Innovative Thinking: Desired Skills and Related Activities

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Abstract

This paper describes a new interdisciplinary graduate course titled: “Innovative Thinking” aimed at enhancing students’ innovation-related skills as well as students’ reflections on the class. The main idea is to develop a student-centered environment that helps students to develop a can-do, proactive, innovative mindset; an environment that will light their spark of innovation, and provide them with resources to translate their ideas from paper to prototype. We have identified four major groups of relevant skills, namely, problem solving, “big picture”, personal and social skills, and used several different activities to try to boost them. A variety of projects and challenges, and multi-sensory activities were synthesized to create an empirical, authentic, and multi-disciplinary experience.

This effort is in line with our college longer term goal to infuse engineering curriculum with overarching traits of innovation, leadership, and entrepreneurship, so that at the end of their formal studies, the students will become “Innovation Ambassadors” who think and lead innovatively.

In addition to my interactive presentations on topics like different types of innovation, and actual innovations of the last century, I used Stanford University Educators’ Corner video clips on Creativity, Innovation, and Entrepreneurship. In addition, the students viewed and discussed innovation in video clips, from “Dead Poet Society”, “Who Moved my Cheese”, and “FISH.”

To achieve the goals of this course, i.e., enhancing innovative skills, the students were involved in multiple activities, among them:

• Team building and communication, for example, finding a way out of an imaginary electric maze, weekly team-based discussions of ideas, web submission of captions to the New Yorker Cartoon Competitions, and inventing games (show and tell)
• Problem solving activities, including solving multidisciplinary advanced brain teasers, and later discuss them in class
• Inventive projects, such as “warning system for those who do not wash hands before leaving a restroom”,” system that calls the elevator when a familiar person is approaching”, and “visual simulation of driving behavior.” Projects had specific deadlines and towards the end of the semester working prototypes had to be presented
• Presentations on “Innovative Ideas”, “Innovative People, Game or Movie”, “Innovative Company”, “Sustainable Innovation”, “Important Innovation”, “Innovation in Arts”, “Innovation in
Architecture”, “Innovation in Science”, “Innovation in Engineering/Technology”, and “Innovation in Business/Marketing”

- Book reading followed by class discussions, e.g., Blink, by Malcom Gladwell, Freakonomics, by Levitt, et al., The art of Innovation, by Tom Kelley, and The Five Temptations of a CEO: A Leadership Fable, by Patrick M. Lencioni.
- Invited speakers on topics such as Innovation and the Enneagram.
- Pattern breaking assignments, e.g., Drive home without exceeding the speed limit

## Introduction

"On such a flat earth the most important attribute you can have is creative imagination – the ability to be the first on your block to figure out how all these enabling tools can be put together in new and exciting ways to create products, communities, opportunities and profits. That has always been America’s strength, because America was, and for now, still is, the world’s greatest dream machine” (Friedman, 2006). To succeed in global competition it is increasingly necessary for all partners in the educational process to actively contribute to the necessary cumulative improvement. Empowering students to reach their full potential is consistent with the aims of education in a free society and congruent with the national goal of developing world class talent to enable the United States to maintain global technological and economic leadership. The keys to this can be found in human creativity supported by information technology and innovation.

This paper describes a new interdisciplinary graduate course IDS 6358 titled: “Innovative Thinking” aimed at enhancing students’ innovation-related skills (see syllabus in Appendix A). This multi-disciplinary, interactive, course provides a broad perspective of innovation as applied to Engineering, Science, Technology, Art, and Business. It introduces students to new and powerful tools to boost their creative and innovative thinking skills. It emphasizes team-based and hands-on projects and activities to stimulate innovation. The main idea is to develop a student-centered environment that helps students to develop a can-do, proactive, innovative mindset; an environment that will light their spark of innovation, and provide them with resources to translate their ideas from paper to prototype.

We have identified four major groups of relevant skills, namely, problem solving, “big picture”, personal and social skills, and used several different activities to try to boost them. See also (Radcliffe, 2005). A variety of projects and challenges, and multi-sensory activities were synthesized to create an empirical, authentic, and multi-disciplinary experience.

### The bigger picture

This effort is part of our college’s longer term goal to infuse engineering curriculum with overarching traits of innovation, leadership, and entrepreneurship, so that at the end of their formal studies, the students will become “Innovation Ambassadors” who think and lead innovatively.

Several different related courses, workshops, approaches and programs have been developed, implemented and assessed over the past years at FAU. Among these are:

1. “Eight-Dimensional (8D) Methodology for Innovative Problem Solving.” (Raviv 2002a) It is a systematic and unified approach that stimulates innovation by effectively using “both sides” of the
brain. It builds on comprehensive problem solving knowledge gathered from industry, business, marketing, math, science, engineering, technology, and daily life, and helps to quickly generate many unique “out-of-the-box” unexpected and high-quality solutions. The dimensions, namely Uniqueness, Dimensionality, Directionality, Consolidation, Segmentation, Modification, Similarity, and Experimentation provide problem solvers of different professions with new insights and thinking strategies to solve day-to-day problems that they face in the workplace. This comprehensive method has been taught as part of Inventive Problem Solving courses at the engineering education level, with heavy emphasis placed on hands-on learning.

2. “Inventive Problem Solving.” (Raviv 2002-2006) This course has been taught since 1996 several times a year for undergraduate and high-school students. It uses hands-on problem-based learning and emphasizes expanding creativity and thinking skills of the participants. The activities include, among others, 3-D mechanical puzzles, games, mind teasers, LEGO® Mindstorms competitions, and design projects. These activities allow for self-paced, semi-guided exploration, and help students to discover and explore creative, intuitive and common sense solutions. The students learn to appreciate diversity and teamwork, and communicate better. The course has been using a “playground for the mind” - a collection of more than 250 different 3-D mechanical puzzles that stimulate the mind. Observations of students “in action” clearly indicate upbeat attitudes, persistence, openness and willingness to take risks in a non-threatening relaxed environment.

Dr. Jim Komiak, IEWS Engineering Fellow, BAE Systems, and ABET reviewer wrote: “Please tell Daniel Raviv that I wish I had the opportunity to take all of his course. I'm already known for thinking out of the box and innovation, but imagine what I could do with that additional perspective !!!!”

