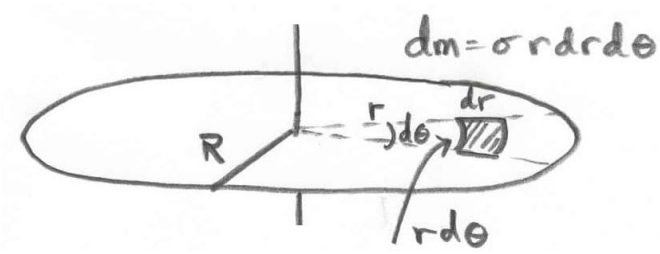
Two Dimensional Rotational Kinematics
Challenge Problems

Problem 1: Moment of Inertia: *Uniform Disc*

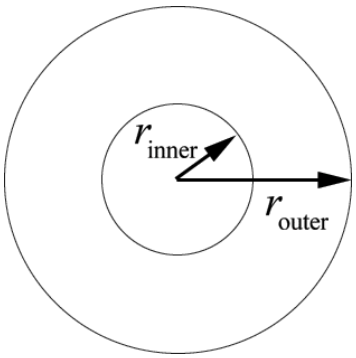
A thin uniform disc of mass M and radius R is mounted on an axis passing through the center of the disc, perpendicular to the plane of the disc. In this problem, you will calculate the moment of inertia about two different axes that pass perpendicular to the disc. One passes through the center of mass of the disc and the second passes through a point on the rim of the disc a distance R from the center.

As a starting point, consider the contribution to the moment of inertia from the mass element dm show in the figure below.



Problem 2: Rotational Dynamics: ***Moment of Inertia of a Washer***

A 1" US Standard Washer has inner radius $r_{\text{inner}} = 13.5\,\text{mm}$ and an outer radius $r_{\text{outer}} = 31.0\,\text{mm}$. The washer is approximately 4.0 mm thick. The density of the washer is $\rho = 7.8 \times 10^{3}\ \text{kg} \cdot \text{m}^{-3}$. Calculate the moment of inertia of the washer about an axis that is perpendicular to the plane of the washer and passes through its center of mass.



Problem 3: Moment of Inertia of a Sheet

a) Find the moment of inertia of a thin sheet of metal of mass m in the shape of an isosceles right triangle about an axis that passes through one vertex of the sheet, perpendicular to the plane of the sheet. The length of the two equal sides is s.

b) Find the moment of inertia of a thin sheet of metal of mass m in the shape of an isosceles right equilateral triangle about an axis that passes through the same vertex of the sheet, but aligned along one side of length s (in the plane of the sheet).

Problem 4:

A turntable is a uniform disc of mass 1.2 kg and radius 1.3×10^{-1} m. The turntable is spinning at a constant rate of $f_0 = 0.5$ Hz. The motor is turned off and the turntable slows to a stop in 8.0 s with constant angular deceleration.

a) What is the moment of inertia of the turntable?

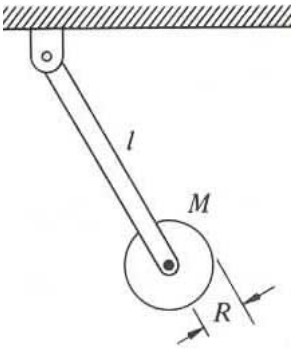
b) What is the initial rotational kinetic energy?

c) What is the angular deceleration of the turntable while it is slowing down?

d) What is the total angle in radians that the turntable spins while slowing down?

Problem 5:

A physical pendulum consists of a disc of radius R and mass m_d fixed at the end of a rod of mass m_r and length l.



a) What is the moment of inertia about the pivot point P?

b) How does the moment of inertia about the pivot point P change if the disk is mounted to the rod by a frictionless bearing so that it is perfectly free to spin?

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