
CHANGE YOUR VIEW OF OUR UNIVERSE
IMAX
HUBBLE 3D
NARRATED BY LEONARDO DiCAPRIO
WARNER BROS. PICTURES AND IMAX FILMED ENTERTAINMENT PRESENT "HUBBLE" IN COOPERATION WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NARRATED BY LEONARDO DiCAPRIO DIRECTOR OF PHOTOGRAPHY AND ASTRONAUT TRAINING JAMES NEIHOUSE MUSIC BY MICKY ERBE AND MARIBETH SOLOMON ASSOCIATE PRODUCER JUDY CARROLL EXECUTIVE PRODUCER GRAEME FERGUSON PRODUCED AND DIRECTED BY TONI MYERS
IMAX.COM/HUBBLE
IN COOPERATION WITH NASA
IMAX
WARNER BROS. PICTURES

EDUCATOR'S RESOURCE GUIDE

GRADES 6-8

	Building a Robotic Arm	The Spacesuit and Extravehicular Activity	Building a Model of the Hubble Space Telescope
Objectives	Students will implement the engineering process to design a robotic arm using common materials.	Students will investigate hazards of extravehicular activity (EVA) in space and the spacesuit design elements that make EVA possible.	Students will implement the engineering process to build a scale model of the Hubble Space Telescope using common materials.
Teacher Prep	You will need: • Computer (1) with internet access • Student handouts provided in activity • Stacking blocks: (4 per team) • Common household/ office supplies: clothes pins, brads, craft sticks, straws, paper clips, rubber bands, tape (clear or masking), twine, cardboard scraps, empty paper towel/tissue rolls, unsharpened pencils	You will need: • Computer (1) with internet access and other research materials • Educator Resource Key provided in activity • Student handouts provided in activity	You will need: • Computer lab with internet access • Student lab notebooks or notebook paper • Student handouts provided in activity • Common household / office supplies: aluminum foil, card stock, cardboard, construction paper, craft sticks, cylindrical items commonly found at home such as a paper towel roll or aluminum cans, glue guns, markers, pipe cleaners, rubber bands, scissors, string, tape
Extensions	Engage students by showing video clips from http://www.nasa.gov/mission_pages/hubble/servicing/SM4/main/SM4_Essentials.html and discuss the difficulties encountered when engineering tools to use in space.	Engage students by researching the hazardous conditions astronauts are exposed to during spacewalks. Demonstrate the effects of extreme low pressure on a "marshmallow astronaut" by showing students the following video segment: http://phun.physics.virginia.edu/demos/marshmallow.html Send students to the following website for an interactive spacesuit experience: http://www.nasa.gov/audience/foreducators/spacesuits/home/clickable_suit.html	Engage students by visiting http://www.nasa.gov/education/hubble or http://hubblesite.org/ to research Hubble's dimensions (length and diameter). Students act as engineers to design and evaluate a scale model of the Hubble Space Telescope.

Lessons address **NSES standards** (Understanding about Science and Technology; Science as a Human Endeavor; Nature of Scientific Knowledge) and **ITEA standards** (Understanding the Influence of Technology on History; Understanding the Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving).

For additional educational materials that support SM4* events, visit : http://amazing-space.stsci.edu/sm4/.

Special acknowledgment and thanks to Bonnie McClain (NASA Goddard Space Flight Center Office of Education) and to Bonnie Eisenhamer (Space Telescope Science Institute HST Education Manager) for their contributions.

BRING THE UNIVERSE TO YOUR STUDENTS' FINGERTIPS:

Each of the activities provides hands-on extensions connected to viewing *Hubble 3D*.

IMAX films are ideal teaching tools that:

- present new knowledge in a powerful, popular medium
- inspire thoughtful and lively classroom discussion
- motivate students for extended learning

Field trips are economical and easily arranged. To book a field trip, contact your local IMAX theatre today. Visit **www.imax.com/newsletter** to sign up for the latest news and updates on IMAX educational programs and events. For locations near you, visit **www.IMAX.com**.

