Teamwork and Problem Solving

ENGR 1181
Class 2
Problem: Ship Wreck Needs Cleaned Up

The cruise ship Costa Concordia struck jagged rocks and sank off the coast of Italy in 2013. It is 2X the size of the Titanic. Salvage engineers wanted to remove the ship and recycle the materials. How would you do this?
20 months with teams working around the clock – problem solved!
Today's Learning Objectives

- After today’s class, students will be able to:
  - List four benefits of teamwork
  - Identify the five steps in problem solving
  - Identify at least four roles of team members
  - Apply the five steps of problem solving to a new problem.
Outline of Class Activities

- Review: teamwork
- Activity
- Introduce Team Working Agreement
- Lecture: problem solving
- Activity
Questions to be Reviewed/Answered

- Are there really benefits to working in teams? What are the benefits?

- Should we assign roles in our team? How do we know who is responsible for each task?

- Are there engineering tools that might help our team?

- Are teams useful when solving problems?
Why Focus on Teamwork + Problem Solving?

Most industry jobs require you to solve problems and have:

- Teamwork skills
- Management skills
- People Skills

No one works in a solitary bubble. Teamwork is a must (even true with monkeys & NASA engineers (video)!)
What are the Benefits of Teams?

- Many problems are better solved as teams
- Other team members may think of ideas you did not
- Broader range of possible solutions can be created
- Each team member may bring a unique skill set or expertise, which helps with idea generation
- Team members can offer ‘fresh eyes’ to help when you are stuck on a problem
Should We Organize Our Team?
Why?

Yes, definitely. Organizing your team will:

- Help you successfully meet deadlines
- Make sure no task is overlooked
- Keep meetings productive
- Give a framework of how to approach discussions
- Reduce wasted time of team members
Organization Suggestion: Team Roles

- **Team leader:** Leads and controls the meeting, ensures all members have a chance to speak

- **Note taker:** Keeps a written record of meeting discussion and team decisions

- **Timekeeper:** Keeps the discussion on topic and on time

...*What do you do if you have a 4th team member?*
Teamwork: Activity

The Challenge: Using only four 4’s, create mathematical expressions that create integers. Start with 0 and work your way up. (e.g., equations equal to 0,1,2,3,4,5...)

The Rules: You can use only four 4’s, but you may use unlimited symbols or operators. Possible operators include: $+ - ! ^ \div \times \sqrt ( )$
Four Fours: Examples

0 = 4-4+4-4

1 = (4+4)/(4+4)

2 = ...

3 = ...

4 = ...
Four Fours: Individual Work

- Working on your own, see how many equations you can come up with in three minutes. Calculators are permitted.
- Time starts now!
- How many equations did you successfully create?
- What was the highest integer you were able to solve for?
Four Fours: Team Work

- Now, see how many equations you can create when you work together with your table mates.
- Time starts now!
- How many equations did you successfully create?
- Were you able to create more as a team?
- Do you think that teamwork helped to solve this problem?
Four Fours: Team Work

- What group roles did you use?
- Do you think it was effective?
Team Working Agreement

- Helps your team achieve success
- Sets expectations that the team has for its members
- Sets methods of conflict resolution
- It is specific to your team
- All members have input to the document
- All members need to be accountable
- It is a contract that you sign with your team
Team Working Agreement

- A template for the agreement is provided for you online
- Once you know who your semester teammates are, meet with your team outside of class to complete it
- Schedule office hours with your GTA if you have questions or concerns as you complete it
- Let’s look at the template now...
# Task Schedule
(Background for Ethics & Train Project)

