ETE 2200

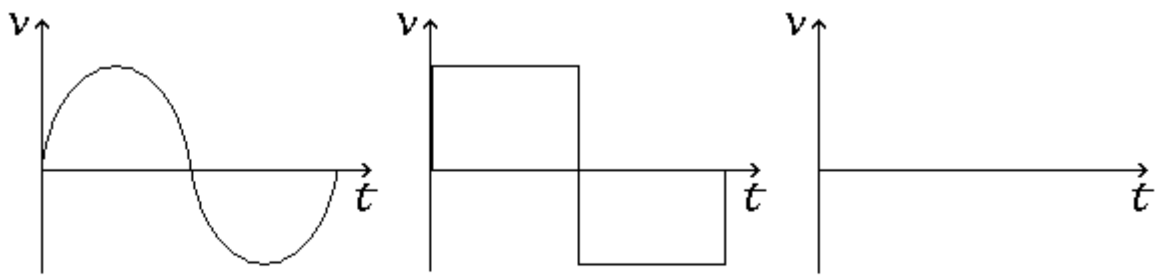
Enhanced Guided Notes: Set 11

Sinusoidal Waveforms

Topics:

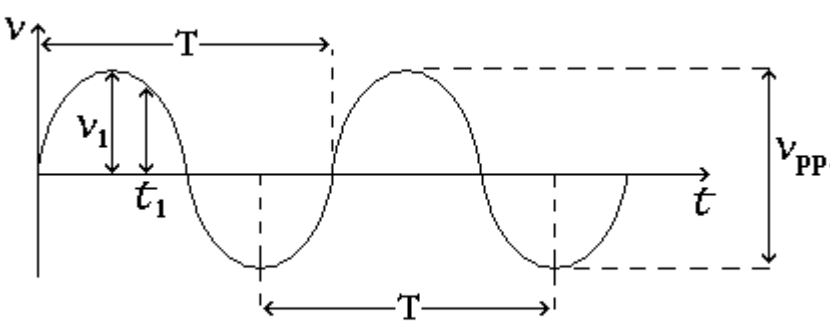
- **A.** **Circuits with Constant Sources**
- **B.** **Circuits Energized by Time-Varying Voltage or Current Sources**

Type Alternating Waveforms



Sinusoidal ________________ Triangular

Sinusoidal



Terms

- Waveform
- Instantaneous value
- Peak amplitude
- Peak-to-peak value
- Period
- Cycle

1 hertz (Hz) = (cps)

$$f = \frac{1}{T}$$

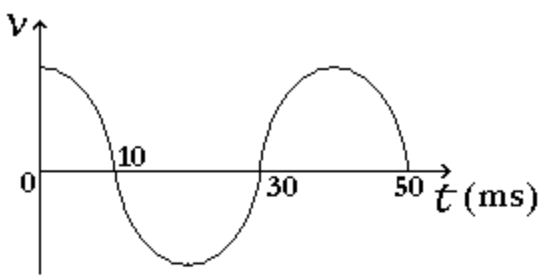
f = Hz
T = seconds (s)

$$T = \frac{1}{\quad}$$

★ What is the period of a periodic waveform with a frequency of 120 Hz?

T = _____________ =

★ What is the frequency of the waveform below?



f =

★ Low vs. High Frequency Waveforms in a graph

Low vs. High Amplitude Waveforms in a graph

★ Angular Frequency (□)

