Mechatronics
MODULES
Promotion of TVET in Viet Nam
Production of mechanical subassemblies by manual production

MD 01
Publisher:

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Training module:  
Production of mechanical subassemblies by manual work

Code of Module: MD01
Time: 120 h.  
(Theory: 26h; Practice: 94h)

I. Position and characteristics of the module
- The overall idea of this module is the production of a mechanical qualification project, for example a sub-assembly, by manual work.
- The sub-assembly consists of several work pieces, which are to be assembled and checked for function. Each work piece contains specific skills to be trained. From special importance is the fact, that all work pieces have to fit together, thus emphasizing the importance of accuracy, tolerances and fits.
- Every work piece, as well as the complete sub-assembly, is to be produced in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- As it is to be expected, that the learning speed of the trainees varies, they will reach a different progress in the project. Lessons 1 to 16 are the minimum performance, which every student has to reach. The following lessons 17 to 20 are optional for especially qualified trainees.
- The following module-structure and the contents are derived from the qualification project “pick and place device” from the South Westfalia Chamber of Commerce and Industry, Germany.
- The module could follow other qualification projects if they contain the same objectives and comparable contents.

II. Objectives of the module
After finishing this module, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Read and apply component,- group and assembly drawings.
- Determine tolerances from technical drawings and observe for production.
- Select and operate measuring – and testing instruments for lengths, angles and areas.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and provide tools corresponding to work order.
- Saw and shear sheet metal and sectional bars corresponding to scribing lines.
- Produce areas and forms at work pieces with given accuracy by manual work.
- Produce holes and counterbores in work pieces with given accuracy.
- Produce internal and external threads manually.
- Produce boreholes in work pieces by reaming.
- Form sheet metal from steel and non-ferrous metals cold.
- Join work pieces with screws, nuts, washers and screw locking devices.
- Join work pieces by brazing and soldering.
- Arrange their work place functional, safe and accessible.
- Read components-lists, assign designations to components and select components from catalogues.
- Describe and follow safety regulations, particularly those arising from mechanical production.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

### III. Contents of the module

**1. Content overview and time allocation:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of lesson in the module</th>
<th>Duration</th>
<th>Sum</th>
<th>Theory</th>
<th>Practice</th>
<th>Tests</th>
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<tr>
<td>1</td>
<td>Cutting and filing channel piece</td>
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<td>30</td>
<td>6</td>
<td>24</td>
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<tr>
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<tr>
<td>8</td>
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<td>6</td>
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<tr>
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<tr>
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<tr>
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</tbody>
</table>
2. Detailed contents:

Lesson 1: Cutting and filing channel piece (30h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read and parts-drawings.
- Determine tolerances from technical drawings and observe for production.
- Select and operate measuring – and testing instruments for lengths, angles and areas.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and provide tools corresponding to work order.
- Saw sectional bars corresponding to scribing lines.
- Produce areas and forms at work pieces with given accuracy by filing.
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from mechanical production.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
1.1 Technical parts drawing
1.2 Working plan
1.3 Scribing
1.4 Stamping ID-number
1.5 Sawing with hacksaw
1.6 Rough and finish filing
1.7 Checking and measuring
Lesson 2:
Scribing guide block

Objectives: (4h)

After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing.
- Determine tolerances from technical drawings and observe for production.
- Select and operate measuring – and testing instruments for lengths, angles and areas.
- Scribe the work piece with scribing block.
- Produce areas and forms at work pieces with given accuracy by filing.
- Arrange their work place functional, safe and accessible.

Content:
2.1 Technical parts-drawing
2.2 Types of steel bars, form and accuracy
2.3 Reference planes
2.4 Scribing with scribing block
2.5 Filing guide block

Lesson 3:
Chiseling manifold block

Objectives: (4h)

After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing.
- Determine tolerances from technical drawings and observe for production.
- Chisel grooves
- Produce areas and forms at work pieces with given accuracy by filing.
- Arrange their work place functional, safe and accessible.

Content:
3.1 Filing reference surface
3.2 Scribing with scribing block
3.3 Chiseling grooves

Lesson 4:
Drilling manifold block

Objectives: (6h)
After finishing this lesson, the trainees are able to:
- Determine working steps for production of work pieces.
- Read technical parts-drawing.
- Scribe and centre-punch work pieces under consideration of properties of materials.
- Select and provide drilling tools corresponding to work order.
- Drilling and counterboring of holes in work pieces.
- Operate drilling machines.
- Determine and adjust drilling speed at drilling machine.
- Clamp drilling tools in chucks and taper sleeves
- Clamp work pieces in machine vice.
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from operation of drilling machines.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
4.1 Technical parts-drawing with sectional views
4.2 Scribing with scribing block, centre punching
4.3 Function and operation of drilling machine
4.4 Determination and adjustment of cutting and drilling speed.
4.5 Construction and types of twist drills
4.6 Clamping of work pieces
4.7 Safety regulations for drilling machines
4.8 Cooling lubricant
4.9 Drilling operations

Lesson 5:
**Boring manifold block** (3h)

Objectives:
After finishing this lesson, the trainees are able to:
- Determine working steps for production of drilling profile recesses.
- Read technical parts-drawing with sectional views.
- Select and provide tools for countersinking and counterboring.
- Produce profile recesses at holes by countersinking and counterboring.
- Determine and adjust drilling speed for countersinking and counterboring.
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from operation of drilling machines.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
5.1 Technical parts-drawing with sectional views
5.2 Countersinks and counterbores for screw heads.
5.3 Construction and types of countersinks and counterbores
5.4 Determination and adjustment of cutting and drilling speed.
5.5 Cooling lubricants
5.6 Boring operation

Lesson 6:
Tapping manifold block

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of internal threads.
- Read technical parts-drawing with sectional views.
- Describe standards and characteristic dimension of threads
- Select and provide tools for tapping.
- Cut internal threads manually.
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
6.1 Technical parts-drawing with sectional views and threads
6.2 Standards and dimensions of threads
6.3 Tools for tapping
6.4 Tapping operation

Lesson 7:
Notching and drilling channel piece and clamping bar

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing with sectional views.
- Produce notches by sawing and filing.
- Produce holes and threads by drilling, countersinking and tapping.
- Produce corresponding holes by clamping the work pieces together
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

**Content:**
7.1 Technical parts-drawing with sectional views
7.2 Scribing notches and holes
7.2 Production of notches in channel piece
7.3 Filing clamping bars
7.4 Drilling and countersinking channel piece and clamping bar

**Lesson 8:**

**Bending supports**

**(6h)**

**Objectives:**
After finishing this lesson, the trainees are able to;
- Determine working steps for production supports.
- Read technical parts-drawing.
- Cut sheet metal by shearing.
- Describe bending process and calculate stretched lengths.
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from metal shears machines.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

**Content:**
8.1 Technical parts-drawing.
8.2 Scribing form of developed view.
8.3 Cutting with hand lever shears
8.4 Producing of cut-outs at sheet metal
8.5 Process of bending, neutral axis
8.6 Calculation of stretched length.
8.6 Bending in vice with bending block
8.7 Drilling together with channel piece and clamping bar.
Lesson 9:
Drilling, reaming and boring guide block  
(4h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing with sectional views.
- Select and provide tools for drilling, counterboring, reaming and tapping.
- Produce fitting holes by reaming.
- Check fitting holes with limit plug gauges.
- Determine and adjust drilling speed for reaming.
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
9.1 Technical parts-drawing with sectional views
9.2 Basics of tolerances and fits.
9.3 Checking of tolerances with limit plug gauges
9.4 Construction and types of reamers
9.5 Scribing and centre punching
9.6 Drilling and boring
9.7 Reaming operation

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Lesson 10:
Producing flanges  
(4h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing with sectional views.
- Produce profile recesses at holes by countersinking and counterboring.
- Produce chamfers by filing
- Produce square cutouts.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
10.1 Technical parts-drawing with sectional views
10.2 Filing outside dimensions
10.3 Scribing and centre punching
10.4 Drilling, sinking and boring
10.5 Producing of square cut-out
10.6 Filing of chamfers

Lesson 11:
Mounting sub-assembly 1

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for mounting assemblies.
- Read group- and assembly drawings.
- Select and provide tools for assembling.
- Connect components with screws and fitting connections.
- Check the function of moving parts.
- Check components for flush mounting
- Adjust components for mounting and rework
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
11.1 Assembly drawings.
11.2 Components list.
11.3 Standard part, especially types of screws
11.4 Joining components with screws and washers.
11.5 Mounting sub-assembly 1
11.6 Checking of function

Lesson 12:
Bending of bearing plate

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of bearing plate.
- Read technical parts-drawing.
- Scribe outline with radii on sheet metal.
- Shear sheet metal on hand lever shears.
- File outline with radii.
- Bend sheet metal with bending block in vice.
- Drill sheet metal
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
12.1 Technical parts-drawing
12.2 Working plan for production of bearing plate.
12.3 Scribing outline with radii
12.4 Cutting outline with hand lever shears.
12.5 Drilling
12.6 Bending with bending block
12.6 Drilling

Lesson 13:
Production of gripper jaws

Objectives:
After finishing this lesson, the trainees are able to:
- Determine working steps for production of gripper jaws.
- Read technical parts-drawing with sectional views.
- Select and provide tools for production
- Scribe outlines and centre punch holes.
- Produce work pieces by sawing, filing and drilling.
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
13.1 Technical parts-drawing with sectional views
13.2 Working plan for production of gripper jaws.
13.3 Scribing slopes
13.4 Drilling through and blind holes
13.5 Sawing slopes.
13.6 Filing slopes and radii

Lesson 14: Producing clamping rail and square

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of clamping rail and square.
- Read technical parts-drawing with sectional views.
- Select and provide tools for production
- Scribe outlines and centre punch holes.
- Produce work pieces by filing and drilling.
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

**Content:**
14.1 Technical parts-drawing with sectional views
14.2 Working plan for production of clamping rail and square.
13.3 Scribing and centre punching
13.4 Filing to finished size
13.5 Drilling and tapping.
13.6 Filing chamfers

**Lesson 5:**
**Winding of compression spring**

**Objectives:**
- After finishing this lesson, the trainees are able to;
  - Wind a compression spring

**Content:**
15.1 Compression spring as standard part
15.2 Winding of compression spring.

**Lesson 16:**
**Mounting sub-assembly 2: gripper**

**Objectives:**
- After finishing this lesson, the trainees are able to;
  - Determine working steps for mounting assemblies.
  - Read group- and assembly drawings.
  - Select and provide tools for assembling.
  - Connect components with screws and fitting connections.
  - Check the function of moving parts.
- Check components for flush mounting
- Adjust components for mounting and rework
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
16.1 Assembly drawings.
16.2 Components list.
16.3 Joining components with screws and washers.
16.4 Mounting sub-assembly 1
16.5 Checking of function

Lesson 17:
Cutting guide block (3h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing
- Scribe outlines of work pieces.
- Cut sectional bars by sawing
- Produce areas at work pieces with given accuracy by filing.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
17.1 Technical parts-drawing
17.2 Dismantling sub-assembly 2
17.3 Scribing
17.4 Sawing
17.5 Filing to new dimensions

Lesson 18:
Production of guide frame (5h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing with sectional views
- Scribe outlines and centre lines of work pieces.
- Produce areas at work pieces with given accuracy by filing.
- Find drilling diameters for tapping and reaming from tables.
- Produce holes, profile recesses and threads by drilling, counterboring, tapping and reaming.
- Observe rules for production of pin connections such as fits and drilling and reaming of components in assembled condition.
- Join components with pins and screws.
- Follow safety regulation arising from operation of drilling machines.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
18.1 Technical group- and parts-drawing
18.2 Filing guide blocks and guide bars to finished size.
18.3 Scribing
18.4 Drilling and counterboring
18.5 Tapping
18.6 Mounting and adjustment of components
18.7 Reaming
18.8 Joining with dowel pins

Lesson19:
Production of guide carriage (8h)
Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces.
- Read technical parts-drawing with sectional views
- Scribe outlines of work pieces.
- Produce areas at work pieces with given accuracy by filing.
- Produce holes, profile recesses and fit holes by drilling, counterboring, tapping and reaming
- Observe rules for production of pin connections such as fits and drilling and reaming of components in assembled condition.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
19.1 Technical parts-and group-drawing
19.2 Filing, drilling and counterboring of guide plate
19.3 Filing, drilling and counterboring of guides
19.4 Filing surfaces of guide block, guide plate and guides flush to each other
19.5 Drilling and reaming of guide and guide block together

Lesson 20:
Mounting of subassembly 3 –guide carriage

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for mounting assemblies.
- Read group- and assembly drawings.
- Select and provide tools for assembling.
- Connect components with screws and fitting connections.
- Check the function of moving parts.
- Check components for flush mounting
- Adjust components for mounting and rework
- Arrange their work place functional, safe and accessible.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
20.1 Assembly drawings.
20.2 Components list.
20.3 Mounting guide frame on channel piece.
20.4 Adjust and rework components of guide carriage flush
20.5 Mounting of guide carriage in guide frame
20.6 Checking of function

Lesson 21:
Module examination

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- read and apply component,- group and assembly drawings.
- Determine tolerances from technical drawings and observe for production.
- Select and operate measuring – and testing instruments for lengths, angles and areas.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and provide tools corresponding to work order.
- Saw and shear sheet metal and sectional bars corresponding to scribing lines.
- Produce areas and forms at work pieces with given accuracy by manual work.
- Produce holes and counterbores in work pieces with given accuracy.
- Produce internal and external threads manually.
- Produce boreholes in work pieces by reaming.
- Form sheet metal from steel and non-ferrous metals cold.
- Join work pieces with screws, nuts, washers and screw locking devices.
- Join work pieces by brazing and soldering.
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from mechanical production.

