

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.

Also see for this chapter:

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.

EXPERT'S SOLUTION : Rohan Kapoor, B.Arch, SPA Delhi

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° 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° 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.

Q3.11 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.

EXPERT'S SOLUTION : *Rahul Bhat, B.Tech Mechanical Engineering, IIT Jodhpur*

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° 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° 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 .

EXPERT'S SOLUTION : Tara Banerjee, M.Arch, CEPT University

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.

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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.

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End of Whole Chapter