MECHANICS OF FLUIDS

Buoyancy: the ability of a body to float

person floating in water:
Archimedes’ Principle: When an object is submerged in a fluid, it receives an upward force called buoyancy. The buoyancy force is equal to the weight of the displaced water.
density = mass / volume

density of fresh water = 1 kg/liter

if density <1 → the body floats in fresh water
if density >1 → the body sinks in fresh water
materials of human body:

<table>
<thead>
<tr>
<th>density (kg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>fat</td>
</tr>
<tr>
<td>muscle</td>
</tr>
<tr>
<td>bone</td>
</tr>
<tr>
<td>air</td>
</tr>
</tbody>
</table>

In fresh water:

<table>
<thead>
<tr>
<th>with air out</th>
<th>men</th>
<th>women</th>
</tr>
</thead>
<tbody>
<tr>
<td>all sink</td>
<td></td>
<td></td>
</tr>
<tr>
<td>most float, some sink</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>with air in</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>all float</td>
<td></td>
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</tbody>
</table>

ocean water density ≈ 1.026 kg/l
Center of buoyancy
Lift and drag forces
drag force

(NOTE: This is an oversimplified view of how air resistance works, but it's a helpful way of thinking about it.)
Factors that affect the drag force

- Larger speed $\rightarrow$ larger drag force

- Larger frontal area $\rightarrow$ larger drag force
• Shape of object

intact streamlined object:

object with tail end cut off:

object with front end cut off:
- Roughness of surface
laminar flow

turbulent flow
early separation

partial vacuum

F_3

early separation

late separation

partial vacuum

F_3

smaller F_3 force
lift force

discus:

frisbee:
Magnus effect

boundary layer

low pressure zone

high pressure zone

$F_L$
soccer kick with Magnus effect: