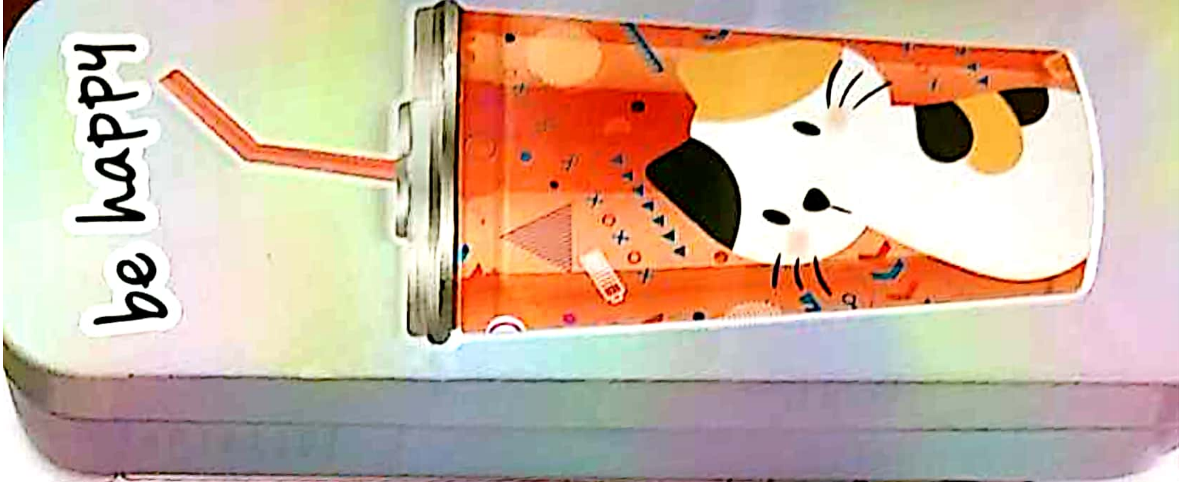

Tutorial 1

1. A 30 cm long circular iron rod is bent into circular ring & 600 turns of windings are wound on it. The diameter of rod is 20 mm & relative permeability of iron is 4000.

A time varying current $i = 5\sin 314.16t$ is passed through the winding. Calculate inductance of coil & avg value of emf in coil?

Given,

mean length of coil $(l) = 30\text{cm}$
$= 30 \times 10^{-2}$ m

no. of turns $(N) = 600$

diameter of rod $(d) = 20\text{mm}$
$= 20 \times 10^{-3}$ m

relative permeability $(\mu_r) = 4000$

time varying current $(i) = 5\sin 314.16t$

To calculate,

Inductance $(L) = ?$

Avg value of emf $(e_{avg}) = ?$

We know that,

$$L = \frac{N^2 \mu_0 \mu_r A}{l}$$

Thus, $A = \frac{\pi d^2}{4} = \frac{\pi \times (20 \times 10^{-3})^2}{4}$

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$= 3.14 \times 10^{-4}\ m^2$

Thus,

$$L = \frac{(1600)^2 \times 4\pi \times 10^{-7} \times 4000 \times 3.14 \times 10^{-4}}{30 \times 10^{-2}}$$

