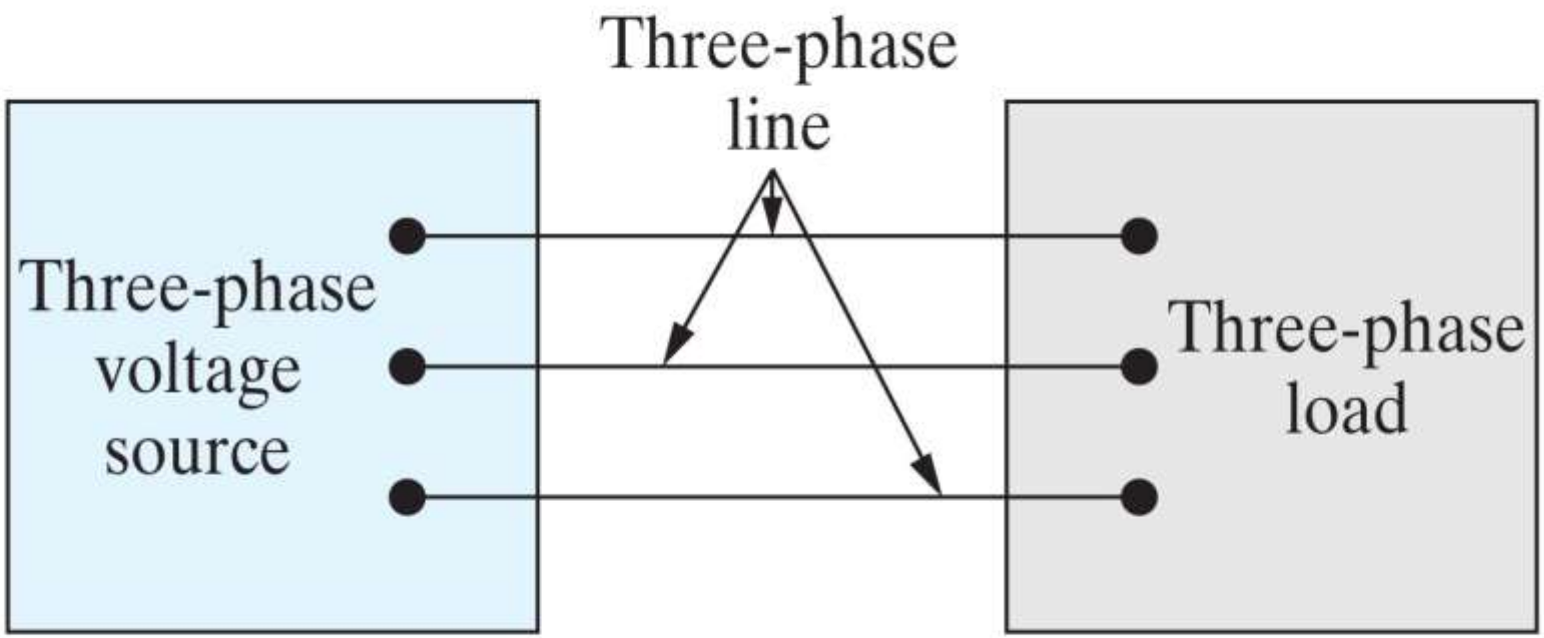
THREE PHASE Connections

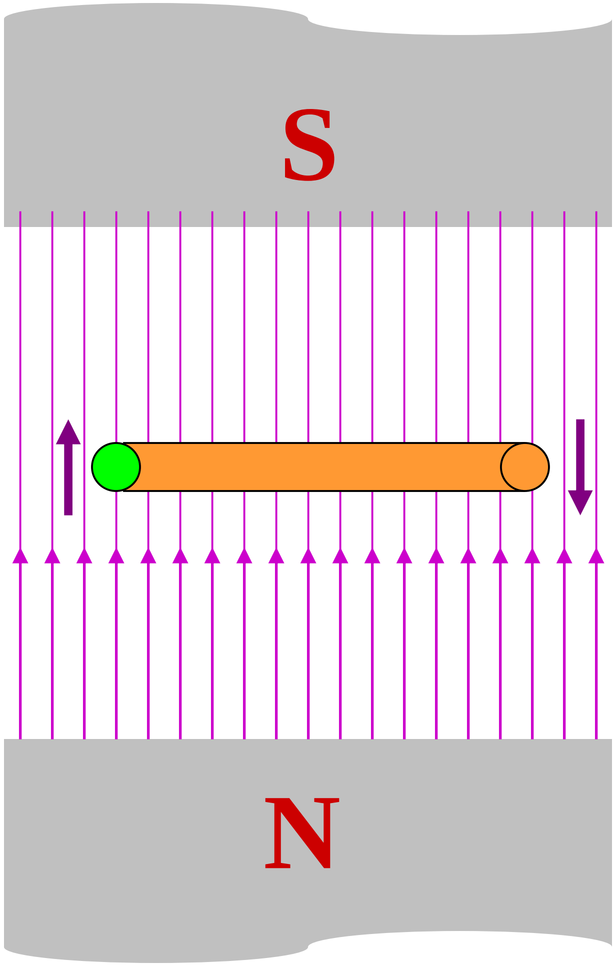
Basic Three-Phase Circuit

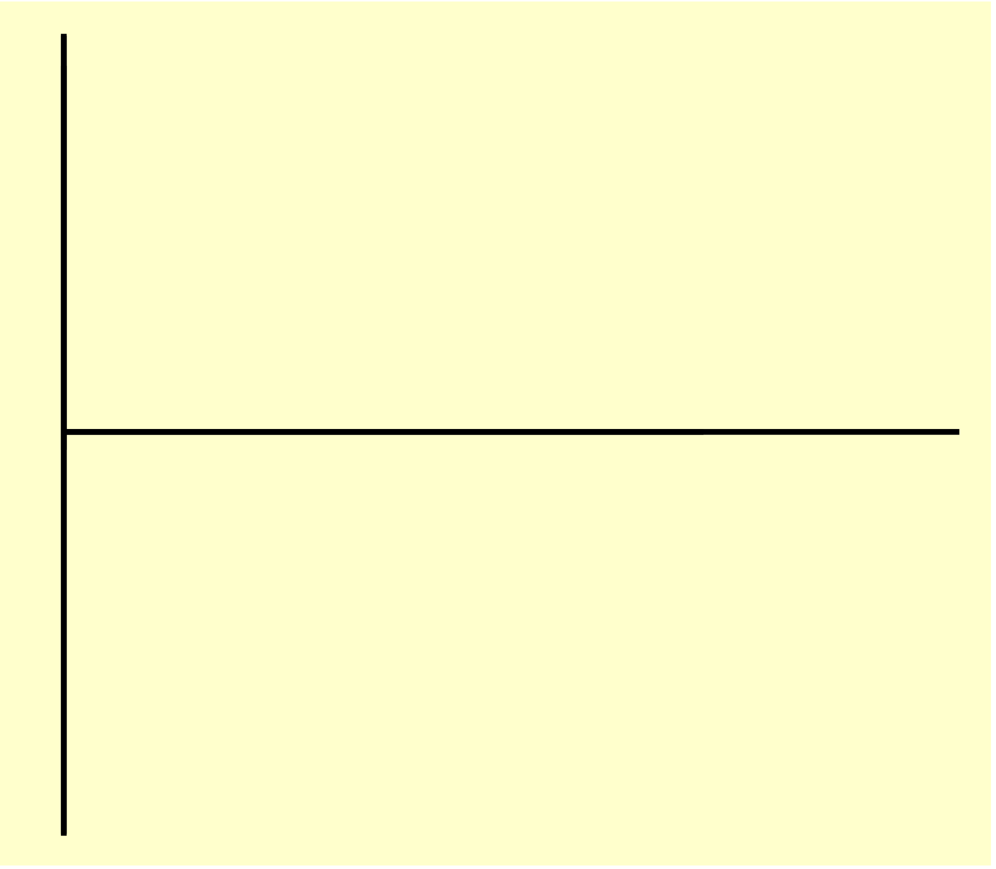


What is Three-Phase Power?

- Three sinusoidal voltages of equal amplitude and frequency out of phase with each other by 120°. Known as “balanced”.
- Phases are labeled A, B, and C. or R,Y and B.
- Phases are sequenced as A, B, C (positive) or A, C, B (negative).

