Breakdown of Topics:

**Kirchhoff’s Law:** Understand the junction and loop rules and be able to apply them to a circuit to determine current through any branch or the voltage across a circuit element.

**RC Circuits:** Have a general understanding of how capacitors charge and discharge. Be able to calculate charge, current, voltage, or energy at a specific time.

**Magnetic Fields, Lines, Flux, and Moving Charges:** Be able to calculate the force on a moving particle through a B field. Be able to find the radius of the circular path a charged particle will follow in a uniform B field. UNDERSTAND RIGHT HAND RULE FOR MOVING CHARGES. Be able to calculate the magnetic flux through a surface.

**Magnetic Force on a Current:** Be able to calculate the force on a current. UNDERSTAND RIGHT HAND RULE FOR CURRENTS.

**Magnetic Dipole:** Be able to calculate the magnetic dipole moment of a current loop. Find the torque on a current loop caused by an external B field. Find the potential energy of a current loop at different orientations.

**Hall Effect:** Be able to determine the direction of the magnetic force and electric field force (from Hall Effect) for positive and negative charge carriers. Be able to determine if the charge carriers if the Hall Effect is given.

**Sources of Magnetic Fields:** Be able to calculate the magnetic field produced by a moving charge, a current segment, or a loop at a given point. USE RIGHT HAND RULE TO FIND DIRECTION B FIELD WILL POINT.

**Ampere’s Law:** Be able to calculate the line integral B*dl using the current enclosed. Be able to calculate the magnetic field of an infinite wire, infinite cylinder, infinite coaxial cable, an ideal solenoid, an ideal toroid

**Magnetic Material:** Know the difference between Paramagnetic, diamagnetic, and ferromagnetic materials. Be able to calculate magnetization and understand how magnetic field changes inside a magnetic material.

**Faraday’s and Lenz’s Law:** Be able to calculate the induced emf and direction of current produced from a changing B field. USE RIGHT HAND RULE TO FIND DIRECTION OF INDUCED CURRENT THAT OPPOSES THE CHANGING B FIELD.

**Inductance:** Be able to calculate the inductance of a conductor. Be able to analyze RL circuits i.e. calculate voltage, current, and energy of the inductor at a specific time and recognize their plots.

**LC and RLC Circuits:** Understand how current and voltage oscillate. Be able to calculate and use the oscillating frequency.

**AC Circuit analysis:** Be able to draw a phasor diagram. Calculate the reactance of capacitors and inductors. Be able to use ohms law, \( V = IR \), to calculate current, voltage or reactance.

**AC Power and Transformers:** Be able to calculate average AC power and Transformer voltages
1. (Q 46 spring 2011)
Consider the circuit depicted below. Choose the correct constraint obtained by Kirchhoff's laws. Take the current to be positive if it goes in the direction of the arrow and negative if it goes in the other direction.

\[
\begin{align*}
\text{a. } & \quad 6 + I_{\text{right}} \cdot 1 \Omega + 13 + I_{\text{right}} \cdot 7 \Omega - I_{\text{center}} \cdot 12 \Omega = 0 \\
\text{b. } & \quad 6 + I_{\text{right}} \cdot 1 \Omega - 13 + I_{\text{right}} \cdot 7 \Omega - I_{\text{center}} \cdot 12 \Omega = 0 \\
\text{c. } & \quad 6 - I_{\text{right}} \cdot 1 \Omega + 13 - I_{\text{right}} \cdot 7 \Omega - I_{\text{center}} \cdot 12 \Omega = 0 \\
\text{d. } & \quad 6 - I_{\text{right}} \cdot 1 \Omega - 13 - I_{\text{right}} \cdot 7 \Omega - I_{\text{center}} \cdot 12 \Omega = 0
\end{align*}
\]

2. (Q 35 fall 2015)
For the circuit shown in the figure, the switch S is initially open and the capacitor is uncharged. The switch is then closed at time \( t = 0 \). How many seconds after closing the switch will the energy stored in the capacitor be equal to 50.2 mJ?

\[
\begin{align*}
& \quad 40 \text{ V} \\
& \quad 0.50 \text{ M}\Omega \\
\end{align*}
\]

\[
\begin{align*}
\text{A)} & \quad 110 \text{ s} \quad \text{B)} \quad 81 \text{ s} \quad \text{C)} \quad 65 \text{ s} \quad \text{D)} \quad 130 \text{ s} \quad \text{E)} \quad 97 \text{ s}
\end{align*}
\]
3. (Q 29 fall 2015)

A particle with positive charge $q = 2C$ moves upward and enters a region where both a magnetic field and an electric field are present. The magnetic field has a magnitude of $B = 4.0 \times 10^{-4} \text{ T}$ and points out of the page. The electric field has a magnitude of $E = 0.1 \text{ N/C}$ and points to the left. At what speed must the particle be moving if it is not deflected when it enters this region?

