APS111: Engineering Strategies & Practice I

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Lecture 2-1

⊙ Engineering Design Process has five main stages

↳ Design Brief

↳ Information Gathering (Researching)

↳ Problem Statement and Requirements

↳ Solution Generation

↳ Evaluation and Testing

• Idea is to take a direct-provided design brief and convert it into a problem statement

Design Brief ⟶ Problem Statement
        ✓ Describes design problem
        ✓ Engineering perspectives
        ✓ Solution Independent

② • Focus on finding and removing ERRORS, BIASES, and IMPLIED SOLUTIONS

③ • The Gap explains the current state of the world and what is missing

The World   ⟶ How the client
as it is today [The Gap] wants things to
          be in the future.

④ • Analyze the client statement: Gather information

↳ Add: information through research and observation

• Areas of research will depend on the project → context

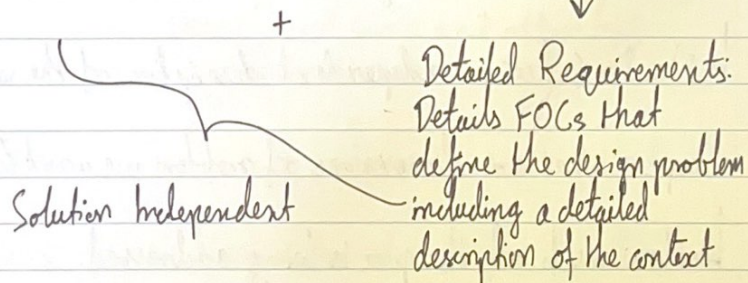↳ Multiple modes of research always useful. → TRIANGULATE your findings

⑤ • Define the need → must be SOLUTION-INDEPENDENT

⑥ Engineering Design Project Requirements

• Problem Statements
↳ Intro to design project ←
↳ Briefly describes gap
need, scope, and context
↳ Does not describe a solution
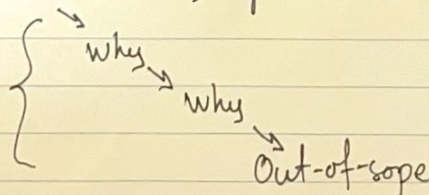
Information gathering
through research and
observation

+

Solution Independent

Detailed Requirements:
Details FOCs that
define the design problem
including a detailed
description of the context

Lecture 2-2

① Problem Analysis → Need and Scope

② • 5 Whys method   Client Statement ﹛ Implied Solution

Need lies
somewhere in here. ﹛ why
why
Out-of-scope
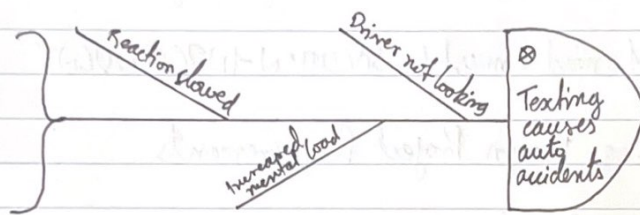
③ • Can also be used to find alternate scope.

④ Ishikawa diagrams → "fishbone diagram"

↳ A way of visualizing root cause — may help identify need,
gap, or scope

⑤ Now we can define gap and need:

↳ Gap → Difference b/w current world and desired world.
What is missing?

↳ Need → Solution-Independent description of the root problem

• Scope → What are dimensions of problem we want to solve

↳ How much of the gap is being addressed.

⑦ Project Triangle → can only control 2 out of 3

```
        Scope
         /\
        /  \
       /    \
Time  /_____\  Resources
```

⑧ • How can the scope go wrong?

↳ Too big/narrow

↳ Wrong problem addressed

↳ Implied solution identified

↳ Uncontrolled change over time : scope creep

⑨ Problem Statement → Brings together essentials of gap, need, and scope and other key requirements

Lecture 2-3

② The Context : Service Environment

↳ Technology is designed for an operating environment

↳ Does NOT describe the design or how it will operate

↳ Uses ranges mainly but also averages

⑧ Common pitfalls when writing Service Environment

  ↳ Interpreting effect of service environment rather than describing it.

