Mechanical Analysis and Design
ME 2104

Lecture 9

Concept evaluation

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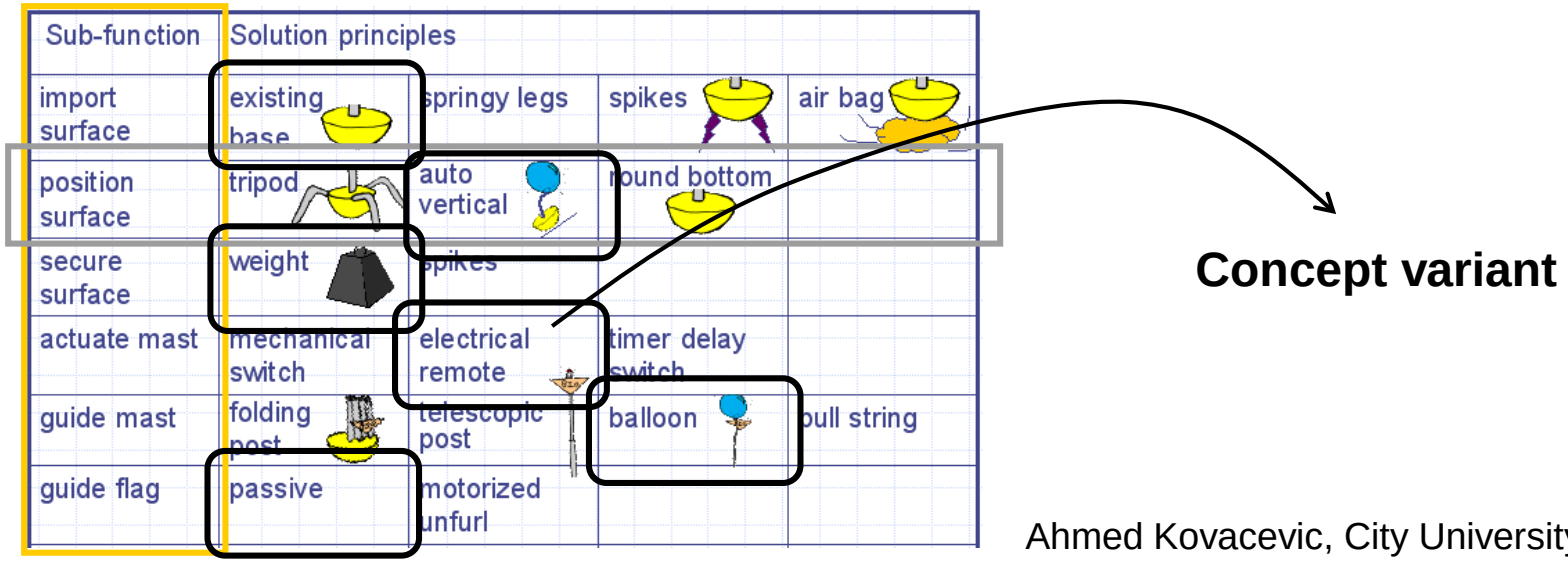
www.staff.city.ac.uk/~ra600/intro.htm

Plan for today

- Morphological chart (15 min)
- Lecture (30 min)
  - » Concept evaluation
- Team meeting (Morphological chart, concept variants) (55 min)
- Q&A (10 min)
  - » Concept development and evaluation

Morphological Chart

- **Used to generate** possible design solutions
  - » After the problem and the function of the device is understood, **brainstorming** can be used to generate potential solutions
- **Very useful** visual way of organizing and assessing the range of possible solution combinations for a problem
- **Very simple** – it is a **table**
  - » Sub-functions listed in the first column
  - » Possible solutions to each sub-function shown in the rows to the right
  - » Possible solutions then selected to form a concept variant



