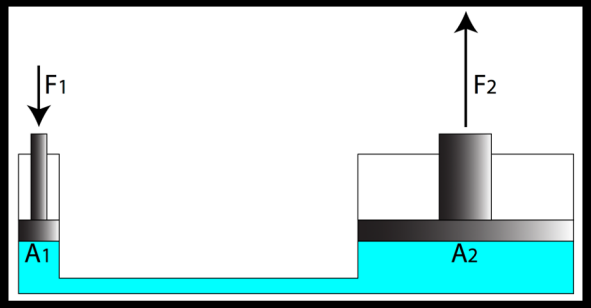
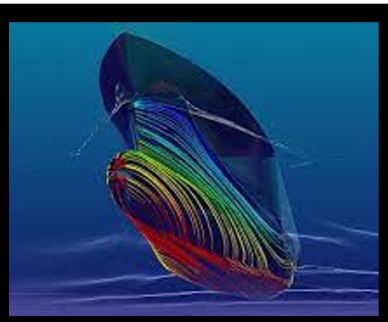
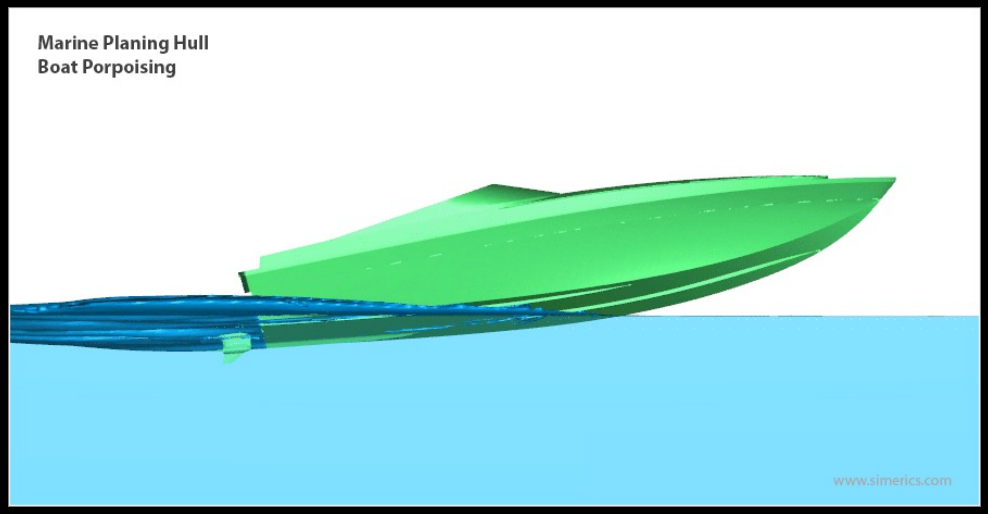






https://www.simerics.com/simulation-gallery/planing-hull

Engineering Principles (Fluidics & Hydrodynamics)

John R. Wright, Jr., Ph.D., CSTM, CLSSGB, CSCE, F.ATMAE

AENG 101 Introduction to Engineering

Department of Applied Engineering, Safety, & Technology (AEST)

Schwaller, A. E. (1989). Transportation, energy and power technology. Albany, NY: Delmar.

Outline

Fluidics

- Hydraulic & Pneumatic
- Laws and Theorems

Hydrodynamics

- Boat Terminology
- Hull Types
- Resistance & Buoyancy

Fluidics

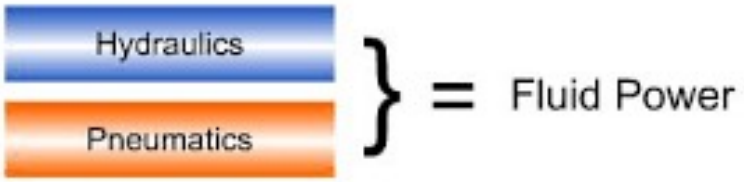
Fluid power is used to transmit power from one point to another

- They are used in many transportation devices
- Example: brake system on a car

2 types of Fluid Power Systems:

- 1) Hydraulic systems are those that use a liquid, such as oil as the transmitting medium
- 2) Pneumatic systems use air or gas as the medium

Both hydraulics and pneumatics are defined as *fluid power*. They use fluid to transmit power from one point to another.



