

STEM EDUCATION

Elementary-Level Engineering
ACTIVITY PACKET



**NORTHROP
GRUMMAN**



Welcome friends! Come visit us at Northrop Grumman and see what we are all about!

Welcome friends, today is your day.
There are a lot of fun and games coming your way.

Here at Northrop Grumman there are really cool things to do.
We are happy to have you, on this field trip away from school.

From airplanes to radars, here we do it all.
Various gizmos and gadgets, reach for the stars.

Science and Technology; Engineering and Math
Radars and Rockets; Airplanes, what a blast!

So let's get started, we are ready... how about you?
Let's turn to page 1, a scavenger hunt awaits you!



Meet the Tour Guides



Shosanna - Science

Shosanna is a recent graduate of University of Maryland and has been at Northrop Grumman for 6 months. She went to school to study Material Science and Chemistry and now she works as a microelectronics engineer. In 2nd grade, she loved making her own volcanoes and slime. In high school, she was the President of the Science Club! In middle school, Shosanna would experiment with food by creating her own recipes altering the ingredients to make new creative dishes to share with her family.



Thomas - Technology

Thomas is a Cyber Engineer who works on some of Northrop Grumman's most complex problems. While at work, Thomas helps us communicate with satellites and protects our computers, and at home he also enjoys building robots and tutoring high school physics students. Thomas earned his Bachelor's degree in Electrical Engineering from the University of Cambridge and his Master's degree in Cybersecurity from California Polytechnic State University. In high school, Thomas enjoyed solving math and logic puzzles, but he never knew that he could do that as a career!



Elena - Engineering

Elena is an Aerospace Engineer and has been at Northrop Grumman for ten years. She helps ensure our planes are safe and pass all the test flights. She was born in Spain and went to the Technical University of Madrid and studied both Aeronautical Engineering and Computer Science. After college, Elena immigrated to the United States to work for a tech start-up. After a few years, she joined Northrop Grumman.



Mohamet - Math

Mohamet is an alumni from North Carolina A & T State University and has been at Northrop Grumman for 2 years. He went to school to be a Mathematician and a Mechanical Engineer and now works in design and structural analysis for airplanes – so cool! He loves that he can use his math skills in his job every day! In 3rd grade, he made his first invention by sewing velcro on each sock so they would stick together during the wash & dry cycle. In high school, he enjoyed working on cars to make them faster!

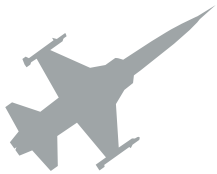
Activity Packet Target Groups

Teachers/Parents: This packet is designed for children ages 5-11. You will notice that each page has an aircraft in the upper right corner identifying the grade level. Some children will be able to complete higher-level activities, while some children will need assistance. Please use this time to engage with your children while they explore the fun and interesting things we do at Northrop Grumman!



GLOBALHAWK K/1st grades

The Global Hawk is an autonomous unmanned aircraft. That means the pilot is located in a building in front of a screen watching the Global Hawk fly itself. How cool is that? The Global Hawk set a U.S. Air Force record for longest unrefueled flight in 2014. It flew for over 34 hours! That's almost a day and a half.



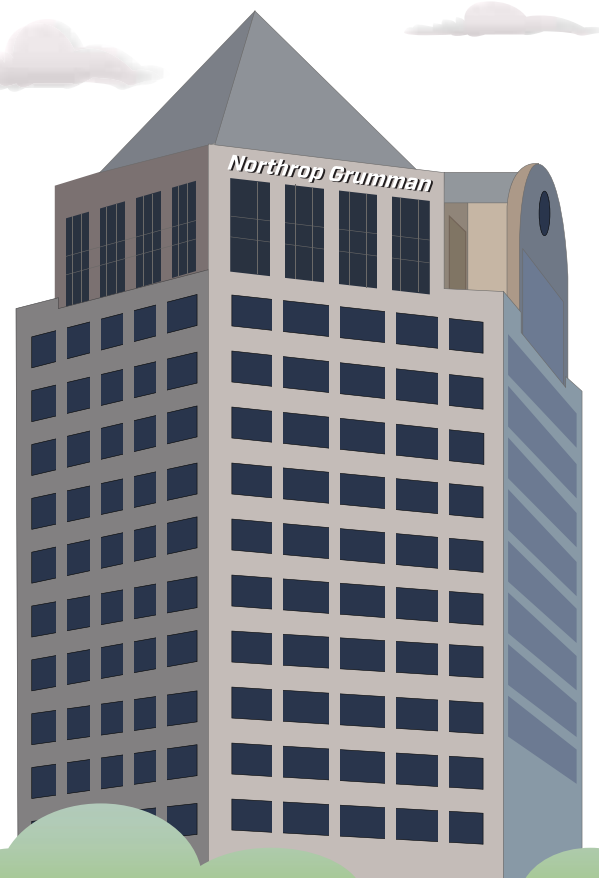
F-5 Freedom Fighter 2nd/3rd grades

This airplane first flew in 1959 and has served with many air forces around the world. Early F-5s were called Freedom Fighters. Later F-5s were called Tiger IIs. Tiger IIs were a little bigger and faster than the Freedom Fighters. Many F-5s are still flying today. They have been around for almost 60 years! Isn't that amazing?



