CE 380

HIGHWAY AND TRAFFIC ENGINEERING

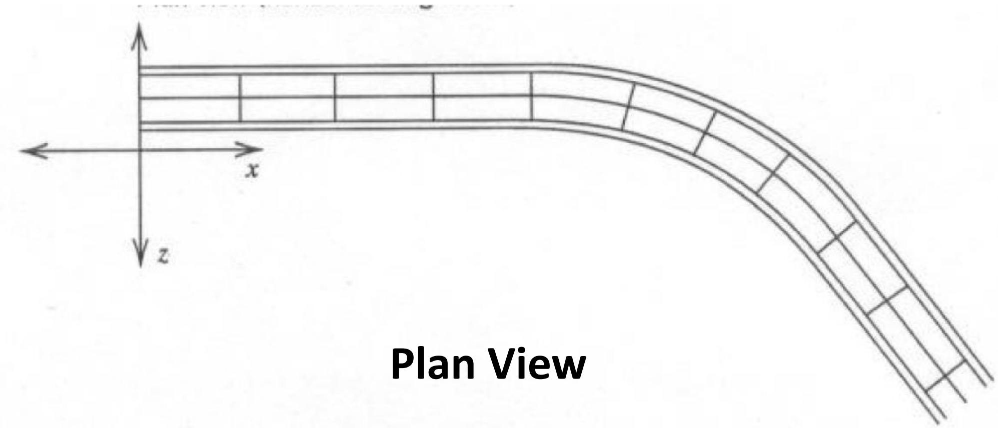
Lec . 6

Vertical alignments

Dr. Mahmoud Owais

Components of Highway Design

Horizontal Alignment

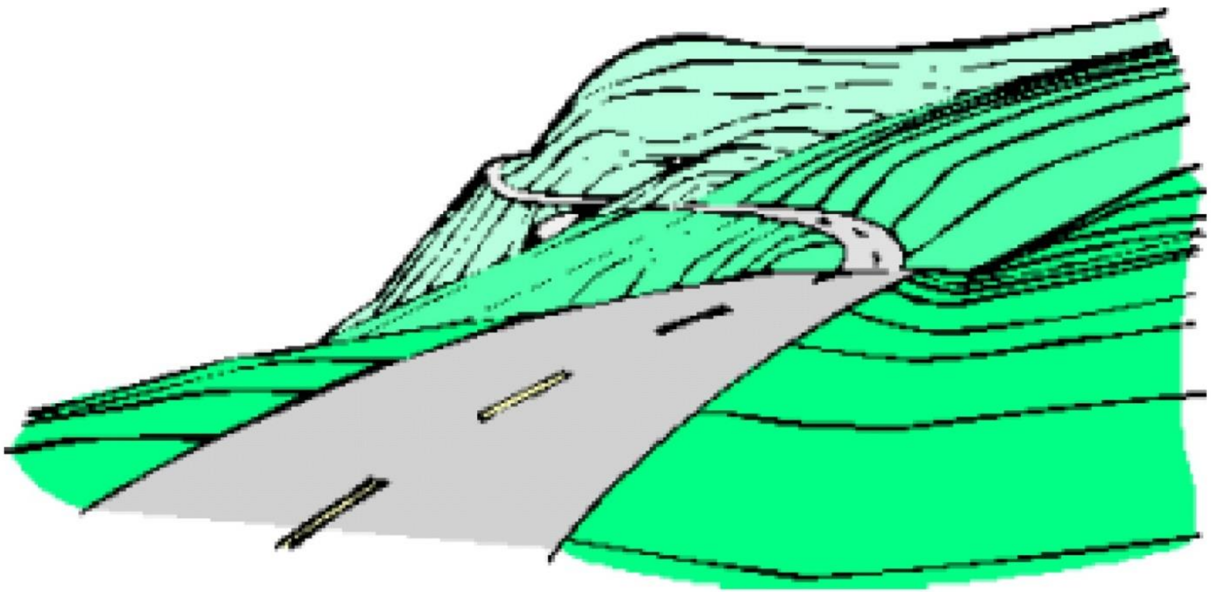


Plan View

Vertical Alignment

Profile View

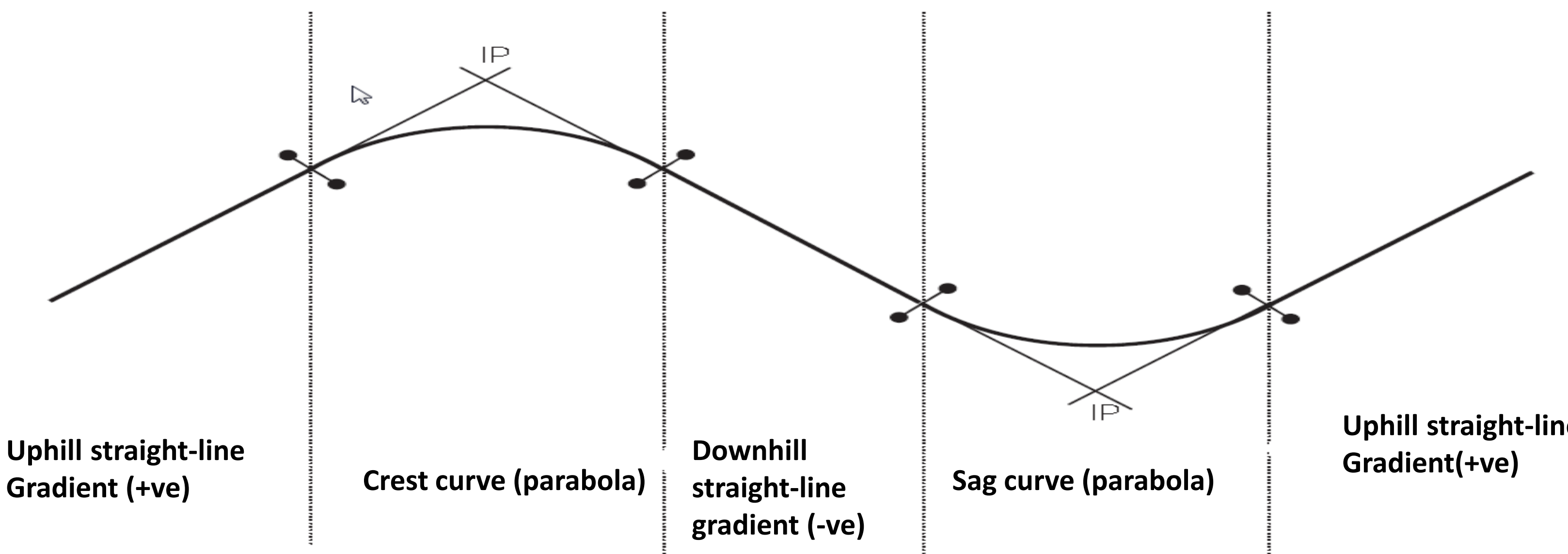
Vertical Alignment & Topography



Texas DOT

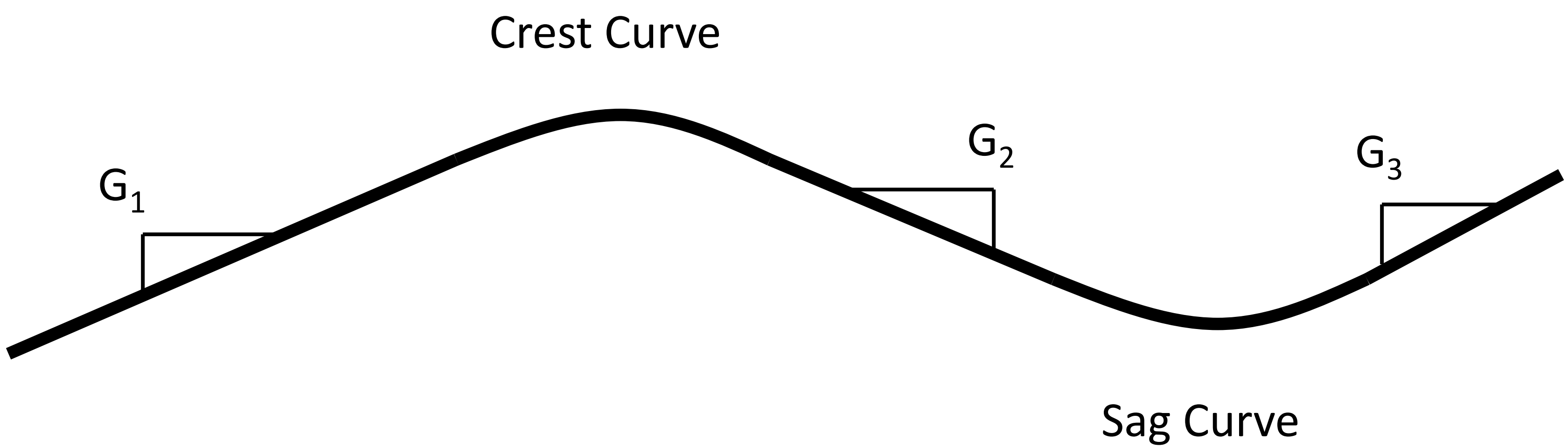
Vertical alignment

The vertical alignment is composed of a series of straight-line gradients connected by curves, normally parabolic in form. These vertical parabolic curves must therefore be provided at all changes in gradient. The curvature will be determined by the design speed, being sufficient to provide adequate driver comfort with appropriate stopping sight distances provided. .

