Disclaimer Statement

Contributions of many individuals and from written resources have collectively made this curriculum guide possible. The major authors, however, do not claim or guarantee that its contents will eliminate acts of malpractice or negligence. The responsibility to adhere to safety standards and best professional practices is the duty of the practitioners, teachers, students, and/or others who apply the contents of this document.

This guide was developed with federal Carl Perkins Act funds.

2003
Career-Technical Education
North Carolina Department of Public Instruction

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This course introduces students to the use of simple and complex graphic tools used to communicate and understand ideas and concepts found in the areas of architecture, manufacturing, engineering, science and mathematics. Topics include business meeting skills and goal setting strategies, classical representation methods such as sketching, geometric construction techniques, CAD, orthographic projection, and dimensioning.

Skills in communication, mathematics, science, leadership, teamwork, and problem-solving are reinforced in this course. Job shadowing is an appropriate work-based learning strategy for this course. Hands-on work experience and SkillsUSA leadership activities provide many opportunities to enhance classroom instruction and career development. (Note that 3-D Solid Modeling has been added to the curriculum).

This curriculum was developed as a resource for teachers to use in planning and implementing a competency-based instructional management drafting program in their school. These materials are tools used in the curriculum management process. Included are specific learning objectives, recommended activities, performance assessments, equipment list, facility specifications, a bibliography of reference media, and the names and addresses of media vendors.

It is our goal to provide the children of our state education of the highest quality. As this guide reflects our goal of continuous improvement, we encourage you to communicate to us ways to improve the material within this publication. Your suggestions will be welcomed and appreciated.

Michael E. Ward, State Superintendent
# TABLE OF CONTENTS

## SECTION I

<table>
<thead>
<tr>
<th>Foreword</th>
<th>. . . . . . . . . . . . . .</th>
<th>iv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgments</td>
<td>. . . . . . . . . . . . . .</td>
<td>vi</td>
</tr>
<tr>
<td>Using the Curriculum Materials</td>
<td>. . . . . . . . . . . . . .</td>
<td>vii</td>
</tr>
<tr>
<td>Course Blueprint</td>
<td>. . . . . . . . . . . . . .</td>
<td>x</td>
</tr>
</tbody>
</table>

## SECTION II – UNITS OF INSTRUCTION

<table>
<thead>
<tr>
<th>Unit I</th>
<th>Leadership Development</th>
<th>. . . . . . . . . . . . . .</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit II</td>
<td>Sketching</td>
<td>. . . . . . . . . . . . . .</td>
<td>15</td>
</tr>
<tr>
<td>Unit III</td>
<td>Basic Drafting Skills</td>
<td>. . . . . . . . . . . . . .</td>
<td>26</td>
</tr>
<tr>
<td>Unit IV</td>
<td>Basic Geometric Terms and Construction</td>
<td>. . . . . . . . . . . . . .</td>
<td>35</td>
</tr>
<tr>
<td>Unit V</td>
<td>Multiview Drawing</td>
<td>. . . . . . . . . . . . . .</td>
<td>42</td>
</tr>
<tr>
<td>Unit VI</td>
<td>Basic Dimensioning Skills</td>
<td>. . . . . . . . . . . . . .</td>
<td>51</td>
</tr>
<tr>
<td>Unit VII</td>
<td>Computer-Aided Design and Drafting (CAD)</td>
<td>. . . . . . . . . . . . . .</td>
<td>60</td>
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## SECTION III - APPENDICES

<table>
<thead>
<tr>
<th>A.</th>
<th>Bibliography / References</th>
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</tr>
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<tbody>
<tr>
<td>B.</td>
<td>Vendor's Addresses for Texts, Literature, Software and Films</td>
<td>. . . . . . . . . . . . . .</td>
<td>78</td>
</tr>
<tr>
<td>C.</td>
<td>Equipment List</td>
<td>. . . . . . . . . . . . . .</td>
<td>79</td>
</tr>
<tr>
<td>D.</td>
<td>Facility Design.</td>
<td>. . . . . . . . . . . . . .</td>
<td>80</td>
</tr>
<tr>
<td>E.</td>
<td>Curriculum Products Evaluation Form</td>
<td>. . . . . . . . . . . . . .</td>
<td>84</td>
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</table>
ACKNOWLEDGMENTS

The Division of Instructional and Accountability Services and the Trade and Industrial Education staff wish to give special thanks to the individuals who spent many hours revising the Drafting I curriculum and test-item bank. The process included a review of international literature, review of suggestions offered by teachers and administrators from throughout the state, and many hours spent in constructive discussion and development.

The following individuals developed the Summer 2003 Drafting I blueprint, curriculum guide and classroom test-item bank:

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ted Branoff</td>
<td>Professor</td>
<td>NCSU</td>
</tr>
<tr>
<td>Gilbert Blaylock</td>
<td>Drafting Teacher</td>
<td>North Vance High School</td>
</tr>
<tr>
<td>David Lambert</td>
<td>Drafting Teacher</td>
<td>Northwest Guilford High School</td>
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<tr>
<td>Robin Migliorato</td>
<td>Drafting Teacher</td>
<td>New Bern High School</td>
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<td>Drafting Teacher</td>
<td>Union County Career Center</td>
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<tr>
<td>Patty Weavil</td>
<td>Drafting Teacher</td>
<td>South Rowan High School</td>
</tr>
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</table>

Previous teams include the following people:

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<thead>
<tr>
<th>Name</th>
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<th>Institution</th>
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<tr>
<td>Tommy Bass</td>
<td>Drafting Teacher</td>
<td>Southern Nash High School</td>
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<td>Gilbert Blaylock</td>
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<tr>
<td>Aaron Clark</td>
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<td>Dennis Fruits</td>
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<td>Bob Hodgin</td>
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<td>Weaver Education Center</td>
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<tr>
<td>Brian Matthews</td>
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<td>NCSU</td>
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<tr>
<td>Mike Metzner</td>
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<td>Southwest Guilford High School</td>
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<tr>
<td>Sandra K. Nato</td>
<td>Drafting Teacher</td>
<td>East Wake High School</td>
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<tr>
<td>Angela Patane</td>
<td>Drafting Teacher</td>
<td>Brevard High School</td>
</tr>
<tr>
<td>Monty Rogers</td>
<td>Drafting Teacher</td>
<td>Erwin High School</td>
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<tr>
<td>Steve Satterwhite</td>
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<td>Chapel Hill High School</td>
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<td>Patty Weavil</td>
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</tr>
<tr>
<td>Eric Wiebe</td>
<td>Professor</td>
<td>NCSU</td>
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</table>

Finally, we extend our thanks to the teachers, directors, and others who have taken their time to critique our progress and offer suggestion during this process. Our work is better for their effort.

Tom Shown      Consultant, Trade and Industrial Education, NCDPI

Rebecca Payne  Section Chief, Industrial Technology and Human Services, NCDPI

June S. Atkinson Director, Instructional Services, NCDPI
USING THE CURRICULUM MATERIALS

Purpose

The *Drafting I Curriculum Materials* was developed as a resource for teachers to use in planning and implementing a competency-based instructional management drafting program in their school. These materials are tools used in the curriculum management process.

Curriculum Guide Description

Drafting I was designed to be a one unit course (135-180 hours of instruction). The following description is from the *North Carolina Vocational and Technical Education Programs of Studies and Support Services Guide*:

This course introduces students to the use of simple and complex graphic tools used to communicate and understand ideas and concepts found in the areas of architecture, manufacturing, engineering, science and mathematics. Topics include business meeting skills and goal setting strategies, classical representation methods such as sketching, geometric construction techniques, CAD, orthographic projection, and dimensioning. Skills in communication, mathematics, science, leadership, teamwork, and problem-solving are reinforced in this course. Job shadowing is an appropriate work-based learning strategy for this course. Hands-on work experience and VICA leadership activities provide many opportunities to enhance classroom instruction and career development. (Note that 3-D Solid Modeling has been added to the curriculum).

General Instruction

Drafting I may be taught using individualized, whole class or small team strategies, or a combination of each. Regardless of the method used, it is essential that the activities reflect the competencies and objectives of this course.

The course demands much from the student and teacher in terms of its complexity and the brevity of time in which the materials are to be mastered. Because of time limitations and the amount of material to be covered, one cannot teach objectives as discrete units of instruction. Objectives must be taught concurrently within the larger context of activities. This allows for the efficient use of time as well as reflecting good pedagogy.

A *Project-Based Authentic Assessment* is included in this curriculum guide. Suggestions for activities are provided with appropriate units to reinforce objective concepts. This project enhances learning and supports problem-solving, teamwork, and communication skills. Creativity in developing individual variations of the *Project-Based Authentic Assessment* will provide students with opportunities for real-world experiences.

Blueprint

The blueprint (See the *Drafting I Blueprint* on the following pages) lists the competencies that the student is to achieve. Competencies are mastered when a student masters the objectives, which make up the competency. Course weight is the degree of importance given to each objective in relation to the entire course of study. This in turn will determine the number of test-items per
objective on any test developed by the state department. For example, on a state pre/post 100 item assessment, a cognitive objective having a value of 10% will have 10 test-items representing that objective.

Units of Instruction

The Units of Instruction section is designed to give the teacher detailed information directly correlated to the blueprint and test-item bank. It attempts to explain in more detail what information or behavior the student is expected to know or do. Unless a student has an individualized education plan, he/she will be expected to become competent in all areas covered within this course at the end of 135-180 hours of instruction. It is important to recognize that Unit sequencing DOES NOT IMPLY SEQUENCE OF INSTRUCTION. Therefore, information within the course should be used as it best fits and makes sense. Using information from a variety of competencies and objectives are used when it is most pedagogically sound.

Leadership Development Unit

Objective 1.01 covers the formal procedures for conducting a meeting. This section is particularly useful to those teachers and students who participate in SkillsUSA-VICA. Objective 1.02 covers information designed to help students develop career goals, planning and job search. Objective 1.03 includes information about careers and opportunities related to engineering and technical graphics.

Sketching Unit

Objective 2.01 introduces students to sketching techniques and the various types of sketches. Objective 2.02 presents concepts and principles of multiview and pictorial sketching. Objectives 2.03, 2.04, and 2.05 are performance activities requiring students to construct isometric, oblique, and multiview sketches. Rubrics are included for performance assessment.

Basic Drafting Skills Unit

Objective 3.01 introduces students to the mechanical tools of drafting. Objective 3.02 covers lettering technique. Objective 3.03 acquaints students with correct drawing procedures and the Alphabet of Lines. Objective 3.04 is a performance activity requiring students to construct a single-view drawing. A rubric is included for performance assessment.

Basic Geometric Terms and Construction Unit

In Objective 3.01, students are introduced to selected geometric terms, definitions, and symbols. Objective 4.02 presents procedures for drawing standard geometric constructions. Objective 4.03 requires students to complete a geometric construction. A rubric is included for performance assessment.

Multiview Drawing Unit

Objective 5.01 covers the concepts and principles of orthographic projection. In Objective 5.02, students deal with visualizing objects and views. Objective 5.03 is a performance activity requiring students to complete a multiview drawing. Rubrics are included for performance assessment of board and CAD drawings.
Basic Dimensioning Skills Unit

In Objective 6.01 & 6.02, students deal with concepts and principles of dimensioning practices. Objective 6.03 requires students to dimension an engineering drawing. Rubrics are included for performance assessment of board and CAD drawings.

Computer-Aided Design and Drafting (CAD)

Objective 7.01 introduces students to CAD. Note that many teachers will have students doing the previously listed activities using CAD tools. Objective 7.02 covers basic 2D CAD commands. Objective 7.03 presents 3D modeling commands and concepts. Note that 3D modeling is new to this course. A large percentage of teachers argued for its inclusion, and advances in industry dictate that students should be knowledgeable in the area of 3D modeling. In Objective 7.04, students are required to construct a 2D CAD drawing. Objective 7.05 requires students to construct a 3D CAD model. Rubrics are included for performance assessment.

Bibliography/References (Appendix A)

This section provides the texts’ author(s), name of the texts, and publishers of the texts listed within the Units of Instruction section.

Vendor’s Addresses for Texts, Literature, and Film (Appendix B)

We have included a partial listing of where and who to contact for obtaining texts, literature, software, and videos.

Equipment List (Appendix C)

The equipment list (updated as of this printing, May 2003), gives the minimum number of tools, equipment, and software necessary for the instruction of Drafting I.

Facility Design (Appendix D)

This is the most recent facility plan. It was drawn by several of our drafting teachers.

Drafting I Curriculum Products Evaluation Form (Appendix E)

Included in this guide is an evaluation form. We sincerely want your thoughtful suggestions for improving the curriculum products. Many of the improvements within this guide and the test-item bank is the result of teachers who have taken the time to make suggestions for improvement. Please take the time to respond to us on ways to improve our work.

Final Comment

If you have any questions regarding any aspect of this course, curriculum guide, test-item bank, equipment, literature, or software needs, please call or write Tom Shown 919.870.3880, tshown@dpi.state.nc.us.
VoCATS
Course Blueprint

Trade and Industrial Education

7921 Drafting I

Public Schools of North Carolina
State Board of Education • Department of Public Instruction
Curriculum and School Reform Services
Division of Instructional Services

Raleigh, North Carolina
Summer 2003

Special thanks to the following educators and business people who reviewed and approved this blueprint for technical content and appropriateness for the industry.

Ted Branoff – NCSU
Gilbert Blaylock – North Vance High School
David Lambert – Northwest Guilford High School
Robin Migliorato – New Bern High School
Sonny Tomberlin – Union County Career Center
Patty Weavil – South Rowan High School
VoCATS Course Blueprint

A course blueprint is a document laying out the framework of the curriculum for a given course.

Shown on the blueprint are the units of instruction, the core competencies in each unit, and the specific objectives for each competency. The blueprint illustrates the recommended sequence of units and competencies and the cognitive and performance weight of the objective within the course.

The blueprint should be used by teachers to plan the course of work for the year, prepare daily lesson plans, construct instructionally valid interim assessments. Statewide assessments are aligned directly with the course blueprint.

For additional information about this blueprint, contact program area staff. For additional information about VoCATS, contact program area staff or VoCATS, Career-Technical Education, Division of Instructional Services, North Carolina Department of Public Instruction, 301 North Wilmington Street, Raleigh, North Carolina 27601-2825, 919/807-3876, email: rwelfare@dpi.state.nc.us.

