

Study Guide

AutoCAD Applications for Engineering Technology

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INSTRUCTIONS

INTRODUCTION

For many decades, the study of engineering graphics has been a standard part of a wide range of engineering and technology-based instructional programs. More recently, the personal computer has been integrated with software packages designed to facilitate the drawing process. This newer software has changed the methods used to produce engineering graphics. However, the basic language of drafting and design remains the same, and continues to communicate the essential production details that lead to finished products. The student who can combine classic drafting knowledge with updated software design techniques will gain valuable career skills.

In this course, you'll learn the standard rules and practices used to generate detailed parts drawings and assemblies, and then discover how to apply AutoCAD software to the actual execution of the drawing process. The best way to become proficient at technical drawing is to develop those skills by creating many variations of drawings. Therefore, this course will be more "hands-on" than others you may have experienced to date. You'll have fewer examinations; instead, you'll be preparing multiple drawings that will be submitted for grading to meet the requirements for the course.

Like any skill, learning how to create technical drawings takes time, patience, and repetition. You'll need to condition your mind to visualize objects in the views that are required for orthographic projections. You'll also learn rules for correct dimensioning and tolerancing, and where to locate dimensional information for standard machine elements.

Your course won't be easy, but if you're willing to invest the time and effort required, you'll be able to master the art and the science of technical drawing. In the process, you'll gain a great deal of personal satisfaction in seeing the work that you're able to produce.

COURSE OBJECTIVES

When you complete this course, you'll be able to:

- Utilize the AutoCAD workspace and interface to create engineering drawings and orthographic projections
- Create drawings that contain dimensions section views, and other advanced techniques
- Apply tolerancing, fasteners and threads to engineering drawings
- Create pictorial and assembly drawings

YOUR TEXTBOOK

Your textbook, *Engineering Graphics Essentials with AutoCAD 2017 Instruction*, by Kirstie Plantenberg, contains the material on which you'll be tested. You need to become familiar with this textbook prior to beginning your studies.

You'll want to begin by skimming the table of contents. This will give you an overview of the entire textbook. Then read the preface as a brief introduction to the textbook. A glossary, which provides definitions for terms you may or may not be familiar with, can be found at the end of your textbook, followed by a bibliography, a list of photo credits, and an index.

COURSE MATERIALS

This course includes the following materials:

1. This study guide, which contains an introduction to your course, plus:
 - A lesson assignments page with a schedule of study assignments as well as exam for the four lessons you'll complete during this course
 - Assignment lessons emphasizing the main points in the textbook
2. Self-checks and answers to help you assess your understanding of the material
 - Your course textbook, *Engineering Graphics Essentials with AutoCAD 2017 Instruction*, which contains the assignment reading material
3. It's also important that you use the independent learning material provided on the publisher's website. Access the SDC Publications website via <https://tinyurl.com/y7arygqu>. Your level of success will be greatly improved if you fully integrate the instruction in the textbook with the videos and other resources in this independent learning material.

INDEPENDENT LEARNING MATERIAL

Your textbook provides valuable online bonus content. On the inside front cover of your textbook are instructions for accessing this material. Once you register, you'll have access to interactive exercises, instructional videos, supplemental problem solutions, and more. Throughout this study guide, you'll be reminded to take advantage of this supplemental information related to the topic you're studying. Be sure to take advantage of all of this additional helpful information.

A good idea is to download the files to your computer. In that way, you'll be able to access them easily when you need them.

Specific instructions for downloading the material are presented on page i in your textbook. *Note:* Once you unzip the files, you'll see a file named **index.htm**. This is the file you'll use to access all of the independent learning material. Before you begin your studies, you should open this file and become familiar with how to access and view the graphics content and the AutoCAD content for the various chapters in your textbook.

A STUDY PLAN

Think of this study guide as a blueprint for your course. You should read it carefully. Using the following procedures should help you receive the maximum benefit from your studies:

- Read the lessons in the study guide to introduce you to concepts that are discussed in the textbook. The lessons emphasize the important material discussed in the text and provide additional tips or examples to help you grasp the material.
- Note the chapters for each assignment in the textbook and read the assignment in the textbook to get a general idea of its content. Then study the assignment, paying attention to all details, especially the main concepts.
- Answer the questions and problems provided in the self-checks in the study guide. This will serve as a review of the material covered.
- After answering the suggested questions, check your answers against those provided in the Solutions Supplement attachment on your student portal. If you miss any questions, review the pages of the textbook covering those questions. The self-checks are designed to reveal weak points that you need to review. Do not send the self-check answers to the school. They're for you to evaluate your understanding of the material. Complete each assignment in this way.
- After you've completed and checked the self-checks for Lesson 1, go to your student portal and complete your first exam.
- Follow this procedure for all four lessons. At any time, you can contact your instructor for information regarding the materials.

Now you're ready to begin Lesson 1.

Good luck!



Remember to regularly check your student portal. Additional resources to enhance your learning experience may be posted.

READING ASSIGNMENTS

Lesson 1: Basics of AutoCAD and Orthographic Projections

Read in the study guide:

Section 1.1

Section 1.2

Examination 499808

Read in the textbook:

Chapter 1 and 2

Chapter 3 and 4

Lesson 2: Dimensioning and Sectioning

Read in the study guide:

Section 2.1

Section 2.2

Examination 499809

Read in the textbook:

Chapter 7 and 8

Chapter 9 and 10

Lesson 3: Advanced Techniques, Tolerancing, and Threads

Read in the study guide:

Section 3.1

Section 3.2

Section 3.3

Graded Project 49981000

Read in the textbook:

Chapter 11 and 12

Chapter 13 and 14

Chapter 15 and 16

Lesson 4: Assembly and Pictorial Drawings

Read in the study guide:

Section 4.1

Section 4.2

Examination 499811

Final Graded Project 49981200

Read in the textbook:

Chapter 17 and 18

Chapter 5 and 6

Note: To access and complete any of the examinations for this study guide, click on the appropriate **Take Exam** icon on your student portal page. You should not have to enter the examination numbers. These numbers are for reference only if you have reason to contact Student CARE.

LESSON 1: BASICS OF AUTOCAD AND ORTHOGRAPHIC PROJECTIONS

This course on AutoCAD applications is specific to the development of standard engineering graphics. You should already have completed a course on the fundamentals of AutoCAD as a prerequisite for this course. However, this lesson includes a thorough review of the basic menus, drawing spaces, tool bars, and functionality of AutoCAD. No matter what your level of AutoCAD experience is, you may find this review to be useful.

Once you've accessed AutoCAD software and you reacquaint yourself with its basic functionality, you'll move on to the study of the most fundamental element of engineering drawings: the orthographic projection. When you understand the basic manual practices of orthographic projections and the overall construction of a detailed engineering drawing, you'll conclude this first lesson with instruction and practice on how to generate these same standard drawing views using AutoCAD.

LESSON OBJECTIVES

When you complete this lesson, you'll be able to:

- Identify AutoCAD 2-D drawing functions, including the workspaces, tool bars, and drawings spaces
- Describe how AutoCAD is used to create orthographic projections, including the correct application of layers

SECTION 1.1

Read the following section. Then read Chapters 1 and 2 in your textbook.

The AutoCAD Software

Before you begin your studies, it's important to have AutoCAD software available to use during demonstrations and to complete the assigned problems. Although your textbook is specifically designed for AutoCAD 2017, you'll have some flexibility with the version that you actually use. If you already have an older or newer version of AutoCAD installed on your computer, you can still meet the objectives of the course. The objective isn't to make you an expert user of the software, but rather to make you comfortable with the features that are most commonly used to create and print engineering graphics. With a little trial and error (and possibly some help from user groups and other Internet resources), you'll be able to successfully complete this course no matter what version of AutoCAD you use.

If you already have a fully licensed version of AutoCAD software, you can use that with this course. However, if you don't have a fully licensed version, you can get a free trial version for students from AutoDesk. There are instructions about how to download the free trial version on your student portal.

Getting the Most from Your Textbook

Your textbook, *Engineering Graphics Essentials with AutoCAD 2017 Instruction*, was selected for this course for a number of reasons. This textbook provides an excellent blend of instruction on the development of engineering drawings, integrated with the software practices you'll need to generate those drawings in AutoCAD. The textbook is also serious in its attempt to provide features that are specifically designed to benefit students learning on their own outside the setting of a traditional classroom. You'll find the construction of the book lends itself to a very hands-on approach to the study of engineering drawings. Quickly review some of the key features before you begin your readings.

Independent Learning Material

If you haven't already downloaded the independent learning material from the publisher's website, please do so now. Once you have unzipped and saved the material to your computer, double-click on **index**. On the home page, click on **Engineering Graphics Content** and scan the materials available to you. Then from the home page again, click on **AutoCAD Content**. In the box at the left, you'll see the various topics covered. This content presents helpful videos and provides a means for you to complete the textbook exercises online with immediate feedback.

In addition, this material also includes answers to supplemental problems (SP) and files that you'll use as you complete the tutorials throughout the textbook.

Before you proceed with your course, browse these materials so you'll be able to easily access them as you advance in your studies.

Textbook Functionality

The philosophy of your textbook is that manual drawings should be sketched so that you can determine the details and the eventual layout of the drawing that will be completed in AutoCAD, and this makes perfect sense. You'll find that the problem pages contain grids and construction lines that will help make the hand-drawing process easier to understand and to execute. If you prefer, you can tape paper to a drawing board where you can use T-squares and triangles to obtain a more finished look.

