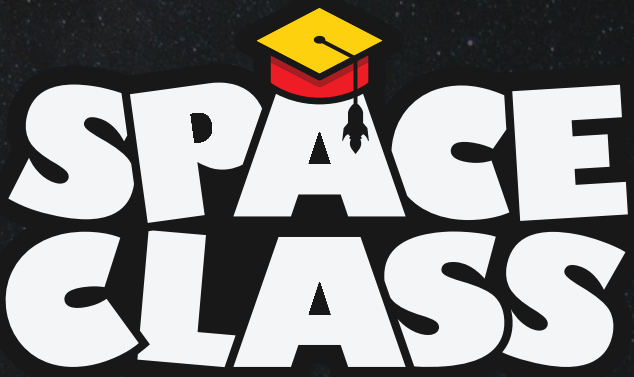

LESSON GUIDE

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INTRODUCTION

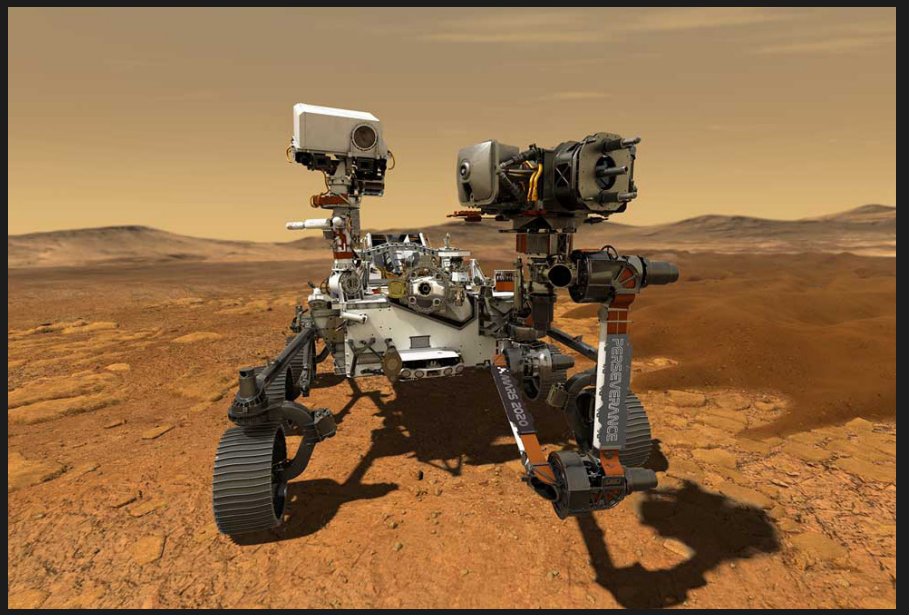
Welcome to Space Class!

We're headed to space from the comfort of your own home, school, or wherever you may be. Together we're going to blast off and learn about Rovers, Submarines, Landers, Astronauts, CPU Fundamentals, Communications, Spectroscopy, Rocks, Nebula and Rockets! Make sure you buckle up and put your thinking astronaut helmets on, it's going to be a wild adventure!

Kevin J DeBruin

1

ROVERS



Rovers are machines that can move across the surface of an astronomical body (planets, moons, asteroids, comets). There are three main ways rovers currently move: wheels, tracks, and legs.

How do we control rovers? Well there are three ways we do that too!

1. **Direct Control**
   Humans control the rover directly. This is like driving a car.

2. **Remote Control**
   Humans control the rover from a distance. This is like driving a remote control car.

3. **Autonomous Control**
   The rover controls the rover. This is Artificial Intelligence (AI) where the rover has computer coding to figure out itself how to move.

Since we can't drive all rovers like a car, how do we communicate with them? We can either attach cables, called tethered, to send signals to it like a wired video game controller. Or we can go wireless like WiFi and send radio waves to communicate with the rover. This is mostly how we do it.

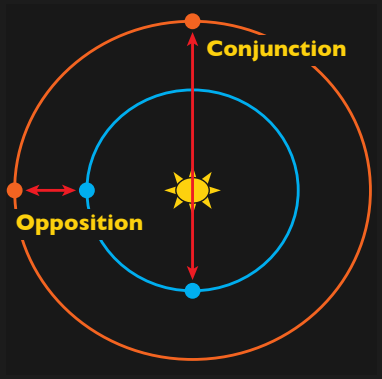
Direct Control

Pro's	*Con's*
• Driver can pick the best path	• Life Support needed
• Fastest way to get around	• More dangerous for people

Remote Control

Pro's	*Con's*
• No people to worry about	• Cannot fix it since it's far away
• Can perform much longer missions	• Takes long to send commands
	• Can not drive the rover like a car

Since the rover is far away, when we send wireless commands it takes a while. The fastest radio waves can travel is 300,000 km/s or 186,000 miles per second. Mars at its closest to Earth, which is called *Opposition*, is about 55 million kilometers (34 million miles) away! The furthest away Mars can be is 400 million kilometers (250 million miles) when it is at *Conjunction*. It can take 5-20 minutes to send commands to the rover.

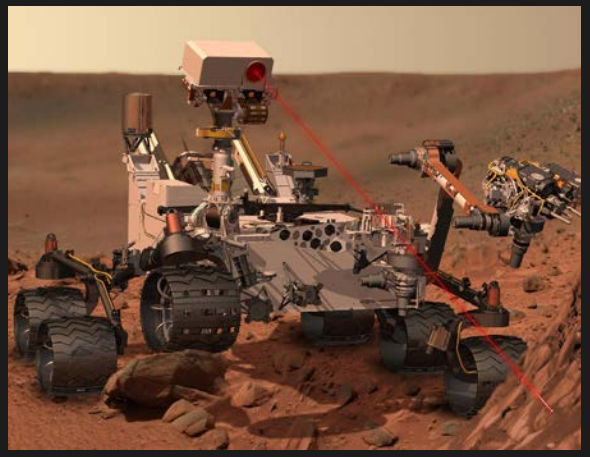


Autonomous Control

Pro's	*Con's*
• Rover picks the route	• A lot more software is needed
• Rover requires minimal human involvement	• More difficult to see what is happening

Direct Control

Remote Control



Autonomous Control

NOTES

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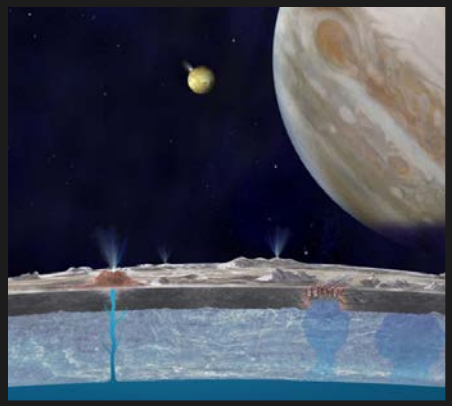
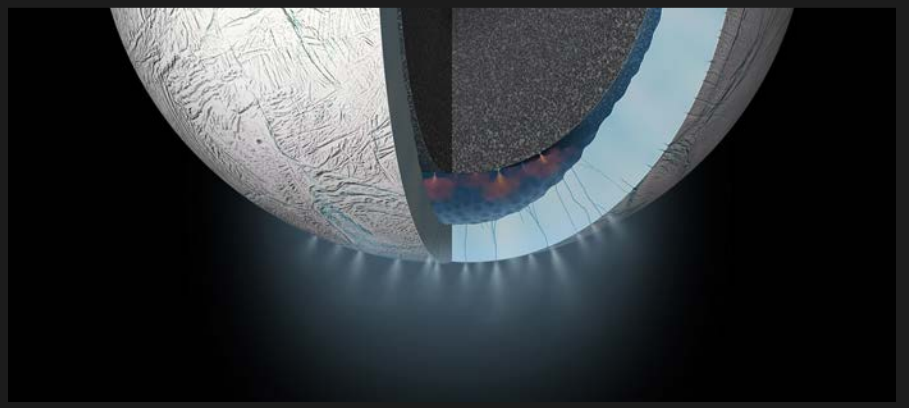
SUBMARINES





We can also use submarines to explore! There are oceans throughout the solar system, they aren't only on Earth. Europa and Enceladus are two moons that have oceans locked underneath an icy surface. Scientists and engineers use submarines in Antarctica to help study the Earth.

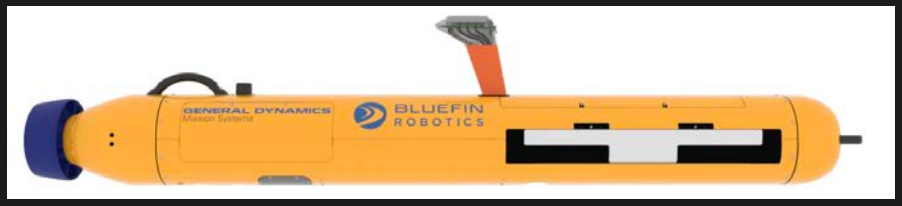
There are challenges with the Icy Worlds. How do we get through the ice? Drill? Bore? Melt?

How do we communicate through kilometers of ice? There is no sunlight for solar power. There is also a large amount of pressure underwater.

So far we've only explored the oceans on Earth, but we're training for the space oceans!

Submarines are crewed, underwater vehicles to explore depths.

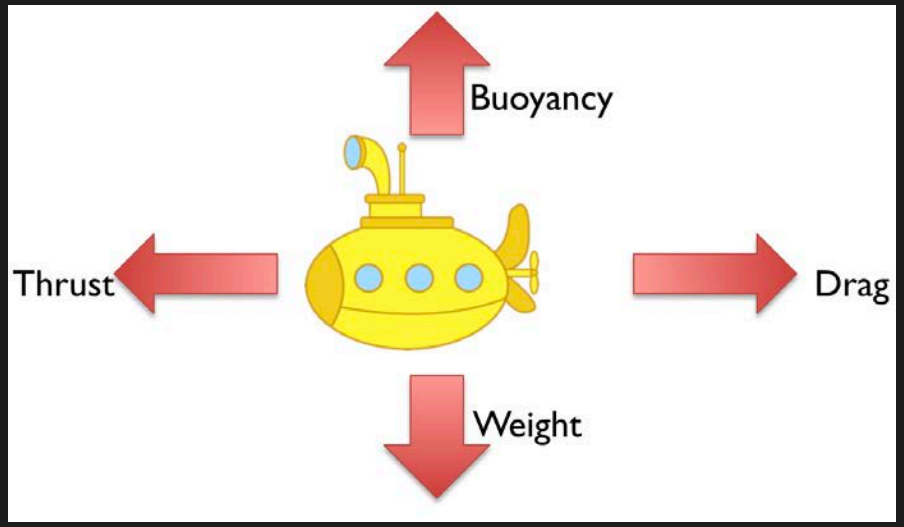
Submersibles are uncrewed, underwater vehicles used to explore. They may be tethered or autonomous (free floating or self-guided). They contain sensors to observe their environment.



Photosynthesis is when plants take in sunlight for energy. But that doesn't occur down there that we can see. What we're seeing is chemo-synthesis, chemical energy. We have things called hydrothermal vents we've found at about 4,000 meters or 4 kilometers down. These hydrothermal vents, or chimneys, are releasing salts, minerals, and energy. You could think of it like an underwater volcano and that releases chemical energy. So chemo synthesis, chemo - chemical energy, is what we believe is allowing life to thrive down there. We get a unique ecosystem of things like hairy snails, shrimp, crab, mussels, all weird things that are living down there that don't need sunlight to live. We've even found a Ghost Fish in the Mariana Trench 8,143 meters deep!

There are four forces on a submersible: Buoyancy, Thrust, Drag, and Weight.

Buoyancy
The tendency or capacity to remain afloat in a liquid or rise in air or gas. The upward force that a fluid exerts on an object less dense than itself.



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LANDERS

We want to land on other planets and moons to explore! We also need to know how to land on Earth to bring our astronauts safely back from space and also to bring back samples we take from asteroids and comets.

It's VERY HARD to land safely… We need to consider many things about the place we are going to land. Is there a thick or thin atmosphere? How strong is the gravity? Is there liquid for a softer landing? How much mass are we trying to land?

Atmosphere
The thickness of the atmosphere can slow down our landing with friction, but it can make things VERY hot. If there is no atmosphere, we need to find a different way to slow down.

Gravity
Different places have different gravity and the higher the gravity, the harder it is to land safe. Gravity doesn't just come from the size of the planet or moon. The materials it is made out of are important too. The more dense the materials, how tight the molecules are packed, the higher the gravity is.

For example, Uranus is four times wider than Earth. If Earth was a nickel, then Uranus would be a softball. BUT Uranus has LESS gravity than Earth. What?! How?! This is because of what it's made of. Earth is mostly rock, it's a rocky planet. Where Uranus is a gas planet made up of mostly ice. It has different types of ice: mostly water-ice but also methane, and ammonia ice.

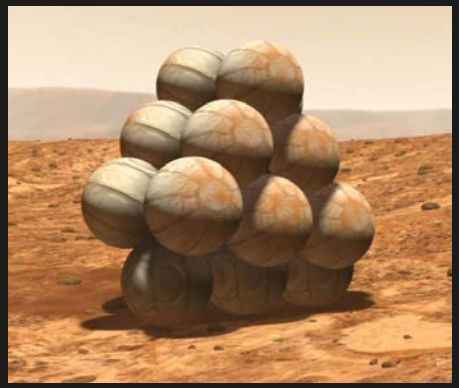
What is the surface made out of?
On Earth some of the things we can land on are: rocks, dirt, sand, ice, snow, water, and concrete runways.

Let's do a quick thought experiment. If you were on the roof of a burning building and you had to jump off, would you rather land in a pile of snow, in the water, or in a pile of rocks? Well no one's going to choose the rocks! You're either are going to want jump in the snow or the water. So what we land on can help. We can maybe choose our landing site thinking about the softness or hardness of the surface.

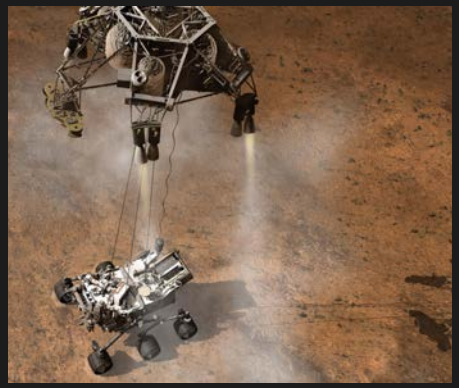
Mass & Size of Lander
The size of your lander matters! The bigger your lander is, the more friction it can create to slow down in an atmosphere. BUT, the bigger the lander the heavier it can be. Which means they can impact harder when they land.

How do we land?

Parachutes



Inflatables



Retro-Rockets/ SkyCrane

NOTES

4 ASTRONAUTS

What are the requirements to be a NASA Astronaut?

- Be a U.S. Citizen
- At least Master's Degree in STEM related field
  - Science, Technology, Engineering, Math
- At least 2 years of work experience
- Ability to pass a NASA Astronaut Physical

Other skills NASA is looking for:

- Leadership
- Teamwork
- Communication
- Followership (Because you can't always be a leader, you need to follow orders)

Additional things that NASA smiles at when they see:

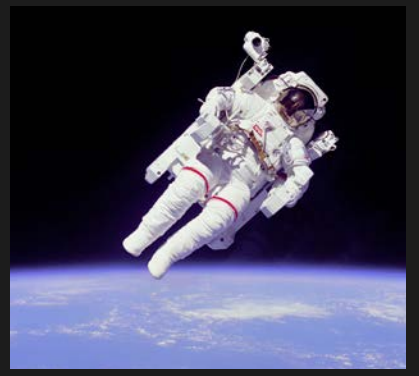
- SCUBA certification
- Pilot's license
- HAM Radio
- Speak multiple languages (Most importantly Russian)
- Wilderness Survival

How do I apply?

- Online Application
- ~120 chosen to be interviewed
- ~40-60 invited for a weeklong interview
- NASA selects ~20 Astronaut Candidates (AsCans)
- Training & await a mission

Where have Astronauts gone?

- The Moon in 1969 with Apollo 11
  - 5 more missions to the moon
- Earth Orbit
  - International Space Station (ISS)
- Suborbital
  - Over 50-miles high, but not around the Earth
- NOT MARS...yet.



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CPU FUNDAMENTALS

Robots help us out in space and also on Earth! They can go places humans can't or shouldn't go. Places that are dangerous. Robots don't need food or water like humans. They also don't need sleep, unless they need to recharge some batteries or save power. Robots are also smaller and lighter because we don't have to bring everything we need to survive like humans.

In order for robots to move and do stuff, we need to tell them what to do. We program robots with computer coding. Robots follow computer coding like how we follow instructions. NASA's robots use a code called Flight Software. All robots have a CPU (Central Processing Unit) inside of them and that is how we control them.

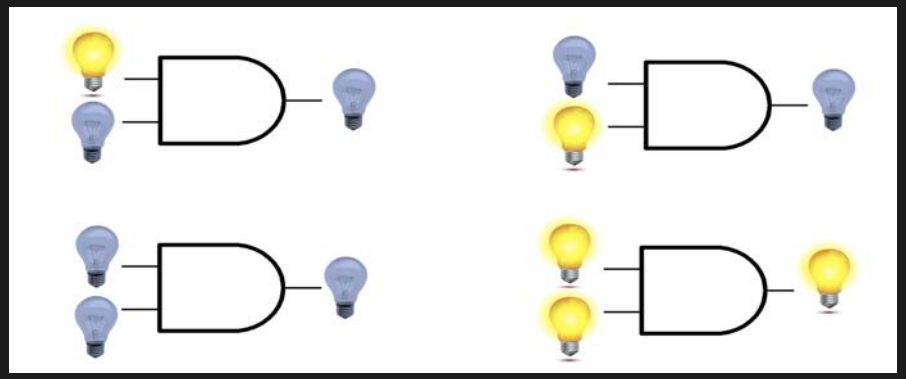
Robots are complicated machines, but complicated machines are just made up of many simple parts! A CPU is a complicated item made up of many simple parts called "Logic Gates." A Logic Gate is made up of Transistors (which are made up of 2 Diodes), that makes a decision or output based on the inputs.

Transitor
A switch that you use electricity to operate made up of two diodes.

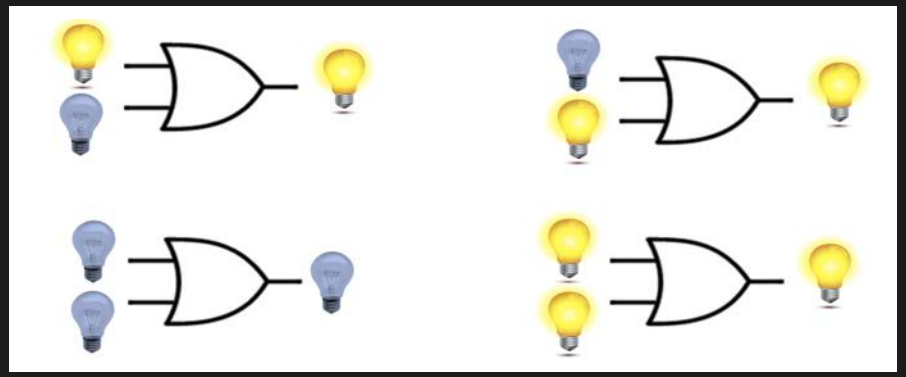
There are many different types of Logic Gates.

NOT	AND	NAND	OR	NOR	XOR	XNOR
$\overline{A}$	AB	$\overline{AB}$	$A+B$	$\overline{A+B}$	$A \oplus B$	$\overline{A \oplus B}$
A — X	A, B — X					

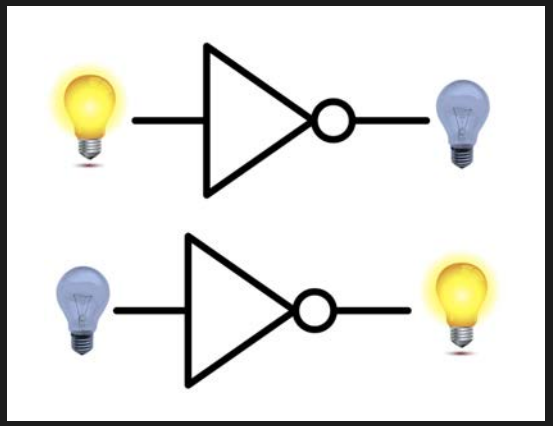
The **AND** Logic Gate: If the first wire AND the second wire have power, then the output has power.



The **OR** Logic Gate: If the first wire OR the second wire have power, then the output has power.



The **NOT** Logic Gate: This automatically changes things to the opposite. If the power was on, the output is NOT on. If the power was off, the output is NOT off.



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6 COMMUNICATIONS

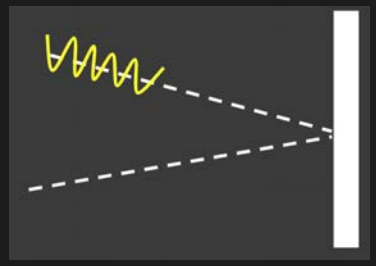
How do we communicate in space? The basics are that we need a transmitter, something to send a signal, and a receiver, something to receive the signal. The transmitter sends out a signal that is encoded through space. When we receive it, we have to decode the message so we can understand it. Our spacecraft can talk to Earth using lasers and radios with antennas.

Lasers are a newer form of communication in space. We also call it optical communication. Laser or Optical communication uses infrared lasers to send data between a transmitter and a receiver. The main advantage of using laser communication over radio waves is increased bandwidth, or how much data we can send. This means we can transfer more data, or communicate more information, in less time. This new method is 10-100 times better than using radio waves and antennas. But, it's pretty new, so we're still testing it out with demonstrations in space.

There are different types of antennas. We will learn about non-directional and directional antennas. We will also learn how to code signals and will try communicating with someone using code!

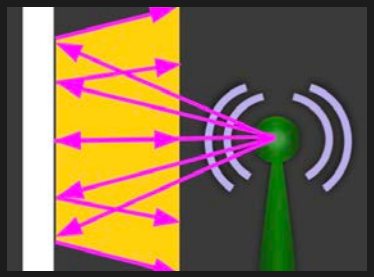
Non-Directional Antennas
These can send and receive signals in all directions. A weak point of non-directional antennas is that the signal is spread.

Directional Antennas
Radio waves reflect when meeting an obstacle. Directional Antennas can focus the signal in one direction instead of in all directions.

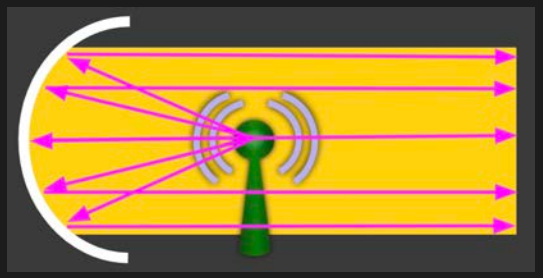


We can use flat and paraboloid-shaped reflecting plates. Which one do you think has the advantage to focus the signal?

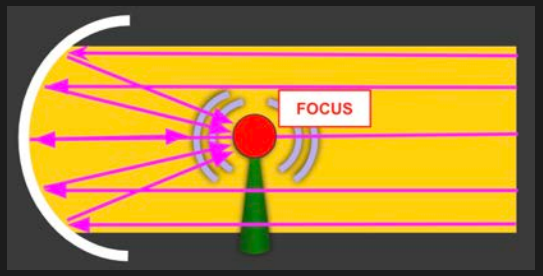
A Flat reflecting plate spreads the signal.



A Paraboloid-shaped reflecting plate can direct signals in a particular direction.

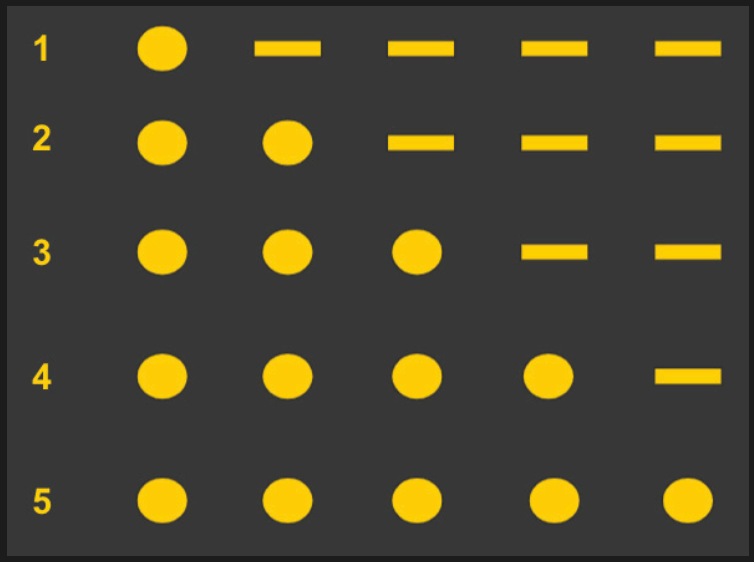


This means we can also receive a signal using a paraboloid-shaped reflecting plate because it gets focused on the Focus.



Morse Code is a code made by Samuel Morse that can be done with sound or light. There are two signals. A Dot means short and a Dash means long.

These are numbers using Morse Code. Even though it looks very complicated, we can make it easy.



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SPRECTROSCOPY

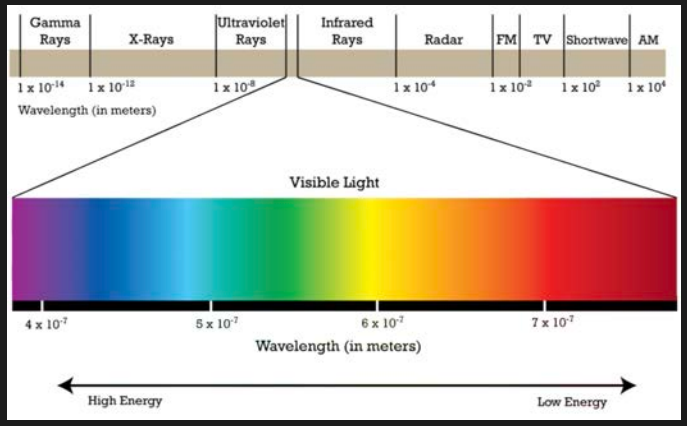
Spectroscopy is a big word, what does it mean? Spectroscopy is the study of how Electromagnetic Radiation (visible light, x-rays, infrared) interacts with matter (atoms, molecules, entire planets!). Also big words, basically is the study of different kinds of light and what we can learn from them.

Examples:

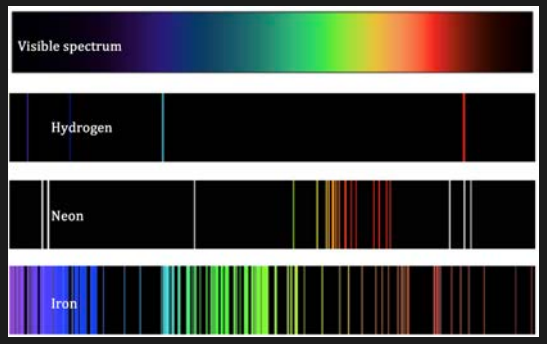
- Emission – Radiation created by the object
- Absorption – Radiation consumed by the object
- Diffraction/Scattering – Radiation bounces off an object
- Doppler/Radial velocity – Radiation changes with rotation/movement

A simple prism interacts with white light, separating into colors by dispersion to give the rainbow! Which we call an Optical Spectrum.

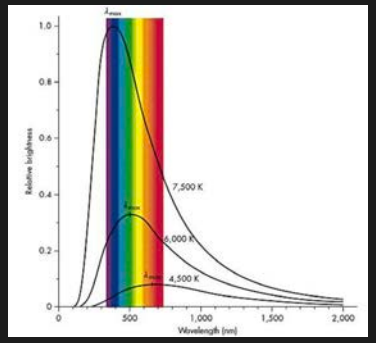
There are many different types of light. You know visible light, the colors of the rainbow. You may have heard of x-rays and UV light too. There are many more!



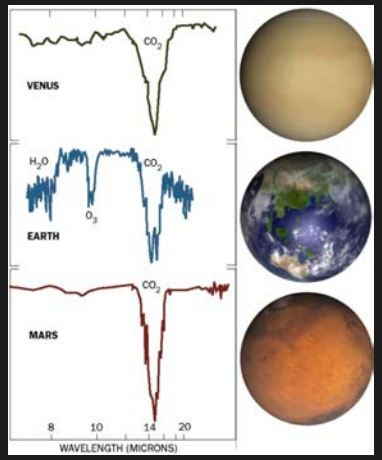
We can learn A LOT from just light. We can learn what things are made out of, their elements. Each element has a special rainbow as its fingerprint and we can see those! We use different energies called emission lines to see what different materials there are. Check out the special rainbow fingerprints of Hydrogen, Neon and Iron.



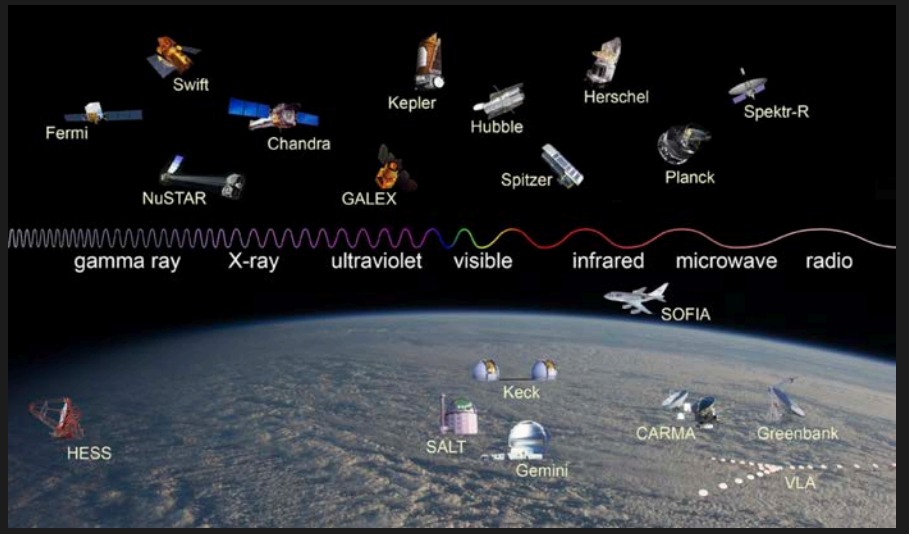
We can also learn about temperature with Spectroscopy. We can tell how hot a star or planet is based upon its light spectrum. We use things called emission intensity and wavelength to determine temperature.



How about Aliens?! Maybe… We can look for "BioMarkers" like liquid water or things that are evidence of life by seeing what elements are on certain planets. There's a lot of Oxygen on Earth because of life. There's a bunch of carbon dioxide at Mars, meaning no life. We can also tell if there is a planet hiding around a distant star. Those are called Exoplanets.



We can only see so much from Earth so we send telescopes into space to look for those rainbow fingerprints!



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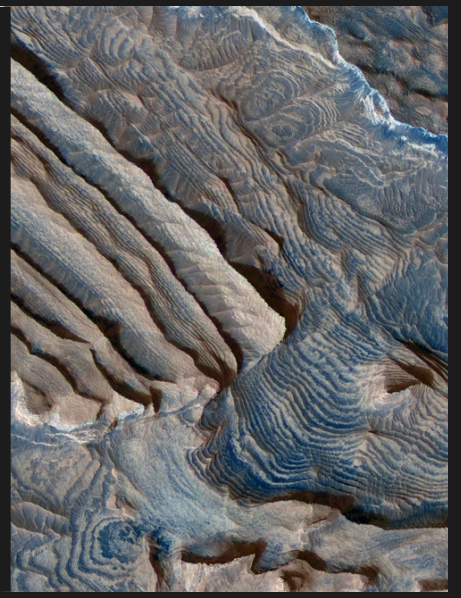
8

ROCKS

Rocks! And how they can tell us about the history of the Earth (and other planets)

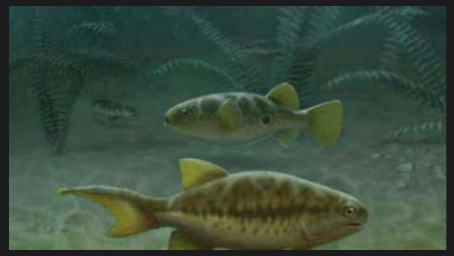
We will investigate what rocks are, how they tell us about the environment they formed in, and how different layers of rocks tell us about different times in history. Rocks can be formed from sand sticking together, from melted rock, or from being smushed! You will learn that we can then 'read' different layers of rocks like pages in a history book about the Earth. This is the field of science called stratigraphy: the study of rock layers to learn about how the environment has changed through time. Stratigraphy was mostly developed to study the history of the Earth, but we'll also learn about how we can do the same thing on Mars!

Layers of rocks on Earth!



Layers of rocks on Mars!

Each layer formed in a different environment, so the types of rocks and the fossils in them tell us about what the environment was like when each layer formed. For example, if there are fish fossils in a rock, it probably formed underwater!



Or if there are sand layers it was probably a desert with sand sundes!

If we find basalt rock, we can say there was a volcano with lava!

Steno's First Law
Layers of rock form on top of each other. The bottom layers of rock are the oldest and the top layers are the youngest. So the farther down we look in a stack of rocks, the farther back in time we're going!

NOTES

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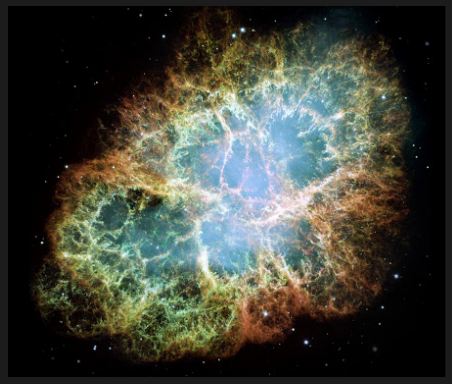
NEBULA

A nebula is a giant cloud of dust and gas in space!

Nebulas have so many cool colors. How does that happen? The process is similar to that of a neon light. This causes the nebula to glow. Emission nebulae tend to be red in color because of the abundance of hydrogen. Additional colors, such as blue and green, can be produced by the atoms of other elements, but hydrogen is almost always the most abundant.

What are nebulas made out of? What kind of elements are floating around out there? Most nebulae are composed of about 90% hydrogen, 10% helium, and 0.1% heavy elements such as: carbon, nitrogen, magnesium, potassium, calcium, iron. These clouds of matter are also quite large. In fact, they are among the largest objects in the galaxy.



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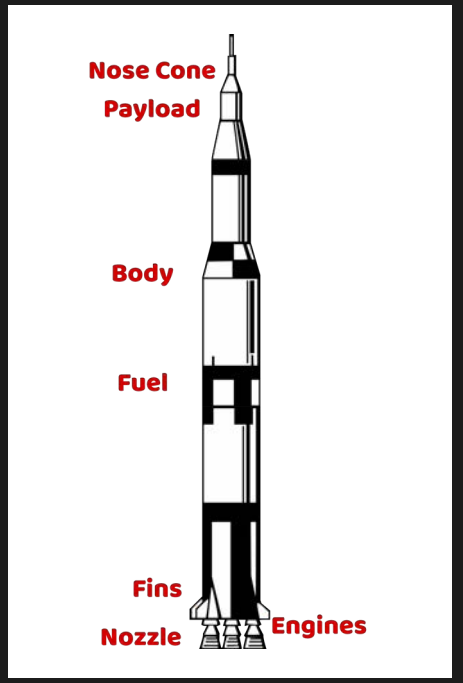
10

ROCKETS

How do we get into space? Well with Rockets of course! We need to learn the basics of Rocket

What are the parts of a rocket?

- Nose Cone
- Payload
- Body
- Fuel
- Fins
- Engine
- Nozzle



Rockets can launch during the day or at night. But rockets NEVER launch in stormy weather. Wind and lightning are especially bad for rockets.

Rockets fly because of Newton's Laws of Motion.

First Law
Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force

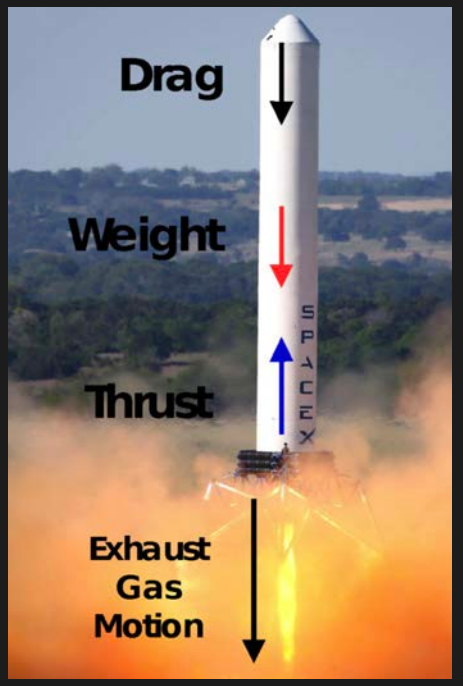
Second Law
Force (F) = Mass(m)* Acceleration(a)

Third Law
For every action there is an equal and opposite reaction

There are three big forces on a rocket: Thrust, Weight, and Drag

Thrust has to be bigger than both Weight and Drag to get the rocket off the ground

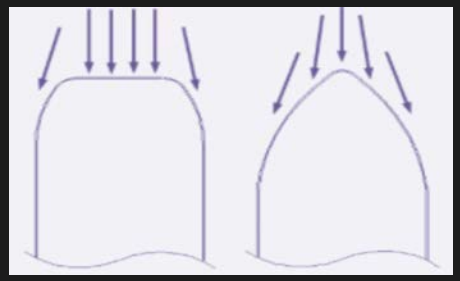
Thrust > Weight + Drag to launch!



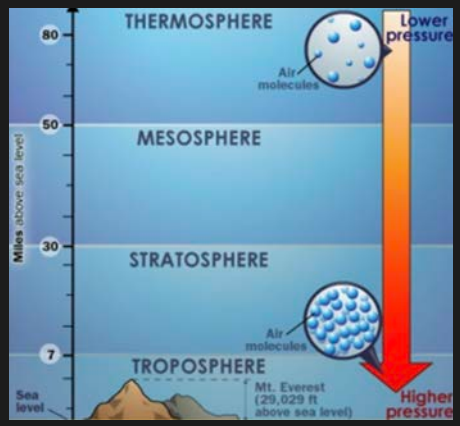
Thrust
Comes from the engine. In our rockets it's the pressurized air. The air gives Mass and the pressurized air gives Acceleration. Air pressure pushes the air out, causing the rocket to move the opposite way. This is an example of an equal but opposite reaction – Newton's 3rd Law.

Weight
Is due to gravity. Weight = mass*acceleration where the acceleration is the gravity. Weight is the force that works against the thrust, trying to keep the rocket on the ground.

Drag
Comes from air resistance. Air pushes back as the rocket moves through it, like your hand out of a car window. A good sharp nose cone helps us with this.



Air Pressure
The weight of the atmosphere pressing down on the Earth due to gravity. Air pressure is highest when you are at ground level (or sea level), and goes down as you go up.



Barometer
A pressure sensor instrument that measures air pressure. This is how airplane pilots know how high they are flying.

NOTES

NOTES

REVIEW

Rovers

What are the 3 types of Rover control?

- We have direct control like your hands on the steering wheel, you're in the rover driving around. Remote control where you have a remote control sending signals to the rover. And the third one is autonomous, where the rover makes its own decisions.

What is the speed of light?
(You can answer in kilometers per second or miles per second.)

- It's 300,000 kilometers per second or 186,000 miles per second.

What does opposition mean?

- Opposition occurs when Earth is the closest to the planet of interest. When the Earth is in the middle and the sun & the planet are on opposite sides.

What does conjunction mean?

- Conjunction occurs when Earth is furthest from the planet of interest, on the other side of the sun.

Submarines

What are some of the icy worlds in our Solar System?

- The main ones we talked about are Earth, Europa, a moon of Jupiter, and Enceladus, a moon of Saturn.

What is the difference between a submarine and a submersible?

- A submarine is crewed and a submersible is uncrewed.

What type of energy is chemosynthesis?

- Chemical energy

What are some of the challenges of exploring icy worlds?

- **We need to get through the ice**, how to **communicate** with sub, how to **power** it, how to **see & explore since it's dark**, and then dealing with **large pressures.**

What are the four main forces on a submarine?

- Buoyancy, weight, thrust, and drag.

Landers

Why do we want to land on other places?

- To explore, land astronauts, bring then home too, and to return samples.

What are the main factors affecting landing?

- We need to think about atmosphere, gravity, the surface, and the size & mass of our lander.

What are the three main ways we land?

- Parachutes, inflatables, and retrorockets. Oh! And a bonus point if you said wheels on runways too.

Astronauts

Where do you have to be a citizen to be a NASA astronaut?

- The United States of America.

How many people have walked on the moon so far?

- 12 people, all of them men so far.

How long have we had continual human presence in space?

- Over 21 years, Since Halloween Oct. 31, 2000.

What does the ISS stand for?

- The International Space Station.

CPU Fundamentals

What does CPU stand for?

- It is a central processing unit, and it is also called a Processor.

What is a CPU made up of?

- A CPU is made up of many, many logic gates.

What is the logic gate?

- It's a decision output based upon the inputs, and there are many different types.

CPU Fundamentals (Continued)

What is a logic gate made up of?

- Logic Gate is made up of transistors.

What is the transistor?

- A transistor is like a water valve – a mechanism we can use to control the flow rate of electricity.

Communication

What are the two basic things you need for communication?

- A transmitter, something to send a signal, and a receiver, something to receive a signal?

What are 2 ways that we can communicate in space?

- Lasers and radios with antennas. Lasers are newer and have a higher bandwidth which means more data.

What is the difference between non-directional or omni directional and directional antennas?

- A non-directional antenna goes everywhere where are a directional antenna can be pointed. Non-directional antenna have lower data rates which means getting data more slowly. Directional antennas have higher data rates which means getting data faster.

What is the thing that we use to bounce a signal with an antenna?

- It is a reflecting plate.

Which reflecting plate is used to focus a signal?

- That is the paraboloid reflecting plate, the satellite dish.

Now here might be a tricky one. What is the Morse code for the number three?

- It is three dots and two dashes. So three short, two long, so beep beep, beep, beeeep beeeep. It's Morse code. The number three.

Spectroscopy

First up, what is spectroscopy?

- Spectroscopy is the study of how electromagnetic radiation (like visible light, X-rays, infrared) interacts with matter. Which is our atoms, molecules, or entire planets.

What are some different types of wavelengths of light?

- Gamma rays, X-rays, UV or ultraviolet rays, visible light - that's the rainbow, infrared, Radar, FM, TV, shortwave, and AM. There's a lot of them. How many you get?

And what can we learn with spectroscopy?

- We can learn atomic composition - what something is made up of, what's the temperature - how hot or cold is it, aliens? - maybe. We can look for the biomarkers which tell us maybe life is able to survive there and exoplanets. We can determine a hidden planet orbiting a star by the shifting spectrum of the light.

Rocks

What is Geology?

- The study of rocks...and liquids and how they change environments over time.

What is Steno's First Law?

- It is that younger rocks sit on top of older rocks.

Next, what can rocks tell you?

- Well, they can tell you about the place that they formed. Was it sand dunes? A volcano? Maybe a lake?

And how do rocks form?

- Stand sticking together, melted rock from lava or a volcano, or rocks crashing and melting together.

Lastly, what is stratigraphy?

- It is the study of rock layers to understand how the environment has changed throughout time.

Nebulas

What is the nebula?

- It is a giant cloud of gas and dust in outer space.

What determines a nebula's color?

- It's what it's made up of. It's like hydrogen gives it that red glow.

And what are the elements in the nebula?

- It's about 90% hydrogen, 10% helium and 0.1% other heavy elements like carbon, nitrogen, magnesium, potassium, calcium, and iron.

Rockets

When can we launch rockets and when don't we?

- Well we can launch rockets during the day or the night, and we do not launch rockets in stormy weather or when there is something close by that can be dangerous.

What are the principles that describe why a rocket moves?

- Thrust, weight, and drag.

What is a barometer?

- It is a scientific instrument that measures the air pressure and determines altitude.

What is the force a rocket can experience in flight?

- Lift. For a total of four forces: Thrust, Weight, Drag, and Lift.

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