
CHAP6 exercises

Electromagnetism

謝志誠

Exercise 2

- For the electromagnet in Fig. 6.58, determine the direction of I needed to establish the flux pattern, and label the induced north and south poles.

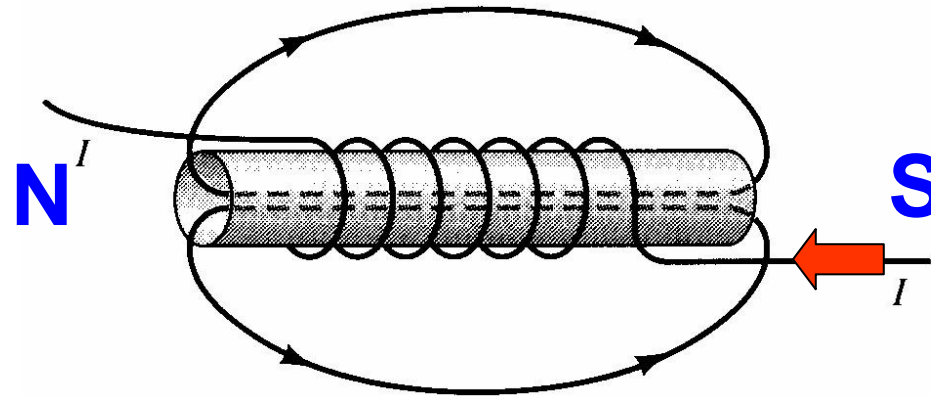


FIG. 6.58

Exercise 4

- a. If the length of a magnetic core is increased for the same magnetomotive force, what will happen to the magnitude of the resulting flux?

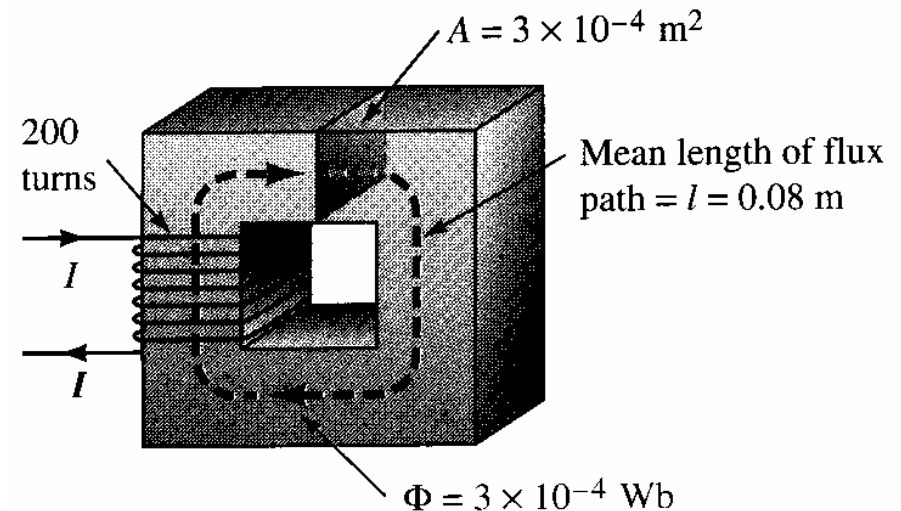
$$\Phi = \frac{\mathcal{F}}{\mathcal{R}} = \frac{\mathcal{F}}{\ell/\mu A} = \frac{\mathcal{F}\mu A}{\ell} \quad \ell \text{ 增加, } \Phi \text{ 降低}$$

- b. If the area of a magnetic core is doubled and the length reduced to one-third, what will be the effect on the resulting flux if the magnetomotive force is held constant?

A增加 1倍, ℓ 減少為1/3, Φ 增加為6倍

Exercise 5

- For the system in Fig. 6.17, determine the current I if the area is doubled.
- Is the resulting current in part (a) half of that obtained in the descriptive example? Why not ?