**Content:**

16.1 Written test
16.2 Assembly and parts drawings of examination device.
16.3 Developing working plan
16.4 Scribing of outlines and centre lines
16.5 Production of components
16.6 Mounting and joining of examination device
16.7 Checking of function

**IV. Prerequisites for implementation of module**

- **Mechanical workshop:**
  - For every trainee:
    - Working bench with vice
    - Drawer cabinet under working bench
    - Standard tool set for metal working
    - Standard set of measuring instruments
  - For every group of 4 to 6 trainees:
    - Table-top or column drilling machine with accessories
    - Marking plate with scribing block
    - Tool set for drilling, countersinking and counterboring, tapping and reaming.
  - For the entire workshop:
    - 1 machine saw (hacksaw, ribbon-saw or circular-saw)
- Material store
- Store for standard parts
- 2 hand-lever shears
- 1 gas welding station

• **Basic equipment for workshop**
  - Compressed air supply (2 safety sockets)
  - Electrical power 230V
  - 3-phase power 400 V
  - Emergency switch-off for complete workshop
  - Instructors desk
  - Cabinets for tools and didactic materials
  - Store for spare tools and consumeables

• **Classroom or teaching corner (in the workshop or directly beside the workshop)**
  - Blackboard, min. 2.5 x 1.2m
  - Overheadprojector and projection screen
  - Students chair with writing desk

• **Consumables**
  - Flat rolled steel, bright steel
  - Profile steel
  - Sheet metal (steel, aluminum, brass)
  - Tools (hacksaw blades, drills, tapers)
  - Cooling lubricant, cutting oil
  - Solder, fluxing agents, oxygen, acetylene

**V. Evaluation methods and contents of tests**
- The evaluation of this modules contains:

  1. **Accompanied evaluation**
     Every task-element (lesson) is evaluated in an evaluation form. The evaluation contains function check, visual inspection and dimension check.

  2. **Written examination**
     The written examination takes place at the end of the module.
     The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module, either in form of multiple choice questions or essay questions.
3. Examination work piece
   The trainee shall fabricate a sub-assembly under usage of prefabricated parts in max 420 min by manual cutting, drilling, bending and joining.

VI. Guide for implementation of the module

- Fields of implementation of this module:
  - This module is used to qualify the trainees of vocational training programme at 2-year intermediate level for mechatronic trade on the level of skilled worker.
  - This module is a basic module, that could be also used to train:
    - mechatronic trade on college level
    - trades in the field of mechanical engineering

- Organization:
  - The lessons of this module should be organized in large blocks of at least one week up to 4 weeks duration to guarantee a steady work.

- Some main guides in view of teaching methods for this module:
  - Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
  - The teaching staff should guide the trainees to the ability to plan, execute and monitor their work independently.
  - The teaching staff should guide the trainees to arrange their working place functional, safe and accessible.
  - The teaching staff should guide the trainees to time management, this means that the trainees should finish the work pieces in a given time frame.
  - The teaching staff should instruct, give examples and correct errors while the trainees practice.
  - The teaching staff should especially watch the quality and accuracy of the work and the observation of tolerances.
  - The teaching staff should guide the trainees to self-evaluation of their work pieces.

- Teaching and learning materials for module 01:
  - "Qualification Project Pick & Place Device"
    published by: South Westphalia Chamber of Commerce and Industry, Hagen (Germany) Technical Training Centers, 1993
Production of mechanical subassemblies by manual production

Craftsmanship of mechanical components by machining

Module

Fabrication of mechanical components by machining

MD 02
Publisher:

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Translation: Dr. Bui Trung Thanh
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Place and year of publishing: Hanoi, 2010
Training module:
Fabrication of mechanical components by machining

Code of Module: MD02
Time: 120 h. (Theory: 34h; Practice: 86h)

I. Position and characteristics of the module
- The overall idea of this module is the production of a mechanical qualification project, for example a sub-assembly, by machining.
- The sub-assembly consists of several work pieces, which are to be assembled and checked for function. Each work piece contains specific skills to be trained. From special importance is the fact, that all work pieces have to fit together, thus emphasizing the importance of accuracy, tolerances and fits.
- Every work piece, as well as the complete sub-assembly, is to be produced in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- The following module-structure and the contents are derived from the qualification project “pick and place device” from the South Westfalia Chamber of Commerce and Industry, Germany.
- The module could follow other qualification projects if they contain the same objectives and comparable contents.
- Before this module is implemented, the trainee should have skills and experience in manual production, material science and technical drawing.

II. Objectives of the module
After finishing this module, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Describe manufacturing processes (turning, milling, drilling, grinding) and their characteristics (movements of work piece and tool, reachable accuracy).
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5’).
- Check parallelism of surface and concentricity with dial gauges.
- Describe ISO-system of fits, determine limit deviations and check dimensions with limit plug gauges and external limit gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling, milling and turning.
- Align and hold work pieces with machine vices, clamping jaws, step-blocks, three jawed chucks and centres with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks, clamping cones, holding clamps and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring, turning and milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce holes in work pieces up to a positional tolerance of ± 0.2mm on drilling machines, including profile holes by countersinking and counterboring, fit holes up to a dimensional accuracy IT 7 by circular reaming and tapping
- Produce work pieces of ferrous and non-ferrous metals by turning up to a dimensional accuracy of ± 0,05 mm and surface finish Rz 25 μm by transverse and longitudinal facing, longitudinal turning, internal turning, transverse cut-off turning and form turning (chamfer, radii, taper, thread).
- Produce work pieces of ferrous and non-ferrous metals by milling up to a dimensional accuracy of ± 0,05 mm and a surface finish Rz 25 μm by horizontal and vertical face milling, groove and slot milling.
- Join work pieces by bolted/screwed and pin connections, fits and keys.
- Arrange their work place functional, safe and accessible.
- Read components-lists, assign designations to components and select components from catalogues.
- Describe and follow safety regulations, particularly those arising from operation of drilling machines, lathes and milling machines.
- Specify environmental pollution at workplace and contribute to its reduction.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

III. Contents of the module
1. Content overview and time allocation:


2. Detailed contents:

Lesson 1: Basic skills turning 1 – Step shaft (10h)

Objectives:

- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Describe manufacturing processes (turning, milling, drilling, grinding) and their characteristics (movements of work piece and tool, reachable accuracy).
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm)
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for turning.
- Align and hold work pieces with three jawed chucks with particular attention to work piece stability and surface protection.
- Align and hold tools with on a lathe with tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools for turning according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on lathe with the aid of tables and diagrams.
- Prepare lathe for operation
- Produce work pieces of ferrous and non-ferrous metals by turning up to a dimensional accuracy of ± 0.05 mm and surface finish Rz 25 μm by transverse and longitudinal facing, longitudinal turning, internal turning, transverse cut-off turning and form turning (chamfer, radii, taper, thread).
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from operation of lathes.
- Specify environmental pollution at workplace and contribute to its reduction.
- Develop readiness for self learning to improve knowledge and working skills.

Content:
1.1 Technical parts drawing
1.2 Working plan
1.3 Clamping work pieces with three-jawed chuck
1.4 Lathe tools
1.5 Clamping and aligning of lathe tools
1.6 Transverse facing, roughing
1.7 Turning of shoulders, roughing
1.8 Turning of chamfer
1.9 Finishing of right side of work piece
1.10 Rechucking of work pieces
1.11 Turning left side of work piece
1.12 Checking and measuring

Lesson 2:
Basic skills turning 2 – Arbor (10h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm)
- Select and fasten centres in the spindle and tailstock of a lathe.
- Align and hold work pieces with three jawed chucks and centres with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide lathe tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for turning operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce work pieces of ferrous metals by turning up to a dimensional accuracy of ± 0.05 mm and surface finish Rz 25 μm by transverse and longitudinal facing, longitudinal turning and form turning (chamfer, ring groove).
- Arrange their work place functional, safe and accessible.

Content:
2.1 Technical parts drawing
2.2 Working plan
2.3 Transverse facing
2.4 Centerboring
2.5 Clamping work piece between centres
2.6 Turning of shoulders with left turning tools, roughing
2.7 Turning of shoulders with right turning tools, roughing
2.8 Turning of snap ring groove
2.10 Finishing with accuracy of 0.05 mm
2.11 Measuring dimensions with caliper and micrometer

Lesson 3:
Turning piston rod

Objectives:
After finishing this lesson, the trainees are able to;
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Operate measuring instruments for lengths (accuracy of 0.01mm), micrometer
- Select and fasten centres in the spindle and tailstock of a lathe.
- Align and hold work pieces with three jawed chucks and centres with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for turning operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce work pieces of ferrous and non-ferrous metals by turning up to a dimensional accuracy of ± 0.05 mm and surface finish Rz 25 μm by transverse and longitudinal facing, longitudinal turning and form turning (chamfer, thread).
- Arrange their work place functional, safe and accessible.

Content:
3.1 Technical parts drawing
3.2 Working plan
3.3 Transverse facing to length
3.4 Centerboring
3.5 Clamping work piece between centres
3.6 Longitudinal turning of piston rods
3.7 Turning of shoulder
3.8 Turning of grooves and chamfers
3.9 Threading with die
2.10 Measuring dimensions with caliper and micrometer

Lesson 4:
Turning piston

Objectives: (4 h)
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm)
- Align and hold work pieces with three jawed chucks with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for turning and drilling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce work pieces of ferrous and non-ferrous metals by turning up to a dimensional accuracy of ± 0.05 mm and surface finish Rz 25 μm by transverse and longitudinal facing, longitudinal turning, internal turning, transverse cut-off turning and form turning (chamfer, ring groove).
- Produce holes in work pieces with drills clamped in chucks in tailstock.
- Arrange their work place functional, safe and accessible.

Content:
4.1 Technical parts drawing
4.2 Working plan
4.3 Transverse facing to length
4.4 Longitudinal turning
4.5 Drilling
4.6 Cut-off turning
4.7 Turning of grooves and chamfers
4.8 Checking and measuring
4.9 Drilling operations

Lesson 5:
Turning cylinder housing (8 h)

Objectives:
After finishing this lesson, the trainees are able to;
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5´).
- Check parallelism of surface and concentricity with dial gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling, milling and turning.
- Align and hold work pieces with three jawed chucks and centres with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks, clamping cones, holding clamps and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.

- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring, turning and milling operations with the aid of tables and diagrams.

- Prepare machine tools for operation

- Produce work pieces of ferrous metals by turning up to a dimensional accuracy of $\pm 0.05 \text{ mm}$ and surface finish $R_z 25 \mu \text{m}$ by transverse and longitudinal facing, longitudinal turning, internal turning.

- Produce work pieces of ferrous metals by milling up to a dimensional accuracy of $\pm 0.05 \text{ mm}$ and a surface finish $R_z 25 \mu \text{m}$ by horizontal and vertical face milling and drilling.

- Arrange their work place functional, safe and accessible.

**Content:**

- 5.1 Technical parts drawing
- 5.2 Working plan
- 5.3 Transverse facing
- 5.4 Centerboring
- 5.5 Longitudinal turning
- 5.6 Clamping with steady rest
- 5.7 Drilling
- 5.8 Internal turning
- 5.9 Milling of clamping areas
- 5.10 Drilling of holes for fixing screws
- 5.11 Checking and measuring

**Lesson 6:**

**Manufacturing of mounting plate**

**Objectives:**

After finishing this lesson, the trainees are able to:

- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01\text{mm}) and angles (accuracy up to $5^\circ$).
- Check parallelism of surface and concentricity with dial gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling, milling and turning.
- Align and hold work pieces with three jawed chucks and mandrels with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks, clamping cones, holding clamps and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring, turning and milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce work pieces of ferrous materials by turning up to a dimensional accuracy of ± 0,05 mm and surface finish Rz 25 μm by transverse facing and longitudinal turning.
- Produce work pieces of ferrous metals by milling up to a dimensional accuracy of ± 0,05 mm and a surface finish Rz 25 μm by horizontal and vertical face milling and drilling.
- Arrange their work place functional, safe and accessible.

Content:
6.1 Technical parts drawing
6.2 Working plan
6.3 Transverse facing
6.4 Drilling
6.5 Clamping with mandrel
6.6 Longitudinal turning
6.7 Milling of flat area
6.8 Drilling of holes for fixing screws, tapping
6.9 Checking and measuring

Lesson 7:
Assembling of cylinder (4 h)

Objectives:
After finishing this lesson, the trainees are able to:
- Read group- and assembly drawings and component lists.
- Determine working steps for mounting assemblies.
- Select and provide tools for assembling.
- Connect components with screws and fitting connections.
- Check the function of moving parts.
- Check components for flush mounting
- Adjust components for mounting and rework
- Arrange the work place functional, safe and accessible.

