INVENTION & TECHNOLOGY DEVELOPMENT – ENGR 555

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About the Course

Great systems, processes and products are usually based largely on the exercise of inventive thinking and not on routine procedures for analysis and optimization. Research could conservatively aim at making marginal improvements to the state-of-the-art in the chosen domain, or it may be based on original and novel ideas and potentially lead to breakthrough impacts and discovery of new frontiers. Creative artists, engineers, researchers and business persons use inventive, non-routine approaches and in most instances their creations clearly stand out. Inventive thinking and problem solving enriches professional life and brings prosperity to organizations and society. As in any other field, creativity in technology, i.e., the ability to invent, can be acquired and enhanced.

This course intends to prepare the students with a strong motivation and some knowledge to take the path of inventive thinking and to initiate and pursue novel ideas that lead to successful creation of new products, processes, and systems.

The course uses a pragmatic approach to familiarize the students with the process of engaging creative thought that when augmented by the tools and techniques introduced in the course can lead to meaningful inventions. Essentials of inventive thinking and technological creativity that could lead to breakthrough engineering designs and research endeavors will be presented and several realistic case studies in invention and technology development will be discussed. The course also covers the related activities required for bringing inventions to the production phase. Methodologies that aid the invention process will be taught. Student teams are then guided through the process of idea formation, patent search, design, prototyping, manufacturability considerations, product design and evaluation, and inception of the production and commercialization stage in the context of a practical term project. The course offers:

- A systematic approach to establishing an attitude and a skill set conducive to creativity
- Use of tools such as software and prototyping hardware to aid in the invention and design processes
- Presentation of realistic case studies (see last page) in invention and product development based on the instructor's experience.

References

1. Various handouts by the instructor.
2. *Thinkertoys: A handbook of creative-thinking techniques*, M. Michalko, 2nd Edition, 10 Speed Press, 2006.
3. *The Innovation Algorithm*, G. Altshuller, Technical Innovation Center, Inc., 2000.
4. John H. Lienhard, *The Engines of Our Ingenuity: An Engineer Looks at Technology and Culture*. Oxford University Press. 2003
5. *Product Design and Development*, K. Ulrich, S. Eppinger, McGraw-Hill, 2017.

About the Instructor

Behrokh "Berok" Khoshnevis is the Louise L. Dunn Distinguished Professor of engineering at the University of Southern California and is the President and CEO of Contour Crafting Corporation. He has been active in robotics and mechatronics related research and development projects that include the development of several novel Additive Manufacturing (3D Printing) processes such as Contour Crafting for mega-scale fabrication, SIS family of technologies for polymeric and metallic parts fabrication (licensed to HP) and SSS for high temperature alloys and ceramics, as well as development of mechatronics systems for biomedical applications (e.g., digital dental prostheses fabrication, robotics for orthodontics, rehabilitation engineering, and tactile sensing devices), autonomous mobile and modular robots for fabrication and assembly on earth, in space and on other planets, and innovative technologies for oil and gas industry. He has numerous inventions and over 100 US and international patents and nearly 200 refereed technical publications. He is a member of the National Academy of Engineering, a Fellow of the National Academy of Inventors, a Fellow member of the Society of Manufacturing Engineers, a Fellow of Society for Computer Simulation, a Fellow of the Institute of Industrial & Systems Engineering, and a NASA Innovative Advanced Concepts (NIAC) Fellow. Because of his Contour Crafting invention he received the 2014 NASA Grand Prize among 1000+ globally competing. In 2016 SSS, his other 3D printing invention, won another international competition Grand Prize by NASA. In 2017 Dr. Khoshnevis was selected by the Connected World magazine as one of top10 pioneers in Internet of Things (IoT).

Course Content

Inspirational

The duality of human mind – left and right brain thiking distinction

Essentials of creative thinking

- Goodness: The right attitude and value system – Roles of intention, vision and passion
- Beauty: The artistic side of us - appreciation and creation of beauty
- Truth: In search of what is real with an inquisitive, open, knowledgeable and imaginative mind

Seeing the world differently – Being a silent non-judgmental observer. Knowing how to see. Making thoughts visible. The power of visual thinking. Characterizing what is sensed (seen, heard, touched, …)

Thinking differently – How to pursue knowledge. Knowing what drives imagination. in balance with realism, noting the unseen connections, appreciating the significance and depth in everything, thinking in parallel worlds of analogy, thinking in opposite worlds, lateral thinking, thinking in *systems* terms – the generalities of everything, understanding the way of nature

