A Sample
Millwright Curriculum

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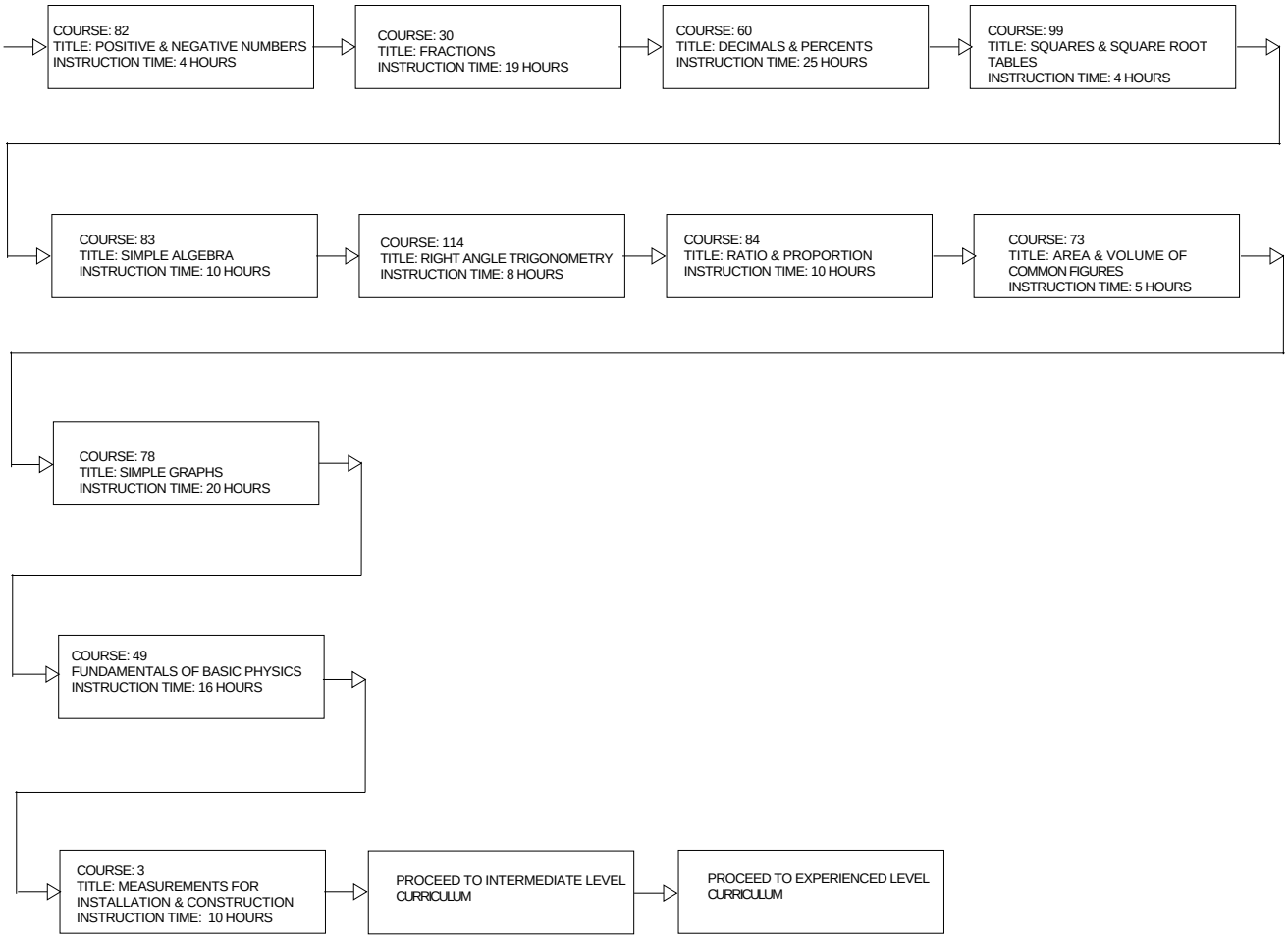
This training curriculum for millwrights is designed to provide the fundamental knowledge used in performing traditional millwright tasks. The program begins with a foundation in mathematics, physics, and basic measurement techniques. It progresses through 41 course units and includes 356 hours of training. The training materials are in a self-study format and are designed for use without the aid of an instructor. It is recommended, however, that a resource person be available to trainees to answer questions should they encounter any difficulty in doing a course. Each course includes a set of review questions that can be retained by the trainer and given to the trainee after completing the course. These questions provide a means of verifying that the student has adequately learned and retained the course material.

