NAZARBAYEV UNIVERSITY
SCHOOL OF ENGINEERING

Department of Chemical and Materials Engineering

Program Handbook

Master of Science in Chemical and Materials Engineering

Academic year 2021-22

Welcome Note

Dear Students,

On behalf of our Faculty and Staff, it is a pleasure and a privilege to welcome you to the Department of Chemical and Materials Engineering (ChME) at Nazarbayev University!

In particular, I wish to congratulate you for choosing to pursue the advanced degree of Master of Science in ChME, an ambitious, demanding and challenging course of study. We are confident in our selection process and therefore in your own abilities to rise to the challenge. From our part, we promise that we will strive to deliver to you, in an effective and inspiring manner, a modern and interactive curriculum.

Chemical and Materials Engineering is the engineering discipline that makes extensive use of both chemical and physical transformations to achieve added value. Our profession relies on the concept of "scale-up", that is, the transition of a discovery (a new material, a new catalyst, a new molecule, a new physical phenomenon) from the laboratory to the production plant. In our times we are fortunate to be experiencing a literal explosion in new materials and new chemistries with applications in many and diverse fields, such as environmental protection and remediation, energy production and storage, hydrocarbon processing, plastics production and processing, foods, pharmaceuticals and so many others. This has made Chemical Engineers worldwide well sought after by employers and commanding top salaries; we are confident that your program of study in Chemical and Materials Engineering will make your future career prospects even brighter.

The MSc in ChME is a two-year specialized degree program. The program is designed to provide advanced skills and a detailed knowledge base at the graduate level for a career in academia, industry or research, in Kazakhstan or abroad. At the same time you will obtain first-hand experience in research by completing an original Thesis. The Program Handbook serves as a guide of the main elements and expectations of the program. I urge you to study it carefully and contact your faculty advisor. I also urge to take every opportunity to interact and get to know your Professors, their research groups and their laboratories. There is much for you to learn here; you only need to ask, try and challenge yourselves.

Once again, welcome to Nazarbayev University and the MSc-ChME program. Let's work together to make your study here the most exciting and unforgettable period ever!

Sincerely,

Dr. Stavros Poulopoulos

Head of the Department of Chemical and Materials Engineering

Welcome Note

Dear Candidates of MSc in Chemical and Materials Engineering,

The MSc in Chemical and Materials Engineering at NU offers world-class Chemical and Materials engineering education as well as research and innovation, with its international faculty and outstanding research facilities. In our program, we are providing learning and researching opportunities in both chemical process engineering and materials engineering. Especially, the research experiences in process design and simulation, functional materials for energy generation, conversion, and storage, environmental protection, and computational materials engineering will be a valuable asset for your future.

Chemical and Materials Engineers are ideally suited to work at this interface which is important for industry as well as cutting edge areas such as nanotechnology, renewable energy and novel composites.

On behalf of our Faculty and Staff, it is a pleasure and a privilege to welcome you to the MSc in Chemical and Materials Engineering Program at Nazarbayev University.

Sincerely,

Dr. Chang-Keun Lim

Director of the MSc in Chemical and Materials Engineering Program

Contents

Program Overview

The Master of Science in Chemical and Materials Engineering (MSc-ChME) degree program is a specialized degree program offered by the School of Engineering (SEng) at Nazarbayev University (NU). Students are required to complete 120 ECTS credits, in 4 semesters, which satisfies the requirements stipulated by the Bologna Process and the European Credit Transfer and Accumulation System (ECTS) for Master's Degrees. The program is research oriented and it is designed to provide the skills required to solve advanced technical problems in chemical and materials engineering through a combination of Thesis Research and advanced coursework.

All students in the MSc-ChME program are required to complete five advanced core courses (30 ECTS) in key fundamental chemical and materials engineering areas such as Applied Mathematics, Transport Phenomena, Materials Processing, Materials Characterization and Chemical Reaction Engineering. Three additional core courses, Research Methods and Ethics, Research Seminar and Technical Communication (18 ECTS), will be offered to provide students with the general knowledge that is necessary for them to design or present their research in an effective way. Students will also be able to select four elective courses (24 ECTS), from a list of possible options, based on their research interests. Students will be enrolled in MSc Thesis I (24 ECTS) and MSc Thesis II (24 ECTS) courses in the third and fourth semesters to carry out an independent research. A wide variety of research topics will be offered by the Department of Chemical and Materials Engineering in areas as diverse as energy generation, conversion and storage; environmental protection, remediation and resource efficiency; process design and simulation; composite functional materials etc. Through its research-intensive nature, the program aims at providing its graduates with the skills required for innovative engineering, to translate research into production, and to foster the future technological development in the country and abroad.

Aims and Objectives

The mission of the School of Engineering at Nazarbayev University is to contribute to the development of Kazakhstan in terms of:

- Educating students with engineering expertise to lead organizations and provide innovative solutions for complex technical issues of enterprises.
- Conducting innovative and pioneering basics of applied research that evolve the body of knowledge in Engineering through interdisciplinary collaboration with other schools and research centers at Nazarbayev University and leading universities worldwide.

- Advancing the professional development in engineering through our service to the professional community and providing lifelong learning opportunities for practitioners.

The MSc-ChME program aims to reflect the mission of the School of Engineering and accomplishes this by pursuing the following objectives:

1. Educate graduate students with the advanced knowledge and skills required to solve research oriented technical problems in chemical and materials engineering;
2. Provide graduate students with an advanced grasp of theories and the insight required for successful professional careers and/or in order to pursue further higher education and lifelong learning;
3. Develop the ability to contribute towards the improvement of the nation's technological level and to provide the necessary base for future technological developments in the country;
4. Promote a sense of leadership with emphasis on scholarship and professional ethics.

Graduate Attributes

NU graduates from the MSc-ChME program shall:

1) Possess an in-depth and sophisticated understanding of their domain of study;
2) Be intellectually agile, curious, creative and open-minded;
3) Be thoughtful decision makers who know how to involve others;
4) Be entrepreneurial, self-propelling and able to create new opportunities;
5) Be fluent and nuanced communicators across languages and cultures;
6) Be cultured and tolerant citizens of the world while being good citizens of their respective countries;
7) Possess high personal integrity;
8) Be prepared to take a leading role in the development of their country.

The MSc-ChME program delivers the graduate attributes by providing the students opportunities to

- be involved in individual and group work, team building exercises for developing decision making skills,
- be engaged with design tasks for developing creativity, presenting project reports to polish their communication skills and through group discussions among group members and faculty,
- develop personal integrity and cultural tolerance.

These attributes are addressed by the learning outcomes that follow.

Program Learning Outcomes

On successful completion of the program, our graduates will be able to:

1. Apply chemical and materials engineering concepts at an advanced level;
2. Plan and conduct research in their field of study using advanced research skills and appropriate methodology;
3. Critically appraise their own research work and existing scientific literature;
4. Communicate effectively about their research work to the general public as well as to experts;
5. Collaborate in teams as well as assume leadership role when needed.

Alignment of Program Learning Outcomes to NU Graduate attributes is summarized in the following table:

		Program Learning Outcomes				
		1	2	3	4	5
NU Graduate Attributes	1	☑	☑	☑		
	2		☑	☑		
	3				☑	☑
	4		☑			
	5				☑	
	6				☑	
	7		☑	☑		
	8					☑

Program Duration

The nominal MSc program duration is **two years**, while the maximum allowable duration can be extended up to **two and half years** (excluding leave of absence and deferment of admission; see "*ACADEMIC POLICIES AND PROCEDURES FOR GRADUATE PROGRAMS OF THE AUTONOMOUS ORGANIZATION OF EDUCATION 'NAZARBAYEV UNIVERSITY'*" for further details).

Assessment

Assessment is aligned with the learning outcomes of the program and those of each course. Course assessment tasks are performed during and at the end of each course. Types of assessment vary from successful completion of integrated coursework, assignments, and project work to evaluation of performance of case studies, interviews, and deliverance of presentations.

The following table summarizes assessment and evaluation points for all stages of the MSc program:

Stage of Program	***Significance***	***Possible Results***	***Evaluation Point***
ADMISSION TO PROGRAM	Initial Evaluation	Admission Admission with Conditional Status, Subject to Satisfactory Completion of Conditions Rejection	***Key Evaluation Point*** Admission is handled on a case-by-case basis by evaluating the student's undergraduate curriculum, English proficiency and letters of recommendation among

			other documents and interview (only for shortlisted candidates)
COURSEWORK	Determination of Student Competence in Fundamentals of Discipline	Continue in Program Continue on Probation Dismissed from Program	***Continuous Evaluation*** The coursework component for the Master of Science is assessed by the module instructor. It is enforced that all faculty provide a module descriptor to students at the start of the course outlining the weight of each assessment.
DEGREE CANDIDACY	Demonstration of Student's Mastery of Content Knowledge and Skills in the Discipline	Pass and Continue in Program Required to Re-Take Some Courses Dismissed from Program	***Key Evaluation Point*** Content knowledge and skills are assessed by the supervisor/co-supervisor.
COMPLETION OF THESIS PROJECT	Demonstration of Student's Mastery of Content Knowledge and Skills Needed to Graduate	Pass Recommend Changes with or without re-defense Fail and dismissal from Program	***Key Evaluation Point*** Content knowledge and skills are assessed by the thesis committee.

Coursework Assessment methods by course & correspondence to Program Learning outcomes are summarized in the following table:

Program Learning Outcome	***Where addressed*** *(course)*	***How addressed*** *(L&T Methods)*
1.	All core and elective courses	Lectures, problem-based tutorials, laboratory practicum, problem-based projects and independent studies
2.	Research methods & ethics, Research seminar, Thesis research I and II	Lectures, problem-based tutorials, Independent study
3.	Research seminar, Thesis research I and II, Research methods & ethics, All courses that include project.	Independent study, presentation, project
4.	Technical communication, Research methods & ethics, Research seminar, Thesis research I and II	Tutorial, presentation, thesis report and presentation, research report and presentation
5.	All courses that include team project, Research methods & ethics, Research seminar, Thesis research I and II	Problem-based project

MASTER OF SCIENCE - PROGRAM CALENDAR 2021-2022

Course-type key

Program Core courses

Program Elective courses

SEMESTER 1

Classes

TYPE	COURSE CODE & TITLE	ECTS
Program core	MSC 601, Technical Communication	6
Program core	MSC 602, Advanced Applied Mathematics	6
Program core	MCHME 603, Advanced Materials Processing	6
Program core	MCHME 604, Advanced Materials Characterization Methods	6
Program core	MCHME 605, Advanced Chemical Reaction Engineering	6

SEMESTER 2

Classes

TYPE	COURSE CODE & TITLE	ECTS
Program Core	MSC 600, Research Methods and Ethics	6
Program Core	MCHME 600, Research Seminar	6
Program Core	MCHME 606, Advanced Heat and Mass Transfer	6
Elective	Elective 1 (Pick one From Electives Pool)	6
Elective	Elective 2 (Pick one From Electives Pool)	6

* Student can choose an elective course from other Departments in SEDS or Schools per approval of the advisor and the Head of Department. At least two electives should be taken from the MSc-ChME Program.

MASTER OF SCIENCE - PROGRAM CALENDAR 2021-2022

SEMESTER 3

TYPE	COURSE CODE & TITLE	ECTS
Program core	MCHME 601, Master Thesis I	24
Elective	Elective 3 (Pick one From Electives Pool)	6

SEMESTER 4

TYPE	COURSE CODE & TITLE	ECTS
Program core	**MCHME 602, Master Thesis II**	24
Elective	**Elective 4** (Pick one From Electives Pool)	6

* Student can choose an elective course from other Departments in SEDS or Schools per approval of the advisor and the Head of Department. At least two electives should be taken from the MSc-ChME Program.

Academic Policies and Procedures

All academic policies and procedures (APP) that are not explicitly covered in this handbook are conformant with the corresponding items described in "*SCHOOL OF ENGINEERING MASTERS STUDENT HANDBOOK*", which covers School of Engineering Master Programs, and the "*ACADEMIC POLICIES AND PROCEDURES FOR GRADUATE PROGRAMS OF THE AUTONOMOUS ORGANIZATION OF EDUCATION "NAZARBAYEV UNIVERSITY" (APP-Graduate Programs-NU)*", which covers all graduate programs in Nazarbayev University. These policies and procedures include, among others, the following:

1. Admissions
2. Registration
3. Credits (Requirements, awarding & transfers)
4. Grading issues such as: administrative grades, grade appeals
5. Course re-takes
6. Degree withdrawals
7. Academic code of behavior
8. Leaves of absence, including medical reasons, immediate family member issues and others
9. Dismissal & voluntary withdrawal.

