2D Architectural and Mechanical Board Drafting

2D Mechanical and Architectural CAD

Activity Plans
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Drafting Dictionary (PPT)
Staedler Drafting Dots—image courtesy of DickBlick.com and/or Blick Art Materials ph. #800-828-4548.
Drafting Careers

Description
This Activity Plan introduces students to various drafting-related occupations. Drafting is foundational to most trades careers, including supervisory positions in the construction and manufacturing sectors. The goals of this resource are first and foremost to explain what is involved in being a draftsperson, and to expose students to the existence of these careers to potentially excite their curiosity and interest.

Beginning the Design and Drafting module in Skills Exploration 10-12 by walking students through this information may not be the most engaging approach to the subject matter. Instead, having students actually do drafting, beginning with the Activity Plans found in the Board Drafting unit and then moving on to CAD, may be a more engaging approach to the material. At that point students will have a better sense of the range of practices that drafting can involve, which will allow them to better appreciate various potential careers in the field.

Lesson Objectives
The student will be able to:

• Define drafting
• Differentiate between board drafting and CAD drafting
• Differentiate between architectural drafting and mechanical drafting
• Understand the importance of plan reading/interpreting drawings in the manufacturing and trade sectors
• Recognize that drafting is a foundation for success in many industries
• Identify careers in which drafting and reading plans are necessary skills
• Find local and regional post-secondary institutions that offer drafting training
• Understand the working conditions of a drafting technician or technologist
• Understand what is required, and the order of events necessary to become a drafting technician or technologist
• Retrieve information about a selected career through website navigation
• Identify key terminology related to drafting

Assumptions
The student will have:

• Minimal previous exposure to information about drafting careers
• Minimal knowledge about CAD and board drafting
• Been informed in advance that this Activity Plan material involves completing a small research assignment
Terminology

Artifact: a product of human art and workmanship.

Computer Aided Drawing (CAD): the use of precision-drawing software programs to accelerate the design process by making it easier to create and modify draft designs. CAD used to be called CADD (Computer Aided Drafting and Design).

Design: a plan or drawing that demonstrates the form and function of a building, garment, or other object prior to its being created.

Domain: a discrete sphere of activity or knowledge.

Drafting: the use of established design standards and specifications to create visual representations of mechanical and architectural structures.

Manufacturing: the creation and assembly of materials, components, and parts into objects designed for use or sale. Manufacturing generally refers to the production of these goods in large numbers.

Occupation: a job for which people are recruited, retained, and compensated, including self-employment. Occupations comprise many broad activities, called duties, that the incumbent performs. Trades are one occupational subcategory for which apprenticeship training is the traditional method of acquiring skill and knowledge.

Plan: a drawing or diagram, particularly one illustrating the layout and constituent components to design a building, made by projection on a horizontal plane. Architectural designs may include separate sets of plans for construction, electrical, plumbing, and mechanical components.

Schematic: a representation intended to explain how something works. Schematics are generally simplified diagrams that include all relevant components of a circuit, device, flow, process, project, or object. Schematics follow conventional design standards to make them useful and easily understandable.

Technologist: in Canada, the terms technician and technologist are professional designations that indicate that a minimum standard of education and experience have been met within a number of different career specializations. Technicians and technologists must possess certification in one of the following areas in order to be fully recognized by industry:

- CET (Certified Engineering Technologist)
- AScT (Applied Science Technologist)
- CCIT (Certified Computer Information Technologist)
- RET (Registered Engineering Technologist)
- TP (Technologue Professionnel)
- PTech (Professional Technologist)
- CTech (Certified Technician)
Estimated Time
45–90 minutes

Recommended Number of Students
20, based on the BC Technology Educators’ Best Practice Guide

Facilities
Classroom, library, or computer lab

Tools
Computer with projector, speakers, and Internet access. This activity could be conducted using mobile devices (e.g., tablets or phones) if there is no access to a computer lab.

Resources
Skills Exploration 10-12 Program Guide
See Appendix C: Glossary of Terms (pp. 26–28) in the Skills Exploration 10-12 Program Guide for a comprehensive Glossary of Terms.
http://www.bced.gov.bc.ca/irp/pdfs/applied_skills/2014skills_exploration1012.pdf

Drafting technologists and technicians: National Occupational Classification (NOC)

Education Planner
Type “drafting” in the search engine to find relevant programs.
http://www.educationplanner.ca/

Government of Canada: Job Futures Quebec: Drafting Technologists and Technicians NOC 2253
https://www.jobbank.gc.ca/content_pieces-eng.do?cid=10558&ilang=eng

Job Roles and Responsibilities in Canada: Drafters: Drafting Technologists and Technicians

Technology Education 11 and 12: Drafting and Design Integrated Resource Package, 2001
(BC Ministry of Education)
http://tinyurl.com/z3kzczz

(BC Ministry of Education)
http://tinyurl.com/jcmo3n4
WorkBC: Drafting technologists and technicians (NOC 2253)
https://www.workbc.ca/Job-Seekers/Career-Profiles/2253

Teacher-led Activity

Begin by explaining to students that drafting is the use of established design standards and specifications to create visual representations of mechanical and architectural structures.

Architectural drafting generally refers to the drawing of buildings, while mechanical drafting refers to the drawing of machines and machine parts. The technical drawings created through either of these means are indispensable communication tools in industry and engineering.

Drafting is an integral part of all foundation trades, and drafting and design skills are integral to the success of tradespeople. It is important that tradespeople can read and understand plans and symbols so they can execute a job correctly. The foreman at a job site must interpret plans; if there are discrepancies between plans or between a plan and the physical work site, the foreman must find out what information is correct and make necessary changes.

In the manufacturing sector, prototyping and modelling are essential steps to a complete design and build process. For example, a technologist may print a 3D model of a proposed mechanical part and then test the part to make sure it fits properly. If it doesn’t fit properly, the technologist must go back to the design team for any necessary changes. This step is essential to the successful manufacturing of parts.

Board Drafting

Board drafting (also known as manual drafting) involves creating visual representations on a right-angled sheet of paper laid flat on a smooth surface, typically a drawing board. Various drafting tools are used to facilitate the process of designing on paper.

For a comprehensive list of tools involved in board drafting, see:

2D Architectural Board > Activity 1: Drafting Dictionary

The Drafting Dictionary activity is also included in 2D Mechanical Board. There is a Drafting Dictionary PowerPoint presentation designed to accompany this Activity Plan.

Computer Aided Drawing

Computer aided drawing (CAD) involves the use of precision-drawing software programs to accelerate the design process by making it easier to create and modify draft designs.
Drafting Technologists and Technicians: National Occupational Classification

The following information describes the many applications of design and drafting within the workplace. It is from the Government of Canada’s National Occupational Classification (NOC), a framework used as a reference to help organize jobs in Canada’s labour market into meaningful categories.

Drafting Technologists and Technicians

Drafting technologists and technicians prepare engineering designs, drawings, and related technical information, in multidisciplinary engineering teams or in support of engineers, architects, or industrial designers, or they may work independently. They are employed by consulting and construction companies; utility, resource, and manufacturing companies; all levels of government; and by a wide range of other establishments. Drafting technicians are classified under the National Occupation Classification (NOC) # 2253. Example titles:

- Architectural draftsperson
- Computer aided design and drafting technologist
- Computer aided drafting (CAD) technician
- Design and drafting technologist
- Drafting technician
- Drafting technologist
- Draftsperson
- Electrical draftsperson
- Electromechanical draftsperson
- Electronic draftsperson
- Engineering design and drafting technologist
- Mechanical draftsperson
- Steel detailer – drafting
- Structural draftsperson
- Structural steel drafter-detaller
- Supervisor, drafting office
Student Activity
The teacher will give a brief explanation of the computer lab activity. The worksheet provided is designed to take approximately 1–2 hours. The sheet directs students to several websites where they can find the answers. Some reflective questions are also asked; the answers are not found on any particular website. The questions are designed to get students thinking a little deeper about working as a drafting technologist or technician, as well as what they have learned in this assignment.

Part 1: Teacher-led discussion
- Describe the various careers and training
- Discuss the fact that drafting is embedded in every trade; provide examples from the ITA website

Part 2: Web-based activity
- Retrieve information about a selected drafting career through website navigation

Extension Activity
Bring in one of the following as a guest speaker:
- A post-secondary instructor to describe programs or someone employed as a drafting technologist or technician working in the field
- A tradesperson/foreman who builds homes/buildings
- An engineer/technologist
- The maintenance supervisor of your school district who oversees all district maintenance

Assessment
Student participation in discussion
Student completion of activity
Web-based Activity

Preparing to Become a Drafting Technologist or Technician

1. What courses can you take in high school (academic or otherwise) if you’re interested in becoming a drafting technologist or technician?

__________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________

2. List three different activities or hobbies you could do at home that would help you become a drafting technologist or technician.
   a. ___________________________________________________________________________________________________________
   b. ___________________________________________________________________________________________________________
   c. ___________________________________________________________________________________________________________

3. What types of people should you talk to or question if you’re interested in becoming a drafting technologist or technician?

__________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________

4. What qualities, skills, or talents do you think a prospective employer would want you to have if they were considering hiring you as a drafting technologist or technician?

__________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________
Training (Education Planner BC)
Go to the Education Planner BC website: http://www.educationplannerbc.ca

1. Find a drafting-related program at a college or university in British Columbia. Where is the training institution? What is the name of the program? How long is it?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

2. Are you interested in a career as a drafting technologist or technician? Explain your answer.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

National Occupational Analysis (NOA)

What is the NOA’s code number (NOC) for drafting technologists and technicians?

__________________________________________________________________________

Related Careers (WorkBC)
Go to the WorkBC website: https://www.workbc.ca

1. List five other careers related to becoming a drafting technologist or technician.
   a. ______________________________________________________________________
   b. ______________________________________________________________________
   c. ______________________________________________________________________
   d. ______________________________________________________________________
   e. ______________________________________________________________________
2. Select one of the careers you identified above and compare it to being a drafting technologist or technician. How is it similar? How is it different? Consider the following points of comparison:
   a. Earnings

   b. Employment outlook

   c. Education, training, and qualifications

3. Describe each of the skills below, all of which are related to being a successful drafting technologist or technician:
   a. Spatial perception

   b. Innovative
c. Numerical ability

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

d. Detail-oriented

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

4. In a sentence or two, discuss what you think the work environment might be like for a drafting technologist or technician.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Web-based Activity Answers

Preparing to Become a Drafting Technologist or Technician

1. Answers will vary but could include any number of Applied Design, Skills and Technology (ADST) or Technology Education classes—in particular, Drafting and Design and Industrial Design. Any other classes where reading plans is required may also be of value, including Technology Education 8-10, Carpentry and Joinery, Metal Fabrication and Machining.

2. Answers will vary but could include manual drawing or the use of CAD software to develop plans, building using plans (this could include woodwork, modelling or robotics kits, etc.), as well as reading and/or researching information related to design and drafting.

3. Answers will vary but could include speaking with career counsellors and advisers within the post-secondary system, Technology Education teachers, as well as drafting technologists or technicians, designers, and architects.

4. Students with a background using a variety of CAD software applications will be much better positioned to become a drafting technologist or technician. Model making and woodworking are also valuable skills that can contribute to an understanding of reading and developing plans.

Training (Education Planner BC)

1. Answers will vary. A search for “drafting” yields results for nine different programs from six different institutions:

   a. British Columbia Institute of Technology (BCIT)
      - Architectural and Structural CADD and Graphics Technician (Architectural Option)
        Certificate of Technical Studies (40 weeks, full-time)
      - Architectural and Structural CADD and Graphics Technician (Structural Option)
        Certificate of Technical Studies (40 weeks, full-time)

   b. Kwantlen Polytechnic University
      - Computer Aided Design & Drafting (two-year diploma)

   c. University of the Fraser Valley
      - Architectural Drafting Technician Certificate (10-month certificate)

   d. Camosun College
      - AutoCAD Graphics Certificate (200 hours of instruction)

   e. Thompson Rivers University
      - Architectural and Engineering Technology Diploma (three-year program)

   f. Vancouver Community College
      - Drafting Technician (Architectural Certificate, 10 months)
      - Drafting Technician (Architectural, Civil and Structural Certificate, 10 months)
      - Drafting Technician (Steel Detailing Certificate, 10 months)
2. Answers may vary. Students may be attracted to the technical and/or creative aspects of drafting. Alternatively, working with CAD software means spending long hours in front of a computer screen, which may not be attractive to some students.

National Occupational Analysis (NOA)

2253: Drafting technologists and technicians

Related Careers (WorkBC)

1. a. Civil engineering technologists and technicians
   b. Mechanical engineering technologists and technicians
   c. Electrical and electronics engineering technologists and technicians
   d. Architectural technologists and technicians
   e. Industrial designers

The following additional careers are also listed under “Technical occupations in architecture, drafting, surveying, geomatics and meteorology” (NOC 225):

- Land survey technologists and technicians (NOC 2254)
- Technical occupations in geomatics and meteorology (NOC 2255)

2. Answers will vary.

   a. Spatial perception
      Can you draw things accurately?
      The ability to perceive or react to the size, distance, or depth of the environment.
      • Recognizes size, distance, or depth
      • Can imagine a 3D form from a diagram
      • Awareness of surrounding environment
      • The ability to draw things accurately
      • Understands geometry
   b. Innovative
      Do you like to dig deeply to solve problems?
      You like to explore things in depth and solve problems by experimenting. You prefer to be challenged with new and unexpected experiences.
Think outside the box
• Adjusts to change easily
• Likes testing and measuring
• In-depth exploration
• Enjoys science

c. Numerical ability
Are you good with numbers?
The ability to understand numbers and perform math.
• Solve numeric problems
• Collect data and analyze statistics
• Solve math problems
• Make accurate measurements
• Work with money

d. Detail-oriented
Can you pick out differences in two similar pictures?
Ability to see fine details in objects.
Eye for detail:
• Recognizes small parts
• Sees fine detail in objects
• Visually perceptive
• Inspects objects

4. Answers will vary.
Drafting Dictionary

Description
In this lesson the teacher will introduce the tools and equipment specific to board drafting. Board drafting (also known as manual drafting) refers to precision drawing with specialized instruments. It is expected that as part of this Activity Plan, the instructor will demonstrate the appropriate usage of each tool.

Lesson Objectives
The student will be able to:

• Introduce common drafting equipment and tools
• Demonstrate appropriate and correct tool usage

Assumptions
The teacher will have a general working knowledge of drafting tools and equipment.
The student will have minimal knowledge of drafting equipment.

Terminology
Compass: a tool used to draw circles, bisect lines, and create dividing lines. Can be fitted with pencil leads or points.

Drafting board: a flat, smooth surface, designed with square, parallel edges that allow a T-square to slide easily. Most boards are covered with a vinyl material to allow for even surfaces to which paper can be affixed.

Drafting brush: a hand brush used to sweep away debris from a drawing to prevent smearing.

Drafting templates (plants, furniture, circle, appliance standards): standardized cut-outs used to draw repeated shapes to scale.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without damage to the rest.

French curve: a rigid plastic template used to draw irregular curves or radii.

Lettering guide: a plastic template designed to assist in the drawing of uniform strings of letters for consistent, evenly spaced lettering.

Masking tape (drafting dots): used to hold drawing paper/vellum to the drafting board so it does not shift while drawing.

Metric and imperial scale: a three-faced ruler with a triangular base, used to reduce or enlarge drawings. The triangular scale ruler has more than one graduated scale and is used only as a measurement instrument, not as a ruler.
Protractor: a semicircular template made of transparent plastic, used to measure angles.

Spline: a flexible plastic or rubber template with a metal core that can be shaped into most curves.

Steel rule: a straightedge made of rigid material, divided into specific increments. Can be found in metric and imperial measurement divisions.

Triangles (right angle and isosceles): hard, clear plastic triangular templates used to draw vertical lines as well as lines at set angles: 45°–90°–45°, 30°–60°–90°

T-square: a precision drawing instrument, used as a guide for other drafting equipment. Has a 90° angle where the head and blade attach.

**Estimated Time**

40–90 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

Regular classroom space with desks/chairs for all students, a projector with computer and speakers, and Internet access

**Tools**

- T-square
- Metric and architectural scale
- Steel rule
- French curve
- Triangles (right angle and isosceles)
- Assorted drafting templates (plants, furniture, circle, appliance standards)
- Eraser shield
- Drafting brush
- Protractor
- Compass
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
Materials

- Handout for students with images of equipment and descriptions of each. Use printout of PowerPoint presentation as handout (also available on the Youth Explore Trades Skills website as a PPT presentation and a PDF).
- 8.5" × 11" paper
- Computer
- Projector

Resources

- PowerPoint presentation for Drafting Dictionary

Teacher-led Activity

- Introduce each tool. Visual aids could be used to show each piece of equipment, or where available the tools themselves could be presented.
- List each tool's use and demonstrate on whiteboard.
- Students could copy notes, or a handout could be created from the PowerPoint file.
- Review any feedback and questions with students.

Student Activity

Students will complete a quiz activity after the introductory lesson.

Assessment

Students will be assessed based on discussion participation and completion of quiz.

Appendix Acknowledgment

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Appendix

Describe the drafting tools and materials used in drawing plans

Traditionally, drafters sat at drafting boards and used pencils, pens, compasses, protractors, triangles, and other drafting devices to prepare a drawing manually. Today, however, most professional drafters use computer-aided drafting (CAD) systems to prepare drawings. Although drafters use CAD extensively, it is only a tool. Drafters and tradespersons still need knowledge of traditional drafting tools and techniques.

Tools
Drafting tools are needed to lay out the different shapes and lines used to create drawings and sketches. A basic knowledge of the available tools and how to use them will assist you in your drawing.

Drafting board or table
The drafting board is an essential tool. Paper will be attached and kept straight and still, so the surface of the drafting board must be smooth and true, with no warps or twists. The surfaces of most drafting boards are covered with vinyl because it is smooth and even.

The drafting board or table should have two parallel outside working edges made of either hardwood or steel.

Most drafting table tops can be set at different heights from the floor and at any angle from vertical to horizontal. Other drafting tables may not have the same adjustments and may be limited to being raised only from horizontal to a low slope.

To reduce back strain, use an adjustable drafting stool when working at a drafting table. Tables or boards should be a minimum of 1.2 m (4') in width and 0.9 m (3') in height.

T-square
The fixed head T-square is used for most work. It should be made of durable materials and have a transparent edge on the blade. To do accurate work, the blade must be perfectly square and straight; this should be checked regularly.

The T-square is used to draw horizontal lines and to align other drawing instruments. If you are right-handed, you hold it tight against the left edge of the drawing board and move it up and down as required. When you make close adjustments, your fingers should be on top of the square and you should use your thumb to control the T-square’s movement (Figure 1).
When drawing horizontal lines, incline your pencil in the direction you are drawing the line. Hold the pencil point as close as possible to the blade. Roll the pencil between your fingers to prevent the point from becoming flat on one side.

**Triangle**
A triangle (set-square) is made of a clear plastic. Some triangles have rabbeted edges (Figure 2), so that when you draw lines, the corner of the edge is set away from the paper to help prevent smudges and ink blotches.

Triangles are available in 45°-90°-45° or 30°-60°-90° combinations. For most work, triangles should be about 200 mm to 250 mm (8" to 10") long. Triangles should be stored flat to prevent warping, and not stored underneath other objects to prevent any pressure from causing them to deform.
Check a triangle for accuracy by drawing a perpendicular line, then reversing the triangle and drawing another perpendicular line (Figure 3).

Triangles are used to draw vertical lines and other lines at set angles. Rest the triangle on the T-square blade and slide it along the blade to the desired location. Draw the full length of the vertical line in one pass if possible. Hold the blades of the T-square and the triangle together to prevent any movement when you are drawing, and hold the pencil point as close as possible to the triangle. You can also draw 15° and 75° angles by using both a 45°-90°-45° and a 30°-60°-90° in combination. Figure 4 shows how triangles are placed to draw angles that are every multiple of 15°.
**Protractor**

A protractor (Figure 5) is an instrument used to measure angles. It is typically made of transparent plastic or glass. Protractors can be used for checking and transferring angles to and from a drawing sheet.

![Figure 5 — Protractor](image)

**Drafting machine**

A drafting machine (Figure 6) is a device that is mounted to the drawing board. The drafting machine replaces the T-square and triangles, as it has rulers with angles that can be precisely adjusted with a controlling mechanism. A drafting machine allows easy drawing of parallel lines over the paper. The adjustable angle between the rulers allows the lines to be drawn in a variety of accurate angles. Rulers may also be used as a support for separate special rulers and letter templates. The rulers are replaceable and can be replaced with scale rulers.

![Figure 6 — Drafting machine](image)
Drawing pencils
Both wood and mechanical pencils are used for drafting (Figure 7).

Manufacturers grade drawing pencils using numbers and letters. These range from 6B (very soft and black) to 9H (the hardest). From 6B the pencils progress through 5B, 4B, 3B, 2B, B, and HB, and then to F, the medium grade. After that they move to the harder graphite: H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, and finally 9H. The softer grades are used for sketching and rendering drawings. The harder grades are used for instrument drawings.

Mechanical pencils do not require sharpening and are made to hold leads (they are actually made of graphite) that are bought separately. Thin-lead mechanical pencils, with leads as small as 0.5 mm, are available in different grades of lead. Most draftspersons use four or five different mechanical pencils with a different lead in each. The pencils come in different colours so it is easy to keep track of which lead is in each.

Figure 7 — Wood and mechanical pencils

Erasers and erasing shields
The best eraser to use on drawings is either a soft pink eraser that has bevelled ends, or the white plastic eraser. Electric rotary erasers are also available. They permit easy erasure of small errors without erasing adjacent lines.

A metal erasing shield helps to confine erasures to the desired area. Erasing shields are made from very thin stainless steel and have holes of various shapes to accommodate the sections to be erased. Figure 8 shows two erasers and an erasing shield.

Figure 8 — Erasers and erasing shield
**Templates**

Templates (Figure 9) are available for many different trades. Templates incorporate cut-outs of symbols and fixtures that are commonly used in that trade. These cut-outs make it easy to trace shapes onto drawing paper.

![Figure 9 — Templates](image)

**French curves and splines**

A French curve (Figure 10) is a plastic template designed to help you draw curves. The French curve contains many different curves, but each one is represented over a very short distance only. One radius of curve blends into another radius. It takes a lot of practice to use French curves effectively.

![Figure 10 — French curve](image)

A spline or flexible curve (Figure 11) can be used instead of a French curve to draw most curves. A spline is a plastic or rubber rod that is reinforced with metal. To use a spline, bend it to the shape of the curve you need. The design of the spline lets you hold a pencil against an edge and draw an accurate line without smudging. A spline cannot be used to draw curves that have a very short radius because the spline will not bend tightly.

![Figure 11 — Spline](image)
Compass

A compass can be used for drawing circles, bisecting lines, or dividing angles. For very large circles you can use a beam compass. The four types of compasses are shown in Figure 12. Most compasses can be fitted with leads, pens, or points.

![Friction compass](image1)
![Bow compass](image2)
![Wing compass](image3)
![Beam compass](image4)

Figure 12—Four types of compasses
When using the compass, tilt it in the direction of the line, as shown in Figure 13.

![Figure 13 — Drawing a circle with a compass](image)

**Dividers**
Dividers (Figure 14) are used for transferring dimensions from a drawing to a measuring device such as a ruler or scale. They are also used when scribing directly on material like metal.

![Figure 14 — Dividers](image)

**Dusting cloth or brush**
It is very important to keep your drawings and drafting surface clean. When equipment gets dirty from the lead pencils, you should clean it regularly so that it does not smudge your drawings. Any soft, clean cloth is suitable. You may want to wash your board occasionally with a spray cleaner.
Use a brush like the one in Figure 15 to clean your table prior to placing paper down and to sweep away any debris as you are drawing. If you use your hand to brush, you could leave marks on the paper. After sharpening a pencil, wipe off any dust that is clinging to the point of the pencil to prevent smudging.

**Figure 15 — Dusting brush**

**Scale rulers**

Scale rulers let you draw diagrams at a reduced scale. They also let you obtain dimensions from a scaled drawing. Scale rulers come in a variety of types to meet the requirements of many different kinds of work. Most scale rulers have three edges and six different scales. The scales are read from either end of the rule. A typical combination of metric scales is 1:20, 1:50, 1:100, 1:25, 1:75, and 1:125.

Because of the decimal basis of metric measurements, metric scale rulers are both applicable and easy to use at any scale. Figure 16 shows the two scales from both ends of the same side.

**Figure 16 — Metric scale ruler**

Imperial scale rulers may be an architect’s ruler, a mechanical engineer’s ruler, or a civil engineer’s ruler (Figure 17). The architect’s scale ruler is the most common, and is in inches and fractions of inches. A mechanical engineer’s scale ruler comes in inches and decimals of inches. A civil engineer’s scale ruler comes in feet and decimals of feet.
Drafting materials
The most common support for drawing is paper. Even though the original creative surface has changed from the drafting table to the computer screen, on the work site drawings are still primarily in printed form.

Drawing paper
There is a wide variety of drawing paper available in many sizes and of different qualities. Good quality drawing paper is acid-free and will not turn yellow with age. Light-coloured drawing papers are available in pale yellow or buff, but these should be used only when it is not necessary to make copies.

Tracing paper
Tracing paper, which is transparent, can be used to make copies of drawings. It is thin enough to allow the light of photocopy machines to shine through the unmarked areas, and only the lines and figures will block the light. Materials used for tracing include tracing paper, vellum, tracing cloth, glass cloth, and polyester film with a matte finish.

Standard paper sizes
Paper sizes typically comply with one of two different standards: ISO (world standard) or ANSI/ASME Y14 (American).

The standard ISO series of paper sizes is as follows:

- A0 841 mm × 1189 mm
- A1 594 mm × 841 mm
- A2 420 mm × 594 mm
- A3 297 mm × 420 mm
A4  210 mm × 297 mm
A5  148 mm × 210 mm

The standard ANSI/ASME series of paper sizes is as follows:

- E  34 inch × 44 inch
- D  22 inch × 34 inch
- C  17 inch × 22 inch
- B  11 inch × 17 inch
- A  8.5 inch × 11 inch

The 8½" × 11" standard letter paper corresponds to 216 mm × 279 mm. You can buy precut sheets that have a border and a preprinted title block in the lower right-hand corner. These are available in many standard sizes.

If the paper you use does not have a border and title block, you will have to draw them in. The left-hand border should be wider than the right-hand border and should be at least 50 mm wide to allow room for the prints to be bound. Figure 18 shows a title block with suitable dimensions added.

![Figure 18 — Dimensions for title block](image)

**Paper rolls**
Many grades of paper rolls are available in different widths that can be cut to any length required.

**Drafting or masking tape**
Use drafting or masking tape to hold the paper on the drafting surface. The tape should be attached at the corners to hold the sheet firmly stretched with no wrinkles. Only short pieces of tape are required.
Computer drafting printing

Computer drafting programs are used effectively for all manner of drafting and have virtually replaced manual drafting. Small size computer-generated drawings can be printed on normal computer printers. However, larger drawings require a plotter. Older plotters used pencils, pens, or felt pens, but the new plotters are laser-based or jet printers and are capable of multiple colours. They are made to print all the sizes of drawings. Plotters also print well on vellum and some other non-paper media.

Now complete the Student Activity.
Student Activity

Complete the following quiz by filling in the descriptions of the tools and sketching images of each tool in the boxes provided.

1. Steel rule

2. T-square

3. Protractor
   • Checking and transferring angles to drawings
   • Calculating and measuring angles

4. Triangle (right angle & isosceles)

5. Eraser shield
   • Made from thin stainless steel
   • Allows you to erase specific areas

6. French curve/spline
   • Drawing of irregular curves
7. Drafting brush

8. Compass

9. Drafting templates
   • Made of plastic
   • Standardization of shapes

10. Metric and imperial scales
    • Allow you to draw a diagram at a reduced scale

11. Lettering guide
    • Allows for uniform lettering
Introduction to Title Blocks

Description
In this activity the teacher will demonstrate the use of board drafting tools and equipment to create a title block. A title block is comprised of the information boxes found on the bottom right-hand corner of a drawing, which indicate drawing details such as the title, author name, scale, and date the drawing was created.

This is an introductory activity designed to be completed prior to any other board drawing activities. It will cover basic standards in precision drawing techniques, pencil hardness/selection, and lettering.

Lesson Objectives
The student will be able to:

- Complete a board and page setup
- Use tools appropriately to draw a title block
- Differentiate pencil hardness relative to line weight, and select a pencil accordingly
- Understand and identify architectural measurement standards (imperial units of measurement)
- Use basic line weight techniques
- Identify and implement lettering techniques

Assumptions
The teacher will have a fundamental knowledge of drafting tools and equipment (see Drafting Dictionary Activity Plan).

The student will:

- Have a basic knowledge of drafting tools and equipment
- Have a foundational understanding of how to appropriately use drafting equipment

Terminology
Border lines: thick, dark lines used to create a solid border around a blank page.

Drafting board: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

Drafting brush: used to sweep away debris from a drawing so the full drawing is not smeared.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.
Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy, dark lines (border lines).

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly spaced lettering.

Line weight: the thickness and darkness of drawn lines.

Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H is recommended for these activities.

Precision drawing: the act of creating drawings with specialized tools and equipment.

Steel rule: a straightedge made of rigid material and divided into specific increments, found both in metric and imperial units.

Title block: comprised of the information boxes found on the bottom right-hand corner of a drawing, the title block indicates drawing details such as the title, author name, scale, and date a drawing was created.

Triangles (right angle and isosceles): drafting guides made of hard, clear plastic that are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: a precision drawing instrument that is used as a guide with other drafting equipment. The T-square has a 90° angle where the head and blade attach.

Estimated Time
30–60 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide

Facilities
• Regular classroom space with desks/chairs for all students, a projector with computer and speakers, and Internet access
• Drafting boards (any large enough smooth, flat surface will also work)

Tools
• T-square
• Steel rule
• Triangles (right angle and isosceles)
• Eraser shield
• Drafting brush
• Masking tape (drafting dots)
• Drafting board
• Lettering guide
• Mechanical pencil or drafting pencil with 2H lead (most versatile for drawing at this stage)

Materials
• Handout for students with instructions (suggestion: develop a handout using the instructions from the teacher-led activity that follows).

Resources
• Drafting Dictionary Activity Plan

Student Activity
1. Complete title block drawing.
2. Fill in title block with appropriate information as noted below.

<table>
<thead>
<tr>
<th>TITLE OF EXERCISE</th>
<th>STUDENT NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DATE</td>
</tr>
<tr>
<td>NAME OF DRAWING</td>
<td>SCALE OF DRAWING</td>
</tr>
<tr>
<td></td>
<td>PAGE</td>
</tr>
</tbody>
</table>

Extension Activity
Have students create multiple title block pages for further use in subsequent exercises.

Assessment
• Student participation in discussion/demonstration
• Completion of drawing with overall neatness:
  – Lines are drawn correctly.
  – Border lines cross to ensure closed corners.
  – Lettering is done to a high quality (all uppercase).
  – Title block is filled out correctly with appropriate information.
Teacher-led Activity

1. Gather all materials listed above.

2. Using the T-square and masking tape and/or drafting dots, align blank paper to your drafting board and securely tape down (Figure 1).

3. Using the imperial ruler, mark out lines with your pencil around the entire page at ½” from the outside edge (Figure 2). These lines should be small, should align with the direction of the page, and should be very light (layout lines).
4. Using the T-square and right angle triangle, join these lines to create a border around the entire page (Figure 3). These lines should be solid, dark lines with no breaks (border/title block lines).

**Note:** The border lines should cross over each other to ensure closed corners (Figure 4), but they should not extend to the edges of the page.
5. Mark a point $\frac{3}{4}''$ above the bottom border line (Figure 5) and draw a layout line joining the left and right vertical border lines.

![Figure 5](image)

**Figure 5**—Measure layout line $\frac{3}{4}''$ horizontally above bottom border

6. Repeat step 5, measuring up another $\frac{3}{4}''$ from the line you just drew (Figure 6).

![Figure 6](image)

**Figure 6**—Measure a second horizontal layout line $\frac{3}{4}''$ from the line drawn in step 5 (or $1\frac{1}{2}''$ from the bottom border!)
7. From the vertical border line on the right-hand side of the page, measure in 2½" toward the left (Figure 7) and use layout lines to mark in the title block.