A seven-year long assessment research that focused on quantitative divergent thinking looked for, given a problem, the average number of solutions per student, and the total number of different solutions. The pre- and post-test results clearly indicate a consistent and significant improvement in idea generation of students who took the class. They show an average increase in the number of ideas by a factor of nearly two and a half produced by approximately 130 participants.

3. “Innovative Thinking” is the course described in this paper.

4. “Bridge to Engineering” is a ready to launch 3-credit 6-module course aiming at bridging the gap between Science and Engineering. Students are engaged in a creative problem solving process from exploration to demonstration. They:
   - Explore historical, current, and new technologies,
   - Discover new knowledge,
   - Become more creative and inventive,
   - Interact with peers and team members and lead teams,
   - Share their knowledge and solutions with others, and
   - Put it all together for the betterment of the community.

5. Workshops. Dr. Raviv has been delivering workshops and seminars on Innovative Thinking to high level administrators in academia (e.g., workshops at ASEE, NCIIA), business and industry (e.g., at Pace Micro, Inc.), both nationally and internationally (e.g., University of Maryland, and The Technion, I.I.T. in Israel). He was a keynote speaker at an induction ceremony of the National
Inventors Hall of Fame (NIHF), consultant for NIHF, and the South Florida Regional Coordinator for Camp Invention, a program of NIHF.

6. “Students to Engineering Practice” (STEP). FAU is currently in the last year of an eight-year NSF-funded STEP Program. It is an industry-academia partnership that focuses on student development and workforce enhancement. It involves a unique combination of scholarship, academic support (tutoring, personal and academic guidance, oversight and counseling) and professional development. The interpersonal relationship that develops as a result of the additional oversight provided to these students helps create a feeling of belonging avoiding the sense of anonymity experienced by many students in large academic settings. The professional development component provides a student centered active learning environment in which participation and involvement are key. It also includes an internship experience and various workshops. The workshops address the so-called “soft skills” and other relevant issues not typically part of an IT or engineering curriculum. These interactive, innovative workshops are taught by practicing professionals whose real world involvement, language and style give them immediate credibility with students. These business and industry leaders help to expand the theoretical world of the college experience. Some of the proposed workshops would cover: (a) Teambuilding and Teamwork, (b) Creating and Maintaining Professional Portfolios, (c) Developing a Resume, (d) Making Effective Presentations, (e) Knowing Yourself – True Colors, (f) Developing a Career Plan; (g) Corporate Culture and You, and (f) Graduate School Opportunities.

**Class structure**

The class met once a week for three hours each time, and usually had most of the following elements:

- Group discussion of brain teasers (led by a group of students)
- Presenting cartoon caption winners (students)
- A creativity, innovation, entrepreneurship or marketing related video clip followed by a brief discussion (instructor)
- Teaming and communication activity
- Presentation and discussion (instructor)
- Presentation on innovation followed by Q/A and group discussion (students)
- Project discussion and presentation (towards the second part of the class)
- Book discussion (5 discussions during the semester; usually led by students)
- Invited speaker (4 times a semester)
- Behavior, mainly driving, assignment (students)

Homework assignments included: inventing, designing, building, testing, reporting and presenting projects; book readings; studying and presenting innovation topics in different disciplines; and brain teasers.
**Activities**

**Introductory exercises**

- An ice breaking exercise
  
  In an introductory game, each student (and the instructor as well) was asked to state the following:
  1. My name is…;
  2. I was… and did…;
  3. I am… and do…;
  4. I would like to be… and do…
  
  This turned out to be a bonding exercise, and sometimes resulted with unexpected emotions.

- Name Game
  
  Many students recognize each other by face but not by name, and this game helps to change that. In the beginning of the first few classes the students are asked to, one at a time, say their names, and something interesting about themselves. In addition, they are asked to state the first names of the students that spoke before them. (This of course does not apply to the first two students.) Participation of the instructor in the game helps reduce initial barriers.

**New Yorkers’ cartoon competition**

Students were asked to submit captions for the popular weekly web-based New Yorker’s Cartoon Caption Competition, both on-line and in class. Different groups of students reviewed the captions and each week announced the top three class winners. Cartoons used were by Tom Cheney, Drew Dernavich, Michael Crawford, Lee Lorenz, and Leo Collum.

**Mini assignments**

A set of activities meant to break driving behavior patterns exceeded expectations in terms of impact on students and the instructor. The assignments show participants how difficult it is to change our “normal” behavior. The following is a description of some tasks:

- At every stop sign: make a complete stop and wait at least 2 seconds
- Drive at a speed lower than the official speed limit (this was very difficult to accomplish)
- Wait 5 seconds before changing a lane
- Drive home safely using a different route even if it adds a few minutes to your driving
- Do not eat, drink, smoke, or talk on the phone while driving
- Do not listen to radio or CD/MP3 while driving (this turned out to be a very difficult task)
- Drive with both hands on the steering wheel
- Stop before each left turn (unless there is specific green left turn arrow signal)
- Drive as if a policeman is driving behind you (tough, but very efficient)
- Smile to and thank those who are unhappy with you driving
- Plan your trip: leave the university without driving through any speed bump (at least minimize the number of bumps)
Visitors

- Michael Levine, Inventor and Entrepreneur, talked about “Common Sense in Engineering Practice”
- Dr. Alex Padva, an expert in conflict resolution, introduced the Enneagram and its nine personality types
- Tal Raviv, student, introduced a new method for idea generation
- Paula Mendelssohn, a nutrition expert, introduced innovation in nutrition

In the future I plan to invite artists (for related activities see (Edwards, 1999)), musician, marketing and business people as well.

Videos on innovation

- DuPont innovative commercial series
- Short clip from the movie Dead Poet Society
- FISH
- Paradigm shift
- Paradigm shift related video: Who Moved my Cheese
- Innovation, Creativity, Marketing and Entrepreneurship interview clips, available on line from Educators’ Corner, Stanford University.

In the future I plan to use Cornell’s e-clips (a project led by Dr. Streeter), and other innovation clips from movies, for example Charlie Chaplin’s Modern Times silent movie.

A team in-class activity: The Amazing Maze

The most exciting team activity was The Amazing Maze. The apparatus and the rules are available on the web (Google: “electric maze”). Due to the high cost of the commercial maze, we designed and built our own version, and modified the rules as well. A short video of the game as we played it is available at: mms://131.91.97.42/axon/amazingmaze.wmv

Task: Starting from opposite sides of the maze, each one of two teams must find a way out of an imaginary electric maze, i.e., cross the maze to the “other side.”

