Constructions using Python

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Contents

***Abstract*—This book introduces constructions in high school geometry using Python. The content and exercises are based on NCERT textbooks from Class 6-12. A simple introduction to Python and LaTeXfigures is provided in the process.**

Download all python codes from

```
svn co https://github.com/gadepall/school/trunk/
    ncert/constructions/codes
```

and latex-tikz codes from

```
svn co https://github.com/gadepall/school/trunk/
    ncert/constructions/figs
```

1 Examples

1.1. Draw Fig. 1.1.1 for $a = 4, c = 3$.

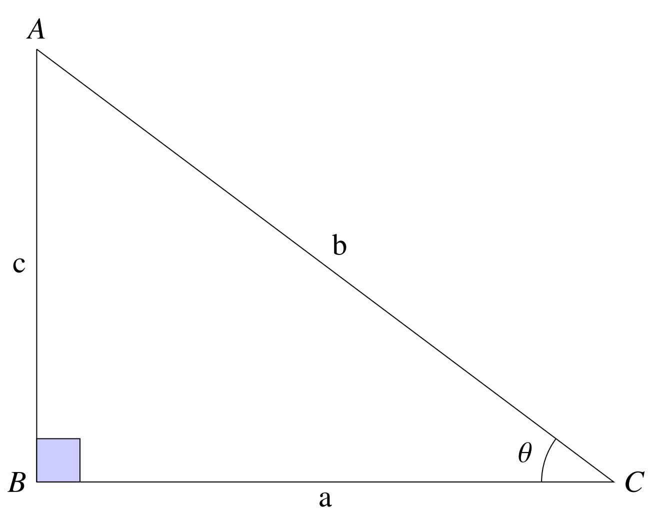

Fig. 1.1.1: Right Angled Triangle

Solution: The vertices of $\triangle ABC$ are

$$\mathbf{A} = \begin{pmatrix} 0 \\ c \end{pmatrix} = \begin{pmatrix} 0 \\ 3 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} a \\ 0 \end{pmatrix} = \begin{pmatrix} 4 \\ 0 \end{pmatrix} \tag{1.1.1}$$

The python code for Fig. 1.1.1 is

```
codes/triangle/tri_right_angle.py
```

and the equivalent latex-tikz code is

```
figs/triangle/tri_right_angle.tex
```

The above latex code can be compiled as a standalone document as

```
figs/triangle/tri_right_angle_alone.tex
```

1.2. Draw Fig. 1.2.1 for $a = 4, c = 3$.
Solution: The vertex $\mathbf{A}$ can be expressed in *polar coordinate form* as

$$\mathbf{A} = b \begin{pmatrix} \cos\theta \\ \sin\theta \end{pmatrix} \tag{1.2.1}$$

where

$$b = \sqrt{a^2 + c^2} = 5, \tan\theta = \frac{3}{4} \tag{1.2.2}$$

The python code for Fig. 1.2.1 is

```
codes/triangle/tri_polar.py
```

and the equivalent latex-tikz code is

```
figs/triangle/tri_polar.tex
```

1.3. Draw Fig. 1.3.1 with $a = 6$, $b = 5$ and $c = 4$.
Solution: Let the vertices of $\triangle ABC$ and $\mathbf{D}$ be

$$\mathbf{A} = \begin{pmatrix} p \\ q \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} a \\ 0 \end{pmatrix}, \mathbf{D} = \begin{pmatrix} p \\ 0 \end{pmatrix} \tag{1.3.1}$$

Then

$$AB = \|\mathbf{A} - \mathbf{B}\|^2 = \|\mathbf{A}\|^2 = c^2 \quad \because \mathbf{B} = \mathbf{0} \tag{1.3.2}$$

$$BC = \|\mathbf{C} - \mathbf{B}\|^2 = \|\mathbf{C}\|^2 = a^2 \tag{1.3.3}$$

$$AC = \|\mathbf{A} - \mathbf{C}\|^2 = b^2 \tag{1.3.4}$$

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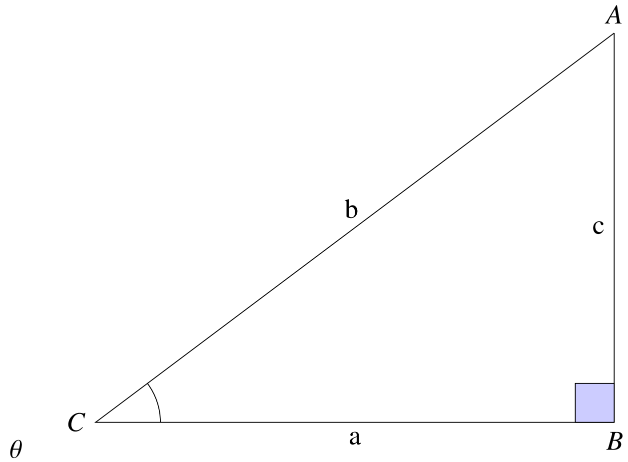

