FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF POLYMER, TEXTILE AND INDUSTRIAL ENGINEERING

Master of Science in Materials Engineering

Approved in June 2021 by NCHE

EXECUTIVE SUMMARY

Africa experiences a shortage of skilled engineers and this has led to a skewed market place (*Royal Academy of Engineering Conference*, 2016). In order to address this gap, the Faculty of Engineering (Busitema University) currently offers three postgraduate engineering programmes: Master of Science in Irrigation and Drainage Engineering; Master of Computer Forensics and a Postgraduate Diploma in Computer Forensics. The students on these programmes are employed in government, universities as well as other established companies and agencies. While these programmes deliver the graduates as planned, a major gap has been identified in the area of materials engineering.

Massive infrastructure and technological projects in Uganda pay less attention to training of locals thus importing skills from abroad further haemorrhaging the engineering capacity and impending skills transfer. Technological projects such as hydropower dams; oil and gas; Kiira EV; Standard Gauge Railway (SGR); Tororo Cement and Phosphate plants to mention but a few need support of materials engineers. In the same vein, Uganda loses millions of dollars through exporting unprocessed materials and yet imports more processed products due to lack of value addition to her rich material source.

The Master of Science in Materials Engineering programme is therefore designed to bridge this critical gap, through developing human capacities for utilization of the country's raw material resources in the sphere of fibers, polymers, plastics, composites, ceramics and cementitious materials to engineer novel products for sustainable development of the country.

The purpose of this programme is to:

a) Provide students with an advanced understanding of Materials Engineering and working processes.
b) Equip graduates with the tools necessary to design, develop and engineer a wide variety of engineering products.
c) Produce graduates with an innovation mind-set who can make relevant contributions in any field of engineering and/or fundamental science at the national/international context.
d) Advance research in materials engineering relevant to Uganda's current needs and development agenda.

The programme duration is two years comprising of two semesters of taught courses, followed by two semesters devoted to research work leading to a thesis. The courses have been designed to have both a firm theoretical knowledge of materials engineering as well as practical skills which can be transferable and beneficial to the industry so as to address the skills gap in materials engineering sectors.

The following courses in the programme will impart hands on skills to the graduates: Advanced CAD and Finite Element Analysis; Computer Programming for Engineering Design; Materials Selection and Design; Fatigue Design and Fracture Mechanics; Fiber Reinforced Composites and Polymer Processing; Nano-structured Materials and Nanotechnology and the four Electives (Ceramics and Powder Technology; Computational Fluid Mechanics; Biomaterials and Tissue

Engineering; Cementitious Materials and Concrete; Materials for Energy; Materials Joining Technology)

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1. 0. INTRODUCTION

1.1 PROGRAMME BACKGROUND

Evolution never stops and customer expectations on products continue to grow. At the same time, resource consumption for both development and production are expected to decrease to ensure profitable business and a sustainable society. Specifically, individual companies want to increase their competitive advantage by offering products that stand out from the competition. Product development as an aspect of Materials Engineering is a core industrial activity that addresses all of these aspects – it is a multidisciplinary process of identifying and envisaging the needs of the user, company and society, and bringing those needs to life.

According to the United Nation's "Sustainable Development Goal (SDG) 9: Industry, Innovation and Infrastructure", Product manufacturing is a principal driver of economic development, employment and social stability. Globally, manufacturing value, added as a share of GDP increased from 15.3 per cent in 2005 to 16.2 per cent in 2016. In 2016, manufacturing value added per capita amounted to $4,621 in Europe and Northern America, compared to about $100 in the least developed countries, Uganda inclusive. Furthermore, manufacturing is increasingly shifting towards more technologically complex products. While medium and high-tech products continue to dominate manufacturing production in industrialized economies (where they contribute about 80 per cent of total manufacturing output), the share has barely reached 10 per cent in least developed countries.

Globally, the programme therefore intends to achieve: SDG goal 9 through increased value addition and development of engineered products for sustainable development; SDG goal 12 through using eco-friendly production methods and reducing the amount of waste.
Nationally, the programme directly addresses Uganda's Vision 2040 with a gist of transforming the Ugandan society from a peasant to a modern and prosperous country within 30 years, which proposes under cap 2.4. "rapid acceleration, cultivation and development of strategic emerging high tech industries, and the development of industries in areas of new materials industries, bio-technology, heavy industries and equipment manufacturing". Furthermore, the National Development Plan (NDP III) stipulates that government will put emphasis on projects geared towards the enhancement of Materials Engineering and Nanotechnology.

The university vision is to be "*a center of academic and professional excellence in science, technology and innovation*" whereas the mission is "*to provide inclusive high standard Training, quality research and outreach for industrialization and sustainable development*." The proposed program is in line with the vision and mission as well as the University Strategic Plan (2020/21 – 2024/25) under objective 2: Increasing High Impact Research, Innovation and Entrepreneurship, the university will "increase the number of graduate programmes and strengthening their relevance and quality." The proposed programme is geared towards adding impetus to value addition of materials hence producing new industrial products leading to sustainable development of communities and the country as a whole.

1.2. JUSTIFICATION OF THE MASTER OF SCIENCE PROGRAMME

Materials such as fibers and polymers are playing a leading role in society through production of products for packaging, transportation, construction, electronics etc. In the same vein, the envisaged oil production in the Albertine region with the proposed set up of an oil refinery, will widen the petroleum offshoot industries. Furthermore, the country is on the road towards utilization of nuclear materials for energy generation, this will need well trained cadre of materials scientists.
The internal structure of materials is the key for developing products with improved functional or structural properties and enhanced performance during operation. Understanding the relevant parameters for engineering materials allows tailoring their internal structure and associated properties to develop products.

Material engineers are therefore needed to engineer products and to add value to our local materials. The off shoot industries utilizing the refinery by-products together with industries arising from the utilization of natural gas require expert knowledge so as to engineer refinery by-products such as plastics, paints, medicine, fibers among others. The industry therefore, needs a generation of creative minds with the necessary scientific background to understand the technology behind products and also engineer products for the future. The Master of Science in Materials Engineering is tailor made to answer the challenge of value addition to local materials for engineered products as well as a precursor for science, technology and innovation and entrepreneurship leading to the setting up of material engineering industries.

1.2.1. Uniqueness and Relevance of the programme

According to the Uganda Forum for Economic Policy Analysis, Uganda experiences capital flight because the country hasn't harnessed the potential to export processed products; furthermore, there is little or no meaningful technology transfer. The Master of Science in Materials Engineering is a new specialization in Uganda’s higher education system. There is no similar program available at the moment in any of the country’s higher institutions of learning yet it is a critical specialization that answers the challenges faced by the country in the sphere of product development, packaging, value addition, material recycling, material forensics etc. Industries and universities have often relied to sending graduate students abroad to obtain the materials specialization which isn’t sustainable. The Program will therefore offer the local and regional industries an excellent opportunity to conduct specialized research locally which has previously been outsourced from institutions overseas.

1.3. TITLE

The title of the programme is: “**Master of Science in Materials Engineering** (**MME**)”

1.4. PROGRAMME OBJECTIVES AND OUTCOMES

1.4.1. Overall Objective

The general objective of the programme is to produce skilled and creative graduates capable of taking part in scientific research and professional applications and developments of products in the sphere of fibers, polymers, composites, semiconductors, ceramics, energy, cementitious materials and materials for oil and gas.

1.4.2. Specific Objectives

To produce graduates capable of:

a) Applying the mastered skills for solving specific problems in the selected areas of material engineering.
b) Using critical analysis, evaluation and synthesis of material production systems and processes.
c) Interpretation of deep scientific and technical knowledge that will allow them to grasp the structure of matter down to the atomic scale.
d) Understanding the relationship between microstructure and functional properties of materials.
e) Designing, transforming and fabrication of materials for cutting-edge technological applications.
f) Carrying out of research and development in the sphere of materials engineering.

1.5. LEARNING OUTCOMES OF THE PROGRAMME

The learning outcomes of the programmes are sub-divided into four groups namely; Cognitive Skills, Knowledge and Understanding, Course specific and Transferable skills as shown below:

COGNITIVE SKILLS On the completion of this course successful students will be able to:	**TEACHING/LEARNING METHODS AND STRATEGIES**	**METHODS OF ASSESSMENT**
a) Critically analyze data and solve materials related problems.	Lectures; 'dry' practical classes; assignments; research project	Assessed course work, Class tests, dissertation
b) Demonstrate an ability for independent learning.	Emphasised and necessary for success in all aspects of the course	Class tests, course work and dissertation
c) Combine knowledge from a variety of sources, including previous learning, to solve an advanced problem in materials science.	Lectures and directed reading; dry practicals; research project; assignments	Marking of dry practicals, research project dissertation and assignments.
KNOWLEDGE AND UNDERSTANDING On the completion of this course successful students will be able to:		
d) Demonstrate knowledge and understanding in materials	Challenges involved in the "dry practicals" in which lecture	Assessed coursework, Class tests,

physics, chemistry and engineering.	content is applied to problem solving by the students. Directed self-study to achieve objectives in course work. Research project.	dissertation
e) Demonstrate Material characterization techniques.	Lecture course material specifically on characterisation along with assignments and associated dry practicals; for many the research project will also give experience in materials characterisation.	Marking of relevant dry practicals, assignments on characterisation and dissertation where relevant.
f) Demonstrate Material selection techniques.	Lectures in materials selection strategies (e.g. use of Ashby diagrams); training on commercial materials selection software.	Dry practicals and assignments on materials selection
COURSE SPECIFIC On the completion of this course successful students will be able to:		
g) Provide evidence of detailed knowledge of particular areas of Materials Science and Engineering.	Lectures, dry practicals, directed self-study and research project	Dissertation, written coursework, Class tests
h) Demonstrate a high degree of specialised knowledge in a chosen area of materias research.	Research project proposal and associated literature surveys / reviews	Dissertation, written coursework, Class tests
i) Demonstrate evidence of advanced research skills in a chosen area of materials research.	Research project proposal	Dissertation, written coursework
j) Plan and execute a substantial investigation in a specific research area of materials including critical and quantitative assessment of their own work and the work of others.	One-to one supervision of substantial project performed individually in a current area of materials research; training in project management and project management software.	Online safety tests, risk assessments, literature review, oral presentations, laboratory performance, oral review meeting, written report
TRANSFERABLE SKILLS On the completion of this course successful students will		

be able to:		
k) Search for, evaluate and reference relevant information from a range of sources	Guidelines for formal reports and literature survey as part of dissertation	Written coursework, literature review and project dissertation
l) Communicate complex information in a clear and concise manner both orally and in a written format with proper regard for the needs of the audience.	Guidelines for formal reports and literature surveys; feedback on oral presentations	Written reports and dissertation; oral presentations as stage assessment in project; orally presented and written assignments.
m) Use software packages to analyse data, report results, manage projects and prepare documents.	Dry practicals; lecture module on data handling and project management; research project	Coursework & Dissertation
n) Work independently while demonstrating time management and the ability to meet deadlines.	Dry practicals, independent coursework, research project; preparatory reading	Coursework assessment, dissertation and Class tests
o) Work in a team situation	Group elements in dry practicals; integration into a research team environment during research project	Subset of dry practical student portfolio; supervisor "lab performance" element of research project marks
p) Problem-solving skills	Dry practicals; assignments; research project	

1.6. PREPARATORY ACTIVITIES

The following preparatory activities were undertaken:

- Consultation of stakeholders (Academics at Universities: Makerere University, Kyambogo University, Gulu University, Moi University, Ndejje University etc. Private Sector Foundation Uganda (PSFU), Uganda National Bureau of Standards (UNBS), Uganda Industrial Research Institute (UIRI), Uganda National Roads Authority (UNRA), among others.
- Two-day workshop with the stakeholders at Hotel Paradise, Jinja (the minutes of the workshop in appendix)
- Correspondences from an expert from the University of Stavanger, Norway on the programme.
- The curriculum was taken through (i) Department Board (ii) Faculty of Engineering Board; Higher Degrees and Research Committee (iii) Board of Graduate Studies, Research and Innovations a committee of Senate.

1.7. OPPORTUNITIES FOR THE GRADUATES

This programme intends to strengthen the Uganda's capacity in the areas of product development and material sciences utilizing polymeric and composite materials. A Master of Science in Materials Engineering is the gateway to entrepreneurship and a career in a wide variety of industries ranging from the production of materials to the manufacturing of finished products such as watches, sports equipment, aeronautics, foods, metallurgy, automobiles, electronics and multimedia. It also provides ideal training for the innovative application of advanced materials in areas such as bio- and nanotechnologies leading to the set-up of Small Medium Scale Industries as well as a strong foundation for those who wish to pursue a PhD degree in Materials Science or related fields.

Graduates of the programme will find employment in organizations such as:

a) Processing industries that use polymers, metals and fibers in their research divisions.
b) Quality and Standards organizations e.g. Uganda National Bureau of Standards (UNBS).
c) Training institutions e.g. Universities
d) Research and development institutions e.g. Uganda Industrial Research Institute (UIRI), Cotton Development Organization (CDO), and National Semi - Arid Resources Research Institute (NaSARRI)
e) Management and Leadership positions.
f) Medical Technology facilities
g) Transportation production facilities.
h) Energy technological industries.
i) Defense and Police forces as Materials Forensic experts.

2.0. RESOURCES

2.1. HUMAN RESOURCE

Busitema University Faculty of Engineering already has qualified staff with PhDs in Materials Engineering, Textile Engineering, Mechanical Engineering and other relevant areas. Relevant qualified staff are also available in sister faculties such as the Faculty of Science and Education, Faculty of Health Sciences, Faculty of Management Sciences. The above staff will offer fulltime teaching and research services of the programme. **See Appendix B.**

2.2. TECHNICAL AND INFRASTRUCTURE FACILITIES

2.2.1. Teaching and learning facilities

Workshop facilities:

The University Main Campus that houses the programme has a spacious and well equipped mechanical workshop that serves as the training hub of the Engineering Faculty. The workshop consists of specialized engineering sections that include welding section, foundry sections; workshop equipment and machining section, and industrial machinery repairs and maintenance section, as well as electrical engineering and electronics section. These facilities are vital for practical and hands-on teaching and learning and shall be used by students to fabricate, maintain and repair irrigation and drainage related equipment and accessories during training and during their research project works.

