

## SE 200 | MEC Line Engineering mechanics



## Didactic concept for experiments in statics and strength of materials

- smart, communication-enabled components
- wireless digital connection



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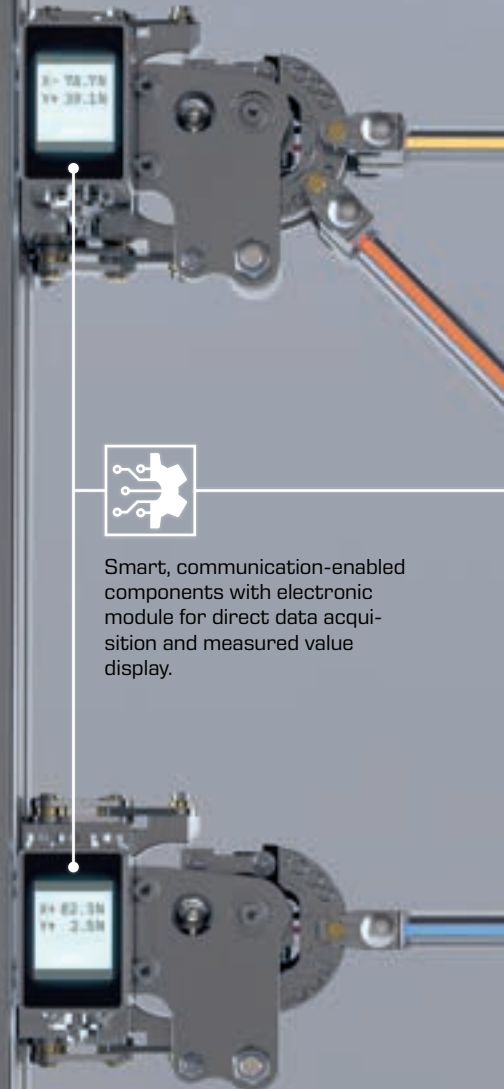
Custom GUNT software with content adapted to the individual experiments enables real-time display and analysis.



The GUNT Science Media Center provides technical descriptions, manuals, exercises, videos and E-Learning courses with fundamental knowledge, theory and calculations for all experiments.

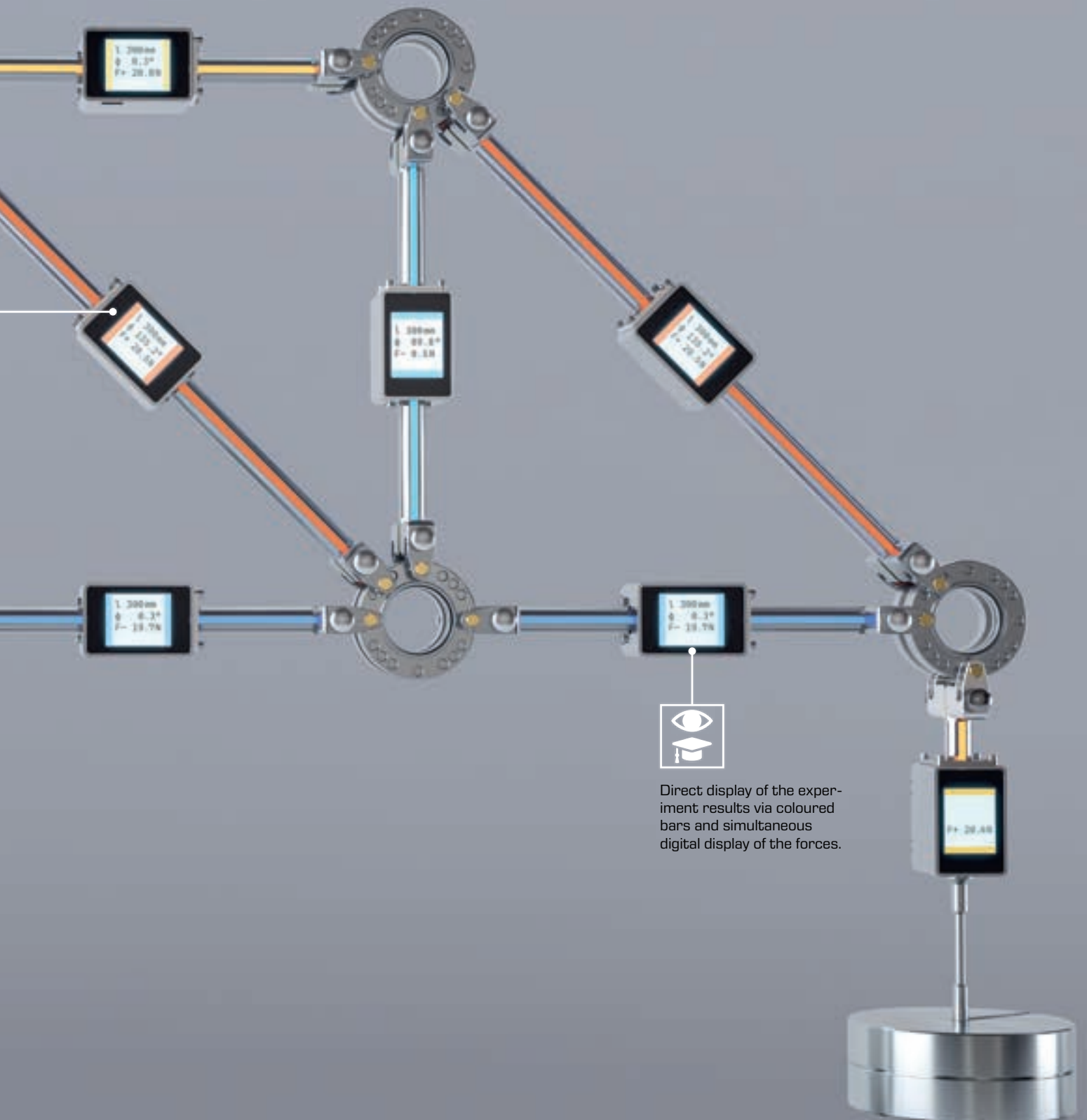


Smart, communication-enabled components with electronic module for direct data acquisition and measured value display.



