AC Fundamentals

Day 9

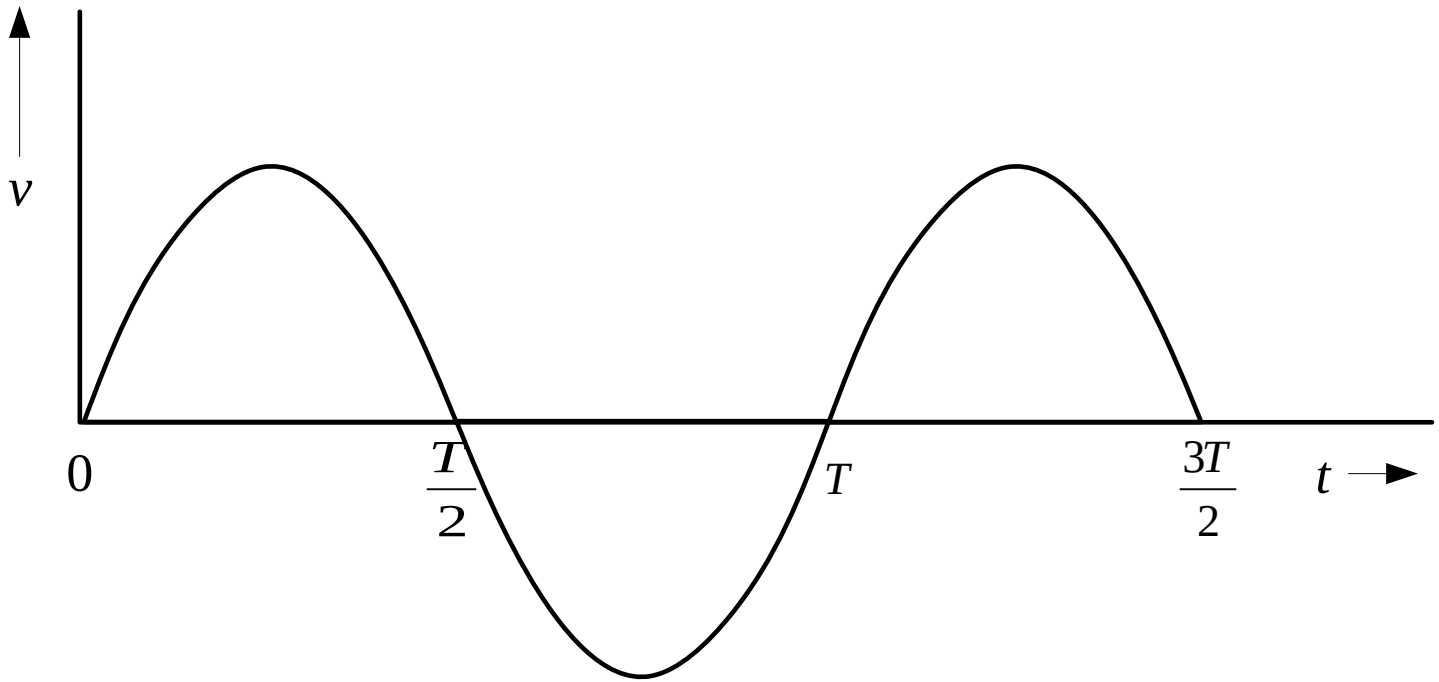
Phase angle of AC signals

ILOs – Day 9

- Define and explain phase angle of an AC signal
- Explain the concept of phase angle difference between two AC signals
- Explain the concept of phasor diagram
- For and purely resistive circuit with AC operation:
  - Draw the phasor diagram
  - Obtain expression for power

