

# Circles, Inscribing and Circumscribing of Circles class 11 engineering graphics ncert solutions

*Step-by-step answers for the 2026-27 NCERT  
Engineering Graphics chapter*

## **Chapter 3: Circles, Inscribing and Circumscribing of Circles**

---

This PDF solves the assignment questions from the Class 11

Engineering Graphics chapter on circles, tangents, common tangents and inscribed circles. Each answer gives the construction order a student can follow on the drawing sheet.

---

## Complete Chapter Solutions

**Q 3.1** Draw a circle of any convenient radius without using compass and find its centre.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Locate the centre of a given circle. Level: Core.

### QUICK SOLUTION

**Concept:** The perpendicular bisectors of two non-parallel chords meet at the centre of the circle.

**Answer:** The intersection of the perpendicular bisectors of two chords is the centre of the circle.

### SOLUTION

**Concept used.** The perpendicular bisectors of two non-parallel chords meet at the centre of the circle.

- Step 1.** Draw the circle by tracing any circular object such as a cap.
- Step 2.** Mark four points on the circumference and draw two chords  $AB$  and  $CD$ .
- Step 3.** Construct the perpendicular bisector of chord  $AB$ .
- Step 4.** Construct the perpendicular bisector of chord  $CD$ .
- Step 5.** Let the two bisectors meet at  $O$ . This point is the centre of the circle.

 **Drawing check**

Choose chords in different directions.  
Parallel or nearly parallel chords make the centre harder to locate neatly.

**Final Answer:** The intersection of the perpendicular bisectors of two chords is the centre of the circle.

**EXPERT'S SOLUTION** : *Aarav Mehta, M.Tech  
Mechanical Design, IIT Delhi*

**Centre route.** The drawing is solved by converting the unknown centre into two chord-bisector lines.

- Step 1.** Draw the circle by tracing any circular object such as a cap.
- Step 2.** Mark four points on the circumference and draw two chords  $AB$  and  $CD$ .
- Step 3.** Construct the perpendicular bisector of chord  $AB$ .
- Step 4.** Construct the perpendicular bisector of chord  $CD$ .
- Step 5.** Let the two bisectors meet at  $O$ . This point is the centre of the circle.

This method is reliable because both chord bisectors must pass through the same centre. Check by measuring equal radii from  $O$ .

**Final Answer:** The intersection of the perpendicular bisectors of two chords is the centre of the circle.

**Q 3.2** Draw a triangle  $ABC$  with  $AB = 40$  mm,  $BC = 50$  mm and  $CA = 60$  mm. Draw a circle passing through  $A$ ,  $B$  and  $C$ .

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Construct a circumcircle. Level: Core.

### QUICK SOLUTION

**Concept:** The circumcentre of a triangle is the common meeting point of the perpendicular bisectors of its sides.

**Answer:** The circle with centre  $O$  and radius  $OA$  passes through  $A$ ,  $B$  and  $C$ .

### SOLUTION

**Concept used.** The circumcentre of a triangle is the common meeting point of the perpendicular bisectors of its sides.

**Step 1.** Draw  $BC = 50$  mm.

**Step 2.** With  $B$  as centre and radius 40 mm, draw an arc.

**Step 3.** With  $C$  as centre and radius 60 mm, draw another arc cutting the first arc at  $A$ .

**Step 4.** Join  $AB$  and  $AC$  to complete triangle  $ABC$ .

**Step 5.** Draw the perpendicular bisectors of  $AB$  and  $BC$ .

**Step 6.** Let them meet at  $O$ . With  $O$  as centre and  $OA$  as radius, draw the circle.

 **Drawing check**

$OA$ ,  $OB$  and  $OC$  are equal because  $O$  lies on the bisectors of the triangle sides.

**Final Answer:** The circle with centre  $O$  and radius  $OA$  passes through  $A$ ,  $B$  and  $C$ .

**EXPERT'S SOLUTION** : *Priya Iyer, M.Sc  
Mathematics, Delhi University*

**Circumcircle route.** Build the triangle first, then locate the point equally distant from all three vertices.

**Step 1.** Draw  $BC = 50$  mm.

**Step 2.** With  $B$  as centre and radius 40 mm, draw an arc.

**Step 3.** With  $C$  as centre and radius 60 mm, draw another arc cutting the first arc at  $A$ .

**Step 4.** Join  $AB$  and  $AC$  to complete triangle  $ABC$ .

**Step 5.** Draw the perpendicular bisectors of  $AB$  and  $BC$ .

**Step 6.** Let them meet at  $O$ . With  $O$  as centre and  $OA$  as radius, draw the circle.

The construction is complete when  $OA$ ,  $OB$  and  $OC$  are equal. That equality confirms the circle passes through all vertices.

**Final Answer:** The circle with centre  $O$  and radius  $OA$  passes through  $A$ ,  $B$  and  $C$ .

**Q 3.3** Draw any arc without using compass.

Now complete the circle of which this arc is a part.

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

Complete a circle from an arc. **Level:** Core.

### QUICK SOLUTION

**Concept:** A circular arc is part of one circle. If we locate the centre of that circle, the whole circle can be drawn.

**Answer:** The completed circle has centre  $O$  and radius  $OP$ , where  $O$  is found from the two chord bisectors.

## SOLUTION

**Concept used.** A circular arc is part of one circle. If we locate the centre of that circle, the whole circle can be drawn.

**Step 1.** Draw a smooth arc and mark three points  $P$ ,  $R$  and  $Q$  on it.

**Step 2.** Join  $P$  to  $R$  and  $R$  to  $Q$  to form two chords.

**Step 3.** Draw the perpendicular bisector of chord  $PR$ .

**Step 4.** Draw the perpendicular bisector of chord  $RQ$ .

**Step 5.** Let the bisectors meet at  $O$ .

**Step 6.** With  $O$  as centre and  $OP$  as radius, draw the complete circle.

### Drawing check

Keep the three points well separated on the arc. Very close points produce tiny chords and poor accuracy.