B-2 Spirit 4th/5th grades

The B-2 Spirit is a stealth aircraft. While not invisible, it is very difficult to spot and track on radar. The B-2 can also fly a long way. With one in-flight refueling, it can go over 10,000 miles. With more, it can go a lot farther. It can fly to the other side of the world and back without landing! How tired would you be after a 40-hour car ride without stops? Are we there, yet?



Science - Shosanna takes us to the Advanced Interconnects and Multilayer Solutions (AIMS) manufacturing cell where Northrop Grumman engineers build printed circuit boards (PCBs).

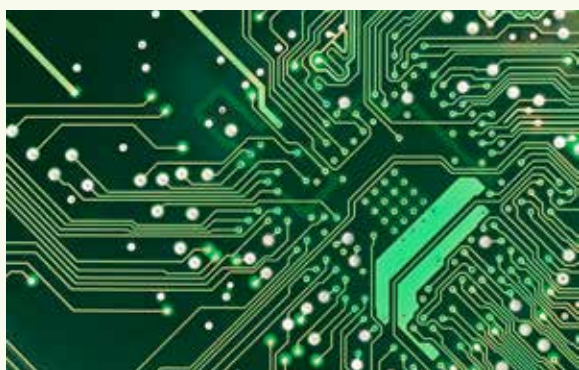
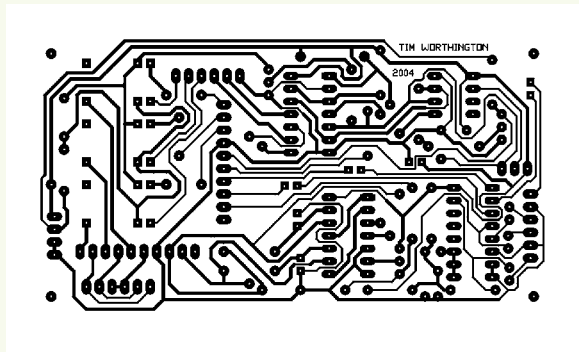


PCBs mechanically support and electrically connect electronic components to one another and are the basis of most electronic products built at Northrop Grumman. PCB designers use computer aided software tools to create PCB artwork patterns (as displayed below) that show the placing of the electrical traces and via holes that connect every component which will be mounted on the board.

Component: A smaller, self-contained part of a larger entity.

Electrical Traces: Electrically connect the various connectors and components to each other.

Mounted: To place or fix an object in its operating position



Where will you place your printed circuit board?

Activity: Draw your own printed circuit board



Did you know?

- PCBs are located in your computer, TV, digital clock and microwave! If you have heard of a “motherboard” in your computer, then you are talking about a PCB!
- Printed circuit boards have made connecting components easier and cheaper.



Activity: Decode the following statement to learn how semiconductors work!

A semiconductor is a material that has an electrical conductivity between a _____ and _____ (or non-conductor). An example of a conductor is () _____. An example of an insulator or non-conductor is () _____. The purpose of a semiconductor is to connect insulating materials and conductors. Semiconductors have made technologies available to many people. Did you know that everyday items around your house have tiny semiconductors inside?

Code:
 A= B= C= D=
 E= F= G= H=
 I= J= K= L=
 M= N= O= P=
 Q= R= S= T=
 U= V= W= X=
 Y= Z=

Activity: Circle the items in your home that have semi-conductors.



Conductors vs. Insulators

In conductors, electricity flows freely. Most metals are good conductors. In insulators, electricity does not flow freely. Most non-metal solids are insulators. Conductors are used to conduct electricity in electronic parts like computers and cell phones. Insulators are used in electronic devices and protective equipment to block electrical conduction.

Activity: Which of these items are conductors and which are insulators?

Silver Spoon



Gold Bracelet



Rubber Glove



Mercury in a Thermometer



Air



Aluminum Foil



Wool Sweater



Pennies (95% Copper)



Iron Armor



Ceramic Mug



Paper



Cooking Oil



Science

Now we visit the Environmental Test Lab (ETL) is where our products undergo testing to make sure they can handle various weather conditions, stresses and vibrations.



All materials will react differently based on how they are made. Can you name an item that goes through similar testing? (hint: it has 4 wheels!) We need to know our systems can work in snow and the desert. The same for cars – imagine if a car only worked in warm weather! The foundation of vibration testing is waves. Waves transport energy through a medium from one location to another without transporting matter.

Activity: Using the words from the page, identify the types of waves for each picture.

