Fluids

I. Statics
- density, specific gravity
- pressure, Pascal's principle
- buoyancy, Archimedes principle

II. Dynamics
- laminar and turbulent flow
- flow rate and continuity
- Bernoulli's principle and equation

	The student will be able to:	HW:
1	Define and apply concepts of density, specific gravity, and pressure and solve related problems.	1 – 6
2	Define, distinguish, and apply concepts of absolute, atmospheric, and gauge pressure and solve related problems including application of Pascal's principle and relationship with depth, density, and gravitational field.	7 – 14
3	Define and apply Archimedes principle and the concept of buoyancy and solve related problems.	15 – 19
4	Define and apply the concept of continuity of flow and conservation of matter and solve related problems.	20 – 21
5	State and apply Bernoulli's principle and equation and the conservation of energy and solve related problems.	22 – 29

Fluid Basics

- Matter can exist in various forms – solid, liquid, gas, and plasma.
- The ability to flow is the defining property of a fluid. Gases and liquids can flow and are fluid.
- Liquid fluids are not significantly compressible and maintain are fairly constant volume.
- A gas is fluid in the sense that it can flow but it is readily compressible (or expandable) and its volume can vary significantly depending on circumstance.

Density

For a given type of material in particular conditions the mass per unit volume will tend to be uniform throughout. This observation leads to the concept of density – an intrinsic property of the material.

$$\rho = \frac{m}{V}$$

where: ρ = density
V = a volume of space
m = mass of matter within that volume

	Density (kg/m^3)	Density (g/cm^3)	Specific Gravity
Helium	0.18	0.00018	0.00018
Air	1.3	0.0013	0.0013
Wood	300 - 900	0.3 – 0.9	0.3 – 0.9
Gasoline	680	0.68	0.68
Ice	917	0.917	0.917
Water	1000	1.00	1.00
Granite	2700	2.7	2.7
Aluminum	2700	2.70	2.70
Iron	7800	7.8	7.8
Lead	11300	11.3	11.3
Mercury	13600	13.6	13.6
Gold	19300	19.3	19.3

Pressure

Pressure is a scalar measure of the amount of force per unit area acting perpendicular to a real or imaginary surface.

$$P = \frac{F}{A}$$

where: P = pressure
A = an area of a surface
F = amount of force acting perpendicular to the surface

Atmospheric Pressure

- Molecules and atoms in a gaseous state bound by a gravitational field constitute the atmosphere.
- Because these particles are in a constant state of motion there is a force acting on any solid or liquid surface due to the impacts of the atoms and molecules.
- Atmospheric pressure is a measure of the net effect of the gaseous matter impacting and rebounding off of any exposed surface.

Pressure Units

- th Pascal: $1\ Pa = 1\ N/m^2$
- the bar: $1\ bar = 100000\ Pa$
- pounds per square inch: $1\ psi = 1\ lbf/in^2$
- millimeters of mercury: 1 mm-Hg = 133 Pa
- the torr: 1 torr = 1 mm-Hg
- the atmosphere: 1 atm = 101.3 kPa
  1 atm = 14.7 psi
  1 atm = 760 torr