Content:
7.1 Assembly drawings.
7.2 Components list.
7.3 Mounting piston and cylinder.
7.4 Checking of function
7.5 Adjust and mount cylinder at flange of horizontal guide
7.6 Checking of function

Lesson 8:
Basic skills milling 1 – Guiding plate  
(12 h)

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Describe manufacturing processes of milling and its characteristics (movements of work piece and tool, reachable accuracy).
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5˚).
- Check parallelism of surface and concentricity with dial gauges.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for milling.
- Align and hold work pieces with machine vices with particular attention to work piece stability and surface protection.
- Clamp milling tools with collet chucks and milling arbors.
- Develop working plans for production of components according to given work order.
- Select and provide milling tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce work pieces of ferrous metals by milling up to a dimensional accuracy of \( \pm 0.05 \) mm and a surface finish \( R_z 25 \mu m \) by horizontal and vertical face milling, groove and slot milling.
- Arrange their work place functional, safe and accessible.
- Describe and follow safety regulations, particularly those arising from operation of milling machines.

**Content:**

8.1 Technical parts drawing  
8.2 Working plan  
8.3 Clamping work piece in machine vice  
8.4 Clamping milling tools in milling arbors  
8.5 Face milling of areas  
8.6 Milling of shoulders  
8.7 Drilling  
8.8 Clamping end mills in collet chucks  
8.9 Milling of grooves  
8.10 Checking and measuring

**Lesson 9:**  
**Basic skills milling 2 – Housing**  
**Objectives:**

After finishing this lesson, the trainees are able to:
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5´).
- Check parallelism of surface and concentricity with dial gauges.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling, milling and turning.
- Align and hold work pieces with machine vices with particular attention to work piece stability and surface protection.
- Clamp milling tools with collet chucks and arbors.
- Develop working plans for production of components according to given work order.
- Select and provide milling tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on milling machines with the aid of tables and diagrams.
- Prepare milling machine for operation
- Produce work pieces of ferrous and non-ferrous metals by milling up to a dimensional accuracy of ± 0,05 mm and a surface finish Rz 25 μm by horizontal and vertical face milling, groove and slot milling.
- Arrange their work place functional, safe and accessible.

Content:
9.1 Technical parts drawing
9.2 Working plan
9.3 Face milling of areas
9.4 Milling of shoulders
9.5 Clamping end mills in collet chucks
9.6 Milling of grooves
9.7 Milling of slots
9.8 Checking and measuring

Lesson10:
Cutting guide block (8 h)
Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5°).
- Check parallelism of surface and concentricity with dial gauges.
- Describe ISO-system of fits, determine limit deviations and check dimensions with limit plug gauges and external limit gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling and milling.
- Align and hold work pieces with machine vices with particular attention to work piece stability and surface protection.
- Align and hold tools with drilling chucks, collet chucks and milling arbors.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring and milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce holes in work pieces up to a positional tolerance of $\pm 0.2\text{mm}$ on drilling machines, including profile holes by countersinking and counterboring, fit holes up to a dimensional accuracy IT 7 by circular reaming and tapping
- Produce work pieces of ferrous and non-ferrous metals by milling up to a dimensional accuracy of $\pm 0.05\text{mm}$ and a surface finish Rz $25\mu\text{m}$ by horizontal and vertical face milling, groove and slot milling.
- Arrange their work place functional, safe and accessible.

Content:
10.1 Technical parts drawing
10.2 Working plan
10.3 Cutting of guide block
10.4 Milling of guide block and distance pieces
10.5 Scribing of center lines for drilling
10.6 Drilling and counterboring
10.7 Tapping
10.8 Checking and measuring

Lesson 11:
Milling of guide frame

Objectives:
After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to $5'$).
- Check parallelism of surface and concentricity with dial gauges.
- Describe ISO-system of fits, determine limit deviations and check dimensions with limit plug gauges and external limit gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling and milling.
- Align and hold work pieces with machine vices with particular attention to work piece stability and surface protection.
- Align and hold tools with drilling chucks, collet chucks and milling arbors.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring and milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce holes in work pieces up to a positional tolerance of $\pm 0.2\text{mm}$ on drilling machines, including profile holes by countersinking and counterboring, fit holes up to a dimensional accuracy IT 7 by circular reaming and tapping
- Produce work pieces of ferrous and non-ferrous metals by milling up to a dimensional accuracy of $\pm 0.05\text{mm}$ and a surface finish Rz 25 $\mu\text{m}$ by horizontal and vertical face milling, groove and slot milling.
- Arrange their work place functional, safe and accessible.

**Content:**

11.1 Technical parts-and assembly drawing
11.2 Working plan for production of guide frame.
11.3 Milling vertical stands
11.4 Scribing centre lines for drilling
11.5 Clamping frame stands and distance pieces together.
11.6 Drilling and tapping
11.7 Connecting frame stands and distance pieces by screws
11.8 Drilling and reaming of pin holes

**Lesson 12:**

**Milling of guide carriage** (10 h)

**Objectives:**

After finishing this lesson, the trainees are able to;
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5´).
- Check parallelism of surface and concentricity with dial gauges.
- Describe ISO-system of fits, determine limit deviations and check dimensions with limit plug gauges and external limit gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling and milling.
- Align and hold work pieces with machine vices with particular attention to work piece stability and surface protection.
- Align and hold tools with drilling chucks, collet chucks and milling arbors.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring and milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce holes in work pieces up to a positional tolerance of ± 0.2mm on drilling machines, including profile holes by countersinking and counterboring, fit holes up to a dimensional accuracy IT 7 by circular reaming and tapping
- Produce work pieces of ferrous and non-ferrous metals by milling up to a dimensional accuracy of ± 0,05 mm and a surface finish Rz 25 μm by horizontal and vertical face milling, groove and slot milling.
- Arrange their work place functional, safe and accessible.

Content:
12.1 Technical parts-and assembly drawing
12.2 Working plan for production of guide frame.
12.3 Milling guide carriages
12.4 Scribing centre lines for drilling
12.5 Clamping guide and guide carriages together.
12.6 Drilling and tapping
12.7 Connecting guide and guide carriages by screws
12.8 Drilling and reaming of pin holes

Lesson 13:
Mounting of subassembly 3 – Vertical guide

Objectives:
After finishing this lesson, the trainees are able to:
- Determine working steps for mounting assemblies.
- Read group- and assembly drawings.
- Select and provide tools for assembling.
- Connect components with screws and fitting connections.
- Check the function of moving parts.
- Check components for flush mounting
- Adjust components for mounting and rework
- Arrange their work place functional, safe and accessible.

Content:
13.1 Assembly drawings.
13.2 Components list.
13.3 Mounting guide frame on channel piece.
13.4 Adjust and rework components of guide carriage flush
13.5 Mounting of guide carriage in guide frame
13.6 Adjust and rework guide carriage in guide frame
13.7 Checking of function

Lesson 14:
Module examination (10 h)
Objectives:
After finishing this lesson, the trainees are able to:
- Determine working steps for production of work pieces and assemblies according to functional, manufacturing and economical criteria.
- Describe manufacturing processes (turning, milling, drilling, grinding) and their characteristics (movements of work piece and tool, reachable accuracy).
- Read and use engineering drawings of components and sub-assemblies.
- Determine tolerances, fits and surface finish from technical drawings and observe for production.
- Select and operate measuring instruments for lengths (accuracy of 0.01mm) and angles (accuracy up to 5’).
- Check parallelism of surface and concentricity with dial gauges.
- Describe ISO-system of fits, determine limit deviations and check dimensions with limit plug gauges and external limit gauges.
- Scribe, centre-punch and mark work pieces under consideration of properties of materials.
- Select and fasten clamping tools in accordance with size, form, working material and the machining of work pieces for drilling, milling and turning.
- Align and hold work pieces with machine vices, clamping jaws, step-blocks, three jawed chucks and centres with particular attention to work piece stability and surface protection.
- Align and hold tools with chucks, clamping cones, holding clamps and tool-holders.
- Develop working plans for production of components according to given work order.
- Select and provide tools according to production method and work order, type of material (work piece and cutting material) and cutting edge geometry.
- Determine and set speed of revolution, feed and depth of cut on machine tools for drilling/boring, turning and milling operations with the aid of tables and diagrams.
- Prepare machine tools for operation
- Produce holes in work pieces up to a positional tolerance of \( \pm 0.2 \)mm on drilling machines, including profile holes by countersinking and counterboring, fit holes up to a dimensional accuracy IT 7 by circular reaming and tapping
- Produce work pieces of ferrous and non-ferrous metals by turning up to a dimensional accuracy of \( \pm 0.05 \) mm and surface finish Rz 25 \( \mu \)m by transverse and longitudinal facing, longitudinal turning, internal turning, transverse cut-off turning and form turning (chamfer, radii, taper, thread).
- Produce work pieces of ferrous and non-ferrous metals by milling up to a dimensional accuracy of \( \pm 0.05 \) mm and a surface finish Rz 25 \( \mu \)m by horizontal and vertical face milling, groove and slot milling.
- Join work pieces by bolted/screwed and pin connections, fits and keys.
- Arrange their work place functional, safe and accessible.
- Read components-lists, assign designations to components and select components from catalogues.
- Describe and follow safety regulations, particularly those arising from operation of drilling machines, lathes and milling machines.
- Specify environmental pollution at workplace and contribute to its reduction.

Content:
14.1 Written test
14.2 Assembly and parts drawings of examination device.
14.3 Developing working plan
14.4 Turning of components
14.5 Milling of components
15.6 Scribing of marking out of work pieces
15.7 Drilling, counterboring, reaming and tapping
15.8 Mounting of components to subassembly
IV. Prerequisites for implementation of module
Machining workshop for 16 students:

- **8 lathes, complete with**
  - Width between centers appr. 800mm
  - Tailstock
  - Three jawed chucks, centers
  - Quick change tool holders with accessories and spare parts
  - Tool set with carbide inserts and spare parts and spare inserts
  - Measuring instruments, caliper, micrometer, dial gauge
  - Machine cabinet

- **8 universal milling machines, complete with**
  - for horizontal and vertical milling
  - Power: min. 2.2kW
  - Table area: min 850 x 260mm
  - Machine vice, parallel sets, work piece clamping devices
  - Collet chucks and milling arbors
  - Tool set : shell end mills, side and face cutters, end mills, slot drills, form and profile mills (T-slot, dovetail, V-profile).
  - Measuring instruments, caliper, micrometer, dial gauge
  - Machine cabinet

- **1 set accessories for milling machines:**
  - work holding set for T-slots
  - dividing head with accessories
  - three jawed chuck for milling machines

- **2 drilling machines, complete with**
  - Pillar type or table top drilling machines
  - Diameter drilled: min 16mm
  - Table area min. 400x300mm
  - Machine vice
  - Quick change chuck and morse-tapers
  - Set of drills and spare drills

- **1 marking plates with stands**
  - 1200 x 800 mm
  - quality 3
  - marking tools

- **1 double wheel grinder with stand**
  - Grinding wheel 200x32x32
  - Grinding wheels for HSS-tools and carbides

- **1 ribbon or circular saw, complete with**
- cutting diameter: 200mm
- for mitre-cuts
- cooling system
- accessories and spare parts

• **4 working benches, complete**
  - workbench top 1500x700 x 50
  - vice, height adjustable
  - Drawer block
  - Tool set for manual production
  - Tool set for assembling

• **1 bar rack for long material**

• **2 Store-cabinets for standard parts**
  - Drawer cabinets appr. 1000x800x1000mm
  - Appr. 6 drawers
  - Inserts and sections for drawers
  - Stock of standard parts (screws, nuts washers, pins)

• **2 Store cabinets for tools**
  - Drawer cabinets appr. 1000x800x1000mm
  - Appr. 6 drawers
  - Inserts and sections for drawers
  - Special measuring instruments for instructor
  - Stock of spare tools (lathe tools, millers, drills, tappers)

• **Instructors workplace**
  - Workshop desk with drawers
  - Swivel chair

• **Classroom or teaching corner (in the workshop or directly beside the workshop)**
  - Blackboard, min. 2.5 x 1.2m
  - Overheadprojector and projection screen
  - Students chair with writing desk

• **Consumables**
  - Flat rolled steel, bright steel
  - Profile steel
  - Tools (lathe tools, milling tools, hacksaw blades, drills, tappers)
  - Cooling lubricant, cutting oil

### V. Evaluation methods and contents of tests
- The evaluation of this modules contains:

  1. **Accompanied evaluation**
Every task-element (lesson) is evaluated in an evaluation form. The evaluation contains function check, visual inspection and dimension check.

2. **Written examination**
   The written examination takes place at the end of the module.
   The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module, either in form of multiple choice questions or essay questions.

3. **Examination work piece**
   The trainee shall fabricate a sub-assembly under usage of prefabricated parts in max 480min by turning, milling, drilling, manual cutting and joining.

VI. **Guide for implementation of the module**

- **Fields of implementation of this module:**
  - This module is used to qualify the trainees of vocational training programme at 2-year intermediate level for mechatronic trade on the level of skilled worker.
  - This module is a basic module, that could be also used to train:
    - mechatronic trade on college level
    - trades in the field of mechanical engineering

- **Organization:**
  - The lessons of this module should be organized in large blocks of at least one week up to 4 weeks duration to guarantee a steady work.

- **Some main guides in view of teaching methods for this module:**
  - Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
  - The teaching staff should guide the trainees to the ability to plan, execute and monitor their work independently.
  - The teaching staff should guide the trainees to arrange their working place functional, safe and accessible.
  - The teaching staff should guide the trainees to time management, this means that the trainees should finish the work pieces in a given time frame.
  - The teaching staff should instruct, give examples and correct errors while the trainees practice.
  - The teaching staff should especially watch the quality and accuracy of the work and the observation of tolerances.
  - The teaching staff should guide the trainees to self-evaluation of their work pieces.