Interpretation of Columns on VoCATS Course Blueprints

<table>
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<th>No.</th>
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<th>Column information</th>
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<tr>
<td>1</td>
<td>Comp#</td>
<td>Comp=Competency number (two digits); Obj.=Objective number (unique course identifier plus competency number and two-digit objective number).</td>
</tr>
<tr>
<td>2</td>
<td>Unit Titles/Competency and Objective Statements</td>
<td>Statements of unit titles, competencies per unit, and specific objectives per competency. Each competency statement or specific objective begins with an action verb and makes a complete sentence when combined with the stem “The learner will be able to. . .” (The stem appears once in Column 2.) Outcome behavior in each competency/objective statement is denoted by the verb plus its object.</td>
</tr>
<tr>
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<td>Time Hrs</td>
<td>Space for teachers to calculate time to be spent on each objective based on the course blueprint, their individual school schedule, and analysis of students’ previous knowledge on the topic.</td>
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<td>4-5</td>
<td>Course Weight</td>
<td>Shows the relative importance of each objective, competency, and unit. Weight is broken down into two components: cognitive and performance. Add the cognitive and performance weights shown for an objective in columns 4 and 5 to determine its total course weight. Course weight is used to help determine the percentage of total class time that is spent on each objective. The breakdown in columns 4 and 5 indicates the relative amount of class time that should be devoted to cognitive and performance activities as part of the instruction and assessment of each objective. Objectives with performance weight should include performance activities as part of instruction and/or assessment.</td>
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<td>6</td>
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<td>Classification of outcome behavior in competency and objective statements. (C=Cognitive; P=Performance)</td>
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<td>7</td>
<td>Integrated Skill Area</td>
<td>Shows links to other academic areas. Integrated skills codes: A=Arts; E=English Language Arts; CD=Career Development; CS=Information/Computer Skills; H=Healthful Living; M=Math; SC=Science; SS=Social Studies.</td>
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<td>8</td>
<td>Core Supp</td>
<td>Designation of the competencies and objectives as Core or Supplemental. Competencies and objectives designated “Core” must be included in the Annual Planning Calendar and are assessed on the statewide assessments.</td>
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Career-Technical Education conducts all activities and procedures without regard to race, color, creed, national origin, gender, or disability. The responsibility to adhere to safety standards and best professional practices is the duty of the practitioners, teachers, students, and/or others who apply the contents of this document.
## TRADE AND INDUSTRIAL EDUCATION
### COURSE BLUEPRINT for 7921 DRAFTING I
(Recommended hours of instruction: 135-180)

<table>
<thead>
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<th>Comp #</th>
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<td>Construct drawings that require geometric constructions.</td>
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<td>Course Weight</td>
<td>Type</td>
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<tr>
<td>E</td>
<td>MULTIVIEW DRAWING</td>
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<td>005.</td>
<td></td>
<td>Demonstrate orthographic projection techniques and principles as they apply to multiview drawings.</td>
<td>18%</td>
<td>8%</td>
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<td>A/CS</td>
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<td>Explain the concepts and principles underlying the creation of multiview drawings.</td>
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Leadership Development

001.
Demonstrate basic business meeting skills and goal setting

001.01
Demonstrate basic business meeting skills

001.02
Demonstrate personal and organizational goals

001.03
Identify career goals and opportunities related to engineering and technical graphics.
UNIT I: Leadership

Competency: 001.00
Demonstrate basic business meeting skills and goal setting.

Objective: 001.01
Demonstrate basic business meeting skills.

Introduction: The purpose of this unit is to familiarize students with running a basic business meeting, set personal goals, and identify career goals and opportunities related to engineering and technical graphics. Students participating in Skills USA VICA competitions should become proficient in running business meetings especially if they are local chapter officers. See the T&I Leadership Guide for a complete set of materials for this section of the curriculum guide.

Basic Parliamentary Procedure – The complete guide to Parliamentary Procedure is Robert’s Rules of Order, Newly Revised. Parliamentary Procedure is set of rules for conduct at meetings which keeps assemblies orderly and guarantees that all people have equal opportunity to express themselves. See the T&I Leadership Guide for a complete set of materials for this section of the curriculum guide.

Motions and their purposes

A. Main Motion – To present an item of business for consideration and action by the assembly.
B. Amend – To change a main motion in some way; add to, take away from, or substitute words for.
C. Postpone – To defer action of a motion until a later time.
D. Point of order – To call attention to a mistake in correct parliamentary procedure made during the meeting.
E. Question of privilege – To ask a question or call attention to the assembly of an important issue during the meeting.
F. Division of the assembly – To revote in a specific counting method especially after using a voice vote.
G. Refer – To place a motion in the hands of a committee.
H. Previous question – To immediately stop debate and go directly to a vote.
I. Adjourn – To dismiss a meeting.
Terms and definitions associated with business meetings

A. Parliamentary Procedure – A set of rules for conduct at meetings which keeps assemblies orderly and guarantees that all people have equal opportunity to express themselves.

B. Item of Business – A single matter to be discussed or acted on by an organization.

C. Assembly – Group of persons gathered for any purpose.

D. Debate – Any discussion of opposing ideas relating to a motion being considered.

E. Minutes – The official written record of what was said and done in a meeting.

F. Committee – A group of people delegated to study, investigate, make recommendations, and report on certain matters.

G. Ad Hoc – A special committee formed to consider a single matter.

H. Standing – A regular committee which usually serves for a one year period to plan and carry out activities that fall within a certain subject area.

I. Unfinished Business – Any business previously discussed and held over from a previous meeting.

J. Majority vote – More than half the votes cast.

K. Two-thirds vote – Two-thirds or more of the legal votes cast.

L. Second – An indication by a member that he or she wants to consider the motion just proposed by another member.

M. Pending motion – The immediate motion before the assembly.

N. Meeting – An official gathering of the members in order to transact business.

O. Minority – Less than half.

P. Majority – More than half.

Q. Quorum – The number of members needed to be present to legally transact business.

I. Parts to an order of business.

(It is recommended that an order of business be developed for each business meeting. A suggestion is to follow the outline below and plug in what would be appropriate to individual business meetings.)

A. Opening
(Call to order, emblem ceremony, pledge to the flag)

B. Roll call

C. Reading of the Secretary’s minutes

D. Treasurer’s report

E. Committee reports
   1. Standing
   2. Ad Hoc

F. Unfinished business

G. New business

H. Program (speaker, film, etc.)

I. Adjournment

J. Refreshments

II. Suggested guidelines to ensure a good meeting.

A. Advance planning

B. Start and stop the meeting on time

C. Follow the order of business

D. Have well-prepared and organized committee reports

E. Involve all members in some way

F. Provide entertainment or refreshments

Raps of the gavel and their purposes

A. One rap – Everyone should be seated

B. Two raps – The meeting is called to order

C. Three raps – Everyone should stand up

Parliamentary Procedure principles and purposes

A. Majority rules

B. Minority has the right to express opinions

C. Justice and courtesy for all
D. One item is considered at a time
E. Maintain order at all times
F. Business is transacted quickly and efficiently

III. Purpose of using a motion is to bring a question before the assembly for consideration.

Steps for processing a main motion
A. Obtain the floor (Be recognized by the Chair by standing and saying Mr. Chairman)
B. Chair assigns the floor (The Chair recognizes one of the members by pointing or nodding)
C. Member makes the motion (states “I move that …”)
D. Another member seconds the motion
E. Chair restates the motion to the assembly
F. Motion is discussed/debated by the assembly
G. Vote is taken on the motion
H. Vote is announced and appropriate action is taken

Methods of voting during a business meeting
A. Secret ballot
B. Voice – Used on majority vote motions by stating Aye or No
C. Show of hands – Used in smaller assemblies to count the votes
D. Rising – Used in larger assemblies to count the votes

General Consent – Used in matters generally understood to have no objection
UNIT I: Leadership

Competency: 001.00
Demonstrate basic business meeting skills and goal setting.

Objective: 001.02
Establish personal and organizational goals.

A. Personal career planning process
   1. Self Assessment
      a. Talents – “What do I like to do?”
      b. Skills – “What do I do well?”
      c. Values – “What do I feel strongly about?”
      d. Personality – “Who am I?”
      e. Only YOU can determine the best career path
   2. Career Exploration
      a. Career choices, options, opportunities
      b. Variety of school courses
      c. Career fairs and Job Shadowing
      d. Education, Experience, Certifications
   3. Goal Setting
      a. Short-Term Goals
         1. Generally can be achieved in less than five years
         2. Built around existing knowledge and training
         3. Should be realistic
      b. Long-Term Goals - Project short-term goals into the future
         a. Professionally
         b. Financially
         c. Emotionally and socially
   4. Take Action
      a. Personal action plan
      b. Constantly evaluate action plan
   5. Lifelong Learning
      a. In a world of dynamic change, continued learning is essential
b. To progress in any career, individuals must keep up with changes and progress

c. Company-provided courses
d. Continuing education
e. Internet courses
f. Trade journals

B. Department of Labor classifies occupations into four broad categories
   1. People
      a. Working for the betterment of others
      b. Teachers, social workers, childcare workers, policemen, etc.

2. Data
   a. Working with numbers, information processing, policies and procedures
   b. Accountants, computer programmers, researchers, data examiners, clerks

3. Things
   a. Working with tools, equipment and machines
   b. Cooks, air traffic controllers, carpenters, mechanics, electronic technicians, drafters

4. Ideas
   a. Working with concepts, themes or inventions
   b. Musicians, artists, composers, writers

C. Drafting is an occupation in the “Things” category
   1. Drafters typically work alone or in small groups
   2. Sharing information is necessary to accomplish tasks

D. Resources
   1. Career Choices In North Carolina
   4. Getting Started: North Carolina Jobs and Careers
UNIT I: Leadership

Competency: 001.00
*Demonstrate basic business meeting skills and goal setting.*

Objective: 001.03
*Identify career goals and opportunities related to engineering and technical graphics.*

A. Successful designer/drafter
   1. Knowledge
   2. Skills
   3. Characteristics
   4. Education

B. Drafting Careers
   1. Engineer
   2. Manufacturing
   3. Electrical
   4. Transportation
   5. Fabrication
   6. Construction
   7. Architecture
   8. Public Utilities
   9. State and Local Government
   10. Armed Services
   11. College and Universities

C. Term definitions
   1. Career – a series of related jobs built on a foundation of interest, knowledge, training, and experience
   2. Job – work that people do for pay
   3. CAD – Computer-Aided Drafting or Computer-Aided Design
   4. CADD – Computer Aided Design & Drafting
   5. Conceptual Design
   6. Computer Literacy
   7. Prototype – an actual physical model of a product. Rapid prototyping – creates a 3D “print” of a proposed part
D. Basic Drafting Jobs

1. Drafter Trainee
   a. Assists with drawing preparation and performs support tasks
   b. Typically requires high school diploma including drafting classes and/or apprenticeships during high school

2. Junior Drafter
   a. Prepares drawings under direction of drafting technician or senior detailer
   b. Typically requires at least one year of high school drafting and an associate degree in drafting technology

3. Drafting Technician (Drafter)
   a. Prepares drawings with less supervision than a Junior Drafter
   b. Typically requires an associate degree in drafting technology and one year of drafting experience

4. Design Drafting Technician
   a. Combines design and drafting skills, interpretation of designer’s sketches and engineer’s details
   b. Typically requires an associate degree in drafting technology and one year of drafting experience

5. Designer
   a. Works with engineers and drafters to turn conceptual design into usable production drawings and specifications
   b. Typically requires an associate degree and at least five years industrial experience, knowledge of design process and drawing requirements

6. Checker
   a. Experienced drafter who checks drawings created by drafting technicians for accuracy and completeness
   b. Typically requires an associate degree and at least five years industrial experience, detailed knowledge of design process and drawing requirements

7. Senior Detailer
   a. Especially skilled in understanding details of how things work and go together, capable of detailing complex parts and making details understandable
   b. Typically requires an associate degree and at least five years industrial experience, knowledge of drawing requirements

8. Engineer
   a. Has at least a four-year degree in an engineering specialty
b. Must be licensed by the states in which they operate  
c. Many specialized branches  
d. Uses technical drawings to communicate ideas and products for manufacturing or construction  
e. Most major corporations employ a complete engineering design team  
   1) Research and development personnel  
   2) Development engineer  
   3) Project engineer  
   4) Design engineer  
   5) Technical illustrator  

E. Branches of Engineering  
   1. Aerospace  
      a. Designs aircraft for NASA, public transportation and military applications.  
      b. May work with sub-systems, such as electrical, mechanical, structural, etc.  
   2. Architecture  
      a. Interest in building and construction  
      b. Typically, Architects and Architectural Designers have a four or five-year degree and must be licensed by the states in which they operate  
      c. Additional courses of study for specializing in various fields  
         1) Landscape architects  
         2) City planners  
         3) Interior designers  
      d. Create original designs that are pleasing to the eye as well as functional and meet client and code requirements  
      e. Drawings include floor plans, foundation plans, site plans, elevations, and specialty plans for electrical, plumbing, heating & air, etc.  
   3. Civil  
      a. Designs structures, environmental systems, and various construction projects.  
      b. Arguably the oldest engineering profession.  
      c. May do analysis and design for materials and structural systems for buildings, aircraft, etc.  
   4. Electrical/Electronic  
      a. Designs electric power devices, controls, mechanisms, and electrical systems.
b. Works with power transmission, analog and digital circuits, and communications.

