PHYS 1501 Final Review

Projectile Motion

Calculating Projectile Motion: Tennis Player

A tennis player wins a match at Arthur Ashe stadium and hits a ball into the stands at 30 m/s and at an angle $45°$ above the horizontal (Figure 4.14). On its way down, the ball is caught by a spectator 10 m above the point where the ball was hit. (a) Calculate the time it takes the tennis ball to reach the spectator. (b) What are the magnitude and direction of the ball's velocity at impact?

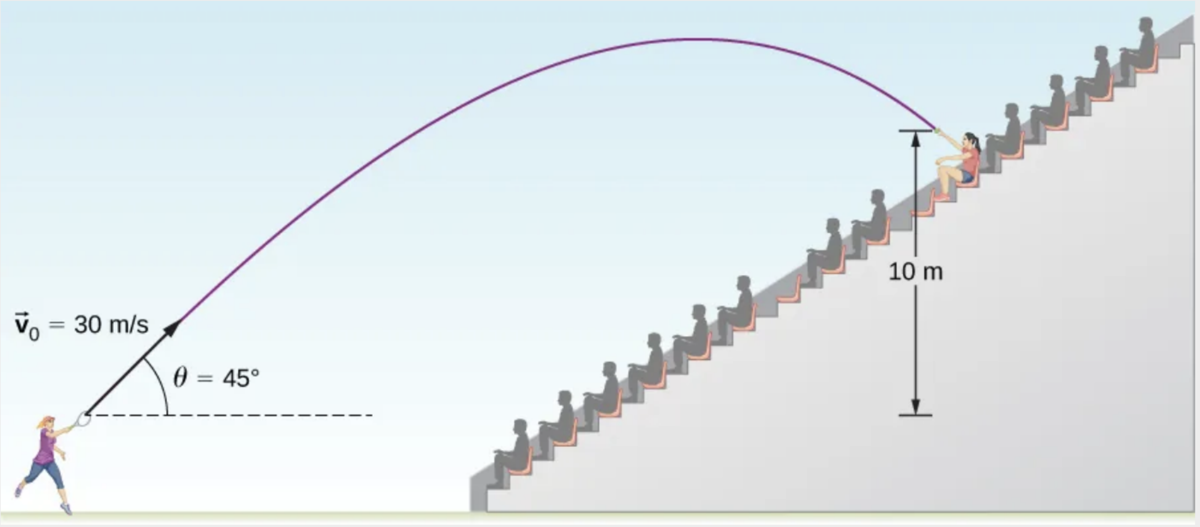


Figure 4.14 The trajectory of a tennis ball hit into the stands.

Relative and Circular Motion

- A jet is flying at 134.1 m/s along a straight line and makes a turn along a circular path level with the ground. What does the radius of the circle have to be to produce a centripetal acceleration of 1 g on the pilot and jet toward the center of the circular trajectory?

