SYE6105: RISK AND DECISION ANALYSIS

Effective Term
Semester B 2025/26

Part I Course Overview

Course Title
Risk and Decision Analysis

Subject Code
SYE - Systems Engineering
Course Number
6105

Academic Unit
Systems Engineering (SYE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
SEEM6105 Risk and Decision Analysis (offered until 2021/22) / ADSE6105 Risk and Decision Analysis (offered until 2023/24)

Exclusive Courses
Nil

Part II Course Details

Abstract
The course provides the basic elements of risk and decision analysis. It will cover case studies, methods and tools currently used in the domain. A key aspect is on how to deal with random variables. It is indispensable to obtain the most accurate

values for the probabilities of the outcomes, as well as for the costs of failure. It is important to define precisely the correlations, or links between the variables. An additional issue is on how to decide under uncertainties. For instance, considering the worst case cannot work in general, since it will lead to negative decisions in many situations. This raises the issue of accepting some risks to get opportunities. The general idea is to mitigate risks as much as possible, and to be prepared to handle situations when risks materialize. Risk and Decision Analysis is a combination of quantitative techniques, organizational aspects as well as behavioural considerations, essential for developing future leaders in advanced manufacturing and supply chain management to navigate the multifaceted challenges inherent in these sectors.

General Course Information

Risk analysis is prevalent in most technical and business aspects of economic activity. The 2008 financial crisis transformed into a general economic and industrial meltdown shows that the key issue in business and government decisions lies in the understanding and mitigation of risks. On the other hand risks are the counterpart of opportunities. Without taking risks there is no human activity. More globally the situation is that of decision making under uncertainty.

The general idea is to replace the variables of interest by random variables (or time dependent random variables termed as "stochastic processes"). How to decide in front of random variables? A first difficulty is to get the right probability distributions. The outcome is not unique, so it is indispensable to obtain the most accurate values of the probabilities of these outcomes.

A second difficulty lies in the correlations, or links between the variables. In a deterministic framework, if a link exists, it is clear and explicit. One variable is a function of another one. In a probabilistic set up this is not apparent. It may have catastrophic consequences. In a physical system like a building, one may have extremely reliable elements and a high risk of collapse. The globalization which is at the origin of the 2008 crisis is a good example of the consequences of links. No activity is immune, because links are not apparent.

A third difficulty is on how to decide in front of probabilities. Consider an investment decision; if the framework is deterministic, the decision is easy. One simply compares the discounted cash flow to the investment cost. Clearly it is far from obvious in a probabilistic framework. The solution does not lie either in the worst case scenario. In general this leads to a negative decision. This emphasizes that 0- risk is not possible in a meaningful world. For significant investments in new process development or facility expansion within a high-tech industry, decision-makers must weigh technical, market, and financial risks under uncertainty to achieve long-term growth, rather than merely avoiding all risks.

Course Description

In this course, one will review the techniques which exist to deal with uncertainties in decision making. From basic situations in which a simple risk-consequence analysis can be performed, to more complex situations in which one manipulates random variables, a progressive approach will be performed. The course is self-contained. All what is necessary to know in probability and statistics will be presented, but of course it is helpful to have some background.

The course will review in particular the techniques to improve the knowledge on probability distributions with learning procedures, how to derive solid information from expert opinion, the differences between structural randomness and uncertainties.

The interaction between risk management and systems engineering and management will be described and illustrated. Techniques of decision making under uncertainties, like utility functions, risk indicators (value at risk) will be presented. One will also insist on the fact that techniques do not eliminate risks, but allow integrating them in the decision process. Homework will require the use of python, for which some specific training will be provided, if needed. Students who prefer to use a different mathematical software can do it.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand the main approaches to deal with risk problems	35		x	
2	Perform a risk analysis study	15		x	
3	Integrate Risk Management in Systems Engineering	10	x		
4	Conduct risk analysis using relevant software like Python	15			x
5	Recall of important cases	10	x		
6	Understand risk issues in industry and finance	15	x		

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 real-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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Presentation and Discussion	1, 2, 3, 4, 5, 6	26 hours/sem
2	Tutorial	Help for Assignment	1, 2, 3, 4, 5, 6	13 hours/sem

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Assignment	1, 2, 3, 4, 5, 6	30	-	Yes
2	Project	1, 2, 3, 4, 5, 6	20	-	Yes
3	Oral Presentation and Test	1, 2, 3, 4, 5, 6	50	-	No

Continuous Assessment (%)
100

Minimum Continuous Assessment Passing Requirement (%)
30

Assessment Rubrics (AR)

Assessment Task
Assignment (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Correct answers

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

Assessment Task
Project (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Innovation, creativity, team efficiency

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

Assessment Task
Oral Presentation or Mid Term Test (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Synthesis ability and clarity

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

Assessment Task
Assignment (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Correct answers

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Moderate/Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Project (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Innovation, creativity, team efficiency

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Moderate/Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Oral Presentation or Mid Term Test (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Synthesis ability and clarity

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Moderate/Basic

Failure
(F) Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

- Probability
- Statistics
- Risk Assessment
- Risk Analysis
- Risk Management
- Utility Function
- Value at Risk
- Decision Making
- Systems

Reading List

Compulsory Readings

	Title
1	Lecture Notes

Additional Readings

	Title
1	Ross Sheldon M. A First Course in Probability, 10th ed., Pearson, 2018
2	Wackerly, Dennis, William Mendenhall, and Richard L. Scheaffer. Mathematical statis- tics with applications, 7th ed., Cengage Learning, 2014.
3	Risk Analysis-A quantitative guide by David Vose, 4th edition; John Wiley and sons, Chichester. UK 2000