STOMP@HI

AQUABOTICA

University of Hawai'i Science Outreach Program

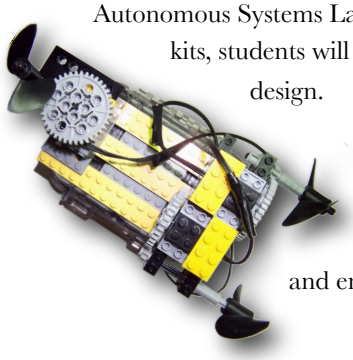
Teacher & Mentor Packet

AN INTRODUCTION TO AQUABOTICA

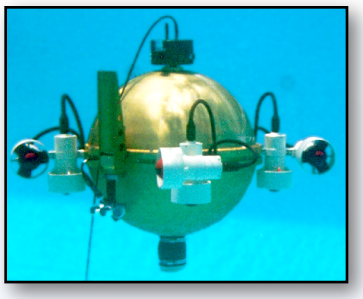
The Student Teacher Outreach Mentorship Program pairs University of Hawai'i students with local K-8 educators who want to implement engineering activities in their classrooms or after school programs.

Targeted towards students in grades of K-8, this program brings together graduate students, undergraduate students and teachers in the classroom for a week-long presentation designed to introduce topics from hydrodynamics, engineering, mathematics and autonomous control to students using an exciting hands on approach. The students will learn concepts such as mechanics, buoyancy, viscosity and autonomy which will immediately be applied towards their own AUV design using a LEGO Mindstorm robotic kit. The program culminates in a presentation of the students AUV design.

The topics covered during the program relate to actual research currently underway at the University of Hawai'i (UH). Students will be introduced to the Omni-Directional Intelligent Navigator (ODIN), an autonomous underwater vehicle (AUV) being developed at the UH Autonomous Systems Laboratory (ASL). With the help of Lego MindStorm robotic kits, students will design their own AUV, seeing firsthand the results of their design.



The STOMP@HI program brings students in to direct contact with the science research being conducted in their own backyard through a hands-on, and exciting method which will stimulate their interest in math, science and engineering.



ODIN - Omni-Directional Underwater Navigator

ODIN is a sphere-shaped, eight-thrustered underwater robotic vehicle capable of instantaneous movement in all 6 degrees-of-freedom motions from both a tethered and autonomous mode.

University of Hawai'i • Department of Mathematics, Ocean & Resources Engineering Department and Autonomous Systems Laboratory

STOMP@HI - INTRODUCTION

Welcome to STOMP-HI, Aquabotica!

The STOMP@HI program

The STOMP@HI program is designed around five classroom visits, each ninety minutes long. The students will be introduced to concepts and terminology that is usually not encountered at their grade level but is entirely within their ability to understand, such as buoyancy or viscosity. Also, the students will gain insight as to what happens on the UH campus.

The lessons center around ODIN, the focus of much current research. Using Lego MindStorm kits, the students will design their own version of an AUV and have the opportunity to test it similarly to how researchers at UH test ODIN.

The topics that are covered during the five days are related to what goes into engineering an AUV. Students will learn what it means to be buoyant, what the port side of a ship is, what autonomy means and much more. Each topic will is presented along with an activity or demonstration to help the students understand.

With the guidance of the mentor, the students will have hands-on time to build and design their own AUV with the Lego MindStorm kits. This is intended to foster the students creativity.

The teachers also benefit from fresh lesson plans that are related to research that is happening on the local level, tying their science education to our unique environment in Hawai'i.

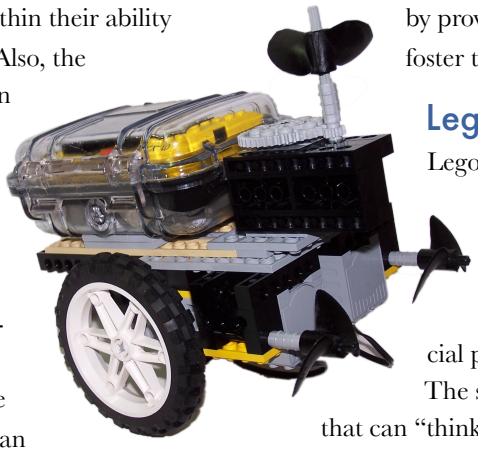
After the week is over, the program leaves students with a renewed interest in science and leaves the teacher with new teaching resources.

Role of a mentor

The mentor will work alongside the classroom teacher, assist with the presentations and will be the one most familiar with the activities, topics and MindStorm kits. The mentor helps gather and maintain the materials required for the visits, as well as preparation for each visit.

The benefits of outreach to mentors

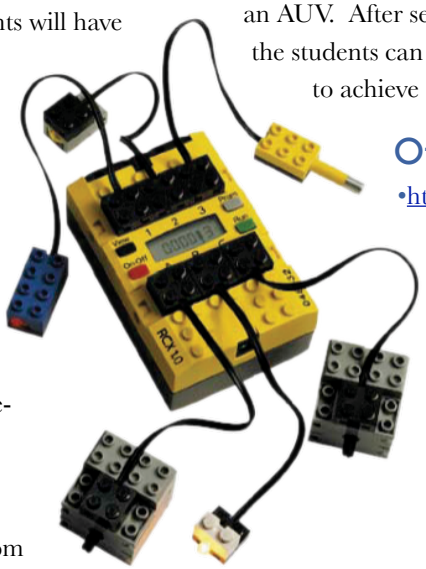
STOMP@HI provides a unique opportunity for engineering undergraduates to develop leadership skills as well as boost self-confidence. A mentor will benefit local children by providing them a unique experience that will foster their interest in science and engineering.



Lego MindStorm kits

Lego MindStorm is a Lego kit that integrates robotics and programming. It is a great hands-on tool for helping students learn about topics including math, science and engineering. Our kits are fitted with special parts to allow them to be used in water.

The students will use the kits to design a robot that can "think" for itself and is suited towards the challenge provided to them. The ROBOLAB software included with the kits is an interactive and intuitive way to program the robot to perform specific tasks. After designing their instructions, the program can be downloaded to the vehicle and run as an AUV. After seeing the immediate results of their program, the students can easily modify and optimize their instructions to achieve their goal.



Other Information

- http://stompnetwork.org/tufts/ - Contains information relating to the STOMP program, including sample activities and support.
- http://mindstorms.lego.com/ - Official Lego Mindstorm site
- http://www2.hawaii.edu/~azamora/ - STOMP@HI - Aquabotica site

STOMP@HI - STANDARDS

Listed below are some of the Hawai'i Content and Performance Standards that STOMP@HI addresses. The complete set of standards can be found at http://www.hcps.k12.hi.us/.

- **Mathematics Content Standards**
  - Geometry and Spatial Sense
    - Content Standard 1 - Students analyze properties of objects and relationships among the properties
      - Identify, build, draw, describe, compare, and sort geometric solids; and identify, describe, and draw common plane figures.
    - Content Standard 3 - Students use visualization and spatial reasoning to solve problems both within and outside of mathematics.
      - Describe how to get from a given point to another
  - Patterns, Functions, and Algebra
    - Content Standard 2 - Students use symbolic forms to represent, model, and analyze mathematical situations.
      - Use concrete, pictorial, and verbal representations of simple numerical situations.
      - Symbolize mathematical situations.
      - Quantify comparisons and describe change in familiar situations (e.g., measuring temperature and height changes).
  - Measurement
    - Content Standard 1 - Students understand attributes, units, and systems of units in measurement; and develop and use techniques, tools, and formulas for measuring.
      - Estimate with and use nonstandard units to measure length, weight, and capacity; and standard units of inch, foot, and centimeter to measure length.
      - Describe and identify area, volume.
- **Science Content Standards**
  - The Physical Environment
    - Content Standard 13 - Students examine the nature of matter.
      - Identify the properties of matter from which objects are made.
      - Give examples of how the properties of a material can be used to predict how that material will behave under different conditions.
    - Content Standard 15 - Students explain the relationship between force, mass and motion of objects; they analyze the nature of sound and electromagnetic radiation.
      - Explain how force and mass can change the speed or direction of an object.
    - Content Standard 17 - Forces of the Universe
      - Describe how the Earth's gravity pulls any object toward it without touching it.

STOMP@HI - CURRICULUM

K-6 Curriculum

Welcome!

This section contains an overview of the curriculum outline. It has everything you will need to guide you in preparing for the activities.

- **Day 1 - Introductions**
  - **Day 1 Topics**
    - University of Hawai'i
    - The fields of science, mathematics, engineering
    - The underwater world
    - Lego MindStorm Kits
  - **Materials**
    - Lego MindStorm Kits
    - Demonstration Tank
    - Demonstration AUV
    - TV/DVD
    - Student handout
  - **Preparation**
    - Fill tank
    - Check MindStorm kits are complete
  - **Lesson outline**
    - Discussion of weeks activities (5 minutes)
      - This week will learn about principles and terminology relating to the ocean
      - Design an AUV using LEGO MindStorm kits
      - Demonstrate AUV
    - Movie presentation (10 minutes)
    - The University of Hawai'i discussion (10 minutes)
      - What kinds of things do people study at the University of Hawai'i?
        - Math, Science, Medicine, Language, Art, etc.
      - University of Hawai'i research
        - Researchers learn about new things and share their new knowledge with society.
      - Examples of research in progress
        - ODIN – Omni directional intelligent navigator
          - ODIN is able to find its way around without help
          - What we learn about ODIN can be used for lots of other things.
          - Many people learn from ODIN
      - What do mathematicians, engineers and scientists do?
      - In cooperation they achieve great things such as…
        - Robots
        - Space exploration
        - Life saving medicine
        - Computers
        - Bridges
      - The fields applied to ODIN
        - Engineers design the computers used for navigation
        - Mathematicians give ODIN instructions on how to navigate
        - Scientists use ODIN to gather information about places they cannot go for them-

STOMP@HI - CURRICULUM

selves, such as the deep ocean.

- The Ocean and its vessels (10 minutes)
  - Why is the ocean important to us?
  - Some facts about the ocean
    - Cover ¾ of the earths surface
    - Ocean exploration is similar to space exploration. They are both largely undiscovered and difficult to explore.
    - Most of the plant and animal life on Earth relies on the Ocean
  - Has anyone been on a boat? How about a submarine?
  - What is the difference between a boat, ship and submarine?
    - "A boat can fit on a ship, but a ship can't fit on a boat"
    - Submarine can stay underwater for a long time
  - ROV – Remotely operated vehicle
  - AUV – Autonomous operated vehicle
    - Vehicle with a "brain"
    - Is different from ROV because it is making its own decisions.
  - What kind of things do they do?
    - Can operate in remote and hazardous places
      - Deep ocean, space
    - Mapping of ocean floor
    - Gather information for scientists
    - Repair underwater pipelines
- Activity – Intro to MindStorm kits (55 minutes)
  - Split into groups of two or three
  - Handout kits to groups
  - Introduce parts to students
    - For example, hold up RCX and have each group find their RCX. Describe what that part does. Do so for motors, propellers, wheels, axels.
  - Have students design and build freely. Allow them to be creative.
  - At end of session, have each group present design to mentor and describe what it is.

- **Day 2 – Statics and AUV's**
  - **Day 2 Topics**
    - Nautical terminology
    - Learn physical concepts relating to submarines and forces in water (hydrostatics).
    - Begin design of AUV
  - **Materials**
    - Lego MindStorm Kits
    - Prepare distance, area, volume Lego kit
      - For each student gather a single brick, a single "sheet", and also construct a cube (or open box) all with same dimensions. For example, 1X10, 10X10, and 10X10X10.
    - Demonstration AUV for force demonstration
    - Sinkable Lego boat (no motor) and weights for buoyancy demonstration.
    - Sponge and three sealed containers with weights for density demonstration
    - Demonstration Tank
  - **Preparation**
    - Fill demonstration tank
    - Have built boat and demonstration AUV
  - **Lesson Outline**
    - Activity - Nautical terms (10 minutes)
      - Q&A – Has anyone been on a boat or ship? Have they heard different words being used?
      - Have students pretend their desks are their ship

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- For each of the terms, have students stand by that part of their "ship".
  - Port
    - Left of ship when facing forward
    - Four letters in left and port
  - Starboard
    - Right ship when facing forward
  - Bow
    - Front of ship
  - Stern
    - Rear of ship
- For each of these terms, have students do the motion…
  - Sway
    - Side to side, horizontal motion without turning.
  - Surge
    - Front to back, horizontal motion.
  - Pitch
    - Front to back rocking motion.
  - Roll
    - Side to side rocking motion.
  - Heave
    - Vertical, up and down motion.
  - Yaw
    - Turn from side to side.
- Drill terms randomly for to help students to remember terms and have fun.

▪ Activity – Distance, Area, Volume (10 minutes)
- Hand out distance, area, volume Lego kit to each student
- Distance
  - Q&A – What is distance?
    - Measurement of how far apart things are
    - Relate to string
  - Find single Lego brick
  - Count number of "studs". Piece is ? "studs" long
- Area
  - Q&A – What is area?
    - Measurement of a size of a surface
    - Relate to sheet of paper
  - Find square shaped Lego "surface"
  - Count number of studs on each side
  - Measure with ruler.
  - Describe in terms of square studs, inches or cm
- Volume
  - Q&A – What is volume?
    - Measurement of how much space something occupies or holds
    - Relate to box, tank, etc.
  - Find Lego cube
  - Count number of studs on each length, width and depth
  - Measure each side with ruler
  - Describe in terms of square studs, inches or cm

▪ Force, pressure and buoyancy demonstration (10 minutes)
- Q&A – What do you think force is? Pressure? Buoyancy? Why do you feel lighter when you are swimming in the water?
  - Force causes something to move

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        - Pressure is a force exerted over an area
        - Buoyancy is the force of water on an object causing it to float or sink.
    - Demonstrate force with demonstration AUV being propelled through water.
        - The force from the propeller is causing the AUV to move
    - Demonstrate pressure and buoyancy by placing boat in the tank.
        - Boat is floating because the water is applying a pressure to the bottom of the boat.
        - The pressure is the force from the water over the area of its hull.
        - The boat is floating – called "positively buoyant"
        - Have students add weights to boat, causing it to start to sink
        - The weights overcome the force from the water, "hydrostatic pressure", and are causing it to sink.
        - Keep adding weights until it sinks, it is now "negatively buoyant".
- Density demonstration (5 minutes)
    - Density is the mass per volume of an object. Demonstrate with a sponge. Show sponge then squeeze the sponge. Sponge is same weight in both cases, but is smaller and therefore denser when squeezed.
    - Demonstrate with three sealed containers. One with no weights (positively buoyant) and the other with weights (negatively buoyant).
        - Both are the same volume, but different mass.
        - Density is related to buoyancy.
- Activity – Submerge and surface (55 minutes)
    - Have students freely design an AUV (or build upon their last project).
    - Students should think about how certain parts and placement will affect the movement of AUV.
    - Mentors program RCX and have students run their AUV in the tank to see their results.

- **Day 3 - Dynamics and AUV's**
    - **Day 3 Topics**
        - Learn physical concepts of motion (dynamics) and motion in water (hydrodynamics).
        - Apply knowledge of concepts and terminology to design
        - Complete design of AUV
    - **Materials**
        - Demonstration tank
        - MindStorm kits
        - Opaque tape to mark measured distance on floor.
        - Stopwatch
        - 3 jars, one with honey, one with water, one empty (air)
        - A small object to drop into jars, such as a marble or coin.
    - **Preparation**
        - Fill demonstration tank
        - Have assembled two Lego cars. Have one of them geared "low", so as to drive with a constant velocity. The other car should be geared "high", so as to demonstrate acceleration.
        - Measure a distance of about 3 meters and mark on ground for velocity demonstration
    - **Lesson Outline**
        - Velocity demonstration (10 minutes)
            - Q&A – What do you think velocity is?
            - Speed
                - How fast an object is moving
                - Does not keep track of direction, called scalar.
                - Example - Speedometer in car
            - Velocity
                - Like speed but keeps track of direction;

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        - Example - 55mph heading *east*.
    - Rate of change
        - Introduce equation: $v = \Delta x/\Delta t$
        - Velocity is the distance traveled divided by the time it took to do so.
    - Procedure:
        - Time how long it takes for car to travel from start to finish on the tape marks
        - Show how to calculate its average velocity
- Acceleration demonstration (10 minutes)
    - Q&A – Does anybody know what acceleration means?
    - Acceleration is the change in velocity over time
    - Procedure:
        - Acceleration
            - Run "high-geared" car on an open path in classroom
            - Point out how car starts of slow, then goes faster and faster with time. It is accelerating.
        - Deceleration
            - Disconnect motors allowing car to run freely
            - Push car and point out how car keeps going slower and slower, then eventually stops
        - Both are examples of what acceleration is. When something is not moving, or keeps moving at the same speed, it has no acceleration.
- Viscosity demonstration (10 minutes)
    - Q&A – What is thicker, water or honey? Honey or air?
    - Viscosity Is the "thickness" of a fluid
    - The more viscous the fluid, the harder it is for something to move though it. There is more friction.
    - Procedure:
        - Set up jars of water, honey and air
        - Get 3 volunteers. Have each of them stand ready to drop the object into the jar at the same time.
        - Q&A – Which one will hit the bottom first? Get some predictions.
        - Have them drop the objects and observe what happened.
        - Q&A – Which fluid is the most viscous? Which objects experienced the most friction?
- Activity – AUV performance (60 minutes)
    - Allow students refine their AUV design
    - With help of a mentor, have AUV travel in straight path and measure its velocity.
    - With the help of a mentor and using calculated velocity, find the time the motors should stay on in order to travel from end to end of the tank.
    - Program AUV to travel from end to end of the tank, stopping its motors as close as possible to the end of the tank.

- **Day 4 – Autonomy**
    - **Day 4 Topics**
        - Explore autonomy
        - Design logic that controls AUV to perform goals
        - Present final activity challenge
    - **Materials**
        - Demonstration tank
        - MindStorm kits
        - Demo AUV
    - **Preparation**
    - **Lesson Outline**

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- Autonomy discussion (10 minutes)
  - Q&A - What is autonomy?
    - Robot with a “brain”
  - Autonomous robots may be able to…
    - Perform tasks without direct human guidance
    - Get information about its surroundings via sensors
    - Travel and navigate without human help
    - Avoid dangerous situations and traps
    - May be able to learn and adapt to its surroundings
  - Challenges related to AUV?
    - Lack of communication
    - Unpredictable. Hydrodynamics are difficult to determine.
    - Navigation relies on advanced technology, such as technology that goes into ODIN.
- Demonstration - Logic design and instructions for the AUV (5 minutes)
    - Present MindStorm software
    - Demonstrate pre-built program for an AUV traversing an obstacle.
- Activity – Obstacle course (80 minutes)
  - Depending on progress so far, create a suitable challenge. Following are some example ideas...
    - Have students design AUV that is capable of
      - Submerge
      - Travel underneath obstacle
      - Surface
      - Re-submerge
      - Turn around
      - Pass underneath obstacle
      - Surface

- **Day 5 - Presentation**
  - **Day 5 Topics**
    - Present groups AUV design
    - Explain design choices for groups AUV
    - Demonstration
  - **Materials**
    - Demonstration tank
    - MindStorm kits
  - **Preparation**
    - Fill demonstration tank
  - **Lesson Outline**
    - Groups will present design and give demonstration
      - Q&A with group. Example questions….
        - What is the name of AUV?
        - What features does it have?
        - Why did you choose to design it how you did?
      - Demonstrate AUV in tank