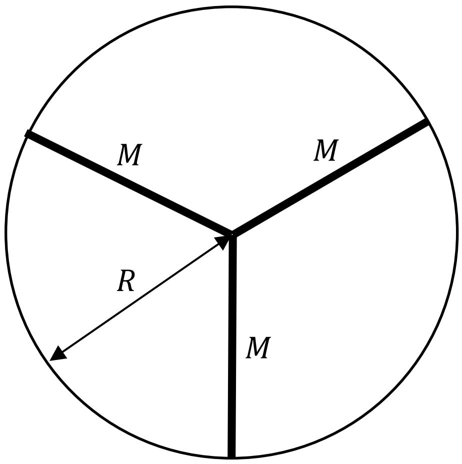
Problem 1.

A revolving door consists of three vertical, thin, homogeneous wings, each with mass M. The length of the wings is R. The revolving door is shown from above in the figure. The three wings are attached to each other and can rotate freely about a vertical rotation axis through the center of the



revolving door. When a person approaches the revolving door, the door must reach an angular speed of ω from rest during a time interval Δt. To obtain this rotation, a constant torque τ is applied to the revolving door in the direction of the rotation axis.

We use the following values: $\omega = 1.50\ \mathrm{rad/s}$ and $\Delta t = 1.00$ s, and the moment of inertia of the revolving door is $I = 112.5$ kg·m^2.

The magnitude of the constant torque τ is

A) $\tau = 14.1$ Nm
B) $\tau = 56.3$ Nm
C) $\tau = 169$ Nm
D) $\tau = 506$ Nm
E) Do not know

Problem 2.

A grinding wheel, shaped like a solid cylinder, rotates with 180 rotations per minute. The grinding wheel has mass 40 kg and a radius of 0.50 m.

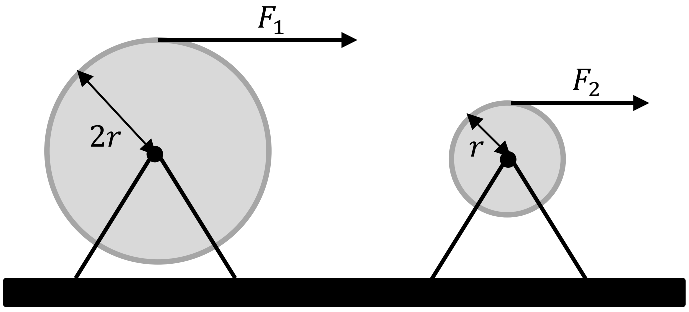
You hold an axe to the edge of the wheel to sharpen it. You press the axe into the wheel with a normal force of 120 N and the axe has a coefficient of friction with the grinding wheel of 0.60.

How fast does the grinding wheel stop rotating?

A) 1.6 s
B) 2.6 s
C) 12 s
D) 25 s
E) Do not know

Problem 3.

Two homogeneous cylinders have equal mass m. One has radius r and the other has radius $2r$. The cylinders are mounted such that they can rotate freely about a horizontal axis going through their centres. The cylinders are affected by the forces F_1 and F_2 (see the figure) in the horizontal direction with which they both reach the same angular acceleration α.

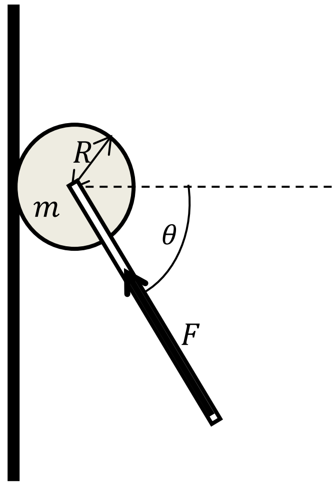


The proportionality between F_1 and F_2 is

A) $F_1 = \frac{1}{8}F_2$
B) $F_1 = \frac{1}{4}F_2$
C) $F_1 = \frac{1}{2}F_2$
D) $F_1 = F_2$
E) $F_1 = 2F_2$
F) $F_1 = 4F_2$
G) $F_1 = 8F_2$
H) Do not know

Problem 4.

A paint roller is pushed up along a vertical wall by a stiff, massless rod. The pushing force, F, is known and is always at angle θ with the horizontal (see figure). The paint roller, which can be viewed as a solid cylinder, rolls without slipping along the wall and has mass m, radius R and moment of inertia $I = \frac{1}{2}mR^2$ with respect to a horizontal axis going through the cylinder's center of mass. All of the parameters mentioned above are known.