Exercise 5

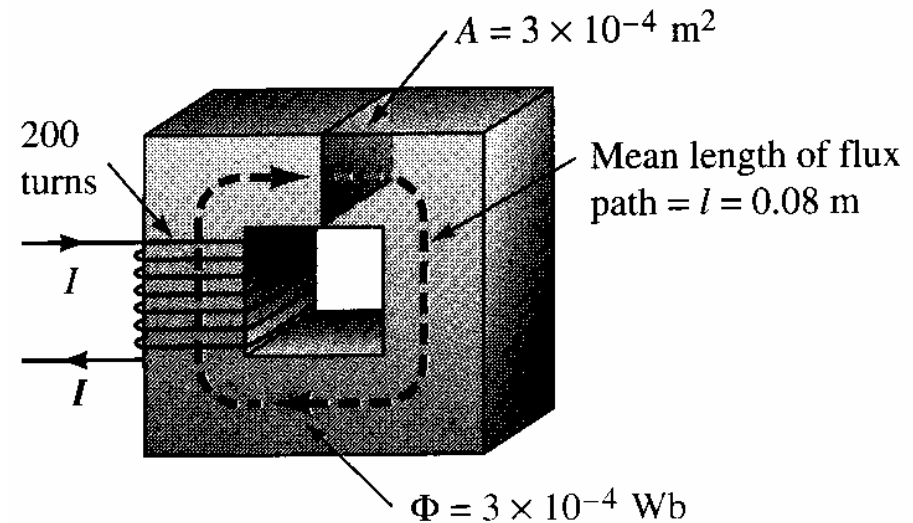
A 增為兩倍 $\rightarrow 6 \times 10^{-4} \text{ m}^2$

$$B = \frac{\Phi}{A} = \frac{3 \times 10^{-4} \text{ Wb}}{6 \times 10^{-4} \text{ m}^2} = 0.5 \text{ T}$$

利用 Fig. 6.15，由 B 找 H， $H = 275 \text{ At/m}$ 。

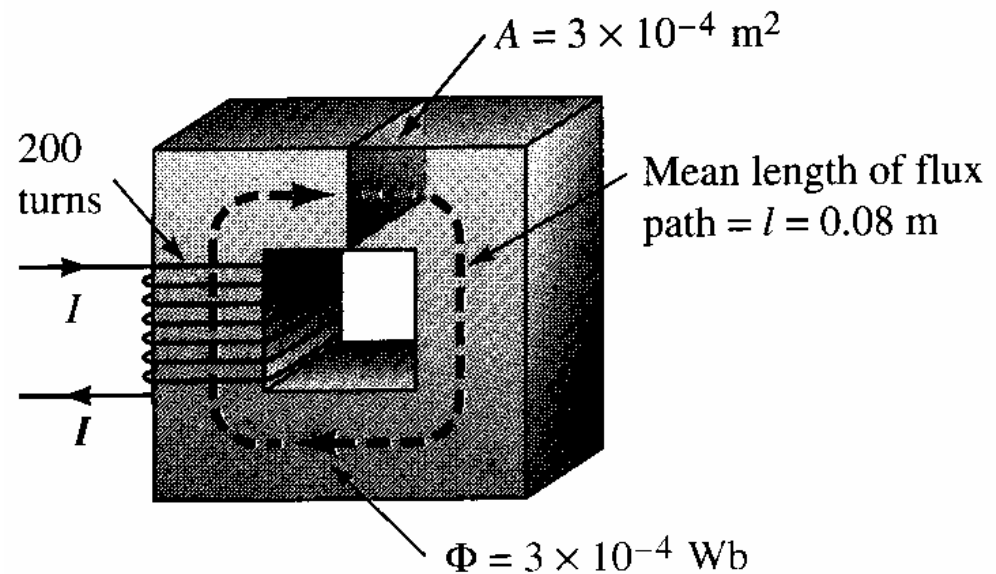
$$NI = Hl \Rightarrow I = \frac{Hl}{N} = \frac{(275 \text{ At/m})(0.08 \text{ m})}{200 \text{ t}} = 110 \text{ mA}$$

A 增加一倍，電流降為原電流的 35.7%，兩者間並無比例關係。



Exercise 6

- For the system in Fig. 6.17, determine the resulting flux if the current is reduced to 200 mA.
- Find the relative permeability of the core.



