UNIVERSITY OF NAIROBI

COLLEGE OF ARCHITECTURE AND ENGINEERING

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

REGULATIONS AND SYLLABUS FOR THE DEGREE OF BACHELOR OF SCIENCE (BSc) IN MECHANICAL ENGINEERING

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TABLE OF CONTENTS

1. INTRODUCTION

1.1. Background

Mechanical engineers apply the principles of science to design, manufacture, operate, maintain and model machinery. Such machinery is in turn used in transportation (aircraft, aerospace, railway, automobiles); manufacturing (machine tools, manufacturing industries, and process industries); defence systems; energy and building services among others. The design and other operations involve not only the hardware but also the systems and processes involved as well as the materials used to actualize such designs. The BSc. Degree program presented here is a 5-year program that addresses society's needs by combining the fundamentals of Mechanical Engineering with innovative ideas. Consequently, the program is structured to emphasize both the engineering theory and technical skills. These skills enable the learners who have gone through this programme to solve practical problems and analyse different situations by converting concepts into reliable and cost-effective designs of devices and processes. The program is under *mechanics and machine trades (0715)* in the UNESCO *International Standard Classification of Education.*

The curriculum is tailored to give the students a solid scientific foundation from the start, where in the first year of study, courses of mathematics, physics, chemistry, computer programming, and engineering drawing are taught as well as other courses in the humanities. From the second year to the fifth year, students get well-grounded in the core Mechanical Engineering disciplines, which include, Solid and Structural Mechanics, Engineering Materials, Fluid Mechanics, Thermodynamics and Heat Transfer, Mechanics of Machines, Systems and Controls, Engineering Drawing and Design, Industrial Engineering, Engineering Management as well as Mathematics. In the final year of study, students work on an engineering project that could be experimental or design-based, and this exposes them to the design process from concept to the final product, emphasizing effective communication and presentation skills.

1.2. Philosophy

The philosophy of the undergraduate program in mechanical engineering is to promote the design, manufacture, operation, and maintenance of mechanical systems for the economic progress of society in an environmentally sustainable manner.

1.3. Rationale

Mechanical engineers apply the principles of science to design, manufacture, operate, maintain and model mechanical systems. Such systems are in turn used in transportation (aircraft, aerospace, railway, automobiles); manufacturing (machine tools, manufacturing industries, and process industries); defence; energy and building services among others. The design and other operations involve not only the hardware but also the systems and processes involved as well as the materials used to actualize such designs. All the above are essential for industrialization which is one of the main tenets of Vision 2030. Furthermore, manufacturing is the main part of the Kenya Governments' Big Four Agenda. There is a need to develop human resources with competence to take up the high level leadership role in providing solutions to challenges in the highly competitive environment of the manufacturing/ service industry. The programme presented here will equip the learner with adequate knowledge and skills in innovation to be able to carry out research and development activities in the highly specialized areas of manufacturing and service provision. On completion of the programme the learners will be adequately prepared to independently carry out industrial research and development activities. They will also be well equipped to pursue post-graduate studies and generate specialized innovations in this field.

A programme in Mechanical Engineering has been offered at the University of Nairobi for over five decades. The motivation to review the curriculum comes from consideration of the following factors:

1. The need to keep abreast of technological advances. This dictates that new content be incorporated while other content, which might have become obsolete, is expunged or revised.
2. The need to comply with emerging regulatory requirements such as those issued by the Commission for University Education (CUE)
3. The desire to introduce some element of specialization given that the breadth of mechanical engineering has grown as a result of technological advancement.

To achieve the above objectives, the following changes have been incorporated during the current review:

a. The course descriptions have been rewritten to be consistent with the guidelines issued by CUE, specifically ensuring that the learning process is outcome-based.
b. Introduction of two courses in Engineering Mechanics (covering “Statics” and “Dynamics”) to replace courses in Applied Maths.
c. Re-alignment of the courses in “Engineering Drawing” to emphasize computer-aided drawing, solid modelling, and similar digital techniques.
d. The introduction of courses on the computational modelling of mechanical systems. This recognizes the increasing role of numerical modelling in engineering.
e. Introduction of a course on “Micro Controllers” to prepare the learners for the dictates of manufacturing automation.
f. Introduction of clusters of elective (optional) courses in the final year of study to introduce an element of specialization for the learners.
g. Introduction of courses in entrepreneurship, project management, building services engineering and innovation.

1.4. Goal

The goal of the mechanical engineering program is to create a pool of well trained, motivated and innovative mechanical engineers. Such engineers should play an integral role in the achievement of National and Global development goals such as Vision 2030 and Sustainable Development Goals as revised from time to time.

1.5. Expected Learning Outcomes

At the end of the five-year degree program, the learners should be able to:

1. Apply the principles of mathematics, science, and engineering to the solution of societal problems.
2. Conceptualize and conduct experiments in mechanical engineering, and to analyse and interpret experimental data.
3. Identify, formulate, optimize and solve mechanical engineering problems.

4. Communicate Mechanical Engineering concepts and solutions effectively.
5. Design efficient systems, components and processes to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
6. Apply interpersonal skills and ability to work effectively in multidisciplinary teams to solve engineering problems.
7. Develop and implement entrepreneurship models for employment creation.
8. Describe and practice professional and ethical responsibilities of the Mechanical Engineering profession.
9. Analyse contemporary issues impacting the Mechanical Engineering profession.
10. Demonstrate the need for and practice life-long learning.

The above attributes and abilities will enable a graduate of Mechanical Engineering to fit in the job market. This curriculum has been bench-marked with reputable institutions.

2. MODE OF DELIVERY

2.1. Face-to-Face Mode

The main mode of delivery of the program will be through Face-to-Face lectures, interactive tutorials, and instruction on the use of laboratory and workshop equipment as well as computing and numerical exercises.

2.2. ODeL and Blended Learning Mode

Where delivery through digital platforms including open and distance learning is used, arrangements shall be made for delivery of practical aspects of the course. Alternatively, special residential sessions may be arranged for the affected learners.

3. ADMISSION REQUIREMENTS

3.1. Minimum Requirements

The minimum entrance requirements as spelt out in Statute XXII of the University of Nairobi statutes shall apply.

In addition to the minimum university requirements the candidates, must have any of the following:

a) KCSE Candidates

The basic admission requirement shall be the minimum requirement set for entry into Public Universities which is a mean grade of at least C+ in Kenya Certificate of Secondary Education (KCSE). In addition, candidates shall have obtained at least C+ in each of the four cluster subjects from any of the following alternative clusters. However, a cut-off grade higher than C+ in each cluster subject shall be preferred if limitations of the number of places available for each degree programme versus the number of qualified candidates so demand. The said cut-off grades shall be determined and implemented by the School Board.

Alternative A:

Physics	Biology or Geography or any Group IV Subject
Chemistry	
Mathematics	

Alternative B:

Physical Sciences	Geography or any Group IV Subject
Biological Sciences	
Mathematics	

Group IV Subjects:

Home Science	Building Construction
Art and Design	Power Mechanics
Agriculture	Electricity
Woodwork	Drawing and Design
Metalwork	Aviation Technology

b) A-Level Candidates

Candidates with a minimum entry requirement of principal C passes in Mathematics and Physics and a Subsidiary level pass in Chemistry with a credit pass in English at 'O' level, except that for Geospatial Engineering, a subsidiary level pass in Geography shall also be accepted in lieu of Chemistry.

c) KNEC Higher National Diploma (HND) or Equivalent

Candidates with Higher National Diploma in the following broad areas of study:

i) Agricultural Engineering
ii) Civil engineering
iii) Electrical engineering
iv) Mechanical engineering
v) Geospatial Engineering
vi) Any other approved subject area.

d) Ordinary KNEC Diploma or equivalent (with credit pass)

i) Agricultural Engineering
ii) Civil engineering
iii) Electrical engineering
iv) Mechanical engineering
v) Geospatial Engineering
vi) Any other approved subject area.

e) Diploma from Science/Technical Teacher Training Colleges

Candidates with a Diploma in Mathematics and Physics from recognized teacher training colleges.

f) BSc/BEd (Science) degrees from Universities or any other relevant degrees

Candidates with a Bachelor of Science or Education degree in Physics and Mathematics from recognized institutions or any other relevant degree from a recognized institution.

Exemption from any Courses in the Programme

a) The point of entry into the programme for candidates with a KNEC Higher National Diploma or its equivalent in accordance with clause (c) above shall be in the second year of study.

b) The point of entry into the programme for candidates with an ordinary KNEC diploma or its equivalent in accordance with clause (d) shall be in the first year of study.

c) The point of entry into the programme for candidates with qualification other than those outlined in clause (a), (b), (c) and (d) shall be approved by Senate on the recommendations of the School Board of Engineering and the College Academic Board and shall be based on the qualifications of the applicant.

d) Where a candidate wishes to be exempted from any course or courses, he/she shall send a formal application to the Academic Registrar justifying his/her request and attaching evidence of the credentials which support such request. Such a candidate may be required to sit and pass an exemption examination set and administered by the School, and approved under the authority of the Senate after payment of a prescribed fee.

e) Based on the assessment of the exemption examination, the School Board of Engineering shall make its recommendations to the Senate. The Academic Registrar shall communicate to the candidate, the Senate's decision.

Applicants from non-English speaking countries should produce a certificate of proficiency in English (the equivalent of at least a Credit Pass at "O" Level)

3.2. Credit Transfer & Exemptions

A candidate may be exempted from some course units and credit transferred from approved institutions subject to the following conditions:

i) Request for exemption should be made in writing on admission to the Academic Registrar and must be accompanied by officially endorsed supporting documents including the institutions' syllabuses for the relevant courses and the candidate's official transcript.

ii) No candidate shall be exempted from more than one third of the total number of units required for the course.

iii) Where there is doubt as to the equivalence of courses, a candidate may be required to sit and pass applicable University of Nairobi examination in relevant course units.

iv) Payment of appropriate exemption fees and examination fees where applicable.

4. COURSE REQUIREMENTS

4.1. Student Obligations

The learner is obliged to:

a. Attend as many lectures in every course as possible and at any rate, not less than two thirds of the lectures given in the course.
b. Attend all workshop, computing and laboratory sessions. In case the learner misses any of these due to unavoidable circumstances e.g. sickness, he/she shall ask for remedial sessions.
c. Participate actively in all class activities e.g. tutorial sessions.
d. Complete and hand in all assignments, lab reports, computing exercises, design exercises and similar assigned work.
e. Take all prescribed quizzes, tests and examinations when they are offered.
f. Engage in community service.

4.2. Lecturer Obligations

The lecturer is obliged to:

a. Prepare his/her lectures thoroughly.
b. Attend and deliver all scheduled lectures in a course. In the event that he/she is unable to attend any lecture sessions, to arrange with the learners for appropriate make up.
c. Avail to the learners the necessary tutorial problems and other assignments.
d. Assess (mark) and discuss with the learners all assignments, labs, computer programmes and continuous assessment tests in a timely manner.
e. Keep abreast of new developments in his/her field and update the teaching materials accordingly.
f. Set and mark all examinations in a timely manner
g. Be available for consultation outside class hours
h. Counsel and mentor the learners.

5. STUDENT ASSESSMENT CRITERIA

5.1. Formative Assessments

The learners shall be assessed (as appropriate for each course) through:

Assignments

i. Quizzes
ii. Laboratory reports

iii. Workshop exercises
iv. Computing exercises
v. Reports of Industrial visits and attachments
vi. Continuous assessment tests.
vii. Projects

The marked scripts pertaining to all the above shall be returned to the learners in good time and discussed so the learners can take corrective action where necessary.

5.2. Summative Assessments

Except where stated otherwise, each course shall be examined by an end of semester examination. The final grade in each course shall take into consideration both the formative assessment results as well as the examination result.

6. GRADING SYSTEM

In line with the grading system in use at the University of Nairobi, an aggregate score in the assessments will result in the following grades:

Score	Grade
70% and above	A
60 – 69%	B
50 – 59%	C
40 – 49%	D
0 – 39%	E

Attainment of grade E means a student has failed the course and the student does not get academic credit for the subject. A student who obtains an E grade is allowed to remedy the situation by sitting for a supplementary examination at the end of the academic year or repeating and passing the course in the following academic year depending on the number of courses failed. A supplementary examination will only be available to a student who has failed a maximum of four courses in the academic year. A pass in a supplementary examination will result in an overall E* grade in the subject.

7. EXAMINATION REGULATIONS

7.1. Written Examinations

The current approved examinations regulations of the School of Engineering and any subsequent changes approved by the Senate shall apply. The current regulations are as follows;

7.1.1 Courses shall be evaluated in terms of course units. A course unit shall be defined as made up of three (3) hours of lectures and tutorials per week for 15 weeks, totalling 45 hours.

7.1.2 Courses that are spread over two semesters shall be examined at the end of the second semester.

7.1.3 All courses taken in a given semester shall be examined by Ordinary examinations at the end of that semester unless otherwise specified.

7.1.4 A written ordinary examination for a course unit, where it applies, shall have a minimum duration of two hours. A course with more than or less than 45 contact hours shall generally be examined for a duration proportional to the 2 hours for one course unit, such as:

45 contact hours	2.0 hour examination
60 contact hours	2.5 hour examination

7.1.5 The pass mark in each course unit shall be 40% of the maximum mark possible in the course unit.

7.1.6 Each course unit covered in a semester shall be graded independently out of a maximum of 100 marks.

7.1.7 The complete assessment of a course unit shall consist of continuous assessment tests, course/laboratory/field assignments and end of semester written examinations, with the three components ordinarily carrying 10, 20, and 70 marks out of 100 respectively.

7.1.8 Where a course unit does not have any laboratory/field assignments, or coursework, the continuous assessment test and semester written examinations shall carry 30 and 70 marks out of 100 respectively.

7.1.9 Where a course unit is examined entirely by coursework, or laboratory/field assignments, such course unit shall carry all 100 marks.

7.1.10 Where distribution of the marks for a course does not conform to 7.1.7, 7.1.8 or 7.1.9 above, the distribution of the marks for the course unit as approved by the Senate shall be followed.

7.1.11 The final year project shall be considered as two course units.

7.1.12 In order to be allowed to proceed to the next year of study a candidate shall have obtained an aggregated mark of not less than 40% and passed all course units or satisfied clause 7.1.13 (2) below.

a) A candidate who fails an accumulated number of not more than four units and attains an aggregate mark of not less than 30% in any academic year of study shall be allowed to sit for supplementary examinations within three months.
b) A candidate who fails the project in the final year of study shall be allowed to resubmit the revised project within three months' time. A candidate who fails the re-submitted project shall repeat the project unit during the next academic year.
c) A candidate who fails a course unit examined entirely by coursework shall be allowed to resubmit the coursework within three months' time. A candidate who fails the re-submitted coursework shall repeat the unit during the next academic year.

7.1.13 A candidate who fails to satisfy the examiners in the supplementary examinations:

a) In not more than two units in any one academic year, shall on recommendation of the School Board of examiners and approval by Senate, be allowed to proceed to the next year of study and sit the examinations in the failed course units at the next Ordinary University Examinations, subject to the provision of regulation in clause p below. A pass obtained in such examination shall be adopted as 40% and will be entered as such in the candidate's academic record.
b) In more than two units shall on recommendation of the Board of examiners and approval by Senate, be allowed to repeat the year and sit the examinations in the failed course units at the next Ordinary University Examination, subject to the provision of regulation in clause p.

7.1.14 A candidate who obtains an aggregate mark of not less than 30% and has failed in more than an equivalent of 4 course units but in not more than an equivalent of 8, shall on the recommendation of the School Board of Examiners and approval by the Senate, be required to repeat the year of study and attend classes in the failed units and take the examination in the failed course units at the next

Ordinary University Examinations. Marks obtained in such examination shall be adopted fully and will be entered as such in the candidate's academic record.

7.1.15 A candidate who:

a) Obtains an aggregate mark of less than 30% or
b) Has failed in more than an equivalent of eight (8) course units, or
c) Has failed the same course unit four times or
d) Has failed to take prescribed examinations without good cause,

7.1.16 Shall on the recommendation of the School Board of Examiners and approval by Senate, be discontinued from the course of study.

a) A candidate who fails to take prescribed examinations with good cause shall be allowed by Senate on the recommendation of the School Board of Examiners to take Special Examinations at the next Ordinary University Examination/Supplementary Examinations.
b) Examinations taken under clause 7.1.16 (1) shall be treated in accordance with clause g and shall be graded in full.

7.1.17 Compensation may be allowed in a maximum of two failed course units only for any year of study, provided the mark for the failed unit is between 35% and 39% inclusive and the average mark for the candidate is 50% or above and shall be applied by taking two marks from the highest scores to make up for each mark failed. The compensation shall not apply to Final Year Project.

7.2. Moderation of Examinations

Before any examination paper is taken, it shall be moderated by an internal moderator nominated by the Departmental Board of Examiners from amongst the senior academic staff. The moderated paper shall be sent for external moderation by the external examiner. Likewise, the marked scripts shall be moderated by the same set of internal moderator and external examiner. Further moderation of the marks shall be undertaken by the Departmental Board of Examiners, the School Board of Examiners (School of Engineering) and the College Academic Board (College of Architecture and Engineering) before sending to the University Senate for approval.

8. GRADUATION REQUIREMENTS

8.1. Award of the Degree

The final award of the degree shall be based on a weighting of the last three years of the degree programme with relative weights of 1:2:3 for the third, fourth and fifth year of study respectively. A candidate who satisfies the Examiners in all examinations shall, on recommendation of the Board of Examiners of the School of Engineering and approval of the Senate, be awarded the Degree of Bachelor of Science (BSc) in Mechanical Engineering.

8.2. Classification of the Degree

A candidate who qualifies for the award of the degree shall be placed in one of the four classes to be described as First Class, Second Class (Upper Division), Second Class (Lower Division) and Pass. Honours degrees shall be awarded to candidates who have been awarded First Class, Second Class (Upper Division), Second Class (Lower Division).

The classification of the final award shall be based on aggregate score according to 8.1 above as follows:

First Class Honours	70-100%
Second Class (Upper Division)	60-69%
Second Class (Lower Division)	50-59%
Pass	40-49%

A candidate, who repeats in the fifth year of study, or fails a supplementary examination in the fifth year of study, shall not be eligible for the award of an Honours degree.

9. COURSE EVALUATION

The course shall be evaluated by the learners at the end of the course through a structured evaluation form. The learners shall nominate an individual from amongst themselves (usually the class representative) to coordinate the evaluation. The learners will evaluate the suitability of the course content, instructional infrastructure, equipment, reading and reference materials, effectiveness of the lecturer, etc. The evaluations forms shall be forwarded to the Chairman, Department of Mechanical Engineering for analysis and further action.

10. MANAGEMENT AND ADMINISTRATION

10.1. Placement of the Program

The program shall be housed in the Department of Mechanical and Manufacturing Engineering, University of Nairobi.

10.2. Academic Leadership

The Chairman assisted by the Thematic Heads of the Department of Mechanical and Manufacturing shall oversee implementation and assume academic leadership of the program.

10.3. Quality Assurance Mechanisms

The quality of delivery of the program shall be assured through moderation of all examinations by the internal and external examiners, periodic review of the program (at least once every five years) which shall involve the participation of stakeholders (including industry players) and accreditation by the Engineers Board of Kenya and the Commission for University Education.

