Berfikir Kreatif bagi Para Engineers

Sumber :
Creativity in Science and Engineering:

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TOPICS

1.Creativity in Science and Engineering

2.How to Get a Good Idea

3.Colleagues

4.The Art of Obsession

5.The Technology You Use

6.Future Technology

SLAC: A Model for an R&D Laboratory

1. CREATIVITY IN SCIENCE AND ENGINEERING

Creativity

Creativity is sought everywhere: in the arts, in entertainment, in business, in mathematics, in engineering, in medicine, in the social sciences, in the physical sciences.

Common elements in creativity are originality and imagination.

Creativity carries feelings of wide ranging freedom to design and to invent and to dream.

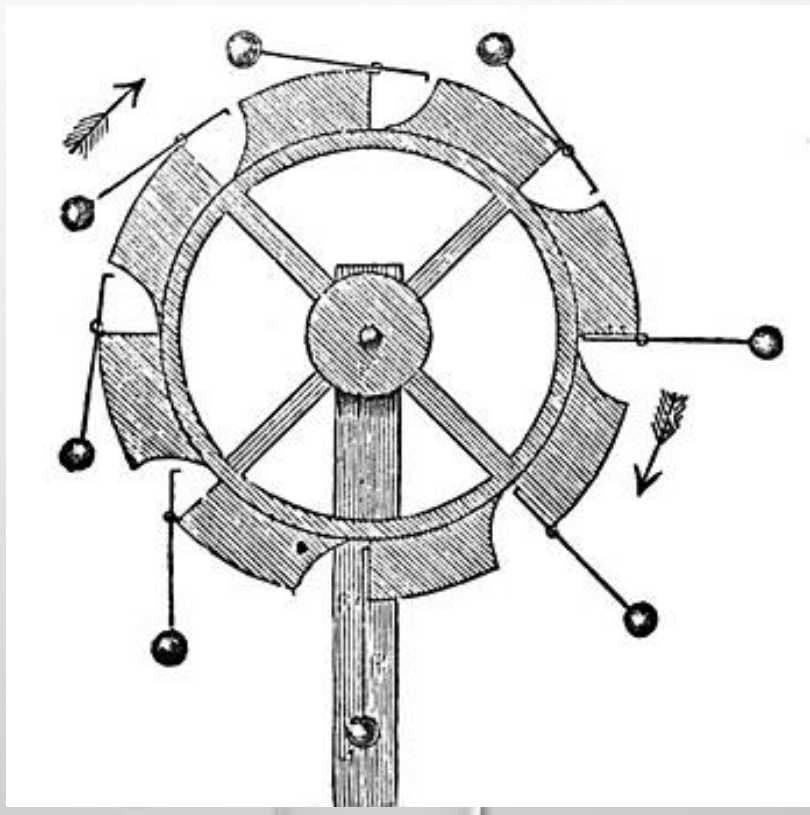
But in <u>engineering and science creativity</u> is useful only if it fits into the realities of the physical world.

Example of Constraint on Creativity

A creative idea in science or engineering must conform to the " law of conservation of energy (including the mass energy mc^2)".

