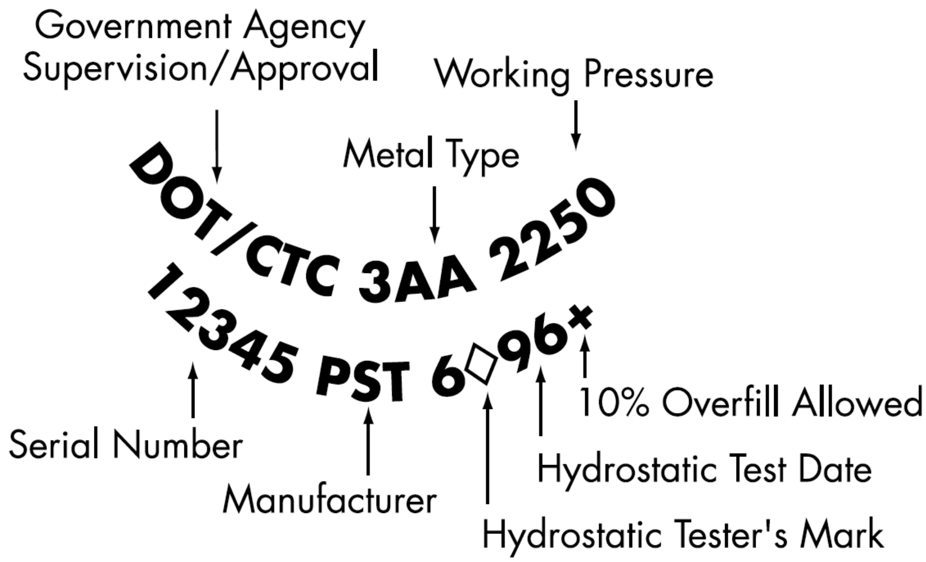
DIVE THEORY - EQUIPMENT

TANKS / CYLINDERS

TANK MARKINGS



- **Govt. Agency Supervision / Approval**
  DOT or DOT/CTC = Dept. of Transport or Canadian Transport Comm.

- **Metal Type**
  3AA = Steel)
  SP6498, E6498 or 3AL = Aluminium

- **Working Pressure**
  Maximum pressure lbs / inch2 (steel = 2250, al = 3000-4000)

- **Serial Number**
  12345 = Unique to tank

- **Manufacturer**
  PST = Manufacturer that made it

- **Hydrostatic Test Date / Hydrostatic Tester's Mark**
  6*96+ = Hydrostatic Test Date (Month, initials of tester, year)

- **10% Overfill Allowed**
  + = 10% overfill allowed on STEEL TANKS

These marking should always be checked before filling.
This is important even in different countries with different tank markings

TANK METALS	

	STEEL	**ALUMINIUM**
Resistance to corrosion	Quicker (lasts longer)	Slower
Galvanic Action	Brass values can react with steel (rust)	Brass values can react with Al. (Al. Oxide)
Weight	Heavier	Lighter
Size	Smaller (stronger)	Larger (less strong)
Base	Flat / Square	Rounded
Buoyancy	Less Buoyant (diver is not affected as tank pressure drops)	More buoyant (more weight required as tank pressure drops)
Normal Working Pressure	220 Bar (300 Bar for tec. diving)	220 Bar
Hardness	Harder	Softer
Maintenance	Harder to clean	Easier to clean (preferred by dive operators)
Availability	Less available	More available

VISUAL INSPECTION

A visual inspection test is required by international law to be conducted on all tanks (steel and aluminium) once (1) a year.

A visual inspection is conducted by looking inside the tank for any corrosion (steel tanks = rust / aluminium tanks = aluminium oxide). If there is any corrosion the tanks will be machined and chemically cleaned. If the corrosion has done damage to the wall of the tank the tank will be destroyed.

The threading at the neck of the tank (where the tank valve screws into) is also inspected for any damage.

HYDROSTATIC INSPECTION

Hydrostatic inspection = water pressure test

Laws differ from country to country
US - required every five years
UK - required every four years

A hydrostatic test is performed to ensure that the tank has no weak points in the body, and to make sure that the tank can withstand acceptable high-pressure air used for diving.

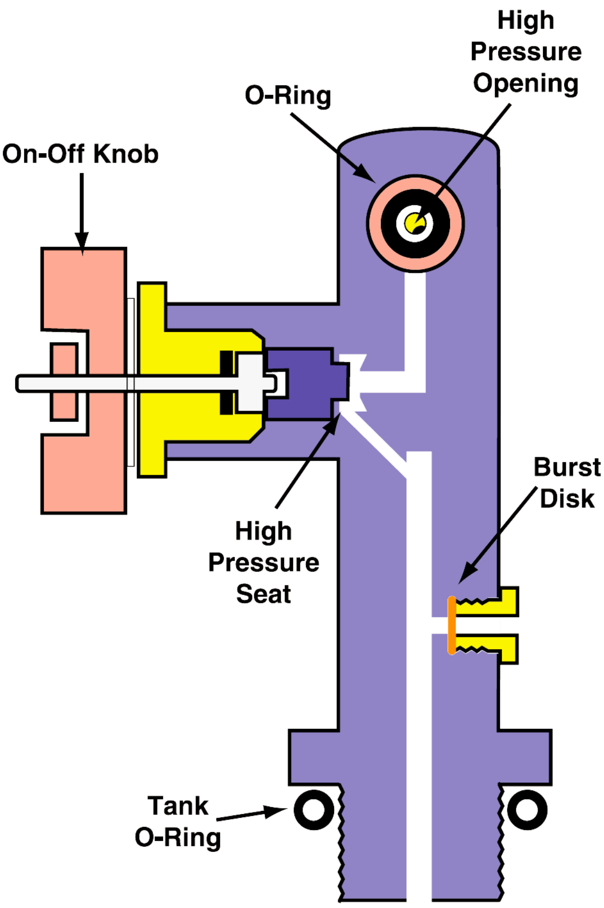
- A hydrostatic inspection is conducted by placing the tank in a pressure container filled with water.
- The tank is then filled with water, which will be used to pressurize the tank to approximately 7/5 of its working pressure.
- Afterwards the tank is checked for any damage or disfigurement (shape change) that may have occurred during the test.

Certain circumstances can weaken tanks before a hydrostatic test is required.

Have tanks hydrostatically tested after exposure to any of the following:

- Tumbling (or sandblasting) to remove corrosion.
- Damage due to impact
- Exposure to heat in excess of 82 degrees Celsius may affect the metals integrity. Never paint a cylinder using a heat painting process such as that used on automobiles.
- If left unused for more than 2 years

TANK VALVES

K-VALVE	K-valves are our modern tank valves. The K-valve is a simple valve that will open or close the tank pressure coming out of the tank opening.  K-valves will either have a yoke fitting or a DIN fitting for the tank opening. This is for the different designs of first stages on scuba regulators. DIN screws into the tank valve.

J-VALVE	J-valves (which are no longer used but are still found) are also called RESERVE VALVES. They were used before pressure gauges came into use. It's a spring-loaded valve that would close off a divers air supply once the pressure in the tank became low (between 40-60 Bar). The diver would then reach back and pull a pin, which would then re-open the valve. The diver would then know that he had a RESERVE of air and had to make his way back to the surface. When refilling the pin must be in the DOWN position.

BURST DISK	A BURST DISK is a thin copper disk that is located on the valve and will break if the tank pressure becomes too high (140% of working pressure). Disks are replaced every year, due to weakening of disk from filling / emptying Instead of the tank exploding the air will vent (come out) through the burst disk. Newer disks, which vent air from both sides prevents the spinning of cylinder

REGULATORS

OPEN CIRCUIT SCUBA	Typically used by recreational divers. The diver inhales air from the cylinder via a demand valve regulator and exhales it into the water, thus the circuit is open because none of the air is recycled. Though open circuit doesn't recycle breathing gases, it is the main stay of recreational diving for several reasons. ▪ It's a much simpler design, which makes it reliable and less costly (closed and semi-closed systems are more prone to malfunctions) ▪ It requires only a cylinder of air (closed and semi-closed units require chemicals and access to pure gases or enriched air) ▪ It is much easier to use ▪ It is much simpler to maintain and service.

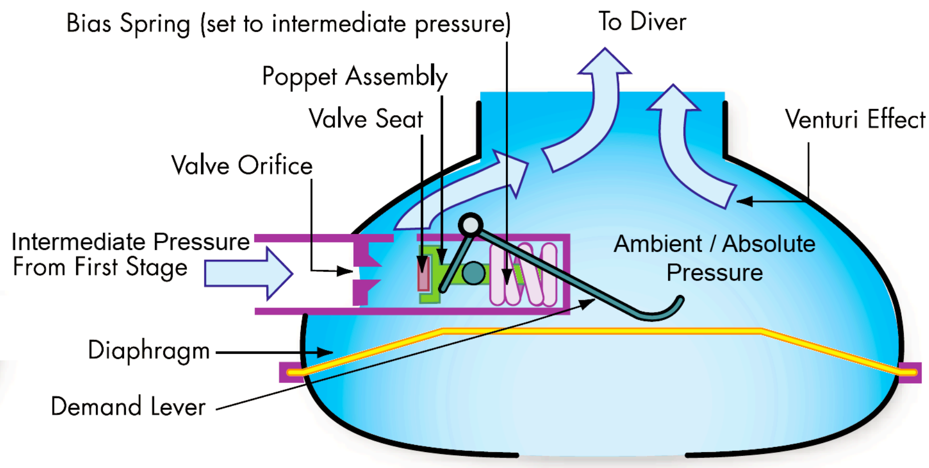
SEMI-CLOSED CIRCUIT SCUBA	The diver inhales from a breathing bag that receives a steady flow of gas (usually enriched air). The diver exhales back into the breathing bag and the gas has carbon dioxide removed chemically – excess gas from the steady flow trickles out through a valve. The circuit is semi-open because part of the gas is recycled and part of it is released (except to vent expanding air on ascent)

CLOSED CIRCUIT SCUBA	The diver exhales from a breathing bag and then exhales back into the breathing bag. The gas had carbon dioxide removed chemically and electronic sensors control flow of oxygen and other gases as required. The circuit is closed because all gas is recycled and none released (except to vent expanding air on ascent)

FIRST STAGE	When high pressure (220 Bar) from a tank enters the first stage the first stage will do two things: ▪ It will reduce the high pressure from the tank (220 Bar) to between 9-12 Bar. This new pressure is called **INTERMEDIATE PRESSURE**. ▪ The first stage will channel, or guide, the tank pressure to the high-pressure hose (which goes to the pressure gauge, so that the diver can monitor air pressure). The intermediate pressure will go to the second stages and the low pressure inflator hose for the BCD

<table>
<tr><td>SECOND STAGE</td><td>As the diver inhales, the diaphragm will move inward and press down onto a lever. This lever is connected to a valve.

