Mechanism Feasibility Design

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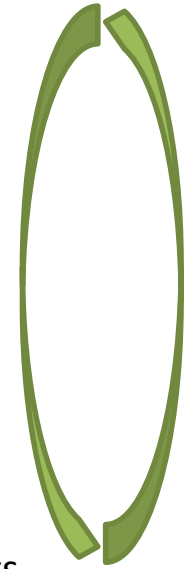
Contents

But First.

Well done on submitting the first exercise!

- Familiarised yourself with the exercise
- Generated a Product Design Specification
- Performed some initial calculations (Torque, Power, Speed)
- Resolved forces for two arrangements
- Shear force diagrams
- Bending moment diagrams
- Torque through the shaft
- Concept selection
- Beam bending
- Torsional stresses
- Bending stresses
- Node selection
- Chain & sprocket selection
- Bearing selection
- Stress concentrations
- Safety factors
- Fixings & fasteners
- Design report & detailed drawings



Before Reading Week

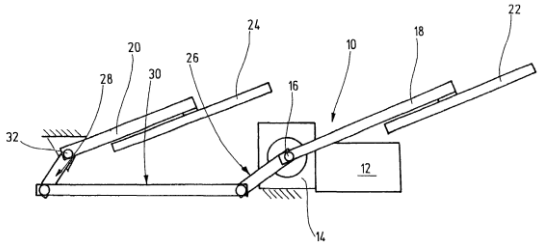
Product Design Specification

Concept Design

Concept Selection

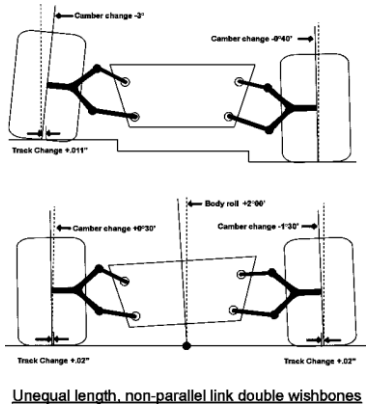
Introduced you to:

- Multi-bar mechanisms
- Exercise
- Design Process

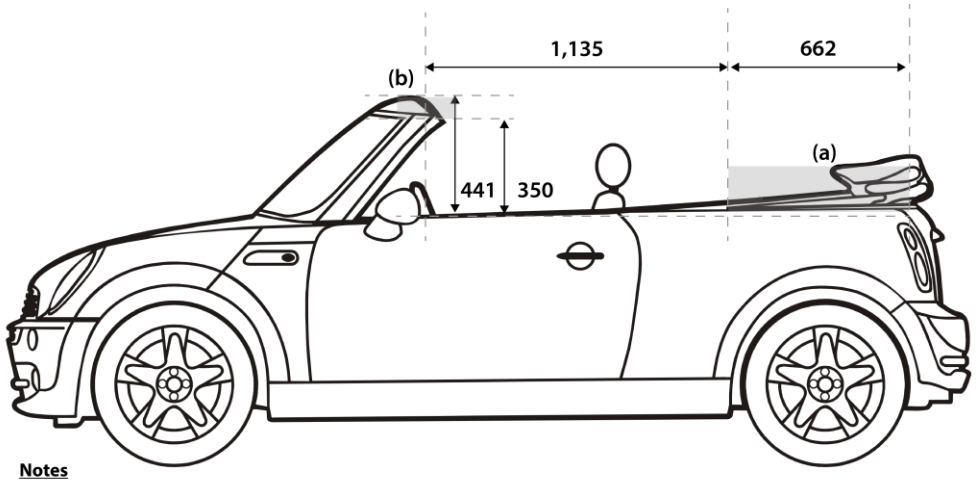


Where you should be at:

- Formed pairs
- Signed up and received Lego kits
- Familiarised yourself with the exercise



Unequal length, non-parallel link double wishbones



Notes
All dimensions in mm
(a) - Ideal position where the deployment mechanism can be connected to the vehicle
(b) - Windscreen connection point