https://www.rg-group.com/resources/blog/hydraulics-vs-pneumatics

Hydraulic & Pneumatic

- Hydraulic fluids are considered uncompressible
- Hydraulic fluids must have complete hydraulic circuits. Return lines must be used, and a reservoir is needed to hold the extra fluid

- Pneumatic fluids are considered gases and are compressible
- Pneumatic fluids do not need complete circuits. Air may be vented to the atmosphere

Force & Pressure

- Force is defined as *"the pushing or pulling action of one object upon another"*
  - Force usually causes an object to move
  - Usually measured in pounds
- Pressure is defined as *"a force acting upon an area"*
  - Measured commonly in psi

Pascal's Law

- *"A pressure applied to a confined fluid is transmitted undiminished to every portion of the surface of the containing vessel"*
- Also states: *"Pressure on a fluid is equal to the force applied divided by the area"*

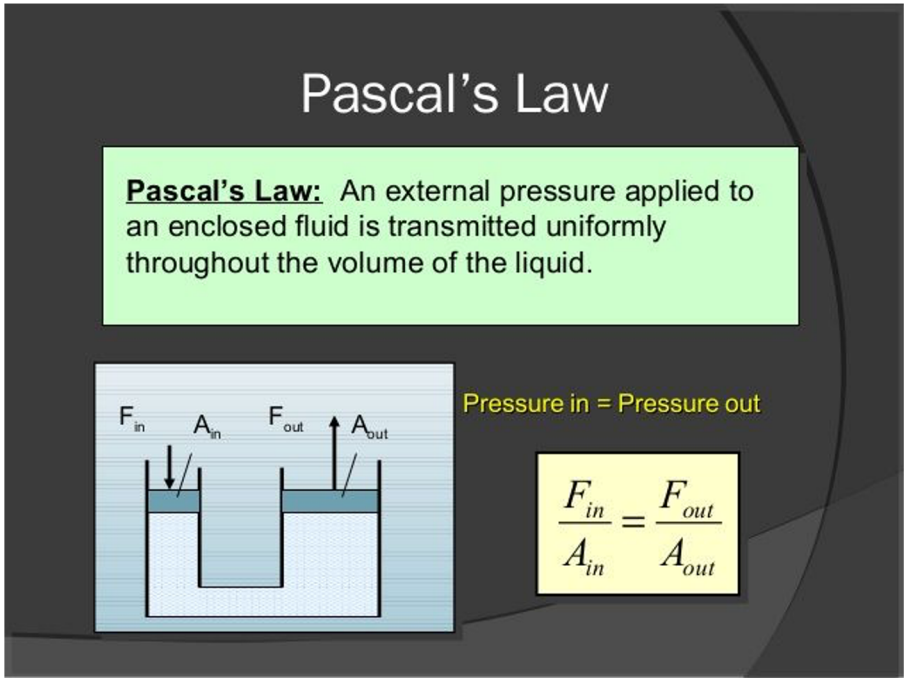
  P = F / A

  - where:

    P = pressure in psi

    F = force applied in pounds

    A = area to which the force is applied



https://www.pinterest.com/pin/106467978673146524/

Pascal's Law

F_1 = 100 lbs

A_1 = 1in^2

A_2 = 5in^2

P = ? psi

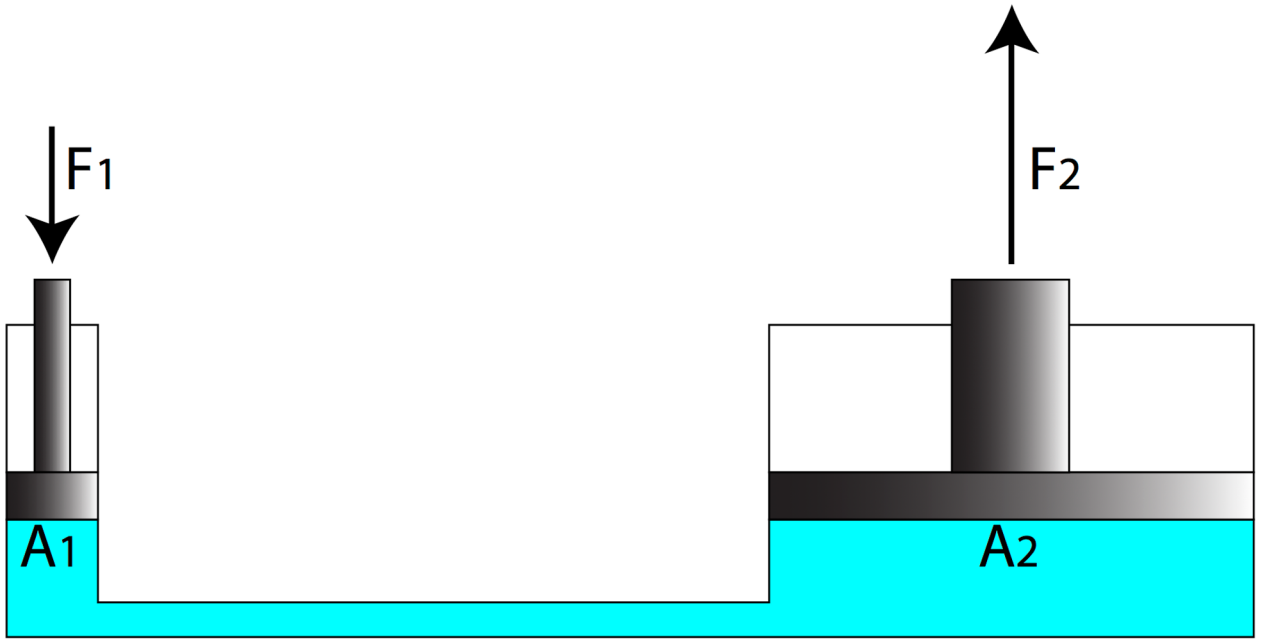
F_2 = ? Lbs

IMA = ?

P = F / A

$F_1 / A_1 = F_2 / A_2$

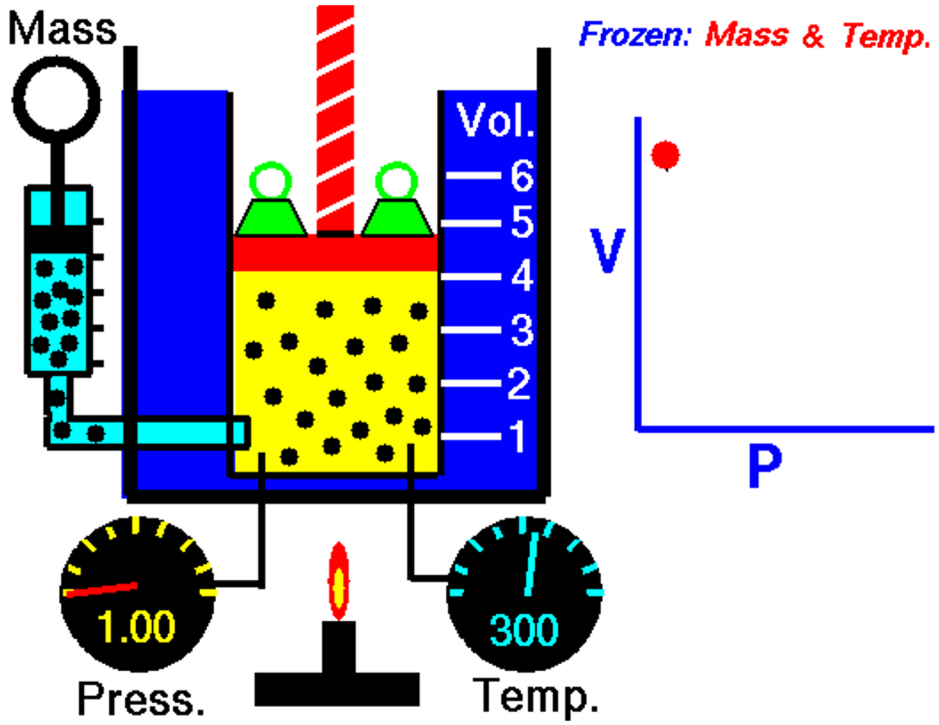
IMA = F_2 / F_1



Boyle's Law

- *"The volume of a gas varies inversely with the pressure applied to it, provided the temperature of the gas remains constant"*
  - This means that as the volume of a gas is reduced such as in an engine when the piston compresses air - the pressure is increased
  - If the volume was halved, the pressure would be doubled