  ↳ Failing to filter out irrelevant aspects of the environment.

⑨ DETAILED REQUIREMENTS

• Turning information gathered from

↳ Client Statement ↳ Research ↳ Thinking, analyzing,   Use SHALL

Into: ↗ Functions: MUST do ➔ instead.

↳ Engineering specifications → Objectives: SHOULD be

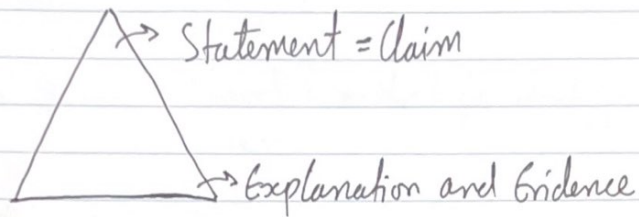   ↳ Constraints: CANNOT be

⑩ Primary Function ⟶ Secondary Functions

     ⇓

     ∅ Means Statements ⇒ Solution-Independent.

Lecture 3-1

• Investigation → Multimodal evidence gathering

• Documentation → An approximate mix of modes to communicate relevant details

△ → Statement = Claim

→ Explanation and Evidence

- Research → Primary → Evidence gathered by oneself
  ↳ Secondary → Evidence gathered by others
↳ ⭑Triangulation → Supporting claims with multiple
                    sources of evidence

Lecture 3-3

- Inter-Team Communication Variables

↳ Synchronous / Real-Time   → ⭑ Necessary for
                                                      conversation
  ↳ Message must be responded to before the next   and decision-
     message is sent.   making

  ↳ Sent within a set, dedicated time period.

↳ Asynchronous / Time-Lagged   → ⭑ Useful for
                                                      updates and
  ↳ Messages sent independent of response   source items
                                                      for discussion

Lecture 4-1

⑨ • Functional Basis → Powerful method for identifying functions

    ↳ All factors of functions come down to

        ↳ Energy   ↳ Mass   ↳ Information

⑩ • Pitfalls to avoid when writing functions

    ↳ Mix up functional basis with functions

    ↳ Writing means or results instead of functions

    ↳ Not using multiple tools to generate functions
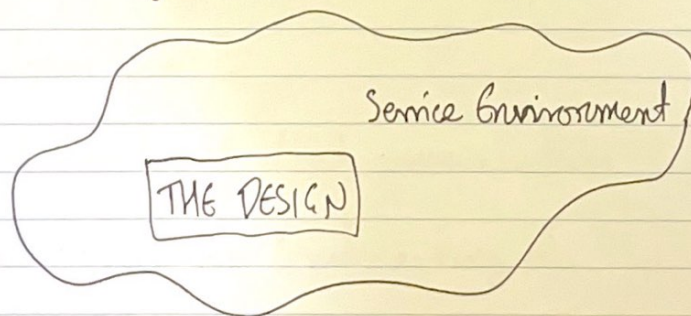
  • Methods used to generate functions

    ↳ Functional Basis   ↳ Black Box Method

    ↳ Decomposition   ↳ Benchmarking
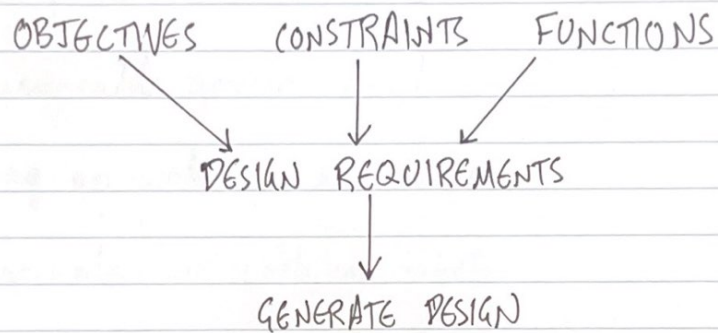
⑪ • Black Box Method:

    ↳ Functions ↳ Objectives ↳ Constraints ↳ Solutions

Service Environment

THE DESIGN

Lecture 4-2

⑤ • Objectives are part of the requirements

↳ What the design should BE!

