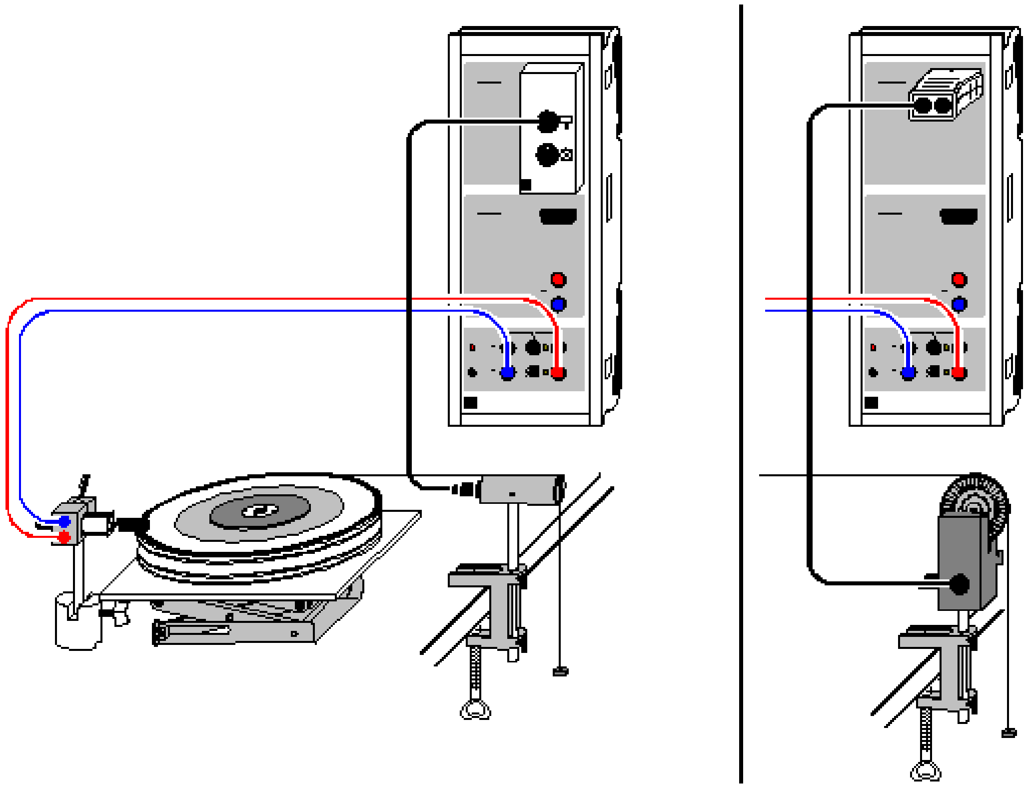
Rotational motions (Newton's equation of motion)



Load example

Experiment description

A rotating body with a constant moment of inertia J is accelerated with different torque values. When the angular accelerations α determined are plotted as a function of the accelerating torques M, M is found to be proportional to α (with J as the proportionality factor), thus confirming Newton's equation of motion $M=J\cdot \alpha$.

Alternatively, you can keep the accelerating torque M constant and vary the moment of inertia J. The result here is J proportional to $1/\alpha$ (with M as the proportionality factor).

Equipment list

1	Sensor-CASSY	524 010
1	CASSY Lab	524 200
1	BMW box	524 032
1	Motion sensing element	337 631
	or	
1	Timer S	524 074
1	Combi-light barrier	337 462
1	Combi-spoked wheel	337 464
1	Rotation model	347 23
1	Multicore cable, 6-pole	501 16
1	Holding magnet	336 21
1	Stand rod, 25 cm	300 41
1	Base	300 11
1	Bench clamp, simple	301 07
1	Laboratory stand II	300 76
1	Pair of cables, 1 m, red and blue	501 46
1	Paper clip	
1	PC with Windows 98/2000/XP/Vista	

Experiment setup (see drawing)

Tie the transmission thread to the flag of the rotation model (r = 10 cm) or to one of the pins of the extra disk (r = 5 cm, 2.5 cm) and run it over the motion sensing element, which is connected to Sensor-CASSY via the top socket of the BMW box. The holding magnet prevents the start of rotation when it is placed close to the paper clip attached to the flag of the rotation model.

The accelerating force is generated e.g. by 3 small suspended weights of 1 g each (F = 0.0294 N). The different torques at a constant moment of inertia are realized using the different pulley radii (M = r·F = 2.94 mNm, 1.47 mNm, 0.73 mNm). Alternatively, you can realize different moments of inertia for a constant torque using extra disks.

Carrying out the experiment

- Load settings
- Modify the maximum rolling angle β_{A1} in the measuring condition of the Measuring Parameters dialog (accessible via **F5**); current setting: **&bA1 < 6** for 6 radii, &b stands for β)
- You may want to modify the time interval (currently 500 ms) in the Measuring Parameters dialog (accessible with **F5**); a longer interval means fewer measured values and less scattering in α(t).
- You may need to invert the sign of angular measurement (**s <—> -s** in Settings βA1).
- Allow the rotating disk to fall from the holding magnet.
- Define the current rolling radius and the path zero point (both in Settings βA1)
- Start the measurement with **F9** and stop it with **F9** when the experiment is finished. You can delete a faulty measurement series from the table with **Delete Last Measurement Series** (click right mouse button over table).
- Repeat the measurement with different parameters (different accelerating torque or accelerated moment of inertia). Be sure to redefine the rolling radius and path zero point.

Evaluation

In addition to the β(t) diagrams, the software also calculates the ω(t) and α(t) diagrams. You can see these simply by clicking on the tabs of the other displays. Suitable evaluation functions are parabola and line fits and calculation of mean value.

To confirm Newton's equation of motion, you need to fill out a further table, which has already been prepared on the Newton display tab. After determining an angular acceleration value as the mean of an α(t) diagram or the slope of an ω(t) diagram, you can use the mouse to drag this value from the status line and drop it into the table (drag & drop). As the parameter, enter the parameter angular momentum M or moment of inertia directly via the keyboard. The desired diagram is generated as you enter the values. You can easily convert or rescale the axes by clicking on them with the right mouse button (e.g. α —> 1/α).

As a further evaluation, you can e.g. compare the rotational energy with the work performed using formulas. The rotational energy is

E = **0.5*J*&w^2** (enter the numerical value for J, &w stands for ω)

and the work performed is

W = **M*&bA1** (enter the numerical value for M, &b stands for β).