Exercise 6

電流I降為200mA

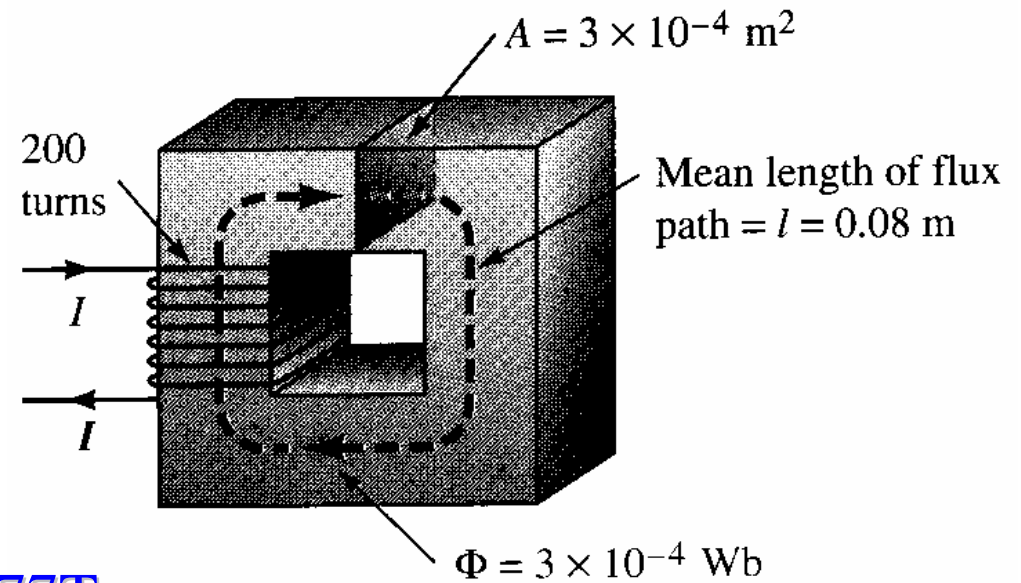
$$NI = Hl \Rightarrow H = \frac{NI}{l} = 500 \text{ At/m}$$

利用Fig.6.15，由H找B， $B = 0.77 \text{ T}$

$$\Phi = B \cdot A = 2.31 \times 10^{-4} \text{ Wb}$$

$$\mu = \frac{B}{H} = 1.54 \times 10^{-3} \frac{\text{Wb}}{\text{A} \cdot \text{m}}$$

$$\mu_r = \frac{\mu}{\mu_0} = 1225.5$$



Exercise 7

For the magnetic system in Fig. 6.59, determine:

- The magnetomotive force.
- The magnetizing force applied to the core.
- The flux density.
- The flux Φ in the core.

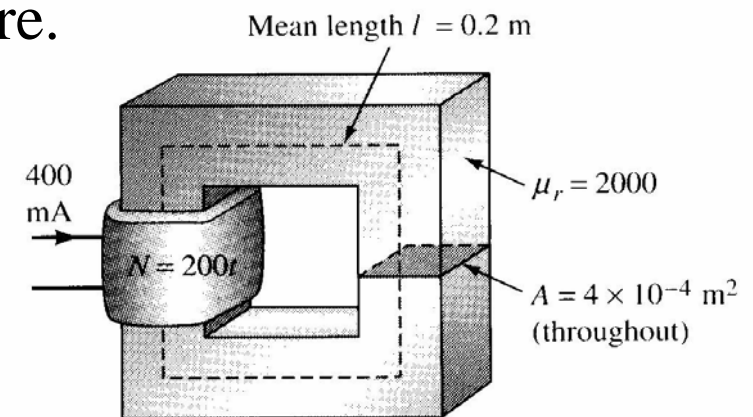


FIG. 6.59

a. $\mathcal{F} = NI = (200\text{t})(400\text{mA}) = 80\text{At}$

b. $H = \frac{\mathcal{F}}{l} = \frac{80\text{At}}{0.2\text{m}} = 400\text{At/m}$

c. $B = \mu H = \mu_r \mu_0 H = (2000)(4\pi \times 10^{-7} \text{ Wb/Am})(400\text{At/m}) = 1\text{T}$

d. $\Phi = BA = 4 \times 10^{-4} \text{ Wb}$

Exercise 8

- Determine the **current I** necessary to establish **the flux** indicated in Fig. 6.60.

$$B = \frac{\Phi}{A} = \frac{1.4 \times 10^{-4} \text{ Wb}}{2 \times 10^{-4} \text{ m}^2} = 0.7 \text{ T}$$

