Extension Activities

**Recommended Grade Levels:** k-6

**Major Concepts**
- Solar System Scale
- Constellations/Stars
- Gravity

**Key Words**

**Planet** – A planet is a celestial body which satisfies all three of the following criteria, as adopted by the International Astronomical Union in 2006:
1) Orbits the sun;
2) Is nearly round, and
3) Has cleared the “neighborhood” of its orbit by virtue of its gravity (either attracting other masses into itself or ejecting them) out of its path

- There are currently eight recognized planets in our solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

**Asteroid Belt** – The Asteroid Belt is between the orbits of Mars and Jupiter and consists of millions of objects. Even though there are so many asteroids, they are so spread out that it is not a “crowded” space. It would be difficult to hit one without precisely aiming for it. Despite there being millions of asteroids, just four very large ones make up half of the mass of the Asteroid Belt.

**Kuiper Belt** – The Kuiper Belt refers to the area of our solar system outside the orbit of Neptune, from about 30 AU to 50 AU. It is similar to the asteroid belt, with many small bodies in orbit around the sun. It is the home to the dwarf planets Pluto, Makemake, and Haumea. Some of the moons of planets in the solar system are theorized to have originated from here. While the Asteroid Belt consists mostly of rock and metal asteroids, Kuiper Belt objects are more commonly frozen masses of methane, ammonia, water and other compounds.
**Light Rays** – For everyday observations of light we can say that light moves in straight lines called rays. Using the small opening of the camera obscura will only let in a few of these rays from each point of the object we want to look at. This will make a picture together. Our eyes work like camera obscura, with the pupil being the opening and the image forming on the back of the eye (the retina). Our eyes also have lenses to help focus light. The image formed in our eyes, just like the image formed in our camera obscura’s, is upside down. Our brain interprets this image and we “see” the upright world around us.

**Additional Resources**

- National Geographic Kids Website about Pinhole Camera, pictures to follow along and a alternative version with wax paper. ([http://kids.nationalgeographic.com/explore/books/pinholes-camera/](http://kids.nationalgeographic.com/explore/books/pinholes-camera/))
- National Geographic Video Tutorial how to make a giant room sized Camera Obscura ([https://www.youtube.com/watch?v=gvzpuOQ9RTU](https://www.youtube.com/watch?v=gvzpuOQ9RTU))
- Youtube Video Explaining Camera Obscura principles ([https://www.youtube.com/watch?v=KWlEsotgAFs](https://www.youtube.com/watch?v=KWlEsotgAFs))
- Veritasium Newton’s Laws video. 8min long but could be good for background or just certain parts could be useful ([https://www.youtube.com/watch?v=Hx9Tm4PmhC](https://www.youtube.com/watch?v=Hx9Tm4PmhC))
- TEDEd hosted video of Bill Nye The Science Guy clip showing a scale model of the solar system, 4min long ([https://ed.ted.com/on/GBHMQgpn](https://ed.ted.com/on/GBHMQgpn))
ACTIVITY A: Universe on a Tape

- **Objective:** Students will create a distance scale model of the solar system which is scaled to their arm span to recognize the scale of our “solar neighborhood.”
- **Time:** 10-15 minutes

**Materials**
- Roll of paper register tape
- Pen or pencils
- Planet stickers (optional)

**Key Words**
Planet, Astronomical Unit, Kuiper Belt.

**Introduction**
The distance between the sun and the different planets in the solar system is huge! Much larger than we normally imagine. Here the students will make a distance scale of the solar system which is personalized to be scaled to their own arm span.

**What To Do**
Talk with the students about the concept of an astronomical unit being the distance between the Sun and the Earth and how this unit works well for our solar system, but not as well beyond. Explain that while we typically see drawings or models of the solar system with the planets close to each other, in reality they are very far apart from each other and from the Sun. Next tell the students that they are going to create a scale model of the distances between the planets.

Have each student come up (or they can work in groups or pairs) to measure their arm span using the register tape. Have them spread their arms as far apart as they can and cut a length of register tape to this size. Then cut one for yourself. Have the students follow along as you demonstrate on yours. You can provide the students stickers for the planets or give them time to write in/draw/color the planets on their tape.
• First label one end of the paper “Sun” and the other “Kuiper Belt” (optionally, using the planet stickers to label).

• **FIRST FOLD:** Fold tape in half and crease well in the middle. Open the tape and label the new crease “Uranus.” (1/2)

• **SECOND FOLD:** Re-fold the tape in half, then fold it *again* to create two more creases. Unfold so it lays flat. The tape should now be in divided into quarters with the Sun at one end, Uranus in the middle, and the Kuiper Belt at the other end. The new crease closer to the Sun (1/4) is “Saturn” the crease closer to the Kuiper Belt is “Neptune” (3/4).

