Maryland Engineering Challenges 2020
Cargo Ship Challenge

High School – Grades 9 to 12

Supported By:
Technology and Engineering Education Association of Maryland

Engineer Contact:
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Important Dates:

Coaches' Information Session

⇒ **Wednesday, November 13, 2019** **4:00 p.m. to 7:00 p.m.**

This "drop-in" event is designed for adults interested in coaching a team to stop by and chat with engineers. Find out if a particular Challenge is a good fit for your students. The Information Session is not required and there is no cost. Registration is strongly encouraged. Contact Jessica at jcelmer@thebmi.org

Registration and Written Report Due

⇒ **April 17th, 2020** **Prior to 4:00 p.m.**

In order to be a registered team, each team must have their adult Coach do the following:

- Register online https://forms.gle/Sq9ZFXhqLXjC9wj76
- AND submit the team's Written Report as a HARD COPY to the Baltimore Museum of Industry
- AND pay a $5 Coach's Fee, details at https://48278.blackbaudhosting.com/48278/MEC-Coach-Fee

Cargo Ship Competition

⇒ **April 26, 2020** **Doors open at 11:00 AM, starts at 12:00 PM**

Important Information:

All Cargo Ship activities will be hosted at the Baltimore Museum of Industry, 1415 Key Highway, Baltimore, MD 21230

For more information on Cargo Ship engineering requirements, written reports, or judging criteria, please contact Paul Wiedorn at Paul_Wiedorn@hcpss.org . For assistance in setting up propulsion and control systems or obtaining propellers contact Douglas Griggs (dbdbgriggs@gmail.com).

For registration information or general questions about the Maryland Engineering Challenges, contact Jessica at jcelmer@thebmi.org . Final details about the competition event will be sent to registered Coaches after the registration deadline. Please note: this registration form is for adult Coaches of participating teams only. Only one Coach is needed per team, although a team may have as many adult helpers as needed.

Written reports can be, either by mail or in person, to: BMI, 1415 Key Highway, Baltimore MD 21230 prior to 4:00 PM on Friday, April 17th, 2020. Or emailed to jcelmer@thebmi.org .

NOTE TO PARTICIPANTS

The specified Kelvin.com, stock number 850962 motor is suitable for direct drive of the propeller shaft. A commercial speed control (such as the Goolsky WP-1060-RTR Waterproof Brushed 2S-3S 60A ESC for 1/10 Tamiya Traxxas Redcat HSP HPI RC Car) can be used, connected to any battery. Speed controls intended for radio control cars are usually suitable for marine use, as they provide forward and reverse operation. Airplane speed controls are generally not usable since they only operate in one direction.

There are commercially available running gear that you can purchase, or you can design your own. The propeller shaft could be any reasonable size and length to suit your design, but it should use a stuffing tube with some internal space for packing compound (*e.g.* Vaseline) to provide a watertight seal. Your design needs to keep the shaft in place radially, and needs to provide something for the shaft to thrust against to keep the shaft from moving forward while the ship is going forward, and some way to keep the shaft from backing out of the stuffing tube as you go in reverse.

Although there are many ways to design a hull-form, you may consider looking into the *DELFTship: Visual hull modelling and stability analysis* software (https://www.delftship.net/DELFTwp/)as a design aid.

A sample report for this challenge is available to help teams overcome any barriers to entry that they may have. This sample report contains a shopping list with possible sources of supply.

THE CHALLENGE

A local Baltimore company would like your team to design a bulk carrier cargo ship to deliver 40,000 tons of processed sugar to remote ports. The shortest wharf on the expected route is 600 feet long and the minimum depth in any port is 40 feet. As part of your solution you should build a 1" to 10'0" scale, radio controlled model to be tested in the inner harbor.

CRITERIA

The competition involves five main components: a written report submitted two weeks prior to the actual competition, an oral report on the day of the competition, the actual design and construction of the entry, the reliability of the entry, and the demonstrated performance. Basic requirements for the reports and guidance for preparing for the competition are given in the High School "Guide to Entry", which should be read in connection with these details which are specific to the cargo ship challenge.

I Written Report (includes drawings) (30 points)

Provide a written report in the required format (see "High School Guide to Entry") that presents and explains all facets of the design and the rationale for selecting specific design parameters and selecting/rejecting individual features. For example, what were the overall length, beam, and draft? How was the hull shape chosen? What testing was performed? What were the results? Be sure and include working drawings of the propulsion system and wiring diagrams and a final lines drawing of your hull.

II Oral Report (10 points)

One or more of the team members should present a 5-10 minute oral report that summarizes the written report. This will be followed by 5 minutes of questioning by the judges.

III Design and Fabrication (30 points)

Design a mono-hull ship to meet the requirements and construct a 1" to 10'0" (1:120) scale model with the hull constructed of any rigid material. The model should be robust enough to withstand minor collisions and must have enough watertight integrity to protect the cargo, the propulsion plant and the radio controls. The model should conform to the constraints listed below.

