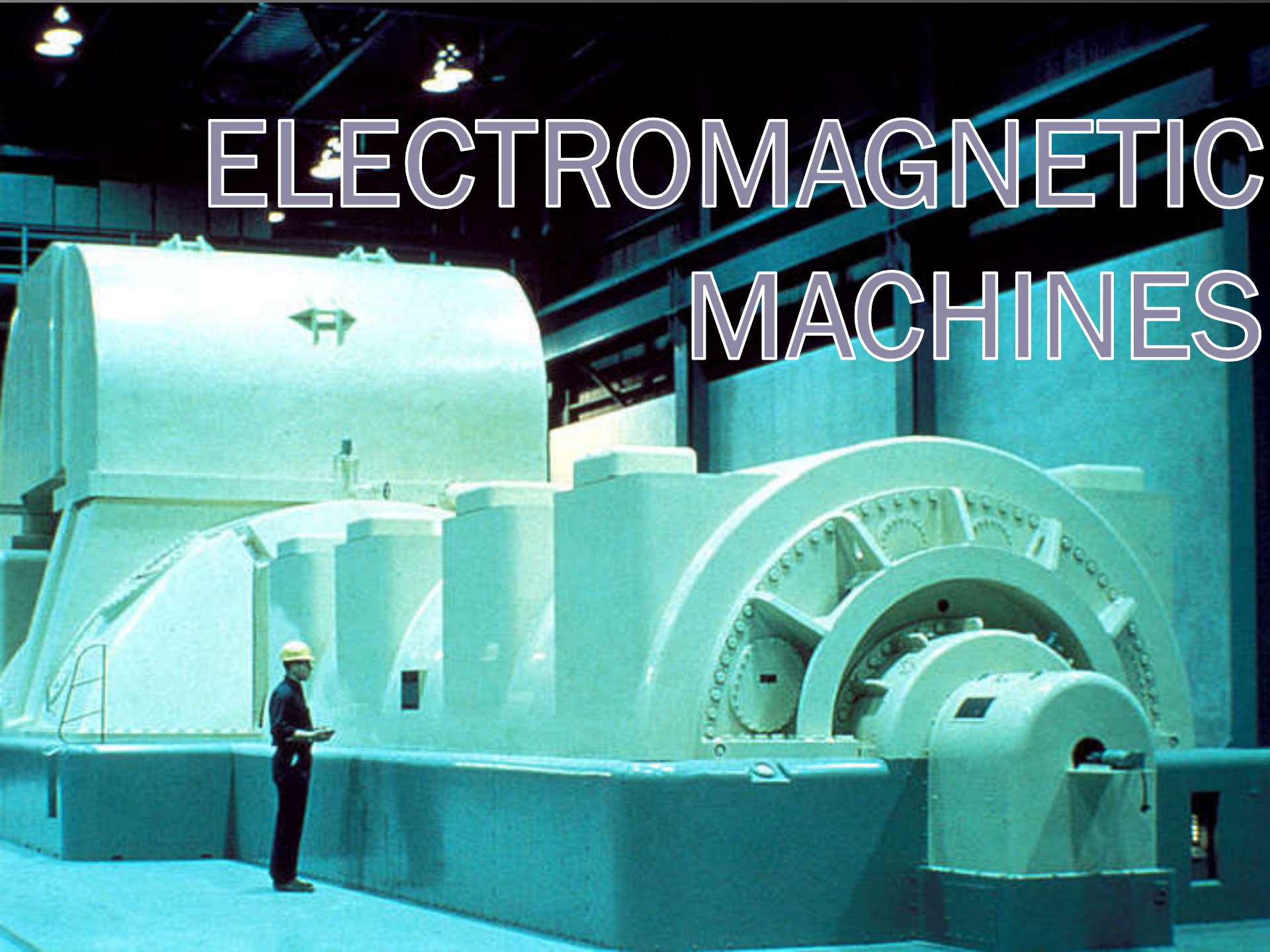
OGUN DIGICLASS

CLASS: SECONDARY SCHOOL

SUBJECT: PHYSICS

TOPIC: ELECTROMAGNETIC MACHINES

SUB-TOPIC: TRANSFORMERS


ELECTROMAGNETIC
MACHINES

Learning Outcomes

1

describe and explain the action of a transformer.

