GENERAL COMPETENCIES FOR STUDENTS

The following is a list of general competencies which the student will acquire through completion of this program.

1. Demonstrate the correct operation of all basic hand and machine tools normally found in the Machine-Tool trade (U/A B.2).

2. Use reference materials appropriate to the trade (S/C A.7).

3. Understand drawings and blueprints as they pertain to the trade (S/C F.4).

4. Exhibit safe work habits and attitudes (A/A E.1 & U/A B.6).

PERSONAL COMPETENCIES FOR STUDENTS

After completing this program, the student will demonstrate a willingness to:

1. do assigned tasks without constant supervision (A/A C.3);
2. work as a team member and assist others (A/A E.3);
3. observe safety rules (A/A C.2);
4. maintain tools, equipment, and work stations (A/A F.2); and
5. adapt to changes in schedules, job assignments, or supervisors (U/A B.6).

INTEGRATING CONNECTICUT'S COMMON CORE OF LEARNING

The following components of Connecticut's Common Core of Learning (CCL) receive primary emphasis in the General Competencies and the Personal Competencies for Students in the Machine-Tool program. However, the instruction and experiences which are directed toward achievement of each competency and goal will address other CCL components, as well. Instructors may determine the extent of those extended relationships by analyzing the complete Common Core of Learning contained in Appendix B.

Attitudes and Attributes

C.3 Demonstrate dependability.
E.1 Develop productive and satisfying relationships with others based upon mutual respect.
E.3 Participate actively in reaching group decisions.
F.2 Develop an understanding of the importance of each individual to the improvement of the quality of life for all in the community.

Skills and Competencies

A.7 Use the features of books and other reference materials to locate information.*

F.4 Locate and use a variety of sources of information including print and nonprint materials, computers, and other technologies.*

Understandings and Applications

B.2 Demonstrate attitudes and habits (such as pride in good workmanship, dependability and regular attendance) and the employability skills and specialized knowledge of the Machine-Tool trade that will make the individual a productive participant in economic life and a contributor to society.*

B.6 Exhibit the interpersonal skills necessary for success in the workplace.

*Modified wording of the CCL.

GRADE 9 - EXPLORATORY: MACHINE-TOOL

Suggested Instructional Time: 5 Days

Overview: After completing the exploratory cycle, the student should be able to identify basic machine tools and measuring instruments. The student should also be informed on the advantages of selecting Machine-Tool as their trade.

Student Competencies: After completing the Machine-Tool Exploratory Program, the student should:

1. Know the layout and safety procedures of the machine shop.

2. Appreciate the need for proper and safe use and maintenance of tools.

3. Identify common hand and measuring tools.

4. Apply various measuring techniques to stock turned on an engine lathe.

Exploratory - Theory and Shop Outline:

Theory

A. Opportunities in the Machine Trade

    1. Layout
    2. Safety rules

B. Shop Orientation

C. Guidelines for Care and Safe Use of Tools

    1. Use the correct tool for the job being done
    2. Keep tools clean and in good condition

D. Common Hand and Measuring Tools

    1. 6" steel rule
    2. 0-1" micrometer
    3. Ball peen hammer
    4. Center and prick punch
    5. Combination square set
    6. Outside and inside calipers
    7. Center gage
    8. 5/16" tool bit

Shop

A. Safety Principles and Procedures

B. Turning on an Engine Lathe

1. Turning a diameter within 1/64" using an outside caliper
2. Turning a step to length using a 6" steel rule
3. Turning a diameter to .005 using a micrometer
4. Turning a diameter to a certain size for cutting an American standard thread

Evaluation and Testing:

Instructors are encouraged to use a variety of evaluative instruments and techniques. Where tests and quizzes are employed, Instructors should have a variety of question types including short answer and essay.

Use of pre/post-tests and competency-based testing are highly recommended.

GRADE 10 - MACHINE-TOOL

Suggested Instructional Time: 90 Days

Overview: During this year the students will review basic machine tools and measuring instruments such as the engine lathe, drill press, and the horizontal and vertical millers.