GENERATING A SINGLE PHASE

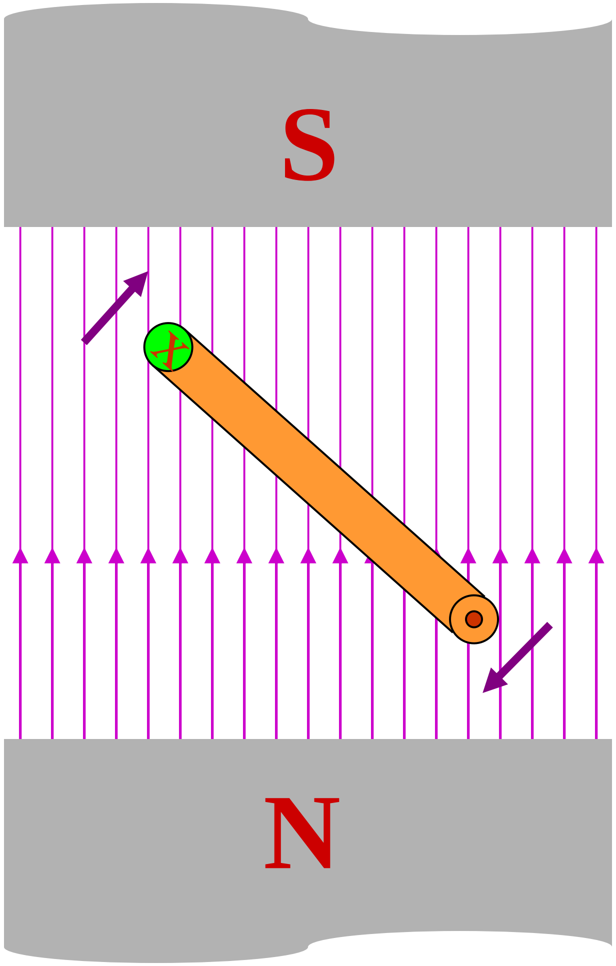


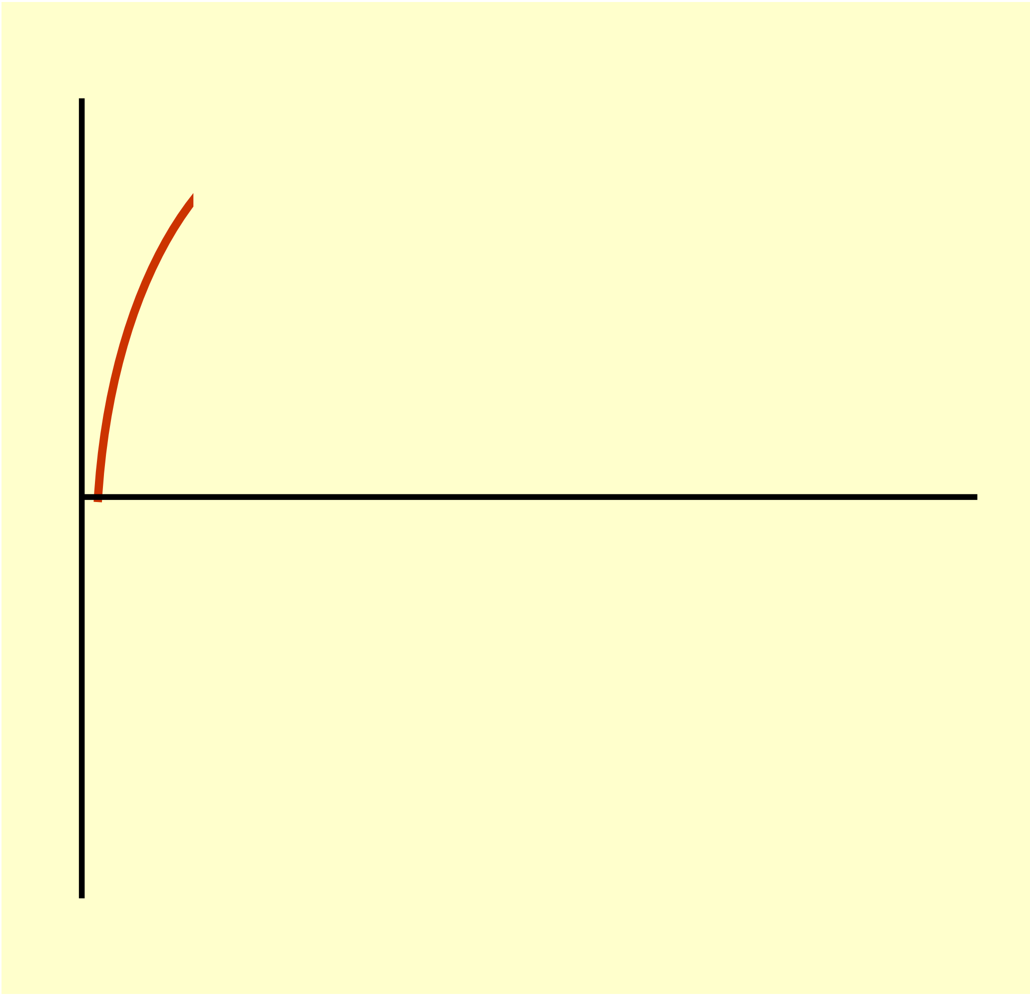


Motion is parallel to the flux.

No voltage is induced.

GENERATING A SINGLE PHASE

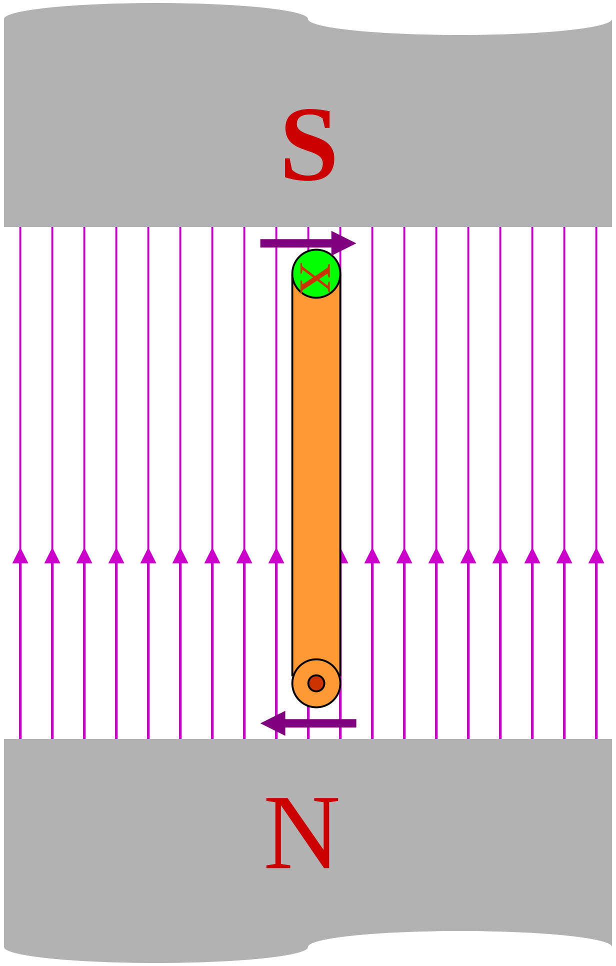


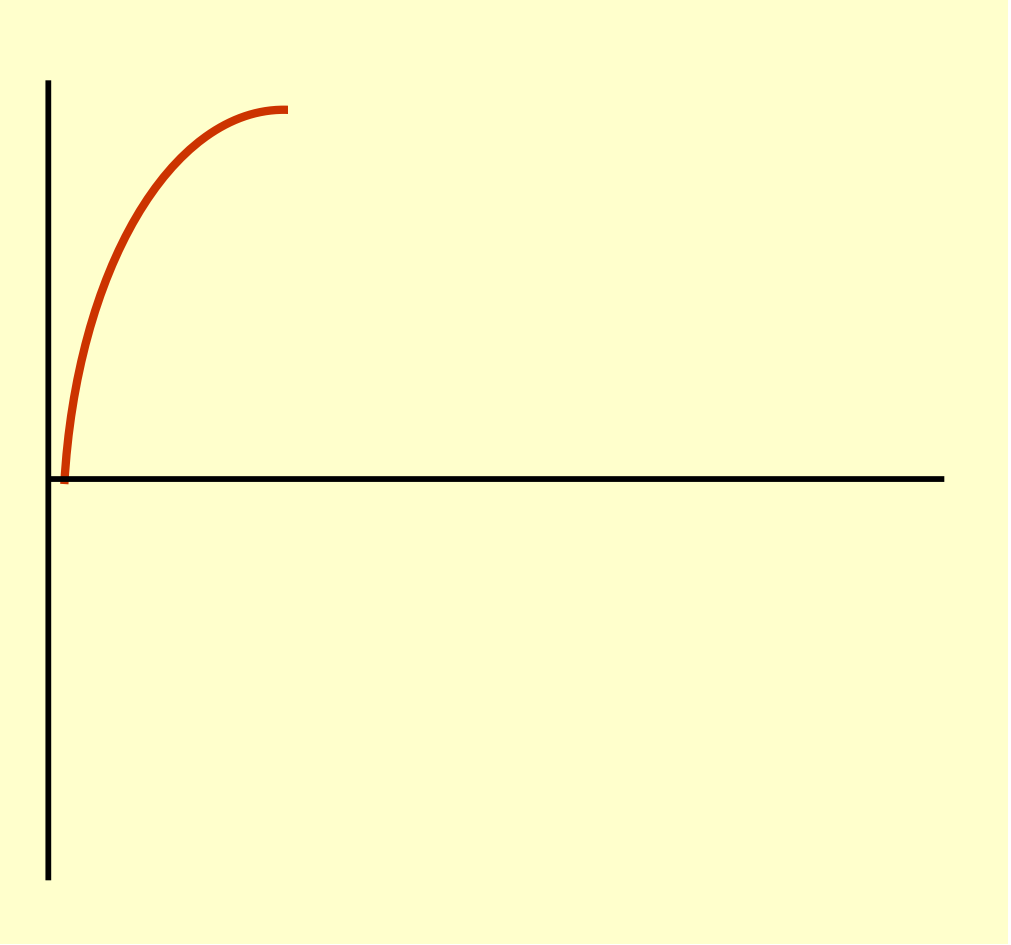


Motion is 45° to flux.

Induced voltage is 0.707 of maximum.

