

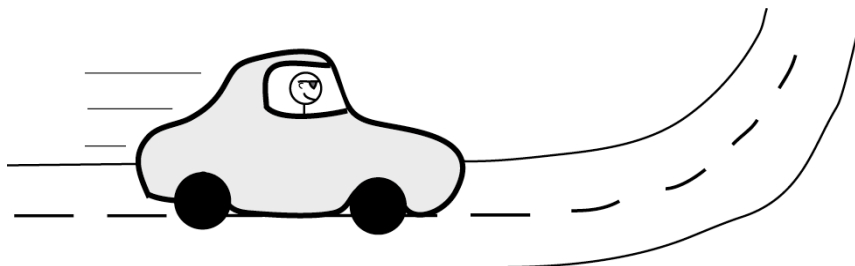
PHYS 1901 Physics Advanced

Tutorial 4: Mechanics

A. Qualitative Questions:

1. Car around a bend

As a car speeds around a curve, the passengers tend to be thrown radially outward. Why are the astronauts in a space shuttle not similarly affected as their shuttle orbits around the earth?



2. Rebecca in Cairns and Brent in Sydney

Rebecca has gone to a conference in Cairns in North Queensland, leaving Brent at home in Sydney to look after his pet axolotl, Barry. Using a diagram showing their positions on the Earth explain:

- Which one of them has a greater angular velocity, ω ?
- Which one of them has a greater linear velocity, v ?

B. Demonstration Questions:

1. Tools

On display are tools that use ‘torque’ in their design and application. Identify their pivots, axes of rotation and the direction of forces on the tools.

Why is it easier to loosen a tight screw with a thick handled screwdriver than a skinny one?

2. Finding your own centre of mass

Use the two bathroom scales and the plank to find your own centre of mass.

Where is your centre of mass when the readings on the two scales are the same?

On a human the centre of mass is usually around 55% of the height, up from the feet, when the arms are at the sides of the body, a little lower on average for females than males.

3. Physical pendulum

A rigid body is free to rotate about a fixed axis. Can the body have non-zero angular acceleration even if the angular velocity of the body is (perhaps instantaneously) zero?

What is the linear equivalent of this question?

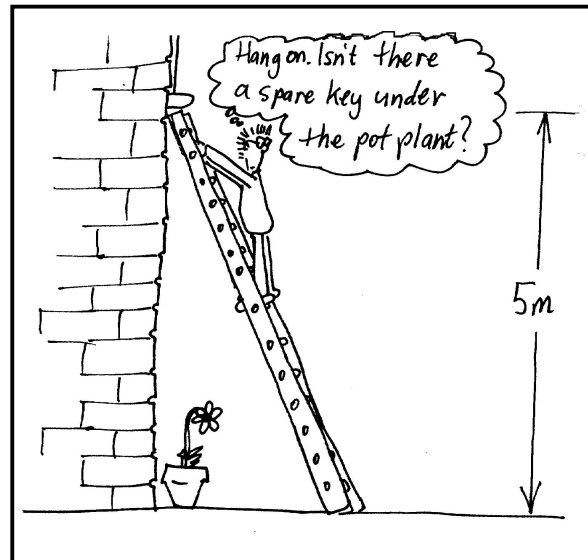
Give examples to illustrate both the angular and linear situations.

C. Quantitative Questions:

1. Brent's ladder

Brent has locked himself out of his house and is trying to break back in. He discovers that an upstairs window is open. The window is 5.0 m above ground level and the wall is made of smooth bricks (i.e., is effectively frictionless). Brent, whose mass is 70 kg, sets up his ladder so that the top rests on the window sill. The ladder is 7.0 m long and weighs 25 kg. The coefficient of friction between the ground and the ladder is $\mu_s = 0.45$.

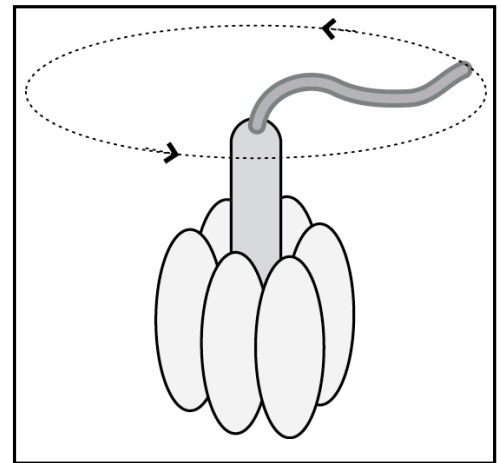
- Draw a diagram of Brent climbing the ladder. Label the forces acting on the ladder.
- Will Brent be able to climb to the top of the ladder (with his feet on the top rung) without it sliding?
- How could Brent's friend Rebecca help? (Apart from having a spare set of keys!!!)



2. FI-ATPase molecule

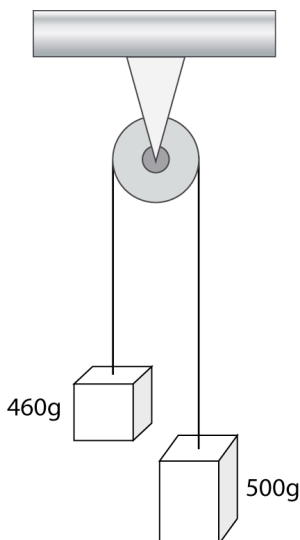
Many bacteria have flagella or cilia, tiny little waving appendages, which they use to propel themselves, some of which act as tiny propellers. The smallest natural propeller is part of an ATPase molecule. The FI-ATPase molecule has seven sub-units, six of which form a ring around the seventh sub-unit, as shown opposite. This middle piece spins around like the rotor of an electric motor.

- If one complete rotation takes 100 ms, what is the angular velocity of the attached actin molecule?
- If the actin propeller molecule is $1\text{ }\mu\text{m}$ long and has a mass of $2 \times 10^{-22}\text{ kg}$, what is its moment of inertia? [Hint: treat the actin molecule as a rod: $I = ml^2/3$]
- Assuming constant angular acceleration, if it takes 100 ms to perform a rotation starting from rest, what is the angular acceleration of the actin?
- What torque must the ATPase apply to achieve this acceleration?



3. Atwood's machine

In an Atwood's machine one block has a mass of 500 g, and the other a mass of 460 g. The pulley, which is mounted in horizontal frictionless bearings, has a radius of 50.0 mm.



The pulley has a mass and so the tension in the two parts of the rope is different. When released from rest, the heavier block is observed to fall 750 mm in 5.00 s (without the cord slipping on the pulley).

- Describe the motion of the blocks when they are released from rest. What is the acceleration of each block?
- What is the tension in the part of the rope that supports the heavier block?
- What is the tension in the part of the rope that supports the lighter block?
- Describe the motion of the pulley. What causes its angular acceleration?
- What is the angular acceleration of the pulley?
- What is the moment of inertia of the pulley?