Product Design Specification (PDS)

Product Design Specification

PDS format to follow

No.	Requirement	Must/Wish	Method of Assessment	Success Criteria	Will be assessed during the feasibility stage
1	Deployment Time	Wish	Simulink deployment model	<20secs	Yes, *and where in the report*?
2	Minimise mass of the convertible roof	…	…	…	…
3					
…					

- System-level
- Component-level (Motor, Gearbox & Mechanism)

Product Design Specification

Starting points

- Mass
- Deployment Time
- Packing space
- Interior space
- Energy consumption

Should be as exhaustive as possible

Include items that you will not be able to assess during the feasibility stage

Remember to reference material used to generate requirements

Product Design Specification

What can you discover on Google in 5mins?

Product Design Specification

Design Report

- Introduction
  - A few paragraphs discussing the context of the problem.
  - Why would you want to make a convertible car?
  - What is the market and market size?
- Product Design Specification
  - A couple of paragraphs describing how you formed the PDS and the process you have followed
  - Discuss the PDS table you have generated
  - Are you going to weight any of the requirements?

Q & A

Concept Generation Methods

Concept Generation – Competitor Analysis

Competitor Analysis

Evaluate their designs against your PDS to help steer your design

Quickly generate viable designs

Provides confidence that the design will work

Concept Generation - Brainstorming

Competitor Analysis | Brainstorming

Brainstorming: a technique by which a group attempts to find a solution for a specific problem by amassing all the members' ideas spontaneously.

A set of rules devised by Alex Osborn in 1941 to improve the creation of new ideas in business meetings:

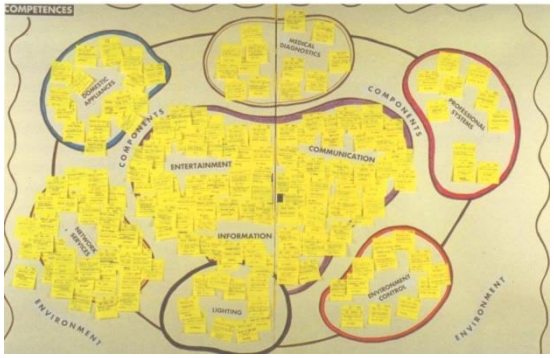
- **No criticism** of ideas
- Go for **large quantities** of ideas
- **Build** on other ideas or **combine** them
- Encourage **wild and unusual** ideas

Using these rules he found that more ideas were created.

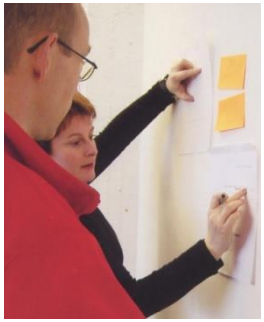
"Quantity produces quality"

Concept Generation - Brainstorming

Competitor Analysis | Brainstorming



Post-it notes



Pass the sheet

Brain-sketching

Concept Generation - Brainstorming

Competitor Analysis | Brainstorming

Assign a facilitator	It's their job to make sure EVERYBODY is contributing, and to keep everyone on track, and to record ideas.
Record everything	Every idea that anyone says should be drawn or written down.
Build on others	Use everyone else's ideas as a starting point for more of your own.
Contribute	Everyone should speak or draw. Take it turns if required.
Park ideas	If you are struggling or hit a dead end, park that idea until later.