利用Fig.6.15，由B找H，
 $H = 400 \text{ At/m}$ 。

$$NI = H\ell$$

$$I = \frac{H\ell}{N} = 1.6 \text{ A}$$

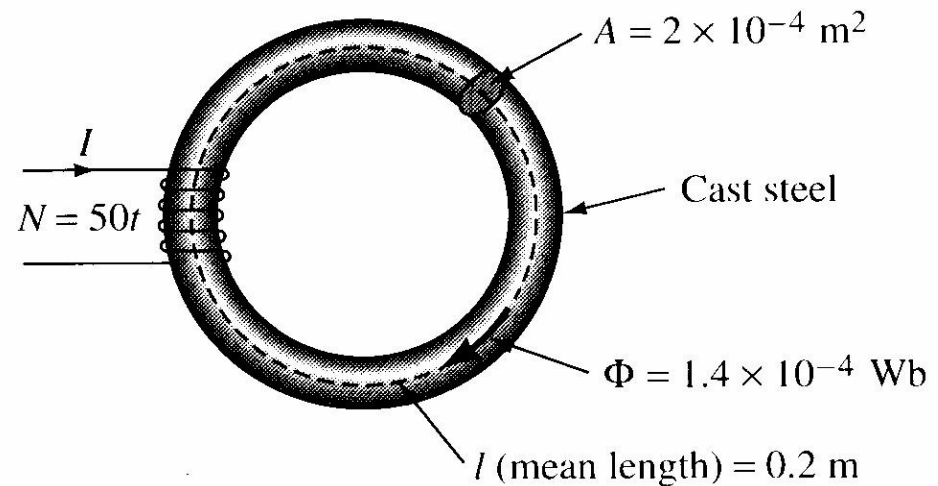


FIG. 6.60

Exercise 9

- Determine the current I_1 necessary to establish a net flux $\Phi = 5 \times 10^{-4}$ Wb in the transformer in Fig. 6.61.

$$B = \frac{\Phi}{A} = \frac{5 \times 10^{-4} \text{ Wb}}{4 \times 10^{-4} \text{ m}^2} = 1.25 \text{ T}$$

利用Fig.6.15，由B找H，
 $H = 1500 \text{ At/m}$ 。

$$N_1 I_1 + N_2 I_2 = H \ell$$

$$(200t)I_1 + (75t)2A = (1500 \text{ At/m})(0.15\text{m})$$

$$I_1 = 0.375 \text{ A}$$

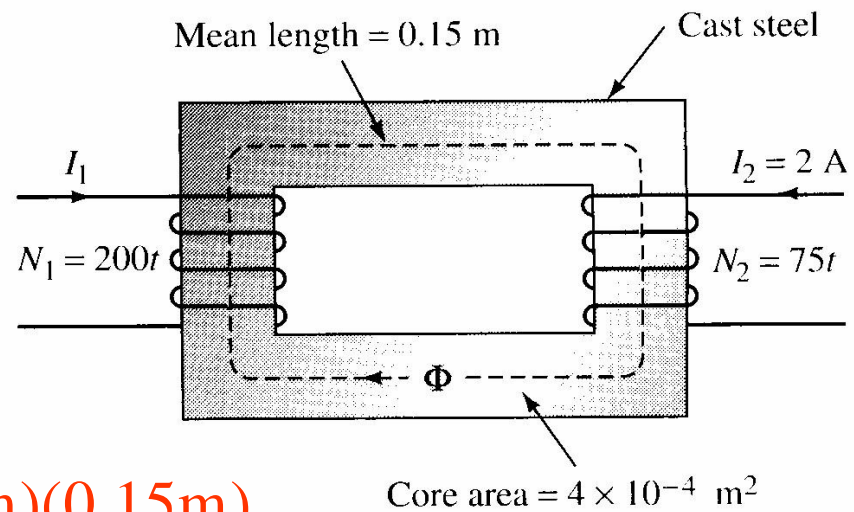


FIG. 6.61

Exercise 10

□ Repeat Problem 7 if an air gap of 0.01 in. is cut through the core.

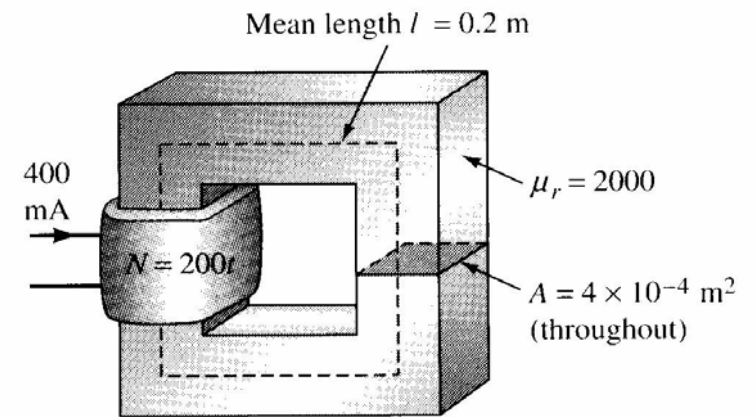


FIG. 6.59

Exercise 11

□ Repeat Problem 8 if an air gap of $250 \mu\text{m}$ is cut through the core.

