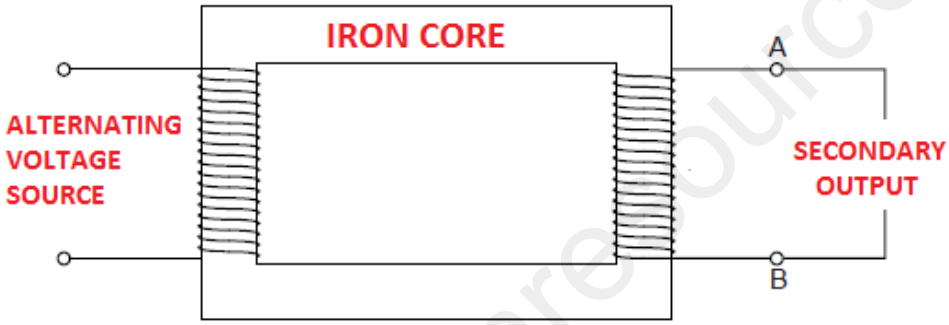
Transformers

Transformers:

Transformers are electrical devices consisting of two or more coils of wires used to transfer electrical energy by means of a changing magnetic field.

Construction and working of a transformer in general:



A transformer consists of two coils of insulated wires. Both the wires are wound around the same soft iron core. The coil connected to the alternating voltage source is referred to as the primary coil. The coil connected to the output is called as the secondary coil.

Working:

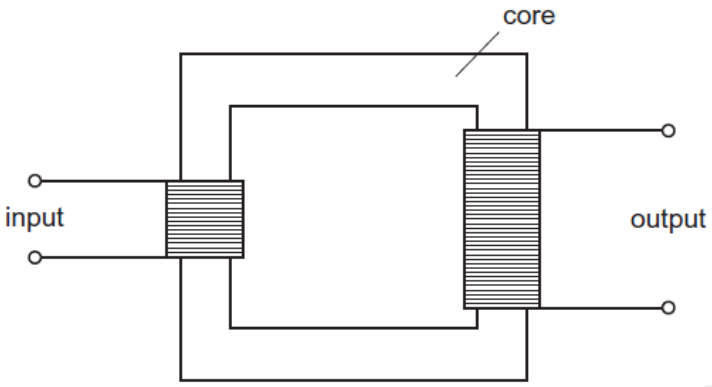
- When a voltage is applied across the primary coil, an alternating current is induced in the primary coil.
- This alternating current induces an alternating magnetic field in the soft iron core.
- These alternating magnetic field lines from the iron core cut the secondary coil and induce an alternating voltage across it.
- Thus electrical energy is transferred from the primary to the secondary coil. It is to be noted that the two coils are not connected to each other.
- If the core of the transformer is split and are separated by a considerable distance then the transformer does not work because the magnetic field does not get transferred from the primary to the secondary coil.

The transformer does not work on a DC voltage: This is because a constant voltage cannot cause electromagnetic induction.

There are 2 types of transformers:

- Step up transformers
- Step down transformers

Step up transformer: A step up transformer steps up the primary voltage. As a result the secondary voltage is greater than the primary voltage.



For a step up transformer:
The number of turns of secondary (N_s) are greater than the number of turns of the primary (N_p), so
The voltage of the secondary(V_s) > the voltage of the primary(V_p)

$N_s > N_p$ and $V_s > V_p$

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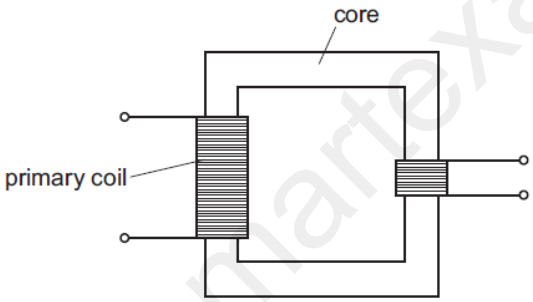
Step down transformer: A step down transformer steps down the primary voltage. As a result the secondary voltage is lesser than the primary voltage



For a step down transformer:
The number of turns of secondary (N_s) are lesser than the number of turns of the primary (N_p), so the voltage of the secondary(V_s) < the voltage of the primary(V_p)

$N_s < N_p$ and $V_s < V_p$

Uses of transformers:

- Transformers are used in low voltage supply units such as mobile phone charges to step down the alternating voltage from the mains down to the required voltage.

