

**Exercise 11.4****Question 1:**

Find the coordinates of the foci and the vertices, the eccentricity, and the length of the

latus rectum of the hyperbola  $\frac{x^2}{16} - \frac{y^2}{9} = 1$

Answer

The given equation is  $\frac{x^2}{16} - \frac{y^2}{9} = 1$  or  $\frac{x^2}{4^2} - \frac{y^2}{3^2} = 1$ .

On comparing this equation with the standard equation of hyperbola i.e.,  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ , we obtain  $a = 4$  and  $b = 3$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore c^2 = 4^2 + 3^2 = 25$$

$$\Rightarrow c = 5$$

Therefore,

The coordinates of the foci are  $(\pm 5, 0)$ .

The coordinates of the vertices are  $(\pm 4, 0)$ .

$$\text{Eccentricity, } e = \frac{c}{a} = \frac{5}{4}$$

$$\text{Length of latus rectum} = \frac{2b^2}{a} = \frac{2 \times 9}{4} = \frac{9}{2}$$

**Question 2:**

Find the coordinates of the foci and the vertices, the eccentricity, and the length of the

latus rectum of the hyperbola  $\frac{y^2}{9} - \frac{x^2}{27} = 1$

Answer

The given equation is  $\frac{y^2}{9} - \frac{x^2}{27} = 1$  or  $\frac{y^2}{3^2} - \frac{x^2}{(\sqrt{27})^2} = 1$ .

On comparing this equation with the standard equation of hyperbola i.e.,  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ , we

obtain  $a = 3$  and  $b = \sqrt{27}$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore c^2 = 3^2 + (\sqrt{27})^2 = 9 + 27 = 36$$

$$\Rightarrow c = 6$$

Therefore,

The coordinates of the foci are  $(0, \pm 6)$ .

The coordinates of the vertices are  $(0, \pm 3)$ .

$$\text{Eccentricity, } e = \frac{c}{a} = \frac{6}{3} = 2$$

$$\text{Length of latus rectum} = \frac{2b^2}{a} = \frac{2 \times 27}{3} = 18$$

### Question 3:

Find the coordinates of the foci and the vertices, the eccentricity, and the length of the latus rectum of the hyperbola  $9y^2 - 4x^2 = 36$

Answer

The given equation is  $9y^2 - 4x^2 = 36$ .

It can be written as

$$9y^2 - 4x^2 = 36$$

$$\text{Or, } \frac{y^2}{4} - \frac{x^2}{9} = 1$$

$$\text{Or, } \frac{y^2}{2^2} - \frac{x^2}{3^2} = 1 \quad \dots(1)$$

On comparing equation (1) with the standard equation of hyperbola i.e.,  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ , we obtain  $a = 2$  and  $b = 3$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore c^2 = 4 + 9 = 13$$

$$\Rightarrow c = \sqrt{13}$$

Therefore,

The coordinates of the foci are  $(0, \pm\sqrt{13})$ .

The coordinates of the vertices are  $(0, \pm 2)$ .

$$\begin{aligned} \text{Eccentricity, } e &= \frac{c}{a} = \frac{\sqrt{13}}{2} \\ \text{Length of latus rectum} &= \frac{2b^2}{a} = \frac{2 \times 9}{2} = 9 \end{aligned}$$

#### Question 4:

Find the coordinates of the foci and the vertices, the eccentricity, and the length of the latus rectum of the hyperbola  $16x^2 - 9y^2 = 576$

Answer

The given equation is  $16x^2 - 9y^2 = 576$ .

It can be written as

$$16x^2 - 9y^2 = 576$$

$$\Rightarrow \frac{x^2}{36} - \frac{y^2}{64} = 1$$

$$\Rightarrow \frac{x^2}{6^2} - \frac{y^2}{8^2} = 1 \quad \dots(1)$$

On comparing equation (1) with the standard equation of hyperbola i.e.,  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ , we obtain  $a = 6$  and  $b = 8$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore c^2 = 36 + 64 = 100$$

$$\Rightarrow c = 10$$

Therefore,

The coordinates of the foci are  $(\pm 10, 0)$ .

