Girls of Energy

SAFETY AND SECURITY CHALLENGE

TOP SUPERCOMPUTERS IN THE WORLD - FEATURING TWO of DOE'S!!

Summary: The U.S. Department of Energy (DOE) plays a very special role in keeping you safe. DOE has two supercomputers in the top ten supercomputers in the whole world. Titan is the name of the supercomputer at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. Sequoia is the name of the supercomputer at Lawrence Livermore National Laboratory (LLNL) in Livermore, California. How do supercomputers keep us safe and what makes them in the Top Ten in the world?

Titan Supercomputer at Oak Ridge National Laboratory

Background: ORNL is using computing to tackle national challenges such as safe nuclear energy systems and running simulations for lower costs for vehicle engines, airplane wings and power plants. Because virtual prototypes can be tested before their physical construction, Titan runs simulations on these prototypes to lower production costs.

In fields where scientists deal with issues from disaster relief to the electric grid, simulations provide real-time situational awareness to inform decisions. DOE supercomputers have helped the Federal Bureau of Investigation find criminals, and the Department of Defense assess terrorist threats. Currently, ORNL is building a computing infrastructure to help the Centers for Medicare and Medicaid Services combat fraud. An important focus lab-wide is managing the tsunamis of data generated by supercomputers and facilities like ORNL's Spallation Neutron Source.

In terms of national security, ORNL plays an important role in national and global security due to its expertise in advanced materials, nuclear science, supercomputing and other scientific specialties. Discovery and innovation in these areas are essential for protecting US citizens and advancing national and global security priorities.

Lawrence Livermore's Sequoia ranked No. 1 on the Graph 500 list for using new techniques to solve large complex national security problems.

Sequoia and LLNL: At Lawrence Livermore National Laboratory (LLNL), Sequoia is ranked No. 1 on the Graph 500 list for using new techniques to solve large complex national security problems. The Graph500 benchmark measures how quickly a system can search through vast (petabyte and exabyte-size) data sets. This is an important indicator of a system's usefulness because computer scientists increasingly use supercomputers to analyze massive data-intensive workloads in addition to executing traditional modeling and simulation tasks. Sequoia is one of the most efficient systems in the world for processing large data sets.

Sequoia supports two missions: quantify the uncertainties in numerical simulations of nuclear weapons performance and perform the advanced weapons science calculations needed to develop the accurate physics-based models for weapon codes. Both Sequoia and Titan are primarily water-cooled and significantly more energy efficient than comparable systems, which is essential in controlling operating costs.

Learning Objectives --After this activity, students should be able to:

- Understand the orders of magnitude and prefixes used in computing
- Manipulate the binary digit system
- Be introduced to the language of computers
- Describe the different missions for security available at the National Labs.
- Connect the Women @ Energy STEM professionals with the safety and security missions at the National Labs

Introduction: Supercomputers have the ability to process massive amounts of data very quickly. In order to learn more about what they are capable of doing and how supercomputers at DOE keep us safe, we need to have a general understanding of the basics. Learning the "language" of computing is just like learning the special phrases and meanings of different disciplines. Through the activities in this lesson, you will become more familiar with how computers work and what makes a supercomputer so awesome.

Activities: The Power-Up Activities that support this lesson can be viewed in the entirety in the activity section. The Power-Ups are introduced in the lesson to enable flow for the lesson activity.

Materials:

- Stopwatch (you can use the digital timer on your phone)
- Calculator
- Access to internet
- Set of five binary cards per group for Bits and Bytes

The Big and small—Working with Orders of Magnitude: As you begin your study of computer science, there are certain words and prefixes that you will become familiar with using. In order to understand large numbers (such as the capacity for memory on a supercomputer) or small numbers (such as those needed to describe the size of an electron), we must have a basic understanding of "orders of magnitude".