11. COURSES OFFERED

11.1. List of Courses

The following points should be noted when interpreting the syllabus:

1. The course code shall comprise 6 alpha numerals as: FME XXX. FME identifies the specialization which is mechanical and manufacturing engineering while XXX are numerals.
2. The first numeral denotes the academic year when the course is offered, while the second is reserved for the (general) thematic area. For the compulsory courses, the last integer is reserved for the semester; odd numbers being for the first semester, while even numbers are for the second semesters. Optional courses offering will be as agreed by the Department from year to year.
3. At the end of the third year there will be a residential Internal Attachment term of 8 weeks. Additionally, the Department will try to assist in finding industrial attachment during the long vacations between the third and fourth years, and fourth and fifth years.
4. Each course unit shall have a minimum of 45 hours of lectures and tutorials, plus laboratory, workshop or computing exercises as necessary.
5. The following number of units shall be completed for the undergraduate program:

Year	No. of course units	Contact hours
First	15	735
Second	15	840
Third	17 (Including 8 weeks of assessed internal practical training)	900 + 320 hrs Internal Attachment
Fourth	16 (Including at least 8 weeks of assessed Industrial Attachment)	825 + 320 hrs Industrial attachment
Fifth	14 (Inclusive of Engineering Project)	810
Total	**77**	**4020 + 640 hrs**

6. Service courses to be provided by other Departments/Faculties as follows:

Board of Common Undergraduate Courses:

FME 165 (CCS 001): Communication Skills

FME 168 (CCS 008): Elements of Philosophy

FME 169 (CCS 010): HIV/AIDS.

Business Administration:

FME 343: Business Management for Engineers

FME 441: Engineering Project Management

FME 543: Entrepreneurship for Engineers

Chemistry:

FME 151: Chemistry I: Physical & Inorganic Chemistry

FME 152: Chemistry II: Organic & Analytical Chemistry

Physics:

FME 111: Physics I

FME 112: Physics II

Department of Electrical and Information Engineering:

FME 291: Electrical Circuit Theory

FME 292: Electrical Machines

FME 491: Measurements and Instrumentation

Faculty of Law:

FME 344: Law for Engineers

Institute of Computer Science:

FME 181: Computer Science I

FME 182: Computer Science II

Management Science:

FME 541: Industrial Management I

FME 542: Industrial Management II

FME 545: Operations Research

School of Mathematics:

FME 171: Fundamentals of Engineering Mathematics

FME 172: Calculus I

FME 271: Calculus II

FME 272: Differential Equations and Linear Algebra

FME 371: Complex Analysis and Differential Equations

FME 372: Probability and Statistics for Engineers

FME 472: Numerical Methods for Engineers

11.2. Course Structure and Duration

The course shall run for a minimum of five academic years. The courses shall be distributed as detailed below:

First Year Courses

Course Code	Course Title	Semester I Hours	Semester II Hours	Credit Units
FME 111	Physics I	45		3
FME 112	Physics II		45	3
FME 151	Chemistry I	45		3
FME 152	Chemistry II		45	3
FME 161	Engineering Drawing I	60		4
FME 162	*Engineering Drawing II*		60	4
FME 165	Communication Skills (CCS 001)	45		3
FME 168	Elements of Philosophy (CCS 008)		45	3
FME 169	HIV/AIDS (CCS 010)	45		3
FME 171	Fundamentals of Engineering Mathematics	45		3
FME 172	Calculus I		45	3
FME 173	Engineering Mechanics I (Statics)	60		4
FME 174	Engineering Mechanics II (Dynamics)		60	4
FME 181	Computer Science I	45		3
FME 182	Computer Science II		45	3
Total		**390**	**345**	**49**

Second Year Courses:

Course Code	Course Title	Semester I Hours	Semester II Hours	Credit Units
FME 201	Solid & Structural Mechanics I	60		4
FME 202	Solid & Structural Mechanics II		60	4
FME 211	Kinematics of Mechanisms	60		4
FME 212	Mechanical Power Transmission I		60	4
FME 221	Thermodynamics I	60		4
FME 222	Thermodynamics II		60	4
FME 231	Fluid Mechanics I	60		4

FME 232	Fluid Mechanics II		60	4
FME 243	Workshop Technology and Practice	60		4
FME 251	Materials Science and Engineering I: Fundamentals	60		4
FME 262	***Engineering Drawing III***		60	4
FME 271	Calculus II	45		3
FME 272	Differential Equations and Linear Algebra		45	3
FME 291	Electrical Circuit Theory	45		3
FME 292	Electrical Machines		45	3
TOTAL		**450**	**390**	**56**

Third Year Courses

Course Code	Course Title	Semester I Hours	Semester II Hours	Credit Units
FME 301	Solid & Structural Mechanics III	60		4
FME 302	Solid & Structural Mechanics IV		60	4
FME 311	Mechanical Power Transmission II	60		4
FME 312	Dynamics of Machines		60	4
FME 321	Thermodynamics – III – Standard Cycles	60		4
FME 331	Fluid Mechanics III	60		4
FME 332	Fluid Mechanics IV		60	4
FME 343	Business Management for Engineers	45		3
FME 344	Law for Engineers		45	3
FME 351	Materials Processing I	60		4
FME 352	Materials Processing II		60	4
FME 353	Materials Science & Engineering II: Metallic Alloys	60		4
FME 354	Materials Science and Engineering III: Non Metals		60	4
FME 362	Mechanical Engineering Design I		60	4
FME 371	Complex Analysis and Differential Equations	45		3
FME 372	Probability and Statistics for Engineers		45	3
Total		**450**	**450**	**60**

FME 399: INTERNAL ATTACHMENT – (8 weeks)

MODULE	TITLE	HOURS	CREDITS
I	Computer Aided Drawing and Workshop Practice	192	13
II	Creativity and Innovation	32	2
III	Technical Writing and Presentation Skills	32	2
IV	Industrial Visits	64	4
TOTAL		**320**	**21**

FOURTH YEAR COURSES

Course Code	Course Title	Semester I Hours	Semester II Hours	Credit Units
FME 401	Solid & Structural Mechanics V	60		4
FME402	*Introduction to Finite Element*		*60*	*4*

	Analysis			
FME 412	Mechanical Vibrations I		60	4
FME 421	Thermodynamics IV – Power Cycles	60		4
FME 422	Thermodynamics V – Combustion		60	4
FME 431	Fluid Mechanics V	60		4
FME 432	Fluid Mechanics VI		60	4
FME 441	*Engineering Project Management*	*45*		*3*
FME442	*Maintenance Engineering*		*45*	*3*
FME 451	Materials Science & Engineering IV	60		4
FME 461	Mechanical Engineering Design II	60		4
FME 462	Mechanical Engineering Design III		60	4
FME 472	Numerical Methods for Engineers		45	3
FME 491	Electrical Measurement and Instrumentation	45		3
FME 492	*Programmable Logic Controllers*		45	*3*
	Total	**390**	**435**	**55**

INDUSTRIAL ATTACHMENT – (Minimum of 8 weeks)

CODE	TITLE	HOURS	CREDITS
FME 499	Industrial Attachment	320	21
TOTAL		**320**	**21**

FIFTH YEAR COURSES

Course Code	Course Title	Semester I Hours	Semester II Hours	Credit Units
FME 502	Solid & Structural Mechanics VI		60	4
FME 511	Dynamic Systems and Control	60		4
FME 521	Heat Transfer I	60		4
FME 522	Heat Transfer II		60	4
FME 541	Industrial Management I	45		4
FME 542	Industrial Management II		60	4
FME 554	*Materials Selection in Design*		60	4
FME 557	*Manufacturing Automation*	60		4
FME 561	Engineering Project I	60		4
FME 562	Engineering Project II		60	4
	Elective I	60		4
	Elective II	60		4
	Elective III		60	4
	Elective IV		45	3
TOTAL		**405**	**405**	**55**

Learners must choose **ALL** the four electives from one of the following Thematic areas: Applied mechanics; Industrial and Manufacturing Engineering; Materials Engineering or Thermo-fluids.

(a) Electives for Applied Mechanics Thematic Area (Select any four)

Course Code	Course Title	Semester Hours	Credit Units
FME 503	Elasticity and Plasticity	45	3
FME 504	Experimental Stress Analysis	60	4
FME 506	*Vehicle Structural Design*	*60*	4
FME 507	Non Destructive Testing	60	4
FME 513	Advanced Mechanical Vibrations	60	4
FME 548	*Valuation of Plant and Machinery*	*60*	4
FME 551	Fracture Mechanics	60	4
FME 556	*Additive Manufacturing*	*60*	4
FME 560	Machine Tool Design	60	4
FME 563	CAD/CAM	60	4

(b) Electives from Industrial and Manufacturing Engineering Thematic Area (Select any four)

Course Code	Course Title	Semester hours	Credit Units
FME 507	Non Destructive Testing	60	4
FME 526	Engineering Processes, Pollution and Pollution Control	45	3
FME 544	*Entrepreneurship for Engineers*	*60*	*4*
FME 545	Operations Research	60	4
FME 546	Occupational Health and Safety	45	3
FME 548	*Valuation of Plant and Machinery*	*60*	*4*
FME 555	Theory of Production Processes	60	4
FME 556	*Additive Manufacturing*	*60*	*4*
FME 560	Machine Tool Design	60	4
FME 563	CAD/CAM	60	4

(c) Electives from Materials Engineering Thematic Area (Select any four)

Course Code	Course Title	Semester Hours	Credit Units
FME 504	Experimental Stress Analysis	60	4
FME 507	Non Destructive Testing	60	4
FME 548	Valuation of Plant and Machinery	60	4
FME 551	Fracture Mechanics	60	4
FME 552	Ceramic Materials	60	4
FME 553	Composite Materials	60	4
FME 555	Theory of Production Processes	60	4
FME 556	*Additive Manufacturing*	*60*	*4*
FME 560	Machine Tool Design	60	4
FME 563	CAD/CAM	60	4

(d) Electives from Thermo-Fluids Thematic Area (Select any four)

Course Code	Course Title	Semester hours	Credit Units
FME 523	Air-Conditioning and Refrigeration	60	4

FME 524	Energy Conversion Technologies	60	4
FME 525	Internal Combustion Engines	60	4
FME 526	Engineering Processes, Pollution and Pollution Control	45	3
FME 527	Industrial Energy Management	60	4
FME 528	Building Services Engineering	60	4
FME 532	Advanced Fluid Mechanics	60	4
FME 533	Non-Newtonian Fluid Mechanics	60	4
FME 535	Advanced Fluid Machinery	60	4
FME 536	*Computational Fluid Dynamics*	*60*	*4*
FME 548	*Valuation of Plant and Machinery*	*60*	*4*

11.3. Course Matrix

The matrix given below clarifies how each of the course units specified above leads to satisfaction of the expected outcomes of the program as given in section 1.5.

Learning Outcomes	Course Units
ELO1	FME 111 FME 112 FME 151 FME 152 FME 202 FME 211 FME 212 FME 221 FME 271 FME 272 FME 291 FME 292 FME 331 FME 332 FME 351 FME 352 FME 421 FME 422 FME 431 FME 432 FME 503 FME 504 FME 507 FME 511 FME 525 FME 535 FME 536 FME 544 FME 555 FME 556 FME 557 FME 171 FME 172 FME 173 FME 174 FME 201 FME 222 FME 231 FME 232 FME 251 FME 252 FME 301 FME 302 FME 311 FME 321 FME 322 FME 353 FME 371 FME 372 FME 401 FME 412 FME 452 FME 472 FME 491 FME 492 FME 502 FME 513 FME 521 FME 522 FME 523 FME 524 FME 545 FME 548 FME 551 FME 552 FME 553
ELO2	FME 173 FME 174 FME 201 FME 202 FME 232 FME 251 FME 252 FME 301 FME 332 FME 351 FME 352 FME 353 FME 431 FME 432 FME 452 FME 491 FME 511 FME 513 FME 521 FME 522 FME 211 FME 212 FME 221 FME 222 FME 231 FME 302 FME 311 FME 321 FME 322 FME 331 FME 401 FME 402 FME 412 FME 421 FME 422 FME 492 FME 502 FME 504 FME 506 FME 507 FME 523 FME 524 FME 535 FME 536 FME 555
ELO3	FME 201 FME 202 FME 211 FME 212 FME 251 FME 252 FME 262 FME 301 FME 332 FME 351 FME 352 FME 353 FME 421 FME 422 FME 431 FME 432 FME 499 FME 502 FME 503 FME 504 FME 522 FME 523 FME 524 FME 525 FME 541 FME 542 FME 543 FME 544 FME 554 FME 555 FME 556 FME 557 FME 221 FME 222 FME 231 FME 232 FME 243 FME 302 FME 311 FME 321 FME 322 FME 331 FME 362 FME 399 FME 401 FME 402 FME 412 FME 452 FME 461 FME 462 FME 491 FME 492 FME 506 FME 507 FME 511 FME 513 FME 521 FME 526 FME 527 FME 528 FME 535 FME 536 FME 545 FME 546 FME 551 FME 552 FME 553 FME 560 FME 561 FME 562 FME 563
ELO4	FME 165 FME 181 FME 182 FME 399 FME 441 FME 442
ELO5	FME 161 FME 162 FME 201 FME 202 FME 232 FME 251 FME 252 FME 262 FME 322 FME 331 FME 332 FME 351 FME 402 FME 412 FME 421 FME 422 FME 462 FME 491 FME 492 FME 499 FME 211 FME 212 FME 221 FME 222 FME 231 FME 292 FME 301 FME 302 FME 311 FME 321 FME FME FME FME FME

	FME 513 FME 535 FME 556	FME 521 FME 536 FME 557	FME 522 FME 545 FME 560	FME 523 FME 546 FME 561	352 FME 431 FME 502 FME 524 FME 551 FME 562	353 FME 432 FME 503 FME 525 FME 552 FME 563	362 FME 442 FME 504 FME 526 FME 553	399 FME 452 FME 506 FME 527 FME 554	401 FME 461 FME 511 FME 528 FME 555
ELO6	FME 165	FME 168	FME 343	FME 344	FME 499				
ELO7	FME 343	FME 399	FME 541	FME 542	FME 543				
ELO8	FME 344	FME 441	FME 442	FME 499	FME 526	FME 546			
ELO9	FME 168	FME 169	FME 343	FME 499					
ELO10	FME 557								

12. COURSE DESCRIPTION

FME 111: Physics I (45 hours)

Prerequisites

None

Purpose of the course unit

This course will provide students with knowledge of the basic concepts of physics including mechanics, sound and vibration, heat, and the kinetics of gases.

Expected Learning Outcomes

At the end of this course, the learner will be able to;

1) Appraise the basic static and dynamic mechanics
2) Apply the knowledge of basic properties of matter
3) Explain basic concepts of sound and vibration
4) Apply knowledge of basic concepts of heat
5) Solve problems involving the kinetic theory of gases

Course Content

1) Mechanics and Properties of Matter: Introduction to dynamics: circular motion; simple harmonic motion (SHM); rotation of rigid bodies; Newton's Law of gravitation. Introduction to statics: force systems on rigid bodies at rest; equilibrium; fluid statics. Introduction to properties of matter: elasticity in solids, viscosity in fluids, friction.
2) Sound and Vibration: Introduction to sound, wave phenomenon, sound waves, velocity of sound; Introduction to vibrations - Free vibrations of particles (Simple Harmonic Motion), simple pendulum, free vibrations of rigid bodies.
3) Heat: Internal energy and temperature, phase changes of the pure substance. Isothermal and isobaric compressibility of gases, liquids and solids. Heat transfer; conduction, convection, and radiation.
4) Kinetic theory of gases: perfect gas equation; intermolecular forces, specific heats, and equi-partition of energy.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory Exercises

1) Measurement of physical properties of solids, liquids and gases
2) Measurement of Sound and vibration
3) Pendulum tests

Instruction materials and equipment:

1) Lecture room with white board
2) Handouts: soft and hard copies
3) Power point presentation on screens
4) LCD/Overhead projector presentations
5) Audio-visual presentations
6) Library books and linkages
7) Necessary laboratory equipment

Course Assessment

The course shall be assessed as follows:

1) 2 hours written examination at the end of the semester (70%)
2) Continuous Assessment (assignments, labs, class participation, written tests) (30%).

Core reading materials

1) Nelkon, M and P. Parker, *Advanced Level Physics*, 7th Edition, Heinemann, ISBN: 9780435923037.
2) Ohanian, H. C. &Markert, J. (2007) *Physics for Engineers*, W.W. Norton & Co. Ltd.ISBN: 978-0-393-92631-6.
3) Young, H. D. & Freedman, R. A. (2015) *University Physics with Modern Physics,* Addison Wesley.ISBN-10: 0321973615, ISBN-13: 978-0321973610

Recommended references materials

1) Muller-Kirsten, H. J. W. (2011). *Electrodynamics*, 2nd Edition. World Scientific. ISBN-13: 978-9814340731
2) Scharf, G. (2014). *Finite Quantum Electrodynamics: the Causal Approach*. Courier Corporation. ISBN 978-3-642-57750-5

FME 112: Physics II (45 hours)

Prerequisites

None

Purpose of the Course Unit

This course will provide students with knowledge of the concepts of physics including basic optics, electricity and magnetism, and atomic states.

Expected Learning Outcomes

At the end of this course, the learner will be able to;

1) Explain the principles of basic optics.
2) Solve problems that involve electricity and magnetism.
3) Illustrate atomic states of matter

Course Content

1) Optics: Wave theory of light, interference, diffraction, polarization.
2) Electricity and Magnetism: Electrostatics, capacitors, resistors, current, voltage, power.
3) Ohm's law and its applications, measurements, networks, chemical effect of current.
4) Magnetic field, force on a conductor, electromagnetic induction, magnetic properties of matter, AC circuits, electromagnetic waves. Electrons, electron ballistics, valves, CRO, junction diode, transistors.
5) Atomic Physics: Radioactivity, isotopes, the nucleus, photo-electricity, energy levels.

Mode of delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board
2. Handouts: soft and hard copies
3. Power point presentation on screens
4. LCD/Overhead projector presentations
5. Audio-visual presentations
6. Library books and linkages
7. Necessary laboratory equipment

Laboratory Exercises

1. Performance characteristics of electronic valves, diodes and transistors
2. Band width of a semiconductor
3. Determination of magnetic properties of various materials
4. Transmission of light through a prism
5. Study of transmissivity, absorbability and reflectivity of various media.

Course Assessment

The course shall be assessed as follows:

3) 2 hours written examination at the end of the semester (70%)
4) Continuous Assessment (assignments, labs, class participation, written tests) (30%).

Core reading materials

1) Nelkon, M and P. Parker, *Advanced Level Physics*, 7th Edition, Heinemann, ISBN: 9780435923037.
2) Ohanian H. C. &Markert J. (2007) *Physics for Engineers*, W.W. Norton & Co. Ltd.ISBN: 978-0-393-92631-6.
3) Young, H. D. & Freedman, R. A. (2015) *University Physics with Modern Physics*, Addison Wesley.ISBN-10: 0321973615, ISBN-13: 978-0321973610

Recommended references materials

1) Muller-Kirsten, H. J. W. (2011). *Electrodynamics*, 2nd Edition. World Scientific. ISBN-13: 978-9814340731

2) Scharf, G. (2014). *Finite quantum electrodynamics: the causal approach*. Courier Corporation. ISBN 978-3-642-57750-5

FME 151: Chemistry I: Physical and Inorganic Chemistry (45 hours)

Prerequisites

None

Purpose of the Course Unit

This course will provide students with knowledge and skills in inorganic and physical chemistry.

Expected Learning Outcomes

At the end of this course, the learner will be able to;

1) Explain the atomic theory including atomic structure, and electronic configurations.
2) Illustrate use of the periodic table and atomic bonding.
3) Calculate oxidation-reduction, solubility and precipitation, and common gases and chemical compounds.
4) Apply gas laws and basic concepts of gas kinetics for simple calculations
5) Solve problems involving viscosity, liquid state, liquid vapour equilibrium, effect of temperature on vapour pressure, liquefaction of gases, and surface tension.
6) Explain thermo-chemistry, electrochemistry, enthalpy of reactions, chemical kinetics and ionic equilibrium.

