



BASIC TECHNICAL DRAWING

Teacher Guide

Grade 12

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Foreword

Education and development are closely related endeavours. This is the main reason why it is said that education is the key instrument in Ethiopia's development. The fast and globalised world we now live in requires new knowledge, skills, attitudes and values on the part of each individual. It is with this objective that the curriculum, which is a reflection of a country's education system, must be responsive to changing conditions.

It is more than fifteen years since Ethiopia launched and implemented the *Education and Training Policy*. Since then our country has made remarkable progress in terms of access, equity and relevance. Vigorous efforts also have been made, and continue to be made, to improve the quality of education.

To continue this progress, the Ministry of Education has developed a Framework for Curriculum Development. The Framework covers all pre-primary, primary, general secondary and preparatory subjects and grades. It aims to reinforce the basic tenets and principles outlined in the *Education and Training Policy*, and provides guidance on the preparation of all subsequent curriculum materials – including this teacher guide and the student textbooks that come with it – to be based on active-learning methods and a competency-based approach.

Publication of a new Framework and revised textbooks and teacher guides are not the sole solution to improving the quality of education in any country. Continued improvement calls for the efforts of all stakeholders. The teacher's role must become more flexible ranging from lecturer to motivator, guide and facilitator. To assist this, teachers have been given, and will continue to receive, training on the strategies suggested in the Framework and in this teacher guide.

Teachers are urged read this guide carefully and to support their students by putting into action the strategies and activities suggested in it. The guide includes possible answers for the review questions at the end of each unit in the student textbook, but these answers should not bar the students from looking for alternative answers. What is required is that the students are able to come up with, and explain knowledgeably, their own possible answers to the questions in the textbook.

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UNIT 1

SKETCHING AND VISUALIZATION

Total Periods: 5

Unit Outcome

At the end of this unit, students should be able to:

- ✓ Understand basic principles and techniques of free-hand sketching.
- ✓ Know how sketching integrates into the design process.
- ✓ Apply the sketching techniques in the initial phases of design and product development.
- ✓ Appreciate the importance of free-hand sketching help to put idea on paper.

Unit Overview

Sketching is a fast form of graphical communication that helps organize thoughts, generate ideas, record dimensions, and transfer information from place to place. Ideas, designs, and manufacturing/construction procedures/techniques are communicated by words, numbers, and visual images. Sketching is a free-form exercise to develop geometric size, shapes, and features for a specific design idea. It is the beginning phase of a more concerted effort to fix the final geometric parameters and constraints that will ultimately define a design.

Therefore this topic introduces students to freehand sketching, giving them the knowledge necessary to formulate, express, and record ideas and objects in the form of sketches. Students will also be exposed to works of visual arts such as perspectives.

Lesson 1.1 *Principles of sketching*

Number of Period: 1

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ describe the use and application of free- hand sketching;
- ✓ Describe how sketching integrate into the design process;
- ✓ Identify free-hand sketching materials;
- ✓ use free-hand sketching materials properly.

Planning ahead

This lesson is to introduce students to the techniques of sketching through demonstration, and handouts, the students will learn the beginning principles for techniques in sketching.

Give an overview on technical drawing plus a purpose of sketching. Therefore the teacher should get himself ready by:

1. Preparing visual aids to show “examples of free-hand drawings”
2. Reviewing essential questions, “why are the uses of free-hand sketching in a design process?”
3. Practicing the three materials required for freehand sketching and developing a skill how to use them for sketching if you were not practicing free-hand sketching before.

Hints for Teaching

Sketching is a necessary part of drafting because the drafter in industry frequently sketches ideas and designs prior to making the drawing. Therefore the suggested instructional strategies are:

1. You can start the class by inviting students in text question/brain storming question about free hand sketching they did and how they did it.
2. Conduct class discussions by comparing instruments drawing with free-hand sketching; the importance of sketching and how organizing one's ideas through sketching.
3. Display and discuss examples of sketches (student and professional). Have students keep sketch ideas in a notebook.
4. Allow students to practice on check point 1.1.

Teaching Notes

The ability to sketch ideas is not only important to engineers it is absolutely essential. Even if an engineer was stranded alone on an island, the ability to sketch would help to work out details in ideas and help to identify potential problems. Sketching does NOT require any artistic ability. Once one is made aware of the basic techniques, it is no longer the "ability to draw" that will limit his/her sketches. But rather, the limitation is one's "ability to think through the details of their design." In industry sketching is used to quickly document rough ideas and identify general needs for improvement. Technical drawing would be employed only for those ideas deserving a permanent record. Sketches are composed of the same basic information, but there is a tradeoff between times required to generate it verses the level of design detail (and accuracy). The basics of sketching can be learned in a single sitting. However, it

will take considerable practice to achieve the fluency that really facilitates team discussions in the future. Don't be surprised if those who are new to sketching actually enjoy working on sketching assignments. It is an easy area for most students to achieve in.

Lesson 1.2 *Sketching Techniques*

Number of Periods: 3

(1 period theory and 2 periods for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ sketch a line in free hand;
- ✓ Sketch different types of lines, areas, angles, circles, and arcs by applying sketching techniques;
- ✓ Lay out a sketch using proportion;
- ✓ sketch multi-view drawing of 3D objects;

Planning ahead

In advance you should prepare to describe and demonstrate the students on the techniques/procedures for: sketching straight lines, sketching long lines, finding the midpoint of a line, the four methods of drawing a circle and maintaining proportion.

Given instruction and sample problems, the student will implement sketching procedures and demonstrate the skills and techniques essential to creating art products such as perspective drawings, to the satisfaction of the instructor.

Teacher uses one period for theoretical concept and demonstration about Sketching techniques. In addition two periods for student practice on activities and check points.

Hints for Teaching

Insist the students to make a sketch before making any kind of instrumental drawing all the time because free-hand sketching transfer ideas in clear, concise way. Encourage students to practice as “sketching is a personal skill which everyone can improve.”

Therefore the suggested instructional strategies are:

1. You can start the class by inviting students in text question about Techniques of free hand sketching.
2. Conduct class discussions on verbal versus graphic language on the sketching technique and on organizing one's ideas through sketching.
3. Provide sketching activities 1.1 & 1.2 and check points from 1.2 up to 1.10 to students.

Teaching Notes

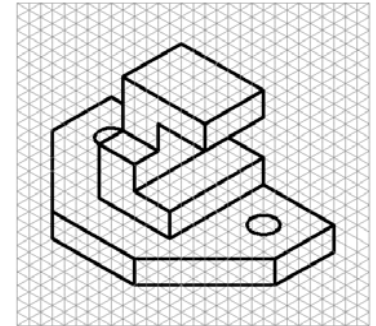
Construction lines and points will improve the appearance of freehand circles. It takes only a few seconds to block in horizontal, vertical and 45 degree points shown. These points help when sketching the arcs for the circle. Note that the edge of a piece of paper may be used as a gage for measuring points on a circle and the final shape is sketched by pressing down hard on the pencil to create a smooth block outline.

Activities

Drafting I - Construct a Multi-view Sketch

Requirements: Each student is required to create a simple multi-view sketch.

1. Using only pencil, eraser, and the paper provided by your instructor sketch a MULTI-VIEW sketch of the object whose pictorial is given below.
2. The sketch should be done at a scale of 1:1 (full size) using the measurements provided.
3. Use accepted drafting standards for lines and freehand lettering.
4. Letter your name, scale, and date in the title block.
5. Time Limit = 40 minutes.
6. Your sketch should reflect an understanding of the object's shape and features as determined from the pictorial. Other areas of evaluation will include the accuracy of your measurements, and the quality of your line work and lettering.



Assessment: The multi-view sketch should be evaluated based on the following criteria:

Concepts and principles of orthographic projection	50 points
Measurements	20 points
Lines	20 points
Lettering	5 points
Layout & balance	5 points

Lesson 1.3 *Pictorial Sketching Techniques*

Number of Periods: 3

(1 period theory and 2 periods for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ create an isometric sketch of an object;
- ✓ create an oblique sketch an object;
- ✓ create a one-point perspective sketch;
- ✓ prepare a free-hand sketch of any 3D objects in three types of pictorial drawing.

Planning ahead

Teacher Preparation

Given a presentation and pictorial sketching, the student will demonstrate skill in using sketching solutions for problem assignments, with a degree of accuracy and completeness acceptable to the instructor.

Teacher uses one period for theoretical concept and demonstration about pictorial sketching and techniques. In addition two periods for student practice on activities and check points. Therefore the suggested instructional preparations are;

1. Gather some simple objects that have varying features on each side (like video cassette tapes, stapler, etc.) and produce reasonably accurate orthographic projections for at least one of the objects.
2. Prepare isometric sketches of objects composed of basic shapes (rectangles and circles) that will be used to practice orthographic projection sketching.

3. Prepare isometric and orthographic graphing paper appropriately scaled for the objects that you have chosen.

Hints for Teaching

You can start the class by inviting students in text question about Techniques for pictorial free hand sketching.

Without any introduction to technical sketching guidelines, have the students sketch one of your selected objects "with enough detail that someone else can make a similar object." Compare their sketches to a detailed technical sketch (that describes features on every side, has basic dimensions, and includes basic material descriptions). Explain the basic rules of orthographic sketching using a few examples. Then allow the students to practice in small groups. Explain the basic rules of isometric sketching using a few examples. Then allow the students to practice in small groups. Allow the students to work together to answer questions about a real part based on dimensioned sketches (or drawings) of the part. Therefore suggested instructional strategy is to have students' complete two- and three-dimensional sketches (isometric, oblique, perspective and orthographic). Provide pictorial sketching check points from 1.11 up to 1.14 to students.

Teaching Notes

Orthographic Projection is a generally accepted convention for representing 3D objects using multiple 2D views of the front, top, bottom, back, and sides of the object. In practice, the minimal number of views possible is used to describe all the details of the object. Usually, the Front View, Top View, and a single Side View are sufficient and are oriented on the paper according to accepted convention. Isometric Projection attempts to represent 3D objects

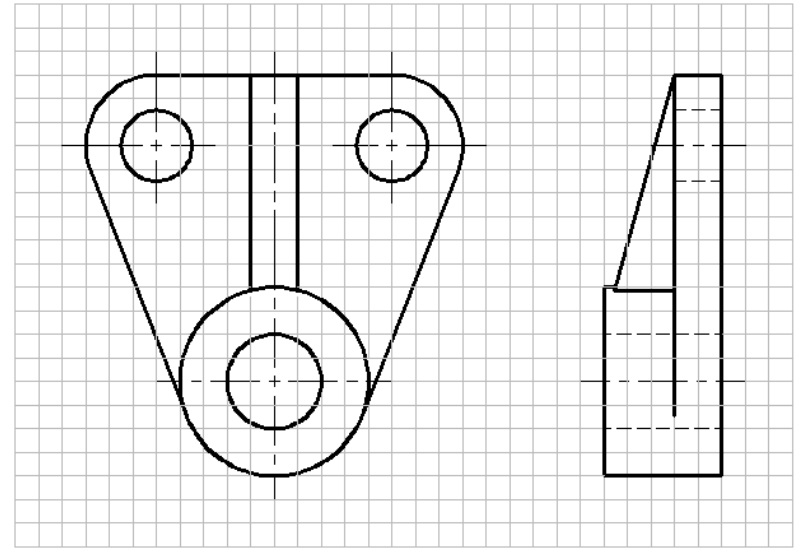
using a single view. Instead of the observer viewing the object perpendicular to the object, the object is rotated both horizontally and vertically relative to the observer.

There are rules and conventions to guide the creation of both types of projections. Additionally, either of them can be supplemented with various types of dimensions. Whether sketching or drawing, the goal is the same. The goal is to communicate the necessary detail to the intended audience.

Drafting I - Construct an Oblique Sketch

Requirements: Each student is required to create a simple oblique pictorial sketch.

1. Using only pencil, eraser, and the paper provided by your instructor, sketch a **CAVALIER OBLIQUE** pictorial (using a receding axis angle specified by your instructor) of the object whose orthographic views are given below.
2. The drawing should be done at a scale of 1:1. One square grid equals one oblique grid.
3. Use accepted drafting standards for lines and freehand lettering.
4. Letter your name, scale, and date in the title block.
5. Do **NOT** include any hidden lines on your oblique sketch.
6. Time Limit = 40 minutes.
7. An effort should be made to create a balanced appearance of the sketch on the paper provided.
8. Your sketch should reflect an understanding of the object's shape and features as determined from the orthographic views. Other areas of evaluation will include the accuracy of your measurements, and the quality of your line work and lettering.

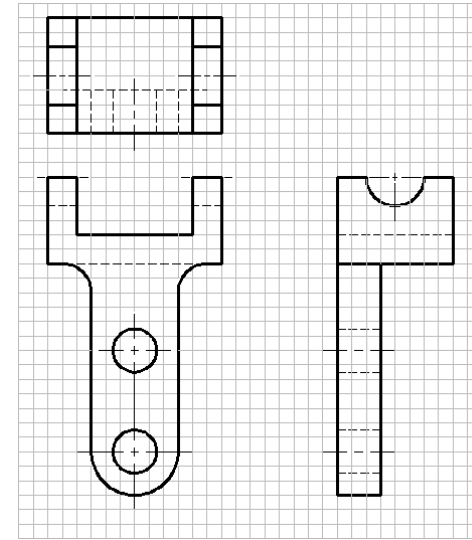


Drafting II - Construct an Isometric Sketch

Requirements: Each student is required to create a simple isometric pictorial sketch.

1. Using only pencil, eraser, and isometric grid paper sketch an **ISOMETRIC** pictorial of the object whose views are given on the next page.
2. The sketch should be done at a scale of 1:1. One square grid equals one isometric grid.
3. Use accepted drafting standards for lines and freehand lettering.
4. Letter your name, scale, and date in the title block.
5. Do **NOT** include any hidden lines on your isometric sketch.
6. Time Limit = 40 minutes.
7. An effort should be made to create a balanced appearance of the sketch on the paper provided.
8. Your sketch should reflect an understanding of the object's shape and features as determined from the orthographic views.

Other areas of evaluation will include the accuracy of your measurements, and the quality of your line work/lettering.



Assessment: The isometric sketch should be evaluated based on the following criteria:

Concepts and principles of isometric sketches	50 points
Accuracy	25 points
Line weight, technique, and neatness	20 points
Lettering	5 points

Lesson Guide

Period	Lesson title	Starter activity	Main activities	Concluding activities
1	1.1 Principle of sketching	<ul style="list-style-type: none"> Ask brain storming question about sketching from the textbook. 	<ul style="list-style-type: none"> Discuss and demonstrate the principle and material used in sketching Let the students to practice on check point 1.1. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook
2	1.2 Sketching techniques	<ul style="list-style-type: none"> Ask brain storming question about sketching from the textbook. 	<ul style="list-style-type: none"> Discuss and demonstrate the techniques of sketching on line, angle, circle and Multi-view drawing Let the students to practice activities 1.1 & 1.2 and check point 1.2 up to 1.10. Help to do activity of the teachers guide 	<ul style="list-style-type: none"> Individually practice sketching techniques guided by the teacher. (Teacher acts as facilitator.) Give home work to do exercises from the textbook
2	1.3 Pictorial sketching techniques	<ul style="list-style-type: none"> Ask brain storming question about sketching from the textbook. 	<ul style="list-style-type: none"> Discuss and demonstrate the techniques of sketching on pictorial sketching Let the students to practice on check point 1.11 up to 1.14. Help to do activities of the teachers guide 	<ul style="list-style-type: none"> Individually practice sketching techniques guided by the teacher. (Teacher acts as facilitator.) Give home work to do exercises from the textbook

Method

- Discussion and Demonstration
- Group discussion (6-8 students per a group)
- Individual practice

Assessments

The teacher should follow and assess each student's work continuously over the whole activity of the each lesson and compare

it with the following description to determine whether the student has achieved the minimum required level.

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional activities at the end of the lesson or during breaks.

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

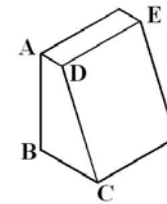
Quiz

(you can select any number of questions depending on the time you give)

Read each of the following multiple-choice items and the possible answers carefully. Mark the letter of the correct answer on your answer sheet or as instructed by your teacher.

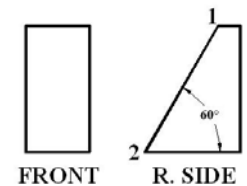
1. In the sketch below, which line is **NONISOMETRIC**?

- A. AB B. BC
C. CD D. DE

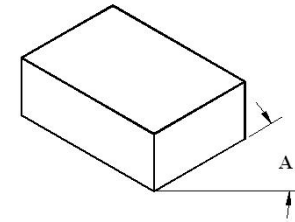


2. To construct an **ISOMETRIC** sketch using the views below, how would line 1,2 be drawn?

- A. Locate points 1 and 2, then connect them
B. Locate point 1, then draw a line at 60°
C. Locate point 2, then draw a line at 60°
D. Use a protractor to construct a 60° angle

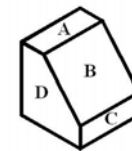


3. In the **ISOMETRIC** sketch below, what is angle “A”?



- A . 15° B . 30° C. 45° D. 60°

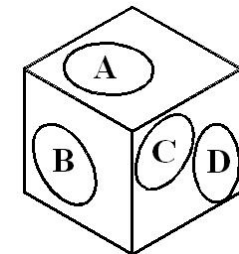
4. A normal **ISOMETRIC** ellipse should **NOT** be drawn on which surface?



