Hierarchical TRIZ Algorithms

11th Installment- Mar 2006

Hierarchical TRIZ Algorithms is a how-to TRIZ book. It is designed to assist both beginning and advanced users. Each month, the TRIZ-Journal will publish another chapter of the book. This month's installment includes the 9th step of the 10 step algorithm (shown on the cover):

I. Resolve Resulting Contradictions

Next month's installation will cover the tenth process step :

J. Implement the Solution

In all, there will be 12 installments. Should you decide to purchase the most current edition of the complete book contact the publisher at:

http://www.3mpub.com/TRIZ/

I Resolve Resulting Contradictions

Contradiction → [I Resolve Resulting Contradictions] → Resolved Contradiction

Introduction

Turning the knobs to high has caused other problems. Now we must find a way of setting the knobs to both settings and thus removing the contradiction. The input to this step is a contradiction. The output is a solution to the contradiction.

Types of Contradictions

Classical TRIZ considers three types of contradictions, Administrative, Technical and Physical. The **Administrative** Contradiction states that there is a problem with an unknown solution. The **Technical Contradiction** states that as something improves, something else gets worse. The **Physical Contradiction** states that an object attribute or property must have two very different or conflicting values. Most TRIZ practitioners completely ignore the Administrative Contradiction due to its lack of tangible meaning. Many ignore the Technical Contradiction in favor of the Physical Contradiction.

Relation of Technical Physical and Full Contradictions

Classical ARIZ asserts that the Physical Contradiction is formed after first illuminating the Technical Contradiction. This thinking is *not* correct and has created difficulties in moving the theory of TRIZ forward.

In classical TRIZ either type of contradiction is formed after first considering an improvement to our system. Let us consider the situation of a common garden rake. When the rake is used to collect loose debris such as rocks and loose weeds over an uneven surface, a problem arises: The rake "leaks" some of the debris that is to be collected under the tines and several strokes are required to fully collect the debris. The dependent variable that we want to improve is "Debris Leakage". Let us now ask, "what is the debris leakage a function of?" (For the sake of discussion, only three of the many possible knobs are shown).

Debris Leakage = f (Tine Flexibility, Ground Stiffness, Tine Spacing, . . .)
(Note that we are not considering all of the possible independent variables).

This can also be shown pictorially with a cause-effect diagram. (The arrows indicate "cause").
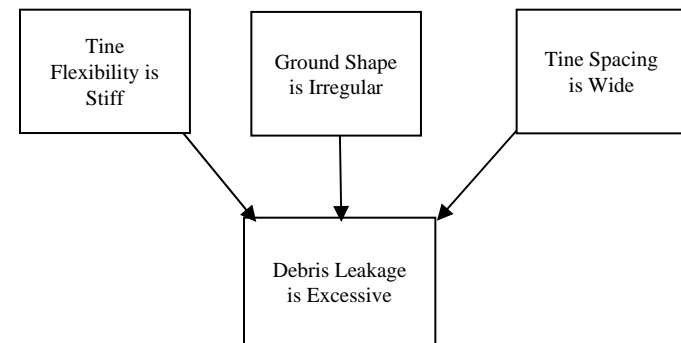
Now, let us improve the situation by turning *one* of the knobs: Tine Flexibility. (We show this by creating another box with the conflicting knob setting). Flexible tines follow the contour of the earth and collect much more effectively.

Unfortunately, other things get worse. It is more difficult to extract embedded debris from the soil and to move soil around (other functions of the rake). This difficulty can by represented by the following diagram. (For the sake of simplicity we will only consider debris extraction).
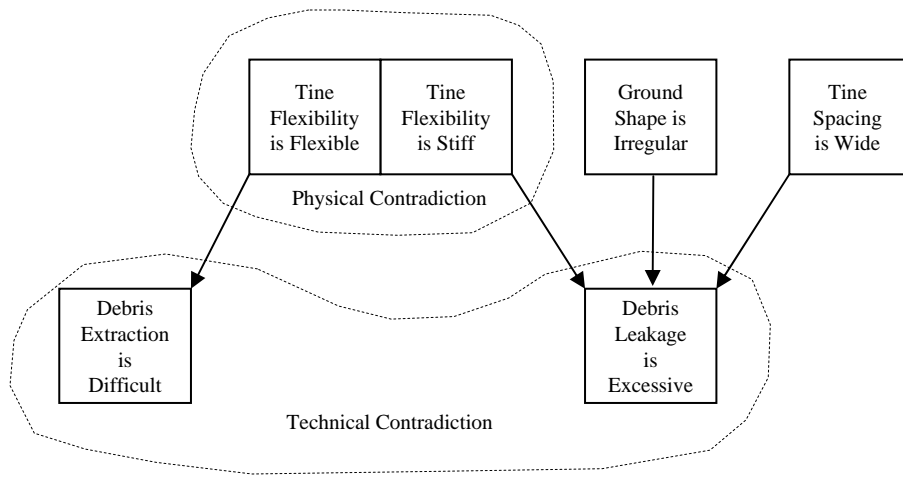
Both the Physical and Technical Contradictions show up in this diagram. The complete contradiction can now be stated: "The rake tines need to be flexible in order to collect and they need to be rigid in order to extract embedded debris from the ground". The Technical Contradiction is stated "as collecting improves, extracting becomes worse". The Physical Contradiction is stated, "the tines need to be stiff and flexible".

Note that the Technical Contradiction could be deduced only after identifying tine Flexibility as an independent variable. In other words, it does not always follow that as "Debris Leakage improves, Debris Extraction becomes worse". Different Technical Contradictions arise if we choose different knobs to turn. Had we chosen to decrease Tine Space, we would have found that the rake now collects too much useful small debris (mulch) that would ordinarily be left behind. Now the Technical Contradiction is different: "while improving Debris Leakage, Collection of Mulch becomes worse". *The Technical Contradiction is dependent on which knob we choose to turn.*
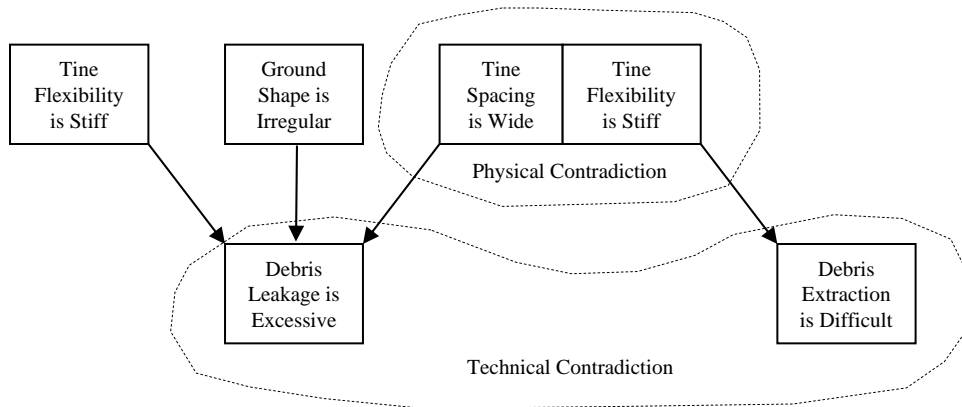
Conditions where it is difficult to State a Technical Contradiction
A properly stated contradiction may not include a well-stated Technical Contradiction. Suppose that we had chosen the ground shape as the knob to turn. In this case it would be clumsy and artificial to identify something that gets worse if we make the ground flat. Instead it is better to conclude that the ground shape comes in many different "flavors" other than flat. The full contradiction can be stated, "in order to improve Debris Leakage, the Ground Shape needs to be flat, but since the ground shape comes in many different forms, it needs to be Irregular". The Physical Contradiction can still be stated, "the Ground Shape is Flat and Irregular". Many contradictions arise because a knob only comes in one "flavor". While this fact does not stop us from resolving the contradiction, it does serve to show that it is not always practical to state something else that becomes worse.
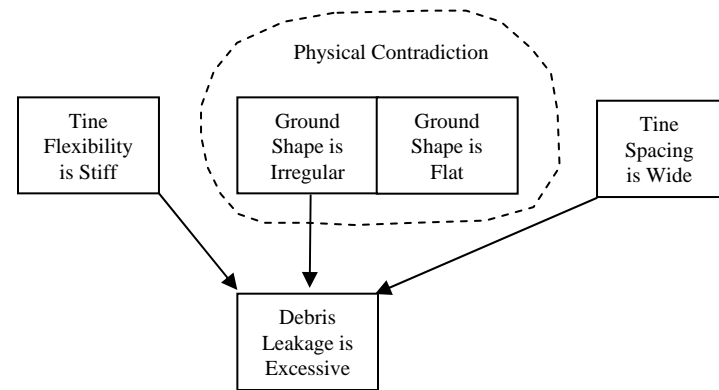
A second example of a contradiction, which does not include a well-stated Technical Contradiction, occurs when we try to turn an "outcome knob" without consideration for the inputs. In other words, we want to improve something without regard for the independent variables or knobs that cause the problem. The full contradiction can be stated "the Debris Leakage must be excessive because the ground is irregular, the tine spacing is wide and the ground is irregularly shaped. The Debris Leakage must be minimal because that is what we want to improve". The Physical Contradiction is stated, " the Debris Leakage is excessive and minimal".

I 2

```
┌──────────┐   ┌──────────┐   ┌──────────┐
│  Tine    │   │  Ground  │   │  Tine    │
│Flexibility│  │ Shape is │   │ Spacing  │
│ is Stiff │   │Irregular │   │ is Wide  │
└──────────┘   └──────────┘   └──────────┘
```

Physical Contradiction
(Debris Leakage is Excessive | Debris Leakage is Minimal)
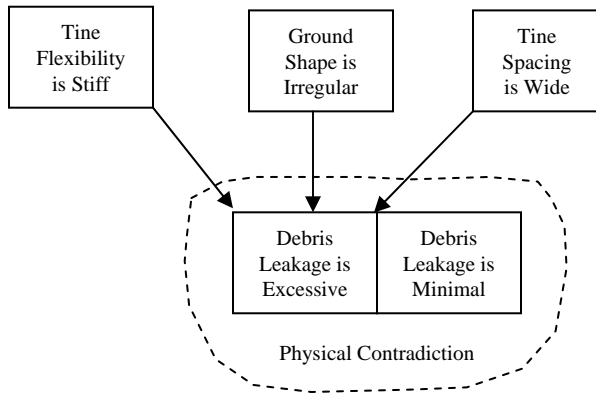
Note that while the Technical Contradiction may be difficult to state due to the foregoing reasons, the Physical Contradiction is almost always possible to state and becomes the focus for resolving the conflict.

Full Contradiction
One is better off with knowledge of the fully formed contradiction. Solving the Technical Contradiction, without knowledge of the Physical Contradiction does not increase the ability of the problem solver to directly visualize the solution. One only knows that "something" must be merged, made non-uniform, etc. Also, it may not be possible to form a technical contradiction according to the previous argument.

Solving the Physical Contradiction without knowledge of what improves and what gets worse (the Technical Contradiction) makes it difficult to know how far the knobs must be turned to create an enduring and practical solution.

Both the Technical Contradiction and the Physical Contradiction are important parts of a fully stated Contradiction. For this reason, the terms Technical and Physical will be dropped and the conflict will simply be referred to as "the Contradiction": The tines must be flexible in order to collect and stiff in order to extract.

Focus on Physical Contradictions and Table of Contradictions
Focusing on the Contradiction and the Table of Contradictions rather than the Technical Contradiction and the Contradiction Matrix is encouraged to enhance visualization of the solution. (For example, if an object must be both sharp and blunt, applying the Table of Contradictions enhances mental images of the solution).
The Table of Contradictions provides a large number of methods for resolving contradictions. A process is presented for rapidly narrowing down possible solution methods.

As stated in the book introduction, several new problem solving groups are introduced here which are distinct from separation in space, separation in time and separation between the parts and the whole (Separation by Scale). Additions are: Separate Gradually , Separation by Direction, Separate by Perspective, Separation by Field Properties and Separation Between Substance and Field.

One might wonder whether some of these are uniquely different from the three classical separation groups. Consider Separation by Direction. At the same moment in time and in the same space, a piece of sheet metal can be flexible in one direction and not in another. Separation by Perspective has little to do with time, space and scale. Here separation occurs because of unique ways of looking at the contradiction. Consider Separation by Field Properties. At the same moment and in the same space, a light bulb can both transparent to light and non-transparent to air. Consider Separation Between Substance and Field. At the same moment and in the same space, the field coils of a motor can be stationary while its field is moving. Consider Separate Gradually. There are cases where there is no definitive moment in time where an object or system has different properties. These properties can creep gradually until the full transformation is complete.

The author believes that there may yet be other groups which are distinct from the classical groups of time, space and scale.

Recursive Improvement
Once we have solutions to the contradiction, the final stage of this step ask us to check whether our goals have been met. Are there any major risks or disadvantages left? Have we met the specification which we have made to satisfy our market? If we have not, then we must loop back and continue to improve the product or process. If we have met the goals, then it is time to continue to refine the ideas and commercialize the product.

Testing Solutions
We may be convinced that we have the solution, but we will not know for sure until we test our ideas. There are many ways to test an idea. It would not be unusual to use physics based models and simple calculations to prove out some ideas. Paper or cardboard models require little expense and yet can give a wealth of information. Further models can be created with other inexpensive materials which can often be purchased at second hand stores. At some point, it is valuable to create a prototype which demonstrates the various concepts.

Simplified

Disposing of Carrier

34

24

Silver

Tar

Flexible on Stiff

Flexible

15 Adding / Subtracting

Low Thrust

High Thrust

16 Excessive Action

Masking

Painted Grossly then Detailed

1 Segmenting

10 Prior Action

Cut Slow then Fast
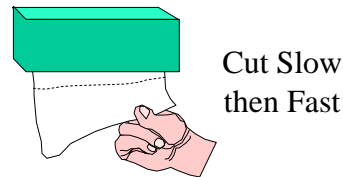
36 Transformable States

Abraidable Material

26 Copy

Drive Sharp Copy

Remove Sharp Copy

Drive Blunt Pile
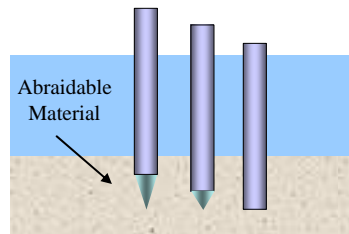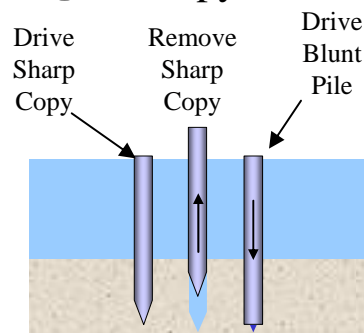
Rearranging

7 Nesting

Shaping Cap
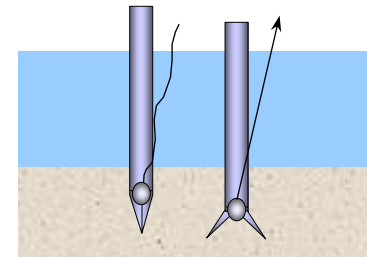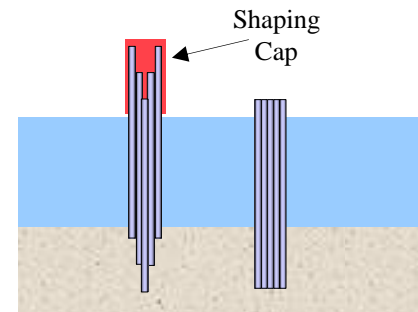
11
9 Prior Counter Action / Cushion
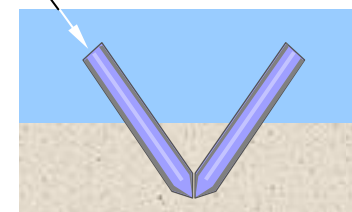
Separate Gradually -- Can opposing property be built up over time?

