Mix and Flow of Matter

1.0 – Fluids are used in technological devices and everyday materials

1.1 – WHMIS Symbols and Safety Procedures

Use the Safety Notes and the Practice Test

- **Safety Notes -** **http://www.edquest.ca/Labs/labsafety.html**
- **Practice Safety Test -** **http://www.edquest.ca/Tests/safety.html**

1.2 – The Many Uses of Fluids

A **fluid** is anything that has no fixed shape and can flow. Usually it is a **liquid**, or a **gas**.

> Info**BIT**: **Agrifoam** is a fluid – a shaving-cream-like material that can be sprayed onto plants to protect them from freezing.

Fluids Make It Easier To Use Materials

Fluids move materials, even if they are solids.

Slurries
A mixture of water and a solid (like dirt and water) is called a **slurry**. Slurry technology – the transport of solids in water – has many important applications. One of these is mining in the Oil Sands. Syncrude originally used conveyor belts to move the oil sand from the mine to the processing plant, but found it was too expensive. It is now pumped to the plant by way of a slurry pipeline.

Fluids Become Solids
Fluids take the shape of their containers.
Many solid materials are originally prepared as fluids. Glass, Steel and concrete are examples where the solids are processed as liquids to shape them easier, so then they cool or dry as a solid they are in the form they should be.

Fluids Can Hold Other Materials

The ability of fluids to **flow** and **carry other materials** makes them useful in many different applications. Toothpaste has a ***'binder'*** (which is made from wood pulp) that keeps all of the ingredients together.

Useful Properties Of Fluids

Fluid properties enable a wide variety of uses to be possible. By understanding these properties, such as: density, buoyancy, viscosity and compressibility; technological devices can be designed which make use of these properties.

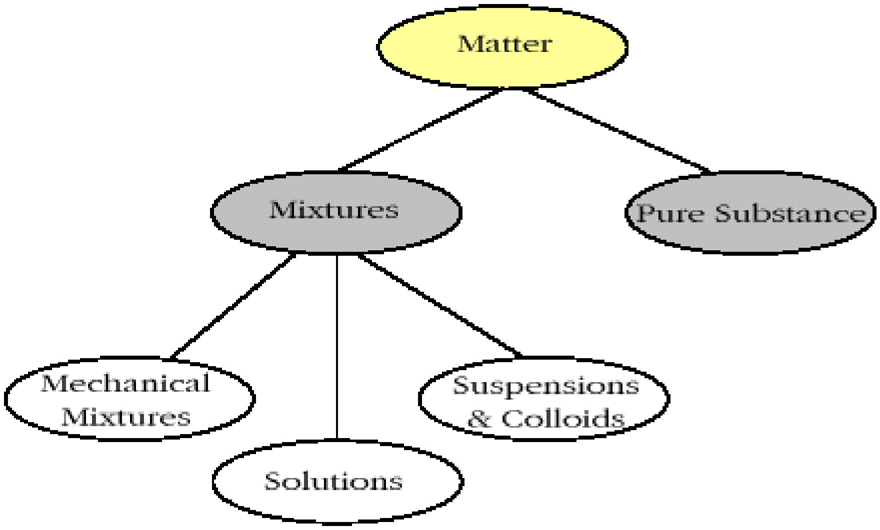
A common method of processing mineral ore is called **froth flotation**.
Find out more: http://www.engr.pitt.edu/chemical/undergrad/lab_manuals/flotation.pdf

2.0 The properties of mixtures and fluids can be explained by the particle model of matter

2.1 Pure Substances and Mixtures

- All pure substances have their own unique set of properties, or characteristics
  All mixtures contain two or more pure substances, which have their own distinct properties (some of which may be hidden)

Classification of Matter Chart (p.20)



Homogenous Mixtures
- are mixtures which look as though they have only one set of properties.
- the blended mixture has equal amounts of both substances (all parts of the mixture are the same)
- if the homogenous mixture does not have any settling of any of the substances it is made of, then it is called a solution
- solutions occur because each particle slips between each other particle and is evenly distributed throughout the entire mixture

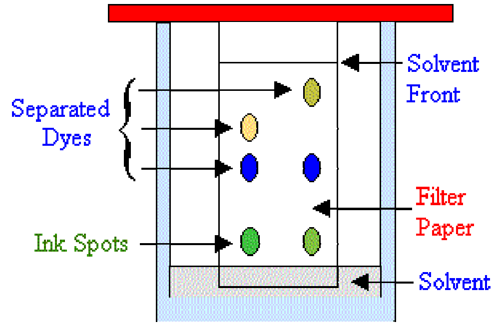
Heterogenous Mixtures
- the properties of the pure substances, in a heterogeneous mixture, are not hidden
- if there are two or more materials that are visible within a mixture, then it is called a heterogeneous mixture

In-Between Mixtures
- a heterogeneous mixture, in which the particles settle slowly after mixing, is called a **suspension** (eg. orange juice)
- a heterogeneous mixture, in which the particles do not settle at all, is called a **colloid** (eg. fog)
- to disperse the particles for a longer period of time, an **emulsifying agent** (like a protein) is used to form an emulsion (eg. mayonnaise)
- mixtures that are obviously two or more substances are called **mechanical mixtures**
the separate parts of the mechanical mixture are called ***phases***.

Paper Chromatography

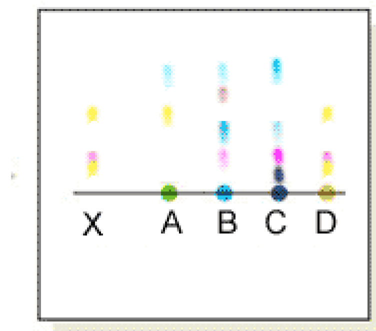
A paper chromatography test can be used to determine if a substance is pure or a solution.

A filter paper is placed partially in a solution – if the fluid moves up to only one level it is a pure substance – if it moves up to multiple levels showing each substance, then it is a solution.



Reading Chromatograms

The filter paper used in the paper chromatography test is called a **chromatogram**.
The distance a substance move up the chromatogram depends on its attraction to the paper. Those with a stronger attraction to the paper don't move up as far as those with a weaker attraction.



Applications

Separation systems are used in a wide variety of industrial and scientific applications. These systems isolate and analyze products that come from mixtures formed during chemical synthesis. Chromatography applications are used in many scientific analyses, including:

- Medical/biomedical research, quality control of pharmaceuticals, routine clinical determination, and drug screening
- Space-related and geo-chemical research and development
- Forensic sciences
- Food and cosmetic chemical measurement
- Process control in the petroleum industry
- Environmental monitoring and pollution control
- Investigation of the chemistry and metabolism of biological systems

2.2 Concentration and Solubility

Forming a solution by mixing two or more materials together is called **dissolving**.
- dissolving occurs because of the attracting between the particles (there may be a stronger attraction to the particles of another substance, than to the particles of the same substance)

Solutes and Solvents

The **solute** is the substance that dissolves in a solvent. The **solvent** is the substance that dissolves the solute to form a solution.
Soluble means to be able to be dissolved in a particular solvent. Solutes and solvents can be gases or liquids. **Measuring Concentration**

The **concentration** of a solution is the actual amount of solute in a specific amount of solvent. example: 50 grams of solute dissolved in 100 ml of water has a concentration of 50g/100ml (Another common way to express concentration is how much solute is dissolved in a 100 ml of a solvent) Concentration can also be stated as a percentage - ie. 5% (means, 5g/100ml). Extremely low concentrations are stated in ppm (parts per million).

Comparing Concentrations

To compare concentrations of two solutions, you need to know the amount of solute in the **same volume** of solvent for each solution.

Solution 1	**10g of salt in 50ml of water (10g/50ml)**	**= 20g/100ml**
Solution 2	**25g of salt in 100ml of water (25g/100ml)**	**= 25g/100ml**

***Solution 2** has a higher concentration*

Saturated and Unsaturated Solutions

The limit to concentration is called **solubility**. (The maximum amount of solute that can be dissolved in a fixed volume of solvent at a given temperature.)

- a **saturated solution** is one in which no more solute will dissolve in a specific amount of solvent at a specific temperature (Using the particle theory, the attractive forces between the particles becomes balanced and no more particles of the solute can be attracted by the particles of the solvent)
- an **unsaturated solution** is one in which more solute can be dissolved in a specific solvent at the same specific temperature

Supersaturated Solutions (**Solubility** is a unique property **-** ***Solubility Chart*** (**sia** p. 28)

- a solution that contains more solute than would normally dissolve at a certain temperature is called a super-saturated solution.

2.3 Factors Affecting Solubility

Water - is called the **'universal solvent'**, because it can dissolve so many materials. The term ' ***aqueous*** ' means water. 97% of the water on Earth is Ocean water, 2% is frozen and only about 0.5% is 'usable' (and even this has materials already dissolved in it that can be harmful), Solutions are not only made up of liquids. The chart on p. 29 illustrates other mixtures that can make solutions.

Solubility Changes With Temperature

Solubility increases as the temperature of the solvent increases, because more space is provided between the particles for the solute particles to fit (dissolve) into. The reverse is true for a gas though - as the temperature increases, the solubility of a gas, in a liquid solvent decreases.

Thermal Pollution

This decrease in the solubility of gases can have a serious effect on the environment. If the temperature of water increases (warm industrial waste water poured directly into lakes and rivers) then there is less oxygen that can be dissolved in the water – thus, affecting the living organisms in the water. This is called thermal pollution.

2.4 The Particle Model of Matter and The Behaviour of Mixtures

- All matter is made up of tiny particles. Different substances have different particles.
- The particles are always moving and vibrating
- The particles in matter may be attracted to each other or bonded together
- The particles have spaces between them

The particles flow in a fluid by moving freely past one another and at rest have a flat surface. For this reason, solids do not flow, because at rest, they form a cone-shaped *heap*.

How The Particle Model Explains Mixing Substances

Particles are different sizes and when two substances are mixed, the smaller particles fill the spaces between the larger particles. The particle model also states that particles are attracted to each other. However, in some substances particles can be attracted more to particles in other substances than to its own particles.

Factors Affecting The Rate Of Dissolving

The speed at which the solute dissolves in a solvent is called the **rate of dissolving** and can be affected by:

- **Temperature**
- **Agitation (** *stirring or shaking* **)**
- **Size of pieces (** *surface area exposed* **)**

Section 3.0 – The Particle Model of Matter can explain the properties of gases and liquids.

3.1 Viscosity and the Effects of Temperature

Fluids can flow. How quickly they can flow is called flow rate. A substance's resistance to flow (how thick or thin it is), or viscosity, affects flow rate. The ***internal resistance*** or friction between the particles of the substance determines the viscosity of that substance.

Ketchup

More Viscous

Soda pop

Less Viscous

The more friction **- the** more viscous **(thicker) a substance is.**
The higher the viscosity of a substance, the slower it flows.

The Effect of Temperature on Viscosity

Temperature has an effect on the viscosity of a substance.

When thick syrup is poured over hot pancakes, the syrup becomes thinner and runs over the sides of the pancakes.

When thick oil is added to the engine of a car, the oil thins out when the engine heats up.

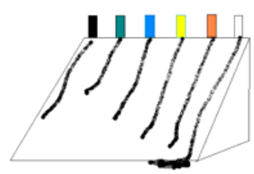
Olive oil is very thin (almost watery). To make it a little thicker it can be placed in the fridge, where it's viscosity can be increased.

Asphalt (road paving) materials are heated up (making them less viscous) so they can be poured easily before it hardens.

Viscosity can be easily measured using the **ramp method.**

Pour different liquids down a ramp and time how long it takes for each of them to get to the bottom.

The one that is the slowest will be the most viscous.



Reminder:

Increasing temperature lowers viscosity (makes it thinner)
Decreasing temperature increases viscosity (making it thicker)

3.2 Density of Fluids

Density is the amount of matter in a given volume. Every substance has a different density, because each substance is made up of different particles. The density of a substance depends on the particles it is made up of. When we talk about density, it's usually mass density we're referring to. The mass density of an object is simply its mass divided by its volume.
Density depends on whether the object is solid, filled with air pockets, or something in between. Substances that have a higher density than the density of the substance it is placed in will sink; substances that have a lower density than the density of the substance it is placed in will float.

Calculating Density
Density is the mass of a substance divided by its volume, which changes as temperature changes.
This is shown in the following equation form:

Density (d) = mass (m) / volume (V)

Density Calculations (Memory Method)
This simple equation will help you figure out how to solve density problems:

$$\frac{\mathbf{M}}{\mathbf{dV}}$$

Simply cover up whichever value you need to calculate and the other two are shown in their proper placement, be it to multiply or to divide.
For example: cover up the M. This leaves you with d/V (ignore the fact that it is in the de-nominator). Density times volume will give you mass.
You can also check it out by way of the units: (g / cm^3) x cm^3 cancels out the volume unit leaving grams, the desired unit for mass.

solids: d = grams/cubic centimeters (cm3)
liquids: d = grams/milliliters (mL)

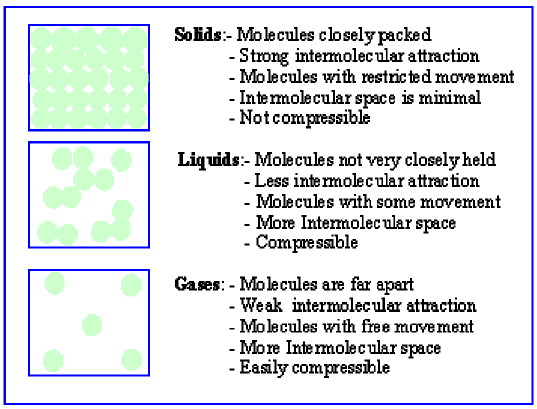
(**Figure 3-4** *Densities of some common substances at 20°* - **SIA p. 43**)

One way to determine the volume of an irregular object is to measure its mass in air and then in water, subtract the second measurement from the first, and divide by the density of water.
Another way to determine the volume of an irregularly shaped object is to submerge the object in a full container of water. The volume of the object equals the volume of water that overflows.
Ships can float because they contain large volume of air. The overall density of the ship is less dense than water, so it floats.

3.3 Density, Temperature and Buoyancy

Viscosity changes with temperature.

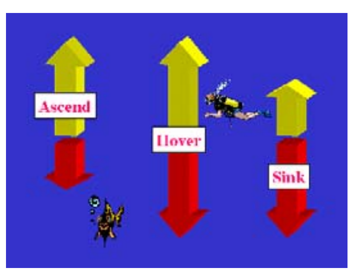
Density does not change as long as the temperature remains the same.
The particle model of matter states that for every substance, the number of particles in a given volume, remain constant, if the temperature is kept constant. As energy is added, the particles move more quickly and further apart, thus increasing the substance's volume. When this happens, the density of the substance (which is the mass to volume ratio) decreases because the mass remains constant, but the volume increases. One substance can have different densities, depending on the state it is in.



Changing Density by Changing Concentration

Objects that are less dense than 1g/ml float in water. The **Dead Sea** is one of the saltiest bodies of water on the Earth. When salt is added to water, there are more particles in a given volume, which increases the density of the water, allowing denser objects to float in the saltwater.

Buoyancy is the tendency of a substance to float. Buoyant objects take up space in a fluid. pushing some of the fluid away or displacing it, causing them to float, because the fluid pushes back against the force of gravity.



When an object is in a liquid, the force of gravity pulls it down. The liquid itself has a force that acts against the force of gravity. This **buoyant force** pushes objects upward. Objects that are denser than water will ***sink*** (**negative buoyancy**); objects that are less dense than water will ***float*** (**positive buoyancy**); objects with the same density as water will ***hover*** (or, be **suspended** - ***(neutral buoyancy)***, neither sinking nor floating.)

Measurement of Buoyancy

Force is a push or a pull on an object, and is measured in Newtons (N).
The upward force of a fluid on an object is called its buoyant force, which is also measured in Newtons.

Calculation of Buoyant Force

Buoyant Force = Weight in Air - Weight in Liquid

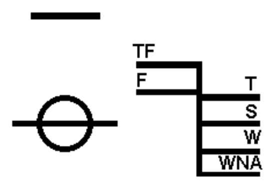
Applications of Buoyancy

Figure 3.11
(**sia** p.51)

Buoyancy has important applications in transportation.

Ships are designed to float in all types of water, regardless of the density of the water.

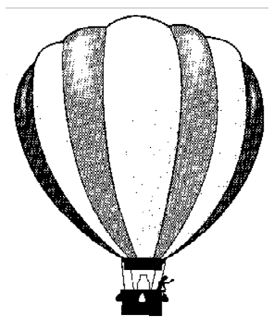
This is possible because of the **Plimsoll Line** - which shows how heavily a ship can be loaded in different water conditions.



The marks on the left indicate fresh water - while the marks on the right are for saltwater.

Hot Air Balloons –

As the air inside the balloon is heated, it becomes less dense than the surrounding air. The buoyant force of the air will push the hot air balloon upwards, until the buoyant force equals the force of gravity.

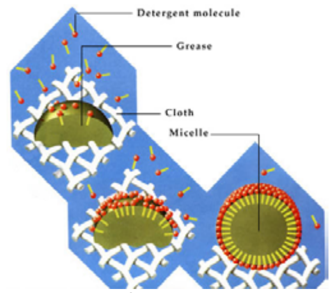


Section 4.0 – Many technologies are based on properties of fluids.

4.1 Technologies Based on Solubility

Fat & dirt are most times "**hydrophobic**" (meaning "*afraid of water*"). Hydrophobic materials do not solve in water. A detergent is a substance that can remove dirt from fabrics.

Most detergents are liquids or powders that are soluble in water. They contain a cleaning agent called a **surfactant**. Soap (the surfactant) encapsulates the fat & dirt molecules in the water, removing them from the fabric. In this way the dirt and water forms an ***emulsion***, which can then be drained away.



http://www.gridclub.com/fact_gadget/images/qa2c06f3.jpg

See also Textbook Illustration **(Figure 4.1** p. 63**)**

Phosphates were once used in detergents, but the environmental side effects were bad. Because phosphates encourage plant growth, the phosphates would cause weeds to overgrow in water systems and choke out the sunlight.

Typical Laundry Detergent Ingredients

Ingredient	Function	Ingredient	Function
surfactant	cleans fabric	*builder*	softens water
filler	prevents clumping	*corrosion inhibitor*	prevents rusting
suspension agent	prevents reattachment	*enzyme*	removes protein stains
bleach	removes stains	*optical whitener*	adds brightness
fragrance	adds scent	*colouring agent*	gives detergent colour

Diving and Decompression

Going below the surface of the water is now possible because of the (*Self-Contained Underwater Breathing Apparatus*) **S.C.U.B.A.** gear (air tanks and regulators) that was invented to help a diver breath underwater. When going deeper, nitrogen can dissolve in the divers body cells and tissues in a higher concentration than normal. As the diver rises slowly back to the surface, the nitrogen will leave the body gradually. If the diver ascends too quickly the nitrogen gas bubbles out of the blood and tissue, or collects in different parts of the body causing extreme pain. ***"The bends"*** can be treated in a **hyperbaric chamber**, which forces the nitrogen to re-dissolve back into the blood and tissue.

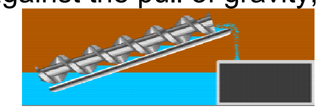
How Does DRY CLEANING work?
– Find out at - http://science.howstuffworks.com/dry-cleaning.htm

4.2 Technologies Based on Flow Rates and Moving Fluids

Pumps

Visit: **Glossary of Pumps** ... it's fantastic as a resource for this Topic.
http://www.animatedsoftware.com/pumpglos/pumpglos.htm

To obtain water from below the surface (the groundwater) and to move a fluid through a fluid system, you need to use something that will work against the pull of gravity, a **pump**.



One of the first pumps invented was **Archimedes Screw** (***invented to remove water from the hold of a ship***).

Other Applications include:
... Pumps in a city to move water to an elevated reservoir (so the force of gravity can allow the water to flow into all the homes - you see this in a small town as well - a water tower is usually the tallest structure in this town).
... Pumps are also use to move oil, natural gas and other fluids through pipelines.
... Pumps are located in automobiles to get the gasoline from the fuel tank to the engine.
... Pumps are also use to force air into tires.
... Your mouth is also a pump that can be used to draw a fluid up a straw and into your mouth.

See if you can find more information about the operation of a **sphygmomanometer**
http://www.sahaj.com/sphygmostetho.html

Valves

Valves are devices that regulate the flow of a fluid.
Today's valves can control not only the flow, but the rate, the volume, the pressure or the direction of liquids, gases, slurries or dry materials through a pipeline, chute or similar passageway.

Valves can:
... turn on and turn off, regulate, modulate or isolate.
... control flow of all types, from the thinnest gas to highly corrosive chemicals, superheated steam, abrasive slurries, toxic gases and radio active materials.
... handle temperatures from cryogenic region to molten metal, and pressures from high vacuum to thousands of pounds per square inch.
... range in size from a fraction of an inch to as large as 30 feet in diameter
... vary in complexity from a simple brass valve available at the local hardware store to a precision-designed, highly sophisticated coolant system control valve, made of an exotic metal alloy, in a nuclear reactor.

Practical Applications: (for Valves)

A Valve is a product rarely noticed by the average person, yet it plays an important role in the quality of our lives.
… It is essential to virtually all manufacturing processes and every energy production and supply system. Yet it is one of the oldest products known to man, with a history of thousands of years.
… Each time you turn on a water faucet, use your dishwasher, turn on a gas range, or step on the accelerator of your car, you operate a valve. Without modern valve systems, there would be no fresh pure water or automatic heat in your home. There would be no public utilities, and beyond wood and coal, almost no energy of any kind. Plastics would be unheard of, as would many inexpensive consumer products.

4.3 Designing a Working model of a Fluid-Using Device

A deep-diving submarine used to explore the ocean is called a submersible. Submersibles are usually smaller than submarines. They are often equipped with external cameras, manipulating arms, and special lights. Submersibles are built to do specific jobs, not for long-distance travel. We use them to help us recover "black box" flight recorders from wrecked airplanes, bury cables in the sea floor, investigate ancient shipwrecks, map the ocean floor, look for signs of undersea earthquakes, study marine life, repair damaged offshore oil wells, take rock samples of the ocean floor, and study ocean currents.

LINKS	*Explorer Submarine Specs*	*How Subs work*

SUBMARINES

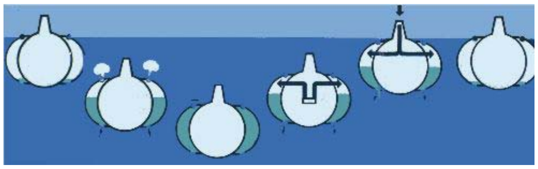
Inside a submarine there are containers called ballast tanks. If these are full of air, the submarine will float. Even though it is made of steel, the average density of the submarine is less than that of water. By pumping water into the ballast tanks, the submarine can sink. This is because when its ballast tanks fill with water, the submarine has a greater density than water.

History of Submarines

Submarines are ships that can operate both under and on top of the water. One of the first submersible vessels was built around 1620 by a Dutchman named Cornelius van Drebbel. We don't know that much about Drebbel's vessel, but diaries and books written at the time tell us his sub was really just a rowboat covered with a waterproof leather skin. Apparently 12 people with oars moved the vessel through the water. It could submerge to about 4.5 metres and go up to 8 kilometres before it needed to surface. It must have had some type of portholes to let in the light because one passenger wrote that people could see well enough underwater to read.

How Submarines Work

Buoyancy is the upward force of water pushing against the submarine. When an object is underwater, it pushes aside (or "displaces") an amount of water equal to its volume. An object floats if it displaces enough water to support its weight. Subs don't sink because their metal shell (or "hull") surrounds a volume weighing less than an equal amount of water.



Submarines are designed for use at great depths. Their rigid, double-walled hulls allow the crew to live and work normally underwater for as long as air and power supplies last. Submarines are steered by turning a rudder left and right. A propeller moves the sub through the water--pushing against the water and creating a forward force.

Subs can sink, rise, and float underwater (maintain "neutral buoyancy"). Subs do all this by adjusting the amount of water and air in their ballast tanks. When the tanks are full of air, the sub weighs less than the volume of water it displaces and it floats. When the ballast tanks are flooded with water, the sub weighs more than the water it displaces, and it sinks.

To rise again, the sub reduces its weight by pushing compressed air into the ballast tanks. The air forces the sea water out, and the sub goes up toward the surface. To move beneath the surface and to hover, the amount of water in a submarine's ballast tanks is made equal to the weight of the water it is displacing.

Submarine Facts

Trieste is a bathyscaph, which went 11km beneath the surface to the bottom of the ocean in 1960. A submersible, called **Alvin,** was used to recover a hydrogen bomb accidentally dropped from an air force bomber back in 1966.
Japan also has a bathyscaph called Kaiko that can dive over 11 kilometres. In 1994, Kaiko went down to the **Mariana Trench**, the deepest spot in the ocean! While the largest submarines stretch up to almost 200 metres, the smallest working submarine, the Water Beetle, is only 2.7 metres long! It can go down to 30 metres and stay underwater for four hours.