Precise and resilient frame structure. The click system enables a simple, quick experimental setup without cabling.





# Didactics and methodology

Experiments using all the senses – for an in-depth learning experience

**Develop the fundamentals of engineering mechanics according to textbook and curriculum in experiments**

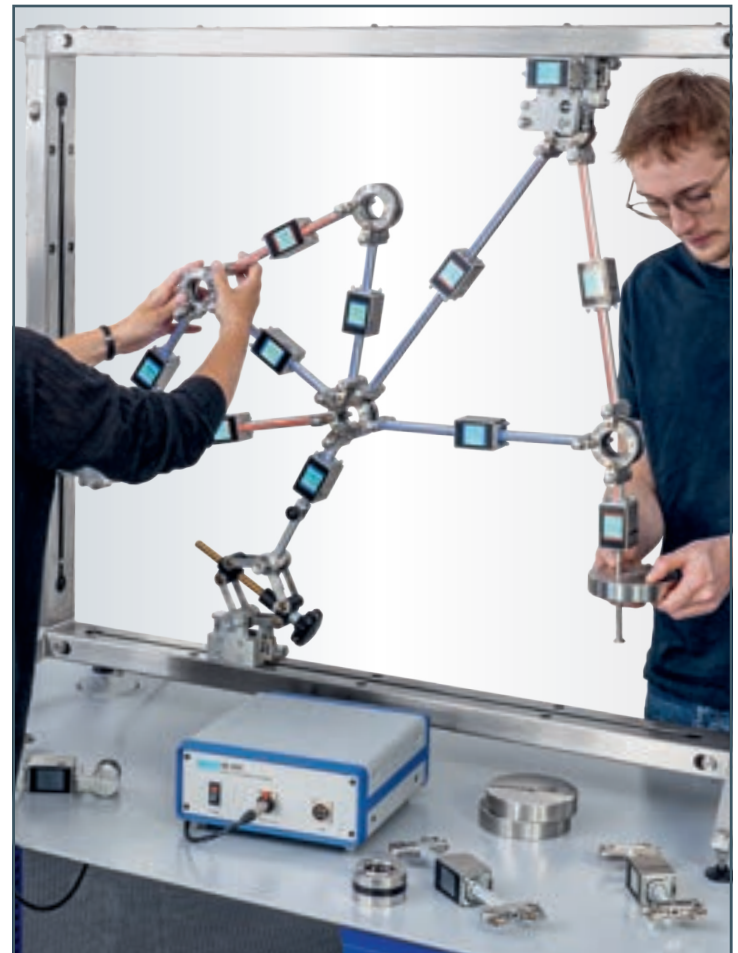
## What

- static systems in equilibrium of forces
- trusses: internal reaction and support reaction under external loads
- elastic reactions under external loads
- analysis of typical elements from civil engineering: beams, bridges
- familiarisation with stability problems



## Haptic experience

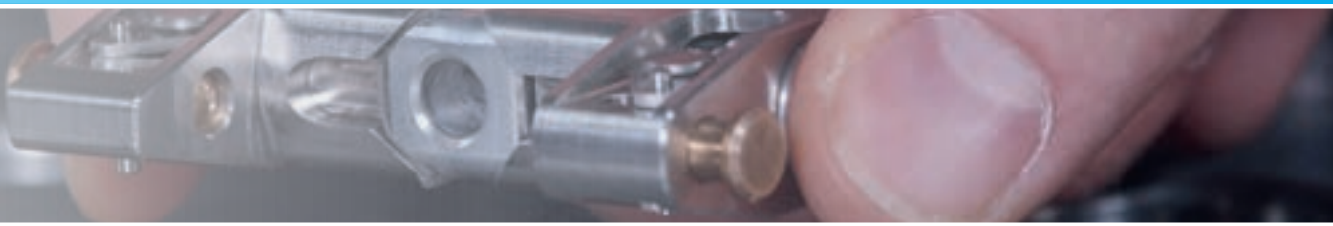
- promotes the comprehension and internalisation of learning content through the sense of touch
- manual work and skill in setting up experiments
- no disruptive cabling of the individual elements
- sturdy components with click system, quick and easy to assemble



## Experimental learning

- promotes self-directed learning and effective teamwork
- accessories of the series can be combined in a modular way for setup and extension of the experiments
- possibility to create your own experiments with many variations

