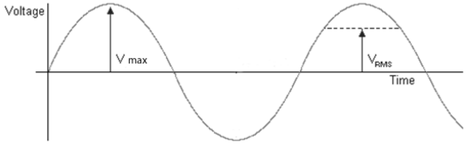
Mains Electricity

Definitions



Electricity Generation

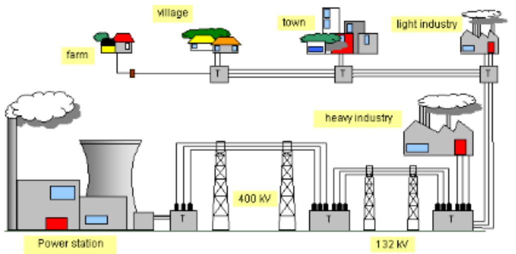
Electricity can be generated by a coil rotating with a constant angular velocity in a uniform magnetic field – This is what happens in nearly all power stations worldwide. I_{MAX} and V_{MAX} are the maximum values of the current produced when the movement of the coils is 90° to the magnetic field. Domestic Mains electricity in New Zealand is 240 V_{rms} 50Hz (although Mains electricity actually varies between + 340 V and – 340 V).
Due to energy losses at medium to high currents, electricity is converted to 330,000 Volts for transmission around NZ.

Two inductors linked by a common magnetic field are more commonly called a transformer.

Transformers can step-up or step-down Voltages with high efficiency. Effective inductors require **changing** currents so A.C. electricity is used for distribution of mains electricity for most of NZ

Equations

$\frac{N_p}{N_s} = \frac{V_p}{V_s}$	Number of turns on primary	N_p	-
	Number of turns on secondary	N_s	-
	Voltage across primary	V_p	V
	Voltage across secondary	V_s	V
$I = I_{MAX} \sin \omega t$	Current	I	A
	Maximum Current	I_{max}	A
	Angular frequency	ω	s^{-1}
	Time	t	s
$V = V_{MAX} \sin \omega t$	Voltage	V	V
	Maximum Voltage	V_{max}	V
	Angular frequency	ω	s^{-1}
	Time	t	s
$I_{MAX} = \sqrt{2}\, I_{rms}$	Maximum Current	I_{max}	A
	Root Mean Square Current	I_{rms}	A
$V_{MAX} = \sqrt{2}\, V_{rms}$	Maximum Voltage	V_{max}	V
	Root Mean Square Voltage	V_{rms}	V



Questions

THE TRANSFORMER (2016;2)

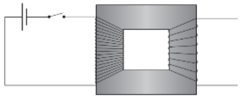
Transformers can be used to increase or decrease the size of an AC voltage. Wei has a transformer that is designed to convert 240 V into 12.0 V.

The secondary coil has 40 turns.

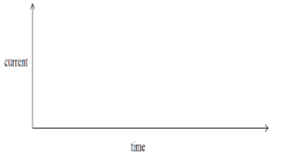
(a) Calculate the number of turns on the primary coil.

(b) Explain how an alternating voltage across the primary coil creates an alternating current in a light bulb connected to the secondary coil.

Each coil of a transformer acts as an inductor. A primary coil is attached to a battery and switch as shown in the diagram below. The switch is closed and then some time later the switch is opened.



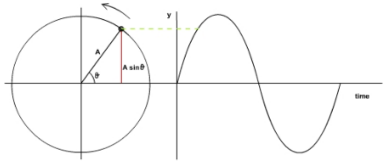
(c) Sketch a graph showing how the current in the coil changes when the switch is closed and then some time later is opened. Give a comprehensive explanation for the shape of your graph.



Terms

Tips

- Mains A.C. electricity can be described by drawing a sine wave with time period 0.02 s – it is best drawn using phasors.



Answers

(a)

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

$$N_P = \frac{V_P}{V_S} \times N_S = \frac{240}{12} \times 40 = 800 \text{ turns}$$

(b) An alternating voltage across the primary causes an an alternating magnetic flux in the core, which causes an alternating voltage in the secondary, which causes a current in the lamp

(c) When the switch closes, there is an increase in current which causes a back emf that opposes the current change. This causes the current to rise gradually. When the current reaches a maximum value, there is no flux change and no induced emf. The current is limited only by the resistance. When the switch opens, there is an open circuit; this means the current must drop to zero (almost) instantaneously.