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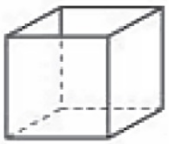
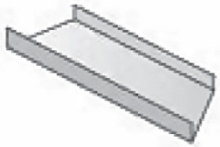
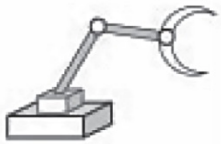
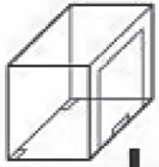
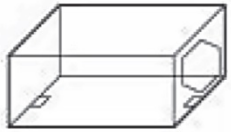
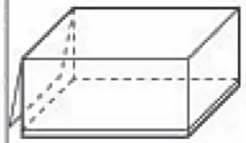
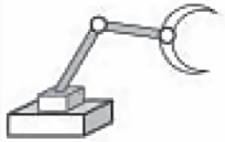
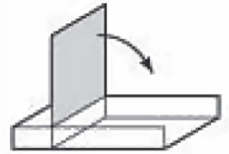
Loader						
Aligner						
Holder						
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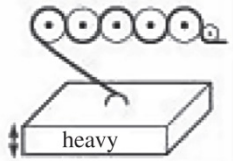
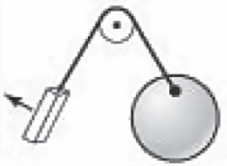
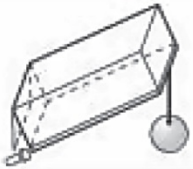
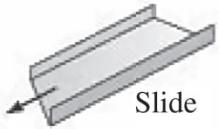
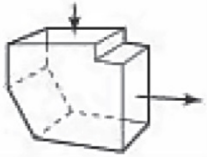
Crusher						
Ejector						

Figure 7.5 Morphological chart of automatic can crusher.

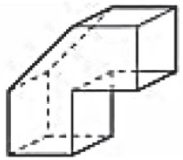
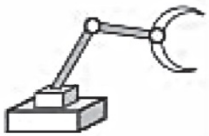
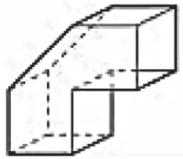
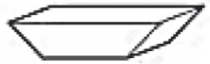
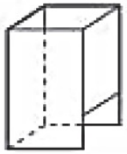
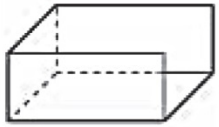
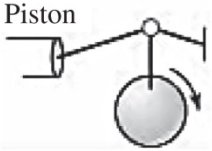
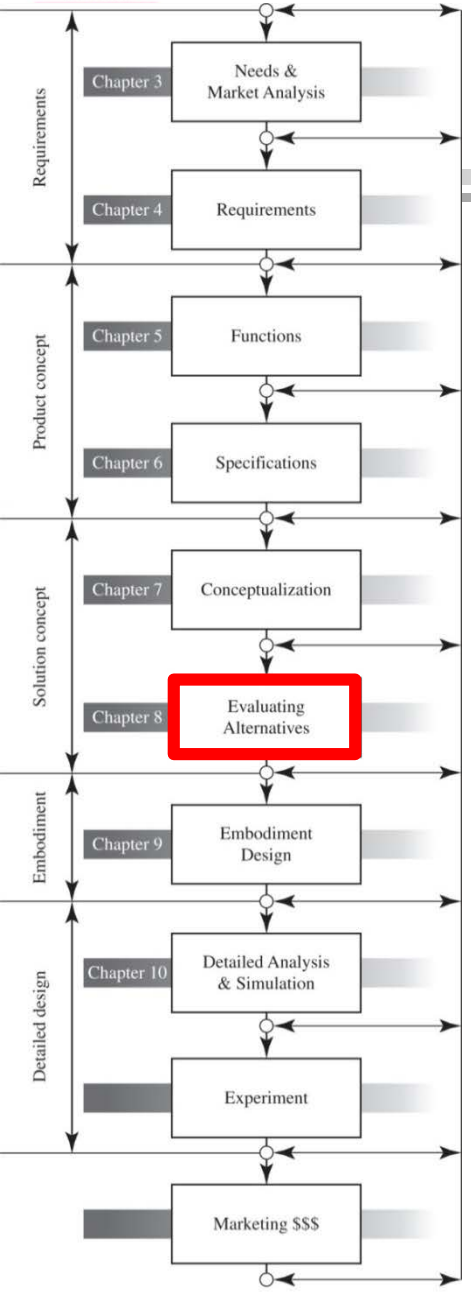
	Option 7	Option 8	Option 9	Option 10		
Loader						
Aligner						
Holder						
Actuator						
Crusher	Piston 					
Ejector		Gravity 				

Figure 7.5 Morphological chart of automatic can crusher (continued).



