



ConceptTest 13.7a

The Straw I

When you drink liquid through a straw, which of the items listed below is primarily responsible for this to work?

- 1) water pressure
- 2) gravity
- 3) inertia
- 4) atmospheric pressure
- 5) mass

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- 2) gravity
- 3) inertia
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When you suck on a straw, you expand your lungs, which reduces the air pressure inside your mouth to less than atmospheric pressure. Then the atmospheric pressure pushing on the liquid in the glass provides a net upward force on the liquid in the straw sufficient to push the liquid up the straw.

Follow-up: Is it possible to sip liquid through a straw on the Moon?

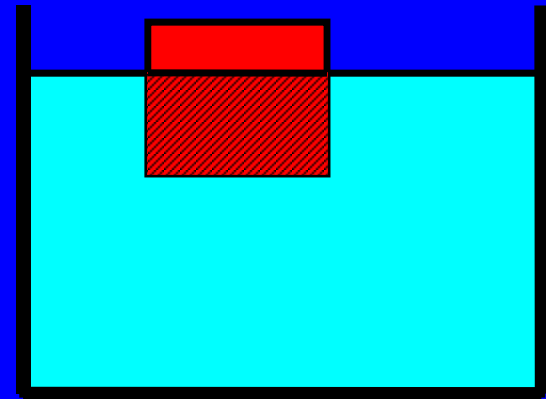
ConceptTest 13.12a

Archimedes I



An object floats in water with $\frac{3}{4}$ of its volume submerged. What is the ratio of the density of the object to that of water?

- 1) $\frac{1}{4}$
- 2) $\frac{1}{3}$
- 3) $\frac{4}{3}$
- 4) $\frac{3}{4}$
- 5) $\frac{2}{1}$



ConceptTest 13.12a Archimedes I

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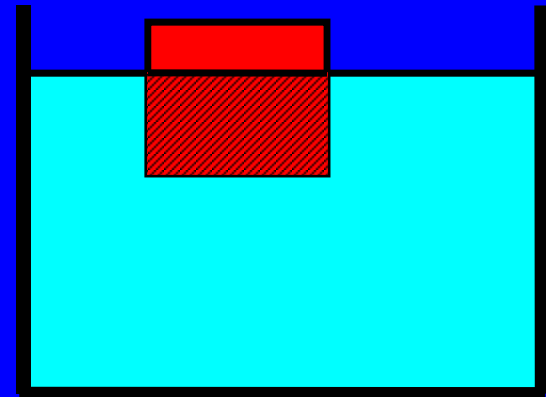
4) $\frac{3}{4}$

5) $\frac{2}{1}$

Remember that we have:

$$\frac{V_{fluid}}{V_{object}} = \frac{\rho_{object}}{\rho_{fluid}}$$

so if the ratio of the volume of the displaced water to the volume of the object is $\frac{3}{4}$, the object has $\frac{3}{4}$ the density of water.



ConceptTest 13.12d

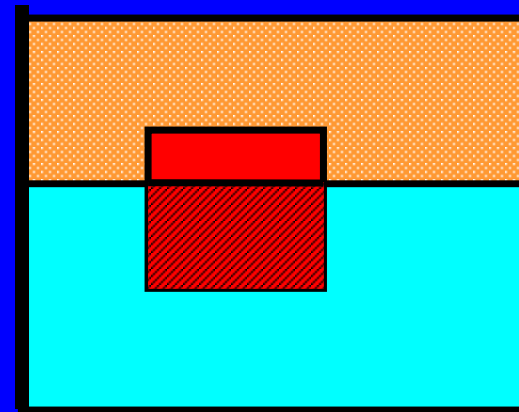
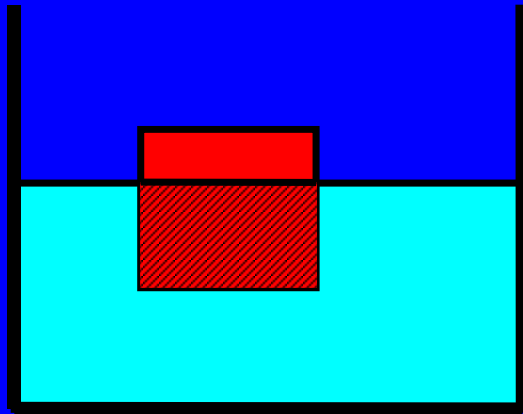
Archimedes IV



An object floats in **water** with $\frac{3}{4}$ of its volume submerged.