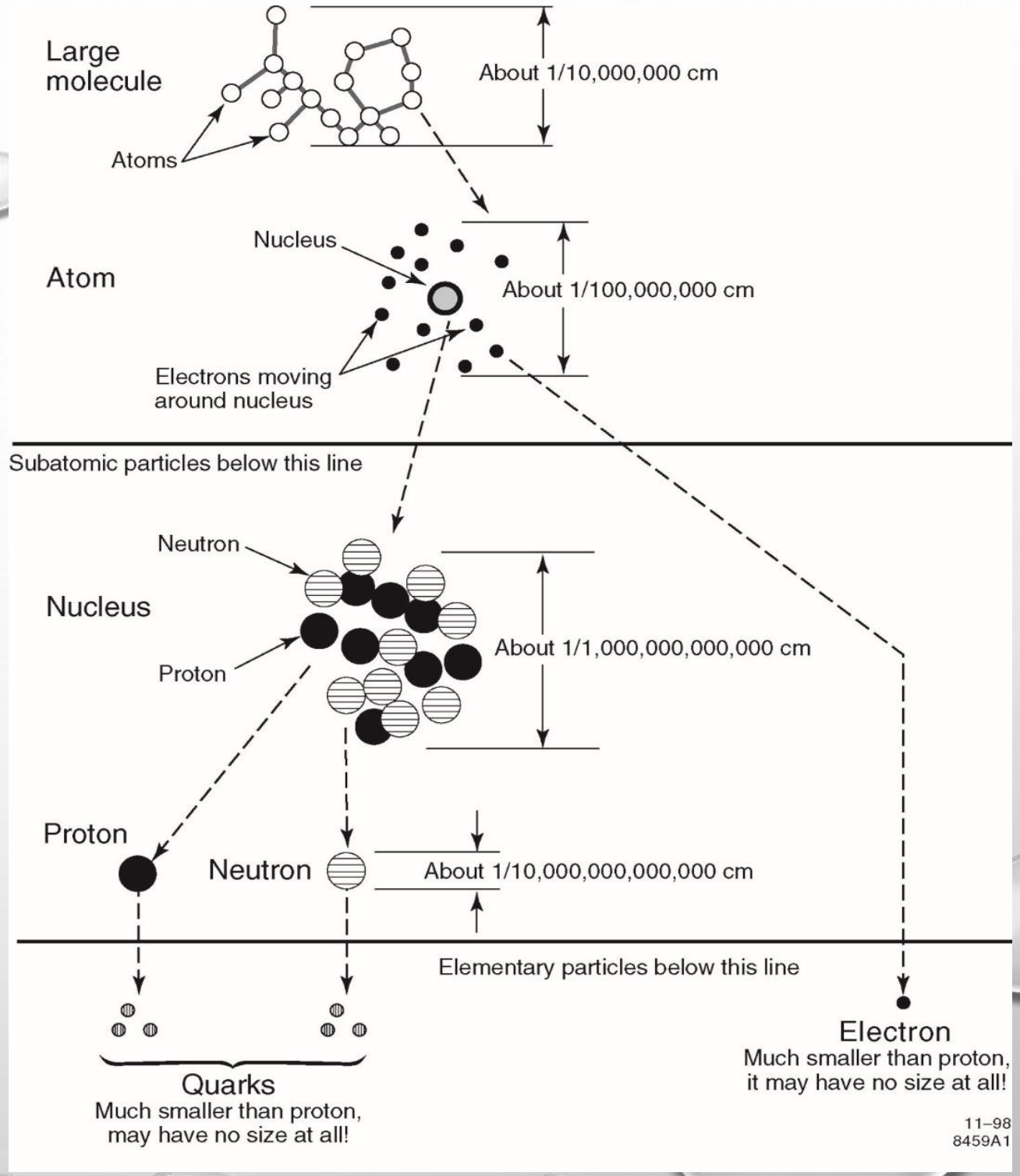
If an inventor thinks that they know how to violate the conservation of energy, he or she will have to overcome a vast amount of laboratory measurements and accepted theory.

A perpetual motion machine violates the conservation of energy



Example of Constraint on Creativity

A creative idea in science or engineering must conform to "our present knowledge of the nature of matter, unless we invent or find a new form of matter".



Example of Constraint on Creativity

A creative idea in computer science must "obey the laws of mathematics and logic".

```
> F:=x->x^2;
```