5. Mechanical
   a. Similar to engineering with more emphasis on creative abilities of the drafter: creativity, ingenuity and technical knowledge
   b. Work from sketches or just a memo describing a new product idea
   c. Determine how or if ideas might work and provide accurate drawings and specifications for proposed products

6. Technical Illustration
   a. Provides realistic pictorial drawings or 3D computer models of proposed new products or construction that show how a proposed product will look and work in a way that a client with no technical training can understand
   b. Must have a strong background in drafting principles and understand how to read technical drawings
   c. Must have a good imagination

7. Entrepreneurship
   a. Organizes and then runs a business
   b. Self-employed, often working at home from a computer
   c. Some subcontract specialized jobs
   d. Positive aspects include job satisfaction, good income, you are in charge
   e. Negative aspects include financial risk, long hours, no guarantee of success

F. Workplace Skills
   1. *Soft skills* involve getting along with others and working well with them
      a. Employers want employees who follow policies and procedures
         1) Dress code
         2) Attendance
         3) Promptness
      b. Form good habits while still in school
   2. Personal Relationships
      a. Maintain good relationships with employer and coworkers
      b. Take genuine interest in people who work around you
      c. Respect that people come from a variety of cultures
   3. Attitude
      a. Maintain a positive, enthusiastic attitude
b. Others may judge you on your personal attitude as well as your work
c. Try to see yourself as others see you
d. Be willing to learn

4. Communication Skills
   a. Communicate clearly and precisely
   b. Understand spoken and written instructions from others
   c. Give clear instructions verbally and in written form
   d. Explain potential problems effectively
   e. Use appropriate body language
   f. Demonstrate good telephone etiquette
   g. Use good e-mail etiquette

5. Self-Management
   a. Manage work with minimal supervision, be a “self-starter”
   b. Recognize problems related to work, identify causes, develop and implement solutions
   c. Punctuality, dependability, reliability

6. Time Management
   a. In business, time *is* money
   b. Develop a work schedule
      1) Determine deadlines as realistically as possible
      2) Maintain a project calendar

7. Ethical Behavior - Principles of conduct that govern any group or society
   a. Deal honestly with employers and coworkers
   b. Respect company property
   c. Keep company information confidential
   d. Maintain personal integrity, while honoring the values of others

8. Leadership
   a. Take responsibility by joining organizations and becoming a worker while still in school
   b. Skills USA-VICA provides opportunity for leadership development
   c. Good leadership requires people skills
   d. Good leaders must know how to follow directions
   e. Be aware of codes, laws, standards and regulations that apply to work
9. Teamwork – The ability to work as part of a team is a critical employability skill
   a. Involves two important concepts
      1) Cooperation - Team members must work together to achieve a common goal
      2) Communication - Essential for work to go smoothly
   b. Cooperative work, sharing knowledge and skills within the group results in higher quality of work
   c. Assess knowledge and skills within the group - Responsibilities delegated effectively
   d. Periodic evaluation of team performance will help the group stay on track
AUTHENTIC ASSESSMENT:  Product Development

This “real world” project is designed to reinforce concepts for each competency in the Drafting Curriculum. In addition, the project incorporates the use of teamwork, communication skills, and problem solving.

- Working in teams of 4-6, students will collaborate to design, draw and develop a marketable product.
- Upon completion of each competency, students will produce appropriate drawings and research.
- Communication skills may be reinforced by having students present preliminary and final project portfolios to local business representatives.
  - A “Job Fair” type presentation works well and puts less pressure on individuals than a formal “Stand Up” speech.
Sketching

002.
Demonstrate basic sketching skills and techniques

002.01
Identify the concepts related to sketching

002.02
Explain the concepts related to sketching multiviews and pictorials

002.03
Construct an isometric sketch

002.04
Construct an oblique sketch

002.05
Construct a multiview sketch
UNIT II: Sketching

Competency: 002.00
Demonstrate basic sketching skills and techniques.

Objective: 002.01
Explain the concepts related to sketching.

Introduction: As instrument drawing becomes less prevalent in industry, the ability to create accurate technical sketches becomes more important. The curriculum team feels that it is critical for students to be able to communicate technical information through different types of sketches. This unit will cover the purpose of sketching, materials needed for sketching, techniques for sketching, importance of proportions, the types of sketches, and differences between isometric, oblique and perspective sketches.

Sketching - Explain the following:

A. The purpose of a sketch is to quickly and easily get an idea on paper. Sketches can take the form of the following:
   1. Design sketches - Design sketches are rough sketches that are used to quickly capture an idea. They tend to have less detail, structure and restrictions than freehand or technical illustrations. R1(22):R2(53)
   2. Freehand technical sketches - Freehand technical sketches can be multiview or pictorial sketches. This type of sketch usually includes more detail and structure than design sketches. They also typically include dimensions. R1(54-56):R2(130-133)
   3. Technical illustrations - Technical illustrations include more detail, structure, and restrictions than other types of sketches. The objective here is to create a sketch that looks as close to the final object as possible. R1(56-58):R2(377-393)

B. Only pencil and paper (plain or grid) are needed to make a sketch. R1(23):R2(63)

C. Techniques for sketching: R1(24-29):R2(63-69)
   1. straight lines
   2. angles
   3. circles

D. Sketches must be proportional. Use aids when sketching (pencil as measuring device to divide lines equally or proportionally). R1(25-27):R2(58-60)

E. Types of sketches R1(21-29):R2(53-71)
   1. Single-view
   2. Multiview
   3. Pictorials
UNIT II: Sketching

Competency: 002.00
Demonstrate basic sketching skills and techniques.

Objective: 002.02
Explain the concepts and principles underlying multiview, isometric, oblique, and pictorial sketching.

R1(374-399):R2(53-71)

A. Explain the following:
   1. A multiview sketch shows different views of an object as seen from different positions and arranged in a standard order. R2 (842)
   2. Pictorial sketches show height, width and depth of an object in one view.
   3. The three basic types of pictorials are isometric, oblique, and perspective.

B. Explain the following terms, concepts and procedures for isometric drawings:
   1. In an isometric sketch the three axes are equally spaced 120° apart. The prefix "iso" means equal.
   2. The isometric axes are most often positioned so that the receding lines are 30° off the horizontal. Other positions are possible depending on what surfaces of the object are being emphasized.
   3. Circular shapes will typically appear as ellipses in isometric sketches. Ellipses must be oriented according to the plane in which they appear.
   4. Lines parallel to the isometric axes are called "isometric lines". You can measure along these lines.
   5. Lines that are not parallel to the isometric axes are called "non-isometric lines". You cannot measure along these lines.
   6. A standard angle measuring device such as a protractor cannot be used to measure angles in isometric. Angles are drawn by locating their end points.

C. Explain the following terms, concepts and procedures for oblique sketching:
   1. The front view is normal to the viewer's line of sight in an oblique sketch.
   2. A circle drawn on the frontal plane will appear as a circle. A curve drawn on the frontal plane will appear true shape.
   3. Circles and curves appearing on the side and top planes will be distorted.
   4. Receding edges can be sketched at any angle except vertical or horizontal but are usually drawn at an angle of 30°, 45° or 60°.
   5. The long side of an object should be shown in the frontal plane to lessen distortion.
6. Cavalier oblique pictorials are drawn or sketched at full depth. Cabinet oblique pictorials are drawn or sketched at a reduced depth (usually half).

D. Explain the following terms, concepts and procedures for perspective sketching:

1. The most common types of perspective drawings are one-point perspective and two-point perspective.

2. A perspective sketch is the most realistic of the pictorial sketches because it appears the most natural. Features that are farther from the observer appear shorter than features closer to the observer.

3. The receding axes converge at the vanishing point and are not parallel as they are in isometric and oblique drawings.

E. Explain the following terms, concepts and procedures for multiview sketching: R2 (54-56)

1. Choose an appropriate number of views to fully describe the shape of the object.

2. If an object can be described with only two dimensions, a one-view drawing may be sufficient. Two, three or more views may be necessary to fully describe the shape of more complicated objects.
UNIT II: Sketching

Competency: 002.00
Demonstrate basic sketching skills and techniques.

Objective: 002.03
Construct an isometric sketch.

Requirements: Each student is required to create a simple isometric pictorial sketch.
1. Using only pencil, eraser, and isometric grid paper, sketch an ISOMETRIC pictorial of the object whose views are given on the next page.
2. The sketch should be done at a scale of 1:1. One square grid equals one isometric grid.
3. Use accepted drafting standards for lines and freehand lettering.
4. Letter your name, problem number (002.03.001), scale, and date in the title block.
5. Do NOT include any hidden lines on your isometric sketch.
6. Time Limit = 60 minutes.
7. An effort should be made to create a balanced appearance of the sketch on the paper provided.
8. Your sketch should reflect an understanding of the object’s shape and features as determined from the orthographic views. Other areas of evaluation will include the accuracy of your measurements, and the quality of your line work/lettering.

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

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<th>Category</th>
<th>Points</th>
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<td>Concepts and principles of isometric sketches</td>
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<tr>
<td>Accuracy</td>
<td>25</td>
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<td>Line weight, technique, and neatness</td>
<td>20</td>
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<tr>
<td>Lettering</td>
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Rubric for PICTORIAL SKETCHING – Construct an isometric sketch - 002.03

**Accuracy**

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<td>0-17 points</td>
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<tr>
<td>Some errors in measurement (contains one gross measurement error or a minor measurement error).</td>
<td>18-23 points</td>
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<tr>
<td>When measured, the sizes of features and their locations closely (±.0625&quot;) agree with the given problem. Scale is correct.</td>
<td>24-25 points</td>
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**Concepts and principles of pictorial drawings**

<table>
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<td>Numerous lines are missing from the sketch. Most lines are not parallel to their corresponding isometric axis. Ellipses are not sketched or oriented correctly.</td>
<td>0-35 points</td>
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<tr>
<td>Some lines are missing from the sketch. Some lines are not parallel to their corresponding isometric axis. Some ellipses are not sketched or oriented correctly.</td>
<td>36-45 points</td>
</tr>
<tr>
<td>The shape of the object is correctly described. All isometric lines are parallel to their corresponding axis. Elliptical shapes are correctly sketched and oriented.</td>
<td>46-50 points</td>
</tr>
</tbody>
</table>

**Line weight/technique/neatness**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line weights are not uniform. Numerous double lines. Intersections are not correctly formed. Construction lines are too dark. ANSI standards for thickness and darkness not followed.</td>
<td>0-14 points</td>
</tr>
<tr>
<td>Some lines are not uniform. Some intersections are not formed correctly. Some lines do not meet ANSI standards.</td>
<td>15-18 points</td>
</tr>
<tr>
<td>Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding.</td>
<td>19-20 points</td>
</tr>
</tbody>
</table>

**Lettering**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter height, thickness, and spacing are not uniform. Letters are not uniformly vertical or inclined. Several spelling errors.</td>
<td>0-2 points</td>
</tr>
<tr>
<td>Some letters are not uniform in height, thickness, and spacing. Some letters are not uniformly vertical or inclined. No more than one spelling error.</td>
<td>3-4 points</td>
</tr>
<tr>
<td>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</td>
<td>5 points</td>
</tr>
</tbody>
</table>

**Total Score**

---

20
UNIT II: Sketching

Competency: 002.00

Demonstrate basic sketching skills and techniques.

Objective: 002.04

Construct an oblique sketch.

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

1. Using only pencil, eraser, and the paper provided by your instructor, sketch a CAVALIER OBLIQUE pictorial (using a receding axis angle specified by your instructor) of the object whose orthographic views are given below.
2. The drawing should be done at a scale of 1:1. One square grid equals one oblique grid.
3. Use accepted drafting standards for lines and freehand lettering.
4. Letter your name, problem number (002.04.001), scale, and date in the title block.
5. Do NOT include any hidden lines on your oblique sketch.
6. Time Limit = 60 minutes.
7. An effort should be made to create a balanced appearance of the sketch on the paper provided.
8. Your sketch should reflect an understanding of the object’s shape and features as determined from the orthographic views. Other areas of evaluation will include the accuracy of your measurements, and the quality of your line work and lettering.

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and principles of oblique sketches</td>
<td>50</td>
</tr>
<tr>
<td>Accuracy</td>
<td>25</td>
</tr>
<tr>
<td>Line weight, technique, and neatness</td>
<td>20</td>
</tr>
</tbody>
</table>
Lettering 5 points
### Rubric for OBLIQUE SKETCHING – Construct an oblique sketch - 002.04

#### Concepts and principles of oblique drawings

<table>
<thead>
<tr>
<th>Number of lines</th>
<th>Depth lines</th>
<th>Circles and arcs</th>
<th>Depth axis</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous lines are missing from the sketch.</td>
<td>Some lines are missing from the drawing.</td>
<td>Some arcs and circles are not correctly sketched or oriented.</td>
<td>The shape of the object is correctly described. All depth lines recede at required angle. Arcs and circles are correctly drawn and oriented. Depth axis is at full scale.</td>
<td></td>
</tr>
</tbody>
</table>

#### Accuracy

<table>
<thead>
<tr>
<th>Errors in measurements</th>
<th>Measurement</th>
<th>Sizes and locations closely agree with the given problem. Scale is correct.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in measurements. Inappropriate scale used.</td>
<td>Some errors in measurements.</td>
<td>When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct.</td>
<td>0-17 points</td>
</tr>
</tbody>
</table>

#### Line weight/technique/neatness

<table>
<thead>
<tr>
<th>Line weights</th>
<th>Intersections</th>
<th>Construction lines</th>
<th>Line quality</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform. Numerous double lines. Intersections are not correctly formed. Construction lines too dark. ANSI standards not followed.</td>
<td>Some lines are not uniform. Some intersections are not formed correctly. Some lines do not meet ANSI standards.</td>
<td>Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding.</td>
<td>0-14 points</td>
<td>15-18 points</td>
</tr>
</tbody>
</table>

#### Lettering

<table>
<thead>
<tr>
<th>Letter height, thickness, and spacing</th>
<th>Some letters are not uniform in height, thickness, and spacing. Some letters are not uniformly vertical or inclined. No more than one spelling error.</th>
<th>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter height, thickness, and spacing are not uniform. Letters are not uniformly vertical or inclined. Several spelling errors.</td>
<td>Some letters are not uniform in height, thickness, and spacing.</td>
<td>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</td>
<td>0-2 points</td>
</tr>
</tbody>
</table>

**Total Score**

23
UNIT II: Sketching

Competency: 002.00
*Demonstrate basic sketching skills and techniques.*

Objective: 002.05
*Construct a multiview sketch.*

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

1. Using only pencil, eraser, and the paper provided by your instructor, sketch a MULTIVIEW sketch of the object whose pictorial is given below.
2. The sketch should be done at a scale of 1:1 (full size) using the measurements provided.
3. Use accepted drafting standards for lines and freehand lettering.
4. Letter your name, problem number (002.05.001), scale, and date in the title block.
5. Time Limit = 60 minutes.
6. An effort should be made to create a balanced appearance of the sketch on the paper provided.
7. Your sketch should reflect an understanding of the object’s shape and features as determined from the pictorial. Other areas of evaluation will include the accuracy of your measurements, and the quality of your line work and lettering.

