

Two Dimensional Rotation and Translation Dynamics

Concept Questions

Question 1: Rotation and Translation

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

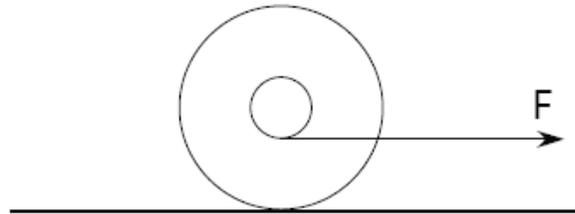
1. A
2. B
3. Both have the same

Answer 2. Both cylinders begin with the same potential energy with respect to the bottom of the inclined plane. When the cylinders reach the bottom of the inclined plane, each has the same amount of kinetic energy

$$K = (1/2)I_{cm}\omega^2 + (1/2)mv_{cm}^2 = (1/2)(I_{cm} + mR^2)\omega^2 .$$

The cylinder with the smaller moment of inertia I_{cm} (cylinder B) has the larger angular speed ω , hence the larger speed. Therefore cylinder B reaches the bottom of the incline plane first.

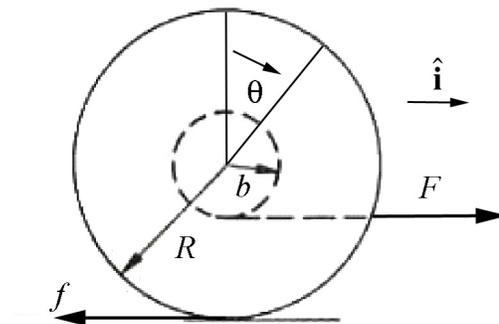
Question 2



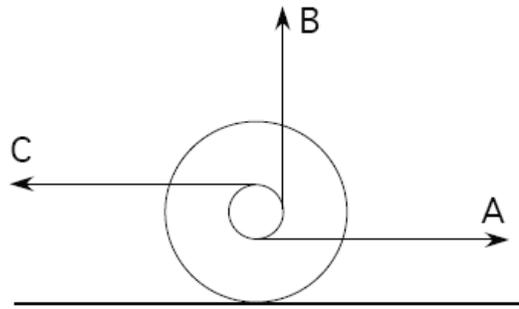
Two disks are separated by a spindle of smaller diameter. A string is wound around the spindle and pulled gently. In which direction does it roll?

- 1) To the right, in the direction of F , winding up the string
- 2) To the left, opposite to F , unwinding the string
- 3) It does not roll, it slides to the right
- 4) It does not roll, it slides to the left

Answer 1. For forces below a fixed maximum value, the torque due to the force of friction is larger in magnitude than the torque due to the pulling force. Therefore the cylinder has an angular acceleration pointing into the page (in the clockwise direction) hence the cylinder rolls to the right, in the direction of F , winding up the string.



Question 3



Two disks are separated by a spindle of smaller diameter. A string is wound around the spindle and pulled gently. At what position of the string does the direction of rotation change?

- 1) At A
- 2) Somewhere between A and B
- 3) At B
- 4) Somewhere between B and C
- 5) At C
- 6) It always rolls to the right

Answer 2. When the string is pulled up, the only horizontal force is static friction and it points to the left so the yo-yo accelerates to the left. Therefore somewhere between A and B the direction of rotation changes.

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8.01SC Physics I: Classical Mechanics

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