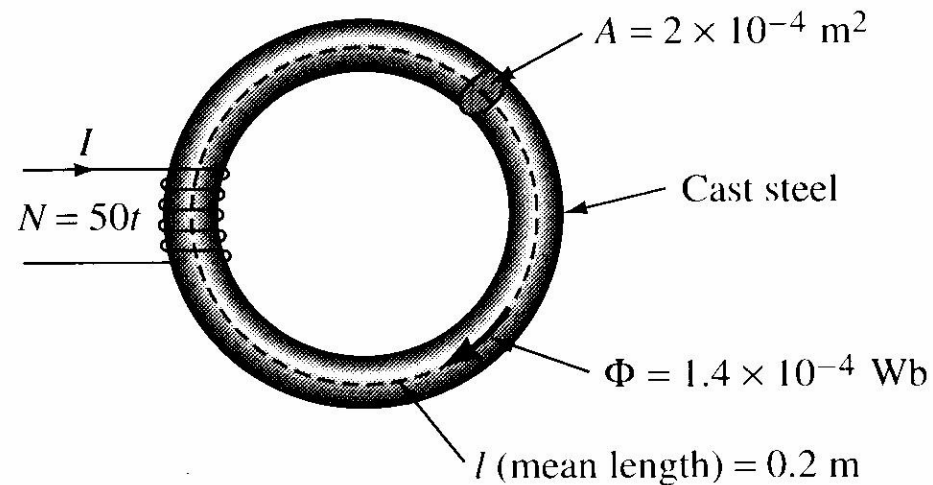


FIG. 6.60

Exercise 11

$$B = \frac{\Phi}{A} = \frac{1.4 \times 10^{-4} \text{ Wb}}{2 \times 10^{-4} \text{ m}^2} = 0.7 \text{ T} = B_c = B_g$$

利用Fig.6.15，由B找H， $H = 400 \text{ At/m}$ 。

$$NI = H_c l_c + H_g l_g$$

$$l_c = 0.2 \text{ m} - 250 \mu\text{m} = 199,750 \mu\text{m} \approx 0.2 \text{ m}$$

$$NI = (400 \text{ At/m})(0.2 \text{ m}) + (7.96 \times 10^5 \text{ B}_g) l_g = 219.3 \text{ At}$$

$$I = \frac{219.3 \text{ At}}{50t} = 4.386 \text{ A}$$

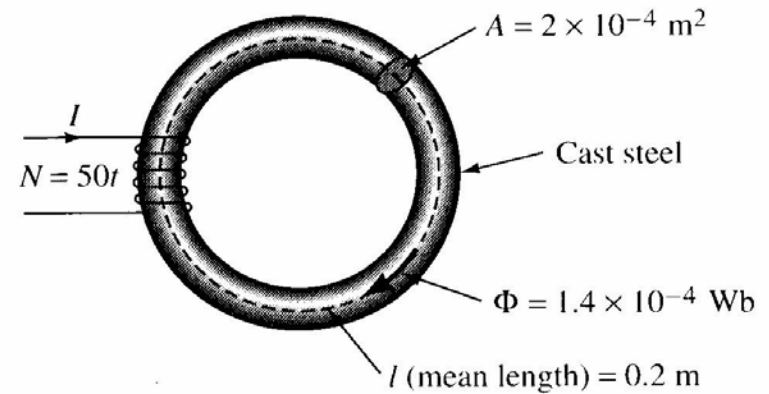


FIG. 6.60

Exercise 12

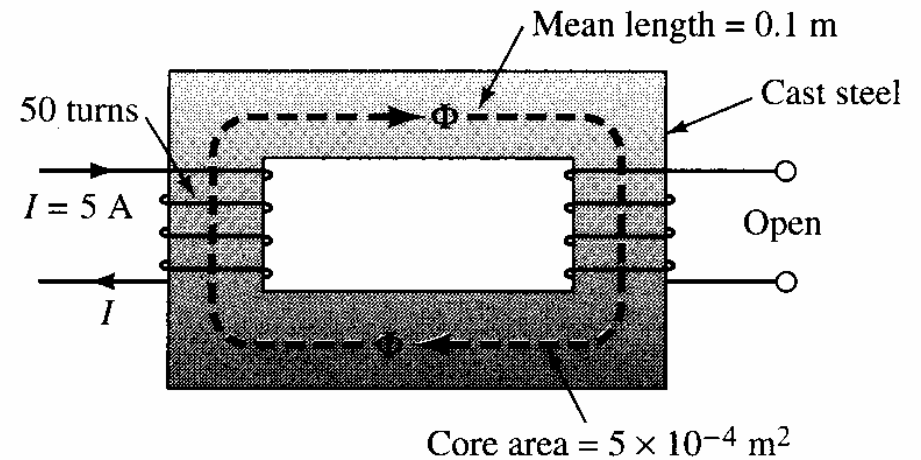
- Determine the current required to establish a flux of 5×10^{-4} Wb in the core of the transformer in Fig. 6.18.

