



Maynard F. Jordan Planetarium

Worlds In Motion

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Mission Statement:

The mission of the Maynard F. Jordan Planetarium of the University of Maine is to provide the University and the public with educational multi-media programs and observational activities in astronomy and related subjects.

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Cosmic Classroom



Looking for fun and interesting space activities? The planetarium staff has prepared a collection of materials we call the Cosmic Classroom for you to use before and/or after your visit. These materials are entirely for use at your own discretion and are not intended to be required curricula or a prerequisite to any planetarium visit. The Cosmic Classroom is one more way that the Jordan Planetarium extends its resources to help the front line teacher and support the teaching of astronomy and space science in Maine schools.

The lessons in this Cosmic Classroom have been edited and selected for the range of ages/grades that might attend a showing of this program at the Jordan Planetarium. Those activities that are not focused at your students may be adapted up or down in level. Our staff has invested the time to key these materials to the State of Maine Learning Results in order to save you time.

The State of Maine Learning Results performance indicators have been identified and listed for the program, the Cosmic Classroom as a package, and each individual activity within the package. The guide also includes related vocabulary and a list of other available resources including links to the virtual universe. We intend to support educators, so if there are additions or changes that you think would improve, PLEASE let us know.

Thank you, and may the stars light your way.

The Maynard F. Jordan Planetarium Staff

The Program – *Worlds in Motion*

Worlds in Motion helps to answer the question “How fast are you moving right now?”. From the microscopic world of electrons zipping around the nucleus of an atom to our own galaxy zooming across the universe, this show explores how and why everything moves the way it does. This program helps us to discover that we do not live on a stationary planet. Our place in the universe is constantly changing. It may not seem like we are moving 67,000 mph right now but in some directions we are moving even faster! When the Sun “moves” out of sight, we see the stars of winter and spring, and enjoy the imaginary pictures they can make.

We are very glad that you have chosen to visit our planetarium with your group. We hope that this guide either will help you prepare your group or help you review their experience at the University of Maine's sky theater.

State of Maine Learning Results Guiding Principles

The lessons in this guide, in combination with *Worlds In Motion*, will help students to work towards some of the Guiding Principles set forth by the State of Maine Learning Results. By the simple act of visiting the planetarium, students of all ages open an avenue for self-directed lifelong learning. A field trip encourages students to think about learning from all environments including those beyond the schoolyard. A Jordan Planetarium visit also introduces visitors to the campus of the largest post-secondary school in Maine and encourages them to think of this as a place that holds opportunities for their future education, enjoyment and success.

Other sites on the University campus, including three museums, explore a variety of subjects, and the Visitors Center is always willing to arrange tours of the campus. A field trip can contribute to many different disciplines of the school curriculum and demonstrate that science is not separate from art, from mathematics, from history, etc. The world is not segregated into neat little boxes with labels such as social studies and science. A field trip is an opportunity for learning in an interdisciplinary setting, to bring it all together and to start the process of thinking. For a more complete discussion of field trips, please visit the Jordan Planetarium web site.

If used in its entirety and accompanied by the Planetarium visit this guide will help students to:

Become **a clear and effective communicator** through

- A. oral expression such as class discussions, and written presentations
- B. listening to classmates while doing group work, cooperation, and record keeping.

Become **a self-directed and life long learner** by

- A. introducing students to career and educational opportunities at the University of Maine and the Maynard F. Jordan Planetarium.
- B. encouraging students to go further into the study of the subject at hand, and explore the question of “what if?”
- C. giving students a chance to use a variety of resources for gathering information

Become **a creative and practical problem solver** by

- A. asking students to observe phenomena and problems, and present solutions
- B. urging students to ask extending questions and find answers to those questions
- C. developing and applying problem solving techniques
- D. encouraging alternative outcomes and solutions to presented problems

Become **a collaborative and quality worker** through

- A. an understanding of the teamwork necessary to complete tasks
- B. applying that understanding and working effectively in assigned groups
- C. demonstrating a concern for the quality and accuracy needed to complete an activity

Become **an integrative and informed thinker** by

- A. applying concepts learned in one subject area to solve problems and answer questions in another
- B. participating in class discussion

State of Maine Learning Results Performance Indicators

In conjunction with the Maynard F. Jordan Planetarium show *Worlds In Motion*, this guide will help you meet the following State of Maine Learning Results Performance Indicators in your classroom.

Grades 3-4

Science and Technology –

G. The Universe

- #3. Describe earth’s rotation on its axis and its revolution around the sun.

I. Motion

- #2. Draw conclusions about how the amount of force affects the motion of more massive and less massive objects.

Mathematics–

F. Measurement

- #1. Solve and justify solutions to real-life problems involving the measurement of time, length, area, perimeter, weight, temperature, mass, capacity, and volume.

Grades 5-8

Science and Technology –

E. Structure of Matter

#2. Describe the evidence that all matter consists of particles called atoms that are made up of certain smaller particles.

G. Universe

#4. Describe scientists' exploration of space and the objects they have found.

5. Describe the motions of moons, planets, stars, solar systems, and galaxies.

I. Motion

#1. Describe the motion of objects using knowledge of Newton's Laws.

#2. Use mathematics to describe the motion of objects (e.g. speed, distance, time, acceleration).

Mathematics–

F. Measurement

#2. Develop and use concepts that can be measured directly, or indirectly (e.g. the concept of rate).

Performance Indicators Snapshot

<p>The Show</p>	<p><u>Grades 3-4</u> Science and Technology G. #3 I. #2 Mathematics F. #1</p> <p><u>Grades 5-8</u> Science and Technology E. #2 G. #4, #5 I. #1, #2 Mathematics F. #2</p>
<p>The Guide</p>	<p><u>Grades 3-4</u> Science and Technology I. #1, #2</p> <p><u>Grades 5-8</u> Science and Technology G. #5, I. #1, #2 Mathematics A. #1, G. #1</p>

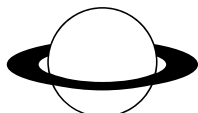


How High Can you Jump on Another Planet?

From “The Universe at Your Fingertips” Astronomical Society of the Pacific.

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to use mathematics to describe the motion of objects (e.g. speed, distance, time, and acceleration). (5-8. Science and Technology. I. #2.)
2. Learners will be able to draw conclusions about how the amount of force affects the motion of more massive and less massive objects. (3-4 Science and Technology.I.#2)



The General Idea:

We have seen footage of Apollo astronauts “hopping” around on the moon’s surface. What would it be like on other planets? This activity introduces the ideas of surface gravity and mass, to help students calculate weight and jumping abilities on different planets and the sun.

What You Need:

Yardsticks
Pencils
Paper

Getting Ready:

Ask your students to speculate about factors that would influence the height of a jump.

What To Do:

- Give a student a yardstick to hold vertically, touching the floor. Have another kneel so that he or she can see the yardstick in order to measure the height of a jump. A third student will be the jumper.
- Record the height of the jump.
- Use the following table to calculate how high they could jump on other planets:

Object	Procedure For Height of Jump
Sun	Divide by 30
Mercury	Multiply by 5 then divide by 2
Venus	Multiply by 10 then divide by 9
Mars	Multiply by 5 then divide by 2
Jupiter	Multiply by 2 then divide by 5
Saturn	Multiply by 7 then divide by 8
Uranus	Multiply by 11 then divide by 12
Neptune	Multiply by 5 then divide by 7
Pluto	Multiply by 30
Earth’s moon	Multiply by 6

What To Discuss/Extensions:

The surface gravity of a star, planet, moon, etc. depends upon the object's mass, and the object's radius. The radius is a factor because (1) an object's gravity acts as though its source is at the object's center, and (2) the "strength" of an object's gravity diminishes with distance. For example, suppose that two planets have the same mass, but unequal radii. The planet with the smaller radius will have a stronger surface gravity. Gravitational force depends not only on the mass of the planet, but also on our distance from its center of gravity.

Ask students to consider how sports like baseball, soccer, golf or gymnastics might be played on other planets.





Staying Up While Falling Down

From “The Universe at Your Fingertips” Astronomical Society of the Pacific.