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and principles of orthographic projection</td>
<td>50</td>
</tr>
<tr>
<td>Measurements</td>
<td>20</td>
</tr>
<tr>
<td>Lines</td>
<td>20</td>
</tr>
<tr>
<td>Lettering</td>
<td>5</td>
</tr>
<tr>
<td>Layout &amp; balance</td>
<td>5</td>
</tr>
</tbody>
</table>
### Rubric for MULTIVIEW SKETCHING – Construct a multiview sketch - 002.05

#### Concepts and principles of orthographic projection

<table>
<thead>
<tr>
<th>Views not aligned or in projection. A view is missing. Numerous lines are misplaced or missing. Precedence of lines not followed.</th>
<th>Features are aligned or correctly projected between the views. Some visible or hidden lines are missing. Precedence of lines followed for most lines.</th>
<th>The views (visible &amp; hidden edges) correctly describe the shape of the object. The views are oriented correctly. Features are aligned or correctly projected between the views. Precedence of lines correctly followed.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-35 points</td>
<td>36-45 points</td>
<td>46-50 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Measurements

<table>
<thead>
<tr>
<th>Numerous errors in measurements. Inappropriate scale used.</th>
<th>Some errors in measurement.</th>
<th>When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14 points</td>
<td>15-18 points</td>
<td>19-20 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Lines

<table>
<thead>
<tr>
<th>Line weights are not uniform. Numerous double lines. Intersections are not correctly formed. Construction lines are too dark. ANSI standards for thickness and darkness not followed. Numerous missing or improperly placed center lines.</th>
<th>Some lines are not uniform. Some intersections are not formed correctly. Some lines do not meet ANSI standards. Some intersections for hidden lines not correct. Few misplaced or missing center lines.</th>
<th>Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding. Correct practices for hidden lines and center lines followed. Center lines are properly placed.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14 points</td>
<td>15-18 points</td>
<td>19-20 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Lettering

<table>
<thead>
<tr>
<th>Letter height, thickness, and spacing are not uniform. Letters are not uniformly vertical or inclined. Several spelling errors.</th>
<th>Some letters are not uniform in height, thickness, and spacing. Some letters are not uniformly vertical or inclined. No more than one spelling error.</th>
<th>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 points</td>
<td>3-4 points</td>
<td>5 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Layout & balance

<table>
<thead>
<tr>
<th>The sketch is not centered vertically nor horizontally.</th>
<th>The sketch is centered vertically but not horizontally (or horizontally but not vertically).</th>
<th>The sketch is centered within the working space.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 points</td>
<td>3 points</td>
<td>5 points</td>
<td></td>
</tr>
</tbody>
</table>
Total Score

__________
AUTHENTIC ASSESSMENT: Product Development

First steps

• Produce a detailed organizational chart, such as Lotus Diagram, Fish Bone, etc. and an Action Plan.
  • The action plan should include as many tasks as students can think of and include deadlines and individual responsibility for tasks.
• Team members use Brainstorming techniques to list a specified number of product ideas.
  • The more ideas students begin with, the better the chances of them choosing a product that will engage them for the entire course.
• Team members should narrow choices and prioritize the top 3-5 products for development.
  • Instructor should reserve the right of final approval.
  • Be sure the product is not so simple that it doesn’t adequately demonstrate competency, and not so difficult that students cannot effectively produce appropriate drawings.
  • The product should be one that allows each team member to develop a distinctly different design of a single concept.
    • Examples: Rocket powered cars, wooden puzzles, travel games, models.

Sketching Performance Assessment

• Each team member will produce a design sketch of individual design concept.
  • Instructor may have students produce any or all of the following:
    • Single View
    • Multiview
    • Pictorial
      • Isometric
      • Oblique
      • Perspective
  • Sketches may be assessed using rubrics for each sketching performance competency.

Product Research

• Teams should use internet, catalogs and retail stores to research similar products.
• Teams should establish quality criteria and target audience for products.
  • The process of researching similar products may continue through the duration of the project as students have time to break from formal instruction, drawing assignments, or outside of class.
003.
Demonstrate basic drafting skills and techniques

003.01
Explain the correct use of manual drafting equipment and supplies

003.02
Explain correct lettering technique

003.03
Demonstrate correct drawing procedures

003.04
Construct a single-view drawing
UNIT III: Basic Drafting Skills

Competency: 003.00
Demonstrate basic drafting skills and techniques.

Objective: 003.01
Explain the correct use of manual drafting equipment and supplies.

Introduction: The purpose of this unit is to give students a basic understanding of the equipment used for instrument drawing. Although instrument drawing is now rare in industrial settings, the curriculum team feels that the concepts in this unit are important because they give students a good foundation for CAD activities. This unit will cover traditional equipment, the types of scales used in various professions, drawing scales, and the importance of precision and accuracy when producing engineering and technical drawings.

A. Equipment - Identify and demonstrate the use of the following equipment:
   1. 45° triangle
   2. 30° X 60° triangle
   3. Adjustable triangle
   4. T-square
   5. Parallel edge
   6. Drafting Machine
      a. Arm/elbow type
      b. Track type
   7. Drawing board/table
   8. Compass
   9. Dividers
   10. Brush
   11. Erasing shield
   12. Protractor
   13. Templates
      a. Circle
      b. Ellipse
   14. Pencil
      a. Mechanical
b. Lead holders
c. Wooden

15. Lead
   a. Hardness
      i. **Hard** (9H, 8H, 7H, 6H, 5H, 4H). Used for accuracy. Produce light lines.
      ii. **Medium** (3H, 2H, H, F, HB, B). General purpose leads.
      iii. **Soft** (2B, 3B, 4B, 5B, 6B, 7B). Too soft for mechanical drafting. Good for art work.

   b. Size (Thin - .020" or .5mm, Thick - .028" or .7mm).

16. Scales
   a. Engineer (Civil)
   b. Mechanical drafter (Combination)
   c. Metric
   d. Architect

17. Reproduction techniques - Discuss differences between printers and plotters.

18. Eraser

B. **Media**

1. sizes (U.S. customary series)
2. types (bond, vellum, and mylar)
UNIT III: Basic Drafting Skills

Competency: 003.00
Demonstrate basic drafting skills and techniques.

Objective: 003.02
Demonstrate correct lettering technique.

Lettering - Explain and demonstrate the following:

A. The purpose of neat lettering:
   1. the most important reason is to convey information without misunderstanding
   2. adds to the overall appearance of the drawing

B. ANSI (American National Standards Institute) recognizes the use of single-stroke gothic letters.

C. Typically all capital letters are used.

D. Horizontal guidelines (very light, very thin lines) keep letters the same height.

E. Vertical guidelines may be used as an aid to keep letters from slanting.

F. Typically, most letters are .125” or 3mm tall.

G. A uniform vertical space should be left between lines of letters.

H. The background area between letters should appear equal.

I. Fraction bar is horizontal and does not touch numbers.

J. Fractions are typically twice as tall as numbers.

K. Space between words equal to the letter “O”.

L. Letters are formed using a series of strokes.
UNIT III: Basic Drafting Skills

Competency: 003.00
*Demonstrate basic drafting skills and techniques.*

Objective: 003.03
*Demonstrate correct drawing procedures.*

R1(48-76):R2(111-128)

A. **Basic Drawing Skills** – Identify and/or explain the following:

1. Aligning and taping paper to the drawing table.
2. Drawing horizontal, vertical, and inclined lines.
3. Drawing standards angles at 15°, 30°, 45°, 60°, 75°, and 90° using triangle(s).
4. Drawing lines parallel or perpendicular to other lines using triangles.
5. Drawing border lines and a title block.
6. Centering one-view symmetrical or non-symmetrical drawings in the working space.
7. Read a 1:1 ratio fractional, decimal, and metric scale.
8. Scale drawings using a reduction and enlargement scale—example: (1:2) (1:4) (2:1) etc.
9. Convert fractional measurements to decimal equivalents.
10. Add, subtract, and divide fractions and decimals.
11. Measuring an angle with a protractor.
12. Drawing arcs and curves using a compass.
13. Drawing arcs and curves using a circle template.
14. Use dividers to transfer and divide measurements.

B. **Alphabet of Lines** - The following specifications for line thickness and darkness are based on pencil drawings and sketches. When creating plots of CAD files, some of the specifications may vary (mainly color). Students should be able to identify and explain the purpose of the following line types:

1. **Construction lines** (thin & light) - .020" (0.5mm) with a hard lead (eg. 4H lead).
2. **Visible lines** (thick & dark) - .028" (0.7mm) with a softer lead (eg. F or HB lead).
3. **Hidden lines** (thin & dark) - .020" (0.5mm) with a softer lead (eg. F or HB lead). Dashes are approximately .125" (3mm) long with a .030" (1mm) space in between them.
4. **Center lines** (thin & dark) - .020" (0.5mm) with a softer lead (eg. F or HB lead). Center lines consist of long lines with a short dash spaced appropriately. Dashes are approximately .125" (3mm) long with a .030" (1mm) space in between them and the longer lines.
5. **Dimension, Extension, and Leader Lines** (thin & dark) - .020" (0.5mm) with a softer lead (eg. F or HB lead). These lines types appear on drawings with dimensions.

<table>
<thead>
<tr>
<th>Darkness</th>
<th>Thickness</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thick (.028&quot; / 0.7mm)</td>
<td>Thin (.020&quot; / 0.5mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark (F or HB)</td>
<td>Visible Lines</td>
<td></td>
<td>Hidden Lines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light (F or HB)</td>
<td>None</td>
<td></td>
<td>Center Lines</td>
<td>Dimension Lines</td>
<td>Extension Lines</td>
<td>Leader Lines</td>
</tr>
</tbody>
</table>
UNIT III: Basic Drafting Skills

Competency: 003.00
*Demonstrate basic drafting skills and techniques.*

Objective: 003.04
*Construct a single-view drawing.*

Requirements: Each student is required to construct a single-view drawing.

1. Using the drafting equipment provided, make a mechanical drawing of the object shown below.
2. The drawing should be done at a scale of 1:1 (full size) using the measurements provided.
3. Center the drawing on the sheet.
4. Use accepted drafting standards for lines and freehand lettering.
5. Letter your name, problem number (003.04.001), scale, and date in the title block.
6. Time Limit = 60 minutes.
7. Your work will be evaluated on the accuracy of your measurements, the quality of your line work/lettering, and your centering of the drawing.

Assessment: The single-view drawing should be evaluated based on the following criteria:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>60</td>
</tr>
<tr>
<td>Line weight, technique and neatness</td>
<td>25</td>
</tr>
<tr>
<td>Lettering</td>
<td>10</td>
</tr>
<tr>
<td>Layout and balance</td>
<td>5</td>
</tr>
</tbody>
</table>
Rubric for BASIC DRAFTING SKILLS – Construct a single-view drawing - 003.04

### Accuracy

<table>
<thead>
<tr>
<th>Description</th>
<th>Remarks</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in measurements.</td>
<td>Inappropriate scale used.</td>
<td>No more than one or two errors in measurement.</td>
</tr>
<tr>
<td>0-42 points</td>
<td>43-54 points</td>
<td>55-60 points</td>
</tr>
</tbody>
</table>

### Line weight/technique/neatness

<table>
<thead>
<tr>
<th>Description</th>
<th>Remarks</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line weights are not uniform. Numerous double lines. Intersections are not correctly formed. Construction lines are too dark. ANSI standards for thickness and darkness not followed.</td>
<td>Some lines are not uniform. Some intersections are not formed correctly. Some lines do not meet ANSI standards.</td>
<td>Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding.</td>
</tr>
<tr>
<td>0-17 points</td>
<td>18-22 points</td>
<td>23-25 points</td>
</tr>
</tbody>
</table>

### Lettering

<table>
<thead>
<tr>
<th>Description</th>
<th>Remarks</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter height is not uniform. Thickness of stroke varies. Letters are not uniformly vertical or inclined. Poor spacing of words and letters. Several spelling errors.</td>
<td>Some letters are not uniform in height. Thickness of stroke varies for some letters. Some letters are not uniformly vertical or inclined. Most spacing of words and letters is correct. No more than one spelling error.</td>
<td>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</td>
</tr>
<tr>
<td>0-7 points</td>
<td>8-9 points</td>
<td>10 points</td>
</tr>
</tbody>
</table>

### Layout & balance

<table>
<thead>
<tr>
<th>Description</th>
<th>Remarks</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The drawing is not centered vertically nor horizontally.</td>
<td>The drawing is centered vertically but not horizontally (or horizontally but not vertically).</td>
<td>The drawing is centered within the working space.</td>
</tr>
<tr>
<td>0 points</td>
<td>3 points</td>
<td>5 points</td>
</tr>
</tbody>
</table>

Total Score: __________
AUTHENTIC ASSESSMENT: Product Development

Basic Skills Project Assessment

- Each team member will produce a single-view drawing of individual design concept.
  - Evaluate drawings based on Basic Drafting Skills Performance Objective 003.04.
Basic Geometric Terms and Construction

004. Explain geometric terms and apply geometric construction techniques

004.01 Explain selected geometric terms

004.02 Explain the procedures for drawing standard geometric constructions

004.03 Construct drawings that require geometric constructions
UNIT IV: Basic Geometric Terms and Construction

Competency: 004.00
*Explain geometric terms and apply geometric construction techniques.*

Objective: 004.01
*Explain selected geometric terms.*

**Introduction:** The purpose of this unit is to give students a basic understanding of 2D and 3D geometry related to technical drawing. Emphasis should be placed on recognizing geometry that exists within objects for the purpose of creating solid models within the CAD software or creating multiview drawings. This unit covers basic geometric shapes and terms and the types of constructions necessary to create and model basic objects.

R1(102-113):R2(151-174)

A. Identify geometric shapes and terms.
   1. Angle Definition
      a. acute angle - An angle that measures less than 90°.
      b. obtuse angle - An angle that measures more than 90°.
      c. right angle - Angle that measures exactly 90°.
      d. vertex - The point at which two lines of an angle meet.
   2. Circle Definition
      a. radius - The distance from the center of a circle to its edge.
      b. diameter - The distance across a circle through its center point.
      c. circumference - The distance around the edge of a circle, better know as the circle’s rim.
      d. concentric - Two or more circles of different sizes that share the same center point.
      e. chord - Line across a circle that does not pass at the circle’s center.
      f. quadrant - One fourth (quarter) of a circle.
   3. Triangle Definition
      a. hypotenuse - The side of a right triangle that is opposite the 90° angle.
      b. equilateral - A triangle in which all three sides are of equal length and all three angles are equal.
      c. scalene - A triangle that has sides of three different lengths and angles with three different values.
      d. isosceles - A triangle in which two sides are of equal length.
4. **Quadrilaterals Definition**
   a. **square** - Four equal sides and all angles equal 90°.
   b. **rectangle** - Two sides equal lengths and all angles equal 90°.
   c. **trapezoid** - Only two sides are equal length.
   d. **rhombus** - All sides are equal length and opposite angles are equal.
   e. **rhomboid** - Opposite sides are equal length and opposite angles are equal.

