**SMART Center Portside Robotics**

**An Educational Module for Middle School and High School   
(8-11 grade) STEM classes**



**Additional modules can be found at:**

**www.maritime-technology.org**



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**Enduring Understanding**

Production systems are made up of subsystems that must work together to produce a product. Many processes are necessary for an entire production system to operate efficiently.

**Essential Questions**

“How do we apply the Engineering Design Process to solve a real problem?”

**Outcomes**

During this module the student will learn…

* basics of the Engineering Design Process,
* that energy used in our environment is not used efficiently,
* the processes that are necessary for the entire production system to operate efficiently, and
* the role of requirements in the development of a product or system.

As a result of this module the student will be able to…

* research the system used to or for an invention or innovation, and
* continue with the UBD process and innovate a crane design of their own or at a minimum use the plan that is a part of this portfolio.

**General Teaching Strategies**

Should address multiple intelligences and individual differences.

**Materials (including technology):**

* Computer stations
* Graphic organizer handout
* Pencil and paper
* Reading folder
* Various power and hand tools for construction

**Course Objectives/SOL Addressed**

**International Technology Education Association/Standards for Technological Literacy, (ITEA/STL)**

* ITEA/STL 8- emerging
* ITEA/STL 9- emerging
* ITEA/STL 10- emerging
* ITEA/STL 11- emerging

**National Council of Teachers of Mathematics (NCTM), Mathematics: Principals and Standards for School Mathematics**

* NCTM Geometry, Grades 6-8
* NCTM Measurement, Grades 6-8
* NCTM Mathematical expressions, all grades
* NCTM Communication Standard, all grades
* NCTM Connection Standard, all grades
* NCTM Representation Standard, all grades

**American Association for the Advancement of Science (AAA), Benchmarks for Science Literacy**

* AAAS 3B, Design and Systems, Grades 6-8
* AAAS 4F, Motion, Grades 6-8
* AAAS 11A, Systems, Grades 6-8

**Commonwealth of Virginia Standards of Learning (SOLs)**

* 6th Grade Math- 6.1, 6.2, 6.4,6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 6.12, 6.14, 6.15, 6.16, 6.18, 6.19, 6.20, 6.21
* 7th Grade Math- 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.12, 7.13, 7.14, 7.15, 7.19, 7.22
* 6th Grade English- 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7
* 7th Grade English- 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9
* 6th Grade Science- 6.1, 6.2, 6.3
* 7th Grade Physical Science- PS1 f-n, PS10 a-d
* 6-8th Grade Computer Science- 1, 2, 3, 4, 5, 6, 7, 8, 9

**VBCPS Continuum for 21st Century Skills**

* Critical and Creative Thinkers, Innovators, and Problem Solvers
* CT1-Critical Thinking - emerging
* CT2- Creative/Innovative Thinking – emerging
* CT3 – Problem Solving
* Effective Communicators and Collaborators
* EC1 – Information Literacy
* EC2 – Listening – novice and emerging
* EC3- Collaboration – emerging
* EC4- Communication – emerging

**Globally Aware, Independent, Responsible Learners and Citizens**

* GA1- Socially Responsibility – emerging
* GA2 - Sustainability
* GA3-Interdependence – emerging
* GA4 \_ Health Literacy - novice

**Schedule of Classroom Activities**

**Day 1**

* Identify the need or problem and develop the needs statement for the crane.
* Research the Problem
* Go to and list 3 different web sites and investigate 3 different crane types. Complete 3 drawings of 3 different cranes to include a top, front and side views.