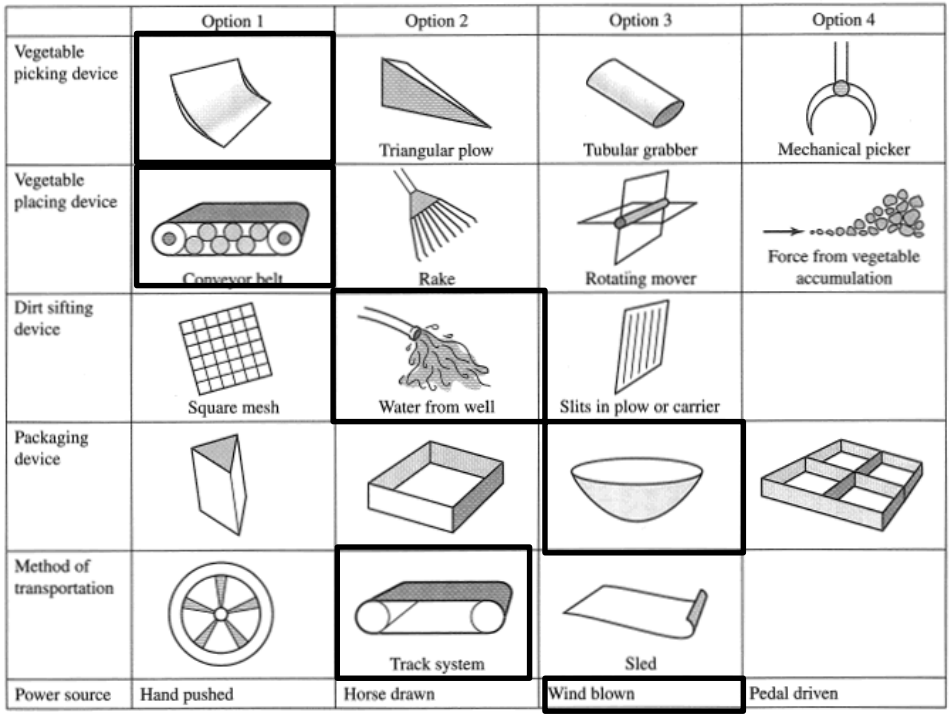
Concept Generation – Morphological Charts

Competitor Analysis | Brainstorming | Morphological Charts

Good for a PDS that has requirements that can be that are not highly dependent on one another

Look at developing sub-systems that meet specific requirements

You can then work through the matrix to quickly generate a large number of system designs



Morphological Analysis for vegetable collection system with selections (Haik and Shahin 2011: 175)

Concept Generation - Prototyping

Competitor Analysis	Brainstorming	Morphological Charts	Prototyping

Refine the concepts to the same level, which enables unbiased comparisons to be made

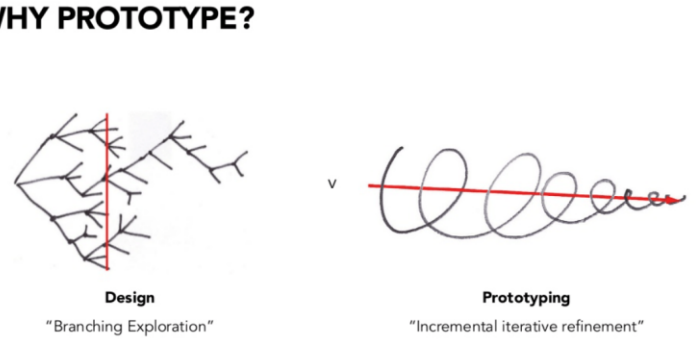
Identify interface issues that were not captured through sketching

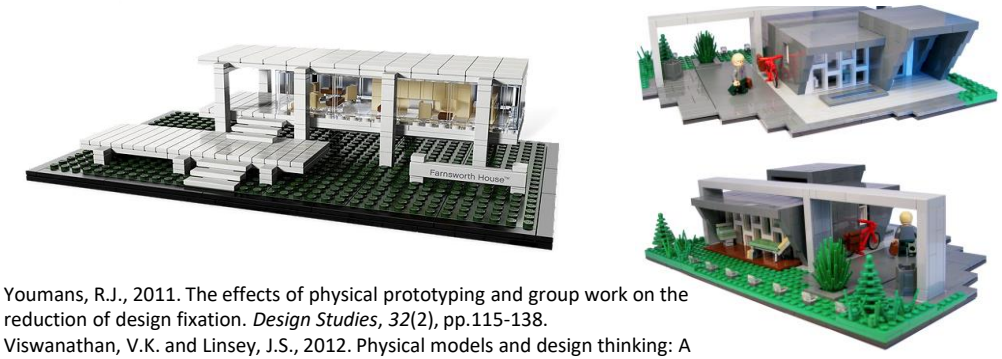
Identify design issues earlier in the design process and reduce the number of engineering changes required later in the design process

