Physics 6B

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http://www.deepspace.ucsb.edu/classes/physics-6b-spring-2015

Course Outline

- Text – College Physics – Freedman 2014
- Cover Chap 11-13, 16-21
- Chap 11- Fluid
- Chap 12 – Oscillations
- Chap 13 – Waves
- Chap 16 – Electrostatics
- Chap 17 – Electrostatics
- Chap 18 – Moving Charges
- Chap 19 – Magnetism
- Chap 20 – Magnetic Induction
- Cha- 21 – AC Circuits

Info

- HW due each week – Sapling ~ 10% grade
- Midterm – date not set yet ~ 25% grade
- Bring large pink scantron, calculator, 1 sheet notes
- Final 10 AM class: Mon 6/8 8-11
- Final 12 Am class: Tue 6/9 12-3
- iClicker questions and in class participation ~ 5%
- **All phones away please. All computers OFF**
- **Electronic detox during class**
- Think about how material relates to your life
- Participate!

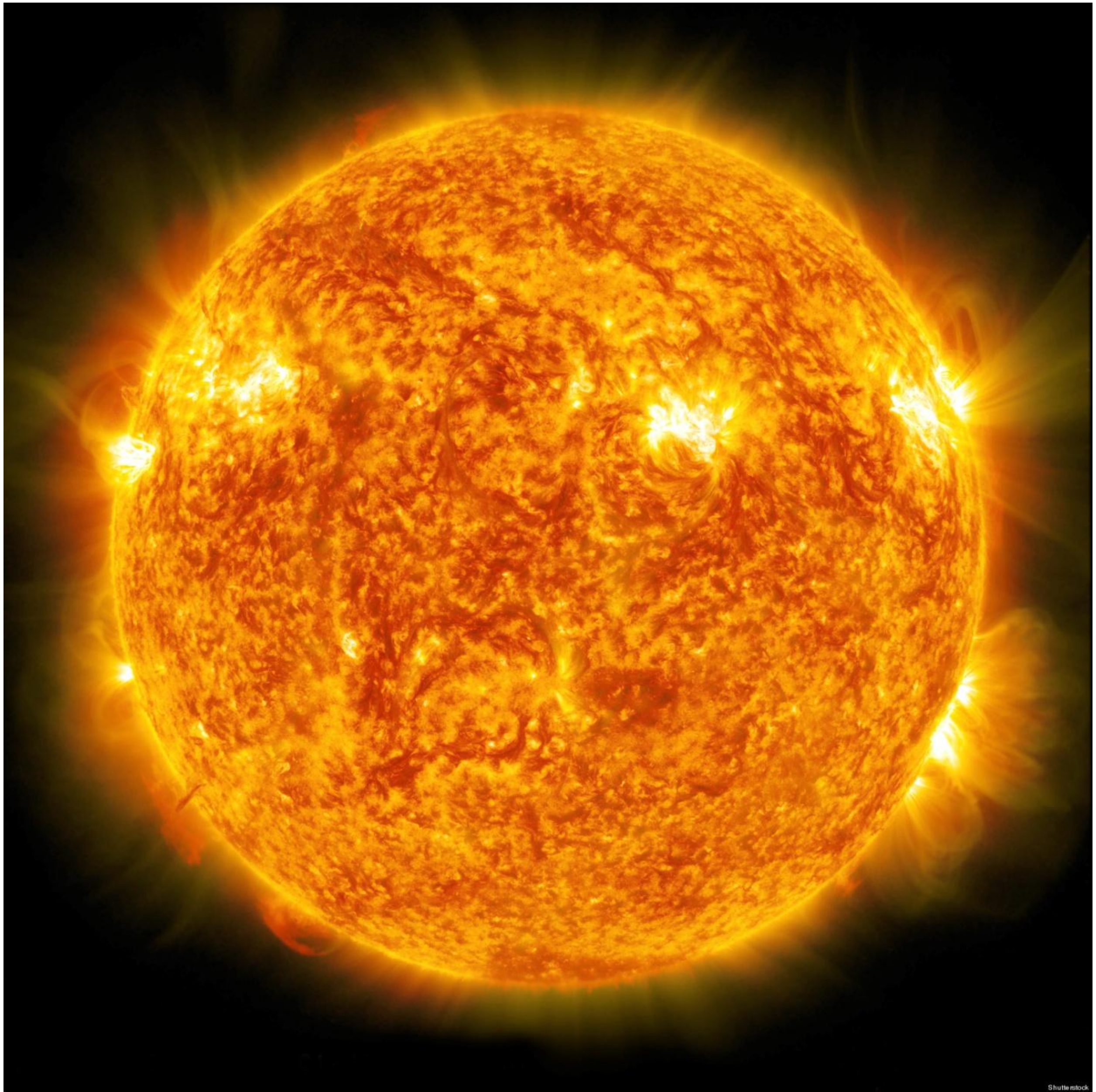
Smile - Humor in Life is a Must

There is more to life than Physics – not really

- http://www.deepspace.ucsb.edu/misc
- http://www.xkcd.com
- http://www.phdcomics.com/comics.php
- http://www.youtube.com/watch?v=Fl4L4M8m4d0
- http://www.youtube.com/user/NurdRage
- Why did Karl Marx Dislike Earl Grey tea?
- Because all Proper Tea is Theft

This is where you live

This is why you live

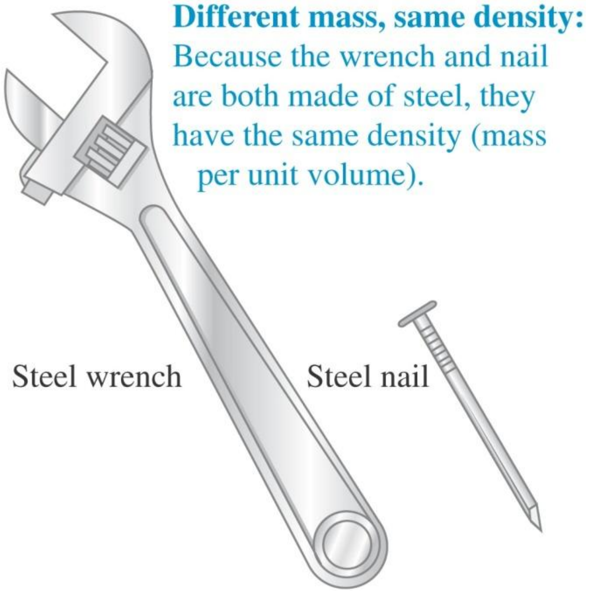


Next time you are at the beach

- Why must the shark keep moving to stay afloat while the small fish can remain at the same level with little effort?
- We begin with fluids at rest and then move on to the more complex field of fluid dynamics.

Density

- The *density* of a material is its mass per unit volume: $\rho = m/V$.
- The *specific gravity* of a material is its density compared to that of water at 4°C (densest T) .
- How much does the air in a room weigh?



Densities of some common substances

Table 12.1 Densities of Some Common Substances

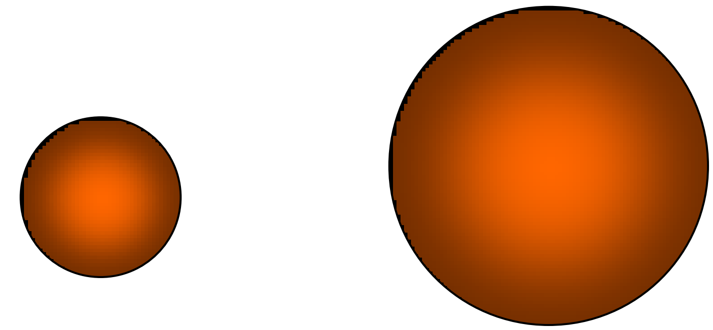
Material	Density (kg/m^3)*	Material	Density (kg/m^3)*
Air (1 atm, 20°C)	1.20	Iron, steel	7.8×10^3
Ethanol	0.81×10^3	Brass	8.6×10^3
Benzene	0.90×10^3	Copper	8.9×10^3
Ice	0.92×10^3	Silver	10.5×10^3
Water	1.00×10^3	Lead	11.3×10^3
Seawater	1.03×10^3	Mercury	13.6×10^3
Blood	1.06×10^3	Gold	19.3×10^3
Glycerine	1.26×10^3	Platinum	21.4×10^3
Concrete	2×10^3	White dwarf star	10^{10}
Aluminum	2.7×10^3	Neutron star	10^{18}

*To obtain the densities in grams per cubic centimeter, simply divide by 10^3.

Density question

The sphere on the right has twice the mass and twice the radius of the sphere on the left.

Compared to the sphere on the left, the larger sphere on the right has



mass m
radius R

mass $2m$
radius $2R$

A. twice the density.

B. the same density.

C. 1/2 the density.

D. 1/4 the density.

E. 1/8 the density.

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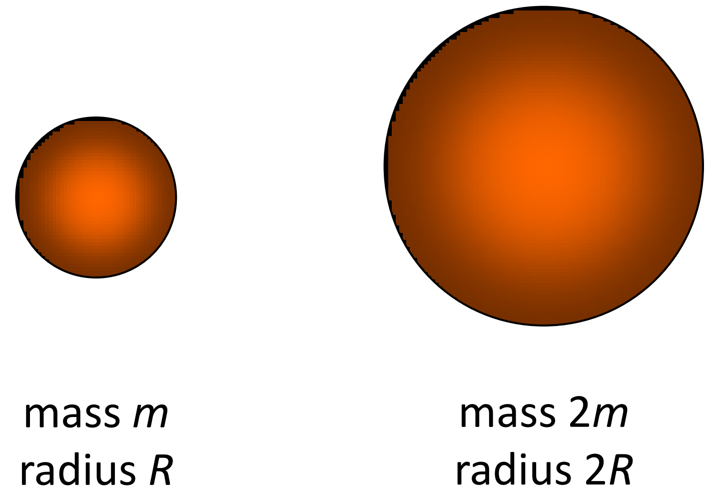