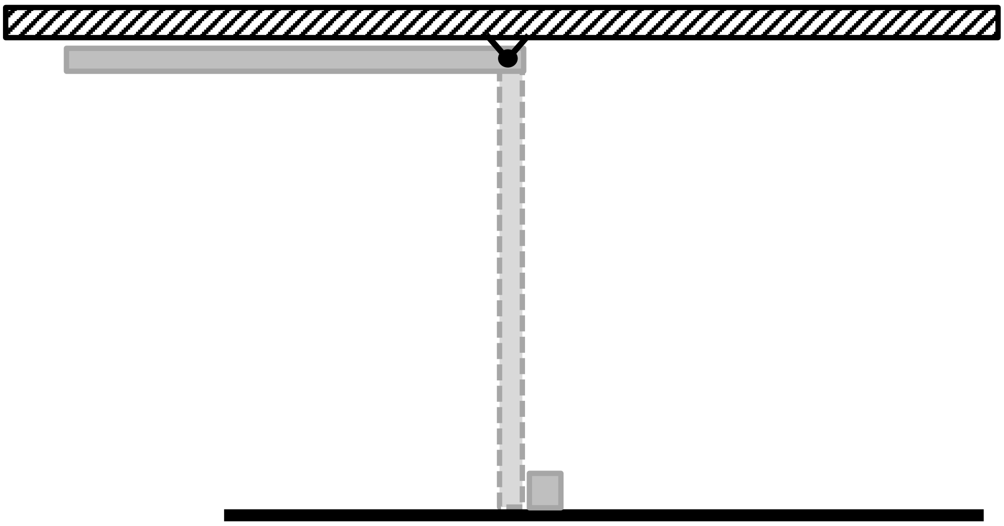


a) Draw a force-body diagram for the paint roller.
b) Determine the acceleration a of the paint roller.

The static coefficient of friction between the wall and the roller is μ_s.

c) Express the condition μ_s must fulfill for the paint roller to roll up the wall without slipping.

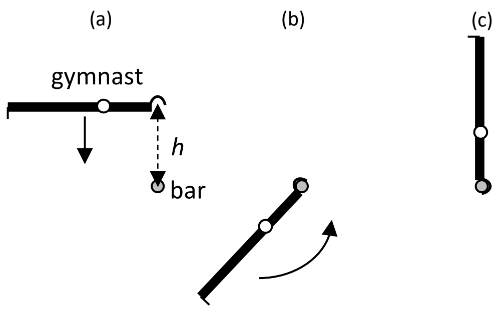
Problem 5.
A narrow, vertical rod with mass $6m$ and length L can rotate freely about a horizontal rotational axis through one end of the rod. The rod is released from the horizontal position and in the instant it is vertical, it collides (shown dashed) completely inelastically with a small block of mass m.



a) Find the rod's angular velocity, ω_1, just before the impact.
b) Find the rod's angular velocity, ω_2, just after the impact.

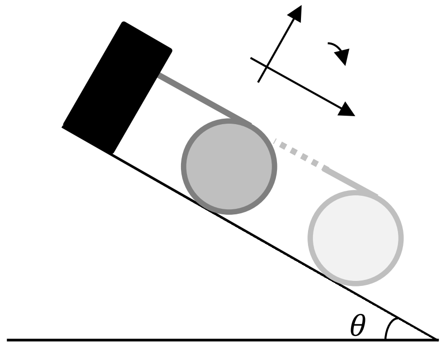
Problem 6.

A gymnast with raised arms can, as a simple approximation, be modelled as a homogeneous rod with length L. The gymnast falls from rest from a height h without rotating (see figure (a)), and catches a bar (a stationary, horizontal rod) and begins to rotate around the bar without friction between bar and hands (see figure (b)).



a) What is the angular velocity of the gymnast immediately after the collision with the bar?

b) What should h be for the gymnast to finish in a handstand (at rest in vertical position, see figure (c))?



Problem 7.

A homogeneous cylinder with mass m and radius r is on a slope, angled θ to the horizontal. The slope's surface is rough. A string is wound around the cylinder and its end is fastened to a wall. The string does not slip relative to the cylinder. The system is released from rest and the cylinder begins to rotate counterclockwise simultaneously with sliding relative to the slope. In the figure, the cylinder is illustrated in its starting position (dark) and at a later point in time (light, the entire string is not shown). The moment of inertia of the cylinder with respect to a horizontal rotational axis through its center of mass is $I = \frac{1}{2}mr^2$.

a) Which forces generate a torque on the cylinder with respect to an axis (away from the paper's plane) through the cylinder's contact point with the slope?
A) Gravitational force
B) Normal force
C) Friction force
D) Tension
E) Do not know

b) Which forces generate a torque on the cylinder with respect to an axis (away from the paper's plane) through the cylinder's contact point with the string?
A) Gravitational force
B) Normal force
C) Friction force
D) Tension
E) Do not know

The slope in the previous questions is now replaced by a smooth slope.

Using the coordinate system shown in the figure and the chosen rotation direction (clockwise)

c) Determine the geometric relation between the acceleration of the cylinder's center of mass, a_x, and the cylinder's angular acceleration, α.
d) What is the acceleration, a_x, of the cylinder's center of mass when it is released (the slope's surface is still smooth)?