# Basic Electrical Technology

## [ELE 1051]

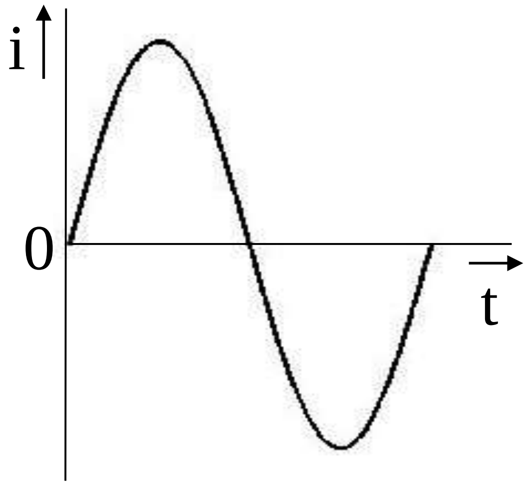
***CHAPTER 3 - SINGLE PHASE AC CIRCUITS***

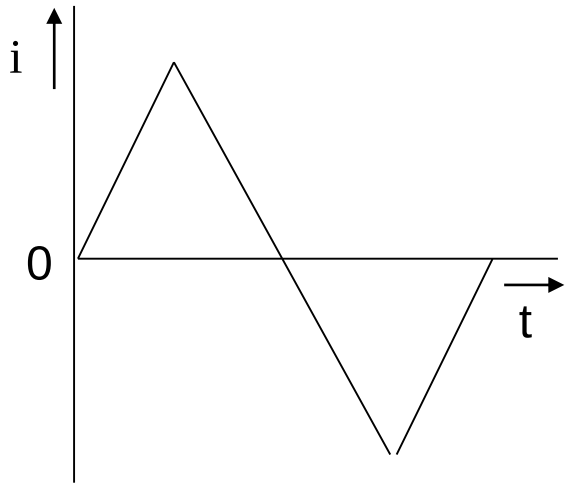
***(3.1)***

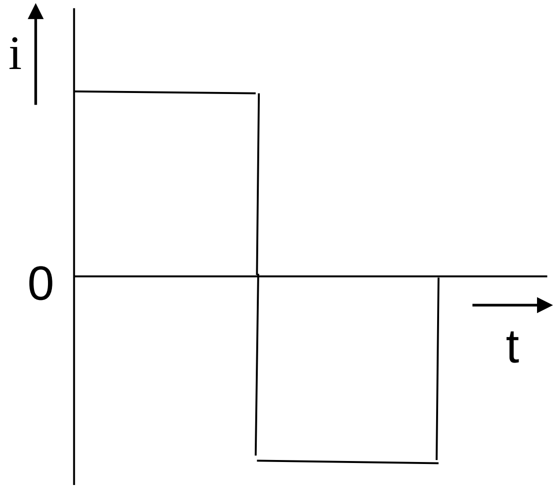
# Introduction

## ➢ Alternating Quantity

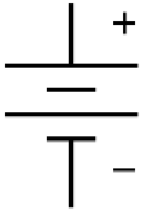
- An alternating quantity is time dependent or frequency dependent.
- The  direction changes  over every half cycle.
- Eg: Time varying voltage, current etc.