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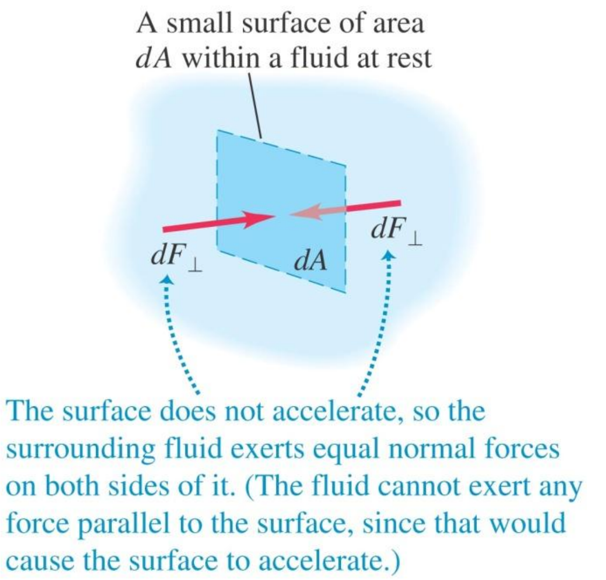
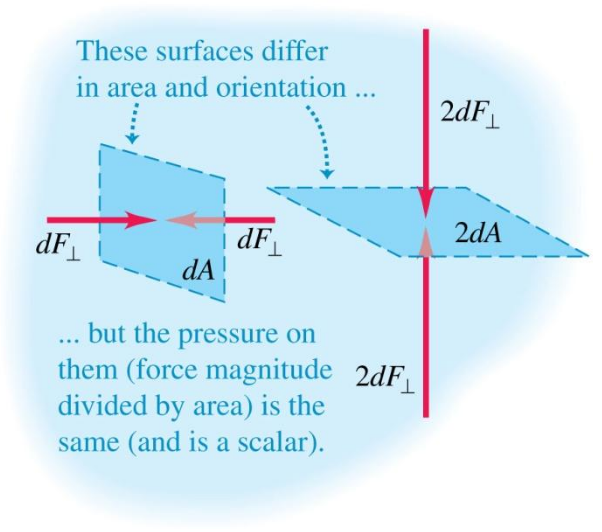
Pressure in a fluid

- The pressure in a fluid is the **normal** force per unit area: p= $F_{\perp}/A$
- Or in Calculus: $p = dF_{\perp}/dA$
- Pressure units: Newtons/m^2
- 1 N/m^2 = 1 Pa (Pascal)
- With gravity $P_{total} = P_{atm} + \rho gh$
- P_{total}
- ρ = density fluid (kg/m^3)
- g = 9.8 m/s^2
- h=height of fluid above (m)
- Scuba diving: 10 m depth ~ 1 bar additional pressure

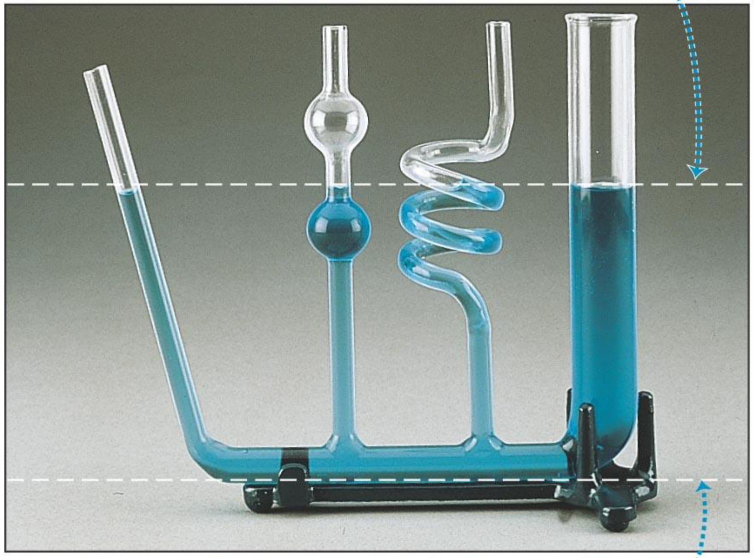




Pressure at depth in a fluid

- The pressure at a depth h in a fluid of uniform density is given by $P = P_0 + \rho gh$. As Figure at the right illustrates, **the shape of the container does not matter**.
- The ***gauge pressure*** is the pressure **above atmospheric pressure**. The ***absolute pressure*** is the total pressure.
- Pressure at sea level = 1.01325 **bar**
- **Pressure at sea level ~ 14.7 psi**
- **Pressure at sea level = 760 mm Hg**
- **1 bar = 1 atm (atmosphere)**
- **1 bar = 10^5** N/m^2
- **1bar = 1000 millibar (mb)**

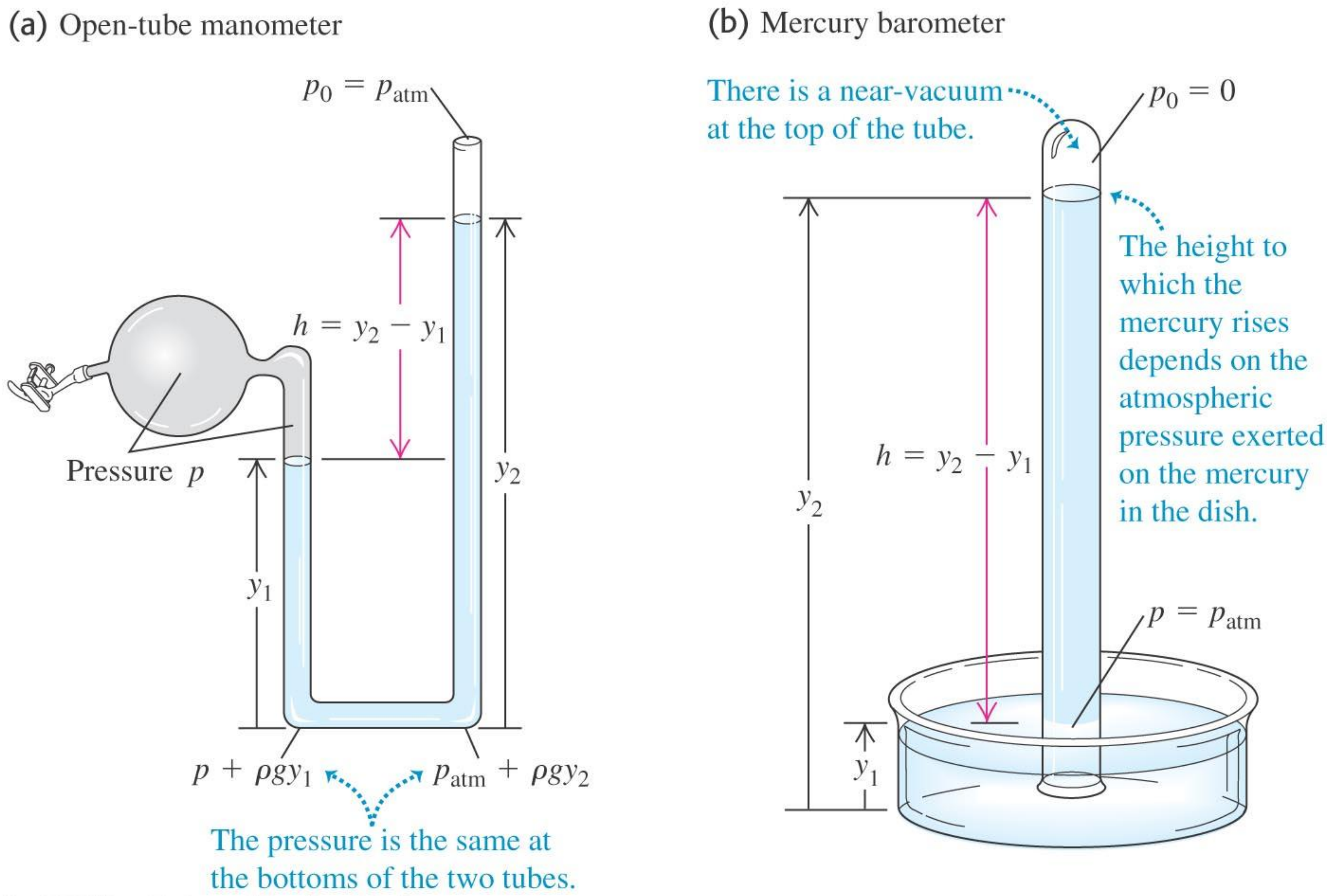
The pressure at the top of each liquid column is atmospheric pressure, p_0.



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.