GENERATING A SINGLE PHASE

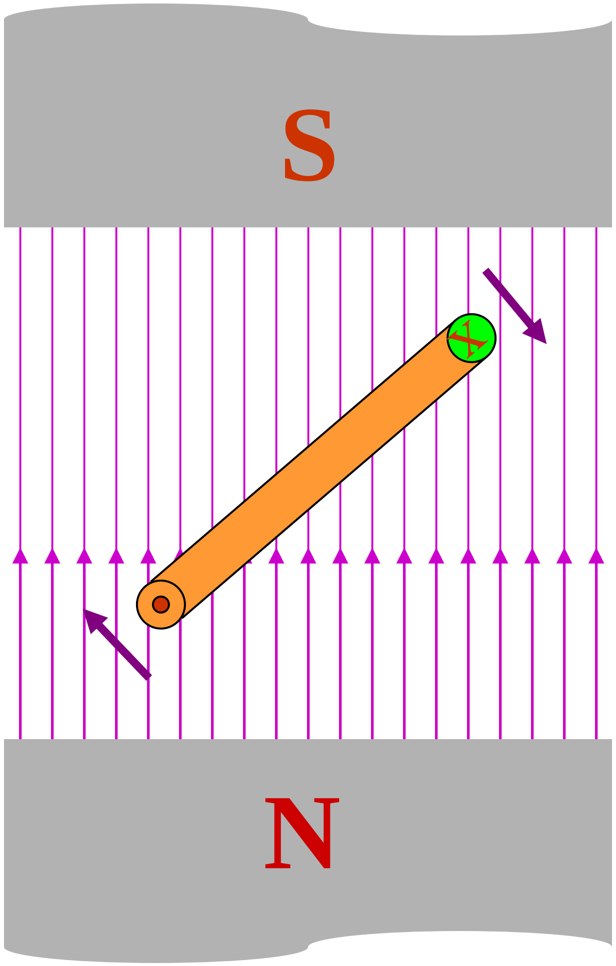


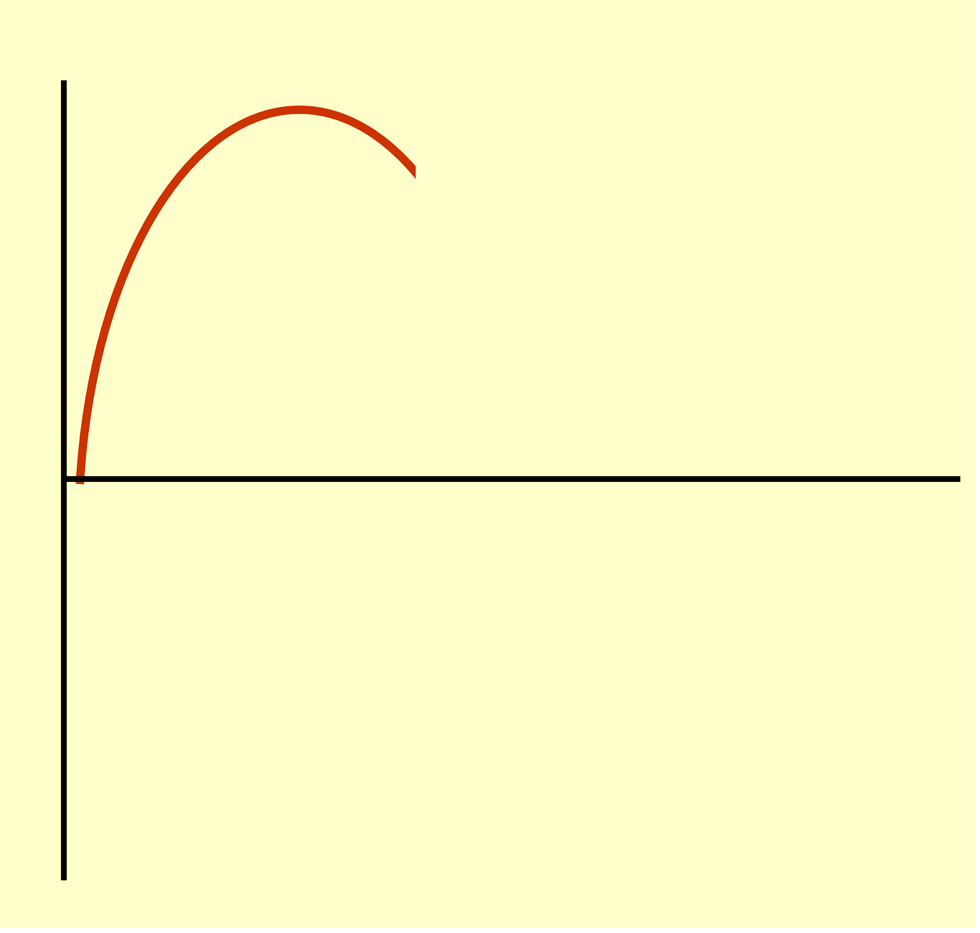


Motion is perpendicular to flux.

Induced voltage is maximum.

GENERATING A SINGLE PHASE

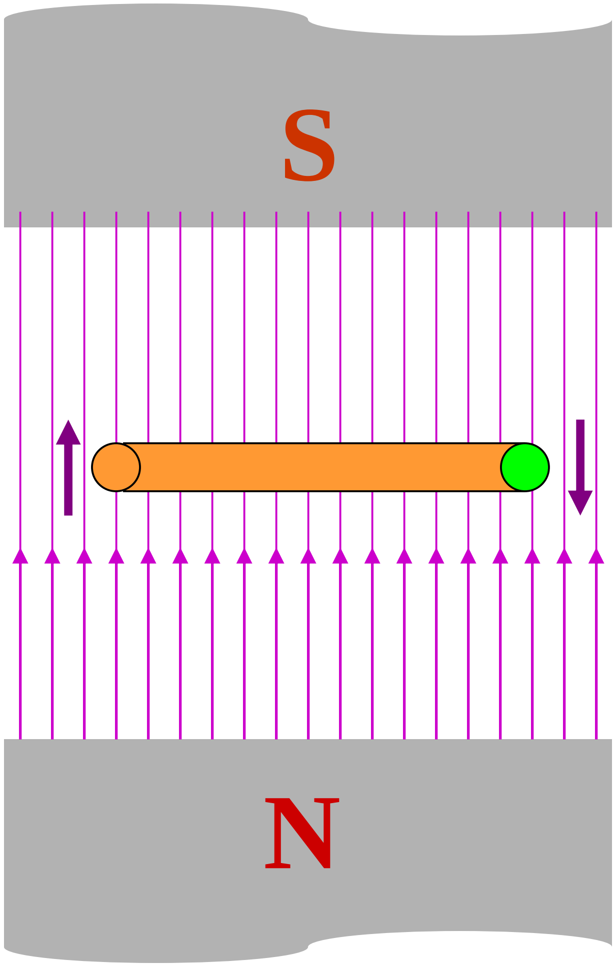


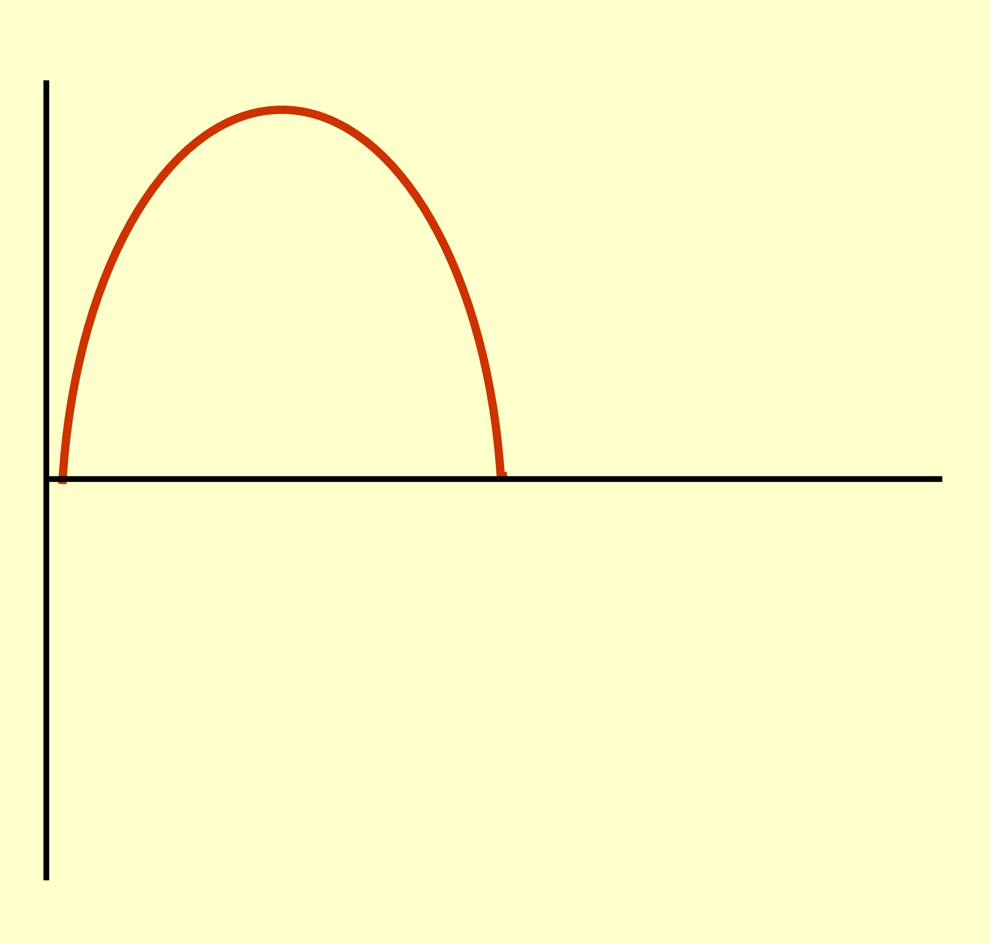


Motion is 45° to flux.

Induced voltage is 0.707 of maximum.

