History of Pressure

"Are your ears popping?"

Outcomes:

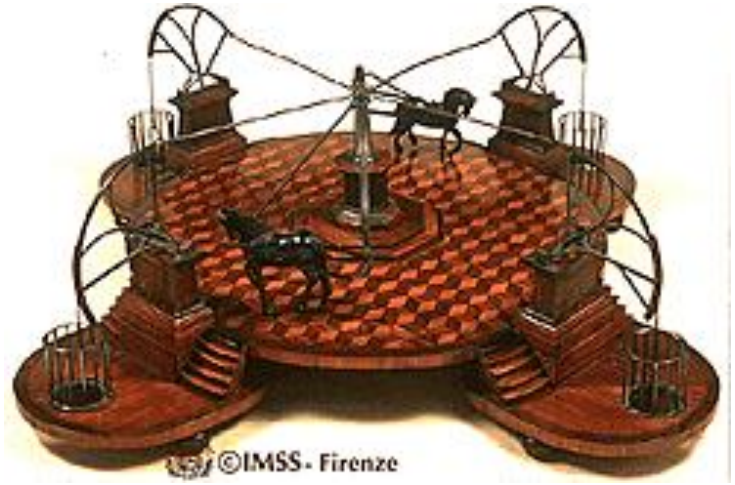
- Example the historical development of the measurement of pressure. *Include: Galileo, Toricelli, von Gureick, Pascal, Huygens, Avogadro, Dalton.*
- Describe the various units used to measure pressure. *Include: atm, kPa, mmHg, mb*

History of the Atmosphere

The study of pressure and its measurement dates back to the late 1500's. Here is a brief summary of the history of pressure measurement.

Galileo Galilei (1564-1642):

- Developed the first **SUCTION PUMP**.
- Used **AIR** to draw **WATER** up a column (like a **SYRINGE**).
- Found that there was a **LIMIT** to how high water could be raised (about **10** meters)
- Thought this was the limit of the "**SUCTION**" of the **VACUUM** created by the **PUMP**.



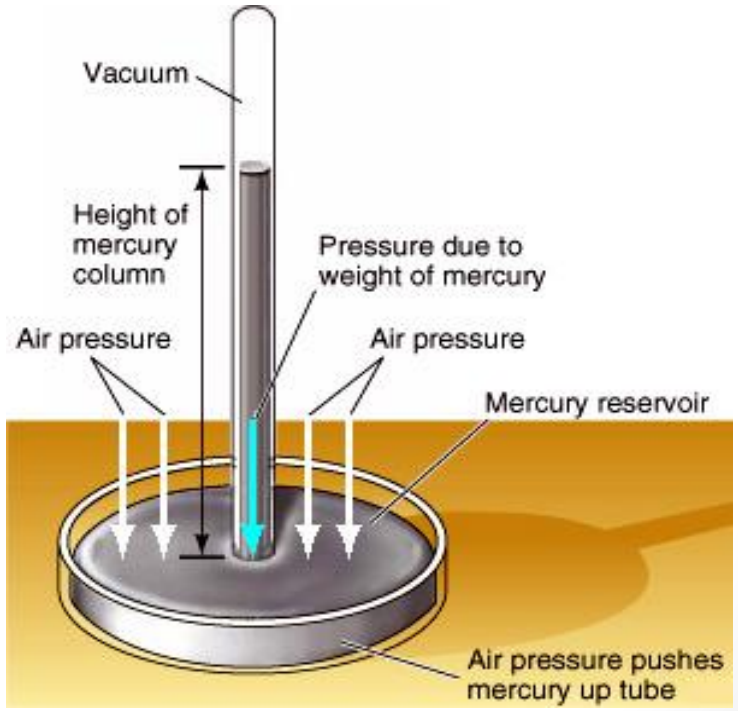
http://galileo.rice.edu/sci/instruments/pump.html

History of the Atmosphere

Evangelista Toricelli (1643):