Lecture rooms and engineering laboratories:
The campus also has adequate lecture rooms, spacious lecture halls. The African Development Bank under the Higher Education Science Technology (ADB-HEST V) project set up a four-storied faculty of engineering block housing staff offices, conference centre, lecture halls and discipline specific laboratories.
The building shall consist of offices for the programme teaching staff, a specialized and well equipped materials engineering laboratory plus other laboratories including a modern hydraulic, thermodynamic laboratory, a soils and soil mechanics lab, a water quality lab besides other specialized engineering laboratories. These facilities will strongly support this program.

Modern library and ICT facilities:
The African Development Bank under the Higher Education Science Technology project set up a three- storied library with offices. Furthermore, the ADB support set up a state-of-the arts ICT-based library with E-learning facilities, linking together all campuses of the university.

2.2.2. Research and innovations facilities

The university procured laboratory equipment which will support the programme for instance equipment found in materials laboratory, textile laboratory and other engineering laboratories.
The Materials Engineering Laboratory of Busitema University has got the following materials testing and characterization equipment, to mention but a few:

i. Scanning Electron Microscope (SEM)
ii. X-Ray Diffraction (XRD)
iii. Fourier Transform Infra-Red (FTIR)
iv. Thermogravimetric Analysis (TGA)
v. Differential Scanning Calorimetry (DSC)
vi. Universal Tensile Testing Machine

Furthermore, the faculty has computer rooms, discussion rooms and design laboratories with networked computers to support computer aided design (CAD) and computer aided engineering (CAE) using industry-standard software packages. Furthermore, the university also has linkages and partnerships with world class institutions running similar programmes:

i. Dar es Salaam University, Tanzania.
ii. Mekele University, Ethiopia.
iii. Makerere University, Uganda.
iv. Moi University, Kenya.
v. Masinde Muliro University of Science and Technology, Kenya.
vi. Technical University of Liberec, Czech Republic.
vii. Ivanovo State Textile Academy, Ivanova, Russia.
viii. Indian Institute of Technology, Delhi.
ix. Uganda Industrial Research Institute (UIRI)

2.2.3. Outreach and knowledge transfer facilities

Busitema University established the Technology, Business, Innovation and Incubation Centre (TBIIC) at Busitema campus. The centre will serve as a site for practical testing, modification and fine tuning of developed technologies of graduates therefore leading to entrepreneurship and strengthening the capacity of the country in engineering innovations from laboratory to the market place.

2.3. PROGRAMME FUNDING

The main source of funding for the programme shall be through tuition fees (self or private institutional student sponsorships). **See Appendix A**. Various resources shall also be generated by faculty staff under the programme through bankable research and outreach projects, consultancies and donor support, some of which resources will be used to strengthen programme facilities and activities.

3.0. PROGRAMME REGULATIONS

3.1. PROGRAMME DURATION

The Masters of Science in Materials Engineering will be a two-year (four- semester) programme by Taught Courses and Dissertation.
During the training:

- A student must complete an approved program of courses totalling to 35 Credit Units in year one and 20 Credit Units in year two of the programme.
- A student must submit a Dissertation on an approved topic that carries a minimum of 7 Credit Units in year two. Joint internal and external examination of the Dissertation is mandatory.
- The Minimum Graduation load for the programme is therefore 55 CUs.

3.2. ADMISSION REQUIREMENTS

To be eligible to apply for the Master of Science in Material Engineering, the candidate must hold any of the following:

1. A Bachelor's degree in Engineering of second class lower division and above from a recognized university.
2. A Bachelor's degree of second class lower division and above in the Natural Sciences or (Chemistry, Industrial Chemistry, Physics, Mathematics)
3. A Bachelor's degree of second class lower division and above in Technology or Science Technology in the relevant disciplines.

3.3. TARGET GROUP

The development of products demands understanding of the structural elements and components. Expertise in the area of materials sciences is in high demand in nearly every field.

The Master of Science in Materials Engineering is aimed at Engineers, Scientists and Technologists working in industry, as well as natural scientists who wish to expand their knowledge in the field of materials science.

3.3.1. Projected Student numbers

It is proposed that the programme starts with 20 students in 2021/22 academic year and the number shall be increased gradually to 10 students per intake over a period of 3 years as shown in Table 1. The increase in student number will take into account both infrastructures, human and financial resource capacity to handle the programme.

Table 1: Projected student numbers

Activity	2021/22	2022/23	2023/24	2024/25
Student numbers admitted	20	20	20	20
Cumulative student numbers	20	40	60	80

3.4. ASPECTS ON GENDER AND EQUITY

Uganda is actively promoting gender and equity at all levels because it's a pre-condition for sustainable development, Busitema University has a strong affirmative policy. The current female enrollment at graduate level at the Faculty of Engineering is about 10% compared to about 30% and increasing at undergraduate levels.

The programme will specifically target female candidates with a view to increasing the percentage to 25%.

4.0. EXAMINATION REGULATIONS

4.1. GENERAL REGULATIONS

The general Master's degree regulations of Busitema University as stipulated in the Graduate Studies Handbook shall apply.

4.2. METHOD OF ASSESSMENT

Assessment will be done through coursework which will include home assignments, class room and take-home tests, field study trips with trip reports, project work and presentations and written examination. Course work will carry a total of 40% and written examination carries 60%. The overall pass mark is 60%.

4.3. GRADING OF COURSES

Each course shall be graded out of a maximum of 100% marks and assigned an appropriate letter grades as shown below: To record a pass mark in a course unit, a student must achieve a minimum mark of 60%. The student must also have attended at least 70% of all scheduled classes and practicals and presentations.

Marks % Point	Letter grade	Grade	Remarks
80-100	A	5.0	Excellent
75-79	B+	4.5	Very good
70-74	B	4.0	Good
65-69	C+	3.5	Fairly good
60-64	C	3.0	Satisfactory

0-59	D	0.0-2.5	Fail

4.4. CALCULATION OF CUMULATIVE GRADE POINT AVERAGE (CGPA)

The Cumulative Grade Point Average at a given time shall be calculated based on using the Equation (1) shown below:

$$GPA = \frac{\sum_{i=1}^{n}(PG_i \times CU_i)}{\sum_{i=1}^{n} CU_i} \quad \text{..(1)}$$

Where $PG_i$is the Grade Point score in course, i; $CU_i$is the number of Credit Units of course, i; and, $n$is the number of courses taken in that semester or recess term. CGPA is calculated using a formula similar to the one above, but *n* is the number of courses taken from the beginning of the program up to the time when the CGPA is being calculated.

4.5. COURSE RETAKING

i. A student shall retake a Course or Courses when next offered again in order to obtain at least the Pass Mark (60%) if he/she had failed during the first assessment in the course or courses.
ii. A student who has not done course work will not be allowed to sit for final examinations
iii. A student who has failed to obtain at least the Pass Mark (60%) during the Second Assessment in the same Course or Courses retaken shall receive a warning.
iv. A student may retake a Course or Courses when next offered again in order to improve his/her Pass Grade(s) if the Pass Grade(s) got at the first Assessment in the Course or Courses were low. A student who fails to attain higher marks after retaking to improve, the examination results of the first sitting are recorded on the transcript and shall not be recorded as **Retake**.
v. Where a student misses to sit examinations for justified reasons, his/her results shall be not recorded as **Retake** when the examination(s) is/are next offered.
vi. Attend all the prescribed lectures/ tutorials/ practicals/fieldwork in the Course or Courses;
vii. Satisfy all the requirements for the course-work component in the Course or Courses; and
viii. Shall sit for the University Examinations in the course or courses.
ix. A student shall who accumulates more than four (4) Retake Courses will be requested to stay put.
x. Students are required to register for retake course(s) first before registering for new courses offered in that semester and the retake courses should fit into the approved normal load so as to avoid timetable clashes.
xi. A final year student whose final Examination Results have already been approved by the Graduate Board and has qualified for the Award of the MSc. in Materials Engineering Degree, shall not be permitted to retake any Course(s).

xii. When a student has retaken a course the better of the two Grades he/she has obtained in that course shall be used in the computation of his/her cumulative Grade Average (CGPA).
xiii. Whenever a course or courses has/have been retaken, the Academic Transcript shall accordingly indicate so.
xiv. Students shall pay for retake(s) registered for.

4.6. ACADEMIC PROGRESS

At the end of every semester and recess term, students' progress shall be classified in the categories; Normal Progress, Probationary Progress, and Discontinuation.

4.6.1. Normal progress

This occurs when a student has passed (Grade point of 3.0) all the courses that he/she has taken so far, since the beginning of the program.

4.6.2 Probationary Progress

A student who has obtained the Grade Point (GP) of less than 3.0 shall be placed on probation. Such a student shall be allowed to progress to the next semester/academic year but shall still retake the course(s) he/she has failed the assessments in later on and obtained at least the pass mark (60%) in the course(s).

4.6.3 Discontinuation

When a student accumulates three consecutive probations based on CGPA he/she shall be discontinued.

i. A student who fails to obtain at least the Pass Mark (60%) during the Third Assessment in the same course or courses retaken shall be discontinued from his/her studies at the University.
ii. A student who has overstayed on the programme by more than five (5) years shall be discontinued from his/her studies at the University.

4.7. DISSERTATION

Students are required to demonstrate their ability to independently undertake research and analysis. Each student will be required to pursue and complete the dissertation. To pass the dissertation, the candidate shall satisfy the supervisor(s), reviewers and examiners in the written report and in project presentation(s).

4.8. REQUIREMENTS FOR THE AWARD OF THE DEGREE

The degree of Master of Science in Materials Engineering shall be awarded to a candidate who obtains 59 credit units, gained from 12 courses. Furthermore, the student will have to pass all the courses in a period stipulated by the University Senate and Council.

4.9. CLASSIFICATION OF THE AWARD

The degree of Master of Science in Materials Engineering shall be awarded to a student who fulfills all the requirements for the programme. The Master degree shall not be classified.

4.10. QUALITY ASSURANCE

The quality assurance practices like the other programmes in the Faculty of Engineering in particular, and Busitema University in general shall apply. A student will be required to attend at least 70% of the lectures given in a course, do and pass all the coursework assignments, tests and laboratory exercises before he/she can sit for a written examination. Performance of each of the lecturers assigned to teach the students shall also be closely monitored to ensure they comply with the curriculum requirements. This will be partly achieved through giving the students assessment forms to assess their teaching staff on the content taught, mode of delivery, self-explanation; appearing for lectures, tutorials and at practical field study trips sessions.

5.0. PROGRAM STRUCTURE

In order to balance first-class theoretical education with extensive industry experience to prepare students for a challenging and diverse career, the programme is designed as follows:
First year covers the theoretical/lecture (including laboratories), and practical component of the course. The student will develop a research proposal during the first semester of second year which will have to be defended before the faculty's higher degrees committee.

5.1. PROGRAMME COURSES

The programme courses shall give the students the required skills for problem solving, empower them for critical thinking and shall give them the necessary communication and negotiation capabilities that they need to succeed in their careers. The emphasis of the courses will be on process and product development using polymer and textile materials, and common industrial processes.

5.2 SYLLABUS

Table 2: Syllabus breakup

	Domain	Allied Courses	Credit [Hrs] Units	Percentage [%]
1	Applied Mathematics	i. Advanced CAD and Finite Element Analysis ii. Statistics and Research Methods	7	13
2	Materials Engineering	i. Materials Selection and Design ii. Thermodynamics and Kinetics of Materials iii. Fatigue Design and Fracture Mechanics iv. Fiber Reinforced Composites and Polymer Processing v. Nano-structured Materials and Nanotechnology vi. Electives	18	32
3	Product Development	i. Product Design and Development ii. Life Cycle Analysis and Sustainability iii. Optimization Driven Design	10	18
4	General Research Courses	i. Dissertation Proposal ii. Seminar Series iii. Scholarly Writing	13	24
5	MSc Dissertation		7	13
	TOTAL		**55**	**100**

5.3. SKILLS COURSES

Table 3: Hands on Skills courses in the programme.

	Domain	Allied Courses
1	Applied Mathematics	i. Advanced CAD and Finite Element Analysis
2	Materials Engineering	i. Materials Selection and Design ii. Fatigue Design and Fracture Mechanics iii. Fiber Reinforced Composites and Polymer Processing iv. Nano-structured Materials and Nanotechnology v. Electives
3	Product Development	i. Product Design and Development ii. Optimization Driven Design
4	General Research Courses	i. Scholarly Writing

6.0. PROGRAMME STRUCTURE AND DETAILED COURSE CONTENT

6.1. PROGRAM STRUCTURE

The MSc. MME programme just like the other programmes in Busitema will be run on semester system. The Tables below outline the courses and their loading to be offered in the programme.

Table 3: First Year Courses

Semester	Course Code	Course Name	LH	TH	PH	CH	CU
ONE	MME8101	Product Design and Development	45	0	45	60	4
	MME8102	Materials Selection and Design	30	30	0	45	3
	MME8103	Lifecycle Analysis and Sustainability	30	30	0	45	3
	MME8104	Thermodynamics and Kinetics of Materials	30	0	45	45	3
	MME8105	Advanced CAD and Finite Element Analysis	30	0	90	60	4
	MME8106	Fatigue Design and Fracture Mechanics	30	30	0	45	3
	Sub-Total						20
TWO	MME8201	Fiber Reinforced Composites and Polymer Processing	30	0	45	45	3
	MME8202	Nano-structured Materials and Nanotechnology	30	0	45	45	3
	MME8203	Optimization Driven Design	30	30	0	45	3
	MME8204	Statistics and Research Methods	30	30	0	45	3
		Electives* (SELECT ONE)	30	30	0	45	3
	MME8205	Ceramics and Powder Technology					
	MME8206	Computational Fluid Mechanics					
	MME8207	Biomaterials and Tissue Engineering					
	MME8208	Cementitious Materials and Concrete					
	MME8209	Materials for Clean Energy Technologies					
	MME8210	Materials Joining Technology					
	Sub-Total						15
	Grand Total						**35**

Table 4: Second Year Courses

Semester	Course Code	Course Name	LH	TH	PH	CH	CU
	MME9101	Dissertation Proposal	0	0	315	105	7
	MME9102	Seminar Series	45	0	0	45	3
	Sub-Total						10
TWO	MME9201	MSc. Dissertation	0	0	315	105	7
	MME9202	Scholarly Writing	0	0	135	45	3
	Sub-Total						`10
	Grand Total						**20**

DETAILED COURSE DESCRIPTION
YEAR 1: SEMESTER 1

MME8101 Product Design and Development **3 Credit Units**

Course Description

The course covers the activities undertaken and decisions made during the product development process that affects the ability to achieve efficient and effective production. The course further addresses the methods and approaches that can be used to make product development and production to work together in a cost effective way for the holistic picture.

Course Objectives

The focus of Product Design and Development is integration of the marketing, design, and manufacturing functions of the firm in creating a new product. The course is intended to provide the student with the following benefits:

- Competence with a set of tools and methods for product design and development.
- Confidence in your own abilities to create a new product.
- Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
- Ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective.
- Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting. Enhanced team working skills.

Learning Outcomes

After completing the course, the student shall:

Knowledge and understanding

- Demonstrate knowledge about and be able to describe the structure and content of the product development process.
- Have knowledge of methods and approaches that are used during product development to analyze and improve a product's manufacturability
- Have knowledge of cost management techniques used during the product development

Skills and abilities

- Demonstrate skills in describing and analyzing how various product development activities and decisions affect production
- Demonstrate an ability to explain how the physical design of a product affects production
- Demonstrate skills in describing the various factors that affect the interaction between product development and production

Judgement and approach

- Demonstrate the ability to relate a company's practical work to theories of collaboration between product development and production

- Demonstrate the ability as a group member to perform and present project and seminar assignments, both orally and in writing and to critically and constructively provide feedback on such presentations.

Detailed Course Content

The course includes the following topics:

1. Product Development System: Introduction; Product Development Process – Uncertainty, People Based, Ambiguity, Non-linearity, Complexity; Product Development Performance Drivers – External Environment, Internal Environment, Project Environment, Resources; Product Development Metrics
2. Integrated Product Design and Development process: Sequential product design and integrated product design, serial product development
3. Integrated product development – Teams, Tools (Design by Features, DbF; Knowledge Based Engineering, KBE; Design for Excellence, DFX; Integrative Design Variables, IDV
4. Waste in Product Development:
   Over production – unnecessary processes, unsynchronized processes.
   Waiting – Scheduled and Unscheduled waiting.
   Transportation – Change of ownership, Structural barriers, knowledge barriers, continuity barriers.
   Over processing – Over engineering, data conversion, re-invention.
   Inventory – Inprocess; Inproduct, Incompany inventories.
   Motion,Defects, Correcting, Wishful thinking, Happenings

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 30 Tutorial hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Product development system	9	12	0	15
Integrated product design and development	6	12	0	12
Integrated product development	9	4	0	11

Waste in product development	6	4	0	8
Total Hours	**30**	**30**	**0**	**45**

Reading List/References

1. Pessôa, M. V. P., & Trabasso, L. G. (2016). *The Lean Product Design and Development Journey: A Practical View*. Springer. ISBN 9783319467924
2. Ulrich, K. T. (2003). *Product design and development*. Tata McGraw-Hill Education. ISBN 9780070585133
3. Haik, Y., Sivaloganathan, S., & Shahin, T. M. (2018). *Engineering design process*. Nelson Education. ISBN 9781337515290
4. Khanka, S. S. (2006). *Entrepreneurial development*. S. Chand Publishing. ISBN 9788121918015
5. Shetty, D. (2015). *Product Design for Engineers*. Nelson Education. ISBN 9781305537194

MME8102 Materials Selection and Design **3 Credit Units**

Course Description

An important part of the product development process is about selecting a suitable material. A large part of the course is therefore intended to give deeper skills in materials selection and knowledge about the methods needed to choose the most optimal material for a specific product or component. To do this, a thorough understanding about the demands a product and its application is imposing on the materials properties is needed. In the course, not only mechanical and physical material properties are treated but also tactile and visual properties. Product design and how the product will be manufactured also influence the materials selection, and therefore design tools are introduced. The course also includes discussions on how the choice of materials affects the environment from a sustainability perspective. After completing the course, the student shall

Course objectives

- Recognize and develop lists of independent and dependent parameters for an engineering design from which to develop quantitative measures of performance.
- Develop optimization equations for selection of materials for defined design projects.
- Use material property plots to identify the best performing materials for a given application.
- Use materials property databases for identification of candidate materials.

Learning Outcomes

After completing the course, the student shall:

Knowledge and understanding

- Demonstrate knowledge about methods and strategies to perform different materials selection tasks
- Demonstrate understanding of the material properties that are important in the design/dimensioning of products.

Skills and abilities

- demonstrate ability to communicate issues regarding materials with different groups such as experts, suppliers, customers and users
- demonstrate ability to use different strategies to perform suitable materials selection

Judgment and approach

- demonstrate insights about different materials and their influence on both humans and environment

Detailed Course Content

The course includes the following topics:

1. Overview of Materials Selection and Design: Introduction, Importance of Material Selection, Relation to Design, Product Analysis, Activities of Product Development. Case Examples

2. Design Phases: Factors influence Engineering Design, Major phases of design, design tool and material data, design reviews, design codes, specification and standards, probabilistic approach in design, factor of safety and de-rating factors, Case studies.
3. Material Properties and Design: Design under different conditions (Surface finish factor, size factor, reliability factor, operating temperature factor, loading factor, stress concentration factor, service environment factor, manufacturing process factor); designs against fatigue load; case study
4. Materials Selection Process: Events in materials selection process, materials performance requirements, development of different solutions, quantitative methods of material selection, application of digital logic method, optimum material selection, How to use diagrams/charts to present materials selection, case study.
5. Development of instructions for materials selection
6. Knowledge Based System in Materials Selection: How to use software in the materials selection process, expert systems,
7. Influence of product design on materials selection and introduction to design tools such as DFM, DFA, and DFD

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 30 lecture hours and 30 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Overview	3	2	0	4
Design phases	6	6	0	9
Material properties and design	6	6	0	9
Materials selection process	6	6	0	9
Instruction development	3	4	0	5
Knowledge Based systems	3	2	0	4
Design tools	3	4	0	5
Total Hours	**30**	**30**	**0**	**45**

Reading List/References

1. Maleque, M. A., & Salit, M. S. (2013). *Materials selection and design*. Imprint: Springer. ISBN 9789814560382
2. Ashby, M. F., & Johnson, K. (2013). *Materials and design: the art and science of material selection in product design*. Butterworth-Heinemann. ISBN 9780080982823
3. Ashby, M. F. (2005). Materials selection in mechanical design. *MRS Bull*, *30*(12), 995. ISBN 9780080468648
4. Ashby, M. F., Shercliff, H., & Cebon, D. (2013). *Materials: engineering, science, processing and design*. Butterworth-Heinemann. ISBN 9780080982816
5. Pfeifer, M. (2009). *Materials enabled designs: the materials engineering perspective to product design and manufacturing*. Butterworth-Heinemann. ISBN 9780080941837

MME8103 Life Cycle Analysis and Sustainability

Course Description

This course assesses the environmental and economic considerations of a product from production through to use and end-of-life options. The course explores life cycle assessment (LCA), life cycle costing (LCC), technical challenges and opportunities for incorporating this strategy within engineering design, and future trends informing sustainable development, including the potential for focus within environmental management systems and the ISO 14000 suite.

Objectives

- study the environmental and economic impacts associated with a product from production through to use and end-of-life options.
- emphasize on the energy and eco-efficiency improvement of products and processes within a manufacturing plant.

Learning Outcomes

After completing the course, the student shall:

Knowledge and understanding

- Able to cost the product or services at every process, and be able to make decisions using lifecycle tools and management strategies.

Skills and abilities

- Analyze the sustainability of product and service developments.
- Able to apply life cycle analysis tool to any product and service.
- Ability to make an impact analysis of the products lifecycle of products to the environment.

Judgement and approach

- Show ability to perform lifecycle analysis on a developed product.

Detailed Course Content

The course includes the following topics:

Life Cycle Engineering, Energy and Eco-Efficiency:

Introduction:

i. Global manufacturing,
ii. Sustainability,
iii. Life cycle thinking,
iv. Closed-loop product life cycle.

Life Cycle Management and Strategy:

i. Potential Driving forces for sustainable development, legislation national/international.
ii. Life Cycle Management: Interaction between life cycle sectors / stakeholders.

iii. Life Cycle Strategy: Cleaner production for product life cycle, Product stewardship,
iv. Environmental Management System

Energy and Resource Efficiency of Products and Processes:

i. Energy efficiency of a product life cycle: energy and material flows.
ii. Energy efficiency of manufacturing processes and systems: Energy efficiency calculation of processes, Energy efficiency cases.
iii. Future challenge: Energy and Eco-efficiency

Environmental Footprint of Products and Processes:

Life Cycle Assessment: main phases of LCA (i.e. Goal and Scope Definition, Life Cycle Inventory Analysis, Life Cycle Impact Assessment, Interpretation), Environmental footprint (including carbon and water footprint), Databases and tools, Case studies

Eco-efficiency and Eco-design for a Product Life Cycle

Life Cycle Costing and Eco-Efficiency:

i. Introduction to economic models
ii. Material Flow Cost Accounting (MFCA)
iii. Life Cycle Cost (LCC)
iv. Introduction to Eco-Efficiency of Products and Processes: Revisiting LCA and LCC
v. Eco-efficiency concept to analyze environmental and economic trade-offs
vi. Methodology

Environmentally Sustainable Product Development

i. Introduction to eco-design
ii. Sustainable product development
iii. Eco-design/ Design for Environment (DFE) definition
iv. Eco-design characteristics and roles
v. Design and industrial approaches
vi. Eco-design implementation and applications
vii. Eco-labelling.

End-of-life Management of Products

Product Collection and Recovery,
End-of-Life Management

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 60 Tutorial hours. The total contact hours of the course are therefore, 60 contact hours. The detailed mode of delivery is as shown in Table

Topic	**Lecture Hours**	**Tutorial Hours**	**Practical Hours**	**Contact Hours**
Life Cycle Engineering, Energy and Eco-Efficiency	12	10	0	17
Eco-efficiency and Eco-design for a Product Life Cycle	9	10	0	14
End-of-life Management of Products	9	10	0	14
Total Hours	**30**	**30**	**0**	**45**

Reading List/References

1. Curran, M. A. (Ed.). (2012). *Life cycle assessment handbook: a guide for environmentally sustainable products*. John Wiley & Sons. ISBN 9781118528273
2. Jo Dewulf, Steven De Meester, Rodrigo A. F. Alvarenga. Sustainability Assessment of Renewables-Based Products: Methods and Case Studies, John Wiley & Sons, 2016, ISBN 9781118933947
3. Curran, M. A. (2015). *Life cycle assessment student handbook*. John Wiley & Sons. ISBN 9781119083542
4. Finkbeiner, M. (Ed.). (2011). *Towards life cycle sustainability management*. Springer Science & Business Media. ISBN 9789400718999
5. Wang, H. F., & Gupta, S. M. (2012). Green supply chain management: Product life cycle approach. ISBN 9780071626088
6. Guo, M. (2013). *Life cycle assessment (LCA) of light-weight eco-composites*. Springer Science & Business Media. ISBN 9783642350375
7. Olsen, S. I., Pant, D., & Singh, A. (2013). *Life Cycle Assessment of Renewable Energy Sources*. Springer. ISBN 9781447153641

MME8104 Thermodynamics and Kinetics of materials 4 Credit Units

Course Description

An introduction to advanced concepts on thermodynamics and kinetic of materials and how they interact with materials: covering concepts of irreversible thermodynamics, Diffusional Transport, Phase Transportation, solidification, microstructural changes

Course Objectives

- Understand fundamentals of state, equations of state, equilibrium, and cycles as applied to material systems.
- Use phase diagrams to understand and predict composition microstructure relations in materials.
- Design processing steps to attain desired microstructures and nanostructures in materials.
- Understand microstructural evolution of materials under operating conditions.

Learning Outcomes

After completing the course, the student shall:

Knowledge and understanding

- Demonstrate knowledge and understanding on how thermodynamics and kinetics play a key role in material behavior.
- Demonstrate a clear understanding of the principle of irreversible thermodynamics, diffusional transport, phase transportation and micro-structures

Skills and abilities

- Demonstrate ability to conduct experiments regarding the measurement and calibration of temperatures and pressures
- Demonstrate ability to identify the properties of substances on property diagrams and obtain the data from property tables

Judgment and approach

- Demonstrate ability to conduct experiments regarding the measurement and calibration of temperatures and pressures in groups.
- Demonstrate ability to identify the properties of substances on property diagrams and obtain the data from property tables

Detailed Course Contents

Irreversible Thermodynamics

Fields and Gradients; Fluxes; Continuity Equation; Entropy Production; Conjugate Driving Forces and Fluxes.

Diffusional Transport

Mass Diffusion in a Continuum; Diffusion Coefficients; Mass Diffusion: Fick's Laws; Self-Diffusion; Inter-diffusion; The Kirkendall Effect; Capillarity-Driven Diffusion; Stress-Driven

Diffusion; Solutions to the Diffusion/Heat Equation; Atomistic Mechanisms of Diffusion; Diffusion in Ionic Crystals: Kroger-Vink Notation for Point Imperfections; Short-Circuit Diffusion in Crystals: Diffusion Spectrum in Defective Crystals, Dislocation Structure and Short Circuits,; Grain-Boundary Structure and Diffusion.

Phase Transformations

Homogeneous and Heterogeneous Nucleation; Continuous vs. Discontinuous Transformations Nucleation Theory, including Interplay between Surface and Volumetric Energy Terms, Coherency Strain Energy; Diffusional Growth; The "Moving Boundary" Problem; Growth Phenomena: Interface Control vs. Diffusion Control; Diffusion-Controlled Growth, including Melting of a Pure Material, Inter-diffusion with a Moving Boundary, and Alloy Solidification

Solidification

Thermal and Solute Gradients and Interfacial Shape Stability; Cells and Dendrites
Casting Microstructures; Microsegregation; Spinodal Decomposition: Phase Diagrams with a Spinodal Region; Free Energy of a Compositionally Inhomogeneous Solution
Interdiffusion within the Spinodal Region; Kinetics of Spinodal Decomposition

Microstructural Change

Particle Coarsening: Capillarity as a Driving Force; Coarsening in Pb–Sn Solid/Liquid Alloys
Gibbs-Thomson Effect; Kinetics in the Diffusion-Controlled Regime
Sintering; Grain Growth; Grain-Growth Kinetics in Two and Three Dimensions; Kinetics of Nucleation and Growth Transformations: Time-Temperature-Transformation Diagrams

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 60 Tutorial hours. The total contact hours of the course are therefore, 60 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Irreversible thermodynamics	4	8	0	8
Diffusional Transport	6	12	0	12
Phase Transformation	6	12	0	12
Solidification	6	12	0	12
Microstructural changes	8	16	0	16

Total Hours	**30**	**60**	**0**	**60**

References

1. Thermodynamics and kinetics of materials, Boris S. Bokstein, Mikhail I. Mendelev, and David J. Srolovitz, 3rd edition. ISBN: 9780198528043
2. D. A. Porter and K. E. Easterling, Phase Transformations in Metals and Alloys, 2nd edition, Chapman & Hall, London, UK, 1992 This textbook (2nd edition) was reprinted by CRC Press in 2003; 3rd edition was published by CRC Press in 2009. ISBN 9781439883570
3. Gaskell, D. R., & Laughlin, D. E. (2017). *Introduction to the Thermodynamics of Materials*. CRC press. ISBN 9781498757034
4. Robert W. Balluffi, Sam Allen, W. Craig Caeter, Kinetics of materials published by John Wiley & Sons Inc. ISBN 13978-0-471-24689isbn-10-0-471-24689-1 ©2005
5. Brent fultz, Phase transitions in materials, first edition 2014, ISBN 978-1-107-06724-0

MME8105 Advanced CAD and Finite Element Method 4 Credit Units

Course Description

The course teaches elaborate handling of CAD-system for the creation of production specifications at an advanced level. Products specifications include injection molding or other production methods. The specifications encompass all aspects of production such as tapers and parting lines. The parts should be specified in engineering drawings complying with applicable industrial standards.