• Note that we’ve only mapped out the farthest two planets and the Kuiper Belt but we’ve taken up ¾ of the tape! 5 planets and the asteroid belt must now fit between Saturn and the Sun.

• **THIRD FOLD:** Fold the Sun to Saturn. Crease well, then lay it flat. This crease is “Jupiter” (1/8). Now we have all four of the gas giants labeled!

• Fold the Sun to Jupiter, crease, and lay flat. Label this “Asteroid Belt” and “1/16”. Tape should now look like the picture below. Note that it is hard to fit the remaining planets in precisely and well in the remaining space.

• **FINAL FOLDS:** Fold the Sun to the Asteroid Belt. Crease well. Open and label this crease as “Mars”. Fold the Sun to Mars. Crease well. *Leave folded*, then fold this portion in half again and crease well. Open flat. There should be three creases.
  - The crease nearest Mars is labelled “Earth”.
  - The middle crease is labelled “Venus”.
  - The crease nearest the Sun is labelled “Mercury”.

• Challenge the students to complete the fractions for the creases they just labelled. Open tape completely and lay flat. What do the students notice about the distances between the planets and the grouping of the planets?
Conclusion
We can see using this that not only are the planets far apart, but that Neptune is a lot farther out than the sun and other planets. In fact it’s 30 times the distance between the Sun and the Earth, or 30 AU! The “rocky planets” like Earth are all group closer to the Sun and then the planets really begin to spread far out. You can also comment that just as the distance between planets are not shown to scale typically, neither are the size of the planets. Jupiter is 1,300 times the sun of the Earth and the Sun is 1.3million times the size!

<table>
<thead>
<tr>
<th>Object</th>
<th>Distance in kilometers</th>
<th>Distance in AU①</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58 million</td>
<td>0.39</td>
</tr>
<tr>
<td>Venus</td>
<td>108 million</td>
<td>0.72</td>
</tr>
<tr>
<td>Earth</td>
<td>150 million</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>228 million</td>
<td>1.52</td>
</tr>
<tr>
<td>Asteroid Belt (including Ceres ②)</td>
<td>416 million</td>
<td>2.77</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778 million</td>
<td>5.2</td>
</tr>
<tr>
<td>Saturn</td>
<td>1,427 million</td>
<td>9.54</td>
</tr>
<tr>
<td>Uranus</td>
<td>2,870 million</td>
<td>19.2</td>
</tr>
<tr>
<td>Neptune</td>
<td>4,497 million</td>
<td>30.1</td>
</tr>
<tr>
<td>Pluto and the inner edge of the Kuiper belt</td>
<td>5,850 million</td>
<td>39.5</td>
</tr>
<tr>
<td>Eris ③</td>
<td>10,200 million</td>
<td>67.8</td>
</tr>
</tbody>
</table>

①AU stands for Astronomical Unit and is defined as the average distance between the Sun and the Earth (about 93 million miles or 150 million kilometers).
②The International Astronomical Union (IAU), the organization in charge of naming celestial objects, classified these objects as “dwarf planets” in 2006.
ACTIVITY B: Rover Races

- **Objective:** Students will explore the challenges of operating remotely operated vehicles (ROVs) and problem solve solutions using a hands-on simulation.
- **Time:** 15 – 25 minutes

**Materials**
- Blindfolds
- Obstacles (Chairs, cones, ramps, balls, etc)
- Stopwatch
- Paper and pencils

**Introduction**
Robots are tools used in science to do work that’s too dirty, too dangerous, or too distant for people to do. Can you think of a robot that does work that’s too dirty for a person? What about a job that’s too dangerous? How about too far away? One way we use robots is through remotely operated vehicles (or ROVs) that can explore places too dirty, dangerous, or distant while a human operator controls the robot from afar.

Much of space exploration is done through ROVs since the climates of distance planets and celestial bodies are not suitable for human life. Additionally, to go explore the outer planets just the travel can take years. It took 7 years for the Cassini probe to travel from Earth to Saturn. The US currently has two ROVs on Mars, Opportunity and Curiosity, which are still in operation.

**What to Do**
Set up an “obstacle course” of chairs, cones, or other physical obstacles and explain that the course is simulating the ROVs on Mars. Place a cup or ball at the end of the course to present an object to retrieve. Multiple courses throughout the room can allow groups to work simultaneously as well as for a single group to try multiple courses and refine their technique and give the opportunity to change roles.
Explain to students that in order to learn how remotely-operated vehicles work, they’re going to pretend to become an ROV themselves to pilot through the course and retrieve the object.