- Studied under **GALILEO**
- Determined that the limit to the height that the pump could draw water was due to **ATMOSPHERIC PRESSURE**.
- Inverted a closed-end **TUBE** filled with **MERCURY** into a **PAN** of mercury at **SEA LEVEL**.
- The **HEIGHT** of the mercury in the tube (in **mmHG)** is equal to the **ATMOSPHERIC PRESSURE** on the mercury in the **PAN**.
- This is the first **BAROMETER**.
- In doing so, he found that air has **MASS** (exerts **PRESSURE**).
- Also believed that the space in the top of the column was a **VACUUM**.

Veritasium - World's Longest Straw



http://faculty.wcas.northwestern.edu/~infocom/Ideas/thermodate.html

History of the Atmosphere

Otto von Guericke (1643-1645):

- Invented the **AIR PUMP**.
- Used the air pump to create a **VACUUM** in two **METAL HEMISPHERES**.
- The **VACUUM** was so strong that a team of **16 HORSES** could not pull them apart.
- He reasoned that the **HEMISPHERES** were being held together by **ATMOSPHERIC PRESSURE** and **NOT** the **VACUUM**.

Note:

→ von Guericke was **CORRECT**, vacuums don't "**SUCK**" it is the **ATMOSPHERE** that **PUSHES**.

History of the Atmosphere

Blaise Pascal (1648):

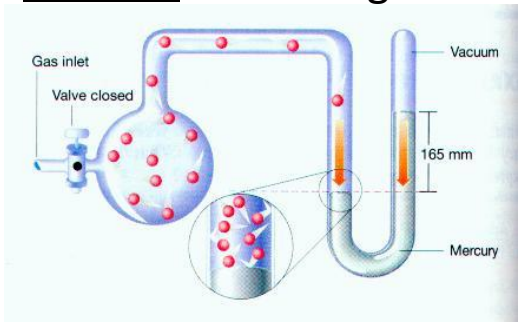
- Used Toricelli's Barometer, and traveled up and down a **MOUNTAIN**.
- He found that the column of mercury would **RISE** as he moved **DOWN** the mountain, indicating that the **ATMOSPHERIC PRESSURE** was **INCREASING**.
- Later, the S.I. unit of pressure, the '**PASCAL'** was named after him.

https://www.britannica.com/biography/Blaise-Pascal

History of the Atmosphere

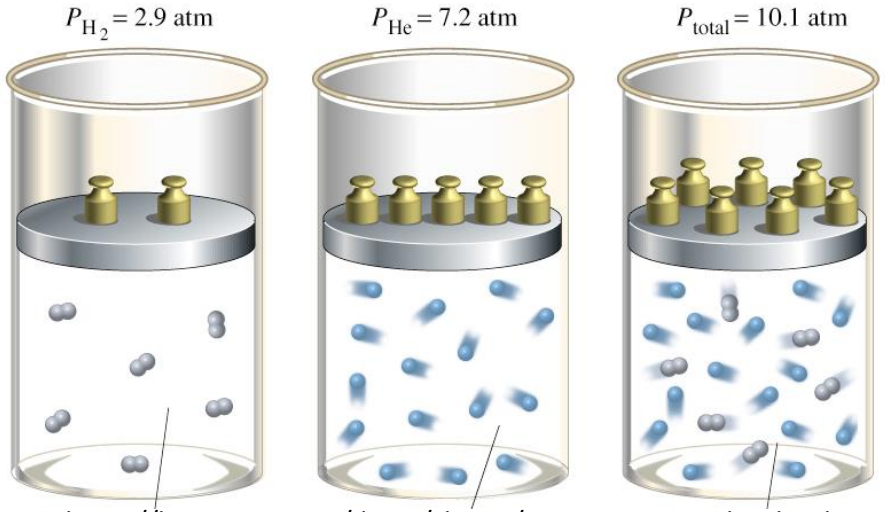
Christian Huygens (1661):

- Developed the **MANOMETER** to study the **ELASTIC** forces in gases.