Objectives and State of Maine Learning Results Performance Indicators:

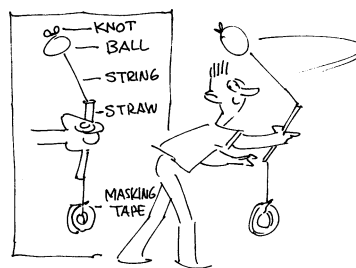
1. Learners will be able to describe the motion of objects using knowledge of Newton’s Laws. (5-8. Science and Technology. I. #1.)

The General Idea:

This activity will demonstrate how a satellite stays in orbit by modeling the effects of Earth’s gravity on a satellite and the Sun’s gravity on the planets.

What You Need:

4-foot length of string
Plastic drinking straw
Canvas sewing needle
Small, soft rubber ball (about 1 inch diameter)
Roll of masking tape
Information sheet



Getting Ready:

- Using the needle, thread string through ball and tie a knot at the end.
- Thread other end of string through the straw and tie the roll of tape to it.

What To Do:

- Hold the straw and swing the ball around to simulate an object in orbit.
- Observe the orbital radius shrinking and orbital velocity increasing by pulling on the weight (tape).

What To Discuss:

Ideas on information sheet.

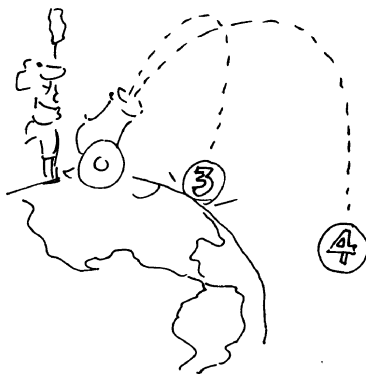
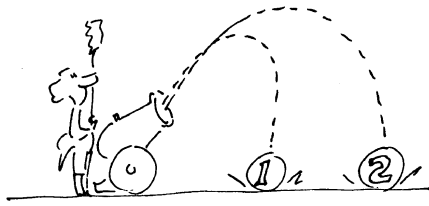
Continuations/Extensions:

- You can discuss what would happen if the string was cut. Would it keep moving in a circle? Fly in a straight line? Cut the string to find out!
- Create different ball/string combinations to represent the orbits of other planets.

★ **Why does the Earth stay in orbit around the Sun?**

★ **What keeps the Moon going around the Earth?**

★ **What makes up and down on Earth?**



For thousands of years people thought that objects fell to Earth because they were trying to “return to their natural place”. The British scientist Sir Isaac Newton thought differently. He called this phenomenon gravity and described it as an attractive force between any two objects.

All objects - even you, even a feather – have a gravitational force that attracts other objects. The strength of the force is related to the object’s mass, which is the amount of material the object contains. On Earth, the mass of the Earth itself is so great that its gravitational force completely overpowers the force of any object on Earth.

So how does gravity keep satellites orbiting the Earth? An orbit is the path in space of one object, like a satellite, circling around another object, like Earth. Why don’t these objects fall? Actually, they do! But because the satellites are moving, they stay in orbit.

Newton figured this out 300 years ago. He imagined placing a cannon on top of a very high mountain. If he fired the cannon, the cannonball would eventually fall to the ground. If he increased the firepower, the cannonball would fly out farther before it fell, but it would still fall to the ground.

With enough firepower the cannonball would fly far enough away from the Earth’s curved surface. Gravity would still cause it to fall, but at the same time the Earth’s surface would “curve away” from the ball. So the ball would never hit the ground. The “free fall” that the orbiting ball experiences is the cause of weightlessness.

Gravity helps to keep objects in orbit by acting as a centripetal force. This force makes objects go in a circular path. If gravity did not exist, these objects would keep moving out and eventually fly off into space.

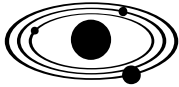
The moon is a satellite circling the Earth, and the Earth is a satellite circling the sun. The Earth’s gravity also keeps the Moon in Orbit, and the Sun’s gravity keeps the planets orbiting around it.



How Fast do the Planets Move?