When the lever is pushed down by the diaphragm (when a diver inhales) the valve will move and allow intermediate pressure air coming from the first stage to enter the second stage where it will become AMBIENT / ABSOLUTE PRESSURE so that the diver may breath.



Downstream Second Stage (Open)</td></tr>
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DOWNSTREAM VALVE	The pilot valve moves **with** the airflow

UPSTREAM VALVE	The pilot valve moves **against** the airflow

UNBALANCED	A regulator designed so that tank air pressure resists or assists (**DOES AFFECT**) the opening of valves in the first stage is called an unbalanced regulator ▪ Breathing will become more difficult as the tank pressure drops ▪ Breathing is more difficult at greater depths ▪ Unbalanced regulators are no longer commonly found

BALANCED	A regulator designed so that tank air pressure neither resists nor assists (**DOES NOT AFFECT**) the opening of valves is called a balanced regulator. The tank pressure does not affect the ease of breathing, even when two divers breathe from the same first stage, and inhale at the same time. ▪ Depth is not a concern. ▪ Virtually all modern regulators are balanced regulators

FAIL SAFE	Free flows during a malfunction, which gives the regulator a fail-safe design. It will fail in a safe manner in that it continues to provide air. Obviously the tank will loose air faster, so the diver must ascend immediately.

ENVIRONMENTAL SEAL	In very cold water (such as cold water deep diving or ice diving) the temperature drop can cause water to freeze the regulator first stage valves into the open, free flowing position. To avoid free flow in extremely cold water some regulator first stages have environmental sealing. This seals silicone grease or oil, which doesn't freeze, around the first stage. The silicone or oil transmits the pressure from the water to the diaphragm or piston so the regulator operates normally

DEPTH GAUGES

CAPILLARY GAUGE	Capillary depth gauges are a simple piece of clear tubing, sealed at one end and open at the other, based on Boyle's Law. ▪ They are hard to read accurately at much deeper than 10m. ▪ Best used when diving at altitude.
OPEN BOURDON TUBE GAUGE	Open bourdon tube gauges contain a spiral shaped tube. Water enters the tube and increasing pressure causes the tube to straighten. The straightening of the tube moves the depth gauge needle. ▪ Because the tube is open, clogging can be a problem with these devices.
OIL-FILLED GAUGE	Oil-filled gauges also use bourdon tube design, but using a sealed tube in an oil-filled gauge housing. Pressure transmitted through the oil causes the tube to coil more tightly. This moves the depth gauge needle. ▪ The depth gauge is not open to the water and therefore not prone to clogging.
DIAPHRAGM GAUGE	Diaphragm gauges function by connecting a flexible diaphragm to a series of levers and gears that mover the display needle.
DIGITAL GAUGE	Digital gauges are electronic gauges that read depth with a transducer, which varies the electricity it transmits depending on the pressure exerted on it. They provide a digital display. ▪ These offer the highest degree of accuracy and are used in dive computers to determine depth.
SUBMERSIBLE PRESSURE GAUGE (SPG)	The SPG works on the same principle as the bourdon tube gauge. Electronic SPGs use a pressure transducer similar to those in dove computers / electronic depth gauges. SPGs may be integrated with dive computers. The most recent design is a transducer on the regulator first stage that transmits the air pressure to a wrist-worn computer, eliminating the SPG hose

ENRICHED AIR DIVING CONSIDERATIONS

EQUIPMENT CONSIDERATIONS	Because enriched air has more oxygen than air has oxygen, there is a greater potential for fire or explosion related to equipment that has not been properly cleaned. **Industry guidelines involving equipment used with enriched air:** Most manufacturers require their equipment to be cleaned to oxygen service specifications if tit will be exposed to more the 23 percent oxygen When using 40 percent oxygen, or more, special cleaning materials are recommended. This is called the '40 percent rule'. Any piece of equipment that will be exposed to more than 40 percent oxygen requires special cleaning, lubrication and materials to meet oxygen service specifications. If such equipment is used with air from a standard source, it may need to be re-cleaned. Follow the manufacturers guidelines with respect to using equipment with enriched air.

SPECIAL MARKINGS	**A 15cm band at the tank shoulder.** The top and bottom of the band should be a yellow 2.5cm band. The centre 10cm band should be green and contain the words 'Enriched Air', 'Enriched Air Nitrox', 'Nitrox', or similar. Yellow cylinders need only the green portion. **A visual inspection sticker** stating the cylinder has been cleaned to oxygen service specifications, or not if enriched air will not be blended in the cylinder 9partial pressure blending in the cylinder requires putting pure oxygen in the cylinder, even if the final blend will have less than 40 percent oxygen). **A contents sticker or tag** identifying the current blend, the fill date, the blends maximum depth and the analyzer / divers name.

ANALAYZING CYLINDERS	Enriched air divers must **personally analyze** the contents of their cylinders before using them. On some dive boats the normal practice is to grab any full cylinder available for the next dive – this isn't appropriate with enriched air, which practice calls for divers to use the tanks that they have personally analyzed.

DIVE THEORY - THE RECREATIONAL DIVE PLANNER

COMPARTMENT

Where different tissues in the body release / absorb nitrogen at different rates

Different parts of the body absorb and release nitrogen at different rates. Blood and fat absorbs nitrogen easier and faster than muscle and bone.

Because of these different TISSUES, a decompression model has what we call THEORETICAL TISSUES or COMPARTMENTS. Compartments are a way to measure / identify how fast or slow our body (and body tissues) absorb and release nitrogen.

FAST COMPARTMENT (blood and fat) = absorb and release nitrogen fast
SLOW COMPARTMENT (muscle and bone) = absorb and release nitrogen slowly

HALFTIME

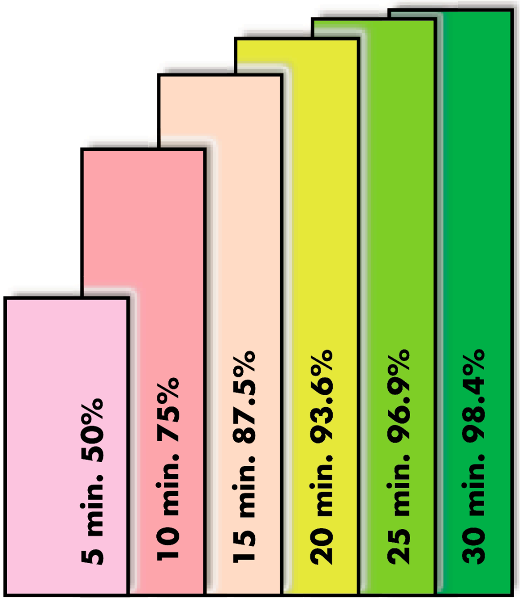
The rate at which the compartment absorbs / releases half capacity of nitrogen

Each compartment has a halftime for the rate at which it absorbs and releases nitrogen

A halftime is the time, in minutes, that it takes for a certain compartment to reach halfway from its initial tissue pressure to full pressure, (saturation), at a new depth.

FAST (tissue) **COMPARTMENT** (gas washout) = **SHORTER HALFTIME**

SLOW (tissue) **COMPARTMENT** (gas washout) = **LONGER HALFTIME**



Tissue Halftimes

1. After 5 minutes the compartment will go to halfway (half full)

2. After 5 minutes more the half from the first 20 minutes will half again

3. This halfing can only happen 6 times. The new compartment will always be considered saturated (full) when it reaches approx 98.6 percent

To make it easier the tissue pressure can be expressed or called ‘metres’

PRESSURE IN HALFTIME COMPARTMENTS	1 Halftime (50%) in 18m = 9m of pressure (18 x 0.5) 2 Halftime (75%) in 18m = 13.5m of pressure (18 x 0.75) 3 Halftime (87.5%) in 18m = 15.75m of pressure (18 x 0.875) 4 Halftime (93.6%) in 18m = 16.8m of pressure (18 x 0.936) 5 Halftime (96.9%) in 18m = 17.4m of pressure (18 x 0.969) 6 Halftime (100%) in 18m = 18.0m of pressure
Example:	**A 5-minute halftime compartment will have how much tissue pressure 5 minutes after taken from the surface to 18 metres depth?** After 5 minutes the compartment will go half way to saturation. So if this is a 18m compartment, then half of 18m is 9m. Answer = 9m of pressure To continue: After 10 minutes the pressure will go half way again. Half the remaining 9m. Half of 9m = 4.5m. Add this to the first 9m (9m+4.5m) = 13.5m

M-VALUE	The M-Value is the **MAXIMUM TISSUE PRESSURE** (nitrogen level) that is allowed to be left in the body after a dive. The **faster** the compartment, the **shorter** halftime. The **slower** the compartment, the **lower** the M-value The higher the M-value, the more nitrogen it is allowed to have upon surfacing. The M-value represents what does and does not result in DCS. These M-values are the A-Z on the RDP A = a low level (low pressure) of nitrogen Z = a high level (high pressure) of nitrogen. At 12m our halftimes are shorter, so we can have a high M-value E.g. We can dive at 12m for 147 minutes = X (M-value) At 30m our halftimes are longer so we have a low M-value E.g. we can dive at 30m for only 20 minutes = N (M-value) The compartment that reaches its M-value first, is called the CONTROLLING COMPARTMENT

WHY THE US NAVY (USN) TABLE WAS 'STANDARD' FOR RECREATIONAL DIVING	The USN table was developed mainly for military decompression diving, but they became almost the standard in recreational diving until the mid-1980s for several reasons Before computers, developing a table was a difficult process that had to be calculated by hand. Few outside the Navy had the information or the ability to produce tables. Many early sport divers began as military divers, bringing the USN tables with them. The USN tables were widely available in the public domain, allowing publishers to reproduce and re-arrange them. Though they weren't ideal for recreational divers, they could be relied upon when following accepted conservative diving practices.

