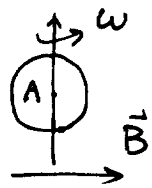
Chp. 31.

#17



Take the area of the coil to be aligned with the field at $t=0$, then the angle between $\vec{A}$ and $\vec{B}$ is $\theta(t) = \omega t$

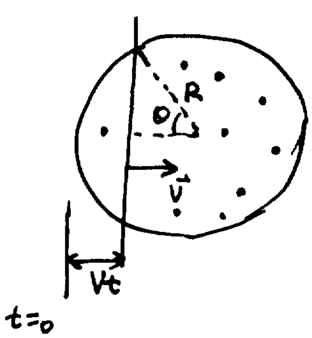
$$\Rightarrow \quad \phi_B = \vec{B}\cdot\vec{A} = BA\cos\omega t$$

$\therefore$ the emf induced in the coil is:

$$\mathcal{E} = -\frac{d\phi_B}{dt} = -\frac{d}{dt}[BA\cos(\omega t)] = BA\omega\sin(\omega t)$$

#19. Since the velocity is perpendicular to the magnetic field and the antenna, $\mathcal{E} = BLv = 2\times10^{-10}\times5\times8\times10^{3} = 8\times10^{-6}$ V

#27.



let $t=0$ when the rod enters the magnetic field. When the rod has traveled a distance $x = vt$, the length of the rod in the magnetic field is $2R\sin\theta$, where $\cos\theta = \frac{R-vt}{R}$

and so $\sin\theta = \sqrt{1-\left(\frac{R-vt}{R}\right)^2} = \frac{1}{R}\sqrt{R^2-(R-vt)^2}$

Since $\vec{v}$, $\vec{B}$ and $\vec{L}$ are perpendicular, the motional emf is:

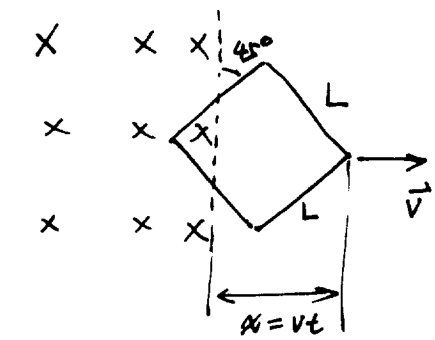
$$\mathcal{E} = -BvL = -Bv2R\sin\theta = -2Bv(2Rvt-v^2t^2)^{1/2}$$

From Lenz's law, we see that emf will be directed down.

After the rod leaves the field at $t = 2R/v$, the emf will be zero.

$\therefore \quad \mathcal{E} = -2Bv(2Rvt-v^2t^2)^{1/2} \quad$ for $0<t<2R/v$

#32



The power supplied by the force equals the power dissipated by the current in the resistance of the loop.

We take $t=0$ when the front tip of the loop is leaving the region of the magnetic field.

The position of the front tip is $x = vt$.

(a) For $0 < t < L/\sqrt{2}v$, the first half of the loop is leaving the field:

the mag. flux: $\phi_B = BA = B(L^2 - x^2)$

The induced emf is: $\mathcal{E} = -d\phi_B/dt = B\,2x\left(\frac{dx}{dt}\right) = 2Bxv = 2Bv^2t$

The power dissipated in the resistance:

$$P = I^2R = \mathcal{E}^2/R = (2Bv^2t)^2/R \quad \text{for } 0 < t < L/v\sqrt{2}$$

(b) For $L/v\sqrt{2} < t < \frac{2L}{\sqrt{2}v} = \sqrt{2}\frac{L}{v}$, the second half of the loop is leaving the field.

$$\therefore \phi_B = BA = B[\sqrt{2}L - x]^2 = B(\sqrt{2}L - x)^2$$

The induced emf is:

$$\mathcal{E} = -d\phi_B/dt = -B2(\sqrt{2}L - x)\frac{-dx}{dt} = 2B(\sqrt{2}L - x)v = 2Bv(\sqrt{2}L - vt)$$

The power dissipated in the resistance which is equal to the power supplied by the external force, is

$$P = I^2R = \mathcal{E}^2/R = [2Bv(\sqrt{2}L - vt)]^2/R \quad \text{for } L/\sqrt{2}v < t < \frac{\sqrt{2}L}{v}$$

#47. If we assume rolling without slipping, the tangential speed of the friction wheel is the tangential speed of the bicycle, which is the linear speed of the bicycle. Thus the angular speed of the friction wheel is $\omega = v/r$ ($r = 1\,cm$)

the magnetic flux through each coil is: $\phi_B = N B_0 A \cos(\omega t)$

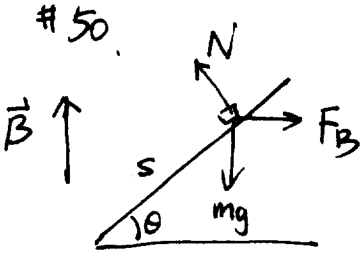
For two coils: $\mathcal{E} = 2\left(-\frac{d\phi_B}{dt}\right) = +2N B_0 A \omega \sin(\omega t)$

$\therefore \mathcal{E}_{max} = 2N B_0 A \omega$

$\Rightarrow \quad 6.4 = 2 \times 70 \times 0.1 \times 8 \times 10^{-4} \times v / 0.01$

$\Rightarrow \quad v = 5.7\ m/s$

#50.



when the wire is a distance s from the bottom.

$\phi_B = \iint \vec{B} \cdot d\vec{A} = \vec{B} \cdot \vec{A} = BLs \cos\theta$

$\therefore \mathcal{E} = -\frac{d\phi_B}{dt} = -BL\cos\theta \frac{ds}{dt} = -BL(-v)\cos\theta = BLv\cos\theta$

$\Rightarrow$ the induced current $I = \mathcal{E}/R = BLv\cos\theta / R$ into the page.

From right hand rule $\vec{F}_B$ is horizontal to the right.

$F_B = ILB = B^2L^2 v \cos\theta / R$

For the wire to have a steady speed, the net force must be zero.

$\Rightarrow \quad F_B \cos\theta - mg\sin\theta = 0$

$\Rightarrow \quad \frac{B^2L^2 v \cos^2\theta}{R} = mg\sin\theta$

$\Rightarrow \quad \frac{0.18^2 \times 0.3^2 \times v \times \cos^2 35^\circ}{0.05} = 25 \times 10^{-3} \times 9.8 \times \sin 35^\circ$

$\Rightarrow \quad v = 3.6\ m/s$