Boğaziçi University

Introductory Phys Labs

STATIC EQUILIBRIUM OF A RIGID BODY

PHYL102

THEORY

A rigid body is in static equilibrium only if

- The net force is zero in each direction. (The body is in translational equilibrium.)
- The net torque around the pivot point is zero in each direction. (The body is in rotational equilibrium.)

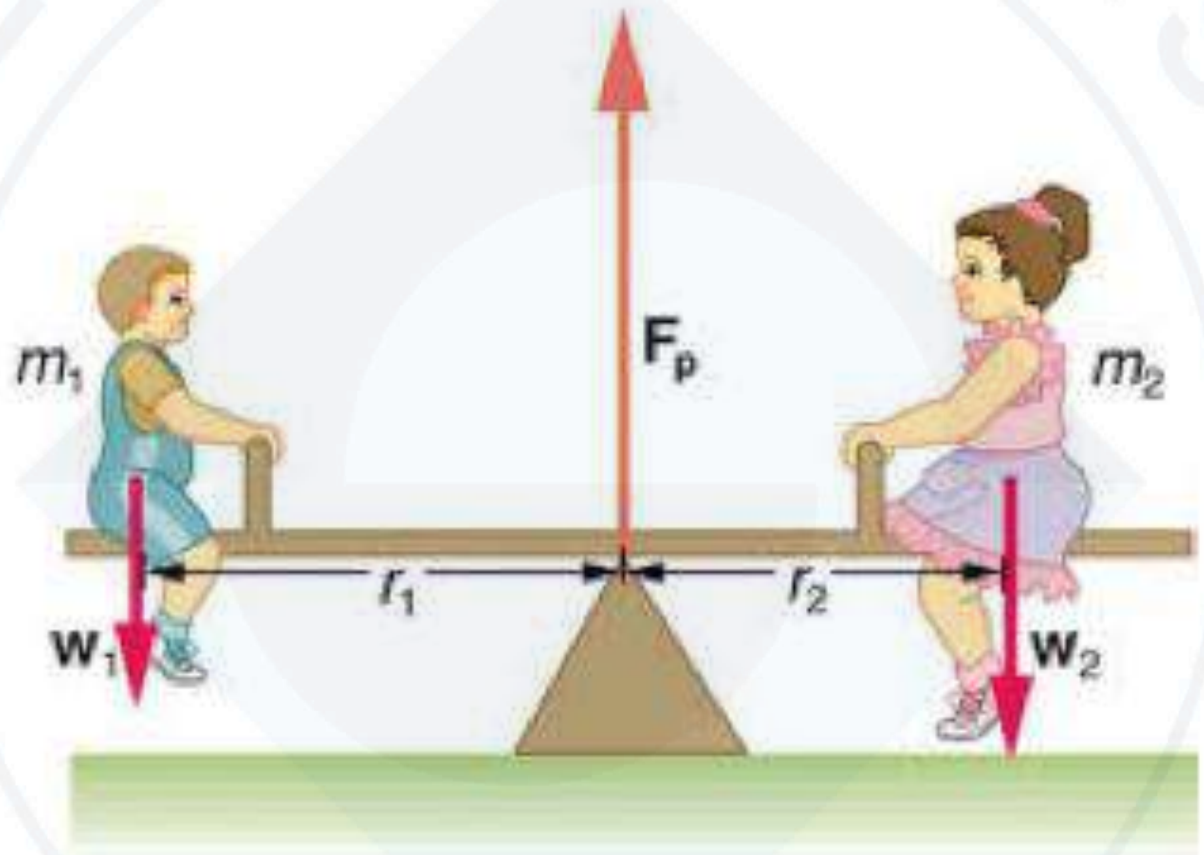
Translational Equilibrium:

Linear acceleration is equal to zero with respect to an inertial frame of reference.

$$\sum F_x = 0, \sum F_y = 0.$$

Rotational Equilibrium:

Angular acceleration around the pivot point is equal to zero with respect to an inertial frame of reference.

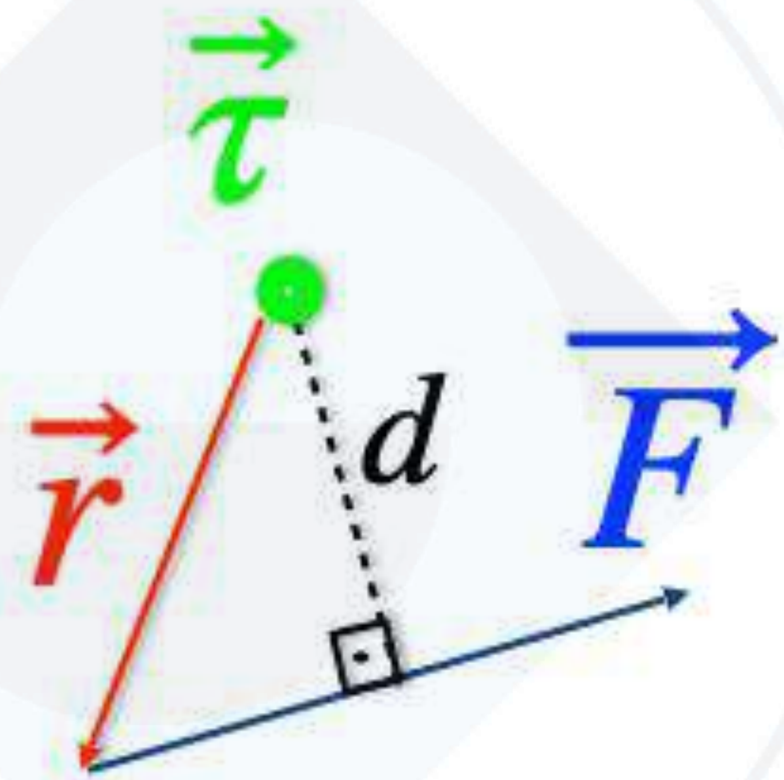


$$\sum \tau_x = 0, \sum \tau_y = 0, \sum \tau_z = 0.$$

Where

$$\vec{\tau} = \vec{r} \times \vec{F}.$$

Magnitude of the torque is the magnitude of the force times the perpendicular distance.



