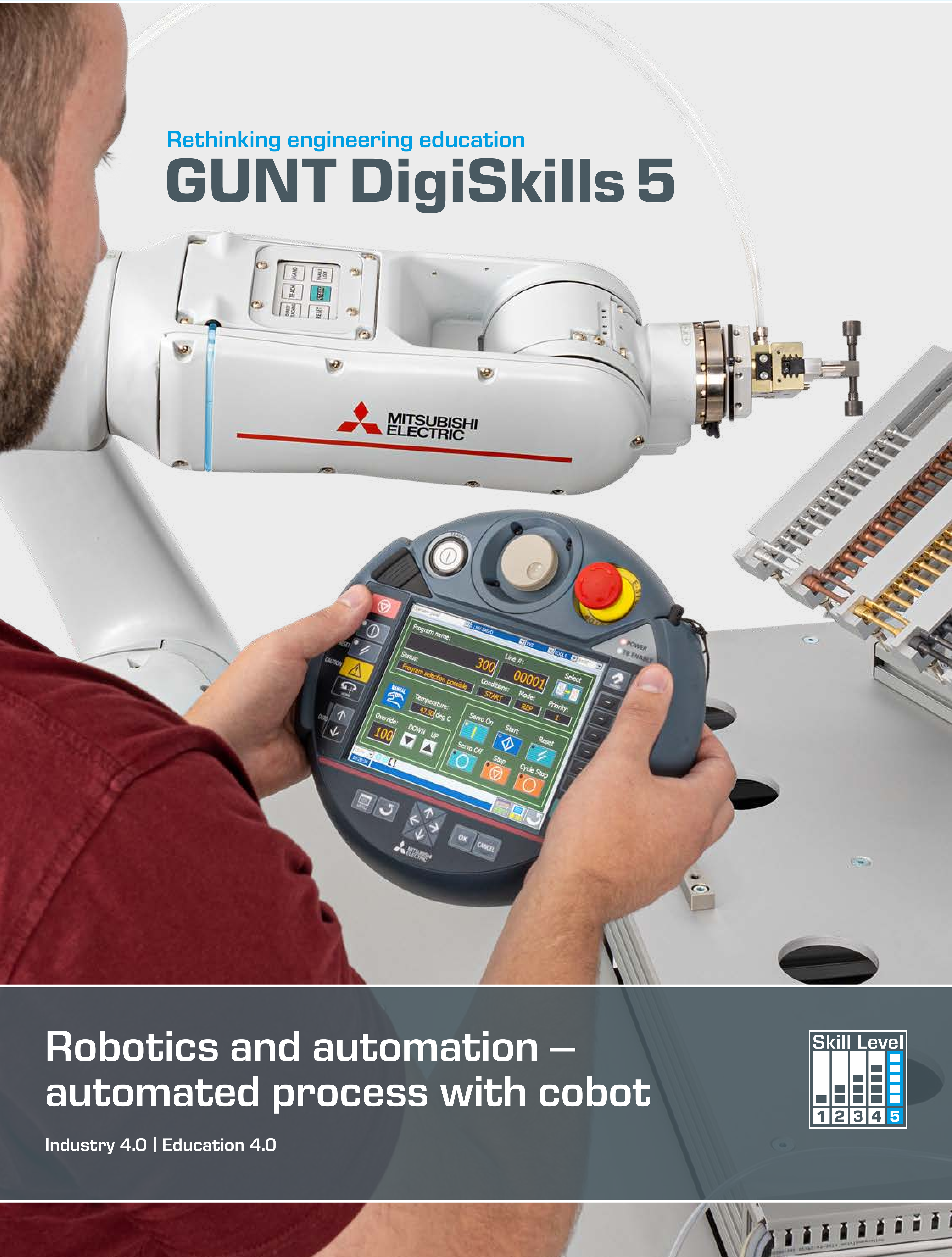
GUNT TECHNOLOGY LIMITED

Rethinking engineering education

GUNT DigiSkills 5



Robotics and automation – automated process with cobot

Industry 4.0 | Education 4.0

Skill Level 1 2 3 4 5

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Foreword

More than any other group, the industrial metalworking and electrical professions are in the spotlight when it comes to **digitalisation** and **Industry 4.0**. The new profession profile Digitalisation of Work – binding for all German establishments – requires the concrete implementation of the fields of competence and training content relevant to Industry 4.0. Conventional and innovative techniques coexist and must both be mastered. As a **vertical integration of learning content**, the new profession profile: Digitalisation of Work, is taught over the entire training period in the training company and in the vocational school.

The DigiSkills 5 learning project is also ideally suited for university-level lectures in the field of robotics and automation.

GUNT can help you with these complex vocational educational tasks. Our practical, work process-oriented learning projects, which are perfectly suited to developing digital skills, are available to you in the form of the **GUNT DigiSkills product line**.

Develop skills for the world of work 4.0 with the **GUNT DigiSkills 5** learning project

interdisciplinary – digital

Skill Level 1 2 3 4 5

Visit the DigiSkills website

The **GUNT DigiSkills 5** learning project

This learning project covers the topics of **automation** and **robotics**. Both are important components in the fields of **mechatronics, mechanics, electrical engineering** or **computer science**. The project covers the topics of control systems, PLC, programming, system integration, process integration, hydraulics and pneumatics. The core element of this learning project is a collaborative robot, a cobot.

Cobots are used in fields such as machine loading and quality inspection. Their use is based on process automation. The **DigiSkills 5** learning project sets out to automate processes for a mechanical testing procedure. Automation is explained step by step and underpinned with practical tasks, instructions and information.

The manually operated **WP 300** materials tester is used to analyse the process and divide the system into smaller units, e.g. into assemblies and functions including the appropriate tools. The analysis leads into working out the automation potential for the **IA 500** system. The solutions developed in this way are then implemented, tested and optimised. In addition to and independently of the IA 500 system, interesting programming tasks can be carried out with the **IA 501** programming a servo drive device, developed for precisely this purpose.

The **GUNT Skills Media Center** provides a digital learning environment for all steps of the automation process.