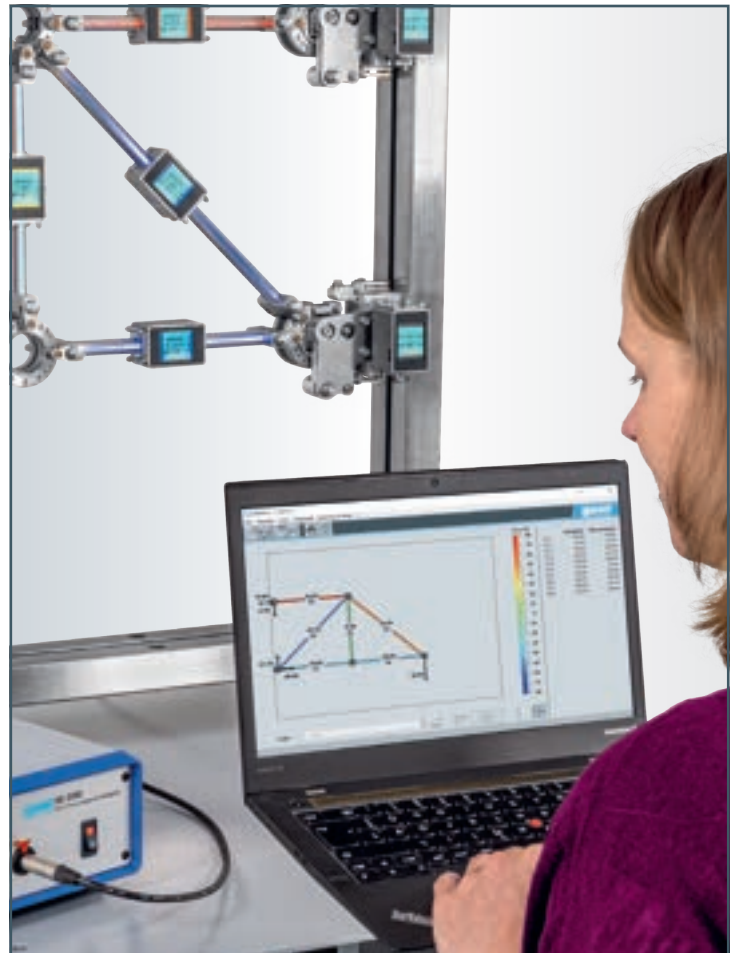




## Familiarisation with digital concepts and methods of measurement technology and data processing simultaneously

### How

- implement theoretical teaching topics in experiments by planning series of experiments and setting up your own experiments
- technically realise terms such as fixation or articulated support
- coloured display of forces, display of the loading as well as automatic topology transmission for direct feedback
- microprocessor-based measurement technology for force and angle, distance, position and identification
- application of Gray codes (reflected binary, RB)
- integration of FEM models, strength verification, etc.



## Visual comprehension

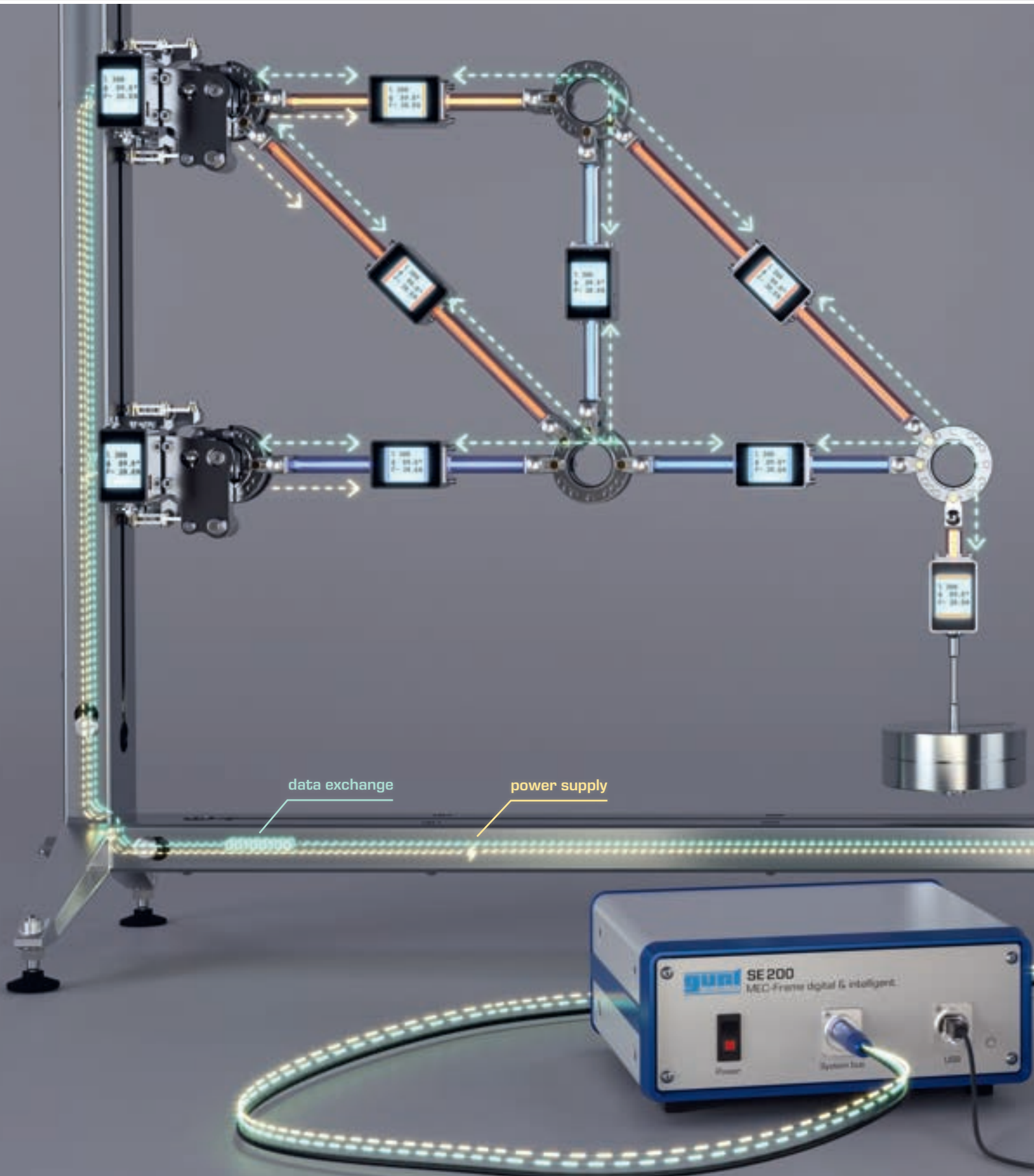
- promotes abstraction skills
- visual representation of experimental processes that are otherwise invisible and can only be understood through calculation