$\therefore L = 1.89\ H$

We know,

$$e = L\frac{di}{dt}$$

$$= 1.89 \frac{d(5 \sin 314.16 t)}{dt}$$

$$= 1.89 \times 5 \times 314.16 \times \cos 314.16 t$$

$$= \underbrace{2968.812}_{e_m} \cos 314.16 t$$

Then,

- For average emf

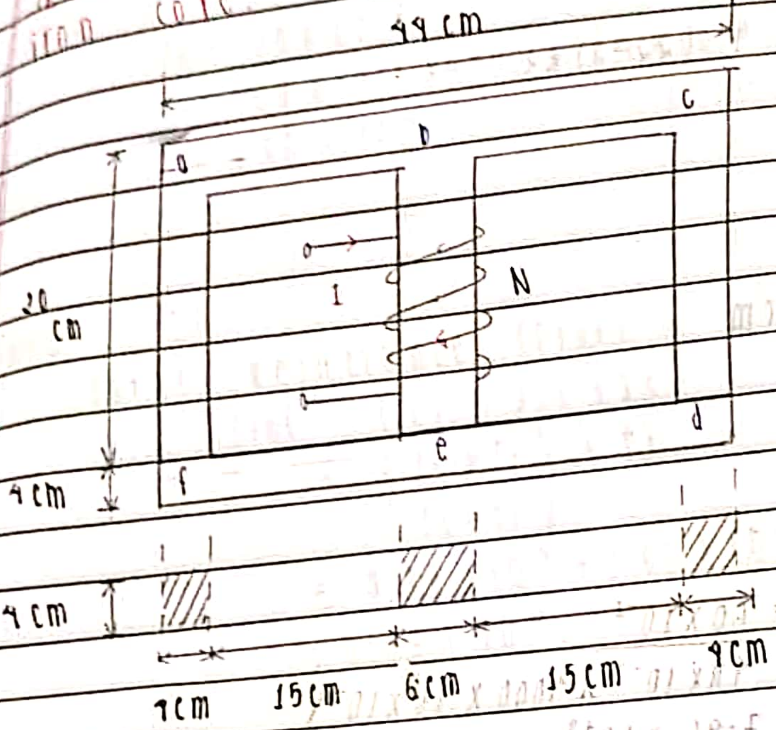
$$e_{avg} = \frac{2 e_m}{\pi}$$

$$= \frac{2 \times 2968.812}{\pi}$$

$$= 1890\ V$$

$\therefore$ The inductance of coil is 1.89 H & avg value of emf induced is 1890 V.

2) For mag. ckt shown below, calculate amp-turn will reqd. to establish a flux of 0.75 Wb in central limb. Given that $\mu_r = 4000$ for iron core.



Given,

Flux $(\phi) = 0.75$ Wb

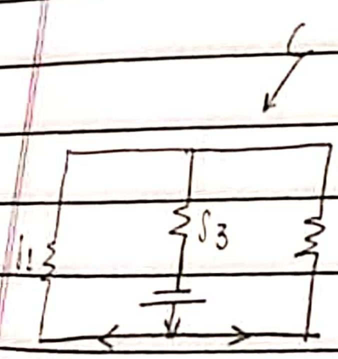
Relative permeability $(\mu_r) = 4000$

To find,

Amp. turn $(NI) = ?$

· Total Reluctance of ckt (S)

$$S = (S_{bafe} \parallel S_{bcde}) + S_{be}$$



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• For S_1,

$$S_1 = \frac{l_1}{\mu_0 \mu_r A_1}$$

$l_1 = (16+2+2) + (22-2) \times 2$
$= 20 + 40$
$= 60\,cm$

$A_1 = 4\,cm \times 4\,cm$
$= 16\,cm^2$

Then,

$$S_1 = \frac{60 \times 10^{-2}}{4\pi \times 10^{-7} \times 4000 \times 16 \times 10^{-4}}$$
$$= 7.46 \times 10^{4}\ amp\text{-}turn / Wb$$

Since,
the above fig. is symmetrical
$S_1 = S_2$

$= 7.46 \times 10^{4}$ amp-turn / Wb

• For S_3

$$S_3 = \frac{l_3}{\mu_0 \mu_r A_3}$$

$l_3 = 16+2+2$
$= 20\,cm$

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$A_3 = 6cm \times 4cm$
$= 24cm^2$

Then,

$$S_3 = \frac{20 \times 10^{-2}}{4\pi \times 10^{-7} \times 4000 \times 24 \times 10^{-4}}$$
$$= 1.66 \times 10^4 \text{ amp-turn/wb}$$

Now,

• Total Reluctance (S_{tot})

$$S_{tot} = (S_1 \parallel S_2) + S_3$$
$$= \left(\frac{S_1 \times S_2}{S_1 + S_2}\right) + S_3$$
$$= 3.74 \times 10^4 + 1.66 \times 10^4$$
$$= 5.39 \times 10^4 \text{ amp-turn/wb}$$

We know,

$$NI = \phi \times S_{tot}$$
$$\text{or, } NI = 0.75 \times 5.39 \times 10^4$$
$$= 40.4 \times 10^3 \text{ amp-turn}$$

∴ The reqd. amp-turn is 40.4×10^3 amp-turn.