Winner: The team that finishes the task first wins

Rules:
Planning phase:
- The teams have 5 minutes to plan a crossing strategy
- Discussion is allowed during this phase
- No stepping on maze during this phase

Action phase:
- Absolutely no talking
- Body movements are allowed
- No objects, no computing/communication devices, no paper, no writing, etc.
Each team must send an explorer first, i.e., a team member that explores a non-beeping “clear” path. A clear path must include all rows. No row skipping (but path may include horizontal movement (left/right))

After the explorer crosses, the team must cross. The team (or member(s) of) may follow the same exploration path or chooses a different/modified path

More than one team member on a maze at one time is allowed

No row skipping (but path may include horizontal movement (left/right))

If one of your team members steps on a beeping tile: all team members must leave the maze and go back to the starting point (via maze edges, without stepping on the tile)

Reflection session:

Includes discussion on “what went right”; “what went wrong”; “now that you played the game how would you do it differently”; “can you invent another game using the maze?”

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**The Amazing Maze**

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**Book reading and discussion**

Each group of students was asked to choose a book from the list and prepare a discussion session. The book *Blink* had to be read by all students by a specific discussion day; *Blink* discussion was led by the instructor.

*Blink*, by Malcom Gladwell

*Freakonomics*, by Levitt, et al.

*The Seven Habits of Highly Effective People*, by Stephen R. Covey

*Ten Faces of Innovation*, by Tom Kelley

*The art of Innovation*, by Tom Kelley and the Deep Dive story

*Five Dysfunctions of a Team*, by Patrick M. Lencioni

*The Five Temptations of a CEO: A Leadership Fable*, by Patrick M. Lencioni

*Multiple Intelligences: The Theory in Practice*, by Howard E. Gardner

*How to think like Leonardo De Vinci*, by Michael Gelb.

*Total Creativity*, by David Tanner
Puzzle activity

3D puzzles have shown to consistently lead the students to become more open-minded.

Brain Teasers

In class as well as assigned brain teasers are listed in Appendices C and D.

Just for fun

Occasionally, a spontaneous activity was introduced. During a class break and just two days before his marriage (“zero anniversary”), we asked a student to perform a task outside the classroom. When he came back the party began… lots of fun at 9 pm.
Funnies

Several short stories were used in class. They enhanced creativity and fun. Here are some examples:

- In my engineering design class, students were asked to submit ideas for their design projects, based on daily problems they encountered. One student raised his hand and said that he had a problem waking up each morning. Even with his alarm clock, and even when he used more than one clock or placed it far from his bedside, he would still oversleep. My co-instructor responded, saying that he once had the same problem but already solved it. “My wife pulls me out of bed every morning, and this makes sure I get to work on time,” he said.
  “Yes,” the student replied, “but I was looking for a less expensive solution...”
- When my sister came to visit, she brought my daughter chocolates, but warned her, “Don’t eat too much chocolate, because if you do you will grow up and be fat!” to which the three-year-old replied, “You must have eaten a lot of chocolate when you were a kid.”

Projects

Students were divided into groups of 2 each and were asked to come up with a hardware and/or software project. The theme for the projects was “behavior.”

The following suggestions for project topics were given.

- Visual simulation of bacteria communication
- Warning system for those who do not wash hands before leaving public restrooms
- System to notify elevators that a specific resident is arriving and where he/she wants to go
- Visual simulation of driving
- Set of implementable rules and visual simulation for “rage” driving
The following are the actual team projects. 1-3 slides from each team PowerPoint presentation are included. The projects were peer-reviewed (Appendix B).

1. A method to insure that people wash hands before leaving public restrooms

![Soap/Chip Dispenser](Image)

**Soap/Chip Dispenser**

A mechanical operated dispenser

2. A parking space notification system

**PROJECT: INNOVATIVE SOLUTION FOR CRITICAL PARKING AREAS**

*By Joe Moore, Art Rozenbaum, and Carlos Murillo*

![Automatic Parking Monitoring & Message Announcement System](Image)

3. A system that reminds user to lock doors

**Solution**

- A handheld keyfob that lights up depending on if the door in question is locked or unlocked.
- Buttons to activate the lights when a reminder is needed.
- Memory in the keyfob that keeps the information stored even when away from the door.
4. Cellular phone LCD display preserver

Cellular Phone LCD Preserver

Group C4-B
George Morales and Alex Kotlarchyk

5. A elevator system that calls the elevator for you

SMART ELEVATOR

Presented by:
Demetris Pentaras
&
Rodrigo Calderon
(Group C3-B)

18 April 2007

Approach of the Problem

- An external device is designed with a microprocessor, a Bluetooth receiver and a servo that can be placed close to the external call button of the elevator.
- Elevator users must have a Bluetooth Device (e.g. cell phone), in order the system to be functional.

Approach of the Problem (Contd…)

- The system was programmed so that it will recognize the name or address of the Bluetooth device carried by an authorized person whose intention is to use the elevator.
- For the people not carrying a Bluetooth device or not authorized, there will be a button that will allow them to call the elevator as normal.
6. A simulation for designing sidewalk paths

Optimal Walking Path Simulation – group C2B
This simulation models the formation of a desire path that is produced across a right-angle turn in a sidewalk leading to a building.

7. A simulation for multi agent obstacle avoidance

Collision Avoidance by Visual Looming

Objectives
- Use the looming effect on simple “creatures” to detect the presence of other creatures and make them avoid each others
- Implementation of several behaviors, tasks;
  - random displacement
  - crossing an area (a street for example)
  - simulate a group of fishes staying together and running away together when a predator comes near

8. A Warning system for those whom do not wash their hands before leaving public restrooms

SYSTEM TO WARN PEOPLE THAT DO NOT WASH THEIR HANDS!

