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.

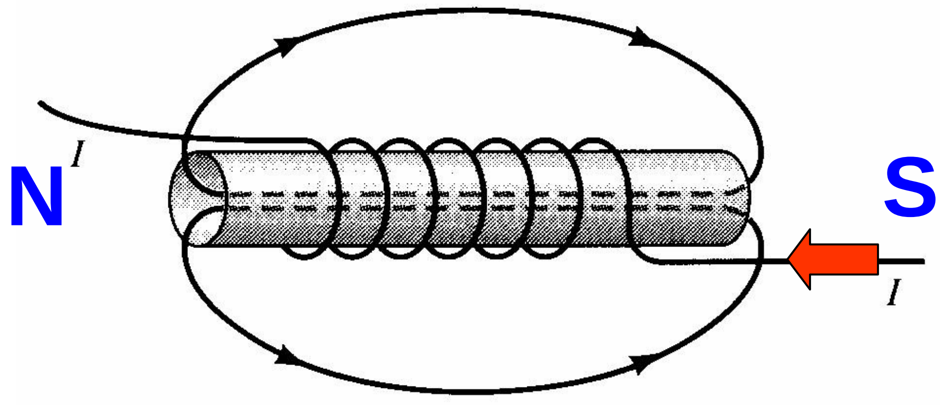


FIG. 6.58

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?

$$\Phi = \frac{\Im}{\Re} = \frac{\Im}{\ell/\mu A} = \frac{\Im \mu A}{\ell}$$

ℓ 增加，Φ降低

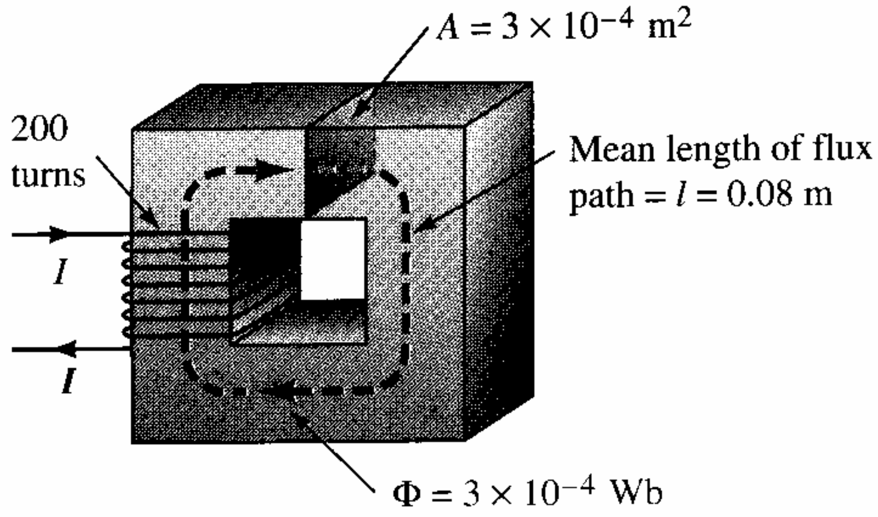
b. If the area of a magnetic core is doubled and the length reduced to one-third, what will be the effect on the resulting flux if the magnetomotive force is held constant?