Traditional Drafting Techniques

If you like using traditional board drafting techniques, you might want to assemble a few items to facilitate your drawing. A portable drafting board, T-square, 30-60-90 triangle, compass, French curve, architect's and engineer's scale, ellipse/circle template, lead holders and different-sized leads, and an eraser should get you through most of the drawing examples in your text. You can, of course, simply use a pencil and straight edge to sketch most of the problems suggested in your textbook.

Introduction to Engineering Drawings

Each of the major heads in Chapter 1 is explained in a short audio presentation in the independent learning material. As you read each section in this chapter, listen to the related audio clip to supplement your learning. To access this material, click on the **index** file. From the home page, click on **Engineering Graphics Content** and then on **Introduction**. In the box at the left, you'll see the links to the supplemental materials.

Engineering drawings are designed with a specific purpose in mind: to clearly communicate a design from the engineer who designed it to those who must use and work with the drawing—generally those who will manufacture the item shown in the drawing. Engineering drawings generally include dimensions, notes, various types of lines, symbols—any information that gives an accurate portrayal of what the engineer intends.

You may be familiar with a lot of the information in Chapter 1, but read it through carefully and remember to take advantage of the independent learning material. This chapter is really the foundation for what you'll study in the remainder of the textbook.

Drawing in AutoCAD

Before you begin your study of Chapter 2, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Drawing in AutoCAD**. You should see a list of the videos available for Chapter 2. Take note of the topics covered; then when you get to that topic in your study, take time to watch the associated video.

You should also see links to the files you'll need to complete some of the tutorials in Chapter 2.

Technical drawing courses are short on lecture and long on practice. The lectures included in these videos is similar to having a classroom lecture series available for your review. But you must also practice what you are learning. It's really the only way to develop your ability to use and apply the AutoCAD software.

You'll be covering a lot of ground in this textbook chapter. This assignment attempts to cover all of the AutoCAD features you'll need to progress through your studies. Even though you'll review a very long list of features and commands, you'll come to appreciate that this is just a fraction of the functionality and capability that the software has to offer.

Have the software running as you read through the content. In that way, you can work through any examples and exercises provided in the readings. When options exist to customize toolbars, pallets, and functions, experiment with each option and begin to set up your personal workspace in a way that helps you draw accurately and efficiently.

Many AutoCAD commands are covered in Chapter 2, but don't forget about the **UNDO** command. As in other software programs, the **UNDO** function in AutoCAD is accessed by the familiar arrow curved to the left. If you make a mistake when you're experimenting with options and commands, you can almost always click **UNDO** to "erase" your mistake and be taken back one step in the drawing.

The textbook content is very comprehensive. All of the workspaces and user interfaces are reviewed, as well as the location of commands, the location and description of quick-access toolbars, and the basic startup process. From your previous AutoCAD experiences, you'll recall the importance of coordinates, so be sure to review both WCS and UCS methodologies.

In this course, you'll be submitting drawings to the school electronically as drawing files. However, the procedure for plotting or printing is very important for most workplace applications. Once you've reviewed the printing and plotting process, you'll cover a long list of drawing, text, modify, and OSNAP commands that you'll use regularly throughout the remainder of the course.

The final sections of this chapter cover methods for selecting objects, polar tracking, dynamic inputs, grip boxes, and parametric constraints. There, you'll learn how to improve the speed and accuracy of the drawing process by taking advantage of the power of the AutoCAD software.



Self-Check 1

At the end of each section of *AutoCAD Applications for Engineering Technology*, you'll be asked to pause and check your understanding of what you've just read by completing a "Self-Check" exercise. Answering these questions will help you review what you've studied so far. Please complete *Self-Check 1* now.

For Chapter 1, complete the "Introduction to Engineering Drawings Questions" on pages 1-13 to 1-15. Then, complete the "Introduction to Engineering Drawings Problems" P1-1 to P1-5 on pages 1-17 to 1-25.

For Chapter 2, complete the "Drawing in AutoCAD Questions" on pages 2-130 to 2-141. Then complete the "Drawing in AutoCAD Problems" P2-1 to P2-5 on pages 2-142 to 2-150.

When you've completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal.

SECTION 1.2

Read the following section. Then read Chapters 3 and 4 in your textbook.

Now that you've refreshed your AutoCAD skills, it's time to turn your attention to the basic structure and format of engineering drawings: the orthographic projection. If you didn't know it by its formal name, chances are that you're still familiar with the concept of orthographic projection. You may have worked in a manufacturing setting where shop drawings were presented in three views. Or you may have seen multiple views of objects illustrated in the assembly instructions or user's manuals for products you've purchased. Orthographic projection is the very core of engineering graphics, and it's very important to be skilled in this essential concept.

Throughout the remainder of the course, your textbook will explain and demonstrate a technical concept related to engineering drawings as a manual drawing. Then, the following chapter will provide instruction for the execution of that drawing component using AutoCAD. So, Chapter 3 in your textbook explains the basics of orthographic projection, and Chapter 4 shows how to create orthographic projections using AutoCAD.

Orthographic Projections

Before you begin your study of Chapter 3, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Orthographic Projection**. In the box at the left, you should see a list of the audio clips, videos, and exercises available for Chapter 3. Complete the exercises as you encounter them in the textbook. The independent learning material will provide immediate results of how well you've done.

Simply put, *orthographic projection* is a method of representing a three-dimensional object in only two dimensions. The concept of orthographic projection isn't difficult to understand. You're simply looking at three-dimensional objects head on in very specific views, and positioning those views in an organized manner on a formal drawing. (See Figure 3.1-1 in your textbook.) This perspective and alignment allows you to show two-dimensional details about the object very accurately. You then use a series of specific line types to communicate even more detail about the features of those views for your intended readers. This simple process has been the basic language of technical drawing for a very long time.

The difficult part for many students is that humans don't see objects in two dimensions. Consequently, it can become a mental challenge to visualize objects and to focus only on how the lines of an object relate to one unique view. Some students develop the ability to visualize objects in orthographic projection quickly, while others may struggle a bit. However, with patience and practice, almost all students become proficient at this essential skill.

Practice is also a very important concept when it comes to technical drawing. As mentioned earlier, a traditional classroom instructor devotes less time to lecture and more time to hands-on practice. Knowing a lot of facts about technical drawing isn't the important thing—the real skill is being able to produce an accurate drawing. Thus, you'll find that much of the written information presented in each chapter is brief. Instead, the development of your AutoCAD skills will come from repeated attempts to produce accurate drawings, and a critical self-evaluation of where you succeeded and where you didn't.

The most important things to learn as you study this chapter are the principal views and the application of the different line types that represent the elements of those views. Line types and line weights (thicknesses) provide valuable information to a print reader. They are the main starting point in any study of orthographic projection, so be sure to carefully

work through these concepts before you move forward. AutoCAD creates different line weights for you, but you still need to understand the rules of where and when each type should be applied.

If you find that you're having a difficult time visualizing the correct views for the practice problems or the exercises, try locating some simple objects around your desk or study space, and attempt to sketch three views of each item. Sometimes, being able to rotate an object by hand makes it easier to gain the perspective you need to develop this skill.

Most students want to know "What's on the test?" The more important question in this course of study is, "What's important in my drawing?" We'll provide a grading requirements table to help you understand how your drawings will be evaluated. However, it's crucial to understand that *all* of the little details matter. Where should lines touch and where should they be separated? When and where can lines cross? Be sure to position views according to established rules, and use the correct line type and weight. Remember that the drawings you produce may be the only guide that a technician has when creating the part required for a project. Engineering graphics and technical drawing use an established language, and it's critical that you communicate the requirements accurately to your audience.

Creating Orthographic Projections in AutoCAD

Before you begin your study of Chapter 4, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Creating an Orthographic Projection in AutoCAD**. You should see a list of the videos available for Chapter 4. Take note of the topics covered; then when you get to that topic in your study, take time to watch the associated video.

You should also see links to the files you'll need to complete the work in Chapter 4.

This final chapter of your first lesson includes the first application of AutoCAD to an element of engineering graphics. You'll be learning about the functions in AutoCAD that help to automate the orthographic projection process. You should be familiar with *layers* from your previous experiences with AutoCAD. Layers allow you to manage and control line weights and line types. If you set up your layers correctly in AutoCAD, many of the critical technical drawing details will be executed properly every time by the software. Using a layer for construction lines and projection lines provides better visibility and accuracy. Also, a simple click of your mouse will make them invisible to the end user of the print.

Use your textbook and the video tutorials to set up the correct layers for each line type described in the previous chapter. You'll be repeating this process often as you begin to create your drawing collection.

A very useful exercise in this chapter is the creation of your border and title block. You'll learn that every drawing should have both a border and a title block, but you'll also learn about the general use of *blocks* in AutoCAD. Blocks allow you to build objects such as borders and title blocks (and bolt heads, nuts, and all kinds of common objects) and save them under their own file names for quick reuse.

Note: As you create drawing elements that will be reused, develop the discipline to save those elements properly so you can easily access them when you need them. AutoCAD provides unprecedented ways to create drawings in a fraction of the time of even the most efficient draftsman using manual drafting techniques.