THE RDP TODAY	The RDP, as we know it today, was developed in 1987 and tested in 1988 by Dr. Raymond E Rogers (a PADI dive master) working with DSAT (Diving Science And Technology)

DIFFERENCES BETWEEN US NAVY TABLES & RDP

RDP	**USN Table**
NO–DECOMPRESSION (NO STOP)	STAGE DECOMPRESSION USE
14 Compartments	6 Compartments
60 minute surface credit	120 minute surface credit
Halftimes have faster gas washout	Halftimes have slower gas washout
6 hours to be clean of nitrogen after diving	12 hours to be clean of nitrogen after diving
Designed for multiple dives a day with a shorter surface interval (recreational diver)	Designed for limited dives a day with a longer surface interval (military use)
Longer bottom time on repetitive dives	Shorter bottom time on repetitive dives

HOW COMPUTERS COMPARE WITH EACH OTHER & THE RDP WITH RESPECT TO SURFACE INTERVAL & M-VALUES	Computers at times give longer no-decompression limits, because they: ▪ Calculate the dive exactly ▪ Eliminate unnecessary rounding (that you would do when using a table)

SPENCER LIMITS, EE WASHOUT EE = 'Exponential-Exponential'	Approximately the same M-value as the RDP All compartments release theoretical nitrogen at the surface at their underwater halftime rate, as compared to the RDP, which releases theoretical nitrogen at the 60-minute rate for all compartments of 60 minutes or faster. This washout means these computers can permit dives beyond what has been tested to work. E.g. 3 dives to 40m in a row for 10 minutes each with only 30 minutes between them. This washout is not a problem if divers avoid multiple deep dives with short surface intervals (generally not recommended whether using a computer or not)

SPENCER LIMITS, 60-MINUTE WASHOUT	Based on data for RDP At the surface, all compartments 60 minutes and faster washout at 60 minute rate, all slower compartments wash out at their underwater halftime rate (like the RDP). Dives very similar to what the RDP model allows

BUHLMANN LIMITS, EE WASHOUT	Further reduced M-values (based on the work of Dr. Buhlmann) All compartments washout at their underwater halftime rate With reduced M-values repetitive dives similar to what the RDP supports, though repetitive deep dives with short surface intervals may still permit dives beyond what has been tested to work. ▪ Spencer limits, 60-minute washout and Buhlmann limits, EE washout seem to be the most popular types of computers.

GENERAL RULES FOR USING THE RDP

PRESSURE GROUPS ON THE RDP	▪ Letters (pressure groups) CANNOT be swapped (are not interchangeable) between the RDP, USN or any other tables. ▪ You can link pressure groups between different versions of the RDP, such as the wheel and the enriched air 32% and 36% recreational dive planner.

COLD WATER DIVING	▪ When planning a dive in cold water or under conditions that may be strenuous (difficult), plan the dive as if the depth is 4m deeper than actual.

REPETITIVE DIVES	▪ Plan repetitive (2nd or 3rd) dives so each next dive is to the same, or a shallower depth. ▪ Don't follow a dive with a deeper dive. ▪ Plan your deepest dive first

LIMIT MAXIMUM DEPTHS TO TRAINING & EXPERIENCE	▪ Discover Scuba Diver / Scuba Diver – 12m ▪ Open Water Diver – 18m ▪ Divers with greater training and experience – 30m ▪ 40m is the maximum training depth for Deep Specialty Course ▪ The 42m on the RDP is for emergency purposes only

SPECIAL RULES FOR SURFACING PRESSURE GROUPS	When planning 3 or more dives in a day: ▪ If the ending pressure group after any dive is **W or X** the minimum surface interval between all next dives is **1 hour**. ▪ If the ending pressure group is **Y or Z** the minimum surface interval between all next dives is **3 hours**. Limit following dives to 30m / 100 feet or shallower

SAFETY STOPS	▪ Make a safety stop for 3 minutes at 5m after every dive (recommended). The time at a safety stop need not be added to the bottom time of the dive. Always make a safety stop: ▪ After any dive to 30m or deeper ▪ Anytime you will surface within 3 pressure groups of your NDL ▪ When a dive is made to any limit (black box) of the RDP

IN-WATER RECOMPRESSION	▪ In-water recompression – treating DCI by putting the diver back underwater shouldn't be attempted. ▪ Recompression takes a long time and requires oxygen and often drug therapy. ▪ Normally the required resources aren't available at a dive site and incomplete recompression will usually make the diver even worse.

EMERGENCY DECOMPRESSION	▪ An emergency decompression stop for 8 minutes at 5m must be made if a no-decompression limit is accidentally exceeded by 5 minutes or less. Upon surfacing the diver must stay out of the water for at least 6 hours before making another dive. ▪ If a no-decompression limit is exceeded by more than 5 minutes a 5m emergency decompression stop of no less than 15 minutes is needed (air supply permitting). Upon surfacing the diver must remain out of the water for at least 24 hours before making another dive.

DEEPER THAN 40M?	▪ If you accidentally go below 40m immediately ascend (18m per minute) to 5m and make an emergency decompression stop for 8 minutes. ▪ If the no-decompression limit for 40m is NOT exceeded by more than 5 minutes. Do not dive again for at least 6 hours.

MISSED DECOMPRESSION STOP	▪ If you accidentally miss a required decompression stop and have already surfaced and exited the water, remain out of the water and stop diving for 24 hours and breath pure (100%) oxygen if available

DIVING AT ALTITUDE	▪ Using the RDP at altitudes 300m above sea level requires the use of special training and procedures. ▪ Add 4% to the depth for every 300m above sea level. Conversion table is on page 15 in PADI Adventures In Diving manual.

FLYING AFTER DIVING	▪ A minimum surface interval of 12 hours is required before flying. ▪ If you make daily, multiple repetitive dives for several days, or make dives that require decompression stops a minimum surface interval of 18 hours is required before flying.

DIVE THEORY - PHYSIOLOGY

CIRCULATORY SYSTEM	The circulatory, transports oxygen fuel and materials from the respiratory and digestive systems to your body tissues. It carries waste carbon dioxide and other material wastes from your tissues for elimination. The transport of gases to and from the respiratory system is the most urgent function, and the one most relevant to diving. The components of the respiratory system include:
Heart:	Specialized 4 chambered muscle Pumps blood through arteries to tissues throughout the body
Arteries / Capillaries:	Arteries, elastic vessels that carry blood away from the heart, branch into capillaries, the body's smallest blood vessels, where the bloodstream and tissues exchange gas and nutrients.
Veins:	Receive blood from the capillaries, returning it back to the respiratory system and heart to exchange gases in the lungs and repeat the cycle

RESPIRATORY SYSTEM	Your respiratory system integrates with your cardiovascular system by providing your blood with the environment it needs for gas exchange. The respiratory system consists of passages and organs that bring atmospheric air into the body. The components of the respiratory system include the oral-nasal passage, pharynx, larynx, trachea, bronchi, bronchioles, alveolar ducts, and alveoli
Oral / nasal passage:	The oral-nasal passage includes the mouth and nasal cavities. The nasal passages are lined with a mucous membrane that contains many fine, ciliated hair cells. The membrane's primary purpose is to filter air as it enters the nasal cavity. The hairs continually clean the membrane by sweeping filtered material to the back of the throat where it is either swallowed or expelled through the mouth. Therefore, air that enters through the nasal cavity is better filtered than air that enters through the mouth.
Pharynx:	The pharynx, the back of the throat, is connected to the nasal and oral cavities. It primarily humidifies and warms the air entering the respiratory system.
Trachea:	The trachea, or windpipe, is a tube through which air moves down into the bronchi. From there, air continues to move down increasingly smaller passages, or ducts, until it reaches the small alveoli within the lung tissue.
Alveoli:	The actual gaseous exchange between Carbon Dioxide and Oxygen occurs in the alveoli. The alveoli are surrounded by a network of capillaries that joins veins and arteries. Carbon dioxide and oxygen move in and out of alveoli because of the pressure differentials between their CO_2 and O_2 levels and those in surrounding capillaries. This movement is based on the law of gaseous diffusion: a gas always moves from an area of high pressure to an area of lower pressure.

BLOOD	Blood consists of several components to accomplish its different functions:
Plasma:	Liquid that carries nutrients and chemicals Carries dissolved gases i.e. carbon dioxide waste & nitrogen
Red Blood Cells:	Carry the majority of oxygen required via haemoglobin (a protein that bonds with oxygen)
Haemoglobin:	Without haemoglobin – blood speed would have to be 15-20 times faster Blood circulates through lungs, where higher oxygen pressure enables better bonding with haemoglobin, which is then released to the tissues Once released it picks up carbon dioxide (in the plasma in the form of bicarbonate) to the lungs for elimination.