Two types of pressure gauge

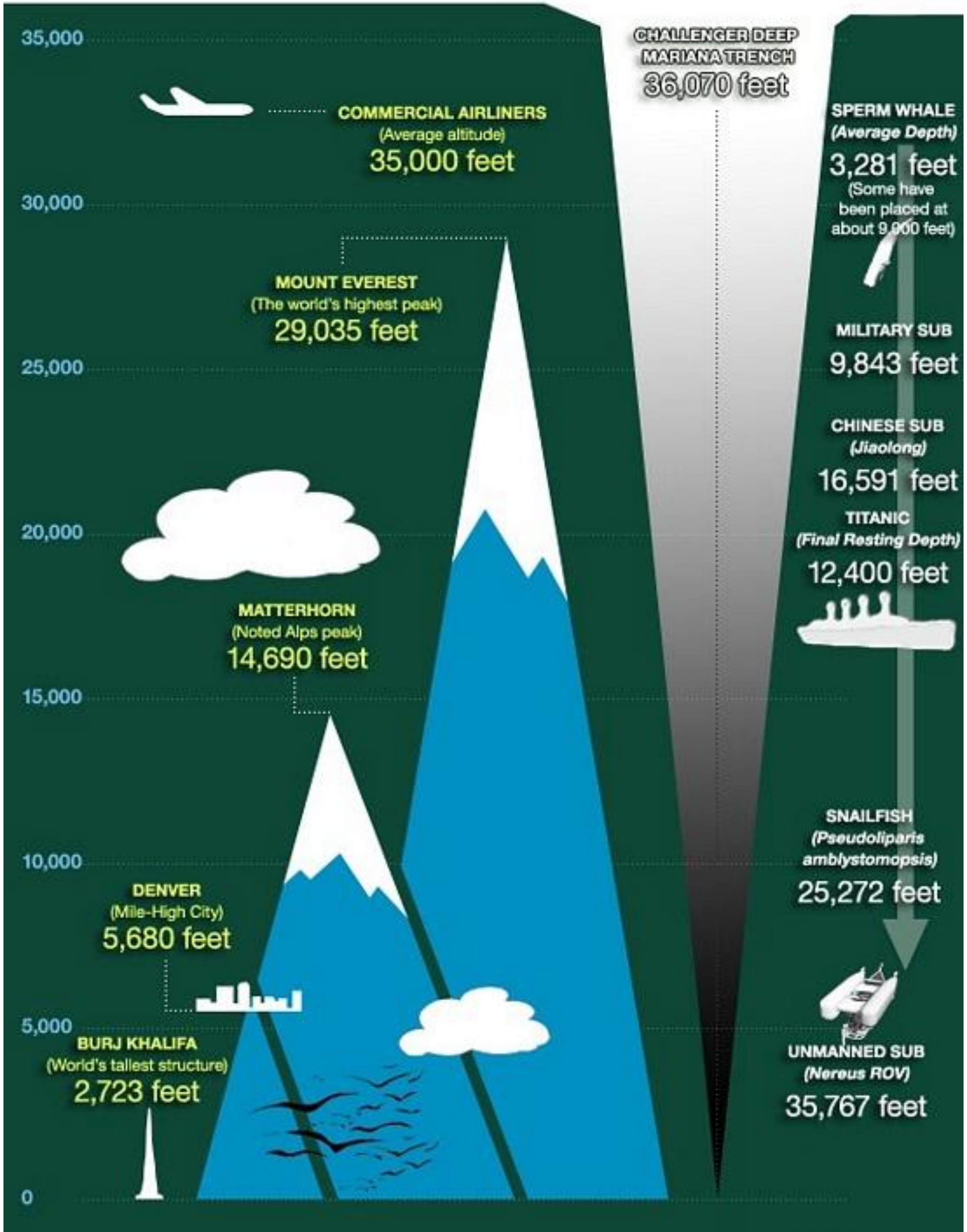


Scuba diving

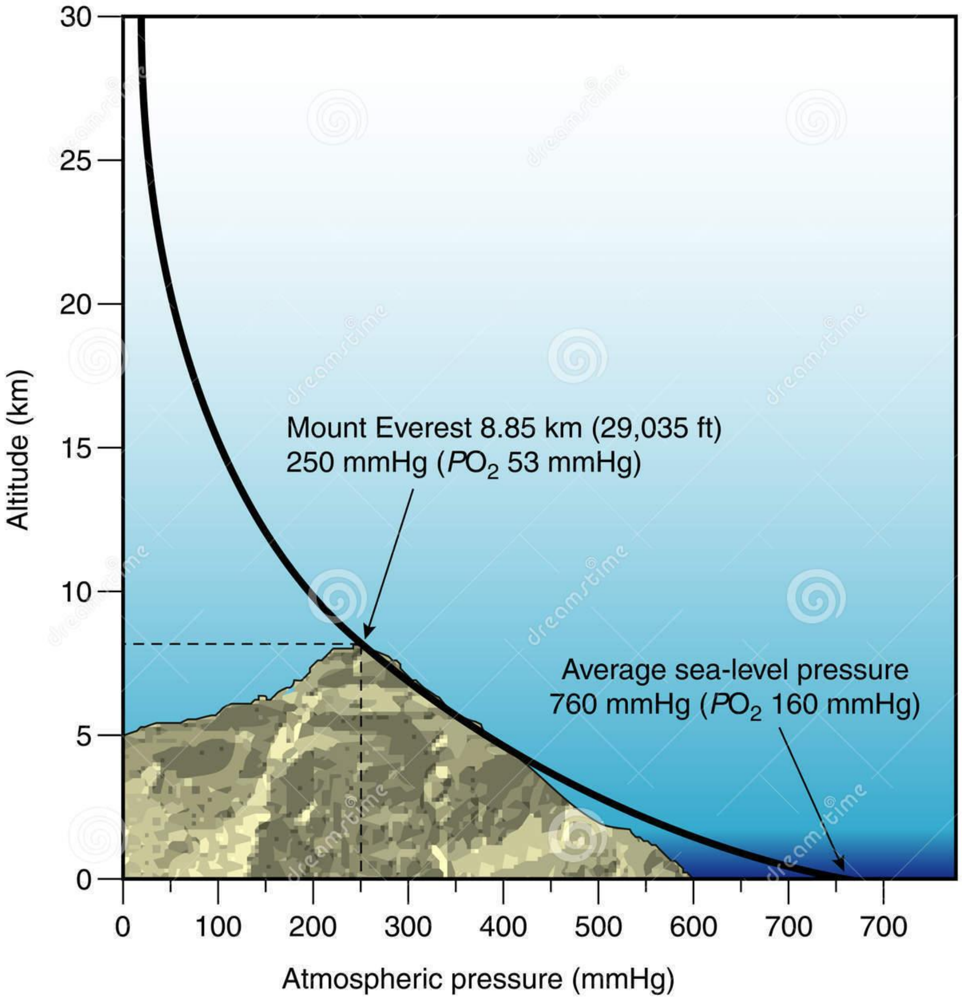
- Fresh water density (4 C = 39F) ~ 1000 kg/m^3
- Salt (Ocean) water density ~ 1025 kg/m^3
- Salt water ~ 2.5 % denser than fresh water
- Salt water is denser
- You are more buoyant in salt water
- For same depth in salt water pressure is higher
- 1 atmosphere ~ 10 m in fresh water (~ 34 feet)
- 1 atmosphere ~ 33 feet in salt (ocean) water

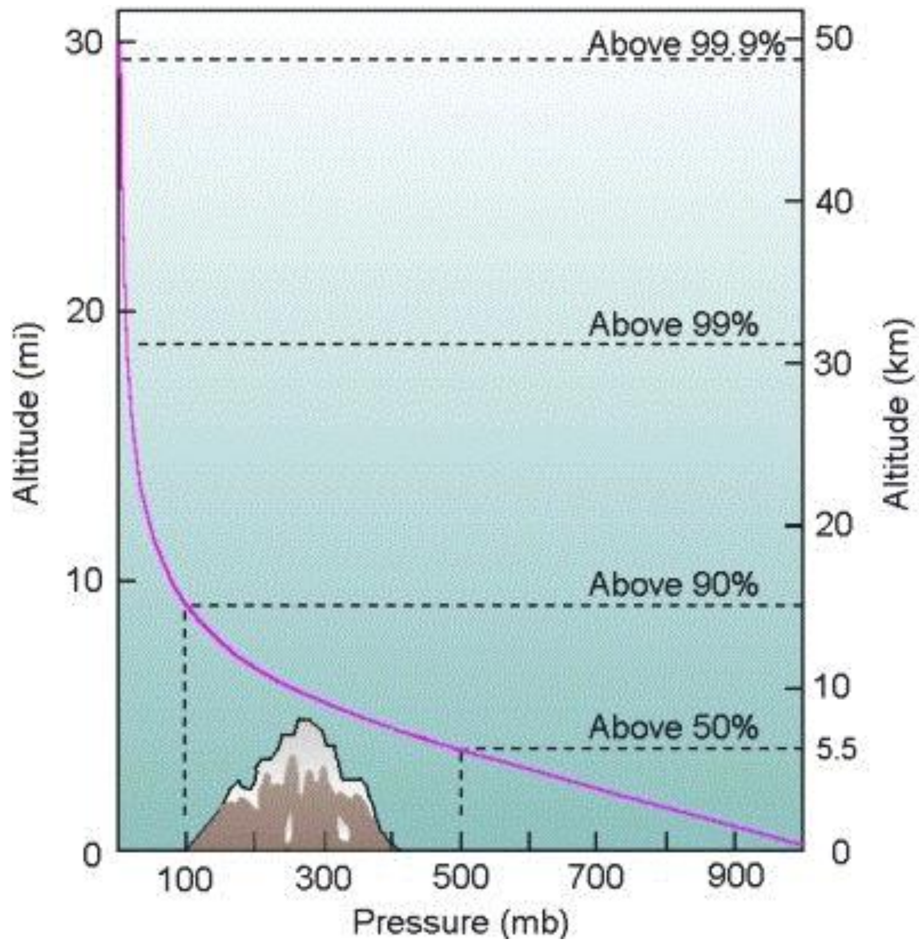
Why are you ~ neutral buoyant in water?

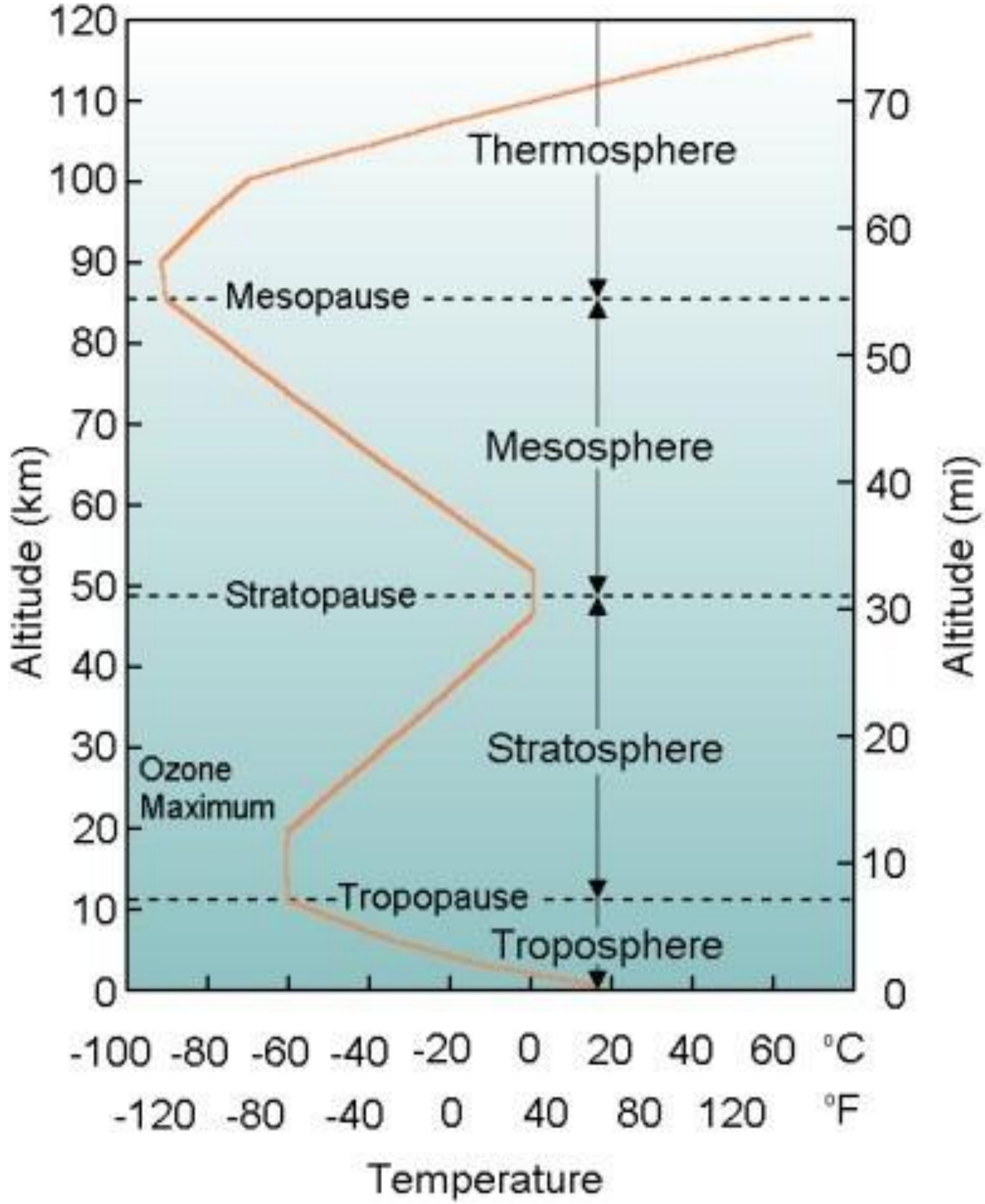
If trapped in car under water
Can you open door??


