MODEL 4

Distance measurer

Measuring and surveying

KEY QUESTIONS:

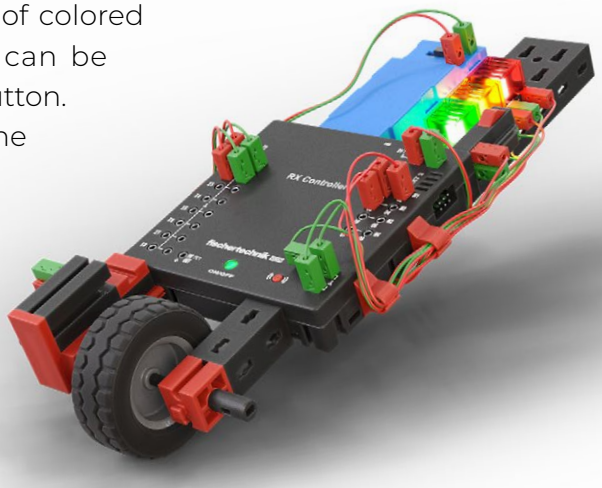
- **What are everyday life examples for the use of rangefinders? *(Communication)***
- **How or with what simple technical means can a route be recorded? *(Communication)***
- **What problems can occur during use? *(Critical thinking)***
- **How must the distance measurer be designed with regard to the housing and the associated programming (distance to the measuring device) in order to record exact measuring points? *(Creativity and collaboration)***

THE TEACHING CONCEPT AT A GLANCE

Grade level:	5–7
Time required:	2–4 double lessons
Degree of difficulty:	Model Programming up to
Model type:	mobile device for rangefinder for near and far targets

MODEL DESCRIPTION / TASK

The students plan and realize a portable rangefinder. The device can be used for short and medium distances. The measured distance of the device is displayed via three colored LEDs in the form of colored pulses (units, tens, and hundreds). The information can be displayed again after the counting process via another button. The user adds the displayed values to a total distance. The device resets itself when a new measurement is taken. A simple redesign or reprogramming can also record shorter or longer distances.



As a challenging differentiation task, the students can work on reading in, temporarily storing, and redisplaying the measurement results activated by pressing a button.

EVERYDAY RELEVANCE

Recording and outputting distances is not an unfamiliar topic for the students, unlike counting with a pulse generator (this is usually familiar from a bicycle speedometer). The effect of the pulse generator can also be observed in toys for small children (e.g., a wobbling duck).

The topic is a good basis for preprofessional orientation in the field of coding. This is increasingly important in many modern (technical) professions.

SUBJECT REFERENCE

- **Information technology:** Programming basics, time loops
- **Physics:** Route, distances
- **Technology:** Construction technology, gear theory
- **Mathematics:** Conversion factors, conversion of numbers from different number systems

LESSON PLAN

Introductory phase		
	Classroom discussion	• Inquire about scenarios in which distance measurement is required. • Work out the precision of distance measurements (1 m, 10 m, 100 m [3.28 ft, 32.8 ft, 328 ft]) • Develop various possible sensors that can be used to detect distances (e.g., in everyday appliances). • Presentation of the task. • Work out the gear ratio required for the supplied wheel. For this purpose, the rolling circumference of the wheel is recorded and the pulse frequency of the clock generator is explained.
	Support, if necessary	• Show sensors, actuators, and components (wheel for measuring circumference) from the assembly kit, use presentation media if necessary.
Planning Phase		
	Classroom discussion	• The teacher specifies the procedure using the work steps in the app.
	Partner or individual work	• The students familiarize themselves with the app and download the corresponding task. • Students work on a task to set up the system and calculate the distance meter.

	Optional: Partner or group work	• The students sketch a possible system. • The students discuss the results and agree on a design.
Construction Phase		
	Partner or individual work	• The students use the app to build the rangefinder. The app guides them through the program in short steps.
Programming Phase		
	Partner or group work	• The students write the program for the range finder. The app guides them through the program in short steps. • The app offers assistance. • The program is transferred to the RX controller.
Experimentation and Test Phase		
	Partner or group work	• The rangefinder is put into operation and tested. • Possible malfunctions in the functional sequence must be found and eliminated. The app offers assistance. • Any optimizations to the hardware and the programming of the sensor sensitivity are carried out.
Final Phase		
	Optional: Presentation and allocation of differentia-tions	• The app offers a differentiation option for fast learners: - **Differentiation 1:** The counting wheel can be marked so that the start position can be recognized. The LEDs can also be labeled (adhesive labels). This makes it easier to read the units. Relevant material must be provided. - **Differentiation 2:** The system can be programmed so that the shortest distance is reduced to 2 cm (halved) by tapping the edge change from positive to negative edge. - **Differentiation 3:** The system can be designed with a gearbox extension so that even greater distances (e.g., 2.1 km [1.3 mi]) can be determined. - **Differentiation 4:** The system can describe and show the previously saved measurement results with the three LEDs at the touch of a button. • The additional procedure is realized via the app.
	Discussion in plenary	• Project debriefing in class. • The strengths and weaknesses of the individual group solutions or distance measuring meters for short or long distances are recognized and discussed.