Concept evaluation

- Engineering Design Process 2nd Edition, Chapter 8
  - » Use different methods to evaluate the different concepts that were generated in the previous design step
  - » Select a design alternative for further development

Kano Model

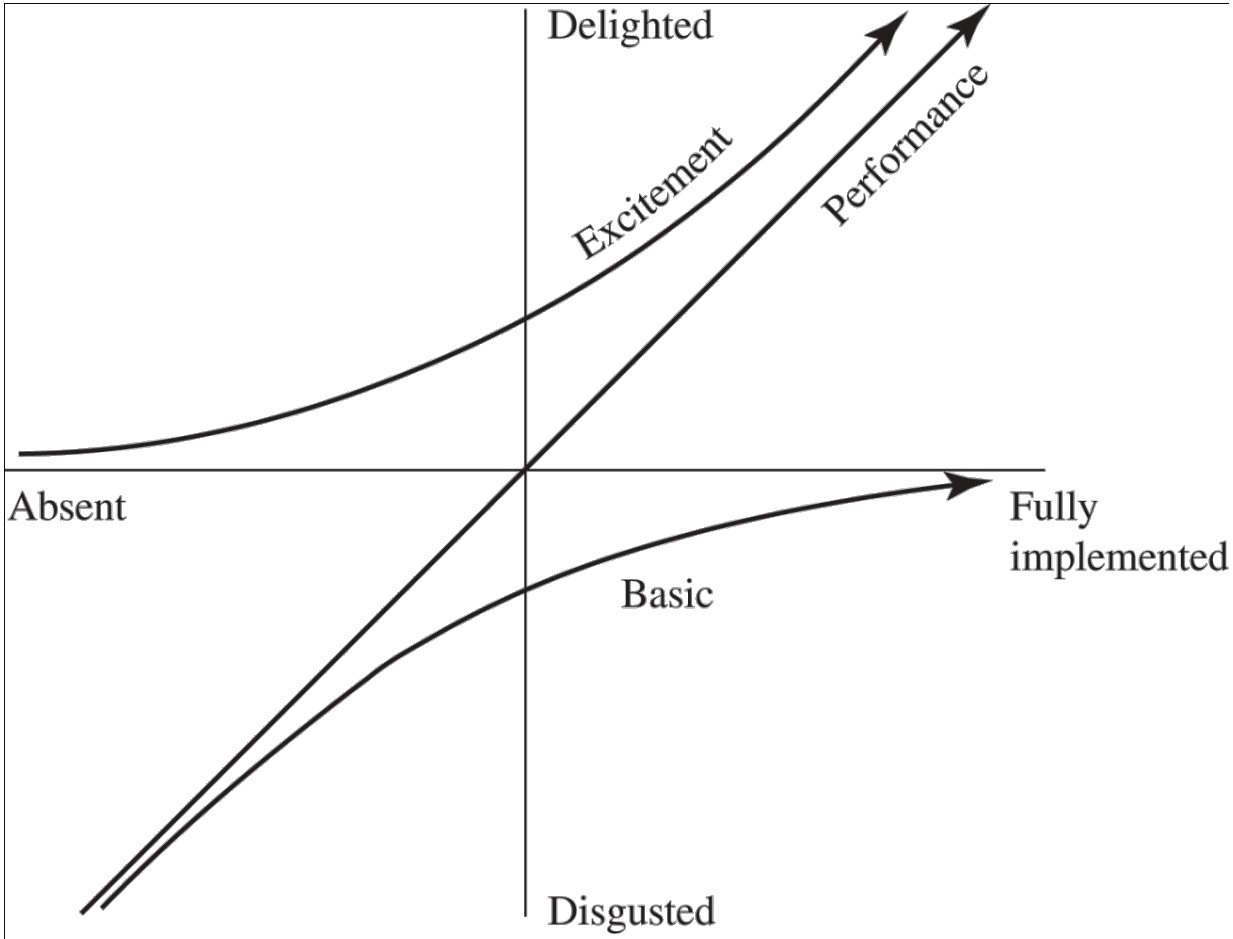


Figure 6.4 Kano model for customer satisfaction.

How to create concept variants?

