Physic² 121:
Phundament°ls of Phy²ics I

November 20, 2006

Make-Up Exam

- 8:00-9:00
  - Room PHYS 1201
- 12:00-1:00
  - Room PHYS 4220
- 5:00-6:00
  - Room PHYS 1201
- 1201 is a fairly large room (seats ~70)

Chapter 8

Rotational Equilibrium
and
Rotational Dynamics

Torque and Angular Acceleration

- When a rigid object is subject to a net torque ($\neq 0$), it undergoes an angular acceleration
- The angular acceleration is directly proportional to the net torque
  - The relationship is analogous to $\sum F = ma$
    - Newton's Second Law

Moment of Inertia

- The angular acceleration is inversely proportional to the analogy of the mass in a rotating system
- This mass analog is called the *moment of inertia,* I, of the object

$$I \equiv \Sigma m r^2$$

  - SI units are kg m^2

Newton's Second Law for a Rotating Object

$$\Sigma\tau = I\alpha$$

- The angular acceleration is directly proportional to the net torque
- The angular acceleration is inversely proportional to the moment of inertia of the object

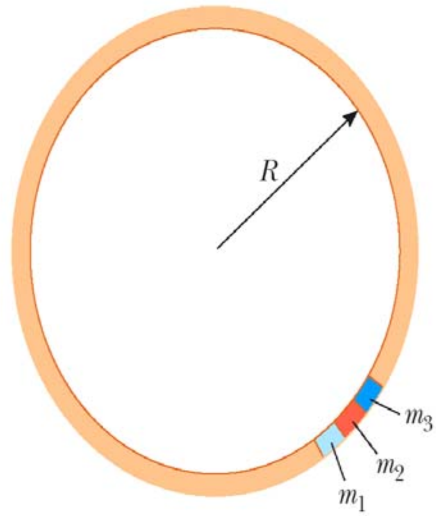
More About Moment of Inertia

- There is a major difference between moment of inertia and mass: the moment of inertia depends on the quantity of matter *and its distribution* in the rigid object.
- The moment of inertia also depends upon the location of the axis of rotation

Moment of Inertia of a Uniform Ring

- Image the hoop is divided into a number of small segments, m_1 …
- These segments are equidistant from the axis

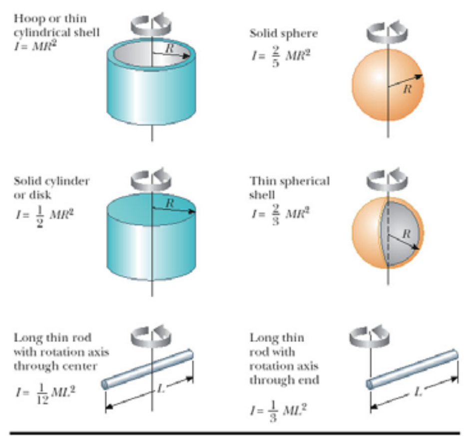
$$I = \Sigma m_i r_i^2 = MR^2$$



Other Moments of Inertia

TABLE 8.1

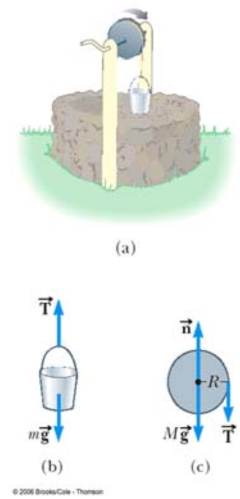
Moments of Inertia for Various Rigid Objects of Uniform Composition



Example, Newton's Second Law for Rotation

- Draw free body diagrams of each object
- Only the cylinder is rotating, so apply $\Sigma\tau = I\,\alpha$
- The bucket is falling, but not rotating, so apply $\Sigma F = m\,a$
- Remember that $a = \alpha\, r$ and solve the resulting equations

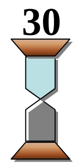
- Problem: A solid, frictionless cylindrical reel of mass M = 3 kg and radius R = 0.4 m is used to draw water from a well. A bucket of mass 2 kg is attached to a cord wrapped around the cylinder.
  – Find the tension in the cord and acceleration of the bucket

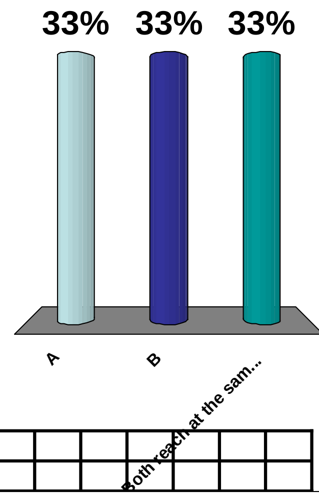


?

Two cylinders of the same size and mass roll down an incline. Cylinder *A* has most of its weight concentrated at the rim, while cylinder *B* has most its weight concentrated at the center. Which reaches the bottom of the incline first?

1. A
2. B
3. Both reach at the same time





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1 2 3 4 5

Rotational Kinetic Energy

- An object rotating about some axis with an angular speed, ω, has rotational kinetic energy $\frac{1}{2}I\omega^2$
- Energy concepts can be useful for simplifying the analysis of rotational motion

Total Energy of a System

- Conservation of Mechanical Energy

$$(KE_t + KE_r + PE_g)_i = (KE_t + KE_r + PE_g)_f$$

  - Remember, this is for conservative forces, no dissipative forces such as friction can be present
  - Potential energies of any other conservative forces could be added

Work-Energy in a Rotating System

- In the case where there are dissipative forces such as friction, use the generalized Work-Energy Theorem instead of Conservation of Energy
- $W_{nc} = \Delta KE_t + \Delta KE_R + \Delta PE$