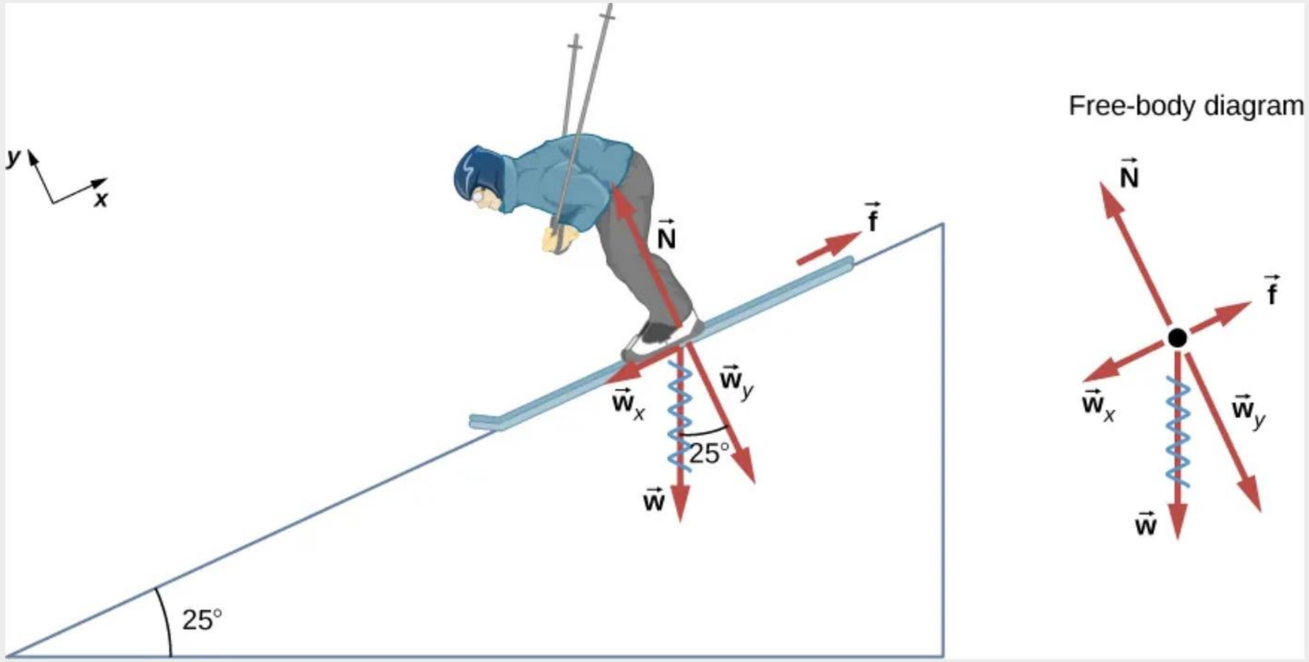
Newton's Laws

- When Does Newton’s First Law Apply to Your Car? Newton’s laws can be applied to all physical processes involving force and motion, including something as mundane as driving a car.
- (a) Your car is parked outside your house. Does Newton’s first law apply in this situation? Why or why not?
- (b) Your car moves at constant velocity down the street. Does Newton’s first law apply in this situation? Why or why not?

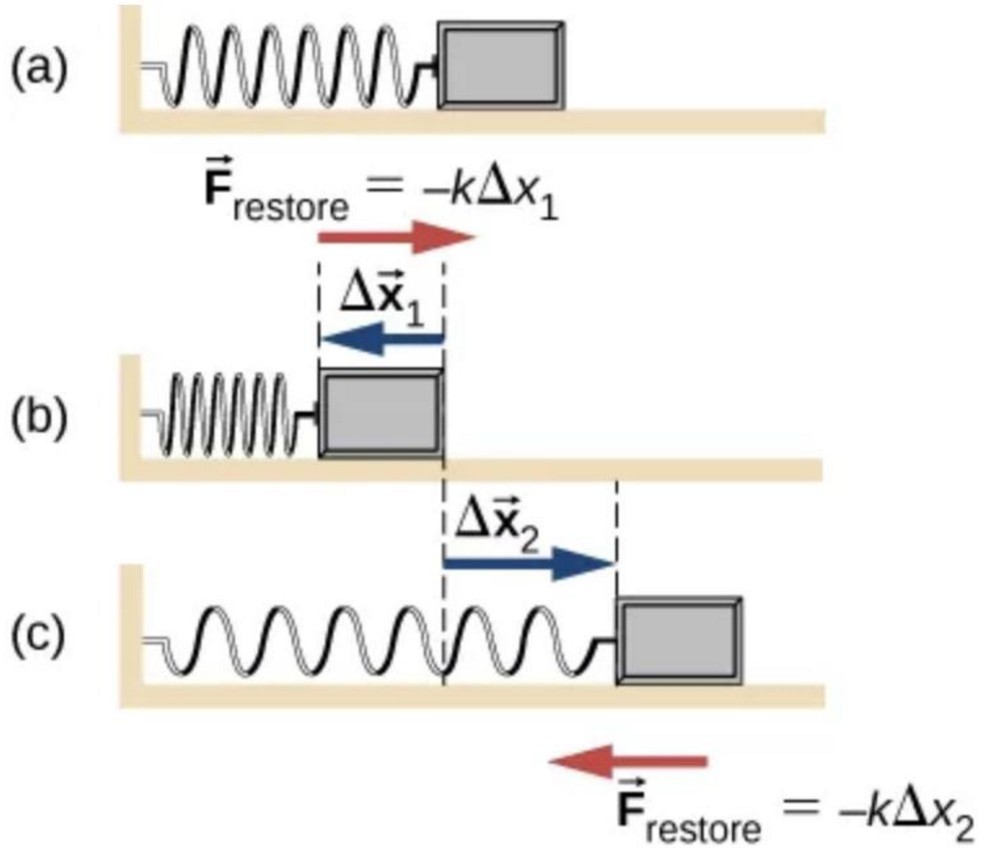
Free Body Diagrams

Weight on an Incline

Consider the skier on the slope in Figure 5.22. Her mass including equipment is 60.0 kg. (a) What is her acceleration if friction is negligible? (b) What is her acceleration if friction is 45.0 N?