Student Competencies:

At the end of Grade 10 each student will be able to:

1. Turn outside diameters to shoulder and to ± .001 tolerance.
2. Mount work between centers, collets and chucks.
3. Read scales, micrometers and verniers.
4. Grind tool bits and sharpen drills to proper angles.
5. Mill square and parallel to ± .005 and do simple indexing.
6. Contour saw stock to layout lines and cut off to length.
7. Drill, tap and ream holes to commercial tolerances.
8. Cut threads, turn tapers and bore holes to ± .005.
9. Grind O.D.s to ± .001 and flats square and parallel to ± .001.

Grade 10 - Theory and Shop Outline:

Theory

A. Orientation - Problems Pertinent to Local Situation

    1. What is the machine-tool industry
    2. General shop safety
        a. eyes
        b. moving parts, guards
        c. clothing and hair
        d. cutters and grinding wheels
        e. safe work holding practices

B. Occupational Safety and Health Act (OSHA)

1. Purpose
2. Guarding devices
3. Safe handling of
   a. cutting tools
   b. grinding wheels
4. Personal protection
   a. eyes
   b. clothing
   c. face and hair
   d. respiratory
5. Fire protection
   a. maintain extinguishers
   b. safety cans and containers
   c. wire electrical connections
   d. fire alarm systems
6. Shop areas
   a. housekeeping
      1. clear aisles, stairs, etc.
      2. clear floors
      3. clear doors
   b. ladders - safe use of
7. Material and data for dangerous chemicals

C. Measurement and Measuring Tools

1. The steel rule
   a. types (fractions - decimals)
   b. graduations
   c. apply fraction (addition, subtraction and division)
   d. metric measurement
   e. geometrical tolerancing and measurement
2. The micrometer
   a. nomenclature, care and types
   b. graduations
   c. apply decimals (addition, subtraction, and division)
3. Protractor
   a. types and nomenclature
   b. application of the circle (degrees and minutes)
   c. angular measure (complementary and supplementary angles)
4. Indicators
   a. types and care of
   b. dial .001 graduations

5. Miscellaneous
   a. inside, outside and hermaphrodite calipers
   b. screw pitch gage
   c. drill gages (all types)
   d. square (combination, etc.)
   e. surface gage
   f. center gage
6. Standards for measurements
   a. history of the International Bureau of Weights and Measurements

D. Bench Work

1. Hand tools
   a. files - types and safe practices
   b. electric hand tools - safe practices
   c. hacksaws, punches, scribers, etc. - safe practices
   d. adjustable wrench, spanner, box and solid-safe practices
2. Layout
   a. preparation of surfaces
   b. use of square, scriber, centerhead, protractor, divider, surface gage

E. Threads and Threading

1. Thread forms and types
   a. Unified and U.S. Standard (60°)
      1. pitch of thread (apply formula)
      2. lead of thread
      3. major diameter and minor diameter (apply formula)
      4. compound rest setting (apply formula)
      5. classify types of fits
      6. set up
2. Thread cutting (types of machines)
   a. thread series (4-40 - 5-40 etc.)
   b. tapping
      1. selection of tap drill
   c. chasing with die
      1. adjust die
   d. lathe
      1. gear box setting (chart on box setting)
   e. other thread cutting equipment

F. Cutting Tools

1. Single point tools
    a. characteristics (hardness)
    b. clearances for cutting edge
    c. chip control
    d. shapes of tools
        1. turning, facing, threading
        2. necking (cut off)
        3. shaping
        4. boring
2. Milling cutters
    a. safety
        1. sharp edges, moving parts, etc.
    b. concept of cutting angles (relate to tool bits)
    c. types of cutters
        1. plain milling
        2. end mills (2 lip, etc.)
        3. slab mills

G. Engine Lathe

1. History of the lathe
2. Safety
    a. safety glasses
    b. machine guards
    c. electric brake
    d. foot brake
    e. red safety button
3. Orientation
    a. nomenclature, types -- belt drive, gear drive
    b. maintenance
    c. sizes - swing overways, length of bed, distance between contours
4. Methods of mounting work
    a. centers (centering stock)
    b. chucking (collets, 3 & 4 jaw chucks)
    c. turning, boring & facing operations
    d. drilling, reaming & tapping operations
    e. knurling & thread operations (external)
    f. cut off stock
    g. true work in chuck (indicator, chalk, etc.)
    h. square, round, irregular shapes
5. Frictions and lubrication
    a. centers
    b. ways
    c. moving parts