8. Divide the blocks in the small section at ⅜". You should end up with four small sections that are ⅜" high and 2½" wide (Figure 8).
9. Demonstrate how to use a lettering guide aligned with the T-square (Figure 9) to draw light guide lines to fill in the title block (Figure 10).

![Figure 9—Using a lettering guide](image1)

![Figure 10—Letter guide lines](image2)

10. Fill in the title block with the appropriate information. Remind students that drafting convention requires that all lettering be done in CAPITALS.

**Appendix Acknowledgment**

© Camosun College. Trades Access Common Core: *Competency D-3: Read Drawings and Specifications* (pp. 25–33). The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Describe lines, lettering, and dimensioning in drawings

The purpose of engineering drawings is to convey objective facts, whereas artistic drawings convey emotion or artistic sensitivity in some way.

Engineering drawings and sketches need to display simplicity and uniformity, and they must be executed with speed. Engineering drawing has evolved into a language that uses an extensive set of conventions to convey information very precisely, with very little ambiguity.

Standardization is also very important, as it aids internationalization; that is, people from different countries who speak different languages can read the same engineering drawing and interpret it the same way. To that end, drawings should be as free of notes and abbreviations as possible so that the meaning is conveyed graphically.

Line styles and types

Standard lines have been developed so that every drawing or sketch conveys the same meaning to everyone. In order to convey that meaning, the lines used in technical drawings have both a definite pattern and a definite thickness. Some lines are complete and others are broken. Some lines are thick and others are thin. A visible line, for example, is used to show the edges (or “outline”) of an object and to make it stand out for easy reading. This line is made thick and dark. On the other hand, a centre line, which locates the precise centre of a hole or shaft, is drawn thin and made with long and short dashes. This makes it easily distinguishable from the visible line.

When you draw, use a fairly sharp pencil of the correct grade and try to maintain an even, consistent pressure to make it easier for you to produce acceptable lines (Figure 1). Study the line thicknesses (or “line weights”) shown in Figure 2 and practise making them.

![Figure 1 — Lead grade and usage](image)
In computer drafting, the line shape remains the same, but line thickness may not vary as it does in manually created drawings. Some lines, such as centre lines, may not cross in the same manner as in a manual drawing. For most computer drafting, line thickness is not important.

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight</th>
<th>Line Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object line  Margin line</td>
<td>Heavy</td>
<td>Solid line to show visible shape, edges, and outlines.</td>
</tr>
<tr>
<td>Hidden body line</td>
<td>Medium</td>
<td>Broken line of long and short dashes to show hidden</td>
</tr>
<tr>
<td></td>
<td></td>
<td>object lines not visible to the eye.</td>
</tr>
<tr>
<td>Phantom line</td>
<td>Light</td>
<td>Broken line of short dashes to show alternate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>positions or movement of a part.</td>
</tr>
<tr>
<td>Section line</td>
<td>Light</td>
<td>Unbroken lines arranged in a pattern, usually straight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and at a 45° diagonal.</td>
</tr>
<tr>
<td>Projection line</td>
<td>Light</td>
<td>Unbroken lines that extend away from the object or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>feature for emphasis.</td>
</tr>
<tr>
<td>Centre line</td>
<td>Light</td>
<td>Broken line of long and short dashes to show the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>centre of an object.</td>
</tr>
<tr>
<td>Extension line/</td>
<td>Light</td>
<td>Extension lines are small lines that extend outward</td>
</tr>
<tr>
<td>Dimension line</td>
<td></td>
<td>from an object or feature. Dimension lines span</td>
</tr>
<tr>
<td></td>
<td></td>
<td>between the extension lines with arrowheads and a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>given dimension.</td>
</tr>
<tr>
<td>Leader line</td>
<td>Light</td>
<td>Unbroken line usually drawn at an angle often with a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>“dogleg” and an arrowhead. A dot is used in place of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>an arrowhead where a surface is referenced. Usually</td>
</tr>
<tr>
<td></td>
<td></td>
<td>accompanied by a label.</td>
</tr>
<tr>
<td>Cutting plane line</td>
<td>Heavy</td>
<td>Broken line of one long and two short dashes to show</td>
</tr>
<tr>
<td></td>
<td></td>
<td>an imaginary cross-section. The arrowheads show the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>direction from where the cross-section is viewed. A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>corresponding image will show the view of A.</td>
</tr>
<tr>
<td>Break lines for</td>
<td>Heavy</td>
<td>Unbroken freehand or straight zig-zag lines to</td>
</tr>
<tr>
<td>wood and metal</td>
<td></td>
<td>abbreviate longer spans of wood or metal.</td>
</tr>
<tr>
<td>Break lines for</td>
<td>Heavy</td>
<td>Curled lines to abbreviate a longer span of pipe.</td>
</tr>
<tr>
<td>piping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2 — Weights of lines**
To properly read and interpret drawings, you must know the meaning of each line and understand how each is used to construct a drawing. The ten most common are often referred to as the “alphabet of lines.” Let’s look at an explanation and example of each type.

**Object lines**
Object lines (Figure 3) are the most common lines used in drawings. These thick, solid lines show the visible edges, corners, and surfaces of a part. Object lines stand out on the drawing and clearly define the outline and features of the object.

![Figure 3 — Object lines](image)

**Hidden lines**
Hidden lines (Figure 4) are used to show edges and surfaces that are not visible in a view. These lines are drawn as thin, evenly spaced dashes. A surface or edge that is shown in one view with an object line will be shown in another view with a hidden line.

![Figure 4 — Hidden lines](image)
Centre lines
Centre lines (Figure 5) are used in drawings for several different applications. The meaning of a centre line is normally determined by how it is used. Centre lines are thin, alternating long and short dashes that are generally used to show hole centres and centre positions of rounded features, such as arcs and radii. Arcs are sections of a circle, and radii are rounded corners or edges of a part. Centre lines can also show the symmetry of an object.

![Centre lines](https://example.com/centre_lines.png)

**Figure 5 — Centre lines**

Dimension and extension lines
Dimension and extension lines (Figure 6) are thin, solid lines that show the direction, length, and limits of the dimensions of a part. Dimension lines are drawn with an arrowhead at both ends.

Extension lines are drawn close to, but never touching, the edges or surface they limit. They should be perpendicular, or at right angles, to the dimension line. The length of extension lines is generally suited to the number of dimensions they limit.

![Dimension and extension lines](https://example.com/dimension_extension_lines.png)

**Figure 6 — Dimension and extension lines**
Leader lines
Leader lines (Figure 7) show information such as dimensional notes, material specifications, and process notes. These lines are normally drawn as thin, solid lines with an arrowhead at one end. They are bent or angled at the start, but should always end horizontal at the notation. When leader lines reference a surface, a dot is used instead of an arrowhead.

![Leader line (thin and solid)](image)

Note that the symbol ø is used to indicate a diameter rather than the abbreviation “DIA.” The number that immediately follows this symbol is the diameter of the hole, followed by the number of holes that must be drilled to that dimension.

Phantom lines
Like centre lines, phantom lines (Figure 8) are used for several purposes in blueprints. Phantom lines are used to show alternate positions for moving parts and the positions of related or adjacent parts, and to eliminate repeated details. Phantom lines are drawn as thin, alternating long dashes separated by two short dashes.
Cutting plane lines

Cutting plane lines (Figure 9) show the location and path of imaginary cuts made through parts to show internal details. In most cases, sectional views (or views that show complicated internal details of a part) are indicated by using a cutting plane line. These lines are thick, alternating long lines separated by two short dashes. The arrowheads at each end show the viewing direction of the related sectional view. The two main types of cutting plane lines are the straight and the offset.

Figure 9 — Cutting plane lines
Section lines
Section lines, also known as sectional lining, (Figure 10) indicate the surfaces in a sectional view as they would appear if the part were actually cut along the cutting plane line. These are solid lines that are normally drawn at 45 degree angles. Different symbols are used to represent different types of materials.

Figure 10 — Section lines combined with cutting plane lines

Break lines
Break lines are drawn to show that a part has been shortened to reduce its size on the drawing. The two variations of break lines common to blueprints are the long break line and the short break line (Figure 11). Long break lines are thin solid lines that have zigzags to indicate a break. Short break lines are thick, wavy solid lines that are drawn freehand. When either of these break lines is used to shorten an object, you can assume that the section removed from the part is identical to the portions shown on either side of the break.

Figure 11 — Break line
Standard lettering

The letters and numbers on a drawing or sketch are as important as the lines. Scribbled, smudged, or badly written letters and numbers can become impossible to read. This may lead to time-consuming and costly errors. Lettering is necessary to describe:

- the name or title of a drawing
- when it was made
- the scale
- who sketched it
- the dimensions
- the special notations that describe the size
- the materials to be used
- the construction methods

The American Standard Vertical letters (Figure 12) have become the most accepted style of lettering used in the production of manual drafting. This lettering is a Gothic sans serif script, formed by a series of short strokes.

Font styles and sizes may vary in computer drafting. Note that all letters are written as capital (upper case) letters. Practise these characters, concentrating on forming the correct shape. Remember that letters and numbers must be black so that they will stand out and be easy to read. Lettering and figures should have the same weight and darkness as hidden lines.

Title and drawing sizes = 6 mm (¼”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Dimension and notation sizes = 3 mm (⅛”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Figure 12 — Standard lettering
## Abbreviations

Abbreviations are commonly used to help simplify a drawing and conserve space. Although many fields share common abbreviation conventions, there are also field- or trades-specific conventions that you will see as you become more specialized. Here is a common list of abbreviations that are used on drawings. Each trade will have specific abbreviations from this list, and therefore a set of drawings will usually include an abbreviation key.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>anchor bolt</td>
</tr>
<tr>
<td>ABT</td>
<td>about</td>
</tr>
<tr>
<td>AUX</td>
<td>auxiliary</td>
</tr>
<tr>
<td>BC</td>
<td>bolt circle</td>
</tr>
<tr>
<td>BBE</td>
<td>bevel both ends</td>
</tr>
<tr>
<td>BCD</td>
<td>bolt circle diameter</td>
</tr>
<tr>
<td>BOE</td>
<td>bevel one end</td>
</tr>
<tr>
<td>BE</td>
<td>both ends</td>
</tr>
<tr>
<td>BL</td>
<td>baseline</td>
</tr>
<tr>
<td>BM</td>
<td>bench mark</td>
</tr>
<tr>
<td>Btm</td>
<td>bottom</td>
</tr>
<tr>
<td>BP</td>
<td>base plate</td>
</tr>
<tr>
<td>B/P</td>
<td>blueprint</td>
</tr>
<tr>
<td>BLD</td>
<td>blind</td>
</tr>
<tr>
<td>C/C</td>
<td>centre to centre</td>
</tr>
<tr>
<td>COL</td>
<td>column</td>
</tr>
<tr>
<td>CPLG</td>
<td>coupling</td>
</tr>
<tr>
<td>CS</td>
<td>carbon steel</td>
</tr>
<tr>
<td>C/W</td>
<td>complete with</td>
</tr>
<tr>
<td>CYL</td>
<td>cylinder</td>
</tr>
<tr>
<td>DIA</td>
<td>diameter</td>
</tr>
<tr>
<td>DIAG</td>
<td>diagonal</td>
</tr>
<tr>
<td>DIM</td>
<td>dimension</td>
</tr>
<tr>
<td>DWG</td>
<td>drawing</td>
</tr>
<tr>
<td>EA</td>
<td>each</td>
</tr>
<tr>
<td>EL</td>
<td>elevation</td>
</tr>
<tr>
<td>EXT</td>
<td>external</td>
</tr>
<tr>
<td>F/F</td>
<td>face to face</td>
</tr>
<tr>
<td>FF</td>
<td>flat face</td>
</tr>
<tr>
<td>FLG</td>
<td>flange</td>
</tr>
<tr>
<td>FW</td>
<td>fillet weld</td>
</tr>
<tr>
<td>Ga</td>
<td>gauge</td>
</tr>
<tr>
<td>Galv</td>
<td>galvanized</td>
</tr>
<tr>
<td>HPY</td>
<td>heavy</td>
</tr>
<tr>
<td>HH</td>
<td>hex head</td>
</tr>
<tr>
<td>HR</td>
<td>hot rolled</td>
</tr>
<tr>
<td>HT</td>
<td>heat treatment</td>
</tr>
<tr>
<td>HLS</td>
<td>holes</td>
</tr>
<tr>
<td>HSS</td>
<td>hollow structural steel</td>
</tr>
<tr>
<td>ID</td>
<td>inside diameter</td>
</tr>
<tr>
<td>INT</td>
<td>internal</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Org.</td>
</tr>
<tr>
<td>KP</td>
<td>kick plate</td>
</tr>
<tr>
<td>LH</td>
<td>left hand</td>
</tr>
<tr>
<td>LAT</td>
<td>lateral</td>
</tr>
<tr>
<td>LR</td>
<td>long radius</td>
</tr>
<tr>
<td>LG</td>
<td>long</td>
</tr>
<tr>
<td>MB</td>
<td>machine bolt</td>
</tr>
<tr>
<td>MS</td>
<td>mild steel</td>
</tr>
<tr>
<td>MIN</td>
<td>minimum</td>
</tr>
<tr>
<td>MAT’L</td>
<td>material</td>
</tr>
<tr>
<td>MISC</td>
<td>miscellaneous</td>
</tr>
<tr>
<td>NC</td>
<td>national course</td>
</tr>
<tr>
<td>NF</td>
<td>national fine</td>
</tr>
<tr>
<td>NO</td>
<td>number</td>
</tr>
<tr>
<td>MOM</td>
<td>nominal</td>
</tr>
<tr>
<td>NTS</td>
<td>not to scale</td>
</tr>
<tr>
<td>NPS</td>
<td>nominal pipe size</td>
</tr>
<tr>
<td>NPT</td>
<td>national pipe thread</td>
</tr>
<tr>
<td>O/C</td>
<td>on centre</td>
</tr>
<tr>
<td>OA</td>
<td>overall</td>
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<tr>
<td>OD</td>
<td>outside diameter</td>
</tr>
<tr>
<td>OR</td>
<td>outside radius</td>
</tr>
<tr>
<td>OPP</td>
<td>opposite</td>
</tr>
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<td>PAT</td>
<td>pattern</td>
</tr>
<tr>
<td>PBE</td>
<td>plain both ends</td>
</tr>
<tr>
<td>POE</td>
<td>plain one end</td>
</tr>
<tr>
<td>PSI</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>PROJ</td>
<td>project</td>
</tr>
<tr>
<td>RD</td>
<td>running dimension</td>
</tr>
<tr>
<td>RND</td>
<td>round</td>
</tr>
<tr>
<td>REF</td>
<td>reference</td>
</tr>
<tr>
<td>REQ’D</td>
<td>required</td>
</tr>
<tr>
<td>REV</td>
<td>revision</td>
</tr>
<tr>
<td>RF</td>
<td>raised face</td>
</tr>
<tr>
<td>RH</td>
<td>right hand</td>
</tr>
<tr>
<td>SCH</td>
<td>schedule</td>
</tr>
<tr>
<td>SI</td>
<td>International System of Units</td>
</tr>
<tr>
<td>SPECS</td>
<td>specifications</td>
</tr>
<tr>
<td>SQ</td>
<td>square</td>
</tr>
<tr>
<td>SM</td>
<td>seam</td>
</tr>
<tr>
<td>SMLS</td>
<td>seamless</td>
</tr>
<tr>
<td>S/S</td>
<td>seam to seam</td>
</tr>
<tr>
<td>SO</td>
<td>slip on</td>
</tr>
<tr>
<td>SEC</td>
<td>section</td>
</tr>
<tr>
<td>STD</td>
<td>standard</td>
</tr>
<tr>
<td>SS</td>
<td>stainless steel</td>
</tr>
<tr>
<td>SYM</td>
<td>symmetrical</td>
</tr>
<tr>
<td>T</td>
<td>top</td>
</tr>
<tr>
<td>T&amp;B</td>
<td>top and bottom</td>
</tr>
<tr>
<td>T&amp;C</td>
<td>threaded and coupled</td>
</tr>
<tr>
<td>THD</td>
<td>threaded</td>
</tr>
<tr>
<td>TBE</td>
<td>threaded both ends</td>
</tr>
<tr>
<td>TOE</td>
<td>threaded one end</td>
</tr>
<tr>
<td>THK</td>
<td>thick</td>
</tr>
<tr>
<td>TOL</td>
<td>tolerance</td>
</tr>
<tr>
<td>TOC</td>
<td>top of concrete</td>
</tr>
<tr>
<td>TOS</td>
<td>top of steel</td>
</tr>
<tr>
<td>TYP</td>
<td>typical</td>
</tr>
<tr>
<td>U/N</td>
<td>unless noted</td>
</tr>
<tr>
<td>VERT</td>
<td>vertical</td>
</tr>
<tr>
<td>WD</td>
<td>working drawing</td>
</tr>
<tr>
<td>WP</td>
<td>working point</td>
</tr>
<tr>
<td>WT</td>
<td>weight</td>
</tr>
<tr>
<td>W/O</td>
<td>without</td>
</tr>
<tr>
<td>XH</td>
<td>extra heavy</td>
</tr>
<tr>
<td>XS</td>
<td>extra strong</td>
</tr>
</tbody>
</table>
Youth Explore Trades Skills  Design and Drafting – 2D Drawing

Drawing Objects

Description
In this activity the teacher will demonstrate the use of drafting equipment to create basic object shapes. Students will use a piece of paper with a title block to complete this activity. Students will practise lettering and line-weight techniques.

Lesson Objectives
The student will be able to:

• Complete a board set-up
• Identify and appropriately use drafting tools
• Differentiate line weights
• Refine lettering techniques
• Create basic object shapes, based on instructions

Assumptions
The student will:

• Have a basic knowledge of drafting tools and equipment
• Have a foundational understanding of how to appropriately use drafting equipment
• Know how to create a title block on which to complete this activity

Terminology
Border lines: thick, dark lines used to create a solid border around a blank page.

Drafting board: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

Drafting brush: used to sweep away debris from a drawing so the full drawing is not smeared.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy, dark lines (border lines).

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly spaced lettering.

Linewidth: the thickness and darkness of drawn lines.

Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.
Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H is recommended for these activities.

Precision drawing: the act of creating drawings with specialized tools and equipment.

Steel rule: a straightedge made of rigid material and divided into specific increments, found both in metric and imperial units.

Title block: comprised of the information boxes found on the bottom right-hand corner of a drawing, the title block indicates drawing details such as the title, author name, scale, and date a drawing was created.

Triangles (right angle and isosceles): drafting guides made of hard, clear plastic that are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: a precision drawing instrument that is used as a guide with other drafting equipment. The T-square has a 90° angle where the head and blade attach.

**Estimated Time**

30–60 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

- Regular classroom space with desks/chairs for all students
- Drafting boards (any large enough smooth, flat surface will also work)

**Tools**

- T-square
- Steel rule
- Triangles (right angle and isosceles)
- Eraser shield
- Drafting brush
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
- French curve/spline
- Circle template
- Compass
- 2H mechanical pencil
Materials

- Handout for students with instructions (suggestion: develop a handout using the instructions from the teacher-led activity).

Resources

- Drafting Dictionary Activity Plan

Teacher-led Activity

1. Gather all materials listed above.

2. Using the T-square and masking tape and/or drafting dots, align blank paper to your drafting board and securely tape down (Figure 1).

3. Using the steel rule, divide the drawing space of your paper into four even sections (each section should be 3¾" wide by 4¼" high). Draw these lines lightly (layout lines).
4. In the top left section, draw an object that focusses on sloping and parallel lines. Practise using the right angle, isosceles triangle, and T-square. Leave enough room underneath the object for the following label: OBJECT No. 1 PARALLEL LINES AND SLOPING LINES (Figure 2).

Figure 2—Parallel lines and sloping lines

5. In the top right section, students will draw an object that focusses on circular lines. Practise using the circle template and protractor. Leave enough room underneath the object for the following label: OBJECT No. 2 CIRCULAR LINES (Figure 3).

Figure 3—Circular lines
6. In the bottom left section, students will draw an object that focusses on lines at right angles. Practise using the right angle and isosceles triangles. Leave enough room underneath the object for the following label: OBJECT No. 3 LINES AT RIGHT ANGLES (Figure 4).

![Figure 4—Lines at right angles](image)

7. In the bottom right section students will draw an object that focusses on free-form lines. Practise using the French curve and/or spline too. Leave enough room underneath the object for the following label: OBJECT No. 4 FREE FORM WITH FRENCH CURVE (Figure 5).

![Figure 5—Free form with French curve](image)
8. Fill in the title block at the bottom of the page with the information below. Remind students that drafting convention requires that all lettering be done in CAPITALS.

<table>
<thead>
<tr>
<th>ACTIVITY # 1</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DATE</td>
</tr>
<tr>
<td>OBJECTS</td>
<td>SCALE OF DRAWING 1:1</td>
</tr>
<tr>
<td></td>
<td>PAGE 1 OF 1</td>
</tr>
</tbody>
</table>

**Student Activity**
- Complete object shape drawings.
- Fill in title block with appropriate information.

**Extension Activity**
- Practise drawing more objects, using all the tools in the Drafting Dictionary Activity Plan.
- Practise lettering when labelling object drawings.

**Assessment**
- Student participation in discussion/demonstration
- Criteria for completed drawing:
  - Basic object shapes are drawn based on instructions.
  - Corners of borders are closed (horizontal and vertical lines cross).
  - Lettering is neat, even, and all uppercase.
  - Title block is filled out correctly with appropriate information.

**Appendix Acknowledgment**
© Camosun College. Trades Access Common Core: *Competency D-3: Read Drawings and Specifications* (pp. 25–33). The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Describe lines, lettering, and dimensioning in drawings

The purpose of engineering drawings is to convey objective facts, whereas artistic drawings convey emotion or artistic sensitivity in some way.

Engineering drawings and sketches need to display simplicity and uniformity, and they must be executed with speed. Engineering drawing has evolved into a language that uses an extensive set of conventions to convey information very precisely, with very little ambiguity.

Standardization is also very important, as it aids internationalization; that is, people from different countries who speak different languages can read the same engineering drawing and interpret it the same way. To that end, drawings should be as free of notes and abbreviations as possible so that the meaning is conveyed graphically.

Line styles and types

Standard lines have been developed so that every drawing or sketch conveys the same meaning to everyone. In order to convey that meaning, the lines used in technical drawings have both a definite pattern and a definite thickness. Some lines are complete and others are broken. Some lines are thick and others are thin. A visible line, for example, is used to show the edges (or “outline”) of an object and to make it stand out for easy reading. This line is made thick and dark. On the other hand, a centre line, which locates the precise centre of a hole or shaft, is drawn thin and made with long and short dashes. This makes it easily distinguishable from the visible line.

When you draw, use a fairly sharp pencil of the correct grade and try to maintain an even, consistent pressure to make it easier for you to produce acceptable lines (Figure 1). Study the line thicknesses (or “line weights”) shown in Figure 2 and practise making them.

![Figure 1 — Lead grade and usage](image-url)
In computer drafting, the line shape remains the same, but line thickness may not vary as it does in manually created drawings. Some lines, such as centre lines, may not cross in the same manner as in a manual drawing. For most computer drafting, line thickness is not important.

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight</th>
<th>Line Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object line Margin line</td>
<td>Heavy</td>
<td>Solid line to show visible shape, edges, and outlines.</td>
</tr>
<tr>
<td>Hidden body line</td>
<td>Medium</td>
<td>Broken line of long and short dashes to show hidden object lines not visible to the eye.</td>
</tr>
<tr>
<td>Phantom line</td>
<td>Light</td>
<td>Broken line of short dashes to show alternate positions or movement of a part.</td>
</tr>
<tr>
<td>Section line</td>
<td>Light</td>
<td>Unbroken lines arranged in a pattern, usually straight and at a 45° diagonal.</td>
</tr>
<tr>
<td>Steel Copper/Brass Lead Cast iron/General purpose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projection line</td>
<td>Light</td>
<td>Unbroken lines that extend away from the object or feature for emphasis.</td>
</tr>
<tr>
<td>Centre line</td>
<td>Light</td>
<td>Broken line of long and short dashes to show the centre of an object.</td>
</tr>
<tr>
<td>Extension line/Dimension line</td>
<td>Light</td>
<td>Extension lines are small lines that extend outward from an object or feature. Dimension lines span between the extension lines with arrowheads and a given dimension.</td>
</tr>
<tr>
<td>25 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leader line</td>
<td>Light</td>
<td>Unbroken line usually drawn at an angle often with a “dogleg” and an arrowhead. A dot is used in place of an arrowhead where a surface is referenced. Usually accompanied by a label.</td>
</tr>
<tr>
<td>Cutting plane line</td>
<td>Heavy</td>
<td>Broken line of one long and two short dashes to show an imaginary cross-section. The arrowheads show the direction from where the cross-section is viewed. A corresponding image will show the view of A.</td>
</tr>
<tr>
<td>Break lines for wood and metal</td>
<td>Heavy</td>
<td>Unbroken freehand or straight zig-zag lines to abbreviate longer spans of wood or metal.</td>
</tr>
<tr>
<td>Break lines for piping</td>
<td>Heavy</td>
<td>Curled lines to abbreviate a longer span of pipe.</td>
</tr>
</tbody>
</table>

Figure 2 — Weights of lines
To properly read and interpret drawings, you must know the meaning of each line and understand how each is used to construct a drawing. The ten most common are often referred to as the “alphabet of lines.” Let’s look at an explanation and example of each type.

**Object lines**
Object lines (Figure 3) are the most common lines used in drawings. These thick, solid lines show the visible edges, corners, and surfaces of a part. Object lines stand out on the drawing and clearly define the outline and features of the object.

![Object lines](image)

**Hidden lines**
Hidden lines (Figure 4) are used to show edges and surfaces that are not visible in a view. These lines are drawn as thin, evenly spaced dashes. A surface or edge that is shown in one view with an object line will be shown in another view with a hidden line.

![Hidden lines](image)
Centre lines
Centre lines (Figure 5) are used in drawings for several different applications. The meaning of a centre line is normally determined by how it is used. Centre lines are thin, alternating long and short dashes that are generally used to show hole centres and centre positions of rounded features, such as arcs and radii. Arcs are sections of a circle, and radii are rounded corners or edges of a part. Centre lines can also show the symmetry of an object.

![Figure 5 — Centre lines](image)

Dimension and extension lines
Dimension and extension lines (Figure 6) are thin, solid lines that show the direction, length, and limits of the dimensions of a part. Dimension lines are drawn with an arrowhead at both ends.

Extension lines are drawn close to, but never touching, the edges or surface they limit. They should be perpendicular, or at right angles, to the dimension line. The length of extension lines is generally suited to the number of dimensions they limit.

![Figure 6 — Dimension and extension lines](image)
**Leader lines**

Leader lines (Figure 7) show information such as dimensional notes, material specifications, and process notes. These lines are normally drawn as thin, solid lines with an arrowhead at one end. They are bent or angled at the start, but should always end horizontal at the notation. When leader lines reference a surface, a dot is used instead of an arrowhead.

![Leader line (thin and solid)](image)

Note that the symbol ø is used to indicate a diameter rather than the abbreviation “DIA.” The number that immediately follows this symbol is the diameter of the hole, followed by the number of holes that must be drilled to that dimension.

**Phantom lines**

Like centre lines, phantom lines (Figure 8) are used for several purposes in blueprints. Phantom lines are used to show alternate positions for moving parts and the positions of related or adjacent parts, and to eliminate repeated details. Phantom lines are drawn as thin, alternating long dashes separated by two short dashes.
Cutting plane lines

Cutting plane lines (Figure 9) show the location and path of imaginary cuts made through parts to show internal details. In most cases, sectional views (or views that show complicated internal details of a part) are indicated by using a cutting plane line. These lines are thick, alternating long lines separated by two short dashes. The arrowheads at each end show the viewing direction of the related sectional view. The two main types of cutting plane lines are the straight and the offset.
**Section lines**

Section lines, also known as sectional lining, indicate the surfaces in a sectional view as they would appear if the part were actually cut along the cutting plane line. These are solid lines that are normally drawn at 45 degree angles. Different symbols are used to represent different types of materials.

![Section lines combined with cutting plane lines](image)

**Figure 10** — Section lines combined with cutting plane lines

**Break lines**

Break lines are drawn to show that a part has been shortened to reduce its size on the drawing. The two variations of break lines common to blueprints are the long break line and the short break line (Figure 11). Long break lines are thin solid lines that have zigzags to indicate a break. Short break lines are thick, wavy solid lines that are drawn freehand. When either of these break lines is used to shorten an object, you can assume that the section removed from the part is identical to the portions shown on either side of the break.

![Break lines](image)

**Figure 11** — Break line
Standard lettering

The letters and numbers on a drawing or sketch are as important as the lines. Scribbled, smudged, or badly written letters and numbers can become impossible to read. This may lead to time-consuming and costly errors. Lettering is necessary to describe:

- the name or title of a drawing
- when it was made
- the scale
- who sketched it
- the dimensions
- the special notations that describe the size
- the materials to be used
- the construction methods

The American Standard Vertical letters (Figure 12) have become the most accepted style of lettering used in the production of manual drafting. This lettering is a Gothic sans serif script, formed by a series of short strokes.

Font styles and sizes may vary in computer drafting. Note that all letters are written as capital (upper case) letters. Practise these characters, concentrating on forming the correct shape. Remember that letters and numbers must be black so that they will stand out and be easy to read. Lettering and figures should have the same weight and darkness as hidden lines.