John Dalton (1801):

- Stated that in a mixture of gases, the **TOTAL PRESSURE** is equal to the **SUM** of the **PRESSURES** of **EACH GAS**.
- The pressure exerted by each as is called it's **PARTIAL PRESSURE.**

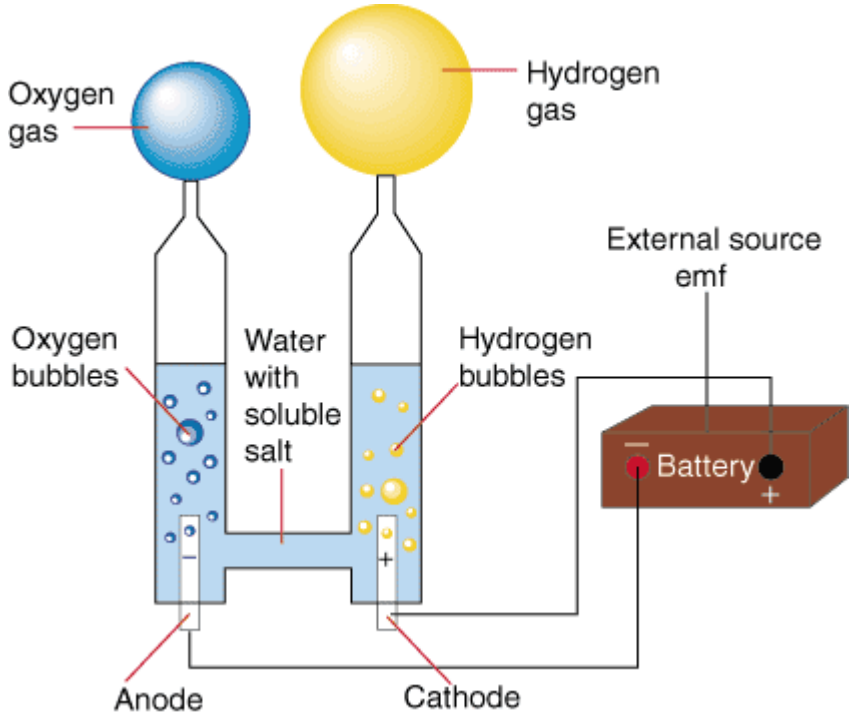


https://legacy.etap.org/demo/chem5/instructiontutor_last.html

History of the Atmosphere

Joseph Louis Gay-Lussac (1808):

- Observed the law of **COMBINING VOLUMES**.
- "***Gases react in simple volumetric proportions and the volumes of the reactants can be related to the volumes of the products in simple proportions.***"
- He noticed that **2 VOLUMES** of hydrogen combine with **ONE VOLUME** of oxygen to make **TWO VOLUMES** of water.

