Chapter 10: Fluids

AP Physics B

Rank the densities

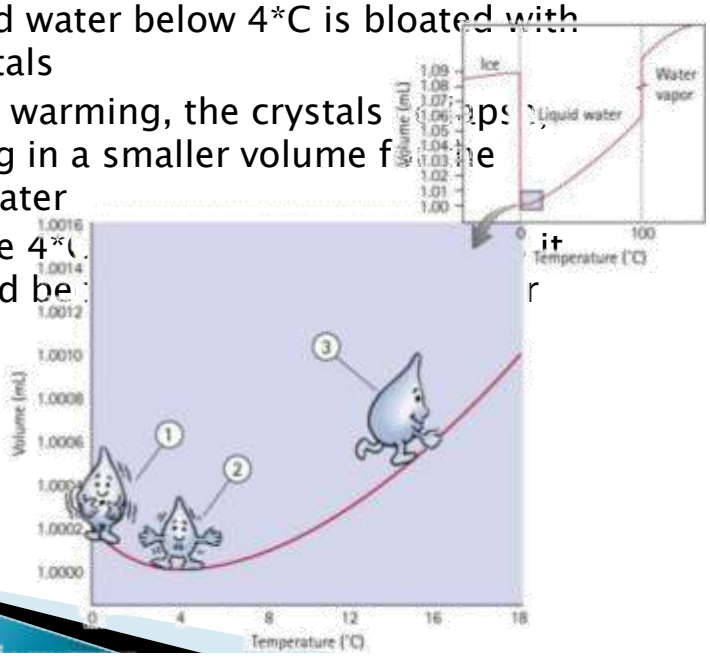
Rank the densities

Substance	ρ (kg/m^3)
Hydrogen	0.0899
Helium	0.179
Steam (100°C)	0.598
Air	1.29
Oxygen	1.43
Carbon dioxide	1.98
Ethanol	0.806×10^3
Ice	0.917×10^3
Fresh water (4°C)	1.00×10^3
Sea water (15°C)	1.025×10^3
Iron	7.86×10^3
Mercury	13.6×10^3
Gold	19.3×10^3

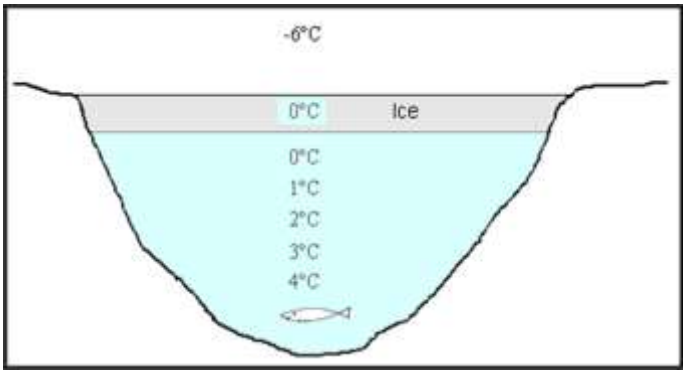
*All densities are measured at 0°C and 1 atm unless otherwise noted.

6.7 Expansion of Water

- 1) Liquid water below 4*C is bloated with ice crystals
- 2) Upon warming, the crystals collapse, resulting in a smaller volume for the liquid water
- 3) Above 4*C, it is heated by ... motion



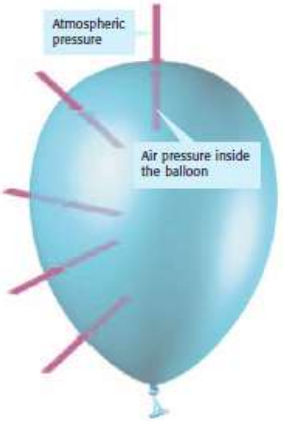
6.7 Expansion of Water



- What was the precise temperature at the bottom of Lake Michigan on New Year's Eve in 1901?

7.1 Fluids and Pressure

- Atmospheric pressure – pressure caused by weight of the atmosphere
  - 101,300 N ~ 101 kPa at sea level
- Why don't you implode?
  - The fluids in your body exert pressure.



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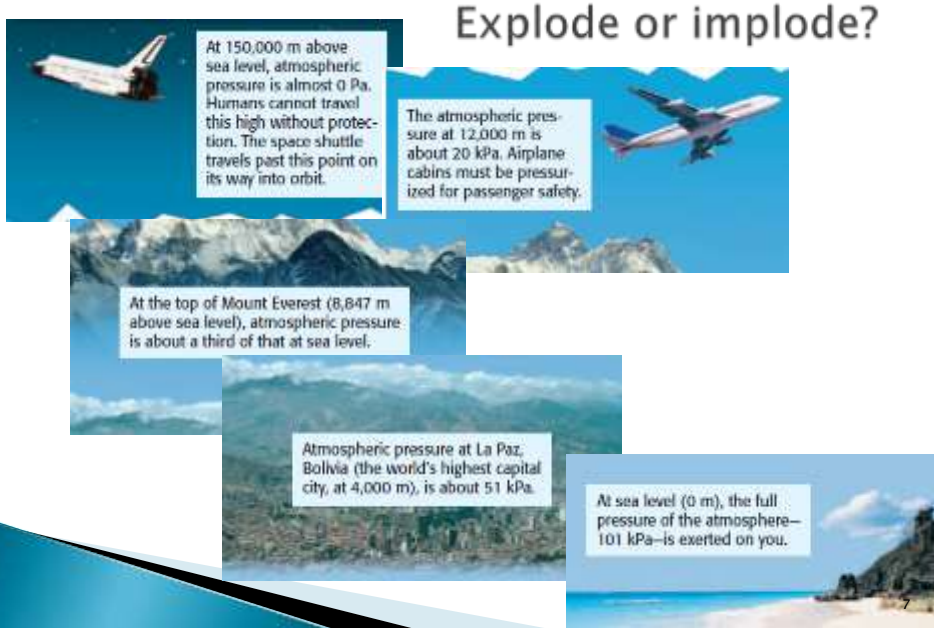
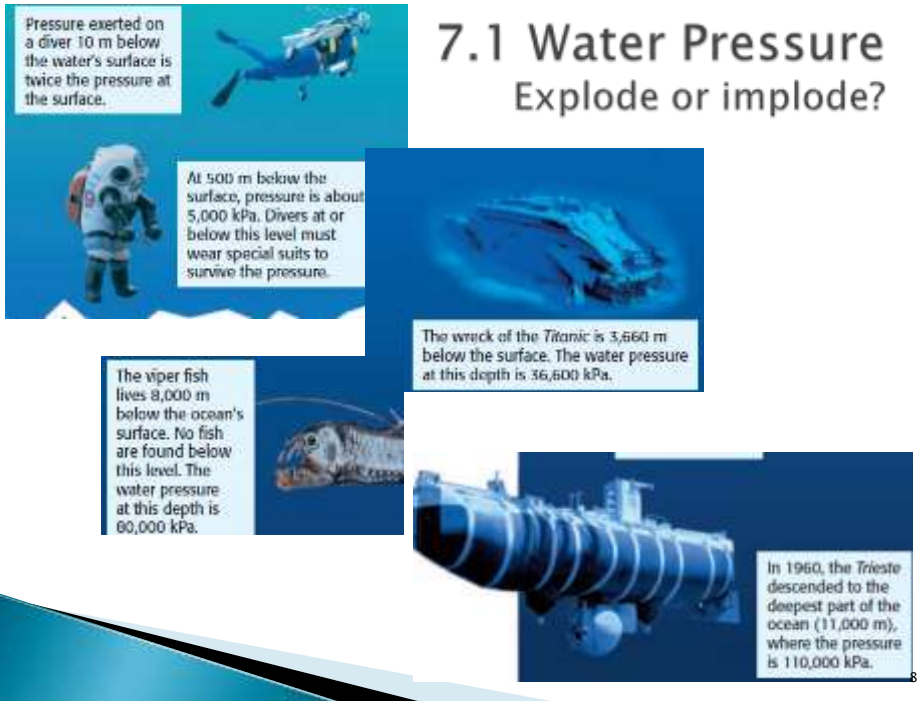
7.1 Atmospheric Pressure
Explode or implode?



7.1 Water Pressure
Explode or implode?



7.1 Fluids and Pressure

- Pressure Difference: Fluids flow from high/low to high/low pressure
- Everyday examples:
  - How does a dropper work?
  - How does a straw work?
  - How do your lungs inhale air?
  - Why are tornadoes like vacuum cleaners?