In the course, the prediction of which parameters that is governing for a design will be identified. Thus, a purposeful structure of parameters may be created in the CAD-models maximizing their value in the product realization process.

Course Objectives

- To provide students with an introduction to Finite Element Analysis and to help the students use this method and commercial software package to solve problems in heat transfer, mechanics of materials and machine design.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses performed by others.
- Learn to model complex geometry problems and solution techniques.

Learning Outcomes

After completing the course, the student shall:

Knowledge and understanding

- Show elaborated knowledge on the theoretical background on CAD-systems
- Show knowledge on advanced geometric tolerance and material conditions.
- Show knowledge of basic principles of nonlinear FEA, in particular the disciplines of contact mechanics, plasticity and transient problems
- Understand derivations of methods from governing equations

Skills and abilities

- show ability to use advanced functions in CAD for surface and solid modeling
- show skills in creating advanced engineering drawings in CAD
- show ability to create purposeful CAD-models to support product realization
- perform linear and nonlinear FEA of real engineering problems
- Interpret FEA problems published scientific journals

Judgement and approach

- Show ability to judge what is required from a production specification to be used in industrial practice (to some extent).
- Able to suggest appropriate analysis for different types of problems

- Able to evaluate and criticizes results from a finite analysis.

Detailed Course Contents

The course covers the following topics:

CAD-modeling

- Theoretical background to the CAD-systems
- Advanced engineering drawings
- Identification of governing parameters in designs
- Structure of parameters in CAD-models
- Advanced CAD functions such as variable sweeps; Surface modelling in CAD

FEA-formulation

- Transient problems, implicit and explicit methods, Runga-Kutta's method, the central difference method, Newmark's method, Eigen value problems.
- Finite element formulations, (strong and weak formulations), isoparametric formulation, numerical integration.

Finite element analysis, one dimensional

- Strong and weak formulations of a one-dimensional problem in FEA.

Two dimensional element analysis

- Linear elasticity, continuum mechanics, stress, strain, balance laws, Eulerian and Lagrangian formulations.
- Contact mechanics, Signorini's contact conditions, trial and error approach, penalty formulation, augmented Lagrangian formulation, Newton's method, the KKT-conditions.

Dynamic finite element analysis

- Plasticity, associative plasticity, the principle of maximal dissipation, J2-plasticity, radial return, isotropic hardening.
- Projects and tutorial using Abaqus.

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 60 Tutorial hours. The total contact hours of the course are therefore, 60 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
CAD modelling	4	8	0	8
FEA mathematical formulation	6	12	0	12
FEA analysis-one dimensional	6	12	0	12

FEA two dimensional	6	12	0	12
FEA Dynamic analysis	8	16	0	16
Total Hours	**30**	**60**	**0**	**60**

Reading List/References

1. Nonlinear FEA and Design Optimization for Mechanical Engineers, N.Strömberg, 2012
2. Seshu P., Text book of finite element analysis, ISBN 978-81-203-2315-5, ©2003
3. Saeed Moaveni, Finite element analysis with ANSYS, ISBN 0-13-785098-0 ©199
4. Hsu, T. R. (2012). *The finite element method in thermomechanics*. Springer Science & Business Media. ISBN 9789401159982
5. Hsu, T. R. (2018). *Applied Engineering Analysis*. John Wiley & Sons. ISBN 9781119071204

MME8106 Fatigue Design and Fracture Mechanics

Course Description

This course provides a detailed treatment of fatigue failure due to cyclic loading of mechanical components. Numerous design examples are provided including: stress concentration, notch sensitivity, mean stress, multi-axial stress and variable amplitude loading. A course project on a relevant topic is required which must be presented orally and in writing.

Course objectives

- Introduce design approaches for high cycle (stress-life).
- Study of Methods for low cycle (plastic strain-life) problems.
- Understanding of linear Elastic Fracture Mechanics concepts.
- Present the microscopic and macroscopic features of fatigue and fracture.

Learning Outcomes

Knowledge and understanding

- understand and explain the theoretical background of linear and nonlinear fracture mechanics
- explain the underlying theories of the methods used for dimensioning
- explain the mechanisms for crack propagation explain the mechanism of fatigue
- explain the basic theories of fracture mechanics and fatigue

Skills and abilities

- dimensioning steel structure against fracture and fatigue
- assess the risk of failure and fatigue
- assist in planning and carrying out fracture mechanics testing and analysis
- investigate fundamental reasons for failure
- determine whether or not stable crack growth can become unstable.
- apply the knowledge from the course on practical cases where linear fracture mechanics is sufficient
- get experience in team work and report writing

Ability of assessment and attitude

- understand how fracture mechanics and fatigue affect people, environment and safety
- understand the role dimensioning plays in sustainable development
- know the challenges of today in fracture mechanics and fatigue
- know the increased experience of engineering assessments and the identification and formulation of problems

Detailed Course Content

The course covers basic theories of fracture mechanics and fatigue. Dimensioning of structures in a systematic way, using rules of fracture mechanics and fatigue is an important part. Fundamentals in fracture mechanical testing and fatigue are covered. Basic understanding and knowledge of mechanics, physics and mathematics are important tools. Course be divided into two parts below:

1. **Fracture Mechanics:**

- Review - Fatigue basics, Stress-Life Diagrams, Stress Concentrations, Notch Sensitivity, Mean Stress Effects
- Multi-axial Fatigue: States of Stress
- Variable Amplitude Load Histories
- Low cycle fatigue (Plastic strain cycling, 2 to 1000 cycle life)
- Cyclic Stress-strain Curves & Plastic Strain-life Diagrams (ε-N diagrams)
- Notch Strain Analysis, Neuber's Rule
- Microscopic/Material Aspects of Fatigue, Fracture Mechanics (LEFM, Linear Elastic Fracture Mechanics)
- Stress Intensity Factor & Plane Strain Fracture Toughness
- LEFM and Fatigue Crack Growth Rate
- Failure Analysis - Observations on Failed Parts
- "Fail Safe" Design Practices

2**. Design against Fatigue: Deformation controlled fatigue; Weld standards.**

- Plated steel structures: Fatigue strength of welded steel elements, size effect, residual stresses influence, application of fracture mechanics to fatigue.
- Tubular steel structures: Hot spot stress method for fatigue design, welded vs cast steel joints
- Structural glass: Subcritical crack growth, predicting time to failure.
- Reinforced concrete structures: Fracture mechanics, fracture of concrete, size effect, brittle failure, fatigue of reinforced concrete elements, evaluation of fatigue safety of bridge decks, fracture due to dynamic effects.
- Polymer structures: fracture and fatigue properties of Ultra-High Performance Fiber Reinforced Composites, structural implications, design provisions.
- Asphalt/Bitumen: fatigue design of roads, failure of bitumen, optimal design of bridge deck – asphalt composites bonds.

This course provides an important basis from which to study and work in areas where mechanical components and systems are included, such as engineering design, product innovation, engineering, product development and so on.

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 30 Tutorial hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Fracture Mechanics	15	18	0	24
Fatigue Weld Design	15	12	0	21
Total Hours	**30**	**30**	**0**	**45**

References

1. Osgood, C. C. (2013). *Fatigue design: International series on the strength and fracture of materials and structures*. Elsevier. ISBN 9781483155227
2. Tait, R. B., & Garrett, G. G. (Eds.). (2013). *Fracture and Fracture Mechanics: Case Studies*. Elsevier. ISBN 9781483155470
3. Sih, G. C., Ryan, N., & Jones, R. (Eds.). (2012). *Fracture Mechanics Technology Applied to Material Evaluation and Structure Design: Proceedings of an International Conference on 'Fracture Mechanics Technology Applied to Material Evaluation and Structure Design', Held at the University of Melbourne, Melbourne, Australia, August 10–13, 1982*. Springer Science & Business Media. ISBN 9789400969148
4. Hobbacher, A. (2015). *Recommendations for fatigue design of welded joints and components*. Springer. ISBN 9783319237572
5. François, D., Pineau, A., & Zaoui, A. (2012). *Mechanical behaviour of materials: volume II: fracture mechanics and damage* (Vol. 191). Springer Science & Business Media. ISBN 9789400749306
6. Sai, R. K. (2010). *Design of steel structures*. Pearson Education India. ISBN 9788131733233

DETAILED COURSE DESCRIPTION
YEAR 1: SEMESTER 2

MME8201 Fiber Reinforced Composites and Polymer Processing
Course Description

The module will provide a deeper understanding of the technology of plastics processing. The material covered will cross cut the engineering disciplines of advanced manufacturing technology and polymer science to broaden the technical and industrial context of polymer processing. Within the content of the module simulation software will be applied to industrial case study examples for critical evaluation. In addition, the application of polymer replication technologies within the emerging field of micro manufacturing will be presented, focusing on the advantage and limitations of size effect and length scale integration. The module will included practical demonstration laboratories and also include industrial visits.

Course objectives

- explain the fundamental background sciences to processing of polymeric materials: rheology, heat transfer and solidification processes.
- Identify and describe main material components responsible for building lightweight composite materials
- Understand and analyze material mechanical behavior in composite materials and their components
- Select different materials and design lightweight composites
- Understand and select different approaches to manufacturing lightweight composites

Learning Outcomes

After completing the course, the student shall:

- motivate the choice of polymeric material for a product to be used in a given application.
- describe how the product should be processed in order to obtain suitable properties
- describe the geometry how the product interacts with the properties of the material.
- design products in polymeric materials accounting for the time dependence of the mechanical properties.
- Demonstrate in an industrial context using the appropriate terminology, the principles of the injection moulding process.
- Demonstrate a systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of their academic discipline, field of study or area of professional practice.
- Demonstrate a comprehensive understanding of state-of-the-art developments within injection moulding at both macro and micro scale.
- Understand how to apply simulation software to optimize the performance of injection moulding for industrial case studies.
- Through conceptual understanding evaluate critically current research and methodologies and if appropriate propose new hypothesis.

- Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.
- Use creativity to establish innovative solutions.
- Knowledge of characteristics of particular equipment, processes or products.
- Understanding of the need for a high level of professional and ethical conduct in engineering

Detailed Course Content

1. Fibers:
    i. Introduction, Types of fibres and yarns, Market overview.
    ii. Man-made fibre spinning processes, Man-made fibres from cellulosic materials: Viscose fibres: Chemical reactions, production technology, products, properties. Lyocell fibres: Basics, production technology, products, properties.
    iii. Synthetic man-made fibres: Spinning processes and machines, Plant design, Polyester and polyamide: chemistry, processes, properties, applications.
    iv. High-performance fibres: Carbon, aramide, glass, steel; Production processes, properties, applications
2. Polymers:
    i. Polymer structure and properties.
    ii. Selection of Polymeric Materials.
    iii. Mechanical properties of Polymers and Rubbers
    iv. Viscoelasticity of Polymers.
    v. Production technology: Injection moulding, Blow moulding.
    vi. Computational simulation Shrinkage and warpage.
    vii. Polymer melt rheology Mould cooling systems
3. Advanced Textile Technology for Technical Textiles
    i. Overview of the manufacturing of technical textiles, the basic properties of the fabrics and their application.
    ii. Warp knitting technology, including stitch-bonding technology for non-crimp fabrics, and also spacer fabrics and special articles.
    iii. Weft knitting technology, especially such with weft and warp insertion
    iv. Weaving.
    v. Braiding.
    vi. Nonwoven technology.
4. Fiber reinforced polymer composites:
    i. Introduction: Review of fibers and polymer matrices.
    ii. Mechanics of Composite Materials: Macromechanical Behavior of a Lamina, Micromechanical Behavior of a Lamina, Macromechanical Behavior of a Laminate, Design and Failure of a Laminate,
    iii. Natural Fiber Reinforced Composites in Automotive, Building and Road Applications.
5. Class Project and Case Studies

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 30 lecture hours and 30 Tutorial hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Fibers	6	0	9	5
Polymers	6	0	9	5
Advanced Textile Technology for Technical Textiles	6	0	9	5
Fiber reinforced polymer composites	6	0	9	5
Class project and case studies	6	0	9	5
Total Hours	**30**	**0**	**45**	**45**

Reading List/References

1. Horrocks, A. R., & Anand, S. C. (Eds.). (2016). *Handbook of Technical Textiles: Technical Textile Applications*. Woodhead Publishing. ISBN 9781782424888
2. Bhat, G. (Ed.). (2016). *Structure and properties of high-performance fibers*. Woodhead Publishing. ISBN 9780081005514
3. Hearle, J. W. (Ed.). (2001). *High-performance fibres*. Elsevier. ISBN 9781855737549
4. Baird, D. G., & Collias, D. I. (2014). *Polymer processing: principles and design*. John Wiley & Sons. ISBN 9780470930588
5. Tadmor, Z., & Gogos, C. G. (2013). *Principles of polymer processing*. John Wiley & Sons. ISBN 9780470355923
6. Thomas, S., Ponnamma, D., & Zachariah, A. K. (Eds.). (2012). *Polymer Processing and Characterization*. CRC Press. ISBN 9781466558274
7. Carraher Jr, C. E. (2017). *Introduction to polymer chemistry*. CRC press. ISBN 9781439809532
8. Thomas, S., & Zaikov, G. (2009). *Recent advances in polymer nanocomposites*. CRC Press. ISBN 9789047426448
9. Thomas, S., & Pothan, L. A. (Eds.). (2009). *Natural fibre reinforced polymer composites: from macro to nanoscale*. Archives contemporaines. ISBN 9782914610995

10. Kalia, S., Kaith, B. S., & Kaur, I. (Eds.). (2011). *Cellulose fibers: bio-and nano-polymer composites: green chemistry and technology*. Springer Science & Business Media. ISBN 9783642173707
11. Rammerstorfer, F. G. (2014). *Engineering Mechanics of Fibre Reinforced Polymers and Composite Structures*. ISBN 9783709127025
12. Elmarakbi, A. (2013). *Advanced composite materials for automotive applications: Structural integrity and crashworthiness*. John Wiley & Sons. ISBN 9781118535264

MME8202 Nano-structured Materials and Nanotechnology
Course Description
Without nanomaterials, there is no nanotechnology. As such, this course covers the basic principles associated with Nano science and nanotechnology including the fabrication and synthesis, size dependent properties, characterization, and applications of materials at nanometer length scales with an emphasis on recent technological breakthroughs in the field. In this course, the student can critically assess the promise of nanomaterials. Has practical skills in conducting the entire cycle of scientific experiment: from fabrication of nanostructures to their characterization. Knows the key methods of synthesis and characterization of nanomaterials. Has essential scientific background for understanding the properties and behavior of materials with reduced dimensions. Has understanding of several size effects in nanomaterials

Course Objectives
- To introduce and provide a broad view of the nascent field of nanoscience and nanotechnology. undergraduates.
- To introduce students to inter- and multi-disciplinary science and engineering of nanostructured materials.