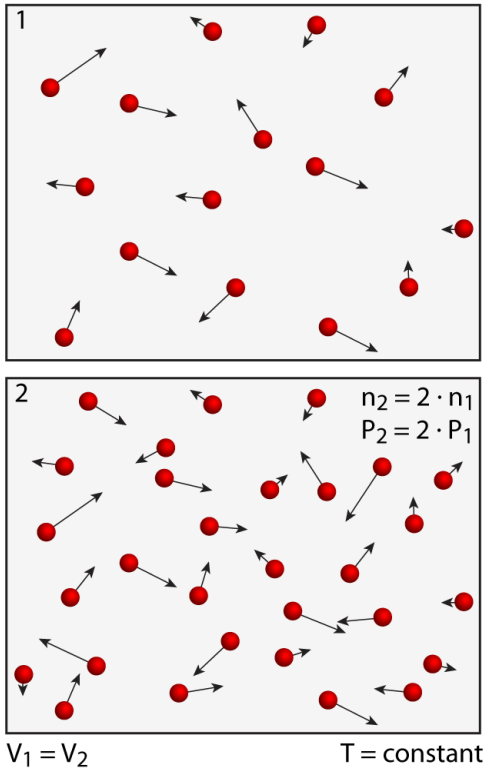


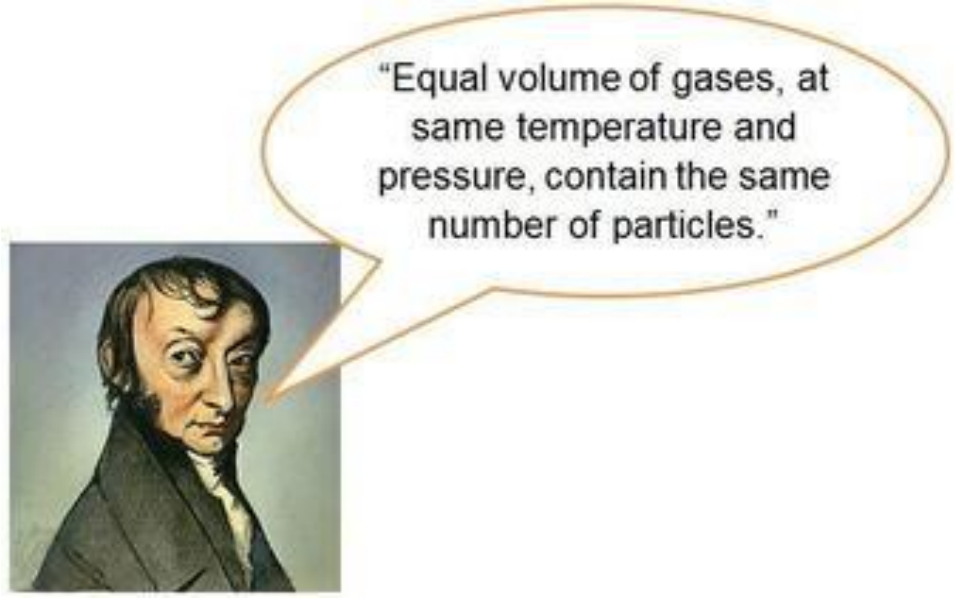
http://www.instructables.com/id/Separate-Hydrogen-and-Oxygen-from-Water-Through-El/

History of the Atmosphere

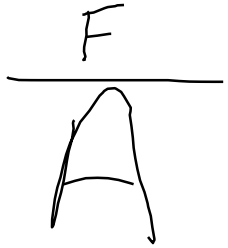
Amadeo Avogadro (1811)

- Used some of Gay-Lussac's experiments to determine that the **PRESSURE** in a container is **DIRECTLY PROPORTIONAL** to the **NUMBER** of **PARTICLES** in the container.
- Ex. **BALLOON**, **TIRES** etc.





Units of Pressure



Pressure

- is the **FORCE** that a gas exerts on a certain **AREA**.
- The pressure exerted by the atmosphere is called **ATMOSPHERIC PRESSURE.**