Springs and Friction



Work-Energy Theorem

Loop-the-Loop

The frictionless track for a toy car includes a loop-the-loop of radius *R*. How high, measured from the bottom of the loop, must the car be placed to start from rest on the approaching section of track and go all the way around the loop?

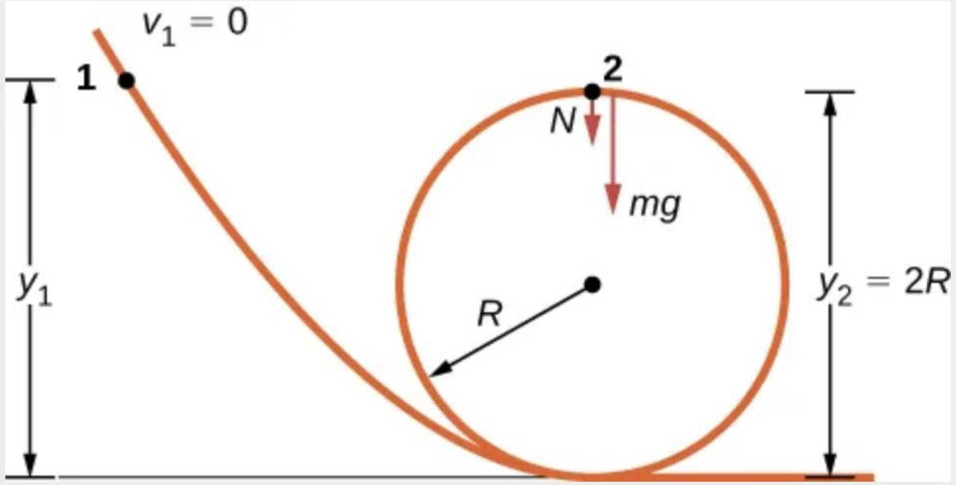
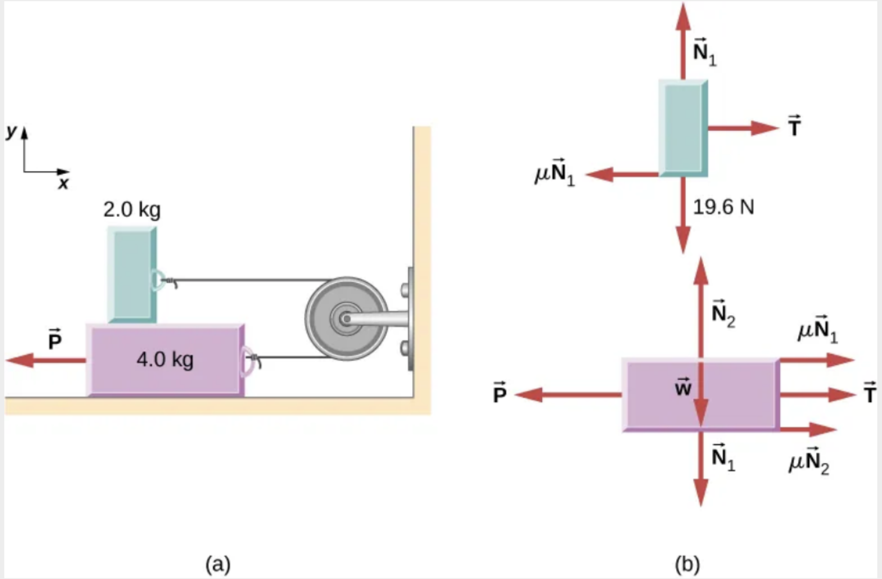


Figure 7.12 A frictionless track for a toy car has a loop-the-loop in it. How high must the car start so that it can go around the loop without falling off?