A增加 1倍，ℓ 減少為1/3，Φ增加為6倍

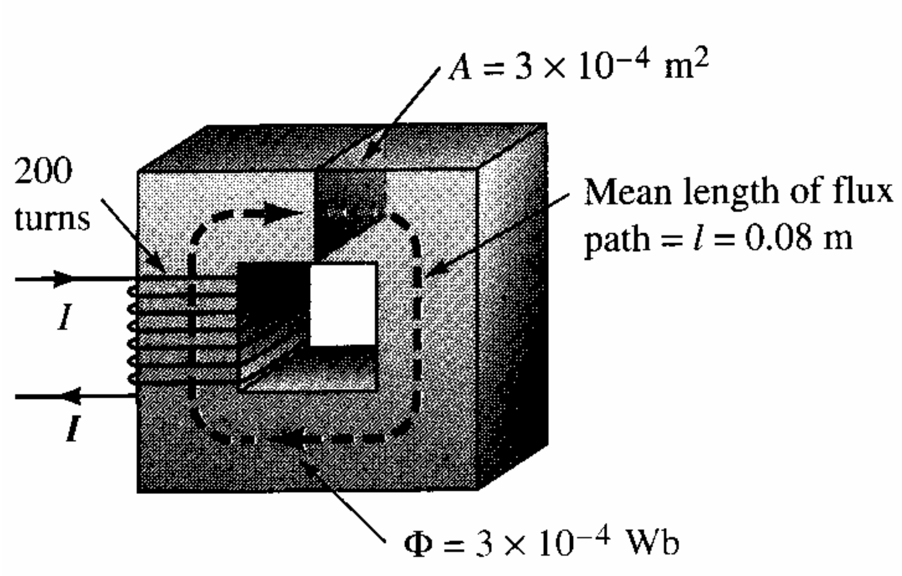
Exercise 5

a. For the system in Fig. 6.17, determine the current I if the area is doubled.

b. Is the resulting current in part (a) half of that obtained in the descriptive example? Why not ?



Exercise 5



A增為兩倍→$6\times10^{-4}\ m^2$

$$B=\frac{\Phi}{A}=\frac{3\times10^{-4}Wb}{6\times10^{-4}m^2}=0.5T$$

利用Fig.6.15，由B找H，H = 275 At/m。

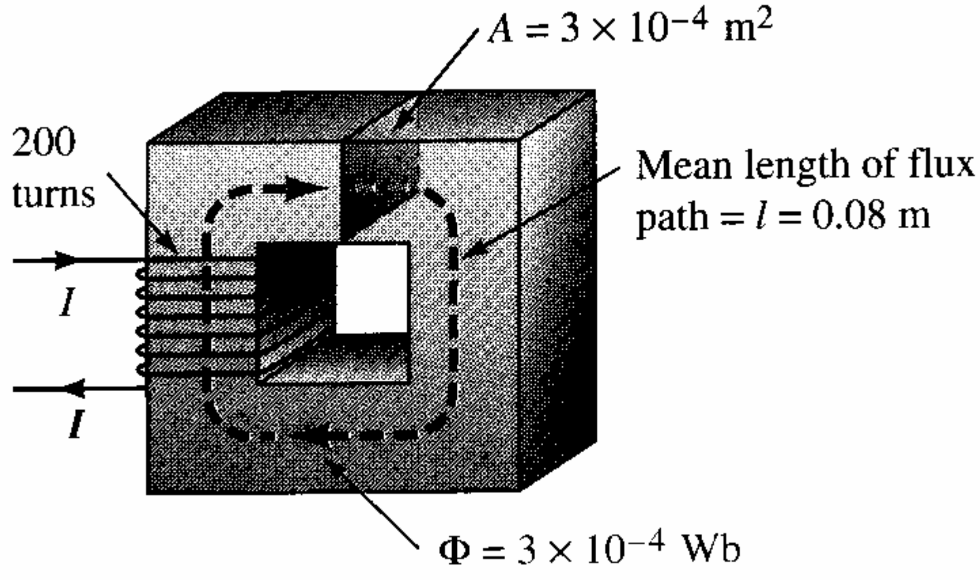
$$NI=H\ell\Rightarrow I=\frac{H\ell}{N}=\frac{(275At/m)(0.08m)}{200t}=110mA$$