$$B = \frac{\Phi}{A} = \frac{5 \times 10^{-4} \text{ Wb}}{5 \times 10^{-4} \text{ m}^2} = 1.0 \text{ T}$$

利用Fig.6.15，由B找H，
 $H = 780 \text{ At/m}$ 。

$$NI = Hl$$

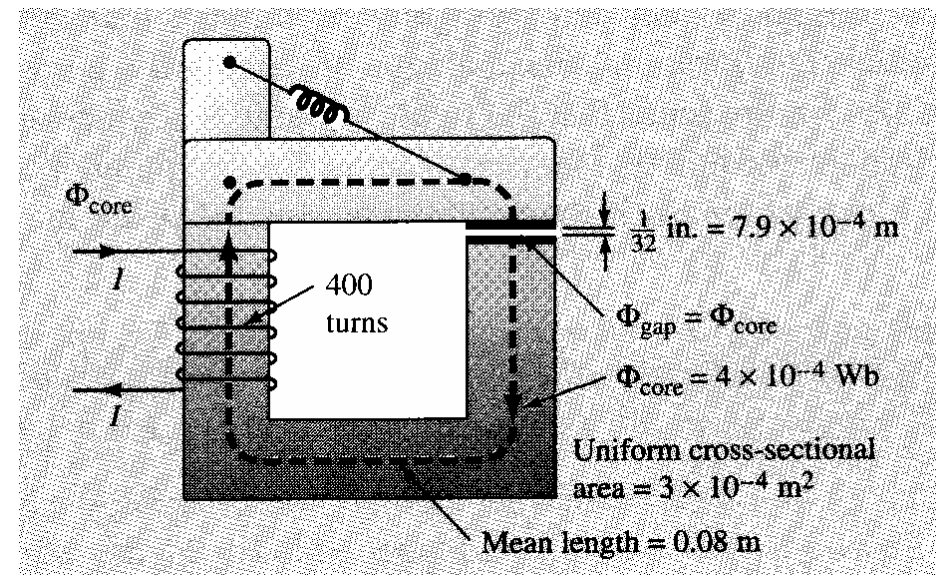
$$I = \frac{Hl}{N} = 1.56 \text{ A}$$



Exercise 13

- If the air gap in Fig. 6.19 is doubled (1/16 in.), will the current required to establish the same flux increase by a factor of 2 also? Determine the resulting current and comment on the results.

Air gap放大一倍，且要建立相同的flux， $B=1.33\text{T}$ ，
電流是否要加倍？



Exercise 13

$$B = B_c = B_g = 1.33\text{T}$$

$$l_g = \frac{1}{16}\text{in} = 15.9 \times 10^{-4}\text{m}$$

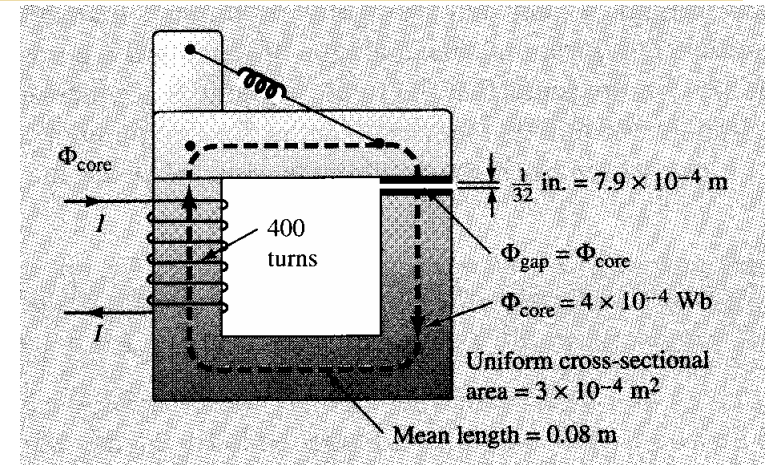
利用Fig.6.15，由B找H， $H_c = 1750\text{ At/m}$ 。