Title and drawing sizes = 6 mm (¼”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Dimension and notation sizes = 3 mm (¼")

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Figure 12 — Standard lettering
### Abbreviations

Abbreviations are commonly used to help simplify a drawing and conserve space. Although many fields share common abbreviation conventions, there are also field- or trades-specific conventions that you will see as you become more specialized. Here is a common list of abbreviations that are used on drawings. Each trade will have specific abbreviations from this list, and therefore a set of drawings will usually include an abbreviation key.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>anchor bolt</td>
</tr>
<tr>
<td>ABT</td>
<td>about</td>
</tr>
<tr>
<td>AUX</td>
<td>auxiliary</td>
</tr>
<tr>
<td>BC</td>
<td>bolt circle</td>
</tr>
<tr>
<td>BBE</td>
<td>bevel both ends</td>
</tr>
<tr>
<td>BCD</td>
<td>bolt circle diameter</td>
</tr>
<tr>
<td>BOE</td>
<td>bevel one end</td>
</tr>
<tr>
<td>BE</td>
<td>both ends</td>
</tr>
<tr>
<td>BL</td>
<td>baseline</td>
</tr>
<tr>
<td>BM</td>
<td>bench mark</td>
</tr>
<tr>
<td>Btm</td>
<td>bottom</td>
</tr>
<tr>
<td>BP</td>
<td>base plate</td>
</tr>
<tr>
<td>B/P</td>
<td>blueprint</td>
</tr>
<tr>
<td>BLD</td>
<td>blind</td>
</tr>
<tr>
<td>C/C</td>
<td>centre to centre</td>
</tr>
<tr>
<td>COL</td>
<td>column</td>
</tr>
<tr>
<td>CPLG</td>
<td>coupling</td>
</tr>
<tr>
<td>CS</td>
<td>carbon steel</td>
</tr>
<tr>
<td>C/W</td>
<td>complete with</td>
</tr>
<tr>
<td>CYL</td>
<td>cylinder</td>
</tr>
<tr>
<td>DIA</td>
<td>diameter</td>
</tr>
<tr>
<td>DIAG</td>
<td>diagonal</td>
</tr>
<tr>
<td>DIM</td>
<td>dimension</td>
</tr>
<tr>
<td>DWG</td>
<td>drawing</td>
</tr>
<tr>
<td>EA</td>
<td>each</td>
</tr>
<tr>
<td>EL</td>
<td>elevation</td>
</tr>
<tr>
<td>EXT</td>
<td>external</td>
</tr>
<tr>
<td>F/F</td>
<td>face to face</td>
</tr>
<tr>
<td>FF</td>
<td>flat face</td>
</tr>
<tr>
<td>FLG</td>
<td>flange</td>
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<tr>
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<td>fillet weld</td>
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<td>Ga</td>
<td>gauge</td>
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<td>Galv</td>
<td>galvanized</td>
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<td>HVY</td>
<td>heavy</td>
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<td>HH</td>
<td>hex head</td>
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<td>HR</td>
<td>hot rolled</td>
</tr>
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<td>HT</td>
<td>heat treatment</td>
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<td>HLS</td>
<td>holes</td>
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<td>HSS</td>
<td>hollow structural steel</td>
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<tr>
<td>ID</td>
<td>inside diameter</td>
</tr>
<tr>
<td>IN</td>
<td>inches</td>
</tr>
<tr>
<td>INT</td>
<td>internal</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Org.</td>
</tr>
<tr>
<td>KP</td>
<td>kick plate</td>
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<tr>
<td>LH</td>
<td>left hand</td>
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<tr>
<td>LAT</td>
<td>lateral</td>
</tr>
<tr>
<td>LR</td>
<td>long radius</td>
</tr>
<tr>
<td>LG</td>
<td>long</td>
</tr>
<tr>
<td>MB</td>
<td>machine bolt</td>
</tr>
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<td>MS</td>
<td>mild steel</td>
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<td>MIN</td>
<td>minimum</td>
</tr>
<tr>
<td>MAX</td>
<td>maximum</td>
</tr>
<tr>
<td>MAT'L</td>
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</tr>
<tr>
<td>MIS</td>
<td>miscellaneous</td>
</tr>
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<td>NC</td>
<td>national course</td>
</tr>
<tr>
<td>NF</td>
<td>national fine</td>
</tr>
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<td>number</td>
</tr>
<tr>
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<td>nominal</td>
</tr>
<tr>
<td>NTS</td>
<td>not to scale</td>
</tr>
<tr>
<td>NPS</td>
<td>nominal pipe size</td>
</tr>
<tr>
<td>NPT</td>
<td>national pipe thread</td>
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<td>O/C</td>
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<td>PSI</td>
<td>pounds per square inch</td>
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<td>radius</td>
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<tr>
<td>REV</td>
<td>revision</td>
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<tr>
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<td>raised face</td>
</tr>
<tr>
<td>RH</td>
<td>right hand</td>
</tr>
<tr>
<td>SCH</td>
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<td>S/S</td>
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<td>SO</td>
<td>slip on</td>
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<tr>
<td>SEC</td>
<td>section</td>
</tr>
<tr>
<td>STD</td>
<td>standard</td>
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</tr>
<tr>
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<tr>
<td>T</td>
<td>top</td>
</tr>
<tr>
<td>T&amp;B</td>
<td>top and bottom</td>
</tr>
<tr>
<td>T&amp;C</td>
<td>threaded and coupled</td>
</tr>
<tr>
<td>THD</td>
<td>threaded</td>
</tr>
<tr>
<td>TBE</td>
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</tr>
<tr>
<td>TOE</td>
<td>threaded one end</td>
</tr>
<tr>
<td>THK</td>
<td>thick</td>
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<tr>
<td>TOL</td>
<td>tolerance</td>
</tr>
<tr>
<td>TOC</td>
<td>top of concrete</td>
</tr>
<tr>
<td>TOS</td>
<td>top of steel</td>
</tr>
<tr>
<td>TYP</td>
<td>typical</td>
</tr>
<tr>
<td>U/N</td>
<td>unless noted</td>
</tr>
<tr>
<td>VERT</td>
<td>vertical</td>
</tr>
<tr>
<td>WD</td>
<td>working drawing</td>
</tr>
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<td>WP</td>
<td>working point</td>
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<tr>
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<tr>
<td>W/O</td>
<td>without</td>
</tr>
<tr>
<td>XH</td>
<td>extra heavy</td>
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<tr>
<td>XS</td>
<td>extra strong</td>
</tr>
</tbody>
</table>
Scale and Dimensioning

Description
In this activity, the teacher will first select an object that is larger than the page and scale it to fit in the designated drawing area to explain architectural imperial scale. Second, the teacher will then dimension the scaled object using standard conventions. Students will use paper with a title block to complete this activity. Students will also continue to improve their skills with lettering techniques and lineweights.

Lesson Objectives
The student will be able to:

- Complete a board set-up
- Identify and appropriately use drafting tools
- Differentiate lineweights by varying pencil pressure while creating scale drawings of objects
- Determine the appropriate scale to ensure an object is proportionally drawn
- Incorporate dimensioning standards
- Refine lettering techniques

Assumptions
The student will:

- Have a basic knowledge of drafting tools and equipment
- Understand the basics of appropriate use of drafting equipment
- Have previously drawn a title block for use in completing this activity

Terminology
Aligned dimensions: numerical dimension values that are aligned with the direction of the dimension line. The drawing therefore has to be turned to correctly read the dimensions.

Border lines: thick, dark lines used to create a solid border around a blank page.

Dimensions: a measurement of something in a specific linear direction. Most often this includes the length, width, and height of an object.

Dimension lines: lines spanning the distance between extension lines; they have arrowheads and include a numerical dimension measurement.

Drafting board: a flat, smooth surface usually covered in vinyl, which helps to hold paper affixed to it. It has square, parallel edges that allow a T-square to slide easily.
Drafting brush: used to sweep away debris from a drawing so it does not smear the full drawing.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

Extension line: small lines that extend outward from an object or feature to indicate a dimension point.

Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy dark lines.

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly-spaced lettering.

Lineweight: the thickness and darkness of drawn lines.

Masking tape (drafting dots): holds drawing paper/vellum to the drafting board so the paper does not shift while drawing.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H will be used for these activities.

Precision drawing: creating drawings with specialized tools and equipment.

Scale: a ratio of length of a drawn object relative to its length in “real space.” A proportional representation of an object either reduced or enlarged.

Steel rule: a straightedge made of rigid material, divided into specific increments, found both in metric and imperial units.

Triangles (right angle and isosceles): made of hard, clear plastic, they are used to draw lines at vertical and set angles: 45°-90°-45°, 30°-60°-90°

T-square: a precision drawing instrument, used as a guide for other drafting equipment. Has a 90° angle where the head and blade attach.

Unidirectional dimensions: show the numerical values in a normal reading position (horizontally); no rotation of the drawing is required.

Estimated Time
30–60 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide
Facilities

- Regular classroom space with desks/chairs for all students
- Drafting boards would be ideal; however, smooth, clean, and flat surfaces will also suffice

Tools

- T-square
- Steel rule
- Triangles (right angle and isosceles)
- Eraser shield
- Drafting brush
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
- 2H mechanical pencil
- Architectural scale
- Sample blocks for drawing (should be 2” wide × 4” high x 6” long)

Materials

- Handout for students with instructions (suggestion: develop a handout from the instructions for the teacher-led activity)
- Title block drawing page (created in the Introduction to Title Blocks activity)
- Practice worksheet for reading architectural scales
- Practice worksheets for dimensioning
**Teacher-led Activity**

**Part 1: Scale an object to fit title block**

1. Gather all materials listed above.

2. Using the T-square and masking tape and/or drafting dots, align title-blocked paper to your drafting board and securely tape down (Figure 1).

![Figure 1—Secure paper to board](image)

3. Have students take measurements of the object block using the steel rule. This should include at least length, width, and height (thickness) of the object (Figure 2). Have students make notes on a scrap piece of paper for future reference in the activity.

![Figure 2—Dimensions for length, thickness, and width of a block of wood](image)
4. Using the architectural scale, identify the best scale for this assignment. Explain that the chosen scale must allow for all object details to appear on the page, while still drawing the object proportionally.

The architectural scale uses ratios of feet and inches, the most commonly used of which is the \( \frac{1}{4}'' = 1'-0'' \) scale. This expression indicates that each \( \frac{1}{4}'' \) line on the drawing equals one foot in length in real life. An architectural scale has 11 different scale options. Measurements are read from both ends of the scale.

Figure 3 shows five different lengths, read from both sides of the scale.

![Figure 3—Reading dimensions using an architect’s ruler (NTS)](image)

If students need further practise with the scale before drawing, have them complete the student activities on pages 7 and 21.

5. Have the students draw the object using the measurements they took with the steel rule in Step 3.

**Note:** Students should draw the object in the centre near the bottom of the drawing space (Figure 4). They should use appropriate tools and equipment to ensure their drawing is square and is a detailed representation of the three-dimensional object.
6. Once students have completed the drawing of their scaled object, have them label the drawing and locate the title underneath the object.

7. Students can also fill in the title block information (see below). The scale box will be specific to the scale chosen. Responses will vary. Scale is represented as a ratio in the title block space. For example, if the drawing was completed using the ½” measurements on an architectural scale, the ratio would be ½”:1”.

<table>
<thead>
<tr>
<th>ACTIVITY # 4</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DATE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE AND DIMENSIONING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALE</td>
</tr>
<tr>
<td>PAGE 1 OF 1</td>
</tr>
</tbody>
</table>

**Part 2: Dimensioning the object**

**Dimensioning notes:**

1. When dimensioning objects, remember three key points:
   • Never leave any size, shape, or object in doubt.
   • Do not repeat the same dimension. Doing so could lead to confusion in reading the drawing measurements.
   • All dimensions should be located on the drawing in a clear, concise, and easy-to-follow manner.
2. There are two styles of dimensioning (Figure 5). For this lesson use the unidirectional dimension style.

- **Aligned dimensions** show the numerical values aligned with the direction of the dimension lines. This results in having to turn the drawing to correctly read the dimensions.
- **Unidirectional dimensions** show the numerical values in a normal reading position (horizontally); no rotation of the drawing is required.

![Figure 5](image)

**Figure 5**—Dimensioning systems

**Student Activity**

1. Using the scale-drawn object (and/or drawing) from the previous section, identify the areas that will require dimensions. Remember not to leave any areas in doubt.

2. Dimension and extension lines should be light in weight, clean, and a consistent thickness. Extension lines are drawn out from the object and act as a border edge for the dimension lines.

![Figure 6](image)

**Figure 6**—Extension lines
3. The dimension line should be drawn between the extension lines with arrows indicating where the measurement falls between the extension lines. A space must be left in the centre of each dimension line where the numerical value is placed. Be sure to include units of measurement with each dimension.

![Dimension line](image)

Figure 7—Dimension line

4. Complete each area of the drawing to ensure that no area is left out. A good rule of thumb is to ask yourself the question: “Could I build the object with the dimensions currently on the drawing?” If not, review the drawing and add the missing dimensions.

**Extension Activity**

- Further practice drawing, scaling objects, and dimensioning
- Worksheets to practise reading dimensions from drawings

**Assessment**

- Student participation in discussion/demonstration
- Drawing completed with the following:
  - Lines are drawn correctly.
  - Corners of border lines are closed (horizontal and vertical lines cross).
  - Dimensions meet standard convention styles.
  - Dimensions are neat and tidy.
  - Scale is appropriate to the size of the object and space available for drawing.
  - Lettering is neat, clean, and uppercase.
  - Title block is filled out correctly with appropriate information.
Appendix Acknowledgment

© Camosun College. Trades Access Common Core: Competency D-3: Read Drawings and Specifications (pp. 34-40). The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Figure 13 shows a simple drawing. Notice that the dimensions are given between arrows that point to extension lines. By using this method, the dimensions do not get in the way of the drawing. One extension line can be used for several dimensions. Notice also that the titles require larger letter sizes than those used for dimensions and notations. It is important that the title and sketch number stand out, as shown in Figure 13. When you begin lettering, you may wish to use very light lettering guide lines to ensure uniformity in lettering size and alignment.

![Figure 13 — Standard lettering sizes](image)

### Principles of dimensioning

A good sketch of an object is one that you can use as a blueprint to manufacture the object. Your sketch must show all the necessary dimensions of the part, locate any features it may have (such as holes and slots), give information on the material it is to be made from, and if necessary, stipulate the processes to be used in the manufacture of the object.
Three principles of dimensioning must be followed:

1. Do not leave any size, shape, or material in doubt.

2. To avoid confusion and the possibility of error, no dimension should be repeated twice on any sketch or drawing.

3. Dimensions and notations must be placed on the sketch where they can be clearly and easily read.

Consider Figure 14 and note whether these three dimensioning principles have been followed.

Although the dimensions and notations are clear and easy to read in Figure 14, the following points should be made:

- Leg and rail sizes have not been shown.
- The thickness of the top has not been given.
- The material has not been given as a notation.
- The 600 dimension has been repeated.
- The type of finish to be used has not been given.
- Note 2 is redundant.
The sketch of the shop table is far from complete, and the table could not be made without a lot of guesswork. Figure 15, on the other hand, shows a completed sketch that, along with the necessary notes and dimension information, can be readily used for construction purposes.

![Dimensioning Diagram](image)

**Figure 15 — Dimensioning**

### Rules of dimensioning

For most objects, there are three types of dimensions:

- size dimensions
- location dimensions
- notation dimensions

Figure 16 illustrates the difference between size and location dimensions. (S = size dimension and L = location dimension).
Size dimensions are necessary so that the material size of the object can be determined. Location dimensions are necessary so that parts, holes, or other features can be positioned in or on the object. Notation dimensions describe the part, hole, or other feature with a short note such as the “Ø20 2 holes” notation (see Figure 16). Keep these points in mind:

- Keep all dimension lines at least 10 mm (⅜") clear of object lines wherever possible.
- Try to group related dimensions rather than scattering them.
- Try to keep dimensions off the views themselves.
- Separate one line of dimensions from another line of dimensions or from a notation by a space of at least 10 mm (⅜").
- Leave a space of approximately 3 mm (⅛") between the object outline and the beginning of any extension line.
- Keep arrowheads slim and neat.
- Never dimension to a hidden line.
- Draw leader lines at an angle when intersecting object lines to avoid confusing them with extension lines.

Figure 17 illustrates good placement of dimensions and notations. Note the placement of extension lines and the use of centre lines to locate features such as holes. Also, note the shape and size of arrowheads.
Overall or larger dimensions should be farther from the drawing than smaller dimensions.

Arrowhead ratio should be approx. 3:1

S = size dimensions and notations
L = location dimensions

Leaving approx. 3 mm between object line and extension line.

Allow the extension line to go past the dimension line by approx. 2 mm.

Figure 17 — Extension line usage

Dimensioning systems

Two systems are used for dimensioning drawings. They are the aligned and the unidirectional systems. Figure 18 shows examples of both systems. As you can see, the aligned system requires that you turn the drawing on its side, whereas the unidirectional system may be read from the normal reading position. For most drawings, the unidirectional system is preferred, as it is easier to read; however, architectural drawings still use the aligned system.

Figure 18 — Dimensioning systems
**Systems of measurement**
You may be required to sketch or read drawings constructed with either metric (SI) or imperial dimensions. You may also encounter drawings that are dual dimensioned and contain both systems of measurement on the same drawing.

**SI system of measurement**
The SI system of measurement has become the official standard in Canada. It is common practice on shop drawings to express all metric dimensions in millimetres. Figure 19 shows a detail drawing for a connector arm using metric measurements. All metric drawings should contain a note specifying that all dimensions are in millimetres.

![Diagram of a connector arm with dimensions](image)

**Notes:**
1. All dimensions are in mm
2. Materials - 6 × 60 mild steel plate

*Figure 19 — Connector arm – metric measurement*

**Imperial system of measurement**
An imperial drawing may use the decimal-inch system, the fractional-inch system, or feet and inches.

- In the decimal-inch system, very accurate dimensions for items such as machine parts are expressed as decimals of an inch, such as 0.005”. In words this reads as five one-thousandths of an inch.

- In the fraction-inch system, dimensions for things such as steel and lumber sizes are expressed as inches and fractions of an inch from as small as ⅛” (Figure 20). Most drawings that are dimensioned in the imperial system will use the fraction-inch system.
In the feet-inch system (Figure 21), the dimensions of large structures such as machine frames and buildings are expressed in feet and inches, such as 2'-6" (two feet, six inches).
Use scale rulers to determine actual dimensions from drawings

Scale drawings are accurate and convenient visual representations made and used by engineers, architects, and people in the construction trades. The accuracy is achieved because the drawing is proportional to the real thing. The convenience comes from the size of the drawing. It is large enough to provide the desired detail but small enough to be handy.

The flexibility to draw proportionally in different sizes is provided by scales. For the purposes of representation, we will only be concerned with reduction scales. Reduction scales make the drawing smaller than the object. The kinds of rulers we will be discussing for making scaled drawings are the architect’s scale and the metric scale, both shown in Figure 1.

![Architect's scale ruler](image1)

![Metric scale ruler](image2)

Figure 1 — Architect’s and metric rulers

The scale of the drawing is always written on the drawing, unless the drawing is not drawn to scale. In the latter case, this will be indicated by the “not to scale” abbreviation (NTS). The scale is the ratio of the size of the drawing to the object. For drawings smaller than the object, the ratio is that of a smaller distance to a larger one.

The architect’s scales use ratios of inches to a foot. The most common architect’s scale used is \( \frac{1}{4} \) inch to the foot, written on drawings as:

\[
\text{Scale } \frac{1}{4}” = 1’-0”
\]

This means that a line \( \frac{1}{4}” \) long on the drawing represents an object that is one foot long. At the same scale, a line \( 1\frac{1}{2}” \) long represents an object 6’ long, because \( 1\frac{1}{2}” \) contains 6 quarter-inches.

Metric scale ratios use the same units in both ratio terms, resulting in an expression of how many times smaller than the object the drawing is. For example, the standard metric scale ratio that corresponds approximately to \( \frac{1}{4}” = 1’-0” \) is written on drawings as "Scale 1:50."
This means that the object is 50 times as large as the drawing, so that 50 mm on the object is represented by 1 mm on the drawing. For another example, 30 mm on the drawing represents \( 50 \times 30 \text{ mm} = 1500 \text{ mm} \) (or 1.5 metres) on the object.

Figure 2 lists the scale ratios used for building plans and construction drawings in both metric and the approximate equivalent architectural scale ratios.

<table>
<thead>
<tr>
<th>Type of Drawing</th>
<th>Common Metric Ratios</th>
<th>Imperial Equivalents and Ratios</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site plan</td>
<td>1:500 1:200</td>
<td>( 1&quot; = 40')-0&quot; ( \frac{1}{66}&quot; = 1')-0&quot;</td>
<td>1:480 1:192</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To locate the building, services and reference points on the site</td>
</tr>
<tr>
<td>Sketch plans</td>
<td>1:200</td>
<td>( \frac{1}{66}&quot; = 1')-0&quot;</td>
<td>1:192</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To show the overall design of the building</td>
</tr>
<tr>
<td>General locations</td>
<td>1:100</td>
<td>( \frac{1}{6}&quot; = 1')-0&quot;</td>
<td>1:96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To indicate the juxtaposition of the rooms and locate the positions of piping systems and components</td>
</tr>
<tr>
<td>Drawings</td>
<td>1:50</td>
<td>( \frac{1}{4}&quot; = 1')-0&quot;</td>
<td>1:48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To show the detail of system components and assemblies</td>
</tr>
<tr>
<td>Construction details</td>
<td>1:20 1:10 1:5 1:1</td>
<td>( \frac{1}{2}&quot; = 1')-0&quot; ( 1&quot; = 1')-0&quot; ( 3&quot; = 1')-0&quot;</td>
<td>1:24 1:12 1:4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full size</td>
<td>1:1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To show the detail of system components and assemblies</td>
</tr>
</tbody>
</table>

Figure 2 — Preferred scales for building drawings

**Architect’s (imperial) scales**

Traditional architectural measurements of length are written very precisely in feet and inches using the appropriate symbols for feet and inches separated by a dash (e.g., 4'-3 \( \frac{1}{2} " \) and 7'-0"). This is the way that all imperial measurements are written on construction drawings.

Listed below are the scales found on the architect’s triangular scale ruler.

1. \( \frac{3}{8}" = 1'\)-0"
2. \( \frac{3}{16}" = 1'\)-0"
3. \( \frac{1}{8}" = 1'\)-0"
4. \( \frac{1}{4}" = 1'\)-0"
5. \( \frac{3}{4}" = 1'\)-0"
6. \( \frac{5}{8}" = 1'\)-0"
7. \( 1" = 1'\)-0"
8. \( \frac{1}{2}" = 1'\)-0"
9. \( 1\frac{1}{2}" = 1'\)-0"
10. \( 3" = 1'\)-0"
11. \( 1" = 1" \) (full size—use the scale labelled 16)
Figure 3 shows one face of an architect’s imperial triangular scale ruler. There are two edges on each face and each edge contains two scales that run in opposite directions. At each end of an edge, a number or fraction indicates the distance in inches that represents one foot. The top edge is in eighths of an inch from left to right, and in quarters of an inch from right to left. Note that the 1/8” scale from 0 to the right end represents 95 feet, and the 1/4” scale from 0 to the left end represents 47 feet.

At each end, between the zero and the number indicating scale, the length representing one foot is subdivided into 6, 12, 24, or more parts to indicate inches and, in some scales, fractions of an inch. For example, each of the six marks on the 1/8” scale represents two inches, while each mark equals a quarter of an inch on the 1” reduction scale and one inch on the 1/4” scale.

Now look at the 1½” scale in Figure 4. The subdivided unit is divided into inches and fractions of an inch. Reading left from the zero, notice the figures 3, 6, and 9, which represent measurements of 3”, 6”, and 9”. From the zero to the first long mark represents 1”. Between the zero and the one-inch mark there are four spaces, each of which represent one-quarter of an inch.

Piping drawings usually use a ⅛” scale for larger buildings, a ¼” scale for smaller buildings and houses, and a ½” scale for details. Each drawing will state in the title block the scale that is used. Sometimes when special details are given, the scale is placed directly under the detail.

To draw or measure a length to scale, first find the edge of the ruler containing the scale. One end of the length will rest exactly on one of the foot marks of the scale, and the other end should rest either on the zero marker or somewhere on the inch subdivision of the scale. The length can then be marked and drawn or read off from a drawing.
Figures 5 and 6 demonstrate this manner of reading dimensions from four of the ratios on the architect’s scale.

Architectural units have feet divided into inches, whereas engineering units divide feet into tenths and hundredths. Engineers’ scales are not used to make piping drawings.

**Metric scales**

A triangular metric scale is similar to the architectural scale in that it has six edges, but it has only one scale ratio per edge. The ratio is marked at the left end of the scale. For example, the scale of 1:50 means that 1 mm on the drawing represents 50 mm on the object. This means that the object is 50 times larger than the drawing of it. An object 450 mm long would be represented by a line 9 mm long (450 mm/50).

Figure 7 shows one of the three sides of a metric scale. The scale labelled 1:50 is read from left to right, from 0 to 15 m. The 1:5 scale (on the bottom) can also be read from left to right (0 to 600 mm) by turning the scale around.
Student Activity

1. List the correct measurements for the lettered dimensions in Figure 1.

Figure 1

- a. ____________________________  b. ____________________________
- c. ____________________________  d. ____________________________
- e. ____________________________  f. ____________________________
- g. ____________________________  h. ____________________________
- i. ____________________________  j. ____________________________
## Answer Key

1. a. 9.65 m  
   b. 6.05 m  
   c. 0.58 m  
   d. 1.13 m  
   e. 2.36 m  
   f. 2.8m  
   g. 3.4 m  
   h. 8.6 m  
   i. 1.02 m  
   j. 1.66 m  
   k. 1.8 m
Orthographic Drawing

Description
In this activity, the teacher will introduce orthographic projection, in which a multi-view drawing shows how the sides of an object are related to each other. Students will use a title-blocked piece of paper to complete this activity. Students will also continue to improve their skills by practising using different lineweights and lettering techniques.

Lesson Objectives
The student will be able to:
- Complete a board set-up
- Identify and appropriately use drafting tools
- Create an orthographic projection of an object
- Differentiate lineweights
- Refine lettering techniques

Assumptions
The student will:
- Have basic knowledge of drafting tools and equipment
- Have a foundational understanding of how to appropriately use drafting equipment
- Have created a title block with which to complete this activity

Terminology
**Border or title block lines**: thick, dark lines used to create a solid border around a blank page.

**Drafting board**: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

**Drafting brush**: used to sweep away debris from a drawing so it does not smear the full drawing.

**Eraser shield**: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

**Guide lines**: thin, light lines drawn using the lettering guide for evenly spaced letters.

**Layout lines**: very light lines used to lay out measurements before those measurements are drawn in heavy dark lines.

**Lettering guide**: used to assist in the drawing of uniform lines to draw consistent, evenly-spaced lettering.

**Lineweight**: the thickness and darkness of drawn lines.
Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

Object lines: solid lines used to indicate object shapes.

Orthographic projection: a multi-view representation of a three-dimensional object. Placement of the views depends on how the parts of the object work together.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H will be used for these activities.

Steel rule: a straightedge made of rigid material, divided into specific increments, found both in metric and imperial units.

Triangles (right angle and isosceles): made of hard, clear plastic, they are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: a precision drawing instrument that is used as a guide for other drafting equipment. Has a 90° angle where the head and blade attach.

Estimated Time

60–90 minutes

Recommended Number of Students

20, based on the BC Technology Educators’ Best Practice Guide

Facilities

• Regular classroom space with desks/chairs for all students
• Drafting boards would be ideal. However, smooth, clean, flat surfaces will also suffice.

Tools

• T-square
• Steel rule
• Triangles (right angle and isosceles)
• Eraser shield
• Drafting brush
• Masking tape (drafting dots)
• Drafting board
• Lettering guide
• 2H mechanical pencil
• Architectural scale
Materials

- Handout with instructions for students (take directly from this document; copy and print the text under “Teacher-led Activity”)
- Title block drawing page (created in Introduction to Title Blocks activity)
- Wooden block from the Scale and Dimensioning activity

Teacher-led Activity: Orthographic Projection Notes

The front, top, and right sides are the most common views used in orthographic projections. When selecting views to include, be sure to include enough that the object could be constructed from the chosen views.

1. Gather all materials listed above.
2. Using the T-square and masking tape/drafting dots, align title-blocked paper to your drafting board and securely tape down (Figure 5).

![Figure 5—Secure paper to board]

3. Draw the same wooden block used in the Scale and Dimensioning activity (2" x 4" x 6" block). Have students measure and then scale down the dimensions to fit the drawing space. Students should start by drawing the front view in the bottom left-hand corner of the page. This should be done using object lines (Figure 6). Any hidden details should be drawn using a hidden line. Remind students to leave enough space under the drawing to insert a label.

![Figure 6—Front view]

4. Students should draw the top view next. This view should be drawn in the top left-hand corner of the page, aligned with the front view projection (Figure 7). Be sure to leave a 1" space below the object for a label. Using the T-square to align the shapes will ensure their correct layout.
5. Finally, draw the right-side view or end view projection in the bottom right-hand corner of the page (Figure 8). Align this view with the bottom line and top line of the front view. Leave a 1” space between the front view and the end view.

6. Complete the activity by filling in the title block as follows:

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Extension Activity

Further drawing practice: draw more orthographic projections using different wooden shapes as reference.

Assessment

- Student participation in discussion/demonstration
- Completion of drawing:
  - Lines are drawn correctly.
  - Orthographic views are aligned and evenly spaced on the page.
  - Corners of borders are closed (lines cross at corners).
  - Lettering is done to a high quality (all uppercase).
  - Title block is filled out correctly with appropriate information.

Appendix Acknowledgment

© Camosun College. Trades Access Common Core: Competency D-3: Read Drawings and Specifications pp. 57–60 as a reference for further details on orthographic drawing. The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Describe drawing projections

Architectural drawings are made according to a set of conventions, which include particular views (floor plan, section, etc.), sheet sizes, units of measurement and scales, annotation, and cross-referencing.

Types of views used in drawings
The two main types of views (or “projections”) used in drawings are:

- pictorial
- orthographic

Pictorial views
Pictorial views show a 3-D view of how something should look when completed. There are three types of pictorial views:

- perspective
- isometric
- oblique

Perspective view
A perspective view presents a building or an object just as it would look to you. A perspective view has a vanishing point; that is, lines that move away from you come together in the distance. For example, in Figure 1, we see a road and line of telephone poles. Even though the poles get smaller in their actual measurement, we recognize them as being the same size but more distant.

Isometric view
An isometric view is a three-dimensional view. The plumb lines are vertical. The horizontal lines are set at 30 degree angles from a line parallel to the bottom of the page. Isometric views have no vanishing point, so the objects do not appear as they would in a perspective view.
Lengths are exact on isometric drawings only when the item is parallel to one of the axes of the drawing. Figure 2 shows an isometric view of a simple object, as well as the lines that represent the three dimensions.

![An isometric view](image)

**Oblique view**

An oblique view is similar to an isometric view, except that the face or front view is drawn to exact scale and the oblique lines are extended at a 30 degree to 45 degree angle to create a three-dimensional representation (Figure 3).

![Oblique view of the object in Figure 2](image)

**Multi-view (orthographic) drawings**

Pictorial drawings are excellent for presenting easy-to-visualize pictures to the viewer, but there are some problems. The main problem is that these drawings cannot be accurately drawn to scale. Also, they cannot accurately duplicate exact shapes and angles. As this information can be essential, another form of drawing is used, one that has several names, including orthographic projection, third angle projection, multi-view projection, and working drawing. Each projection is a view that shows only one face of an object, such as the front, side, top, or back. These views are not pictorial.

To interpret or read these drawings you must first understand how the views in a multi-view drawing are developed and how each view relates to the other views. The best way to
understand the principle of orthographic views is to suspend the object you wish to draw inside an imaginary glass box. If you were to look at the object through each side of the box and draw onto the glass the view of the object you see through the glass, you would end up with a sketch similar to that shown in Figure 4.

The view through each side of the glass box shows only the end view of one side of the object. All lines are straight and parallel because the original object has sides that are straight and parallel. Each view represents what you see when you look directly at the object.

If you were to open up the glass box, as shown in Figure 5, each view would be in the correct position for a true orthographic drawing. Each view is given a name that reflects its position in relation to the other views.
When the imaginary glass box is flattened as shown in Figure 6, you can see that each view is in line with the adjacent view. Then the edges of the box are removed and you have a six-view orthographic drawing of the original object (Figure 7). These six views are called the six principal orthographic views. This view alignment is important and is always consistent in orthographic projection. You will seldom need to show views of all six sides of an object; usually it is sufficient to show just two or three. You should remember the names of these six views and understand how they are obtained in case you ever need to show an object that cannot be truly represented in two or three views.

Unless the object is very complex, only the front, top, and right-side views are necessary. If the object has a uniform thickness, only one or two views are necessary. You should not show more views than are necessary. The front, left, back, and right views are also referred to as elevations.
Isometric Drawing

Description
Isometric drawings use perspective to communicate a large amount of information in a single drawing. Isometric drawings show three sides of an object, making it easier to better understand how a finished object may look or how the pieces of the object will fit together. In this activity, students will draw an isometric drawing on a piece of paper with a title block. Students will also continue to practise lineweights and lettering techniques.

Lesson Objectives
The student will be able to:
- Complete a board set-up
- Identify and appropriately use drafting tools
- Create an isometric drawing of an object
- Differentiate lineweights
- Refine lettering techniques

Assumptions
The student will:
- Have a basic knowledge of drafting tools and equipment
- Have a foundational understanding of how to appropriately use drafting equipment
- Have created a title block on which to complete this activity

Terminology
Border or title block lines: thick, dark lines used to create a solid border around a blank page.

Drafting board: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

Drafting brush: used to sweep away debris from a drawing so the full drawing is not smeared.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

Guide lines: thin, light lines, drawn when using the lettering guide for evenly spaced letters.

Isometric drawing: a two-dimensional drawing that looks 3D. This drawing will show three sides of the object in one view and will be created using lines primarily at 30 and 90 degrees from horizontal. When drawing on paper, you will use a 30/60/90 triangle.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy, dark lines.
**Lettering guide**: used to assist in the drawing of uniform lines to draw consistent, evenly spaced lettering.

**Linewidth**: the thickness and darkness of drawn lines.

**Masking tape** (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

**Pencil**: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H will be used for these activities.

**Precision drawing**: the act of creating drawings with specialized tools and equipment.

**Steel rule**: a straightedge made of rigid material and divided into specific increments, found both in metric and imperial units.