GUNT DigiSkills learning projects

1 **Engineering drawing – Technical communication**

2 **Dimensional metrology**

3 **Preventive maintenance**

4 **Energy efficiency in compressed air systems**

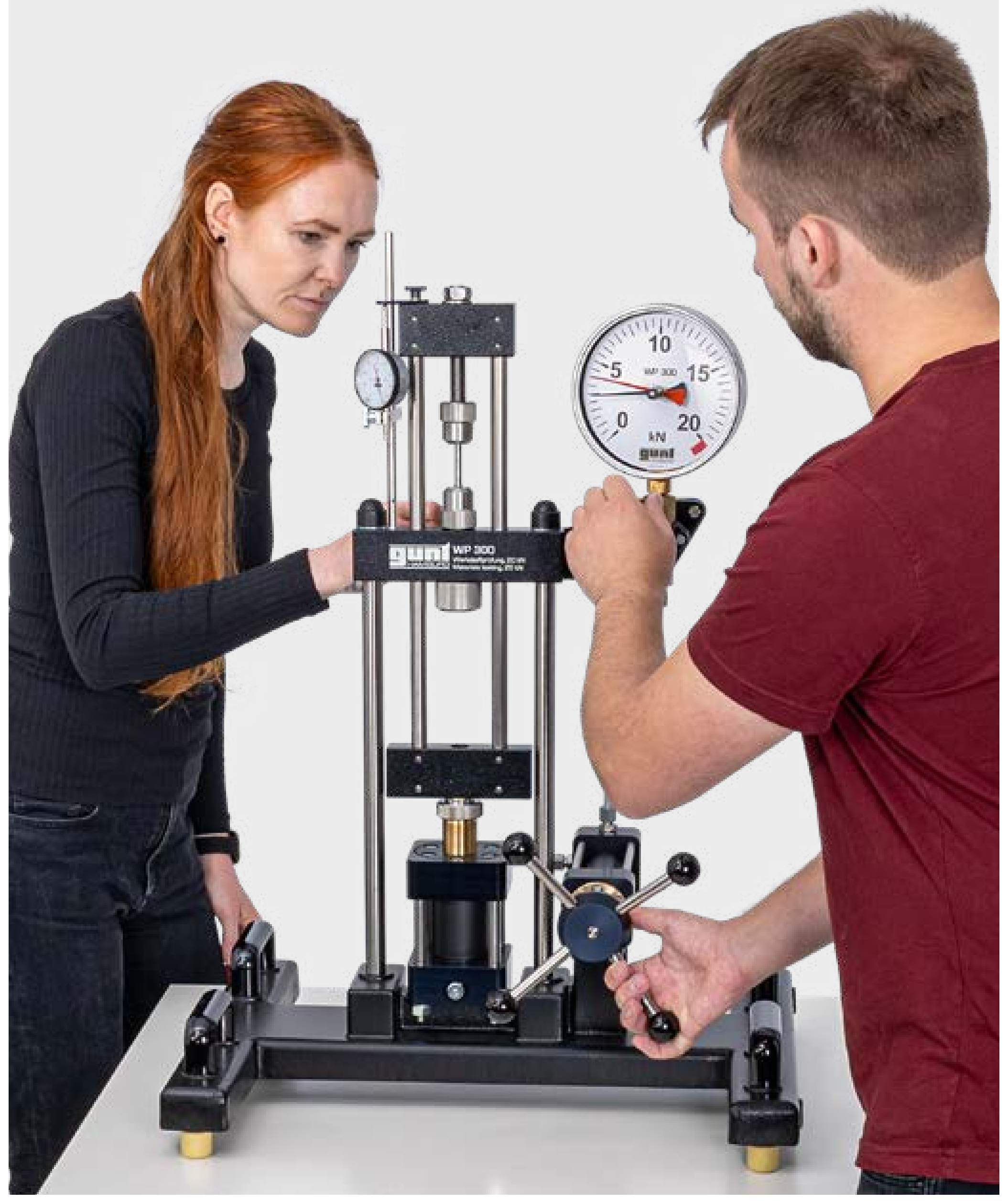
5 **Robotics and automation**

How is a process automated?

Process analysis

Identification and analysis of the process: the work steps are identified using the manually operated materials tester **WP 300**.

- describe the system
- recognise potential for automation
- develop solutions for movements and communication



Concept creation

Development of a concept that defines the work steps, the required tools and the goal of automation.

- create a sequence plan
- implementation in a flow chart

Implementation

Implementation of the automation concept

- programming the process sequence from the flow chart using the controller
- tools: designing, defining the interfaces and their interaction, e.g.
  - store for material specimens,
  - drive of the worm gear screw jack via servomotor,
  - hydraulics for power transmission

Testing and optimisation

Commissioning and review of the process

- review of the operation and results of automation
- make appropriate adjustments if necessary

1 | Automated process with cobot IA 500

Tasks of the automated process

- continuous determination of material data from a standardised tensile test
- insertion of tensile specimens and removal of the fragments by robot
- hydraulic generation of the test force

Cobot – High-quality collaborative robot

- industrial control for 6 axes
- low occupational safety requirements
- power and force limitation according to ISO TS 15066

Store for specimens

- 4 different materials
- automatic detection of the number of parts and material selection of the specimens

Hydraulic system

- generation of the test force

Controller

Low-code functions for creating automation scripts

Overall structure on sturdy aluminium frame

- mobile experimental plant for flexible use in the workshop, in the lab, in the lecture hal…

The **GUNT DigiSkills 5** learning project … at the heart of **mechatronics** teaching

The IA 500 system and the other devices in the DigiSkills 5 learning project put you right at the heart of the topic. The enormous breadth of technology makes it possible to study, understand and apply a wide range of mechatronics topics from the perspective of concrete applications.

As for all DigiSkills learning projects:

- work in a digital environment
- access all digital content of the GUNT Skills Media Center
- learning **for** Industry 4.0 and learning **with** Industry 4.0

A standard metallic tensile specimen is "torn" under standard conditions

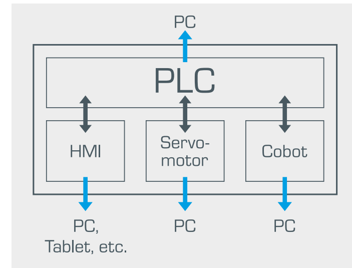
- versatile data on the test result is automatically available

Freely movable control element (HMI) in separate case with touch screen

- versatile menus for operation, monitoring and displaying data
- many didactic elements support the learning process
- screen mirroring option

Automated process sequence

Programming



Smart communication from actuators

Switch cabinet with all control components

You can make the assembly, wiring and functionality the actual subject of learning.