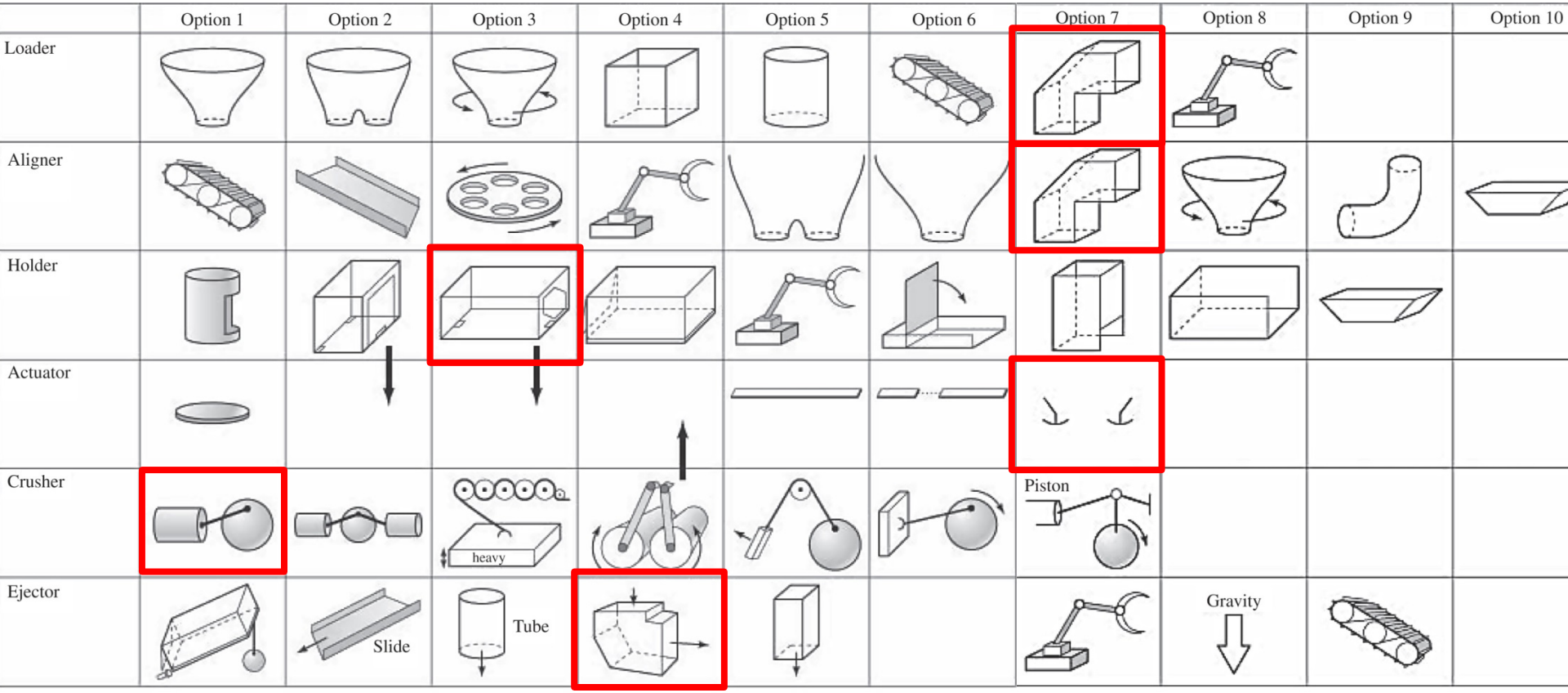
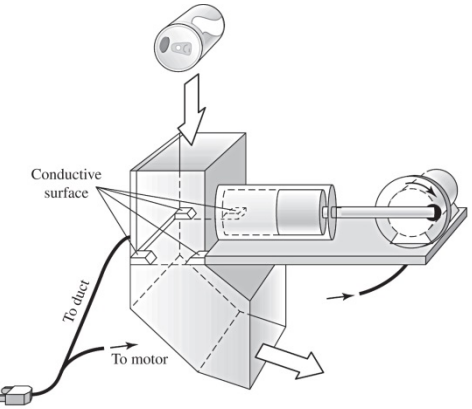


Figure 7.5 Morphological chart of automatic can crusher.

ıological chart of automatic can crusher (continued).

How to create concept variants?



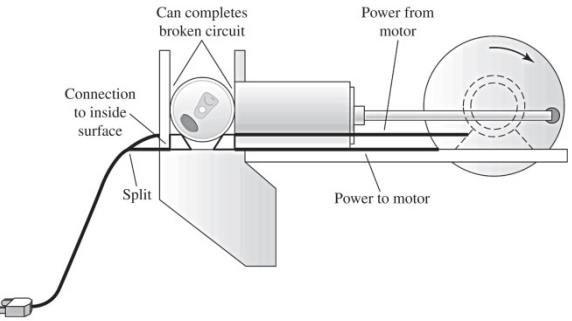
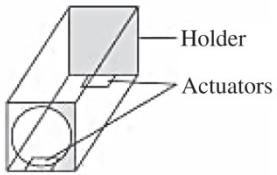
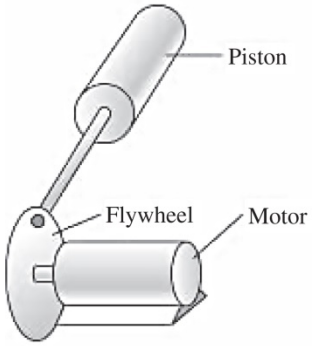


Figure 8.17 Concept IV of automatic can crusher.