By C2 Lochard Murat Lina Ortega
Goal

The goal of this project was to implement a model of a multi species environment as an application of synthetic ethology. Through a software simulation of this environment, we show that a stable living system can be easily upset and undergo massive changes as a consequence of exogenous influence. Changes in available living space, species migration, and biological interdependencies are all influences that are portrayed by the software model.
Presentations: Innovations in different disciplines

1. Innovations in architecture

<table>
<thead>
<tr>
<th>Innovation In Architecture</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A presentation by: François Gasnier, Paul Gomez, Jared Gordon, Nick Hanzimanolis</td>
<td>Architecture (from Latin, <em>architecture</em> and ultimately from Greek, &quot;a master builder&quot;, from ἀρχι- &quot;chiefs, leaders&quot;, &quot;builder, carpenter&quot;) is the art and science of designing buildings and structures.</td>
</tr>
</tbody>
</table>

2. Innovations in science

<table>
<thead>
<tr>
<th>Innovations in Science</th>
<th>Innovation in Biology</th>
</tr>
</thead>
</table>
| Eiki Martinson, Alex Kottarchyk, Irena Li, Philip Kunzelmann | • Tools are now available to make huge leaps in molecular biology  
• Biology has become a computer science problem  
• Bioinformatics: develops techniques (algorithms, etc)  
• Computational Biology: Tests hypotheses using these techniques |

| Florida Atlantic University | |

3. Innovations in engineering

<table>
<thead>
<tr>
<th>Innovation in Engineering</th>
<th>History</th>
</tr>
</thead>
</table>
| Pacemakers, Insulin Infusion Pumps, Hearing Aids and DDR Memory | • 1950's – Not totally implanted in the body. One end of a small wire, called a "lead," was implanted into the heart. The other end of the lead was connected to an external pacemaker that was AC powered. One serious drawback—patients could go only as far as their extension cord and a power failure was a constant concern.  
• 1957 – 1st battery powered pacemaker |

| | |
4. Innovations in business

**BUSINESS INNOVATION**

Presented by
Aquiles Perez
Carlos Murillo
Lina Ortega
Arthur Rozenbaum

Business innovation means:
- To do something substantially different
- A change that must increase value (customer/maker)
- Succession of many innovations grows the whole economy
- Innovation in process, products, and services (maintain balance)

Inspirational question
- what if...?
  - What if we paid our customers to buy it? —offering rebates
  - What if we shrink the chips? —Silicon valley inspiration
  - What if I could find some way to get paid for doing what I love?

Business innovation goal
- TO SOLVE A PROBLEM

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5. Innovations in Art

**Innovation In Art**

Primary Areas of Innovation

- 1) The technology revolution, specially, computers and micro-electronics.
- 2) The decline in the use of hand tools and conversely, a greater reliance on power tools.
- 3) Access to a tremendous range of materials and processes.
- 4) The issue and practice of safety, both personal and industrial.
Presentations: What’s innovation?

1. Innovative ideas

   ![Innovative Ideas Group A1](image)

   **Types of innovation**
   - Business Model innovation
   - Marketing innovation
   - Organizational innovation
   - Process innovation
   - Product innovation
   - Service innovation
   - Supply chain innovation

2. Innovative people, games and movies

   ![Innovative People, Game and Movies](image)

   **Outline**
   - Introduction
   - Innovative People
   - Innovative Game
   - Innovative Movies

3. Innovative companies

   ![Innovative Companies](image)

   **Introduction**
   - What makes a company innovative?
   - What different kinds of innovation exist?
   - Culture
   - Technology
   - Leadership
   - Business Operations
   - Marketing
4. Sustainable innovations

Sustainable Innovation

What is Sustainable Innovation?
- Sustainable Innovation is a pattern of social learning and problem-solving that is, itself, sustainable.
- To be sustainable, patterns of learning and innovation in human social systems must:
  1. Actually enhance their members’ ability to adapt.
  2. Be similar to patterns of self-organization for problem solving.
  3. Be transparent to and inclusive of stakeholders of all kinds regardless of their rank or standing in the system, and reject the notion that anyone can ever know anything with certainty.

http://www.sustainableinnovation.org

5. Important innovations

IMPORTANT INNOVATION

Presented by
Aquiles Perez
Carlos Murillo
Lina Ortega
Arthur Rozenbaum

Future expansions of the class

The future of the class will evolve towards solving a very specific problem: How to create an environment where students become better innovative thinkers. (Leach, E. & Little, T., 2005).

For engineers of the future, technical capability alone will no longer be a distinguishing feature. Clearly, a broader-based educational experience that teaches leadership, innovation, and entrepreneurship is required in an environment that enhances and extends “non-traditional Engineering” curricula. The “Stay within the lines,” “Do not break the crayon” and “Find the ‘right’ (and only) answer” attitudes are archaic. Instead, we must focus on thinking outside-the-box, taking risks, and being critical thinkers, creative and imaginative.

The so-called “soft skills” not previously associated with technical people have become vital workplace tools. New graduates must be prepared for a work environment that breaks down feelings of anonymity and encourages trust and respect for individuals and ideas. Graduates are now called upon to contribute to a dynamic global economy. They are sharing projects with colleagues around the world, and must exhibit managerial and entrepreneurial skills with a clearer understanding of other cultures and ethics (Chau, 2005).
We believe that a good way to proceed is to:

- Explore the most relevant skills to become more innovative
- Develop multiple hands-on activity-based Innovation Modules, each of which aims at specific skills, and with focused objectives and outcomes
- Aggregate the modules into Innovation Units that are actual classes required to be taken by the students in eight consecutive semesters
- Implement, assess, modify and disseminate the Innovation Units

The new student-centered environment will help students to develop a can-do, proactive, innovative mindset; an environment that will light the students’ spark of innovation, and provide them with resources to translate their ideas from paper to prototype. This will be achieved using modules composed of multi-sensory activities that will be synthesized to create an interactive, empirical, authentic, and team-based multi-disciplinary experience.

The environment will emphasize interaction with a cultural-, racial- and age-diverse community. It will be based on building-up interpersonal relationships that will develop as a result of additional supervision provided to the students. The feeling of belonging experienced by the students will serve to build self-confidence and self-reliance, i.e., qualities of individuals willing to take a risk, think outside-the-box, and develop new and unique solutions to problems and impediments that they will encounter.

