# GE2336: SYSTEMS THINKING TO UNDERSTANDING PHENOMENA

**Effective Term**
Semester A 2023/24

## Part I Course Overview

**Course Title**
Systems Thinking to Understanding Phenomena

**Subject Code**
GE - Gateway Education
**Course Number**
2336

**Academic Unit**
Systems Engineering (SYE)

**College/School**
College of Engineering (EG)

**Course Duration**
One Semester

**Credit Units**
3

**Level**
B1, B2, B3, B4 - Bachelor's Degree

**GE Area (Primary)**
Area 3 - Science and Technology

**Medium of Instruction**
English

**Medium of Assessment**
English

**Prerequisites**
Nil

**Precursors**
Nil

**Equivalent Courses**
Nil

**Exclusive Courses**
Nil

# Part II Course Details

**Abstract**

There are three levels of thinking to understand phenomena around us: At the event level, we observe snapshots-in-time (e.g. "IT analyst Mr. Adam resigns today."). At the pattern level, we see trends ("In our department, several IT analysts have successively resigned over the past month."). At the structure level, we attempt to discover the underlying network of causes and feedbacks leading to the observed patterns ("The manager cut expenditure by laying off technical support staff. As a result, the IT analysts got increasing workloads. Then some IT analysts started to resign, creating even more workload for the remaining IT analysts, and leading to more resignations.") This course aims to introduce the elements of systems thinking – a methodology for comprehending, at the structure level, why things happen– so that our students, regardless of their majors, can achieve a higher understanding of phenomena surrounding them. The main questions to be studied are: What constitutes a system? How to identify its components and their inter-relations (e.g. causation, feedback)? How to model a system as a network of its components? We will use the basic tools from systems thinking (understandable by university students of any major) to answer these questions. This course consists of lectures, group problem solving, in-class discussions, as well as a student-centered project on a real case study of the student's choice.

**Course Intended Learning Outcomes (CILOs)**

| | CILOs | Weighting (if app.) | DEC-A1 | DEC-A2 | DEC-A3 |
|---|---|---|---|---|---|
| 1 | Describe the basic defining characteristics of a system. Describe the basic concepts of structures, events, and patterns, e.g. via the use of simple diagrams to illustrate how a given structure (i.e. a network model of causes and feedbacks) of a system (e.g. a system describing workplace morale) can give rise to events and patterns (e.g. the workload and employee resignation patterns). Additional illustrative examples such as unintended consequences of pesticide use, growth of new products, dynamics of disease epidemics. [approximately the first 2 lectures] | 10 | | | |
| 2 | Apply basic systems thinking techniques to discover a system and its components, by identifying/articulating systemic problems to address (e.g. why more and more employees resigned?), and by identifying key variables (i.e. components, such as staff morale, workload) of these problems. Sketch graph illustrating the behaviour of a variable over time (i.e. graph the patterns). [approximately the next 3 lectures] | 20 | x | x | |
| 3 | Apply basic tools of systems thinking, including the causal loop to represent cause-and-effect feedback, and the stocks-and-flows to represent accumulations and distributions (e.g. cash flow of a company), to build a network model with causal loops and stocks-and-flows describing the inter-relations among components. [approximately the next 4 lectures] | 30 | x | x | |
| 4 | Use basic mathematics to describe, understand and predict the basic behaviour of the built network model. Use freely available software to simulate the built network model. [approximately the final 4 lectures] | 25 | x | x | |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Demonstrate, in a team project, the ability to use the knowledge gained in CILOs 1-4: to apply them to a real case study (e.g. to understand/predict the effects of an environmental policy; to deepen understanding of the operations of an engineering system, e.g. public transportation; to apply systems thinking to reframe the body of knowledge of a student' s own major) | 10 | x | x | |
| 6 | Demonstrate the ability to work effectively in a team, via peer evaluation as well as communicating the results of the team project in writing and orally effectively. | 5 | | | |

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to self-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

**Teaching and Learning Activities (TLAs)**

| | **TLAs** | **Brief Description** | **CILO No.** | **Hours/week (if applicable)** |
|---|---|---|---|---|
| 1 | Lectures (including in-class problem solving, and in-class discussions) | Understanding the basic defining characteristics of a system, and the basic concepts of structures, events, and patterns of a system; illustrative examples. | 1 | 6 hrs/ semester |
| 2 | Lectures (including in-class problem solving, and in-class discussions) | Using basic systems thinking techniques to discover a system and its components. | 1, 2 | 9 hrs/ semester |
| 3 | Lectures (including in-class problem solving, and in-class discussions) | Using basic tools of systems thinking, including the causal loop, and the stocks-and-flows, to build a network model describing the system and its components. | 1, 3 | 12 hrs/ semester |
| 4 | Lectures (including in-class problem solving, and in-class discussions) | Using basic mathematics to describe the basic behaviour of the built model. Using free software to simulate the built model. | 1, 4 | 12 hrs/ semester |

| | | | | |
|---|---|---|---|---|
| 5 | Group and individual discussions and consultations (weekly consultation hour) | Each group of students working on their group project will discuss and consult with the instructor regarding the progress and the obstacles encountered. Individual student can also meet with the instructor for clarifying concepts. | 1, 2, 3, 4, 5 | 13 hrs/semester |

