Buoyancy

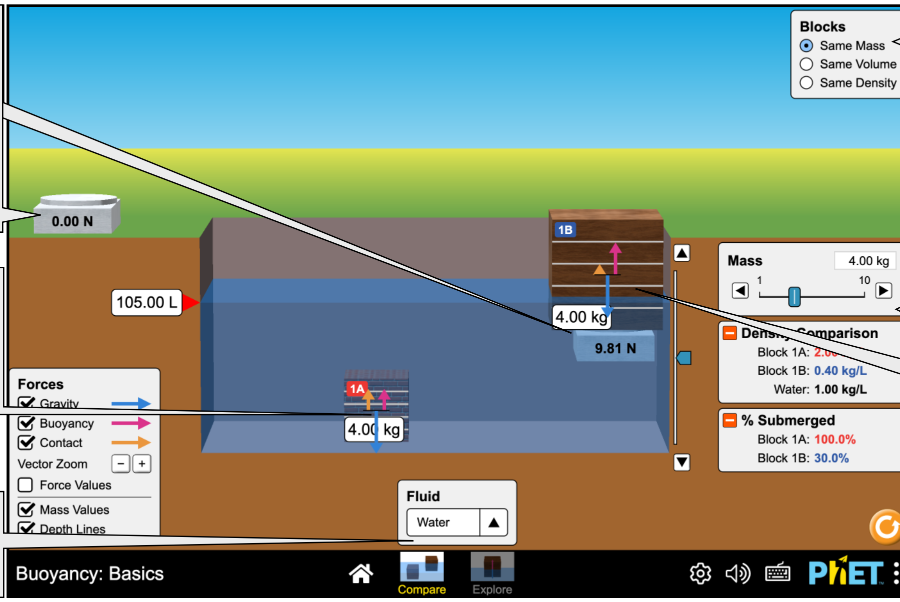
Compare Screen

Compare the buoyant behavior of two blocks that can have the same mass, volume, or density when they are placed in a pool of different fluids.

MEASURE the block's weight out and inside the pool. The scales are movable.

OBSERVE and **ANALYZE** the forces

CHANGE the fluid in the pool



SELECT the scenario to compare

MODIFY the value of the shared parameter

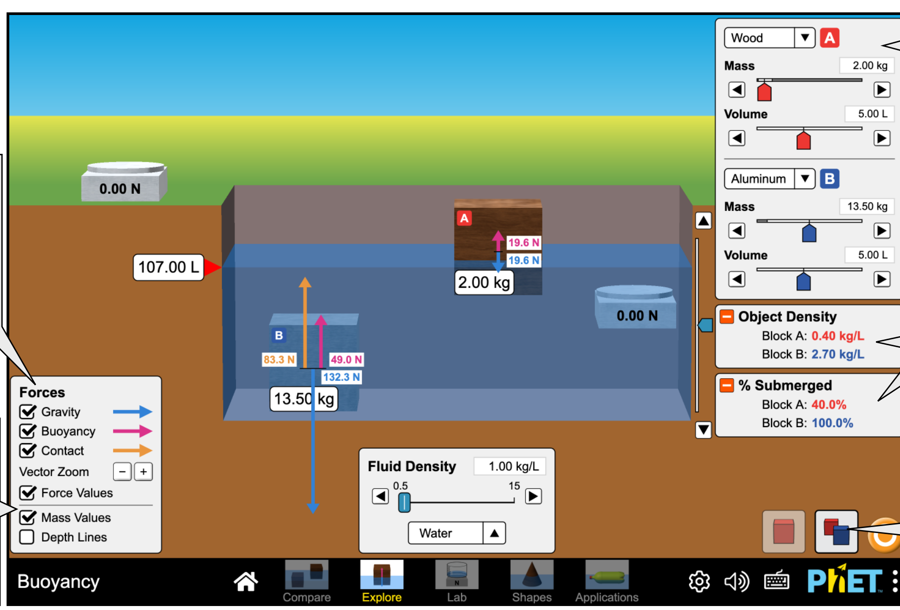
DESCRIBE how a block floats/ sinks using the depth lines reference

Explore Screen

Interact with blocks of different materials. Modify their mass and volume and explore how it sinks/floats in a pool with different fluids. Analyze the changes in the forces and their relationship with the buoyant behavior of the block.