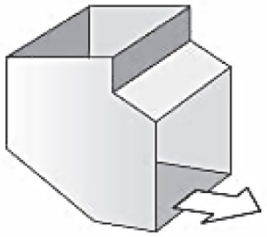
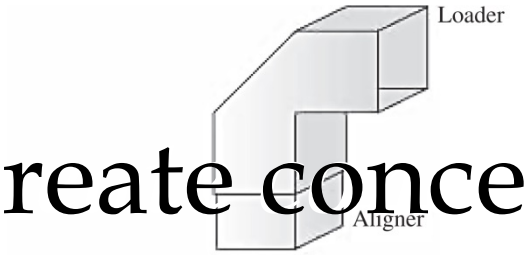


Figure 8.18 Concept V of automatic can crusher.



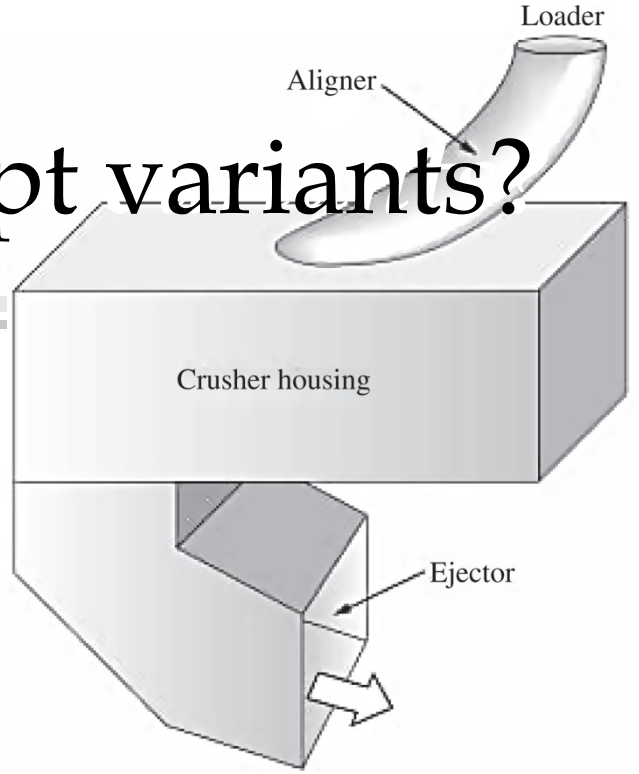


Figure 8.16 Concept III of automatic can crusher.

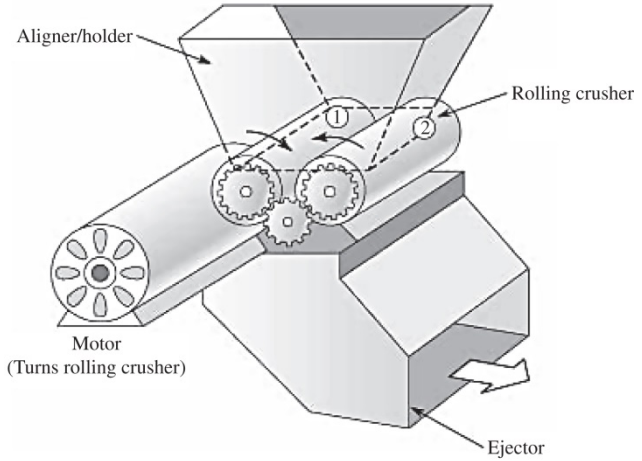


Figure 8.14 Concept I of automatic can crusher.