In this chapter, you'll also review how to print drawings and how to properly scale and position the components you draw for professional printouts. Remember that technically the term *printing* is used to refer to smaller-sized drawings produced on a printer. If you're producing larger format drawings using a plotter, then you're *plotting*, not printing.

At the end of this chapter (beginning on page 4-28) is a tutorial that provides step-by-step directions for creating an orthographic projection (up to and including the printing process).

Carefully work through this tutorial, and compare your results to the finished drawing at the end of the segment.

A Review of Your Required Drawing Assignments

At the end of Lessons 3 and 4, you will submit a series of drawings to the school for grading. This summary explains how these drawings will be evaluated. Be sure to read this section carefully.

To determine that you've developed the drawing and AutoCAD skills necessary to create accurate engineering drawings, your instructor will need to see examples of your work. This will provide your instructor with the opportunity not only to assess your progress, but also to provide you with valuable feedback that you can use to improve your drawings.

The drawings that you submit to the school will be divided into two graded projects. The first graded project is located at the end of Lesson 3, where you'll submit a series of eight drawings as AutoCAD files. These eight drawings will be taken from the problem sets found at the ends of the chapters you've studied. They'll contain features of all the drawing components you've studied and practiced in Lessons 1 through 3. Note that since these problems will be graded, the solutions to them will not be found in the **Solutions Supplement** attachment on your student portal.

The second graded project is a final project that you will submit after you take your exam for Lesson 4. This project is a set of drawings that will require a pictorial drawing, an assembly drawing, detailed drawings for each part, and an appropriate parts list. You'll learn more about your final graded project after you finish Lesson 4.

Here are some tips to help you successfully complete the drawings for your graded projects:

- Make sure that you've covered the material in both your textbook and the independent learning material before you attempt any of the required drawings. You should be comfortable with your skills before you create any of the drawings that you'll submit for grading. Complete the required readings and the assigned problems at the end of the chapter before you begin.
- Do *not* wait until the end of Lesson 3 to begin the graded drawing assignments. You'll find it useful to complete the required assignments at the same time that you complete the other materials in your lessons. If you wait until the end of Lesson 3, you may delay your progress on the rest of this course.
- Do read all of the required assignments before you begin this series. There may be situations in which you can start portions of a drawing while you continue to learn new material. For example, you'll know how to draw three views of an object before you learn to dimension. So, if one of the dimensioning assignments also requires you to draw three views, you can complete that portion of the assignment before you complete the dimensioning.
- Do *not* skip the nongraded drawings in the self-checks at the end of each assignment. Even though you aren't required to submit those drawings for grading, you still need the practice and experience that comes from completing those drawings. In fact, try to complete all of the nongraded drawings *before* you attempt the drawings that you'll submit to the school.
- Make sure you carefully save each assignment. Use a form of the problem number and your name for the file name. Create a folder on your hard drive to hold the assignments so that you can organize the submission in one location for easy access and upload.

At the end of Lesson 3, you'll submit a series of eight drawings as AutoCAD files. These eight drawings are outlined in the following table for your reference.

| Drawing Topic | Problem Number | Textbook Page |
|-------------------------|----------------|---------------|
| Orthographic Projection | P4-12 | 4-58 |
| Orthographic Projection | P4-17 | 4-62 |
| Dimensioning | P8-17 | 8-49 |
| Dimensioning | P8-20 | 8-52 |
| Sections | P10-8 | 10-24 |
| Tolerancing | P14-2 | 14-9 (18-15) |
| Tolerancing | P14-6 | 14-10 (18-21) |
| Threads | P16-4 | 16-11 (18-20) |

When you get to the end of Lesson 3, you'll receive specific instructions on how to deliver the drawing files to the school, and a grading summary that will describe how the drawings will be evaluated.



Self-Check 2

For Chapter 3, complete the “Orthographic Projection Questions” on pages 3-31 and 3-32 of your textbook. Then, complete the “Orthographic Projection Problems” P3-1 to P3-15, P3-19, P3-24, P3-26, P3-33, P3-34, P3-35, and SP3-1 on pages 3-33 to 3-109.

For Chapter 4, complete the “Orthographic Projections in AutoCAD Questions” on pages 4-46 to 4-48. Then, complete the “Orthographic Projections in AutoCAD Problems” P4-1, P4-3, P4-7, P4-10, P4-13, and P4-18 on pages 4-50 to 4-63.

When you’ve completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal. (Note: The solution for SP3-1 is available in the independent learning material that’s included in the material you downloaded.)

LESSON 2: DIMENSIONING AND SECTIONING

Lesson 2 covers dimensioning and sectioning, which are important features in engineering drawings. No matter how accurately the features of a specification are drawn, the information is valuable only if the sizes can be communicated in an accurate format. Proper *dimensioning* allows any technician anywhere in the world to be able to clearly understand the drawing. *Sectioning* is a technique that allows a drawing to show complex part features that would otherwise be hidden from view.

Once you learn how to dimension and section drawings, you'll see how AutoCAD can be used to provide consistency to the drawings and accelerate the overall drawing process.

LESSON OBJECTIVES

When you complete this lesson, you'll be able to:

- Identify the lines, symbols, and lettering required for the accurate dimensioning of drawings
- Explain how AutoCAD is used to create sectional drawings

SECTION 2.1

Read the following section. Then read Chapters 7 and 8 in your textbook.

Section 3 covers the proper placement of dimensions on engineering drawings. There are symbols to learn, and a few additional line types that are exclusive to the dimensioning process. As you'll see, there are very formal requirements for the placement of dimensions, the way in which features (such as holes and radii) are identified and located, and the way in which measurement units are selected, identified, and displayed.

Adding dimensions to a drawing was once a very time-consuming and tedious task. Making changes and corrections to drawings was almost as difficult, and presented an opportunity for errors to reach the manufacturing floor. If changes are needed, they must be made carefully at every location on a set of drawings where a dimension is referenced. You'll learn how AutoCAD makes it easy to add dimensions to drawings, as well as assure that all occurrences of a dimension are changed when modifications are required.

Dimensioning

Before you begin your study of Chapter 7, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Dimensioning**. In the box at the left you'll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

So far in your course, you've learned about the language of technical drawings and how to communicate object shapes and feature locations. You've learned how different line types and positions are used to tell more information about an object. The next step in this process is to learn how the actual sizes of objects are added to a drawing in the form of *dimensions*.

ASME Standards

As your knowledge of engineering practices grows, you'll view many standards documents that provide very exact directions on how specifications should be written and organized. In this section, you'll be introduced to a standard used to dimension drawings. *Standards* help to ensure that everyone involved in a process use dimensions in a way that everyone recognizes and understands. The organization that develops and maintains the standards for dimensions on technical drawings is the *American Society of Mechanical Engineers (ASME)*, and the standard is *ASME Y14.5M-1994*. Your textbook does a good job of familiarizing you with the basic dimensioning practices of the ASME standard. Note that standards publications are expensive, and most individuals won't purchase them for personal use. Typically, they'll be purchased by an engineering firm that provides a single copy for multiple users.

Dimension Lines and Notes

In this assignment, you'll learn about the pieces that make up a dimension line, as well as the line types and weights that you'll use to add them to a drawing. Once you learn how to indicate a dimension's location, you'll learn where and how to add text. The organization of dimensions on a drawing is important for readability. It's also needed to communicate how that dimension applies to multiple views on your drawing.

Special Dimensioning Requirements

Note that circular forms and components (such as radii and arcs) require their own dimensioning techniques. You'll also learn how to minimize the number of dimensions on your drawing when you encounter repetitive features and symmetrical forms. Drawings will be more clear when you use the fewest number of dimensions needed to provide the necessary information.

Drawing dimensions are typically given in either inches (English system) or millimeters (metric system), although drawings will occasionally provide measurements in both formats. Your drawings should clearly communicate to the user what unit of measurement you're using.

Tolerances

You'll learn about tolerances in detail in a future assignment. However, several topics in this assignment are related to tolerances. It's important to understand the concepts of datums and datum dimensioning, accuracy levels for a dimension, and error buildup so that you can apply that understanding later to tolerances.

In the material on tolerancing, your textbook mentions *geometric dimensioning and tolerancing (GD&T)*. The textbook author is alerting you to the fact that this course will teach you basic dimensioning techniques, but not the advanced concepts of GD&T. This is a common practice for introductory courses in engineering graphics. GD&T is complex enough that it's typically the subject of a single course by itself.

The Importance of Dimensioning

Dimensioning requires patience, discipline, neatness, and accuracy. Plan the dimensioning portion of your drawings carefully, and pay close attention to details, such as the number of decimal places you use in your dimensions. You should always be looking to improve the way you communicate with your drawings by improving your dimensioning techniques.

Dimensioning in AutoCAD

Before you begin your study of Chapter 8, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Dimensioning in AutoCAD**. You should see a list of the videos available for Chapter 8. Take note of the topics covered; then when you get to that topic in your study, take time to watch the associated video.

You should also see a link to the file you'll need to complete one of the tutorials in Chapter 8.