OBJECTIVES   CONSTRAINTS   FUNCTIONS

↓   ↓   ↙

DESIGN REQUIREMENTS

↓

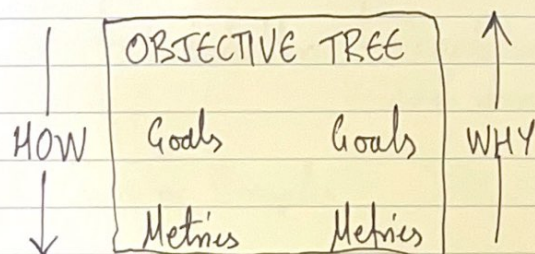GENERATE DESIGN

⑥ • Objectives usually take form of adjectives

↳ Objectives broken up into goals that can be
measured by metrics ⇒ not a Measure of Success

⑨ Objectives → Goals → How-Why Chart

```
      ┌─────────────────┐  ↑
    │ │ OBJECTIVE TREE  │  │
    │ │                 │  │
HOW │ │ Goals    Goals  │ WHY
    ↓ │                 │  │
      │ Metrics  Metrics│  │
      └─────────────────┘
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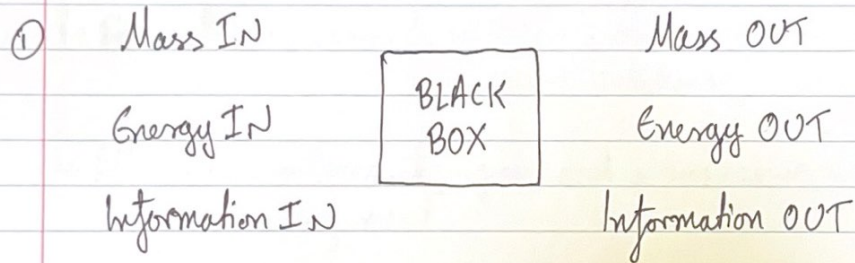
⑩ Objectives come from:

↳ Client statement and client communications

↳ Research: Publications, benchmarking, etc.

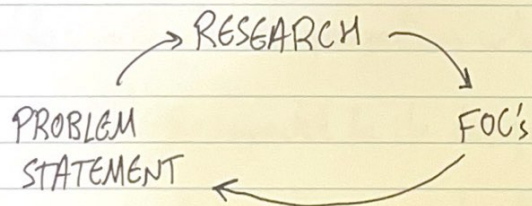↳ Broader considerations: Service environment, stakeholders

④ • Use Pairwise Comparison to Prioritize Objectives

    ↳ Pick the list of objectives at the same "level" when
      doing this prioritization

• Common pitfalls when writing objectives :

↳ Unmeasureable general objectives

↳ Making up goals without evidence

↳ Confuse objectives with constraints

↳ Confuse objectives with functions

Lecture 5-1

⑤ • Constraints : What the design CANNOT BE.

⑥ • Sources of Constraints → They are limits

    ↳ Clients   ↳ Stakeholders ↳ Regulations, codes
                                      and standards

    ↳ Scientific Laws or Principles

⑪ • If a design fails to meet an objective goal, then
    it is simply less desirable.

    ↳ However if it fails to meet a constraint, it is
      completely DISCARDED

⑬ • Common Pitfalls When Writing Constraints

└ Creating unmeasureable constraints

└ Creating unnecessary constraints

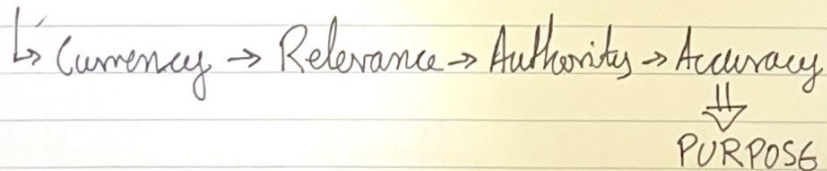└ Assuming all objectives have a corresponding
constraint

Lecture 5-2

①   Mass IN   Mass OUT