From “Rainy Day Astronomy” by Diane Tesmer

Objectives and State of Maine Learning Results Performance Indicators:



1. Learners will be able to use numbers in a variety of equivalent and interchangeable forms in problem solving. (5-8. Mathematics.A.#1)
2. Learners will be able to describe and represent relationships with equations. (5-8. Mathematics.G.#1)
3. Learners will be able to describe the motions of planets. (5-8. Science and Technology.G.#5)

The General Idea:

This activity interests students in multiplication and division by producing amazing answers about the speeds of the planets as they revolve around the Sun.

What You Need:

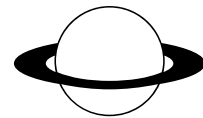
Attached worksheet

What To Discuss:

Planetary motion. You may be surprised to find out how fast the planets are moving around the sun.

Continuations/Extensions:

Students can find speeds of other objects and compare them to the planets. How fast does an airplane fly? How fast can a person run? How fast can someone ride a bike? Students might find these answers by tracing out a length on a sidewalk. Research in the library may produce an answer.



How Fast do the Planets Move?

Name(s) _____

Date _____

On the average highway, a car travels at approximately 100 km/hour. How fast do the planets travel as they revolve around the Sun?

Planet	Circumference of Orbit (km)	Earth Time to Complete Orbit (days)	Earth Time to Complete Orbit (hours)	Planet Speed (km/hr)
<u>Mercury</u>	5.79×10^7	88		
<u>Venus</u>	1.08×10^8	225		
<u>Earth</u>	1.50×10^8	365		
<u>Mars</u>	2.28×10^8	687		
<u>Jupiter</u>	7.78×10^8	4333		
<u>Saturn</u>	1.43×10^9	10759		
<u>Uranus</u>	2.87×10^9	30685		
<u>Neptune</u>	4.50×10^9	60189		
<u>Pluto</u>	5.90×10^9	90465		

1. If the Earth day comprises 24 hours, calculate the number of Earth hours required to complete the orbit of each planet. Fill in the third column with this information.

Example: $88 \text{ days} \times 24 \text{ hours/day} = 2112 \text{ hours}$

2. You know the circumference of each planet's orbit and the number of hours to complete that orbit. Use this information to calculate the planet's speed.

Example: $5.79 \times 10^7 \text{ km} / 2112 \text{ hours} = 27415 \text{ km/hour}$

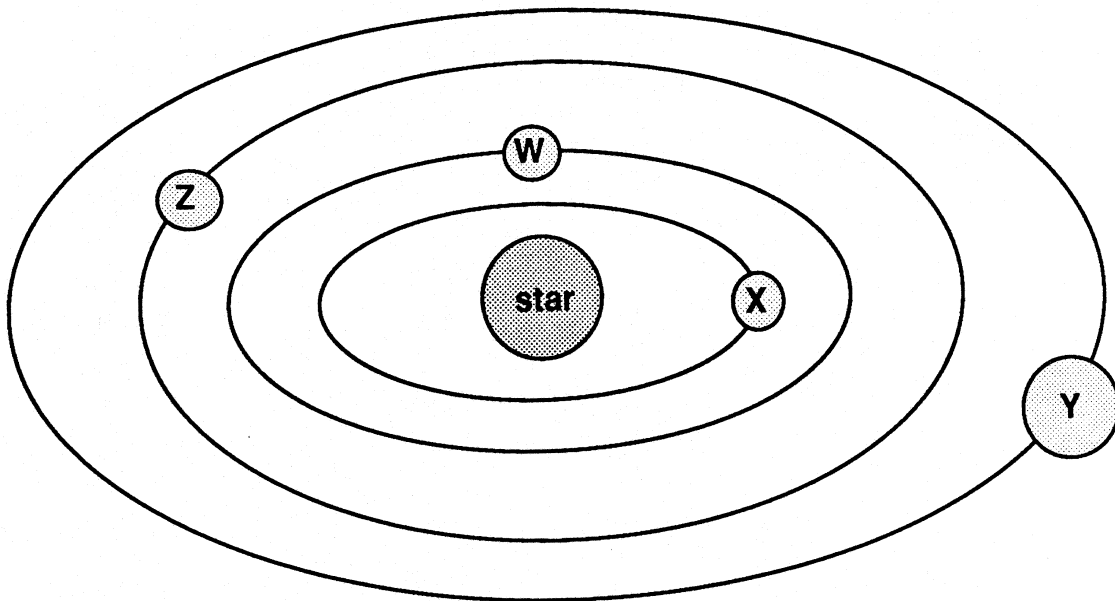
Questions:

1. Which planet travels the fastest?

2. Which planet travels the slowest?

3. Is there a pattern to the planets' speeds?

4. If a solar system contained four planets (as labeled below), list the order of the planets' speeds (from slowest to fastest). 1=slowest 4=fastest



5. If 1 mile = 1.609 kilometers, what is the speed of the Earth in miles per hour? What is Neptune's speed? What is Mercury's speed?