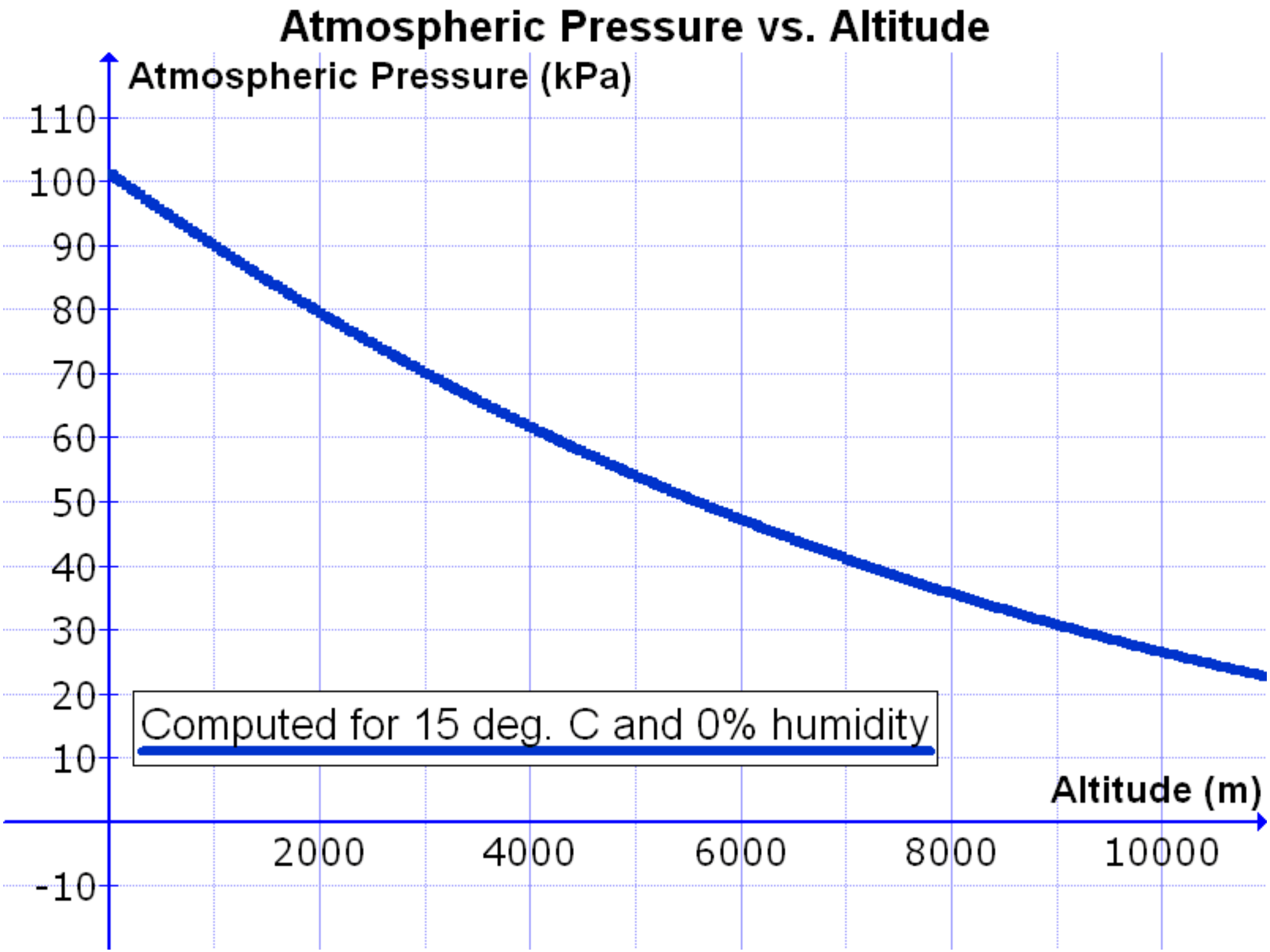

image: wikipedia

14000 ft | 9000 ft | 1000 ft