**Triangles** (right angle and isosceles): drafting guides made of hard, clear plastic that are used to draw lines at vertical and set angles (45°-90°-45°, 30°-60°-90°).

**T-square**: precision drawing instrument that is used as a guide with other drafting equipment. The T-square has a 90° angle where the head and blade attach.

**Estimated Time**
60–90 minutes

**Recommended Number of Students**
20, based on the *BC Technology Educators' Best Practice Guide*

**Facilities**
- Regular classroom space with desks/chairs for all students
- Drafting boards would be ideal. However smooth, clean, flat surfaces will also suffice.

**Tools**
- T-square
- Steel rule
- Triangles (right angle and isosceles)
- Eraser shield
- Drafting brush
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
- 2H mechanical pencil
- Isometric dot paper for practice
Materials

- Handout for students with instructions (this could be directly from this document—i.e., print the text under the Teacher-led Activity)
- Title-block drawing page (created in Introduction to Title Blocks activity)
- Isometric dot paper for practice
- Wooden block used in the Scale and Dimensioning and Orthographic Drawing activities

Teacher-led Activity: Isometric Notes

An isometric drawing is based on three axes that are equally spaced apart at 120° (Figure 1). Lines that run parallel to the axes are called isometric lines. Lines that are NOT parallel are called non-isometric lines.

An isometric drawing can be identified by several factors:

- Vertical planes or edges are still drawn vertically.
- Left and right planes are drawn at an angle of 30° above horizontal.
- No horizontal lines are found on isometrics.

![Isometric View](image)

**Figure 1**—An isometric view. Isometrics show a three-dimensional object from three perspectives in a single drawing.
Teacher-led Activity

Have students sketch an object using correct isometric standards. Labelling the sides of the object with a sticky note may assist novices to differentiate between the different planes. Isometric paper (includes vertical axes as well as 30° axes already laid out) is an excellent way to begin.

1. Gather all materials listed above.

2. Demonstrate: Using the T-square and masking tape/drafting dots, align title-blocked paper to your drafting board and securely tape down (Figure 2).

3. The three dimensions of length, width, and height are drawn along the isometric axes shown in Figure 3. The lengths of objects running parallel to these axes can be drawn to scale. Lines at other angles will not be to scale.
4. Draw a small, six-pointed star-shaped axis on the bottom corner of your paper (Figure 4). The sloping axes should be drawn at a 30° angle from the horizontal grid line. The vertical axis of the star indicates height (H) or depth (D), and the two sloping axes indicate the length (L) and the width (W) of the rectangle. The vertical axis can be used as a reference guide when making lines on your drawing.

![Figure 4—Six-pointed star-shaped axis](image)

5. Sketch the top of the block by drawing two lines, one parallel to L and one parallel to W (Figure 5).

![Figure 5—Sketching the top of the block](image)
6. Sketch two lines, one parallel to L and one parallel to D as shown in Figure 6.

![Figure 6—Sketching the side of the block](image1)

7. Sketch two lines, one parallel to W and one parallel to D, to complete the outline of the rectangular block (Figure 7). Begin with light layout lines so that you can make any necessary adjustments before darkening them. The finished isometric sketch is drawn with dark object lines in Figure 8.

![Figure 7—Full outline of rectangular block](image2)  
![Figure 8—Isometric object](image3)

8. Complete the activity by filling in the title block as follows:

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**Extension Activity**

Further drawing practice creating more isometric objects, using different wooden cut-out shapes.
Assessment

- Student participation in discussion/demonstration
- Completion of drawing with overall neatness:
  - Lines are concisely drawn.
  - Isometric object is accurate and proportional to page.
  - Border lines cross to ensure closed corners.
  - Lettering is done to a high quality (all uppercase).
  - Title block is filled out correctly with appropriate information.

Appendix Acknowledgment

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Appendix

Make isometric sketches of simple rectangular objects

Isometric sketches are useful because they are easy to draw and clearly represent an object or system. This clarity comes from using directional lines to represent the three dimensions of length, width, and height, much like a picture.

Construction methods

The following steps explain how to draw an isometric cube. The three dimensions of length, width, and height are drawn along the isometric axes shown in Figure 8. The lengths of objects running parallel to these axes can be drawn to scale. Lines at other angles will not be to scale.

Draw a small star-shaped axis on the bottom corner of your grid paper. The sloping axes should be drawn at a 30° degree angle from the horizontal grid line. The vertical axis of the star indicates height (H) or depth (D), and the two sloping axes indicate the length (L) and the width (W) of the rectangle. The vertical axis can be used as a guide when making lines on your drawing. Notice we have labelled the points on the star in Figure 9. These labels can change depending on the view that you may want when drawing a stationary object. The bottom two horizontal points indicate the view that is being drawn. In this case we would be creating a front-right view.
Sketch the top of the block by drawing two lines, one parallel to L and one parallel to W (Figure 10).

![Figure 10 — Step 2: Isometric view of top surface of a rectangular block](image)

Sketch two lines, one parallel to L and one parallel to D as shown in Figure 11.

![Figure 11 — Step 3: Lines parallel to L and D](image)

Sketch two lines, one parallel to W and one parallel to D, to complete the outline of the rectangular block as shown in Figure 12. Begin with light construction lines so that you can make any necessary adjustments before darkening them. The finished isometric sketch is shown in Figure 13.

![Figure 12 — Step 4: Completed outline of rectangular block](image)
Sketching irregular shapes with isometric lines

Not all rectangular objects are as simple as the block you have just sketched. Sometimes the shapes are irregular and have cut-out sections or some sides longer than others. All rectangular objects can be fitted into a box having the maximum length (L), width (W), and depth (D). Begin by sketching a light outline of a basic box that is the size of the object to be drawn.

As an example, consider the object shown in the three-view orthographic sketch in Figure 14. To produce an isometric sketch of this object, you need to find the maximum L, W, and D for the containing box (Figure 14). In this case:

- L = 5 grid spaces
- W = 3 grid spaces
- D = 3 grid spaces
Sketch a light outline of the basic rectangular box to the required size, as shown in Figure 15.

![Figure 15 — Basic outline](image)

The front view shows the outline most clearly. Place this view on the front surface of the isometric box. Use the dimension given in the front view of Figure 14 and mark the number of units indicated along the axes L and D (Figure 16).

![Figure 16 — Location of marks on axes](image)

Lightly sketch lines parallel to the L and D axes from the marked points on the front surface (Figure 17). The step outline is drawn more heavily to emphasize the profile of the object, once you are sure your sketch is correct.

![Figure 17 — Location of main features](image)
Sketch in a series of lines parallel to the axes (L, W, and D) from the corners numbered 1 to 7 (Figure 18). These lines establish the stepped outline as shown in Figure 19.

When you are sure your isometric sketch is correct, erase all unnecessary construction lines and darken the object lines. Your completed sketch of the rectangular object should be similar to that in Figure 20.
Drafting Dictionary

Description
In this lesson the teacher will introduce the tools and equipment specific to board drafting. Board drafting (also known as manual drafting) refers to precision drawing with specialized instruments. It is expected that as part of this Activity Plan, the instructor will demonstrate the appropriate usage of each tool.

Lesson Objectives
The student will be able to:
- Introduce common drafting equipment and tools
- Demonstrate appropriate and correct tool usage

Assumptions
The teacher will have a general working knowledge of drafting tools and equipment.
The student will have minimal knowledge of drafting equipment.

Terminology
Compass: a tool used to draw circles, bisect lines, and create dividing lines. Can be fitted with pencil leads or points.

Drafting board: a flat, smooth surface, designed with square, parallel edges that allow a T-square to slide easily. Most boards are covered with a vinyl material to allow for even surfaces to which paper can be affixed.

Drafting brush: a hand brush used to sweep away debris from a drawing to prevent smearing.

Drafting templates (plants, furniture, circle, appliance standards): standardized cut-outs used to draw repeated shapes to scale.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without damage to the rest.

French curve: a rigid plastic template used to draw irregular curves or radii.

Lettering guide: a plastic template designed to assist in the drawing of uniform strings of letters for consistent, evenly spaced lettering.

Masking tape (drafting dots): used to hold drawing paper/vellum to the drafting board so it does not shift while drawing.

Metric and imperial scale: a three-faced ruler with a triangular base, used to reduce or enlarge drawings. The triangular scale ruler has more than one graduated scale and is used only as a measurement instrument, not as a ruler.
**Protractor**: a semicircular template made of transparent plastic, used to measure angles.

**Spline**: a flexible plastic or rubber template with a metal core that can be shaped into most curves.

**Steel rule**: a straightedge made of rigid material, divided into specific increments. Can be found in metric and imperial measurement divisions.

**Triangles** (right angle and isosceles): hard, clear plastic triangular templates used to draw vertical lines as well as lines at set angles: 45°–90°–45°, 30°–60°–90°

**T-square**: a precision drawing instrument, used as a guide for other drafting equipment. Has a 90° angle where the head and blade attach.

**Estimated Time**

40–90 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

Regular classroom space with desks/chairs for all students, a projector with computer and speakers, and Internet access

**Tools**

- T-square
- Metric and architectural scale
- Steel rule
- French curve
- Triangles (right angle and isosceles)
- Assorted drafting templates (plants, furniture, circle, appliance standards)
- Eraser shield
- Drafting brush
- Protractor
- Compass
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
Materials

- Handout for students with images of equipment and descriptions of each. Use printout of PowerPoint presentation as handout (also available on the Youth Explore Trades Skills website as a PPT presentation and a PDF).
- 8.5” × 11” paper
- Computer
- Projector
- Whiteboard

Resources

- PowerPoint presentation for Drafting Dictionary

Teacher-led Activity

- Introduce each tool. Visual aids could be used to show each piece of equipment, or where available the tools themselves could be presented.
- List each tool’s use and demonstrate on whiteboard.
- Students could copy notes, or a handout could be created from the PowerPoint file.
- Review any feedback and questions with students.

Student Activity

Students will complete a quiz activity after the introductory lesson.

Assessment

Students will be assessed based on discussion participation and completion of quiz.

Appendix Acknowledgment

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Appendix

Describe the drafting tools and materials used in drawing plans

Traditionally, drafters sat at drafting boards and used pencils, pens, compasses, protractors, triangles, and other drafting devices to prepare a drawing manually. Today, however, most professional drafters use computer-aided drafting (CAD) systems to prepare drawings. Although drafters use CAD extensively, it is only a tool. Drafters and tradespersons still need knowledge of traditional drafting tools and techniques.

Tools

Drafting tools are needed to lay out the different shapes and lines used to create drawings and sketches. A basic knowledge of the available tools and how to use them will assist you in your drawing.

Drafting board or table

The drafting board is an essential tool. Paper will be attached and kept straight and still, so the surface of the drafting board must be smooth and true, with no warps or twists. The surfaces of most drafting boards are covered with vinyl because it is smooth and even.

The drafting board or table should have two parallel outside working edges made of either hardwood or steel.

Most drafting table tops can be set at different heights from the floor and at any angle from vertical to horizontal. Other drafting tables may not have the same adjustments and may be limited to being raised only from horizontal to a low slope.

To reduce back strain, use an adjustable drafting stool when working at a drafting table. Tables or boards should be a minimum of 1.2 m (4’) in width and 0.9 m (3’) in height.

T-square

The fixed head T-square is used for most work. It should be made of durable materials and have a transparent edge on the blade. To do accurate work, the blade must be perfectly square and straight; this should be checked regularly.

The T-square is used to draw horizontal lines and to align other drawing instruments. If you are right-handed, you hold it tight against the left edge of the drawing board and move it up and down as required. When you make close adjustments, your fingers should be on top of the square and you should use your thumb to control the T-square’s movement (Figure 1).
When drawing horizontal lines, incline your pencil in the direction you are drawing the line. Hold the pencil point as close as possible to the blade. Roll the pencil between your fingers to prevent the point from becoming flat on one side.

**Triangle**

A triangle (set-square) is made of a clear plastic. Some triangles have rabbeted edges (Figure 2), so that when you draw lines, the corner of the edge is set away from the paper to help prevent smudges and ink blotches.

Triangles are available in 45°-90°-45° or 30°-60°-90° combinations. For most work, triangles should be about 200 mm to 250 mm (8” to 10”) long. Triangles should be stored flat to prevent warping, and not stored underneath other objects to prevent any pressure from causing them to deform.
Check a triangle for accuracy by drawing a perpendicular line, then reversing the triangle and drawing another perpendicular line (Figure 3).

Triangles are used to draw vertical lines and other lines at set angles. Rest the triangle on the T-square blade and slide it along the blade to the desired location. Draw the full length of the vertical line in one pass if possible. Hold the blades of the T-square and the triangle together to prevent any movement when you are drawing, and hold the pencil point as close as possible to the triangle. You can also draw 15° and 75° angles by using both a 45°-90°-45° and a 30°-60°-90° in combination. Figure 4 shows how triangles are placed to draw angles that are every multiple of 15°.
Protractor
A protractor (Figure 5) is an instrument used to measure angles. It is typically made of transparent plastic or glass. Protractors can be used for checking and transferring angles to and from a drawing sheet.

![Protractor](image)

**Figure 5 — Protractor**

Drafting machine
A drafting machine (Figure 6) is a device that is mounted to the drawing board. The drafting machine replaces the T-square and triangles, as it has rulers with angles that can be precisely adjusted with a controlling mechanism. A drafting machine allows easy drawing of parallel lines over the paper. The adjustable angle between the rulers allows the lines to be drawn in a variety of accurate angles. Rulers may also be used as a support for separate special rulers and letter templates. The rulers are replaceable and can be replaced with scale rulers.

![Drafting machine](image)

**Figure 6 — Drafting machine**
Drawing pencils
Both wood and mechanical pencils are used for drafting (Figure 7).

Manufacturers grade drawing pencils using numbers and letters. These range from 6B (very soft and black) to 9H (the hardest). From 6B the pencils progress through 5B, 4B, 3B, 2B, B, and HB, and then to F, the medium grade. After that they move to the harder graphite: H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, and finally 9H. The softer grades are used for sketching and rendering drawings. The harder grades are used for instrument drawings.

Mechanical pencils do not require sharpening and are made to hold leads (they are actually made of graphite) that are bought separately. Thin-lead mechanical pencils, with leads as small as 0.5 mm, are available in different grades of lead. Most draftspersons use four or five different mechanical pencils with a different lead in each. The pencils come in different colours so it is easy to keep track of which lead is in each.

Figure 7 — Wood and mechanical pencils

Erasers and erasing shields
The best eraser to use on drawings is either a soft pink eraser that has bevelled ends, or the white plastic eraser. Electric rotary erasers are also available. They permit easy erasure of small errors without erasing adjacent lines.

A metal erasing shield helps to confine erasures to the desired area. Erasing shields are made from very thin stainless steel and have holes of various shapes to accommodate the sections to be erased. Figure 8 shows two erasers and an erasing shield.

Figure 8 — Erasers and erasing shield
Templates

Templates (Figure 9) are available for many different trades. Templates incorporate cut-outs of symbols and fixtures that are commonly used in that trade. These cut-outs make it easy to trace shapes onto drawing paper.

![Templates](image)

Figure 9 — Templates

French curves and splines

A French curve (Figure 10) is a plastic template designed to help you draw curves. The French curve contains many different curves, but each one is represented over a very short distance only. One radius of curve blends into another radius. It takes a lot of practice to use French curves effectively.

![French curve](image)

Figure 10 — French curve

A spline or flexible curve (Figure 11) can be used instead of a French curve to draw most curves. A spline is a plastic or rubber rod that is reinforced with metal. To use a spline, bend it to the shape of the curve you need. The design of the spline lets you hold a pencil against an edge and draw an accurate line without smudging. A spline cannot be used to draw curves that have a very short radius because the spline will not bend tightly.

![Spline](image)

Figure 11 — Spline
Compass

A compass can be used for drawing circles, bisecting lines, or dividing angles. For very large circles you can use a beam compass. The four types of compasses are shown in Figure 12. Most compasses can be fitted with leads, pens, or points.

Figure 12 — Four types of compasses
When using the compass, tilt it in the direction of the line, as shown in Figure 13.

Figure 13 — Drawing a circle with a compass

Dividers

Dividers (Figure 14) are used for transferring dimensions from a drawing to a measuring device such as a ruler or scale. They are also used when scribing directly on material like metal.

Figure 14 — Dividers

Dusting cloth or brush

It is very important to keep your drawings and drafting surface clean. When equipment gets dirty from the lead pencils, you should clean it regularly so that it does not smudge your drawings. Any soft, clean cloth is suitable. You may want to wash your board occasionally with a spray cleaner.
Use a brush like the one in Figure 15 to clean your table prior to placing paper down and to sweep away any debris as you are drawing. If you use your hand to brush, you could leave marks on the paper. After sharpening a pencil, wipe off any dust that is clinging to the point of the pencil to prevent smudging.

Figure 15 — Dusting brush

**Scale rulers**

Scale rulers let you draw diagrams at a reduced scale. They also let you obtain dimensions from a scaled drawing. Scale rulers come in a variety of types to meet the requirements of many different kinds of work. Most scale rulers have three edges and six different scales. The scales are read from either end of the rule. A typical combination of metric scales is 1:20, 1:50, 1:100, 1:25, 1:75, and 1:125.

Because of the decimal basis of metric measurements, metric scale rulers are both applicable and easy to use at any scale. Figure 16 shows the two scales from both ends of the same side.

Figure 16 — Metric scale ruler

Imperial scale rulers may be an architect’s ruler, a mechanical engineer’s ruler, or a civil engineer’s ruler (Figure 17). The architect’s scale ruler is the most common, and is in inches and fractions of inches. A mechanical engineer’s scale ruler comes in inches and decimals of inches. A civil engineer’s scale ruler comes in feet and decimals of feet.
Drafting materials

The most common support for drawing is paper. Even though the original creative surface has changed from the drafting table to the computer screen, on the work site drawings are still primarily in printed form.

Drawing paper

There is a wide variety of drawing paper available in many sizes and of different qualities. Good quality drawing paper is acid-free and will not turn yellow with age. Light-coloured drawing papers are available in pale yellow or buff, but these should be used only when it is not necessary to make copies.

Tracing paper

Tracing paper, which is transparent, can be used to make copies of drawings. It is thin enough to allow the light of photocopy machines to shine through the unmarked areas, and only the lines and figures will block the light. Materials used for tracing include tracing paper, vellum, tracing cloth, glass cloth, and polyester film with a matte finish.

Standard paper sizes

Paper sizes typically comply with one of two different standards: ISO (world standard) or ANSI/ASME Y14 (American).

The standard ISO series of paper sizes is as follows:

- A0 841 mm x 1189 mm
- A1 594 mm x 841 mm
- A2 420 mm x 594 mm
- A3 297 mm x 420 mm
The standard ANSI/ASME series of paper sizes is as follows:

- E 34 inch × 44 inch
- D 22 inch × 34 inch
- C 17 inch × 22 inch
- B 11 inch × 17 inch
- A 8.5 inch × 11 inch

The 8½” × 11” standard letter paper corresponds to 216 mm × 279 mm. You can buy precut sheets that have a border and a preprinted title block in the lower right-hand corner. These are available in many standard sizes.

If the paper you use does not have a border and title block, you will have to draw them in. The left-hand border should be wider than the right-hand border and should be at least 50 mm wide to allow room for the prints to be bound. Figure 18 shows a title block with suitable dimensions added.

Paper rolls
Many grades of paper rolls are available in different widths that can be cut to any length required.

Drafting or masking tape
Use drafting or masking tape to hold the paper on the drafting surface. The tape should be attached at the corners to hold the sheet firmly stretched with no wrinkles. Only short pieces of tape are required.
Computer drafting printing

Computer drafting programs are used effectively for all manner of drafting and have virtually replaced manual drafting. Small size computer-generated drawings can be printed on normal computer printers. However, larger drawings require a plotter. Older plotters used pencils, pens, or felt pens, but the new plotters are laser-based or jet printers and are capable of multiple colours. They are made to print all the sizes of drawings. Plotters also print well on vellum and some other non-paper media.

Now complete the Student Activity.
Student Activity

Complete the following quiz by filling in the descriptions of the tools and sketching images of each tool in the boxes provided.

1. Steel rule

2. T-square

3. Protractor
   - Checking and transferring angles to drawings
   - Calculating and measuring angles

4. Triangle (right angle & isosceles)

5. Eraser shield
   - Made from thin stainless steel
   - Allows you to erase specific areas

6. French curve/spline
   - Drawing of irregular curves
7. Drafting brush

8. Compass

9. Drafting templates
   • Made of plastic
   • Standardization of shapes

10. Metric and imperial scales
    • Allow you to draw a diagram at a reduced scale

11. Lettering guide
    • Allows for uniform lettering
Introduction to Title Blocks

Description
In this activity the teacher will demonstrate the use of board drafting tools and equipment to create a title block. A title block is comprised of the information boxes found on the bottom right-hand corner of a drawing, which indicate drawing details such as the title, author name, scale, and date the drawing was created.

This is an introductory activity designed to be completed prior to any other board drawing activities. It will cover basic standards in precision drawing techniques, pencil hardness/selection, and lettering.

Lesson Objectives
The student will be able to:

• Complete a board and page setup
• Use tools appropriately to draw a title block
• Differentiate pencil hardness relative to line weight, and select a pencil accordingly
• Understand and identify architectural measurement standards (imperial units of measurement)
• Use basic line weight techniques
• Identify and implement lettering techniques

Assumptions
The teacher will have a fundamental knowledge of drafting tools and equipment (see Drafting Dictionary Activity Plan).

The student will:

• Have a basic knowledge of drafting tools and equipment
• Have a foundational understanding of how to appropriately use drafting equipment

Terminology

Border lines: thick, dark lines used to create a solid border around a blank page.

Drafting board: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

Drafting brush: used to sweep away debris from a drawing so the full drawing is not smeared.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.
Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy, dark lines (border lines).

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly spaced lettering.

Line weight: the thickness and darkness of drawn lines.

Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H is recommended for these activities.

Precision drawing: the act of creating drawings with specialized tools and equipment.

Steel rule: a straightedge made of rigid material and divided into specific increments, found both in metric and imperial units.

Title block: comprised of the information boxes found on the bottom right-hand corner of a drawing, the title block indicates drawing details such as the title, author name, scale, and date a drawing was created.

Triangles (right angle and isosceles): drafting guides made of hard, clear plastic that are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: a precision drawing instrument that is used as a guide with other drafting equipment. The T-square has a 90° angle where the head and blade attach.

Estimated Time

30–60 minutes

Recommended Number of Students

20, based on BC Technology Educators’ Best Practice Guide

Facilities

- Regular classroom space with desks/chairs for all students, a projector with computer and speakers, and Internet access
- Drafting boards (any large enough smooth, flat surface will also work)
Tools

• T-square
• Steel rule
• Triangles (right angle and isosceles)
• Eraser shield
• Drafting brush
• Masking tape (drafting dots)
• Drafting board
• Lettering guide
• Mechanical pencil or drafting pencil with 2H lead (most versatile for drawing at this stage)

Materials

• Handout for students with instructions (suggestion: develop a handout using the instructions from the teacher-led activity that follows).

Resources

• Drafting Dictionary Activity Plan

Student Activity

1. Complete title block drawing.

2. Fill in title block with appropriate information as noted below.

<table>
<thead>
<tr>
<th>TITLE OF EXERCISE</th>
<th>STUDENT NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DATE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NAME OF DRAWING</th>
<th>SCALE OF DRAWING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PAGE</td>
</tr>
</tbody>
</table>

Extension Activity

Have students create multiple title block pages for further use in subsequent exercises.

Assessment

• Student participation in discussion/demonstration
• Completion of drawing with overall neatness:
  – Lines are drawn correctly.
  – Border lines cross to ensure closed corners.
  – Lettering is done to a high quality (all uppercase).
  – Title block is filled out correctly with appropriate information.
Teacher-led Activity

1. Gather all materials listed above.

2. Using the T-square and masking tape and/or drafting dots, align blank paper to your drafting board and securely tape down (Figure 1).

3. Using the metric ruler, mark out lines with your pencil around the entire page at 13 mm from the outside edge (Figure 2). These lines should be small, should align with the direction of the page, and should be very light (layout lines).

Figure 1—Secure paper to board

Figure 2—Mark off border
4. Using the T-square and right angle triangle, join these lines to create a border around the entire page (Figure 3). These lines should be solid, dark lines with no breaks (border/title block lines).

Note: The border lines should cross over each other to ensure closed corners (Figure 4), but they should not extend to the edges of the page.

Figure 3—Draw border

Figure 4—Closed corner
5. Mark a point 20 mm above the bottom border line (Figure 5) and draw a layout line joining
the left and right vertical border lines.

![Image of a hand marking a point on a sheet of paper with a 20 mm measurement]

Figure 5—Measure layout line 20 mm horizontally above bottom border

6. Repeat step 5, measuring up another 20 mm from the line you just drew (Figure 6).

![Image of a hand extending a horizontal line 20 mm from the previous line]

Figure 6—Measure a second horizontal layout line 20 mm from the line drawn in
step 5 (or 40 mm from the bottom border)
7. From the vertical border line on the right-hand side of the page, measure in 60 mm toward the left (Figure 7) and use layout lines to mark in the title block.

8. Divide the blocks in the small section at 10 mm. You should end up with four small sections that are 10 mm high and 60 mm wide (Figure 8).
9. Demonstrate how to use a lettering guide aligned with the T-square (Figure 9) to draw light guide lines to fill in the title block (Figure 10).

![Figure 9—Using a lettering guide](image)

10. Fill in the title block with the appropriate information. Remind students that drafting convention requires that all lettering be done in CAPITALS.

![Figure 10—Letter guide lines](image)

Appendix Acknowledgment

© Camosun College. Trades Access Common Core: Competency D-3: Read Drawings and Specifications (pp. 25–33). The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Describe lines, lettering, and dimensioning in drawings

The purpose of engineering drawings is to convey objective facts, whereas artistic drawings convey emotion or artistic sensitivity in some way.

Engineering drawings and sketches need to display simplicity and uniformity, and they must be executed with speed. Engineering drawing has evolved into a language that uses an extensive set of conventions to convey information very precisely, with very little ambiguity.

Standardization is also very important, as it aids internationalization; that is, people from different countries who speak different languages can read the same engineering drawing and interpret it the same way. To that end, drawings should be as free of notes and abbreviations as possible so that the meaning is conveyed graphically.

Line styles and types

Standard lines have been developed so that every drawing or sketch conveys the same meaning to everyone. In order to convey that meaning, the lines used in technical drawings have both a definite pattern and a definite thickness. Some lines are complete and others are broken. Some lines are thick and others are thin. A visible line, for example, is used to show the edges (or “outline”) of an object and to make it stand out for easy reading. This line is made thick and dark. On the other hand, a centre line, which locates the precise centre of a hole or shaft, is drawn thin and made with long and short dashes. This makes it easily distinguishable from the visible line.

When you draw, use a fairly sharp pencil of the correct grade and try to maintain an even, consistent pressure to make it easier for you to produce acceptable lines (Figure 1). Study the line thicknesses (or “line weights”) shown in Figure 2 and practise making them.

![Figure 1 — Lead grade and usage](image-url)
In computer drafting, the line shape remains the same, but line thickness may not vary as it does in manually created drawings. Some lines, such as centre lines, may not cross in the same manner as in a manual drawing. For most computer drafting, line thickness is not important.

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight</th>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object line Margin line</td>
<td>Heavy</td>
<td></td>
<td>Solid line to show visible shape, edges, and outlines.</td>
</tr>
<tr>
<td>Hidden body line</td>
<td>Medium</td>
<td></td>
<td>Broken line of long and short dashes to show hidden object lines not visible to the eye.</td>
</tr>
<tr>
<td>Phantom line</td>
<td>Light</td>
<td></td>
<td>Broken line of short dashes to show alternate positions or movement of a part.</td>
</tr>
<tr>
<td>Section line</td>
<td>Light</td>
<td></td>
<td>Unbroken lines arranged in a pattern, usually straight and at a 45° diagonal.</td>
</tr>
<tr>
<td>Projection line</td>
<td>Light</td>
<td></td>
<td>Unbroken lines that extend away from the object or feature for emphasis.</td>
</tr>
<tr>
<td>Centre line</td>
<td>Light</td>
<td></td>
<td>Broken line of long and short dashes to show the centre of an object.</td>
</tr>
<tr>
<td>Extension line/Dimension line</td>
<td>Light</td>
<td></td>
<td>Extension lines are small lines that extend outward from an object or feature. Dimension lines span between the extension lines with arrowheads and a given dimension.</td>
</tr>
<tr>
<td>Leader line</td>
<td>Light</td>
<td></td>
<td>Unbroken line usually drawn at an angle often with a “dogleg” and an arrowhead. A dot is used in place of an arrowhead where a surface is referenced. Usually accompanied by a label.</td>
</tr>
<tr>
<td>Cutting plane line</td>
<td>Heavy</td>
<td></td>
<td>Broken line of one long and two short dashes to show an imaginary cross-section. The arrowheads show the direction from where the cross-section is viewed. A corresponding image will show the view of A.</td>
</tr>
<tr>
<td>Break lines for wood and metal</td>
<td>Heavy</td>
<td></td>
<td>Unbroken freehand or straight zig-zag lines to abbreviate longer spans of wood or metal.</td>
</tr>
<tr>
<td>Break lines for piping</td>
<td>Heavy</td>
<td></td>
<td>Curled lines to abbreviate a longer span of pipe.</td>
</tr>
</tbody>
</table>

**Figure 2 — Weights of lines**
To properly read and interpret drawings, you must know the meaning of each line and understand how each is used to construct a drawing. The ten most common are often referred to as the “alphabet of lines.” Let’s look at an explanation and example of each type.

**Object lines**

Object lines (Figure 3) are the most common lines used in drawings. These thick, solid lines show the visible edges, corners, and surfaces of a part. Object lines stand out on the drawing and clearly define the outline and features of the object.

**Hidden lines**

Hidden lines (Figure 4) are used to show edges and surfaces that are not visible in a view. These lines are drawn as thin, evenly spaced dashes. A surface or edge that is shown in one view with an object line will be shown in another view with a hidden line.
Centre lines
Centre lines (Figure 5) are used in drawings for several different applications. The meaning of a centre line is normally determined by how it is used. Centre lines are thin, alternating long and short dashes that are generally used to show hole centres and centre positions of rounded features, such as arcs and radii. Arcs are sections of a circle, and radii are rounded corners or edges of a part. Centre lines can also show the symmetry of an object.

![Figure 5 — Centre lines](image)

Dimension and extension lines
Dimension and extension lines (Figure 6) are thin, solid lines that show the direction, length, and limits of the dimensions of a part. Dimension lines are drawn with an arrowhead at both ends.

Extension lines are drawn close to, but never touching, the edges or surface they limit. They should be perpendicular, or at right angles, to the dimension line. The length of extension lines is generally suited to the number of dimensions they limit.

![Figure 6 — Dimension and extension lines](image)
**Leader lines**

Leader lines (Figure 7) show information such as dimensional notes, material specifications, and process notes. These lines are normally drawn as thin, solid lines with an arrowhead at one end. They are bent or angled at the start, but should always end horizontal at the notation. When leader lines reference a surface, a dot is used instead of an arrowhead.

![Leader line (thin and solid)](image)

Note that the symbol ø is used to indicate a diameter rather than the abbreviation “DIA.” The number that immediately follows this symbol is the diameter of the hole, followed by the number of holes that must be drilled to that dimension.

**Phantom lines**

Like centre lines, phantom lines (Figure 8) are used for several purposes in blueprints. Phantom lines are used to show alternate positions for moving parts and the positions of related or adjacent parts, and to eliminate repeated details. Phantom lines are drawn as thin, alternating long dashes separated by two short dashes.
Cutting plane lines
Cutting plane lines (Figure 9) show the location and path of imaginary cuts made through parts to show internal details. In most cases, sectional views (or views that show complicated internal details of a part) are indicated by using a cutting plane line. These lines are thick, alternating long lines separated by two short dashes. The arrowheads at each end show the viewing direction of the related sectional view. The two main types of cutting plane lines are the straight and the offset.
Section lines
Section lines, also known as sectional lining, (Figure 10) indicate the surfaces in a sectional view as they would appear if the part were actually cut along the cutting plane line. These are solid lines that are normally drawn at 45 degree angles. Different symbols are used to represent different types of materials.