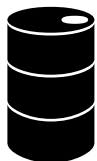
How Much Would a Can of Soda Weigh?

Objectives and State of Maine Learning Results Performance Indicators:

1. Learners will be able to demonstrate that gravity is what causes objects to have weight (3-4. Science and Technology. I. #1.).
2. Learners will be able to explain that the nine planets do not exert the same amount of gravitational force.

The General Idea:

Weight is the name we give to the force acting in a direction toward the center of a planet. The pull of gravity is the natural force of attraction exerted by a planet upon objects at or near its surface. The force depends both on the mass of the planet and its diameter. (For example: a planet having twice the mass, but with the same diameter, of Mars would result in a surface gravity twice that of Mars). This activity will help students understand this concept by comparing the various relative weights of a can of soda if placed on the surface of each of the nine planets and our Moon.



Getting Ready:

- Mark each can with the name of one of the nine planets and our Moon.
- Place the number of pennies (from the chart below) in each can.

Planet	Number of pennies
Mercury	42
Venus	100
Earth	Full can of soda
Moon	18
Mars	42
Jupiter	275
Saturn	117
Uranus	99
Neptune	125
Pluto	7

What You Need:

1 unopened can of soda
 10 clean, empty soft drink cans
 Approximately 850 pennies
 A permanent marker

What To Do:

1. Allow each student to pick up and compare the weights of the cans

What To Discuss:

1. After the students have all had a chance to lift the cans and feel the differences in weight, ask students to discuss why they think the same can of soda would have different weights on different planets and our Moon.

Continuations/Extensions:

1. Place a half-gallon plastic milk jug upright and punch a small hole 2.5 cm (1") up from the bottom. Placing your finger over the hole, fill the jug with water. Go to a playground with a friend as an observer. Find a high place and make sure nobody is standing directly below. Take your finger off the hole and drop the jug. What does the observer see happening to the flow of water during the drop?

Does the weight of objects affect how fast they fall? Take 14 pennies. Make two piles of seven. Tape one pile together. Hold one pile in your right hand and the other in your left. Reach both hands up high and cleanly drop the two piles at the same time. The taped pile is at least seven times the weight of each penny in the other pile. Any conclusions?

2. How old would you be on another planet? If a year is described as the amount of time it takes for a planet to revolve around the Sun, for the Earth it's 365.25 days, then your age would be different on each planet. Use the chart below to figure out how old you would be.

Planet	Number of days in a planetary year	Multiply your age by
Mercury	87.97	4.152
Venus	224.7	1.626
Earth	365.25	1
Mars	687	.53
Jupiter	4,333	.084
Saturn	10,759	.034
Uranus	30,685	.012
Neptune	60,188	.006
Pluto	90,700	.004

There are now two ways for you to figure out your age. The first is to multiply your age by 365 (to find the number of days) and then divide that number by the number in the middle column above to find out your age on that planet. For example, if you are 20 years old here on Earth and want to know your age on Jupiter, $20 \times 365 = 7300$ and then $7300/4900 =$ (approximately) 1.5. That means you'd be one and a half years old on Jupiter!

The second method is to multiply your age by the number in the right hand column. For example, if you are 20 and want to know your age on Neptune, $20 \times .006 = .12$ (years).