Watch the video

2 | Procedure for automating a process

Process analysis | Concept creation | Implementation | Testing and optimisation

All process automation is preceded by a diligent process analysis. Understanding the current process provides insights into the potential for automation:

- identification of the movement sequences
- effect of forces
- acquisition of measurement data

Suggestion for tasks

- Develop a strategy: start by describing the process and finish by selecting a solution. In order to find lots of good solutions to the questions, it makes sense to use creativity techniques. Examples include the 635 Method, mind mapping or the morphological box.
- Choose the best solution from the many available. To do this, compare and evaluate the solutions, for example using the weighted point score method.


Take the tensile specimen from the store

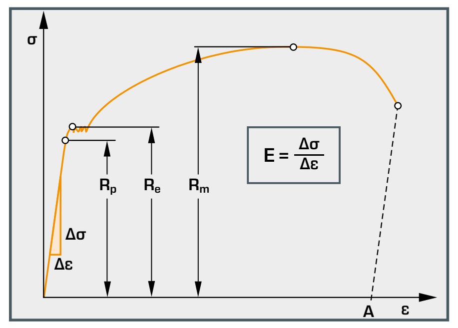

Clamp tensile specimen in the materials tester


Apply force with handwheel

Read the force on the manometer


Data acquisition: force and length are recorded


Remove and dispose of the tensile specimen

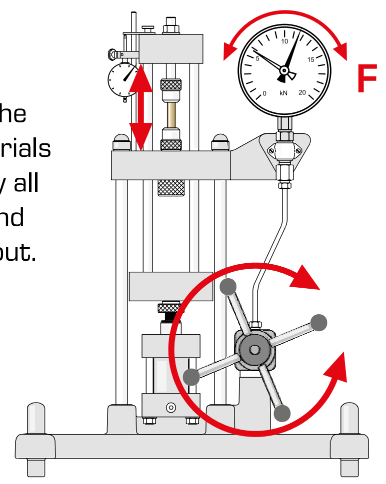


Analysis of the data in a stress-strain diagram, calculate the strength

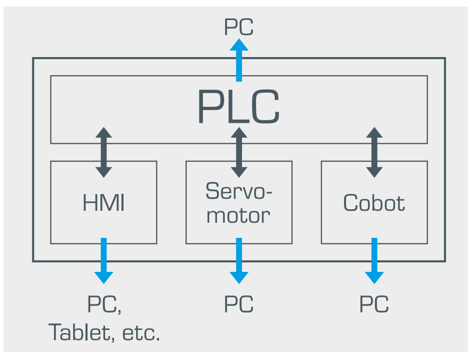
Watch the video

Example tasks from the GUNT Skills Media Center

- Name all fixed elements on the WP 300 materials tester. Identify all movements and sketch them out.



- Create a topology of the communication pathways.

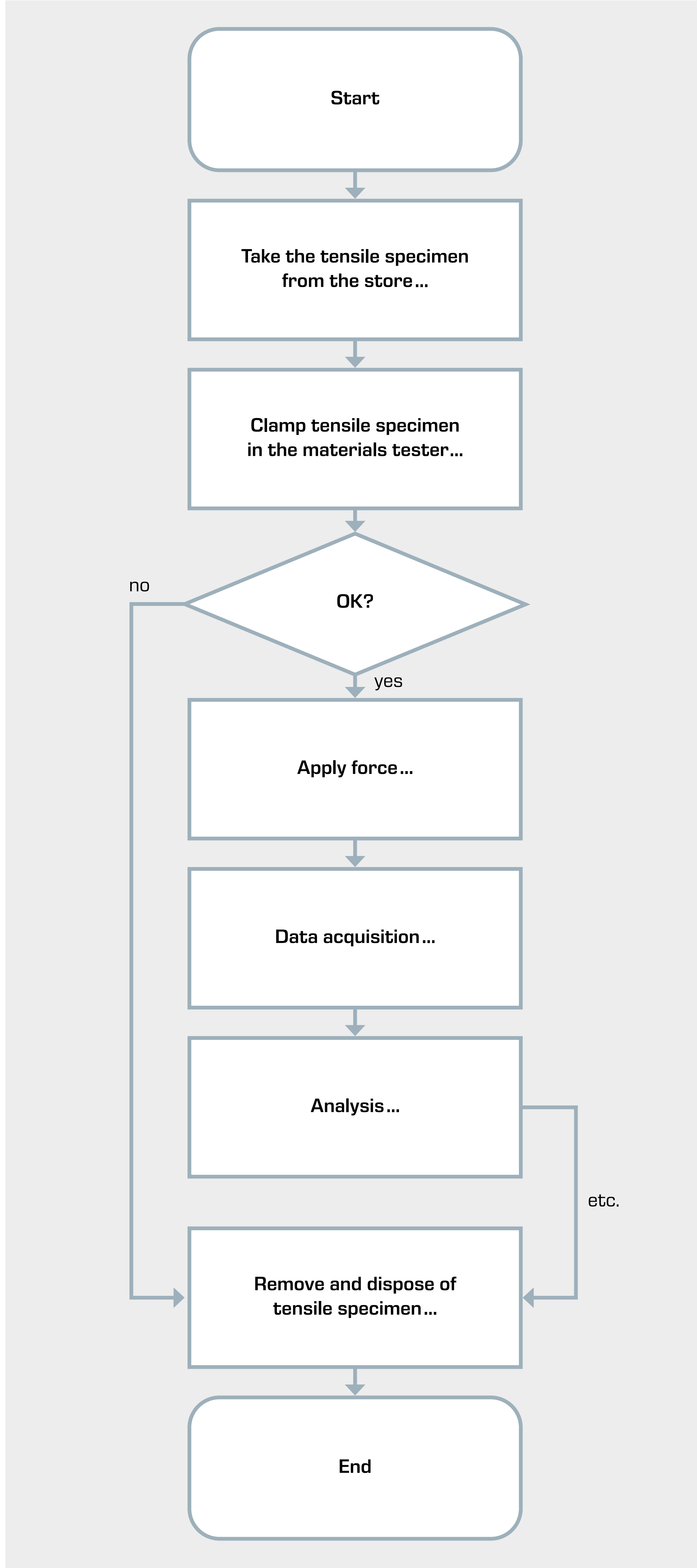


Process analysis | **Concept creation** | Implementation | Testing and optimisation

Development of a concept that defines the work steps, the required tools and the goal of automation:

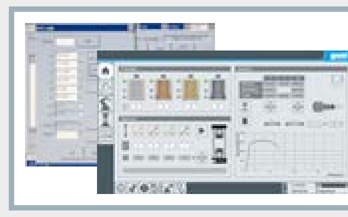
- create a sequence plan
- implementation in a flow chart

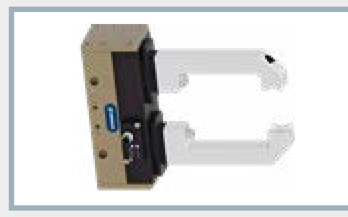
Example layout of a flow chart



Required tools


Transporting
Cobot, e.g. Mitsubishi


Control and communication
Software, PLC, bus systems...