5. Most drawings done with instruments start from:

- A. Blueprint drawings for manufacturing.
- B. Models of a proposed object.
- C. Parts drawings found in catalogues.
- D. Sketches provided by engineers or designers.

6. In the figure below, which **ISOMETRIC** ellipse is **NOT** correctly oriented?



7. In an **OBLIQUE** sketch, on which plane are arcs, holes, and irregular features commonly placed?

- A. Any plane
- B. Frontal
- C. Horizontal
- D. Profile

8. When sketching long, narrow objects in **OBLIQUE**, distortion can be lessened by placing the long dimension along:
- A. A 30° receding axis
 - B. A 45° receding axis
 - C. The horizontal axis
 - D. The vertical axis
9. Which type of **PICTORIAL** sketch allows circles to appear on the front face as a true circle?
- A. Dimetric
 - B. Isometric
 - C. Oblique
 - D. Perspective
10. Which **PICTORIAL** sketch shows the most descriptive features parallel to the plane of projection?
- A. Dimetric
 - B. Isometric
 - C. Oblique
 - D. Perspective
11. What type of sketch is **BEST** for describing a new product?
- A. CAD detail
 - B. Design
 - C. Multi-view
 - D. Orthographic
12. What are the materials required for making a sketch?
- A. Pencil and compass
 - B. Pencil and paper
 - C. Pencil, paper and scale
 - D. Pencil, paper and triangle
13. It is commonly accepted practice that sketches are made with:
- A. 3mm leads.
 - B. Red pencils.
 - C. Softer leads.
 - D. Harder leads.

14. A good sketching technique for drawing a straight line is to focus on the:
- A. End point of the line.
 - B. Left side of the page.
 - C. Pencil point.
 - D. Right side of the page.
15. What is the advantage of using “pencil-sight” sketching technique?
- A. Aids in keeping correct proportion
 - B. Makes the sketch perspective
 - C. Makes the sketch pictorial
 - D. Provides a sketching grid
16. What is the symbol that describes a location in space?
- A. Line
 - B. Plane
 - C. Point
 - D. Surface
17. What is the path between two points (straight or curved) called?
- A. Line
 - B. Plane
 - C. Point
 - D. Surface
18. What is a flat or non-flat element created from curved lines?
- A. Line
 - B. Plane
 - C. Surface
 - D. Texture
19. What type of sketch is typically used for an object with very little thickness?
- A. Isometric
 - B. Multiview
 - C. Pictorial
 - D. Single view

20. In an **ISOMETRIC** sketch, a circle will appear as a(n):
- A. Arc.
 - B. Circle.
 - C. Ellipse.
 - D. Straight line.
21. The first step in sketching an isometric circle or ellipse is to sketch a(n):
- A. Large arc tangent at points.
 - B. Isometric square/rhombus.
 - C. Small arc tangent at points.
 - D. Square.
22. In an **ISOMETRIC** sketch, what lines are **NOT** parallel to the three isometric axes?
- A. Elliptical
 - B. Non-isometric
 - C. Trimetric
 - D. Vertical
23. In an isometric sketch, how are **NONISOMETRIC** lines drawn?
- A. 30° off horizontal
 - B. 60° off horizontal
 - C. Locate endpoints and connect
 - D. Use a protractor to measure the angle
24. Which type of **OBLIQUE** sketch has the receding axis drawn at one-half the true-depth?
- A. Cabinet
 - B. Cavalier
 - C. General
 - D. Uniform
25. Which **PICTORIAL** sketch has a 90° angle between two of its three axes?
- A. Dimetric
 - B. Isometric
 - C. Oblique
 - D. Perspective

Answer to quiz

1. C	6. D	11. B	16. C	21. B
2. A	7. B	12. B	17. A	22. B
3. B	8. C	13. C	18. C	23. C
4. B	9. C	14. A	19. D	24. A
5. D	10. C	15. A	20. C	25. C

UNIT 2

AUXILIARY VIEWS

Total Periods: 13

Unit Outcomes

At the end of this unit, students should be able to:

- ✓ understand the basic principle of orthographic projection;
- ✓ recognize the type and main purpose of auxiliary views;
- ✓ produce auxiliary view drawing of objects to describe the true shape of inclined surface.

Unit Overview

There are times when one of the six principal views will not completely describe an object. This is especially true when there are inclined or oblique planes or features on an object. For these cases, a special orthographic view called an auxiliary view can be created.

Therefore Auxiliary views are a type of orthographic projection used to determine the true size and shape of inclined and oblique surfaces of objects. Normally, auxiliary views are projected from existing principal views. However, auxiliary views can also be drawn first and then used to create a principal view. This is done when a true measurement can only be obtained by an auxiliary view and that measurement is needed in order to create a principal view. This technique is called reverse construction. Any number of auxiliary views of an object can be created. Successive auxiliary views can be created by projecting from an existing auxiliary view.

In conclusion this unit introduces the drawing techniques and skills used to depict inclined or curved surfaces.

Lesson 2.1 *Overview of Orthographic drawing*

Number of Period: 6

(2 period theory and 4 periods for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ describe the basic concept of orthographic projection;
- ✓ explain the use of auxiliary views;
- ✓ Use folding line or reference lines when creating auxiliary views;
- ✓ find the projection of a point, line and plane in space;
- ✓ identify the three classification of surfaces;
- ✓ describe normal view of a line, a plane, inclined surface and the edge view of a plane;
- ✓ construct normal view a line, a plane, inclined surface and the edge view of a plane.

Planning ahead

Prepare model and diagrams to show orthographic drawing and inclined surface to be shown in auxiliary view in class. You can also use a model to show projection of a point and a line. Make a further reading on true length and edge view too. The activities in this lesson are designed to give students a basic understanding about what orthographic drawings.

Teacher uses two periods for theoretical concept and demonstration about projection, true length and edge view. Four periods for student practice on check points.

Hints for Teaching

The suggested instructional strategies are:

1. You can start the class by inviting students in text question about what they know before about auxiliary.
2. Discuss and demonstrate by explaining the purpose of auxiliary views and possible position that inclined surface may occur.
3. Display and discuss examples of auxiliary view and orthographic drawing.
4. Discuss and demonstrate the three classifications of surfaces.
And show the normal view of a line, inclined surfaces and edge view of a plane. Have students keep orthographic drawing and auxiliary view ideas in a notebook.
5. Allow students to practice on activity 2.1 and check points 2.1 up to 2.4 one by one individually.

Teaching Note

An **auxiliary view** is an orthographic view that is projected onto any plane other than the frontal, horizontal, or profile plane. An auxiliary view is not one of the six principal views. To show the true size and shape of surface ABCD, an auxiliary view can be created by positioning a line of sight perpendicular to the inclined plane, then constructing the new view.

In **fold-line method**, the object is suspended in a glass box to show the six principal views, created by projecting the object onto the

planes of the box. The box is then unfolded, resulting in the six principal views. However, when the six views are created, surface ABCD never appears true in size and shape; it always appears either foreshortened or on edge.

The object suspended inside a glass box, which has a special or auxiliary plane that is parallel to inclined surface ABCD. The line of sight required to create the auxiliary view is perpendicular to the new projection plane and to surface ABCD.

The auxiliary glass box is unfolded with the fold lines between the views shown as phantom lines. In the auxiliary view, surface ABCD is shown true in size and shape and is located at distance M from the fold line. The line AB in the top view is also located at distance M from its fold line.

Changing the position of the object, such as moving it closer to the frontal plane, changes distance M, the distance from the nearest edge of the object to the fold line.

The **reference plane method** is a technique that locates a plane relative to the object instead of suspending the object in a glass box.

When using reference planes or fold lines always remember the following:

- Reference or fold lines are always drawn perpendicular to the projection lines between the views.
- Transfer measurements are always taken parallel to the projection lines and perpendicular to the reference or fold lines.

- Reference planes always appear on edge as a line in the views adjacent to the central view but never in two adjacent views.
- Distances from the object to the reference or fold lines in the auxiliary view and the measuring view are the same.

Auxiliary views are used to determine the true size and shape of features that would appear foreshortened in any of the principal views. The applications for auxiliary views can be grouped into the following five areas: Reverse construction, True length of a line, Point view of a line, Edge view of a plane and True size of a plane

For some objects, an auxiliary view must be created before a principal view can be drawn, using a technique called *reverse construction*.

Auxiliary views can be used to draw a view in a specified direction. *To create a view of an object in a specified direction, find the point view of the line of sight.*

A **dihedral angle** is the angle between two planes. Determining the true measurement of a dihedral angle is a common application for auxiliary views.

Successive auxiliary views are multiple auxiliary views of an object created by projecting from previous auxiliary views. Successive auxiliary views can be used to draw an oblique surface in true size and shape.

Lesson 2.2 *Auxiliary projection of objects*

Number of Periods: 2

(1 period theory and 1 period for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ explain the position of auxiliary projection plane.
- ✓ identify the steps in drawing auxiliary projection.
- ✓ identify the types of auxiliary views
- ✓ draw primary views of an object.

Planning ahead

You could given a demonstration and sample problem solutions that the students will produce an auxiliary view, to specifications provided by you. So in advance you should be able to know:

- How to draw a primary auxiliary view.
- When an auxiliary view is necessary.
- How to draw a primary auxiliary view.

Teacher uses one period for theoretical concept and demonstration about Auxiliary plane and types of auxiliary view specifically about primary. One period for student practice on class work exercise.

Hints for Teaching

The lesson concentrates on types of auxiliary view, planes in auxiliary and primary auxiliary view. Therefore, the lesson strategies are:

1. Before starting to demonstrate ask in text question about types of auxiliary view like “how many auxiliary planes did you use

to find the end view of a line and a plane”, let the students say something (brainstorming) about it.

2. Discuss and demonstrate about auxiliary plane, types of auxiliary view and show how to draw primary auxiliary view.
3. Have students keep auxiliary plane, types of auxiliary view and how to draw primary auxiliary view ideas in a notebook.
4. Allow students to practice on activity 2.2 and class work exercises one by one individually.

Teaching Note

Auxiliary views are created by positioning a new line of sight relative to the object. It is possible to create any number of auxiliary views, including a new auxiliary view from an existing auxiliary view. Therefore, auxiliary views are first classified as: primary, secondary, or tertiary.

A primary auxiliary view is a single view projected from one of the six principal views. A secondary auxiliary view is a single view projected from a primary auxiliary view. A tertiary auxiliary view is a single view projected from a secondary or another tertiary auxiliary view.

The labeling convention for the reference or fold lines in auxiliary view construction can vary. However, the labels are normally descriptive in nature. For example in Figure 6.7, the fold line located between the front and top views is labeled T–F, where the F means front and the T means top.

Lesson 2.3 *Secondary auxiliary views*

Number of Periods: 5

(1 period theory and 4 period for practice)

Learning Out comes

At the end of this lesson, students should be able to:

- ✓ describe the difference between primary and secondary auxiliary views.
- ✓ describe the advantage of partial and complete auxiliary views.
- ✓ draw circular features in auxiliary projection.
- ✓ describe the advantage of half auxiliary view.
- ✓ Perform the type of auxiliary view of an object.

Planning ahead

Prepare model and diagrams of secondary auxiliary views and partial and complete auxiliary views to be shown in class. You can also use a model to show partial and complete auxiliary views.

Make a further reading on types of Auxiliary view in general too. The activities in this lesson are designed to give students a basic understanding about secondary, partial and complete Auxiliary views.

You could give a demonstration and sample problem solutions that the students will produce an auxiliary view, to specifications provided by you.

- How will an oblique plane surface appear in the three regular views?
- How will a skewed surface appear in the three regular views?

Teacher uses one period for theoretical concept and demonstration about secondary, partial and complete auxiliary view. Four periods for student practice on check points.

Hints for Teaching

This lesson will be concentrated on auxiliary planes, types of auxiliary and demonstration on primary auxiliary views. Suggested instructional strategies are:

1. Provide visual examples of the three types of auxiliary views and have students label them while describing how they arrived at the decision.
2. Provide students with example of a partial and complete auxiliary view and have them an idea to do it. .
3. Provide students with a curve problem and have them generate an auxiliary curve to specifications.
4. Show a visual example of a partial auxiliary.
5. Provide examples of trades people that use auxiliary views, and have students tell how they think trades people would use auxiliary views in their work.
6. Invite a tradesperson to be guest speaker.
7. Take a field trip to a drafting firm.
8. Have students keep secondary, partial and complete auxiliary view and how to draw these auxiliary view ideas in a notebook.
9. Allow students to practice on check point 2.5 up to 2.7 one by one individually.

Teaching Note

A depth auxiliary view is projected from the front view, and the depth dimension is shown true length. A height auxiliary view is an auxiliary view projected from the top view, and the height dimension is shown true length. A width auxiliary view is an auxiliary view projected from the profile view, and the width dimension is shown true length.

In auxiliary views, it is normal practice not to project hidden features or other features that are not part of the inclined surface. When only the details for the inclined surface are projected and drawn in the auxiliary view, the view is called a partial auxiliary view.

Symmetrical objects can be represented as a half auxiliary view. When a cylindrical part is cut by an inclined plane, the resulting surface is an ellipse and can only be shown true size and shape with an auxiliary view.

Lesson Guide

Period	Lesson title	Starter activity	Main activities	Concluding activities
6	2.1 Overview of orthographic drawing	<ul style="list-style-type: none"> Ask brain storming question like how to make projection of inclined and oblique surfaces and others from the textbook. 	<ul style="list-style-type: none"> Discuss the difference between auxiliary planes and principal planes with students. Demonstrate projection of point, line and plane Let the students to practice on activity 2.1 and check points 2.1 up to 2.4. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook
2	2.2 Auxiliary projection of objects	<ul style="list-style-type: none"> Ask brain storming question about types of auxiliary view and its purpose from the textbook 	<ul style="list-style-type: none"> Discuss and demonstrate types of auxiliary view and purpose of auxiliary views. Let the students to practice on activity 2.2 and class work exercises by the teacher. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook
5	2.3 Secondary Auxiliary views	<ul style="list-style-type: none"> Ask brain storming question about secondary auxiliary view and other features in auxiliary view from the textbook 	<ul style="list-style-type: none"> Discuss and demonstrate on secondary auxiliary view and other features in auxiliary views. Assist students to project second auxiliary plane and elevation from given views. Let the students to practice on check points 2.5 up to 2.7 and class work exercises by the teacher. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook

Evaluation

Ask your students the following concepts

- Describe the basic concept of orthographic projection.
- State the three classifications of surfaces.
- Explain the position of auxiliary projection plane.
- State the steps in drawing auxiliary projection.

- Identify the types of auxiliary views
- Describe the difference between primary and secondary auxiliary views.
- Describe the advantage of partial and complete auxiliary view.
- Describe the advantage of half auxiliary view.

Method

1. Presentation (lecture)
2. demonstration
3. group discussion (6-8 students per a group)
4. individual practice

Equipment/Materials

1. Drawings showing projections of point, line and plane.
2. Drawings illustrating auxiliary projection
3. Small models of objects having inclined, circular features and oblique surfaces

Assessments

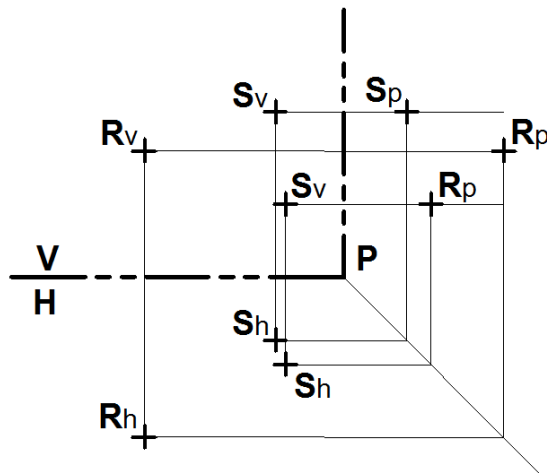
The teacher should follow and assess each student's work continuously over the whole activity of the each lesson and compare it with the following description to determine whether the student has achieved the minimum required level.