When **oil** is poured on top of the water, the object will:

- 1) move up slightly
- 2) stay at the same place
- 3) move down slightly
- 4) sink to the bottom
- 5) float to the top



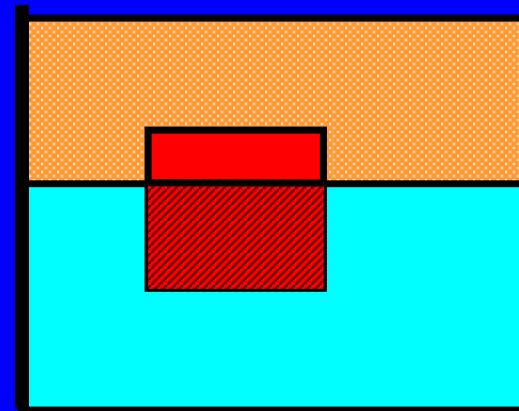
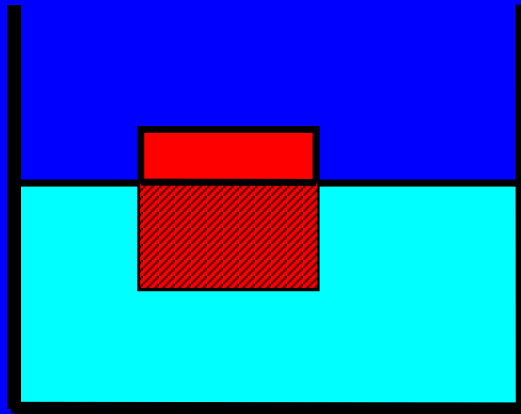
Assumption: the density of oil is $\frac{1}{2}$ of the density of water.

ConceptTest 13.12d Archimedes IV

An object floats in water with $\frac{3}{4}$ of its volume submerged.

When oil is poured on top of the water, the object will:

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- 2) stay at the same place
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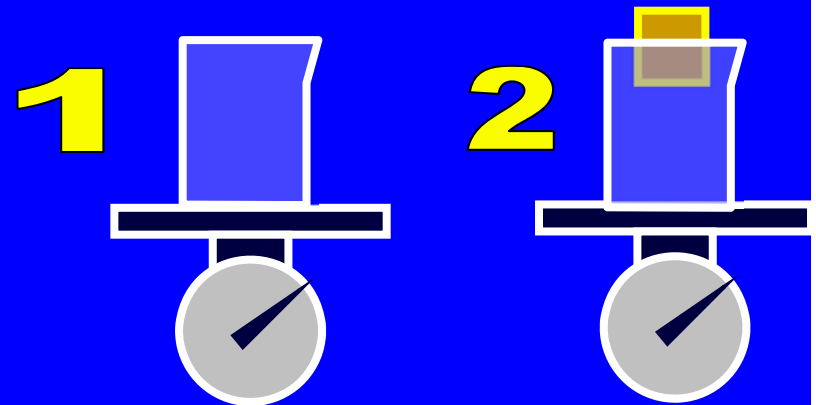


With the oil on top of the water, there is an **additional buoyant force** on the object equal to the weight of the displaced oil. The effect of this extra force is to **move the object upward** slightly, although it is not enough to make the object float up to the top.

ConceptTest 13.14a Wood in Water I



Two beakers are filled to the brim with water. A wooden block is placed in the beaker 2 so it floats. (Some of the water will overflow the beaker). Both beakers are then weighed. Which scale reads a **larger weight**?