A增加一倍，電流降為原電流的35.7%，兩者間並無比例關係。

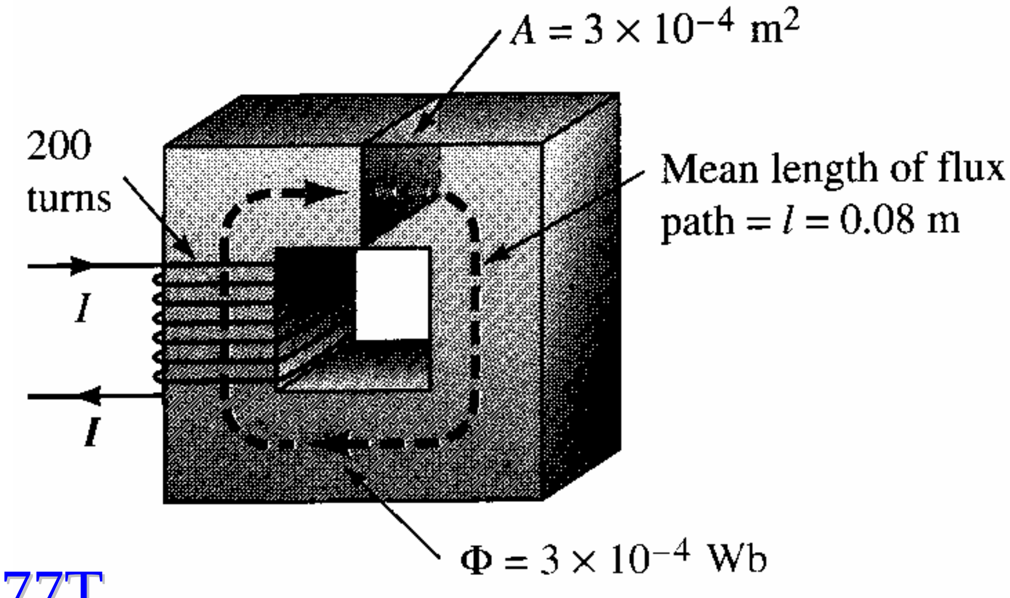
Exercise 6

a. For the system in Fig. 6.17, determine the resulting flux if the current is reduced to 200 mA.

b. Find the relative permeability of the core.



Exercise 6



電流I降為200mA

$$NI = H\ell \Rightarrow H = \frac{NI}{\ell} = 500\,At/m$$

利用Fig.6.15，由H找B，B = 0.77T

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

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

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

Exercise 7

For the magnetic system in Fig. 6.59, determine:

a. The magnetomotive force.

b. The magnetizing force applied to the core.

c. The flux density.

d. The flux Φ in the core.