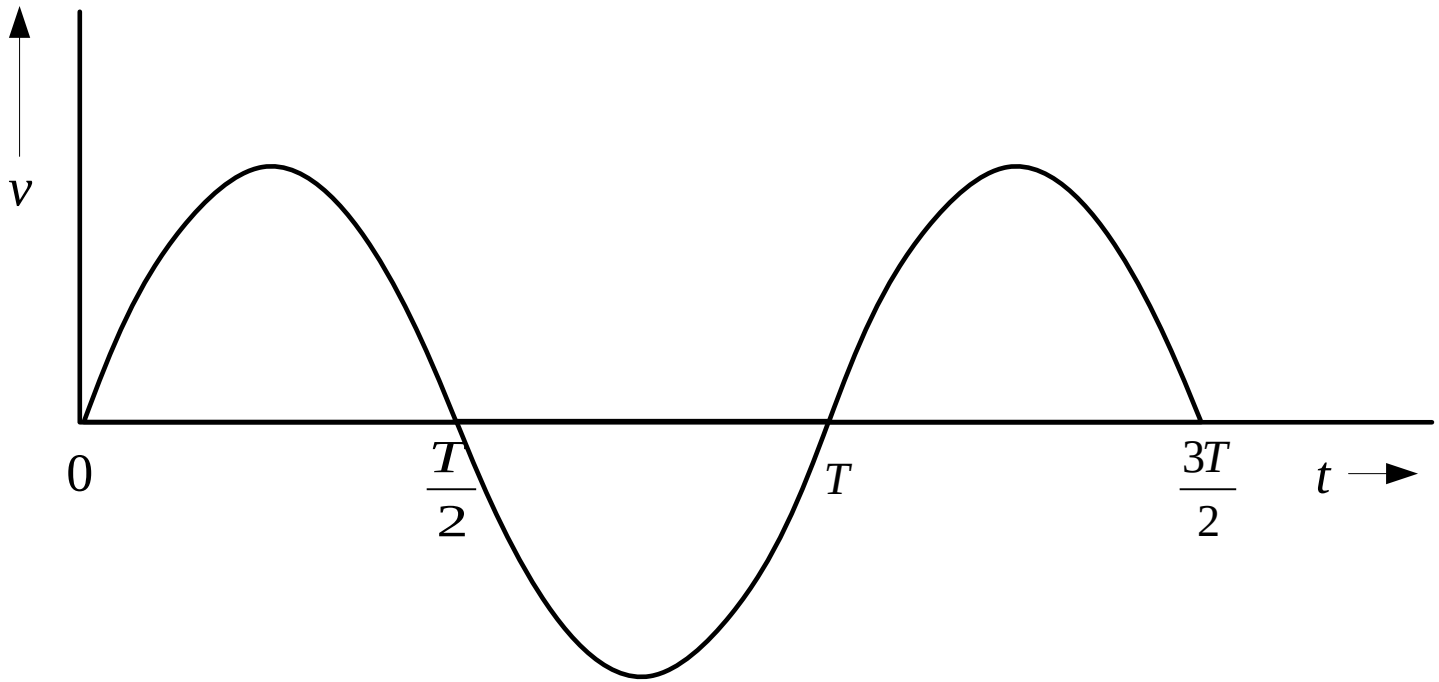
Phase angle of alternating signals

- The instantaneous value of an alternating voltage or current is different at different instants of time
- i.e. it varies continuously with time



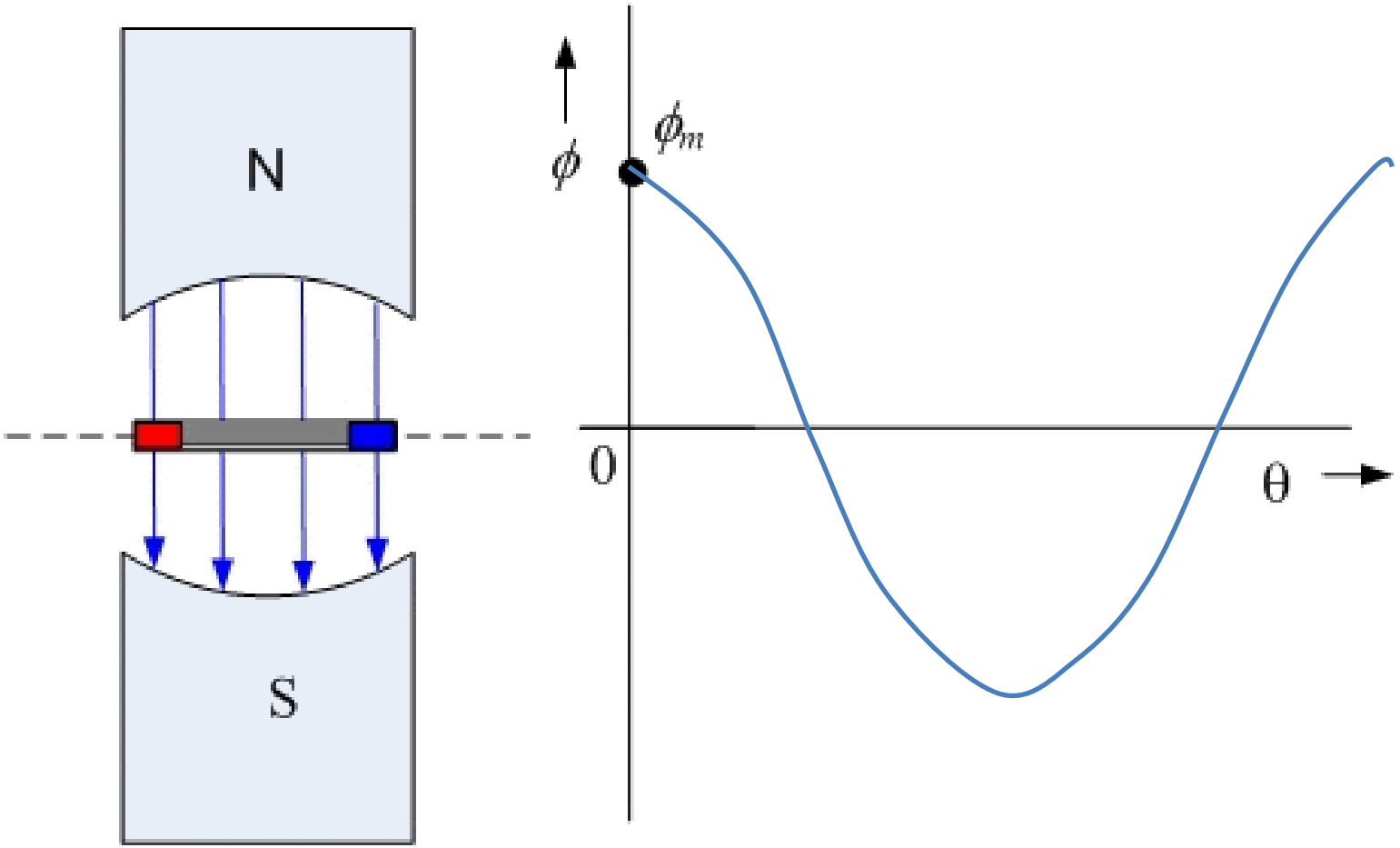
Phase angle of alternating signals

- The phase of an alternating signal is used to identify the state of its instantaneous value at a certain instant of time with respect to some origin (reference point)



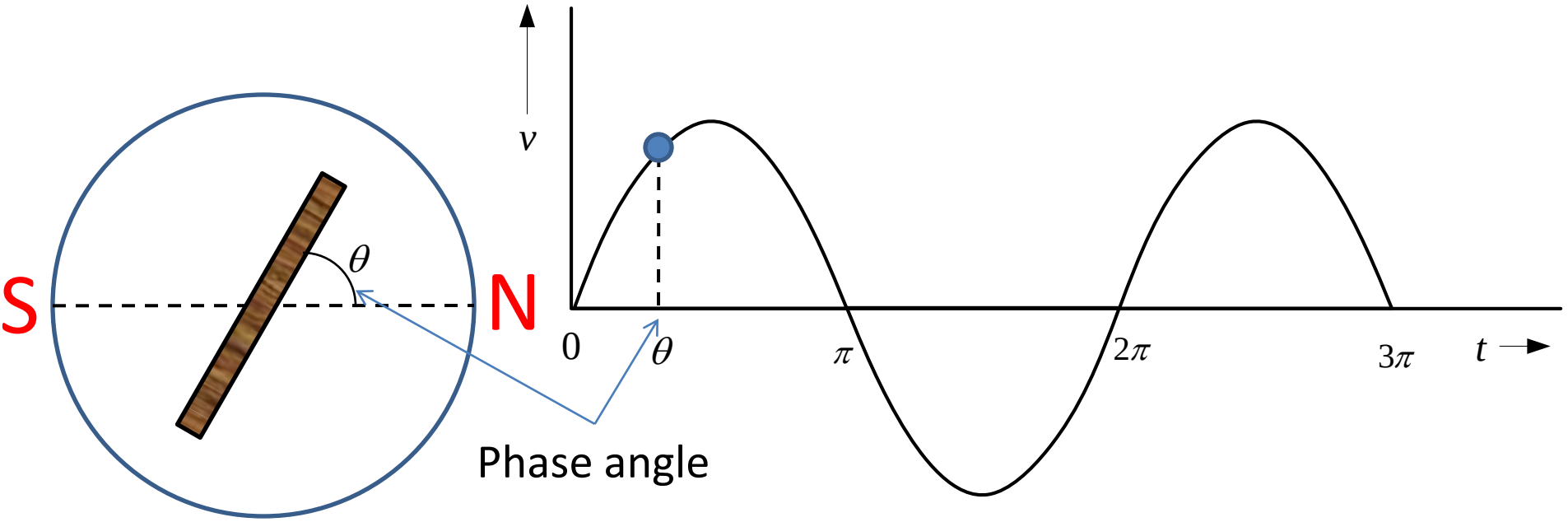
Phase angle of alternating signals

- Remember how AC signals were generated?
  - By rotation of a coil in a magnetic field



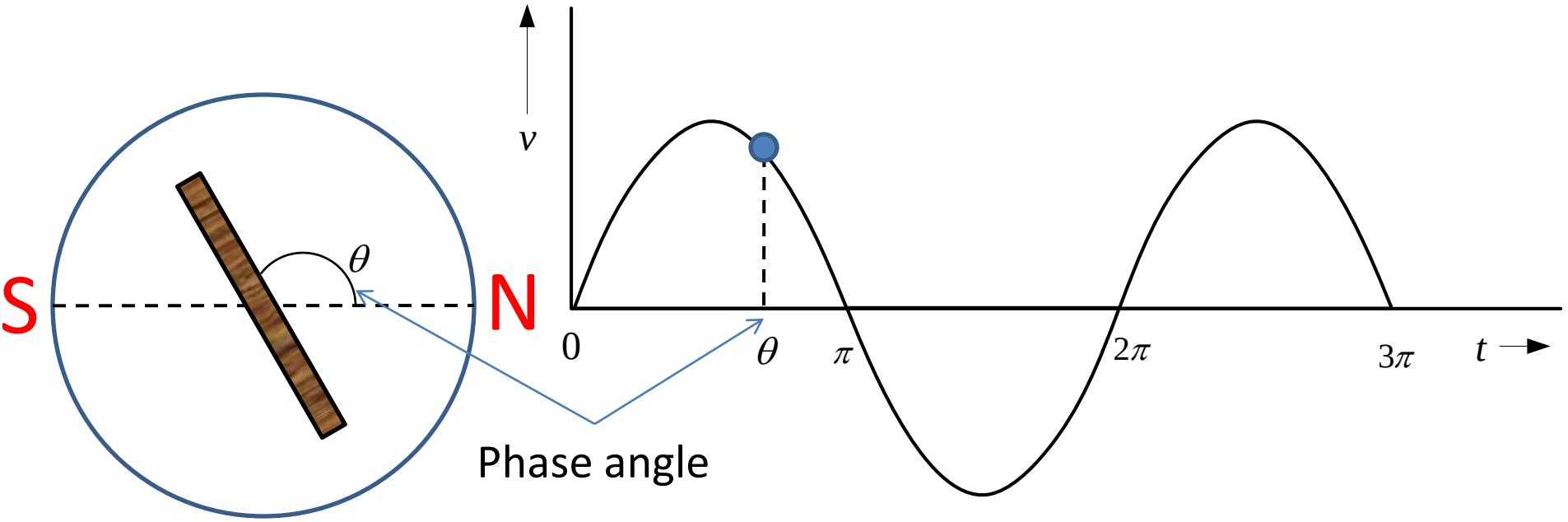
Phase angle of alternating signals

- Remember how AC signals were generated?
  - By rotation of a coil in a magnetic field
- Instantaneous phase angle is actually the angle made the rotating coil at that given instant with respect to a reference axis