Course Content

1) Inorganic Chemistry: Solubility, precipitation, ion-exchange, nitrification and denitrification, oxidation–reduction reactions, adsorption, characteristics and significance of some salts and elements (ammonia, nitrates, phosphates, sulphates, silicates, chlorine, oxygen, ozone, carbon etc.)
2) Physical Chemistry: Ions in solution, ionization energy, chemical energetics and bonding, chemical equilibrium, reactor kinetics.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory Exercises

1. Determination of the morality of an acid or base
2. Experimental determination of Avogadro's number
3. Effect of concentration on rate of reaction
4. Demonstration of Le Chatelier's principle

Instruction materials and equipment:

1. Lecture room with white board
2. Handouts: soft and hard copies
3. Power point presentation on screens
4. LCD/Overhead projector presentations
5. Audio-visual presentations
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

The course shall be assessed as follows:

1) 2 hours written examination at the end of the semester (70%)
2) Continuous Assessment (assignments, labs, class participation, written tests) (30%).

Core Reading Materials

1) Miessler, G L, Fischer, P J and Tarr, D A (2013) *Inorganic Chemistry*, Pearson.
2) Housecroft, C (2018) *Inorganic Chemistry*, Pearson.
3) Atkins, P, de Paula, J and Keeler, J (2018) *Atkin's Physical Chemistry*, Oxford University Press.
4) Shultz M J (2006) *Chemistry for Engineers: An Applied Approach*, Houghton Mifflin Company.ISBN-10: 0618271945, ISBN-13: 978-0618271948.

Recommended Reference Materials:

1) Epstein L. M. & Krieger P. (2013) *Schaum's Outline of College Chemistry*, McGraw-Hill, 9th Ed.ISBN-10: 007181082X, ISBN-13: 978-0071810821.
2) Zumdahl S. S. & Zumdahl S. A. (2013) *Chemistry*, Houghton Mifflin Company.ISBN-10: 1133611095, ISBN-13: 978-1133611097.

FME 152: Chemistry II: Organic and Analytical Chemistry (45 hours)

Prerequisite:

FME 151: Chemistry I

Purpose of the Course Unit

This course will provide the learner with knowledge and skills in organic and analytical chemistry.

Expected Learning Outcomes

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

1) Describe structure-activity relationships in organic chemistry.
2) Explain the structure of organic chemicals.
3) Classify the spectroscopy of different organic groups.
4) Determine experimentally the reactivity of various organic groups.
5) Identify and classify chemical substances using analytical instruments

Course Content

1) Organic Chemistry: Significance of saturated and unsaturated hydrocarbons, phenols, alcohols, ketones, aldehydes, organic nitrogen compounds, organic halogen compounds. Structures and characteristics of carbohydrates, proteins, and lipids.
2) Applied Chemistry: Introduction of polymer science, hard and soft water (causes and treatment), electrochemistry, the nitrogen cycle, fuels, fertilizers, soaps and non-soapy detergents, aerobic and anaerobic digestion.

Teaching organization

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical work/Laboratory exercises

1) Testing the presence of carbon double bond
2) Test for Aldehydes
3) Test for carboxylic acids and esters.

Instruction materials and equipment:

1) Lecture room with white board
2) Handouts: soft and hard copies
3) Power point presentation on screens
4) LCD/Overhead projector presentations
5) Audio-visual presentations
6) Library books and linkages
7) Necessary laboratory equipment

Course Assessment

The course shall be assessed as follows:

8) 2 hours written examination at the end of the semester (70%)
9) Continuous Assessment (assignments, quizzes, lab reports, class participation, written tests) (30%).

Core Reading Materials

1) Carey, F A and Sundberg R J (2008) *Advanced Organic Chemistry Part B Reaction and Synthesis,* 5th edition, Springer. New York U.S.A.
2) Michael B. S & J March (2007) *March's Advanced Organic Chemistry: Reaction Mechanisms and Structures,* 7th edition, Wiley. New York U.S.A ISBN-10: 0470462590, ISBN-13: 978-0470462591.
3) Shultz, M J (2006) *Chemistry for Engineers: An Applied Approach*, Houghton Mifflin Company. ASIN: B00Y31AGBA.
4) Volhardt, P, and Schore, N (2014) *Organic Chemistry Structure and Functions.* Freeman, New York, U.S.A. ISBN-10: 1464120277, ISBN-13: 978-1464120275.

Recommended Reference Materials

1. Hill, G and J. Holman, *Chemistry in Context*, Nelson Thornes Pub.
2. Rosenberg, J, L. M. Epstein and P. Krieger, *College Chemistry*, Schaum Outline Series, McGraw-Hill.

FME 161: Engineering Drawing I (Manual Drawing) (60 hours)

Prerequisite:

None

Purpose of the Course Unit

The course will introduce the learners on how to communicate an object using isometric and orthographic drawings, lettering and line techniques, tolerances, dimensioning and sectioning, multiple views and free hand sketching.

Expected Learning Outcomes

At the end of the course, the learner will be able to:

1. Use common drafting tools to construct engineering drawings.
2. Construction of Title and Revision Block on a drawing
3. Dimensions engineering drawings and relate dimensions from one view to another.
4. Create 2D drawings, construct and Interpret views and sectional views
5. Build orthographic projections using three view drawings and utilize various line types to give best descriptive drawings.
6. Create isometric and oblique sketches and identify standard features on an object
7. Bisect and transfer lines and angles, and locate centres of regular shapes
8. Produce simple assembly drawings and free hand sketches

Course Content

- Definition of technical drawing, various aspects of technical drawing, uses of technical drawings, technical drawing equipment for pencil work and ink work;
- Types of lines, lettering and tilting;
- *Views:* Types of 3-dimensional views, i.e. isometric, perspective and oblique; Construction of loci, different types of thread forms, cam and gear teeth profiles.

- Introduction to graphic techniques and design. Introduction to necessity of drawing to design and production;
- Free hand sketching of three orthographic views of simple shaped objects;
- Third angle projection (First angle mentioned);
- Three principle views of objects;
- Synthesis of three views into an isometric view;
- Correct dimensioning procedure;
- Concept of sectioning and its use

Mode of Delivery:

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Drawing room with necessary drawing boards and drawing instruments
2. Handouts: soft and hard copies
3. Power point presentation facilities (PC and screen)
4. LCD/Overhead projector.
5. Audio-visual presentation aids
6. Library books and linkages

Course Assessment:

The course shall be examined by both coursework (accounting for 60%) which shall include weekly submission of work and an end of semester written examination constituting 40%.

Core Reading Materials

1. Green, P (2007) *The Mechanical Engineering Drawing Desk Reference: Creating and Understanding ISO Standard Technical Drawings, Lulu.Com.*
2. Simmons, C H and Maguire, D E (2012) *Manual for Engineering Drawing, 4th Ed.* Butterworth-Heinemann.

FME 162: Engineering Drawing II (Computer Aided Drawing) (60 hours)

Prerequisite:

FME 161: Engineering Drawing I

Purpose of the Course Unit

To provide the learner with the ability to communicate using Computer Aided Drawings (CAD) and present the drawings in two and three dimensions.

Expected Learning Outcomes

At the end of the course, the learner will be able to:

1. *Set up a drawing electronically;*
2. *Draw and edit an object using CAD*
3. *Draw objects on layers*
4. *Dimension objects*
5. *Annotate a drawing using dimensions, letters and hatching*
6. *Add parametric constraints to objects*
7. *Add parametric constraints to objects and creating local and global blocks.*
8. *Set up layers, styles, and templates.*

Course Content

- *Basics- Editing and reusing data;*
- *Mastering viewing tools, hatching and other tools;*
- *Printing, plotting & layouts,*
- *Adding texts to drawings, using fields and tables;*
- *Dimensioning;*
- *Advanced topics such as parametric, dynamic blocks, exchange data.*

Mode of Delivery:

Lectures, practical computer activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Drawing/computer Exercises:

1. *Computer Hardware components*
2. *Application of software packages*

Instruction materials and equipment:

1. PC's loaded with AutoCAD software
2. Handouts: soft and hard copies
3. Power point presentation facilities
4. LCD/Overhead projector
5. Audio-visual aids
6. Library books and linkages

Course Assessment

The course shall be examined by both coursework (accounting for 60%) which shall include weekly submission of work and an end of semester written examination constituting 40%.

Core Reading Materials

1. Omura, G & B C Benton (2014), *Mastering Autocad 2014 & AutocadLite 2014,* Wiley, New York.
2. Kirkpatrick J M (2014) *The AutoCAD text Book*, Merrill Pub Co.
3. Madsen D A (2016) *Engineering Drawing &Design,* Cengage Learning.

FME 165 (CCS 001): Communication Skills (45 hours)

Prerequisites

None

Purpose of the Course Unit

To develop the necessary skills for learning and employment by enabling the learner to organize, present (by writing and oral presentation) ideas and statements in a clear, logical, concise and appropriate form.

Expected Learning Outcomes

Upon completion of this course, the learner will be able to;

1) Record and present ideas and statements in written and oral form clearly, logically, concisely and correctly.
2) Critically assess written text.
3) Find, evaluate and cite relevant literature correctly.

Course Content

Overview of the communication process in relation to reading, writing, and speaking skills; the nature of the reading process with a focus on the evaluation of bottom-up, top-down and interactive models; important factors in readability; cohesion, coherence, sentence length and complexity, organization; paragraph structure and reader strategy; fundamentals factors in effective writing process; principles of development in expressive, informative argumentative and persuasive writing skills, exploring works and meanings; denotations, connotations, metaphors, euphemisms and clichés; report writing; writing a research or library paper plagiarism and how to avoid it. Library and information skills, information sources, types of libraries, reference works and techniques, evaluation of information sources, Classification schemes. Options: transcoding, oral presentation techniques in seminars, tutorials, public places; listening in academic contexts; information technology; creative writing; grammar review of academic communication.

Mode of delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room fitted with white board
2. Handouts: soft and hard copies
3. Power point presentation on screens
4. LCD projector presentations
5. Audio-visual presentations
6. Library books and linkages

Course Assessment

1) One 2-hour written examination at the end of the semester (50%)
2) Writing and Oral Presentation Tests (30%)
3) Continuous Assessment Tests (20%)

Core Reading Materials

1) Davies J.W. (2011) *Communication Skills: A Guide for Engineering and Applied Science Students,* Published by Prentice Hall.ISBN-10: 0273729527, ISBN-13: 978-0273729525.
2) Richard L. W. & Saundra H. (2011) *Communicating Effectively*, McGraw Hill, 10th Ed.ISBN-10: 0073534331, ISBN-13: 978-0073534336.

Recommended Reference Materials:

1) Brumif C.J. & Johnson K. (1980) *Communicative Approach to Language Teaching*, Oxford University Press.
2) Leech G. & Svartrik J. (2003) *Communicative Grammar of English,* Longman Publishers.ISBN-10: 0582506336, ISBN-13: 978-0582506336

FME 168 (CSS 008): Elements of Philosophy (45 hours)

Prerequisites

None

Purpose of the Course Unit

The purpose of this unit is to introduce the learner to the three main branches of philosophy: epistemology, metaphysics and ethics and the contemporary questions related to these fields.

Expected Learning Outcomes

At the end of this course, the student should be able to;

1) Explain some of the problems of the history of Philosophy that have shaped contemporary thought.
2) Demonstrate familiarity with the major questions and issues in the core areas of philosophy such as ethics, metaphysics, and epistemology.

3) Employ the tools of formal and informal logic to identify, construct, analyse, evaluate, and respond to arguments.
4) Evaluate a philosophical argument in terms of the rigor of its logic and the plausibility of its premises
5) Demonstrate a capacity to read closely and analytically, interpreting texts in sophisticated, fair, and cogent ways
6) Identify the thesis that the author is trying to establish.
7) Identify the premises and intermediate statements that allegedly entail the conclusion
8) Develop and effectively present a counterargument, taking into account other perspectives that find expression in contemporary society/the history of philosophy
9) Systematically defending and recommending concepts of right and wrong behaviour using philosophical arguments.

Course Content

1) Nature of philosophy: philosophical mind; common sense; systematic and reflective thinking.
2) Philosophy and culture
3) Philosophy and science
4) Right reasoning; deduction and induction; truth and falsehood; critical analysis
5) Ethics; ethics as providing norms for the good of individuals and society
6) The individual and society; freedom and determinism; rights and duties; basic values

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room fitted with white board
2. Handouts: soft and hard copies
3. Power point presentation facilities (PC, screen)
4. LCD projector

5. Audio-visual aids
6. Library books and linkages

Course Assessment

The course shall be assessed as follows:

1) 2 hours written examination at the end of the semester (70%)
2) Continuous Assessment (assignments, quizzes, lab reports, class participation, written tests) (30%).

Core Reading Materials

1. Perry, J and Bratman, M (2009) *Introduction to Philosophy*, Classical and Contemporary Readings.
2. Pecorino, P A (2016) *Introduction to Philosophy*, Queensborough Community College, New York.
3. Rauhut, N. C and Bass R. H. (2009) *Readings on Ultimate Questions: An Introduction to Philosophy.*

FME 169 (CCS 010): HIV & AIDS (45 Hrs)

Prerequisites

None.

Purpose of the Course Unit

To equip the learner with accurate and adequate information on HIV/AIDS and Drugs and Substance Abuse and their impact on their lives and the society.

Expected Learning Outcomes

At the end of this course, the student should be able to;

1) Define communicable diseases and HIV/AIDS, Drugs, Substances, Drugs and Substance Abuse and counselling.
2) Identify the difference between HIV and AIDS.
3) Identify sources of infection and list the risk behaviours that cause HIV.
4) List the risk behaviours that lead to Drugs and Substance Abuse.
5) Describe the impact of HIV and AIDS and Drugs and Substance Abuse on the

society.

6) List the various approaches of HIV infection and Drugs and Substance Abuse management and supportive management.
7) Describe the impact of HIV and AIDS and Drugs and Substance Abuse on development.
8) Identify suitable strategies to address HIV/AIDS and Drugs and Substance Abuse challenges.

Course Content

1) Historical background, development of human population and settlements, historical human population control factors, sex and sexuality, male and female anatomy and physiology, sexual behaviour, male/female relationships within culture.
2) Communicable diseases, types and definitions, socio economic, cultural and geopolitical context and impact of communicable diseases, HIV and AIDS, general biology of HIV, HIV AIDS as gender issues, prevention and control of HIV infection, the individual, family, community, institutional and national responsibilities, management of HIV related infections, levels of management, individual, family, community, institutional and national, legal and ethical issues in HIV AIDS, recent advances and challenges in HIV AIDs, HIV AIDs resistant persons, development of HIV AIDS as a national disaster. The concept of national disaster, prevention and mitigation measure.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room fitted with white board
2. Handouts: soft and hard copies
3. Power point presentation facilities (PC, screen)
4. LCD projector
5. Audio-visual aids
6. Library books and linkages

Course Assessment

The course shall be assessed as follows:

1) 2 hours written examination at the end of the semester (70%)
2) Continuous Assessment (assignments, quizzes, lab reports, class participation, written tests) (30%).

Core Reading Materials:

1. Bernie F C (2004) *HIV/AIDS Resource Manual for Public Health Education*, Nairobi: Peace Corps, 4th Ed.
2. Jacquelyn H Fand Ungvarski PJ (1995) *HIV/AIDS: A Guide to Nursing Care*, Philadelphia: WB Saders.

Recommended Reference Materials:

1) Valerio, A. & Donald A.P. (2004) *Education and HIV/Aids: A Sourcebook of HIV/Aids Prevention Programs*, World Bank Publications.
2) Welcome, T. (2003) *HIV/AIDS*, London, 2nd Ed.

FME 171: Fundamentals of Engineering Mathematics (45 hours)

Prerequisites

None

Purpose of the Course Unit

To provide the learner with a firm foundational knowledge in functions and their graphs, trigonometry, algebra, analytical geometry, probability and statistics.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1) Sketch graphs of various equations, including conic sections,
2) Formulate simple mathematical models,
3) Solve trigonometric equations,
4) Evaluate limits of algebraic and trigonometric functions,
5) Describe statistical distributions and examine relationships between data sets

Course Content

The Cartesian Plane and Functions:

Real numbers and the number line; order and inequalities, absolute value and distance. The Cartesian plane; the distance and midpoint formulae, equations of circles. Graphs of equations; the graph of an equation, intercepts of a graph, symmetry of a graph, points of intersection, mathematical models, examples of mathematical models. Lines in the plane; the slope of a line, equations of lines, sketching the graph of a line, parallel and perpendicular lines.

Functions; function notation, the domain and range of a function, the graph of a function, transformations of functions, classifications and combinations of functions. Trigonometric functions; angles and degree measure, radian measure, the trigonometric functions, evaluating trigonometric functions, solving trigonometric equations, graphs of trigonometric functions.

Conic Sections; Parabolas, Ellipses, Hyperbolas, Rotation and the general second-order equation.

Limits and Their Properties:

Introduction; the tangent line problem, introduction to limits, limits that fail to exists, formal definition of limits. Properties of limits; limits of algebraic functions, limits of trigonometric functions. Evaluating limits; strategy for finding limits, cancellation and rationalization techniques, the squeeze theorem.

Continuity and one-sided limits; continuity at a point and on an open interval, one-sided limits and continuity on a closed interval, properties of continuity, the intermediate value theorem. Infinite limits, vertical asymptotes.

Introductory Statistics:

Examining distributions; individuals and variables, categorical and quantitative variables, histograms, stem plots, time plots, outliers, symmetric and skewed distributions. Describing distributions with numbers; the mean, the median, the quartiles, the five-number summary and box plots, the standard deviation. Density curves, the median and mean of density curves, normal distributions, the standard normal distribution, normal proportions and assessing normality.

Examining relationships; response variable and explanatory variable, scatter plots, correlation, least squares regression, interpreting correlation and regression, relations in categorical data.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room fitted with white board
2. Handouts: soft and hard copies
3. Power point presentation facilities (PC, screen)
4. LCD projector
5. Audio-visual aids
6. Library books and linkages

Course Assessment

1) One 2-hour written examination at the end of the semester (70%)
2) Course work: Continuous Assessment Tests (20%)
   Assignments (10%)

Core Reading Materials

1) Larson, R. and R. Hostetler (2007) *Precalculus*, *Seventh Edition*. Houghton Mifflin Company, Boston and New York.
2) Stewart, J., L. Redlin and S. Watson (2015) *Precalculus: Mathematics for Calculus, Seventh Edition*. Brooks Cole.
3) Sullivan, M (2012) *Precalculus, Ninth Edition*. Prentice Hall.

Recommended Reference Materials

1) Hoffman, D (2013) *Contemporary Calculus I*.
2) Larson, R and Edwards, B H (2014) *Calculus,* Cengage Learning.
3) Varberg, D E, Purcell, E J and Rigdon, S E (2000) *Calculus*, 8th Edition, Prentice Hall.

FME 172: Calculus I (45 hours)

Prerequisite

FME 171 Fundamentals of Engineering Mathematics

Purpose of the Course Unit

To furnish the learner with knowledge of the differential and integral calculus, and their applications, particularly in engineering and the physical sciences.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1) Differentiate different kinds of functions, by use of the available rules,
2) Apply differentiation to the finding of extrema, curve sketching and optimization problems,
3) Perform integration of various kinds of functions by use of the various rules and techniques, including numerical integration,
4) Apply integration in determining areas and volumes, arc lengths and surfaces of revolution.
5) Use integration to calculate work, fluid pressure and fluid force, moments, centres of mass, centroids and moments of inertia.

Course Content

Differentiation:

The derivative and the tangent line problem. Basic rules of differentiation and rates of change; the constant rule, the power rule, the constant multiple rule, the sum and difference rules, derivatives of sine and cosine functions, rates of change.

The product and quotient rules and higher derivatives; the product rule, the quotient rule, derivatives of trigonometric function, higher order derivatives. The chain rule, the general power rule, simplifying derivatives, trigonometric functions and the chain rule. Implicit and explicit functions, implicit differentiation. Related rates; finding related rates, problem solving with related rates.

Applications of Differentiation:

Extrema of a function, relative extrema and critical numbers, finding extrema on a closed interval. Rolle's Theorem, the mean value theorem, applications. Increasing and decreasing functions, the first derivative test, applying the first derivative test.
Concavity and the second derivative test; concavity, points of inflection, the second derivative test, using the second derivative test. Limits at infinity; limits at infinity, horizontal asymptotes. Curve sketching technique; a summary of curve sketching techniques.
Optimization problems; applied minimum and maximum problems. Newton's method and the algebraic solution of polynomial equations. Linear approximations, differentials, error propagation, calculating differentials. Business and economic applications.