![Section lines](image)

Figure 10 — Section lines combined with cutting plane lines

Break lines
Break lines are drawn to show that a part has been shortened to reduce its size on the drawing. The two variations of break lines common to blueprints are the long break line and the short break line (Figure 11). Long break lines are thin solid lines that have zigzags to indicate a break. Short break lines are thick, wavy solid lines that are drawn freehand. When either of these break lines is used to shorten an object, you can assume that the section removed from the part is identical to the portions shown on either side of the break.

![Break lines](image)

Figure 11 — Break line
Standard lettering

The letters and numbers on a drawing or sketch are as important as the lines. Scribbled, smudged, or badly written letters and numbers can become impossible to read. This may lead to time-consuming and costly errors. Lettering is necessary to describe:

- the name or title of a drawing
- when it was made
- the scale
- who sketched it
- the dimensions
- the special notations that describe the size
- the materials to be used
- the construction methods

The American Standard Vertical letters (Figure 12) have become the most accepted style of lettering used in the production of manual drafting. This lettering is a Gothic sans serif script, formed by a series of short strokes.

Font styles and sizes may vary in computer drafting. Note that all letters are written as capital (upper case) letters. Practise these characters, concentrating on forming the correct shape. Remember that letters and numbers must be black so that they will stand out and be easy to read. Lettering and figures should have the same weight and darkness as hidden lines.

Title and drawing sizes = 6 mm (¼”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Dimension and notation sizes = 3 mm (⅛”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Figure 12 — Standard lettering
Abbreviations

Abbreviations are commonly used to help simplify a drawing and conserve space. Although many fields share common abbreviation conventions, there are also field- or trades-specific conventions that you will see as you become more specialized. Here is a common list of abbreviations that are used on drawings. Each trade will have specific abbreviations from this list, and therefore a set of drawings will usually include an abbreviation key.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>anchor bolt</td>
</tr>
<tr>
<td>ABT</td>
<td>about</td>
</tr>
<tr>
<td>AUX</td>
<td>auxiliary</td>
</tr>
<tr>
<td>BC</td>
<td>bolt circle</td>
</tr>
<tr>
<td>BBE</td>
<td>bevel both ends</td>
</tr>
<tr>
<td>BCD</td>
<td>bolt circle diameter</td>
</tr>
<tr>
<td>BOE</td>
<td>bevel one end</td>
</tr>
<tr>
<td>BE</td>
<td>both ends</td>
</tr>
<tr>
<td>BL</td>
<td>baseline</td>
</tr>
<tr>
<td>BM</td>
<td>bench mark</td>
</tr>
<tr>
<td>Btm</td>
<td>bottom</td>
</tr>
<tr>
<td>BP</td>
<td>base plate</td>
</tr>
<tr>
<td>B/P</td>
<td>blueprint</td>
</tr>
<tr>
<td>BLD</td>
<td>blind</td>
</tr>
<tr>
<td>C/C</td>
<td>centre to centre</td>
</tr>
<tr>
<td>COL</td>
<td>column</td>
</tr>
<tr>
<td>CPLG</td>
<td>coupling</td>
</tr>
<tr>
<td>CS</td>
<td>carbon steel</td>
</tr>
<tr>
<td>C/W</td>
<td>complete with</td>
</tr>
<tr>
<td>CYL</td>
<td>cylinder</td>
</tr>
<tr>
<td>DIA</td>
<td>diameter</td>
</tr>
<tr>
<td>DIAG</td>
<td>diagonal</td>
</tr>
<tr>
<td>DIM</td>
<td>dimension</td>
</tr>
<tr>
<td>DWG</td>
<td>drawing</td>
</tr>
<tr>
<td>EA</td>
<td>each</td>
</tr>
<tr>
<td>EL</td>
<td>elevation</td>
</tr>
<tr>
<td>EXT</td>
<td>external</td>
</tr>
<tr>
<td>F/F</td>
<td>face to face</td>
</tr>
<tr>
<td>FF</td>
<td>flat face</td>
</tr>
<tr>
<td>FLG</td>
<td>flange</td>
</tr>
<tr>
<td>FW</td>
<td>fillet weld</td>
</tr>
<tr>
<td>Ga</td>
<td>gauge</td>
</tr>
<tr>
<td>Galv</td>
<td>galvanized</td>
</tr>
<tr>
<td>HVY</td>
<td>heavy</td>
</tr>
<tr>
<td>HH</td>
<td>hex head</td>
</tr>
<tr>
<td>HR</td>
<td>hot rolled</td>
</tr>
<tr>
<td>HT</td>
<td>heat treatment</td>
</tr>
<tr>
<td>HLS</td>
<td>holes</td>
</tr>
<tr>
<td>HSS</td>
<td>hollow structural steel</td>
</tr>
<tr>
<td>ID</td>
<td>inside diameter</td>
</tr>
<tr>
<td>INT</td>
<td>internal</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Org.</td>
</tr>
<tr>
<td>KP</td>
<td>kick plate</td>
</tr>
<tr>
<td>LH</td>
<td>left hand</td>
</tr>
<tr>
<td>LAT</td>
<td>lateral</td>
</tr>
<tr>
<td>LR</td>
<td>long radius</td>
</tr>
<tr>
<td>LG</td>
<td>long</td>
</tr>
<tr>
<td>MB</td>
<td>machine bolt</td>
</tr>
<tr>
<td>MS</td>
<td>mild steel</td>
</tr>
<tr>
<td>MIN</td>
<td>minimum</td>
</tr>
<tr>
<td>MAT’L</td>
<td>material</td>
</tr>
<tr>
<td>MISC</td>
<td>miscellaneous</td>
</tr>
<tr>
<td>NC</td>
<td>national course</td>
</tr>
<tr>
<td>NF</td>
<td>national fine</td>
</tr>
<tr>
<td>NO</td>
<td>number</td>
</tr>
<tr>
<td>MOM</td>
<td>nominal</td>
</tr>
<tr>
<td>NTS</td>
<td>not to scale</td>
</tr>
<tr>
<td>NPS</td>
<td>nominal pipe size</td>
</tr>
<tr>
<td>NPT</td>
<td>national pipe thread</td>
</tr>
<tr>
<td>O/C</td>
<td>on centre</td>
</tr>
<tr>
<td>OA</td>
<td>overall</td>
</tr>
<tr>
<td>OD</td>
<td>outside diameter</td>
</tr>
<tr>
<td>OR</td>
<td>outside radius</td>
</tr>
<tr>
<td>OPP</td>
<td>opposite</td>
</tr>
<tr>
<td>PAT</td>
<td>pattern</td>
</tr>
<tr>
<td>PBE</td>
<td>plain both ends</td>
</tr>
<tr>
<td>POE</td>
<td>plain one end</td>
</tr>
<tr>
<td>PSI</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>PROJ</td>
<td>project</td>
</tr>
<tr>
<td>RD</td>
<td>running dimension</td>
</tr>
<tr>
<td>R</td>
<td>round</td>
</tr>
<tr>
<td>RND</td>
<td>round</td>
</tr>
<tr>
<td>REF</td>
<td>reference</td>
</tr>
<tr>
<td>REQ’D</td>
<td>required</td>
</tr>
<tr>
<td>REV</td>
<td>revision</td>
</tr>
<tr>
<td>RF</td>
<td>raised face</td>
</tr>
<tr>
<td>RH</td>
<td>right hand</td>
</tr>
<tr>
<td>SCH</td>
<td>schedule</td>
</tr>
<tr>
<td>SI</td>
<td>International System of Units</td>
</tr>
<tr>
<td>SPECS</td>
<td>specifications</td>
</tr>
<tr>
<td>SQ</td>
<td>square</td>
</tr>
<tr>
<td>SM</td>
<td>seam</td>
</tr>
<tr>
<td>SMLS</td>
<td>seamless</td>
</tr>
<tr>
<td>S/S</td>
<td>seam to seam</td>
</tr>
<tr>
<td>SO</td>
<td>slip on</td>
</tr>
<tr>
<td>SEC</td>
<td>section</td>
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<td>STD</td>
<td>standard</td>
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<tr>
<td>SS</td>
<td>stainless steel</td>
</tr>
<tr>
<td>SYM</td>
<td>symmetrical</td>
</tr>
<tr>
<td>T</td>
<td>top</td>
</tr>
<tr>
<td>T&amp;B</td>
<td>top and bottom</td>
</tr>
<tr>
<td>T&amp;C</td>
<td>threaded and coupled</td>
</tr>
<tr>
<td>THD</td>
<td>threaded</td>
</tr>
<tr>
<td>TOE</td>
<td>threaded one end</td>
</tr>
<tr>
<td>THK</td>
<td>thick</td>
</tr>
<tr>
<td>TOL</td>
<td>tolerance</td>
</tr>
<tr>
<td>TOC</td>
<td>top of concrete</td>
</tr>
<tr>
<td>TOS</td>
<td>top of steel</td>
</tr>
<tr>
<td>TYP</td>
<td>typical</td>
</tr>
<tr>
<td>U/N</td>
<td>unless noted</td>
</tr>
<tr>
<td>VERT</td>
<td>vertical</td>
</tr>
<tr>
<td>WD</td>
<td>working drawing</td>
</tr>
<tr>
<td>WP</td>
<td>working point</td>
</tr>
<tr>
<td>WT</td>
<td>weight</td>
</tr>
<tr>
<td>W/O</td>
<td>without</td>
</tr>
<tr>
<td>XH</td>
<td>extra heavy</td>
</tr>
<tr>
<td>XS</td>
<td>extra strong</td>
</tr>
</tbody>
</table>
Drawing Objects

Description
In this activity the teacher will demonstrate the use of drafting equipment to create basic object shapes. Students will use a piece of paper with a title block to complete this activity. Students will practise lettering and line-weight techniques.

Lesson Objectives
The student will be able to:

- Complete a board set-up
- Identify and appropriately use drafting tools
- Differentiate line weights
- Refine lettering techniques
- Create basic object shapes, based on instructions

Assumptions
The student will:

- Have a basic knowledge of drafting tools and equipment
- Have a foundational understanding of how to appropriately use drafting equipment
- Know how to create a title block on which to complete this activity

Terminology
Border lines: thick, dark lines used to create a solid border around a blank page.

Drafting board: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

Drafting brush: used to sweep away debris from a drawing so the full drawing is not smeared.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy, dark lines (border lines).

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly spaced lettering.

Lineweight: the thickness and darkness of drawn lines.
Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H is recommended for these activities.

Precision drawing: the act of creating drawings with specialized tools and equipment.

Steel rule: a straightedge made of rigid material and divided into specific increments, found both in metric and imperial units.

Title block: comprised of the information boxes found on the bottom right-hand corner of a drawing, the title block indicates drawing details such as the title, author name, scale, and date a drawing was created.

Triangles (right angle and isosceles): drafting guides made of hard, clear plastic that are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: a precision drawing instrument that is used as a guide with other drafting equipment. The T-square has a 90° angle where the head and blade attach.

**Estimated Time**
30–60 minutes

**Recommended Number of Students**
20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**
- Regular classroom space with desks/chairs for all students
- Drafting boards (any large enough smooth, flat surface will also work)

**Tools**
- T-square
- Steel rule
- Triangles (right angle and isosceles)
- Eraser shield
- Drafting brush
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
- French curve/spline
- Circle template
- Compass
- 2H mechanical pencil
Materials
• Handout for students with instructions (suggestion: develop a handout using the instructions from the teacher-led activity).

Resources
• Drafting Dictionary Activity Plan

Teacher-led Activity
1. Gather all materials listed above.

2. Using the T-square and masking tape and/or drafting dots, align blank paper to your drafting board and securely tape down (Figure 1).

![Figure 1—Secure paper to board](image)

3. Using the steel rule, divide the drawing space of your paper into four even sections (each section should be 95 mm wide by 108 mm high). Draw these lines lightly (layout lines).
4. In the top left section, draw an object that focusses on sloping and parallel lines. Practise using the right angle, isosceles triangle, and T-square. Leave enough room underneath the object for the following label: OBJECT No. 1 PARALLEL LINES AND SLOPING LINES (Figure 2).

![Figure 2—Parallel lines and sloping lines](image)

5. In the top right section, students will draw an object that focusses on circular lines. Practise using the circle template and protractor. Leave enough room underneath the object for the following label: OBJECT No. 2 CIRCULAR LINES (Figure 3).

![Figure 3—Circular lines](image)
6. In the bottom left section, students will draw an object that focuses on lines at right angles. Practise using the right angle and isosceles triangles. Leave enough room underneath the object for the following label: OBJECT No. 3 LINES AT RIGHT ANGLES (Figure 4).

![Figure 4—Lines at right angles](image)

7. In the bottom right section, students will draw an object that focuses on free-form lines. Practise using the French curve and/or spline too. Leave enough room underneath the object for the following label: OBJECT No. 4 FREE FORM WITH FRENCH CURVE (Figure 5).

![Figure 5—Free form with French curve](image)
8. Fill in the title block at the bottom of the page with the information below. Remind students that drafting convention requires that all lettering be done in CAPITALS.

<table>
<thead>
<tr>
<th>ACTIVITY # 1</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>OBJECTS</td>
<td>DATE</td>
</tr>
<tr>
<td></td>
<td>SCALE OF DRAWING 1:1</td>
</tr>
<tr>
<td></td>
<td>PAGE 1 OF 1</td>
</tr>
</tbody>
</table>

**Student Activity**

- Complete object shape drawings.
- Fill in title block with appropriate information.

**Extension Activity**

- Practise drawing more objects, using all the tools in the Drafting Dictionary Activity Plan.
- Practise lettering when labelling object drawings.

**Assessment**

- Student participation in discussion/demonstration
- Criteria for completed drawing:
  - Basic object shapes are drawn based on instructions.
  - Corners of borders are closed (horizontal and vertical lines cross).
  - Lettering is neat, even, and all uppercase.
  - Title block is filled out correctly with appropriate information.

**Appendix Acknowledgment**

© Camosun College. Trades Access Common Core: Competency D-3: Read Drawings and Specifications (pp. 25–33). The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Describe lines, lettering, and dimensioning in drawings

The purpose of engineering drawings is to convey objective facts, whereas artistic drawings convey emotion or artistic sensitivity in some way.

Engineering drawings and sketches need to display simplicity and uniformity, and they must be executed with speed. Engineering drawing has evolved into a language that uses an extensive set of conventions to convey information very precisely, with very little ambiguity.

Standardization is also very important, as it aids internationalization; that is, people from different countries who speak different languages can read the same engineering drawing and interpret it the same way. To that end, drawings should be as free of notes and abbreviations as possible so that the meaning is conveyed graphically.

Line styles and types

Standard lines have been developed so that every drawing or sketch conveys the same meaning to everyone. In order to convey that meaning, the lines used in technical drawings have both a definite pattern and a definite thickness. Some lines are complete and others are broken. Some lines are thick and others are thin. A visible line, for example, is used to show the edges (or “outline”) of an object and to make it stand out for easy reading. This line is made thick and dark. On the other hand, a centre line, which locates the precise centre of a hole or shaft, is drawn thin and made with long and short dashes. This makes it easily distinguishable from the visible line.

When you draw, use a fairly sharp pencil of the correct grade and try to maintain an even, consistent pressure to make it easier for you to produce acceptable lines (Figure 1). Study the line thicknesses (or “line weights”) shown in Figure 2 and practise making them.

Figure 1 — Lead grade and usage
In computer drafting, the line shape remains the same, but line thickness may not vary as it does in manually created drawings. Some lines, such as centre lines, may not cross in the same manner as in a manual drawing. For most computer drafting, line thickness is not important.

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight</th>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object line</td>
<td>Heavy</td>
<td>__</td>
<td>Solid line to show visible shape, edges, and outlines.</td>
</tr>
<tr>
<td>Margin line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hidden body line</td>
<td>Medium</td>
<td>——</td>
<td>Broken line of long and short dashes to show hidden object lines not visible to the eye.</td>
</tr>
<tr>
<td>Phantom line</td>
<td>Light</td>
<td>—</td>
<td>Broken line of short dashes to show alternate positions or movement of a part.</td>
</tr>
<tr>
<td>Section line</td>
<td>Light</td>
<td>Steel, Copper/Brass, Lead, Cast iron/General purpose</td>
<td>Unbroken lines arranged in a pattern, usually straight and at a 45° diagonal.</td>
</tr>
<tr>
<td>Projection line</td>
<td>Light</td>
<td></td>
<td>Unbroken lines that extend away from the object or feature for emphasis.</td>
</tr>
<tr>
<td>Centre line</td>
<td>Light</td>
<td>—</td>
<td>Broken line of long and short dashes to show the centre of an object.</td>
</tr>
<tr>
<td>Extension line/Dimension line</td>
<td>Light</td>
<td>25 mm</td>
<td>Extension lines are small lines that extend outward from an object or feature. Dimension lines span between the extension lines with arrowheads and a given dimension.</td>
</tr>
<tr>
<td>Leader line</td>
<td>Light</td>
<td>Label</td>
<td>Unbroken lines usually drawn at an angle often with a “dogleg” and an arrowhead. A dot is used in place of an arrowhead where a surface is referenced. Usually accompanied by a label.</td>
</tr>
<tr>
<td>Cutting plane line</td>
<td>Heavy</td>
<td>A</td>
<td>Broken line of one long and two short dashes to show an imaginary cross-section. The arrowheads show the direction from where the cross-section is viewed. A corresponding image will show the view of A.</td>
</tr>
<tr>
<td>Break lines for wood and metal</td>
<td>Heavy</td>
<td></td>
<td>Unbroken freehand or straight zig-zag lines to abbreviate longer spans of wood or metal.</td>
</tr>
<tr>
<td>Break lines for piping</td>
<td>Heavy</td>
<td></td>
<td>Curled lines to abbreviate a longer span of pipe.</td>
</tr>
</tbody>
</table>

Figure 2 — Weights of lines
To properly read and interpret drawings, you must know the meaning of each line and understand how each is used to construct a drawing. The ten most common are often referred to as the “alphabet of lines.” Let’s look at an explanation and example of each type.

**Object lines**

Object lines (Figure 3) are the most common lines used in drawings. These thick, solid lines show the visible edges, corners, and surfaces of a part. Object lines stand out on the drawing and clearly define the outline and features of the object.

![Figure 3 — Object lines](image)

**Hidden lines**

Hidden lines (Figure 4) are used to show edges and surfaces that are not visible in a view. These lines are drawn as thin, evenly spaced dashes. A surface or edge that is shown in one view with an object line will be shown in another view with a hidden line.

![Figure 4 — Hidden lines](image)
Centre lines

Centre lines (Figure 5) are used in drawings for several different applications. The meaning of a centre line is normally determined by how it is used. Centre lines are thin, alternating long and short dashes that are generally used to show hole centres and centre positions of rounded features, such as arcs and radii. Arcs are sections of a circle, and radii are rounded corners or edges of a part. Centre lines can also show the symmetry of an object.

![Figure 5 — Centre lines](image)

Dimension and extension lines

Dimension and extension lines (Figure 6) are thin, solid lines that show the direction, length, and limits of the dimensions of a part. Dimension lines are drawn with an arrowhead at both ends.

Extension lines are drawn close to, but never touching, the edges or surface they limit. They should be perpendicular, or at right angles, to the dimension line. The length of extension lines is generally suited to the number of dimensions they limit.

![Figure 6 — Dimension and extension lines](image)
**Leader lines**

Leader lines (Figure 7) show information such as dimensional notes, material specifications, and process notes. These lines are normally drawn as thin, solid lines with an arrowhead at one end. They are bent or angled at the start, but should always end horizontal at the notation. When leader lines reference a surface, a dot is used instead of an arrowhead.

![Leader line diagram](image)

Note that the symbol ø is used to indicate a diameter rather than the abbreviation “DIA.” The number that immediately follows this symbol is the diameter of the hole, followed by the number of holes that must be drilled to that dimension.

**Phantom lines**

Like centre lines, phantom lines (Figure 8) are used for several purposes in blueprints. Phantom lines are used to show alternate positions for moving parts and the positions of related or adjacent parts, and to eliminate repeated details. Phantom lines are drawn as thin, alternating long dashes separated by two short dashes.

![Phantom line diagram](image)
Cutting plane lines

Cutting plane lines (Figure 9) show the location and path of imaginary cuts made through parts to show internal details. In most cases, sectional views (or views that show complicated internal details of a part) are indicated by using a cutting plane line. These lines are thick, alternating long lines separated by two short dashes. The arrowheads at each end show the viewing direction of the related sectional view. The two main types of cutting plane lines are the straight and the offset.

Figure 8 — Phantom lines

Figure 9 — Cutting plane lines
Section lines
Section lines, also known as sectional lining, (Figure 10) indicate the surfaces in a sectional view as they would appear if the part were actually cut along the cutting plane line. These are solid lines that are normally drawn at 45 degree angles. Different symbols are used to represent different types of materials.

![Section lines combined with cutting plane lines](image)

**Figure 10** — Section lines combined with cutting plane lines

Break lines
Break lines are drawn to show that a part has been shortened to reduce its size on the drawing. The two variations of break lines common to blueprints are the long break line and the short break line (Figure 11). Long break lines are thin solid lines that have zigzags to indicate a break. Short break lines are thick, wavy solid lines that are drawn freehand. When either of these break lines is used to shorten an object, you can assume that the section removed from the part is identical to the portions shown on either side of the break.

![Break lines](image)

**Figure 11** — Break line
Standard lettering

The letters and numbers on a drawing or sketch are as important as the lines. Scribbled, smudged, or badly written letters and numbers can become impossible to read. This may lead to time-consuming and costly errors. Lettering is necessary to describe:

- the name or title of a drawing
- when it was made
- the scale
- who sketched it
- the dimensions
- the special notations that describe the size
- the materials to be used
- the construction methods

The American Standard Vertical letters (Figure 12) have become the most accepted style of lettering used in the production of manual drafting. This lettering is a Gothic sans serif script, formed by a series of short strokes.

Font styles and sizes may vary in computer drafting. Note that all letters are written as capital (upper case) letters. Practise these characters, concentrating on forming the correct shape. Remember that letters and numbers must be black so that they will stand out and be easy to read. Lettering and figures should have the same weight and darkness as hidden lines.

Title and drawing sizes = 6 mm (¼”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Dimension and notation sizes = 3 mm (⅛”)

A B C D E F G H I J K L
M N O P Q R S T U V W
X Y Z 0 1 2 3 4 5 6 7 8 9

Figure 12 — Standard lettering
### Abbreviations

Abbreviations are commonly used to help simplify a drawing and conserve space. Although many fields share common abbreviation conventions, there are also field- or trades-specific conventions that you will see as you become more specialized. Here is a common list of abbreviations that are used on drawings. Each trade will have specific abbreviations from this list, and therefore a set of drawings will usually include an abbreviation key.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>anchor bolt</td>
</tr>
<tr>
<td>ABT</td>
<td>about</td>
</tr>
<tr>
<td>AUX</td>
<td>auxiliary</td>
</tr>
<tr>
<td>BC</td>
<td>bolt circle</td>
</tr>
<tr>
<td>BBE</td>
<td>bevel both ends</td>
</tr>
<tr>
<td>BCD</td>
<td>bolt circle diameter</td>
</tr>
<tr>
<td>BOE</td>
<td>bevel one end</td>
</tr>
<tr>
<td>BE</td>
<td>both ends</td>
</tr>
<tr>
<td>BL</td>
<td>baseline</td>
</tr>
<tr>
<td>BM</td>
<td>bench mark</td>
</tr>
<tr>
<td>Btm</td>
<td>bottom</td>
</tr>
<tr>
<td>BP</td>
<td>base plate</td>
</tr>
<tr>
<td>B/P</td>
<td>blueprint</td>
</tr>
<tr>
<td>BLD</td>
<td>blind</td>
</tr>
<tr>
<td>C/C</td>
<td>centre to centre</td>
</tr>
<tr>
<td>COL</td>
<td>column</td>
</tr>
<tr>
<td>CPLG</td>
<td>coupling</td>
</tr>
<tr>
<td>CS</td>
<td>carbon steel</td>
</tr>
<tr>
<td>C/W</td>
<td>complete with</td>
</tr>
<tr>
<td>CYL</td>
<td>cylinder</td>
</tr>
<tr>
<td>DIA</td>
<td>diameter</td>
</tr>
<tr>
<td>DIAG</td>
<td>diagonal</td>
</tr>
<tr>
<td>DIM</td>
<td>dimension</td>
</tr>
<tr>
<td>DWG</td>
<td>drawing</td>
</tr>
<tr>
<td>EA</td>
<td>each</td>
</tr>
<tr>
<td>EL</td>
<td>elevation</td>
</tr>
<tr>
<td>EXT</td>
<td>external</td>
</tr>
<tr>
<td>F/F</td>
<td>face to face</td>
</tr>
<tr>
<td>FF</td>
<td>flat face</td>
</tr>
<tr>
<td>FLG</td>
<td>flange</td>
</tr>
<tr>
<td>FW</td>
<td>fillet weld</td>
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<td>Ga</td>
<td>gauge</td>
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<tr>
<td>Galv</td>
<td>galvanized</td>
</tr>
<tr>
<td>H</td>
<td>heavy</td>
</tr>
<tr>
<td>HH</td>
<td>hex head</td>
</tr>
<tr>
<td>HR</td>
<td>hot rolled</td>
</tr>
<tr>
<td>HT</td>
<td>heat treatment</td>
</tr>
<tr>
<td>HLS</td>
<td>holes</td>
</tr>
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<td>HSS</td>
<td>hollow structural steel</td>
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<tr>
<td>ID</td>
<td>inside diameter</td>
</tr>
<tr>
<td>IN</td>
<td>inches</td>
</tr>
<tr>
<td>INT</td>
<td>internal</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Org.</td>
</tr>
<tr>
<td>KP</td>
<td>kick plate</td>
</tr>
<tr>
<td>LH</td>
<td>left hand</td>
</tr>
<tr>
<td>LAT</td>
<td>lateral</td>
</tr>
<tr>
<td>LR</td>
<td>long radius</td>
</tr>
<tr>
<td>LG</td>
<td>long</td>
</tr>
<tr>
<td>MB</td>
<td>machine bolt</td>
</tr>
<tr>
<td>MS</td>
<td>mild steel</td>
</tr>
<tr>
<td>MIN</td>
<td>minimum</td>
</tr>
<tr>
<td>MAX</td>
<td>maximum</td>
</tr>
<tr>
<td>MAT’L</td>
<td>material</td>
</tr>
<tr>
<td>MISC</td>
<td>miscellaneous</td>
</tr>
<tr>
<td>NC</td>
<td>national course</td>
</tr>
<tr>
<td>NF</td>
<td>national fine</td>
</tr>
<tr>
<td>NO</td>
<td>number</td>
</tr>
<tr>
<td>MOM</td>
<td>nominal</td>
</tr>
<tr>
<td>NTS</td>
<td>not to scale</td>
</tr>
<tr>
<td>NPS</td>
<td>nominal pipe size</td>
</tr>
<tr>
<td>NPT</td>
<td>national pipe thread</td>
</tr>
<tr>
<td>O/C</td>
<td>on centre</td>
</tr>
<tr>
<td>OA</td>
<td>overall</td>
</tr>
<tr>
<td>OD</td>
<td>outside diameter</td>
</tr>
<tr>
<td>OR</td>
<td>outside radius</td>
</tr>
<tr>
<td>OPP</td>
<td>opposite</td>
</tr>
<tr>
<td>PAT</td>
<td>pattern</td>
</tr>
<tr>
<td>PBE</td>
<td>plain both ends</td>
</tr>
<tr>
<td>POE</td>
<td>plain one end</td>
</tr>
<tr>
<td>PSI</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>RD</td>
<td>running dimension</td>
</tr>
<tr>
<td>RE</td>
<td>reference</td>
</tr>
<tr>
<td>REQ’D</td>
<td>required</td>
</tr>
<tr>
<td>REV</td>
<td>revision</td>
</tr>
<tr>
<td>RF</td>
<td>raised face</td>
</tr>
<tr>
<td>RH</td>
<td>right hand</td>
</tr>
<tr>
<td>SCH</td>
<td>schedule</td>
</tr>
<tr>
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<td>International System of Units</td>
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<td>square</td>
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<td>seamless</td>
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<td>seam to seam</td>
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<td>SO</td>
<td>slip on</td>
</tr>
<tr>
<td>SEC</td>
<td>section</td>
</tr>
<tr>
<td>STD</td>
<td>standard</td>
</tr>
<tr>
<td>SS</td>
<td>stainless steel</td>
</tr>
<tr>
<td>SYM</td>
<td>symmetrical</td>
</tr>
<tr>
<td>T</td>
<td>top</td>
</tr>
<tr>
<td>T&amp;B</td>
<td>top and bottom</td>
</tr>
<tr>
<td>T&amp;C</td>
<td>threaded and coupled</td>
</tr>
<tr>
<td>THD</td>
<td>threaded</td>
</tr>
<tr>
<td>TBE</td>
<td>threaded both ends</td>
</tr>
<tr>
<td>TOE</td>
<td>threaded one end</td>
</tr>
<tr>
<td>TOC</td>
<td>top of concrete</td>
</tr>
<tr>
<td>TOC</td>
<td>top of steel</td>
</tr>
<tr>
<td>TOL</td>
<td>tolerance</td>
</tr>
<tr>
<td>U/N</td>
<td>unless noted</td>
</tr>
<tr>
<td>VERT</td>
<td>vertical</td>
</tr>
<tr>
<td>WD</td>
<td>working drawing</td>
</tr>
<tr>
<td>WP</td>
<td>working point</td>
</tr>
<tr>
<td>WT</td>
<td>weight</td>
</tr>
<tr>
<td>W/O</td>
<td>without</td>
</tr>
<tr>
<td>XH</td>
<td>extra heavy</td>
</tr>
<tr>
<td>XS</td>
<td>extra strong</td>
</tr>
</tbody>
</table>
Scale and Dimensioning

Description
In this activity, the teacher will first select an object that is larger than the page and scale it to fit in the drawing area to explain metric scale. Second, the teacher will then dimension the scaled object using standard conventions. Students will use paper with a title block to complete this activity. Students will also continue to improve their skills with lettering techniques and lineweights.

Lesson Objectives
The student will be able to:
- Complete a board set-up
- Identify and appropriately use drafting tools
- Differentiate lineweights by varying pencil pressure while creating scale drawings of objects
- Determine the appropriate scale to ensure an object is proportionally drawn
- Incorporate dimensioning standards
- Refine lettering techniques

Assumptions
The student will:
- Have a basic knowledge of drafting tools and equipment
- Understand the basics of appropriate use of drafting equipment
- Have previously drawn a title block for use in completing this activity

Terminology
Aligned dimensions: numerical dimension values that are aligned with the direction of the dimension line. The drawing therefore has to be turned to correctly read the dimensions.

Border lines: thick, dark lines used to create a solid border around a blank page.

Dimensions: a measurement of something in a specific linear direction. Most often this includes the length, width, and height of an object.

Dimension lines: lines spanning the distance between extension lines; they have arrowheads and include a numerical dimension measurement.

Drafting board: a flat, smooth surface usually covered in vinyl, which helps to hold paper affixed to it. It has square, parallel edges that allow a T-square to slide easily.
Drafting brush: used to sweep away debris from a drawing so it does not smear the full drawing.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

Extension line: small lines that extend outward from an object or feature to indicate a dimension point.

Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy dark lines.

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly-spaced lettering.

Lineweight: the thickness and darkness of drawn lines.

Masking tape (drafting dots): holds drawing paper/vellum to the drafting board so the paper does not shift while drawing.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H will be used for these activities.

Precision drawing: creating drawings with specialized tools and equipment.

Scale: ratio of length of a drawn object relative to its length in “real space.” A proportional representation of an object either reduced or enlarged.

Steel rule: straightedge made of rigid material, divided into specific increments, found both in metric and imperial units.

Title block: comprised of the information boxes found on the bottom right-hand corner of a drawing, the title block indicates drawing details such as the title, author name, scale, and date a drawing was created.

Triangles (right angle and isosceles): made of hard, clear plastic, they are used to draw lines at vertical and set angles: 45°–90°–45°, 30°–60°–90°

T-square: a precision drawing instrument, used as a guide for other drafting equipment. Has a 90° angle where the head and blade attach.

