EGD LEARNING

ENGINEERING GRAPHICS AND DESIGN THEORY BUNDLE

GRADE 10 - 12 IEB

Engineering Graphics and Design Theory Bundle Grade 10 - 12
First Edition

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Table of Contents

Note (Instructions for use):

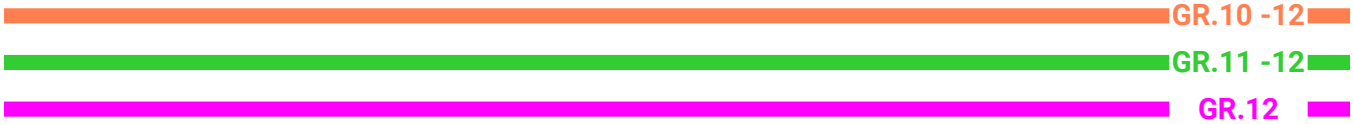
All content in this theory bundle corresponds with the modules included in the EGD Learning (DBE) workbooks for grade 10, 11 and 12. The relevant workbook modules for each section in the theory bundle is indicated in the top right corner at the start of the section.

e.g.:

Corresponds with

Gr.10 Mod. 12, Gr.11 Mod. 4, Gr.12 Mod. 4

This bundle contains theory related to all topics for grade 10 to 12. Note the colour ribbons throughout the bundle. Each ribbon indicates if the content is relevant to all grades, only grade 11 and 12 or only grade 12.



1. Introduction to Engineering Graphics and Design

Corresponds with Gr.10 Module 1

1.1 Purpose of EGD

Engineering Graphics and Design (EGD) teaches internationally acknowledged principles that have both academic and technical applications. The emphasis in EGD is on teaching specific basic knowledge and various drawing techniques and skills so that the EGD learners will be able to interpret and produce drawings within the contexts of Mechanical Technology, Civil Technology and Electrical Technology.

1.2 The main topics of EGD

- General drawing principles for all technological drawings
- Freehand drawing
- Instrument drawing
- First- and third-angle orthographic projections
- Descriptive and solid geometry
- Mechanical working drawing
- Civil working drawing
- Isometric drawing
- Perspective drawing
- Electrical diagrams
- Interpenetrations and developments
- Loci of helixes, cams and mechanisms
- The Design Process
- CAD (Computer-Aided Drawing/Design)

1.3 Specific aims of EGD are to teach the following

- Graphical drawings as the primary means of communication in the technological world.
- Specific basic content and concepts within the context of Mechanical Technology, Civil Technology and Electrical Technology.
- Various instrument and freehand drawing techniques and skills.
- Solving technological problems through graphical drawings.
- The application of the Design Process.
- The implementation of CAD (Computer Aided Drawing/Desing) as a drawing method.

1.4 EGD career opportunities

- Architecture
- Most engineering fields (e.g. Civil, Mechanical, Aviation, Maritime, Agricultural,
- Mining, etc.)
- Medical technician
- Industrial designer
- Interior designer

- Landscape architect
- Quantity surveyor
- Building management
- City planner
- Land surveyor
- Teacher
- Graphic illustrator
- Jewellery designer
- Model builder (scale models)
- Draughtsperson (e.g. Steel structure, Architectural, Civil, Design, Electrical, etc.)
- Technicians
- Most manufacturers
- Most artisans
- CAD system operator

2. General Drawing Principles

Corresponds with Gr.10 Module 2

2.1 Drawing instruments

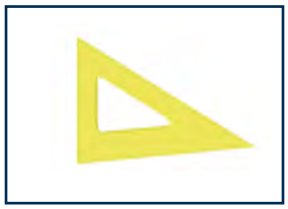
The following instruments are used in EGD:

- **A3 Drawing board and T-square**

Used to hold the page in position and keep the drawing square. The T-square slides in the grooves on the edges of the board and can be used vertically and horizontally.

- **30°/60° Set square**

Used to draw 90°, 30° and 60° lines.
Protect the edges and corners from damage.

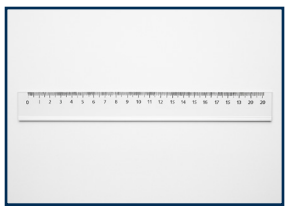


- **45° Set square**

Used to draw 90° and 45° lines.
Protect the edges and corners from damage.

- **Ruler**

Used to measure dimensions.

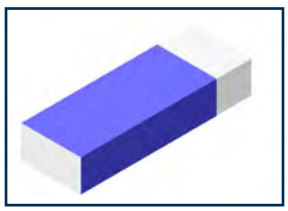


- **Clutch pencil and lead**

Used to draw lines. Only use the specified lead for the clutch pencil. Preferably use 0.3, 2H or H lead.

- **Eraser**

Used to erase drawing mistakes. Always keep your eraser clean. Use an eraser specifically for EGD. Sharp edges on the eraser will help with fine erasing work.



- **180° Protractor**

Used to determine and measure angles.

- **Compass and divider**

Compasses are used to draw circles and arcs using a radius. Dividers are used to measure dimensions. Be careful with the sharp needle point. Never drop your compass and keep the lead point sharp. Store your compass and divider in a holder for safety.

- **Circle stencil**

Used to draw small diameter circles and arcs. Avoid using a circle stencil for full circles bigger than diameter 10.

- **Eraser shield**

Used to prevent you from erasing adjacent features by covering the space around the drawing mistake.

General care instructions for drawing instruments:

- To ensure the neatness and cleanliness of your drawing, you must keep all your drawing instruments clean.
- Store all instruments in dedicated holders for safe keeping.
- Regularly clean your drawing instruments with a damp cloth.

2.2 Line types and qualities

2.2.1 Line qualities:

A-type line (darkest line):	Border & title/name block/panel; outlines & visible parts; answers of e.g. loci; projection symbol; tables
B-type line (medium line):	All writing & numbering; dimensions; projection planes; auxiliary views; hatching; screw threads; folding lines, break lines
C-type line (lightest line):	Constructions; planning; projections; guidelines (for writing)

2.2.2 Line types:

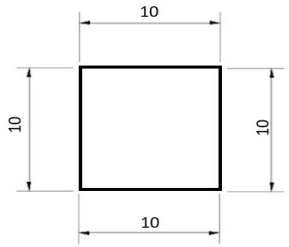
Medium chain-line (B-type)	Centre points of circles; centre lines; cutting planes; assembly diagrams; building lines. When drawn in an A-type line quality, it can represent plumbing, water pipes and drainage.
Short broken-line (B-type)	Hidden detail; items to be removed on civil drawings. When drawn as a long broken line, it can represent contour lines.

2.3 General lettering requirements

- All writing must be 3 mm high for labels and dimensions and 5 mm high for titles.
- All writing must be in capital letters and in print.
- All writing must be horizontal, read from left to right or vertical, read from bottom to top, but NEVER diagonal.
- All writing must be in a B-type line quality.
- Construction line guides may be used to help with writing the correct height.

2.4 General dimensioning requirements

- Dimensions always indicate the object's true size, not necessarily the size it is drawn on the page.
- Dimensions are always written in millimetres.
- The number must always be written on top and/or on the left of the dimension line. NEVER underneath or on the right side of the dimension line.
- The number must always be written in the centre of the distance.



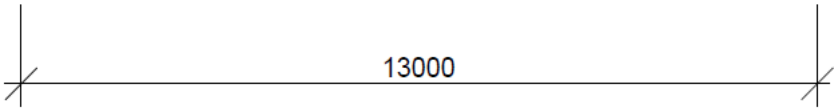
- Dimensions must always be written from smallest to biggest.

2.5 Dimensioning

2.5.1 Types of arrowheads:

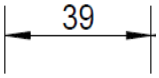
- Civil (Architectural arrow)

Used in civil drawing.



- Mechanical (Mechanical arrow)

Used in all other drawing.



2.5.2 Specific dimensions for circles

Diameter

- The distance from one side of the circle, through the centre point, to the other side.
- Symbol: Ø (ALWAYS placed before the number, not after, e.g. Ø12)
- This dimension cannot be used directly to draw a circle with a compass — it must first be converted to a radius.
- Circle stencils use diameter dimensions directly.

Radius

- The distance from the centre point to the edge of the circle. (Half of the diameter)
- Symbol: R (ALWAYS placed before the number, e.g. R6)
- Convert a diameter to a radius by dividing the diameter in half. (÷2).

3. Freehand Drawing

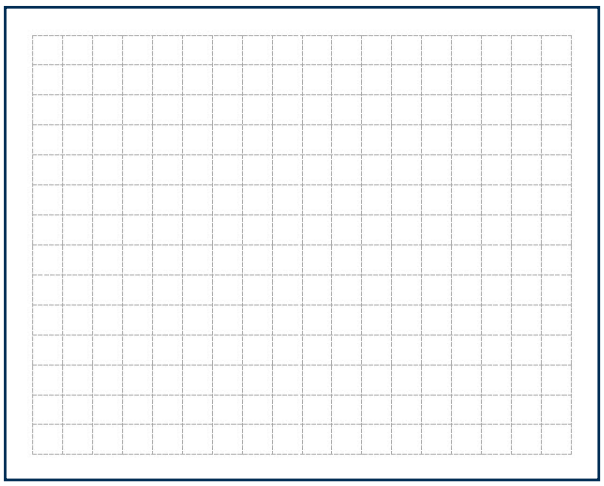
Corresponds with Gr.10 Module 3

Freehand drawing is an essential skill in EGD because every structure, machine, or product ever created began with a simple sketch. Before anything can be built or manufactured, it must first be visualised and planned, and freehand drawing is often the first step in that process.

3.1 Types of freehand drawing

Freehand drawing can be done on plain paper and/or grid sheets. In EGD we mainly use two types of grids:

1. Orthographic grid paper – used for single or multi-view drawings.
2. Pictorial grid paper – used for 3D drawings.



Orthographic grid paper

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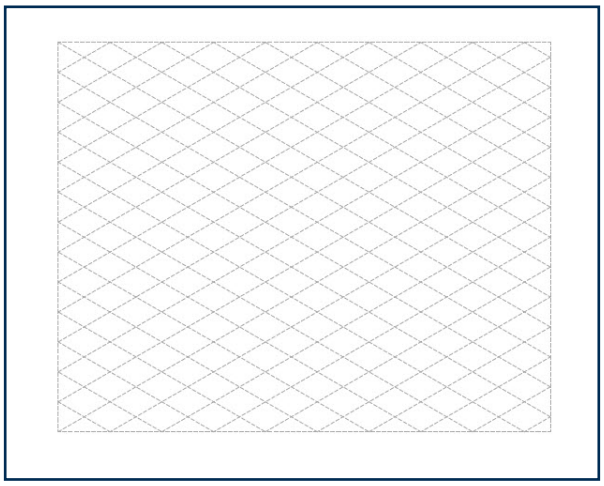


Pictorial grid paper

3.2 General freehand drawing principles:

- Use only a clutch pencil, eraser, and your hand - no rulers, compasses, or stencils. Draw directly on the grid, which serves as your guide for proportion and alignment.
- Visualise the entire line before starting - identify its start and end points.
- Practice the hand movement slightly above the paper to check your motion before touching the page. This helps your brain and hand align and gives you time to adjust your grip or movement.
- Avoid “feathery” or scratchy lines. Each line should be drawn in one continuous motion.
- Try to draw longer sections in one go, but not so long that you have to reposition your hand mid-line.
- Maintain consistent pressure to produce uniform line thickness and quality.
- Regularly rotate your clutch pencil while drawing so that you continue using the sharpest edge of the lead. A sharp edge gives better control and cleaner lines, especially on grid paper.
- Learn to recognize the natural motion range of your hand.
- Rather than forcing uncomfortable angles, rotate the page to match the motion that feels most controlled and natural to you.
- Practice drawing hidden detail lines and centre lines accurately.
- Focus on both the type and quality of the lines. Lines should be straight and consistent in thickness.
- For circles and arcs: Plot key points through which the circle should pass before sketching. Try drawing a quarter of the circle at a time, starting and stopping at the plotted points. For larger curves, use your palm as a pivot point for smoother motion and greater control.

4. Geometrical Construction

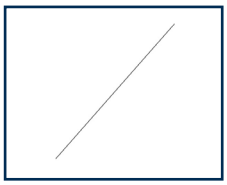
Corresponds with Gr.10 Module 4

Geometrical construction is the foundation of technical drawing. It refers to the precise drawing of shapes, angles, and lines using only a pencil, compass, and ruler (not measuring tools). This is not just about drawing, it's about learning the thinking and planning behind engineering, architecture, and design.

Everything that has been designed, manufactured, or built, from buildings to bridges, furniture to machines, began with a simple freehand or geometrical construction sketch. The techniques you learn in this module will not be revised in detail every year, but they will be applied in almost every topic throughout Grades 10 to 12.

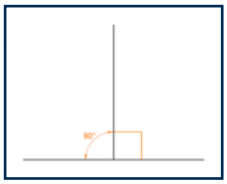
4.1 General terminology and concepts used in EGD:

Here is a list of terms and concepts that you will come across in this module. Each concept will be covered in more detail in its dedicated lesson, but understanding the terminology is essential before you begin.

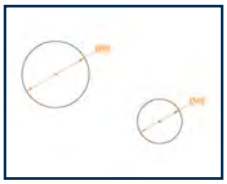


Diagonal line
A straight line drawn on an angle which is not 0°, 90° or 180°.

Bisecting an angle
A line that divides an angle into two equal parts.

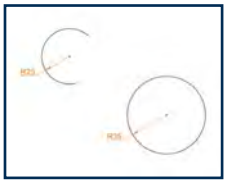


Perpendicular lines
Lines that intersect at exactly 90°.

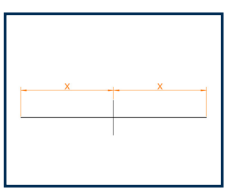


Diameter
A line passing through the centre that connects two points on the circle.

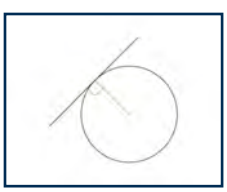
Parallel lines
Lines that remain equidistant and never meet.



Radius
The distance from the centre of a circle to any point on its edge.



Bisecting a line
Dividing a line exactly in half. Called a perpendicular bisector when done with a perpendicular line.

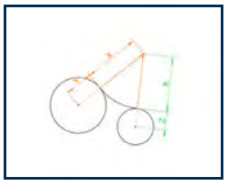


Tangent line
A straight line that touches a circle at one single point only.

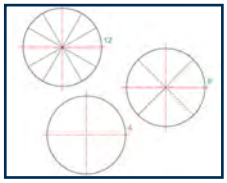
Inscribed circle
A circle drawn inside a triangle, touching all three sides.

Including arc
An arc that includes another circle inside its radius.

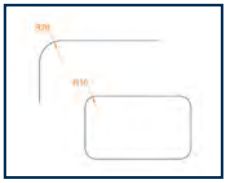
Circumscribed circle
A circle that passes through all three vertices of a triangle.



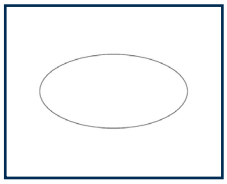
Excluding arc
An arc that excludes another arc outside its radius.



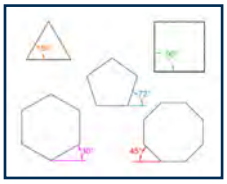
Division of a circle
Dividing a circle's circumference into equal parts.



Fillet / Tangential arc
A smooth curve joining two straight lines. Used to round corners.



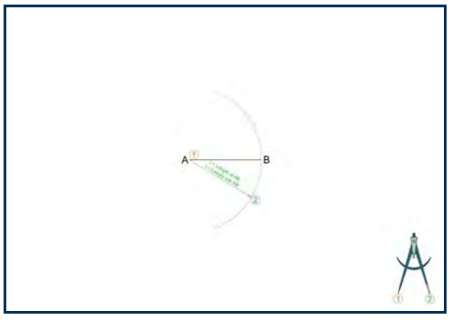
Ellipse
An oval shape that looks like a stretched circle.



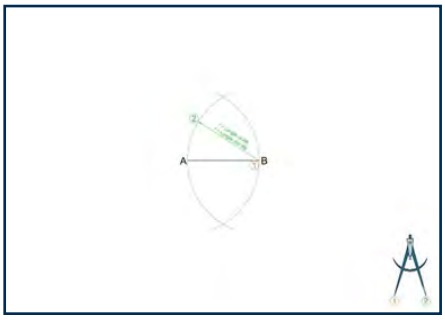
Polygon
A closed shape made of straight lines.

4.2 Construction methods

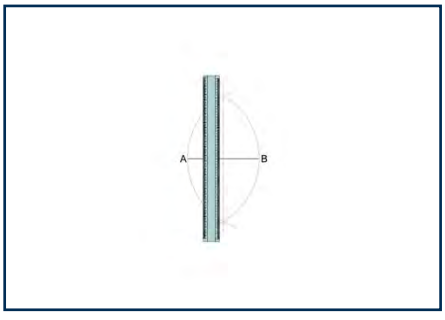
4.2.1 Bisecting a line



Step 1



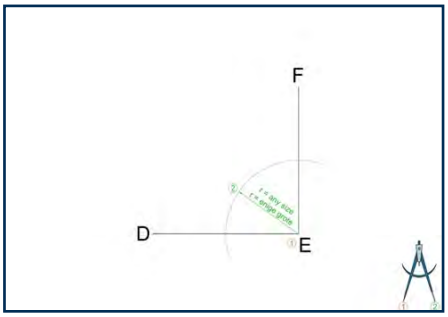
Step 2



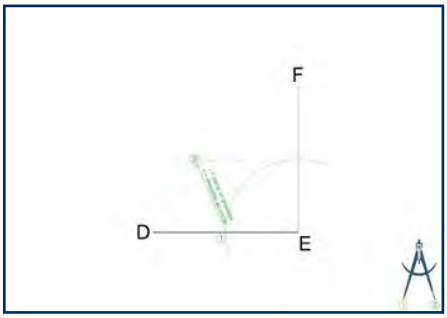
Step 3

Step 1: Measure the length of line AB with the compass. Place the needle point of the compass on point 1 and draw an arc through point B, in a C-type line.
Step 2: Measure the length of line AB with the compass. Place the needle point of the compass on point 1 and draw an arc through point A, in a C-type line.
Step 3: Use the ruler and draw a C-type line through the two points where the arcs intersect, bisecting the line.

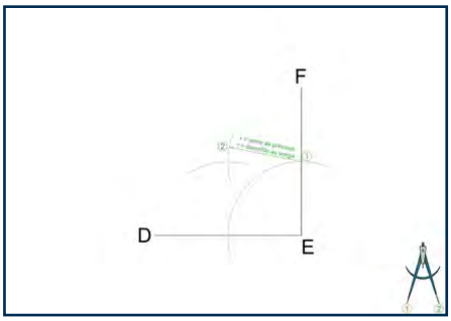
4.2.2 Bisecting an angle



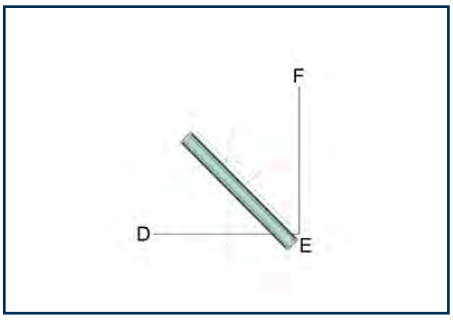
Step 1



Step 2



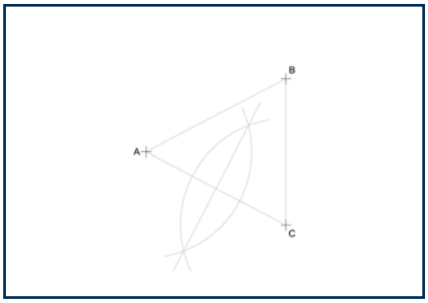
Step 3



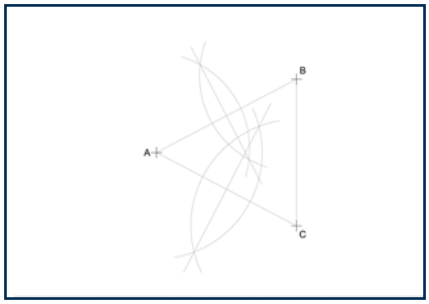
Step 4

Step 1: Place the needle point of the compass on point 1 and draw an arc of any size, in C-type line, as long as the arc is not bigger than line DE/EF.
Step 2: Using the same radius as the previous arc, place the needle point of the compass on point 1 and draw an arc in the area of point 2, in a C-type line.
Step 3: Using the same radius as the previous arc, place the needle point of the compass on point 1 and draw an arc in the area of point 2, in a C-type line, ensuring that you now have two intersecting arcs.
Step 4: With a ruler, draw a C-type line from point E through the two intersecting arcs to bisect the angle into two equal parts.

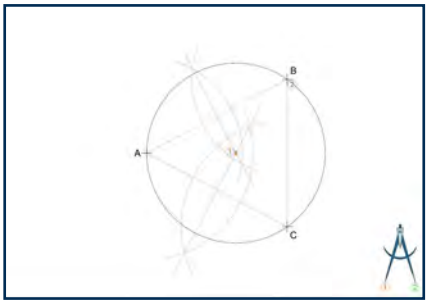
4.2.3 Circumscribed circle



Step 1



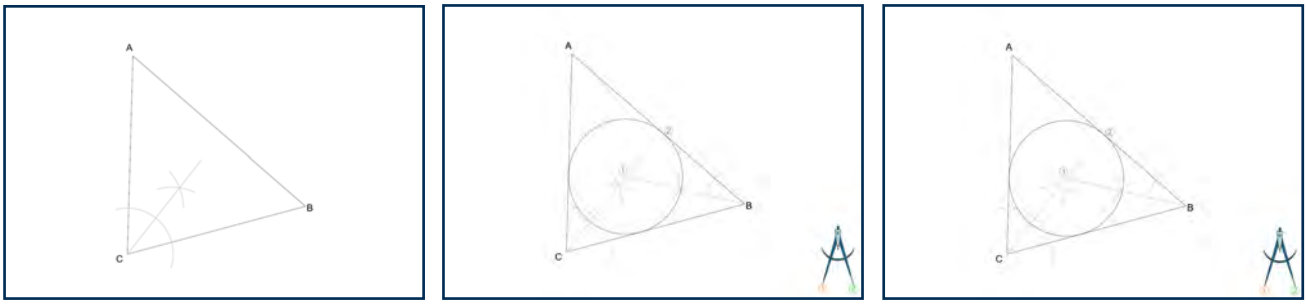
Step 2



Step 3

Step 1: Construct a perpendicular bisector for line AC.
Step 2: Construct a perpendicular bisector for line AB.
Step 3: Place the needle point of your compass where the perpendicular bisectors intersect (point 1), and open it to point 2 at point A, B or C and draw a circle. The circle must simultaneously intersect A, B and C.