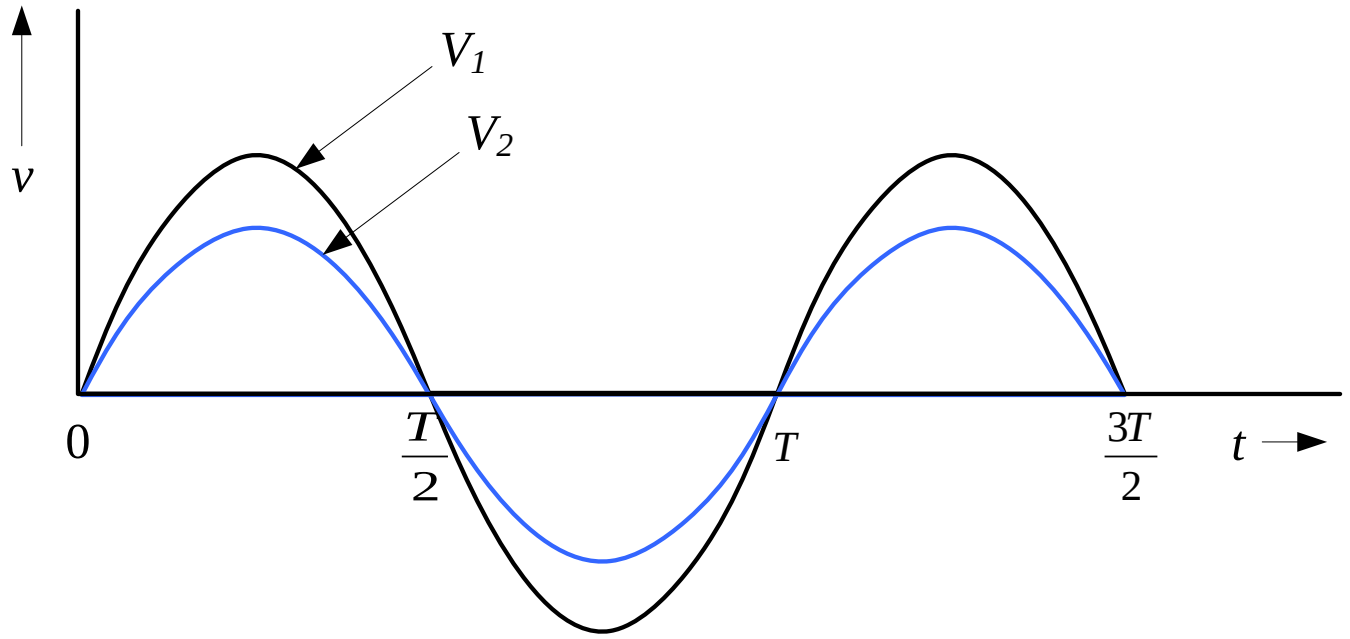
Phase angle of alternating signals

- Remember how AC signals were generated?
  - By rotation of a coil in a magnetic field
- Instantaneous phase angle is actually the angle made the rotating coil at that given instant with respect to a reference axis



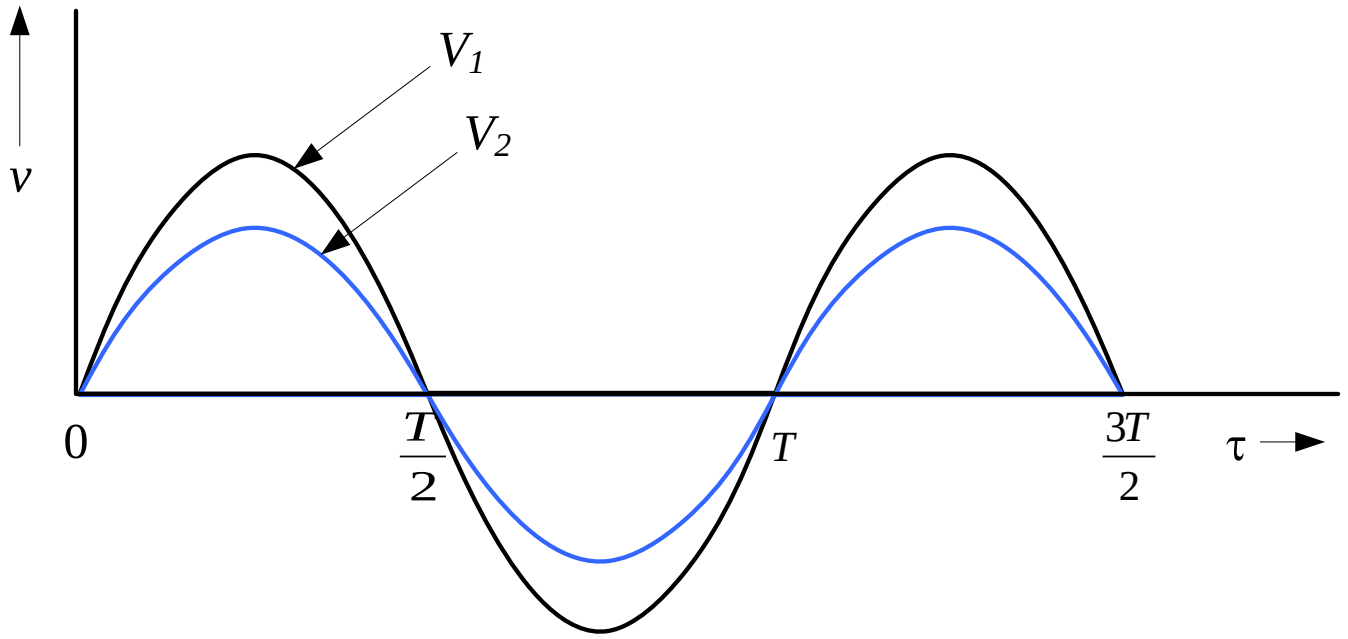
Phase difference of alternating signals

- When two or more such alternating waveforms attain their positive or negative peak (or zero) values at the same instant of time, they are said to be in the same phase (i.e. NO phase difference)



