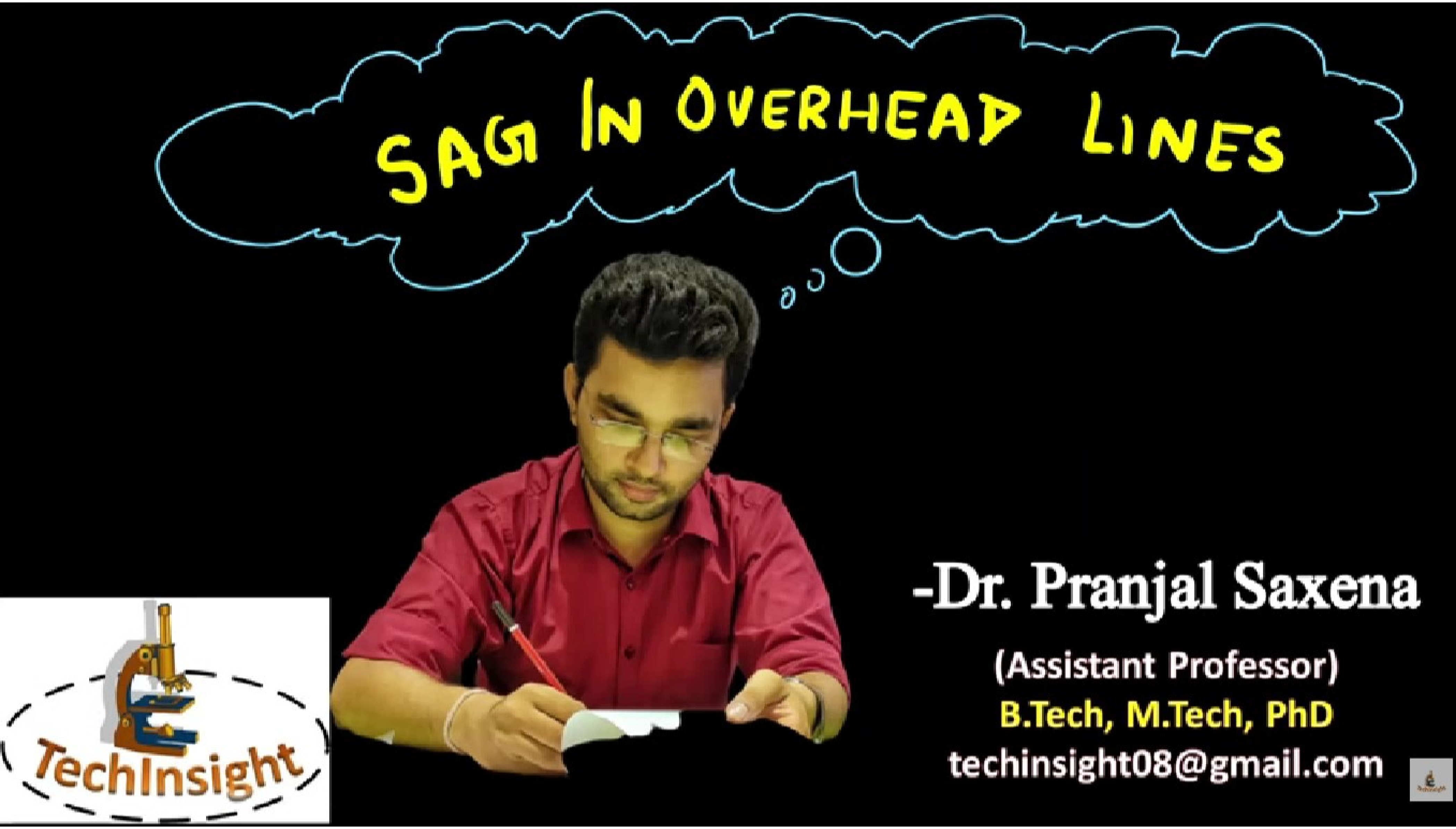
SAG IN OVERHEAD LINES
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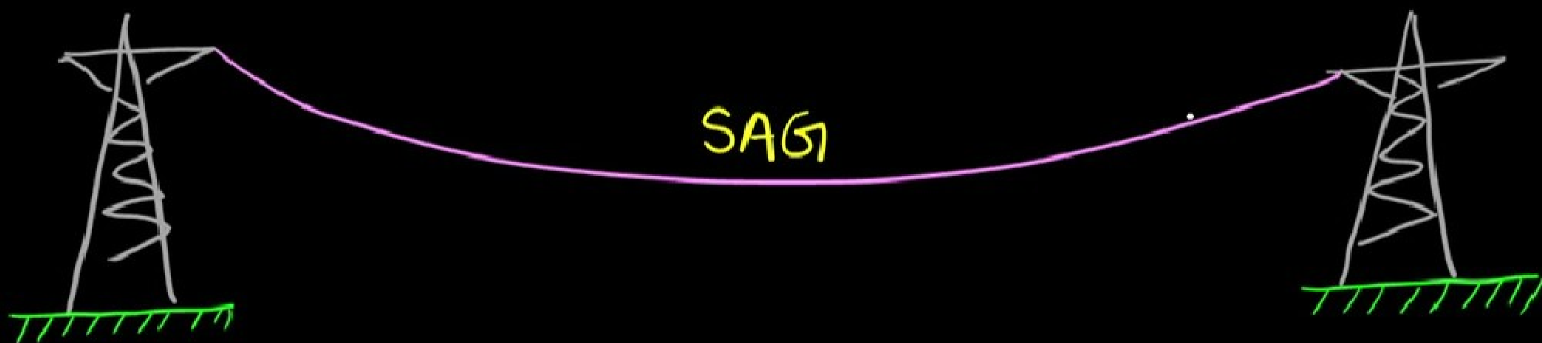


* while erecting an overhead transmission line, it is important that conductors are under safe tension