ACTIVATE the vectors of the forces and adjust their zoom level

PERFORM deeper analysis by displaying the values



MODIFY the block's material, mass and volume

COMPARE the density and % submerged of each block

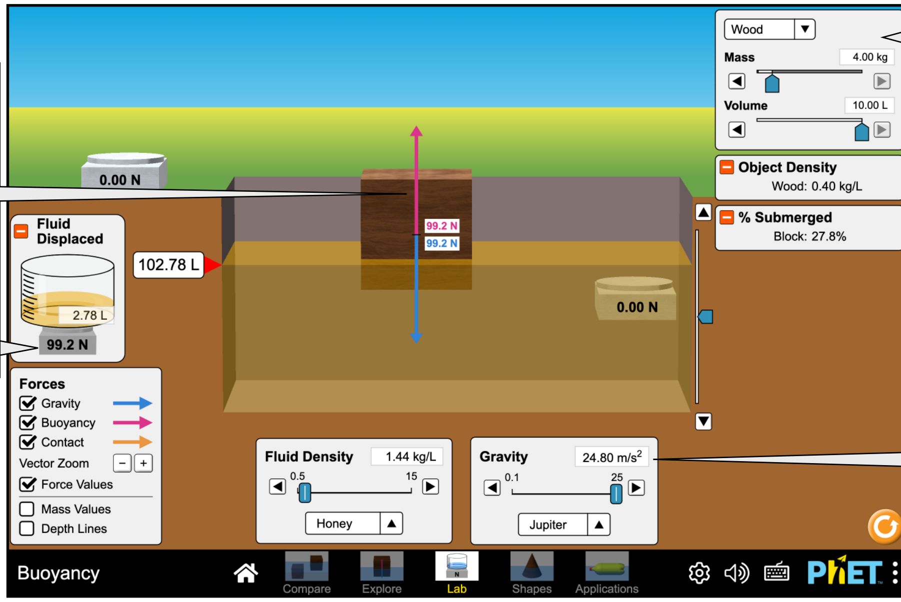
ADD a second block for comparison

López & Rouinfar, August 2024

Lab Screen

Experiment with the weight of the fluid displaced by an object to derive mathematical model of Archimedes' Principle.

ANALYZE the volume and weight of the Fluid Displaced and compare it with the buoyant force



MODIFY the block's material, mass and volume

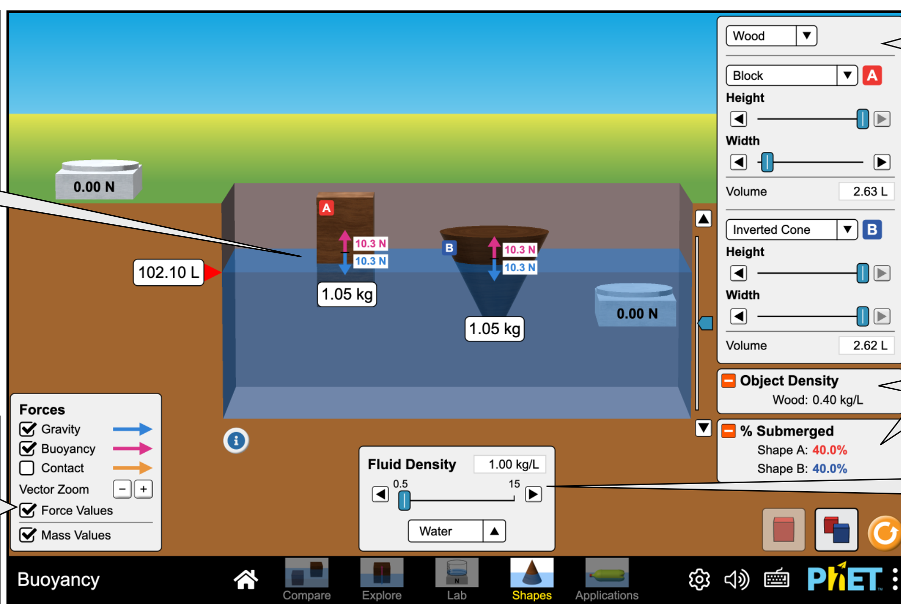
EXPERIMENT with the value of the acceleration due to gravity