Gripping
Parallel grippers, angular grippers, magnetic grippers, e.g. SCHUNK


Storing
Store for material

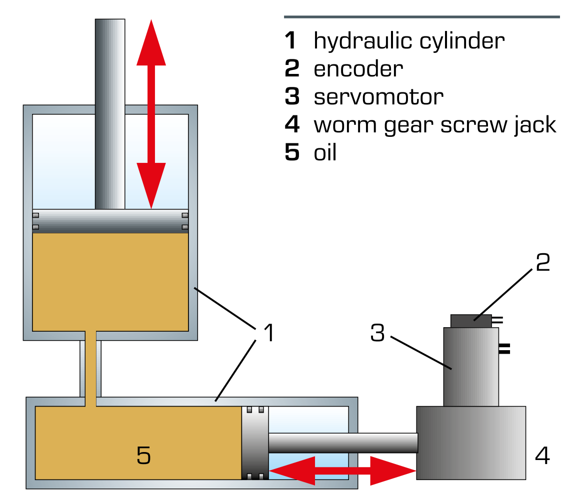

Drive
Motor, gear, e.g. ZIMM


Energy transfer
Pneumatics, hydraulics, e.g. FESTO, SMC


Measuring
Sensors, e.g. OPCON, Huba Control

Suggestion for tasks

- Draw a sketch of the hydraulic system that can be used to apply tensile force to the specimen.
- What tools are needed to implement these movements?



1 hydraulic cylinder
2 encoder
3 servomotor
4 worm gear screw jack
5 oil

2 | Procedure for automating a process

Process analysis → **Concept creation** → Implementation → Testing and optimisation

Tools for implementation of the automation concept

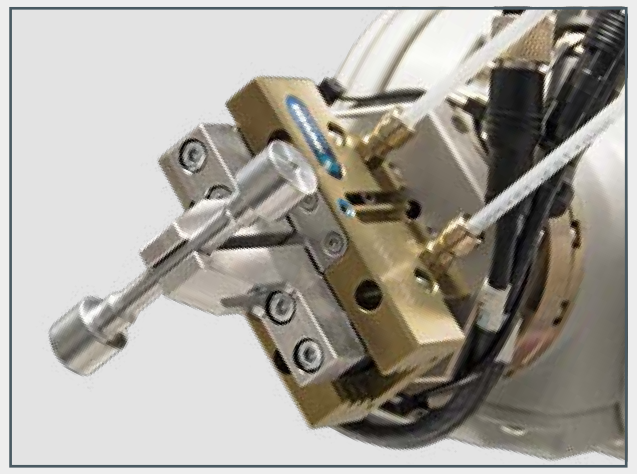
Collaborative robot (cobot)

- modern, high-quality industrial robot, with associated controller
- can be used near people without additional safety equipment
- defined geometry with 6 axes
- loads the material tester with tensile specimens and disposes of the fragments

Controller

- define operating areas
- create robot programs

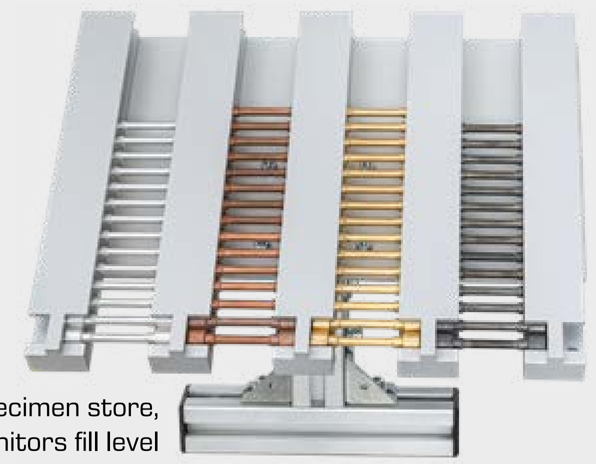
Gripper



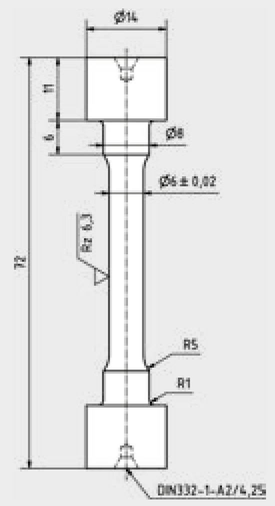
- gripper fingers take tensile specimens from the specimen store at defined positions
- the tensile specimens are inserted into the collet chucks of the materials tester
- gripping is achieved by pneumatically generated forces
- pneumatic control elements located in the robot arm

Specimen store, container for fragments

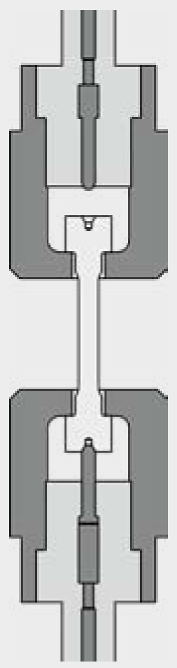
- space for 20 tensile specimens per material
- materials: aluminium, copper, brass, steel
- sensor detects whether a tensile specimen is present at the picking position and the number of specimens present
- fragments are sorted by material and collected in appropriate containers



Specimen store, monitors fill level



Collet chucks with built-in centring pins



- primary function: transfer of tensile force to the tensile specimen
- secondary function: centring and clamping the tensile specimen, holding the fragments after the tensile test
- centring pins are pneumatically controlled by electropneumatic 3/2-way valves

Servomotor with worm gear screw jack

- generation of tensile force with the aid of 2 hydraulic cylinders
- drive of the worm gear screw jack via servomotor with encoder
- servomotor controller communicates with the central PLC

Engaging programming tasks can be worked on independently of the **IA 500** system using the **IA 501** servomotor drive device developed for this purpose.