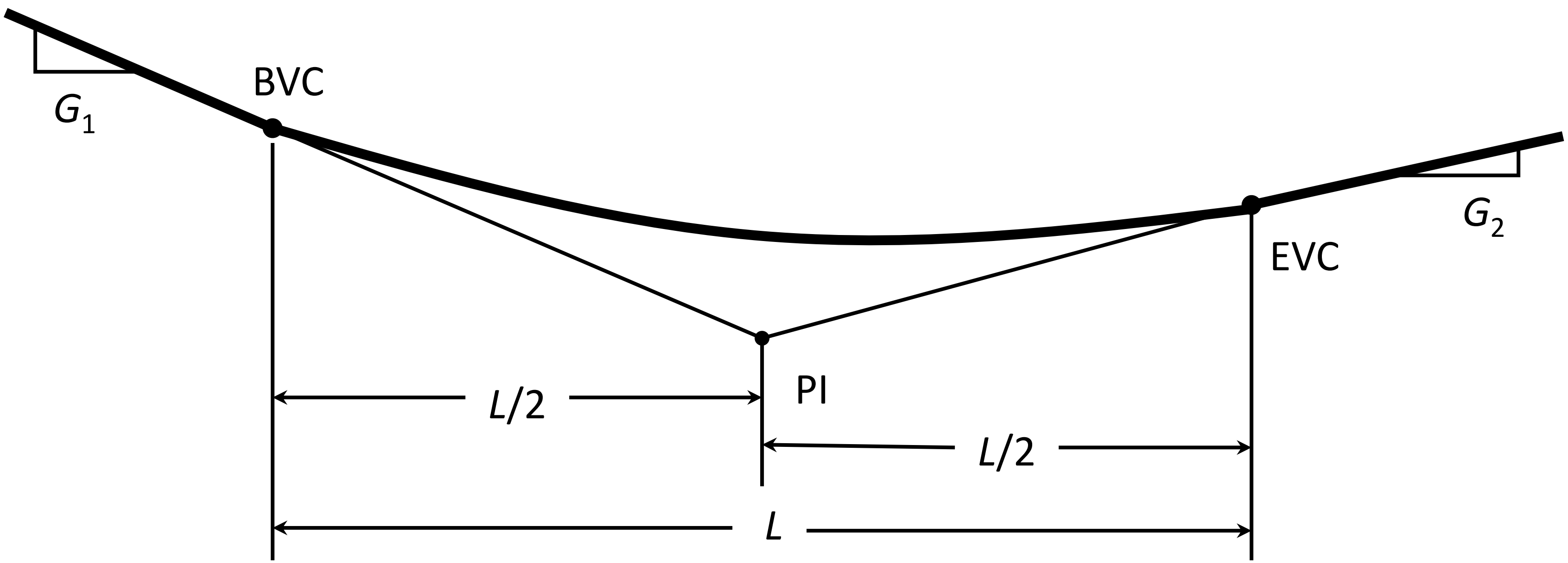


Example of typical vertical alignment

Vertical Alignment - Overview



Properties of Vertical Curves



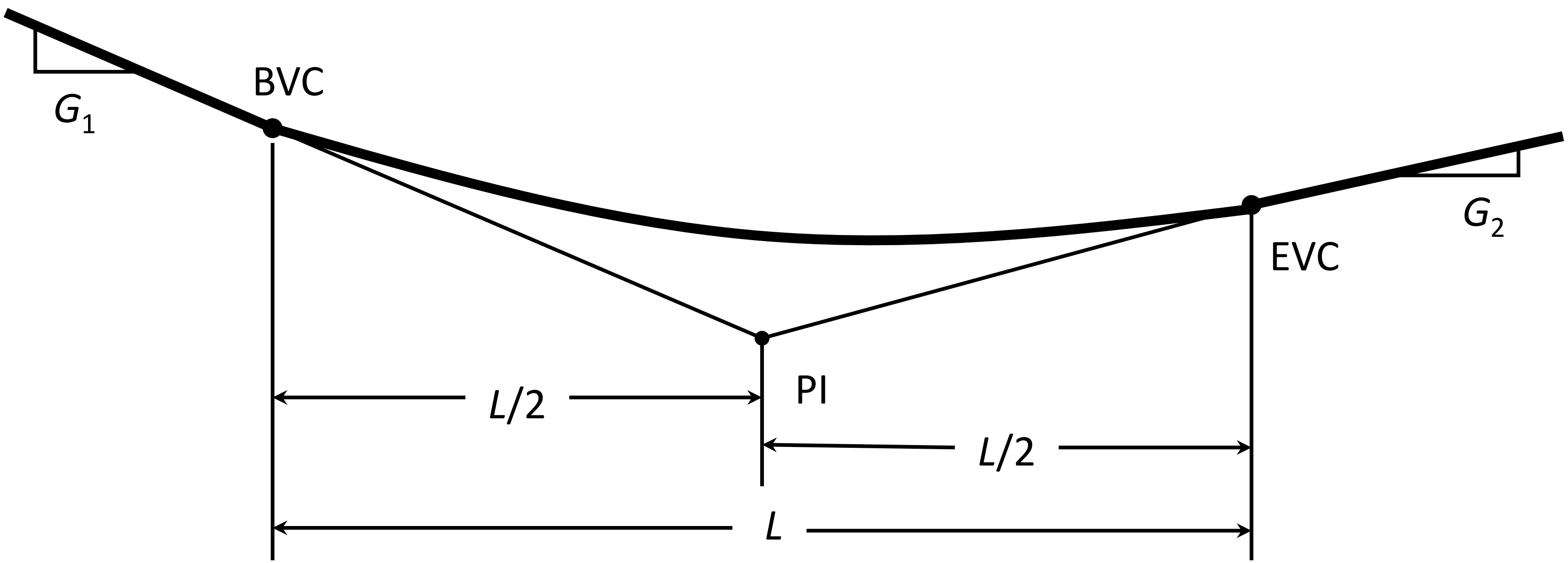
Change in grade: $A = G_2 - G_1$

where G is expressed as % (positive /, negative \)