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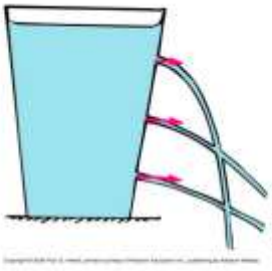
7.1 Fluids and Pressure

- Question: Why does pressure increase with depth?



If there is a hole in the container's surface then liquid will initially flow out perpendicular to the surface (gravity eventually causes path of flow to curve)

at greater depths…net force & pressure are greater…velocity of escaping liquid is greater (note: longer velocity vectors)

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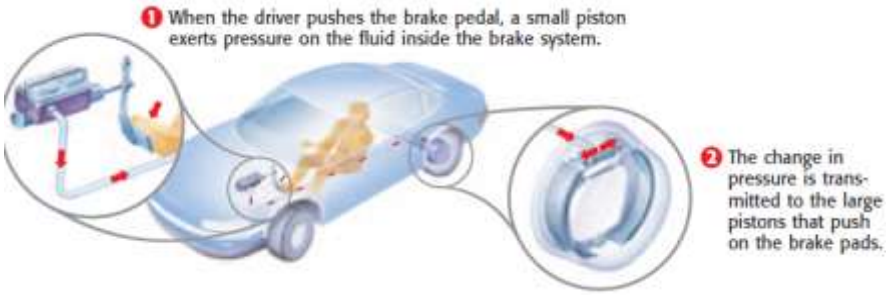
7.3 Pascal's Principle

- For an enclosed fluid, change in pressure in 1 place = change in pressure everywhere.



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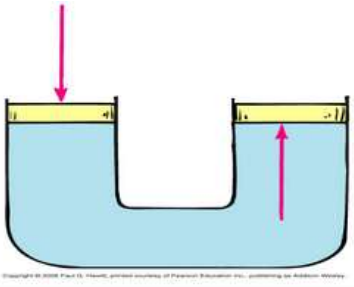
Pascal's Principle



Pressures are equal. Since the areas are equal then the forces exerted on the areas are equal as well.

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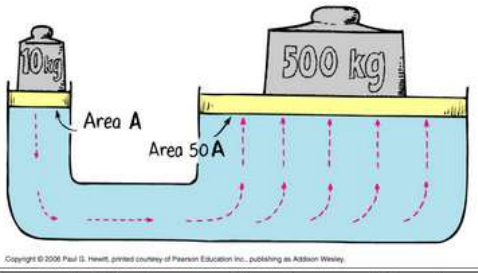
Pascal's Principle



The pressures (P = F/A) are equal. If the diameters of the pistons are different then the forces exerted on them will be different as well. If area of second piston is 50 times greater, then the force exerted will be 50 times greater. Note: the force needed to lift a 500kg mass is equal to its weight (w = mg).

$\frac{F1}{A1} = \frac{F2}{A2}$ a small force exerted over a small area will result in a large force exerted over a large area

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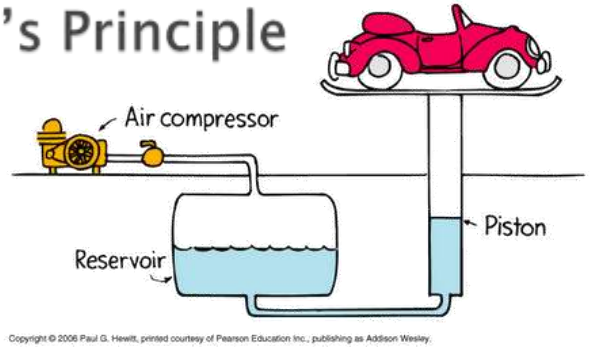
Pascal's Principle



Air compressor puts pressure on a large surface area of fluid in underground reservoir tank. The pressure exerted on reservoir fluid is equal to pressure the fluid will exert on smaller surface area piston.

Pressure = force / area

Since both Pressures are equal and the areas are different, then the forces should be different (in a reciprocal fashion) as well to yield equal pressures.