Learning Outcomes
Knowledge and understanding
- The properties of nanoparticles are strongly dependent on size and shape.
- It is therefore important to synthesize these materials using a methodology that is able to finely control these structural parameters and the corresponding polydispersity degree.
- focus on synthetic aspects for the design of nanostructured materials.
- describe different approaches including both the bottom-up (includes both chemical and physical methods) and the top-down methods (mainly physical methods) for the synthesis of nanostructured materials.
- focus on different type of nanostructures with a special emphasis on carbon nanotubes(CNT), metal and metal oxide nanoparticles, core-shell nanostructures and self-assembly of these nanostructures.
- The dependence of various properties (dielectric, magnetic and optical) with size will be discussed.

Skills and abilities
- Describe what a nanostructured material is
- Describe nanostructured materials that can be found in nature and in technology
- Describe different methods for preparation of nanostructured materials
- Describe self-association phenomena that lead to formation of nanostructured materials
- Describe the unique physical properties that arise in nanostructured materials and why they appear
- Describe how the unique properties of nanostructured materials are used in nature and technology
- Describe some different characterization methods for nanostructured materials

Detailed Course Content

1. Why use/explore new nanomaterials?
2. Synthesis and Fabrication: Top down vs. bottom up techniques, nucleation theory, surface energy and stabilization.
3. Characterization: Composition, structure, porosity, crystallinity, single vs. ensemble measurements
4. Examples: General classification (zero – two dimensional and assembled nanostructures), materials composition/function (metals, metal oxides, semiconductors, carbon, biological)
5. Size Dependent Chemical and Physical Properties: Electrical, optical, catalytic, magnetic, thermodynamic, why purification is needed
6. Applications: Electrical, optical, catalytic, magnetic, thermodynamic, purification, sensing, biology, medicine, solar cells, etc. (literature)
7. Implications: Environment, health, and safety as well as impacts on policy, society, and education

Laboratory

1. Production of Thin Films by Means of PVD Technique.
2. Production of nanocellulose from biomass.
3. Encapsulation of nanoparticles for drug delivery
4. Electron Microscopy Characterization of Nanomaterials.

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 30 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Why nanomaterials	3	0	0	3
Synthesis and Fabrication	6	0	8	10
Characterization	6	0	4	8
Examples of nanostructures/materials	6	0	4	8
Properties	3	0	4	5

Applications	3	0	6	6
Implications	3	0	0	3
Total Hours	**30**	**0**	**30**	**45**

Reading List/References

1. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Cao and Ying Wang, World Scientific (2011), ISBN: 13 978-981-4324-55-7 (pbk)
2. G. Cao, Y. Wang, Nanostructures and nanomaterials: Synthesis properties and applications (2nd ed.) World Scientific, Singapore, 2011. ISBN 9789814324557
3. Khitab, A. (Ed.). (2016). *Advanced research on nanotechnology for civil engineering applications*. IGI Global. ISBN 9781522503453
4. Rafiei, S., Maghsoodlou, S., Afzali, A., & Thomas, S. (2014). *Foundations of nanotechnology, volume two: Nanoelements formation and interaction*. Apple Academic Press. ISBN 9781771880282
5. Ozoemena, K. I., & Chen, S. (Eds.). (2016). *Nanomaterials in advanced batteries and supercapacitors* (p. 423). Switzerland: Springer. ISBN 9783319260822

MME8203 Optimization Driven Design

Course Description

The course introduces mathematical programming methods for engineering design optimization for engineering applications and appropriate design problems from other engineering disciplines.

Course Objectives

- Examine the description of an engineering design problem to assess whether the solution may be facilitated by an optimization method.
- Translate the description of the problem at hand into a formal, mathematical optimization statement suitable for application of one of the established optimization methods.
- Select a specific optimization technique appropriate to the problem and determine whether to use “off-the-shelf” software or develop a new code.
- Execute the optimization, recover from execution difficulties, evaluate whether the results appear reasonable, reformulate and re-execute the problem, if necessary. Interpret the results in terms of the original description of the problem.

Learning Outcomes

After completing the course, the student shall:

Knowledge and understanding

- Have knowledge about how structural and design optimization can be used during the design process.
- Able to show knowledge about how fundamental basic optimization algorithms are used.
- Have understanding about how optimization driven design is used in the development of sustainable products.

Skills and abilities

- Show ability to use response surfaces optimization in structural analyses.
- Show the ability to perform sensitivity analyses.

Judgement and approach

- Show ability to perform a major optimization driven design project.

Detailed Course Content

The course includes the following topics:

1. Introduction to Optimization: The optimization framework in the context of the engineering science; Definition of the programmatic contain and student initiation in the formulation and language of the optimization; Review of fundamental concepts.
2. Single-variable minimization;
3. Multivariable optimization with no constraints: basic concepts and numerical solution methods; Multivariable optimization with constraints: presentation based on previous classification of the optimization techniques.

4. Mathematical programming and optimality criteria search methods.
5. Sensitivity analysis and gradient calculation: analytical, semi-analytical and numerical methods.
6. Optimization methods based on evolutionary search.
7. Genetic algorithms: definition of the main aspects. Comparison of different optimization methods for the same problem.
8. Advanced topics: duality, multi-objective optimization and multilevel decomposition.

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 30 lecture hours and 60 Tutorial hours. The total contact hours of the course are therefore, 60 contact hours. The detailed mode of delivery is as shown in Table

Topic	**Lecture Hours**	**Tutorial Hours**	**Practical Hours**	**Contact Hours**
Introduction to Optimization	3	2	0	4
Single variable minimization	3	2	0	4
Multivariable optimization	3	4	0	5
Mathematical programming methods of optimization	6	6	0	9
Sensitivity analysis	3	4	0	5
Evolutionary search optimization methods	3	2	0	4
Genetic algorithms	6	6	0	9
Advanced topics	3	4	0	5
Total Hours	**30**	**30**	**0**	**45**

Reading List/References
1. Arora, J. S. (2004). *Introduction to optimum design*. Elsevier. ISBN 9780123813763
2. Chawdhry, P. K., Roy, R., & Pant, R. K. (Eds.). (2012). *Soft computing in engineering design and manufacturing*. Springer Science & Business Media. ISBN 9781447104278

3. Rao, R. V., & Savsani, V. J. (2012). *Mechanical design optimization using advanced optimization techniques*. Springer Science & Business Media. ISBN 9781447127482
4. Chang, K. H. (2014). *Design theory and methods using CAD/CAE: The computer aided engineering design series*. Academic Press. ISBN 9780123985163
5. Koziel, S., & Yang, X. S. (Eds.). (2011). *Computational optimization, methods and algorithms* (Vol. 356). Springer. ISBN 9783642208591

MME8204 STATISTICS AND RESEARCH METHODS 3 Credit Units

Course Description

This course covers selected topics in statistics that are of relevance to engineers in general. Topics include: a brief review of basic statistical concepts and methods (random variables, statistical models and hypothesis tests); linear models (analysis of variance and regression); the design of efficient experiments, including factorial experiments and response surface methods; models for discrete data; and the effective display of data using tables and graphs.

Objectives

The course is meant to enable students to:

- Design efficient experiments;
- Correctly analyze experimental data;
- Select an appropriate model and method for the analysis of engineering data in general

Learning Outcomes

After completing the course, the student shall:

Knowledge and Understanding

- Understand concepts such as random variable, probability, distribution, independence.
- Understand the basic linear statistical models such as those used in regression and analysis of variance.
- Understand the logic of hypothesis tests and the meaning of the terms "significance level" and "power".
- Have an appreciation of the wide variety of statistical models that are used in engineering and an understanding of some of them.
- Understand the principles of good experiment design.

Skills and Abilities

- Design an efficient experiment involving several factors.
- Estimate the power of the experiment and how many subjects would be needed to achieve a specified power.
- Correctly analyze experimental data;
- Select an appropriate model and method for the analysis of engineering data in general
- Understand engineering statistics in literature.

Content

Statistics: Random variables, distributions, summarizing data; Point estimation, confidence intervals; Comparing 2 means (t-test), test of proportions, goodness of fit tests; Bivariate distributions, linear regression, (chi-squared test); Comparing more than 2 means. One way Anova; Two-way Anova, higher order models; Multiple linear regression, model building

Research Methods:

Design of experiments: Nonparametric methods, graphing.

Development of Dissertation Proposal

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 30 lecture hours and 60 Tutorial hours. The total contact hours of the course are therefore, 60 contact hours. The detailed mode of delivery is as shown in Table

Topic	**Lecture Hours**	**Tutorial Hours**	**Practical Hours**	**Contact Hours**
Statistics	24	48	0	48
Design of Experiments	6	12	0	12
Total Hours	**30**	**60**	**0**	**60**

Reading List/References

1. Morrison, J. (2009). *Statistics for engineers: an introduction*. John Wiley & Sons. ISBN 9780470746431
2. Montgomery, D. C., & Runger, G. C. (2010). *Applied statistics and probability for engineers*. John Wiley & Sons. ISBN 9780470053041
3. Biddix, J. P. (2018). *Research methods and applications for student affairs*. John Wiley & Sons. ISBN 9781119299707
4. Martin, W. E., & Bridgmon, K. D. (2012). *Quantitative and statistical research methods: From hypothesis to results* (Vol. 42). John Wiley & Sons. ISBN 9781118234570
5. Politano, P. M., & Walton, R. O. (2017). *Statistics and Research Methodology: A Gentle Conversation 2nd ed*. Lulu. com. ISBN 9780692166598

DETAILED COURSE DESCRIPTION
YEAR 1: SEMESTER 11 ELECTIVES

MME8205 Ceramics and Powder Technology 3 Credit Units

Course Description

This module provides a detailed coverage of the structure, properties and engineering use of advanced structural ceramics. It focuses on how control of the microstructure can lead to material improvements, especially in regard to toughness. In the exercises, practical problems involving the preparation and use of ceramics and powder metallurgy products will be quantitatively illustrated.

Course objectives

- to introduce the students into the technology of powder metallurgy
- to review the most important fabrication processes for the manufacturing of advanced technical ceramic components
- to introduce the microstructure, properties and life cycle of the different ceramic material classes

Learning Outcomes

After completing the course, the student shall:

- explain how crystal structure and chemical bonding give ceramics their typical properties
- fabricate a ceramic component in the lab by using standard ceramic processing methods
- describe the behaviours of fine (micro- of nanosized) powders, granulates, and powder dispersions and be familiar with the basic uses of colloid chemistry in the processing of fine powders
- explain the driving forces for sintering and be familiar with commonly used sintering methods
- select proper forming methods based on the geometric design of a ceramic component
- analyse the fracture surface of a ceramic component and recognize typical fracture origins
- have a basic knowledge about how ceramics are used in electronic applications as insulators, dielectrics, piezoelectrics and magnets and be able to describe the structural properties that makes this possible
- explain how mechanical properties are measured in brittle materials and be able to evaluate and compare strength data from different sources
- describe how fracture toughening mechanisms such as transformation toughening and crack deflection can be used to strengthen ceramics

Detailed Course Content

Basic ceramic types; typical properties, mechanical properties and dislocations.

Preparation routes for ceramics; single crystals, polycrystalline ceramics, sintering methods.
Mechanical Properties of ceramics; Griffith flaws, high-strength sintered ceramics. - Silicate glasses; structure, properties, processing routes.
Refractory materials; properties required, test methods, thermal shock and spalling.
Glass ceramic materials; composite microstructure development by partial devitrification, control of microstructure by nucleation and growth, properties.
Transformation toughened ceramics; Zirconia - Yttria ceramics, PSZ, toughening mechanisms and engineering applications - Fibre and whisker reinforced ceramics; fabrication routes, toughening mechanisms and properties.
High temperature ceramics; silicon nitride, silicon carbide, boron nitride, sialons, oxidation resistance. - Comparison of ceramic materials and materials selection issues.
Electroceramics; solid electrolytes, fuel cells, sensors, oxygen pumps.

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 15 Lecture hours and 90 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Basic ceramic types	3	0	3	4
Preparation and processing	3	0	6	5
Mechanical properties	6	0	6	8
Refractory materials	3	0	6	5
Glass	3	0	6	5
Transformation of ceramics	6	0	6	8
High temperature ceramics	3	0	6	5
Electroceramics	3	0	6	5
Total Hours	**30**	**0**	**45**	**45**

References

1. Richerson, D. W., & Lee, W. E. (2018). *Modern ceramic engineering: properties, processing, and use in design*. CRC press. ISBN 9781574446937
2. Somiya, S. (2013). *Handbook of advanced ceramics: materials, applications, processing, and properties*. Academic press. ISBN 9780123854704

3. Riedel, R., & Chen, I. W. (Eds.). (2011). *Ceramics Science and Technology, Volume 3: Synthesis and Processing*. John Wiley & Sons. ISBN 9783527311576
4. Rahaman, M. N. (2017). *Ceramic processing*. CRC press. ISBN 9780849372858
5. Loehman, R. E. (2010). *Characterization of ceramics*. Momentum Press. ISBN 9781606501948
6. Richerson, D. W., & Lee, W. E. (2018). *Modern ceramic engineering: properties, processing, and use in design*. CRC press. ISBN 9781574446937

MME8206 Computational Fluid Mechanics
Course Description
The course covers numerical methods for physical simulations of gas and liquid flows. The course is based on the finite difference method and the finite element method with emphasis on fluid dynamics and includes various computational problems in fluid mechanics such as boundary conditions and meshing. In the practical part of the course, the software package ANSYS Fluent is used and the course provides an introduction of relevant features of the program.