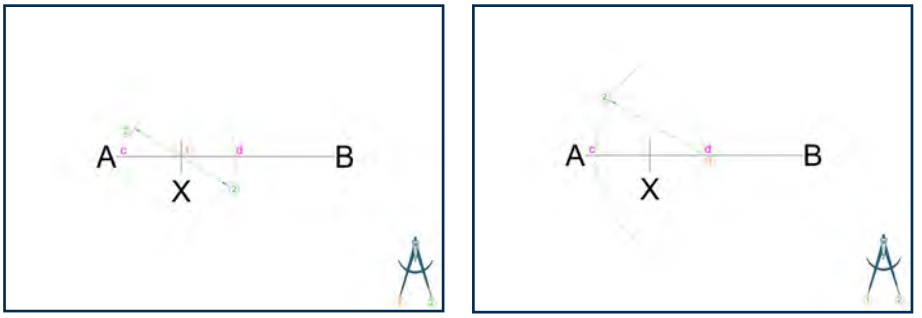
4.2.4 Inscribed circle



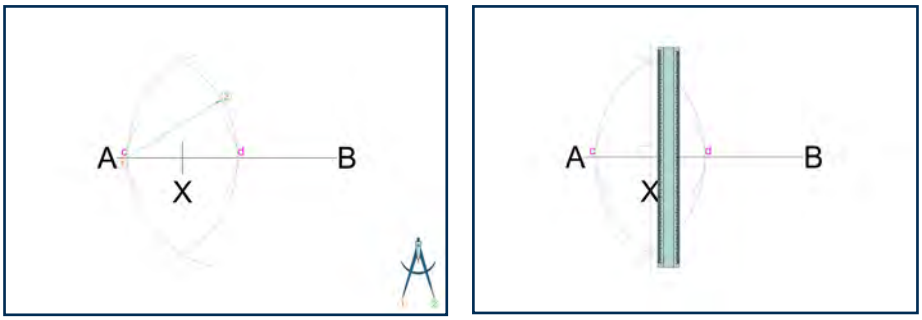
Step 1 Step 2 Step 3

Step 1: Bisect the angle at C.
Step 2: Bisect the angle at B.
Step 3: Place the needle point of your compass where the bisecting lines intersect (point 1) and open it to the edge of the triangle (point 2) and draw a circle. The circle must simultaneously touch all the sides of the triangle without intersecting.

4.2.5 Perpendicular lines



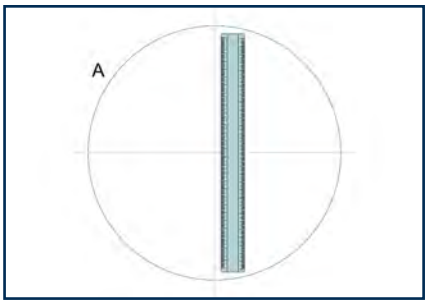
Step 1 Step 2



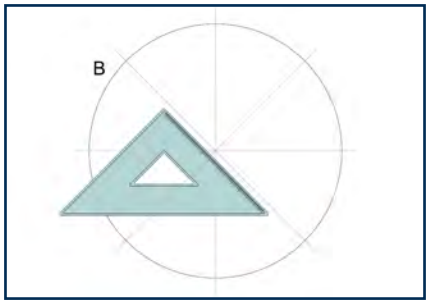
Step 3 Step 4

Step 1: Place the needle point of the compass on point 1 and draw 2 arcs of the same radius ensuring that they intersect line AB. Label the intersection points as C and D.
Step 2: Place the needle point of the compass on point 1 and draw an arc using the length of line CD as the radius.
Step 3: Place the needle point of the compass on point 1 and draw an arc using the length of line CD as the radius.
Step 4: Draw a C-type line that starts above line AB where the 2 arcs intersect and ends below line AB where the arcs intersect.

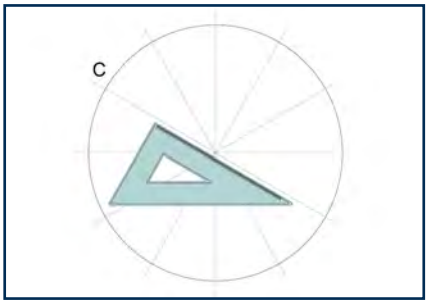
4.2.6 Dividing a circle



4 Sections



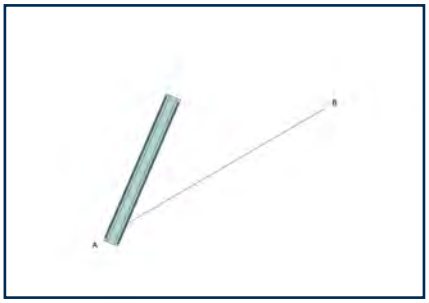
8 Sections



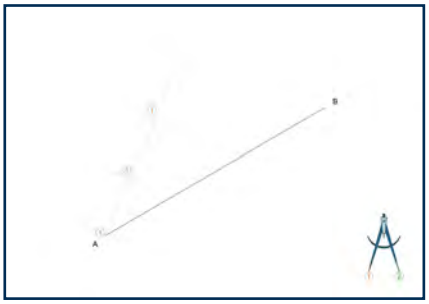
12 Sections

4 Sections: Divide the circle with a horizontal and vertical line.
8 Sections: Divide the circle with a horizontal, vertical and 45° lines.
12 Sections: Divide the circle with a horizontal, vertical, 30° and 60° lines.

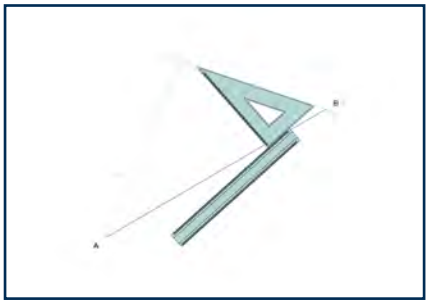
4.2.7 Dividing a line



Step 1



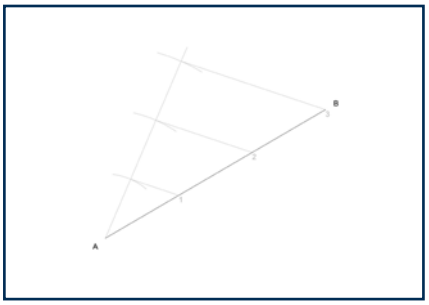
Step 2



Step 3

Step 4

Step 5

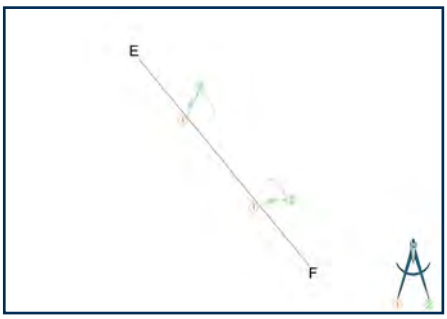


Step 6

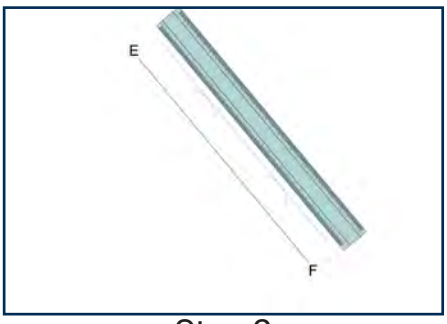
Step 1: Project an inclined construction line starting at point A. This line does not require a specific angle.
Step 2: Measure 10 mm on your compass. Place the needle point on point 1 and make a small arc on the inclined line. Repeat this action by each turn, placing the needle point where the previous arc intersects the inclined line. Repeat until you have the required number of sections (3).
Step 3: Use one of your set squares to project a construction line between the last arc and the end of the given line (point B). Keep the set square in place. Now, place your ruler against one of the other two edges of the set square and keep in place.
Step 4: While pressing down on the ruler, slide the set square on the edge of the ruler until it lines up with the next arc. Project a construction line. This line is now parallel to the first one.

Step 5: Repeat the previous step by sliding the set square further to the next arc and projecting another parallel construction line.
Step 6: Confirm that you have divided the given line into the correct number of equal sections.

4.2.8 Parallel lines



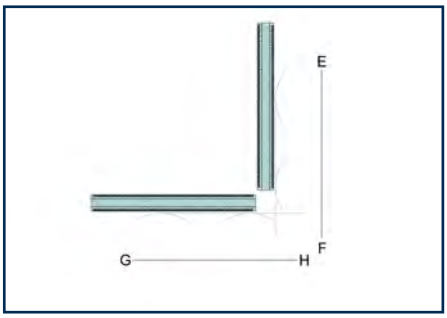
Step 1



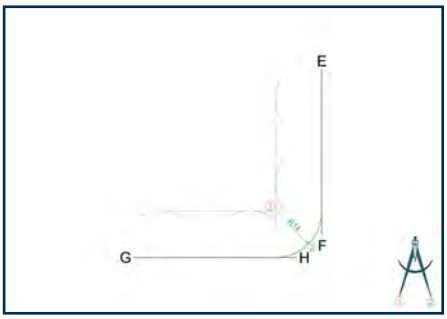
Step 2

Step 1: Open your compass to the same size of the distance between the parallel lines. Place your compass on any two points on line EF and draw two arcs.
Step 2: Use a ruler to draw a line that connects the top of both arcs.

4.2.9 Tangent arcs



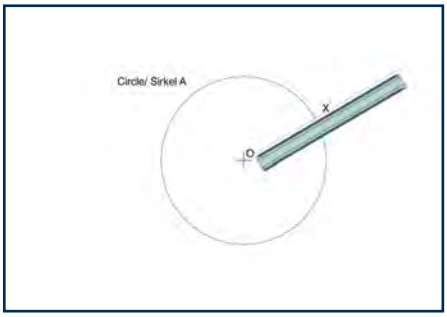
Step 1



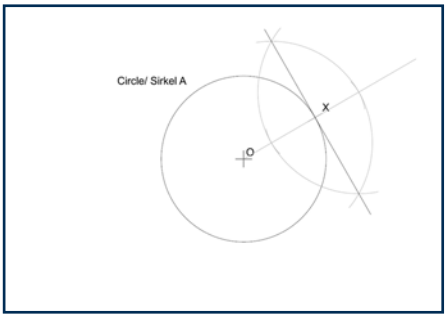
Step 2

Step 1: Construct parallel lines to lines GH and EF, the same distance away as the radius of the tangent arc.
Step 2: Place point 1 of your compass on the point where the parallel lines intersect and draw the tangent arc connecting line GH and EF.

4.2.10 Tangent lines



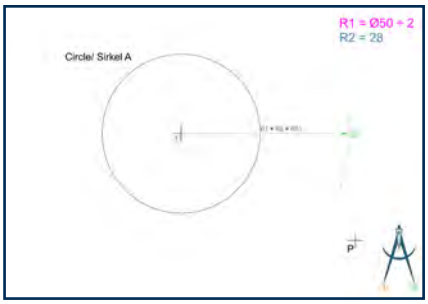
Step 1



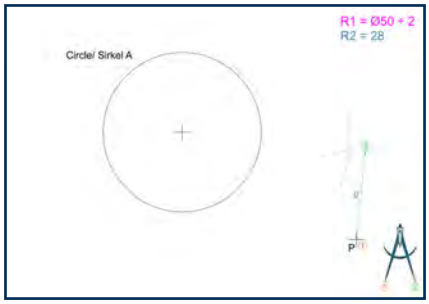
Step 2

Step 1: With your ruler, draw a construction line from the centre of the circle (O) through point X and extend it beyond the circle.
Step 2: Construct a perpendicular line through point X.

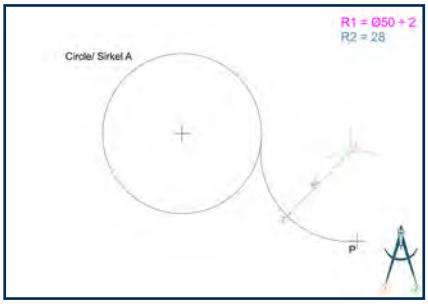
4.2.11 Tangential arc to a circle and a point



Step 1



Step 2



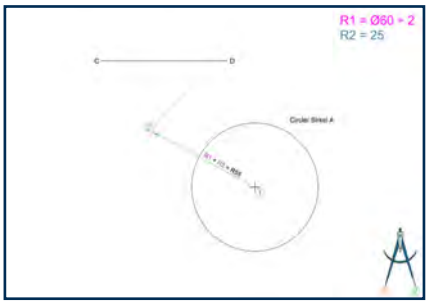
Step 3

Step 1: Using your compass, draw an arc from the centre of the circle (point 1). Use the radius of the circle plus the radius of the tangential arc to get the measurement needed to draw the arc.

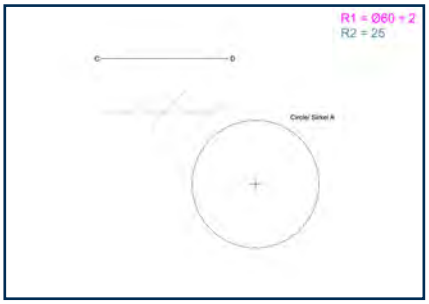
Step 2: Open your compass to the radius of the tangential arc. Place your compass on point P and draw an arc to intersect the first arc.

Step 3: Keep your compass open to the radius of the tangential arc and place your compass where the arcs intersect. Draw an arc connecting circle A to point P.

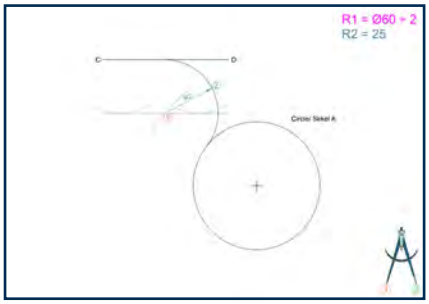
4.2.12 Tangential arc to a circle and a line



Step 1



Step 2



Step 3

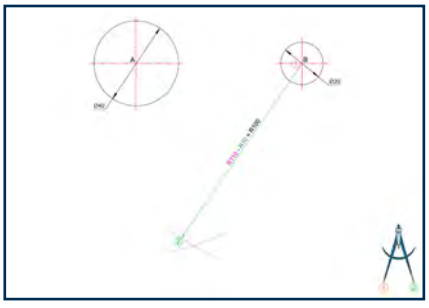
Step 1: Using your compass, draw an arc from the centre of the circle (point 1). Use the radius of the circle plus the radius of the tangential arc to get the measurement needed to draw the arc.

Step 2: Draw a line parallel to line CD with the same distance away as the radius of the tangential arc. The line should intersect the arc drawn in the previous step.

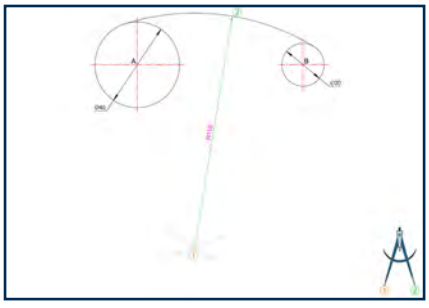
Step 3: Open your compass to the radius of the tangent arc. Place your compass where the arc and parallel line intersect and draw an arc to connect circle A and line CD.

4.2.13 Including tangential arcs

Step 1



Step 2



Step 3

Step 1: Using your compass, draw an arc from the centre of circle A (point 1). Use the radius of the tangential arc MINUS the radius of the circle to get the measurement needed to draw the arc.

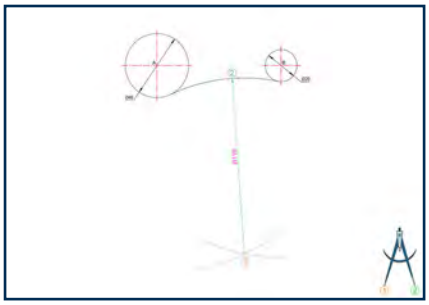
Step 2: Using your compass, draw an arc from the centre of circle B (point 1). Use the radius of the tangential arc MINUS the radius of the circle to get the measurement needed to draw the arc.

Step 3: Open your compass to the radius of the tangential arc. Place your compass where the arcs intersect and draw an arc to include circle A and B.

4.2.14 Excluding tangential arcs

Step 1

Step 2



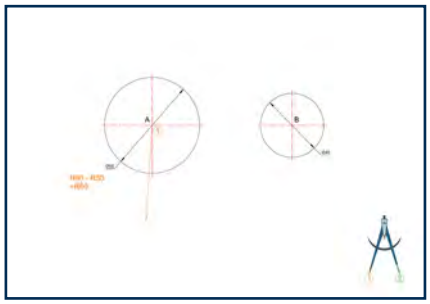
Step 3

Step 1: Using your compass, draw an arc from the centre of circle A (point 1). Use the radius of the tangential arc PLUS the radius of the circle to get the measurement needed to draw the arc.

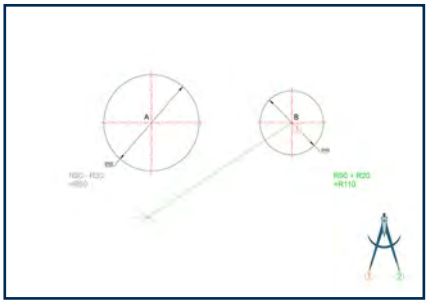
Step 2: Using your compass, draw an arc from the centre of circle B (point 1). Use the radius of the tangential arc PLUS the radius of the circle to get the measurement needed to draw the arc.

Step 3: Open your compass to the radius of the tangential arc. Place your compass where the arcs intersect and draw an arc to exclude circle A and B.

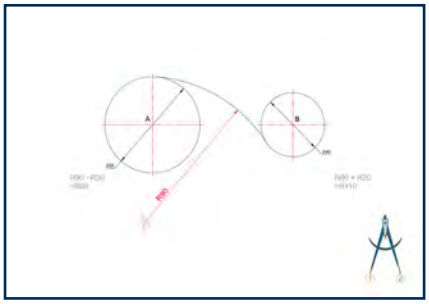
4.2.15 Including and excluding tangential arcs



Step 1



Step 2



Step 3

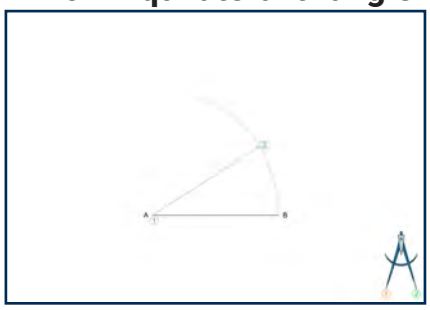
Step 1: Using your compass, draw an arc from the centre of circle A (point 1). Use the radius of the tangential arc MINUS the radius of the circle to get the measurement needed to draw the arc.

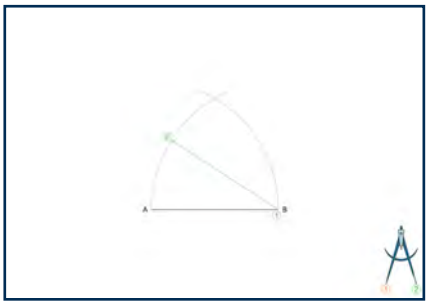
Step 2: Using your compass, draw an arc from the centre of circle B (point 1). Use the radius of the tangential arc PLUS the radius of the circle to get the measurement needed to draw the arc.

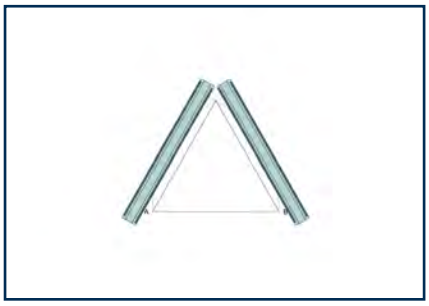
Step 3: Open your compass to the radius of the tangential arc. Place your compass where the arcs intersect and draw an arc to include circle A and exclude circle B.

4.2.16 Polygon construction

4.2.16.1 Equilateral triangle

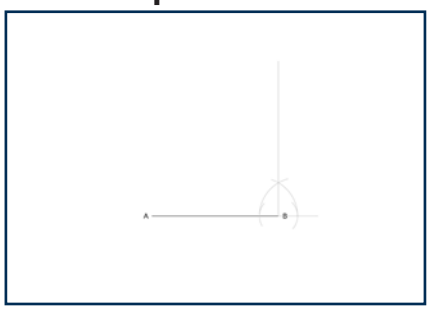

Step 1

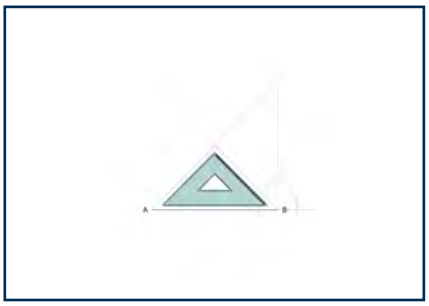

Step 2


Step 3

Step 1: Place point 1 of your compass on A and draw an arc using the length of line AB.
Step 2: Place point 1 of your compass on B and draw an arc using the length of line AB.
Step 3: The intersection point of these 2 arcs will form the third point of the triangle. Using a ruler draw A-type lines connecting point A and B to the intersection point.

4.2.16.2 Square

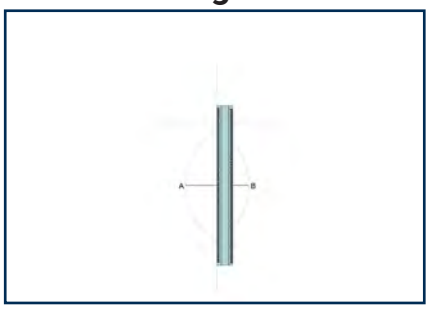

Step 1

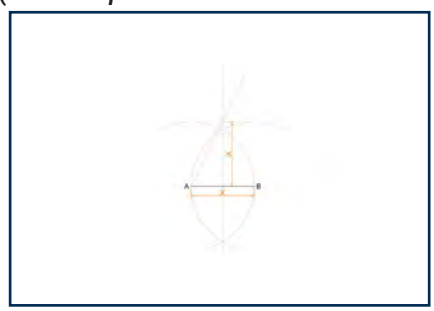

Step 2

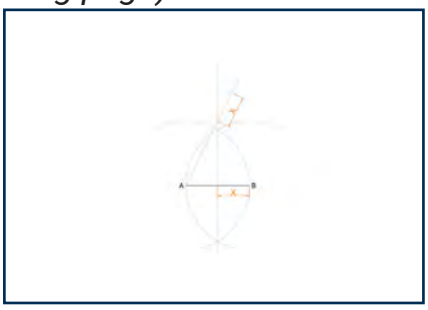

Step 3

Step 1: Construct a perpendicular line from point B.
Step 2: Using your 45° set square draw 2 diagonal lines from point A and point B.
Step 3: Where the diagonal line intersects the vertical line, you will have the second side to the square. Using a ruler complete the square using an A-type line.