Fig. 1.2.1: Right Angled Triangle

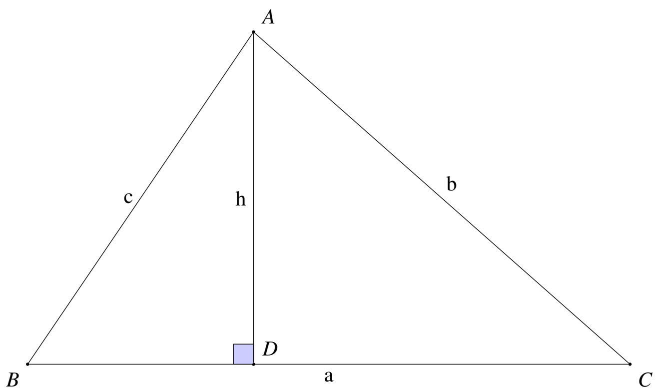

Fig. 1.3.1

From (1.3.4),

$$b^2 = \|\mathbf{A}-\mathbf{C}\|^2 = \|\mathbf{A}-\mathbf{C}\|^T \|\mathbf{A}-\mathbf{C}\| \tag{1.3.5}$$

$$= \mathbf{A}^T\mathbf{A} + \mathbf{C}^T\mathbf{C} - \mathbf{A}^T\mathbf{C} - \mathbf{C}^T\mathbf{A} \tag{1.3.6}$$

$$= \|\mathbf{A}\|^2 + \|\mathbf{C}\|^2 - 2\mathbf{A}^T\mathbf{C} \quad \left(\because \mathbf{A}^T\mathbf{C} = \mathbf{C}^T\mathbf{A}\right) \tag{1.3.7}$$

$$= a^2 + c^2 - 2ap \tag{1.3.8}$$

yielding

$$p = \frac{a^2 + c^2 - b^2}{2a} \tag{1.3.9}$$

From (1.3.2),

$$\|\mathbf{A}\|^2 = c^2 = p^2 + q^2 \tag{1.3.10}$$

$$\implies q = \pm\sqrt{c^2 - p^2} \tag{1.3.11}$$

The python code for Fig. 1.3.1 is

```
codes/triangle/tri_sss.py
```

and the equivalent latex-tikz code is

```
figs/triangle/tri_sss.tex
```

1.4. Construct parallelogram $ABCD$ in Fig. 1.4.1 given that $BC = 5, AB = 6, \angle C = 85°$.

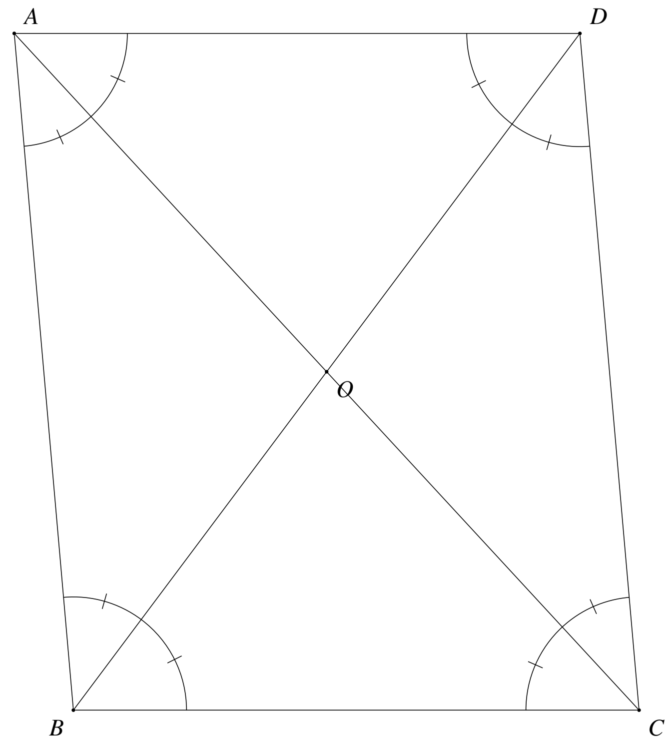

Fig. 1.4.1: Parallelogram Properties

Solution: BD is found using the cosine formula and $\triangle BDC$ is drawn using the approach in Construction 1.3 with

$$\mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} 5 \\ 0 \end{pmatrix}, \tag{1.4.1}$$

Since the diagonals bisect each other,

$$\mathbf{O} = \frac{\mathbf{B} + \mathbf{D}}{2} \tag{1.4.2}$$

$$\mathbf{A} = 2\mathbf{O} - \mathbf{C}. \tag{1.4.3}$$

AB and AD are then joined to complete the ||gm. The python code for Fig. 1.4.1 is

```
codes/quad/pgm_sas.py
```

and The equivalent latex-tikz code is

```
figs/quad/pgm_sas.tex
```

1.5. Draw the ||gm $ABCD$ in Fig. 1.5.1 with $BC = 6, CD = 4.5$ and $BD = 7.5$. Show that it is a rectangle.

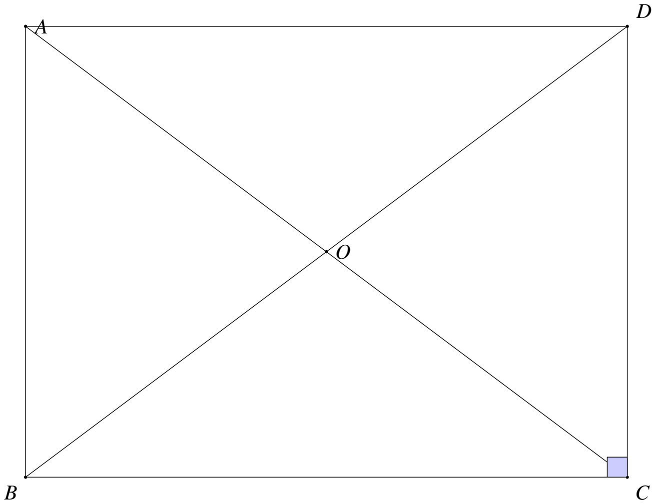

Fig. 1.5.1: Rectangle

Solution: It is easy to verify that

$$BD^2 = BC^2 + C^2 \tag{1.5.1}$$

Hence, using Baudhayana theorem,

$$\angle BCD = 90^\circ \tag{1.5.2}$$

and $ABCD$ is a rectangle.

$$\mathbf{A} = \begin{pmatrix} 0 \\ 4.5 \end{pmatrix} \mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \mathbf{C} = \begin{pmatrix} 6 \\ 0 \end{pmatrix} \mathbf{D} = \begin{pmatrix} 6 \\ 4 \end{pmatrix} \tag{1.5.3}$$