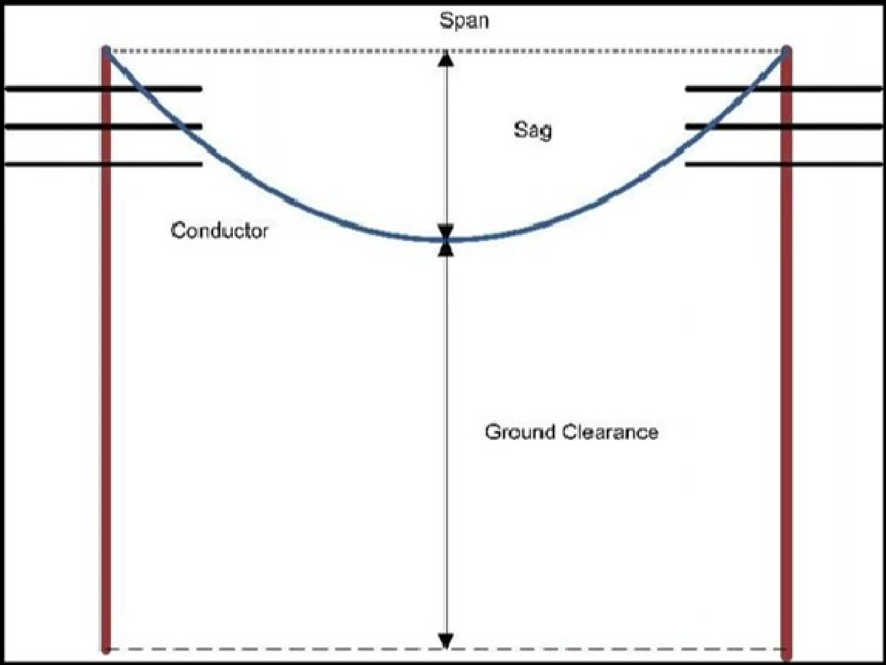
stretch ↑ → conductor save
→ chances of Breakdown

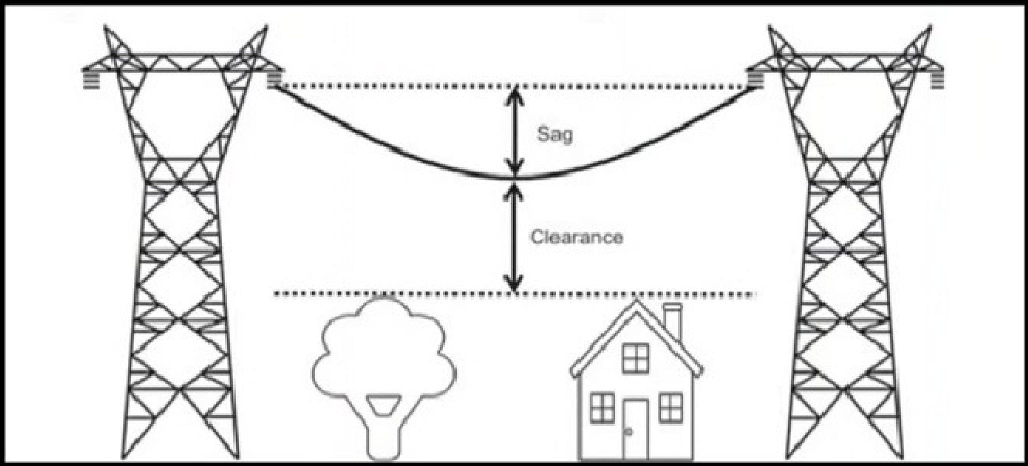
stretch ↓ → Requires large conductor

* Safe Tension → we allow dip or Sag

Sag

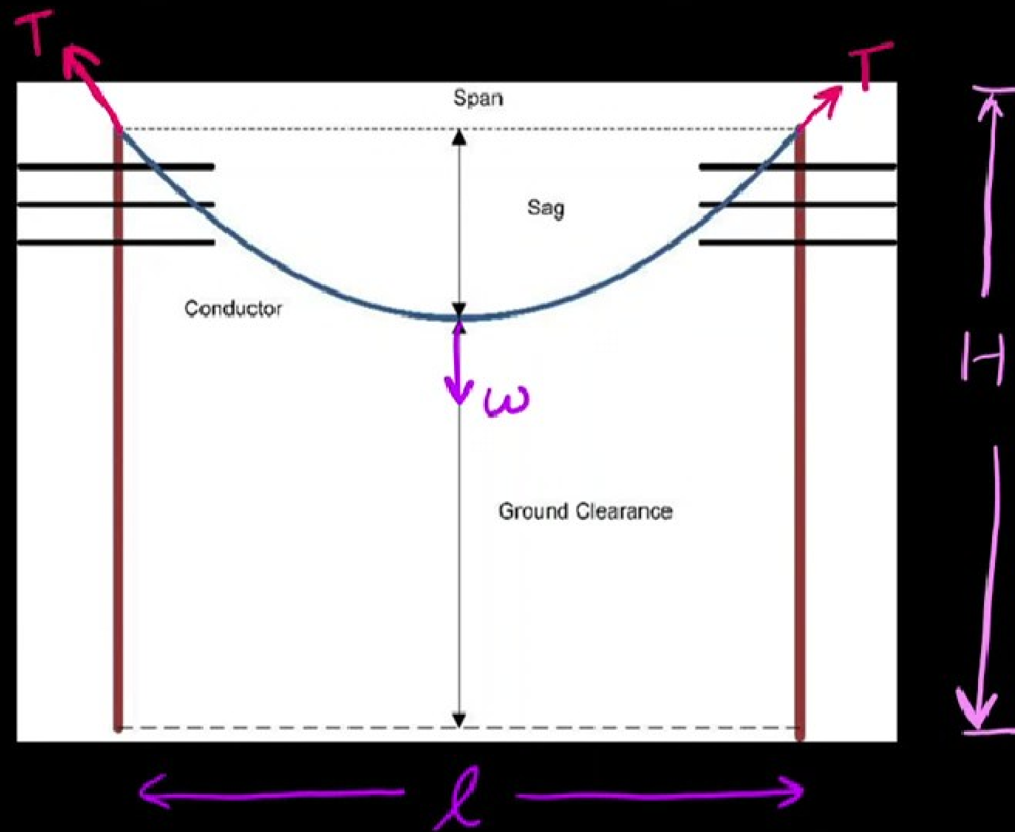
"The difference in level b/w points of support and lowest pt. on conductor"