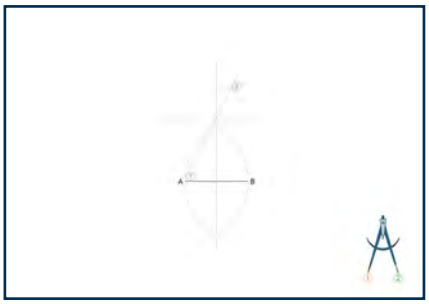
4.2.16.3 Pentagon method 1 *(Six steps - next three on following page)*

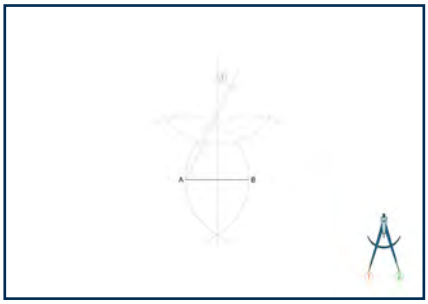

Step 1

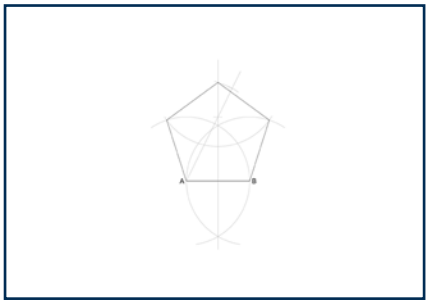

Step 2


Step 3

Step 1: Construct a perpendicular bisector for line AB in a C-type line.
Step 2: Using the length of AB, measure from the centre of the line AB, on the perpendicular bisector and plot a point. Project a construction line from point A through the plotted point.
Step 3: Measure half the length of line AB on the construction line, starting where it intersects with the perpendicular bisector.


Step 4


Step 5


Step 6

Step 4: Place the needle point of your compass on the end of line AB (point 1) and open it to point 2. Project a C-type arc until it intersects with the perpendicular bisector.
Step 5: Open your compass to the length of AB. Place the needle point where the previous arc intersects with the perpendicular line (point 1) and project a C-type arc to intersect with the arcs used for the perpendicular bisector.
Step 6: Connect the sides of the pentagon in an A-type line.

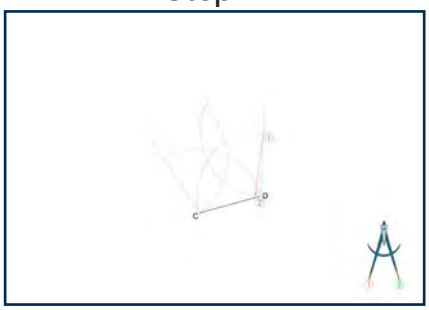
4.2.16.4 Pentagon method 2

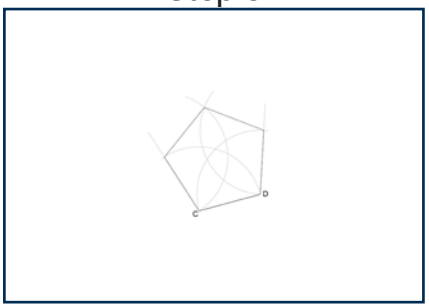

Step 1


Step 2


Step 3


Step 4

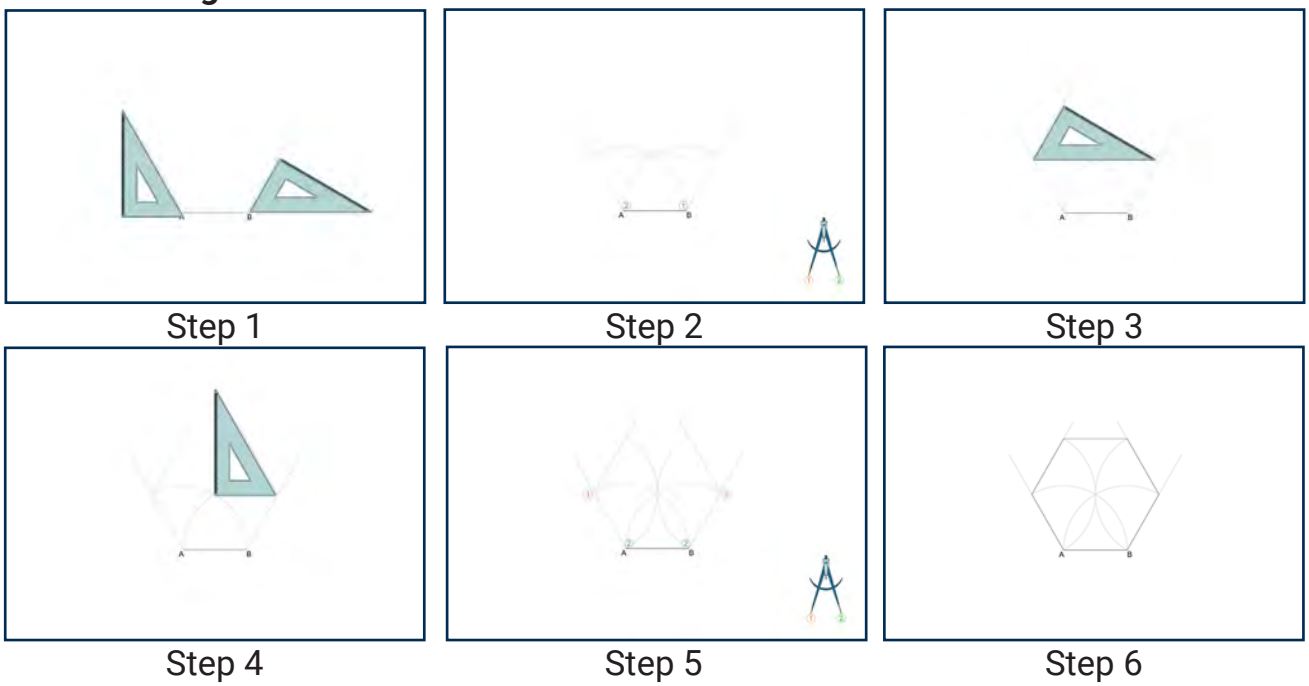

Step 5


Step 6

Step 1: Place the cross point of your protractor on the left end of the given line at C. Ensure that the 0° and 180° on the protractor line up with the given line. Measure 72° and project a construction line from the left end to the 72° mark.
Step 2: Place the cross point of your protractor on the right end of the given line at D. Ensure that the 0° and 180° on the protractor line up with the given line. Measure 72° and project a construction line from the left end to the 72° mark.
Step 3: Place the needle point of your compass on point 1 and open it to the length of the given line (point 2). Project a C-type arc to intersect with the 72° line. Repeat for the other side.

Step 4: Place the needle point of your compass where the arc and 72° line intersects (point 1) and open it to the length of the given line (point 2). Project a C-type arc up between the two 72° lines.
Step 5: Place the needle point of your compass where the arc and 72° line intersects (point 1) and open it to the length of the given line (point 2). Project a C-type arc up between the two 72° lines.
Step 6: Connect the sides of the pentagon in an A-type line.

4.2.16.5 Hexagon method 1



Step 1 | Step 2 | Step 3

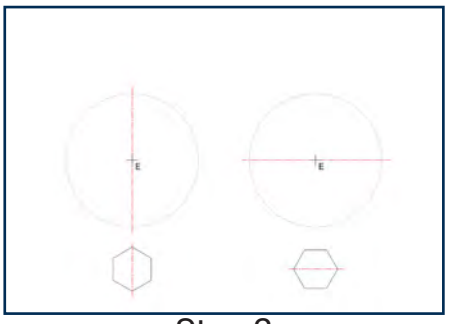
Step 4 | Step 5 | Step 6

Step 1: Project 60° construction lines, outward from the ends of the given line AB.
Step 2: Project the length of the given side over to the 60° line. Place the needle point of your compass on point 1 and open it to point 2. Repeat for the other side.
Step 3: Project a 60° construction line, inward from where the arc intersects the first 60° construction line.
Step 4: Project a 60° construction line, inward from where the second arc intersects the second 60° construction line
Step 5: Project the length of the given side over to the new 60° lines. Place the needle point of your compass on point 1 and open it to point 2.
Step 6: Connect the sides of the hexagon in A-type lines.

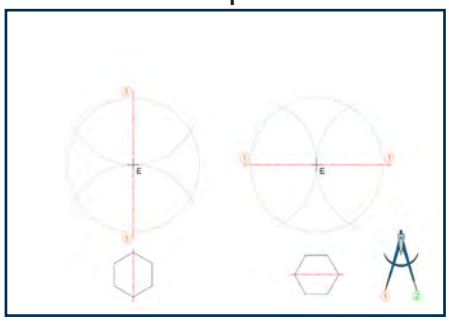
4.2.16.6 Hexagon method 2 *(images on next page)*

Step 1: Choose the hexagon you want to draw. Open your compass to the length of the side, place the needle point on point 1 and draw a full circle in C-type lines.
Step 2: Draw the corresponding centre line for your hexagon.
Step 3: Keep your compass open to the size of the side length. Place the needle point where the centre line and the circle intersect point 1 and project arcs to the edge of the circle.
Step 4: Connect the sides of the hexagon in A-type lines.

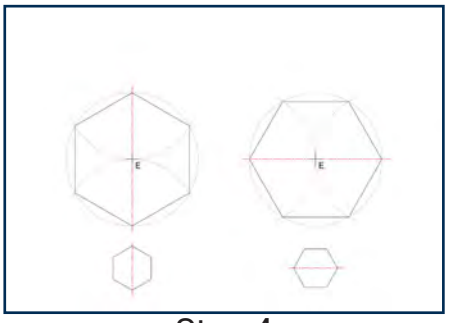
Step 1



Step 2

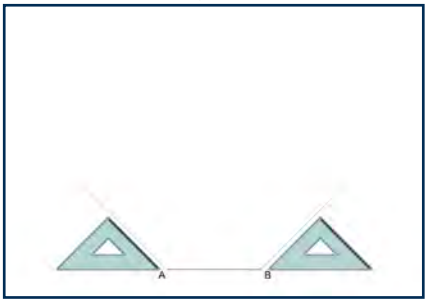


Step 3

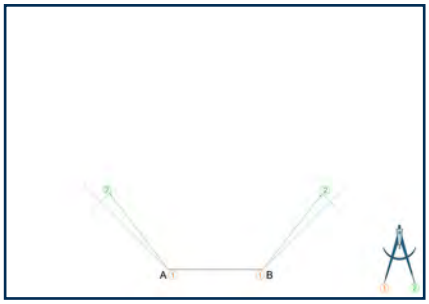


Step 4

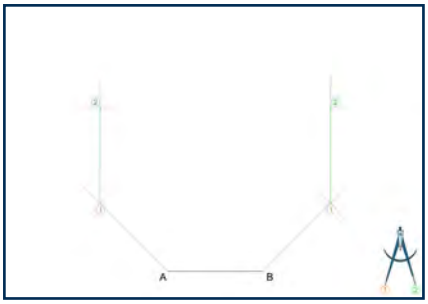
4.2.16.7 Octagon method 1



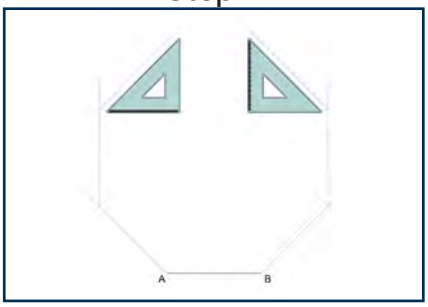
Step 1



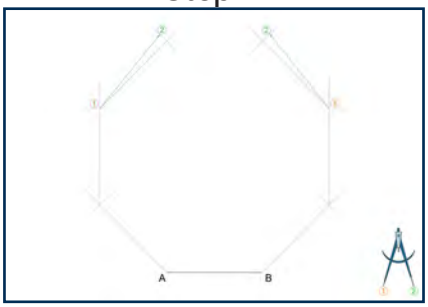
Step 2



Step 3



Step 4



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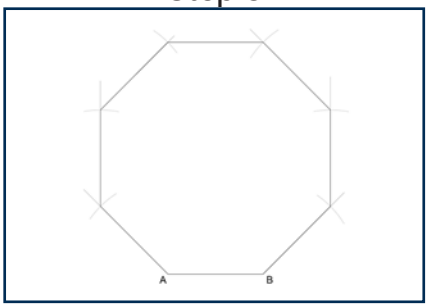
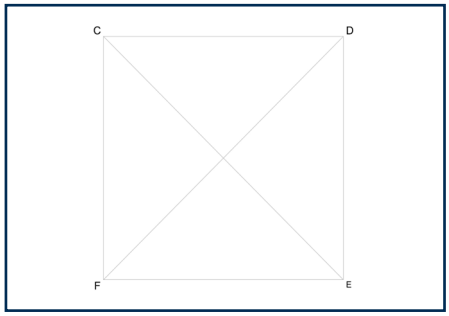


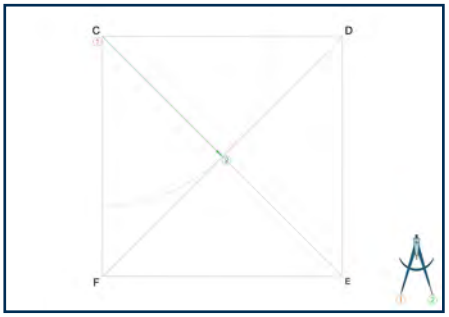
Step 6

Step 1: Using a 45° triangle draw 2 construction lines going from point A and point B.
Step 2: Place your compass on both points and draw an arc intersecting the construction lines previously drawn with the radius being the length of side AB.
Step 3: Draw 2 construction lines going straight up from the previously determined points and measure the length of the side on both projected lines.
Step 4: Using a 45° triangle draw 2 construction lines going from the previously determined points.
Step 5: Place your compass on both points and draw an arc intersecting the construction lines previously drawn with the radius being the length of side AB
Step 6: Finish off the octagon by drawing it with an A-type line.

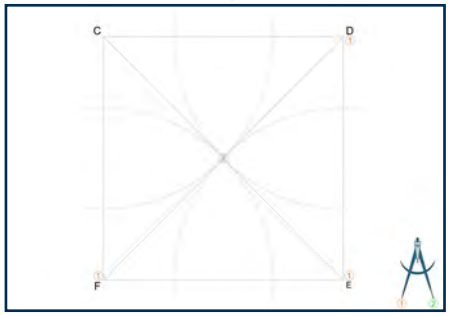
4.2.16.8 Octagon method 2



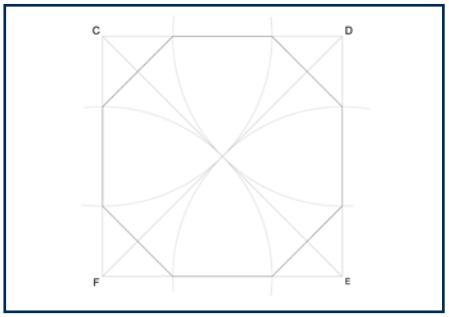
Step 1



Step 2



Step 3



Step 4

Step 1: Determine the centre of the square.
Step 2: Place point 1 of the compass on point C and point 2 on the centre point and draw an arc that intersects the sides of the square.
Step 3: Repeat the previous step on each corner of the square.
Step 4: Connect each point determined using an A-type line.

4.2.17 Ellipse

(Images on next page)

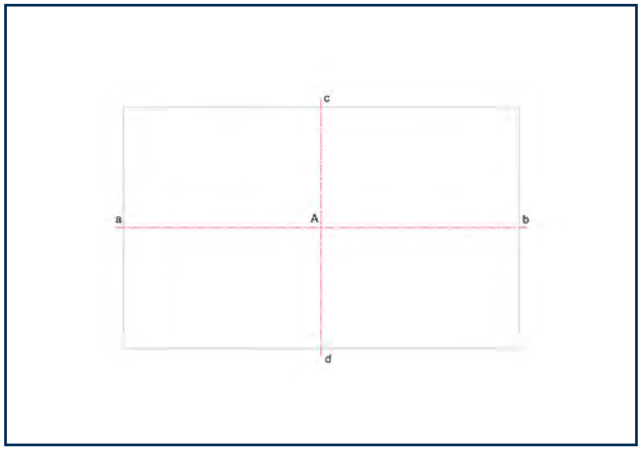
Step 1: The rectangle indicates the length and width of the ellipse. Label the points where the centre line intersects with the length of the ellipse, a and b. Label the point where the centre line intersects with the width of the ellipse, c and d.
Step 2: Project a construction line from point a to c. (The ellipse constructions can be done in any quadrant of the ellipse).
Step 3: Place the needle point of your compass in the centre of the ellipse (point 1) and open it to the length of the ellipse (point 2). Project a C-type quarter arc up to intersect with centre line cd. Label the point where the arc intersects the centre line, e.
Step 4: Place the needle point of your compass on c (point 1) and open it to e (point 2). Project a C-type arc to intersect with line ac. Label the point where the arc intersects line ac, f.
Step 5: Construct a perpendicular bisector for line af. Extend the perpendicular bisector to intersect the vertical and horizontal centre lines.
Step 6: Label the point where the perpendicular bisector intersects the first centre line, M1 and where it intersects the second centre line, M2.
Step 7: Place the needle point of your compass in the centre of the ellipse (point 1) and open it to M1 (point 2). Project a C-type arc 180° across to find M3.

Step 8: Place the needle point of your compass in the centre of the ellipse (point 1) and open it to M2 (point 2). Project a C-type arc 180° across to find M4.

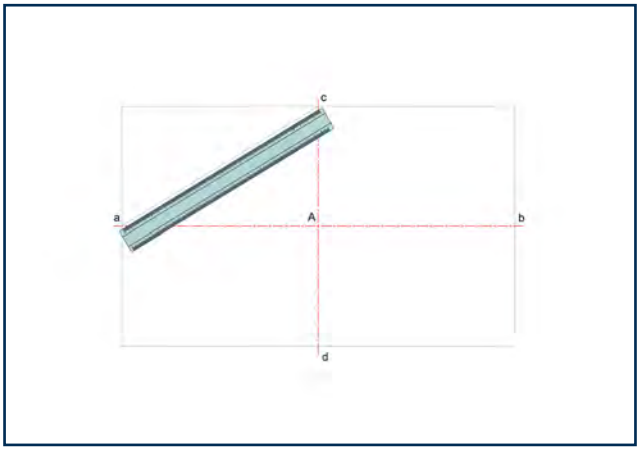
Step 9: Project long construction lines through M2 and M3, M3 and M4, and M4 and M1.

Step 10: Place the needle point of your compass on M2 (point 1) and open it to c (point 2). Draw an A-type arc stretching between the extended parts of the construction lines projected in the previous step. Repeat with M4 and d.

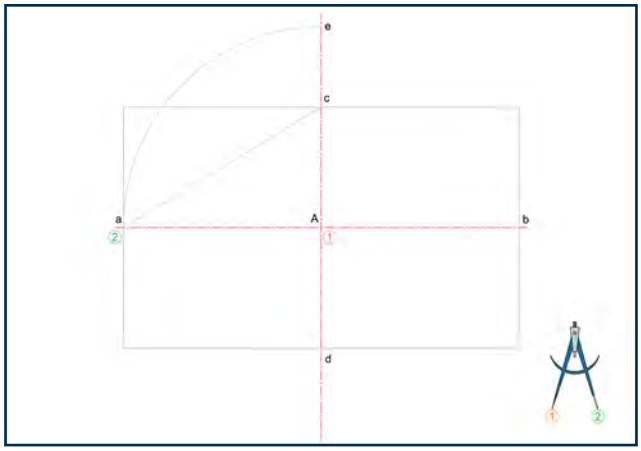
Step 11: Place the needle point of your compass on M1 (point 1) and open it to a (point 2). Draw an A-type arc to connect to the arcs drawn in the previous step. Repeat with M3 and b.