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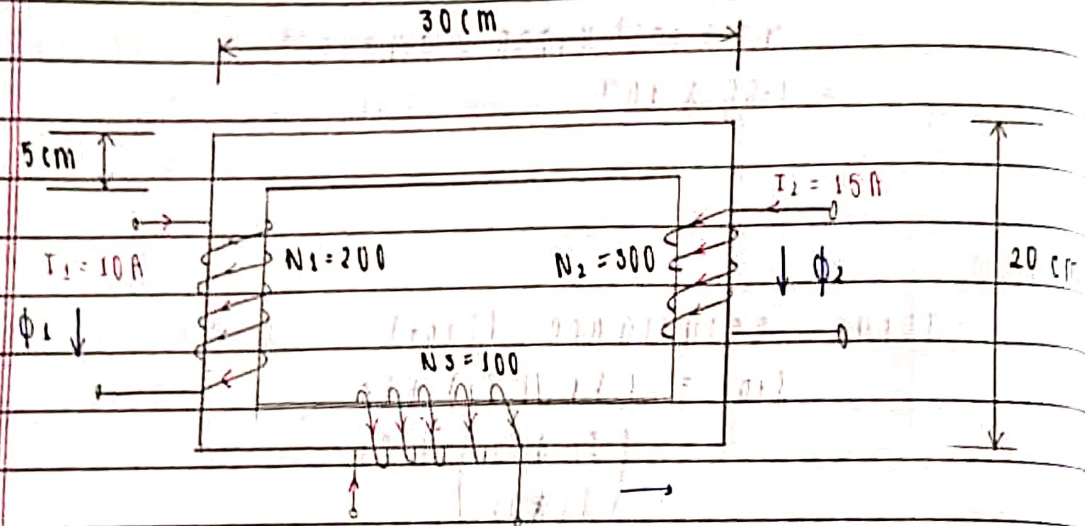
3. Calculate net magnetic flux in the core of following magnetic ckt. & show the dirn of magnetic flux in the core given that the cross sectional area of core is 25 sq. cm & μ_r =



Given,

cross sectional area (A) = 25 cm²

relative permeability (μ_r) = 4000

We know,

$$NI = \phi \times S$$

$$\therefore \phi = \frac{NI}{S} \quad S = l/\mu_0\mu_r A$$

$$= \frac{NI \times \mu_0 \times \mu_r \times A}{l}$$

- For ϕ_1

$$l_1 = (10 + 2.5 + 2.5) \times 2 + (20 + 2.5 + 2.5) \times 2$$

$$= 80 \text{ cm}$$

$N_1 I_1 = 200 \times 10$

$= 2000$ Amp-turn

Thus,

$\cdot \phi_1 = \dfrac{2000 \times 4\pi \times 10^{-7} \times 4000 \times 25 \times 10^{-4}}{80 \times 10^{-2}}$

$= \pi/100$ Wb ($\circlearrowleft$)

- For ϕ_2

$l_2 = l_1$

$N_2 I_2 = 300 \times 15$

$= 4500$ Amp-turn

Thus,

$\cdot \phi_2 = \dfrac{4500 \times 4\pi \times 10^{-7} \times 4000 \times 25 \times 10^{-4}}{80 \times 10^{-2}}$

$= \dfrac{9\pi}{400}$ Wb ($\circlearrowleft$)

- For ϕ_3

$l_3 = l_2 = l_1$

$N_3 I_3 = 100 \times 10$

$= 1000$ Amp-turn

Thus,

$\cdot \phi_3 = \dfrac{1000 \times 4\pi \times 10^{-7} \times 4000 \times 25 \times 10^{-4}}{80 \times 10^{-2}}$

$= \dfrac{\pi}{2000}$ Wb ($\circlearrowleft$)

Taking clock-wise dir^n as, +ve
anti clock-wise dir^n as, -ve

Then,

$$\phi = -\phi_1 + \phi_2 - \phi_3$$
$$= -\frac{\pi}{100} + \frac{9\pi}{400} - \frac{\pi}{200}$$
$$= \frac{3\pi}{400}$$
$$= 0.02356 \text{ wb}$$
$$= 23.56 \text{ mWb} \quad (2)$$

∴ The net magnetic flux in the circuit is 23.56 mWb. in clockwise dir^n

Y A circular iron core has a cross sectional area of 5 sq. cm & mean length of 15 cm It has two coils A & B w. 100 turns & 500 turns resp. The current in coil A is changed from zero to 10 amp. in 0.1 sec calculate emf induced in coil B given the relative permeability of core is 3000.

