Module Overview	
For grade level(s)	Middle and High school – 6th - 12th
Suggested Time	MESA Period: 6 weeks of daily 50-60 minute sessions MESA Afterschool: 4 total sessions of 60-90 minutes each MESA Saturday: 2 Saturdays for total of 8 hours
Purpose	This module is intended to introduce the concepts of structural design through mathematics and geometry. The bridge competition is also intended to highlight the importance of math and engineering in addressing some of the challenges that face society today in the area of transportation. Students will be introduced to geometry and vector analysis as well as structural shapes and analysis. The program will take students through the analysis of the problem (rules), discussion of possible solutions, and construction techniques resulting in a better understanding of the importance of problem solving. Students will be prepared to build a small-scale balsawood bridge that will achieve the greatest strength-to-weight ratio at MESA Day.
Objectives	Upon completion of this module, students will have a fundamental understanding of: • Bridge & structure design and construction • Forces and loads • Strength of materials • Destructive testing
Sample Standards Addressed	Lesson 1: • HS-ETS1 Engineering Design Lesson 2: • A-SSE 1,3,4, A-CED 4, A-REI 3 • HS-ETS1 Engineering Design Lesson 3: • HS-ETS1 Engineering Design Lesson 4: • A-SSE 1,3,4, A-CED 4, A-REI 3 • HS-PS2 Motion and Stability: Forces and Interactions • HS-ETS1 Engineering Design Lesson 5: • A-SSE 1,3,4, A-CED 4, A-REI 3 • G-SRT 6,7,8 • HS-ETS1 Engineering Design Lesson 6: • A-SSE 1,3,4, A-CED 4, A-REI 3 • G-SRT 6,7,8

	• HS-PS2 Motion and Stability: Forces and Interactions • HS-ETS1 Engineering Design
Assessment	Students will be evaluated through the following methods: • Assessment worksheets • Oral presentations with rubrics • Lab reports with rubric • Project testing
Additional Resources	The following are available on the California MESA website: • PowerPoint presentations • Design software

Background

Civil engineering is the branch of engineering concerned with the design and construction of public structures. As you walk around any human-inhabited part of the world, you will likely observe examples of civil engineering. From public building and roads, to bridges and tunnels, civil engineers help to design all the essential structures of the modern world. The origin of civil engineering dates back thousands of years. Who designed the breathtaking pyramids of Ancient Egypt or the beautiful arch bridges of Ancient Rome? Today we would call them civil engineers.

Many people believe that civil engineers actually build the structures they design. This is not the case in modern societies – civil engineers design structures such as bridges, tunnels, amusement park rides, skyscrapers, and stadiums. These designs are then passed along to contractors and construction workers, who build the actual structures. Most public structures are the result of many teams working together.

- Average median salary in US (2011): $77,990
- Can work for state and local governments or private sector
- Public company: Caltrans – www.dot.ca.gov
- Private company: Rick Engineering – www.rickengineering.com

Benefit To Society

One of the greatest challenges for civil engineers is designing structures appropriate to the environmental conditions in a particular region. Civil engineers must ensure that the structures they design will be stable, strong, and safe – able to withstand wind and rain, the wear and tear of everyday use, and even earthquakes and hurricanes.

The job includes plenty of analysis of such factors like construction costs, consideration for government regulations and potential environmental hazards, and test soils and building materials.

An Alumni Story

My name is Juanito Landis and I'm a civil engineer with Rick Engineering. I was also a MESA student when I was in high school and college and obtained a bachelors degree in civil engineering from San Diego State University.

I became interested in civil engineering after a couple of years competing in the MESA bridge competitions. One year we used manila folders and the next year it was balsa wood sticks. I liked the idea of working together in a team to design and build a structure that could one day become a real bridge. But working on these projects also helped me to be better at managing my time between academics and social life.

While studying at SDSU, I was fortunate to get an internship in engineering and allowed me to experience what a career in this field might be like. After graduating, the hard work paid off and I was able to secure a job with Rick Engineering. I've worked not just on bridges, but also on different types of buildings and transportation structures.

Engineering Design Process

The engineering design process will be a theme that spans all of the PBL modules, so an extensive lesson isn't required to be included in each module. However, it may be more effective to focus on particular parts of the process that work well with this module. For instance, there are various forms of brainstorming that could be recommended such as collaborative sketching (C-sketching) and mind-mapping.

