

Physics

Objectives

- To discuss properties of light in water.
- To discuss properties of sound in water.
- To discuss the types and properties of matter.
- To discuss factors affecting buoyancy.
- To discuss air as a mixture of gases.
- To define pressure and the 4 gas laws affecting divers.
- To know the most common diver hand signals.

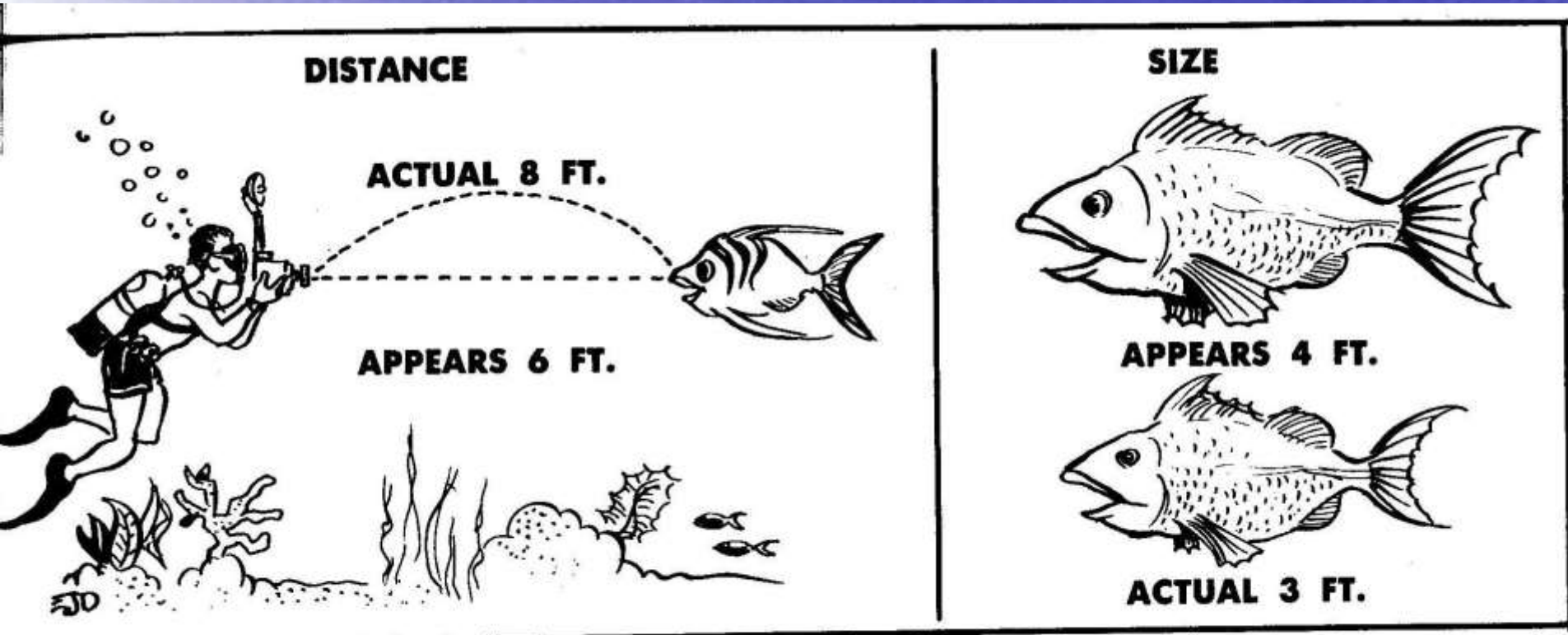
LIGHT

Reflection

- Darker under water

Refraction (double refraction of mask & eye lens)