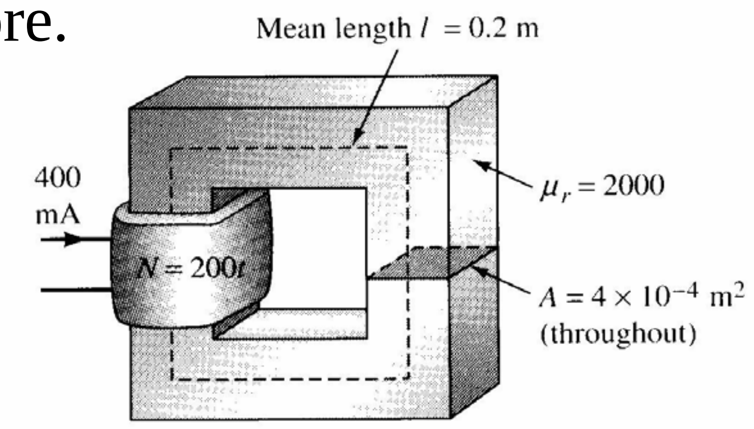


FIG. 6.59

$$a.\ \Im = NI = (200t)(400mA) = 80At$$

$$b.\ H = \frac{\Im}{\ell} = \frac{80At}{0.2m} = 400At/m$$

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

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

Exercise 8

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

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

利用Fig.6.15，由B找H，H =400 At/m。

$$NI = H\ell$$

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

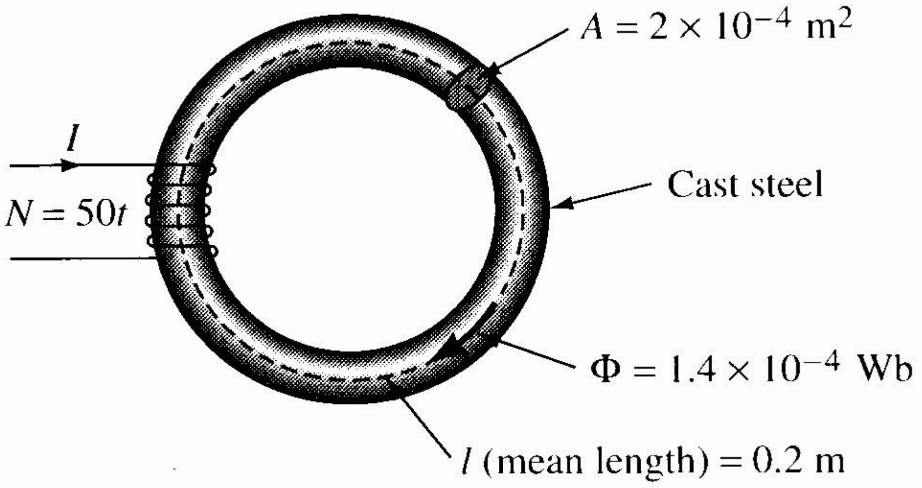


FIG. 6.60

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.

$$B = \frac{\Phi}{A} = \frac{5\times10^{-4}\,\text{Wb}}{4\times10^{-4}\,\text{m}^2} = 1.25\text{T}$$

利用Fig.6.15，由B找H，
H =1500 At/m 。

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

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

$$I_1 = 0.375A$$

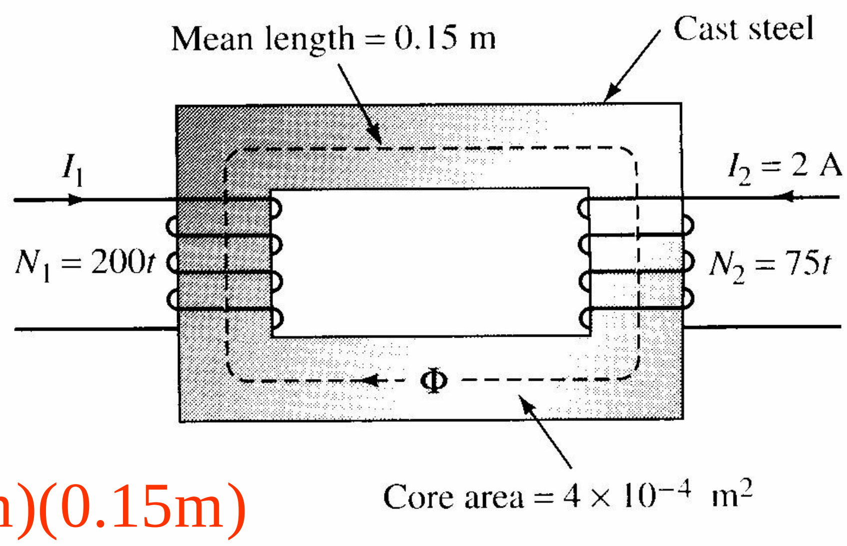


FIG. 6.61

Exercise 10

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

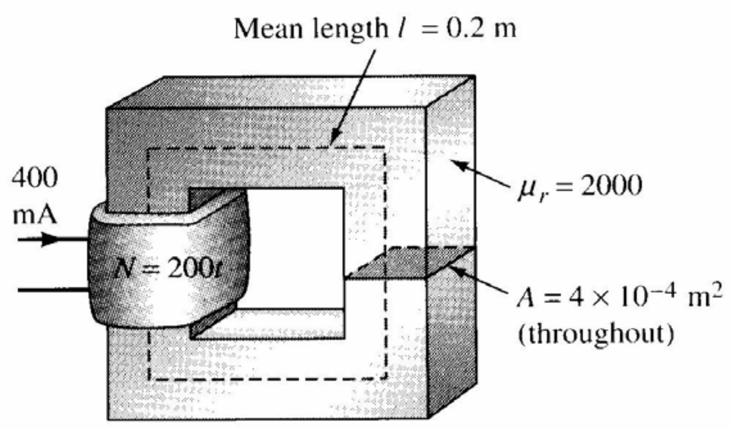


FIG. 6.59

Exercise 11

- Repeat Problem 8 if an air gap of 250 μ m is cut through the core.