      Energy IN   BLACK BOX   Energy OUT

      Information IN   Information OUT

⑤ • Iteration is important

               → RESEARCH

     PROBLEM   FOC's

     STATEMENT

Lecture 5-3

• Use the CRAAP method to evaluate sources:

└ Currency → Relevance → Authority → Accuracy
                                        ⇓
   PURPOSE

Lecture 6-2

• Project Requirements → a contract between a team
and a client.

↳ Introduction/Problem Statement → Add precision and
depth to client statement

↳ Broader Considerations → Stakeholders and service
environment provide context.

↳ Detailed Requirements → Trustworthy measures to
assess solutions

↳ All sections → Research, rigour, and a persuasive
argument.

Lecture 6-3

① • Stakeholders → People or organizations who might:

↳ Be impacted by the design

↳ Have influence on the design

↳ Users, and operators/clients not usually considered
stakeholders

⑤ • Stakeholder Analysis

↳ Identify possible stakeholders ↳ Understand perspective

↳ Prioritize and sort the list ↳ Focus on key stakeholders

⑥

Influence (vertical axis) / Interest/Impact (horizontal axis)
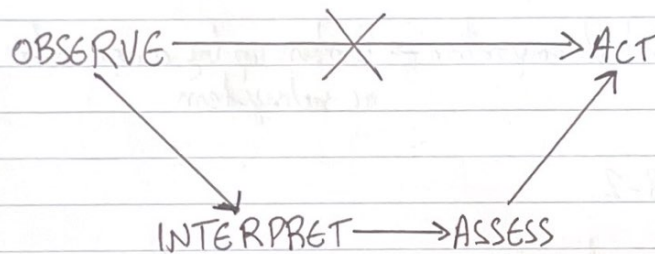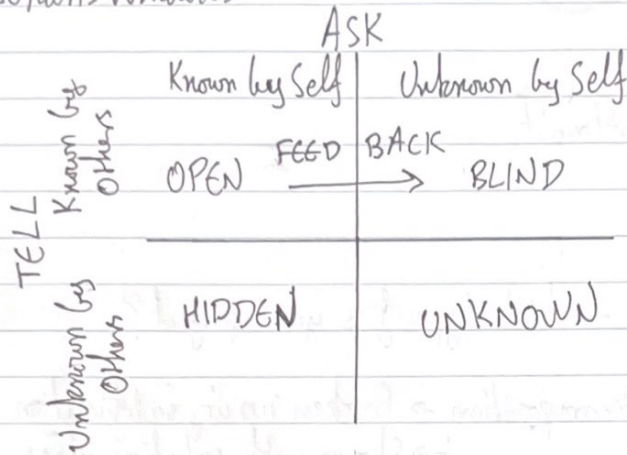
→ Area of focus for stakeholders
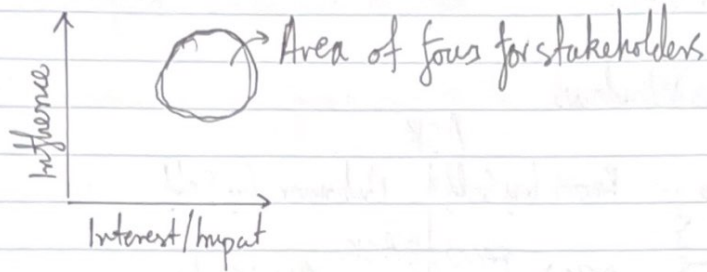
Lecture 7-2

⑥ Decomposition — which type fits your project?

⑦ • Functional Decomposition → Broken up by subfunction
   ↳ Shown with solution ideas

• Structural Decomposition → Broken up by components
   or subsystem

Lecture 8-2

① • Idea Generation

↳ Use multiple methods to achieve a wide variety of ideas

↳ Make sure you fully explore the design space,
   including "magic" ideas.

③ • Structured Brainstorming → Individual then compile
                              into a master list.
   ↳ ESP Recommended Way

Lecture 8-2.

- Johan's Windows