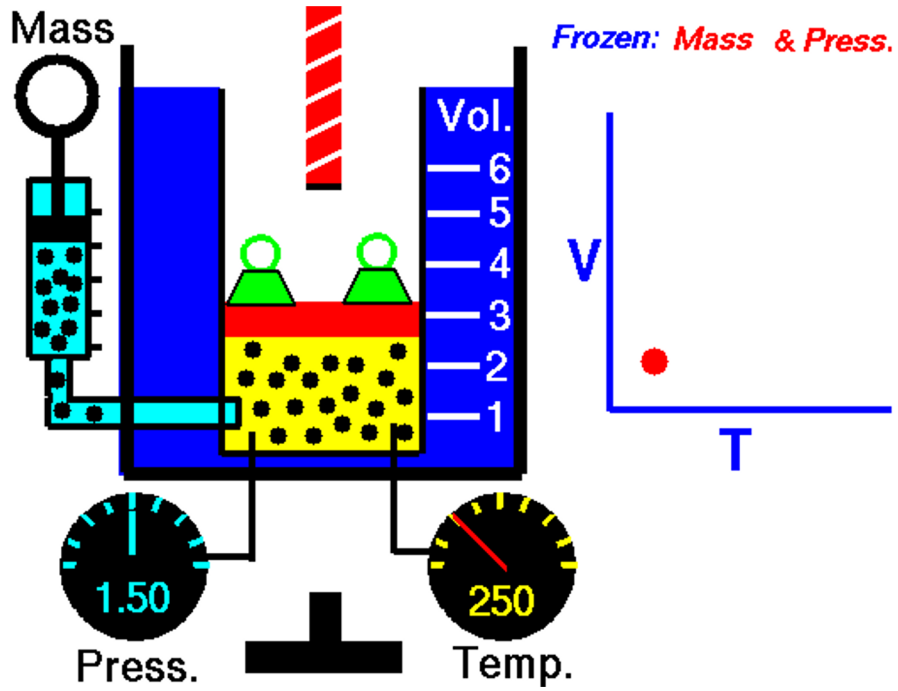
    Note: remember hydraulic fluids may not be compressed, but pneumatic fluids can



https://www.grc.nasa.gov/WWW/K-12/airplane/aboyle.html

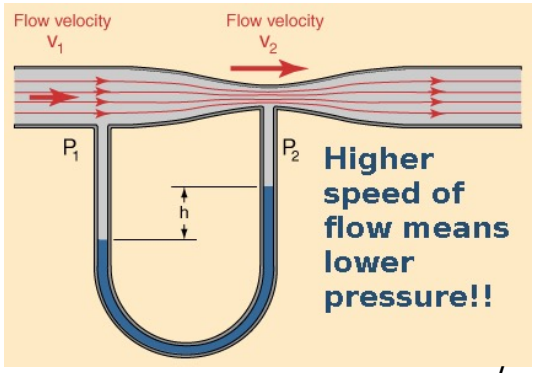
Charles' Law

- *"As the temperature of a gas increases, the volume of the gas increases proportionally, keeping the pressure constant*
  - This means that as the temperature of a gas goes up, so will the volume of that gas
  - If the volume is doubled, then the temperature was doubled

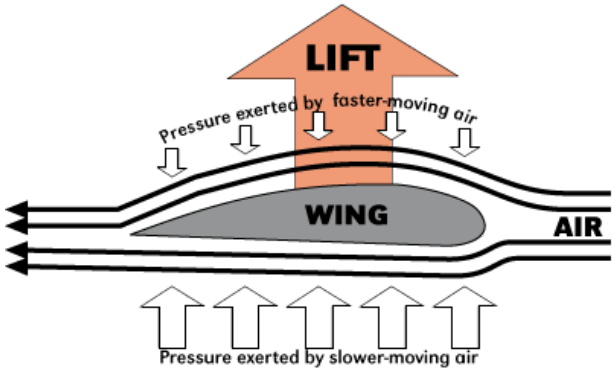


https://en.wikipedia.org/wiki/Charles%27s_law#/media/File:Charles_and_Gay-Lussac's_Law_animated.gif

