Concept Generation, Selection & Test

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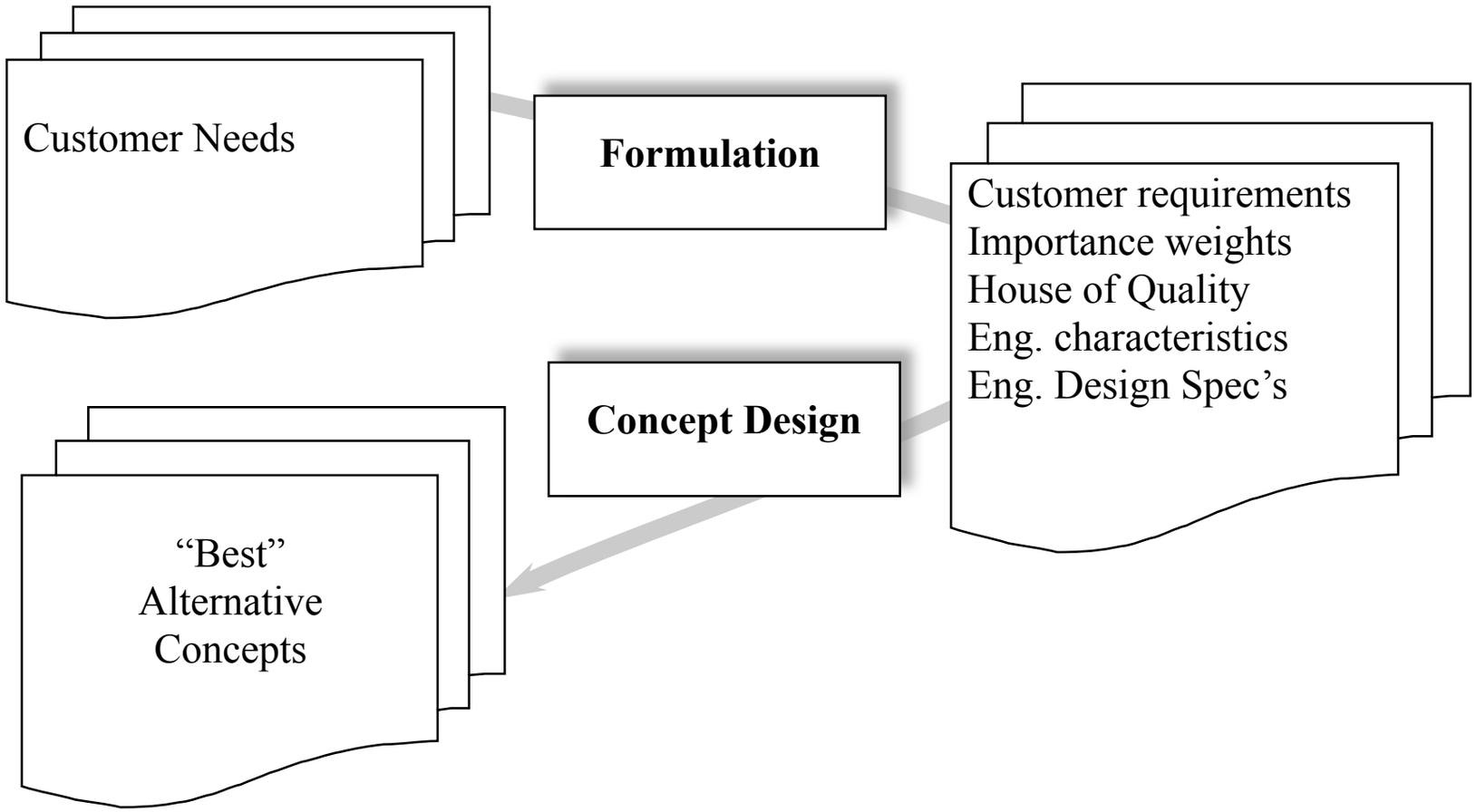
basics

- ‘concept’ = idea that satisfies some or all of the design requirements
- ‘design concept’ = abstract embodiment of: physical principle, material and geometry
- fragmented or complete, abstract or detailed
- concept generation is easy & cheap
- do early & often
- have a process, know when to stop but don’t ever stop

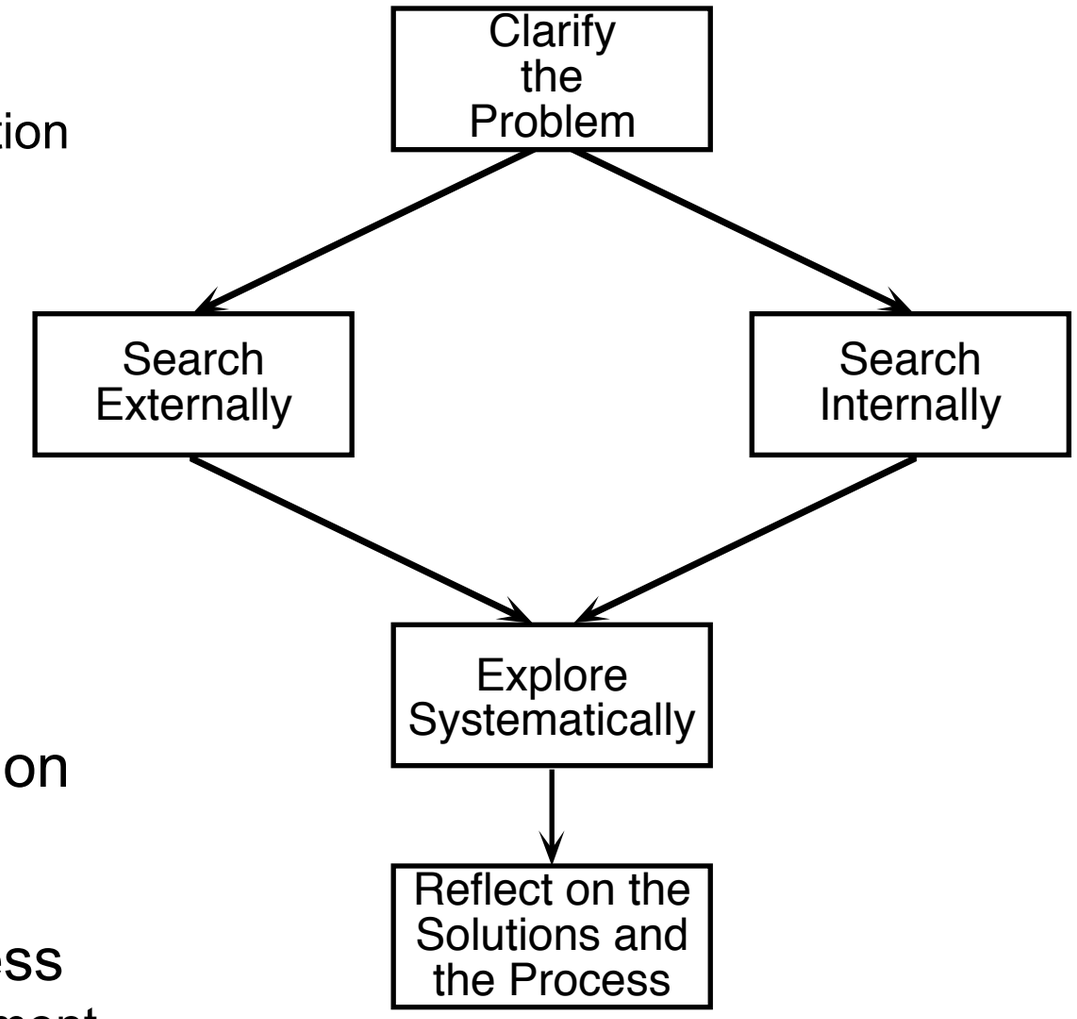
more basics

- LOTS of ideas...100's
- first idea is rarely the best
- goal: final ALL the ideas
- it's more than brainstorming
- internal & external search
- need some idea of the design requirements 1st
- divide (by function) & conquer in pieces
- document, document, document


Customer Needs
Formulation
Customer requirements
Importance weights
House of Quality
Eng. characteristics
Eng. Design Spec's
Concept Design
"Best"
Alternative
Concepts

Concept Generation Process

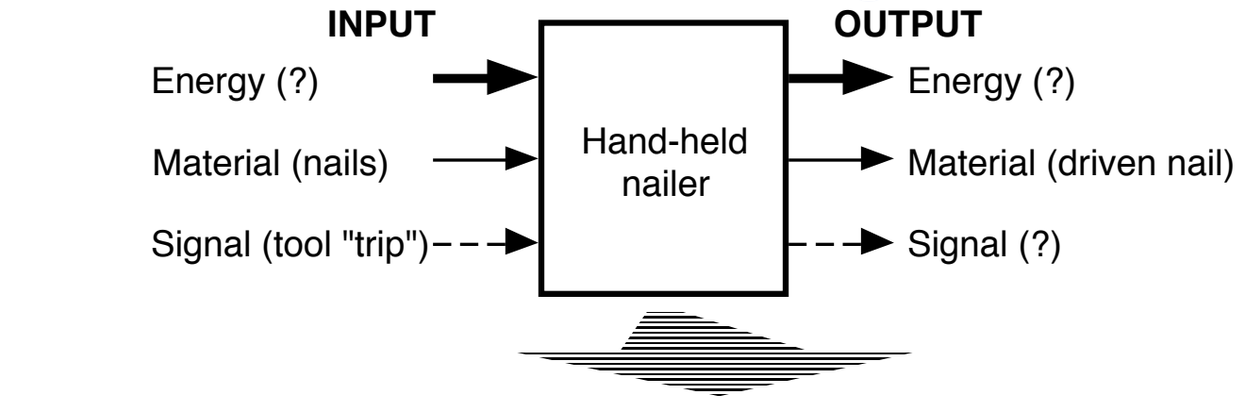
- Clarify the Problem
  - Problem Decomposition
- External Search
  - Lead Users
  - Experts
  - Patents
  - Literature
  - Benchmarking
- Internal Search
  - Individual Methods
  - Group Methods
- Systematic Exploration
  - Classification Tree
  - Combination Table
- Reflect on the Process
  - Continuous Improvement

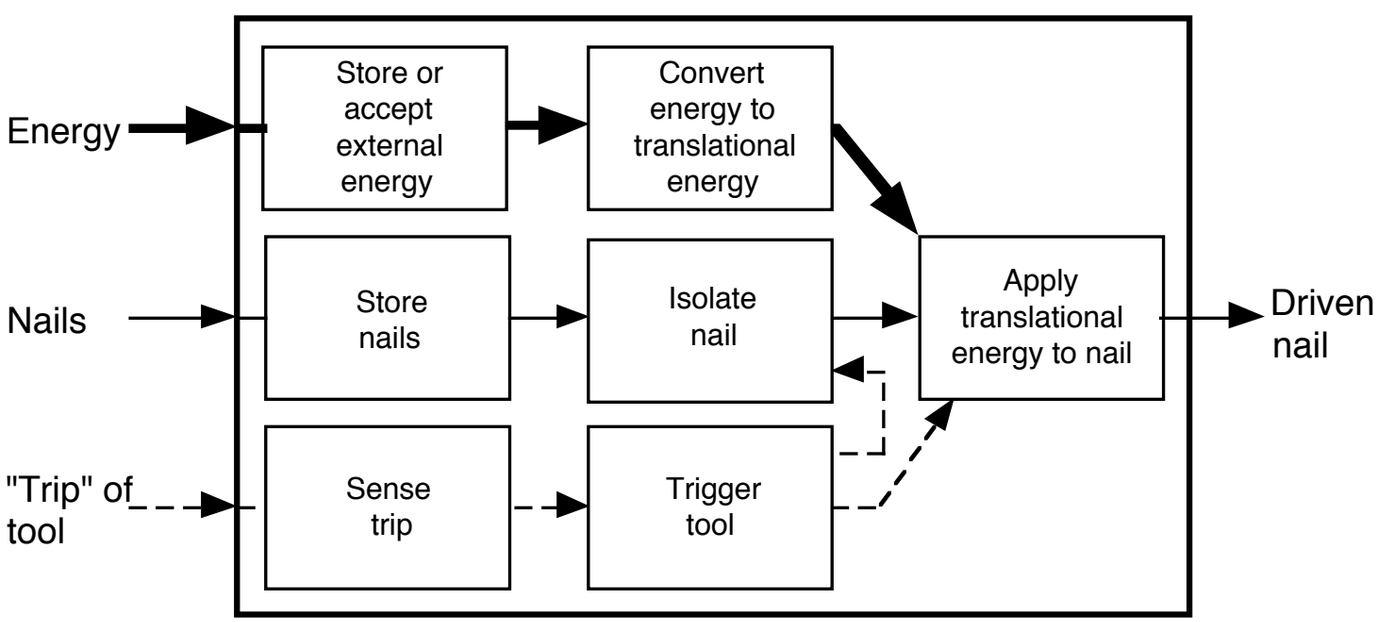


note: document the process using index cards (thumbnail sketch, trigger words) & your design notebooks.

Concept Generation Example:
Power Nailer

Problem Decomposition:
Function Diagram





External Search:
Hints for Finding Related Solutions

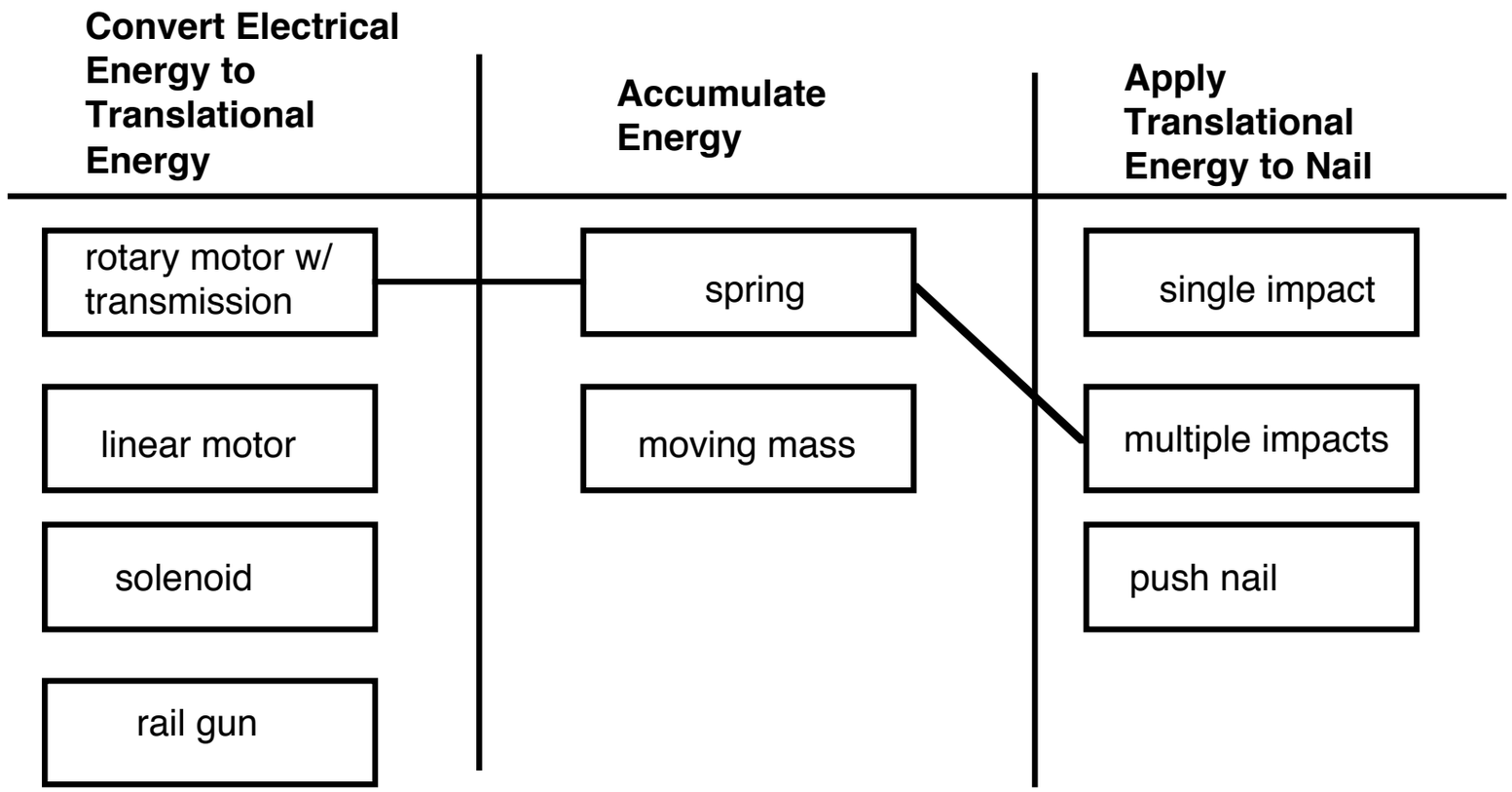
- Lead Users
  - benefit from improvement
  - innovation source
- Benchmarking
  - competitive products
- Experts
  - technical experts
  - experienced customers
- Patents
  - search related inventions
- Literature
  - technical journals
  - trade literature

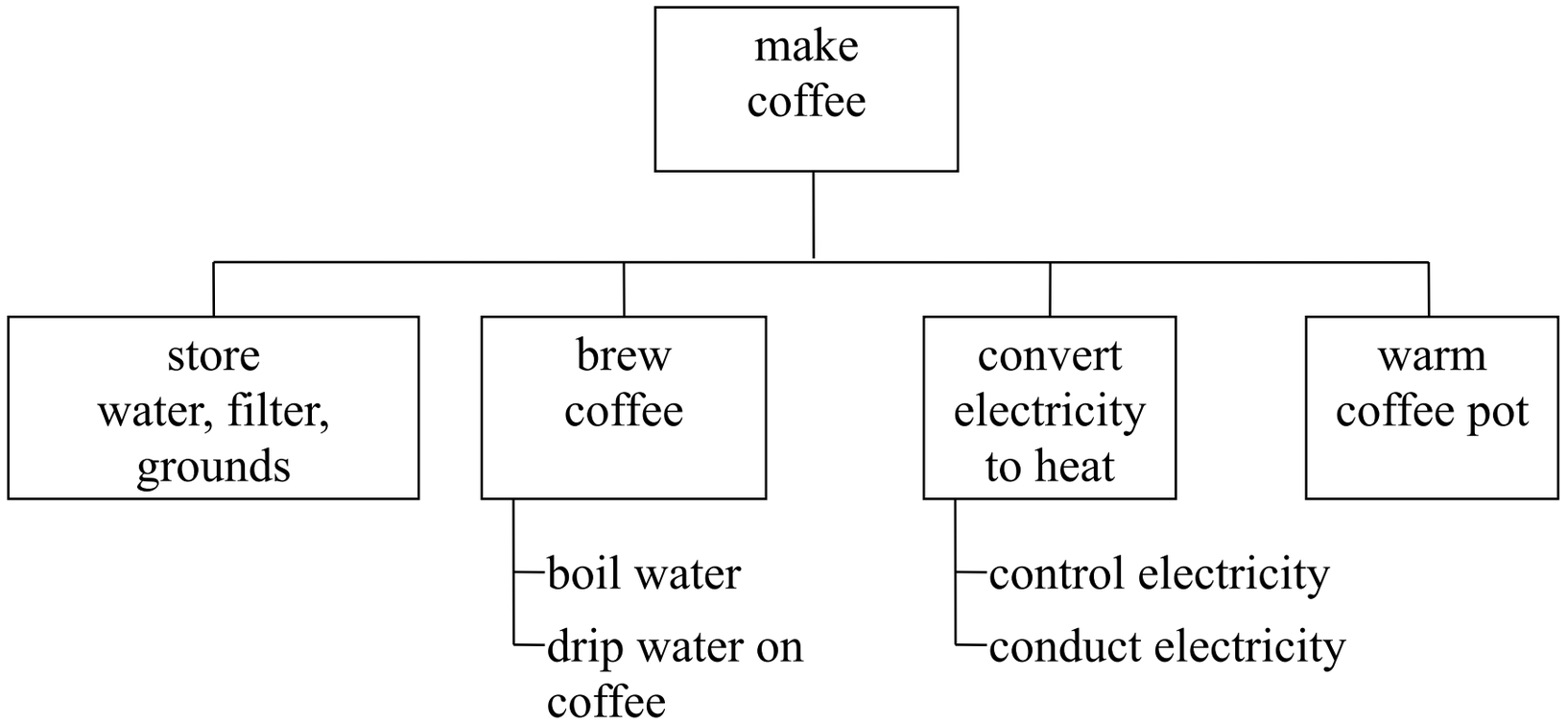
note: reverse engineer existing products (direct and indirect competitors; consult vendors

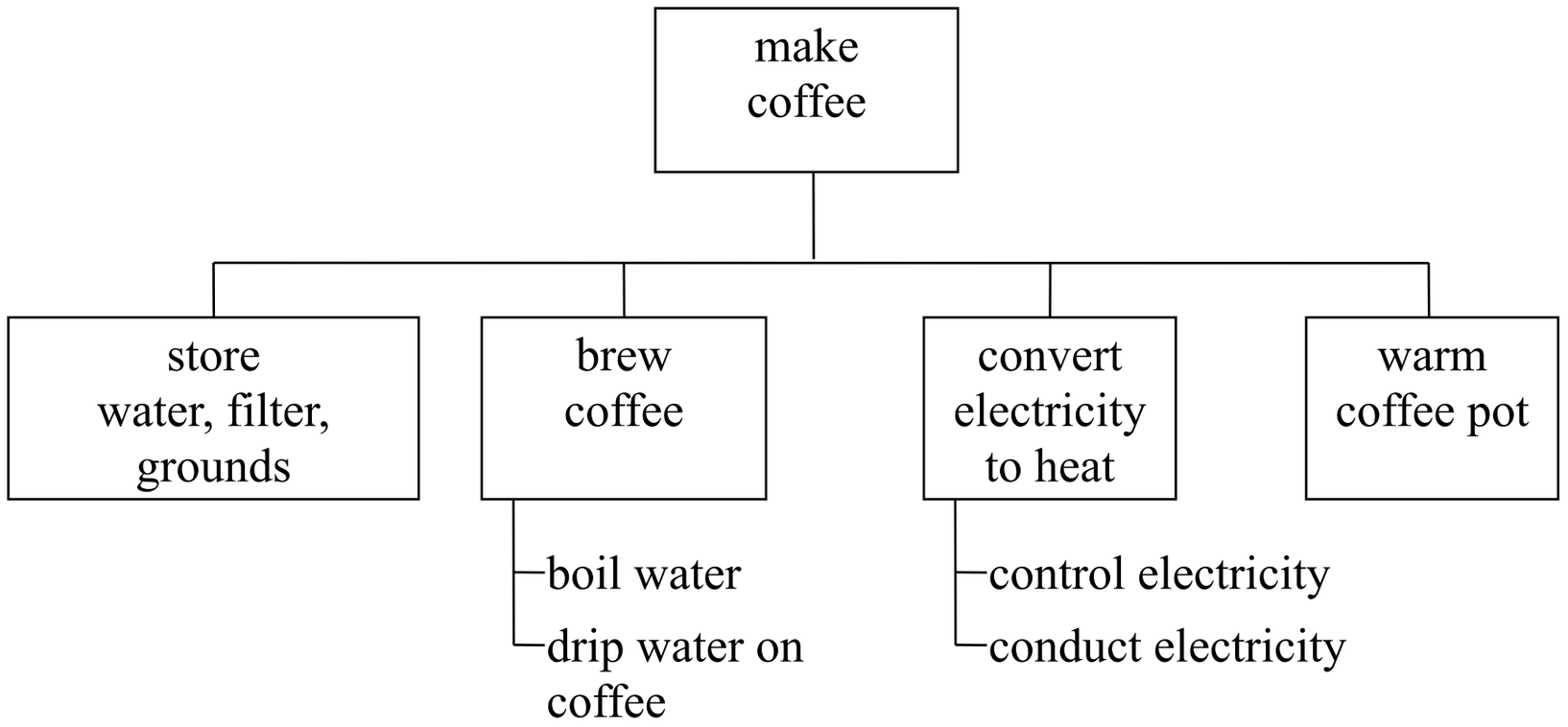
Internal Search:
Hints for Generating Many Concepts

- Suspend judgment
- Generate a lot of ideas
- Infeasible ideas are welcome
- Use graphical and physical media
- Make analogies
- Wish and wonder
- Solve the conflict
- Use related stimuli
- Use unrelated stimuli
- Set quantitative goals
- Use the gallery method
- Trade ideas in a group

Systematic Exploration:
Concept Combination Table




make coffee
store water, filter, grounds
brew coffee
boil water
drip water on coffee
convert electricity to heat
control electricity
conduct electricity
warm coffee pot

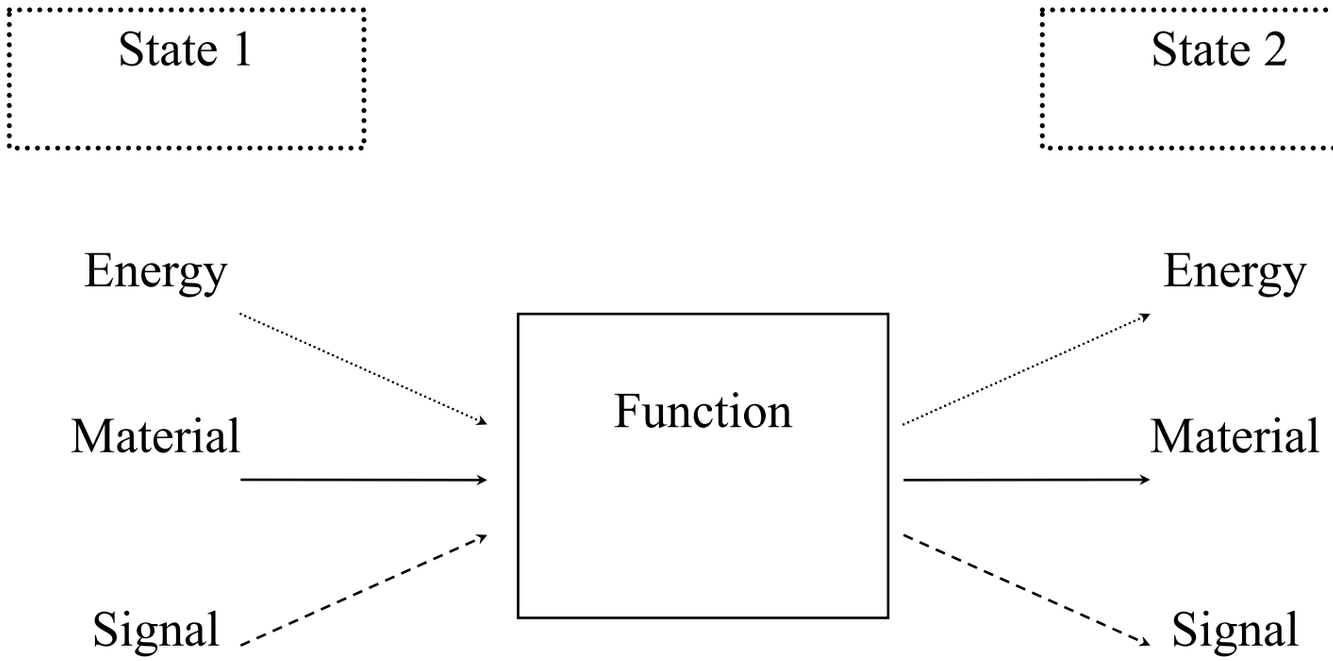


Remove? Combine? Reorganize?

Some functions that products/parts perform

amplify	dissipate	protect
change	fasten	release
channel	heat	rotate
collect	hold	separate
conduct	increase	store
control	join	supply
convert	lift	support
cool	lower	transform
decrease	move	translate

Function structure diagrams show all inputs and outputs



Review:

Concept Generation Process

- Clarify the Problem
  - Problem Decomposition
- External Search
  - Lead Users
  - Experts
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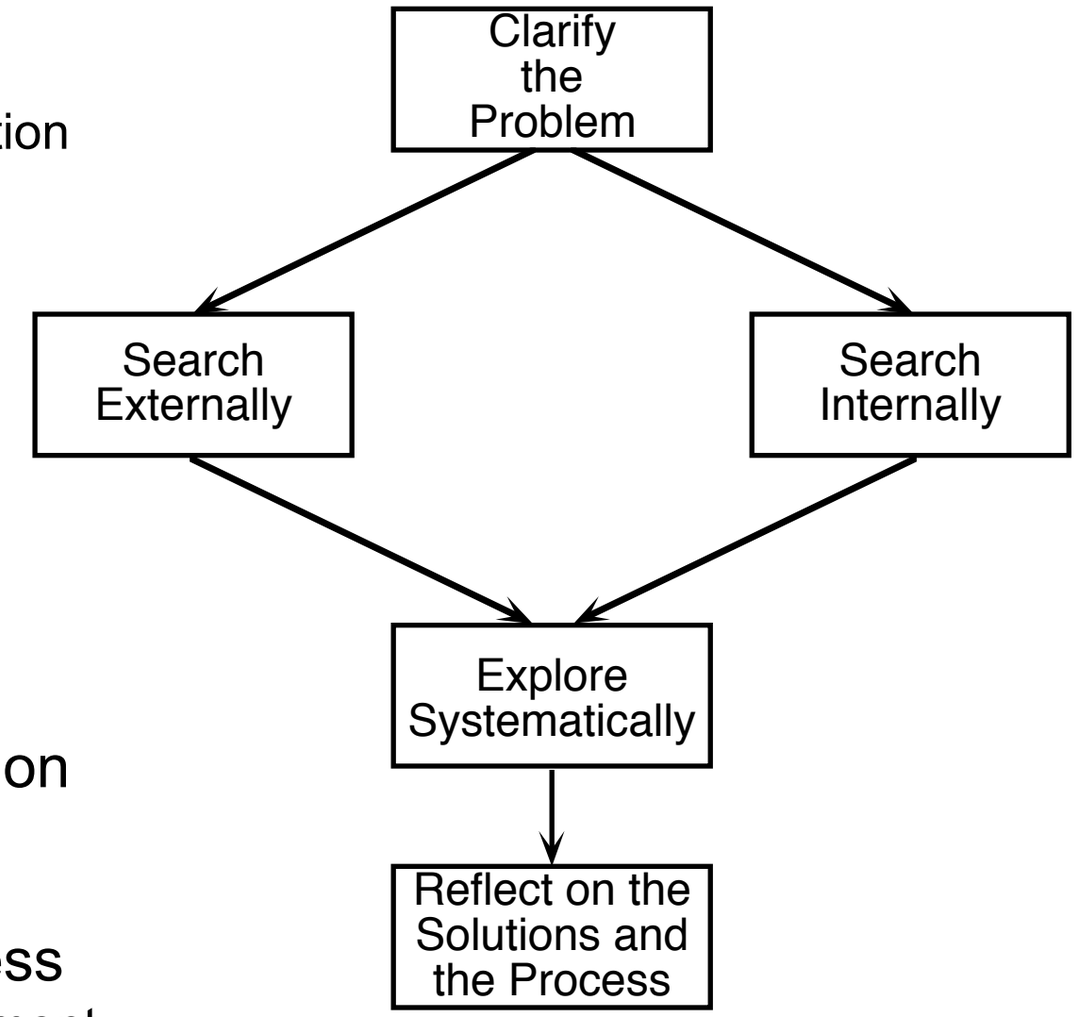


- Functional decomposition
  - Complex problems must be broken down into simpler constituent subproblems. This strategy is also useful for simple problems. The function diagram is useful for documenting this step. Note that function diagrams are not unique; several decompositions may be found for a given problem.
- explore solutions for the subproblems
  - It is generally helpful to consider solutions to the subproblems in addition to (or instead of) the entire problem at once. This strategy allows solutions from various sources & related problems domains to be incorporated.
- explore externally
  - It is essential to search for solutions from sources outside the team, such as lead users, experts, patents, literature, & competitive products (reverse engineer?).
- internal concept generation
  - Brainstorming. Some tips for idea generation include analogies, wish & wonder, related stimuli, unrelated stimuli, goals, gallery method
  -

- balance individual & group search
  - It has been shown that individuals generate ideas more quickly than groups do, it is recommended that teams devote some time to generating solutions individually. However the group interaction is critical for refinement, combination, & critique of the solution fragments. Group sessions should therefore be a major part of the concept generation activity for improvement of the concepts and for building team consensus that the solution space has been adequately explored.
- Quantity breeds quality
  - The team's best ideas are not likely to be found within the first few solutions considered. Rather, the best ideas are probably distributed uniformly over time. The selected concept is just as likely to be found among the 2nd 20 solution concepts as within the 1st 20.
- overlapping and iteration
  - While the concept development process shown earlier appears purely sequential, in fact there are usually parts of the concept generation process beginning during customer needs analysis. Consequently, the customer needs list may perhaps require modification on the basis of new capabilities considered during concept generation. Also, the concept selection process may involve substantial refinement of the concepts, thus repeating some portion of concept generation.

- Systematic Exploration
  - This step is particularly valuable when the problem has been successfully decomposed into subproblems. However, for some simple or highly integrated products, the team may find it more useful to consider entire concepts from the start, rather than combining solution fragments.
- Reflection
  - Teams should reflect on the process & improve on it. continuous improvement is an essential part of the product development process.

brainstorming (1)

- generate lots of ideas
- wild ideas ok
- without judgement

brainstorming (1)

- assign facilitator
- define topic
- agree on stop time
- agree on recording method (index cards)
- build on ideas of others
- no stopping to evaluate
- interruptions are ok

brainstorming (1) -resist the urge to….

- “Oh that will never work..”
- “that’s way too expensive...”
- “gee, where are we going to get an anti-gravity machine...”
- “The sponsor will think that’s ridiculous..”
- “That will never be light enough...”
- “That’s not going to be the idea we end up with”

brainstorming (1) - paradigm shifts

- analogous tasks
- change the scale
- combine ideas
- relax one spec.
- imagine new technologies
- invert

brainstorming (1) - what do you do with these ideas?

- catalog
- sort..affinity grouping (cluster)
- combine
- post on the wall
- preserve
- revisit

brainstorming (1) - mistakes your teams WON'T make!

- all ideas generated before requirements set
- judgement mixed into generation process
- too few
- going with 1st idea
- equating brainstorming with concept generation... brainstorming products solution concepts

brainstorming (2) -gallery method

- display large # of concepts simultaneously for discussion
- sketches, usually 1 concept to a sheet are taped on walls
- team members circulate & evaluate all concepts
- creator may offer explanation

concept development - some references

- Jacob Goldenberg and David Mazursky, Creativity in Product Innovation, Cambridge University Press, Cambridge, 2002
- Hanks, Kurt & Larry Belliston, Rapid Viz, Crisp Publications, Menlo PArk, CA, 1992 [excellent guide to basic sketching & drawing]

Brainstorming - organization

- select a diverse group 4-10 people representing all aspects of the topic to be brainstormed
- select a facilitator
- choose an appropriate location where participants will not be distracted or disturbed
- select a recorder to write down ideas as they are presented. Use a large board or overhead where everyone can see them

Brainstorming - divergent thinking

- ask each participant for ideas. listen to everyone. individuals may pass if they have nothing more to contribute.
- do not allow judgements or critical discussion to take place during the initial idea generating phase
- strive for quantity
- let participants build spontaneously on the ideas of others

Brainstorming - convergent phase

- when all the ideas are generated, go back and review and discuss the ideas based on similarity and importance
- narrow in on the most important ideas and formulate a group consensus on a short list of ideas

Brainstorming - method 6-3-5

- Rohrbach (1969)
- a group of **6** members gather
- each member writes down **3** ideas on a sheet of paper
- each sheet of paper is circulated to a neighbour
- after reading the ideas, the neighbour writes down **3** more ideas
- the sheets of paper are circulated **5** times

Brainstorming - synectics

- view problem from 4 perspectives (Gordon, 1961)
  - analogy - (e.g., tree is an analogy to a structure)
  - fantasy - imagine impossible (eg., anti-gravity)
  - empathy - imagine being the product
  - inversion - take reverse point of view (e.g., inside vs. outside)

Brainstorming - checklists stimulate creativity

- Osborn (1957) 9 starter questions
  1. substitute
  2. combine
  3. adapt
  4. magnify
  5. modify
  6. pat to other uses
  7. eliminate
  8. rearrange
  9. reverse

Conceptual Blockbusting

- http://www.amazon.com/Conceptual-Blockbusting-Guide-Better-Ideas/dp/0201550865
- Conceptual blockbusting: a guide to better ideas, James Adams

Conceptual Blockbusting

- Conceptualization is the process by which one has ideas in design and open-ended problem solving
- Conceptual blocks are mental walls that block the problem solver from correctly perceiving a problem or conceiving its solution
- Everybody can be creative
- Everybody has some conceptual blocks limiting creativity

Conceptual blocks

- Conceptual blocks are a kind of mental inflexibility
- Seeing what you expect to see; stereotyping
- Difficulty isolating the problem
- Tendency to delimit the problem too closely
- Inability to see the problem from various viewpoints
- Saturation
- Failure to utilize sensory inputs (graphical and physical media)

Perceptual blocks & stereotyping

- **Perceptual blocks** are obstacles that prevent the problem-solver from clearly perceiving either the problem itself or the information needed to solve the problem
  - Seeing what you expect to see; stereotyped seeing; premature labeling
  - Inability to view problem from various viewpoints
  - Saturation
  - Difficulty in isolating the problem
  - Tendency to delimit the problem area too closely

- **Perceptual stereotyping** is part of the explanation for the success of various types of optical trickery. It is not all bad, as it allows people to complete incomplete data. However, it can be a handicap in perceiving new combinations.

Emotional blocks

- Fear to make a mistake, to fail, to risk
- Excessive zeal; over motivation to succeed quickly; can only see one direction to go (ours)
- Inability to tolerate ambiguity; overriding desire for security, order, no appetite for chaos
- Difficulty in isolating the problem
- Cannot relax, incubate, "sleep on it."

Cultural blocks

- Cultural blocks are acquired by exposure to a set of cultural patterns. Sometimes they get codified into law, and are not challenged as society changes.
  - Taboos
  - Fantasy and reflection are waste of time, lazy, even crazy
  - Playfulness is for children only
  - Reason, logic, number, utility, practicality are good; feeling, intuition, qualitative judgments, pleasure are bad.

Environmental and Organizational blocks

- Distractions -- phone, easy intrusions
- Lack of support to bring ideas into action
- Lack of cooperation and trust among colleagues -- insecurity in job
- Autocratic boss who only values his own ideas; does not reward others
- Inhibiting organizational management styles

Intellectual and Expressive blocks

- Lack of information; incorrect information
- Inflexible or inadequate use of intellectual problem-solving strategies
- Formulating problem in incorrect language (e.g., verbal, math, visual)
- Inadequate language skill to express ideas

ThinkerToys -creativity methods

- ThinkerToys by Michael Michalko
- http://search.barnesandnoble.com/booksearch/isbninquiry.asp?ean=9781580087735&z=y
- SCAMPER method of transforming any object, service, or process into something new
- **Substitute, Combine, Adapt, Modify or magnify, Put to other uses, Eliminate or minify, Reverse or rearrange**

Substitute

- What can be substituted? Who else? What else?
- Can the rules be changed?
- Other ingredient? Other material?
- Other process or procedure?
- Other power?
- Other place?
- Other approach?
- What else instead?

Combine

- Can we combine purposes?
- How about an assortment?
- How about a blend? An alloy?
- Combine units?
- What other article could be merged with this?
- Combine appeals?

Adapt

- What else is like this?
- What other idea does this suggest?
- Does the past offer a parallel?
- What could I copy?
- Whom could I emulate?
- What idea could I incorporate?
- What other process could be adapted?

Magnify?

- What can be magnified, made larger, or extended?
- What can be exaggerated? Overstated?
- What can be added? More time? Stronger? Higher?
- How about greater frequency? Extra features?
- What can add extra value?
- What can be duplicated?
- How could I carry it to a dramatic extreme?

Modify?

- How can this be altered for the better?
- What can be modified?
- Is there a new twist?
- Change meaning, color, motion, sound, odor, form, shape?
- Change name?
- What changes can be made in the plans? In the process? In the marketing?

Put to other uses?

- What else can this be used for?
- Are there new ways to use as is?
- Other uses if modified?
- What else could be made form this?
- Other extensions? Other markets?

Eliminate or minify?

- What if this were smaller?
- What should I omit?
- Should I divide it? Split it up? Separate it into different parts?
- Understate?
- Streamline? Make miniature? Condense? Compact?
- Subtract? Delete?
- Can the rules be eliminated?
- What's not necessary?

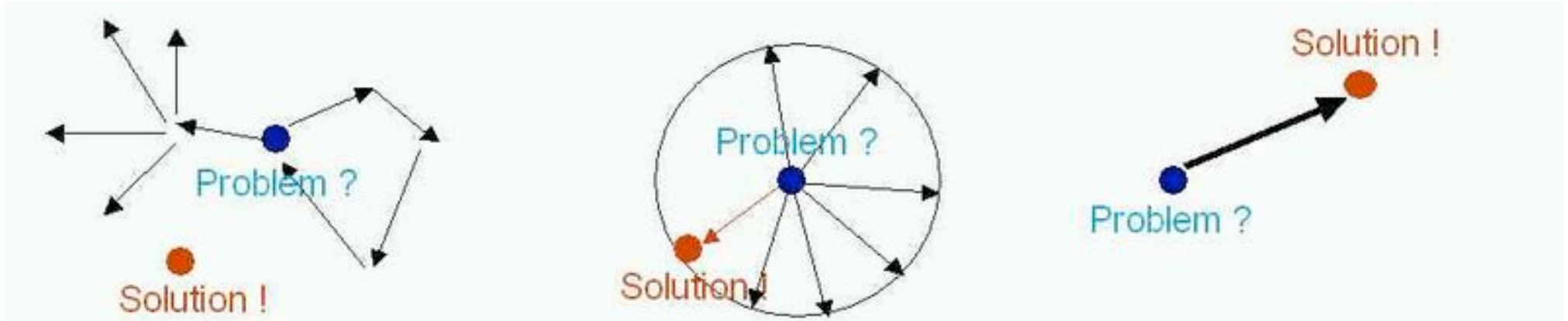
rearrange

- What other arrangements might be better?
- Interchange components?
- Other pattern? Other layout?
- Other sequence? Change the order?
- Transpose cause and effect?
- Change pace or schedule?

reverse

- Can I transpose positive and negative?
- What are the opposites?
- What are the negatives?
- Should I turn it around? Up instead of down?
- Consider it backwards?
- Reverse roles?
- Do the unexpected?

Check out TRIZ - theory of inventive problem solving



Chaos: “Let’s just try!” “Let’s try everything!” “Let’s go forward!”

Brainstorming, Synectics, etc. **Morfological analysis, Osborn questionary, etc.** **TRIZ, ARIZ**

Concept Selection

feasible concept designs

best alternative concept design

Concept Selection

feasible concept designs

best alternative concept design

However: e-“valu”-ate = values? whose?

Pugh's evaluation method

Pugh's evaluation method

1. Select criteria,
2. Establish datum column,
3. Rate alternatives (+, -, S) against datum
4. Select best, or better alternatives

	Concept Alternatives		
Criteria	Gears	V-belts	Chain
high efficiency	+	D	+
high reliability	+	A	+
low maintenance	+	T	S
low cost	-	U	-
light weight	-	M	-
Σ +	3	NA	2
Σ -	2	NA	2
Σ S	0	NA	1

modified Pugh's method

Add new column

		Concept Alternatives		
Criteria	Importance Wt. (%)	Gears	V-belts	Chain
high efficiency	30	+	D	+
high reliability	25	+	A	+
low maintenance	20	+	T	S
low cost	15	-	U	-
light weight	10	-	M	-
	100			
Σ_+		75	NA	55
Σ_-		25	NA	25
Σ_S		0	NA	20

weighted rating method

		Concept Alternatives					
		gears		v-belts		chain	
Criteria	Importance Weight (%)	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
high efficiency	30	4	1.20	2	0.60	3	0.90
high reliability	25	4	1.00	3	0.75	3	0.75
low maintenance	20	4	0.80	3	0.60	2	0.40
low cost	15	2	0.30	4	0.60	3	0.45
light weight	10	2	0.20	4	0.40	3	0.30
	100	NA	3.50	NA	2.95	NA	2.80

Rating	Value
Unsatisfactory	0
Just tolerable	e 1
Adequate	2
Good	3
Very Good	4

weighted rating method

		Concept Alternatives					
		gears		v-belts		chain	
Criteria	Importance Weight (%)	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
high efficiency	30	4	1.20	2	0.60	3	0.90
high reliability	25	4	1.00	3	0.75	3	0.75
low maintenance	20	4	0.80	3	0.60	2	0.40
low cost	15	2	0.30	4	0.60	3	0.45
light weight	10	2	0.20	4	0.40	3	0.30
	100	NA	3.50	NA	2.95	NA	2.80

Rating	Value
Unsatisfactory	0
Just tolerable	e 1
Adequate	2
Good	3
Very Good	4