## Logical thinking

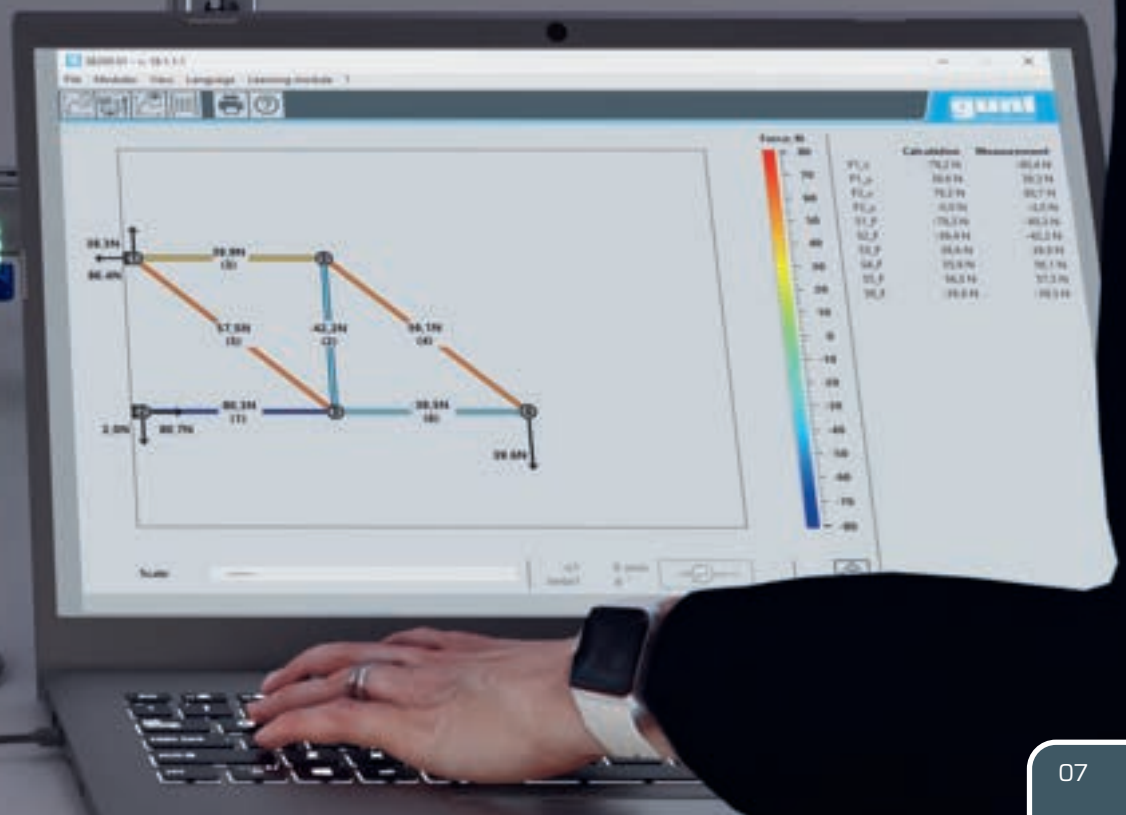
- promotes the recognition of interrelationships through the transmission of topology
- analysis of measurement results and estimation of errors



## Smart data flow – wireless information and power supply



-  tensile load
-  compressive load
-  neutral
-  data exchange
-  power supply







## Structure of the MEC Line

Full experimental setups are created from the mounting frame and the components for experiments, setup and measurement technology. The experiments are accompanied by software for real-time visualisation, measurement data acquisition and analysis.

### MEC – Frame: digital & smart

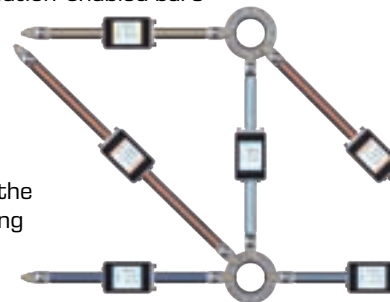
Mounting frame to hold smart, communication-enabled components with a master module for digital connection and measurement data acquisition



### Components for experiments in statics and strength of materials as accessories

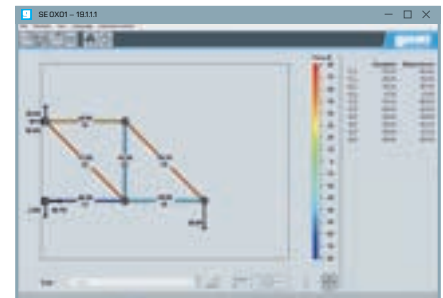
- smart, communication-enabled bars with electronic module
- bridge components and beams
- pulley blocks, etc.

All components for the experiments including GUNT software



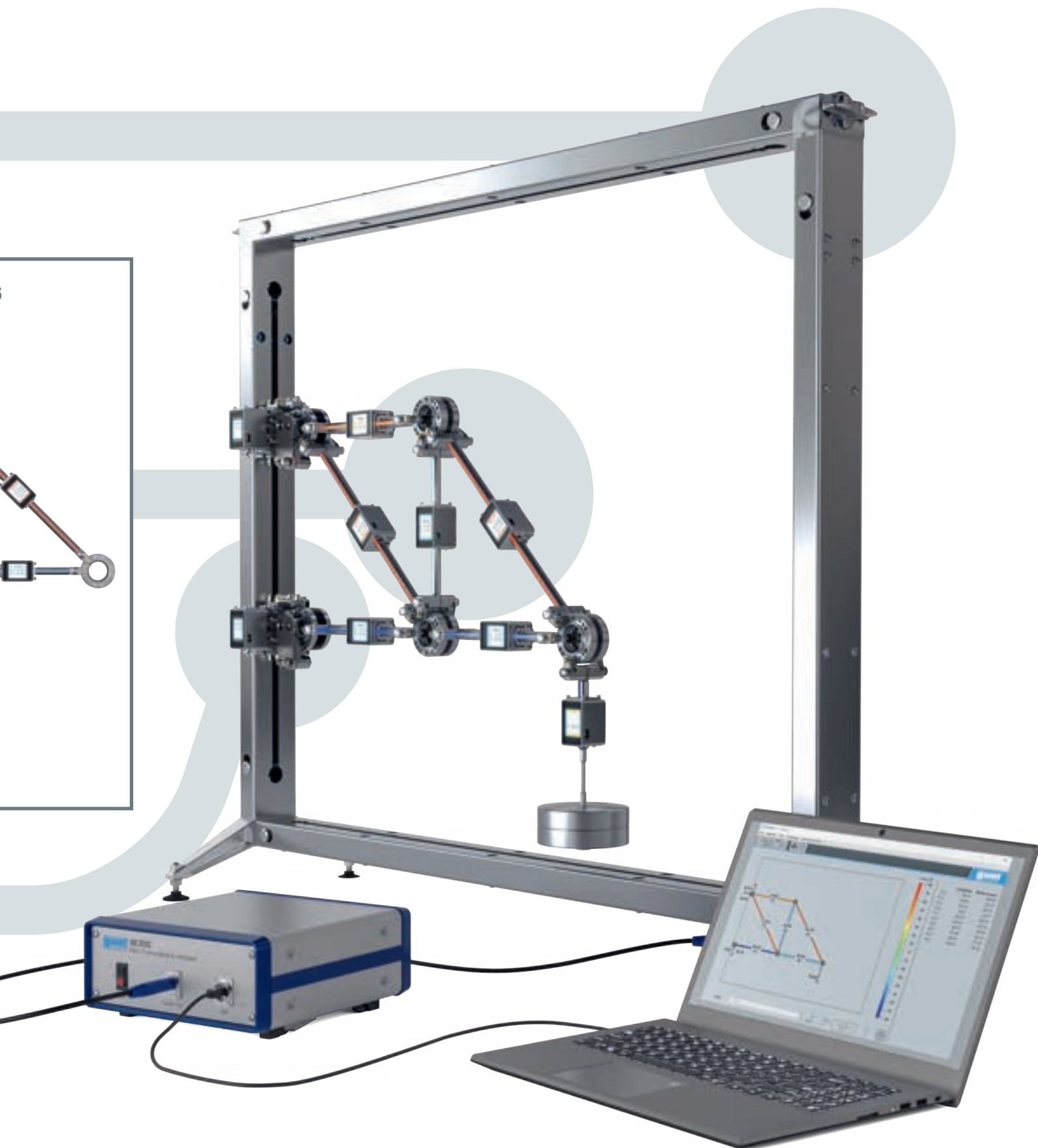
### Components for the setup and measurement technology as accessories

