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**AGH UNIVERSITY OF SCIENCE  
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# **Essential Thinking. Introduction to Problem Solving Example Problems I**

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# Outline

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- 2 Introduction
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- 4 Three Further Example Problems
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- 6 Some Problems: Do Not Stop Thinking

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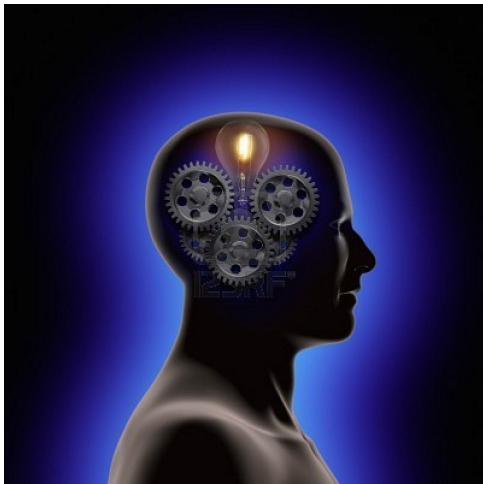
- 1 George Polya: *How to Solve it?*. Princeton University Press, 1945; PWN 1993. [http://en.wikipedia.org/wiki/How\\_to\\_Solve\\_It](http://en.wikipedia.org/wiki/How_to_Solve_It).
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# What is worth learning?

## A bit provocative position statement

- **Languages** — enable communication and knowledge representation;  
**Wievil Sprachen du sprichst, sooftmal bist du Mensch; Goethe**
- **Problem Solving** — analytical thinking;  
**cross-curricular competencies,**
- **Learning** — persistent learning, quick learning, focused learning, learning on-demand, ...

# Thinking — What is the Essence of it?



## Another Example: Four-Digit Palindrom Case

### Four Digit Palindrom

- a four digit palindrom: 1221, 7337, 2992,...
- observe:  $1221:11=111$ ,  $7337:11=667$ ,  $2992:11=272$ ,...
- **Hypothesis:** Every four-digit palindrom numebr is divisible by 11.

### Analytical thinking vs. brute search

- is the hypothesis true or not?
- try several examples; try to invent a **counterexample**,
- try to induce regularity — or chcek **all cases**?
- proove or disprove!

Analytical Thinking



Brute Search

## A cryptarithmic problem

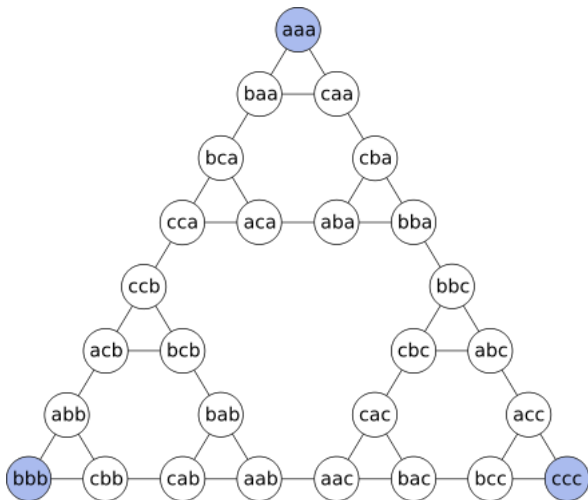
$$\begin{array}{r} \text{SEND} \\ + \text{MORE} \\ \hline \text{MONEY} \end{array}$$