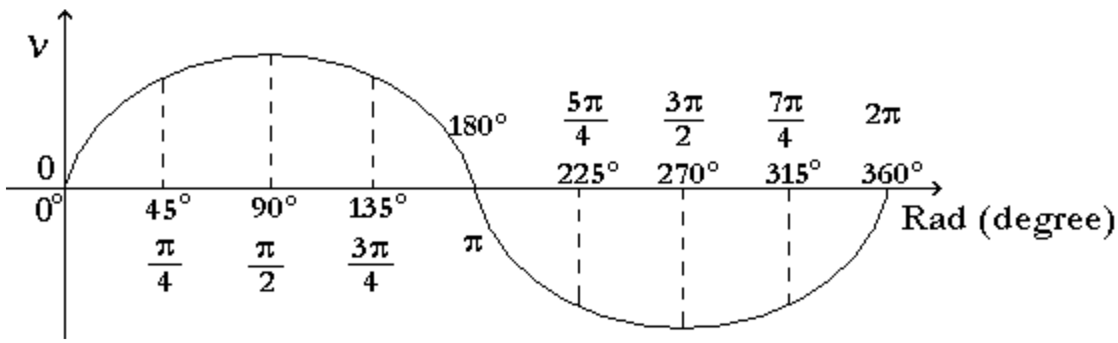
□ = 2□ f = $\frac{2\pi}{T}$ (Radians/second)

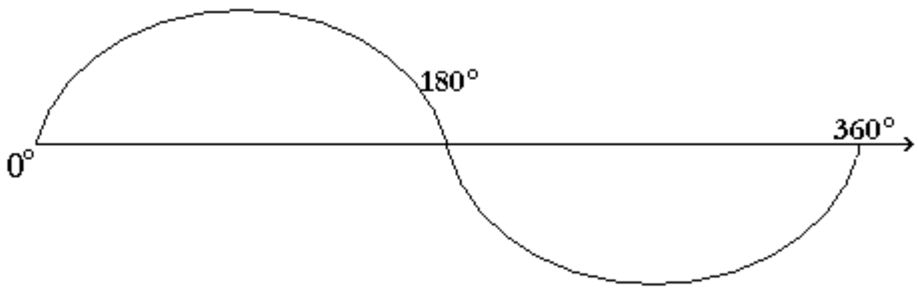
Radii

(number of Radians) = $\left(\frac{\pi}{180^\circ}\right)$ (number of degrees)

★ 90˚ = $(\frac{\pi}{180^\circ})$ 90˚ = □ / 2

★ 30˚ = =





$$\omega = \frac{\alpha}{t}$$

□ = angular velocity

□ = distance (degrees or radians)

□ =

t = seconds (time)

★ Given f = 60 Hz

Determine how long it will take the sinusoidal waveform to pass through an angle of 45˚

□ = and □ = = Rad =

Rad

2□ f = ~> t = ________________

= ________________

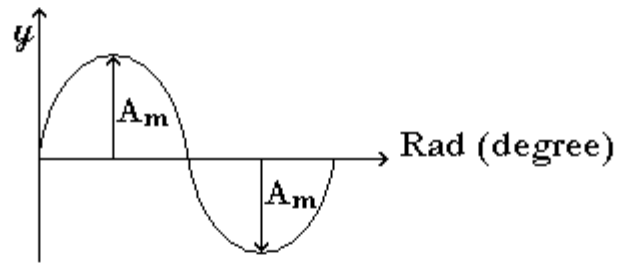
= _________ = ________ = ms

★ Find the angle through which a sinusoidal waveform of 60Hz will pass in a period of 5 ms.

□ = □ t = =

$\square = \qquad = \quad {}^{\circ}$

Sinusoidal Voltage/ Current



$y = A_m \sin$ □ if we want to express v or i,

$y = A_m \cos$ □ ∴ $v = V_m \sin$ □ $= V_m \sin$ □ t

$i = I_m$

Therefore

□ $= \sin^{-1} v/V_m$ or □ $= \sin^{-1}$ ________

★ Given $v = (30 * 10^{-3} \sin$ □$)$ V

Determine the angles at which v will be 6 mV

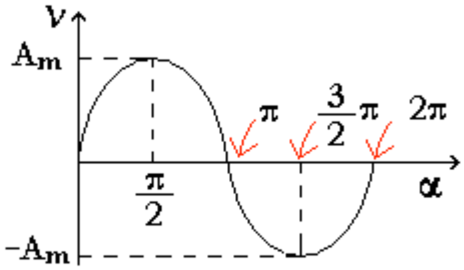
From the expression of v, we find $V_m =$