$$\tau = Fd$$

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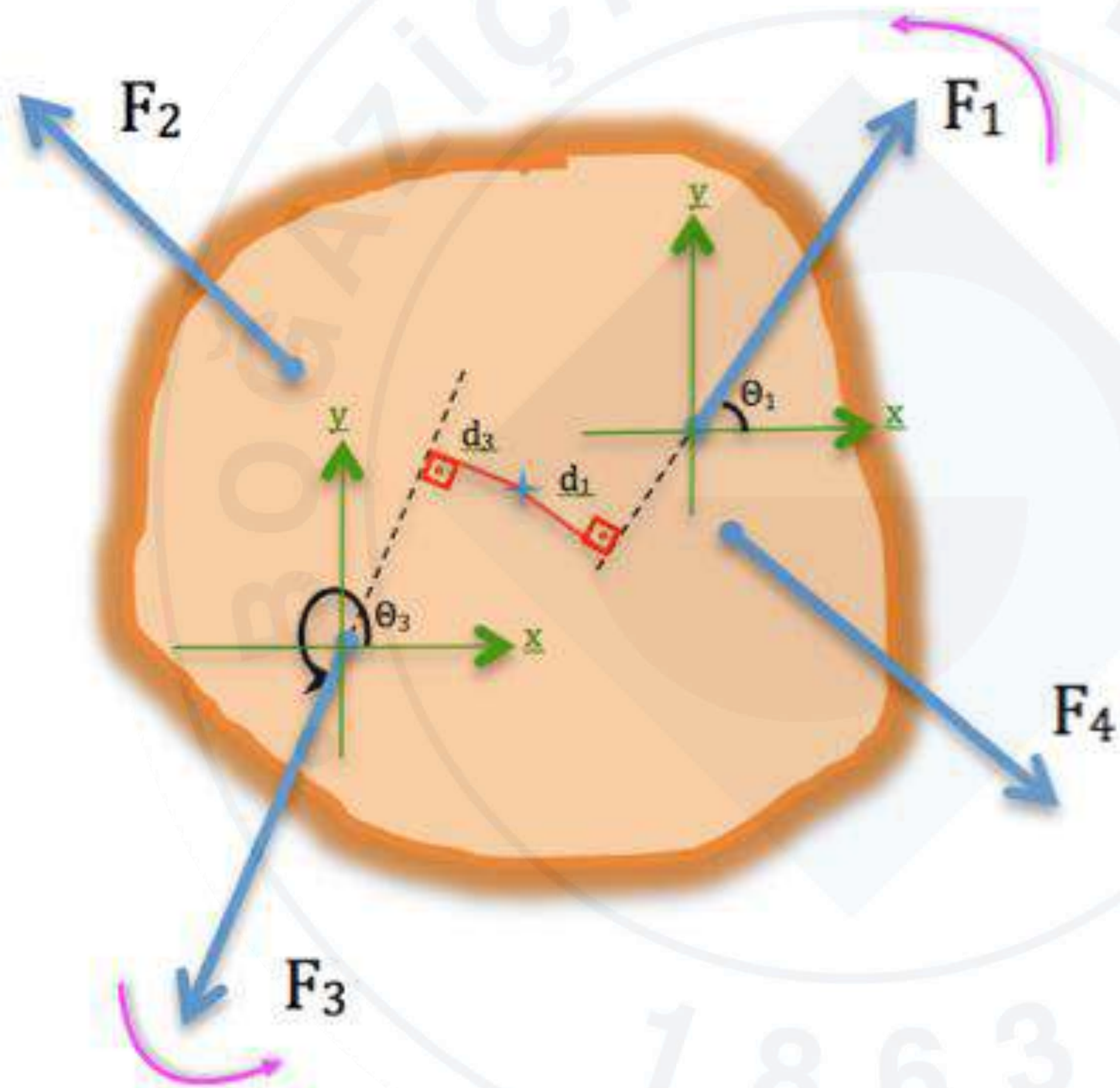


Conditions for Static Equilibrium:

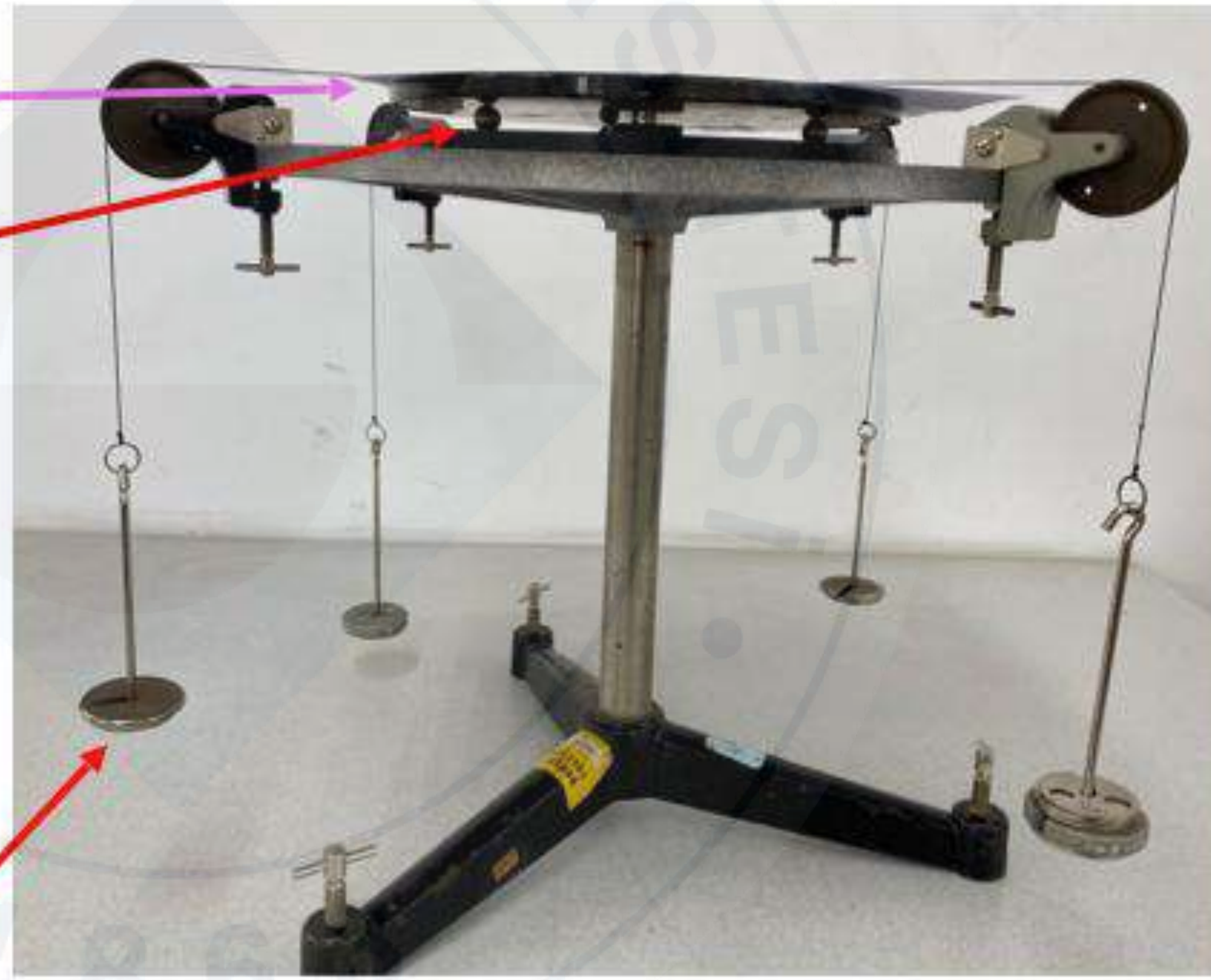
- The net force acting on the object must be zero.
- Net torque around the pivot point must be zero. A rotating body or system can be in equilibrium only if its rate of rotation is constant and remains unchanged by the forces acting on it.