**Final Answer:** The completed circle has centre  $O$  and radius  $OP$ , where  $O$  is found from the two chord bisectors.

**Arc route.** Treat the arc as part of a hidden circle and recover its centre from two chords.

**Step 1.** Draw a smooth arc and mark three points  $P$ ,  $R$  and  $Q$  on it.

**Step 2.** Join  $P$  to  $R$  and  $R$  to  $Q$  to form two chords.

**Step 3.** Draw the perpendicular bisector of chord  $PR$ .

**Step 4.** Draw the perpendicular bisector of chord  $RQ$ .

**Step 5.** Let the bisectors meet at  $O$ .

**Step 6.** With  $O$  as centre and  $OP$  as radius, draw the complete circle.

The three selected arc points should lie on the completed circle. If one misses, redraw the chord bisectors more carefully.

**Final Answer:** The completed circle has centre  $O$  and radius  $OP$ , where  $O$  is found from the two chord bisectors.

**Q 3.4** Draw a circle of radius 20 mm and take a point  $P$  on it. Draw a tangent at  $P$ .

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Draw tangent at a point. Level: Core.

### QUICK SOLUTION

**Concept:** At the point of contact, the radius and tangent are perpendicular to each other.

**Answer:** The required tangent is the line through  $P$  perpendicular to radius  $OP$ .

### SOLUTION

**Concept used.** At the point of contact, the radius and tangent are perpendicular to each other.

**Step 1.** Draw a circle of radius 20 mm with centre  $O$ .

**Step 2.** Mark any point  $P$  on the circumference.

**Step 3.** Join  $O$  to  $P$ .

**Step 4.** At  $P$ , construct a line making  $90^\circ$  with  $OP$ .

**Step 5.** Name this line  $ST$ . It touches the circle only at  $P$ .

### Drawing check

Radius to point of contact is always normal to the tangent.

**Final Answer:** The required tangent is the line through  $P$  perpendicular to radius  $OP$ .

**EXPERT'S SOLUTION** : *Meera Joshi, M.Tech CAD CAM, VNIT Nagpur*

**Tangent-at-point route.** Once the radius to the contact point is drawn, the tangent direction is fixed.

**Step 1.** Draw a circle of radius 20 mm with centre  $O$ .

**Step 2.** Mark any point  $P$  on the circumference.

**Step 3.** Join  $O$  to  $P$ .

**Step 4.** At  $P$ , construct a line making  $90^\circ$  with  $OP$ .

**Step 5.** Name this line  $ST$ . It touches the circle only at  $P$ .

Only one tangent can pass through a fixed point on a circle. The right angle at  $P$  is the

proof of correctness.

**Final Answer:** The required tangent is the line through  $P$  perpendicular to radius  $OP$ .

**Q 3.5** You are given a circle of radius 25 mm and a point  $P$ , 55 mm from the centre of this circle. Draw two tangents from this point on the circle.

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

Draw tangents from an external point. **Level:** Core.

### QUICK SOLUTION

**Concept:** The angle in a circle drawn on  $OP$  as diameter is a right angle. Therefore, the line from  $P$  to each intersection point is perpendicular to the radius at that point.

**Answer:**  $PT_1$  and  $PT_2$  are the two required tangents from external point  $P$ .

### SOLUTION

**Concept used.** The angle in a circle drawn on  $OP$  as diameter is a right angle. Therefore, the line from  $P$  to each intersection point is

perpendicular to the radius at that point.

**Step 1.** Draw the given circle with centre  $O$  and radius 25 mm.

**Step 2.** Mark point  $P$  so that  $OP = 55$  mm.

**Step 3.** Join  $O$  and  $P$ .

**Step 4.** Bisect  $OP$  at  $M$  and draw the full circle with centre  $M$  and radius  $MO$ .

**Step 5.** Let this diameter-circle cut the given circle at  $T_1$  and  $T_2$ , one point on each side of  $OP$ .

**Step 6.** Join  $PT_1$  and  $PT_2$ . These are the two tangents.

#### **Drawing check**

Both tangent lengths  $PT_1$  and  $PT_2$  should be equal if the construction is accurate.

**Final Answer:**  $PT_1$  and  $PT_2$  are the two required tangents from external point  $P$ .

**EXPERT'S SOLUTION** : *Kavya Rao, B.Tech  
Mechanical Engineering, IIT Roorkee*

**External-point route.** The tangent points are found by making right angles on the full circle with diameter  $OP$ .

- Step 1.** Draw the given circle with centre  $O$  and radius 25 mm.
- Step 2.** Mark point  $P$  so that  $OP = 55$  mm.
- Step 3.** Join  $O$  and  $P$ .
- Step 4.** Bisect  $OP$  at  $M$  and draw the full circle with centre  $M$  and radius  $MO$ .
- Step 5.** Let this diameter-circle cut the given circle at  $T_1$  and  $T_2$ , one point on each side of  $OP$ .
- Step 6.** Join  $PT_1$  and  $PT_2$ . These are the two tangents.

The full diameter circle gives two intersections, one on each side of  $OP$ . Equal tangent lengths from  $P$  confirm the answer.

**Final Answer:**  $PT_1$  and  $PT_2$  are the two required tangents from external point  $P$ .

**Q 3.6** Two circles of radii 25 mm each have their centres 65 mm apart. Draw two external common tangents to these circles.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

External tangents to equal circles. Level: Core.

### QUICK SOLUTION

**Concept:** The radius to a tangent point is perpendicular to the tangent. Equal radii make the two external tangents parallel to the line joining centres.

**Answer:**  $PQ$  and  $P'Q'$  are the two external common tangents.

### SOLUTION

**Concept used.** The radius to a tangent point is perpendicular to the tangent. Equal radii make the two external tangents parallel to the line joining centres.

**Step 1.** Draw centres  $O$  and  $O_1$  with  $OO_1 = 65$  mm.

**Step 2.** Draw two circles, each of radius 25 mm.

**Step 3.** At  $O$ , draw a line perpendicular to  $OO_1$  and mark its intersections with the first circle as  $P$  and  $P'$ .

**Step 4.** At  $O_1$ , draw a parallel perpendicular

and mark intersections with the second circle as  $Q$  and  $Q'$ .

**Step 5.** Join  $P$  to  $Q$  for the upper external tangent.

**Step 6.** Join  $P'$  to  $Q'$  for the lower external tangent.

 **Drawing check**

For equal circles, the two external tangents are simple parallel lines.

**Final Answer:**  $PQ$  and  $P'Q'$  are the two external common tangents.

**EXPERT'S SOLUTION** : *Dev Singh, M.Tech  
Manufacturing, IIT Kanpur*

**Equal-circle route.** Equal radii make the direct common tangents parallel to the centre line.

**Step 1.** Draw centres  $O$  and  $O_1$  with  $OO_1 = 65$  mm.

**Step 2.** Draw two circles, each of radius 25 mm.

**Step 3.** At  $O$ , draw a line perpendicular to  $OO_1$  and mark its intersections with

the first circle as  $P$  and  $P'$ .

**Step 4.** At  $O_1$ , draw a parallel perpendicular and mark intersections with the second circle as  $Q$  and  $Q'$ .

**Step 5.** Join  $P$  to  $Q$  for the upper external tangent.

**Step 6.** Join  $P'$  to  $Q'$  for the lower external tangent.

Both tangent lines should be parallel to  $OO_1$ . Equal perpendicular radii at both contact points confirm the construction.

**Final Answer:**  $PQ$  and  $P'Q'$  are the two external common tangents.

**Q 3.7** There are two circles which touch externally. Draw them by taking each radius 30 mm and then draw two external common tangents to these circles.

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

External tangents to externally touching equal circles. **Level:** Core.

## QUICK SOLUTION

**Concept:** If two circles touch externally, their centres are separated by the sum of their radii.

**Answer:** The two external common tangents are the upper and lower lines through corresponding perpendicular tangent points.

## SOLUTION

**Concept used.** If two circles touch externally, their centres are separated by the sum of their radii.

**Step 1.** Draw  $OO_1 = 60$  mm because  
 $30 + 30 = 60$  mm.

**Step 2.** Draw a circle of radius 30 mm with centre  $O$ .

**Step 3.** Draw another circle of radius 30 mm with centre  $O_1$ . The circles touch at one point on  $OO_1$ .

**Step 4.** Draw perpendiculars to  $OO_1$  at  $O$  and  $O_1$ .

**Step 5.** Mark the upper tangent points and join them.

**Step 6.** Mark the lower tangent points and join them.

### Drawing check

The circles should touch at exactly one point between the two centres.

**Final Answer:** The two external common tangents are the upper and lower lines through corresponding perpendicular tangent points.

**EXPERT'S SOLUTION** : *Ananya Gupta, B.Tech  
Mechanical Engineering, NIT Trichy*

**Touching-circle route.** The centre distance comes from the sum of radii, then the equal-circle tangent rule applies.

**Step 1.** Draw  $OO_1 = 60$  mm because  $30 + 30 = 60$  mm.

**Step 2.** Draw a circle of radius 30 mm with centre  $O$ .

**Step 3.** Draw another circle of radius 30 mm with centre  $O_1$ . The circles touch at one point on  $OO_1$ .

**Step 4.** Draw perpendiculars to  $OO_1$  at  $O$  and  $O_1$ .

**Step 5.** Mark the upper tangent points and

join them.

**Step 6.** Mark the lower tangent points and join them.

The two circles should touch at one point and the tangents should sit symmetrically above and below the centre line.

**Final Answer:** The two external common tangents are the upper and lower lines through corresponding perpendicular tangent points.

**Q 3.8** Draw two touching circles whose radii are 20 mm and 15 mm. Draw an external common tangent to these circles.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Tangent to externally touching unequal circles. Level: Core.

### QUICK SOLUTION

**Concept:** Externally touching circles have centre distance equal to the sum of radii, and the common tangent touches both circles on the same side.

**Answer:**  $PQ$  is the required external common tangent to the two touching unequal circles.

## SOLUTION

**Concept used.** Externally touching circles have centre distance equal to the sum of radii, and the common tangent touches both circles on the same side.

**Step 1.** Draw  $OO_1 = 35$  mm because  $20 + 15 = 35$  mm.

**Step 2.** Draw the two circles with radii 20 mm and 15 mm so they touch externally at  $A$ .

**Step 3.** Draw a semicircle on  $OO_1$ .

**Step 4.** At  $A$ , draw a perpendicular to  $OO_1$  meeting the semicircle at  $B$ .

**Step 5.** With  $B$  as centre and  $BA$  as radius, draw an arc cutting the two circles at  $P$  and  $Q$ .

**Step 6.** Join  $P$  and  $Q$ . This is the external common tangent.

### Drawing check

The same construction can be mirrored below the line of centres for the other external tangent.