METHODOLOGICAL AND INSTRUCTIVE TIPS

Instructive tip

Due to the complexity of the model, it is recommended that the distance measurer is only introduced and processed at the end of the respective learning unit. The programming skills required are quite complex, and the programming-based knowledge (see Programming Skills) should already have been learned and applied in other models. For this reason, step-by-step-programming instructions are not included in the student section.

The primary calculation of the measurement factors and the subsequent conversion of numbers from different number systems are relatively challenging for the students. This is why the student section focuses on the necessary conversions and pulse/edge control.

Differentiations

- The LEDs can have markings on labels for easier readability of the units. The starting position on the wheel can also be marked with a colored marker.
- If required, shorter or longer distances can be measured by changing the programming or hardware.
- The measurement results can be temporarily stored in a variable. Using a conversion algorithm, the measured values can then be recoded into multiples of 2, 10 and 100 by surveying the measured value and displayed by an LED after pressing the second button. This program is very complex due to the recoding, divisions with remainder, use of counting variables, and the necessary call up of a subprogram. It should only be given to advanced students as a differentiation task.

Competition

- The distance measurer with the greatest measuring accuracy should be determined in a practical application under competitiveconditions.
- Various measurements of known and standardized distances, e.g., 400-m race track [437.4 yards] on the sports field, can be carried out.

Motivational Aspects

Students are highly motivated by the acquisition of analog data, its conversion into digital data, and the output of the results. Converting one size into another presents a certain challenge. The subject provides a good basis for coding, which is becoming increasingly important in many professions.

PROGRAMMING SKILLS

- Program start
- Continuous loop
- Integration of sensors
- Integration of actuators
- Loop **if – then**
- Loop **repeat until**
- Loop **repeat – x times**
- Loop **wait**
- Integration of variables
- Manipulation of variables (addition, multiplication, division [also with remainder])
- Call up subprograms
- Output of results

ADDITIONAL MATERIALS

Optional download:
- Circuit diagram
- Building instructions

If necessary, use realia to introduce the topic:
- Visual aids in the form of simple rollers or wheels to show the distance covered in one rotation.
- If necessary, various commercially available rangefinders that can be triggered manually, e.g., bicycle speedometer with Hall sensor.
- Optional: Drawing media (paper, whiteboard, or projection screen).

FUNCTIONS OF THE MODEL AND THEIR TECHNICAL SOLUTIONS

Function of the distance measurer	Technical solution
Start of the measuring process	Traveling the distance to be measured
Recording a route/path	Pulse generator on the counter wheel outputs data
Output of the recorded distance of “4 cm” [1.57 in]	Color output of the green LED
Output of the recorded distance of “16 cm” [6.3 in]	Color output of the yellow LED
Output of the recorded distance of “64 cm” [25.2 in]	Color output of the red LED
Output result	LED output by pressing the button
New measurement	Restart the system

MATERIAL LIST

Sensors	Function
1 wheel on a shaft	Recording the distance
1 button	Pulse counter
Differentiation 4: 1 button	Intermediate storage and later retrieval of the measurement results by 2nd button

Actuators	Function
1 LED, green	Output for units of 2^2, e.g., 4 cm [1.57 in] or multiples thereof **Differentiation 2:** Units of 2, e.g., 2 cm or multiples thereof **Differentiation 3:** Display of the measurement result for multiples of 2 cm
1 LED, yellow	Output for units of 2^4, e.g., 16 cm [6.3 in] or multiples thereof **Differentiation 2:** Units of 10, e.g. 10 cm [3.9 in] or multiples thereof **Differentiation 3:** Display of the measurement result for multiples of 10 cm [3.9 in]
1 LED, red	Output for units of 2^6, e.g., 64 cm [25.2 in] or multiples thereof **Differentiation 2:** Units of 100, e.g., 100 cm [39.4 in] or multiples **Differentiation 3:** Display of the measurement result for multiples of 100 cm [39.4 in]
Differentiation 3: Gearbox on the shaft	Extension of the possible measurement paths/measurement results