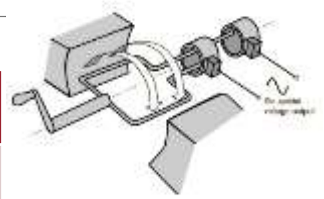



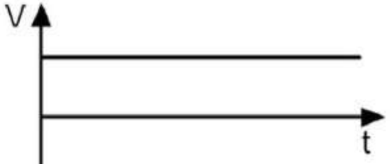



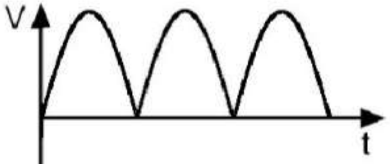
# DC vs. AC

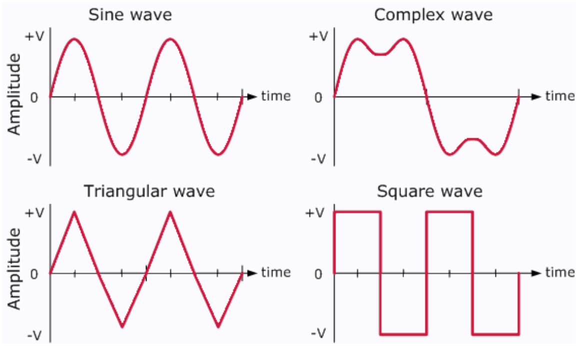



| | DC | AC |
|---|---|---|
| **Obtained from** | Battery / cell / derived from AC | AC Generator |
| **Polarity** | Positive and Negative | Oscillatory |
| **Frequency** | Zero | 50Hz or 60Hz |
| **Types** | Constant or pulsating | **Sinusoidal**, Trapezoidal, Triangular, Square |

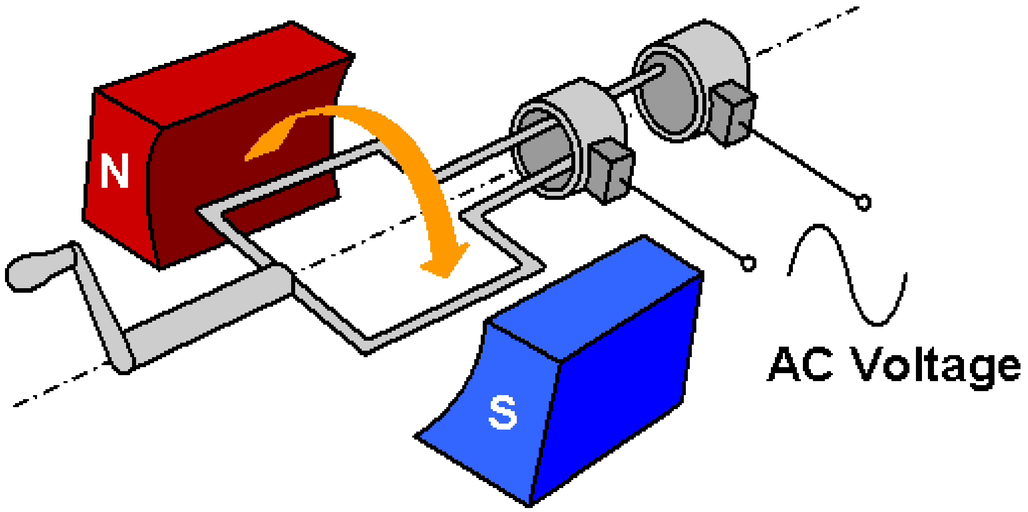


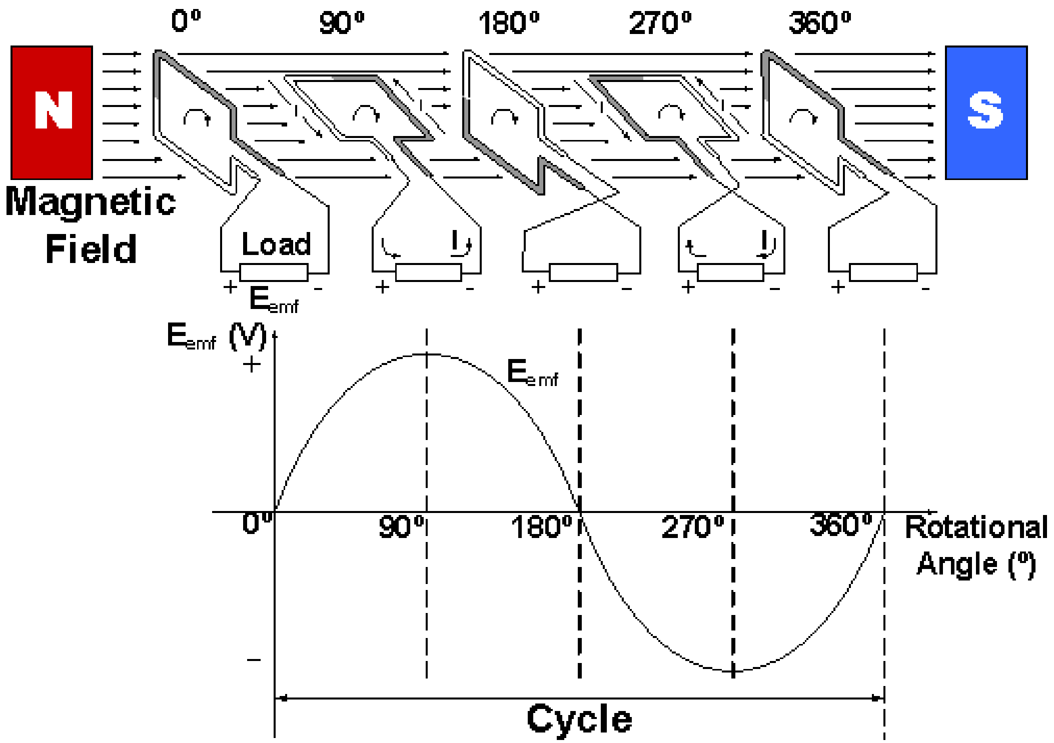



# Generation of Alternating EMF




Generator working principle



# EMF Equation

EMF induced per conductor is

$$e = B\,l\,v\sin\theta$$

EMF Induced in one turn of a coil is

$$e = 2\,B\,l\,v\sin\theta$$

If, b = width of the coil,

$$v = \pi\,b\,n$$ *'n' is the speed in revolutions per sec.*

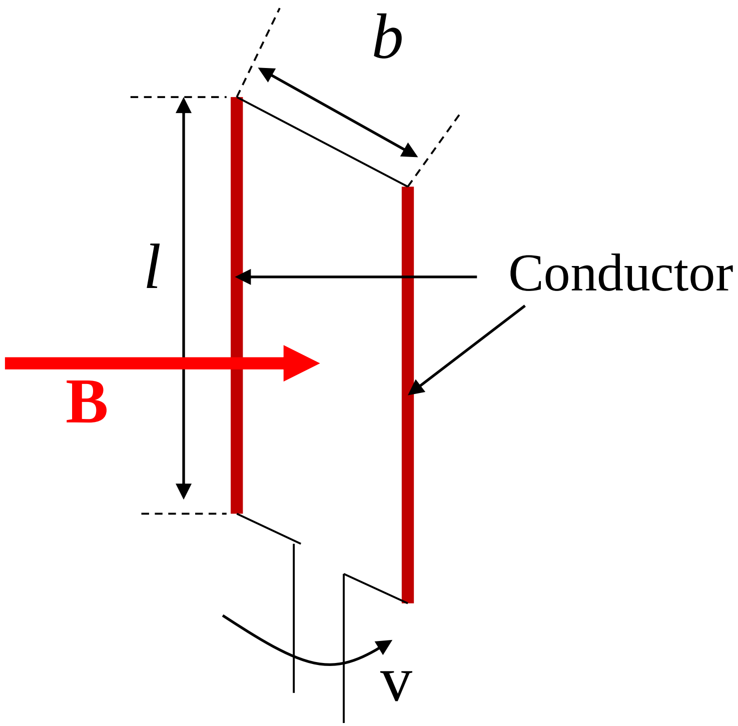
$$e = 2\,B\,l\,b\,\pi\,n\sin\theta$$

$$= 2\,B\,A\,\pi\,n\sin\theta$$

If there are N turns in the coil, the emf induced is,

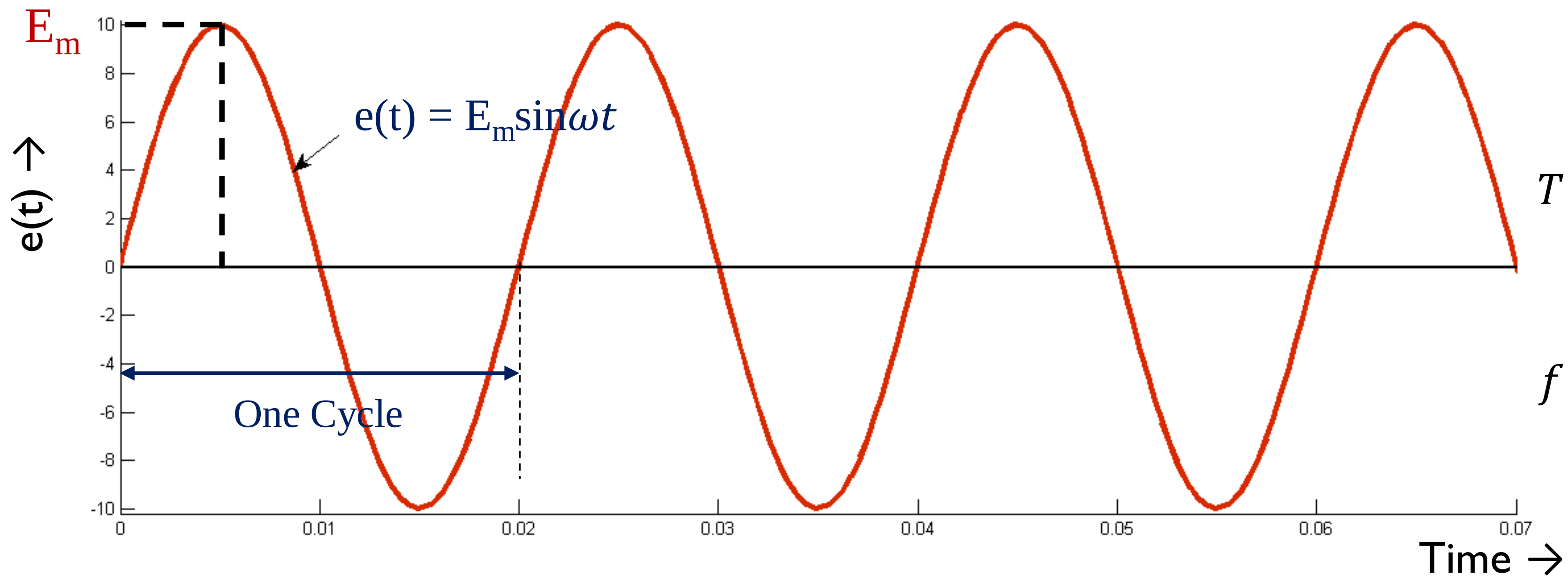
$$e = 2\,\pi\,n\,B\,A\,N\sin\theta$$

$$\boxed{e = E_m \sin\theta}$$




**Turn of a coil**

# Terminologies in AC waveform




$T = 0.02s$

$f = 50Hz$

**Cycle:** Each repetition of the alternating quantity, recurring at equal intervals

**Period (T):** Duration of one cycle

**Instantaneous Value (e(t)):** The magnitude of a waveform at any instant in time

**Peak Amplitude:** Maximum value or peak value of alternating quantity

**Frequency (f):** Number of cycles in one second (Hz) $\quad f = \frac{1}{T}$

# Average value of Sinusoidal Alternating Current

**Definition:** *"The average value of an alternating quantity is defined as that value which is obtained by averaging all the instantaneous values over a period of half cycle".*