Course objectives

Learning Outcomes
Knowledge and understanding
- explain the underlying theories of the methods used for CFD
- Understand partial differential equations and governing equations for fluid flows.
- Explain the finite volume method.
- Explain the Navier – Stokes equations and turbulence modeling.

Skills and abilities
- Experience in engineering scripting languages
- Complex geometric modeling
- Running flow solver routines

Ability of assessment and attitude
- apply CFD methods in modeling of engineering processes in environment, construction and health
- ability to model products obtained from CAD and apply CFD
- apply the finite volume models and their challenges in everyday life.

Detailed Course Content
Theoretical Formulation
i. Partial differential equations
ii. Navier-Stokes equations
iii. Turbulence modeling
iv. Discretisation of equations
v. Initial and boundary conditions
vi. Preprocessing including meshing
vii. Solution of governing equations (Fluent)
viii. Convergence
ix. Post-processing
x. Validation of results

Practical Application with CFD Fluent

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 15 Lecture hours and 90 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Theoretical formulation	15	0	90	45
Total Hours	**15**	**0**	**90**	**45**

References

1. Dorfman, A. S. (2017). *Applications of Mathematical Heat Transfer and Fluid Flow Models in Engineering and Medicine*. John Wiley & Sons. ISBN 9781119320562
2. Amano, R., & Sundén, B. (Eds.). (2011). *Computational fluid dynamics and heat transfer: emerging topics* (Vol. 23). WIT Press. ISBN 9781845641443
3. Vajravelu, K., & Mukhopadhyay, S. (2015). *Fluid flow, heat and mass transfer at bodies of different shapes: Numerical solutions*. Academic Press. ISBN 9780128037850
4. Sharma, A. (2016). *Introduction to Computational Fluid Dynamics: Development, Application and Analysis*. John Wiley & Sons. ISBN 9781119002994
5. Reddy, J. N., & Gartling, D. K. (2010). *The finite element method in heat transfer and fluid dynamics.* CRC press. ISBN 9781420085983
6. Spalding, D. B. (2015). *Numerical prediction of flow, heat transfer, turbulence and combustion*. Elsevier. ISBN 9781483160665
7. Chung, T. J. (2010). *Computational fluid dynamics*. Cambridge university press. ISBN 9781107425255
8. Anderson, J. D., Degrez, G., Dick, E., & Grundmann, R. (2013). *Computational fluid dynamics: an introduction*. Springer Science & Business Media.
9. Versteeg, H. K., & Malalasekera, W. (2007). *An introduction to computational fluid dynamics: the finite volume method*. Pearson education. ISBN 9780131274983

MME8207 Biomaterials and Tissue Engineering
Course Description
This course is designed to impart an understanding of how materials should be designed for optimal results in tissue engineering. An additional aim is to understand how cells and proteins interact with materials.

Course objectives
- To understand the biological requirement for designed tissue engineering systems
- To design scaffolds for growing biological materials
- To fabricate multicomponent biomaterials using advanced manufacturing technologies including 3D printing.
- To design diagnostic and drug materials systems.
- To design a biomaterial system considering the main issues of biocompatibility including toxicity.

Learning Outcomes
Knowledge and understanding
- Analyze advantages and disadvantages of methods for scaffold fabrication
- Discuss advantages and disadvantages of commercial materials that are used in tissue engineering today
- Explain how material properties influence the cell response.
- Explain different techniques for cell identification and quantification of cell properties
- Describe the regulations and ethics in tissue engineering
- Understand the fundamental principals in biomedical engineering, material science and chemistry, and how they contribute to biomaterial development and performance.
- Apply the math, science, and engineering knowledge gained in the course to biomaterial selection and design.
- Critically review papers from the scientific literature and identify areas of research opportunities
- Understanding the Fundamentals in design, fabrication and selection of biomaterials for medical applications.
- Familiarizing with the physical, chemical and mechanical properties and bio-compatibility of different types of biomaterials, e.g. natural, synthetic, inorganic and composite, etc. for the basis of tissue engineering.
- Applying the principles of tissue engineering for medical application.
- Considering the physical and biological concerns of biomaterials applications in clinical indications

Skills and abilities
- Experience in engineering scripting languages
- Complex geometric modeling

- Running flow solver routines

Ability of assessment and attitude
- apply CFD methods in modeling of engineering processes in environment, construction and health
- ability to model products obtained from CAD and apply CFD
- apply the finite volume models and their challenges in everyday life.

Detailed Course Content
Introduction: General overview of components in the human body used to construct tissue. **Implantable materials**: temporary or permanent implants, biodegradable materials, cell substrates, tailored tissue. Bioactive materials and drug delivery systems. Protein surface interactions.
Interactions between human tissue and biomaterials: properties at natural tissue and transplantation techniques.
Tissue Engineering and regenerative medicine. Biomimetic systems. Sterilisation. Evaluation procedures for medical devices. Cell/extracellular matrix interactions; Cellular processes and interactions with materials/nanotechnology in tissue engineering; Transport of nutrients and metabolites; Scaffolds for tissue engineering; case study in medicine

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 30 lecture hours and 45 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	**Lecture Hours**	**Tutorial Hours**	**Practical Hours**	**Contact Hours**
Introduction	6	0		6
Implantable Materials	8	0	15	13
Interactions between human tissue and biomaterials	8	0	15	13
Tissue Engineering and regenerative medicine	8	0	15	13
Total Hours	**30**	**0**	**45**	**45**

References

1. Ramalingam, M., Haidar, Z., Ramakrishna, S., Haikel, Y., & Kobayashi, H. (Eds.). (2012). *Integrated Biomaterials in Tissue Engineering* (Vol. 1). John Wiley & Sons. ISBN 9781118311981
2. Basu, B. (2017). *Biomaterials science and tissue engineering: principles and methods*. Cambridge University Press. ISBN 9781108415156
3. Berardi, A. C. (Ed.). (2018). *Extracellular Matrix for Tissue Engineering and Biomaterials*. Humana Press. ISBN 9783319770239
4. Ducheyne, P. (2015). *Comprehensive biomaterials* (Vol. 1). Elsevier. ISBN 9780080552941
5. Sharma, K. R. (2010). *Transport Phenomena in Biomedical Engineering: Artifical organ Design and Development, and Tissue Engineering*. McGraw Hill Professional. ISBN 9780071663984
6. Ramakrishna, S., Ramalingam, M., Kumar, T. S., & Soboyejo, W. O. (2016). *Biomaterials: a nano approach*. CRC press. ISBN 9781420047813

MME8208 Cement, Concrete and Bituminous Materials
Course Description
The course gives a deep understanding of concrete and pavements as composite material, its properties in the fresh, young and hardened states. The effects from the various basic materials are studied and also how these can be varied to produce concrete and other cement based materials with prescribed properties.

Course Objectives
- Transmit materials knowledge and techniques of applying them to design of novel cements.
- Design concrete materials for different exposures.
- Design internally cured concrete for structural and pavement applications
- Explain the microstructure development in portland cement systems
- Explain the deterioration mechanisms and factor affecting durability of concrete
- Explain the fundamental difference between portland cement and non-portland cement binders
- Use service life prediction models for concrete structures as design tools while understanding their limitation

Learning Outcomes
Knowledge and understanding

Skills and abilities
- Experience in engineering testing of materials
- Design new products using cement, bitumen and other binders.

Ability of assessment and attitude
- Ability to test concrete, cement and bitumen.
- Design novel products using cementitious materials and bitumen.

Detailed Course Content
Cement:
i. Cementitious materials (Geopolymers and inorganic binders, Low clinker binders and limestone replacement, aluminate cements).
ii. Hydration mechanisms,
iii. Properties of aggregates,
iv. Mix design and admixtures.

Concrete:
i. Mechanical properties and loading,
ii. Fracture mechanics of Concrete,
iii. Volume Stability: Shrinkage and Creep, measurement,

iv. The effects from each basic material on mixed concrete and other cement based materials.

Cementitious materials and Environment: co-operation with the environment; Durability, repair methods and life-time design.
Bituminous Materials:

i. Sources of asphalt and bitumen
ii. Chemical characteristics of bitumen
iii. Alternatives forms of bitumen
iv. Mechanical properties of asphalt concrete

Experimental testing of Cement, Concrete Materials and Bitumen

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 20 lecture hours and 20 Tutorial hours and 45 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Cement	4	4	9	9
Concrete	4	4	9	9
Cementitious materials and environment	4	4	9	9
Bituminous materials	4	4	9	9
Experimental testing	4	4	9	9
Total Hours	**20**	**20**	**45**	**45**

References

1. Ghosh, S. N. (Ed.). (2014). *Advances in cement technology: critical reviews and case studies on manufacturing, quality control, optimization and use*. Elsevier. ISBN 9781483190389
2. Eckel, E. C. (2015). *Cements, limes and plasters: Their materials, manufacture and properties*. Routledge. ISBN 9781317742586
3. Mehta, P. K., & Monteiro, P. J. (2017). CONCRETE Microstructure, Properties and Materials. ISBN 9780071797870
4. Aranda, M. A., Artioli, I., Bier, T., Àngeles, G., Freyer, D., Kaden, R., ... & Södje, J. (2017). *Cementitious materials: composition, properties, application*. Walter de Gruyter GmbH & Co KG. ISBN 9783110473728

5. Pijaudier-Cabot, G., & Dufour, F. (Eds.). (2013). *Damage Mechanics of cementitious materials and structures*. John Wiley & Sons. ISBN 9781118566220
6. Tokyay, M. (2016). *Cement and concrete mineral admixtures*. CRC Press. ISBN 9781498716550
7. Skok, E. (Ed.). (2015). *Asphalt Paving Technology 2014: Volume 83, Journal of the Association of Asphalt Paving Technologists*. DEStech Publications, Inc. ISBN 9781605952062
8. You, Z., Dai, Q., & Xiao, F. (2018). *Advanced Asphalt Materials and Paving Technologies*. MDPI. ISBN 9783038428893
9. Gonçalves, M. C., & Margarido, F. (2015). *Materials for Construction and Civil Engineering*. Springer International Publishing, Cham. ISBN 9783319082363

MME8209 Materials for Clean Energy Technologies

Course Description

The course introduces the fundamental concepts, principles and application. This course gradually goes deeper into the various aspects of materials for energy application along with bringing out the advanced theories and practical knowledge. Each topic is developed in logical progression with up-to-date information with references. The topics cover materials for hydro power generation, thermal power generation and materials for energy storage like batteries.

Course Objectives

- to give the students an overview of structure and properties of some important material groups which are the basis of modern energy technology. Course
- to introduce some principles for applications of materials.

Learning Outcomes

Knowledge and understanding

- Use the chemistry and physics to understand the fundamentals of material issues in conventional and renewable energy technologies.
- Assess the current sources of energy and materials used for existing production, transportation and storage of energy.
- Understand the continuous depletion of energy resources.
- Quantify the short-term and long-term potentials for improving energy and material technologies.
- Explore a number of alternative energy sources such as geothermal energy, wind, natural gas, and solar energy.
- Define material properties and explore structure – properties relationship of new materials that may radically improve the energy economy.
- Analyze the potential of advanced materials for energy conservation and more efficient energy technologies in reduction of the environmental consequences.

Skills and abilities

- Understand the material interplay for the development of energy products.
- Understand the economic impact of materials for energy.

Ability of assessment and attitude

- Use computational methods in the development of energy products.
- Do tests on materials developed for energy applications.

Detailed Course Content

Introduction: Essential aspects of energy conversion and storage (energy and the law of conservation of energy, conversion of energy in nature, physical and chemical bases of energy conversion phenomena, physical and chemical bases of energy storage).
Sources of Energy: A review of conventional and non-conventional sources of energy.
Energy Conversion: Selected methods of converting mechanical, thermal and solar energy to electrical energy (wind power, hydropower, geothermal energy, thermoelectricity, photovoltaics).
Materials for sustainable development: recycling and sustainable use will be discussed. Water as energy source and energy transmit
Materials for solar cells: semiconductors.
Materials for batteries: Li-batteries, metal hydride-batteries.
Conversion of Chemical to Electrical Energy: production (electrolysis), storage (hydrides), fuel cells (solid electrolytes, ion conductors).
Materials related to gas-power plants (catalysts, microporous materials, membranes).
Experimental Testing of Energy materials: X-ray diffraction analysis, scanning electron microscopy microanalysis, transmission electron microscopy analysis, atomic absorption and emission spectroscopy analysis, X-ray fluorescence spectroscopy analysis, thermal analysis, UV-visible diffuse reflectance absorption analysis testing t

Course Assessment:
The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery
This course is delivered using a total of 30 lecture hours and 45 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	**Lecture Hours**	**Tutorial Hours**	**Practical Hours**	**Contact Hours**
Introduction	6	0	3	7
Sources of Energy	3	0	6	5
Energy conversion	3	0	6	5
Materials for sustainable development	6	0	6	8
Materials for solar cells	3	0	6	5
Materials for batteries	3	0	6	5
Conversion of chemical to electrical energy	3	0	6	5
Experimental testing of energy materials	3	0	6	5

Total Hours	**30**	**0**	**45**	**45**

References

1. Ginley, D. S., & Cahen, D. (Eds.). (2011). *Fundamentals of materials for energy and environmental sustainability*. Cambridge university press. ISBN 9781139502689
2. Bruce, D. W., O'Hare, D., & Walton, R. I. (Eds.). (2011). *Energy materials*. John Wiley & Sons. ISBN 9780470978061
3. Zhou, Y. (Ed.). (2015). *Eco-and Renewable Energy Materials*. Springer. ISBN 9783642334979
4. Tiwari, A., & Valyukh, S. (Eds.). (2014). *Advanced energy materials*. John Wiley & Sons. 9781118686294
5. Oku, T. (2017). *Solar Cells and Energy Materials*. Walter de Gruyter GmbH & Co KG. ISBN 9783110298505
6. Richard Catlow, Alexey Sokol, Aron Walsh, (2013). *Computational Approaches to Energy Materials.* John Wiley & Sons.