The transformer equation:

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

Where;

V_P = voltage applied to the primary coil
V_S = voltage applied to the secondary coil
N_P = number of turns of the primary coil
N_s = number of turns of the secondary coil

Equation to use when a transformer is 100% efficient:

$$I_P V_P = I_S V_S$$

Thus if a transformer is 100% efficient, the input power=output power.

Energy losses in the transformer may be due to:

- Heating up of the coil or the wires.
- Eddy current in the core or heat losses in the core
- Sound from the core or the coil.

Advantages of high voltage transmission:

High voltage transmission is much more efficient than transmission at much lower voltages. This is because by operating the grid at a high voltage, we can reduce the current in the cables and transfer the same amount of electrical energy every second through them. Thus less energy is wasted in the form of heat.

Note: The greater the efficiency, the lower is the energy wasted in the cables.

A step up or a step down transformer does not change the frequency of the output current.

Disadvantages of using transformers:

- **It has led to increased dependence on electricity**
- **It has led to the automation of industry, reducing demand for unskilled labour – loss of jobs**
- **Increased risk of electrocution**
- **Increased demand – increased burning of fossil fuels, causing decreased air quality and causing respiratory irritation.**

NUMERICALS:

(d) A 100% efficient transformer is used to step up the voltage of a supply from 100 V to 200 V. A resistor is connected to the output. The current in the primary coil is 0.4 A.

Calculate the current in the secondary coil.

O/N/05-P3-Q10

current = ... [2]

Solution:

Given:

- **The transformer is 100% efficient.**
- **Transformer is a step -up transformer.**
- **V_p=100V ; V_s=200V ; I_p=0.4A ; I_s=?**

$$I_P V_P = I_S V_S$$

$$I_S = \frac{I_P V_P}{V_S} = \frac{0.4 \; X \; 100}{200} = 0.2A$$

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11 A battery charger includes a transformer and a rectifier.

Fig. 11.1 represents the transformer, consisting of an iron core with two coils P and Q wound on to the core.

M/J/14-P33

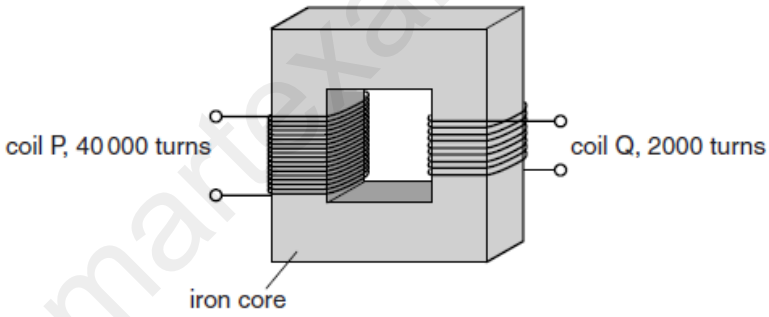


Fig. 11.1

P consists of 40 000 turns and Q consists of 2000 turns.

When P is connected to a 230 V a.c. supply, there is an e.m.f. across the terminals of Q.

(a) (i) Calculate the size of this e.m.f.

11 (a) (i) $(V_2=)V_1N_2/N_2$ **OR** 230 × 2000/40 000

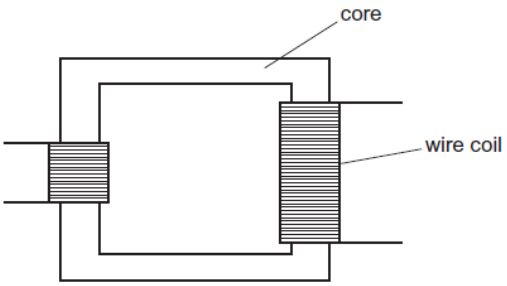
11/11.5/12 V

APPLICATION BASED QUESTIONS:

MCQ:

35 The diagram shows a transformer.

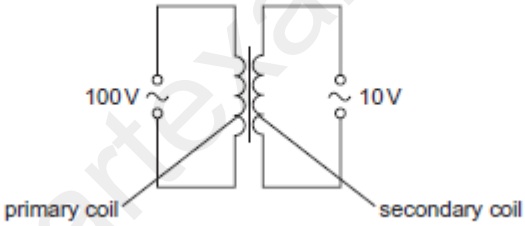
0625/13/O/N/13



Which materials are suitable to use in its construction?

