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Abstract—This manual shows how to construct geometric figures using Python. Exercises are based on NCERT math textbooks of Class 9 and 10.

Download all codes for this manual from

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1 TRIANGLE

- 1.1 Draw a line segment of length 7.6 cm and divide it in the ratio 5 : 8.

Solution: Let the end points of the line be

$$\mathbf{A} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 7.6 \\ 0 \end{pmatrix} \quad (1)$$

Then the point C

$$\mathbf{C} = \frac{k\mathbf{A} + \mathbf{B}}{k + 1} \quad (2)$$

divides AB in the ratio $k : 1$. For the given problem, $k = \frac{5}{8}$. The following code plots Fig. 1.1

codes/draw_section.py

- 1.2 Draw $\triangle ABC$ where $\angle B = 90^\circ$, $a = 4$ and $b = 3$.

Solution: The vertices of $\triangle ABC$ are

$$\mathbf{A} = \begin{pmatrix} 0 \\ 3 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} 4 \\ 0 \end{pmatrix} \quad (3)$$

The following code plots Fig. 1.2

codes/rt_triangle.py

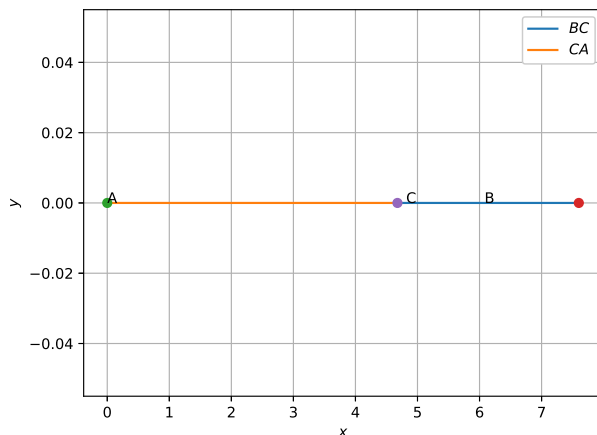


Fig. 1.1

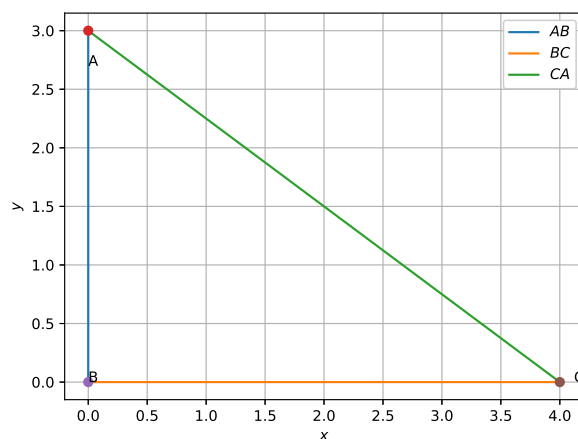


Fig. 1.2

- 1.3 Construct a triangle of sides $a = 4$ cm, $b = 5$ cm and $c = 6$ cm.

Solution: Let the vertices of $\triangle ABC$ be

$$\mathbf{A} = \begin{pmatrix} p \\ q \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} a \\ 0 \end{pmatrix} \quad (4)$$

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Then

$$b^2 = \|\mathbf{A} - \mathbf{C}\|^2 = (p - a)^2 + q^2 \quad (5)$$

$$c^2 = \|\mathbf{A} - \mathbf{C}\|^2 = p^2 + q^2 \quad (6)$$

yielding

$$p = \frac{a^2 + c^2 - b^2}{2a} \quad (7)$$

$$q = \sqrt{c^2 - p^2} \quad (8)$$

The following code plots Fig. 1.3

```
codes/draw_triangle.py
```

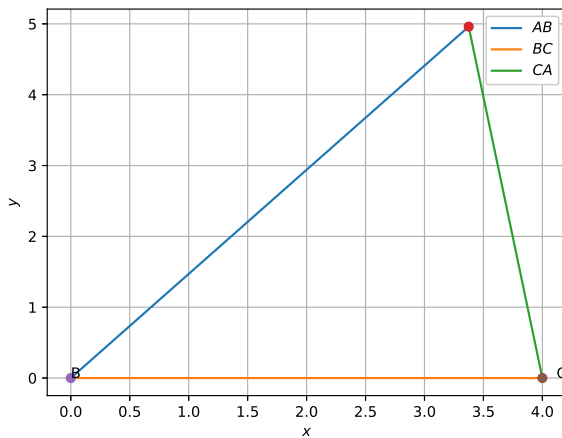


Fig. 1.3

- 1.4 Construct a triangle of sides $a = 5\text{cm}$, $b = 6\text{cm}$ and $c = 7\text{cm}$. Construct a similar triangle whose sides are $\frac{7}{5}$ times the corresponding sides of the first triangle.