Phase difference of alternating signals

- Waveforms that are in the same phase, may or may not have the same magnitude, but they must have the same frequency, and hence the same time period



Phase difference of alternating signals

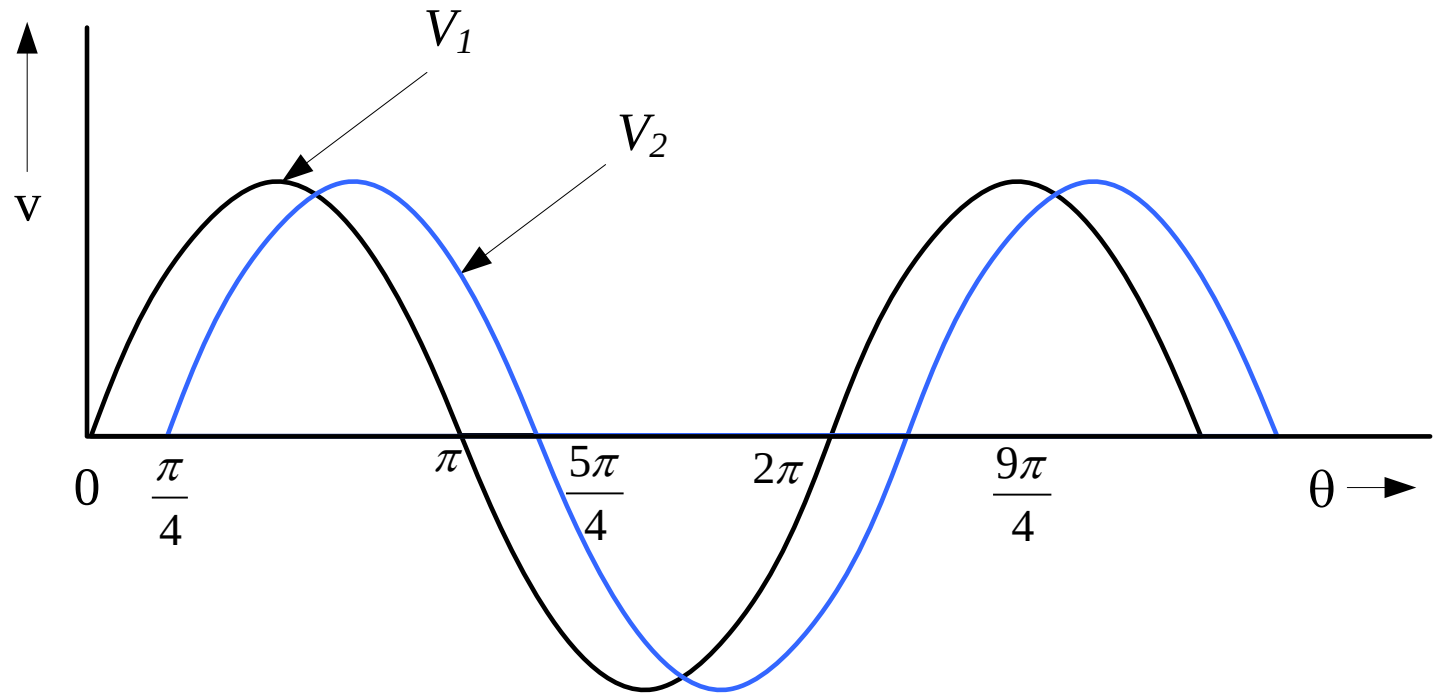
- Phase difference is the difference with respect to angle (or time), between two signals that have the same frequency

- Phase angle of both signals are measured with respect to the same reference

- Two signals that do not attain peak (or zero) at the same instant of time, are said to having certain phase difference

