PH 103 : Electricity and Magnetism

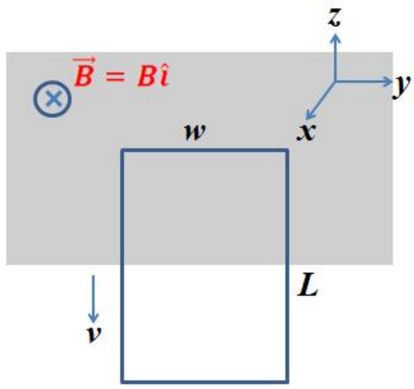
Tutorial Sheet 9 : **Faraday's law**

1. A rectangular metalic wire of mass m, width w, length L and resistance R falls through a magnetic field $\vec{B} = B_0\hat{i}$ in a specified region under the influence of gravity as shown in the figure. The loop first enters the region of magnetic field from the top.

   (a) Draw a qualitative graph of (i) current in the loop vs time and (ii) velocity of the loop vs time, as the loop moves through the magnetic field.

   (b) What is the terminal velocity of the loop when it is at the position shown in the figure?

   (c) What will be the terminal velocity of the loop if the magnetic field is nonuniform, $\vec{B} = B_0(z)\,\hat{i}$



2. A rectangular coil PQRS (length $2L$ and width $2w$) is rotating with a uniform angular speed ω about the z-axis in a uniform magnetic field B directed along the y-direction. Determine the induced emf in the coil using only the concept of motional emf. Check your answer using the concept of change in flux.

3. A Faraday disk generator is a metal disk of radius R rotated about its axis with a constant angular velocity ω in a uniform magnetic field parallel to the axis of rotation. Calculate the emf between the axis and the rim. Verify your results both by Faraday's law and motional emf.

4. A circular loop of radius R rotates about its diameter with the angular velocity ω. A magnetic dipole carrying magnetic moment $\vec{m}$ is placed at the centre of the loop. The axis of the dipole coincides with the rotating diameter of the loop. Find the emf induced between the north pole and a point on the equator of the loop. [Ans. $\mu_0 m\omega/8\pi R$].

5. A long cylindrical shell of radius R carries a uniform surface charge density σ. If the cylinder is rotated about its axis with an angular velocity $\omega = \omega_0 e^{-t/\tau}$, find the electric field inside and outside the shell. [Ans. $E_{in} = \frac{\sigma\omega_0 R}{2\tau} r e^{-t/\tau}\,\hat{\phi}$, $E_{out} = \frac{\sigma\omega_0 R^3}{2\tau r} e^{-t/\tau}\,\hat{\phi} + \frac{\sigma R}{\varepsilon_0 r}\hat{r}$]

6. The current through a long solenoid (radius a) varies as $I(t) = I_0 t$, $(I_0 > 0)$. A circular metallic wire of radius b $(b > a)$ and resistance R is kept concentric with the solenoid. Find the current through the wire. [Ans. $-\frac{\mu_0 N\pi a^2}{R} I_0$]