Shapes Screen

Which object floats the most in water? Explore the effect of the object's shape on its percentage submerged and the Buoyancy Force.

COMPARE two objects of the same material but different shapes

PERFORM deeper analysis by displaying the values



MODIFY the object's material, shape height and width

COMPARE the density and % submerged of each object

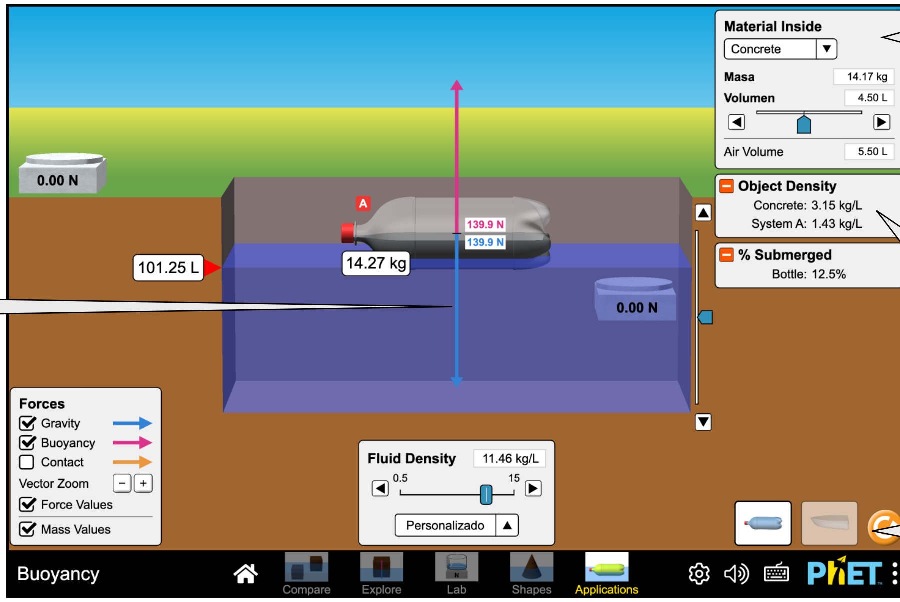
CHANGE the density of the fluid in the pool

López & Rouinfar, August 2024

Application Screen - Bottle

Discover the basic principles of a submarine with an experiment that can be replicated in real life. Experiment with the amount of material you can put inside a bottle to control whether it floats, sinks, or remains floating in the middle of the fluid (neutral buoyancy).

EXPLORE how the bottle floats or sink by analyzing the mass and forces



MODIFY the material inside the bottle and its volume

ANALYZE the density of the system (bottle + material inside)