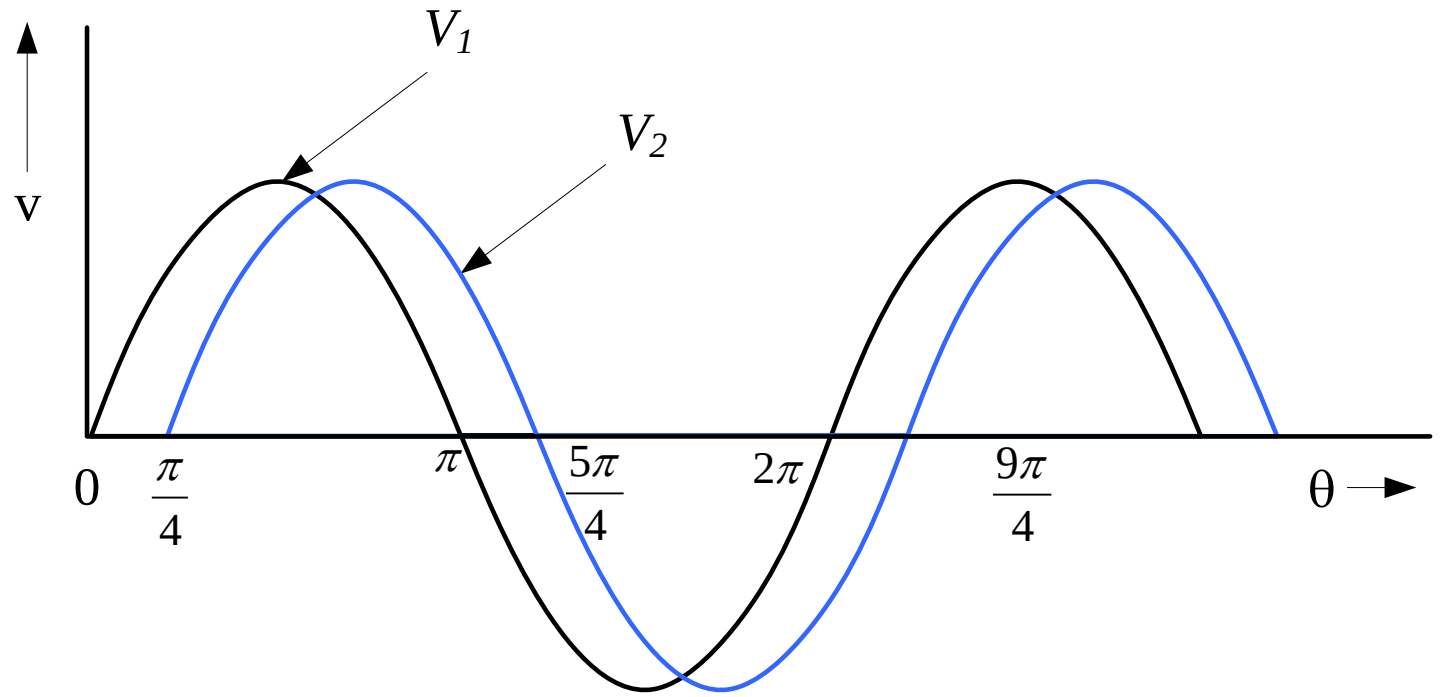
Phase difference of alternating signals

- The two signals in the following figure have the same maximum value (could have been different as well), but they are not in the same phase because they do not attain zero (or peak) values at the same time



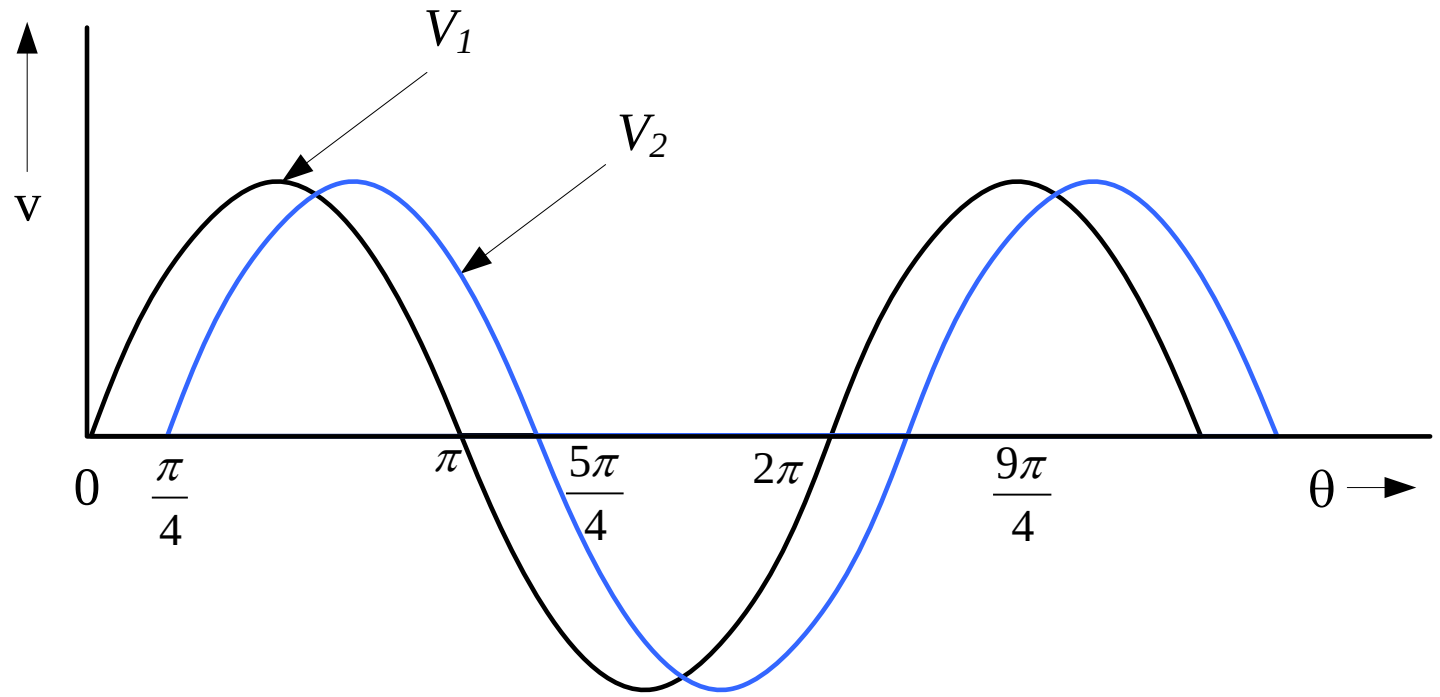
Phase difference of alternating signals

- The two signals V_1 and V_2 do not start at the same time, i.e. their zero values are not coinciding in time, neither have they attained peaks at the same time.
- Thus, these two signals are said to be ***out of phase***.