- **Teaching materials for module 01:**
  - "Qualification Project Pick & Place Device"
Promotion of TVET, Viet Nam

published by: South Westphalia Chamber of Commerce and Industry, Hagen (Germany)
Technical Training Centers, 1993
Promotion of TVET in Viet Nam
Installation of electronic components and assemblies

MD 05
Publisher:

Vietnamese-German Development Cooperation
Promotion of TVET, Viet Nam

General Directorate for Vocational Training (GDVT)
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Nguyen Van Dien

Translation:  Pham Thanh Tung
Design:  Mariette Junk, Berlin
Photo:  Ralf Bäcker, Berlin

Place and year of publishing: Hanoi, 2010
# Module description

## Training module: Installation of Electronic Components and Assemblies

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Name</th>
<th>Training hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MD05</strong></td>
<td><strong>Installation of Electronic Components and Assemblies</strong></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Theory</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
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<td></td>
<td><strong>120</strong></td>
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</table>

### Background

There are many separate assembling projects in this module. Each project is a part of the general project. This module is practice-oriented, as a result, learners gain skills about making plans, assembling and testing.

### Prerequisites

To study this module, learner must have finished the following modules/subjects:
- MH13
- MH14
- MH15
- MH16
- MD 04

### Module objectives

Learners are able to install and test function of components and electronic devices; process printed circuit boards; build up an electronic circuit; find out, analyse and repair errors in the circuit.

### Relationship to competency standards (as described in the DACUM chart)

For detail tasks and works, please refer to the DACUM chart:
- A4
- B4
- C3, C4, C33, C35, C39
- D2, D3, D25, D31
- E6, E7, E8, E9
- F2, F6
- G2, G5, G6
- H31
- I3, I8
- J1, J3, J4
## Learning outcomes

**After finishing the modules, the learners will be able to:**

- Understand and apply technical documents.
- Explain structures, operating principle and application of electronic components.
- Analyze functions relationship of electronic circuits.
- Make a list, select and test electronic components based on requirements.
- Prepare necessary measurement instruments, tools and materials.
- Assemble components on an existing printed circuit board
- Solder a printed circuit board
- Measure and test function of a circuit.
- Find out and repair failures in a circuit
- Follow safety rules at work
- Work in groups.

## Module contents

**Electronic components and basic circuits:**

- Power circuits, function modules
- Switch, buttons
- Diode, transistor, thyristor, triac, Diac and other components
- Warning instruments (light, buzzer, etc.)

**Technical documents:**

- Technical guide
- Sketch, diagrams
- Electronic components handbook

**Circuits:**

- Schematic circuit.
- Pins connection circuit
- Components list.

**Work planning:**

- Pre-process: Prepare necessary components, tools.
- While-process: Practice
- Post-process: Show the result

**Assembling:**

- Choose and test electronic components qualities.
- Assemble components in a circuit.
- Test functions and find out error

**Measuring:**

- Current
- Voltage
- Resistance
- Signal

**Troubleshooting:**
### Assessment

Evaluation of result of the module includes the following parts:

1) Results of individual exercises in module.
2) Written examination at the end of module:
   Learner takes a written examination at the end of module following module objective in maximum time of 90 minutes.
3) Practice examination at the end of module:
   In maximum time of 240 minutes, learners take a practice examination of assembling a basic electronic circuit. This circuit is part of general project.
4) Check practice results:
   Learner check result of practical examination. Including analysis, find out and repair error created by teacher in the maximum time of 60 minutes.

### Necessary Infrastructure

**Practice Laboratory:** We suppose that there are 16 students in a class and students work in groups of two.

- Minimum square is 80 m²
- Teachers' working place, cabinet for learning and teaching materials.
- Magnetic board with minimum size of 2,5 x 1,2m
- Projector and screen
- AC power supply: 220V/50 Hz, DC power supply: 0V÷24V.
- Power supply distribution with NOT-OUT button at each practice place.

**Equipments of each practice place:**

- Standard working table.
- Industrial electronic tools.
- 02 ergonomic chairs.

### Materials

- Necessary electronic components
- Panel and printed circuit board
- Related materials

### Teaching and learning materials

- Task assignment papers
- Instruction for practice exercises.
- Folie sketches
Examples of equipment:
Promotion of TVET in Viet Nam
Installation and testing of pneumatic and electro-pneumatic controls

MD 06
Publisher:

Vietnamese-German Development Cooperation
Promotion of TVET, Viet Nam

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            Khuat Thanh Son,
            Ly Vu Son

Translation:  Pham Thanh Tung
Design:      Mariette Junk, Berlin
Photo:       Ralf Bäcker, Berlin

Place and year of publishing: Hanoi, 2010
Training module:
Installation and testing of pneumatic and electro-pneumatic controls

Code of Module: MD06
Time: 120 h. (Theory: 24h; Practice: 96h)

I. Position and characteristics of the module
- This module is built up from single projects (exercises), each of them developing and implementing a pneumatic or electro-pneumatic system or subsystem.
- Every project is action orientated and carried out in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- Every project is standing alone and contains as many objectives as possible but only a limited number of contents.
- Starting with a real application the trainee has to analize the process, design the documentation and circuit diagrams, to mount and install the system, commission the system and do the trouble-shooting.
- Before this module is implemented, the trainee should have basic skills in mechanical engineering, special in assembling technology, and electrical installation.

II. Objectives of the module
After finishing this module, the trainees are able to;

- Develop the scheme of a mechatronic system in principle.
- Read and apply technical documentations.
- Solve problems systematically in a team.
- Develop solutions for problems related to industrial processes and draw up in standardized diagrams.
- Describe functions and applications of pneumatic and electric components in electro-pneumatic controls.
- Read and draw up circuit diagrams for pneumatic and electro-pneumatic controls as solution for given applications.
- Determine the work steps required for carrying out the mounting and installation of pneumatic and electro-pneumatic controls.
- Select components, mount and install pneumatic and electro-pneumatic controls with laboratory and industrial components.
- Measure, check and calculate electrical and pneumatic parameters.
- Commission, operate and test pneumatic and electro-pneumatic controls.
- Carry out systematic trouble-shooting and repair in pneumatic and electro-pneumatic controls,
- Maintain and repair pneumatic and electro-pneumatic systems.
- Read components-lists, assign designations to components and select components from catalogues.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

III. Contents of the module

1. Content overview and time allocation:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of lesson in the module</th>
<th>Duration</th>
<th>Sum</th>
<th>Theory</th>
<th>Practice</th>
<th>Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Installation, operation and testing of pneumatic system</td>
<td></td>
<td>40</td>
<td>9</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Design and installation of applied pneumatic control system</td>
<td></td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Installation, operation and testing of electro-pneumatic system</td>
<td></td>
<td>40</td>
<td>8</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Design, installation and testing of applied electro- pneumatic control system</td>
<td></td>
<td>24</td>
<td>4</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Error identification and Trouble shooting of pneumatic, electro-pneumatic control system</td>
<td></td>
<td>8</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

2. Detailed contents:

**Lesson 1:**

**Installation, operation and testing of pneumatic system**

(40h)

Objectives:

After finishing this lesson, the trainees are able to;
- Develop the scheme of a mechatronic system in principle.
- Solve problems systematically in a team.
- Develop solutions for problems related to industrial processes as group working result.
- Draw up technical solutions in displacement-step or related diagrams.
- Describe functions and applications of components in pneumatic control systems.
Promotion of TVET, Viet Nam

- Read and draw up pneumatic circuit diagrams
- Install, operate and test pneumatic control system
- Maintain and repair pneumatic system
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
1.1 Structure of control system
1.2 Solution of control problems in principle
1.3 Control of stack magazine with pneumatic cylinder
1.4 Automatic retraction of cylinder
1.5 Speed control of cylinder
1.6 Control with logic AND-function
1.7 Stack magazine with cylinder in extended end-position
1.8 Control with logic OR-function
1.9 Control with negation of signal
1.10 Feeding station – control with 2 cylinders
1.11 Sequence control with overlapping signals
1.12 Control with rotary dive
1.13 Control of changer module
1.14 Distribution station with single cycle
1.15 Distribution station with automatic
1.16 Pneumatic press with pressure-dependent control
1.17 Test, theory and practice

Lesson 2:
Design and installation of applied pneumatic control system - Pneumatic press (8h)

Objectives:
After finishing this lesson, the trainees are able to;
- Draw up displacement-step and pneumatic circuit diagrams
- Use technical documents
- Describe function and application of industrial components used in pneumatic control systems
- Read components-lists, assign designations to components and select components from catalogues.
- Determine the work steps required for carrying out the mounting and installation.
- Install, operate and test industrial pneumatic control system
- Maintain and repair pneumatic system
- Communicate with partners in order to find out general processing solution for technical assignment
- Develop readiness for self learning to improve knowledge and working skills.

Content:

2.1. Problem description
2.2. Pneumatic circuit diagram
2.3. Service unit
2.4. Selection of cylinders and accessories
2.5. Valve mounting on manifold
2.6. Selection of connectors
2.7. Selection of tubes
2.8. Detailed components list
2.9. Assembling of control
2.10. Commissioning and testing

Lesson 3:
Installation, operation and testing of electro-pneumatic system (40h)

Objectives:
After finishing this lesson, the trainees are able to;
- Analyze and apply technical documents of electro-pneumatic components
- Solve problems systematically in a team.
- Develop solutions for problems related to industrial processes as group working result.
- Draw up technical solutions in displacement-step or related diagrams.
- Describe functions and applications of components in electro-pneumatic control systems.
- Read and draw up pneumatic- and electric circuit diagrams.
- Install, operate and test electro-pneumatic control system
- Maintain and repair electro-pneumatic system
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improving knowledge and working skills.

Content:
3.1. Control with double solenoid valve
3.2. Proximity sensing - Automatic retraction of cylinder
3.3. Proximity sensing with relay
3.4. Stack magazine with AND-function
3.5. Stack magazine with OR-function
3.6. Stack magazine with negation – Optical sensor
3.7. Stack magazine with single solenoid valve – Self locking control
3.8. Control with 2 cylinders
3.9. Control with 2 cylinders – Reading of electric circuit diagrams
3.10. Changer module with inductive sensing
Lesson 4:
Design, installation and testing of applied electro-pneumatic control system  

Objectives:
After finishing this lesson, the trainees are able to;
- Read and draw up electric-circuit-diagrams for electro-pneumatic controls.
- Draw up terminal diagrams and assign contacts in circuit- and terminal diagrams.
- Read and apply technical documents of electrical components used in industrial control systems.
- Select industrial components for installation.
- Describe functions and applications of components in electro-pneumatic control systems.
- Determine the work steps required for carrying out the mounting and installation.
- Mount electrical components on profile rails.
- Determine the routing of wiring on basis of pre-determined end points.
- Lay and fasten wiring in conduits and cable ducts.
- Trim wires ready for connection and attach to connection devices.
- Install, operate and test applied electro-pneumatic control system.
- Identify components and connections.
- Maintain and repair electro-pneumatic system.
- Communicate with partners (customers, suppliers and colleagues).
- Develop readiness for self learning for improving knowledge and working skills.

Content:
4.1 Mounting and electrical installation of pneumatic press
4.2 Mounting and electrical installation of stack magazine
4.3 Mounting and electrical installation of changer module
4.4 Mounting and electrical installation of distribution station

Lesson 5:
Error identification and trouble shooting of pneumatic, electro-pneumatic control system  

Objectives:
After finishing this lesson, the trainees are able to;
- Find faults by visual inspection.
- Read displacement-step-diagrams in order to determine the status of control in case of malfunction.
- Measure and test pneumatic and electric values.
- Identify faults in electric circuits by checking the current paths.
- Eliminate faults by replacement and adjustment of components and rectification of connections in pneumatic and electro-pneumatic control system.
- Commission and restart systems after trouble shooting.

Content:
5.1 Methodology of error identification and trouble shooting
5.2 Practical exercises for trouble shooting
  5.2.1 Faults in pneumatic part of system
  5.2.2 Faults originated from wrong installation
  5.2.3 Faults in running operating conditions
5.3 Test

IV. Prerequisites for implementation of module

- **Pneumatic Lab:**
  - For 12 to 16 trainees, always two trainees working at 1 working station
  - Size of room: min. 80m²
  - to 8 working stations
  - Power supply in cable duct round the lab. For every workstation 1 compressed air socket, 4x230V, 1 3-phase socket, 1 network socket
  - Control cabinet with fuses and emergency switch off
  - Working place for teacher with PC and printer
  - Blackboard, magnetic, min 2,5 x 1,2m
  - Overheadprojektor, Beamer and projection screen
  - Chairs and tables for theory and practice
  - Powerful compressor, extra silent
  - Storage cabinets for teaching aids and equipment.