$$F := x \to x^2$$

```
> G:=x->x^3;
```

$$G := x \to x^3$$

```
> H:=(x,y)->(F(x)+G(y));
```

$$H := (x, y) \to Fx + Gy$$

```
> H(1,2);
```

9

```
> plot(H(1,y),y=-4..4);
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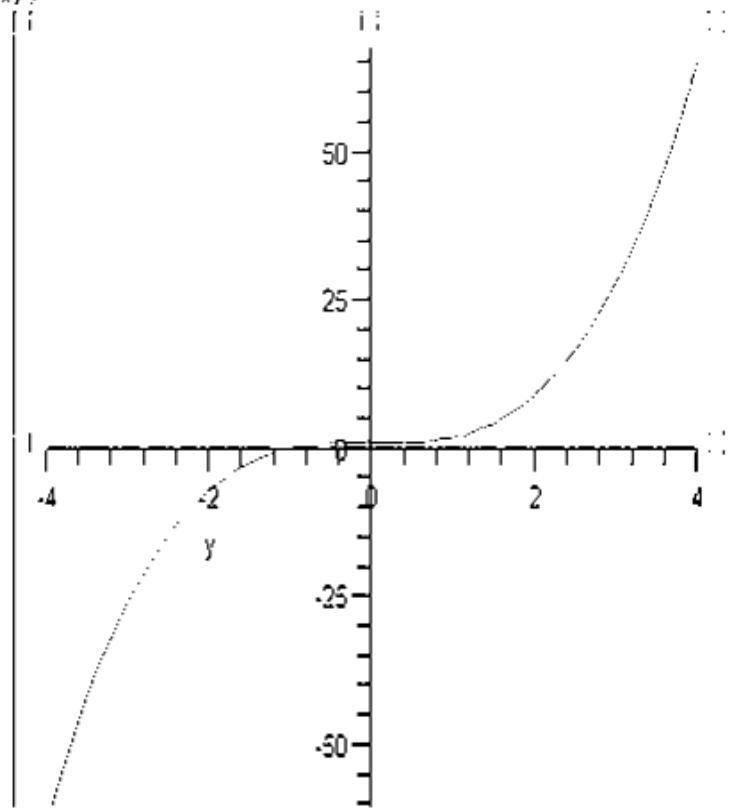
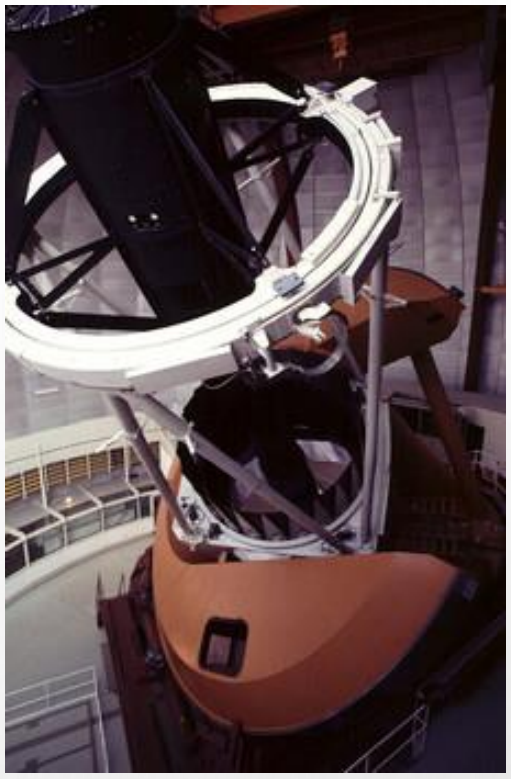


Observations and Rules of Thumb

Your idea may be in an area where the basic science or mathematics is not known, then begin by paying attention to the known observations and rules of thumb in the area.

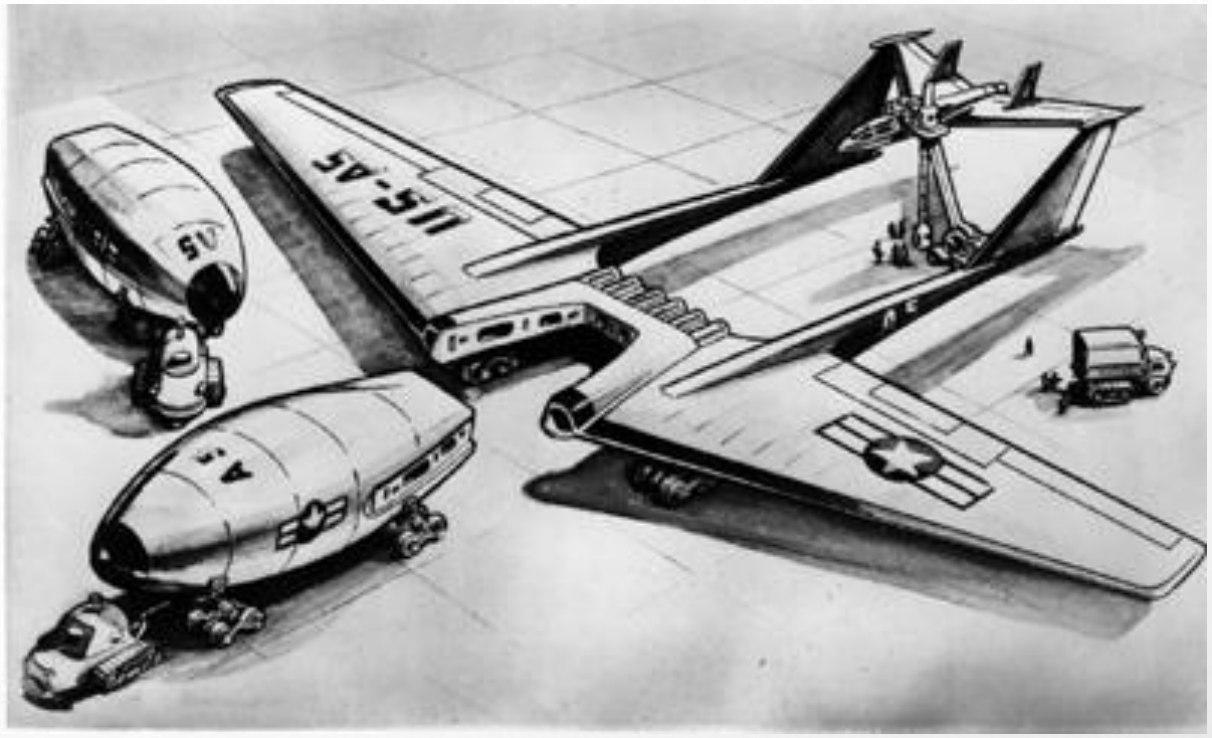
But the observations and rules of thumb may be wrong. Remember when doctors thought that ulcers were caused by spicy food and stress, but now know most ulcers are bacterial infections.



Practicality and Feasibility Constraints

Creativity in science, engineering and computer science is constrained by "feasibility and practicality".

Consider the work in the US on a nuclear reactor powered airplane in the 1950's



The reactor was to be in the front and the crew in the rear.