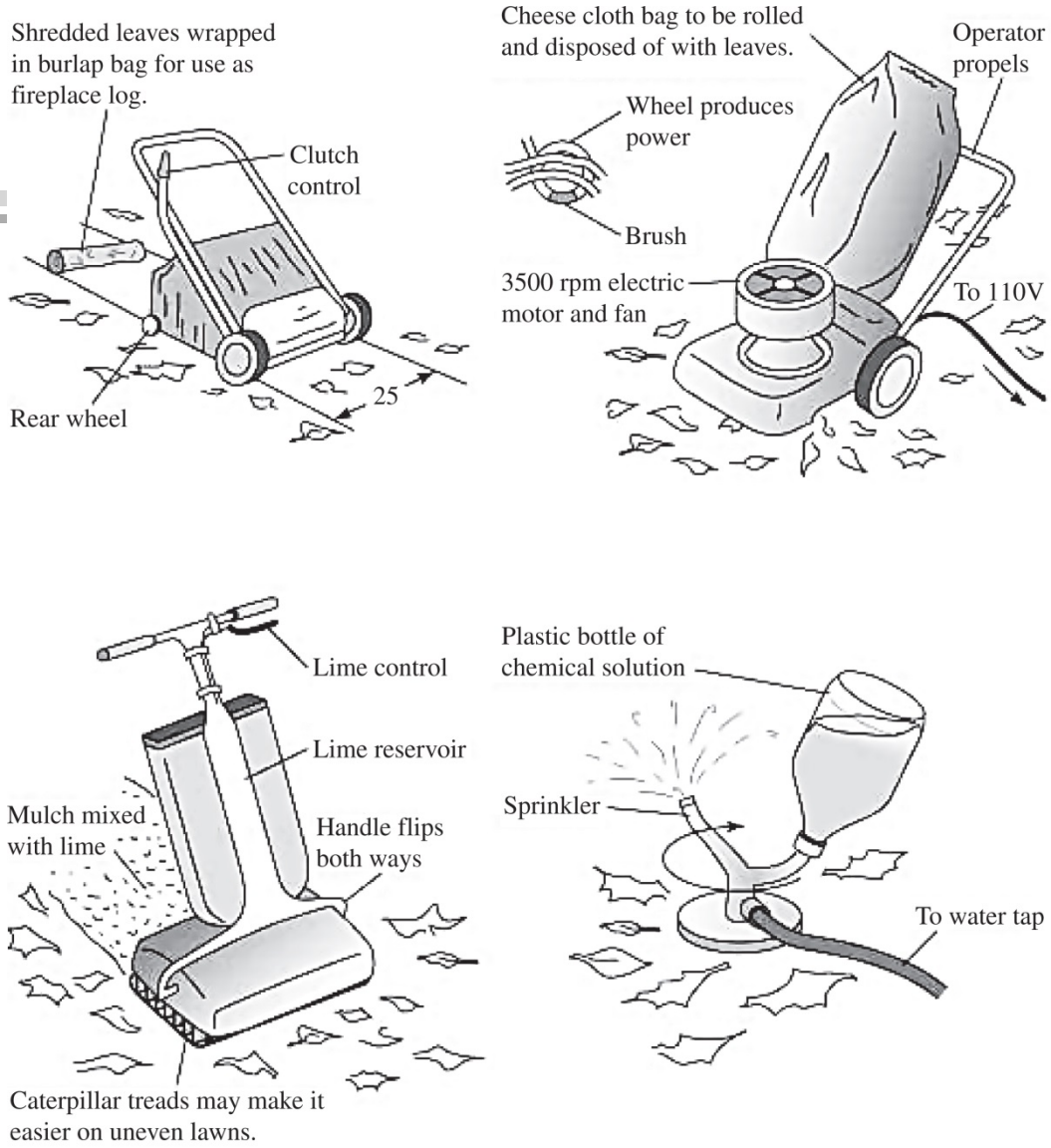


Figure 8.2 Conceptual sketches of yard leaf collector.

Decision Matrix

Design Criteria

Sum of (R.F x W.F)
highest number is the best design concept

Conceptual Design ideas

Design criteria / Weighting factor / Alternatives	Use of standard parts	Safe	Simplicity and maintenance	Dura-bility	Public acceptance	Reliability	Cost to develop	Cost to buyer	Perform-ance	Sum
	0.08	0.12	0.10	0.10	0.18	0.20	0.03	0.04	0.14	1.0
A) Leaf bailer	3 / 0.24	5 / 0.60	2 / 0.20	4 / 0.40	9 / 1.62	6 / 1.20	1 / 0.03	1 / 0.04	3 / 0.45	4.78
B) Vacuum collector	9 / 0.72	10 / 1.20	10 / 1.00	8 / 0.80	6 / 1.08	7 / 1.40	10 / 0.30	10 / 0.40	8 / 1.24	8.14
C) Shredder	5 / 0.40	6 / 0.72	7 / 0.70	7 / 0.70	/ 1.44	6 / 1.20	3 / 0.09	4 / 0.16	5 / 0.75	6.16
D) Chemical decomposer	8 / 0.64	10 / 1.20	9 / 0.90	8 / 0.80	9 / 1.62	7 / 1.40	2 / 0.06	8 / 0.32	8 / 1.24	8.18

R.F. x W.F.
e.g. 4 x 0.12 = 0.48

Weighting factor (W.F.) = Measure of relative importance (0 to 1.0Σ = 1.0)