- **Equipment of working stations (2 Schüler):**
  - Computertable with PC
  - Working stattion with horizontal profile plate, trolley with drawers for components, mounting frame
  - Basic set of components for pneumatic
  - Basic set of components for electro-pneumatic
  - Set of pneumatic sub-stations (Magazine, pneumatic press, rotary drive, vacuum)
  - Set of industrial pneumatic components for assembling
  - Set of electrical components for electrical installation
  - Wiring board
  - Pneumatic components
– Terminal strips
– Electrical components (relays, lamps, switches)
– Cable ducts, profile rail
– Tool set, multimeter

• **Teaching media**
  – Set of magnetic symbols pneumatic
  – Set of magnetic symbols electric
  – Software for design of circuits, demonstration of function of components

V. Evaluation methods and contents of tests

The evaluation of this modules contains:

1. **Intermediate tests**
   1.1 Written examination pneumatic controls
       The trainee solves in max. 120min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lesson “installation, operation and testing of pneumatic controls”.
   1.2 Practical test pneumatic control
       The trainee installs in max 60min a pneumatic control according to given documentation and commissions this control.
   1.3 Written examination electro-pneumatic controls
       The trainee solves in max. 120min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lesson “installation, operation and testing of electro-pneumatic controls”.

2. **Final examination**
   2.1 Written examination theory
       The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module.
   2.2 Examination work piece
       The trainee installs in max 120min an electro-pneumatic control with industrial components according to given documentation and commissions this control.
   2.3 Working exercise
       The trainee conducts in max. 60 min a working exercise. The working exercise contains the trouble-shooting in an electro-pneumatic control with finding and repair of 1 or more faults.
VI. Guide for implementation of the module

- **Fields of implementation of this module:**
  - This module is used to qualify the trainees of vocational training programme at 2-year intermediate level for mechatronic trade on the level of skilled worker.
  - This module is a basic module, that could be also used to train:
    - mechatronic trade on college level
    - mechatronics at university level
    - trades in the field of mechanical engineering

- **Organization:**
  - The lessons of this module should be organized in large blocks of at least one week up to 4 weeks duration to guarantee a steady work, especially in the practical parts. It is not practicable to interrupt the work of the students and use the components for assembling and installation for another group of students.

- **Some main guides in view of teaching methods for this module:**
  - Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
  - The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
  - The teaching staff should guide the students to independent problem solving.
  - All exercises should be focused on real situations, as they could take place in their future work in mechatronic trade. This means in particular that the exercises should mirror real industrial processes.
  - The teaching staff should instruct, give examples and correct errors while the trainees practice.
  - The teaching staff should use real industrial components and applications to implement the exercises.

- **Reference documents**
  - Teaching and learning materials for module 06 "Installation and testing of pneumatic and electro-pneumatic controls", published by GTZ, TVET Vietnam
Installation and testing of hydraulic and electro-hydraulic controls

MD 07

Vietnamese-German Development Cooperation
Training module:
Installation and testing of hydraulic and electro-hydraulic controls

Code of Module: MD07
Time: 120h. (Theory: 40h; Practice: 80h)

I. Position and characteristics of the module
- This module is built up from single projects (exercises), each of them developing and implementing a hydraulic or electro-hydraulic system or subsystem.
- Every project is action orientated and carried out in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- Every project is standing alone and contains as many objectives as possible but only a limited number of contents.
- Starting with a real application the trainee has to analyze the process, design the documentation and circuit diagrams, to mount and install the system, commission the system and do the trouble-shooting. In this context the use and mounting of industrial components as well as the professional connection and installation of tubes and hoses are from special importance.
- Before this module is implemented, the trainee should have basic skills in mechanical engineering, special in assembling technology.

II. Objectives of the module
After finishing this module, the trainees are able to;
- Develop the scheme of hydraulic and electro-hydraulic controls in principle.
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic and electric components in hydraulic and electro-hydraulic controls.
- Measure, check and calculate hydraulic parameters.
- Read and draw up circuit diagrams for hydraulic and electro-hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic and electro-hydraulic controls, commission and operate hydraulic systems and check the function.
- Determine the work steps required for carrying out the industrial mounting and installation of hydraulic controls.
- Read components-lists, assign designations to components and select components from catalogues.
- Mount hydraulic components in industry related manner, especially valves on base plates or modular blocks.
- Determine couplings and connectors for pipes and hoses under consideration of construction types, pressure level and threads.
- Produce pipelines by bending and mount to connectors by progressive ring (or similar) connection.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Carry out systematic maintenance, trouble-shooting and repair in hydraulic and electro-hydraulic controls,
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

III. Contents of the module

1. Content overview and time allocation:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of lesson in the module</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sum</td>
</tr>
<tr>
<td>1</td>
<td>Design and installation of basic hydraulic systems</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Design and installation of hydraulic systems for special applications</td>
<td>16</td>
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<tr>
<td>3</td>
<td>Industrial assembling and commissioning of hydraulic systems</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>Maintenance and trouble-shooting in hydraulic systems</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Installation and testing of electro-hydraulic controls</td>
<td>22</td>
</tr>
<tr>
<td>6</td>
<td>Final examination with electro-hydraulic controls</td>
<td>8 *</td>
</tr>
</tbody>
</table>
2. Detailed contents:

**Lesson 1: Design and installation of basic hydraulic systems**

*Objectives:*
After finishing this lesson, the trainees are able to;
- Develop the scheme of hydraulic and electro-hydraulic controls in principle.
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic components in hydraulic controls.
- Measure, check and calculate pressure, force, volume flow and speed in hydraulic controls.
- Read and draw up circuit diagrams for hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic controls, commission and operate hydraulic systems and check the function.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

*Content:*

1.1 Structure and special features of hydraulic systems
1.2 Hydraulic power unit
1.3 Characteristic of gear pump
1.4 Measurement instruments in hydraulics
1.5 Control of lifting device with cylinder
1.6 Pressure limitation in hydraulic systems
1.7 Adjustment of system pressure
1.8 Lifting of load with middle position
1.9 Holding load in middle position
1.10 Adjustment of cylinder speed
1.11 Control of cylinder with varying load
Lesson 2:
Design and installation of hydraulic systems for special applications

Objectives:
After finishing this lesson, the trainees are able to:
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic components in hydraulic controls.
- Measure, check and calculate pressure, force, volume flow and speed in hydraulic controls.
- Read and draw up circuit diagrams for hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic controls, commission and operate hydraulic systems and check the function.
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.

Content:
2.1 Types and construction of hydraulic pumps
2.2 Hydraulic system with pressure limitation
2.3 Hydraulic systems with hydraulic motors
2.4 Hydraulic system with accumulator
2.5 Sequence control with 2 cylinders

Lesson 3:
Industrial assembling and commissioning of hydraulic systems

Objectives:
After finishing this lesson, the trainees are able to:
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Read and draw up circuit diagrams for hydraulic and electro-hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic and electro-hydraulic controls, commission and operate hydraulic systems and check the function.
- Determine the work steps required for carrying out the industrial mounting and installation of hydraulic controls.
- Read components-lists, assign designations to components and select components from catalogues.
- Mount hydraulic components in industry related manner, especially valves on base plates or modular blocks.
- Determine couplings and connectors for pipes and hoses under consideration of construction types, pressure level and threads.
- Produce pipelines by bending and mount to connectors by progressive ring (or similar) connection.
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)

Content:
3.1 Analyzing hydraulic lifting device
3.2 Selection and mounting of cylinders
3.3 Selection and mounting of valves
3.4 Selection and mounting of fittings
3.5 Manufacturing of tubes
3.6 Installation of tubes and hoses
3.7 Commissioning of lifting device
3.8 Installation of control with hydraulic motor
3.9 Hydraulic circuit with vertical modular block
3.10 Dismantling and mounting of power unit
3.11 Dismantling and mounting of cylinders and pumps
3.12 Intermediate test 2

Lesson 4:
Maintenance and trouble-shooting in hydraulic systems

Objectives:
After finishing this lesson, the trainees are able to;
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Measure and check hydraulic parameters.
- Read hydraulic circuit diagrams and component lists with usage of industrial components.
- Determine the work steps required for carrying out inspection- and maintenance plans.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Carry out systematic maintenance, trouble-shooting and repair in hydraulic controls,
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues).
- Develop readiness for self learning to improve knowledge and working skills.

Content:
4.1 Inspection and service
4.2 Hydraulic fluids
4.3 Trouble shooting in hydraulic controls.

Lesson 5:
Installation and testing of electro-hydraulic controls (22h)

Objectives:
After finishing this lesson, the trainees are able to;
- Read and apply technical documentations of hydraulic components and circuits.
- Solve problems systematically in a team.
- Follow and develop electro-hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic and electric components in electro-hydraulic controls.
- Measure and check electric parameters.
- Read and draw up circuit diagrams for electro-hydraulic controls.
- Select electric components according to specifications and characteristics.
- Install electro-hydraulic controls, commission, operate and check the function.
- Carry out systematic trouble-shooting in electro-hydraulic controls,
- Describe and follow regulations for safety, particularly those arising from electric power.
- Communicate with partners (customers, suppliers and colleagues).
- Develop readiness for self learning to improve knowledge and working skills.

Content:
5.1 Lifting device, operated with 4/2-solenoid valve.
5.2 Lifting device with mid-position
5.3 Bending station – self locking control
5.4 Press fitting device – pressure control
5.5 Machining unit – sensing positions
5.6 Rapid-traverse feed circuit
5.7 Assembly device – sequence control

Lesson 6:
Final examination hydraulic and electro-hydraulic controls (8h)

Objectives:
After finishing this lesson, the trainees are able to;
- develop the scheme of hydraulic and electro-hydraulic controls in principle.
- read and apply technical documentations of hydraulic components and circuits.
- Follow and develop hydraulic systems for applied functional operations.
- Describe functions and applications of hydraulic and electric components in hydraulic and electro-hydraulic controls.
- Measure, check and calculate hydraulic parameters.
- Read and draw up circuit diagrams for hydraulic and electro-hydraulic controls with usage of industrial components.
- Select hydraulic components according to specifications and characteristics.
- Install hydraulic and electro-hydraulic controls, commission and operate hydraulic systems and check the function.
- Determine the work steps required for carrying out the industrial mounting and installation of hydraulic controls.
- Read components-lists, assign designations to components and select components from catalogues.
- Mount hydraulic components in industry related manner, especially valves on base plates or modular blocks.
- Determine couplings and connectors for pipes and hoses under consideration of construction types, pressure level and threads.
- Produce pipelines by bending and mount to connectors by progressive ring (or similar)connection.
- Describe properties of hydraulic fluids and select suitable hydraulic fluids according to given applications.
- Carry out systematic maintenance, trouble-shooting and repair in hydraulic and electro-hydraulic controls,
- Describe and follow regulations for safety and environmental protection, particularly those arising from hydraulic systems.
- Communicate with partners (customers, suppliers and colleagues)

Content:
6.1 Theoretical examination.
6.2 Practical examination training station
5.3 Practical examination industrial assembling

IV. Prerequisites for implementation of module

- **Hydraulic Lab:**
  - Size of room: min. 80m²
  - For 12 to 16 trainees
  - Training stations: max. 3 students at each training station (4 to 5 stations)
  - Assembling stations: max. 2 students at each assembling station (6 to 8 stations)
  - Work-benches with vice (6 to 8)
  - Power supply in cable duct round the lab.
  - For every station 2x230V, 1 3-phase socket, 1 network socket
  - Control cabinet with fuses and emergency switch off
  - Working place for teacher with PC and printer
  - Blackboard, magnetic, min 2,5 x 1,2m
  - Overheadprojektor, Beamer and projection screen
  - Chairs and tables for theory and practice
  - Storage cabinets for teaching aids and equipment.

- **Training stations (for 4 to 6 students):**
  - Moveable working station with two vertical or inclined profile plates for two-sided use
  - Oilpan
  - 2 drawer units with 3 drawers for components
  - Mounting frame for electric components
  - Hose holder
  - Hydraulic power unit with two pumps
    - 3-phase current, 400V, min. 1 kW
    - capacity: min 40l
    - delivery rate: min: 2 x 3.8l/min
    - pressure: min 60 bar, recommended 120 bar
• **Equipment set basic hydraulics (for 2 to 3 students)**
  - Pressure gauges
  - Flow control valve
  - One-way flow control valve
  - Shut-off valve
  - Non-return valve
  - T-connectors
  - Pressure relief valve
  - 3-way pressure reducing valve
  - 2-way flow control valve
  - Non-return valve delockable
  - Double acting cylinder
  - Hydraulic motor
  - Diaphragm accumulator with shut-off block
  - Weight with guidance and cover
  - 4/2 hand lever valve
  - 4/3 hand lever valve with recirculating mid-position
  - set of hose lines

• **Measuring equipment set** (for 2 to 3 students)
  - Digital indication (display)
  - Flow measurement device
  - Pressure sensor
  - Temperature sensor

• **Equipment set advanced hydraulics** (for 2 to 3 students)
  - Double acting cylinder, differential cylinder
  - One way flow control valve
  - Pressure relief valve
  - Flow dividing valve
  - 4/3 hand lever valve, closed mid position
  - 4/3 hand lever valve, relieving mid position

• **Upgrading equipment set from hydraulics to electro-hydraulics** (for 2 to 3 students)
  - Electric power supply for mounting frame
  - Relay, 3-fold
- Signal input, electrical
- Indicator unit and distributor, electrical
- 4/2-way-solenoid valve
- 4/3-way solenoid valve
- Limit switch electrical
- Inductive sensor
- Set of industrial pneumatic components for assembling

- **Assembling stations hydraulic for industrial assembling** (for 2 students)
  - Moveable working station with 1 vertical installation panel
  - Cylinder, pre-assembled
  - 4 base plates pre-assembled
  - Ports for pressure and return line to be connected to hydraulic power unit

- **Set of industrial components for hydraulic assembling on base plates** (for 2 students)
  - 4/3-hand lever valve
  - Pressure relief valve
  - Check valve, delockable
  - One-way flow control valve
  - Assortment of fittings
  - Tubes
    - Modular vertical block

- **Working bench with vice** (for 2 students)

- **Tool set for assembling** (for 2 students)
  - Spanners, allen keys
  - Torque wrench
  - Tube bending device
  - Tube cutting tool
  - Deburring tool
  - Hacksaw, files
  - Measuring instruments

- **Teaching media**
  - Set of magnetic symbols hydraulic
V. Evaluation methods and contents of tests
- The evaluation of this modules contains:

1. **Intermediate test 1**
   1.1 Written examination hydraulic controls
   The trainee solves in max. 90min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lesson “Design and installation of basic hydraulic systems”.
   1.2 Practical test hydraulic controls
   The trainee installs in max 60min a hydraulic control according to given documentation at the hydraulic training station and commissions this control.