For a crest curve, A is negative.

For a sag curve, A is positive.

Properties of Vertical Curves



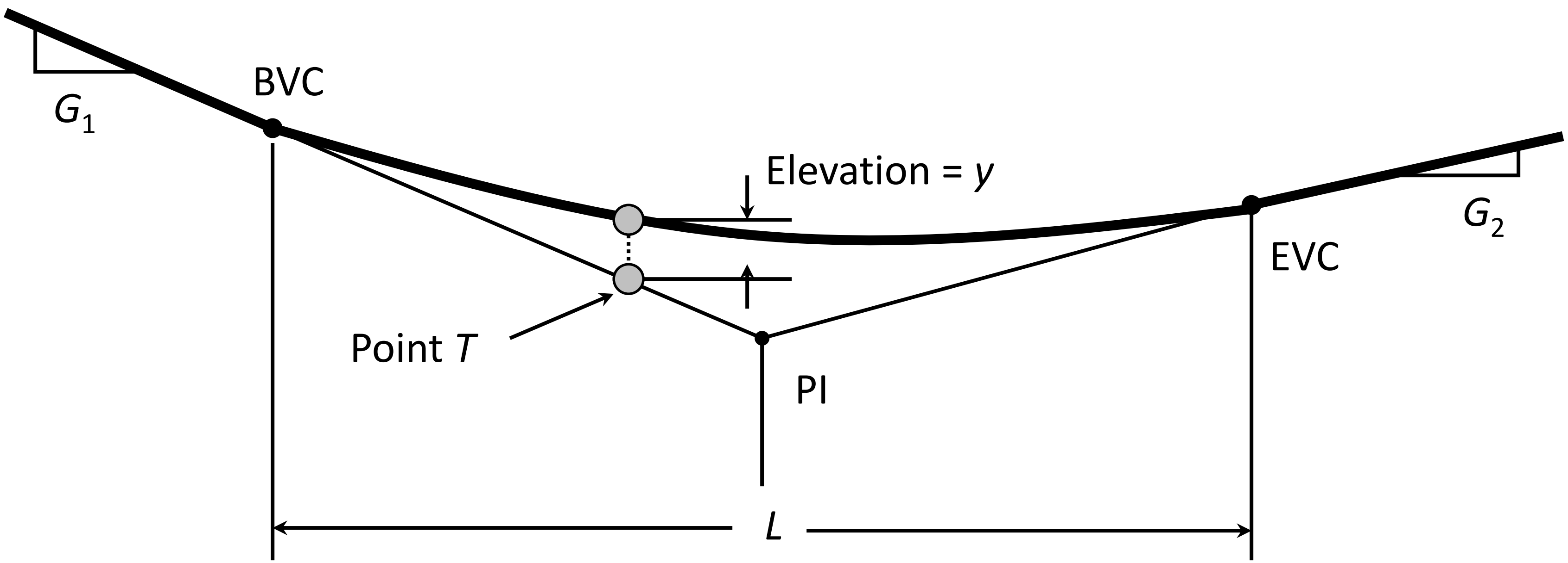
Characterizing the curve:

Rate of change of grade: $r = (g_2 - g_1) / L$ where,

g is expressed as a ratio (positive /, negative \)

L is expressed in feet or meters

Properties of Vertical Curves



Point elevation (meters or feet):