Every student participating in the MSc-ChME program is expected to have read and understood all the policies, rules, procedures, and guidelines described in this program specific handbook, school's MSc handbook and the general APP for graduate programs in NU.

Grading System

Graded courses

Letter Grade	Grade Points	Percentage
A	4.00	95-100%
A-	3.67	90-94.9%
B+	3.33	85-89.9%
B	3.00	80-84.9%
B-	2.67	75-79.9%
C+	2.33	70-74.9%
C	2.00	65-69.9%
C-	1.67	60-64.9%
F	0.00	0-59.9%

Non-graded (PASS/FAIL) courses

In the case of a non-graded course, the following assessment percentages apply

Description	Percentage
Pass	59% or Above
Fail	Below 59%

Program Completion Requirements

Satisfactory completion of the MSc program requires that the student progress through a number of distinct stages, each of which is characterized by a key evaluation point (See Appendix) The necessary stages are:

1) Satisfactory application to the program;
2) Completing all required coursework in the program (72 ECTS);
3) Satisfactory completion of the master thesis (48 ECTS);
4) Satisfactory achievement of minimum GPA for continuation through semesters and graduation (Candidacy).

Continuation / normal progress

To continue in the MSc-ChME graduate program at SEng, NU, a student must maintain a minimum CGPA of no less than a **B- (2.67 on a 4-point scale)** after each grading period and conform to all program rules and policies to maintain normal progress toward degree. A student who fails to satisfy the continuation requirement for the program is subject to dismissal.

Appealing against grades

If a student believes that she or he has received an unfair or erroneous grade, the student may appeal. The following are cases for appeal:
1) In the case of an examination. The student must first consult with the instructor within 5 working days of her or his receipt of the contested grade (this time may be extended in the event that the instructor can be shown to have been unavailable during the period following the student's receipt of the grade in question). The Instructor must respond within the next 5 working days. In the event that the student is still dissatisfied, she or he may appeal to the Dean of the School (or the Dean's designee) within 5 working days. The Dean (or her or his designee) shall consult with the Instructor before making any decision. The decision of the Dean (or of her or his designee) shall be final;
2) In the case of a Final Course Grade. The student must first consult with the instructor within 5 working days of her or his receipt of the contested grade (this time may be extended in the event that the instructor can be shown to have been unavailable during the period following the student's receipt of the grade in question). The date to be used for appeals of Final Course Grades is the date published in the Academic Calendar. The Instructor must respond within the next 5 working days (that time may be extended in the event the instructor is shown to have been unavailable during the period following the student's receipt of their final grade). In the event that the student still believes that the grade is incorrect, or the Instructor has not replied within 15 days, the student may appeal to the Dean of the School (or the Dean's designee) within 5 days. The Dean (or her or his designee) shall consult with the Instructor before making any decision. The decision of the Dean (or her or his designee) shall be final.

Plagiarism

In any coursework or thesis assessment, unacknowledged copying or plagiarism is not acceptable. Plagiarism can result in extremely serious academic actions including cancellation of any or all results, suspension from the program, or even expulsion. Plagiarism means using the work of others in preparing an assignment and presenting it as your own without explicitly acknowledging – or referencing – where it came from. Plagiarism can also mean not acknowledging the full extent of indebtedness to a source. Work can be plagiarized from many sources including books, articles, the internet, and other media. Plagiarism can also occur unconsciously or inadvertently. Direct copying is definitely plagiarism. Paraphrasing of another's work without acknowledgment is also plagiarism. Submitting someone else's work or ideas without attribution is not evidence of your own grasp of the material and cannot earn you marks.

Nazarbayev University's policy on plagiarism sets out student responsibilities in regard to copying. Students are responsible for ensuring that:

- They are familiar with the expected conventions of authorship and the appropriate use and acknowledgement of all forms of intellectual material relevant to their discipline.
- The work submitted for assessment is their own.
- They take all reasonable steps to ensure their work cannot be accessed by others who might seek to submit it, in whole or in part, as their own.

Whenever you refer to another person's research or ideas -either by directly quoting or by paraphrasing them-, you must acknowledge your source by proper referencing. Turnitin is a useful web-based originality checking service that can help in assessing the originality of one's submitted work. More information on Turnitin can be found in Appendix I and service's web site (http://turnitin.com/).

Description of Courses

Course-type key

Core courses

Elective courses

Program Core Courses

MSC 600, Research Methods and Ethics

This course addresses the primary need for graduate students to undertake formal training that will help them in understanding how to conduct their research. The course will develop student's understanding of research plan and engender skills enhancement for reading, interpreting, writing, and presenting key ideas. The course will also instill an understanding of a variety of research methods and ethics and implement appropriate strategies in lecture and workshop settings.

LOs

By the end of this course, students will be able to:

1. Discuss the research process, research methodology, research methods, and research ethics;
2. Effectively use modern technology to plan and manage research projects;
3. Effectively apply the research methodology and appropriate research methods to formulate and validate engineering research problems;
4. Critically analyze and evaluate research findings;

5. Effectively employ appropriate communication techniques to summarize, document and present the research results to both specialists or non-specialists;
6. Develop the skills to maintain good working relations in a research team environment.

MSC 601, Technical Communication

This graduate level course combines the application of rhetorical analysis to stylistic conventions of writing in engineering, with a focus on clarity, conciseness, and coherence. Students will employ process writing to produce genre specific writing familiar to Engineers, including research reports scientific papers designed for specific audiences. This course also trains students to deliver effective and appealing professional and scientific presentations, with attention to best practices in the use of technical English and oral communication.

LOs

By the end of the course, students will be able to:

1. Write rhetorically aware and effective professional texts, presentations, and technical reports with a minimum number of flaws in grammar and style;
2. Develop information literacy skills in order to support academic integrity and engage with scholarship in the field;
3. Understand the quality requirements of high impact journals and international conferences;
4. Effectively design and deliver visual information for use in presentations and papers;
5. Analyze intended audiences to deliver information effectively at business, interdisciplinary and discipline-specific levels;
6. Deliver confident and professional presentations with control of pronunciation, intonation and appropriate body language;
7. Attract and retain audience attention, and appropriately respond to feedback and questions.

MSC 602, Advanced Applied Mathematics

This course reviews and deepens the advanced analytical and numerical methods to solve ODEs and PDEs. The whole course will be supported by a mathematical software package capable to perform symbolical calculations.

The module is designed for graduate students to cover their research needs concerning mathematical modeling via analytical, semi-analytical or numerical techniques.

LOs

By the end of this course, students will be able to:

1. Apply appropriate methods of solution for a given mathematical problem concerning modeling with ODEs and PDEs;
2. Design sophisticated computer program to solve semi-analytically or numerically engineering problems that require modeling with ODEs and PDEs;
3. Justify analytical or numerical results for advanced mathematical models of engineering field.;
4. Create a written document, according to internationally accepted standards (using an appropriate Scopus-Q1/Q4 journal, or equivalent, as a reference in the preparation), presenting theoretical and practical aspects in the evaluation of the results involved in a chosen Applied Mathematics topic, prior approval of the instructor.

MCHME 600, Research Seminar

This course enables students to gain and apply basic research knowledge and skills to select their research projects in Chemical and Materials Engineering. The course aims to develop the following knowledge and skills:

1. Identifying the area of research interest;
2. Surveying of state of the art for the area of interest;
3. Identifying the research topic and associated issues;
4. Understanding of the social, cultural, global and environmental issues associated with chosen research topic;
5. Writing a research paper based on the literature survey under the supervision of a faculty member;
6. Presentation of a seminar and being assessed by a panel.

LOs

By the end of this course, students will be able to:

1. Explore potential areas of research and select his/her research area;
2. Clearly identify the research topic and research issues;
3. Identify the social, environmental and economic issues related to the research topic.

MCHME 601, Master Thesis I

This course intends to give students the opportunity to develop their Master Thesis research proposal and to develop a thorough literature review on their research topic. The course aims to develop the following knowledge and skills:

1. Preparation of a thorough and comprehensive literature review to support the research proposal;
2. Formulation of the research hypothesis;
3. Developing and justifying the methods to conduct the research.
4. Writing a thorough and robust research proposal.
5. Conducting research work.

LOs

By the end of this course, students will be able to:

1. Conduct a comprehensive literature review to support the research proposal;
2. Formulate the research hypothesis;
3. Develop and outline the research methods;
4. Independently apply research methods and techniques to perform experimentation/simulation and hypothesis testing;
5. Effectively present the progress of the research.

MCHME 602, Master Thesis II

This course intends to give students the opportunity to develop their Master Thesis and presentation on their research topic. The course develops the following knowledge and skills:

1. Demonstration of the research hypothesis;
2. Integration and logical arrangement of the results obtained on their research;
3. Developing logical discussion on their research;
4. Writing Master Thesis;

5. Presentation of their research.

LOs

By the end of this course, students will be able to:

1. Conduct proposed research;
2. Demonstrate the research hypothesis;
3. Integrate and logically rearrange the results obtained on their research;
4. Develop logical discussion on their research;
5. Write Thesis;
6. Effectively present the results of the research.

MCHME 603, Advanced Materials Processing

This course provides comprehensive coverage of the main technologies for the production of high-value materials from polymers and ceramics and the theory which underlies materials processing operations. Design and manufacturing of polymeric composites, ceramic matrix composites and ceramic thin films will also be discussed. The conventional and modern manufacturing technologies such as extrusion, molding, sintering, 3D printing, chemical vapor deposition, tape casting and chemical vapor infiltration will be covered in this course.

LOs

By the end of this course, students will be able to:

1. Outline the range and application of materials and processing technologies for manufacturing of high-value products from polymers and ceramics including polymeric composites, ceramic matrix composites and ceramic thin films;
2. Choose the appropriate technologies for the production of given advanced material;
3. Design the production processes of advanced materials based on principles and theory which underlies materials processing operations;
4. Communicate the general aspects of advanced materials and materials technologies.

MCHME 604, Advanced Materials Characterization Methods

This course provides an introduction to the latest developments and breakthroughs in the area of advanced characterization techniques available to examine common types of materials, for example, electron microscopy, diffraction, spectroscopy, thermal analysis. Also, the course explains the principles that control each technique and how they operate.

LOs

By the end of the course the student will be expected to be able to:

1. Identify the most relevant characterization techniques which are applied to analyze materials in the chemical industry, e.g., Transmission and Scanning Electron Microscopy, X-ray Diffraction, Ultraviolet-Visible Spectroscopy, Differential Scanning Calorimetry, Thermogravimetric Analysis;
2. Investigate thoroughly the chemical and physical principles that support each of the techniques;
3. Assess the analytical data generated by each of the techniques and formulated judgements based on complete or incomplete data;
4. Communicate effectively with professional colleagues regarding the results, advantages, and disadvantages provided by each of the techniques.

MCHME 605, Advanced Chemical Reaction Engineering

The course is addressed to graduate students and aims at reinforcing and enhancing the knowledge they have on chemical reaction engineering, focusing on problem solving techniques and on connecting the principles presented with relevant applications, especially in the production of materials. At the introductory part of the course, the fundamentals of reaction kinetics and isothermal ideal reactor design are reviewed. Then, the main cases of heterogeneous reacting systems are analyzed including both non-catalytic and catalytic reactions. Advanced topics will be covered, like chemical vapor deposition reactors and applications, providing students with a broader appreciation of the applications of reaction engineering principles and methods in materials production. Finally, students have to present a project on a chemical process emphasizing on the reactor used.

LOs

On successful completion of the course students will be able to:

1. Formulate and solve advanced chemical reaction and materials engineering problems;
2. Apply advanced numerical and analytical solving techniques in chemical reaction engineering problems;
3. Communicate effectively with colleagues and defend his/her work in front of an audience;
4. Demonstrate ability to use relevant materials, equipment, tools or processes as applied to chemical reaction engineering in a laboratory setting.

MCHME 606, Advanced Heat and Mass Transfer

This course will employ the application of the general conservation equations (conservation of momentum, energy and mass) for studying the heat and mass transfer processes related to different types of systems and geometries. Modeling of heat and mass transfer processes for engineering systems, exposed to variety of initial and boundary conditions, is an integral part of this course. Basic classic techniques to solve the simplified version of the modeled equations will be introduced. Numerical techniques will be applied to solve 3-dimensional complex problems. Applications of heat and mass transfer analyses to different fields of chemical and materials engineering will be considered. Step by step techniques will be shown to model and analyze problems selected from specified application areas.

