## Fundamentals of Drawing - Principles of Tangency

Objectives:

1. To define a tangent.
2. To draw a tangent using geometrical constructions.
3. To recognise the general principles of tangency.
4. To apply the principles of tangency to drawing problems.

The definition

A tangent is a straight line which touches a circle at the point of tangency without intersecting it. At the point of tangency any radius forms a right angle with a tangent.
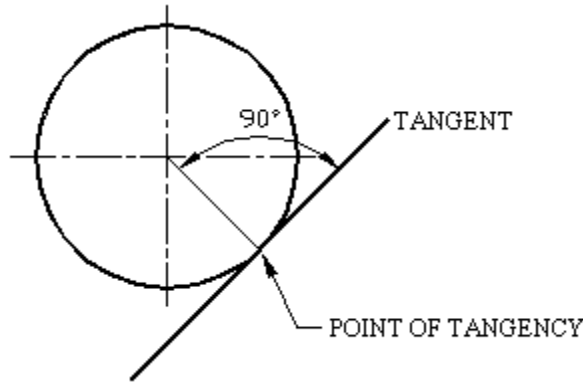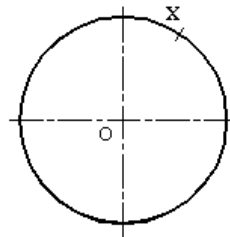

Geometrical constructions of tangent

Attempt all tangency exercises on the blank pages of your Workbook - use own measurements

1. To draw a tangent to a given point on the circumference of the circle.
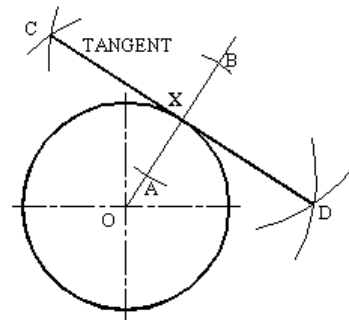
   1. Given:
      A point X is given on the circumference of a circle of any radius.

   2. Construction
      i)   Join OX and produce the line outside the circumference of the circle.
      ii)   Mark points A and B, such that AX=XB.
      iii) Draw perpendicular bisector CD.
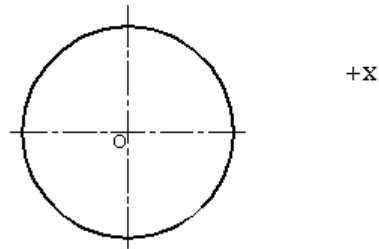   iv)   CD is the required tangent.

2. To draw a tangent to a circle from a given point outside the circle.
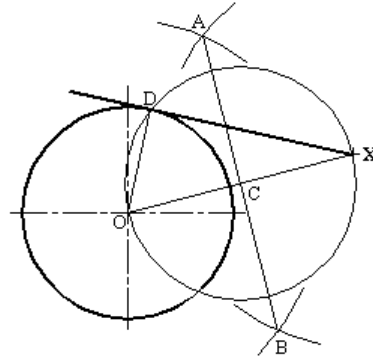
    1. Given:
       A point X is given outside the circle of
       any radius.

    2. Construction
       i)   Join OX.
       ii)   Bisect OX at C.
       iii)   Draw a circle with centre C,
             radius CX.
       iv)   The circle intersects the given
             circle at D.
       v)   Join DX, which is the required
             tangent.
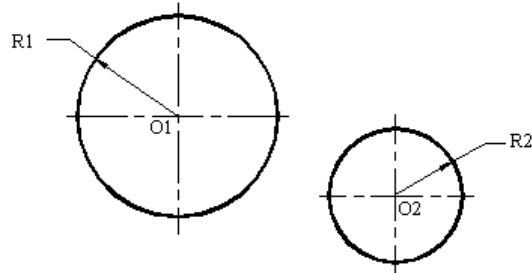
3. To draw an internal tangent to two given circles.
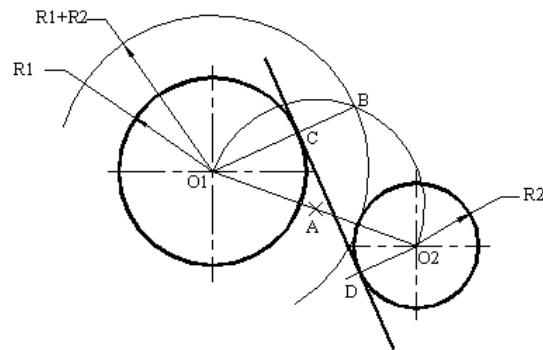
    1. Given:
       Two circles of radii R1 and
       R2.
       (internal tangent is also
       known as transverse common
       tangent)

