Examples on Complex Engineering Problems and Activities in EEE

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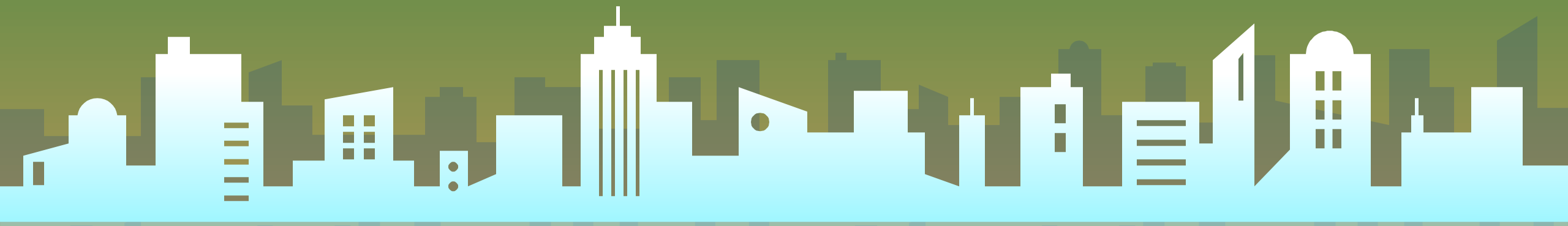

Outline

- Example 1 (An in-course assignment)
- Example 2 (An open-ended lab)
- Example 3 (A Capstone project)

Example 1: An In-class Assignment

In this individual assignment, each student designs the fittings, fixtures, conduit layout (including cable types and sizes), switch board and distribution board connections (including rating of protective equipment) of a modern apartment considering proper lighting, power outlets, ventilation, heating and cooling facilities and communication networks giving due attention to safety and health issues.

Alternate design options should be explored and justification for the selection should be provided. While provisions for all facilities (HVAC, washer/dryer, electric cooking, etc) should be kept, the total load should not exceed the connected load given by the utility. Design should promote sustainability through the use of energy efficient and low power equipment. The design should propose equipment for sustainability where applicable. Lower cost is another desired characteristics of the design.

The design must satisfy the requirements set by the latest version of Bangladesh National Building Code (BNBC 2015: Vol. 1, Part 8, Chapter 1). The students are to submit design report at the end of the assignment.

CO's that the assignment will address

No.	CO	PO
CO1	Analyze electrical power demand in a building based on customer needs	PO(b): Problem Analysis
CO2	Design electrical wiring complete layout including fitting, fixture, switchboard and distribution board subject to specifications and constraints considering applicable standards and codes	PO(c): Design/Development of Solutions
CO4	Prepare and present basic technical documentation of a building services system	PO(j): Communication
CO5	Consider safety and health issues in design of electrical wiring and service systems	PO(c): Design/Development of Solutions

Which P's are addressed?

P1: Depth of knowledge
P2: Conflicting requirements
P3: Depth of analysis
P4: Familiarity of issues
P5: Extent of applicable codes
P6: Extent of stakeholders
P7: Interdependence

- **P1:** Analysis of power demand requires knowledge of K3, K8. Design requires knowledge of K5, K8 (CO1)
- **P2:** Requirements are conflicting. All conveniences/facilities are desired, but power consumption should be minimized (CO2)
- **P3:** No unique solution. Multiple designs possible. Analysis needed to select the most appropriate one (CO2)

PI's of the rubric for assessment of CO1, CO2, CO5

Understands objectives, requirements, constraints, standards and codes clearly (CO2)	P1, P2
Analyzes power demand considering all requirements and constraints (CO1)	P1, P2
Considers multiple solutions and selects suitable one based on analysis (CO2)	P1, P3
Develops a final design which satisfies all requirements, constraints, standards and codes (CO2)	P1, P3
Duly considers safety and health issues in design (CO5)	P1, P2, P3

Which A's are addressed?

A1: Range of resources

A2: Level of interaction

A3: Innovation

A4: Consequences for society and environment

A5: Familiarity

- **A1:** The design involves resources, such as, money, information and technology
- **A3:** Addressing sustainability and reducing cost requires innovative use of engineering principles and knowledge
- **A4:** Successful design will have impact on society and environment in terms of sustainability

PI's of the rubric for assessment of CO4

Explains the design process including engagement of resources clearly	A1
Presents the final design clearly with all supporting information and documents	
Discusses how innovation has been used in design and to resolve conflicting requirements including the impact on sustainability	A3, A4
Prepares a report which is free from mechanical errors (format, grammar, spelling)	

Example 2: An Open-ended Design Lab

In this open-ended design lab, students as a group will investigate and design a simple Bangla Speech Recognition system.

Such a system can be incorporated with a wheelchair to make it voice-controlled and thus enables a physically handicapped person to move freely without the help of a constant care-giver. Moreover, the ability to give commands in Bangla will make the system more user-friendly in the context of Bangladesh.

The system should be speaker-independent, i.e. it is required that the Bangla speech recognition system should work satisfactorily irrespective of sex, age-group, or dialect of the speaker.

Students are required to explore different methodologies to investigate the problem through design of experiment and data analysis and select or develop an optimal methodology for design of the system.

CO's that the open-ended design lab will address

No.	CO	PO
CO5	Investigate signal processing related complex issues through exploration of different methods, design of experiment and data analysis.	PO(d): Investigation
CO6	Design a specific Bangla Speech Recognition system using the selected algorithm to meet the requirements	PO(c): Design/Development of Solutions

Which P's are addressed?