Friction

Sliding Blocks

The two blocks of Figure 6.17 are attached to each other by a massless string that is wrapped around a frictionless pulley. When the bottom 4.00-kg block is pulled to the left by the constant force $\vec{\mathbf{P}}$, the top 2.00-kg block slides across it to the right. Find the magnitude of the force necessary to move the blocks at constant speed. Assume that the coefficient of kinetic friction between all surfaces is 0.400.



Power

How much power must an automobile engine expend to move a 1200-kg car up a 15% grade at 90 km/h (Figure 7.15)? Assume that 25% of this power is dissipated overcoming air resistance and friction.

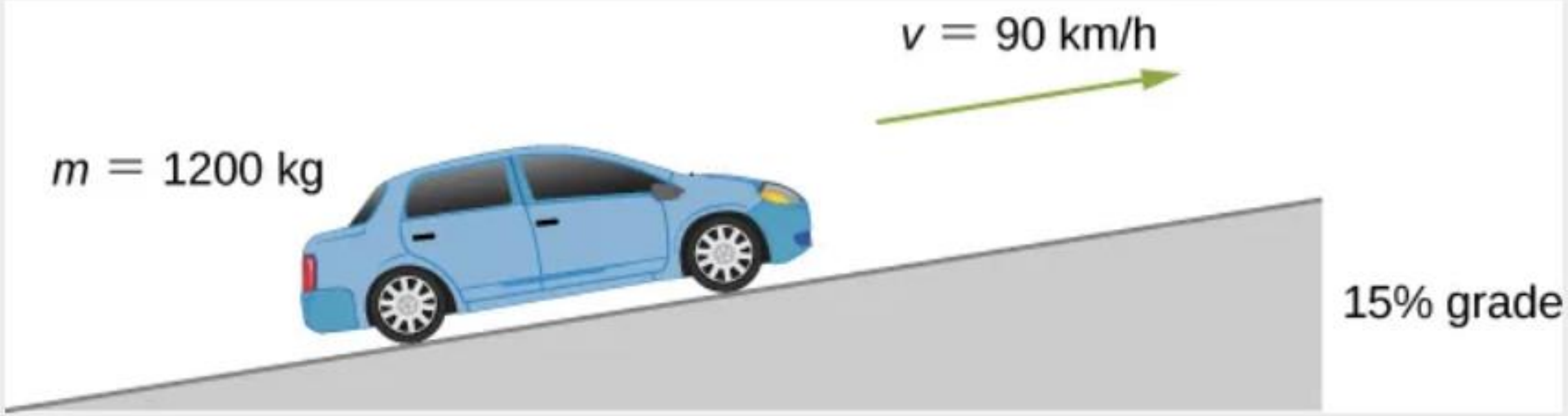


Figure 7.15 We want to calculate the power needed to move a car up a hill at constant speed.

Center of Mass

Determine how far the center of mass of the Earth-moon system is from the center of Earth. Compare this distance to the radius of Earth, and comment on the result. Ignore the other objects in the solar system.