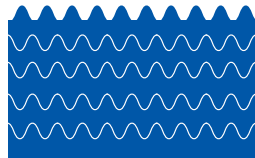
Earthquake waves
X-rays
Light waves

Microwaves
Ultraviolet (UV) waves
Sound waves

Water & Ocean waves
Infrared (IR) waves
Radio waves



Bats use echolocation, which is the production of sound used for communication:



When we swim we are enjoying:

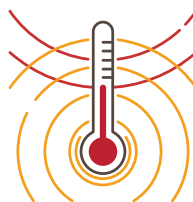
----- & -----



When you turn on a light you are using these:

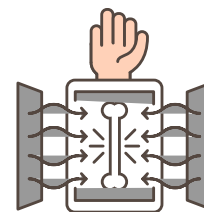


A microwave uses these to heat up our food:

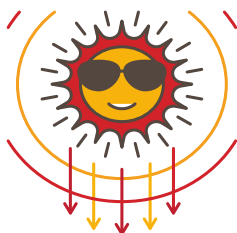


You can not see these, but you can feel their heat:

----- (IR)



To see our bones, doctors use:



We wear sunscreen to avoid the sun's:

----- (UV)



To listen to the radio these are used:



These waves cause the ground to shake:

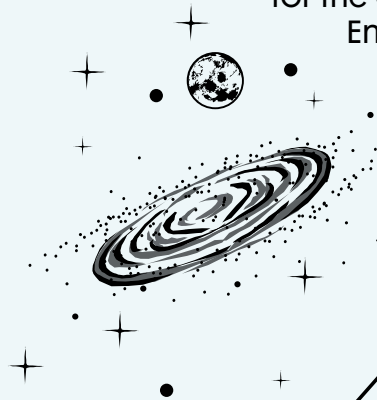
Technology: Satellites

Thomas takes us on a tour of the satellite range.



Making a satellite is tricky business! Once it launches into space, a satellite gathers information and communicates this data back to earth. Satellites are exposed to the harsh environment of outer space and cannot be accessed by humans after they launch, so we are very careful to make sure our design is perfect before it travels thousands of miles away from earth!

Northrop Grumman's James Webb Space Telescope is a space telescope that will be looking for the cosmic dawn which is the first moments of light following the Big Bang. Engineers and scientists like Thomas worked with NASA to develop the technology needed to learn about the formation of stars and galaxies.

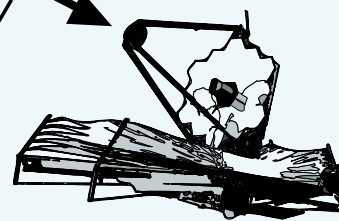


Start Here

Activity: Help light get from the galaxy to the James Webb Space Telescope

Satellite: an artificial body placed in orbit around the earth or moon or another planet in order to collect information or for communication

Big Bang: A scientific theory about how the universe started, and then made the stars and galaxies we see today.



Did you know?

- You use satellites every day! Whether you are using Global Positioning System or checking the weather, your data was probably transmitted by a satellite at some point on its journey to you.
- Low battery! Once in orbit, satellites use solar panels to convert solar energy into electricity. This electricity then powers the satellite.

Technology: Cyber



Thomas takes us to Northrop Grumman's Software Center of Excellence, where engineers work to protect satellite communications using cyber security.

Implementing cyber security in our technology is like installing an alarm system in your house – it protects the information inside and deters attackers outside. Thomas tells us that Northrop Grumman engineers work to anticipate ways in which data transmissions could be interrupted and develop software code that will keep the interruption from being successful. Cyber security also protects against attempts to steal information or damage technology so that it no longer works properly. The work cyber engineers do is a lot like making a vaccine for your computer so that it does not get a virus!

Activity: Using information found on this page, unscramble the words!



s	s	m	t	i	n	a	n	s	i	r	s	o



s	v	u	r	i



c	e	d	o



l	s	a	e	t	e	i	t	l



a	i	r	o	d	a	e	v	w	s

Did you know?

- Sometimes the best way to test something is to try to break it! As new systems are developed, skilled computer programmers attempt to breach cyber security roadblocks. If they are successful, engineers know that these areas need more protection.
- New cyber threats are emerging every day, creating lots of work for innovative puzzle solvers!



Thomas takes us on a journey from outer space to undersea. While radio waves work well for communication above ground, sound waves work best for communication under water. Just like throwing a ball at a wall and watching it bounce back, technology that uses sonar transmits sound waves and detects the echo when the waves bounce off of objects.

A few applications of SONAR (SOUND Navigation And Ranging) are unmanned maritime systems, submarine sensors, and undersea exploration. Northrop Grumman has even used its sonar technology to learn about the behavioral patterns of oysters in the Chesapeake Bay!

Oysters are important natural filter feeders, which means that they can filter more than 50 gallons of water in a single day and help keep the Chesapeake Bay clean!

What would you look for using sonar?

Activity: Using sonar is a lot like the game of I Spy. Can you find all of the undersea objects?

- Starfish
- Submarine
- Green corals
- Telescope
- School of blue fish
- Propeller

Did you know?

- Sonar is used by fishing ships to detect schools of fish, as well as dangerous reefs and rock formations.
- Some animals also use sonar as a form of navigation, including bats and dolphins.

Engineering: Systems -

Elena is a systems engineer specializing in radar.



The MESA radar provides air-to-air coverage, air-to-surface coverage.



Ground/Air Task Oriented Radar (G/ATOR)

WHAT IS RADAR?

Radar is a system that uses strong radio waves to detect objects, determine distances or make maps of objects.

We use radars every day! The weatherperson on TV and police officers both use Doppler radar. Some newer cars have radar to detect the distance in front of the vehicle and warn the driver if they are too close.

Activity: Word Search

Q	N	N	Q	T	C	E	T	E	D	J	W
T	L	A	N	G	I	S	E	U	C	B	M
I	Y	B	O	U	W	R	E	D	R	M	L
O	X	C	T	A	R	G	E	T	I	Z	B
H	T	G	N	E	L	E	V	A	W	E	N
L	I	P	N	E	A	N	N	E	T	N	A
T	E	F	Y	N	U	N	E	C	I	G	M
P	M	L	U	U	U	Q	P	K	C	I	M
D	I	S	T	A	N	C	E	O	Q	N	U
Y	S	J	C	M	H	I	T	R	W	E	R
R	A	D	A	R	D	L	Y	S	F	E	G
Y	N	O	R	T	H	R	O	P	M	R	R

RADAR
NORTHROP
DISTANCE
POWER
ANTENNA
SIGNAL
GRUMMAN
DETECT
TARGET
WAVELENGTH
FREQUENCY
ENGINEER

Did you know?

- The Australian version of the airplane, called Wedgetail, is named after Australia's largest bird of prey: the Wedge-tailed eagle.
- RADAR stands for Radio Detection And Ranging.


Engineering: Aircraft




Elena takes us to the aircraft hangar where we can see a variety of military and commercial airplanes!

The selection of planes below can fly high...can fly low...can fly fast and fly slow. Some can "hover" and others can fly straight up in the air, defying gravity! All of these planes serve a specific purpose, such as the fighter jet, surveillance plane, people transportation, supplies transportation and even an experimental test plane that tests brand new radars and various sensors. They were designed and built by many different types of engineers, such as Aerospace Engineers, Electrical Engineers, Mechanical Engineers, Materials Engineers and more! With the help of very skilled aircraft pilots, these engineering teams can design, build and fly almost anything they can dream up!