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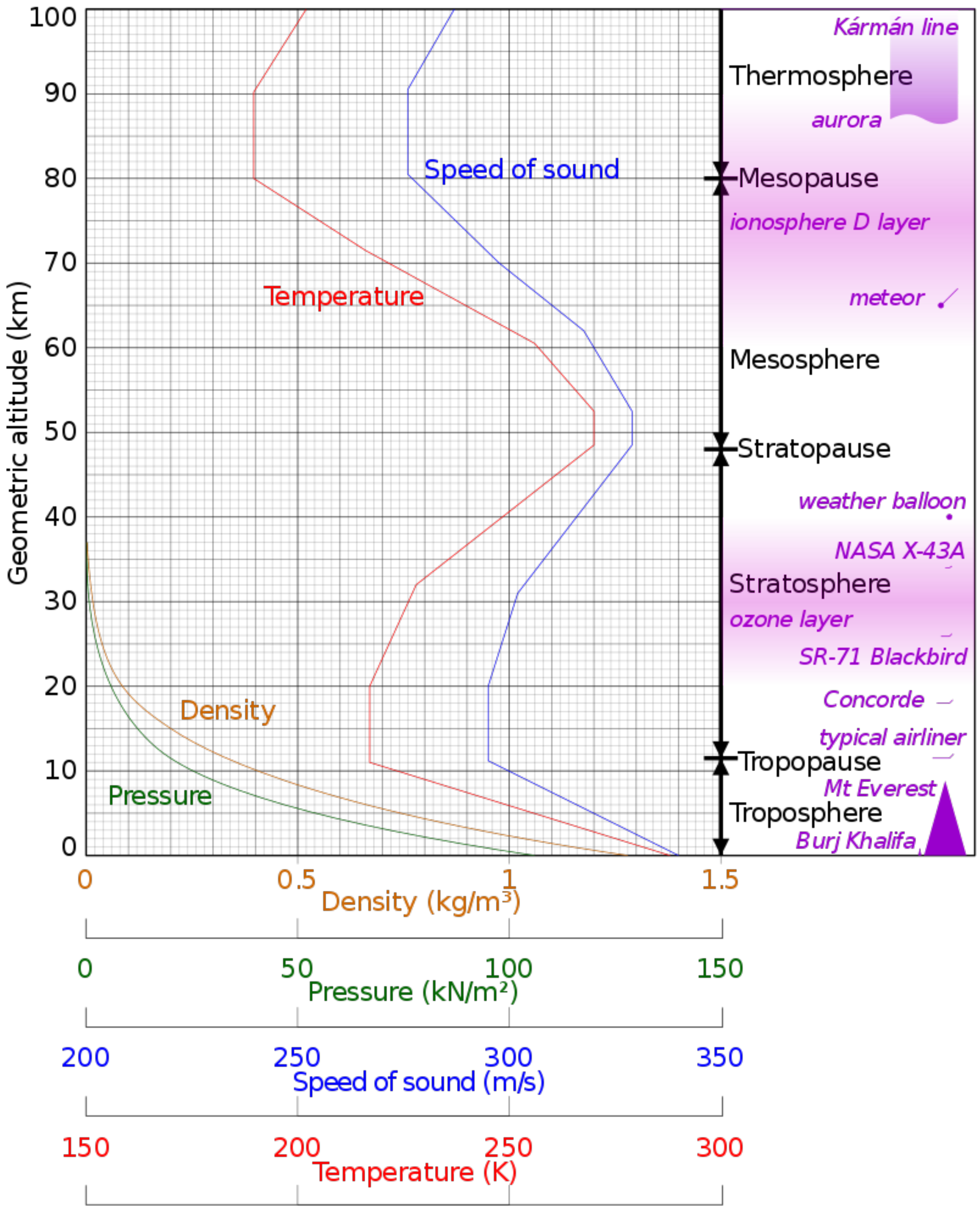