**Final Answer:**  $PQ$  is the required external common tangent to the two touching unequal circles.

**EXPERT'S SOLUTION** : *Ishita Nair, M.Des Product Design, NID Ahmedabad*

**Unequal-touch route.** The touching point and semicircle construction locate the common tangent without trial drawing.

**Step 1.** Draw  $OO_1 = 35$  mm because  $20 + 15 = 35$  mm.

**Step 2.** Draw the two circles with radii 20 mm and 15 mm so they touch externally at  $A$ .

**Step 3.** Draw a semicircle on  $OO_1$ .

**Step 4.** At  $A$ , draw a perpendicular to  $OO_1$  meeting the semicircle at  $B$ .

**Step 5.** With  $B$  as centre and  $BA$  as radius, draw an arc cutting the two circles at  $P$  and  $Q$ .

**Step 6.** Join  $P$  and  $Q$ . This is the external common tangent.

The arc from  $B$  locates tangent points on both unequal circles. Joining them gives a line that touches both circles on the same side.

**Final Answer:**  $PQ$  is the required external common tangent to the two touching unequal circles.

**Q 3.9** Two circles,  $R30$  mm and  $R15$  mm, have their centres 70 mm apart. Draw an external common tangent to these circles.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

External tangent to non-intersecting unequal circles. Level: Core.

### QUICK SOLUTION

**Concept:** An external tangent to unequal circles can be found by shrinking the larger circle by the smaller radius.

**Answer:**  $PQ$  is the required external common tangent.

### SOLUTION

**Concept used.** An external tangent to unequal circles can be found by shrinking the larger circle by the smaller radius.

**Step 1.** Draw  $OO_1 = 70$  mm.

**Step 2.** Draw the larger circle with centre  $O$  and radius 30 mm.

**Step 3.** Draw the smaller circle with centre  $O_1$  and radius 15 mm.

**Step 4.** With  $O$  as centre, draw an auxiliary circle of radius  $30 - 15 = 15$  mm.

**Step 5.** Draw a tangent from  $O_1$  to this auxiliary circle and call the contact point  $A$ .

**Step 6.** Extend  $OA$  to meet the larger circle at  $P$ .

**Step 7.** Through  $O_1$ , draw a line parallel to  $OP$  meeting the smaller circle at  $Q$ .

**Step 8.** Join  $P$  and  $Q$ .

 **Drawing check**

External tangent problems with unequal circles use the difference of radii.

**Final Answer:**  $PQ$  is the required external common tangent.

**EXPERT'S SOLUTION** : *Pranav Sharma, M.Tech Machine Design, IIT Bombay*

**Difference-circle route.** Subtract the smaller radius to convert the external tangent into a simpler tangent problem.

- Step 1.** Draw  $OO_1 = 70$  mm.
- Step 2.** Draw the larger circle with centre  $O$  and radius 30 mm.
- Step 3.** Draw the smaller circle with centre  $O_1$  and radius 15 mm.
- Step 4.** With  $O$  as centre, draw an auxiliary circle of radius  $30 - 15 = 15$  mm.
- Step 5.** Draw a tangent from  $O_1$  to this auxiliary circle and call the contact point  $A$ .
- Step 6.** Extend  $OA$  to meet the larger circle at  $P$ .
- Step 7.** Through  $O_1$ , draw a line parallel to  $OP$  meeting the smaller circle at  $Q$ .
- Step 8.** Join  $P$  and  $Q$ .

The auxiliary circle removes the smaller radius temporarily. The final parallel through  $O_1$  restores the actual smaller circle.

**Final Answer:**  $PQ$  is the required external common tangent.

**Q 3.10** There are two intersecting circles with their centres 30 mm apart and radii equal to 25 mm and 15 mm. Draw an external common tangent to these circles.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

External tangent to intersecting unequal circles. Level: Core.

### QUICK SOLUTION

**Concept:** For intersecting unequal circles, an external common tangent can be constructed by locating an external similarity point.

**Answer:**  $PQ$  is the external common tangent to the two intersecting unequal circles.

### SOLUTION

**Concept used.** For intersecting unequal circles, an external common tangent can be constructed by locating an external similarity point.

**Step 1.** Draw centres  $O$  and  $O_1$  with  $OO_1 = 30$  mm.

**Step 2.** Draw circles of radii 25 mm and 15 mm.

**Step 3.** On the larger circle, draw any radius  $OA$  making a convenient angle.

**Step 4.** Through  $O_1$ , draw  $O_1B$  parallel to  $OA$  to meet the smaller circle at  $B$ .

- Step 5.** Join  $A$  and  $B$  and extend it to meet the extended line  $OO_1$  at  $C$ .
- Step 6.** From  $C$ , draw a tangent to the larger circle. Let the tangent point be  $P$ .
- Step 7.** Draw through  $O_1$  a radius parallel to  $OP$  meeting the smaller circle at  $Q$ .
- Step 8.** Join  $P$  and  $Q$  for the common tangent.

 **Drawing check**

Point  $C$  is outside both circles. It controls the common tangent direction.

**Final Answer:**  $PQ$  is the external common tangent to the two intersecting unequal circles.

**EXPERT'S SOLUTION** : *Sanya Reddy, B.Tech Civil Engineering, IIT Madras*

**Similarity-point route.** Parallel radii locate the external similarity point that controls the tangent direction.

**Step 1.** Draw centres  $O$  and  $O_1$  with  $OO_1 = 30$  mm.

**Step 2.** Draw circles of radii 25 mm and 15

mm.

- Step 3.** On the larger circle, draw any radius  $OA$  making a convenient angle.
- Step 4.** Through  $O_1$ , draw  $O_1B$  parallel to  $OA$  to meet the smaller circle at  $B$ .
- Step 5.** Join  $A$  and  $B$  and extend it to meet the extended line  $OO_1$  at  $C$ .
- Step 6.** From  $C$ , draw a tangent to the larger circle. Let the tangent point be  $P$ .
- Step 7.** Draw through  $O_1$  a radius parallel to  $OP$  meeting the smaller circle at  $Q$ .
- Step 8.** Join  $P$  and  $Q$  for the common tangent.

