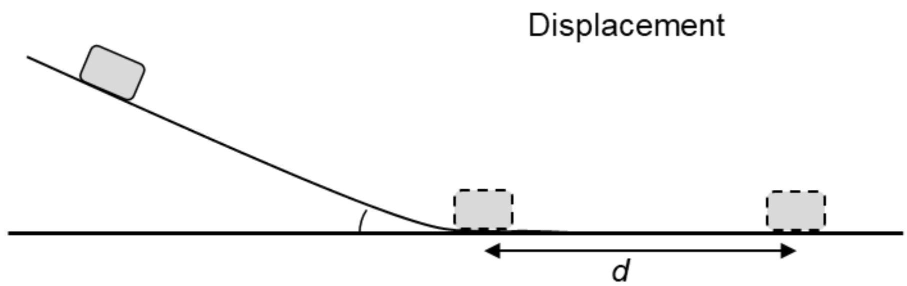
Review – *Answers have not been confirmed.*

Forces

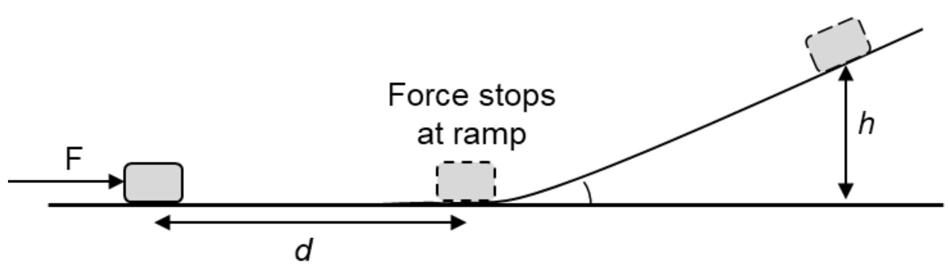
A sled of mass 25-kg slides down a 5-m hill at a constant speed of 2.8 m/s. The slope of the hill is at a 20° degree angle to the horizontal. The sled leaves the hill and encounters a level section that has a coefficient of friction, $\mu=0.4$



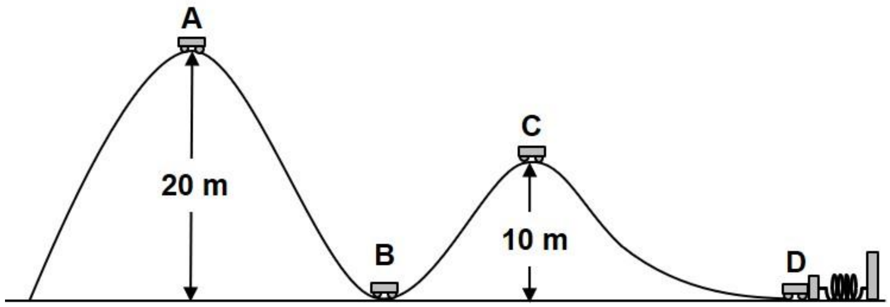
a) How long does it take the sled to reach the bottom of the hill? T = 4.2 seconds
b) What is the frictional force on the sled? $F = mg\sin\theta = 84$ N
c) How far does the sled travel on the horizontal surface before it comes to rest? D = 1.0 m

Energy or Forces

A 10-kg box is pushed 2-meters across a frictionless floor by a 40-N force. After *d* meters, the force stops pushing and the box moves up a frictionless ramp that is inclined 30° to the horizontal. The box slides to a height, h, before sliding back down the ramp.



a) What is the speed of the box at the bottom of the ramp? $Fd = \frac{1}{2} mv^2$, v = 4 m/s
b) How high does the box rise on the ramp? H = 0.82 m
c) How does the height change if ...
    i. The mass of the box is doubled? ½ h = 0.41 m
    ii. The force is doubled? 2h = 1.64 m
    iii. The distance the box is pushed is doubled? 2h = 1.64 m
    iv. The horizontal surface and the box have a coefficient of friction, $\mu = 0.15$. h = 0.52 m



A roller coaster at an amusement park lifts an empty car (400 kg) to point *A* at a height 20 m above the lowest point on the track, as shown above. The car starts from rest at point *A* and rolls with negligible friction along the track through points B and C and to point D, where a heavy spring (k = 15,000 N/m) brings the cart to rest.