$$\alpha = \sin^{-1} \frac{v}{V_m}$$

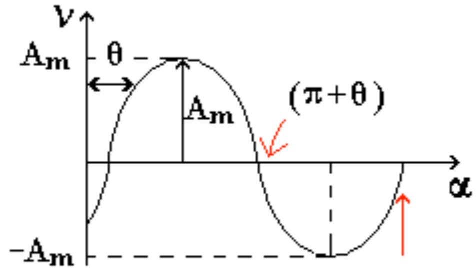
$$\alpha = \sin^{-1} \frac{6\,\text{mV}}{30\,\text{mV}} = \sin^{-1}$$

$$\alpha = 11.54° \text{ and}$$

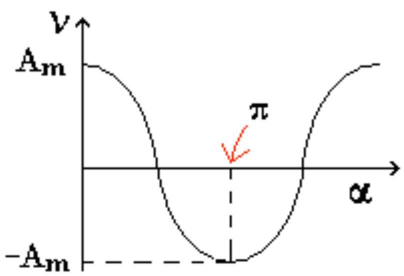
Why do we have two □ s?



$v = A_m \sin \omega t$



$v = A_m \sin(\omega t - \theta)$



$v = A_m \sin(\omega t + 90°)$

$v = A_m \sin(\omega t + \frac{\pi}{2})$

$v = A_m \sin \omega t$

Terms:

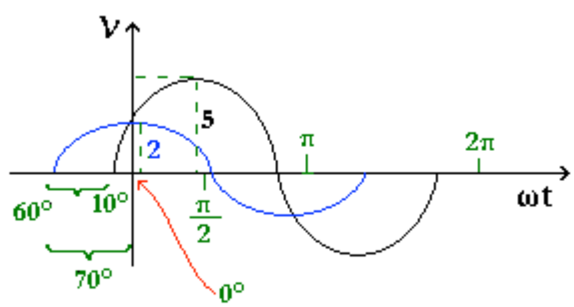
- Leads
- Lags
- In phase

What is the condition?

★ What is the relationship between v and i waveforms below:

a. v = 5 sin (□ t + 10°)

i = 2 sin (□ t + 70°)



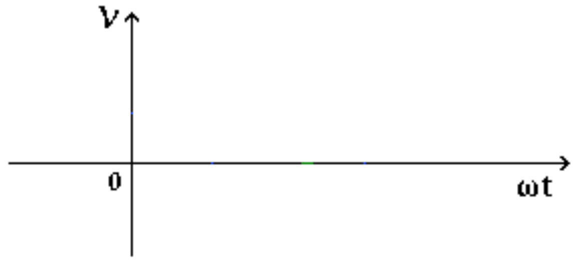
i leads v by 60°

or

v lags i by 60°

b. $i = 6 \cos (\square\, t + 10^\circ)$

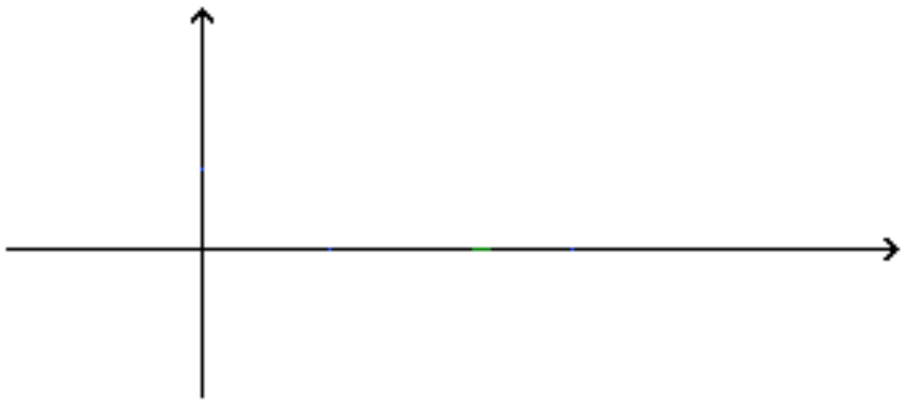
$v = 3 \sin (\square\, t - 15^\circ)$



______ leads ______ by ______
or
______ lags _______ by ______

c. i = -2 cos (□ t - 60°)

v = 3 sin (□ t - 150°)



