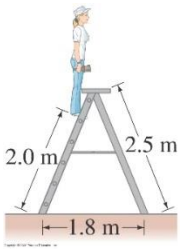
Seminar 4: Lectures 7 - 8

Equilibrium:

1. A 110 kg horizontal beam is supported at each end. A 320 kg piano rests a quarter of the way from one end. What is the vertical force on each of the supports?

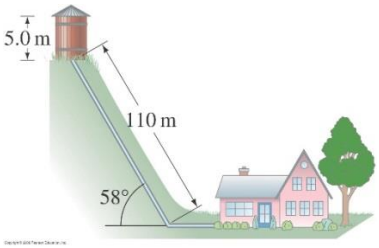
2. A 56.0 kg person stands 2.0 m from the bottom of the stepladder shown in the figure below. Determine (*a*) the tension in the horizontal tie rod, which is halfway up the ladder, (*b*) the normal force the ground exerts on each side of the ladder, and (c) the force (magnitude and direction) that the left side of the ladder exerts on the right side at the hinge on the top. Ignore the mass of the ladder and assume the ground is frictionless. [*Hint:* Consider free-body diagrams for each section of the ladder.]



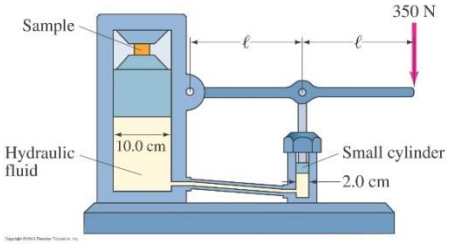
Pressure and Pascal's Principle:

3. Estimate the pressure needed to raise a column of water to the same height as a 35 m tall oak tree.

4. A house at the bottom of a hill is fed by a full tank of water 5.0 m deep and connected to the house by a pipe that is 110 m long at an angle of 58° from the horizontal (see the figure below). (*a*) Determine the water gauge pressure at the house. (*b*) How high could the water shoot if it came vertically out of a broken pipe in front of the house?



5. A hydraulic press for compacting powdered samples has a large cylinder which is 10.0 cm in diameter, and a small cylinder with a diameter of 2.0 cm (see the figure below). A lever is attached to the small cylinder as shown. The sample, which is placed on the large cylinder, has an area of 4.0 cm^2. What is the pressure on the sample if 350 N is applied to the lever?



Buoyancy and Archimedes' Principle:

6. A crane lifts the 16,000 kg steel hull of a sunken ship out of the water. Determine (*a*) the tension in the crane's cable when the hull is fully submerged in the water, and (b) the tension when the hull is completely out of the water.

7. A cube of side length 10.0 cm and made of unknown material floats at the surface between water and oil. The oil has a density of 810 kg/m^3. If the cube floats so that it is 72% in the water and 28% in the oil, what is the mass of the cube and what is the buoyant force on the cube?

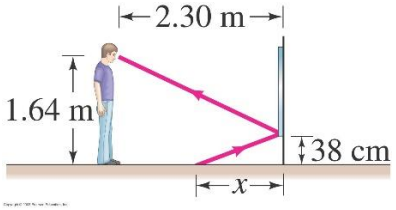
Fluid Flow and Bernoulli's Equation:

8. A fish tank has dimensions 36 cm wide by 1.0 m long by 0.60 m high. If the filter should process all the water in the tank once every 4.0 h, what should the flow speed be in the 3.0 cm diameter input tube for the filter?

9. What is the lift (in newtons) due to Bernoulli's principle on a wing of area 88 m^2 if the air passes over the top and bottom surfaces at speeds of 280 m/s and 150 m/s, respectively?

Reflection and Plane Mirrors:

10. A person whose eyes are 1.64 m above the floor stands 2.30 m in front of a vertical plane mirror whose bottom edge is 38 cm above the floor, as shown in the figure below. What is the horizontal distance x to the base of the wall supporting the mirror of the nearest point on the floor that can be seen reflected in the mirror?



Index of Refraction:

11. The speed of light in ice is 2.29×10^8 m/s. What is the index of refraction of ice?

Total Internal Reflection:

12. A ray of light, after entering a light fiber, reflects at an angle of 14.5° with the long axis of the fiber, as shown in the figure below. Calculate the distance along the axis of the fiber that the light ray travels between successive reflections off the sides of the fiber. Assume that the fiber has an index of refraction of 1.55 and is 1.40×10^{-4} m in diameter.

13. (a) What is the minimum index of refraction for a glass or plastic prism to be used in binoculars (as shown in the figure below) so that total internal reflection occurs at 45°? (b) Will binoculars work if their prisms (assume n = 1.58) are immersed in water? (c) What minimum n is needed if the prisms are immersed in water?