2. HOW TO GET A GOOD IDEA

For every good idea, expect to have five or ten bad or wrong or useless ideas

Phlogiston model of combustion

Astrology

Lamarckian evolution

Homeopathic medicine

Electromagnetic ether

Steam powered a flying automobile

Everyone will own automobiles

Cold fusion

Creative engineers and scientists get bad ideas along with the good ideas.

Nikola Tesla was a pioneer in long distance wireless, a good idea, but he also thought he could use the same tower to transmit large amounts of low frequency power.

Take account of your personality and temperament

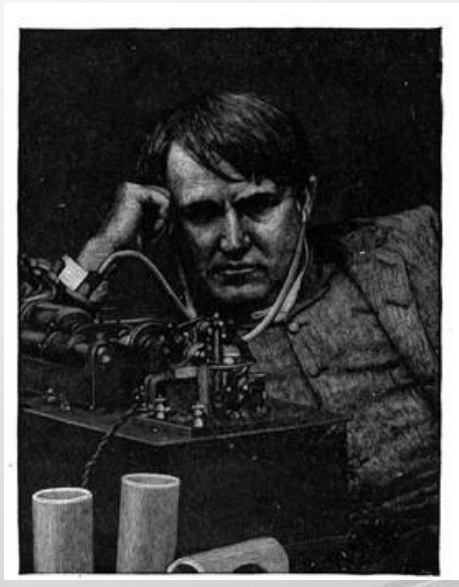
To get good ideas you must take account of your personality and temperament in choosing your technical field or science and your interests in that field. Be yourself.

Creative scientists and engineers have a many different types of personalities

Esaki

Yukawa

Hopper (compiler inventor)

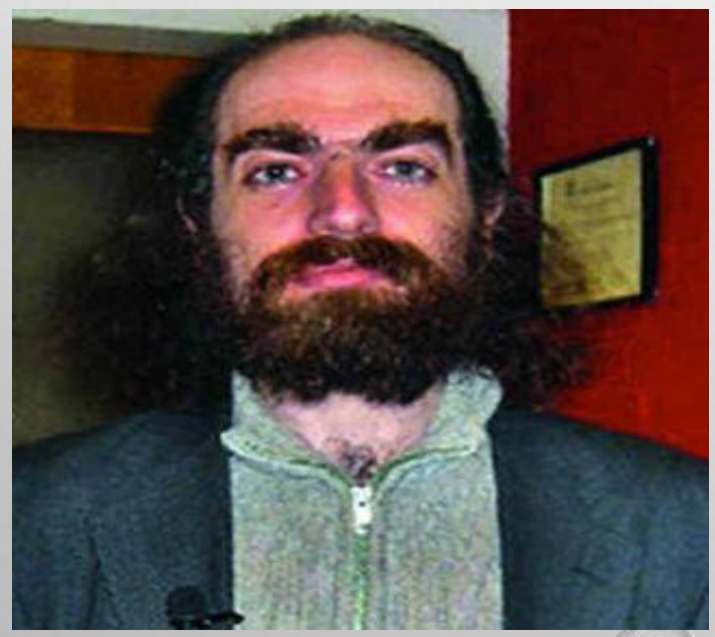


Edison

Curie

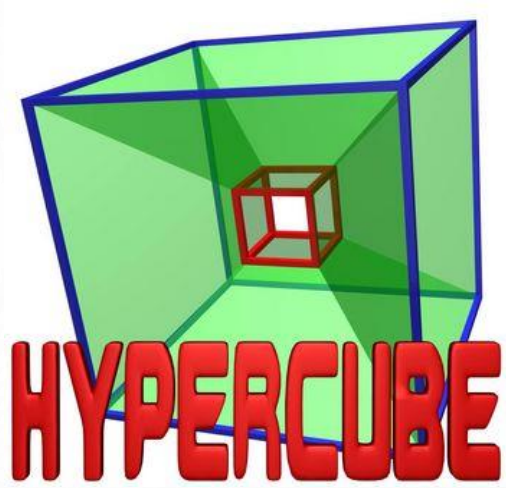
Backus, FORTRAN inventor