The python code for Fig. 1.5.1 is

```
codes/quad/pgm_sss.py
```

and the equivalent latex-tikz code is

```
figs/quad/pgm_sss.tex
```

1.6. Draw the rhombus $BEST$ with $BE = 4.5$ and $ET = 6$.
Solution: The coordinates of the various points in Fig. 1.6.1 are obtained as

$$\mathbf{O} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ -4.5 \end{pmatrix} \tag{1.6.1}$$

$$\mathbf{E} = \begin{pmatrix} 3 \\ 0 \end{pmatrix}, \mathbf{S} = \begin{pmatrix} 4.5 \\ 0 \end{pmatrix}, \mathbf{T} = \begin{pmatrix} 0 \\ -3 \end{pmatrix} \tag{1.6.2}$$

1.7. A square is a rectangle whose sides are equal. Draw a square of side 4.5.
Solution: The coordinates of the various points

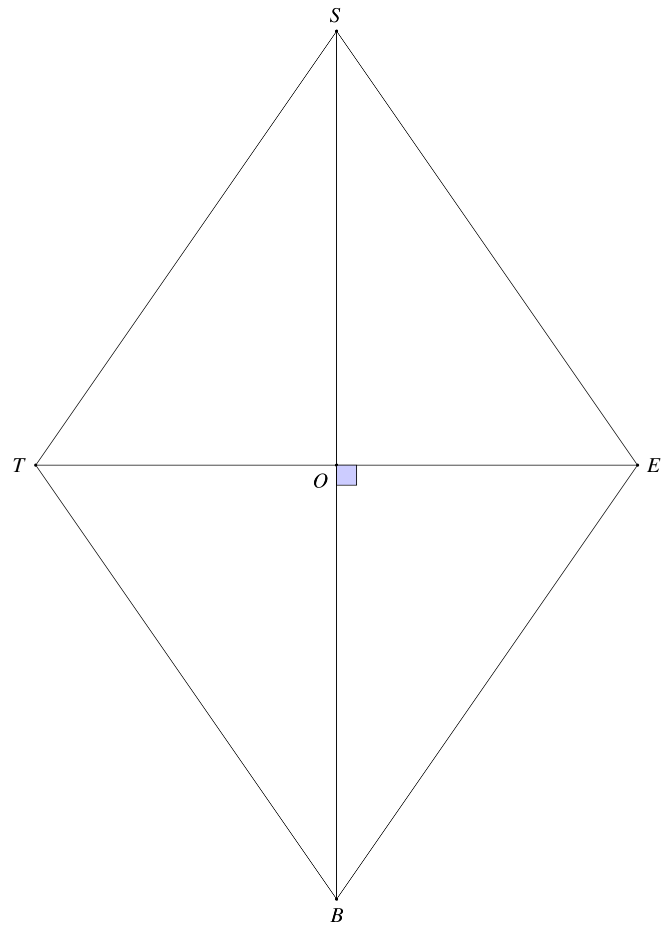

Fig. 1.6.1: Rhombus

in Fig. 1.7.1 are obtained as

$$\mathbf{A} = \begin{pmatrix} 0 \\ 4.5 \end{pmatrix} \tag{1.7.1}$$

$$\mathbf{B} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} 4.5 \\ 0 \end{pmatrix}, \mathbf{D} = \begin{pmatrix} 4.5 \\ 4.5 \end{pmatrix} \mathbf{O} = \frac{\mathbf{B} + \mathbf{C}}{2} \tag{1.7.2}$$

2 Exercises

2.1. Construct a triangle of sides $a = 4$, $b = 5$ and $c = 6$.
2.2. Construct an isosceles triangle whose base is $a = 8$cm and altitude $AD = h = 4$cm
2.3. In $\triangle ABC$, given that $a+b+c = 11$, $\angle B = 45^\circ$ and $\angle C = 45^\circ$, find a, b, c and sketch the triangle.
2.4. Draw $\triangle ABC$ with $a = 6, c = 5$ and $\angle B = 60^\circ$.
2.5. Draw $\triangle ABC$ with $a = 7, \angle B = 45^\circ$ and $\angle A = 105^\circ$.