The coordinates of the vertices are  $(\pm 6, 0)$ .

$$\text{Eccentricity, } e = \frac{c}{a} = \frac{10}{6} = \frac{5}{3}$$

$$\text{Length of latus rectum} = \frac{2b^2}{a} = \frac{2 \times 64}{6} = \frac{64}{3}$$

**Question 5:**

Find the coordinates of the foci and the vertices, the eccentricity, and the length of the latus rectum of the hyperbola  $5y^2 - 9x^2 = 36$

Answer

The given equation is  $5y^2 - 9x^2 = 36$ .

$$\Rightarrow \frac{y^2}{\left(\frac{36}{5}\right)} - \frac{x^2}{4} = 1$$

$$\Rightarrow \frac{y^2}{\left(\frac{6}{\sqrt{5}}\right)^2} - \frac{x^2}{2^2} = 1 \quad \dots(1)$$

On comparing equation (1) with the standard equation of hyperbola i.e.,  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ , we

obtain  $a = \frac{6}{\sqrt{5}}$  and  $b = 2$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore c^2 = \frac{36}{5} + 4 = \frac{56}{5}$$

$$\Rightarrow c = \sqrt{\frac{56}{5}} = \frac{2\sqrt{14}}{\sqrt{5}}$$

Therefore, the coordinates of the foci are  $\left(0, \pm \frac{2\sqrt{14}}{\sqrt{5}}\right)$ .

The coordinates of the vertices are  $\left(0, \pm \frac{6}{\sqrt{5}}\right)$ .

$$\text{Eccentricity, } e = \frac{c}{a} = \frac{\left(\frac{2\sqrt{14}}{\sqrt{5}}\right)}{\left(\frac{6}{\sqrt{5}}\right)} = \frac{\sqrt{14}}{3}$$

$$= \frac{2b^2}{a} = \frac{2 \times 4}{\left(\frac{6}{\sqrt{5}}\right)} = \frac{4\sqrt{5}}{3}$$

Length of latus rectum

**Question 6:**

Find the coordinates of the foci and the vertices, the eccentricity, and the length of the latus rectum of the hyperbola  $49y^2 - 16x^2 = 784$

Answer

The given equation is  $49y^2 - 16x^2 = 784$ .

It can be written as

$$49y^2 - 16x^2 = 784$$

$$\text{Or, } \frac{y^2}{16} - \frac{x^2}{49} = 1$$

$$\text{Or, } \frac{y^2}{4^2} - \frac{x^2}{7^2} = 1 \quad \dots(1)$$

On comparing equation (1) with the standard equation of hyperbola i.e.,  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ , we obtain  $a = 4$  and  $b = 7$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore c^2 = 16 + 49 = 65$$

$$\Rightarrow c = \sqrt{65}$$

Therefore,

The coordinates of the foci are  $(0, \pm\sqrt{65})$ .

The coordinates of the vertices are  $(0, \pm 4)$ .

$$\text{Eccentricity, } e = \frac{c}{a} = \frac{\sqrt{65}}{4}$$

$$\text{Length of latus rectum} = \frac{2b^2}{a} = \frac{2 \times 49}{4} = \frac{49}{2}$$

**Question 7:**

Find the equation of the hyperbola satisfying the give conditions: Vertices  $(\pm 2, 0)$ , foci  $(\pm 3, 0)$

Answer

Vertices  $(\pm 2, 0)$ , foci  $(\pm 3, 0)$

Here, the vertices are on the  $x$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ .

Since the vertices are  $(\pm 2, 0)$ ,  $a = 2$ .

Since the foci are  $(\pm 3, 0)$ ,  $c = 3$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore 2^2 + b^2 = 3^2$$

$$b^2 = 9 - 4 = 5$$

Thus, the equation of the hyperbola is  $\frac{x^2}{4} - \frac{y^2}{5} = 1$ .

