Melbourne School of Engineering

Engineering Systems Design 1

Lecture EN03 – Problem Solving

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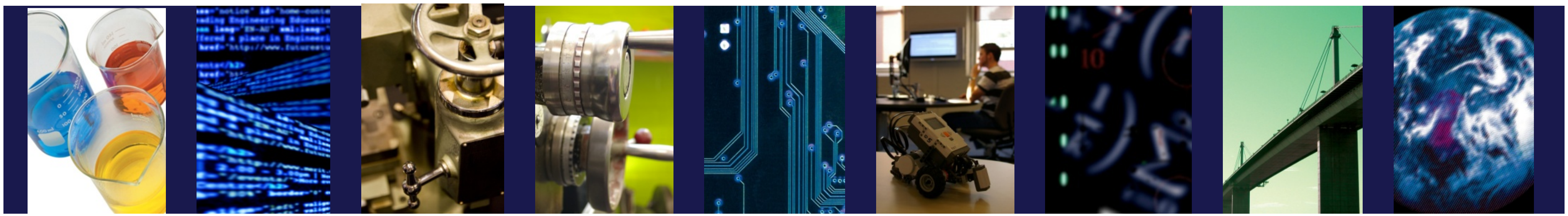

ENGR10004 Reflective Journal (5%)

You will be writing weekly entries. You will be asked to do some preparation work including using lms communities or reading each week to provide context or further information in order for you to complete your journal entry. Remember, your journal is reflective – that is it's about YOU!

The goal of this is to allow the chance to reflect on the design project, consider what about engineering might be interesting to you and use some of the tools avialble to you to succeed in the learning process, time management and group work in this subject and at University.

You will also evaluate three other students journals to provide feedback for each entry.

Number	Description	Week Set	Week Submission Due	Week Evaluation Due	Mark
RJ1	Design Project Overview	1	2	3	0/1
RJ2	What is engineering?/ Why study engineering?	2	3	4	0/1
RJ3	The learning process	3	4	5	0/1
RJ4	Time management	4	5	6	0/1
RJ5	Teamwork	5	6	7	0/1

Reflective Journal
WHY ARE WE DOING THIS?

- **How ~~goo~~….well do you ~~righ~~….write?**
- **Have you ever heard of a monthly highlight???**
  - **It affects your job in ways you don't realise**
- **Our Industry Advisory Group!**
  - **Engineering graduates need to improve their written communication skills**

ALL DETAILS FOR THE RELFECTIVE JOURNAL ARE ON LMS!!!!!

Reflective Journal 1

Design Project Overview

Must be submitted on LMS before 5pm, Friday August 3, 2018

Must be evaluated on LMS before 5pm, Friday August 10, 2018

Read the design project document in detail!!! This located on LMS from the Project Material menu link on the left. The document is in the folder called, Project Documents.

Out of the four sub-systems that will be designed ((1) impeller and pump design, (2) the water treatment disinfection process using a membrane unit, (3) image capture and real-time analysis system to monitor for particle contamination should the membrane fail and (4) the water distribution network). Which one sounds the most interesting to you and why? Please use details or examples from that section of the document.

Societal impact: Why is clean drinking water important? What are some of the implications for a community if it does not have access to clean drinking water?

Write at least one paragraph to answer these two questions, please use at least one example from the resources below to address these questions.

Resources

“Turning Any Water Into Drinking Water”, https://pursuit.unimelb.edu.au/features/turning-any-water-into-drinking-water

World Health Organsiation: Drinking Water, http://www.who.int/topics/drinking_water/en/

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MATLAB

- You should install MATLAB on your computer. MATLAB is available for free using your student id.
- Directions are on lms, in the MATLAB link.
- You will have to create a MathWorks account to install MATLAB
- YOU ALSO NEED TO ACCOUNT TO GET CREDIT FOR THE WORKSHOP ASSESEMENT TASKS.

MATLAB

MATLAB installation instructions - University of Melbourne

1. Create a MathWorks account
2. Create a license
3. Download and activate MATLAB

- Instructions on LMS,
- More detailed instructions at:
- https://github.com/resbaz/lessons/blob/master/matlab/unimelb_matlab_install.md
- If you have problems, contact Student IT:
  - https://studentit.unimelb.edu.au/contact-student-it

Learning Objectives

- To introduce the concept of an “open-ended” problem
- To explain a basic framework for problem solving
- To introduce several heuristics as mechanisms for problem solving
- To apply these heuristics to several puzzles and problems

Open-Ended Problems

- Most problems you will encounter at school and university are crafted to have a single “right” answer
  - “knowns” and “unknowns” clearly identified in the problem statement
  - number of unknowns = number of equations
- Most real engineering problems are *open-ended*
  - not well-defined
  - very many unknowns
- Engineers need strategies for forming an acceptable solution to these problems!