## Towers of Hanoi



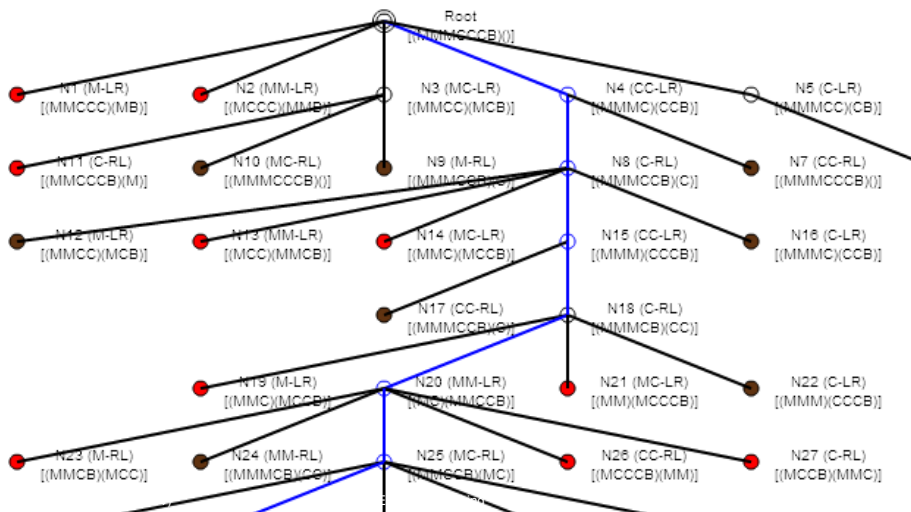
# Three generic examples



## Missionaries and Cannibals



# Three generic examples



## A Generic Problem Example

<http://freeweb.siol.net/danej/riverIQGame.swf>



## Another Example: The Zebra Puzzle

- a) Norweg zamieszkuje pierwszy dom;
- b) Anglik mieszka w czerwonym domu;
- c) Zielony dom znajduje się po lewej stronie domu białego;
- d) Duńczyk pija herbatkę;
- e) Palacz Rothmansów mieszka obok hodowcy kotów;
- f) Mieszkaniec żółtego domu pali Dunhille;
- g) Niemiec pali Marlboro;
- h) Mieszkaniec środkowego domu pija mleko;
- i) Palacz Rothmansów ma sąsiada, który pija wodę;
- j) Palacz Pall Malli hoduje ptaki;
- k) Szwed hoduje psy;
- l) Norweg mieszka obok niebieskiego domu;
- m) Hodowca koni mieszka obok żółtego domu;
- n) Palacz Philip Morris pija piwo;
- o) W zielonym domu pija się kawę.

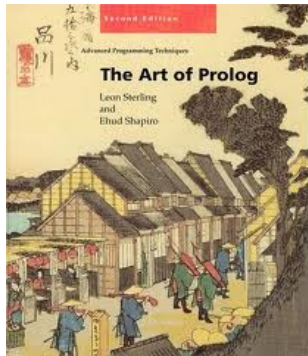
### Analytical thinking — problem solving

- basic problem solving method is **search**,
- **decomposition** is power!
- a stable, appropriate **search space** must be defined,
- one can use a **tree** or a **graph** as search model,
- one can use a **AND-OR tree** or a **AND-OR graph** for decomposition,
- a **search method** is necessary,
- **appropriate formalizm** is power!
- **constraints** are useful!
- **constraint propagation** is power!
- **heureka**: important, but how does it work?

Analytical Thinking



Brute Search





## Three generic examples: weighting

### 9 coins

- 9 identical coins; one is lighter
- how many weightings?

### 10 coins

- 10 identical coins; one is false
- how many weightings?

### N coins

- N identical coins; one is lighter
- 3 weightings
- How big N?
- How big is N in case we know only that the coin is false?

## Three generic examples: combinatorics

### Pages

- Book pages numbered with 2989 digits
- how many pages?

### Buckets

- Two buckets: 4 and 9 liters
- Produce exactly: 1, 2, 3, 4, 5, 6, 7, 8 liters

### Squares on a Chessboard

- A chessboard 8x8 available
- How many squares can be found?



## Three generic examples: planning

### Desert: how many days?

- To cross a desert: 9 days (+ return)
- Two man; each can carry food for 12 days
- Food can be stored and retrieved

### Raft + 3 + 2

- 3 man want to cross a river
- There are two boys with a raft of them
- The raft can carry one man only

### Missionaries and Cannibals: 4 + 4

- 4 missionaries, 4 cannibals,
- a boat for two,
- $M < C$  forbidden (M not 0)

## Desert: how many days?

- Give a polyhedron:
  - ▶ K - the number of edges,
  - ▶ N - the number of corners,
  - ▶ S - the number of walls.
- $N+S-K=2$ 
  - ▶ prove,
  - ▶ disprove