Activity: Look-n-Find

E-2C Hawkeye 


Global Hawk 

Wedgetail 

AWACS 

B-2 Spirit 

B-1 Lancer 

CRJ Test Plane 

X-47 

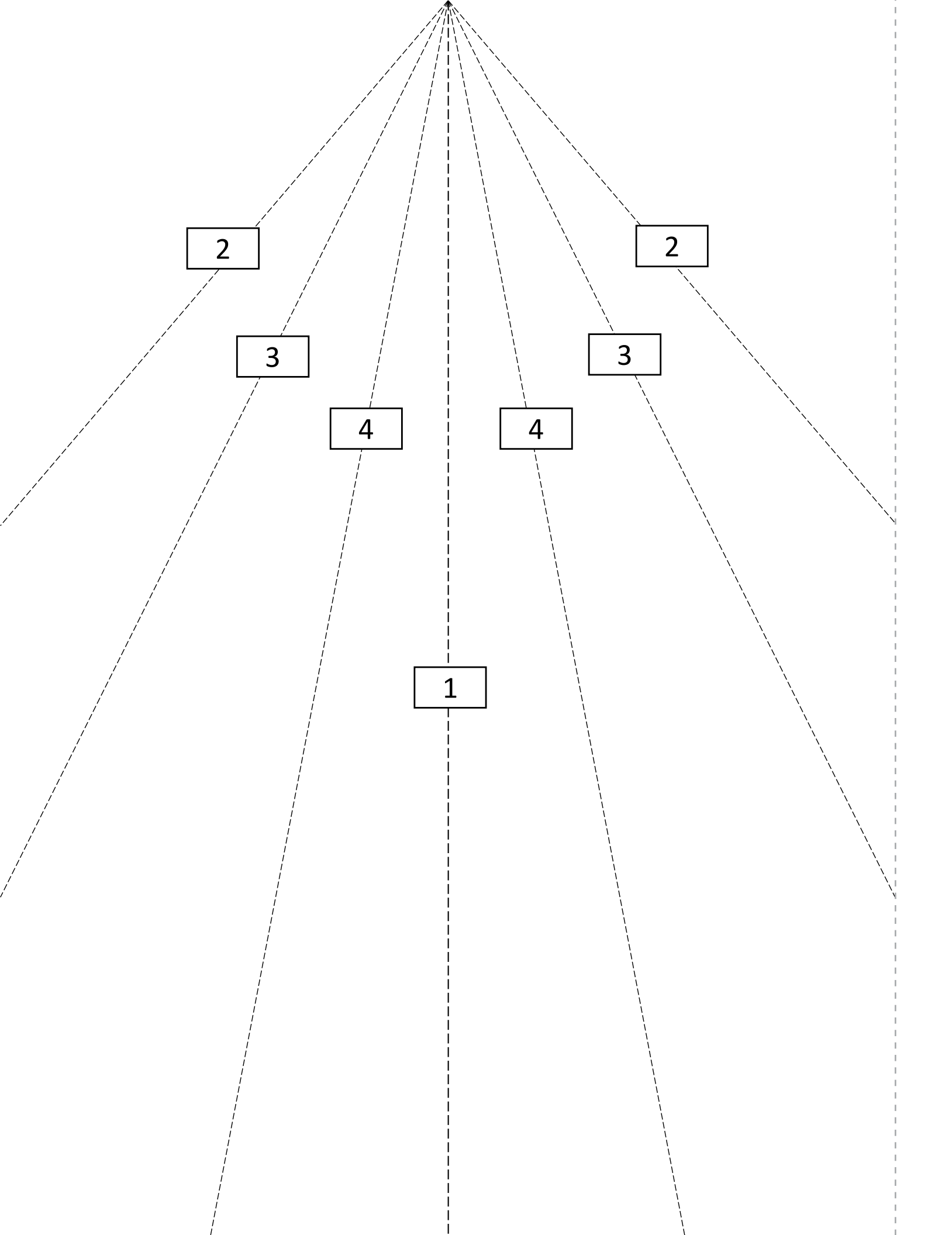


Did you know?

X-47B: The X-47B was a flying wing test aircraft built by Northrop Grumman for the U.S. Navy. It was the first autonomous unmanned airplane to launch from an aircraft carrier by catapult, and the first autonomous unmanned air vehicle to land on a carrier. That means it did it all by itself, without a pilot or a controller on the ground flying it. It was also the first unmanned aircraft to make an autonomous mid-air refueling. That's pretty amazing!

Engineering

**Build your own airplane using the pattern on the next page.
Fold the paper in order, starting with #1 and ending with #4.
Then see how far it will fly!**



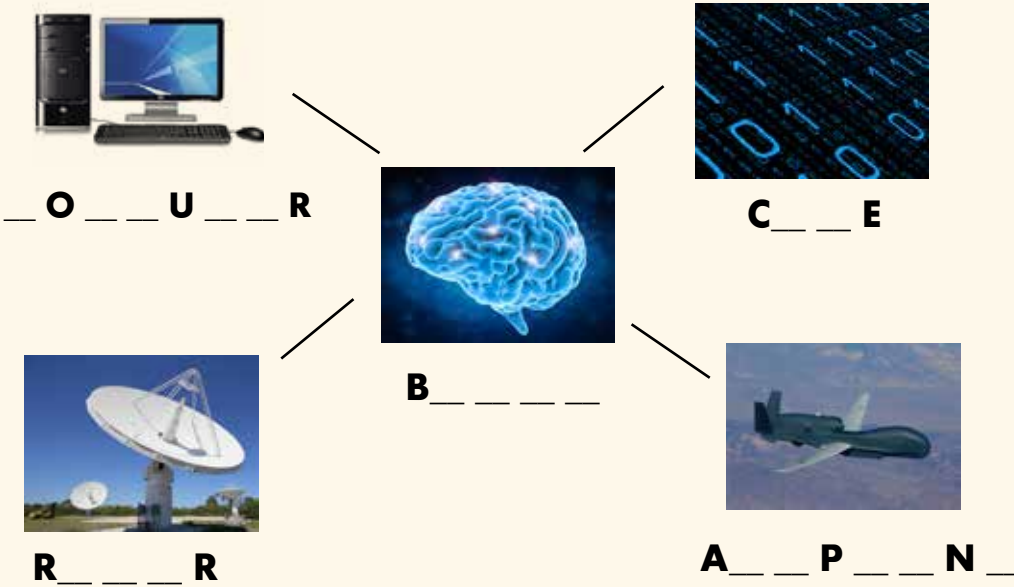


Software is part of a computer! It is the brain of radar and our airplanes. What type of software might you use at home? Well, if you have ever used a tablet, laptop or computer – you have used software! Software is written in code and tells these systems what to do – like which chores to perform, or which lines to read in a play!

Binary code represents text, computer processor instructions, or any other data using a two-symbol system. The two-symbol system used is often “0” and “1” from the binary number system. The binary code assigns a pattern of binary digits, also known as bits, to each character or instruction. In the table on the right, you can see the 0’s and 1’s that represent letters.

Activity: What is missing?

Fill in the missing letters. Use the words from this page to complete the crossword puzzle.