Turing



Perelman

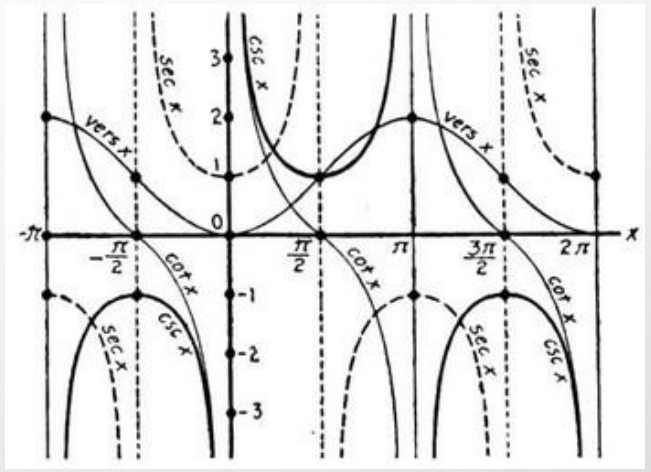
Yalow

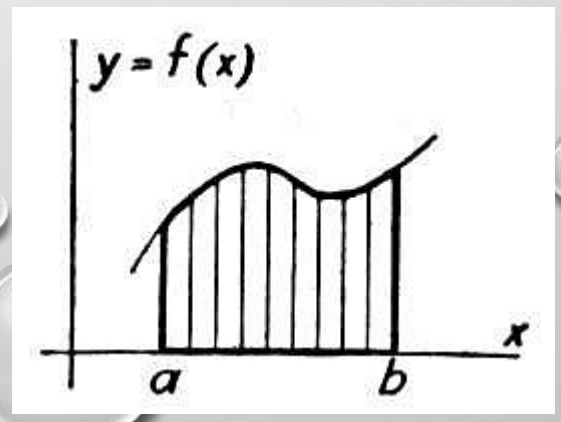


Mathematics and getting good ideas

Don’t try to fit yourself into any particular image of what a scientist or an engineer should be.

You don’t have to be a mathematical genius. There are lots of fields where mathematics is secondary. But you should be competent in mathematics.





Hand-on skills, laboratory skills and getting good ideas

Evaluate the extent of your hands-on skills and laboratory skills Are you good at working with tools, at building equipment, at running equipment – electronics, microscopes, telescopes ,,,?

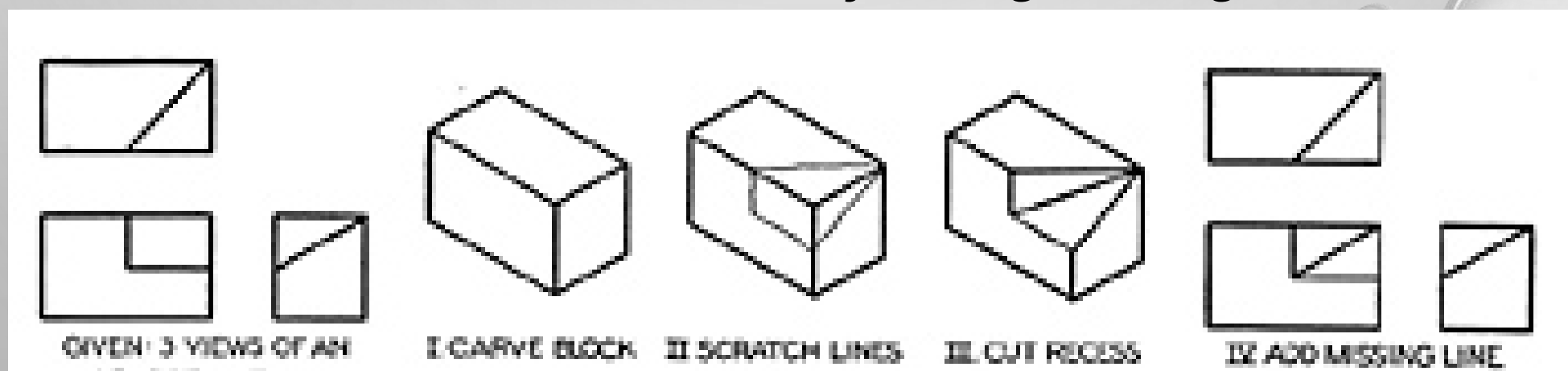
This is my strength. I am an experimenter in physics. because I like to work on equipment, because I am mechanically handy and because I get great pleasure when an experiment works. But hands-on skills do not have to be your strength. Isadore Rabi, who was my doctoral research supervisor at Columbia University in the 1950's had no laboratory skills. Yet Rabi won a Nobel Prize for advancing experimental atomic physics.