5. **Regular Polygons** – A closed figure in which all of the sides and angles are of equal measure.
   a. **pentagon** - A five sided polygon.
   b. **hexagon** - A six sided polygon.
   c. **octagon** - An eight sided polygon.
   d. **distance across flats** - A measurement across the parallel sides of a polygon.
   e. **distance across corners** - A measurement across adjacent corners of a polygon.

6. **Solids**
   a. **Prism**
      i. **right rectangular** (box)
      ii. **right triangular** (wedge)
   b. **cylinder**
   c. **cone**
   d. **sphere**
   e. **pyramid**
   f. **torus**

B. Define the following:

1. **Terms**
   a. **circumscribe** – The process of creating a polygon that fully encloses a circle that is tangent to all of the polygons sides.
   b. **inscribe** – The process of creating a polygon that is fully enclosed by a circle at its corners.
   c. **bisect** - Divide into two equal parts.
   d. **tangent** - A line and arc, or two arcs that touch each other at one point only.
   e. **parallel** - Two or more lines that are always the same distance apart.
f. perpendicular - At a 90° angle.

2. Geometric Shorthand Symbols Used by Drafters.
   a. \( \angle \) (angle)
   b. \( \Delta \) (triangle)
   c. \( R \) (radius)
   d. \( \varnothing \) (diameter) Greek letter Phi
   e. \( // \) (parallel)
   f. \( \perp \) (perpendicular)
   g. \( \Box \) (square)
   h. \( \overline{\gamma} \) (centerline)
UNIT IV: Basic Geometric Terms and Construction

Competency: 004.00
*Explain geometric terms and apply geometric construction techniques.*

Objective: 004.02
*Demonstrate the procedures for drawing standard geometric constructions.*

*R1(105):R2(154-172)*

**Perform the following constructions:**

A. Bisect
   1. lines and arcs
   2. angles

B. Construct the following polygons:
   1. hexagon - Across the flats (circumscribe method)
      Across the corners (inscribe method)
   2. octagon - Across the flats (circumscribe method)
      Across the corners (inscribe method)

C. Construct arcs tangent to:
   1. two arcs
   2. an acute angle, right angle, and an obtuse angle
   3. a straight line and an arc

D. Divide a line into equal parts
UNIT IV: Basic Geometric Terms and Construction

Competency: 004.00
*Explain geometric terms and apply geometric construction techniques.*

Objective: 004.03
*Construct drawings that require geometric constructions.*

Requirements: Each student is required to create a geometric construction.

1. Using the drafting equipment provided, make a mechanical drawing of the object shown below.
2. The drawing should be done at a scale of 1:1 (full size) using the measurements provided.
3. Center the drawing on the sheet.
4. Use accepted drafting standards for lines and freehand lettering.
5. Letter your name, problem number (004.03.001), scale, and date in the title block.
6. Time Limit = 90 minutes.
7. Your work will be evaluated on the accuracy of your measurements, the quality of your line work/lettering, and your centering of the drawing.

Assessment: The geometric construction should be evaluated based on the following criteria:

- Constructions correctly formed: 50 points
- Accuracy: 25 points
- Line weight, technique and neatness: 15 points
- Lettering: 10 points

42
### Rubric for BASIC GEOMETRIC TERMS & CONSTRUCTIONS
Construct drawings that require geometric constructions - 004.03

#### Constructions correctly formed

<table>
<thead>
<tr>
<th>Centers of arcs are not located. Points of tangency are not located. Points of tangency are not used to located start and stops for lines and arcs. Polygons are not drawn using the correct method (flats or corners) and the correct size.</th>
<th>Most centers of arcs are located correctly. Most points of tangency are located. Most points of tangency are used to locate the start and stops for lines and arcs.</th>
<th>Tangent arcs have center points accurately located. Points of tangency for tangent arcs accurately located. Tangent arcs start and stop at points of tangency. Polygons drawn using the appropriate method for the size given (flats or corners).</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-35 points</td>
<td>36-45 points</td>
<td>46-50 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Accuracy

<table>
<thead>
<tr>
<th>Numerous errors in measurements. Inappropriate scale used.</th>
<th>No more than one or two errors in measurement.</th>
<th>When measured, the sizes of features and their locations agree with the given problem. Scale is correct.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-17 points</td>
<td>18-23 points</td>
<td>24-25 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Line weight/technique/neatness

<table>
<thead>
<tr>
<th>Line weights are not uniform. Numerous double lines. Intersections are not correctly formed. Construction lines are too dark. ANSI standards for thickness and darkness not followed.</th>
<th>Some lines are not uniform. Some intersections are not formed correctly. Some lines do not meet ANSI standards.</th>
<th>Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 points</td>
<td>11-13 points</td>
<td>14-15 points</td>
<td></td>
</tr>
</tbody>
</table>

#### Lettering

<table>
<thead>
<tr>
<th>Letter height, thickness, and spacing are not uniform. Letters are not uniformly vertical or inclined. Several spelling errors.</th>
<th>Some letters are not uniform in height, thickness, and spacing. Some letters are not uniformly vertical or inclined. No more than one spelling error.</th>
<th>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7 points</td>
<td>8-9 points</td>
<td>10 points</td>
<td></td>
</tr>
</tbody>
</table>

Total Score: 43
Multiview Drawing

005.
Demonstrate orthographic projection techniques and principles as they apply to multiview drawings

005.01
Explain the concepts and principles underlying the creation of multiview drawings

005.02
Visualize objects and views

005.03
Construct multiview drawings
UNIT V: Multiview Drawing

Competency: 005.00
Demonstrate orthographic projection techniques and principles as they apply to multiview drawings.

Objective: 005.01
Explain the concepts and principles underlying the creation of multiview drawings.

Introduction: The purpose of this unit is to introduce students to the theory behind multiview drawing. Orthographic projection is the technique used to represent 3D objects on a 2D surface. Students should know the theory behind multiview drawings so they will understand why views are placed in certain locations on technical drawings. This unit will cover orthographic projection theory, the selection of views, the types of lines in multiview drawings, types of surfaces, and the intersection of surfaces in multiview drawings.

R1(120-141):R2(195-210)

Explain the following terms, concepts, and procedures concerning orthographic projection:

A. Another name for orthographic projection is multiview drawing.

B. Orthographic projection is a system that allows you to make a two-dimensional drawing of a three-dimensional object.
   1. A box is formed by six mutually perpendicular planes of projection that are located around the object.
   2. Lines are formed on the planes by projecting the edges of the object onto the planes. These images are called “views” or “views of the object”. Typically there are six views:
      a. top view
      b. front view
      c. right side view
      d. left side view
      e. back view
      f. bottom view
   3. Unfolding the box produces an arrangement of the views.
      a. Third Angle Projection - This is the standard in the United States.
      b. First Angle Projection - Used by many other countries around the world.
      c. A view must be placed in its correct position relative to the other views.
      d. The views must be aligned.

C. Choices of views.
1. The most often used views are the top, front, and right side.
2. The most descriptive view is typically designated as the front view.
3. Simple objects can be described with only two views.
4. Thin objects can be described with only one view and a note describing the thickness.
5. More complex objects may require 3 or more views.
6. Use only the number of views necessary to describe the object.
7. Views should be drawn so that they are visually balanced within the working space.

D. All objects have three dimensions: height, width, and depth.
1. Height is the distance from the bottom to the top.
2. Width is the distance from one side to the other side.
3. Depth is the distance from the front of the object to the back.
4. The top view shows the width and depth.
5. The front view shows the width and the height.
6. The side view shows the depth and the height.

E. Depth can be projected between views by using a 45° miter line (mitre line in R1).

F. Lines
1. Edges that can be seen are known as visible lines or object lines. They are thick (.028" or .7mm), dark lines (eg. F or HB lead).
2. Hidden lines represent edges that cannot be seen.
   a. A hidden line is composed of short dashes (approximately .125” or 3mm) with small (.0625” or 1mm) spaces between the dashes. These lines are thin (.020" or .5mm) and dark (eg. F or HB lead).
   b. There are rules for hidden line placement that adds to the clarity of the drawing.
   c. Drawings produced with CAD may violate the hidden line rules.
3. The “Precedence of Lines” refers to which line should be drawn when two lines coincide at the same location.
   a. When a visible line coincides with either a hidden line or a centerline, the visible line is shown.
   b. When a hidden line coincides with a centerline, the hidden line takes precedent.
4. Centerlines show the center of arcs and circles or the axis of symmetrical objects.
   a. Centerlines are drawn with a long dash (.750” - 1.50” or 20mm-40mm) followed by a short dash (approximately .125” or 3mm) at the center, followed by another long dash.
b. The long dash should extend approximately .125” to .250” (3mm to 6mm) beyond the feature.

c. Centerlines should be thin (.020" or .5mm).

d. When an object is circular, two centerlines are used. The two, short centerlines dashes should cross at the center point of the feature.

e. One centerline is drawn where the centerline indicates the longitudinal axis of a cylinder or hole.
UNIT V: Multiview Drawing

Competency: 005.00
Demonstrate orthographic projection techniques and principles as they apply to multiview drawings.

Objective: 005.02
Visualize objects and views.

Visualization
A. Straight edges \( R1(152):R2(197-202) \)
   1. Edges that are perpendicular to a plane of projection appear as a point.
   2. Edges that are parallel to a plane of projection appear as true length lines.
   3. Edges that are inclined to a plane of projection appear as foreshortened lines.
B. Curved edges \( R1(229-230):R2(203-204) \)
   1. Curved edges project as straight lines on the plane to which they are perpendicular.
   2. Curved edges project as curved lines on the planes to which they are parallel or inclined.
C. Surfaces
   1. Normal \( R1(152-153):R2(354) \)
      a. A NORMAL surface is perpendicular to two of the planes of projection and parallel to the third.
      b. Surfaces that are parallel to a plane of projection appear as true size surfaces.
      c. Surfaces that are perpendicular to a plane of projection appear as lines.
   2. Inclined \( R1(276):R2(354-355) \)
      a. An INCLINED surface is perpendicular to one plane of projection and inclined to the other two.
      b. Surfaces that are “inclined” to a plane of projection appear “foreshortened”.
   3. Oblique \( R2(355) \)
      a. An OBLIQUE surface is inclined to all three planes of projection.
      b. Surfaces that are “oblique” to a plane of projection appear as “foreshortened” surfaces on all of the orthographic planes.
D. Intersections and tangencies \( R1(154-155, 230-231) \)
   1. Where a plane surface is tangent to a curved surface, no line should appear where they join.
   2. Where a plane surface intersects a curved surface, an edge is formed.
3. Where the plane surface is horizontal or vertical, exceptions to the above rules may occur.
UNIT V: Multiview Drawing

Competency: 005.00
_Demonstrate orthographic projection techniques and principles as they apply to multiview drawings._

Objective: 005.03
_Construct multiview drawings._

Requirements: Each student is required to complete an orthographic drawing.
1. Using the drafting equipment provided, make a mechanical drawing of the object shown below.
2. Your work should include the top, front, and right side orthographic views.
3. The drawing should be done at a scale of 1:1 (full size) using the measurements provided.
4. Center the drawing on the sheet.
5. Use accepted drafting standards for lines and freehand lettering.
6. Letter your name, problem number (005.03.001), scale, and date in the title block.
7. Time Limit = 90 minutes.
8. Your work will be evaluated on the accuracy of the orthographic views, the correctness of your measurements, the quality of the line work/lettering, and how you balance the views within the working space.

Assessment: The multiview drawing should be evaluated based on the following criteria:

- Concepts and principles of orthographic projection: 50 points
- Measurements: 20 points
- Lines: 20 points
- Lettering: 5 points
Layout and balance 5 points
### Rubric for ORTHOGRAPHIC DRAWING – Construct multiview drawings - 005.03

#### Concepts and principles of orthographic projection

- **Features are aligned or correctly projected between the views. Some visible or hidden lines are missing. Precedence of lines followed for most lines.**
  - 0-35 points
- **The views (visible & hidden edges) correctly describe the shape of the object. The views are oriented correctly. Features are aligned or correctly projected between the views. Precedence of lines correctly followed.**
  - 36-45 points
- **The views (visible & hidden edges) correctly describe the shape of the object. The views are oriented correctly. Features are aligned or correctly projected between the views. Precedence of lines correctly followed.**
  - 46-50 points

#### Measurements

- **When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct.**
  - 0-14 points
- **When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct.**
  - 15-18 points
- **When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct.**
  - 19-20 points

#### Lines

- **Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding. Correct practices for hidden lines and center lines followed. Center lines are properly placed.**
  - 0-14 points
- **Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding. Correct practices for hidden lines and center lines followed. Center lines are properly placed.**
  - 15-18 points
- **Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding. Correct practices for hidden lines and center lines followed. Center lines are properly placed.**
  - 19-20 points

#### Lettering

- **Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.**
  - 0-2 points
- **Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.**
  - 3-4 points
- **Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.**
  - 5 points

#### Layout & balance

- **The drawing is centered within the working space.**
  - 0 points
- **The drawing is centered vertically but not horizontally (or horizontally but not vertically).**
  - 3 points
- **The drawing is centered within the working space.**
  - 5 points
Total Score

__________
Rubric for ORTHOGRAPHIC DRAWING (CAD)–Construct multiview drawings - 004.03

### Concepts and principles of orthographic projection

<table>
<thead>
<tr>
<th>Views are not aligned or in projection. A view is missing. Numerous lines are misplaced or missing. Precedence of lines not followed.</th>
<th>Features are aligned or correctly projected between the views. Some visible or hidden lines are missing. Precedence of lines followed for most lines.</th>
<th>The views (visible &amp; hidden edges) correctly describe the shape of the object. The views are oriented correctly. Features are aligned or correctly projected between the views. Precedence of lines correctly followed.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-35 points</td>
<td>36-45 points</td>
<td>46-50 points</td>
<td></td>
</tr>
</tbody>
</table>

### Accuracy

<table>
<thead>
<tr>
<th>Numerous errors in measurements. Inappropriate scale used.</th>
<th>Some errors in measurement.</th>
<th>When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct. Drawing demonstrates an obvious use of object snaps.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-17 points</td>
<td>18-23 points</td>
<td>24-25 points</td>
<td></td>
</tr>
</tbody>
</table>

### Lines

<table>
<thead>
<tr>
<th>Numerous stray lines or pieces of lines. Intersections are not correctly formed. ANSI standards for thickness and coding not followed.</th>
<th>Some intersections are not formed correctly. Some lines do not meet ANSI standards.</th>
<th>Line quality meets ANSI standards for thickness and coding.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14 points</td>
<td>15-18 points</td>
<td>19-20 points</td>
<td></td>
</tr>
</tbody>
</table>

### Text

<table>
<thead>
<tr>
<th>Text style and size does not meet accepted standards. More than one spelling error. Required information inappropriately placed or missing.</th>
<th>No more than one spelling error. Some required information is missing or misplaced.</th>
<th>Text style and size meets accepted standards. Spelling is correct. All required information is provided and appropriately placed.</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 points</td>
<td>3-4 points</td>
<td>5 points</td>
<td></td>
</tr>
</tbody>
</table>

Total Score 54
AUTHENTIC ASSESSMENT: Product Development

Multiview Drawing Project Assessment

- Each team member will produce a multiview drawing of individual design concept.
  - Evaluate drawings based on Multiview Performance Objective 005.03
Basic Dimensioning Skills

006. Demonstrate basic dimensioning techniques

006.01 Identify the accepted standards for mechanical dimensioning practices

006.02 Explain the procedures for dimensioning mechanical drawings

006.03 Construct dimensions on an engineering drawing
UNIT VI: Basic Dimensioning Skills

Competency: 006.00
*Demonstrate basic dimensioning techniques.*

Objective: 006.01
*Identify the accepted standards for mechanical dimensioning practices.*

**Introduction:** The purpose of this unit is to introduce students to basic dimensioning techniques related to technical drawing. The previous units were mainly focused on describing the shape of objects. This unit will focus on describing the size and location of features. Standards for dimensioning technique, dimension placement, and general rules for dimensioning will be covered per *Dimensioning and Tolerancing, ASME Y14.5M-1994.* Standards for architectural dimensioning are to be covered in Architectural Drafting II.

