ELEC390 – Electrical and Computer Engineering Design

Week 1

January 6, 2014

Acknowledgements

- ELEC390 was originally developed by Prof. Stan Simmons.
- Michael Miron refined the course and provided additional material
- ELEC490/498 information is taken from the 2013/2014 Course Homepage and may not reflect 2014/2015 timelines.

Course Goals

- Introduce Engineering Design Process framework
- Begin final year project – team formation, project selection, requirements analysis and design. Completing front end in 3rd year allows earlier project completion.
- Introduce concepts of evaluating and assembling components in a sequenced design (Rube Goldberg system), introduce basic PCB design skills, refresh Arduino skills in preparation for ELEC490 project.
- Basic project management
- Some discussion of ethics

Course Instructor

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Who is Dave?

- Professional Engineer (Ontario)
- B.Sc. Electrical Eng, M.Sc. Comp.Eng.
- MBA studies, PhD studies
- Owns small computer consulting company
  - Distributed processing
  - Real time control, factory automation
  - Medical instrumentation
  - Mining automation
  - Etc.

This Week's Agenda

- Course overview; how it fits with ELEC490/498
- Discussion of Engineering Design
- Bad design – understanding what makes something bad
- Design improvement exercise

Course Content

- Lectures covering various topics
- Team formation; project selection
- Smaller in-lab exercises
- Mini-design project (2 choices) *due March 14*
- ELEC490/498 Project Proposal *due April 4*

Course Content - Lectures

- Overview of Engineering Design
- Rube-Goldberg systems
- Schematic capture & PCB design using Eagle
- Mini project overviews
- Component selection
- ELEC490/498 projects
- Project planning
- Ethics

Course Content - Labs

- Some in-lab exercises to be completed quickly
- Time to work on mini-project:
  - Rube Goldberg machine using ECE parts
  - PCB design of wearable gadget
- Final Year Project Proposal

Schedule

WEEK	Lecture	Lab
1 – Jan. 06	Introduction	Design Improvement, Skills Inventory
2 – Jan. 13	Rube Goldberg #1	Team R-B design
3 – Jan. 20	PCB #1	Individual Eagle Schematic
4 – Jan. 27	Rube Goldberg #2	Arduino Refresher
5 – Feb. 03	PCB #2	Individual Eagle Part Creation
6 – Feb. 10	Components, Ratings	Individual Part Selection (ELEC49x Open House)
Reading Week	No class	No formal lab activity
7 – Feb. 24	ELEC49x Proposal	Mini-project working time
8 - Mar. 03	Project Planning	Mini-project and ELEC49x proposal
9 – Mar. 10	Project Management	Mini-project and ELEC49x proposal
10 – Mar. 17	Professional Topics	Mini-project and ELEC49x proposal
11 – Mar. 24	Q&A	Mini-project and ELEC49x proposal
12 – Mar. 31	Q&A	Mini-project and ELEC49x proposal

Grading

- Individual/Team exercises in weeks 1-6 – 30% - due Monday after lab 0900 (9:00AM)
- Group Mini-project: R-G machine or PCB gadget design – 35% due March 28 2300 (11:00PM)
- ELEC49x Project Proposal (marked by both project supervisor and me) – 35%. Due April 4 2300 (11:00PM)
- Late penalty: 20% of mark/per day

Project Proposal Timeline

- Step 1. Form teams of 3 students
  - Internship students form teams with other internship students to start September 2015
  - All other students form teams to start September 2014

Timeline (2)

- Step 2. Review faculty-proposed projects before end of week 5
  - Team meets with faculty member (you arrange) OR
  - Attend evening sessions planned for weeks 4 and 5 OR
  - Read detailed project documents from faculty

Timeline (3)

- Step 3. Submit list of your top 6 projects by end of week 6; choose top 4 and email one-page EOI (expression of interest) to faculty and me.

Timeline (4)

- Step 4. Teams will be matched to projects. For projects with several teams interested, faculty will choose based on EOI, etc. This will be settled by end of Reading Week.

Timeline (5)

- Step 5. Research and write ELEC49x Project Proposal by end of term (April 4).
  - Clarify requirements with supervisor; ensure that team and supervisor have common understanding
  - Develop plan for preparing Proposal
  - Research and write proposal.