The external similarity point  $C$  ensures both contact radii are parallel. That is why one line can touch both intersecting circles.

**Final Answer:**  $PQ$  is the external common tangent to the two intersecting unequal circles.

**Q 3.11**

**Two equal circles of radii 30 mm each have their centres 80 mm apart. Draw an internal common tangent to them.**

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Internal tangent to equal circles. Level: Core.

**QUICK SOLUTION**

**Concept:** An internal common tangent crosses the line joining the centres. For equal circles, it crosses at the midpoint.

**Answer:**  $PQ$  is the required internal common tangent.

**SOLUTION**

**Concept used.** An internal common tangent crosses the line joining the centres. For equal circles, it crosses at the midpoint.

**Step 1.** Draw  $OO_1 = 80$  mm.

**Step 2.** Draw two circles, each of radius 30 mm.

**Step 3.** Bisect  $OO_1$  at  $M$ .

**Step 4.** Draw a semicircle on  $OM$  to locate tangent point  $P$  on the first circle.

**Step 5.** Through  $O_1$ , draw  $O_1Q$  parallel to  $OP$  and mark  $Q$  on the second circle on the opposite side.

**Step 6.** Join  $P$  and  $Q$ . The line passes through  $M$  and is the internal tangent.

 **Drawing check**

An internal tangent crosses the space between the circles and cuts the line of centres between the centres.

**Final Answer:**  $PQ$  is the required internal common tangent.

**EXPERT'S SOLUTION** : *Neha Verma, M.Tech  
Structural Engineering, IIT Guwahati*

**Midpoint route.** Equal circles place the crossed tangent through the midpoint of the centre line.

**Step 1.** Draw  $OO_1 = 80$  mm.

**Step 2.** Draw two circles, each of radius 30 mm.

**Step 3.** Bisect  $OO_1$  at  $M$ .

**Step 4.** Draw a semicircle on  $OM$  to locate tangent point  $P$  on the first circle.

**Step 5.** Through  $O_1$ , draw  $O_1Q$  parallel to  $OP$  and mark  $Q$  on the second circle on the opposite side.

**Step 6.** Join  $P$  and  $Q$ . The line passes through  $M$  and is the internal tangent.

The tangent should pass through midpoint  $M$ . If it misses  $M$ , the contact points have been chosen on the wrong sides.

**Final Answer:**  $PQ$  is the required internal common tangent.

**Q 3.12** Draw an internal common tangent to two circles whose radii are 25 mm and 20 mm and whose centres are 70 mm apart.

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

Internal tangent to unequal circles. **Level:** Core.

### QUICK SOLUTION

**Concept:** For an internal common tangent, the auxiliary radius equals the sum of the two given radii.

**Answer:**  $PQ$  is the required internal common tangent.

### SOLUTION

**Concept used.** For an internal common tangent, the auxiliary radius equals the sum of

the two given radii.

**Step 1.** Draw  $OO_1 = 70$  mm.

**Step 2.** Draw the circles of radii 25 mm and 20 mm.

**Step 3.** With  $O$  as centre, draw an auxiliary circle of radius  $25 + 20 = 45$  mm.

**Step 4.** Draw a tangent from  $O_1$  to this auxiliary circle to get the direction.

**Step 5.** Mark  $P$  on the larger circle in that direction.

**Step 6.** Through  $O_1$ , draw a line parallel to  $OP$  on the opposite side to meet the smaller circle at  $Q$ .

**Step 7.** Join  $P$  and  $Q$ .

#### **Drawing check**

Internal tangents use sum of radii, while external tangents use difference of radii.

**Final Answer:**  $PQ$  is the required internal common tangent.

**Sum-circle route.** Internal tangents use the sum of radii because the belt crosses between the circles.

**Step 1.** Draw  $OO_1 = 70$  mm.

**Step 2.** Draw the circles of radii 25 mm and 20 mm.

**Step 3.** With  $O$  as centre, draw an auxiliary circle of radius  $25 + 20 = 45$  mm.

**Step 4.** Draw a tangent from  $O_1$  to this auxiliary circle to get the direction.

**Step 5.** Mark  $P$  on the larger circle in that direction.

**Step 6.** Through  $O_1$ , draw a line parallel to  $OP$  on the opposite side to meet the smaller circle at  $Q$ .

**Step 7.** Join  $P$  and  $Q$ .

The sum-radius auxiliary construction puts the tangent on opposite sides of the two circles, which is the internal tangent condition.

**Final Answer:**  $PQ$  is the required internal common tangent.

**Q 3.13** Draw an equilateral triangle of height 55 mm. Inscribe a circle in it.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Incircle of an equilateral triangle. Level: Core.

### QUICK SOLUTION

**Concept:** An inscribed circle touches all sides of a polygon. Its centre is equidistant from all the sides.

**Answer:** The circle with centre  $O$  and radius  $OD$  is inscribed in the equilateral triangle.

### SOLUTION

**Concept used.** An inscribed circle touches all sides of a polygon. Its centre is equidistant from all the sides.

**Step 1.** Draw altitude  $AD = 55$  mm.

**Step 2.** Through  $D$ , draw base line  $BC$  perpendicular to  $AD$ .

**Step 3.** Through  $A$ , draw two lines making  $30^\circ$  with  $AD$  on either side. Let them meet the base line at  $B$  and  $C$ .

**Step 4.** Join  $AB$  and  $AC$  to complete equilateral triangle  $ABC$ .

**Step 5.** Bisect angles  $B$  and  $C$ .

**Step 6.** Let the angle bisectors meet at  $O$ .

**Step 7.** From  $O$ , draw  $OD$  perpendicular to side  $BC$ .

**Step 8.** With  $O$  as centre and  $OD$  as radius, draw the circle.

 **Drawing check**

The circle should touch all three sides. It must not cut any side.