Gradually Merge
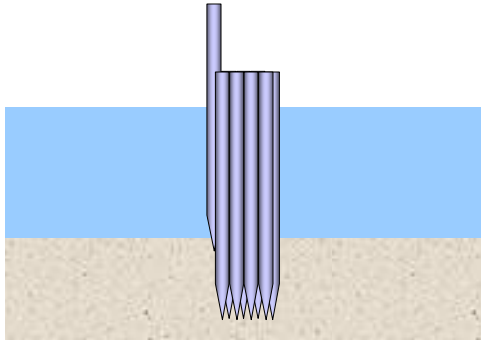
Repeated Use
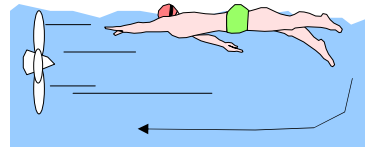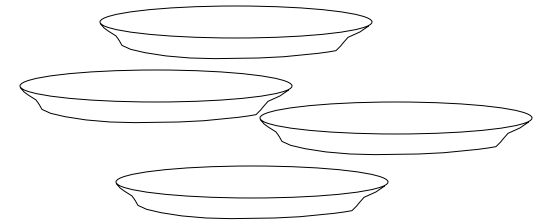
(27) Disposable Objects

Little water used over
and over = much water

A lot of paper plates= 1
porcelain plate

Two Objects

Sharp & Blunt

(2) Extraction

+ → −

No Contact

Contacts

(7) Guided / Nesting

Nested bowls

Sharp pile guiding a blunt pile

Attached

Square   Round

Blunt & Sharp

(3) Non-Uniform

+ −

Round

Square

Blunt & Sharp

I 6

Separate by Scale -- Can elements be segmented or multiplied ?

Multiplication

Square
&
Round

Big and Small
Explosion

Carrier

Sand Paper:

Inflexible
on
Flexible

Long
and
Short
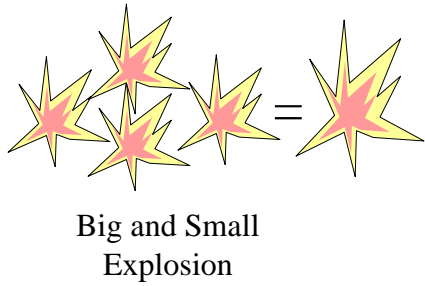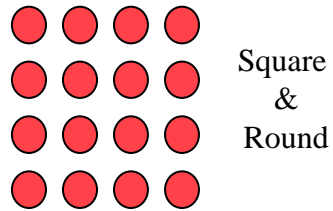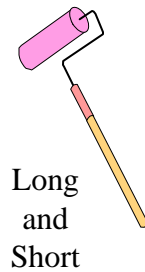
(1) ## Segmentation
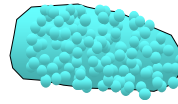
Insoluble and Soluble

(8) ## Countering
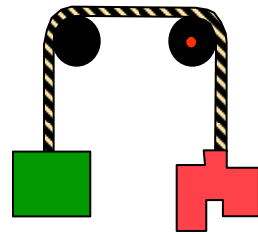
Heavy and Light

(40) ## Mixture
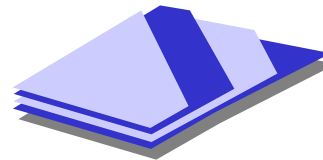
Reflective and
Absorbing

(7) ## Nesting

Round
and
Square

Solid / Powder
Gel-Cap

(1) ## Merging
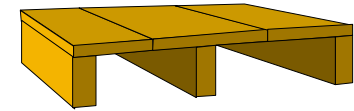
Massive and Light
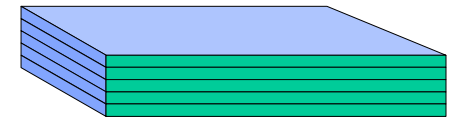
Thick and Thin

Hiding

Smooth and Rough
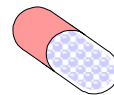
Interacting Parts

Flexible and Stiff

Dull

Sharp

Square

Round

Blunt

Blunt

Sharp

Sharp

Flexible

Stiff

I 8
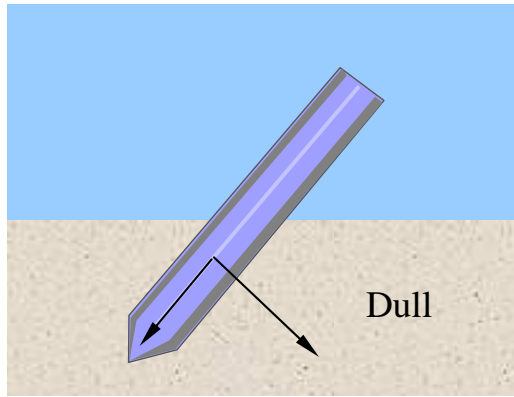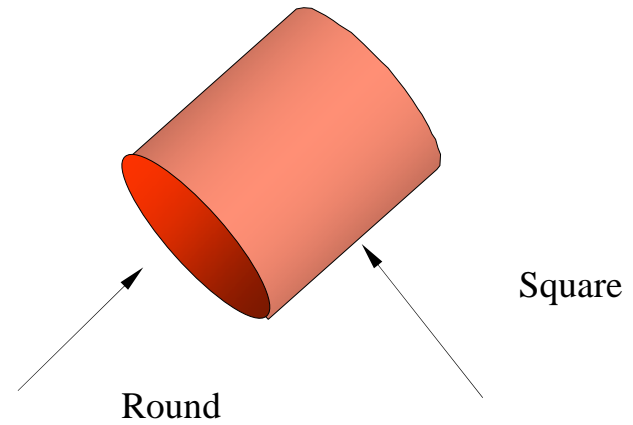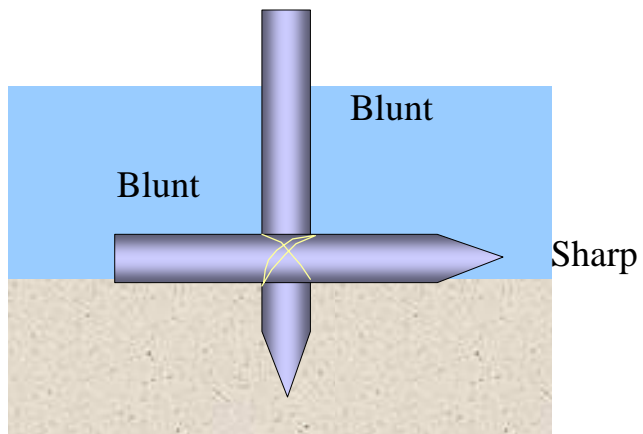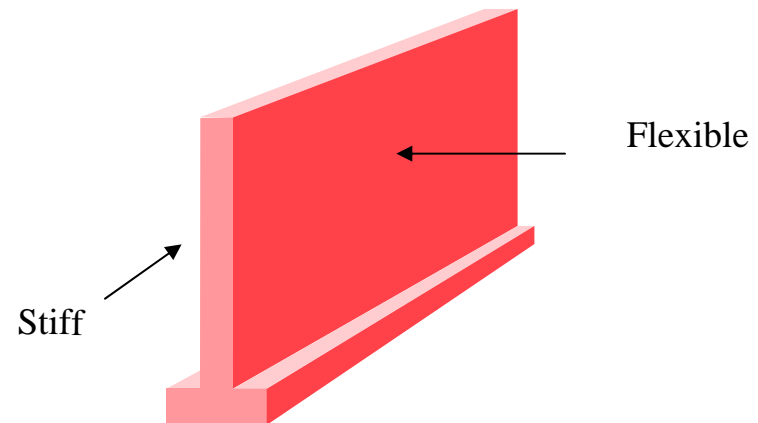
By Comparison
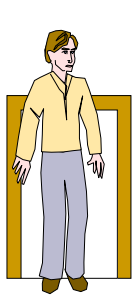
Tall
Compared to
Short Door
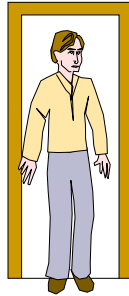
Short
Compared to
Tall Door

How you Look

(32)
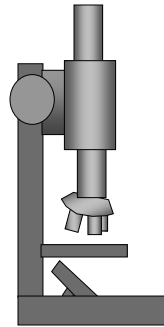
Large
and
Small

Using Paint / Fake

Marble and
Wood

Exist and
Not Exist

(26) ## Facsimile / Copy

Slow

Fast

I 9
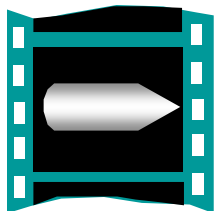
Separate by Field Properties
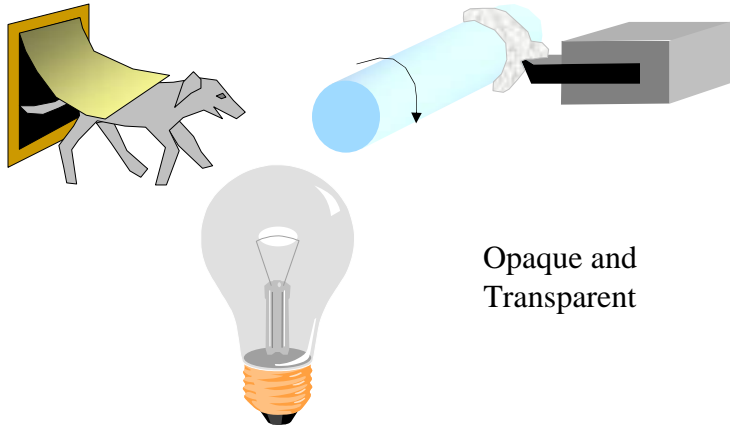
Transparency

Opaque and
Transparent

Frequency / Speed
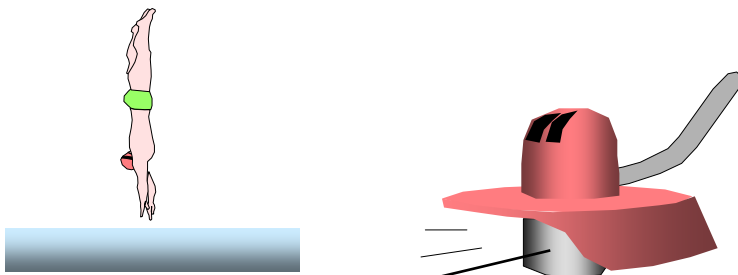
Stiff and
Flexible

Stiff and
Flexible

Separate Between Substance and Field
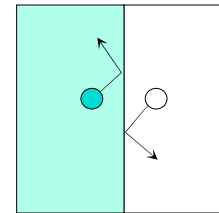
Mixed
and
Unmixed
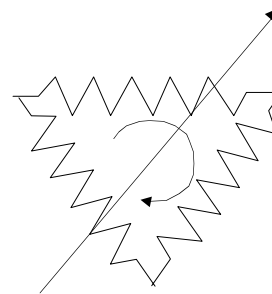
Round
and
Square

Moving
and
Stationary
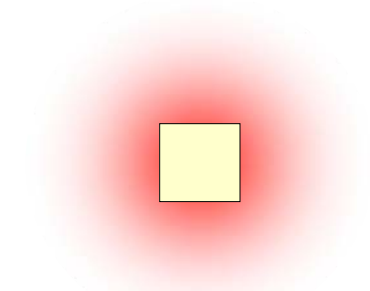
Resolve the Contradiction

Use the Contradiction Table

Contradiction Table
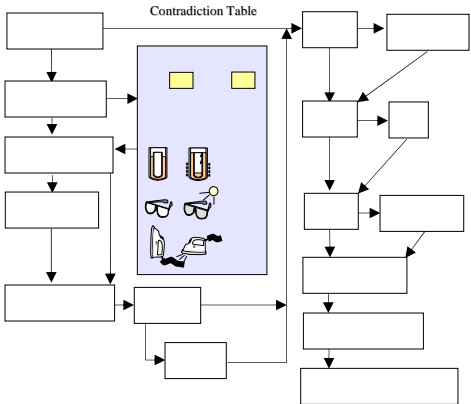
The Contradiction Table (on the following page) is intended to reduce the number of methods which must be considered to resolve the contradiction. Follow the flow of the Contradiction Table to resolve the contradiction. Remember that several methods may be employed, resulting in several solutions.

If there is Difficulty Using a Method
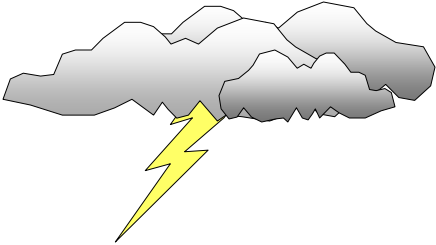
Each method for resolving a contradiction will require some consideration as to how it can be applied to this specific problem. It is common that the problem solver will become confused while trying to apply one of the methods. How does this apply to resolving my contradiction? One way around this problem is to brainstorm *any* objects that use the method *and* have the contradictory properties that you are looking for. This line of reasoning will generally clear the path to using the method.

Recursive Improvement

Met Goals?

Any Major Risks?

Make a Succession of Drawings

Journal

1. Record Ideas as drawings in Journal
2. Refine ideas by drawing successive pictures
3. Perform calculations to establish drawing details

Build and Test Cheap Prototypes for Screening Tests
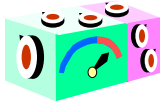
These prototypes are used to determine whether the ideas will work and whether the knobs were as influential as we thought. As such, these prototypical experiments should only include the basic elements necessary **to convince you** that the idea will work. Keep it Cheap. Write down all drawings and test results in your journal

Loop Back or Finish

1. Have you met your goals? Are there major risks left? Have the specifications been met?
2. If major problems or disadvantages remain, loop back and determine the cause and solution of the new problem
3. Otherwise, go to the next step

Contradiction Table

Under what **condition** must each conflicting property exist?

It must be hot when . . . (high altitude)
It must be cold when . . . (low altitude)

Must conflicting properties **overlap** in time? (high and low altitude overlap?)

Yes →

Separate on Condition
Can the fields, positions . . .which accompany the different conditions be used to Drive the Change? (Can pressures at different altitudes be used?)

Yes →

No ↓

Can **at least two** objects be used at the same time or can the object be **segmented**?

Yes ↓

No

Separate in Time
- Mixing / Eliminating---Page I-14
- Segmentation / Unification---Page I-15
- Separation / Merging---Page I-15
- Rearranging / Unfolding---Page I-15
- Interacting---Page I-16
- Merged Interaction---Page I-16
- Adding / Subtracting Parts I-16

- Copy / Facsimile --- Page I-17
- Two Objects---Page I-17
- Extraction---Page I-17
- Touching---Page I-18
- Reorienting Attachments---Page I-18
- Non-Uniform---Page I-18
- Adding a Carrier---Page I-14
- Discarding the Carrier---Page I-14
- Unrolling---Stretching---Page I-19
- Transformable States---Page I-19
- Discarding---Page I-19
- Prior Action---Page I-20
- Prior Counter Action---Page I-20
- Excessive Action---Page I-20
- Changing Direction---Page I-21
- Switching Fields---Page I-21
- Input / Output---Page I-21

On Condition

First   **+**   On Changing Conditions   **—**

- What objects change orientation relative to each other
- Consult the chart of fields . What fields change in the new conditions?
- Can these changing conditions, themselves, drive the change?

Oil Height is Low at Low Temp--High at High Temp

Glass Tint is Light and Dark depending on light conditions

Constrains water when upright and Flows water when Pressing

Can one of the conflicting properties **build up** over time?

Yes ↓   **No** →

Separate Gradually
- Separate Use---Page I-22
- Repeated Use---Page I-22
- Gradually Merged---Page I-22
- Gradually Hidden---Page I-23
- Maturing / Proliferation--- Page I-23
- Disposable Objects--- Page I-23

At **any** critical moment in time, can the contradictory properties **exist in two separate objects**?

No →   **Yes** ↓

Separate in Space
- Two Objects--- Page I-24
- Extraction---Page I-24
- Guided / Nesting---Page I-24
- Attached---Page I-25
- Mixture--Page I-25
- Non-Uniform---Page I-25
- Part Merged--Page I-26
- Part Carried--- Page I-26
- Part I-nteracts---Page I26

Can the object be **segmented** or can **more than one** be used at once?

Yes →   **No** ↓

Separate by Scale
- Multiplication---Page I-27
- Segmentation---Page I-27
- Merging---Page I-27
- Interacting---Page I-28
- Countering---I-28
- Hiding---Page I-28
- Carrier---Page I-29
- Nesting---Page I-29
- Mixture---Page I-29
- Complimentary--Page I-30

Do the conflicting properties **already exist in different directions** or can they be made to?

Yes →   **No** ↓

Separate by Direction
- Direction---Page I-31
- Path---Page I-31
- New Dimension---Page I-31

Separate by Perspective
- By Comparison---Page I-32
- How You Look---Page I-32
- Looks Like---Page I-32
- Facsimile--Page I-33
- Frame of Reference---Page I-33

Separate by Field Properties
- Transparency---Page I-34
- Frequency / Speed---Page I-34

Separate Between Substance and Field Page I-34

Elastic Force Internal & External	Gravity	Friction	Adhesive
Centrifugal Force	Inertia of Bodies (Note Direction)	Coriolis Force	
Buoyant force	Hydrostatic Pressure	Jet Pressure	Surface Tension
Odor & Taste	Diffusion	Osmosis	Chemical Fields
Sound	Vibrations & Oscillations	Ultrasound	Waves
Corona Discharge	Current	Eddie Currents (internal and skin)	Particle Beams
	Thermal Heating or Freezing	Thermal Shocks	Nuclear Forces
	Electrostatic Field	Magnetic Field	
	Electromagnetic (Voltage)		Information

Table
of Fields

Radio Waves	Micro-waves	Infrared	Visible Light	Ultra-violet	X-Ray

Adding a Carrier

First

Then

$+$
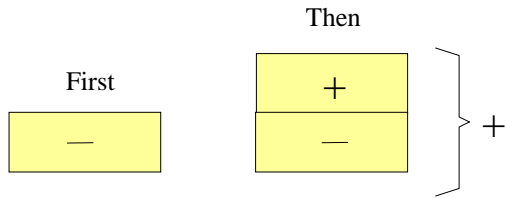
- One element having one property is used first
- The second element having the conflicting property is added (attached)
- The whole now has the property of the added element
- Consider adding multiple elements

First Sharp

Then Blunt

Pumped Concrete

First Short

Then long

First Insoluble in Water

Then Soluble in Water

Unknowledgeable

Then Knowledgeable

First Carrier Wave

Then Carried Signal

Constitution

Constitution

Bill of Rights

Limited Freedom

Freedom

Discarding the Carrier

First

Then

$+$
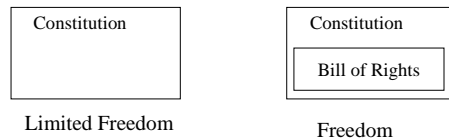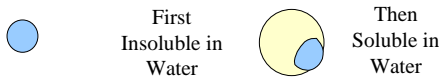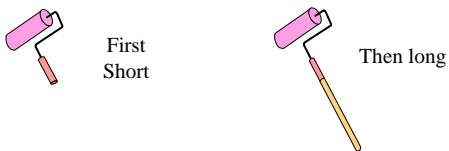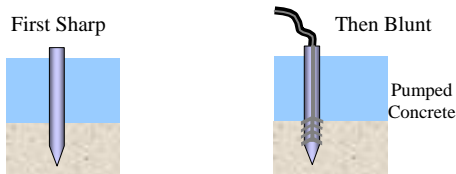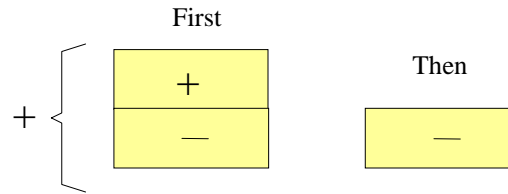
- Two elements having conflicting properties are attached together.
- The whole has the conflicting property of one of the elements
- **Discard** all or part of the element having the main property
- Consider **Replacing** with an object having the conflicting property

First Sharp

Then Blunt

Concrete

First Square

Then square part discarded

Silver

Tar

Locally deforms

Discard Tar

Generally deforms

Solid Mold

Liquid Slurry

Finished Porcelain Piece

Mold Removed

Limp Paper on stiff balloon

Balloon Discarded
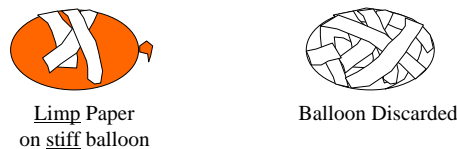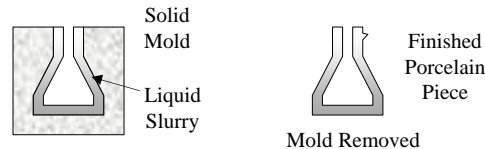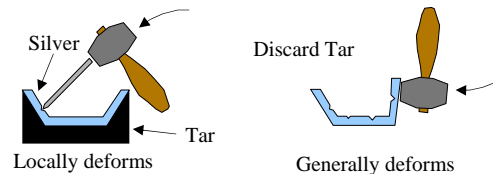
Mixing / Eliminating

$+$

$-$
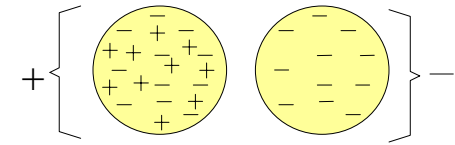
- Either mix in or eliminate a mixture component to give the whole the opposite property
- Consider finer and finer scales down to sub-atomic particles

Fabrics and Matrix
Multi Fiber Fabrics
Multi Property Laminates
Mixtures of Different Molecules
Gels (Liquids + Solids)
Pastes (Liquids + Solids)
Foams (solid or liquid)
Capillary Structures (Solid + Liquid)
Components of Solids or Liquid

First

Then

Liquid with No Formability

A Formable Gel (Solid + Liquid)

First

Then

In-cohesive Group

Cohesive Group

First

Then

Self Contradicting Talk

Logical Talk

First

Then

Metal Laminates Only

Plastic and Metal Laminates

I.14

Segmentation / Unification

first ▭ then ▫▫▫

‒   +
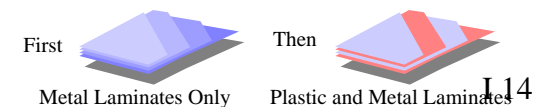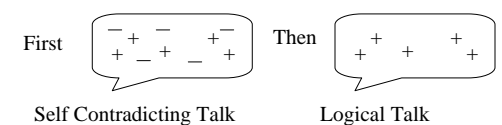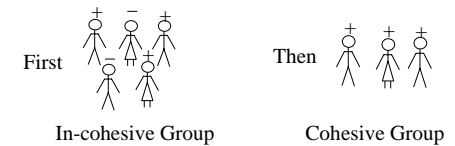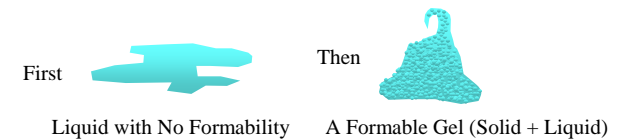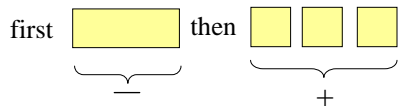
- The properties of the system are changed when the object is segmented or unified
- First segment, then separate
- Or segment and then unify
- Consider performing this at the micro-level. Dissolving, etc.
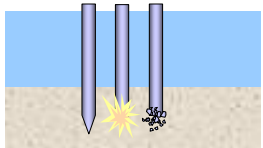
First Sharp then Blunt

Square Fireworks Charge

Round Display
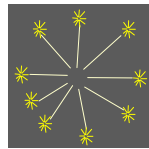
Wheat: Long life

Flour: Short Life

Pill: Slowly Dissolved
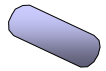
Powder: Rapidly Dissolved

Garlic: Weak Smell

Powder: Strong Smell

Pass-around to Read

Hand Out at Once
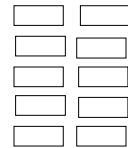
Molecule with One Property
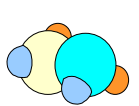
Opposite Property when Dissolved

Separation / Merging

first ▭▭▭ then ▫▫▫

‒   +
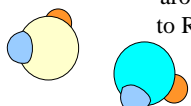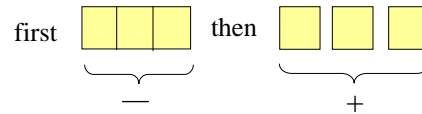
- The properties of the system are changed when a segmented object is separated or merged
- Consider performing this at the micro-level. Dissolving, etc.
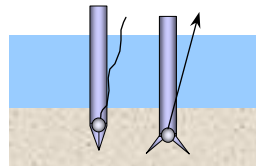
Sharp when Merged-- Blunt when Separated
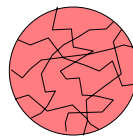
First Round
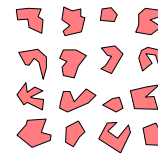
Then Square
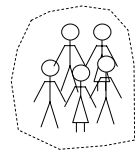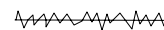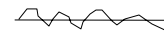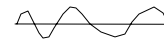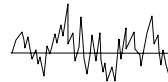
First a Group
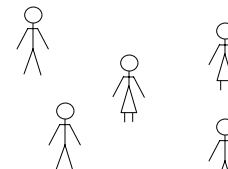
Then Isolated
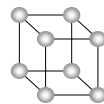
First Crystal

Then In Solution

Rearranging / Unfolding

first ◰ then ◰

+   ‒
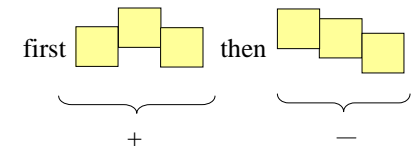
Multiply or segment elements
- Hinged and allow unfolding
- Guided by each other
- Interact through field
- Rearrange on condition if possible
- Consider Nesting

First Sharp Then Blunt

Pointer Or Antenna

Expandable Cup

First Round

Then Square

Self-Adjusting Nut Driver

Folding Chair

Escalator

I 15

Interacting

first ▢▢▢ then ▢▢▢
⎵ ⎵
+ −
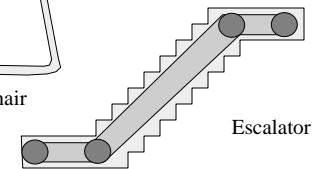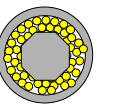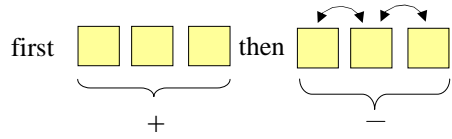
- Identify existing or easily added fields
- Begin with separate parts and then make individual pieces interact.
  - Parts Adhere
  - Parts nestle into each other
  - Parts shaped to interact
  - Parts shaped to inter-link
  - Linked by transmission
  - Interact through field
  - Hinged

First Square   Then Round

Compact   Large

Isolated   Interact

Bungee Cords

Short Polymers   Polymers Inter-link

Merged Interaction

Changes or is changed by what's there

→ + − −
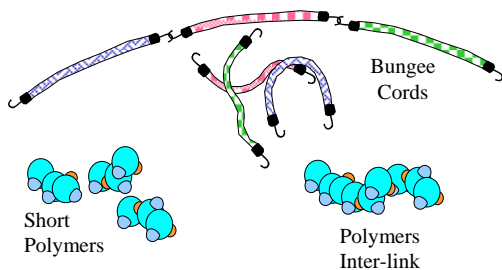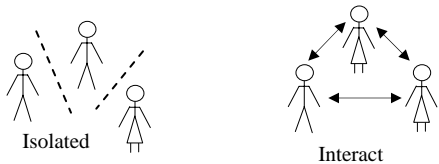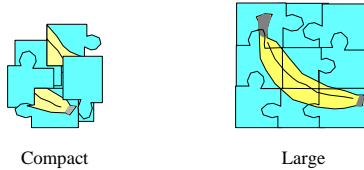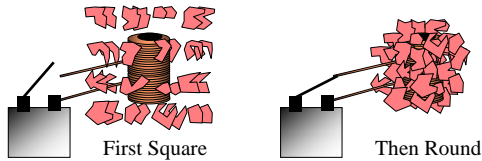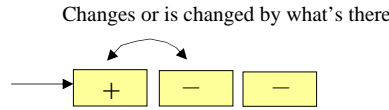
- How can the added part change the parts already in place or be changed to have the conflicting property? (At least a little with each addition until the whole has the conflicting property).
- All or all but the last one added have the conflicting property
- Interact:
  - Parts Adhere
  - Parts Nestle into each other
  - Parts Shaped to Inter-link
  - Parts linked by transmission elements
  - Parts interact by field (Consult table)
  - Parts reshape the existing parts

Added sharp piles push on lip of previous pile making it blunt

Each round roll is pushed against the previous rolls to make them square

Each trainee that is added is educated by the rest of the trained group

Each piece of solid metal is made liquid by the prior pieces added

Adding / Subtracting Parts

First ▢▢▢▢▢ then ▢▢▢
⎵ ⎵
+ −
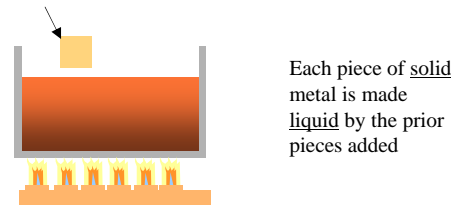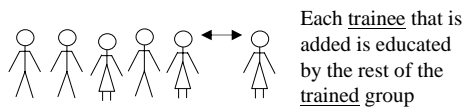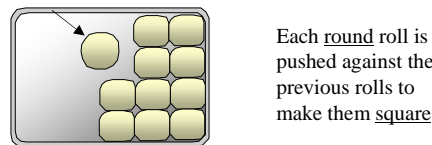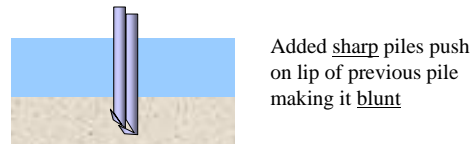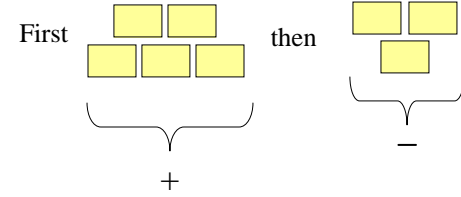
- Make the number of parts adjustable

Low Thrust   High Thrust

Contract Workers

First Small Then Large

Simple   Detailed

Low Load Capacity

High Load Capacity

Large Table

Long Train

Small Table

Short Train

Single Occupant   Multiple Occupants

Copy / Facsimile

First — Copy / Facsimile Then + Original
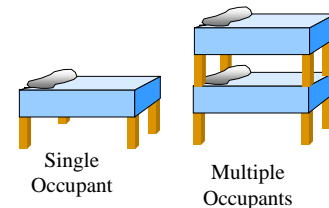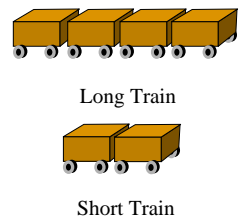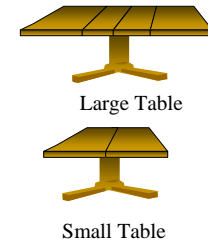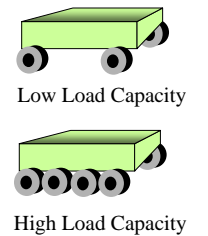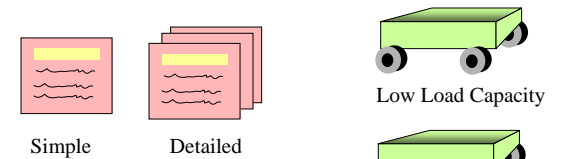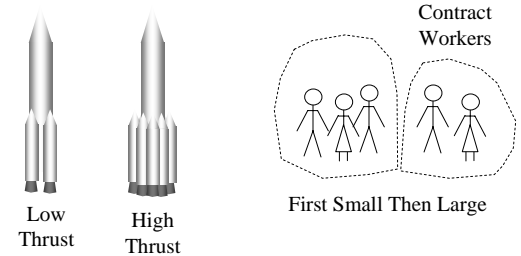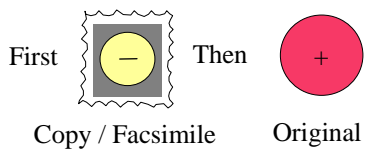
- Can the **essential part** of one of the conflicting properties be **copied** into another object?
- First use the copy and then the original or vice versa

Photographs Movies Paint Coverings Molds Time lapse photos Impressions	Silhouettes Castings Resists Projections Computer Model Dummies

Silk Flowers in Winter   Real Flowers in Summer

Fill out Copy   Fill out Real Tax Return

First Vaccine A+   Then Virus B -

First Dummy Run   Then Real Part

First Mannequins   Then Real Victims

Two Objects

First + Then —
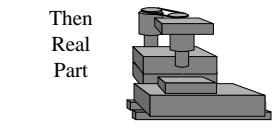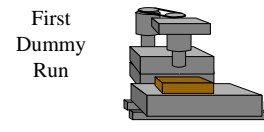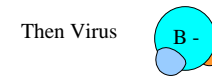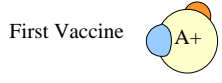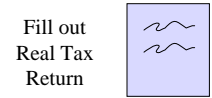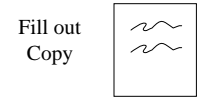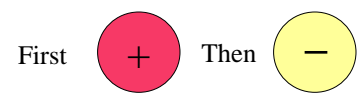
- **Use two separate objects.** The objects are the same in most respects except that they have conflicting properties
- Use one and then the other

First Sharp Copy   Then Real Pile

First Use High Flame   Then Use Low Flame

First Use Rough Sand Paper   Then Use Fine Paper

First Use One Molecule A+   Then Use Another B -

First Use One Organization Org A +   Then Use Another Org B -

First one message Message +   Then Opposing Message Message -

First discrete signal   Then analog signal

Extraction

First Together   Then Extracted
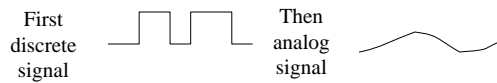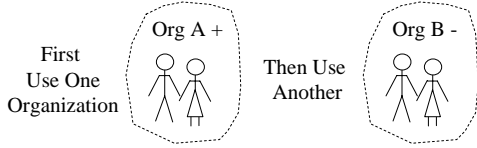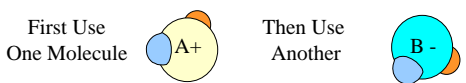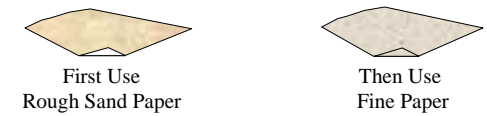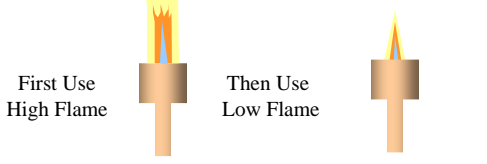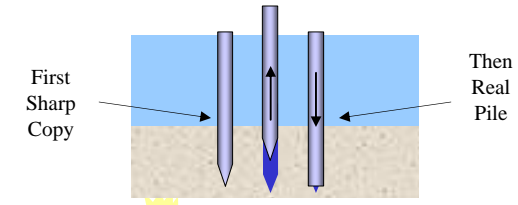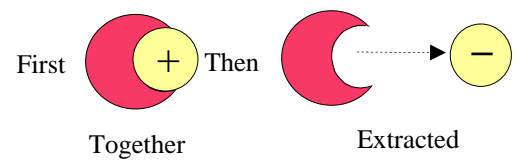
- Part of the original element which requires both properties is made easily removable and as small as possible.
- In the first instance the entire assembly remains whole.
- Later, the element is extracted and separated from the rest.

First Square   Then Round

First No Contact   Then Contacts

First Whole   Then Extracted

First Included   Then Extracted   Criminal

Doc A +   Doc A +   Doc B -

First Included   Then Extracted

I 17

Touching / Separating

First Separate   Then Touching

$+$ $-$
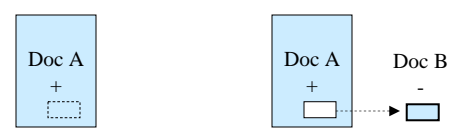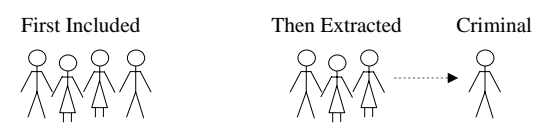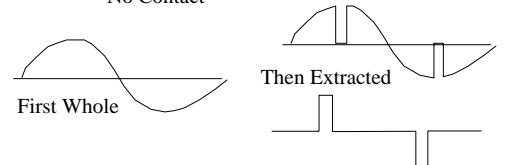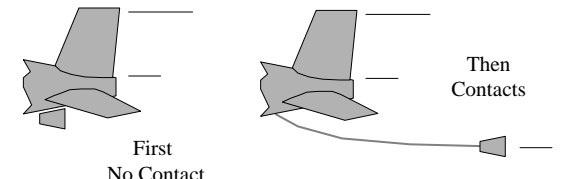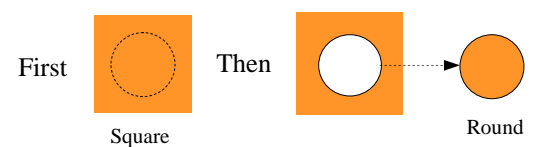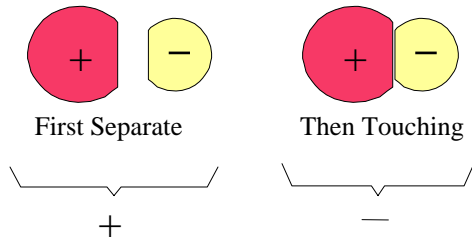
- **Duplicate or segment** the element and give each opposing values. One element guides the other (make use of existing fields)
- When touching the combination has one property. When separated, they have the conflicting property

First   Then
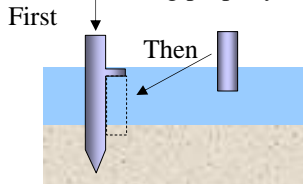
Sharp pile guides a blunt pile

B -
A+

First Separate

A+   B -
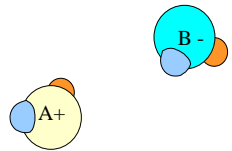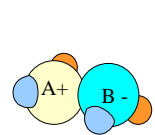
Then Covalent Bonded

Org A +   Org B -   Org A +   Org B -
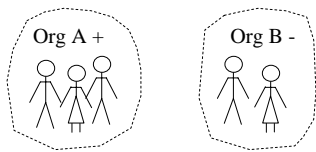
First Separate Groups   Then Co-located Groups
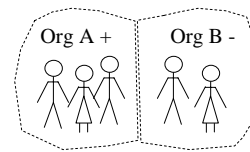
Doc +   Doc -   Doc +   Doc -

First Separate Opposing Messages   Then Back to Back Opposing Messages
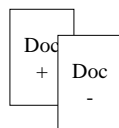
Reorienting Attachments

$+$ { $-$ $+$ $-$ { $+$ $-$
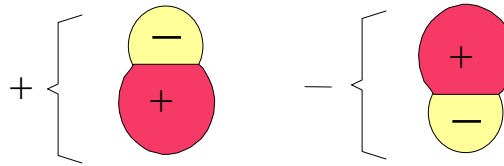
- Two objects are attached, each having conflicting properties
- In orientation, the whole has the property of one element. In another orientation the whole has the conflicting property
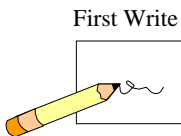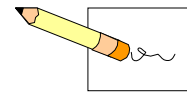
First Write   Then Erase
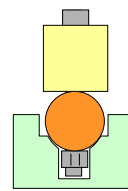
First Able to Rotate   Then Fixed
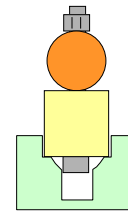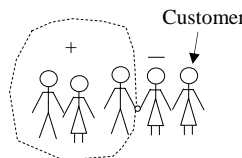
Customer   Customer

First the Individual Meets the Customer   Then the Group Meets the Customer
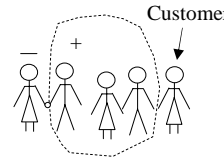
$+$ $-$ $-$ $+$
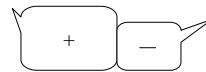
First One Order of Conflicting Messages   Then Reverse the Order

Non-Uniform

First one Orientation $+$ $-$ Then the Other $-$ $+$
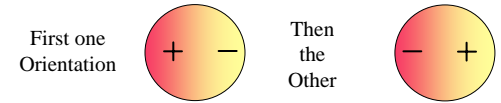
- **A single element** has both conflicting properties. The element is not uniform. If possible, make a smooth transition between conflicting properties
- First **orient one way** for one property and then **orient another way** for the opposing property

Transformers(electric, levers, etc.)
Standing Waves
Concentrated Additives
Especially active Additives
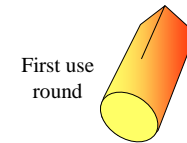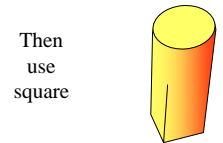
First use round   Then use square

First Blue   Then Red
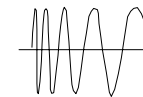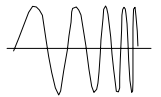
High Proceeds Low   Low Proceeds High
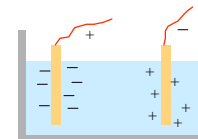
First Left is Negative   Then Right is Negative
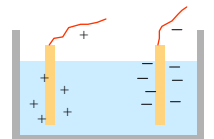
$+$ $-$ $+$ $-$
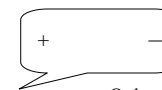
Order of Speech Contents is Reversed

I 18
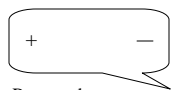
Unrolling--Stretching

first + then −
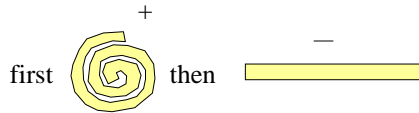
- Fabrics
- Springs
- Molecules which change shape

- Multiply elements and form them for merging and moving about.
- Consider Nesting

Square

Round

Compact

Long

Large

Compact

No Drag

Drag

High Rate Spring (Solid Height)

Low Rate (Extended)

Folded Molecule

Unfolded

Transformable States

first + − then + −
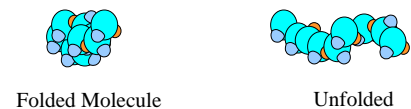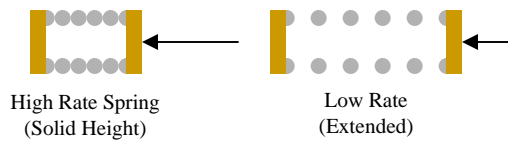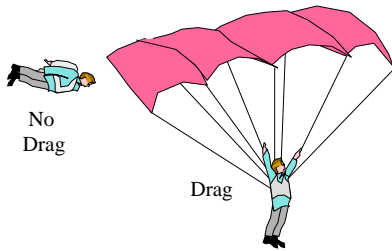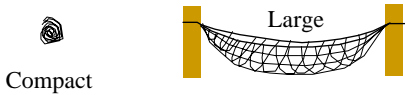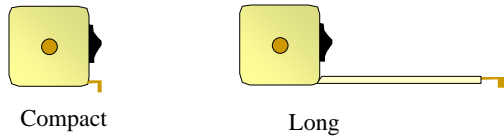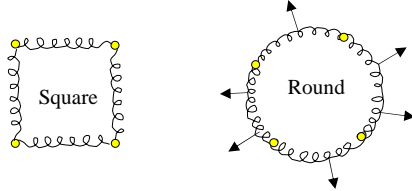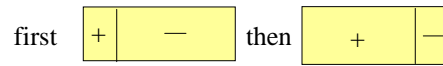
- Consider the **list** of Transformable substances
- Can **both** conflicting properties be present at all times, but only one is in abundance at a time?
- Operate the substances near the **critical point** so that small inputs create strong outputs

- Solid to Liquid
- Solid to gas
- Gas to liquid
- Combustible materials
- Fissable
- Glue
- Explosive
- Exo-Endothermic

- Soluble or dissolvable materials
- Settable liquids--(increase of volume)
- Easily breakable or abraidable
- Polymerizing or de-polymerizing
- Mixture decomposition --Electrolysis
- Disassociation- recombination
- Shape Memory Materials
- Magnetic materials using Curie Effect

Abraidable Material

Square Ice Cube   Round Drop Liquid

Low Volume Liquid   High Volume Foam

Chopsticks: <u>One</u> Piece then <u>Two</u>

Breakable Section

Easily Torn Top of Aluminum Can

Sponge: <u>Soft</u> and <u>Hard</u>

Discarding

first + then ⊠
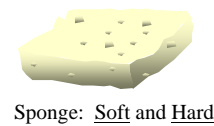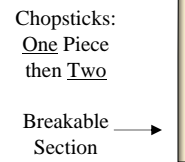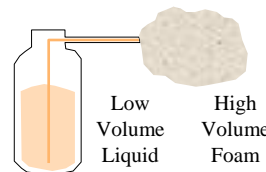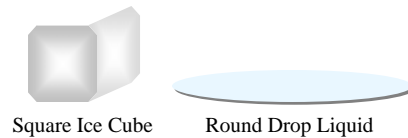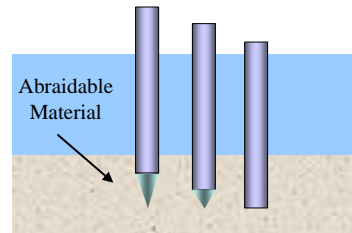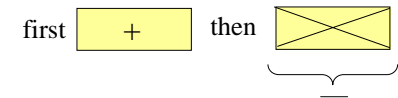
- The discarded object should be inexpensive and harmless
- Can an unwanted conflicting property be discarded with an object?
- Change of State (Solution, phase, breakable, chemical stage, heat effect, phase accompanying effects.
  - Self elimination or "disappears"
  - Chemical decomposition
  - Physical Transition to new state

Burst Disk

Constrained   Unconstrained

Bottle Cap

Constrained   Unconstrained

Alka-Seltzer

In Water

Drops

Doc   Doc

I 19

Prior Action

+ way (partially)	then	- way (fully)
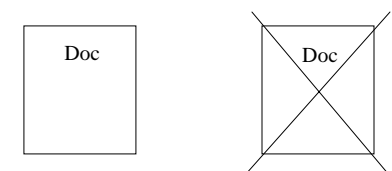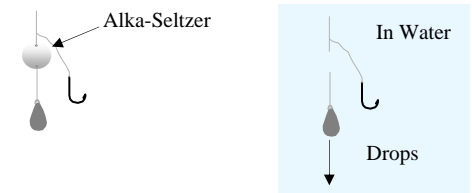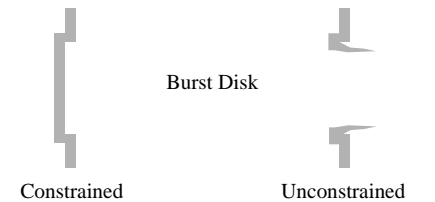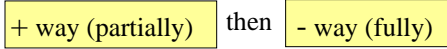
- Are the conflicting properties **the way** that the modification is performed?
- Can the modification be performed one way **partially** and then finished the opposite way? (Cut slowly and rapidly)
- If the **reliability** of an element must be high and low, can another element be placed to take over in the event of a failure? (Previously Placed Cushion).
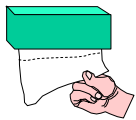
PERFORM PARTIALLY: The paper must be <u>cut</u> for rapid removal and <u>not cut</u> so as to pull out the next towel
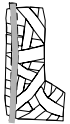
PRE-INSERT TOOL OR PART OF A TOOL: Saw blade is embedded in the cast during forming to facilitate later removal. The cast is <u>cut rapidly</u> and <u>cut slowly</u>
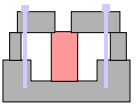
RAPID SETUP (LEAN): Parts are prepared in jigs for rapid insertion into a process while the previous piece is being processed. The piece is being <u>machined</u> and <u>not machined</u>
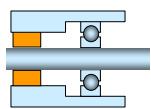
PREVIOUSLY PLACED CUSHION: A part is brought into position to take over a function in the event that another part fails. A bushing takes over for a failed bearing. The Bearing is <u>Unreliable</u> and <u>Reliable</u>
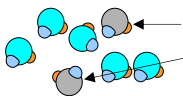
PRE-INSERT "TOOL OR PART OF TOOL": Inactive molecules await later activation or sensing. For instance, iridescent molecules are <u>visible</u> and <u>not visible</u>

PERFORM PARTIALLY: Training--Work is <u>performed in evening</u> and <u>performed during the day</u>. (Part of the work is evening training to prepare for the days work)

Prior Counter Action or Cushion

first → + then ← +
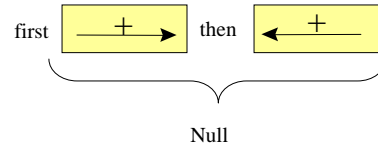
Null

- Counter an action by performing the opposite action in advance.
- Does the feature have direction or can it be changed in some way to have direction?
- Orient elements to nullify each other in the future
- Consider previous placement of a **tool**
- VIBRATION CANCELLATION
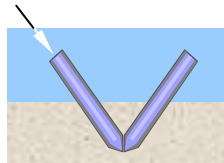
BUTTING OR TENSIONING: One is brought into place (<u>Sharp</u>) and then a duplicate is brought into place that cancels the undesirable property of both (Making both <u>Blunt</u>) Consider using a transmission between elements.
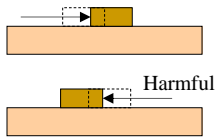
Harmful

Move the object in advance in the <u>opposite direction</u> of a later harmful movement. The harmful movement places the object where you wanted it anyway. Thus the object is <u>Moved</u> and <u>Unmoved</u>

First Freeze

Then   Heat
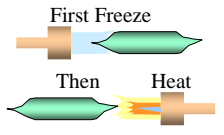
An ampoule filled with heat sensitive medicine must be heat-sealed. The heat will damage the medicine. The ampoule is first cooled with liquid nitrogen and then the end is heat sealed.

Excess material
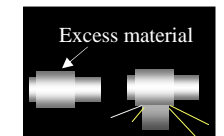
Extra material is added in advance for an anticipated wearing action in the future. Thus, the shaft becomes <u>worn</u> and <u>unworn</u>
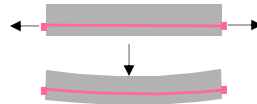
Concrete is pre-stressed (in compression) so that later loads allow the concrete to remain in compression. (Concrete does not sustain high tension loads) The concrete has <u>high stress</u> and <u>low stress</u>

Excessive Action

Too Much	then	Perfect
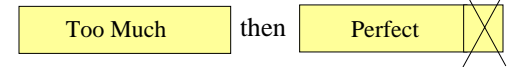
- Perform the action excessively and then remove the excess

Then

Paint all   Remove Masking

Then
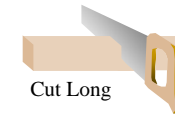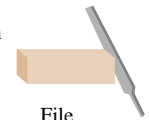
Cut Long   File
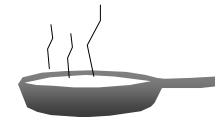
Gravy comes thick

Thinned for consumption
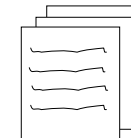
Excessive length for uninterrupted writing
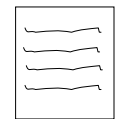
Edited to be precise
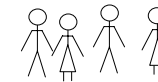
Group excessively large to guarantee enough participants
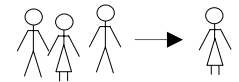
Those not required can leave

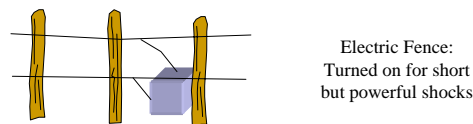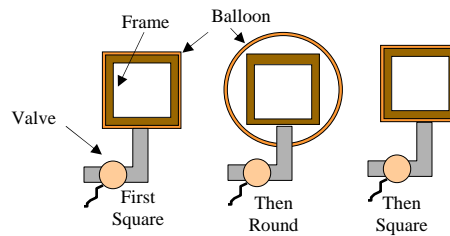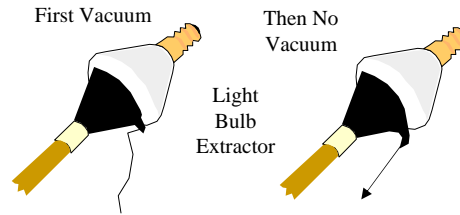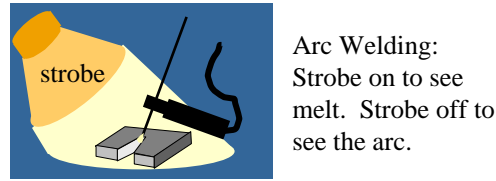# Changing Direction

first $+\uparrow$ then $-\rightarrow$
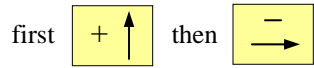
- Can the property be oriented in one direction?
- Change the orientation in time
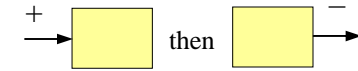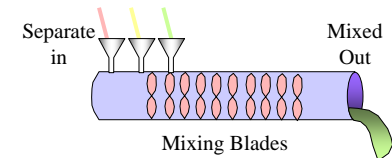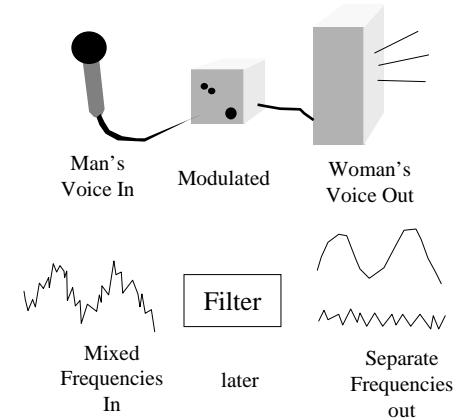- Orient one way for function 1
- Orient 2nd way for function 2

First
Sharp
Then
Blunt

First
Round

Then
Square

First
Lift

Then
Propel

Chopsticks

Eat with
Sharp
End

Serve with
Blunt End

First
Constrained

Then
Unconstrained

Switching Fields

First $+$ then $-$ then $+$ · · ·
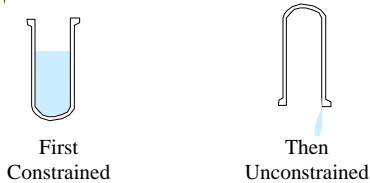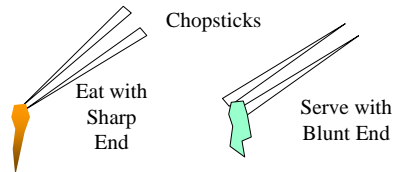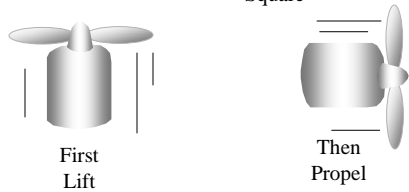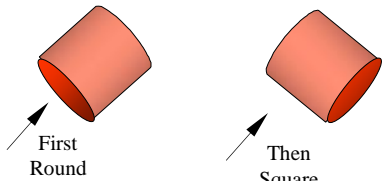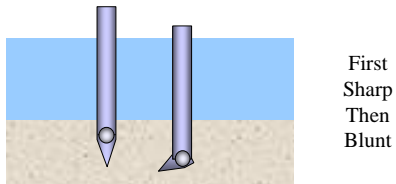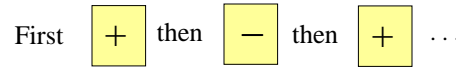
- Add a field or Identify Existing Fields.
  Switch the Field on and Off.

strobe

Arc Welding:
Strobe on to see
melt. Strobe off to
see the arc.

First Vacuum

Then No
Vacuum

Light
Bulb
Extractor

Frame   Balloon

Valve

First
Square

Then
Round

Then
Square

Electric Fence:
Turned on for short
but powerful shocks

$+$ $-$ $+$ $-$

Alternating Opposing Messages
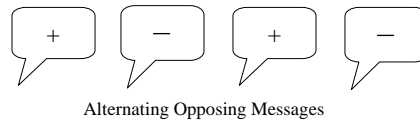
Input / Output

$+$ then $-$

- An object has something with one property
  coming in and then later, the opposite property
  exiting.

Man's
Voice In

Modulated

Woman's
Voice Out

Mixed
Frequencies
In

Filter

later

Separate
Frequencies
out

Separate
in

Mixed
Out

Mixing Blades

Spook Alley

Calm
going in

Scared
Going
Out

Separate Gradually -- Can opposing property be built up over time?

Separate Use

| + | then | + | then | + |
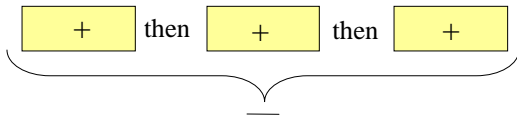
- The variable or action comes into use, one at a time. Over the course of time the addition of elements with one property create the conflicting property of the whole
- PREVIOUSLY PLACED CUSHION: Unreliable + Unreliable = Reliable
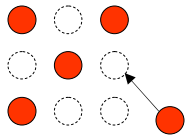
Gradually becomes a square from separated round pieces
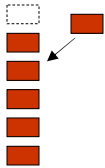
Gradually becomes a long structure from separated short pieces

CHEAP SHORT LIFE: Many cheap disposable plates used over time have same effect as one durable plate

Many separate small explosions can have same effect as one large explosion

Repeated Use

| + | then | Repeat + | then | Repeat + |
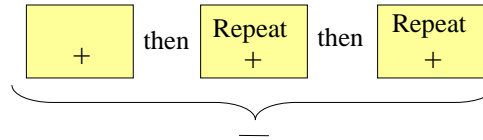
A variable is used repeatedly, perhaps after being recovered. **Usually involves a repeated or circular process.**
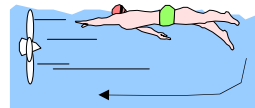
REUSE: Little water used over and over = much water
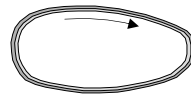
SPHEROIDALITY: Short belt length used over and over becomes infinite length
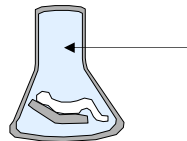
REGENERATION: A little air regenerated becomes a lot of air
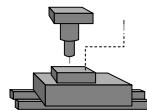
UNINTERRUPTED USEFUL EFFECT: One machine in continuous use = a lot of machines (eliminate dummy runs)
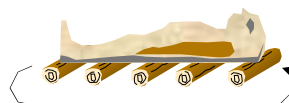
REUSE: few logs used over and over = many logs

Gradually Merged

| + | → | + | + | + |

Keep Adding
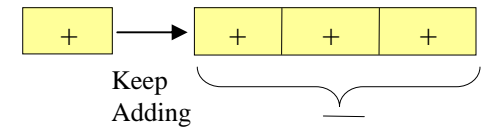
Multiply or **Segment** the object and merge one at a time. Arrange the individual parts so that the merged whole has the conflicting property of the individual parts

- MERGE AT MICRO LEVEL
- PARTIAL ACTION :Partial Action + Partial Action + Partial Action +Partial Action = Whole Action
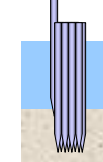
Blunt pile is created from the merging of many sharp piles
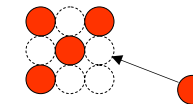
Gradually becomes a square from round pieces

STORAGE: Gradually storing small amounts of water = lots of water
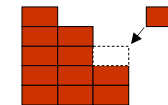
Gradually becomes a large structure from merging of many small pieces

STORAGE: Gradually storing small amounts of electricity = lots of electricity (Solar Panel)

Gradually Hidden / Exposed
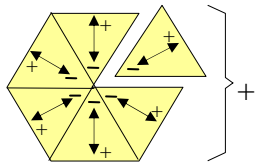
- Applies to multiple elements (same, similar or dissimilar) which have an undesirable property
- Does any part of the object have the desired Property, even in the slightest degree?
- Gradually merge elements and orient them in such a way that the undesirable conflicting property is hidden, (at least functionally).

Circle made gradually from partly round squares

Rounded Side
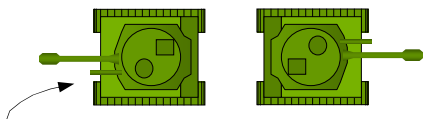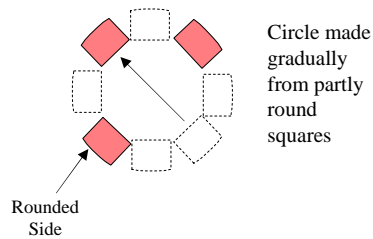
Each tank is protected from the front and vulnerable from the rear. Thus, newly arriving tanks protect each other.

Maturing / Proliferation
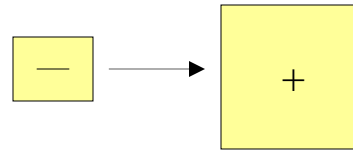
- Over the course of time objects grow (cells or elements divide and change. Some cells or elements die off).
- At one point in time they have one property. That property slowly changes over time

Small

Large

Slowly

Caterpillar   Chrysalis
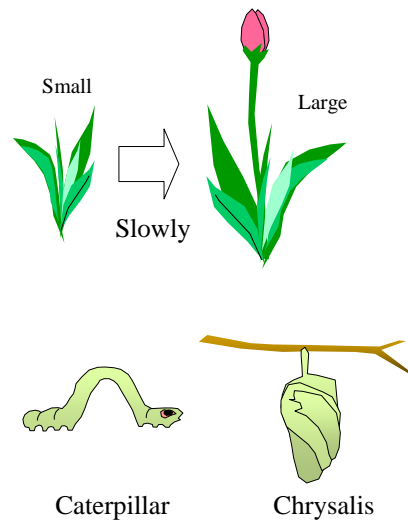
Disposable Objects
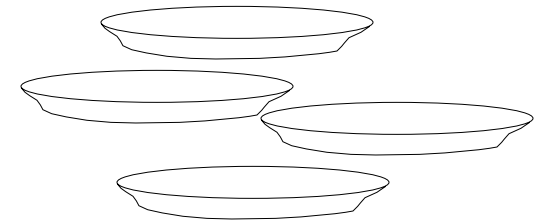
A lot of paper plates= 1 porcelain plate

Separate in Space -- Where must the properties exist at the same moment in time?

Two Objects

- **Two** objects exist with conflicting properties.
- Can start by duplicating the object in question and then giving both the conflicting properties.

Round   Square

Sharp & Blunt

Conductor

Insulator

High Flame   Low Flame

Coarse Spray   Fine Spray

Rough

Smooth

Discrete

Continuous

A+   B -

Org A +   Org B -

Doc +   Doc -

Message +   Message -
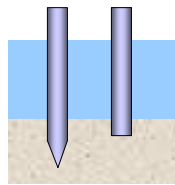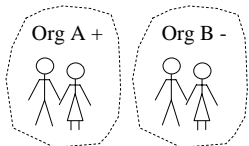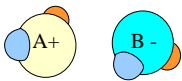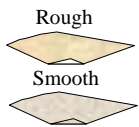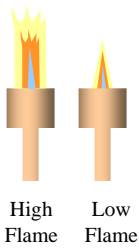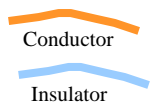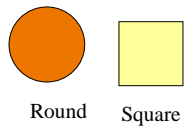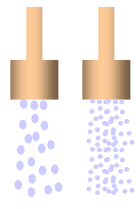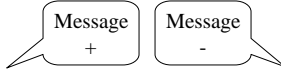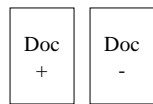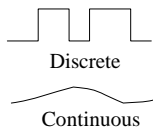
Extraction

- Separate out the **part** of the element that causes or receives the most harm. Make it as small as possible.
- Separate Parts may still interact through a field. Identify the Field

Square   Round

A+   B-

Sensor   Electronics

Hot   Cold

In Acid

Stirrer

In Inert Environment

No Contact

Contacts

Society   Criminal

message   extract

Doc A +   Doc B -
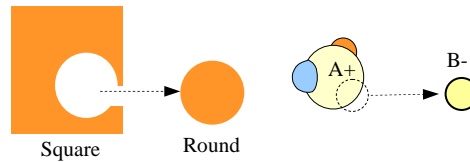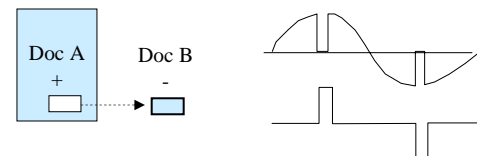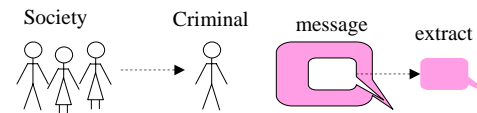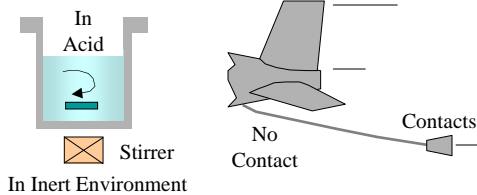
Guided / Nesting / Through

+   -

+   + -
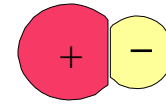
Through   Nesting

- **Duplicate or segment** the element.
- One element goes through the other element
- One element is guided or positioned by the other element.
- One element nestles into the other
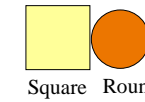
Square   Round
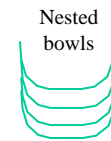
Nested bowls
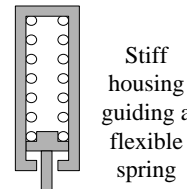
Stiff housing guiding a flexible spring

Sharp pile guiding a blunt pile

A+   B -

Covalently Bonded

Org A +   Org B -
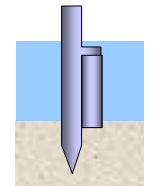
Co-located Groups
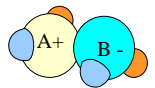
Message +   Message -
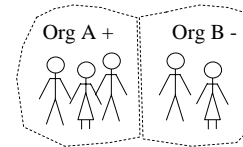
Back to Back Opposing Messages

Conductive brushes guided by insulating commutation sectors

Doc +   Doc -

I24
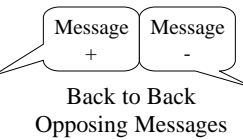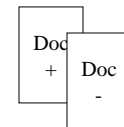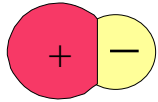
Attached

- One element has the desired property. It is **attached to** another element, having the conflicting property

Inert Carriers
Dual States-same material
Dual Phase Substances
Thin Films
Paint

Square   Round
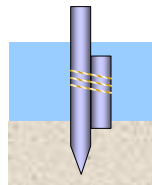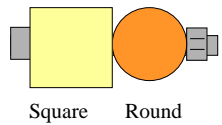
Blunt & Sharp
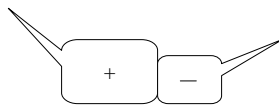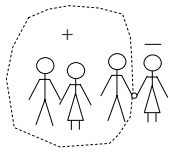
Conflicting Messages
are Attached

Bill +

Amendment

Diaper

Waterproof   Absorbent

Writes

Erases
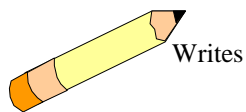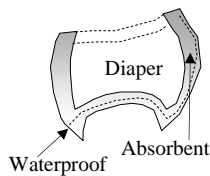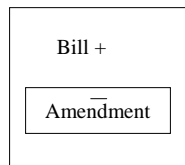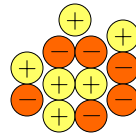
Mixture

- A mixture is made of elements having conflicting properties
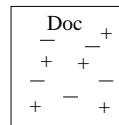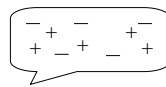- Consider finer and finer scales down to sub-atomic particles

Multi Fiber Fabrics
Multi Property Laminates
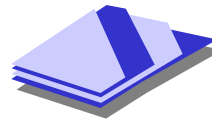
Laminates

Square & Round

Doc
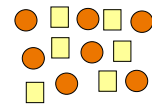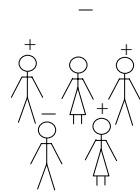
Two fiber types

Non-Uniform
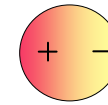
- **A single element** has both conflicting properties. (It is not uniform)
- Consider a smooth transition between conflicting properties
- **INPUT / OUTPUT**--The input has one property, the output the other

Transformers(electric, levers, etc.)
Standing Waves
Concentrated Additives
Especially active Additives

Round   Square

Fence

High
Frequency   Low
Frequency

Tall   Short
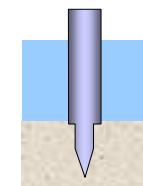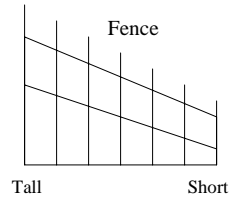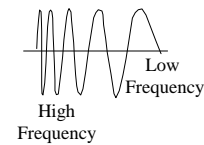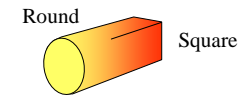
Blunt & Sharp
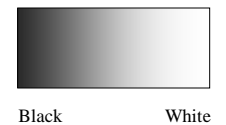
Black   White
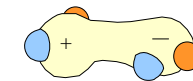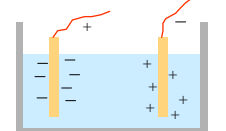
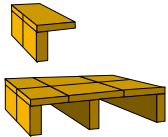Bi-Property Molecule

Slow

Fast
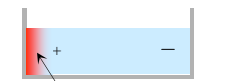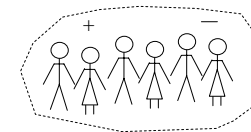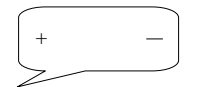
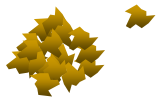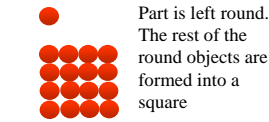Highly active additive

I25

Part is Merged
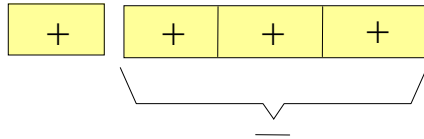
- Multiply or segment the elements
- **Merge** some of the multiplied or segmented elements to give them the conflicting property
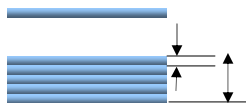- The parts not merged have the conflicting property of the merged parts

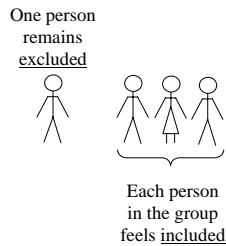Massive table from light parts. One light segment remains

Part is left round. The rest of the round objects are formed into a square

Large object made from many small objects. One small object remains separate

Thick object made from thin parts. One thin object remains

One person remains <u>excluded</u>

Each person in the group feels <u>included</u>

Part Carried
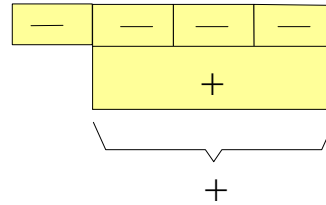
- Multiply or segment the elements
- Several objects with one property are attached to another object having the conflicting property.
- The parts without the carrier have the conflicting properties of the parts with the carrier
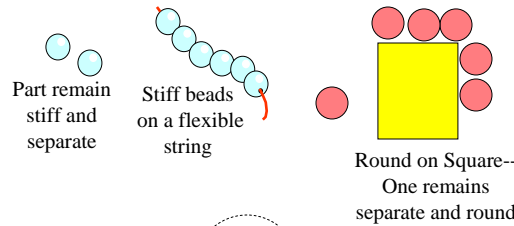
Part remain stiff and separate

Stiff beads on a flexible string
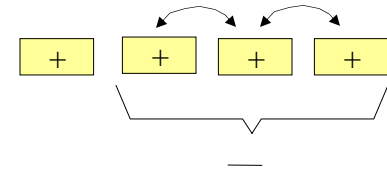
Round on Square-- One remains separate and round
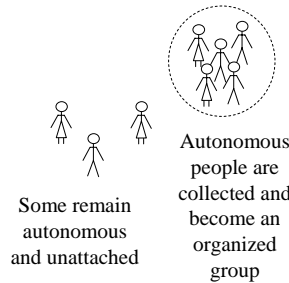
Some remain autonomous and unattached

Autonomous people are collected and become an organized group

Flexible fibers bound in in stiff sheath--some of the fibers extend and are flexible

Part Interacts

- Multiply or segment parts
- Make some of the parts interact thus giving these parts the conflicting property
- Interact:
  - Parts Adhere
  - Parts Nestle into each other
  - Parts Shaped to Inter-link
  - Parts linked by transmission elements
  - Parts interact by field (Consult table)
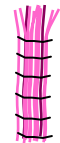 - Parts reshape the existing parts
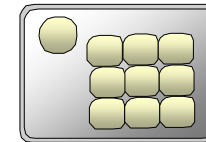
Several rolls stick to each other in a <u>square</u> group. One remains separate and <u>round</u>.
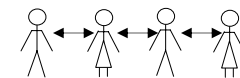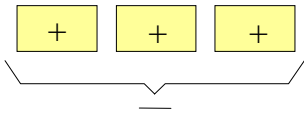
Each <u>trainee</u> in the group educates each other.
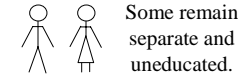
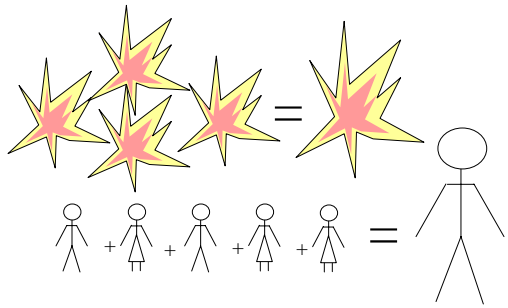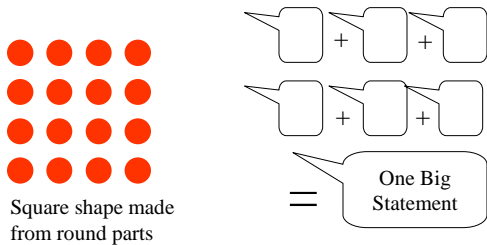Some remain separate and uneducated.