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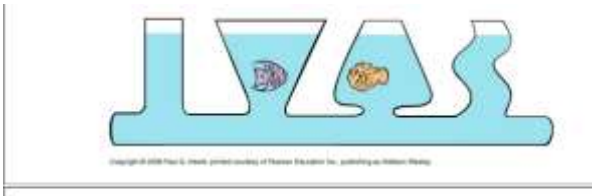
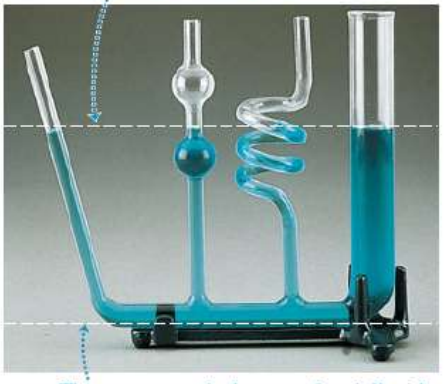


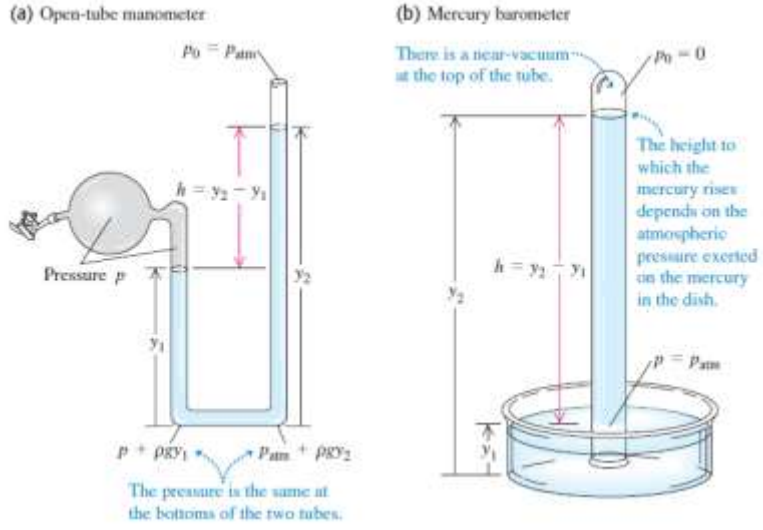
pressure of liquid is same at any given depth below surface regardless of shape of container

The pressure at the top of each liquid column is atmospheric pressure, p_0.



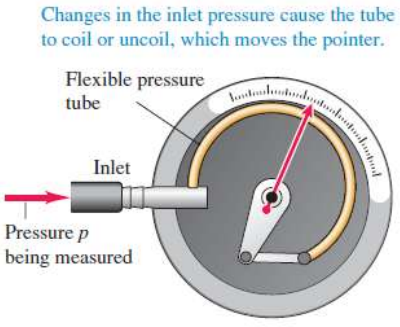
The pressure at the bottom of each liquid column has the same value p.

The difference between p and p_0 is ρgh, where h is the distance from the top to the bottom of the liquid column. Hence all columns have the same height.



mmHg? And Water?

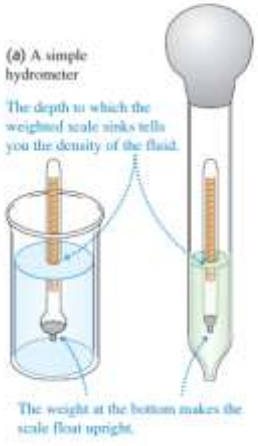
(a)



(b)

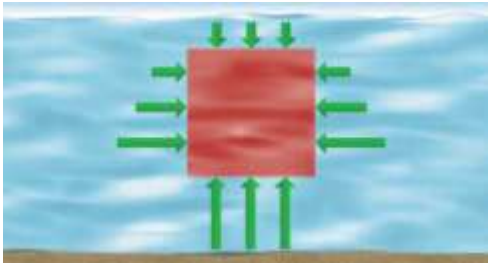
12.12 Measuring the density of a fluid.