**Final Answer:** The circle with centre  $O$  and radius  $OD$  is inscribed in the equilateral triangle.

**EXPERT'S SOLUTION** : *Diya Desai, M.Des  
Industrial Design, IIT Hyderabad*

**Height-first route.** Convert the given altitude into an exact equilateral triangle before finding the incircle.

**Step 1.** Draw altitude  $AD = 55$  mm.

**Step 2.** Through  $D$ , draw base line  $BC$  perpendicular to  $AD$ .

**Step 3.** Through  $A$ , draw two lines making  $30^\circ$  with  $AD$  on either side and meeting the base line at  $B$  and  $C$ .

**Step 4.** Join  $AB$  and  $AC$  to complete

equilateral triangle  $ABC$ .

**Step 5.** Bisect angles  $B$  and  $C$ .

**Step 6.** Let the angle bisectors meet at  $O$ .

**Step 7.** From  $O$ , draw  $OD$  perpendicular to side  $BC$ .

**Step 8.** With  $O$  as centre and  $OD$  as radius, draw the circle.

The circle is correct only when it touches all three sides. The perpendicular from  $O$  to a side is the radius, not the altitude.

**Final Answer:** The circle with centre  $O$  and radius  $OD$  is inscribed in the equilateral triangle.

**Q 3.14** Inscribe a circle in a given square of side 40 mm.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Incircle of a square. Level: Core.

### QUICK SOLUTION

**Concept:** The centre of a square is equally distant from all four sides.

**Answer:** The required inscribed circle has

centre  $O$  and radius  $OE = 20$  mm.

## SOLUTION

**Concept used.** The centre of a square is equally distant from all four sides.

**Step 1.** Draw square  $ABCD$  with side 40 mm.

**Step 2.** Join diagonals  $AC$  and  $BD$ .

**Step 3.** Let the diagonals meet at  $O$ .

**Step 4.** From  $O$ , draw  $OE$  perpendicular to side  $AB$ .

**Step 5.** With  $O$  as centre and  $OE$  as radius, draw the circle.

### Drawing check

For a 40 mm square, the incircle radius is 20 mm.

**Final Answer:** The required inscribed circle has centre  $O$  and radius  $OE = 20$  mm.

**EXPERT'S SOLUTION** : *Arjun Kumar, B.Tech  
Production Engineering, NIT Calicut*

**Square-symmetry route.** The diagonal intersection gives the centre, and half the side gives the radius check.

**Step 1.** Draw square  $ABCD$  with side 40 mm.

**Step 2.** Join diagonals  $AC$  and  $BD$ .

**Step 3.** Let the diagonals meet at  $O$ .

**Step 4.** From  $O$ , draw  $OE$  perpendicular to side  $AB$ .

**Step 5.** With  $O$  as centre and  $OE$  as radius, draw the circle.

The circle should touch all four sides once. In a 40 mm square, 20 mm is the radius check.

**Final Answer:** The required inscribed circle has centre  $O$  and radius  $OE = 20$  mm.

### **Q 3.15** Inscribe a circle in a rhombus whose diagonals are 70 mm and 40 mm.

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

Incircle of a rhombus. **Level:** Core.

#### **QUICK SOLUTION**

**Concept:** A rhombus has an incircle because all sides are equal. The circle touches each side at one point.

**Answer:** The incircle has centre  $O$ , the

intersection of diagonals, and radius  $OE$ .

## SOLUTION

**Concept used.** A rhombus has an incircle because all sides are equal. The circle touches each side at one point.

**Step 1.** Draw diagonal  $AC = 70$  mm.

**Step 2.** Bisect  $AC$  at  $O$ .

**Step 3.** Through  $O$ , draw a perpendicular and mark  $BD = 40$  mm with  
 $OB = OD = 20$  mm.

**Step 4.** Join  $A$  to  $B$ ,  $B$  to  $C$ ,  $C$  to  $D$  and  $D$  to  $A$  to form the rhombus.

**Step 5.** From  $O$ , draw  $OE$  perpendicular to any side, say  $AB$ .

**Step 6.** With  $O$  as centre and  $OE$  as radius, draw the inscribed circle.

### Drawing check

The diagonals of a rhombus bisect each other at right angles.

**Final Answer:** The incircle has centre  $O$ , the intersection of diagonals, and radius  $OE$ .

**Rhombus route.** The perpendicular diagonals build the shape and their intersection gives the incircle centre.

**Step 1.** Draw diagonal  $AC = 70$  mm.

**Step 2.** Bisect  $AC$  at  $O$ .

**Step 3.** Through  $O$ , draw a perpendicular and mark  $BD = 40$  mm with  
 $OB = OD = 20$  mm.

**Step 4.** Join  $A$  to  $B$ ,  $B$  to  $C$ ,  $C$  to  $D$  and  $D$  to  $A$  to form the rhombus.

**Step 5.** From  $O$ , draw  $OE$  perpendicular to any side, say  $AB$ .

**Step 6.** With  $O$  as centre and  $OE$  as radius, draw the inscribed circle.

The incircle is accepted when the same centre-to-side distance works for all four sides of the rhombus.

**Final Answer:** The incircle has centre  $O$ , the intersection of diagonals, and radius  $OE$ .

**Q 3.16** Draw a regular pentagon of side 45 mm. Inscribe a circle in it.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Incircle of a regular pentagon. Level: Core.