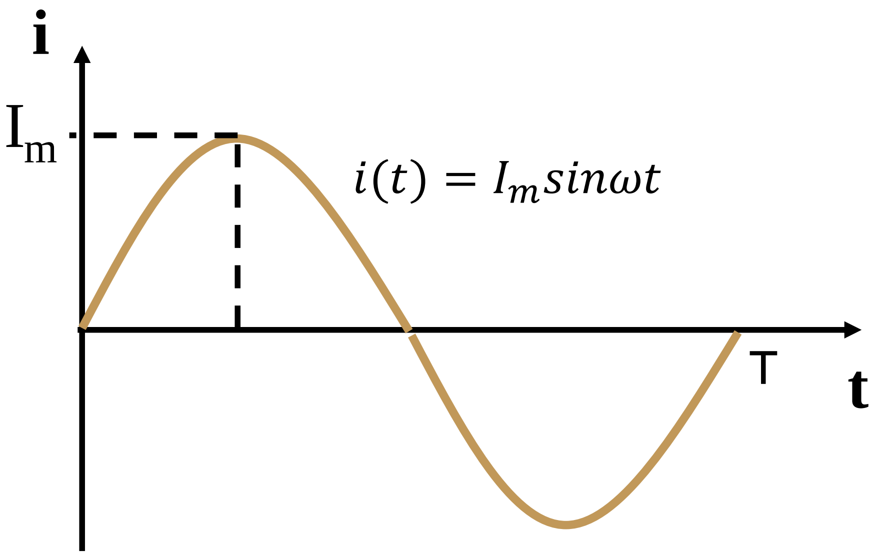
For a periodic function f(t) with period T,

$$\boldsymbol{F_{avg} = \frac{1}{T}\int_0^T f(t)dt}$$

For sinusoidal signal,

$$I_{avg} = \frac{1}{T/2}\int_0^{T/2} I_m \sin\omega t dt$$

$$\boxed{\boldsymbol{I_{avg} = \frac{2I_m}{\pi}}}$$



# RMS value of Sinusoidal Alternating Current

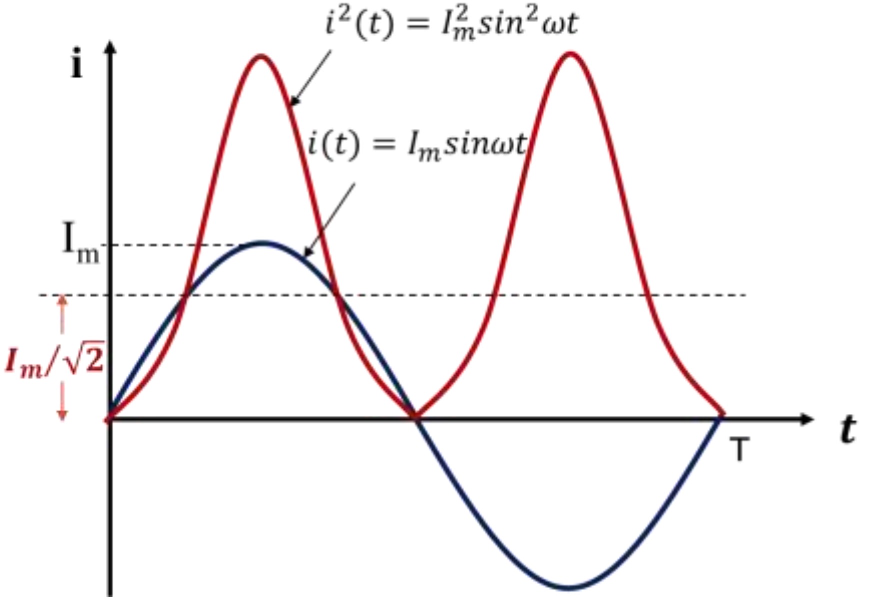
**Definition:** "*The RMS value is the square root of the mean (average) value of the squared function of the instantaneous values*".

