A wire of length \( l_0 \) and cross-sectional area \( A \) supports a hanging weight \( W \). (a) Show that if the wire obeys Eq. (11.7), it behaves like a spring of force constant \( \frac{YA}{l_0} \), where \( Y \) is Young's modulus for the material of which the wire is made. (b) What would the force constant be for a 75.0-cm length of 16-gauge (diameter = 1.291 mm) copper wire? See Table 11.1. (c) What would the force constant be for a 75.0-cm length of 16-gauge copper wire? See Table 11.1. (d) Show that if the wire obeys Eq. (11.7), it behaves like a spring of force constant \( N/m \), where \( X \) is Young's modulus. (e) What would the weight \( W \) be to stretch the wire in part (b) by 1.25 mm?
In lab tests on a 9.25-cm cube of a certain material, a force of 1375 N directed at 8.50° to the cube causes the cube to deform through an angle of 1.24°. What is the shear modulus of the material?

\[ \theta \approx \tan(\theta) = \frac{y}{x} \]

\[ S = \frac{F / A}{x/h} \]

11.38

11.40. What is the shear modulus of the material?
A 2.00-kg frictionless block is attached to an ideal spring with force constant \( k = 315 \text{ N/m} \). Initially, the spring is neither stretched nor compressed, but the block is moving in the negative direction at 12.0 m/s and undergoes a simple harmonic motion (SHM).

Let's characterize the SHM of the block. Find:

(a) (5 pts) the period \( (T) \) in seconds

(b) (5 pts) the maximum speed \( (v_{\text{max}}) \) in m/s

(c) (5 pts) the amplitude \( (A) \) of the motion in meters

(d) (5 pts) the maximum magnitude of the force (in N) on the block exerted by the spring during the motion.

[Bonus (10 pts)] If you have time, sketch \( x \)-t and \( v \)-t graphs of this motion.

1) Visualizing the situation
2) Spring force + no friction
3) Mechanical Energy Conservation

A 2.00-kg frictionless block is attached to an ideal spring with force constant \( k = 315 \text{ N/m} \). Initially, the spring is neither stretched nor compressed, but the block is moving in the negative direction at 12.0 m/s and undergoes a simple harmonic motion (SHM). Let's characterize the SHM of the block.
Problem I (25 points)

In an oil-lit hospital well, a bucket is suspended over the well's mouth at a height of 9.4 meters above the water. The bucket is filled with water. We assume that the water is massless and that it encounters no friction while being lifted. The bucket is filled with water that is 18.0°C and has a mass of 1.75 kg. In order to reach the top of the bucket, the water must descend a height of 2.00 m. The bucket weighs 1.7 kg and travels at a speed of 75 m/s when it reaches the top of the bucket.

We need to find the speed of the bucket just before it reaches the water. The water is assumed to be massless and to have complete kinetic energy.

Using the conservation of energy, we have:

\[ \frac{1}{2} m v^2_{bucket} + mg h_{bucket} = \frac{1}{2} m v^2_{water} + m g h_{water} \]

Where:
- \( m \) is the mass of the water
- \( h_{bucket} \) is the height of the bucket above the water
- \( h_{water} \) is the height of the water above the bucket
- \( v_{bucket} \) is the speed of the bucket
- \( v_{water} \) is the speed of the water

Substituting the given values:

\[ \frac{1}{2} (1.75 \text{ kg}) v^2_{bucket} + (1.7 \text{ kg}) (9.4 \text{ m}) = \frac{1}{2} (1.75 \text{ kg}) v^2_{water} + (1.7 \text{ kg}) (2.00 \text{ m}) \]

Solving for \( v_{bucket} \):

\[ v_{bucket} = \sqrt{\frac{2(1.7 \text{ kg})(9.4 \text{ m}) - 2(1.7 \text{ kg})(2.00 \text{ m})}{1.75 \text{ kg}}} \]

\[ v_{bucket} = \sqrt{\frac{32.92 - 6.8}{1.75}} \]

\[ v_{bucket} = \sqrt{17.39} \]

\[ v_{bucket} \approx 4.2 \text{ m/s} \]

Therefore, the speed of the bucket just before it reaches the water is approximately 4.2 m/s.
A small block on a frictionless horizontal surface has a mass of $2.50 \times 10^{-2}$ kg. It is attached to a massless cord passing through a hole in the surface. (See the figure below.) The block is originally revolving at a distance of 0.300 m from the hole with an angular speed of 1.75 rad/s. The cord is then pulled from below, shortening the radius of the circle in which the block revolves to 0.150 m. You may treat the block as a particle.

(a) What is the new angular speed?
(b) Find the change in kinetic energy of the block.
(c) How much work was done in pulling the cord?
Angular Momentum Conservation

$I_i \omega_i = I_f \omega_f$

Review Card 10-3 (Back)
A person stands, hands at the side, on a platform that is rotating at a rate of 1.60 rev/s. If the person now raises his arms to a horizontal position, the speed of rotation decreases to 0.800 rev/s.

(a) Why does the speed of rotation decrease? Explain using the two key words: external torque, angular momentum.

(b) By what factor has the moment of inertia of the person changed?

(c) Compare $I_f$ and $I_i$.
Review Card 10-5

Solve a system of equations

\[ 0 = (0) y + (0) z + (0.01)(0.008) - (9.81)(N081°) = 0 \]

\[ 0 = (0) y + (0) z + (0.01)(0.008) - (9.81)(N081°) = 0 \]

\[ 0 = (0) y + (0) z + (0.01)(0.008) - (9.81)(N081°) = 0 \]

\[ 0 = (0) y + (0) z + (0.01)(0.008) - (9.81)(N081°) = 0 \]

\[ 0 = (0) y + (0) z + (0.01)(0.008) - (9.81)(N081°) = 0 \]

Three Equations

Step 1

FBD

Static Equilibrium

Example 10.12

A Herocic Rescue

Review Card 10-5

Back
...Model and F.B.D.

Another Example

Starting with...

$$M, m, l, \theta, \mu$$ : Given

$$W, m, l, x$$ : Given
Another Example

Note: \( \sin \theta = \frac{4}{5}, \cos \theta = \frac{3}{5} \)

... Model and F.B.D.

ISEE – F.B.D. for Ladder
Three Equations

\[ \sum F_x = 0 = N - \sum F_y = 0 = \sum M = 0 \]

Smooth surface

Rough surface

\[ 0 = x \delta W - \theta \cos \frac{\pi}{4} \delta m - \delta \theta \sin \frac{\pi}{4} \]

\[ 0 = \delta W - \delta m - \xi \cos \frac{\pi}{4} \]

Three Equations

\[ \xi \cos \frac{\pi}{4} \]

\[ \text{Note: } \sin \theta = \frac{\sqrt{2}}{2}, \cos \theta = \frac{\sqrt{2}}{2} \]
Solve a system of equations

\[ R = \begin{array}{c}
0 = v_0 \sin \phi \\
0 = v_0 \cos \phi \\
(\phi, \theta') = (\phi, \theta') \\
1 = 0 = \theta' \\
\frac{1}{2} \frac{g}{t} = \tan^{-1} \left( \frac{v_y}{v_x} \right) \\
\frac{v_0 x}{v_0} = \cos \phi \\
\frac{v_0 y}{v_0} = \sin \phi
\end{array} \]