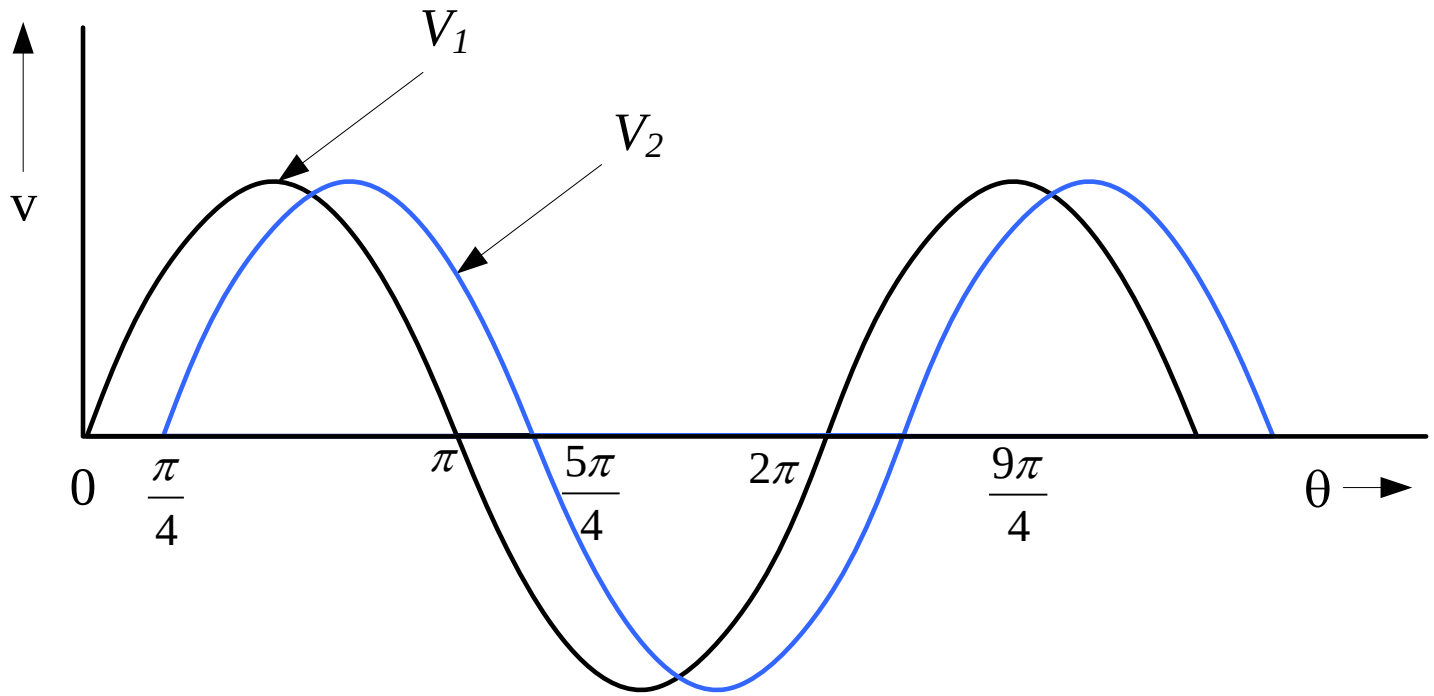
Phase difference of alternating signals

- It can be said that the signal V_1 leads the signal V_2 by a phase angle of $\pi/4$
- As if indicating the V_1 has started before V_2 has started and hence the word "leading"