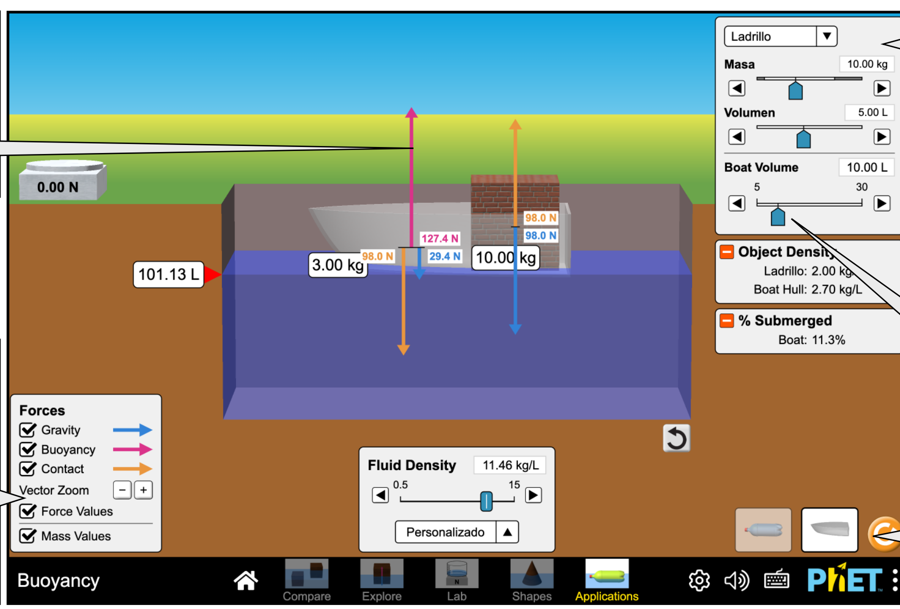
CHANGE to the boat scenario

Application Screen - Boat

Put your knowledge of buoyancy and its mathematical models into action to describe the buoyancy of a boat with a block inside. Analyze the system of forces and calculate the maximum load on the boat for the different materials.

EXPLORE the changes of the boat's and block's forces

PERFORM deeper analysis by displaying the values; **ADJUST** the vector's zoom level



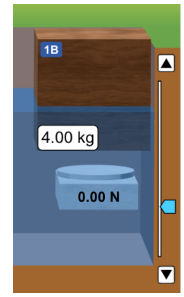
MODIFY the block's material, mass and volume. There are denser materials are in this screen.

TRY with a different boat volume

CHANGE to the bottle scenario

Insights into Student Use

- Students do not need to be told to put the block in the water; it is often their first move.
- Comparing two blocks at a time helps students notice the important ideas about buoyancy. For that reason, the simulation begins with the Compare screen.
- Students naturally want to measure the weight of the blocks on the scale outside and inside the pool, and they conclude where the block weighs less. In scenarios where the block is floating above the scale (as pictured on the right), some students push the block down onto the scale in an attempt to measure its weight. However, the resulting reading will be inaccurate.

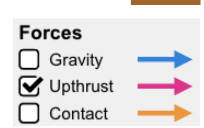


- Students learn that density is what determines whether an object sinks or floats. The "Same Density" scenario in the Compare screen is especially useful for students to achieve that conclusion. To get the most out of this simulation, students should know what density is and how to calculate its value. Consider using PhET's Density simulation first.
- Students may need support to connect the weight of the displaced fluid and the buoyancy force in the Lab Screen.
- Students may need support to interpret that the shape doesn't affect the fluid displaced in the Shapes Screen. A useful scenario for introduction is to create two objects with different shapes, but the same volume and compare the fluid displaced, the buoyant force, and the percentage submerged for each object.
- The boat hull is aluminum with a density of 2.7 kg/L. If the density of the fluid in the pool exceeds this, the boat is going to float even with fluid inside it, creating scenarios with the blocks inside that may be hard for some students to interpret.

Complex Controls

- Sudden changes in the aspect ratio of the simulation can result in blocks being shifted around. In extreme situations, blocks can be lost off-screen, but they can be restored with the Reset All button.
- In the Compare Screen, once the user modifies the mass/volume/density of the blocks, the color of the blocks changes to a gradient blue/yellow color that depends on its density (light color for low-density values, dark for high-density values). Returning to the initial density values with the sliders doesn't return the blocks to wood/brick, but they can be restored with the Reset All button.
- In the Shapes screen, the height and width controls make it easier to create objects that have the same width and height, but different volumes. It may require playing with the height/width controls a bit to compare two objects with the same volume.
- The boat can sink in the pool. To get out the fluid inside the boat, click the in the bottom corner of the pool, or drag the boat out of the pool.

