Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Raman Balajee
Course Author Email	rbalajee@ntu.edu.sg
Course Title	Introduction to Chemical and Biological Safety
Course Code	CB4002
Academic Units	1
Contact Hours	13
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	Year 3 standing
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to teach you about Chemical and Biological Safety at an awareness level; to understand the application of principles and guidelines used to assess the risks, manage, operate safely and to minimize risks through hierarchy of control measures at chemical and biological laboratories and pilot plants.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	By the end of the course, you should be able to: (1) Apply the Safety principles and guidelines to maintain and operate the chemical and biological process plants via Hazard Identification and management of risks.
ILO 2	(2) Apply analytical techniques to establish the scheme to identify risks.
ILO 3	(3) Recommend safety measures in chemical and biological laboratories and pilot plants.

Course Content

1. Introduction to Chemical, Biological and Lab Safety with inherent safety principles.
2. Safety Culture and Communication: Promoting a safety-first mindset, reporting safety incidents and near-misses, importance of clear communication in maintaining safety & health management system (SHMS).
3. Biological Agent and Toxicology: classification, entry, response, measurement, and control in body.
4. Industrial Hygiene: Identification, evaluation, and control from systems.
5. Risk Management and Assessment at the Laboratory and Pilot Plants.
6. Emergency Response and First Aid: Emergency response protocols for fires, chemical spills, toxic exposure, and medical emergencies.
7. Waste Management and Environmental Safety: Proper disposal of chemical and biological waste, recycling and minimizing lab waste, environmental safety and sustainability considerations in labs.

Reading and References (if applicable)

1. Chemical Process Safety: Fundamentals with Applications (3rd Edition 2011) by Daniel A. Crowl, Joseph F. Louvar.
2. Handbook for Risk based process safety in Laboratories and Pilot plants (2023) by CCPS, Wiley.
3. Lecture Notes /Presentation CB4002 (2024), Raman Balajee
4. Code of Practice Workplace Safety and Health (WSH) Risk Management, by the Workplace Safety and Health Council (3rd revision 2021), Singapore.
5. Living in the Environment by G. T. Miller, S. E. Spoolman (17th Edition 2012)

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction to chemical, biological safety 1) Lessons from industrial disasters resulted in major societal, economic and environmental problems. 2) Introduction to Engineering ethics, accident and loss statistics (OSHA Recordable and FAR Metrics), acceptable vs unacceptable risks, public perception, nature of accident processes, and Inherent Safety Principles.	1,2	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	Lecture

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
2	Safety Culture and Communication 1) Promoting a safety-first mindset, reporting safety incidents and near-misses. 2) Importance of clear communication in maintaining safety management system.	1,2	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture
3	Biological Agent and Toxicology 1) Classifications. 2) How toxicant enters in or removed from biological organisms. 3) Effects on biological organisms, toxicological studies. 4) Dose versus response curves, threshold limits (TLV), toxic release model (Probit). 5) Mitigation, etc.	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
4	Industrial hygiene & Hazards identification 1) Regulatory requirements. 2) Intermittent and continuous evaluations. 3) Controls- understand and apply the hierarchy in hazard control, ventilation methods to control toxicant concentration in the workplace. 4) Understand major hazards, preventive and mitigative methods to counter the Industrial Hygiene issues.	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture
5	Risk Management in Labs and Pilot Plants 1) RBPS (Risk based process safety) elements. 2) Risk management approaches. 3) Qualitative vs Quantitative analysis. 4) ACS Hazard Analysis Tools.	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
6	Risk Management in Labs and Pilot Plants-2 1) Team set up. 2) Process safety information. 3) Risk Control Implementation 4) Records keeping 5) Review	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review
7	Risk Assessment Workshop / Assignment 1. To enable the application of skills necessary for the application of tool to achieve the results expected. 2. To review and explain the framework of whole WSH RM (Workplace Safety and Health Risk Management) process including preparation, risk assessment, implementation, record-keeping, and review.	2,3	Lecture notes for the preparation requirements of risk assessment and implementation, record-keeping, and review	In-person	lecture and review

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
8	Risk Assessment Workshop / Assignment 1) Team based practice session requiring a project management and execution skill sets on top of the technical requirements. 2) An example problem is practiced as part of the workshop. – FMEA Tool with Technical Transfer Example	2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review
9	Emergency Response and First Aid 1) Emergency response protocols for fires, chemical spills, toxic exposure, and medical emergencies. 2) Location and use of safety equipment (eye wash stations, safety showers, fire extinguishers, etc.). 3) Basic first aid and training.	2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	Chemical Hazards Information and PPE 1. Definitions /Acronyms - Safety 2. CCPS – learning opportunities 3. Reactive Chemical Hazards 4. Screening via Reactivity outcome tables 5. SDS and PPE requirements	2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review
11	Incident Investigation Techniques: 1. RCA Process, Methods and analyze steps of the incident investigation process. 2. 5Ws+1H, 4M, Fishbone, 5Why Analysis 3. Recurrence prevention solutions, Actions Management.	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
12	Sustainability: 1. Appreciation of the cause of environmental problems, climate changes and ozone depletion due to industrialization. 2. Energy efficiency, CO2 emission reduction and renewable energy in chemical industries and LABs.	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review
13	Waste Management and Environmental Safety 1) Proper disposal of chemical and biological waste. 2) Recycling and minimizing lab waste. 3) Environmental safety and sustainability considerations in lab work.	1,2,3	Students to read Lecture Notes and refer to course textbooks for detailed understanding. Example problems are covered in the lecture. Few exercises and forms Compile all similar queries exchanged from email and response posted back in Blackboard.	In-person	lecture and review

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lecture	Demonstrate how to carry out a procedure such as working through a problem, use incomplete handouts which enabling students participating in class. Quiz is conducted at the end of lecture to test your understanding.
Project /Quiz	Workshop will be conducted to enable your skill-based tool application and facilitation process. Team based project is guided and evaluated for the content, understanding of requirements, your ability to apply the tools effectively to achieve expected results and your concise project report as a professional output.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Quiz at end of every lecture week)	1,2,3	a,b,c,d,f,g,h,j,k	85	Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Assignment(Risk Assessment Project submission)	1.2,3	a,b,c,d,e,f,g,h,I,j,k	15	Team	Analytic	Multistructural

Description of Assessment Components (if applicable)

Brief Summary: Group Project-1- FMEA Analysis (CB4002)
Objective: To perform a Risk Assessment by deploying The FMEA Technique as listed in the 'Requirement' section below and to develop a Hazard Identification Report comprising the following sections

1. Introduction (High-level summary of what has been accomplished by your team)
2. Team with Roles assigned (table form)
3. Recommendations / Actions Summary Table
4. FMEA methodology (refer to the lecture notes)
5. Technology Transfer / New Product Introduction Proposal Study, Bill of Materials, Safety Data Sheets and SOP
6. FMEA Worksheet.

To Perform System/Sequence classification for all Process Steps and Process Equipment of the problem stated.
To Perform FMEA for listed deviations as you see logical and applicable and to assess if the overall Risk is within the acceptable threshold.

Formative Feedback

Examination results: Continuous Assessment at the end of lectures via Quiz + Group Project determining pass or fail.
Marker's report on overall performance will be uploaded to NTUlearn.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

Policy (Others, if applicable)

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Last Updated By: Lai Ru Ying

Appendix 1: Assessment Criteria for Project

A final report is expected as an outcome for the mini project. This is a Team exercise. Maximum score is 15 marks per Project. To do well on the team assessment, it is necessary for you to demonstrate positive interdependence and teamwork. In principle, you will receive the same marks as your team. However, your individual score may vary based on feedback about your contributions to the group work.

Standard	**Criteria**
Excellent (12-15 marks)	Excellent work which is clearly outstanding and characterized by : (a) highly creative, practical, and cost-effective design solution concepts (b) deep understanding of problem, skilful application of engineering knowledge, and thorough analysis of problem/solution (c) excellent build quality, performance, and aesthetics of prototype (d) strict observance of lab/workshop rules and safety, and excellent project/time management (e) excellent presentation of results in report
Good (9-11 marks)	Good work characterized by : (a) creative, practical, and cost-effective design solution concepts (b) proficient understanding of problem, application of engineering knowledge, and analysis of problem/solution (c) high build quality, performance, and aesthetics of prototype (d) good observance of lab/workshop rules and safety, and good project/time management (e) good presentation of results in report
Satisfactory (5-8 marks)	Satisfactory work characterized by : (a) somewhat creative, practical, and cost-effective design solution concepts (b) some understanding of problem, application of engineering knowledge, and analysis of problem/solution (c) moderate build quality, performance, and aesthetics of prototype (d) satisfactory observance of lab/workshop rules and safety, and acceptable project/time management (e) satisfactory presentation of results in report
Poor (0-4 marks)	Work that does not meet minimum criteria and characterized by : (a) lack of creativity, practicality, or cost effectiveness in design solution concepts (b) lack of understanding of problem, application of engineering knowledge, or analysis of problem/solution (c) poor build quality, performance, or aesthetics of prototype (d) unsatisfactory observance of lab/workshop rules and safety, or poor project/time management (e) poor presentation of results in report

Points to Note for report Submission:

a. *Content* – Ensure your team's effort to feature in the report conveys understanding of problem, application of engineering knowledge and analysis of problem. You want to highlight good and practical design attributes that you have incorporated into your system to make it more robust, flexible and intelligent. Especially features that gives your system a superior performance over other team. This information in your report will contribute towards the **Content** component of the assessment.

b. *Teamwork* - Ensure that all team members participate and is seen to be participating in the production of report. Think carefully how you can convey a strong sense of teamwork within your group when composing your report. This will contribute towards the **Teamwork** component of the assessment.

c. *Presentation* - Use the analysis and tools medium effectively. Use these capabilities to convey the resolution of problem, proposed system design via calculations, tabulations, screenshots, schematic drawings, etc. Ensure text and narratives (if used) are correct, concise and clearly articulated. Your effective use of all these elements will contribute towards the **Presentation** component of the assessment.

d. *Creativity* - Be as creative as possible in putting together your report. Remember, this is a pragmatic resolution of engineering problem which allows you much more scope to think out of the box. Ask yourself, "How can I be original in reporting the work done, demonstrate teamwork and highlight our achievements?" Think carefully what you want to feature first before putting the report together. Discuss as a team how you can make the presentation of the content interesting. All these elements will contribute towards the **Creativity** component of the assessment.

Mapping of Course ILOs to EAB Graduate Attributes

Course Code & Title	CB4002 INTRO TO CHEM AND BIO SAFETY
Course Type	ELECTIVE

Overview										
(a)	◐	(b)	●	(c)	◐	(d)	●	(e)	●	(f)	◐
(g)	○	(h)	●	(i)	○	(j)	●	(k)	●		

Legend:

● Fully consistent (contributes to more than 75% of Student Learning Outcome)

◐ Partially consistent (contributes to about 50% of Student Learning Outcome)

○ Weakly consistent (contributes to about 25% of Student Learning Outcome)

Blank Not related to Student Learning Outcome

Course ILOs		**EAB Graduate Attributes**
1)	Apply the Safety principles and guidelines to maintain and operate the chemical and biological process plants via Hazard Identification and management of risks.	a, b, c, d, e, f, h, i, k
2)	Apply analytical techniques to establish the scheme to identify risks.	a, b, c, d, e, f, g, h, k
3)	Recommend safety measures in chemical and biological laboratories and pilot plants.	a, b, c, d, e, f, g, h, j, k
4)		
5)		
6)		
7)		
8)		

9)		
10)		

EAB Graduate Attributes

a) **Engineering Knowledge**: Apply the knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively to the solution of complex engineering problems.

b) **Problem Analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences with holistic considerations for sustainable development. (WK1 to WK4)

c) **Design / Development of Solutions**: Design creative solutions for complex engineering problems and design systems, components or processes that meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required. (WK5)

d) **Investigation**: Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern Tool Usage**: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering problems, with an understanding of the limitations. (WK2 and WK6)

f) **The Engineer and the World**: When solving complex engineering problems, analyse and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks and the environment (WK1, WK5, and WK7).

g) **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9).

h) **Individual and Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9).

i) **Communication**: Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions, taking into account cultural, language, and learning differences.

j) **Project Management and Finance**: Demonstrate knowledge and understanding of engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

k) **Life-long Learning**: Recognise the need for, and have the preparation and ability to (i) engage in independent and life-long learning, and (ii) adapt to new and emerging technologies, and (iii) think critically, in the broadest context of technological change (WK8).

No	Knowledge Profile
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline
WK5	Knowledge including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts that supports engineering design and operations in a practice area
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues
WK9	Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc with mutual understanding and respect, and of inclusive attitudes

Reference: EAB Accreditation Manual