For a periodic function f(t) with period T,

$$F_{rms} = \sqrt{\frac{1}{T}\int_0^T f^2(t)dt}$$

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T I_m^2 sin^2\omega t\ dt}$$

$$\boxed{I_{RMS} = \frac{I_m}{\sqrt{2}}}$$



$$Form\ Factor = \frac{RMS\ Value}{Average\ Value} = 1.11\ for\ sinusoidal$$

$$Peak\ Factor = \frac{Maximum\ Value}{RMS\ Value} = \sqrt{2}\ for\ sinusoidal$$

# Illustration 1

If an alternating voltage has the equation

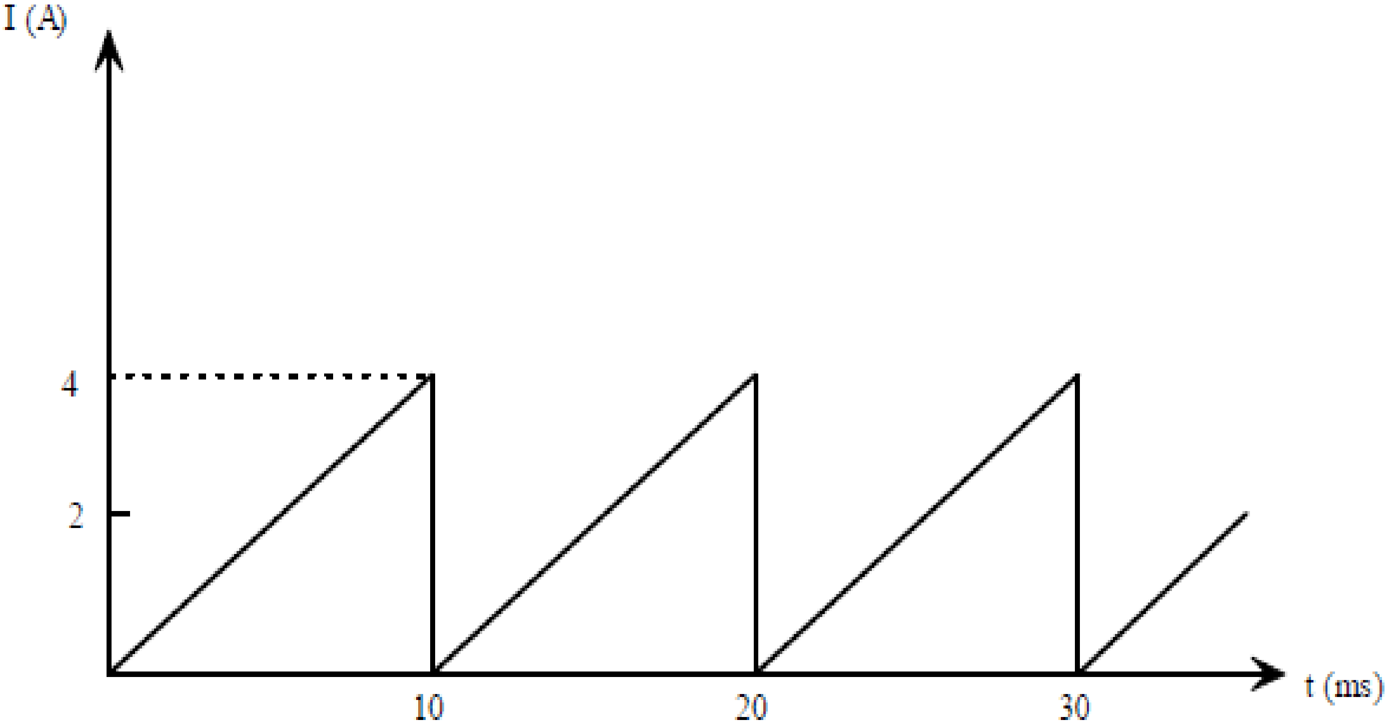
$$v(t) = 155.56 \sin 314t$$

Calculate:

a. Maximum voltage value
b. RMS value of the voltage
c. Frequency
d. The instantaneous voltage when $t = 3ms$

# Illustration 2

Determine the rms value, average value, and form factor of the current waveform shown in Fig.