Integration:
Antiderivatives and indefinite integration; notation for antiderivatives, basic rules of integration, initial conditions and particular solutions. Sigma notation, the area of a plane region, upper and lower sums. Riemann sums, definite integrals, properties of definite integrals. The fundamental theorem of calculus, the mean value theorem for integrals, average value of a function, the second fundamental theorem of calculus. Integration by substitution; pattern recognition, change of variables, the general power rule for integration, change of variables for definite integrals, integration of even and odd functions. Numerical integration; the trapezoidal rule, Simpson's rule, error analysis.

Applications of Integration:
Area of a region between two curves. Volume; the disc method, the shell method. Arc length and surfaces of revolution. Work. Fluid pressure and fluid force. Moments, centres of mass, centroids and moments of inertia

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Course Assessment

1) One 2-hour written examination at the end of the semester (70%)

2) Course work: Continuous Assessment Tests (20%)
Assignments (10%)

Corer Reading Materials

1) Finney, R. L., F. D. Demana, B. K. Waits and D. Kennedy (2006) *Calculus: Graphical, Numerical, Algebraic, Third Edition*. Prentice Hall.
2) Kline, M (2013) *Calculus: An Intuitive and Physical Approach, Second Edition*. Dover Publications.
3) Larson, R., R. P. Hostetler and B. H. Edwards (2005) *Calculus, Eighth Edition*, Brooks Cole.

Recommended Reference Materials

1. Goldstein, L J (2013) *Calculus and its Applications*, Pearson Education, 13^{th} Ed.ISBN-10: 032184890X, ISBN-13: 978-0321848901.

FME 173: Engineering Mechanics I (Statics) (60 hours)

Prerequisite:

None

Purpose of the Course Unit

To provide the learner with a working knowledge of the principles of statics and their use in the analysis of engineering systems. This will form a foundation for further studies in the mechanical engineering sciences such as Solid Mechanics and Fluid Mechanics

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1) Use vector notation to represent forces and moments and carry out the necessary vector algebraic operations,
2) Analyse the forces acting on a particle in equilibrium, both in the two-dimensional and the three-dimensional cases,

3) Analyse the forces and moments acting on a rigid body in equilibrium, both in the two dimensional and three-dimensional cases,
4) Analyse distributed forces and be able to calculate the first moment of area, and to determine centroids and centres of gravity,
5) Analyse simple structures, including cables and trusses and be able to determine bending moments and shear forces,
6) Analyse systems that involve friction forces,
7) Use the principle of virtual work to determine efficiency in simple machines.

Course Content

Introduction:

Units and Dimensions, History of Mechanics, Axioms and Laws of Mechanics, Vectors, Vectorial Representations of Forces and Moments, Vector Operations, Cross Products, Scalar Products and Mixed Triple Products.

Statics of a Particle:

Coplanar Forces, Resolution and Composition of Forces, Cartesian Components, Equilibrium of a Particle in Two and Three Dimensions, Equivalent and Equipollent Systems of Forces, Principle of Transmissibility, Single Equivalent Force.

Statics of Rigid Bodies:

Moments, Couples, Reduction of Force Systems, Free Body Diagram, Types of Supports and their Reactions, Requirements for Stable Equilibrium, Equilibrium of Rigid Bodies in Two and Three Dimensions

Distributed Loads and Properties of Surfaces and Solids:

Distributed Loads, Hydrostatic Pressure, First Moment of Area, Centroid and Centre of Gravity.

Simple Statics of Structures:

Cables, Trusses, Frames and Machines, The Funicular Polygon, Internal Force, Shear and Bending Moment Diagrams.

Friction:

Laws of Coulomb Friction, Simple Contact Friction, Rolling Resistance, Wedges, Screw Threads, Belt, Brake and Clutch Friction.

Principle of Virtual Work:
Equilibrium of Ideal Systems, Efficiency of Simple Machines, Stable and Unstable Equilibrium.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical work/Laboratory exercises

1) Determination of the centroid of an irregular body
2) Equilibrium of a system of forces
3) To verify Hooke's law
4) To determine the law of parallelogram of forces

Instruction materials and equipment:

1. Lecture room fitted with white board/white board markers
2. Handouts: soft and hard copies
3. Power point presentation facilities
4. LCD/Overhead projector
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

The course shall be assessed as follows:

1) 2 hours written examination at the end of the semester (70%)
2) Continuous Assessment (assignments, lab reports, quizzes, class participation, written tests) (30%).

Core Reading Materials

1) Bear, F. P., E. R. Johnston Jr. and D. Mazurek (2015) *Vector Mechanics for Engineers: Statics, Eleventh Edition*, McGraw-Hill Education/Asia.
2) Hibbeler, R. C. (2016) *Engineering Mechanics: Statics, Fourteenth Edition in SI Units*. Prentice Hall.
3) Meriam, J. L., L. G. Kraige and J. N. Bolton (2016) *Engineering Mechanics Volume I: Statics, Eighth Edition, SI Version*. John Wiley and Sons Incorporated.

Recommended Reference Materials

1) Bedford, A. and Fowler, W., Engineering Mechanics (Statics), Pearson.

FME 174: Engineering Mechanics II (Dynamics) (60 hours)

Prerequisite:

FME 173: Engineering Mechanics I: Statics

Purpose of the Course Unit:

To provide the learner with a working knowledge of the principles of dynamics and their use in the analysis of engineering systems. This will form a foundation for further studies in the mechanical engineering sciences such as Mechanics of Machines and Mechanical Vibrations.

Expected Learning Outcomes:

At the end of this course, the learner will be able to

1) Analyse and determine the kinematics of particles, given the initial conditions and the constraints,
2) Analyse the kinetics of particles, including simple harmonic motion, by use of the force-inertia, the work-energy and the impulse-momentum methods,
3) Analyse the kinematics of rigid bodies, including the motion of linkages,
4) Determine the properties of surfaces and solids, including the area moments of inertia and the mass moments of inertia,
5) Analyse the kinetics of rigid bodies, with particular reference to machine components, by use of the force-inertia, the work-energy and the impulse-momentum methods,
6) Analyse the vibrations of simple mechanical system.

Course Content

Kinematics of Particles:

Motion of a Particle, Rectilinear Motion, Position, Velocity and Acceleration Vectors, Tangential/Normal and Radial/Transverse Components, Applications to Motion in a Circle, Projectile Motion.

Kinetics of Particles:

The Force-Inertia Method, Curvilinear Motion and Gravitation, Simple Harmonic Motion. The Work-Energy Method, Principles of Work and Energy. The Impulse-Momentum Method, Impact, Energy and Momentum, System of Particles.

Kinematics of Rigid Bodies:

General Plane Motion, The Rolling Wheel (Cycloidal Motion), Instantaneous Centre, Absolute and Relative Acceleration. Application to Linkage Mechanisms.

Properties of Surfaces and Solids:

Second and Product Moments of Plane Area, Parallel Axis and Perpendicular Axis Theorems, Polar Moment of Inertia, Principal Moments of Inertia of Plane Areas, Principal Axes of Inertia, Mass Moment of Inertia. The Compound Pendulum.

Kinetics of Rigid Bodies:

The Force-Inertia Method, Translation & Rotation, Constrained Plane Motion. The Work-Energy Method, Principles of Work and Energy for a Rigid Body, Conservation of Energy, Atwood's Machine. The Impulse-Momentum Method.

Vibration and Time Response:

Introduction, Simple Harmonic Motion, Free Vibrations of Particles, Free Vibrations of Rigid Bodies, Energy Methods.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical work/Laboratory exercises

1) Determination of the moment of inertia of an irregular object.
2) Verification of Newton's Second Law of motion.
3) Determination of energy stored in a moving body.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

The course shall be assessed as follows:

1) 2 hours written examination at the end of the semester (70%)
2) Continuous Assessment (assignments, lab reports, quizzes, class participation, written tests) (30%).

Core Reading Materials

1) Hibbeler, R. C. (2016) *Engineering Mechanics: Dynamics, (SI Units),* Prentice Hall.
2) Meriam, J. L., L. G. Kraige and J. N. Bolton (2016) *Engineering Mechanics Volume II: Dynamics, SI Version*. John Wiley and Sons Incorporated.

Recommended Reference Materials

1) Bear, F P and Johnson, E R, (2012) *Vector Mechanics for Engineers: Dynamics*, McGraw-Hill.
2) Bedford, A. and Fowler, W., *Engineering Mechanics:* Dynamics, 5th Ed. Prentice Hall.

FME 181: Computer Science I (45 hours)

Prerequisites:

None

Purpose of the Course:

To provide the learner with knowledge and skills of computers and their applications in processing of different types of data.

Expected Learning Outcomes:

At the end of the course, a learner will be able to:

1) Explain how computers work – how they acquire, process, store and communicate information.
2) Specify computer hardware and software requirements for a given engineering application
3) Explain how information is stored in a computer storage system
4) Explain the different types of errors generated by computer systems
5) Use different types of computer software packages

Course Content:

1. Computer systems fundamentals;
2. Hardware: Input devices, output devices, secondary storage devices, CPU and the control step. Machine code. Communication; Cloud Computing
3. Software: Systems software, operating systems, compiling systems, utilities. Information storage: bits, bytes, words;
4. Binary Numbers: Binary integers and fractions, floating point; Character codes: ASCII, EBCDIC;
5. Errors generated by computers: rounding, truncation, and cancellation errors;
6. Application Software Packages: word-processing, spreadsheets, database management, mathematical programming and statistical software (tabulations and regression)
7. Introduction to software development: knowledge-based systems (A.I.).

Mode of Delivery:

Lectures, practical computer laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations and student practice
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages

Course Assessment:

The course shall be examined by both coursework (accounting for 30%) and an end of semester written examination constituting 70%. The coursework shall in term consist of written continuous assessment tests (15%), laboratories (10%) and tutorials, quizzes, assignments, etc. (5%).

Core Reading Materials

1) Diebach C. (2014) *Introduction to Computer Science Using Python: A Computational Problem Solving Focus,* Wiley.
2) Larson, R W (2017) *Engineering with Excel,* Pearson Inc, 5th Edition.
3) Wempen, F (2015) *Word 2016 in Depth,* Que Publishing.

FME 182: Computer Science II (45 HRS)

Prerequisite

FME 182 – Computer Science I

Purpose of the course:

To introduce the principles and fundamentals of computer programming and equip learners with the required skills and knowledge of using a programming language to solve engineering problems.

Expected Learning Outcomes:

At the end of the course, a learner will be able to:

1. Develop algorithms for computer programming
2. Explain the syntax and variables encountered during a computer programming exercise
3. Analyse an engineering problem, create an algorithm, and then write the code to execute the algorithm in at least one high-level language

Course Content:

- Algorithms and Structured programming: Algorithms: concept of an algorithm, flowcharts, decision trees, structured programming, program structures (sequence, if, then, else, while, do, repeat, until, case), pseudocode, top-down design, stepwise refinement.
- Methodical Computer Programming: Programming using a high-level language (e.g. C++, Python, Fortran and Matlab), variable types, abstract data types, arrays, mathematical operations and expressions, logical operations and expressions, local and global parameters, printed and graphical output, backing storage files, procedure libraries, real time programming.

Mode of Delivery:

Lectures, practical computer laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations and student practice
4. Overhead projectors
5. Audio-visual aides
6. Library books and linkages

Course Assessment:

The course shall be examined by both coursework (accounting for 30%) and an end of semester written examination constituting 70%. The coursework shall in term consist of written continuous assessment tests (15%), laboratories (10%) and tutorials, quizzes, assignments, etc (5%).

Core Reading Materials

1. Codecademy (2017) *Learn Python*. Available at: http://www.codecademy.com/tracks/python
2. Deitel, Harvey M. and Deitel, Paul J. (2017) *C++ How to Program*. 10th Edition. Pearson Publishing.
3. Fangohr Hans(2015) *Introduction to Python for Computational Science and Engineering (A beginner's guide).* Available at: https://www.southampton.ac.uk/~fangohr/training/python/pdfs/Python-for-Computational-Science-and-Engineering.pdf.
4. Moore, Holly (2015) *Matlab for Engineers.* 4th Edition. Pearson Publishing.
5. Stroustrup, Bjarne (2013) *The C++ Programming Language.* 4th Edition. Addison-Wesley.

SECOND YEAR UNITS

FME 201: Solid & Structural Mechanics I (60 hours)

Prerequisites

1. FME 111: Physics I
2. FME 173: Engineering Mechanics I (Statics)

Purpose of the Course Unit

The purpose of the course is to provide the learner with knowledge on stresses and strains induced by axial loading, torsional loading of circular prismatic structures. Additionally, the course will provide students with knowledge on the theory relating to stresses and strains in thin walled cylinders.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Analyse elastic stresses and strains in materials loaded in simple tension and compression.
2. Describe the basics of material behaviour under static loading and demonstrate the ability to set up experiments to determine basic material properties.
3. Analyse stresses and strains in materials induced by changes in temperature.
4. Analyse torsional stresses and strains in solid and hollow circular shafts and apply this to the analysis of helical springs.
5. Analyse stresses, strains and displacements in thin walled pressure vessels.

Course Content

1. Behaviour of Materials Under Static Loading: The tensile test, load-extension diagram, the stress-strain diagram and engineering properties of materials, linear elasticity and Hooke's law, elastic limit, 0.1%, proof stress, ultimate strength, allowable or working stress, safety factor, tension instability, elastic constants, Young's modulus of elasticity, Poisson's ratio, modulus of rigidity, volumetric strain, strain energy in tension, compression and shear.
2. Analysis of Design in Simple Tension and Compression: Deflection of axially loaded structures, members with variable cross-sections, compound members, non-uniform stresses and strains, rotating members, impact loading. Thermal stresses and strains.

3. Torsion of shafts: Torsion in solid and hollow circular shafts, shearing stress, polar moment of inertia, torsional stiffness, torsion equation, design of shafts, shafts of varying cross-section, strain energy in elastic torsion, application to close-coiled helical spring.
4. Analysis of thin-walled Pressure Vessels: Hoop and longitudinal stresses and strains for cylinders and spheres, volumetric strain, bulk modulus of contained fluid and pressure effects.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises

1. Tensile test
2. Compression test
3. Torsion test
4. Deflection in springs,
5. Deformation in pressure vessels.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

1. One, two-hour examination at the end of the semester (70%),
2. Course work (continuous assessment tests, lab reports, assignments, quizzes, class participation) (30%),

Core Reading Materials

1. Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
2. Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.
3. Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.
4. Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.
5. Nganga, S P (2019) *Solving Problems in Solid and Structural Mechanics (Vol 1),* Lambert Academic Publishing, 2019.

Recommended Reference Materials

1. Journal of Pressure Vessel Technology.

FME 202: Solid & Structural Mechanics II (60 hours)

Prerequisites

FME 201: Solid and Structural Mechanics I

Purpose of the Course Unit

The purpose of the course is to provide the learner with knowledge on the basics on the simple beam theory. The course will also provide the learner with knowledge on the treatment of 2D and 3D states of stress and strain resulting from combined loading.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Solve problems relating to bending stresses, strains and deflections in statically determinate beams by applying the simple bending theory.
2. Design simple beams on the basis of loads and deflections.
3. Analyse stresses and strains in structures subjected to multi-axial loading.

Course Content

1. Bending of Beams: Reactions by supports, importance for analysis and design, equations for bending moments and shear force along the beam length, qualitative

sketching of bending moments and shear force diagrams, determination of bending moments and shear force equations from free body diagrams.

2. Simple Bending Theory: Concepts of loading plane, moment plane and neutral axis; constant strength beams; development of simple bending theory equation, calculation of stresses due to bending.
3. Deflection of Beams due to Pure Bending: Integration method for statically determinate beams, Macaulay's method, moment-area method, superposition method, strain energy in bending, application of constant strength beam theory to carriage spring.
4. Analysis of Stress and Strain: Two and three-dimensional stress/strain fields, Mohr's circle of stress and strain, principal stresses and strains, pure shear, relationship between Young's modulus and Shear modulus.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises / Design exercise

1. Beam deflection (statically determinate beams with varied supports).
2. Design of limiting loads for a multi-axially loaded structure.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

One, two-hour examination at the end of the semester (70%),

Course work (continuous assessment tests, lab reports, assignments, quizzes, class participation) (30%),

Core Reading Materials

1. Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
2. Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.
3. Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.
4. Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.
5. Nganga, S P (2019) *Solving Problems in Solid and Structural Mechanics (Vol 1),* Lambert Academic Publishing, 2019.

FME 211: Kinematics of Mechanisms (60 hours)

Prerequisites

FME 174: Engineering Mechanics II: Dynamics

Purpose of the Course Unit

To provide the learner with knowledge of the classifications and analysis of planar mechanisms and cam mechanisms, and to introduce the learner to the synthesis of planar mechanisms.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1) Define and apply the basic concepts of mechanisms, including mobility, degrees of freedom and Grashoff's law,
2) Analyse mechanisms and determine the position, velocity and acceleration of given points in a planar mechanism, using the various available methods,
3) Analyse the kinematics of cam mechanisms and synthesize cam profiles,
4) Synthesize simple planar mechanisms, using graphical and linear analytical methods,
5) Use the digital computer in the kinematic analysis and synthesis of mechanisms.

Course Content

Basic Concepts:

Links, Kinematic Pairs, Kinematic Chains, Mechanisms, Kinematic Inversions, Motion, Mobility, Degree of Freedom, The Kutzbach Criterion, Grashoff's Law, Mechanical Advantage, Transmission Angle, Description of Common Mechanisms, Analysis vs. Synthesis.

Displacement, Velocity and Acceleration Analysis of Planar Mechanisms:

Graphical and Analytical Methods, Relative Velocity Methods, Instantaneous Centre, Centroids, The Aronhold-Kennedy Theorem of Three Centres, The Angular Velocity Ratio Theorem, Kinematic Analysis by Algebraic Methods, The Complex Algebra Method, The Vector Approach, Coincident Points, Acceleration Diagram, Acceleration Centre, Relative Acceleration, Coriolis Acceleration, Mechanisms with Curved Slots.

Kinematics of Cams:

Cam and Follower Classifications, Displacement Diagrams by Graphical and Analytical Methods, Parabolic, Simple Harmonic and Cycloidal Motions, Derivatives of Follower Motion, High Speed Cams, Circular Arc and Tangent Cams, Standard Cam Motions, Pressure Angle and Undercutting, Cam Profile Layout Techniques, Graphical and Analytical Cam Profile Synthesis.

Introduction to Kinematic Synthesis:

Graphical and Linear Analytical Methods. Examples of each.

Computer Methods:

Use of Computer for Kinematic Analysis of a Four Bar Linkage, Introduction to Computer-aided Mechanism Design.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical work/Laboratory exercises

1. Determination of efficiency of gear train

2. Belt friction
3. Coupler curves for a kinematic chain
4. Computer Analysis of 4 bar linkage
5. Design of a mechanism using computer techniques

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations and analysis
4. LCD/Overhead projectors
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

1) One, two-hour examination at the end of the semester (70%),
2) Continuous assessment tests (20%),
3) Computer and laboratory assignments (10%).

Core Reading Materials

1) Mata, Antonio Simon et al. (2016) *Fundamentals of Machine Theory and Mechanisms*. Springer International Publishing, Switzerland.
2) Myszka, David H. (2012) *Machines and Mechanisms: Applied Kinematic Analysis, Fourth Edition*. Prentice Hall.
3) Vinogradov, Oleg (2000) *Fundamentals of Kinematics and Dynamics of Machines and Mechanisms*. CRC Press.

Recommended Reference Materials

1) Uicker, J. J. Jr., G. R. Pennock and J. E. Shigley. (2016)*Theory of Machines and Mechanisms, Fifth Edition*. Oxford University Press.
2) Norton, R. L. (2011) *Design of Machinery:An Introduction to the Synthesis and Analysis of Machines and Mechanisms, Fifth Edition*. McGraw-Hill Education.
3) Journal of Mechanical Design

FME 212: Mechanical Power Transmission I (60 hours)

Prerequisites

FME 174 Engineering Mechanics II: Dynamics.