NITROGEN	When we breathe, from the lungs, our body takes the Oxygen and delivers it to the body's muscles. The body uses Oxygen but the body DOES NOT use the Nitrogen for anything. This is what we call an inert gas. Nitrogen is an inert gas.

GAS EXCHANGE	Gas exchange between the respiratory and circulatory system occurs between the bronchi and the pulmonary capillaries. It is here that the blood releases carbon dioxide and picks up oxygen.

DECOMPRESSION SICKNESS (D.C.S)

CAUSES OF DCS	Relating to Henry's Law, if the pressure increases (gets more) the more gas will be dissolved (go into) the liquid. If the pressure is decreased (gets less) the gas will come out of the liquid (the human body is mostly made of liquids) Because the body does not use Nitrogen, however when under pressure (diving) our body is exposed to a higher absorption rate of Nitrogen (he body has to store this Nitrogen within the body) On ascent when diving the pressure on the body is reduced (gets less) and the Nitrogen in the body has a higher pressure and has to come out (Super-saturation – like when opening a Coca-Cola bottle after shaking it) As long as the Nitrogen comes out slowly and is controlled, there is no problem. However, if the pressure is released too fast the nitrogen will come out too fast. This will cause **BUBBLES**, WHICH CAUSES DECOMPRESSION SICKNESS
OTHER FACTORS THAT MAY PREDISPOSE A DIVER TO DEVELOP DCS	• **Fat:** Fat releases Nitrogen slowly. More Nitrogen in solution after a dive • **Age:** As we age our circulatory system becomes less efficient • **Dehydration:** reduces blood in circulation, slowing Nitrogen elimination • **Injuries / illness:** may alter or restrict circulation • **Alcohol:** before or after diving will alter circulation and causes dehydration • **Carbon Dioxide excess:** skip breathing • **Cold water:** circulation to the extremities reduces as a diver cools, slowing Nitrogen elimination from those areas • **Heavy Exercise:** before, during or after a dive accelerates circulation • **Altitude / flying:** dive tables / computers are based on surfacing at sea level, thus exposure t to lower pressure increases the tissue pressure gradient and may
DCS (two types)	**<u>TYPE I – identified as 'pain only' DCS</u>** • Limb pain is the most common – may be mid-limb or joints • Cutaneous DCS (skin bends) – red rashes / patches usually on shoulders and upper chest **<u>TYPE II – identified as having life threatening or immediate injurious symptoms – involves brain nervous system, lungs</u>** • Numbness and / or tingling • Paralysis • Weakness / fatigue / nausea (getting sick) • Unconsciousness and death

FIRST AID	Treat all DCS as serious – even pain only **Give patient oxygen – preferably 100%** • Lowers alveolar Nitrogen to accelerate elimination from tissues • Raises blood Oxygen levels to assist tissues with blood flow reduced by bubble blockage **Keep a breathing patient lying down on their left side, with head supported (recovery position)** • Helps keep airway clear if patient vomits • Lying level ensures blood flow to brain • Advise patient not to sit up or walk around, even during transport or feeling better **Lay non-breathing patient on back for rescue breathing** **Contact emergency medical care**

TREATMENT FOR DCS	DCS treatment requires putting patient in a recompression chamber Recompression reduces bubbles in body to a smaller size and forces them back into solution – often alleviates symptoms immediately Treatment involves a long slow decompression with Oxygen and drug therapy. Duration and need for drugs / Oxygen makes attempting recompression in water very difficult, requiring manpower and special equipment. The sooner recompression begins, the more likely the patient will recover without permanent injury. Patients sometimes don’t want to believe they are suffering from DCI and object to seeing a doctor Strongly urge patients to allow medical examination by emergency medical care

LUNG OVER-EXPANSION INJURIES

CAUSES OF LUNG OVER-EXPANSION INJURIES	Lung over-expansion injuries are caused by: • Holding breath during ascent • Diving with a chest cold • Local blockage in the lungs due to loss of surfactant (due to smoking) • Expanding air over-expands and causes lung rupture

AIR EMBOLISM	Air embolism – also called arterial gas embolism (AGE). Air enters the bloodstream and flows into arteries Serious and immediately life threatening. Bubbles can lodge anywhere, but the most common is to flow through the carotid arteries and cause cerebral air embolism, which stops the blood flow to the brain.
Signs and symptoms:	• Dizziness • Confusion • Shock • Paralysis • Personality change • Unconsciousness and death.

PNEUMOTHORAX	Air from a rupture goes between the lung and chest wall causing the lung to collapse Also serious.
Signs and symptoms:	• Chest pain • Patient may cough up blood

MEDIASTINAL EMPHYSEMA	Air from the rupture accumulates in the centre of the chest, over the heart, causing pain in the middle of the chest. Serious because air presses on the heart and vessels, interfering with circulation.
Signs and symptoms:	• Patient may feel faint or short of breath.

SUBCUTANEOUS EMPHYSEMA	Air from a rupture accumulates in soft tissues at the base of the neck The victim feels fullness in neck and voice may change.
Signs and symptoms:	• The skin may crackle to the touch

FIRST AID	First Aid is the same as for DCS, hence the common term 'decompression illness' for both • Giving Oxygen helps supply tissues deprived of blood flow because of bubbles • Treatment of air embolism requires recompression to reduce bubble size (as with DCS).

DCS OR DCI?	• Decompression Sickness - Nitrogen in the body coming out too fast only • Decompression Illness - decompression sickness and lung over-expansion injuries

SILENT BUBBLES	Some Nitrogen dissolves into microscopic gas pockets in the body and form tiny bubbles that are trapped. These then diffuse harmlessly into air. Silent bubbles are found after some dives, especially those close to table / computer limits. These are larger bubbles than the tiny bubbles theorized to form after most dives, but are still harmless.

NITROGEN NARCOSIS	Caused by breathing a high partial pressure of Nitrogen. Using air or enriched air, narcosis is expected to be noticeable at about 30m depth Helium is not narcotic even under very high pressures – this is why it is used by technical and commercial divers making very deep dives Ascent (going to a shallower depth) relieves narcotic symptoms and usually has no after effects Not directly hazardous – hazard comes from impaired judgement that may delay reactions or lead to poor decisions.

BREATH-HOLD DIVING

APNEA	During APNEA (breath-holding) the circulatory system uses Oxygen stored in the lungs, muscles and blood to meet oxygen needs

BRADYCARDIA	In cool water, BRADYCARDIA (slowing of the heart) reduces circulation and is triggered by apnea (felt by cold on the face). Though this doesn't appear to reduce Oxygen consumption in humans (it does in marine mammals).

SHALLOW WATER BLACKOUT	You can increase breath-hold time by first hyperventilating (breathing deeply and rapidly) three or four times. This reduces circulatory carbon dioxide so it takes longer to get enough to cause breathing. Too much hyperventilation may lead to shallow water blackout. Occurs on ascent, near the surface. The reduced oxygen pressure prevents the haemoglobin bonding with oxygen so tissues and brain become starved of oxygen This is because the low carbon dioxide cannot stimulate breathing. It is the high carbon dioxide that stimulates the body to want to breath, not the lack of oxygen

CAROTID SINUS REFLEX	Carotid sinus receptors monitor pressure of arterial blood reaching the brain through the carotid arteries Low blood pressure triggers a higher heart rate, and high blood pressure triggers a lower heart rate Receptors interpret pressure from an excessively tight hood or wet suit constricting the neck as high blood pressure. The heart rate slows, reducing blood flow to the brain, but pressure remains, causing yet slower heart rate The diver feels uncomfortable and light-headed but may lose consciousness if constriction continues unrelieved. Avoid by not wearing excessively tight hoods, wet suit or dry suit neck seals

HYPERCAPNIA (Hyper = too much)	Hypercapnia is **TOO MUCH** Carbon Dioxide
Causes:	▪ Shallow rapid breathing ▪ Skip breathing (holding the breath periodically) ▪ Overexertion or a combination of these. In very rare cases air supply may be high in Carbon Dioxide.
Signs and symptoms:	▪ Headache ▪ Accelerated breathing. ▪ Confusion ▪ Loss of consciousness. Avoid by breathing deeply and normally, not skip breathing and by avoiding overexertion.

HYPOCAPNIA (Hypo = too little)	Hypocapnia is **NOT ENOUGH** Carbon Dioxide Too little Carbon Dioxide may interrupt the normal breathing cycle because Carbon Dioxide actually stimulates breathing.
Causes:	▪ Excessive hyperventilation (more than three or four breaths) This may be voluntary (quick breaths) or involuntary (due to stress or a fright while scuba diving) – causes light-headedness
Symptoms	▪ Light headedness ▪ Shallow water blackout. A diver ascends; the partial pressure drops and haemoglobin can no longer bond with oxygen. The diver blacks out without warning due to hypoxia (**NOT ENOUGH** OXYGEN)

CARBON MONOXIDE POISONING	Caused by contaminated (bad) air. Smoking is another source of carbon monoxide. Carbon monoxide bonds more readily with haemoglobin than oxygen (by 200 times) but doesn't release as easily. Breathing air contaminated with carbon monoxide at depth, haemoglobin carries less and less oxygen as carbon monoxide bonds with it. When a diver surfaces, plasma no longer can carry enough dissolved oxygen. The diver blacks out from hypoxia (NOT ENOUGH OXYGEN)
Signs and Symptoms:	Signs and Symptoms of carbon monoxide include Headache Confusion Narrow vision Bright red lips / nails (not easily observed while underwater) Symptoms of mild cases subside after several hours of fresh air
First Aid procedures:	Severe cases – give the diver 100% oxygen and contact emergency medical care.