APPARATUS

Apparatus: Force & Torque Table, Paper, known masses, unknown masses

Movable Disc

3 metal balls

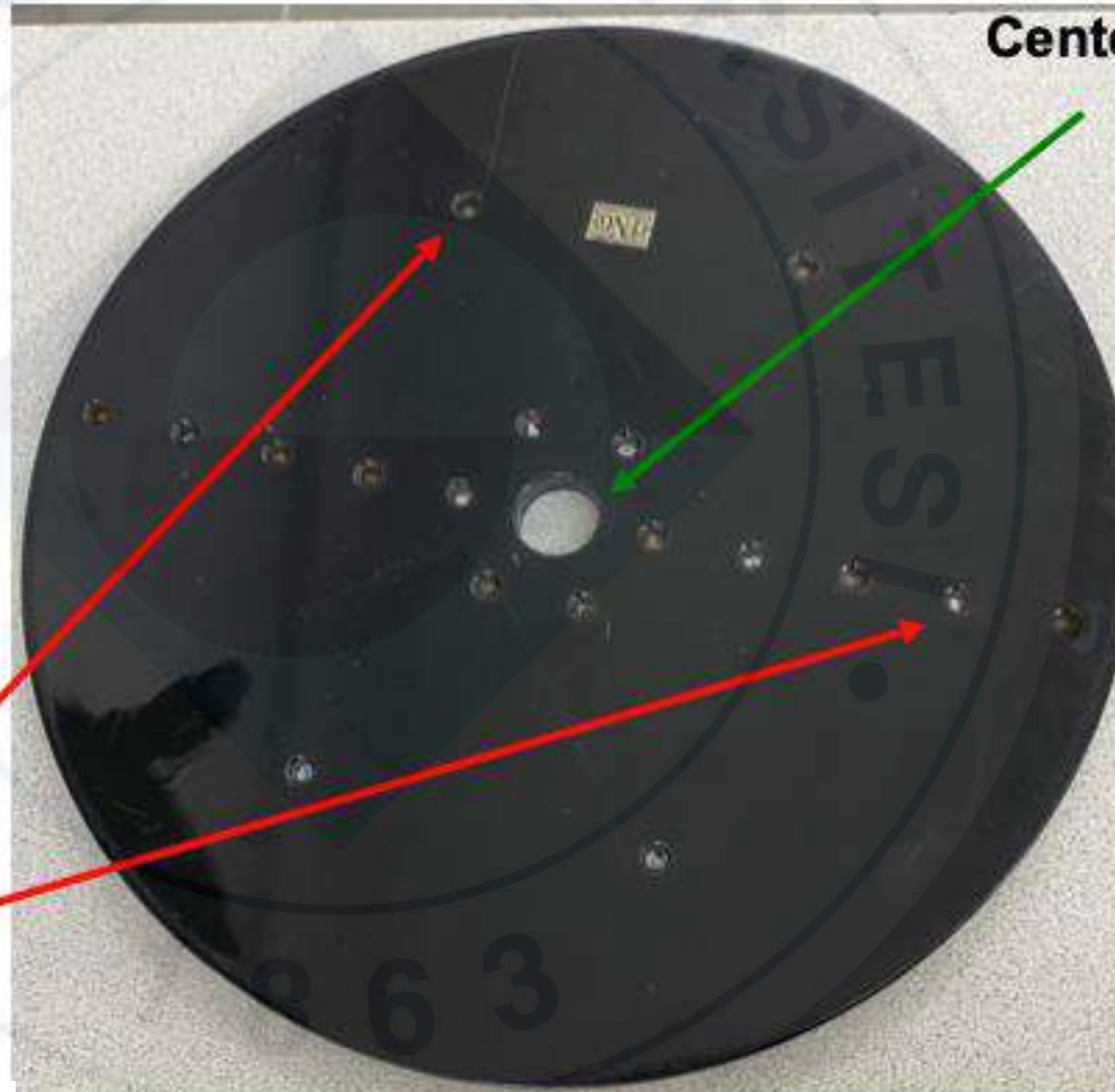


Mass holder and masses

Force & Torque Table in details

Movable Disc

Hole for Center Pin