Given,

cross sectional area (A) = $5 cm^2 = 5 \times 10^{-4} m^2$

mean length (l) = 15 cm
$= 15 \times 10^{-2}$ m

no. of turns of coil A (N_A) = 100

no. of turns of coil B (N_B) = 500

di = 10 amp

dt = 0.1 sec

We know,

- Mutual Inductance (M)

$$M = \frac{N_A N_B \mu_0 \mu_r A}{l}$$

$$= \frac{100 \times 300 \times 4\pi \times 10^{-7} \times 5000 \times 5 \times 10^{-4}}{15 \times 10^{-2}}$$

$$= \frac{\pi}{5} \text{ H}$$

We also know,

$$M = \frac{-e_m}{\frac{di}{dt}}$$

$$\text{or, } -e_m = M \times \left(\frac{di}{dt}\right)$$

$$= \frac{\pi}{5} \times \left(\frac{10}{0.1}\right)$$

$$= 20\pi$$

$$= 62.83 \text{ V}$$

∴ The emf induced in coil B is 62.83 V.

5. An iron ring of ~~mean~~ length of 1.2 m & cross sectional area of 0.005 m² is wound w a coil of 900 turns. If a current of 2 Amp in coil produces a flux density of 2T in iron ring. Calculate:

a) The mmf

b) Total flux in core

c) magnetic ~~flux~~ field strength

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d) Relative permeability of core

soln

Given,

mean length (l) = 1.2 m

cross sectional area (A) = 0.005 m^2

no. of turns (N) = 900

current (I) = 2 amp

flux density (B) = 2T

a) mmf = ?

We know,

$$mmf = NI$$
$$= 900 \times 2$$
$$= 1800 \text{ AT}$$

∴ The mmf is 1800 AT.

b) Total flux in core (ϕ) = ?

We know,

$$\phi = BA$$
$$= 2 \times 0.005$$
$$= 0.01 \text{ Wb}$$

∴ The mmf is 0.01 Wb.

c) magnetic field strength (H) = ?

We know,

$$H = \frac{NI}{l}$$
$$= \frac{1800}{1.2} = 1500 \text{ AT/m}$$

∴ The magnetic field strength is 1500 AT/m.

d) Relative permeability (μ_r) = ?

$$mmf = \frac{\phi \times l}{\mu_0 \mu_r A}$$

$$\mu_r = \frac{\phi\, l}{\mu_0 A\, mmf}$$

$$= \frac{0.01 \times 1.2}{4\pi \times 10^{-7} \times 0.005 \times 1800}$$

$$= 1061.032954$$

∴ The relative permeability is 1061.032954.

6. An iron ring of mean length of 1.5m & cross sectional area of 0.01 m². It has a radial air gap of 4mm. Ring is wound w. 250 turns. What current would be needed in coil to produce a flux of 0.8 Wb in the gap? Assume that μ_r = 400 & leakage factor is 1.2

Soln Given,

mean length (l) = 1.5m

cross sectional area (A) = 0.01m²

air gap (l_g) = 4mm

$= 4 \times 10^{-3}$ m

no. of turns (N) = 250 turns

flux in air gap (ϕ_g) = 0.8 Wb

relative permeability (μ_r) = 400

leakage factor (K) = 1.2

since,

leakage factor is given

$\phi_{iron} = \phi_g \times k$

$= 0.8 \times 1.25$

$= 1\ Wb$

Then,

· total reluctance

$S_{tot} = S_{iron} + S_{gas}$

$S = \dfrac{l}{\mu_0 \mu_r A}$

$\Rightarrow \dfrac{1.5}{4\pi \times 10^{-7} \times 400 \times 0.01} + \dfrac{4 \times 10^{-3}}{4\pi \times 10^{-7} \times 1 \times 0.01}$