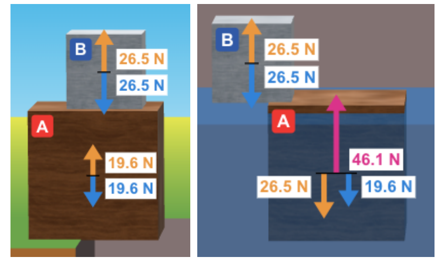
- o change "buoyancy" for "upthrust" use the locale sim in English (United Kingdom) that correspond to this link, or by adding ?locale=en_GB at the end of the sim's URL.



Model Simplifications

- When in the pool, the scale is not affected by the hydrostatic pressure of the fluid.
- The Contact Force is not intended to be analyzed while the block is user-controlled, either directly or indirectly. This force only makes sense when the block is at rest.
- The model is limited to vertical forces, without considering torque. Blocks cannot rotate. This limitation is more evident in the Shapes screen, so we include a disclaimer in the info dialog.

- In the model, the air outside the pool is not considered.
- WebGL is required to run the simulation, see more information here.
- The simulation is centered on the behavior of the blocks in the pool to analyze the buoyant force and the equilibrium of forces. For this reason, the Contact Force generated by one block on another is only considered inside of the pool. For example, in the right scenario, we observe a 26.5N downward contact force on Block A generated by Block B) when it is in the pool. When the blocks are on the ground, this contact force is not present (left scenario).
- See the Model Documentation for more information about the simulation model.



Suggestions for Use

Sample Challenge Prompts

- Determine all the variables that affect if a block sinks or floats in a fluid.
- Describe the relationship between the block's percentage submerged, the density of the block, and the fluid in the pool.
- Design an experiment to describe the behavior of the apparent weight of a block in terms of its percentage submerged.
- Identify the variables that affect the buoyant force.
- Describe the mathematical model of the Archimedes' Principle.
- Describe how the shape of an object affects its buoyancy.
- Calculate the amount of a material inside a bottle that generates a neutral buoyancy.
- Explains the basic principles of the operation of a submarine using the bottle as an example.
- Describe in terms of the forces of the system in a static equilibrium of one block inside a boat.
- Find the maximum weight that the boat can carry. What size of a silver block does it correspond to?
- Create a scenario where the boat can carry a platinum block of 2L.

Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:
`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Buoyancy, if you only want to use the second screen (`screens=2`), and set the gravitational acceleration to 10 m/s² (`gEarth=10`) use:
https://phet.colorado.edu/sims/html/buoyancy/latest/buoyancy_all.html?screens=2&gEarth=10

To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/buoyancy/latest/buoyancy_all.html?screens=2&gEarth=10&locale=es

⚙ Indicates this customization can be accessed from the Preferences menu within the simulation.

Query Parameter and Description	Examples
⚙ `volumeUnits` - specifies units for volume, `decimetersCubed` or `liters` (default).	`volumeUnits=decimetersCubed`
⚙ `percentSubmergedVisible` - when `true` the '% Submerged' readouts are visible in the simulation.	`percentSubmergedVisible=false`
`gEarth` - sets the value of Earth's gravitational acceleration between `9` and `10` m/s². Default is `9.8`.	`gEarth=10`

Query Parameter and Description	Examples
`screens` - launches the screens listed after the '`=`'. For more information, visit the Help Center.	`screens=1` `screens=2,1`
`initialScreen` - opens the sim directly to the specified screen, bypassing the home screen.	`initialScreen=1` `initialScreen=2`
⚙ `audio` - if muted, audio is muted by default. If disabled, all audio is permanently turned off.	`audio=muted` `audio=disabled`
⚙ `locale` - specify the language of the simulation using ISO 639-1 codes. Available locales are listed at the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html".	`locale=es` (Spanish) `locale=fr` (French)
`supportsPanAndZoom` - when `true`, enables panning and zooming of the simulation using pinch-to-zoom or browser zoom controls.	`supportsPanAndZoom=false`
`allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`.	`allowLinks=false`

See all published activities for Buoyancy here.
For more tips on using PhET sims with your students, see Tips for Using PhET.