LESSON # 1 of 6
1.1 Introduction to Civil Engineering

1. **Lesson Objectives**
   Students will:
   - **a.** Learn how civil engineers impact our daily lives
   - **b.** Identify different areas of specialization
   - **c.** Understand the benefits of a career in civil engineering
   - **d.** Identify the necessary skills to develop in high school
2. **Materials List**
   - **a.** Team building activities
   - **b.** PowerPoint/video about civil engineering
3. **Classroom Management & Delivery Strategies**
   - **a.** Choose one activity from the team-building guide to reinforce the importance of teamwork. Afterwards, set up students in the teams they will be in for the duration of this project.
   - **b.** Deliver PowerPoint in lecture style and encourage students to take notes in their engineering notebooks, if possible.
4. **Activity/Challenge**
   - **a.** **5 min** – Go over the rules for the team-building exercise.
   - **b.** **15 min** – Go through at least on round of the activity and always reinforce the need to communicate and work together to achieve the goal.

c. **5 min** – Have students form teams of 2-3 and explain that this their team for the duration of this module.
d. **15 min** – Present the PowerPoint on "What is Civil Engineering?"
e. **10 min** – Introduce the Civil Structures Balsawood Bridge competition for MESA Day
f. **5 min** – Reflection on importance of teamwork

LESSONS 1-6
Pacing Guide

Note: The MESA Curriculum is intended to be flexible and to meet the needs of all MESA delivery models. As the lessons are developed, please keep in mind what components can be "sacrificed" for the afterschool/lunch/Saturday models where the instruction time is usually less than a MESA period.

Recommended pace for MESA Periods:

Week 1 – Introduction to Civil Engineering	
Monday	• 1.1 Introduction to Civil Engineering
Tuesday	• 1.2 Career Opportunities
Wednesday	• 1.3 Great Civil Structures
Thursday	• 1.4 Presentation and Evaluation
Friday	• 1.4 Presentation and Evaluation (continued)
Week 2 – Materials Characterization	
Monday	• 2.1 Materials Introduction
Tuesday	• 2.2 Materials Terms and Definitions
Wednesday	• 2.3 Observing Elasticity & Stiffness
Thursday	• 2.4 Observing Elasticity & Stiffness (continued)
Friday	• 2.5 Presentation & Evaluation
Week 3 – Bridge Construction	
Monday	• 3.1 Bridge Construction
Tuesday	• 3.1 Bridge Construction (continued)
Wednesday	• 3.1 Bridge Construction (continued)
Thursday	• 3.1 Bridge Construction (continued)
Friday	• 3.1 Bridge Construction (continued)
Week 4 – Truss Factor of Safety and Bridge Characterization	
Monday	• 4.1 Introduction to Bridge Simulation
Tuesday	• 4.2 Factor of Safety in Design
Wednesday	• 4.3 Geometry Member Characterization
Thursday	• 4.3 Geometry Member Characterization (continued)
Friday	• 4.4 Load Testing and Evaluation
Week 5 – Structural Analysis I	
Monday	• 5.1 Geometry of a Bridge
Tuesday	• 5.2 Using Mathematics for Analysis

Wednesday	• 5.3 Force Vectors
Thursday	• 5.3 Force Vectors (continued)
Friday	• 5.4 Evaluation
Week 6 – Structural Analysis II	
Monday	• 6.1 Reducing Factor of Safety
Tuesday	• 6.2 Method of Joints
Wednesday	• 6.3 Examples of Isolated Joints
Thursday	• 6.3 Examples of Isolated Joints (continued)
Friday	• 6.4 Evaluation & Reflection

**** Add as many weeks as necessary for the module**

Recommended pace for MESA Afterschool Programs:

Afterschool	
Day 1	• 1.1 Introduction to Civil Engineering • 5.3 Geometry of a Bridge
Day 2	• 3.1 Bridge Construction
Day 3	• 4.4 Load Test and Evaluation
Day 4	• 5.2 Using Mathematics for Analysis • 1.2 Career Opportunities

**** Add as many days as necessary for the module**

Recommended pace for MESA Saturday programs:

Saturday	
Day 1	• 1.1 Introduction to Civil Engineering • 5.1 Geometry of a Bridge • 5.3 Force Vectors • 3.1 Bridge Construction
Day 2	• 3.1 Bridge Construction (continued) • 4.4 Load Test and Evaluation • 5.2 Using Mathematics for Analysis • 1.2 Career Opportunities

**** Add as many days as necessary for the module**