- 1/4 closer, 1/3 bigger



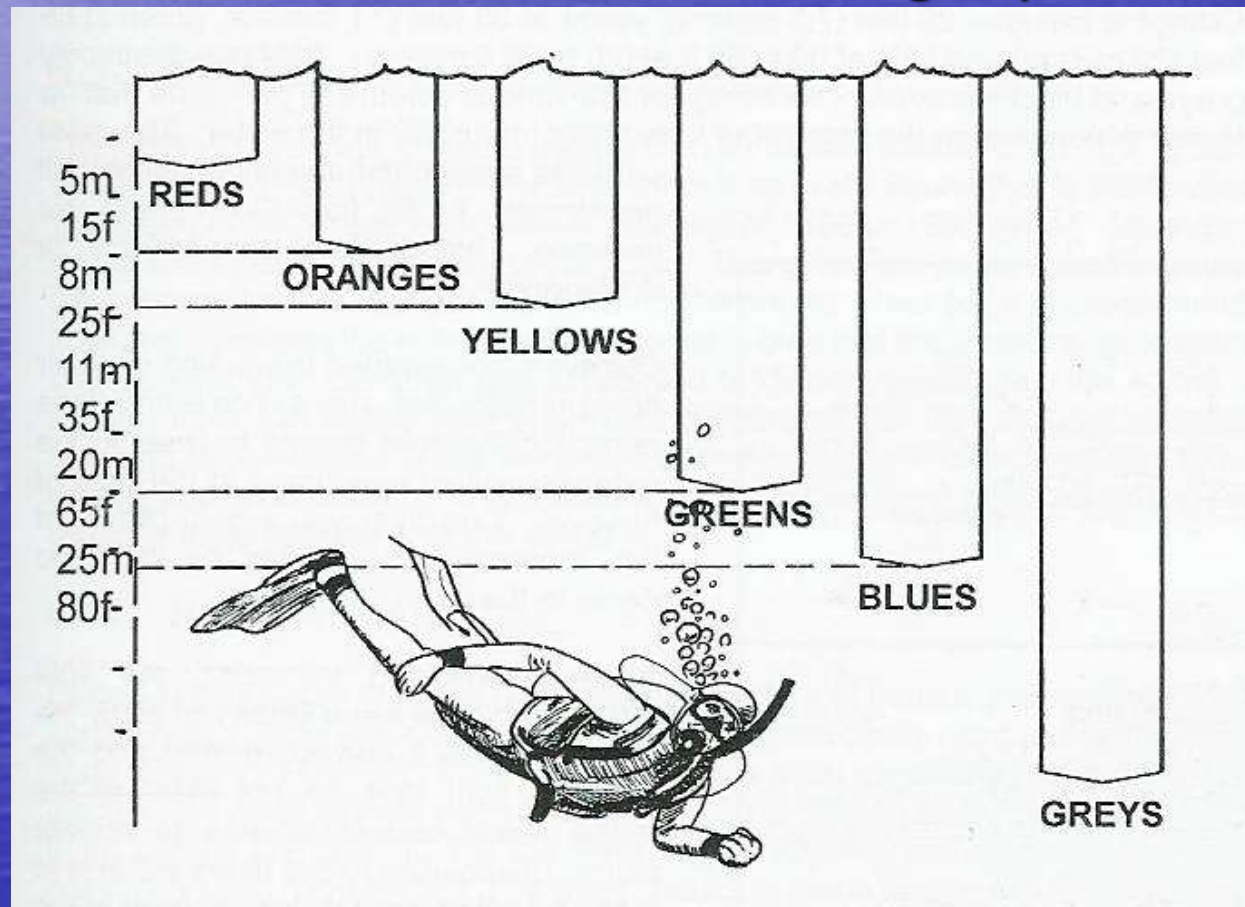
Light

Absorption

- Lose colors with depth
- lose reds first

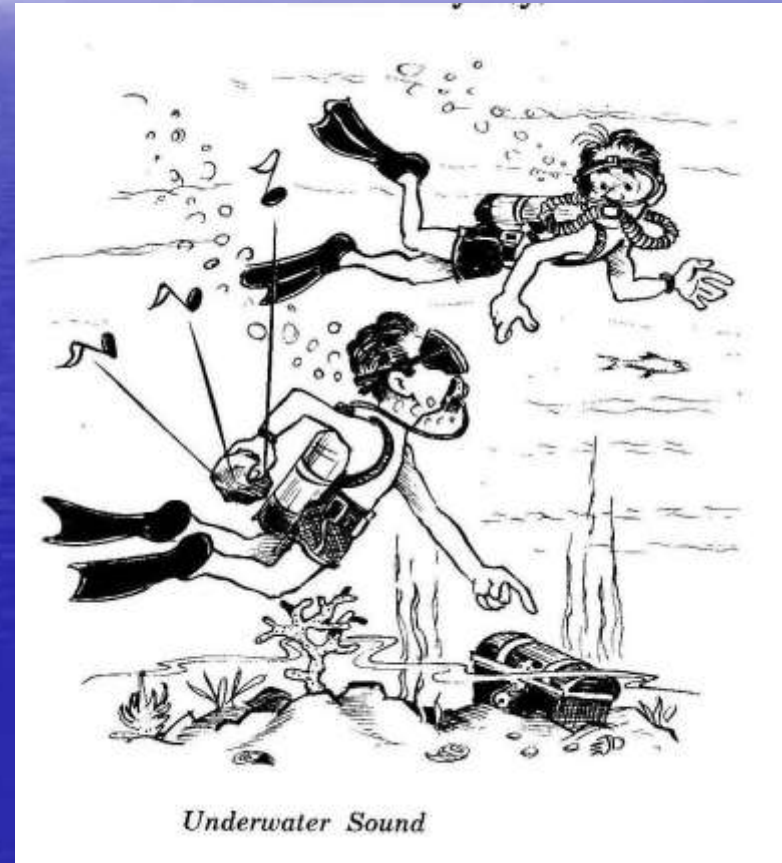
Turbidity (impurities)

- influences light penetration



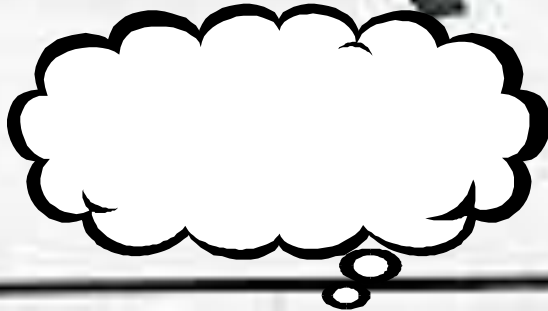
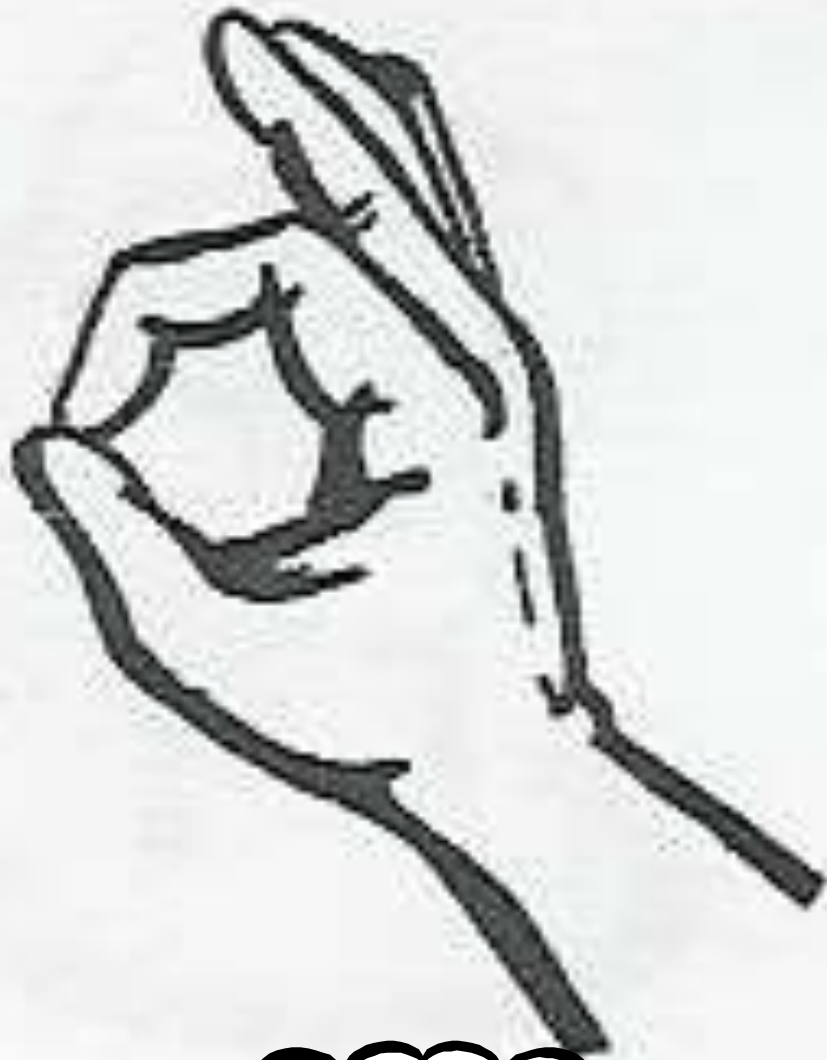
Sound