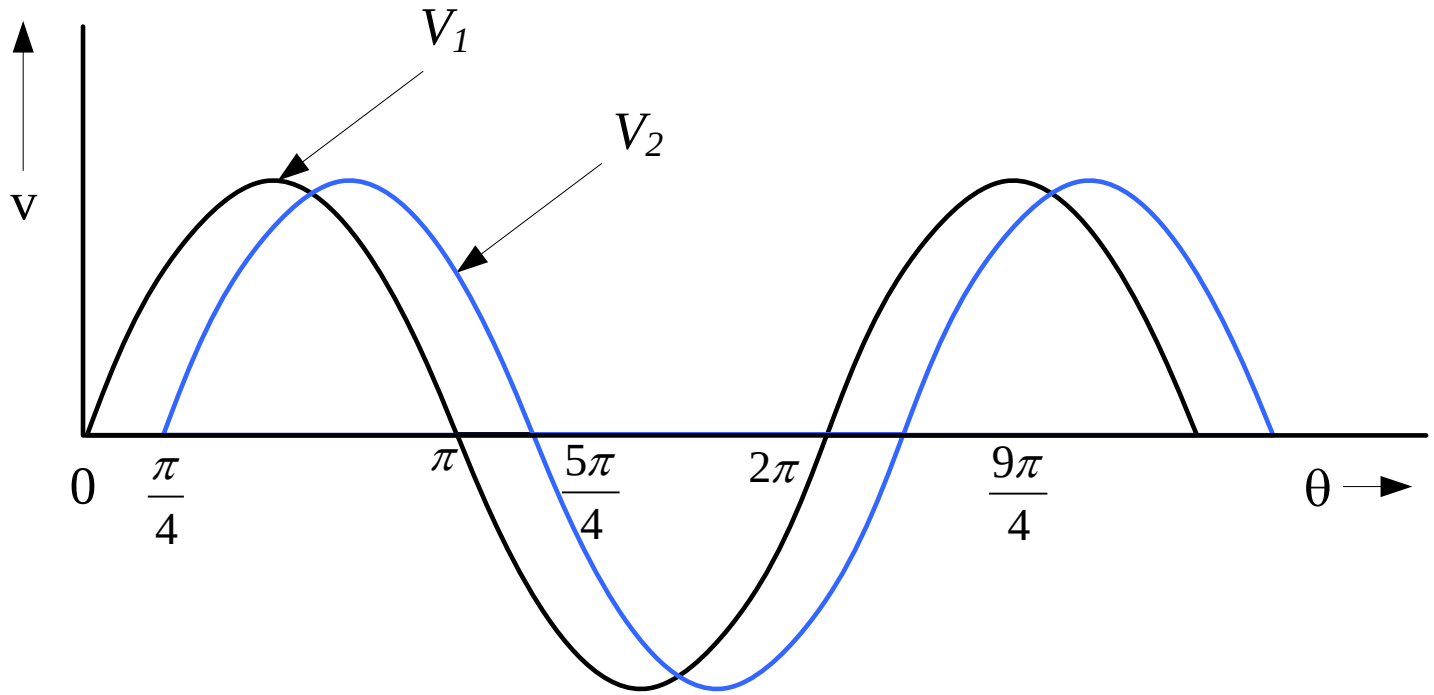
Phase difference of alternating signals

- Alternately it can be said that V_2 lags V_1 by a phase angle of $\pi/4$
- Since V_2 reaches it peak (or zero) $\pi/4$ angle after the signal V_1



Phase difference of alternating signals

- These two signals can only maintain a constant phase difference if their frequencies remain same all the time.

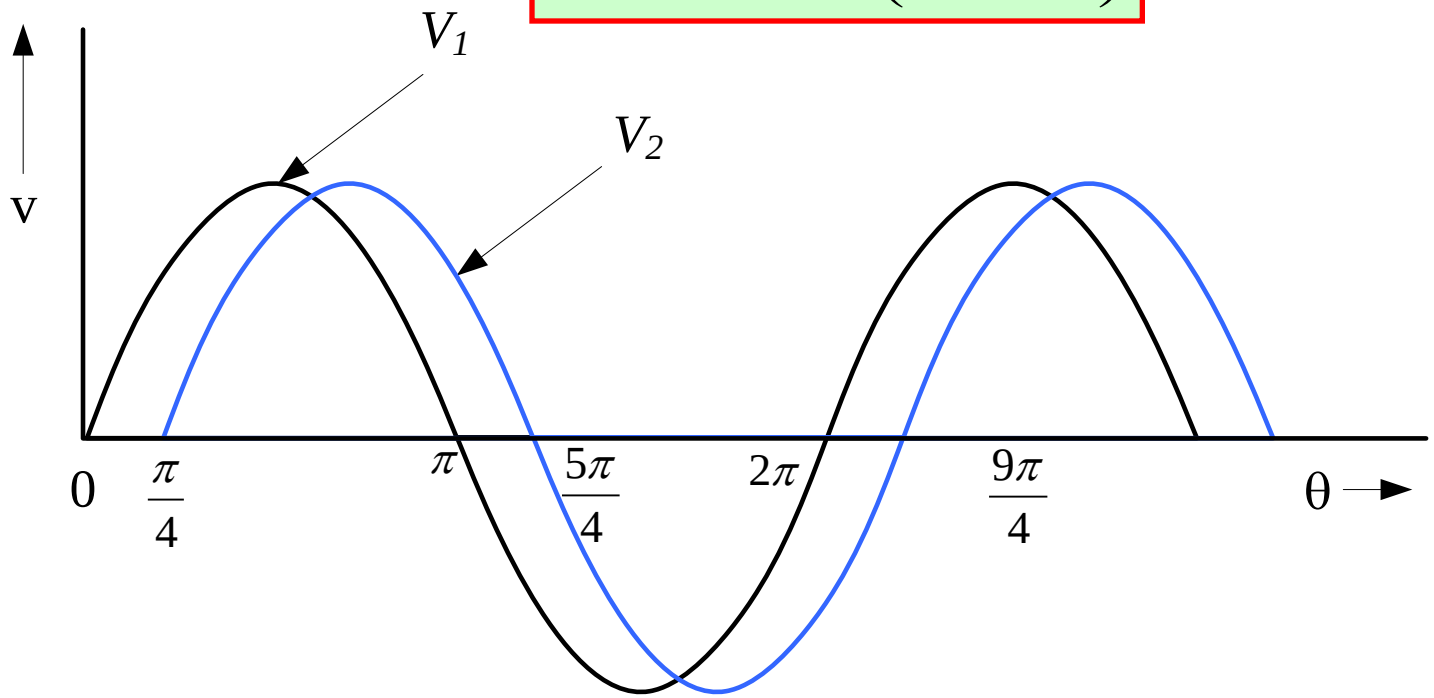


Phase difference of alternating signals

- The two signals can hence be mathematically written as:

$$V_1 = V_{m1} \sin \omega t$$

$$V_2 = V_{m2} \sin\left(\omega t - \frac{\pi}{4}\right)$$



Phase difference of alternating signals

- In general, the angle of lead or lag ϕ of a signal with respect to the origin is shown in the expression for AC signal as:

$$v = V_m \sin(\omega t \pm \phi)$$

+ for lead
- for lag

For V_1, $\phi = 0$

For V_2, $\phi = \pi/4$