6. Attachments (set-up procedures and functions)
    a. taper (3 methods)
        1. taper attachment
        2. tail stock offset
        3. compound
    b. steady rests
    c. tool post grinder

H. Miller

1. History of the miller
2. Safety
3. Principles of milling machine operations
    a. work fixed
    b. cutter rotates
4. Milling machine and nomenclature
    a. classification and size
        1. vertical
        2. plain
        3. Universal
5. Milling processes
    a. climb and conventional
    b. horizontal, vertical
    c. drilling
6. Work holding devices
    a. vises
    b. fixtures
    c. strapping
7. Dividing head
    a. direct indexing
    b. simple indexing
        1. formula $T = \frac{40}{N}$
        2. plate selection
        3. Use of handbooks and tables

I. Grinding

1. History of the grinder
2. Types of grinders
    a. pedestal
    b. surface
    c. O.D. & I.D.
    d. tool & cutter
3. Grinding wheels
    a. dressing wheels (basic)

Shop

A. Safety Principles and Procedures

B. Engine Lathe

1. Face and center
2. Mount stock on centers
3. Turn to ± or - .001
4. Mount work 3-jaw chuck

C. Drill Press

1. Strap work to table
2. C'bore and spot face
3. Drill and tap

D. Milling

1. Mill work square
2. Locate edges
3. Indicate vise square
4. Tram head

Evaluation and Testing:

Instructors are encouraged to use a variety of evaluative instruments and techniques. Where tests and quizzes are employed, instructors should have a variety of question types including short answer and essay.

Use of pre/post-tests and competency-based testing are highly recommended.

GRADE 11 - MACHINE-TOOL

Suggested Instructional Time: 90 Days

Overview: After completing the 11th grade, the student will be able to work to closer tolerances, set up different machine-tool attachments and will be introduced to grinding, heat treating and CNC equipment.

Student Competencies:

At the end of Grade 11 each student will be able to:

1. Indicate work to ± .001, turn shoulders to ± .001, mount work in steady rest and set-up taper attachment.

2. Select speeds and feeds.

3. Grind slots, O'D's, radii and angles to within ± .0005.

4. Program jobs and produce them in the N/C machine.

5. Layout and inspect work with indicator height gage, sine bar and size blocks to specifications.

6. Harden and temper to specifications.

7. Mill radii, slots and irregular shapes to ± .001.

8. Drill, bore, ream and tap to commercial tolerances in milling machine.

9. Set-up vises and locate work on rotary tables, tram heads, mount work on angle irons, sine plates and chucks to tolerances ± .001.

Grade 11 - Theory and Shop Outline:

Theory

A. Review Shop Safety Procedures

B. Measurement and Measuring Tools

1. Principles of the vernier scale
   a. application to
      1. height gage
      2. calipers
      3. machine positioning dial
      4. protractor
      5. rotary table
      6. review angular measures
2. Gage blocks
   a. classification
   b. assembling
   c. building combinations
   d. effects of temperature and dust
   e. review of decimals
3. Sine bar
   a. principles
   b. types (5" - 10", sine plate)
   c. use of trig tables and handbook
   d. set-up for angles (planner gage, angle plate and size blocks)
4. Special gages
   a. "Go" and "No Go" gages (also thread)
   b. ring gages
   c. taper gages
   d. wire measurement (1 to 3)
   e. adjustable parallels
   f. hardness tester
5. Principles of linear measurements
   a. English System
   b. Metric System

C. Bench Work

1. Broaching
2. Layout
   a. blueing
   b. copper sulphate
   c. chalk
   d. oxidizing
3. Layout technique
   a. surface plate, planer gage, dial indicator
   b. sine bar, size blocks, angle layout
   c. bevel protractor, V blocks, etc.
   d. review trigonometric and geometric principles
   e. inspection technique

D. Threads and Threading

1. Thread forms and types
   a. acme
   b. square
   c. multiple lead
2. Thread nomenclature and measurement
   a. thread series
   b. helix angle
   c. pitch diameter - apply formula
   d. crest - apply formula
   e. root - apply formula
   f. use of handbook and tables
   g. thread micrometers, gages, three wire systems and comparators