- Speed
 - *4 times faster than in air*
- Results in difficulties with locating the direction or distance of source
- Hand signals become the main source of communication



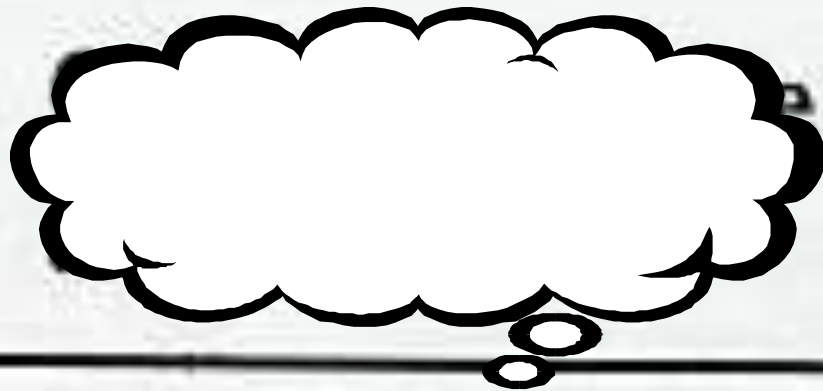
To Locate the Source of a Sound

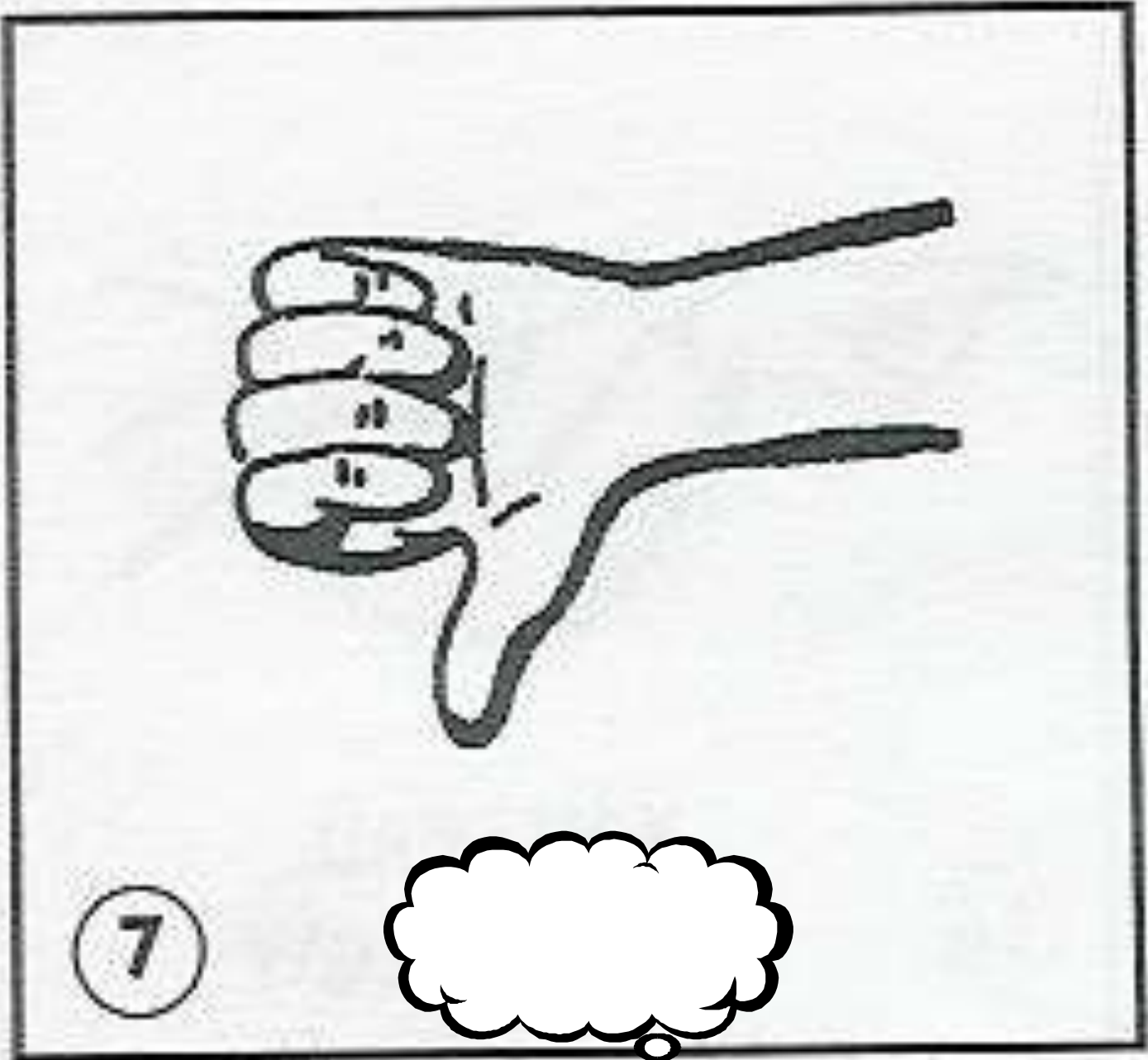
- Stop, look around you 360°
- Look below
- Look above



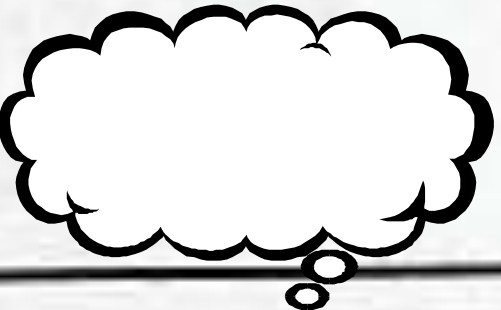


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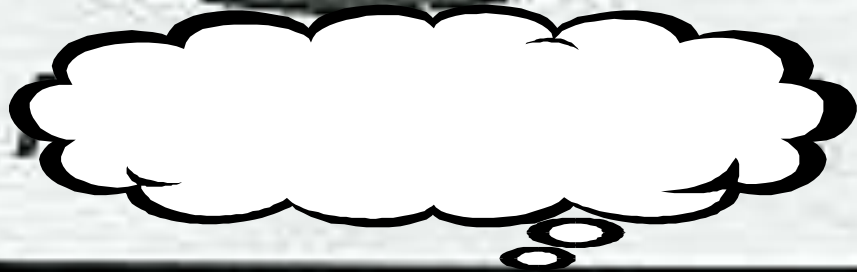