Smart, communication-enabled loads, supports, distance measurement etc. equipped with an electronic module for data acquisition and measured value display



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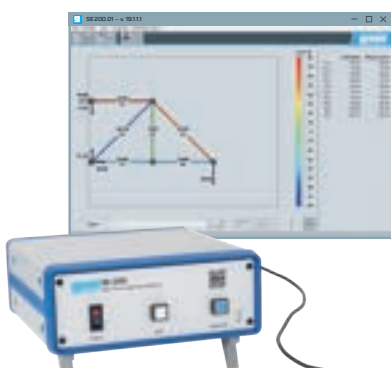
# Smart, communication-enabled components for the setup and measurement technology

## Components for the setup



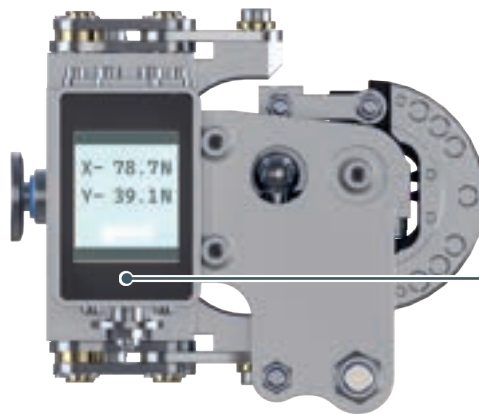
### Mounting frame

- base element for setting up versatile experiments
- click system for easy setup and reconfiguration, no tools required
- stainless steel hollow sections with integrated electrical cable
- defined snap-in points for exact topology determination and transmission



### Master module and software

- master module detects all data from the electronic modules and transmits it to the GUNT software via USB
- automatic identification of the smart, communication-enabled components including position and alignment
- master module connected via Plug&Play and only 1 power BUS line



### Support

- fixed support for connecting smart, communication-enabled components via click system
- horizontal or vertical installation at different positions in the mounting frame
- automatic detection of the installation position and dynamic adjustment in the GUNT software

### Electronic module

- equipped with planar beam load cells for direct force measurement in x, y direction
- integrated acceleration sensor for angle measurement for correct display of the geometry



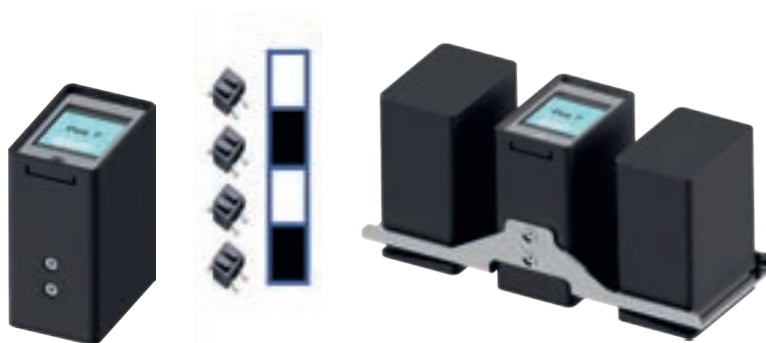
### Bar

- tool-free setup and reconfiguration of various trusses without cabling
- force displayed as a measured value and as coloured illumination directly on the bar
- bars with articulated connection to node disks; loading only on compression or tension

### Electronic module

- equipped with planar beam load cell for direct force measurement in the x direction
- communication in both bar directions to determine topology
- integrated acceleration sensor for angle measurement for correct display of the geometry

## Components for measurement technology



### Load

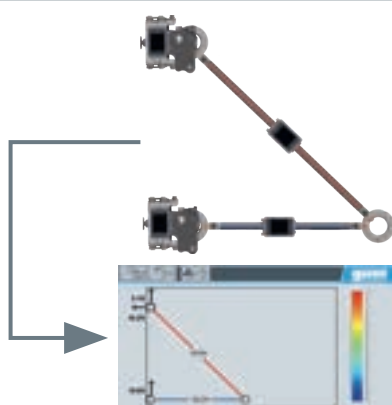
- generation of weight forces through concentrated load
- generation of line loads by combining several load elements
- **electronic module** with Gray code reader for position detection and transmission to the GUNT software

### Line load



### Vertical load

- various weights included in delivery
- visual representation of the force as coloured illumination
- **electronic module** contains Planar Beam load cell for direct force measurement; transfer of position using topology



### Topology

- real-time transmission of the topology to the geometry display in the GUNT software
- exact visualisation of the experiments during setup
- special algorithm for topology transmission, developed by GUNT



### Distance measurement

- articulated arm with long reach
- **electronic module** contains linear potentiometer for detecting paths and an acceleration sensor for detecting the measuring direction