Sag Calculation

$$\boxed{Sag = \frac{w l^2}{8T}}$$



$w \rightarrow$ wt per unit length of conductor

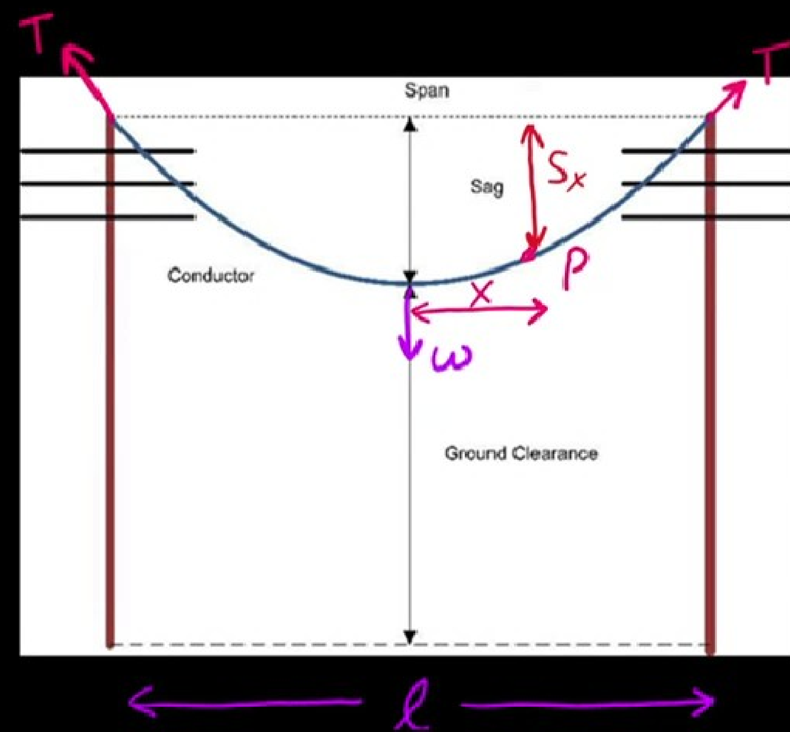
$T \rightarrow$ Tension

$l \rightarrow$ length of span

* $\boxed{H = \text{Ground Clearance} + Sag}$

Sag at Point "P"

$$\boxed{S_x = \frac{w}{8T}\left[l^2 - 4x^2\right]}$$



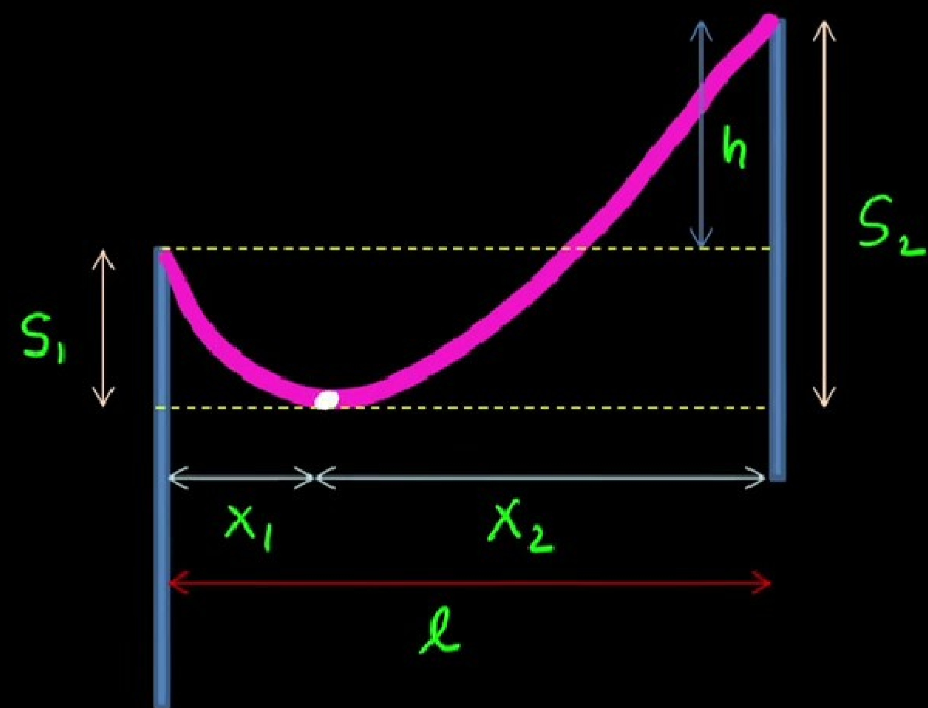
Sag when support are at unequal level

* $X_1 = \frac{l}{2} - \frac{Th}{wl}$

* $X_2 = \frac{l}{2} + \frac{Th}{wl}$

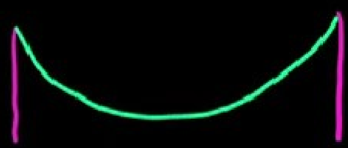
* $S_1 = \frac{w x_1^2}{2T}$

* $S_2 = \frac{w x_2^2}{2T}$



$$\boxed{x_1 + x_2 = l}$$

Sag Calculations



Sag ↑

- → Tension ↓
- → conductor ↑
- → Pole height ↑

Sag ↓

- → Tension ↑
- → conductor ↓
- → Pole height ↓

* Sag should be adjusted such that tension should be within safe limit.

Factor of safety

* Every conductor has certain ultimate strength which it can sustain
  ↳ Breaking stress

* If Tension apply or working stress > Ultimate strength $\xrightarrow{\text{leads}}$ Breakdown

* $$\text{Factor of safety } (S_F) = \frac{\text{Breaking stress or ultimate strength}}{\text{working Tension}}$$

* Min. Factor of safety = 2

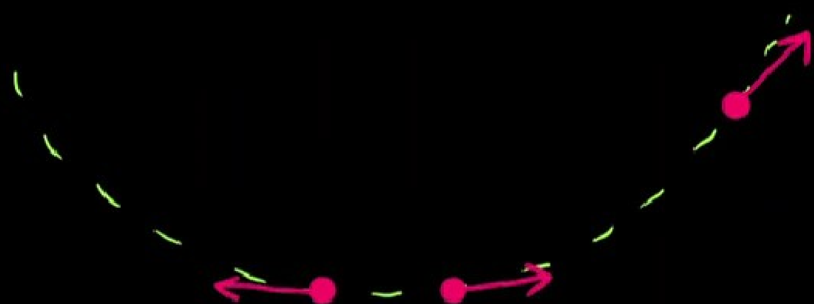
Important Points about Sag

1. Shape : when conductors is suspended b/w 2 support at same level → it takes catenary shape.

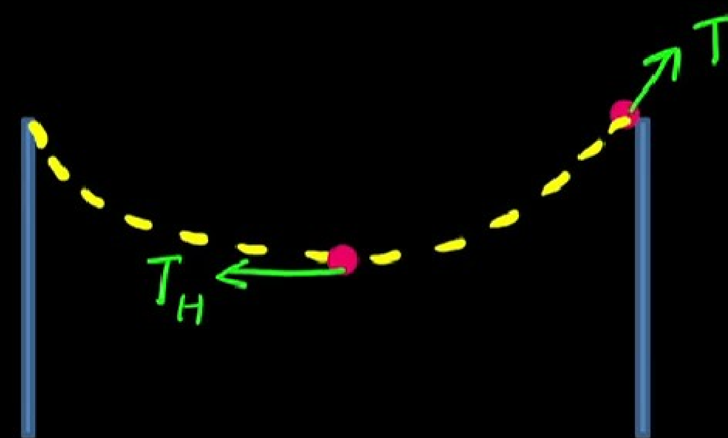
"If sag is very small, curve is parabola"

"If sag is large, it takes catenary shape"