$y = y_0 + g_1 x + 1/2\, r x^2$ where,

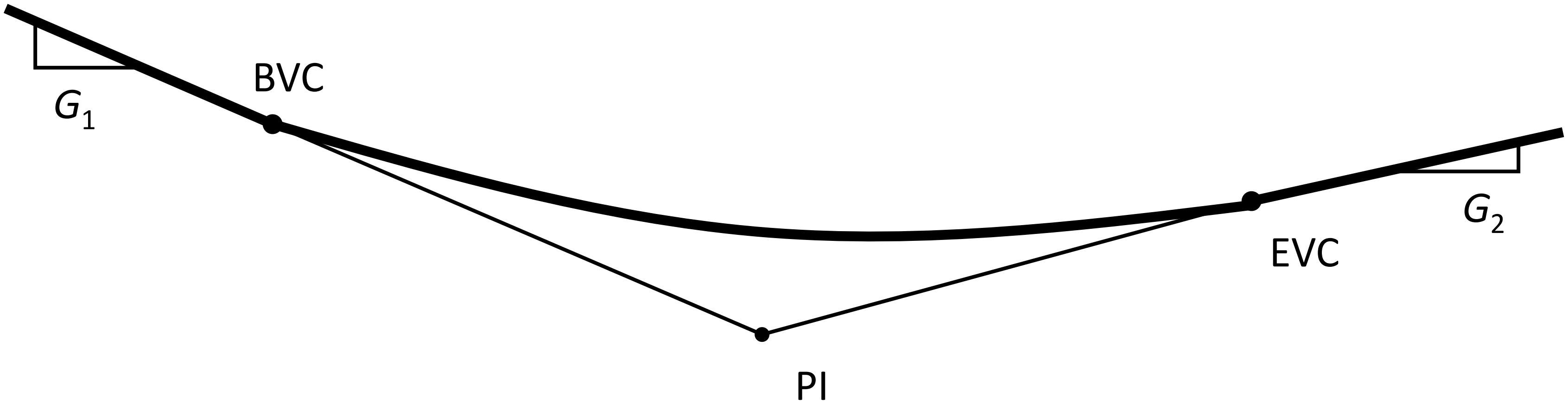
y_0 = elevation at the BVC (meters or feet)

g = grade expressed as a ratio (positive /, negative \)

x = horizontal distance from BVC (meters or feet)

r = rate of change of grade expressed as ratio (+ sag, - crest)

Properties of Vertical Curves



Example:

G_1 = -1% G_2 = +2%

Elevation of PI = 125.00 m

Station of EVC = 25+00

Station of PI = 24+00

Length of curve?

$L/2$ = 2500 m - 2400 m = 100 m

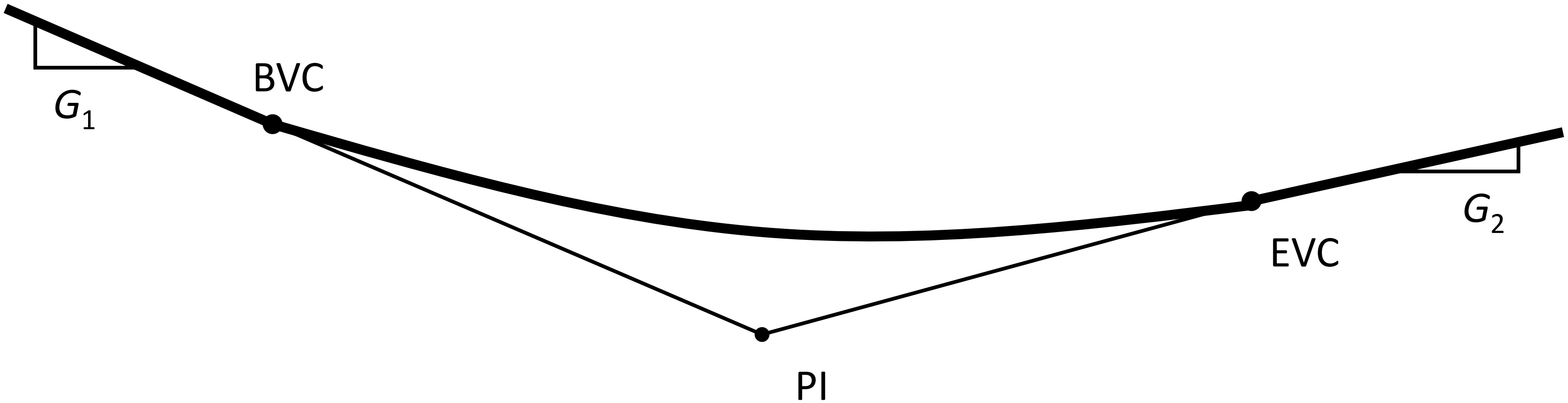
Sta. BVC = Sta. PI - $L/2$

Sta. BVC = [24+00] - 100 m

Sta. BVC = 23+00

L = 200 m

Properties of Vertical Curves



Example:

G_1 = -1% G_2 = +2%

Elevation of PI = 125.00 m

Station of EVC = 25+00

Station of PI = 24+00

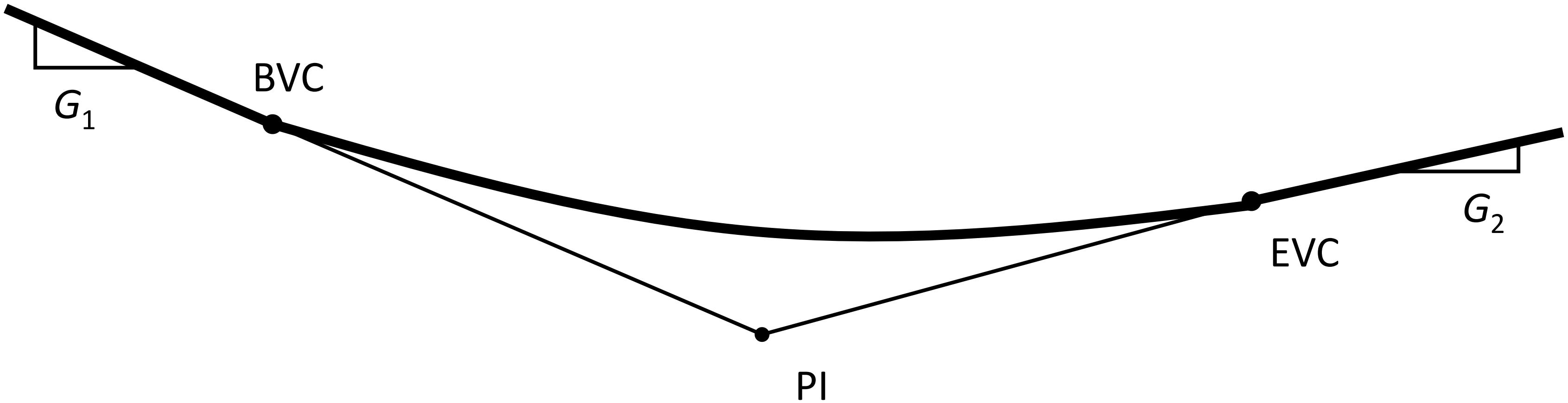
***r* - value?**

$r = (g_2 - g_1)/L$

r = (0.02 - [-0.01])/200 m

r = 0.00015 / meter

Properties of Vertical Curves



Example:

G_1 = -1% G_2 = +2%

Elevation of PI = 125.00 m

Station of EVC = 25+00

Station of PI = 24+00

Station of low point?

$x = -(g_1/r)$

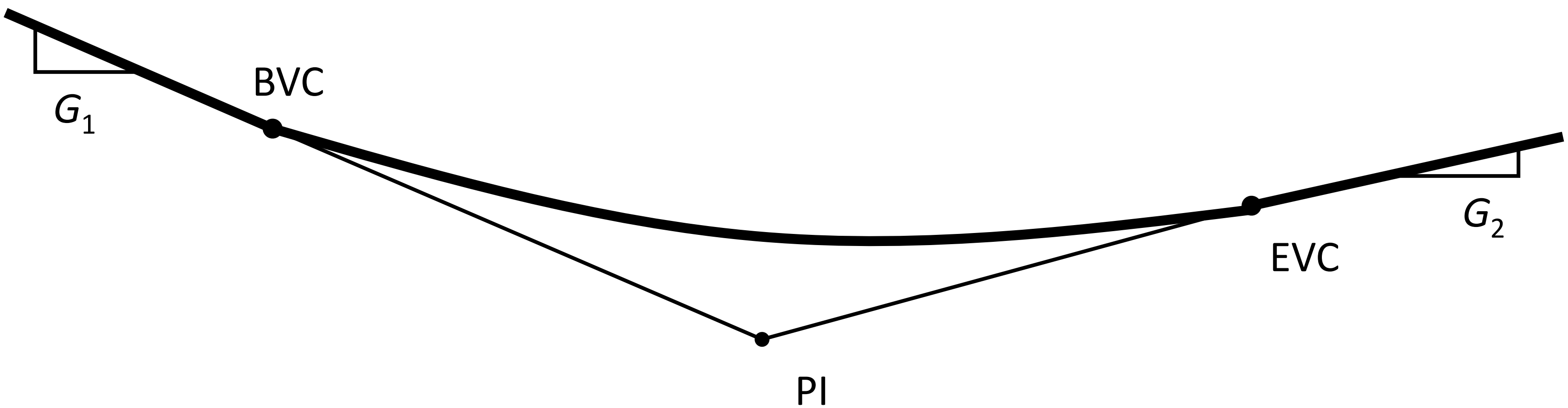
x = -([-0.01] / [0.00015/m])

x = 66.67 m

Station = [23+00] + 67.67 m

Station 23+67

Properties of Vertical Curves



Example:

G_1 = -1% G_2 = +2%

Elevation of PI = 125.00 m

Station of EVC = 25+00

Station of PI = 24+00

Elevation at low point?