GENERATING A SINGLE PHASE

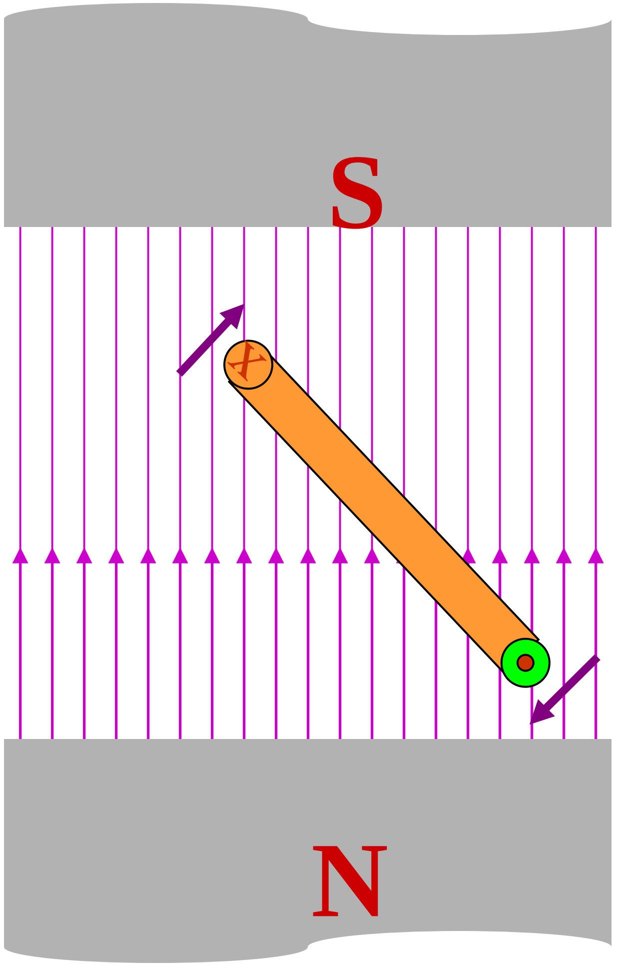


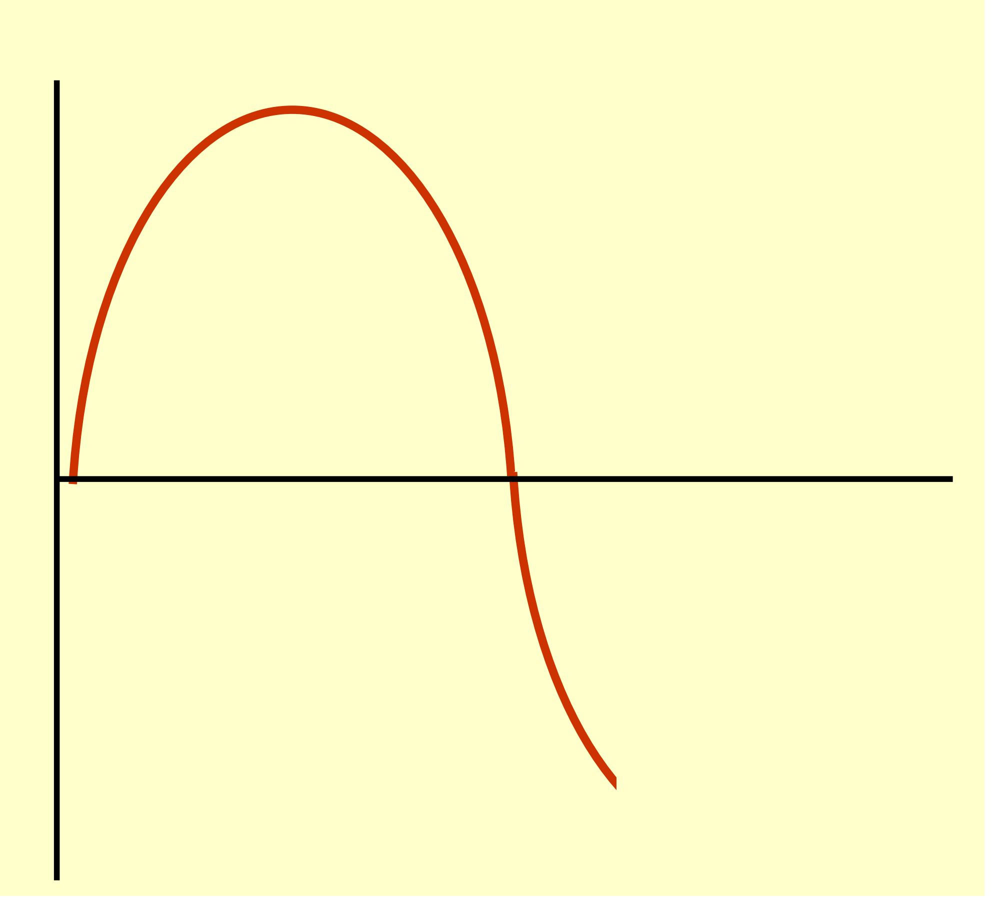


Motion is parallel to flux.

No voltage is induced.

GENERATING A SINGLE PHASE



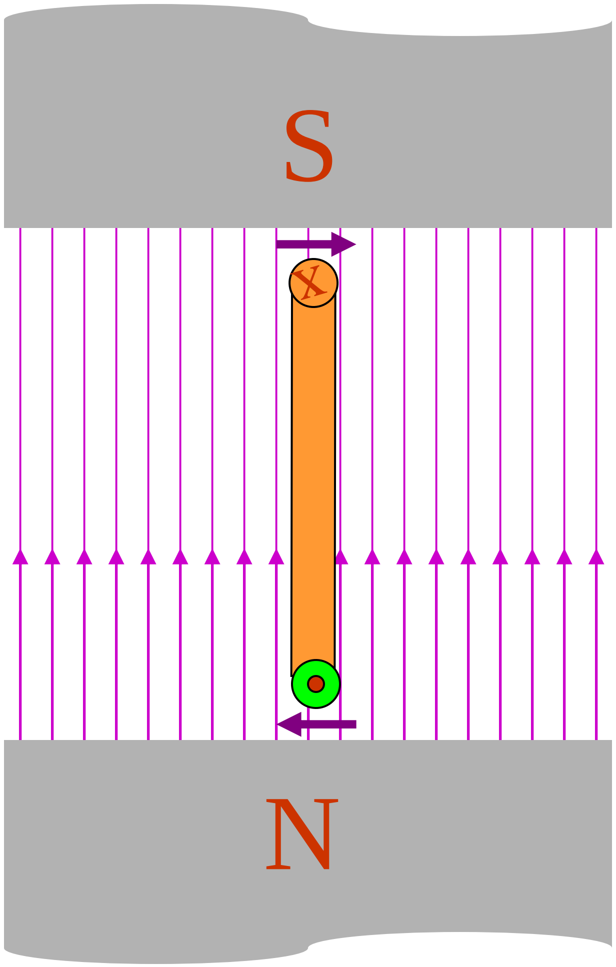


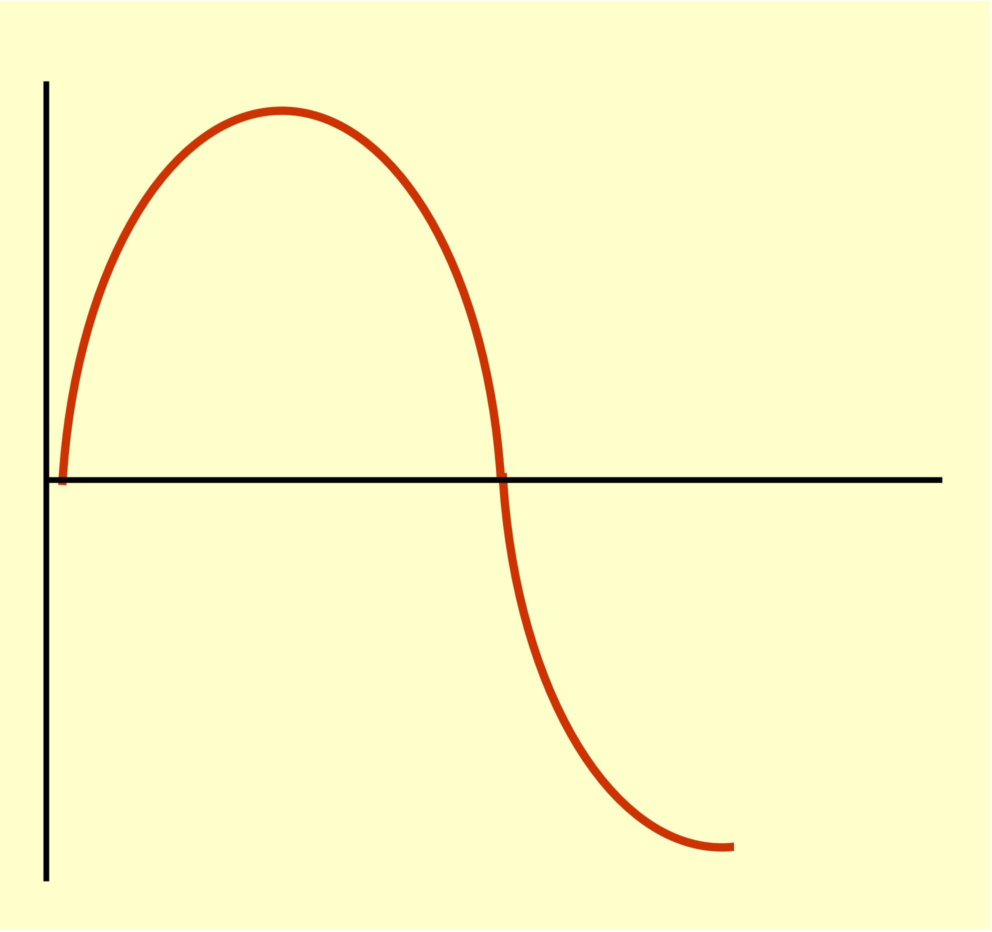
Motion is 45° to flux.