Letter	Binary
a	01100001
b	01100010
c	01100011
d	01100100
e	01100101
f	01100110
g	01100111
h	01101000
i	01101001
j	01101010
k	01101011
l	01101100
m	01101101
n	01101110
o	01101111
p	01110000
q	01110001
r	01110010
s	01110011
t	01110100
u	01110101
v	01110110
w	01110111
x	01111000
y	01111001
z	01111010

Did you know?

- Northrop Grumman software can contain millions of lines of code. That’s one big brain!
- The modern binary number system was invented in 1689 by Gottfried Leibniz!

Activity: Write Your Name in Binary!

Using the binary decoder on the right of the page, use the space below to write your name in Binary! This is how Elena would write her name: 01100101 01101100 01100101 01101110 01100001



Math is used in each area of STEM that you were introduced to today. Each uses a similar problem-solving approach and tools such as observation, comparison, measurement, and communication.

Mathematics is important to many different types of jobs at Northrop Grumman, including those related to engineering, manufacturing, finance and more. Each job uses math in a different way.

Decoder Box			
A	↘	L	↶
B	↗	M	↷
C	↙	N	↘
D	↔	O	↷
E	↕	P	↻
F	↔	Q	↷
G	↕	R	↻
H	←	S	↗
I	⇒	T	^
J	↑↑	U	↘
K	↓↓	V	└

Math is also important in our daily lives. We use addition, subtraction, multiplication and division when shopping, cooking, and other activities.

Types of mathematics include arithmetic, algebra, geometry, calculus, number theory and applied mathematics.

With a mathematics college education, you could have a career in medicine, cryptography, architecture, teaching, robotics or accounting. Each is challenging and fun in its own way!

Activity: Decode the message to find out an interesting fact.

↕ ↘ ↕ ↗ ⇒ ↘ ↕ ↕ ↕ ↻ ↗ ↗ ↷ ↶ ↷ ↕ ↻ ↻ ↷ ↗ ↶ ↕ ↕ ↗
 —————
 ↗ ↻ ↘ ↻ ↻ ↶ ↻ ⇒ ↘ ↕ ↕ ↘ ^ ← ↘ ↘ ↗
 —————
 ↗ ↙ ⇒ ↕ ↘ ↙ ↕
 —————

MATH-

Mohamet takes us to the Mission Control Center (MCC) where Northrop Grumman engineers use math equations to model the positions and velocities of our spacecraft!



Northrop Grumman Rockets launch Northrop Grumman spacecraft into orbits around the Earth or to other destinations in the solar system. The bigger the spacecraft, the heavier it is – which makes it harder to push up into orbit. A bigger rocket has a bigger force to push that spacecraft into orbit, but a bigger rocket is also heavier. How high a spacecraft will get is based on the Acceleration that the rocket can give it.



$$\text{Acceleration} = \frac{\text{Rocket Force}}{\text{Spacecraft Weight (Mass)}}$$

So acceleration is larger for smaller spacecraft and is larger for larger rocket force.

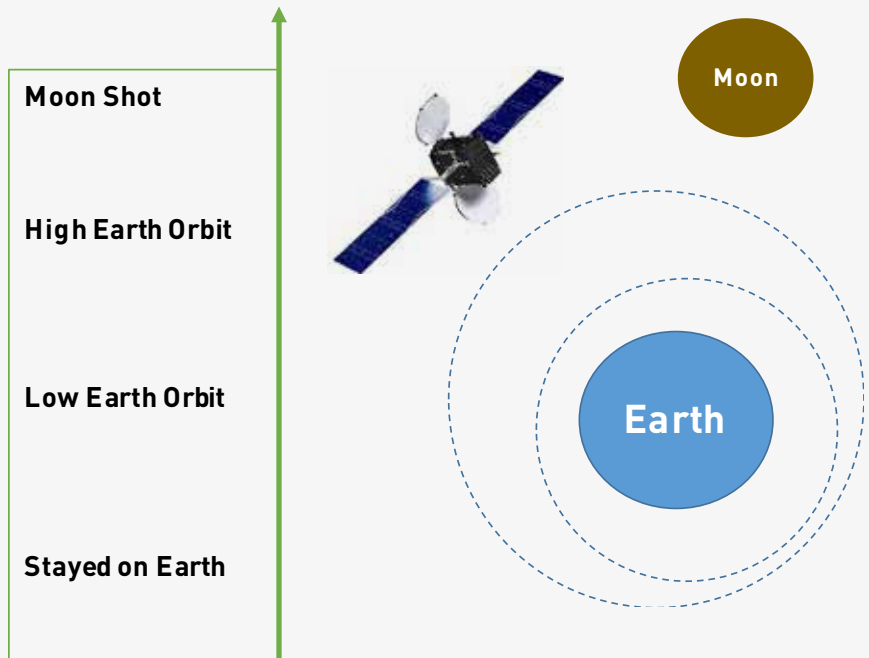
Our tour guide, Mohamet, has selected four combinations of spacecraft and rocket sizes...help him determine how high each will go! Solve the math division problems for them to determine how high the spacecraft will go in orbit! Sort the values from largest to smallest into the right boxes for how high they'll go.