MME8210 Materials Joining Technology

Course Description

The aim of the course is to introduce important manufacturing aspects of metal forming and joining focusing on welding.

To equip the students with the necessary background for understanding the selection and control of appropriate joining technologies for industrial applications with emphasis on welding, adhesive bonding, brazing and soldering. Original Summary: The welding and joining of materials is essential in engineering and this module provides a grounding in the various techniques available and their applications. Traditional and modern joining techniques are explored and subsequent design and quality issues are reviewed. A laboratory provides students with an opportunity to demonstrate communication skills, research-related skills and depth of understanding (and associated cognitive skills).

Course objectives

- To introduce the most common joining methods for metals, ceramics and polymer composites
- Understand the metallurgy of welding technology
- Model various joining technologies using the Finite Element Method.

Learning Outcomes

After completing the course, the student shall:

- Define and compare the most common joining methods for metals, with focus on welding, and their relation to products and production.
- Discuss forming and cutting methods in the perspective to prepare for welding processes.
- Discuss the physical metallurgy of welding in important alloys and judge weldability, phase transformations, microstructure development and properties of welds and heat affected zones.
- Discuss advanced weld simulation and analyse important welding-induced effects on materials and components with simplified models.
- Describe typical weld defects, generation of internal stresses and their influence on mechanical properties.
- Discuss weld design and quality assurance of welded components.

Detailed Course Content

Important joining methods for metals are introduced.

1. Mechanical Joining: Sources and types of joint loading; shear loaded fastened joints, tension loaded fastened joints, fatigue loading of fastened joint, other factors affecting fasteners and fastened joints.
2. Mechanical fasteners, integral attachments, and other mechanical joining methods: Threaded fasteners, unthreaded fasteners, integral mechanical attachments
3. Adhesive bonding and cementing: Adhesive bonding as a joining process; mechanisms of adhesion, failure in adhesive bonded joints, key requirements for quality adhesive bonding, adhesive joint designs, design criteria, and analysis. Use of FEM for analysis of adhesive bonds.
4. Adhesives, Cements, Mortars, and the Bonding Process
5. Welding processes
   Temperature distribution, residual stress and distortion are treated via simulation and literature studies.; Basic metallurgy of welding, brazing and soldering; Metal forming and cutting methods; Welding specific material classes; plain carbon and carbon-manganese steels, low alloy steels, stainless steels, copper alloys, aluminium alloys, nickel and nickel alloys, transition welds; Design and performance of welded structures; joint design, static and dynamic loading Quality assurance of welds; NDT, control and recording; quality of welds
6. Joining of Ceramics and Glasses
7. Joining of Polymers
8. Joining Composite Materials and Structures

Course Assessment:

The course assessment contribution is as below:

Continuous assessment tests, Assignments	40%
Final Examination	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 30 Practical hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Mechanical Joining	9	0	4	11
Mechanical fasteners, integral attachments, and other mechanical joining methods	9	0	4	11
Adhesive bonding and cementing	6	0	4	8
Adhesives, Cements, Mortars, and the Bonding Process	6	0	6	9

Welding processes	6	0	6	9
Joining of Ceramics and Glasses	3	0	2	4
Joining of Polymers	3	0	2	4
Joining of Composite Materials and Structures	3	0	2	4
Total Hours	**45**	0	**30**	**45**

Reading List/References

1. Singh, M., Ohji, T., Asthana, R., & Mathur, S. (Eds.). (2011). *Ceramic integration and joining technologies: from macro to nanoscale*. John Wiley & Sons. ISBN 9780470391228
2. Jeffus, L. (2011). *Welding: principles and applications*. Nelson Education. ISBN 9781305494695
3. da Silva, L. F., Pirondi, A., & Öchsner, A. (Eds.). (2011). *Hybrid adhesive joints* (Vol. 6). Springer Science & Business Media. ISBN 9783642166235
4. Possart, W., & Brede, M. (Eds.). (2018). *Adhesive Joints: Ageing and Durability of Epoxies and Polyurethanes*. Wiley-VCH. ISBN 9783527341856
5. Adams, R. D. (2012). *Structural adhesive joints in engineering*. Springer Science & Business Media. ISBN 9789400956162
6. Da Silva, L. F., & Campilho, R. D. (2012). Advances in numerical modelling of adhesive joints. In *Advances in numerical modeling of adhesive joints* (pp. 1-93). Springer, Berlin, Heidelberg. ISBN 9783642236082
7. Bellosi, A., Kosmac, T., & Tomsia, A. P. (Eds.). (2013). *Interfacial science in ceramic joining* (Vol. 58). Springer Science & Business Media. ISBN 9789401719179
8. Savage, W. (2013). *Joining of advanced materials*. Elsevier. ISBN 9781483292144
9. Wahab, M. A. (Ed.). (2015). *Joining Composites with Adhesives: theory and applications*. DEStech Publications, Inc. ISBN 9781605950938

DETAILED COURSE DESCRIPTION
YEAR 2: SEMESTER 2

MME9101 Dissertation Proposal **7 Credit Units**

Course Description

This course is a continuation of MME8204 and it will enable students to develop a research proposal with the help of their supervisors. The students will defend the proposals during the first month of the semester.

Course objectives

- Formulate research ideas that are both innovative and worthy for research
- Evaluate the capability of scientific proposal writing

Course Assessment:

The course assessment contribution is as below:

Dissertation Proposal Report	40%
Oral Defense of the Proposal	60%
Total	100%

MME9102 Seminar Series **3 Credit Units**

Course Description

This course will introduce students to the state of art in the field through expert presentations from faculty or experts in the industry.

The students will present twice on the progress of their research and will also be required to attend at least four (4) seminar series throughout the semester.

Course Assessment:

The course assessment contribution is as below:

Seminar reports	40%
Dissertation progress reports	60%
Total	100%

MME9202 Scientific Writing 3 Credit Units

Course Description

This course aims to demystify the writing process and teach the fundamentals of effective scientific writing. Instruction will focus primarily on the process of writing and publishing scientific manuscripts but grant writing will also be addressed. The course will be presented in three segments: Part (1) teaches students how to write effectively, concisely, and clearly and part (2) takes them through the preparation of an actual scientific manuscript or grant and part (3) will be dedicated for the writing a journal manuscript/patent arising from the work done.

Course objectives

- Learn how to write a coherent article
- Develop good sentence and paragraph structure
- Identify and correct the most common and stylistic errors
- Learn to use powerful language and to write more succinctly
- Improve grammar and punctuation and edit your work more independently

Learning Outcomes

Knowledge and understanding

After completing the course, the student shall:

- Describe the scientific writing process and its key stages;
- Reflect on what constitutes a research problem to be addressed in a scientific paper;
- Organize and compose a scientific paper in accordance with the IMRAD (Introduction, Methods, Results and Discussion) model;
- Analyze and review scientific papers in terms of key message, consistency and justification;
- Reflect on the benefits of working in teams in scientific writing and describe the rules of co-authorship;
- Reflect on the ethics in scientific writing

Skills and abilities

- Able to develop a Master’s thesis research proposal and defend it before the higher degrees committee.
- Able to write a review manuscript for publication.

Judgement and approach

Students are able to report scientific findings in a precise and concise way to both a specialized community and a broader audience, and to critically analyze scientific papers following the same criteria. They know how to describe experiments, processes and simulations in a way that ensures their reproducibility, they clearly distinguish results and their discussion, they make sure that conclusions are drawn and indeed substantiated by the reported findings. Finally, they manage to summarize approach, results and conclusions in an appropriate abstract. Students are familiar with the rules and procedures of scientific publishing in international journals.

Detailed Course Content

1. Literature Review: motivating scientific research and summarizing the state of the art
2. Problem statement - Reporting the work: describing experimental, modeling or theoretical work such that it can be reproduced, indispensable information, criteria for reproducibility
3. Reflecting the work: interpreting and discussing the results in a sound and convincing way, logical structure, ambiguities, statistical relevance
4. Conclusions and Abstract - Publishing an article: selecting a journal, preparing a submission, responding to the referees, plagiarism.
5. Popularizing science: presenting research work for a broad audience
6. Patents: Structure, Writing of Patents

Course Assessment:

The course assessment contribution is as below:

Continuous assessment, Assignments	40%
Peer reviewed Journal paper or Patent submitted/published	60%
Total	100%

Mode of delivery

This course is delivered using a total of 30 lecture hours and 30 Tutorial hours. The total contact hours of the course are therefore, 45 contact hours. The detailed mode of delivery is as shown in Table

Topic	Lecture Hours	Tutorial Hours	Practical Hours	Contact Hours
Literature Review	6	0	0	6
Problem Statement	6	0	0	6
Results and Discussion	3	0	0	3
Conclusions and Abstract	3	0	0	3
Popularizing Science	3	0	0	3
Patents	3	0	0	3
Journal Paper	0	0	63	21
Total Hours	**30**	**30**	**0**	**45**

Reading List/References

1. Lebrun, J. L. (2011). *Scientific writing 2.0: a reader and writer's guide*. ISBN 9789814350617
2. Katz, M. J. (2009). *From research to manuscript: a guide to scientific writing*. Springer Science & Business Media. ISBN 9781402094675
3. Schimel, J. (2012). *Writing science: how to write papers that get cited and proposals that get funded*. OUP USA. ISBN 9780199760237
4. Cargill, M., & O'Connor, P. (2013). *Writing scientific research articles: Strategy and steps*. John Wiley & Sons. ISBN 9781444356212
5. www.busitema.ac.ug/graduatestudies/

APPENDIX A: PROGRAMME FUNDING

The Master of Science in Materials Engineering will be funded through:

i. **Tuition fees.**
   *S*ee Table 2 below
ii. **Government funding.**
   Presidential initiative proposal has incorporated into funding to the programme
iii. **Development partners**
   - Project Proposals to donor agencies
   - Position the programme for the upcoming Africa Mobility Scheme proposals later this year.
   - Engage SIDA for possible support of MSc and PhD in Materials Engineering.

The budget for the MSc in Materials Engineering has been developed based on costs chargeable to Uganda students admitted to the course. The budget is based on the assumption that 10 students are admitted to the course. Each of the budgets includes recurrent expenditures and projected staff costs (both academic, administrative and support staff), as well as capital expenditure and other running costs.

Table 4. Proposed programme budget

Assuming intake of 10 students		
A. REVENUE PER SEMESTER	**Semester I**	**Semester II**
Tuition fees	Amounts (UGX)	Amounts (UGX)
Students fees	3,500,00	3,500,00
(UGX 7,000,000 per annum)		
Tuition fees for 10 students @UGX 3,500,000	35,000,000	35,000,000
Total	***35,000,000***	***35,000,000***
B. EXPENDITURE PER SEMESTER		
University Council 9%	3,150,000	3,150,000
Teaching Expenses 50%	17,500,000	17,500,000
Administrative Expenses 5%	1,750,000	1,750,000
Office Expenses 3%	1,050,000	1,050,000
Library Materials 2%	700,000	700,000
Faculty levy 5%	1,750,000	1,750,000
Utilities/Furniture 2%	700,000	700,000
Staff Development 2%	700,000	700,000

Repair/reinforcement of Materials lab 10%	3,500,000	3,500,000
Air ticket for visiting professors 12%	4,200,000	4,200,000
Total 100%	***35,000,000***	**3,500,000**

S/N	FULL NAME	GENDER	HIGHEST QUALIFICATION	AWARDING INSTITUTION	YEAR	FIELD OF SPECIALIZATION	EMPLOYMENT STATUS	RANK	CURRENT TEACHING LOAD		PROPOSED TEACHING LOAD	
									COURSES	CU	COURSES	CU
1	Assoc. Prof. Samuel Kucel Baker	Male	PhD	University of Udine, Italy	2002	Energetics (Mechanical Engineering)	Permanent	Associate Professor	-	-	DISSERTATION	7
2	Assoc. Prof. Samson Rwahwire	Male	PhD	Technical University of Liberec, Czech Republic	2016	Materials Engineering	Permanent	Associate Professor			MME8106	3
											MME8201	3
3	Assoc. Prof. Kant Kanyarusoke	Male	PhD			Mechanical Engineering	Contract	Associate Professor			MME8104	3
											MME8210	3
4	Dr. Eng. Daniel Otim	Male	PhD	University of Kwazulu Natal	2019	Civil Engineering	Permanent	Senior Lecturer			MME8208	3
5	Dr. Ildephonse Nibikora	Male	PhD	Donghua University, China	2011	Textile Materials	Contract	Senior Lecturer			MME8101	4
											MME8203	3
6	Assoc. Prof. Wilson Musinguzi	Male	PhD	Makerere University, Uganda	2014	Mechanical Engineering	Permanent	Associate Professor			MME8209	3
7	Assoc. Prof. Twaib Ssemogerere	Male	PhD	Makerere University, Uganda	2017	Mechanical Engineering	Permanent	Associate Professor			MME8202	3
8	Dr. Umar Kamoga Lwako	Male	PhD	Makerere University, Uganda	2017	Mechanical Engineering	Permanent	Senior Lecturer			MME8102	3
9	Dr. Biira Saphina	Female	PhD	University of Pretoria, South Africa	2018	Energy Materials	Permanent	Senior Lecturer	-		MME8204	3
10	Dr. Edwin Kamalha	Male	PhD		2019	Textile Materials	Permanent	Senior Lecturer			MME8205	3
11	Mr. Loum Janani	Male	PhD Candidate	Makerere University, Uganda	2020	Chemistry	Permanent	Lecturer			MME9202	3
12	Dr. Moses Andima	Male	PhD	University of Nairobi	2020	Chemistry	Permanent	Senior Lecturer			MME8103	3
13	Ms. Yvonne Tusiimire	Male	PhD Candidate	Makerere University, Uganda	2024	Nanomaterials (Mechanical Engineering)	Permanent	Lecturer			MME8203	3
14	Mr. Allan Kasedde	Male	MSc Candidate		2019		Contract				MME8105	3

15	Mr. Ddumba Joseph Lwanyaga	Male	PhD Candidate	Makerere University, Uganda	2020	Materials (Mechanical Engineering)	Permanent	Lecturer			MME8206	3
16	Prof. B. K. Behera	Male	PhD	Indian Institute of Technology, Delhi		Textile Materials	Visiting Professor	Professor	-	-	DISSERTATION	7
17	Prof. L. Y. Mwaikambo	Male	PhD	University of Dar es Salaam		Polymer Materials	Visiting Professor	Associate Professor	-	-	DISSERTATION	7

APPENDIX C: NEEDS ASSESSMENT SURVERY AND COMMENTS FROM STAKEHOLDER HIGHER INSTITUTIONS OF LEARNING

NEEDS ASSESSMENT
FOR A NEW
MASTER OF SCIENCE IN MATERIALS ENGINEERING DEGREE PROGRAMME

Africa experiences a shortage of skilled engineers and this has led to a skewed market place, which has led to brain drain and still attracts huge numbers of African professionals away from their home countries thus weakening the local engineering capacity. Massive infrastructure and technological projects pay less attention to training of locals thus importing skills from abroad further haemorrhaging the engineering capacity of the continent and impending skills transfer.