$$m_e = 5.97 \times 10^{24} \text{ kg}$$

$$m_m = 7.36 \times 10^{22} \text{ kg}$$

$$r_m = 3.82 \times 10^{8} \text{ m.}$$

Lets take a short break

Conservation of Momentum

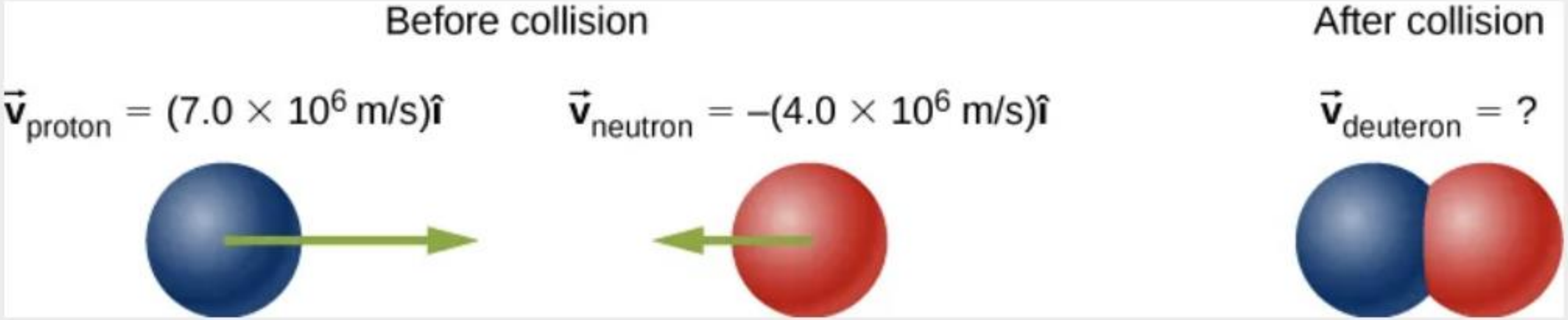
Thor vs. Iron Man

The 2012 movie "The Avengers" has a scene where Iron Man and Thor fight. At the beginning of the fight, Thor throws his hammer at Iron Man, hitting him and throwing him slightly up into the air and against a small tree, which breaks. From the video, Iron Man is standing still when the hammer hits him. The distance between Thor and Iron Man is approximately 10 m, and the hammer takes about 1 s to reach Iron Man after Thor releases it. The tree is about 2 m behind Iron Man, which he hits in about 0.75 s. Also from the video, Iron Man's trajectory to the tree is very close to horizontal. Assuming Iron Man's total mass is 200 kg:

a. Estimate the mass of Thor's hammer
b. Estimate how much kinetic energy was lost in this collision

Inelastic Collisions

A proton (mass 1.67×10^{-27} kg) collides with a neutron (with essentially the same mass as the proton) to form a particle called a *deuteron*. What is the velocity of the deuteron if it is formed from a proton moving with velocity 7.0×10^{6} m/s to the left and a neutron moving with velocity 4.0×10^{6} m/s to the right?



Rotational Kinematics

A Spinning Bicycle Wheel

A bicycle mechanic mounts a bicycle on the repair stand and starts the rear wheel spinning from rest to a final angular velocity of 250 rpm in 5.00 s. (a) Calculate the average angular acceleration in $\mathrm{rad/s^2}$. (b) If she now hits the brakes, causing an angular acceleration of $-87.3\ \mathrm{rad/s^2}$, how long does it take the wheel to stop?

Moment of Inertia

Moment of Inertia of a System of Particles

Six small washers are spaced 10 cm apart on a rod of negligible mass and 0.5 m in length. The mass of each washer is 20 g. The rod rotates about an axis located at 25 cm, as shown in Figure 10.19. (a) What is the moment of inertia of the system? (b) If the two washers closest to the axis are removed, what is the moment of inertia of the remaining four washers? (c) If the system with six washers rotates at 5 rev/s, what is its rotational kinetic energy?

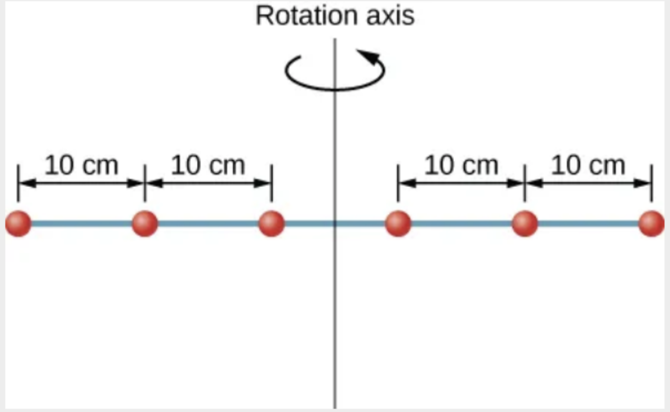


Figure 10.19 Six washers are spaced 10 cm apart on a rod of negligible mass and rotating about a vertical axis.

Torque

Calculating Torque on a rigid body

Figure 10.35 shows several forces acting at different locations and angles on a flywheel. We have $|\vec{F}_1| = 20\,N$, $|\vec{F}_2| = 30\,N$, $|\vec{F}_3| = 30\,N$, and $r = 0.5\,m$. Find the net torque on the flywheel about an axis through the center.