The following table shows the curriculum, giving the units in the recommended order with their hours of instructional content and unit cost shown. The average cost per hour of instruction is $3.37. The curriculum has been broken into three levels. The entry level is suggested as the starting point for individuals coming out of minimum wage positions, with no applicable vocational training or work experience in the trades. This portion insures that the trainee has the basic knowledge to progress in learning job specific material. The intermediate level progresses into basic skills common to many millwright activities. The experienced level addresses more complex tasks such as coupling alignment and reading piping and instrumentation diagrams This curriculum in combination with on-the-job experience should allow trainees to achieve a level of professional excellence.

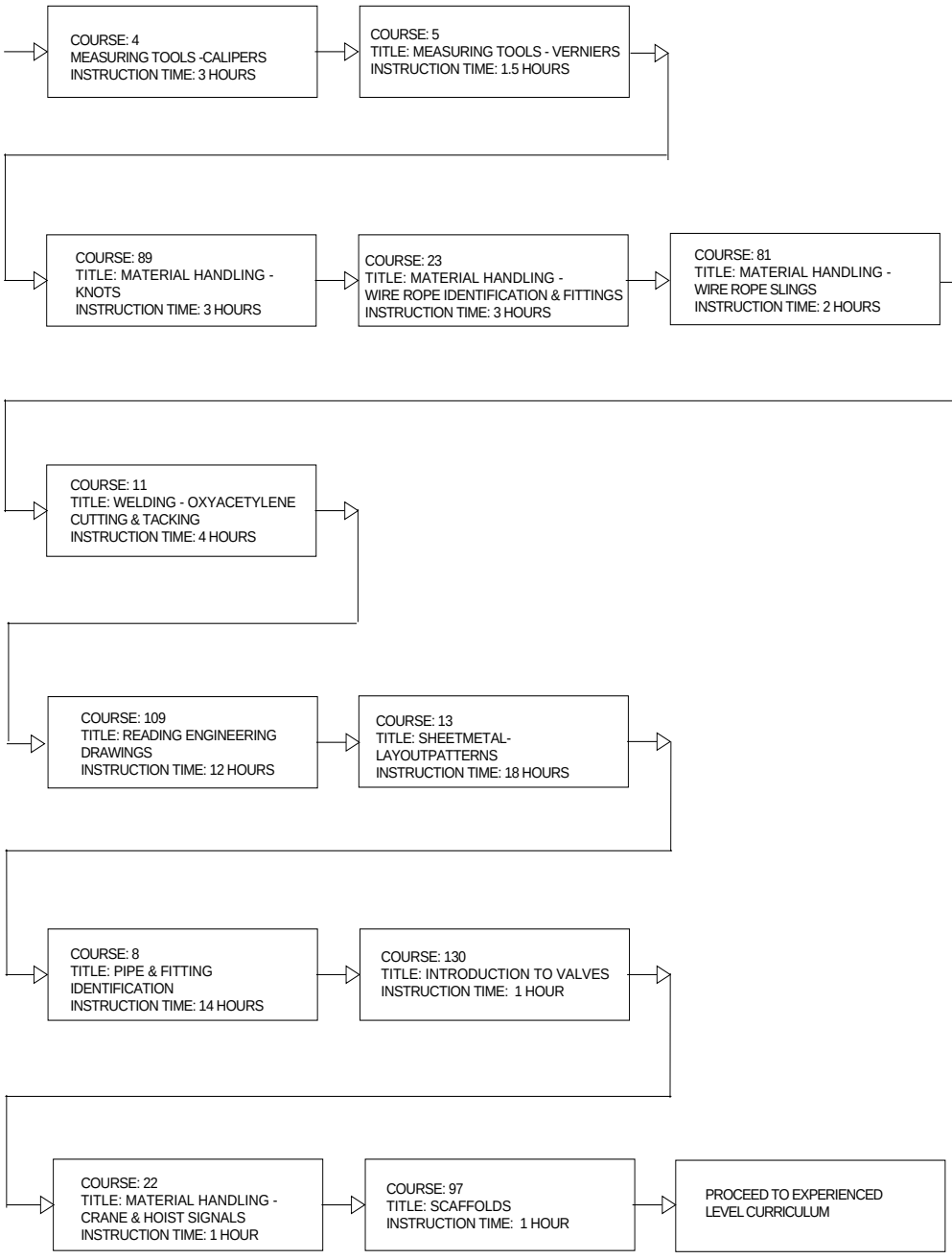
Course #	Course Title	Hours of Instruction	Unit Price	Level
82	Positive & Negative Numbers	4	$15.50	Entry level curriculum
30	Fractions	19	$52.00	
60	Decimals & Percents	25	$52.00	
99	Squares & Square Root Tables	4	$13.75	
83	Simple Algebra	10	$30.25	
114	Right Angle Trigonometry	8	$25.25	
84	Ratio & Proportion	10	$30.25	
73	Area & Volume of Common Figures	5	$17.50	
78	Reading & Preparing Simple Graphs	20	$39.75	
49	Fundamentals of Basic Physics	16	$55.00	
3	Measurements - Installation & Construction	10	$34.75	
4	Calipers	3	$13.25	Intermediate level curriculum
5	Verniers	1.5	$11.00	
89	Knots	3	$12.00	
23	Wire Rope Identification & Fittings	3	$12.25	
81	Wire Rope Slings	2	$10.50	
11	Oxyacetylene Cutting & Tacking	4	$18.00	
109	Reading Engineering Drawings	12	$41.00	
13	Sheet Metal- Layout Patterns	18	$51.00	
8	Pipe & Fitting Identification	14	$40.25	
130	Introduction To Valves	1	$10.50	
22	Crane & Hoist Signals	1	$9.00	
97	Scaffolds	1	$10.50	
6	Plain Bearings	8	$35.00	Experienced level curriculum
7	Anti-Friction Bearings	10	$41.50	
28	Coupling Alignment	14	$49.50	
119	Centrifugal Pumps	9	$41.50	
79	Mechanical Seals	14	$49.75	
68	Valve Operation & Maintenance	12	$37.00	
131	Steam Traps - Introduction	2	$12.75	
91	Steam Traps - Installation	3	$14.75	
55	Roller Chains	7	$21.00	
112	Sprockets & Drives	12	$35.75	
26	Spur Gears	8	$26.50	
61	Gear Ratios	11	$32.75	
66	Gear Installation	9	$27.75	
71	Helical Gears	4.5	$18.50	
76	Bevel Gears	6.5	$23.25	
98	Worms and Worm Gears	9.5	$30.00	
27	Field Sketching	16	$48.50	
203	Reading A P&ID	6	$47.00	
	Totals	356	$1,198.00	
	Total Curriculum - Cost/Hour of Instruction	$3.37		