Unidirectional dimensions: show the numerical values in a normal reading position (horizontally); no rotation of the drawing is required.

Estimated Time
30–60 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide
Facilities

- Regular classroom space with desks/chairs for all students
- Drafting boards would be ideal; however, smooth, clean, and flat surfaces will also suffice

Tools

- T-square
- Steel rule
- Triangles (right angle and isosceles)
- Eraser shield
- Drafting brush
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
- 2H mechanical pencil
- Architectural scale
- Sample blocks for drawing (should be 50 mm wide × 100 mm high × 150 mm long)

Materials

- Handout for students with instructions (suggestion: develop a handout from the instructions for the teacher-led activity)
- Title block drawing page (created in the Introduction to Title Blocks activity)
- Practice worksheet for reading metric scales
- Practice worksheets for dimensioning
Teacher-led Activity

Part 1: Scale an object to fit title block

1. Gather all materials listed above.

2. Using the T-square and masking tape and/or drafting dots, align title-blocked paper to your drafting board and securely tape down (Figure 1).

3. Have students take measurements of the object block using the steel rule. This should include at a minimum length, width, and height (thickness) of the object (Figure 2). Have students make notes on a scrap piece of paper for future reference in the activity.

If students need further practice with the scale before drawing, have them complete the student activities on pages 7 and 22.
4. Using the metric scale, explain how to choose the best scale for this assignment.

Explain that the chosen scale must allow for all object details while still drawing the object proportionally onto the page.

The metric scale uses ratios of the same units in both ratio terms, resulting in an expression of how many times smaller the object is compared with the drawing. For example, if the ratio is 1:20, the object is 20 times larger than the object drawn.

On a metric scale there are only six scale ratios: 1:10, 1:5, 1:20, 1:2, 1:50, and 1:1. The units on the scale are represented as 1 m.

![Figure 3—Metric Scale](image)

5. Have the students draw the object using the measurements they took with the steel rule in Step 3.

**Note:** Students should draw the object in the centre near the bottom of the drawing space (Figure 4). They should use appropriate tools and equipment to ensure their drawing is square and is a detailed representation of the three-dimensional object.

![Figure 4—Students should draw the object in the centre near the bottom of the drawing space](image)
6. Once students have completed the drawing of their scaled object, have them label the drawing and locate the title underneath the object.

7. Students can also fill in the title block information (see below). The scale box will be specific to the scale chosen. Responses will vary. Scale is represented as a ratio in the title block space. For example, if the drawing was completed using the 1:2 measurements on a metric scale, then the ratio would be 1:2 on the title block.

<table>
<thead>
<tr>
<th>ACTIVITY # 4</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCALE AND DIMENSIONING</td>
<td>DATE</td>
</tr>
<tr>
<td></td>
<td>SCALE</td>
</tr>
<tr>
<td></td>
<td>PAGE 1 OF 1</td>
</tr>
</tbody>
</table>

**Part 2: Dimensioning the object**

**Dimensioning notes:**

1. When dimensioning objects, remember three key points:
   - Never leave any size, shape, or object in doubt.
   - Do not repeat the same dimension. Doing so could lead to confusion in reading the drawing measurements.
   - All dimensions should be located on the drawing in a clear, concise, and easy-to-follow manner.

2. There are two styles of dimensioning (Figure 5). For this lesson use the *unidirectional dimension* style.
   - *Aligned dimensions* show the numerical values aligned with the direction of the dimension lines. This results in having to turn the drawing to correctly read the dimensions.
   - *Unidirectional dimensions* show the numerical values in a normal reading position (horizontally); no rotation of the drawing is required.

![Figure 5—Dimensioning systems](image-url)
Student Activity

1. Using the scale-drawn object (and/or drawing) from the previous section, identify the areas that will require dimensions. Remember not to leave any areas in doubt.

2. Dimension and extension lines should be light in weight, clean, and a consistent thickness. Extension lines are drawn out from the object and act as a border edge for the dimension lines.

3. The dimension line should be drawn between the extension lines with arrows indicating where the measurement falls between the extension lines. A space must be left in the centre of each dimension line where the numerical value is placed. Be sure to include units of measurement with each dimension.
4. Complete each area of the drawing to ensure that no area is left out. A good rule of thumb is to ask yourself the question: “Could I build the object with the dimensions currently on the drawing?” If not, review the drawing and add the missing dimensions.

**Extension Activity**

- Further practice drawing, scaling objects, and dimensioning.
- Worksheets to practise reading dimensions from drawings.

**Assessment**

- Student participation in discussion/demonstration
- Drawing completed with the following:
  - Lines are drawn correctly.
  - Corners of border lines are closed (horizontal and vertical lines cross).
  - Dimensions meet standard convention styles.
  - Dimensions are neat and tidy.
  - Scale is appropriate to the size of the object and space available for drawing.
  - Lettering is neat, clean, and uppercase.
  - Title block is filled out correctly with appropriate information.

**Appendix Acknowledgment**

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Appendix

Figure 13 shows a simple drawing. Notice that the dimensions are given between arrows that point to extension lines. By using this method, the dimensions do not get in the way of the drawing. One extension line can be used for several dimensions. Notice also that the titles require larger letter sizes than those used for dimensions and notations. It is important that the title and sketch number stand out, as shown in Figure 13. When you begin lettering, you may wish to use very light lettering guide lines to ensure uniformity in lettering size and alignment.

Principles of dimensioning

A good sketch of an object is one that you can use as a blueprint to manufacture the object. Your sketch must show all the necessary dimensions of the part, locate any features it may have (such as holes and slots), give information on the material it is to be made from, and if necessary, stipulate the processes to be used in the manufacture of the object.
Three principles of dimensioning must be followed:

1. Do not leave any size, shape, or material in doubt.

2. To avoid confusion and the possibility of error, no dimension should be repeated twice on any sketch or drawing.

3. Dimensions and notations must be placed on the sketch where they can be clearly and easily read.

Consider Figure 14 and note whether these three dimensioning principles have been followed.

Figure 14 — Shop table

Although the dimensions and notations are clear and easy to read in Figure 14, the following points should be made:

• Leg and rail sizes have not been shown.
• The thickness of the top has not been given.
• The material has not been given as a notation.
• The 600 dimension has been repeated.
• The type of finish to be used has not been given.
• Note 2 is redundant.
The sketch of the shop table is far from complete, and the table could not be made without a lot of guesswork. Figure 15, on the other hand, shows a completed sketch that, along with the necessary notes and dimension information, can be readily used for construction purposes.

**Figure 15 — Dimensioning**

**Rules of dimensioning**

For most objects, there are three types of dimensions:

- size dimensions
- location dimensions
- notation dimensions

Figure 16 illustrates the difference between size and location dimensions. (S = size dimension and L = location dimension).
Size dimensions are necessary so that the material size of the object can be determined. Location dimensions are necessary so that parts, holes, or other features can be positioned in or on the object. Notation dimensions describe the part, hole, or other feature with a short note such as the “ø20 2 holes” notation (see Figure 16). Keep these points in mind:

- Keep all dimension lines at least 10 mm (3/8”) clear of object lines wherever possible.
- Try to group related dimensions rather than scattering them.
- Try to keep dimensions off the views themselves.
- Separate one line of dimensions from another line of dimensions or from a notation by a space of at least 10 mm (3/8”).
- Leave a space of approximately 3 mm (1/8”) between the object outline and the beginning of any extension line.
- Keep arrowheads slim and neat.
- Never dimension to a hidden line.
- Draw leader lines at an angle when intersecting object lines to avoid confusing them with extension lines.

Figure 17 illustrates good placement of dimensions and notations. Note the placement of extension lines and the use of centre lines to locate features such as holes. Also, note the shape and size of arrowheads.
Dimensioning systems

Two systems are used for dimensioning drawings. They are the aligned and the unidirectional systems. Figure 18 shows examples of both systems. As you can see, the aligned system requires that you turn the drawing on its side, whereas the unidirectional system may be read from the normal reading position. For most drawings, the unidirectional system is preferred, as it is easier to read; however, architectural drawings still use the aligned system.

Figure 17 — Extension line usage

**Figure 18** — Dimensioning systems
Systems of measurement
You may be required to sketch or read drawings constructed with either metric (SI) or imperial dimensions. You may also encounter drawings that are dual dimensioned and contain both systems of measurement on the same drawing.

SI system of measurement
The SI system of measurement has become the official standard in Canada. It is common practice on shop drawings to express all metric dimensions in millimetres. Figure 19 shows a detail drawing for a connector arm using metric measurements. All metric drawings should contain a note specifying that all dimensions are in millimetres.

Imperial system of measurement
An imperial drawing may use the decimal-inch system, the fractional-inch system, or feet and inches.

- In the decimal-inch system, very accurate dimensions for items such as machine parts are expressed as decimals of an inch, such as 0.005". In words this reads as five one-thousandths of an inch.
- In the fraction-inch system, dimensions for things such as steel and lumber sizes are expressed as inches and fractions of an inch from as small as \( \frac{1}{64} \)" (Figure 20). Most drawings that are dimensioned in the imperial system will use the fraction-inch system.
Notes:
1. All dimensions are in inches
2. Materials - 5/16 × 3 mild steel plate

Figure 20 — Connector arm – imperial measurement

In the feet-inch system (Figure 21), the dimensions of large structures such as machine frames and buildings are expressed in feet and inches, such as 2'-6" (two feet, six inches).

Figure 21 — Fuel storage shed
Use scale rulers to determine actual dimensions from drawings

Scale drawings are accurate and convenient visual representations made and used by engineers, architects, and people in the construction trades. The accuracy is achieved because the drawing is proportional to the real thing. The convenience comes from the size of the drawing. It is large enough to provide the desired detail but small enough to be handy.

The flexibility to draw proportionally in different sizes is provided by scales. For the purposes of representation, we will only be concerned with reduction scales. Reduction scales make the drawing smaller than the object. The kinds of rulers we will be discussing for making scaled drawings are the architect’s scale and the metric scale, both shown in Figure 1.

![Architect’s scale ruler](image1.png)
![Metric scale ruler](image2.png)

The scale of the drawing is always written on the drawing, unless the drawing is not drawn to scale. In the latter case, this will be indicated by the “not to scale” abbreviation (NTS). The scale is the ratio of the size of the drawing to the object. For drawings smaller than the object, the ratio is that of a smaller distance to a larger one.

The architect’s scales use ratios of inches to a foot. The most common architect’s scale used is ¼ inch to the foot, written on drawings as:

\[
\text{Scale}\ ¼'' = 1'-0''
\]

This means that a line ¼” long on the drawing represents an object that is one foot long. At the same scale, a line 1½” long represents an object 6' long, because 1½” contains 6 quarter-inches.

Metric scale ratios use the same units in both ratio terms, resulting in an expression of how many times smaller than the object the drawing is. For example, the standard metric scale ratio that corresponds approximately to ¼" = 1'-0" is written on drawings as "Scale 1:50."
This means that the object is 50 times as large as the drawing, so that 50 mm on the object is represented by 1 mm on the drawing. For another example, 30 mm on the drawing represents \(50 \times 30 \text{ mm} = 1500 \text{ mm (or 1.5 metres)}\) on the object.

Figure 2 lists the scale ratios used for building plans and construction drawings in both metric and the approximate equivalent architectural scale ratios.

<table>
<thead>
<tr>
<th>Type of Drawing</th>
<th>Common Metric Ratios</th>
<th>Imperial Equivalents and Ratios</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site plan</td>
<td>1:500</td>
<td>(1&quot; = 40\text{-}0&quot;)</td>
<td>• To locate the building, services and reference points on the site</td>
</tr>
<tr>
<td></td>
<td>1:200</td>
<td>(\frac{1}{60}&quot; = 1\text{-}0&quot;)</td>
<td></td>
</tr>
<tr>
<td>Sketch plans</td>
<td>1:200</td>
<td>(\frac{1}{60}&quot; = 1\text{-}0&quot;)</td>
<td>• To show the overall design of the building</td>
</tr>
<tr>
<td>General locations</td>
<td>1:100</td>
<td>(\frac{1}{60}&quot; = 1\text{-}0&quot;)</td>
<td>• To indicate the juxtaposition of the rooms and locate the positions of piping systems and components</td>
</tr>
<tr>
<td>Drawings</td>
<td>1:50</td>
<td>(\frac{1}{4}&quot; = 1\text{-}0&quot;)</td>
<td></td>
</tr>
<tr>
<td>Construction details</td>
<td>1:20</td>
<td>(\frac{1}{2}&quot; = 1\text{-}0&quot;)</td>
<td>• To show the detail of system components and assemblies</td>
</tr>
<tr>
<td></td>
<td>1:10</td>
<td>(1&quot; = 1\text{-}0&quot;)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:5</td>
<td>(3&quot; = 1\text{-}0&quot;)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1:1</td>
<td>Full size</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2** — Preferred scales for building drawings

**Architect’s (imperial) scales**

Traditional architectural measurements of length are written very precisely in feet and inches using the appropriate symbols for feet and inches separated by a dash (e.g., \(4’\text{-}3\frac{1}{2}”\) and \(7’\text{-}0”\)). This is the way that all imperial measurements are written on construction drawings.

Listed below are the scales found on the architect’s triangular scale ruler.

1. \(\frac{3}{2}’’ = 1\text{-}0”\)
2. \(\frac{3}{8}’’ = 1\text{-}0”\)
3. \(\frac{1}{6}’’ = 1\text{-}0”\)
4. \(\frac{1}{4}’’ = 1\text{-}0”\)
5. \(\frac{3}{4}’’ = 1\text{-}0”\)
6. \(\frac{3}{8}’’ = 1\text{-}0”\)
7. \(1” = 1\text{-}0”\)
8. \(\frac{1}{2}” = 1\text{-}0”\)
9. \(1\frac{1}{2}” = 1\text{-}0”\)
10. \(3” = 1\text{-}0”\)
11. \(1” = 1”\) (full size—use the scale labelled 16)
Figure 3 shows one face of an architect’s imperial triangular scale ruler. There are two edges on each face and each edge contains two scales that run in opposite directions. At each end of an edge, a number or fraction indicates the distance in inches that represents one foot. The top edge is in eighths of an inch from left to right, and in quarters of an inch from right to left. Note that the ¼” scale from 0 to the right end represents 95 feet, and the ¼” scale from 0 to the left end represents 47 feet.

![Figure 3 — One face of an architect’s ruler (NTS)](image)

At each end, between the zero and the number indicating scale, the length representing one foot is subdivided into 6, 12, 24, or more parts to indicate inches and, in some scales, fractions of an inch. For example, each of the six marks on the ¼” scale represents two inches, while each mark equals a quarter of an inch on the 1” reduction scale and one inch on the ¼” scale.

Now look at the 1½” scale in Figure 4. The subdivided unit is divided into inches and fractions of an inch. Reading left from the zero, notice the figures 3, 6, and 9, which represent measurements of 3”, 6”, and 9”. From the zero to the first long mark represents 1”. Between the zero and the one-inch mark there are four spaces, each of which represent one-quarter of an inch.

![Figure 4 — Units in an architect’s scale ruler (NTS)](image)

Piping drawings usually use a ⅛” scale for larger buildings, a ¼” scale for smaller buildings and houses, and a ½” scale for details. Each drawing will state in the title block the scale that is used. Sometimes when special details are given, the scale is placed directly under the detail.

To draw or measure a length to scale, first find the edge of the ruler containing the scale. One end of the length will rest exactly on one of the foot marks of the scale, and the other end should rest either on the zero marker or somewhere on the inch subdivision of the scale. The length can then be marked and drawn or read off from a drawing.
Figures 5 and 6 demonstrate this manner of reading dimensions from four of the ratios on the architect’s scale.

Architectural units have feet divided into inches, whereas engineering units divide feet into tenths and hundredths. Engineers’ scales are not used to make piping drawings.

Metric scales

A triangular metric scale is similar to the architectural scale in that it has six edges, but it has only one scale ratio per edge. The ratio is marked at the left end of the scale. For example, the scale of 1:50 means that 1 mm on the drawing represents 50 mm on the object. This means that the object is 50 times larger than the drawing of it. An object 450 mm long would be represented by a line 9 mm long (450 mm/50).

Figure 7 shows one of the three sides of a metric scale. The scale labelled 1:50 is read from left to right, from 0 to 15 m. The 1:5 scale (on the bottom) can also be read from left to right (0 to 600 mm) by turning the scale around.
1. Write the correct measurement of the dimensions shown below in the box at the right.

Sample
1:100

a.
1:100

b.
1:50

c.
1:5

d.
1:10

e.
1:20

11.5 m
Answer Key

1. a. 6’-5"
b. 12’-10"
c. 1’-6"
d. 4’-9"
e. 0’-6"
f. 0’-11"
g. 2’-0"
h. 0’-3"
i. 1’-9"
j. 2’-11"
Orthographic Drawing

Description
In this activity, the teacher will introduce orthographic projection, in which a multi-view drawing shows how the sides of an object are related to each another. Students will use a title-blocked piece of paper to complete this activity. Students will also continue to improve their skills by practising using different lineweights and lettering techniques.

Lesson Objectives
The student will be able to:
- Complete a board set-up
- Identify and appropriately use drafting tools
- Create an orthographic projection of an object
- Differentiate lineweights
- Refine lettering techniques

Assumptions
The student will:
- Have basic knowledge of drafting tools and equipment
- Have a foundational understanding of how to appropriately use drafting equipment
- Have created a title block with which to complete this activity

Terminology
Border lines: thick, dark lines used to create a solid border around a blank page.

Drafting board: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

Drafting brush: used to sweep away debris from a drawing so it does not smear the full drawing.

Eraser shield: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

Guide lines: thin, light lines drawn using the lettering guide for evenly spaced letters.

Layout lines: very light lines used to lay out measurements before those measurements are drawn in heavy dark lines.

Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly-spaced lettering.

Lineweight: the thickness and darkness of drawn lines.
Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

Object lines: solid lines used to indicate object shapes.

Orthographic projection: a multi-view representation of a three-dimensional object. Placement of the views depends on how the parts of the object work together.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H will be used for these activities.

Steel rule: a straightedge made of rigid material, divided into specific increments, found both in metric and imperial units.

Title block: comprised of the information boxes found on the bottom right-hand corner of a drawing, the title block indicates drawing details such as the title, author name, scale, and date a drawing was created.

Triangles (right angle and isosceles): made of hard, clear plastic, they are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: a precision drawing instrument that is used as a guide for other drafting equipment. Has a 90° angle where the head and blade attach.

Estimated Time
60–90 minutes

Recommended Number of Students
20, based on the BC Technology Educators’ Best Practice Guide

Facilities
- Regular classroom space with desks/chairs for all students
- Drafting boards would be ideal. However, smooth, clean, flat surfaces will also suffice.

Tools
- T-square
- Steel rule
- Triangles (right angle and isosceles)
- Eraser shield
- Drafting brush
- Masking tape (drafting dots)
- Drafting board
- Lettering guide
- 2H mechanical pencil
- Architectural scale
Materials

- Handout with instructions for students (take directly from this document; copy and print the text under “Teacher-led Activity”)
- Title block drawing page (created in Introduction to Title Blocks activity)
- Wooden block from the Scale and Dimensioning activity

Teacher-led Activity: Orthographic Projection Notes

Figure 1—Imagine the object in a glass box

Figure 2—Each side of the object is a flat surface plane

Figure 3—Views of the orthographic projection

Figure 4—Each side of the object is a flat surface plane

The front, top, and right sides are the most common views used in orthographic projections. When selecting views to include, be sure to include enough that the object could be constructed from the chosen views.
1. Gather all materials listed above.

2. Using the T-square and masking tape/drafting dots, align title-blocked paper to your drafting board and securely tape down (Figure 5).

![Figure 5—Secure paper to board](image)

3. Draw the same wooden block used in the Scale and Dimensioning activity (50 mm × 100 mm × 150 mm block). Have students measure and then scale down the dimensions to fit the drawing space. Students should start by drawing the front view in the bottom left-hand corner of the page. This should be done using object lines (Figure 6). Any hidden details should be drawn using a hidden line. Remind students to leave enough space under the drawing to insert a label.

![Figure 6—Front view](image)
4. Students should draw the top view next. This view should be drawn in the top left-hand corner of the page, aligned with the front view projection (Figure 7). Be sure to leave a 25 mm space below for a label. Using the T-square to align the shapes will ensure their correct layout.

![Top view and front view](image)

**Figure 7**—Top view and front view

5. Finally, draw the right-side view or end view projection in the bottom right-hand corner of the page (Figure 8). Align this view with the bottom line and top line of the front view. Leave a 25 mm space between the front view and the end view.

![Top view, front view, and end view](image)

**Figure 8**—Top view, front view, and end view

6. Complete the activity by filling in the title block as follows:

<table>
<thead>
<tr>
<th>ACTIVITY # 5</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORTHOGRAPHIC PROJECTION</td>
<td>DATE</td>
</tr>
<tr>
<td></td>
<td>SCALE OF DRAWING 1:2</td>
</tr>
<tr>
<td></td>
<td>PAGE 1 OF 1</td>
</tr>
</tbody>
</table>
Extension Activity

Further drawing practice: draw more orthographic projections using different wooden shapes as reference.

Assessment

• Student participation in discussion/demonstration
• Completion of drawing:
  – Lines are drawn correctly.
  – Orthographic views are aligned and evenly spaced on the page.
  – Corners of borders are closed (lines cross at corners).
  – Lettering is done to a high quality (all uppercase).
  – Title block is filled out correctly with appropriate information.

Appendix Acknowledgment

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Appendix

Describe drawing projections

Architectural drawings are made according to a set of conventions, which include particular views (floor plan, section, etc.), sheet sizes, units of measurement and scales, annotation, and cross-referencing.

Types of views used in drawings
The two main types of views (or “projections”) used in drawings are:

- pictorial
- orthographic

Pictorial views
Pictorial views show a 3-D view of how something should look when completed. There are three types of pictorial views:

- perspective
- isometric
- oblique

Perspective view
A perspective view presents a building or an object just as it would look to you. A perspective view has a vanishing point; that is, lines that move away from you come together in the distance. For example, in Figure 1, we see a road and line of telephone poles. Even though the poles get smaller in their actual measurement, we recognize them as being the same size but more distant.

![Perspective view](image)

Isometric view
An isometric view is a three-dimensional view. The plumb lines are vertical. The horizontal lines are set at 30 degree angles from a line parallel to the bottom of the page. Isometric views have no vanishing point, so the objects do not appear as they would in a perspective view.
Lengths are exact on isometric drawings only when the item is parallel to one of the axes of the drawing. Figure 2 shows an isometric view of a simple object, as well as the lines that represent the three dimensions.

![Isometric View](image)

**Figure 2 — An isometric view**

**Oblique view**

An oblique view is similar to an isometric view, except that the face or front view is drawn to exact scale and the oblique lines are extended at a 30 degree to 45 degree angle to create a three-dimensional representation (Figure 3).

![Oblique View](image)

**Figure 3 — Oblique view of the object in Figure 2**

**Multi-view (orthographic) drawings**

Pictorial drawings are excellent for presenting easy-to-visualize pictures to the viewer, but there are some problems. The main problem is that these drawings cannot be accurately drawn to scale. Also, they cannot accurately duplicate exact shapes and angles. As this information can be essential, another form of drawing is used, one that has several names, including *orthographic projection*, *third angle projection*, *multi-view projection*, and *working drawing*. Each projection is a view that shows only one face of an object, such as the front, side, top, or back. These views are not pictorial.

To interpret or read these drawings you must first understand how the views in a multi-view drawing are developed and how each view relates to the other views. The best way to
understand the principle of orthographic views is to suspend the object you wish to draw inside an imaginary glass box. If you were to look at the object through each side of the box and draw onto the glass the view of the object you see through the glass, you would end up with a sketch similar to that shown in Figure 4.

The view through each side of the glass box shows only the end view of one side of the object. All lines are straight and parallel because the original object has sides that are straight and parallel. Each view represents what you see when you look directly at the object.

If you were to open up the glass box, as shown in Figure 5, each view would be in the correct position for a true orthographic drawing. Each view is given a name that reflects its position in relation to the other views.

![Figure 4 — Multi-view through a glass box](image)

![Figure 5 — Box opened to produce orthographic views](image)
When the imaginary glass box is flattened as shown in Figure 6, you can see that each view is in line with the adjacent view. Then the edges of the box are removed and you have a six-view orthographic drawing of the original object (Figure 7). These six views are called the six principal orthographic views. This view alignment is important and is always consistent in orthographic projection. You will seldom need to show views of all six sides of an object; usually it is sufficient to show just two or three. You should remember the names of these six views and understand how they are obtained in case you ever need to show an object that cannot be truly represented in two or three views.

### Figure 6 — Drawing with the glass box flattened out

### Figure 7 — Orthographic views of the object in Figure 2

Unless the object is very complex, only the front, top, and right-side views are necessary. If the object has a uniform thickness, only one or two views are necessary. You should not show more views than are necessary. The front, left, back, and right views are also referred to as elevations.
Isometric Drawing

Description
Isometric drawings use perspective to communicate a large amount of information in a single drawing. Isometric drawings show three sides of an object, making it easier to better understand how a finished object may look or how the pieces of the object will fit together. In this activity, students will draw an isometric drawing on a piece of paper with a title block. Students will also continue to practise lineweights and lettering techniques.

Lesson Objectives
The student will be able to:
- Complete a board set-up
- Identify and appropriately use drafting tools
- Create an isometric drawing of an object
- Differentiate lineweights
- Refine lettering techniques

Assumptions
The student will:
- Have a basic knowledge of drafting tools and equipment
- Have a foundational understanding of how to appropriately use drafting equipment
- Have created a title block on which to complete this activity

Terminology
**Border or title block lines**: thick, dark lines used to create a solid border around a blank page.

**Drafting board**: a flat, smooth surface usually covered in vinyl to which paper is affixed. The drafting board has square, parallel edges that allow a T-square to slide easily.

**Drafting brush**: used to sweep away debris from a drawing so the full drawing is not smeared.

**Eraser shield**: a micro-thin piece of metal with cut-outs that allow the user to erase detailed sections of a drawing without erasing the rest of the drawing.

**Guide lines**: thin, light lines, drawn when using the lettering guide for evenly spaced letters.

**Isometric drawing**: a two-dimensional drawing that looks 3D. This drawing will show three sides of the object in one view and will be created using lines primarily at 30 and 90 degrees from horizontal. When drawing on paper, you will use a 30/60/90 triangle.

**Layout lines**: very light lines used to lay out measurements before those measurements are drawn in heavy, dark lines.
Lettering guide: used to assist in the drawing of uniform lines to draw consistent, evenly spaced lettering.

Lineweight: the thickness and darkness of drawn lines.

Masking tape (drafting dots): holds drawing paper and/or vellum to the drafting board so the paper does not shift while drawing.

Pencil: a drawing utensil with a mechanical or solid core (lead). Leads range from hard to soft: 6H, 4H, 2H, H, HB, 2B, 4B, 6B. H is very hard with a fine point and B is extremely soft with a blunt point. A hardness of 2H will be used for these activities.

Precision drawing: the act of creating drawings with specialized tools and equipment.

Steel rule: a straightedge made of rigid material and divided into specific increments, found both in metric and imperial units.

Triangles (right angle and isosceles): drafting guides made of hard, clear plastic that are used to draw lines at vertical and set angles (45°–90°–45°, 30°–60°–90°).

T-square: precision drawing instrument that is used as a guide with other drafting equipment. The T-square has a 90° angle where the head and blade attach.

Estimated Time
60–90 minutes

Recommended Number of Students
20, based on the BC Technology Educators’ Best Practice Guide

Facilities

• Regular classroom space with desks/chairs for all students
• Drafting boards would be ideal. However smooth, clean, flat surfaces will also suffice.

Tools

• T-square
• Steel rule
• Triangles (right angle and isosceles)
• Eraser shield
• Drafting brush
• Masking tape (drafting dots)
• Drafting board
• Lettering guide
• 2H mechanical pencil
• Isometric dot paper for practice
Materials

- Handout for students with instructions (this could be directly from this document—i.e., print the text under the Teacher-led Activity)
- Title-block drawing page (created in Introduction to Title Blocks activity)
- Isometric dot paper for practice
- Wooden block used in the Scale and Dimensioning and Orthographic Drawing activities

Teacher-led Activity: Isometric Notes

An isometric drawing is based on three axes that are equally spaced apart at 120° (Figure 1). Lines that run parallel to the axes are called isometric lines. Lines that are NOT parallel are called non-isometric lines.

An isometric drawing can be identified by several factors:
- Vertical planes or edges are still drawn vertically.
- Left and right planes are drawn at an angle of 30° above horizontal.
- No horizontal lines are found on isometrics.

Figure 1—An isometric view. Isometrics show a three-dimensional object from three perspectives in a single drawing.
Teacher-led Activity

Have students sketch an object using correct isometric standards. Labelling the sides of the object with a sticky note may assist novices to differentiate between the different planes. Isometric paper (includes vertical axes as well as 30° axes already laid out) is an excellent way to begin.

1. Gather all materials listed above.

2. Demonstrate: Using the T-square and masking tape/drafting dots, align title-blocked paper to your drafting board and securely tape down (Figure 2).

3. The three dimensions of length, width, and height are drawn along the isometric axes shown in Figure 3. The lengths of objects running parallel to these axes can be drawn to scale. Lines at other angles will not be to scale.
4. Draw a small, six-pointed star-shaped axis on the bottom corner of your paper (Figure 4). The sloping axes should be drawn at a 30° angle from the horizontal grid line. The vertical axis of the star indicates height (H) or depth (D), and the two sloping axes indicate the length (L) and the width (W) of the rectangle. The vertical axis can be used as a reference guide when making lines on your drawing.

![Figure 4—Six-pointed star-shaped axis](image)

5. Sketch the top of the block by drawing two lines, one parallel to L and one parallel to W (Figure 5).

![Figure 5—Sketching the top of the block](image)
6. Sketch two lines, one parallel to L and one parallel to D as shown in Figure 6.

![Figure 6—Sketching the side of the block](image)

7. Sketch two lines, one parallel to W and one parallel to D, to complete the outline of the rectangular block (Figure 7). Begin with light layout lines so that you can make any necessary adjustments before darkening them. The finished isometric sketch is drawn with dark object lines in Figure 8.

![Figure 7—Full outline of rectangular block](image)

![Figure 8—Isometric object](image)

8. Complete the activity by filling in the title block as follows:

<table>
<thead>
<tr>
<th>ACTIVITY # 6</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DATE</td>
</tr>
<tr>
<td>ISOMETRIC</td>
<td>SCALE OF DRAWING 1:1</td>
</tr>
<tr>
<td></td>
<td>PAGE 1 OF 1</td>
</tr>
</tbody>
</table>
Extension Activity
Further drawing practice creating more isometric objects, using different wooden cut-out shapes.

Assessment
• Student participation in discussion/demonstration
• Completion of drawing with overall neatness:
  – Lines are concisely drawn.
  – Isometric object is accurate and proportional to page.
  – Border lines cross to ensure closed corners.
  – Lettering is done to a high quality (all uppercase).
  – Title block is filled out correctly with appropriate information.

Appendix Acknowledgment
© Camosun College. Trades Access Common Core: Competency D-3: Read Drawings and Specifications (pp. 79–83). The Trades Access Common Core resources are licensed under the Creative Commons Attribution 4.0 Unported Licence (http://creativecommons.org/licenses/by/4.0/), except where otherwise noted.
Appendix

Make isometric sketches of simple rectangular objects

Isometric sketches are useful because they are easy to draw and clearly represent an object or system. This clarity comes from using directional lines to represent the three dimensions of length, width, and height, much like a picture.

Construction methods

The following steps explain how to draw an isometric cube. The three dimensions of length, width, and height are drawn along the isometric axes shown in Figure 8. The lengths of objects running parallel to these axes can be drawn to scale. Lines at other angles will not be to scale.