LOs

By the end of the course the student will be expected to be able to:

1. Derive and characterize the fundamental equations using in heat and mass transfer;
2. Build the mathematical model which describes the selected heat and (or) mass transfer process and explain the basic assumptions;
3. Develop and solve (numerically or analytically if possible) the model describing a coupled heat and mass transfer;
4. Rationalize the selection of algorithms employed to obtain the numerical solution of the equations representing heat and mass process.

*Note: In future, the course description and CLOs may change if approved by SEDS Teaching and Learning Committee. The changes would be reflected in the respective Course Specification Form.

Program Elective Courses

MCHME 700, Computational Fluid Dynamics in Chemical and Materials Engineering

Computational fluid dynamics or CFD is the analysis of systems involving fluid flow, heat transfer and associated phenomena such as chemical reactions by means of computer-based simulation. The technique is very powerful and spans a wide range of industrial and non-industrial application areas. Some examples are: (1) chemical process engineering: mixing and separation, polymer molding; (2) simulation of flow pattern in gas-liquid systems; (3) simulation of air bearing materials; (4) environment engineering: distribution of pollutants and effluents; (5) biomedical engineering: blood flows through arteries and veins, etc. Prior to setting up and running a CFD simulation there is an important stage of identification and formulation of the flow and (or) transport process problem in terms of the physical and chemical phenomena that need to be considered.

LOs

By the end of this course, students will be able to:

1. Set forth forcefully the basic CFD concepts and assess the range of applicability of CFD to the problems in chemical and materials engineering;
2. Rationalize the usage of fundamental conservation laws in fluid motion, heat and mass transfer processes. Demonstrate basic knowledge of numerical methods and algorithms;
3. Set up and solve the appropriate model for specified particular applications.

MCHME 701, Advanced Chemical Thermodynamics

The course covers the laws of thermodynamics and their applications to equilibrium and the properties of materials, including phase equilibrium modeling, the concepts of chemical and electrochemical potential and fugacity, surface thermodynamics, interpretation of experimental data and evaluating different thermodynamic models for multiple phases and chemical reaction equilibrium. Furthermore, this course shows application of chemical engineering thermodynamics to real world problems using process simulation software.

LOs

By the end of this course, students will be able to:

1. Describe the fundamental thermodynamic equations, equilibrium phase diagrams, phase transition behavior;
2. Calculate physical and thermodynamic properties of different materials;
3. Implement commercial simulation software to estimate and analyze phase and reaction equilibrium;
4. Use the thermodynamic models to predict the behavior of electrochemical systems;
5. Apply the fundamental thermodynamic equations to analyze the surface properties of materials.

MCHME 702, Biofilm Science and Engineering

This course will introduce the students to Biofilm Science and Engineering and outline the current antimicrobial strategies for biofilm control and mitigation in industrial and health settings.

Part 1: Biofilm life cycle, methods for determination of biofilm structure and activity; biofilm matrix and mechanism of quorum sensing; microbial ecology of industrial biofilms.
Part 2: Biofilms in wastewater treatment and industrial process; Biofilms in heat exchangers (Biofouling), metal structures (microbially influenced corrosion) and food processing (biocontamination).
Part 3: Design of antibiofilm surfaces and coatings for biofilm control and mitigation
Part 4: Case studies on biofilm control and mitigation of specific biocontaminants (e.g., Pseudomonas aeruginosa and Listeria monocytogenes)
The course will include four guest lectures by industrial biofilm specialists.
Project: The students will write a short group project on biofilms in industrial processes.

LOs

By the end of this course, students will be able to:

1. Understand basic elements of Microbiology and Biochemistry
2. Understand the complex chemical structure and metabolism of biofilms;
3. Conceptualize devices and methods for biofilm characterization and biofilm removal;
4. Understand and communicate the role of biofilms in productive processes;
5. Work in group to review and communicate applications of biofilms in the industry

MCHME 703, Crude Oil Processing

This course will present an overview of the modern, integrated crude oil refinery, its feedstocks, product, and the processes employed to convert crude oil and intermediate streams into finished products. Each refining process will be presented, covering operating description, feedstock and catalyst selection, unit performance, and product output and properties. This course provides major insights into processes like atmospheric distillation, vacuum distillation, desalting, cracking, hydrocracking, catalytic reforming, isomerization and polymerization, coking, visbreaking, and sulfur removal in a typical refinery.

LOs

By the end of the course the student will be expected to be able to:

1. Apply engineering design methodologies to plan, manage, identify constraints, and create innovative solutions in field operation and petrochemical processes;
2. Develop engineering solutions for petrochemical products taking into considerations professional responsibilities as well as the industry standards, legal, ethical, economic, commercial, environmental, social, health & safety, risks, production, quality, sustainability constraints, in a multicultural, global, and societal context;
3. Communicate effectively technical information both orally and in writing in a variety of audiences.

MCHME 704, Advanced Safety, Reliability and Risk Engineering in Process Industries

The course aims to provide a detailed understanding of advanced safety concepts, risk assessment and management approaches, accident models, and more recent advancement in the field of risk and reliability engineering. Uncertainty analysis and modeling approaches will also be discussed. This course presents: overview of safety issues in oil and gas industries, definition of various terms used in risk and safety studies, accident modeling, risk assessment methodologies, methods of hazard identification and assessments, probabilistic hazard assessment, and lessons from past accidents.

LOs

By the end of this course, students will be able to:

1. Formulate dynamic accident models and apply risk management to chemical plants operation;
2. Explain human error mechanism and practice human reliability assessment;
3. Apply process safety data analysis and modelling to chemical processes design and operation.

MCHME 705, Emerging Pollutants: Sources, Fate, and Control

Emerging pollutants are released into the environment from various anthropogenic sources and are distributed throughout environmental matrices. Most of them escape common detection techniques or conventional treatment facilities. In this course, the most important emerging pollutants like heavy metals, criteria pollutants, endocrine disruptors, pesticides etc. will be presented and discussed along with their main sources, dispersion and transport routes in the environment, monitoring instruments and the most modern abatement technologies. Issues like health effects on humans and impact on eco-systems will be also addressed. Students will get hands on experience through dedicated experimental labs, and will have to work in small groups to deliver a report and presentation of a research topic in the field.

LOs

By the end of this course, students will be able to:

1. Relate emerging pollutants to sources and effects;
2. Propose appropriate abatement options depending on the type of emerging pollutant;
3. Communicate efficiently with colleagues and present effectively his/her work in front of an audience;
4. Utilize relevant materials, equipment, tools or processes in a laboratory setting.

MCHME 706, Analysis of Exposure to Toxic Chemicals

Human exposure analysis is an emerging science concerned with how humans come into contact with chemicals in the environment via inhalation, ingestion, and dermal contact. This course examines individual and population exposure particularly workers of chemical industries to toxic pollutants, the levels of exposure, why exposures occur, and how to quantify exposure events. The course focuses on scientific and engineering issues, including direct measurement and model constructs. Students gain an understanding of the complexities, uncertainties, and physical, chemical and biological issues relevant to human exposure resulting from the use and release of toxic compounds. Topics include human exposure analysis terminology, pollutant fate and transport, human activity patterns, occupational exposure, indoor air quality, dosimetry, statistical tools, and assessment tools for inhalation, ingestion and dermal exposure. For the final project, the students design and perform a small-scale human exposure study using monitoring instruments and/or exposure models.

LOs

By the end of this course, students will be able to:

1. Quantify source emission rates using mass balance approach;

2. Assess the qualitative and quantitative changes to the atmospheric environment induced by anthropogenic activities;
3. Read and critique peer review journal articles related to course material;
4. Design, conduct, analyze and synthesize a small-scale human exposure study;
5. Apply chemical engineering principles such as thermodynamics, mass balance and transport phenomena to indoor and outdoor exposure problems.

MCHME 707, Polymer Melt Fluid Mechanics and Processing

This course will cover the use of fluid mechanics in the analysis of several key processing operations for polymeric materials, namely extrusion, injection molding and calendering. Initially we present the topic of the viscosity of polymeric melts and models used for its description, such as Power-law, Carreau and Ellis. Next we present the equations of conservation of mass, energy and momentum and their use in the case of non-Newtonian fluids. Finally we present a theoretical analysis of the typical flows used for the derivation of the flow curve of polymer melts (simple shear, cone-and-plate, parallel plate, Couette, Poiseuille, slit flow), derive the models on which rheometry is based and illustrate the limitations of each technique. In the last part of the course we present the application of the lubrication approximation to derive workable models for polymer processing operations. Simplified models are typically one-dimensional models; these will be derived and their relevance to actual processing operations discussed. More advanced models include use of Hele-Shaw and other lubrication flows. During the last segment of the course, the students undertake an individual research project of computational (simulation and analysis of some polymer processing operation, possibly outside those covered in the class), experimental (measurement of an important property of a polymer system, such as viscosity or glass transition temperature) or bibliographical (critical review and exposition of a novel polymeric product or processing technology) nature. The final grade is the result of a final exam, a project and eight homework assignments.

LOs

After completing this course, students will be able to:

1. Derive the conservation equations for mass, energy and momentum;
2. Use the conservation equations in the case of a non-Newtonian fluid;
3. Derive and solve one-dimensional models for processing related flows;
4. Simplify the above using the lubrication approximation and derive models for polymer processing operations.

MCHME 708, Advanced Powder Processing

The course covers the preparation, characterization and processing of powder for functional applications. Synthesis of particles by sol-gel and CVD methods. Preparation of fine particles by milling. Characterization of particle size, morphology, shear and mechanical properties. Agglomeration, coating, spray drying, extrusion and 3D printing of particles for production of functional materials. Mathematical modeling of powder processing.

LOs

By the end of the course the student will be expected to be able to:

1. Compare chemical and mechanical methods of powder preparation including sol-gel, CVD and milling;
2. Characterize quantitatively the powder size distribution, morphology and mechanical properties;
3. Outline theoretical principles and applied aspects of powder agglomeration, coating, spray drying, extrusion and 3D printing;
4. Model unit operations in powder processing using the continuum and discrete approaches.

MCHME 709, Food Engineering and Processing

The food industry is commonly the largest industrial sector of most economies. Food engineering involves the conception, design, and operation of food processes, equipment, and plants for efficient and safe food production. Core chemical engineering principles, such as heat and mass transfer and fluid mechanics, are applied, and are expected to be mastered by interested graduate students. However, the average food is substantially more complex than the normal compounds presented in a ChE degree: they present complex rheology, composition, microstructure, etc. In this course, it will be presented the principles of food processing, such as drying, food formulation and characterization, and some relevant chemical and biochemical reactions to the food industry.

LOs

By the end of this course, students will be able to:

1. Apply chemical engineering principles to complex foods systems;
2. Characterize and model the complex properties of foods and important chemical reactions;
3. Design and model food processing operations;
4. Formulate food with enhanced stability and functionality.

MCHME 710, Porous and Powder Materials Characterization

This course aims to provide a general understanding of the principles of instrumental analysis with focus on porous materials and powders characterization including pore size distribution, surface area, pore volume, particle density and particle size and shape. It covers the theory, measurement principles and modern analytical techniques and equipment and is complemented by lab sessions. The course focuses on porosimetry (gas and mercury) and particle size distribution (light scattering, sedimentation and mechanical sieves) techniques.

LOs

By the end of the course the student will be expected to be able to:

1. Select appropriate techniques for the characterization of porous materials and powders;
2. Summarize the basic steps of operation of the instruments used for the characterization of porous materials and powders;
3. Analyze, interpret and validate measurement results from the techniques that are studied in the course.

MCHME 711, Advanced Materials for Environmental and Biomedical Applications

Resource efficiency means using the Earth's limited resources in a sustainable manner. The first part of the course is related to clean air, water and soil. Sustainable development, related research findings, and the relevant international environmental policies will be recurring topics throughout. The relation between the quality of environment and human health will be discussed, and emphasis will be given on both current and future challenges. The second part of the course will be dedicated to the solutions that advanced materials can offer in environmental and biomedical applications. Research will be integrated to teaching by presenting the latest findings on a variety of topics: natural and synthetic zeolites, cryogels, thermo ablation and nanomaterials, and photocatalysis and nanocatalysts for environmental protection and cancer treatment.

LOs

By the end of the course the student will be expected to be able to:

1. Describe the most important environmental challenges following a holistic, integrated and interdisciplinary approach;
2. Critically analyze scientific literature to propose advanced materials for environmental and biomedical applications;
3. Articulate and defend a team project in front of an audience.

