

## Mechanics

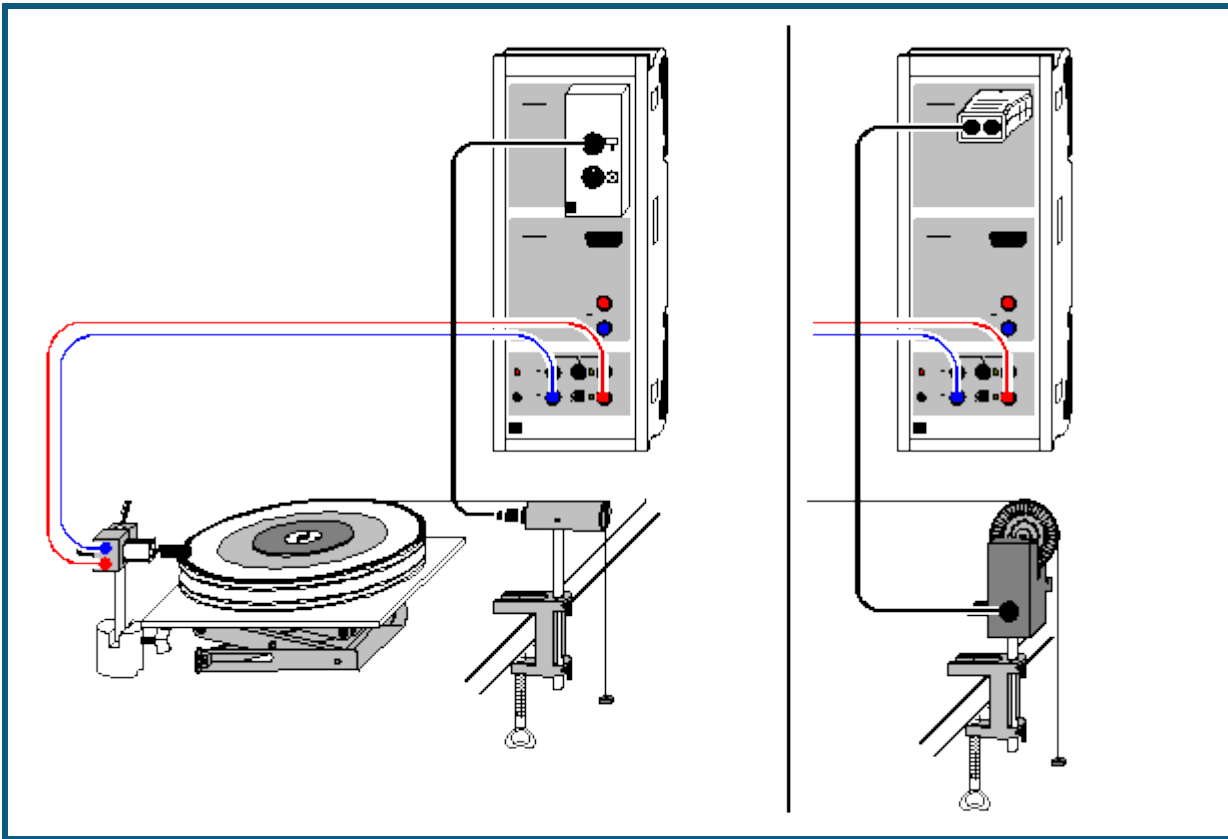
Rotational motions of a rigid body  
*Rotational motions*

Path-time diagrams of  
rotational motions -  
Recording and evaluating  
with CASSY

### Description from CASSY Lab 2

For loading examples and settings,  
please use the CASSY Lab 2 help.

## Rotational motions (Newton's equation of motion)



### Experiment description

A rotating body with a constant moment of inertia  $J$  is accelerated with different torque values. When the angular accelerations  $\alpha$  determined are plotted as a function of the accelerating torques  $M$ ,  $M$  is found to be proportional to  $\alpha$  (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	<a href="#">Sensor-CASSY</a>	524 010 or 524 013
1	<a href="#">CASSY Lab 2</a>	524 220
1	<a href="#">BMW box</a>	524 032
1	Motion sensing element	337 631
	or	
1	<a href="#">Timer S</a>	524 074
1	Combination light barrier	337 462
1	Combination spoked wheel	337 464
1	Rotation model	347 23
1	Multi-core cable, 6-pole	501 16
1	Holding magnet	336 21
1	Stand rod, 25 cm	300 41
1	Saddle base	300 11
1	Bench clamp, simple	301 07
1	Laboratory stand II	300 76
1	Pair of cables, 100 cm, red and blue	501 46
1	Paper clip	
1	PC with Windows XP/Vista/7/8	


### Experiment setup (see drawing)

Tie the transmission thread to the flag of the rotation model ( $r = 10 \text{ cm}$ ) or to one of the pins of the extra disk ( $r = 5 \text{ cm}$ ,  $2.5 \text{ cm}$ ) 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  $1 \text{ g}$  each ( $F = 0.0294 \text{ N}$ ). The different torques at a constant moment of inertia are realized using the different pulley radii ( $M = r \cdot F = 2.94 \text{ mNm}$ ,  $1.47 \text{ mNm}$ ,  $0.73 \text{ mNm}$ ). 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  $\beta_{A1}$  in the stop condition of the [Measuring Parameters](#) (**Window** → **Show Measuring Parameters**); current setting: **&bA1 > 6** for 6 radii, &b stands for  $\beta$
- You may want to modify the time interval (currently 500 ms) in the [Measuring Parameters window](#); a longer interval means fewer measured values and less scattering in  $\alpha(t)$ .
- You may need to invert the sign of angular measurement ( $s \leftrightarrow -s$  in [Settings  \$\beta A1\$](#) ).
- Allow the rotating disk to fall from the holding magnet.
- Define the current rolling radius and the path zero point (both in [Settings  \$\beta A1\$](#) )
- Start the measurement with . You can delete a faulty measurement series from the table with [Measurement](#) → [Delete Current Measurement Series](#).
- 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  $\beta(t)$  diagrams, the software also calculates the  $\omega(t)$  and  $\alpha(t)$  diagrams. You can see these simply by clicking on the tabs of the other displays. Suitable evaluation functions include [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  $\alpha(t)$  diagram or the slope of an  $\omega(t)$  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.  $\alpha \rightarrow 1/\alpha$ ).

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

$$E = 0.5 \cdot J \cdot \omega^2 \quad (\text{enter the numerical value for } J, \text{ \&w stands for } \omega)$$

and the work performed is

$$W = M \cdot \beta \quad (\text{enter the numerical value for } M, \text{ \&b stands for } \beta).$$