### QUICK SOLUTION

**Concept:** In a regular pentagon, all sides and angles are equal. The centre is equally distant from every side.

**Answer:** The circle centred at  $O$  with radius  $OF$  is inscribed in the pentagon.

### SOLUTION

**Concept used.** In a regular pentagon, all sides and angles are equal. The centre is equally distant from every side.

**Step 1.** Draw regular pentagon  $ABCDE$  with each side 45 mm.

**Step 2.** Bisect angle  $EAB$ .

**Step 3.** Bisect angle  $ABC$ .

**Step 4.** Let the angle bisectors meet at  $O$ .

**Step 5.** From  $O$ , draw  $OF$  perpendicular to side  $AB$ .

**Step 6.** With  $O$  as centre and  $OF$  as radius, draw the circle.

### Drawing check

For any regular polygon, the centre is common for the inscribed and circumscribed circles.

**Final Answer:** The circle centred at  $O$  with radius  $OF$  is inscribed in the pentagon.

**EXPERT'S SOLUTION** : Vivaan Nair, B.Tech  
Mechanical Engineering, IIT Patna

**Pentagon route.** In a regular pentagon, two angle bisectors are enough to locate the common centre.

**Step 1.** Draw regular pentagon  $ABCDE$  with each side 45 mm.

**Step 2.** Bisect angle  $EAB$ .

**Step 3.** Bisect angle  $ABC$ .

**Step 4.** Let the angle bisectors meet at  $O$ .

**Step 5.** From  $O$ , draw  $OF$  perpendicular to side  $AB$ .

**Step 6.** With  $O$  as centre and  $OF$  as radius, draw the circle.

The perpendicular from  $O$  to one side is the

apothem. It must touch each side once when the pentagon is regular.

**Final Answer:** The circle centred at  $O$  with radius  $OF$  is inscribed in the pentagon.

**Q 3.17** In a regular hexagon of diagonal 70 mm, inscribe a circle in it.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Incircle of a regular hexagon. Level: Core.

### QUICK SOLUTION

**Concept:** The incircle radius of a regular hexagon is the perpendicular distance from its centre to any side.

**Answer:** The required incircle has centre  $O$  and radius  $OG$ .

### SOLUTION

**Concept used.** The incircle radius of a regular hexagon is the perpendicular distance from its centre to any side.

**Step 1.** Draw the regular hexagon  $ABCDEF$  with diagonal  $AD = 70$  mm.

**Step 2.** Join opposite vertices  $AD$ ,  $BE$  and  $CF$ .

**Step 3.** Let these diagonals meet at  $O$ .

**Step 4.** From  $O$ , draw  $OG$  perpendicular to side  $AB$ .

**Step 5.** With  $O$  as centre and  $OG$  as radius, draw the inscribed circle.

 **Drawing check**

The three long diagonals of a regular hexagon should meet at the same centre.

**Final Answer:** The required incircle has centre  $O$  and radius  $OG$ .

**EXPERT'S SOLUTION** : *Aditi Chatterjee, M.Tech  
Design Engineering, IIT Kharagpur*

**Hexagon route.** Opposite vertices reveal the centre, then the centre-to-side distance gives the incircle.

**Step 1.** Draw the regular hexagon  $ABCDEF$  with diagonal  $AD = 70$  mm.

**Step 2.** Join opposite vertices  $AD$ ,  $BE$  and  $CF$ .

**Step 3.** Let these diagonals meet at  $O$ .

**Step 4.** From  $O$ , draw  $OG$  perpendicular to side  $AB$ .

**Step 5.** With  $O$  as centre and  $OG$  as radius, draw the inscribed circle.

The centre-to-side perpendicular is the apothem. The circle should touch all six sides without crossing them.

**Final Answer:** The required incircle has centre  $O$  and radius  $OG$ .

**Q 3.18** Draw a regular octagon of side 25 mm. Inscribe a circle in it.

Source: NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. Intent:

Incircle of a regular octagon. Level: Core.

### QUICK SOLUTION

**Concept:** In a regular octagon, all sides are tangents to the same inscribed circle.

**Answer:** The circle with centre  $O$  and radius  $OK$  is inscribed in the octagon.

### SOLUTION

**Concept used.** In a regular octagon, all sides are tangents to the same inscribed circle.

**Step 1.** Draw regular octagon  $ABCDEFGH$  with side 25 mm.

**Step 2.** Join opposite vertices, such as  $AE$  and  $BF$ .

**Step 3.** Let the diagonals meet at  $O$ .

**Step 4.** From  $O$ , draw  $OK$  perpendicular to side  $AB$ .

**Step 5.** With  $O$  as centre and  $OK$  as radius, draw the circle.

 **Drawing check**

The perpendicular from the centre of a regular polygon to a side is called the apothem.

**Final Answer:** The circle with centre  $O$  and radius  $OK$  is inscribed in the octagon.

**EXPERT'S SOLUTION** : Yash Pillai, B.Tech  
Mechanical Engineering, IIT Indore

**Octagon route.** Opposite diagonals locate the centre of the regular octagon before the incircle is drawn.

**Step 1.** Draw regular octagon  $ABCDEFGH$  with side 25 mm.

**Step 2.** Join opposite vertices, such as  $AE$  and  $BF$ .

**Step 3.** Let the diagonals meet at  $O$ .

**Step 4.** From  $O$ , draw  $OK$  perpendicular to side  $AB$ .

**Step 5.** With  $O$  as centre and  $OK$  as radius, draw the circle.

The same apothem idea works for the octagon. Opposite diagonals are only used to locate the centre cleanly.

**Final Answer:** The circle with centre  $O$  and radius  $OK$  is inscribed in the octagon.

**Q 3.19** Draw an angle  $ABC = 60^\circ$  with  $AB = BC = 80$  mm. Now draw a circle of radius 15 mm touching lines  $AB$  and  $BC$ .

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

Circle tangent to two sides of an angle. **Level:** Core.