2

state how the number of coils relates to the voltage in an ideal transformer.

3

Carry out simple calculations involving transformers.

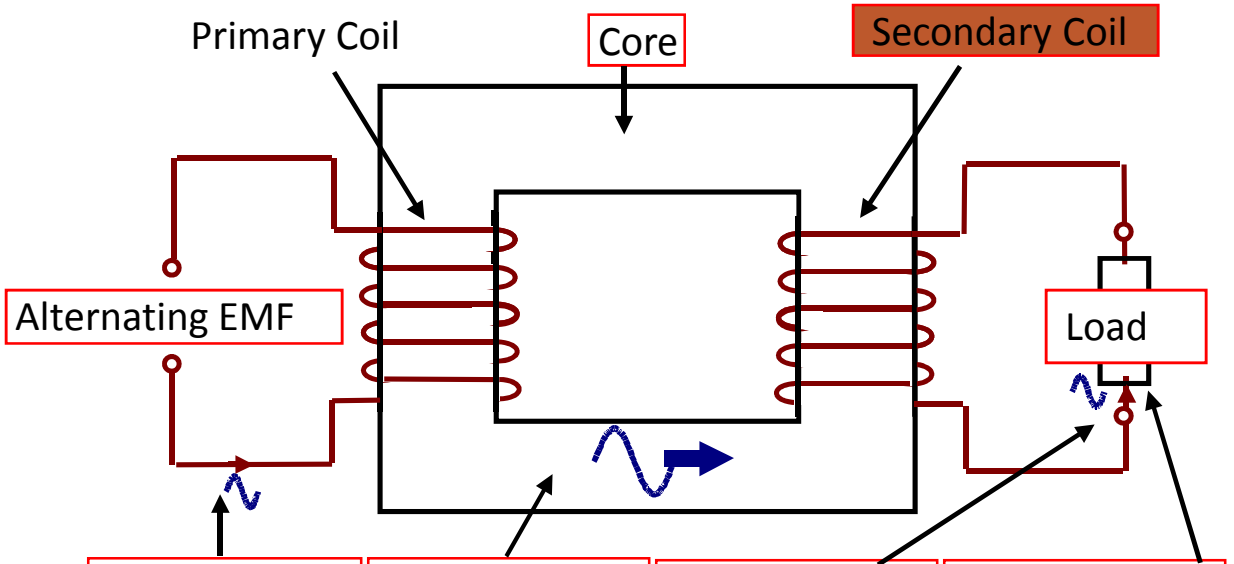
Transformers are electromagnetic machines are the workhorses of modern industrial society.

They generate, help to distribute and put into use the electrical power on which society depends.

- Faraday's iron ring apparatus directly links to transformers – modern transformers are also two coils wound around a common iron core.
- The conservation of energy states that if the emf is stepped up, the current must be stepped down.
- This reduces energy loss in cables.
- If a voltage of 400kV is used, the current needed to transmit 10MW of power is only 25A (the same as a car starter motor)

Transformers

Represented diagramatically:

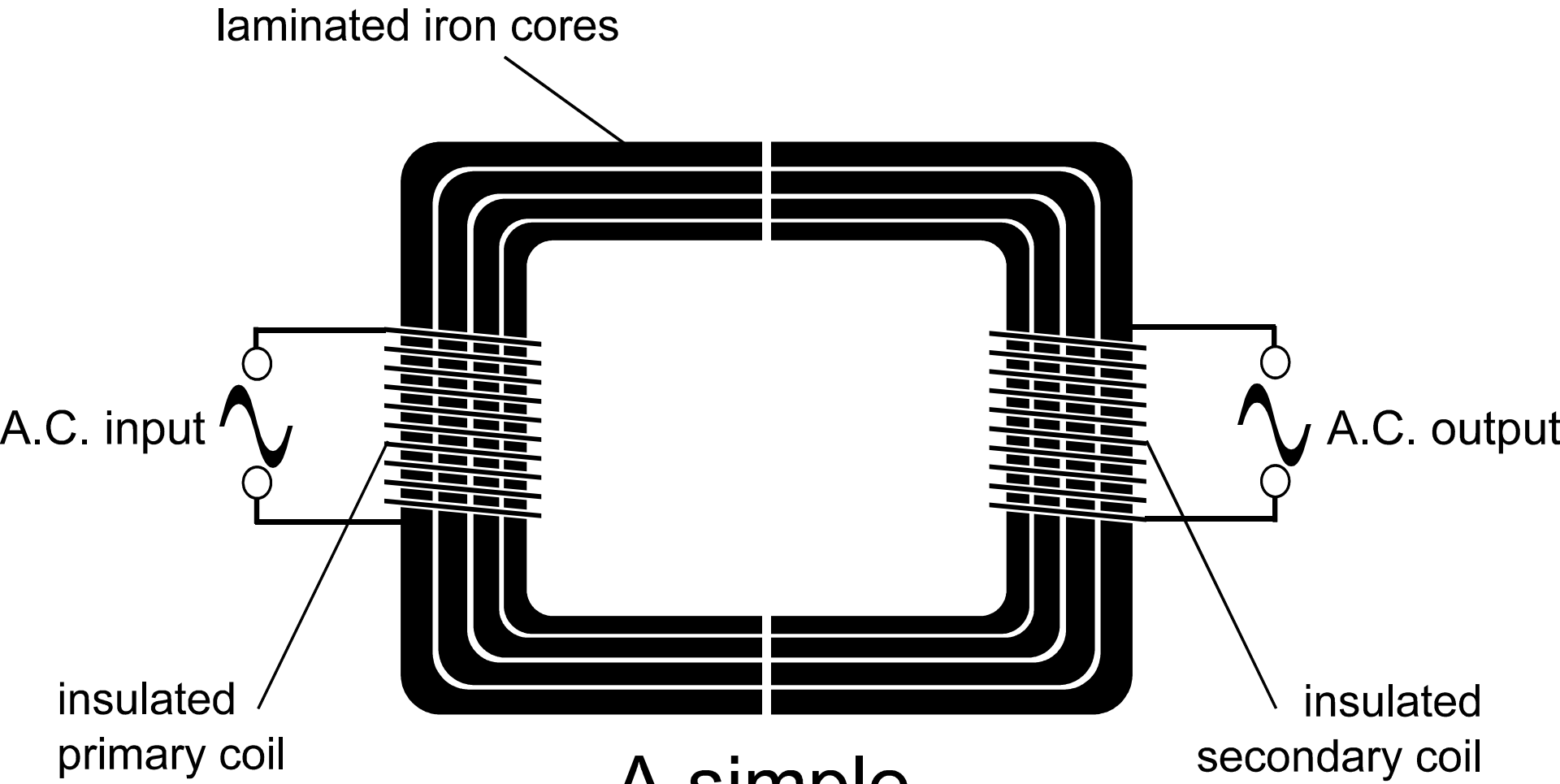


1.Alternating EMF causes alternating current in primary coil

2. This causes alternating magnetic field in the core

3. This causes alternating EMF at terminals of secondary coil

4. This causes alternating current in load.



A simple transformer.

Practical transformers

- Most transformers have the two coils on top of one another rather than side by side
- the core is *laminated* to reduce eddy currents and made of soft iron to allow easy magnetic reversals
- often transformers have multiple outputs allowing many voltages to be tapped off
- Transformers are very efficient but larger ones require cooling (usually with oil) hence we can often assume that:

- Power in = power out

$V_{in}\ I_{in} = V_{out}\ I_{out}$ or $V_P I_P = V_S I_S$

Why are transformers important?

They enable us to ‘step up’ or ‘step down’ voltages. This is done by having different numbers of coils on the primary and secondary coils.