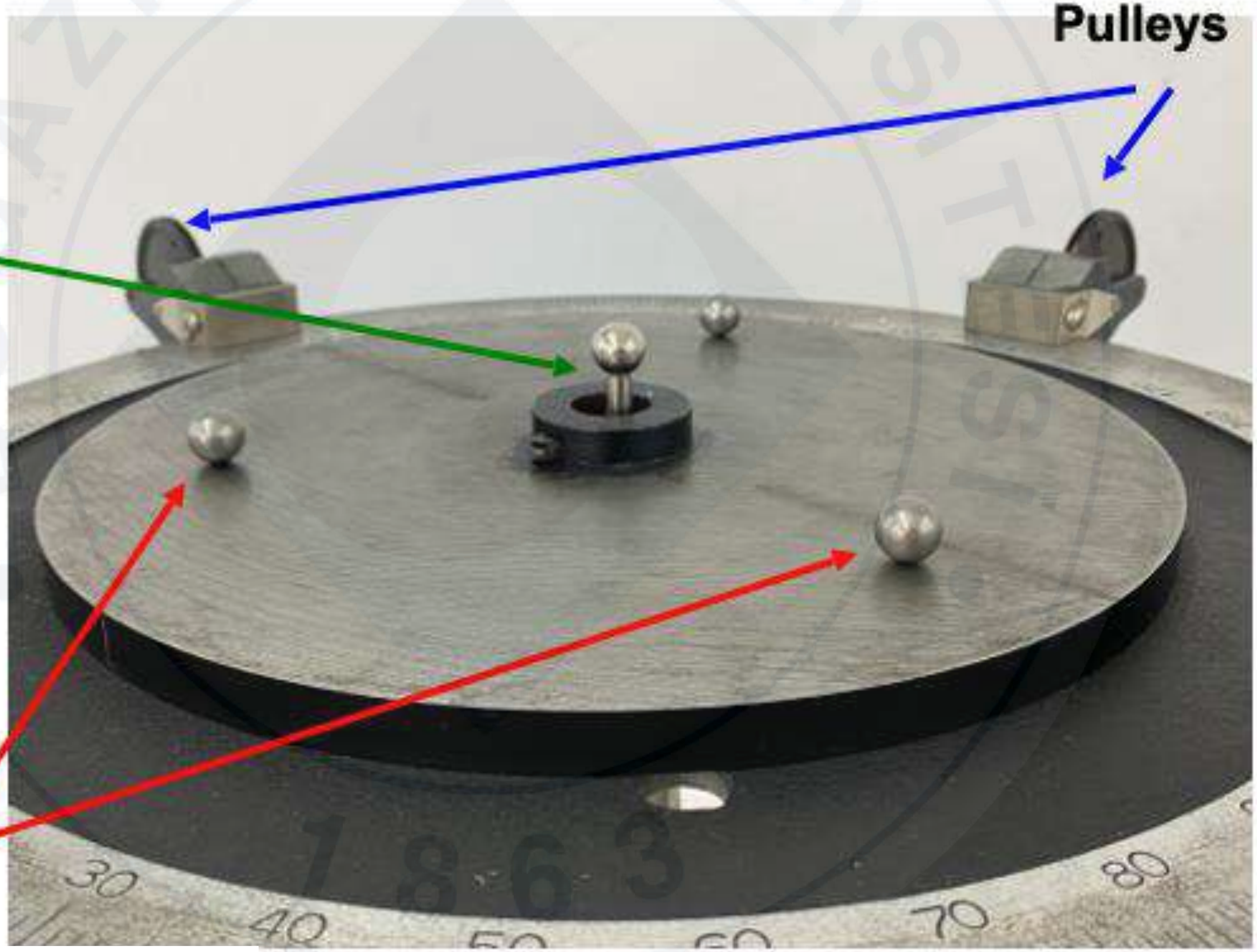


Holes to attach the masses

Force & Torque Table without movable disc in details

Pulleys

Center pin

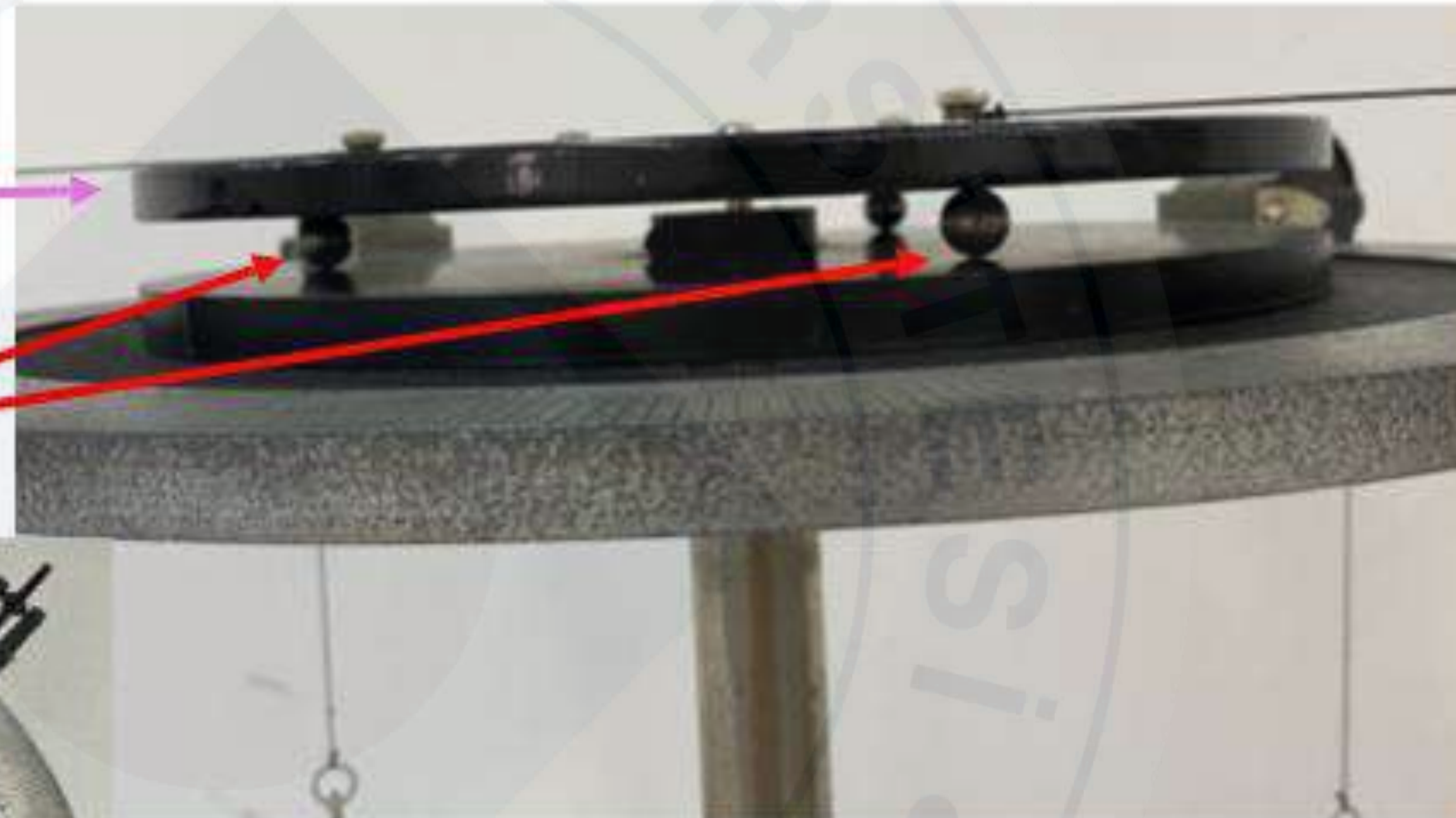


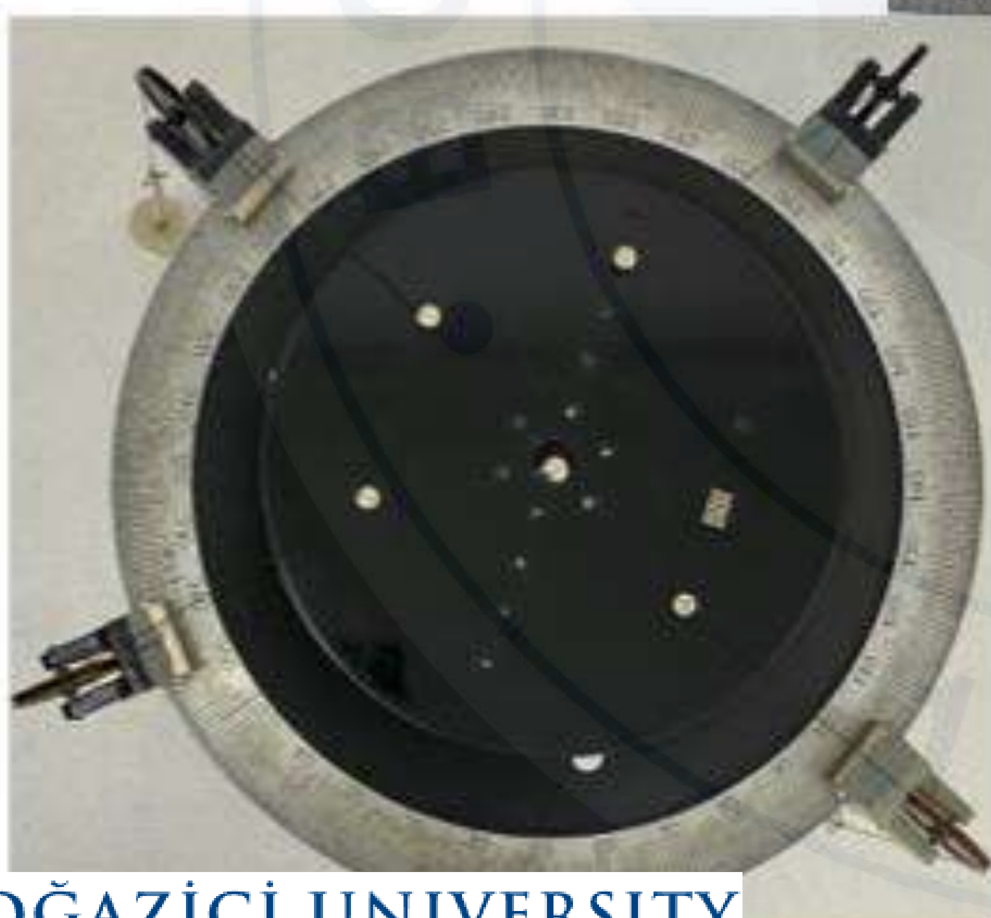
Metal balls

Force & Torque Table in details

Movable disc

Metal balls





Top view

If we remove the center pin, the table is NOT in equilibrium and it moves; Center pin is NOT at center of the hole.

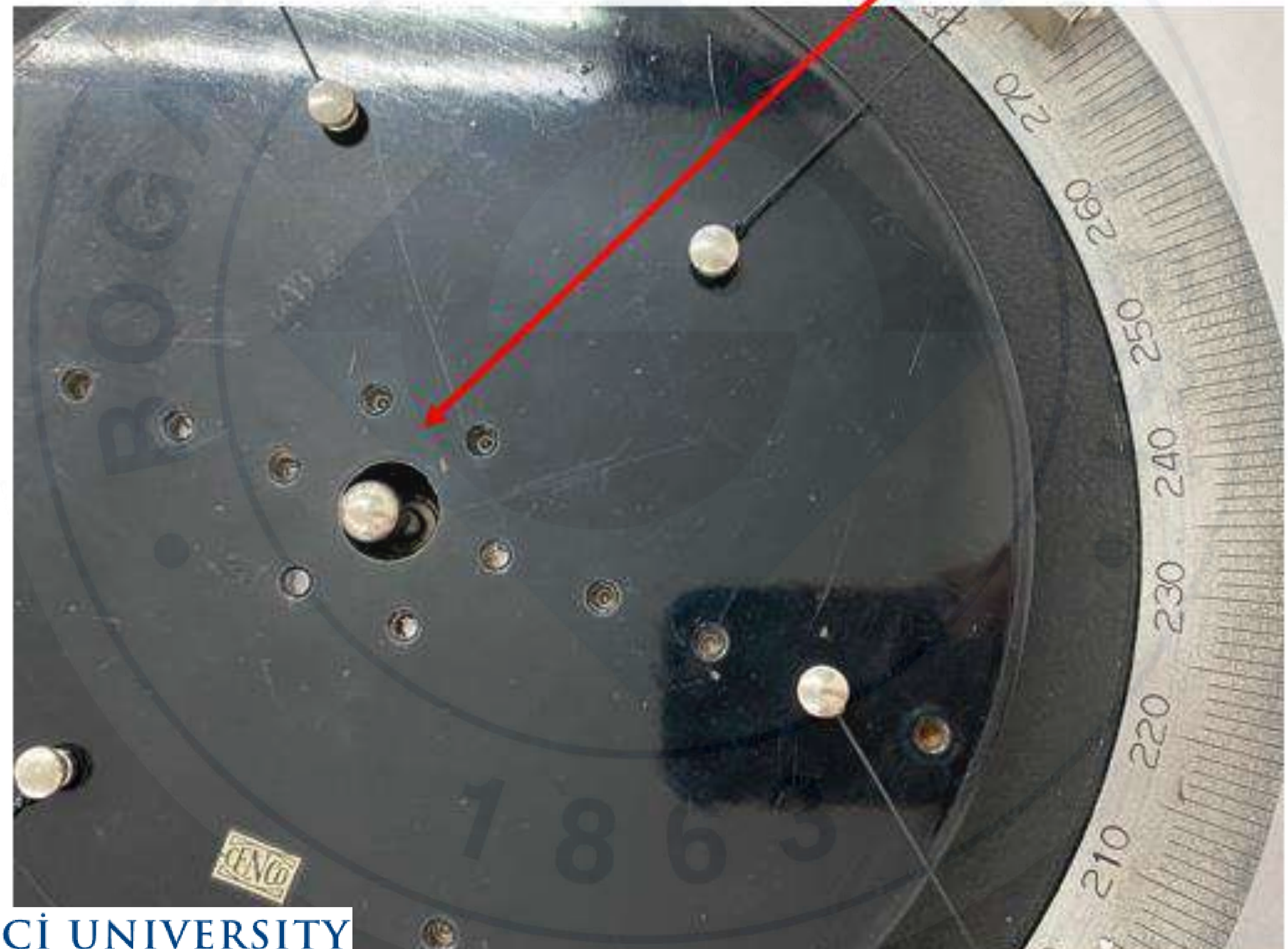
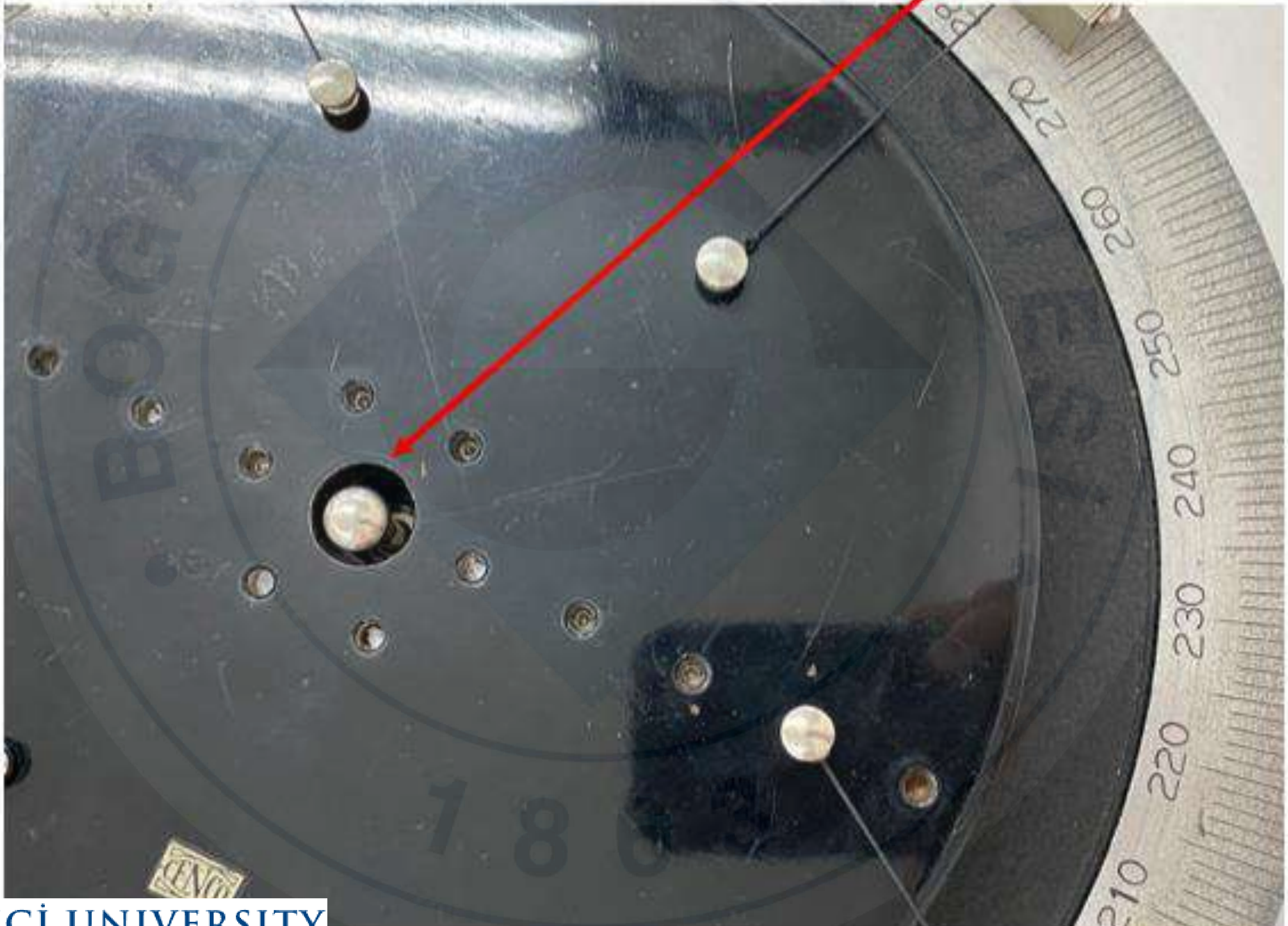


Table IS in equilibrium; Center pin does not touch the disc.



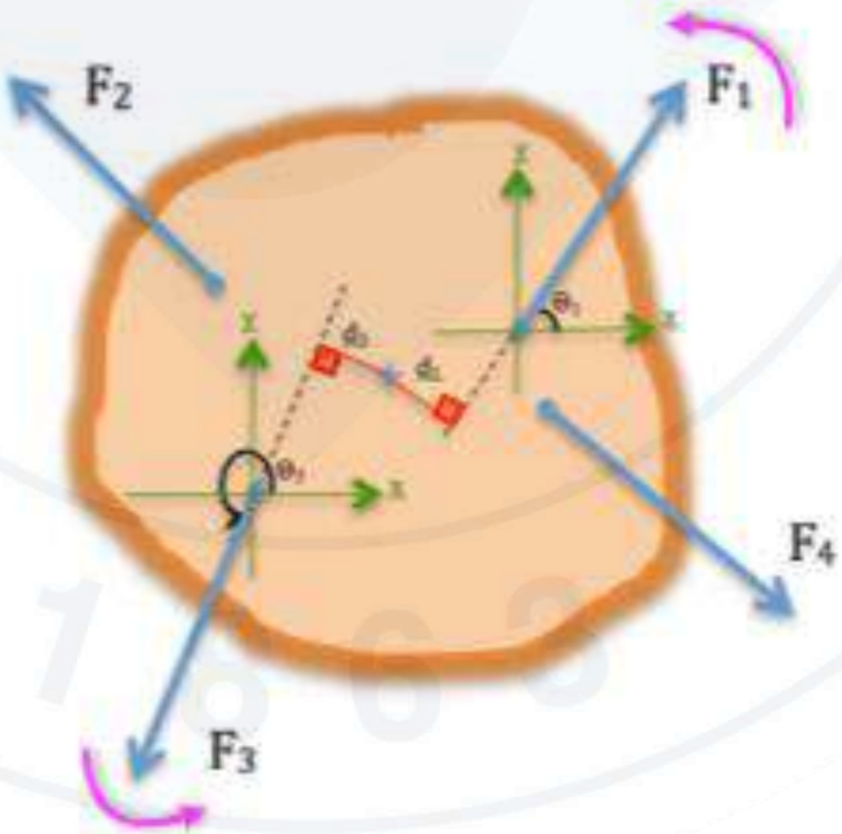
EXPERIMENT

STATIC EQUILIBRIUM OF A RIGID BODY

- What to measure (Protractor and ruler): Angles θ and perpendicular distances to axes of rotation d, rotation directions of forces