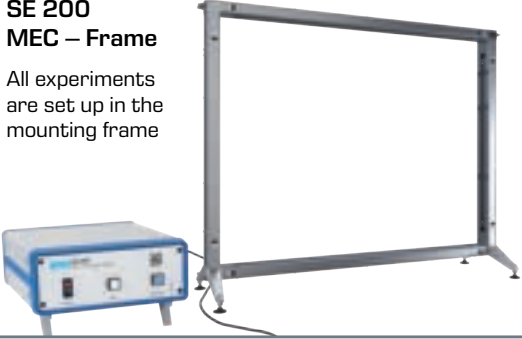
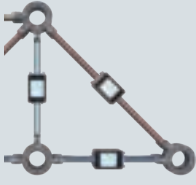
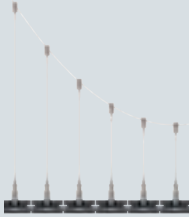


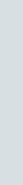


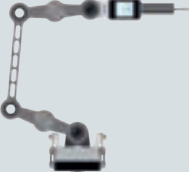






### Load unit

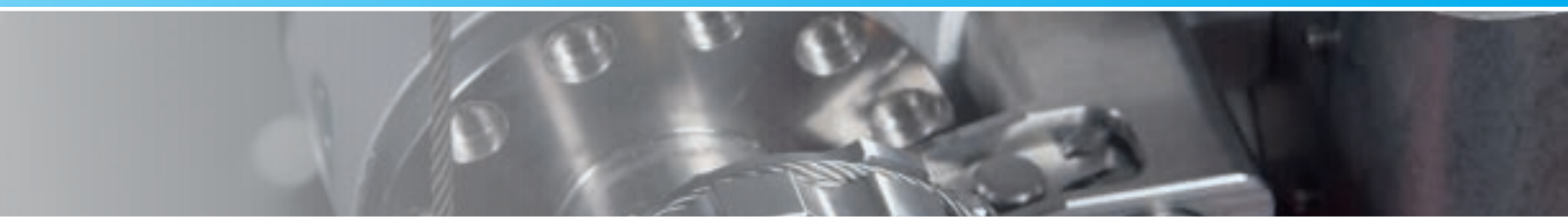
- stepless generation of tensile and compressive forces in any direction
- visual representation of force
- **electronic module** contains Planar Beam load cell for direct force measurement and an acceleration sensor to detect the measuring direction





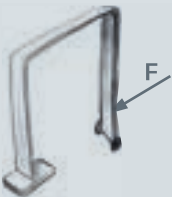
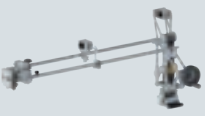



## Accessories

<b>SE 200 MEC – Frame</b> All experiments are set up in the mounting frame 	<b>SE 200.01 Forces in trusses</b> 	<b>SE 200.02 Forces on a sus- pension bridge</b> 	<b>SE 200.03 Parabolic arch bridge</b> 	<b>SE 200.04 Friction on the inclined plane</b> 	<b>SE 200.05 Forces on a beam</b> 
<b>SE 200.21 Support</b> 	2	2	2	—	—
<b>SE 200.22 Load unit</b> 	max. 2	—	—	—	—
<b>SE 200.23 Distance measurement</b> 	max. 1	—	2	—	—
<b>SE 200.24 Vertical load</b> 	min. 1 max. 2	—	max. 1	—	—
<b>SE 200.25 Load (Set of 5)</b> 	—	1	1	—	—
<b>SE 200.26 Distributed load (Set of 3)</b> 	—	max. 1	max. 1	—	—
<b>SE 200.27 Bar set</b> 	any quantity	—	—	—	—





SE 200.05 Cable forces and pulley blocks 	SE 200.06 Three-hinged arch 	SE 200.07 Gerber beam 	SE 200.08 Buckling 	SE 200.09 Deformation of frames 	SE 200.10 Torsion of bars 	SE 200.11 Elastic line of beams 
min. 1 max. 2	2	2	—	2	—	2
—	—	—	1	1	—	1
—	—	—	min. 1 max. 2	min. 1 max. 2	—	min. 1 max. 2
min. 1 max. 2	1	max. 1	—	1	—	max. 1
—	1	1	—	—	—	—
—	max. 1	max. 1	—	—	—	—
—	—	—	—	—	—	—



## SE 200.01 MEC – Forces in trusses

- smart, communication-enabled bars with electronic modules for data acquisition and measured value display
- setup of various trusses without cabling
- automatic identification and assignment of the bars in the GUNT software
- measured values and coloured display of the force directly on the bar
- calculated displacement of the truss can be magnified in the software



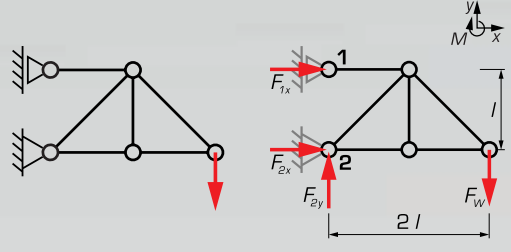
### Learning objectives

- measurement of the bar forces in a statically determinate and statically indeterminate plane truss
- dependence of bar forces on the external force
- comparison of measurement results with mathematical solution methods
- basic principle: using strain gauge technology to measure forces

## Exercises

- 1 Setup of any truss with at least 6 bars and 1 load
  - exact recording of the geometry with real-time transmission to the GUNT software
  - measured values displayed directly on the bar, can be hidden if required

- 2 Calculation of external forces: loading by load, reaction of the supports



$$\sum F_x = F_{1x} + F_{2x} = 0$$

$$\sum F_y = F_{2y} + F_w = 0$$

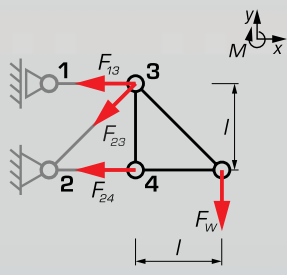
$$\sum M_2 = F_{1x} \cdot l + F_w \cdot 2 \cdot l = 0$$