```
                      ASK
          Known by Self  |  Unknown by Self
  ⌐                       |
  |        OPEN  FEED BACK|
  |                 →     |  BLIND
T |  Known by Others      |
E | ─────────────────────────────────────
L |                       |
L |        HIDDEN         |  UNKNOWN
  |  Unknown by Others    |
  ⌐                       |
```

```
  OBSERVE ───────────✕──────────→ ACT
        \                          ↗
         ↘                        /
          INTERPRET ──→ ASSESS
```

- Behavioral Feedback Model

↳ Action: Specific examples of behaviour

↳ Impact: How did this behaviour affect the team?

↳ Development / Desired Outcome: What is the desired change?

④ • Morphological Charting Method ⎫ Should be done by
⎭ this point

   ↳① Decompose the problem ⇒ Use decomposition

   ↳② Use brainstorming or other methods for each part.

   ↳③ Combine them into an alternative solution.

⑧ • Apply the SCAMPER method to your solutions

   ↳ SUBSTITUTE

   ↳ COMBINE

   ↳ ADAPT

   ↳ MODIFY/MAGNIFY/MINIFY

   ↳ PUT to Other Use

   ↳ ELIMINATE

   ↳ REARRANGE/REVERSE

Lecture 9-1

• How to analyze team dynamics?

↳ Reflect on team organization

↳ Describe a situation

↳ Analyze situation using Team Charter

↳ Determine what change was made to the Team Charter as a result.

↳ Determine if the change was effective

- GRIP Model of Teamwork

↳ Goals: Everyone must be fully committed to the team

↳ Roles: All team members must know what role they play and how to be accountable

↳ Interpersonal: Quality communication and collaboration requires trust

↳ Processes: How teams solve problems and address conflict

Lecture 11-1

③ • 5 Steps to a Recommended Solution → Overview.

↳① Consolidate Team Idea List

  ↳② Feasibility check

    ↳③ Multi-Voting Solutions

      ↳④ Graphical Decision Chart

        ↳⑤ Pugh Method

⑤ Step 1: Consolidate Team List

• Input → Multiple Individual Solution Lists
↓
• Merge everyone's ideas as a team → IDEA MASTER LIST
↓
• Briefly discuss each idea
↓
• Remove any duplicate ideas.
↓
• Output → One team list w/ 50-100+ solutions

⑥ Step 2: Feasibility Check

• Input: One consolidated master list of ideas.
↓
• Confirm each solution from master list Functions and Constraints
↓
• Output: If you cannot make it meet Figures and Constraints, discard

⑦ Step 3: Multi-Voting

- Input: List of 50+ feasible solutions
  ↓
- Output: Approximately 10 good solutions

⑧ Step 4: Graphical Decision Chart

- Input: Approximately 10 good solutions
  ↓
- Top-ranked objectives on x, second-top ranked on y
  ↓
- Through discussion score each design idea relative to the ranked Objective
  ↓
- Output: 3+ Great Alternative Solutions

⑨ Step 5: Pugh Method

- Input: 3 Great Alternative Solutions
  ↓
- Evaluate each alternative against a standard/reference solution
  ↓
- Output: 1 Design to recommend.

Lecture 12-1

① • What is the difference between a metric and MoS?

⤷ Metric → An idea for how to measure an objective

⤷ Measure of Success → A test procedure based on
a metric to test the design

② • MoS: Bringing a metric for an objective into action

• Estimation → Quick calculation of an indicator of design

• Modelling → Numerical model to verify design

• Prototyping → One-off example of the design

⑦ • Prototyping should be as inexpensive and simple/fast
to make as possible → "low-fidelity"

⑩

ACCURACY ≈ VALIDITY
↓   ↓
Are you measuring   Are you measuring
the true value?   what you think?

⑪ PRECISION   RELIABILITY
↓   ↓
How close are   Is my measurement
my measurements?   repeatable?