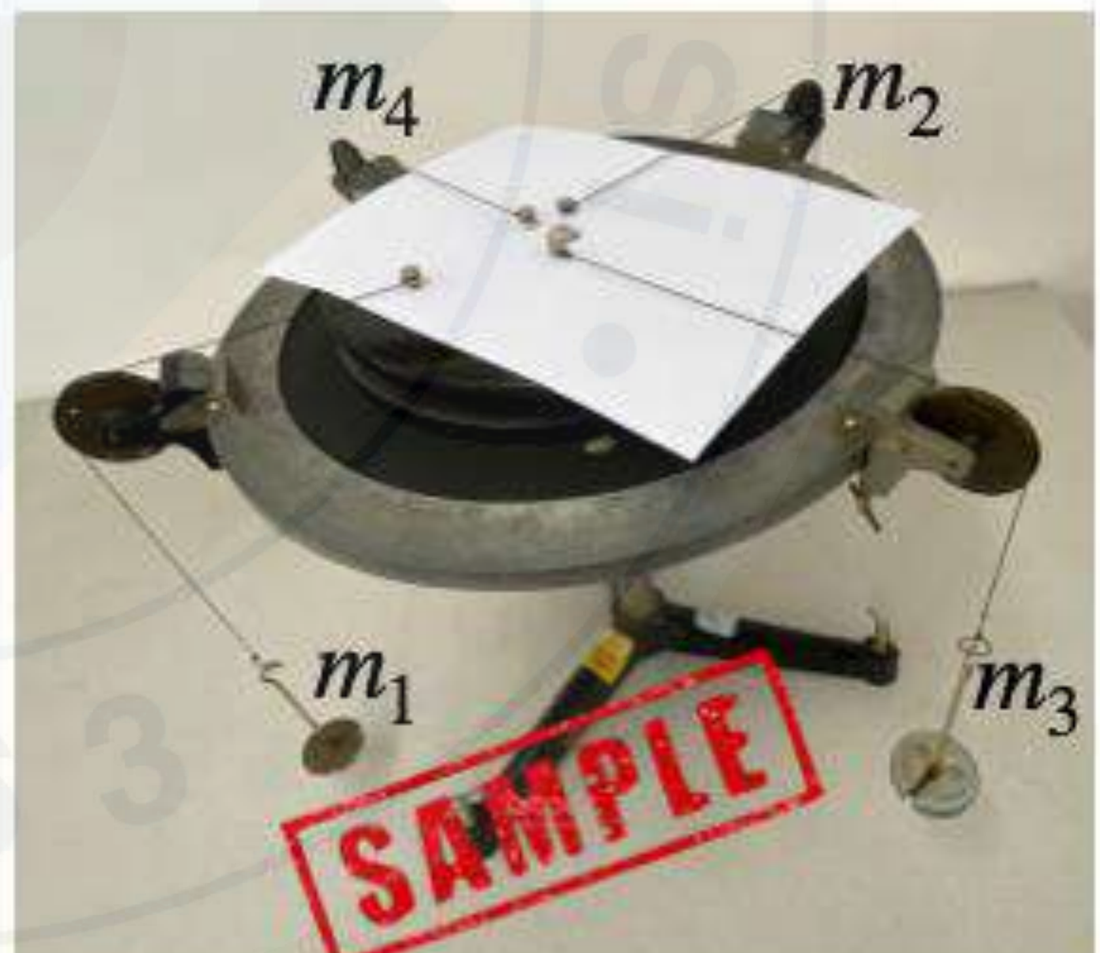
- What to calculate: x and y components of forces F_x and F_y, magnitudes of torques τ_z

- Experimental findings : Unkown masses m_{uk1} and m_{uk2}

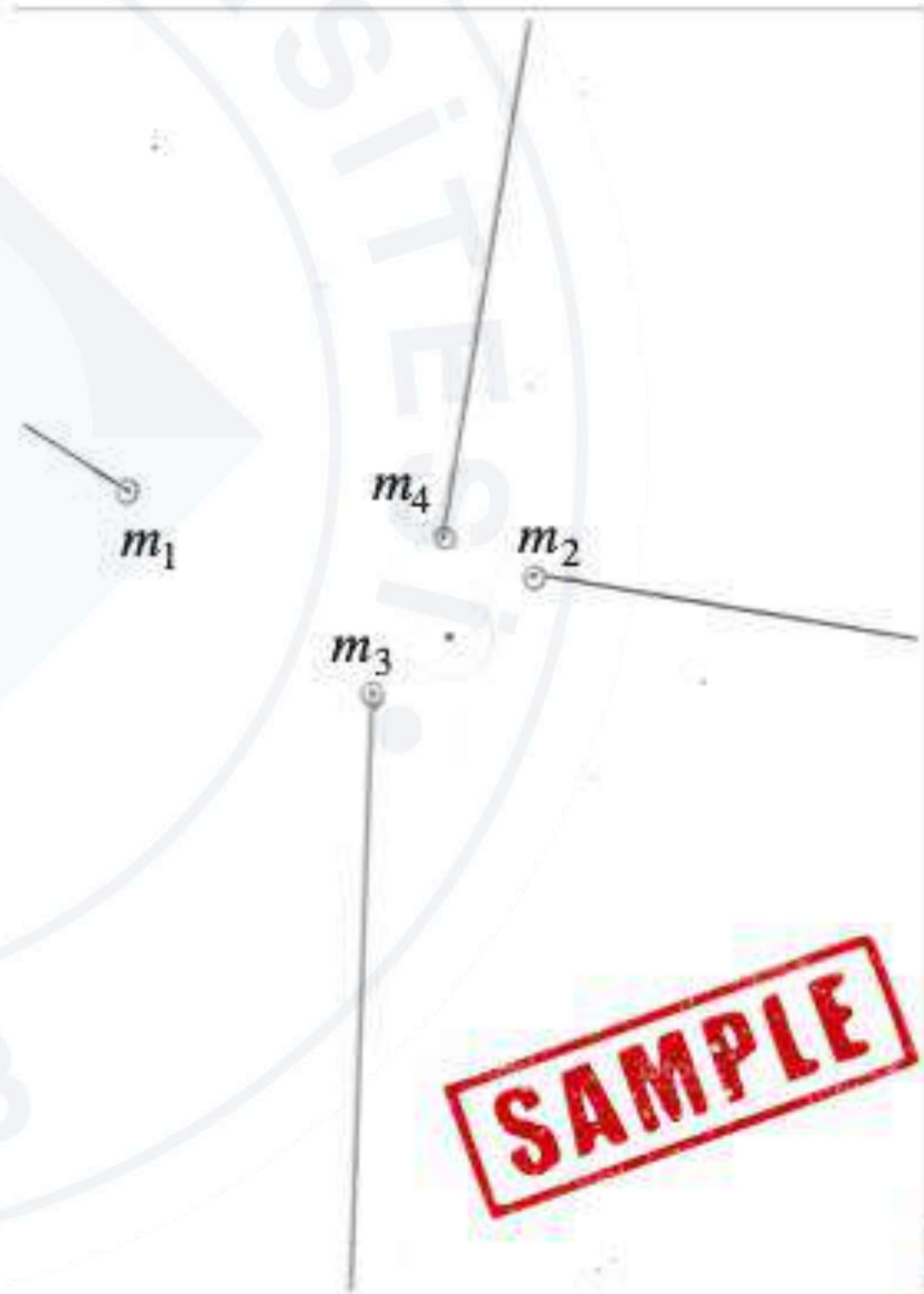


The verification of static equilibrium conditions. (Known masses are used.)