E. Cutting Tools

1. Single point tools
   a. types of steel
      1. H.S.S.
      2. cobalt
      3. carbide
      4. coated
      5. titanium
      6. ceramic
   b. cutting angles and principles
      1. side cutting edge angle
      2. rake angles
      3. chip breakers
      4. cutting feed and speeds - related to clearance angles and materials (H.S.S. & carbide tools)
      5. handbook, tables, math formulas for feeds and speeds
2. Form tools
   a. radius tools
   b. irregular and special shapes

F. Lathe

1. History of the lathe
2. Speeds and feeds
3. Boring and cutting internal and external threads
4. Truing soft jaws
5. Turning eccentrics
6. Form tool work
7. Tapers
   a. types
   b. calculating tapers (ft./inch)
      1. handbook and tables
      2. tapered reamers, Jarno, B & S, Morse, etc.

G. Miller

1. History of the miller
2. Safety
3. Work holding device
   a. rotary tables
   b. angle plate work
   c. V-block work
   d. dividing head
      1. direct indexing
      2. simple indexing
      3. formulas $T = \frac{40}{N}$, $T = \frac{5}{N}$
4. Milling processes
   a. drilling, boring, reaming and tapping
   b. speeds and feeds
      1. tooth loads
   c. straddle and gang milling
   d. compound indexing
   e. indexing for angles (degrees, minutes)
   f. truing table and mounting devices
   g. tram spindle to table
   h. locate edges
5. Work holding techniques
   a. mill against solid jaw, etc.
6. Milling cutters
   a. safety
   b. review of concepts of cutting
   c. types of cutters, face milling, form and angle milling and slitting saws, etc.
   d. principles of mounting cutters
   e. locating edges

H. Shaper

1. History of the shaper
2. Principles of shaper operation
   a. types
   b. nomenclature
   c. work holding techniques
   d. uses for and tool clearances

I. Grinders

1. History of the grinder
2. Types and maintenance
    a. surface
    b. O.D. and I.D.
    c. cutter
    d. special
    e. oiling, emery dust, etc.
    f. micro-finishes
    g. effects of wheel selection
    h. effects of heat
3. Wheels
    a. selection
    b. coding
    c. abrasives and bands
    d. mounting and dressing technique
    e. work holding devices

J. Band Saws

1. History of band saws
2. Types
    a. horizontal
    b. vertical
    c. nomenclature
3. Blade selection
    a. materials
    b. speeds and feeds
    c. cutting actions
    d. effects of numbers of teeth
    e. mounting blades
    f. work holding and cutting techniques

<u>Shop</u>

A. Safety Principles and Procedures

B. Grinding
1. Select wheels
2. Mount wheels
3. True and dress wheels
4. Grind surfaces parallel and square

C. Heat Treating
1. Set temperature controls
2. Case harden
3. Carburize
4. Test hardness

D. CNC Equipment
   1. Types of CNC (mill, turning)
   2. Programming
   3. Simple milling and turning

Evaluation and Testing:

Instructors are encouraged to use a variety of evaluative instruments and techniques. Where tests and quizzes are employed, instructors should have a variety of question types including short answer and essay.

Use of pre/post-tests and competency-based testing are highly recommended.

GRADE 12 - MACHINE-TOOL

Suggested Instructional Time: 90 days

Overview: After completing the 12th grade the students will be able to layout and turn eccentrics, bore holes to ± .0005, program using CNC equipment and also operate the EDM, the jig borer or other available special machines.

Student Competencies:

After completing Grade 12, each student will be able to:

1. Layout and turn eccentrics and irregular shapes.
2. Lap or hone work to ± .0002.
3. Bore holes in millers, lathes and jig borers to ± .0005.
4. Program irregular shapes on N/C machine.
5. Sharpen milling cutters.
6. Set-up special attachments and equipment on the vertical miller.
7. Under instruction operate the EDM, the jig borer or other available special machines as reflected by the industrial needs of the area.