OXYGEN TOXICITY (two types)	One involves the symptoms in the respiratory system, and the other involves the nervous system. Using enriched air nitrox (EANx) you can have oxygen toxicity.

CNS TOXICITY (most serious) Signs and Symptoms:	*Central nervous system* (CNS) oxygen toxicity involves nervous system reactions to oxygen exposure, and tends to be unpredictable, beyond the fact that it occurs at elevated oxygen partial pressures (greater than 1.4 bar/ata.) • Visual disturbances • Ear ringing • Nausea • Twitching muscles • Irritability • Dizziness. • Most serious is convulsion (which cause a diver to drown)

PULMONARY TOXICITY Signs and Symptoms:	Results from continuous exposure to an oxygen partial pressure greater than 0.5 bar/ata. • Burning in the chest • Irritated cough. Usually resolves itself by ceasing diving for several days. Not considered immediately life threatening or hazardous

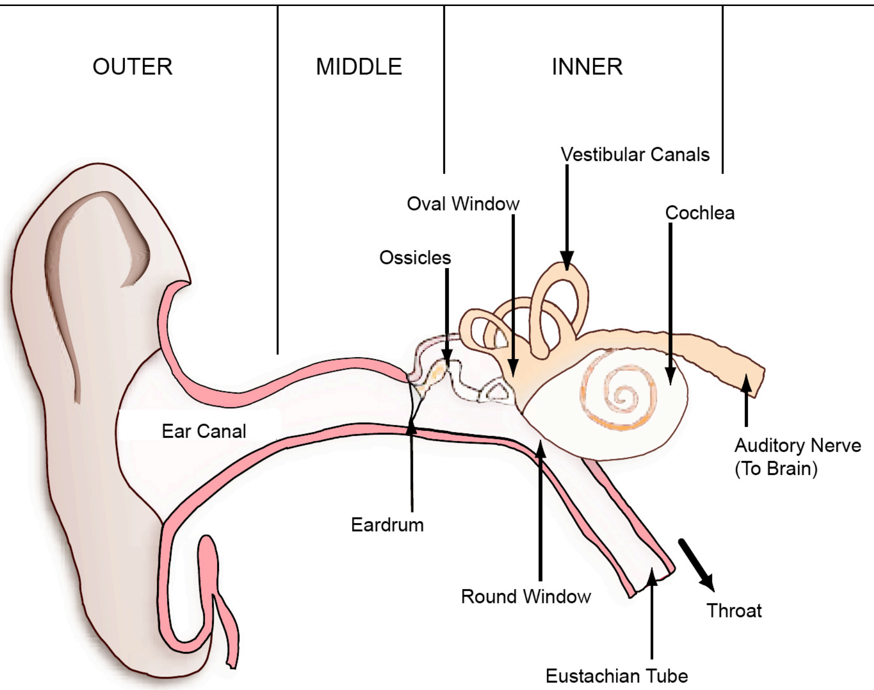
HEAT EXHAUSTION Signs and Symptoms:	A condition in which the body works at full capacity to cool • Weak, rapid breathing • Weak rapid pulse • Cool clammy skin • Profuse sweating • Dehydration • Nausea A diver with heat exhaustion should remove their exposure suit, seek shade, drink non-alcoholic fluids and rest until cool.

HEATSTROKE Signs and Symptoms:	A condition in which cooling has failed – an emergency medical condition • Strong and rapid pulse • No perspiration • Skin flushed, hot to the touch • Brain damage, system damage or possible death A diver with heatstroke should remove exposure suit and out the diver in a cool environment and contact emergency medical aid

HYPOTHERMIA	Occurs when then diver ignores uncontrollable shivering or numbness and continues to cool Body temperature regulation mechanisms fail, the body core temperature drops and the shivering stops Diver may feel warm as blood rushes to skin – a dangerous condition because the diver doesn't feel cold, but heat loss is now unchecked. As the core temperature drops mental processes slow – diver becomes drowsy, uncoordinated and forgetful. Unchecked, hypothermia leads to unconsciousness, coma and death. Advanced hypothermia is a medical emergency requiring emergency care

EARS & SINUSES

EARS	The ear is not only an organ of hearing but also one of regulating equilibrium

BASIC STRUCTURE	
Outer Ear:	▪ Always equalized as open to environment ▪ Traps sound waves and channels them to middle ear, via ear canal to the ear drum (middle ear)
Middle Ear:	▪ Responses to dive pressures – only one with air pocket ▪ Sound waves vibrate the eardrum (attached to the ossicles) ▪ Vibrations go from eardrum to ossicles to cochlea (located in the inner ear)
Inner Ear:	▪ Cochlea - liquid filled ▪ Oval Window - ossicles are attached to the oval window (which flexes to vibration) of the cochlea ▪ Round Window - compensates pressure, flexing opposite to the oval window ▪ Vestibular canals - control balance and orientation

CHANGING PRESSURE	When descending, increasing pressure pushes in on the eardrum – the diver feels discomfort. By equalizing, the diver forces air up the Eustachian tube to equalize the pressure, alleviating the discomfort. Expanding air normally exits the Eustachian tube easily – seldom required to do anything during ascent

PROBLEMS IN BODY AIR SPACES

BAROTRAUMA	Barotrauma means **'pressure injury'**, and results when a body air space isn't equalized and pressure continues or increases

MIDDLE EAR SQUEEZE	
Causes:	▪ Caused by failure to equalize or inability to equalize due to congestion (diving with a cold).
Signs and Symptoms:	▪ Sharp pain caused by the hydrostatic pressure forcing the eardrum inward towards the airspace with less pressure (i.e. inside your ear)

EARDRUM RUPTURE	
Causes:	▪ Also caused by failure to equalize, but pressure increases faster than fluids can fill the middle ear. The eardrum tears (bursts inward) due to pressure.
Signs and Symptoms:	Usually heals without complication, but requires medical attention to prevent infection and permanent damage because water contaminates the ear with organic matter and dirt.

REVERSE SQUEEZE	Ears equalize on decent but congestion at depth prevents air from escaping during ascent. Eardrum flexes outward
Causes:	• Usually caused by diving with a cold using decongestants (decongestant wears off during dive causing blockage)
Signs and symptoms:	• Reduced hearing • Vertigo • Balance problems • Ear ringing • A feeling that the ears are blocked This is a serious injury requiring medical treatment to avoid or reduce permanent hearing damage

ROUND WINDOW RUPTURE	
Causes:	▪ Caused by delayed equalization accompanied by forceful Valsalva manoeuvre (exhaling against pinched nostrils).
Signs and symptoms:	▪ Valsalva raises pressure in thorax, which causes increase in pressure in cochlea (connected by fluid as part of the nervous system). This plus transmitted pressure bursts round window outward.

VERTIGO	Occurs when the eardrum ruptures and cold water on the vestibular canals cause momentary loss of sense of direction and dizziness.

DIVE THEORY - THE PHYSICS OF DIVING

WATER & HEAT	▪ Water removes body heat quicker than air ▪ It is 20 times a better conductor than air ▪ Water is 770 times more dense than air ▪ 3200 more heat is required to raise to same temperature water, than air of the same volume.

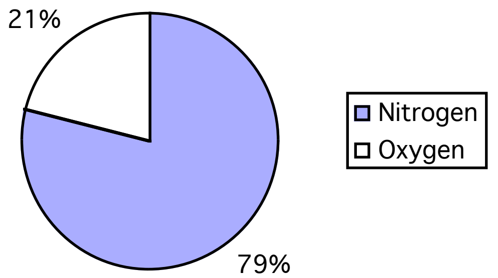
HEAT TRANSMISSION?	▪ Conduction (heat removal via direct contact) ▪ Convection (heat removal via fluids) ▪ Radiation (heat removal via electromagnetic waves) Divers are mostly affected by Conduction – water is a very good conductor

WATER & LIGHT	Light - Made up of electromagnetic energy Water affects light through: ▪ Diffusion ▪ Absorption ▪ Refraction ▪ Turbidity
Diffusion:	Scattering of light (prevents light reaching a certain depth)
Absorption:	▪ Absorbs the weakest wavelengths first i.e. red, orange, yellow, violet. ▪ As less light is available the eye's pupil opens up, resulting in less colour detail. ▪ Fluorescents can be seen underwater, why? ▪ Don't simply reflect colour. ▪ They emit colour when stimulated by light of any shorter wavelength
Refraction:	Apparent size & closeness is affected by refraction ▪ Light bends as it passes from air to water, due to water being more dense, therefore light slows in speed ▪ Divers – Objects appear closer by ratio of 4:3 (an object 4 meters, will appear 3 meters away) ▪ Visual Reversal – at greater distances, the apparent distance is reversed – objects are closer than they appear to the diver (caused by reduced contrast, turbid water). ▪ Size – Refraction causes the size of an object to be magnified – approx. 33%
Turbidity:	The concentration of suspended particles – i.e. silt, rainwater runoff In highly Turbid water, objects at a distance are closer than they appear (VISUAL REVERSAL). Turbidity is the most important factor affecting VISUAL REVERSAL

REFLECTION	Affects light i.e. the light from the sun does no reflect from the surface of the water when the sun is directly above

WATER & SOUND	Sound travels in waves with acoustical energy (a form of mechanical energy) Light can exist apart from matter, sound exists only within matter (cannot travel in vacuum i.e. space)
Speed:	Sound travels best in dense matter i.e. travels better in water (solids or liquids) than air (gas). Therefore as water temperature changes, so does the affect of sound travel. At 15 degrees Celsius, water transmits sound at 1410 meters per second (fresh), 1550 (salt) – 4 times faster than air Sound travels faster in water due to elasticity, not density (but denser matter = more elasticity) RESULT: Divers can hear better and at more distance than on air
Direction:	Direction difficult for diver, due to the high speed that sound travels – eardrums cannot work out (seems like sound from overhead)

SUMMARY	▪ Water conducts heat (from our body 20 times) more efficiently than air by CONDUCTION (Radiation = least effect) ▪ The bending of light is called REFRACTION. Water absorbs colour – RED disappears first. ▪ Sound travels 4 times faster in water (is denser / thicker than air) and always sounds as if it is coming from above you ▪ Object appear to be 25% larger and 33% closer underwater (ration 4:3) due to REFRACTION ▪ VISUAL REVERSAL is when objects appear to be FURTHER AWAY. This is caused by TURBIDITY (particles) in the water.