Although most of this unit focuses on dimensioning technique (how dimensions should look on a drawing), students should be introduced to methods for determining the critical dimensions for a part. Since most objects exist within the context of an assembly, it is recommended that teachers make the students aware of how the part functions within the assembly before dimensioning the drawing.

*R1(192-220):R2(230-244)*

**Identify the following standard practices for dimensioning:**

**A. Dimension lines:**
1. Shows the beginning and the end of the measurement.
2. Terminated by arrowheads.
3. Thin line weight.
4. Should be broken to allow for the numbers to be inserted.
5. Must be a minimum of .375" or 10mm away from the object.
6. Must be a minimum of .250" or 6mm away from parallel dimension lines.

**B. Extension lines:**
1. Extend the edge of the object.
2. Thin line weight.
3. There should be a visible gap (.0625" or 1mm) between the object and the start of the extension line.
4. Extension lines should extend about .125" or 2.5mm beyond the last dimension line.

**C. Leader lines:**
1. Are drawn from a note or dimension to place where the note applies.
2. Are drawn at an angle (usually 30°, 45°, or 60°).
3. Should have a short (.125" or 3mm) shoulder that if extended, would intersect the note at mid-height.
4. May end with an arrowhead or dot.
5. If extended, the leader would pass through the center of arcs or circles (radial).
6. Leaders should not cross over or through other leaders or dimension lines.
7. Avoid making leaders parallel or perpendicular to visible edges.
8. Should extend from the first word or the last word of the note.

D. Arrowheads:
1. Can be solid filled or open.
2. Should be approximately .125" or 3mm long.
3. Should be approximately 2.5 to 3 times as long as wide.

E. Dimensioning placement for reading.
UNIT VI: Basic Dimensioning Skills

Competency: 006.00
Demonstrate basic dimensioning techniques.

Objective: 006.02
Explain the procedures for dimensioning mechanical drawings.

R1(192-220):R2(230-244)

A. Procedures for using decimal and metric measurement.
   1. Decimal inches:
      a. Decimals are the ANSI standard.
      b. Decimals are easier to add, subtract, multiply and divide than fractions.
      c. Preferably, decimals should be rounded to two decimal places. (Unless more precision is required.)
      d. Omit zero before the decimal point for values of less than one.
      e. Display trailing zeros equal to the drawing's precision.
   2. Fractional inches:
      a. Used where close tolerances are not important.
      b. The horizontal fraction bar is preferred.
      c. Omit the inch mark when dimensions are all in inches.
   3. Metric:
      a. Where linear measurement are less than 10,000 millimeters, the millimeter is the standard unit of measure.
      b. The abbreviation for millimeters (mm) is usually omitted when all dimensions are in millimeters.
      c. The period is used as a decimal point only in English speaking countries, others use a comma.
      d. If the value is less than one millimeter, a zero should precede the decimal point.
      e. Omit trailing zeros.

B. Be able to list, explain, and give examples of the following general rules of dimension placement.
   1. The number one rule of dimensioning is that of clarity.
   2. Place dimensions where the shape is best shown.
   3. Shortest dimensions placed closest to the object.
4. Group and align dimensions when possible.
5. Avoid duplicate and/or unnecessary dimensions.
6. Do not place a dimension to coincide with a line of a drawing.
7. Try to avoid placing dimensions inside a view.
8. Avoid crowding dimensions.
9. Avoid dimensioning to hidden features.
10. Place dimensions between the views to which they relate.
11. Lines should be thin and contrast noticeably with visible lines.
12. Dimensions should be included that describe both size and location of features.
13. The diameter of cylinders is dimensioned in the rectangular view. The diameter of machined holes is dimensioned in the circular view.

C. Identify, explain, and be able to illustrate the correct placement of dimensions on the following circular features:

1. Arcs
   a. dimension by using the radius
   b. The letter "R" should precede the arc size.
2. Circles
   a. dimension by using the diameter
   b. The diameter symbol should precede the circle size.
   c. Use a "X" when describing the number or quantity of circles.

D. Correct placement of dimensions on angular features where the angles are expressed in degrees.

E. A point-to-point dimension consisting of "chains" of dimensions placed end to end.
   1. one dimension is omitted
   2. adequate for simple parts

F. ANSI establishes the standard or "correct" rules regarding dimension placement when creating technical drawings.
UNIT VI: Basic Dimensioning Skills

Competency: 006.00
Demonstrate basic dimensioning techniques.

Objective: 006.03
Construct dimensions on an engineering drawing.

Requirements: Each student is required to apply basic dimensioning techniques to a drawing.

1. Using the drafting equipment provided, give all of the dimensions and notes required to describe the object’s size and features.
2. The drawing is produced at a scale of 1:1 (full size).
3. Use decimal inches for all measurements. Give dimensions to two (2) decimal places.
4. Use accepted drafting standards for lines and freehand lettering.
5. Letter your name, problem number (006.03.001), scale, and date in the title block.
6. Time Limit = 60 minutes.

Assessment: The dimensioned drawing should be evaluated based on the following criteria:

- Dimensioning concepts and techniques: 50 points
- Accuracy: 25 points
- Line weight, technique and neatness: 20 points
- Lettering: 5 points
**Rubric for BASIC DIMENSIONING SKILLS – Board drawing**

**Construct dimensions on an engineering drawing - 006.03**

<table>
<thead>
<tr>
<th>Dimensioning concepts and techniques</th>
<th>0-35 points</th>
<th>36-45 points</th>
<th>46-50 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous dimensions are missing. Numerous dimensions are duplicated or are not placed where shape is best shown. Arrowheads are missing. Dimensions are not grouped or aligned. Dimensions are crowded.</td>
<td>Necessary dimensions &amp; notes to manufacture the part are given. Dimensions given where shape is best shown. Dimensions are grouped and aligned. Unnecessary dimensions have been avoided. Shortest dimensions are placed closest to the object. Dimensions not crowded. Understanding of the rules for dimension placement should be clearly evident.</td>
<td>Total Points</td>
<td></td>
</tr>
<tr>
<td>Some needed dimensions and/or notes are missing. There is some crowding of dimensional text. Some dimensions are not grouped or aligned. Some dimensions are given where the shape was not best shown.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Accuracy**

<table>
<thead>
<tr>
<th>0-17 points</th>
<th>18-23 points</th>
<th>24-25 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in measurements. Inappropriate scale used.</td>
<td>Some errors in measurement. When measured, the sizes of features and their locations closely agree with the given problem. Scale is correct.</td>
<td>Total Points</td>
</tr>
</tbody>
</table>

**Line weight/technique/neatness**

<table>
<thead>
<tr>
<th>0-14 points</th>
<th>15-18 points</th>
<th>19-20 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line weights are not uniform. ANSI standards for thickness and darkness not followed. Poor spacing of dimension lines and/or extension line distances past arrowheads. Rules for leader line placement not followed. Poor gaping of extension lines. Size/formation of arrowheads not acceptable.</td>
<td>Some lines are not uniform. Some lines do not meet ANSI standards. Arrowheads are poorly formed.</td>
<td>Line quality is neat, clean, well-formed, and meets ANSI standards for thickness, darkness, and coding. Correct practices for center, dimension, extension and leader lines are followed.</td>
</tr>
</tbody>
</table>

**Lettering**

<table>
<thead>
<tr>
<th>0 points</th>
<th>3 points</th>
<th>5 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter height, thickness, and spacing are not uniform. Letters are not uniformly vertical or inclined. Several spelling errors.</td>
<td>Some letters are not uniform in height, thickness, and spacing. Some letters are not uniformly vertical or inclined. No more than one spelling error.</td>
<td>Lettering is neat, uniform, and correctly formed and spaced. Spelling is correct. All required information is provided.</td>
</tr>
</tbody>
</table>

**Total Score**

62
Rubric for BASIC DIMENSIONING SKILLS using CAD
Apply simple dimensioning to an engineering drawing - 006.03

<table>
<thead>
<tr>
<th>Dimensioning concepts and techniques</th>
<th></th>
<th></th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous dimensions are missing. Numerous dimensions are duplicated or are not placed where shape is best shown. Arrowheads are missing. Dimensions are not grouped or aligned. Dimensions are crowded.</td>
<td>Some needed dimensions and/or notes are missing. There is some crowding of dimensional text. Some dimensions are not grouped or aligned. Some dimensions are given where the shape was not best shown.</td>
<td>Dimensions and notes necessary to manufacture the part are given. Dimensions given where shape is best shown. Dimensions are grouped and aligned. Unnecessary dimensions have been avoided. Shortest dimensions are placed closest to the object. Dimensions are not crowded. Understanding of the rules for dimension placement should be clearly evident.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accuracy</th>
<th></th>
<th></th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 2 dimension values do not agree with actual sizes on the part.</td>
<td>One or two dimension values do not agree with actual sizes on the part.</td>
<td>When measured, the sizes of features and their locations agree with the given problem. Drawing demonstrates an obvious use of object snaps.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension, Extension, Center, and Leader Lines</th>
<th></th>
<th></th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI standards for coding not followed. Poor spacing of dimension lines. Rules for leader line placement not followed. Poor gaping of extension lines.</td>
<td>Some lines do not meet ANSI standards. Visible gaps not included on some extension lines. Some dimension lines not spaced properly.</td>
<td>Lines meet ANSI standards for coding. Correct practices for center, dimension, extension and leader lines are followed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensioning Text and Notes</th>
<th></th>
<th></th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text style and size does not meet accepted standards. More than one spelling error.</td>
<td>No more than one spelling error.</td>
<td>Text style and size meets accepted standards. Spelling is correct.</td>
<td></td>
</tr>
</tbody>
</table>

Total Score

63
AUTHENTIC ASSESSMENT: Product Development

Basic Dimensioning Skills Project Assessment

- Each team member will add basic dimensions to multiview drawing of individual design concept.
  - The multiview drawing original should be preserved and dimensions added to a copy if drawn using instruments rather than CAD.
  - Evaluate drawings based on Basic Dimensioning Skills Performance Objective 006.02
- Teams will generate materials lists and cost estimates.
- Begin prototype construction.
  - Class periods may be used if time permits.
  - Prototype construction may be an out-of-class assignment.
Computer Aided Design & Drafting

007.
Explain and demonstrate basic CAD commands and techniques

007.01
Explain basic CADD terms and concepts

007.02
Explain basic 2D CAD commands

007.03
Explain basic 3D CAD modeling commands and concepts

007.04
Construct a 2D CAD drawing

007.05
Construct a 3D CAD model
UNIT VII: Computer-Aided Design and Drafting (CAD)

Competency: 007.00
*Explain and demonstrate basic CAD commands and techniques.*

Objective: 007.01
*Explain basic CAD terms and concepts.*

**Introduction:** The purpose of this unit is to introduce students to basic 2D and 3D CAD concepts and commands. Over the last 20 years, CAD technology has advanced from only being able to construct simple 2D drawings to the functionality to create sophisticated, rendered, 3D solid models. The curriculum team feels strongly that 3D CAD should be introduced to students in Drafting I. This gives them a good foundation for the upper level courses. This unit will cover terms related to CAD, reasons for using CAD, set-up, draw, and modify commands, point-entry methods, and basic 3D modeling terms and commands. The 2D CAD material can be sufficiently covered with AutoCAD LT, AutoCAD, CADKEY, DATACAD, or the equivalent.

A. Identify the following acronyms: \( R1(46):R2(43) \)
   1. CAD – This term has come to represent many different things. The most common are computer-aided design, computer-aided drafting, and computer aided design/drafting. The usage of the term really depends on the context. If one is producing mainly 2D documents, computer-aided drafting is probably appropriate. Computer-aided design generally reflects design utilizing a 3D modeling database.
   2. CAM – Computer-aided manufacturing. The use of computers to control the production process. The 3D CAD database can be used to run numerically controlled machine tools.

B. Identify reasons for using CAD in place of manual drawing: \( R1(34-46):R2(43-45) \)
   1. Can reduce drawing time and improves productivity
   2. Prevents having to make repeated drawings of often-used symbols
   3. Improves overall appearance and readability of drawing
   4. Allows for easy revision of drawings
   5. Can be transmitted electronically
   6. 3D models, as a 3D database, can be used to:
      a. generate multiview drawings
      b. construct prototypes
      c. generate code for CAM
      d. increase visualization
      e. analyze mass properties of objects (volume, center of gravity, moments of inertia, etc.)