The Advantages of Dimensioning in AutoCAD

AutoCAD is a powerful tool with many useful functions. Even if the AutoCAD software had been developed *only* to assist with the dimensioning process, it would have saved thousands of work hours for the typical draftsman or designer over the span of his or her career. If you've ever had to add dimensions manually to a technical drawing, you'll appreciate the enormous value that AutoCAD adds to the dimensioning process. In the days of manual drafting, if last-minute changes were made to specifications, the draftsman would have to spend many hours updating pages of drawings and verifying that all of the dimensional modifications were correct.

As you'll discover in this chapter, though, the AutoCAD software can automate this entire process. Changes can be updated and verified in hours rather than days. Of course, today's design professionals will still need to be careful to perform quality checks on their drawings. However, the functionality of the AutoCAD software allows the designer to spend more time checking the quality of the dimensions and less time on the mechanics of making the changes.

Dimensioning Features

Your textbook starts Chapter 8 by discussing some of the features that AutoCAD offers to assist with the dimensioning process. Take a moment to think of how valuable the *layers* concept of drawing software is to dimensioning. Because of layers, all of your dimensions will be isolated on a single level of your drawing for easy access and modification.

AutoCAD has a style manager that assures that all of your dimensions are consistent, and a single function to control leaders. The concept of *associative dimensions* means that when you make changes to the size of a drawing component, the software ensures that the dimension is corrected for you. *Annotative objects* keep the text size of your dimension consistent and legible when you change the scale of the drawing for printing. The software recognizes that you're dimensioning a circle or radius and applies the correct symbols in your dimensions.

There is an amazing amount of detail that the software will control if you learn the basics and keep some simple rules in mind. Also, remember that the features described in this chapter are just a fraction of all the ways that AutoCAD can assist you in generating accurate and well-designed dimensions on your drawings.

Tutorials

The tutorials in Chapter 8 are very helpful in showing how the software will allow you to concentrate on the details of your design while the software takes care of the drawing rules and requirements. For example, imagine that you completed a set of drawings using the ASME standard, and your company's bid required that the drawings be made using ISO-25 standards. If you were doing the drawings manually, you would have to

learn the differences between the two formats, and possibly make hundreds of changes to an entire set of drawings. By using AutoCAD, however, you could simply apply the new style by using the style manager.

Work through all of the tutorials as they appear in your textbook. Pay special attention to the editing dimension tutorial in that it explains how to change dimensions without affecting their associativity.



Self-Check 3

For Chapter 7, complete the “Dimensioning Questions” on pages 7-53 to 7-56 of your textbook. Then, complete the “Dimensioning Problems” P7-1 through P7-8, P7-10, and SP7-2 on pages 7-57 to 7-82.

For Chapter 8, complete the “Dimensioning in AutoCAD Questions” on pages 8-35 and 8-36. Then, complete the “Dimensioning in AutoCAD Problems” P8-1, P8-3, P8-5, P8-10, and P8-15 on pages 8-37 through 8-47.

When you’ve completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal. (Note: The solution for SP7-2 is available in the independent learning material that’s included in the material you downloaded.)

SECTION 2.2

Read the following section. Then read Chapters 9 and 10 in your textbook.

This reading assignment introduces the concept of drawing sections and demonstrates how to draw different types of sections. Sections have their own line types and rules, just like projections and dimensions. Once you understand how sections are created, you’ll learn how AutoCAD can be used to simplify the process and improve the overall quality of your drawings.

Sectioning

Before you begin your study of Chapter 9, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Sectioning**. In the box at the left you'll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

The Importance of Section Views

All engineers, designers, and draftspersons will be required to create sectional views of drawings at some point in their careers. The section view is used to show the detailed shapes on the inside of an object that might not be communicated clearly using standard views and dimensions. The mental discipline of visualizing a section will take some time and practice to develop, but with a little persistence, you'll be able to add sectioning to your drawing arsenal without too much trouble.

Learning when to use sections, and exactly what form you should use, will take practice and experience. Feedback from the technicians who use your drawings will help develop your sense of how to cut the drawings in the best way to illustrate the details that are needed. Section views are sometimes called *cutaway views*, and thinking about "cutting" the object will be helpful. Essentially, when you're creating a section drawing, you're cutting away a piece of the object in order to provide a better look inside. In some real-life situations, you may even use an actual object that's cut into sections to help create section views.

Some New Vocabulary

At this time, you're continuing to learn the language of engineering graphics. Just like learning a new spoken language, this visual language requires some new vocabulary in terms of *line types*. To create a section view, you'll use cutting plane lines and section lines. These new line types have rules for when and how they're used in drawings. You'll be introduced to three different forms of the basic section: *full sections*, *half sections*, and *offset sections*. You'll also discover five variations of more complex sections: *aligned sections*, *rib/web sections*, *broken sections*, *removed sections*, and *revolved sections*.

Creating Section Views in AutoCAD

Before you begin your study of Chapter 10, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Sectioning in AutoCAD**. You should see a link to a sectioning video and another link to the file containing the drawing you'll use in the tutorial for Chapter 10.

Chapter 10 is short, but it provides two interesting and important applications of AutoCAD for the creation of section views. It starts with some basic adaptations of line types and leaders to draw cutting plane lines. Then, you'll learn how the **HATCH** command is used to draw section lines. You'll see how easy it is to use the **HATCH** command to fill spaces, and view the wide selection of hatch patterns that's available.

When you work through the half-section tutorial, you should understand and appreciate the process of reusing drawing elements to create the next required element. Notice that in the tutorial file, you're renaming and manipulating the standard views of the part to create the section view. One of the great strengths of AutoCAD is the efficiency it brings to processes like these.



Self-Check 4

For Chapter 9, complete the “Sectioning Questions” on pages 9-27 and 9-28. Then, complete the “Sectioning Problems” P9-1 through P9-7, P9-10, P9-13, P9-23, and SP9-2 on pages 9-29 through 9-61.

For Chapter 10, complete the “Section Views in AutoCAD Questions” on pages 10-15 and 10-16. Then, complete the “Section Views in AutoCAD Problems” P10-3, P10-4, P10-5, P10-11, and P10-15 on pages 10-19 through 10-29.

When you've completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal. (Note: The solution for SP6-2 is available in the independent learning material that's included in the material you downloaded.)

LESSON 3: ADVANCED TECHNIQUES, TOLERANCING, AND THREADS

Lesson 3 covers six chapters in your textbook. You'll begin with a study of advanced drawing techniques that will help you hone your AutoCAD skills.

You'll also learn about tolerances, tolerancing, threads, and fasteners. These topics, which are fundamental to engineering graphics and technical drawings, will be applied extensively throughout your career whether you're creating drawings, developing design concepts, or just using the drawings and designs created by others. Once you understand the applications of tolerances, threads, and fasteners and you know how to communicate those applications in drawing formats, you'll broaden your AutoCAD skill set by learning to execute those principles using the software.

LESSON OBJECTIVES

When you complete this lesson, you'll be able to:

- Describe a variety of views created with advanced drawing techniques
- Demonstrate the proper application of English and metric tolerances to engineering drawings
- Explain how to draw and label internal and external threads using AutoCAD

SECTION 3.1

Read the following section. Then read Chapters 11 and 12 in your textbook.

Advanced Drawing Techniques

Before you begin your study of Chapter 11, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Advanced Drawing Techniques**. In the box at the left you'll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

Advanced View Techniques

In your studies so far, you've already learned about the six principal views of orthographic drawing: the front view, the back view, the top view, the bottom view, the left view, and the right view. Most objects can be adequately represented by these views. However, as your textbook states, there are drawing techniques that can “enhance the standard views” and “are used when a feature of the part cannot be completely described using the six principal views.”

For example, consider these possibilities:

- A *revolved view* can be a useful tool for illustrating a cross section of a part when that cross section varies or when the shape of the part is not apparent from the orthographic view. A revolved view is superimposed on the orthographic view.
- A *removed view* is similar to a revolved view, except the section is not drawn directly on the view. Instead, it's “removed” to an open area on the drawing. This type of view is helpful when you have no room for a revolved view.
- A *detail view* can appear as either a callout or a section in other views. As its name implies, a detail view shows finer levels of detail than those shown in the orthographic view.
- A *partial view* can be called a “view within a view.” It illustrates a portion of an orthographic view that's included within a boundary.
- An object can have any number of *auxiliary views*. The views are projected from the original object and are designed to show the true shape of features of the object.

Carefully study the textbook's description of these advanced views. As you read the descriptions, study the sample drawings in Figures 11.1-1 through 11.1-7 and listen to the audio clips in the independent learning material that you downloaded from the textbook's website. These audio clips should prove very helpful to you in understanding the differences between the views and their uses.

Once you feel that you understand these view, complete Exercises 11.1-1 through Exercise 11.1-3, using the independent learning material. You'll receive immediate feedback on your answers.

Advanced Part Techniques

Although you won't be learning any new commands or features of AutoCAD in Chapter 11, you're going to study two types of parts that require special drawing symbols. These are cast and molded parts and welded parts. As with many other facets of drawing, cast and molded parts have their own vocabulary. Your textbook defines and illustrates some of these terms on pages 11-14 through 11-18.

After parts have been cast or molded, they sometimes have rough surfaces that need to be machined. Specific surface texture symbols are included on the drawings of these parts to indicate how these parts should be finished. Some of these symbols are illustrated in Figure 11.2-4.

Welded parts are created by joining pieces of metal through heat. Although there are a great number of different ways that welds can be made, your textbook illustrates some of the more common ones in Figure 11.2-7.