Enables wider stakeholder engagement

Improves the number of functional designs to be developed

The tools used to prototype can focus a designer on a specific element of the design problem





Youmans, R.J., 2011. The effects of physical prototyping and group work on the reduction of design fixation. *Design Studies*, *32*(2), pp.115-138.
Viswanathan, V.K. and Linsey, J.S., 2012. Physical models and design thinking: A study of functionality, novelty and variety of ideas. *Journal of Mechanical Design*, *134*(9), p.091004.

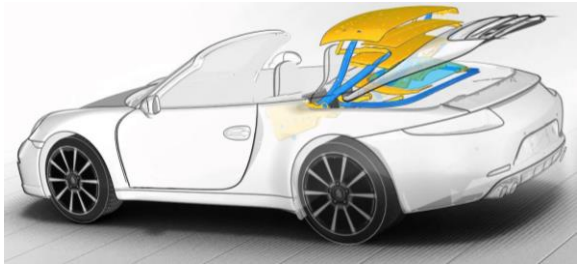
Concept Generation – For this design exercise

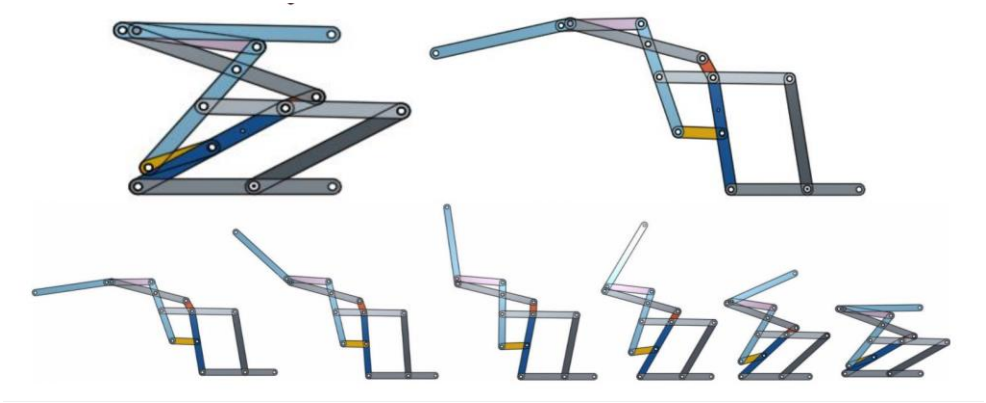
Competitor Analysis

Brainstorming

Prototyping

- Lego Sets
- Linkage Modeller





Concept Generation

Design Report

- Concept Generation
  - Introduce this section by informing us on the strategy you applied to generate your concepts
  - Come up with a systematic approach to reporting your concepts
    - Present figures in a consistent manner (for example, deployed and retracted views captured from linkage)
    - Provide the same level of detail for each concept
    - Perform the same rough calculations to each concept
    - Be impartial at this stage

Q & A

Concept Selection

Concept Selection

Controlled Convergence

Devised by Pugh in the 1980s

Matrix comparing requirements and concepts

Select one as a datum

Iterate through each concepts (+,- or s)

Sum values and rank concepts

Check if any concepts could be combined

Criteria	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6
Ease of use	DATUM	+	+	-	-	S
Aesthetic appeal		-	+	+	-	-
Manufacturability		+	+	-	+	+
Low weight		+	-	+	-	+
Energy efficiency		S	+	-	+	+
Safety		-	+	S	-	+
Σ+		3	5	2	2	4
Σ-		2	1	3	4	1
ΣS		1	0	1	0	1
Net Score	0	1	4	-1	-2	3
Rank	4	3	1	5	6	2
Continue or combine?	Combine	Combine	Yes	No	No	Yes

Pugh, S., 1991. *Total design: integrated methods for successful product engineering*. Addison-Wesley.