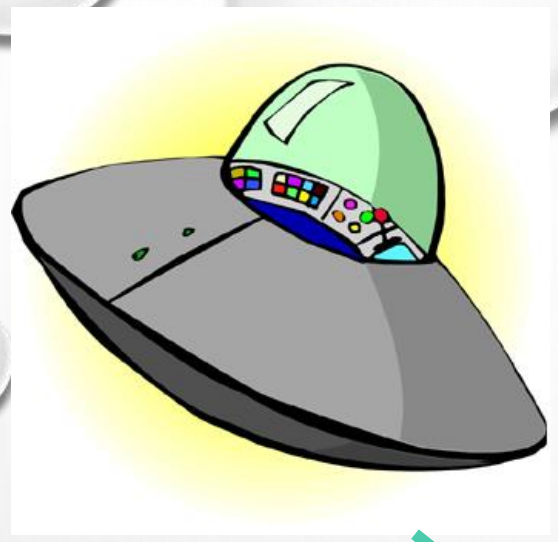
When choosing what you work on in engineering and science honestly evaluate the extent of your hands-on and laboratory skills.

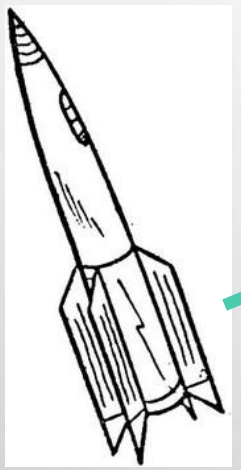
Visualization and getting good ideas

In engineering and scientific work it is crucial to be able to visualize how the work could be accomplished. The intended work might be the invention of a mechanical or electronic device, it might be the synthesis of a complicated molecule, it might be the design of an experiment to evaluate the efficacy of a new drug, it might be the full modeling of how proteins fold and unfold.

Different kinds of work require different kinds of visualization. Spread sheets or flow charts may be best. Drawings might be best. Always, the importance of visualization is to find the best way to proceed and to avoid mistakes and to perhaps find alternative solutions and related good ideas. Do not go into engineering or science if you are do not have visualization ability. Visualization is crucial for creativity in engineering and science







