“Symmetrical Parabolic Curve”

In highway practice, abrupt change in the vertical direction of moving vehicles should be avoided. In order to provide gradual change in its vertical direction, a parabolic vertical curve is adopted on account of its slope which varies at constant rate with respect to horizontal distances.
“Properties of Vertical Parabolic Curve”

1. The vertical offsets from the tangents to the curve are proportional to the squares of the distances from the point of tangency,

2. The curve bisects the distance between the vertex and the midpoint of the long chord.

3. If the algebraic difference in the rate of grade of the two slopes is positive, that is \(( g_1 - g_2 )\), we have a “summit” curve, but if it is negative, we have “sag curve”.

“Properties of Vertical Parabolic Curve”

4. The length of curve of a parabolic vertical curve, refers to the horizontal distance from the P.C. to the P.T.

5. The stationing of vertical parabolic curves is measured not along the curve but along a horizontal line.
“Properties of Vertical Parabolic Curve”

6. For a symmetrical parabolic curve, the number of stations to the left must be equal to the number of stations to the right, of the intersection of the slopes or forward and back tangent.

7. The slope of the parabola varies uniformly along the curve, Therefore the rate of change of slope is constant and equal to:

\[ r = \frac{(g_2 - g_1)}{L} \]
“Properties of Vertical Parabolic Curve”

8. The maximum offset \( H = 1/8 \) the product of the algebraic difference between the two rates of grade and the length of curve:

\[
H = (1/8)(L)(g_1 - g_2)
\]

9. Location of the highest or lowest point of the curve.

   From the P.C. \( \rightarrow S_1 = (g_1L)/(g_1 - g_2) \)
   
   From the P.T. \( \rightarrow S_2 = (g_2L)/(g_2 - g_1) \)

   and \( S_1 + S_2 = L \)
Example 1:

A parabolic curve has a descending grade of -0.8% which meets an ascending grade of 0.4% at Sta. 10 + 020. If the maximum allowable change of grade per 20m. Station is 0.15 and the elevation at Sta. 10 + 020 is 240.60m. (a) What is the length of the curve? (b) Compute the elevation of the lowest point of the curve (c) Compute the elevation of the curve at Station 10 + 000.
Example 1:

A symmetrical vertical summit curve has tangents of +4% and -2%. The allowable rate of change of grade is 0.3% per 20-m station. If the stationing and elevation of P.T is at 10 + 020 and 142.63m, respectively. Compute the elevation of the highest point.
Example 1:

A vertical parabolic sag curve has a grade of -0.4% followed by a grade of +2% intersecting at station 12 + 150.60 at elevation 124.80 m above sea level. The change of grade of the sag curve is restricted to 0.6%. (a) Compute the length of the curve (b) Compute the elevation of the lowest point of the curve (c) Compute the elevation at Sta. 12 + 125.60.
Example 1:

A vertical summit parabolic curve has its P.I. at station 14 +750 with elevation of 76.30 m. The grade of the back tangent is 3.4% and forward tangent of -4.8%. If the length of curve is 300 m. Determine the (a) location of the vertical curve turning point from the P.I. (b) elevation of the vertical curve turning point in meters (c) stationing of the vertical curve turning point.
Example 1:

A vertical summit parabolic curve has vertical offset of 0.37 m. from the curve to the grade tangent at Station 10 + 050. The curve has a slope of +4% and -2% grades intersecting at the P.I. The offset distance of the curve at P.I. is equal to 1.5 m. If the stationing of the P.C. is at 10 + 000. Compute the (a) required length of curve (b) horizontal distance of the vertical curve turning point from the point of intersection of the grades. (c) elevation of the vertical curve turning point if the elevation of P.T. is 86.42 m.
Example 1:

A -3% grade meets a +5% grade at a vertex (El. 146.24) directly under an over pass bridge whose underside is at elev. 152.74, and carries another road across the grades at right angles. (a) What is the longest parabolic that can be used to connect the two grades and at the same time provide at least 5m of clearance under the bridge at its center line? (b) If the underside of the bridge is level and is 12 m wide, find the actual clearance at the left and right edge of the bridge.
Example 1:

A grade descending at the rate of -4% intersects another grade ascending at the rate of +8% at station 2 + 000, elevation 100 m. A vertical curve is to connect the two such that the curve will clear a boulder located at station 1 + 980, elevation 101.34 m. Determine the (a) necessary length of the curve (b) station and elevation of the lowest point.
Example:

On a railroad, a -0.8% grade meets a +0.4% grade at Sta. 2 + 700 whose elevation is 30 m. The maximum allowable change in grade per station having a length of 20 m is 0.15 %. It is desired to place a culvert to draw the waters during heavy downpour. Where must this culvert be located? At what elevation must the invert of the culvert be set if the pipe has a diameter of 0.9 m and the backfill is 0.3 m high. Neglect the thickness of the pipe.
Example:

A vertical summit curve has its highest point of the curve at a distance 48 m from the P.T. The back tangent has a grade of +6% and a forward grade of -4%. The curve passes thru point A on the curve at station 25 + 140. The elevation of the grade intersection is 100 m at station 25 + 160. Compute the (a) length of curve (b) stationing of P.T. (c) elevation of point A on the curve which is 40 m from PC.
Example:

A vertical symmetrical sag curve has a descending grade of -4.2% and an ascending grade of +3% intersecting at station 10 + 020, whose elevation is 100 m. The two grade lines are connected by a 260 m vertical parabolic sag curve. (a) At what distance from the P.C. is the lowest point of the curve located? (b) What is the vertical offset of the parabolic curve to the point of intersection of the tangent grades. (c) If a 1m diameter culvert is placed at the lowest point of the curve with the top of the culvert buried 0.6 m below the sub grade, what will be the elevation of the invert of the culvert?
Example:

A horizontal laid circular pipe culvert having an elevation of its top to be 26 m crosses at right angles under a proposed 120 m high way parabolic curve. The point of intersection of the grade lines is at station 5 + 216 and its elevation is 27.0 m while the culvert is located at station 5 + 228. The backward tangent has a grade of 3% and the grade of the forward tangent is -16%. (a) Compute the stationing and elevation of the highest point (b) Under this conditions, what will be the depth of cover over the pipe?
Example:

A symmetrical parabolic summit curve connects two grades of +6% and -4%. It is to pass through a point “P” the stationing of which is 35 + 280 and the elevation of the grade intersection is 200 m with stationing 35 +300. Determine the (a) length of the curve (b) stationing and elevation of P.C. (c) stationing and elevation of P.T.
Example:

An underpass road crossing a reinforced concrete bridge along Shaw Blvd. has a downward grade of -4% meeting an upward grade of +8% at the vertex, V (elev. 70 m) at sta. 7 + 700 exactly underneath the centerline of the bridge having a width of 10 m. If the required minimum clearance under the bridge is 5m and the elevation of the bottom of the bridge is 78.10 m. Determine the (a) length of the vertical parabolic curve that shall connect the two tangents. (b) Station and elevation where a catch basin will be placed.
**Example:**

Point “P” is the location of the center lie of an existing highway. An underpass is to be designed perpendicular to the existing highway with a vertical parabolic curve such that its lowest point is directly below “P” with a vertical clearance of 5.5 m. Stationing of the P.I. is 5 + 800 and has an elevation of 105 m. The slope of the tangent passing thru the P.C. is -4% and that of the P.T. is +3%. Determine the (a) length of the vertical parabolic curve (b) stationing of point “P” being on the right side of the curve if it has an elevation of 120m (c) elevation of the P.T. of the curve.
Example:

A symmetrical parabolic curve passes through point A whose elevation is 23.23 m at a distance of 54 m from the PC. The elevation of the PC at station 4 + 100 is 22.56 m. The grade of the back tangent is +2% and the length of curve is 120m. Compute the (a) grade of the forward tangent (b) stationing and elevation of the highest point.