Bernoulli's Theorem

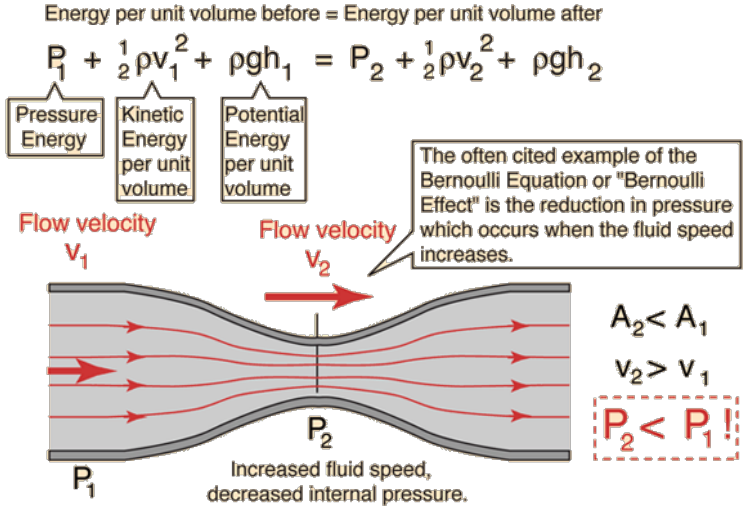


https://zharuosi.github.io/blog/2019/03/19/Bernoulli/



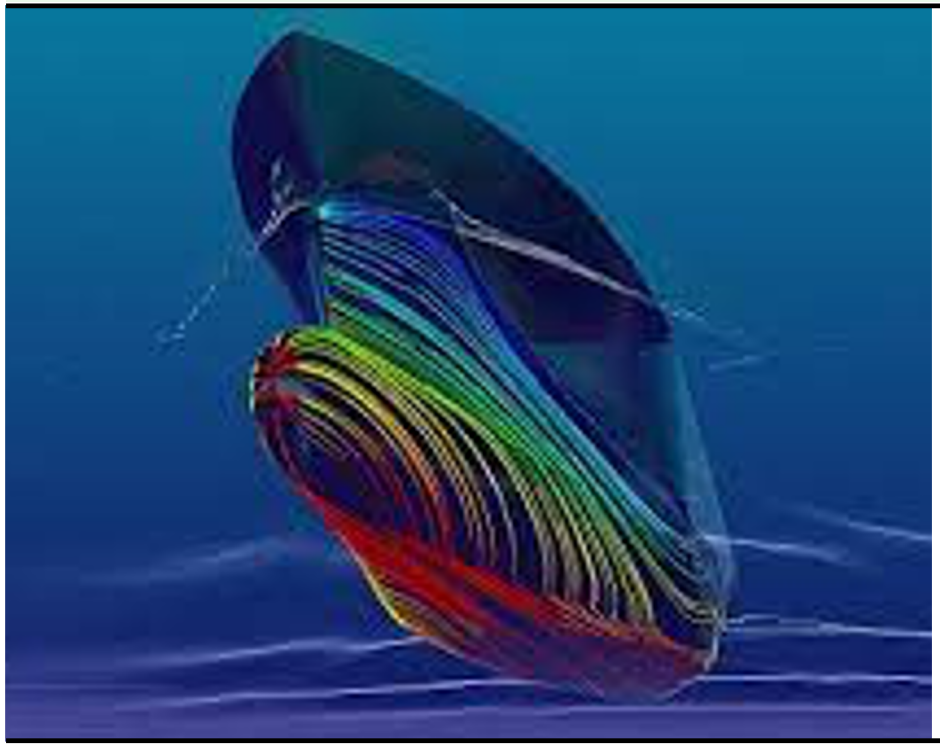
https://truppi6thgrade.weebly.com/bernoullis-principle.html

- *"When a fluid flows through a pipe, pressure will remain constant unless the diameter of the pipe changes"*
  - Going from a wide diameter pipe to a smaller diameter pipe with cause the fluid to increase its velocity, but the pressure (static) will be reduced at that point