Grade 12 -Theory and Shop Outline:

Theory

A. Measurement and Measuring Tools

   1. Cutter clearance gages
   2. Comparitor
      a. principles of
      b. purpose
      c. lenses and their use
   3. Review
      a. sine bars (trig. and handbook)
      b. special gages
      c. vernier scales
      d. angular measure (degrees, minutes and seconds)

B. Bench Work

1. Cold working (peening)
   a. principles of
      1. distortion of grain structure
      2. hardness
      3. allowances

C. Lathe

1. Safety
2. History of the lathe
3. Face plate work technique
4. Machinability of metals

D. Miller

1. History of the miller
2. Safety
3. Milling process
   a. climb and conventional
   b. horizontal, vertical
   c. drilling, boring, reaming and tapping
   d. speeds and feeds
      1. tooth loads
   e. straddle and gang milling
   f. truing table and mounting devices
   g. tram spindle to table
   h. locate edges
   i. mill against solid jaw, etc.
   j. cutter rotation - with thread rotation
4. Work holding devices
   a. vises
   b. fixtures
   c. strapping
   d. rotary table
   e. angle plate work
   f. "V" block work
5. Dividing head
   a. direct indexing
   b. simple indexing
      1. formula $T = \frac{40}{N}$
      2. plate selection
      3. use of handbooks and tables
      4. angle indexing (degrees, minutes)

E. Grinders

1. History of the grinder
2. Review types (surface, O.D., I.D. - special)
3. Grinding angles and work mounting techniques
    a. sine bar
    b. wheel forming
    c. cut off wheels
    d. plunge grinding
    e. coolants
4. Tool and cutter grinding
    a. types
    b. mounting wheels
    c. truing and dressing wheels
    d. setting up cutters
        1. plain
        2. stagger tooth
        3. slab mills
        4. angle cutters
        5. cutter angles and clearances
        6. gages
5. Surface finishes
    a. micro-finishes
    b. effects of wheel selection
    c. effects of heat

F. Heat Treatment

1. Basic metallurgy
    a. introduction to metals
    b. properties of metals
2. Basic metals
    a. ferrous
    b. non ferrous
3. Surface treatment of metals
    a. heat treatment
    b. cold working
4. Carbon steels
    a. iron carbon diagram
    b. low, medium and high carbon content
    c. alloys (types of H.S.S.)
        1. effects of alloying
5. Heat treatment processes
    a. case hardening
    b. carburizing
    c. tempering
    d. annealing
    e. normalizing
    f. soaking before quenching

6. Quenching
    a. air
    b. water
    c. oil
    d. brine

G. Electrical Discharge Machine (EDM)

1. Function of EDM
    a. types of EDM's
    b. operation of machine
2. Set up techniques and work holding devices
    a. flushing techniques
    b. accessories and their uses
3. Electrode materials
    a. carbon
    b. copper
    c. others
    d. surface finishes
    e. making electrodes for EDM
    f. calculating overcut, wear, stock removal, wear ratio
    g. methods of 2 dimensional electrode construction
    h. duplicating from template and layout
    i. methods of 3 dimensional electrode construction
4. Duplicating from models, sample part, mold
    a. types of duplicating machine tools 2D & 3D hand - hydraulically operated
    b. operation of equipment
    c. selection of cutters
        1. ball mill
        2. single lip
        3. carbide burrs
    d. speeds and feeds

<u>Shop</u>

A. Safety Principles and Procedures

B. Engine Lathe

1. Turn eccentrics
    a. bore to shoulders
    b. bore tapers
    c. turn irregular shapes

2. Computerized Numerical Control (CNC)
   a. establish origin points
   b. set tool length offsets
   c. cold start machine
   d. program milling in the "X" and "Y" axis at a feed rate
3. Jig borer
   a. mount work
   b. establish reference points
   c. set tool depths
   d. select feeds and speeds
4. Electric Discharge Machine (EDM)
   a. mount electrodes
   b. locate work piece
   c. select surface finish
   d. select frequency

Evaluation and Testing:

Instructors are encouraged to use a variety of evaluative instruments and techniques. Where tests and quizzes are employed, instructors should have a variety of question types including short answer and essay.

Use of pre/post-tests and competency-based testing are highly recommended.