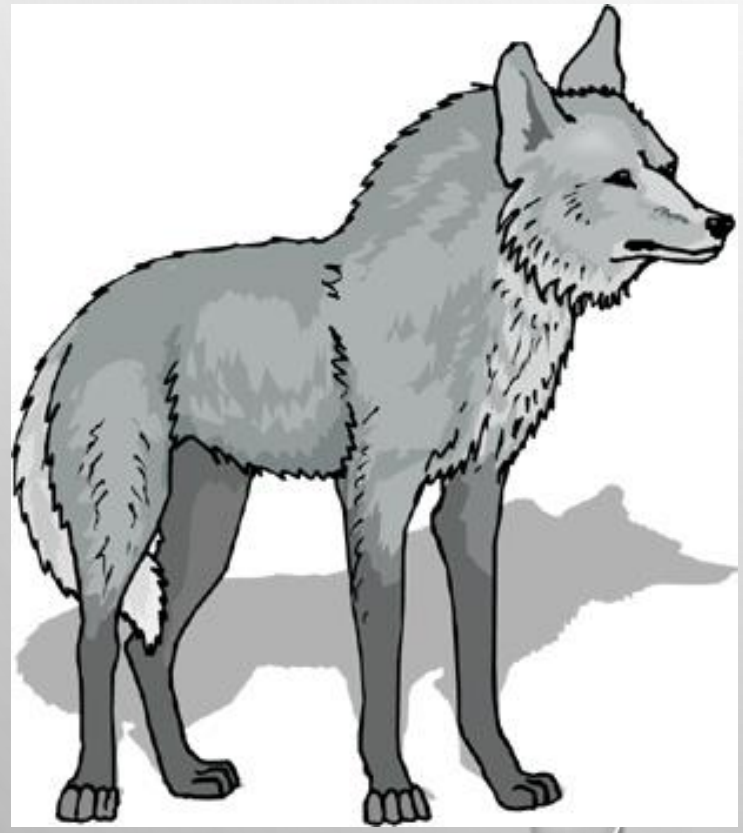
Imagination and getting good ideas

Imagination is a second crucial ability required to be creative in engineering and science, imagination with the constraints I have talked about: known physical laws, correct observation and experimentation, feasibility, practicality.

Begin with the far reaches of imagination at the science fiction level, then apply the constraints gradually.

Lone wolf or leader of the pack

There are two opposite personality traits that can contribute to getting good ideas. One personality trait is to be a lone wolf, a contrarian in your field.
The opposite is to lead the pack of colleagues and competitors. I prefer the contrarian style. If others are successfully developing a new technology I'd rather copy it or buy it.



Keep busy between good ideas by computing or designing or building even if it is routine.

Keep a notebook.