![Isometric axes](image)

Draw a small star-shaped axis on the bottom corner of your grid paper. The sloping axes should be drawn at a 30° degree angle from the horizontal grid line. The vertical axis of the star indicates height (H) or depth (D), and the two sloping axes indicate the length (L) and the width (W) of the rectangle. The vertical axis can be used as a guide when making lines on your drawing. Notice we have labelled the points on the star in Figure 9. These labels can change depending on the view that you may want when drawing a stationary object. The bottom two horizontal points indicate the view that is being drawn. In this case we would be creating a front-right view.

![Step 1: Isometric guide for front-right view](image)
Sketch the top of the block by drawing two lines, one parallel to L and one parallel to W (Figure 10).

![Figure 10 — Step 2: Isometric view of top surface of a rectangular block](image)

Sketch two lines, one parallel to L and one parallel to D as shown in Figure 11.

![Figure 11 — Step 3: Lines parallel to L and D](image)

Sketch two lines, one parallel to W and one parallel to D, to complete the outline of the rectangular block as shown in Figure 12. Begin with light construction lines so that you can make any necessary adjustments before darkening them. The finished isometric sketch is shown in Figure 13.

![Figure 12 — Step 4: Completed outline of rectangular block](image)
Sketching irregular shapes with isometric lines

Not all rectangular objects are as simple as the block you have just sketched. Sometimes the shapes are irregular and have cut-out sections or some sides longer than others. All rectangular objects can be fitted into a box having the maximum length (L), width (W), and depth (D). Begin by sketching a light outline of a basic box that is the size of the object to be drawn.

As an example, consider the object shown in the three-view orthographic sketch in Figure 14. To produce an isometric sketch of this object, you need to find the maximum L, W, and D for the containing box (Figure 14). In this case:

- L = 5 grid spaces
- W = 3 grid spaces
- D = 3 grid spaces

![Isometric sketch](image-url)

*Figure 13 — Completed isometric sketch*

*Figure 14 — Orthographic views*
Sketch a light outline of the basic rectangular box to the required size, as shown in Figure 15.

![Figure 15 — Basic outline](image)

The front view shows the outline most clearly. Place this view on the front surface of the isometric box. Use the dimension given in the front view of Figure 14 and mark the number of units indicated along the axes L and D (Figure 16).

![Figure 16 — Location of marks on axes](image)

Lightly sketch lines parallel to the L and D axes from the marked points on the front surface (Figure 17). The step outline is drawn more heavily to emphasize the profile of the object, once you are sure your sketch is correct.

![Figure 17 — Location of main features](image)
Sketch in a series of lines parallel to the axes (L, W, and D) from the corners numbered 1 to 7 (Figure 18). These lines establish the stepped outline as shown in Figure 19.

When you are sure your isometric sketch is correct, erase all unnecessary construction lines and darken the object lines. Your completed sketch of the rectangular object should be similar to that in Figure 20.
# Computer and Network Orientation

(Mechanical and Architectural CAD)

## Description

In this activity, students will learn about the set-up and use of lab computers and a school network. By grade eight, most students have had access to computers. However, with the use of cell phones and tablets, some students may have never actually logged into school computers and accessed their home drive (network drive). They may not understand how to setup directories to organize and store their files.

## Lesson Objectives

The student will be able to:

- Log in
- Understand how a network works (server, client computer)
- Gain access to networks with passwords
- Navigate to a home drive, create directories, and save files

## Assumptions

The student will:

- Have a username and password to access the school network
- Not know how to log into a network
- Not know what a home drive on a network is (My Documents)
- Not understand the importance of keeping files organized, nor know how to navigate a network

## Terminology

**Client computer**: a single “user” computer that has access to the network and can connect to the server, access files, access the Internet, and print to a networked printer.

**Home drive**: a location on the server that is reserved for users (students and teachers) to store their files. Typically the only people that have access to the user’s home drive are the user and a network administrator.

**Internet**: a system of computers (servers) that link millions of computers together to form a global network of computers that can share information if they “talk” in the same language. This language is called the *Internet Protocol*. Personal devices brought to school can access the Internet through a wireless router, but are typically not on a school network.
**Network**: a group of computers that are linked together by wire through hubs and switches, or wirelessly through routers. A school network usually contains a main computer called a **server**, many client computers that users (teachers and students) use, and many different pieces of hardware such as printers, hubs and switches (Figure 1).

**Network administrator**: a person who is responsible for maintaining the server. This person will add/delete or give access to users and enable access to software and printers. If you cannot access the network (login) or a specific printer, the network administrator has restricted your access.

**Network hub/switch**: a device that connects different devices together (desktop computers, printers, server, router, etc.) so they can “talk” to each other and pass information between them.

**Router**: a device used to connect networks together. In a school, a router usually connects the server, Internet, wi-fi, and client computers together.

**Server**: a computer in the school that is the “main” computer that manages software, hardware (printers), and user information (files, passwords, etc.) that other computers (clients) can access from different rooms or parts of the building.

**Shared drive**: a location on the network that the network administrator sets up for users on client computers to access files that can be commonly shared between them. A teacher might put files in a location under their name for students to access instead of printing out handouts, especially if the students will always have access to the network.
**Username**: a way that the server recognizes who is logging into the network; what access to give them (end user or administrator, etc.); and where to direct that user to their appropriate home drive and shared drives. A username on every network can vary. Some networks use a first name+last name combination (e.g., johndoe), or just a student identification number associated with the school. Your network administrator can tell you this.

**User password**: a password that the user sets to limit access to files, email, marks, etc., to only them. A password is *not* meant to be shared. If you think someone may know your password, change it immediately.

**Wi-fi**: a wireless way (no wires) to access a network or the Internet.

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**Estimated Time**

30–60 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

Computer lab installed with CAD software (Google SketchUp, AutoCAD, CADopia, etc.)

**Tools**

Projector with computer and speakers, Internet access

**Materials**

N/A

**Resources**

Contact the network administrator for your school or district to make sure your students can access the school network, Internet, and required software.

Another colleague may have a better understanding of how the network is set up; this may be a dedicated person on staff. Ask your school administration or the librarian.

**Networking 101**

[https://www.youtube.com/watch?v=aQVuZKLtBJg](https://www.youtube.com/watch?v=aQVuZKLtBJg)

**Authenticating on a network**

[https://www.youtube.com/watch?v=3JzalEkugkI](https://www.youtube.com/watch?v=3JzalEkugkI)

**Networking devices**

[https://www.youtube.com/watch?v=ulfNIP_NBH0](https://www.youtube.com/watch?v=ulfNIP_NBH0)
Assessment

Have students show they have logged in and have created a folder under their home drive for the course.

Teacher-led Activity

Use a computer with a projector to demonstrate the following information. Have students follow along.

Note: Depending on your network and version of Windows or MacOS, the following information may vary. Ask your network administrator or another colleague to show you any of the following you are unable to find.

1. Demonstrate how to turn on the computer and monitor. Computer labs are all set up differently.

   Note: You may have to turn on wall switches before students can turn on their computers and monitors.

2. Computers on a network will always boot up to a login screen. At this point you can have students enter their username and password. This may be the first time that students have done this at the school, especially if they are new to the school or your district has upgraded the network.

   Note: Ensure you have talked to your computer network administrator before the class begins to ensure all students have been added to the network as users. If students are new, usually the network administrator has given the user a temporary password. You may want a “dummy” account that students can temporarily access to get started if your network administrator will allow you to have one.

   If this is the first time a student is logging in, ensure he/she changes his/her password. Usually the first time a student logs into the network, the network automatically asks the student to change the password.

3. Confirm everyone in the class has logged in. If not, make sure students enter in their correct username and password by doing it yourself. If correct login does not work, check to make sure the network cable is connected to the computer and to the network. Also try having the student login on another computer. If still no success, give the temporary user and password account you had created for you by your network administrator for this reason (take note of users that cannot login and contact your network administrator to have their accounts fixed for the next class).

4. Once the class is all logged in, navigate to the network (Finder in MacOS, Explorer in Windows).
5. Demonstrate how to find a shared drive on the network. If you have created a folder for your course, show students the folder and explain that all handouts will be available in the folder for students to access.

   **Note:** You may want to create a folder under the shared drive where you can add files and handouts for students to access. Ask your network administrator to set this folder up so you can add/delete files, **but** make sure students can only open the files and **not** add/delete or modify the files (“read-only”).

6. Demonstrate to students how to find their home drive on the network.

   **Note:** The contents in the home drive may already include several directories created by the system.

7. Demonstrate how to create folders in the home drive to keep the students’ information organized. Create a folder named “Youth Explore Trades Skills.”

8. Demonstrate how to find a printer on your network. Do not have students print at this time.

9. Demonstrate how to navigate to the software you are going to use with them.

   **Note:** Make sure the software you want to use is installed in the lab you are using. If not, contact the network administrator.

10. Demonstrate how to logout. Explain that logging out is very important because leaving yourself logged in allows the next person who uses the computer to access your files, printers, and the Internet.
CAD Orientation

Description
This is an introductory computer aided design (CAD) activity designed to give students the foundational skills required to complete future lessons. Students will learn all the key parts of the CAD software (navigating, command line input, menus, opening and saving drawings, etc.) that will be required to complete this activity.

Lesson Objectives
The student will be able to:
• Navigate software
• Use simple drawing commands
• Move around drawing space (zoom, pan)
• Input xy coordinates into CAD software
• Use command line entry
• Modify commands: copy, move, paste, offset, fillet
• Print a drawing on the classroom printer

Assumptions
The student will:
• Know how to login to a computer and open up the software
• Not know how to navigate the program they will be using
• Not understand how to start a new drawing or know what drawing commands are

Terminology
Absolute coordinate entry: procedure used in CAD (based on the Cartesian system) to specify a position and establish a point on the x, y, and z axes. For example, if you type 4,2 (no spaces) for a location, the entity would start/end at 4 units along the x axis and 2 units up the y axis.

Basepoint: the point on an entity or object that you select when you are moving, copying, scaling, etc.

Cartesian system: a system that has x, y, and z coordinates that all intersect at 0,0,0, known as the origin.

Command: instruction to a computer.
Command line: an area—typically at the bottom of the screen—that allows for keyboard input, and which shows messages or prompts for information. Keyboard entry in CAD software is sometimes easier.

Computer aided design (CAD): software used by engineers, artists, architects, etc., to create precision drawings and technical illustrations.

Entity: the object in CAD programs (line, circle, text, etc.).

Fillet: a command in CAD software allowing you to create a rounded inside or outside curved corner.

Grid: a pattern of dots or lines within the work area of the software that can be used to aid in drawing.

Limits: a command to set the size of the drawing space for your drawing.

Object snap (Osnap): a mode that allows you to “snap” to an object (line) at its endpoint, midpoint, etc.

Offset: a command that creates a copy of an entity (line, circle, etc.) that is a specified parallel distance away from the current object(s) selected.

Pan: a command used to shift the view of your drawing to see different parts. It differs from zoom in that it does not change the size of the viewing area.

Polar coordinate entry: allows you to establish an x, y, z position at a specific length and angle relative to the last point you had specified. For example, if you want a 45-degree angle that is 2 units long, the command line would be @2<45.

Relative coordinate entry: allows you to establish an x, y, z position relative to the last point you had specified. For example, when drawing a line, your last point was 4,2 (no spaces), now you want to go over 2 on the x and 0 on the y to make a line 2 units long on the x axis. The command line would be @2,0.

Snap: used to limit your movement of the crosshairs of the cursor to a predetermined interval to aid in drawing to specific measurements.

Text: a command used to add text to a drawing.

Title block: an area of a drawing sheet that contains information about the actual drawing, including project name, author, scale, drawing number.

Trim: a command used to “trim” off excess length on an object or entity, to end exactly at the end or intersection of another entity.

Zoom: a command used to magnify or change the view of a drawing to get a closer or further look at part of your drawing. If you type in the word ZOOM, you have many options with letters on the keyboard, including the following:

- A = All — Zooms to everything you have drawn, including the limits of the drawing
- E = Extents — Zooms to everything you have drawn
- W = Window — Zooms to the window you pick by holding the left mouse button down and dragging the mouse over the area to create a rectangle to zoom into
Estimated Time
45–90 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide

Facilities
Computer lab installed with CAD software (Google SketchUp, AutoCAD, CADopia, Vectorworks, etc.) and Internet access

Tools
Computer with projector and speakers. Computers with CAD software and Internet access

Materials
Student activity handout for students with instructions

Resources
Instructional videos for the teacher and/or students. The teacher can eventually create their own video(s) to match the software they are using in class, as required.

Instructional videos created using AutoCAD 2013:

- Teacher Video 2.1 - Intro to CAD Software for the Teacher-3
- 2.1 CAD Program Interface (MCAD)
- 2.2 Basic Command Line Entry and Page Setup for Activity 2 (MCAD)
- 2.3 Absolute and Relative Coordinate Entry (MCAD)
- 2.4 Polar Coordinate Entry and Mouse Entry (MCAD)
- 2.5 Offset Command-2 (MCAD)
- 2.6 Fillet Command (MCAD)
- 2.7 Move Command and Object Snap (MCAD)
- 2.8 Trim Command (MCAD)
- 2.9 Drawing a Simple Border (MCAD)
- 2.10 Inserting Text into a Title Block (MCAD)
- 2.11 Plotting or Printing Your Drawing-2
Teacher-led Activity
Before starting the activity, the teacher will demonstrate the software for the students so they understand how it works. The following activity can be covered all at once but is most likely best broken into a couple of demos based on class time:

• Opening the program and navigating the toolbar and/or ribbon
• Mouse movement (scroll in/out, right/left buttons, pan)
• Command line: inputting commands (zoom, limits, grid, etc.)
• Coordinate entry and the line command (absolute, relative, polar)

Student Activity
Students will follow the “Student Activity: Intro to CAD” and/or the video tutorials to complete the coordinate entry exercise and introduction to drawing in CAD software.

Assessment
Students will show the teacher their completed assignment. The teacher can have the assignment printed out or look at it on the computer screen. If the student does not produce exactly what was shown, then an associated mark based on mistakes can be derived.
Student Activity: CAD Orientation

Using the software, create the following drawing using the commands you have learned through the videos. Videos to support the lesson are located in the “Resources” section.

![Diagram of chain links](image)

Figure 1

Commands/concepts to learn in this activity

Absolute coordinate entry:

- **LINE**
- **MOVE**
- **TRIM**

Relative coordinate entry:

- **COPY**
- **OFFSET**
- **TEXT**

Polar coordinate entry:

- **FILLET**
- **PRINT**
- **ZOOM**
Procedure

1. CAD Program Interface (Video 2.1)

Start the CAD software in a blank drawing. Once the program has loaded you should have a blank drawing space (Figure 2). See Student Video #1.

![Figure 2](image)

2. Basic Command Line Entry and Page Setup: Limits, Grid, and Snap (Video 2.2)

   a. Type the word LIMITS (Figure 3). You will notice it will show up in the status bar in the bottom left corner of the program. Pressing enter on the keyboard selects the command.

   ![Figure 3](image)

   b. Specify the “LOWER LEFT CORNER” (Figure 4). This is the origin. Make sure it is 0,0. Press enter.

   ![Figure 4](image)

   c. Specify the UPPER RIGHT CORNER (Figure 5). Change this to 11,8.5 to match a piece of letter paper that is landscape. Press enter. Your drawing limits are now set.
d. You cannot see the limits of the drawing yet, so type `GRIDDISPLAY`. Change the value to 0. Press `enter`. Now type `ZOOM`. Press `enter`, then type A for All. Press `enter`. The screen adjusts to show the limits of the drawing (Figure 6).

e. Type `GRIDSTYLE`. Change the value to 1. Press `enter`. The lines now change to dots.

f. Finally, type `GRID`. Press `enter`. Set your grid to .5. Press `enter` again.

g. Type the word `SNAP` (Figure 7). Press `enter`. Change the snap to .25 by typing it in. Press `enter`.

3. Absolute and Relative Coordinate Entry (Video 2.3)

You will be learning how to enter coordinates in multiple ways by drawing lines. F12 toggles what is called dynamic input on/off. Having dynamic input on/off sometimes helps when drawing lines. In this case, make sure it is off when using command line entries. See Student Video #3.
3.1 Absolute Coordinate Entry
a. Command: **LINE (enter)**
b. From point: **1.5,3.5 (enter)**
c. To point: **4,3.5 (enter)**
d. To point: **4,5 (enter)**
e. To point: **1.5,5 (enter)**
f. To point: **1.5,3.5 (enter) (enter)**
g. Pressing return twice completes the command.

The first completed square should look like Figure 8 below:

![Figure 8](image)

3.2 Relative Coordinate Entry
a. Command: **LINE (enter)**
b. From point: **3,6 (enter)**
c. To point: **@2.5,0 (enter)**
d. To point: **@0,1.5 (enter)**
e. To point: **@-2.5,0 (enter)**
f. **C (enter)** will close a polygon.

You should now have two squares (Figure 9). Did you save your work yet?
4. Line Command, Polar Coordinate Entry, and Mouse Entry (Video 2.4)

See Student Video #4.

4.1 Polar Coordinate Entry (Student Video #4)

a. Command: **LINE (enter)**
b. From point: **6,2 (enter)**
c. To point: **@2.5<0 (enter)**
d. To point: **@1.5<90 (enter)**
e. To point: **@2.5<180 (enter)**
f. **C (enter)** will close a polygon.
4.2 Mouse Entry Method

a. Command: **LINE (enter)**
b. From point: **7,6 (enter)**
c. Move mouse a length of 2.5@ an angle of 0, left mouse click
d. Move mouse a length of 1.5@ angle of 90, left mouse click
e. Move mouse a length of 2.5@ angle of 180, left mouse click
f. **C (enter)** to close the polygon.

The drawing should now have four rectangles as shown in Figure 11. Keep in mind that this one of many ways to draw lines.
5. Zoom and Offset Commands (Video 2.5)

Now we will draw four smaller rectangles inside the existing four rectangles using the “Offset” command. But first let’s make the rectangles bigger on the screen. We will zoom in to the rectangles.

5.1 Zoom

a. Command: ZOOM (enter).

b. The capitalized letters (e.g., A, E, W, etc.) are shortcut keys:

   A = All. This shortcut zooms to everything you have drawn, including the limits of the drawing
   E = Extents. This command zooms to everything you have drawn.
   W = Window. This command zooms to the window you pick by holding the left mouse button down and dragging the mouse over to the area to create a rectangle to zoom into.

Type the shortcut key W (enter). Use the mouse to pick a point in the upper left corner, then hold the left mouse button down and drag the mouse across to the lower right corner. You now zoom in.
5.2 Offset
Now use the Offset command to create a box in a box (Figure 12). See Student Video #5.

a. Command: OFFSET (enter)
b. Offset distance or through: .25 (enter)
c. Select object to offset: (with the mouse pick one side of a square)
d. Side to offset: (pick a point inside the square)
e. Select object to offset: (repeat the above two steps until all the squares are doubled)
f. The drawings should now look like the picture in Figure 12. Have you saved recently?

![Figure 12](image)

6. Fillet Command (Video 2.6)
Now clean up the corners of the inside squares with the Fillet command (Figure 13). See Student Video #6.

a. Command: FILLET (enter)
b. Fillet (radius=0.5000): Radius/Settings/Polyline /: R (enter)
c. Enter fillet radius <0.5000>: 0 (enter)
d. Fillet (radius=0.0000): Radius/Settings/Polyline /:
e. With the mouse pick the two sides of an inner square.
f. Command: spacebar or (enter) to repeat the fillet command
g. Repeat step f for all four corners.
7. **Move Command and Object Snap (Video 2.7)**

   Now move the rectangles to create the chain link (Figure 14). See Student Video #7.

   a. Command: **MOVE (enter)**

   b. Highlight the second rectangle you drew by holding down the left mouse button and dragging over the entire object from right to left.

   c. Right mouse click.

   d. Specify base point: left mouse click on the bottom left corner of the rectangle.

   e. Move the rectangle to create the first chain as show to the right.

   f. Left mouse click to place it.
g. Repeat the above process until you have all the links in place (Figure 15).

![Figure 15]

8. Trim Command (Video 2.8)

Now use the Trim command to remove the pieces out of the lines to give the appearance that the links are connected to form a chain (Figure 16). See Student Video #8.

a. Command: TRIM (enter)

b. Pick the two lines you want to trim between using the left mouse button (right mouse click).

c. Pick the short pieces (left mouse button) that you want gone between the highlighted lines and they will disappear.

d. Press Esc to cancel.

e. Press space bar to repeat the command.

f. Your drawing should now look like Figure 16 below. Time to save again.
Finish the drawing properly by zooming to full limits (All). Always leave and save your pictures as a full view (Figure 17). Remember Zoom?

a. Command: **ZOOM (enter) A (enter)**
9. Border and Title Block (Student Video #9)

Now we need to finish this off with a border, a title block, and some text.

9.1 Border

a. Draw lines to create a border. Start at .5,.5. Make the border box 10 wide and 7.5 high. Which coordinate entry command will allow you to do this correctly?

9.2 Title Block

A. OFFSET the bottom line 0.5 for the title block (Figure 18).

b. Next draw 2 vertical lines, one at 3.5,.5 and the other at 8,.5 (Figure 19). Which coordinate entry is the quickest?
10. Inserting Text into a Title Block (Student Video #10)

10.1 Create Text for Title Block
Now use the Text command to fill in the title block (Figure 20). See Student Video #10.

a. Command: **TEXT (enter)**
b. Pick the point you want to start at. Don’t worry about it not being where you want it. We will move it after.
c. Height of Text: `<.20>` (enter). Rotation angle of text: `<0>` (enter).
d. Now, type in the text you want in CAPITAL LETTERS.
e. Press (enter) twice to exit the command.
f. Repeat this command sequence for each of the title block entries below.

![Figure 20]

10.2 Move Text into Title Block
Now that you have the text entered, you are going to move the text into position. The problem is the snap setting won’t let you centre the text, so you have to change it.

a. Command: **SNAP (enter) Type .05 (enter)**
b. Command: **MOVE (enter)**. Select one of your texts (enter).
c. Use your mouse to move your text to where you want it so it is centred in the box.
d. Repeat the command sequence for the other two texts so they are centred in the appropriate spots as shown in Figure 21.
10.3 Save and Print Your Drawing

a. Save your drawing as chain links-name.dwg.

b. Show your instructor the completed drawing.

c. To print the drawing, see Activity 10: Set Up Your Plot Window, Print on 8.5” × 11” Paper (Student Video #11).
Set Up Your Model Space

Description
In this activity, students will learn to set up a model space in CAD software by setting limits, grid, snap, layers, and object snap.

Lesson Objectives
The student will be able to:

• Set model space limits
• Set grid spacing
• Set snap spacing
• Set up five layers and change colour, linetype, and lineweight
• Input using keyboard commands and icons
• Explore object snap options

Assumptions
The student will:

• Know how to login to a computer and open up the software
• Be familiar with navigating the software (Activity 1)
• Know how to input coordinates and use drawing commands (CAD Orientation activity)

Terminology
Grid: a pattern of dots or lines within the work area of the software that can be used to aid in drawing.

Imperial file: a CAD drawing file that is set up in imperial measure: inches, or feet and inches. Often an imperial file is defaulted to inch input.

Layers: CAD layers are powerful organizational tools for drawing. In graphics software, layers are the different levels at which you can place an object or image file.

Letter-sized sheet: a standard-sized sheet that is 8.5” × 11”.

Limits: a command to set the size of the drawing space for your drawing.

Linetype: In CAD software, there are many different linetypes, both solid and broken, most commonly including continuous, hidden, and centre. Linetypes represent different aspects of an entity.

Lineweight: the assigned thickness of a line.
Model space: your drawing space in CAD software.

Object snap (Osnap): a mode that allows you to “snap” to an object (line) at its endpoint, midpoint, etc.

Origin: the place where the x and y axes meet, which has a coordinate value of (0,0).

Snap: used to limit your movement of the crosshairs of the cursor to a predetermined interval to aid in drawing to specific measurements.

Template: a CAD file with pre-set parameters, possibly including layers, limits, border, font, title block, etc.

Estimated Time
30 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide

Facilities
Computer lab installed with CAD software (Google SketchUp, AutoCAD, etc.)

Tools
Projector with computer and speakers, Internet access

Materials
Student activity sheet and Internet access so students can watch video tutorials

Resources
Instructional videos for teacher and students to follow:
- 3.1: Setting Up Your Model Space (Part 1)
- 3.2: Setting Up Your Model Space (Part 2)

Teacher-led Activity
Use a computer with a projector to demonstrate the following:
- Open an imperial/inches drawing file
- Set up limits
- Set up grid and snap
- Set up five layers and modification of lineweight, linetype, and colour
- Explore object snap properties
**Student Activity**
Students will follow video tutorials, complete the activity sheet, and set up their model space.

**Extension Activity**
Have students make more layers, or draw and modify drawings using the object snap properties.

**Assessment**
Students will show the teacher that their imperial model space is set up and saved.
Student Activity: Set Up Your Model Space

Using the software, set up your model space according to this activity sheet. Videos to support the lesson are located under Resources.

Commands to Use/Learn

GRID
LAYER
LIMITS
OSNAP
SNAP
STARTUP

Procedure

1. Open up your CAD software, and while the software loads watch the tutorial video “Setting Up Your Model Space,” Part 1.

2. Once the software has loaded, select an imperial or inches file. If your software opens to a default and does not allow you to select the file, type STARTUP ENTER into the command bar, and change the default to 1 ENTER. Then you can open a new file, and the option to select an imperial or metric file will pop up.

3. Once the drawing file is open, set up your drawing space limits. Type LIMITS ENTER, then set your origin 0,0 ENTER. Then type your upper right corner 11,8.5 ENTER. Now your drawing space is set to the same size as a letter-sized piece of paper.

4. Next type GRID ENTER, and set spacing to 0.5 ENTER. You may have to turn the grid on; you can do this by typing GRID ENTER ON ENTER. You should be able to see a series of dots spaced in half-inch intervals on your page.

5. Type SNAP ENTER. Set spacing to 0.5 ENTER. When you open any drawing command your cursor will hop and snap in half-inch intervals. This is a handy tool to turn on when you are drawing. If you decide that you no longer want your snap on, you can turn it off by typing SNAP ENTER OFF ENTER. Sometimes the software will have icons at the bottom of the page that you can turn on and off.

6. Watch the video “Setting Up Your Model Space,” Part 2, and then set up your layers using the steps below.
7. To set up your layers, use the Layer command. It will open up the layer manager video (Figure 1). Set up the five layers as demonstrated in the video, starting with **BORDER** and ending with **TEXT**. It is important to set the lineweight and linetype as listed for each layer.

8. Finally, set up your object snap properties to fit your drawing needs. Type **OSNAP**; the object snap properties window will open. Select whatever object snap modes you think will be useful. Commonly used modes include endpoint, midpoint, centre, and intersection. You can also edit your snap and grid settings in the Drafting Settings window (Figure 2).

9. When finished hit **OK**, and then save the file as *imperial template-name.dwg*. 
Draw Your Border

Description
In this activity students will create a border with a completed title block to be used for all future drawings. When finished, students will save the border as a drawing template with all the settings necessary saved within it (layers, limits, grid, etc.).

Lesson Objectives
The student will be able to:
- Open up a drawing template
- Create a border and title block
- Save a drawing template
- Use commands from previous activities

Assumptions
The student will:
- Know how to login to a computer and open up the software
- Know how to use basic commands
- Know how to input objects (line) using various entry methods (absolute, relative, polar, and mouse)
- Understand the importance of a drawing template and why you use them

Terminology
Absolute coordinate entry: a method of specifying a position in the x, y, z axes to establish a point; based on the Cartesian system. Example: If you type 4,2 (no spaces) for a location, the point the entity would start/end at would be 4 units along the x axis and 2 units up on the y axis.

Application menu: the icon in the top left corner of the screen that contains New, Open, Save, etc.

Array: a command used to create multiple copies of a pattern in either a rectangle or a circle.

Command line: an area, typically at the bottom of the screen, that allows for keyboard input, or shows messages or prompts for information. In CAD software keyboard entry is sometimes easier.

Drawing template: a default file that consists of the settings you would consistently use many times over.
**Entity**: in CAD programs, it is the object (line, circle, text, etc.).

**Grid**: a pattern of dots or lines within the work area of the software that can be used to aid in drawing.

**Object snap (Osnap)**: a mode that allows you to “snap” to an object (line) at its endpoint, midpoint, etc.

**Offset**: a command that creates a copy of an entity (line, circle, etc.) a specified parallel distance away from the current object(s) selected.

**Polar coordinate entry**: allows you to establish an x, y, z position at a specific length and angle relative to the LAST point you had specified. Example: You want a 45-degree angle that is 2 units long. The command line would be @2<45.

**Relative coordinate entry**: allows you to establish an x, y, z position relative to the LAST point you had specified. Example: When drawing a line, your last point was 4,2 (no spaces). Now you want to go over 2 on the x and 0 on the y to make a line 2 units long on the x axis. The command line would be @2,0.

**Scale**: a command used to proportionally resize objects; the multiplying factor by which you make an object larger or smaller.

**Snap**: used to limit your movement of the crosshairs of the cursor to a predetermined interval to aid in drawing to specific measurements.

**Trim**: a command used to “trim” off excess length of an object or entity to end exactly at the end or intersection of another entity.

**Estimated Time**

45–60 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

Computer lab installed with CAD software (Google SketchUp, AutoCAD, CADopia, etc.)

**Tools**

Projector with computer and speakers, Internet access

**Materials**

Handout for students with instructions
Resources
Instructional videos created using AutoCAD 2013:

- 4.1 Open a Drawing Template
- 4.2 Draw a Border and Title Block
- 4.3 Complete the Lines of the Title Block
- 4.4 Inserting Labels into Your Title Block
- 4.5 Drawing a Logo to Complete the Title Block and Border
- 4.6 Save Your Completed Border and Title Block as a Drawing Template

Teacher-led Activity
Use a computer with a projector to demo/cover the following:

- Opening a drawing template from the student's directory
- Drawing the basic border and title block
- Adding the small text titles
- Drawing a custom logo

Student Activity
Students will follow Student Activity Sheet “Drawing a Border and Title Block” and/or the video tutorials to complete their own border and title block to be used for all future drawings.

Assessment
Students will show the teacher their completed assignment. The teacher can have the assignment printed out or look at it on the computer screen. If the student does not produce exactly what was shown, then an associated mark based on mistakes can be derived.
Student Activity: Drawing a Border and Title Block

Using your software, create the title block shown in Figure 1 using the commands you have learned watching the video. Locate the video under Resources.

Figure 1

Commands to Use/Learn

COPY
EXTEND
MOVE
OFFSET
OSNAP
Polar Coordinate Entry
Relative Coordinate Entry
SCALE
TEXT
**Procedure**

1. **Open a Drawing Template (Student Video #1)**
   
a. Open up the imperial template file that you created in Activity #3: Set Up Your Model Space.

b. Go to the ribbon layer pulldown or type `LAYER` to access the Layer Properties Manager to change the current layer to Border (Figures 2 and 3).

![Figure 2](image1.png)

![Figure 3](image2.png)

c. Go to the Object Snap Setting. Type `OSNAP` in the command bar. Or hover on the bottom toolbar and right mouse click on the Object Snap icon. Then, left mouse click on Settings.

**Note:** You may have to change these settings to be able to draw your border and text because the lines for your title block may not start where you want them to if the wrong Osnap is selected (Figure 4).
2. Draw and Complete the Lines of the Title Block (Student Videos #2 and #3)

   a. Using the BOLDED information below, complete the border and title block drawing as seen in Figure 1. Use the Line command and whichever coordinate entry method (absolute, relative, polar, mouse) you feel most comfortable using.

   **Border:** .5 inches in from the edge of the paper
   **Title Block Height:** .75 inches up from the bottom border line
   **Name, Date, Scale Drawing, No. Sections:** 1.75 inches long × .375 high
   **Title section:** 4.5 inches long × .75 high
   **Logo section:** 2 inches long × .75 inches high

3. Inserting Labels into Your Title Block (Student Video #4)

   a. Once you complete the title block, add text labels to each box to indicate what should go in it. Change the snap to .025 and, using the Text command, add small text (.075") into the remaining blocks for Name, Scale, Date, Drawing No., and Title as shown in Figure 5.

![Figure 4](image)

![Figure 5](image)
4. Drawing a Logo to Complete the Title Block and Border (Student Video #5)
   a. When the title block is complete, create a personal symbol (Figure 6). Draw this in a relatively big size and then scale it down to fit after.