$= 616725.4045$ Amp turn/Wb

Thus,

$\phi_{iron} = \dfrac{NI}{S_{tot}}$

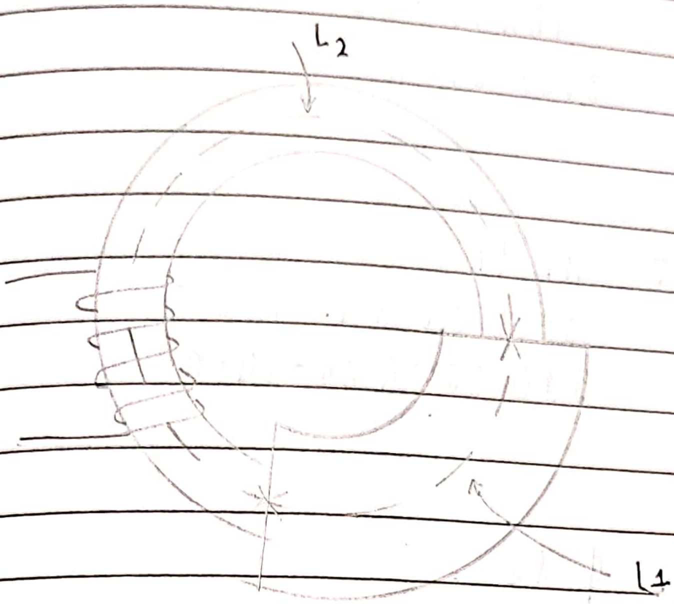
or, $I = \dfrac{\phi_{iron} \times S_{tot}}{N}$

$= \dfrac{1 \times 616725.4045}{250}$

$= 2.46 \times 10^3$ Amp

∴ The reqd. current is 2.46×10^3 Amp.

7. An uneven ring shaped core (as shown below) has $\mu_r = 100$ & flux density in larger section is 0.75 T. If current through the coil is 500 mA determine the no. of turns in the coil.



$l_1 = 10\ cm$, $A_1 = 6\ sq.cm$
$l_2 = 25\ cm$, $A_2 = 4\ sq.cm$

soln

Given,
relative permeability $(\mu_r) = 100$
flux density in larger section $(B_1) = 0.75T$
current through coil $(I) = 500\ mA$
$= 500 \times 10^{-3}\ A$

To find,
no. of turns $(N) = ?$

Thus,
we know,
$NI = Hl$

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we know,

$$B = \mu_0 \mu_r H$$

$$H_1 = \frac{0.75}{4\pi \times 10^{-7} \times 100}$$

$$= 5968.31 \text{ AT/m}$$

Then,

$$NI = H_1 l_1$$

$$= 5968.31 \times 10 \times 10^{-2}$$

$$= 596.83 \text{ Amp-turn}$$

- For AT_2

$$AT_2 = \frac{\phi \, l_2}{\mu_0 \mu_r A}$$

since its a series ckt, the flux is same

$$AT_1 = \frac{\phi \, l}{\mu_0 \mu_r A}$$

$$\phi = \frac{596.83 \times 4\pi \times 10^{-7} \times 100 \times 6 \times 10^{-4}}{10 \times 10^{-2}}$$

$$= 0.00045$$

Then,

$$AT_2 = \frac{0.00045 \times 25 \times 10^{-2}}{4\pi \times 10^{-7} \times 100 \times 4 \times 10^{-4}}$$