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Start</th>
<th>Finish</th>
<th>Due Date</th>
<th>Est Time</th>
<th>Team Member 1</th>
<th>Team Member 2</th>
<th>Team Member 3</th>
<th>Team Member 4</th>
<th>% Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wind Tunnel</td>
<td>8 - June</td>
<td>8 - June</td>
<td>12 - June</td>
<td>4.0 h</td>
<td>1.0 h</td>
<td>1.0 h</td>
<td>1.0 h</td>
<td>1.0 h</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>AEV 1 Construction</td>
<td>8 - June</td>
<td>12 - June</td>
<td>12 - June</td>
<td>1.0 h</td>
<td>.75 h</td>
<td>.75 h</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>AEV 1 Testing</td>
<td>8 - June</td>
<td>12 - June</td>
<td>12 - June</td>
<td>1.5 h</td>
<td></td>
<td></td>
<td>0.5 h</td>
<td>0.5 h</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>AEV 2 Construction</td>
<td>10 - June</td>
<td>12 - June</td>
<td>12 - June</td>
<td>1.0 h</td>
<td>0.5 h</td>
<td>0.5 h</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>AEV 2 Testing</td>
<td>10 - June</td>
<td>12 - June</td>
<td>12 - June</td>
<td>1.5 h</td>
<td></td>
<td></td>
<td>0.5 h</td>
<td>0.5 h</td>
<td>67</td>
</tr>
<tr>
<td>6</td>
<td>Weekly Report</td>
<td>8 - June</td>
<td>12 - June</td>
<td>12 - June</td>
<td>3.0 h</td>
<td>1.0 h</td>
<td>1.0 h</td>
<td>1.0 h</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>SolidWorks Model</td>
<td>8 - June</td>
<td>15 - June</td>
<td>17 - June</td>
<td>1.0 h</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
# Gantt Chart

(Background for Ethics & Train Project)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Test 1</td>
<td>13.0 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Wind Tunnel</td>
<td>4.0 h</td>
<td>4 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>AEV 1 Construction</td>
<td>1.0 h</td>
<td>1.5 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>AEV 1 Testing</td>
<td>1.5 h</td>
<td>1.5 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67</td>
</tr>
<tr>
<td>AEV 2 Construction</td>
<td>1.0 h</td>
<td></td>
<td>1 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>AEV 2 Testing</td>
<td>1.5 h</td>
<td></td>
<td>1.5 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>67</td>
</tr>
<tr>
<td>Weekly Report</td>
<td>3.0 h</td>
<td>1 h</td>
<td>1 h</td>
<td>1 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Solidowkrs Model</td>
<td>1.0 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>
Team Meeting Minutes

The team meeting notes should be informative of what the team discussed and what needs to be completed. Typical team meeting notes include the following:

- Header (date, time, method, members present)
- Objective of Meeting (1 or 2 sentences)
- Tasks completed from previous week or last meeting
  - Bullets with task
  - Assigned person to each task
  - Short summary of status
- Tasks to be completed for the upcoming week
  - Bullets with task
  - Assigned person to each task
- Timeline/Gantt Chart with major milestones
- Decisions made by group (were they a consensus or did the project manager decide?)
- Reflection on previous assignment
  - Were there any roadblocks or bottlenecks
  - Were any deadlines missed
  - Was any work sub-standard
  - Were there differing expectations
  - Any conflicts or misunderstandings
  - How can things be improved for the next time
Addressing Typical Teamwork Issues

Teamwork Scenario 1

A team is encountering problems with one of its members. This team member does not complete his team assignments as he agreed, he misses team meetings, and doesn’t inform other members when he is going to miss a team activity or assignment.

What should the team do?
Addressing Typical Teamwork Issues

Teamwork Scenario 2

A team is having difficulty finding a time to have face-to-face meetings, which is causing their team assignments to suffer.

What should the team do?
We have a team, now what........
Problem Solving Method

1. Define
2. Represent
3. Plan
4. Implement
5. Evaluate

- Problem solving is an iterative process. At any point you may need to go back to a previous step (even the beginning!) and re-work the problem.

- Reworking the problem will provide a better solution than rushing through the steps. Your first solution may not be your best solution!
1. Define

What is the problem? What are the constraints?

- Restate the problem so the goal is clearly identified
- Document what is known and unknown
- Identify and document constraints/limitations (e.g., time, materials, budget, technology, etc.)
- Document initial assumptions or estimates for values of parameters needed
2. Represent

Display the problem in a visual form so it is easier to understand:

- Sketch or Diagram
- Graph
- Flowchart
- Orthographic Drawing
2. Represent
3. Plan

- Identify underlying principles to help solve the problem (math rules, laws of physics, etc.)
- Look for similarities and differences with previously encountered problems
- Identify potential tools to be used
- If required, make additional assumptions/estimates
- Confirm that assumptions are valid (use references!)
4. Implement

Implement the plan!

