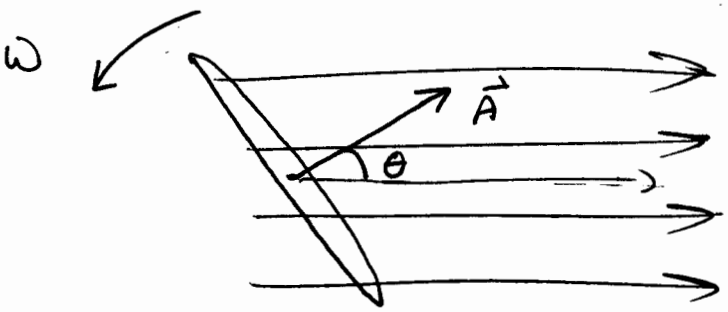
10. An electric generator consists of a rectangular coil of wire rotating about its longitudinal axis which is perpendicular to a magnetic field of 2.0×10^{-2} T. The coil measures 10.0 cm $\times$ 20.0 cm and has 120 turns of wire. The ends of the wire are connected to an external circuit. At what speed (in rev/s) must you rotate this coil in order to induce an alternating emf of amplitude 12.0 V between the ends of the wire?

e.g. generator. (#10)



uniform
$\vec{B} = 2 \times 10^{-2} T \hat{\imath}$

Loop, area $0.02\ m^2 = A$

$N = 120$ turns.

Want $\mathcal{E}_{max} = 120\ V$

Frequency of rotation $f = ?$

$$\Phi_B = N \int \vec{B} \cdot d\vec{A} = N \int B\, dA \cos\theta = N B \cos\theta \int dA$$

$$\Phi_B = NBA\cos\theta$$

$\frac{d\theta}{dt} = \omega$ = angular velocity

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -NBA\sin\theta\left(\frac{d\theta}{dt}\right)$$

$$= -NBA\sin(\omega t)\cdot\omega$$

$$\mathcal{E} = -NBA\,2\pi f \underbrace{\sin(\omega t)}_{\text{oscillates } -1 \text{ to } +1}$$

$$\mathcal{E}_{max} = NBA\,2\pi f$$

Want $\mathcal{E}_{max} = 120$, $12.0 = (120)(0.02)(0.02)\,2\pi f$

$$39.8\ Hz = f$$