MCHME 713, Advanced Energy Materials and Their Application

The purpose of the course is to give an understanding of principles energy material science. This course includes lectures on the fundamentals, characterizations, preparation and evaluation methods of advanced and currently used materials for energy applications. Energy generation, conversion and storage in solar cells, fuel cells and particularly Li-ion batteries are going to be presented. Additionally, some unique properties of materials will be considered for designing of batteries for particular applications. Other advanced energy related technologies as fuel cell and photovoltaics will be introduced and the mainly applied materials will be discussed. Students will be engaged in the experimental works involving preparation of electrodes and electrolytes, and also assembly of coin cells and performance testing. Fabrication and studying of nanomaterials will be also taken into account in the laboratory works, as well as their physical properties characterization through the techniques of XRD, BET, spectroscopy etc. Finally, assembled batteries will undergo evaluation by its electrochemical measurement. Students will carry our individual and group projects, therefore be trained to design the experimental work, characterization/evaluation of the physical/electrochemical properties and interpret the overall obtained results.

LOs

By the end of the course the student will be expected to be able to:

1. Understand and classify the active materials for energy application and their properties;
2. Choose an appropriate technique for synthesis and characterization of the materials;
3. Plan and implement experimental work related to battery research and interpret the results.

MCHME 714, Computational Material Engineering

Computational Materials Science and Engineering (CMSE) is the computer-based employment of modeling and simulation to understand/predict materials behavior and to design next generation material systems. While the complexity of the physics and multi-scale nature of materials makes computational modeling challenging, modern methods of CMSE are beginning to produce widespread impact in the design and development of new materials. A number of computational methods and tools targeted to different spatio-temporal scales have been well established, ranging from electronic structure calculations based on density functional theory, atomic molecular dynamics and Monte Carlo techniques, mesoscale dynamics, phase-field method, to continuum-level macroscopic approaches. The basic theoretical background and applications of these computational methods in chemical and materials research will be introduced, but the course will also emphasize hands-on training through computational exercises.

LOs

By the end of the course the student will be expected to be able to:

1. Understand basics concepts, applications, and emerging trends in computational materials science and engineering;
2. Be able to describe the basic ideas, workflow, strengths and limitations of DFT, atomistic MD, MC, mesoscale dynamics, phase-field method, and continuum-level macroscopic approaches;
3. Select a suitable modeling and simulation method for a specific research problem in chemical & materials engineering and be able to provide arguments as to its suitability.

MCHME 715, Air Quality, Toxicity, and Health

This course will discuss the chemistry of the chromium in airborne particles; tropospheric gas-phase chemistry; tropospheric heterogeneous chemistry; stratospheric chemistry; and characterization of the atmospheric aerosol and its role in heterogeneous reactions and materials transport. The course includes indoor air chemistry as well. The course will detail the chemistry and physics of current atmospheric pollution issues, including urban smog, acid rain, global warming, stratospheric ozone depletion, visibility, and indoor air quality. Additionally, the course discusses the health impact and toxicity of airborne and engineered nanoparticles that enter the human body via inhalation. A particular attention will be given to indoor air quality and the existing aerosol sources. Human exposure analysis is an emerging science concerned with how humans come into contact with chemicals in the environment via inhalation, ingestion, and dermal contact. Human exposure analysis examines individual and population exposure to pollutants, the levels of exposure, why exposures occur, and how to quantify exposure events. The course focuses on scientific and engineering issues, including direct measurement and model constructs. Students gain an understanding of the complexities, uncertainties, and physical, chemical and biological issues relevant to human exposures resulting from the use and release of toxic compounds. Topics include human exposure analysis terminology, pollutant fate and transport, human activity patterns, occupational exposure, indoor air quality, dosimetry, statistical tools. The course strongly incorporates research into teaching and is tied with its laboratory and field measurements. The laboratory and field measurements help the students to learn about gas and aerosol instrumentations and their applications on indoor/outdoor air monitoring and conduct research in this field. The M.Sc. students will do computer and modeling research and present their findings in the form of a project report.

LOs

By the end of the course the student will be expected to be able to:

1. Justify atmospheric processes both conceptually and mathematically using physical chemistry, notably kinetics, thermodynamics and transport phenomena principles;
2. Identify the potential sources of pollutants indoors, workplaces and outdoor, their marker and approaches to reduce the emissions;
3. Explain the mechanisms for translocations of nanoparticles to human body and their health impact
4. Operate aerosol and gas instrumentations;
5. Report their research findings in the form of a research article and present them to peers;
6. Read and critique peer review journal articles related to course material.

*Note: In future, the course description and CLOs may change if approved by SEDS Teaching and Learning Committee. The changes would be reflected in the respective Course Specification Form.

Master Thesis Guidelines

The guidelines presented herein form a manual designed to provide you with a quick reference for planning, preparation, and compilation of your thesis manuscript. In this manual, explanations of form and style, as well as a wide range of suggestions and advice, are offered for serving this goal. It is among the aims of this document to clarify the rules and explain possible options in areas where decisions about form and layout are at your discretion.

Finally, it is important that you read the entire manual **before** you begin preparing your manuscript so that you understand the format and purposes behind the rules.

Aims and Objectives

The Master's thesis constitutes a piece of applied research and in this context, your primary goal is to analyze, solve and present your research findings for an existing problem relevant to your field of study. This process should be based on existing scientific and engineering knowledge and follow the principles of responsible research conduct.

The **topic** of your thesis should be related to the advanced studies of the degree program and should be decided in agreement with your thesis supervisor through the preparation and presentation of your Thesis Agreement to the MSc program coordinator for approval.

The primary focus of your research project is usually expressed in terms of **aims** and **objectives**. Your aims should comprise aspirations and/or intentions defined in broad terms which essentially describe what you are hoping to achieve. These aims set out what you are targeting to deliver at the end of the project. Objectives, on the other hand, are specific statements that define measurable outcomes and comprise specific goals and steps that must be followed for achieving your aims. Your objectives must be:

Specific; provide precise descriptions of what you are going to do.

Measurable; be able to provide concrete evidence when reaching a goal.
Achievable; avoid setting infeasible goals.
Realistic; plan your steps and goals based on the available resources (time, lab equipment, skills etc.).
Timely delivered; create a timetable, know when each stage needs to be completed, allow extra time for unexpected delays

Thesis components and contents

Thesis components

Your thesis may have up to three components: a core thesis, essential supporting material, and non-essential supplementary material.

Core Thesis. The core thesis must be a self-contained, narrative description of the argument, methods, and evidence used in your thesis project. Despite the ability to present evidence more directly and with greater sophistication using mixed media, the core thesis must provide an accessible textual description of the whole project.
The core thesis must stand alone and be printable on paper, meeting the formatting requirements described in these guidelines. The electronic version of the thesis must be provided in the most stable and universal format available—currently Portable Document Format (PDF) for textual materials. These files may also include embedded visual images.

Essential Supporting Material. Essential supporting material is defined as mixed media content that cannot be integrated into the core thesis, i.e., material that cannot be adequately expressed as text. Your thesis committee is responsible for deciding whether this material is essential to the thesis. Essential supporting material does not include the actual project data. Supporting material is essential if it is necessary for the actual argument of the thesis and cannot be integrated into a traditional textual narrative. Essential supporting material must be submitted in the most stable and least risky format consistent with its representation.

Non-essential Supplementary Material. Supplementary material includes any supporting content that is useful for understanding the thesis but is not essential to the argument. This might include, for example, electronic files of the works analyzed in the thesis or additional support for the argument (simulations, samples of experimental situations, etc.). Supplementary material is to be submitted in the most stable and most accessible format.

Core thesis/manuscript contents

This Master's program includes courses presenting and explaining research methodologies and reporting methods, however, you should always keep the following in mind when conducting research and compiling your thesis manuscript:

- Always include a pertinent literature review. The literature review aims at describing the existing and established theory and research in your thesis area and, hence, providing a context for your work. Reference all sources mentioned in the review and give full citation in thesis' Reference List.

- Explain the methods used in researching and developing your work. It is highly important to explain what research methods you used to acquire data and/or information and present the conducted work.
- Discuss with your thesis supervisor the extent and level of detail required; different levels of research depth will obviously require different levels of detail.
- Clearly present your findings. Describe what have been discovered through your research. Give all results, as long as they are products of your research activities. Include tables, graphs, illustrations etc., so that it is easier for the reader to understand your results.
- Always, include a discussion of your findings. Use a discursive and evaluative writing approach and fully present your interpretations and judgements of the results. Contextualize your ideas in relation to other theories and with other similar research, particularly in reference to the works mentioned in your literature review.

Stages and Procedures

Actions described in Stages 1 & 2 need to be completed within the first eight weeks of the program's 2nd semester. During the 2nd semester the student has the opportunity, after discussion with his/her current supervisor, to change the topic and/or the supervising committee. After the end of the 2nd semester no changes are allowed.

STAGE 1: Identify Thesis Supervisors (supervisory committee)

Students must select their potential MSc thesis supervisors (Lead- & Co-supervisors) within the first 8 weeks of the Program's second semester and inform the MSc Program Coordinator, who is going to initiate the required approval of your supervisory committee by the departmental MSc Program Committee. Both supervisors must be from the ChME Department. In exceptional cases, with the approval of the Department MSc. Committee, HoD, and Dean, it will be accepted to have the Co-Supervisor external to the Department in which the student is enrolled. But, with no exception, the Lead Supervisor must be a faculty of the Department of ChME. In the case of having an external member as Co-Supervisor, that member will act as internal to the effects of evaluation of the Master Thesis. Furthermore, an external examiner needs to be assigned to each student, who will not be part of the student supervisory committee but will be involved in the approval of the final MSc thesis report and the evaluation of the MSc Thesis defense. The external examiner must be external to your department and can be an academic from another NU department, university or, alternatively, an expert from the industry holding PhD degree and specializing in your thesis's scientific field. Department's MSc committee will choose the External Examiner from a list of supervisor-proposed candidates. In all stages, all involved individuals and bodies are responsible for identifying and declaring potential or perceived conflict of interest among involved parties and following the rules and guidelines mentioned in Appendix VI.

Constructive supervision is a significant component aiming in the success of your thesis work and requires the vivid interaction between you and your supervisors. However, you should never forget that it is you, the student, who is carrying out the work and it is your motivation, academic knowledge, and interest central in making the supervision process work.

Your supervisory committee comprises academic professionals that will help you track appropriate research sources and support your research and the compilation of your thesis work. Your supervisor may also refer you to other experts (either internal or external to the university) who may have specialized knowledge in the specific topic of your thesis. Your Lead Supervisor is responsible for ensuring that the Master's thesis meets the goals and requirements set by the School of Engineering. Your supervisory committee will be able to predict common pitfalls and protect you from them while at the same time providing you with advice regarding your thesis' objectives. However, keep in mind that it is required by you to be the dynamic party in interacting with your supervisors. Discussion and critical argumentation are key features that should be present in your meetings. Supervision is not a monologue, and neither the supervisors nor the student should restrain themselves from asking the other party for clarification of claims. Mutually challenging dialogues can help you in delivering a successful result.

STAGE 2: Selection of topic

Supervisors are in position to suggest appropriate MSc thesis' topics. These may stem from research work being conducted at the school/department or may arise from material covered during your coursework. Furthermore, thesis' topics may be also related to work carried out in the context of research projects involving industrial partners. The topic of the thesis is decided in discussions between you and your chosen supervisors; however, the final choice is always made by you. In this regard, it is customary for interested department faculty members to announce topics and/or areas of interest in helping you choose your thesis topic.

Furthermore, during your first supervised meetings you should spend some time discussing, in addition to academic matters, all practical matters that may arise during your work:

- Do you need all-round supervision? Have you got prior experience in using equipment of software required in the proposed topic? Will you be able to use them?
- When can you meet with your supervisor? How often? Can you set up regular meeting intervals or do you prefer an on-demand approach? Keep in mind that supervisors are bound to offer at least 12 hours of supervision for a 48-credit master thesis.
- How ambitious are you? Are you thinking of later applying for a funded PhD position?

Finally, a *Supervision Agreement* form, found in Appendix II, must be filed in, signed, and submitted to the MSc Coordinator for review and approval by MSc Committee and Head of Department by the end of the second semester. The Supervision Agreement must state the proposed thesis title, supervisors, start date, and intended submission date.