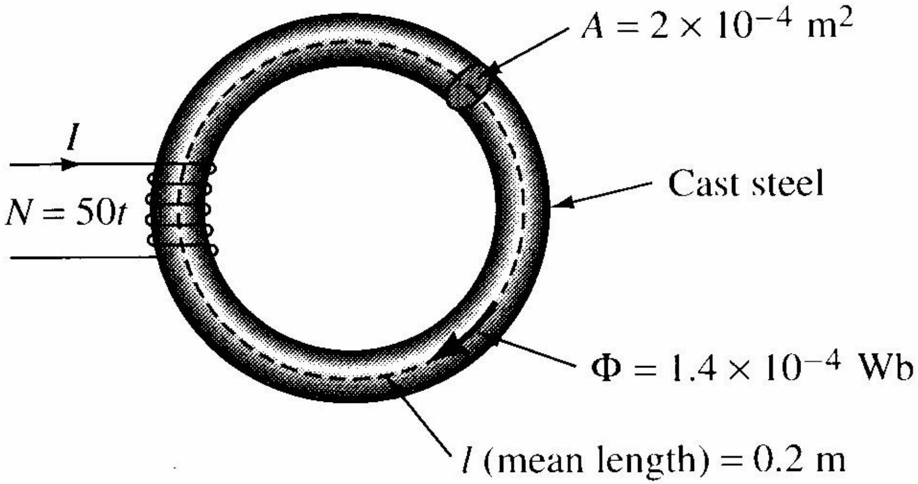


FIG. 6.60

Exercise 11

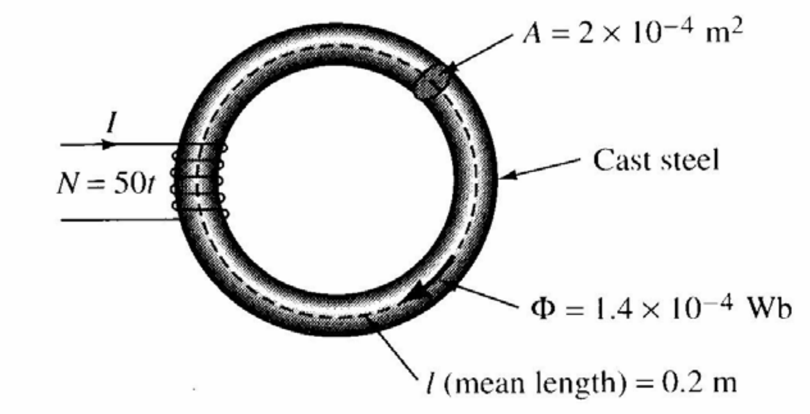


FIG. 6.60

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

利用Fig.6.15，由B找H，H =400 At/m。

$$NI = H_c \ell_c + H_g \ell_g$$

$$\ell_c = 0.2\mathrm{m} - 250\mu\mathrm{m} = 199{,}750\mu\mathrm{m} \approx 0.2\mathrm{m}$$

$$NI = (400\,\mathrm{At/m})(0.2\mathrm{m}) + (7.96 \times 10^5 B_g)\ell_g = 219.3\mathrm{At}$$

