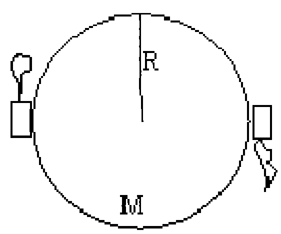
Physics 211 Week 8

Rotational Kinematics and Energy: Space Station

A space station is constructed in the shape of a wheel 22m in diameter, with essentially all its weight (5.0×10^5 kg) at the rim. Once the space station is completed, it is set rotating at a rate such that an object at the rim experiences a radial acceleration equal to the Earth's gravitational acceleration g, thus simulating Earth's gravity. To accomplish this, two small rockets are attached on opposite sides of the rim, each able to provide a 100N force. How long will it take to reach the desired rotation rate and how many revolutions will the space station make in this time?

The space station will start from rest. Torque from the rockets will cause an angular acceleration until the desired rate of rotation is achieved. Begin by finding the desired rotation rate where the centripetal acceleration is equal to the earth's acceleration. Next, set the torque created by the applied force of the rockets equal to the moment of inertia times the angular acceleration to find the acceleration of the wheel; you may ignore the mass of the rockets. Then you can use rotational kinematics with the angular acceleration and angular velocity to find the time it takes and the number of revolutions the station will make to reach the desired rate of rotation. You should obtain a time of 2.6×10^4 seconds and a total of 1.95×10^3 revolutions.



Physics 211 Week 8

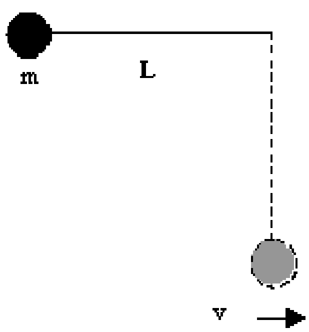
Rotational Kinematics and Energy: Rotating Tip

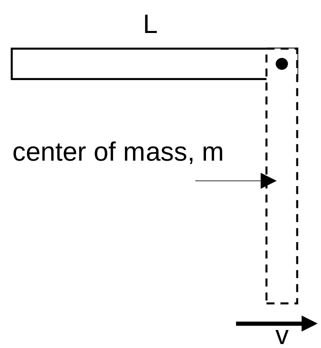
In the Physics 211 Laboratory one group of students has decided to pursue their own experiments. They make a simple pendulum from a weight attached to a string of length L. They attach the other end of the string to a fixed support. They hold the weight with the string taut and horizontal and then released it. With their motion sensor they measure the speed of the weight as the string passes through the vertical. Remembering that all objects fall with the same acceleration, the students do a second experiment. They attach one end of a uniform stick of length L to the support, which acts as a pivot. They hold the stick horizontal and release it. They then measure the speed of the tip of the stick with their motion sensor. Do they measure the same speed?

Both situations can be treated as a conservation of energy where gravitational potential energy becomes rotational kinetic energy. The simple pendulum will have a change in gravitational potential energy equal to the length of the string; however, the rod will have a change half of that value since the center of mass of the rod is not at the tip as it is for the simple pendulum. The two set-ups also have different moments of inertia. Write a conservation of energy equation for each of the two set-ups. Solving for the translational speeds of the tips, the pendulum will measure $v = \sqrt{2gL}$

while the speed of the rod will measure $v = \sqrt{3gL}$

Therefore, the tip of the stick is faster than the pendulum.





Physics 211 Week 8

Energy Conservation: Pothole (Solutions)

A car is traveling along a horizontal road when it suddenly encounters a pothole, in which the level of the road abruptly changes by a height *h*. The suspension springs of the car have a spring constant of 110,000 N/m and can compress a maximum distance of 0.4m. The mass of the car is 1200 kg. What is the maximum value of *h* that the car can tolerate before bottoming out?

All of the gravitational potential energy becomes spring potential energy when the car enters the pothole. Because the gravitational potential energy changes as the spring compresses vertically, the height that should be used for the change in gravitational potential energy is the sum of the height of the pothole and the amount the spring is compressed. Equating this value with the expression for spring potential energy, you can solve for the spring compression. You should obtain a compression of 0.35 *m*.

Physics 211 Week 8

Momentum: Skate-Board Exhibition

You are helping your friend prepare for his skate-board clowning stunt. For his program, he plans to take a running start, then jump onto a gigantic 7kg stationary skateboard. He and the skateboard will glide in a straight line along a short, level section of track, then up a sloped concrete wall. He has measured his maximum running speed to jump safely on the skateboard at 6 m/s, and he wants to know how high above ground level he will make as he rolls up the slope. He tells you his weight is 70 kg.

The first part of the problem is an inelastic collision; your moving friend collides with and sticks to a skateboard. Using conservation of momentum, you can find the speed that your friend will move with while on the skateboard. The second part of the problem uses energy conservation. The kinetic energy your friend has with his skateboard becomes gravitational potential energy as he moves up the incline. You can find the height that he reaches by equating the gravitational potential energy at the highest point, where the skateboard has ceased motion, to the kinetic energy of your friend on the board when he is on the level section of the track. You should obtain a height of 1.52 *m*.