- 1.5 Construct an isosceles triangle whose base is $a = 8\text{cm}$ and altitude $AD = p = 4\text{cm}$

Solution: Using Baudhayana's theorem,

$$b = c = \sqrt{p^2 + \left(\frac{a}{2}\right)^2} \quad (9)$$

- 1.6 Draw $\triangle ABC$ with $a = 6$, $c = 5$ and $\angle B = 60^\circ$.

Solution: Using the cosine formula,

$$b^2 = c^2 + a^2 - 2ca \cos B \quad (10)$$

- 1.7 Draw $\triangle ABC$ with $a = 7$, $\angle B = 45^\circ$ and $\angle A = 105^\circ$.

- 1.8 In $\triangle ABC$, $a = 7$, $\angle B = 75^\circ$ and $b + c = 13$. Find b and c and sketch $\triangle ABC$.

- 1.9 In $\triangle ABC$, $a = 8$, $\angle B = 45^\circ$ and $c - b = 3.5$. Sketch $\triangle ABC$.

- 1.10 In $\triangle ABC$, $a = 6$, $\angle B = 60^\circ$ and $b - c = 2$. Sketch $\triangle ABC$.

- 1.11 $\triangle ABC$ is right angled at **B**. If $a = 12$ and $b + c = 18$, find a, b, c and draw the triangle.

Solution: From Baudhayana's theorem,

$$b^2 = a^2 + c^2 \quad (11)$$

- 1.12 In $\triangle ABC$, given that $a + b + c = 11$, $\angle B = 45^\circ$ and $\angle C = 45^\circ$, find a, b, c .

Solution: We have

$$a = b \cos C + c \cos B \quad (12)$$

$$b \sin C = c \sin B \quad (13)$$

$$a + b + c = 11 \quad (14)$$

resulting in the matrix equation

$$\begin{pmatrix} 1 & -\cos C & -\cos B \\ 0 & \sin C & -\sin B \\ 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 11 \end{pmatrix} \quad (15)$$

Solving the equivalent matrix equation gives the desired answer.

- 1.13 Draw $\triangle ABC$, given that $a + b + c = 11$, $\angle B = 30^\circ$ and $\angle C = 90^\circ$, find a, b, c .

2 CIRCLE

- 2.1 Draw a circle with centre **B** and radius 6. If **C** be a point 10 units away from its centre, construct the pair of tangents AC and CD to the circle.

Solution: From the given information, in $\triangle ABC$, $AC \perp AB$, $a = 10$ and $c = 6$.

$$b = \sqrt{a^2 - c^2} \quad (16)$$

The following code plots Fig. 2.1

```
codes/draw_circle_eg.py
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- 2.2 Construct a tangent to a circle of radius 4 units from a point on the concentric circle of radius 6 units.

- 2.3 Draw a circle of radius 3 units. Take two points **P** and **Q** on one of its extended diameter each at a distance of 7 units from its centre. Draw tangents to the circle from these two points **P** and **Q**.

- 2.4 Draw a pair of tangents to a circle of radius 5 units which are inclined to each other at an angle of 60° .

- 2.5 Draw a line segment AB of length 8 units. Taking **A** as centre, draw a circle of radius

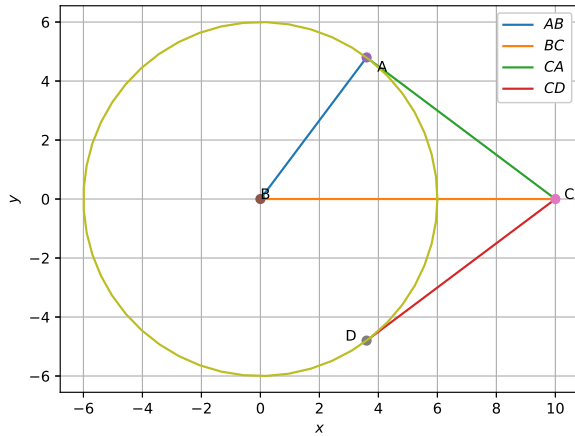


Fig. 2.1

4 units and taking **B** as centre, draw another circle of radius 3 units. Construct tangents to each circle from the centre of the other circle.

- 2.6 Let ABC be a right triangle in which $a = 8$, $c = 6$ and $\angle B = 90^\circ$. BD is the perpendicular from **B** on AC . The circle through **B**, **C**, **D** is drawn. Construct the tangents from **A** to this circle.