Possible modules are:

- Community (e.g., help in teaching k-12 students)
- Camps (e.g., cross a real river with a large group and limited resources)
- Short courses (e.g., learn systematic methods for inventive problem solving)
- Competitions (e.g., build a robot that can autonomously exit a maze…first)
- Projects (e.g., invent a warning system that detects those who do not wash their hands before leaving the bathroom)
- Challenges (e.g., solve 3-D puzzles)
- Workshops (e.g., discover yourself and appreciate diversity)
- Meetings (e.g., learn about professional societies)
- Beyond engineering (e.g., listen to music and read books)
- Business and industry (e.g., work with industry)

Acknowledgement

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References


Appendix A: Course Syllabus

Florida Atlantic University
College of Engineering
Department of Electrical Engineering

IDS 6358 – Innovative Thinking

Description: This multi-disciplinary course provides a broad perspective of innovation as applied to Engineering, Science, Technology, and Business. It introduces students to new and powerful tools to boost their creative and innovative thinking skills. Participants re-discover their personal thinking preferences, identify and eliminate mental blocks, and enhance their communication and teaming skills. They explore win-win approaches to explore, define and solve problems of different disciplines. This interactive course uses team-based and hands-on projects and activities to stimulate innovation. The course is designed for graduate students and may be taken by senior undergraduates with permission of the instructor.

Catalog Description: This multi-disciplinary course provides a broad perspective of innovation as applied to engineering, Science, Technology, and Business. It introduces students to new and powerful tools to boost their creative and innovative thinking skills. The course is for graduate students and may be taken by senior undergraduates with permission of the instructor.

Course Prerequisites: Undergraduate degree in Engineering, Computer Science, Science, and Business

Course Co-requisites: None

Specialization: Creativity, Innovation and Entrepreneurship

Special Features: Invited Lectures, Interdisciplinary Nature, Team-based Projects, Hands-on Activities

Credits: 3

Required Texts:
Lectures are based on instructor’s notes and selected chapters from recommended texts.

Recommended Texts

**Course Objectives:** The objectives of this course are to introduce the “art and science” of innovation and develop creative and innovative thinking as well as teaming and communications skills. Specifically, the course deals with the understanding and application of:
- Building blocks of innovation
- Creativity and innovation styles
- Valuing teaming, communication, and diversity
- Risk taking, Paradigm Shift and Paradigm Paralysis
- Processes and methods of creative problem solving:
  - Observation, definition, representation, ideation, evaluation and decision making
- Systematic innovation
- Acting and marketing
- Intellectual property

**Topics:**
1. Making the case for creativity and innovation
2. Building blocks of innovation
3. Valuing styles, teaming and diversity in thinking
4. Setting the stage for success
5. Pattern breaking, risk taking, Paradigm Shift and Paradigm Paralysis
7. Creativity in problem solving
   - Problem observation
   - Problem definition and representation,
   - Systematic and non systematic ideation methodologies
   - Evaluating ideas and decision making
   - Implementation and marketing
8. Intellectual property

**Grading Scheme:**
- Participation: 20%
- Homework: 30%
- Projects and presentations: 50%

**Grading Scale:**

Note: No final exam
A (95%-100%), A- (90%-94%), B+ (85%-89%), B (81%-85%), B- (76%-80%), C+ (71%-75%), C (67%-71%), C- (62%-66%), D+ (57%-61%), D (52%-56%), D- (45%-51%), F (below 45%)

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Appendix B: Self and Peer Evaluation Form

Florida Atlantic University
Innovative Thinking – graduate Course

- Date: _______________________________________________________________
- Your Name: _________________________________________________________
- Project name: ________________________________ Project Code: ____________

Project Evaluation

PART I (fill it out only if it is YOUR project)

Rank each team member from 1(low) to 10(high)

Share them between the members of your group (according to effort, hard work, smart work, success, teaming, communication, peer help, etc.)

Your name: _______________________________________ Points: ___________
Team Member name: ________________________________ Points: ___________
Team Member name: ________________________________ Points: ___________
Team Member name: ________________________________ Points: ___________
Team Member name: ________________________________ Points: ___________
Team Member name: ________________________________ Points: ___________

PART II (fill it out only if it is NOT your project)

Rank the project and the team on each item from 1(low) to 10(high)

Effort (Hard work) ____________________________________________________
Innovation and creativity (Smart work)_____________________________________
Presentation____________________________________________________________
Overall________________________________________________________________

Comments about specific team members: __________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

What did you like most? ________________________________________________

Comments:
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Appendix C: In class Brain Teasers

1. The year is 2006
   I was born in 53 years ago in ’53, and I am 35 years young. How come?
   Provide at least 2 different solutions.

   (Reading right to left; 35 in Hex is 53 in Decimal)

2. You are a detective. You are asked to find out as accurately as possible when was the last time
   that a person visited a specific address in a city. List ideas.

3. 5+5+5 = 550
   Add a line to make it equality.

4. You have fifteen seconds. Using standard math notation, name a single whole number—not an
   infinity—on a blank index card. Be precise enough for any reasonable modern mathematician to
   determine exactly what number you’ve named.

5. Suppose you have a bag with 3 pieces of paper in it. On every piece of paper there is a real
   number. The numbers are all different and there is no upper or lower bound. You draw out numbers
   one at a time until you decide to stop (or you’ve drawn all the numbers), and the last number you drew
   is your selection. What strategy will maximize your chances of selecting the largest number in the
   bag?

6. Take the integers from 1 to 25 (inclusive) and arrange them in a straight line such that any two
   numbers next to each other will sum to either 2^i or 5^j where i and j are integers.

   For example, pretend the following numbers are all on one line:
   1  2  4  3  5  6  7  8  9  10 11 12 13 ...
   14 15 16 17 18 19 20 21 22 23 24 25

   The numbers 12 and 13 are next to each other and they sum to 25 which is 5^2.
   Also, 3 and 5 are next to each other and they sum to 8 which is 2^3.
   However, 1+2 = 3 is not 2^i or 5^j for any integer i or j.
   So, the above arrangement is not correct.

   Submit the MIDDLE number.
   (For the above incorrect example, this would be 13.)

7. Two motor-boats on opposite shores of a river start moving towards each other, but at a different
   speeds. (Neglect all other factors, like acceleration, turn around and current.) when they pass each
   other the first time, they are 700 yards from one shoreline. They continue to the opposite shore, then
   turn around and start moving towards each other again. When they pass the second time they are 300
   yards from the other shoreline. (Their speeds, although different, remain constant.)
   How wide is the river?
8. This is mathematical in nature. I want you to get a pencil and write down the numbers, 1 to 9, inclusive, and leave enough space between them. At your disposal you have one plus sign and two minus signs. You can insert those plus and minus signs wherever you want, to make the total come out to 100. In other words, if you were to put an equal sign after the 9, you want to be able to write 100 after it. Now I'll give you an example, you could do $12 + 345 - 67 - 89$. It doesn't work, but you get the idea. You can't change the order. You can't monkey with the plus or minus signs. You've got one plus sign and two minus signs, you can put them any place you want, and the total has to equal 100. What's the equation?

