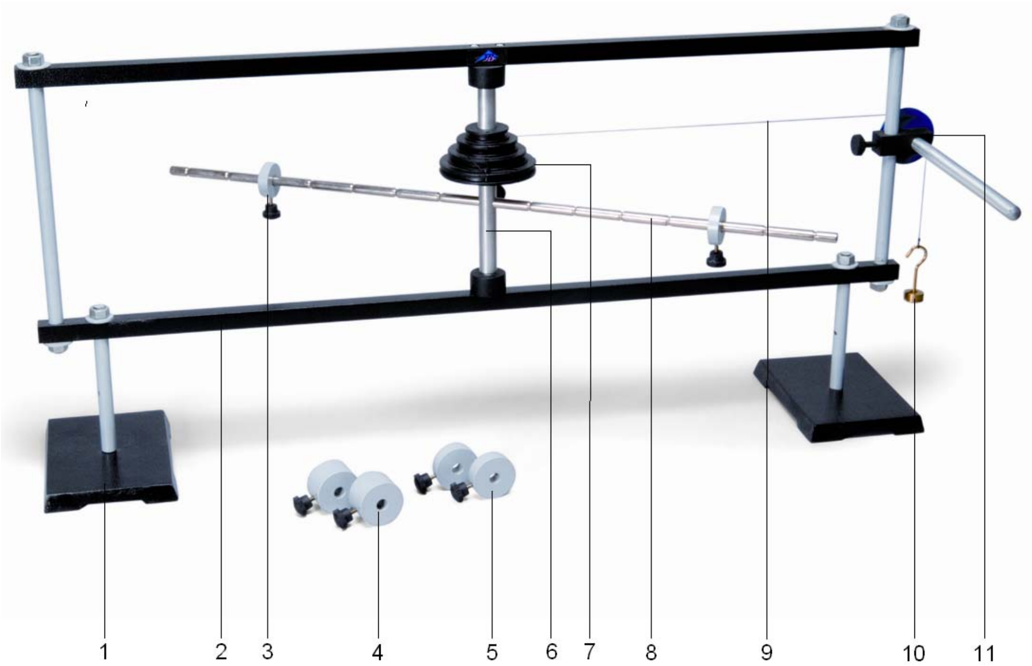
3B SCIENTIFIC® PHYSICS

Rotary Motion Apparatus 1010084

Instruction sheet

11/12 ALF



1 Base
2 Frame
3 Weight discs 50 g
4 Weight discs 200 g
5 Weight discs 100 g
6 Rotating axle
7 Multiple pulley
8 Crossbar
9 String
10 Hanger for slotted weights
11 Deflection pulley

1. Safety instructions

To avoid injuries:

- Maintain a safe distance from the device while it is in operation. Be especially careful to keep your eyes and face away from moving parts.
- Do not use your hand to spin the apparatus to a high angular velocity! The screws are not designed to stay in position at high velocities and the weights will fly off.

2. Description

The rotary motion apparatus is used for investigating the effect of a constant torque on a rotating body with variable moment of inertia.

A vertical, rotating axle on ball bearings in a stable frame.supports a crossbar with equidistant grooves for holding the weights. For safety, the weights are fixed in place with screws. The torque is generated by a rotating plate with hooks and up to three slotted weights, acting via a string threaded over a multiple pulley with four different pulley diameters.

3. Technical data

Crossbar:	600 mm x 8 mm diam.
Groove separation:	40 mm
Weights:	2x 50 g, 2x 100 g, 2x200g
Diameters of multiple pulley:	30 mm, 45 mm, 60 mm, 75 mm
Overall weight:	7 kg

4. Additionally required

1 Ruler, 1 m	1000742
2 Mechanical stopwatches, 15 min	1003369

5. Sample experiments

5.1 Calculating angular acceleration

- Place masses on crossbar and secure with screws, insert thread and wind around multiple pulley, run thread over pulley and wind up, connect to mass hanger keep threat perpendicular to spindle. Hold mass hanger.
- Have two students standing ready with stopwatches.
- Release the mass hanger.
- One student will record the time between the release of the mass hanger and when it touches the ground.
- As soon as the mass touches the ground, the second student will record the time it takes the crossbar to rotate twice. Be sure to take this measurement before the apparatus has slowed due to friction.
- Calculate angular velocity, ω, of the crossbar in radians/second, remembering that one rotation is 2 π radians.
- Angular acceleration is given by the equation

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

- Δω is the value calculated for final angular velocity (initial was zero) and Δ*t* is the time it took the mass to fall to the ground.
- Repeat your measurement a few times and average the results.
- Change hanger mass, mass on the rod and position of the mass on rod and casually compare effects on angular velocity.

5.2 Calculating torque *M*

The torque can be calculated theoretically and experimentally and these two values can be compared. Use the same experimental setup as in 5.1.

The theoretical torque is given by the equation:

$$M = r \cdot F \cdot \sin\theta$$

$\theta = 90$ because the thread is perpendicular to the radius of the apparatus. *r* is the radius of the multiple pulley $F = m \cdot g$ where *m* is the sum of the slotted masses and hanger and $g = 9{,}81 \frac{m}{s^2}$, the gravitational acceleration constant. Thus, the theoretical torque is given by:

$$M = r \cdot m \cdot g$$

- To find experimental torque, first calculate the angular acceleration using the methods outlined in section 5.1.
- Calculate the moment of inertia *J* by measuring the distances to the masses on the crossbar and using the following equation

$$J = \frac{1}{12} M_{rod} L^2 + M_{weights} R^2$$

M_{rod} = weight of crossbar

L = length of crossbar

$M_{weights}$ = weight of masses on crossbar

R = distance mass on crossbar - axle

- Multiply angular acceleration by the moment of inertia to find torque

$$M = J \cdot \alpha$$

- Measure the change in torque from changing spindle radius and from varying the amount of mass on the hangers.

5.3 Calculating moment of inertia *J*

- Measure the distance from the mass to the pivot axle.
- Calculate the angular acceleration as in 5.1
- Calculate the theoretical torque as in 5.2
- The moment of inertia is given by the equation:

$$J = \frac{M}{\alpha}$$

- Repeat the experiment, keeping the mass on the crossbar fixed and varying the distance.
- Plot moment of inertia versus distance.
- Repeat the experiment, but this time keep the distance fixed and vary the mass on the rod and plot moment of inertia versus mass.

You should find that the moment of inertia varies accoring to the equation

$$J = M \cdot R^2$$