$y = y_0 + g_1 x + 1/2\ r x^2$

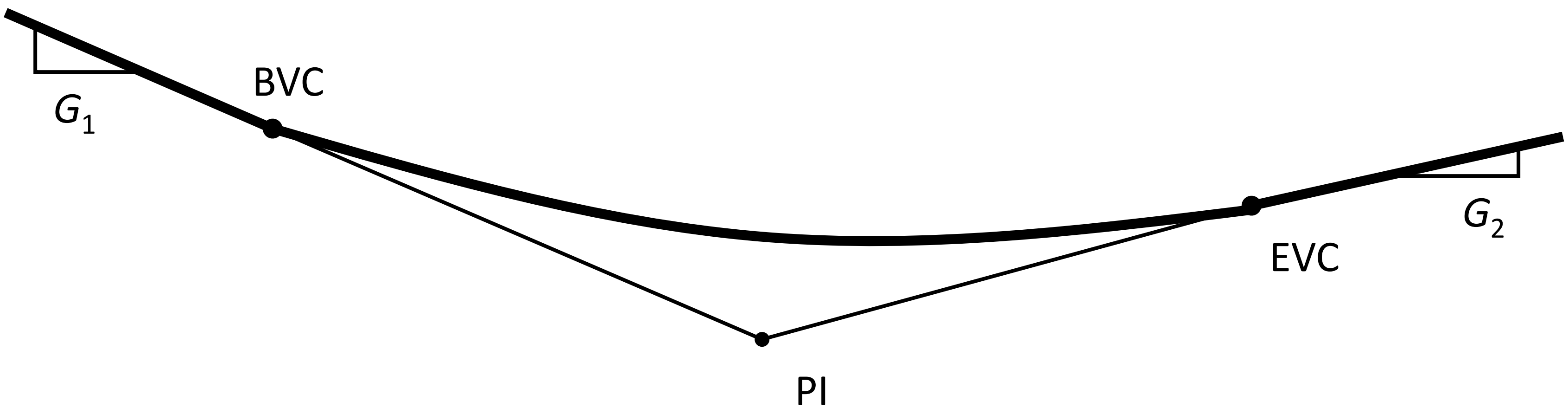
y_0 = Elev. BVC

Elev. BVC = Elev. PI - $g_1 L/2$

Elev. BVC = 125 m - [-0.01][100 m]

Elev. BVC = 126 m

Properties of Vertical Curves



Example:

G_1 = -1% G_2 = +2%

Elevation of PI = 125.00 m

Station of EVC = 25+00

Station of PI = 24+00

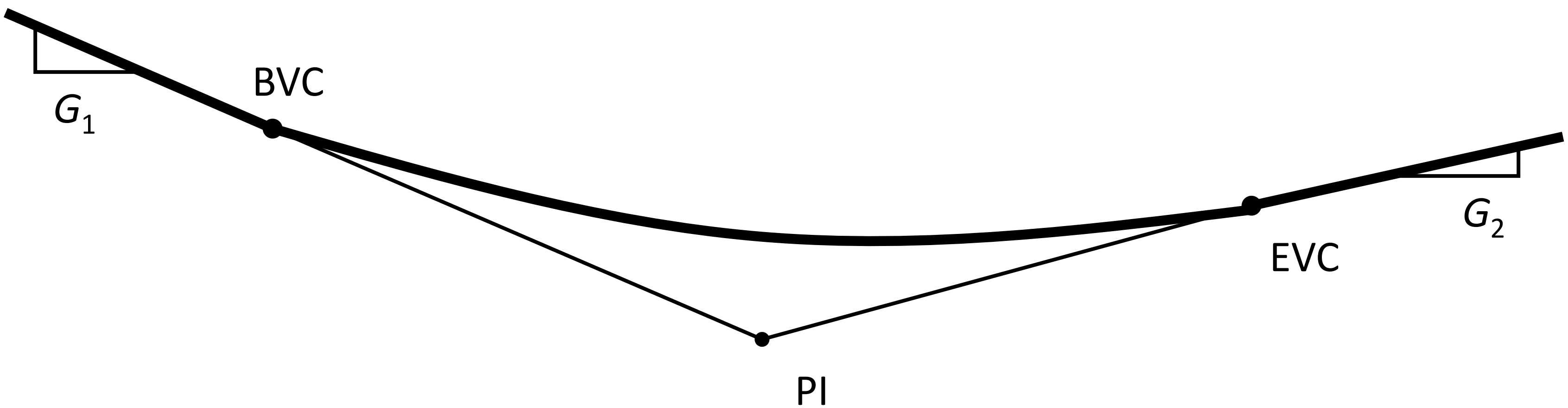
Elevation at low point?

$y = y_0 + g_1 x + 1/2\ r x^2$

y = 126 m + [-0.01][66.67 m] + 1/2 [0.00015/m][66.67 m]^2

y = 125.67 m

Properties of Vertical Curves



Example:

G_1 = -1% G_2 = +2%

Elevation of PI = 125.00 m

Station of EVC = 25+00

Station of PI = 24+00

Elevation at station 23+50?

y = 126 m + [-0.01][50 m] + 1/2 [0.00015/m][50 m]^2

y = 125.69 m

Elevation at station 24+50?