C. Printers and plotters are used to produce hardcopies of CAD files. \( R1(45-46):R2(777-778) \)
UNIT VII: Computer-Aided Design and Drafting (CAD)

Competency: 007.00
Explain and demonstrate basic CAD commands and techniques.

Objective: 007.02
Explain basic 2D CAD commands.


A. Identify and explain the following setup commands:
   1. Units
   2. Limits
   3. Object Snap
   4. Snap
   5. Grid
   6. Ortho
   7. Polar
   8. Layer Controls
      a. Color
      b. Linetype
      c. Line weight
      d. On/Off
      e. Freeze/Thaw
      f. Lock/Unlock
   9. Save/Save As

B. Identify and explain DRAW commands used to create:
   1. a straight line at a stated length, using the keyboard or mouse
   2. circles
   3. arcs
   4. regular polygons
   5. ellipses
   6. text of a stated size and font
   7. lines parallel, perpendicular, or tangent to other lines

C. Display commands
   1. Zoom
      a. Extents
      b. All
      c. Window
      d. Dynamic
      e. Previous
      f. Limits
   2. Pan
3. Change layers
4. Regenerate (REGEN)

D. Dimensions commands
   a. Linear
   b. Angles
   c. Circles (diameter)
   d. Arcs (radius)
   e. Center mark/line
   f. Leaders
   g. Modify properties (Lines & Arrows, Text, Fit, Primary Units)

E. Other commands used to create geometry
   1. Hatch
   2. Blocks
   3. Polylines
   4. Divide
   5. Mirror
   6. Scale
   7. Stretch
   8. Array

F. Modify commands
   1. Selection options and techniques
      a. Crossing window
      b. Window
      c. Crossing polygon
      d. Fence
      e. All
      f. Last
      g. Previous
      h. Remove
   2. Copy lines and/or entities to a new location
   3. Erase
   4. Fillet
   5. Chamfer
   6. Move
   7. Rotate
   8. Trim
   9. Extend
   10. Offset
   11. Grips

G. Edit commands
   1. Inquire/List (area/length)
2. LTSCALE
3. Break
4. Change properties
5. Undo
6. Explode
7. Polyline edit

H. 2D Point Entry Methods
1. Cartesian or Rectangular Coordinates
2. Polar Coordinates (Distance and angle constraints)
3. Absolute Coordinates (global)
4. Relative Coordinates (local)
5. Direct distance entry
UNIT VII: Computer-Aided Design and Drafting (CAD)

Competency: 007.00
*Explain and demonstrate basic CAD commands and techniques.*

Objective: 007.03
*Explain basic 3D modeling commands and concepts.*

**NOTE:** When covering the 3D CAD material, it is recommended that one of the following programs be used: AutoCAD® (not AutoCAD® LT), Inventor®, Rhinoceros®, ProDesktop®, SolidWorks®, or SolidEdge®.

*References: Users Guides, Tutorials, and/or Help menus provided with each software.*

A. Explain 3D modeling concepts: Types of modeling - Wireframe, Surface, and Solid.
   1. Wireframe models
      a. Object has no surfaces, but instead is composed of wire-like edges.
      b. Can see through the object (transparent).
      c. Visualization of object may be difficult because it can be tricky to tell which “wires” are on the front and which are on the back.
      d. Software used for creating wireframe models may include “hidden line” features that make model visualization more understandable by hiding “wires” on the back.
      e. Is very easy and fast for computer to calculate wireframe shapes.
   2. Surface models
      a. Surfaces define the shape of a hollow model.
      b. Surfaces are defined by using light, color and shadow to identify surface shape.
   3. Solid models
      a. Objects are defined as a solid mass.
      b. May contain information about the density, mass, moment of inertia, volume and center of gravity of the object.

B. Set up a 3D scene and view 3D space
   1. Basic software interface
      a. Command line
      b. Menu bar
      c. Toolbars
      d. Graphics area
      e. Status bar
2. Viewports
   a. Creating and changing viewports
   b. Zoom and Pan
   c. Undo/Redo

C. Use basic Boolean commands and capabilities for 3D solid modeling.
   1. Solid Primitives.
      a. Box or rectangular prism
      b. Wedge or triangular prism
      c. Cone
      d. Cylinder
      e. Sphere
      f. Torus
      g. Ortho mode
      h. Shade
   2. Boolean Commands.
      a. Union (+ or ∪) – adds parts together
      b. Subtract or Difference (−) – removes parts or features
      c. Intersection (* or ∩) – Intersects overlapping volumes into a single feature
   3. Extruding 2D profiles or surfaces
   4. Revolving 2D profiles or surfaces

E. Display presentations of the model using shade and basic rendering techniques.
   1. Hide – hides edges that are not visible.
   2. Shade – a flat coloring system that takes minimum lighting into account.
   3. Render allows for more realistic and complex surfaces.
      a. includes sophisticated lighting and shadows.
      b. includes texture and bump maps.
      c. includes sophisticated backgrounds.
      d. raytracing generates reflections, refraction and more precise shadows.

F. Plotting and/or exporting drawings and files.

G. Basic 3D operations that the student should be able to perform:
   1. Generate a model by creating a profile and extruding or sweeping.
2. Generate a model by creating a profile and revolving it around an axis along a circular path.

3. Generate a model by using primitives and Boolean operations.

4. Rotate parts by understanding which axis to use and what angle is required.

5. Shade a model (no shadows or textures required).

6. Plot the drawing.

7. Export the drawing.

**Using Rhinoceros® 3D NURBS Modeling Software**

A. Introduction

1. *Rhinoceros* combines the accuracy of traditional CAD with spline-based modeling to create objects with NURBS curves and surfaces rather than line segments or polygon meshes.

2. Non-Uniform Rational B-Splines (NURBS) are mathematical representations that can accurately define any shape.

3. *Rhinoceros* has a menu structure and operating procedure that is similar to AutoCAD®, making a quick and comfortable transition to 3D modeling for the 2D AutoCAD® user.

4. The program is very powerful and is suitable for constructing varied shapes and objects. *Rhinoceros* would be used by a wide range of designers who work in 3D, especially where the forms are free flowing. It is suggested that you visit their web site to view various applications. (www.rhino3d.com) Rhinoceros is not a parametric feature-based solid modeler like Inventor®, ProDesktop®, SolidWorks®, or SolidEdge®. It may not be as suitable for the type of modeling required in Engineering II or Engineering III as a constraint-based CAD program.

5. Training materials and tutorial problems are available with the software, at bookstores, on-line, or through the software vendor.

B. A sample schedule for learning software basics (taken and modified from *Rhinoceros Teacher Workshop Guide, R30-TWSGUIDE 31-Dec-02*)

1. As you introduce the software, have the students learn only those commands that will help them finish the project. Other commands can be learned as needed and as they are applicable to more advanced projects.

2. Using a 90 minute class, students should reach a reasonable level of proficiency within two to three weeks of instruction.

3. After a reasonable amount of teacher guided/demonstrated projects, students should be allowed some time to explore and create on their own. Consider demonstrating the power of *Rhinoceros* by exposing them to shapes that would not be found in the typical Drafting I textbook (using commands such as the *loft* and *rail revolve* or *control point* modification.

4. Sequence of learning
a. Basic interface: *command line, changing viewports, zoom, pan, undo/redo*

b. Solid primitives: *cone, sphere, box cylinder, torus, ortho, shade*

c. Basic editing: *move, copy, rotate, delete, mirror, scale, object snap*

d. Boolean operatives: *union, difference, intersection*

e. Rendering: *properties, spotlight, render*

f. Creating curves and surfaces: *line, curve, arc, trim, join*

g. Extruding surfaces: *extrude*

h. Revolving surfaces: *revolve*

i. Sweeping surfaces: *sweep 1 rail, sweep 2 rail, rail revolve*

j. Lofted surfaces: *loft*

**Creating 3D solid models in SolidWorks®, SolidEdge®, Inventor®, or ProDesktop®**

SolidWorks®, SolidEdge®, Inventor®, and ProDesktop® are constraint-based CAD programs. They all function in a similar fashion. The biggest difference between these programs and software such as AutoCAD® is the way they take advantage of the 3D database. Within the constraint-based modeler environment the **3D solid model** is typically the first type of file that is created. Once the 3D model files are created, **assemblies** and **drawings** of parts can be generated. Most of these programs take advantage of **bi-directional associativity** between the files. In other words, if a dimension is changed in the model, the drawing file and assembly files automatically update. If a change is made in the drawing file, the change is reflected in the part and/or assembly files.

Constraint-based programs also organize solid models into a series of modifiable **features**. These features are organized in some type of **feature tree** (see Figure 1). The feature tree includes the default planes of projection, the origin, and the individual features that make up each object.

![Figure 1. Solid Model of the BASE PLATE with its Feature Tree.](image)
Another important concept for students to understand when working within constraint-based programs is how constraints work. Within a single part a constraint may be a dimension or it may define the relationship between geometric elements. In Figure 2, three dimensional constraints are shown, but there are many geometric constraints that were applied to make sure the geometry changes correctly if the dimensions are modified. For example, tangent constraints were applied between the four arcs and their corresponding lines. An equal constraint was applied between the four arcs. The two vertical lines are symmetric about the vertical center line. The two horizontal lines are symmetric about the horizontal center line.

By adding the dimensions and constraints in this fashion the part designer is establishing some type of design intent. In other words, if a dimension is modified, the geometry should change only in a way defined by the designer. These changes should reflect how the part works within the assembly. For the part in Figure 2 the intent is to always keep the part centered about the origin. The symmetric constraint will maintain this intent when either the 3.000 or 5.750 dimensions are modified.

Creating Parts within a Constraint-Based Modeler

The following procedure is recommended when modeling using a constraint-based program:

A. Think about design intent. How might things be changed later?

B. Define/select a sketch plane. Use one of the default planes (Frontal, Horizontal, Profile), select a planar surface, or construct a new plane.

C. Sketch the new profile.

D. Constrain the profile by adding relations and dimensions.

E. Define the sweep parameters.
1. Extrude/Revolve/Path/Blend
2. One Side/Two Side
3. Distance
4. Outside/Inside
5. Boolean

F. Execute/Revise.
G. Repeat the procedure for the next feature.

**HOW TO CREATE STUDENT SUCCESS ON VoCATS SECTION 007.03**

A. Students should know that shapes are typically formed by extrusion, Boolean operations, creating a profile and revolving it, or by sweeping operations and should have experience with each of these operations.

B. Students will be expected to know the most efficient method for 3D shape construction. For example, “Should I draw the shape and extrude or would it be easier to create a profile and revolve?”

C. Students should be able identify basic solids and should be able to visualize the results of Boolean operations.

D. Students should be able to explain the advantages/disadvantages of wireframe, surface and solid models.

E. The teacher test item bank provides examples of questions that are typical of the VoCATS exam.
UNIT VII: Computer-Aided Design and Drafting (CAD)

Competency: 007.00
*Explain and demonstrate basic CAD commands and techniques.*

Objective: 007.04
*Construct a 2D CAD drawing.*

**Requirements:** Each student is required to create a 2D CAD drawing.

1. Using the equipment provided, make a CAD drawing of the object shown on the next page.
2. When plotted the drawing should fit on a size A (8.5” X 11”) sheet of paper at a scale of 1:1 (Full Scale). Ask your test administrator for plotting limits.
3. Center the drawing on the sheet.
4. Letter your name, problem number (007.04.001), scale, and date in the title block.
5. Save your work on the diskette provided or as directed by the test administrator.
6. Time Limit = 60 minutes.
7. Your drawing will be evaluated on its accuracy and completeness.
8. Dimension the drawing as shown.
9. Use the following specification:
   a. Units – decimal
   b. Grid – 1 inch
   c. Limits – 10 X 7 inches
   d. Snap - .1 inch
   e. Layers

<table>
<thead>
<tr>
<th>Layer Title</th>
<th>Linetype</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISIBLE</td>
<td>CONTINUOUS</td>
<td>BLACK (WHITE)</td>
</tr>
<tr>
<td>HIDDEN</td>
<td>HIDDEN</td>
<td>DARK BLUE</td>
</tr>
<tr>
<td>CENTER</td>
<td>CENTER</td>
<td>RED</td>
</tr>
<tr>
<td>DIMENSIONS</td>
<td>CONTINUOUS</td>
<td>RED</td>
</tr>
</tbody>
</table>

**Assessment:** The 2D CAD drawing should be evaluated based on the following criteria:

- CAD set-up: 30 points
- Accuracy: 30 points
- Lines: 20 points
- Dimensioning text and notes: 15 points
- Layout and balance: 5 points
ALTERNATE WRENCH HEADS
HALF SIZE

CLOSED-END WRENCH
Rubric for BASIC CAD – Construct a 2D CAD drawing - 007.04

**CAD Setup**

<table>
<thead>
<tr>
<th>Description</th>
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<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in setting up layers, limits, units, grid, snap, colors,</td>
<td>0-21</td>
<td>Some errors in setting up layers, limits, units, grid, snap, colors, and linetype.</td>
<td>22-27</td>
<td>Layers, limits, units, grid, snap, colors, and linetype are constructed according to the specifications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and linetype.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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**Accuracy**

<table>
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<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in measurements.</td>
<td>0-21</td>
<td>Some errors in measurement.</td>
<td>22-27</td>
<td>When measured, the sizes of features and their locations agree with the given problem.</td>
<td>28-30</td>
<td></td>
</tr>
</tbody>
</table>

**Lines**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous stray lines or pieces of lines. Intersections are not formed. ANSI</td>
<td>0-14</td>
<td>Some intersections are not formed. Some lines do not meet ANSI standards.</td>
<td>15-18</td>
<td>Line quality meets ANSI standards for coding. Drawing demonstrates an obvious use of object snaps. No stray lines.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>standards for coding not followed.</td>
<td></td>
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</tbody>
</table>

**Dimensioning Text and Notes**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions and text styles and sizes do not meet accepted standards. More</td>
<td>0-10</td>
<td>Some errors in settings for dimensions and text. No more than one spelling error.</td>
<td>11-13</td>
<td>Styles and sizes for dimensions and text meet standards as determined by the teacher. All dimensions and text are given as shown. Spelling is correct.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>than one spelling error. Misplaced or missing dimensions and/or text.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Layout & balance**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
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<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The drawing is not centered vertically or horizontally. Major errors in</td>
<td>0-1</td>
<td>The drawing is centered vertically but not horizontally (or horizontally but not vertically). Some errors in constructing the border and title block.</td>
<td></td>
<td></td>
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<tr>
<td>constructing the border and title block.</td>
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<tr>
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<td>2-3</td>
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</tr>
</tbody>
</table>

Total Score

78
UNIT VII: Computer-Aided Design and Drafting (CAD)

Competency: 007.00
*Explain and demonstrate basic CAD commands and techniques.*

Objective: 007.05
*Construct a 3D CAD model.*

Requirements: Each student is required to create a 3D model.
1. Using the equipment provided, create a 3D model of the object below and use an appropriate method to shade/color the model as specified by your test administrator.
2. When plotted the drawing should fit on a size A (8.5” X 11”) sheet of paper. Ask your test administrator for printing or plotting limits.
3. Include your name, problem number (007.05.001), and date in the file.
4. Save your work on the diskette provided or as directed by the test administrator.
5. Time Limit = 90 minutes.