Concept Selection

Controlled Convergence | Multi-Criteria Decision Analysis

Score each concept against the requirements using a lickert scale scoring metric

Can provide a weighting to each criteria to highlight priorities

Adjust the scores by the weighting

Rank each concepts and make a judgement on the one to select

		Project A		Project B	
	Weighting	**Score**	**Weighted**	**Score**	**Weighted**
Criteria:					
Compatibility with strategic objectives	7	4	28	4	28
High Market Value	9	4	36	4	36
Genuine advantages over competition	9	4	36	5	45
Generate or save large amounts of money	10	4	40	4	40
Contact with the market	8	4	32	4	32
Technical expertise available	4	5	20	3	12
Commercial expertise available	7	1	7	1	7
Project management resources available	4	3	12	3	12
Clear route for implementation	4	2	8	2	8
Evolving/lurking risk factors	6	2	12	2	12
Compliance with industry standards	3	2	6	2	6
Total	**450**	44	292	46	317
% of Total			65%		70%
Rank			2		1

Concept Selection

Controlled Convergence | Multi-Criteria Decision Analysis

Pair-Wise Comparison

How do you weight your requirements?

One method:

Compare each requirement to one another and decide which one takes priority

Re-order the matrix to define a priority listing

Function		A	B	C	D	E	F	G	H	I
functionality	**A**	-	A	C	D	A	F	A	AH	I
durability	**B**	-	-	C	D	B	B	B	H	BI
quality	**C**	-	-	-	D	C	F	C	H	C
affordability	**D**	-	-	-	-	D	F	D	D	I
manufacturability	**E**	-	-	-	-	-	F	E	H	E
usability	**F**	-	-	-	-	-	-	F	FH	I
maintainability	**G**	-	-	-	-	-	-	-	H	I
safety	**H**	-	-	-	-	-	-	-	-	H
marketability	**I**	-	-	-	-	-	-	-	-	-

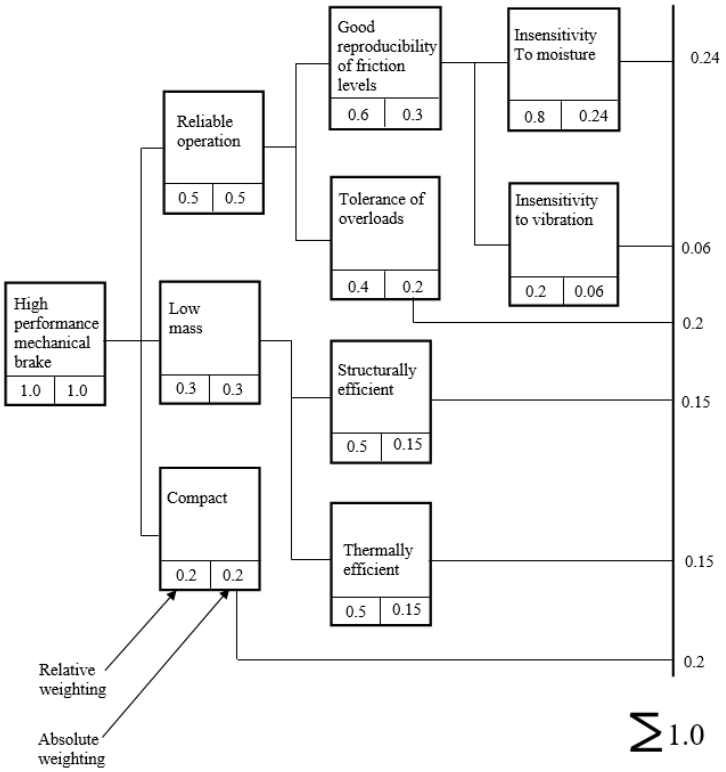
Concept Selection

Controlled Convergence | Multi-Criteria Decision Analysis | Weighted Objectives Tree | Pair-Wise Comparison