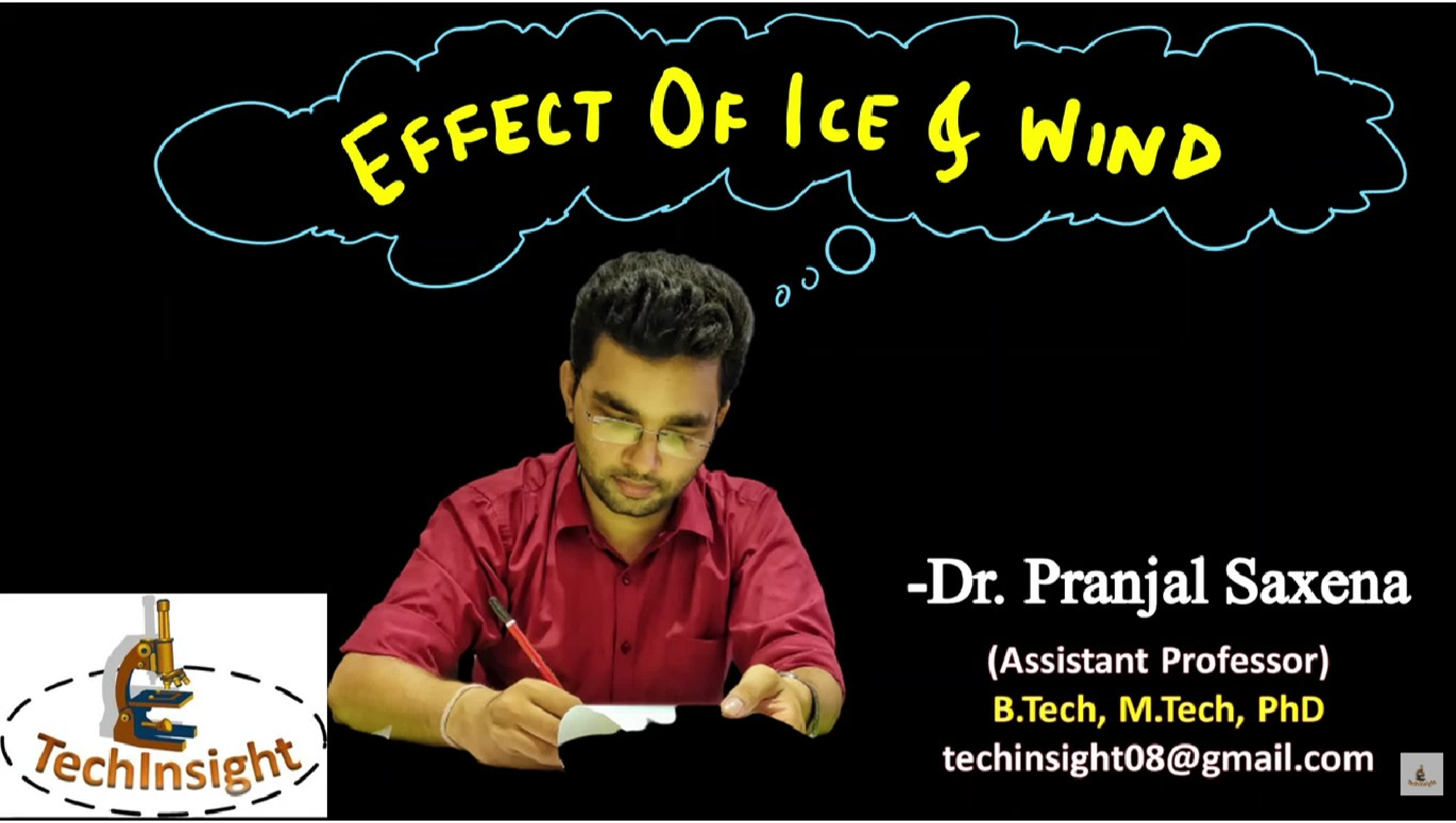
2. Tension at any pt act tangentially



3. Tension at support, is approximatly equal to Horizontal Tension



$$\boxed{T_H \approx T}$$


EFFECT OF ICE & WIND
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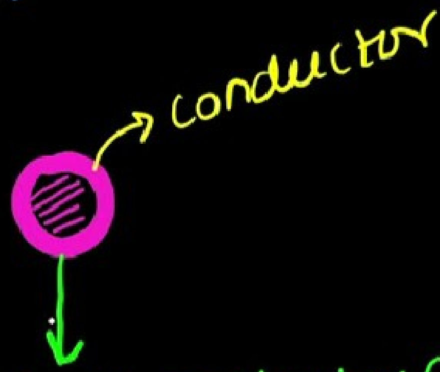
Sag Calculation

$$\boxed{Sag = \frac{w l^2}{8T}}$$

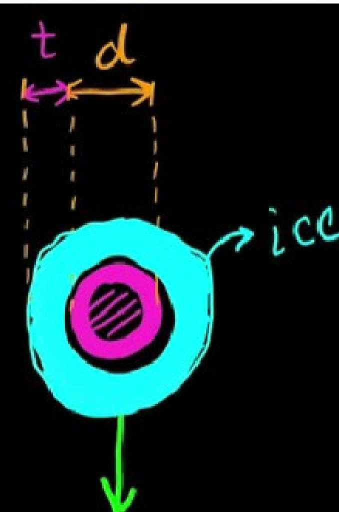
→ only valid in
- still air
- Normal Temp.
- Conductor bent by its own weight

* Presence of wind and ice change the scenario, and affect Sag

Effect of ice



wt of conductor (W)



wt of conductor (W)
+
wt of ice (W_i)

$t \rightarrow$ thickness of ice coating

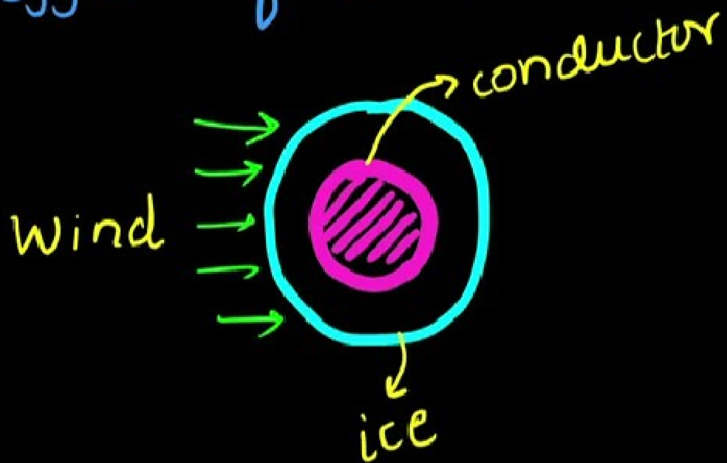
$d \rightarrow$ diameter of conductor

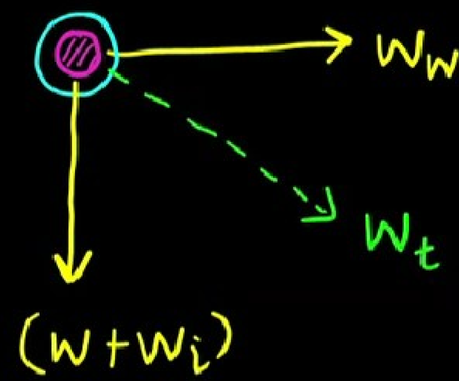
$W_i \rightarrow$ wt of ice per unit length

W_i = (density of ice) × (volume of ice per unit length)

$$\boxed{W_i = (\text{density of ice}) \times \pi t (d + t)}$$

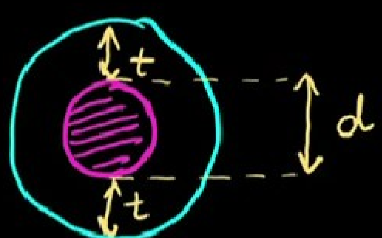
Effect of wind





$W_w \rightarrow$ wind force per unit length

$$W_t = \sqrt{(W+W_i)^2 + (W_w)^2}$$



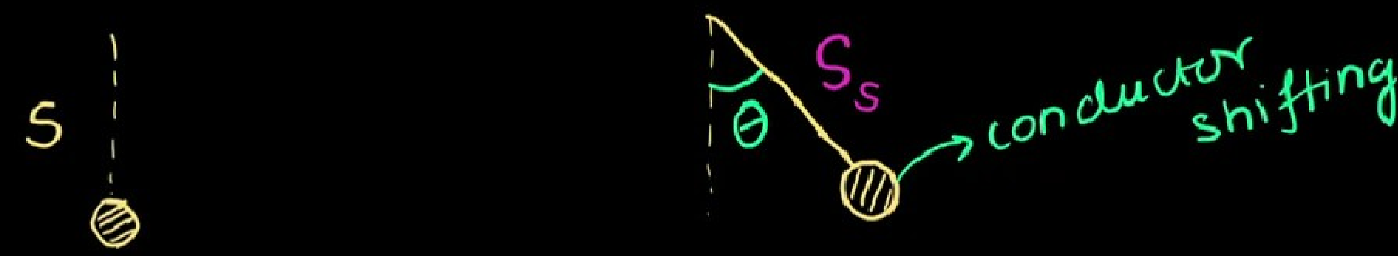
W_w = wind Pressure × projected area

$$\boxed{W_w = \text{wind Pressure} \times (2t+d)}$$

Slant Sag

* when both wind and ice loading acts on conductor,

(S) Sag $\longrightarrow$ slant sag (S_s)