- Perform a dimensional analysis: crunch the numbers & keep track of your units!
- Keep work organized and well-documented
- Display results appropriately in a well-labeled table or graph
- Track progress if task is extensive
5. Evaluate

Always evaluate your work!

- Does the solution make sense and answer the original question?
- Is the magnitude of the answer reasonable?
- Are the units correct and reasonable?

How can we verify our answer?

- Use another approach with the same variables
- Research your answer, compare to existing solutions
Let’s work through a sample problem together.

**Problem:** Determine how much paint is needed to paint a room that is 16’ x 20’ with a 10 foot ceiling.

**Given Info:** There are two windows and two doors, and the room needs two coats of paint.
1. Define Sample Problem

Identify the Goal:

Determine the number of cans of paint needed to paint the room.

Identify Constraints:

- Two coats of paint
1. Define Sample Problem

Document known and unknown information:

<table>
<thead>
<tr>
<th>Known:</th>
<th>Unknown:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length: 16 ft</td>
<td>Are doors painted?</td>
</tr>
<tr>
<td>Width: 20 ft</td>
<td>Are windows painted?</td>
</tr>
<tr>
<td>Height: 10 ft</td>
<td>Use the same paint as wall?</td>
</tr>
<tr>
<td>Two doors</td>
<td>Dimensions of doors?</td>
</tr>
<tr>
<td>Two windows</td>
<td>Dimensions of windows?</td>
</tr>
</tbody>
</table>
1. Define Sample Problem

Document assumptions, estimates, and research:

- The ceiling of the room will also be painted
- The same paint will be used for walls and ceiling
- Doors are not painted
- Windows are not painted
- Size of doors and windows
- Coverage of paint (thick or thin)
1. Define Sample Problem

**Painting Problem**  
Johnny B. Student  
Engineering 1181  
Prof. Trotz  
8:30 am

*Problem title/number  
Name  
Class  
Instructor  
Class time

**DEFINE**

How many cans of paint are needed to paint a 16' x 20' room with 10' ceilings, 2 doors and 2 windows?

**KNOWNS**
- Length = 16'
- Width = 20'
- Height = 10'
- 2 doors
- 2 windows
- 2 coats of paint

**UNKNOWNs**
- Are we painting doors? Ceiling?
- Same paint for all surfaces?
- Area of doors? Windows?
- Shape of room?

* List all knowns, unknowns, and constraints

**CONSTRAINTS**
- No additional constraints

**ASSUMPTIONS**
1. Doors will not be painted.
2. Ceiling will be painted.
3. Same paint for all surfaces.
4. Rectangular room, doors and windows.
5. Doors are identical.
6. Windows are identical

* List all initial assumptions
2. Represent Sample Problem

Note: Ceiling height is 10 ft.
2. Represent Sample Problem

* This doesn’t need to be a perfect picture, but it should be clear and well labeled to help you and others understand the problem.
3. Plan Sample Problem

Identify the underlying principle(s):

- Geometry Problem (area calculations)
- Paint Coverage Problem (ft²/gallon)

Recognize similarities and differences of the problem:

- Area calculations: find surface area
  \[
  \text{Area} = \text{length} \times \text{width}
  \]
  \[
  = \text{Area}_{\text{walls}} + \text{Area}_{\text{ceiling}} - \text{Area}_{\text{windows}} - \text{Area}_{\text{doors}}
  \]
3. Plan Sample Problem

Paint Coverage: calculate needed cans of paint

1 can of paint = 1 gallon of paint

Coverage (ft$^2$/gal)

Gallons = # Coats x Area$_{tot}$/Coverage
3. Plan Sample Problem

Identify tools to be used:

Calculator, spreadsheet, iPhone app, pencil, etc.