Purpose of the Course Unit

To provide the learner with knowledge of the principles and methods of transmitting mechanical power, particularly where friction plays an important role in the power transmitting devices.

Expected Learning Outcomes:

At the end of this course, the learner will be able to:

1) Explain the various modes of transmitting motion and power in mechanical devices, and give examples of each,
2) Describe the laws of friction and apply these laws in analysing the functioning of various mechanical power transmitting devices,
3) Analyse the mechanics and functioning of power screws and screw fasteners,
4) Analyse the mechanics and functioning of various types of brakes and clutches,
5) Analyse the mechanics and functioning of various types belt drives,
6) Analyse the mechanics of vehicle propulsion and braking.

Course Content

Modes of Mechanical Power Transmission:

Rigid coupler, flexible connector and direct contact.

Friction:

Review of the laws of friction, surface contact friction and rolling resistance, coefficient of friction, angle of friction and coefficient of rolling resistance.

Screw Threads:

Friction in square threaded and V-threaded screws, power transmission screws and screw-threaded fasteners.

Brakes and Clutches: Types of brakes and clutches, Analysis of Brakes and Clutches, Dynamics of Clutched Systems.

Belt Drives:
Flat and V belt drives, the mechanics of belt drives, and power transmission in belt drives.

Vehicle Propulsion and Braking:
The Mechanics of Propulsion and Braking of Vehicles, Traction and Tractive Resistance.

Mode of Delivery
Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory Work
1) Screw jack experiment,
2) Belt drive experiment.

Instruction materials and equipment:
1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentation
4. LCD/Overhead projector
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment
1) One, two-hour examination at the end of the semester (70%),
2) Continuous assessment tests (20%),
3) Laboratory reports (10%).

Core Reading Materials

1) Childs, Peter. *Mechanical Design, Second Edition*. Elsevier, Butterworth Heinemann, 2004.
2) Juvinall, R. C. and K. M. Marshek. *Fundamentals of Machine Component Design, Fifth Edition*. John Wiley and Sons, Incorporated, 2012.
3) Ugural, Ansel C. *Mechanical Design of Machine Components, Second Edition*. CRC Press, Taylor and Francis Group, 2015.

Recommended Reference Materials

1) Budynas, R. G. and J. K. Nisbett. *Shigley's Mechanical Engineering Design, Tenth Edition*. McGraw-Hill Education, 2015.
2) Shigley, J. E., C. R. Mischke and T. H. Brown Jr. *Standard Handbook of Machine Design, Third Edition*. McGraw-Hill Education, 2004.
3) SAE Transactions Journal of Commercial Vehicles

FME 221: Thermodynamics I (60 hours)

Prerequisites

FME 111: Physics I

FME 151: Chemistry I

FME 172: Calculus I

Purpose of the Course Unit

To provide the learner with knowledge on basic concepts of Engineering Thermodynamics.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1) Critique the First Law of Thermodynamics.
2) Apply the first law of thermodynamics to systems.
3) Apply knowledge to measuring of temperature.
4) Identify different states of matter, perfect gas equation and
5) Use relevant thermodynamic property Tables and Charts.

Course Content

Introductory Concepts:

The science of Thermodynamics, basic definitions, classical versus microscopic Thermodynamics, Thermodynamic processes (quasi-static, reversible)

Energy and the First Law of Thermodynamics:

The concept of energy, definition of work transfer, different types of work and generalization of the concept of work, the concept of heat transfer, the First Law of Thermodynamics for a closed and open systems, and the steady flow energy equation (SFEE). Perpetual motion machine of first kind, Enthalpy: a thermodynamics property. Application of first law to non-flow system: Constant volume, constant pressure, adiabatic, isothermal and polytrophic processes. Definition of C_P and C_V (general).

Properties of fluids

The state postulate, properties of a simple compressible substance including tables and charts, common important coefficients (specific heats, isothermal and isobaric compressibility), the perfect gas, the throttling calorimeter.

1. Saturated liquid and vapour lines: solid, liquid and vapour regimes, superheating, undercooling.
2. Property diagrams (P-T, T-V, P-V, p-h, and T-S diagrams)
3. Property tables.

Thermodynamic temperature scale:

Zeroth law, Temperature Scales and Measurements.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory Exercises

1) Bomb calorimeter.
2) Demonstration experiments

Instruction materials and equipment:

1. Lecture room with white board.

2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

1. One, two-hour examination at the end of the semester (70%).
2. Course work (continuous assessment tests, lab reports, assignments, quizzes, class participation) (30%).

Core Reading Materials

1) Rodgers, G F C & Mayhew Y R (1992) Engineering Thermodynamics, Longman Singapore Publishers, 4th Ed.
2) Eastop TD and McConkey A. (1993) Applied Thermodynamics for Engineering Technologists, Prentice and Hall, 4th Ed.
3) Yunus Cengel, Michael Boles (2014), Thermodynamics: An Engineering Approach (Mechanical Engineering), 8th Edition, Publisher: McGraw-Hill. ISBN-13: 978-0077366742.

Recommended Reference Materials

1) Richard E., Claus B. and Gordon J., (2013) Fundamentals of Thermodynamics 5th Ed., Don Fowley. ISBN-13: 978-0471183617.
2) Claus Borgnakke, Richard E. Sonntag, (2013) Fundamentals of Thermodynamics, 8th Ed., John Wiley & Sons, Inc, ISBN-13: 978-1118131992.

FME 222: Thermodynamics II (60 hours)

Prerequisites

FME 221 Thermodynamics I

Purpose of the Course Unit

The purpose of this course is to provide the learner with knowledge of the principle behind degradation of energy, the second law of thermodynamics, the Carnot engine and the concepts of entropy, thermodynamic potentials and availability.

Expected Learning Outcomes

At the end of this unit, the student will be able to:

1) Apply the principle of degradation of energy.
2) Apply second law of thermodynamics to thermodynamic processes.
3) Evaluate irreversibility using the concept of entropy.

Course Content

Second Law

Heat and work reservoirs (definitions)

Heat engine (definitions)

Principle of degradation of energy.

Cycle and process efficiency.

Plank's statement of second law

Perpetual motion machine of second kind.

Kelvin's statement of second law.

Reversibility and irreversibility.

Mechanical work, viscous work and reversible work on a gas

Heat transfer and the Second law.

Clausius statement of second law and proof.

Most efficient engine is reversible: Proof.

All reversible engines have same efficiency: Proof

Carnot's principle

Thermodynamic temperature scale (definition)

Entropy

Concept

Clausius inequality

Definition of entropy change.

Tabular and Graphical entropy data.

Temperature - Entropy diagram

Enthalpy- Entropy diagram

T-s equations.

Entropy change of an ideal gas.

Use of entropy for evaluation of irreversible changes.

Equality of enclosed areas on T-s and p-v diagrams

Thermodynamic Potentials and Availability

Second law for closed and open systems. Maximum and minimum compression /expansion work. Steady-flow processes, adiabatic processes. Shaft work.

Helmholtz and Gibbs functions.

Availability.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1) Rogers, G.F.C. & Mayhew Y.R. (1992) Engineering Thermodynamics, Longman Singapore Publishers, 4th Ed.
2) Eastop T.D. and McConkey A. (1993) Applied Thermodynamics for Engineering Technologists, Prentice and Hall, 4th Ed.
3) Yunus Cengel , Michael Boles (2014), Thermodynamics: An Engineering Approach (Mechanical Engineering), 8th Edition, Publisher: McGraw-Hill. ISBN-13: 978-0077366742.

Recommended Reference Materials

1) Richard E., Claus B. and Gordon J., (2013) Fundamentals of Thermodynamics 5th Ed., Don Fowley. ISBN-13: 978-0471183617.
2) Claus Borgnakke , Richard E. Sonntag, (2013) Fundamentals of Thermodynamics, 8th Ed., John Wiley & Sons, ISBN-13: 978-1118131992.

FME 231: Fluid Mechanics I (60 hours)

Prerequisite:

None

Purpose of the course

The purpose of this course is to enable the learner to gain knowledge and skills in the following:

1) The properties of Newtonian fluids.
2) The pressure distribution for static fluids.
3) The forces acting on surfaces for static fluids.
4) Concepts of mass, momentum and energy conservation to flows.
5) Basic ideas of turbulence

Expected Learning outcomes

At the end of this course, the student will be able to;

1) Determine the dimensions and units of physical quantities.
2) Identify the key fluid properties used in the analysis of fluid behaviour.
3) Analyse common fluid properties given appropriate information.
4) Explain effects of fluid compressibility.

5) Apply the concepts of viscosity, vapour pressure, and surface tension.
6) Determine the pressure at various locations in a fluid at rest.
7) Explain the concept of manometers and apply appropriate equations to determine pressures.
8) Analyse the hydrostatic pressure force on a plane or curved submerged surface.
9) Analyse the buoyant force and discuss the stability of floating or submerged objects.

Course Content

Properties of Fluid:

Definitions, dimensions. Pressure, Temperature, Density, Viscosity, Vapour Pressure, Surface Tension, etc. Measurements of temperature and viscosity.

Fluid Statics:

Pressure changes in gravity field with and without temperature gradients, pressure measurements by Bourdon gauge and manometers, fluids in relative equilibrium, pressure distribution in a liquid subject to vertical and horizontal acceleration, forced vortex hydrostatic pressure, steady and unsteady flow, uniform and non-uniform flow, streamlines, discharge and mean velocity, control surface and control volume, substantial derivative for velocity, transport theorem, continuity equation.

Static Forces on Surfaces:

Hydrostatic pressure, forces and centres of pressure on plane and curved surfaces, buoyancy stability of floating and submerged bodies, metacentre, determination of metacentric height, stability of vessels carrying liquids with open surfaces.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises

1) Calibration of pressure gauges
2) Measurement of pressure by manometers

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

1) One 2-hour written examination at the end of the semester (70%)
2) Continuous Assessment Tests (20%)
3) Written laboratory reports (10%)

Core Reading Materials

1) Douglas, J. F., Gasiorek, J. M. and Swaffield, J. A. (2001) *Fluid Mechanics*, Prentice Hall, 2nd Ed.
2) Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.
3) Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.
4) Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

Recommended Reference Materials:

Journal of Fluids Engineering.

FME 232: Fluid Mechanics II (60 hours)

Prerequisite:

FME 231 Fluid Mechanics I

Purpose of the Course Unit

The purpose of this course is to introduce the learner to the fundamental principles governing the flow of liquids in open channels and pipes and the principles underlying various flow measurements.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1) Compute pressures and velocities in various fluid flow situations
2) Analyse various flow parameters in a variety of closed pipe and open channels connections/configurations and pipe networks.
3) Derive, identify and apply the dimensionless numbers encountered in fluid mechanics.
4) Evaluate pressures and mean flow velocities in pipes and pipe networks.

Course Content

1) Euler's and other equations – Euler's equation
2) Generalised energy equation. One-dimensional steady flow equation
3) Bernoulli's equation for unsteady, irrotational flow of an inviscid incompressible fluid
4) Application of above equations, pitot tubes, nozzles, venturi meters, orifices, notches etc.
5) Time to empty tanks.
6) Flow in Pipes and circular annulus.
7) Flow in smooth and rough pipes and circular annulus. Kinetic energy correction.
8) Energy grade lines.
9) Piezometric head. Darcy-Weisbach equation.
10) Friction factors in pipes. Effects of Reynold's number.
11) Nikuradse and Moody charts.
12) Network Analysis: Pipes in series and parallel, combination of pipes in parallel and series, losses at entry, exit, corners, elbows, etc. Hardy-Cross computation method.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

1) Determination of metacentre in a floating vessel
2) Laminar and Turbulent flow (Osborne experiment)
3) Flow measurement orifice/Venturi-meter
4) Friction loss in pipes

Instruction materials and equipment:

1. Lecture room with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1. Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.

2. Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.

3. Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

4. Gasiorek J.M. & Swaffield J. A., (2001), *Fluid Mechanics*, Prentice Hall, 4th Ed.

Recommended Reference Materials

Journal of Fluids Engineering.

FME 243: Workshop Technology& Practice (60 Hours)

Prerequisites

None

Purpose of the Course Unit

The purpose of this course is to provide the learner with knowledge and skills on basic operations in a mechanical engineering workshop and gain practical experience on how to carry out these operations i.e.: measurements, marking, hand tools, machining, drilling, sheet metal operations, welding, jigs and fixtures, fittings, etc.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Create components using the knowledge and skills on the different types of tools and machines in a mechanical engineering workshop e.g. Hand tools, lathe, drilling, milling & cutting machines; jigs and fixtures, measurements, marking, sheet metal cutting & forming, fasteners, welding, soldering, brazing, metal fitting, etc.

Course Content

1) Safety in the workshop and care of Machines: Personal safety, machine safety, good housekeeping, wear and lubrication, etc.
2) Marking out: Datums, marking out equipment, examples of marking out.
3) Hand tools and processes: Engineer’s files, the hacksaw, cold chisels, scrapers, engineer’s hammers, taps, dies, powered hand tools, etc.
4) Introduction to Machine Tools: lathes, milling and drilling machines, shaping and planning machines. Introduction to machine tools used for mass production: Semi-automatic lathes, drilling machines, introduction to CNC machines.
5) Machine tool processes: Work holding, plain turning, boring, facing, parting, plain milling, drilling, shaping, etc.
6) Tools used in machine tools: Lathe tools, milling tools, tools used in drilling machines, shaping tools, etc.

7) Introduction to fasteners: Classification of nuts, bolts and screws, different types of screw threads, etc.
8) Machine Tool Processes: Taper turning and boring, thread cutting, taper milling, cutting feeds and speeds, metal removal rates and machining time, indexing.
9) Metal cutting tools and cutting Fluids: Tool materials, tool geometry, tool wear and tool life, types of fluids, application of fluids, safety in the use of fluids.
10) Sheet metal operations: Cutting, piercing and blanking, profile development.
11) Introduction to joining using heat processes: Soldering, brazing, welding processes and types of welding joints.
12) Introduction to metal behaviour during cutting: Machinability, machining of steel, aluminium alloys, copper and its alloys, free cutting alloys, etc.
13) Basic concepts in metrology:
    - Standards of measurement, wavelength standard, line and end standard, errors in measurement and calibration, etc.
    - Linear Measurement: Measurement using vernier, micrometers and gauges. Design and working principles of linear measurement instruments. Design and working principles of comparators, etc
    - Angular Measurement and Circular Division: Angle standards. Measurement of angles from length measurement – the sine bar. The precision level. Angular measurement using optical instruments. Circular division.
    - Straightness, Flatness and Squareness Testing and Alignment: The nature of light, monochromatic rays. Interferometry applied to flatness testing, interferometers, machine tool alignment.
    - Gear Measurement: Rolling gear tests, tooth thickness measurement, measurement over rollers, gear pitch measurement, etc
    - Measurement of Screw Threads: Major diameter, minor diameter, thread form, effective diameter.
    - Measurement of Surface Texture and Roughness: Definition and specifications and specifications of surface texture and roughness, measurement of surface texture

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages
7. Necessary workshop equipment: lathes, drilling machines, welding equipment, etc.

Course Assessment

The course shall be assessed as follows:

- An end of semester written examination constituting of 40%.
- Coursework: Continuous assessment tests (20%)
  Workshop activities (produced articles) and reports (40%)

Core Reading Materials

1) Black, J T and Kohser, R A (2019), *Degarmo's Materials and Processes in Manufacturing*, Wiley.
2) Raghavendra, N.V. and Krishnamurthy, L. (2013) *Engineering Metrology and Measurements*. Oxford University Press.
3) Kalpakjian, S and Schmid, S.R. (2018), *Manufacturing Engineering and Technology*, Wiley.

Recommended Reference Materials

1) Grover, M P (2019), *Fundamentals of Modern Manufacturing*, Wiley.
2) Madou, M.J. (2011), *Fundamentals of Microfabrication and Nanotechnology*, CRC Press.
3) Journal of Manufacturing Science and Engineering.
4) Measurement, Elsevier (Journal of the International Measurement Confederation)
5) Metrologia, IOP Publishing.

FME 251: Materials Science and Engineering I: Fundamentals (60 hours)

Prerequisites:

FME 151: Chemistry I

FME 111: Physics I

FME 152: Chemistry II

FME 112: Physics II

Purpose of the course unit:

To provide the learner with the fundamental knowledge of the principles needed to understand the behaviour of engineering materials.

Expected learning outcomes:

At the end of the course, the learner will be able to;

1. Describe the various types of atomic/molecular bonds possible between atoms and molecules and relate materials properties to the type of bond and crystal structure.

2. Sketch unit cells of crystals of the most common metals and perform calculations involving crystal structures e.g. angle between crystal directions, theoretical density, etc.

3. Describe the various types of defects that occur in crystals and analyse their effect on the mechanical properties and perform simple calculations involving crystal defects.

4. Prepare high quality samples for metallography and carry out light optical microscopy.

5. Compare, contrast and perform various mechanical tests, and select the right method for an application.

6. Construct and interpret binary phase diagrams including those showing eutectic, eutectoid and peritectic reactions, and to perform calculations involving phase diagrams e.g. determination of phase quantities.

Course content:

Introduction: Role of materials science and engineering, classification of materials.
Atomic structure and bonding: Review of atomic structure of matter, atomic models: Rutherford-Bohr model, wave mechanics model, periodic Table, atomic bonding: ionic bond, covalent bond, metallic bond, secondary bonds.
The Crystal structure of matter: Crystal patterns, metal crystals: simple cubic, body cantered cubic, face centered cubic, hexagonal close packed; polymorphism, crystal planes and directions (Miller index notation), X-ray diffraction.
Crystal imperfections and microsections: Crystal defects: point defects, line defects or dislocations, planar defects, volume defects; Microsections: preparation of microsections, the metallurgical microscope, macro-examination, sulphur printing.
Testing of mechanical properties: The tensile test, the hardness tests: Brinell hardness test, Vickers hardness test and Rockwell hardness test, other mechanical tests.
Equilibrium phase diagrams and alloy theory: Alloying systems: phases, solid solutions, intermetallic compounds; phase diagrams: isomorphous system, complete insolubility in solid state, partial solubility in solid state, systems with intermetallic compounds, eutectoid and peritectic reactions, cooling curves for simple alloy systems, composition and quantities of phases (the lever rule).

Mode of delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages
7. Necessary workshop equipment: lathes, drilling machines, welding equipment, etc.

Laboratory exercises:

1. Preparation of metallographic sections and microstructure examination using a light optical microscope.
2. Hardness tests
3. Tensile test
4. Plotting of an exemplar binary phase equilibrium diagram

Course Assessment:

The course shall be assessed by both coursework (accounting for 30 %) and an end of semester written examination constituting 70 %. The coursework shall in turn consist of laboratory practicals (10 %), written continuous assessment tests, tutorials, quizzes, assignments, etc. (20 %).

Core reading materials:

Note: *readers should look for the latest edition of each recommended book.*

1. Callister, W D and Rethwisch, D G (2019) *Materials Science and Engineering,* John Wiley and Sons.
2. Askerland, D R and Wright, W J (2018), *Essentials of Materials Science and Engineering*, Cengage Learning.
3. Rading, G O (2007) *Concise Notes on Materials Science and Engineering,* Trafford Publishing, Victoria, Canada.