P1: Depth of knowledge
P2: Conflicting requirements
P3: Depth of analysis
P4: Familiarity of issues
P5: Extent of applicable codes
P6: Extent of stakeholders
P7: Interdependence

- **P1:** Requires knowledge of DSP (K4), design of speech processing system (K5), use of DSP tools (K6) and engagement in research literature (K8)
- **P3:** Numerous algorithms can be adopted. Choice of the selected algorithm requires in-detail analysis
- **P5:** Requires going beyond the use of standardized features of common English audio commands to design speech recognition application in Bangla

PI's of the rubric for assessment of CO5 and CO6 through Lab-report

Methodically investigates different algorithms and/or methodologies and organizes evidence/data to demonstrate patterns and highlight differences and/or similarities (CO5)	P1, P3
Selects an optimal algorithm and/or methodology with proper justification (CO5)	P3, P5
Designs a Bangla speech recognition system to meet the requirements subject to the constraints (CO6)	P1, P5
Identifies limitations and implications of the proposed solution (CO6)	P1

Example 3:
A Capstone Project

The project is to develop a PV powered remote water quality monitoring plant for pisciculture. The significances are as follows.

- Pisciculture has become an important part of economy and nutrition in Bangladesh
- Fish production has more than doubled since 2000
- Sweet water fish cultivated in ponds and water bodies contributes a significant fraction to this growth
- Fish yield and quality depends on water quality as determined by the pH level, dissolved oxygen content and other parameters

Continual monitoring of water quality and prompt remedial action when needed can increase yield and quality of fish even further.

The water quality monitoring plant, powered by PV panels, will continuously sense and record values of certain water parameters and send the data to a cloud storage in real time. An app will download the data continually to the user's smart phone for viewing and monitoring

The Capstone Project addresses 11 of the 12 PO's through 19 CO's over a period of 1 year

A few example CO's that the Capstone project will address

No.	CO	PO
CO2 – Part A	Explain the objectives and functional requirements of the solution subject to regulatory compliance, standards and codes of practice	PO(c): Design/Development of Solutions
CO1 – Part B	Analyze solutions of the problem to select the most suitable one	PO(b): Problem Analysis
CO2 – Part B	Design an engineering solution subject to the constraints and standards	PO(c): Design/Development of Solutions
CO8 – Part C	Write professional technical documents related to the project and orally present project results	PO(j): Communication

Which P's are addressed?

P1: Depth of knowledge
P2: Conflicting requirements
P3: Depth of analysis
P4: Familiarity of issues
P5: Extent of applicable codes
P6: Extent of stakeholders
P7: Interdependence

- **P1:** Project requires knowledge of design of PV systems (K3, K4, K5), embedded system with sensors (K4, K5, K6), wireless communication with cloud data storage (K4), integration of sub-systems (K8) and physical implementation (K6)
- **P3:** No unique way to design. Depth of analysis needed to select a specific solution from many alternatives
- **P4:** Electrical engineers are not typically exposed to issues related to pisciculture. So the project involves infrequently encountered issues
- **P7:** Project involves a number of interdependent sub-systems (components), such as, PV system, sensor system, wireless communication system , user app

Example PI's of the rubric for assessment of CO2 – Part A, CO1 – Part B, CO2 – Part B

Explains the objectives, functional requirements and constraints of the solution considering the expectations of the stakeholders (CO2 – Part A)	P1, P2 (?), P4 (?), P6 (?)
Identifies the regulatory requirements, standards and codes of practice (CO2 – Part A)	P4 (?), P5 (?)
Formulates and evaluates alternate solutions (CO1 – Part B)	P1, P3
Develops a design process considering constraints, applicable standards, codes of practice, health, safety, and environmental considerations (CO2 – Part B)	P2 (?), P5 (?), P6 (?), P7 (?)
Prepares preliminary design with analysis and/or simulation (CO2 – Part B)	P1

Which A's are addressed?

A1: Range of resources
A2: Level of interaction
A3: Innovation
A4: Consequences for society and environment
A5: Familiarity

- **A1:** It is necessary to mobilize and engage money, people, equipment and information to implement the project:.
- **A3, A4:** The project involves innovative use of engineering in an area with high social impact.
- **A5:** The project deals with a new, unfamiliar area for electrical engineers. Necessary to document and communicate how principle-based approaches address the project requirements

CO8 – Part C is assessed using 2 rubrics (1 for report, 1 for presentation) containing 9 PI's in total

A few example PI's of the rubrics for assessment of CO8 – Part C

Explains clearly the project planning and implementation process and schedule including mobilizing and engaging resources and resolving conflicts (written report)	A1, A2
Highlights the creative and unfamiliar aspects of the solution (oral presentation)	A3, A5
Discusses the impact of the solution on society and environment (written report)	A4

Conclusion

Solution of complex engineering problems should not be only in the capstone project. Assignments/ projects/open ended labs in other courses should also include complex engineering problem solution

Complex engineering problem based learning activities should be well designed following a systematic approach to ensure that a few Ps are always addressed

Complex engineering activities should also not be only in the capstone project. Assignments/ projects in other courses should also include complex engineering activities

Relevant assessment rubrics should be aligned with the corresponding P's and A's

Thank You