Sensors

- measurement data from the experiment: path and force
- linear potentiometer for path measurement
- pressure sensor for force measurement
- inductive proximity switches to monitor the store

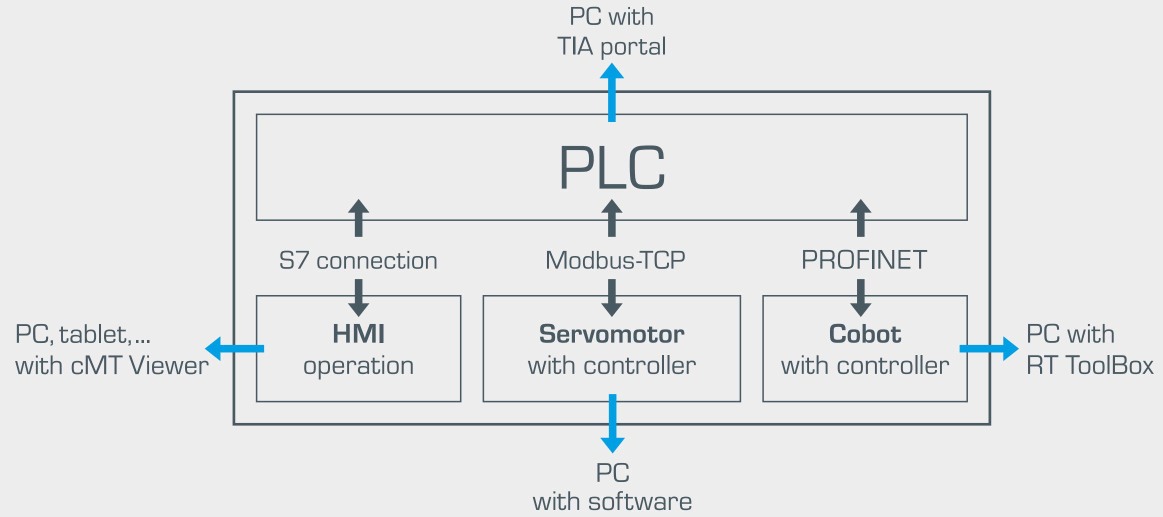
Linear potentiometer

Pressure sensor

Inductive proximity sensor

Communication topology

- communication topology offers a lot of depth for the learning process
- communication of the system within an IP network
- PLC as the central unit in the process



PLC

- controls all processes in the system: communication with the cobot controller and servomotor controller (force generation)
- storage and processing of the recorded measured values
- own programming environment
- as didactic support, the complete work step chain for the tensile test is displayed graphically, with dynamic status indicator

Watch the video

HMI

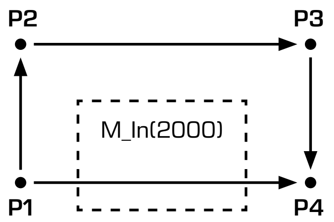
- Human-Machine Interface (HMI) with touch screen and intuitive user interface
- separate portable enclosure
- operation of the cobot to load the materials tester and dispose of the tensile specimens
- operation of the servomotor to generate force
- control of the experiment and recording of measured values
- representation of force-path diagram/stress-strain diagram
- can be connected to PC or tablet; user interface screen can be mirrored

2 | Procedure for automating a process

Process analysis | Concept creation | **Implementation** | Testing and optimisation

Programming the cobot with the controller in IA 500

- teach the cobot and define the working coordinates by saving points in the room
- determine pick-up and set-down points in the operating area

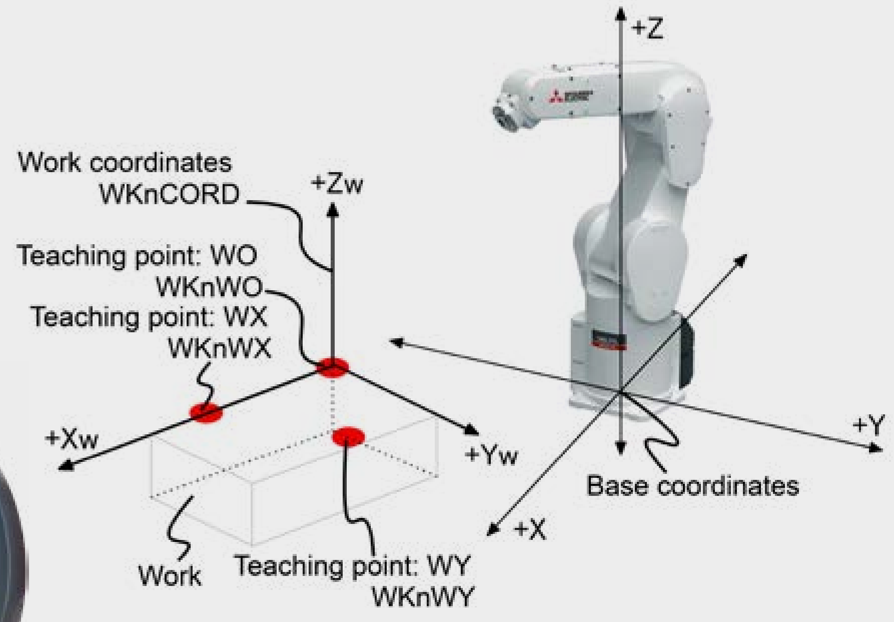


Program	Comment
...	
Mvs P1	Linear movement P1
Dly 0,5	Delay 0,5 seconds
HClose 1	Close hand
Dly 0,5	Delay 0,5 seconds
If M_In(2000)=1 Then	Branch to object
Mvs P2	Linear movement P2
Mvs P3	Linear movement P3
EndIf	End of If loop
Mvs P4	Linear movement P4
Dly 0,5	Delay 0,5 seconds
HOpen 1	Open hand
Dly 0,5	Delay 0,5 seconds
Mvs P3	Linear movement P2

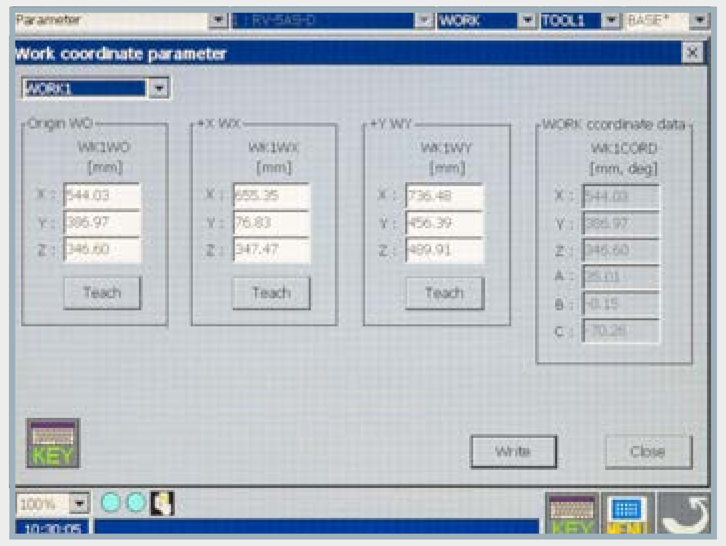
Suggestion for tasks

Write a brief program section with the aim of moving an object from point 1 to point 4. Use the MELFAbasic programming language. Comment your program.