Flexible fibers partially bound in stiff bundle--some of the fibers extend and are flexible
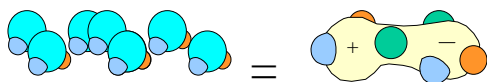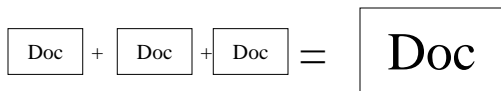
I26

Multiplication

- **Multiply** the object and **separate** in space. Arrange so that the multiplied parts have the conflicting properties of the whole
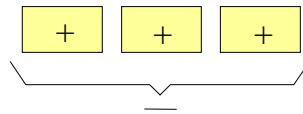- Scale down multiplied versions if necessary

Square shape made from round parts

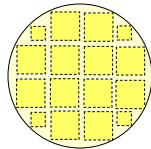Many small people can do the work of one large one

Many sulfuric acid molecules
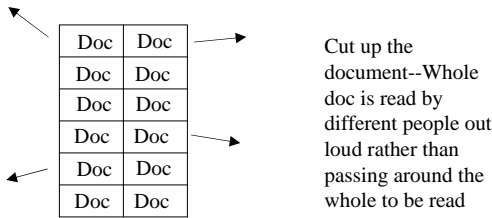
Ion exchange membrane molecule

Segmentation

- **Segment** an object having one property into objects with the conflicting property

Small squares cut from a large round piece

Solid = hard to dissolve
Particles = dissolves quickly

Cut up the document--Whole doc is read by different people out loud rather than passing around the whole to be read
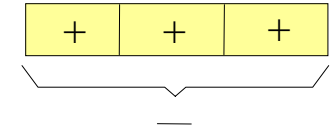

Centrally organized group becomes collection of autonomous individuals when separated and given rules
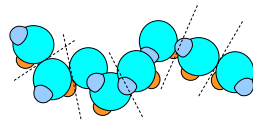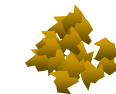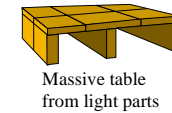

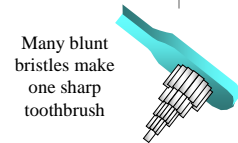Molecules after cleaving have opposite property of whole molecule
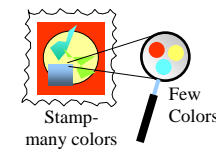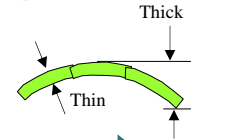
Merging

- **Merge** Multiplied or Segmented parts. The merged whole has the conflicting property of the individual parts
- POROUS MATERIALS (Many Small volumes = large volume)
- EXCESSIVE ACTION (Uncontrolled + Uncontrolled = Controlled
- BLESSING IN DISGUISE multiply a harmful variable and then arrange and merge to make useful
- FRACTALS Consider Fractal constructions

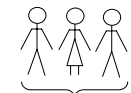Massive table from light parts

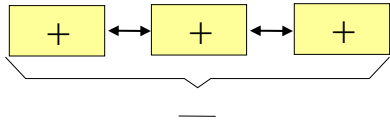Large object made from many small objects

Stamp-many colors

Few Colors

Many inflexible coils = flexible

Square shape made from round objects

Thick object made from thin parts

Thick

Thin

Many blunt bristles make one sharp toothbrush

Each person is <u>uninformed</u>
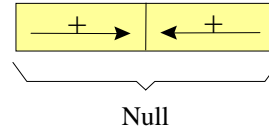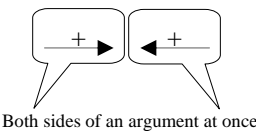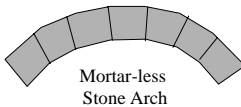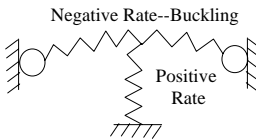
The group is <u>informed</u>

I27

Interacting

- **Multiply or Segment** the main object
- The parts and the whole have conflicting properties. The the parts interact (control each other)
  - Parts Adhere
  - Parts Nestle into each other
  - Parts Shaped to Inter-link
  - Parts linked by transmission elements
  - Parts interact by field (Consult table)
- BLESSING IN DISGUISE multiply a harmful variable and then arrange and interact to make useful

Flexible Chain from Stiff interacting Parts

Square from round with Springs

Part of picture

Whole picture

Transfers No Moment

Transfers Moment

Doc — Doc

Changing one changes the other

Individuals know little

High velocities

Zero Velocity

Group know a lot
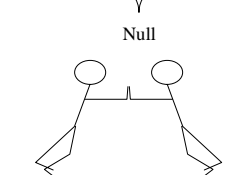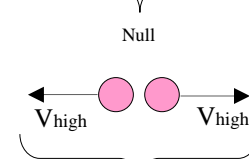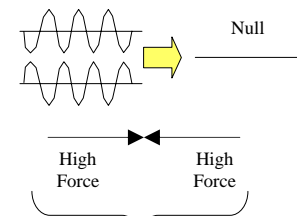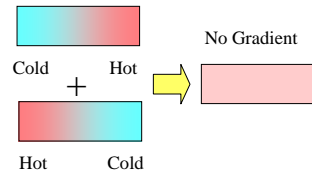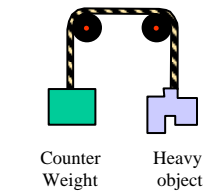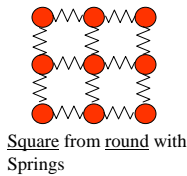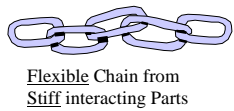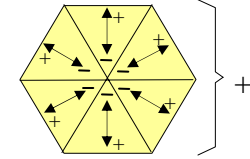
Countering

Null

- Two strong actions give a null action. Typically used with fields and movements
- Does the variable have direction or can it be changed in some way to have direction?
- Draw the field gradients or vectors. Can elements be oriented such that the fields overlap, counter or otherwise nullify each other? (COUNTER WEIGHT) Can the elements **Butt or Tension** each other? (Consider a **transmission** between elements).
- NEGATIVE + POSITIVE SPRING RATE
- NEGATIVE RATE CHANGE OF LEVER ARM

Counter Weight   Heavy object

Cold   Hot   No Gradient

Hot   Cold

Negative Rate--Buckling

Positive Rate

Null

High Force   High Force

Null

Mortar-less Stone Arch

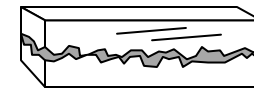V_{high} V_{high}

Null

Both sides of an argument at once

Organizations strengths pitted against itself

Hiding

- Multiple elements are involved. Each element has an undesirable feature.
- Does any part of the object have the **desired feature**, even in the slightest degree?
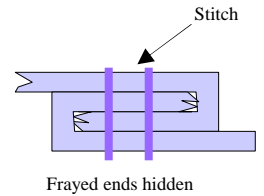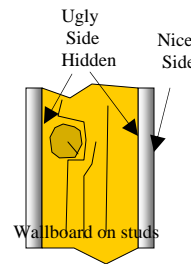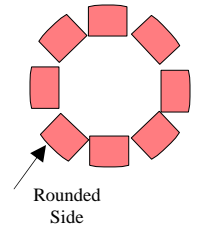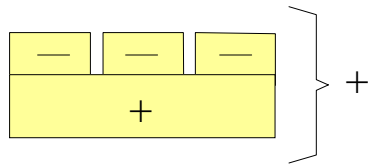- Merge **2 or more** elements and orient them in such a way that the undesirable feature is **hidden**, (at least functionally).
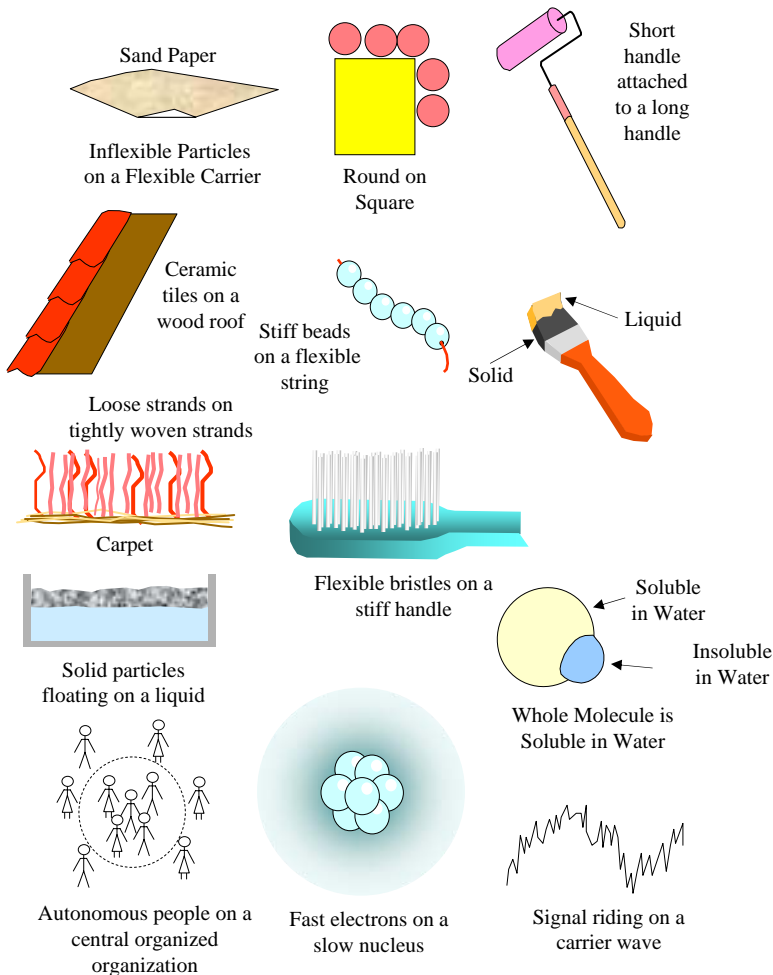
Smooth Object from Partially Rough Objects

Rounded Side

Ugly Side Hidden   Nice Side

Stitch

Wallboard on studs

Frayed ends hidden

Not messy bread   Messy fixings

Ham Sandwich
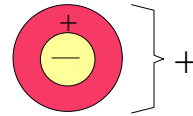
Can top is sharp and not sharp

I28
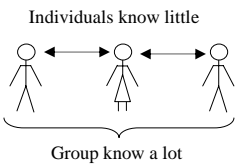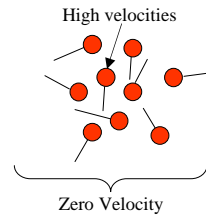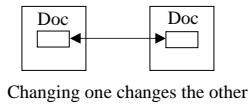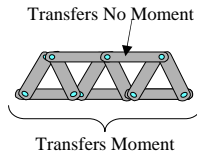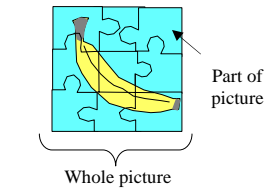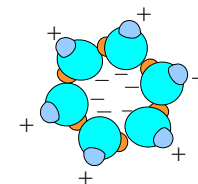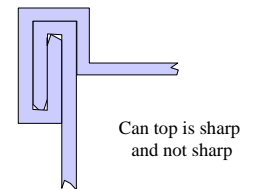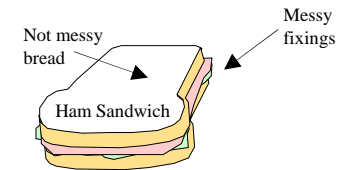
Carrier

- One or more objects with one property are attached to another object having the conflicting property.
- The whole takes on the property of the second object
- COMPOSITE MATERIALS

Sand Paper

Inflexible Particles on a Flexible Carrier

Round on Square

Short handle attached to a long handle

Ceramic tiles on a wood roof

Stiff beads on a flexible string

Liquid

Solid

Loose strands on tightly woven strands

Carpet

Flexible bristles on a stiff handle

Solid particles floating on a liquid

Soluble in Water

Insoluble in Water

Whole Molecule is Soluble in Water

Autonomous people on a central organized organization

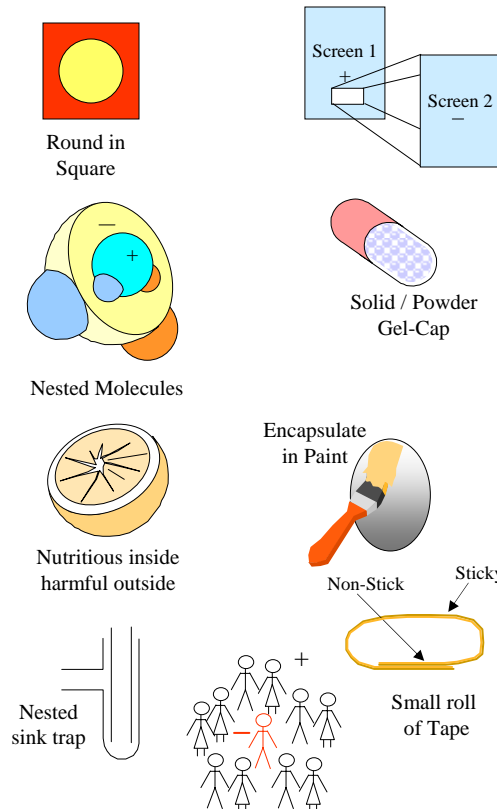Fast electrons on a slow nucleus

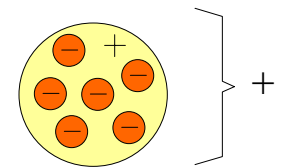Signal riding on a carrier wave

Nesting

- Separate into two elements with opposing properties. Nest the elements
- The whole has the opposite property of the nested element