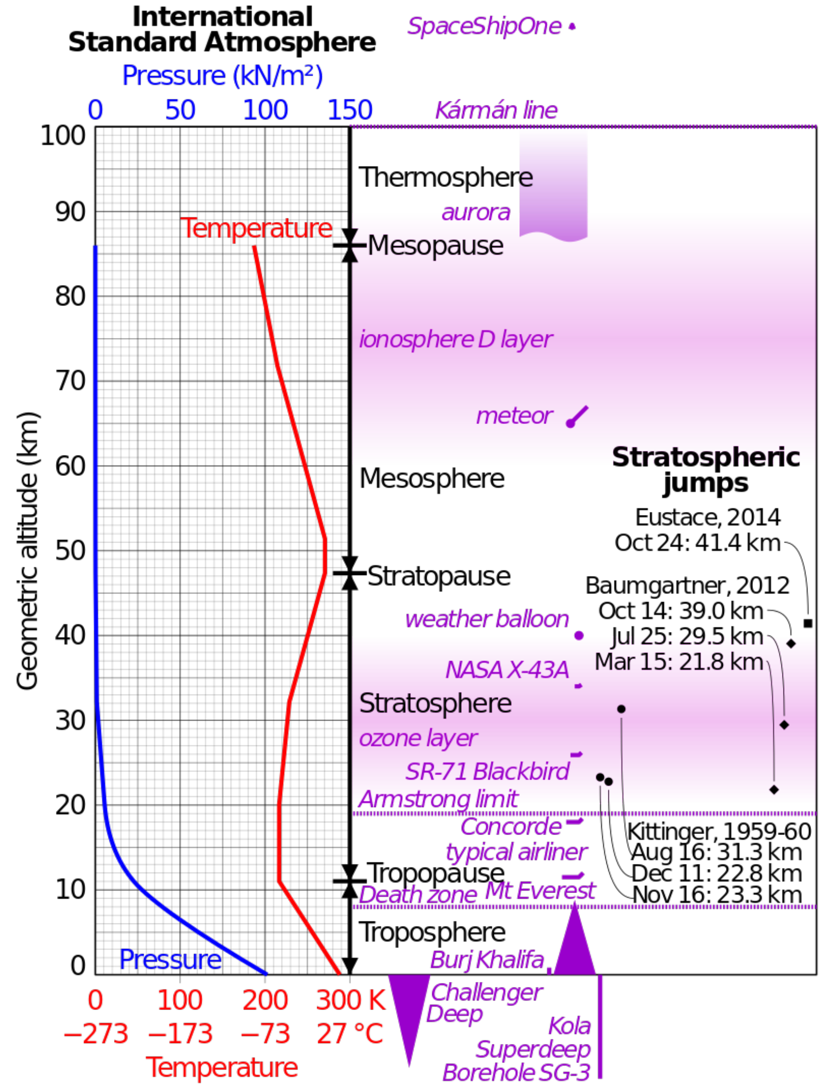

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Pressure Activity

- Work with a partner. Connect two syringes of unequal diameter with a piece of tubing.
- Does moving one plunger cause the other to move? One person hold their plunger in place while the other moves their plunger.
- Add a couple of milliliters of water inside the syringes <u>and</u> the tubing and <u>remove all air</u> (figure it out!) so that only water is enclosed.
- Repeat the experiments above. Compare the amount of force and distance moved on each side. Can you explain?

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Fluid Statics

- Although the matter is always in motion on the atomic level, if there is no flow or organized motion a fluid is at rest and it is a system of mass at equilibrium.
- Static fluids have various important properties. If fluid motion is slow and steady the same properties may be reasonably assumed true.
- Pascal's principle states that a certain amount of pressure applied to a confined fluid increases the pressure throughout the fluid by the same amount.

Compressibility

- Gases that undergo a change in pressure can have a drastically altered volume and are said to be **compressible**. Increased pressure reduces volume and the gas is compressed in size.
- Liquids that undergo a change in pressure will show an extremely small change in volume – usually insignificant. For this reason liquids are usually assumed to be **incompressible**. Changes in pressure have no perceptible effect on the volume and it remains essentially constant.

Absolute vs. Gauge Pressure

- Because the atmosphere is all around us its pressure is a constant "presence".
- In many situations what matters is the *difference* from this atmospheric "norm".
- A pressure gauge such as that for measuring a tire has a mechanism that responds to the difference of pressure within the tire to that out side of the tire – this is called "gauge pressure".
- "Absolute pressure" includes the effect of atmosphere – often found by adding gauge pressure to atmospheric pressure.

Pressure vs. Gravity

Pressure within a fluid relates to gravity and depth. The increase in pressure is directly proportional to density of the fluid and depth:

$$P = P_0 + \rho g h$$

$$\Delta P = \rho g h$$

where: P = absolute pressure at depth h

P_0 = pressure at surface

ρ = density of fluid

g = gravitational field strength

h = depth

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Archimedes Principle & Buoyancy

- Anything in a fluid experiences a force related to the fluid's pressure and the area of contact.
- A floating object on the surface is held up by this force called buoyancy.
- By Archimedes principle, the volume of water displaced by a floating object has a mass equal to that of the object.
- If an object is submerged there is still a force of buoyancy, whether it floats or not.
- The force of buoyancy is the net force of a fluid acting on an object in a static situation.

Buoyancy

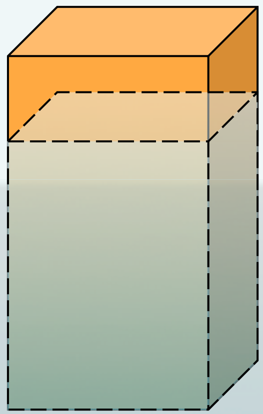
An object in a fluid experiences a force of buoyancy related to the density of the fluid, volume, and gravitational field strength:

$$F_b = \rho V g$$

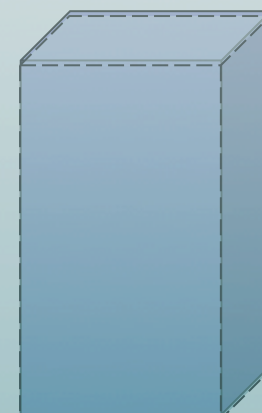
where: F_b = force of buoyancy
ρ = density of fluid
V = volume of displaced fluid
g = gravitational field strength

Understanding the "displaced volume":

$F_b = \rho V g$ $V = ?$



submerged object:
V = entire volume of object



floating object:
V = only the volume below the surface