### QUICK SOLUTION

**Concept:** A circle tangent to a line has its centre at a perpendicular distance equal to the

radius from that line.

**Answer:** The required circle has centre on the angle bisector and radius 15 mm.

## SOLUTION

**Concept used.** A circle tangent to a line has its centre at a perpendicular distance equal to the radius from that line.

**Step 1.** Draw angle  $ABC = 60^\circ$  with  $AB = 80$  mm and  $BC = 80$  mm.

**Step 2.** Draw the bisector of angle  $ABC$ .

**Step 3.** Draw a line parallel to  $AB$  at a perpendicular distance of 15 mm inside the angle.

**Step 4.** Let this parallel line meet the angle bisector at  $O$ .

**Step 5.** From  $O$ , drop perpendiculars to  $AB$  and  $BC$  to check that each distance is 15 mm.

**Step 6.** With  $O$  as centre and radius 15 mm, draw the circle.

### Drawing check

Every point on an angle bisector is equally distant from the two arms of the angle.

**Final Answer:** The required circle has centre on the angle bisector and radius 15 mm.

**EXPERT'S SOLUTION** : *Sneha Patel, M.Tech  
Transportation Engineering, IIT Roorkee*

**Angle-bisector route.** A circle touching both arms has its centre on the angle bisector and at the given offset.

**Step 1.** Draw angle  $ABC = 60^\circ$  with  $AB = 80$  mm and  $BC = 80$  mm.

**Step 2.** Draw the bisector of angle  $ABC$ .

**Step 3.** Draw a line parallel to  $AB$  at a perpendicular distance of 15 mm inside the angle.

**Step 4.** Let this parallel line meet the angle bisector at  $O$ .

**Step 5.** From  $O$ , drop perpendiculars to  $AB$  and  $BC$  to check that each distance is 15 mm.

**Step 6.** With  $O$  as centre and radius 15 mm, draw the circle.

The two perpendicular distances from  $O$  to the arms must both be 15 mm. That confirms the tangent circle.

**Final Answer:** The required circle has centre on the angle bisector and radius 15 mm.

**Q 3.20** Two pulleys of radii 30 mm and 20 mm have their centres 70 mm apart. Show the arrangement: (i) direct belt with two direct common tangents and (ii) cross-belt with two internal common tangents.

**Source:** NCERT Class 11 Engineering Graphics, Chapter 3 Assignment. **Intent:**

Apply external and internal tangents to pulley belts. **Level:** Core.

### QUICK SOLUTION

**Concept:** Belt edges are tangent lines to pulley circles. Direct belt tangents do not cross, while cross-belt tangents cross between the pulleys.

**Answer:** Show direct belt by two external tangents and cross-belt by two internal tangents to the pulleys.

### SOLUTION

**Concept used.** Belt edges are tangent lines to pulley circles. Direct belt tangents do not cross, while cross-belt tangents cross between the pulleys.

- Step 1.** Draw centres  $O$  and  $O_1$  with  $OO_1 = 70$  mm.
- Step 2.** Draw pulley circles of radii 30 mm and 20 mm.
- Step 3.** For the direct belt, draw an auxiliary circle about  $O$  with radius  $30 - 20 = 10$  mm.
- Step 4.** From  $O_1$ , draw tangents to this auxiliary circle and extend the corresponding radii to the larger pulley.
- Step 5.** Through  $O_1$ , draw parallels to these radii to get the two smaller-pulley tangent points. Join matching points for the two direct belt edges.
- Step 6.** For the cross-belt, draw an auxiliary circle about  $O$  with radius  $30 + 20 = 50$  mm.
- Step 7.** From  $O_1$ , draw tangents to the sum-radius auxiliary circle. Transfer the contact directions to opposite sides of the pulleys.
- Step 8.** Join the two opposite-side tangent-point pairs to show the crossed belt edges.

### Drawing check

Direct belt means external tangents.

Cross-belt means internal tangents.

**Final Answer:** Show direct belt by two external tangents and cross-belt by two internal tangents to the pulleys.

**EXPERT'S SOLUTION** : *Karan Rao, B.Tech  
Mechanical Engineering, IIT Bombay*

**Pulley-belt route.** Direct belts use difference-radius external tangents, while crossed belts use sum-radius internal tangents.

**Step 1.** Draw centres  $O$  and  $O_1$  with  $OO_1 = 70$  mm.

**Step 2.** Draw pulley circles of radii 30 mm and 20 mm.

**Step 3.** For the direct belt, draw an auxiliary circle about  $O$  with radius  $30 - 20 = 10$  mm.

**Step 4.** From  $O_1$ , draw tangents to this auxiliary circle and extend the corresponding radii to the larger pulley.

**Step 5.** Through  $O_1$ , draw parallels to these radii to get the two smaller-pulley tangent points. Join matching points for the two direct belt edges.

**Step 6.** For the cross-belt, draw an auxiliary circle about  $O$  with radius  $30 + 20 = 50$  mm.

**Step 7.** From  $O_1$ , draw tangents to the sum-radius auxiliary circle. Transfer the contact directions to opposite sides of the pulleys.

**Step 8.** Join the two opposite-side tangent-point pairs to show the crossed belt edges.

The final drawing must show four belt edges in two arrangements. Label direct belt and cross-belt separately to avoid confusion.

**Final Answer:** Show direct belt by two external tangents and cross-belt by two internal tangents to the pulleys.

Download the Full NCERT Chapter PDF

### Key Takeaways

- A tangent is perpendicular to the radius at the point of contact.

- External tangent constructions for unequal circles use the difference of radii.
- Internal tangent constructions for unequal circles use the sum of radii.
- An inscribed circle uses a centre equally distant from all sides.
- Direct belts use external tangents, while crossed belts use internal tangents.

End of Whole Chapter