a current-carrying conductor equals the sum of the forces exerted on all charges moving with a "drift velocity" inside the conductor.
(A) True (B) False

**Problem 15** Parallel conducting wires carrying currents in the same direction repel each other.
(A) True (B) False

**Problem 16** Gauss’s law of magnetism states that the net magnetic flux through any closed surface is zero.
(A) True (B) False

**Problem 17** A large, steady magnetic flux through a circuit induces a large emf.
(A) True (B) False

**Problem 18** Lenz's law states that the induced current and induced emf in a conductor are in such a direction as to oppose the magnetic flux change that produced them.
(A) True (B) False

**Problem 19** The energy density of a magnetic field at a given point is given by: \( u_B = \frac{B^2}{2\mu_0} \)
(A) True (B) False

**Problem 20** Due to the oscillations of current and charge in an LC circuit, the total energy of the system also oscillates.
(A) True (B) False