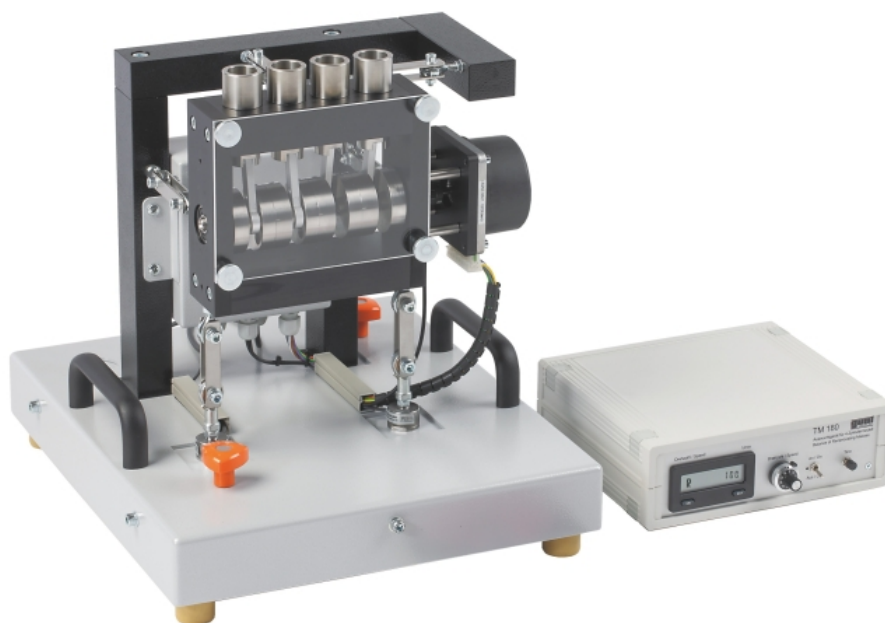


# TM 180

## Forces in reciprocating engines



### Description

- investigation of free mass forces and moments of a reciprocating engine
- continuous adjustment of the angle between cranks
- simulation of single, two- or four-cylinder engines

Every reciprocating engine generates mass forces. The mass forces of the oscillating masses cannot be compensated completely, while the mass forces of the rotating masses are fully compensated. By using several cylinders it is possible that the forces compensate each other. However, disturbing moments may still occur.

The experimental unit TM 180 enables investigation of the free masses and moments of a reciprocating engine with a single cylinder, with two cylinders or with four cylinders.

The engine model comprises pistons with plastic slide bushes. The slide bushes do not require lubrication. For each cylinder, the angle between cranks can be adjusted continuously. As an aid, marks are provided at 0°, 90°, 180° and 270°.

The oscillating masses can be varied by using additional weights at the pistons. The four-throw crankshaft is directly driven by a DC motor via a claw coupling. The speed is electronically controlled and digitally displayed. The free forces and moments are recorded by force sensors placed at the support of the model. All electronic functions are integrated in the display and control unit. The display and control unit also contains the USB interface for data acquisition.

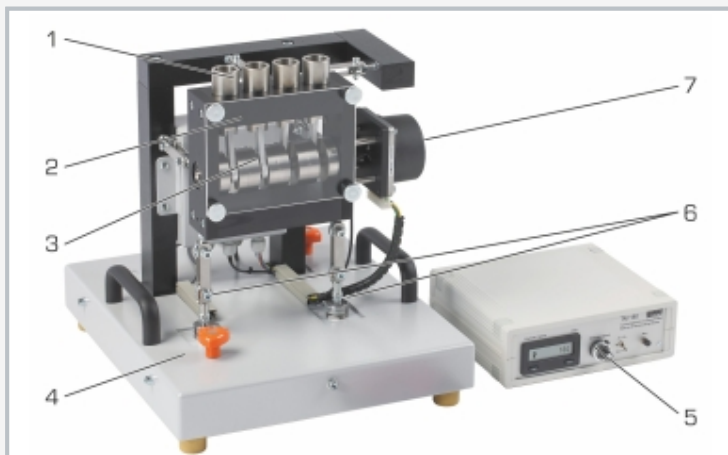
The GUNT software enables the detailed evaluation of the signals of forces and moments.