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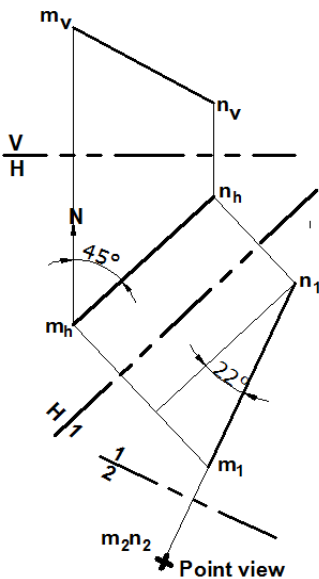
Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Answer key for the question in the textbook

Solution for check point 2.1

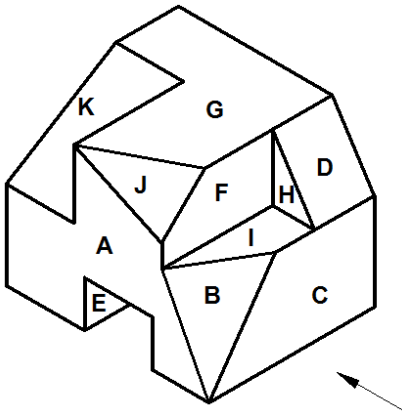


Solution for check point 2.2



Bearing (MN) = N 45° E
 Slope (MN) = 22° CCW
 True Length Projection = m_1n_1
 End View Projection = m_2n_2

Answer for check point 2.3



GIVEN OBJECT

Vertical:- F ,C & E

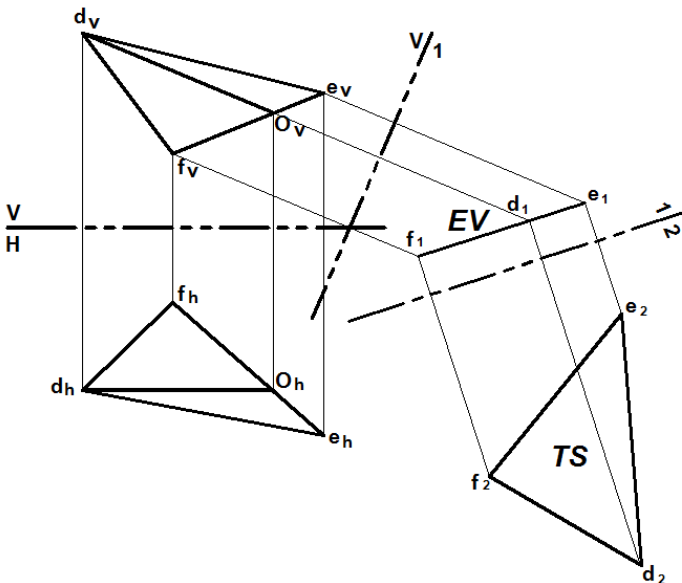
Horizontal:- G&I

Profile:- A&H

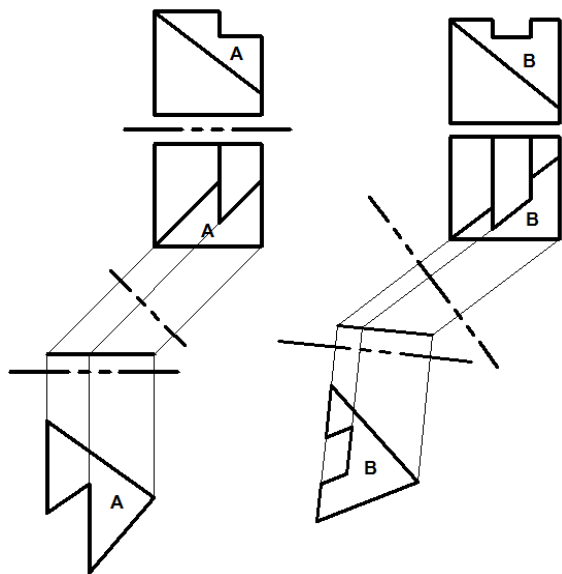
Inclined:- D&K

Oblique:- B&J

Solution for check point 2.4

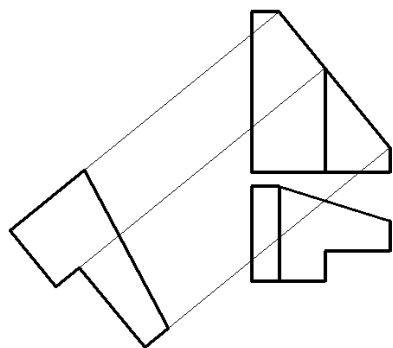


Solution for check point 2.5



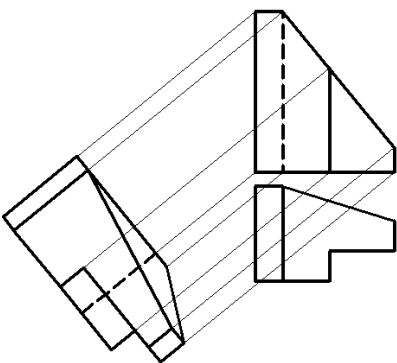
Solution for check point 2.6

A

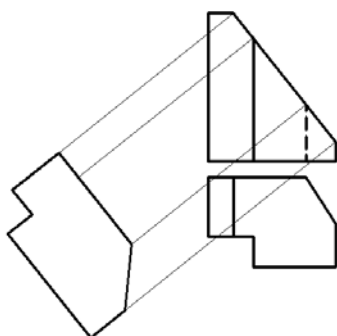


Partial

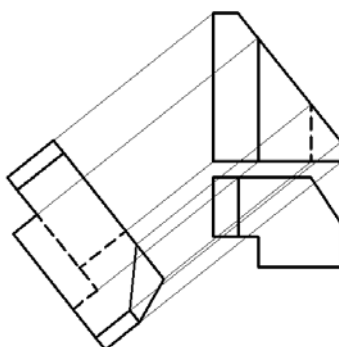
B



Complete

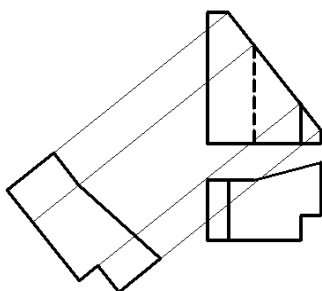


Partial

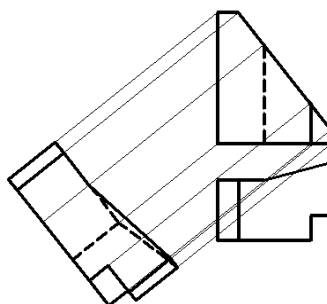


Complete

C

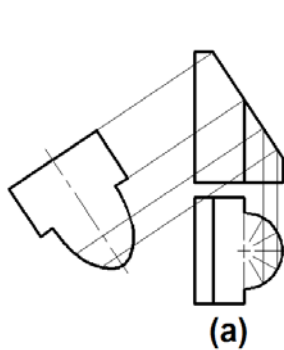


Partial

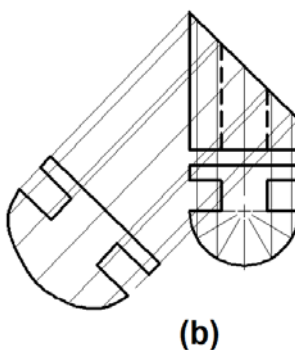


Complete

Solution for check point 2.7

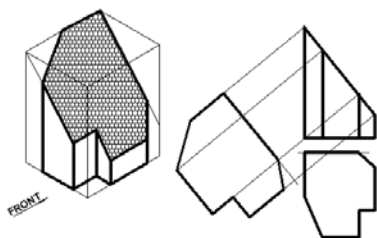


(a)

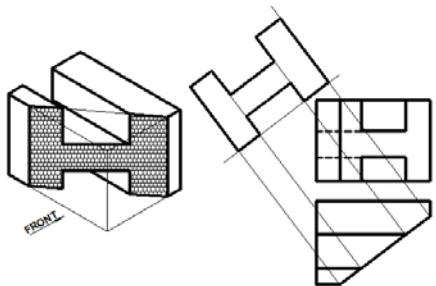


(b)

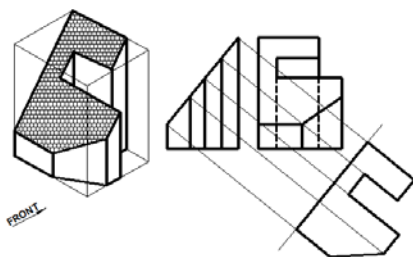
Solution for exercise 1



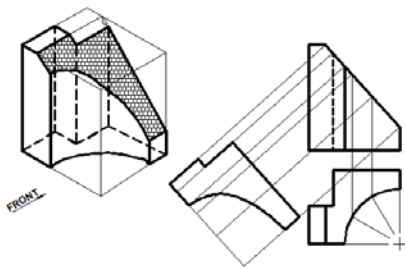
(a)



(b)

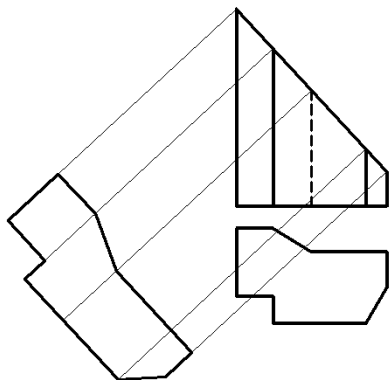


(c)

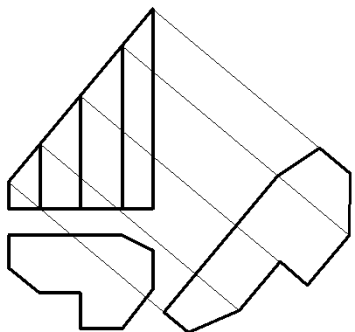


(d)

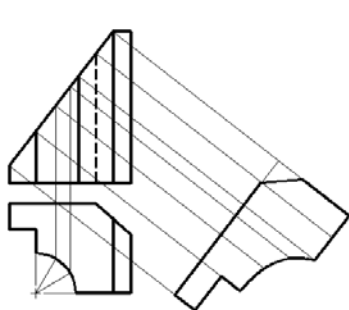
Solution for exercise 2



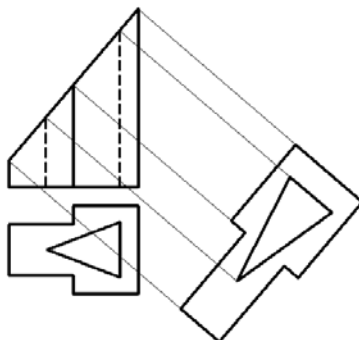
(a)



(b)

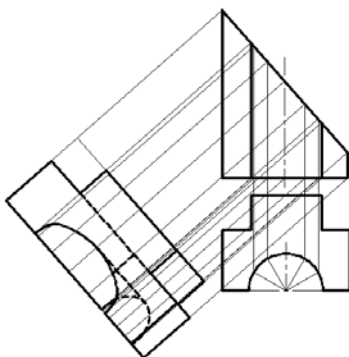


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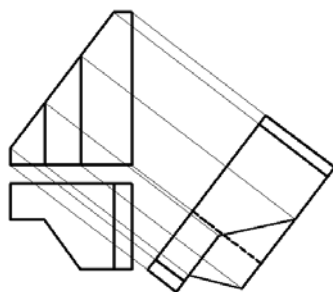


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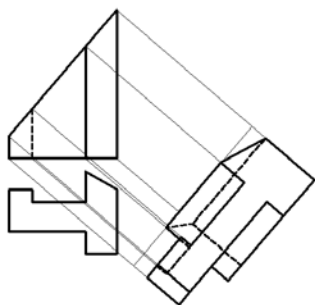
Solution for exercise 3



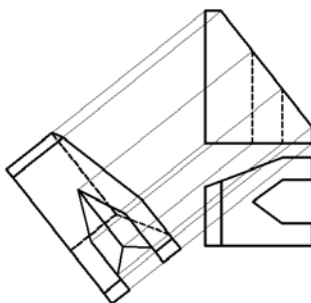
(a)



(b)



(c)



(d)

UNIT 3

SECTIONAL VIEW

Total Periods: 12

Unit Outcomes

At the end of this unit, students should be able to:

- ✓ Understand the main purpose of sectional views;
- ✓ Analyze the types of sectional views according to their particular advantage in describing the interior feature of objects;
- ✓ Show sectional view of structure to describe the interior feature for complete description.

Unit Overview

Sections are used to show interior details clearly. For sections it is commonly used a cutting-plane line which shows where object was cut to obtain the section view. In addition a cross hatching in the section view shows the solid surface of the object which was cut through to produce the section.

Section views may replace standard views however there're some conventional practices, such as not showing hatching on ribs and webs, help make sections easier to interpret correctly. Mainly section views are used when important hidden details are in the interior of an object. These details appear as hidden lines in one of

the orthographic principal views; therefore, their shapes are not very well described by pure orthographic projection. Consequently this unit familiarizes students with the purposes and the many different types of sections

Lesson 3.1 *Terminology and common practices of sectioning*

Number of Periods: 1

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ explain the concept and importance of sections;
- ✓ describe the location of cutting plane to create sectional view;
- ✓ Select the location of cutting plane line;
- ✓ Identify the different types of section lining symbols;
- ✓ Make different types of section lining;
- ✓ visualize the sectional view of an object.

Planning ahead

Organize yourself in advance to given a review on multi-view drawing, plus presentations, reading assignments, and discussion, so that the students will explain the rationale for using sectioning and the major elements in a section view, with a degree of accuracy and completeness. Therefore, plan the following instructional materials

1. Prepare visual aids to show “examples of sectional view drawings”
2. Review essential questions, “what are the importances of sectional view in a design process?”

Hints for Teaching

Suggested instructional strategies are:

1. You can start the class by inviting students in text question about section like what are the importances of sectional view in a design process.
2. Provide various split wood block forms which have been predrilled, counter bored, and counter sunk. Illustrate the sectioned interior split apart versus a hidden line image which is drawn on the outside of the block.
3. Discuss and demonstrate the importance of sectional view, cutting plane line and section lining. Have students keep main points from discussion about sectional view in a notebook.
4. Use the split wood block forms to illustrate a sectioned interior versus hidden line representation.
5. Allow students to practice on activity 3.1 individually or in group.

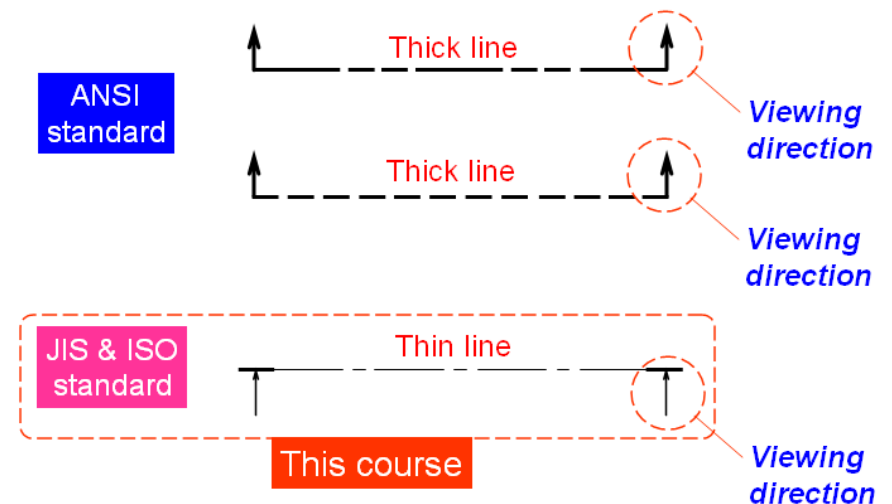
Teaching Note

The purpose of sectioning is:

- Drawings are intended to communicate design intent from the engineer/drafter to the craftsman making the components.
- If an orthographic view does not clearly identify design intent, due to the number of features and details involved, then the section view is often utilized to show interior details and to provide additional clarity.

- Also, according to ANSI, you should not dimension to hidden lines, so a section view may be the only way to properly dimension an interior feature.

Cutting plane is a plane that *imaginarily cuts* the object to reveal the internal features, whereas *cutting plane line* is an *edge view* of the cutting plane. Below is cutting plane line styles using ANSI standard, JIS and ISO standards.



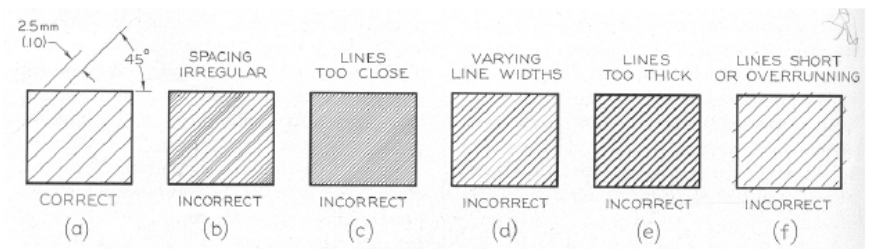
Section lines or **cross-hatch lines** are used to *indicate the surfaces that are cut* by the cutting plane. The section lines are different for each of material's type. For practical purpose, the cast iron symbol is used most often for any materials.

Section lining practices are that the spaces between lines may vary from 1.5 mm for small sections to 3 mm for large sections and It

should not be drawn *parallel* or *perpendicular* to contour of the view.

Section-lining rules

- The correct method of drawing section lines is shown in part (a). Draw section lines with a sharp medium-grade pencil (H or 2H).
- Always draw lines at 45° with the horizontal unless there is an advantage of using different angles.
- Space the section lines as uniformly spaced as possible by eye. Section lines should be uniformly thin, and not varying in thickness.
- Avoid running the section lines beyond the visible outline, or stopping the line too short.



If section lines drawn at 45° with horizontal would be parallel or perpendicular (Or nearly so) to a prominent visible outline, the angle should be changed to 39° or some odd angle.

Lesson 3.2 *Types of Sections*

Number of Periods: 8

(2 period theory and 6 periods for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ identify the types of sectional views;
- ✓ select the appropriate types of sectional views;
- ✓ perform the sectional view of an object with preferable type of section.
- ✓ Compare and contrast the advantage of all types of sectional views;

Planning ahead

Be ready to give a presentation on sectional views, so that the student will demonstrate sectioning techniques and the various types of sections, to the satisfaction of you; hence:

- Prepare visual aids to show “examples of sectional view drawings”
- Teacher uses two periods for theoretical concept and demonstration about types of section and compare and contrast the types of section. Six periods for student practice on activities and check points.