Group students into teams of six and assign a role to each team member:

1. Team Navigator
2. Team Timer
3. Team Judge
4. ROV Member 1
5. ROV Member 2
6. ROV Member 3

First, the Team Navigator should proceed through the obstacle course, using the paper and pencil to record step-by-step directions (i.e. 3 steps forward, stop, 2 steps left, etc.)

Once the Team Navigator has recorded their sequence on the sheet, the first team’s ROV will step forward with the three ROV Members in a line, hands on the shoulders of the person in front of them. Once the three ROV Members are in place, blindfold them.

To begin the experiment, the Team Navigator will call out their directions verbatim as written on the page, and the blindfolded ROV will proceed through the course. (NOTE: Instruct the Team Navigator that they’ll need to read word-for-word, even if the ROV drifts off course! In many ROV missions, once the sequence of commands is sent, it’s set-meaning that changes will need to be made later!)

The Team Timer will record the amount of time it takes to complete the course, and the Team Judge will watch for and record any “foot faults” – any time an ROV member touches an obstacle. Ask students watching, which is more important – speed, or accuracy? What would a scientist piloting an ROV say?

After team’s initial test runs, re-try the course or switch to a different course and begin again with the Team Navigator again, but this time, help them consider, how can we be more accurate when we describe? Encourage them to use “heel-to-toe” steps or say “turn 90 degrees right” or “turn 90 degrees left.” How is driving a three-piece ROV different from walking the course alone?

**Conclusion**

Many participants think that remotely operated vehicles can be flown much like they drive their toy radio-controlled cars. They imagine a ROV pilot watching a computer screen showing the ROV in an underwater environment and moving a joystick to make it go. The reality isn’t quite that simple! For some ROVs, the time it takes for a command
to reach the ROV deep below the surface varies with the distance between the control panel and the ROV involved. This can prevent "joy-stick" driving in real time!

Would this have been easier or harder if the Team Navigator was in another room and couldn’t walk through the course at the beginning and still had to come up with a program of steps? Consider that that’s the reality of exploring the ocean or the moon with ROVs! If you’re able to actually use a camera and monitor to act out this scenario, you may position a “Runner” student to bring the messages from the Team Navigator to the ROV Members, simulating the real communication delay experiences from here to the moon.
ACTIVITY C: Camera Obscura

- **Objective:** Students will build a camera obscura and discuss how light rays travel to project an image
- **Time:** 20 minutes

**Key Words**
Light Rays

**Materials**
- Empty cereal / snack boxes
- Aluminum foil
- Masking tape

**Introduction**
In our everyday life, we can observe light move in a predictable way. Light will move in a continuous and straight line unless absorbed or reflective by an object. Draw a candle on the board, in line with a wall with a box with a hole in one side as seen below (you can draw a tree, a line, or even just an arrow).

Show the lines starting from the top and bottom and explain that the light rays reflecting off the object (or in this case created by the candle flame) travel in all directions, and some go through the small hole in the box. Those continue on and end on the opposite site of the box creating an image. The larger the hole in the box, the more light goes in and so the brighter the image, but also the less sharp it will be. This is because multiple light rays from the same part of the object, but with slightly different directions, will go through the hole and they will

overlap. The smaller the hole, the dimmer the image will be... but the sharper and more focused it will be.

**What to Do**
Collect enough small boxes (cereal boxes, cheese-its/wheat thin/etc.) boxes for each student to have one and use a box cutter to cut out two square holes approximately one inch square. The holes should be at the opposite ends of one of the long sides of the box (see diagram below).

Then have the students tape aluminum foil to the outside of the entire box, except for one of the cut-out squares. The more of the box is covered with foil and the darker the interior of the box, the better the light will be blocked and the easier it will be to see the image created inside. Then they can poke a hole in the foil which covers the cut-out square. You can have them see if they can tell the difference in the size of the hole by starting with a pencil and just making the hole the size of the sharpened pencil lead. They can observe and slowly start to widen the hole with the pencil and see the difference. The best image will be formed by turning off the lights and having one, or a few, bright sources such as windows or lamps.