9. Re-order

DORMITORY
When you rearrange the letters: DIRTY ROOM
PRESBYTERIAN
When you rearrange the letters: BEST IN PRAYER
ASTRONOMER
When you rearrange the letters: MOON STARER
DESERTATION
When you rearrange the letters: A ROPE ENDS IT
THE EYES
When you rearrange the letters: THEY SEE
GEORGE BUSH
When you rearrange the letters: HE BUGS GORE
THE MORSODE
When you rearrange the letters: HERE COME DOTS
SLOT MACHINES
When you rearrange the letters: CASH LOST IN ME
ANI MOSITY
When you rearrange the letters: IS NO AMITY
ELECTION RESULTS
When you rearrange the letters: LIES LET'S RECOUNT
SNOOZE ALARMS
When you rearrange the letters: ALAS NO MORE Z'S
A DECIMAL POINT
When you rearrange the letters: IM A DOT IN PLACE
THE EARTHQUAKES
When you rearrange the letters: THAT QUEER SHAKE
ELEVEN PLUS TWO
When you rearrange the letters: TWELVE PLUS ONE

10. Can you make 6 identical triangles out of 12 toothpicks? Give it a try!
11. Can you draw the picture below starting at one point and not lifting your pencil or redrawing over any lines twice?

Answer:

![Hexagon Diagram]

Start at the bottom left corner and move the pencil in the order of the numbers. Follow the direction of the arrows.

12. Can you solve these word puzzles?
Answer:

1. Downpour
2. Backwards glance
3. Who's on first
4. Tall tale
5. Mother-in-law
6. Four score
7. Split personality
8. Heads up
9. All by myself

13. Here is a school bus in the USA. It is moving forward on the road. Is it moving to the right or to the left? (Hint: think about the location of its door)
14. What is $\alpha$? No trigonometry or electronic computations are allowed.
Appendix D: Brain Teasers – Homework Assignments

Innovative Thinking

Main sources:

http://discuss.fogcreek.com/techinterview/

Book: How would you move Mount Fuji?

Books: IQ and Mensa

IBM puzzle website

Car Talk (NPR weekly program)

1. The 7-11 problem

A guy walks into a 7-11 store and selects four items to buy. The clerk at the counter informs the gentleman that the total cost of the four items is $7.11. He was completely surprised that the cost was the same as the name of the store. The clerk informed the man that he simply multiplied the cost of each item and arrived at the total. The customer calmly informed the clerk that the items should be added and not multiplied. The clerk then added the items together and informed the customer that the total was still exactly $7.11.

What are the exact costs of each item?

2. Switches puzzle

The warden meets with 23 new prisoners when they arrive. He tells them, "You may meet today and plan a strategy. But after today, you will be in isolated cells and will have no communication with one another.

"In the prison is a switch room, which contains two light switches labeled A and B, each of which can be in either the 'on' or the 'off' position. I am not telling you their present positions. The switches are not connected to anything.

"After today, from time to time whenever I feel so inclined, I will select one prisoner at random and escort him to the switch room. This prisoner will select one of the two switches and reverse its position. He must move one, but only one of the switches. He can't move both but he can't move none either. Then he'll be led back to his cell."
"No one else will enter the switch room until I lead the next prisoner there, and he'll be
instructed to do the same thing. I'm going to choose prisoners at random. I may choose the same
guy three times in a row, or I may jump around and come back.

"But, given enough time, everyone will eventually visit the switch room as many times as
everyone else. At any time anyone of you may declare to me, 'We have all visited the switch
room.' and be 100% sure.

"If it is true, then you will all be set free. If it is false, and somebody has not yet visited the
switch room, you will be fed to the alligators."

What is the strategy they come up with so that they can be free?

3. Vienna

It's the middle ages, you're traveling across Europe and you want to find the way to Vienna.
You come to a crossroads, now there are two ways to go. At the crossroads stand a knight and a
knave. The knight answers every question truthfully. The knave answers every question falsely.
You don't know which guy is which. How can you figure out which road leads to Vienna by only
asking one question?

4. Chameleons

"at one point, a remote island's population of chameleons was divided as follows:

- 13 red chameleons
- 15 green chameleons
- 17 blue chameleons

Each time two different colored chameleons would meet, they would change their color to the
third one. (i.e., If green meets red, they both change their color to blue.) Is it ever possible for all
chameleons to become the same color? Why or why not?"

5. Wanna play?

I offer to play a card game with you using a normal deck of 52 cards. The rules of the game
are that we will turn over two cards at a time. If the cards are both black, they go into my pile. If
they are both red, they go into your pile. If there is one red and one black, they go into the discard
pile. We repeat the two card flipping until we've gone through all 52 cards. Whoever has more
cards in their pile at the end wins. I win if there is a tie. If you win, I pay you a dollar. How much
would you pay to play this game?

6. X implies Y
I have a black triangle, a white triangle, a black circle and a white circle. If I gave you a shape (triangle or circle) and a color (black or white), the "frobbly" items would be those that had either the shape or the color, but not both. That is, in order to be frobbly, the item must be of the specified color OR the specified shape, but not both the specified shape AND the specified color. I'm thinking of a shape and a color in my head and I tell you that the white triangle is frobbly. Can you tell me the "frobbiness" of the other items?

7. Box o' numbers

Arrange the numbers 1 to 8 in the grid below such that adjacent numbers are not in adjacent boxes (horizontally, vertically, or diagonally).

```
====
| 1 |
||
====
| 6 | 4 | 3 |
||
====
| 2 | 7 | 5 |
||
====
| 8 |
```

The arrangement above, for example, is wrong because 3 & 4, 4 & 5, 6 & 7, and 7 & 8 are adjacent.

8. Hen

If a hen and a half lay an egg and a half in a day and a half, how many hens does it take to lay six eggs in six days?

9. Duel

You find yourself in a duel with two other gunmen. You shoot with 33% accuracy, and the other two shoot with 100% and 50% accuracy, respectively. The rules of the duel are one shot person per-round. The shooting order is from worst shooter to best shooter, so you go first, the 50% guy goes second, and the 100% guy goes third.

10. Railroad bridge
A man needs to go through a train tunnel. He starts through the tunnel and when he gets 1/4
the way through the tunnel, he hears the train whistle behind him. You don't know how far away
the train is, or how fast it is going, (or how fast he is going). All you know is that

1. If the man turns around and runs back the way he came, he will just barely make it out of
the tunnel alive before the train hits him.
2. If the man keeps running through the tunnel, he will also just barely make it out of the
tunnel alive before the train hits him.

Assume the man runs the same speed whether he goes back to the start or continues on
through the tunnel. Also assume that he accelerates to his top speed instantaneously. Assume the
train misses him by an infinitesimal amount and all those other reasonable assumptions that go
along with puzzles like this so that someone doesn't say the problem isn't well defined.

How fast is the train going compared to the man?

11. Salary

Three coworkers would like to know their average salary. How can they do it, without
disclosing their own salaries?

12. Chinese emperor

A Chinese emperor had to choose a new adviser amongst 3 sages, all of them equally wise. He
placed a problem to them: "To choose one of you, you'll play a simple and fair game: In this sack
there are 3 white balls and 2 black balls. Each of you will be blindfolded and will pick one ball and
place it on your head. After that, the blindfolds will be removed and each one in turn will try to
guess the color of the ball upon his head, by observation of the other picked balls. However,
beware. You may pass your turn in guessing, but if you state a color and fail, you're disqualified.
This way I'll learn which one is the most intelligent amongst you" The sages talked briefly to each
other and promptly refused: "Dear lord, it's of no use, since the game is not fair. The last one of us
to guess in the first round will know the answer." and the sages promptly demonstrated this to the
emperor, who was so amazed by their wits that he appointed all 3 has his advisers. Could you
demonstrated it ? NOTE: If the emperor had any wits at all he would have named them all advisers
in the first place... Maybe spending reduction? :)

13. Painfully easy

I flip a penny and a dime and hide the result from you. "one of the coins came up heads", I
announce. What is the chance that the other coin also came up heads?

14. Boys and girls
In a country in which people only want boys, every family continues to have children until they have a boy. If they have a girl, they have another child. If they have a boy, they stop. What is the proportion of boys to girls in the country?

15. Calendar cubes

A man has two cubes on his desk. Every day he arranges both cubes so that the front faces show the current day of the month. What numbers are on the faces of the cubes to allow this?

16. Last ball

You have 20 blue balls and 14 red balls in a bag. You put your hand in and remove 2 at a time. If they're of the same color, you add a blue ball to the bag. If they're of different colors, you add a red ball to the bag. (Assume you have a big supply of blue & red balls for this purpose. Note: when you take the two balls out, you don't put them back in, so the number of balls in the bag keeps decreasing). What will be the color of the last ball left in the bag?

Once you tackle that, what if there are 20 blue balls and 13 red balls to start with?

17. Coin on a table

You die and the devil says he'll let you go to heaven if you beat him in a game. The devil sits you down at a round table. He gives himself and you a huge pile of quarters. He says "ok, we'll take turns putting quarters down, no overlapping allowed, and the quarters must rest on the table surface. The first guy who can't put a quarter down loses." the devil says he wants to go first.

Being the smart programmer you are, you realize that if the devil goes first, he may automatically win. So you convince him to let you go first, which makes your day because you know you can't lose. What is your winning strategy?

18. More hat puzzles

I buried four fishermen up to their necks in the sand on the beach at low tide for keeping their fishing spot a secret from me. I put a hat on each of their heads and told them that one of them must shout out the correct color of their own hat or they will all be drowned by the incoming tide. I give them 10 minutes to do this. Fisherman A and B can only see the sand dune I erected. Fisherman C can see that fisherman B has a white hat on. Fisherman D can see that C has a black hat, and B has a white hat. The fisherman have been told that there are four hats, two white and two black, so they know that they must have either a white or a black hat on. Who shouts out the color of their hat and how do they know?
19. Cube

This is difficult to describe in words, so read this carefully, lest there be any confusion. You have a normal six sided cube. I give you six different colors that you can paint each side of the cube with (one color to each side). How many different cubes can you make?

Different means that the cubes can not be rotated so that they look the same. This is important! If you give me two cubes and i can rotate them so that they appear identical in color, they are the same cube.

20. One mile south

How many places are there on the earth that one could walk one mile south, then one mile east, then one mile north and end up in the same spot? To be precise, let's assume the earth is a solid smooth sphere, so oceans and mountains and other such things do not exist. You can start at any point on the sphere and walk in any direction you like.

Think you've figured it out? I'll tell you now, there is more than one. In fact, there are more than two. Also be advised that walking north from the north pole (or south from the south pole) is illogical and therefore does not enter into the problem. All normal assumptions about directions will be used.

There are no tricks involved with this question. It just forces you to really think about the problem to come up with all the solutions.

21. Treasure island

You find an old treasure map in your grandma's attic. The map shows a cannon, a coconut tree, and a palm tree. The map states that to find the treasure you must:

a. Start at the cannon, walk toward the palm tree while counting your paces. When you reach the palm tree, turn 90 degrees to your left and walk the same number of paces. Mark that spot on the ground with a stake.

B. Start at the cannon again, walk toward the coconut tree while counting your steps. When you reach the coconut tree, turn 90 degrees to your right and walk the same number of paces. Mark that spot on the ground with a stake.

C. Find the midpoint between the two stakes and dig for the treasure.
You set off in secrecy to the deserted island. Upon reaching the shore you site the coconut tree and the palm tree, but someone has removed the cannon. Without digging randomly all over the island, is it still possible to find the treasure?

**22. Mountain man**

At 6 a.m. A man starts hiking a path up a mountain. He walks at a variable pace, resting occasionally, but never actually reversing his direction. At 6 p.m. He reaches the top. He camps out overnight. The next morning he wakes up at 6 a.m. and starts his descent down the mountain. Again he walks down the path at a variable pace, resting occasionally, but always going downhill. At 6 p.m. He reaches the bottom. What is the probability that at some time during the second day, he is in the exact same spot he was in on the first day?

**23. Clock**

Part I: what is the angle between the minute hand and the hour hand at 3:15 on an analog clock? No, its not 0.

Part II: how often does the minute hand pass the hour hand on an analog clock?