An order of magnitude is based on the power of ten (10), so the difference in one order of magnitude is 10. If there is a difference in 2 orders of magnitude, then there is a difference of 10x10 or 100. And the difference in 3 orders of magnitude is 10x10x10 or 1,000.

How can we understand orders of magnitude using our heart and provide order of magnitude by just looking as a number?

Before you begin, set your timer for one minute. Then, use your fingertips of your first two fingers on your right hand to find your pulse on your left wrist. Did you find it? Count the number of pulses in just 1 minute. What was your resting heart rate? How many times would your heart beat in an hour, in a day, in a week, in a year? What would the order of magnitude be for each time period?

THE POWER OF A PREFIX! In this power-up activity, you will learn about the different prefixes and the order of magnitude related to each name. These prefixes are important to understand both ends of the spectrum, from numbers that are extremely small to numbers that are extremely large.

What role does a prefix play in words like *micro*scope, *nano*technology, *Giga*bytes and *Tera*flops?

Using the table of prefixes, record all of the ones you have encountered before and what it is used to describe. See if you can come up with a list of 15 words that use different prefixes.

The Beauty of Energy Safety and Security: The Department of Energy works 24 hours a day to keep everyone safe and secure. This activity will help you match the picture to the special program involved in our safety and security. As you match the pictures, think about all of the different careers that are associated with this energy challenge. Visit the Women @ Energy page to learn more about the many career opportunities.

What are the different areas in which the Department of Energy is working for our safety and security? Look at each of the photos in the accompanying power-up activity and try to match it to the different areas of safety and security listed here:

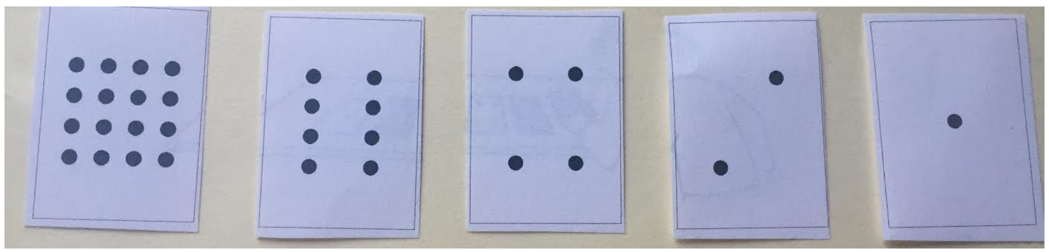
Biosecurity	Counterterrorism
Defense	Energy
Intelligence	Nonproliferation
Science	Weapons

Are there other pictures from other DOE National Labs that you can place in each special topic? Did you find STEM professionals at Women @ Energy that work in these specialty areas? What looks interesting to you?

Bits and Bytes: Learning the Basics

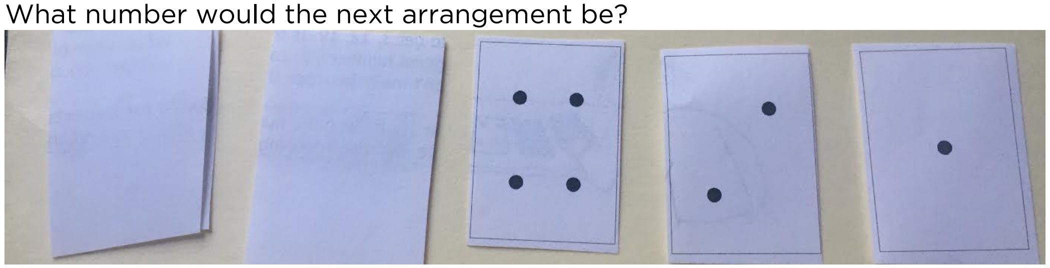
In this activity, you will be introduced to the binary digit or “bit” for short. A collection of 8 bits is called a “byte”. By using this special code, a computer translates information fed into it as just zeros (0) and ones (1) to turn the information into data and back to information for the user. You will do an activity to learn about how data in computers is stored and transmitted as a series of zeros and ones.

