Due 4/15/2005, 4 PM in mailboxes outside Science Center 109

Instructions: Please box your solutions. The homework problems are graded out of 3 points, and then the total re-scaled to 30. For each problem, in order to get full credit, you must also include a sentence explaining the most important idea you used in order to solve it. Do not summarize the whole solution, simply the one most important idea.

HW Problems

1. Serway & Jewett 31.3
A 25-turn circular coil of wire has diameter 1.00 m. It is placed with its axis along the direction of the Earth’s magnetic field of 50.0 $\mu$T, and then in 0.200 s it is flipped 180°. An average emf of what magnitude is generated in the coil?

2. Serway & Jewett 31.10
A coil of 15 turns and radius 10.0 cm surrounds a long solenoid of radius 2.00 cm and $1.00 \times 10^3$ turns/meter (figure below). The current in the solenoid changes as $I = (5.00 \text{ A}) \sin(120t)$. Find the induced emf in the 15-turn coil as a function of time.
3. Serway & Jewett 31.24
The *homopolar generator*, also called the *Faraday disk*, is a low-voltage, high-current electric generator. It consists of a rotating conducting disk with one stationary brush (a sliding electrical contact) at its axle and another at a point on its circumference, as shown in the figure below. A magnetic field is applied perpendicular to the plane of the disk. Assume the field is 0.900 T, the angular speed is 3 200 rev/min, and the radius of the disk is 0.400 m. Find the emf generated between the brushes.

4. Serway & Jewett 31.26
The square loop in the figure below is made of wires with total series resistance 10.0 Ω. It is placed in a uniform 0.100-T magnetic field directed perpendicularly into the plane of the paper. The loop, which is hinged at each corner, is pulled as shown until the separation between points *A* and *B* is 3.00 m. If this process takes 0.100 s, what is the average current generated in the loop? What is the direction of the current?
5. Serway & Jewett 31.40
A semicircular conductor of radius $R = 0.250 \text{ m}$ is rotated about the axis $AC$ at a constant rate of 120 rev/min (figure below). A uniform magnetic field in all of the lower half of the figure is directed out of the plane of rotation and has a magnitude of 1.30 T. (a) Calculate the maximum value of the emf induced in the conductor. (b) What is the value of the average induced emf for each complete rotation? (c) What If? How would the answers to (a) and (b) change if $B$ were allowed to extend a distance $R$ above the axis of rotation? Sketch the emf versus time (d) when the field is as drawn in the figure and (e) when the field is extended as described in (c).

6. Serway & Jewett 31.42
The figure below represents an electromagnetic brake that uses eddy currents. An electromagnet hangs from a railroad car near one rail. To stop the car, a large current is sent through the coils of the electromagnet. The moving electromagnet induces eddy currents in the rails, whose fields oppose the change in the field of the electromagnet. The magnetic fields of the eddy currents exert force on the current in the electromagnet, thereby slowing the car. The direction of the car’s motion and the direction of the current in the electromagnet are shown correctly in the picture. Determine which of the eddy currents shown on the rails is correct. Explain your answer.
7. Serway & Jewett 32.6
An emf of 24.0 mV is induced in a 500-turn coil at an instant when the current is 4.00 A and is changing at the rate of 10.0 A/s. What is the magnetic flux through each turn of the coil?

8. Serway & Jewett 32.23
The switch in the figure below is open for \( t < 0 \) and then closed at time \( t = 0 \). Find the current in the inductor and the current in the switch as functions of time thereafter.

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\begin{center}
\begin{tikzpicture}
\draw (0,0) -- (3,0) -- (3,3) -- (0,3) -- cycle;
\draw (0.5,0.5) rectangle (2.5,2.5);
\draw (1,1) node {4.00 \( \Omega \)};
\draw (2,1) node {8.00 \( \Omega \)};
\draw (1,1.5) node {10.0 V};
\draw (1,2) node {4.00 \( \Omega \)};
\draw (2,2) node {1.00 H};
\end{tikzpicture}
\end{center}
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9. Serway & Jewett 32.45
Two inductors having self-inductances \( L_1 \) and \( L_2 \) are connected in parallel as shown in the figure (a) below. The mutual inductance between the two inductors is \( M \). Determine the equivalent self-inductance \( L_{eq} \) for the system (as in figure (b)).

```
\begin{center}
\begin{tikzpicture}
\draw (0,0) -- (3,0) -- (3,3) -- (0,3) -- cycle;
\draw (0.5,0.5) rectangle (2.5,2.5);
\draw (1,1) node {\( I(t) \)};
\draw (1,1.5) node {\( L_1 \)};
\draw (2,1) node {\( M \)};
\draw (2,1.5) node {\( L_2 \)};
\end{tikzpicture}
\end{center}
```

10. Serway & Jewett 32.48
In the circuit shown in the figure below, the battery emf is 50.0 V, the resistance is 250 \( \Omega \), and the capacitance is 0.500 \( \mu F \). The switch S is closed for a long time and no voltage is measured across the capacitor. After the switch is opened, the potential difference across the capacitor reaches a maximum value of 150 V. What is the value of the inductance?

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\begin{center}
\begin{tikzpicture}
\draw (0,0) -- (3,0) -- (3,3) -- (0,3) -- cycle;
\draw (0.5,0.5) rectangle (2.5,2.5);
\draw (1,1) node {\( R \)};
\draw (1,1.5) node {\( E \)};
\draw (2,1) node {\( L \)};
\draw (2,1.5) node {\( C \)};
\end{tikzpicture}
\end{center}
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