(b) Using a hydrometer to measure the density of battery acid or antifreeze



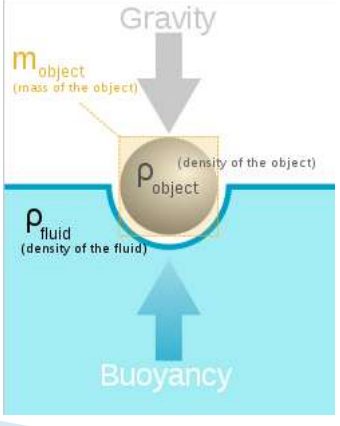
7.2 Buoyant Force

- There is more pressure below than above



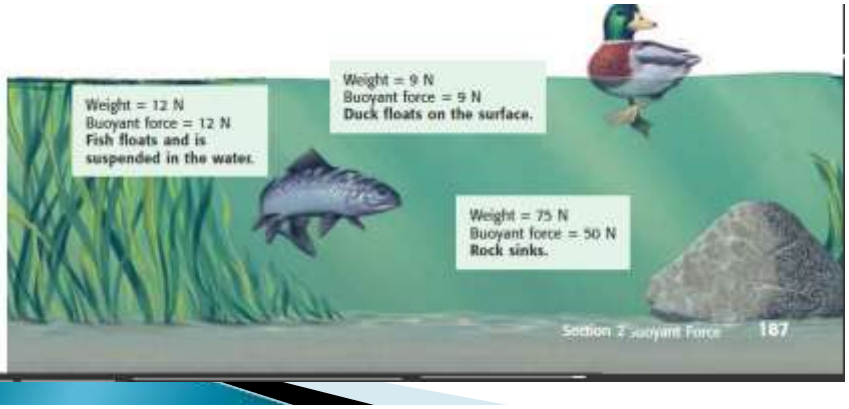
7.2 Buoyant Force

- Buoyant force = upward force that fluids exert on all matter.



7.2 Buoyant Force

- Archimedes' Principle:
  The buoyant force = weight of displaced fluid
- The weight of the object does not matter!



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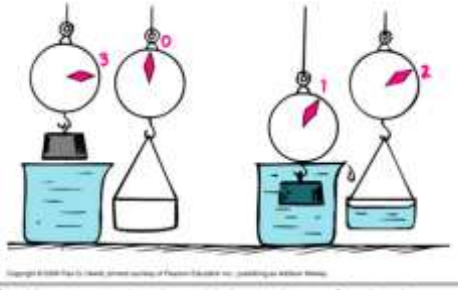

Apparent weight: object appears to have less weight because buoyant force is acting upward on object. Buoyant force is equal to weight of volume of fluid displaced.

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7.2 Buoyant Force

- Math
  - You need a force of 15 N
    to lift an object that is underwater.
    The object displaces 2 L of water

    What is the weight of the object?

7.2 Buoyant Force

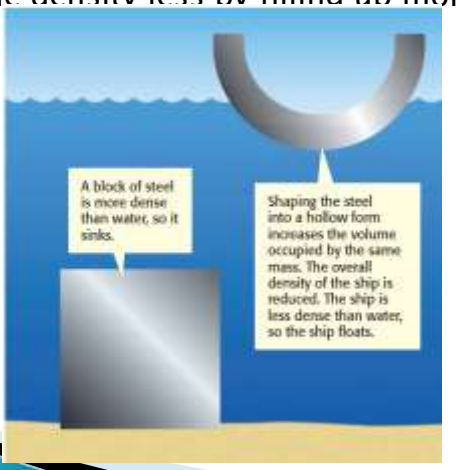
- Floating, sinking, and density.
  - When the object is more/less dense than the fluid, the object will sink/float.

- Density =

  mass/volume

7.2 Buoyant Force

- Changing overall density.
  - Make the density less by filling up more space with air.



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7.2 Buoyant Force

- Changing density by changing mass.

When a submarine is floating on the ocean's surface, its ballast tanks are filled mostly with air.

Vent holes on the ballast tanks are opened to allow the submarine to dive. Air escapes as the tanks fill with water.

Vent holes are closed, and compressed air is pumped into the ballast tanks to force the water out, so the submarine rises.

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7.2 Buoyant Force

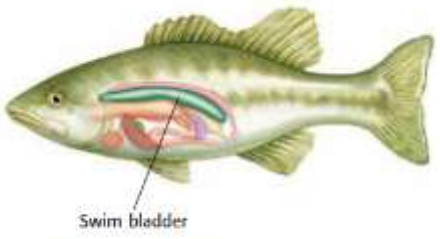

Figure 6 *Most bony fishes have an organ called a swim bladder that allows them to adjust their overall density.*

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From Archimedes
Buoyant force and density?