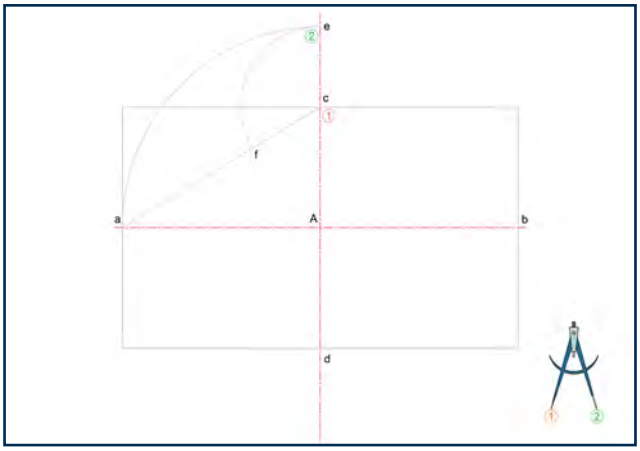
Step 1



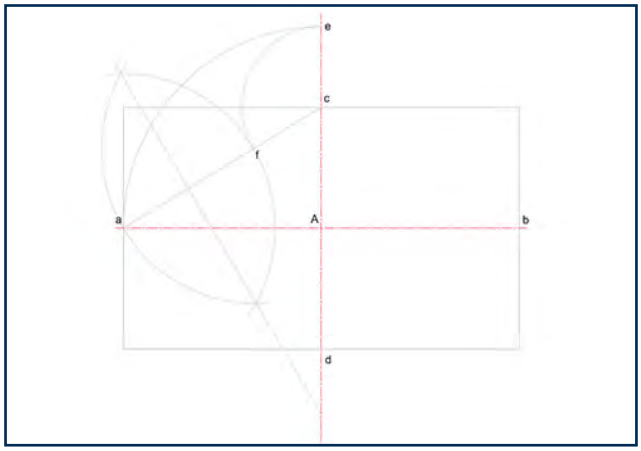
Step 2



Step 3



Step 4



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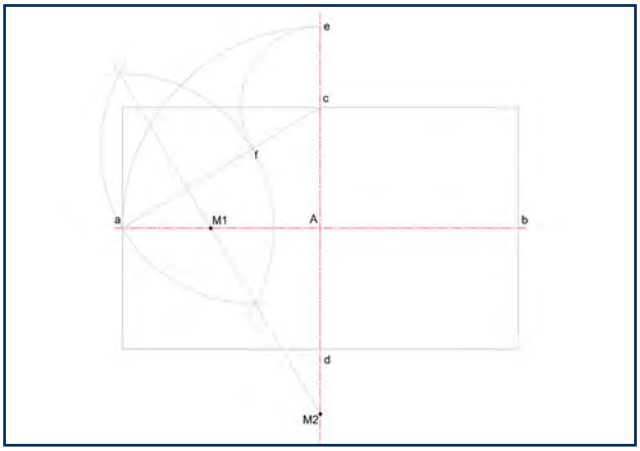
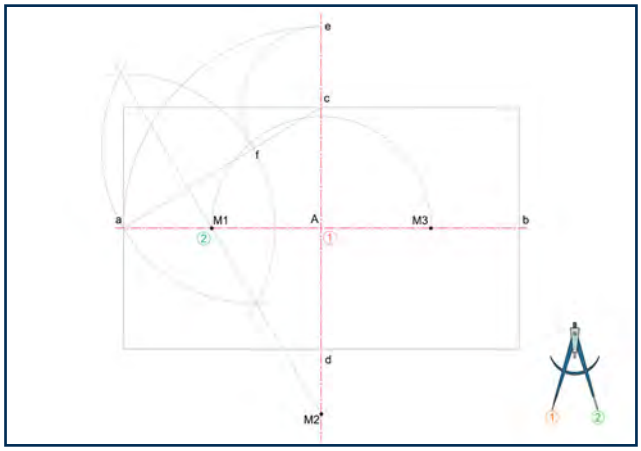
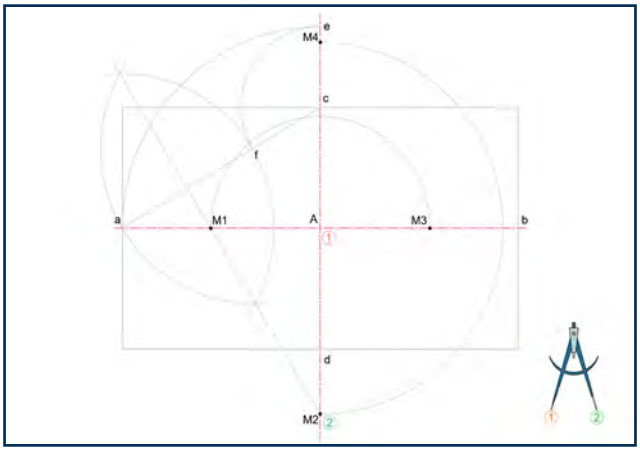


Step 6



Step 7



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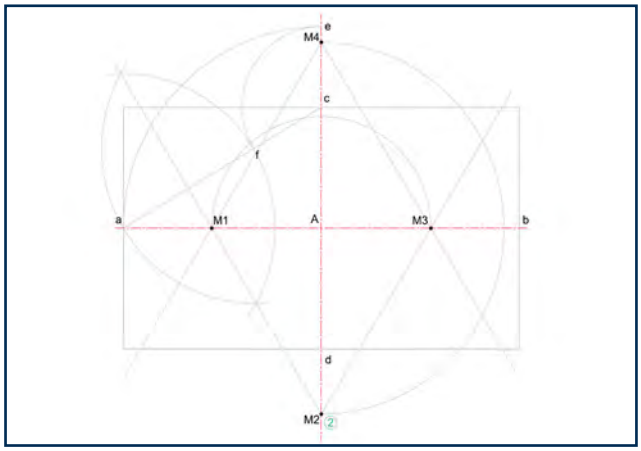
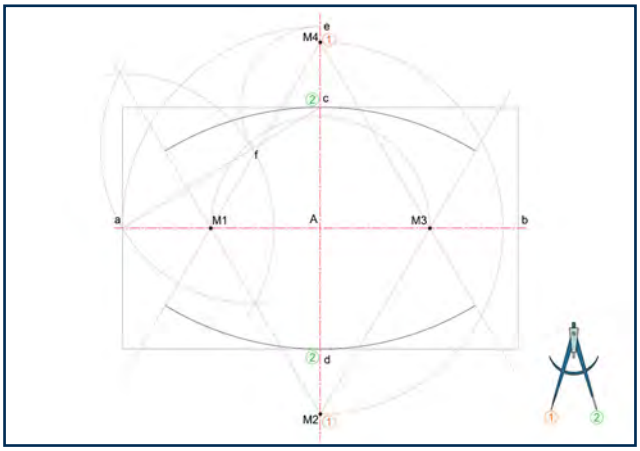
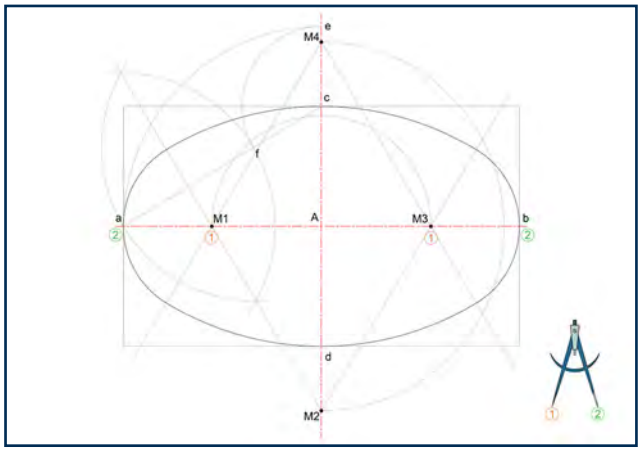


Step 9



Step 10



Step 11

5. Scale Drawing

Corresponds with Gr.10 Module 5

In EGD, a scale is used when an object is too large or too small to be drawn at its actual, real-life size. We either enlarge or reduce the object on paper, but always keep the proportions accurate.

Definition
A scale is a ratio that compares the size of the drawing to the size of the actual object.

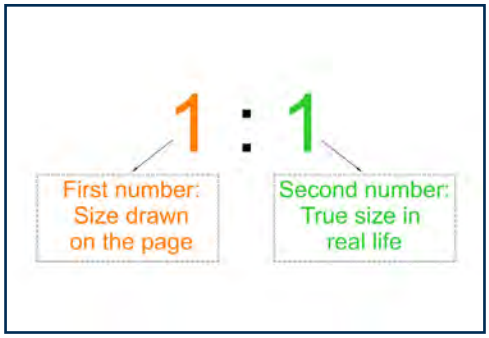
5.1 Three types of scales

- Full-size scale: Drawing is the same size as in real-life.
- Enlarging scale: Drawing is bigger that the real object.
- Reducing scale: Drawing is smaller than the real object.

5.2 Understanding the scale ratio

5.2.1 Full-size scale

First number: Size on the drawing
Second number: Actual size of the object



5.2.2 Enlarging scale

If the first number is larger = Multiply dimensions by the first number.
Example:

- *Real length = 40 mm*
- *Drawing = 40 × 2 = 80 mm*

5.2.3 Reducing scale

If second number is bigger = Divide dimensions by the second number.
Example:

- *Real length = 40 mm*
- *Drawing = 40 ÷ 2 = 20 mm*

6. Orthographic Projection

Corresponds with Gr.10 Module 6

In orthographic projection we draw a three-dimensional object in two dimensions, on a flat plane. An orthographic projection drawing can consist of up to six views of an object, with each projection plane parallel to one of the coordinate axes (x- or y-) of the object. A view represents the direction from which we look at the object and each view is drawn separately.

Typically, an orthographic projection drawing consists of the most important views, namely:

1. Front view
2. Top view
3. Side view (Right or Left)

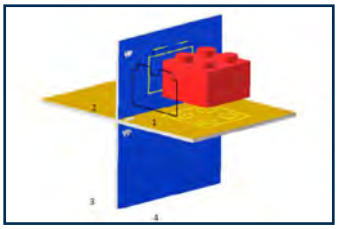
6.1 Orthographic projection systems

There are two different systems used for orthographic projection which determines the placement of the orthographic views.

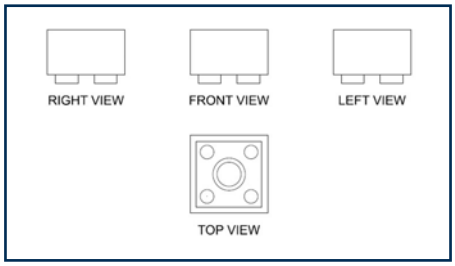
- First-angle orthographic projection.
- Third-angle orthographic projection.

6.1.1 First-angle orthographic projection

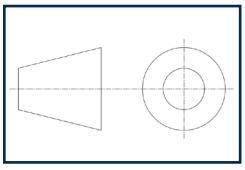
The object is placed in the first quadrant, normally displaying the front, top, and left views in their corresponding positions.



The observer is on the left side of the object and the orthographic view is projected on a plane located between the viewport and the object. Each view of the object is projected in the direction of sight of the object, onto the interior wall of the box. A two-dimensional representation of the object is then created by unfolding the box to view all the interior walls and show the different views.

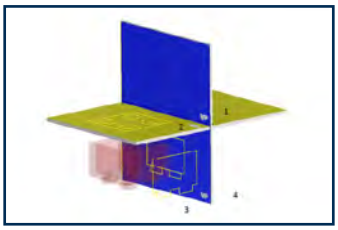


Projection symbols are universal symbols used to indicate the projection system used. The first-angle orthographic projection symbol:

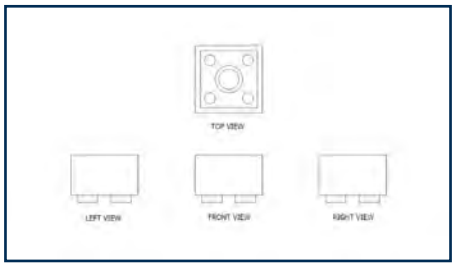


6.1.2 Third-angle orthographic projection

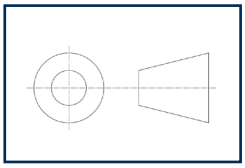
In third-angle orthographic projection, the object is placed in the third quadrant normally displaying the front, top, and right views in their corresponding positions.



The observer is on the right side of the object and the orthographic view is projected on a plane located between the viewport and the object. Each view of the object is projected in the direction of sight of the object, onto the interior wall of the box. A two-dimensional representation of the object is then created by unfolding the box to view all the interior walls and show the different views.



Projection symbols are universal symbols used to indicate the projection system used. The third-angle orthographic projection symbol:



7. Mechanical Drawing

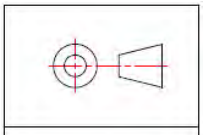
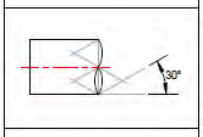
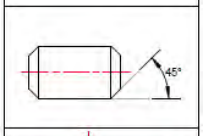
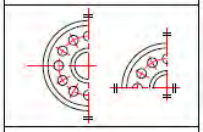
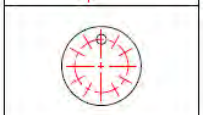
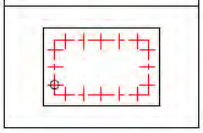
Corresponds with
Gr.10 Mod. 7, Gr.11 Mod.2, Gr.12 Mod. 2

Mechanical drawing is the precise graphical representation of machinery components and mechanical systems. In EGD, this type of drawing is used to communicate the form, dimensions, function, and assembly of parts in a clear and standardised way, in third-angle orthographic projection. Mechanical drawings are not just artistic sketches—they are technical blueprints created to strict conventions, allowing engineers, artisans, and manufacturers to build and inspect machines with accuracy.

7.1 Abbreviations in mechanical drawing

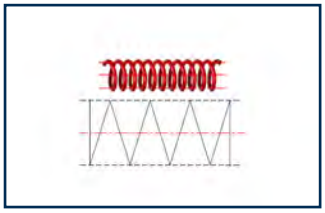
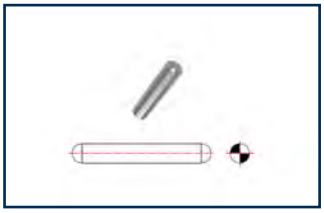
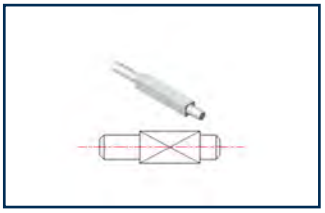
AF - Across Flats
NTS - Not to Scale
PCD - Pitch Circle Diameter
CAD - Computer-Aided Drawing/Design

7.2 Symbols in mechanical drawing

	Third-angle orthographic projection symbol
	S-Break (interrupted view)
	Bevelled edge (45° ends)
	Symmetrical components
	Holes on a circular pitch
	Holes on a linear pitch

7.3 Conventions in mechanical drawing

GR.10 -12

			
Spring	Bearing	Dowel pin	Square on a shaft

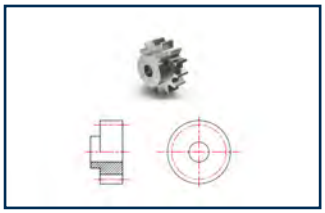
GR.10 -12

Splined shaft

Serrated shaft

Straight & Diamond knurling

GR.11 -12



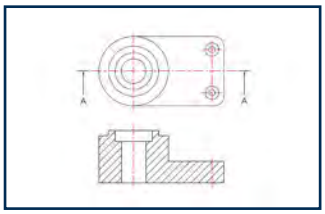
Spur gear

Bevel gear

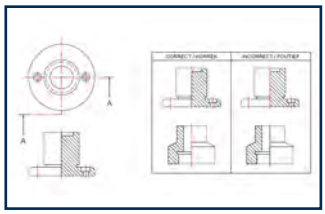
Assembled gears

7.4 Sections used in mechanical drawing

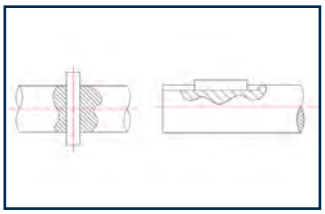
GR.10 -12



Full section

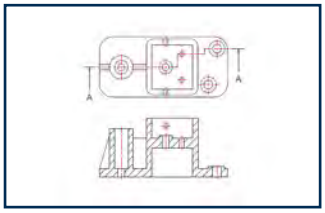


Half section

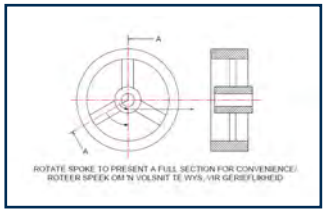


Partial section

GR.11 -12



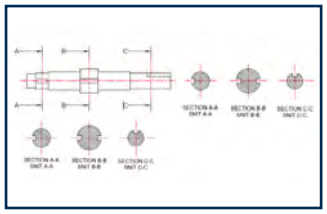
Multi-plane section



Aligned section

Removed section

Revolved section

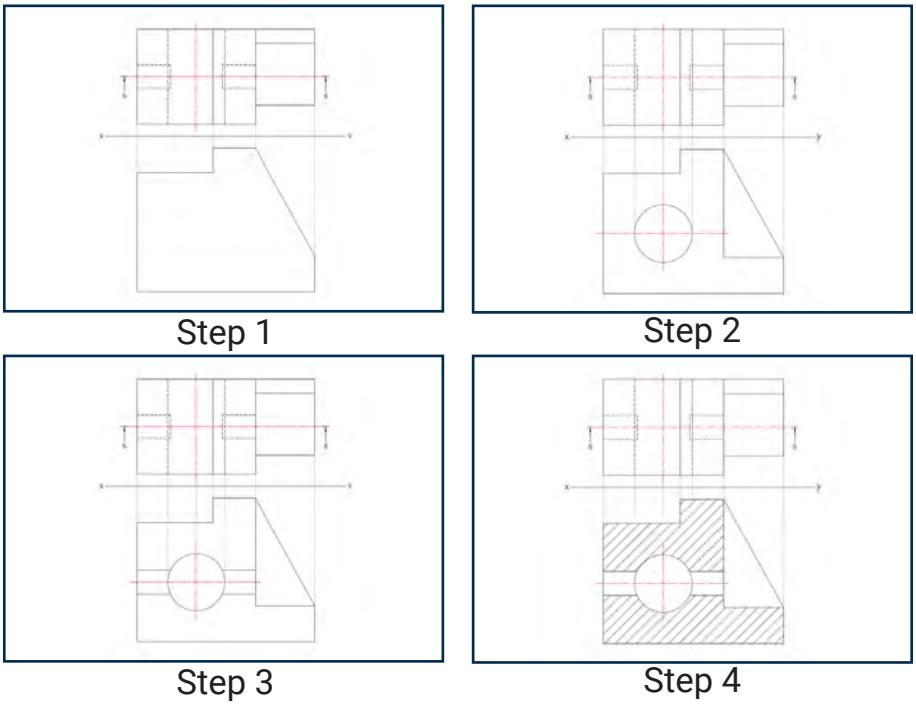


Successive section

7.5 Sectioning mechanical parts in mechanical drawing

GR.10 -12

When drawing mechanical parts, each part should be drawn with its section. To draw each part in section, follow the following steps:



Step 1: Draw the outlines of the figure
Step 2: Draw the parts that do not get sectioned. (webs, holes visible from the outside, shafts with thread, spokes)
Step 3: Draw the holes on the inside that get sectioned in solid A-type lines.
Step 4: Hatch the part in B-type lines, in one direction, with a consistent distance apart. Hatch the whole part except for the pieces that were drawn in step 2 and 3.

GR.11 -12

In Gr.11 and 12 Mechanical drawing includes assemblies where multiple mechanical parts are assembled and then sectioned together. When drawing mechanical assemblies, each part should be drawn with its section as well as assembled with the other parts. To draw each part in section, follow the same 4 steps discussed above.
In Gr.11 and 12, step 2 however includes shafts with thread as part of the non-sectioned parts.

Exceptions to sectioning

GR.10 -12

There are certain mechanical parts that do not get sectioned under certain circumstance. Some parts may never be sectioned. Some parts are sectioned, with hatching, depending on whether they are sectioned transversely. If sectioned longitudinally, they may not be sectioned.

Parts that may be sectioned transversely:

- Ribs, webs and spokes
- Shafts with thread
- Keys and pins
- Rivets, nails and screws
- Bolts

Parts that may never be sectioned:
- Washer
- Nuts

7.6 Mechanical assemblies

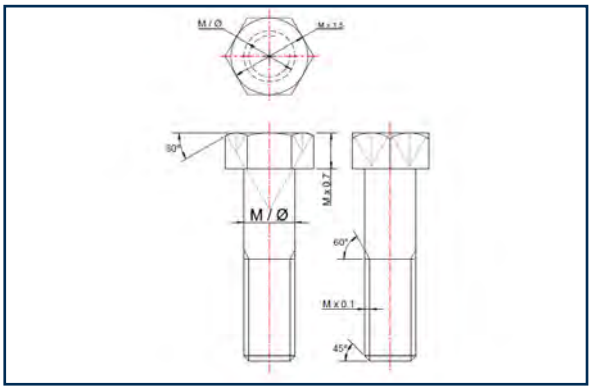
GR.10 -12

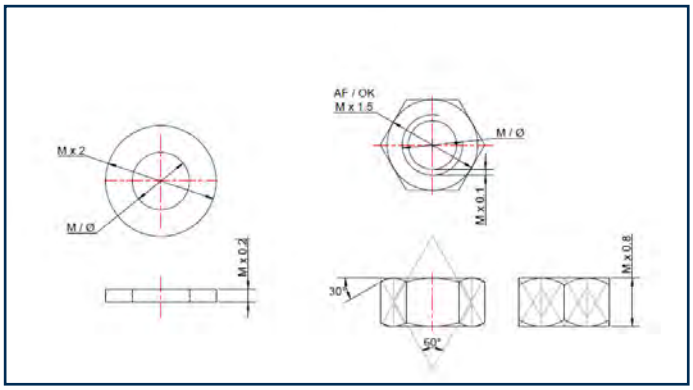
Mechanical assembly is the process of joining multiple parts together to form a finished product or sub-assembly. This is achieved by connecting parts using methods such as fasteners (screws, bolts, pins, rivets), interference fits, snap-fits, or welding to create a functional system.

Fastening methods used in EGD, include:
- Fastening: Using screws, bolts, or rivets to connect parts.
- Welding: Fusing parts together using heat.

7.6.1 Bolts and nuts

Mechanical assemblies mainly use bolts and nuts to fasten parts in EGD. We use specific formulas to calculate the dimensions needed to draw bolts, nuts and washers.





7.6.1.1 Formulas

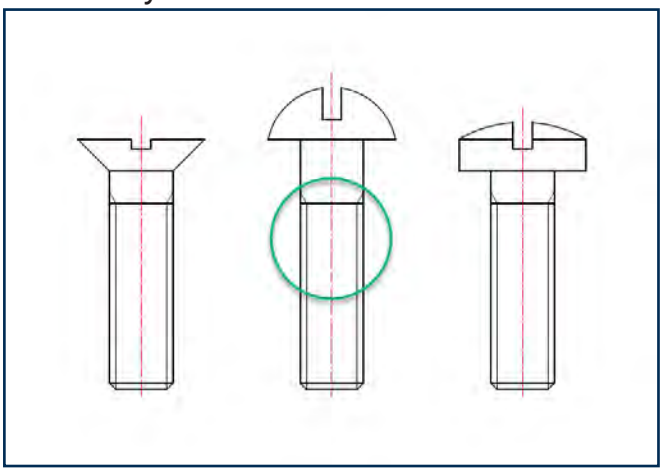
Shaft diameter: M
Bolt head size: M x 1,5
Bolt head height: M x 0,7
Angle of bevelled edge: 45°
Thread thickness: M x 0,1
Nut head height: M x 0,8
Washer diameter: M x 2
Washer thickness: M x 0,2

7.6.1.2 Thread

When drawing thread in Mechanical Drawing, it is important to note the difference in drawing convention and line types between external and internal thread and thread assemblies.