A) $4.0 \times 10^{-3} \text{ m/s}$
B) 125 m/s
C) 250 m/s
D) 500 m/s
E) The particle will be deflected to the left regardless of its velocity.

4. (Q 40 fall 2014)

Two isotopes of uranium are separated by charging each atom to magnitude of $q = 1.6 \times 10^{-19} \text{ C}$ and shooting them into a $1.0 \text{ T}$ magnetic field as shown in the figure. The masses of the isotopes, $U - 235$ and $U - 238$, are $M_{235} = 3.90 \times 10^{-25} \text{ kg}$ and $M_{238} = 3.95 \times 10^{-25} \text{ kg}$. The charged uranium atoms follow circular arcs as shown. Assuming that both isotopes have the same speed, what is the ratio $R_{235}/R_{238}$ of the radii of the paths taken by the two isotopes?

(a) 0.987
(b) 1.013
(c) 1.217
(d) 0.793
(e) 2.090
5. (Q 45 spring 2012)
A circular coil of wire of 100 turns and diameter 20.0 cm carries a current of 2.0A. It is placed in a uniform magnetic field of 3.0 T with the plane of the coil making an angle of 45o with the magnetic field. What is the torque on the coil?

A) 6.4 Nm  
B) 8.0 Nm  
C) 11 Nm  
D) 13 Nm  
E) 16 Nm

6. (Q 41 spring 2015)
A triangular loop is in a uniform magnetic field \( B = 0.50 \ T \) as shown in the figure. A 1.5 A current flows in the loop in the clockwise direction. What is the magnetic force on the bc side?

A. 1.1 N  
B. 1.4 N  
C. 2.3 N  
D. 2.9 N  
E. 3.5 N

A circular coil of wire of 100 turns and diameter 20.0 cm carries a current of 2.0A. It is placed in a uniform magnetic field of 3.0 T with the plane of the coil making an angle of 45o with the magnetic field. What is the torque on the coil?

A) 6.4 Nm  
B) 8.0 Nm  
C) 11 Nm  
D) 13 Nm  
E) 16 Nm
7. (Q 53 spring 2012)
A straight wire runs along the x axis and carries a current \( I \) in the +x direction as shown in the figure. Consider now a differential portion of this wire, of length \( dx \), located at distance \( x \) from the origin. What is the magnetic field produced by this differential element at a point \( P \) on the y axis, at \( y = a \)?

![Diagram of a straight wire with a differential element and a point P on the y axis](image)

A. \( dB = \frac{\mu_0 I}{4\pi} \frac{adx}{(x^2 + a^2)^{3/2}} \), out of the page

B. \( dB = \frac{\mu_0 I}{4\pi} \frac{adx}{(x^2 + a^2)^{3/2}} \), into the page

C. \( dB = \frac{\mu_0 I}{4\pi} \frac{x dx}{(x^2 + a^2)^{3/2}} \), into the page

D. \( dB = \frac{\mu_0 I}{4\pi} \frac{dx}{x^2 + a^2} \), into the page

E. \( dB = \frac{\mu_0 I}{4\pi} \frac{dx}{x^2 + a^2} \), out of the page

8. (Q 54 spring 2015)
Two long straight wires are oriented perpendicular to the plane of an equilateral triangle and going through two of its corners as shown in the figure. Both wires carry a current of 2.0 A, out of the paper. The magnetic field at the third corner (P) has a magnitude of

A) \( 1.7 \times 10^{-5} \) T
B) \( 1.0 \times 10^{-5} \) T
C) \( 2.0 \times 10^{-5} \) T
D) \( 5.0 \times 10^{-6} \) T
E) \( 8.7 \times 10^{-6} \) T
9. (Q 28 spring 2010)