Define a set of high-level requirements for the system you're designing

Breakdown each requirement to a set of sub-requirements that are weighted

Keep breaking down the requirements to a level where you can have a method of assessing it



Concept Selection

Controlled Convergence | Multi-Criteria Decision Analysis | Weighted Objectives Tree

Dot Sticking | Pair-Wise Comparison

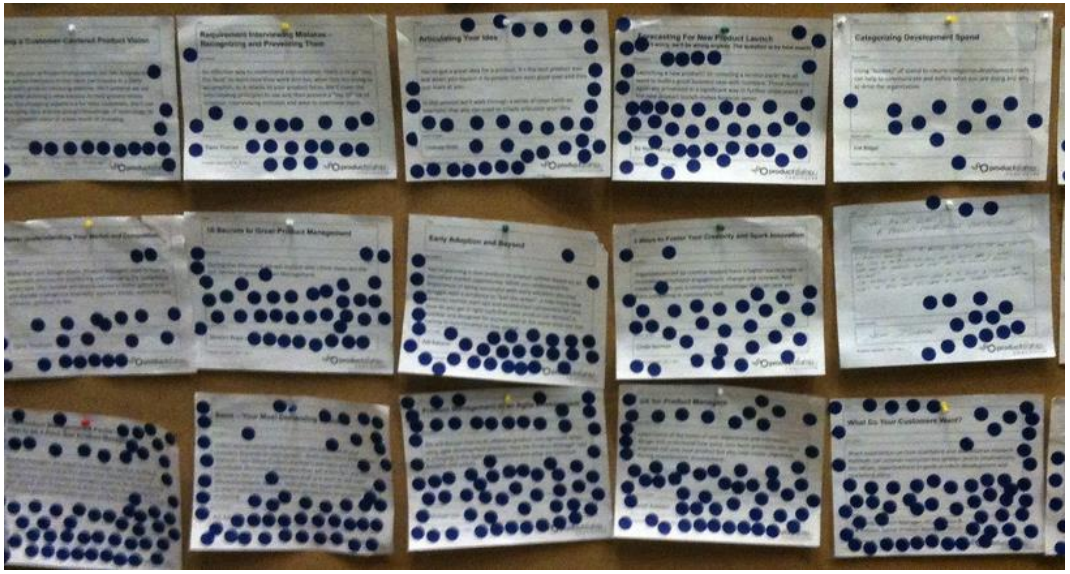
Present each design

Useful in very early-stage design problems

Enables wider stakeholder engagement

Anonymous feedback

Quick evaluation of designs



Concept Selection – for this exercise

Controlled Convergence Strategy

Criteria	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6
Ease of use	DATUM	+	+	-	-	S
Aesthetic appeal		-	+	+	-	-
Manufacturability		+	+	-	+	+
Low weight		+	-	+	-	+
Energy efficiency		S	+	-	+	+
Safety		-	+	S	-	+
Σ+		3	5	2	2	4
Σ-		2	1	3	4	1
ΣS		1	0	1	0	1
Net Score	0	1	4	-1	-2	3
Rank	4	3	1	5	6	2
Continue or combine?	Combine	Combine	Yes	No	No	Yes

Concept Selection

Design Report

- Concept Selection
  - Discuss and present your controlled convergence selection process for your three concepts
  - Provide a few paragraphs discussing your final selection and whether there have been any refinements from your selection process

Q & A

This Week

Generate three concepts for you mechanism

Compare them through controlled convergence

Select a concept to carry forward

And! Write it up as you go along.

Recommended: Use the sessions to help your with the task as well as how it should be reported.

Next Weeks Lecture

Systems Modelling

Thank You