Hints for Teaching

Suggested instructional strategies are:

1. You can start the class by inviting students in text question about types of section from the textbook.

2. Discuss and demonstrate the types of sectional view and their special purpose. Have students keep discussion main points about types of section view in a notebook.
3. Provide enough split forms for the entire class to draw.
4. Have students display models of sectioned articles along with drawings. Use transparent colored Plexiglas to illustrate the cutting plane line.
5. Create a display illustrating materials and the sectioned symbols they represent.
6. Provide parts of a small gas engine from which sections have been precut. Have students draw these parts as section drawings. (Be sure all parts are thoroughly cleaned.)
7. Allow students to practice on check points 3.1 up to 3.4 one by one individually.

Teaching Note

A full section is obtained when the cutting-plane line extends entirely through an object in a straight line and the front half of the object is “removed.” But a half-section is a view of an assembly or object that shows one-half of the view in section.

An offset section is used for features that are not in a straight line. But revolved or removed sections are used to show the cross-sectional shape of ribs, spokes, and arms when the shape is not obvious in the regular views. And therefore a revolved section is often used for spokes and arms for clarity. While a partial or broken-out section is used to show just a portion of an object.

Lesson 3.2 *Other sectional view representation and conventional Practices in sectioning*

*Number of Periods: 3
(1 period theory and 2 periods for practice)*

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ identify the conventional representation of section;
- ✓ apply conventional representation of section in technical drawing;
- ✓ use other sectional view representation when they are needed.

Planning ahead

You could give presentations, demonstrations, assigned readings, and related assignments, that the student will draw a section view, with a degree of accuracy. In order to do this, the teacher must be able to practice visualization and implementation of information in order to develop a sectional drawing. And need to understand how ribs, webs and spokes are treated when in section view and how are the patterns chosen for hatching sectioned views? In addition,

- Prepare visual aids to show “examples of other representation of sectional view and conventional representation in sectioning”.
- Teacher uses one period for theoretical concept and demonstration about conventional representation in sectioning. Two periods for student practice on activities and check points.

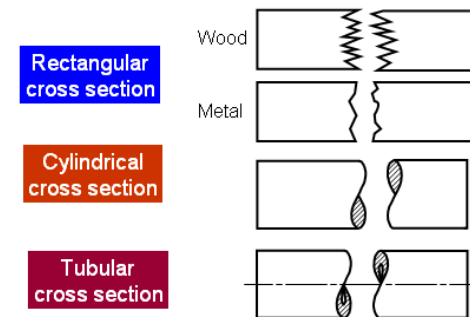
Hints for Teaching

Suggested instructional strategies are:

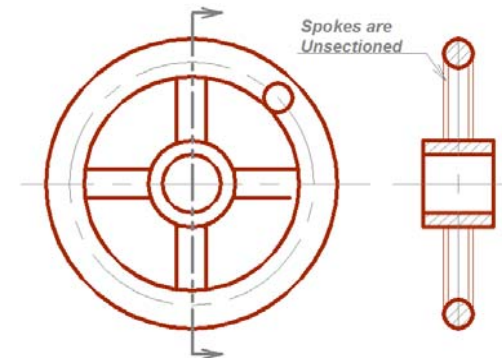
1. You can start the class by inviting students in text question about conventional representation in sectioning and other sectional view representation from the textbook.
2. Create a display illustrating materials and the sectioned symbols they represent
3. Discuss and demonstrate about conventional representation in sectioning and other sectional view representation. Have students keep main points from the discussion in a notebook.
4. Provide parts of a small gas engine from which sections have been precut. Have students draw these parts as section drawings. (Be sure all parts are thoroughly cleaned.)
5. Allow students to practice on check points 3.5 and exercises in class individually and in group.

Teaching Note

One of an example of conventional practice is for *long objects* that have to draw in a small scale to fit them on the paper; it is recommended to remove its long portion (which contains *no* important information) and draw the break lines at the broken ends.



Some solid features of certain parts like spokes of a wheel are not sectioned, even though the cutting plane passes through them. Such representation is used to distinguish a wheel with spokes from a wheel with thin plate or web. The general practice, the sectional representation of a wheel with spokes and with plate is as follows.



Lesson Guide

Period	Lesson title	Starter activity	Main activities	Concluding activities
1	1.1 Introduction, terminology and common practices of sectioning	<ul style="list-style-type: none"> Ask brain storming question like what are the importance of sectional view in a design process 	<ul style="list-style-type: none"> Discuss the difference between auxiliary planes and principal planes with students. Demonstrate with visual aid principles and rules to draw sectional views of an object. Let the students to practice on activity 3.1. 	<ul style="list-style-type: none"> Allow students to present their group work activity result in front of the class Give home work to do exercises from the textbook
8	1.2 Types of sections	<ul style="list-style-type: none"> Ask brain storming question about types of section from the textbook purposes. 	<ul style="list-style-type: none"> Discuss and demonstrate using visual aids the different types of section Let the students to practice on check points 3.1 up to 3.4. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook
3	1.3 Other sectional view representation and conventional Practices in sectioning	<ul style="list-style-type: none"> Ask brain storming question about Other sectional view representation and conventional Practices in sectioning from the textbook. 	<ul style="list-style-type: none"> Demonstrate all the conventional practices in sectioning and other representation of sectional view using visual aid. allow the student to practice on them by providing activities and check points 3.5 from the text or from yourself 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Make the students to work in a group of six and eight on the exercises and to peer observed by any other group Give home work to do exercises from the textbook

Evaluation

Ask your students the following concepts

- state concept of sectioning.
- state five reasons of using sectional view.

- explain the principles of constructing true shapes of cut surfaces.
- Describe other conventional representation in sectioning

Method

- Presentation (lecture) and Demonstration
- group discussion (6-8 students per a group)
- individual practice

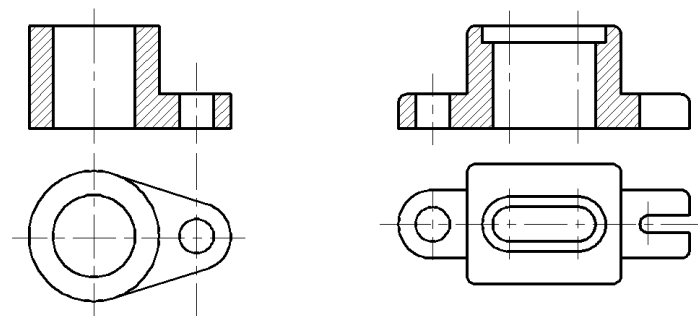
Assessments

The teacher should follow and assess each student's work continuously over the whole activity of the each lesson and compare it with the following description to determine whether the student has achieved the minimum required level.

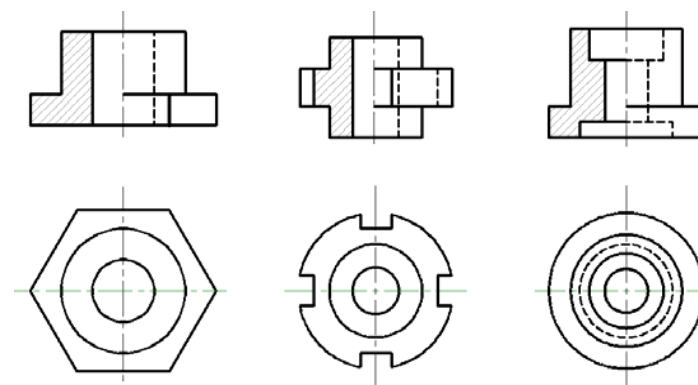
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Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

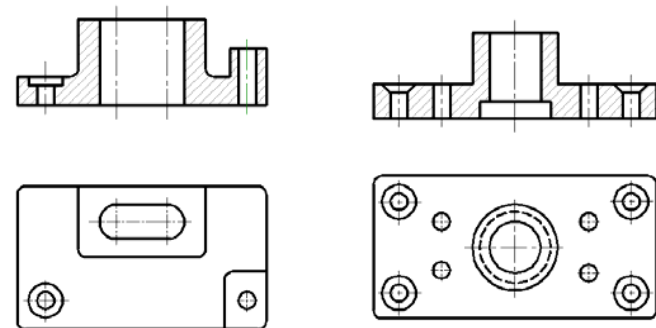
Answer key for the question in the textbook
Answer to check point 3.1



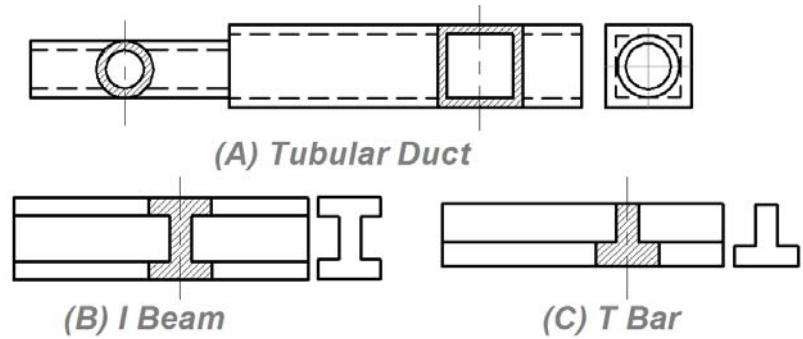
Answer to check point 3.2



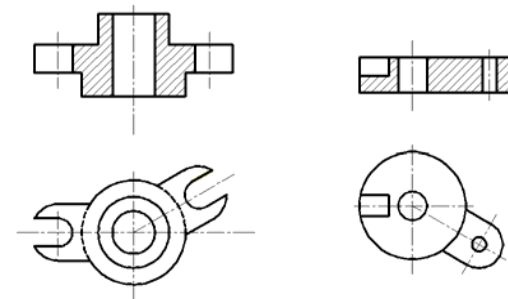
Answer to check point 3.3



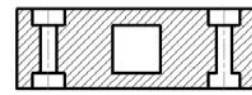
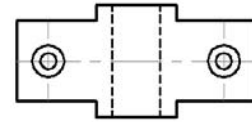
Answer to check point 3.4



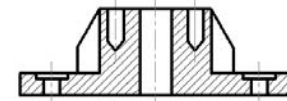
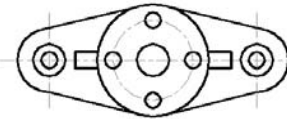
Answer to check point 3.5



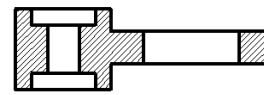
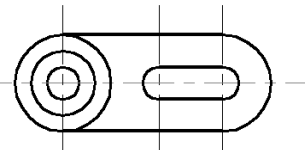
Answer to exercise 1



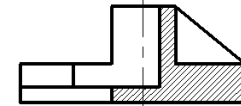
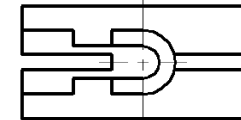
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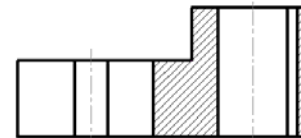
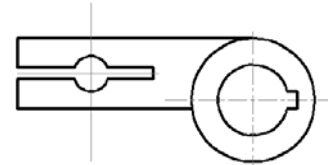
B



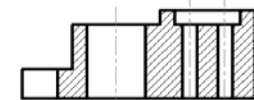
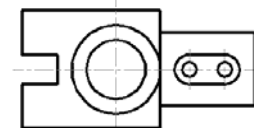
C



D

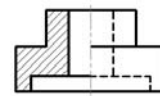
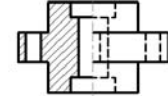
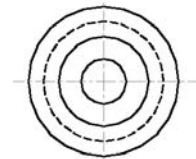
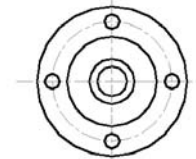


E



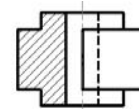
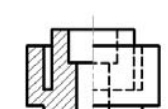
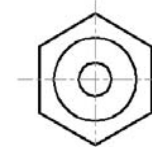
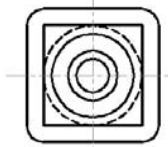
F

Answer to exercise 2



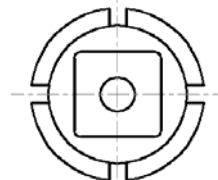
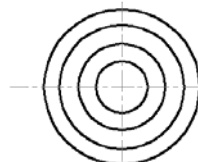
A

B



C

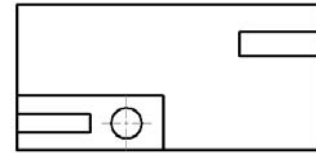
D



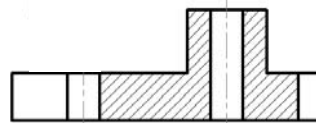
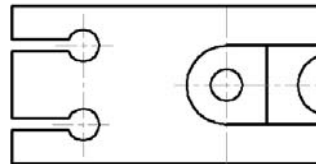
E

F

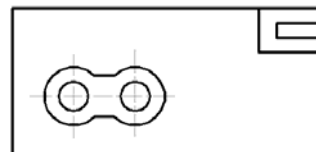
Answer to exercise 3



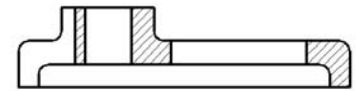
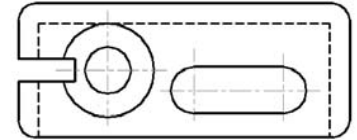
A



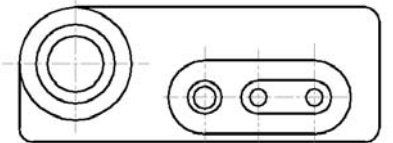
C



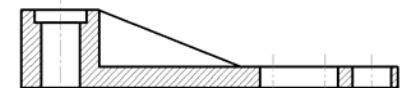
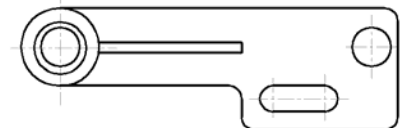
E



B



D



F

UNIT 4

DIMENSIONING

Total Periods: 7

Unit Outcome

At the end of this unit, students should be able to:

- ✓ Understand the purpose, convention and principle of dimensioning;
- ✓ Apply the standard dimensioning practice to describe the size of objects on technical drawing;
- ✓ apply the principles to dimension a given drawing.

Unit Overview

A working drawing is one form which a part can be produced. The drawing must be a complete set of instructions, so that it will not be necessary to give further information by word to the people fabricating the object. A working drawing, then, consists of the views necessary to explain the shape, the dimensions needed for manufacture, and required specifications may be found in the notes on the drawing, or they may be located in the title block.

There are rules and principles dimensioning a working drawing clearly and accurately. Therefore, mastering with the rules and principles is very important for drafters and engineers.

Lesson 4.1

Line, symbols, and reading direction of figures

Number of Period: 1

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ Explain the use of dimensioning;
- ✓ Identify where to apply dimensioning;
- ✓ Identify the basic symbols, forms and elements of dimensioning;
- ✓ Identify the two systems in reading direction of figures.

Planning ahead

The lesson concentrate on basic symbols, forms and elements of dimensioning; purpose of dimensioning and where to apply dimension. Following instruction, the student will produce dimensioning arrows, lines, letters, and numerals, to the satisfaction of the teacher Therefore, plan the following instructional materials

1. Prepare visual aids to show “basic symbols, forms and elements of dimensioning”
2. Review essential questions, “what are the drawing principles to have a working drawing with complete description in a design process?”
3. Use the lesson with discussion and demonstration by showing visual aids.

Hints for Teaching

This lesson will be presented with the following suggested instructional strategies

1. Before giving idea on dimensioning directly, let the students say something (brainstorming) about dimensioning from the textbook.
2. Discuss and demonstrate the exact idea and concept of dimensioning with practical examples and visual aids. You can refer working drawings of machine parts and assembly drawings. Have students keep main points from discussion about sectional view in a notebook.
3. Show filmstrips/films/slides/video cassettes on dimensioning and careers in technical drawing.
4. Allow students to practice on activity individually and in group provided by the teacher and on check point 4.1.

Teaching Note

Dimension: the numerical value that defines the size, shape, location, surface texture, or geometric characteristic of a feature.

Dimension line: A thin, solid line ending with arrowheads that shows the extent and direction of a dimension.

Extension Line: A thin, solid line perpendicular to a dimension line, indicating the feature to which a dimension is associated.

A gap is left between the end of the extension line and the associated feature.

Center Line: A long, thin line shown with alternating short and long dashes that indicates an axis of symmetry or a path of motion. It may also be used in the same fashion as an extension line for dimensioning purposes.

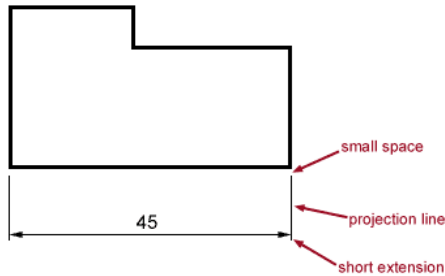
Leader Line: A thin, solid line used to indicate the feature with which a dimension, note, or symbol is associated. Leaders terminate with an arrow (for features in edge view) or a dot (for features appearing as a surface) on the drawing side and a horizontal shoulder at mid-letter height on the other.