35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
COMMERCIAL AIRLINERS
(Average altitude)
35,000 feet
MOUNT EVEREST
(The world's highest peak)
29,035 feet
MATTERHORN
(Noted Alps peak)
14,690 feet
DENVER
(Mile-High City)
5,680 feet
BURJ KHALIFA
(World's tallest structure)
2,723 feet
CHALLENGER DEEP
MARIANA TRENCH
36,070 feet
SPERM WHALE
(Average Depth)
3,281 feet
(Some have been placed at about 9,900 feet)
MILITARY SUB
9,843 feet
CHINESE SUB
(Jiaolong)
16,591 feet
TITANIC
(Final Resting Depth)
12,400 feet
SNAILFISH
(Pseudoliparis amblystomopsis)
25,272 feet
UNMANNED SUB
(Nereus ROV)
35,767 feet

Air Pressure changes with altitude
Less air above you

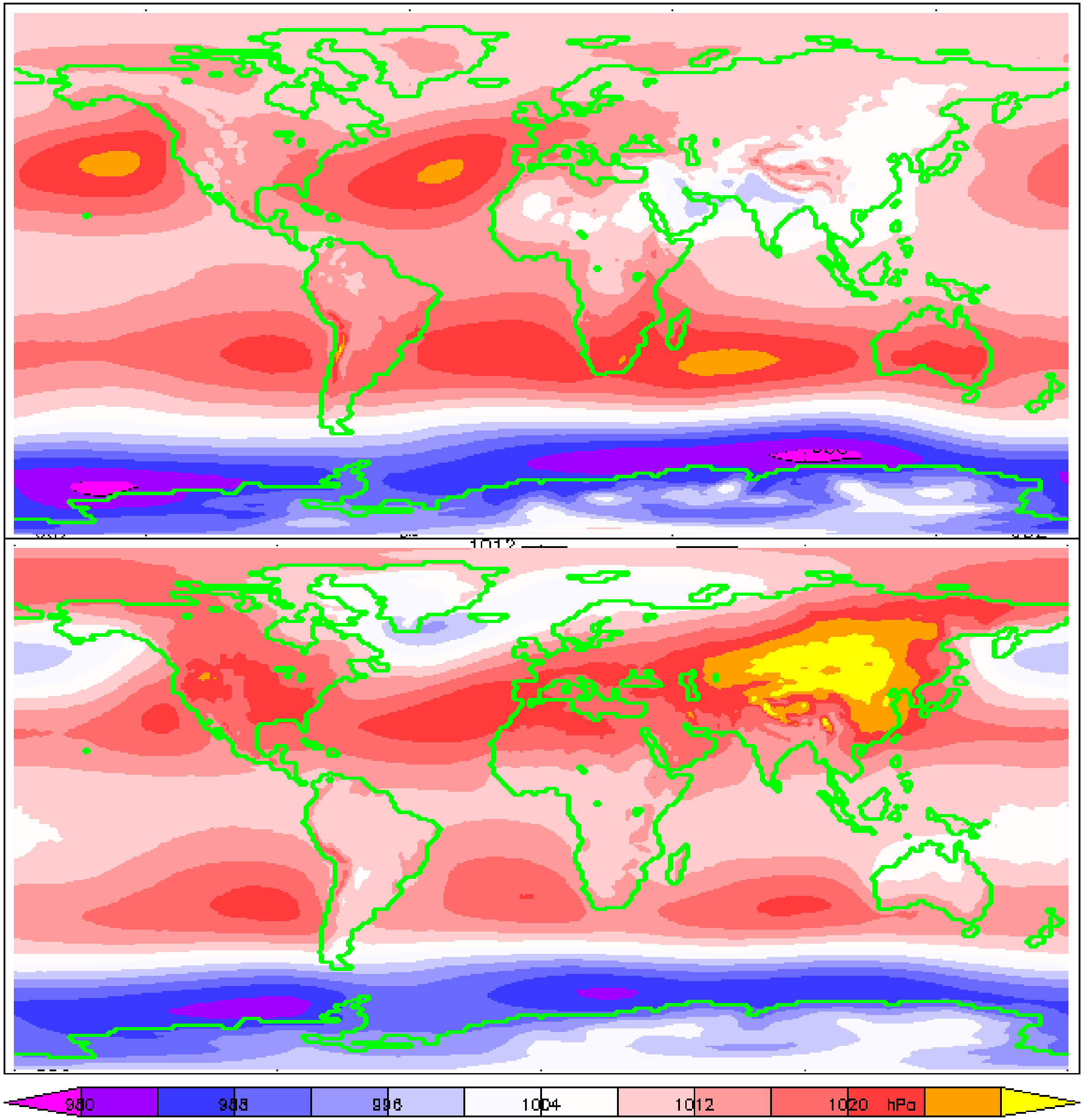






Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Ozone Maximum
Tropopause
Troposphere
Altitude (km)
Altitude (mi)
0
10
20
30
40
50
60
70
80
90
100
110
120
-100 -80 -60 -40 -20 0 20 40 60 °C
-120 -80 -40 0 40 80 120 °F
Temperature

15 yr ave pressure(mb) Top: June-Aug – Bottom: Dec-Feb



Additional pressure

A cylinder is completely filled with water. The top of the cylinder is sealed with a tight-fitting lid.

If you push down on the lid with a pressure of 1000 Pa, the water pressure at the bottom of the cylinder

A. increases by more than 1000 Pa.

B. increases by 1000 Pa.

C. increases by less than 1000 Pa.

D. is unchanged.

E. The answer depends on the height of the cylinder.

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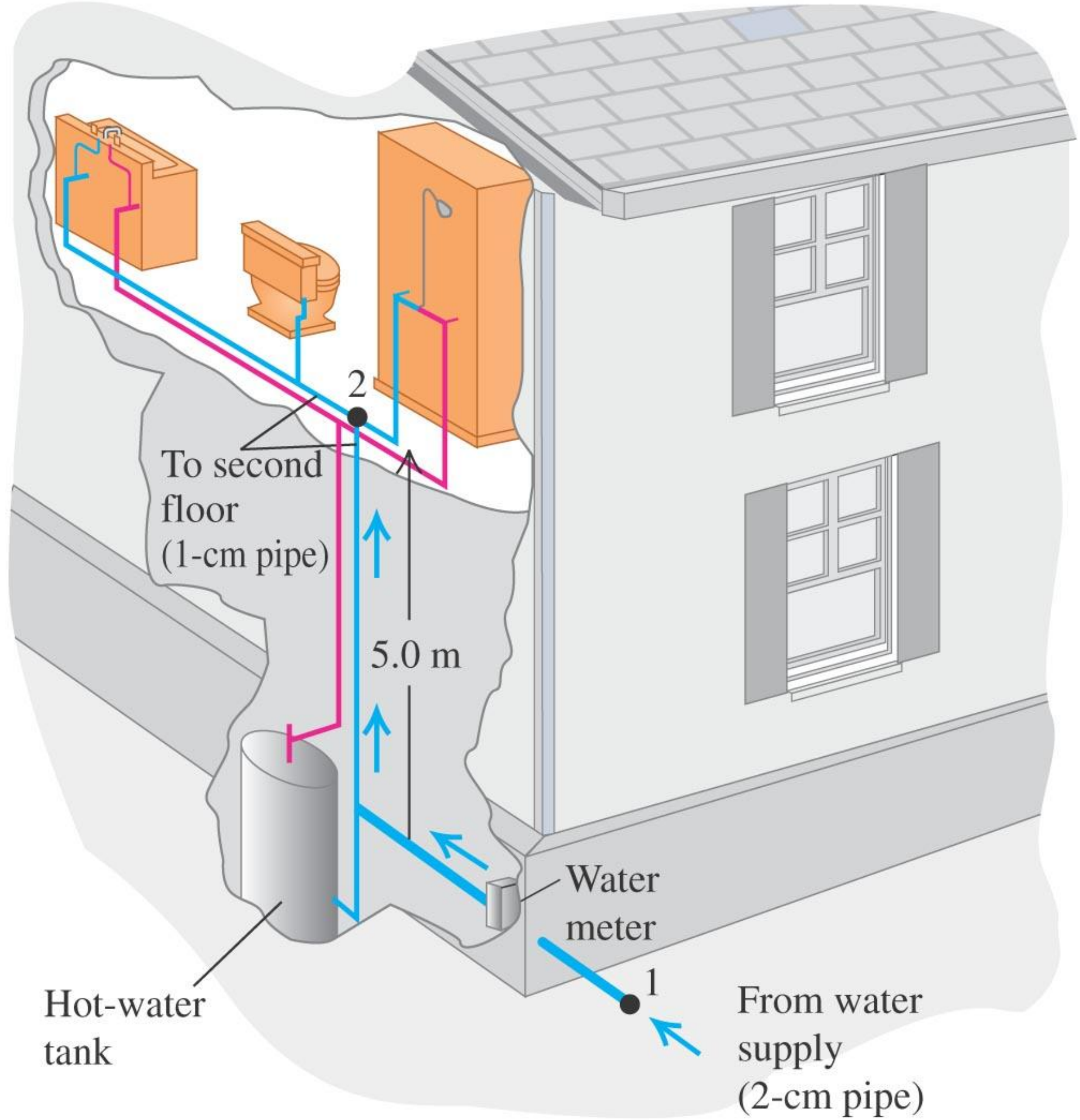
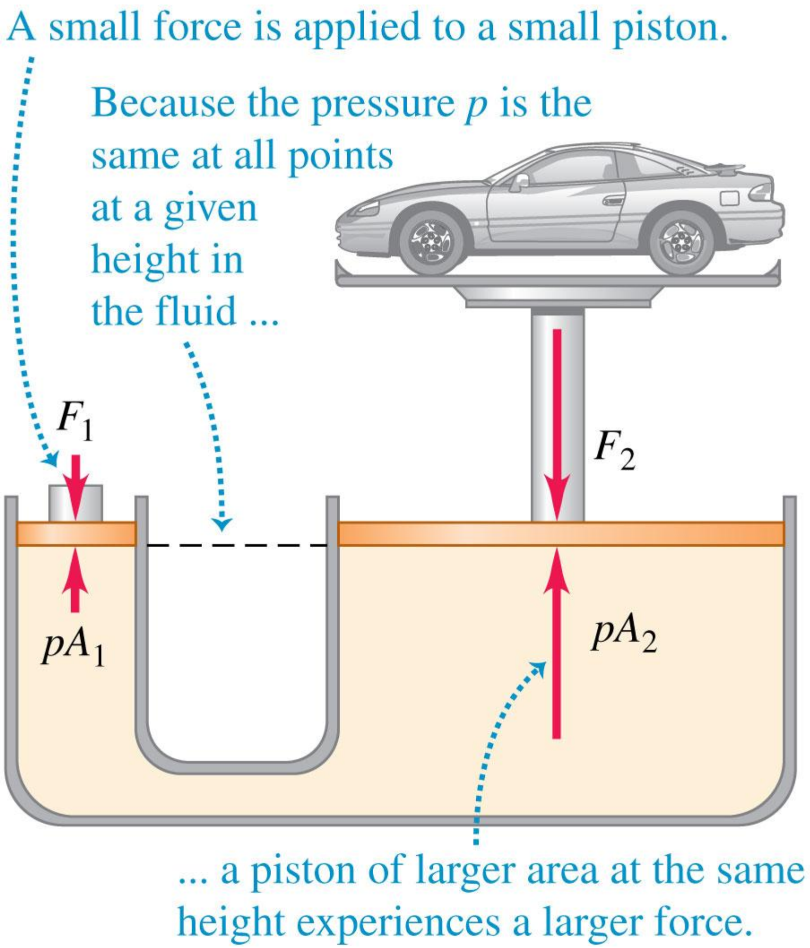
Water pressure in the home

