P4E:STEM

LESSON PLAN

Team Problem Solving Jigsaw Activity

Title	Team Problem Solving Jigsaw Activity
Course	Any course where students could solve problems in teams This example assignment was used in Engineering Mechanics: Statics
Author	Rebecca Atadero, Ph.D., P.E. Associate Professor Daniel Baker, Ph.D., P.E. Assistant Professor Civil and Environmental Engineering Colorado State University
Time duration	45 minute pre-class assignment 1 hour in-class activity 30 minute out-of class follow-up assignment
Overview	This activity is designed to explore how teams work together and how teams need diversity of ideas and problem-solving approaches to effectively solve problems in engineering. When this activity is applied in Statics, students work in a team to design a steel rail to support one side of a moving crane. The activity is a challenging problem that is closely related to what students are learning in class about shear and moment diagrams, but the problem is a “stretch.” Students are individually given hints to help them better understand the problem. In their problem-solving groups they must share hints, listen to each other, and work as a team to solve the problem.
Objectives	• Work effectively with other students taking into account input from all team members and recognizing different working styles.

- Explain how diversity (of ideas and potentially identities) is relevant to engineering problem solving.
- Apply knowledge of shear and moment diagrams to a simple design scenario.

Pedagogical Background

This activity is similar to what is called a “Jigsaw” activity. In a Jigsaw, students work in ‘expert’ groups to become knowledgeable with a particular idea or concept, and then ‘applied/problem solving’ groups are formed with a member from each expert group and asked to work on a problem, each bringing their expertise to the problem.

For more information on the Jigsaw approach, visit: https://www.educationworld.com/a_curr/strategy/strategy036.shtml

Materials

- Team Problem Solving Handout (to be given to all groups)
- Hints Handouts (to be printed and divided up so that each hint is only given to the members of the hint group)

Procedures

Before the class with the team problem-solving session, have students and reflect on a preliminary video prepping them for working in teams.

Pre-Class

Video used in our Statics implementation:

https://www.youtube.com/watch?v=wULRXoYThDc

There is the opportunity here to have students watch different videos and learn about different aspects of working with people. This would be especially relevant if students were going to encounter this type of teamwork format in several courses within their curriculum. They could have a familiar format – but new things to learn about in each course. Other topics might include psychological safety or microaggressions.

Ask students to reflect on the video, including some questions that are about the video itself (to ensure students watch).

Sample questions include:

- In the video (around the 3:45-3:50 mark) Professor Page describes people as a “vector of skills, experiences, and talents”. What are some of the skills, experiences and talents that make up your vector?
- What is one aspect of your identity that might lead you to approach problems in a different way from your peers (i.e. something that makes you cognitively diverse from other engineering students you know?), and why?

- What type of group is best suited to solving complex problems? Why is this type of group particularly important in the modern world?
- At the end of the video, Professor Page talks about how diverse teams can produce the best work, but in some cases can also produce very poor work. The diversity of the team will only benefit the product if the team members can work together effectively. How can we set up environments so that there are optimal interactions among group members? In other words, what can professors do in the classroom or what can YOU do in a group setting so that your team is making the most of group work?

Note: Consider giving students access to the In-class assignment before class.

In-class Activity Debrief/Discussion

At the beginning of the class session, assign students to groups and have the groups talk about the problem for a few minutes to gain familiarity with the problem and its associated challenges.

Have the groups split up and send one team member to each of the hint groups. Give students the opportunity to talk in the hint groups – and if possible, to ask questions of the instructor, TA or learning assistant. Give the students the time to “take ownership” of the hint.

Have students return to their original group and proceed to solve the problem as a team using the shared hints contributed by the team members. Teams may need time outside of class to finish solving the problem.

Post-activity reflection

After the activity, students individually fill out a reflection piece, to be submitted following the activity.

Reflection questions:

- What did you learn from this assignment?
- Think about interacting with other engineering students, especially those who thought differently or had a different approach to the problem from you. How can you apply what you learned to your future interactions?
- Did what you learned in this assignment change your views on how engineers’ function or their roles? If so, how?
- What did you like about this assignment?