Induced voltage is 0.707 of maximum.

Notice current in the conductor has reversed.

GENERATING A SINGLE PHASE

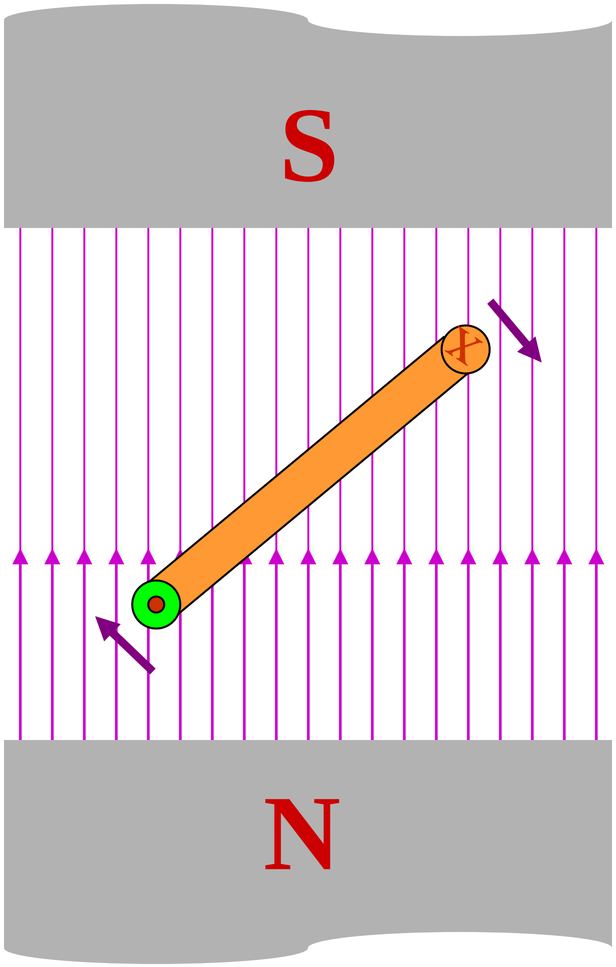


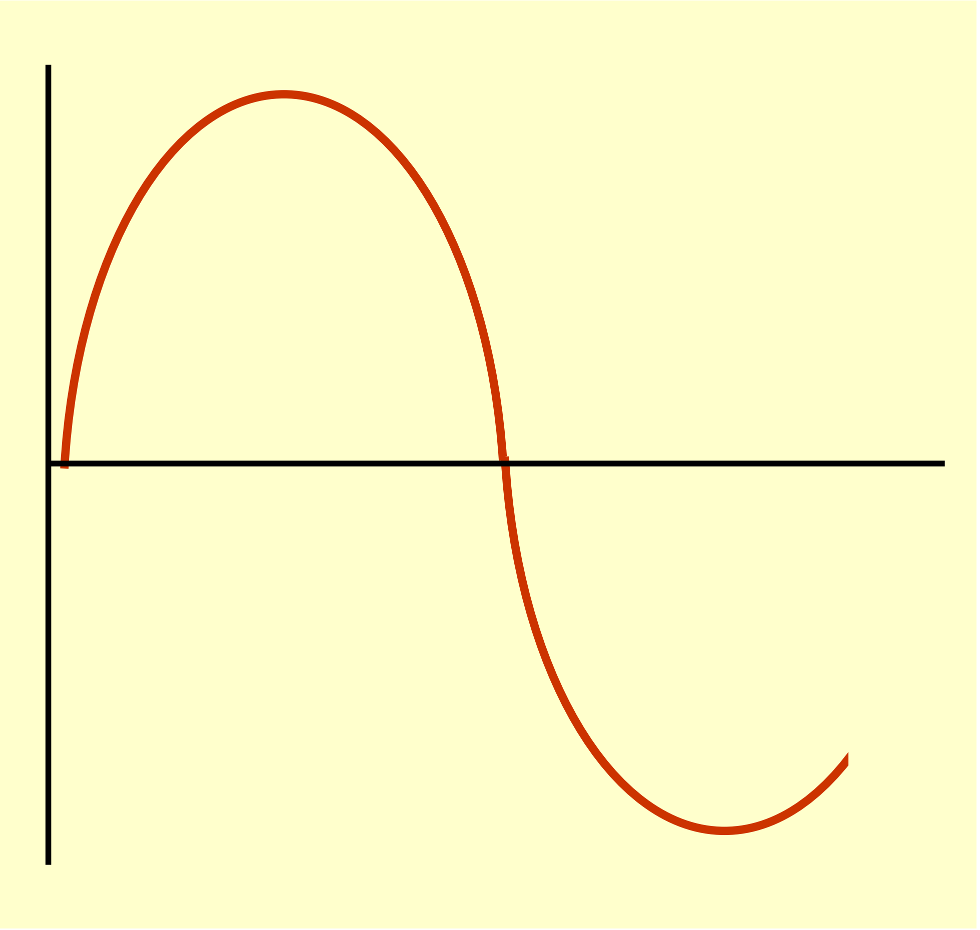


Motion is perpendicular to flux.

Induced voltage is maximum.

GENERATING A SINGLE PHASE

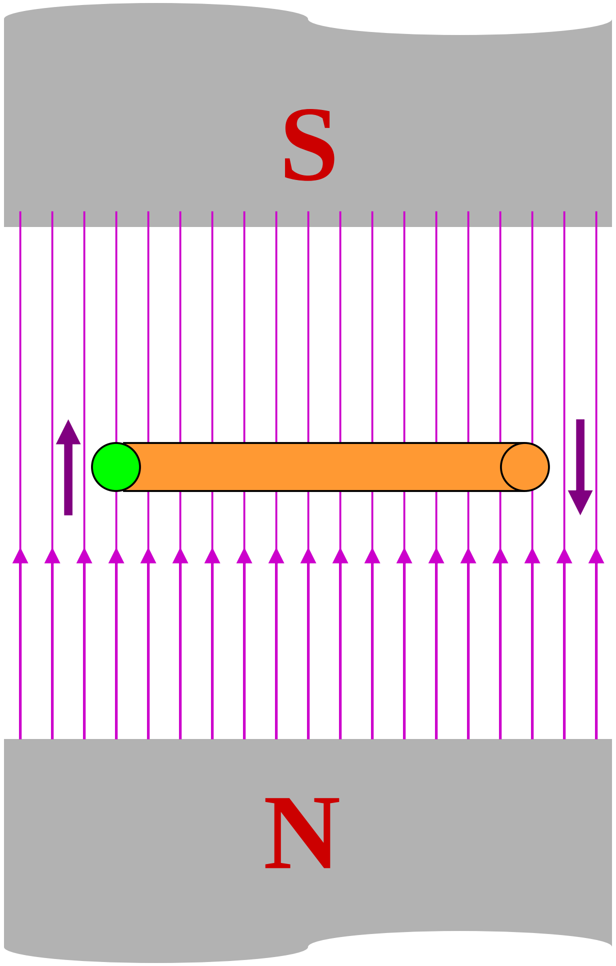


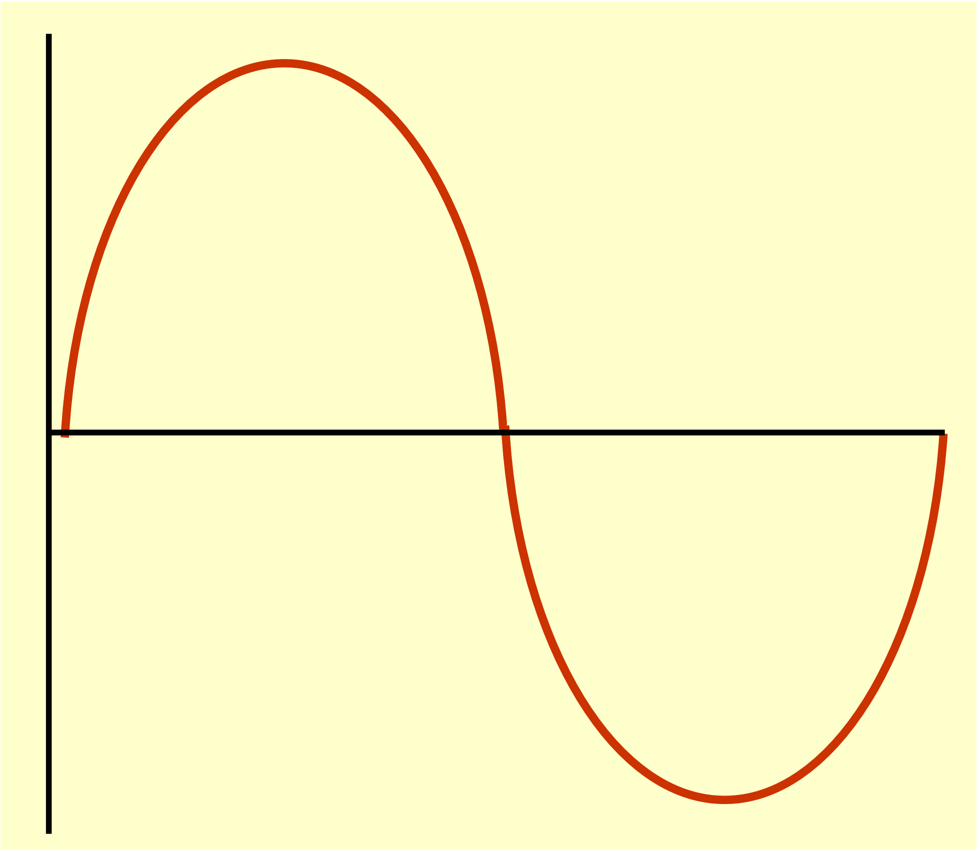


Motion is 45° to flux.