- Typical water pressure in home is about 50 psi
- Depends on where you live



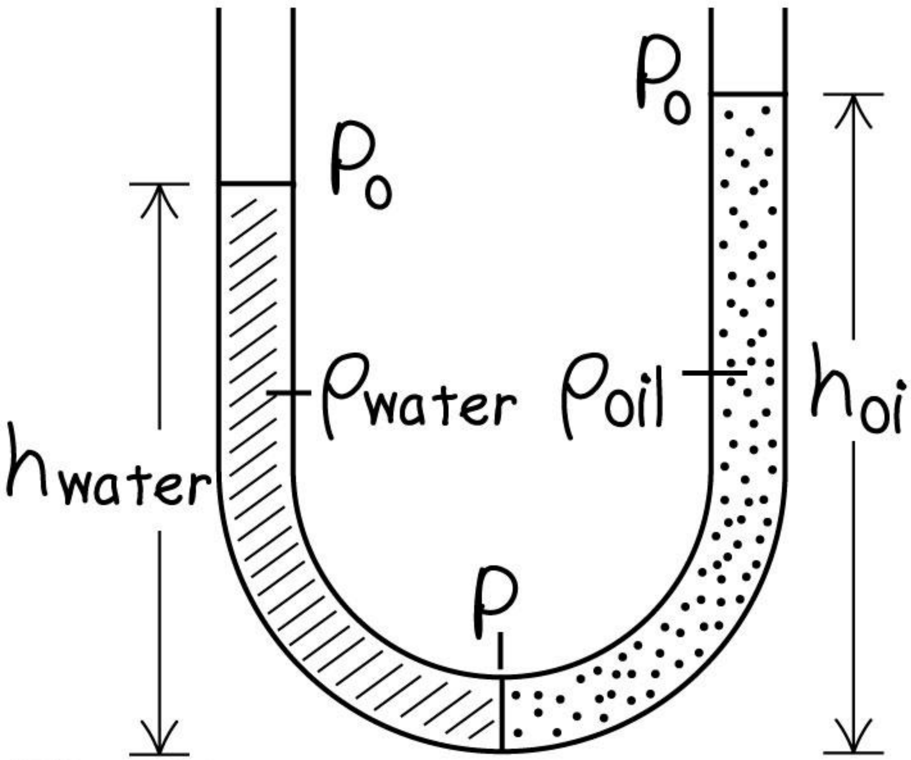
Pascal’s law

- *Pascal’s law*: Pressure applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and the walls of the containing vessel.
- The hydraulic life shown in is an application of Pascal’s law.



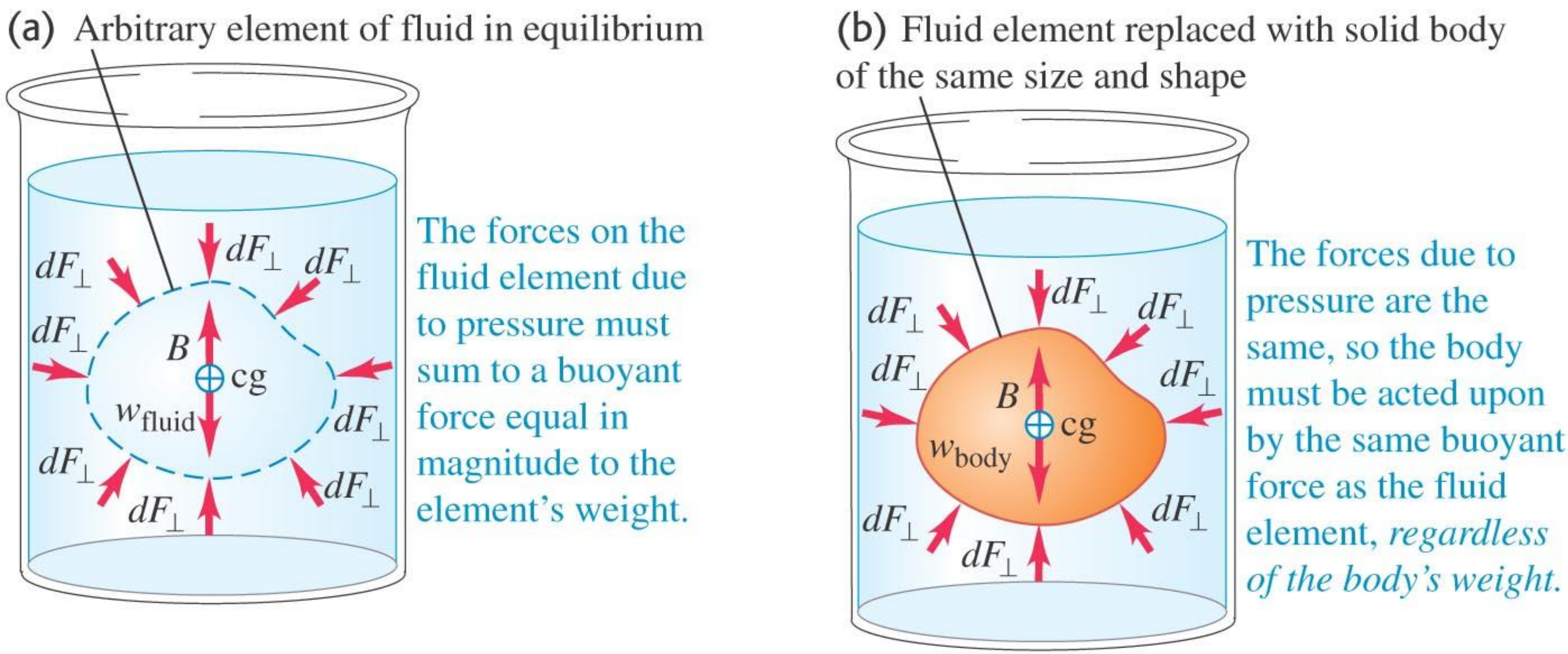
A tale of two fluids

- Why are the fluids at two different heights?



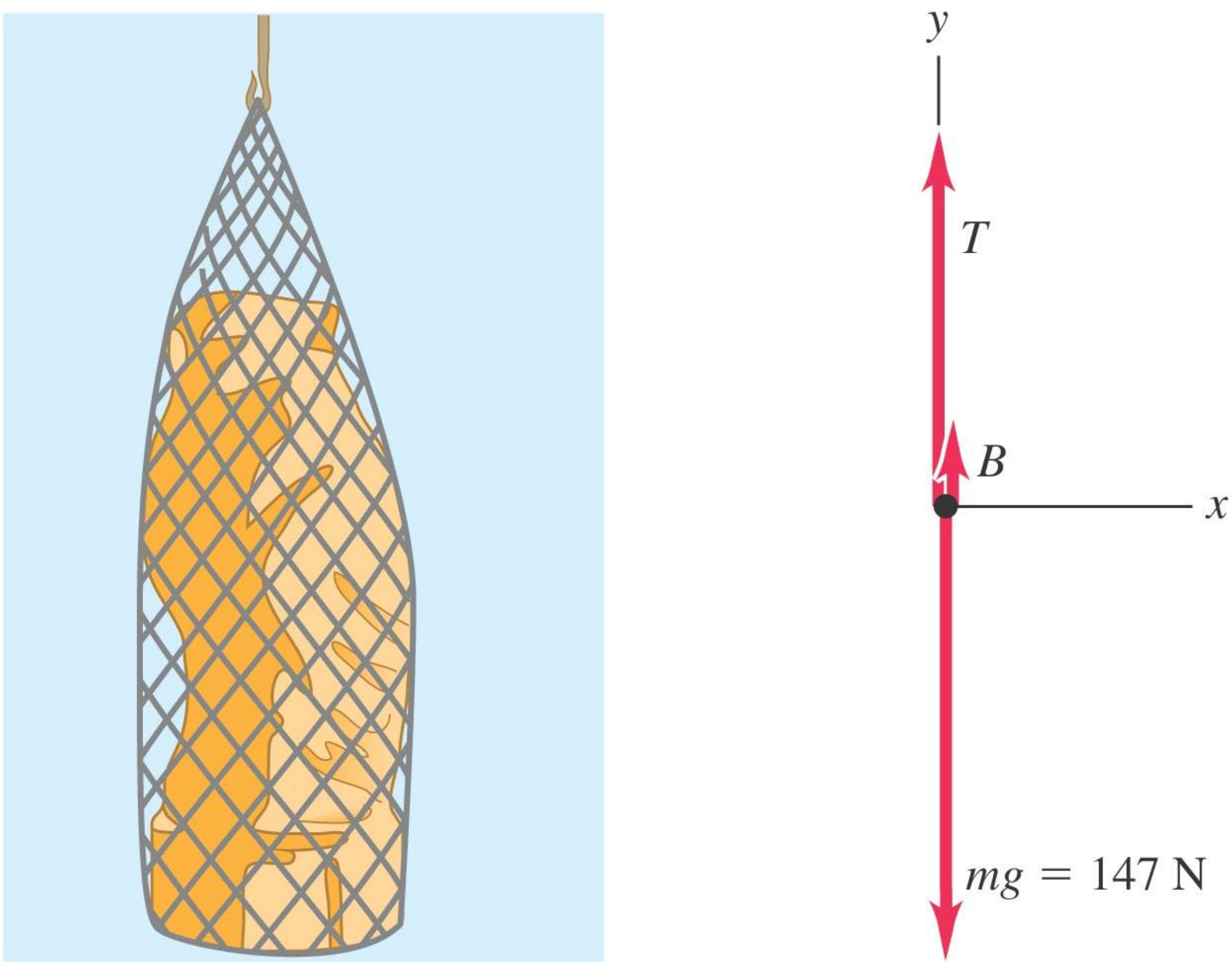
Archimedes Principle

- *Archimedes' Principle*: When a body is completely or partially immersed in a fluid, the fluid exerts an upward force (the "buoyant force") on the body equal to the weight of the fluid displaced by the body.



Buoyancy

(a) Immersed statue in equilibrium (b) Free-body diagram of statue



Buoyancy

A block of ice (density 920 kg/m^3) and a block of iron (density 7800 kg/m^3) are both submerged in a fluid. Both blocks have the same volume. Which block experiences the greater buoyant force?