	core	wire coil
A	copper	iron
B	iron	copper
C	steel	copper
D	steel	iron

35 A transformer is to be used to provide a 10 V output from a 100 V supply.

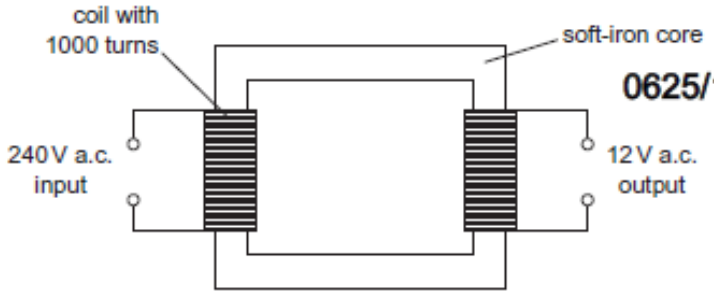


What are suitable numbers of turns for the primary coil and for the secondary coil?

	number of turns on the primary coil	number of turns on the secondary coil
A	100	1000
B	200	110
C	400	490
D	800	80

0625/11/O/N/09

35 The diagram shows a mains transformer that has an output voltage of 12V.



0625/13/M/J/13

How many turns of wire are in the secondary coil?

A 12 **B** 20 **C** 50 **D** 20 000

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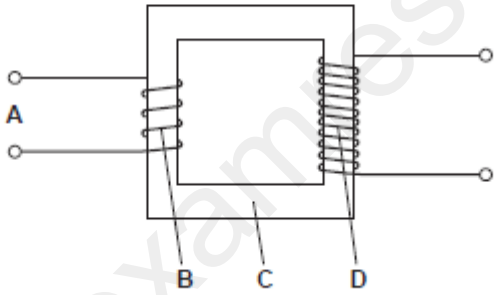
34 The diagram shows a simple step-down transformer used to decrease a voltage.

Which part is the primary coil?

0625/12/M/J/11



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35 A transformer has 15 000 turns on its primary coil and 750 turns on its secondary coil.

Connected in this way, for what purpose could this transformer be used?

A to convert the 8000 V a.c. output of a power station to 160 000 V for long-distance power transmission

B to convert the 160 000 V d.c. supply from a power line to 8000 V for local power transmission

C to use a 12V d.c. supply to operate a 240V razor

0625/11/M/J/10

D to use a 240 V a.c. mains supply to operate a 12 V motor

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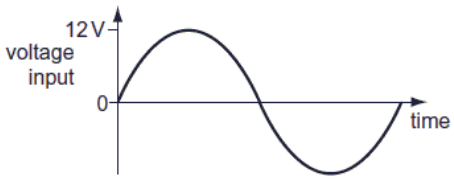
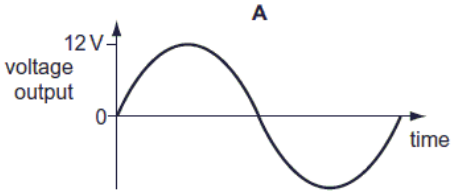
35 The graph shows the voltage input to a step-down transformer. 0625/01/O/N/06

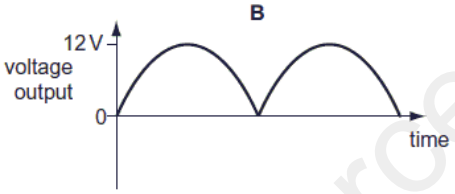


Which diagram shows the voltage output from the transformer?

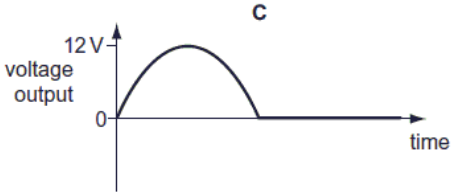
A



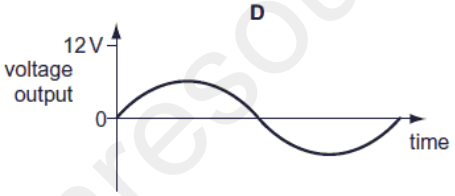
B



C

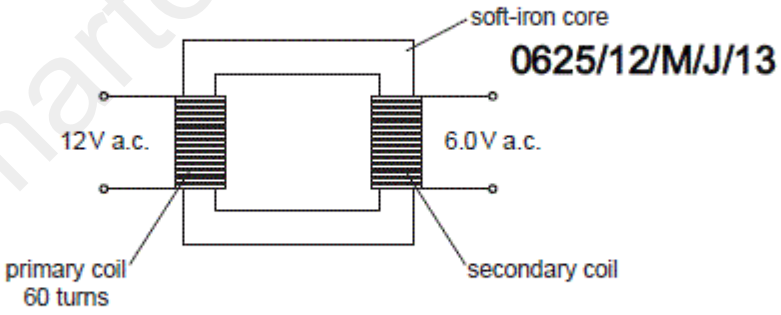


D



35 A student wants to make a transformer to step 12 V down to 6.0 V.

She winds 60 turns of wire around an iron core as shown in the diagram.