The flow diagram below shows the sequence of training for the entry level part of the curriculum. The entry level portion contains 131 hours of training, which is 37% of the total curriculum training time. The material cost for this segment of the training is $366.00 per trainee. The material cost for taking an entry level trainee through the entire program would be $1,198.00.



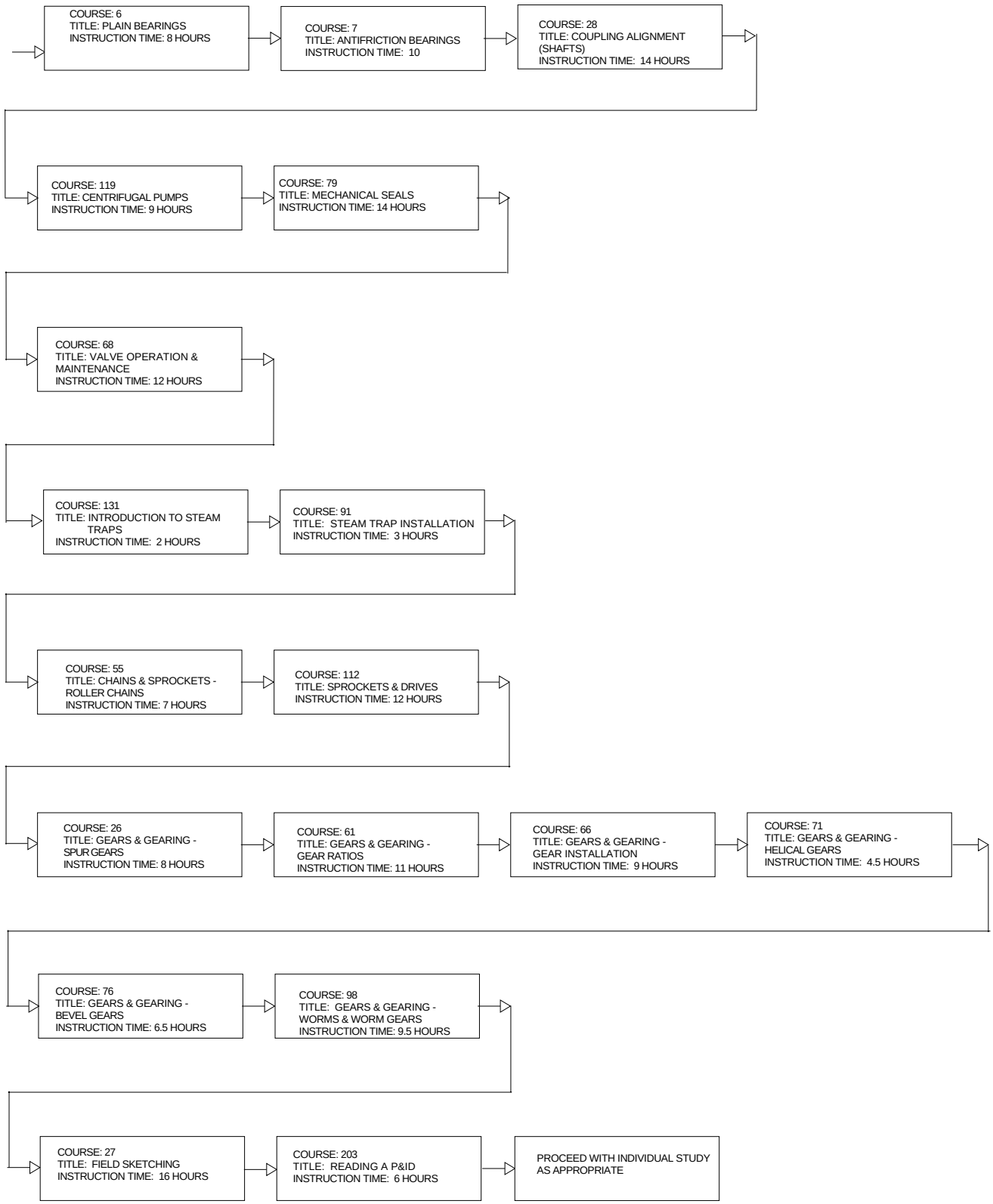
Entry Level Training Curriculum Flow Diagram

