Practice Problems Section 11 Solutions

1. A rectangular loop of wire is moving at a constant velocity to the right. It approaches a region with a uniform magnetic field pointing out of the page. The magnetic field is zero outside of the region. Consider the following times:
2. : the right side of the loop is just about to enter into the region of the magnetic field.
3. : the first instant that the entire loop is in the magnetic field.
4. : the last instant that the entire loop is in the magnetic field.
5. : the entire loop has just left the region of magnetic field.

Find the direction of the induced current in the loop (clockwise or counterclockwise, as viewed from above) during the following time intervals. If there is no current write "none". **Briefly explain each answer.**

1. The time interval between times and .

An emf (and thus a current) will be induced in a loop any time the magnetic flux through that loop changes. In the interval between and , the flux does indeed change. At , there is no flux, and at , there is a flux through the loop pointing out of the page. Thus, there will be an induced current.

In order to find the direction, we note Lenz’s Law: the loop will produce a current such as to create a magnetic flux that opposes the external change. In this case, the external change is out of the page (0 to out of the page is a change out of the page). Thus the loop will produce a current to create an inward magnetic flux. To do this, via the RHR, it must have a current flowing clockwise.

**Direction of induced current: Clockwise**

1. The time interval between times and .

In the interval between and , no change in flux occurs. Note that this is true even though there is a flux during this interval, but it is constant (out of the page). Thus, according to Faraday’s law, no emf and thus no current will be induced.

**Induced current: None**

1. The time interval between times and .

In this interval, the flux changes. At , the flux is out of the page, and at there is no flux. As Lenz’s law states, the loop will produce its own magnetic flux to oppose the change. Thus, the loop will produce a flux out of the page to try to “get back to” its original flux. To do this, it must produce a counter-clockwise current.

**Direction of induced current: Counter-Clockwise**

1. A current is flowing through a long solenoid with turns/meter. The current through the solenoid is increasing at a constant rate of 0.05 A/s and the interior of the solenoid is vacuum.
2. What is the rate of change of the magnetic field (in T/s) that the solenoid produces? **Show your work**.

The magnitude of the magnetic field of a solenoid is . The number of turns per length is not changing, but the current in the solenoid is. Therefore, there will be a rate of change for the magnetic field.

1. Now you place a circular loop of wire with radius m inside the solenoid and center it on the solenoid axis. The area vector of the loop is oriented parallel to the direction of the magnetic field inside the solenoid. What will be the magnitude of the induced emf in the loop? **Show your work.**

An emf will be induced in a loop of wire any time the magnetic flux through the loop changes. In this case, the magnetic flux through the loop is produced by the solenoid, and it is indeed changing. In general, the magnetic flux can change due to three factors: a change in the area of the loop, a change in the magnetic field strength at the location of the loop, and a change in the angle of the area vector of the loop with respect to the magnetic field.

In this case, the area of the loop is constant, as is the angle of the area vector with respect to the magnetic field (they are parallel, since the area vector points along the axis of the solenoid, as does the magnetic field vector of the solenoid). So the change in flux is entirely due to the change in magnetic field produced by the solenoid. Mathematically, Faraday’s law says that

Permeability: