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Mechanical Analysis and Design
ME 2104

Lecture 9

Concept evaluation

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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

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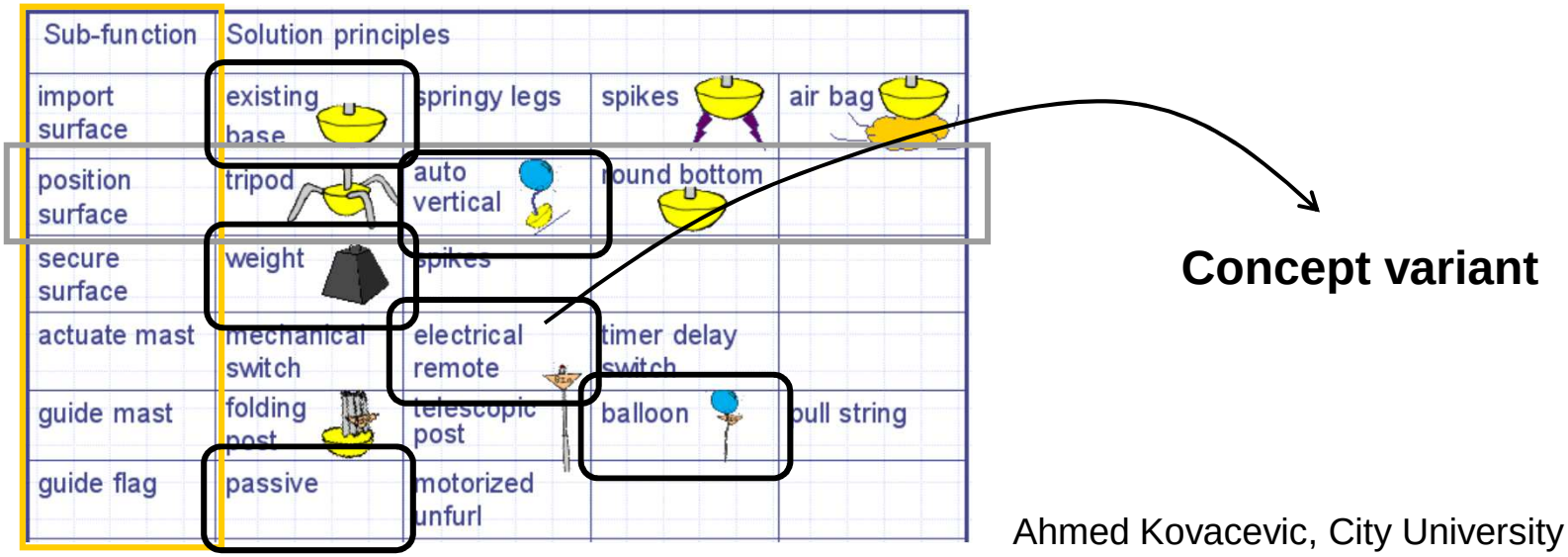
Morphological Chart

- **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



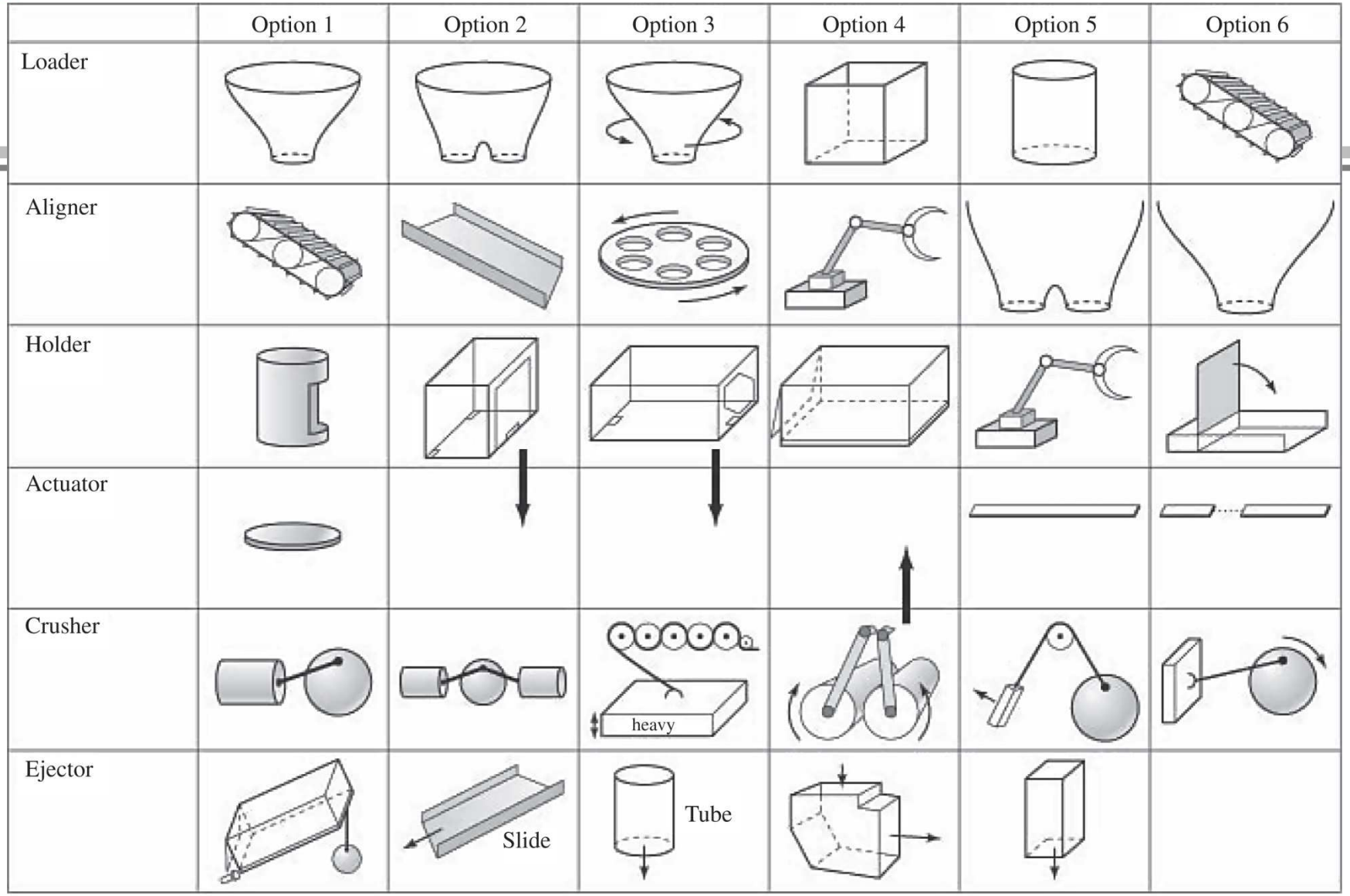


Figure 7.5 Morphological chart of automatic can crusher.

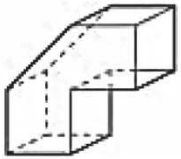
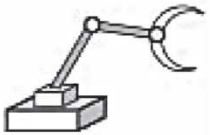
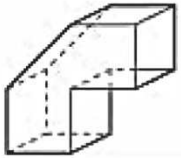
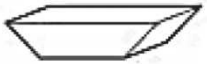
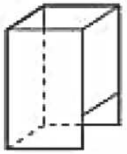
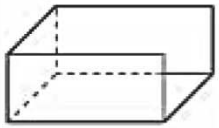
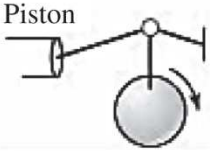
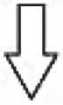
	Option 7	Option 8	Option 9	Option 10		
Loader						
Aligner						
Holder						
Actuator						
Crusher	Piston 					
Ejector		Gravity 				

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

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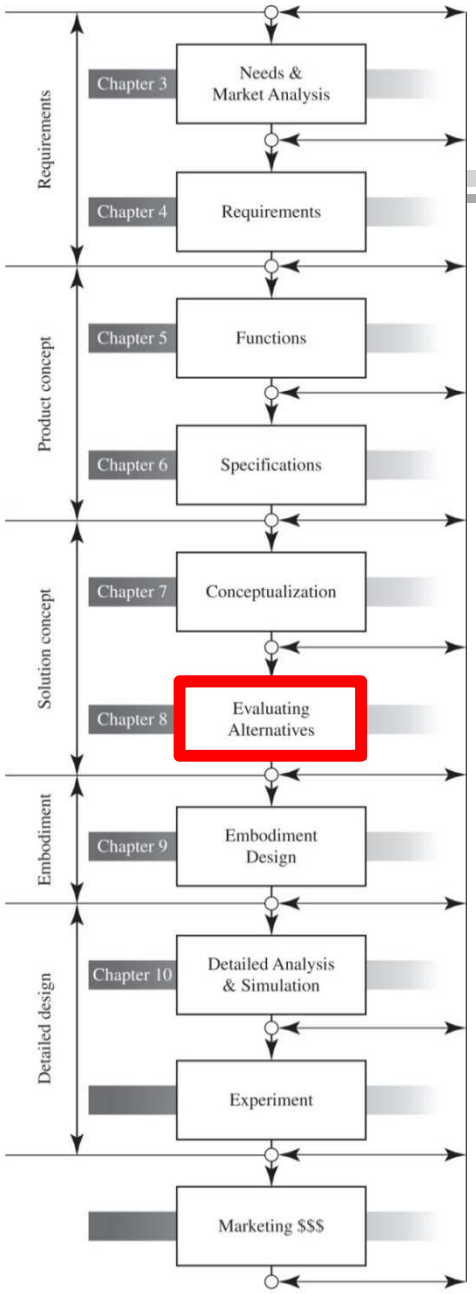

Concept evaluation

- 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

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Kano Model

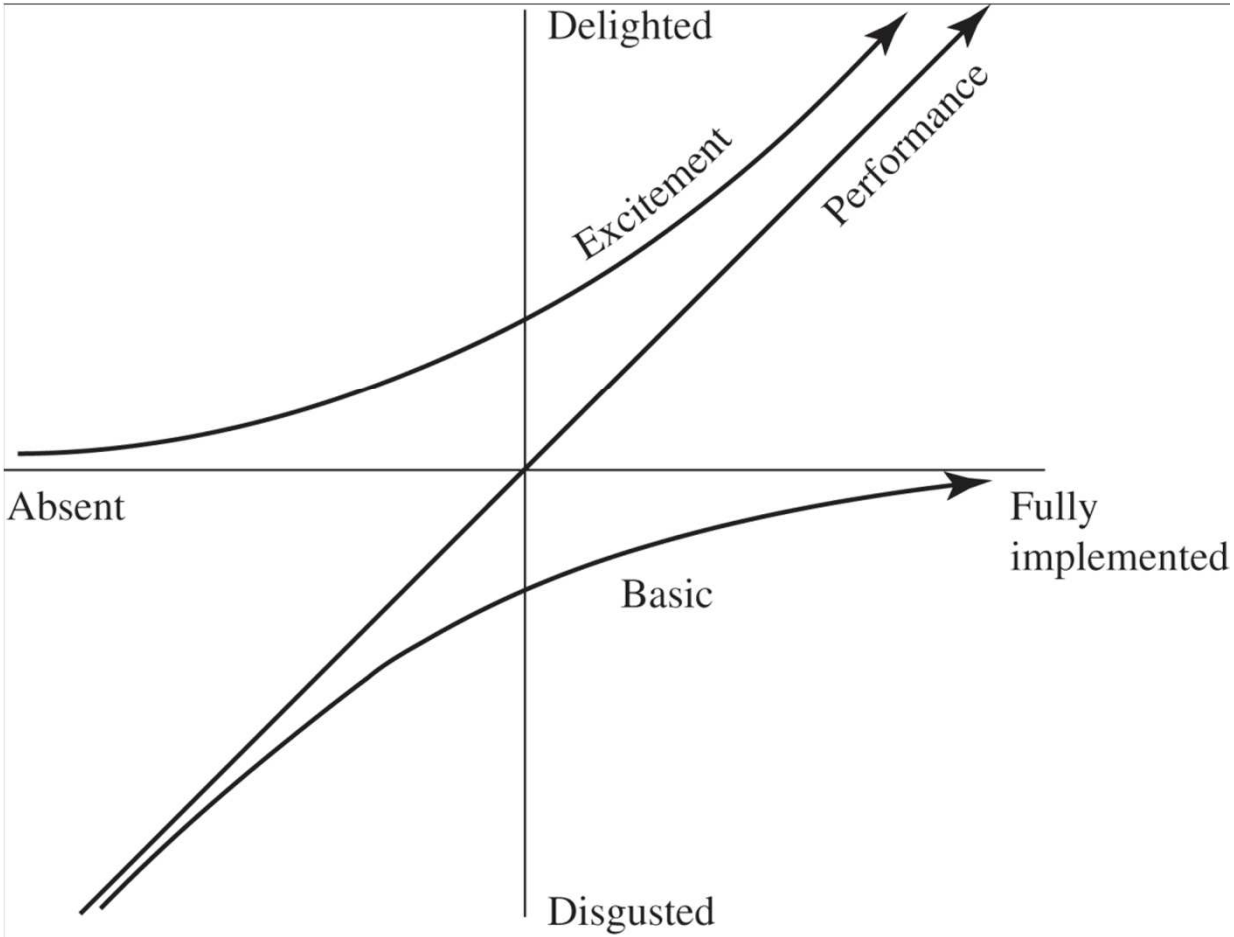

Figure 6.4 Kano model for customer satisfaction.

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How to create concept variants?

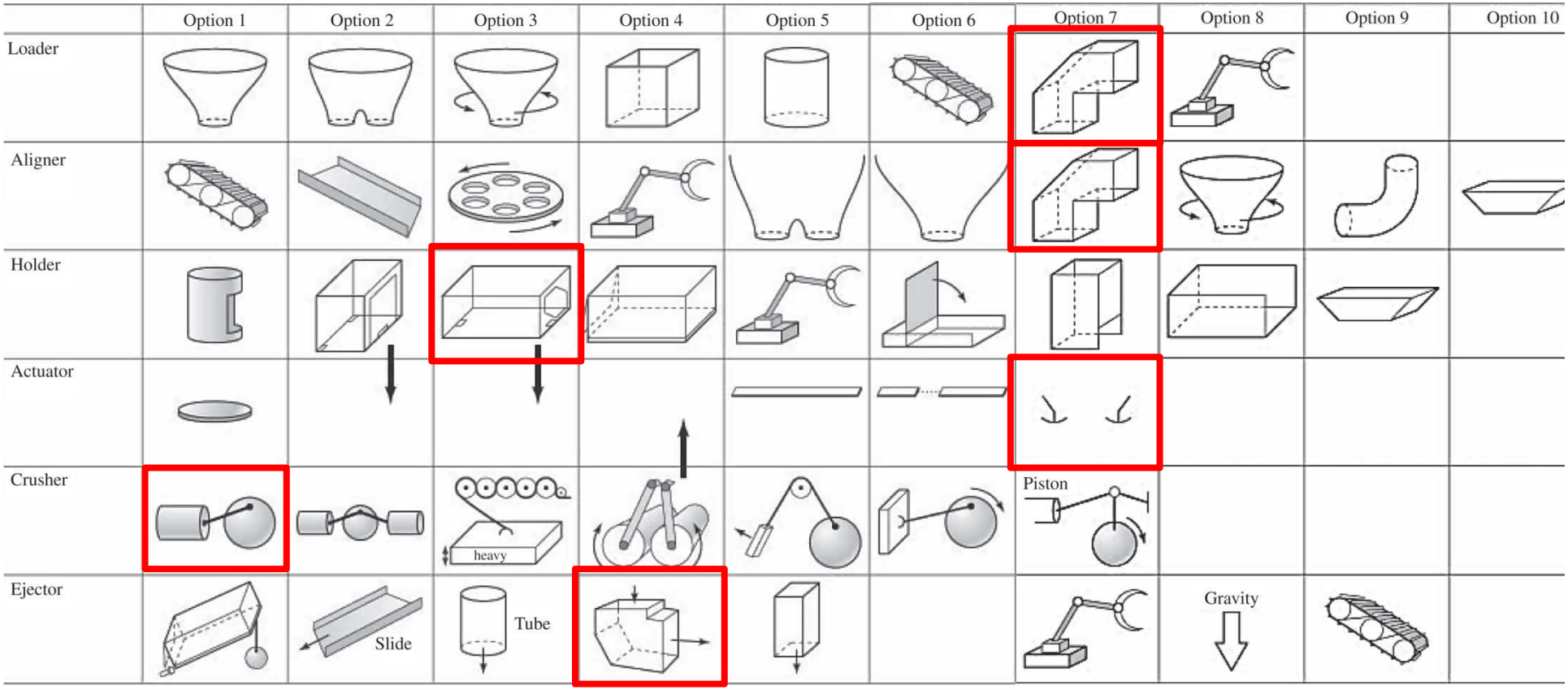

Figure 7.5 Morphological chart of automatic can crusher.

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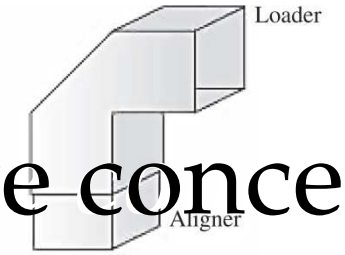
How to create concept variants?



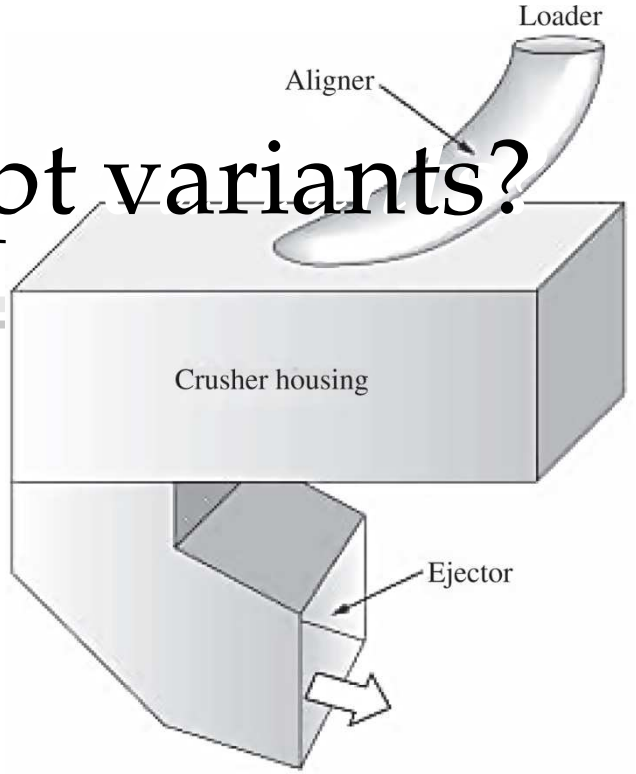
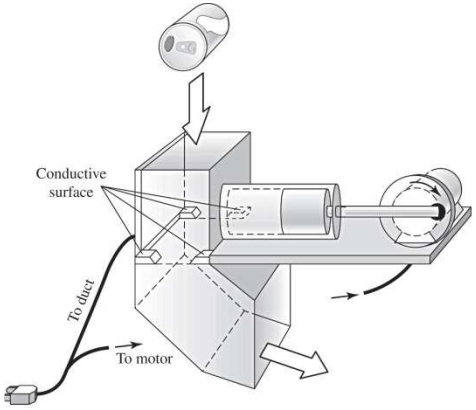
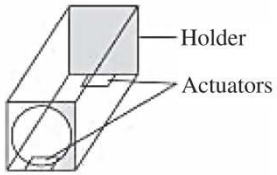
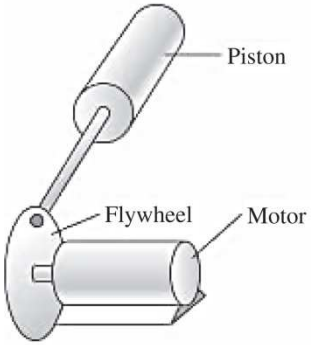
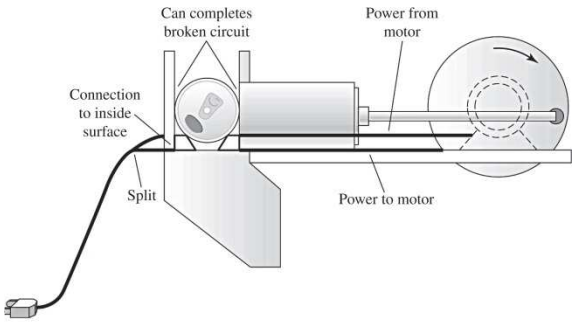


Figure 8.16 Concept III of automatic can crusher.









igure 8.17 Concept IV of automatic can crusher.

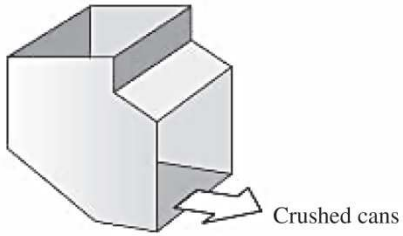


Figure 8.18 Concept V of automatic can crusher.

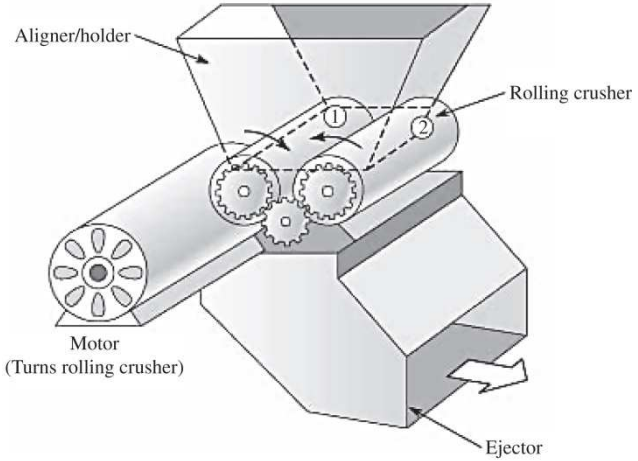


Figure 8.14 Concept I of automatic can crusher.

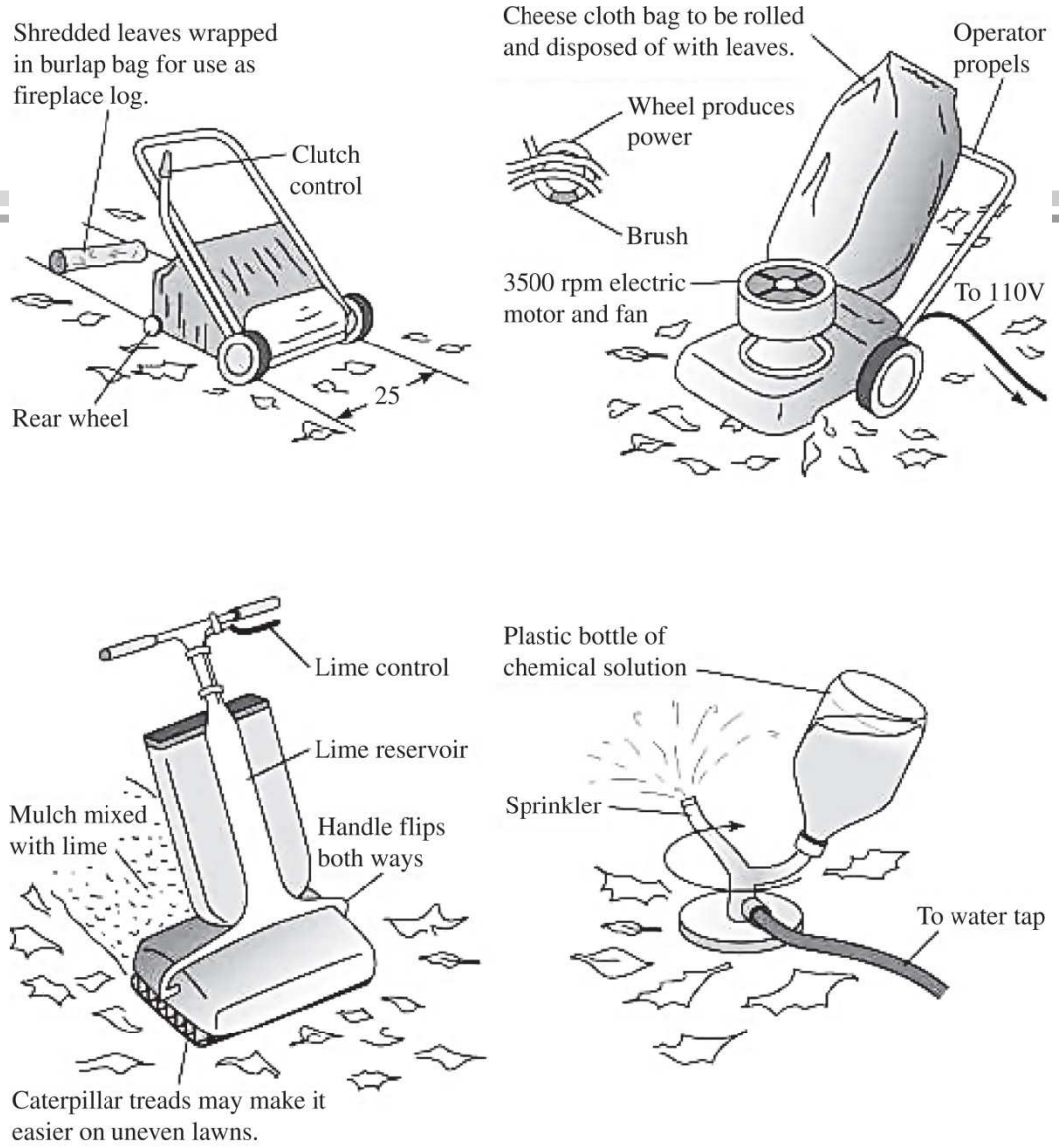


Figure 8.2 Conceptual sketches of yard leaf collector.

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Decision Matrix

Design Criteria

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

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

Conceptual Design ideas

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

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

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)

Figure 8.3 Decision matrix.

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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

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Q & A

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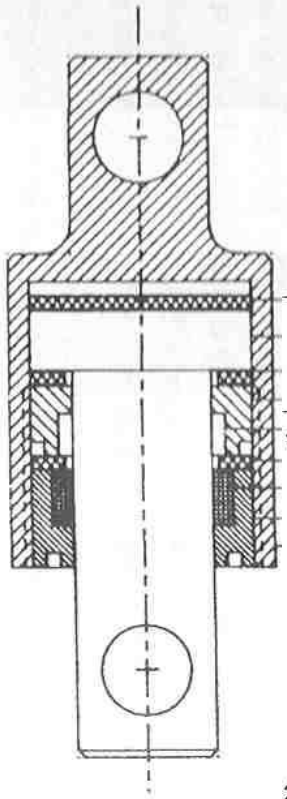
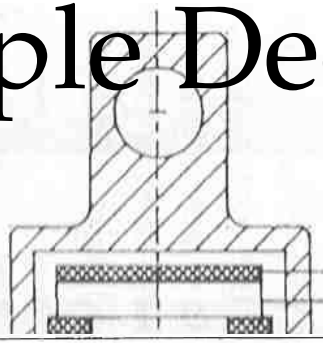
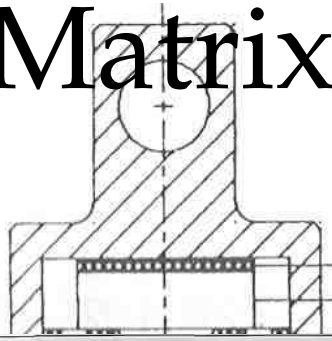
Example Decision Matrix



Design 1





	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 = $W \times S$

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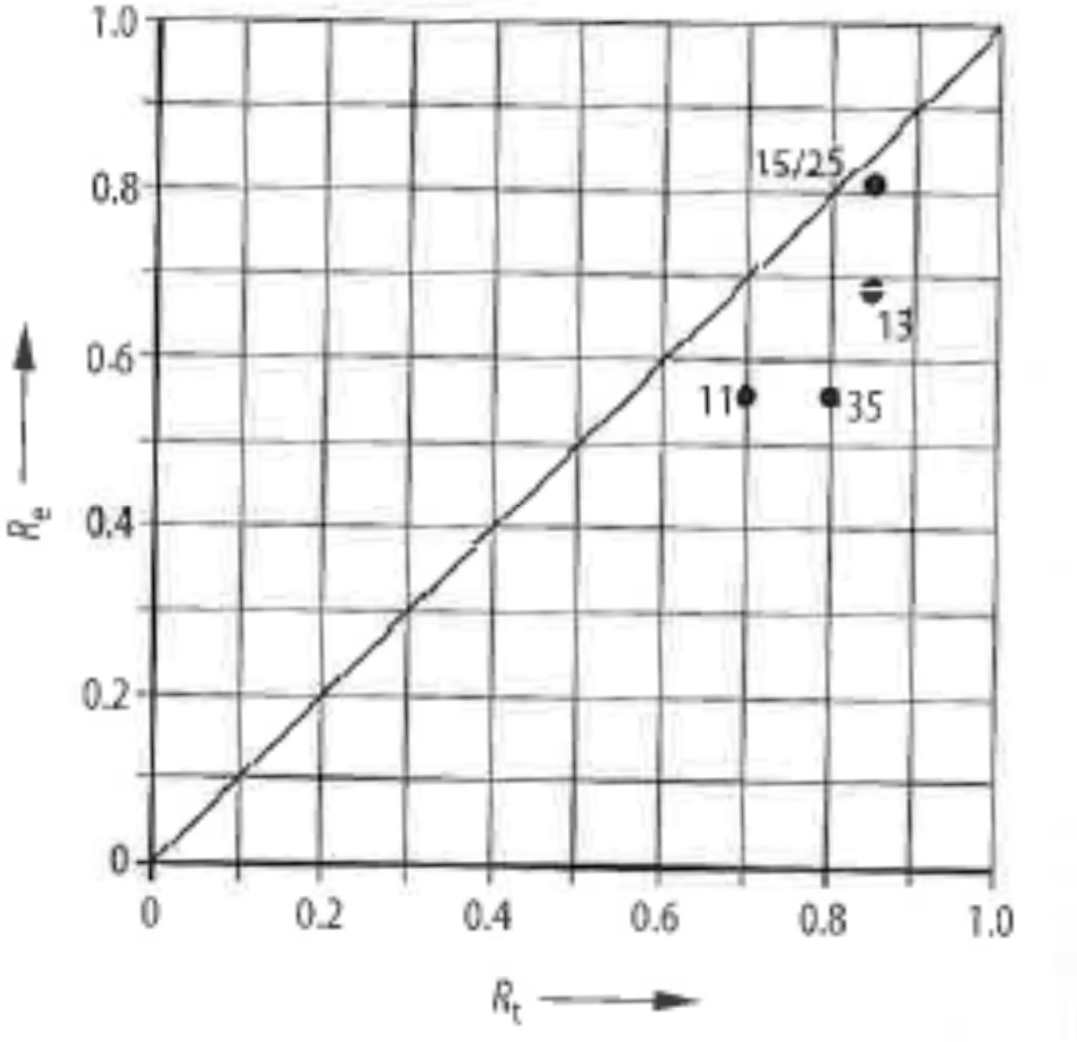
Technical-Economy diagram

Variants / Technical criteria	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

Variants / Economic criteria
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) T



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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

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Content for 2nd Project Review

- Updated Objectives, Functional model, QFD, Requirements list
- Morphological chat
- At least three concept variants
- Evaluation of concepts (technical & economical)
- Decision matrix
- Technical-Economy Diagram
- Evaluation of the proposed concept