- What would you change about this assignment to make it more engaging for you?

Possible Extensions to the Activity

During a pilot of this activity, some students commented on the benefits of hearing from the entire team and led us to believe that students might also benefit from instruction on specific teamwork skills. An alternative approach might include:

1. Pick 2 assignments during the semester where this model of teamwork can be used.
2. Run assignment 1 as described above with the pre-video and pre and post questions.
3. For the second assignment, the emphasis of the teamwork learning would be on actual strategies for working in teams. For example, give students a different video to watch or article to read about teamwork skills – or have an in-class discussion about what they learned about teamwork during the previous activity and what they might want to do differently for the second assignment.
4. After the different lead-in activity, the in-class problem solving portion would be conducted in the same way as the first assignment. Follow-up questions would be similar but also tailored to the fact this is the second time students have done this type of teamwork during the semester.

Application to other problems

To apply this activity to a different subject matter or problem, develop a challenging assignment that is closely related to what students are doing in class, but that is a "stretch". As part of determining the problem think of about 4 hints that can be used to help students better understand the problem. (The number of hints should match the number of students you plan to have in each group.)

This work was supported by grants from the National Science Foundation (NSF Award #: 1725880, 1432601). Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

CIVE 260 Statics Team Problem Solving

Learning Outcomes

1. Apply knowledge of shear and moment diagrams to a simple design scenario.
2. Work effectively with other students taking into account input from all team members and recognizing different working styles.
3. Explain how diversity (of ideas and identities) is relevant to engineering problem solving.

Problem Solving Goal

Work in a team to **design a steel rail** to support one side of a moving crane.

Getting Started with Design

In design we need to always satisfy the following inequality:

Demand < Capacity

For this problem this means the load applied on a beam must be less than the strength of the beam.

Or, in other words, the internal forces caused by the loading must be less than the internal forces the material can withstand. Furthermore, we must consider design factor(s) to provide for additional safety.

For this situation we need to make sure the rail beam is adequate to carry two types of internal forces: Moment and Shear. Thus, you need to determine the moment caused by the applied loads and the moment a particular size of rail beam can carry. You also need to compute the shear caused by the applied loads and the shear force a particular size of rail beam can carry. Just because a beam works for moment does not necessarily mean it will also be adequate for shear. It is important to check both modes of failure.

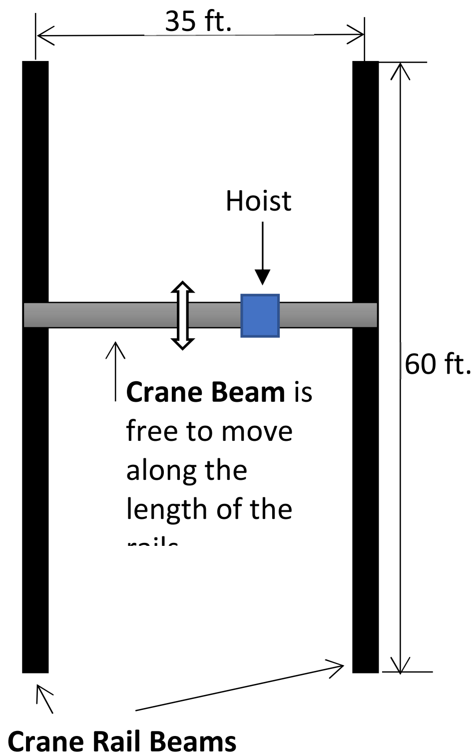
Based on your Statics knowledge, your team should be able to determine the maximum moment and shear caused by the applied loads. We have provided the attached design tables from the American Institute of Steel Construction (AISC) *Steel Construction Manual* to help you find beam sizes that are adequate to carry the applied loads.

Explanation of the Situation.