Induced voltage is 0.707 of maximum.

GENERATING A SINGLE PHASE





Motion is parallel to flux.

No voltage is induced.

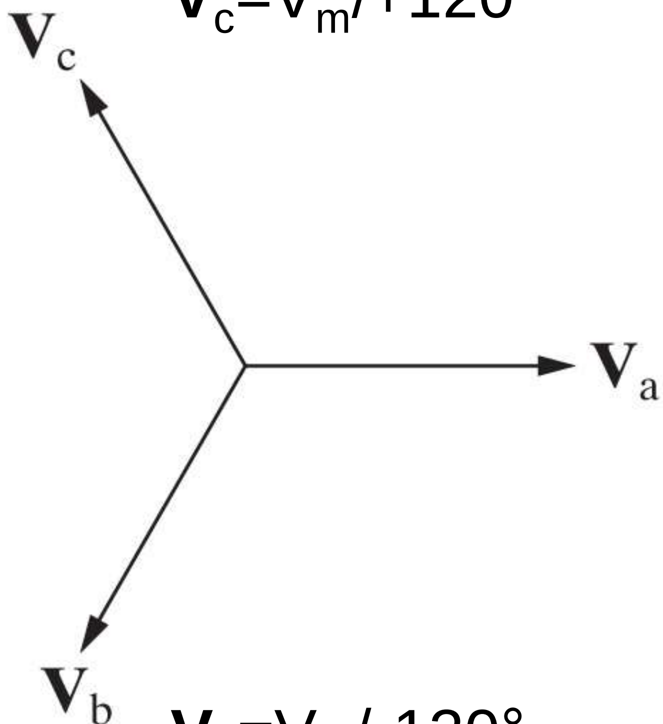
Ready to produce another cycle.

Three phase system

- 4 wires
  - 3 “active” phases, A, B, C
  - 1 “ground”, or “neutral”
- Color Code
  - Phase A Red
  - Phase B Yellow
  - Phase C Blue
  - Neutral Black