a) What is the speed of the cart at Point B? v = 19.8 m/s
b) How fast is the car moving at Point C? v = 14 m/s
c) How far does the cart compress the spring if the spring is massless? Δx = 3.2 m

The car is returned to its starting point and loaded with 2 passengers, increasing the total mass of the cart to 500 kg. The loaded car repeats the ride.

d) How does the speed at Point B with the fully loaded car compare to the speed in part (a)? Same speed; total energy increases with increased mass.
e) How far does the compression of the spring with the fully loaded car compare to the compression in part (c)? Greater compression due to greater total energy, Δx = 3.6 m

Consider the case where the spring is not massless and the 500-kg cart and spring move together after the car collides with the spring. The mass of the spring is 200-kg. How much does the spring compress now?

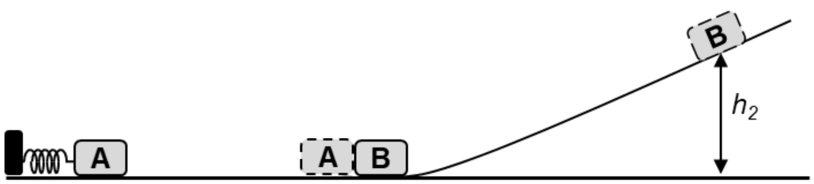
Momentum: velocity after collision = 14.1 m/s

Δx = 3.06 m

Momentum

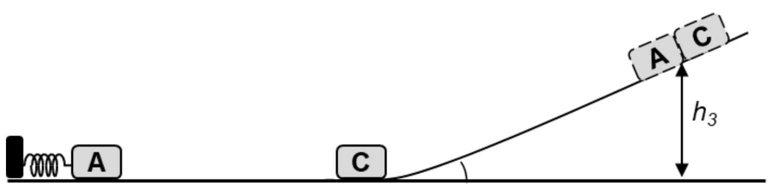
Block *A* of mass 4.0 kg is on a horizontal, *frictionless* surface and is placed against a spring with spring constant *k*. The block is pushed backward and compresses the spring a distance *x*. The block is released and travels up an incline and comes to maximum height, *h*.

The trial is repeated. Now Block *B*, of identical mass, is placed between Block A and the incline. The spring is compressed the same distance x and Block *A* is released. At the base of the ramp, Block A collides with block *B*. The two blocks *collide elastically,* and Block B moves up the incline.



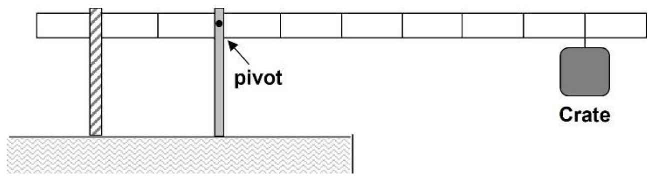
How far does Block B move up the incline? Same height.

The trial is repeated a third time. Block C, of identical mass, is placed exactly where Block B was placed in Trial 2. The spring is compressed the same amount and Block is released. This time, the collision is *perfectly inelastic*. Blocks A and C move up the incline together.



How far do Blocks and C move up the incline? $h_3 = \frac{1}{4} h_1$

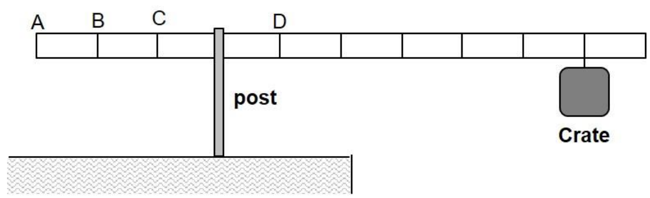
Rotation



A thin beam is attached to a post by a pivot and hangs over the edge of a table. A 0.5-kg crate is attached to the right end of the beam, 60 cm from the post. A rope attached 20 cm to the left of the pivot keeps the beam from rotating clockwise about the pivot. The crate and rope are placed as shown in the diagram. The beam in the diagram is marked at 10-cm intervals.

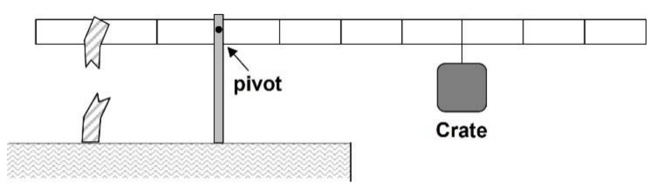
a) What is the tension in the rope? $F_T = 14.7$ N
b) What is the net torque on the beam after the rope breaks? $\tau = 2.94$ Nm

The crate is overloaded, the rope breaks and the beam rotates.