Timeline ELEC49x

Fall 2014 (or 2015) – begin detailed design on first day back

- Team changes settled by end week 1
- Meeting schedule (supervisor and team) settled by end week 2
- Blueprint document by end week 3; approval by supervisor end week 4.

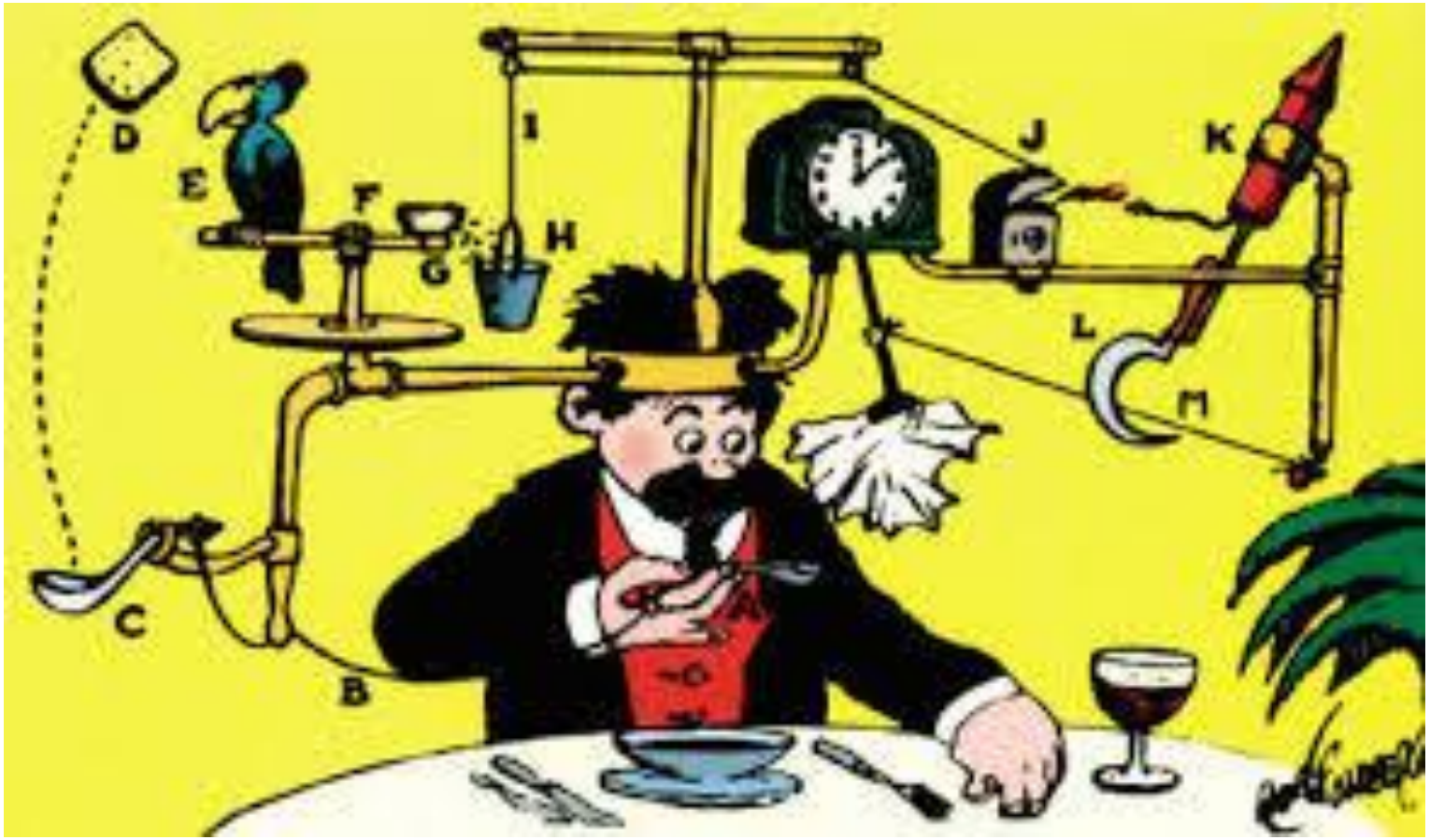
Timeline ELEC49x (2)

- Parts ordered before end of October
- Build/program/test October, November, December, January
- Essentially complete by Open House mid-February (Thursday before Reading Week)
- Adjustments, Final Presentations, Final Report in last 6 weeks

Mini-project #1
Rube Goldberg Machine

- Rube Goldberg – American cartoonist who drew fantastic multi-step machines to do simple tasks.
- Your version will be a machine to turn on a light using available ECE parts (no animals, rockets, etc.)