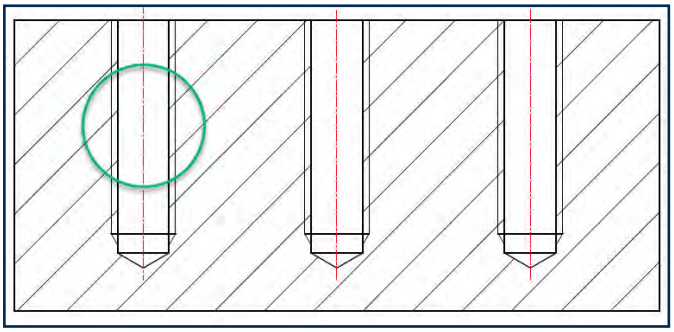
External thread

When drawing external thread, the outline of the shaft is drawn in A-type lines and the thread lines on the inside in B-type lines. Shafts with external thread do not get sectioned longitudinally, only transversely.



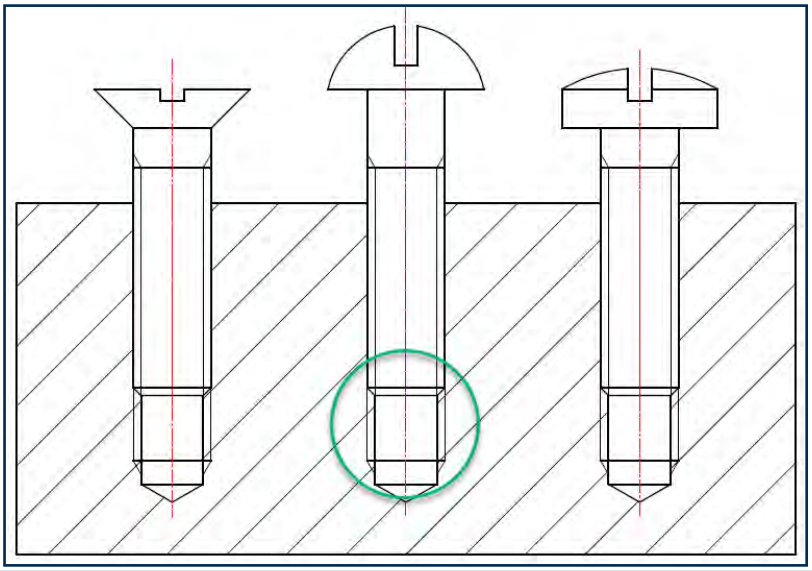
Internal thread

When drawing internal thread, the inner lines are drawn in A-type lines and the thread lines on the outside in B-type lines. Holes with internal thread may be sectioned. Note that the hatching lines extend over the thread line to the inner A-type line.



Assembled thread

Note the hatching on an assembled drawing between internal and external thread. The hatching stops against the outer A-type line of the shaft but extends past the B-type thread line where the hole is not filled with the shaft.

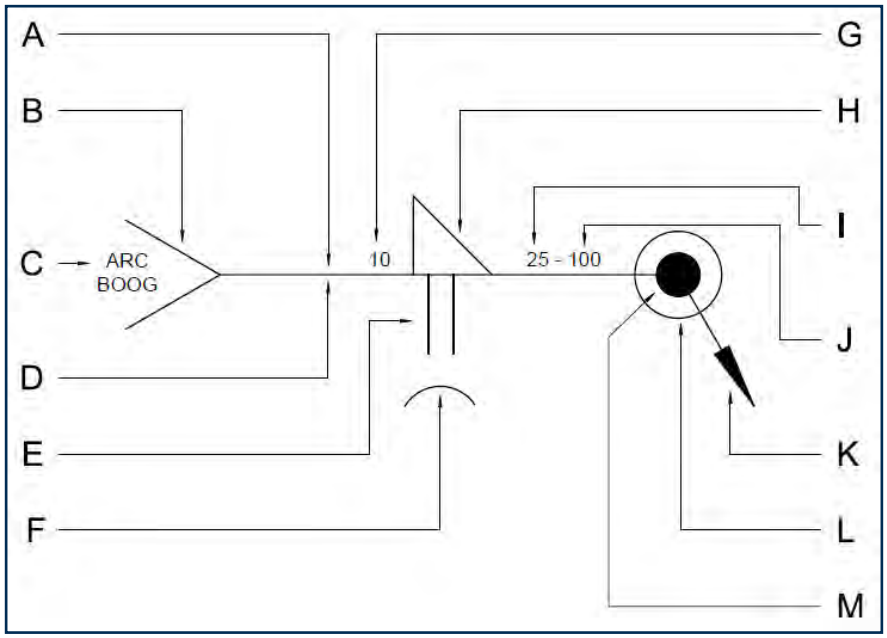


7.6.2 Welding

GR.12

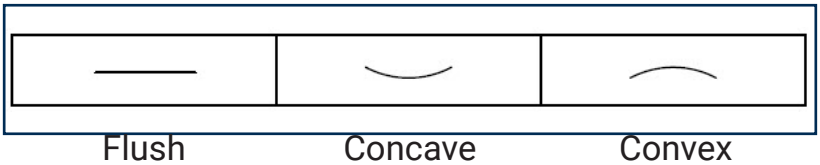
Mechanical parts can also be fastened by welding. In gr.12 you may be asked to draw parts that are welded together and add the welding symbol to the drawing. The welding symbol can also be included into analytical questions where you can be asked to identify the symbol and parts of the symbol.

7.6.2.1 Features on the welding symbol



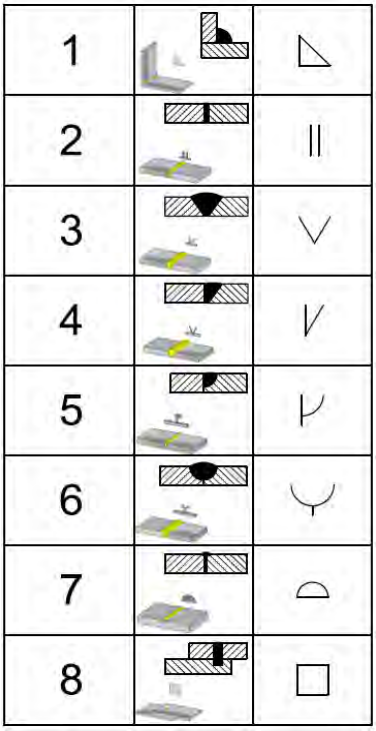
A - Other side
B - Tail
C - Welding process
D - Arrow side
E - Welding symbol (arrow side)
F - Contour symbol
G - Width of weld
H - Welding symbol (other side)
I - Length of weld
J - Distance between consecutive welds (pitch)
K - Arrow
L - Weld all around
M - Site weld

7.6.2.2 Types of contours



7.6.2.3 Types of welds

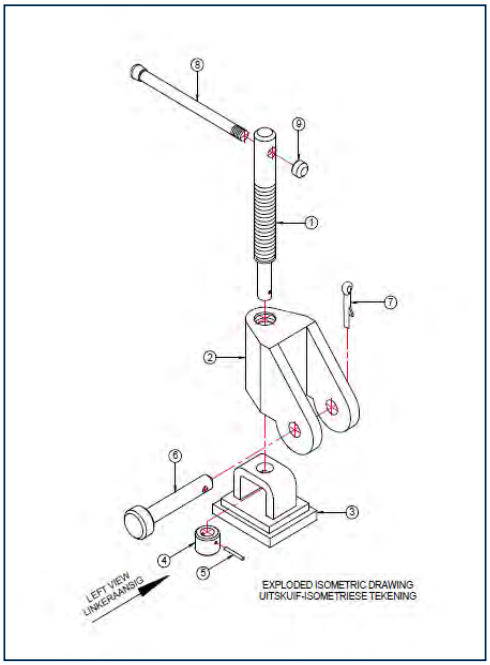
1 - Fillet
2 - Square
3 - Bevel
4 - Single “v”
5 - Single “J”
6 - Single “U”
7 - Bead
8 - Plug (Slot)



7.6.3 Exploded isometric drawings

GR.10 -12

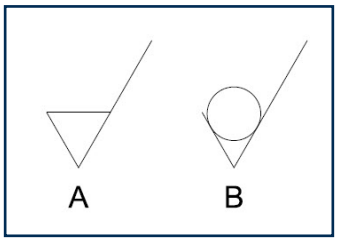
When drawing mechanical assemblies, the order in which parts are assembled is shown on the exploded isometric drawing. The assembly order is indicated with the centre line.



7.7 Machining symbol

GR.11 -12

Machining is a manufacturing process where a cutting tool removes material from a workpiece to create a desired shape, size, and surface finish with high precision. The machining symbol can be included into analytical questions where you can be asked to identify the symbol and parts of the symbol.

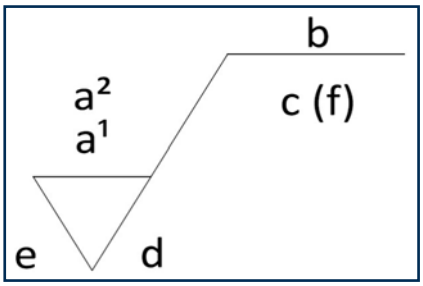


A - Removal of material
B - Machining not permitted / No machining

7.7.1 Features on the welding symbol

GR.12

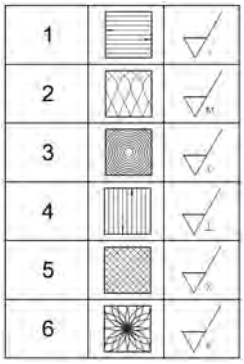
a1 - Roughness value (minimum)
a2 - Roughness value (maxsimum)
b - Production method
c - Sampling length
d - Direction of lay
e - Machining allowance
f - Other roughness value



7.7.2 Directions of lay

GR.12

1 - Parallel
2 - Multi-directional
3 - Circular
4 - Perpendicular
5 - Crossed
6 - Radial



7.7.3 Types of production methods

GR.12

- Chemical
- Lapping
- Honing
- Machining
- Grinding
- Plating

8. Isometric Drawing

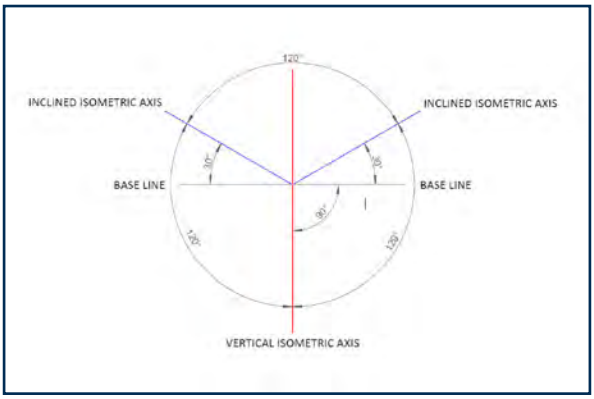
Corresponds with
Gr.10 Mod. 8, Gr.11 Mod.3, Gr.12 Mod. 5

Isometric drawings are 3D sketches used to show objects as seen from a corner. They are popular in engineering graphics because they are quick and easy to draw. In isometric drawings, sides are drawn at 30° angles to the left and right, while vertical lines stay upright.

8.1 Basic principles for isometric drawing

GR.10 -12

- All drawings are in third-angle orthographic projection.
- All dimensions that are measured on an isometric drawing are the true lengths of the object.
- The main lines in isometric drawing are vertical lines and 30° inclined lines to the left and right.



8.2 Isometric and non-isometric lines

GR.10 -12

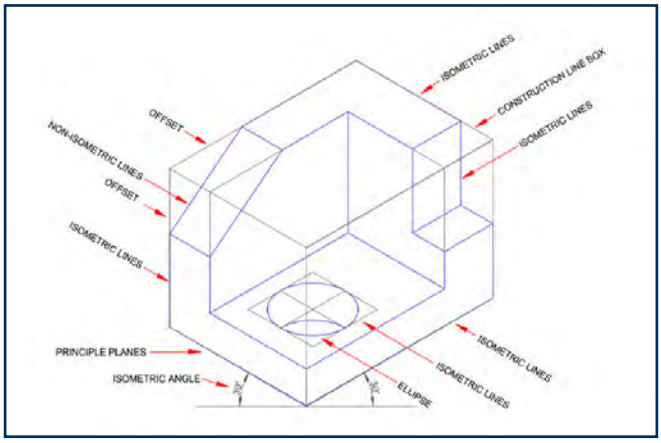
An isometric drawing consists of isometric and non-isometric lines.

Isometric lines:

- All lines falling on the main lines (90° and 30°)
- Lengths can directly be measured onto the drawing.

Non-isometric lines:

- Lines that are on different angles than the main lines.
- Can not be measured directly on the drawing. Must be plotted through vertical and horizontal dimensions.
- Uses guides and auxiliary views.

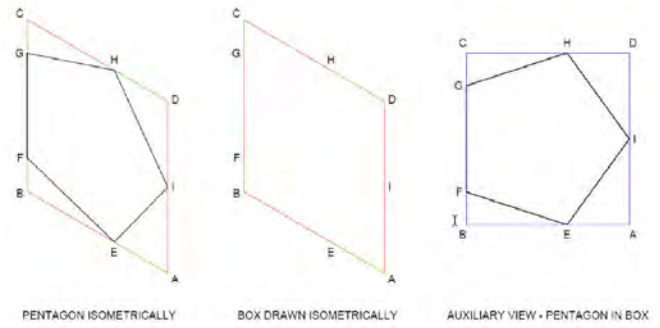


8.3 Auxiliary views

GR.10 -12

When a slanted line appears in an orthographic view and its length cannot be measured directly, an auxiliary view is used:

- Draw a flat orthographic view on the side of your page.
- Use it to determine the vertical and horizontal lengths of angled lines.
- Take all measurements horizontally or vertically from this view.

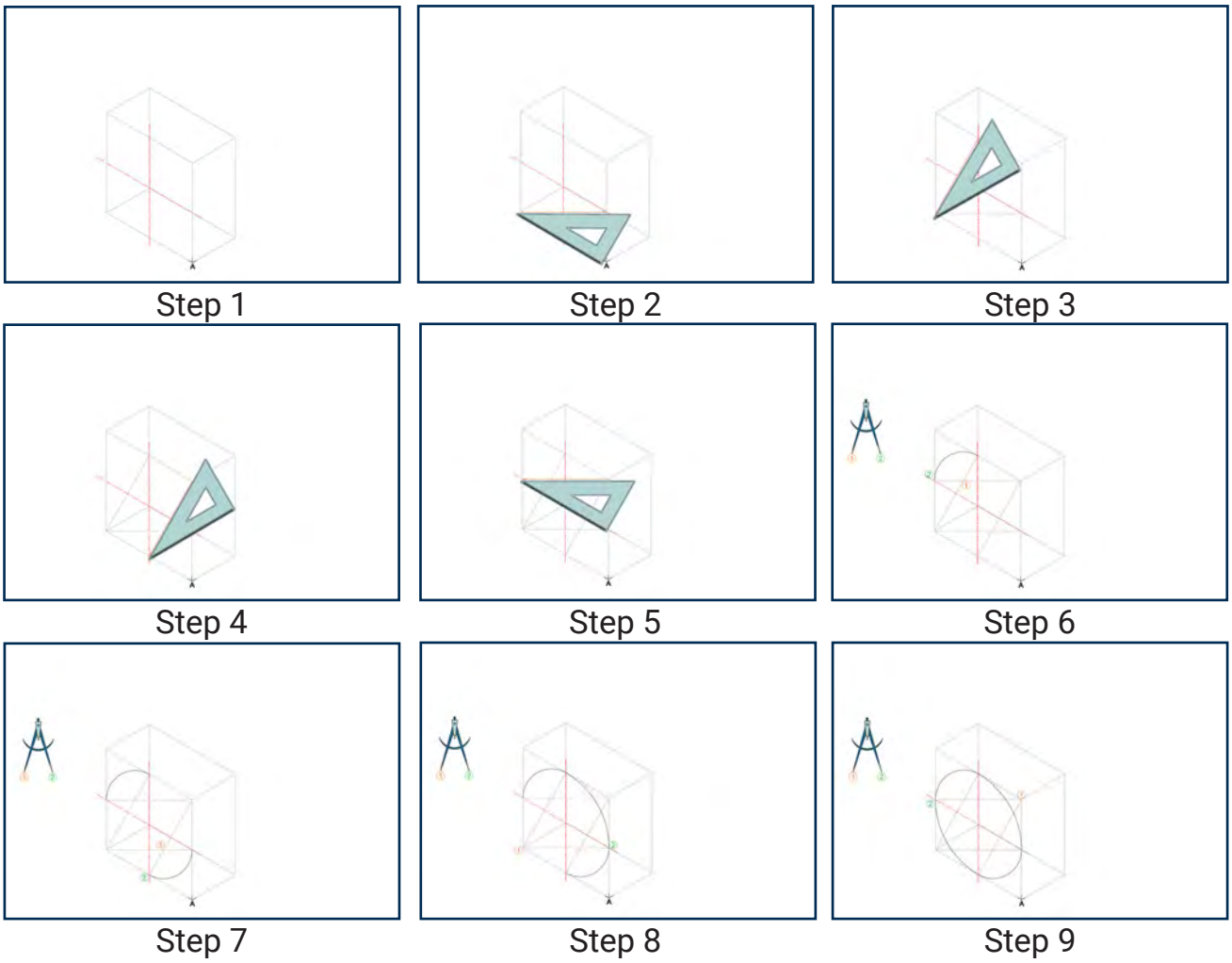


8.4 Isometric circles

GR.10 -12

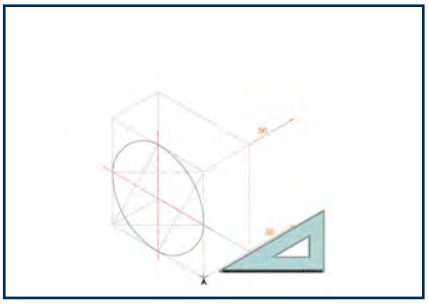
Circles required specific construction methods when drawn in isometric.

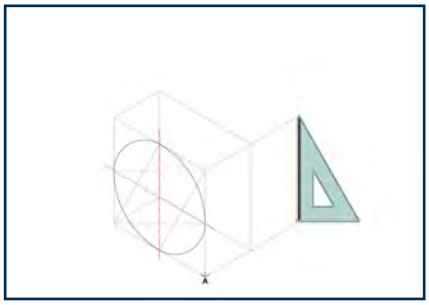
Full isometric circle



Step 1: Draw an isometric square with a side length equal to the diameter of the circle.
Step 2: Draw a construction line connecting the first obtuse angle to the right midpoint.
Step 3: Draw a construction line connecting the first obtuse angle to the top midpoint.
Step 4: Draw a construction line from the opposite obtuse angle to the bottom midpoint.
Step 5: Draw a construction line from the opposite obtuse angle to the left midpoint.
Step 6: Using the compass, place point 1 where the construction lines intersect in the top left quadrant and open to point 2 at the closest midpoint and draw an arc.
Step 7: Place point 1 where the construction lines intersect in the bottom right quadrant and open to point 2 at the closest midpoint and draw an arc.
Step 8: Place point 1 on the first obtuse corner and open to point 2 at the right midpoint and draw an arc.
Step 9: Place point 1 on the opposite obtuse corner and open to point 2 on the left midpoint and draw an arc.

Half isometric circle


Step 1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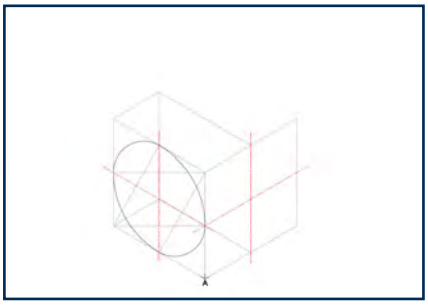
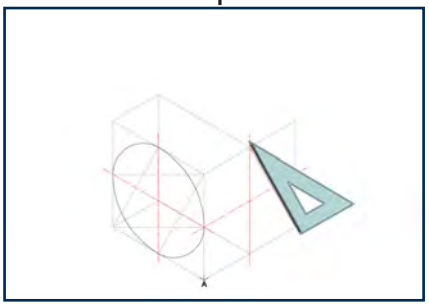

Step 3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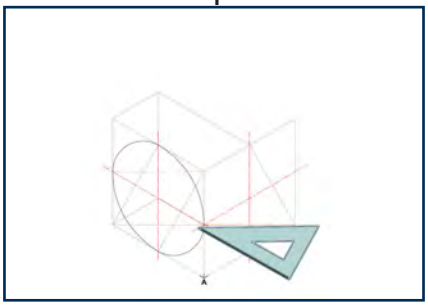
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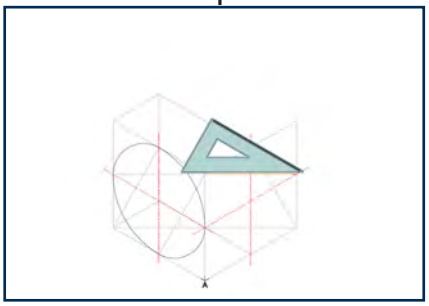
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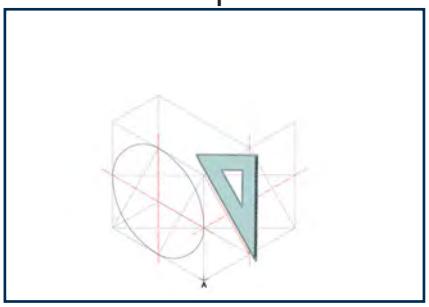
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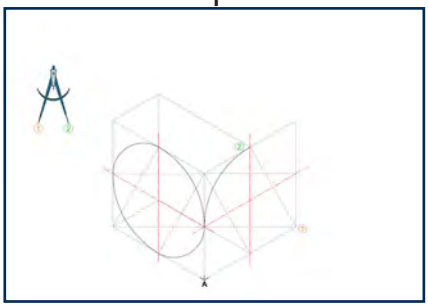
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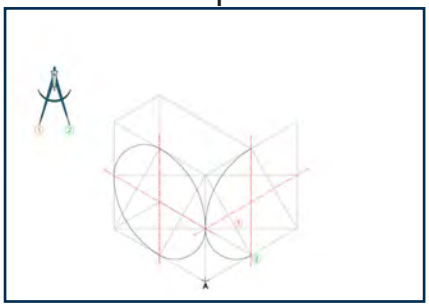
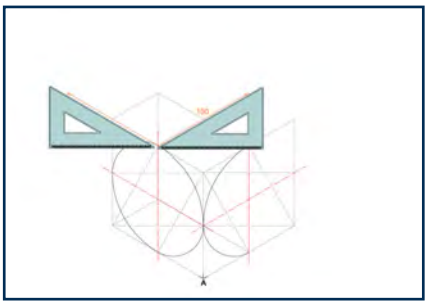
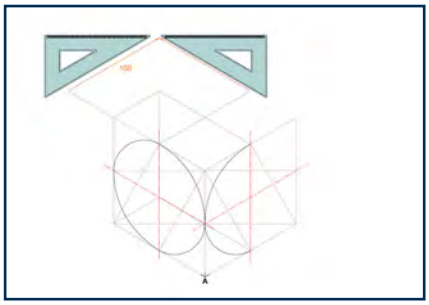

Step 9

Step 1: You need an isometric square construction block to fit around a full circle. Extend the right view by (the radius) to complete an isometric square for a full circle.
Step 2: Close the isometric square with a vertical line.