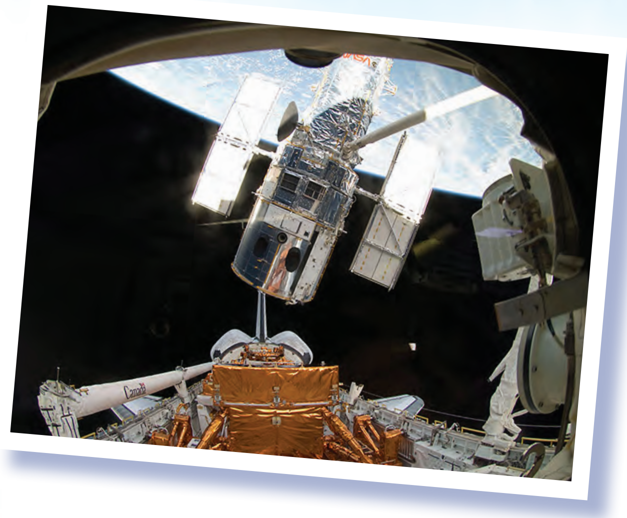
Engage your students with an unforgettable learning experience.

BOOK YOUR IMAX FIELD TRIP TODAY!

*Also referred to as the STS-125 mission.

NAME: ______________________ GRADE: ________

BUILDING A ROBOTIC ARM



BACKGROUND:

In May 2009, astronauts visited the Hubble Space Telescope for the last time. Service Mission 4 (SM4) was one of the most daring space repair efforts ever attempted. Supported by engineers at Goddard Space Flight Center, space shuttle astronauts made many improvements to Hubble during several challenging spacewalks. During SM4, astronaut Megan McArthur operated a robotic arm to grab the Hubble Space Telescope and pull it onto a platform at the rear of the shuttle's payload bay. Scientists hope all the improvements made during SM4 will extend Hubble's service by at least five years.

YOUR MISSION:

Plan and build a robotic arm from common items. The robotic arm needs to be able to stack four (4) blocks without you or your team touching them with your hands.

YOUR TASK:

PART 1:

DESIGN AND CREATE A ROBOTIC ARM.

STEP 1: Form a team of four members.

STEP 2: Examine the materials your teacher has made available. Your team may use any of these items to design and build a robotic arm.

STEP 3: Use HANDOUT A to brainstorm ideas on how your team will build a robotic arm.

STEP 4: Use HANDOUT B to finalize your team's design, identify the materials needed and sketch a detailed drawing of your design.

STEP 5: Build and test your team's robotic arm.

STEP 6: Use HANDOUT B to evaluate your team's robotic arm by listing the strengths and weaknesses of the design as well as possible improvements that could be applied.

PART 2:

DEMONSTRATE AND SHARE THE ROBOTIC ARM DESIGN WITH THE OTHER DESIGN TEAMS.

PART 3:

DISCUSS WAYS TO IMPROVE THE DESIGNS. USE THESE QUESTIONS TO GUIDE DISCUSSION:

1. How is your robotic arm similar to the arm shown in the video segments and images? In what ways does it differ?
2. How would you redesign your model for different tasks (heavier blocks, smaller blocks)?

NAME: ______________________________ GRADE: __________

BUILDING A ROBOTIC ARM

HANDOUT A - BRAINSTORM

BRAINSTORM:

As a team, brainstorm three possible ideas for designing and building a robotic arm. Use this worksheet to take notes.

IDEA 1:

IDEA 2:

IDEA 3:

CHALLENGES:

Identify any challenges you anticipate with the design ideas your team has identified.

NAME: ______________________________ GRADE: ____________

BUILDING A ROBOTIC ARM

HANDOUT B - FINALIZING YOUR TEAM'S PLAN

MATERIALS:

List the materials your team will need to construct your robotic arm. Take your proposed list of materials to the Mission Specialist (your teacher) for approval.

DRAW:

Draw a detailed sketch of your team's final design. Label the sketch with dimensions and materials needed for each part.