Simplified sketch for the constructed truss

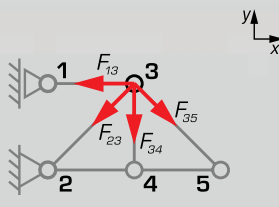
Freeing the support forces

Setting up the equilibrium conditions

- 3 Calculation of internal forces: select and apply method of joints or Ritter's method of sections

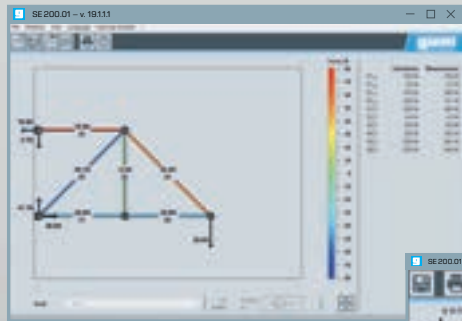



Ritter's method of sections: freeing the bar forces at nodes 3 and 4

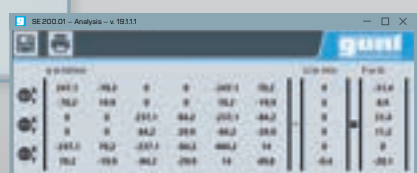


Method of joints: freeing the bar forces at node 3

- 4 Checking the calculation: comparison of results with measured values and results in the GUNT software

Forces displayed in colour and measured values displayed in matrix form





# SE 200.02 MEC – Forces on a suspension bridge

## Exercises

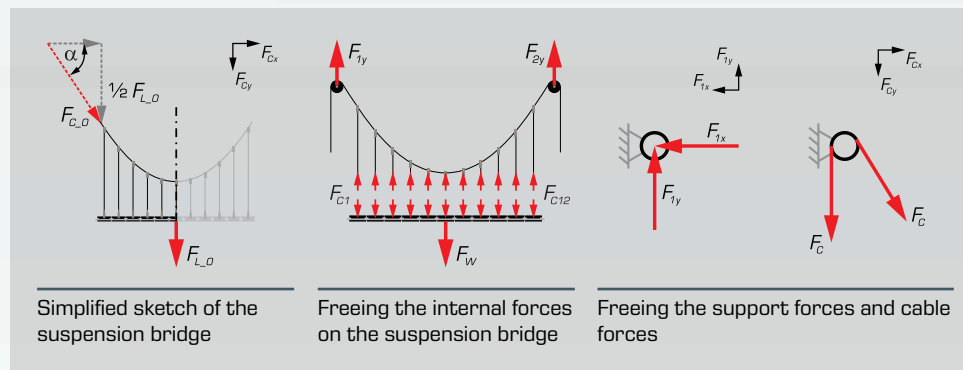
1

Setup of a suspension bridge with rigid roadway and no additional loading

- exact recording of the geometry with real-time transmission to the GUNT software
- measured values displayed directly on the supports, can be hidden if required software

2

Calculation of external and internal forces without additional loading



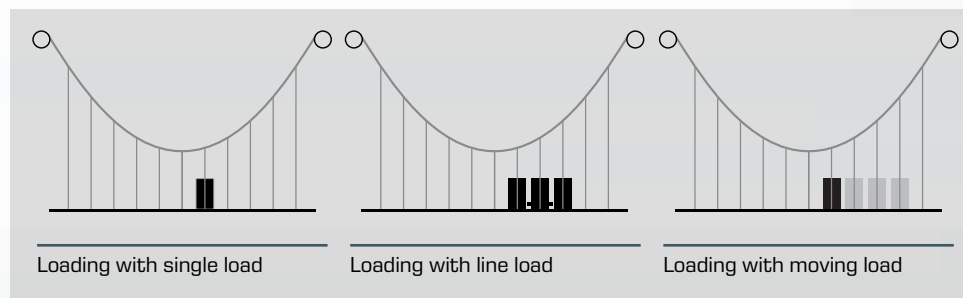
Simplified sketch of the suspension bridge

Freeing the internal forces on the suspension bridge

Freeing the support forces and cable forces

3

Calculation of external and internal forces with additional loading by single load, line load or moving load



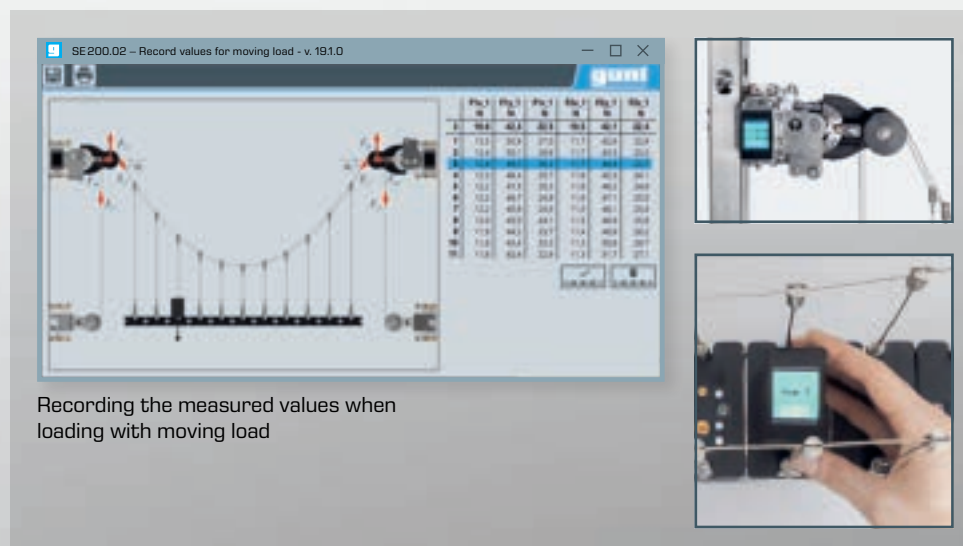
Loading with single load

Loading with line load

Loading with moving load

4

Checking the calculation: comparison of results with measured values at load/supports and the results from the GUNT software



Recording the measured values when loading with moving load



- setup of a suspension bridge together with smart, communication-enabled accessories
- experiments with rigid or flexible roadway
- automatic identification and assignment of the loads in the GUNT software