$$\boxed{\tan\theta = \frac{W_w}{W + W_i}}$$

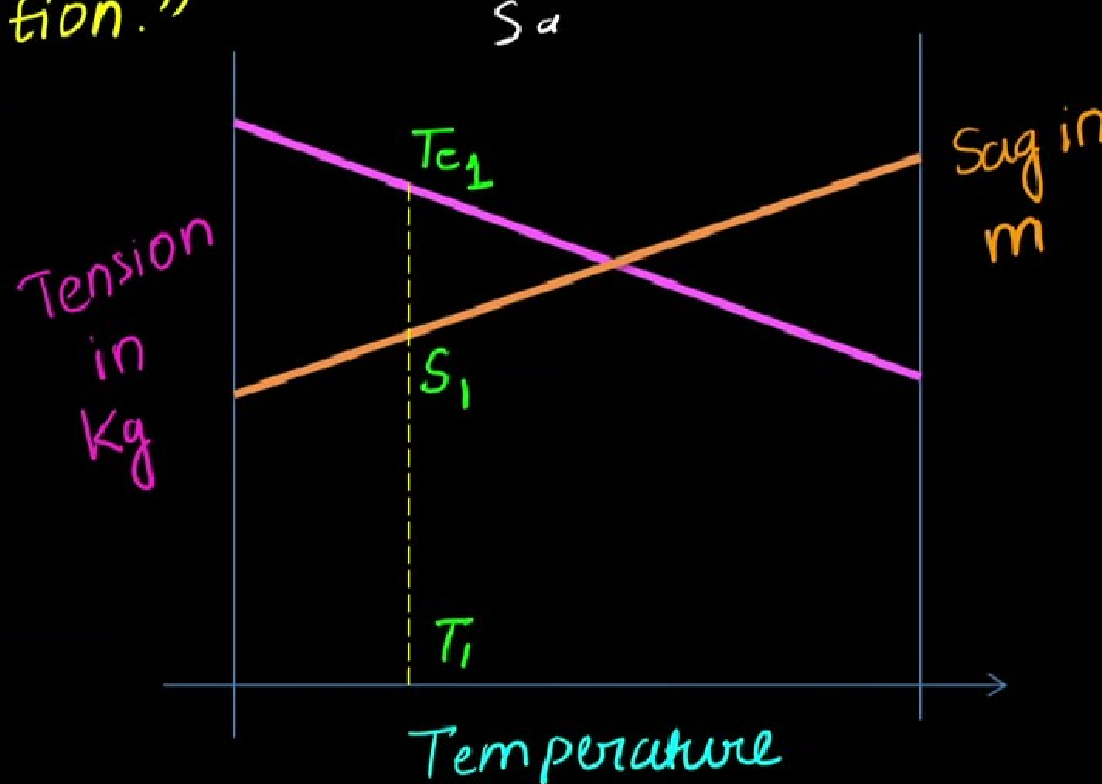
$$\boxed{S_s = \frac{W_t' \cdot l^2}{2T}}$$

$$\boxed{\text{Vertical sag } (S) = S_s \cos\theta}$$

$$W_t' \rightarrow \sqrt{(W + W_i)^2 + (W_w)^2}$$

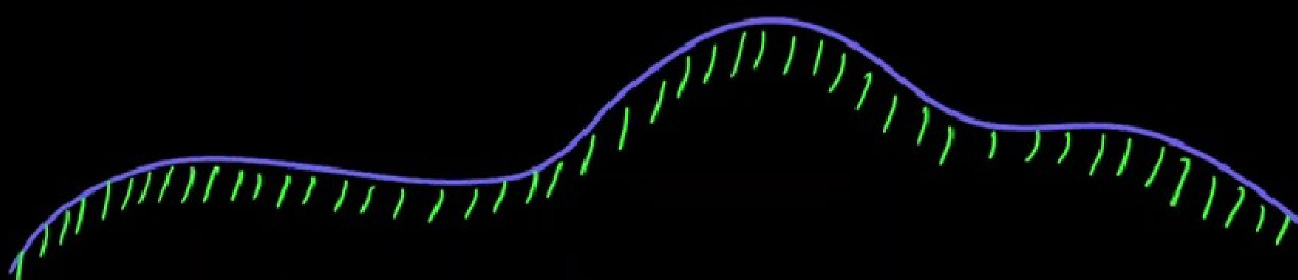
Stringing chart

"very useful in finding Sag and Tension at any temp. and loading condition."



* Stringing chart is useful under all environmental conditions.