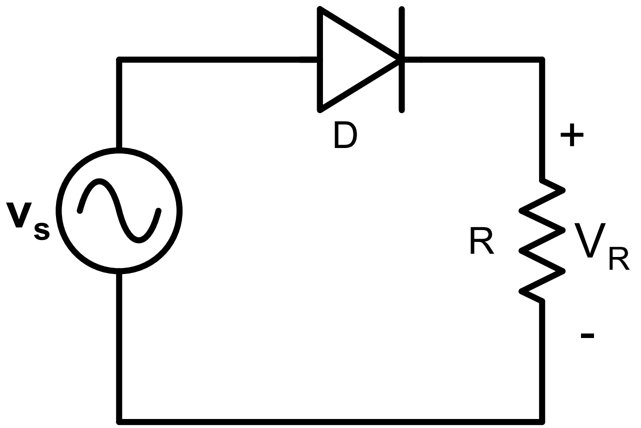



I avg = 2A

I rms = 2.3 A

# Illustration 3

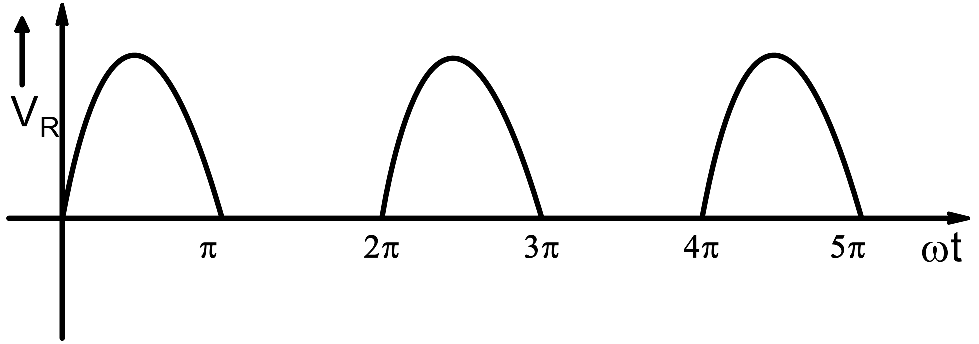
For the circuit shown below, sketch the voltage across the resistance, & then find the Average value and RMS value of the same.




Vavg = $\frac{2Vm}{\pi}$

Vrms = Vm/2

**Solution:**




***Average Value***

$$V_{avg} = \frac{1}{2\pi}\left[\int_0^{\pi} V_m \sin\omega t\,.d\omega t + \int_{\pi}^{2\pi} 0.d\omega t\right]$$

$$V_{avg} = \frac{V_m}{2\pi}(-\cos\omega t)_0^{\pi}$$

$$V_{avg} = \frac{-V_m}{2\pi}(-1-1)$$

$$\boldsymbol{V_{avg} = \frac{V_m}{\pi}}$$

***RMS Value***

$$V_{rms}^2 = \frac{1}{2\pi}\left[\int_0^{\pi} V_m^2 sin^2\omega t.d\omega t + \int_{\pi}^{2\pi} 0.d\omega t\right]$$

$$V_{rms}^2 = \frac{V_m^2}{2\pi}\left[\int_0^{\pi} \frac{1-\cos 2\omega t}{2}.d\omega t\right]$$

$$V_{rms}^2 = \frac{V_m^2}{4\pi}\left[\omega t|_0^{\pi} - \sin 2\omega t|_0^{\pi}\right]$$

$$V_{rms}^2 = \frac{V_m^2}{4\pi}[\pi]$$

$$\boldsymbol{V_{rms} = \frac{V_m}{2}}$$

# Thank You!