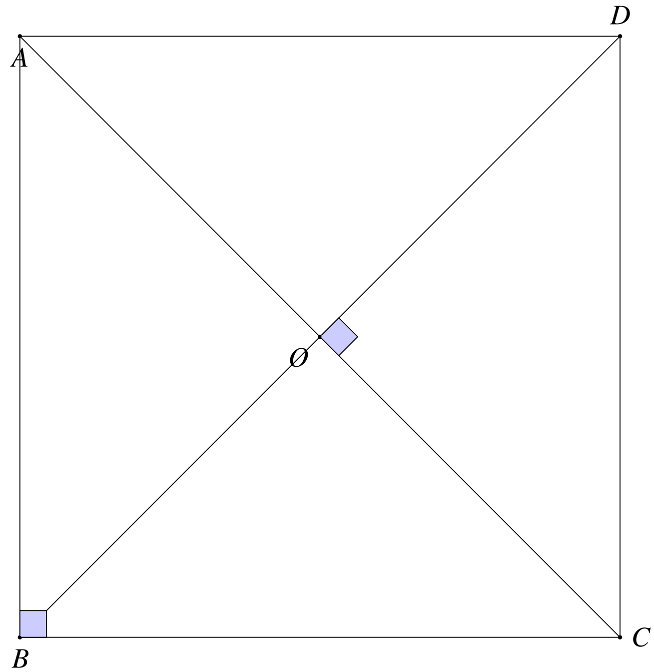

Fig. 1.7.1: Square

2.6. $\triangle ABC$ is right angled at **B**. If $a = 12$ and $b+c = 18$, find b, c and draw the triangle.
2.7. In $\triangle ABC$, $a = 8, \angle B = 45^\circ$ and $c - b = 3.5$. Sketch $\triangle ABC$.
Solution:
2.8. In $\triangle ABC$, $a = 6, \angle B = 60^\circ$ and $b-c = 2$. Sketch $\triangle ABC$.
2.9. Draw $\triangle ABC$, given that $a+b+c = 11, \angle B = 30^\circ$ and $\angle C = 90^\circ$.
2.10. Construct $\triangle xyz$ where $xy = 4.5, yz = 5$ and $zx = 6$.
2.11. Draw an equilateral triangle of side 5.5.
2.12. Draw $\triangle PQR$ with $PQ = 4, QR = 3.5$ and $PR = 4$. What type of triangle is this?
2.13. Construct $\triangle ABC$ such that $AB = 2.5, BC = 6$ and $AC = 6.5$. Find $\angle B$.
2.14. Construct $\triangle PQR$, given that $PQ = 3, QR = 5.5$ and $\angle PQR = 60°$.
2.15. Construct $\triangle DEF$ such that $DE = 5, DF = 3$ and $\angle D = 90°$.
Solution: From the given information, the vertices of $\triangle DEF$ are

$$\mathbf{E} = \begin{pmatrix} 0 \\ 5 \end{pmatrix}, \mathbf{D} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{F} = \begin{pmatrix} 3 \\ 0 \end{pmatrix} \tag{2.15.1}$$

which are used to plot Fig. 2.15.1.

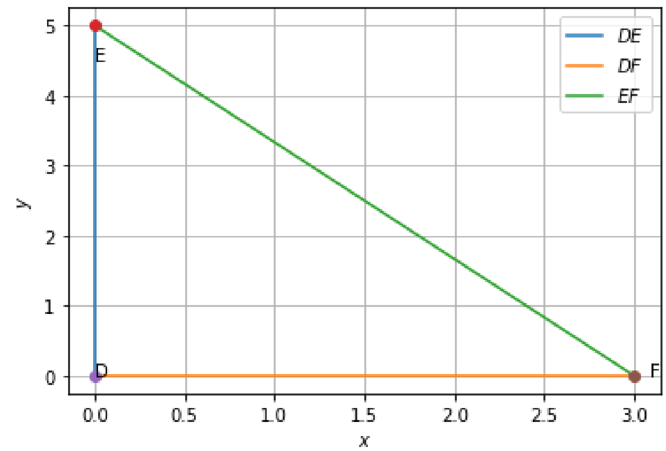

Fig. 2.15.1

2.16. Construct an isosceles triangle in which the lengths of the equal sides is 6.5 and the angle between them is 110°.
2.17. Construct $\triangle ABC$ with $BC = 7.5, AC = 5$ and $\angle C = 60°$.
2.18. Construct $\triangle XYZ$ if $XY = 6, \angle X = 30°$ and $\angle Y = 100°$.
2.19. If $AC = 7, \angle A = 60°$ and $\angle B = 50°$, can you draw the triangle?
2.20. Construct $\triangle ABC$ given that $\angle A = 60°, \angle B = 30°$ and $AB = 5.8$.
2.21. Construct $\triangle PQR$ if $PQ = 5, \angle Q = 105°$ and $\angle R = 40°$.
2.22. Can you construct $\triangle DEF$ such that $EF = 7.2, \angle E = 110°$ and $\angle F = 180°$?
2.23. Construct $\triangle LMN$ right angled at M such that $LN = 5$ and $MN = 3$.
Solution:
Let

$$\mathbf{L} = \begin{pmatrix} 0 \\ l \end{pmatrix}, \mathbf{M} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{N} = \begin{pmatrix} 3 \\ 0 \end{pmatrix} \tag{2.23.1}$$

From the given information,

$$\|\mathbf{N} - \mathbf{M}\|^2 = \|\mathbf{N}\|^2 = 3^2 = 9 \tag{2.23.2}$$
$$\|\mathbf{L} - \mathbf{M}\|^2 = \|\mathbf{L}\|^2 = l^2 \tag{2.23.3}$$
$$\|\mathbf{L} - \mathbf{N}\|^2 = 5^2 = 25 \tag{2.23.4}$$

which can be expressed as

$$\|\mathbf{L} - \mathbf{N}\|^2 = (\mathbf{L} - \mathbf{N})^T(\mathbf{L} - \mathbf{N}) \tag{2.23.5}$$
$$= \|\mathbf{L}\|^2 + \|\mathbf{N}\|^2 - 2\mathbf{L}^T\mathbf{N} \tag{2.23.6}$$
$$\implies l^2 + 9 = 25 \tag{2.23.7}$$
$$\text{or, } l = \pm 4 \tag{2.23.8}$$

For l=4, $\triangle LMN$ is plotted in the first quadrant in Fig. 2.23.1.

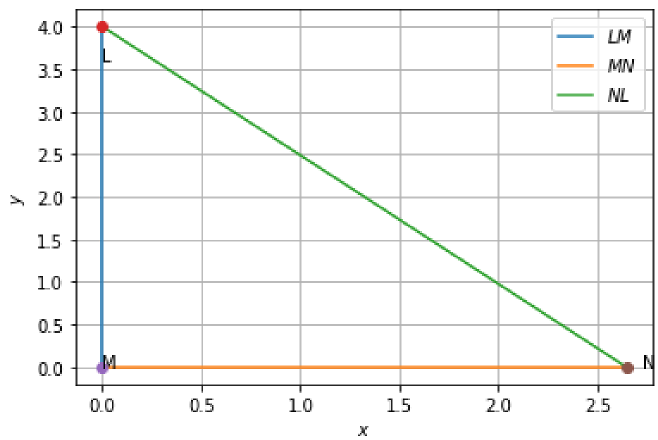

Fig. 2.23.1

2.24. Construct $\triangle PQR$ right angled at Q such that $QR = 8$ and $PR = 10$.
Solution: Let

$$\mathbf{Q} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{R} = \begin{pmatrix} 8 \\ 0 \end{pmatrix}, \mathbf{P} = \begin{pmatrix} 0 \\ p \end{pmatrix} \tag{2.24.1}$$