    2. Construction
       i)   Join O1 and O2.
       ii)   Bisect line O1O2 at A.
       iii)   Draw a semi-circle with
             centre A, radius AO1.
       iv)   Draw a circle, centre O1
             and radius R1+R2.
       v)   This circle intersects
             the circle (centre A) at
             B.
       vi)   Join O1B, which cuts
             the circumference at C.
       vii)   Join O1C.
       viii) Through O2, draw a line
             O2D parallel to O1C.
       ix)   Join CD, which is the
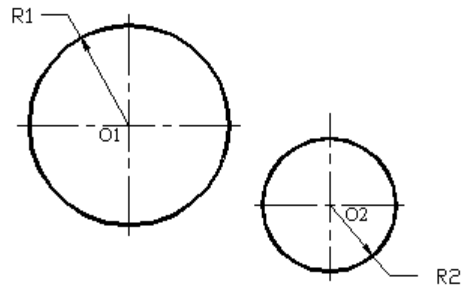   required internal
             tangent.

4. To draw an external tangent to two given circles.

1. Given:
   Two circles of radii R1 and R2.
   (external tangent is also known as direct common tangent)

2. Construction
   i)   Join O1 and O2.
   ii) Bisect line O1O2 at A.
   iii) Draw a semi-circle with centre A, radius AO1.
   iv) Draw a circle, centre O1 and radius R1-R2.
   v)   This circle intersects the circle (centre A) at B.
   vi) Join O1B, and produce it until it cuts the circumference at C.
   vii) Through O2, draw a line O2D parallel to O1C.
   viii) Join CD, which is the required external tangent.
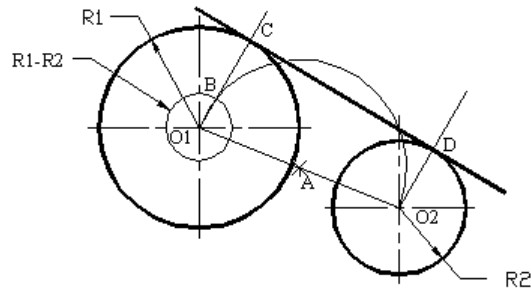
General principles of tangency

In geometrical construction, it is common to join arcs with straight lines and arcs with other arcs. To do this with accuracy, it requires a knowledge of the principles of tangency.
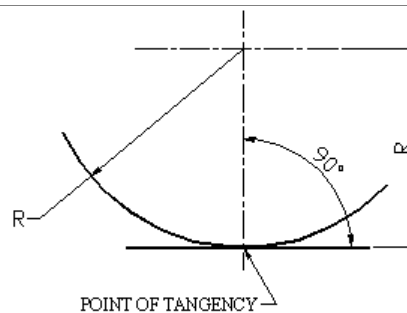
There are three general principles:

1. To join an arc with a straight line
   Principle 1: To join an arc with a straight line

   1. The principle
      To draw an arc of given radius to touch a given straight line, then the point of tangency is the point that lies on a line through the centre of the arc, at a distance equals to the given radius, and at 90^0 to the given straight line.
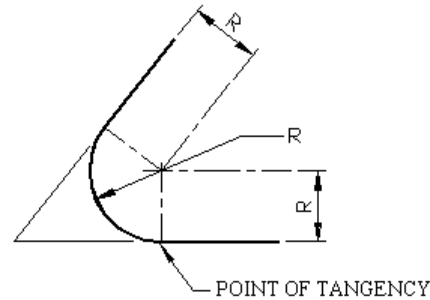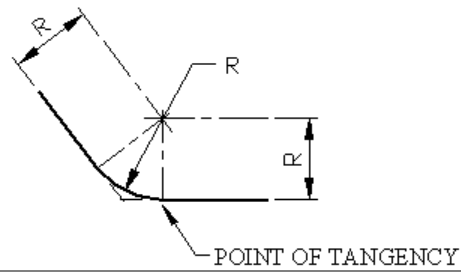
2. Practical applications
   (i)   To draw an arc of radius R tangential to the arms of a right angle.