INDEX	LAW	DIVING
DALTONS LAW Pressure (density) & Partial pressure of gases Oxygen Helium Nitrogen Carbon Dioxide	**The sum of gases will always equal a whole (100%)** As the pressure increases (gets more), the partial pressure (NOT THE PERCENTAGE, THE PERCENTAGE NEVER CHANGES) will increase (get more)  21% Oxygen + 79% Nitrogen = 100% Air OR 0.21 oxygen (Bar) 0.79 nitrogen (Bar) + ------ 1.0 BAR / 1 ATM (sea level) 100%air will always be 100% no matter what gas mix is used 10m = 2 BAR (2 BAR x 0.21) = 0.42 oxygen (BAR) + (2 BAR x 0.79) = 1.58 nitrogen (BAR) ------ 2.0 BAR 30m = 4 BAR (4 BAR x 0.21) = 0.84 oxygen (BAR) + (4 BAR x 0.79) = 3.16 nitrogen (BAR) ------ 4.0 BAR This can be used with any gas mix such as Helium, Nitrogen, Carbon Dioxide, etc. E.g. Nitrox 36% Oxygen at 20m (3 Bar) = 0.36 x 3 (Bar) = 1.08 Bar	Air = 21% Oxygen 79% Nitrogen (ALWAYS) This is important to be able to calculate the partial pressure of gases to any depth. Doing this you'll be able to see when Oxygen reaches high levels that may cause oxygen toxicity. 1.4 Bar (Maximum) 1.6 Bar (Contingency) Nitrogen levels become narcotic when it reaches +/- 3 Bar 3 Bar / (divided by) 0.79 (if using air) = 3.7 Bar = 27m (Ambient)

HENRYS LAW **Gases & Liquids**	**If the pressure increases (gets more), the more gas will be dissolved (go into) the liquid. If the pressure is decreased (gets less), the gas will come out of the liquid** E.g. If you shake a Coca-Cola bottle, you're building up pressure inside the bottle, forcing gas into the cola. When you quickly open the bottle you decrease the pressure and all the gas comes out of the cola. THE BUBBLES!	
Saturation:	When the pressure (an amount) of gas that has been forced into a liquid is the same as the surrounding pressure (outside pressure). Like when shaking the Coca-cola bottle, you can shake it all you want until there is no more gas to be dissolved. It has reached an equal pressure so the pressure is therefore the same inside the bottle as the pressure outside the bottle.	
Super-saturation:	When the pressure becomes less, the same as when you open the Coca-Cola bottle, the gas that was dissolved into the liquid starts coming out of the liquid (out of solution). If it is controlled the bubbles come out slowly. However, if the pressure is released too fast, the bubbles will come out too fast as well.	

CHARLES LAW Temperature & Pressure (density)	**The amount of change in either volume or pressure of a given volume, is proportional to temperature changes** As the temperature increases (gets more) the volume of a flexible container will increase (get more) and the density (pressure) inside the container (flexible or non-flexible) will increase (get more). The opposite happens when the temperature decreases (gets less). As the temperature decreases (gets less) the volume of a flexible container will decrease (get less) and the density (pressure) inside the container (flexible or non-flexible) will decrease (get less). **FOR EVERY 1 DEGREE CELCIUS CHANGE (up or down) IN TEMPERATURE THERE IS A 0.6 BAR CHANGE IN PRESSURE** **More heat = more volume / more density** Air molecules move fast because its so hot causing more density (pressure) **Less heat = less volume / less density** Air molecules stay closer together causing less density (pressure)	

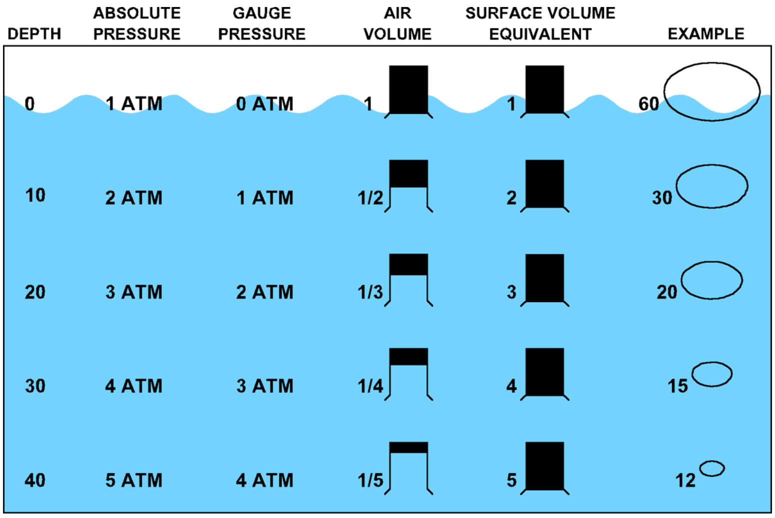
BOYLES LAW

Pressure & Volume

As the pressure surrounding an object increases (gets more) the volume will decrease (get less) and the density will increase (get more)

Gauge pressure = Water pressure (excluding atmospheric pressure)
20msw (metres of sea water) = 2 Bar

Ambient / Absolute pressure = Water pressure AND Atmospheric pressure
20msw (metres of sea water) = 2 Bar
+ 1 Bar Atmospheric pressure = 3 Bar



Take a note of points 1 & 2 of FACTS

E.g. A flexible container with a volume of 35 Litres is at 28mfw (metres of fresh water), and is taken to the surface. What will the new volume of the container be?

28mfw = 2.7 Bar (28 / 10.3) Gauge pressure
+ 1 Bar for Ambient pressure = 3.7 Bar

Volume of the container = 35 litres
35 (Litres) x 3.7 (Bar) = 129.5 Litres at the surface

If you were to take the same container back down to 24msw (metres of sea water) what would the new volume be?

28msw = 2.4 Bar (24 / 10) Gauge pressure
+ 1 Bar for Ambient pressure = 3.4 Bar

Volume of the container at the surface is 129.5 Litres
129.5 (Litres) / 3.4 (Bar) = 38 Litres at 24m

FACTS

1. 10m of SEA WATER = 1 BAR
E.g. 34m = 3.4 Bar gauge pressure
(34m / 10 = 3.4)
+ 1 Bar for Ambient pressure = 4.4 Bar

2. 10.3m FRESH WATER = 1 BAR
E.g. 34m = 3.3 Bar gauge pressure
(34m / 10.3 = 3.3)
+ 1 Bar for Ambient pressure = 4.3 Bar

If you take a container filled with air up from a certain depth – the volume will increase (get bigger) and the air will become less dense (less pressure)

You multiply (x) the volume when taking down

You divide (/) the volume when taking up

If you have 2 different depths underwater. First calculate the volume at the surface, and then back down at new depth again.

ARCHIMEDES PRINCIPLE

The Greek mathematician Archimedes determined that '**An object wholly or partially immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the object'**

An object that weighs less than the water it displaces will float and is POSITIVELY BUOYANT. It's buoyancy is expressed as a positive number, such as being 2 kgs positive.

An object that weighs exactly the same as the water it displaces with neither sink nor float and is NEUTRALLY BUOYANT. Adding or removing weight will make it sink or float.

An object that weighs more than the water it displaces will sink and is NEGATIVELY BUOYANT. It's buoyancy is expressed as a negative number, such as being 2 kgs negative

To determine the buoyancy of an object in water you need to know:
The objects weight
How much water the object displaces (the objects volume)
The weight of the water displaced

THE DEPTH OF EITHER SALT WATER / FRESH WATER HAS NO EFFECT TO DETERMINE THE BUOYANCY OF THE OBJECT

OPEN		WATER		DIVER
O	**/**	**W**	**-**	**D**
Objects weight		Sea = 1.03 OR Fresh = 1.00		Displacement

= ?

Example:

You plan to recover a 150kg outboard motor in sea water that displaces 60 litres and lies at 30m. How much air must you put in a lifting device to make the motor neutrally buoyant?

Open (O) Objects weight = 150kg
Water (W) Water = 1.03kg (Sea)
Diver (D) Displacement = 60 litres
DEPTH = MEANS NOTHING!!!

(O) 150 / (divide by) **(W)** 1.03 – (subtract) **(D)** 60

= 85.6 Litres (of air)

FACTS

1 Litre of Salt Water = 1.03 KGS

1 Litre of Fresh Water = 1.00 KGS

If an object has either neutral or positive buoyancy in sea water and you take it into fresh water, the buoyancy cannot be determined without additional information

HOWEVER

If you take an object from fresh water to sea water you can determine the buoyancy of the object

E.g. If an object is neutrally buoyant in fresh water it will be positively buoyant in sea water.

Example: You must sink into fresh water an object that weighs 50kg and displaces 300 litres. How much lead weight must you affix to the object to make it 10kg negative on the bottom?