Creating Advanced Drawings in AutoCAD

Before you begin your study of Chapter 12, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Advanced Drawing in AutoCAD**. Although this chapter has no video, it includes two student files that you can use for the tutorials in this chapter.

Chapter 12 continues your study of the advanced views you learned about in Chapter 11. Through the two tutorials presented in Chapter 12, you'll be learning how to apply what you learned in the previous chapter. The first tutorial walks you step by step through the creation of an auxiliary view; the second tutorial is related to surface textures.

Remember: The files that you need for these tutorials are available in your independent learning materials.



Self-Check 5

For Chapter 11, complete the “Advanced Drawing Techniques Questions” on pages 11-23 and 11-24. Then, complete the “Advanced Drawing Techniques Problems” P11-1, P11-2, and P11-3 on pages 11-25 through 11-29.

For Chapter 12, complete the “Advanced Drawings in AutoCAD Problems” P12-1, P12-2, P12-3, and P12-11 on pages 12-11 through 12-19.

When you’ve completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal.

SECTION 3.2

Read the following section. Then read Chapters 13 and 14 in your textbook.

Tolerancing

Before you begin your study of Chapter 13, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Tolerancing**. In the box at the left you’ll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

The Importance of Section Tolerances

Previously in your studies, you learned how important dimensions are to the effective communication of engineering graphics. *Tolerances* are an equally important offshoot of the dimensioning process. Tolerances tell the technician how large a portion of an

object should be, and also the amount of size variation that can be allowed and still have the part function as required. If you've ever participated in quality control or assurance checks of very precise machined parts, you know that very few inspected parts would be acceptable if you could accept only parts with the exact size specified. Some very small size variations are allowed, and these are described by the tolerances.

Types of Tolerances

Once you understand the basic concept of tolerances and are aware of the standards that may apply to your work, it's time to learn about the different types of tolerances that can be used on a drawing (and when each type can or should be used on a drawing). As with dimensioning, consistency and accuracy are very important to the application of tolerances. You don't want to confuse your intended audience by changing formats in your drawing unless it's absolutely necessary. You'll also need to appreciate how meaningful the number of decimal places you use can be to your drawing once tolerances are applied. You might think that it adds clarity to dimension $\frac{3}{8}$ " as 0.375", since that's the accurate decimal equivalent of the fraction. However, this might not be the best practice if the difference between a two-place decimal and a three-place decimal has a significant impact on the allowable tolerance. This is a common mistake that's made by students who are new to technical drawing.

Clearances and Fits

Clearances and fits are other valuable concepts for those new to technical drawing. Often, the design engineer will indicate only that a clearance or a certain type of fit is required, and the technician who develops the drawings will need to define and specify the exact clearance and fit. In addition to tolerancing standards, this portion of your textbook will also introduce you to ANSI specifications related to a specific *class of fit*. This is important material for you to grasp in this chapter, because it relates to the chapter on threads and fasteners that follows. Work through the exercises carefully, and make good use of the content in the independent learning material.

Once you work through most of the basic concepts of tolerances, fits, and clearances for the English system (inches), you'll then see how similar elements are designated and identified for metric dimensions.

Final Notes on Tolerances

Don't overlook the closing pages of this chapter. It's very important material that will come into play often when you're responsible for the content of technical drawings. Selecting a reduced tolerance has a direct impact on manufacturing costs—they rise rapidly. Therefore, make sure you understand the importance of applying meaningful tolerances.

Tolerance accumulation is another area that often presents a problem for students who are new to technical drawing. When you work through the exercise on tolerance accumulation, return to the lesson on dimensioning, and note how dimensions that are laid out logically from a common datum help to avoid tolerance accumulation.

The final topic for this chapter can also be somewhat related to your study of dimensions. In addition to following the practices outlined in standards for the formatting of tolerances, you should also be consistent in formatting to improve the appearance and overall clarity of your work.

Tolerancing in AutoCAD

Before you begin your study of Chapter 14, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Tolerancing in AutoCAD**. Although this chapter has only one video, don't overlook it. In fact, since the video is only a few minutes long, you may want to view it several times.

In the same way that the chapter on tolerances was related to the chapter on dimensioning, you'll now see that the AutoCAD tolerancing functions are also connected to the AutoCAD dimensioning. In fact, the Tolerancing tab in AutoCAD is a feature of the Dimensions Style Manager that you learned about and used when you added dimensions to your AutoCAD drawings.

There aren't a lot of new steps in this process, and there is no video content on your DVD for the tutorial in the book. If you have a good grasp of the dimensioning process from the previous lesson, this should be one of the easier practices for you to learn.

Graded Project Reminder

This is a good point in the course to remind you about the status of the required drawings that you'll be asked to submit at the end of this lesson. Almost every student who has learned technical drawing has procrastinated when it comes to completing their drawings. The graded project represents a significant amount of work, and there may be a tendency to put that work off for another day.

Remember: At the end of Lesson 3, you'll submit a series of eight drawings as AutoCAD files. You've covered enough course material to have made significant progress on the required drawings for Chapters 4, 8, and 10. You don't need to be 100 percent complete at this point, but you should be well underway.

So, just to review, you should be working on the following five problems at this point: P4-12, P4-17, P8-17, P8-20, and P10-8. You can delay the next set of reading assignments in order to get caught up on these drawings. It's important that you continue to develop the stages of your actual drawing skills, and not try to cram the process together as you near the end of your studies.



Self-Check 6

For Chapter 13, complete the “Tolerancing Questions” on pages 13-27 through 13-30. Then, complete the “Tolerancing Problems” P13-1, P13-2, P13-3, and SP13-1 on pages 13-31 through 13-39.

For Chapter 14, complete the “Tolerancing in AutoCAD Questions” on page 14-7. Then complete the “Tolerancing in AutoCAD Problems” P14-1, P14-4, and P14-5 on pages 14-9 and 14-10.

When you’ve completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal. (Note: The solution for SP13-1 is available in the independent learning material that’s included in the material you downloaded.)

SECTION 3.3

Read the following section. Then read Chapters 15 and 16 in your textbook.

The next topic in your study of technical drawing and AutoCAD applications is threads and fasteners (predominantly, threaded fasteners). Until you’re in a position to specify nuts and bolts and define threads for various applications, you won’t appreciate the amount of detail and precision that’s involved in drawing screw threads.

In addition to the threads themselves, you’ll often need to plan for and account for methods that conceal the fastener head, such as counterbores and countersinks. Once you learn the fundamentals of threads, you’ll learn how to draw both internal and external threads using AutoCAD. You’ll also learn how to draw nuts and bolt heads, and how to save those drawn components as blocks for future use.

Threads and Fasteners

Before you begin your study of Chapter 15, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Threads & Fasteners**. In the box at the left you'll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

At first glance, Chapter 15 might seem light in terms of content. However, you'll find as you complete your readings and the related exercises that there's a lot of important information packed into this portion of your assignment. Despite the amount of material you'll cover, this chapter only starts to scratch the surface of the whole range of fasteners that you might encounter in technical drawings. The content focuses on threads and threaded fasteners because you'll encounter threads in various formats in a great many drawings and design projects. There's also a focus on threaded fasteners because there's a greater level of detail found in specifications for threads and related fasteners than for most other types of fastening devices.

Thread Terminology

You'll find a lot of terminology that's related to threads in the first few pages. Some of the terminology will be commonplace in all drawing specifications related to threads, such as the *major* and *minor diameters* and the *pitch of the thread*. Some of the terminology will be used only if the thread needs to be machined as part of the manufacturing process, rather than simply being purchased. To fully understand the detailed elements of the thread, take the time to complete the interactive exercises available through the independent learning material (and presented in your textbook).

Also, don't overlook the descriptions and visual representations of the different types of threads. While *unified* and *metric* will be the most common, you'll also encounter *square*, *ACME*, and *buttress* threads. It's useful to be able to visualize the shape and application of these various threads if they occur on a drawing.

Manufacturing Screw Threads

The short paragraph on the manufacturing of screw threads (page 15-5) is very important information. You need to understand the basic techniques for drilling and tapping internal threads, and how threads are cut for external threads. This information is almost always required on engineering drawings, and it could be your job to specify these details properly.

If you're lucky enough to have a machine shop at the facility where you work, it's well worth your time to consult with the machinists when you need to specify threads and threading operations on a drawing. They'll not only know the exact process involved, but they'll also have great input on how to locate and display the specifications to communicate the information effectively.

Representing Threads on a Drawing

Once you understand the basic terminology and construction of threads, you'll then need to know how to represent them correctly on a drawing. This is another area of technical drawings in which the art form of hand-drawing threads has given way to simplified schematic formats that are easier and faster to draw and that lend themselves to computer drafting. Much of the need-to-know information about these threads will be found in the specifications and thread notes. Your textbook correctly points out that once you become accustomed to simple formats, you'll see a thread and understand the requirements. This is the main purpose of the drawing.

Unified and Metric Threads

The textbook devotes most of the instruction in this chapter to unified and metric threads, and these are the thread types that you'll encounter most often. Thread information is almost always displayed at the end of a leader line in much the same fashion as a drawing note. Your text shows the full detail of the thread specification, but as is noted in the reading, you would normally use only the first three elements of the specification. So, for a unified thread, you would typically use 1/4-20 UNC and for metric M10 × 1.5.