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Matter

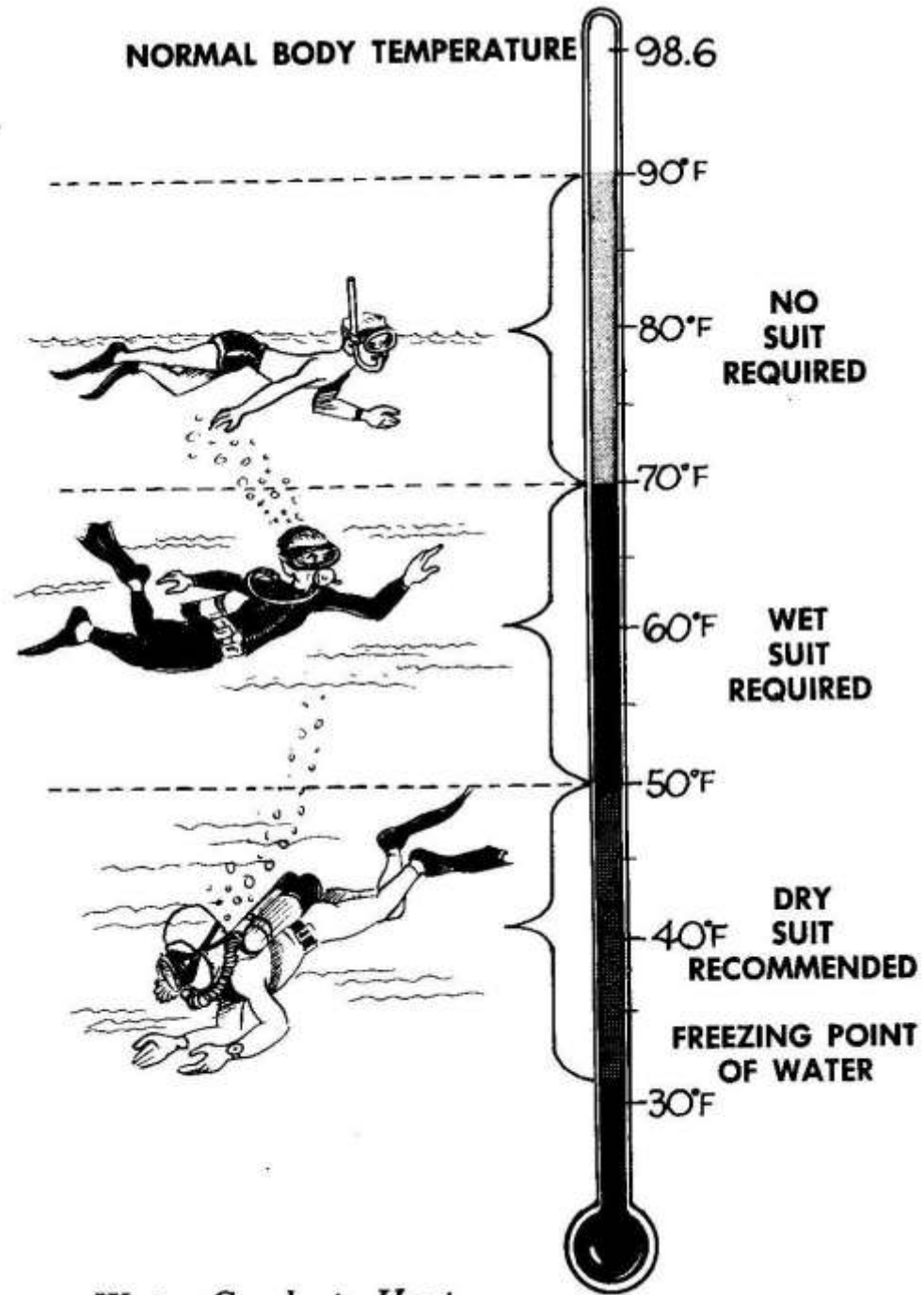
Matter

- Anything that occupies space and has weight
- Subject to volume, density, shape, compressibility and temperature effects.

Properties of Matter

Temperature is measured in F° or C°

Water draws heat away 25 X faster than in air



Properties of Matter

Density is the quantity of matter in a given volume

- The mass per unit volume of a substance
- Water is 800 times more dense than air

- The weight of fresh water is 62.4 lbs / ft³
- The weight of salt water is 64 lbs / ft³

Types of Matter

Solids

- a) Set volume
- b) Set density
- c) Set shape
- d) Low compressibility
- e) Little temperature effect

Types of Matter

Liquids

- a) Set volume
- b) Set density
- c) Changes shape
- d) Low compressibility
- e) Some temperature effect

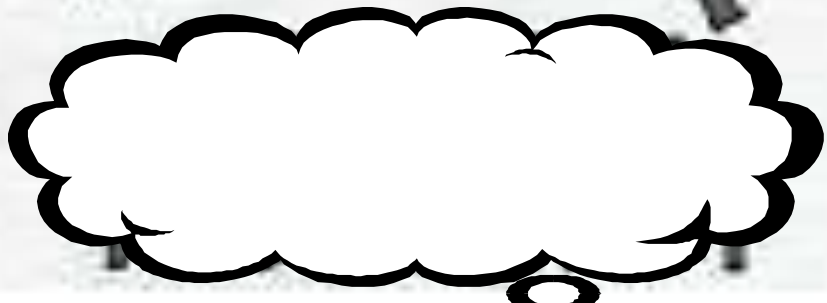
Types of Matter

Gas

- a) Changes volume
- b) Changes density
- c) Changes shape
- d) Highly compressibility
- e) High temperature effect



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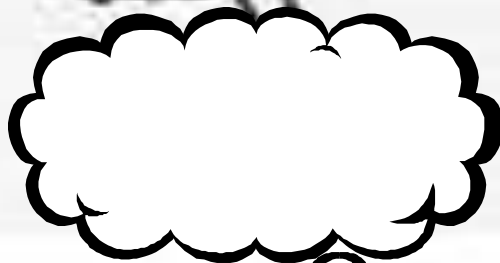


