

From Faraday's Law, the induced emf  $\mathcal{E}$  at time  $t$  in an  $N$ -turn coil of cross-sectional area  $A$  is given by:

$$\mathcal{E}(t) = -N \frac{d\Phi_m}{dt} = -NA \frac{dB}{dt} = -NA \frac{dB}{dr} \frac{dr}{dt} \quad (1)$$

The magnetic field  $B$  at a point along the dipole axis a distance  $r$  from the magnet's center is given by:

$$B = \frac{\mu_0 m}{2\pi r^3} \quad (2)$$

Differentiating with respect to  $r$ :

$$\frac{dB}{dr} = \frac{-3\mu_0 m}{2\pi r^4} \quad (3)$$

If the magnet is dropped from a distance  $h$  above the coil, then:

$$r = h - \frac{gt^2}{2} \quad (4)$$

Differentiating with respect to  $t$ :

$$\frac{dr}{dt} = -gt \quad (5)$$

Then substituting (3) and (5) into (1):

$$\mathcal{E} = -NA \left[ \frac{-3\mu_0 m}{2\pi r^4} \right] (-gt) \quad (6)$$

Substituting (4) into (6) and simplifying gives:

$$\mathcal{E}(t) = -NA \frac{3\mu_0 mgt}{2\pi \left( h - \frac{gt^2}{2} \right)^4} \quad (7)$$