Location of tower



Structure → 1. most economical

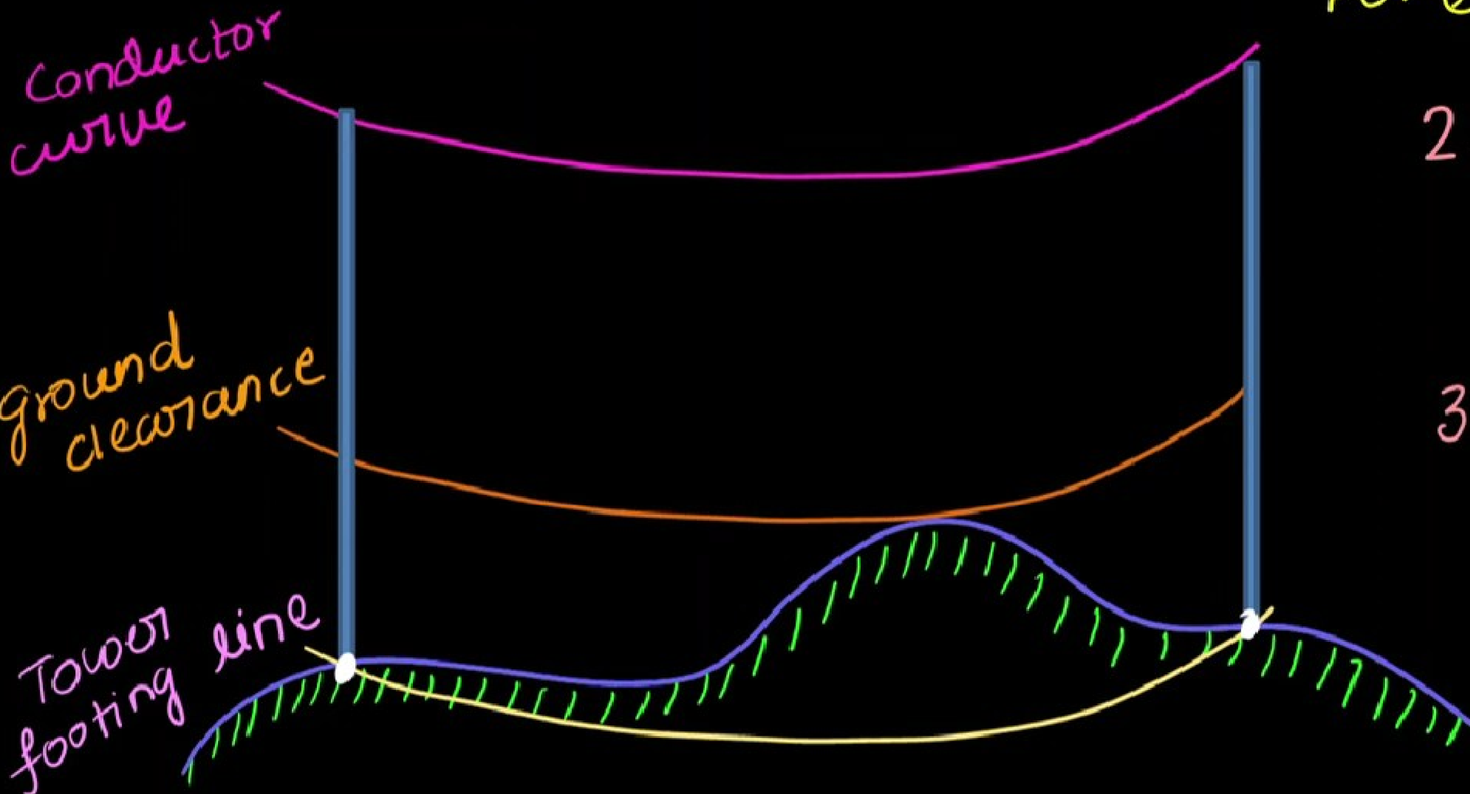
2. Satisfy electrical & mechanical requirement

sag

Tension

Manual Template Method

1. Plot conductor curve
   ↳ considering sag as per expected load



2. Plot parallel line for grnd clearance

3. Plot Tower footing line

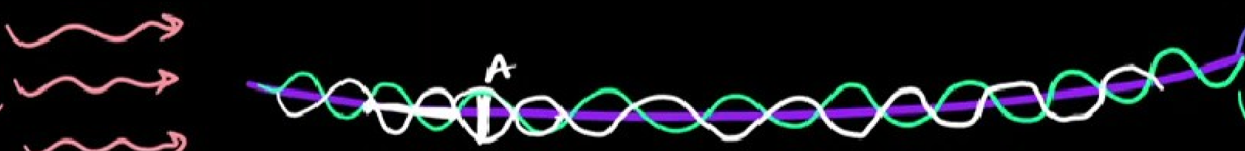
Vibrations of conductors

" Due to strong wind velocities, conductor start vibrating in vertical plane "

* There are 2 types of vibrations in vertical plane
  - 1. Aeoline Vibrations
  - 2. Galloping or Dancing of conductors

1. Aeoline Vibration

wind



→ conductor

→ small amplitude vibrations

2 to 40 Km/Hr

"High frequency, Low amplitude vibrations"

~~High~~ $\boxed{8\ \text{Hz to } 40\ \text{Hz}}$

2 cm to 5 cm

$$\boxed{\text{frequency of vibrations}} = \frac{2 \cdot V_P \cdot \times 10^3}{d}\ \text{Hz}$$