Open (O) Objects weight = 50kg
Water (W) Water = 1.00kg (Fresh)
Diver (D) Displacement = 300 litres

(O) 50 / (divide by) **(W)** 1.00 – (subtract) **(D)** 300

= -250kg (positively buoyant)

The object is 250kg positively buoyant. To make it 10kg negative, first make it neutrally buoyant, and then 10kg negatively buoyant

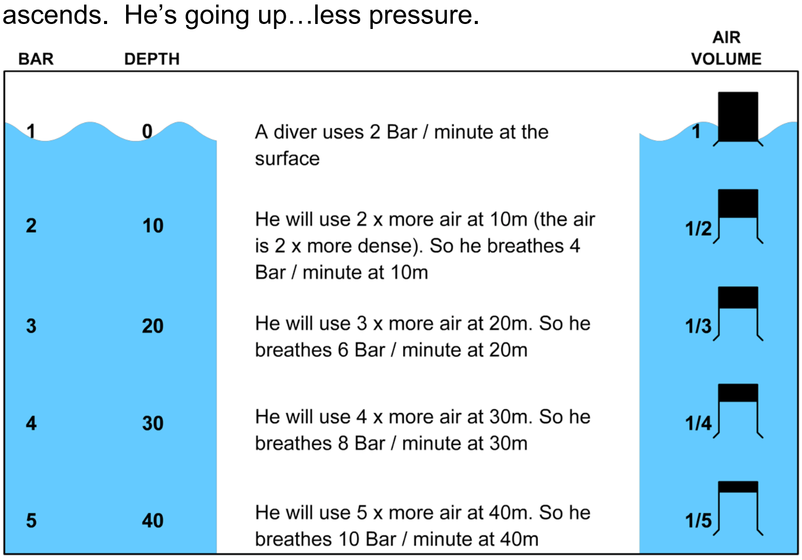
+ (add) 250kg (to make neutral)
+ (add) 10kg more (to make it negative)

= 260kg (of lead weight)

AIR CONSUMPTION

Air becomes denser (more pressure) as you descend underwater. A diver will use more air due to increased (more) pressure. He's going deeper…more pressure.

A diver will use less air due to the decreased (less) pressure as he ascends. He's going up…less pressure.



E.g. A divers air consumption rate is 3 Bar per minute at the surface. What will the air density be at 30m compared to the surface, and what will the divers air consumption be?

4 times as dense (30m = 4 Bar)
12 Bar per minute (3 Bar x 4 Bar)

FACTS

10m of Salt Water = 1.0 Bar
E.g. 18m = 1.8 Bar gauge pressure (18m / 10 = 1.8)
+ 1 Bar for Ambient pressure = 2.8 Bar

10 m of Fresh Water = 1.3 Bar
E.g. 18m = 1.75 Bar gauge pressure (18m / 10.3 = 1.75)
+ 1 Bar for Ambient pressure = 2.75 Bar

You multiply (x) the volume of the air the diver uses when the diver descends (goes down deeper)

You divide (/) the volume of the air the diver uses when the diver ascends (comes up shallower)

CLASSROOM PRESENTATIONS

Throughout your IDC you will be expected to conduct classroom presentations. This is part of the prescriptive teaching process because you only need explain areas that students are not already familiar with and there will be PADI PowerPoint slideshow presentations, called lesson guides, available to assist you in each of your presentations.

Example of slide

On the following page there is an example IDC LESSON PLAN FORM that outlines the criteria for conducting the perfect classroom presentation. To score top marks it is necessary for you to cover all the bullet-points in a fluid manner.

During each presentation you are also marked on:

- Use of PADI visual aids.

The PADI Continuing Education poster (which clearly, and visually, gives an overview of the PADI education systems) is a very good visual aid.   The poster is a established marketing product on which PADI has carried out extensive market research. It is commonplace for an instructor to use the poster to promote continuing education, a criteria of every classroom presentation.

- Use of non-PADI visual aids.

A white board is a nice way to help you to explain things visually.
Equipment is always a good visual aid tool to use.

- Student interaction

Something as simple as asking a student to read the objective or a keypoint from the slide will suffice.

IDC LESSON PLAN FORM

INTRODUCTION:

- **CONTACT STORY** "RELATED TO TOPIC"

Have you ever been on a plane? Did you notice something happen to your ears? This is due to pressure change…

- **VALUE** "WHAT IS THE IMPORTANCE OF THIS INFORMATION / HOW WILL THIS INFORMATION HELP US BE SAFER OR MORE FUN"

The value of this is that we also experience pressure change when scuba diving and we have to know what to do in these circumstances so that we don not experience any discomfort or injury

- **APPLICATION** "HOW & WHEN WILL WE USE THIS INFORMATION DURING THIS COURSE"

We will experience slight pressure changes when we practice our skills in the pool this afternoon during our confined water session and we have to know what to do when we feel the pressure change. We'll start to use some techniques as soon as we start descending into the deepest part of the pool.

- **KEY POINTS** "READ FROM THE SLIDE"

We will discuss the key points as described on the slide (simply refer to the keypoints – do not explain them until the body of the presentation)

- **CONDUCT** "PLEASE FOLLOW ON PAGE………. / ASK ANY QUESTIONS"

Open your manual to page 23, take notes, make high-lights, stop me and ask questions

BODY:

- **OBJECTIVE** "READ OBJECTIVE / QUESTION FROM SLIDE"

(The objective will be listed on the slide. Simply read it (or ask a student to read it)

- GO OVER & DISCUSS THE KEY POINTS

(The key points will be listed on the slide and it is here that you explain each in more detail)

- **DIVE STORY** "HOW YOU ONCE USED THIS INFORMATION"

When I first learnt to dive I was so overwhelmed by the experience that I forgot to equalize my ears on descent. I think the instructor could see by the expression on my face that I was experiencing some slight discomfort and she reminded me of the technique I should use. I did so and the discomfort went immediately. Now I use the same simple techniques on every dive to ensure that I don't suffer any unnecessary discomfort while descending.

- **LOCAL ENVIRONMENT** "DRAW MAP / EXPLAIN LOCAL REEF/AREA"

On our first confined water dive this afternoon we will go the swimming pool. It has a nice shallow area, where we can stand up, which gradually slopes down to a maximum depth of 3m. We will have plenty of space to practice, as the pool is 20m wide by 30m long.

- **APPLICATION** "HOW & WHEN WILL WE USE THIS INFORMATION DURING THIS COURSE"

So, in the pool this afternoon our confined water session we will definitely experience some slight pressure change as we sit on the bottom at the deep end. We'll start to use some techniques as soon as we start descending from the surface into the deepest part of the pool.

- **CONTINUED EDUCATION** "PROMOTE NEXT COURSE & GIVE EXAMPLES OF WHAT IS DONE DURING THE COURSE"

After your Open Water Diver course you will be ready to continue to the PADI advanced Open Water Diver (use the poster to help you explain) where you will dive to a greater depth and experience even greater pressure change. You'll know exactly how to prevent any discomfort before it starts and you'll also learn more about buoyancy and…etc.

- **PROMOTE EQUIPMENT** "EXPLAIN IMPORTANCE OF HAVING OWN EQUIPMENT RELATED TO TOPIC"

Our mask is a piece of equipment that is directly linked to pressure change. If you have a tight mask at the surface you know that with increased pressure it will only feel tighter as you descend. The internal volume of your mask also affects how pressure will…

SUMMARY:

- **VALUE** “ WHAT IS THE IMPORTANCE OF THIS INFORMATION / HOW WILL THIS INFORMATION HELP US BE SAFER OR HAVE MORE FUN”

So we know the value of this is that we also experience pressure change when scuba diving and we have to know what to do in these circumstances so that we do not experience any discomfort or injury.

- **APPLICATION** “HOW & WHEN WILL WE USE THIS INFORMATION DURING THIS COURSE”

We know that we will experience slight pressure changes when we practice our skills in the pool tomorrow during our confined water session and now we know what have to know what to do when we feel the pressure change. We’ll start to use these techniques as soon as we start descending at the very beginning of the dive.

- **OBJECTIVE** “READ OBJECTIVE / QUESTION FROM SLIDE”

We now know the objective, which is…(The objective will be listed on the slide. Simply read it (or ask a student to read it)

- **KEY POINTS “**READ FROM THE SLIDE”

And we know the keypoints are…(read from the slide)

- **CONTINUED EDUCATION** “PROMOTE NEXT COURSE & GIVE EXAMPLES OF WHAT IS DONE DURING THE COURSE”

We know hat the Advanced Open Water course will give us more opportunity to practice these techniques and we can also benefit from learning lots of additional skills on this fun and rewarding 2-day course.

- **PROMOTE EQUIPMENT** “EXPLAIN IMPORTANCE OF HAVING OWN EQUIPMENT RELATED TO TOPIC”

And we all understand the importance of having proper fitting equipment. Especially a well-fitted, fhypocomfortable mask.