$$\text{Accel} = \frac{2000}{200} = \underline{\hspace{2cm}}$$

$$\text{Accel} = \frac{100}{200} = \underline{\hspace{2cm}}$$

$$\text{Accel} = \frac{1000}{200} = \underline{\hspace{2cm}}$$

$$\text{Accel} = \frac{1000}{20} = \underline{\hspace{2cm}}$$



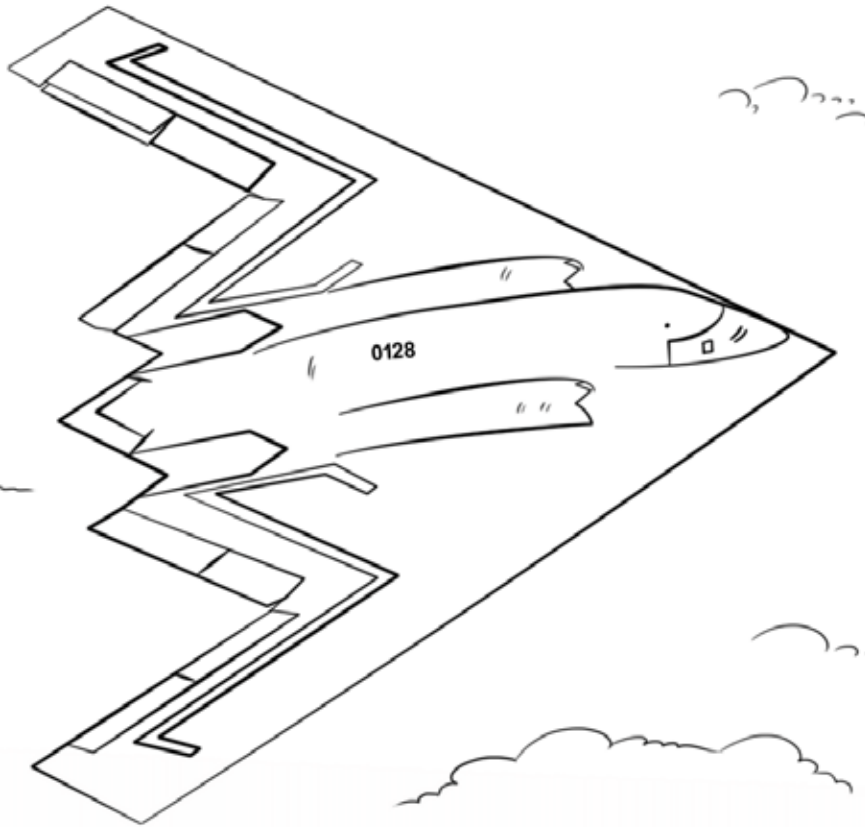
Did you know?

- Isaac Newton originally discovered the physics used in Mohamet's calculations in 17th Century, which Newton expressed as Force = Mass*Acceleration, which is shortened to F=m*a. For Mohamet's usage in this problem, he re-wrote the equation to solve for the Acceleration = Force / Mass.
- Gravity on Earth is actually an acceleration, which mathematicians refer to as g, the acceleration of gravity. The value of this gravitational constant on Earth is 9.8 meters/seconds².
- Johannes Kepler was a mathematician in the 16th century who is considered the 'father' of the equations and math models that were later developed for spacecraft orbit modeling and analyses.

MATH-

Mohamet reminds us that math and geometry are everywhere!

Mathematics has evolved just like airplanes...Fun fact: A "plane" in mathematics is a perfectly flat surface extending in all directions.



**Did you know
the B2 can fly
for 40 hours?!**

**If you could fly anywhere
in the world for 40 hours,
where would you go?**

Activity: Match the airplane with its fun fact!

- 1903 Wright Flyer
- 1918 J-13 Junker (F-13)
- 1926 Ford Trimotor
- 1947 F-86 Sabre
- 1970 Boeing 747
- First all metal transport aircraft
- First passenger aircraft
- First successful heavier-than-air powered aircraft
- Jumbo jet that revolutionized air transport
- First swept wing US jet fighter

What did you learn?

**Thank you, friends, for joining us today.
You were a big help; we had fun along the ways!**

**We made a great team; we hope you come back. There
is always so much to learn, about Science, Technology,
Engineering and Math.**

**From radars to cyber, from submarines to aerospace.
Dream big, work hard; you can be anything you want
to be.**

**Keep on learning, and doing your best in school.
Always remember, S-T-E-M is cool!**

**Thank you for visiting Northrop Grumman; this was such a blast.
Woohoo! We hope to see you again, real soon!**

Let's work as a team and re-discover what we learned today. Teamwork is a major part of engineering. Solving problems with a group of people with diverse ideas, varied skills and different ways of thinking is the most effective way. Communication, listening and respect are a part of teamwork.