Make assumptions or estimates:

- Area of door: 7 ft x 3 ft = 21 ft$^2$ per door
- Area of window: 3 ft x 5 ft = 15 ft$^2$ per window
- Paint coverage: 320 ft$^2$ per gallon
3. Plan Sample Problem

**Plan Sample Problem**

**Plan**

**NEW ASSUMPTIONS**

1. Doors have an area of 20 $[\text{ft}^2]$
2. Windows have an area of 15 $[\text{ft}^2]$
3. Paint covers 320 $[\text{ft}^2/\text{gallon}]$
4. Paint comes in 1 gallon cans.

**Tools**

- Calculator
- Internet

**Equations**

$A_{tot} = A_{room} + A_{ceiling} - A_{doors} - A_{windows}$

$A = L \times W$ and $G = \frac{A_{tot}}{C} \times n$

Where $G =$ gallons of paint

$A_{tot} =$ total area to paint

$L =$ coverage

$n =$ number of coats

**Implement**

* Document all new assumptions needed to solve the problem

* Equations should "describe" the problem

* Label variables
4. Implement Sample Problem

Execute the Plan!

Painted Area = Area_{walls} + Area_{ceiling} - Area_{windows} - Area_{doors}

Painted Area = 968 \text{ ft}^2
4. Implement Sample Problem

Execute the Plan! (continued)

Gallons = # Coats x Area_{tot}/Coverage

Gallons of Paint = 6.1 Gallons

Since 1 gallon = 1 can

Paint needed = 6.1 cans
4. Implement Sample Problem

*IMPLEMENT

\[ A_{\text{tot}} = 2 \left( 16 \text{[ft]} \times 10 \text{[ft]} \right) + 2 \left( 20 \text{[ft]} \times 10 \text{[ft]} \right) + \left( 16 \text{[ft]} \times 20 \text{[ft]} \right) - 2 \left( 20 \text{[ft]} \right) - 2 \left( 15 \text{[ft]} \right) \]

2 of each size wall

Ceiling

Maintain conventions to keep your work organized

A_{\text{tot}} = 2 \times 160 \text{[ft}^2] + 2 \times 200 \text{[ft}^2] + 320 \text{[ft}^2] - 40 \text{[ft}^2] - 30 \text{[ft}^2] \]

Ceiling

A_{\text{tot}} = 970 \text{[ft}^2] \]

Follow units all the way through!

G = \frac{970 \text{[ft}^2]}{320 \frac{\text{ft}^2}{gal}} \times 2 = 6.1 \text{ gallons. Therefore, I need 7 1 gallon cans of paint.}

* Note significant figures.

* EVALUATE

The amount of paint seems reasonable.
5. Evaluate Sample Problem

Does 6.1 cans of paint make sense?

- Does it answer the original question?
- Are the units appropriate?
- Is 6.1 cans an appropriate scale?
- What about lost/wasted paint?
- Is the paint coverage rate reasonable? What did this include? (i.e., type of surface)
5. Evaluate Sample Problem

To verify our calculations, can we use other approaches involving the same variables?

Yes! One possible way is:

1. Calculate a total length for the walls and multiply by the height to find total area.

2. Calculate gallons of paint for each all walls and the ceiling.

3. Add up total paint needed.
5. Evaluate Sample Problem

- Now that we have an acceptable answer, we need to present it clearly in the appropriate format.
- Sometimes this includes a graph or chart.
- With this example, we can simply state the answer in a complete, descriptive sentence:

“7 cans of paint are required to paint the walls and ceiling of the room, given the assumptions above.”
5. Evaluate Sample Problem

*Note significant figures.*

**EVALUATE**

- The amount of paint seems reasonable.
- From outside source, Olympic.com Paint Calculator, a similar value is obtained.

**PRESENT THE SOLUTION**

7 cans of paint are needed to apply two coats to a 16’ x 20’ room with the aforementioned assumptions.
Homework Assignment

- Let’s look at the assignment together.
- What is the problem statement?
- What is known information?
- What is unknown?
- How could we represent the problem?
Important Takeaways

- Teamwork makes problem solving easier, but...it takes work to make a good team work well.
Preview of Next Class

- Ethics + Academic Integrity
What’s Next?

- Review today’s lecture and activities.
- Start working on homework with your table mates and the team agreement with your semester teammates.