http://hyperphysics.phy-astr.gsu.edu/hbase/pber.html

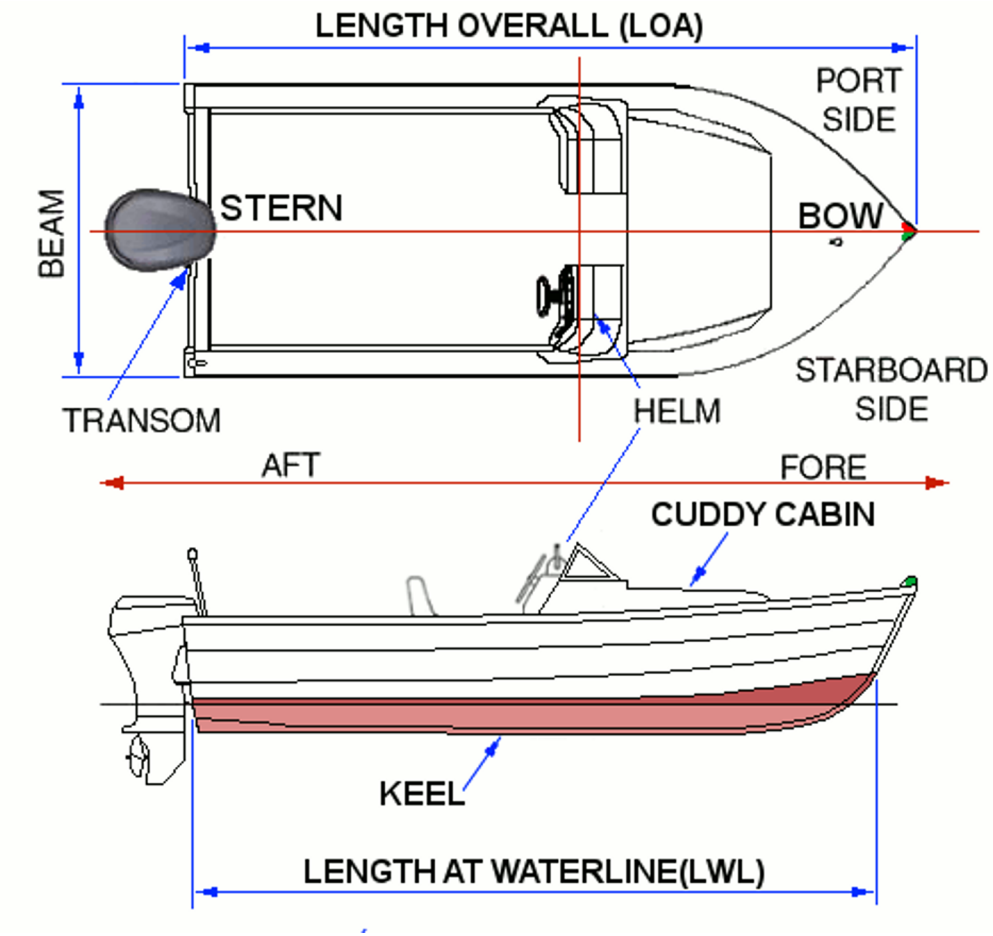
Hydrodynamics



- Basic Boat Terminology
- Hull Types
- Buoyancy / Archimedes Principle
- Center of Gravity
- Stability

https://www.plm.automation.siemens.com/global/en/industries/marine/hydrodynamics.html

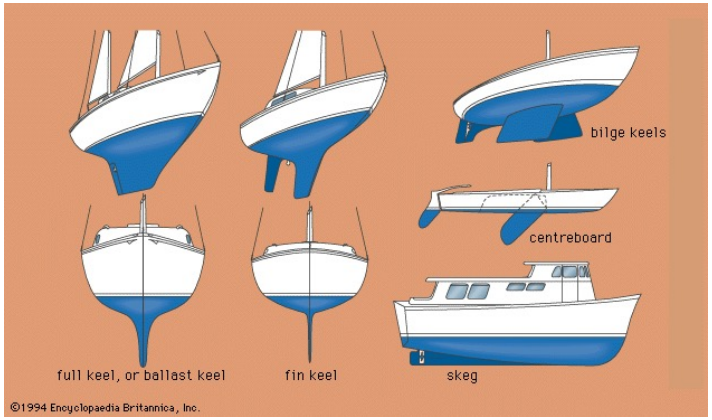
Basic Boat Terminology



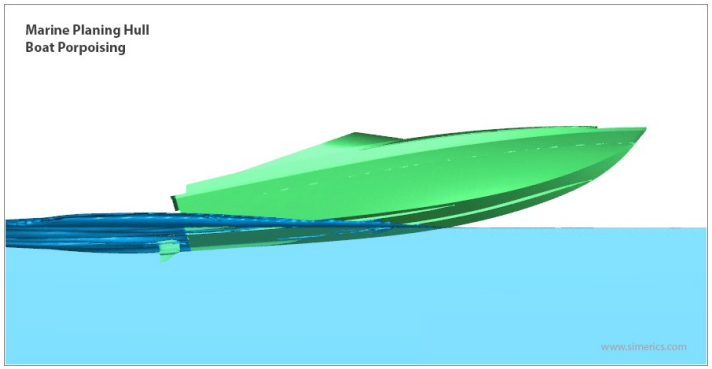
http://www.poughkeepsieyachtclub.org/boating-terms