1. What material has an electrical conductivity between a conductor and non-conductor?
2. What is the foundation of vibration testing?
3. What must gather information and communicate back to earth while being exposed to the harsh environment of outer space?
4. What protects against attempts to steal information or damage technology?
5. What is being used to transmit sound waves and detect the echo when the waves bounce off of objects?
6. Name the eight planes you searched for in "Look-n-Find"
7. What is used to represent text, computer processor instructions, or any other data using a two-symbol system?
8. In mathematics, what is a perfectly flat surface extending in all directions?



Answer Sheet

Science pg. 6

CONDUCTOR, INSULATOR, METAL, GLASS



CONDUCTORS



INSULATORS



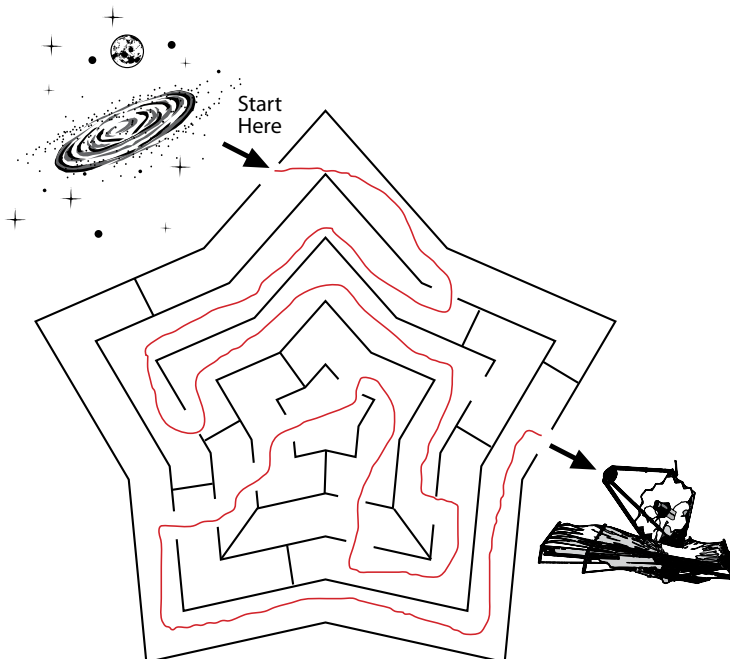
Science pg. 7

Sound waves
Microwaves
Ultraviolet (UV) waves

Water & Ocean Waves
Infrared (IR) waves
Radio waves

Light waves
X-rays
Earthquake waves

Technology pg. 8



Technology pg. 9

s s m t i n a n s i r s o
t r a n s m i s s i o n s

s v u r i c e d o
v i r u s **c o d e**

l s a e t e i t l
s a t e l l i t e

a i r o d a e v w s
r a d i o **w a v e s**

Answer Sheet

Math pg. 17

$$\text{Accel} = \frac{2000}{200} = \underline{\quad}$$

$$\text{Accel} = \frac{100}{200} = \underline{\quad}$$

$$\text{Accel} = \frac{1000}{200} = \underline{\quad}$$

$$\text{Accel} = \frac{1000}{20} = \underline{\quad}$$

Moon Shot

50

High Earth Orbit

10

Low Earth Orbit

5

Stayed on Earth

0.5

Math pg. 18

Activity: Match the airplane with it's fun fact!

1903 Wright Flyer	•	•	First all metal transport aircraft
1918 J-13 Junker (F-13)	•	•	First passenger aircraft
1926 Ford Trimotor	•	•	First successful heavier-than-air powered aircraft
1947 F-86 Sabre	•	•	Jumbo jet that revolutionized air transport
1970 Boeing 747	•	•	First swept wing US jet fighter

What did you know pg. 19

1. **Semiconductor**
2. **Waves**
3. **Satellite**
4. **Cyber security**
5. **Sonar**
6. **E-2C Hawkeye, Global Hawk, Wedgetail, AWACS, B-2 Spirit, B-1 Lancer, CRJ Test Plane, X-47**
7. **Binary code**
8. **Plane**

NORTHROP GRUMMAN

Northrop Grumman is a world-wide company that creates awesome systems, products and solutions to help keep us and our allies safe. We have employees across the world that come to work every day and help make a difference for all of us today and for the future for all of our customers, government and commercial.

Northrop Grumman isn't just powered by the latest and greatest technologies, but also some of the best engineers. We work really hard to be the best in five key areas:

- **Cyber** looks at computers and computer networks.
- **Logistics** is all about how to get things and people in the right place and the right time to get a job done.
- **Autonomous Systems** are things that work without a human to operate it – like airplanes that fly without a pilot.
- **C4ISR** stands for command, control, communications, computers, intelligence, surveillance and reconnaissance. C4ISR is all about getting the right information to the right people at the right time to make the right decision and achieve success.
- **Strike** provides the resources to our military and our allies to protect.

Stay Connected



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