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

Exercise 12

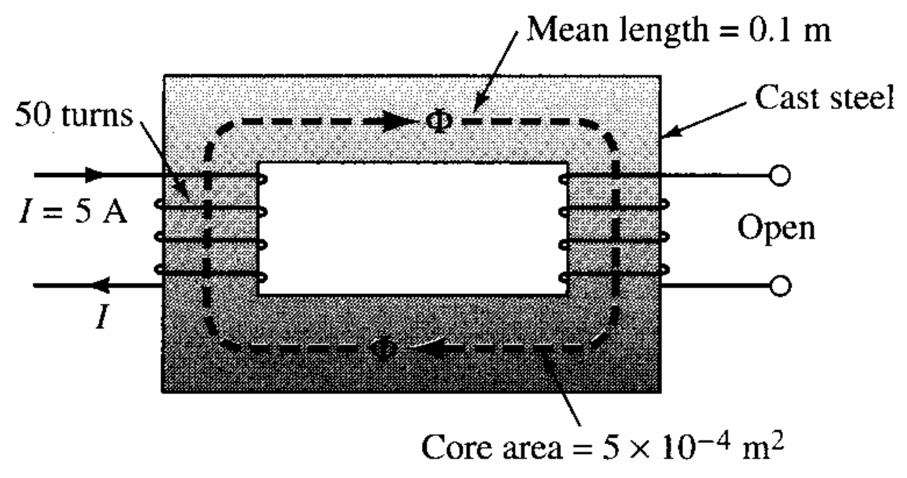
- Determine the current required to establish a flux of 5×10^{-4} Wb in the core of the transformer in Fig. 6.18.

$$B = \frac{\Phi}{A} = \frac{5\times10^{-4}\,\text{Wb}}{5\times10^{-4}\,\text{m}^2} = 1.0\,\text{T}$$

利用Fig.6.15，由B找H，
H =780 At/m。

$$NI = H\ell$$

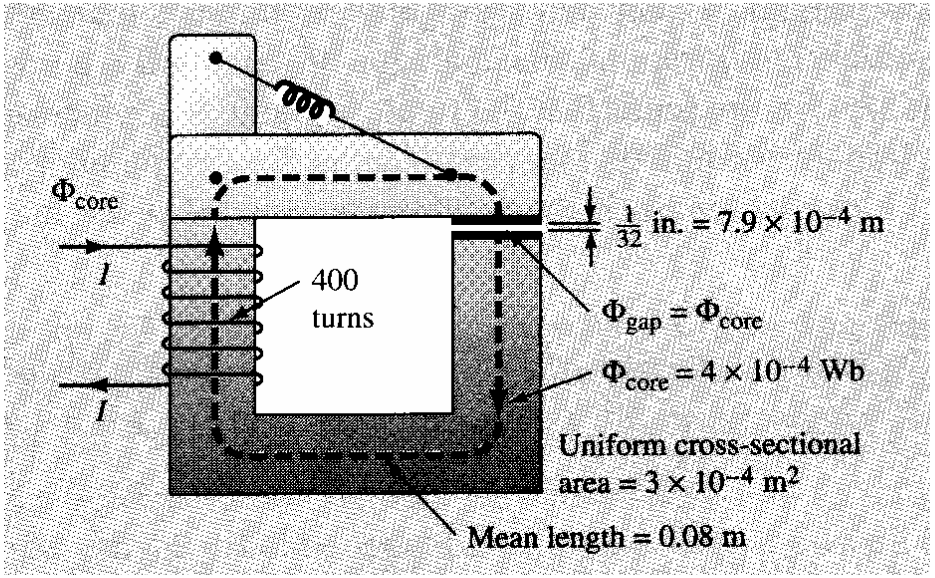
$$I = \frac{H\ell}{N} = 1.56\,\text{A}$$