Living differently – The importance of having a quest for meaning in life, the reality of failure and success, true meaning of productivity, meaning of happiness and meaning of mortality

The creative style - The impacts of *problem identification (i.e., asking the right questions), lateral thinking, tolerance for ambiguity* and *practice* on creativity and invention

Creativity inhibitors

Related case studies

Idea Generation

Technological creativity in idea generation

Creating ideas based on needs (Application Pull)

Creating ideas based on observation of phenomena (Technology Push)

Understanding the role and use of *Space*, *Time*, *Matter*, and *Energy* in invention

Recognition and effective use of *resources* and making use of *constraints* in invention

Using analogy and feature transfer for invention

Recognition of patterns of technological evolution and their use in invention

Related case studies

Turning Ideas into Meaningful Inventions

The importance of basic technical knowledge

Being able to ask around

Using tools that can augment solution finding (e.g., TRIZ)

Related case studies

Technology Development

Turning inventions into functional designs

Quick tests of feasibility

Basics of design and design tools - Computer Aided Design (CAD), Computer Aided Engineering (CAE)

Building working prototypes - Classical and modern tools – 3D Printing

How to run systematic experiments with prototypes

Related case studies

Intellectual Property

Is idea protection always necessary?

Basic legal matters regarding IP

Patent search

Patent types and application process

Basics of patent law

Related case studies

The Innovation Process

The social impact of technology – non-disruptive and disruptive technologies

Licensing out an invention or creating a venture to market it

Basics of intrapreneurship – Innovation within established companies

Basic of entrepreneurship – Innovation through start up companies

Market evaluation

Creating a business plan

Raising necessary funds

Creating the company

Operating the company

Turning prototypes into commercial products

Design for manufacturability, serviceability, and disposal

Incorporating the human element

Incorporating environmental issues

Related case studies

Grading

Rigorous homework and projects are assigned. The overall performance will be rated as Credit / No Credit based on:

1. Attendance and performance in pop quizzes on reading materials.
2. Performance in homework projects and class presentations -- 35%
   a. Correctness of methodology (as taught in the course)
   b. Quality of solutions based on specific criteria for each project (e.g., cost, functionality, environmental impact, etc.)
   c. Quality of written and oral presentation

3. Performance in term project (as measured by the extent of creativity, rigor and quality) – 35%
   a. Extent of departure from convention
   b. Extent of rigor as represented by the amount of effort in following and implementing the related methodologies, and by the complexity of the project
   c. Quality of solution based on the applicable criteria

4. Extent of teamwork as evaluated by team members and reflected in students extent of participation – 30%
   a. Evaluation will be based on questionnaire forms filled by team members
   b. Instructor's observation of student's performance in collaborative activities.

The overall percentage of effort will be the basis for the CR / No CR decision. According to the Graduate School the minimum grade for a graduate course to count toward degree is C (or 2 points out of a maximum of 4 points). This corresponds to at least 50% effort. Accordingly, all students whose aggregate percentage effort in the above categories exceeds 50% will receive a CR for the course.

CR/ No CR rating is more appropriate for this course because of the following reasons:

- The course attempts to awaken and utilize the creative power in students. Credit/No Credit grading allows a wider margin of risk taking than letter grading. This wider margin encourages spontaneity and risk taking – two important aspects of creativity.
- Being concerned about the teacher's evaluation of their work, students tend to lose confidence in the self evaluation and judging of their own work. This lack of confidence in the self evaluation of the virtues and shortcomings of one's creation seriously inhibits creativity.
- The course is largely based on team projects and attempts to promote the spirit of cooperation rather than competition. Precise grading practice puts the students in a competitive mode that inhibits the growth of team creativity.

The School of Engineering adheres to the University's policies and procedures governing academic integrity as described in SCampus. Students are expected to be aware of and to observe the academic integrity standards described in SCampus, and to expect those standards to be enforced in this course.

"Any Student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776."