Nuts, Bolts, and Clearances

The drawing of nuts and bolts is accomplished by combining basic geometric constructions. You would probably use a template (or a combination of templates) if you were drawing nuts and bolts by hand.

The final topic of this chapter covers clearance holes, as well as countersink and counterbore clearances. This information falls into the category of essential content, because you'll often have to specify these details based on information from the designer. The textbook provides good practice in using references by including ASME standards in the appendix section at the end of your book.

Due to the depth of content that this chapter tries to cover, you should make every effort to work through all of the additional material and exercises in the independent learning material. The multiple visual aids will enhance your understanding of this important topic.

Drawing Threads in AutoCAD

Chapter 16 has no videos in the independent learning material.

Chapter 16 doesn't contain much new information in terms of AutoCAD features or techniques. As you might have guessed from the chapter on threads, you'll use the simplified thread representation for the threads you draw in the exercises in this chapter. You'll also draw a hex bolt and nut, which relies almost entirely on a series of basic geometry commands.

One thing that's new and worth some investigation in this chapter is the *Mechanical Tool* palette. AutoCAD contains an extensive collection of pre-drawn objects that can often be used as-is or with minor modifications. This might also be an opportunity for some Internet research that could yield time-saving dividends. There are often user's groups that are willing to share objects that members have drawn. In other cases, vendors and manufacturers sometimes have stock collections of their components available as drawn objects in the **.dwg** format. When suppliers have drawn objects, not only do you get access to the drawing, but in almost every case, you'll also find detailed specifications that can be used to fill in gaps in your specifications. The usual Internet rules apply: make sure that the content is identified as royalty-free, be careful to scan files for computer viruses, and pay attention to the scale and dimensions that might be used on objects you obtain as free downloads.

If you do need to create drawings for items like bolts and nuts and standard threads, remember that you can save them as objects to your tool palette under a file name that describes what you've drawn. Over time, you'll create a library of objects that you'll be able to use to save significant time on future drawings.



Self-Check 7

For Chapter 15, complete the “Thread and Fastener Questions” on pages 15-27 through 15-30. Then, complete the “Thread and Fastener Problems” P15-1, P15-2, P15-3, P15-5, P15-7, P15-10, SP15-1, SP15-2, SP15-7, and SP15-10 on pages 15-31 through 15-41.

For Chapter 16, complete the “Drawing Threads in AutoCAD Problems” P16-1, P16-2, P16-3, and P16-4 on page 16-11.

When you’ve completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal. (Note: The solutions for SP15-1, SP15-2, SP15-7, and SP15-10 are available in the independent learning material that’s included in the material you downloaded.)

GRADED PROJECT FOR LESSON 3

SUBMITTING YOUR REQUIRED DRAWINGS FOR GRADING

It's now time to submit your set of required drawings to the school for evaluation and grading. The eight AutoCAD drawings you need to submit are listed below for your review.

| Drawing Topic | Problem Number | Textbook Page |
|-------------------------|----------------|---------------|
| Orthographic Projection | P4-12 | 4-58 |
| Orthographic Projection | P4-17 | 4-62 |
| Dimensioning | P8-17 | 8-49 |
| Dimensioning | P8-20 | 8-52 |
| Sections | P10-8 | 10-24 |
| Tolerancing | P14-2 | 14-9 (18-15) |
| Tolerancing | P14-6 | 14-10 (18-21) |
| Threads | P16-4 | 16-11 (18-20) |

When you're sure that you've completed each drawing to the best of your ability, prepare the drawings for submission using the school's online exam system, which is located on your **student portal**. In order to assure that your drawings are properly received and evaluated by your instructor, follow these instructions:

1. Submit only AutoCAD drawings and files (with the **.dwg** extension) for this assignment. Do *not* submit scans of mechanical drawings, and do *not* mail mechanical drawings to the school.
2. Save each drawing using the problem number and your eight-digit student number in this format:

P4_12_XXXXXXXX

3. If possible, create one zip file that contains all eight drawing files, and save the zip file with the exam number and your student number in this format:

49981000_XXXXXXXX

If you can't create a zip file, the exam system will allow you to attach the eight drawing files separately.

4. When you're ready to submit your drawings, go to the student portal and click the **Take Exam** button for exam number **49981000**. A dialog box will then become available with instructions for attaching the drawing files.
5. Use Table 1 as a guide as to the way in which your drawings will be evaluated. The total number of points possible for each drawing is 100, and your scores for the eight drawings will be averaged to obtain your grade for this lesson.

Table 1—Grading Rubric—49981000

| Required Drawings, Autocad Applications: Engineering Technology | | | | | | | | | |
|--|-------------------------|-------------------------|---------------|---------------|-------------------------|---------------|---------------|---------------|---------------|
| Topic | Orthographic Projection | Orthographic Projection | Dimensioning | Dimensioning | Sections | Tolerancing | Tolerancing | Tolerancing | Threads |
| Problem | P4-12 | P4-17 | P8-17 | P8-20 | P10-8 | P14-2 | P14-6 | P16-4 | |
| | Dimensions not Required | Dimensions not Required | | | Dimensions not Required | | | | |
| Grading Considerations | Points/Actual | Points/Actual | Points/Actual | Points/Actual | Points/Actual | Points/Actual | Points/Actual | Points/Actual | Points/Actual |
| Drawing Submitted as .dwg file | 5/ | 5/ | 5/ | 5/ | 5/ | 5/ | 5/ | 5/ | 5/ |
| Drawing has appropriate title block and border | 15/ | 15/ | 5/ | 5/ | 5/ | 5/ | 5/ | 5/ | 5/ |
| Correct views selected and created in proper positions; all required features/lines are included | 25/ | 25/ | 10/ | 10/ | 15/ | 10/ | 10/ | 10/ | 10/ |
| Correct line types used; proper technique/rules followed for line types | 25/ | 25/ | 15/ | 15/ | 10/ | 10/ | 10/ | 10/ | 10/ |
| Correct linewidths used | 15/ | 15/ | 10/ | 10/ | 5/ | 5/ | 5/ | 5/ | 5/ |
| Lineweights and line types on appropriate AutoCAD layers; Construction lines, etc., not visible | 15/ | 15/ | 10/ | 10/ | 10/ | 10/ | 10/ | 10/ | 5/ |

Table 1—Grading Rubric—49981000 Continued

| Topic | Orthographic Projection | Orthographic Projection | Dimensioning | Dimensioning | Sections | Tolerancing | Tolerancing | Threads |
|---|--------------------------------|--------------------------------|---------------------|---------------------|-----------------|--------------------|--------------------|----------------|
| Dimension lines and leader lines used correctly | N/A | N/A | 10/ | 10/ | N/A | 10/ | 10/ | 10/ |
| Dimensions positioned correctly and dimensioning rules applied correctly | N/A | N/A | 15/ | 15/ | N/A | 10/ | 10/ | 15/ |
| Dimension symbols and text used correctly; dimension rounded per rules | N/A | N/A | 15/ | 15/ | N/A | 10/ | 10/ | 15/ |
| Dimensions applied to correct layers | N/A | N/A | 5/ | 5/ | N/A | 5/ | 5/ | 5/ |
| Section lines and cut lines applied correctly | N/A | N/A | N/A | N/A | 10/ | N/A | N/A | N/A |
| Section shows correct detail; section lines fill correct drawing elements | N/A | N/A | N/A | N/A | 20/ | N/A | N/A | N/A |
| Correct line types, weights, and hatch pattern applied | N/A | N/A | N/A | N/A | 20/ | N/A | N/A | N/A |
| All dimensions tolerated per text instruction | N/A | N/A | N/A | N/A | N/A | 20/ | 20/ | 15/ |
| Total Points Possible | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Total Points Earned (Each Drawing) | | | | | | | | |
| Average – 8 drawings (Exam Grade) | | | | | | | | |

LESSON 4: ASSEMBLY AND PICTORIAL DRAWINGS

Lesson 4 contains the final set of reading assignments and some new material for this course on AutoCAD applications for engineering technology. You've learned a lot about the language of technical drawing and how to make your communications more efficient and easy to execute using AutoCAD software. There are a few more important topics to cover in this lesson before you move on to the final drawing project and the completion of this course.

In this lesson, you'll learn a few more components and drawing techniques that you'll need to be fully fluent in technical drawing, followed by the AutoCAD adaptations of those drawing elements. First, you'll learn about *assembly drawings* and how to collate detailed drawings into a complete specification package. The final drawing topic for this course is *pictorial drawings* and how to create visuals that appear 3-D by using *isometric drawing techniques*.

LESSON OBJECTIVES

When you complete this lesson, you'll be able to:

- Create assembly drawings, including appropriate drawing details, parts lists, and bills of materials
- Create isometric pictorial drawings as both traditional and AutoCAD drawings

SECTION 4.1

Read the following section. Then read Chapters 17 and 18 in your textbook.

Throughout this course, we've discussed technical drawing in terms of learning a new language. That comparison continues to work well for this next assignment on assembly drawings. Consider that what you've learned to date about engineering graphics is similar to learning individual words, phrases, and sentence structure in a new language. Now, you're ready to assemble those words, phrases, and sentences into whole paragraphs and into a complete communication that can be used to share information with others. Think how word-processing software (such as Microsoft Word) makes the process of written communication easier by automating, collating, page numbering, and modifying your documents. In the same way, AutoCAD makes the process of assembling technical drawings easier to execute and manage.