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7.3 Fluids and Motion

- http://www.youtube.com/watch?v=WDGNcmEOjs4
- http://www.youtube.com/watch?v=yvz_pS3pZ8s&feature=related
- http://www.youtube.com/watch?v=fgHvC55AKig&feature=related

7.3 Fluids and Motion

- What happened?
- Bernoulli's Principle: The faster the fluid moves, the less pressure there is.
  - Think of a running crowd.

7.3 Bernoulli's Principle

- Explain this

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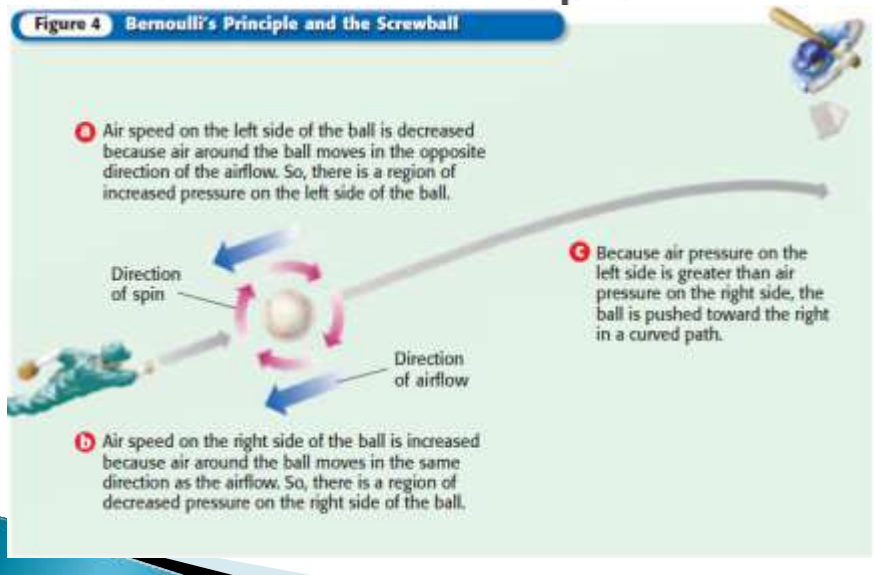
7.3 Bernoulli's Principle

Figure 4 Bernoulli's Principle and the Screwball



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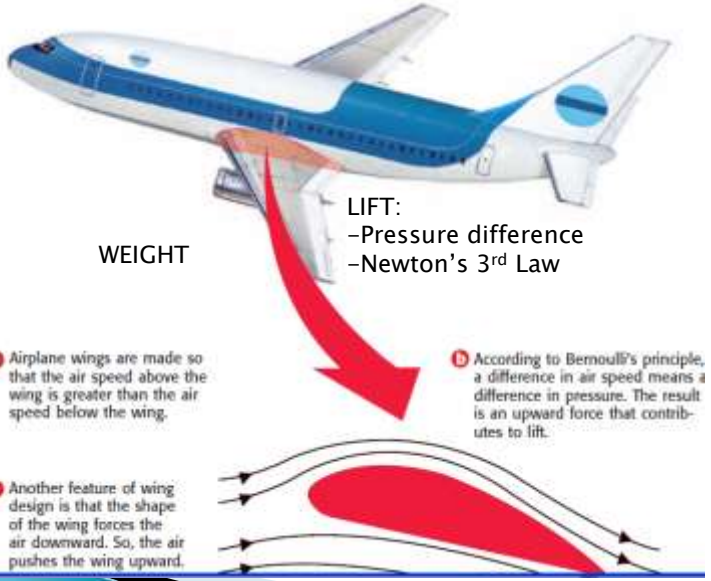
7.3 Bernoulli in Flight