EVALUATE:

1. List the strengths and weaknesses of your robotic arm's design.

Strengths	Weaknesses

2. List possible improvements to your team's design. If you were to rebuild, what would you do differently and why?

NAME: ______________________ GRADE: __________

THE SPACESUIT AND EXTRAVEHICULAR ACTIVITY

BACKGROUND:

Orbiting for the past 19 years, 350 miles above the Earth's surface, the Hubble Space Telescope has been visited five times by NASA astronauts. On the last servicing mission (SM4), the astronauts performed a series of five spacewalks (also known as extravehicular activity or EVA) to improve and maintain instruments so that Hubble may continue to gather data until 2014. Constant support from engineers on the ground at Goddard Space Flight Center also aided the astronauts during these dangerous spacewalks. In order to survive the extreme environment of space during EVA, astronauts wore specially engineered spacesuits. Footage of these awe-inspiring spacewalks can be seen in *Hubble 3D*.

YOUR MISSION:

List hazardous conditions encountered by astronauts during spacewalks. Then, identify design elements on spacesuits that were created to protect astronauts when in space.

YOUR TASK:

STEP 1: Go to **http:/nasa.gov/home.index.html** and research the hazardous conditions that astronauts encounter in space. Record your findings in the "Research" column on the Spacesuit Solutions worksheet (HANDOUT A).

STEP 2: Visit **http://www.nasa.gov/audience/fore-ducators/spacesuits/home/clickable_suit.html** for an interactive spacesuit experience where you will learn more about the components of a spacesuit. Identify design elements engineers use to protect astronauts from the hazardous conditions in space. Record these design elements in the "Spacesuit Solutions" column on your Spacesuit Solutions worksheet (HANDOUT A).

STEP 3: Debrief. Share your list with the rest of the design team and discuss what you have learned about hazardous conditions in space and how spacesuits protect astronauts during EVA.

1. Are any of the spacesuit solutions you identified designed to address multiple hazards?
2. Are there risks that you identified for which spacesuits do not appear to protect astronauts?

YOU MAY FIND THESE WEBSITES HELPFUL:

- NASA article, NASA "Spacesuits" Help Brothers With Rare Genetic Defect **http://www.nasa.gov/centers/john-son/news/releases/1996_1998/j97-30.html**
- NASA eClips video segment, The Making of the Biosuit (7:02). **http://www.youtube.com/watch?v=GoS4Lzr4dhE&feature=PlayList&p=D7BEC5371B22BDD9&index=1**
- NASA eClips video segment, Protective Materials for Spacecraft (6:27) **http://www.youtube.com/watch?v=H6EL9kdzaXw&feature=PlayList&p=D7BEC5371B22BDD9&index=2**
- NASA multimedia gallery, Evolution of the NASA Spacesuit **http://www.nasa.gov/multimedia/mmgallery/fea-tures_archive_1.html**

NAME: ______________________ GRADE: __________

SPACESUIT SOLUTIONS

HANDOUT A

DIRECTIONS:

Every time an astronaut goes into space, he/she must be prepared for the space environment. Using the following two website links, **http://www.nasa.gov/home/index.html** and **http://www.nasa.gov/audience/foreducators/space-suits/home/clickable_suit.html**, research the hazardous conditions astronauts experience during the spacewalks and find the "spacesuit solutions" designed by scientists and engineers to address these hazards.

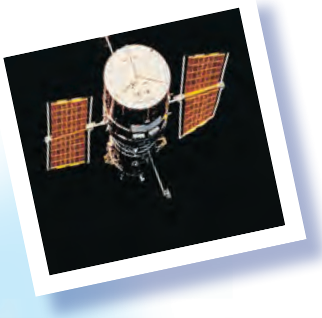
Factors	Research	Spacesuit Solutions
Atmosphere		
Radiation		
Pressure		
Debris		
Temperature		
Light		
Microgravity		

