Session 5 and 6

Theory of Inventive Problem Solving

Lecture delivered by
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- Session Objectives
  - At the end of the session the delegates will be able to understand the principles and approach of TRIZ

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Session Topics

1. TRIZ –Theory of Inventive Problem Solving
2. TRIZ – Degree of Inventiveness
3. TRIZ – Invention and Risk
4. TRIZ – Philosophy
5. TRIZ – 40 Inventive Principles

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TRIZ –Theory of Inventive Problem Solving

- Developed by Genrich Altshuller-1946

  Patent Investigator for the Russian Navy

  TRIZ (Teoriya Resheniya Izobreatatelskikh Zadatch)

- Patents provided solutions to contradictions and the solutions often represented one point along repeatable lines of evolution

- **Elements of TRIZ :**

1. Regularities in design evolution
2. The concept of Ideality
3. 40 principles used in most innovative patents.

- **Degree of Inventiveness:**

An Inventive problem is the one that contains at least one contradiction. Contradiction is a situation where an attempt to improve one feature of the system detracts another feature

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TRIZ – Degree of Inventiveness :

- **Level 1** …… Apparent (no invention) ……. 32%

Employs obvious solutions drawn from only a few clear options.Established solutions, well known and readily accessible Patents provided solutions to contradictions and the solutions often represented one point along repeatable lines of evolution

- **Level 2** …….. Improvement. ……. 45%

Small improvement of an existing system by reducing a contradiction inherent in the system, usually with some compromise.(45%). Example : Adding new features - use of adjustable steering column to increase the range of body types.

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TRIZ – Degree of Inventiveness :

- **Level 3** …… Invention inside paradigm ……. 18%

Invention inside paradigm. Essential improvement of an existing system .Contradiction is resolved within existing system, often through the introduction of some entirely new element.

Example: Standard transmission in a car replaced by an automatic transmission .

Involves technology integral to other industries but not widely known within the industry in which the inventive problem arose. This causes a paradigm shift within that industry.

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TRIZ – Degree of Inventiveness :

- **Level 4** …… Invention Outside Paradigm,……. 4%

A concept for a new generation of an existing system based on changing the principle of performing the primary function.

Solutions are found ‘not in technology but in science’, through the utilization of previously little known physical effects and phenomena.

The solutions lie outside a technology’s normal paradigm.

The contradiction is eliminated because its existence is impossible within the new system.

Example : Use of materials with thermal memory.

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TRIZ – Degree of Inventiveness :

- **Level 5** …Solution exist outside the confines contemporary scientific knowledge…… 1%

Discovery : Pioneer invention of an essentially new system.

Example: Lasers, transistors. They create new systems and industries.

Once a level 5 discovery becomes known, subsequent applications or inventions occur at one of the four lower levels.

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TRIZ – Degree of Inventiveness :

- Inventions involving levels 1, 2, 3 are usually transferable from one discipline to another .
- This means that 95% of inventive problem in a particular area have already been solved in another area.

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TRIZ – **Invention and Risk**

- Risk :

" A task that is far ahead of its time is not easy to solve . And the more difficult task is to prove that a new system is possible and necessary"

- Altshuller

- Radar when introduced in world War 2 was first refused because as they became aware of twice many planes they thought that the radar must be attracting the planes.

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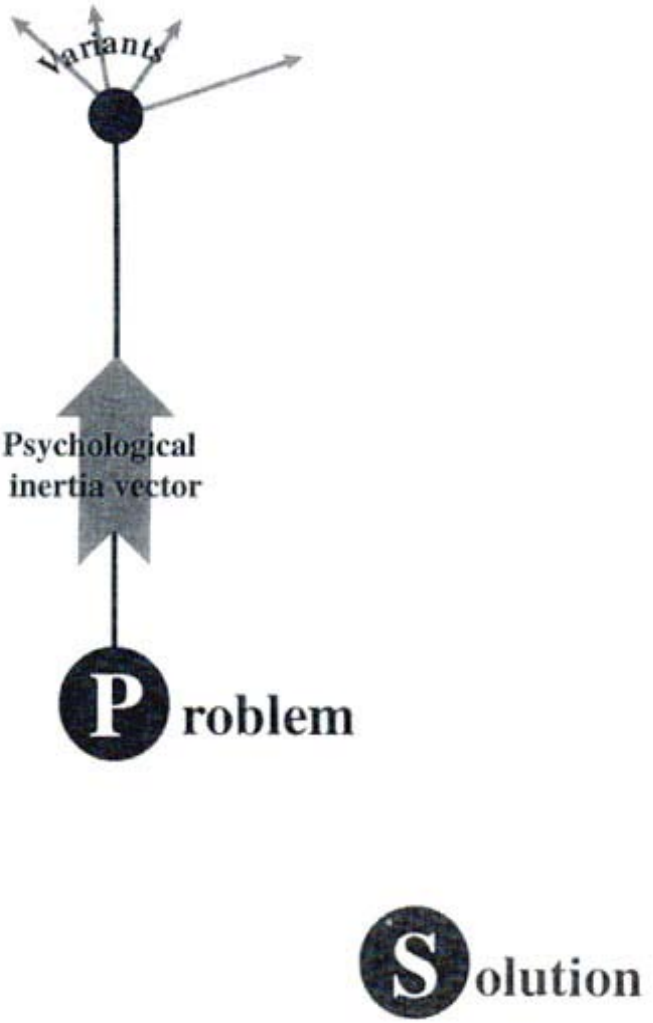
TRIZ – Paradigm Shift/Psychological Inertia

- If you look in the wrong place, innovative concepts will not be found.
- Processes that encourage creativity provide many branches radiating from one technological direction, but do not access solutions that exist in other technologies/fields.
- Creative potential of the inventor is increased when more knowledge becomes available.



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TRIZ – Philosophy

- Knowledge about inventions may be extracted, compiled and generalized to enable easy access by an inventor to any area.
- Information on 40 principles used to resolve contradictions between pairs of 48 parameters increase the knowledge available to a designer.

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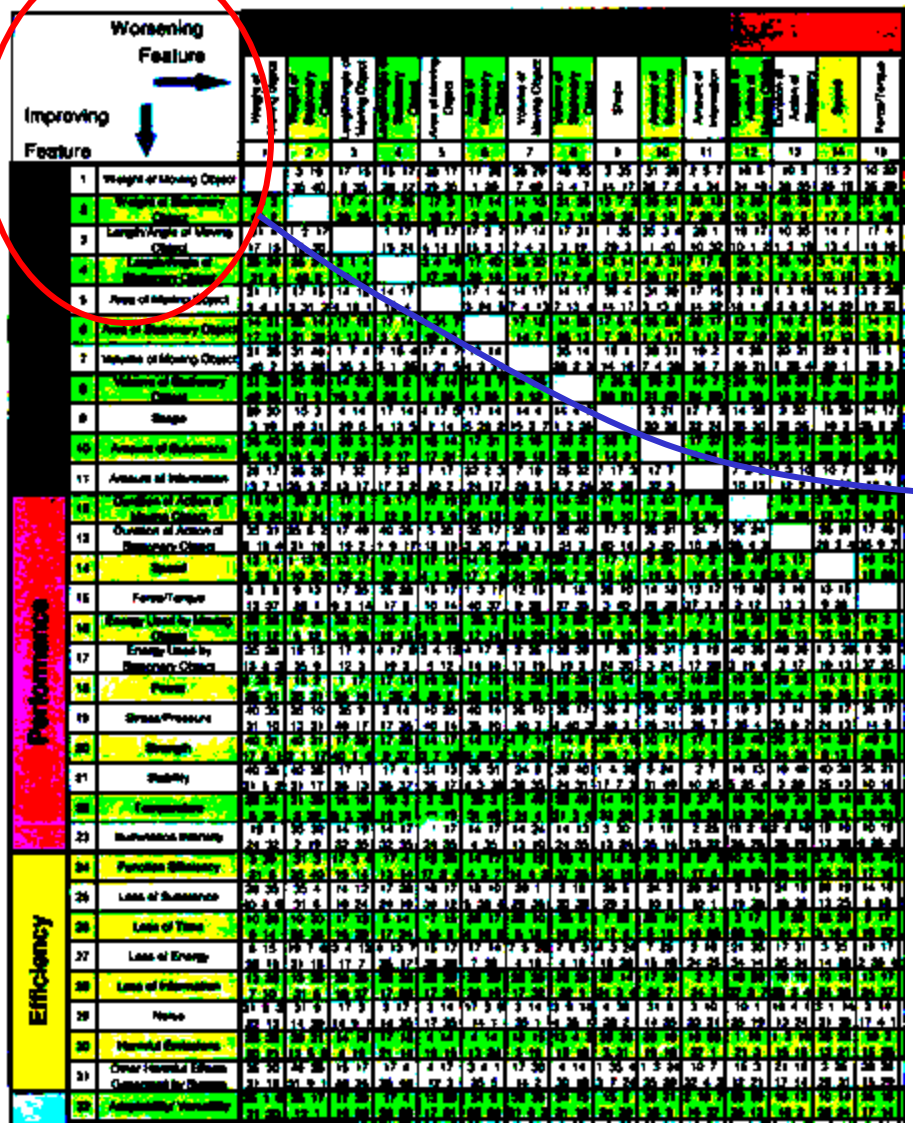
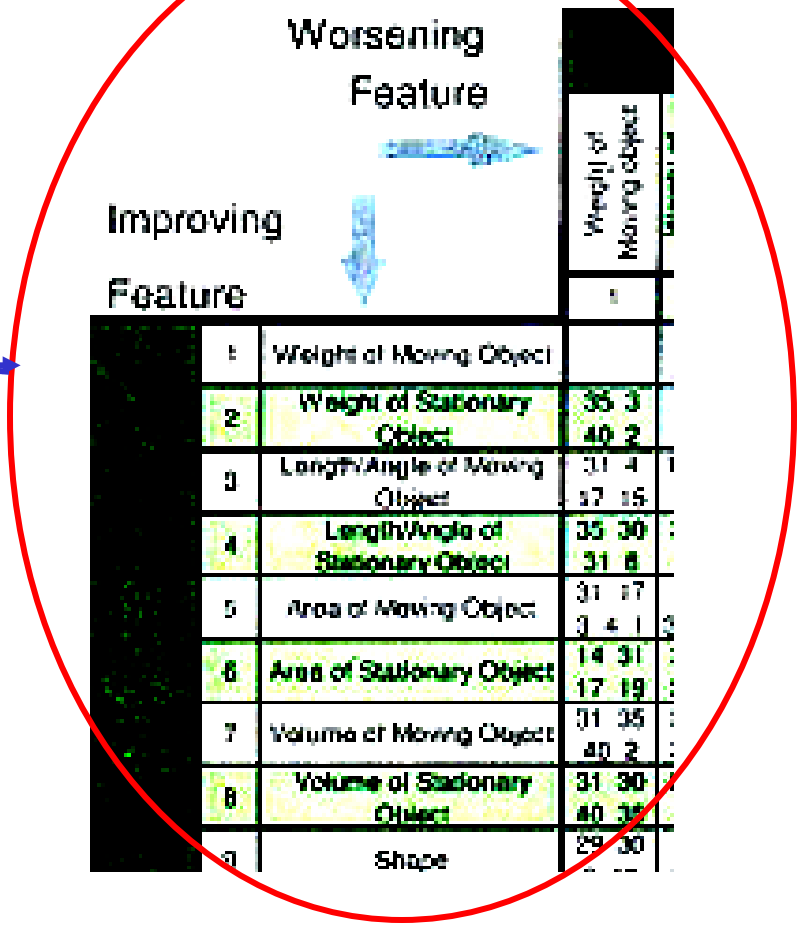
TRIZ – Philosophy





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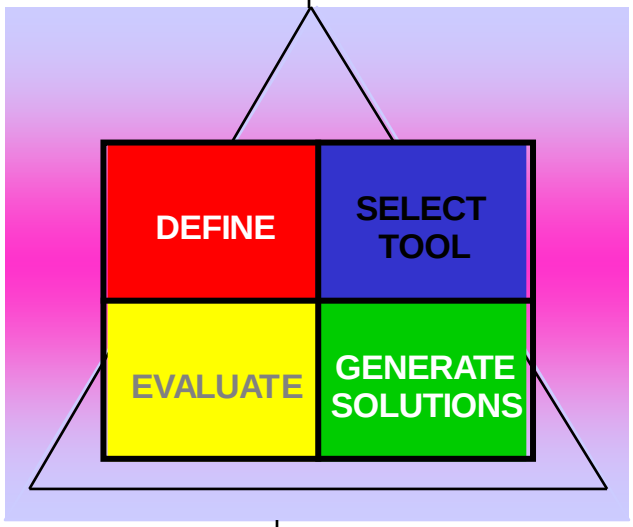
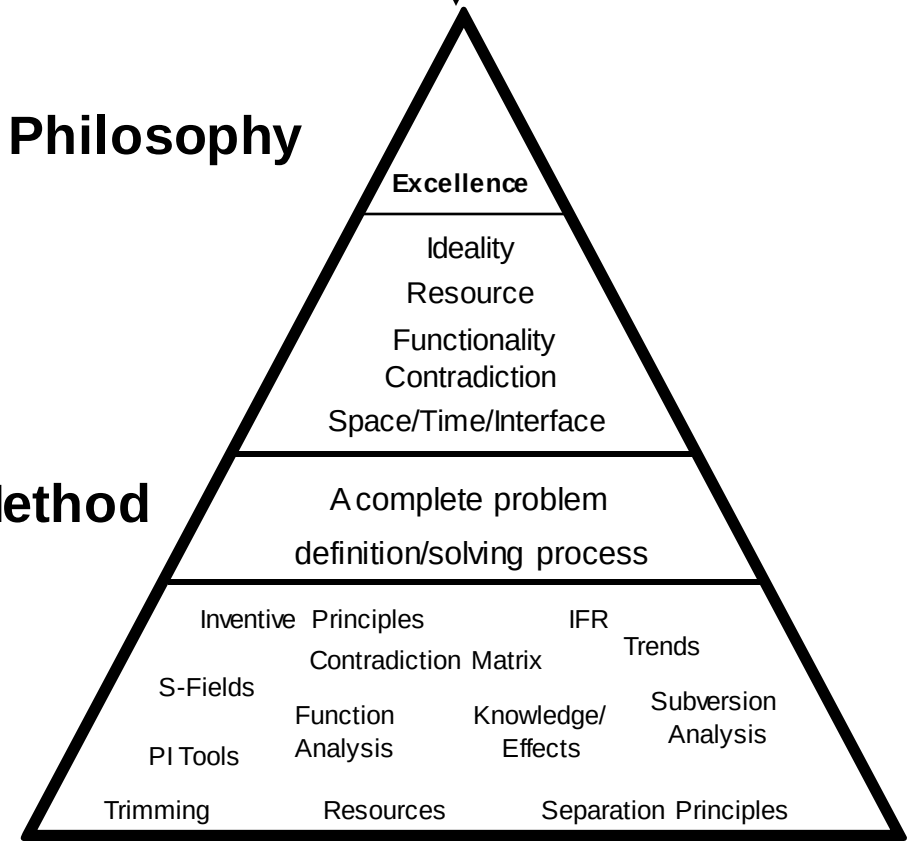
TRIZ – Pyramid





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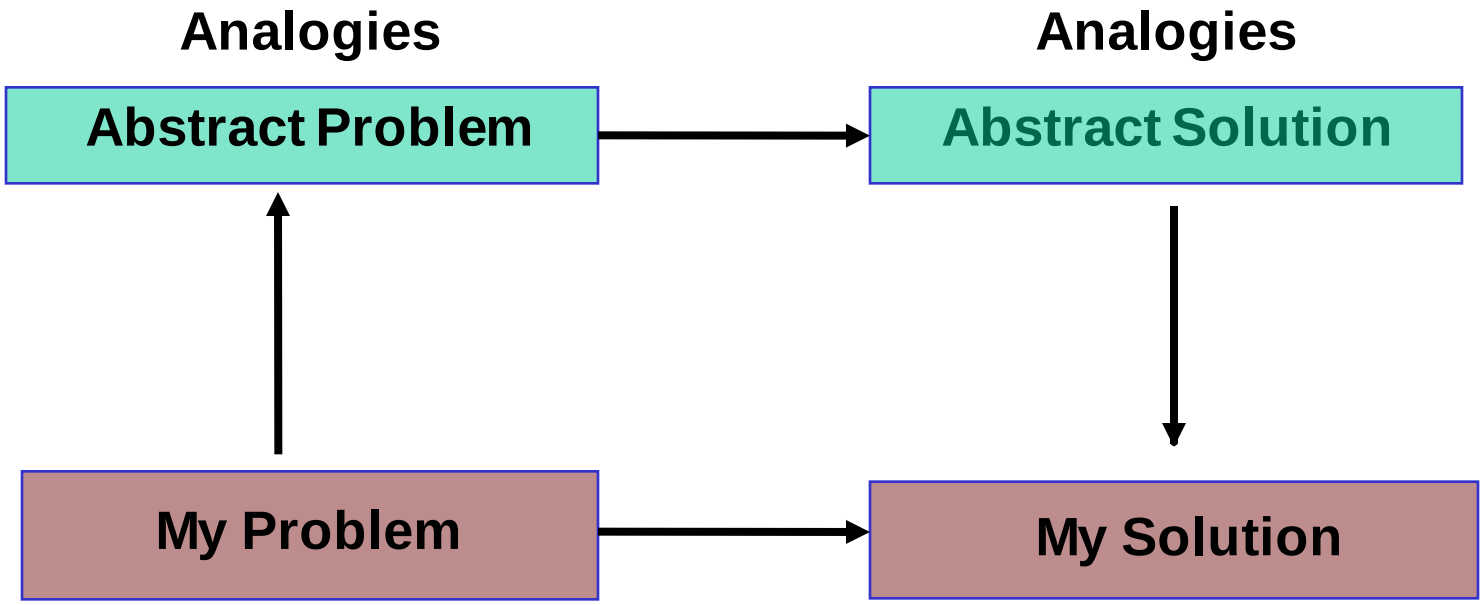
TRIZ – Analogous problems



- Knowledge about inventions may be extracted, compiled and generalized to enable easy access by an inventor to any area

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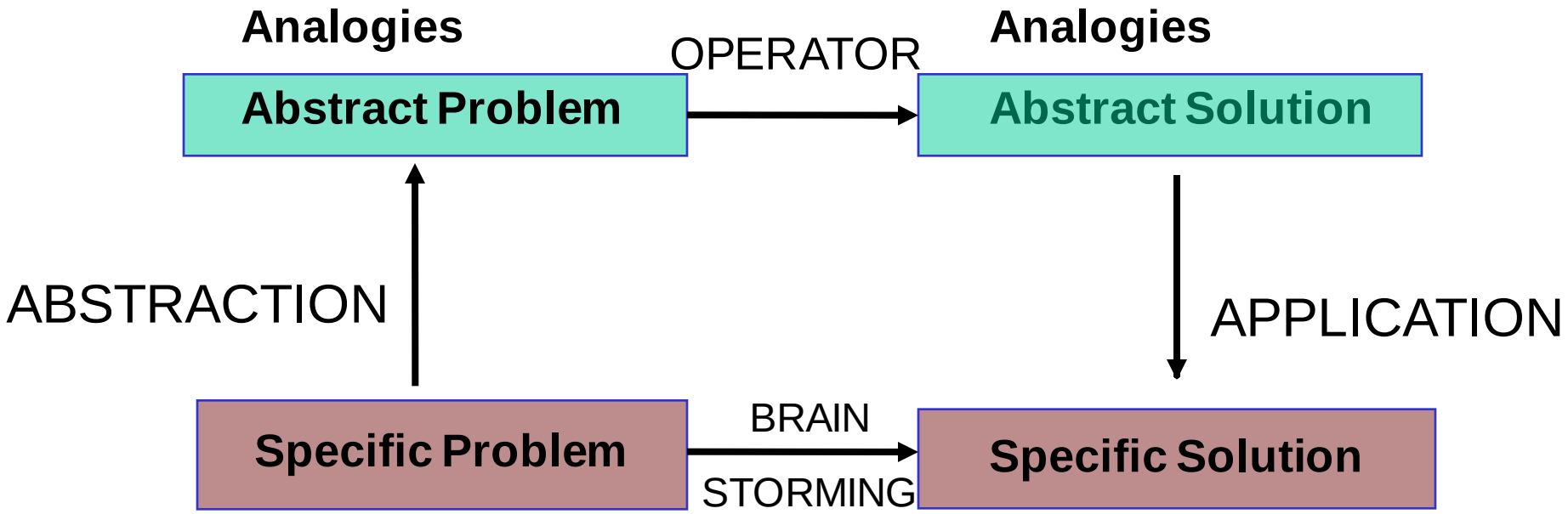
TRIZ – Analogous problems



- Knowledge about inventions may be extracted, compiled and generalized to enable easy access by an inventor to any area

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TRIZ – Analogous

- **Analogous problems examples :**

Separation of stalk and seeds from the

- Pod(sweet pepper).
- Shelling cedar nuts.
- Shelling Krill.
- Husking sunflower seeds.
- Producing sugar powder.
- Splitting imperfect crystals.

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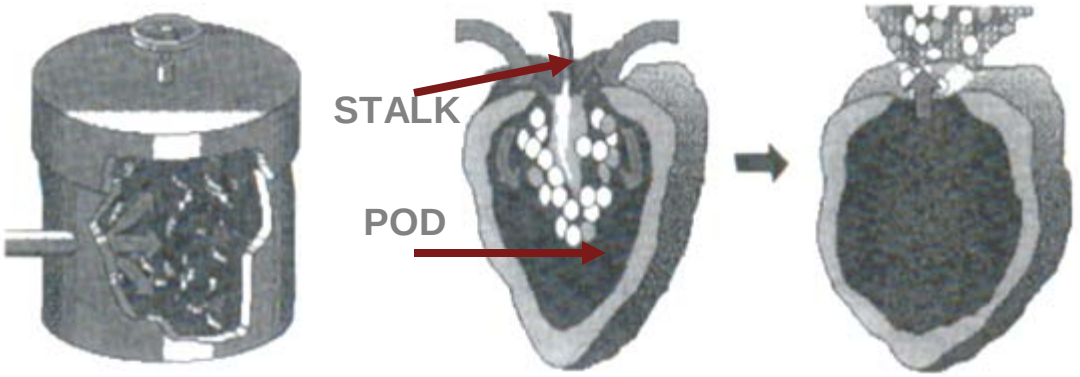
TRIZ – Analogous examples

Separation of

stalk and seeds from
the pod(sweet pepper).



1. Place pods in an airtight container.
2. Increase pressure gradually to 8 atmospheres.
3. The pods shrink, and this results in fracturing at the weakest point , where the pod bottom joins the stalk .
4. Compressed air penetrates the pepper at the fractures . The inside and outside pressures are equalized .
5. Release quickly the inside pressure.
6. Pod bursts at its weakest point and the pod bottom is ejected taking the seeds with it.

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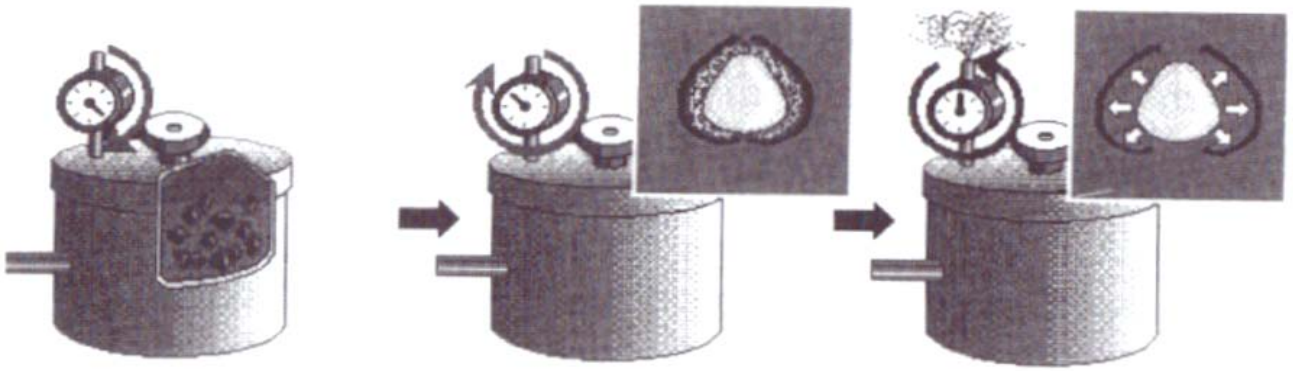
TRIZ – Analogous examples

Shelling of **Cedar nuts**



1. Place under water in a pressure cooker
2. Heat until pressure reaches several atmospheres
3. Drop quickly the pressure to 1 atmosphere
4. After overheated high pressure water penetrates the nuts,the sudden pressure drop, the resulting strain, causes the shells to break and fly off.

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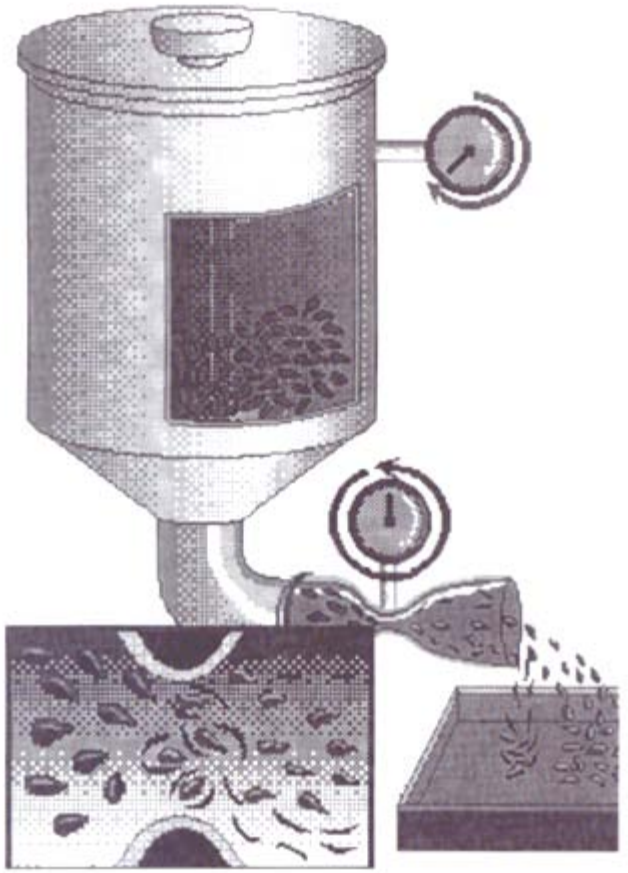
TRIZ – Analogous examples

Husking sunflower seeds

1. Load into a sealed container
2. Increase pressure
3. Decrease pressure quickly.
4. Air that penetrates the husks under high pressure expands as pressure drops, there by splitting and releasing husks.



Producing sugar powder : Similar procedure as above using low pressure breaks crystals into powder.

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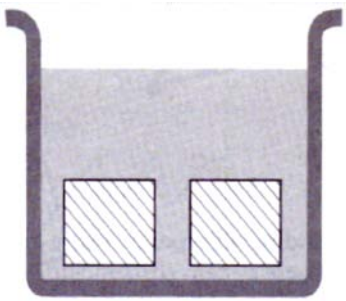
TRIZ – Philosophy Ideality

- **IDEALITY**:

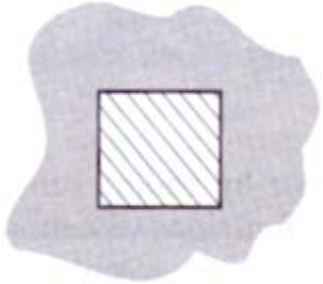
The ideal system performs a required function without actually existing

$$\text{Ideality} = \frac{\text{All Useful Effects} \uparrow}{\text{All Harmful Effects} \downarrow}$$

Example : To compare the resistance of different alloys to an acid:



SPECIMENS IN A CONTAINER CONTAINING ACID. CONTAINER MUST BE MADE ACID-PROOF WHICH IS EXPENSIVE



EXPOSE SPECIMEN TO ACID WITHOUT REQUIRING THE USE OF A CONTAINER

KEEP THE ACID IN CONTACT WITH THE SPECIMEN WITHOUT A CONTAINER

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- **TRIZ provides 2 general approaches for achieving close to ideal solutions :**

1.Use of resources :

A resource is any substance (including waste) in the system or its environment which has the functional or technological ability to jointly perform additional functions.

Some examples of resources are energy reserves, free time, unoccupied space, information etc.,.

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TRIZ – Philosophy

2. Use of physical, chemical, geometrical and other effects.

Often a complex system can be replaced with a simple one if a physical , chemical or geometrical effect is used.

Granite was split in North America in winter by placing water in drilled holes. Increase in volume when water changes phase from liquid to solid provides the force necessary to split rocks.

There are over 250 physical effects , such as using thermal expansion for precision adjustment. There are over 120 chemical effects such as etching to remove materials .

There are over 50 geometrical effects such as using a mobius strip for sanding.

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TRIZ – Philosophy

- Humans solve problems by analogical thinking. Problem confronting is related to some standard class of problems (analogs) with which we are familiar and for which a solution exists . Right analogy leads to right solution . Knowledge of analogous problem is the result of our educational , professional and life experiences .
- But if we have never encountered a problem analogous to the one we face now…..?
- Altshuller's 40 principals help us to expand our knowledge base of analogous problems .

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TRIZ – Philosophy

- Altshuller's definition of PROBLEM - " Inventive problem must have at least one contradiction" is based on examination of 40000 inventive patents which involved only 39 parameters
- Look for the contradictions and the associated principles to find ideas to solve a problem
- The recommended solution can be selected from the contradiction table . The parameter needing improvement is to be selected in the table of rows. The degraded parameter is to be selected in the columns. The intersection identifies the recommended principles
- If none of the principles suggests a new design other alternative contradictions are formulated.

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TRIZ – Philosophy

1. Weight of moving object
2. Weight of stationary object
3. Length/Angle of moving object
4. Length/Angle of stationary object
5. Area of moving object
6. Area of stationary object
7. Volume of moving object
8. Volume of stationary object
9. Shape
10. Amount of Substance
11. Amount of Information

Physical Features

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TRIZ – Philosophy

12. Duration of Action of moving object
13. Duration of Action of stationary object
14. Speed
15. Force/Torque
16. Energy Used by Moving Object
17. Energy Used by stationary Object
18. Power
19. Stress/pressure
20. Strength
21. Stability
22. Temperature
23. Illumination Intensity

Performance Features

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TRIZ – Philosophy

24. Function Efficiency
25. Loss of Substance
26. Loss of Time
27. Loss of Energy
28. Loss of Information
29. Noise
30. Harmful Emissions
31. Other Harmful Effects Generated by System

Efficiency Features

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TRIZ – Philosophy

32. Adaptability/Versatility
33. Compatibility/Connectability
34. Trainability/Operability/Controllability
35. Reliability/Robustness
36. Reparability
37. Security
38. Safety/Vulnerability
39. Aesthetics/Appearance
40. Other harmful effects acting on System

‘ ility Features

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41. Manufacturability
42. Manufacture Precision/Consistency
43. Automation
44. System Complexity
45. Control Complexity

Manufacture/Cost Features

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TRIZ – Philosophy

47. Ability to detect/measure
48. Measurement Precision

} **Measurement Features**

*** Data from Creax Matrix 2003**

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TRIZ – 40 Inventive Principles

1. Segmentation
2. Extraction
3. Local quality
4. Asymmetry
5. Combining
6. Universality
7. Nesting
8. Counterweight
9. Prior counterweight
10. Prior action

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TRIZ – 40 Inventive Principles

11. Cushion in advance
12. Equipotentiality
13. Inversion
14. Spheroidality
15. Dynamicity partial or overdone action
16. Partial or overdone action
17. Moving to a new dimension
18. Mechanical vibration
19. Periodic action
20. Continuity of useful action

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TRIZ – 40 Inventive Principles

21. Rushing through
22. Convert harm in to benefit
23. Feedback
24. Mediator
25. Self-service
26. Copying
27. An inexpensive short – lived object instead of an expensive durable one
28. Replacement of a mechanical system
29. Use a pneumatic or hydraulic construction
30. Flexible film or thin membranes

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TRIZ – 40 Inventive Principles

31. Use of of porous material
32. Changing the color
33. Homogeneity
34. Rejecting and regenerating parts transformation of physical and chemical state of an object
35. Phase transition
36. Thermal expansion
37. Use expansion
38. Use strong oxidizers
39. Inert environment
40. Composite materials

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TRIZ – Inventive principles ordered by frequency of use

35. Transformation of physical and chemical state of an object
10. Prior action
1. Segmentation
28. Replacement of a mechanical system
2. Extraction
15. Dynamicity partial or overdone action
19. Periodic action
18. Mechanical vibration
32. Changing the color
13. Inversion
26. Copying
3. Local quality
27. An inexpensive short – lived object instead of an expensive durable one
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16. Partial or overdone action
40. Composite materials
24. Mediator
17. Moving to a new dimension
6. Universality

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TRIZ – Inventive principles ordered by frequency of use

14. Spheroidality
22. Convert harm in to benefit
39. Inert environment
4. Asymmetry
30. Flexible film or thin membranes
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11. Cushion in advance
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33. Homogeneity
9. Prior counteraction
20. Continuity of useful action

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Summary/Conclusion

- The session helps the delegates to Understand the basics of TRIZ,
- Understand the approach for problem solving using systematic innovation methods.
- Build up a knowledge of application of various lateral thinking methods.

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