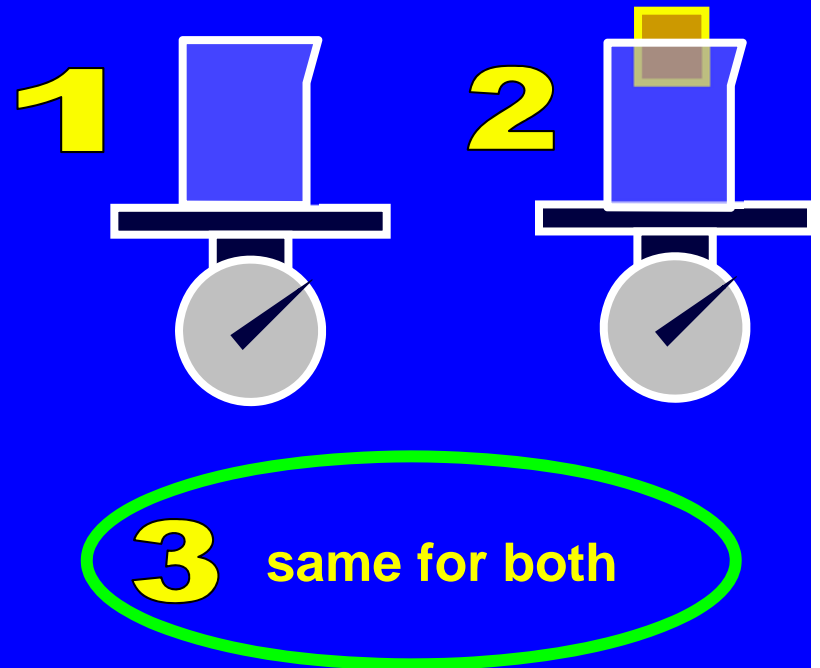


3 same for both

ConceptTest 13.14a Wood in Water I

Two beakers are filled to the brim with water. A wooden block is placed in the beaker 2 so it floats. (Some of the water will overflow the beaker). Both beakers are then weighed. Which scale reads a **larger weight**?

The block in 2 displaces an amount of water equal to its weight, because it is floating. That means that the weight of the overflowed water is equal to the weight of the block, and so the beaker in 2 has the same weight as that in 1.





ConceptTest 13.3 **On a Frozen Lake**

You are walking out on a frozen lake and you begin to hear the ice cracking beneath you. What is your best strategy for getting off the ice safely?

- 1) stand absolutely still and don't move a muscle**
- 2) jump up and down to lessen your contact time with the ice**
- 3) try to leap in one bound to the bank of the lake**
- 4) shuffle your feet (without lifting them) to move toward shore**
- 5) lie down flat on the ice and crawl toward shore**

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- 5) lie down flat on the ice and crawl toward shore

As long as you are on the ice, your weight is pushing down. What is important is not the net force on the ice, but the force exerted on a given small area of ice (i.e., the pressure!). By lying down flat, you distribute your weight over the widest possible area, thus reducing the force per unit area.

ConceptTest 13.5

Three Containers



Three containers are filled with water to the same height and have the same surface area at the base, but the total weight of water is different for each. Which container has the greatest total force acting on its base?

- 1) container 1
- 2) container 2
- 3) container 3
- 4) all three are equal



ConceptTest 13.5

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The pressure at the bottom of each container depends only on the height of water above it! This is the same for all the containers. The total force is the product of the pressure times the area of the base, but because the base is also the same for all containers, the total force is the same.



ConceptTest 13.1

Density



If one material has a higher density than another, does this mean that the molecules of the first material must be more massive than those of the second?

1) yes

2) no

ConceptTest 13.1

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1) yes

2) no

Because density is defined as $\rho = M/V$, the volume matters as well. Thus, it could be simply that the first material has a more compact arrangement of molecules, such that there are more molecules in a given volume, which would lead to a higher density.

ConcepTest 13.2

Too Much Pressure



Consider what happens when you push both a pin and the blunt end of a pen against your skin with the same force. What will determine whether your skin will be punctured?