Assembly Drawings

Before you begin your study of Chapter 17, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Assembly**. In the box at the left you'll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

The assembly drawing and the working drawing package are the final stages of building a set of specifications. The detailed drawings show the specifications for each part that are required to build some device. Now, you need to communicate how those individual parts come together, and you need a structure to share information about the descriptions and quantities of each part. In real-life execution, the assembly drawing may not always be the last step in the process. There will be many cases in which it's easier to start by creating the assembly drawing, and then using that as your guide to create all of the detailed drawings for the individual parts.

Bill of Materials

There's very little to learn in this chapter in terms of new drawing techniques. You'll be using a *balloon* (a circle at the end of a leader line) as a means to identify a part and tie that identification to a *parts list*, or *bill of materials* (BOM). You'll see the basic structure of the parts list, or BOM, on the drawings. The location and format of a BOM are two drawing components that you'll find to be very specific to each individual business or field. However, the basic structure is always similar, and you just need to make sure that you follow the required protocols for your particular situation when creating one.

Even though the bill of materials is often one of the last components of a drawing you'll create, it's also one of the most important. The bill of materials is the document that the rest of the manufacturing operation will use to purchase and requisition the materials needed to manufacture the object that's been drawn. Mistakes on the BOM are often the cause of delays, rework, materials that need to be returned to inventory, and other situations that the manufacturing team wants to avoid.

Finishing Touches

What remains are the standard rules for the selection of views, the location of balloons, and the organization of the working drawing package. You'll see that many of these decisions are left up to the creator of the drawing. In terms of using the minimum number of dimensions to accurately communicate the way to build the part, and the same holds true for assembly drawings. You want to use the fewest number of views, hidden lines, and

dimensions that you can to provide a complete story to the intended audience. Thinking about language again, it's like writing a good business letter or email: a simple and clear message always provides the best communication.

Pay attention to the concept of *drawing order* and the components you'll need to assemble in order to have a complete working drawing package. This will be part of the requirements for your final project. Your text refers to a standard *parts sheet*, which is used to list standard items like machine screws, nuts, washers, and so on that aren't drawn, but still must be available to assemble the device. A standard parts sheet is one approach, but if there aren't a great many standard parts in the object and if the specifications aren't too complicated, they can also be identified with a balloon on the assembly drawing, and the purchasing information can be added to the bill of materials.

At this point, even though it's late in your course, don't forget to check out the content on assembly drawings found on your DVD.

Creating Assembly Drawings in AutoCAD

Before you begin your study of Chapter 18, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Creating Assembly Drawings in**

AutoCAD. There is one video available for Chapter 18, along with a link to the file you'll need to complete the tutorial in Chapter 18.

Creating the Assembly Drawing

In the previous section on assembly drawings, you learned that in some instances you might actually create the assembly drawings first and work back to the detailed drawings. In Chapter 18, you'll learn that computer drafting lends itself better to the process of creating the detailed drawings *first*. Once the detailed drawings exist, you can use commands like **Copy**, **Move**, and **Mirror** to quickly create your assembly drawings.

Chapter 18 will also add to your knowledge of the dimensioning features of AutoCAD, and the multileader style manager that can be used to add balloons to your drawings. The final topic of this chapter will walk you through the development of the parts list. As you create the parts list, keep in mind that you'll want to save these elements as part of your object library for reuse.

The video for this chapter is very helpful in demonstrating how to move pieces into their functional positions, how to erase lines, and how to add balloons.

Exploring AutoCAD on Your Own

Remember to explore AutoCAD on your own. There are a great many features of AutoCAD that simply can't be covered in this introductory course. There are also a number of learning aids built into AutoCAD that can help you with the exploration process. *AutoDesk Help* is an easy-to-use search tool that you can access by clicking the question mark icon on your main menu, or by pressing F1 on your keyboard. *Help* is basically a user's manual for the software that's stored on your hard drive during installation. You should also check out the DesignCenter feature of the software, which contains a large library of pre-drawn objects for reuse. *DesignCenter* also contains a command called **Seek**. This is an Internet-based tool that can be used to locate additional objects to add to your collection. One tool in AutoCAD that is also worth some investigation is the *Sheet Set Manager*. This functionality helps to assemble sets of drawings into managed collections. This is a very useful tool for creating working drawing packages.



Self-Check 8

For Chapter 17, complete the “Assembly Questions” on page 17-17. Then, complete the “Assembly Problems” P17-1 and 17-3 on pages 17-19 and 17-31 through 17-37.

For Chapter 18, complete the “Assembly Drawings in AutoCAD Problems” P18-1 on pages 18-13 through 18-16.

When you've completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal.

SECTION 4.2

Read the following section. Then read Chapters 5 and 6 in your textbook.

Congratulations on reaching this final assignment in your course! Learning to create technical drawings and engineering graphics requires dedication and great focus. You should be proud of your efforts. If you've completed all of the drawing problems assigned, you should now be confident in your ability to generate drawings that can be used to communicate complex technical specifications. Take the time to review all of the drawings you created, and be proud of the skill that you've developed as a result.

This final assignment covers pictorial drawings and, specifically, isometric drawings. *Isometric drawings* create an illusion of three dimensions that allow the user to visualize what the drawn object actually looks like. When drawings were created before computers and AutoCAD, isometric drawings might have been the most artistic element of the drawing process, and each draftsman developed his or her own enhancements to the mechanical process to help bring life and depth to the drawing.

Pictorial Drawings

Before you begin your study of Chapter 5, open your independent learning material. At the home page, click on **Engineering Graphics Content** and then **Pictorials**. In the box at the left you'll see a list of supplementary materials for each of the major sections in the chapter. As you get to each topic in your study, take the time to access these valuable resources.

Remember: All of the exercises in the textbook are available with immediate feedback in the independent learning material.

What Are Pictorial Drawings?

Chapter 5 begins with an introduction to the three types of pictorial drawings: axonometric, oblique, and perspective. After a brief definition of these drawings, the text illustrates and clearly describes each one. Here is a brief description of these three types of pictorial drawings:

- An *axonometric projection* is one in which the projectors are perpendicular to the plane of projection and parallel to each other.
- In an *oblique projection*, the projections are not perpendicular to the plane of projection but they are parallel to each other.
- In a *perspective projection*, the projectors converge to a point of sight, called the vanishing point.

There's really nothing new about the actual drawing process. You're simply using visible lines along fixed angles that add the appearance of depth to a drawing. If you talk to technicians who learned board drafting techniques before AutoCAD, they're likely to tell you that isometric drawings were one of those parts of the process that looked much harder than it actually turned out to be.

Drafting Tools

If you assembled some drafting tools, this is where you'll use the 30-60-90 triangle and ellipse template. As you'll see demonstrated in your text, you build construction lines that form a box at the maximum dimensions of your object using 30° angles. Then, it's a simple matter of drawing the lines to scale that exist on the lines of the box, and connecting points for the lines that don't exist on the lines. An ellipse (or parts of an ellipse) is used to create the correct visual effect for circular objects.

If you didn't invest in some basic drafting tools, there are graph paper variations that are designed specifically for different perspective drawings. Thanks to modern technology, you can download a printout of each variation that you might find helpful (usually at no charge). One website that provides these downloads is www.printablepaper.net. If for some reason you can't access this particular site, a quick Internet search for *perspective graph paper* will give you more options.

Exploded views

Your textbook very briefly mentions *exploded views* of drawings. This is an interesting technique that expands on isometric drawing skills to create a visual that provides great detail on how parts fit together in an assembly. Basically, an exploded view is an isometric version of an assembly drawing. Take the time to experiment, and you'll find that it's not that difficult to create such a drawing. You just need to expand the box to allow for how far you'll expand the parts in the exploded view.

Creating Pictorial Drawings in AutoCAD

Before you begin your study of Chapter 6, open your independent learning material. At the home page, click on **AutoCAD Content** and then **Creating Isometric Pictorials in AutoCAD**. There is one video available for Chapter 6.

Chapter 6 in your textbook walks you through the features and commands that, like all of the other features of AutoCAD, greatly simplify the process of creating isometric drawings. You'll activate an option of the **SNap** command that instructs AutoCAD to apply

the elements that you've drawn along the isometric axis. Similarly, you'll use **ISOCIRCLE** as an option of the **ELLIPSE** command to generate the ellipses necessary for circular elements of the drawing.

Another valuable modification to some tools you've used throughout this course is the ability to modify the layout of the drawing grid so that it's in line with the isometric axis. This is essentially the computer equivalent of isometric graph paper. Remember to set your polar tracking to 30° when you're working on isometric drawings.

Chapter 6 has two important tutorials. Be sure to watch the video associated with this chapter before you begin the tutorials. When you complete this chapter, you should be ready to review for the multiple-choice examination and to begin work on your final graded project. Remember that the material in the examination includes information from both Lesson 3 and Lesson 4.



Self-Check 9

For Chapter 5, complete the “Pictorial Drawings Questions” on pages 5-39 and 5-40. Then, complete the “Pictorial Drawings Problems” P5-1 through P5-5, P5-8, and SP5-2 on pages 5-41 through 5-61.