**24. Surgeons**

A one armed surgeon with a hand wound needs to operate on three patients. The surgeon only has two gloves. How can he operate on the three patients in turn without risking exchange of fluids? (remember he only has one arm so he only needs to wear one glove at a time.)

**25. Gold chain**

A man has a gold chain with 7 links. He needs the service of a laborer for 7 days at a fee of one gold link per day. However, each day of work needs to be paid for separately. In other words, the worker must be paid each day after working and if the laborer is ever overpaid he will quit with the extra money. Also he will never allow himself to be owed a link.

What is the fewest # of cuts to the chain to facilitate this arrangement and how does that guarantee payment?

**26. Monty hall problem**
Another well known problem in probability is the monty hall problem.

You are presented with three doors (door 1, door 2, door 3). One door has a million dollars behind it. The other two have goats behind them. You do not know ahead of time what is behind any of the doors.

Monty asks you to choose a door. You pick one of the doors and announce it. Monty then counters by showing you one of the doors with a goat behind it and asks you if you would like to keep the door you chose, or switch to the other unknown door.

Should you switch? If so, why? What is the probability if you don't switch? What is the probability if you do?

Lots of people have heard this problem. So just knowing what to do isn't sufficient. Its the explanation that counts!

27. Classic weighing

This is a classic problem which I have heard many times before. This is the "harder" of the two problems, since in this one, you do not know if the invalid item weighs more or less than the others.

Solving it is only half the battle. Writing up a solution that anyone including your grandma could understand, is very hard.

Problem: the evil king from before sends his own assassin to take care of the evil queen who tried to poison him. Of course, her trusty guards catch the assassin before any harm is done. The queen notices that the assassin is quite handsome and doesn't really want to punish him by death. She decides to test his wisdom.

The queen gives the assassin 12 pills which are all completely identical in shape, smell, texture, size, except 1 pill has a different weight. The queen gives the man a balance and tells him that all the pills are deadly poison except for the pill of a different weight. The assassin can make three weightings and then must swallow the pill of his choice. If he lives, he will be sent back to the bad king's kingdom. If he dies, well, that’s what you get for being an assassin.

Only one pill is not poison and it is the pill which has a different weight. The assassin does not know if it weighs more or less than the other pills. How can he save his skin?

28. Hard river crossing
A dysfunctional family has to cross the river. On one side of the river are a mom and 2 daughters, dad and 2 sons, the maid and the dog. There is a boat only big enough to hold 2 people (counting the dog as 1 person). Only the adults are capable of operating the boat. Everyone has to get to the other side, without anything bad happening.

Difficulties: if the dog is left with anyone and the maid isn't there to control him, he'll bite. The dad can't be left with any of the daughters when the mom isn't there. Likewise, the mom can't be trusted alone with either of the sons when the dad isn't there.

Remember! Only an adult can operate the boat, AND the boat can't drive itself.

29. Chessboard

Problem: using 31 dominoes, where one domino covers exactly two squares, can you cover all the empty squares on this chessboard (which has 62 spaces). If so, how? If not, why?

30. Dave's on fire

Dave is stuck on a deserted island, with lots of trees, which is very thin and ten miles long (east to west). Large cliffs surround the entire island and if he jumped off, he wouldn't survive the fall. A fire starts burning at the west side of the island. Unfortunately this island always has a west to east blowing wind blowing at 2mph and this moves the fire slowly toward Dave at 1mph. (so he only has ten hours left). Save Dave (or maybe, let him burn :-) ! What to do?

31. Jelly beans

You have three jars that are all mislabeled. One contains peanut butter jelly beans, another grape jelly beans, and the third has a mix of both (not necessarily a 50/50 mix, could be a 1/99 mix or a 399/22 mix). How many jelly beans would you have to pull out, and out of which jars, to find out how to fix the labels on the jars?

32. Bad king

A bad king has a cellar of 1000 bottles of delightful and very expensive wine. A neighboring queen plots to kill the bad king and sends a servant to poison the wine. (un)fortunately the bad
king's guards catch the servant after he has only poisoned one bottle. Alas, the guards don't know which bottle but know that the poison is so strong that even if diluted 1,000,000 times it would still kill the king. Furthermore, it takes one month to have an effect. The bad king decides he will get some of the prisoners in his vast dungeons to drink the wine. Being a clever bad king he knows he needs to murder no more than 10 prisoners - believing he can fob off such a low death rate - and will still be able to drink the rest of the wine at his anniversary party in 5 weeks time.

Explain how....

33. Pirates

Five pirates have 100 gold coins. They have to divide up the loot. In order of seniority (suppose pirate 5 is most senior, pirate 1 is least senior), the most senior pirate proposes a distribution of the loot. They vote and if at least 50% accept the proposal, the loot is divided as proposed. Otherwise the most senior pirate is executed, and they start over again with the next senior pirate. What solution does the most senior pirate propose? Assume they are very intelligent and extremely greedy (and that they would prefer not to die).

34. Palindromes

Problem: on October 2, 2001, the date in MMDDYYYY format is a palindrome (same forwards as backwards).
10/02/2001
when was the last date prior to that date that this occurred on? (see if you can do it in your head!)

35. Bumblebee

Problem: two trains enter a tunnel 200 miles long (yeah, its a big tunnel) travelling at 100 mph at the same time from opposite directions. As soon as they enter the tunnel a supersonic bee flying at 1000 mph starts from one train and heads toward the other one. As soon as it reaches the other one it turns around and heads back toward the first, going back and forth between the trains until the trains collide in a fiery explosion in the middle of the tunnel (the bee survives). How far did the bee travel?

36. Red marbles, blue marbles

Problem: you have two jars, 50 red marbles, 50 blue marbles. You need to place all the marbles into the jars such that when you blindly pick one marble out of one jar, you maximize the chances that it will be red. (when picking, you'll first randomly pick a jar, and then randomly pick a marble out of that jar) you can arrange the marbles however you like, but each marble must be in a jar.
37. 100 doors in a row

Problem: you have 100 doors in a row that are all initially closed. You make 100 passes by the doors starting with the first door every time. The first time through you visit every door and toggle the door (if the door is closed, you open it, if its open, you close it). The second time you only visit every 2nd door (door #2, #4, #6). The third time, every 3rd door (door #3, #6, #9), etc, until you only visit the 100th door.

Question: what state are the doors in after the last pass? Which are open which are closed?