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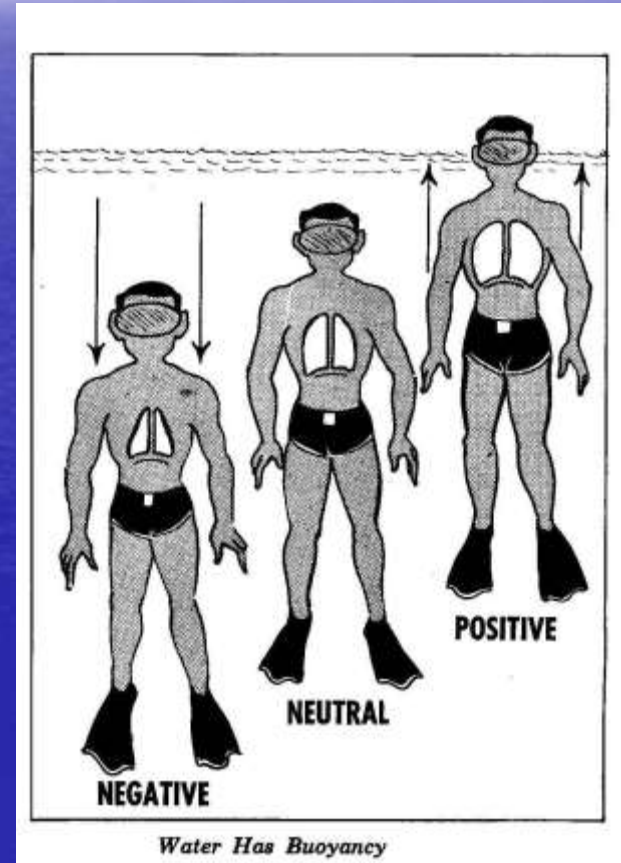
Buoyancy

Archimedes Principle

"A body submerged in a liquid is buoyed upward by the weight of the volume of water it displaces".

Buoyancy

- positive
- neutral
- negative



Buoyancy

- If a person weighs LESS than the water they displace, they will float. This is referred to as POSITIVE buoyancy.
- If a person weighs More than the water they displace, they will sink. This is referred to as NEGATIVE buoyancy.
- If a person weighs the SAME than the water they displace, they will stay in one spot. This is referred to as NUTREAL buoyancy.

Factors Affecting a Diver's Buoyancy

1. Body size & shape

a) Fat weighs less than muscle

2. Lung volume

3. Diver's equipment

a) exposure suits

b) full / empty scuba cylinders

c) buoyancy compensating devices

d) weight belts

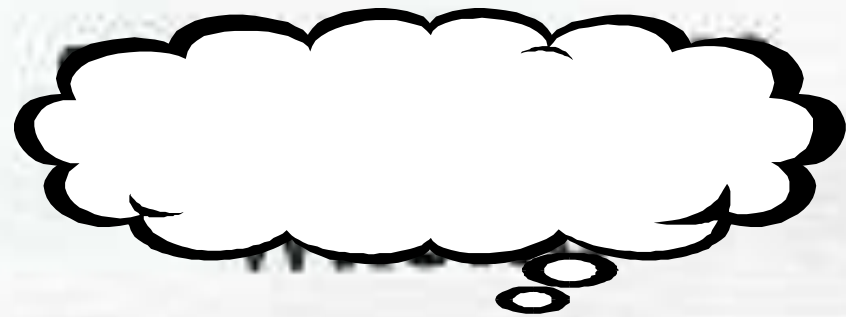
It is essential to master buoyancy control to avoid damaging the marine environment and to avoid a rapid ascent.