Notes: Additional comments used to describe features of the body. Notes may be attached to a feature by use of leader or may be placed anywhere without a leader to provide a general comment regarding multiple or all features on the body.

Some common dimensioning symbols (often used in notes):

					
Counterbore or Spotface	Countersink	Depth or Deep	Slope	Conical Taper	
					
Diameter	Square (Shape)	Places, By, or Times,	Radius	Spherical Radius	Spherical Diameter

A dimensioned drawing should provide all the information necessary for a finished product or part to be manufactured. An example dimension is shown below.



Dimensions are always drawn using continuous thin lines. Two projection lines indicate where the dimension starts and finishes. Projection lines do not touch the object and are drawn perpendicular to the element you are dimensioning.

In general units can be omitted from dimensions if a statement of the units is included on your drawing. The general convention is to dimension in mm.

All dimensions less than 1 should have a leading zero. i.e. .35 should be written as 0.35

All notes and dimensions should be clear and easy to read. In general all notes should be written in capital letters to aid legibility. All lettering should be of the same size and preferably no smaller than 3mm. An example typeface is shown below.

Lesson 4.2 *Theory of dimensioning*

Number of Periods: 2

(1 period theory and 1 period for practice)

Learning Competencies

At the end of this lesson, students will be able to:

- ✓ Differentiate size and location dimensioning;
- ✓ Apply size and location dimension on different drawing;
- ✓ Select convenient dimensions properly to describe a feature of an object;
- ✓ Identify the relationship between scale of drawing and dimension figures;
- ✓ Write letters and numerals in an accepted standard form.

Planning ahead

Being able to teach dimensioning skill does require you to develop the first basic knowledge and skill, where you are expected to pass on to the students: learn the **technique of dimensioning**. Understand the different line types and techniques used to show dimensions.

Therefore, plan the following instructional materials

1. Prepare visual aids to show “Theory of dimensioning such as reading direction of figures”. If possible also prepare working drawings of machine parts and assembly drawings.
2. Teacher uses one period for theoretical concept and demonstration about theory of dimensioning like size and location dimensions. Two periods for student practice on activities and check points.

Hints for Teaching

Understanding geometric dimensioning is an instructor-lead course that simplifies dimensioning learning. You should be using mostly visual illustrations and less textual material. You have to explain basic dimensioning application, interpretation and verification. Students learn faster and retain more information when dimensioning concepts and rules are presented in visual format presentations.

Important dimensioning concepts should be reemphasized throughout the course. You should apply pop-quiz at the end of the lesson, it require immediate application and reinforce key learning points.

Standardization is a dynamic and continuous process. The ISO standards follow the development in engineering. Changing in standardization may make it compulsory to update some content of dimensioning course notes.

Suggested instructional strategies are:

1. You can start the class by inviting students in text question about theory of dimensioning from the textbook.
2. Discuss and demonstrate the theory of dimensioning and techniques used in drawing. Have students keep discussion main points about types of section view in a notebook.
3. Display visual aids like working drawings of machine parts and assembly drawings.
4. Allow students to practice on activity 4.1 and on check points 4.2 individually or in group.

Teaching Note

The object is said to be fully dimensioned when the two types of dimensions i.e. size dimension and location dimension are included. Size dimensioning describes size of an object such as height, width, depth, thickness, length, radius, diameter etc, with regard to its form and other features like holes and slots. Location dimensioning locates the various features like hole, slot etc, of an object relative to each other from center of one feature to centerline of another similar/ different feature or to a reference edge. It can be given in all width, height and depth direction.

When dimensioning an object the dimensions to be given should be selected in such a way that they are convenient for the workmen to use during manufacturing. The following points should be noted during selection of dimensions:

Dimensions of mating parts should be selected so as to ensure proper functioning.

Dimension should not be duplicated or minimum number of dimensions should be used (Fig.4.7 (c) and (d)).

Dimensions should be selected so that it will not be necessary to calculate, scale, or assume a dimension during manufacturing.

Selection of location dimension requires more attention than size dimensioning.

A hole dimension is given using diameter than radius on its circular view

Lesson 4.3 *Methods of dimensioning*

Number of Periods: 2
(1 period theory and 1 period for practice)

Learning Competencies:

At the end of the lesson, students should be able to:

- ✓ Identify the two methods of arrangement of dimensions;
- ✓ Select the appropriate methods of arrangement of dimensions;
- ✓ Use the two basic arrangement of dimensions alternately on drawing;
- ✓ Select dimensions to reduce the number of dimension lines;
- ✓ Perform different types of dimensioning techniques for any shapes of objects;
- ✓ Prepare dimensions of different views and objects.

Planning a Head

Learn the methods of dimensioning. Can you pick the most logical and practical place to put dimensions with respect to an object?

The lesson concentrates on methods of dimensioning such as chain and datum and also combined dimension.

Therefore, plan the following instructional materials

1. Prepare visual aids to show “methods of dimensioning like chain, datum and combined dimensioning”
2. Review essential questions, “what are the basic elements of dimensioning?”
3. Teacher uses one period for theoretical concept and demonstration about methods of dimensioning. One period for student practice on activities and check points.

Hints for Teaching

This lesson will be presented with the following suggested instructional strategies

1. let the students say something (brainstorming) about methods of dimensioning from the textbook.
2. Discuss and demonstrate the exact idea and concept of dimensioning with practical examples and visual aids. You can refer working drawings of machine parts and assembly drawings. Have students use Ames Lettering Guide for dimensioning. Have students keep main points from discussion about methods of dimensioning in a notebook.
3. Show filmstrips/films/slides/video cassettes on dimensioning and careers in technical drawing.
4. Allow students to practice on activity 4.2 individually or in group and on check point 4.3.

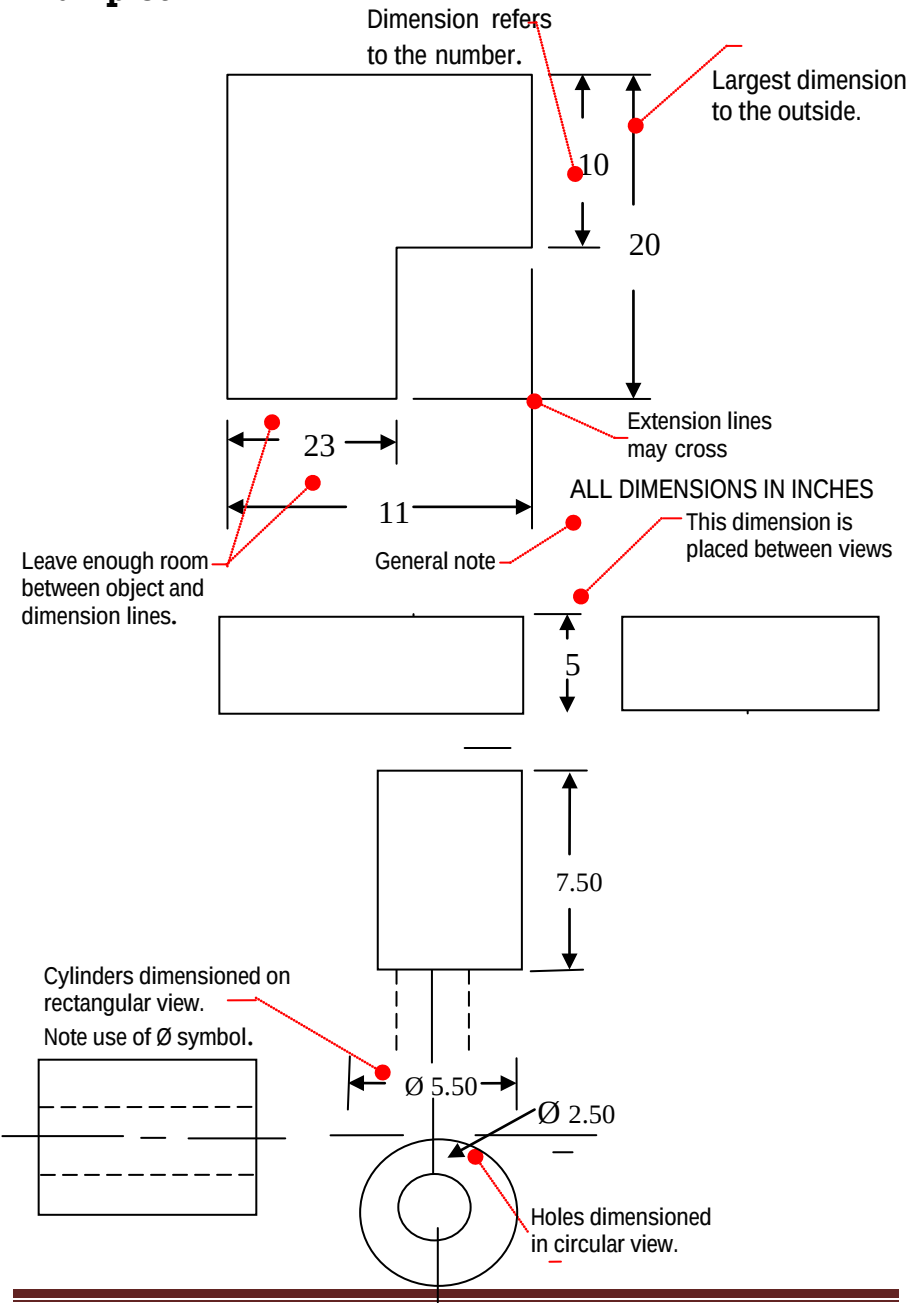
Teaching Note

Datum: A theoretically exact point, line, or plane often used as reference for tabular dimensioning.

Reference dimension: A redundant dimension provided for information only, not to be used for fabrication of the part. It is shown enclosed in parenthesis () or followed by the word REF.

Contour Principle: The concept of dimensioning a feature in the view where it is most clearly shown (preferably in true size/true shape if possible).

Examples



For dimensioning rules the overriding principle of dimensioning is CLARITY.

1. Each feature of an object is dimensioned once and only once.
2. Dimensions should be placed in the most descriptive view of the feature being dimensioned.
3. Dimensions should specify only the size of the feature. The manufacturing method should only be specified if it is a mandatory design requirement.
4. Angles shown on drawings as right angles are assumed to be 90 degrees unless specified otherwise and need not be dimensioned.
5. Dimensions should be moved outside the boundaries of the object whenever possible.
6. Dimension lines should be aligned and grouped where possible to promote clarity and uniform appearance.
7. Crossing dimension lines should be avoided whenever possible.
8. The space between the first dimension line and the object should be at least $\frac{3}{8}$ inch (.375). The space between all other dimension lines should be at least $\frac{1}{4}$ inch (.250).
9. There should be a visible gap between the object and the origin of the extension line.
10. Extension lines should extend $\frac{1}{8}$ inch (.125) beyond the last dimension line.
11. Extension lines should be broken if they cross or are close to arrowheads.
12. Leader lines should be oriented to be read from the bottom of the drawing.

13. Diameters are dimensioned with a numerical value preceded by the diameter symbol.
14. Radii are dimensioned with a numerical value preceded by the radius symbol.
15. Cylinders should be dimensioned in the Rectangular view where possible.
16. When a dimension is given to the center of an arc or radius a small cross is shown at the center.
17. The diameter and depth of holes that are counter-bored, spot faced, or countersunk, should be specified in a note.
18. The depth of a blind hole may be specified in a note, and is the depth of the full diameter from the surface of the object.

Lesson 4.4 *Placement of dimensions*

Number of Periods: 2

(1 period theory and 1 period for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ Identify the placement of dimensions on views, on limited space and pictorial drawing;
- ✓ Apply dimension on views, on limited space rule and pictorial drawing;
- ✓ select dimensions to reduce the number of dimension lines;
- ✓ perform different types of dimensioning techniques for any shapes of objects;
- ✓ prepare dimensions of different views and objects.

Planning ahead

The lesson concentrates on placement of dimension on views, on limited space and pictorial drawing. So, prepare to teach this topic of dimensioning. Which dimensions should you show and which ones should you not show? Therefore, plan the following instructional materials

1. Prepare visual aids to show “methods of dimensioning like chain, datum and combined dimensioning”
2. Review essential questions, “what are the basic elements of dimensioning?”
3. Teacher uses one period for theoretical concept and demonstration about placement of dimension on view, limited space and pictorial drawing. One period for student practice on activities and check points.

Hints for Teaching

Suggested instructional strategies are:

1. Let the students say something (brainstorming) about placement of dimension from the textbook.
2. Discuss and demonstrate the placement of dimension with practical examples and visual aids. You can refer working drawings of machine parts and assembly drawings. Have students use Ames Lettering Guide for dimensioning. Have students keep main points from discussion about placement of dimensions in a notebook.
3. Show filmstrips/films/slides/video cassettes on dimensioning and careers in technical drawing.

4. Use continuing evaluation procedures which enhance student's dimensioning performance.
5. Arrange for a guest speaker whose work involves interpreting/applying drawing dimensions.
6. Allow students to practice on activity 4.3 individually or in group and teacher will give class work exercises.

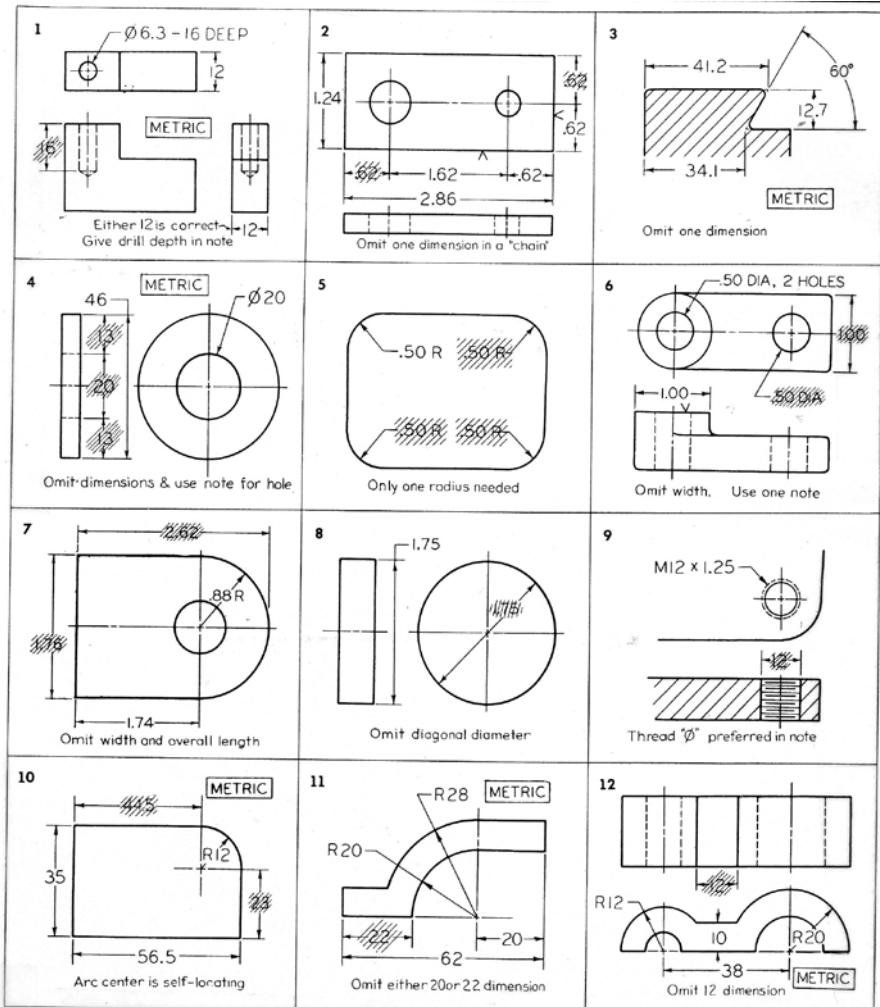
Teaching Note

Principles of placement of dimension on views, limited space and pictorial drawing is very essential. Just because you know how to place dimensions doesn't mean you always use every possible dimension you can. You typically only want to give the minimum number of dimensions that can completely define the object.

Some of the rules are:

1. Dimension should be placed between views whenever possible unless required elsewhere.
2. Use the same unit of measurement and dimension line terminator (arrowhead) on a single view.
3. Dimension the view that best shows the characteristic contour or shape of the object.
4. Avoid any dimension line which passes through a dimension figure.
5. Avoid crossing of two dimension lines and extension line.
6. Avoid using centerline and outline of a view of an object as dimension line, however centerline may be used as extension line.
7. In a parallel method of dimensioning the shortest and longest dimension lines should be placed closest and farthest from the outline of the view respectively.

Note of Caution: While the following examples show good choices for placing dimensions, some of the actual notes are given using an outdated ANSI standard.