STAGE 3: Submission of your thesis proposal

When you and your supervisor come to an agreement for an appropriate thesis topic, you are required to submit a thesis proposal/candidature within the first four (4) weeks of the Program's 3rd semester. This proposal will be presented with the aid of a short report and defended orally in front of an academic panel, comprising your two supervisors and a third faculty from the Department of Chemical and Materials Engineering appointed by the MSc-ChME Committee and approved by the Head of Department. This panel will decide on the appropriateness of your proposed thesis topic and the scientific concreteness of the methodologies you are aiming to apply. Your research/thesis topic proposal should clearly address the following items:

- Outline of the problem/area of application
    - Explain why you think it is worth investigating
    - Set your ideas into a theoretical/academic context
- Aims and Objectives
    - Describe what you are aiming to achieve
    - Present the steps and approaches you will employ for reaching your goals
- Methodology
    - Explain what methods you intend to use when researching and developing your work
    - Use a descriptive writing approach corresponding to the detail required for the panel's comprehension of your approach
- Scope and constraints
    - Set clearly your scope and anticipated constraints:
        - Your selected topic may be vast with numerous applications and thus, you might want to limit your work in a particular area of application
        - You may not be able to conduct some research due to constraints on time, cost, or availability of resources
- Discuss requirements on resources
    - Do you need any special lab equipment?
    - Is literature review possible with library's resources?
    - Are any materials and/or consumables required in your research?
- Propose a draft timetable for your thesis

The panel may accept your proposal or provide you with feedback and change suggestions that will help you meet the required academic standards for starting your thesis. If the proposal is deemed unacceptable you will have a second chance to revise and present your modified proposal within four weeks. If your proposal is not accepted for a second time, you will be recommended for dismissal from the program[1].

Your thesis proposal should be obviously discussed during the preliminary meetings with your supervisory committee. Your Lead Supervisor will usually provide pertinent literature and/or additional resources to accelerate your initial work. Finding suitable and reliable information may prove challenging, but there are many ways including library books, databases, international sources, articles, journals, reviews, and a lot more.

STAGE 4: Carrying out research and preparation of your thesis manuscript

Once your proposal has been officially approved, the actual work may begin. It is crucial that you are always well-prepared in meetings with your supervisor. In this context, it is a good practice to always keep minutes of your meetings and circulate agendas with clearly outlined discussion points and expected results prior to your meetings. This makes it easier for the supervisor to focus on significant issues, leading to a better response for you. If you feel that you may have misunderstood a concept, or you are not certain of the steps required for performing a particular task, ask your supervisor for clarifications or further guidance. The supervisors should always guide you with advices on the topics and

[1]Failing of MSc thesis or dismissal from program are subject to regular appeal process and rules established in the program handbook and guidelines.

tasks you should put emphasis on and at the same time turn you away of meaningless tasks that may waste your time.

Try to establish a communication channel that suits both you and your supervisors. Emailing is an easy, asynchronous way of communication that overcomes time and place barriers. Furthermore, since it is primarily based on writing, it requires a certain amount of prior thinking and planning that helps you avoid getting 'off-track' as it may be the case when speaking. However, emails are cumbersome when lengthy and lack the directness of a real meeting. So, it is important to balance the ways of communication based on your needs and supervisor's availability.

Try to follow the work schedule as close as possible and report unexpected delays or difficulties to your supervisor. This does not mean that whenever you are faced with a difficulty, you will turn to your supervisor for doing the work for you. It essentially means that after putting reasonable effort on accomplishing a specific result which is still elusive, you should turn to your supervisor for additional guidance.

Finally, you must keep in mind that writing a thesis cannot happen in one go. You should, as soon as possible, keep track of your work, make notes and sketches, write intermediate reports so that when your work has approached a certain maturity level, you'll be able to compile, with the aid of this material, a successful thesis' manuscript. **In this regard a progress report is required to be submitted by you to the MSc Coordinator as a proof of progress by the end of the 3rd semester. This progress report should include as a minimum requirement a complete literature review and must be approved by your supervisor.**

STAGE 5: Thesis submission & Defense of your work

Before submitting your manuscript, your supervisor will check it thoroughly and give you feedback on corrections and changes that need to be made. Usually, thesis's revision may take up to 1-2 weeks, and an appropriate amount of time should be also reserved for making corrections.

When you have prepared the revised document, you submit to your supervisory committee and external examiner for evaluation. Keep also in mind that you should aim at meticulously following your supervisor's comment and corrections so that a series of multiple revisions can be avoided. When your supervisory committee & the external examiner approve the final document, your Lead supervisor will fill the required form and you will get permission to submit your final thesis report for evaluation.

The overall grade for your degree is calculated as the credit-weighted average of all course grades. Additionally, a SUCCESSFUL submission and defense of your thesis is required to be considered for graduation; see §Thesis Grading below for the employed scheme in your thesis evaluation.

Thesis submission process involves the following steps:

- **Thesis report submission (in electronic format).**
- **Thesis oral defense in front of the examination committee.**
- **Thesis revision, if required.**
- **Submission of final version of your report (Thesis manuscript).**
- **Thesis mark appeal, if any. The appeal should be submitted to the MSc-ChME committee, which is responsible for the Thesis evaluation process.**

The exact deadlines for each submission process step will be announced every year in due time. Commonly, the submission and examination process begin about 1.5 months before the end of the program's 4th (last) semester and may end few days after the end of the semester.

If your supervisory committee does not approve your thesis for defense or you fail the defense, you may continue to work on your thesis during the immediate summer semester and defend the amended thesis in the summer term before the beginning of the following fall semester. You will not receive a scholarship and you may need to cover the tuition and other fees by yourself during the summer term.

You may also request the Dean's permission to extend your MSc program for the following fall semester if needed to complete the program requirements. The student's academic supervisor must endorse the request. During this period, you will not receive a scholarship and you may need to cover the tuition and other fees by yourself. If you cannot present and/or defend your thesis during this last semester, you will be recommended for dismissal from the program[2].

In any case, re-examination of the MSc thesis may be permitted only once, with the approval of the Dean of School of Engineering.

Thesis Assessment Criteria

The grade assigned depends on the level to which the following criteria have been met:

Manuscript Grading (MSc Thesis Manuscript)

<u>Maximum MSc Thesis Manuscript score: **100**</u>

- ***Presentation of the research problem and thesis' objectives (10%)***
  - Is the research problem clearly specified and contextualized?
  - Are the research questions and hypotheses clearly formulated?
  - Does the thesis capture the relevance, rationale, and objectives of the proposed research?
- ***Literature and technology review (15%)***
  - Does the thesis include a comprehensive review and critical discussion of the relevant literature and/or technological developments?
  - Is there a description on how the conducted research positions itself within the generic context of works which have been published in the area?
  - Is the relevant background theory covered? Are the presentation, discussion and explanation provided, adequate? Has the theory been contextualized appropriately within the framework of the research problem being investigated?
  - Have the latest theoretical developments in the area been presented and described?
  - Does the student demonstrate a systematic understanding of the relevant background material and knowledge?
- ***Methodology, design and implementation (35%)***
  - Are the adopted methodologies and/or design approaches clearly justified and described?
  - Is the implementation well explained?
  - Is there a clear identification of any limitations, assumptions and constraints which affect the application of the employed methodology, design approach and implementation?
- ***Testing, results, analysis, evaluation concluding remarks & future work (30%)***
  - Are the test procedures sound and objective?
  - Do the proposed tests address the research problem being investigated?
  - Are the test conditions, assumptions, constraints, and limitations clearly identified?

[2] Failing of MSc thesis or dismissal from program are subject to regular appeal process and rules established in the program handbook and guidelines.

- Are the results clearly presented, analyzed objectively and critically evaluated?
- Do the concluding remarks summarize the work done? Are there suggestions for any future development and/or enhancements?

- ***Structure and presentation of thesis (10%)***
  - Are the thesis contents well structured, focused, and easy to follow?
  - Are the student's contributions and assumptions clearly communicated to the reader?
  - Is it in compliance with the given guidelines?
  - Is it clearly presented and organized? Is the grammar and usage of English of an appropriate level?

Oral Presentation Grading (MSc Thesis Defense)

<u>Maximum MSc Thesis Defense score (presentation + technical content) **100**</u>

PRESENTATION SCORE: *(Maximum presentation score: 50)*

- ***Speech & Style*** *(10p.)*
  - Clear and easily understood. Correct use of terms.
  - Easy-to-understand sequence. Professional appearance. Use of good English.
- ***Structure of the Presentation*** *(10p.)*
  - Logical sequence, good flow. Supporting body of literature mentioned.
  - Development of topics described clearly. Smooth progression from topic to topic.
  - Key points & challenges sufficiently highlighted.
- ***Layout of Visual Aids*** *(10p.)*
  - Clear power point slides, uncluttered. Concise & precise slides.
  - Use of good English. Good use of charts, tables, diagrams, etc.
- ***Questions & Answers*** *(20p.)*
  - Clearly understood the question.
  - Concise answer responding to the point of the question.

TECHNICAL CONTENT SCORE: *(Maximum technical content score: 50)*

- ***Introduction*** *(10p.)*
  - Problem statement & project objectives. Coverage of all main points of the project.
  - Literature review and conclusions. Relevance to the need of industry, society etc.
- ***Technical Competency*** *(30p.)*
  - Viability of the design concept. Justification of the approach
  - Design methodology. Practical Implications.
  - Quality of the concept presentation. Interpretation of the achieved results.
  - Use of relevant tools/equipment/software. Costs and efficiency considerations.
- ***Conclusions, Future Work & Professional ethics*** *(10p.)*
  - Conclusions: advantages and disadvantages.
  - Level of the project objectives achievement.
  - Future work and possible improvements.
  - Consideration in design and solution. Applicability to real-life situations.
  - Compliance with good practices and standards.

Thesis Grading

The MSc Thesis must be compiled in a report (manuscript) according to the specification provided herein and defended in front of MSc Examination Thesis committee, which comprises your two supervisors and your external examiner. The MSc. <u>Thesis manuscript</u> and MSc Defense <u>Oral presentation</u> will be evaluated using the assessment criteria and weighting presented in the previous section, Thesis Assessment Criteria and Oral Presentation Assessment Criteria, respectively. The Thesis manuscript evaluation (M) contributes 70% to your final thesis evaluation while the remaining 30% comes for your Oral presentation (O).

Thesis is not graded with a letter scale as in the case of other MSc courses, but a SUCCESSFUL / UNSUCCESSFUL attribution is utilized. For a successful completion of your thesis, you are required to achieve an overall supervisory committee evaluation **greater or equal to 75%.** The examination committee members' evaluations contribute to your MSc thesis result as follows:

1. External examiner's (EE_M and EE_O) evaluations are weighted with a 30% weight, and
2. Lead and Co-Supervisor's evaluations (S1_M, S1_O & S2_M, S2_O) are weighted with a 35% weight each

Hence, your final thesis evaluation (FE) is calculated as follows:
FE = 0.3 O + 0.7 M,
where O = (0.3 EE_O + 0.35 S1_O + 0.35 S2_O) and M = (0.3 EE_M + 0.35 S1_M + 0.35 S2_M)
If FE is greater or equal to 75%, your thesis manuscript and defense is considered SUCCESSFUL, otherwise it will be considered UNSUCCESSFUL.

In case of a difference larger than 25% between evaluation marks given by External and average of Internal Examiners, the Department MSc Committee will decide the final evaluation of the thesis. The percentage difference will be calculated using the following relation:

$$\text{Percentage Difference} = \frac{|V_i - V_e|}{\frac{(V_i + V_e)}{2}} \times 100\%,$$

where V_i is the average evaluation of the internal members and V_e the evaluation of the external member.

Manuscript Structure & Formatting

Detailed description of manuscript's structure along with specific guidelines for the document's styling can be found in Appendix III – Manuscript Format Specifications.

Referencing

Whenever writing a piece of academic work, you are required to acknowledge the sources of data and information that you have used. This permits you to:

- prove that your work has a substantial factual basis;
- offer your readers the means to identify and retrieve the references for their own use;
- acknowledge the creators/authors of material/methods you have used/employed in your own research work
- support the research methodology and approaches you have used to reach your conclusions.

You can use any established engineering citation methodology to reference any material used in your work. For more information on AICHE[3]'s referring style and alternative approaches see Appendix IV – Referencing style.

[3] THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

Always keep in mind that referencing is divided into two key components:

1. *In-text references* where references might be numbered in the order of appearance, as in [1] or using the author's name and date of publication as in (James et al., 2002);
2. *A reference list* displayed at the end of the piece of work which provides full details of all references cited in-text. The references can be ordered as they appear in text or in alphabetical order according to the selected style. In any case, the identification mark for each item in the list must coincide with the in-text reference used.