It leads to the equation:….

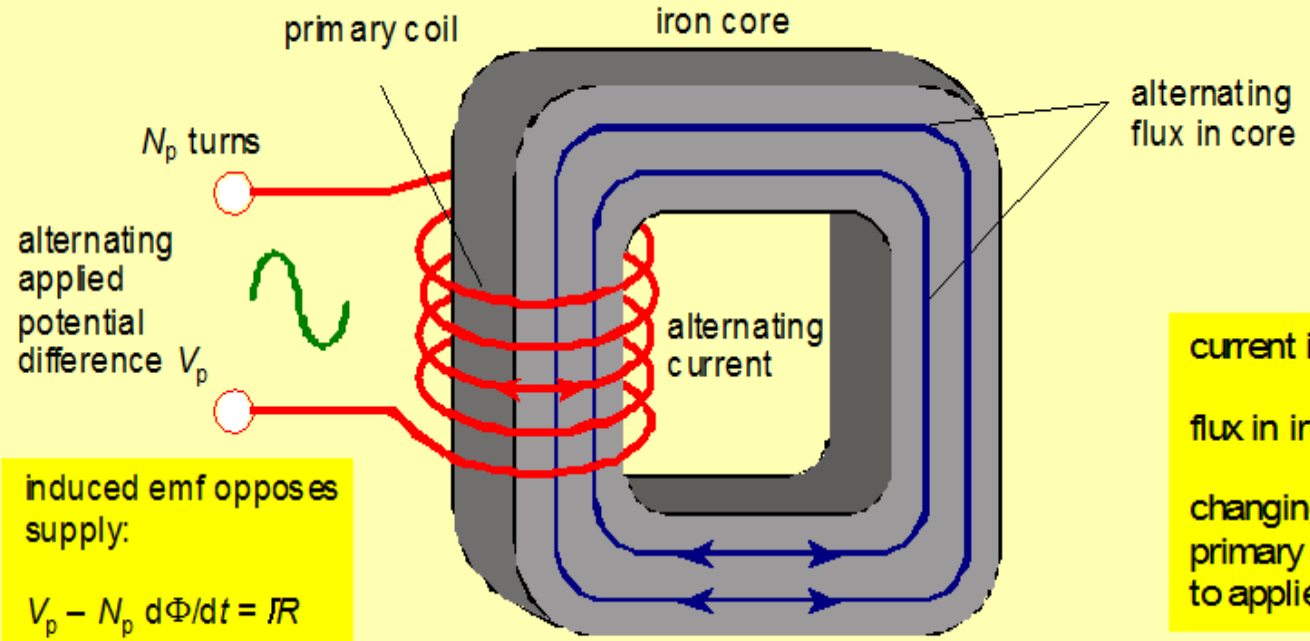
$$\frac{\text{Primary Coil Voltage}}{\text{Secondary Coil Voltage}} = \frac{\text{No. of turns on Primary Coil}}{\text{No. of turns on Secondary Coil}}$$

$\frac{N_P}{N_S}$ is sometimes known as the turns ratio

How a transformer works

Use alternating current so that current, flux and emf are changing all the time

Flux is changing in the primary coil



induced emf opposes supply:

$V_p - N_p \, d\Phi/dt = IR$

current in primary is changing all the time

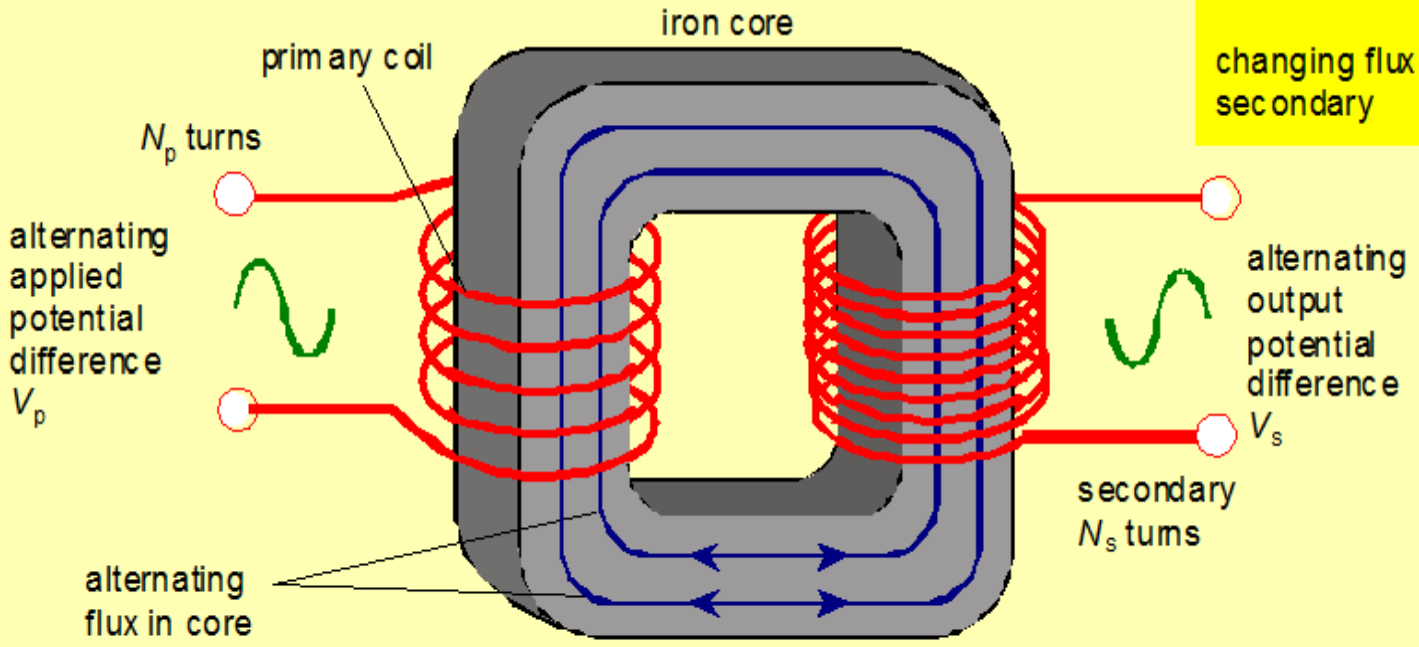
flux in iron is changing all the time

changing flux induces changing emf in primary approximately equal and opposite to applied emf

if primary resistance R is low:

then approximately: $V_p = N_p \, d\Phi/dt$

Flux is changing in the secondary coil



flux in iron is changing all the time

changing flux induces changing emf in secondary

if secondary resistance R is low and current drawn is relatively small:

then approximately: $V_s = -N_s \, d\Phi / dt$

Examples

The primary of a transformer is connected to an AC supply and the secondary connected to a bulb rated at 12V 36W.

There are 4000 turns on the primary and 200 turns on the secondary.

Calculate:

a) the supply voltage

b) The current in the primary

c) the power taken from the supply

(assume the transformer is 100% efficient)

a) 240v b) 0.15A c) 36W

SOLUTION

From transformer equation, i.e

(a) Es/Ep = Ns/Np

12/Ep = 200/4000

Ep * 200 =12*4000

Ep = 12*4000/ 200

Therefore, the supply voltage = 240v

For the current in the primary

Ns/Np = Ip/Is

4000/200 = Ip/Is

From P = IV

36 = Is * 12

Therefore, Is = 36 / 12 = 3amp

Now, if 4000/ 200 = Ip / Is and Is = 3amp

Then, Ip =4000 *3 / 200 = 0.15amp

(c) Power taken from the supply:

It is assumed that when the transformer is 100% efficient,

power input = power output

= 36W.

ASSIGNMENT

A transformer has 500 turns in the primary coil and 300 turns in the secondary coil.

If the primary coil is connected to a 220V mains, what voltage will be obtained from the secondary coil?

What type of transformer is it?