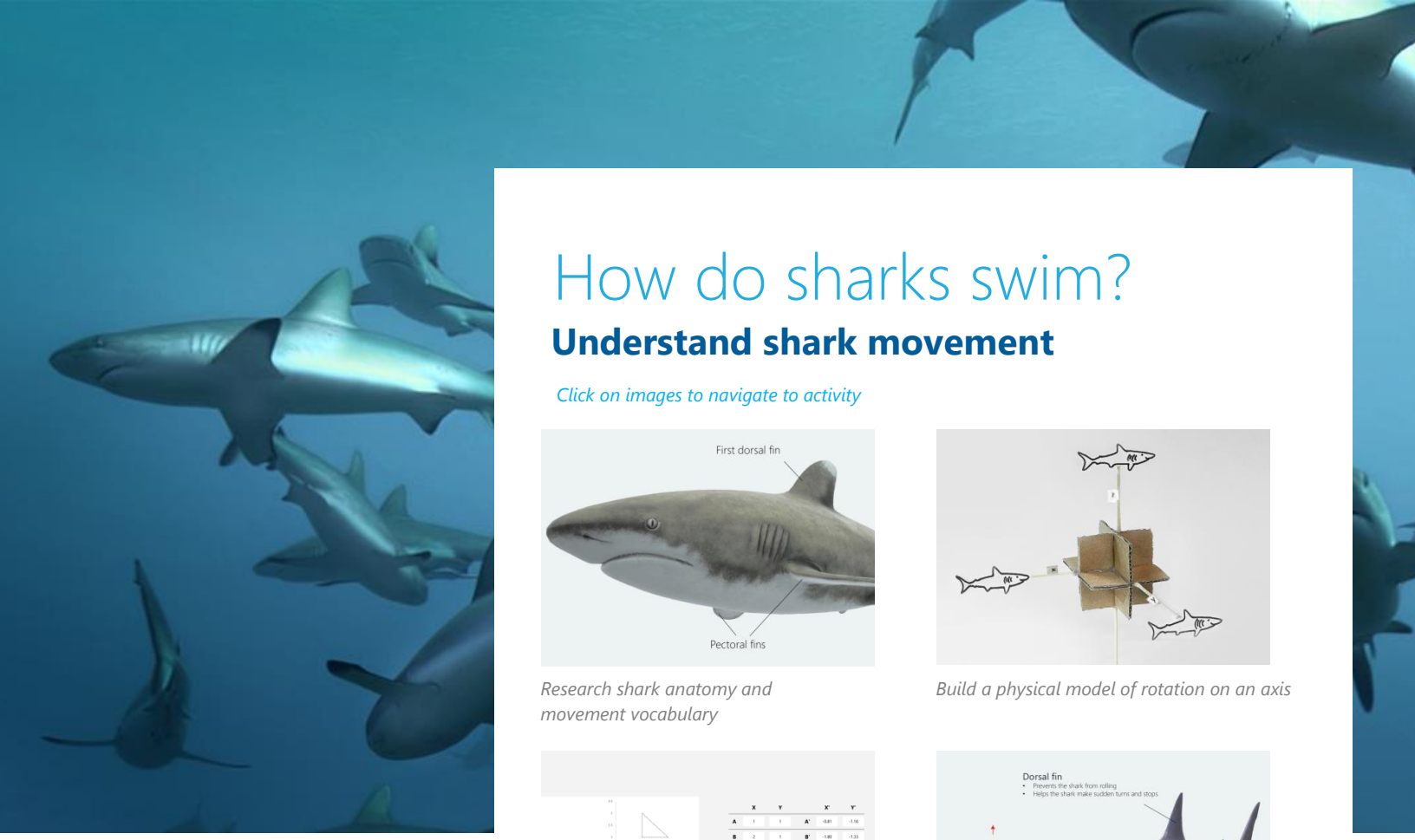


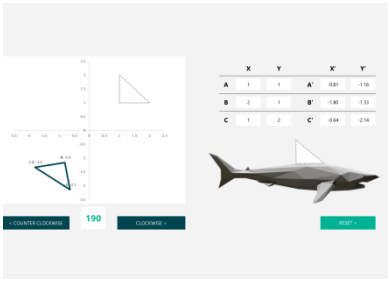
How do sharks swim?

Understand shark movement

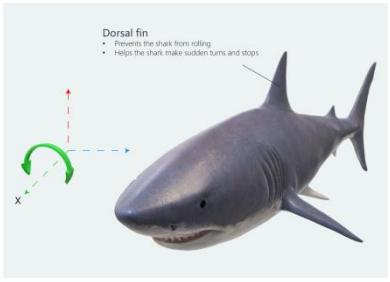
Click on images to navigate to activity

Research shark anatomy and movement vocabulary

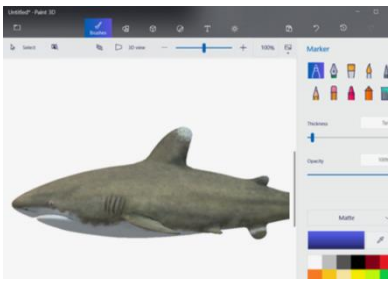
Build a physical model of rotation on an axis



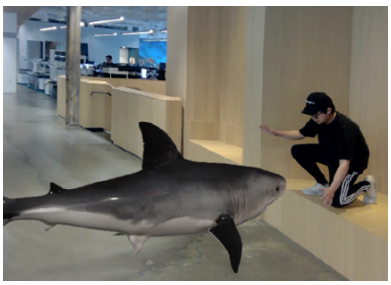
Model rotation mathematically using Excel



Model a shark in 3D



Bring your shark to life with Paint 3D



Explore a shark with mixed reality

Create a video reflection

Microsoft Education and BBC Learning bring you *Oceans*-inspired, inquiry-based STEM lessons that challenge students to build sensors, create in 3D, analyze data, and experience mixed reality. Using affordable, hands-on, standards-aligned STEM activities, students discover ocean phenomena.

This lesson engages students in the question: How do sharks change direction as they swim through the ocean?

Related lesson Build a joystick to control shark movement

Download all lesson materials
Understand shark movement

Microsoft

in partnership with
BBC LEARNING

Lesson overview

Standards

NGSS

Performance Expectation

MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Science and Engineering Practices: Developing and Using Models

MS-ETS1-4: Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

Disciplinary Core Ideas

MS-ETS1-4: Models of all kinds are important for testing solutions.

Crosscutting Concepts: Structure and Function

MS-LS3-1: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

CCSS MATHEMATICS

CCSS.Math.Content.8.G.A.3: describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

ISTE

3a: Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.

5b: Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

7c: Students contribute to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

How do sharks swim?

Understand shark movement

Target grades: 6-8 (ages: 10-14)
Duration: 75 minutes (1.5 50-minute class periods)
Please note that lesson activities will require adult supervision.

Background

In this lesson, you will guide students to understand three-dimensional space and how sharks move within it. Students will explore how sharks change direction using rotations on the z, y, and x axes (yaw, pitch, and roll), and connect shark anatomy to these movements. This lesson can be applied to instruction on aeronautics.

Student introduction

Students take on the role of marine biologists to investigate how sharks move in three-dimensional space (3D). Understanding the mathematics behind shark movement will inform the design of a prototype joystick for a robotic exploration shark used to collect oceanic data.

Scientific phenomenon

When a shark moves through the water, it is able to remain balanced as it swims and turns.

Lesson question

How do sharks change direction as they swim through the ocean?

Learning target(s)

Students can use an analog and digital models to describe rotational movement on the z, y, and x axes.

Students can describe the structures of a shark's anatomy that help it change direction as it swims using digital 3D models.

Lesson core

Students build a 3D coordinate model to explore rotations of a model shark on the z, y, and x axes (yaw, pitch, and roll).

Students research the anatomy of a shark to determine structures that aid in yaw, pitch, and roll rotations.

Related lessons

This lesson is related to Build a joystick to control shark movement and can be used on its own or in sequence.

Recommended preparation

These activities can be grouped together or can stand alone—depending on educational needs and objectives. Items that may require your attention:

1 | For footage of wondrous *Oceans*, view the BBC Earth & OceanX Film *Oceans: Our Blue Planet* trailer.

2 | Acquire materials for activities with a build or an experiment.

3 | Familiarize yourself with instructions and tech requirements before teaching to mitigate unforeseen challenges.

4 | Download the free Data Streamer add-in for Excel to support real-time data streaming.

5 | Confirm students have access to all links. Download PowerPoint resources.

6 | Confirm that each student computer has all required software:

- Office 365
- Microsoft Excel 2016 (desktop version) with Office 365 subscription
- Microsoft PowerPoint 2016 (desktop version) with Office 365 subscription
- Windows 10 Fall Creators Update

Lesson assets

Download individual elements of the lesson as you go through the Science and engineering notebook or download all assets for understand shark movement.

Welcome young scientists and engineers!

You have been invited to participate in an important science and engineering project!

A multinational technology corporation is funding an effort to explore and research some of Earth's last unexplored regions: our oceans! Engineers from the corporation have developed a robotic shark that can be deployed from research submarines. The shark will be used to collect data on ocean pollution and study marine organisms in their habitat. Project leaders have asked you and your team of marine biologists to explore the three-dimensional movement of sharks. This knowledge will prepare you for testing a prototype joystick to control a robotic shark.

FIELD NOTES:

As you complete this lesson, use the margin to keep note of any interesting finds or insights.

Relevance to science, technology and the world

Engineers use robotic fish to collect data in aquatic ecosystems. Their designs mimic the elegant physical structures of fish that allow them to move within their three-dimensional environments. These movements are related to the mathematics of rotations on the z, y, and x axes. These rotations, known as yaw, pitch, and roll, are the same type of movements that must be considered by aeronautical engineers when they design airplanes.

Find out more!*
Robotic Fish to Keep a Fishy Eye on the Health of the Oceans
UW Researchers create "Robofish"

Your mission

Investigate how sharks move in three-dimensional space (3D) to inform the design of a prototype joystick for a robotic exploration shark.

Your contribution has the potential to positively impact the health of aquatic ecosystems and unlock secrets that lie beneath the ocean surface.

Good luck!

**Microsoft Education provides contextual links for informational purposes only; they do not imply support or affiliation with the authors or source of publication.*

Science and engineering notebook

Use your science and engineering notebook to record ideas and findings. Remember to document your discoveries with photos and video to enhance your final reflection.

LESSON:

Understand shark movement

DATE:

TEAM/NAME:

FIELD NOTES:

As you complete this lesson, use the margin to keep note of any interesting finds or insights.

Prior knowledge

Complete questions 1-3 individually, then discuss with your team and share responses with the class.

1 | Compare and contrast the movement of a car and an airplane.

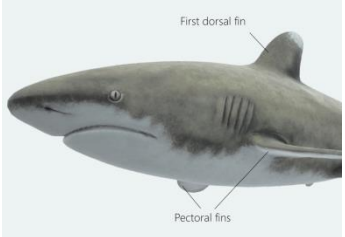
2 | If you had both a model car and a model airplane, what would the controllers that move the vehicles be like? How would they be the same? How would they be different?

3 | What types of movement would you need to control the direction of a robotic shark?

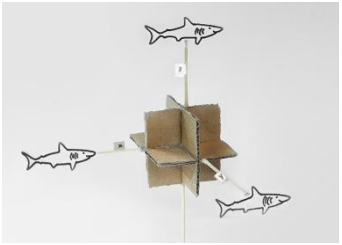
Vocabulary

Research vocabulary terms listed below using the Shark anatomy and movement PowerPoint. Write a definition for each in your own words and add sketches to help clarify your answers. This will give you some background information about the specific words related to shark movement.

Dorsal fin | Pectoral fin | Pelvic fin | Anal fin | Caudal fin
Pitch | Yaw | Roll | Rotation | Axis



Shark anatomy and movement



Rotation on an axis model

Thinking about motion on three axes

Build the Rotation on an axis model using the instructions.

1 | Describe the rotation of your shark on the x-axis. How would this type of movement help a shark as it moves through the water?

2 | Describe the rotation of your shark on the y-axis. How would this type of movement help a shark as it moves through the water?

3 | Describe the rotation of your shark on the z-axis. How would this type of movement help a shark as it moves through the water?

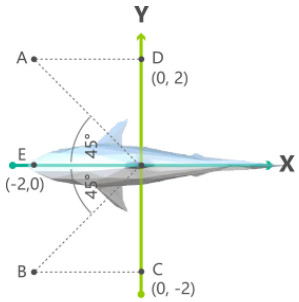


*Figure **1***

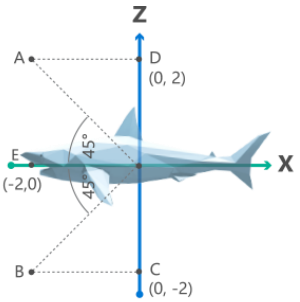


*Figure **2***

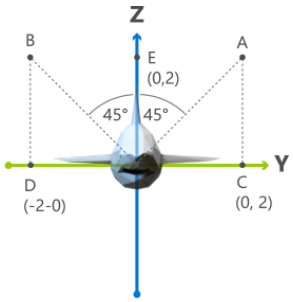


*Figure **3***

Use the three-axis rotation diagrams in Figures 1-3 and your Rotation on an axis model to answer the following questions:

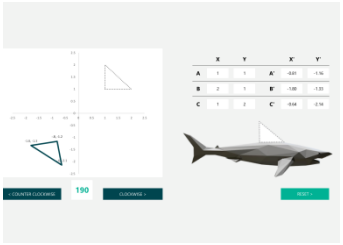
4 | Which figure represents roll?

5 | What are the coordinates of points A and B in the figure that represents roll?

6 | Which figure represents pitch?

7 | What are the coordinates of points A and B in the figure that represents pitch?

Mathematical modeling of rotation



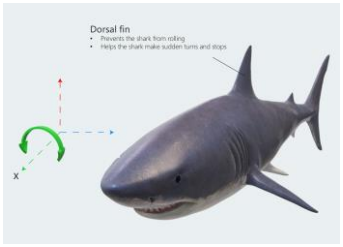
Mathematical modeling of rotation

Use Excel to understand 2D and 3D space using the Mathematical modeling of rotation workbook to see how rotation on the x and y axes changes the coordinates of a polygon.

1 | How is the rotation of points A, B, or C on the triangle in the Polygon Rotation sheet similar or different to points A and B on the 3-axis rotation figures?

2 | In Excel, extend your understanding of rotation to 3-dimensions by studying how a 3-dimensional pyramid rotates on the z, y, and x axes in the 3-axis rotation sheet.

Yaw, pitch, and roll

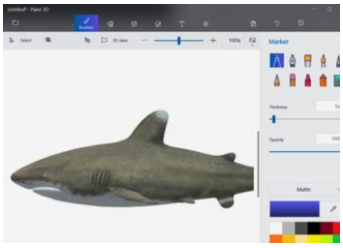


Shark anatomy and movement PowerPoint

Use the Shark anatomy and movement PowerPoint to research and answer the following questions:

1 | What are yaw, pitch, and roll? Which axes rotations relate to yaw, pitch, and roll of a shark?

2 | What other types of things exhibit yaw, pitch, and roll movements?

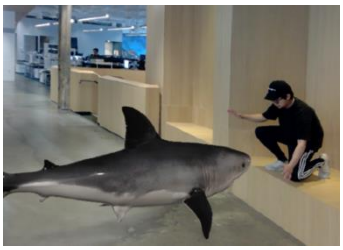


Bring your shark to life

3 | Bring your shark to life by using Paint 3D and importing models into PowerPoint to paint shark anatomy that control yaw, pitch, and roll.

- Import your shark model into PowerPoint.
- Label the parts that are used for yaw, pitch, and roll.
- Animate the model to demonstrate yaw, pitch, and roll rotations.

Self-guided real-world exploration



Explore a shark

1 | Visit Exploring a shark in mixed reality to engage in a self-guided exploration of the shark's anatomy and movement in the real world.

Reflection questions

Sample student reflection

Use the How to create a video reflection tutorial to discover how to use Microsoft Photos to reflect on your learning. See an example of how to combine photos and videos. Use these questions to guide you in creating a reflection:

1 | How is a shark's anatomy related to how it changes direction and stays balanced?

2 | Sketch an initial plan for a controller that would direct a robotic shark's movement in yaw, pitch, and roll.

3 | What would you like to investigate further about shark movement?