- 1) the pressure on your skin
- 2) the net applied force on your skin
- 3) both pressure and net applied force are equivalent
- 4) neither pressure nor net applied force are relevant here

ConceptTest 13.2

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The net force is the same in both cases. However, in the case of the pin, that force is concentrated over a much smaller area of contact with the skin, such that the pressure is much greater. Because the force per unit area (*i.e.*, pressure) is greater, the pin is more likely to puncture the skin for that reason.

ConceptTest 13.4

Bubbling Up



While swimming near the bottom of a pool, you let out a small bubble of air. As the bubble rises toward the surface, what happens to its diameter?

- 1) **bubble diameter decreases**
- 2) **bubble diameter stays the same**
- 3) **bubble diameter increases**

ConceptTest 13.4

Bubbling Up

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- 1) bubble diameter decreases
- 2) bubble diameter stays the same
- 3) bubble diameter increases

As the bubble rises, its depth decreases, so the water pressure surrounding the bubble also decreases. This allows the air in the bubble to expand (due to the decreased pressure outside) and so the bubble diameter will increase.

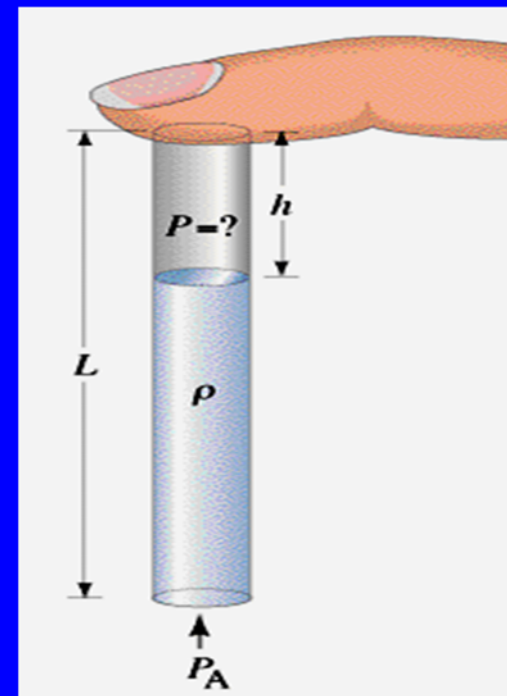
ConceptTest 13.7b

The Straw II



You put a straw into a glass of water, place your finger over the top so no air can get in or out, and then lift the straw from the liquid. You find that the straw retains some liquid. How does the air pressure P in the upper part compare to atmospheric pressure P_A ?

- 1) greater than P_A
- 2) equal to P_A
- 3) less than P_A



ConceptTest 13.7b

The Straw II

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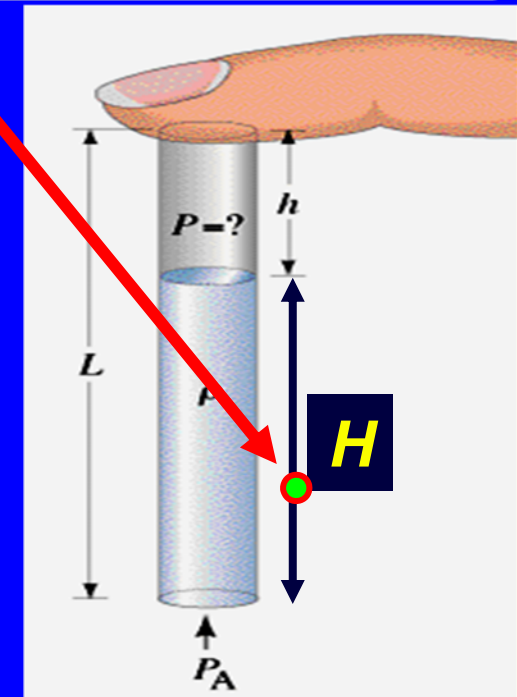
3) less than P_A

Consider the forces acting at the bottom of the straw:

$$P_A - P - \rho g H = 0$$

This point is in equilibrium, so net force is zero.

