Pressure & Density

• Pressure is defined as *force divided by area* (force/area)
• One can also assume that pressure = weight/area
Pressure & Density

Air pressure is considered to be the weight of the air above some region.

More air above a region will result in higher pressure while less air above a region will result in lower pressure.

Standard atmospheric sea-level pressure is 1013.2 mb, 29.92 in (of mercury), or 14.7 lb/in².

One may convert inches into millibars by multiplying by 33.865 or convert millibars into inches by dividing by 33.865.
Pressure & Density

- On weather maps, pressure is recorded as a "sea-level" pressure and is coded on the upper right of the station circle as the last three digits of millibar pressure.

- For example, 1019.6 mb would be coded as 196. 994.8 mb would be coded as 948.

- To decode pressure data given on a station circle one must place a decimal in between the 2nd and 3rd digits and add a "9" or a "10" in front of the three digits, whichever brings the pressure closest to 1013.2 mb.

- For example, 159 = 1015.9 mb. 804 = 980.4 mb.
Pressure & Density

- All pressures observed on a weather map are considered to be sea level values.
- Stations at heights above sea level must “adjust” their observed air pressure readings to represent sea level pressure.
Pressure & Density

- When drawing isobars, each isobar represents a pressure interval of 4 mb with the standard values being a multiple of 4 mb above or below 1000.0 mb

- For example, 992, 996, 1000, 1004, 1008, 1012, etc.
Pressure & Density

- Density is defined as mass divided by volume \((\text{mass/volume})\).

- Increasing the mass or decreasing the volume will increase density.

- Decreasing the mass or increasing the volume will decrease density.
Pressure & Density

\[ \text{density} = \frac{\text{mass}}{\text{volume}} \]

Simpler way to consider density?

\[ \text{density} = \frac{\text{stuff}}{\text{space}} \]
Density is defined as mass *divided by volume* (mass/volume).

Mass is determined by:

1. The number of molecules (more pennies = greater mass = greater density)
2. The type of molecules [atomic mass per molecule] (See next slide)
• Assuming 100 coins:
  
  • Quarters have more mass each = greater total mass = greater density
  
  • Type of molecules determined mass in this example
Pressure & Density

- Solids have tightly packed atoms with lower KE
- Liquids have atoms that are a bit more loosely packed
- Gases have atoms that are randomly flying about with higher KE
Pressure & Density

- Given a constant volume:
  - Solids: greatest # of molecules = most mass = greatest density
  - Gases: fewest # of molecules = least mass = lowest density
Pressure & Density

$T = 72 \, ^\circ F$

$T = 68 \, ^\circ F$

$V = 600 \text{ml}$
$P = 1013.2 \text{mb}$

Which has greatest # of molecules?
Pressure & Density

- **Cooler air** has **less kinetic energy** and therefore less motion than warmer air. It has **more molecules** (more mass) in any given volume so is **more dense**.

- **Warmer air** has **more energy** and more motion and therefore has **fewer molecules** (less mass) in a given volume so is **less dense**.
Assuming a gas (such as air) at a constant volume and pressure, the **number of molecules** is controlled by the **temperature**.
Pressure & Density

- Air is made up of mostly Nitrogen gas (N\textsubscript{2}) and Oxygen gas (O\textsubscript{2}) molecules
- Nitrogen makes up 78% of air by volume
- Oxygen makes up 21% of air by volume
- The other 1% is made up of water vapor, carbon dioxide, and other trace gases
- N\textsubscript{2} has an atomic mass = 28 amu (atomic mass units) \{2 x 14 amu\} per molecule
- O\textsubscript{2} has an atomic mass = 32 amu (atomic mass units) \{2 x 16 amu\} per molecule
- For simplicity, assume “one air molecule” has mass = 29 amu
- Water vapor (H\textsubscript{2}O) contains two hydrogen atoms (H) and one oxygen atom (O)
- Water vapor has atomic mass = 18 amu per molecule
- Dry air will be assumed to be made up entirely of molecules with 29 amu
- Humid air is a mixture of air molecules and water vapor so it contains molecules with 29 amu and 18 amu
The type of molecule also influences mass and density
Pressure & Density

- Dry air contains only molecules with 29 amu each
• Because an air molecule (29 amu) was replaced by a water vapor (18 amu), the mass of humid air is less than dry air

• Humid air is less dense than dry air at a constant T and P
• Density is important because it is what determines whether a parcel of air will rise or sink in the atmosphere.

• If a parcel of air is **MORE DENSE (cooler)** than its surroundings it will **SINK**.

• If a parcel of air is **LESS DENSE (warmer)** than its surroundings it will **RISE**.