SATURDAY ENRICHMENT SPRING 2019
EARTH MATH

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Location: Loew Hall 219

Course Description

If all the ice in the Greenland ice sheet melted, would your house be underwater? When will you be able to sail across the North Pole? What's so special about an icosahedron? How big is the solar system? We will answer these questions as we learn about estimation, scaling, 3D objects, and ancient and modern models of the solar system.

Essential Questions

We will spend two class periods on each of four questions:

1. If all the ice in the Greenland ice sheet melted, would your house be underwater?

Motivation: Sea level is rising for two main reasons: (1) ice that has been locked up in glaciers and ice sheets is melting and running off into the ocean, and (2) the ocean is warming, and warm water takes up more space than cold water ("thermal expansion"), raising the sea level. Both of these factors are due to global warming. Sea level is expected to rise by 30 to 60 centimeters by the end of the century, and the rate of sea level rise is speeding up (i.e. accelerating). How much would sea level rise if all the ice in the Greenland ice sheet melted? Would that put your house underwater? (Don't worry – this would take hundreds or even thousands of years). What if all the ice in Antarctica melted?

Approach: We will start with a topographic map of the Greenland ice sheet and divide it into squares (i.e. a grid). In each square, we will estimate the ice thickness from the contours on the map. From this we will calculate the volume of ice in each square, and then add up the volumes in all the squares to get the total volume. We will then calculate the surface area of the oceans, and imagine that all the ice in Greenland melts and spreads out evenly over the ocean, allowing us to calculate the thickness (height) of this added layer of water. We will then look at a topographic map of Seattle and see what parts would be underwater.

2. When will you be able to sail across the North Pole?

Motivation: In winter, the Arctic Ocean is completely covered by sea ice, which forms from freezing seawater. In summer, the sea ice melts back, but some ice persists in the central Arctic Ocean even at the end of summer. However, the area of this summer sea ice has been shrinking over the past 40 years due to global warming. This is probably the biggest visible change to the surface of the Earth that can be seen from space. By what year will the summer sea ice melt back far enough that a ship could sail straight across the Arctic Ocean via the North Pole?

Approach: We will look at satellite data collected over the past 40 years that shows the area of sea ice in the Arctic Ocean at the end of summer. From the graph of area vs. time, we will fit a line to the data and extend the line into the future to see when the area reaches zero. We will compare this with predictions from Global Climate Models.

3. What's so special about an icosahedron?

Motivation: The "Platonic" solids, named for the Greek philosopher Plato, are 3-D objects with flat faces and straight edges, in which all the faces have the same shape and all the edges have the same length. It turns out there are only five of them. The "icosahedron" has 20 faces, each one an equilateral triangle. Geodesic domes (in architecture) and geodesic grids (in Global Climate Models) are based on the icosahedron.

Approach: We will make 3-D models of the five Platonic solids from straws and pipe-cleaners. We will learn about some of their special properties, and calculate their surface areas and volumes.

4. How big is the Solar System?

Motivation: On January 1, 2019, NASA's New Horizons spacecraft flew past a tiny frozen rock in the outer reaches of the solar system, about 6.5 billion kilometers from Earth, sending back pictures of the most distant object that's ever been visited by humanity. How can we get a grasp of such vast distances?

Approach: Using planetary data from NASA, we will design a model of the solar system in which the diameters of the planets and their distances from the Sun are in the correct proportions. For example, if we choose a scale factor of 1 billion, the Earth would be about 1.3 centimeters in diameter (the size of a grape) and the Sun would be about 150 meters away (1½ soccer fields). The New Horizons spacecraft would be about 6.5 kilometers away. We will calculate the sizes and distances of the planets in our model, and then lay out the model on a map of Seattle to get an idea of the size of our solar system. We may also extend the model to include the nearest star to the Sun (Proxima Centauri, 4 light-years away), our own galaxy (the Milky Way, 100,000 light-years across), the nearest spiral galaxy (Andromeda, 2.5 million light-years away), and beyond!

Learning Outcomes

Common Core math standards are posted here: http://www.corestandards.org/Math/Content/
We will touch on the following "critical areas" from the Common Core math standards:

Grade 6

(1) Connecting ratio and rate to whole number multiplication and division;
(2) extending the notion of numbers to the system of rational numbers;
(3) writing, interpreting, and using expressions and equations.

Grade 7

(1) Developing understanding of and applying proportional relationships;
(2) developing understanding of operations with rational numbers and working with expressions and linear equations;

(3) solving problems involving scale drawings and informal geometric constructions, and working with two- and three-dimensional shapes to solve problems involving area, surface area, and volume.

Grade 8

(1) Formulating and reasoning about expressions and equations, including modeling an association in bivariate data with a linear equation, and solving linear equations;
(2) analyzing two- and three-dimensional space and figures using distance, angle, similarity, and congruence, and understanding and applying the Pythagorean Theorem.

Instructional Strategies

After a brief introductory lecture, students will work in small groups (2 or 3) with help from the instructor. Class will end with a brief discussion of what was learned.

Student Assessment

No tests or quizzes. Instructor will observe students and make qualitative assessments.

Resources and Materials

Calculators will be necessary for some activities. There will be handouts for every activity. Paper, pencil, and ruler will be necessary. You can bring your own if you want, otherwise, they will be provided during class.

Tentative Course Schedule

Date	**Topic(s)**	**In-Class Activities**
April 6	Greenland ice sheet and sea level rise, part 1	Calculate the volume of ice in Greenland
April 13	Greenland ice sheet and sea level rise, part 2	Calculate sea level rise if all the ice in Greenland melted
April 27	Arctic sea ice, part 1	Look at maps of Arctic sea ice, plot area vs. time, fit curves to data
May 4	Arctic sea ice, part 2	Learn least squares method, project area into future, compare to models
May 11	Platonic solids, part 1	Construct 3-D models, observe properties, learn Euler’s formula
May 18	Platonic solids, part 2	Calculate angles, edge lengths, surface areas, and volumes
June 1	Size of the solar system, part 1	Calculate sizes and distances of planets in a scale model
June 8	Size of the solar system, part 2	Lay out scale model on map, extend model beyond solar system