Thus, $P = P_A - \rho g H$ and so we see that the pressure P inside the straw must be less than the outside pressure P_A .



ConceptTest 13.7c

The Straw III



In a mercury barometer at atmospheric pressure, the height of the column of mercury in a glass tube is 760 mm. If another mercury barometer is used that has a tube of **larger diameter**, how high will the column of mercury be in this case?

- 1) greater than 760 mm
- 2) less than 760 mm
- 3) equal to 760 mm

ConceptTest 13.7c

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- 1) greater than 760 mm
- 2) less than 760 mm
- 3) equal to 760 mm

While the weight of the liquid in the tube has increased (volume = height \times area) due to the larger area of the tube, the net upward force on the mercury (force = pressure \times area) has also increased by the same amount! Thus, as long as the pressure is the same, the height of the mercury will be the same.

ConceptTest 13.8

Thermometers



Thermometers often use mercury or alcohol in a thin glass tube, but barometers never use alcohol. Why?

- 1) mercury is less flammable than alcohol
- 2) mercury's color is easier to see than alcohol
- 3) mercury is less toxic than alcohol
- 4) mercury is denser than alcohol
- 5) mercury is cheaper than alcohol

ConceptTest 13.8

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Mercury is very dense, so the height of the column that supports atmospheric pressure is only 760 mm. A water barometer would require a height of about 10 m, which would be inconvenient. Alcohol is less dense than water, so that would be even worse!

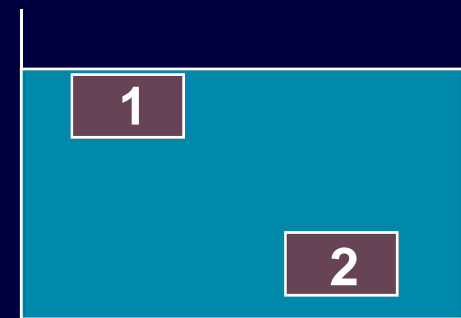
ConceptTest 13.9

Two Bricks



Imagine holding two identical bricks in place underwater. Brick 1 is just beneath the surface of the water, and brick 2 is held about 2 feet down. The force needed to hold brick 2 in place is:

- 1) greater
- 2) the same
- 3) smaller



ConceptTest 13.9

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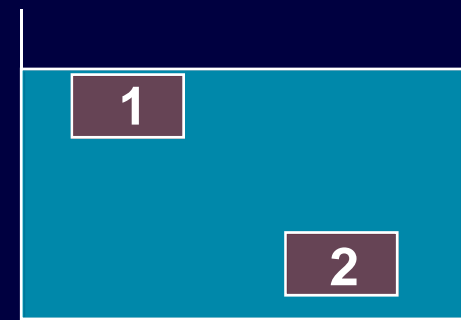
1) greater

2) the same

3) smaller

The force needed to hold the brick in place underwater is $W - F_B$. According to Archimedes' Principle, F_B is equal to the weight of the fluid displaced.

Because each brick displaces the same amount of fluid, then F_B is the same in both cases.





ConceptTest 13.10a **Cylinder and Pail I**

An aluminum cylinder and a pail together weigh 29 N, as read on a scale. With the cylinder submerged, the scale reads 20 N. If the displaced water is poured into the pail, what will the scale read?

- 1) less than 20 N
- 2) 20 N
- 3) between 20 N and 29 N
- 4) 29 N
- 5) greater than 29 N

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- 1) less than 20 N
- 2) 20 N
- 3) between 20 N and 29 N
- 4) 29 N
- 5) greater than 29 N

The buoyant force is equal to the weight of the displaced fluid. Thus, the reduction in the “apparent” weight of the cylinder when it is submerged is exactly equal to the weight of the water that overflowed. When that water is poured back into the pail, the total weight returns to its original value of 29 N.