Then,

$$\|\mathbf{P} - \mathbf{R}\|^2 = (\mathbf{P} - \mathbf{R})^T (\mathbf{P} - \mathbf{R}) \tag{2.24.2}$$
$$= \|\mathbf{P}\|^2 + \|\mathbf{R}\|^2 \tag{2.24.3}$$
$$\because \mathbf{P}^T\mathbf{R} = \mathbf{R}^T\mathbf{P}, \mathbf{R}^T\mathbf{P} = 0 \tag{2.24.4}$$
$$= p^2 + 64 = 10^2 \tag{2.24.5}$$
$$\implies p = \pm 6 \tag{2.24.6}$$

Since positive area is considered here,only $p = 6$ is taken into consideration. Thus,

$$\mathbf{P} = \begin{pmatrix} 0 \\ 6 \end{pmatrix} \tag{2.24.7}$$

and the desired traingle is plotted in Fig. 2.24.1

2.25. Construct right angled $\triangle$ whose hypotenuse is 6 and one of the legs is 4.
Solution: Let us consider $\triangle PQR$ right angled at Q and assume that we are restricted to first quadrant such that

$$\mathbf{Q} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{R} = \begin{pmatrix} 4 \\ 0 \end{pmatrix}, \mathbf{P} = \begin{pmatrix} 0 \\ p \end{pmatrix} \tag{2.25.1}$$

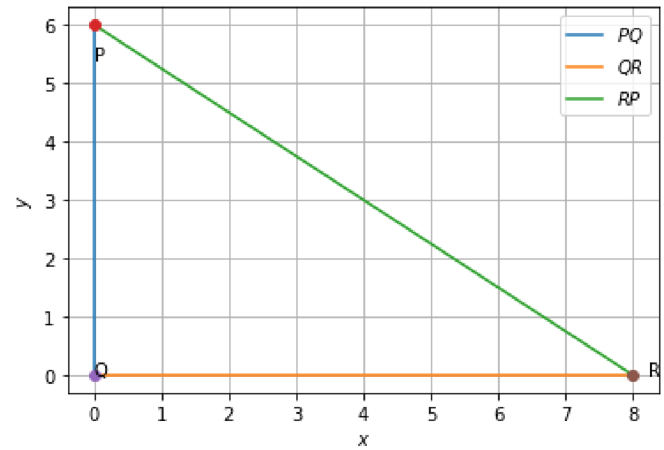

Fig. 2.24.1: Right Angle $\triangle PQR$

Then,

$$\|\mathbf{P} - \mathbf{R}\|^2 = 36 \tag{2.25.2}$$
$$\implies p^2 + 16 = 36 \tag{2.25.3}$$
$$\implies p = \pm 2\sqrt{5} \tag{2.25.4}$$

Since first quadrant was assumed here,only $p = +2\sqrt{5}$ is taken into consideration. So,the vertices of $\triangle PQR$ in Fig. 2.25.1 are

$$\mathbf{P} = \begin{pmatrix} 0 \\ 2\sqrt{5} \end{pmatrix}, \mathbf{Q} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{R} = \begin{pmatrix} 4 \\ 0 \end{pmatrix} \tag{2.25.5}$$

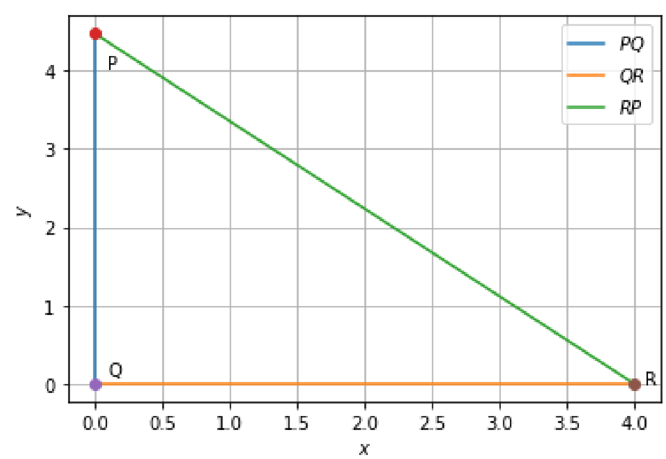

Fig. 2.25.1: Right Angled $\triangle PQR$

2.26. Construct an isosceles right angled $\triangle ABC$ right angled at C such $AC = 6$.
Solution:

$\because \triangle ABC$ is isosceles, its vertices are

$$\mathbf{C} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{A} = \begin{pmatrix} 6 \\ 0 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ 6 \end{pmatrix} \tag{2.26.1}$$

which are used to plot the desired triangle in Fig. 2.26.1.