Appendices

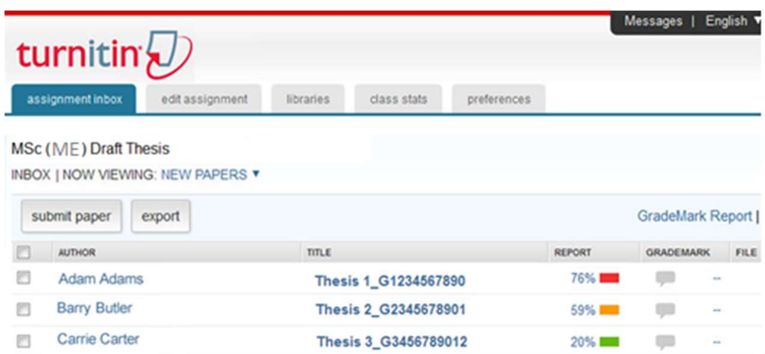
Appendix I - Turnitin

Turnitin is a web-based originality checking service that is used by many universities worldwide to prevent plagiarism. When a student's work is submitted to Turnitin it is matched against millions of internet pages, electronic journals, books, and a database of all previously and concurrently submitted assignments. Turnitin then generates an originality report providing a summary of matching or similar text found in the submitted work. Turnitin can be used to check sources that have been correctly acknowledged and cited.

The higher the percentage indicated on the originality report, the greater the amount of text copied. The similarity percentage index ranges from 0% to 100% and is specified by distinct Colors:

- **Blue** (No matching words)
- **Green** (1 - 24% similarity index)
- **Yellow** (25 – 49% similarity index)
- **Orange** (50 – 74% similarity index)
- **Red** (75 – 100% similarity index)

Acceptable similarity index for plagiarism using Turnitin should be equal or below 20%. The figure below illustrates a sample originality report.



Appendix II – Supervision Agreement Form

MSc Thesis-Supervision Agreement Form
School of Engineering, Nazarbayev University

NAZARBAYEV UNIVERSITY

Department of Chemical and Materials Engineering
53 Kabanbay Batyr Ave. Astana, Kazakhstan, 010000
Tel. No: +7 (7172) 70 64 23, 70 65 43, 70 65 99
E-mail address: seng@nu.edu.kz
Web-page: seng.nu.edu.kz

Student Name and ID	Name: ID:		
Program	**Master of Science in Chemical and Materials Engineering (MSc-ChME)**		
Lead Supervisor	Name: Institute / School / Department: Address:		
Co-supervisor	Name: Institute / School / Department: Address:		
External Examiner	Name: Institute / School / Department: Address:		
Proposed thesis title			
Starting date		Intended date of thesis submission	

RIGHTS AND OBLIGATIONS IN THE SUPERVISORY RELATIONSHIP

- The supervisor and the student should, at the outset of the supervisory relationship, discuss and agree on the format of supervision, the expected progress, and the intended date of thesis submission.
- The supervisor and the student should observe the regulations and instructions governing the supervision of the master thesis.
- Regulations and instructions regarding conflict of interest (as described in Appendix VI of MSc-ChME handbook) in supervision and assignment of external examiners should be observed by the student, the supervisor, and the MSc-ChME committee.

Student

- The student should be well-prepared for meetings with supervisors.
- The student should provide sufficient notice to the supervisors if he/she is not able to attend a scheduled meeting.
- When there are serious problems in supervision, the student should immediately bring this to the attention of the Master's Program Coordinator or Head of Department.
- In case the thesis cannot be completed within the period of the agreement, the student must apply for an extension of the supervision agreement.

Supervisors

- The supervisors should be familiar with and follow the ethical guidelines of supervisors at Nazarbayev University. He/she should also ensure that students are aware of the guidelines.
- The supervisors should ensure that the first meeting with the student takes place shortly after having been assigned, in which the supervisors should discuss with and inform the student about how the supervision is to be organized.
- The supervisors should offer the student at least 12 hours of supervision for a 48-credit master thesis, distributed evenly throughout the supervision period.

- The supervisors should be well prepared for the meetings with the student.
- The supervisors should discuss with the student as well as evaluate the plan, the methodology and execution of the proposed research. He/she should assist the student in planning the research with a view to completing it within the normal period of study.
- The supervisors are expected to read and give detailed comments on the draft of the thesis chapters at least once, but the supervisors will exercise their own judgment in how far it is necessary to give detailed comments on revised chapters and the completed thesis.
- The supervisors may, if appropriate, carry out part of the supervision in small research seminars.
- The supervisors should, through the meetings with the student, monitor the progress of the student's work and evaluate the progress in relation to the planned schedule.
- The supervisors should give sufficient notice to the student if he/she needs to re-schedule a meeting.

Modification or Termination of Supervision Agreement

- Changes can be made to the supervision agreement (i.e. changing the research topic) when both the student and lead supervisor agree.
- Changes to the supervisor and/or co-supervisor and/or research topic can only happen before the end of the program's 2nd semester.
- When the supervisor is to be absent for an extended period of time in the course of the supervisory relationship, the department should, in consultation with the student, determine how the supervision can be organized during this period.
- In case the department considers that the student is not acting according to the supervision agreement, he/she should be notified in writing.
- If the supervisory relationship is not deemed, by the student or the supervisor, to be working satisfactorily, for academic or other reasons, either side may request to be released from the supervisory relationship. A new supervisor should then be arranged.
- The student may be considered as not acting according to the supervision agreement in cases when:
  (a) the student fails to submit the master thesis within the semester which the thesis is due for submission and has not been given approval for an extension and a new submission date.
  (b) the student has not contacted the supervisor for one semester. In such a case, the research can be taken up by other students.
  (c) the allocated hours of supervision have been used up, and the student has no approved plan for submission of thesis.
- The supervision agreement ends when the student:
  (a) submits the master thesis
  (b) is considered as not acting according to the agreement and has been notified of it in writing, and has not received approval for a new plan for submission
  (c) forfeits or gives up the right to his/her place in the master program concerned.

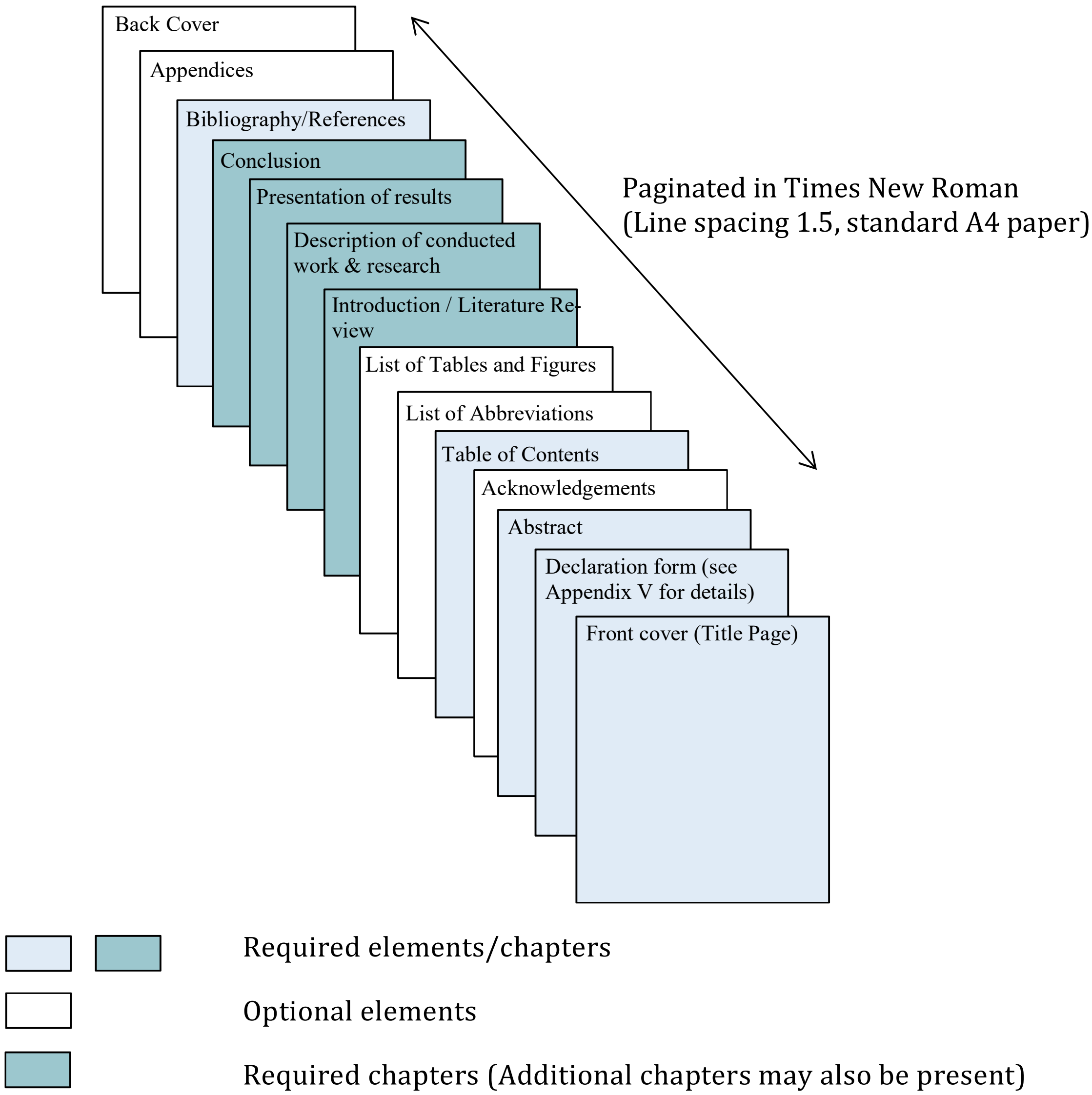
Student	Date	Signature
Lead Supervisor	Date	Signature
Co-supervisor	Date	Signature
Master's Program Coordinator	Date	Signature
Head of Department	Date	Signature
Dean of School	Date	Signature

(Dean's approval is required only for the exceptional case where a co-supervisor is external to the department)

Appendix III – Manuscript Format Specifications

1. **Style Requirements**
    - The thesis must be written in English language. Quotations in languages other than English may be included; however, the quotations' translation should be also included.
    - An abstract of the thesis, not exceeding **500** words, should be part of the preliminary material.
    - Supplementary materials, such as questionnaires, large data sets, or copies of photographs, may be placed into appendices. The appendices must be consecutively paginated with the text. The paper quality and margins of the appendices must conform to the standards for the rest of the thesis.
2. **General Thesis Format Requirements**
    - The MSc. Thesis format will be strictly according to the specifications described in this handbook and needs to be limited to **100** pages excluding appendices.
    - The font type will be Times New Roman, in black and size 12 point with the exceptions noted in the detailed guidelines below. The text line-spacing will be one and half. Lengthy quotations, footnotes, and bibliographies may be single-spaced.
    - Your thesis should be divided into chapters. A chapter should be divided into sections and subsections. Sections and subsections of chapters are to be identified by numbers. Chapters use 1st level numbering, i.e., Chapter 1, 2, 3 etc. chapter sections use 2nd level numbering, i.e., C.1, C.2 where C is the number of the corresponding chapter; e.g., the 3rd section in the 2nd chapter should be numbered as 2.3. Subsections use 3rd level numbering and their numbers are preceded by the chapter and section number, e.g., 2.1.4, 2.1.5 etc. Numbering should be used up to subsections.
    - Computer-generated figures, graphs and other diagrams are acceptable. Each diagram should be numerated, include a caption, and should not be divided between two pages.
    - Tables may be used either in the text or in appendices. All tables should include a numerated header (caption) and named rows and columns.
    - All mathematical and/or chemical equations and relations are considered as text and numbered using a chapter numbering scheme; see above. Detailed, lengthy derivations and mathematical proofs should be placed in Appendices.
    - Page headers or decorative borders should not be used.
    - The text should be justified. The beginning of the first line of text of each paragraph should be indented to **1.25 cm**.
    - The page margins for the text will begin at least **2.5cm** from all sides.
    - The second and subsequent pages should be numbered in Arabic figures in the middle of the top of each page.

3. **Detailed Guidelines & Examples**
   Order of manuscript elements and chapters



NOTE: All text should by typed using Times New Roman font face. If your word-processing software does not support Times New Roman, substitute with a font face that closely resembles it.