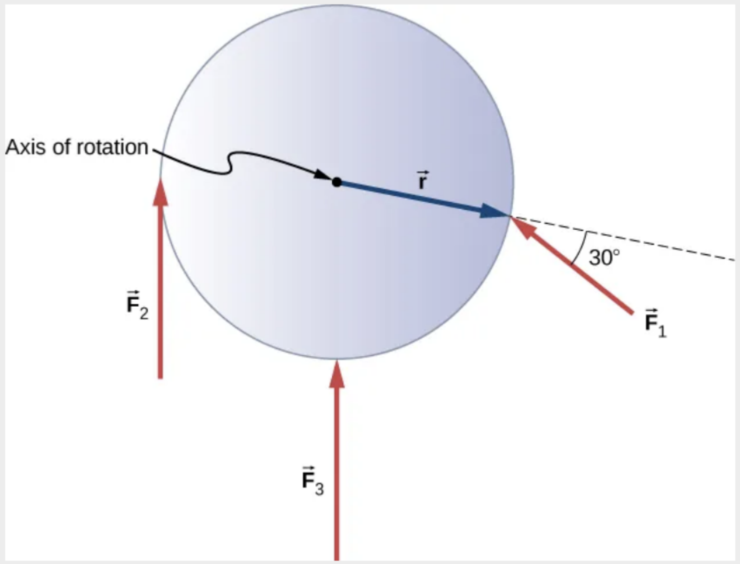


Figure 10.35 Three forces acting on a flywheel.

Statics

Three masses are attached to a uniform meter stick, as shown in Figure 12.9. The mass of the meter stick is 150.0 g and the masses to the left of the fulcrum are $m_1 = 50.0$ g and $m_2 = 75.0$ g. Find the mass m_3 that balances the system when it is attached at the right end of the stick, and the normal reaction force at the fulcrum when the system is balanced.

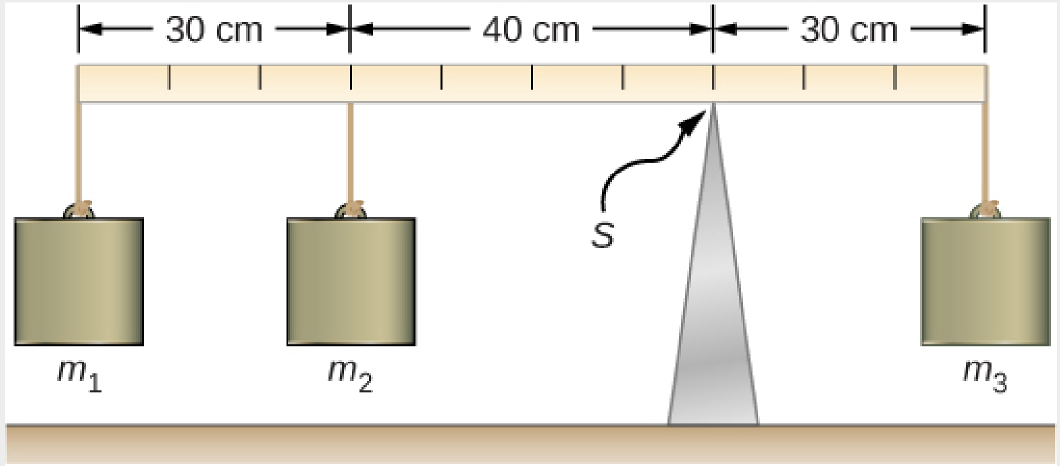


Figure 12.9 In a torque balance, a horizontal beam is supported at a fulcrum (indicated by *S*) and masses are attached to both sides of the fulcrum. The system is in static equilibrium when the beam does not rotate. It is balanced when the beam remains level.

Angular Momentum

A meteor enters Earth's atmosphere (Figure 11.10) and is observed by someone on the ground before it burns up in the atmosphere. The vector $\vec{\mathbf{r}} = 25\ \text{km}\hat{\mathbf{i}} + 25\ \text{km}\hat{\mathbf{j}}$ gives the position of the meteor with respect to the observer. At the instant the observer sees the meteor, it has linear momentum $\vec{\mathbf{p}} = 15.0\ \text{kg}(-2.0\text{km/s}\hat{\mathbf{j}})$, and it is accelerating at a constant $2.0\ \text{m/s}^2(-\hat{\mathbf{j}})$ along its path, which for our purposes can be taken as a straight line. (a) What is the angular momentum of the meteor about the origin, which is at the location of the observer? (b) What is the torque on the meteor about the origin?