Lesson Guide

Period	Lesson title	Starter activity	Main activities	Concluding activities
1	4.1 Introduction,	<ul style="list-style-type: none"> • Ask brain storming question like what the use of dimensioning in working drawing is? • Show visual aids on dimensioning and careers in technical drawing. 	<ul style="list-style-type: none"> • . Discuss the difference between auxiliary planes and principal planes with students. • Demonstrate with visual aid principles and rules to draw sectional views of an object. • Let the students to practice on check points 4.1. 	<ul style="list-style-type: none"> • Allow students to present their group work activity result in front of the class • Give as a home work to do exercises from the textbook
2	4.2 Theory of dimensioning	<ul style="list-style-type: none"> • Allow them to discuss previous lesson 	<ul style="list-style-type: none"> • Provide demonstrations on theory of dimensioning. • Have students use Ames Lettering Guide for dimensioning. • Let the students to practice on activity 4.1 and check point 4.2. 	<ul style="list-style-type: none"> • Allow students to present their group work activity result in front of the class • Give as a home work to do exercises from the textbook
2	4.3 <i>Methods of dimensioning</i>	Introduce the different cases on the placement of dimension	<ul style="list-style-type: none"> • Provide demonstrations on methods of dimensioning such as datum and chain. • Let the students to practice on activity 4.2 and check points 4.3. 	<ul style="list-style-type: none"> • Arrange for a guest speaker whose work involves interpreting/applying drawing dimensions • Give home work to do exercises from the textbook
2	4.4 <i>Placement of dimension</i>	<ul style="list-style-type: none"> • Ask brain storming question like what are the rules to choices of dimension? • Show visual aids on dimensioning and careers in technical drawing. 	<ul style="list-style-type: none"> • Provide demonstrations on rules for placement of dimension. • Let the students to practice on activity 4.3. 	<ul style="list-style-type: none"> • Allow students to present their group work activity result in front of the class • Give as a home work to do exercises from the textbook

Evaluation

Instruct your students to:

- Students to explain the principles of dimensioning.
- Students to explain the importance of dimensioning.
- Students to dimension given drawings correctly using B.S 308 and B.S 1192.

Method

- Presentation (lecture) and Demonstration
- Group discussion (6-8 students per a group)
- Individual practice

Assessments

The teacher should follow and assess each student's work continuously over the whole activity of the each lesson and compare it with the following description to determine whether the student has achieved the minimum required level.

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional activities at the end of the lesson or during breaks.

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

View Dimensions quiz

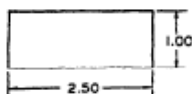
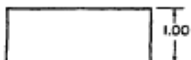
Name _____

1. The height, width, and depth of a non-symmetrical object can be shown with a minimum of how many views? *Two views.*
2. Width is shown in which two views?
3. Depth is shown in which two views?
4. Height is shown in which two views?
5. What dimension does the top and front view have in common?
Width, height, or depth?
6. What dimension does the side view and front view have in common? Width, height, or depth?
7. What dimension does the top and right side view have in common? Width, height, or depth?

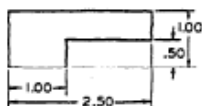
View Dimensions quiz key

1. The height, width, and depth of a non-symmetrical object can be shown with a minimum of how many views?
2. Width is shown in which two views? Front and top
3. Depth is shown in which two views? Top and side
4. Height is shown in which two views? Front and side
5. What dimension does the top and front view have in common?
Width, height, or depth?
6. What dimension does the side view and front view have in common? Width, height, or depth?
7. What dimension does the top and right side view have in common? Width, height, or depth?

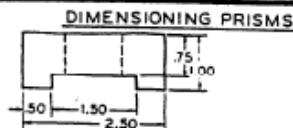
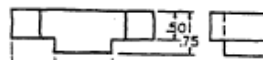
DIMENSIONING WORKSHEET 1



THE METHOD OF DIMENSIONING A SIMPLE BLOCK.

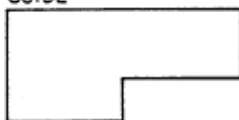


PLACEMENT OF DIMENSIONS ON A BLOCK WITH A NOTCH.



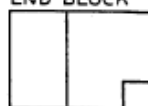
DIMENSIONS ARE PLACED ON THE MOST REPRESENTATIVE VIEWS.

1 GUIDE

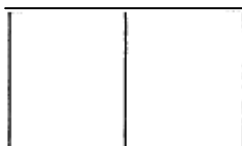
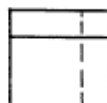


REQUIRED: DIMENSION THE FULL-SIZE PARTS. EITHER SKETCH OR USE INSTRUMENTS AS ASSIGNED.

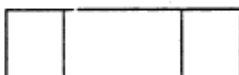
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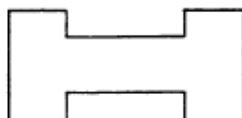
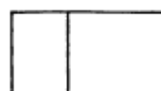
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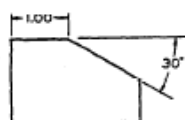
3 SEAT



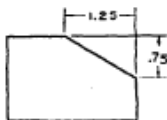
4 TONGUE



DIMENSIONING WORKSHEET 2



DIMENSIONING AN ANGLE USING DEGREES.

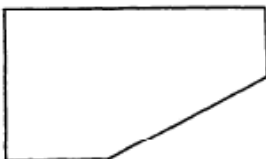
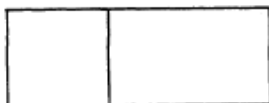


DIMENSIONING AN ANGLE USING COORDINATES.

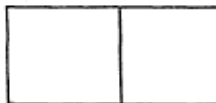
DIMENSIONING ANGLES

REQUIRED: DIMENSION THE FULL-SIZE PARTS BELOW. SKETCH OR USE INSTRUMENTS AS ASSIGNED.

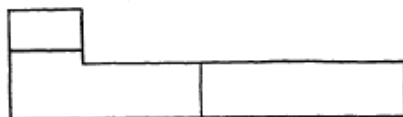
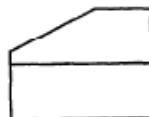
1 LIFTER



2 WEDGE



3 FIXTURE BASE



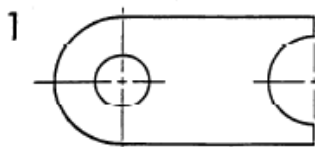
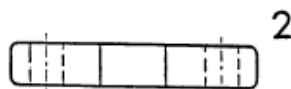
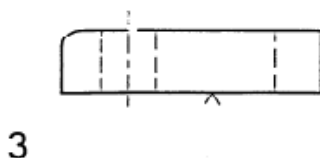
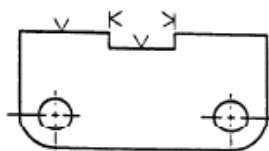
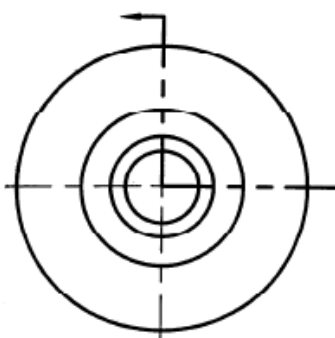
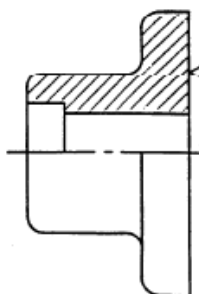
DIMENSIONING WORKSHEET 3



NOTES
ALL FILLETS &
ROUNDS R.25

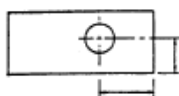
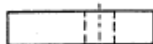
FILLETS & ROUNDS
R.25 UNLESS
OTHERWISE SPECIFIED

DIMENSIONING ARCS
TYPICAL METHODS OF DIMENSIONING ARCS
ARE SHOWN AT THE LEFT. NOTICE THAT A
RADIUS IS USED WHEN THE ARC IS LESS
THAN A FULL CIRCLE. NOTES CAN BE USED
TO SPECIFY FILLETS AND ROUNDS TO RE-
DUCE REPETITIVE DIMENSIONS.

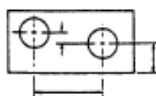


DIMENSIONING WORKSHEET 4

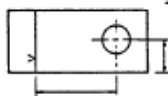
LOCATION DIMENSIONS



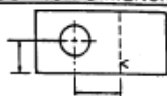
Holes should be located in the circular view with two dimensions.



Holes should be located from center to center when more than one hole is given.

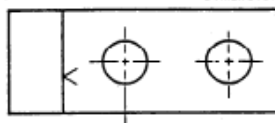


Holes should be located from finished surfaces for greater accuracy.



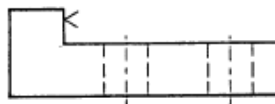
Holes should be located from finished surfaces even if the surface is hidden.

1 GUIDE

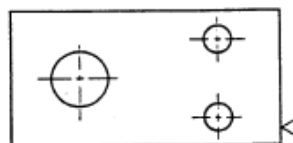
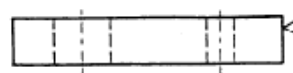


COMPLETELY DIMENSION THE FULL-SIZE PART: POSITION, LOCATION AND SIZE

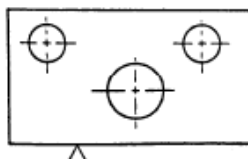
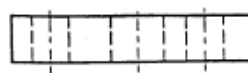
2 ADAPTER



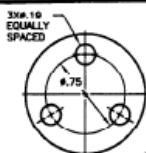
3 FLANGE



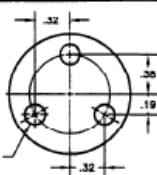
4 CASE



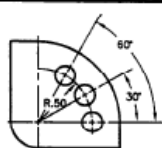
DIMENSIONING WORKSHEET 5



HOLES CAN BE LOCATED BY DIMENSIONING THE CIRCLE OF CENTERS AND WITH A NOTE.



HOLES CAN BE LOCATED WITH COORDINATE DIMENSIONS FROM THE CENTER LINES.



HOLES CAN BE LOCATED WITH ANGULAR DIMENSIONS AND THE RADIUS FROM A POLE POINT.

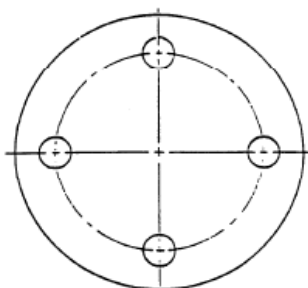
LOCATION DIMENSIONS



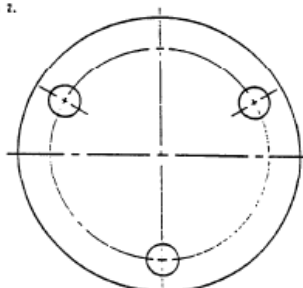
2

1

LOCATE THE HOLES USING THE CIRCLE OF CENTERS METHOD FOR PROBLEM 1 AND THE COORDINATE METHOD FOR PROBLEM 2. GIVE HOLE NOTES.

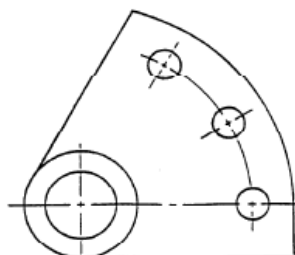


END CAP
HALF SIZE

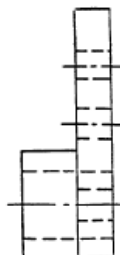


END CAP
HALF SIZE

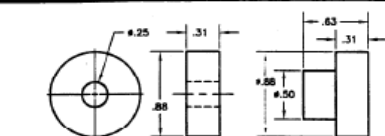
3 COMPLETELY DIMENSION THE PART BELOW.



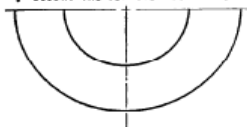
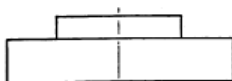
SHAFT BRACKET HALF SIZE



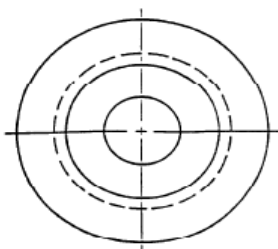
DIMENSIONING WORKSHEET 6



1 DIMENSION THE FULL-SIZE CYLINDRICAL PART BELOW. THE TOP VIEW IS A HALF VIEW.



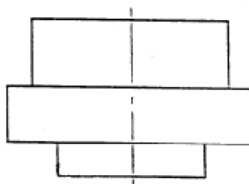
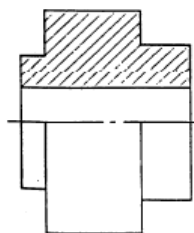
3 DIMENSION THE FULL-SIZE CYLINDRICAL PART SHOWN IN THE HALF SECTION.



DIMENSIONING CYLINDERS

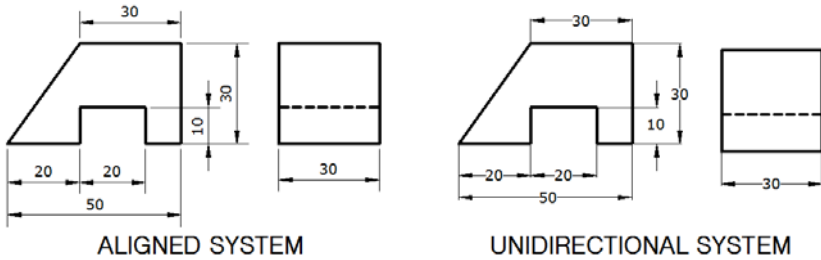
EXAMPLES OF DIMENSIONED CYLINDERS ARE SHOWN AT THE LEFT. DIMENSIONS ARE PLACED ON THE RECTANGULAR VIEW USING DIAMETERS INSTEAD OF RADII. SMALL HOLES ARE DIMENSIONED WITH A NOTE IN THE CIRCULAR VIEW. THE CIRCULAR VIEW CAN BE OMITTED WHEN DIMENSIONING CYLINDERS IF "DIA" IS PLACED AFTER EACH DIMENSIONED DIAMETER IN THE RECTANGULAR VIEW.

2 DIMENSION THE FULL-SIZE CYLINDRICAL PART. THE CIRCULAR VIEW HAS BEEN OMITTED.

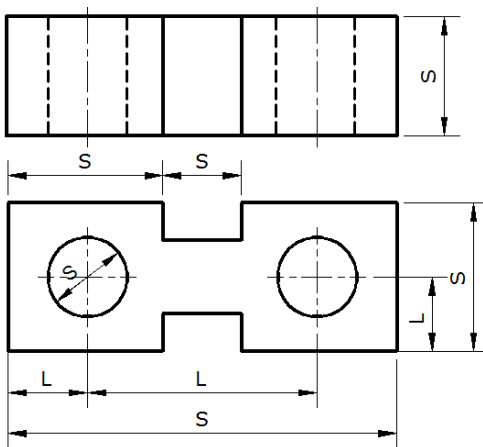


Answer key for the question in the textbook

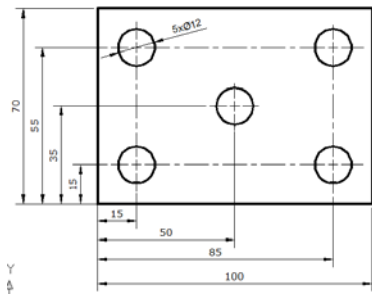
Solution for check point 4.1



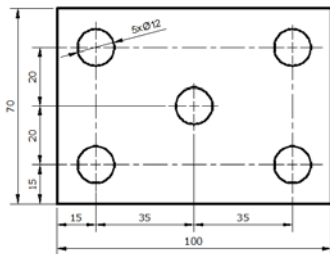
Solution for check point 4.2



Solution for check point 4.3

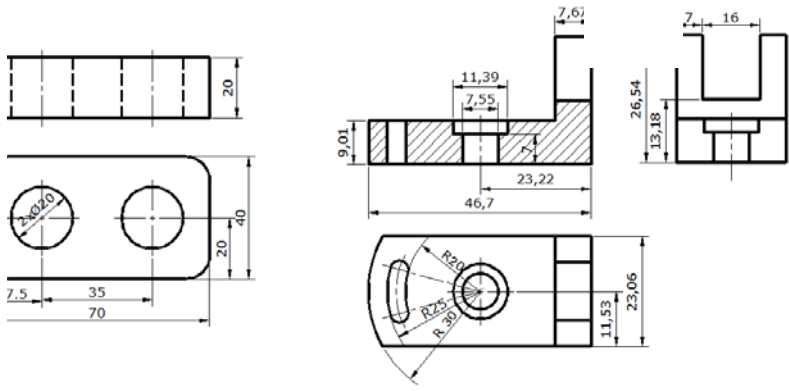


Parallel dimensioning



Chain dimensioning

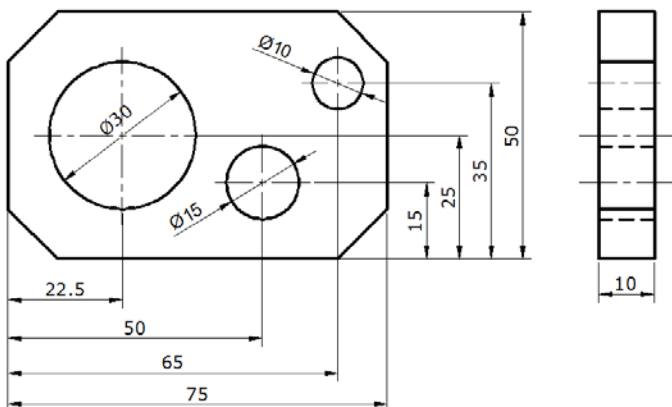
Solution for exercise 1



A

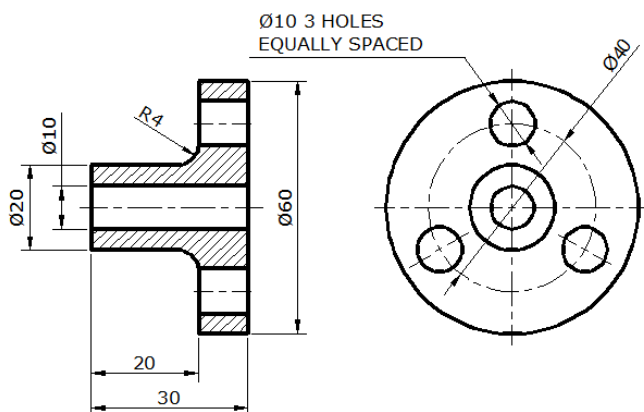
ALL ROUNDS R 10

B



ALL CHAMERS 10X45°

C



D

Isometric view of a mechanical part with dimensions:

- Overall width: 45
- Overall height: 30
- Overall depth: 25
- Top surface width (left): 15
- Top surface width (right): 15
- Top surface depth (left): 5
- Top surface depth (right): 15
- Front face width (left): 10
- Front face width (right): 15
- Front face depth (left): 20
- Front face depth (right): 25
- Internal width (left): 15
- Internal width (right): 15
- Internal depth (left): 10
- Internal depth (right): 15

Isometric drawing of a mechanical part with the following dimensions:

- Top surface width: 72.5
- Top surface depth: 22.5
- Left side height: 15
- Right side height: 57.5
- Front face width: 52.5
- Front face depth: 22.5
- Bottom surface width: 52.5
- Bottom surface depth: 22.5
- Internal width: 15
- Internal depth: 22.5
- Internal height: 15
- Bottom surface width (right side): 15
- Bottom surface depth (right side): 22.5
- Bottom surface width (left side): 22.5
- Bottom surface depth (left side): 22.5

An isometric drawing of a mechanical part. The part has a rectangular base with a width of 60 and a depth of 37.5. The total height is 45. On the right side, there is a sloped face with a height of 22.5. The top surface has a width of 30. There are two vertical faces on the left side, each with a width of 15.