Rating factor (R.F.) = Measured value of alternatives against design criteria (0 to 10)

Rating for each concept against the design criteria (R.F)

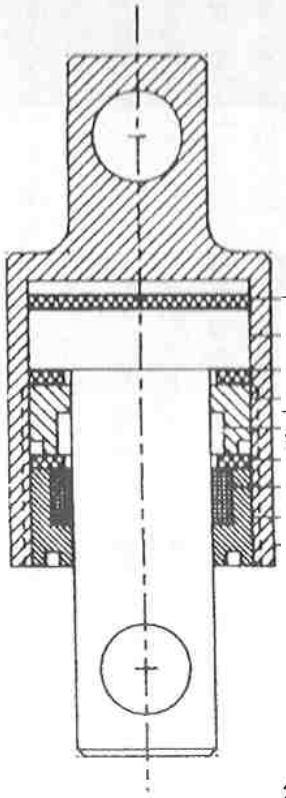
Figure 8.3 Decision matrix.

Team meeting

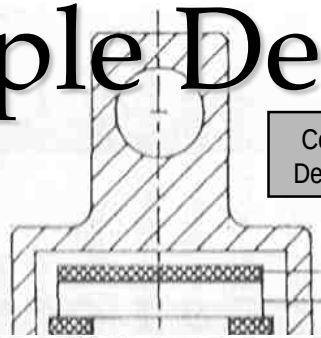
- Attention to:
  - » Select max 12 functions from the functional model
  - » Develop Morphological chart
  - » Agree on who will finalise sketches in morphological chart
  - » Agree on who needs to finalise performance specification

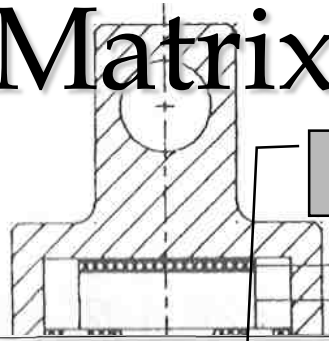
Q & A

Example Decision Matrix



Design 1





Design Criteria

Conceptual Design ideas

U=W x S/100
e.g. 9 x 8/100 = 0.72

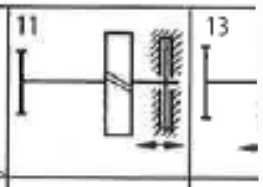
	Design criteria	Weight	Design 1		Design 2		Design 3	
		W*	S	U	S	U	S	U
1	Cost							
	Materials	6	8.5	0.51	5.5	0.33	7	0.42
	Seals	2	8	0 16	8	0 16	8	0 16
	Bearings	4	9	0.36	5	0.2	8	0.28
	Washers	1	7.5	0.07	7 5	0.07	7 5	0 07
	Squeeze packing	2	9	0.18	9	0.18	9	0.18
	Bolts	1	9	0 09	9	0.09	8	0 08
	Labour	6	8	0 48	5	0 3	7.5	0.45
	Tools and equipment	6	8	0 48	5	0 3	7.5	0.45
	Indirect cost	20	8.5	1.7	7	1 4	7 5	1 5
	Marketing	2	7	0 14	8	0.16	9	0 18
2	Performance							
	Sealing	9	8	0 72	8	0.72	8	0.72
	Smoothness	9	5	0 45	9	0.81	8.5	0.76
	Alignment	6	5	0.3	7	0 42	8	0 48
	Growth formation	2	8	0 16	8	0.16	8	0.16
	Maintenance	4	8	0 32	8	0 32	8	0 32
3	Manufacturing							
	Ease	5	8.5	0.42	7	0.35	7.5	0.37
	Time	5	9	0.45	4.5	0.22	7.5	0.37
	Assembly	5	9	0.45	6.5	0 32	8	0.4
4	Strength	5	8	0 4	9.5	0.47	9 5	0.47
	The overall utility			7 84		6.98		7.82

*W = percentage weight of each criterion (from 100)
S = score of quality of each design (from 10)
U = utility (weighted score) of design = W × S

Rating for each concept against the design criteria (R.F)