### Learning objectives/experiments

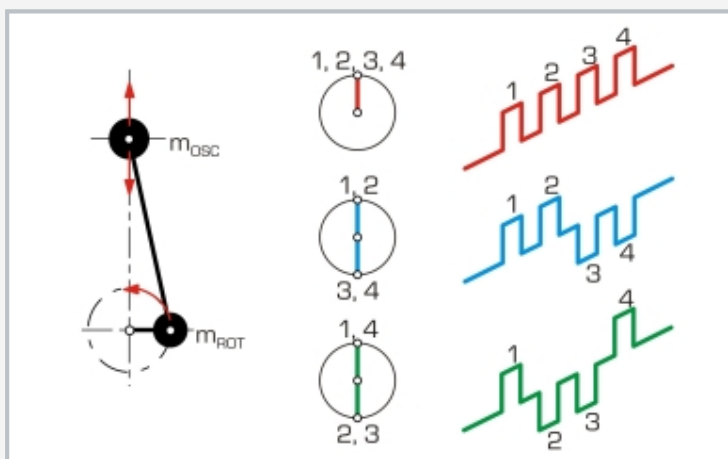
- effect of mass forces
  - ▶ mass forces in dependence on the speed
  - ▶ mass forces in dependence on the piston mass
  - ▶ first and second order mass forces
- comparison of different crank drives
  - ▶ 4-cylinder, symmetrical, 180° angle between cranks
  - ▶ 4-cylinder, non-symmetrical, 90° angle between cranks
  - ▶ 2-cylinder, 180° angle between cranks
  - ▶ single cylinder

# TM 180

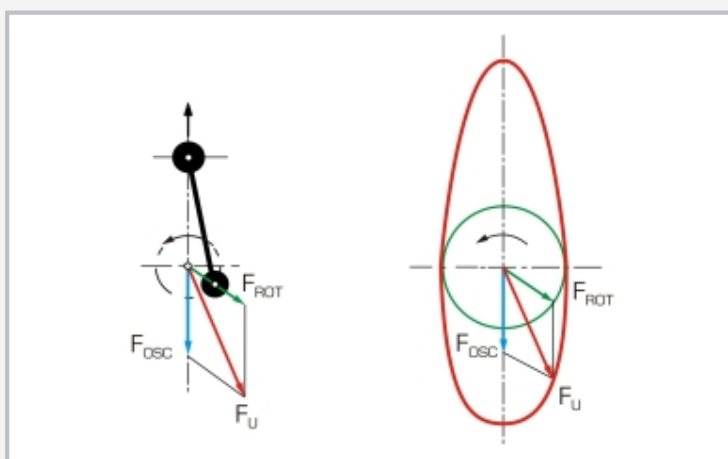
## Forces in reciprocating engines



1 piston, 2 cylinder, 3 crankshaft, 4 foundation plate, 5 display and control unit, 6 force sensor, 7 drive motor



Left: definition of the rotating ( $m_{ROT}$ ) and oscillating ( $m_{OSC}$ ) masses at the crank drive, right: possible configurations of the crankshaft: red: single cylinder, blue: two-cylinder, green: four-cylinder



Left: effect of the oscillating (blue,  $F_{OSC}$ ) and the rotating (green,  $F_{ROT}$ ) mass forces and their vectorial addition to the free mass force (red,  $F_U$ ).  
Right: mass forces course during a crankshaft revolution

### Specification

- [1] investigation of oscillating and rotating mass forces and moments of a reciprocating engine with up to 4 cylinders
- [2] simulation of single, 2- or 4-cylinder engines
- [3] electronically commutated and speed-controlled drive motor with digital speed display
- [4] continuous adjustment of the angle between cranks
- [5] force sensors to measure forces and moments
- [6] vibration isolation using rubber elements and suitable tuning
- [7] GUNT software for data acquisition via USB under Windows 10

### Technical data

#### Engine

- number of cylinders: 4
- piston mass: 40g
- additional mass: 41g

#### Crank drive

- mass of connecting rod: 18g
- centre distance of cylinders: 35mm
- crank radius: 15mm
- length of connecting rod: 70mm

#### Measuring ranges

- speed: 100...3000min<sup>-1</sup>
- force: 0...500N

230V, 50Hz, 1 phase

230V, 60Hz, 1 phase; 120V, 60Hz, 1 phase

UL/CSA optional

LxWxH: 370x420x390mm

Weight: approx. 40kg

LxWxH: 230x230x80mm (display and control unit)

Weight: approx. 1kg

### Required for operation

PC with Windows

### Scope of delivery

- 1 engine model
- 1 display and control unit
- 1 set of accessories (tools, additional masses)
- 1 GUNT software + USB cable
- 1 set of instructional material

# TM 180

## Forces in reciprocating engines

Optional accessories

WP 300.09

Laboratory trolley