OPTIONAL UNIT
MACHINE-TOOL TRADE

Suggested Instructional Time: Open

Overview: This unit is to be used at the instructor's discretion. If the instructor feels that a student could be advanced to more difficult work, they have the option of using this unit.

Student Competencies:

During this year the more advanced student will be able to:

1. Produce special types of gearing.

2. Trouble shoot manufacturing problems on CNC equipment.

3. Jig bore and jig grind to extremely difficult tolerances.

4. Build and run a die set to produce a part to certain specifications.

Optional Unit - Theory and Shop Outline:

Theory

A. Special Gearing and Milling

   1. Spur gear terminology
   2. Principles of hilical milling
   3. Irregular shapes
   4. Cams

B. Jig Bore

   1. General maintenance and practice
      a. variable speeds - spindle
      b. pressurized lubrication for tables
      c. cleanliness
      d. spindle and vertical slide lubrication
      e. switches and machine handles readily accessible from one position
      f. use "Way Lube" oil for table lubrication
      g. proper use of accessories
      h. be sure machine is properly leveled - 3 point
      i. locking mechanisms - table
      j. vertical spindle stop

2. Location problems
   a. machine conditions
   b. cleanliness
   c. clamping work to table
   d. temperature changes
   e. dimensioning
   f. stresses of materials
   g. stock removal
   h. single point cutting tool
   i. screw-backlash
3. Foundation of accuracy
   a. basic elements
   b. flat plane
   c. surface plate (cleanliness)
   d. perpendicular
   e. cylindrical and blade type squares
   f. linear standards
   g. lead screw
   h. gage blocks
   i. angular division of the circle
4. Coordinate locating system
   a. rectilinear movements
   b. zero lines external to work piece
   c. edge finder (use of Indicator)
   d. locating microscope
   e. relation of coordinates to machine
5. Polar coordinates
   a. rotary table
   b. angular values
   c. pick-up points
6. Jig borer accessories
   a. quick change tool adapters
   b. precision vise
   c. extensions parallels
   d. 1" x 2" x 3" blocks $\pm$ .0001
   e. micro sine plates
   f. rotary table
   g. indicator and holder
   h. edge finder
   i. locating microscope
   j. precision drill chucks
   k. spotting tools - single lip
   l. jig borer drills - straight shanks
   m. sweeping tools for facing and rapid hold enlargement
   n. end reamers - straight shanks
   o. adapter collets
   p. boring chuck - swivel block type
   q. boring chuck - dovetail offset type
   r. solid type boring bars
   s. boring bars - high speed or carbide
   t. leaf taper gages

7. Jig grinder
    a. safety
    b. methods of location
    c. lubrication of grinder
    d. operation of grinder
    e. methods of set ups
    f. wheel selection
    g. head selections
    h. speeds and feeds
    i. measuring techniques
    j. use of accessories
8. Jig grind contours and angular clearances
    a. spindle set over
    b. caution in setting screws
    c. measure with indicator
    d. set up with indicator
    e. set head and stops
    f. wheel dressing
9. Jig grind radii and to shoulders
    a. set ups
    b. purpose of stops
    c. use (extender) large holes
    d. techniques of precision grinding

C. Computer-Aided Manufacturing

1. Introduction to the computer for CNC
    a. why a computer
    b. define a computer
    c. computer hardware
        1. main unit
            a. CRT screen
            b. rear unit ports
            c. controls and indicators
            d. keyboard
            e. diskette drive doors
    d. computer software
        2. floppy diskettes
            a. care of diskettes
            b. loading diskettes
2. Post processor
    a. post processor
    b. micro processor
3. Computer programming applications
    a. advantages
    b. computer languages related to CNC

4. Programming concepts
    a. define easy-cam (Bridgeport Executive Modular System)
        1. filer
            a. date
            b. file information
            c. rename
            d. transfer
            e. delete
            f. check
            g. format
        2. editor
            a. entry
            b. exit
            c. editor modes
            d. commands
            e. direct line commands
            f. page commands
            g. display commands
            h. find string commands
            i. change string commands
            j. change line commands
        3. utilities
            a. download CNC
            b. download via CNC editor
            c. upload CNC
            d. load via local terminal
            e. punch tape
            f. read tape via teletype
            g. new disk
    b. define EZ-Mill (Bridgeport Milling Module) system relating to manual programming
        1. concept of segment
        2. concept of window
        3. type of diskette files available
            a. geometry date files
            b. geometry text files
            c. part program date files
            d. CNC part program files
            e. part program text files
        4. input
            a. menu selections
            b. move and enter cursor
            c. numeric data
            d. calculator
            e. answering questions
            f. entering part name
            g. terminating a routine