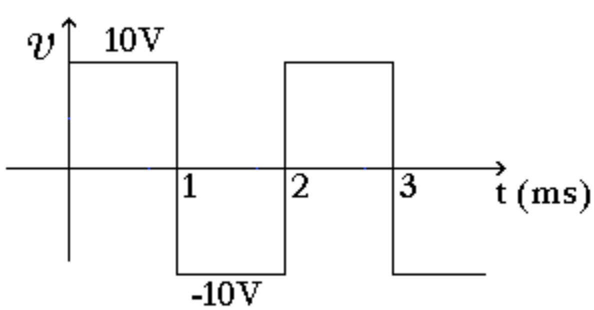
★ What is "Average Value"?

G (average value) = $\dfrac{\text{Algebraic sum of areas}}{\text{Length of curve}}$

★ What happens if some area contributions area from below the horizontal axis?

★ Determine the average value of the following waveforms:

a.

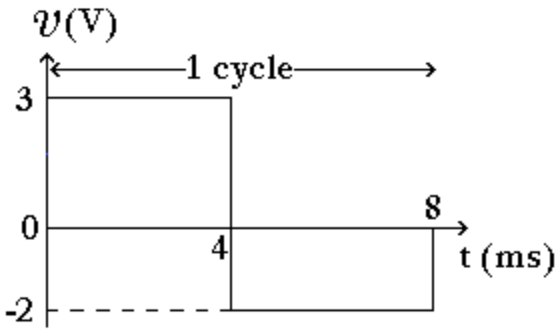


Any condition applied? What?

How to calculate

G = ________________________ = = V

b.

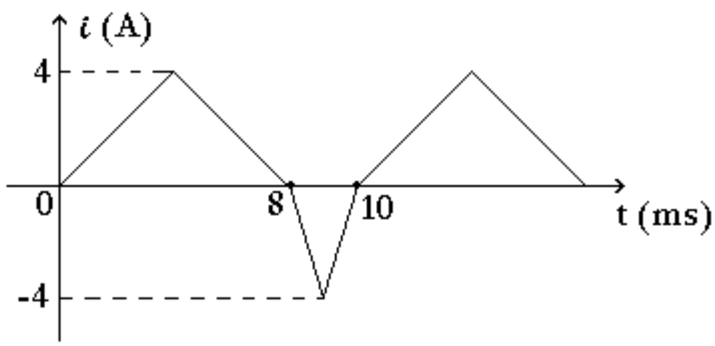


- Condition?

- How to calculate G?

G = ____________________________ = = V

c.

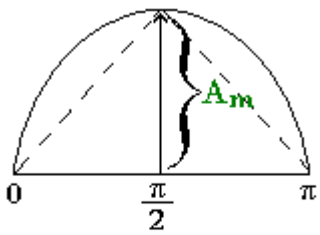


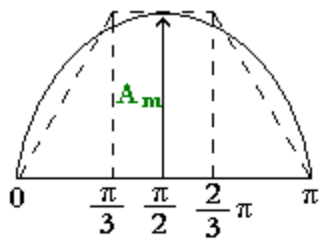
Conditions?

How to calculate G?