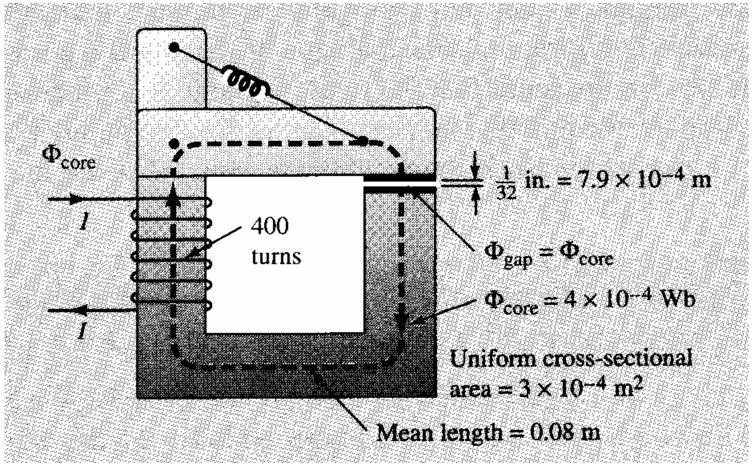
Exercise 13

- 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=1.33T，電流是否要加倍？



Exercise 13



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

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

利用Fig.6.15，由B找H，H_c =1750 At/m。

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

$$NI = H_c \ell_c + H_g \ell_g$$

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

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

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 =0.7T。

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

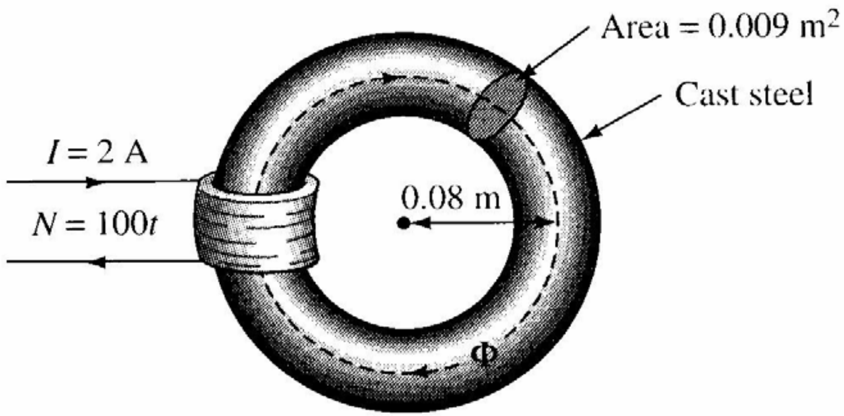


FIG. 6.62

Exercise 15

- Using a 50-μA，20,000Ω movement, design:

  a. A 10-A ammeter.

  調整R_{shunt} ~0.1Ω

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

  b. A 10-V voltmeter.

  調整R_{series}~180kΩ

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

Exercise 16

- A transformer with a turns ratio $a = N_p/N_s = 12$ has a load of 2.2 kΩ applied to the secondary. If 120 V is applied to the primary, determine:

a. The reflected impedance at the primary. **$Z_P = a^2 Z_L = 316.84k\Omega$**

b. The primary and secondary currents. **$I_P = E_P/Z_P = 0.379$ mA $I_S = a \times I_P = 4.55$ mA**

c. The load voltage. **$V_S = I_S \times R_L = 10.01$ V**

d. The power to the load. **$P = I_S^2 \times R_L = 45.55$ mW**

e. The power supplied by source. **P = 45.55 mW**

↑ **real**

Exercise 17

- For a power transformer, E_p = 120 V, E_S = 6000 V, and I_p = 20A:

a. Determine the secondary current I_S. **$I_P/I_S = E_S/E_P = 50$ $I_S = 0.4A$**