Dual Phases-Change of State
Foams
Porous materials
Paint
Inert Environments

Round in Square

Screen 1

Screen 2

Solid / Powder Gel-Cap

Nested Molecules

Nutritious inside harmful outside

Encapsulate in Paint

Non-Stick

Sticky

Nested sink trap

Small roll of Tape

Mixture

- Elements having one property are mixed with a medium having the conflicting property
- The whole generally has one of the properties of one constituent for one situation and another for another situation
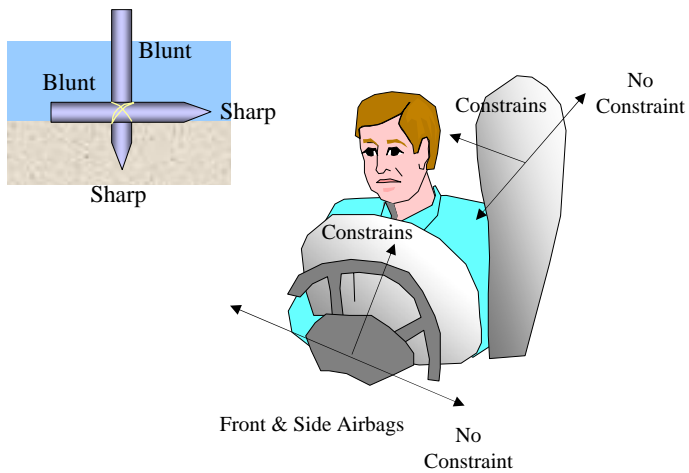- Consider finer and finer scales down to sub-atomic particles

Fabrics and Matrix
Mixtures of Different Molecules
Gels (Liquids + Solids)
Pastes (Liquids + Solids)
Foams (solid or liquid)
Capillary Structures (Solid + Liquid)
Components of Solids or Liquid

Laminates with Liquid layers

Square & Round

Fiber in a matrix

Solid + Liquid = Gel
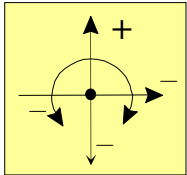
I29
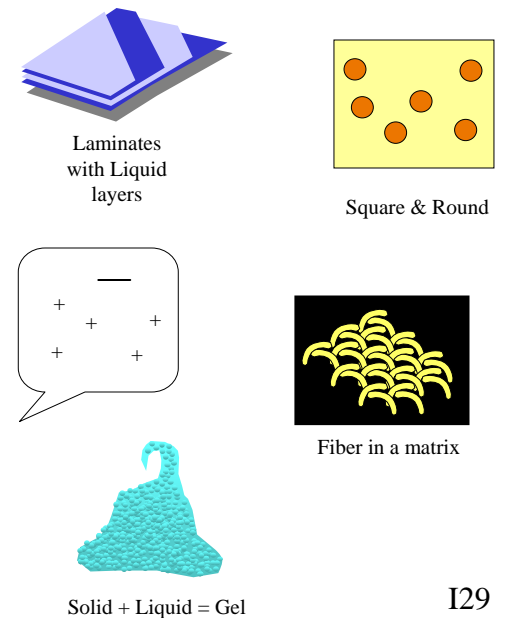
Complimentary Directions
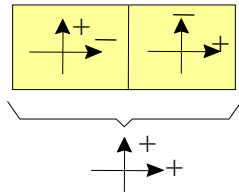
- Does each element come with one property in one direction and the other conflicting property in the other?
- Can the variable be oriented in a direction, such as force or velocity?
- Do any other directions have the conflicting property?
- Combine and orient elements in complimentary directions, the whole now has the required property in both directions.
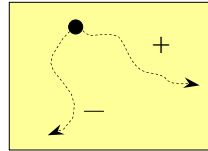

Blunt

Blunt

Sharp

Sharp

No Constraint

Constrains

Constrains

Front & Side Airbags

No Constraint

Separate by Direction Can there be opposing properties in different dimensions?

Direction

• Does the object have a desirable property in one direction and not in the other? Can it be made to?
• Identify the two functions that it must perform. Orient the object so that it performs one function in one direction and the other in the other direction
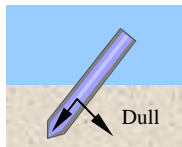
Dull

Sharp

Square

Round

Short

Long

Broad Span

Shallow

No movement

Moves

Many

Few

Smooth

Rough

Grater

Stiff

Flexible

String

Path

• Can the object operate along a path with two end points?
• Can the feature be envisioned as a path with two end points?
• Consider paths in other dimensions
• EQUIPOTENTIALITY: In a potential field, limit position changes against the potential gradient. For example, eliminate the need to raise or lower objects against gravity. Moves (+) rotationally but No Movement (-) up or down.

Allowed to turn while driving

Constrained while supporting

Round Path

Square Path

Short Path Through Board

Long Path Around Board

Sidewalk

Cracked and not cracked

High Work

Low Work

Potential Lines

High Heat Differential

Low Heat Differential

New Dimension

• Does the object already have the desirable property in one dimension (plane, object intersection) and the conflicting one in another?
• Can the object be formed to be this way?
• For example, a city is large in only one plane
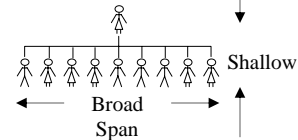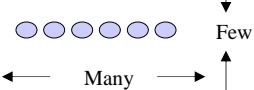• **Consider moving to a new dimension**

Small

Big

Big

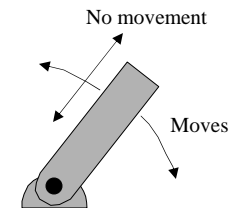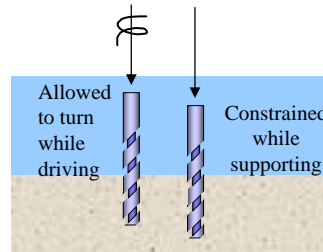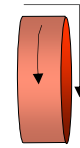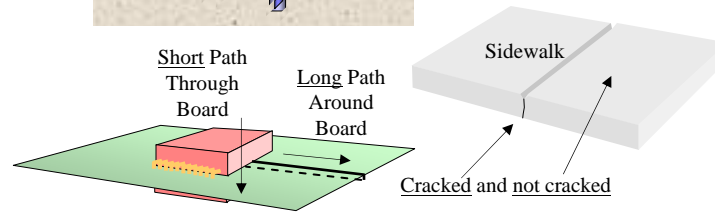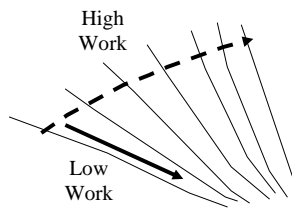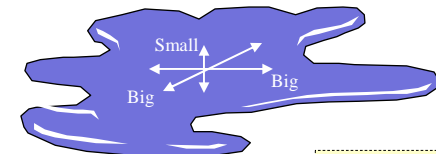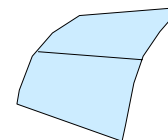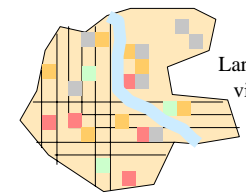Square in one section-Round in another
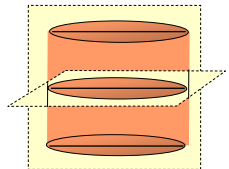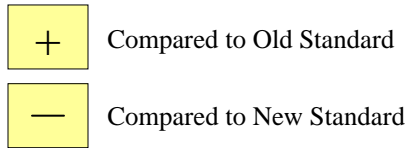
Line is Straight While Surface is Curved
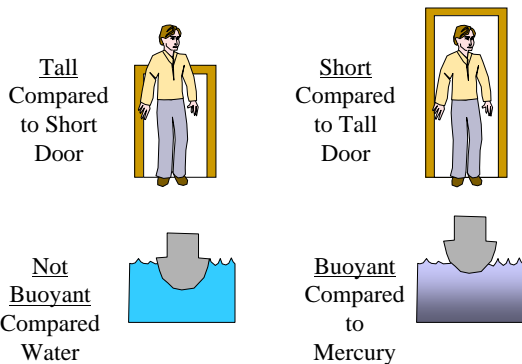
Large city when viewed from above

Small city area when viewed from side

I31

Separate by Perspective What if you look at it in a different way ?

By Comparison

+ Compared to Old Standard
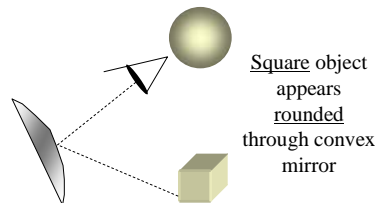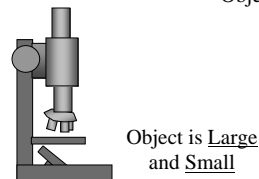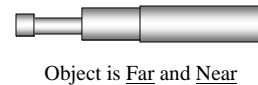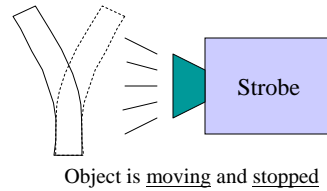
− Compared to New Standard

- What is the variable compared to? Change that object instead. (Change the standard by which it is measured)
- STRONG ACIDIFIERS: Strong compared to small objects and Weak compared to large objects
- Easy for you and Hard for me
- It is _____ in my eyes and _____ in someone else's eyes

Tall Compared to Short Door

Short Compared to Tall Door

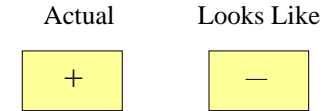Not Buoyant Compared Water

Buoyant Compared to Mercury

$$ Something can be Expensive or Cheap depending upon the number of functions that it performs. (Also may be expensive to one customer and inexpensive to another)

How you Look

Normally

+

How you Look

−

Strobe

Object is moving and stopped

Object is Far and Near

Object is Large and Small

Square object appears rounded through convex mirror

Looks Like

Actual

+

Looks Like

−

Using Paint: Use Paint or equivalent to make something look like the opposite of what it is

Marble and Wood

Using Camouflage: Use Camouflage to make something blend into its surrounding. It exists and doesn't Exist

Exist and Not Exist

Using a fake object: The fake object has the conflicting properties. Its construction is designed to deceive the senses

Blond and Black Hair

I32
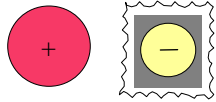
Facsimile

Original   Facsimile

- Make a **facsimile** of the element that requires conflicting properties.
- **Consider the following facsimiles:**

| Photographs |
| Movies |
| Paint Coverings |
| Molds |
| Time lapse photos |
| Impressions |

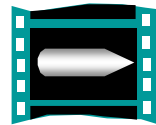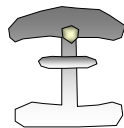| Silhouettes |
| Castings |
| Resists |
| Projections |
| Computer Model |

Round   Square (Mould)

Fast

Slow
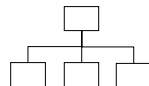
Immeasurable Reactions   Measurable Reactions

Difficult to Alter

Blah blah
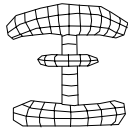
Meeting Discussions   Record of Meeting
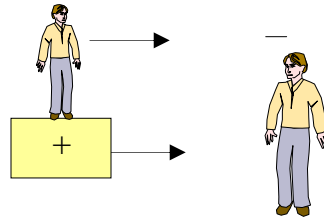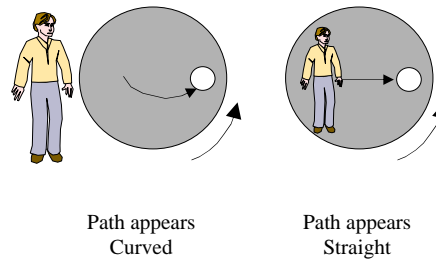
Rapidly Altered
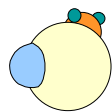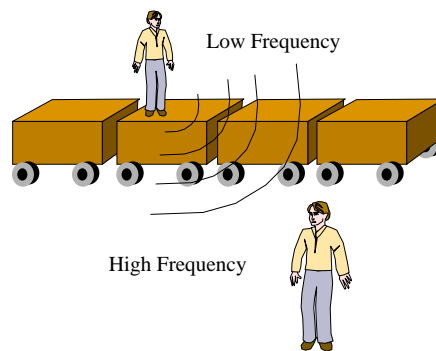
Virus   Vaccine

Frame of Reference

- Change your position, consider it from other points of view
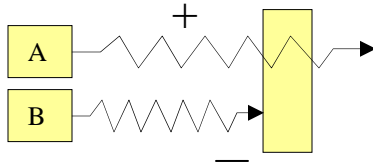- Move or rotate <u>with</u> the object in question
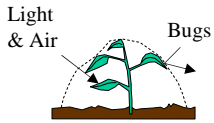
Path appears Curved   Path appears Straight
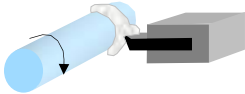
Low Frequency

High Frequency

Separate by Field Properties

Transparency

HINGED ELEMENTS: Selectively passes solids in motion. May stop gasses and liquids and small objects.
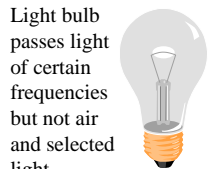
Light & Air / Bugs

MECHANICAL FILTERS (Sieves, Fabrics, Filament wraps, Molecular Sieves): passes liquids or gasses

Evolved gasses are stopped by foam during machining

FOAMS, LIQUIDS, FLOATING SOLIDS: Selectively passes solids in motion. May stop gasses other liquids and very small objects. Especially consider inert materials

Light bulb passes light of certain frequencies but not air and selected light frequencies

TRANSPARENT MATERIALS AND COATINGS (INCLUDING PAINT): Selectively passes physical fields. May be solids, liquids or gasses. May selectively pass certain frequencies. (Remember that all substances are transparent to gravity)

Frequency / Speed / Energy
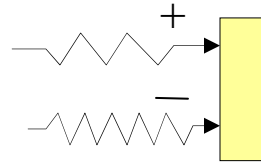
- The system has one effect when acted on by a field at high frequency and the opposite effect when acted on with low frequency
- The system has one property at one linear or rotational speed and the conflicting property at another speed or when stopped
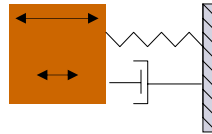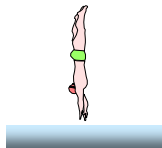
BY FREQUENCY: At low frequency the movement is large . At high frequency, the movement is small
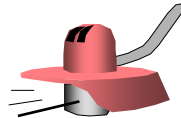
BY SPEED: String Trimmer: Stiff at high Speed but comes Flexible at low speed or when stopped
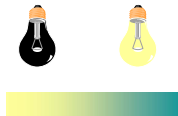
BY FREQUENCY: Fluorescent material only responds radiation at certain frequencies (Ultraviolet wavelengths)
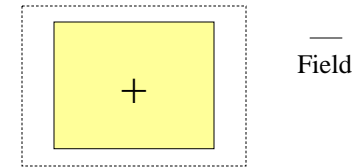
BY SPEED: When jumping from low heights, the water is soft. When jumping from great heights, the water is hard.
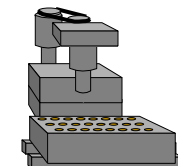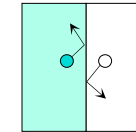
UNINTERRUPTED USEFUL EFFECT: When operating continuously, one machine may look like many machines
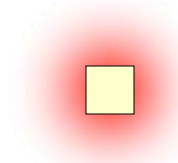
Separate Between Substance and Field
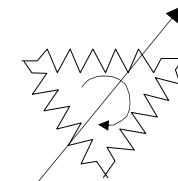
Separate Between Substance and Field

Field

- The Field has one property, the substance has the conflicting property

The Gasses are not mixed, but the heat energy is mixed

The Object is square but the heated area is round

The Field Coils remain stationary but the field rotates

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