G = _____________________ =

For sinusoidal waveforms





Area = ½ b h

$$= \frac{(\pi)(A_m)}{2}$$

$\approx 1.584\ A_m$

Area = (□ + □/3) (1/2 A_m)

$$= \frac{2}{3}\pi\,(A_m)$$

$= 2.094\ A_m$

$$\text{Area} = \int_0^{\pi} A_m \sin\alpha\, d_\alpha$$

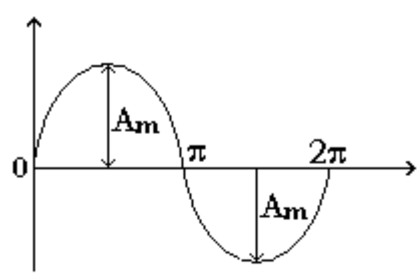
$$= A_m[-\cos\alpha]_0^{\alpha}$$

$$= \qquad\qquad =$$

∴ $\boxed{\text{Area} = 2\ A_m}$ ~> G = Area/□ = $2A_m$/□ = 0.637 A_m

Now,

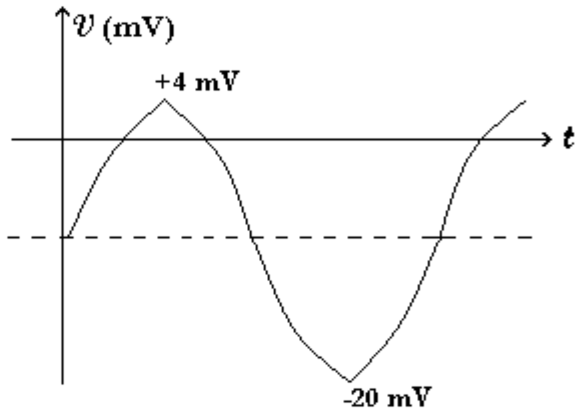
★ Determine the average value of the sinusoidal waveform.



Guess what would be the average time

Why?

What about this waveform?



Peak to peak = mV

Peak amplitude = mV

Average (dc level) = mV

Why?

<u>Effective (RMS) Values</u>

Why RMS value?

$P_{ac} = P_{dc}$

$P_{dc} = I_{dc}^2 \; R$

$= \; (I_m \sin \omega t)^2 \; R \; = \; (I_m^2 \sin^2 \omega t) \; R$

And

$P_{ac} \; =$

$\therefore \; I_{dc}^2 R \; =$

$I_{dc} = \dfrac{I_m}{\sqrt{2}} = 0.707 \; I_m$

$$\sqrt{\frac{\int_0^T i^2 (t) \, dt}{T}}$$

the area of $i^2(t)$

We can also express I_{RMS} =

What about $\mathcal{V}_{dc}$?

We can conclude: $I_{RMS} = \frac{1}{\sqrt{2}} \mathbf{I_m}$ =

V_{RMS} (E_{RMS}) =

Similarly, $I_m = \sqrt{2}\, I_{RMS} = 1.414\, I_{RMS}$

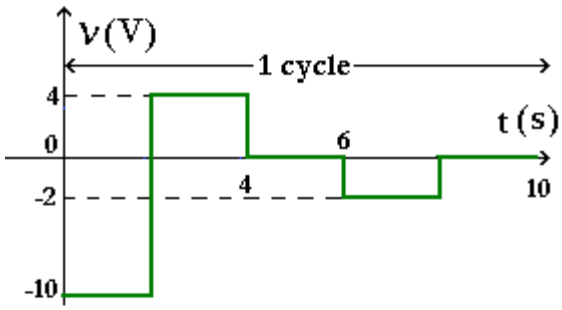
$V_m = \sqrt{2}\, V_{RMS}$ =

★ The 120 V_{dc} source delivers 3.6W to the load.
Determine the peak value of the applied voltage (V_m) and the current (I_m) if the ac source is to deliver the same power to the load.

What is the problem?

How to calculate?

★ Find the RMS value of the waveform below



$$V_{RMS} = \sqrt{\frac{\qquad}{\qquad}}$$

$= \qquad\qquad\qquad$ V

If you have a waveform that has a dc and an ac component, you should calculate the total RMS value using this formula

$$V_{RMS} = \sqrt{V_{dc}^2 + V_{ac}^2{}_{(RMS)}}$$