2. **Intermediate test 2**
   2.1 Written examination industrial assembling
   The trainee solves in max. 60 min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lesson “Industrial assembling and commissioning of hydraulic systems”.
   2.2 Practical test industrial assembling
   The trainee manufactures in max 120 min one or more tubes and connects tubes and hoses in industrial manner with selected fittings to assembling station, commissions the system and check via pressure trial for leakage.

3. **Final examination with electro-hydraulic controls**
   3.1 Written examination theory
   The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module, under special observance of electro-hydraulic controls.
   3.2 Examination work piece
   The trainee installs in max 120min an electro-hydraulic control with industrial components at the training station according to given documentation and commissions this control.

VI. Guide for implementation of the module
- **Fields of implementation of this module:**
  - This module is used to qualify the trainees of vocational training programme at 2-year intermediate level for mechatronic trade on the level of skilled worker.
- This module is a basic module, that could be also used to train:
  - mechatronic trade on college level
  - mechatronics at university level
  - trades in the field of mechanical engineering
  - Trades in the field of automotive, specialized in heavy trucks and building and construction machinery

• **Organization:**
  - The lessons of this module should be organized in large blocks of at least one week up to 4 weeks duration to guarantee a steady work, especially in the practical parts. It is not practicable to interrupt the work of the students and use the components for assembling and installation for another group of students.

• **Some main guides in view of teaching methods for this module:**
  - Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
  - The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
  - The teaching staff should guide the students to independent problem solving.
  - All exercises should be focused on real situations, as they could take place in hydraulic application.
  - The teaching staff should instruct, give examples and correct errors while the trainees practice.
  - The teaching staff should use real industrial components and applications to implement the exercises.
  - From special importance are safety regulations and measures for environmental protection. Oil should never come in contact with soil. There must be precautions to absorb leakage oil and dispose according to regulations.
  - Students should wear protective clothes while working with hydraulic systems.
  - As the industrial bending of tubes and their assembling needs a lot of experience, the teachers or trainers have to test and upgrade their skills before starting the training in lesson 3.

• **Reference documents**
  - Teaching and learning materials for module 07 "Installation and testing of pneumatic and electro-pneumatic controls", published by GTZ, TVET Vietnam (if available)
  - Bosch AT-didactic: “Hydraulics, theory and applications" ISBN 3-9805925-3-7
- Bosch Rexroth AG “BIBB Hydraulics, Basics” Order No. R900071655
- Bosch Rexroth AG “BIBB Electro-hydraulics” Order No. R900071655
- Bosch Rexroth AG „The Hydraulic Trainer“ Order No. R 900018614
- FESTO DIDACTIC “Hydraulics, Basic level, textbook” Order No. 093 281
- FESTO DIDACTIC “Hydraulics, Basic level, workbook” Order No.094468
- FESTO DIDACTIC “Hydraulics, advanced level, workbook” Order No. 094015
- FESTO DIDACTIC “Electro-hydraulics, basic level, textbook” Order No. 093611
- FESTO DIDACTIC “Electro-hydraulics, basic level, workbook”Order No. 094470
Assembling station

Training station

There is only one hydraulic power unit necessary for both stations.

<table>
<thead>
<tr>
<th>Special features:</th>
<th>Special features:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The assembling station could be build locally.</td>
<td>• The training station is designed from didactic-providers</td>
</tr>
<tr>
<td>• The trolley could be assembled from profiles or welded from square tubes.</td>
<td>• The components are fixed on profile plates</td>
</tr>
<tr>
<td>• There is no profile plate but a sheet metal plate</td>
<td>• All components are connected with hoses</td>
</tr>
<tr>
<td>• The standard industrial cylinder is mounted</td>
<td>• The valves are fixed to base plates, no mounting on backside</td>
</tr>
<tr>
<td>• At least 4 base plates are mounted</td>
<td>• Hoses and components are equipped with quick couplings, not industrial standard.</td>
</tr>
<tr>
<td>• The valves are to be mounted by the students on the base plates</td>
<td>• All leakage oil during assembling and</td>
</tr>
<tr>
<td>• All tubes are connected at the backside of the base plate, as it is common in industry.</td>
<td>• very little leakage oil</td>
</tr>
<tr>
<td>dismantling</td>
<td></td>
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<tr>
<td>-------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>• Not recommended for experimental circuits because of the leakage.</td>
<td>• Not possible for industrial assembling because backside of base plate is covered from profile plate.</td>
</tr>
</tbody>
</table>

**Both systems are complementing each other. It is not possible to replace one system by the other.**
Promotion of TVET in Viet Nam
Installation and wiring of 3 - Phase motor control circuits and drivers

MD 08
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Place and year of publishing: Hanoi, 2010
Training module:
Programming of mechatronic systems with PLC

Code of Module: MD09
Time: 120 h. (Theory: 24h; Practice: 96h)

I. Position and characteristics of the module

- This module is built up from single projects (exercises), each of them developing and implementing a mechatronic system or subsystem.
- Every project is action orientated and carried out in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- Every project is standing alone and contains as many objectives as possible but only a limited number of contents.
- Starting with a real application the trainee has to analyze the process, design the documentation and circuit diagrams, develop, write and download the PLC-program, mount and install the system, commission the system and do the trouble-shooting.
- Before this module is implemented, the trainee should have basic skills in mechanical engineering, special in assembling technology, electrical installation and pneumatic controls.

II. Objectives of the module

After finishing this module, the trainees are able to;
- describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Describe functions and applications of pneumatic and electric components in mechatronic stations.
- Describe structure, working principle and applications of PLC.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems in at least one programming language according to IEC 1131.
Program sequence controls
Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
Select components, mount and install sensors and actuators in mechatronics systems and connect to interface.
Install industrial PLC, carry out the industrial wiring to interface and connect to mechatronic station.
Download programs to PLC, commission, operate and test mechatronic stations.
Carry out systematic trouble-shooting and repair in PLC-operated systems.
Describe and follow safety regulations, particularly those arising from electrical power.
Communicate with partners (customers, suppliers and colleagues)
Develop readiness for self learning to improve knowledge and working skills.
Solve problems systematically in a team.

III. Contents of the module
1. Content overview and time allocation:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of lesson in the module</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Theory</td>
</tr>
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<td></td>
<td></td>
<td>Practice</td>
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<tr>
<td></td>
<td></td>
<td>Tests</td>
</tr>
<tr>
<td>1</td>
<td>Programming of pneumatic stations with basic logic operations</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Programming of pneumatic stations with several actuators</td>
<td>30</td>
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<td>3</td>
<td>Programming of timer operations</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Programming of counter operations</td>
<td>6</td>
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<td>5</td>
<td>Installation of PLC-operated systems</td>
<td>18</td>
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<td>6</td>
<td>Control of electrical machines by PLC</td>
<td>20</td>
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<tr>
<td>7</td>
<td>Pneumatic station programmed in a second programming language</td>
<td>4</td>
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<tr>
<td>8</td>
<td>Programming of mechatronic stations with sequence controls</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Final examination</td>
<td>6</td>
</tr>
</tbody>
</table>
2. Detailed contents:

Lesson 1: Programming of pneumatic stations with basic logic operations (16h)

Objectives:
After finishing this module, the trainees are able to;
- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Describe functions and applications of pneumatic and electric components in mechatronic stations.
- Describe structure, working principle and applications of PLC.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

1.1 Control with double solenoid valve – statement assignment
1.2 Control of stack magazine – statement AND
1.3 Control with interrogation of positions – symbolic names
1.4 Alternative retraction of cylinder – statement OR
1.5 Interrogation of working area – statement NOT
1.6 Control with single-solenoid valve – function block SR
Lesson 2:
Programming of pneumatic stations with several actuators (30h)

Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
2.1. Control with parallel working actuators -branching
2.2. Pneumatic station with 2 cylinders
2.3. Rotary drive with vacuum suction cup
2.4. Trouble shooting in mechatronic systems
2.5. Control with overlapping signals – flag command
2.6. Exercise with overlapping signals
2.7. Distribution station in single cycle
2.8. Distribution station with operation mode automatic
2.9. Distribution station with interrogations and indications
2.10. Exercise with 3 actuators and overlapping signals
2.11. Test: Programming of pneumatic stations

Lesson 3:
Programming of timer operations (8h)

Objectives:
After finishing this lesson, the trainees are able to;
- Procure, read and apply information from technical documents, diagrams and internet.
- Program control systems with timer operations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
3.1. Pneumatic press with time delay
3.2. Control with timer TP
3.3. Control with timer TOF3.

Lesson 4:
Programming of counter operations

Objectives:
After finishing this lesson, the trainees are able to;
- Procure, read and apply information from technical documents, diagrams and internet.
- Program control systems with counter operations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
4.1 Counting work-pieces at distribution station with CTU-counter
4.2 Counting work-pieces in stack magazine with CTD-counter

Lesson 5:
Installation of PLC-operated systems

Objectives:
After finishing this lesson, the trainees are able to;
- Procure, read and apply information from technical documents, diagrams and internet.
- Describe functions and applications of pneumatic and electric components in mechatronic stations.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Select components, mount and install sensors and actuators in mechatronic systems and connect to interface.
- Install industrial PLC, carry out the industrial wiring to interface and connect to mechatronic station.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

**Content:**

5.1. Installation and wiring of PLC on PLC-board
5.2. Installation of pneumatic press
5.3. Installation of distribution station
5.4. Installation of pneumatic press with emergency switch-off
5.5. Installation of mechatronic station (press with work-piece feed)

**Lesson 6:**

**Control of electrical machines by PLC**

(20h)

**Objectives:**

After finishing this lesson, the trainees are able to;

- Read and draw up power and control circuit diagrams for electrical machines.
- Operate computer, PLC and peripheral devices.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated controls for electrical machines.
- Download programs to PLC, commission, operate and test controls for electrical machines.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

**Content:**
6.1 Inching operation of three-phase motor
6.2 Continuous operation from 1 position
6.3 Continuous operation from 2 positions
6.4 Three-phase motor with 2 directions of rotation
6.5 Automatic star-delta-connection

Lesson 7:
Programming of pneumatic station in a second programming language (STL, LAD, FBD) (4h)
Objectives:
After finishing this lesson, the trainees are able to;
- Procure, read and apply information from technical documents, diagrams and internet.
- Operate computer, PLC and peripheral devices.
- Program logic control systems in two programming languages according to IEC 1131.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
7.1 Pneumatic station programmed in a second programming language

Lesson 8:
Programming of mechatronic stations as sequence controls (12h)
Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Operate computer, PLC and peripheral devices.
- Program sequence controls
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.
Content:
8.1 Control with overlapping signals – linear sequence
8.2 Distribution station – linear sequence
8.3 Lifting and sorting station – alternative branching
8.4 Control with simultaneous branching

Lesson 9:
Final examination  (6h)

Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems and sequence controls in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Select components, mount and install sensors and actuators in mechatronic systems and connect to interface.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.

Content:
9.1 Theoretical examination
9.2 Practical examination

IV. Prerequisites for implementation of module
- Basic mechatronic lab:
  - For 12 to 16 trainees, always two trainees working at 1 working station
  - Size of room: min. 80m²
- 6 to 8 working stations
- Power supply in cable duct round the lab. For every workstation 1 compressed air socket, 4x230V, 1 3-phase socket, 1 network socket
- Control cabinet with fuses and emergency switch off
- Working place for teacher with PC and printer
- Blackboard, magnetic, min 2.5 x 1.2m
- Overheadprojektor, Beamer and projection screen
- Chairs and tables for theory and practice
- Powerful compressor, extra silent
- Storage cabinets for teaching aids and equipment.

- Equipment of working stations (2 Students)
  - Computertable with PC
  - Working station with horizontal profile plate, trolley with drawers for components, mounting frame
  - Basic set of components for pneumatic
  - Basic set of components for electro-pneumatic
  - Set of pneumatic sub-stations (Magazine, pneumatic press, rotary drive, vacuum)
  - PLC-board with PLC connected to interface (SUB-D, I/O-terminal) and socket board with 16 digital inputs and 16 digital outputs.
    - Set of electrical components for electrical installation
      - Wiring board with interfaces (SUB-D, I/O-terminal)
      - PLC-board with compact PLC and interfaces
      - Pneumatic components
      - Terminal strips
      - Electrical components (relays, lamps, switches)
      - Cable ducts, profile rail
  - Tool set, multimeter

- Teaching media
  - Set of magnetic symbols pneumatic
  - Set of magnetic symbols electric
  - Software for design of circuits, demonstration of function of components

V. Evaluation methods and contents of tests
- The evaluation of this modules contains:
1. Intermediate tests after lesson 2
1.1 Written examination PLC-operated controls
   The trainee solves in max. 90 min questions and exercises, multiple choice or essay
   questions, related to objectives and contents of the lessons “Programming of
   pneumatic stations with basic logic operations” and “Programming of pneumatic
   stations with several actuators”.
1.2 Practical test PLC-operated control
   The trainee installs in max 90 min a mechatronic station or pneumatic control at a
   training station according to given documentation, develops the program, download
   the program to PLC and commissions the station or control.