Controller



Watch the video



Program interface

Programming the servo drive with IA 501

A small training device with a great learning effect: structure, function and programming of a servo drive. Targeted learning, completely independent of the large IA 500 system.

The experimental unit is an independent teaching system for analysing, implementing and testing a work step of the automation process from IA 500. Programs can be safely developed and tested with this device. The device comes with the manufacturer's Plug&Drive Studio software from Nanotec. The programming language used is NanoJ, which is close to C/C++.

Servomotor controller

Process analysis | Concept creation | Implementation | **Testing and optimisation**

Automated process with cobot IA 500

- carry out the automated process in which the complete tensile test is executed
- adaptation of paths and travel speeds
- check that the hydraulic systems clamp the tensile specimen and apply the tensile force to the specimen
- check the communication of all systems involved

Suggestion for tasks

Carry out a tensile test. Save your results. Download the created file from IA 500 and save it on a PC.

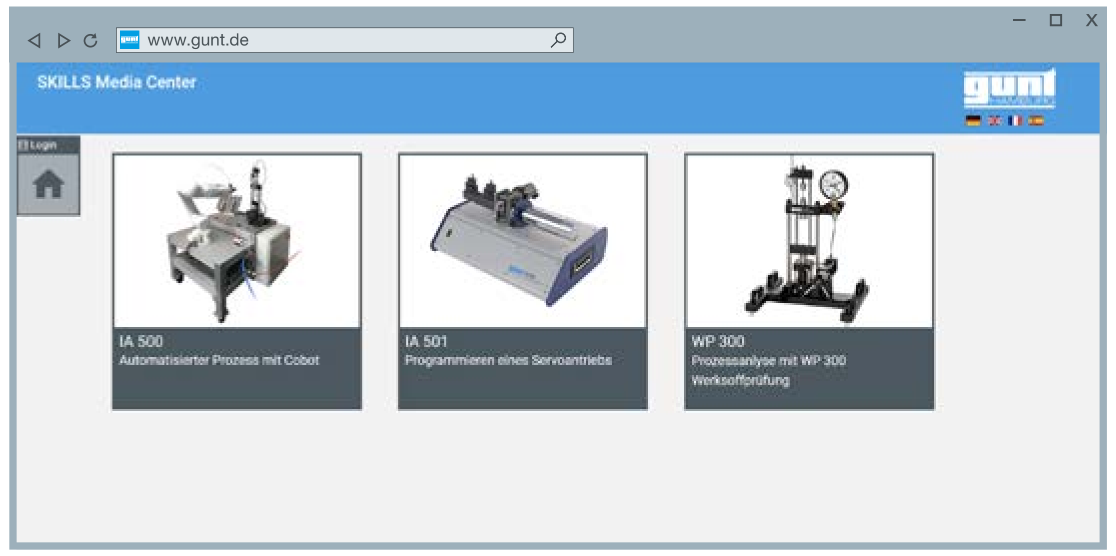
Open the file with a spreadsheet program (MS Excel, OpenOffice) and interpret the result.

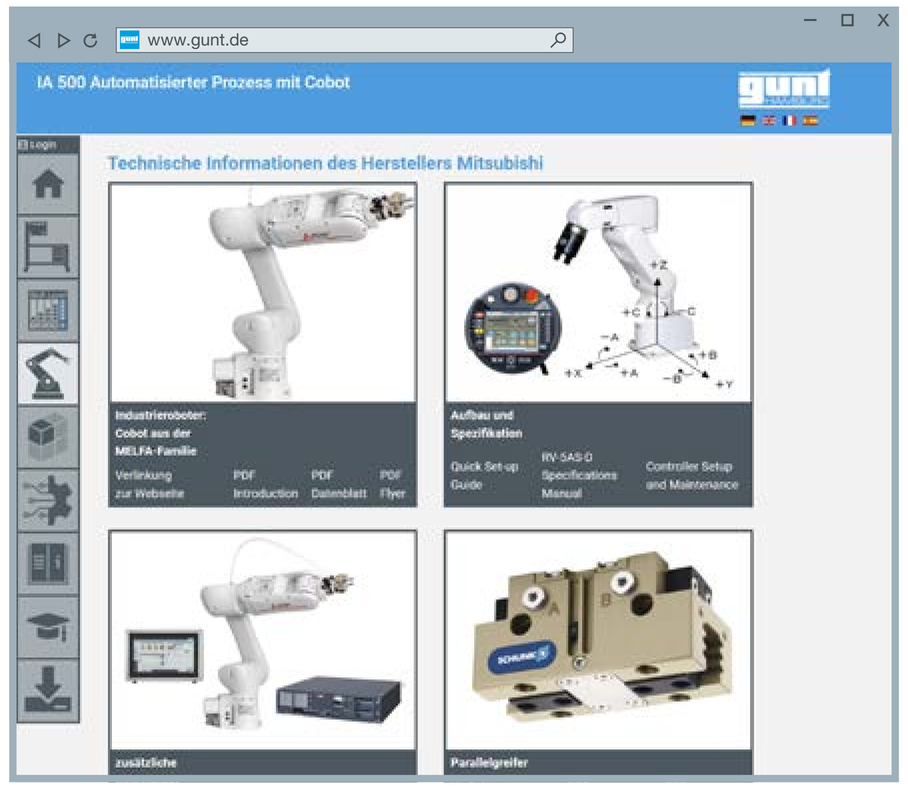
Plot a stress-strain diagram. Make a note of the material parameters in the table.