IV Reliability (5 bonus points)

Up to 5 bonus points will be awarded by the judges to vessels that are consistently ready to test when called, need few repairs, and operate reliably.

V Performance Demonstration (30 Points)

The performance of the vessel will be based on Required Freight Rate (how much the operator must charge per ton·mile to break even). The vessel with the lowest Required Freight Rate (RFR) will be declared the performance winner.

Once loaded, each entry will perform a timed run consisting of getting underway from a wharf, running a specified course around buoys, and maneuvering back alongside the wharf. This simplified formula for Required Freight Rate will be used:

$$RFR = (L+T) / (CD)$$

Where:

L = Length of Vessel

T = Time to run course in seconds

C = Pounds of Cargo carried

D = Scale Distance of course (considered to be 4 scale miles).

Example: 50" Long model with a full load of 40 pounds around course in 3 minutes

RFR = (50+180)/(40x4) = 230/160 = $1.44 per ton·mile

CONSTRAINTS

- The model must be powered by a Kelvin.com, stock number 850962 motor.
- A standard multi-channel radio control unit functioning in the R/C band must be used, capable of controlling at least forward/off/reverse, and the rudder. A radio controlled speed control may be used.
- The overall length of the model, including all appendages, may not exceed 60 inches.
- The navigational draft may not exceed 4 inches. That is to say, no part of the vessel (propeller, rudder, *etc.*) may extend more than 4 inches into the water.
- The depth of the hull (keel to deck edge), measured everywhere along the length, must be at least 8 inches.
- The vessel must be provided with a collision bulkhead at least 10% of the overall length aft of the bow. No cargo may be loaded forward of this bulkhead. A bulkhead must also be provided between the cargo and the propulsion plant. All cargo must be carried inside of the hull.
- The vessel must have a deckhouse that rises at least 5 inches above the gunwales (top of the hull sides). This deckhouse should be removable to provide access to the engine compartment for repairs and inspection.
- While there is no need to make a model of an actual ship, credit will be given for adding details that make your vessel looks like it might actually be able to put to sea.
- Paint the vessel for ease of identification. The quality of workmanship and finish is a factor in the judging. The design draft (waterline at full load) must be marked on the hull.
- The cargo should be visible for inspection prior to testing. Removable cargo hold covers and/or hatches must be fitted that will make the hull reasonably resistant to water intrusion during testing.

- The vessel should be designed to carry 40 pounds of sugar in their original packaging of ten 4-lbs. bags or eight 5-lbs. bags. The original packaging may be encased in plastic wrap but must be filled with sugar. Sand or other materials are not acceptable.
- The vessel must have adequate stability when fully loaded.
    - The vessel may be inclined to show a meta-centric height (GM) of > ¾ inch OR
    - Have a roll (left-right-back again) period of less than 2 seconds.
- If, on the day of competition, the vessel is unable to demonstrate adequate stability, the judges may elect to remove one or more bags of cargo with the associated performance penalty.

CURRICULUM TIES-- Maryland Engineering Challenges and the Next Generation Science Standards

Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.1 The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.	**In preparing for the challenge, students will:** • Recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues. 1.1.1 • Modify or affirm scientific ideas according to accumulated evidence. 1.1.2
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.2 The student will pose scientific questions and suggest investigative approaches to provide answers to questions.	**In researching project designs, students will:** • Identify meaningful, answerable scientific questions. 1.2.1 • Formulate a working hypothesis. 1.2.2 • Defend the need for verifiable data. 1.2.8
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.3 The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.	**In constructing their projects, students will:** • Develop and demonstrate skills in using lab and field equipment to perform investigative techniques. 1.3.1 • Demonstrate safe handling of the chemicals and materials of science. 1.3.3 • Learn the use of new instruments and equipment by following instructions

	in a manual or from oral direction. 1.3.4
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.4 The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.	**In testing their projects, students will:** • Analyze data to make predictions, decisions, or draw conclusions. 1.4.2 • Describe trends revealed by data. 1.4.6 • Determine the sources of error that limit the accuracy or precision of experimental results. 1.4.7
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.5 The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.	**In composing their reports, students will:** • Demonstrate the ability to summarize data (measurements/observations). 1.5.1 • Explain scientific concepts and processes through drawing, writing, and/or oral communication. 1.5.2 • Use, explain, and/or construct various classification systems. 1.5.7 • Communicate conclusions derived through a synthesis of ideas. 1.5.9
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.7 The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.	**In reflecting on the engineering process, students will:** • Identify and evaluate the impact of scientific ideas and/or advancements in technology on society. 1.7.2 • Investigate career possibilities in the various areas of science. 1.7.5 • Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments. 1.7.6

GOOD LUCK TO YOUR TEAM!