y = 126 m + [-0.01][150 m] + 1/2 [0.00015/m][150 m]^2

y = 126.19 m

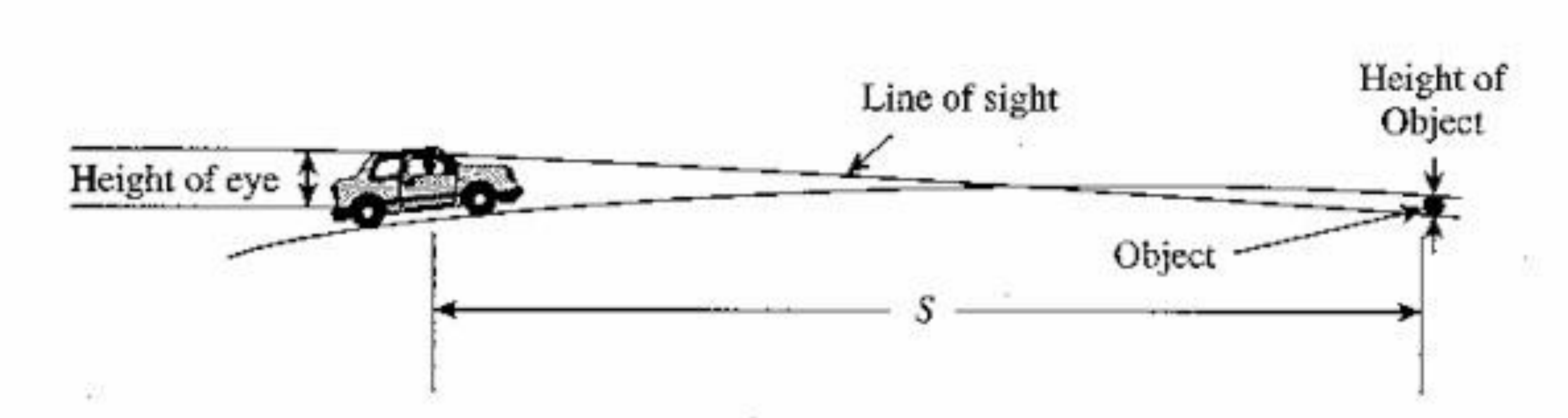
Design of Vertical Curves

- Determine the minimum length for a given design speed:
  - Sufficient sight distance
  - Driver comfort
  - Appearance

Design of Vertical Curves

Crest Vertical Curve

- If sight distance requirements are satisfied then safety, comfort, and appearance will not be a problem.



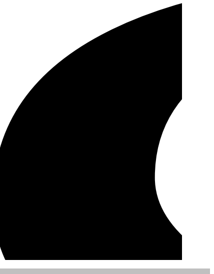
h_1 = height of driver's eyes, in ft

h_2 = height of object, in ft

Design of Vertical Curves

Crest Vertical Curve

Equation:



From AASHTO:

$h_1 \approx 3.5$ ft

$h_2 \approx 0.5$ ft (stopping sight distance)

$h_3 \approx 4.25$ ft (passing sight distance)

Design of Vertical Curves

Sag Vertical Curve

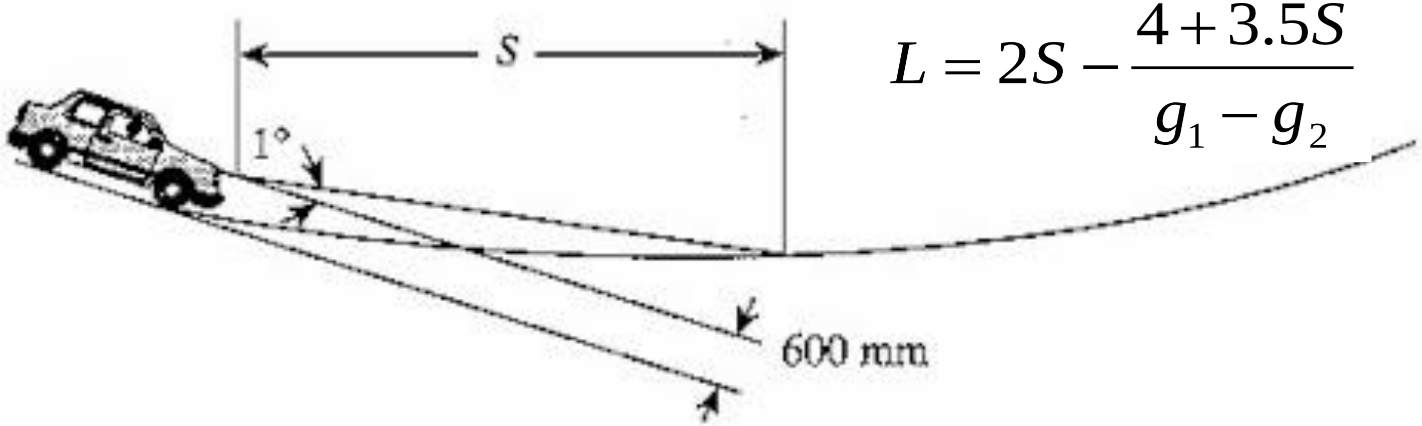
- Stopping sight distance not an issue. What are the criteria?
  - Headlight sight distance
  - Rider comfort
  - Height clearance

$$S \le L$$

$$L = \frac{S^2 (g_2 - g_1)}{4 + 3.5S}$$

$$S \ge L$$

$$L = 2S - \frac{4 + 3.5S}{g_1 - g_2}$$



Dee747 at picasaweb.google.com