Term Project Report

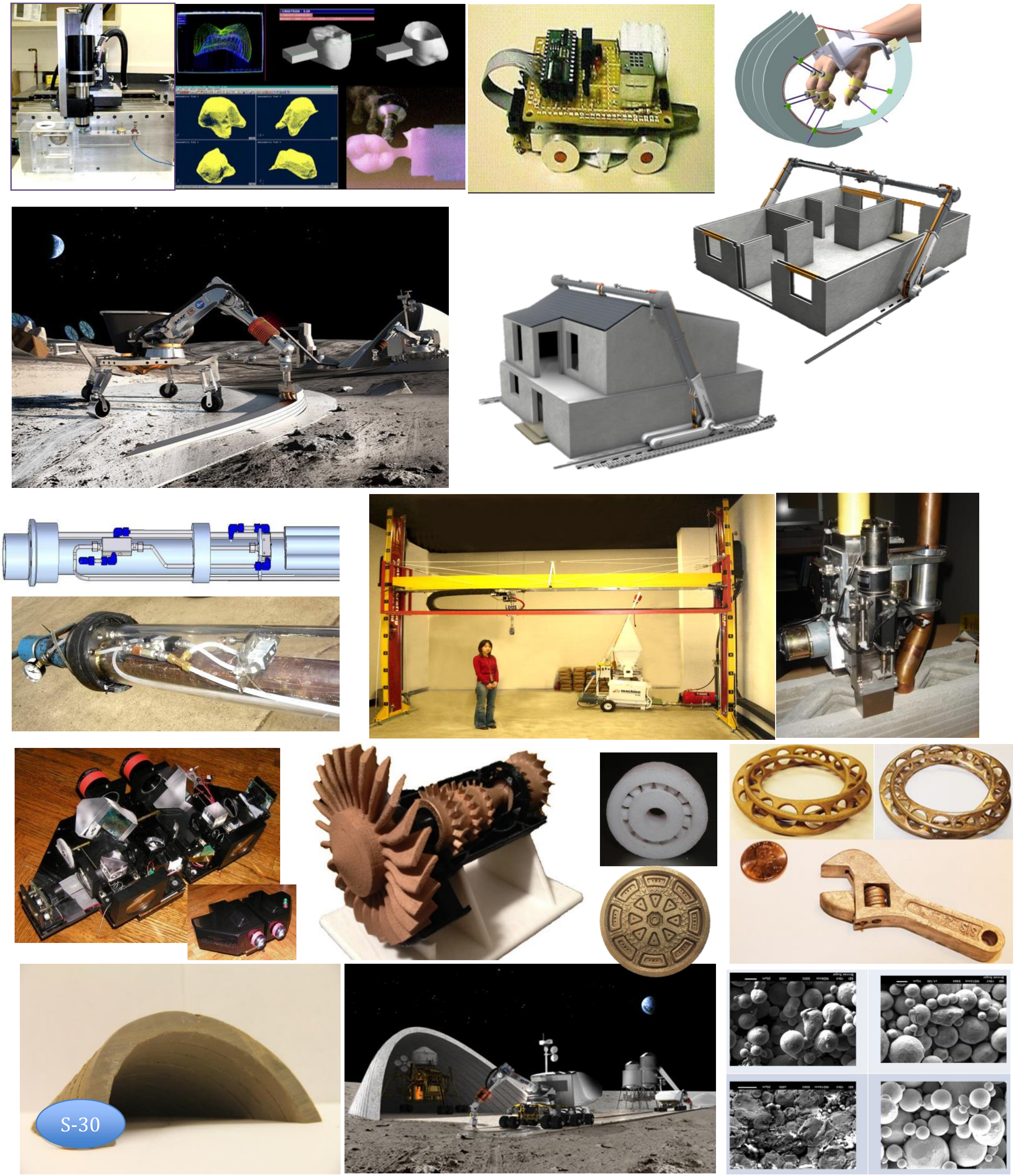
Your term project final report should be such that would help you carry your project further beyond this class. The report should not take much time to create but it is best to divide the effort from the beginning. Here is the list of topics:

- How the idea was conceived (need driven, phenomena observation, serendipity, etc.)
- Did you use any specific technique to arrive at the idea (brainstorming, feature transfer, trend of technological evolution, etc.)
- Background patent search and list of alternative inventions that deliver the same function. Also clarify if some of the alternative inventions are in the market.
- The current (if any) and potential market for your invention.
- Design specifics and rationale (include sketches, CAD models, etc.)
- Prototype development iterations (would be nice to include pictures of all iterations -- unsuccessful and successful)
- Quantification (engineering analysis, optimization, etc.). This need not be very elaborate. Basics attempts, if any, will suffice.
- Mass production issues (how, how much, etc.)
- Possible market share and sales strategy
- Fund raising approach

Appendix:

- The role of each team member in the project. A list of activities performed by each member will be useful.
- What did you learn from the team activity and what would you have done differently had you had the final experience from the start?

Please note that each team member may be asked to evaluate other members of the team.



Some of the technologies invented and developed by the instructor

Instructor’s TEDx video presenting one of his inventions: http://www.youtube.com/watch?v=JdbJP8Gxqog