$$H_g = 7.96 \times 10^5 B_g = 10.59 \times 10^5\text{ At/m}$$

$$NI = H_c l_c + H_g l_g$$

$$(400t)I = (1750\text{ At/m})(0.08\text{m}) + (7.96 \times 10^5 \times 1.33\text{ At/m})(15.9 \times 10^{-4}\text{m})$$

$$I = 4.56\text{A} \approx 2 \cdot 2.44\text{A}$$



Exercise 14

- Find the magnetic flux Φ established in the series magnetic circuit in Fig. 6.62.

$$\ell = 2\pi r = 0.5027\text{m}$$

$$NI = H\ell$$

$$H = \frac{NI}{\ell} = 397.88\text{At/m}$$

利用Fig.6.15，由H找B， $B = 0.7\text{T}$ 。

$$\Phi = BA = 6.3 \times 10^{-3}\text{Wb}$$

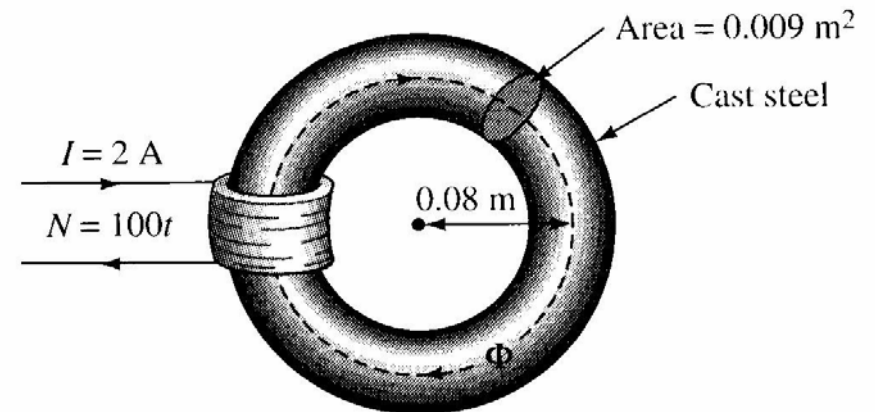


FIG. 6.62

Exercise 15

□ Using a $50\text{-}\mu\text{A}$, $20,000\Omega$ movement, design:

a. A 10-A ammeter.

調整 $R_{\text{shunt}} \sim 0.1\Omega$

$$R_{\text{shunt}} = \frac{V}{I} = \frac{(50\mu\text{A})(20\text{k}\Omega)}{10\text{A}} = 0.1\Omega$$

b. A 10-V voltmeter.

調整 $R_{\text{series}} \sim 180\text{k}\Omega$

$$R_{\text{series}} = \frac{V_{\text{RS}}}{I_{\text{RS}}} = \frac{10\text{V} - (50\mu\text{A})(20\text{k}\Omega)}{50\mu\text{A}} = 180\text{k}\Omega$$

Exercise 16

- A transformer with a turns ratio $a = N_p/N_s = 12$ has a load of $2.2 \text{ k}\Omega$ applied to the secondary. If 120 V is applied to the primary, determine:
- The reflected impedance at the primary. $Z_P = a^2 Z_L = 316.84 \text{ k}\Omega$
 - The primary and secondary currents. $I_P = E_P/Z_P = 0.379 \text{ mA}$ $I_S = a \times I_P = 4.55 \text{ mA}$
 - The load voltage. $V_S = I_S \times R_L = 10.01 \text{ V}$
 - The power to the load. $P = I_S^2 \times R_L = 45.55 \text{ mW}$
 - The **power** supplied by source. $P = 45.55 \text{ mW}$
↑
real

Exercise 17

- For a power transformer, $E_p = 120 \text{ V}$, $E_s = 6000 \text{ V}$, and $I_p = 20\text{A}$:
- Determine the secondary current I_s . **$I_p/I_s = E_s/E_p = 50$ $I_s = 0.4\text{A}$**
 - Calculate the turns ratio a . **$a = N_p/N_s = 1/50$**
 - Is it a step-down or a step-up transformer? **Step-up transformer**
 - If $N_s = 100$ turns, $N_p = ?$ **$N_p = N_s \times a = 2$ turns**

Exercise 18

- An inductive load $Z_L = 4\ \Omega + j4\ \Omega$ is applied to a 120 V / 6 V filament transformer.
 - a. What is the magnitude of the secondary current?
 - b. What is the power delivered to the load?
 - c. What is the primary current?