The flow diagram below shows the sequence of training for the intermediate segment of the curriculum. The intermediate portion contains 63.5 hours of training, which is 18% of the total curriculum training time. The material cost for this segment of the training is $239.25 per trainee. The material cost for taking an intermediate level trainee thorough the intermediate and experienced level portions of the program would be $832.00.



Intermediate Level Training Curriculum Flow Diagram

The flow diagram below shows the sequence of training for the experienced segment of the curriculum. The experienced portion contains 161.5 hours of training, which is 45% of the total curriculum training time. The material cost for this segment of the training is $592.75 per trainee.



Experienced Level Training Curriculum Flow Diagram

The following abstracts describe each course in the millwright training curriculum in the order in which the courses are recommended. This order has been selected to account for prerequisite requirements, to group, as much as possible, similar topics to optimize synergy between the programs and to take into account actual job needs.

Course No. 82 4 hours

Plant Mathematics –Positive and Negative Numbers

A refresher course on positive and negative numbers and their relationship to each other: using signs to determine positive or negative qualities; reading scale values above and below zero; adding negative numbers, positive and negative numbers; subtracting large positive numbers from smaller ones; and working problems that require the use of positive and negative numbers.
Elementary school mathematics.

Course No. 30 19 hours

Plant Mathematics – Fractions

Fraction terminology and the meaning of fractions; the conversion of fractions to whole or mixed numbers and vice versa; the manipulation of fractions in the solution of problems in addition, subtraction, multiplication, and division; the four basic steps in solving mathematical problems; and practical sequential problems with fractions in the fields of laboratory control, production, and maintenance.
Elementary school mathematics.

Course No. 60 25 hours

Plant Mathematics – Decimals and Percents

A refresher course on decimals and percents, their relationships to each other and to fractions, and the mathematical processes involving the three. Conversion from one form of notation (fraction, decimal, or percent) to another; adding, subtracting, multiplying, and dividing with decimals; rounding off and checking of decimal answers in problems; converting measurement units to decimals of other units in the same scale; working in decimals in solving multiplication and division problems involving percents; and practical sequential problems in the fields of production, laboratory control, and maintenance.
Elementary school mathematics.

Course No. 99 4 hours

Plant Mathematics – Squares and Square Root Tables

Definition of square; use of symbols; squares of simple whole numbers; shifting the decimal point to extend table use; interpolation for values not to be found directly; and how to handle fractions. Square roots are covered in the same fashion.
Competence in addition, subtraction, multiplication, division, fractions, and decimals.