A solenoid has length \( L = 1.23 \) m and inner diameter \( d = 3.55 \) cm. It consists of five close-packed layers, each with 850 turns along length \( L \). Each layer carries a current \( i = 5.57 \) A. What is the B-field at its center?

a. 0.00595 T  
b. 0.00484 T  
c. 0.0297 T  
d. 0.0242 T  
e. 0.00193 T

10. (Q 31 spring 2011)

A magnetic field \( B_0 \) is applied to a paramagnetic substance. In the interior of the substance the portion of the magnetic field produced by the magnetic dipoles of the substance is:

a. greater than \( B_0 \) and in the same direction  
b. less than \( B_0 \) and in the same direction  
c. less than \( B_0 \) and in the opposite direction  
d. greater than \( B_0 \) and in the opposite direction  
e. the same as \( B_0 \)
11. (Q 35 spring 2012)

A magnet moves toward a wire loop, north first, as shown. The current induced in the loop as seen from the right of the paper runs in the _______________ direction, and the induced magnetic field associated to this current points _______________ along the axis of the loop.

A. clockwise, left
B. counterclockwise, left
C. clockwise, right
D. counterclockwise, right

![Diagram of a magnet and wire loop]

12. (Q45 spring 2015)

A 7.0-cm radius cylindrical region contains a uniform electric field that is parallel to the cylinder axis and is increasing at a rate of $5.0 \times 10^{12} \text{ V/(m s)}$. The magnetic field at a point 3.0 cm from the cylinder axis has a magnitude of

A) $8.3 \times 10^{-7} \text{ T}$
B) $4.1 \times 10^{-8} \text{ T}$
C) $7.2 \times 10^{-8} \text{ T}$
D) $3.1 \times 10^{-9} \text{ T}$
E) $8.9 \times 10^{-11} \text{ T}$
13. (Q39 spring 2015)

A flat rectangular coil of wire with dimensions $a = 10.0 \text{ cm}$ and $b = 5.0 \text{ cm}$ consisting of 20 turns, is oriented such that its plane makes a $30^\circ$ angle with the direction of a uniform magnetic field. The magnetic field increases its magnitude at a constant rate from 2.0 T to 6.0 T in 2.0 s. If the coil has a total resistance of 0.40 $\Omega$, what is the magnitude of the induced current?

A) 35 mA  
B) 70 mA  
C) 250 mA  
D) 800 mA  
E) 1.0 A

14. (Q35 Fall 2014)

An inductor $L = 0.040 \text{ H}$, a resistor $R = 10.0 \Omega$, and a DC supply with emf $E = 20.0 \text{ V}$ are connected in series. When the switch is closed, what is the steady current reached by this circuit and what is the energy stored in the inductor?

(a) $i = 2.0 \text{ A}$ and $U = 40.0 \text{ J}$  
(b) $i = 2.0 \text{ A}$ and $U = 2.0 \text{ J}$  
(c) $i = 20.0 \text{ A}$ and $U = 0.40 \text{ J}$  
(d) $i = 20.0 \text{ A}$ and $U = 0.04 \text{ J}$  
(e) $i = 2.0 \text{ A}$ and $U = 0.08 \text{ J}$
15. (Q33 fall 2015)

An ac circuit is shown in the figure. The rms current in the circuit is 1.3 A. What is the peak magnetic energy in the inductance?

\[ R = 30 \, \Omega \]
\[ L = 190 \, \text{mH} \]
\[ X_L = 60 \, \Omega \]
\[ X_C = 120 \, \Omega \]

A) 0.64 J  \quad B) 0.80 J  \quad C) 0.16 J  \quad D) 0.32 J  \quad E) 0.48 J

16. (Q31 fall 2015)

Which one of the phasor diagrams shown below best represents a series \( LRC \) circuit driven at resonance?

A) 1  \quad B) 2  \quad C) 3  \quad D) 4  \quad E) 5
17. (Q32 fall 2015)

An ideal transformer consists of a 500-turn primary coil and a 2000-turn secondary coil. If the current in the secondary is 3.0 A, what is the current in the primary?

A) 12 A  B) 24 A  C) 0.75 A  D) 48 A  E) 1.3 A