Procedure: Each group will have 5 cards with dots on one side and nothing on the other side. The cards should be placed from left to right as follows. Do you see a pattern? How many dots would be on the next card to the left?



When a card is “dot” side up, it is a 1, if it is blank it is a 0. You then add the number of dots on the card to give the number representation of the arrangement.

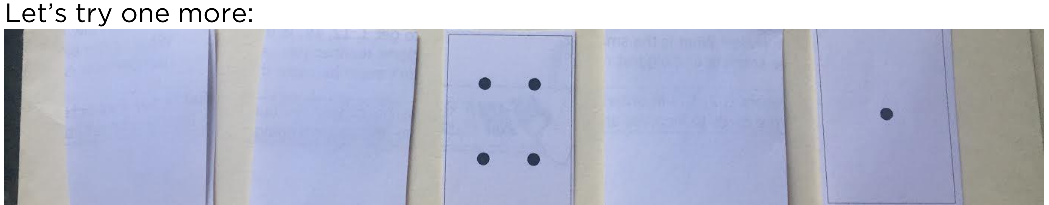
What number would the next arrangement be?



0 0 1 1 1

If you deduced 7, you are correct!

Let’s try one more:

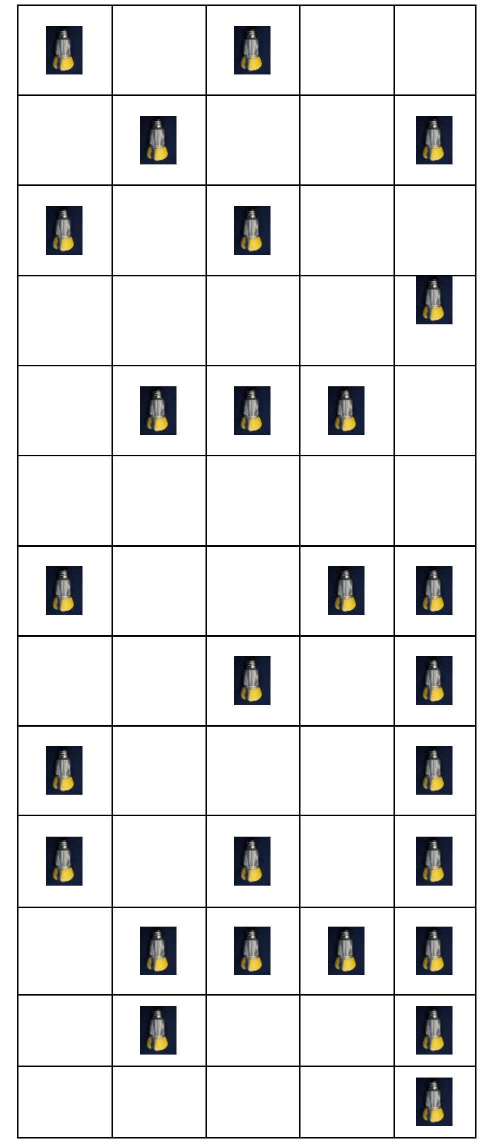


0 0 1 0 1

Did you get 5—if so, you are correct!

Computers use these series of 0’s and 1’s to process every bit of information that enters and everything that the user sees. Arrange your cards and write a number for 10101, 01100, and 00000. (Answers: 21, 12, 0)

Numbers can relate to the alphabet with A=1 all the way through Z=26. Write a number for each letter of the alphabet, then solve for the next message. Assume the 5 blocks represent the five cards in the specific order indicated in the first image of this activity. We will use a light bulb for 1, and the box will remain blank for 0.



What did you decode? Practice with your friends sending messages in your new secret code!

Next Generation Science Standards (NGSS 4,5, MS):
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.

