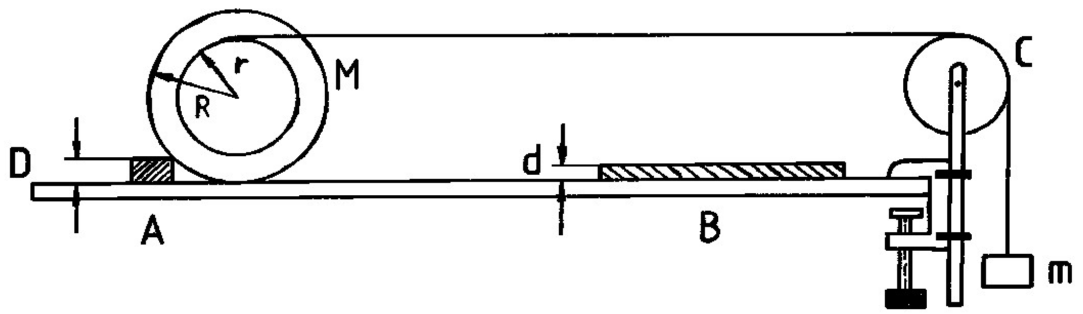
Problem 5: Motion of a rolling cylinder

The rolling motion of a cylinder may be decomposed into rotation about its axis and horizontal translation of the center of gravity. In the present experiment only the translatory acceleration and the forces causing it are determined directly.

Given a cylinder of mass M, radius R, which is placed on a horizontal plane board. At a distance r_i ($i = 1 \dots 6$) from the cylinder axis a force acts on it (see sketch). After letting the cylinder go, it rolls with constant acceleration.



a) Determine the linear accelerations a_i ($i = 1 \dots 6$) of the cylinder axis experimentally for several distances r_i ($i = 1 \dots 6$).

b) From the accelerations a_i and given quantities, compute the forces F_i which act in horizontal direction between cylinder and plane board.

c) Plot the experimental values F_i as functions of r_i. Discuss the results.

Before starting the measurements, adjust the plane board horizontally. For present purposes it suffices to realize the horizontal position with an uncertainty of $\pm$ 1 mm of height difference on 1 m of length; this corresponds to the distance between adjacent markings on the level. What would be the result of a not horizontal position of the plane board?

Describe the determination of auxiliary quantities and possible further adjustments; indicate the extent to which misadjustments would influence the results.

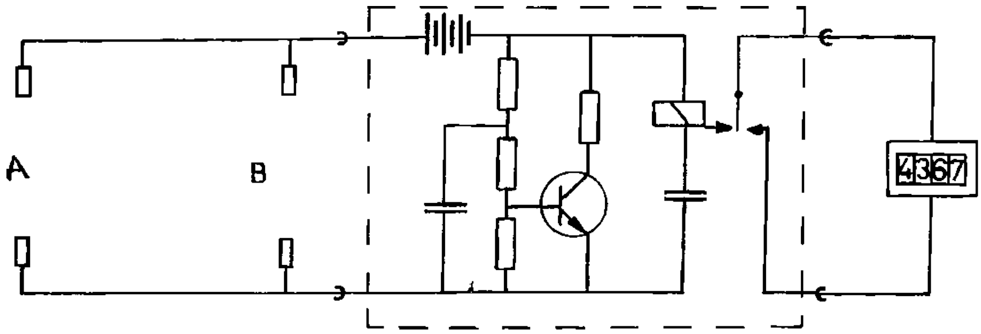
The following quantities are given:

R	=	5 cm	r_1	=	0.75 cm
M	=	3.275 kg	r_2	=	1.50 cm
m	=	2 x 50 g	r_3	=	2.25 cm
D	=	1.50 cm	r_4	=	3.00 cm
d	=	0.1 mm	r_5	=	3.75 cm
			r_6	=	4.50 cm

Mass and friction of the pulleys c may be neglected in the evaluation of the data.

By means of knots, the strings are put into slots at the cylinder. They should be inserted as deeply as possible. You may use the attached paper clip to help in this job.

The stop watch should be connected, as shown in the sketch, with electrical contacts at A and B via an electronic circuit box. The stop watch starts running as soon as the contact at A is opened, and it stops when the contact at B is closed.



The purpose of the transistor circuit is to keep the relay position after closing of the contact at B, even if this contact is opened afterwards for a few milliseconds by a jump or chatter of the cylinder.