A. the block of ice

B. the block of iron

C. Both experience the same buoyant force.

D. The answer depends on the density of the fluid.

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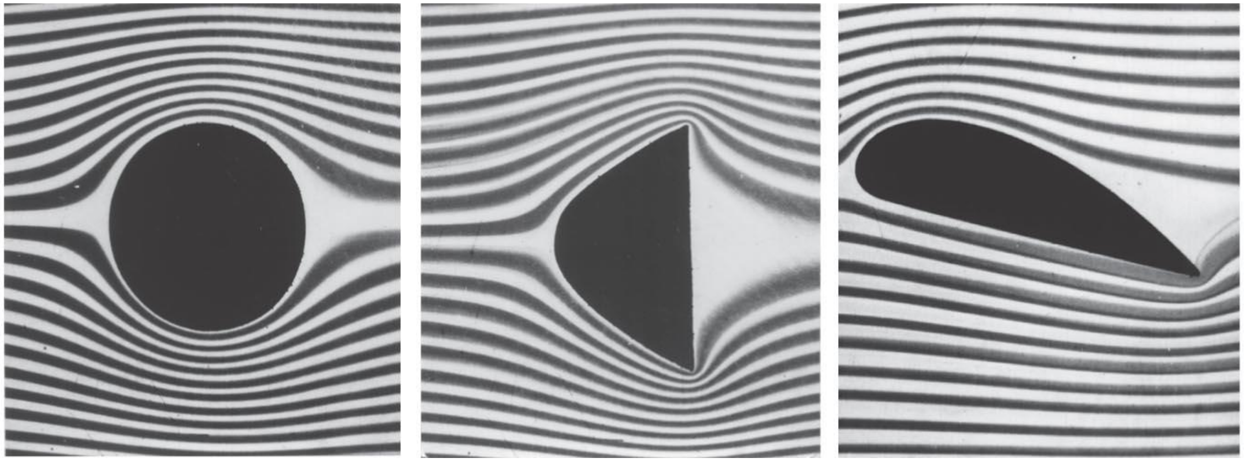
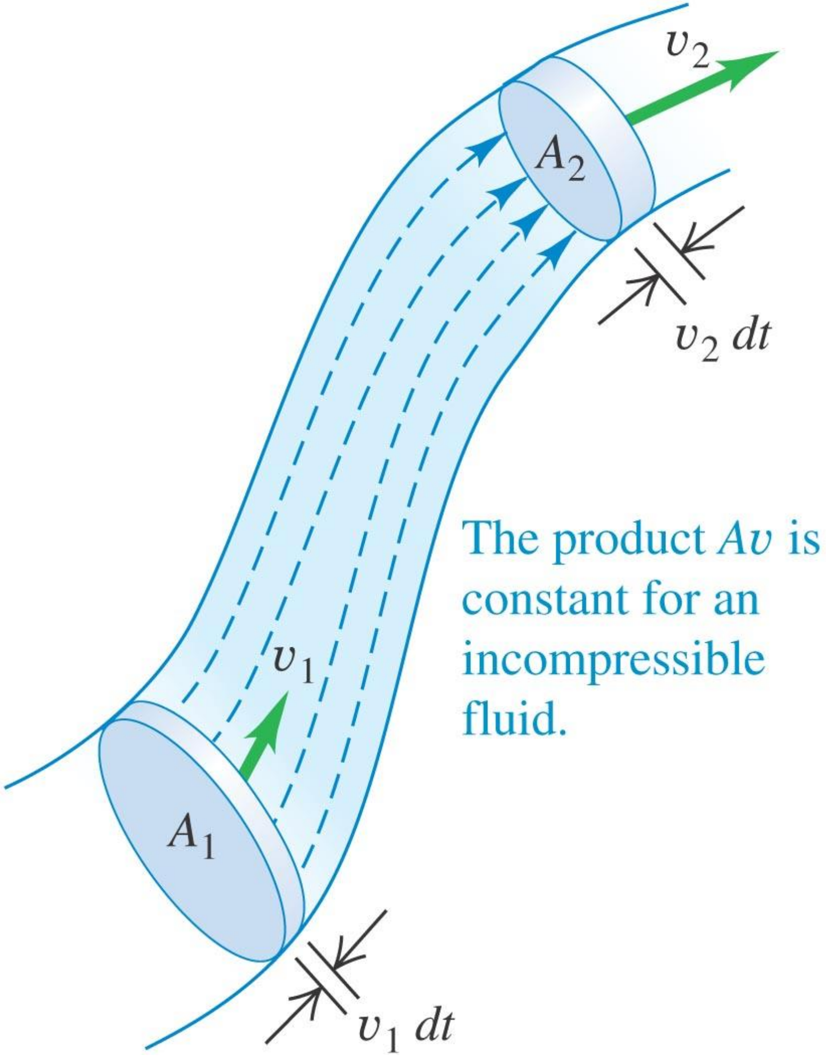
Fluid flow

- The flow lines in the bottom figure are *laminar* because adjacent layers slide smoothly past each other.
- In the figure at the right, the upward flow is laminar at first but then becomes *turbulent flow*.



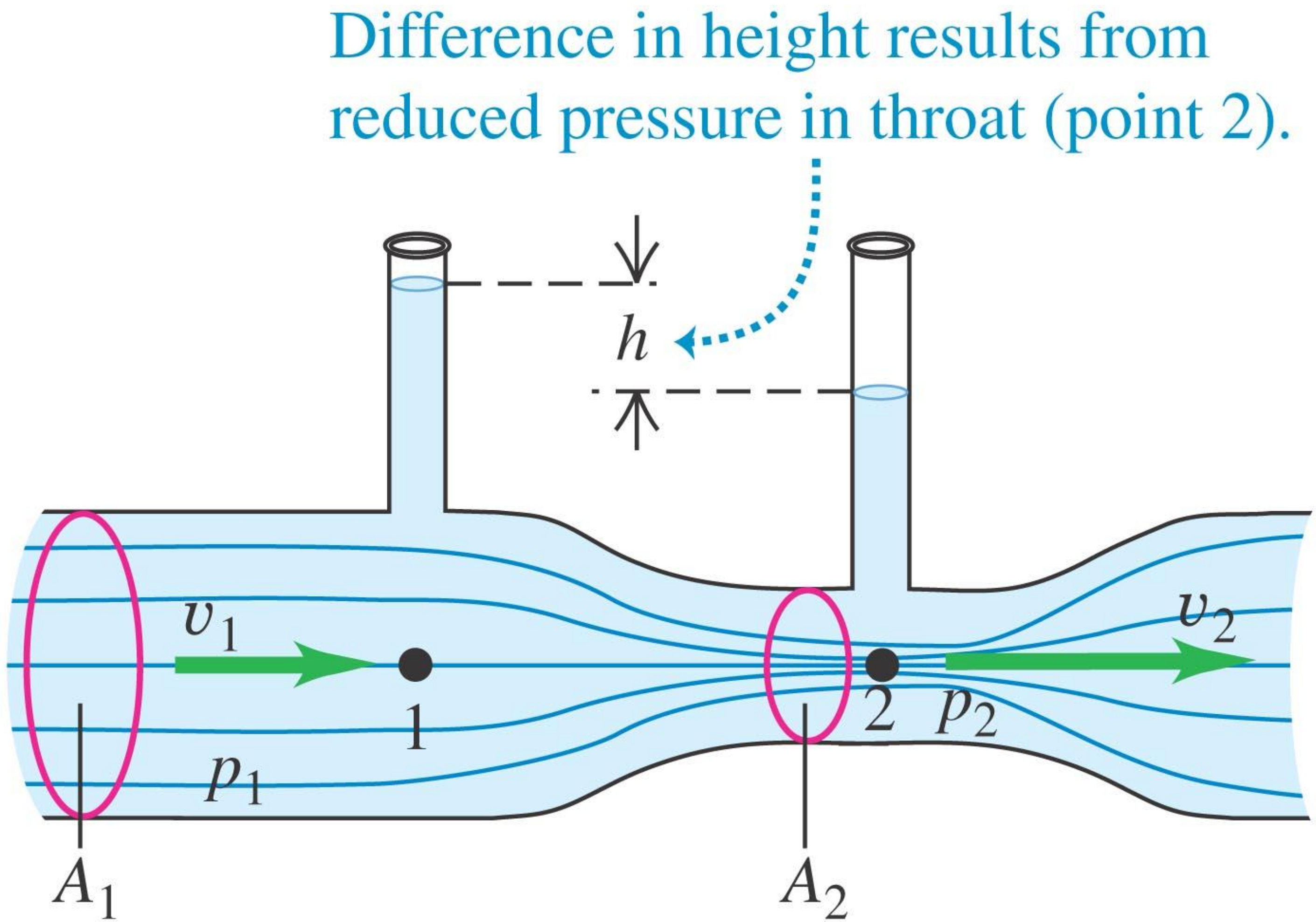
The continuity equation

- The figure at the right shows a flow tube with changing cross-sectional area.
- The ***continuity equation*** for an incompressible fluid is $A_1v_1 = A_2v_2$.
- The *volume flow rate* is $dV/dt = Av$
- Mass flow rate (kg/s)=ρvA



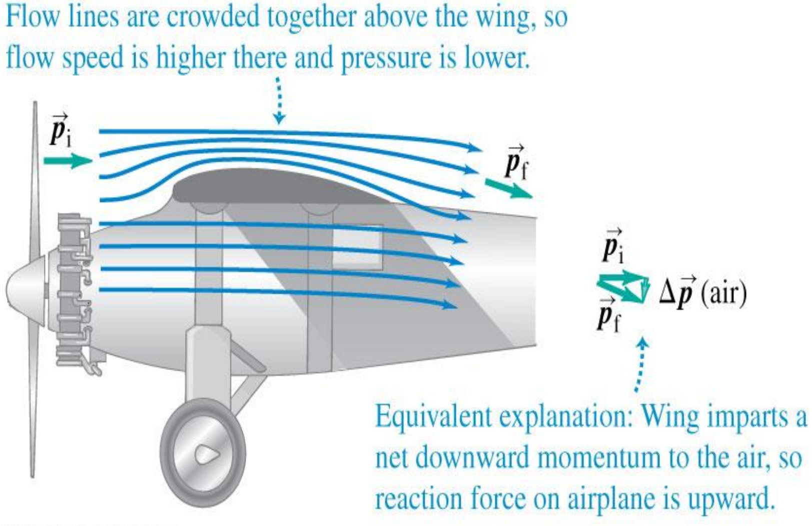
The Venturi meter

- Old carburetors use this effect to draw in gasoline
- Modern cars use fuel injection instead