2. Final examination
2.1 Written examination theory
   The trainee solves in max. 120 min questions and exercises, related to objectives and
   contents of this module.
2.2 Examination work piece
   The trainee installs in max 180 min a PLC-operated mechatronic system with industrial
   components according to given documentation, develops the program and
   commissions this system.
2.3 Working exercise
   The trainee conducts in max. 60 min a working exercise. The working exercise
   contains the trouble-shooting in a PLC-operated system with finding and repair of 1 or
   more faults.

VI. Guide for implementation of the module
- Fields of implementation of this module:
  - This module is used to qualify the trainees of vocational training program at 2-year
    intermediate level for mechatronic trade on the level of skilled worker.
  - This module is a basic module, that could be also used to train:
    - mechatronic trade on college level
    - mechatronics at university level
    - trades in the field of mechanical or electrical engineering

- Organization:
  - The lessons of this module should be organized in large blocks of at least one week up
    to 4 weeks duration to guarantee a steady work, especially in the practical parts. It is not
    practicable to interrupt the work of the students and use the components for assembling
    and installation for another group of students.
• **Some main guides in view of teaching methods for this module:**
  - Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
  - The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
  - The teaching staff should guide the students to independent problem solving.
  - All exercises should be focused on real situations, as they could take place in their future work in mechatronic trade. This means in particular that the exercises should mirror real industrial processes.
  - The teaching staff should instruct, give examples and correct errors while the trainees practice.
  - The teaching staff should use real industrial components and applications to implement the exercises.

• **Reference documents**
  - Teaching and learning materials for module 09 "Programming of mechatronic systems with PLC", published by GTZ, TVET Vietnam
  - Step 7-fundamentals, GB from FESTO-DIDACTIC, Order.No. 184563
  - Programmable Logic Controllers, Basic Level, GB from FESTO-DIDACTIC, Order-No. 93314
  - Programmable Logic Controllers, Basic Level, Solutions, GB from FESTO-DIDACTIC, Order-No. 93316
Promotion of TVET
Viet Nam
Programming of mechatronic system with PLC (Programmable Logics Controllers)

MD 09
Publisher:

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Photo: Ralf Bäcker, Berlin

Place and year of publishing: Hanoi, 2010
Module description

Training module: Programming of mechatronic systems with microcontroller

<table>
<thead>
<tr>
<th>Module code: MD10</th>
<th>Name of the module: Programming mechatronic system equipped with microcontroller</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Theory 30</td>
</tr>
</tbody>
</table>

Theoretical basis
- This module consists of different exercises on controlling mechatronic subsystem or system. After finishing this practice-oriented module, the trainees are able to make and implement working plans and test mechatronic systems.
- Each exercise is closed and includes all training objectives but it often reflects a part of the training contents.
- Based on a real mechatronic system, the trainees are able to analyse functional relationship of the mechatronic system elaborate technical documents; assemble, programme, test the mechatronic system, and put it into operation.

Prerequisites
After finishing following subjects/modules:
- MH 12; MH 13; MH 15; MH 16;
- MD 04; MD 05; MD 06; MD 08; MD 09.

General objectives
The trainees are able to analyse, assemble, programme a mechatronic system equipped with microcontroller and put it into operation; find and fix errors.

Compare with tasks and activities in the occupational description

<table>
<thead>
<tr>
<th>Compare with tasks and activities respectively to symbols in the occupational description (Letter: task; number: Activity):</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2; A4; A5; B1; B2; B4; B6; B7; C29; C30; C31; C33; C34; C35; C37; C39; D3; D20; D21; D22; D23; D24; D28; D29; D30; D31; E1; E3; E8; E9; F1; F2; F3; F6; G2; G5; G6; G7; G8; H1; H17; H20; H21; H23; H25; H29; H31; I3; I8; J1; J2; J3; J4;</td>
</tr>
</tbody>
</table>
### Learning objectives

*After finishing this module, the trainees are able to:*

- analyse functional relationship in a mechatronic system;
- read and create an electric network of a mechatronic system equipped with microcontroller with the aid of a computer;
- describe the construction, operating principle and application of electrical/electronic components;
- assemble and replace electrical/electronic components of a microcontroller;
- programme a mechatronic system by using at least one programming language;
- assemble sensors and press buttons of the mechatronic system and connect them into inputs/outputs of the microcontroller;
- test and put the mechatronic system into operation;
- systematically correct errors of hardwares and softwares of the mechatronic system;
- ensure safety during operation of the mechatronic system;
- undertake tasks in groups.

### Content

**Assembly of a mechatronic system, for example:**
- Sensors;
- Relays, contactors;
- Microcontroller;
- Communication ports;
- Actuators (magnetic valves, cylinder, air compressor, stepper motor, one-line motor, alternating current motor);
- Signaling devices and safety devices.

**Collection of information:**
- from catalogues;
- on the internet.

**Functional relationship, for example:**
- Motion (cycle, time);
- Input signals;
- Conditions, under that the machine operates properly;
- Mode of operation;
- Warnings.

**Graphical presentation, for example:**
- Operational diagram;
- Flow chart;
- Status chart.

**Assembly:**
- Electric circuit of the controlling system.

**Programming:**
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<table>
<thead>
<tr>
<th>* Programming languages, for example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- C programming language</td>
</tr>
<tr>
<td>- Assembly programming language</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>* Programmes with:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Accu, shift register,</td>
</tr>
<tr>
<td>- Timer</td>
</tr>
<tr>
<td>- Calculator, comparator</td>
</tr>
<tr>
<td>- Interruption</td>
</tr>
<tr>
<td>- Converters such as A/D converter, D/A converter</td>
</tr>
</tbody>
</table>

**Assembly of a mechatronic system, for example:**
- Controller;
- Connection of sensors into controllers;
- Connection of electric drive system, mechanical system and pneumatic system;
- Connection of signal and voltage converter
- Connection of warning devices;

**Testing a programme, for example:**
- Simulation of the programme;
- Loading the programme;
- Putting the mechatronic system into operation and monitoring the system;

**Analysis, finding and correction of errors, for example:**
- Status analysis;
- Observation of signals;
- Supervision.
- Correction errors.

**Regulations regarding protection and protective devices, for example:**
- Overcurrent protection and overvoltage protection;
- Emergency stop switches

**Assessment**

The assessment of the trainees consists of following parts:

1. Continuous assessment through practical exercises relating to content of the module
2. Examination after completion of the module: Within 120 minutes the trainees do a test relating to training objectives;
3. Practical examination: Within 240 minutes, the trainees do the examination on programming, connecting mechatronic system and putting it into operation;
4. Evaluation of the practical examination: The trainees test the above practical examination within 60 minutes. The content includes analysis, finding and correction of an error or many errors of the electric subsystem of the mechatronic system, which are given by the teacher.
It is necessary to identify the important part of the assessment.

<table>
<thead>
<tr>
<th>Necessary resources</th>
<th>Workshop: Presumably, there is a group of 16 trainees, two trainees per workplace;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- The area is at least 80 m²;</td>
</tr>
<tr>
<td></td>
<td>- 08 workplaces;</td>
</tr>
<tr>
<td></td>
<td>- Power supply: AC electric power of 220V/50Hz and 380V/50Hz, adjustable electric power (0V-24V) and compressed air supply;</td>
</tr>
<tr>
<td></td>
<td>- Emergency stop switches for each workplace;</td>
</tr>
<tr>
<td></td>
<td>- Workplace for the teacher and cabinet for holding teaching aids;</td>
</tr>
<tr>
<td></td>
<td>- Magnetic board with dimension of at least 2,5 x 1,2m;</td>
</tr>
<tr>
<td></td>
<td>- Projector and projections;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipments for each workplace:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Tables.</td>
</tr>
<tr>
<td>- Specialized tools;</td>
</tr>
<tr>
<td>- 02 chairs per workplace for trainees;</td>
</tr>
<tr>
<td>- Motors of different types (AC motors, DC motors, etc.);</td>
</tr>
<tr>
<td>- Personal computers and application softwares;</td>
</tr>
<tr>
<td>- Programme loader for microcontroller.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Microcontroller, connector and other electronic components;</td>
</tr>
<tr>
<td>- Tin for welding, printed circuit boards;</td>
</tr>
<tr>
<td>- Accessories for assembly;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Teaching and learning aids</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Handouts for trainees</td>
</tr>
<tr>
<td>- Instructions for doing practical exercises</td>
</tr>
<tr>
<td>- Transparencies for presentation</td>
</tr>
<tr>
<td>- Simulation softwares</td>
</tr>
</tbody>
</table>
Programming of mechatronic systems with microcontroller

MD 10
Training module:  
Assembling, commissioning and maintenance of mechatronic systems

Code of Module: MD11  
Time: 240 h.  
(Theory: 44h; Practice:196h)

I. Position and characteristics of the module
- This module is built up from single projects (exercises), each of them developing and implementing a mechatronic system or subsystem.
- Every project is action orientated and carried out in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- Every project is standing alone and contains as many objectives as possible but only a limited number of contents.
- Starting with a real application the trainee has to analyze the process, read and apply the documentation and circuit diagrams, dismantle and mount the mechanical section and install the electrical part of the system, download the program, commission the system and do the trouble-shooting.
- Before this module is implemented, the trainee should have basic skills in mechanical engineering, special in assembling technology, electrical installation and pneumatic controls and PLC programming.

II. Objectives of the module
After finishing this module, the trainees are able to;
- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives, sensors, controller and interfaces.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit (pneumatic, hydraulic and electric) and functional diagrams for mechatronic systems.
- To plan maintenance and repair of mechatronic systems and draw up maintenance plans.
- Describe functions and applications of pneumatic, electric and electronic components in mechatronic stations and systems.
- Operate industrial PLC and peripheral devices.
- Configure the hardware of PLC.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131.
- Develop programs for sequence controls in SFC-language (Simatic GRAPH 7).
- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations and systems.
- Dismantle and assembly mechatronic stations and systems, change and adjust components.
- Install contactor and motor circuits for applications operated by PLC.
- Install industrial PLC, carry out the industrial wiring of PLC and mechatronic station and connect via interface.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- Recognize and describe the structure and application of bus-systems and networks.
- Install and operate industrial bus-systems in mechatronic systems.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Acquire information from documents and internet.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

III. Contents of the module

1. Content overview and time allocation:

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of lesson in the module</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sum</td>
</tr>
<tr>
<td>1</td>
<td>Characteristics and applications of sensors</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Programming of sequence controls in SFC-language</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Building up mechatronic station 1</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Building up mechatronic station with sensor applications</td>
<td>20</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th></th>
<th>Building up mechatronic station: handling</th>
<th>20</th>
<th>4</th>
<th>16</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Building up mechatronic station production</td>
<td>20</td>
<td>4</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Building up industrial transfer (conveyor) system</td>
<td>40</td>
<td>6</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Application of industrial fieldbus in mechatronic system</td>
<td>16</td>
<td>4</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Operation of process visualization</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Project work: Developing own mechatronic station</td>
<td>56</td>
<td>10</td>
<td>44</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Final examination</td>
<td>16*</td>
<td></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

* including preparation and evaluation

2. Detailed contents:

Lesson 1: Characteristics and applications of sensors (18h)

Objectives:
After finishing this lesson, the trainees are able to;
- Describe characteristics and applications of sensors.
- Procure, read and apply information from technical documents, diagrams and internet.
- Assign digital and analogue sensors to given applications.
- Read and draw up symbols and circuit diagrams for controls with sensors.
- Develop programs for controls with analogue sensors.
- Download programs to PLC and test controls with analogue sensors.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
1.1 Detection of objects with magnetic sensors.
1.2 Detection of objects with inductive sensors.
1.3 Detection of objects with optical sensors.
1.4 Detection of objects with capacitive sensors.
1.5 Measuring distances with linear potentiometer
1.6 Measuring pressure with analogue pressure sensor.
1.7 Measuring force with analogue force sensor.
1.8 Design PLC-programs with analogue sensors.
Lesson 2:
Programming of sequence controls in SFC - language (8h)

Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop functional charts of automated processes as function plans or graftec plans.
- Operate computer, PLC and peripheral devices.
- Program sequence controls in SFC-language (Simatic GRAPH7)
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting at sequence controls in SFC-language, assisted by online watch-function.
- Acquire and apply information from documents and internet, especially international standards IEC-1131 and Graftec.
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
2.1 Distribution station – linear sequence
2.2 Lifting and sorting station – alternative branching

Lesson 3: Building up mechatronic station 1 (20h)

Objectives:
After finishing this module, the trainees are able to;
- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives, sensors, controller and interfaces.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams (pneumatic, hydraulic and electric) for mechatronic stations.
- Operate industrial PLC and peripheral devices.
- Configure the hardware of PLC.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131
- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Dismantle and assembly mechatronic stations change and adjust components.
- Describe, mount and install valve terminal with multipol connection
- Install electrical components in mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
3.1 Dismantling of mechatronic station
3.2 Developing working plan for mounting and installation
3.3 Mounting mechanical part of station
3.4 Function, mounting and installation of valve terminal
3.5 Electrical installation to I/O-terminal
3.6 Downloading given program
3.7 Commissioning and testing
3.8 Writing own program as sequence control
3.9 Trouble shooting in mechatronic station 1