Basic Hull Types

1) Displacement:
   - Displace a volume of water equal to the mass of the vessel
   - Designed to cut through the water with little effort
2) Planing:
   - Have flatter bottoms
   - Ride high in the water (Porpoising)
   - Less drag (especially at full speed)



https://forums.sailboatowners.com/threads/fastest-hull-design-and-rig.190543/

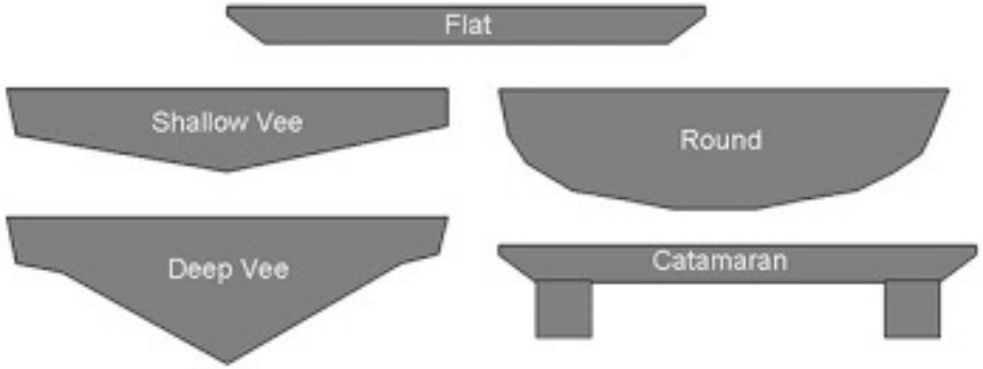


https://www.simerics.com/simulation-gallery/planing-hull/

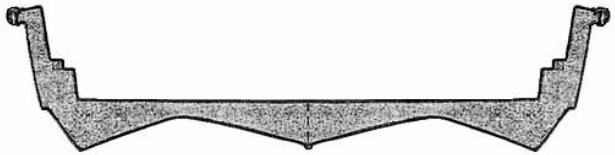
Some Different Boat Hull Types (cross-sections)

https://www.bostonwhaler.com/

https://www.pinterest.com/pin/Aeu95jU_4OBXxS925ZXrh5yma7lxDvlZeI9Xxnro9jOGViU1VVV-tAM/

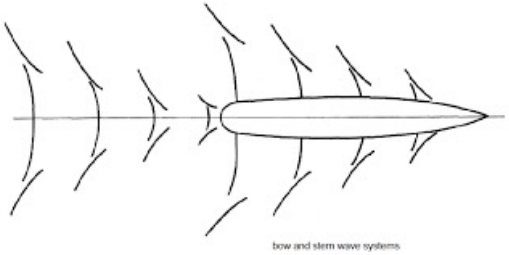


https://www.sciencebuddies.org/science-fair-projects/project-ideas/Aero_p037/aerodynamics-hydrodynamics/milk-carton-boats