Watch the video

3 | GUNT Skills Media Center

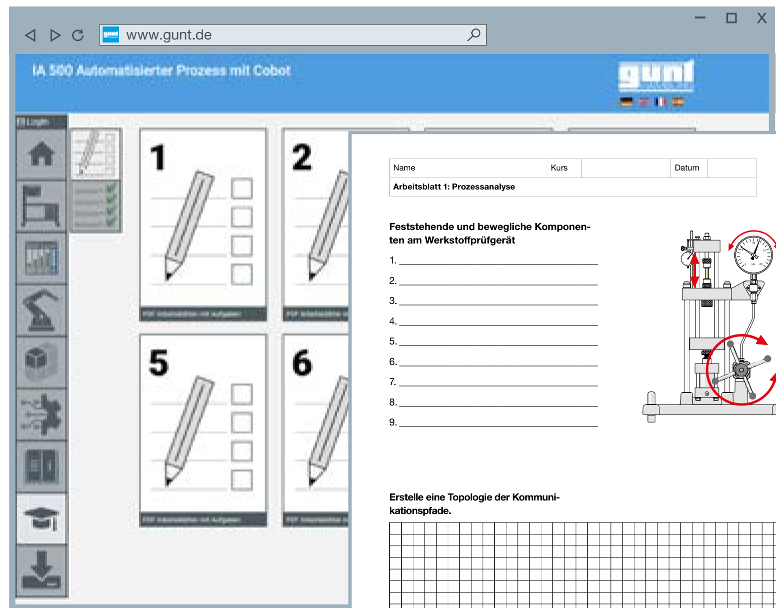
As a digital platform, the **GUNT Media Center** provides enormous added value and expands the use of the training systems.

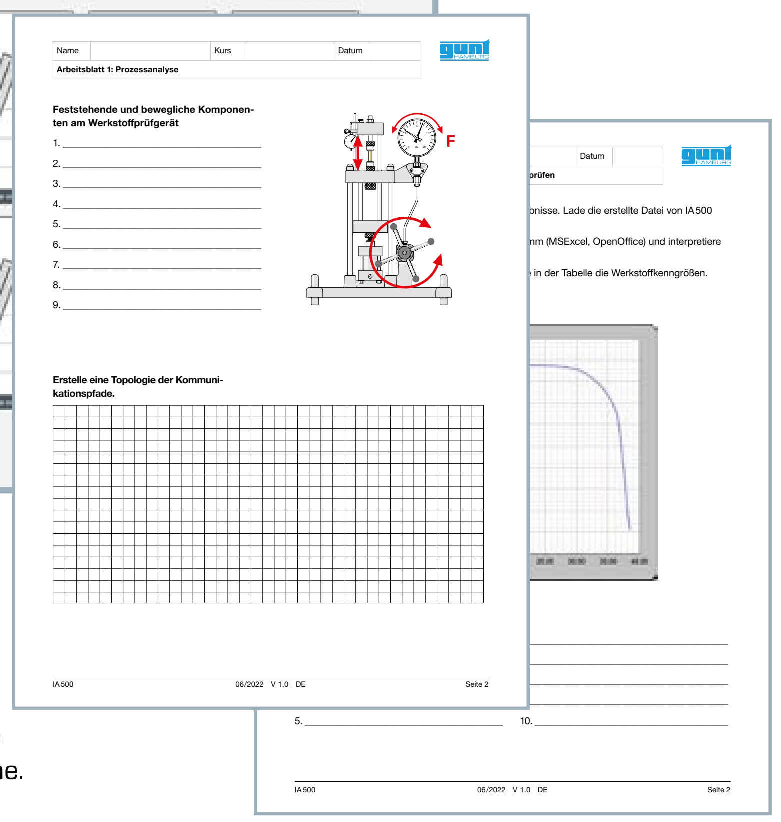




Digital materials for the IA 500, IA 501 and WP 300 devices

- electrical circuit diagrams
- worksheets and solutions
- user videos
- original documents from the component manufacturers





You can access extensive digital learning materials related to the entire DigiSkills 5 learning project. With quick and clear navigation, accessible at any time and for everyone.

4 | Didactics

4.1 | Didactic typology

Didactic level	Features
1 Problem solving: Process analysis	Creativity techniques, design thinking
2 System analysis: Concept creation	Analyse, understand and describe the overall system and subsystems. Find and evaluate solutions.
3 Concrete technical task: Implementation	Work on specific learning fields – achieve specific learning objectives
4 Skills: Testing and optimisation	Commissioning, fault finding and debugging. Optimise process flow

4.2 | Learning contents

General technical content

- application of existing knowledge of mechanics, hydraulics, pneumatics and electrics to analyse technical processes, define target states and design components
- develop, evaluate and match solution variants for system integration
- identify interfaces and develop solutions for interface communication
- interdisciplinary co-operation: mechanical engineering, electrics, mechatronics, robotics, automation
- use of digital technologies and tools

Professional training

- develop digital skills in professional training
- analyse and evaluate the current status of the subsystems
- analyse technical processes and define target status
- network systems using software to create a cyber-physical system
- analyse faults, fault finding, documentation
- knowledge of machines and systems

University studies

- learning project for an internship accompanying a lecture in the field of computer science, robotics and automation
- familiarisation with the basic structure and mode of operation of an industrial robot and learn how to operate it
- behaviour-based programming of simple autonomous robots, path planning for robots
- communication between robot and PLC
- apply knowledge of sequence controls, control engineering, sensors and actuators

5 | Overview of DigiSkills 5 devices

Each of the devices can be used individually. However, the interaction between **IA 500**, **IA 501** and **WP 300** – always in conjunction with the GUNT Media Center – makes the didactic concept highly effective.

… it doesn't have to be everything all at once

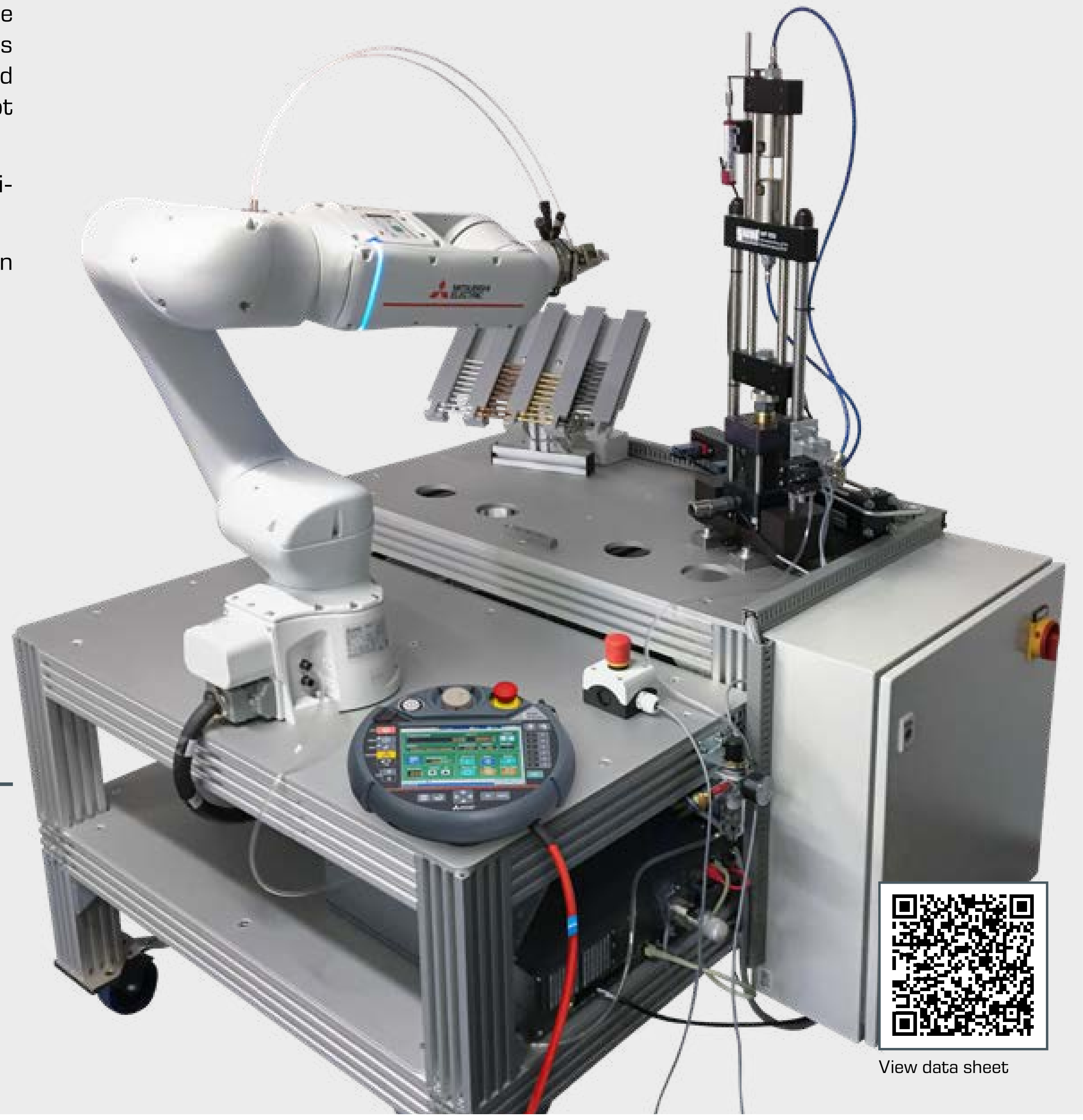
Interesting and meaningful tasks can be developed with each of our individual products

5.1 | IA 500 Automated process with cobot

The IA 500 device shows how a manual process – in this case a classic tensile test – can be automated. Work steps such as picking specimens, inserting the tensile specimen, removing and disposing of the fragments are carried out by a collaborative robot (cobot).

All work steps are triggered by the PLC and controlled and monitored using previously defined parameters.

The device is operated via a touch screen. The user interface can also be displayed on additional end devices (screen mirroring).



Learning objectives

- analyse process and identify potential for automation
- generate solutions using creativity techniques (e.g. 635 Method, mind mapping, morphological box)
- design hydraulic systems
- teach the cobot
- cobot programming, fault finding, program optimisation

View data sheet

5.2 | WP 300 Materials testing, 20 kN

The classic manual materials tester is the starting point for the GUNT DigiSkills 5 learning project. The materials tester is used to carry out a complete tensile test. The results are also displayed manually.

As a challenge and advanced task, the manual test sequence with all its work steps is automated.

Tensile specimens with circular cross-section according to DIN 50125, material: Al, Cu, St, CuZn

View data sheet

5.3 | IA 501 Programming a servo drive

The experimental unit is a stand-alone teaching system, independent of the IA 500 system, designed to develop an understanding of the technology of a servo drive. Programs can be safely developed and tested with this device. Manufacturer software for the motor is included. The manufacturer's Plug&Drive Studio software from Nanotec uses the NanoJ programming language, which is close to C/C++.

Learning objectives

- program the motor controller
- adjust control parameters
- test the software

View data sheet

Features

- supplement to IA 500
- develop and test programs
- includes functional program as a sample

Suggestion for tasks

- Commission the servomotor using the Plug & Drive Studio software. Define the parameters, use the manufacturer's specifications. Then test the settings with a short trial run.
- Parametrise the servo motor controller.
- Program a trial run. Use the GUNT software to check whether the selected values such as speed, acceleration and positioning accuracy are achieved with sufficient precision.

Summary of further DigiSkills learning projects

DigiSkills learning project no.	Subject area	Learning objective areas/ Features	Focus
1	Engineering drawing – Technical communication	 ■ fundamentals of engineering drawing ■ geometric models, functional models ■ Geometrical Product Specifications (GPS) ■ constructive thinking, machine elements, materials	Metalworking professions
2	Dimensional metrology	 ■ fundamentals of inspection technology: testing, measuring, gauging ■ familiarisation with measuring instruments ■ Geometrical Product Specifications (GPS) ■ surface marking, fit systems	Metalworking professions
3	Preventive maintenance	 ■ design and function of a sorting plant ■ predictive maintenance, condition monitoring ■ assembly and disassembly, functional testing, commissioning ■ machine elements, materials	Mechatronics, Metalworking and electrical professions
4	Energy efficiency in compressed air systems	 ■ design and function of a compressed air system ■ assembly and functional testing of compressed air generators ■ systematic optimisation of modern compressed air systems ■ representation of energy flows	Mechatronics, Metalworking and electrical professions
5	Robotics and automation	 ■ robot programming, process automation ■ mechanics, hydraulics, pneumatics, electrics ■ control system, PLC ■ sensors and actuators ■ system integration ■ process integration	Mechatronics, Metalworking and electrical professions

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