b. Calculate the turns ratio a. **$a = N_P/N_S = 1/50$**

c. Is it a step-down or a step-up transformer? **Step-up transformer**

d. 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 V，$V_S = E_S$ = 6 V 。

a. Secondary current $I_S = \dfrac{V_S}{Z_L} = 1.06\text{A}$

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

c. primary current $I_P = I_S \cdot \dfrac{N_S}{N_P} = 53\text{mA}$

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 2Ω， E_P = 120 V，

V_S= E_S = 6 V 。

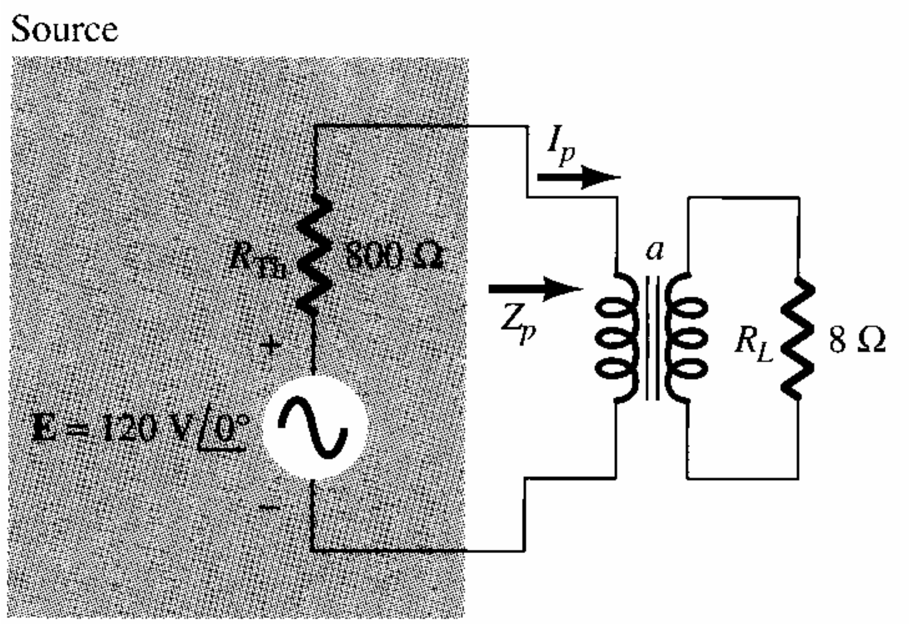
a. $$I_S = \frac{V_S}{Z_L} = 3.0A$$

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

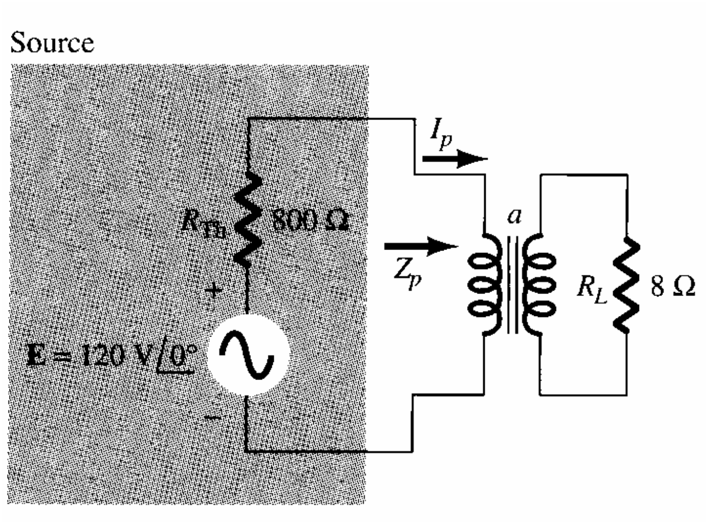
c. Apparent power額定值為12 VA，則secondary端電流額定為2A；由於實際電流為3A，當然會「heat up」。

Exercise 20

- If E = 120 V, R_{TH} = 0.5 kΩ, 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 kΩ；即Z_P = 0.5 kΩ 。

Z_P為 REFLECTED IMPEDANCE

$$Z_P = a^2 Z_L \qquad R_L = Z_L = 20\Omega$$

b.由電壓源出來的電流等於變壓器primary端的電流

$$I_P = \frac{120V}{R_{TH} + Z_P} = 120mA \Rightarrow I_S = a \cdot I_P = 600mA$$

$$P_L = I_S^{\,2} \cdot R_L = 7.2W$$