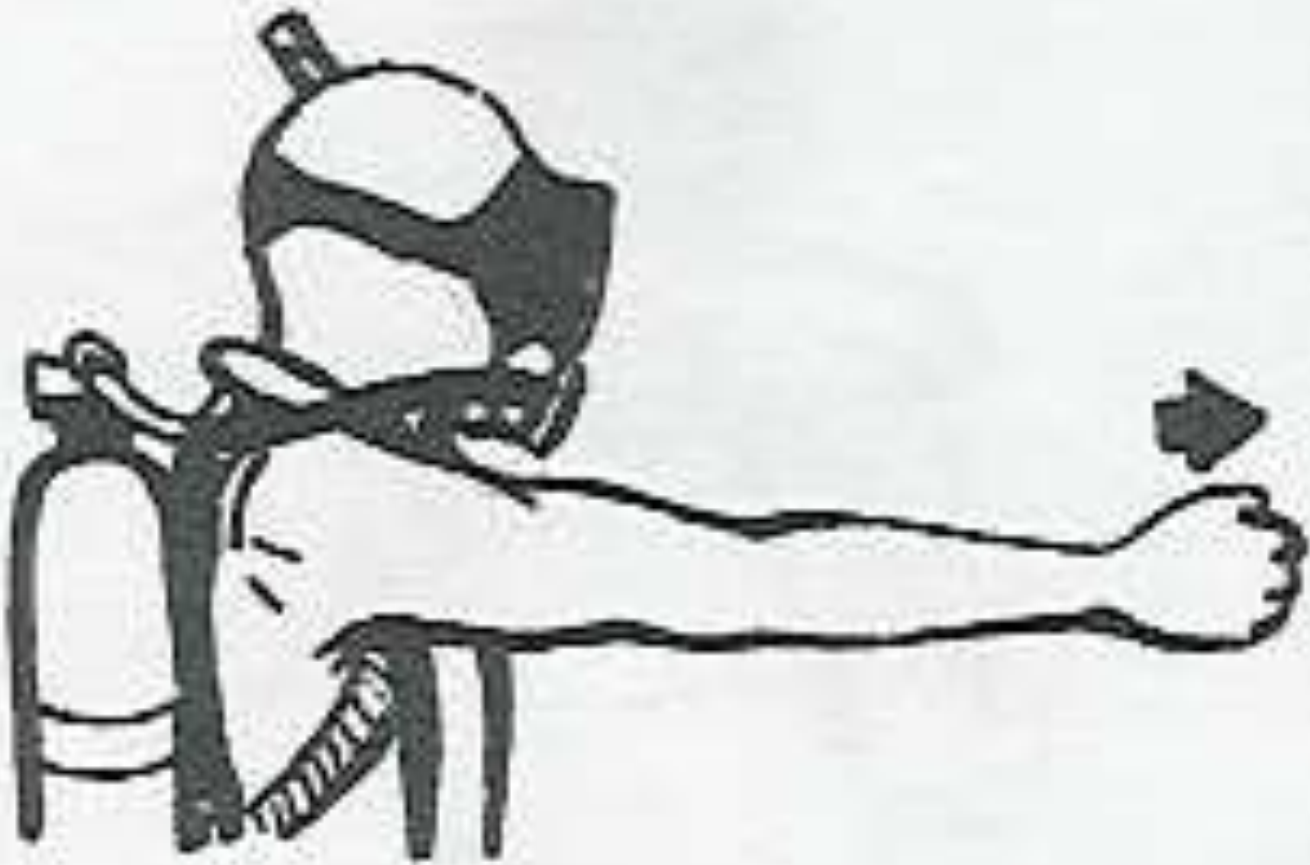
Practical methods

- 1 in 5 method
- Pivot Method



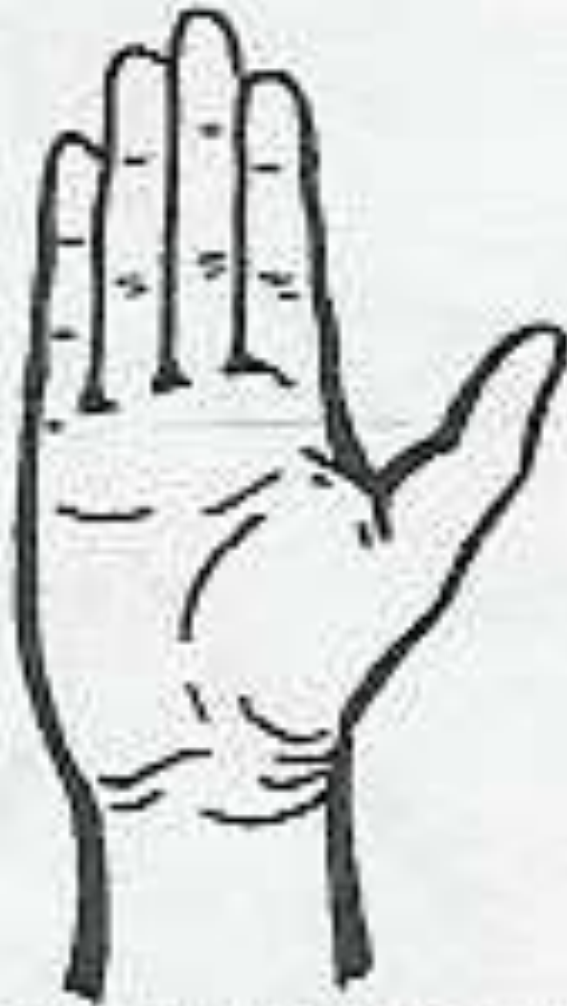
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Components of Air

- Oxygen : 21% (approximately)
- Nitrogen: 79% (approximately)
- Carbon Dioxide : 0.03% (approximately)



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Pressure

- There are three types of pressure you will need to know about:
 - Atmospheric
 - Gauge
 - Absolute

- Ambient Pressure
 - Total pressure experienced at any given depth

Atmospheric Pressure

- Is the result of the weight of the atmosphere *(14.7 PSI)*
- Units of measurement:
 - i.e. Pounds per Square Inch (psi) kg/sq.cm.
- Decreases as altitude increases
 - Atmospheric pressure decreases 0.26 psi per mile

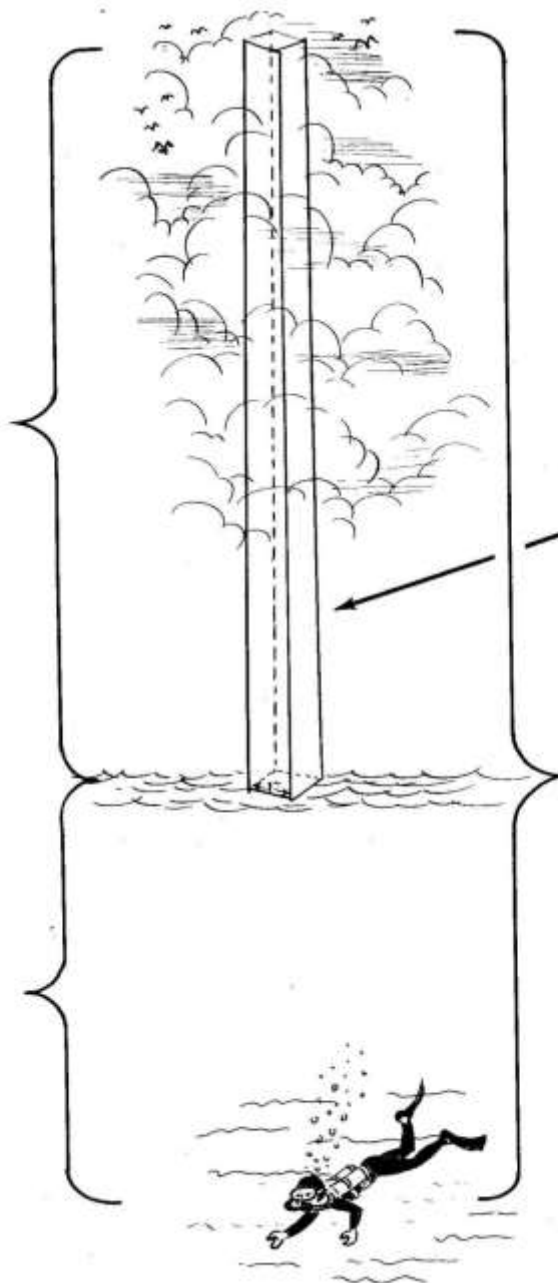
Gauge Pressure

- This is the pressure of the water alone.
- Your “depth gauge” will read the water pressure, not the air.
- At the surface this is zero

Absolute Pressure

- The combination of air and water pressure
- Written as ATA
- Your gauge plus 1

**ATMOSPHERIC PRESSURE
IS THE RESULT OF
WEIGHT OF THE
ATMOSPHERE**



**ABSOLUTE PRESSURE
IS THE SUM OF
ATMOSPHERIC AND
GAGE PRESSURE**

**GAGE PRESSURE
IS THE PRESSURE
EXERTED BY THE
WATER ALONE**

Atmospheric, Gage, Absolute Pressures

Calculating Pressure

1 standard atmosphere = 14.7 PSI

33 feet of salt water is 14.7 PSI *(34 feet fresh water)*

So, we say 33 feet of water has the same pressure as the entire atmosphere and we call that 1 atm.