Uganda being a predominantly agricultural country, the country continues to lose millions of dollars by exporting unprocessed materials and yet imports more processed materials due to lack of value addition to her rich material source.

A gap has been identified in the area of *Product Development and Materials Engineering*, The proposed ***Master of Science in Material Engineering*** programme is therefore designed to bridge this critical gap, through developing human capacities for utilization of available materials to engineer novel products made in Uganda for the region.

The purpose of this programme is to:

a) To provide students with an advanced understanding of the specific Materials Science and Engineering and working processes based partly on their individual desires for specialization.
b) Equip graduates with the tools necessary to design, develop and engineer a wide variety of products.
c) Produce graduates who can make relevant contributions in any field of engineering and/or fundamental science at the national/international context.
d) Promote the students' continued learning and professional development.
e) Produce graduates with an innovation mind-set.

The programme duration is two years comprising of three semesters of taught courses, followed by one semester devoted to research work leading to a thesis. The curriculum consists of a carefully chosen set of core courses, accompanied by a set of electives enabling the student to excel in a sub-discipline of their choosing either tailored especially for them (through discussions with their academic advisor).

Proposed Programme courses breakdown:
Applied Mathematics Courses: Advanced CAD and Finite Element Analysis, Computer Programming for Engineering Design, Engineering Statistics and Experiment Design.
Product Development Courses: Industrial Product Development, Product Design and Development, Optimization Driven Design.

Materials Engineering Courses: Materials Selection and Design, Advanced Materials and Applications, Functional Materials and Surfaces, Thermodynamics and Kinetics of Materials, Fatigue Design and Fracture Mechanics, Fiber Reinforced Composites and Polymer Processing, Materials Joining Technology, Nano-structured Materials and Nanotechnology.
Electives: Ceramics and Powder Technology, Computational Fluid Dynamics, Biomaterials and Tissue Engineering, Cementitious Materials and Concrete, Materials for Energy.

EMPLOYER INTEREST SURVEY

Based upon the attached description of a proposed graduate degree in ***MSc in Materials Engineering*** of Busitema University*, please help us to assess the value and need for establishing such a degree by completing the following survey.*

1. Company/Institution name **Donghua University**
2. Type of industry/business:

X University	❑ Service
❑ Research Organization	❑ Transportation
❑ Manufacturing	❑ Multi-national
❑ Public body	❑ other ______________

3. Your title **Mr.**
4. In your opinion, is there a need for the proposed program?

   X Strong need ❑ Moderate need ❑ No need

5. Would graduates of this program be given preference over baccalaureate and/or other graduate degree candidates for the same position?

   X yes ❑ no

   If no, please explain

6. Would you provide support to current employees to pursue such a Graduate Degree:❑ **X yes** ❑ no

   If the answer is "yes", what type of support would you consider? *(Check all that apply)*

❑ tuition and fees	❑ mentored support
❑ paid time to attend classes (flextime)	❑ paid leave
X access to research facilities	❑ child care
❑ other	

7. Identify those areas of professional knowledge or research that will be important for your organization in the next decade: **materials research expertise, tutors and scientists capable of conducting novel research for the country**
8. What aspects of the proposed program are of most interest/importance to you? ___________
   Research aspect in the last semester

9. What aspects are of least interest/importance to you? **Course conducting**

10. Make any comments or suggestions regarding the proposed program that you may have:

    Course content **To much for the named specialization and type of degree. In my opinion these can be divided for MSc and MEng. MSc for research based direction with less course but more time for research and MEng can remain as it is**

    Time to degree **2 yrs are too little for any masters degree**

    Research experience **Enhanced research and support for research should be shown and provided**

    Professional experience **Fine**

    Internship **Compulsory if MEng. For MSc optional but limited to special research insttitutions in or out of the country**

11. What is your overall assessment of this proposed program? Does it make sense? What are its strengths/limitations? **See 10 above**

12. Who else (individuals/agencies, etc.) within your network should be informed of this initiative? **government agency who will be taking up the graduates such as UNBS, UIRI, UBOS, KCCA, URA, Different government ministries. And university dons**

Thank you so much for sharing your interest and insight.

EMPLOYER INTEREST SURVEY

*Based upon the attached description of a proposed graduate degree in **MSc in Materials Engineering** of* Busitema University*, please help us to assess the value and need for establishing such a degree by completing the following survey.*

1. Company/Institution name Gulu University____

2. Type of industry/business:

   ❑ University ❑ Service

   ❑ Research Organization ❑ Transportation

   ❑ Manufacturing ❑ Multi-national

   ❑ Public body ❑ other ______________

University____

3. Your title Lecturer____

4. In your opinion, is there a need for the proposed program?

   ❑ Strong need ❑ Moderate need ❑ No need

5. Would graduates of this program be given preference over baccalaureate and/or other graduate degree candidates for the same position?

   ❑ yes ❑ no

   If no, please explain____

6. Would you provide support to current employees to pursue such a Graduate Degree:❑ ❑ yes ❑ no

   If the answer is "yes", what type of support would you consider? *(Check all that apply)*

   ❑ tuition and fees ❑ mentored support

   ❑ paid time to attend classes (flextime) ❑ paid leave

   ❑ access to research facilities ❑ child care

   ❑ other ____

7. Identify those areas of professional knowledge or research that will be important for your organization in the next decade: Conversion of agricultural and forest residues into bioenergy and bioproducts____
____

8. What aspects of the proposed program are of most interest/importance to you?

   Biomaterials, Materials for Energy, Functional Materials and Surfaces, Computational Fluid Dynamics, Nano-structured Materials and Nanotechnology.

9. What aspects are of least interest/importance to you? All aspects of the programme seem very crucial. However, Computer Programming for Engineering Design seems to me an area that the students should have covered during their study of the Bachelors degree programme. In my opinion, this slot could be allocated for another course unit.____________
____

10. Make any comments or suggestions regarding the proposed program that you may have:

Course content. The course content is well formulated. However, in my view, CFD could be made compulsory, and not a mere elective. This is due to the versatile application of CFD in nearly all engineering fields. Students could have wide possibilities on how to apply CFD in their research and future applications

Time to degree First year for coursework, while the second year should be left for research

Research experience: The following could be prioritized for students' research including production of biopolymers from agro-residues, zeolite formation from biomass ash, natural coagulants for water treatment, recycling of e-waste for production of nano-materials, production of electrodes from biomass derived carbon, etcetera

Professional experience Students have vast opportunities to work in industry, university, and research institutes

Internship: Students could be attached to industries, where they could identify an industrial related problem. Alternatively, they could be attached to well established laboratories like UIRI, Uganda Geological Survey and Mines Department, etc.

11. What is your overall assessment of this proposed program? Does it make sense? What are its strengths/limitations? The programme is well formulated. It makes a lot of sense, since it could empower future researchers with the ability to search for new materials that can be employed in different applications. Consequently, the over reliance on conventional materials could be reduced.

12. Who else (individuals/agencies, etc.) within your network should be informed of this initiative? Dr. Collins Okello; Collins.okello@gmail.com
Dr. Peter Olupot; polupot@gmail.com
Dr. Michael Lubwama; michaellubwama@gmail.com

Thank you so much for sharing your interest and insight.

EMPLOYER INTEREST SURVEY

Based upon the attached description of a proposed graduate degree in ***MSc in Materials Engineering*** of Busitema University*, please help us to assess the value and need for establishing such a degree by completing the following survey.*

1. Company/Institution name **Kyambogo University**___________________________________
2. Type of industry/business:

   ❑ **University** ❑ Service

   ❑ Research Organization ❑ Transportation

   ❑ Manufacturing ❑ Multi-national

   ❑ Public body ❑ other ______________

____

3. Your title **Senior Lecturer**____
4. In your opinion, is there a need for the proposed program?

   ❑ **Strong need** ❑ Moderate need ❑ No need

5. Would graduates of this program be given preference over baccalaureate and/or other graduate degree candidates for the same position?

   ❑ **yes** ❑ no

   If no, please explain____

6. Would you provide support to current employees to pursue such a Graduate Degree:❑ ❑ **yes** ❑ no

   If the answer is "yes", what type of support would you consider? *(Check all that apply)*

   ❑ tuition and fees ❑ **mentored support**

   ❑ paid time to attend classes (flextime) ❑ paid leave

   ❑ **access to research facilities** ❑ child care

   ❑ other ____

7. Identify those areas of professional knowledge or research that will be important for your organization in the next decade: **Applied Science and Engineering**____________________

   ____

8. What aspects of the proposed program are of most interest/importance to you?

Product Development and Materials Engineering Courses:

9. What aspects are of least interest/importance to you? **None**____________________________

   ____

10. Make any comments or suggestions regarding the proposed program that you may have:

Course content **It is fine**____

Time to degree **I think the time for course work should have been one year, and research/dissertation another full year, instead of one semester for research/dissertation**

Research experience **As a requirement for MSc admission or in what sense**

Professional experience **Not clear**

Internship **Not necessary at Masters level, research can be sufficient in generating and imparting practical skills**

11. What is your overall assessment of this proposed program? Does it make sense? What are its strengths/limitations? **The overall proposed program is okay**

12. Who else (individuals/agencies, etc.) within your network should be informed of this initiative? **Industry; private sector; academia; and NGOs**

Thank you so much for sharing your interest and insight.

EMPLOYER INTEREST SURVEY

Based upon the attached description of a proposed graduate degree in ***MSc in Materials Engineering*** of Busitema University*, please help us to assess the value and need for establishing such a degree by completing the following survey.*

1. Company/Institution name *Makerere University*____________________________________

2. Type of industry/business:

√ University	❑ Service
❑ Research Organization	❑ Transportation
❑ Manufacturing	❑ Multi-national
❑ Public body	❑ other ______________

____

3. Your title: *Senior Lecturer*____

4. In your opinion, is there a need for the proposed program?

   √Strong need ❑ Moderate need ❑ No need

5. Would graduates of this program be given preference over baccalaureate and/or other graduate degree candidates for the same position?

   √ yes ❑ no

   If no, please explain____

6. Would you provide support to current employees to pursue such a Graduate Degree:❑ √ yes ❑ no

   If the answer is "yes", what type of support would you consider? *(Check all that apply)*

❑ tuition and fees	√ mentored support
❑ paid time to attend classes (flextime)	❑ paid leave
√ access to research facilities	❑ child care
❑ other ____	

7. Identify those areas of professional knowledge or research that will be important for your organization in the next decade: *Research Methods and Statistical Analysis, Experimental Methods in Materials Science and Engineering, Materials Property Optimization*____________

8. What aspects of the proposed program are of most interest/importance to you? ____________ Engineering Statistics and Experiment Design. Industrial Product Development,____________

9. What aspects are of least interest/importance to you? ________________________________ Product Design and Development. This component can be included in Industrial Product Development____

10. Make any comments or suggestions regarding the proposed program that you may have:

    Course content: *Include a* ***research methods course*** *in the third semester to train the graduates to be good researchers. At this level students should be able to develop* *proposals for research to be carried out in the fourth semester.*

Time to degree *Sufficient*

Research experience *Ok*

Professional experience

Internship *Not necessary*

11. What is your overall assessment of this proposed program? Does it make sense? What are its strengths/limitations?

    It is a good program. A detailed curriculum might expose that some of the proposed courses may overlap, for example Industrial Product Development vs. Product Design and Development; Selection and Design Vs Advanced Materials and Applications. Make a careful evaluation of the laboratory equipment necessary to impart the planned skills. Provide content to make the program relevant to national and international development agenda

12. Who else (individuals/agencies, etc.) within your network should be informed of this initiative?

Thank you so much for sharing your interest and insight.

EMPLOYER INTEREST SURVEY

*Based upon the attached description of a proposed graduate degree in **MSc in Materials Engineering*** of Busitema University, *please help us to assess the value and need for establishing such a degree by completing the following survey.*

1. Company/Institution name: Ndejje University
2. Type of industry/business:

❑ University ❑ Service
❑ Research Organization ❑ Transportation
❑ Manufacturing ❑ Multi-national
❑ Public body ❑ other ______________

_____________________University_____________________________

3. Your title ___________________Lecturer____
4. In your opinion, is there a need for the proposed program?

√❑Strong need ❑ Moderate need ❑ No need

5. Would graduates of this program be given preference over baccalaureate and/or other graduate degree candidates for the same position?

√❑ yes ❑ no

If no, please explain____

6. Would you provide support to current employees to pursue such a Graduate Degree:❑ √❑ yes ❑ no

If the answer is "yes", what type of support would you consider? *(Check all that apply)*

❑ tuition and fees √❑ mentored support
❑ paid time to attend classes (flextime) ❑ paid leave
❑ access to research facilities ❑ child care
❑ other ____

7. Identify those areas of professional knowledge or research that will be important for your organization in the next decade: Research in energy. The industrial sector is becoming automated and there is need to focus on robotics engineering / mechatronics engineering.
8. What aspects of the proposed program are of most interest/importance to you? Optimization Driven Design, Materials for Energy, Fatigue Design and Fracture Mechanics, Powder Technology, Advanced CAD and Finite Element Analysis, Computer Programming for Engineering Design, Engineering Statistics and Experiment Design.
9. What aspects are of least interest/importance to you? , Nano-structured Materials and Nanotechnology.

10. Make any comments or suggestions regarding the proposed program that you may have:

Course content ;____
The course content suits the program title

Time to degree : I propose to reduce the core courses to four(4) per semester and make the other courses electives

Research experience: A course on research methods is missing

Professional experience: The course content will enable students become specialists in materials engineering and product development

Internship: Industrial visits should be considered. In addition working with the industry to solve a practical problem is also encouraged

11. What is your overall assessment of this proposed program? Does it make sense? What are its strengths/limitations? ________________________________
a) Do you have the necessary laboratories to carry out the practical aspects of the program?
b) Do you have the qualified staff to lecture the recommended courses?

12. Who else (individuals/agencies, etc.) within your network should be informed of this initiative? ____
N/A

Thank you so much for sharing your interest and insight.