**Question 8:**

Find the equation of the hyperbola satisfying the give conditions: Vertices  $(0, \pm 5)$ , foci  $(0, \pm 8)$

Answer

Vertices  $(0, \pm 5)$ , foci  $(0, \pm 8)$

Here, the vertices are on the  $y$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ .

Since the vertices are  $(0, \pm 5)$ ,  $a = 5$ .

Since the foci are  $(0, \pm 8)$ ,  $c = 8$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore 5^2 + b^2 = 8^2$$

$$b^2 = 64 - 25 = 39$$

Thus, the equation of the hyperbola is  $\frac{y^2}{25} - \frac{x^2}{39} = 1$ .

**Question 9:**

Find the equation of the hyperbola satisfying the give conditions: Vertices  $(0, \pm 3)$ , foci  $(0, \pm 5)$

Answer

Vertices  $(0, \pm 3)$ , foci  $(0, \pm 5)$

Here, the vertices are on the  $y$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ .

Since the vertices are  $(0, \pm 3)$ ,  $a = 3$ .

Since the foci are  $(0, \pm 5)$ ,  $c = 5$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore 3^2 + b^2 = 5^2$$

$$\Rightarrow b^2 = 25 - 9 = 16$$

Thus, the equation of the hyperbola is  $\frac{y^2}{9} - \frac{x^2}{16} = 1$ .

**Question 10:**

Find the equation of the hyperbola satisfying the give conditions: Foci  $(\pm 5, 0)$ , the transverse axis is of length 8.

Answer

Foci  $(\pm 5, 0)$ , the transverse axis is of length 8.

Here, the foci are on the  $x$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ .

Since the foci are  $(\pm 5, 0)$ ,  $c = 5$ .

Since the length of the transverse axis is 8,  $2a = 8 \Rightarrow a = 4$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore 4^2 + b^2 = 5^2$$

$$\Rightarrow b^2 = 25 - 16 = 9$$

Thus, the equation of the hyperbola is  $\frac{x^2}{16} - \frac{y^2}{9} = 1$ .

**Question 11:**

Find the equation of the hyperbola satisfying the give conditions: Foci  $(0, \pm 13)$ , the conjugate axis is of length 24.

Answer

Foci  $(0, \pm 13)$ , the conjugate axis is of length 24.

Here, the foci are on the  $y$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ .

Since the foci are  $(0, \pm 13)$ ,  $c = 13$ .

Since the length of the conjugate axis is 24,  $2b = 24 \Rightarrow b = 12$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore a^2 + 12^2 = 13^2$$

$$\Rightarrow a^2 = 169 - 144 = 25$$

Thus, the equation of the hyperbola is  $\frac{y^2}{25} - \frac{x^2}{144} = 1$ .

**Question 12:**

Find the equation of the hyperbola satisfying the give conditions: Foci  $(\pm 3\sqrt{5}, 0)$ , the latus rectum is of length 8.

Answer

Foci  $(\pm 3\sqrt{5}, 0)$ , the latus rectum is of length 8.

Here, the foci are on the  $x$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ .

Since the foci are  $(\pm 3\sqrt{5}, 0)$ ,  $c = \pm 3\sqrt{5}$ .

Length of latus rectum = 8

$$\Rightarrow \frac{2b^2}{a} = 8$$

$$\Rightarrow b^2 = 4a$$

We know that  $a^2 + b^2 = c^2$ .

$$\therefore a^2 + 4a = 45$$

$$\Rightarrow a^2 + 4a - 45 = 0$$

$$\Rightarrow a^2 + 9a - 5a - 45 = 0$$

$$\Rightarrow (a + 9)(a - 5) = 0$$

$$\Rightarrow a = -9, 5$$

Since  $a$  is non-negative,  $a = 5$ .

$$\therefore b^2 = 4a = 4 \times 5 = 20$$

Thus, the equation of the hyperbola is  $\frac{x^2}{25} - \frac{y^2}{20} = 1$ .