Course No. 83 10 hours

Plant Mathematics – Simple Algebra

Simple algebra required for day-to-day operation in an industrial environment: forming equations using simple numbers; rearranging equations so that one side equals zero; unknowns; setting up and solving equations with one unknown; changing multipliers and divisors; checking; and symbols other than X. *Understanding of whole numbers, fractions, decimals, percents, and positive and negative numbers.*

Course No. 114 8 hours

Plant Mathematics – Right Angle Trigonometry

Solving for unknowns in right triangles using the rules of trigonometry: recognition that a triangle has three sides and three angles; that a right angle contains 90°; that a right triangle must have one right angle; that the square of the hypotenuse equals the sum of the squares of the other two sides; and that the sum of the angles is 180°. Also covered are: the definition of the side opposite and the side adjacent to an angle; definition and use of sine, cosine, and tangent functions; and how to handle any triangle using rules of right angle trigonometry.
A knowledge of basic mathematics and the ability to use tables of squares and square roots.

Course No. 84 10 hours

Plant Mathematics – Ratio and Proportion

The use of ratio and proportion to solve simple problems common in industry: explanation and means of expressing ratios; reducing to lower terms; forming a proportion; means and extremes; solving for unknowns in proportions; checking; proportions using verbal descriptions; and alternate and indirect proportions.
Competence with whole numbers, fractions, decimals, percents, positive and negative numbers, and simple algebra.

Course No. 73 5 hours

Plant Mathematics – Area and Volume of Common Figures

A refresher course in the calculation of area and volume of figures encountered in the industrial shop or plant: the recognition of plane surfaces and the use of formulas for the determination of area; the breakdown of irregular surfaces into familiar shapes for area calculation; the calculation of the volumes of familiar shapes; and the conversion of units of volume measurement.
Familiarity with whole numbers, fractions, decimals and percents.

Course No. 78 20 hours

Reading and Preparing Simple Graphs

The reading and preparation of simple bar and line graphs.
Bar Graphs: recognition of the parts of a bar graph, identifying bars and reading their value; interpolation of values between scale divisions; selection of the proper bar graph based on content; preparation of simple bar graphs in both vertical and horizontal position, including selection and ordering of data, setup of scales, and drawing the bars; use of interrupted amount scale for clarity; and reading and preparing component bar graphs.

Line Graphs: identification of scales on line graphs; point coordinates and the proper way to write them; determining the value of a missing coordinate given one coordinate and curve; the concept of positive and negative coordinates; reading values from curve families and multi-scale graphs; plotting points with both positive and negative coordinates; recognition that two points do not determine curve shape; requirements for and setup of scales; preparation of smooth curves from raw data; and use of curve families and multi-scale graphs.

Course No. 49 16 hours

Plant Operator Series – Fundamentals of Basic Physics

Basic principles of physics with which all new plant operators should be familiar: concepts of weight, form, volume, temperature, pressure, density, specific gravity, condensates, and vapors: conversion of “psi” to “feet of water” and “inches of mercury” and vice versa; absolute, gauge, and atmospheric pressure, and vacuum; effects of temperature and pressure on gas volumes (Ideal Gas Laws); compression and expansion; and the effects of temperature and pressure on liquids, vapors, and condensates.
Familiarity with multiplication and division of whole numbers and the use of fractions and decimals.

Course No. 3 10 hours

Measurements for Installation and Construction

Reading the scale on a steel rule to an accuracy of
1/64"; reading the scale on a micrometer to an accuracy of 0.001"; reading the scale on a protractor to an accuracy of 30 minutes; specific techniques for correct placement and use of measuring tools; and instruction in the use of a micrometer with a ratchet drive. *Ability to read fractions and decimals.*

Course No. 4 3 hours

Measuring Tools – Calipers

Identifying the six commonly used calipers; reading scales to an accuracy of 1/64" or 0.01"; and identifying the parts and use of: outside firm joint calipers, inside firm joint calipers, outside lock joint calipers, inside lock joint calipers, outside bow spring calipers, and inside bow spring calipers.
Ability to read steel rule.

Course No. 5 1.5 hours

Measuring Tools – Verniers

Reading verniers on vernier calipers and micrometers.
Ability to read steel rule and a micrometer without a vernier.

Course No. 89 3 hours

Material Handling – Knots

Identification, use, and tying of knots in fiber rope: identification of the parts of a rope; Identification, use, and tying of overhand loop, overhand knot, square knot, granny knot, thief knot, bowline, bowline on a post, sheet bend, bowline on a bight, two half hitches, reverse hitches, buntline hitch, clove hitch, timber hitch, and barrel hitch; discrimination among binding knots, bends, and hitches.

Course No. 23 3 hours

Material Handling – Wire Rope Identification and Fittings

Identification of the more commonly used wire rope fittings including: thimbles, clips, open and closed sockets, wedge-type open sockets, anchor shackles, hooks, and pear links; fabricating an eye made with a thimble and clips; proper assembling of wedge-type sockets; and identifying three commonly used loops or eyes.