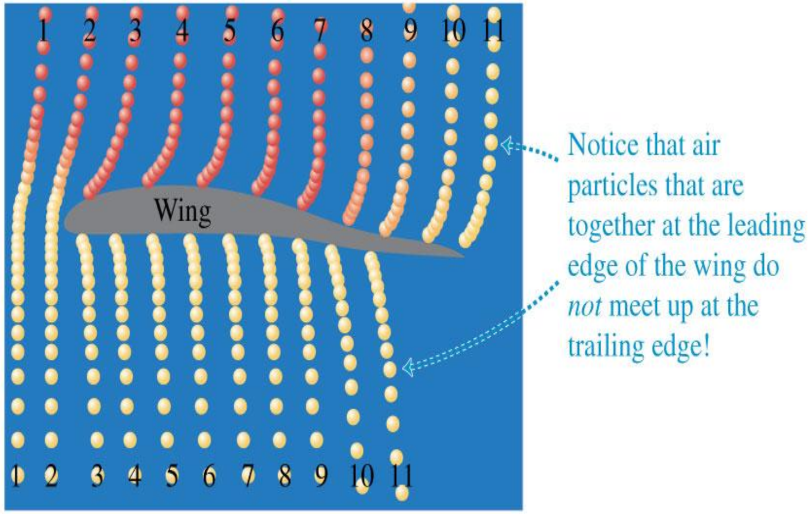


Lift on an airplane wing

(a) Flow lines around an airplane wing

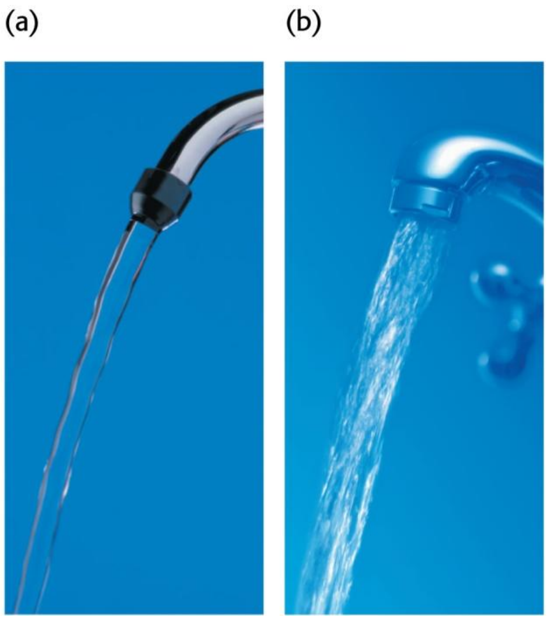


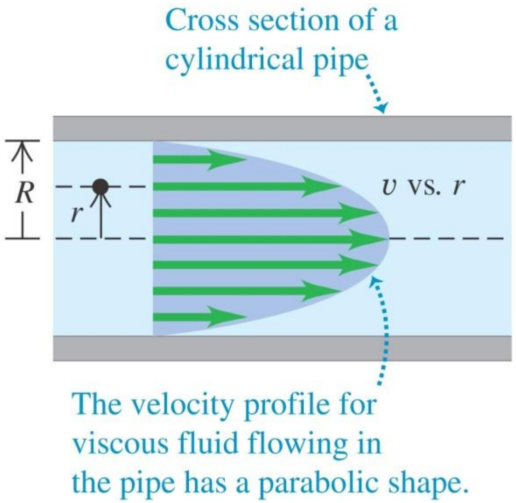
(b) Computer simulation of air parcels flowing around a wing, showing that air moves much faster over the top than over the bottom.



Viscosity and turbulence

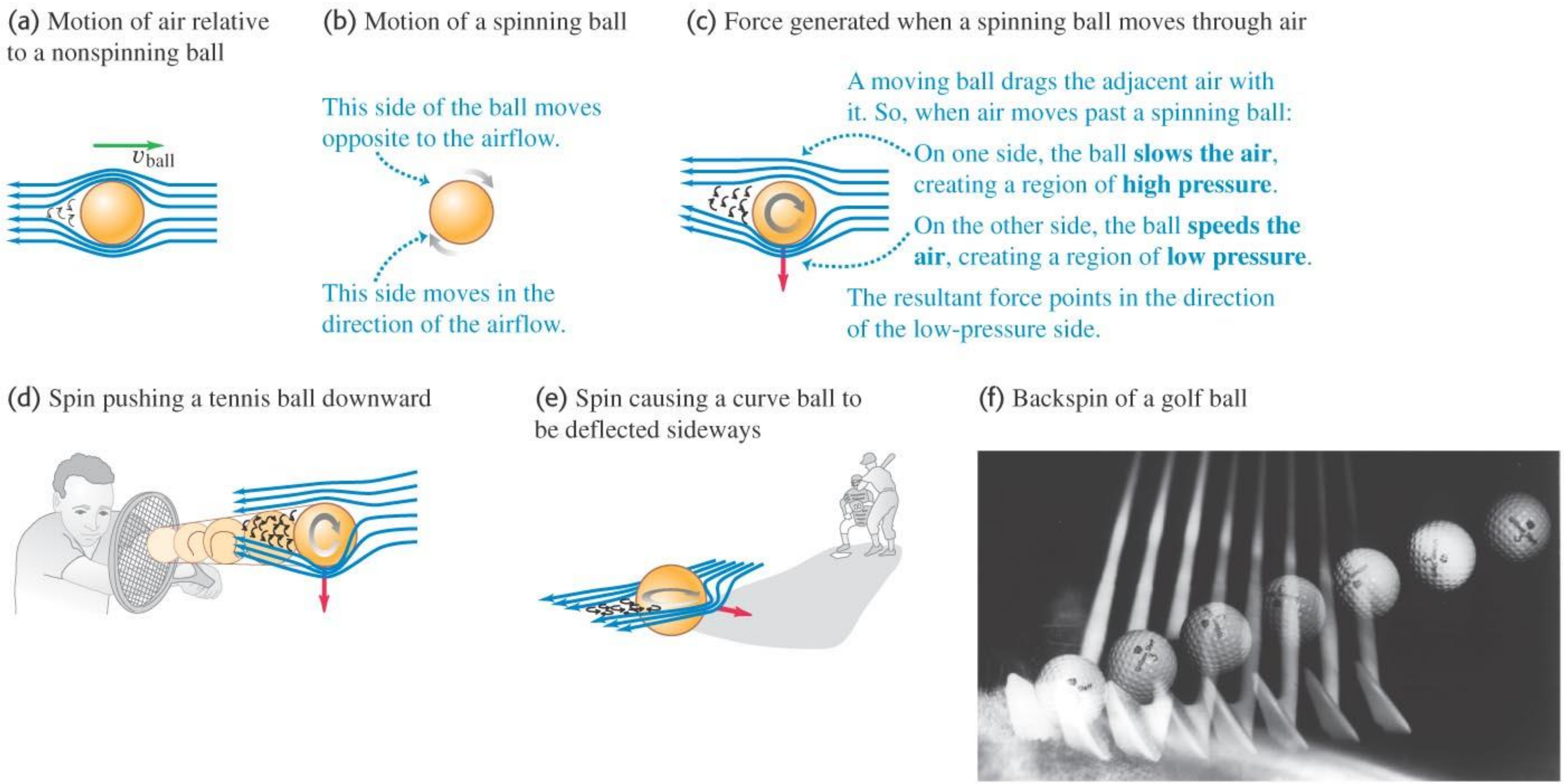
- *Viscosity* is internal friction in a fluid.
- *Turbulence* is irregular chaotic flow that is no longer laminar.





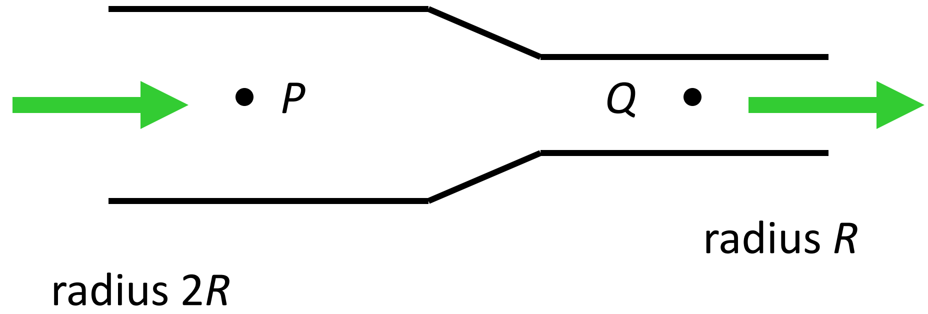
A curve ball (Bernoulli's equation applied to sports)

- Does a curve ball *really* curve?



Fluid Flow

An incompressible fluid flows through a pipe of varying radius (shown in cross-section). Compared to the fluid at point *P*, the fluid at point *Q* has



A. greater pressure and greater volume flow rate.

B. greater pressure and the same volume flow rate.

C. the same pressure and greater volume flow rate.

D. lower pressure and the same volume flow rate.

E. none of the above

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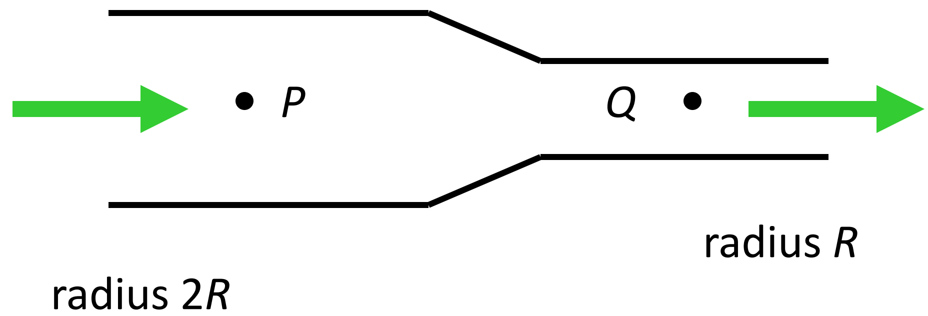