Vocabulary List

Astronomer	A person who studies and contributes to the science of astronomy.
Axis	An imaginary straight line around which an object rotates.
Centripetal Force	The force that keeps an object spinning in a circle around an axis.
Day	The time it takes for a planet to make one full rotation (on Earth, 24 hours).
Galaxy	A cluster of stars, dust, and gas held together by gravity.
Gravity	The force of attraction between two objects which is influenced by the mass of two objects and the distance between the two objects.
Milky Way galaxy	large spiral galaxy consisting of several billion stars, one of which is the Sun.
Moon	A natural satellite orbiting a planet.
Orbit	A specific path followed by a planet, satellite, etc.
Planet	A massive object orbiting a star.
Revolution	The circling of a smaller object around a larger object.
Rotation	The spinning of an object on its axis.
Solar System	The system of planets, moons, and other objects revolving around a star (in our case, the Sun).
Star	a massive, self-luminous celestial body of gas that shines by radiation derived from its internal energy sources.
Sun	Sol, the star that is closest to Earth and from which we get heat and light energy.
Universe	The vast expanse of space which contains all of the matter and energy in existence.
Year	The period for a planet to make one full revolution around a star (in our case the Sun, 365.25 days).

The Universe At Your Fingertips

In addition to the lesson plans included in this teacher guide, we recommend the following activities from [The Universe at your Fingertips: An Astronomy Activity and Resource Notebook](#) published by the Astronomical Society of the Pacific. This very comprehensive compendium of astronomy activities is an excellent resource that is available from the Maynard F. Jordan Planetarium. State of Maine Learning Results performance indicators are listed for each activity.

State of Maine Learning Results Performance Indicators	
“Fingertips” Activity Title	Science and Technology Learning Results
The Sun (B-1)	Gr.3-4. G. #2, H. #1 & Gr.5-8. G. #1
The Reasons for Seasons (B-5)	Gr.3-4. G. #2., G. #3. & Gr.5-8. F. #1.
Observing a Planet (C-4)	Gr.3-4. G. #1. & Gr.5-8. G. #3., G. #5.
Solar System Bingo (C-10)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
Can You Planet? (C-11)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
A Question of Scale (D-1)	Gr.5-8. G. #3.
3-D Model of Earth and Moon (D-2)	Gr.3-4. G. #1., G. #4. Also, Math LR: Gr.3-4. F. #1
Solar System Scale Model Sized to Your room (D-5)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
Toilet Paper Solar System Scale Model (D-6)	Gr.3-4. G. #1 & Gr.5-8. G. #5.
The Thousand Yard Model (D-7)	Gr.3-4. G. #1. & Gr.5-8. G. #5.
Designing a Planetary Probe (I-1)	Gr.3-4. J. #4. & Gr.5-8. J. #6.

Some good web sites to use with *Worlds In Motion*

space.jpl.nasa.gov

NASA’s Jet Propulsion Laboratory web site

www.jsc.nasa.gov/pao/students/

Full of links from Johnson Space Center

Lessons From The World Wide Web

Also, a wide variety of lesson plans and activities can be found on the World Wide Web. These sites are dedicated to lesson planning in a variety of subjects.

btc.montana.edu/ceres

Maintained by the Burns Telecommunications Center, this page links to educational activities and classroom resources.

www.thursdaysclassroom.com

Lesson plans, activities, and teacher resources presented from Science@NASA

spaceplace.jpl.nasa.gov/spacepl.htm

This California Institute of Technology and NASA Jet Propulsion Laboratory site for kids offers information and activities .

school.discovery.com/

This Discovery Channel education site allows teachers to search for lesson plans by grade and subjects.

www.eduref.org/cgi-bin/lessons.cgi/Science/Astronomy

Lesson plans based of the popular PBS series, Newton's Apple

www.thegateway.org

Sponsored by The U.S. Department of Education's National Library of Education and ERIC Clearinghouse on Information & Technology, this site offers lesson plans for all subjects and all grades.

Astronomy Web Sites Worth a Visit

Galaxymaine.com

The Maynard F. Jordan Planetarium and Observatory home page.

ssd.jpl.nasa.gov

A site about our solar system maintained by the Solar System Dynamics Group of the Jet Propulsion Laboratory.

www.calacademy.org/planetarium

Alexander F. Morrison Planetarium home page

stardate.org

Learn what's going on TODAY in astronomy on the "Star Date" web page, maintained by the University of Texas' McDonald Observatory

The Maynard F. Jordan Planetarium does not guarantee that the information given on the above web sites to be accurate, accessible, or appropriate for students.