### Question 13:

Find the equation of the hyperbola satisfying the give conditions: Foci  $(\pm 4, 0)$ , the latus rectum is of length 12

Answer

Foci  $(\pm 4, 0)$ , the latus rectum is of length 12.

Here, the foci are on the  $x$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ .

Since the foci are  $(\pm 4, 0)$ ,  $c = 4$ .

Length of latus rectum = 12

$$\Rightarrow \frac{2b^2}{a} = 12$$

$$\Rightarrow b^2 = 6a$$

We know that  $a^2 + b^2 = c^2$ .

$$\therefore a^2 + 6a = 16$$

$$\Rightarrow a^2 + 6a - 16 = 0$$

$$\Rightarrow a^2 + 8a - 2a - 16 = 0$$

$$\Rightarrow (a + 8)(a - 2) = 0$$

$$\Rightarrow a = -8, 2$$

Since  $a$  is non-negative,  $a = 2$ .

$$\therefore b^2 = 6a = 6 \times 2 = 12$$

Thus, the equation of the hyperbola is  $\frac{x^2}{4} - \frac{y^2}{12} = 1$ .

**Question 14:**

Find the equation of the hyperbola satisfying the give conditions: Vertices  $(\pm 7, 0)$ ,

$$e = \frac{4}{3}$$

Answer

Vertices  $(\pm 7, 0)$ ,  $e = \frac{4}{3}$

Here, the vertices are on the x-axis.

Therefore, the equation of the hyperbola is of the form  $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ .

Since the vertices are  $(\pm 7, 0)$ ,  $a = 7$ .

It is given that  $e = \frac{4}{3}$

$$\therefore \frac{c}{a} = \frac{4}{3} \quad \left[ e = \frac{c}{a} \right]$$

$$\Rightarrow \frac{c}{7} = \frac{4}{3}$$

$$\Rightarrow c = \frac{28}{3}$$

We know that  $a^2 + b^2 = c^2$ .

$$\therefore 7^2 + b^2 = \left( \frac{28}{3} \right)^2$$

$$\Rightarrow b^2 = \frac{784}{9} - 49$$

$$\Rightarrow b^2 = \frac{784 - 441}{9} = \frac{343}{9}$$

Thus, the equation of the hyperbola is  $\frac{x^2}{49} - \frac{9y^2}{343} = 1$ .

**Question 15:**

Find the equation of the hyperbola satisfying the give conditions: Foci  $(0, \pm\sqrt{10})$ , passing through  $(2, 3)$

Answer

Foci  $(0, \pm\sqrt{10})$ , passing through  $(2, 3)$

Here, the foci are on the  $y$ -axis.

Therefore, the equation of the hyperbola is of the form  $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$ .

Since the foci are  $(0, \pm\sqrt{10})$ ,  $c = \sqrt{10}$ .

We know that  $a^2 + b^2 = c^2$ .

$$\therefore a^2 + b^2 = 10$$

$$\Rightarrow b^2 = 10 - a^2 \dots (1)$$

Since the hyperbola passes through point  $(2, 3)$ ,

$$\frac{9}{a^2} - \frac{4}{b^2} = 1 \dots (2)$$

From equations (1) and (2), we obtain

$$\frac{9}{a^2} - \frac{4}{(10 - a^2)} = 1$$

$$\Rightarrow 9(10 - a^2) - 4a^2 = a^2(10 - a^2)$$

$$\Rightarrow 90 - 9a^2 - 4a^2 = 10a^2 - a^4$$

$$\Rightarrow a^4 - 23a^2 + 90 = 0$$

$$\Rightarrow a^4 - 18a^2 - 5a^2 + 90 = 0$$

$$\Rightarrow a^2(a^2 - 18) - 5(a^2 - 18) = 0$$

$$\Rightarrow (a^2 - 18)(a^2 - 5) = 0$$

$$\Rightarrow a^2 = 18 \text{ or } 5$$

In hyperbola,  $c > a$ , i.e.,  $c^2 > a^2$

$$\therefore a^2 = 5$$

$$\Rightarrow b^2 = 10 - a^2 = 10 - 5 = 5$$