83

UNIT 5

DEVELOPMENT AND INTERSECTION

Total Periods: 21

Unit Outcome

At the end of this unit, students should be able to:

- ✓ Understand the principles and advantage of development and intersection;
- ✓ Recognize the types of hems and joints for different kinds of sheet metal job;
- ✓ Form different 3D models by using surface development in the real world application.

Unit Overview

Many objects, such as cardboard and metal boxes, tin cans, funnels, cake pans, furnace pipes, elbows, ducts, and roof gutters, are made from flat sheet materials that, when folded, formed or rolled, will take the shape of an object. Since a definite shape and size are desired, a regular orthographic drawing of the object is made first; then a development drawing is made to show the complete surface laid out in a flat plane. So this unit exposes students to the analytical drawing techniques required for surface layouts and geometric developments.

Lesson 6.1 *Introduction*

Number of Periods: 1

Learning Competencies

At the end of the lesson, students should be able to:

- ✓ describe the use of surface development;
- ✓ identify the different types of surfaces and solids;
- ✓ identify the type of hems and joints used in sheet metal drawing.

Planning a Head

You are expected to give an overview of the uses of developments; that the students will relate their importance to various commercial users, such as sheet metal workers, with a degree of accuracy and completeness acceptable by you.

Therefore, the instructional material pre-arranged should be

1. Prepare visual aids to show “examples about types of surfaces and solids”.
2. Help students to develop their critical thinking skill by essential questions, “what are the importances of surface development in a design process?”

Hints for Teaching

Suggested instructional strategies are:

1. Start introducing the lesson and give brain storming question as an activity for students to discuss in group on the application of surface development what they know before.
2. Discuss and demonstrate the different types of surfaces, solids.

3. Try to use practical examples of development and intersection by bringing models.
4. Finally make the groups to present a precise summary on the introduction part.
5. Allow students to practice on activity individually and in group.

Teaching Note

A surface development drawing is sometimes called a pattern drawing because the layout is used as a pattern for tracing out a developed shape on flat material. When objects are made of thin metals, both the developed surfaces and the joining of the edges of these surfaces and exposed edges must be considered. There are two types of surface: : Ruled surfaces and double-curved surfaces.

I) A ruled surface: It is a surface generated by the motion of a straight line in a certain desired path. This type of surface may include planes, single-curved surfaces and surfaces.

A Single curved surface is a curved ruled surface that can be developed or unrolled to coincide with a plane. Any two adjacent positions of the generatrix of a single-curved surface lie in the same plane.

A warped surface is a curved ruled surface that cannot be developed.; here no two adjacent positions of the generatrix lie in the same plane. Examples are helicoid and hyperboloid

II) Double-curved surface is one that may be generated by a curved line and thus has no straight line element. Examples are sphere, torus and ellipsoid.

Lesson 6.2 *Principles of development*

Number of Periods: 12

(2 period theory and 10 periods for practice)

Learning Competencies

At the end of this lesson, students should be able to:

- ✓ identify the principles of surface development.
- ✓ identify the rules and steps to use parallel line development.
- ✓ perform the development of different types of platonic solids by parallel line development method.
- ✓ identify the rules and steps to use radial-line development;
- ✓ apply the rule of true length by triangulation.
- ✓ perform the development of different types of platonic solids by radial line development method.

Planning ahead

Be ready to give a presentation and demonstration on types of development, so that the student will practice with ten periods by making development of cylinder, prism and pyramid with the two methods.

Therefore, the instructional material prearranged should be

- Prepare visual aids like model to show the development of cylinder, prism and pyramid.
- Teacher uses two periods for theoretical concept and demonstration about types of surface development applied to make cylinder, prism and pyramid. Ten periods for student practice on activities and check points.

Hints for Teaching

Suggested instructional strategies are:

1. You can start the class by inviting students in text question about types of development from the textbook.
2. Discuss clear idea on the principles and types of surface development and demonstrate by showing the rules and steps in parallel line development. Have students keep main points from the in a notebook.
3. Allow to student to perform from the textbook activities and check points on development of the full and truncated prism and cylinder and different exercises on parallel line development. After going through this, give them a short summary on parallel line development. Simultaneously show the students how to find the true length by triangulation. Then let the students perform the full and truncated pyramid and cone development.

Teaching Note

Straight-line development describes the development of an object that has surfaces on a flat plane of projection. But radial line development of flat surfaces involves, for example, the development of a right pyramid and an oblique pyramid. A right pyramid is a pyramid whose lateral edges from vertex to base are all of equal length. However for the development for curved surfaces of cylindrically shaped objects is called parallel-line development.

The surface of a cone is developable because a thin sheet of flexible material can be wrapped smoothly about it. The students should therefore be familiar with the methods used in developing truncated and oblique cones.

Lesson 6.3 *Intersections between geometrical solids*

Number of Periods: 8

(2 period theory and 6 periods for practice)

Learning Competencies

At the end of the lesson, students will be able to:

- ✓ identify piercing point, visible and hidden line of intersection.
- ✓ use the two methods of finding point of intersection alternatively.
- ✓ determine the line of intersection of two solids, such as prisms and cylinders .
- ✓ construct the development of two intersected regular solids such as, prisms and cylinders.

Planning ahead

For teaching this lesson the teacher should make a great effort to understand how to identify piercing point and should list what are the challenges when constructing the development of two intersected regular solids such as, prisms and cylinders. If it is difficult to capture easily you can share the experience of nearby drafters or engineers.

Therefore, the instructional material pre-arranged should be:-

- Prepare visual aids like model to show the piercing point and intersected regular solids such as prism and cylinder.
- Teacher uses two periods for theoretical concept and demonstration about piercing point and development of regular solids. Six periods for student practice on activities and check points

Hints for Teaching

Suggested instructional strategies are:

1. You can start the class by inviting students in text question about intersection between geometrical solids from the textbook
2. Start to discuss the application of intersection between geometrical solids and show by demonstration the types of intersections and developments. Give examples of objects which can be made with this principle and show the models you brought. Give them a brief summary on the above session.
3. On the second lesson, start by Asking students, what they know before on piercing point and visibility of lines.
4. After a short discussion, demonstrate about piercing point and visible and hidden line of intersection. Going through this, proceed on discussing and demonstrating by showing line of intersection of solids and construction method of development of two intersected regular solids.
5. Then allow students to do the activities and check points from the textbook to practice on the mentioned topic. If it is possible allow students to visit metal workshop factory. Finally check whether all the learning outcomes are attained completely by using the summary exercises.
6. Display students' intersection problem solutions and have students build large models of transition pieces.

Teaching Note

When two surfaces meet, the line common to both surfaces is called the line of intersection. In preparing orthographic drawings objects that are made up of two or more intersecting parts, the drafter needs to plot the lines of intersection on the orthographic views. Intersections that occur often are intersections of flat surfaces, cylindrical surfaces, and prisms.

Intersection of two solids with plane surfaces (Example intersection of prism and pyramid). The common intersection outline becomes a straight line so it is called as line of intersection.

Intersection of two solids, one with plane surface and the other with curved surface (Example intersection of prism and cylinder). When they intersect each other the common intersection outline in majority case becomes curve, but sometimes partially line and partially curve depending on the shape, size and orientation of the solids under intersection.

Intersection of two solids bounded by curved surfaces. (Example intersection cylinder and cone). When they intersect each other, the common intersection outline becomes a curve so it is called as curve of intersection and the manufacturing of which will directly depends on the development of solids intersected.

Piercing point is the point of intersection of a line and a plane. The line can represent the lateral edge of a plane solid or the element of a curved solid. The plane can represent the surface of a solid.

A number of piercing points so located by the intersection of the edge or elements of one solid with the plane or surface of another intersecting solid will be joined to each other using set square or French curve to establish the required line or curve of intersection.

Lesson Guide

Period	Lesson title	Starter activity	Main activities	Concluding activities
1	5.1 introduction	<ul style="list-style-type: none"> Ask brain storming question to students where do they use development in real world. 	<ul style="list-style-type: none"> Assist students to discuss the importance of surface development. Discuss the basic geometric elements Demonstrate different type of surface development with students. Let the students to discuss in group about basic elements of geometric elements. 	<ul style="list-style-type: none"> Guide students to list key terms of this lesson on to summarize the class Give home work to do exercises from the textbook
12	5.2 Principles of development	<ul style="list-style-type: none"> Ask brain storming question to students about principles of development from student textbook. 	<ul style="list-style-type: none"> Using models discuss the principles of surface development with students. Use illustrations and models to show how to develop right and oblique solids and frustum of the various solids Let the students to practice on check points 5.1 up to 5.9 and activity given by the teacher. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook
8	5.3 Intersections between geometrical solids	<ul style="list-style-type: none"> Assist students to discuss with the question on the importance of learning intersection of solids for drafters or engineers and to list examples of intersection of solids 	<ul style="list-style-type: none"> Discuss by showing models the rules and principles for drawing intersection of solids. Ask students to make: <ul style="list-style-type: none"> Two square-prisms meeting at right angles Two dissimilar square prisms merely at any angle, dissimilar square prisms meeting, A hexagonal prism meeting a square prism at right angle, Two dissimilar cylinders meeting at an angle. 	<ul style="list-style-type: none"> Students give feedback about today's lessons. (Teacher acts as facilitator.) Give home work to do exercises from the textbook

Evaluation

Instruct your students to:

- list equipment and tools that require the use of manuals, building drawings, working drawings and circuit diagrams.
- identify specific problems that require designing for improvement.
- identify the use of orthographic projection and pictorial drawing in working drawings.
- Students to state differences in the application of orthographic projection and pictorial drawing in working drawings.

Method

- Presentation (lecture) and demonstration
- Group discussion (6-8 students per a group)
- Individual practice

Assessments

The teacher should follow and assess each student's work continuously over the whole activity of the each lesson and compare it with the following description to determine whether the student has achieved the minimum required level.

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional activities at the end of the lesson or during breaks.

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Answer key for the question in the textbook

Solution for check point 5.1

- a) Define three of the basic geometric elements.

Line is one generated by a point moving according to a law which may be expressed by a geometric description or by an algebraic equation.

Surface is a two dimensional geometrical figure, which may be generated by a motion of either straight or curved line.

Solid is a three dimensional representation of an object which may be generated by bounding plane surfaces or revolving of a plane figure about an axis.

- b) Write types of surfaces that are developable and non developable.

Single curved surface are developable but warped surface and Double curved surfaces are nondevelopable.

- c) List three types of hems and joints.

Single, double and wired edge hems are three types of hems; single, double and rolled edge flanges, lap, plain flat, grooved, single, double and standard seams are joints.

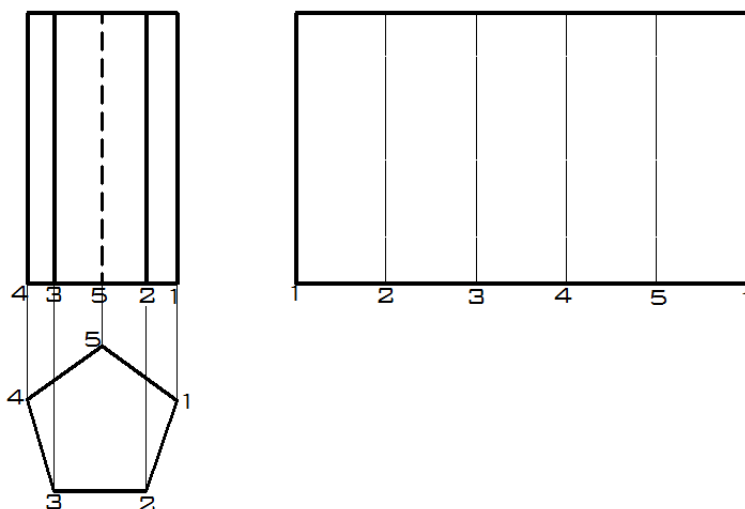
- d) What is development?

When surfaces of an object are laid out on a plane, the drawing obtained is called its developement.

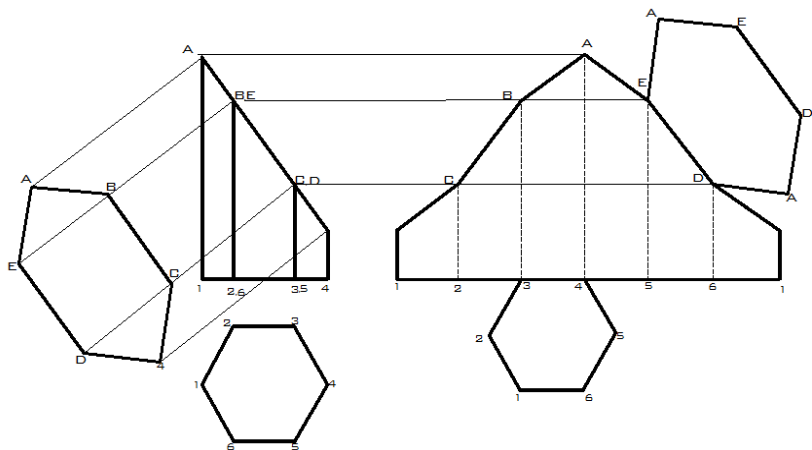
e) List the methods of pattern development you know.

There are three types of pattern development: Parallel line method, radial line methode and triangular methode of which we will see only the first two methods.