Course No. 81 2 hours

Material Handling – Wire Rope Slings

Identification of slings using one piece of wire rope; identification of multi-leg slings; application of various slings and hitches; safe working loads of slings; and 18 rules for guidance in the use of wire rope slings.
Knowledge of wire rope fittings.

Course No. 11 4 hours

Welding –Oxyacetylene Cutting and Tacking

Types of oxyacetylene flames; equipment, including welding torch, tips, hoses and pressure regulators; gas cylinders; cylinder and working pressures; and operating procedures such as opening cylinders, adjusting working pressures, lighting a torch, adjusting the flame, and shutting off the torch. A practical performance test to measure the ability of the trainee and a checklist for the examiner are included.

(Oxyacetylene equipment and supplies are hazardous. Serious injury, fire and explosion can result from unsafe conditions or improper use. This is a course for self-instruction; however, a trainee must not handle any oxyacetylene equipment without specific direction and control by a supervisor.)
Familiarity with the terms pressure, temperature, psi, and ˚F.

Course No. 109 12 hours

Reading Engineering Drawings

Reading and interpreting mechanical arrangement, detail drawings, and piping arrangement drawings: two- and three-view drawings; assembly drawings; detail drawings; threaded and nonthreaded fasteners; dimensions and tolerances; symbols for pipe, valves, and fittings; and arrangement and dimensions for piping layout.
Familiarity with common machine elements, such as screw threads and keys, and familiarity with common pipe and fittings.

Course No. 13 18 hours

Sheet Metal – Layout Patterns

Basic geometric constructions involved in laying out patterns for some of the more common sheet metal shapes: conical transition piece, four-section elbow, drip pans, and rectangular duct sections.
Familiarity with the use of a steel rule; simple arithmetic; multiplying decimal numbers; and reading dimensions in a simple sketch. Course No. 108. 7 hours

Course No. 8 14 hours

Pipe Fitting – Pipe and Fitting Identification

Section A: Identification and selection of common wrought pipe; use of common pipe handbook tables to select pipe by nominal pipe size; iron pipe size; schedule number; standard, extra strong, and double extra strong units of wall thickness; uniform and random lengths; and methods of making pipe.

Section B: Identification and selection of pipe fittings. Identification of screwed and welded fittings and flanges is taught by nominal size, end connections, and specific type, through the use of illustrations; selection is taught through the use of single-line piping sketches.
Ability to use simple arithmetic.

Course No. 130 1 hour

Valves – Introduction

The identification and operation of manual valves commonly used in the process industries: the gate valve, the globe valve, the check valve, and the plug cock; rising stem and nonrising stem; use of the globe valve for regulating flow; use of the gate valve as a shutoff valve; and flow through a check valve.

Course No. 22 1 hour

Material Handling –Crane and Hoist Signals

Giving and receiving hand signals for: raise the load, lower the load, stop, raise the boom, lower the boom, “dog everything”, lower the load slowly, raise the load slowly, swing the load, and move the crane forward or back.

Course No. 97 1 hour

Scaffolds

General requirements for a standard scaffold: handrails, knee rails, toe boards, deck planks, plank cleats, plank overhand, planks tied down, diagonal bracing, horizontal members, bases, ladders, height of handrail, loose couplings, and right side-up couplings.

Course No. 6 8 hours

Plain Bearings

The identification and use of bushings, sleeve bearings, guide bearings, and thrust bearings; materials of construction; inserts; concept of thrust; bearing surfaces; bearing tolerance; clearance; service requirements; symptoms, causes, and types of plain bearing failures.
Familiarity with reading engineering drawings.

Course No. 7 10 hours

Anti-Friction Bearings

Identification and care of anti-friction bearings: cylindrical, spherical and tapered roller bearings; cylindrical, ball and needle bearings; and radial and thrust bearings. Highlights include: care in cleaning and handling; load capacity; installation and removal procedures; and tolerance, clearance, and fits for anti-friction bearings.
Familiarity with machinery and ability to add and subtract decimal numbers.

Course No. 28 14 hours

Coupling Alignment (Shafts)

Functions of a shaft coupling; tapered and cylindrical bore; fits; precision measurement of diameter and bore; fitting keys; the arbor press; installing a coupling half; types of misalignment; alignment; shimming; end play; and alignment check.
Ability to use decimal numbers and a familiarity with industrial equipment.