Step 3: Add centre lines to the isometric square.
Step 4: Draw a construction line connecting the first obtuse angle to the top midpoint.
Step 5: Draw a construction line connecting the first obtuse angle to the left midpoint.
Step 6: Draw a construction line connecting the opposite obtuse angle to the right midpoint.
Step 7: Draw a construction line connecting the opposite obtuse angle to the bottom midpoint.
Step 8: Place point 1 on the obtuse corner and open to point 2 at the top midpoint and draw an arc.
Step 9: Place point 1 where the construction lines intersect in the bottom left quadrant and open to point 2 at the closest midpoint and draw an arc.

Quarter isometric circle


Step 1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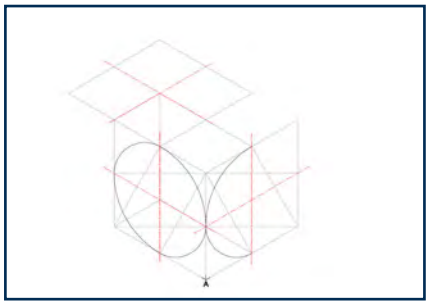
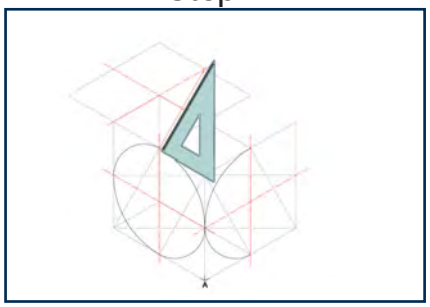
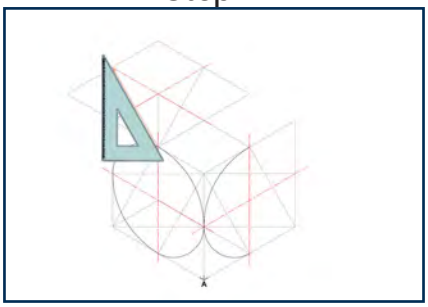
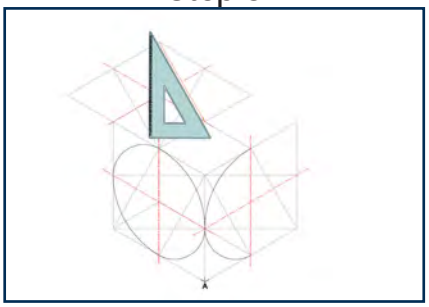

Step 3


Step 4


Step 5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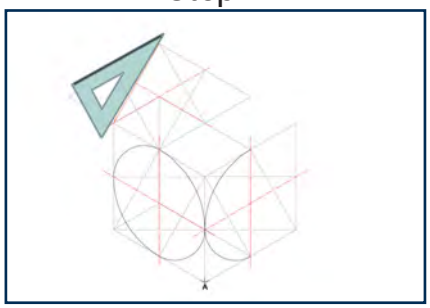
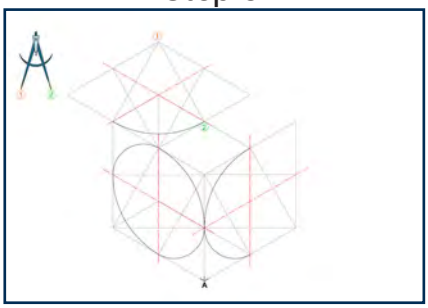
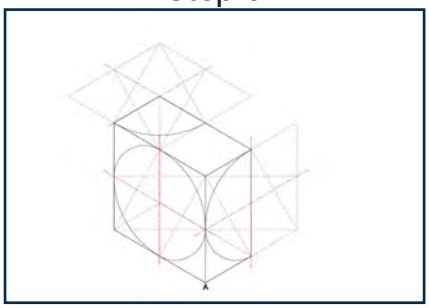

Step 7


Step 8


Step 9

Step 1: You need an isometric square construction block to fit around a full circle. From the top midpoint, draw an isometric square with a side length equal to the diameter of the circle.
Step 2: Close off the isometric square.
Step 3: Add centre lines.
Step 4: Draw a construction line connecting the first obtuse angle to the top right midpoint.

Step 5: Draw a construction line connecting the first obtuse angle to the top left midpoint.
Step 6: Draw a construction line connecting the opposite obtuse angle to the bottom right midpoint.
Step 7: Draw a construction line connecting the opposite obtuse to the bottom left midpoint.
Step 8: Place point 1 on the first obtuse angle and open to point 2 on the bottom right midpoint and draw an arc.
Step 9: Complete the rectangular prism in A-type lines.

8.5 Suggestions for drawing isometric drawing

GR.10 -12

- Measure total dimensions: length, width, height – from the starting point.
- Start with the clearest view, usually the front.
- Use all views together, don't complete one view in isolation.
- Pay attention to line placement – each line shows a change in surface depth or height.
-

8.6 Sectioning in isometric drawing

GR.11 -12

Sectioning is a method used in isometric drawing to show the inside details of a component that would normally be hidden from view. It involves cutting through the object and removing part of it so the internal structure can be seen clearly. The surface where the cut is made is indicated on the orthographic views with a cutting plane. The sectioned area is shown using hatching lines on the surfaces that have been cut. The figure can be sectioned with a full or half section.

9. Descriptive Geometry

Corresponds with Gr.10 Module 10

Descriptive Geometry is the graphical method of representing three-dimensional objects in two dimensions using orthographic projections to determine true lengths, true inclinations, and shapes of lines or surfaces that are inclined in space.

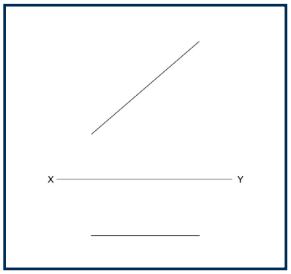
Descriptive Geometry is first-angle orthographic views of points and line segments that are perpendicular, inclined or oblique to the projection planes. These type of drawings include the true length and true inclination of line segments to the horizontal plane (HP) or vertical plane (VP) using different methods. It also includes the true shape of surfaces from given edge (side) views.

GR.10 -12

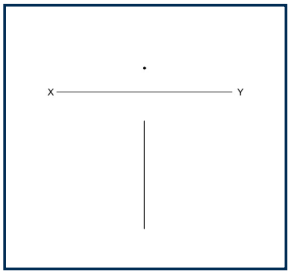
9.1 True length

A line is a true length when it is viewed perpendicular (90°) to the observer's line of sight. Only then can the actual length of the line be observed and measured accurately.

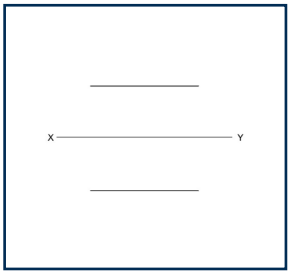
9.1.1 When is a line a true length?



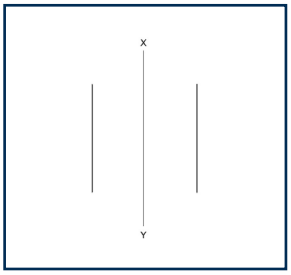
If the line is horizontal in the one view and slanted in the other view - the slanted line is the true length.



If the line is vertical in the one view and presented as a point in the other view - the vertical line is the true length.



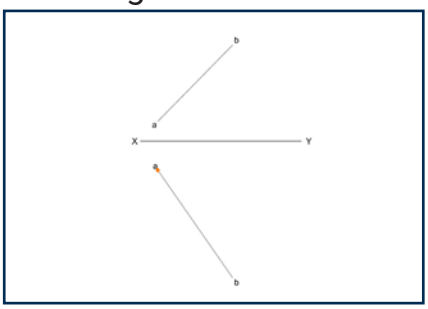
If the line is horizontal in the front and top view - both are true lengths.



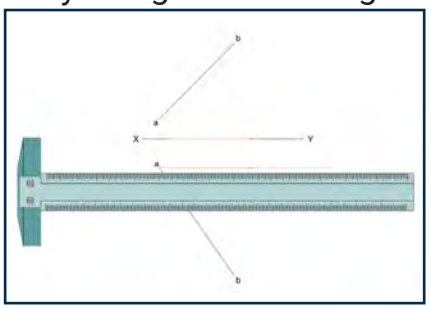
If the line is vertical in the front and side view - both are true lengths.

9.1.2 What if a line is not a true length?

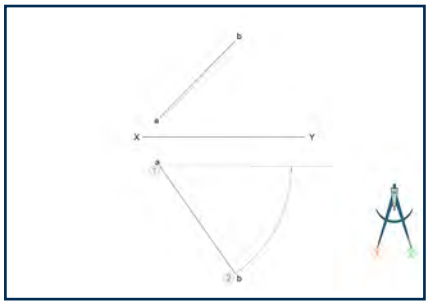
A true length can be determined by using the following method:



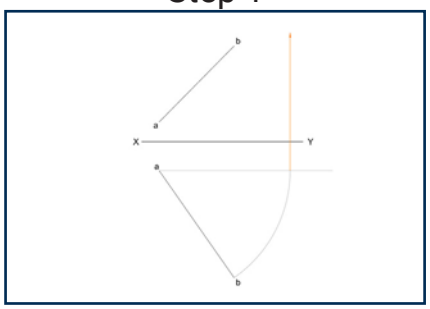
Step 1



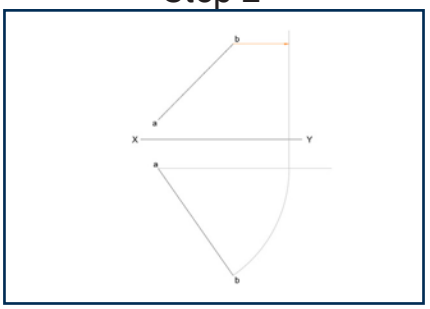
Step 2



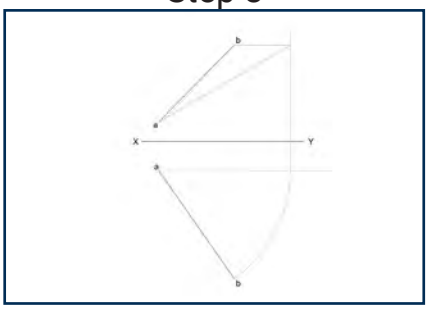
Step 3



Step 4



Step 5



Step 6

Step 1: Choose the end of the line closest to the XY-axis.
Step 2: Draw a construction line, parallel to the XY-axis, through that point.
Step 3: Place your compass at that point and open to the other point of the line. Swing an arc from the line against the construction line.
Step 4: Project the point where the arc and construction line intersect to the other view.
Step 5: Identify which point of the line has been rotated and move the corresponding point in the other view, in line, to touch the projected line.
Step 6: Connect the starting point of the line and the new point - the result is the true length.

9.2 True inclination

A true inclination is only visible and measurable when the line is viewed perpendicularly (90°) to the observer's line of sight. The angle can then be measured with a protractor. When a line is not a true length, the true length must first be determined and the inclination must then be measured with the new true length line.

10. Solid Geometry

Corresponds with

Gr.10 Mod. 9, Gr.11 Mod. 6, Gr.12 Mod. 6

Solid geometry is the study of basic solid geometric shapes, or solids. Solid Geometry is first-angle orthographic views of right regular prisms and pyramids with 3,4, 5, 6 and 8 sides only, as well as cylinders and cones. The axis of the solids may be perpendicular, parallel or inclined to one principle projection plane only. These type of drawings include sectional views and true shapes of the cut surfaces.

GR.10 -12

10.1 Classification of solids

The basic solids can be classified or categorised in different ways however, the main solids are:

- Prisms
- Pyramids
- Cylinders
- Cones

Solids can further be broken down into two additional categories, as given below. These two types of solids can also be combined to create right regular solids.

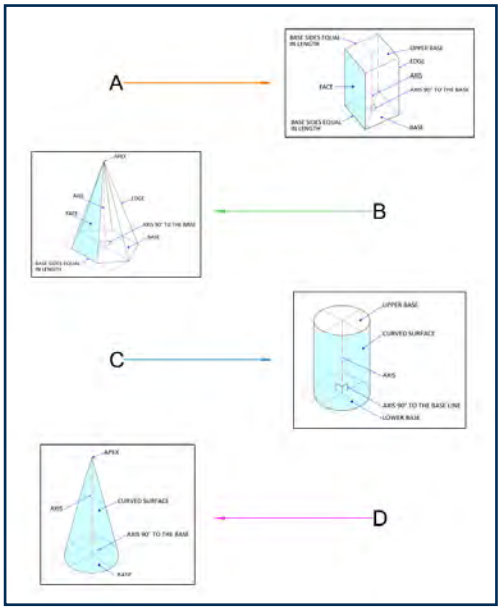
- Right Solids
- Regular Solids

10.1.1 Right regular solids

Right regular solids are the combination of the properties of right solids and regular solids.

- A right solid is a solid where the axis of the solid is perpendicular to and in the centre of its base (the axis divides the solid into two symmetrical halves).
- A regular solid is a solid where only the base sides are equal in length, and the interior angles between the base sides are equal.

10.2 Description of solids classifications



10.2.1 Prism (A)

A prism is a solid with two ends that are identical and parallel to each other. The ends are also known as bases and are joined to each other by three or more right-angled planes called faces. The faces are parallel to the axis of the prism. The axis of the prism is a line, perpendicular from the centre of the lower end to the centre of the upper end of the prism. We can use the shape of the base to name the prism.

10.2.2 Pyramid (B)

There are many types of solid pyramids, and all are named according to the geometrical shape of the base. This means that a pyramid is a solid with a geometrical shape such as a triangle or hexagon for a base, and triangular slanted edges from each corner of the base that converge and join at the apex. The axis of the solid is a line perpendicular from the centre of the base to the apex of the solid.

10.2.3 Cylinder (C)

A cylinder is a solid with a circular (round) upper and lower base which are identical, and two parallel lines connecting the circular bases. The bases are joined to each other by a curved surface. The curved surface is parallel to the axis of the cylinder. The axis of the cylinder is a line perpendicular from the centre of the lower round base to the centre of the upper round base.

10.2.4 Cone (D)

A cone is a solid with a circular base and a single apex with a curved side which tapers to the apex. The axis of the cone is a line perpendicular from the centre of the base to the apex.

10.3 Drawing the orthographic views

GR.10 -12

10.3.1 When drawing solids that are perpendicular and parallel to the projection planes you can use the following methods:

1. Read the question. Check which views must be drawn and whether anything must be sectioned.
2. Plan where the views must be drawn.
3. Transfer the given information. Views that are not sectioned may be drawn in A-type lines. Views that are sectioned must be drawn in C-type lines. Always draw the view that shows the type of prism / pyramid, first.
4. Number the corners, starting with the view that shows the type of prism / pyramid, first. (Pyramids: 1 set of numbers and an apex. Prisms: 2 sets of numbers).

Now you can section:

5. Project the cutting points across to the view that must be sectioned.
6. Follow the numbers in order (create a pattern: top – bottom – sides in between). Identify each line/ corner is intersected by the cutting plane and plot where the projected cutting points intersect with the corresponding lines on the view to be sectioned.
7. Connect the plotted points in A-type lines.
8. Hatch the shape.
9. Determine what remains of the figure. [Rule: EVERYTHING BETWEEN YOU AND THE CUTTING PLANE FALLS AWAY]
10. Everything that remains on the remaining side must be drawn in.
11. Lines that remain and should be drawn through the hatching must be drawn as hidden detail lines.

10.3.2 When drawing solids that are inclined to the projection planes you can use the following methods:

1. Read the question. Check which views must be drawn and whether anything must be sectioned.
2. Plan where the views must be drawn.
3. Transfer the given information. Views that are not sectioned may be drawn in A-type lines. The auxiliary view must be drawn in B-type lines. Always draw the auxiliary view that shows the type of prism / pyramid, first.
4. Number the corners, starting with the auxiliary view that shows the type of prism / pyramid, first. (Pyramids: 1 set of numbers and an apex. Prisms: 2 sets of numbers).

For the first new view that must be added:

5. Project ALL the corners of the figure vertically down (for a top view) or horizontally across (for a side view).
6. Draw a new XY-axis (horizontal for a top view / vertical for a side view) as close as possible to the given view.
7. Measure from the given XY-axis to the corners of the auxiliary view.
8. Plot the distances on the corresponding projected lines, from your new XY-axis. Remember to add the numbers of each point.
9. Connect all the points in numerical order in construction lines.

Now you can section:

10. Project the cutting points across to the view that must be sectioned.
11. Follow the numbers in order (create a pattern: top – bottom – sides in between). Identify each line/ corner is intersected by the cutting plane and plot where the projected cutting points intersect with the corresponding lines on the view to be sectioned.
12. Connect the plotted points in A-type lines.
13. Hatch the shape.
14. Determine what remains of the figure. [Rule: EVERYTHING BETWEEN YOU AND THE CUTTING PLANE FALLS AWAY]
15. Everything that remains on the remaining side must be drawn in.
16. Lines that remain and should be drawn through the hatching must be drawn as hidden detail lines.

GR.11 -12

In Gr.11 and 12, Solid Geometry can include drawings with a combination of two solids next to each other and/or a solid with a hole. When hatching two solids next to each other, the two cut surfaces must be hatched in opposite directions.

10.4 True shape of the cut surface

GR.10 -12

In EGD, the true shape of a cut surface (or section) is the actual, undistorted shape and size of the area exposed by the cutting plane. This true shape is seen only when the cut surface is viewed perpendicularly to the cutting plane. If the viewing direction is at any other angle, the resulting view is not the true shape, which appears foreshortened.
If a question requires you to draw a true shape, you can follow one of the following methods:

10.4.1 Projection method

1. Draw an XY-axis parallel to the cutting plane, where you have open space.
2. Project the cutting points out at 90˚ onto the XY-axis.
3. In one of the sectioned views, measure the distance from the XY-axis to each point of the hatched surface.
4. Plot the distances from the new XY-axis on the corresponding projected cutting-point lines.
5. Connect the plotted points in A-type lines and hatch the shape.

10.4.2 Construction / Rotation method

1. Identify a space where you can draw the true shape.
2. Identify the cutting point closest to the space where you will draw the true shape.
3. Draw a construction line through that point. (Vertical if you are drawing sideways, horizontal if you are drawing up or down).
4. Place your compass on the same point and open it one by one to each of the other cutting points on the cutting plane and swing an arc to your construction line.
5. Project the point where the arcs and the construction line intersect, across to where you will draw (horizontally or vertically).
6. Draw an XY-axis parallel to your construction line.
7. In one of the sectioned views, measure the distance from the XY-axis to each point of the hatched surface.
8. Plot the distances from the new XY-axis on the corresponding projected cutting-point lines.
9. Connect the plotted points in A-type lines and hatch the shape.

11. Civil Drawing

Corresponds with
Gr.10 Mod. 11, Gr.11 Mod. 5, Gr.12 Mod. 3

We use civil drawing in the construction of bridges and large structures such as warehouses, office blocks and houses. The drawings communicate structural and building requirements to the teams that build these structures. The preferred projection system in building (architectural) drawing is first-angle orthographic projection.

11.1 Types of civil drawings

Civil drawings include the following:

- Sketch and Freehand Design Drawings
- Working Drawings, including:
  - * Floorplans
  - * Elevations
  - * Sectional elevations
  - * Site Plans

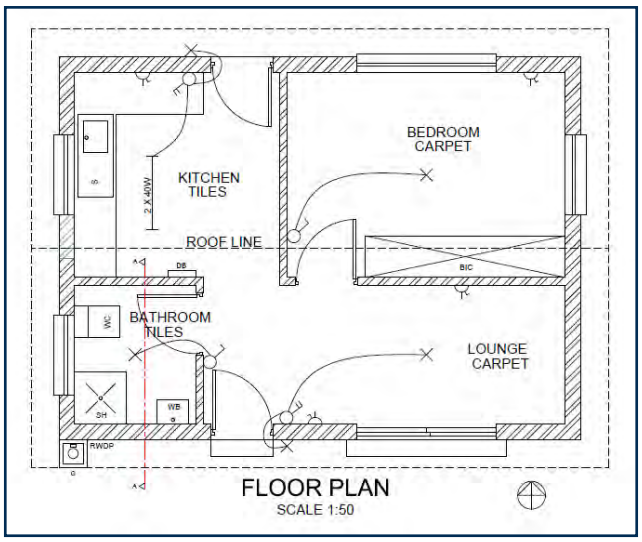
11.1.1 Floor plans

When drawing floor plans we primarily look at the dimensions and the placement of windows, doors and sanitary fixtures, as well as wall thickness. Drawn to scale 1:50.

GR.10 -12

Floor plans show the following detail:

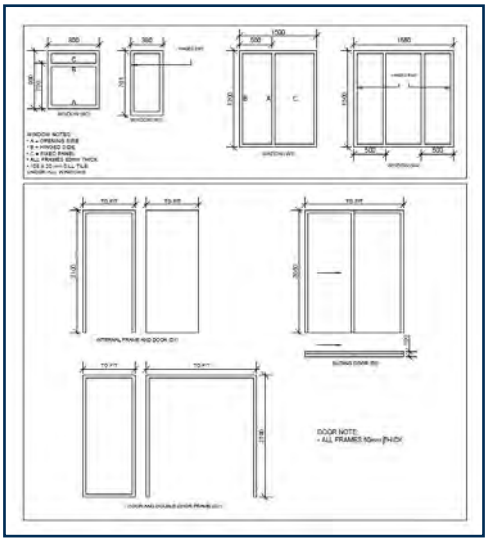
- The thickness of the walls. Load-bearing walls (typically outside walls) are 220 mm thick and non-load-bearing walls (typically inside walls) are 110 mm thick.
- The position and types of windows and doors, including the door swings. You can typically find the window and door types and dimensions in a schedule accompanying the drawing.
- The position, dimension and types of sanitary fixtures.
- Built-in cupboards (BIC).
- Any other information such as floor finishes and steps.
- The position and types of electrical appliances, switches and electrical wiring.