Sum of U
highest is the best concept

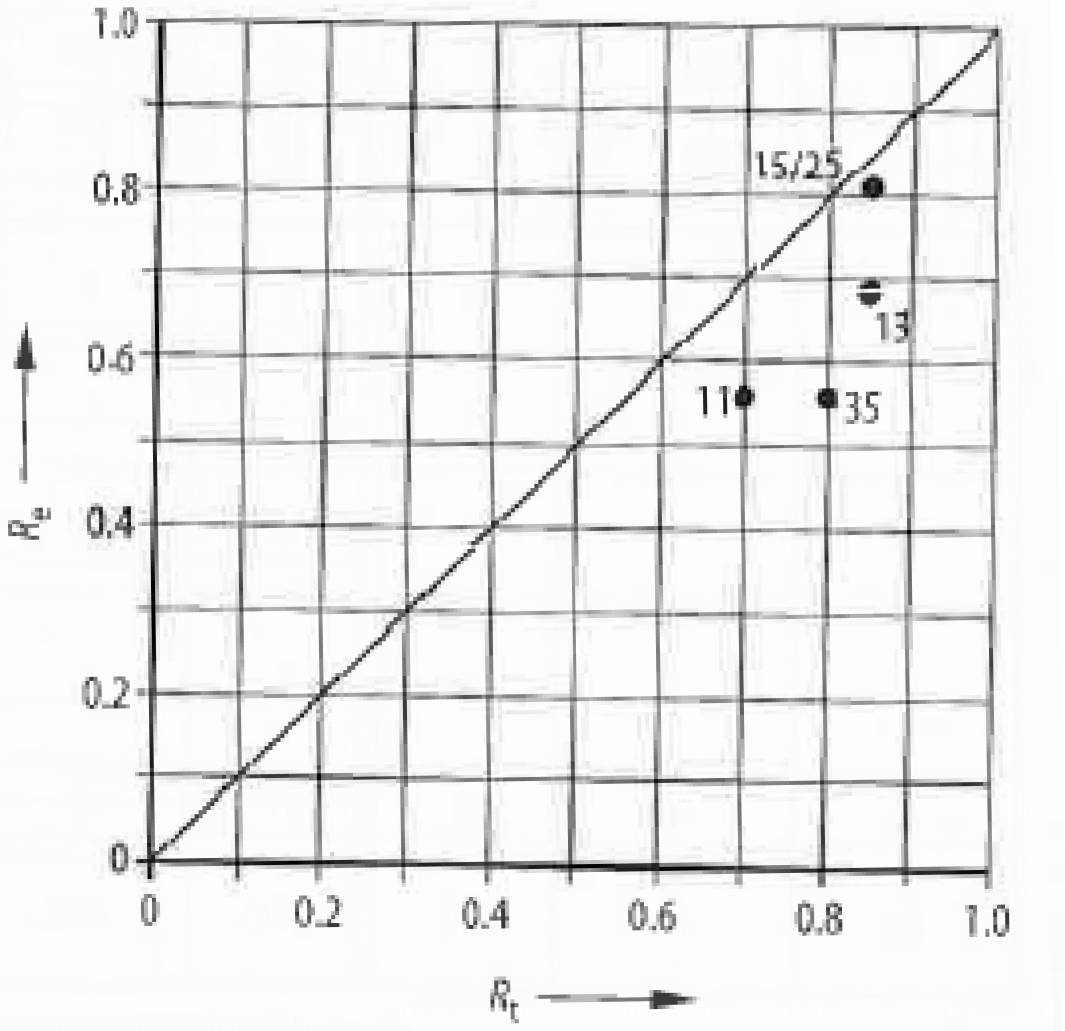
Technical-Economy diagram

Technical criteria \ Variants	11 	13
1) Small disturbance of coupling kinematics	(1) 3	
2) Simple operation	3	
3) Easy exchange of coupling	4	
4) Functional safety	2	
5) Simple construction	(1) 2	
Total	14	1
$R_t = \frac{\text{Total}}{20}$	0.7	0.8

(1) Torque changes with axial displacement of pinion

Economic criteria \ Variants
1) Low material costs
2) Low reassembly costs
3) Short testing time
4) Possibility of manufacturing in own workshop
Total
$R_e = \frac{\text{Total}}{16}$

(1) Austenitic shaft (2) Tc



Tasks for this week

Until Thursday:

- Finish sketches in morphological chart
- Finalise performance specification

Meeting on Thursday:

- Decide on sub-solutions for each concept variant (3-6)
- Distribute work to individuals to draw and describe concept variants
- Decide on who is doing QFD2

Until next Monday:

- Finalise concept variants
- Finalise QFD2

Content for 2nd Project Review

- Updated Objectives, Functional model, QFD, Requirements list
- Updated Projectile Motion Calculation
- Updated Pressure Calculation
- Evaluation of concepts (technical & economical); Technical-Economy Diagram
- Decision matrix
- Selection of gear and belts
- 3D CAD model embodying the selected concept