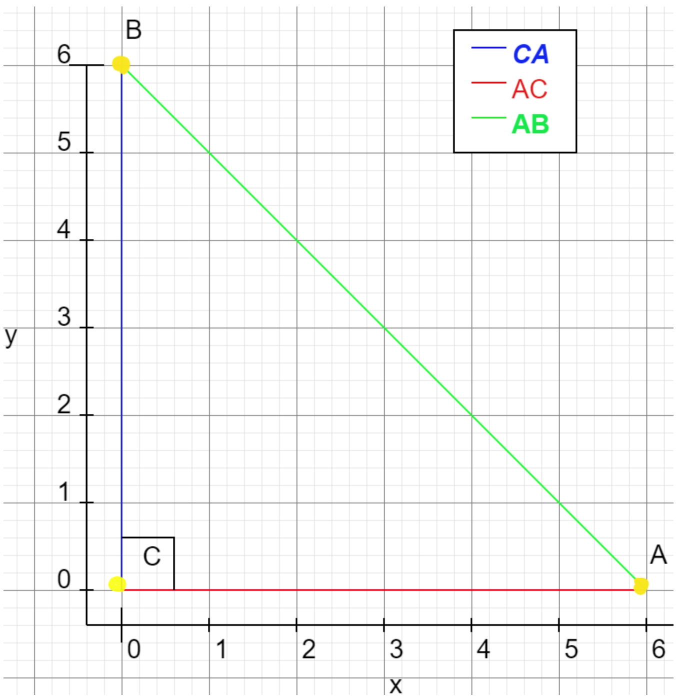

Fig. 2.26.1: Isosceles Right Angle $\triangle ABC$

2.27. Construct the triangles in Table 2.27.1.

S.No	Triangle	Given Measurements		
1	$\triangle$ABC	$\angle A = 85°$	$\angle B = 115°$	AB = 5
2	$\triangle$PQR	$\angle Q = 30°$	$\angle R = 60°$	QR = 4.7
3	$\triangle$ABC	$\angle A = 70°$	$\angle B = 50°$	AC = 3
4	$\triangle$LMN	$\angle L = 60°$	$\angle N = 120°$	LM = 5
5	$\triangle$ABC	BC = 2	AB = 4	AC = 2
6	$\triangle$PQR	PQ = 2.5	QR = 4	PR = 3.5
7	$\triangle$XYZ	XY = 3	YZ = 4	XZ = 5
8	$\triangle$DEF	DE = 4.5	EF = 5.5	DF = 4

TABLE 2.27.1

2.28. Construct a quadrilateral $ABCD$ such that $AB = 5, \angle A = 50°, AC = 4, BD = 5$ and $AD = 6$.
Solution:
The rough figure of the expected quadrilateral ABCD is given in Fig. 2.28.1

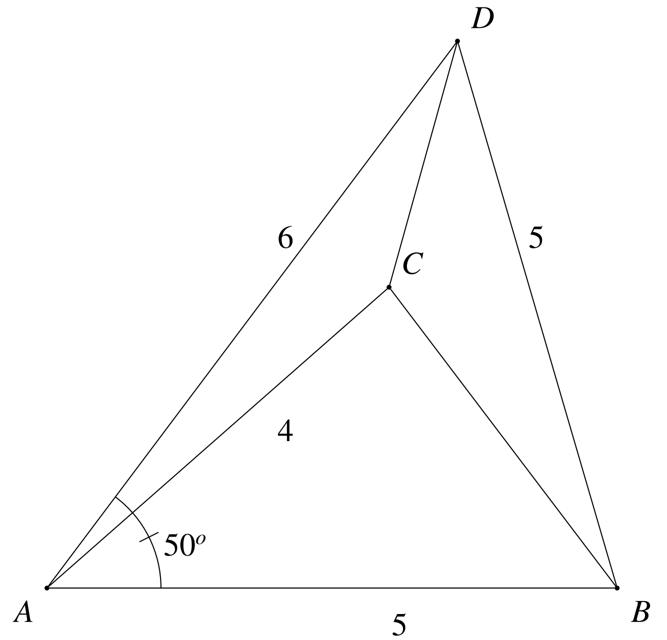

Fig. 2.28.1: Rough Figure

From the given information, in $\triangle ABD$,

$$\cos A = \frac{\|\mathbf{B}-\mathbf{A}\|^2 + \|\mathbf{D}-\mathbf{A}\|^2 - \|\mathbf{D}-\mathbf{B}\|^2}{2\,\|\mathbf{B}-\mathbf{A}\|\,\|\mathbf{D}-\mathbf{A}\|} \tag{2.28.1}$$

$$\implies \angle A = \cos^{-1}(0.6) \approx 53.13° \tag{2.28.2}$$

$$\neq 50° \tag{2.28.3}$$

resulting in a contradiction. Therefore construction of quadrilateral with given measurements is not possible.

2.29. Construct $PQRS$ where $PQ = 4, QR = 6, RS = 5, PS = 5.5$ and $PR = 7$.

2.30. Draw $JUMP$ with $JU = 3.5, UM = 4, MP = 5, PJ = 4.5$ and $PU = 6.5$

2.31. Construct a quadrilateral $ABCD$ such that $BC = 4.5, AC = 5.5, CD = 5, BD = 7$ and $AD = 5.5$.

2.32. Can you construct a quadrilateral $PQRS$ with $PQ = 3, RS = 3, PS = 7.5, PR = 8$ and $SQ = 4$?
Solution: From the given information,

$$\|\mathbf{P}-\mathbf{Q}\| = 3 \tag{2.32.1}$$

$$\|\mathbf{R}-\mathbf{S}\| = 3 \tag{2.32.2}$$

$$\|\mathbf{P}-\mathbf{S}\| = 7.5 \tag{2.32.3}$$

$$\|\mathbf{P}-\mathbf{R}\| = 8 \tag{2.32.4}$$

$$\|\mathbf{S}-\mathbf{Q}\| = 4 \tag{2.32.5}$$

Let quadrilateral $PQRS$ be made up of two triangles $\triangle PSQ$ and $\triangle PSR$ on base PS.