IDC LESSON PLAN FORM

INTRODUCTION:

- **CONTACT STORY** "RELATED TO TOPIC"
- **VALUE** "WHAT'S THE IMPORTANCE OF THIS INFORMATION / HOW WILL IT HELP US BE SAFER"
- **APPLICATION** "HOW & WHEN WILL WE USE THIS INFORMATION DURING THIS COURSE"
- **KEY POINTS** "READ FROM THE SLIDE"
- **CONDUCT** "PLEASE FOLLOW ON PAGE………. / ASK ANY QUESTIONS"

BODY:

- **OBJECTIVE** "READ OBJECTIVE / QUESTION FROM SLIDE"
- GO OVER & DISCUSS THE KEY POINTS
- **DIVE STORY** "HOW YOU ONCE USED THIS INFORMATION"
- **LOCAL ENVIRONMENT** "DRAW MAP / EXPLAIN LOCAL REEF/AREA"
- **APPLICATION** "HOW & WHEN WILL WE USE THIS INFORMATION DURING THIS COURSE"
- **CONTINUED EDUCATION** "PROMOTE NEXT COURSE & GIVE EXAMPLES OF WHAT IS DONE DURING THE COURSE"
- **PROMOTE EQUIPMENT** "EXPLAIN IMPORTANCE OF HAVING OWN EQUIPMENT RELATED TO TOPIC"

SUMMARY:

- **VALUE** "WHAT'S THE IMPORTANCE OF THIS INFORMATION / HOW WILL IT HELP US BE SAFER"
- **APPLICATION** "HOW & WHEN WILL WE USE THIS INFORMATION DURING THIS COURSE"
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- **PROMOTE EQUIPMENT** "EXPLAIN IMPORTANCE OF HAVING OWN EQUIPMENT RELATED TO TOPIC"

IN-WATER TRAINING

PRESENTATIONS

The phases of presentations:

CONFINED WATER
Briefing
Demonstration
Control & Delivery
Problem Solving
De-Briefing

OPEN WATER
Briefing
Control & Delivery
Problem Solving
De-Briefing

As you will have noticed, confined water training requires one more phase than open water training. This is because, in confined water, the students receive a demonstration of how each skill should be performed to meet the performance requirement before they actually practise the skill themselves.

Confined Water
Students perform each skill after a demonstration of the skill
Students can receive instruction to help them

Open Water
Students perform each skill on your signal.
Students are expected to self correct (as long as safety isn't compromised

Don't teach skills - just apply reminders of critical attributes
(only teach good dives practices - such as checking air)
Inform students of the difference if performing skill in open water as opposed to confined water
Control is very important as open water environment is less predictable than confined
You can practice more than one skill at once whereas in confined you only practice one skill at a time

CONFINED WATER TRAINING

BRIEFING

Intro / overview
- Introduction of skills

Value
- Realistic value of why divers will learn the skill and a reason to apply it during diving

Objective
- A clear statement of measurable performance requirement for each skill

Explanation
- A brief description of the critical steps required to complete the skill
  Tip: it may be beneficial to demonstrate the steps while explaining them or have student divers go through the skill's motions

Conduct
- A clear description of where and when the skill practice will be performed
- Where the students will be positioned
- Also include statements describing what they should do before, during and after their performance.
- It may be appropriate to explain the instructor & any assistants roles

Signals
- A demonstration of the signals that will be used throughout the skill performance.
- Establish specific signals used to indicate each skill, so divers will later recognize what is being asked of them

DEMONSTRATION

- Ensure that all the student divers can clearly see the demonstration
  Tip: think how it is best for you to be positioned while demonstrating the skill. For example if you are demonstrating the fin-pivot ensure that your left side (where your low pressure inflator hose is located) is nearest the students so that they can clearly see how it is used during the skill.
- Show all the critical steps as described in the briefing
- Use slow, smooth, exaggerated and deliberate movements to draw attention to details that will make performing the skill easier
- If necessary use your assistant to help you demonstrate the skill

CONTROL & DELIVERY

- Position yourself and students appropriately, in an area conducive to the skill (shallow or deep water, corner of pool, back to face wall of pool etc.)
  Tip: it may be beneficial to position students with their back facing the pool wall so that they cannot float away very far. You will generally be positioned in front of them. The poolside will also act as a support for them should they need to surface. If you have many students you could use the corner of the pool so that they still all have their backs to the wall and can still see you clearly.
- Consider ways of conducting the skill to minimize problems or reduce the risk to student divers should problems occur.
- Position assistants, if necessary, where they can observe student divers not directly under your supervision
  Tip: communicate with your assistant frequently to ask them if they are ok and to instruct them to watch the group whenever they are not under your direct supervision (when you are supervising a student practising a skill)
- Organize activity flow efficiently.
  Tip: connect the skills performed in shallow area and those performed in deeper water, for efficient use of time.
- Provide guidance and adequate positive re-enforcement

Tip: shake the students hand and/or clap while underwater once the student has successfully performed the skill and met the performance requirement.

Student practise

- Ensure that each student practices each skill
- Have them repeat it until each demonstrates mastery of the skill

PROBLEM SOLVING

- Anticipate problems and make provisions to correctly respond, or prevent, each
  Tip: For skills that require student to swap to their alternate air source is it is a good idea to anticipate that may experience a problem and have your alternate air source ready in your hand to offer them in such circumstances.
- Be close to student divers and ready to help
  Tip: When a student is performing a hover ensure that you are positioned close enough to stop them from making a rapid ascent should they fill their BCD too fast. Maybe hold onto their SPG. Remember to explain in your briefing that you will do this and why.
- Offer guidance through signals and touch
- Reinforce the proper technique after identifying and correcting a problem
  Tip: remind students of any problems that they encountered (maybe tap your head with your finger, to signal ' remember', and remind them of the specific problem by mimicking it exaggeratedly. Then wag your finger, to represent ' no' or 'not like that', and then demonstrate how to perform the attribute of the skill correctly. Ensure you give the 'ok' signal at the very end to confirm that the student has understood what you've told them. Then gesture for them to return to the group and call the next student forward (remember at this point to ask your assistant if they are ok and to watch the group)

DEBRIEFING

Examples

- Give specific examples of how well students performed the skill (positive re-enforcement)
- Highlight parts of the skill that students performed smoothly

Performance

- Clearly state that students met required performance requirements

Problems

- Identify specific problems

Suggestions

- Give specific suggestions for avoiding problems & improving performance

Value

- Re-enforce the value of the skill and how it was applied

OPEN WATER TRAINING

BRIEFING

Intro / overview	▪ Introduction of skills ▪ Brief statement welcoming divers to the dive site
Value	▪ Realistic value of why divers have learned the skill and a reason to apply them in open water
Objective	▪ A clear statement of measurable performance requirements
Skill review	▪ Quick reminder of the key steps ▪ Quick reminder / suggestion for successfully accomplishing the skills in open water
Conduct	▪ A clear description of how the skill practice will be organised ▪ Where the students will be positioned, the sequence of events and the instructor & any assistants roles
Signals	▪ A reminder of the signals used to indicate each skill and guide practice.

CONTROL & DELIVERY

- Position yourself and students appropriately
- Position assistant if necessary
- Organize activity flow efficiently
- Provide guidance and adequate positive re-enforcement
- Observe surroundings & diver interaction with environment and each other

Student practise	▪ Allow students to **self correct** (only as long as safety isn't compromised) ▪ Tell students what they did wrong and how to prevent from occurring again

PROBLEM SOLVING

- Anticipate problems and make provisions to correctly respond, or prevent, each
- Be close to student divers and ready to help
- Offer guidance through signals and touch
- Reinforce the proper technique after identifying and correcting a problem

DEBRIEFING

Examples	▪ Give specific examples of how well students performed the skill (positive re-enforcement)
Performance	▪ Clearly state that students met required performance requirements
Problems	▪ Identify specific problems
Suggestions	▪ Give specific suggestions for avoiding problems & improving performance
Value	▪ Re-enforce the value of the skill and how it was applied

RESCUE – UNRESPONSIVE DIVER AT THE SURFACE

APPROACH	▪ Splash water to try to get divers attention ▪ Shout 'Diver, diver – I am a rescue diver, are you okay?
SHAKE VICTIM	▪ Ask if okay.
TURN OVER VICTIM	▪ Crossover arm turn.
CALL FOR HELP	▪ Shout 'Help, help – I have an unconscious diver, call for EMS'
ESTABLISH BUOYANCY	▪ Inflate the victims BCD ▪ Inflate your BCD ▪ Remove the victims weight belt ▪ Remove your weight belt
POSITION YOURSELF	Position yourself on one side of the victim, at their shoulder, so that your head is near the victim's head. Whichever side of victim you are positioned will determine which hand should be used to support their head and which should be used to remove equipment. Always use the hand that is closest to their weight belt to remove equipment and the hand that is nearest the head to support their head. If you prefer to use your right hand to remove equipment position yourself on the victims left side and support the their head with your left.
REMOVE REGULATOR	▪ Remove the victims regulator
REMOVE MASK	▪ Remove the victims mask ▪ Remove your own mask
OPEN AIRWAY	▪ Head tilt, chin lift method Left hand under head (head tilt, chin lift method - never stop supporting the head throughout the rescue. It is vital that you keep their face above the water – water continually flowing across the face s deemed as a failed rescue attempt)
CHECK FOR BREATHING 10 seconds (count aloud)	▪ Look – for chest rising and falling ▪ Listen – for breathing or coughing ▪ Feel – for breathe (To perform the above 3 key-points simultaneously: position your head with your earlobe over the victims mouth and nose area so that you can feel any exhalations on your ear lobe. You will also be able to hear any murmuring or coughing that may occur. Face your head so that you are looking down the victims body, towards their feet, and look to see if their chest rises and falls)
2 RESCUE BREATHS	▪ Perform 2 slow rescue breaths – remembering to pinch the victims nose
COUNT 5 SECONDS (count aloud)	▪ 1 one thousand, 2 one thousand… (Flick any excess water from your hand at 4 one thousand)
1 RESCUE BREATH	▪ Perform 1 breath
CONTINUE RESUSCITATION	Continuously repeat the cycle of the above 2 key-points until the victim is at the exit point and can be removed from the water.

EQUIPMENT REMOVAL This should be carried out between performing resuscitation	▪ Remove victims BCD (undo releases and cummerbund, you may wish to vent some air using the Low Pressure Inflator hose so that you can easily slide the BCD from beneath them) ▪ Remove your own equipment (It may be preferable for you to remove equipment near the boat or exit point because it may provide necessary buoyancy for both the victim and yourself during the tow)

Please note that if you accidentally leave more than 5 seconds between performing a rescue breath, you must give 2 rescue breaths then continue with the procedure