D. Tool and Die

1. Safety program
   a. personal
   b. safety to others
   c. safe use of equipment
   d. fire safety
   e. good safety housekeeping
2. Layout dies
   a. die design and construction
   b. stock utilization
   c. development of blanks
   d. estimating
   e. development of building allowances
3. Shear blanking punch
   a. punch-die clearances
   b. methods of shearing, brass, solder, chamfer
   c. use of hydraulic press
   d. lubricants
4. Templates
   a. layouts
   b. measuring - indicator, other methods
5. File draft angle in die cavity
   a. purpose of clearance
   b. methods filing
   c. selection of files
6. Relieving punch and die clearance
   a. determine proper clearance
   b. purpose of proper clearance
   c. methods of relieving stock
7. Major repairs on punch - dies
   a. understanding function of tool
   b. trouble shooting
8. Sharpen dies and punches
   a. wheel selection
   b. wheel dressing
   c. job set up
9. Assemble and disassemble simple tools
   a. nomenclature of simple tools
   b. understanding of fastening techniques
10. Set up and operate compound die in press
   a. press operation
   b. purpose of compound
11. Tracing malfunctions in presswork
   a. trouble shooting
   b. function of stops, pilots and automatic feeding devices

Shop

A. Safety Principles and Procedures

B. Gearing

1. Set up special attachments for gear cutting
2. Selecting the proper cutter
3. Cut and measure size of gear teeth

C. Computerized Numerical Control (CNC)

1. Program three axis linear milling
2. Write a boring cycle statement and execute
3. Download via CNC editor
4. Use a local terminal

D. Jig Bore and Jig Grind

1. Bore holes $\pm$ or .0002
2. Locate holes $\pm$ or .0002
3. Grind holes to $\pm$ or .0001
4. Grind angles and contours

E. Die Set

1. Test safe devices/punch press
2. Adjust press cycle/punch press
3. Set up dies/punch press
4. Trial run tools/inch press
5. Run production/inch press

Evaluation and Testing:

Instructors are encouraged to use a variety of evaluative instruments and techniques. Where tests and quizzes are employed, instructors should have a variety of question types including short answer and essay.

Use of pre/post-tests and competency-based testing are highly recommended.

COMPUTERIZED NUMERICAL CONTROL (CNC)
MILL AND TURNING CENTER

Programming Theory

A. History NC and CNC (automated machines)

B. Types of CNC (drill, mill, turning, etc.)

C. Nomenclature (knee, head, table, saddle)

D. Axes Motion

E. Coordinate System (curtain)

F. Absolute and Incremental Positioning

G. Plot X and Y Locations (ABS and Inc.)

H. Tool Clearance Plane

I. Drill Point Formula

J. Letter Address System

K. Programming Procedures (G00, G01, G02, etc.)

Shop

A. CNC Mill

1. Safety
2. Care and maintenance
3. Machine start-up
4. Axes motion, set-up keys
5. Set up holding devices (vices, fixtures, clamps)
6. Set clearance and reference points
7. Set X, Y, origin
8. Set tool length offset (keyboard and preset)
9. Change tools
10. Tool rotation
11. Load program with reader and teletype
12. Select options
13. Set RPM
14. Dry run program
15. Run program

B. Turning Center
   1. Safety
   2. Care and maintenance
   3. Machine start-up
   4. Axes motion, set up keys
   5. Set up holding devices (3-jaw, 4 jaw, collet)
   6. Set clearance and reference points
   7. Tool selection
   8. Load and set tooling
   9. Dry run program
   10. Run program

C. Teletype
   1. Punch tape
   2. Load tape with teletype (edit mode)
   3. Edit tape with CNC
   4. Exit editor, keyboard teletype

APPENDIX A

Reference Sources

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