A Framework for Problem Solving

- Can apply this pattern to problems of all sizes
  - At university and beyond
- Approach based on
  - Wankat (Chemical Engineering, Purdue) and Woods (McMaster University, Canada).
  - Put together by Jay Brockman (Comp Sci and Eng, ND)
- 7+1 steps:

0. I can!	**3. Plan**	6. Generalise
1. Define	4. Implement	7. Present results
2. Explore	5. Check	

Step 0: I Can!

- Have a positive attitude before you start
- See problem solving as a challenge, not a drag (or chore or reminding one of dental work…)

Step 1: Define

- Identify the “knowns”
- Identify the “unknowns”
- State in simpler terms
- Draw a picture

Step 2: Explore

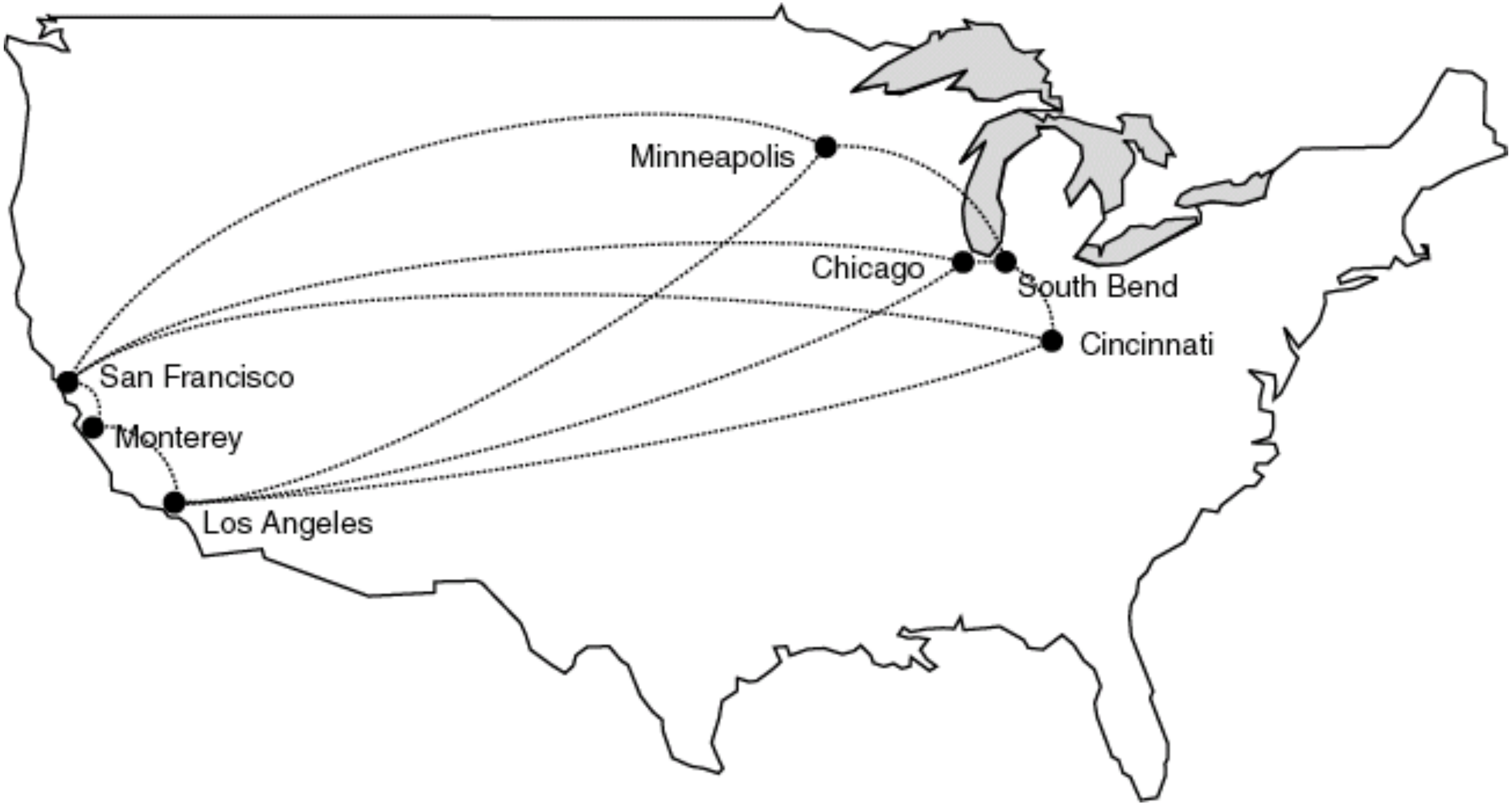
- A pre-planning step—take stock of what you have and what you might need
- Does the problem make sense?
- Do you need to make any assumptions?
- What are the key concepts and possible approaches?
- What level of understanding is being tested?