FME 262: Engineering Drawing III (60 hours)

Prerequisites

FME 161 – Engineering Drawing I

FME 162 – Engineering Drawing II

Purpose of the Course Unit

This course will equip students with knowledge and skills of solid modelling software and its application in engineering design.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. *Create 2D and 3D digital models of engineering components, assemblies and systems.*
2. *Dimension drawings and solid models*
3. *Employ modelling tools*
4. *Edit solid models and drawing*
5. *Create working views of objects from solid models*

Course Content

1) *Drawing Sketches for Solid Models*
2) *Editing and Modifying Sketches*
3) *Adding Relations and Dimensions to Sketches*
4) *Advanced Dimensioning Techniques and Base Feature Options*
5) *Creating Reference Geometries*
6) *Advanced Modelling Tools*
7) *Editing Features*
8) *Assembly Modelling*
9) *Working with Drawing Views*

Mode of Delivery

Lectures, practical computer laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages
7. Necessary workshop equipment: lathes, drilling machines, welding equipment, etc.

Practical/computing Exercises

2 hours weekly CAD practice

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting 40 %.
2) Continuous assessment coursework (60%)

Core Reading Materials

1. Howard, W and J.Musto, (2010) *Introduction to Solid Modelling Using SolidWorks* 2010, McGraw-Hill, ISBN-10:0073375438.
2. Steve Heather (2017)*AutoCAD 3D modelling,* Industrial Press, Inc.; First edition, 2017
3. Randy Shih (2019) *Parametric Modelling with SolidWorks 2019.*

FME 271: Calculus II (45 hours)

Prerequisites

FME172 Calculus I

Purpose of the Course Unit

To fortify the learner's knowledge of the differential and integral calculus and to enable them to apply this knowledge in solving engineering problems of varying difficulty.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Differentiate and integrate transcendental functions, including logarithmic, exponential, trigonometric and hyperbolic functions.
2. Apply sequences and series, including the power series, Taylor series and McLaurin series to the solution of problems,
3. Analyse functions of several variables, partial derivatives, the Chain rule and extrema of functions of two variables,
4. Perform multiple integration and determine centres of mass and moments of inertia.

Course Content

Logarithmic, Exponential and Other Transcendental Functions:

The natural logarithmic function and differentiation. The natural logarithmic function and integration. Inverse functions. Differentiation and integration of exponential functions. Bases other than e and their applications. Introduction to differential equations; growth and decay. Inverse trigonometric functions; differentiation, integration and completing the square. Hyperbolic functions.

Sequences and Series:

Sequences, Series and convergence. The integral test and p-series. Comparisons of series. Alternating series. The ratio and root test. Taylor polynomials and approximations. Power series. Representation of functions by power series. Taylor and Maclaurin series. Applications.

Functions of Several Variables:

Introduction. Limits and continuity. Partial derivatives. Differentials. Chain rules for functions of several variables. Directional derivatives and gradients. Tangent planes and normal lines. Extrema of functions of two variables. Applications of extrema of functions of two variables. Lagrange multipliers.

Multiple Integration:

Iterated integrals and area in the plane. Double integrals and volume. Change of variables; polar coordinates. Centre of mass and moment of inertia. Surface area. Triple integrals and applications. Triple integrals in cylindrical and spherical coordinates. Change of variables; Jacobians.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.

2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment

1) One, two-hour examination at the end of the semester (70%),
2) Continuous assessment tests (20%),
3) Assignments (10%).

Core Reading Materials

1) Bird, John. (2006) *Higher Engineering Mathematics, Fifth Edition*. Newnes, Elsevier.
2) Stroud, K. A. and D. J. Booth (2001) *Engineering Mathematics, Fifth Edition*. Industrial Press, Incorporated, New York.
3) Larson, R., R. P. Hostetler and B. H. Edwards (2005). *Calculus, Eighth Edition*. Brooks Cole.

Recommended Reference Materials

1) Spiegel, M. R. (1971) *Schaum's Outline of Advanced Mathematics for Engineers and Scientists,* McGraw-Hill.
2) Polyanin A. D. & Manzirov A. V. (2006*) Handbook of Mathematics for Engineers and Scientists,* Chapman & Hall/CRC Press.
3) International Journal of Mathematical and Statistical Sciences.

FME 272: Differential Equations and Linear Algebra (45 hours)

Prerequisites

FME 271 Calculus II

Purpose of the Course Unit

To equip the learner with the mathematical tools that will enable them to solve modern engineering problems.

Expected Learning outcomes

At the end of this course, the learner will be able to:

1. Apply ordinary differential equations in the modelling and solution of engineering problems.
2. Apply vectors in the plane and in space to model and solve engineering problems,
3. Formulate systems of linear equations in matrix notation and solve them,
4. Set up eigenvalue problems and determine the eigenvalues and eigenvectors,
5. Apply vector calculus to modelling and solving engineering problems.

Course Content

Ordinary Differential Equations:

Definitions and basic concepts. Separation of variables in first-order equations. Exact first order equations. First-order linear differential equations. Second-order homogeneous linear equations. Second-order non-homogeneous linear equations. Series solutions of differential equations. Legendre and Bessel equations. Higher order equations with constant coefficients. Applications.

Vectors Algebra:

Vectors in the plane. Space coordinates and vectors in space. Scalar (dot) product of two vectors. Vector (cross) product of two vectors in space. Triple products. Lines and planes in space. Surfaces in space. Cylindrical and spherical coordinates. Applications.

Matrices and Linear Equations:

Definitions and elementary properties of matrices. Matrix multiplication. Diagonal matrices. Symmetric and skew symmetric matrices. Determinants. Inverse of a matrix. Systems of matrices. Rank of a Matrix. Systems of linear equations.

Eigenvalues and Eigenvectors:

Eigenvalues and eigenvectors, matrix functions, special matrix partitioning, bilinear and quadratic forms, differentiation of matrices.

Vector Calculus:
Gradient, Divergence and Curl, Curvilinear coordinate systems, Line, Surface and Volume integrals, Stokes and Green's theorems. Applications.

Mode of Delivery
Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Library books and linkages
7. Necessary laboratory equipment

Course Assessment
1) One, two-hour examination at the end of the semester (70%),
2) Continuous assessment tests (20%),
3) Assignments (10%).

Core Reading Materials
1) Bird, John. *Higher Engineering Mathematics, Fifth Edition*. Newnes, Elsevier, 2006.
2) Strang, Gilbert. *Differential Equations and Linear Algebra*. Wellesley-Cambridge UK Edition, 2014.
3) Goode, S. W. and Scott A. Annin. *Differential Equations and Linear Algebra, Fourth Edition*. Pearson, 2016

Recommended Reference Materials

1) Kreyzig, Erwin. *Advanced Engineering Mathematics, Tenth Edition*. John Wiley and Sons, Incorporated, 2011.
2) Duffy, Dean G. *Advanced Engineering Mathematics with MATLAB, Second Edition*. Chapman and Hall/CRC, 2003.

FME 291: Electrical Circuit Theory (45 hours)

Prerequisite

FME 112: Physics II

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge, skill and competence on electric circuit theory including use of complex numbers in the analysis of electric networks.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Analyse RLC networks/circuits.
2. Explain the relationship between electricity and magnetism.
3. Explain the fundamental electric circuit laws and theorems.
4. Employ complex numbers to carry out steady state analysis of networks with reactive elements excited by sinusoids.

Course Content

D.C. circuits:

Ohm's & Kirchhoff's laws, superposition principle, and analysis of DC circuits.

Electromagnetism:

Magnetic circuit, stored energy, magnetic attraction, hysteresis and eddy currents, self and mutual inductance, force between conductors, B-H characteristics.

Electrostatics:

Permittivity, capacitance, electric stress, stored energy.

AC Circuit Theory:

Complex quantities, AC circuit analysis and simple networks current, combination of resistance, capacitance and inductance, resonance, Q-factor, balance three-phase circuits, simple AC networks problems, including parallel circuits.

Three-phase supply:

Nature and characteristics, connections, and power measurements.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory Exercises

1) Study of steady-state: Resistance, reactance, impendence, capacitance, susceptance and admittance.
2) Study of measurement of power factor
3) Study of Kirchhoff's Law and comparison with theoretical calculations
4) Study of performance of capacitors, diodes, switches
5) Study of resonance

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

1) One 2-hour written examination at the end of the semester (70%)
2) Continuous Assessment Tests (20%)
3) Written laboratory reports (10%)

Core Reading Materials

1. Sundararajan, I D (2019) *Introduction to Circuit Theory*, Springer
2. Svoboda, J A and Dorf, R C (2013) *Introduction to Electric Circuits*, Wiley.
3. Mayergoyz, I D and Lawson, W (2012) *Basic Electric Circuit Theory*, Academic Press.

Recommended Reference Materials

1. International Journal of Electrical Systems Science and Engineering

FME 292: Electrical Machines (45 hours)

Prerequisites

FME 291 Electrical Circuit Theory

Purpose of the Course Unit

The purpose of this course is to provide the learner with knowledge, skills and competence on the operating principles of various electrical machines and devices.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Analyse and design simple amplifiers and oscillators.
2. Describe rectified dc power supplies used in electronic circuits.
3. Describe the use of electronic devices in various controls such as voltage, speed and temperature regulation.
4. Analyse industrial machine drives (single and three-phase induction motors) and single-phase transformers.
5. Examine the operation of three-phase transformers.
6. Analyse torque slip characteristics, maximum torque and efficiency of three phase induction motors.

Course Content

1) Electronics: Characteristics of vacuum diodes, characteristics of vacuum valves; the diode and multi-grid valves, introduction to semiconductors, the p-

n junction diode equation, p-n-p and n-p-n junctions, transistor characteristics, amplifiers frequency response, sinusoidal and non-sinusoidal oscillators, power amplifiers. Power electronics, power supplies, thyristor, triac operation, dielectric and induction heating.

2) Machines: DC motors and generators, Construction features, classification and characteristics. AC motors, generators and transformers, Construction features, classification and characteristics.
3) Electrical control circuits and devices relevant to AC and DC machines. Switching and protective gear, cables, electronic controls.
4) Fundamentals of energy conversions, transmission and distribution.

Mode of Delivery

Lectures, practical laboratory activities, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1) Sen, P C (2013) *Principles of Electric Machines and Power Electronics*, Wiley
2) Hubert, C I (2020) *Electric Machines: Theory, Operating Applications and Controls*, Pearson.
3) Wildi, T (2005) *Electrical Machines, Drives and Power Systems*, Pearson.

4) Sedra A. S. & Smith K. C., (2003). Microelectronic circuits. New York: Oxford University Press, 5th Ed.

THIRD YEAR COURSES

FME 301: Solid & Structural Mechanics III (60 hours)

Prerequisites

FME 202 Solid and Structural Mechanics II

Purpose of the Course Unit

The purpose of the course is to provide the learner with knowledge of the principles behind the design of thick walled and compound cylinders as well as knowledge on the theory of beams including stresses induced, and the resulting deflections.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Calculate stresses, strains and displacements in thick walled pressure vessels subjected to internal and external pressure.
2. Solve problems relating to stresses, strains and deflections in statically indeterminate beams.
3. Design space frames.
4. Analyse and design structures subjected to multiple loads.

Course Content

1. Thick and Compound Cylinders: Lame's equations, thick cylinders with internal and external pressures, effect of end constraints, compound cylinders and stresses produced by shrink-fit, thick spherical shells.
2. Built-in and Continuous Beams Analysis: Shear forces and bending moment equations for built-in and continuous beams, deflection method, three-moment theorem, shear forces and moments diagrams.
3. Force Analysis of Frames: Strain energy methods, Castigliano's theorem and deflection of trusses, virtual work methods, statically indeterminate structures.
4. Combined Loading Applied to Design: Eccentric loading, combined axial, bending and torsion.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Laboratory exercises / Design exercises

1. Deformation of thick walled pressure vessels.
2. Deflection in built-in and continuous beams.
3. Deflection in framed structures.
4. Resolution of multiple loads on beams and framed structures.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's and screens for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

1. One, two-hour examination at the end of the semester (70%),
2. Continuous assessment tests (20%),
3. Laboratory / design reports (10%).

Core Reading Materials

1. Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
2. Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.
3. Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.
4. Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.

Recommended Reference Materials

1. Journal of Pressure Vessel Technology.

FME 302: Solid & Structural Mechanics IV (60 hours)

Prerequisites

FME 301: Solid and Structural Mechanics III

Purpose of the Course Unit

The purpose of this course is to provide the learner with the knowledge and ability to analyse and design structures and components loaded beyond the elastic limit, as well as the theories governing failure of structures and basic design of columns.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Articulate and apply the theories of failure as relates to mechanical structures and components.
2. Solve problems relating to deformation of structures beyond the elastic limit.
3. Evaluate the stresses, strains and deflections in composite beams
4. Analyse columns with various end constraints.
5. Design columns and composite beams

Course Content

1. Elastic Failure in Complex Stress Stems: Von Mises failure criterion, Tresca's failure criterion, failure of brittle materials, application of failure theories.
2. Deformation beyond the Elastic Limit: Bending of beams beyond elastic limit, torsion of shafts beyond elastic limit, plastic deformation of thick cylinders under internal pressure, residual stresses.
3. Composite Beams: Types of composite beams and applications, equivalent section properties; stresses and strain analysis of (a) timber-steel beams, (b) reinforced concrete, (c) Engineered I beams, (d) steel variations in plate girders.
4. Struts: Euler's crippling load for struts with different end constraints, struts with initial curvature, struts with eccentric loading, struts with transverse loading, empirical strut formulae, limitations of Euler load – application of Rankine formula

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Laboratory exercises / Design exercises

1. Deflection of composite beams.
2. Loading of struts - axial and eccentrically loading.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

1. One, two-hour examination at the end of the semester (70%).
2. Course work (continuous assessment tests, lab reports, assignments, quizzes, class participation) (30%).

Core Reading Materials

1. Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
2. Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.
3. Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.
4. Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.

FME 311 – Mechanical Power Transmission II (60 hours)

Prerequisites

FME 212 Mechanical Power Transmission I

Purpose of the Course Unit

To provide the learner with knowledge of the principles and methods of transmitting mechanical power, particularly where positive mesh plays an important role in the power transmitting devices.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Elaborate on the types and applications of chain drives,
2. Analyse the mechanics and transmission of power in chain drives,
3. Elaborate on spur gear geometry, terminology and the fundamental law of gearing,
4. Design various kinds of gear drives, including spur, helical, bevel, worm, rack and pinion,
5. Utilise bearings and lubricants in various design applications.

Course Content

Chain Drives:

Types and Applications of Chain Drives, The Mechanics of Chain Drives, Power Transmission in Chain Drives.

Introduction to Gearing:

Spur Gear Terminology and Definitions, Gear Tooth Nomenclature, Tooth Geometry, The Fundamental Law of Gearing.

Gear Drives:

Involute Teeth, Involutometry and other Forms of Teeth, Interchangeable Gears, Gear Tooth Action, Interference and Undercutting, Non-standard Gear Teeth. Gear Drive Forces and Power Transmission, Helical, Bevel, Worm, Rack and Pinion Gears. Gear Trains, Differentials.

Bearings and Lubrication:

Functions of Lubricants, Modes of Lubrication, Performance of Lubricants, Fluid Film Bearings, Anti-friction Bearings, Applications of Different Types of Bearings.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

1) Gear efficiency experiment

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

1) One 2-hour written examination at the end of the semester (70%)
2) Continuous Assessment Tests (20%)
3) Written laboratory reports (10%)

Core Reading Materials

1) Childs, Peter. *Mechanical Design, Second Edition*. Elsevier, Butterworth Heinemann, 2004.
2) Juvinall, R. C. and K. M. Marshek. *Fundamentals of Machine Component Design, Fifth Edition*. John Wiley and Sons, Incorporated, 2012.
3) Budynas, R. G. and J. K. Nisbett. *Shigley's Mechanical Engineering Design, Tenth Edition*. McGraw-Hill Education, 2015.

Recommended Reference Materials

1) American Chain Association. *Standard Handbook of Chain, Second Edition*. CRC Press, Taylor and Francis Group, 2006.
2) Tsubaki. *The Complete Guide to Chain*. U. S. Tsubaki, Incorporated, 1997.
3) Jelaska, Damir. *Gears and Gear Drives*. John Wiley and Sons Limited, 2012.

FME 312 – Dynamics of Machines (60 hours)

Prerequisites

FME 211: Kinematics of Mechanisms

Purpose of the Course Unit

To provide the learner with knowledge of the dynamical phenomena that occur in mechanical systems, their applications and how to cater for their undesirable effects.

Expected Learning outcomes

At the end of this course, the learner will be able to:

1. Elaborate on the mechanics and functioning of various types of governors.
2. Illustrate the gyroscopic effect and its applications.
3. Analyse the dynamics of various kinds of cams.
4. Evaluate and mitigate the effects of unbalanced rotating masses.
5. Balance reciprocating masses.
6. Apply the principles of reciprocating masses to single and multiple cylinder engines.

Course Content

Governors:

Function of Governors, Inertia, and Centrifugal Type Governors, Different Types of Centrifugal Governors, Controlling Force Analysis, Governor Effort and Hunting, Friction, Insensitiveness.

Gyroscope:

Principles of Gyroscopic Action, Precession and Gyroscopic Acceleration, Gyroscopic Couple, Effect of Gyroscopic Couple on Ships, Aeroplanes, Vehicles, Inclined Rotating Discs, among others. Applications

Cam Dynamics:

Advanced Cam Curves, Cam Dynamics, Mathematical Model, Jump Phenomenon, Ramp of the Cam – Precam, Polydyne Cam.

Balancing:

Dynamic Forces in Mechanisms, Engine Torque and Flywheels. Balancing of Rotating Masses in One and Several Planes, Balancing of Reciprocating Masses in Single and Multi-cylinder Engines – Inclined, Radial and Vee-Types. Primary and Secondary Balancing Analysis. Concept of Direct and Reverse Cranks. Static and Dynamic Balancing Machines.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

Balancing of rotating masses experiment

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1) Uicker, J. J. Jr., G. R. Pennock and J. E. Shigley. *Theory of Machines and Mechanisms, Fifth Edition*. Oxford University Press, 2016.

2) Norton, R. L. *Design of Machinery:An Introduction to the Synthesis and Analysis of Machines and Mechanisms, Fifth Edition*. McGraw-Hill Education, 2011.
3) Wilson, Charles E. and J. Peter Sadler. *Kinematics and Dynamics of Machinery, Third Edition*. Pearson, 2003.

FME 322: Thermodynamics III – Power Cycles (60 hours)

Prerequisites

FME 222: Thermodynamics II

Purpose of the Course Unit

The purpose of this course is to enable the learner to get a thorough grasp of the operation of air standard cycles, as well as the performance parameters of gas power cycles.

Expected Learning outcomes

At the end of this course, the student will be able to;

1. Illustrate the diversity and application of air standard cycles.
2. Analyse performance of air standard cycles.
3. Apply the equations of air standard cycles.
4. Develop equations for engine performance indicators such as thermal efficiency, work ratio and MEP.

Course Content

<u>Perfect Gas</u>

Gas constants, molecular weight, the mole, the molar volume, specific heat relations

The perfect gas and use of gas table at low pressures

Equations of state

The principles of corresponding state and use of Compressibility charts

Perfect gas thermometer

Maxwell relations

Joules closed vessel experiment,

Joule-Thomson's Coefficient

Clausius-Claypeyron equation.

Air-standard Cycles

Introduction to air-standard cycles,

Internal and external combustion engines

Definitions of:

Cycle thermal efficiency

Compression volume ration

Pressure ratio

Work ratio

Mean effective pressure (MEP)

Specific output

Gas power cycles

(i) Carnot cycle, efficiency work ratio m.e.p.

(ii) Otto cycle, T-s, p-v diagrams thermal efficiency, m.e.p., work ratio, sources of irreversibilities
Effect of compression ratio on efficiency
Knock and Octane rating
Introduction to gasoline engine (SI engine)

(iii) Diesel cycles T-s, p-v diagrams
Thermal efficiency, MEP, work ratio
Cut-off ratio
Sources of irreversibilities
Introduction of oil engine (CI engine). Cetane rating

(iv) Dual cycle; T-s and p-v diagrams, thermal efficiency
Comparison between Otto, Diesel and Dual cycles.

(v) Atkinson cycle.

(vi) Joule (Brayton) cycle: T-s and p-v diagrams, thermal efficiency, work ratio
Efficiency, work ratio
Maximum pressure ratio
Optimum pressure ratio and maximum specific output
Sources of irreversibilities

Effects of irreversibility in compression and expansion

Regeneration: effect on efficiency, pressure ratio,

Work ratio

Introduction to gas turbine units

(vii) Erricsson cycle: As a development of joule (Brayton Cycle)

Staged compression/cooling: compressor work

Intercooling and intercooler pressure

Staged expansion and reheating: work output,

Reheat pressure

T-s and p-v diagrams

Efficiency and work ratio

Regeneration

(viii) Stirling cycle: T-s and p-v diagrams

Regeneration, efficiency and work ratio

Practical problems associated with Stirling cycle.

<u>Single- and two-stage reciprocating air compressors:</u>

Illustration, piston, cylinder, con-rod, crank and crank-case, valves

Brief discussion of other types, multi-stage with intercooling, vane, liquid-ring, diagram, centrifugal, axial flow etc.

Machine cycle and theoretical power with and without clearance.

Adiabatic, isothermal and polytropic compression and their effecton theoretical work

Isothermal efficiency

Clearance ratio

Volumetric efficiency

Heat generated

Free air delivery

Actual compressor p-v diagram

Brief discussion on dryness, cleanness, intake filters, compressed air filters, intercoolers, aftercooler and water separators, receivers, safety valves etc.

Engine Performance Testing

Torque

The rope brake, pony brake, hydraulic dynamometer.

Electrical dynamometer and measurement of brake power (BP)

Frictional power

Fuel consumption and specific fuel consumption

Criteria of performance

Indicated thermal efficiency

Brake thermal efficiency

Mechanical efficiency

Overall efficiency

Relative efficiency

Energy balance

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory exercises

1) Ruston engine,
2) Reciprocating compressors.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1) Moran, M J, Shapiro, H N, Boettner, D D and Bailey, M B (2018), *Fundamentals of Engineering Thermodynamics,* 9th Ed, Wiley.
2) Rogers G.F.C. & Mayhew Y.R. (1992) *Engineering Thermodynamics*, Longman Singapore Publishers, 4th Ed.
3) Eastop T.D. and McConkey A. (2002) *Applied Thermodynamics for Engineering Technologists,* Prentice and Hall, 5th Ed.
4) Cengel, Y A, Boles, M A, and Konoghu, M (2019), *Thermodynamics: An Engineering Approach*. McGraw-Hill.

Recommended Reference Materials

1) Richard E., Claus B. and Gordon J., (2013) Fundamentals of Thermodynamics 5th Ed., Don Fowley. ISBN-13: 978-0471183617.
2) Claus Borgnakke , Richard E. Sonntag, (2013) Fundamentals of Thermodynamics, 8th Ed., John Wiley & Sons, Inc, ISBN-13: 978-1118131992.

FME 331: Fluid Mechanics III (60 hours)

Prerequisite:

FME 232 Fluid Mechanics II

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills in the sizing and design of pipe networks, ideal (two-dimensional) flow, and finite control volume methods as well the applications of dimensional analysis.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Calculate various flow parameters in a variety of pipe networks.
2. Determine various kinematic elements of the flow given the velocity field.
3. Appraise the Bernoulli equation for irrotational flow
4. Apply the concepts of stream function and velocity potential.
5. Characterize simple potential flow fields.
6. Identify an appropriate control volume and draw the corresponding diagram.
7. Calculate flowrates using the continuity equation.
8. Calculate forces and torques using the linear momentum and moment-of-momentum equations.
9. Employ dimensional analysis in fluid flow applications.

Course Content

1) Network Analysis: Pipes in series and parallel, combination of pipes in parallel and series, losses at entry, exit, corners, elbows, etc. Hardy-Cross computation method.
2) Ideal Flow Theory: Continuity equation, streamlines, pathlines, streaklines, stream function, Laplace equation, rotational and irrotational flow (Bernoulli equation for irrotational flow), vorticity, circulation, velocity potential, stream function, Thomson's theorem.
3) Patterns of Ideal Fluid Flow: Uniform flow, sinks and sources, combination of flow patterns, doublet, virtual mass, irrotational vortex, patterns of flow past cylinder with and without circulation, magnus effect.
4) Finite Control Volume Methods. Reynolds Transport Equation. Mass and Momentum Equation: Generalised linear and angular momentum equation. Impact of jets on stationary and moving plates. Force on pipe bends. Force on nozzles and reaction of a jet. Momentum theory of a propeller.
5) Dimensional Analysis and Dynamic Similitude: Units, dimensional homogeneity; geometric, dynamic and kinematic similarity, Buckingham Pi theorem, dimensionless parameters, dimensional matrix method similitude (for cases with more than to Pi groups), model studies.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

Wind tunnel

Dimensional analysis

Instruction materials and equipment:

1. Lecture room with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

3) An end of semester written examination constituting of 70%.
4) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1) Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.
2) Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.
3) Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

Recommended Reference Materials

1) Gasiorek J.M. & Swaffield J. A., (2001), *Fluid Mechanics*, Prentice Hall, 4th Ed.
2) Journal of Fluids Engineering.

FME 332: Fluid Mechanics IV (60 hours)

Prerequisite:

FME 331 Fluid Mechanics III

Purpose of the Course Unit

The purpose of this course to enable learners to gain knowledge in the concepts of viscous fluid flow, Navier-Stokes equation for viscous flow, boundary layer theory, effect of viscosity on bluff bodies (External flow) and the basics of Non-Newtonian fluid flow.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Illustrate the fundamental characteristics of a boundary layer, including laminar, transitional and turbulent regimes.
2. Analyse certain types of (simple) flows using the Navier-Stokes equation (Couette, Poiuselle, Hagen-Poiseulle flows).
3. Calculate boundary layer parameters for flow past a flat plate.
4. Provide a description of boundary layer separation.
5. Calculate the lift and drag for various objects. Ideal flow: Characterize simple potential flow fields.
6. Discuss the features of external flow.

Course Content

1) Navier-Stokes Equations
    - Body and surface forces. 3-dimensional equations of motion of a fluid particle. Stress components and the rate of strain tensor.
    - Stokes' constitutive equations. Navier-stokes equations.
    - Common simplifications and applications of N-S equations
    - Time-averaging the continuity equation and the N.S equation for incompressible flow.
    - Reynolds stresses. Prandtl mixing length theory
    - Turbulent velocity profiles from mixing length theory

- ❖ Applications

2) Boundary Layer Theory
   - ❖ Definitions. Laminar, transitional and turbulent regions. Laminar sub-layer, boundary layer thickness.
   - ❖ Boundary layer equations for 2-dimenstional steady flow of an incompressible Newtonian fluid over horizontal flat plate.
   - ❖ Control volume analysis of boundary layer, calculation of boundary layer thickness for laminar and turbulent flows over a horizontal flat plate.
   - ❖ Separation, vortex formation
   - ❖ Diffuser stall. Streamlining
3) Flow past sub-merged bodies
   - ❖ Flow over flat plates, cylinders, spheres, and bluff bodies.
   - ❖ Profile, form, skin friction drags and correlations.
   - ❖ Introduction to flow through porous media and fluidisation.
4) Introduction to Non-Newtonian Fluid Flow
   - ❖ Types of Non-Newtonian fluids. Shear behaviour of inelastic, non-time dependent fluids.
   - ❖ Equations for shear rate. Viscometers.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory exercises

Flow past a cylinder

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1. Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.
2. Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.
3. Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

Recommended Reference Materials

1. Gasiorek J.M. & Swaffield J. A., (2001), *Fluid Mechanics*, Prentice Hall, 4th Ed.
2. Journal of Fluids Engineering.

FME 343: Business Management for Engineers (45 hours)

Prerequisite:

None.

Purpose of the Course Unit

The purpose of this course is to provide learners with knowledge on the origin and evolution of the management function as well as management of different aspects within the organisation.

Expected Learning Outcomes

At the end of the course, a learner will be able to:

1. Discuss the origins of modern management.

2. Discuss theories of management and their applications to modern management with respect to production, employee motivation and interrelations among different organisation components.
3. Evaluate jobs and select appropriate wage system for hired workers.
4. Apply decision theory in analysing decision problems.
5. Perform market analysis for different products manufactured in an organisation.
6. Make investment decisions through the analysis of financial statements
7. Draw budgets for profitable projects in an organization.
8. Discuss emerging issues and trends in the management of engineering organizations.

Course Content

- Introduction to management: Origin and development of modern management and the modern business organisation; the management function, Principles of management and principle of organisation.
- Theories of Management: Scientific management and its influence on mass production, the piece rate principle; theory of bureaucracy, administrative theory; systems approach to management; management and motivation:
- Introduction to motivation theory, personality and psychometric testing, McGregor's theory X and theory Y, Maslaw's "Hierarchy of Needs". Applications.
- Wage systems: Wage systems based on time; Wage systems based on output; other types of wage incentive systems; Systems of job evaluation.
- Leadership: Leadership skills, the impact of organisational culture on leadership, transformational versus transactional leadership;
- Dimension of decision-making: Decision theory; Applications of Decision theory
- Financial management: Financial statements – Statement of comprehensive income (profit and loss statement), statements of financial position (balance sheet) and their main components; Financial statement analysis – Purposes, techniques of analysis (trend, cross sectional and ratio analysis). Applications.
- Budgets and budgeting: The budgeting process, Operating budgets and Capital budgeting.
- Engineering Economics and its applications to investment decision making.

- The marketing concept: Marketing strategy planning, Development of the marketing mix; Marketing management – product and product development, pricing, distribution, promotion; The production system; Stabilisation – emerging markets and trans-national business, supply chain management.
- Managing change: Influence of change in organisations; Contemporary ideas and trends
- Emerging Issues and trends: Business ethics, communication in Industry; health and safety at work.

Mode of Delivery

A combination of lectures, tutorial sessions, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Tutorials, quizzes, assignments, etc. (10%)

Core Reading Materials

- Montana, Patrick, J. And Charnov, Bruce, H. *Management*. 4th Edition. Barron's Educational Series. (2008)
- Cole, Gerald. *Management Theory and Practice*. 6th Edition. South-Western Cengage Learning. (2004)
- Kotler, Philip and Armstrong, Gary. *Principles of Marketing*. 10th Edition. Pearson/Prentice Hall. (2004)

- Kotler, Philip. *Marketing Management*. Prentice Hall of India. (2000)
- Bhat, Sudhindra. *Financial Management*. 2nd Edition. Excel Books.(2007)
- Journal of Engineering and Technology Management, Elsevier

FME 344: Law for Engineers (45 hours)

Prerequisites: None

Purpose of the Course Unit:

The purpose of this course is to equip learners with legal knowledge relevant to engineers, including intellectual property, torts, and contracts.

Expected Learning Outcomes

At the end of the course, a learner will be able to:

1. Identify the nature and sources of law
2. Identify various legal acts relevant to engineering
3. Relate the law of tort and product liability in engineering
4. Discuss laws of contract in project management and intellectual property
5. Discuss laws of contract in project management and intellectual property
6. Discuss environmental, insurance and industrial accident laws in relation to engineering.

Course Content

- The nature and sources of law, an outline of the law of tort and product liability;
- Laws of contract in project management and intellectual property.
- The factories Act. (Cap. 514): main provision as to health, safety and welfare, offences, penalties and legal proceedings;
- Trade Unions Act. (Cap 233): legal status of Trade Unions, registration, figures and liabilities.
- Trade Disputes Act (Cap. 234) – with particular reference to the jurisdiction of the Industrial Court and the protection of essential services, life and property;
- Occupational health and Safety Act

- Environmental laws, NEMA act, regulations and statutory institutions, occupational health and safety;
- Insurance law
- Laws related to industrial accidents, industrial pollution etc., accident reporting;

Mode of Delivery:

A combination of lectures, tutorial sessions, case studies and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD projector
5. Audio-visual aides

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  tutorials, quizzes, assignments, etc. (10%).

Core Reading Materials

1. Gayton, Cynthia M. *Legal Aspects of Engineering*, Kendall-Hunt Publishing, (2012).
2. Howard B. Rockman, *Intellectual Property Law for Engineers and Scientists*, IEEE Press, (2004).
3. Donald L. Marston, *Law for Professional Engineers*, McGraw-Hill Professional, (2008).

FME 351: Materials Processing I (60 hours)

Prerequisites

FME 251: Engineering Materials Science I

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on the processes used in shaping and machining metals and non-metallic materials into final products.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Select appropriate methods for producing metals through plastic deformation and machining.
2. Optimize parameters for plastic deformation processes and machining operations.
3. Select appropriate methods and optimise parameters for welding metallic materials.
4. Select appropriate methods and optimise parameters for microfabrication and nanofabrication.

Course Content

- Metal Machining: Theory of chip formation, forces in orthogonal cutting, velocities in metal cutting, economics of metal cutting.
- Chipless Machining Processes: Electro-discharge machining, water jet and abrasive water jet machining, laser beam machining, electro-chemical machining, chemical machining, electron beam machining.
- Computer Aided Manufacturing: Introduction to numerical control of machines, introduction to automation, numerical control of machines, CNC machines, computer aided part programming, computer aided process planning, flexible manufacturing systems.
- Theory of Metal Forming: Analysis of loads and stresses in metal forming processes such as forging, wire drawing, extrusion, rolling etc.
- Welding: The weld joint, microstructures, defects in welds, welding of ferrous metals, welding of non-ferrous metals, design consideration in welding, welding procedures.

- Microfabrication and nanofabrication: microfabrication techniques: photolithography, soft lithography, film deposition, etching, and bonding. Nanofabrication techniques: Electron beam lithography, X-ray lithography, focussed ion beam lithography, ion projection lithography, colloidal monolayer lithography, molecular self-assembly, electrically induced nanopatterning, rapid prototyping. Other emerging nanofabrication techniques

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary Workshop equipment

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Workshop exercises and reports (10%)

Core Reading Materials

- Black, J T and Kohser, R A (2019), *Degarmo's Materials and Processes in Manufacturing*, Wiley.
- Grover, M P (2019), *Fundamentals of Modern Manufacturing*, Wiley.
- Kalpakjian, S and Schmid, S.R. (2018), *Manufacturing Engineering and Technology*, Wiley.
- Madou, M.J. (2011), *Fundamentals of Microfabrication and Nanotechnology*, CRC Press.

Recommended Reference Materials

- Journal of Manufacturing Science and Engineering, ASME
- *Journal of Manufacturing Processes*(JMP), Elsevier
- Journal of Materials Processing and Technology, Elsevier
- Materials and Manufacturing Processes, Taylor & Francis
- International Journal of Advanced Manufacturing, Springer
- Production Engineering – Research and Development, Springer
- Micro and Nano Engineering, Elsevier

FME 352: Materials Processing II (60 hours)

Prerequisites

FME 251: Materials Science and Engineering I

Purpose of the Course Unit

The purpose of this course is to enable the student to acquire knowledge, skills and competence of the processes used in shaping metals and non-metallic materials into products through casting, powder metallurgy and additive manufacturing.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Select appropriate methods for producing metals through casting.
2. Select appropriate methods for manufacturing glass, plastics, ceramics and different types of composites.
3. Optimise parameters for additive manufacturing of various materials.
4. Optimise parameters for processing of metallic alloys and composites.

Course Content

- Metal Casting: Solidification, melt control, sand and mould control, mould design, defects from solidification, defects from the mould, design consideration in casting, etc.

- Powder Metallurgy and Ceramics Processing: The powder metallurgy process, production of different types of powders, compacting and sintering, secondary and finishing operations, products of powder metallurgy, design considerations in powder metallurgy, ceramic particle size considerations, binders and binder burnout. Other ceramic processing technologies
- Glass processing:
- Polymer Processing: Injection moulding, blow moulding, compression moulding, transfer moulding, extrusion, casting, production of sheet and film, fibre reinforcement of polymers.
- Composite processing: Processing methods for metal matrix composites, ceramic matrix composites, polymer matrix composites, carbon-carbo composites, hybrid composites, laminates and sandwich composites, nanocomposites
- Additive Manufacturing: Introduction to principles and applications of various additive manufacturing methods categorised into: Vat Photopolymerisation, Material jetting, Binder jetting, Material Extrusion, Powder bed fusion, Sheet lamination and Direct energy deposition

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)

Workshop exercises and reports (10%)

Core Reading Materials

1) Black, J T and Kohser, R A (2019), *Degarmo's Materials and Processes in Manufacturing*, Wiley.
2) Grover, M P (2019), *Fundamentals of Modern Manufacturing*, Wiley.
3) Gibson, I., Rosen, D and Stucker, B. *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*, Springer, Latest Edition
4) Kalpakjian, S and Schmid, S.R. (2018), *Manufacturing Engineering and Technology*, Wiley.

Recommended Reference Materials

1) Journal of Manufacturing Science and Engineering, ASME
2) *Journal of Manufacturing Processes*(JMP), ELSEVIER
3) Journal of Materials Processing and Technology, ELSEVIER
4) Materials and Manufacturing Processes, Taylor & Francis
5) International Journal of Advanced Manufacturing, Springer
6) Production Engineering – Research and Development, Springer
7) International Journal of Metal casting, Springer
8) International Journal of Cast Metals Research, Ingenta
9) Additive manufacturing, Elsevier

FME 353: Materials Science and Engineering II: Metallic alloys (60 hours)

Prerequisite:

FME 251: Materials Science and Engineering I

Purpose of the course unit:

To equip the learner with the knowledge of metallic alloys, their properties and uses, and how the said properties may be changed to suit a particular application.

Expected learning outcomes:

At the end of the course, the learner will be able to do the following:

1. Perform calculations involving steady state and non-steady state atomic diffusion.
2. Deduce the most suitable method for strengthening a specific metal and perform simple calculations that quantify the effect of each method on mechanical properties.
3. Sketch and interpret the Fe-C phase diagram.
4. Critique the advantageous and disadvantageous properties of alloys based on aluminium, copper, titanium and other non-ferrous metals.
5. Prescribe the most appropriate heat treatment procedure to obtain desired properties in a given alloy system.
6. Deduce a suitable heat treatment protocol from a TTT curve.

Course content:

Single crystal behaviour and strengthening mechanisms: Dislocations and slip behaviour of crystal systems, critical resolved shear stress, deformation of single crystals; strengthening mechanisms: grain boundary strengthening, solid solution strengthening, fine particle strengthening, martensitic strengthening, and other strengthening mechanisms.

Diffusion: Steady state diffusion (Fick's 1st law), non-steady state diffusion (Fick's 2nd law), factors influencing diffusion.

The iron-carbon diagram and the ferrous alloys: Allotropic forms of iron, eutectic, eutectoid and peritectic decomposition in the Fe-C system, stable and metastable Fe-C systems, plain carbon steels, hypo and hyper-eutectoid steels, quantities of phases in the Fe-C system, properties of annealed plain carbon steels; The cast irons: white cast iron, grey cast iron, malleable cast iron, ductile or nodular cast iron, other types of cast iron.

Heat treatment of steels: Kinetics of transformation processes, driving force for phase transformations, homogeneous versus heterogenous nucleation, matrix-precipitate interface, growth of a phase, metastable versus equilibrium states, isothermal transformation and TTT curves, technical heat treatment processes such as annealing, normalizing, case hardening, quenching, tempering and spheroidizing, hardenability and ruling section.

Effects of alloying elements in steels and cast irons: classification of steels, special steels: stainless steels, tool steels. Effect of alloying elements in cast irons; heat treatment of cast irons.
Aluminium and its alloys: Types of aluminium alloys, properties of aluminium alloys, heat treatment of aluminium alloys (precipitation hardening), modification of cast aluminium alloys, aluminium-lithium alloys, uses of aluminium alloys.
Copper and other non-ferrous alloys: Copper and its alloys, titanium alloys: classification of titanium alloys, nickel and its alloys, cobalt and its alloys, superalloys, magnesium alloys.

Mode of delivery:

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Laboratory exercises:

1. The microstructure of plain carbon steels and other selected steels
2. Microstructure of cast irons.
3. Microstructure of selected mon-ferrous alloys.
4. The Jominy end quench test.

