# Fields and Waves

## Lesson 3.7

## MAGNETIC CIRCUITS

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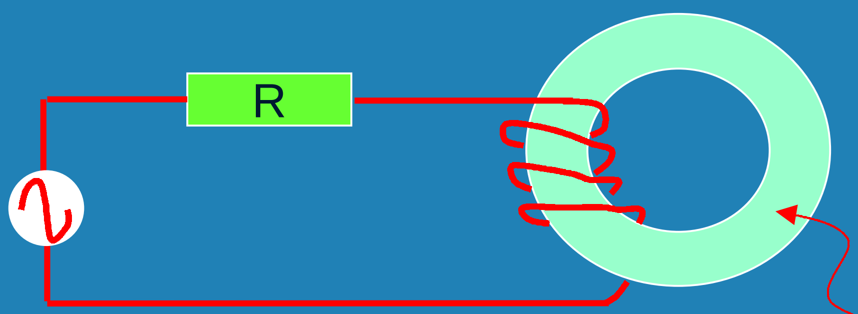
# Introduction

MAGNETIC CIRCUITS used to analyze relays, switches, speakers...

*In Lesson 3.6 experiment:*




- coil not wound symmetrically

**Flux** stayed in TOROID

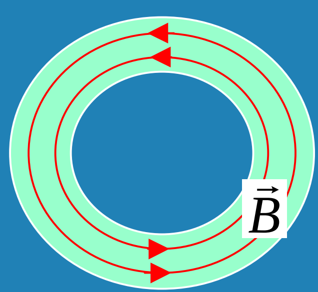
- did not detect with external loop

# Magnetic Flux - TOROID

Flux is a constant = $\int \vec{B} \bullet d\vec{s}$

- Flux stays in toroid - so area is a constant

⇨ B and H are constant along the path




$$\therefore \oint \vec{H} \bullet d\vec{l} = 2 \cdot \pi \cdot r \cdot H_{\varphi} = N \cdot I$$

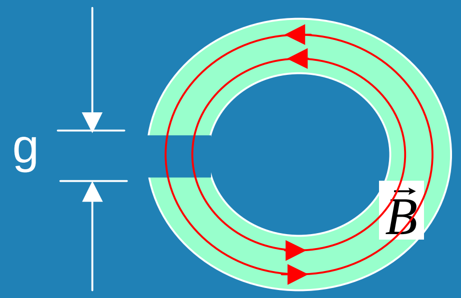
$$\Rightarrow \vec{H} = \frac{N \cdot I}{2 \cdot \pi \cdot r} \hat{a}_{\varphi}$$

*Problem 1 - has square material - get H and B, then get Flux and L*

Do Problem 1a and 1b

# Magnetic Flux - TOROID with GAP

Add gap to toroid:




$$\oint \vec{H} \bullet d\vec{l} = (2 \cdot \pi \cdot r - g) \cdot H_{iron} + g \cdot H_{gap}$$

Apply boundary conditions across gap:

$$B_{1n} = B_{2n} \Rightarrow \mu_{iron} \cdot H_{n,iron} = \mu_0 \cdot H_{n,gap}$$

Can get very large H in gap

$$H_{n,gap} \approx 5000 \cdot H_{n,iron}$$

Gap has very strong effect on H

# Magnetic Circuits - Analogy to E-circuits

$$\oint \vec{H} \bullet d\vec{l} = N \cdot I = \frac{(2\pi \cdot r - g)}{AREA \cdot \mu} \cdot AREA \cdot B_{iron} + \frac{g}{AREA \cdot \mu_0} \cdot AREA \cdot B_{gap}$$

Magneto-motive force: $N \cdot I$

Reluctance of iron: $\frac{(2\pi \cdot r - g)}{AREA \cdot \mu}$

$AREA \cdot B_{iron}$: $\Psi$

Reluctance of gap: $\frac{g}{AREA \cdot \mu_0}$

$AREA \cdot B_{gap}$: $\Psi$

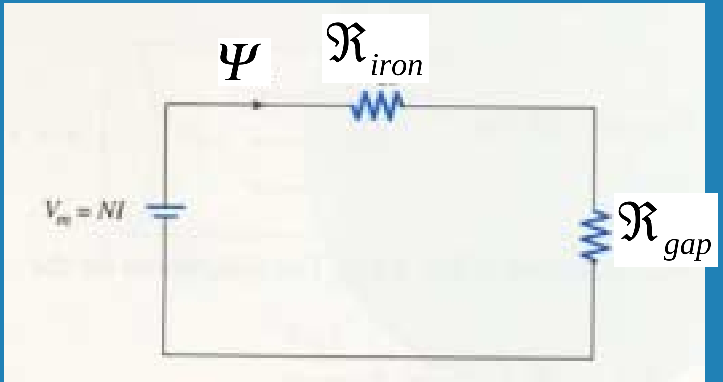
$$= (\Re_{iron} + \Re_{gap}) \cdot \Psi$$

- enables us to draw analogy to electric circuits

# Magnetic Circuits & Electric Circuits

| Electric Circuits | Magnetic Circuits | |
|---|---|---|
| V or e.m.f | NI or m.m.f | |
| I | $\Psi = \int \vec{B} \bullet d\vec{s}$ | |
| $R = \dfrac{l}{\sigma \cdot A}$ | $\Re = \dfrac{l}{\mu \cdot A}$ | High µ - low reluctance path |

*Magnetic circuits model:*




*Finish problem 1*