V_P → wind velocity in Km/Hr

d → diameter of conductor in m

Features

1. Harmful from suspension point of view

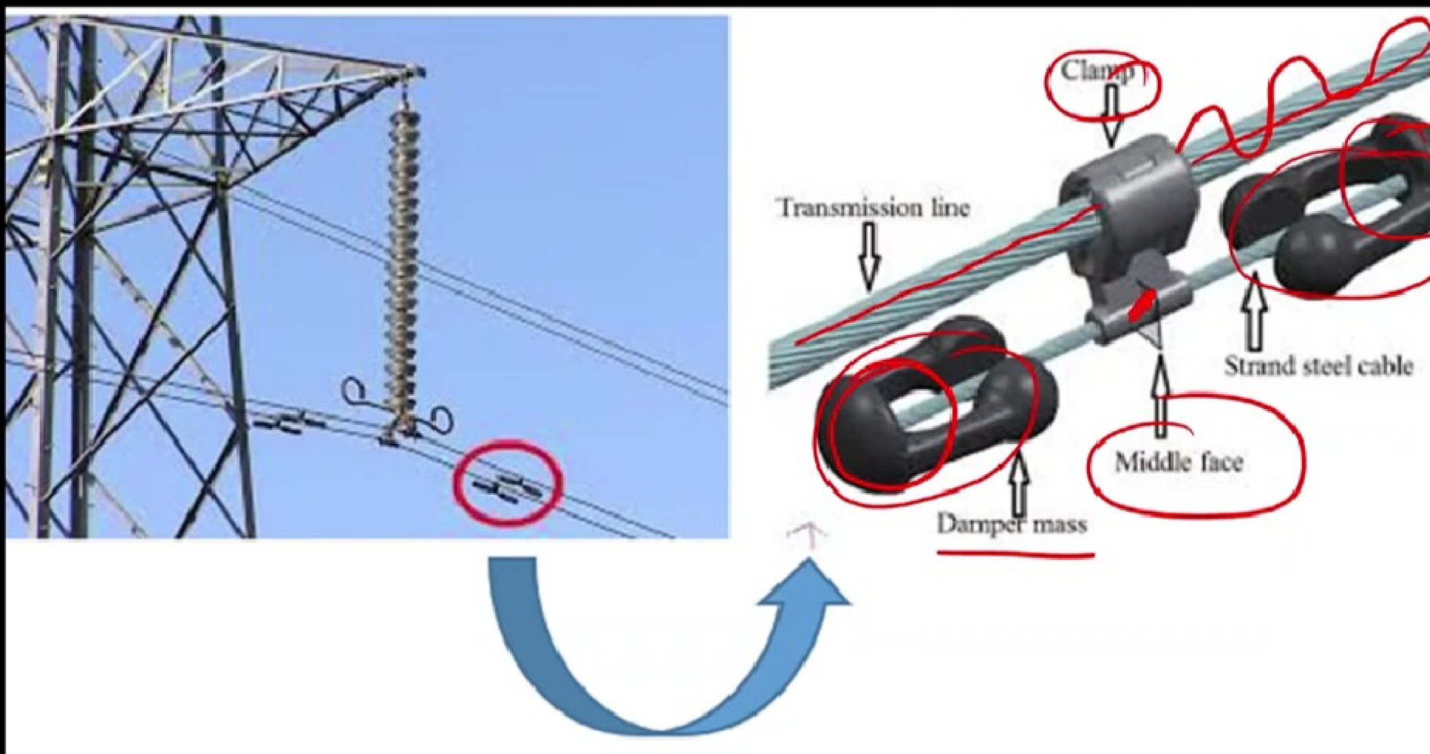
2. Damping

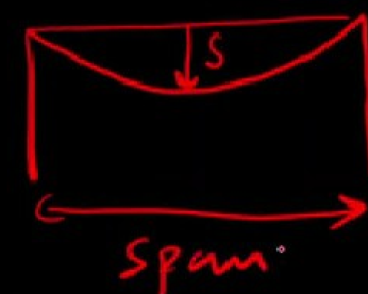
   ↳ By using bundle conductors

   ↳ Proper design

   ↳ Use of dampers

MCQ → Join





↳ No. of dampers

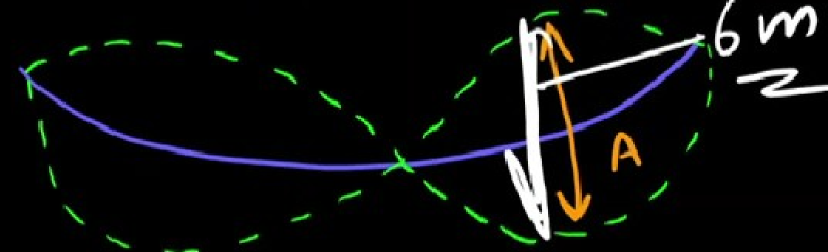
↳ Location of dampers

} → Depends upon span and size of conductor

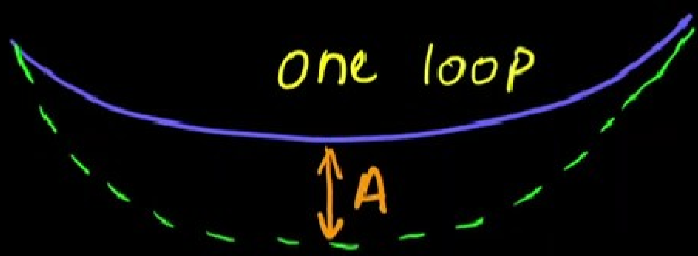
2. Galloping

" Horizontal and vertical dance of conductors with large amplitude"

Two loop



One loop



Three loop

" Dancing of conductor at low frequency and high amplitude"

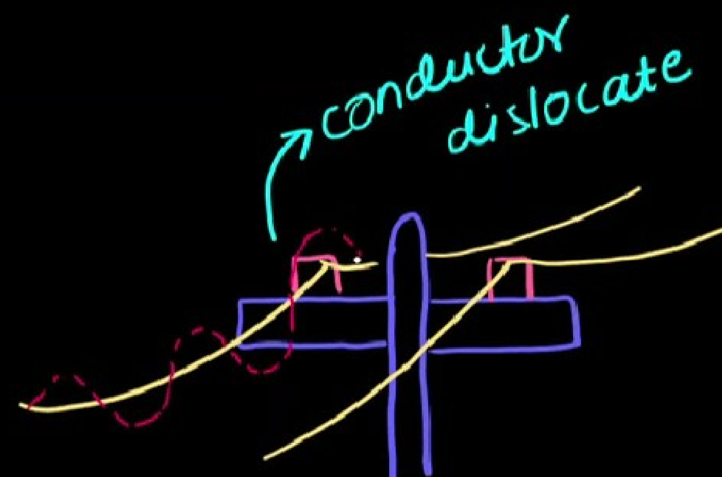
low frequency → 0.25 Hz to 1.5 Hz

high amplitude → 6 m

Features

1. When wind blow past non-circular conductor, galloping initiates

2. Conductor may ripped off from pin insulator



3. Rare but mainly occur in rainy and snowfall conditions