**Assessment Tasks / Activities (ATs)**

| | ATs | CILO No. | Weighting (%) | Remarks |
|---|---|---|---|---|
| 1 | Regular homework | 1, 2, 3, 4 | 10 | Throughout the semester |
| 2 | In-class participation, group problem solving and discussions | 1, 2, 3, 4 | 10 | Throughout the semester |
| 3 | Project assessment 1(Project report) | 1, 2, 3, 4, 5, 6 | 35 | Due near the end of the semester. |
| 4 | Project assessment 2 (Oral presentation of the project) | 1, 2, 3, 4, 5, 6 | 5 | To take place near the end of the semester. |

**Continuous Assessment (%)**

60

**Examination (%)**

40

**Examination Duration (Hours)**

2

**Additional Information for ATs**

For a student to pass the course, at least 30% of the maximum mark for the examination should be obtained.

**Assessment Rubrics (AR)**

**Assessment Task**

Regular homework

**Criterion**

Consisting of small case studies and problem sets, to be done individually.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**
Not even reaching marginal levels

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**Assessment Task**
In-class participation, group problem solving and discussions

**Criterion**
With accompanying worksheet to be completed individually and to be collected at the end of class.

**Excellent (A+, A, A-)**
High

**Good (B+, B, B-)**
Significant

**Fair (C+, C, C-)**
Moderate

**Marginal (D)**
Basic

**Failure (F)**
Not even reaching marginal levels

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**Assessment Task**
Project assessment 1 (Project report)

**Criterion**
This assessment is based on the submitted project report.

**Excellent (A+, A, A-)**
Exemplary documentation, complete, professional or scholarly.

**Good (B+, B, B-)**
Good documentation, very well structured with few deficiencies

**Fair (C+, C, C-)**
Satisfactory presentation, evident of fair understanding in response to questions

**Marginal (D)**
Adequate documentation, comprehensible

**Failure (F)**
Poor documentation, incomplete or poorly structured

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**Assessment Task**
Project assessment 2 (Oral presentation of the project)

**Criterion**

This assessment is based on the oral presentation of the project.

**Excellent (A+, A, A-)**
Impressive presentation, completely clear and very persuasive

**Good (B+, B, B-)**
Clear presentation, well delivered, evident of good understanding in response to questions

**Fair (C+, C, C-)**
Satisfactory presentation, evident of fair understanding in response to questions

**Marginal (D)**
Adequate presentation and answers to questions

**Failure (F)**
Poor presentation, incoherent, unclear; unable to answer questions satisfactorily

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**Assessment Task**
Examination

**Criterion**
Cover the contents and concepts of the teaching material in lectures.
The exam assessment results will reflect student learning outcomes.

**Excellent (A+, A, A-)**
High

**Good (B+, B, B-)**
Significant

**Fair (C+, C, C-)**
Moderate

**Marginal (D)**
Basic

**Failure (F)**
Not even reaching marginal levels

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# Part III Other Information

**Keyword Syllabus**
Understanding the basic characteristics of a system, and the basic concepts of structures, events, and patterns; Basic knowledge engineering techniques for discovering a system and its components; Basic tools of systems thinking, including the causal loop, and the stocks-and-flows, for building a network model to represent the system and its components; Use of basic mathematics to describe the basic behaviour of the built model; Use of free software to simulate the built model.

**Reading List**

**Compulsory Readings**

| | Title |
|---|---|
| 1 | Lecture notes and slides to be provided by the instructor. |

**Additional Readings**

| | Title |
|---|---|
| 1 | Sterman, J.D. (2000). Business dynamics: Systems thinking and modeling for a complex world. New York: McGraw-Hill. (contains diverse examples such as diffusion of innovation, traffic congestions, and efficacy of immunization programs) |
| 2 | System Dynamics Society (2015). http://www.systemdynamics.org/ |
| 3 | Anderson, V., & Johnson, L. (1997). Systems thinking basics: From concepts to causal loops. Waltham, MA: Pegasus Communications, Inc. |
| 4 | Senge, P. (2006). The Fifth Discipline. Doubleday, New York. (discusses the usefulness of systems thinking to a learning organization) |
| 5 | Balle, M. (1996). Managing with Systems Thinking, McGraw-Hill. (focuses on applying systems thinking to workplace) |

# Annex (for GE courses only)

**A. Please specify the Gateway Education Programme Intended Learning Outcomes (PILOs) that the course is aligned to and relate them to the CILOs stated in Part II, Section 2 of this form:**

Please indicate which CILO(s) is/are related to this PILO, if any (can be more than one CILOs in each PILO)

**PILO 1: Demonstrate the capacity for self-directed learning**

5, 6

**PILO 2: Explain the basic methodologies and techniques of inquiry of the arts and humanities, social sciences, business, and science and technology**

1, 2, 3, 4, 5, 6

**PILO 3: Demonstrate critical thinking skills**

5, 6

**PILO 4: Interpret information and numerical data**

3, 4

**PILO 5: Produce structured, well-organised and fluent text**

5

**PILO 6: Demonstrate effective oral communication skills**

6

**PILO 7: Demonstrate an ability to work effectively in a team**

5

**B. Please select an assessment task for collecting evidence of student achievement for quality assurance purposes. Please retain at least one sample of student achievement across a period of three years.**

**Selected Assessment Task**

Student papers of the final examination.