Phasor (Vector) Form for abc

$\mathbf{V}_c = V_m/+120°$

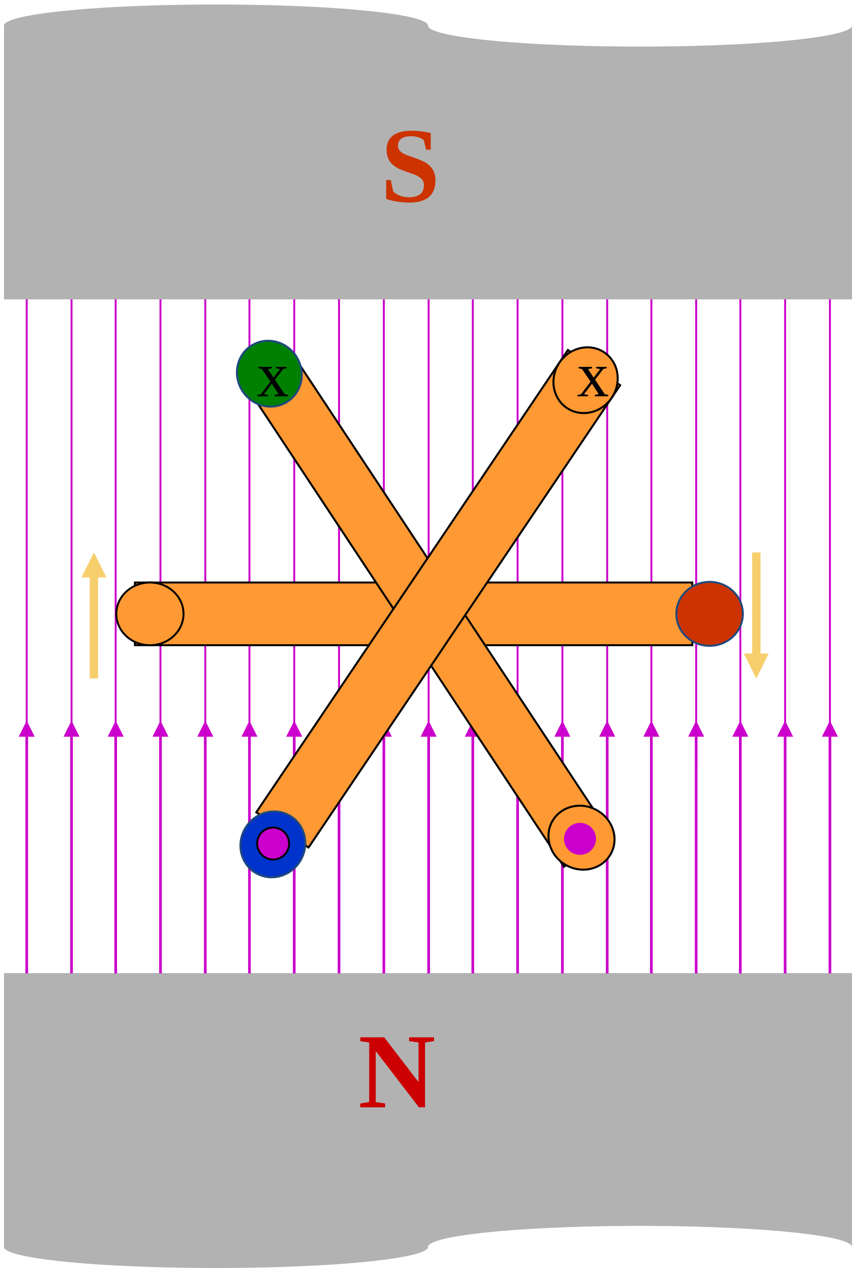


$\mathbf{V}_a = V_m/0°$

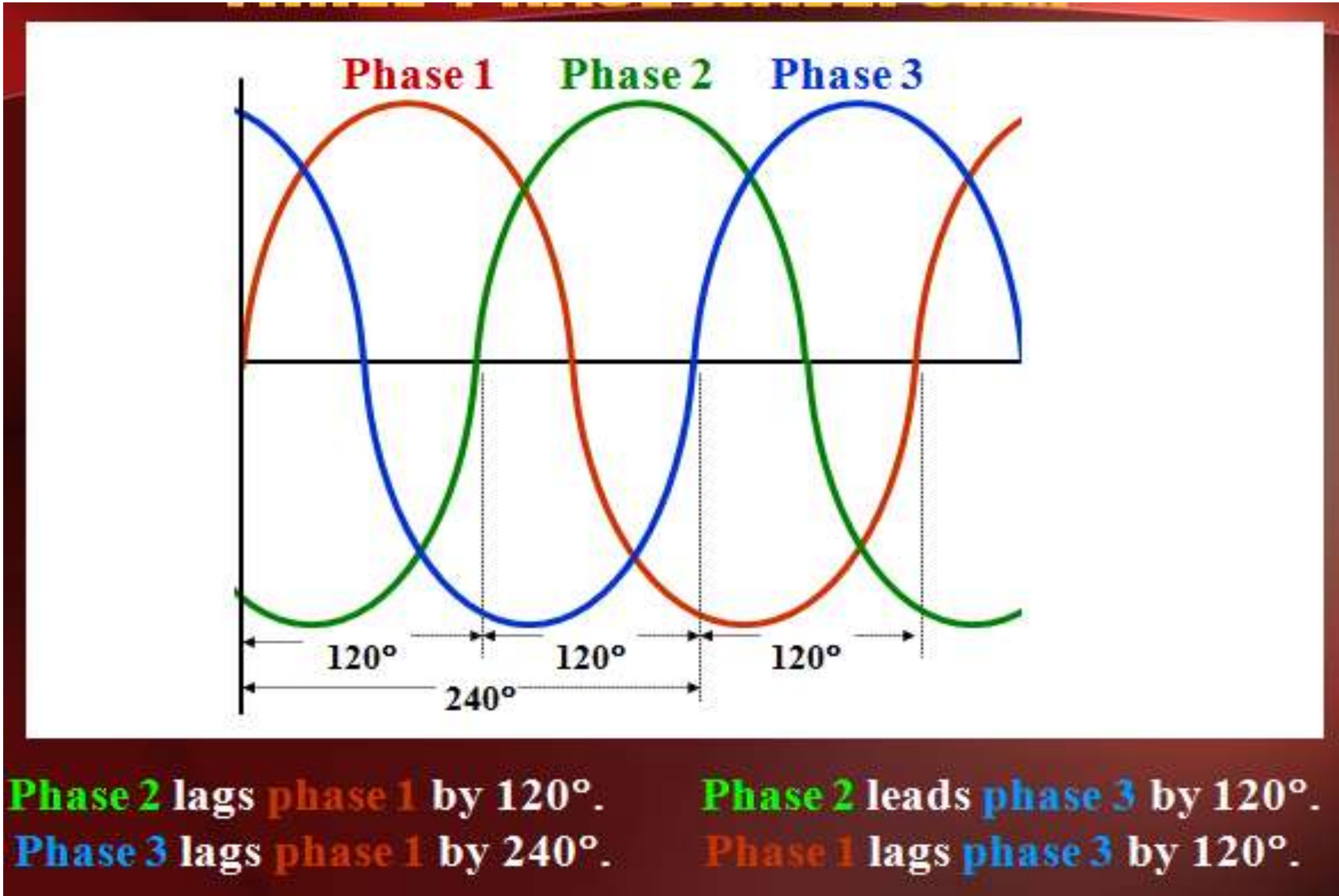
$\mathbf{V}_b = V_m/-120°$

Note that KVL applies .... $\mathbf{V}_a + \mathbf{V}_b + \mathbf{V}_c = 0$

GENERATION OF THREE-PHASE AC



THREE-PHASE WAVEFORM



THREE PHASE SYSTEM

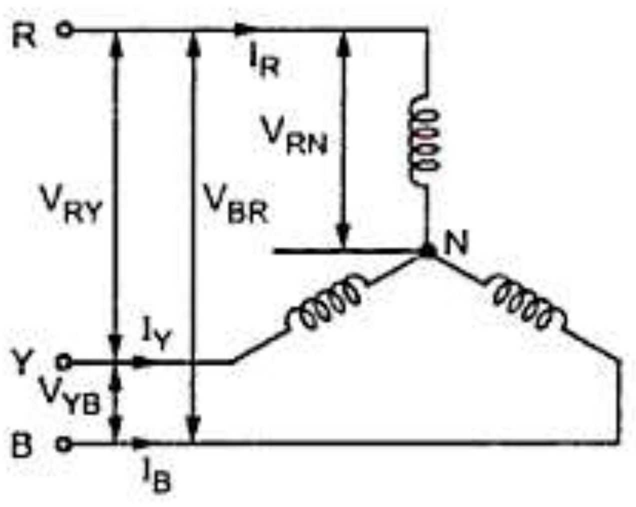
BASICS

Line voltage V_L= voltage between lines

Phase voltage Vph= voltage between a line and neutral

THREE PHASE SYSTEM

BALANCED STAR

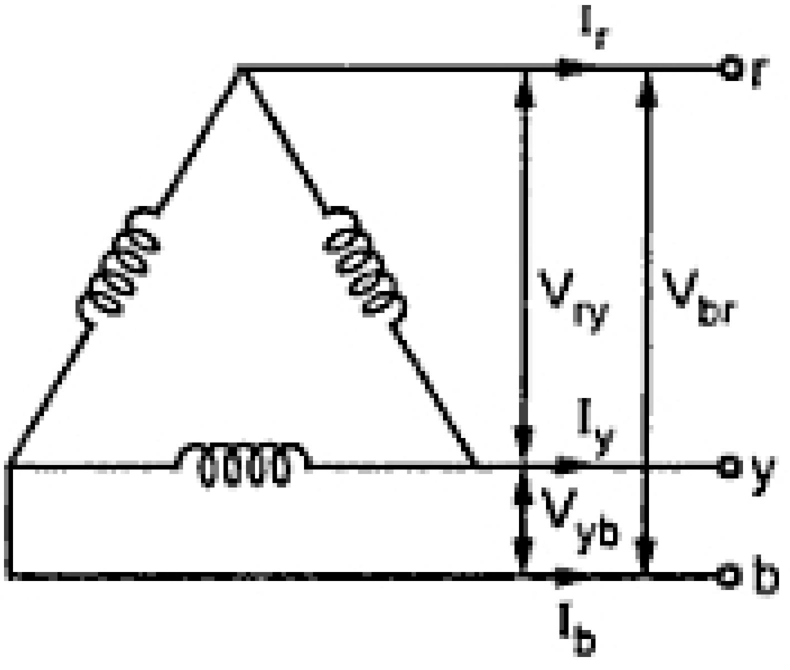


Line Voltage $V_L = \sqrt{3}\, V_{ph}$

Line current $I_L = I_{ph}$

THREE PHASE SYSTEM

BALANCED DELTA



Line Voltage $V_L = V_{ph}$

Line current $I_L = \sqrt{3}\, I_{ph}$

Quick Quiz (Poll 1)

- Power in a Three Phase Circuit = ___________.

a) $P = 3\ V_{Ph}\ I_{Ph}\ Cos\Phi$

b) $P = \sqrt{3}\ V_L\ I_L\ Cos\Phi$

c) Both a & b.

d) None of The Above

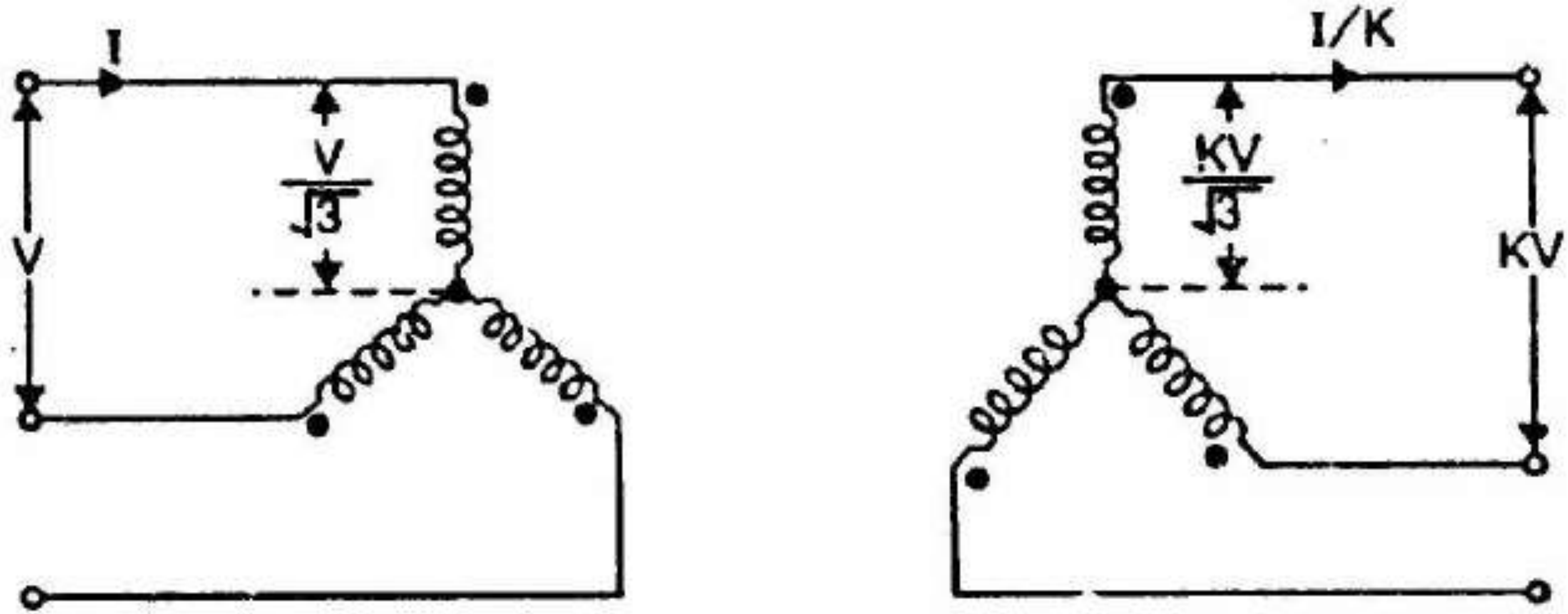
3 phase Transformer connections

By connecting three single phase transformers

1. Star- Star connection
2. Delta- Delta connection
3. Star – Delta connection
4. Delta – Star connection

$$\text{Phase transformation ratio, K} = \frac{\text{Secondary phase voltage}}{\text{Primary phase voltage}} = \frac{N_2}{N_1}$$

Star- Star connection



Y – Y Connection

- This connection satisfactory only in balanced load otherwise neutral point will be shifted.

Star- Star connection

Advantages

1.Requires less turns per winding ie cheaper

Phase voltage is 1/√3 times of line voltage

2.Cross section of winding is large i.e stronger to bear stress during short circuit