Science and Engineering Practices: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)
Develop and use a model to describe phenomena. (MS-PS4-2)

Disciplinary Core Ideas: PS4.C: Information Technologies and Instrumentation Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)
PS4.C: Information Technologies and Instrumentation Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)

Cross-Cutting Concepts: Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)
Engineers improve existing technologies or develop new ones. (4-PS3-4)
Similarities and differences in patterns can be used to sort and classify natural phenomena. (4-PS4-1) Similarities and differences in patterns can be used to sort and classify designed products. (4- PS4-3)
A system can be described in terms of its components and their interactions. (4-LS1-1), (LS1-2)
The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)
Systems and System Models: Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)
Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)

Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-3)

Enrichment: To experience a visual, interactive orders of magnitude activity, go to: Secret Worlds: The Universe Within
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html

Sources:

1. Secret Worlds: The Universe Within http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html
2. Next Generation Science Standards www.nextgenscience.org

POWER UP ACTIVITIES FOR TOP SUPERCOMPUTERS LESSON

ACTIVITY ONE:

THE BIG AND SMALL — USING YOUR HEART

As you begin your study of computer science, there are certain words and prefixes that you will become familiar with using. In order to understand large numbers (such as the capacity for memory on a supercomputer) or small numbers (such as those needed to describe the size of an atom), we must have a basic understanding of orders of magnitude.

An order of magnitude is based on the power of ten (10). A difference in one order of magnitude is simply 10. If there is a difference in 2 orders of magnitude, then there is a difference of 10x10 or 100, and for 3 orders of magnitude the difference is 10x10x10 or 1,000.

Question:

How can we understand orders of magnitude using our heart and provide order of magnitude by just looking as a number?

Explore:

Using a stopwatch (you can use a digital timer on a digital device), set the timer for one minute. You can use the digital calculator later in the activity too. Before you begin, use your fingertips of your first two fingers on your right hand to find your pulse on your left wrist.

Did you find it? Count the number of pulses in just 1 minute. What was your resting heart rate? How many times would your heart beat in an hour, in a day, in a week, in a year? What would the order of magnitude be for each time period?

Explain:

Every time you feel your pulse, your heart beats. If you count 60 beats in one minute, then 60 beats x 60 minutes in an hour =3,600 beats per hour. If 60 is one order of magnitude, then 3,600 has 3 orders of magnitude. If we multiply the number of heartbeats in an hour by 24 hours in a day (3,600 x 24), we get 86,400 beats per day. That would be 4 orders of magnitude.

Do you see a pattern? Let's continue by multiplying 86, 400 beats per day by 7 days in a week (86,400 x 7) equals 604,800 which is 5 orders of magnitude. For the last calculation, figure out how many times on average your heart beat in a year. Multiply 604,800 beats per week by 52 weeks you get 31,449,600 beats per year, which equals seven orders of magnitude.

Did you find a pattern? Because our number system is based on tens, the order of magnitude is simply the number of digits in a number minus 1.

Let's double-check!

Number	Number of Digits (n)	Order of Magnitude (n-1)
60	2	1
3,600	4	3
86,400	5	4
604,800	6	5
31,449,600	8	7

We often use order of magnitude in science and engineering to help us relate to the scale of our world and estimate very small (the number of atoms within a given area) and extremely large numbers (the amount of data Titan and Sequoia can process).

For an interactive look at a specific scaling activity visit Secret Worlds: The Universe Within.

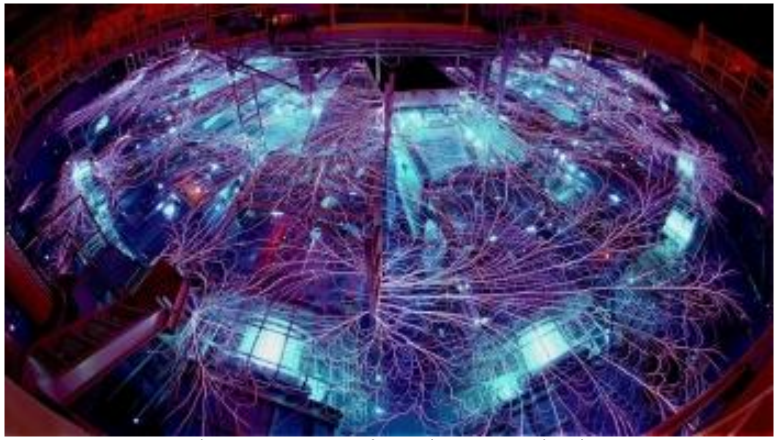


Image: Photo courtesy of Sandia National Laboratory

ACTIVITY TWO:

THE POWER OF A PREFIX

In this power-up activity, you will learn about the different prefixes and the order of magnitude that is related to each name. These prefixes are important to understand both ends of the number spectrum, from numbers that are extremely small to numbers that are extremely large.

Question:

What role does a prefix play in words like *micro*scope, *nano*technology, *Giga*bytes and *Tera*flops?

Explore:

Given the following table, record all of the prefixes you have encountered and what they describe. Can you come up with a list of 15 words that use different prefixes?

Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

Image courtesy of google.com

Explain:

Examine the list of words that you collected and look at the prefixes listed above in the chart. For each of your words, does it describe something small or something large? The table above splits the prefixes into two groups, the left column uses prefixes when referring to large amounts of something and the prefixes in the right column refer to small amounts of an object. So a ***micro***scope helps you to see things that are 1/1000 in size and ***nano***technology uses particles that are one billionth of a meter in size. ***Giga***bytes refer to one billion bytes of information, and a ***Tera***flop refers to a computers speed as 1 trillion operations per second.

ACTIVITY THREE:

THE BEAUTY OF ENERGY SAFETY AND SECURITY

The Department of Energy works 24 hours a day to keep everyone safe and secure. This activity will help you match the picture to the special program involved in our safety and security. As you match the pictures, think about all of the different careers that are associated with this energy challenge. Visit the Women @ Energy page to learn more about the many career opportunities. What are the different areas in which the Department of Energy is working for our safety and security?

Explore:

Look at each of the photos and try to match it to the different areas of Safety and Security listed here.

- Biosecurity
- Defense
- Intelligence
- Science
- Counterterrorism
- Energy
- Nonproliferation
- Weapons

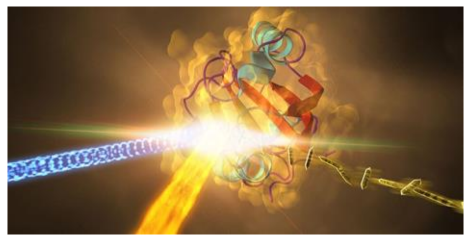


Image: Photo by Lawrence Livermore National Laboratory

Image: Photo by Lawrence Livermore National Laboratory

13-152-65 DOE photo Lynn Freeny 12-12-2013 Oak Ridge Tennessee

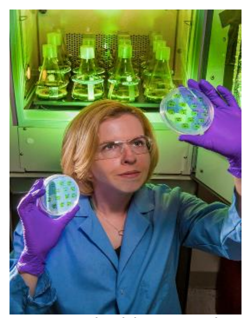


Image provided by Sandia Labs

Image provided by Sandia Labs

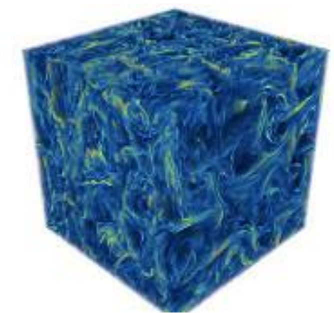


Photo by Los Alamos National Laboratory

Explain:

As you explore each of the types of safety and security provided by our National Labs, match the picture to the specific type of security it exemplifies. You can check your answers by visiting the Image Gallery at each of the labs listed to learn more about each image and how it plays into the mission of each laboratory. Make sure you check the different STEM careers through the Women @ Energy site to learn more about careers in Safety and Security.