Curiosity Hacked Asteroid Badge

Guild Throughlines

1. What kinds of ideas and projects catch my attention and make me excited to explore and learn? What concepts and skills would be valuable to me?
2. When do I feel the most confident during working time?
3. What steps do I need to take in order to take charge of my own learning?
4. How can I use the resources available to meet my goals?
5. How can I share what I learn with others?

Badge Design Process

1. Identify goals
2. Generate ideas
3. Design
4. Create
5. Test
6. Evaluate
7. Redesign (and repeat 4-7 as necessary)
8. Share

Badge Objectives
(what info needs to be acquired, retained, and applied for skill/concept mastery?)

- Understand asteroid composition and behavior
- Learn how to track and report asteroids
- Learn about asteroid avoidance possibilities
- Explore the possibility of asteroid colonization, space travel, and mining

Suggested Prerequisite Badges: Astronomy and Space Technology

Badge Overview
(what is the intention of this badge? Why are we doing this? Why is it important?)

Asteroids are small rocky planet-like objects that are left over debris from the creation of the solar system. The creation of Jupiter was an especially turbulent time when any objects between Mars and Jupiter collided with each other and unable to reform.

Asteroids are vary in size from the 6m (20 feet) across 1991 BA to the 940km (583 mile) Ceres. Most asteroids are irregular in shape, although there are a few spherical exceptions such as Ceres. The average surface temperature of an asteroid is -100°F (-73°C). Asteroids are often pitted and cratered and haven't changed much since the formation of the solar system.

Asteroids can be found just about anywhere in our solar system, however the majority of them orbit the sun in a band between Mars and Jupiter. Scientists estimate that the asteroid belt contains close to 750,000 objects that are at least 1 km in diameter, and at least two hundred of them are larger than 100 km in diameter. Additional asteroids can be found it two separate locations on Jupiters ecliptic. The orbit with Jupiter and maintain a balanced orbit unless something knocks them away. Much like planets, asteroids have elliptical orbits around the sun. Asteroids rotate and tumble erratically, occasionally orbiting other asteroids. Many large asteroids seem to have been captured by the gravity of a much more massive planet, and become moons, such as in the case of Mars's moons Phobos and Deimos.

Asteroids have been a popular target for spacecraft since 1991, when Galileo took the first close-up pictures of an asteroid. Galileo later found the first moon orbiting an asteroid in 1994. NASA's NEAR spacecraft spent a year orbiting the near-Earth asteroid, Eros, before scientists and engineers decided to attempt a landing on the asteroid before ending the program. When NEAR landed in 2001, it successfully became the first spacecraft to land on an asteroid. In 2006, Japan's Hayabusa spacecraft became the first to successfully land and take off from an asteroid. Hayabusa returned to Earth in 2010 with valuable rock samples. NASA sent the Dawn spacecraft, launched in 2007, to explore Vesta and Ceres. Having explored Vesta since 2011, it is scheduled to start exploring Ceres in 2015.

In February 2013, the Chelyabinsk meteor surprised the world with its massive fireball over Russia. The object was undetected prior to the fireball, mostly because its orbital trajectory was very close to the sun's path which made it very hard to see. The Chelyabinsk meteor measured 20 meters in diameter and weighed close to 13,000 metric tonnes, making it the largest recorded object to enter the Earth's atmosphere since the 1908 Tunguska event that destroyed a large Siberian forest. The low entry angle of the Chelyabinsk meteor caused it to explode just less than 30 km above the Earth's surface, showering the area with tiny meteor fragments. The explosion caused a massive shock wave that damaged 7200 buildings and sent thousands of people seeking medical care, mostly from broken glass wounds. The atmosphere absorbed the majority

of the meteors energy, which was equivalent to 500 kilotons of TNT or 20-30 times the energy released from the atomic bomb dropped on Hiroshima. The results of a meteor of this size hitting the Earth would have been devastating, but still not an Earth-killer event. It is surprise events like the Chelyabinsk meteor that has made NASA and other international space organizations take such a keen interest in finding asteroids before they approach the Earth.

In June 2013, NASA announced a Grand Challenge focused on finding asteroid threats to Earth, and determining what to do about them. This Grand Challenge called both professional and citizen scientists to come together to find solutions to potentially killer asteroids.
https://www.youtube.com/watch?v=f5rsJwsyni4

Mentor Resources:
(websites, etc we have found helpful for supporting mentors in guiding this badge)

Sentinel Mission/ B612 - putting a telescope in deep space orbit to hunt asteroids capable of impact.