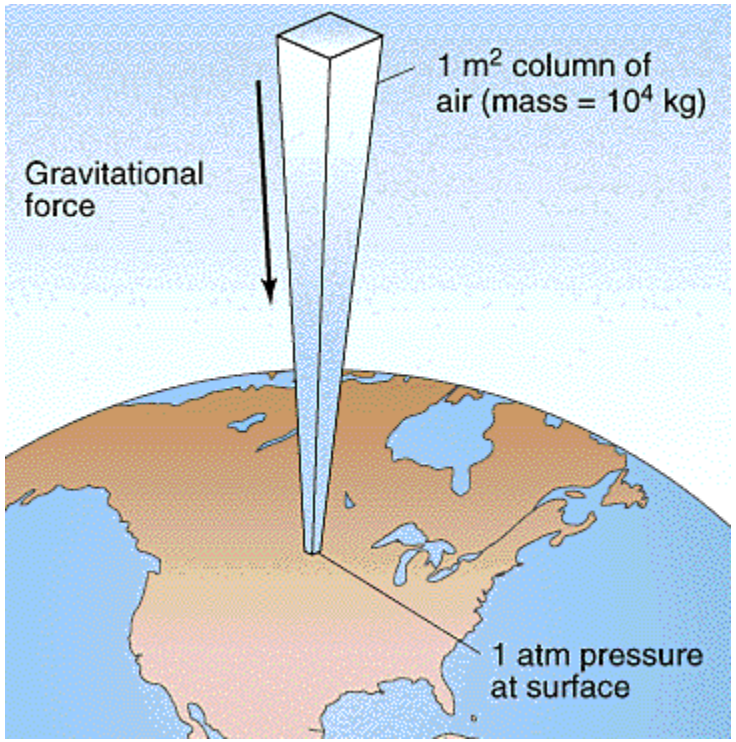
There are many different units that we can use to measure pressure. Pressure is calculated in units of **FORCE** per unit **AREA**.

→ The SI unit of **FORCE** is the **NEWTON** ($kg \bullet m/s^2$).

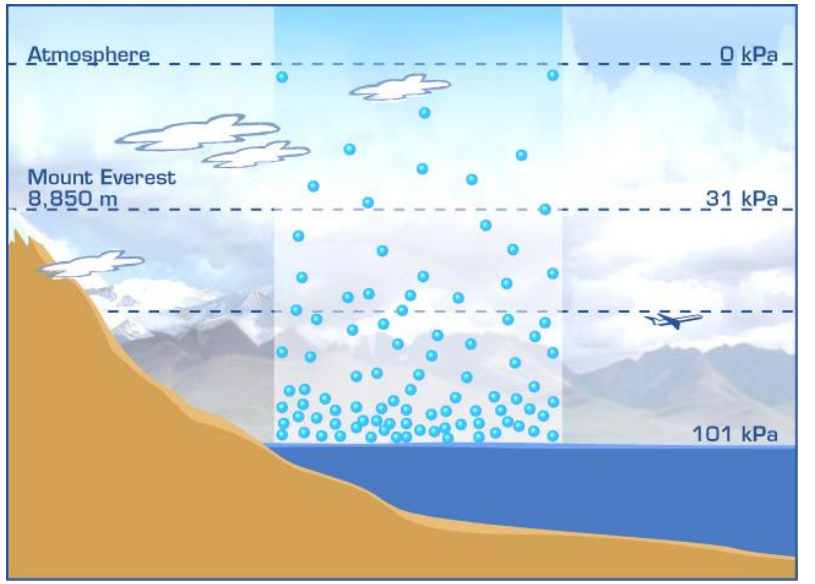
Units of Pressure

Standard Pressure:

- Like any other unit we must have a **STANDARD** to use as a starting point.
- With pressure, we use the atmospheric pressure at **SEA LEVEL**.
- The unit **ATMOSPHERE** ***(atm)*** was derived from standard atmospheric pressure at sea level. ***1 atm = standard pressure***.



http://peter-mulroy.squarespace.com/air-pressure/



https://socratic.org/questions/why-is-atmospheric-pressure-measured-at-sea-level

Units of Pressure

Kilopascal (kPa)

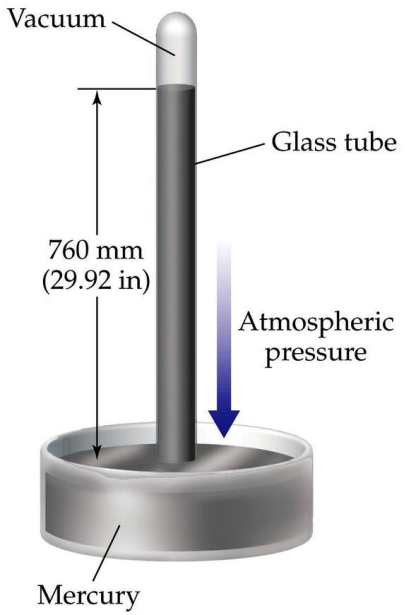
- A force of 1 Newton per meter squared (N/m^2) is our SI unit of pressure, called the **PASCAL *(Pa)***.