For Chapter 6, complete the “Creating Pictorials in AutoCAD Questions” on page 6-12. Then complete the “Creating Pictorials in AutoCAD Problems” P6-1, P6-2, and P6-5 on pages 6-14 through 6-18.

When you've completed the exercises, check your answers against those provided in the Solutions Supplement attachment on your student portal. (Note: The solution for SP5-2 is available in the independent learning material that's included in the material you downloaded.)

FINAL GRADED PROJECT

Assembly Drawing, Working Drawing Package, and Pictorial

Your final requirement for this course is to create another set of drawings that demonstrate the technical drawing expertise you've gained. For this final graded project, you'll be creating a full working drawing package that includes a pictorial, an assembly drawing, a full set of detailed drawings, and (if required) a standard parts sheet. You'll create your drawing set in AutoCAD, so you'll be able to demonstrate your skills and knowledge of AutoCAD as well.

Before you begin to work on this final project, carefully read through all of the information and requirements, including the grading rubrics in Table 3 on pages 49-52 of this study guide.

Project Requirements

Your assignment is to create a set of drawings for a desktop basketball game. You've been given a rough sketch of the desktop basketball game in Figure 1, and the parts descriptions are described in Table 2. This version of the game will be offered at a higher-end price point, so the basic construction will use brass and a walnut wood laminate for the shooting arm.

Table 2

Tabletop Basketball Parts Descriptions

- 1) Court/Base: $\frac{3}{4}$ " thick, 4.50" wide, 10.00" long, chamfer 45° all around, break bottom edge, all around. Drill and tap, blind hole to mate with threaded end of the backboard post. Drill 2 sets of 10 evenly spaced holes for scoring pins, pins should fit snug, but easily extracted. Counterbore 2 places, and appropriate through hole for socket head cap screws to mount shot-arm mounting block.
- 2) Backboard post: $\frac{7}{16}$ " diameter brass rod, length TBD based on thread length, each end for mounting to court/base and to backboard. 8.00" from court surface to bottom of backboard. Refer to Bolt Depot.com for drawing exact dimension of tread at end of brass rod.
- 3) Backboard: Maximum dimensions $\frac{3}{4}$ " thick, 4.12" W \times 5.75" L, 2.87" diameter radius for top curve; 4.50" flat at bottom, arc to meet top curve. Drill and tap center line on bottom to accept threaded portion of backboard post; counterbore and drill through holes for 2 socket head cap screws to mount rim to backboard. *Note:* 2" wide \times 1.625 rectangle (inside dimensions), milled rectangle on backboard surface above rim.
- 4) Rim: $\frac{1}{2}$ " thick, 2.50 \times 2.50 maximum dimensions; 1.25" diameter through hole center line 1.25" from back edge (mounting surface for backboard), 1.25" radius for front curve of rim, outside edge of rim is fully rounded, inside edge of through hole is fully rounded, drill and tap 2 holes for socket head cap screws to mount rim to backboard.
- 5) Shot arm mounting block: $\frac{7}{16}$ " thick, taper to $\frac{3}{8}$ " thick, 2.12" long, 1.00" wide, drill and tap bottom, for 2 socket head cap screws to mount to court/base, drill and tap, counter sink 1 hole on top for mounting shot arm.
- 6) Score pins: $\frac{5}{16}$ " diameter rod, top of pin $\frac{5}{16}$ ", plus pin length $\frac{3}{8}$ " long, turned to approximately $\frac{3}{16}$ " diameter (specify diameter of pin to match drilled scoring holes in court/base)
- 7) Shot arm: $\frac{1}{16}$ " thick wood laminate, 1.62" wide, 6.12" long, tapered .87 at end that connects to mounting block, 1.62" wide at ball/shot end, $\frac{7}{8}$ " diameter through hole; $\frac{13}{16}$ " radius curved end (ball end), .87" radius curved end at mounting end; drill through hole and counter sink for pan head machine screw to mount arm to base.

Bottom diameter of mount screw = 0.12 inch

Top diameter of mount screw = 0.07 inch

Diameter of screw thread = 0.03

- 8) Give a fillet off 0.12" to the edges of backboard and base mount.

Notes:

All parts are brass, unless otherwise noted.

All dimensions are in inches.

Student is responsible for determining and specifying mounting hardware, thread size, and length for backboard post.

Sketch provides basic dimensions as a guideline; student may need to determine other dimensions from the information given. Student is responsible for accurate dimensions and appropriate tolerances. Do not base position of dimensions or tolerances on the sketch; they are for reference only.

Based on the sketches and specifications provided, create a full working package of drawings that would be suitable for the manufacture of the project specifications. The basic dimensions and construction specifications are provided, but you'll have to determine the needed dimensions from the information provided. You'll also need to complete some of the design work related to thread sizes and assembly hardware. You must create a section view for the backboard and rim assembly that shows the detail of the rim shape, and the assembly details connecting the rim to the backboard. In order to receive full credit for the assignment, your drawings must be prepared and formatted as follows:

1. All drawings must be created in AutoCAD and submitted as files in the .dwg format. Do not submit scans of mechanical drawings, and do not mail mechanical drawings to the school.
2. All drawings must have a border and an appropriate title block. The title block data must be complete.
3. The assembly drawing and bill of material should be 11" × 17".
4. The pictorial drawing should be 11" × 17".
5. The individual detailed drawings for each part and the standard parts sheet should be 8 ½" × 11".
6. The drawings should follow the dimensioning, tolerancing, and basic drafting rules described in your textbook.
7. Notes and other specifications should be checked for correct spelling and dimensional accuracy.
8. All drawing components, line types, and so on must be on appropriate AutoCAD layers as identified in your textbook readings.
9. The drawing assembly should be as follows: isometric pictorial, assembly drawing, detailed drawings (in order per the assembly drawing), and standard parts sheet (if required).

Final Graded Project Submission

If possible, create one zip file that contains all of the drawing files, and save the zip file with the exam number and your student number in this format:

49981200_XXXXXXXX

If you can't create a zip file, the exam system will accept multiple file attachments separately. If you're sending multiple file attachments, name each separate file with the exam number, the sheet number, and your student number in this format:

49981200_1_XXXXXXXX

When you're sure that you've completed the entire assignment and you're ready to submit your drawings, go to the student portal and click the **Take Exam** button for exam number 49981200. A dialog box will then become available with instructions for attaching the drawing files.

Assessment Criteria

The school will use the basic criteria outlined in Table 3 to evaluate your final project. You can earn a total of 20 points each for 5 major requirements category, for a total of 100 points. The details below each major category list specific drawing elements, construction techniques, and the rules and standards that the instructor will consider for each category.

| Table 3—Grading Rubric—49981200 | | | | | |
|---|--------|--------------------|---------------------|------------------------|---------------------|
| Final Project—AutoCAD Applications for Engineering Technology | | | | | |
| Required Drawing Elements and Objectives | | Fully Demonstrated | Mostly Demonstrated | Partially Demonstrated | Poorly Demonstrated |
| | Points | 20–18 | 17–16 | 15–14 | 13–0 |
| Grading Considerations | | | | | |
| Drawing Organization and Format | 20 | | | | |
| Full set of drawings per requirements | | | | | |
| Border and title blocks on all sheets | | | | | |
| Title block information complete and accurate | | | | | |
| Drawings submitted as .dwg files | | | | | |
| Correct sheet sizes used | | | | | |
| Proper CAD layers used for all drawing elements | | | | | |

(Continued)

Grading Rubric—49981200 (Continued)

Grading Considerations

| | | | | | |
|---|----|--|--|--|--|
| Orthographic Projection | 20 | | | | |
| Detailed drawings submitted for each part | | | | | |
| Detailed drawings use proper orthographic projection techniques | | | | | |
| Correct line types and lineweights | | | | | |
| All object features hidden and visible included on drawings | | | | | |
| Dimensions, Tolerancing, Specifications | 20 | | | | |
| Dimensions complete and accurate | | | | | |
| Dimension lines organized per text requirements | | | | | |
| Dimensions positioned per rules; proper places after decimal | | | | | |
| Tolerances provided where required | | | | | |
| Tolerances applied per text readings | | | | | |

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Grading Rubric—49981200 (Continued)

Grading Considerations

| | | | | | |
|--|---------|--|--|--|--|
| Dimensions, Tolerancing, Specifications | (Cont.) | | | | |
| Threads and fasteners identified and specified correctly | | | | | |
| Through-holes, counterbores, countersinks accounted for, identified, shown on drawings | | | | | |
| Notes and text specifications spelling, layout, format accurate | | | | | |
| Assembly Drawing, Section, BOM | 20 | | | | |
| All parts and necessary views used in assembly drawing | | | | | |
| Balloons and leaders aligned, accurate, match BOM | | | | | |
| Parts accurately identified on drawing and BOM | | | | | |
| Section drawing including, proper sectioning technique, correct hatch pattern used | | | | | |
| Standard parts sheet submitted, or standard parts identified on BOM and assembly | | | | | |

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Grading Rubric—49981200 (Continued)

Grading Considerations

| | | | | | |
|---|----|--|--|--|--|
| Isometric Pictorial | 20 | | | | |
| Complete assembly pictured | | | | | |
| Correct isometric technique and positioning | | | | | |
| | | | | | |
| Total Points Earned | | | | | |