Planetary Resources - well funded company putting telescopes in earth orbit to find profitable asteroids and eventually mine them

Deep Space Industries - focused on prospecting, harvesting and processing asteroid resources.

Many of the links listed within the activities will also be useful to mentors.

Lessons and Activities to support Badge Objectives:

Note: These are activities and resources meant to help facilitate the acquisition and retention of the skill or concept being mastered. They are not, however, mandatory. A dialogue between the Mentor and young hacker should result in a plan to meet the requirements of this badge with the child's vision as the guide. That may include some or all of the activities below, or it may be designing a new project. The mentor will help to shape the plan so that the child can master the skills through what he or she deems valuable, while still ensuring a comprehensive education in this skill/concept.

Asteroid Motion

Tumbling Asteroid
Create a flipbook of Hubble Space Telescope images to view the tumbling motion of the asteroid Vesta.
http://dawn.jpl.nasa.gov/DawnKids/SAYourMissionFlipbook.pdf

3D Printed Asteroids and their motion

The Japanese sent a probe to Itokawa in 2003 to collect samples of its surface and return them to Earth. While the mission was riddled with problems, they were able to get incredibly detailed images of the asteroid. NASA has released detailed models of two asteroids, Itokawa and Vesta. These models can be loaded into any 3D printer, and you can print your own asteroid.

1. Print one or both of these models on a 3D printer.
    a. Itokawa: http://nasa3d.arc.nasa.gov/detail/itokawa
    b. Vesta: http://nasa3d.arc.nasa.gov/detail/vesta
2. Glue the two halves together with 2 paper clips placed in the seam at the center of gravity about 1 cm apart. These paper clips will be the mounting pins for your rotation device.
3. Paint them with a matte grey paint.
4. Create a rotation system
    a. Materials: a small electric motor with a 1⁄4-inch drive shaft to provide a means of rotating the asteroids at a constant, slow rate. A heavy-duty motor that revolves at a steady 3 rpm is sold by Scientifics at a nominal price that works exceedingly well for this activity. The directions that follow utilize this motor. The motor has a hole in the shaft and a flange that permits it to be attached to plywood or another base with screws if it is so desired; a 2- to 3-inch piece of electrical or other tape that is about 3⁄4-inches wide; a small hose clamp; a 3⁄4-inch long paper clip that has been cut with wire cutters to provide a loop 31⁄4 inches long; and a small screwdriver.
    b. Insert the loop of the cut paper clip into the hole in the motor's shaft so that the cut ends are pointing upward. Hold it in place while you tightly wrap it with the tape. Next, place the hose clamp over the tape and tighten it securely with a screwdriver. The asteroid mounting pins can be taped on the upward-pointing ends of the cut paper clip to mount them securely to the motor and shaft.
    c. First start with Vesta, the more spherical asteroid. Securely tape the asteroid mounting pins to the rotating device.
5. In a darkened room, turn on a 40W lamp so that it is facing the asteroid. Turn on your rotation motor. Make observations and drawings about the asteroid. What can you learn about the shape of the asteroid through observing the changing shadows of the rotating asteroid?
6. Repeat this with the Itokawa model. What do you notice is different between the shapes?
7. Try changing the axis of rotation. How does this change what you can learn about the surface and shape of each asteroid?

Asteroids vs. Meteors vs. Meteorites

While we have discussed asteroids in detail above, asteroids are often confused with meteors or meteorites. A meteorite is any object that has entered the atmosphere of another object and survived to impact the surface. Another way to explain a meteorite is to say that they started out as little chunks of rock and debris in space called meteoroids. They become meteors when they fall through a planet's atmosphere; leaving a bright trail as they are heated to incandescence by

the friction of the atmosphere (shooting stars). Pieces that survive the journey and hit the ground are called meteorites. Occasionally, an object large enough to be considered an asteroid will enter an atmosphere. Its remnants are also called meteorites if they impact the surface. To nail down the answer to ”what is the difference between asteroids and meteorites”, it is their location. An asteroid is always going to be in space. Once it enters an atmosphere it becomes a meteor, then a meteorite if it hits the ground. A meteorite is always going to be on the ground. Each is made of the same basic materials: metal and rock. Each originated in space. The main difference is where they are when they are being observed.