$$= 2238.116387$$

$AT_{total} = AT_1 + AT_2$

$= 2834.947424$

NI

or, $N = \dfrac{2834.947424}{500 \times 10^{-3}}$

$= 5669.89$

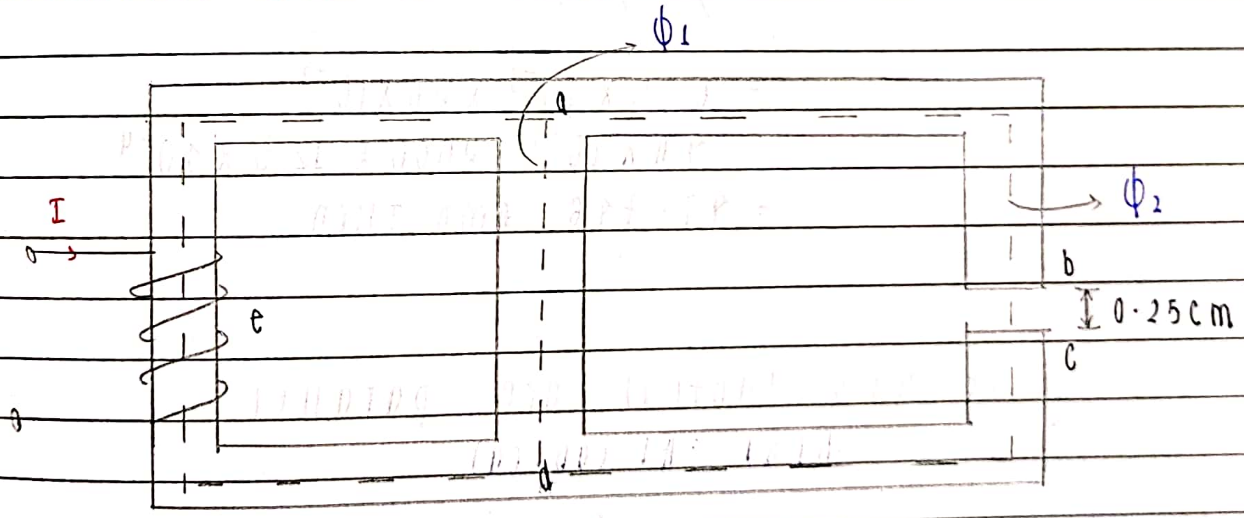
Rounding off

$\therefore N = 5670$ turns

$\therefore$ The no. of coils is 5670 turn

turn in

8 A mag. ckt shown below has cast iron whose dimensions are as below:



length of (ab + cd) = 50cm   A of (ab + cd) = 25 cm²

length of (ad) = 20cm   A of (ad) = 12.5 cm²

length of (dea) = 50 cm   A of (dea) = 25 cm²

Determine 'I' reqd. to produce flux of 0.75 mWb in central limb. N = 500 & μ_r = 20[illegible]

Given,

$$\phi_{ad} = 0.75\ mWb = 0.75 \times 10^{-3}\ Wb$$

no. of turns (N) = 500
relative permeability (μ_r) = 2000

We know,

$$AT_{tot} = AT_{dea} + AT_{ad}\ (\text{or } AT_{abtcd})$$

- For AT_{ad}

$$AT_{ad} = \frac{\phi_{ad} \times l_{ad}}{\mu_0 \mu_r A_{ad}}$$

$$= \frac{0.75 \times 10^{-3} \times 20 \times 10^{-2}}{4\pi \times 10^{-7} \times 2000 \times 12.5 \times 10^{-4}}$$

$$= 47.746 \text{ Amp-Turn}$$

Since ad & (abtcd) are parallel

$$AT_{ad} = AT_{(abtcd)}$$

$$\frac{\phi_2}{\mu_0 A}\left[\frac{l_{(abtcd)}}{\mu_r} + \frac{l_g}{1}\right]$$

50×10^{-2} $0.25 \times$[illegible]

$$\text{or, } \phi_2 = \frac{47.746 \times 4\pi \times 10^{-7} \times 25 \times 10^{-4}}{0.00275}$$

$$= 5.45 \times 10^{-5}\ Wb$$

$\therefore \quad \phi_{tot} = \phi_1 + \phi_2$

$= 0.75 \text{ mWb} + 5.45 \times 10^{-5}$

$= 8.05 \times 10^{-4} \text{ Wb}$

Then,

· For AT deg

$$AT_{deg} = \frac{\phi_{tot} \times l_{deg}}{\mu_0 \mu_r A}$$

$$= \frac{8.05 \times 10^{-4} \times 50 \times 10^{-2}}{4\pi \times 10^{-7} \times 2000 \times 25 \times 10^{-4}}$$

$= 64.0598$ Amp-turns

Then,

· $AT_{tot} = AT_{deg} + AT_{ad}$

$= 64.0598 + 47.746$

$= 111.8058646$ Amp-turns

We know,

$AT_{tot} = NI$

or, $I = \frac{111.8058}{500}$

$= 0.22$ amp

$\therefore$ The reqd. current is 0.22 amp.