a) In $\triangle PSR$,

$$\|\mathbf{P}-\mathbf{S}\| + \|\mathbf{R}-\mathbf{S}\| = 7.5 + 3 = 10.5 > \|\mathbf{P}-\mathbf{R}\| \quad (2.32.6)$$

$$\|\mathbf{P}-\mathbf{R}\| + \|\mathbf{R}-\mathbf{S}\| = 8 + 3 = 11 > \|\mathbf{P}-\mathbf{S}\| \quad (2.32.7)$$

$$\|\mathbf{P}-\mathbf{S}\| + \|\mathbf{P}-\mathbf{R}\| = 7.5 + 8 = 15.5 > \|\mathbf{R}-\mathbf{S}\| \quad (2.32.8)$$

$\therefore$ using triangle inequality, construction of $\triangle PSR$ is possible.

b) In $\triangle PSQ$,

$$\|\mathbf{P}-\mathbf{S}\| + \|\mathbf{S}-\mathbf{Q}\| = 7.5 + 4 = 11.5 > \|\mathbf{P}-\mathbf{Q}\| \quad (2.32.9)$$

$$\|\mathbf{P}-\mathbf{S}\| + \|\mathbf{P}-\mathbf{Q}\| = 7.5 + 3 = 10.5 > \|\mathbf{S}-\mathbf{Q}\| \quad (2.32.10)$$

$$\|\mathbf{P}-\mathbf{Q}\| + \|\mathbf{S}-\mathbf{Q}\| = 3 + 4 = 7 < \|\mathbf{P}-\mathbf{S}\| \quad (2.32.11)$$

which violates triangle inequality. $\therefore$ construction of $\triangle PSQ$ is not possible.

Fig. 2.32.1 highlights this.

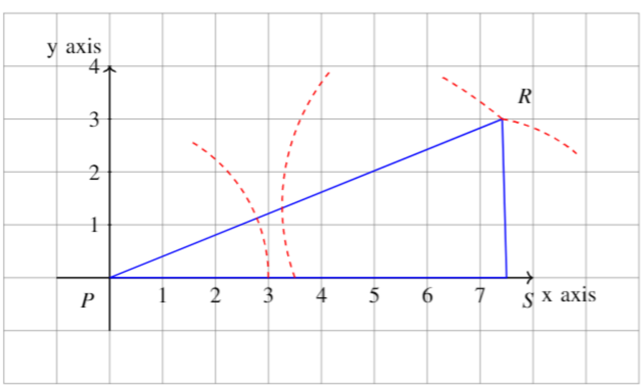

Fig. 2.32.1: Construction of quadrilateral $PQRS$

2.33. Construct $LIFT$ such that $LI = 4, IF = 3, TL = 2.5, LF = 4.5, IT = 4$.

2.34. Draw $GOLD$ such that $OL = 7.5, GL = 6, GD = 6, LD = 5, OD = 10$.

Solution: In $\triangle LDO$

$$\|\mathbf{O}-\mathbf{L}\| + \|\mathbf{O}-\mathbf{D}\| = 17.5 > \|\mathbf{L}-\mathbf{D}\| \quad (2.34.1)$$

$$\|\mathbf{O}-\mathbf{D}\| + \|\mathbf{L}-\mathbf{D}\| = 15 > \|\mathbf{O}-\mathbf{L}\| \quad (2.34.2)$$

$$\|\mathbf{O}-\mathbf{L}\| + \|\mathbf{L}-\mathbf{D}\| = 12.5 > \|\mathbf{O}-\mathbf{D}\| \quad (2.34.3)$$

and triangle inequality is satisfied. Similarly, in $\triangle LDG$

$$\|\mathbf{L}-\mathbf{D}\| + \|\mathbf{G}-\mathbf{L}\| = 11 > \|\mathbf{G}-\mathbf{D}\| \quad (2.34.4)$$

$$\|\mathbf{G}-\mathbf{L}\| + \|\mathbf{G}-\mathbf{D}\| = 12 > \|\mathbf{L}-\mathbf{D}\| \quad (2.34.5)$$

$$\|\mathbf{L}-\mathbf{D}\| + \|\mathbf{G}-\mathbf{D}\| = 11 > \|\mathbf{G}-\mathbf{L}\| \quad (2.34.6)$$

and triangle inequality is satisfied. $\therefore$ the given sides form a quadrilateral which can be constructed by using the approach in Problem 1.3 to obtain the vertices of $\triangle LDO$ and $\triangle LDG$ as

$$\mathbf{L} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \mathbf{D} = \begin{pmatrix} 5 \\ 0 \end{pmatrix}, \mathbf{O} = \begin{pmatrix} -1.875 \\ 7.26 \end{pmatrix}, \mathbf{G} = \begin{pmatrix} 2.5 \\ 5.5 \end{pmatrix} \quad (2.34.7)$$

and plotting the quadrilateral GOLD in Fig. 2.34.1

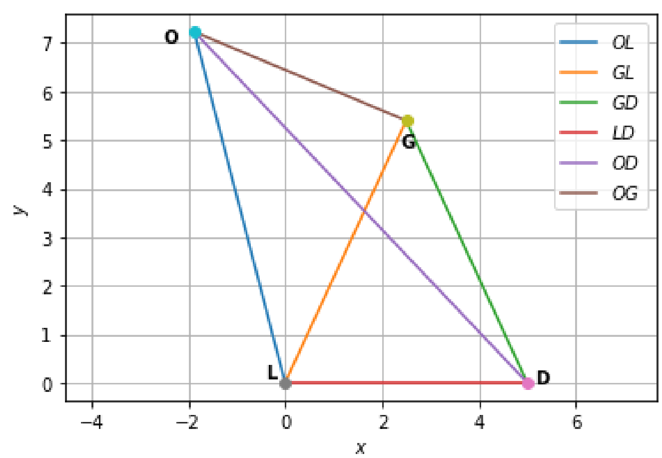

Fig. 2.34.1: Quadrilateral GOLD

2.35. DRAW rhombus $BEND$ such that $BN = 5.6, DE = 6.5$.

2.36. construct a quadrilateral MIST where $MI = 3.5, IS = 6.5, \angle M = 75°, \angle I = 105°$ and $\angle S = 120°$.