**Conclusion**
All cameras are built on the principle just used, a small opening allows only certain light rays in to form an image. This image can be projected onto film, or a computer chip in a digital camera, or even onto light receptors in an eye! In our eyes, just like in the cameras built, the images are upside down and our brains need to interpret this information to show us the upright world.
ACTIVITY D: Marshmallow Constellations

- **Objective:** Students will build a constellation using marshmallows and toothpicks and discuss how stars can form different patterns/shapes
- **Time:** 10 minutes
- **Grade Levels:** Grades 4 – 6

**Key Words**
Constellation

**Materials**
- Printable Constellation Map (found at end of document)
- Mini-Marshmallows
- Toothpicks or Pipe Cleaners
- Paper (Plain or Construction)
- Pen, Pencil, or Crayon
- Scissors
- Tape

**Introduction**
Stars are all around us! We see them in the night sky, but even during the day they are still always there! Sometimes our stars form patterns or shapes that astronomers relate to different people in mythology. These formations of groups of stars are what we call constellations. There are over 80 constellations in the sky! Do you know of any constellations? Two of the most popular constellations are the Big Dipper and the Little Dipper. Today, we are going to see how certain stars make these different shapes using marshmallows and toothpicks!

**What to Do**
Using our constellation map, we are going to recreate some of the constellations with our marshmallows and toothpicks. Our marshmallows will be used as our stars, whereas
our toothpicks will be used to hold them in their formation, or shape. (See picture on next page)

You can break or cut the toothpicks with scissors to make them shorter or longer depending on how far apart the stars are from another in the constellation.

Once you have made a couple of the formations on the Map, take a piece of paper and draw your own constellation. After you finish your drawing, use the marshmallows and toothpicks to make them come alive!

Conclusion
A large portion of constellation names come from the Roman Empire, originated in Latin. They are about different mythological creatures or beings, such as Orion, the hunter, or Hercules.

Some of the constellations we made are also the names of zodiac signs. Zodiaks signs are horoscopes that each person has based upon the day they were born. While not scientifically proven, horoscopes are used to “predict the future” based upon the
position of the stars when you were born. The reason that these zodiac constellations are different than the rest of the constellations is their placement in our universe. They run along the same path as the Sun, Earth, and moon.
ACTIVITY E: Energy Loss

- **Objective:** Students will conduct a hands-on experiment and get to record and analyze their own data to gain knowledge about energy conversion & energy loss.
- **Time:** 15-35 minutes (can be adjusted depending on students)

**Materials**
- Multiple Yard sticks
- Tennis Balls
- Pen or Pencils
- Calculators

**Key Words**
Energy, Kinetic Energy, Potential Energy

**Introduction**
Here students will be given a very open-ended question and with limited guidance arrive at an answer by recording their own data and analyzing it themselves.

**What To Do**
Students can be paired or in groups of 3-4. The students will bounce tennis balls by dropping them from different heights and observing to what height they bounce back up to. It is recommended that up to two yard sticks are able to be taped together for the students to have a large range on heights to test. Alternatively, lines can be marked on butcher paper or something similar if there are not enough yard sticks available. Have the students drop the tennis ball from the same height and record the height it bounces to at least 3 times. They should test dropping the ball from 4 to 5 different initial heights. You can allow the students to organize their own data or alternatively can print a simple sheet similar to the example below.
After the students have recorded all their data you can ask them if the ball had the same amount of energy before it bounced on the ground as it did after. Then ask them to analyze their data to determine what percent of energy was lost during the bounce. Allow the students to examine this question without providing any equations or extra prompts for 5-10 minutes. If students are getting stuck or frustrated then you can slowly provide some hints. Here are some possible hints you can provide.

- If you try different ways of manipulating your data, can you find any pattern?
- When the tennis ball isn’t moving, it has zero Kinetic Energy and only Potential Energy. When does the tennis ball not move? (At the top of each bounce).
- Potential Energy is proportional to the height of the object.
- Is the percent of energy lost during each bounce the same or different?
- How would we find a percent?
- The equation for Potential Energy is PE = mgh

The final formula for finding the percentage of energy lost is [(h-H)/H]*100. The students may not derive this exact equation by stepping through the process of comparing PE at the beginning to PE at the end and cancelling the mass and acceleration due to gravity terms, but instead start by just comparing the heights the balls started at and bounced to. You can point out that they have compared the energies by doing this since those are the only terms that matter for this particular problem, since we’re taking a percent. This also means that as long as both the initial height and the rebound height are in the same units, it doesn’t matter what those units are.

**Conclusion**

The students were able to experiment and record their own data. By simply asking them the question of how much energy was lost and allowing them to explore their own data, they will become very familiar with the concept of energy lost and confident in their own ability to discover concepts and patterns. You can ask the students at which point the tennis ball has zero kinetic energy and entirely potential energy. At what point does
the tennis ball have entirely kinetic energy and zero potential energy. What about all the other points? You can also talk about error and ask the students what are different sources of systematic or random error present in this experiment.