→1000 Pa = **1 KILOPASCAL *(kPa)***.
→ 101.3 kPa = **1 ATM** (***standard pressure***)

mmHg

- Using Torricelli's barometer, we can measure pressure in terms of the **HEIGHT** of the mercury **COLUMN**. This is another unit called **MILLIMETERS OF MERCURY *(mmHg)***.

→ 760 mmHg = **1 ATM** = **101.3 KPA** (***standard pressure***)



https://www.quora.com/How-is-atmospheric-pressure-measured

Units of Pressure

Torr

- In honour of Torricelli, it was meant to be the same as **mmHg**, but its definition has changed over the years.
- We will assume that **1 torr = 1mmHg**

Millibar (mb or mbar)

- The **BAR** is a meteorological unit of pressure. It may also be expressed as **MILLIBARS** ***(mb or mbar)***. 1000 mb = 1 bar

→ 1 bar = **1 ATM** = **760 mmHg** = **101.3 KPA** (***std pressure***)

Converting Units of Pressure

Example:

Convert 1.5atm to kPa, Pa, and mmHg

$$1.5\ atm \times \frac{101.3\ kPa}{1\ atm} = 151.95\ kPa \times \frac{1000\ Pa}{1\ kPa} = 151\,950\ Pa$$

$$1.5\ atm \times \frac{760\ mmHg}{1\ atm} = 1140\ mmHg$$

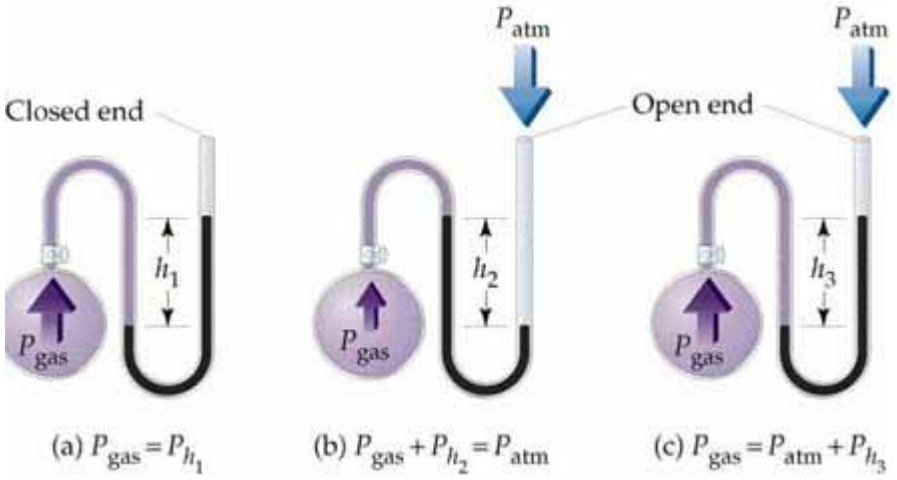
Measuring Pressure

Manometers & Barometers:

Are both used to measure the **PRESSURE** of a gas.

1. *Manometers*

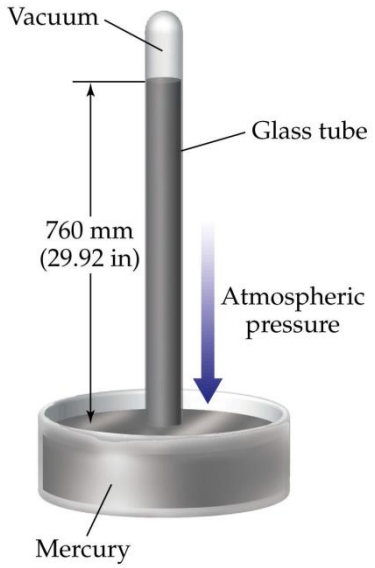
- Measure the pressure of a gas or vapour in a **CLOSED CONTAINER** by **COMPARING** it to that of the **ATMOSPHERE**.
- You have seen this in the first unit.