2.37. Can you construct the above quadrilateral MIST if $\angle M = 100°$ instead of $75°$.

2.38. Can you constrcut the quadrilateral PLAN if $PL = 6, LA = 9.5, \angle P = 75°, \angle L = 150°$ and $\angle A = 140°$?

2.39. Construct $MORE$ where $MO = 6, OR = 4.5, \angle M = 60°, \angle O = 105°, \angle R = 105°$.
2.40. Construct $PLAN$ where $PL = 4, LA = 6.5, \angle P = 90°, \angle A = 110°$ and $\angle N = 85°$.
2.41. Draw rectangle $OKAY$ with $OK = 7$ and $KA = 5$.
2.42. Construct $ABCD$, where $AB = 4, BC = 5, Cd = 6.5, \angle B = 105°$ and $\angle C = 80°$.
2.43. Construct $DEAR$ with $DE = 4, EA = 5, AR = 4.5, \angle E = 60°$ and $\angle A = 90°$.
2.44. Construct $TRUE$ with $TR = 3.5, RU = 3, UE = 4\angle R = 75°$ and $\angle U = 120°$.
2.45. Can you construct a rhombus $ABCD$ with $AC = 6$ and $BD = 7$?
2.46. Draw a square $READ$ with $RE = 5.1$.
2.47. Draw a rhombus who diagonals are 5.2 and 6.4.
2.48. Draw a rectangle with adjacent sides 5 and 4.
2.49. Draw a parallelogram $OKAY$ with $OK = 5.5$ and $KA = 4.2$.
2.50. Construct a kite $EASY$ if $AY = 8, EY = 4$ and $SY = 6$.
2.51. Draw a circle of diameter 6.1
2.52. With the same centre $\mathbf{O}$, draw two circles of radii 4 and 2.5
Solution:
All input values required to plot Fig. 2.52.1 are given in Table 2.52.1 as shown below

	Symbols	Circle1	Circle2
Centre	$\mathbf{O}$	$\begin{pmatrix}0\\0\end{pmatrix}$	$\begin{pmatrix}0\\0\end{pmatrix}$
Radius	r_1,r_2	2.5	4
Polar coordinate	$\mathbf{C}_1$,$\mathbf{C}_2$	$2.5\begin{pmatrix}\cos\theta\\ \sin\theta\end{pmatrix}$	$4\begin{pmatrix}\cos\theta\\ \sin\theta\end{pmatrix}$
Angle	θ	0-2π	0-2π

TABLE 2.52.1: Input values

2.53. Draw a circle with centre $\mathbf{B}$ and radius 6. If $\mathbf{C}$ be a point 10 units away from its centre, construct the pair of tangents AC and CD to the circle.
2.54. Draw a circle of radius 3 and any two of its diameters. Draw the ends of these diameters. What figure do you get?
2.55. Let $\mathbf{A}$ and $\mathbf{B}$ be the centres of two circles of equal radii 3 such that each one of them passes through the centre of the other. Let them intersect at $\mathbf{C}$ and $\mathbf{D}$. Is $AB \perp CD$?

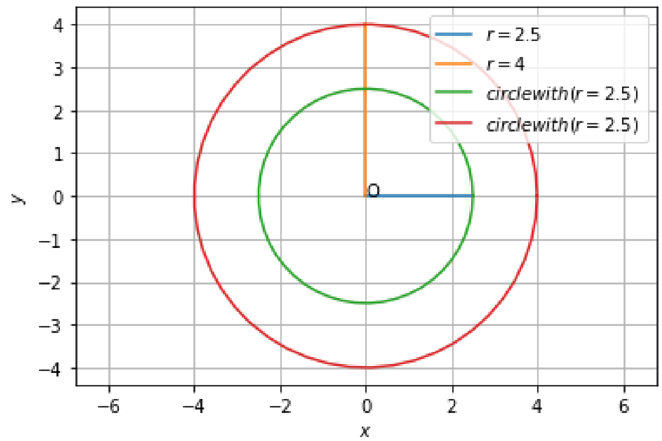

Fig. 2.52.1: Concentric circles with centre as origin and radii 2.5 and 4 respectively

2.56. Construct a tangent to a circle of radius 4 units from a point on the concentric circle of radius 6 units.
Solution: Take the centre of both circles to be at the origin.
2.57. Draw a circle of radius 3 units. Take two points $\mathbf{P}$ and $\mathbf{Q}$ 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 $\mathbf{P}$ and $\mathbf{Q}$.
Solution: Take the diameter to be on the x-axis.
2.58. Draw a pair of tangents to a circle of radius 5 units which are inclined to each other at an angle of 60°.
Solution: The tangent is perpendicular to the radius.
2.59. Draw a line segment AB of length 8 units. Taking $\mathbf{A}$ as centre, draw a circle of radius 4 units and taking $\mathbf{B}$ as centre, draw another circle of radius 3 units. Construct tangents to each circle from the centre of the other circle.
Solution: Let

$$\mathbf{A} = \begin{pmatrix}0\\0\end{pmatrix}, \mathbf{B} = \begin{pmatrix}8\\0\end{pmatrix}. \tag{2.59.1}$$

2.60. Let ABC be a right triangle in which $a = 8, c = 6$ and $\angle B = 90^{\circ}$. BD is the perpendicular from $\mathbf{B}$ on AC (altitude). The circle through $\mathbf{B}, \mathbf{C}, \mathbf{D}$ (circumcircle of $\triangle BCD$) is drawn. Construct the tangents from $\mathbf{A}$ to this circle.
2.61. Draw a circle with centre $\mathbf{C}$ and radius 3.4. Draw any chord. Construct the perpendicular

bisector of the chord and examine if it passes through **C**