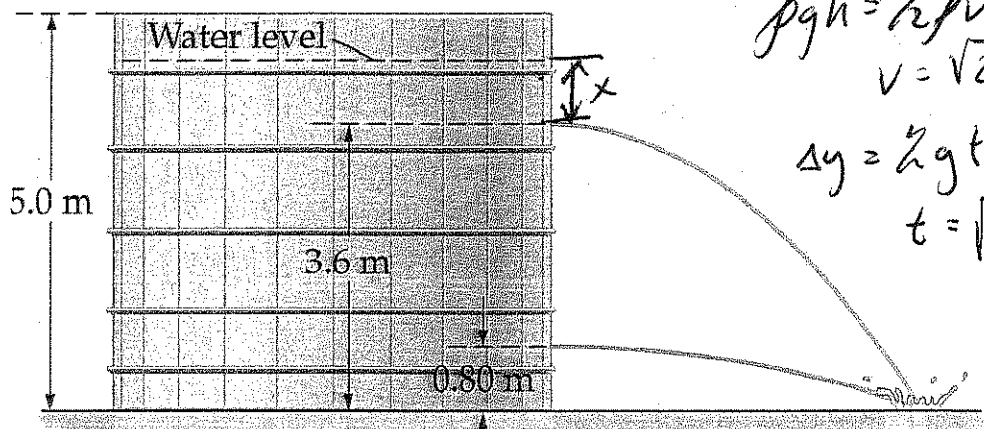


1. The water tank in the figure is open to the atmosphere and has two holes in it, one at a height of 0.8 m from the bottom, and the other at a height of 3.6 m from the bottom. If the two streams of water strike the floor in the same place, what is the depth of water in the tank?



$$\rho g h = \frac{1}{2} \rho v^2$$

$$v = \sqrt{2gh}$$

$$\Delta y = \frac{1}{2} g t^2 + v_y t$$

$$t = \sqrt{\frac{2\Delta y}{g}}$$

$$v_{top} = \sqrt{2gh_{top}} = \sqrt{2gx}$$

$$v_{bot} = \sqrt{2gh_{bot}} = \sqrt{2g(3.6 - 0.8 + x)} = \sqrt{2g(2.8 + x)}$$

$$t_{top} = \sqrt{\frac{2(2.6)}{10}} = 0.85s \quad t_{bot} = \sqrt{\frac{2(0.8)}{10}} = 0.4s$$

$$\Delta x_{top} = v_{top} t_{top}$$

$$\Delta x_{bot} = v_{bot} t_{bot}$$

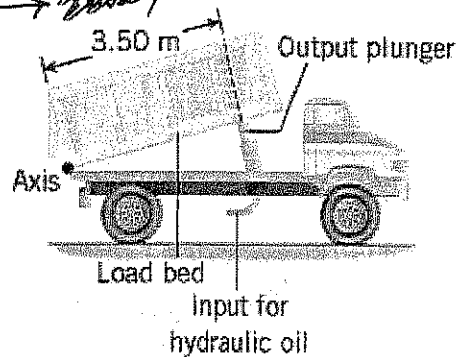
$$\Delta x_{top} = \Delta x_{bot}$$

$$v_{top} t_{top} = v_{bot} t_{bot} \rightarrow \sqrt{2gx} (0.85) = \sqrt{2g(2.8+x)} (0.4)$$

$$0.723x = (2.8+x) \cdot (0.16) \rightarrow x = 0.796m$$

Water level is 4.4m

2. A dump truck uses a hydraulic cylinder, as the drawing illustrates. When activated by the operator, a pump injects hydraulic oil into the cylinder at an absolute pressure of  $3.54 \times 10^6$  Pa and drives the output plunger, which has a radius of 0.150 m. Assuming the plunger remains perpendicular to the floor of the load bed, find the torque that the plunger creates about the axis identified in the drawing.

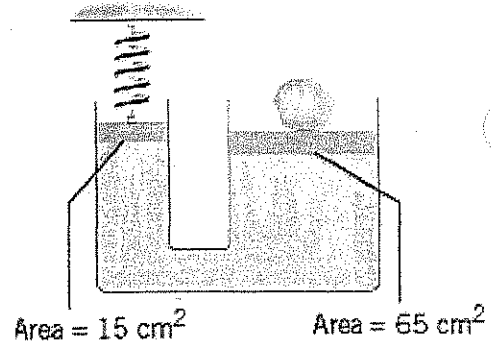


$$\tau = F_{\perp} R = PAR$$

$$= 3.54 \times 10^6 (\pi (0.15)^2) (3.5)$$

$$= 875797 \text{ N}\cdot\text{m} \sim 8.76 \times 10^5 \text{ N}\cdot\text{m}$$

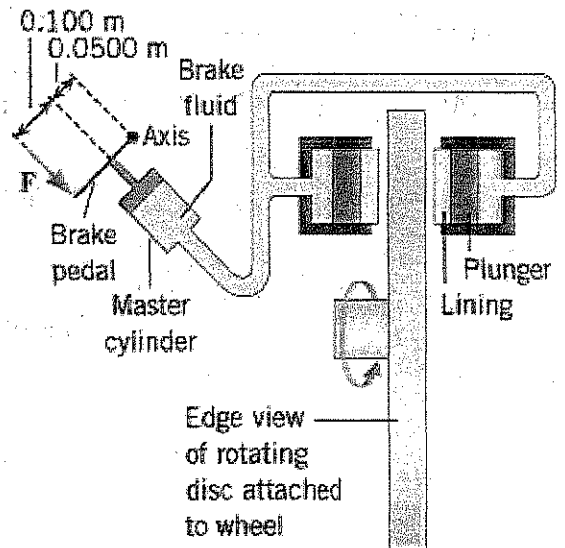
3. The drawing shows a hydraulic chamber in which a spring (spring constant = 1600 N/m) is attached to the input piston, and a rock of mass 40.0 kg rests on the output plunger. The piston and plunger are nearly at the same height, and each has a negligible mass. By how much is the spring compressed from its unstrained position?



$$\frac{F_s}{15 \text{ cm}^2} = \frac{400}{65 \text{ cm}^2} \rightarrow F_s = 92.3 \text{ N} = kx$$

$$x = 0.058 \text{ m}$$

4. The drawing shows a hydraulic system used with disc brakes. The force  $F$  is applied perpendicularly to the brake pedal. The pedal rotates about the axis shown in the drawing and causes a force to be applied perpendicularly to the input piston (radius =  $9.50 \times 10^{-3}$  m) in the master cylinder. The resulting pressure is transmitted by the brake fluid to the output plungers (radii =  $1.90 \times 10^{-2}$  m), which are covered with the brake linings. The linings are pressed against both sides of a disc attached to the rotating wheel. Suppose that the magnitude of  $F$  is 9.00 N. Assume that the input piston and the output plungers are at the same vertical level and find the force applied to each side of the rotating disc.



$$\frac{9}{\pi(9.5 \times 10^{-3})^2} = \frac{F}{\pi(1.9 \times 10^{-2})^2}$$

$$F_{\text{out}} = 36 \text{ N}$$