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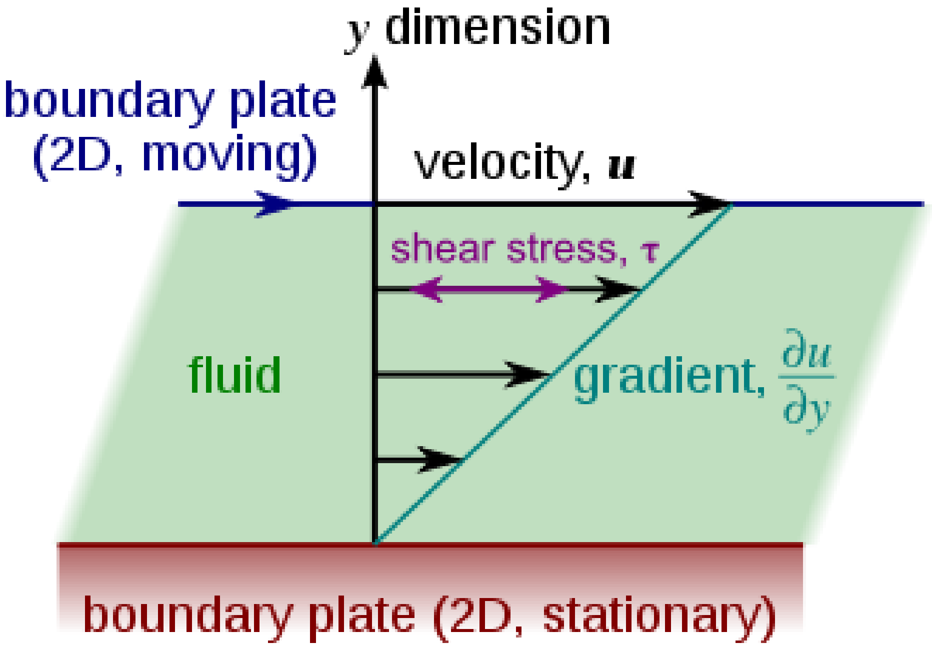
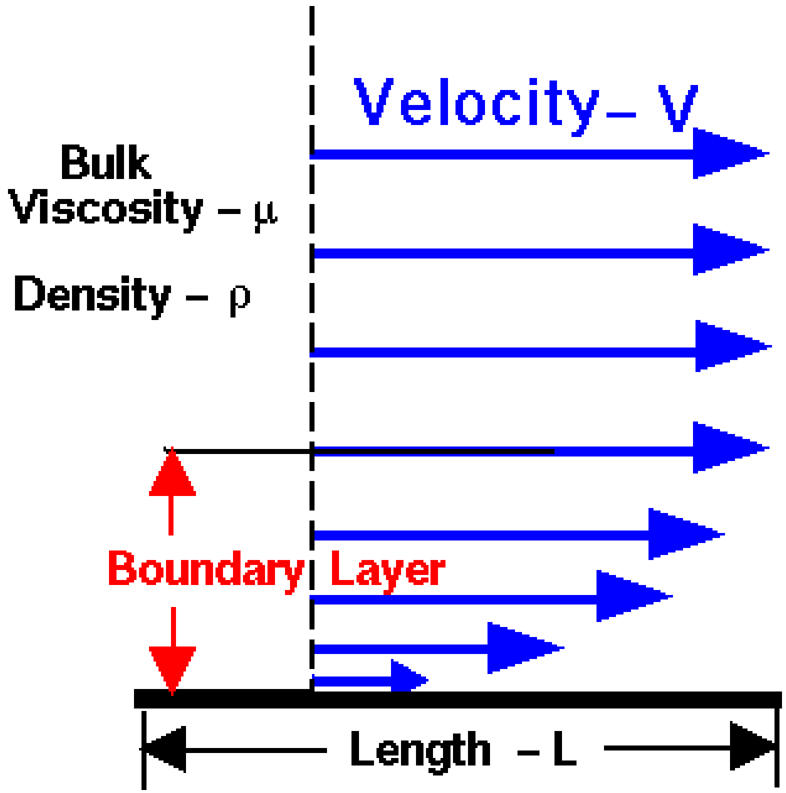
Viscosity
Shearing a Fluid

$$F = \mu A \frac{u}{y}.$$



Reynolds Number

Glenn Research Center



Kinematic Viscosity – $\nu = \dfrac{\mu}{\rho}$

Reynolds Number = Re

$$Re = \text{ratio} = \frac{\text{Inertia Force}}{\text{Viscous Force}}$$

$$Re = \frac{\rho V \; dV/dx}{\mu \; d^2V/dx^2}$$

$$Re = \frac{\rho \; V \; V/L}{\mu \; V/L^2}$$

$$Re = \frac{\rho V L}{\mu}$$

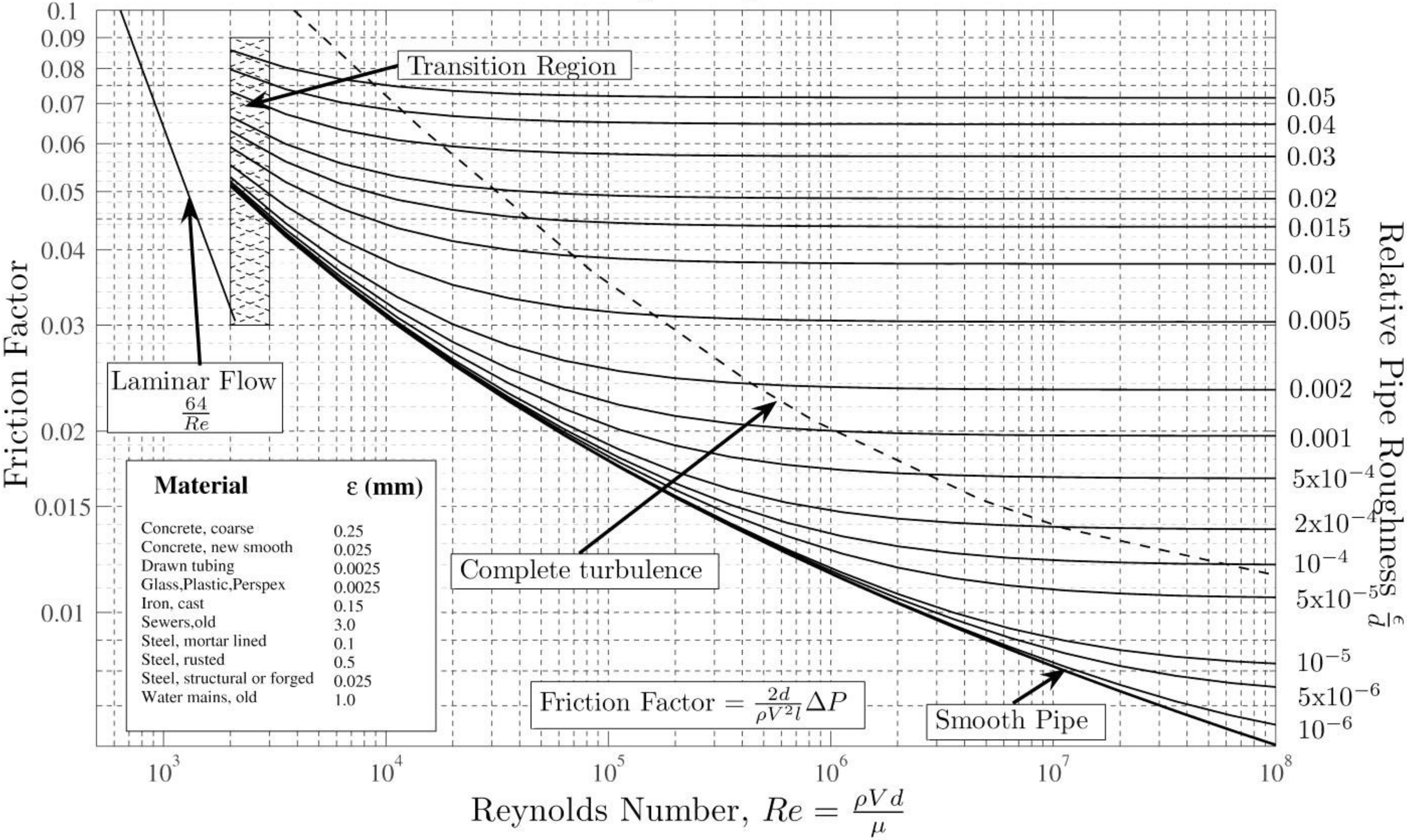
Reynolds Number is dimensionless

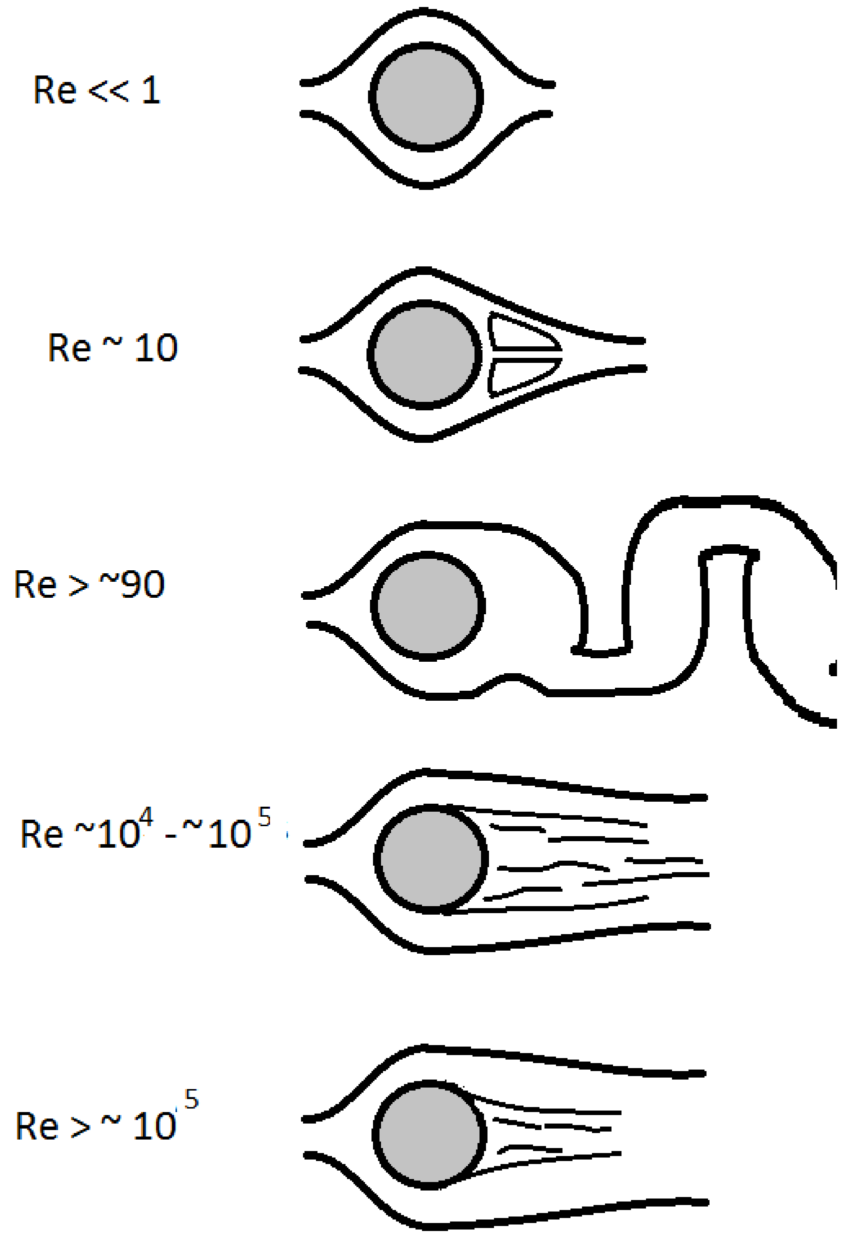
$$Re = \frac{V L}{\nu}$$

Re f = Reynolds Number per foot

$$Re\,f = \frac{V}{\nu}$$

Moody Diagram





Re << 1
Re ~ 10
Re > ~90
Re ~10^4 - ~10^5
Re > ~ 10^5

Very Low Reynolds number

Turbulence – Higher Reynolds Number