Pagination: All pages must be numbered; page numbers must be displayed on all pages, except the title page. Numbering should be placed in the middle of the top or bottom of each page

Front Cover

Times New Roman, Size 16 → **THESIS TITLE**

Times New Roman (Bold), Size 15 Enter your name → **Authors Name**, Degrees held ← Times New Roman, Size 15 Degrees currently attained (i.e. B. Eng)

Times New Roman (Bold), Size 15 →

Submitted in fulfilment of the requirements
for the degree of Master of Science
in Mechanical & Aerospace Engineering

NAZARBAYEV UNIVERSITY ← Authorized University logo

Times New Roman (Bold), Size 15 School, Department, and University Name →

School of Engineering
Department of Mechanical & Aerospace Engineering
Nazarbayev University

53 Kabanbay Batyr Avenue,
Astana, Kazakhstan, 010000
← Times New Roman, Size 15 Institution Address

Supervisors: Supervisors' names

Times New Roman (Bold), Size 15 Date of thesis completion (e.g., December 2016) → **Date of Completion**

Insert the declaration form (see Appendix V) as an unnumbered separate page following the cover page.

Abstract & Acknowledgements (use the same styling)

2 ← Times New Roman, Size 12, (Alternatively you may print the page numbers at the bottom of the page)

Times New Roman (Bold), Size 26 → **Acknowledgements**

Times New Roman, Size 12 (If a new page is needed due to many acknowledgments the text will commence at the top of the next page under the header). →

Use this section to offer "credit where credit is due". An acknowledgement page is optional, however, most thesis include brief statements of appreciation or recognition of special support. There is no limitation on the number of pages you may use for acknowledgements. An example paragraph could be something in the words of:

Firstly, I will like to express my uttermost gratitude towards my supervisors ___________________ and ___________________. It has been their supervision and direction throughout the duration of my studies which has allowed me to successfully complete this Master's program. I am appreciative for all the hours of discussion they have offered me, especially in the areas of communications and embedded systems.

Secondly, I will like to show my indebtedness to the administration staff at Nazarbayev University whose efforts a lot of the time go unnoticed …….

Thirdly, I will like to thank my family/friends/partner …….

Table of Contents

4

Times New Roman, Size 12, Header.

Times New Roman (Bold), Size 26

Table of Contents

Times New Roman (Bold), Size 12

Times New Roman, Size 12

Dedicated chapter if literature review is extensive

Times New Roman (Bold), Size 12

List of Abbreviations

5

Times New Roman, Size 12, Header.

Times New Roman (Bold)

List of Abbreviations & Symbols

A	Area of planar quadrilateral element
Aijl	Component of velocity normal to body surface
BEM	Boundary Element Method
BIE	Boundary Integral Equation
b	Base of triangle (see Figs …)
CFD	Computational Fluid Dynamics
d	distance
FEM	Finite Element Method
R’	Region exterior to body surface

Times New Roman, Size 12,
Left side acronym/symbol, right side definition

List of Figures (List of Tables should follow a similar format)

Times New Roman, Size 12, Header.

6

Times New Roman (Bold), Size 26

List of Figures

Times New Roman, Size 12

Chapters

Times New Roman, Size 12, Header.

64

Times New Roman (Bold), Size 26

Chapter 3 – Computation of Lifting Flow

Times New Roman, Size 12

The body of context is the substance of your thesis. It should introduce, investigate and verify your findings. The conclusion section is often the last part of writing, summarizing and discussing the overall results.

Times New Roman (Bold, Italic), Size 12,
Note: Table captions come before tables. Make sure that font-sizes in tables are suitable for reading.

Table 3.1: Tolerances for shaft alignment

TOLERANCES FOR SHAFT ALIGNMENT (±)

RPM	GAP (mils/10")		OFFSET (mils)		SPACER SHAFT (mils/in.)	
	Excellent	Acceptable	Excellent	Acceptable	Excellent	Acceptable
600	10.0	15.0	5.0	9.0	1.8	3.0
900	7.0	10.0	3.0	6.0	1.2	2.0
1200	5.0	8.0	2.5	4.0	0.9	1.5
1800	3.0	5.0	2.0	3.0	0.6	1.0
3600	2.0	3.0	1.0	1.5	0.3	0.5
7200	1.0	2.0	0.5	1.0	0.15	0.25

All RPM: Maximum Soft Foot Reading 2.0 mils. (1 mil = .001")
Note: Use OEM or in-house tolerances if available.

8ths
1/8 = .125
1/4 = .250
3/8 = .375
1/2 = .500
5/8 = .625
3/4 = .750
7/8 = .875

Related Products:
• SS Shims
• Undercut Bolts
• Portable Jack Bolt Kits
• Heavy Lifting Devices
• and more...

Copyright 2000 by LUDECA, INC., Miami, FL

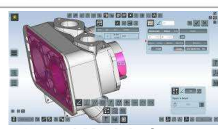


Figure 3.4: 3d Model of component B

Times New Roman (Bold, Italic), Size 12,
Note: Figure captions are placed below the figure. Make sure all figure elements are clear and readable (Always use vector graphics, if possible).

$$\nabla \cdot \left(-k\nabla T\right) = q_{gen} - \rho c \frac{dT}{dt}$$

$$-k\nabla^2 T + \rho c \frac{\partial T}{\partial t} = q_{gen}$$

$$\nabla^2 T - \frac{1}{\alpha}\frac{\partial T}{\partial t} = -\frac{1}{k} q_{gen} \quad (3.1)$$

Times New Roman, Size 12,
Note: Your document editor should support mathematical symbols and formulas

Bibliography/References

Times New Roman, Size 12, Header.

Times New Roman (Bold), Size 26

Times New Roman, Size 12, Conform to the referencing section of this handbook.

100

Bibliography/References

[1] Aftosmis MJ, Melton JE and Berger MJ. Adaptation and surface modeling for Cartesian mesh methods. AIAA Paper, Collection of Technical Papers. Pt. 2 (A95-36501 09-34) 95-1725. In 12th AIAA Computational Fluid Dynamics Conference and Open forum, San Diego, 1995.
[2] Aiso H. Admissibility of difference approximations for scalar conservation laws. *Hiroshima Math. Journal* 1993; **23**: 15–61.
[3] Allmaras S. Analysis of a local matrix preconditioner for the 2-D Navier–Stokes equations. AIAA Paper 93-3330. In AIAA 11th Computational Fluid Dynamics Conference, Orlando, 1993.
[4] Allmaras S. Analysis of semi-implicit preconditioners for multigrid solution of the 2-D Navier–Stokes equations. AIAA Paper 95-1651. In AIAA 12th Computational Fluid Dynamics Conference, San Diego, 1995.
[5] Allmaras S. Algebraic smoothing analysis of multigrid methods for the 2-D compressible Navier–Stokes equations. AIAA Paper 97-1954. In AIAA 13th Computational Fluid Dynamics Conference, Snowmass, 1997.
[6] Alonso JJ and Jameson A. Fully-implicit time-marching aeroelastic solutions. AIAA Paper 94-0056. In AIAA 32nd Aerospace Sciences Meeting, Reno, 1994.
[7] Alonso JJ, Martinelli L and Jameson A. Multigrid unsteady Navier–Stokes calculations with aeroelastic applications. AIAA Paper 95-0048. In AIAA 33rd Aerospace Sciences Meeting, Reno, 1995.
[8] Anderson WK, Thomas JL and Whitfield DL. Multigrid acceleration of the flux split Euler equations. AIAA Paper 86-0274. In AIAA 24th Aerospace Sciences Meeting, Reno, 1986.
[9] Anderson WK and Venkatakrishnan V. Aerodynamic design and optimization on unstructured grids with a continuous adjoint formulation. AIAA Paper 97-0643. In AIAA 35th Aerospace Sciences Meeting, Reno, 1997.
[10] Anderson BK, Thomas JL and Van Leer B. A comparison of flux vector splittings for the Euler equations. AIAA Paper 85-0122. In AIAA 23rd Aerospace Sciences Meeting, Reno, 1985.

Appendices

Times New Roman, Size 12, Header.

Times New Roman (Bold), Size 26

Times New Roman, Size 12.

Times New Roman (Bold, underlined), Size 14

Times New Roman (Bold, Italic), Size 12, Note: use appendix letters in numbering figure captions, i.e. A.1, A.2, B.1.

101

Appendices

Appendices are not necessarily part of every thesis. Appendices may be used for supplementary illustrative material, original data, computer programs, and other material not necessarily appropriate for inclusion within the body text of the thesis.

Appendix A

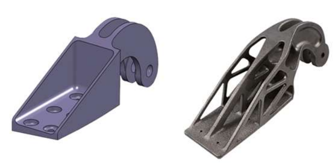


Figure A.1 Shape optimization in additive manufacturing

Appendix B

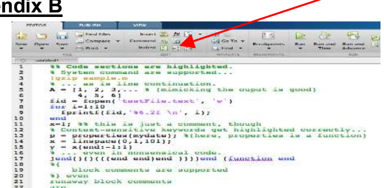


Figure B.1 Code excerpt

Appendix IV –Referencing style

AICHE Referencing style

Works that are specifically cited should be numbered in the order in which they appear in the text, and listed at the end of the article, under the heading Literature Cited. If a reference is cited more than once, always use the same number; do not list the same source multiple times with different numbers, and do not use *ibid* or other Latin terms. Identify cited references by sequential number in the text.; italicize the number, and put it in parentheses. Do not cite references as footnotes and do not use superscript numbers. If the citation is the subject or object of a sentence, refer to it as Ref. x, not (*x*); if it starts the sentence or clause, spell out Reference x; do not italicize Ref. x or Reference x; avoid referring to authors in the text by name, but it is acceptable to do this sparingly.

References that are provided for additional information should be listed under the heading Further Reading after Literature Cited, in alphabetical order according to the author's last name. If no author is given, alphabetize by title after those with authors. For (most) CCPS books, the author is listed as Center for Chemical Process Safety. An exception to this was an article where the further reading section listed several references, including one whose author's last name began with an A. In that instance, the author of the CCPS book was given as "AIChE Center for Chemical Process Safety" so that it would appear at the top of the list. If a similar situation arises, this is an acceptable alternative.

The following style applies to literature cited and further reading citations. This is the information that should be included where available or easily obtainable. Some references will not have every element listed here. When in doubt, it is better to err on the side of providing more information rather than less — if it could help the reader locate the reference, include it.

The basic order of information in a reference citation is: reference number, author, title, publication details, and date. The reference number (followed by a period) and the author's name are in bold; there is a tab between the period and the name. Elements are separated by commas. Dates appear in parentheses. Each citation ends with a period. References use a hanging indent format. Do not use automatic numbering; number and tab manually.

Author. Give the last name first, then first and middle initials (space between initials). If there are two authors, use that format for the first author, and comma and the word "and," then the second author's first and middle initials and last name. If there are three or more authors, use only the primary author's last name and initials with *et al.* (italicized, comma after initials and before *et al.*). Some authors insist on spelling out all the names in reference citations; this is handled on a case-by-case basis, and is acceptable if there are just a few such citations.

If the citation credits an editor rather than an author, follow the name with "ed." or "eds."

If no author is listed for a government document, use the agency as the author. Spell out its name, including U.S. if it is a U.S. government agency.

For industry standards, the issuing organization (e.g., National Fire Protection Association) is listed as the author.

Title. For periodicals, the article title is enclosed in quotation marks, and this is followed by the magazine/journal title in italics. Spelled-out journal titles are preferred; if the author abbreviates journal titles, that is acceptable as long as it is done consistently (all abbreviated or all spelled out). Note that in journal titles, Chemical is usually abbreviated *Chem.* and Engineering as *Eng.*; Chemical Engineering is *Chem. Eng.*; Chemical Processing is *Chem. Processing*; Chemical Week is *Chem. Week*; etc.

Book titles are enclosed in quotation marks and are not italicized. If the citation is for one chapter in a book or an article in a compilation, list the chapter author and chapter title, the word(s) "in" or "Chapter x in," and then the author/editor (not bold) and title of the book (in quotes).

For government regulations or industry standards, the full name of the regulation or standard should be listed as the title.

For online materials, the web page title should be specified.

Publication Details. For periodicals, the publication details consist of the volume and issue number (if available) and the complete range of pages. The volume number is in bold, the issue number in parentheses (not bold), and there is a space (but no comma) between the volume number and the first parenthesis. If the article being cited is contained on a single page, use the abbreviation "p."; if it runs more than one page, use "pp." Use an en-dash (–) between the starting page number and ending page number. Page numbers larger than 1000 do not have a comma.

For books, provide the name of the publisher in shortened form (e.g., McGraw-Hill rather than McGraw-Hill Book Co., Wiley rather than John Wiley & Sons, Inc.), and the publisher's city and state (or non-U.S. equivalent). If a publisher has moved, use the current headquarters location (e.g., Wiley, Hoboken, NJ). If specific pages of a book are being cited, the page numbers go between the title and the publisher.