Lecture 12-3

⑤ • Human-centred design or human centred systems design

• User-centred design - and the concept of affordance

• Interaction design → UI

• Experience design → UX

④ • Human Tech Ladder ←

$\left\{\begin{array}{l}\text{PHYSICAL} \\ \text{PHYSIOLOGICAL} \\ \text{SOCIAL} \\ \text{ORGANIZATION} \\ \text{POLITICAL}\end{array}\right.$

$\left.\begin{array}{l}\text{PHYSICAL}\end{array}\right\}$ ERGONOMICS

$\left.\begin{array}{l}\text{PHYSIOLOGICAL}\end{array}\right\}$ NORMS & PRACTICE

$\left.\begin{array}{l}\text{ORGANIZATION}\end{array}\right\}$ SOCIAL NORMS

Lecture 13-2

⑧ • Intellectual Property

↳ Ideas are our scientific and business assets

• The law protects ideas in the form of:

↳ "Trademarks" → an identifier

↳ "Copyrights" → the right to copy / distribution

↳ "Patents" → protect products, concepts, and ideas

PERUSALL NOTES

Organizing Teams:

- We use the Tuckman Team Model

  ↳ First three stages (forming, storming, norming) are for teams just starting out.

- Forming Stage

  ↳ Team is coming together but still functions as a set of individuals

  ↳ Dominated by teammembers thinking about themselves more than the team

- Storming Stage

  ↳ Least comfortable stage of team lifespan

  ↳ Teams can get stuck in this stage and may revert to individual decision-making and the project work returns to individual pieces.

- Norming Stage

  ↳ Team members develop strategies for accomodating differences and actively engaging all teams members.

Tools for Organizing Teams

• Forming

↳ Create a Team Charter to lay out protocols and envision the team beliefs

↳ Use agendas and keep team minutes

• Dealing with storming → Conflict Management.

↳ ① Separate people from problem

↳ ② Focus on interests, not positions

↳ ③ Develop solutions that will benefit everyone

↳ ④ Define effective performance measures

Management Strategies

• Task and People Problems

↳ One example of Project Management method is RACI

  ↳ Responsible, Accountable, Consulted, Informed

Producing

• Performing Stage of Tuckman Team Model

↳ When teams are in the Performing Stage, the focus is on the tasks at hand and achieving the goals of the project

MISCELLANEOUS TERMS/NOTES

- Affordance → Recognizing that the way people do things is generally not based on what is possible, but based on usage implied by design

  ↳ Most obvious function of UI/UX design

- Biomimetics → Process of adapting solutions from the biological world.

- Bathtub Curve → Possibility of failure of a design over its lifespan

- DFX → Design for a specific consideration

- Fault-Tree Analysis → Means of calculating the probability of an undesirable outcome.

- Means Statement → Specific solution idea or a means of solving the design problem

- Opportunity Cost → Concept that one has to give up an opportunity to do one thing in order to achieve another

- Reversal Method → A creativity method whereby the direction or sequence of things is reversed to generate new ideas

- Strategy of Least Commitment → At any point in the design process the design space is only reduced when necessary.

- Team Collocation → Having the whole team working together at the same time e.g. sprints

- TRIZ → "Theory of Inventive Design" → Set of 40 inventive principles that appear over and over in the solution of inventive problems

- Structural Decomposition → Splitting up the presumed structure of the solution into sub-structures

- Functional Decomposition → Splitting up functions of a design into a set of sub-functions to analyze each separately