

# ASSIGNMENT-6

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1 QUESTION No-2.82 (QUADRATIC FORMS)

where

Find the equation of the tangent to the curve  $y = \sqrt{3x-2}$  which is parallel to the line  $(4 \ -2)\mathbf{x} + 5 = 0$ .

$$\mathbf{P} = (\mathbf{p}_1 \mathbf{p}_2) = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad (2.0.12)$$

$$\mathbf{D} = \begin{pmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{pmatrix} = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \quad (2.0.13)$$

Now (2.0.11) becomes

$$\mathbf{V} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \quad (2.0.14)$$

$$\mathbf{V} = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \quad (2.0.15)$$

2 SOLUTION

Given equation

$$\mathbf{x}^\top \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \mathbf{x} + (-3 \ 0)\mathbf{x} + 2 = 0 \quad (2.0.1)$$

we have

$$\therefore \mathbf{u} = \begin{pmatrix} \frac{-3}{2} \\ 0 \end{pmatrix} \quad (2.0.2)$$

$$\mathbf{V} = \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \quad (2.0.3)$$

$$\Rightarrow |\mathbf{V}| = 0 \quad (2.0.4)$$

Thus the curve is a parabola. Now we find the eigen values corresponding to  $\mathbf{V}$

$$|\mathbf{V} - \lambda \mathbf{I}| = 0 \quad (2.0.5)$$

$$\begin{vmatrix} -\lambda & 0 \\ 0 & 1 - \lambda \end{vmatrix} = 0 \quad (2.0.6)$$

$$\Rightarrow \lambda = 0, 1 \quad (2.0.7)$$

Now we find the eigen vectors corresponding to  $\lambda = 0, 1$  respectively.

$$\mathbf{V}\mathbf{x} = \lambda\mathbf{x} \quad (2.0.8)$$

$$\begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix} \mathbf{x} = 0 \Rightarrow \mathbf{p}_1 = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \quad (2.0.9)$$

$$\begin{pmatrix} -1 & 0 \\ 0 & 0 \end{pmatrix} \mathbf{x} = \mathbf{x} \Rightarrow \mathbf{p}_2 = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \quad (2.0.10)$$

Now by eigen decomposition on  $\mathbf{V}$

$$\mathbf{V} = \mathbf{PDP}^\top \quad (2.0.11)$$

Given parallel line equation

$$(4 \ -2)\mathbf{x} + 5 = 0 \quad (2.0.16)$$

Now the tangent to the parabola is parallel to the line equation (2.0.16), The normal vector  $\mathbf{n}$  and the direction vector  $\mathbf{m}$  is given by

$$\mathbf{n} = \begin{pmatrix} 4 \\ -2 \end{pmatrix} \quad (2.0.17)$$

$$\mathbf{m} = \begin{pmatrix} -2 \\ -4 \end{pmatrix} \quad (2.0.18)$$

Now the equation for the point of contact for the parabola is given as,

$$\begin{pmatrix} \mathbf{u} + \kappa \mathbf{n}^\top \\ \mathbf{V} \end{pmatrix} \mathbf{q} = \begin{pmatrix} -\mathbf{f} \\ \kappa \mathbf{n} - \mathbf{u} \end{pmatrix} \quad (2.0.19)$$

$$\Rightarrow \begin{pmatrix} -3 & \frac{3}{4} \\ 0 & 0 \\ 0 & 1 \end{pmatrix} \mathbf{q} = \begin{pmatrix} -2 \\ 0 \\ \frac{3}{4} \end{pmatrix} \quad (2.0.20)$$

Now solving for  $\mathbf{q}$  by removing the zero row and representing as augmented matrix and then converting it to echelon form.

$$\begin{pmatrix} -3 & \frac{3}{4} & -2 \\ 0 & 1 & \frac{3}{4} \end{pmatrix} \xrightarrow{R_1 \rightarrow (-\frac{1}{3})R_1} \begin{pmatrix} 1 & -\frac{1}{4} & \frac{2}{3} \\ 0 & 1 & \frac{3}{4} \end{pmatrix} \quad (2.0.21)$$

$$\begin{pmatrix} 1 & -\frac{1}{4} & \frac{2}{3} \\ 0 & 1 & \frac{3}{4} \end{pmatrix} \xrightarrow{R_1 \rightarrow R_1 + \frac{1}{4}R_2} \begin{pmatrix} 1 & 0 & \frac{41}{48} \\ 0 & 1 & \frac{3}{4} \end{pmatrix} \quad (2.0.22)$$

Hence from the (2.0.22) we get the point of contact to be

$$\mathbf{q} = \begin{pmatrix} \frac{41}{48} \\ \frac{3}{4} \end{pmatrix} \quad (2.0.23)$$

Now  $\mathbf{q}$  is the point on the tangent. Hence the equation of the line can be expressed as

$$\mathbf{n}^\top (\mathbf{x} - \mathbf{q}) = 0 \quad (2.0.24)$$

where,

$$\mathbf{n}^\top \mathbf{q} = \begin{pmatrix} 4 & -2 \end{pmatrix} \begin{pmatrix} \frac{41}{48} \\ \frac{3}{4} \end{pmatrix} \quad (2.0.25)$$

$$= \frac{23}{12} \quad (2.0.26)$$

Hence the equation of the tangent to the curve (2.0.1) parallel to the line (2.0.16) is given by substituting the value of  $\mathbf{n}^\top \mathbf{q}$  and  $\mathbf{n}$  from (2.0.26) and (2.0.17) respectively to the equation (2.0.24)

$$\begin{pmatrix} 4 & -2 \end{pmatrix} \mathbf{x} = \frac{23}{12} \quad (2.0.27)$$

Hence (2.0.27) is the equation of the tangent. The plot of the figure is given below

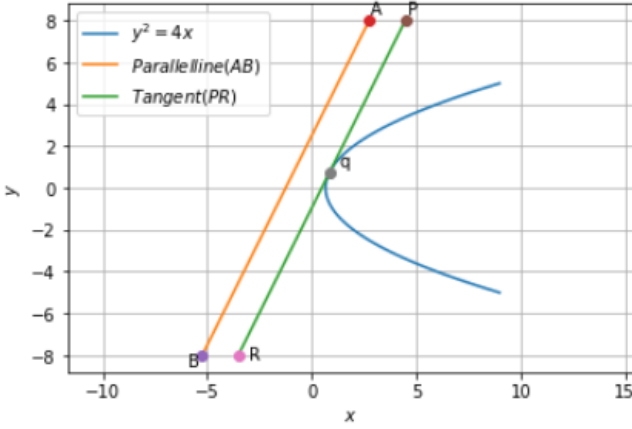


Fig. 2.1: Plot of curve and the lines