The exam will emphasize Chapters 27-31, but you are responsible for knowing the material that came before these sections. In creating the exam I will strive for:

- approximately 60% of the possible points being “easy”, which means either requiring only a quick and basic application of the physics involved, or being very similar to an assigned homework, quiz, or worksheet problem (which you may not have thought of as easy at all at first, but with which I now assume that you are comfortable);
- Approximately 30% of intermediate difficulty requiring some new thought or involving an unfamiliar configuration;
- Approximately 10% requiring significantly creative thinking.

Your best bet for studying for the exam is to review all of the assigned homework, quizzes and worksheets (including this one) and to use them to become comfortable with each problem and to identify your weak areas. You can then work on your weak areas by looking at other similar questions in the book.

1. A long, cylindrical conductor of radius $R$ carries a current $I$ as shown in the figure. The current density is a function of the radius according to the formula $J = br^2$ where $b$ is a constant.

   (a) Find an expression for the magnetic field magnitude $B$ at a distant $r_1 < R$.

   (b) Find an expression for the magnetic field magnitude $B$ at a distant $r_2 > R$.

2. A rectangular coil with resistance $R$ has $N$ turns, each of length $\ell$ and width $w$, as shown in the figure. The coil moves with constant velocity $\vec{v}$ from a region with no magnetic field into an adjacent region with uniform magnetic field $\vec{B}$ perpendicular to the coil. At a moment when the coil has partially the field:

   (a) Find the total magnetic force on the coil.

   (b) Find the current flowing in the coil.

3. In the circuit shown, the switch is thrown to “a” at $t = 0$. If $E = 12$ V, $C = 3 \mu F$, and $R = 10 \Omega$, find the time it takes for the current through the resistor to reach half of its initial value, just after the switch was thrown.
A proton moves through a region with both a constant magnetic field \( \vec{B}_{up} = -0.003 \ T \hat{\mathbf{k}} \) and a constant electric field (not shown). It moves in a straight line perpendicular to the magnetic field with speed \( v = 1.5 \times 10^6 \ \text{m/s} \) as shown. After a short time the electric field is turned off.

(a) Find the magnitude and direction of the electric field before it is turned off.

(b) Find the force vector on the proton at the instant just after the electric field is turned off.

(c) Find the radius of the circle on which the proton moves after the electric field is turned off.

(d) Find the magnetic dipole moment due to the motion of the proton after the field is turned off.

A straight, cylindrical wire lying on the \( x \) axis has a length of 0.5 m and a diameter of 0.2 mm. It is made of a material described by Ohm’s law with a resistivity of \( 4 \times 10^{-8} \ \Omega \cdot \text{m} \). A 12 V potential is placed across the ends of the wire.

(a) Find the electric field in the wire.

(b) Find the resistance in the wire.

(c) Find the current in the wire.

(d) Find the current density in the wire.

(e) The energy delivered to the wire during 60 seconds.

(a) In the circuit shown, solve for the currents \( I_1 \), \( I_2 \), and \( I_3 \) in the 1\( \Omega \), 2\( \Omega \) and 3\( \Omega \) resistors, respectively.

(b) If the 5 V battery is replaced by a piece of wire with zero resistance, then what equivalent resistance does the 4 V battery see between its terminals?
7 A rod of mass \( m \) rests on two parallel rails that are a distance \( d \) apart and have a length \( L \). The rod carries current \( I \) in the direction shown, and slides on the rails without friction. If it starts from rest, what is the speed of the rod as it leaves the rails?

8 A circular wire of radius 0.5 m lies in the \( xy \) plane and carries a 0.2 A current flowing clockwise in the figure.

(a) The current in a short bit of wire of length \( ds \) at position “a” produces a bit of magnetic field at \( P \) that has magnitude _______________ and direction ____________ (draw an arrow).

(b) The current in a short bit of wire of length \( ds \) at position “b” produces a bit of magnetic field at \( P \) that has magnitude _______________ and direction ____________ (draw an arrow).

9 A square wire loop with 2.00 m sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field as shown in Fig. 30.40. The loop contains an ideal battery with emf \( \mathcal{E} = 20.0 \) V. If the magnitude of the field varies with time according to \( B = 0.0420 - 0.870t \) T in seconds, what are

(a) the net emf around the circuit, and

(b) the direction of the current around the loop?

10 A cube of edge length \( \ell = 2.50 \) cm is positioned as shown in Figure P30.89. A uniform magnetic field given by \( \mathbf{B} = (5\mathbf{i} + 4\mathbf{j} + 3\mathbf{k}) \) T exists throughout the region. (a) Calculate the magnetic flux through the shaded face. (b) What is the total flux through the six faces?
A circular coil of radius \( R = 20 \, \text{cm} \) with 10 turns and resistance 15 \( \Omega \) surrounds a long solenoid of radius 3 cm with \( 10^3 \) turns per meter. The current in the solenoid is increasing as \( I = 5Ae^{t/3s} \) where \( t \) is in seconds.

(a) Find the magnitude of the current induced in the coil at \( t = 15 \, \text{s} \).

(b) Consider the part of the 20 cm coil that is closest to you. Is the direction of the induced current in this part up the page or down the page? (circle one)

(c) Find the strength of the induced electric field at a point on the coil.

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\begin{align*}
\dot{F}_B &= q\dot{v} \times \vec{B} \\
d\vec{F}_B &= Id\vec{s} \times \vec{B} \\
\vec{\mu} &= n\vec{I}A \\
\vec{\tau} &= \vec{\mu} \times \vec{B} \\
U &= -\vec{\mu} \cdot \vec{B} \\
d\vec{B} &= \frac{\mu_0}{4\pi} \frac{Id\vec{s} \times \hat{r}}{r^2} \\
\oint \vec{B} \cdot d\vec{s} &= \mu_0 I \\
B &= \frac{\mu_0}{L} I \\
\oint \vec{B} \cdot d\vec{A} &= 0 \\
\oint \vec{E} \cdot d\vec{s} &= -\frac{d\Phi_B}{dt}
\end{align*}
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