R

R

R

POINT OF TANGENCY
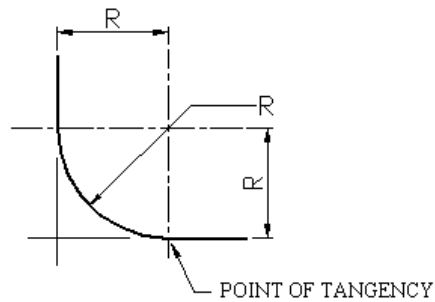
   (ii) To draw an arc of radius R tangential to two straight lines forming an acute angle.

R

R

R

POINT OF TANGENCY

   (iii) To draw an arc of radius R tangential to two straight lines forming an obtuse angle.
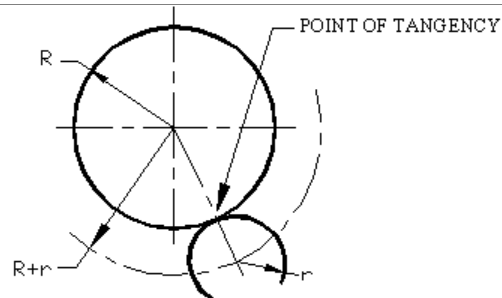
R

R

R

POINT OF TANGENCY

2. To join two arcs externally
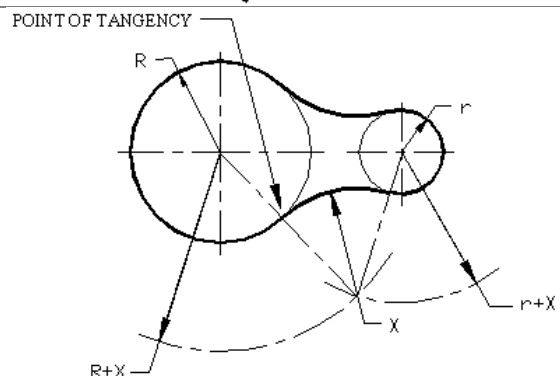   Principle 2: To join two arcs externally

   1. The principle
      To draw an arc of a given radius r to touch a second arc, radius R, externally, then the point of tangency lies on a line joining the centres of the two arcs. The distance between the centres of the arcs is R+r.

POINT OF TANGENCY

R

R+r

r

   2. Practical applications
      (i)   To draw an arc of radius X blending two circles of radii R and r respectively.

POINT OF TANGENCY

R

r

r+X

X

R+X
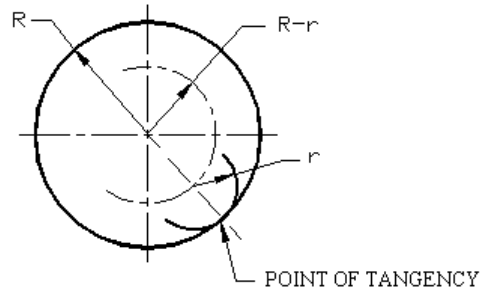
3. To join two arcs internally
   Principle 3: To join two arcs internally
   1. The principle
      To draw an arc of a given radius r to touch a second arc, radius R, internally, then the point of tangency lies on a line joining the centres of the two arcs. The distance between the centres of the arcs is R-r.

      R — R-r

      r

      POINT OF TANGENCY

   2. Practical applications
      (i) To draw an arc of radius X blending two circles of radii R and r internally.

      POINT OF TANGENCY — X

      R

      POT

      r

      X-R

      X-r