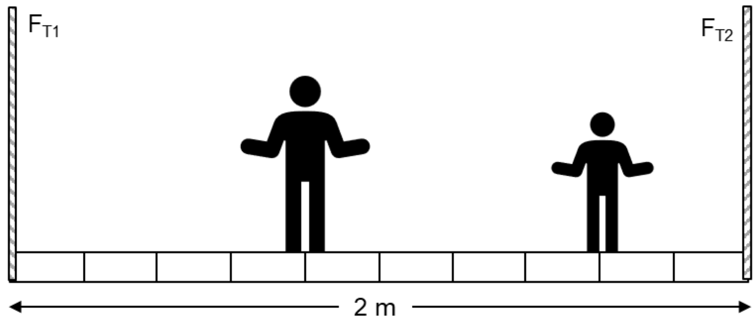
a) Where should a new, identical rope be placed (A, B, C, or D) to keep the beam horizontal? at A
b) What will be the tension in the rope at this location? $F_T = 11.8$ N

Another day, the crate is moved closer to the post and the rope breaks again.



a) How does the initial angular acceleration of the beam on this day compare to the acceleration the first time? Is it greater than, less than, or equal to the first angular acceleration? Explain your answer. Acceleration is less because torque is less (crate is closer to the axis of rotation).

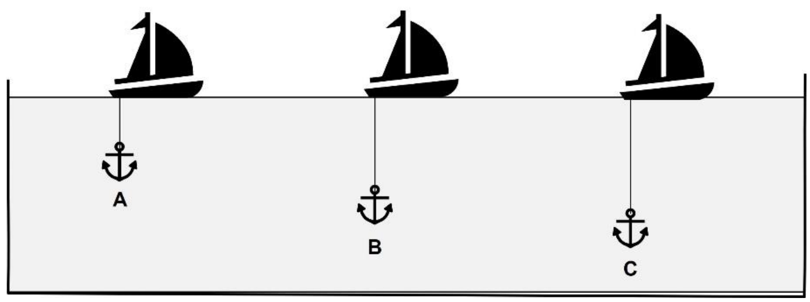
Two window washers are on a plank that is suspended with 2 ropes. The heavier washer is 90 kg and stands 0.80 m from the left rope. The lighter washer is 60 kg and stands 0.40 m from the right rope. The plank is 2 meters and is marked in 0.20 meter intervals.



b) Determine the tension in the left rope, F_{T1}. 647 N

c) Determine the tension in the right rope, F_{T2}. 823 N

Fluids



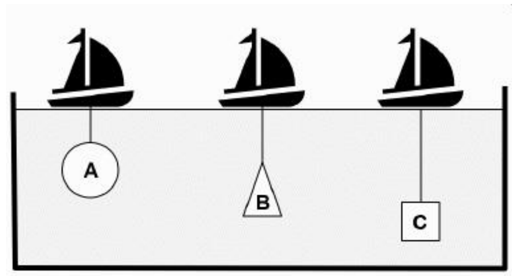
Three identical sailboats drop their anchors and rest near each other on a small lake. The anchors have the same volume (0.013 m^3) but rest at different depths and have different masses.

- Anchor A dangles 4.0 m below the surface of the lake and has a mass of 95 kg.
- Anchor B dangles 6.0 m below the surface of the lake and has a mass of 80 kg.
- Anchor C dangles 12.0 m below the surface of the lake and has a mass of 60 kg.

a) What is the absolute pressure on each of the anchors? P_A = 140500 Pa

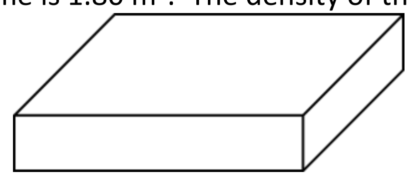
b) A storm approaches and the atmospheric pressure drops by 1000 Pascals. By how much does the pressure on each anchor change? Absolute pressure drops by 1000 Pascals.

c) Anchor A is iron (ρ=7900 kg/m^3). What is the buoyant force on each anchor? F_B = 118 N
d) What is the tension in each rope? F_T = 813 N
e) How is this different if the anchors have the same mass (100-kg) but different volumes? Anchor B with the largest volume has the greatest buoyant force.

