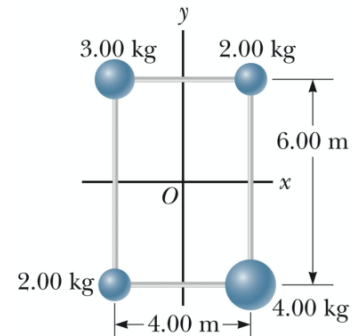


Mechanics 2, exercises week 3, NWI-MOL160

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Question 1: Rotating system of particles

The four particles in the figure are connected by rigid rods of negligible mass. The origin is at the center of the rectangle. The system rotates in the xy plane about the z -axis with an angular speed of 6.00 rad/s .



- 1a. Calculate the moment of inertia of the system about the z axis.
- 1b. Calculate the rotational kinetic energy of the system.
- 1c. Calculate the individual kinetic energies of each particle and confirm that the sum of these equals the total kinetic energy of the system.

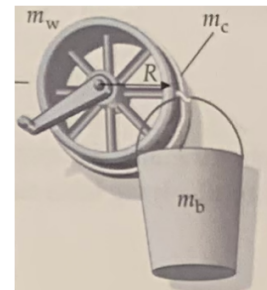
Question 2: A flywheel

Every time a car breaks, energy is wasted (mostly heating up the brakes). One way to avoid this is through systems that can store excess kinetic energy using a flywheel. A flywheel is typically a heavy metal cylinder spinning at high rotational speeds. Your new electric car has such a flywheel system, consisting of a 100 kg hollow metal cylinder (inner radius $R_1 = 25 \text{ cm}$, outer radius $R_2 = 40 \text{ cm}$), spinning at up to $30,000 \text{ rev/min}$. On your way home your batteries run empty 22 km before you reach home, despite your economical driving at 50 km/h that only dissipated 19 kW of energy.

- 2a. What is the maximum kinetic energy stored in the flywheel?
- 2b. If you continue driving economically, and your flywheel is fully charged, is this sufficient to get you home?
- 2c. Unfortunately, you also really need the bathroom. So you speed up to 100 km/h , dissipating 52 kW of power. Will you make it home?

Question 3: A winch and bucket

A winch is at the top of a deep well. The drum of the winch has mass m_w and radius R , with virtually all its mass concentrated a distance R from the axis. A cable wound around the drum holds a bucket of water of mass m_b . The entire cable has mass m_c and length L . Just when you have the full bucket at the highest point your hands slip and the bucket falls back down the well, unwinding the cable as it goes.



- 3a. How fast is the bucket going after it has fallen a distance d (where $d < L$)?
- 3b. How long does it take for the bucket to fall this distance d ?

Question 4: Pure roll

A cylinder of mass 10.0 kg rolls without slipping on a horizontal surface. At a certain instant, its center of mass has a speed of 10.0 m/s . Determine:

- 4a. The translational kinetic energy of its centre of mass.
- 4b. The rotational kinetic energy around its centre of mass.
- 4c. Its total kinetic energy.