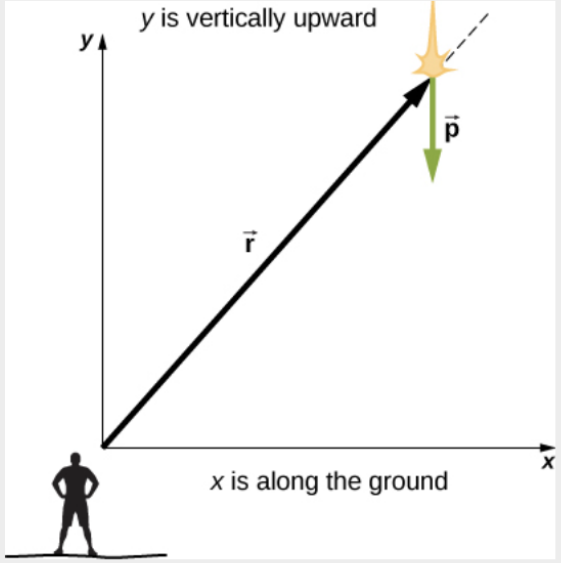


Figure 11.10 An observer on the ground sees a meteor at position $\vec{\mathbf{r}}$ with linear momentum $\vec{\mathbf{p}}$.

Gravitation

- Two asteroids are drifting away from each other. One asteroid has a mass of 240000 kg, and the other has a mass of 100000 kg. What is the change in gravitational potential energy as their centers of mass move from 100 m apart to 1000 m apart?

Harmonic Motion

A 2.00-kg block is placed on a frictionless surface. A spring with a force constant of $k = 32.00 \text{ N/m}$ is attached to the block, and the opposite end of the spring is attached to the wall. The spring can be compressed or extended. The equilibrium position is marked as $x = 0.00 \text{ m}$.

Work is done on the block, pulling it out to $x = +0.02 \text{ m}$. The block is released from rest and oscillates between $x = +0.02 \text{ m}$ and $x = -0.02 \text{ m}$. The period of the motion is 1.57 s. Determine the equations of motion.

Pendulums

- What is the acceleration due to gravity in a region where a simple pendulum having a length 75.000 cm has a period of 1.7357 s?

Wave Mechanics

- A student takes a 30.00-m-long string and attaches one end to the wall in the physics lab. The student then holds the free end of the rope, keeping the tension constant in the rope. The student then begins to send waves down the string by moving the end of the string up and down with a frequency of 2.00 Hz. The maximum displacement of the end of the string is 20.00 cm. The first wave hits the lab wall 6.00 s after it was created. (a) What is the speed of the wave? (b) What is the period of the wave? (c) What is the wavelength of the wave?

Fluids

Fire hoses used in major structural fires have an inside diameter of 6.40 cm (Figure 14.33). Suppose such a hose carries a flow of 40.0 L/s, starting at a gauge pressure of $1.62 \times 10^6 \text{N/m}^2$. The hose rises up 10.0 m along a ladder to a nozzle having an inside diameter of 3.00 cm. What is the pressure in the nozzle?

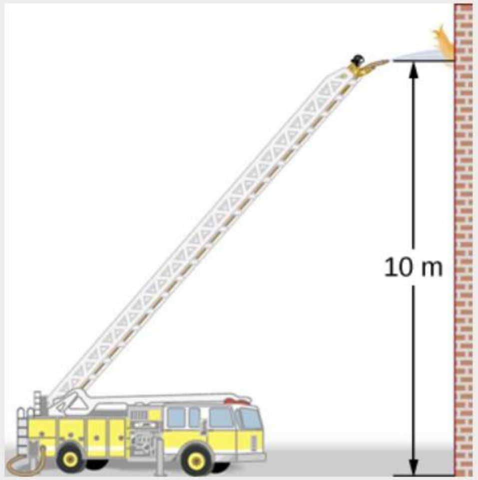


Figure 14.33 Pressure in the nozzle of this fire hose is less than at ground level for two reasons: The water has to go uphill to get to the nozzle, and speed increases in the nozzle. In spite of its lowered pressure, the water can exert a large force on anything it strikes by virtue of its kinetic energy. Pressure in the water stream becomes equal to atmospheric pressure once it emerges into the air.

You Got This!