Mini Project #1



Automatic napkin wipe after finishing soup.

Mini-project #2
PCB Design of Wearable Device

- Eagle PCB Editor (freeware version) is a good learning tool for PCB layout.
- Limits on free version – board maximum about 4” x 3”; only two signal layers

- Schematic for circuit; end version

Today's Content

- Two goals:
  - Begin to discuss Engineering Design
  - Work on Team Skills Inventory

What is Engineering Design?

- The process of
  - Devising a system, device or process to meet requirements under given constraints
- Involves
  - Decision making (often iterative) applying basic science, math, engineering sciences to convert resources to meet objective
  - Establish objectives, criteria – then synthesis, analysis, construction, test, evaluation

User Requirements

- Functionality
- Usability
- Reliability
- Manufacturability
- Etc.

Constraints

- Cost – development cost, operating costs
- Space (size)
- Power consumption
- Development time
- Safety, environmental issues
- Etc.

“You can have it done quick, you can have it done cheap, you can have it done right. Pick two.”

-Red Adair, oil-well fire expert

Engineering Design Steps

- See http://en.wikipedia.org/wiki/Engineering_design_process
- Add
  - Risk assessment – technical risk
  - Test, resolve deficiencies & optimize
  - Integrate and test at next level
  - Verify
  - Iterate

Aside – Project Initiation

- Contract engineering company
  - Clients have projects
  - May negotiate with preferred supplier
  - May issue RFP and evaluate responses
  - Client funds project development
- Development group within company
  - Usually, Marketing Department acts as client
  - Marketing may hold development budget
- “Client” decides requirements

Project Acceptance

- Part of project proposal process is to determine whether the developing agency should go ahead with the project
- Take business risks, other opportunities, etc. into account

Engineering Project Steps

- Opportunity Phase – Idea generation, Concept development, Business analysis
- Feasibility – resource planning, preliminary design costing, requirements analysis, risk assessment, schedules

These are the steps you undertake in ELEC390

Engineering Project Steps (2)

- Implementation
  - Design: team formation, detailed planning and design, documentation
  - Build: unit testing, integration, system testing, documentation
  - Verification against requirements
  - Design close

These steps done in ELEC490/498

Engineering Project Steps (3)

- Productization:
  - Design and documentation clean-up
  - Test fixtures, programs in place
  - Source production quantity for components
  - Begin tracking production yield, user experience (warranty claims, returns, etc.)

Engineering Project Steps (4)

- Maintenance:
  - Deal with component obsolescence
  - Regional variance (perhaps requirement to enter new market means new requirements)
  - Cost reductions (stay ahead of competition)
  - Incremental feature improvement.

Engineering Project Steps (5)

- End-of-life decision
  - At some point, base product platform may no longer be economical to produce or market; may no longer be capable of supporting upgrades, etc.
  - Hopefully, the product paid back its development costs and made money

Engineering Project Steps

- Industrial or commercial products tend to have slightly longer roll-outs and lifetimes than consumer goods.
- What are the differences between a product designed for a 20 year lifetime (e.g. computerized industrial packaging) and a product expected to be obsolete in 12-18 months?

Idea Generation

- Let's look at some ways of generating ideas.
- Sometimes mistakes and other bad examples are excellent learning devices.
- Examine some bad human-factors design.

Aside – true story

A friend of mine developed a device to help manage liquor inventory in bars. This was essentially an intelligent scale – allowing a bar owner to keep track of starting and ending volumes by weighing the opened bottles.

My friend liked designing power supplies. So, he designed his own 120V 60Hz AC supply for the unit and got the necessary approvals to sell the product in the US and Canada.

After exhibiting at a trade show, he was approached by a Greek businessperson who wanted to import the units to Greece, Italy, etc.

The Greek power system is not 120V 60Hz AC. In fact, the systems in Europe are not consistent country to country – some 50Hz, some 60Hz, most 240/250V AC. And their plugs are all different shapes.

My friend had rejected the approach of buying OTS power supplies with a 16VDC output – what he needed. He had to do a major redesign to do the deal – and he didn't have the resources to do it.

Another story

- Ask me about shakers, if you're interested.