0625/12/M/J/13

How many turns of wire should she wind on the secondary coil of her transformer?

A 5 **B** 30 **C** 60 **D** 120

36 In the construction of a transformer, which items must be included?

0625/13/O/N/12

A an iron core and a permanent magnet

B an iron core and two coils of wire

C a steel core and a permanent magnet

D a steel core and two coils of wire

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34 A step-up transformer is used before electricity is transmitted by overhead cables.

Which statement explains why the step-up transformer is used?

A It increases the current to increase the speed at which the electricity travels.

B It increases the current to reduce energy loss in the cables.

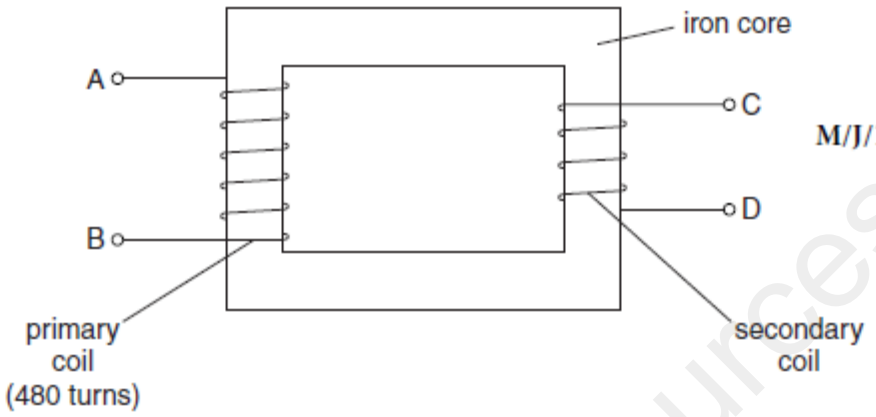
0625/11/O/N/15

C It increases the voltage to increase the speed at which the electricity travels.

D It increases the voltage to reduce energy loss in the cables.

EXTENDED THEORY:

8 **(a)** The transformer in Fig. 8.1 is used to convert 240V a.c. to 6V a.c.



M/J/10-P31

Fig. 8.1

(i) Using the information above, calculate the number of turns on the secondary coil.

number of turns = ... [2]

(ii) Describe how the transformer works.

.....

.....

.....

.....

..... [3]

(iii) State one way in which energy is lost from the transformer, and from which part it is lost.

..... [1]

(b) Fig. 8.2 shows a transformer. P is the primary coil. S is the secondary coil. The coils are wound on an iron core.

O/N/11-P31-Q8

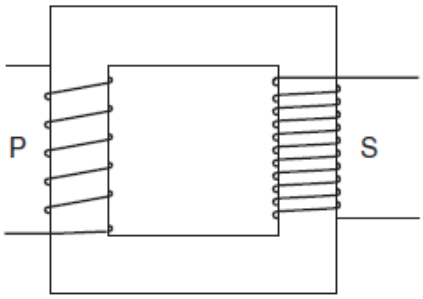


Fig. 8.2

P has 200 turns and S has 800 turns. The e.m.f. induced across S is 24 V. The current in S is 0.50 A. The transformer operates with 100% efficiency.

Calculate

(i) the voltage of the supply to P,

voltage = ...[2]

(ii) the current in P.

current = ...[2]

[Total: 7]

12 Overhead power cables supply electrical power to a town that is a considerable distance from the power station.

The voltage at which the power is transmitted in the cables is very much greater than the voltage at the power station and the voltage of the mains supply in the town.

M/J/14-P33

(a) Explain the advantage of transmitting electrical power at a very high voltage.

.....

.....

.....

.....

..... [3]

(b) It is suggested that the resistance of the cables can be changed by doubling their diameter.

(i) Explain the effect of this change on the resistance of the cables.

.....

.....

..... [2]

(ii) Suggest one disadvantage of doubling the diameter of the cables.

.....

..... [1]

[Total: 6]