Step 3: Plan

- Find a path between here (initial state) and there (goal)
- The most important step—novices often try to skip it with disastrous results
- The step where you're most likely to get stuck
  - We'll discuss strategies for getting "unstuck" soon
- Planning is messy
  - Lots of revision and backtracking
  - The neat solutions in many textbooks hide the tortuous path that the author might have followed
- Requires advanced level of understanding
  - Breaking down (analysing) a problem
  - Formulating (synthesising) alternative plans
  - Evaluating which path to take

Planning a Path Between Here and There

- Booking flights from South Bend, IN to Monterey, CA
  - Work forward, work backward, or from the middle



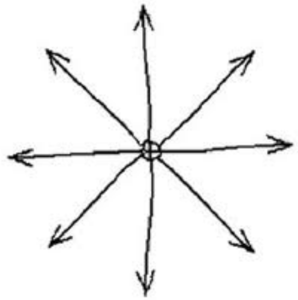
Step 4: Implement

- Begins *after* planning
- The step where you “do the math”
- Goes much more smoothly if you follow a plan
- Consider re-planning if implementation is not going smoothly

Step 5: Check

- Test cases
  - Can you plug in values to get a known solution
  - Especially useful for checking digital circuits

- Sanity check
  - Does the answer make sense? (negative time?)
  - Checking units can be a big help
    - Or production output
    - Or speed or velocity - **Ask NASA!!!!!**



Step 6: Generalise

- What did you learn from solving the problem?
  - Can you apply this to another situation?
- In retrospect, could you have solved it more efficiently?
- Are there any problems or bugs that you should remember in case you run into them again?

Step 7: Present the Results

- Show your work, but be concise
  - Provide supporting statements for all equations and values
  - Use correct units for all numerical results
  - Label sections of the problem, clearly stating any assumptions made
- Give good directions, be convincing
- Be neat!

The Engineering Method – 7+1 steps to Problem Solving

0 I can !
1 Define
2 Explore
3 Plan
4 Implement
5 Check
6 Generalise
7 Present the Results

Getting Unstuck

Heuristics: rules of thumb, learned by experience

- Restate in simpler terms
- **Draw a picture**
- **Related problem?**
- **Work backwards/forwards**
- **Divide and conquer**
- Unnecessary constraints?
- Discuss
- **Try a scaled-down or simpler problem**

- Guess and check
- Use an analogy
- Change perspective
- Do easy part first
- Plug in numbers
- Keep track of progress
- **Change representation**
- Listen to hunches
- Take a break . . .

Example 1 : The Game of 15

- The “game of 15”
  - Play with the person next to you
  - No pens or paper
  - Each person in turn picks a number from 1 to 9
  - A number can only be picked **once**
  - The goal is to collect any 3 numbers such that the total equals 15 (i.e., picking 2, 5, 9, and then 4 would win the game because 2+9+4 = 15).

Example 1 : The Game of 15

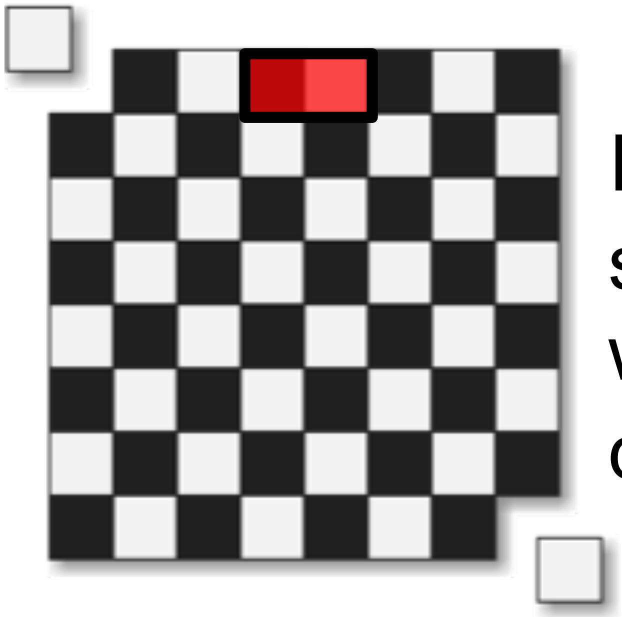
- How would the game change if you could write the numbers down?

Example 2 : How Many Games in a Knockout Tournament?

How many games are played in a knockout tournament of basketball with 64 teams in it?

Example 3 : The Mutilated Chessboard

- Standard chessboard of 64 squares (8 rows, 8 columns) with the diagonal corners removed



Is it possible to cover all squares on the chessboard with a collection of 2 x 1 dominoes?

Why / why not?

Example 4 : Speeding

You drive a car at a constant speed of 40 km/h from A to B, and on arrival at B you return immediately to A, but at a higher speed of 60 km/h.

What Should You Use Heuristics For?

- In ESD 1:
  - Design Project
    - Design (analysis and synthesis) of integrated subsystems
    - Verification of specifications
- In general :
  - Solving Problems!

Summary

- Introduced the concept of an "open-ended" problem
- Explained a basic framework for problem solving
- Introduced several heuristics for problem solving
- Applied these heuristics to several puzzles and problems