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3rd STUDENT ASSIGNMENT SHEET ELEMENTARY PHYSICS IA (FI-1101)
Semester 1 Year 2023-2024
TOPIC: RIGID BODY I

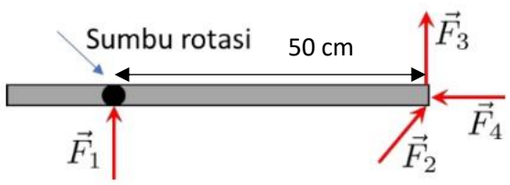
For all problems air resistance can be ignored; use $g = 9{,}8\ \mathrm{m/s^2}$.

1. A wheel of 10 cm radius rotates with a constant angular speed ω of p rad/s.

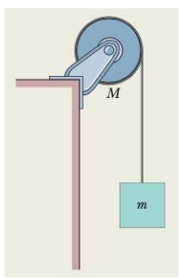
a. If at t = 2 s, a point on the edge of the wheel is at an angle = 30° to the positive x-axis, determine its position at t = 5 s.
b. Determine the magnitude of the velocity t = 2 s.
c. Plot the position, angular velocity, and angular acceleration as a function of time.

2. In the following figure you can see a rod and its axis of rotation which is perpendicular to the image plane. If in this position four forces are applied to the rod with the magnitude of each force, F_1=2 N, F_2=5 N, F_3=7 N and F_4=10 N, and the force F_2 forms an angle of 60° with the rod:

a. Calculate the torque exerted by each force.
b. If the mass of the rod is 2 kg (evenly distributed) and the distance from the axis of rotation to the left end of the rod is 20 cm, calculate the magnitude of the rod's angular acceleration.
c. Calculate the rod's angular velocity when the rod forms an angle of 30° to its initial position.



3. A pulley of uniform mass, M = 2 kg and radius R = 10 cm, is mounted on a fixed horizontal shaft, as shown in the following figure. A block of mass m = 1 kg is suspended from a massless rope wrapped around the edge of a pulley. Calculate (Assume the rope does not slip, and there is no friction on the pulley shaft):

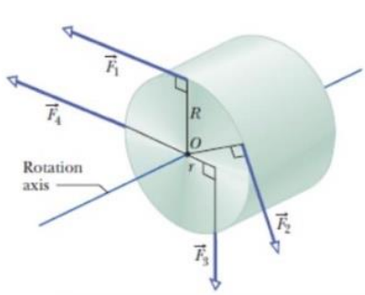


a. acceleration of falling block
b. angular acceleration of the pulley
c. tension of the rope.

4. Angular acceleration of a wheel $\alpha = 5t^4 - 6t^2$ rad/s^2. At t = 0s, the wheel has an angular velocity ω = 2 rad/s and position θ = 1.5 rad. Find:

a. angular velocity equation ω (in rad/s) as a function of time t.
b. angular position θ (in rad) as a function of time t.
c. plot the angular velocity ω and angular position θ as a function of time t.

5. In the following figure, a 1.5 kg cylinder is rotating about its main axis which passes through point O. Some forces which magnitudes are: F_1 = 4 N, F_2 = 3 N, F_3 = 2 N, and F_4 = 5 N works on the cylinder in the direction as shown in the figure. If r = 4 cm and R = 10 cm, and the relative angle of each force with respect to the cylinder does not change when the cylinder rotates, calculate:

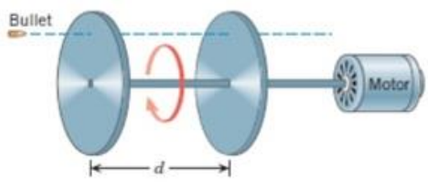


a. the magnitude of total torque
b. the magnitude of angular acceleration
c. angular acceleration direction
d. moment of inertia when cylinder rotates about an axis passing through capture point of F_3 and parallel with the rotation axis.
e. the magnitude of angular acceleration of problem d.

6. There are four particles with masses and coordinates as follows: m_1 = 25 g, x_1 = 2 cm, y_1 = 2 cm; m_2 = 50 g, x_2 = 0 cm, y_2 = 4 cm; m_3 = 30 g, x_3 = −3 cm, y_3 = −3 cm; and m_4 = 25 g, x_4 = −2 cm, y_4 = 4 cm. Determine the moment of inertia of the particle system if the axis of rotation is:

a. y = 1
b. x = 1
c. *z*-axis.

7. In the following picture you can see a tool for determining the speed of a fired bullet. This tool consists of two discs, which can rotate on their axis with an angular speed of 100.0 rad/s, which are separated by a distance of d = 0.5 m. If a bullet penetrates the left disk first before penetrating the right disk, and the difference in the angular positions of the bullet holes in the two disks is θ = 0.25 rad, determine the speed of the bullet.



8. An object rotates about a fixed axis, and the angular position of a reference line on the object is given by q = 0,4 e^{2t} rad/s. Consider a point on the object that is 4 cm from the axis of rotation. At t = 0s, determine the magnitudes of:

a. angular velocity
b. tangential acceleration component
c. radial acceleration component.