Assessment: The 3D solid model should be evaluated based on the following criteria:

- CAD setup and shading: 10 points
- Accuracy of features: 30 points
- Orientation of the model in 3D space: 15 points
- Features modeled correctly: 40 points

ALL FILLETS AND ROUNDS ARE TO BE R.125 UNLESS OTHERWISE SPECIFIED.
Text and notes  5 points
### Rubric for BASIC CAD – Construct a 3D CAD model - 007.05

**CAD Setup and shading**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous or flagrant errors in file setup.</td>
<td>0-6 points</td>
<td>Some errors in file setup.</td>
<td>7-8 points</td>
<td></td>
</tr>
<tr>
<td>CAD file setup (such as units, shading, etc.) is constructed according to the specifications.</td>
<td>9-10 points</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Accuracy of features**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in measurements.</td>
<td>0-21 points</td>
<td>Some errors in measurement.</td>
<td>22-27 points</td>
<td></td>
</tr>
<tr>
<td>When measured, the sizes of features and their locations agree with the given problem.</td>
<td>28-30 points</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Orientation of the model in 3D space**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Important features are hidden from view. Object is not modeled in natural or specified position (upside-down, etc.).</td>
<td>0-10 points</td>
<td>Object is modeled in its natural or specified position. Some features are not clearly presented.</td>
<td>11-13 points</td>
<td>14-15 points</td>
</tr>
<tr>
<td>Object is modeled in its natural or specified position. Object features are clearly presented.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Features modeled correctly**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerous errors in feature size and/or location (slots, holes, fillets, etc.).</td>
<td>0-29 points</td>
<td>Some errors in feature size and/or location (slots, holes, fillets, etc.).</td>
<td>30-37 points</td>
<td>38-40 points</td>
</tr>
<tr>
<td>All features (slots, holes, etc.) are sized and located correctly. Fillets and rounds properly formed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Text and Notes**

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Description</th>
<th>Points</th>
<th>Total Points</th>
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<tbody>
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<td>Text style and size does not meet accepted standards. More than one spelling error.</td>
<td>0 points</td>
<td>No more than one spelling error.</td>
<td>3 points</td>
<td>5 points</td>
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<tr>
<td>Text style and size meets accepted standards. Spelling is correct.</td>
<td></td>
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</tbody>
</table>

Total Score: 81
AUTHENTIC ASSESSMENT: Product Development

Computer-Aided Design and Drafting (CAD) Project Assessment

- Each team member will construct a 2D CAD drawing of individual design concept (if previous drawings are drawn using board techniques).
  - Evaluate drawings based on 2D CAD Performance Objective 007.04

- Each team member will construct a 3D CAD model of individual design concept (if previous drawings are drawn using board techniques).
  - Evaluate drawings based on 3D CAD Performance Objective 007.05
APPENDIX A

Bibliography / References

Textbooks


CAD Software Websites

AutoCADLT, AutoCAD, and Inventor – www.autodesk.com

CADKEY – www.cadkey.com

Pro/Engineer & Pro/Desktop – www.ptc.com

Rhinoceros – www.rhino3d.com

Solid Edge – www.solid-edge.com

SolidWorks – www.solidworks.com

Student Version Pricing for CAD Software – www.journeyed.com
APPENDIX B
Vendor’s – Texts – Software – Literature

Vendor’s – Texts

Amazon.com, Inc. (Book resource)
www.amazon.com

Glencoe/McGraw-Hill
6510 Jimmy Carter Boulevard
Norcross, GA 30071-1705
Phone: (800) 731-2365
Fax: (770) 613-5065

NC SkillsUSA VICA

Glen Barefoot
Department of Public Instruction
Instruction Technology & Human Services
6360 Mail Service Center
Raleigh, NC 27699-6360
Phone: 919-807-3887
Fax: 919-807-3899
Gbarefoot@dpi.state.nc.us

National SkillsUSA VICA
P.O. Box 3000
Leesburg, VA 20177-0300
Phone: 703-777-8810
Fax: 703-777-8999
www.vica.org

Software

Peter Fay
ACADemic
Koger Center
2300 W. Meadowview Rd., Suite 206
Greensboro, NC 27407
Phone: 800-301-0779

NC-DPI

Tom Shown
Department of Public Instruction
Instruction Technology & Human Services
6360 Mail Service Center
Raleigh, NC 27699-6360
Phone: 919-807-3880
Fax: 919-807-3899
Tshown@kpi.state.nc.us
### APPENDIX C

**Trade and Industrial Education - Drafting Facility Equipment List**

Courses taught within the facility:  Drafting I  

<table>
<thead>
<tr>
<th>Code</th>
<th>Equipment Description</th>
<th>DFT</th>
<th>ENG</th>
<th>ARC</th>
</tr>
</thead>
<tbody>
<tr>
<td>7921</td>
<td>2D CAD Software (AutoCAD, AutoCAD LT)</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>3D CAD Software (Rhino 3D, Solidworks)</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>C or D size plotter/printer</td>
<td>1F</td>
<td>1F</td>
<td>1F</td>
</tr>
<tr>
<td></td>
<td>Drafting stool</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>Drafting table/computer printer</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>Instructor chair</td>
<td>1F</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>Instructor desk</td>
<td>1F</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>PC to TV converter or LCD panel screen for projector</td>
<td>1F</td>
<td>1S</td>
<td>1S</td>
</tr>
</tbody>
</table>

- Pentium III (or better) computer w/ 10 GB hard drive or higher, 450 MHz (or better) suggested clock speed, 128 MB RAM, 52X CD-ROM, 3.5 floppy drive, 17” (or larger) monitor, Open GL graphics card w/ 32 MB or better VRAM & input/output, multimedia capability, NIC

<table>
<thead>
<tr>
<th>Code</th>
<th>Equipment Description</th>
<th>DFT</th>
<th>ENG</th>
<th>ARC</th>
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<tr>
<td>7922</td>
<td>Printer</td>
<td>1F</td>
<td>1F</td>
<td>1F</td>
</tr>
<tr>
<td></td>
<td>TV/VCR</td>
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### Tools and Other Items Under $100

<table>
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<tr>
<th>Code</th>
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<tr>
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<td>Ames Lettering Guide</td>
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<td>1S</td>
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<tr>
<td></td>
<td>Brush, dusting</td>
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<td>1S</td>
<td>1S</td>
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<tr>
<td></td>
<td>Calculator</td>
<td>1F</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compass</td>
<td>1S</td>
<td>1S</td>
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</tr>
<tr>
<td></td>
<td>Compass Lead, tube (gross)</td>
<td>1F</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cover, drawing board</td>
<td>1S</td>
<td>1S</td>
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</tr>
<tr>
<td></td>
<td>Erasing Shield</td>
<td>1S</td>
<td>1S</td>
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<tr>
<td></td>
<td>French Curve</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td></td>
<td>Gauge, screw pitch</td>
<td>1:4S</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gauge, small hole</td>
<td>2F</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gauge, vernier height 10”</td>
<td>2F</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Lead Holder</td>
<td>2F</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Lead refills, 2H &amp; 6H</td>
<td>1S</td>
<td>1S</td>
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<tr>
<td></td>
<td>Paper cutter</td>
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</tr>
<tr>
<td></td>
<td>Parallel bar</td>
<td>1S</td>
<td>1S</td>
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<tr>
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<td>Printer table</td>
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<td>Scale, triangular, architect’s 12”</td>
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<td>Scale, triangular, engineer’s 12”</td>
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<tr>
<td></td>
<td>Scale, triangular, metric 12”</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
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<tr>
<td></td>
<td>Template, bolts &amp; nuts</td>
<td>10F</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Template, circles, fraction</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
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<tr>
<td></td>
<td>Template, circles, metric</td>
<td>1S</td>
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<td>1S</td>
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<tr>
<td></td>
<td>Template, electrical</td>
<td>10F</td>
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</tr>
<tr>
<td></td>
<td>Template, ellipses</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
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<tr>
<td></td>
<td>Template, house plan &amp; plumbing</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
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<tr>
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<td>Template, large isometric</td>
<td>10F</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Template, machine &amp; cap screws</td>
<td>10F</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Template, screw threads</td>
<td>10F</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Template, small isometric</td>
<td>1S</td>
<td>1S</td>
<td>1S</td>
</tr>
<tr>
<td>Item</td>
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<td>1:4S</td>
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<td>------</td>
<td></td>
</tr>
<tr>
<td>Triangle, adjustable</td>
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<td>IS</td>
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</tr>
<tr>
<td>Triangle, 30° x 60° 10&quot;</td>
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<td>IS</td>
<td>IS</td>
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</tr>
<tr>
<td>Triangle, 45° 10&quot;</td>
<td>IS</td>
<td>IS</td>
<td>IS</td>
<td></td>
</tr>
</tbody>
</table>

Quantities are listed per:  
F=Facility  C=Center  S=Student
APPENDIX D

Facility Design

Program Area: Trade & Industrial Education
Course Title: Drafting I
Course Description:

Purpose:
To provide training in the use of simple and complex graphic tools to communicate ideas and concepts in the areas of architecture, manufacturing, engineering, mathematics, and the sciences.

Types of Instruction:
Lecture; demonstration; individual inquiry; small-group cooperative learning; individual and small-group viewing of video programs

Typical Activities:
Individual production of technical drawings using conventional and computer-aided drawing equipment; sketching; individual and small-group design projects involving cutting, gluing, and assembling; maintenance of tables and equipment

Maximum Recommended Class Size: 20
Typical Length of Class Period: 90 minutes (block schedule); 55 minutes (traditional)
Typical Duration of Course: Semester (block); Year (traditional)

Rationale for Program Selection:
Success in all areas of business and industry is predicated on the ability to communicate effectively. Complex graphic tools are used in all facets of the economy, including the sciences, for analyzing and sharing information. This program prepares the student to effectively use these communication tools.

Program Locations and Relationships:
May be the center for the school’s most sophisticated computer activities and appropriately located contiguous to other computer-oriented programs; May be a part of an integrated approach to math and science and located accordingly; Need not be located near other trade and industrial education programs.

Shared Space Options:
1. Other Workforce Development:
   Fundamentals of Technology
   Computer Applications (depending upon the number of computers)
   Graphic Communications
   Scientific and Technical Visualization
2. Other Elective:
Art

3. Academic:
   Mathematics
   Science

Space Requirements:

1. Square Footage Range: 1800 – 2200
2. Peculiar Needs:
   A. Deep sink with hot and cold supply
   B. Appropriate ventilation for Diazo printer
   C. 100 foot-candles of artificial lighting required for drawing
3. Special Conditions: N/A
4. Flexibility Needs: N/A

Furnishings and Equipment:

1. Typical Furniture:
   A. Drafting tables (to accommodate size “C” paper) and stools
   B. Flat tracing files (ten drawers minimum)
   C. Teacher drawing table and desk and file cabinets
   D. Lockable storage cabinets with shelves for drawing equipment and software

2. Typical Casework;
   A. Bookshelves for reference books, magazines, and manuals
   B. Storage shelves for drawing and reproduction media up to size “D” sheets
   C. Storage shelves for student models and projects
   D. Storage for Diazo machine filters and ammonia
   E. Counters to accommodate twenty computers and four printers, or counters for printers only, if drafting tables are designed to accommodate computers
   F. Counter space for a size “A” – “D” plotter or printer, a Diazo reproduction machine, and a paper cutter

3. Typical Equipment:
   A. Size “D” plotter or printer
   B. Computers for CAD
   C. Printers
D. TV monitors for display of computer software techniques
E. Computer-to-TV display equipment or computer projection device
F. Small hand tools for project construction
G. CAD/CAM

Special Notes:
1. Perimeter electrical outlets above counter height
2. Accessible to local school network and Internet
3. Light dimmers near teacher station for use of projectors and TV monitors

Sample Floor Plan:  See next page.
# APPENDIX E
## 7921 DRAFTING I EVALUATION FORM

Your suggestions and insights are needed to improve our curriculum products including the curriculum guide, recommended activities, performance assessments, blueprint, test-item bank, and reference media. Please review all the Drafting I curriculum materials carefully. After teaching one full course cycle, please take the time to fill out and return this evaluation form. Note that the more specific and clear your suggestions are, the more useful and influential they will be. You may wish to have an industry representative evaluate the products. Thank you for helping us serve you and your students better.

Rate the following statements from 1-5, with 1 being poor and 5 being excellent. When responding to specific curriculum content found within the curriculum guide or blueprint, please give competency and objective numbers.

**Teacher's Name:**

<table>
<thead>
<tr>
<th>School Name:</th>
<th>Don't Know</th>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Very Good</th>
<th>Excellent</th>
</tr>
</thead>
</table>

1) Blueprint is well structured and focuses on essential concepts and skills. It does not contain superfluous content.  
Comments:

![Unsure][1] 1 2 3 4 5

2) Curriculum guide clearly specifies the content needed to achieve program mastery. It is easy to use and is technically correct.  
Comments:

![Unsure][1] 1 2 3 4 5

3) Curriculum incorporates appropriate math, science, technical concepts, and processes. Content is not too complex or too simple for students. It is technically correct.  
Comments:

![Unsure][1] 1 2 3 4 5

4) Curriculum reflects the use of state-of-the-art technology. Equipment list reflects state-of-the-art technology and meets minimum standards.  
Comments:

![Unsure][1] 1 2 3 4 5
5) Program completers are well prepared for entry level 1
unsure 2 3 4 5 position in industry and/or post-secondary studies.
Comments:

Return To: Tom Shown
Instructional Technology & Human Services Phone: 919-807-3880
6360 Mail Service Center Fax: 919-807-3899
Raleigh, N.C. 27699-6360 tshown@dpi.state.nc.us