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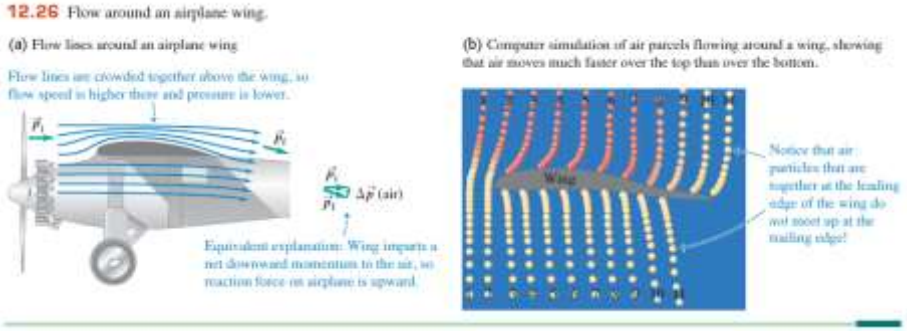

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7.3 Bernoulli's Principle

- Do you think a fast or slow plane needs bigger wings? Why?

Figure 3 Increased Thrust Versus Increased Wing Size

The engine of this jet creates a large amount of thrust, so the wings don't have to be very big.

This glider has no engine and therefore no thrust. So, its wings must be large in order to maximize the amount of lift achieved.

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7.3 Bernoulli's Principle

- Do you think a fast or slow plane needs bigger wings? Why?

  The plane with more thrust (more force to go faster) has less pressure above wings, so it has more lift.
  The slower plane has less pressure above wings, so it needs bigger wings for more lift.

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7.3 Bernoulli's Principle

- Why does a small bird need to flap more to fly? Why does a large bird flap less?

7.3 Bernoulli's Principle

- What are the flaps on an airplane wing for?

7.3 Fluids and Motion

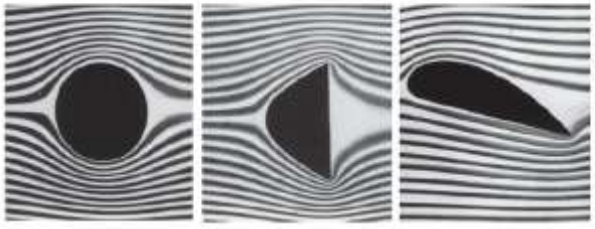
- Review

1. What forces act on an airplane?
2. When an airplane is flying, how does the air pressure above a wing compare with that below the wing?
3. How is thrust related to the speed of an airplane?

- http://w3.shorecrest.org/~Lisa_Peck/Physics/syllabus/phases/liquids/ch19liquid_images/ch19_images.htm
- http://www.vivaphysics.com/animations.php?id=6

Laminar Flow, Streamlines

12.19 Laminar flow around obstacles of different shapes.



12.20 The flow of smoke rising from these incense sticks is laminar up to a certain point, and then becomes turbulent.

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Test Your Understanding of Section 12.4 A maintenance crew is working on a section of a three-lane highway, leaving only one lane open to traffic. The result is much slower traffic flow (a traffic jam). Do cars on a highway behave like (i) the molecules of an incompressible fluid or (ii) the molecules of a compressible fluid?

Test Your Understanding of Section 12.5 Which is the most accurate statement of Bernoulli's principle? (i) Fast-moving air causes lower pressure; (ii) lower pressure causes fast-moving air; (iii) both (i) and (ii) are equally accurate.

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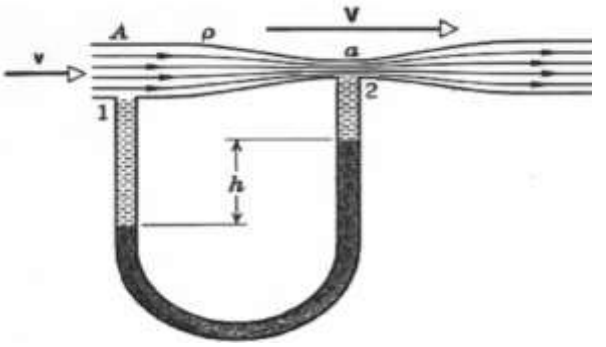
Applications
1. Torricelli's Theorem

Applications
2. Perfume Atomizer

Applications
3. Venturi Meter



Applications
Why collide?

References

- http://www.hbcc.edu.sa/facpages/samaila/ppt/PPA6_Lecture_Ch_10.pdf
- http://www.hbcc.edu.sa/facpages/samaila/ppt/PPA6_Lecture_Ch_11.pdf
- All online!