11.1.1.1 Window and door schedules

GR.10 -12

In civil drawing we use component drawings and schedules to communicate information about the components used in the construction of a building. Windows and door schedules are useful as they show the basic sizes and reference numbers for the windows and doors used in the building.



11.1.1.2 Conventions of sanitary fixtures

GR.10 -12

The following table shows the different sanitary fixtures used in civil drawings along with the front and top view conventions. In EGD we only draw sanitary fixtures according to their conventions.

SYMBOLS ON PLAN SIMBOLE OP PLAN Front and top view conventions Voor- en bo-aansig konvensie	COMPUTER SYMBOLS REKENAAR SIMBOLE
BATH / BAD	BATH / BAD
TOILET (WATER CLOSET / SPOELKLOSET)	TOILET (WATER CLOSET / SPOELKLOSET)
DOUBLE SINK / DUBBEL OPWASBAK	DOUBLE SINK / DUBBEL OPWASBAK
BIDET	BIDET
WALL-MOUNTED URINAL MUUR GEMONTEERDE URINAAL	WALL-MOUNTED URINAL MUUR GEMONTEERDE URINAAL

SYMBOLS ON PLAN SIMBOLE OP PLAN Front and top view conventions Voor- en bo-aansig konvensie	COMPUTER SYMBOLS REKENAAR SIMBOLE
BASIN / WASBAK	BASIN / WASBAK
SHOWER / STORT	SHOWER / STORT
SINGLE SINK / ENKEL OPWASBAK	SINGLE SINK / ENKEL OPWASBAK
WASH TUB / WASTROG	WASH TUB / WASTROG
STALL URINAL / BLOK (STAL) URINAAL	STALL URINAL / BLOK (STAL) URINAAL

11.1.1.3 Abbreviations on floor plans

At times, it is more feasible to use abbreviations in civil drawing, rather than printing the whole name of the material, component or equipment used. The symbols are the same in the singular or plural form. Below is a list of commonly used symbols.

GR.10 -12

B - Bath
BIC - Built-in Cupboard
WB - Wash Basin
S - Sink
SH - Shower
WC - Water Closet (Toilet)
U - Urinal
BT - Bidet
NTS - Not to Scale
WT - Wash Trough / Wash Tub
G - Gully
RWDP- Rainwater down-pipe

11.1.1.4 Colour on floor plans (also used on sectional elevations)

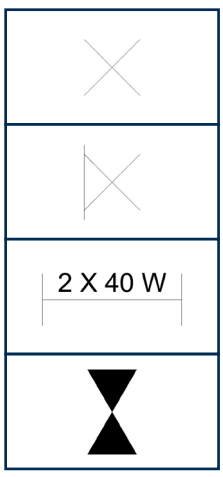
GR.10 -12

National Building Regulations promote the use of the following colours on floor plans:

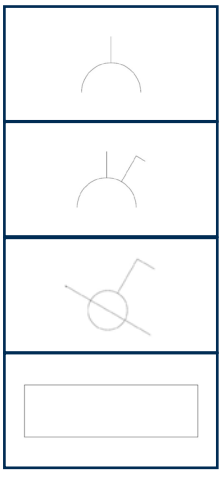
Red - New Masonry
Green - New Concrete
Blue - New Iron or Steel
Yellow - New Wood
Black - New Glass
Grey - Existing Materials (All types)

11.1.1.5 Electricity on floor plans

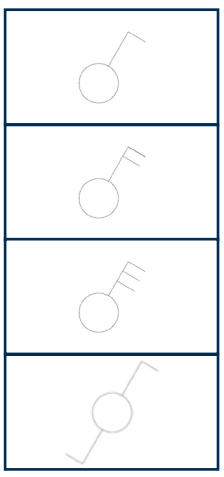
GR.10 -12



Ceiling Light



Socket Outlet



Single-pole one-way switch

Wall-mounted Light

Switched Socket Outlet

Double-pole one-way switch

Fluorescent Light

Regulating Switch

Triple-pole one-way switch

Emergency Light

Distribution Board

Two-way switch

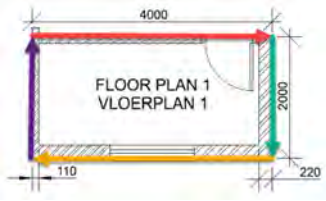
11.1.1.6 Calculating perimeter, total area and floor area

GR.10 -12

When asked to calculate perimeter and area, it is important to note that the answers must always be in metres. When dimensions are given in millimetres, first convert all dimensions to metres by dividing them by 1000. It is also important to note if the question asks for total area or total floor area.

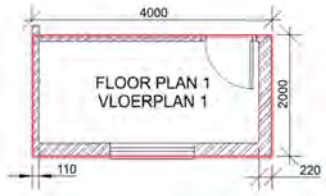
- Perimeter

The perimeter of a floor plan is calculated by adding together the lengths of all the sides on the outside of the building.



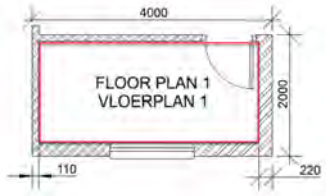
- Total area

The total area of a building is calculated by multiplying the length and width of the building. If the shape is not a rectangle or square, you need to first divide the shape into rectangles and calculate each rectangle separately. Afterwards, add all the answers together for the total area.



- Total floor area

Total floor area is calculated the same as total area but you need to subtract the thickness of the walls from the lengths of the sides, first.



11.1.2 Elevations

GR.11 -12

Elevations (side views) of buildings are added from Gr11, drawn to scale 1:50 and show the following:

- Outer wall detail
- Doors
- Windows
- Steps

GR.12

- Roof configuration, with gutters and rainwater downpipes.

11.1.2.1 Abbreviations on elevations

GR.11 -12

NGL - Natural Ground Level
GL - Ground Level
FFL - Finished Floor Level

11.1.3 Sectional elevations

Sectional elevations show the detail of a section through a wall and the foundation. Sectional elevations include the following:

GR.10 -12

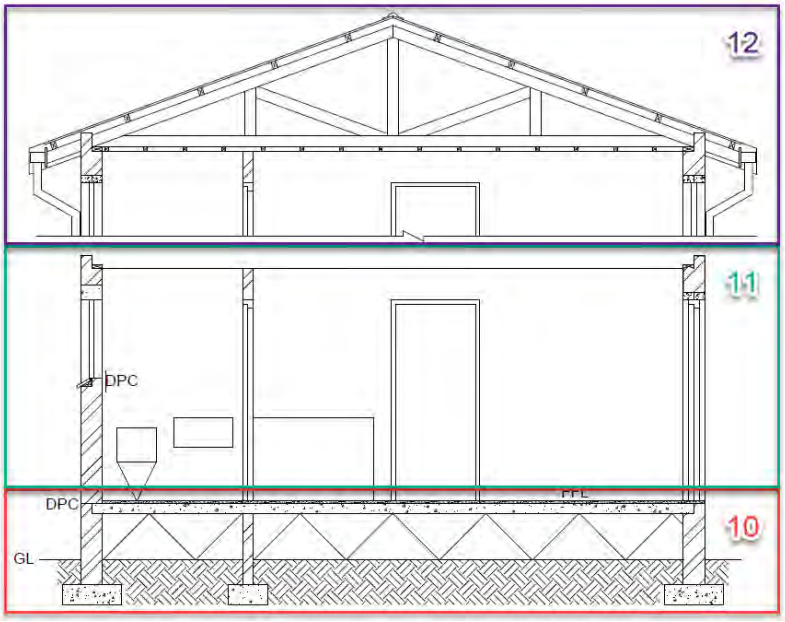
- Foundation
- Earth fill
- Hardcore
- Concrete slab
- Screed
- External and/or internal walls

GR.11 -12

- Section through a window and/or door

GR.12

- Roof detail including wall plates, roof trusses, brandering strips, purlins, roof sheet, ridge plates, fascia boards, barge boards, gutters and rainwater downpipes.



11.1.3.1 Abbreviations on sectional elevations

GR.10 -12

NGL - Natural Ground Level
GL - Ground Level
FFL - Finished Floor Level
DPC - Damp-proof Course

11.1.4 Site plans

GR.10 -12

A site plan is a detailed, scaled map of a property showing existing and proposed improvements, like buildings, landscaping, driveways, and utilities, from a bird's-eye view, serving as a crucial tool for architects, developers, and local authorities to ensure projects comply with zoning and building codes. It illustrates the layout, orientation, and relationship between structures and features, acting as a roadmap for construction and development. Site plans are included as Civil Analytical questions from grade 10 and a working drawing in the PAT, in grade 12.

11.1.4.1 Abbreviations on site plans

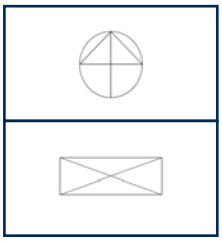
BL - Building Line
G - Gully
IC - Inspection Chamber
IE - Inspection Eye
IP - Inspection Pipe
MH - Man hole
NTS - Not to Scale
RE - Rodding Eye
RWDP- Rainwater down-pipe
ST - Septic Tank
SWD - Stormwater Drain
WP - Water pipe

11.1.4.2 Colour on site plans

National Building Regulations promote the use of the following colours on site plans:

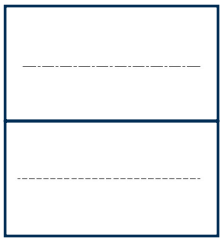
Red - New Proposed Work
Not coloured - Existing Work

11.1.4.3 General features on site plans



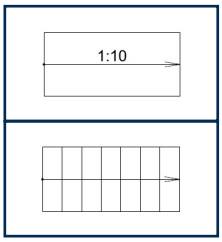
Nortpoint

Built-in Cupboard



Building Line

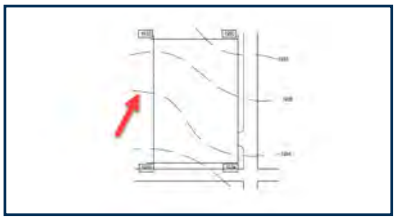
Demolish Structure



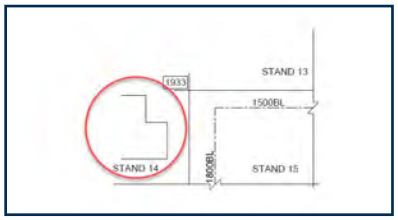
Ramp (Ratio is the inclination)

Steps (Arrow points up)

Corner Heights

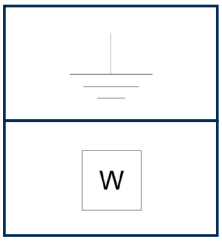


Contour Lines



Adjacent Building

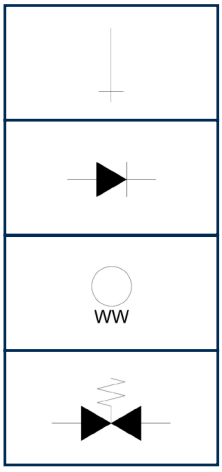
11.1.4.4 Electrical features on site plans



Earth

Electricity Meter

11.1.4.5 Water supply and drainage features on site plans

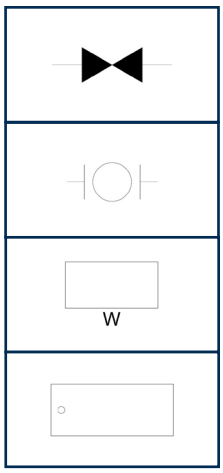


Draw-off Tap

Check Valve

Hot Water Cylinder

Safety Valve

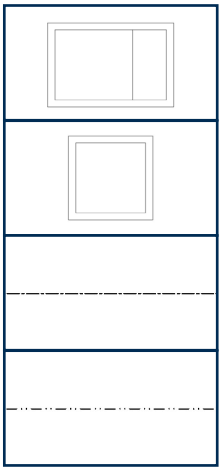


Stop Valve

Water Meter

Water Storage Tank

Water Cistern



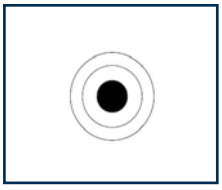
Grease Trap

Gully

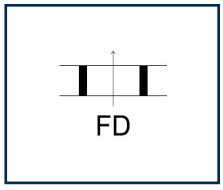
Drainage / Sewerage Line

Stormwater Drain

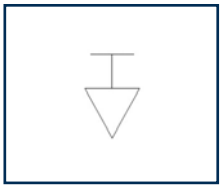
11.1.4.6 Fire protection symbols



Fire Alarm

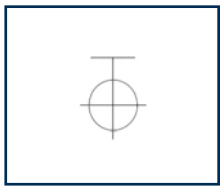


Fire Door

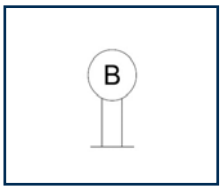


Fire Extinguisher

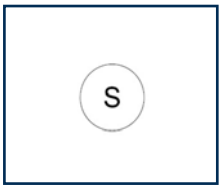
Heat Detector



Hose Cradle with Rubber Hose



Fire Hydrant



Sprinkler

Smoke Detector

Smoke Extractor

12. Perspective Drawing

Corresponds with
Gr.10 Mod. 12, Gr.11 Mod. 4, Gr.12 Mod. 4

Perspective drawing is an artistic technique used to create the illusion of three-dimensional depth on a two-dimensional surface by depicting objects as smaller the further they are from the viewer. Architects and interior designers use this kind of drawing for just this reason, as people may find it difficult to read a working drawing, or to visualise the work drawing in a picture format. In EGD, there are two main types of perspective drawing:

1. One-point perspective
2. Two-point perspective

Regardless of the type, all perspective drawings contain the following features:

PP - Picture Plane: a transparent, two-dimensional plane perpendicular to the observer's line of sight, and between the observer and the object.

HL - Horizon Line: a horizontal line lying within the picture plane at the same height as the 'eye level' of the observer, and parallel to the ground line.

GL - Ground Line: formed at the intersection of the ground plane and picture plane. It is primarily used as a measuring line.

SP - Station Point: the position (point) and orientation from which the observer views an object. The angle of the view, height, and distance from the object and picture plane is critical in determining the final pictorial effect of the perspective drawing.

VP - Vanishing Point: The point of convergence between lines extending from the foreground to the background is called the 'vanishing point'. The vanishing point is always on the horizon line, or 'eye level' of the scene.

12.1 One-point perspective

GR.10 -12

In Grade 10 we focus on one-point perspective drawing although the knowledge and skills are also applied in Grade 11 and 12. One-point perspective is often used for compositions that look at objects from the front. When you place an object parallel to the picture plane, one vanishing point is required to draw a perspective drawing. Follow these steps when drawing a one-point perspective drawing:

Step 1. Determine the vanishing point. Project the SP vertically upwards to intersect with the HL. Clearly indicate this intersection and label it VP.

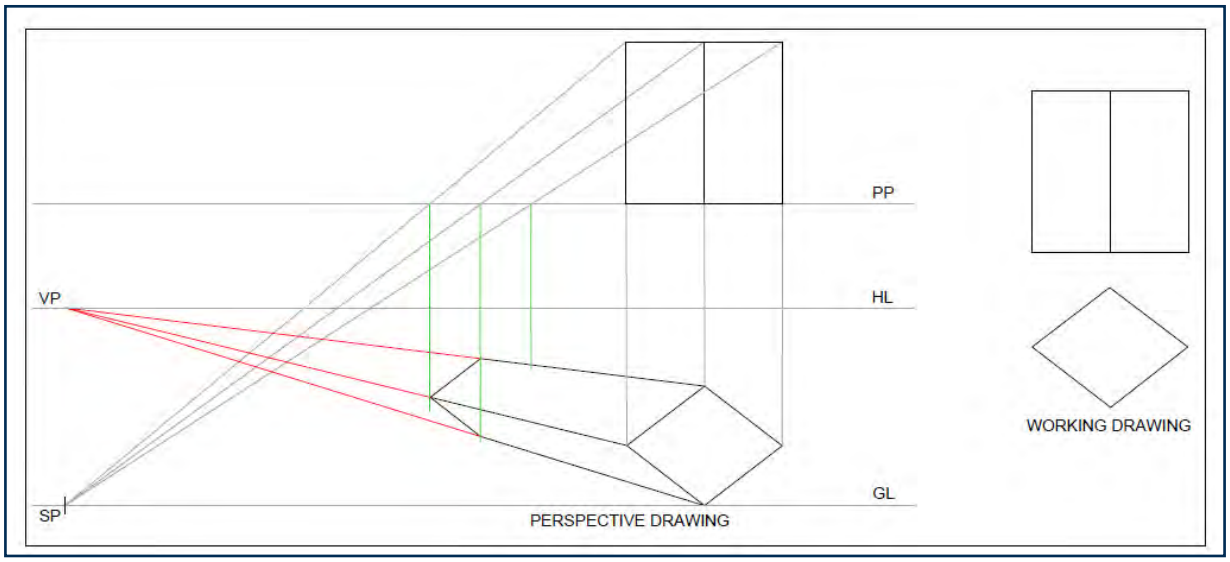
Step 2. Redraw the front view in its correct position in C-type lines. Project the corners from the top view, vertically down and the heights from the front view, horizontally across to draw the front view in construction directly underneath the top view.

Step 3. Draw any part of the figure that is touching the PP, in A-type lines.

Step 4. Project the corners of the new front view to the VP.

Step 5. Project the corners of the top view, in line with the SP, until it touches the PP and then vertically down.

Step 6. Identify where the corresponding lines from the top view and the vanishing lines intersect. Plot the points and complete the figure in A-type lines.



12.2 Two-point perspective

GR.11 -12

Two-point perspective is often used for compositions that look at objects from the corner. Lines extending from the foreground to the background converge at two points. The points of convergence is called the 'vanishing points'. The vanishing points is always on the horizon line, or 'eye level' of the scene. Follow these steps when drawing a two-point perspective drawing:

Step 1. Determine the angle of the top view. Identify if the top view is rotated to a 45° or 30°/60° angle.

Step 2. Determine the VPs. Using the same angle as the top view (must be parallel to the sides of the top view), project construction lines from the SP to the PP (preferably, only draw a short line over the PP and not all the way through). Project a line vertically down to the HL where the angle line intersects the PP.

Step 3. Divide the drawing into different parts and choose a part to start with. Draw the height line for the part you want to draw, where that part touches the PP. If the part does not touch the PP, extend the front of the part, on the same angle as the top view, to touch the PP.

Step 4. Project the heights of the part horizontally from the side view to the height line.

Step 5. Project the height points where the heights and height line intersect, to the VPs. It only needs to projected to the VP on the same side as the part that you are drawing.

Step 6. Project the corners of the top view, in line with the SP, until it touches the PP and then vertically down.

Step 7. Identify where the corresponding lines from the top view and the vanishing lines intersect. Plot the points and complete the figure in A-type lines.

Step 8. Repeat step 3 to 7 for each part of the drawing until complete.

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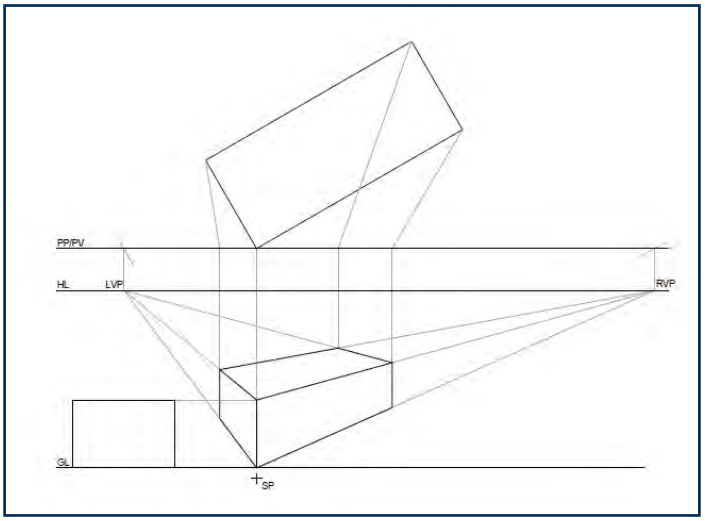


12.2.1 Circles in perspective

GR.12

Perspective drawing can include full, half and quarter circles. The circles can be visible in the top view or visible in the side / front view.

12.2.1.1 Circles visible in the top view

Note: the following steps are relevant specifically to the circles and do not include the steps prior to starting the circle.

Step 1. Divide the circle into sections (12 for a full circle, 6 for a half and 3 for a quarter). Project the divisions to the line used for the height line, according to the same angle as the top view.

Step 2. Project the division points on the line, in line with the SP, until it touches the PP and then vertically down.

Step 3. Project the points where the lines projected in the previous step, intersect the vanishing line, to the VPs.

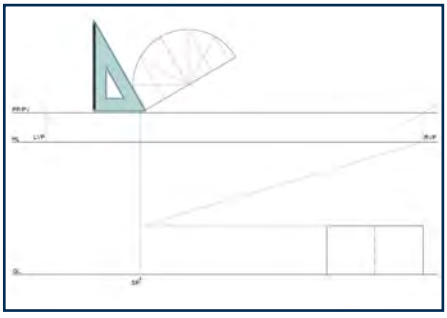
Step 4. Project the division points on the edge of the circle in the top view, in line with the SP, until it touches the PP and then vertically down.

Step 5. Identify where the corresponding lines from the top view and the vanishing lines intersect and plot the points.

Step 6. Complete the top of the circular shape in A-type lines.

Step 7. Repeat step 2 to 5 for the bottom of the circular shape. Only project the points that will be visible.

Step 8. Complete the visible part of the bottom of the circular shape in A-type lines.