Course No. 119 9 hours

Centrifugal Pumps

Operating characteristics and identification of parts of centrifugal pumps; flow-through pump; mechanical and packing seals; seal flush; parts of an impeller, identification of impellers; discharge pressure versus flow; power requirements versus flow; effect of specific gravity on power requirements; multistage operation; methods of priming centrifugal pumps; operating characteristics of self-priming centrifugal pumps; types of oil lubrication; grease-lubricated bearings; bearing housing temperatures; and cavitation and gassing of centrifugal pumps.
Familiarity with terms used to indicate temperature, pressure, and flow (˚F, psig, pph, etc.). Ability to add and subtract whole numbers.

Course No. 79 14 hours

Mechanical Seals

Parts, their functions, and the installation of mechanical seals: balanced and unbalanced seals; inside, outside, and sleeve-mounted seals; seal flushing arrangements; key points in care and maintenance; materials used for various parts; and requirements and techniques involved in mechanical seal installation.
Familiarity with common types of pumps; and ability to do arithmetic of whole numbers.

Course No. 68 12 hours

Valves– Operation and Maintenance

The identification, function, construction, operation, and maintenance of the various types of valves in general use in piping systems; detailed coverage of the general appearance, construction, and function of gate, globe, and check valves; general coverage of plug, diaphragm, pinch, butterfly, three-way-flow, safety, pressure-regulating, control, multiport, and other less common valves; and general coverage of valve operation, installation, and maintenance.
Knowledge of arithmetic; some familiarity with the physical appearance of industrial piping systems; and the ability to understand simple drawings and diagrams.

Course No. 131 2 hours

Steam Traps – Introduction

Information on the five types of steam traps in general use: thermostatic, float-thermostatic, impulse, thermodynamic (disc), and inverted bucket. The principle of operation and the critical operational part of each type of trap are discussed.
A general nontechnical understanding of steam.

Course No. 91 3 hours

Steam Traps – Installation

Location, sequence, and arrangement of components for a standard steam trap installation; where steam traps must be installed; and safety measures to avoid injuries.
Course 88 or equivalent knowledge of how to test a steam trap.

Course No. 55 7 hours

Chains and Sprockets –Roller Chains

Identification of roller chains, parts of chains, and types of links, including pin links, roller links, connecting links, and offset links; press fits and slip fits in chains; “pitch” of roller chains and how to find and identify pitch; standard and ASA roller chains; how to identify a chain by its ASA number, including light, normal and heavy-duty roller chains, strands of chain, double-pitch chain, and rollerless chains; use of catalogs of roller chains and how to identify and read dimensions; how to determine length and the number of “pitches” in a piece of chain; how to use roller chain; pitch conversion charts; and how to determine correct type link for chains having either an odd or an even number of “pitches.”
Ability to perform simple arithmetic calculations and to read simple engineering drawings. Basic understanding of spur gears, gear installation and gear ratios.

Course No. 112 12 hours

Chain and Sprockets –Sprockets and Drives

Identification of roller chain sprockets; dimensions and measurement; styles and strands of sprockets; four standard types of sprockets; split and taper-lock sprockets; pitch and pitch diameter of sprockets; basic rules for meshing; standard and ASA sprockets; three major sprocket diameters and how to find them using tables; sprocket catalogs and how to use them for finding and identifying sprockets; sprocket and speed ratios for single- and multiple-reduction chain drives; exercises in finding number of teeth and speeds of drive and driven sprockets by use of simple formulas. Also explained are speed-increasing drives; direction of rotation of sprockets; idler sprockets; chain "wrap"; sag and tension; relationship between taut and slack side and direction of rotation in chain drives; how to measure chain sag and how to correct chain tension; installation and alignment procedures; procedure for dismantling a chain drive; use of chain-breaking tools; principles and standard types of roller chain and sprocket lubrication; cleaning and storing of chains and sprockets; and safety rules for their operation and maintenance.
Ability to perform simple arithmetic calculations and to read simple engineering drawings. Knowledge of roller chains, spur gears, gear ratios, and gear installation.

Course No. 26 8 hours

Gears and Gearing – Spur Gears

Identification of spur gears and their parts; measuring the commonly used dimensions on spur gears; using pitch gauges; calculation of pitch diameter by formula; using tables of standard keyways and set screws; selecting a gear from gear tables and catalogs; and identification of pressure angle, style, material of construction, and stock gears.
Ability to read engineering drawings and perform simple arithmetic calculations using whole numbers, fractions, and decimals.

Course No. 61 11 hours

Gears and Gearing – Gear Ratios

Identification of drive, driven gears and shafts; idler gears and their uses; direction of rotation and speed of rotation; formulas for gear ratio and speed ratio; how to determine ratios for sets and trains of gears; how to change gears; identification, use, and selection of proper set; multiple reductions; and calculation of gear ratios, speed ratios, speeds, and number of teeth in multiple gearing.
Ability to perform simple arithmetic calculations and to read simple engineering drawings. Basic knowledge of spur gears.