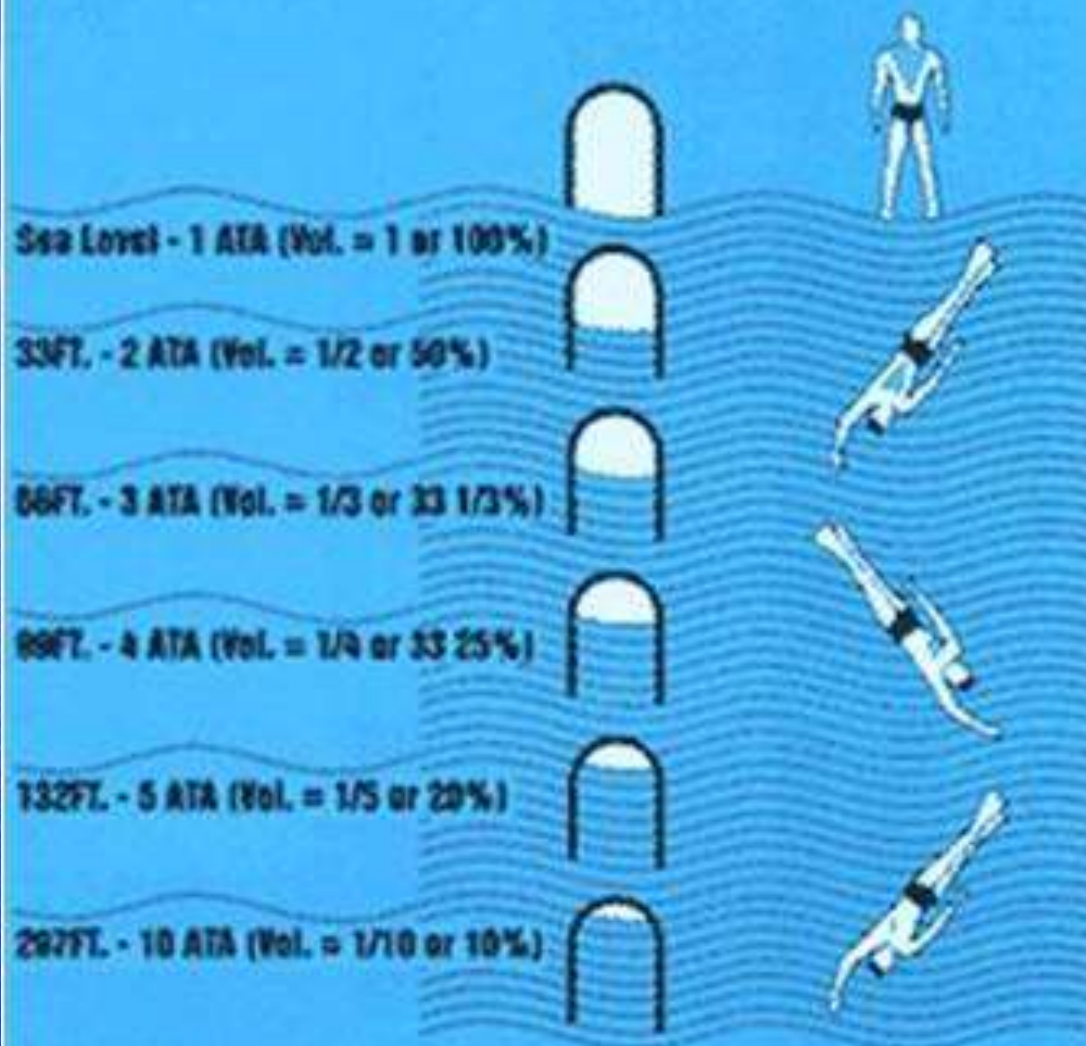
What is the pressure at 66 feet?

Gauge vs. Absolute Pressure

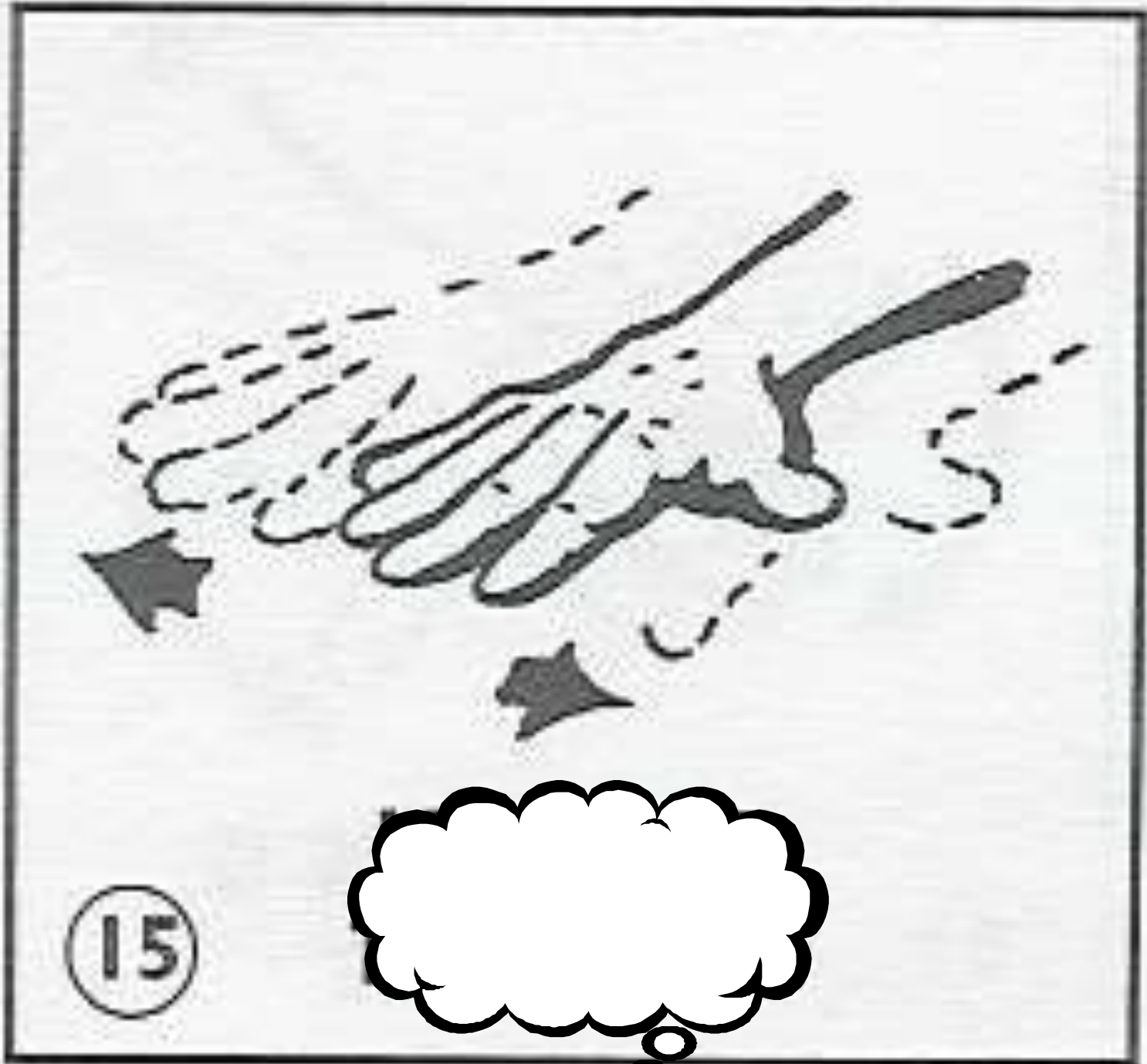
Meters	Feet	Gauge Pressure	Absolute Pressure
0	0	0 psi (0 ATM)	14.7 PSI (1 ATM)
10	33	14.7 (1 ATM)	29.4 PSI (2 ATM)
20	66	29.4 (2 ATM)	44.1 PSI (3 ATM)
30	99	44.1 (3 ATM)	58.8 PSI (4 ATM)
40	132	58.8 (4 ATM)	73.5 PSI (5 ATM)
50	165	73.5 (5 ATM)	88.2 PSI (6 ATM)