#### Learning objectives

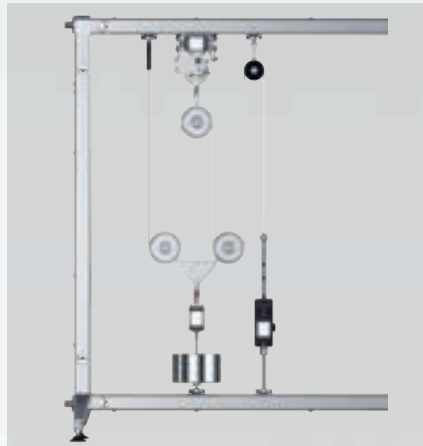
- measurement of suspension cables forces on
  - unloaded suspension bridge
  - loaded suspension bridge
- measurement of the support forces as a function of the loading on the suspension bridge
- behaviour of a suspension bridge with rigid or flexible roadway
- investigation of line loads
- effect of a moving load

# SE 200.05 MEC – Cable forces and pulley blocks

## Exercises

1 Setup of a four-cable pulley block with at least one loose and one fixed pulley

- exact recording of the geometry with real-time transmission to the GUNT software
- measured values displayed directly on the suspension cables, can be hidden if required



- smart, communication-enabled suspension cables with electronic modules for data acquisition and measured value display
- investigate 2 different pulley blocks at the same time
- 2 setup variants possible per pulley block
- automatic identification and assignment of the pulley blocks in the GUNT software

2 Calculation of cable forces and support forces

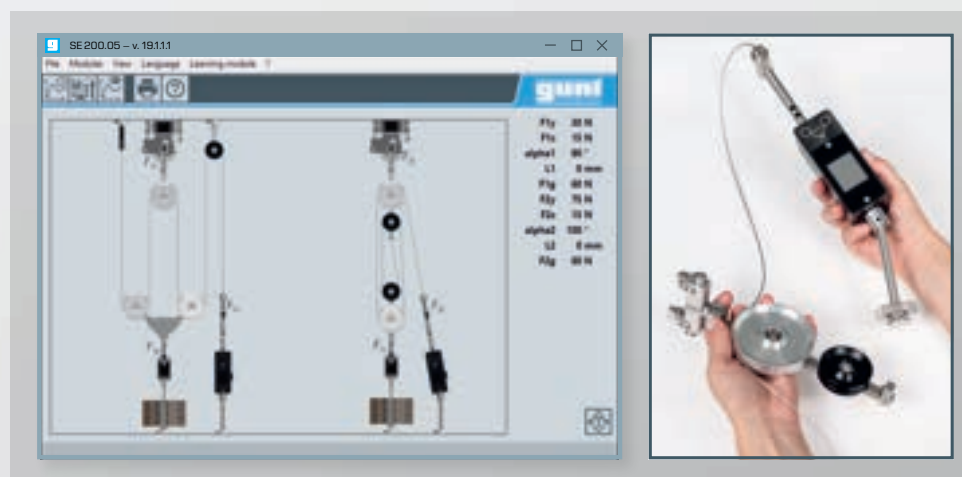
Equilibrium of forces:  
 $\sum F_y = 0 = 4 \cdot F_C - F_L$   
 Cable force:  
 $F_C = \frac{F_L}{4}$   
 Setting the equilibrium condition and calculation of cable force

Freeing the load to determine the cable forces

Equilibrium of forces:  
 $\sum F_y = 0 = F_B - 2 \cdot F_C$   
 Support force:  
 $F_B = \frac{F_C}{2}$   
 Setting the equilibrium condition and calculation of support force

Freeing the support forces

3 Checking the calculation: comparison of results with the measured values on suspension cable/supports and the results from the GUNT software





### Learning objectives

- familiarisation with different pulley blocks
- measurement of
  - ▶ cable forces
  - ▶ support forces
- angular dependence of forces
- force measurement under different loads



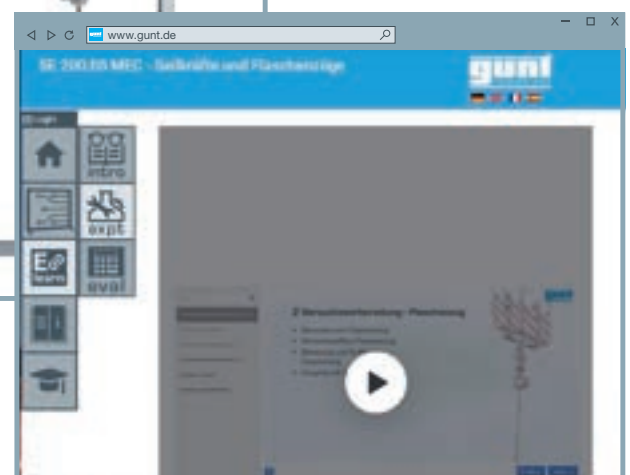


# GUNT Science Media Center



The GUNT Science Media Center provides extensive multimedia teaching material for all experiments.

Customers can access files and product information for selected products at any time and from any place. In addition to digital worksheets and the manual, access to E-Learning is also included.

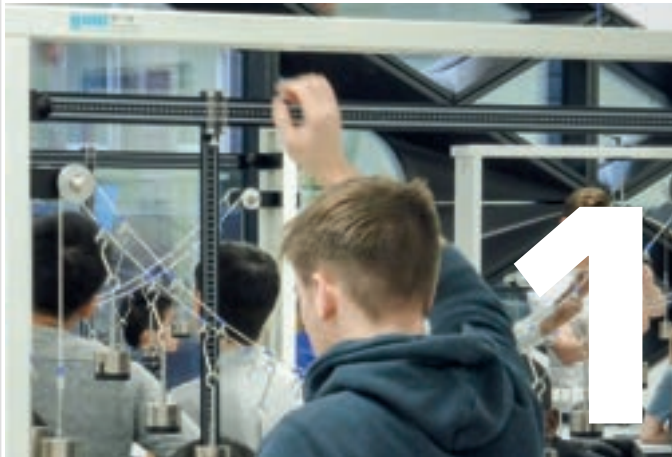








# Our product programme



1

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2

**Mechatronics**



4

**Fluid mechanics**



5

**Process engineering**



## Thermal engineering



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