If a meeting paper (or other presentation record) is published in proceedings, include "Proceedings of the …" and list the meeting title, range of pages, meeting location, meeting sponsor, and sponsor's location (city and state or equivalent). If proceedings were not published, cite the paper as "presented at …", with the meeting title, paper number if applicable, meeting location, sponsor, and sponsor's location. In many cases, the author does not provide all of this information, and that is acceptable as long as there is enough information for the reader to locate the reference.

Citations for government publications should include: the agency publication number; the specific office within the agency; the agency's (or office's) location; and the URL if the document can be found online.

Government regulations can be cited from either the Code of Federal Regulations (CFR) or the *Federal Register*.

Citations for industry standards should include: the standard number or other identifying code; organization name, generally abbreviated as the acronym; and the organization's city and state (or equivalent). It is often helpful to include the organization's website address if it is not obvious (e.g., when citing the ASME Boiler and Pressure Vessel Code, there's no need to list www.asme.org).

Date. For journals that use continuous pagination throughout a volume, it is sufficient to give only the year of publication. For magazines that number the pages in each issue independently, include the complete date (month and year for monthly publications; month, day and year for more-frequent publications). For books, the year is sufficient. For other materials, include the month if available.

If an online reference is dated, use the date of the last revision. If it is undated and the author specifies the date he or she downloaded it, use the "accessed date." Some online sources may be listed without a date (at the editor's discretion).

Examples

Books

1. Eckhoff, R. K., "Dust Explosions in the Process Industries," 3rd ed., Gulf Professional Publishing, Houston, TX (2003).
2. Rothenberg, G., "Catalysis: Concepts and Green Applications," Wiley-VCH, Weinheim, Germany (2008).
3. Allen, M. P., and D. J. Tildesley, "Computer Simulation of Liquids," Oxford Univ. Press, Oxford, U.K. (1987).
4. Center for Chemical Process Safety, "Guidelines for Safe Handling of Powders and Bulk Solids," CCPS, American Institute of Chemical Engineers, New York, NY (2005).
5. Hottel, H. C., "Radiation Heat Transfer," Chapter 4 in McAdams, W. H., ed., "Heat Transmission," 3rd ed., McGraw-Hill, New York, NY, pp. 83–85 (1954).
6. Doherty, M. F., *et al.*, "Distillation," Section 13 in Green, D. W., and R. H. Perry, eds., "Perry's Chemical Engineers' Handbook," 8th ed., McGraw-Hill, New York, NY (2008).
7. Gas Processors and Suppliers Association, "Engineering Data Book," 12th ed., Section 8: Fired Equipment, p. 8–7, GPSA, Tulsa, OK (2004).

Articles

8. Babb, S. E., Jr., "Parameters in the Simon Equation Relating Pressure and Melting Temperature," Reviews of Modern Physics, 35 (2), pp. 400–413 (1963).
9. Bertrand, R. R., and J. H. Siegell, "Emissions of Trace Compounds from Catalytic Reforming Units," Environmental Progress, 22 (1) pp. 74–77 (Apr. 2003).
10. Wolsky, A. M., *et al.*, "CO2 Capture from the Flue Gas of Conventional Fossil-Fuel-Fired Power Plants," Environmental Progress, 13 (3), pp. 214–219 (Aug. 1994).
11. Bönnemann, H., "Organocobalt Compounds in Pyridine Syntheses — An Example for Structure-Activity Relations in Homogeneous Catalysis," Angew. Chem. Int. Ed. Engl., 24, pp. 248–262 (1985).

Meeting Papers and Presentations

12. Benin, A., *et al.*, "Metal Organic Frameworks (MOFs) for CO2 Capture," presented at the 2008 AIChE Spring National Meeting, New Orleans, LA (Apr. 7–9, 2008).
13. Baldwin, P., "Ramgen Power Systems Low-Cost, High-Efficiency CO2 Compressor," presented at the 7th Annual Conference on Carbon Capture and Sequestration, Pittsburgh, PA (May 5–8, 2008).
14. McLarnon, C. R., and J. L. Duncan, "Testing of Ammonia-Based CO2 Capture with Multi-Pollutant Control Technology," Proceedings of the 9th International Conference on Greenhouse Gas Control Technologies, Washington, DC (Nov. 16–20, 2008).

Government Agency Publications

15. U.S. Chemical Safety and Investigation Board, "Combustible Dust Hazard Study," Investigation Report 2006-H-1, CSB, Washington, DC (Nov. 2006).
16. U.S. Chemical Safety and Hazard Investigation Board, "Improving Reactive Hazards," www.csb.gov/reports, CSB, Washington, DC (2002).
17. U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," Publication AP-42, www.epa.gov/ttnchie1/ap42, EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC (Jan. 1995).
18. U.S. Dept. of Energy, "Carbon Dioxide Capture from Existing Coal-Fired Power Plants," Publication No. DOE/NETL-401/110907, DOE Office of Fossil Energy's National Energy Technology Laboratory, Pittsburgh, PA (rev. Nov. 2007).
19. U.S. Environmental Protection Agency, "ECOTOX Database," http://cfpub.epa.gov/ecotox/ index.html, EPA, Office of Research and Development.
20. U.S. National Library of Medicine, "The Hazardous Substances Data Bank (HSDB)," National Library of Medicine Toxicology Data Network, Bethesda, MD, http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB.
21. International Energy Agency, "Improvement in Power Generation with Post-Combustion Capture of CO2, Report Number PH4/3, IEA Greenhouse Gas R&D Programme, IEA, Paris, France (2004).

Government Regulations
22. U.S. Occupational Health and Safety Administration, "Standard for Hazardous Materials — Process Safety Management of Highly Hazardous Chemicals," 29 CFR 1910.119.
23. U.S. Environmental Protection Agency, "National Emissions Standards for Equipment Leaks — Control Level 2 Standards," 40 CFR 63, Supbart UU.
24. U.S. Environmental Protection Agency, "National Emissions Standards for Hazardous Air Pollutants: Miscellaneous Organic Chemical Manufacturing and Miscellaneous Coating Manufacturing: Proposed Rule," *Federal Register*, 67 (65), pp. 16154–16259, www.epa.gov/ttn/atw/mon/monpg.html (Apr. 2, 2002).

Industry Standards
25. National Fire Protection Association, "Standard for the Prevention of the Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids," NFPA 654, NFPA, Quincy, MA (2006).
26. Instrument Society of America, "Application of Safety Instrumented Systems for the Process Industries (S84.01 Standard)," ANSI/ISA-S84.01-1996, ISA, Research Triangle Park, NC (Feb. 1996).
27. European Committee for Electrotechnical Standardization, "Electrostatics — Code of Practice for the Avoidance of Hazards Due to Static Electricity," CLC/TR 50404:2003, CENELEC, Brussels, Belgium (July 2003)

Technical Society and Industry Association Publications
28. American Petroleum Institute, "Development of Emission Factors for Leaks in Refinery Components in Heavy Liquid Service," Publication No. 337, API, Washington, DC (Aug. 1996).
29. American Petroleum Institute, "Evaporative Loss from Storage Tank Floating Roof Landings," Technical Report 2567, API, Washington, DC (2005).
30. ASTM International, "ASTM International Directory of Testing Laboratories," available online at www.astm.org/labs, ASTM, West Conshohocken, PA.

Other referencing styles

You can use any established referencing style as long as you make sure that all referencing uses a single style. Elsevier journals offer the following referencing services and styles (the following example style refers to the journal of Computer Aided Design (CAD)):

Elsevier References

Citation in text: Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list but may be mentioned in the text. If these references are included in the reference list, they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Web references: As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading, if desired, or can be included in the reference list.

References in a special issue: Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software: Most Elsevier journals have a standard template available in key reference management packages. This covers packages using the Citation Style Language, such as Mendeley (http://www.mendeley.com/features/reference-manager) and also others like EndNote (http://www.endnote.com/support/enstyles.asp) and Reference Manager (http://refman.com/downloads/styles). Using plug-ins to word processing packages which are available from the above sites, authors only need to select the appropriate journal template when preparing their article and the list of references and citations to these will be formatted according to the journal style as described in this Guide. The process of including templates in these packages is constantly ongoing. If the journal you are looking for does not have a template available yet, please see the list of sample references and citations provided in this Guide to help you format these according to the journal style.

If you manage your research with Mendeley Desktop, you can easily install the reference style for this journal by clicking the link below: http://open.mendeley.com/use-citation-style/computer-aided-design when preparing your manuscript. You will then be able to select this style using the Mendeley plugins for Microsoft Word or LibreOffice. For more information about the Citation Style Language, visit http://citationstyles.org.

Reference style guidelines:

Text: Indicate references by number(s) in square brackets in line with the text. The actual authors can be referred to, but the reference number(s) must always be given.

List: Number the references (numbers in square brackets) in the list in the order in which they appear in the text.

Examples:

Reference to a journal publication:

[1] Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. J Sci Commun 2010;163:51–9.

Reference to a book:

[2] Strunk Jr W, White EB. The elements of style. 4th ed. New York: Longman; 2000.

Reference to a chapter in an edited book:

[3] Mettam GR, Adams LB. How to prepare an electronic version of your article. In: Jones BS, Smith RZ, editors. Introduction to the electronic age, New York: E-Publishing Inc; 2009, p. 281–304.

Note shortened form for last page number. e.g., 51–9, and that for more than 6 authors the first 6 should be listed followed by 'et al.' For further details you are referred to 'Uniform Requirements for Manuscripts submitted to Biomedical Journals' (J Am Med Assoc 1997;277:927–34) (see also http://www.nlm.nih.gov/bsd/uniform_requirements.html).

Journal abbreviations source

Journal names should be abbreviated according to the List of Title Word Abbreviations: http://www.issn.org/services/online-services/access-to-the-ltwa/.

Appendix V –Declaration Form

The signed declaration form that follows should be first page after your report's cover sheet

DECLARATION

I hereby, declare that this manuscript, entitled "*title of thesis*", is the result of my own work except for quotations and citations which have been duly acknowledged.
I also declare that, to the best of my knowledge and belief, it has not been previously or concurrently submitted, in whole or in part, for any other degree or diploma at Nazarbayev University or any other national or international institution.

(signature of author)

Name:
Date:

Appendix VI –Conflict of Interest

Definitions:

Conflict of interest - refers to a conflict between official University duties and private interests and personal relationships, where the private interests or personal relationships could improperly influence the way in which a person carries out their official duties.

Perceived conflict of interest - where a reasonable person might perceive that such improper influence as described above could exist.

Personal relationships - relationships with individuals or people that extend outside of the University or University duties, or a relationship where a reasonable person might perceive that there could be some bias, either positive or negative, resulting from that relationship. These include relationships with:

1. immediate family, e.g. spouse or partner, parents, children, step-children, etc.;
2. close relatives, e.g. aunts, uncles, cousins, nephews, nieces etc.;
3. rivals, e.g. competitors or persons with whom one has a history of serious conflict or enmity; and
4. all other relationships that could introduce bias in carrying out official duties.

Private interests - refers to any interests that involve potential gain or loss (financial or non-financial) for an individual or for any other person or organization that individual may wish to benefit (e.g. family, friends, associates) or disadvantage (e.g. competitors, rivals).

Rules and Guidelines:

1. All individuals are responsible for identifying, declaring, and managing conflicts of interest that apply to them.
2. Conflicts of interest may affect or have the appearance to affect sound and professional judgement adversely. Conflicts of interest or perceived conflicts of interest must be declared and managed to ensure integrity and transparency.
3. Staff members, students and other individuals who are charged with carrying out University activities and functions have a responsibility to declare and manage conflicts of interest as they arise. When declared, the conflict of interest should be avoided. Where this is not possible, action must be undertaken to ensure that the conflict (or perceived conflict) is managed in a transparent and appropriate manner.
4. Supervisors, chairs of committees/panels/groups and other responsible parties are accountable for ensuring that declared conflicts of interest, real or perceived, are evaluated and managed appropriately.
5. Declarations of conflict of interest should be made by individuals in writing to the relevant supervisor, chair of a committee/panel/group, other relevant person, or body as soon as the conflict is identified. Where circumstances prevent an immediate written declaration (e.g. conflict arises during a meeting), a verbal declaration should be lodged and, if possible, formally noted (e.g. in minutes of the meeting).

6. Where a supervisor, chair of a committee/panel/group, other relevant person or body becomes aware of a conflict of interest (or perceived conflict of interest) that has not been declared they should discuss the matter with the individual and take appropriate actions.
7. The best way in which to handle a conflict of interest is to avoid it. Where it is not possible to avoid a conflict of interest, the MSc-ChME committee, the Head of Department, the School's Vice-Dean for Teaching and Learning and the School's Dean should be responsible for assessing the risk and taking appropriate actions.