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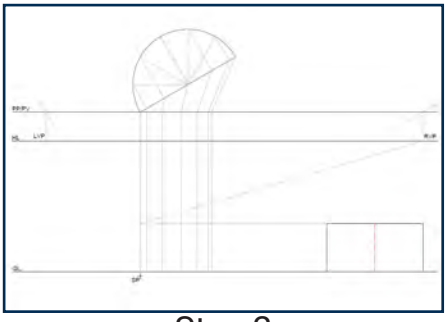

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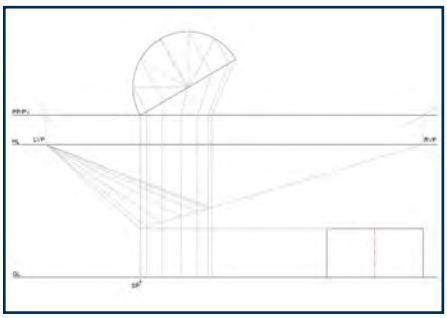

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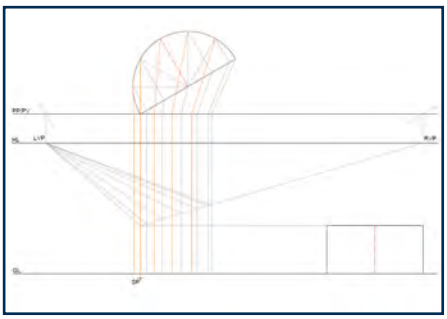

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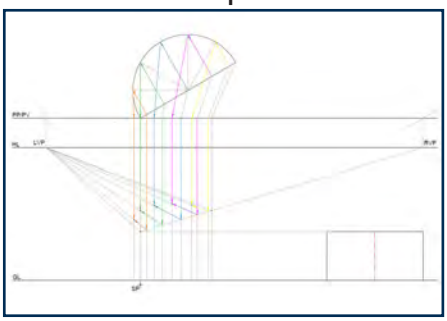

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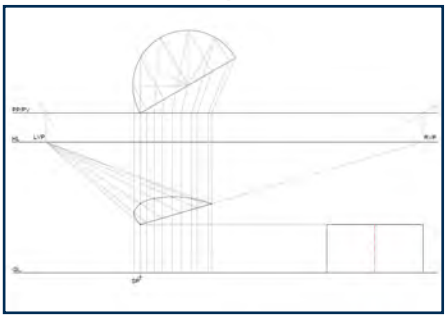

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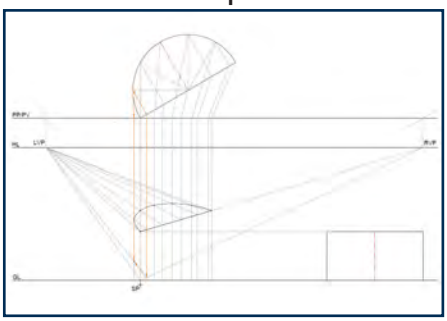

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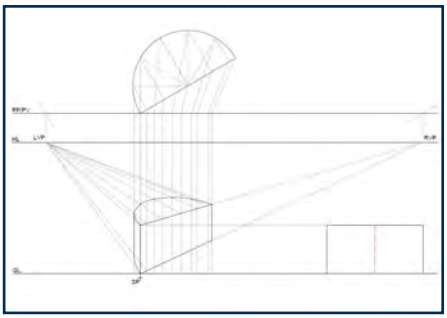
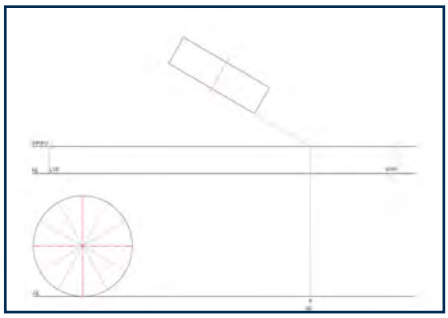


Step 8

12.2.1.2 Circles visible in the side / front view

Note: the following steps are relevant specifically to the circles and do not include the steps prior to starting the circle.

Step 1. Divide the circle into sections (12 for a full circle, 6 for a half and 3 for a quarter).
Step 2. Project the division heights to the height line.
Step 3. Project the height points where the heights and height line intersect, to the VPs.
Step 4. Draw an auxiliary view circle for the top view and divide into six sections. Project the sections to the front of the top view.
Step 5. Project the front division points on the top view, in line with the SP, until it touches the PP and then vertically down.
Step 6. Identify where the corresponding lines from the top view and the vanishing lines intersect and plot the points.
Step 7. Complete the front of the circular shape in A-type lines.
Step 8. Project the back division points on the top view, in line with the SP, until it touches the PP and then vertically down.
Step 9. Identify where the corresponding lines from the top view and the vanishing lines intersect and plot the points.
Step 10. Complete the back of the circular shape in A-type lines.



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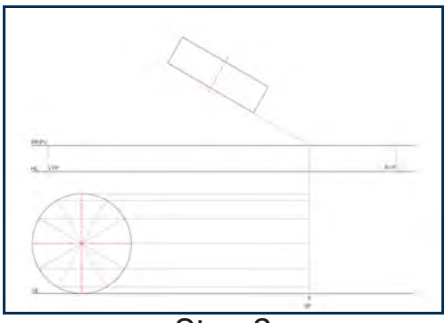

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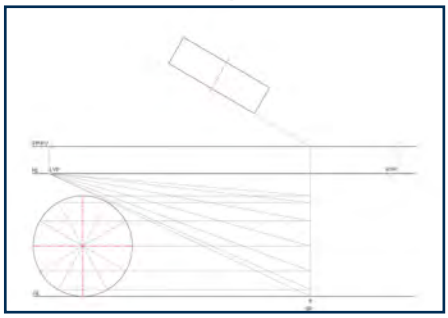

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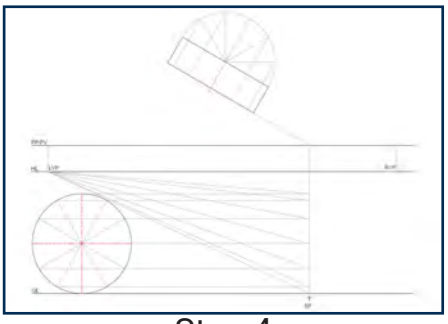

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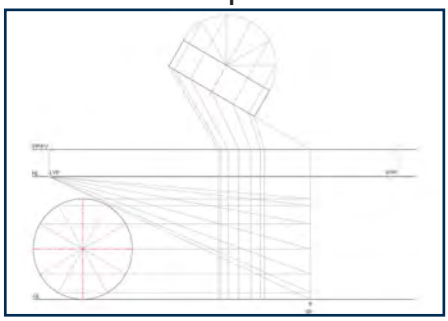

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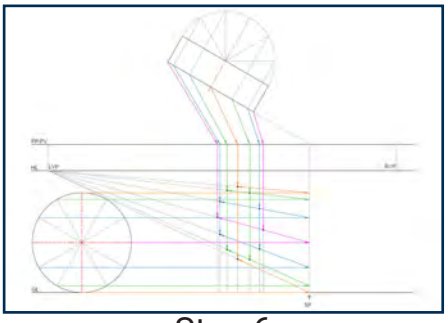

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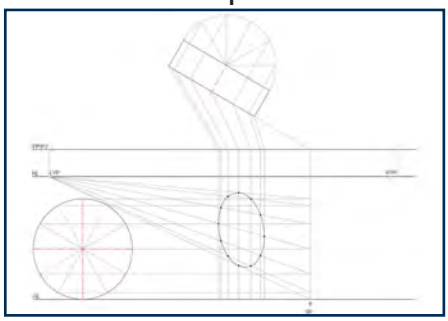

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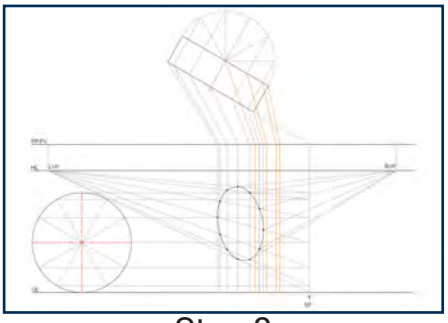

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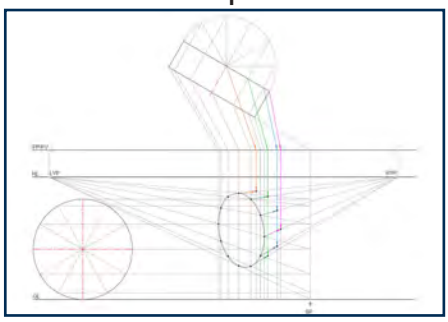

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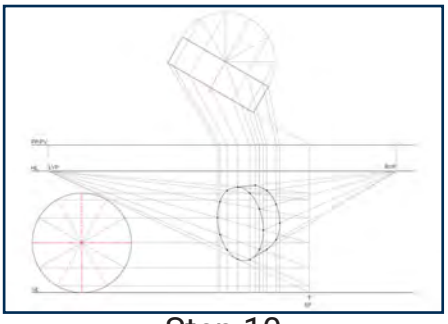


Step 10

13. Interpenetration and Development

Corresponds with
Gr.11 Mod. 7, Gr.12 Mod. 7

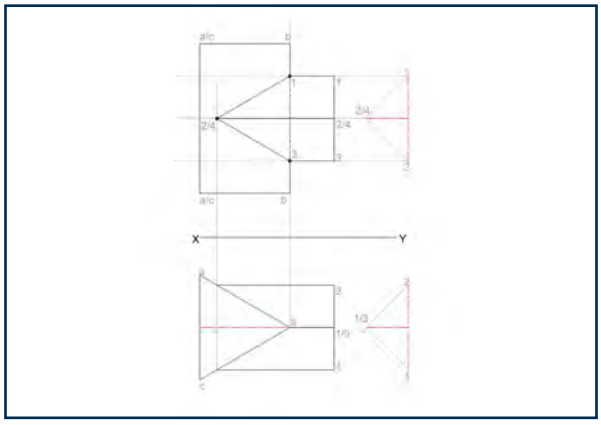
GR.11 -12

Interpenetration and development refers to two or more prisms or prismatic pipes that intersect each other on a 90° angle or an incline. This is common in ductwork, piping systems, and mechanical assemblies. Understanding this helps in accurately drawing the development (unfolded shape) of each object.

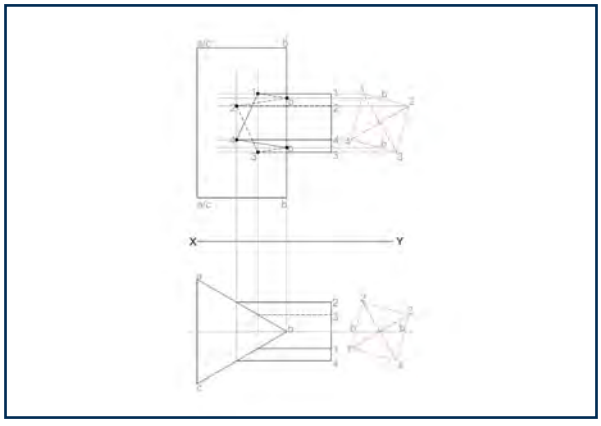
Purpose of Interpenetration and development
- Visualize how shapes fit together.
- Create accurate flat patterns for manufacturing.
- Interpret 3D problems and convert them into 2D developments.

13.1 Interpenetration

When two or more solids intersect, the curve formed where they meet is called the curve of interpenetration. In Grade 11 the pipes/ prisms intersect each other symmetrically which results in a symmetrical curve of interpenetration.

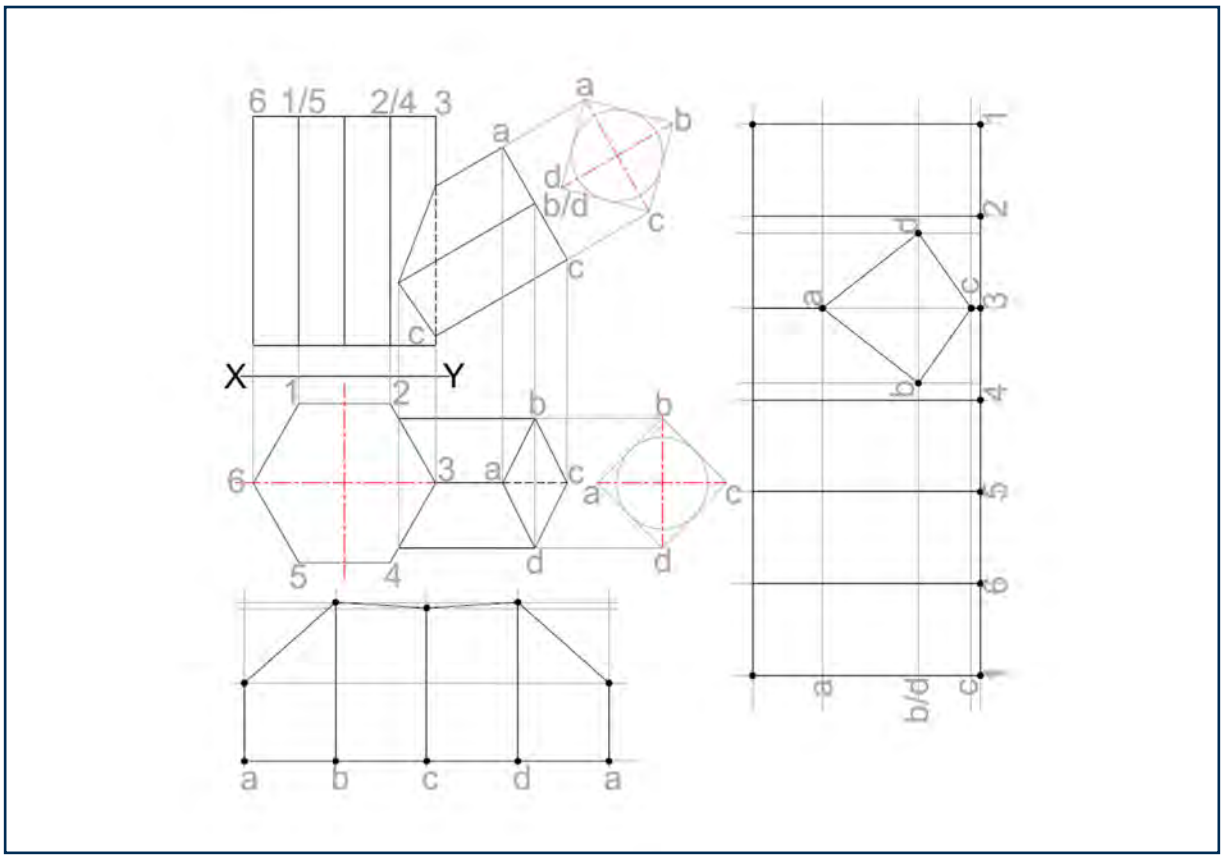


In Grade 12 the pipes/ prisms can be rotated and thus not intersect symmetrically resulting in a non-symmetrical curve of interpenetration. The back of the curve is then drawn in hidden detail.



13.2 Development

A development is the flat pattern you would get if you "unfold" a 3D object along its surfaces. These are especially useful in industries like sheet metal, packaging, and construction.



Key concepts to remember:

1. Use auxiliary views to determine the curve of interpenetration.
2. Project points from the intersecting solids accurately.
3. Transfer these points to the development using construction.
4. Neatness and precision are essential.

14. Loci (Cam)

Corresponds with
Gr.11 Mod. 8, Gr.12 Mod. 8

GR.11 -12

Loci (plural of locus) refers to the path or movement of a point following a specific rule. In mechanical systems, cams are devices used to convert rotary motion into reciprocating or oscillating motion. In this topic, we explore how the follower moves as the cam rotates.

14.1 Components of loci (cam)

A complete Loci of Cam drawing typically includes the following three components:

- **The camshaft**

This is the axis about which the cam rotates. It is usually located at the centre of the cam's circular motion and is drawn as a fixed point in the construction. The camshaft enables the rotary motion of the cam.

- **The follower**

The follower is the part that rests on and moves with the cam profile. Depending on the cam shape and follower type, it follows a distinct path. The type of follower influences how the follower reacts to the cam's motion.

- **The displacement graph**

The displacement graph (also called a displacement diagram) shows how far the follower moves vertically (displacement) over one full rotation of the cam (usually 360°). This graph defines the exact motion of the follower, including:

- Rise – the follower moves up.
- Dwell – the follower stays at the same height.
- Fall – the follower moves down.

The shape of the graph determines how smoothly the follower moves. In essence, the displacement graph is a timeline of the cam's movement and is essential for accurate follower motion plotting.

14.2 Types of cams

- **Circular cam with eccentric centre**

The centre of the circle is offset from the camshaft centre. The follower rises and falls in a smooth sinusoidal motion.

- **Pear-shaped cam**

Designed to allow dwell (no movement) for part of the rotation. The follower moves up and down sharply during the active region.

- **Snail cam**

Has a slow rise followed by a sudden drop. Only rotates in one direction, often used in presses.

- **Heart cam**

Provides uniform acceleration and deceleration. Used where consistent return motion is needed.

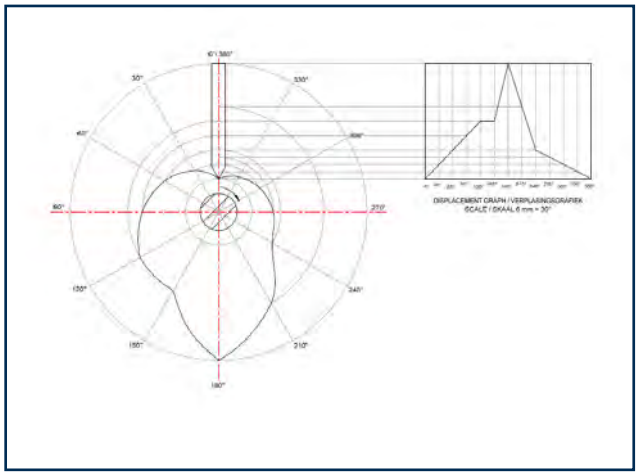
14.3 Types of followers

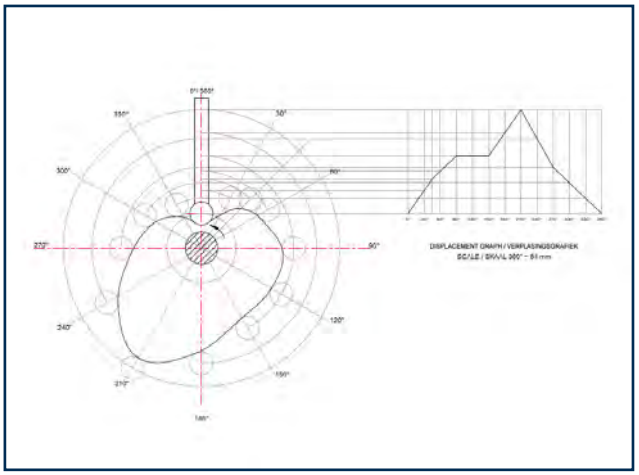
- **Wedge-shaped follower**

Thin point contact, not ideal for real-world use.

- **Roller follower**

A small wheel rolls on the cam surface, reducing friction.



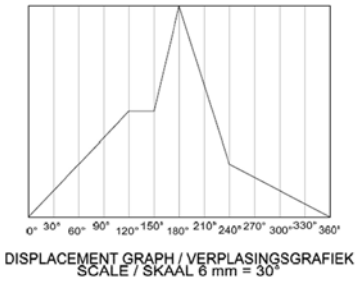


14.4 Displacement graph

The shape of the graph determines how smoothly the follower moves.

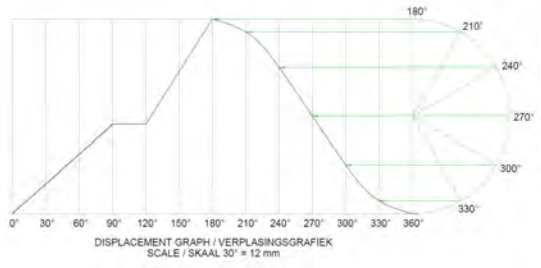
GR.11 -12

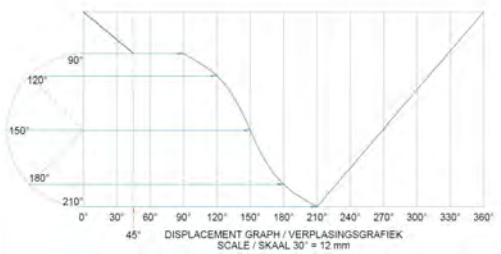
In grade 11 loci (cams) are only drawn with a uniform motion (straight line).



GR.12

In grade 12 loci (cams) are drawn also using simple harmonic motion and uniform acceleration and retardation.





15. Loci (Mechanism)

Corresponds with
Gr.12 Mod. 9

GR.12

A loci (mechanism) refers to tracing the path (locus) of a specific point on a moving mechanical component (like a crank or piston) as the mechanism operates, revealing geometric shapes (circles, arcs, lines, curves) that define its movement for design, analysis, and construction using tools like compasses and rulers.

15.1 Common types of mechanisms

- Cranks
- Gears
- Wheels and arms
- Sliders or gliders
- Eccentric mechanisms
- Link mechanisms (four-bar mechanisms / systems)
- Extension or rotating arms

15.2 Components of a loci (mechanism) question

- A basic setup showing fixed points, rotating rods, or arms.
- You must draw the path or locus of a specific point as the mechanism moves.
- The path is usually circular, arched, linear, or a specific curve.

15.3 Parts found in a mechanism

- Rotating cranks: a crank is a rotating arm that converts circular motion into reciprocating (back-and-forth) motion, or vice-versa, typically via a connecting rod, forming the core of devices like engines or shapers.
- Rotating gears: a gear is defined as a toothed wheel that engages with other components (such as another gear, a rack, or a worm) to transmit rotational motion, force, and torque.
- Rod: a rod is a rigid link (or component) that connects other parts, such cranks or sliding pistons, by means of pin joints or sliding fits.
- Fixed point (Pivot): The point around which a rod rotates.
- Rotating arm: A rod that moves around a fixed point.
- Gliding rod / slider: A glider (also known as a slider or piston) is the component that is constrained to move back and forth in a straight line within a fixed guide, slot, or rail.

15.4 Motions used in a mechanism

- Rotary Motion: Movement in a complete circle around a fixed axis or pivot point. An example is a car's engine crankshaft or a spinning wheel.

- Linear Motion: Movement in a single, straight line, in one direction. A train moving along a straight track is an example.
- Reciprocating motion: A repeated straight-line motion that moves back and forth or up and down.
- Oscillating motion: A curved or arc-shaped movement that swings back and forth on an axis or pivot point, without completing a full circle. A clock pendulum or a swing is an example.

15.5 Process for drawing a loci (mechanism)

- Draw the schematic diagram of the mechanisms. Remember to label the points.
- Identify the condition: Determine the specific point and the fixed distances (link lengths) within the mechanism.
- Divide rotating parts: Divide circles that can rotate into 12 equal sections and label.
- Plot positions: Move the mechanism in small increments, marking the changing positions of the point of interest.
- Connect the points: Connect these marked points to form the locus curve, revealing the component's path.