Course No. 66 9 hours

Gear and Gearing – Gear Installation

Section A: Identification of pitch point, center distance, clearance, and backlash; how to determine the correct center distance and clearance for sets of gears by means of formulas; how to find correct backlash; how to measure clearance and backlash by means of gauges; gear alignment and basic steps in correct alignment of spur gears; and identification of misalignment in a set of gears.

Section B: Handling and storing of gears; precautions for protecting gears from damage; tolerances in gear dimensions; procedure for fastening gears to shafts; basic six-step procedure to follow when installing a set of gears, including cleaning, checking dimensions, fastening to shaft, alignment, lubrication, and checking actual operation; procedure and use of tools for removal of gears from shafts; and safety rules to follow when working with gears and/or shafts.
Ability to perform simple arithmetic calculations using whole numbers, fractions, and decimals; and ability to read simple engineering drawings. Knowledge of spur gears and gear ratios.

Course No. 71 4.5 hours

Gears and Gearing – Helical Gears

Identification of helical gears, their dimensions and measurement procedures; helix angle, shaft angle, and the relationship between them; how to determine the "hand" of helical gears; diametrical pitch (DP), pitch diameter (PD), pressure angle and the use of formulas for DP and PD; selection of a desired helical gear from a stock gear catalog; differences between helical gears on parallel and right angle shafts; direction of rotation of helical gears on parallel shafts and on right angle shafts and how to determine direction of one gear if direction of the other is known on right angle shafts; idler helical gears; thrust of helical gears and how to determine direction of the thrust on parallel and right angle shafts; double helical (or herringbone) gears and how they are different from straight helical gears; and a review of major differences between helical and spur gears.
Ability to perform simple arithmetic calculations and to read simple engineering drawings. A basic understanding of spur gears, gear ratios and gear installation.

Course No. 76 6.5 hours

Gears and Gearing – Bevel Gears

Identification of bevel gears, their dimensions, and how to measure them; similarities and differences among spur, helical, and bevel gears; diametrical pitch and pitch diameter of bevel gears and how to find them by formula; pitch line, apex, pitch angle, pitch cone, and shaft angle of bevel gears; relationship between pitch angle and shaft angle, and use of the formula to determine them; cone distance of bevel gears and its importance in meshing of this type of gearing; "mating" pairs of gears; gear ratios and speed ratios of bevel gears, and the use of formulas to determine them; identification of miter gears and how they differ from bevel gears; direction of rotation of bevel-type gearing; spiral bevel and spiral miter gears and how they differ from bevel and miter gears; the "hand" of spiral bevel gears and how to determine it; thrust of bevel type gears and how to determine it; "mounting" distance and alignment of bevel gearing; three major types of misalignment in bevel-type gearing; and how to use a catalog of stock bevel and miter gears.
Ability to perform simple arithmetic calculations and to read simple engineering drawings. Knowledge of spur gears, gear ratios, gear installation and helical gears.

Course No. 98 9.5 hours

Gears and Gearing – Worms and Worm Gears

Identification of worms and worm gears, their dimensions, and how to measure them; "hand" and threads, and how to determine them; linear pitch and circular pitch, and use of formulas to determine them; requirements for worms and worm gears to mesh; pressure angle, helix angle, and "lead"; relationship among "lead", linear pitch, and number of threads of worms; use of catalogs to select and identify worms and worm gears; gear ratios and speed ratios, and use of standard formulas to find them; direction of rotation and how to determine it; thrust of worms and worm gears and how to determine it; and center distance, alignment, and centering of faces of worms and worm gears.
Ability to perform simple arithmetic calculations and to read simple engineering drawings. Knowledge of spur gears, gear ratios, gear installation, helical gears, and bevel gears.

Course No. 27 16 hours

Field Sketching

Highlights include techniques for drawing straight lines, curved lines, and circles; sketching two- and three-view orthographic projections; freehand lettering and dimensioning practices; and freehand sketches in isometric and oblique projection.
Ability to read engineering drawings, including mechanical arrangement and detail drawings and piping arrangement drawings.

Course No. 203 6 hours

Reading A P&ID

Highlights include parts of a P&ID (body, title block, revisions etc.), using the Master Sheet, equipment symbols, instrument symbols, line designations and identifying process lines, tracing process flow and following instrument control loops
Understand the basic concepts of process equipment such as pumps, check valves, heat exchangers and control valves.