Line current is equal to phase current

3. Less dielectric strength in insulating materials

phase voltage is less

Star- Star connection

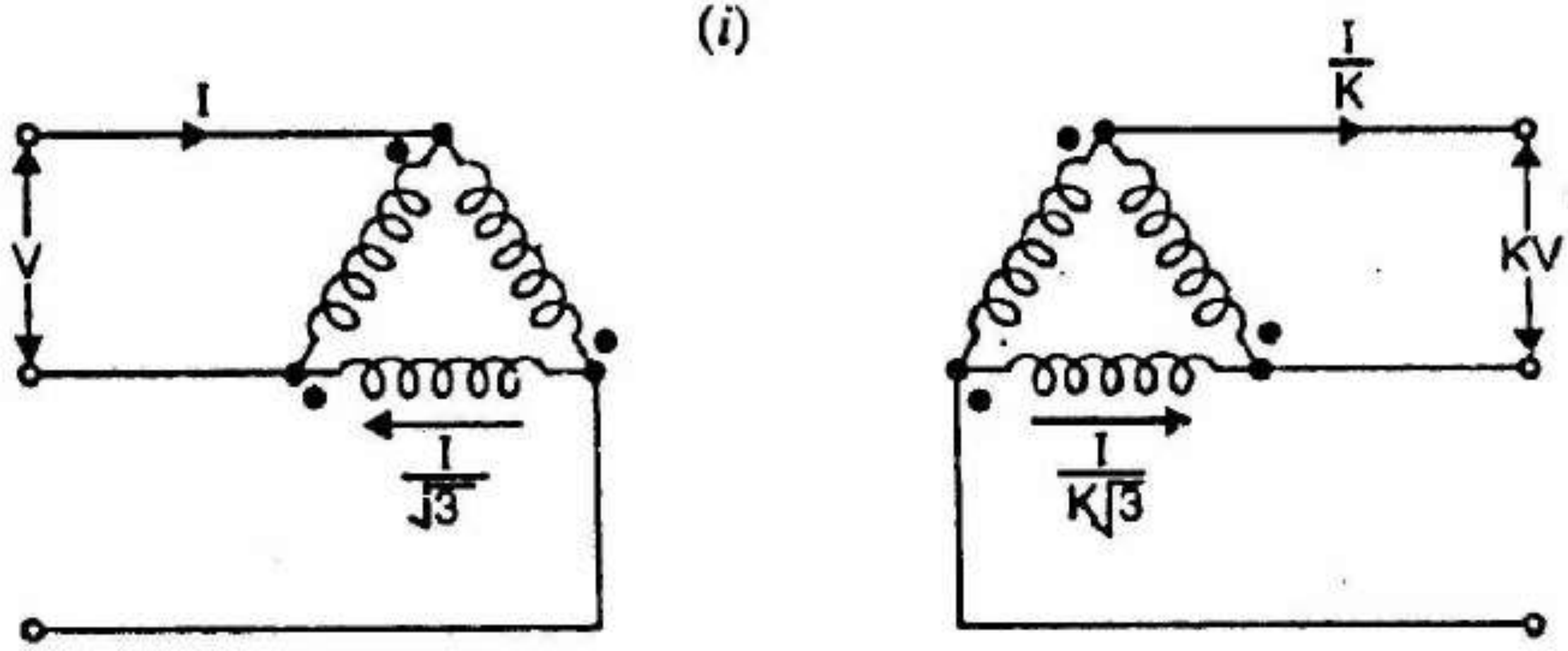
Disadvantages

1.If the load on the secondary side unbalanced then the shifting of neutral point is possible

2.The third harmonic present in the alternator voltage may appear on the secondary side. This causes distortion in the secondary phase voltages

3. Magnetizing current of transformer has 3rd harmonic component

Delta - Delta connection



Δ – Δ Connection

- ➢ **This connection is used for moderate voltages**

Delta - Delta connection

Advantages

1. System voltages are more stable in relation to unbalanced load
2. If one t/f is failed it may be used for low power level ie V-V connection
3. No distortion of flux ie 3rd harmonic current not flowing to the line wire

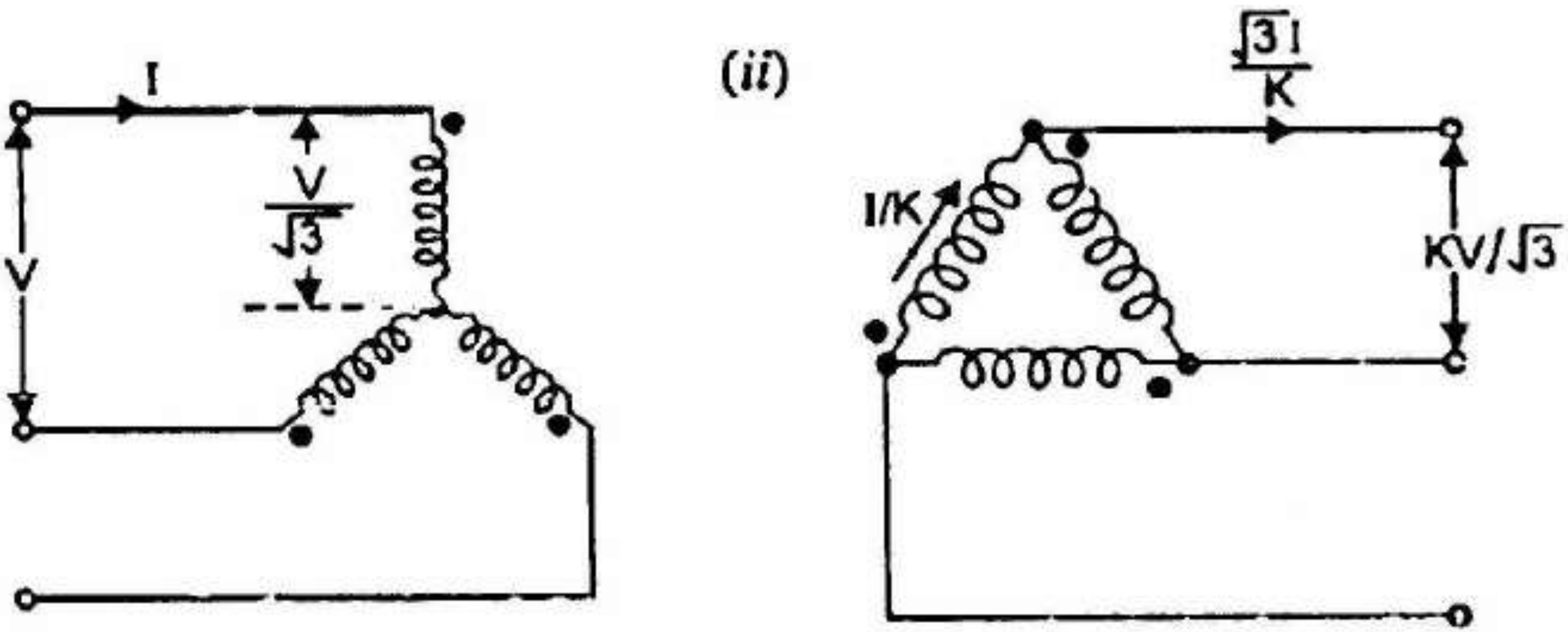
Delta - Delta connection

Disadvantages

1. **Compare to Y-Y require more insulation**

2. **Absence of star point ie fault may severe**

Star- Delta connection



Y – Δ Connection

- Used to step down voltage i.e end of transmission line

Star- Delta connection

Advantages

1. The primary side is star connected. Hence fewer number of turns are required. This makes the connection economical

2. The neutral available on the primary can be earthed to avoid distortion.

3. Large unbalanced loads can be handled satisfactory.

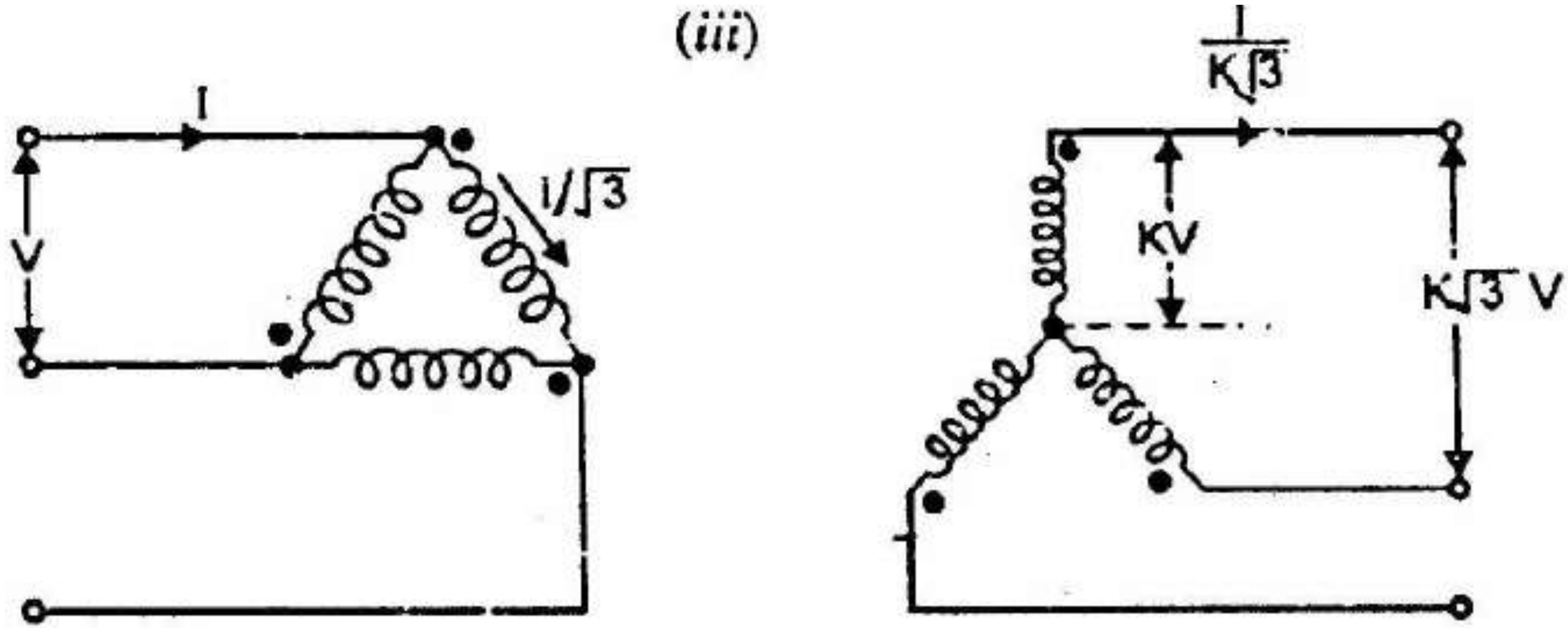
Star- Delta connection

Disadvantages

The secondary voltage is not in phase with the primary. (30 ^{o} phase difference)

Hence it is not possible to operate this connection in parallel with star-star or delta-delta connected transformer.

Delta - Star connection



Δ – Y Connection

- **This connection is used to step up voltage ie. Beginning of high tension line**

Delta - Star connection

Features

- secondary Phase voltage is $1/\sqrt{3}$ times of line voltage
-
- neutral in secondary can be grounded for 3 phase 4 wire system
- Neutral shifting and 3rd harmonics are there
- Phase shift of 30^{o} between secondary and primary currents and voltages