Your pressure gauge will measure 0 atm (0 bars) at the surface, 1 ATM at 33 feet, 2 ATM at 66 feet, 3 ATM at 99 feet and so on.

Note: The first time the absolute pressure doubles is in the first 33 feet. It requires another 66 feet to double again. Therefore, the greatest pressure change is near the surface.



Boyle's law applied to depth versus volume and pressure





1



followed by



2



followed by



3



followed by



4



The Gas Laws

Boyles Law

“At a constant temperature, the **volume** of a gas:
is **inversely proportional** to the **pressure** exerted on that gas
and **directly proportional** to the **density**”

Pressure increase - volume decrease (and density increases)

Pressure decrease - volume increase (and density decreases)

$$P1 \times V1 = P2 \times V2$$

BOYLE'S LAW				
DEPTH	ATA	VOLUME	DENSITY	PRESSURE
0	1	1	1	14.7
10M - 33'	2	1/2	2	29.4
20M - 66'	3	1/3	3	44.1
30M - 99'	4	1/4	4	58.8

Note: The largest change in pressure in the shortest distance occurs in the first 33 feet.

Physiological considerations

- pressure effects on descent (Squeezes)
- lung expansion on ascent (Arterial Gas Embolism)

Equipment considerations

- expansion /contraction of the BC
- expansion /contraction factors of exposure suits
- effect on the air supply due to pressure / volume changes
 - reduced time at depth – takes double the volume of air to fill your lungs at 33' than at the surface
 - nature's air reserve on ascent
 - increased density of breathing air at depth makes it more difficult to breathe

Dalton's Law

“The pressure exerted on a gas is equal to the sum of its Partial Pressures”

This means each gas is given the percentage part of the total pressure in the mixture.

At 0’ 21% O² (14.7 / 100 X 21) = 3.087 psi

79% N² (14.7 / 100 X 79) = 11.613 psi

At 66’ Absolute pressure is 3X

O² = 9.261 psi

N² = 34.839 psi

Implications of Dalton's Law

That each gas can become harmful to the body at certain pressures.

O_2 >>>> Oxygen toxicity

- At 250 ft O_2 component in air becomes toxic
- Pure O_2 toxic at 16 ft

N_2 >>>> Nitrogen narcosis

- Restricts how deep and for how long

Henry's Law

“At a constant temperature, the quantity of gas that will dissolve in a liquid is **directly proportional** to the pressure exerted on the gas”

As pressure increases, more gas will dissolve in that liquid.

The implication of Henry's Law
- Decompression Sickness (N_2)

Charles Law

“At a constant volume, an increase in temperature is **directly proportional** to an increase in pressure”

This means if you have a SCUBA tank and you increase the temperature of it, the pressure will increase as well.

The implications of Charles Law

- purpose of a cylinder burst disk
- purpose of a water bath while filling
- storage of a cylinder in hot environment
 - trunk of car
 - direct sunlight
- correct rate of cylinder filling

NAME	LAW	RELATIONSHIP
BOYLE'S LAW	<i>At a constant temperature, as pressure increases, volume decreases, and density increases.</i>	Buoyancy, Squeezes, Arterial Gas Embolism, Barotraumas
HENRY'S LAW	<i>At a constant temperature, the amount of gas that will dissolve in a liquid is directly proportional to the pressure on the liquid.</i>	Decompression, Decompression Sickness.
DALTON'S LAW	<i>The total pressure of a mix of gasses is equal to the sum of the partial pressures of the gasses of the mix</i>	Nitrogen Narcosis, Oxygen Poisoning, Carbon Monoxide Poisoning, Anoxia, Hypoxia
CHARLES' LAW	<i>Pressure and volume changes are directly related to changes in temperature.</i>	Filling storage tanks,



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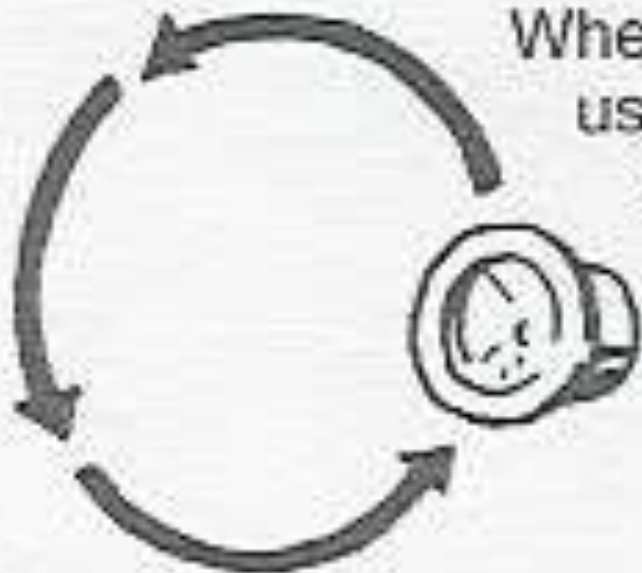


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NIGHT DIVING SIGNALS (buddy at distance)

When Buddy is near,
use regular hand
signals in front
of light.



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Large, slow circles with light.



26

Large, rapid up-and-down motions with arm extended.