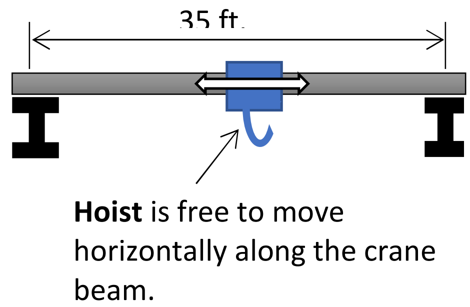
A picture of a moving crane is shown below. Your assignment is to determine the required size for the black beam shown in the picture.

Rail Beam

Plan View (view from



Section View (view from end)



Design Details:

The total length of the crane beam is 35 feet. (Assume the distance between one supporting rail and the other will be 35 feet.)

Treat the crane beam as a simply supported beam with reactions at each of the rails you are designing.

The hoist of the crane is free to move along the length of the crane beam over the middle 30 feet of the span.

The crane beam itself has a total weight of 3000 pounds that is uniformly distributed along its length.

The hoist plus the load being lifted can weigh up to 8 tons.

The rail you are designing will be simply supported at each end, and the total span of the rail will be 60 feet.

The crane beam is free to move along the rails, but must stay perpendicular to the rails. The crane beam is not allowed to travel over the last 2 feet of rail length.

Pick a W shape for the crane rail beam. W stands for wide flange. This type of beam has an I shaped cross-section.

The steel for the rail will be ASTM A 572 Grade 50 steel, which has a yield strength of 50 ksi. The attached tables are intended for this strength of steel.

Also provide students with access to Z shape selection tables from the *AISC Manual of Steel Construction.*

Pages covering W21x55 – W10x54 and W18x35-W8x21 (May need to be updated for newer editions of the manual.)

Hint 1

Engineers must consider and design for the worst possible scenario. When determining the moment and shear applied to the crane rail beam, it is important to determine the largest values for moment and shear the beam will need to support. **The hoist is free to move along the length of the crane. When the hoist is positioned at the center of the crane, the load carried by the hoist will be equally distributed to the crane rail beams on either side. But if the hoist moves to one side, more of the weight will be carried by the crane rail beam on that side.** You should determine the maximum reaction the crane will place on one of the crane rail beams. Keep in mind that the weight of the crane is uniformly distributed along its length, and only the additional weight lifted by the crane is free to move.

Hint 2

Engineers must consider and design for the worst possible scenario. When determining the moment and shear applied to the crane rail beam, it is important to determine the largest values for moment and shear the beam will need to support. **The crane is free to move along the length of the crane rail beam.** We can model the force the crane applies to the crane rail beam as a point load. When a single point load acts on a simply supported beam, the maximum moment will occur when the load is positioned at the center of the beam. However, positioning the point load at the center of the beam does not give you the maximum value of shear. The beam will experience the maximum value of shear when the point load is positioned as close to the end of the beam as possible.

Hint 3

The AISC (American Institute of Steel Construction) Steel Construction Manual includes the specification for structural steel design, and also many useful tables to simplify the design process. The table attached to the assignment directions will allow you to determine a beam size that is acceptable for both moment and shear. The table has information for two different types of design ASD and LRFD. These two types should both produce safe designs, they are just different in how the factor of safety is included in the design process. **To use the LRFD columns of the table, you need to first multiply the loads by load factors.** The moving crane load should be considered a live load, so the moment and shear caused by the moving crane should both be multiplied by 1.6, also because the load is a moving load a 10% increase for impact is recommended. After applying the load and impact factor, use the LRFD $\phi_b M_{px}$ column to find a beam shape that has enough moment capacity. You can also check the shear capacity of the beam using the $\phi_v V_{nx}$ column on the far right of the table. Choose a W shape that has enough capacity in both Moment and Shear. It is common in design to try to pick the lightest shape that will work. The shapes listed in bold are lighter choices than the non-bold shapes listed below them.

Hint 4

In addition to supporting the loads of the crane and its lifting capacity, the support beam also needs to be able to carry its own weight. When you select a W shape, the second number in the name is the weight/foot (for example a one foot long piece of a W22x130 weighs 130 pounds). This weight is a distributed load along the length of the beam. It is considered dead load and should be multiplied by a load factor of 1.2. Is the beam you selected adequate to carry the crane loads and its own weight?