Idea Generation: Design Critique

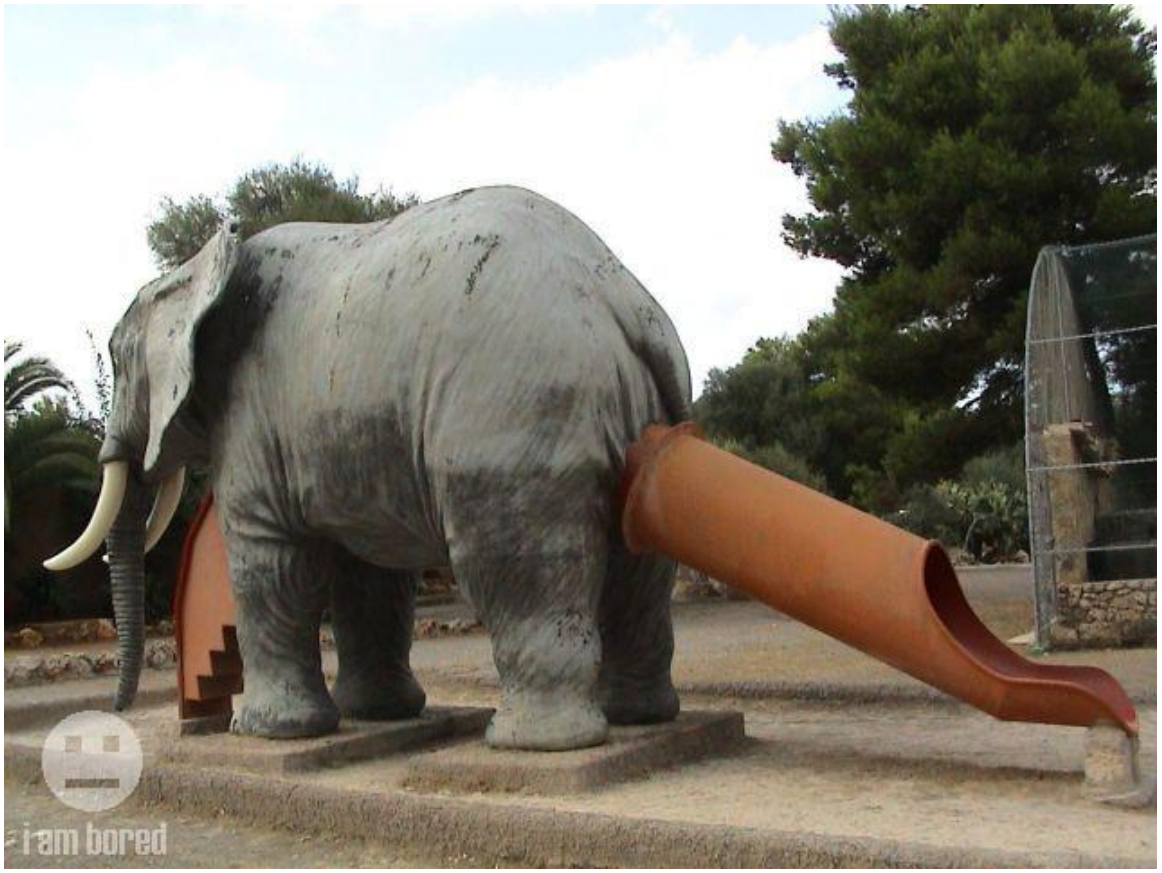
Some "bad" human factors design

- Bad designs website: http://www.baddesigns.com/
- Google "bad designs", "bad human factor engineering", "things that go boom", etc.

Bad Designs

- Device remotes
- Top heavy Shop-Vac
- Style obscuring function
- Ignoring social norms
- Etc.

Bad Design – Ignoring Norms



http://www.i-am-bored.com/bored_link.cfm?link_id=46975

Lab work

- Form groups
- Part 1. Design critique and suggested improvements.
- Part 2. Team skill inventory discussion. You will use this for 490 LOI.

Hand In Instructions

- One report per group.
- Name it with your net ids connected, e.g. wk1_8ab4_9cd5_7ef6.docx
- Submit to ELEC390 dropbox by 1730 (5:30PM) next Tuesday.

Preview

- Brainstorming Rube Goldberg machine using TIM software
- Software can be downloaded from Y:\ELEC390