   ![Figure 6](image)

   b. To scale the logo down in size, use the following commands:
   Command: **SCALE (enter)**
   Highlight the entire object
   Right mouse click
   Select base point
   Scale it to fit the space by dragging the mouse (Figure 7)

   ![Figure 7](image)

5. Saving Your Completed Border and Title Block as a Drawing Template (Student Video #6)
   a. When you are finished, save the file as a drawing template so you can use the border again for future assignments.
   b. To save as a template, select “Save As” from either the Application Menu or the Quick Access toolbar in the upper-left corner of the program. Call the template *imperial bordername.dwg* (Figures 8 and 9).
Figure 8

Figure 9
Create an Orthographic Drawing (Mechanical and Architectural CAD)

Description
In this activity students will create an orthographic drawing. Students will also change line layers.

Lesson Objectives
The student will be able to:
- Define orthographic drawing
- Draw three to six orthographic views
- Change lines into different layers

Assumptions
The student will:
- Know how to login to a computer and open up the software
- Be familiar with all skills taught in the four preceding activities:
  - Computer and Network Orientation
  - CAD Orientation
  - Set Up Your Model Space
  - Draw Your Border

Terminology
Imperial file: a CAD drawing file set up in inches, or feet and inches. Often an imperial file is defaulted to inch input.

Layers: CAD layers are powerful organizational tools for drawing. In graphics software, layers are the different levels at which you can place an object or image file.

Letter-sized sheet: a standard sized sheet that is 8.5" × 11".

Limits: the extents of your drawing space (and of your zoom). Limits can be modified to suit each individual drawing.

Object snap (Osnap): a mode that allows you to “snap” to an object (line) at its endpoint, midpoint, etc.

Origin: the point where x and y axes meet, which has a coordinate value of (0,0).
Orthographic drawing: a two-dimensional representation of a 3D shape. Often there are multiple views; together they make an orthographic projection. A complete projection will have six views: front, right side, top, left side, bottom, and back.

Rise: the vertical height of a stair, or set of stairs.

Run: the horizontal depth of a stair, or a set of stairs.

Snap: used to limit your movement of the crosshairs of the cursor to a predetermined interval to aid in drawing to specific measurements.

Estimated Time
30 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide

Facilities
Computer lab installed with CAD software (Google SketchUp, AutoCAD, etc.)

Tools
Projector with computer and speakers, Internet access

Materials
Student activity sheet, and Internet access so students can watch tutorial videos

Resources
Instructional videos for teacher and students to follow:
  • 5.1 Creating an Orthographic Drawing (Part 1)
  • 5.2 Creating an Orthographic Drawing (Part 2)
  • 5.3 Creating an Orthographic Drawing (Part 3)
  • AUTODESK
Teacher-led Activity
Use a computer with a projector to demonstrate how to:
• Open the imperial border file with layers
• Change page limits
• Draw the three orthographic views: front, right side, and top
• Assign layers to the different lines
• Save the file as an orthographic drawing

Student Activity
Students will follow video tutorials and complete activities wherein they will create an orthographic projection of an object.

Extension Activity
Have students make a full orthographic projection with six views.

Assessment
Students will show the teacher that their orthographic projection is completed and saved.
Student Activity: Create an Orthographic Drawing

Using the software, draw three orthographic views of the object located in this activity. Videos to support the lesson are located under Resources.

Commands to Use/Learn

LIMITS
SNAP
OSNAP
LINE
TRIM

Procedure

1. Open up your CAD software and watch Student Videos #1 and # 2 as the software loads. Once the software has loaded, open up your inches border file with layers.

2. Once the drawing file is open, set up your drawing space limits:
   a. Type LIMITS (enter).
   b. Set your origin to 0,0 (enter).
   c. Type your upper right corner as 100,100 (enter).

   Now your drawing space is large enough to draw your orthographic views and you should have plenty of room to zoom and pan.

3. The object in Figure 1 below is what you will be drawing orthographically

   ![Figure 1—Isometric view of staircase]
4. In the video “Creating an Orthographic Drawing,” Part 1 the “glass box” method to determine orthographic views is discussed. Here are some pictures to help explain that method:

**Figure 2**—Multi-view of object through a glass box

**Figure 3**—Box opened to produce orthographic views
5. Follow the steps in the video “Creating an Orthographic Drawing,” Part 2. Draw the three orthographic views (front, top, and right side) of the stair block. Use the Trim command to remove all of the extension lines.

a. In Part 2 the object snap tracking feature is mentioned; this feature is available in AutoCAD, but it may not be available in all CAD software. In the video, object snap tracking appears as the dotted green line that extends from the endpoints of lines when lining up views. In AutoCAD 2016 this feature is built into your Osnap and polar tracking and will come on automatically anytime you select those commands on the bottom toolbar. Here is a link explaining the feature and how to turn it on:


b. If your software does not offer this option, you can always draw extension lines using the Line command, then trim the unwanted extension lines.

6. Once you have completed your orthographic projection, assign layers to your lines. Select all of your object lines, then click the Layer Manager and select the Object layer. Next, assign the rest of the lines in your border and title block according to the video “Creating an Orthographic Drawing,” Part 2.

7. When you are finished save the file as orthographic drawing.dwg.

8. At this point, if your instructor asks you to do a full orthographic projection with six views, you will need to watch the video “Creating an Orthographic Drawing,” Part 3.
9. Once you have watched the clip, draw the additional views using the appropriate layers, then trim all of the extension lines and re-save your file.

10. Show your instructor that you have completed your orthographic projection.
Create an Isometric Object  
(Mechanical and Architectural CAD)

Description
In this activity students will demonstrate drawing an isometric object.

Lesson Objectives
The student will be able to:

• Define isometric drawing
• Change to an isometric snap
• Toggle between right, left, and top isometric cursor
• Make appropriate changes to the bottom toolbar
• Draw an isometric view of an object

Assumptions
The student will:

• Know how to login to a computer and open up the software
• Be familiar with all skills taught in the five preceding activities:
  – Computer and Network Orientation
  – CAD Orientation
  – Set Up Your Model Space
  – Draw Your Border
  – Create an Orthographic Drawing

Terminology
Imperial file: a CAD drawing file set up in inches, or feet and inches. Often an imperial file is defaulted to inch input.

Isometric drawing: a two-dimensional drawing that looks 3D. This drawing will show three sides of the object in one view, and will be created using lines primarily at 30 and 90 degrees (Figure 1). When drawing on paper, you will use a 30/60/90 triangle.
Layers: CAD layers are powerful organizational tools for drawing. In graphics software, layers are the different levels at which you can place an object or image file.

Letter-sized sheet: a standard sized sheet that is 8.5" × 11".

Limits: the extents of your drawing space (and of your zoom). Limits can be modified to suit each individual drawing.

Object snap (Osnap): a mode that allows you to “snap” to an object (line) at its endpoint, midpoint, etc.

Origin: the point where x and y axes meet, which has a coordinate value of (0,0).

Orthographic drawing: a two-dimensional representation of a 3D shape. Often there are multiple views; together they make an orthographic projection. A complete projection will have six views: front, right side, top, left side, bottom, and back.

Rise: the vertical height of a stair, or set of stairs.

Run: the horizontal depth of a stair, or a set of stairs.

Snap: used to limit your movement of the crosshairs of the cursor to a predetermined interval to aid in drawing to specific measurements. Isometric snap limits your cursor movement to align with an isometric grid.

Estimated Time
90 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide
Facilities
Computer lab installed with CAD software (Google SketchUp, AutoCAD, etc.)

Tools
Projector with computer and speakers, Internet access

Materials
Student activity sheet, and Internet access so students can watch tutorial videos

Resources
Instructional video for teacher and students to follow:
- 6.1 Creating an Isometric Drawing

Teacher-led Activity
Use a computer with a projector to demonstrate how to:
- Open the imperial border file with layers
- Change drafting settings to isometric snap
- Use F5 to toggle between right, left, and top isometric cursor
- Adjust bottom toolbar settings as necessary
- Draw an isometric view of the object
- Save the file as an isometric drawing

Student Activity
Students will follow video tutorials and an activity to create an isometric drawing of the object in the activity.

Extension Activity
Have students create different isometric views of the same object, such as the left isometric view. They could also create an isometric drawing of a different object.

Assessment
Students will show the teacher that their isometric drawing is completed and saved.
Student Activity: Draw an Isometric Object

Using the software, draw an isometric view of the object in this activity. A video to support the lesson is located in Resources.

Commands to Use/Learn

- ISOdraft
- LINE
- DS (Drafting Settings)
- F5 (toggle between different isometric cursor views)

Procedure

1. Open up your CAD software, and watch the tutorial video as the software loads. Once the software has loaded, open up your inches border file with layers.

2. After the drawing file is open, change the drawing settings to allow you to draw in isometric by opening the Drafting Settings window. To do so, type DS (enter). Once the Drafting Setting window is open, select Isometric Snap, rather than Rectangular Snap as shown in the video. Click OK.

3. Once you close the drafting setting window, you will notice that the grid and your cursor have changed. This is an isometric grid and snap.

4. Next, try pressing F5. Doing so will toggle between three different cursors: right, left, and top. Select the appropriate cursor depending on which side you are drawing. You can also click the ISOdraft icon on the bottom toolbar, then select between the three cursor settings.

5. At this point, look at which settings you have selected on the bottom toolbar. Change the settings as shown in the video or to your drawing preference.

6. Following the steps in the video clip, draw the isometric object below.
Design and Drafting—2D Drawing

Create an Isometric Object

7. Once you have completed drawing the isometric object, save the file as *isometric drawing.dwg*.

8. Show your instructor your completed isometric drawing.

Figure 2—An isometric view
Scale Your Border and Title Block  
(Mechanical and Architectural CAD)

Description
In this activity the teacher will demonstrate how to scale the border and title block to fit your orthographic drawing.

Note: Activity Plans 7–10 are not to prevailing industry standards. However, since paperspace and modelspace are not available in all CAD software, these activities have been designed to be accessible to everyone. For further explanation, view this AutoCAD tutorial demonstrating paperspace and modelspace according to Standard: https://www.youtube.com/watch?v=SuyvnxBXysA

Lesson Objectives
The student will be able to:
• Use scale
• Move your objects inside the border

Assumptions
The student will:
• Know how to login to a computer and open up the software
• Be familiar with all skills taught in the six preceding activities:
  – Computer and Network Orientation
  – CAD Orientation
  – Set Up Your Model Space
  – Draw Your Border
  – Create an Orthographic Drawing
  – Draw an Isometric Object

Terminology
Layers: CAD layers are powerful organizational tools for drawing. In graphics software, layers are the different levels at which you can place an object or image file.

Letter-sized sheet: a standard sized sheet that is 8.5” × 11”.

Origin: the point where x and y axes meet, which has a coordinate value of (0,0).
Orthographic drawing: a two-dimensional representation of a 3D shape. Often there are multiple views; together they make an orthographic projection. A complete projection will have six views: front, right side, top, left side, bottom, and back.

Scale: a command used to proportionally resize objects; the multiplying factor by which you make an object larger or smaller

Snap: limits the movement of the cursor crosshairs to a predetermined interval in order to aid in drawing to specific measurements. Isometric snap limits your cursor movement to align with an isometric grid.

Estimated Time
30 minutes

Recommended Number of Students
20, based on BC Technology Educators’ Best Practice Guide

Facilities
Computer lab installed with CAD software (Google SketchUp, AutoCAD, etc.)

Tools
Projector with computer and speakers, Internet access

Materials
Student activity sheet, and Internet access so students can watch tutorial videos

Resources
Instructional video for teacher and students to follow:
- 7.1 Scaling Your Title Block

Teacher-led Activity
Use a computer with a projector to demonstrate how to:
- Open the orthographic drawing
- Draw the letter-sized sheet of paper
- Scale the border by a factor of four
- Move your objects into the border
- Re-save the file as an orthographic drawing
**Student Activity**

Students will follow the video tutorial and activity in order to scale their title block and border to fit their object. Then they will move their orthographic drawing inside the border.

**Extension Activity**

Have students open their isometric drawing, determine the appropriate scale, and then scale the border and move the drawing inside the border.

**Assessment**

Students will show the teacher their completed and saved orthographic drawing.
Student Activity: Scale Your Border and Title Block

Using the software, scale your border and title block so your orthographic drawing can be moved inside. A video to support the lesson is located in Resources.

Commands to Use/Learn

- SCALE
- MOVE
- RECTANG

Procedure

1. Open up your CAD software and watch the tutorial video as the software loads. Once the software loads, open up your orthographic drawing file.

2. Once the drawing file is open, you must draw a rectangle the size of a piece of letter-sized paper around the border. It is important to scale your paper and your drawing together.

3. Next, determine how large to scale your title block and border.

4. Follow the steps in the video tutorial to scale your title block and border.

5. Follow the steps in the video to move your objects inside the scaled border. The views may need to be moved closer together to fit inside the border.

6. Show your instructor your completed scaled border with the orthographic drawing inside.
Dimension an Orthographic Drawing  
(Mechanical and Architectural CAD)

Description
In this activity students will learn how to dimension an orthographic drawing.

Lesson Objectives
The student will be able to:
• Find the dimension tool
• Use the dimension tool
• Scale dimension text by a factor of 4
• Dimension according to general guidelines

Assumptions
The student will:
• Know how to login to a computer and open up software
• Be familiar with all skills taught in the seven preceding activities:
  – Computer and Network Orientation
  – CAD Orientation
  – Set Up Your Model Space
  – Draw Your Border
  – Create an Orthographic Drawing
  – Draw an Isometric Object
  – Dimension an Orthographic Drawing

Terminology
Dimension: the measurement value of an object.

Dimension style: a group of dimension settings that determines the appearance of the dimension and simplifies the setting of dimension variables.

Layers: CAD layers are powerful organizational tools for drawing. In graphics software, layers are the different levels at which you can place an object or image file.

Orthographic drawing: a two-dimensional representation of a 3D shape. Often there are multiple views, and together they make an orthographic projection. A complete projection will have six views: front, right side, top, left side, bottom, and back.
**Scale**: a command used to proportionally resize objects; the multiplying factor by which you make an object larger or smaller.

**Snap**: limits the movement of the cursor crosshairs to a predetermined interval in order to aid in drawing to specific measurements. Isometric snap limits your cursor movement to align with an isometric grid.

**Estimated Time**

60 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

Computer lab installed with CAD software (Google SketchUp, AutoCAD, etc.)

**Tools**

Projector with computer and speakers, Internet access

**Materials**

Student activity sheet, and Internet access so students can watch the tutorial video

**Resources**

Instructional video for teacher and students to follow:

- [8.1 Dimensioning an Orthographic Drawing](#)

**Teacher-led Activity**

Use a computer with a projector to demonstrate how to:

- Open the orthographic drawing
- Change to DIM layer
- Using DIMSTYLE, scale dimensions by 4
- Change precision of drawing
- Insert an MTEXT for notes
- Dimension rules
- Dimension the views
- Re-save the file as an orthographic drawing
Student Activity
Students will follow the video tutorial and activity in order to dimension their views.

Extension Activity
Have students dimension a six-view orthographic projection of either the stair block or a different orthographic drawing. Isometric drawings are not meant to be dimensioned; please do not use isometric drawings to practise dimensioning.

Assessment
Students will show the teacher their completed and saved orthographic drawing.
Student Activity: Filling in a Title Block

Using the software, dimension your orthographic drawing. A video to support the lesson is located in Resources.

Commands to Use/Learn

- DIMENSION
- DIMSTYLE

Procedure

1. Open up your CAD software and watch the tutorial video as the software loads. Once the software has loaded, open up your orthographic drawing file.

2. Once the drawing file is open, select the DIM layer.

3. Next, open the Dimension manager using the DIMSTYLE command. Then change the scale and precision according to the video.

4. Start dimensioning by using the MTEXT command to create and fill in your notes box as shown in the video.

5. There are many governing bodies that create standards in drafting, but the following dimensioning guidelines are general and apply to all standards:
   a. Start by dimensioning basic outside dimensions of an object, i.e., length, width, height.
   b. Add dimensions for the remaining features, including things like radius, chamfer, angle, and location of removed features.
   c. Wherever possible, dimensions should be between views.
   d. Wherever possible, dimensions should line up.
   e. Add general and specific notes:
      - General notes should go in the notes section.
      - Specific notes can be added using the Leader command to point to the feature. The Leader is located in the annotation tab.

6. Wherever possible avoid the following when dimensioning:
   a. Dimensioning to a hidden line
   b. Dimensioning inside an object
   c. Dimensioning between the object and the border
   d. Crossing dimensions
7. Use the Dimension command to dimension your orthographic views as shown in the video.

8. If needed, add additional information to your notes.

9. Show your instructor that you have completed and saved your dimensioned drawing.
Fill In Your Title Block, Including Scale  
(Mechanical and Architectural CAD)

Description
In this activity students will fill in a title block, including Name, Date, Title, Drawing No., and the correct scale. This basic activity will include Snap and Text commands.

Lesson Objectives
The student will be able to:

• Enter text into a title block to identify who drew it, when it was drawn, the scale of the drawing, and if there is more than one drawing of the object.

• Change the snap setting to enable text to align.

• Scale a border. When you scale a border to fit around an object that you have drawn, you must enter the correct scale in the title block so if people measure directly off your drawing after it has been printed, they know the scale they are working with.

Assumptions
The student will:

• Understand how to use the Scale command

• Be comfortable using CAD software

• Have previously completed the Dimension an Orthographic Drawing activity

Terminology
Basepoint: the selected point on an entity or object used when moving, copying, scaling, etc., the object.

Grip: the small blue square that appears when you select or highlight an object or entity. Once you have selected a grip, you can move or modify that object.

Move: a command to move an object a specified distance and direction from where it currently is on a drawing.

Object Snap (Osnap): a mode that allows you to “snap” to an object (line) at its endpoint, midpoint, etc.

Scale: a command used to proportionally resize objects; the multiplying factor by which you make an object larger or smaller.

Snap: used to limit your movement of the crosshairs of the cursor to a predetermined interval to aid in drawing to specific measurements.
Text: a command used to add text to a drawing.

Zoom: a command used to magnify or change the view of a drawing.

**Estimated Time**

15–30 minutes

**Recommended Number of Students**

20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**

Computer lab installed with CAD software (Google SketchUp, AutoCAD, CADopia, etc.)

**Tools**

Projector with computer and speakers, Internet access

**Materials**

Handout for students with instructions

**Resources**

Instructional video for teacher and students to follow:

- 9.1 Filling in Your Title Block

**Teacher-led Activity**

Use a computer with a projector to demonstrate how to:

- Change Snap
- Turn Osnap On/Off
- Use Zoom command
- Enter text
- Move text
- Modify text size, width factor in properties

**Student Activity**

Students will follow the Student Activity “Filling in a Title Block” and/or the video tutorial to fill in their own title block. This will include scale.

**Assessment**

Students will show the teacher their completed assignments. The teacher can have the assignment printed out or look at it on the computer screen. If the student does not produce exactly what was shown, then an associated mark based on mistakes can be derived.
Student Activity: Filling in a Title Block

To complete this activity you must have already completed the Dimension an Orthographic Drawing activity. In this activity you will learn how to add text to a title block and move it into position. A video is provided to accompany the lesson.

Procedure
1. Open the drawing you completed for Activity 8, “Dimension an Orthographic Drawing.” It should look like Figure 1 below. (Note: layer colours have been removed for clarity.)

![Figure 1](image)

2. Zoom in to the title block so you can see what you are doing better (in the previous activity you scaled up the border four times to allow it to fit around the drawing.)

   Command: ZOOM, then WINDOW to get a view similar to Figure 2.

3. Change your Snap to 0.125 so you are able to centre the text within each section of the title block.
4. Make sure your current layer is set to Text.

5. Do you want Osnap on or off? Having Osnap on and getting too close to a line will make the text start where you might not want it, so it’s probably best to turn it off.

6. Enter the text for Name, Date, Drawing No., and Scale (Figure 3). DO NOT worry about the text being centred in each box for the moment! Type `TEXT`.
   a. Specify a start point. It really does not matter where you start, as you can always move it afterward.
   b. Specify height. The height of the text for Name, Date, Scale, and Drawing No. will be 0.75. This will allow you to centre the text in the boxes.
   c. For the rotation angle of the text, enter 0, as we want the text horizontal.
   d. Enter the text where the cursor is for Name, Date, and Drawing No. When complete, press `enter` twice to finish off the command.
   e. When you get to scale, you have to remember how many times you scaled up the border to fit the drawing. In this case, you scaled it up four times. Therefore the scale will be 1:4. Press `enter` twice when complete to finish off the command.

7. Enter the text for the Title. Type `TEXT`.
   a. Specify a start point. It really does not matter where you start, as you can move the start point afterward.
   b. Specify height. The height of the text for the Title will be 1.50. This will allow you to centre the text in the box.
   c. For the rotation angle of the text, enter 0, as we want the text horizontal.
   d. Enter text at cursor: Now enter the text where the cursor is for the Title. In this case the Title will be `STAIRS` (Figure 4).
7. Move the text into position in each box in the title block and centre it. To do this, you can left mouse click on the text and either select the grip (small blue square in the bottom of the text), or type **MOVE** and then pick a base point to move it from. Either way you must centre all your text.

8. If you have to modify your text (spelling, size, width factor) so it can fit in the box, you can right mouse click on the text and select Properties. The Properties dialog box opens up (Figure 7), and you can scroll down the list until you come across the Text properties (Figure 8). Here you can adjust the text as required.
9. Save your drawing as *orthographic stairs-name.dwg*.

10. Your finished drawing should resemble Figure 9.

**Figure 9**—Completed drawing
Set Up Your Plot Window, Print on 8.5" × 11" Paper (Mechanical and Architectural CAD)

Description
In this activity, students will learn how to print a drawing on 8.5" × 11" paper (letter size) in landscape orientation. Each printer/plotter has its own set paper sizes. You can adjust this activity to suit the printer/plotter that will be used in the school.

Lesson Objectives
The student will be able to:
- Print a drawing
- Understand how to print a drawing to scale

Assumptions
The student will have finished the activity Fill in Your Title Block, Including Scale, to have a completed drawing that can be printed.

Terminology
Application menu: the icon in the top left corner of the screen where functions can be chosen such as New, Open, Save, etc.

Drawing orientation: the orientation (portrait or landscape) of the paper when plotting (printing) a drawing.

Extents: the outer limits of all the objects that you have drawn that will fit on the display or paper.

Paper size: the size of the paper that a printer/plotter can handle. Every printer/plotter will have different paper sizes it can handle.

Plot area: the area selected to plot out on paper (Display, Limits, Extents, Window).

Plot display: only objects in the display will plot. If you have zoomed in to part of a drawing, only what is visible on the display will plot. The plot display is not to scale.

Plot extents: when you select this option, extents of a drawing are plotted and fit to the paper. Plot extents are not to scale.

Plot limits: when you select this option, the “limits of the drawing” will plot. If your limits are 100 × 100 (units) and your drawing is 8.5 × 11 (units), the drawing will be very small on the paper. Plot limits are not to scale.
**Plot scale**: the scale that a drawing will plot on paper. If you measure off the paper or want the drawing printed/plotted to full size, you must plot to a scale. *The plot option “Fit to paper” is not to scale.*

**Plot window**: when you select this function, you are given the option to select what you want plotted in a window. *The plot window is not to scale.*

**Printer/plotter**: the device used to plot your drawing. Every printer/plotter will have its own unique settings (paper size, margins, colour settings, etc.). A plotter is a large-format printer.

**Estimated Time**
15–30 minutes

**Recommended Number of Students**
20, based on *BC Technology Educators’ Best Practice Guide*

**Facilities**
Computer lab installed with CAD software (Google SketchUp, AutoCAD, CADopia, etc.)

**Tools**
Projector with computer and speakers, Internet access

**Materials**
Handout for students with instructions

**Resources**
Instructional video for teacher and students to follow:
- 10.1 Plotting Your Drawing

**Teacher-led Activity**
Use a computer with a projector to demonstrate how to:
- Open the Plot window from the Application menu.
- Show students which printer/plotter to select on your school network.
- Show the correct paper size to print on (letter: 8.5" × 11").
- Preview Plot Area options (Display, Extents, Limits, Window) to explain the differences among them.
- Explain the Plot Scale options (Fit to paper, Scale).
- Explain that to plot for direct measurements of a drawing or use a full-size template, the scale must be correct (1:1 = full size).
- Preview each drawing before printing.
- Print/plot a drawing.
**Student Activity**

Students will follow the Student Activity “Plot Window and Print on 8.5” × 11” (Letter) Paper” and/or the video tutorials to print/plot their own drawing.

**Assessment**

Students will show the teacher their completed assignment. The teacher can have the assignment printed out or look at it on the computer screen. If the student does not produce exactly what was shown, then an associated mark based on errors can be derived.
Student Activity: 
Plot Window & Print on 8.5" × 11" (Letter) Paper

This activity can be completed at any time you want to print/plot a drawing. Before you complete this activity, it is suggested that you have a border drawn around an object. The video to support this lesson is located in the Resources section.

Procedure

1. Open the drawing orthographic stairs-name.dwg that you completed for the activity Fill in Your Title Block, Including Scale. It should look like the one in Figure 1 below.

2. Go to the Application menu and select Plot (Figure 2). The menu will look slightly different depending on the software you are using. The Plot dialog box will open up and look something like the one in Figure 3. You may also have to expand it to include the all the settings, depending on the software you are using. Select Landscape under “Drawing orientation” right away (Figure 4).
Design and Drafting–2D Drawing

Set Up Your Plot Window, Print on 8.5” × 11” Paper

Figure 2

Figure 3

Figure 4
3. “Printer/plotter” identifies the device that you will print/plot to. Select the printer/plotter that your instructor wants you to use (Figure 5).

![Figure 5](image)

4. Depending on what “Plot area” you select, you will get different results (Figure 6).

![Figure 6](image)
5. Selecting the Preview button in the lower left of the Plot dialog box will display the following different results of “What to plot:” (Figures 7–10).

Figure 7—Plot area = Display

Figure 8—Plot area = Extents

Figure 9—Plot area = Limits

Figure 10—Plot area = Window
6. Using the “Plot scale” option, set the plot area to Extents. This will show the plot area on the screen when you preview it to get close to what you want. Notice that the “Fit to paper” box is checked and that the scale of 1 inch to every 4.251 units is greyed out (Figure 11).

![Figure 11](image11.jpg)

7. When you originally scaled the border up in the previous activities, it was by a factor of four—so you’re close, but you are not yet to scale! Uncheck “Fit to paper” to allow you to change the scale. Now, adjust your scale to 1:4 (Figure 12). Remember, what you are really doing is saying that 1 unit of inches on paper is equivalent to 4 inches in real life.

![Figure 12](image12.jpg)
8. Preview your drawing. You may receive an error message such as the one in Figure 13 IF you are plotting to a scale that is different from your annotation scale. Do not worry about this; just click **Continue** to preview your drawing. It should look like the one in Figure 14.

![Figure 13](image1.png)

![Figure 14](image2.png)
Set Up to Export to Other Programs
(Mechanical and Architectural CAD)

Description
In this activity the teacher will demonstrate how to export/plot an object that has been drawn in CAD so it can be exported or printed to a variety of other applications. The intent is to show that you can use CAD software to create objects that are more precise and sometimes easier to draw in CAD than in other software.

Lesson Objectives
The student will be able to:

- Review how to create a layer and adjust the setting so that it can be exported to other software for printing or cutting
- Explain how to export a drawing in a different format
- Have students understand that you can move between software packages by exporting correctly

Assumptions
The student will:

- Understand what layers are and how to set up limits
- Have previously completed the Setting Up Your Model Space activity

Terminology
Application menu: The icon in the top left corner of the screen that contains commands such as New, Open, Save, etc.

Drawing eXchange Format (DXF): a file format that AutoCAD can save in so that other programs can open the file. It is very useful when you want to open a drawing in other software (e.g., CorelDRAW, Adobe Illustrator, CNC plasma software and/or vinyl cutter software).

Layers: CAD layers are the digital equivalent of acetates in board drafting, and are powerful organizational tools for drawing. CAD layers are also referred to as levels in different software.

Limits: the extents of your drawing space (and of your zoom). These can be modified to suit each individual drawing.

Estimated Time
15–30 minutes
Recommended Number of Students
20, based on *BC Technology Educators’ Best Practice Guide*

Facilities
Computer lab installed with CAD software (Google SketchUp, AutoCAD, CADopia, etc.)

Tools
Projector with computer and speakers, Internet access

Materials
Handout for students with instructions: Student Activity: Setting Up to Export to Other Programs

Resources
Instructional videos created using [AutoCAD 2013]:

- 1. AutoCAD to Laser
- 2. Exporting a Drawing

Teacher-led Activity
Use a computer with a projector to demonstrate and explain the following:

- Make a new layer and change the line colour and lineweight. This may be needed if you are going to print to a laser engraver. These settings may vary. Typically, though, the colour for a laser engraver to cut is red and the line thickness will be .001” or 0.05 mm.

- Show how to export a file using the Save As command. Explain that not all software applications will allow you to open CAD files. The DXF format that CAD software can Save As may be opened by many applications such as CorelDraw, Adobe Illustrator, CNC plasma cutter software, and/or sign cutter software.

- Demonstrate how to plot to another software application that runs a machine (laser engraver, vinyl cutter, etc.). Many of these machines allow you to plot directly out of CAD software. The trick is to ensure you have the correct settings to allow it to plot correctly.

Student Activity
Initially, students may just watch the teacher demo how to export to another format and/or print to the laser engraver software. At a later date students may come back to this activity to export or print.
Student Activity:  
Set Up to Export to Other Programs

This activity will show you how to take an existing drawing and either export it to another program through Save As or plot the drawing to other software (laser engraver software).

Procedure

1. Open a drawing file you have already created, or start a new drawing using the imperial template that you created in the CAD Orientation activity.

2. Depending on what you are doing with the drawing, you may want to change the drawing limits at this point to match the machine to which you’ll be exporting (laser engraver bed size, CNC bed size, etc.).

3. Layers: When exporting an object to another program, you will most likely want to turn off all layers except for the Object layer. There is no reason to export the border, text, or dimensions if you are going to cut a part out on a laser, CNC, or vinyl cutter.

4. Layers for laser engraver, CNC plasma, or vinyl cutter: some machines require specific line colours and/or lineweights to be able to “cut” on the object lines once your drawing has been brought into the software. You may want to create a new layer and change the Lineweight or Color specifications to match what the machine requires. In Figure 1 below, a layer called Laser Engraver was created with the colour red and a lineweight of 0.05 mm.

5. Highlight your object and change to the laser you may have set up so you can export to the next software.

Figure 1
Exporting a DXF File

1. A DXF is a generic type of file that other programs may be able to open. To save in the DXF format, go to the Application menu and select Save As. Then select Other Formats (Figure 2). The rule of thumb for exporting is to always go with the lowest version of software possible. As you can see in Figure 3 under “Files of type,” the one selected is AutoCAD R12/LT2 (*.dxf). By selecting this format you will most likely have a format that other software applications will read.
2. Save the file. Go to the other application software to which you wanted to export and try to open it. Did it work? Remember, not all software applications will open AutoCAD files.

**Printing a Drawing File to a Machine’s Application Software**

1. Some machines (laser engraver, CNC plasma cutter, vinyl cutter) have a special piece of software to which you can print directly. If needed, make sure you have the object you want to print on the layer you may have set up in Step 4 above.

2. Open up the Plot dialog box by going to the Application menu and selecting “Plot” (Figure 4). As you can see in Figure 5, the following settings have been chosen:

- **Plotter/Printer**: the laser engraver has been selected for this example.
- **Paper size**: set to “User-Defined” (matches the laser engraver bed of 24” wide and 12” high in this case).
- **What to Plot**: set to “Limits” to match the drawing limits AND the bed of the laser engraver.
- **Plot Scale**: set to 1:1. This is important: If you want your object to come out the correct size (full size), make sure this is set to 1:1.

![Figure 4](image-url)
3. Click **Preview** to look at your object. If it looks good, print it to your other software.

4. Open up the application software to which you printed. Did it work? If so, carry on in that software.