**Day 2**

* Researching the problem
* Develop possible solutions

**Day 3**

* Select the most promising solution from the research
* Using graph paper come up with a sketch for the major crane components.
* *Using the rough sketches come up with CADD drawings for the different views of the different crane components using Vex or Pitsco parts. (Grade 9-11)*
* Identify kit parts needed or develop a parts list for the student’s crane design
* *Develop a Vex or Pitsco parts list.*

**Day 4**

* Lay out the drawings and cover with wax paper and secure in place with masking tape.
* Build the base.
* Ensure all pieces are secured so the glue will dry and the base does not shift.
* *Using Vex and Pitsco parts build the base. (Grade 9-11)*

**Day 5**

* Continue to build the base

**Day 6**

* Lay out the drawings and cover with wax paper and secure in place with masking tape.
* Build the boom
* Ensure all pieces are secured so the glue will dry and the base does not shift.
* *Using Vex and Pitsco parts build the base. (Grade 9-11)*

**Day 7**

* Continue building the boom.

**Day 8 and 9**

* Construct the sling and install release mechanisms and add weights.

**Day 10 and 11**

* Test and evaluate the prototype.

**Day 12 and 13**

* Collect, process and display the collected data.

**Day 14**

* Communications and production design
* Review and redesign

**Writing experiences:**

Complete the graphic organizer on the crane

**Primary source reading used: Web**

* Various internet resource sites

**Student Assessment**

* EDL Graphic Organizer
* Crane

**Evaluation of Lesson**

NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

BELL: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

START DATE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Situation at hand**

This evening a cargo ship has pulled into port, after getting all lines over and doubled up and securing the ship’s Main Engines the cargo manifest is reviewed for items that are to be off loaded. The ship is full of all kinds of dry goods that are in crates and containers of various sizes and weights. The ship is to be off loaded starting tomorrow morning. When the off load is complete any cargo that is staying onboard will be redistributed to maintain ship’s ballast and the ease of loading on new cargo the following day after. The new cargo will make the next trip of the ship even more cost effective on fuel savings.

The port needs to have a new crane design that will handle the loads that are coming into port now and will also handle larger loads and containerized cargo in the future. The current cranes were built towards the end of World War 2 and are beyond their service life. Parts are no longer available and maintenance is not cost effective. Whenever maintenance is conducted a component malfunctions or breaks.

A new crane design and a model of the prototype is needed for evaluation and testing. Your company has been contracted to come up with a crane design, prototype model and design test data information.

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**Step 1**

**IDENTIFY the NEED or PROBLEM**

**Given the Crane Design Brief, define your problem . . . .**

Engineers solve problems by creating new products, systems, or environments. Before creating something, it is very important to define the problem. Otherwise, you might build something only to find that it does not meet the original goal!

To define your problem, answer each of these questions.

* What is the problem or need?
* Who has the problem or need?
* Why is it important to solve?

The answers to these three questions are the what, who, and why of your problem. Your problem statement should incorporate the answers as follows:

[*Who*] need(s) [*what*] because [*why*].

In design terms, who, what, and why can be defined as:

Who = user  
What = need  
Why = insight

The problem statement for any good engineering design project should be able to follow the format above. Your problem statement should always look like this:

           \_\_\_\_\_\_\_\_\_\_\_\_\_need(s) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ .

If you are improving an existing solution for your project, keep in mind that the improvements will be part of your problem statement. Making something better, faster, or cheaper should be part of your statement—either in the **"what"** portion and/or the "**why"** portion.

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Step 2

**RESEARCH the PROBLEM**

**Define the details of the problem in clear concise language . . . .**

Understanding the vocabulary and terminology of a crane and engineering will help you in reaching and developing the best design. Define the following words.

Dead Load: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Live Load: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Static Load: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Dynamic Load:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Elasticity: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Compression: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Tension: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Torsion: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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First Class Lever: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Second Class Lever: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Third Class Lever: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Tie: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Battered or tapered: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Shear: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Strut: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Researching the current status: What is working and what is not working right now? By understanding the current processes, we can begin to see where things are going wrong. Investigate 5 different web sites on cranes and list the wed sites below.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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***NOTE: Wikipedia is not considered a good reference source. Do not use it, it will not count as a reference.***

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STEP 3

**DEVELOP POSSIBLE SOLUTIONS**

**Planning solution*s*: Plan and take action to remove (or reduce) the biggest causes identified in poor performance. . . .**

Brainstorming and produce Thumbnail Sketches of 3 different cranes. Review the requirements and constrictions. Apply math (how much it can lift), measurements (how big is it), and science skills pulley and hydraulic workloads and forces) as you refine sketches.