THE SPACESUIT AND EXTRAVEHICULAR ACTIVITY

Factors	Research	Spacesuit Solutions
Atmosphere	No oxygen in space. Above the 63,000-foot threshold, humans must wear spacesuits that supply oxygen for breathing.	• Primary Life Support Subsystem • Secondary Oxygen Pack • Vent Flow Sensor • Contaminant Control Cartridge removes CO2 from the air the astronaut breathes
Radiation	Ultraviolet radiation constitutes one of the most dangerous hazards for crew members on long duration space missions. While small amounts of radiation reach people on Earth, it is much more intense in space. An astronaut performing an EVA is exposed to about 27 times more radiation particles than the average person on Earth.	• 11 fabric layers of thermal micrometeoroid garment • Helmet • Extravehicular visor assembly • Visor
Pressure	No atmospheric pressure in space.	• Pressure garment that maintains pressure around the body to keep body fluids in the liquid state.
Debris	One reason spacewalks are dangerous is collision with space debris (which can be as small as tiny flecks of paint that have come off spacecraft). An object as small as 1 millimeter in length can cause damage to a spacesuit since it is traveling at speeds up to 17,000 mph.	• Thermal micrometeoroid garment provides protection from bombardment by micrometeoroids.
Temperature	Without the Earth's atmosphere to filter the sunlight, the side of the suit facing the Sun may be heated to a temperature as high as 250 degrees Fahrenheit; the other side, exposed to darkness of deep space, may get as cold as -250 degrees Fahrenheit.	• Liquid Cooling and Ventilation Garment contains liquid cooling tubes that maintain body temperature. • Gloves protect from hot or cold thermal objects.
Light	The Hubble Space Telescope orbits the Earth once every 90 minutes. Astronauts working in space experience "day and night" in each orbit.	• Battery provides power to lights. • Extravehicular visor assembly can be adjusted to shield the astronaut's eyes.
Microgravity	The body changes in order to accommodate the environment. Since astronauts don't rely much on the lower body to move, the bones and muscles begin to weaken. The astronauts must exercise every day to maintain their bone and muscle mass.	• Tethers, harnesses

NAME: ______________________ GRADE: __________

BUILDING A SCALE MODEL OF THE HUBBLE SPACE TELESCOPE



BACKGROUND:

Launched in April 1990, the Hubble Space Telescope (HST) is one of the greatest advancements in the history of technology and science. The HST still orbits Earth and collects data that is invaluable to astronomers and the public worldwide. Astronomers have used Hubble data to publish more than 7,500 scientific papers.

YOUR MISSION:

Demonstrate the engineering process involved in the design of the Hubble Space Telescope.

YOUR TASK:

Design and build a scale model of the Hubble Space Telescope while keeping within a designated budget.

STEP 1: Form into a team of two or three members.

STEP 2: Research the dimensions (length and diameter) of the Hubble Space Telescope. Visit **http://www.nasa.gov/education/hubble** or **http://www.hubblesite.org**. Record the dimensions and pertinent notes in your lab notebook.

STEP 3: Examine the materials your teacher has provided. Select a cylindrical item as a base for the model and apply ratios to determine the scale of the model. Use the procedure demonstrated by your teacher.

STEP 4: Draw and label a detailed plan for your team's model. Make sure to keep the scale accurate. Consider moving parts or other possible aspects to your design.

STEP 5: Your team has a budget of $5.00 to "spend" on materials. Determine which of the available materials you will need in order to create your model. Refer to the Suggested Pricelist (HANDOUT A) as you fill in your Budget Worksheet (HANDOUT B). Bring your Budget Worksheet to your teacher for approval and to "purchase" your materials.

STEP 6: Build your model of the Hubble Space Telescope.

STEP 7: Teams, share your models with the class and discuss the process and design you used to construct your model.

STEP 8: Debrief using the following questions:

1. How difficult was it to stick to a budget?
2. Were there elements of your design you left out because they were too costly?
3. Are there features on your model that other teams included, but built with cheaper materials?
4. What features from other designs would you include if you were to build another model?
5. What features would you not include in a second model?

NAME: ______________________________ GRADE: ____________

SUGGESTED PRICELIST

HANDOUT A

Item	Cost
Cylindrical item (paper towel roll, aluminum can…)	**$0.10**
Card stock	**$1.00**
Craft stick	**$0.20**
Construction paper	**$0.20**
Pipe cleaners	**$0.05**
Corrugated cardboard	**$1.00 per sq. foot**
Aluminum foil	**$0.50 per sq. foot**
Markers	**$0.50**
Tape	**$0.50 per foot**
Rubber bands	**$0.05**
String	**$0.05 per foot**
Transparent tape	**$1.00**
Glue guns, scissors	**Free to use**

NAME: ______________________________ GRADE: __________

BUDGET WORKSHEET

HANDOUT B

After completing your budget worksheet, see your teacher for budget approval and to "purchase" your materials.

Material	Cost Per Piece	Quantity Needed	Total

GRAND TOTAL: ____________

(Cannot exceed $5.)