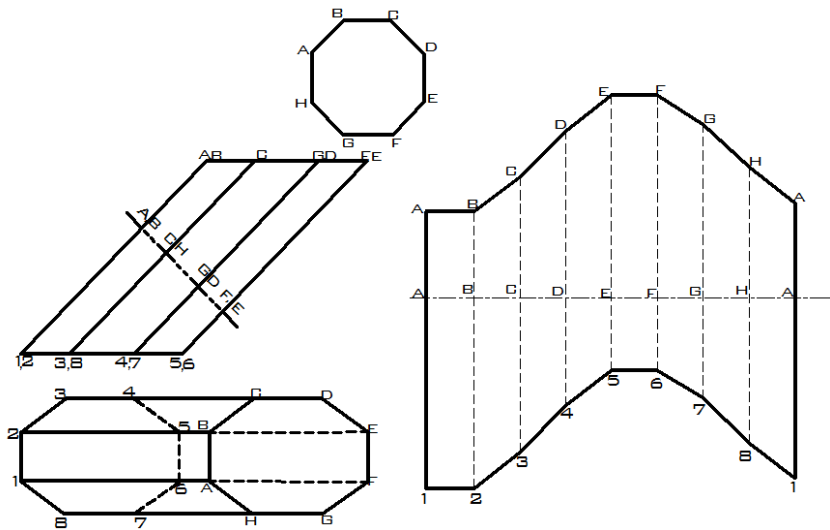
Solution for check point 5.2



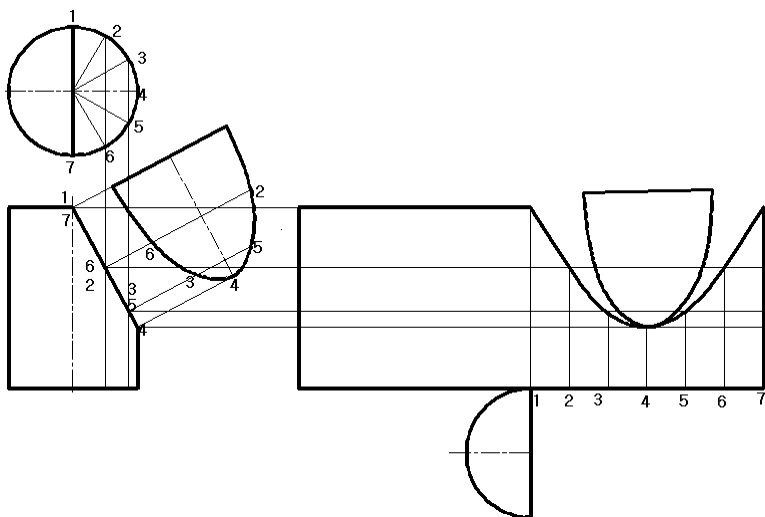
Solution for check point 5.3



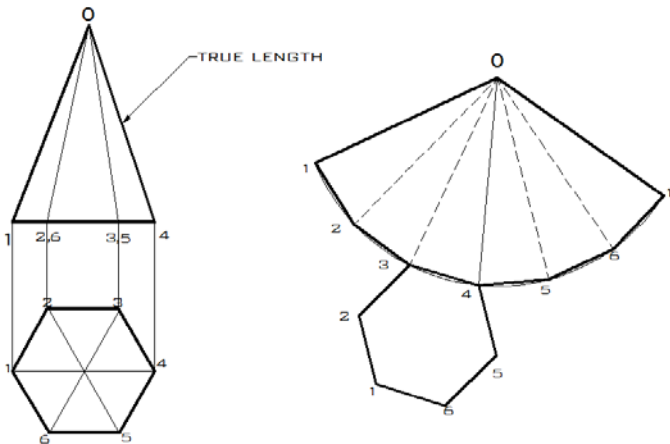
Solution for check point 5.4



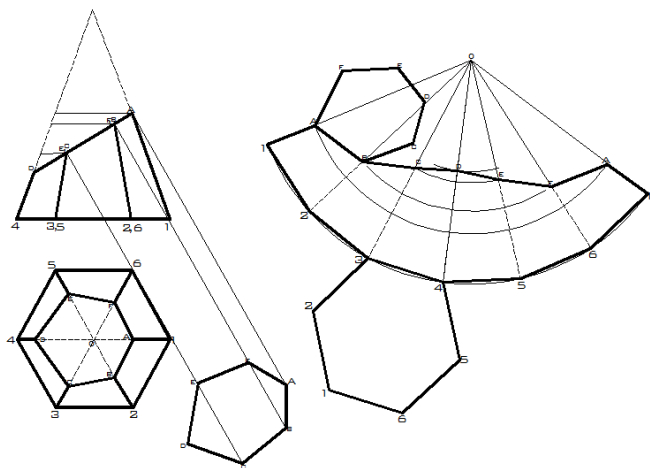
Solution for check point 5.5



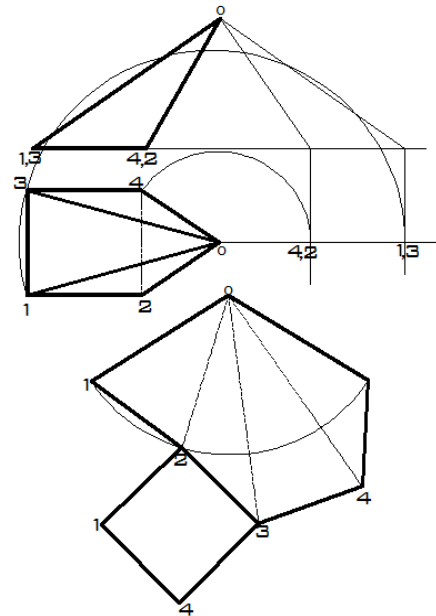
Solution for check point 5.6



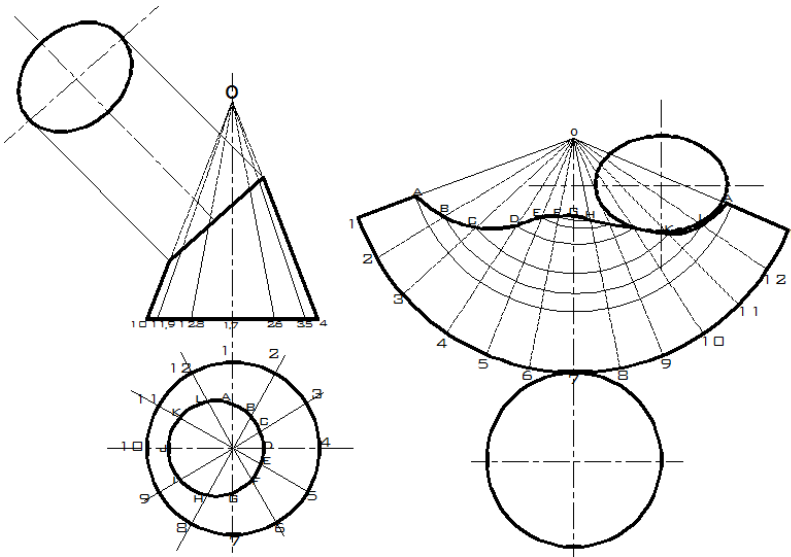
Solution for check point 5.7



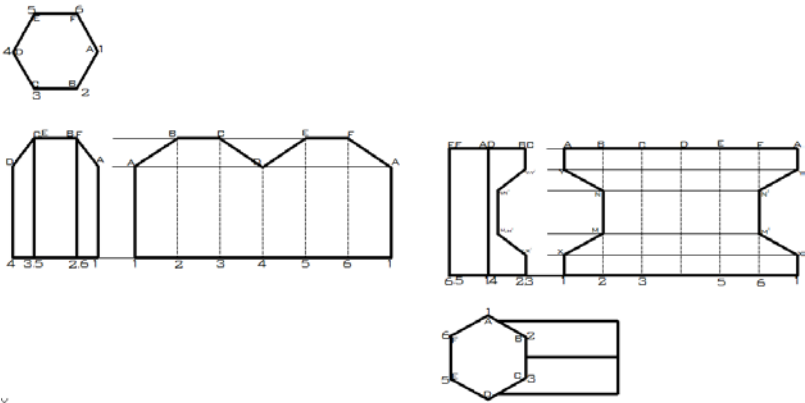
Solution for check point 5.8



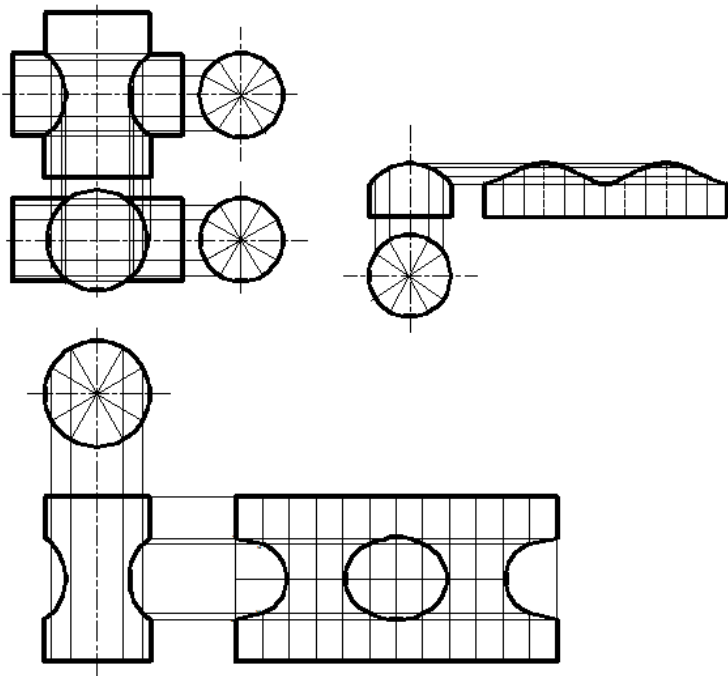
Solution for check point 5.9



\Solution for check point 5.10

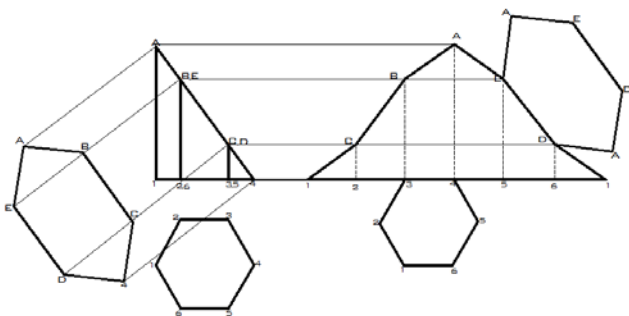


Solution for check point 5.11

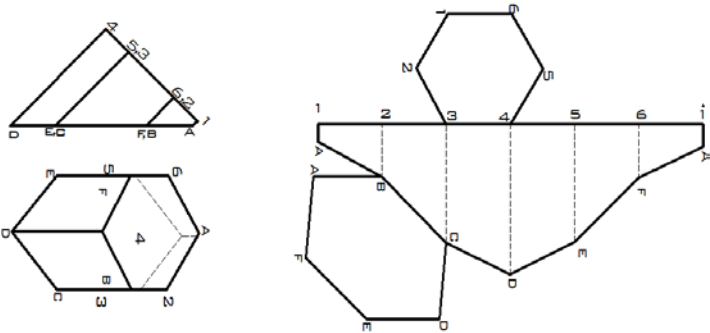


Solution for exercise 1

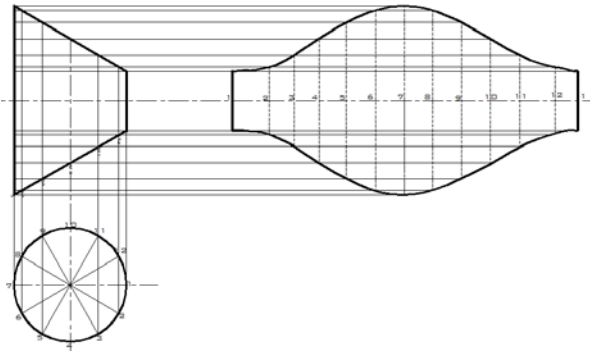
A.



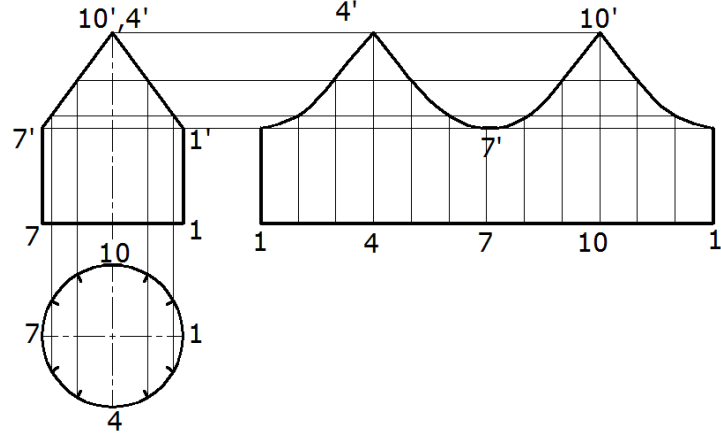
B.



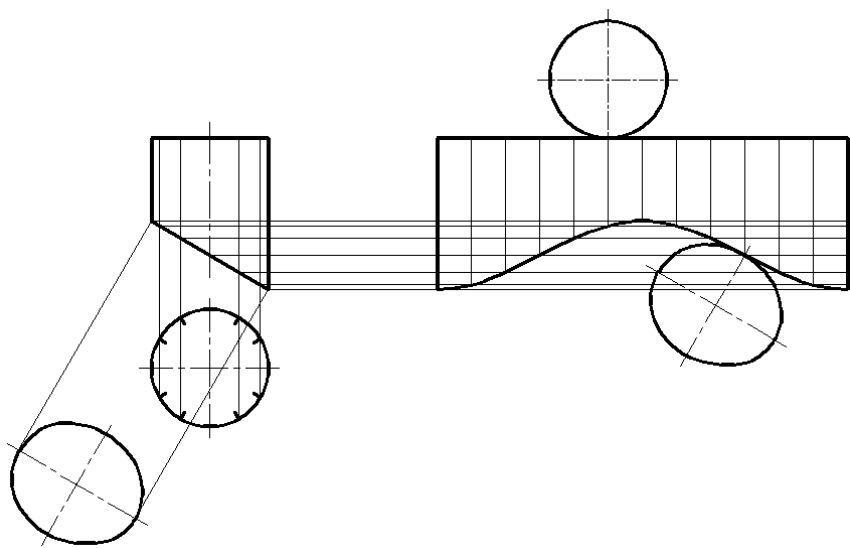
C.



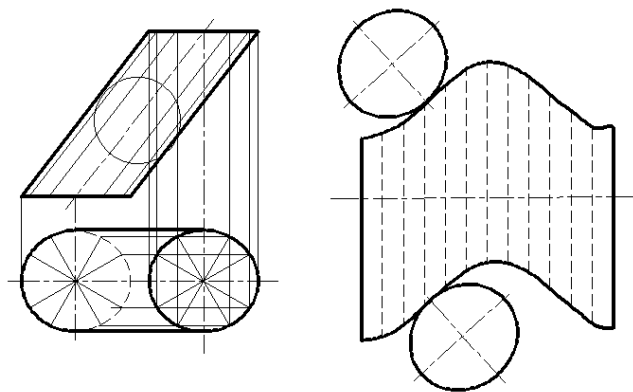
D.



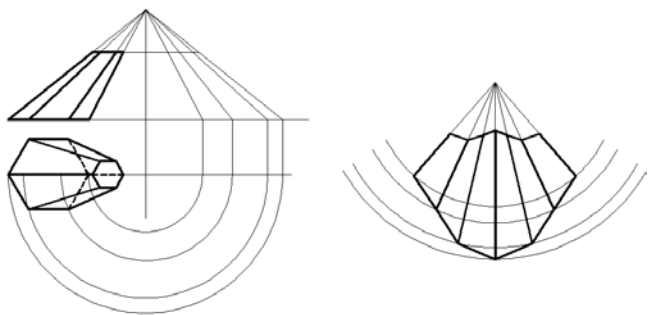
E.



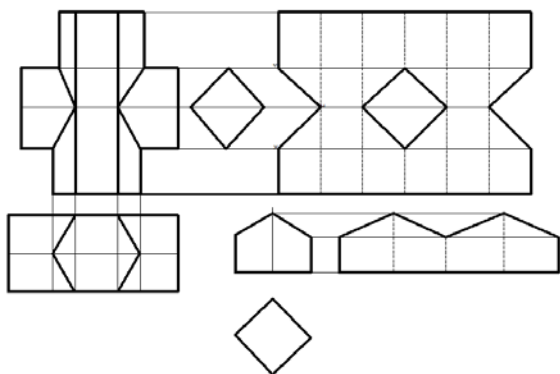
F.



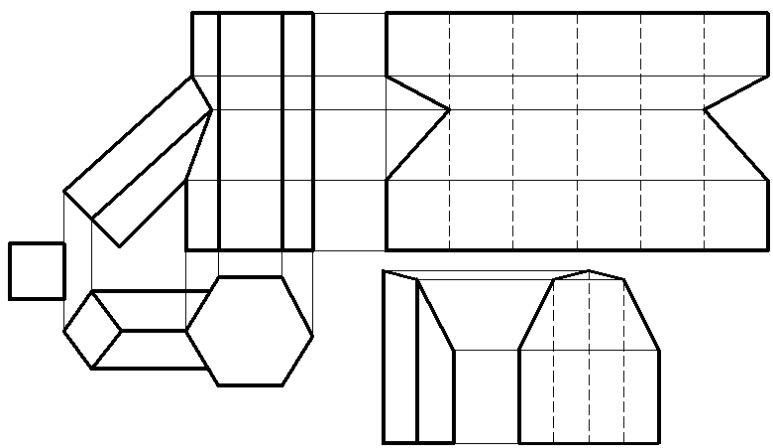
G.



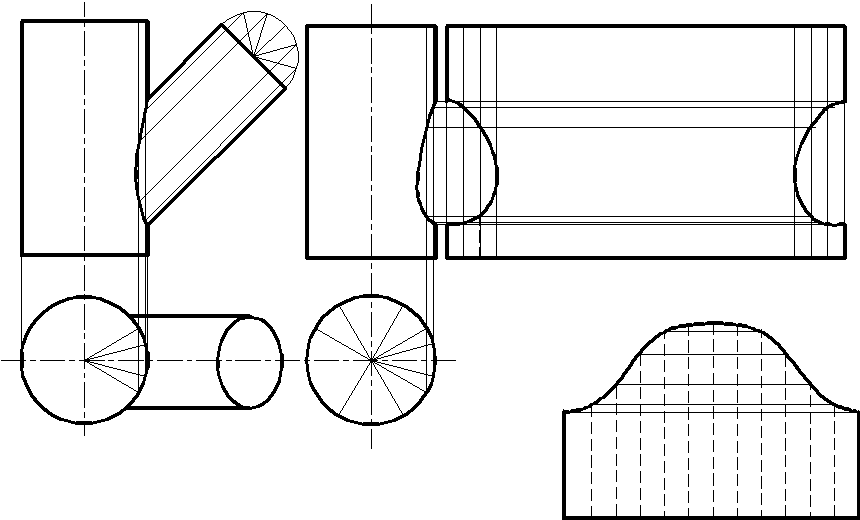
H.



I.



J.



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