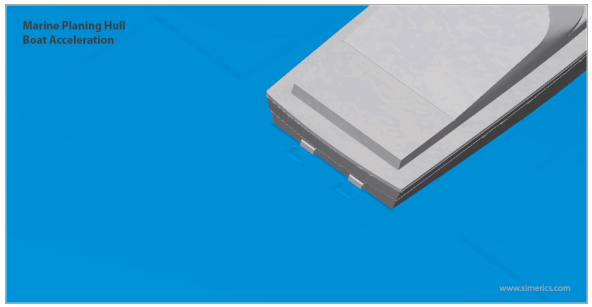


https://continuouswave.com/whaler/reference/13/originalHullDesign.html

Resistance Encountered by Hulls

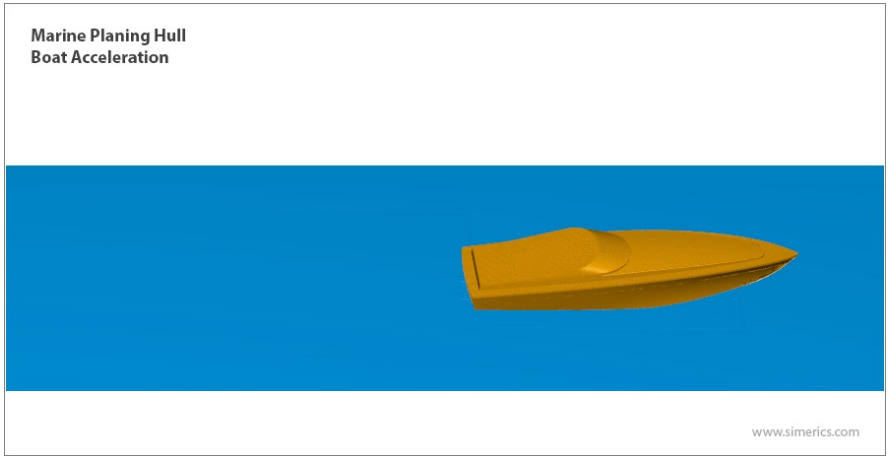


https://www.mermaid-consultants.com/ship-wave-making-resistance.html



3 types of Resistance

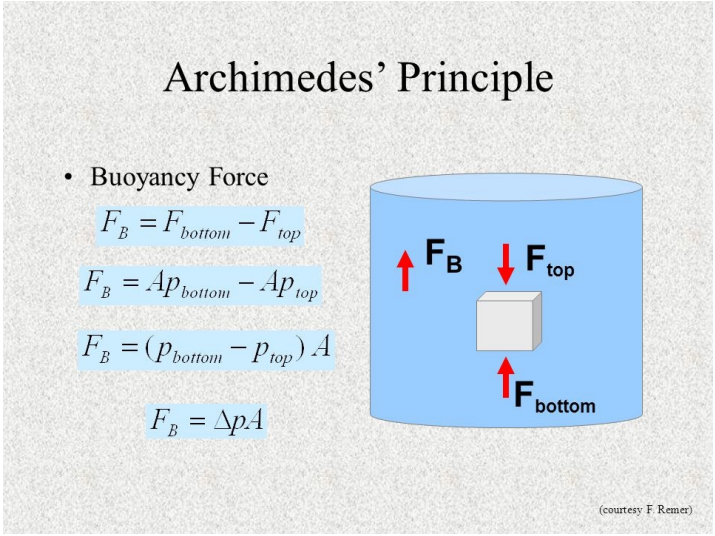
- (1) Bow Wave Making:
- (2) Stern Eddy Making:
- (3) Skin Friction:



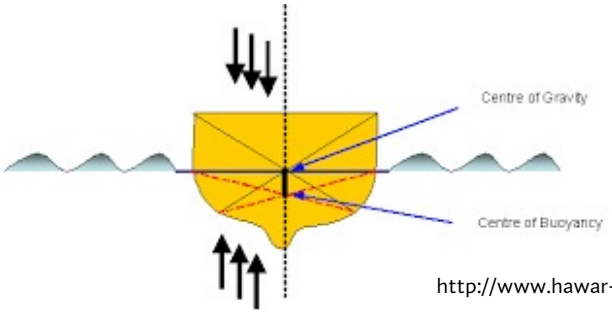
https://www.simerics.com/simulation-gallery/planing-hull/

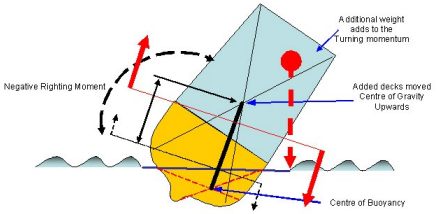
Buoyancy, CG & Reducing Yaw

- Buoyancy (Archimedes Principle)
  - The upward push from the water on the vessel
    - It opposes gravity
    - If upward force is > weight of the object, it will float
- Center of Gravity (CG)
  - Should always be low to improve stability
  - Ballast is usually added to lower the CG
- Reducing Yaw is important in aiding hydrodynamic performance
  - Side to side motion is inefficient and may slow the design



https://slideplayer.com/slide/3493839/





http://www.hawar-islands.com/dhow.html