**Crane 1**

**Crane 2**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Crane3**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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**Step 4**

**SELECT a PROMISING SOLUTION**

**Plus/Delta (+/∆) review of ideas . . . .**

The +/∆ evaluation can help select a solution. List the best and least desired features (characteristics) for each crane design from step 3. Examples are changes in the mast height or shortening the boom. Be clear and specific and use full sentences.

**PLUS** **DELTA**

Features to Keep Features to change

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STEP 5

**CONSTRUCT a PROTOTYPE** (Balsa Prototype)

**Mast Parts List**

**Part Name Number of Pieces Length of Pieces Amount**

Columns 8 10” 80”

Girders 20 4” 80”

Webs 32 4” 128”

Base 1 ¼”x 4”x 5” 1

**Boom Parts List**

**Part Name Number of Pieces Length of Pieces Amount**

Top girders 4 6” 24”

Bottom girders 4 6” 24”

Diagonal Side Webs 4 3 1/4” 13”

Top Beams 4 2” 8”

Side Beams 6 2” 12”

Bottom Beams 4 2” 8”

Diagonal Beams 10 2 ¾” 28”

Hook Plate 1 ¼”x 2”x 2” 1

Total of thirteen (13) ¼” x ¼” x 24” Balsa strips

*(If the student is planning to design their own crane they need to get graph paper to sketch out the mast and the boom design and use the sketch for a CADD drawing.)*

**Building Schedule**

**Day 1**

Identify the need or problem and develop the needs statement for the crane.

**Day 2**

Research the Problem

Go to and list 3 different web sites and investigate 3 different crane types. Complete 3 drawings of 3 different cranes to include a top, front and side views.

Researching the problem

Develop possible solutions

**Day 3**

Select the most promising solution from the research

Using graph paper come up with a sketch for the major crane components.

*Using the rough sketches come up with CADD drawings for the different views of the different crane components using Vex or Pitsco parts. (Grade 9-11)*

Identify kit parts needed or develop a parts list for the student’s crane design

*Develop a Vex or Pitsco parts list.*

**Day 4**

Lay out the drawings and cover with wax paper and secure in place with masking tape.

Build the base.

Ensure all pieces are secured so the glue will dry and the base does not shift.

*Using Vex and Pitsco parts build the base. (Grade 9-11)*

**Day 5**

Continue to build the base

**Day 6**

Lay out the drawings and cover with wax paper and secure in place with masking tape.

Build the boom

Ensure all pieces are secured so the glue will dry and the base does not shift.

*Using Vex and Pitsco parts build the base. (Grade 9-11)*

**Day 7**

Continue building the boom.

**Day 8 and 9**

Construct the sling and install release mechanisms and add weights.

**Day 10 and 11**

Test and evaluate the prototype.

**Day 12 and 13**

Collect, process and display the collected data.

**Day 14**

Communications and production design

Review and redesign

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STEP 6

**TEST and EVALUATE PROTOTYPE**

**Verifying effectiveness: Add weight at ¼ pound and ounce increments until the crane shows breakage or topples over. Each student will track their crane’s weight capabilities for steps 7 and 8 and document the weight below. The student will also collect other crane weight test data and develop a scatter plot. The student will also convert all weight test data to ounces and determine mean, median and mode.**

**Crane weight achieved: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.**

STEP 7

**COMMUNICATIONS & PRODUCTION**

**Document the improvement and set the new solution for the production process . . .**

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STEP 8

**REVIEW and RE-DESIGN**

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