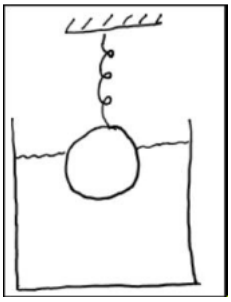
FS.L2.4 | Hydraulics, Buoyancy | Challenge Homework

Submit a digital copy (PDF, jpg, etc.) to gradescope.com. Every page should be labeled on the top left with the question code (e.g. GR.L1.4-01) and there should be only be one solution per page. The questions should be in order. If a solution takes more than one page, be sure to label that it is a continuation of the previous page's solution (e.g. GR.L1.4-01 continued). One question will be randomly selected and graded. Challenge homework for a given week are due the following week by Tuesday at midnight. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. See the course website for further details.

You will be asked to apply sense-making in most problems. Use the list below as a reference to the different sense-making techniques. More information about sense-making can be found on the BoxSand menu under Math Tools => Sense-making.

- *Sign:* Check the **sign** of each quantity makes sense.
- *Dimensionality:* Check the **dimensionality** and units of each quantity makes sense.
- *Order of Magnitude:* Check the **order of magnitude** of the final answer and other important quantities is within a a factor of 10 of what you think it should be.
- *Graphical Analysis:* Use a **graph** to see if the behavior of a solution makes sense.
- *Proportionality:* Using a symbolic solution, check the behavior of the answer when you change a given quantity on which it is dependent. Does the answer vary **proportionally** to what you expect?
- *Special Cases:* Check the behavior of a derived equation in limiting (**special**) cases makes sense, e.g. as x goes to 90 degrees in sin(x).
- *Self-consistency:* Check derived equations, functions, or values, are **self-consistent**, e.g. check that the slope of a derived position plot matches the values of the given velocity plot
- *Known Values:* Compare given or derived quantities with common well **known values**.
- *Related Quantities:* Compare the relative magnitude of two **related quantities**.

FS.L2.4-01

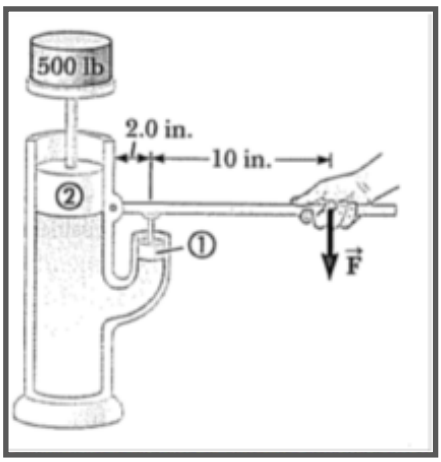


Consider the system in the figure.
State 1: A spring of constant k = 11,990 N/m is hung vertical without anything attached.
State 2: A sphere of density 4250 kg/m^3 is attached to the spring and when 60% of its volume is submerged in water, the system is equilibrium. At this point the spring is displaced 10.0 cm from its original equilibrium position.

(a) Is spring stretched or compressed in state 2 when compared to state 1? Explain using *Related Quantities* and *Known Values* sense-making.

(b) What is the radius of the sphere?

FS.L2.4-02



Piston 1 in the figure to the right has a diameter of 0.250 in. Piston 2 has a diameter of 1.50 in and is 2 inches higher than piston 1. The hydraulic fluid is oil.

(a) In jacks like this (think changing a flat tire on your car), there are two forms of mechanical advantage simultaneously working to make the force applied much smaller than what it lifts. What are the two forms of mechanical advantage in this system?

(b) Determine the magnitude (F) of the force necessary to support the 500 lb. load in the absence of friction.

(c) Use *Order of Magnitude* sense-making to determine if not including the height difference of the fluid is a problem when calculating the force in part (b).