ConceptTest 13.10b

Cylinder and Pail II



When the cylinder is lowered into the water, how will the scale readings for the cylinder and the water change?

- 1) cylinder's scale will decrease, but water's scale will increase**
- 2) cylinder's scale will increase, but water's scale will decrease**
- 3) cylinder's scale will decrease, but water's scale will not change**
- 4) both scales will decrease**
- 5) both scales will increase**

ConceptTest 13.10b **Cylinder and Pail II**

When the cylinder is lowered into the water, how will the scale readings for the cylinder and the water change?

- 1) cylinder's scale will decrease, but water's scale will increase**
- 2) cylinder's scale will increase, but water's scale will decrease**
- 3) cylinder's scale will decrease, but water's scale will not change**
- 4) both scales will decrease**
- 5) both scales will increase**

The buoyant force of the water on the cylinder is an upward force that reduces the “apparent” weight as read on the scale. However, by Newton’s Third Law, there is an equal and opposite reaction force. So, if the water pushes up on the cylinder, then the cylinder must push down on the water, thus increasing the scale reading of the water.

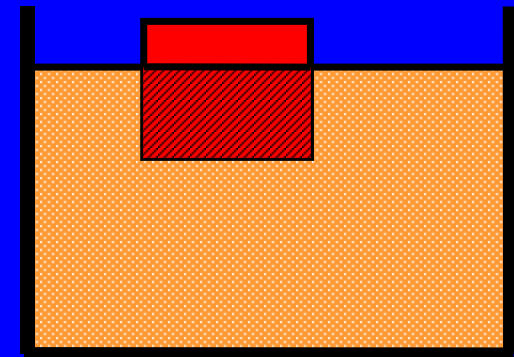
ConceptTest 13.12b Archimedes II



The object is now placed in **oil**
with a density half that of water.

What happens?

- 1) it floats just as before
- 2) it floats higher in the water
- 3) it floats lower in the water
- 4) it sinks to the bottom



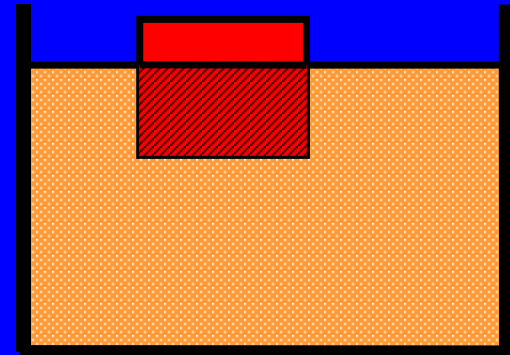
ConceptTest 13.12b Archimedes II

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What happens?

- 1) it floats just as before
- 2) it floats higher in the water
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- 4) it sinks to the bottom

We know from before that the **object has $\frac{3}{4}$ the density of water**. If the water is now replaced with oil, which has $\frac{1}{2}$ the **density of water**, the **density of the object is larger than the density of the oil**. Therefore, it must sink to the bottom.



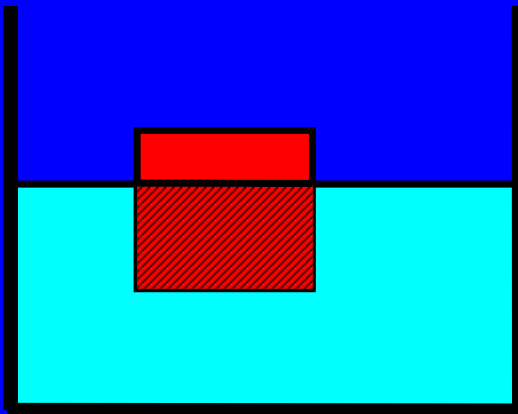
ConceptTest 13.12c

Archimedes III



An object floats in **water** with $\frac{3}{4}$ of its volume submerged. When more **water** is poured on top of the water, the object will:

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- 2) stay at the same place
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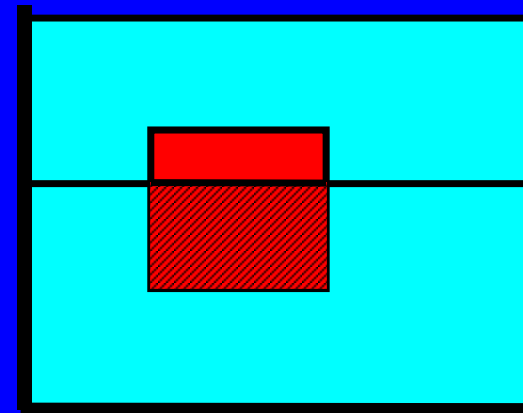
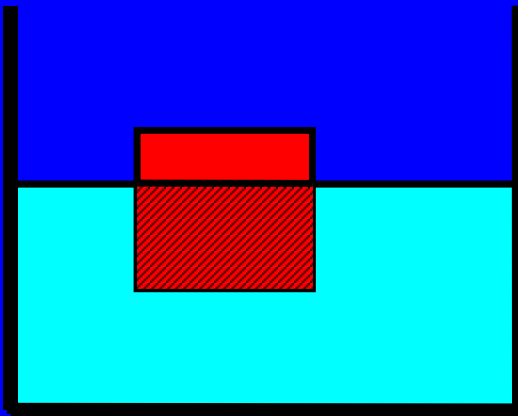


ConceptTest 13.12c

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- 1) move up slightly
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- 3) move down slightly
- 4) sink to the bottom
- 5) float to the top



We already know that **density of the object is $\frac{3}{4}$ of the density of water, so it floats in water** (i.e., the buoyant force is greater than its weight). When covered by more water, it must therefore float to the top.

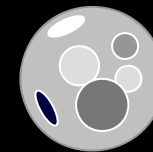
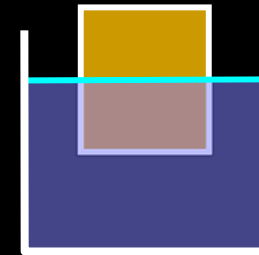
ConceptTest 13.14b Wood in Water II



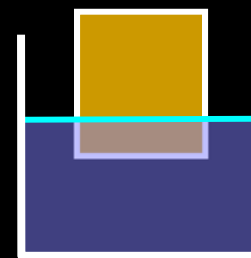
A block of wood floats in a container of water as shown on the right. On the Moon, how would the same block of wood float in the container of water?



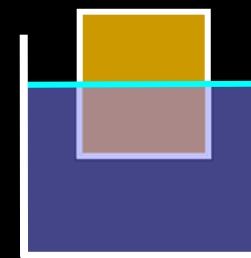
Earth



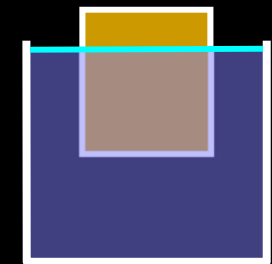
Moon



1



2



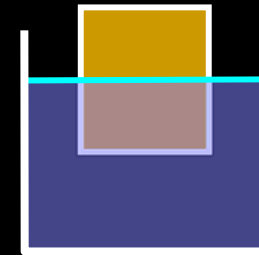
3

ConceptTest 13.14b Wood in Water II

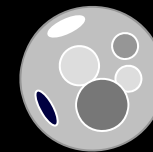
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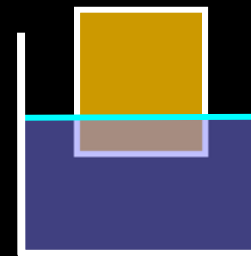
Earth



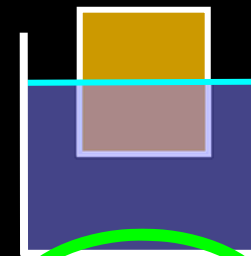
A floating object displaces a weight of water equal to the object's weight. On the Moon, the wooden block has **less weight**, but the water itself also has **less weight**.



Moon



1



2



3