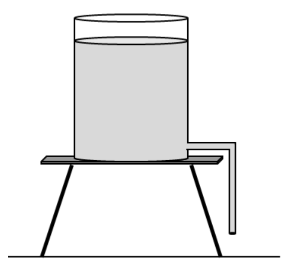


- Anchor A's volume is 0.013 m^3.
- Anchor B's volume is 0.037 m^3.
- Anchor C's volume is 0.014 m^3.

A rectangular raft (density 600 kg/m^3) floats on a fresh water lake. The surface area of the top of the raft is 8.0 m^2 and its volume is 1.80 m^3. The density of the lake water is 1000 kg/m^3.



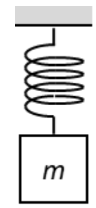
a) What is the buoyant force on the raft? F_B = 10600 N
b) What fraction of the raft is under the surface of the water? 0.6
c) How much mass must be added to the raft for it to be fully submerged? 720 kg



A tank of water drains through a hose as shown. A child can fill a 0.02 m^3 bucket in 11 seconds.

a) What is the flow rate of water from the tank? 0.0018 m^3/s
b) The diameter of the hose is 1.0 inch. What is the speed of the water in the hose? v = 3.6 m/s
c) What is the height of liquid above the hole? h = 0.66 m

SHM



A 0.150-kg block is suspended from a spring with spring constant k = 3.5 N/m.

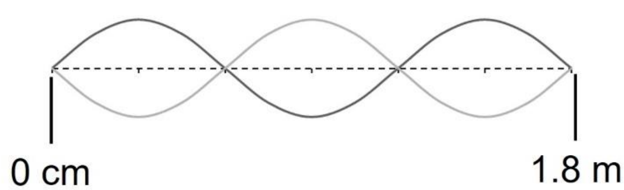
a) How long does the spring stretch when it is at rest? $\Delta x =$ 0.42 m

A student pulls the block down 4 cm and releases it. The block oscillates with simple harmonic motion.

b) What is the initial energy of the system? E = 0.0028 J
c) What is the maximum speed of the block? 0.19 m/s
d) What is the period of motion? 1.3 s
e) what is the frequency of motion? 0.77 Hz
f) Write the equation for the motion of the block. y = (4.0 cm) cos (4.8t)
g) A student makes a change to the system and doubles the period of motion
    a. The student changes the mass.
        i. How did he change it? Quadruples the mass
        ii. Does this affect the total energy of the system? No
    b. The student changes the spring.
        i. How did he change it? Quarters the spring constant
        ii. Does this affect the total energy of the system? Yes, energy also is reduced by ¼

Waves and Sound

In a lab, a student attaches a wave generator to a string and creates tension in the string with a pulley and 600-g hanging mass. The student creates a standing wave on a 1.8-m string using a wave generator. The frequency of the wave generator is 42 Hz.



a) What harmonic is shown on the string? 3rd
b) What is the fundamental frequency of the string? 14 Hz
c) What is the speed of the wave on the string? 50.4 m/s
d) What is the tension in the string? 5.9 N
e) What is the linear mass density of the string? 0.0023 Kg/m
f) The temperature of the lab room is 21°C. What is the speed of sound in the air? 343 m/s
g) What is the frequency of the sound produced by the string in the air? 14 Hz

h) What is the wavelength of the sound produced by the string in the air? 24.5 m

Sound

In a lab, a tuning fork of frequency of 512 Hz resonates in a tube open at both ends. This is the fundamental frequency of the tube. The room temperature is 21°C.

a) What is the wavelength of this note? 67 cm
b) What is the length of the tube? 33.5 cm
c) Draw the 3^{rd} harmonic for this tube.

d) What is the frequency of the 3^{rd} harmonic? 1536 Hz
e) What is the wavelength of the 3^{rd} harmonic? 22.3 cm
f) By what factor does the fundamental frequency change if the air temperature increases to 37°C? 1.01, f_{new} = 517 Hz
g) What is the percent change in the frequency with the temperature change? +1%
h) What length of tube is necessary to resonate f = 512 Hz for a tube closed at one end? 16.8 cm
i) Draw the 3^{rd} harmonic for this tube.