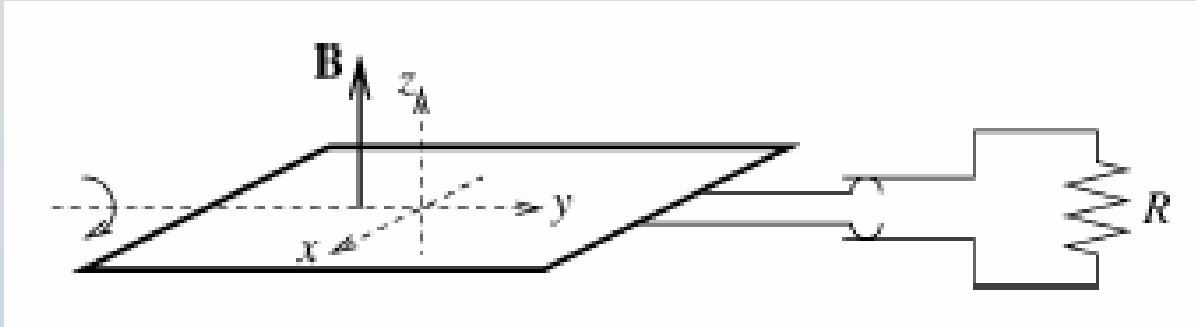


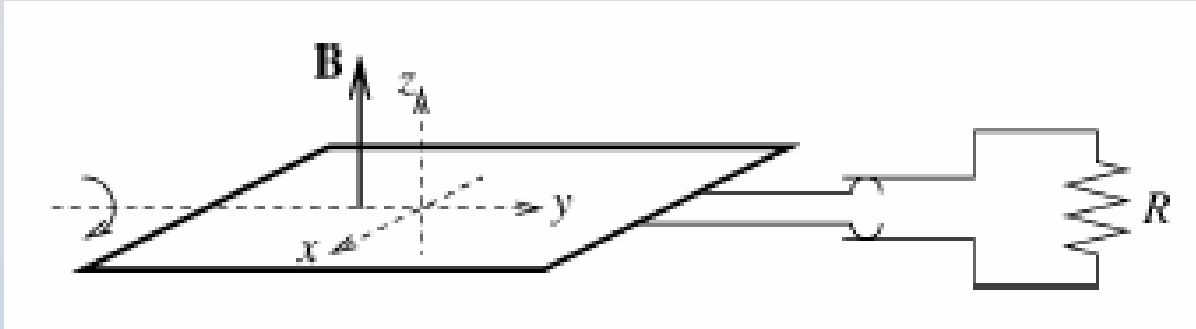
## Problem 2: Faraday's Law



A simple electric generator rotates with frequency  $f$  about the y-axis in a uniform  $B$  field. The rotor consists of  $n$  windings of area  $S$ . It powers a lightbulb of resistance  $R$  (all other wires have no resistance).

1. What is the maximum value  $I_{max}$  of the induced current? What is the orientation of the coil when this current is achieved?
2. What power must be supplied to maintain the rotation (ignoring friction)?

## Solution 2: Faraday's Law



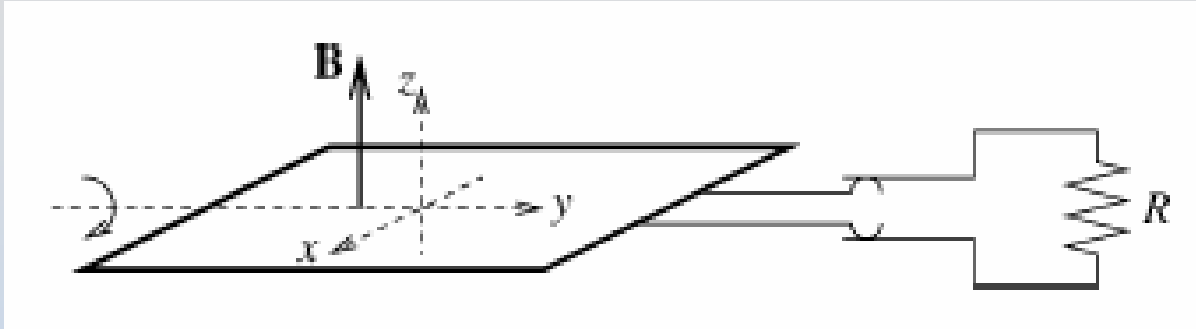
$$\text{Faraday's Law: } \oint_C \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}} = -\frac{d\Phi_B}{dt}$$

$$I = \frac{\mathcal{E}}{R} = -\frac{1}{R} \frac{d\Phi_B}{dt} = -\frac{1}{R} \frac{d}{dt} (nBS \cos(\omega t)) = \frac{nBS}{R} \omega \sin(\omega t)$$

$$I_{\text{max}} = \frac{nBS}{R} \omega = \frac{nBS}{R} 2\pi f$$

Max when flux is changing the most – at  $90^\circ$  to current picture

# Solution 2.2: Faraday's Law



## 2. Power delivered?

Power delivered must equal power dissipated!

$$P = I^2 R = \left( \frac{nBS}{R} 2\pi f \sin(\omega t) \right)^2 R = R \left( \frac{nBS}{R} 2\pi f \right)^2 \sin^2(\omega t)$$

$$\langle P \rangle = \frac{R}{2} \left( \frac{nBS}{R} 2\pi f \right)^2$$