Lesson 4:
Building up mechatronic station with sensor applications (20h)

Objectives:
After finishing this lesson, the trainees are able to;
- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives, sensors, controller and interfaces.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams (pneumatic, hydraulic and electric) for mechatronic stations.
- Develop technical drawing of mechanical parts.
- Produce mechanical parts related to handling station
- Operate industrial PLC and peripheral devices.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131-3.
- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Dismantle and assembly mechatronic stations, change and adjust components.
- Install electrical components in mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

**Content:**

4.0 Pre-condition: station is unassembled
4.1 Problem-solving of sensor applications
4.3 Selection of sensors.
4.4 Design and production of mechanical parts (fixtures for sensors)
4.5 Modification of circuit diagrams (optional on computer)
4.6 Modification of program
4.7 Mounting and adjustment of mechanical parts and sensors
4.8 Electrical installation to I/O-terminals
4.9 Commissioning and testing
4.10 Trouble-shooting, special sensor-adjustment

**Lesson 5:**

**Building up mechatronic station: handling**

**Objectives:**

After finishing this lesson, the trainees are able to;

- Analyze functional connections in handling station, especially movement sequences and logical conditions.
- Procure, read and apply information from technical documents, diagrams and internet.
- Describe function and application of new pneumatic components related to handling process
- Develop solutions for problems related to handling station and draw up in standardized diagrams (displacement-step-diagram / function chart).
- Develop technical drawing of mechanical parts.
- Produce mechanical parts related to handling station
- Read and draw up circuit diagrams (pneumatic and electric) for handling station.
- Develop applied control program in SCL-language
- Determine the working steps required for carrying out the mounting and installation of handling station.
- Dismantle and assembly handling station, change and adjust components.
- Install electrical components in handling station.
- Download programs to PLC, commission, operate and test handling station.
- Carry out systematic trouble-shooting and repair.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
5.0 Pre-condition: station is unassembled
5.1 Problem-solving of handling station
5.2 Information about new components (actuators)
5.3 Design and production of mechanical parts
5.4 Develop working plan for mounting and installation
5.5 Mounting and adjustment of mechanical parts and sensors
5.6 Modification of circuit diagrams (optional on computer)
5.7 Electrical installation to I/O-terminals
5.8 Design of program in SCL-language
5.9 Commissioning and testing
5.10 Trouble-shooting,

Lesson 6:
Building up mechatronic station: production (20h)

Objectives:
After finishing this lesson, the trainees are able to;

- Analyze functional connections in production station, especially movement sequences and logical conditions.
- Procure, read and apply information from technical documents, diagrams and internet.
- Describe function and application of new pneumatic and electric components related to production process
- Develop technical drawing of mechanical parts.
- Produce mechanical parts related to production station
- Select motor-drive for production station (DC / AC)
- Develop solutions for problems related to production station and draw up in standardized diagrams (displacement-step-diagram / function chart).
- Read and draw up circuit diagrams (pneumatic and electric) for production station.
- Develop applied control program in SCL- language
- Determine the working steps required for carrying out the mounting and installation of production station.
- Dismantle and assembly production station, change and adjust components.
- Install electrical components in production station.
- Download programs to PLC, commission, operate and test handling station.
- Carry out systematic trouble-shooting and repair.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
6.0 Pre-condition: station is unassembled
6.1 Problem-solving of handling station
6.2 Information about new components (actuators and motors)
6.3 Design and production of mechanical parts
6.4 Develop working plan for mounting and installation
6.5 Mounting and adjustment of mechanical parts and sensors
6.6 Modification of circuit diagrams (optional on computer)
6.7 Electrical installation to I/O-terminals
6.8 Design of program in SCL - language
6.9 Commissioning and testing
6.10 Trouble-shooting,

Lesson 7:
**Building up industrial transfer (conveyor) system** (40h)

Objectives:
After finishing this module, the trainees are able to:
- Describe the structure of a conveyor system in principle with pneumatic and electric drives.
- Make a plan of installation and commissioning conveyor system
- Select electrical/electronics components and suitable tools, measurement instruments, material according to requirement.
- Mount mechanical parts and pneumatic components.
- Carry out electrical wiring.
- Connect pneumatic components.
- Write and download programs to PLC.
- Commission, operate and test industrial transfer system.
- Carry out systematically trouble-shooting and repair
- Describe and follow safety regulations, particularly those arising from electrical power.
- Solve problems systematically in a team.

Content:
7.1 Analyzing transportation process and conditions
7.2 Plan of installation process
7.3 Mounting of mechanical parts
7.4 Installation of pneumatic components
7.5 Installation of sensors
7.6 Installation of power circuit
7.7 Installation of control circuit
7.8 Downloading sample program, commissioning
7.9 Developing own programs
7.10 Commissioning and testing system
7.11 Trouble shooting
7.12 Evaluation

Lesson 8:
**Application of industrial fieldbus in mechatronic system** (20 h)

Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in mechatronic system.
- Describe function and application of new pneumatic and electric components related to production process
- Define transfer parameters between stations
- Operate mechatronic system by cable connections between stations.
- Name and describe fieldbus systems in principle (ASI, Profinet, Ethernet, and CAN).
- Install one selected fieldbus system for a mechatronic station.
- Program and operate mechatronic station with selected fieldbus system
- Install fieldbus to mechatronic system.
- Download given program, commission and operate mechatronic system with fieldbus
- Do the trouble shooting in mechatronic system with selected fieldbus.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
8.1 Combination of stations to a mechatronic system
8.2 Problem of communication between stations
8.3 Communication by I/O- connection
8.4 Fieldbus systems in principle
8.5 Installation of example fieldbus network
8.6 Programming of example fieldbus network
8.7 Design and building up system network
8.8 Operation of system network with given program
8.9 Commissioning and trouble shooting of system

Lesson 9:
Operation of process visualization (6 h)

Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in automated processes, especially movement sequences and function parameters.
- Draw up process in flowchart.
- Operate software for process visualization.
- Do trouble shooting in mechatronic system with assistance of process visualization system.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
9.1 Analysis of process of mechatronic system
9.2 Symbols and drawing up of flowchart
9.3 Demonstration of process visualization
9.4 Operation of process visualization
9.5 Trouble shooting with assistance of process visualization
Lesson 10:
Project work: Developing and building up own mechatronic station  (56h)

Objectives:
After finishing this lesson, the trainees are able to;

- Analyze functional connections in project, especially movement sequences and logical conditions.
- Procure, read and apply information from technical documents, diagrams and internet.
- Develop solutions for problems related to project and draw up in standardized diagrams (displacement-step-diagram / function chart).
- Develop technical drawings of mechanical parts and assembly drawings
- Produce mechanical parts on industrial standard
- Read and draw up circuit diagrams (pneumatic and electric).
- Develop applied control program
- Determine the working steps required for carrying out the mounting and installation of handling station.
- Assemble project and adjust components.
- Install electrical components with industrial wiring
- Download programs to PLC, commission, operate and test project.
- Present proposals and results to group of experts or colleagues, recommended in power point and partly in English language.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
10.1 Problem- or project description
10.2 Proposals for solution of project
10.3 Presentation of proposals
10.4 Developing of documents
   • Description of process, positional sketch
   • Displacement-step-diagram or function chart
   • Technical drawings for mechanical parts
   • Circuit diagrams
   • Program
10.5 Mechanical production of project
10.6 Installation of electrical components
10.7 Commissioning and testing of system
10.8 Presentation of project
Lesson 11:
Final examination

Objectives: (16 h)

After finishing this lesson, the trainees are able to;

- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives, sensors, controller and interfaces.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read circuit diagrams (pneumatic, hydraulic and electric) for mechatronic stations.
- Operate industrial PLC and peripheral devices.
- Configure the hardware of PLC.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131-3 and SCL-language.
- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Read technical drawings, especially assembly-drawings
- Dismantle and assemble mechatronic stations, change and adjust components.
- Produce mechanical components
- Describe, mount and install valve terminal
- Install electrical components in mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.

Content:

11.1 Theoretical examination
11.2 Practical examination: work piece
11.3 Practical examination: working exercise

IV. Prerequisites for implementation of module

- Advanced Mechatronic lab:
  - For 12 trainees, always two trainees working at 1 working station
  - Size of room: min. 80m²
- 6 working stations
- Power supply in cable duct round the lab. For every workstation 1 compressed air socket, 4x230V, 1 3-phase socket, 1 network socket
- 1 Power supply from ceiling for conveyor system
- Control cabinet with fuses and emergency switch off
- Working place for teacher with PC and printer
- Blackboard, magnetic, min 2,5 x 1,2m
- Overhead projector and projection screen
- Teachers computer and beamer
- Chairs and tables for theory and practice
- Powerful compressor, extra silent
- Storage cabinets for teaching aids and equipment.

**Equipment of working stations** (2 Students):
- Computer table with PC (including fieldbus)
- Mechatronic station complete with:
  - Mechatronic station mounted on profile plate or stand-alone unit
  - Trolley
  - Industrial modular PLC with accessories
  - Operator panel
- Tool set, multimeter
- Set of electrical components for electrical installation
- Training set sensors
- Training set fieldbus
- Set of components for project work
  - Profile plate
  - Set of aluminum profiles and connectors
  - Pneumatic components
  - Wiring board with I/O-terminals
  - Electrical components (relays, lamps, switches)
  - Cable ducts, profile rail

**Important:**
- Two of the stations must contain an industrial conveyor system with 3-phase motor to connect the single stations to a complete mechatronic system

**Additional room equipment:**
- Fielbus system for conveyor and stations
- Process visualization-software for mechatronic system

V. Evaluation methods and contents of tests
- The evaluation of this modules contains:

1. Accompanied evaluation
   Every exercise is evaluated in an evaluation form. The evaluation contains function check, working time, visual inspection and evaluation of documentation.

2. Final examination
   2.1 Written examination theory
   The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module.
   2.2 Examination work piece
   The trainee installs in max 300min a PLC-operated mechatronic system with industrial components according to given documentation., develops the program and commissions this system. This includes the production of at least 1 mechanical part as spare part for this system.
   2.3 Working exercise
   The trainee conducts in max. 60 min a working exercise. The working exercise contains the trouble-shooting in a PLC-operated station or system with finding and repair of 1 or more faults.

3. Project work
   The trainees develop in a group of max. 4 in max.60h a mechatronic station individually, This includes documentation, production of mechanical parts, programming, commissioning and testing. The results are to be presented to the teacher or an examination board.
   The following parts are to be evaluated:
   3.1 The documentation
   3.2 Function and quality of the station
   3.3 Presentation of project work.

VI. Guide for implementation of the module
- Fields of implementation of this module:
  - This module is used to qualify the trainees of vocational training program at 2-year intermediate level for mechatronic trade on the level of skilled worker.
- This module is the final module which should summarize the qualification of all previous modules.

**Organization:**
- The lessons of this module should be organized in large blocks of at least one week up to 8 weeks duration to guarantee a steady work, especially in the practical parts. It is not practicable to interrupt the work of the students and use the components for assembling and installation for another group of students.

**Some main guides in view of teaching methods for this module:**
- Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
- In this module, the teams of students are working at different mechatronic stations in a rotating system (compare annex 1)
- The students have to build up the mechatronic stations from the basis. It is to be ensured, that the stations have to be dismantled, before the students start work - if not, the first step 0 will be the complete dismantling of stations.
- The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
- The students should conduct their work as far as possible on their own and inform themselves from documents and internet.
- As far as the students are working in teams the teaching staff should instruct them in team-work and sharing of work.
- Some lessons, project work and examination contain production of mechanical components. It is of special importance to watch the quality and accuracy of this work.

**Reference documents**
- Teaching materials for every mechatronic station
- FESTO-DIDACTIC: Fieldbus AS-Interface - working book No. 534 272
- FESTO-DIDACTIC: Fieldbus Profibus-DP - working book No. 534 273
ANNEX 1: ORGANIZATION OF WORK

Groups running through terms:

<table>
<thead>
<tr>
<th>Time</th>
<th>Station 1</th>
<th>Station Sensors</th>
<th>Station Production</th>
<th>Station Handling</th>
<th>Station Transfer 1</th>
<th>Station Transfer 2</th>
</tr>
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<tr>
<td>TERM 1</td>
<td>GROUP (A)</td>
<td>GROUP (B)</td>
<td>GROUP (C)</td>
<td>GROUP (D)</td>
<td>GROUP (E)</td>
<td>GROUP (F)</td>
</tr>
<tr>
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<td>GROUP (D)</td>
<td>GROUP (A)</td>
<td>GROUP (B)</td>
<td>GROUP (C)</td>
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<tr>
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<td>GROUP (E)</td>
<td>GROUP (F)</td>
<td>GROUP (A)</td>
<td>GROUP (B)</td>
<td>GROUP (C)</td>
<td>GROUP (D)</td>
</tr>
<tr>
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<td>GROUP (E)</td>
<td>GROUP (F)</td>
<td>GROUP (A)</td>
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</tr>
<tr>
<td>TERM 5</td>
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<td>GROUP (E)</td>
<td>GROUP (F)</td>
<td>GROUP (A)</td>
<td>GROUP (B)</td>
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<tr>
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