Exercise 18

Secondary端接上inductive load $Z_L = 4 \Omega + j 4 \Omega = 5.66 \Omega \angle 45^\circ$

$E_p = 120 \text{ V}$, $V_s = E_s = 6 \text{ V}$ 。

a. Secondary current $I_s = \frac{V_s}{Z_L} = 1.06 \text{ A}$

b. 送到負載的real power $P = I_s^2 \cdot 4\Omega = 4.494 \text{ W}$

c. primary current $I_p = I_s \cdot \frac{N_s}{N_p} = 53 \text{ mA}$

Exercise 19

- A purely capacitive load $Z_L = -j2\ \Omega$ is applied to a 120 V / 6 V filament transformer with a 12 VA apparent power rating.
 - a. Determine the magnitude of the secondary current.
 - b. Calculate the power delivered to the primary and secondary.
 - c. Do you expect the transformer to heat up if operating under these conditions?

Exercise 19

Secondary端接上capacitive load $Z_L = -j 2 \Omega$, $E_p = 120 \text{ V}$,
 $V_s = E_s = 6 \text{ V}$ 。

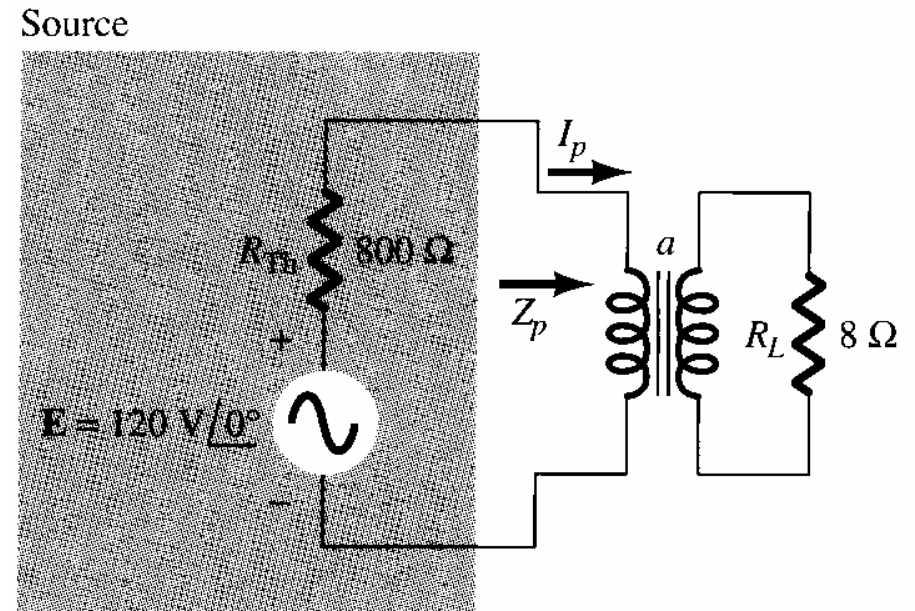
a. $I_s = \frac{V_s}{Z_L} = 3.0 \text{ A}$

b. 負載是純電容， delivered to the primary and secondary為零。

c. Apparent power額定值為12 VA，則secondary端電流額定為2A
；由於實際電流為3A，當然會「heat up」。

Exercise 20

- If $E = 120 \text{ V}$, $R_{\text{TH}} = 0.5 \text{ k}\Omega$, and $a = 5$ in the network in Fig. 6.25, determine the load value for max power to the load.
- Determine the power to the load under these conditions.



Exercise 20

a. 要達到max. power transfer，變壓器的primary端的impedance必需是 $0.5 \text{ k}\Omega$ ；
即 $Z_p = 0.5 \text{ k}\Omega$ 。

Z_p 為 REFLECTED IMPEDANCE

$$Z_p = a^2 Z_L \quad R_L = Z_L = 20\Omega$$

b. 由電壓源出來的電流等於變壓器primary端的電流

$$I_p = \frac{120\text{V}}{R_{\text{TH}} + Z_p} = 120\text{mA} \Rightarrow I_s = a \cdot I_p = 600\text{mA}$$

$$P_L = I_s^2 \cdot R_L = 7.2\text{W}$$