http://wps.prenhall.com/wps/media/objects/3311/3391331/blb1002.html

Measuring Pressure

1. ***Barometers***
   - Measure the pressure of the **ATMOSPHERE**.
   - There are two different types:
     a) ***Mercury Barometers***
        - Use a **COLUMN** of mercury **INVERTED** in a open **DISH** of mercury (like **TORICELLI'S**).
        - The **HEIGHT** of the mercury indicates the **PRESSURE**.
        - Are hard to read, but are more accurate.



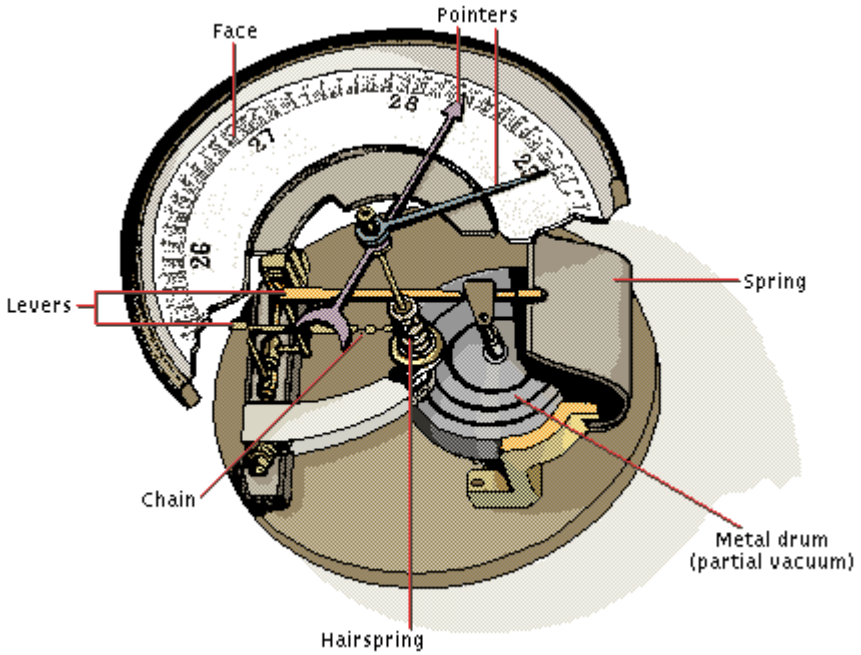
https://www.quora.com/How-is-atmospheric-pressure-measured

http://www.charlesedwin.com/mercury.htm

Measuring Pressure

a) *Aneroid Barometers*

- Use a partially **EVACUATED** metal **DRUM** that **EXPANDS**/**CONTRACTS** with varying pressure.
- Are inexpensive and easy to read, but are less accurate since it is **MECHANICAL**.



http://www.acr.ac.th/acr/ACR_CAI/Tiwawan/FlipAlbumCD/Albums/Atmosphere_opf_files/

Feeling Pressure

https://www.dred.com/uk/causes-of-low-blood-pressure.html

We **FEEL** pressure in various ways:

- ***Ear's popping on a plane.***
- ***Difficulty breathing at higher altitudes.***
- ***The "bends" in divers***
- ***Pressure on the body when diving.***

When diving, the changes in pressure are amplified due to the weight of the **ATMOSPHERE**, and the weight of the **WATER**.

Divers will feel more pressure in **SALT** water than in **FRESH** water. Why might this be?

→ ***The salt adds more weight to the water, and hence more pressure.***

→ In salt water, it takes a depth of **33FT** to equal **1 ATM.**

→ In fresh water it takes a depth of **34FT** to equal **1 ATM**.