A piece of paper is placed on top of the movable disc. Four pegs are inserted by punching through the paper into four different holes in the disc. Strings are placed over the pulleys. The position and the quantity of masses is set in such a way that equilibrium is observed.

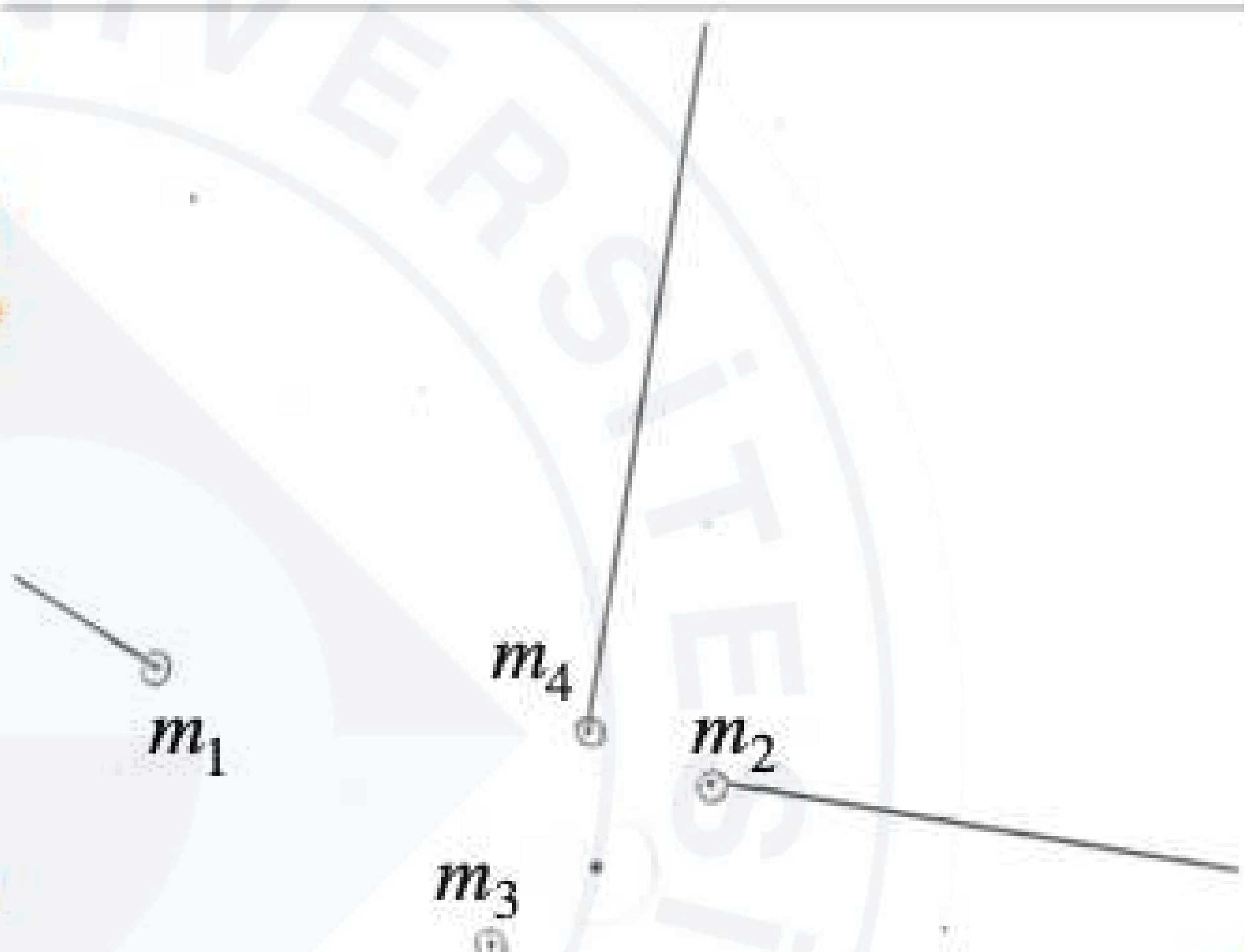


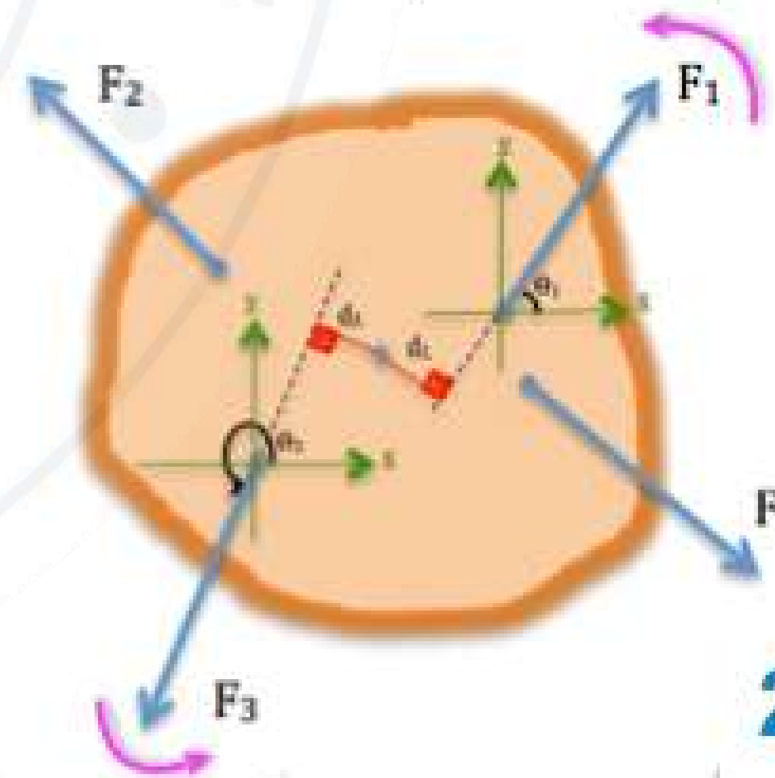
When the disc is in equilibrium, the positions of the strings are marked and the magnitude of each force is written down.



Download the data sheet from the given link. Either print it or adjust its size to A4 on the computer screen. Put your A4 paper on the screen and copy the image on your paper. Indicate the direction of the forces and determine whether the forces are balanced.

- Draw the x and y axes and show the angle for each force.
- Draw the x and y component of each force.
- Show the perpendicular distance to the axis of rotation and rotation direction of each force.





Mass hanged on each mass holder is written on the paper.

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CALCULATIONS :

By using the data sheet

write down:

- **Total Force on x-direction,**
- **Total Force on y-direction and**
- **Total Torque.**

ΣF_x : ....

ΣF_y : ....

$\Sigma \tau_z$: ....

Total force and total torque values will be nearly zero in Newton.