Collect Stardust

Meteorites are space debris that survive the trip through the atmosphere and land on the Earth's surface. You can collect particles in the air and search through them to find micrometeorites that have fallen in your own backyard.
http://www.pbs.org/wgbh/nova/education/activities/3111_origins.html

Virtual Micrometeorite Search

When you don't have the ability to collect your own stardust, this site allows you to virtually search slides of objects just like you would with a regular microscope.
http://virtual.itg.uiuc.edu/

Identify A Meteorite

Rock samples can be bought online or touchable sets can often be borrowed from local museums. Try to determine if each of these samples are a meteorite using the following criteria.

Meteorite!	Not a Meteorite
Dark on the outside. Meteorites have black or rusty brown outer layer – a fusion crust - formed when the meteoroid was heated as it fell through Earth's atmosphere.	*Bubbly or with holes.* If the rock outside looks bubbly or frothy, or if there are holes inside, it's not a meteorite. *Round.* Most meteorites are very irregular in shape. They rarely are round or shaped like a projectile (bullet).
Finger pokes on the outside. Got regmaglypts? Great word, yes? Meteorite surfaces usually are smooth and don't have features. But some have regmaglypts; this just means deep circular pits in the surface of the meteorite. They look like someone has poked their finger in soft playdoh.	*Quartz crystals.* Quartz only occurs on Earth, because of our unique geologic processes. If you see quartz – or fossils – it is not a meteorite. If you see lots of other bright crystals, it also is probably not a meteorite.
HEAVY! Many meteorites have iron or nickel in them, so they are relatively much heavier (actually, more dense) than Earth rocks.	*Color.* If you can make a colored streak of black or red on a piece of unglazed tile, it probably is not a meteorite. Unless the meteorite is very weathered, it will not leave a streak.

Shiny inside! Some meteorites are nearly all iron and they have a silvery inside. Others have small flecks of shiny metal on their insides.	
Magnetic! Most meteorites have some iron or nickel in them, so they attract a magnet easily.	Some Earth rocks are magnetic, too.
Little stoney balls inside. Most meteorites are chondrites . They contain small balls of stony material called chondrules that are about a millimeter (1/25 inch) across	

Solid vs. Bundled Danger

Asteroids can be large solid rocks or bundles of rocks that are joined by a mutual gravitational pull towards each other. Both are dangerous, but you might be surprised by the difficulty in destroying or diverting a simple bundle of rocks compared to a large solid mass.

Deflect an Asteroid

Play a game to see if you can deflect the asteroids from hitting Earth in time.
http://www.killerasteroids.org/interactives/rubblekiosk/index.php

Rubble! Game

Physics based game to teach you how to push asteroids into safe orbits before they hit Earth.
http://www.killerasteroids.org/interactives/rubblegame/index.php

Finding An Asteroid

Asteroids are very small and far away, so they are rarely seen as anything but a small point of light through a telescope. Backyard astronomers use light curves from those points of light to view how the brightness of an object changes over time. Through measuring light curves over time, you can look for brightness patterns to repeat, and determine its rotational speed. When you take observations of the same asteroid over time, meaning that we have moved in the Earth's orbit and the asteroid has moved independently in its own orbit, you can even start to develop an idea of the 3D shape of the asteroid. The big research telescopes don't have the resources to observe possible asteroids for long periods of time, however, small commercial telescopes are powerful enough to do the job. This is why backyard astronomers are so important in the search for asteroids.

The WISE spacecraft is one of the few research spacecraft that are dedicated to the search for asteroids in space. This spacecraft collects light curves in the infrared part of the spectrum, a particularly difficult part of the spectrum to see from ground based instrumentation because of our atmosphere. Visible light curves simply show how much light is reflected from the surface of the object, they will look the same from a large object with a very low albedo, or a small rock with

a high albedo. Infrared light curves show how much the object is warmed and you can determine the size of the object in question.

Identify an Asteroid from its Light Curve
Learn how to virtually recognize an asteroid light curve and learn what the light curve can tell you about the asteroid you are investigating.
http://www.killerasteroids.org/interactives/lightcurveweb/index.php

Blink And They Appear
The National Schools' Observatory is a national website established by Liverpool John Moores University, UK. Using this site, students are able to make their own observations along side professional astronomers with the world's largest fully robotic telescope - the Liverpool Telescope. Five percent of all time allocated to observations on this telescope is specifically for school age kids. As a student you put in a request for time and when it is completed, you are able to download the telescope data and use the LTImage software to analyze the images. The LTImage tool is an image-processing tool that was developed by the NSO and adapted specifically for use by students. LTImage can work with any image in a FITS format, the standard format from most professional telescopes around the world. NSO has provided a step-by-step guide including test images to show you how to use the software to view images and how to utilize a blinking method to find asteroids between images taken at different times in the same night. Once you become proficient with the test images request your own images from Liverpool Telescope or other professional observatory and report possible asteroids online.
http://www.scienceinschool.org/2011/issue20/asteroids

If you think you have found an asteroid, keep a log of the RA and DEC of the object and check your findings with the already known objects using the Minor Planet Checker.
http://scully.cfa.harvard.edu/cgi-bin/checkmp.cgi

Asteroid Zoo
Zooniverse is a collection of web-based citizen science projects that utilize volunteers to help researchers process the massive amounts of data that might contain important information. Asteroid Zoo is a project specifically designed to search for asteroids in the Catalina Sky Survey data, a NASA project specifically funded to find asteroids (or near earth objects) with a radius larger than 100m. Asteroid Zoo does all of the processing for you so that you can use the blink method to find objects that change position or brightness between the 4 images provided. This is a much more user friendly version of the NSO version above, however you are joining a hive mind rather than doing individual discovery.
http://www.asteroidzoo.org

Become a Backyard Astronomer
Learn to use your own telescope in the search for asteroids. Quality commercial telescopes and CCD technology has made this possible, however it is very challenging and should only be

attempted after trying the methods above so that you will know exactly what to look for in your field of view.
http://www.skyandtelescope.com/observing/hunting-asteroids-from-your-backyard/

Asteroid Mining

Asteroids are from the formation of the solar system they, so they are interesting because they teach us about the primordial planetary building blocks. Asteroids could be full of valuable minerals such as platinum and gold that companies could mine for profit. Asteroids could also contain mineable water that could be separated into its hydrogen and oxygen components to create rocket fuel. Learning to mine and process water in space is instrumental in the future of space travel since it allows spacecraft to refuel in space and extend their range.

Mine an Edible Asteroid

The link contained includes a recipe to create an edible asteroid that can be carefully mined for resources, much like a real asteroid. Learn how to scientifically observe an object, take a core sample and make very detailed observation logs about your findings.
Activity 2: https://solarsystem.nasa.gov/docs/Asteroid_Mining.pdf

Space Apps Challenge

Join the International Space Apps Challenge and develop a game to travel across the solar system going from asteroid to asteroid. The strategy is to decide which asteroid to visit and mine next, given a field of asteroids that vary in location, composition, size, and more. You will utilize NASA technical reports to find creative solutions to the international concerns about asteroid mining and utilization. https://2014.spaceappschallenge.org/challenge/asteroid-prospector/

Colonization

Science Fiction has long used asteroids as a base of operations for space travel and mining, however, have you ever considered the advantages or disadvantages to asteroid colonization?

Advantages

- Low gravity reduces the risk of landing compared to large planets with higher gravity.
- Building technologies, i.e. cranes, would be simpler with lower gravity.
- There are many asteroids to choose from so finding a suitable asteroid is more likely.
- Asteroid composition varies, so finding an asteroid that has materials that can be processed and used as building materials is likely.
- Some asteroids that cross the Earth's path require less energy to get to than even the moon.
- Minerals mined from asteroids could be returned to Earth for economic gain.
- The small size of most asteroids allow for efficient exploration and utilization of both the surface and the interior.
- High vacuum of space and the low gravity would facilitate hi-tech industries to evolve their tech beyond what they can do confined to Earth.

Disadvantages

- Humans cannot live in low gravity forever, they would need to adapt or some sort of artificial gravity would need to be created.
- Solar energy would be 4 to 16 times less efficient since most asteroids are further from the sun than the Earth.
- Many asteroids are bundles of rocks rather than solid, and will likely break apart when mined or explored.
- Asteroids have no atmosphere or magnetosphere, so are particularly vulnerable to solar radiation and impacts from space debris.

Issac Asimov believed that cities could be created within hollowed out asteroids. Using the advantages and disadvantages above design your own asteroid colony. It might help to refer to the Space Colonization Badge for more information about what a space colony would need for sustainability.

Additional Resources: **(any other resources that may be related to the badge skill, but not essential to the objectives)**

Asteroid Response Center

Maui Middle School Video Production on Asteroids

Ultrascope

DIY Space Exploration (promotes asteroid hunting)

Share:
How can I share my knowledge with others? Did I document my project through notes and/or photos? Did I find an activity or resource that was particularly interesting or helpful?
Mentors will help our Curiosity Hackers finish their badge by sharing the above on our wiki in the appropriate badge section.