Course Assessment:

The course shall be assessed by both coursework (accounting for 30 %) and an end of semester written examination constituting 70 %. The coursework shall in turn consist of written lab reports (10 %), written continuous assessment tests, tutorials, quizzes, assignments, etc. (20 %).

Core reading materials:

1. Callister, W D and Rethwisch, D G (2019) *Materials Science and Engineering,* John Wiley and Sons.
2. Askerland, D R and Wright, W J (2018), *Essentials of Materials Science and Engineering*, Cengage Learning.
3. Rading, G O (2007) *Concise Notes on Materials Science and Engineering,* Trafford Publishing, Victoria, Canada.

Recommended reference materials

1. Ashby, M F Shercliff, H and Cebon, D (2019), *Materials: Engineering, Science, Processes and Design*, Butterworth-Heinemann.
2. Badheshia, H and Honeycombe, R (2017), *Steels: Microstructure and Properties,* Butterworth-Heinemann.

FME 354: Materials Science and Engineering III: Non-Metals, Corrosion and Economic Factors (60 hours)

Prerequisite:

FME 251: Materials Science and Engineering I

Purpose of the Course Unit:

The purpose of this unit is to enable the learner to gain knowledge and skills of the structure, properties and methods of processing polymers, ceramics and composite materials, so the learner may apply the same to the design of structures or machine components.

Expected Learning Outcomes:

After completing the course, the learner will be able to do the following:

1. Classify polymers and relate their mechanical properties to their molecular structure.
2. Analyse the visco-elastic behaviour of polymers using models made up of springs and dashpots.

3. Compare the crystal structure and crystal imperfections in ceramic materials with those of metals.
4. Determine experimentally the mechanical properties of ceramic materials and relate these to their crystal structures.
5. Deduce suitable methods to determine the mechanical properties of polymers, ceramic and composites.
6. Identify the most appropriate method for the fabrication and/or processing of a given polymer, ceramic or composite.
7. Select the most appropriate material for the design of a structure or machine component.
8. Compare and contrast different methods used in the protection of a structure or machine against corrosion e.g. cathodic versus anodic protection.

Course content:

Organic polymers: Structure of polymers, classification of plastics: thermoplastic and thermosetting polymers, copolymers, crystallinity in polymers, mechanical properties of polymers: stress-strain behaviour, viscoelastic deformation, fracture in polymers, factors influencing mechanical behaviour, thermal behaviour of polymers (glass transition and melting), advanced polymeric materials, polymer processing: additives, forming techniques, fabrication, fibres and films.

Ceramics: Classification of ceramics, ceramic crystal structures, carbon and carbon nanotubes, imperfections in ceramic crystals, diffusion in ceramic materials, ceramic phase diagrams, mechanical properties of ceramics: brittle fracture, stress-strain behaviour, mechanisms of deformation in ceramics, thermal and electrical properties of ceramics, fabrication and processing of glasses and clays, powder processing, tape casting.

Introduction to composites: nature of composites, classification of composites, the matrix, reinforcement and interface in composites, fibre reinforced composites, particle reinforced composites, metal matrix composites, carbon-carbon composites, hybrid composites, structural composites: laminates and sandwich composites, nanocomposites, structure of composites, fracture modes in composites, processing of composites.

Corrosion and degradation of materials: types of corrosion, Pourbaix diagrams, forms of corrosion, prevention of corrosion, degradation in polymers: swelling and dissolution, bond rupture, weathering.

Economic and environmental issues in materials: Component design, materials, manufacturing techniques, recycling biodegradable and biorenewable polymers.

Mode of delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Laboratory exercises:

1. Effect of fibre volume fraction on tensile properties of a selected fibre reinforced composite.
2. Comparison of the tensile properties of PMMA, Formica and rubber.
3. Flexural strength of Al_2O_3.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment:

The course shall be assessed by both coursework (accounting for 30 %) and an end of semester written examination constituting 70 %. The coursework shall in turn consist of laboratory practicals (10 %), written continuous assessment tests, tutorials, quizzes, assignments, etc. (20 %).

Core reading materials:

1. Agrawal, B D and Broutman, L J (2017) *Analysis and Performance of Fibre Composites,* John Wiley and Sons, New York.

2. Callister, W D and Rethwisch, D G (2019) *Materials Science and Engineering*, John Wiley and Sons.

3. Rading, G O (2007) *Concise Notes on Materials Science and Engineering,* Trafford Publishing, Victoria, Canada.

4. Revie, R W (2010), *Corrosion and Corrosion Control,* John Wiley and Sons, New York.

5. Carter, C B and Norton, M G (2013), *Ceramics Materials Science and Engineering,* Springer.

6. Fried, J R (2014), *Polymer Science and Technology,* Butterworth-Heinemann.

Recommended Reference Materials

1. Mark, H F (2004), *Encyclopaedia of Polymer Science and Technology Part 3*, Wiley-Interscience.
2. Richerson, D W and Lee, W E (2018), *Modern Ceramics Engineering*, CRC Press.

FME 362 – Mechanical Engineering Design I (60 hrs)

Prerequisites

FME 261 Engineering Drawing III.

Purpose of the Course Unit

This course equips the learners with knowledge and skills on the mechanical design process including an understanding of basic engineering design process and considerations, design of simple objects and components and presentation of design ideas.

Expected Learning Outcomes

At the end of this course, the learner will be able to;

1. Identify customers problems and opportunities for product development
2. Generate ideas to solve a customer need or problem
3. Evaluate design concepts to ensure they meet the customers need.
4. Select the most appropriate design concept from the ideas generated
5. Generate strategies for solving and meeting the needs of the customer
6. Design a machine component and subsystem while taking the manufacturing process into consideration
7. Synthesise a complete machine with several machine elements
8. Design quality products creatively for a sustainable environment
9. Work as a productive member of an engineering team
10. Communicate effectively engineering solutions to a wide audience using a variety of skills such as drawings, reports and presentations.

Course Content

1) Design Teams, teamwork and problem solving styles
2) Definition of Engineering Design. Objectives of design. Factors considered in design. The managerial and economic elements in relation to design. The relationship of the design function to other departments of the organisation. Product development and design procedure, problems and solutions. The design function in an organisation, Relationship to market research, production, research and development departments.
3) Design Methodology, Recognition of need, definition of task, design synthesis, analysis and optimisation, evaluation, presentation. Relationship between system design and product design. Discussion of major constraints, cost, availability and capacity.
4) Design factors which area considered principally at the conception phase: strength, reliability, size, shape, volume, weight, styling, cost, finish, functional flexibility, stiffness, thermal factors, corrosion, wear, friction, lubrication, maintenance, safety, ergonomic factors, man-machine interface, utility, processing, noise, legal and aesthetic considerations. Relative importance in relation to different types of products.
5) Factors considered chiefly at the detailed face; Standardisation, rationalisation, material variability, and design safety factors (durability,

mortality curves) tolerancing and statistical considerations, limits, fits and value engineering.

6) A small design project and introduction to report writing. Introduction to graphic design technique and equipment, Environmental factors, societal factors.

Mode of Delivery

A combination of lectures, tutorial sessions, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aides

Course Assessment

The course shall be assessed by course work only as follows:

1. Individual design assignments – 30%
2. Group design activities with individual contributions documented in journal entries and submitted for assessment and report – 60%
3. End of semester individual oral presentations – 10%

Core Reading Materials

1) Budynas-Nisbett (2008) *Shigley's Mechanical Engineering Design* – 8th Edition.
2) Collins, J A, H. Busby & G. Staab (2000) *Mechanical Design of Machine Elements & Machines; A failure Prevention Perspective* – 2nd Edition.
3) Mott, R L (2005) *Machine Elements in Mechanical Design* – 3rd Edition.
4) Ullman, D G (2010) *The mechanical Design Process* – 4th Edition.

FME 371: Complex Analysis and Differential Equations (45 hours)

Prerequisites

FME 272: Differential Equations and Linear Algebra

Purpose of the Course Unit

To equip the learners with mathematical tools that will enable them to solve engineering problems that require knowledge of partial differential equations and complex analysis.

Learning Outcomes

At the end of this course, the learner will be able to:

1. Interpret complex numbers and the geometry of the complex plane,
2. Analyse Fourier series and Fourier transforms,
3. Evaluate Laplace transformation and its application to the solution of differential equations,
4. Solve partial differential equations that commonly occur in engineering problems,
5. Apply complex variables to the solution of engineering problems.

Course Content

Complex Numbers and the Complex Plane:

Complex numbers, functions, mapping, differentiation, integration. Geometry of the complex plane, elementary functions, roots of complex numbers, De Moivre’s theorem.

Fourier Series and Fourier Transform:

Periodic functions, odd and even functions. Expansion of functions into Fourier series over a full range and half range. Dirichlet’s conditions. Harmonic Analysis. Differentiation and integration of Fourier integrals and Fourier transforms.

Laplace Transforms:

Properties of Laplace transforms, differentiation and integration, inverse transforms, pole-zero configuration, application to the solution of differential equation, convolution theorem.

Partial Differential Equations:

Methods of separation of variables applied to Laplace's, Heat and Wave Equations. Solution of Laplace's equation in polar, cylindrical and spherical coordinates. Use of Fourier series in simple boundary value problems.

Complex Variables:

Analytic functions, Cauchy-Riemann equations, Application in solving potential problems, complex power series, contour integration, Cauchy's integral theorem and integral formula, expansion of functions as Taylor and Laurent series. Residue theorem.

Mode of Delivery

A combination of lectures, tutorial sessions and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aids

Course Assessment

The course shall be examined as follows:

1) One, two-hour end of semester written examination (70 %).
2) Continuous assessment tests (20 %).
2) Assignments, etc. (10 %).

Core Reading Materials

1) Bird, John. *Higher Engineering Mathematics, Fifth Edition*. Newnes, Elsevier, 2006.
2) Kreyzig, Erwin. *Advanced Engineering Mathematics, Tenth Edition*. John Wiley and Sons, Incorporated, 2011.
3) Barreira Luis and Claudia Valls. *Complex Analysis and Differential Equation*. Springer-Verlag, London, 2012.

Recommended Reference Material:

1) Duffy, Dean G. *Advanced Engineering Mathematics with MATLAB, Second Edition*. Chapman and Hall/CRC, 2003.

FME 372: Probability and Statistics for Engineers (45 hours)

Prerequisite:

FME 171: Fundamentals of Engineering Mathematics

Purpose of the Course Unit

To equip the learners with mathematical tools that will enable them to solve engineering problems that require knowledge of probability and statistics.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Apply probability distributions and densities to the evaluation of the expectation of a random variable,
2. Prepare sampling and estimation schemes,
3. Evaluate statistical hypotheses and perform tests for significance,
4. Design and analyse experiments.
5. Perform regression and correlation analyses,
6. Employ statistical quality control,
7. Develop procedures for reliability and life testing.

Course Content

The Concept of Probability:

Sample spaces and events, counting, probability. Axioms of probability. Elementary theorems. Conditional probability. Bayes' theorem. Mathematical expectation and decision making.

Probability Distributions and Densities:

Random variables. Binomial distribution. Hyper-geometric distribution. Mean and variance of a probability distribution. The Poisson distribution. The geometric distribution. The multinomial distributions. Continuous distributions. Normal, uniform, log-normal, gamma, beta, Weibull, exponential, t, chi-square, F and multi-normal distributions. Joint probability densities. Simulation.

Expectation:

Expectation of a random variable, laws of expectation, variance and covariance, moment generators, Chebyshev's theorem.

Sampling and Estimation:

Populations and samples. Sampling distribution of the mean. Sampling distribution of the variance. Accuracy and precision, methods of estimation, confidence intervals. Estimating the mean, difference of two means, the variance and the ratio of two variances.

Significance Tests:

Statistical hypotheses, tests of sample means, the t test applied to paired comparisons, the chi-square goodness-of-fit test, the F test. Distribution-free or non-parametric tests.

Regression and Correlation:

Linear, curvilinear, and multiple regression and correlation.

The Design and Analysis of Experiments:

Measurements. Propagation of error. Series and parallel arrangements. Combining dissimilar estimates by the method of least squares. Comparative and factorial experiments. One-way and two-way classification. Analysis of variance. Testing for equality of several variances. Multiple range tests. Analysis of covariance.

Quality Control:

Acceptance sampling. Operating characteristics curve. Types of sampling schemes. The military standard plan. Sampling by variables. Process control. Control charts for samples. CUSUM charts. Feedback control.

Reliability and Life Testing:

Problems in measuring reliability. Mathematical distribution of failure times. The exponential distribution. Estimating the conditional failure rate. The Weibull model in life testing.

Mode of Delivery

A combination of lectures, tutorial sessions, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projectors
5. Audio-visual aids.

Course Assessment

The course shall be examined as follows:

1) One, two-hour examination at the end of semester (70 %).
2) Continuous assessment tests (20 %).
3) Assignments (10%)

Core Reading Materials

1) Montgomery, D. C. and G. C. Runger. *Applied Probability and Statistics for Engineers, Sixth Edition*. John Wiley and Sons, Incorporated, 2013.
2) Walpole, R. E., R. H. Myers, S. L. Myers and Keying Ye. *Probability and Statistics for Engineers and Scientists, Ninth Edition*. Prentice Hall, 2012.
3) Devore, Jay L. *Probability and Statistics for Engineering and the Sciences, Eighth Edition*. Brooks/Cole, 2012.

FME 399: INTERNAL ATTACHMENT

MODULE I: CAD and Product Fabrication Practice in Workshops (168 hours)

Prerequisites

FME 161 Engineering Drawing I

FME 261: Engineering Drawing II

FME 262: Engineering Drawing III

FME 182: Computer Science I

FME 281: Computer Science II

FME 244: Workshop Technology

Purpose of the Module

The purpose of this module is to provide the students with practical experience in designing and preparing production drawings in CAD as well as operation of various mechanical engineering workshop equipment.

Expected Learning Outcomes

At the end of the module, the learner will be able to:

1. Design products and prepare production drawings in CAD.
2. Use various tools and machines in mechanical engineering workshops to fabricate components/products.
3. Assemble and disassemble petrol and diesel engines.

Module Content

- Learners will do practical work in all the workshops based on specific project activities, i.e. Fitting shop, Machine Shop, Sheet Metal shop, Welding Shop, Foundry shop etc. As shown below.
    - **Fitting Shop**: Use of hand tools such as files, rulers, hacksaws etc. and their employment in the production of simple items such as bottle openers, chisels, depth gauges etc.
    - **Machine Shop**: Use of lathe machines, drilling machines, milling machines, grinding machines, power saws, tool and cutter grinders etc. in the production of various items.
    - **Sheet metal Shop**: Use of tools in the sheet metal shop such as hydraulic guillotines, drilling machines, roller bending machines, vices etc. in the fabrication of meter boxes, door hinges, steel tool boxes etc.
    - **Welding Shop:** Joining of metals using Oxy-Acetylene welding, Electric Arc welding, induction welding, MIG & TIG welding etc.
    - **Foundry Shop:** Preparation of sand moulds, smelting of metals using furnaces and casting of simple metallic parts.
    - **Engine Shop:** Overhaul and assembly of various engines i.e. petrol engines, diesel engines, electric engines etc., engine service and tune- up.

- Learners will design and draw all production drawings of the project activities using CAD before proceeding to the workshops to fabricate them except for the Engine Shop practice.

Mode of Delivery

Practical computer sessions involving design and CAD, plus practical workshop sessions.

Module Assessment

Continuous assessment: CAD drawings (40%), practical workshop activities and short quizzes (40%) and reports (20%).

References

None

MODULE II: *Creativity and Innovation Seminars and Exercises* ***(32 hours)***

Prerequisite

FME 362 Engineering Design I

Purpose of the Module

The purpose of this module is to enable the learner to gain Knowledge of how to use a range of creative thinking methods, tools and techniques to generate ideas and solve problems.

Expected Learning Outcomes

At the end of the module, the learner will be able to:

1. *Compare and contrast creativity and innovation.*
2. *Engage in creative thinking and creative problem solving.*
3. *Outline the various stages of creativity.*
4. *Diagnose barriers to creativity.*
5. *Generate new ideas.*
6. *Transform creativity into practical innovative solutions*

Module Content

- *Introduction to creativity and innovation, nature of creativity, nature of innovation.*
- *Recognising the difference between creativity & innovation: Understanding the cycle of innovation*
- *Need for creativity and innovation: Benefits of using a creative approach*
- *Role creativity and innovation*
- *Breaking through thought patterns and assumptions: Recognising left and right brain thinking, Identifying how creative we are*
- *Enabling creativity: Simple methods and techniques to develop creativity, Identifying ways to further develop creative thinking*
- *Methods and tools for generating ideas: Brainstorming or blue sky thinking session, Reverse brainstorming, Sort cards or mind maps, Sticky notes/Metaplanning technique, Identifying when best to use each idea generation technique*
- *Logical versus lateral thinking: Recognising the differences between lateral and logical thinking, Appreciating our strengths*
- *Creative problem solving: Creative problem solving techniques, Using the problem checklist, "go wild" and 5 whys, Applying to work related problems*
- *Applying the learning: Turning creative ideas into action*

Mode of Delivery

Seminars and exercise sessions on creativity and innovation.

Module Assessment

Continuous assessment: Quizzes and assignments (30%), practical activity (40%) and report (30%)

Core Reading Materials

1) *Koestler, A. (2013) The Act of Creation.*
2) *Golgenberg, J and Mazursky, D. (2016) Creativity in Product Innovation.*
3) *Finke, R A, Ward, T B and Smith, S M. (2017) Creative Cognition: Theory, Research, and Applications.*
4) *Boden, M A (2012) The Creative Mind: Myths and Mechanisms.*

5) *Utterback, J M. (2014) Mastering the Dynamics of Innovation.*

MODULE III: Technical Writing and Presentation Skills (32 hours)

Prerequisite

FME 165: Communication Skills

Purpose of the Module

The purpose of this module is to enable the learner to gain knowledge and skills in effective writing, writing technical reports, writing presentations and giving oral presentations.

Expected learning outcomes

At the end of the module, the learner will be able to:

1. *Present ideas and information in well written documents.*
2. *Prepare and give good oral presentations*

Module Content

Effective writing, technical writing, preparing and giving oral presentations

Mode of Delivery

Seminars and exercise sessions on technical writing and presentation.

Module Assessment

Continuous assessment: Quizzes and assignments (30%), report writing (40%), oral presentations (30%)

Core Reading Materials

1) *Ashby, M (2017) How to write a paper.*
2) *Fox R (Ed.) (2005) Fundamentals of Communication, McGraw-Hill.*
3) *Adler R.B., Elmhorst J.M. & Lucas K. (2013) Communicating at Work, McGraw-Hill.*
4) *Barass R. (2014) Scientists Must Write: A Guide to Better Writing for Scientists, Engineers and Students, Taylor& Francis.*

MODULE IV: Industrial visits (64 hours)

Prerequisite

None

Purpose of the Module

The purpose of this module is to facilitate visits by the learners to various Industries and observe industrial operations.

Expected learning outcomes

At the end of the module, the learner will be able to:

1. Describe various industrial operations.
2. Appraise the implementation of occupational health and safety at the workplace.
3. Assess the implementation of industrial management principles.

Module Content

- Visits to selected industries and go through guided tours of their operations touching on various aspects of the organisation.
- Guided discussions and quizzes after each tour

Mode of Delivery

Guided Industry visits followed by discussions and quizzes.

Module Assessment

Attending of Industrial visits (50%), quizzes based on each industrial visit (50%)

References

None

Each of the Modules offered during internal attachment shall be assessed independently and the pass mark is 40%. A candidate who fails any of the Modules offered during internal attachment shall be required to repeat the Module during the following academic year. A candidate who fails to repeat the failed Module(s) during the following academic year without good cause shall be discontinued.

FOURTH YEAR

FME 401: Solid & Structural Mechanics V (60 Hours)

Prerequisites

FME 302: Solid & Structural Mechanics IV

Purpose of the Course Unit

The purpose of the course is to provide the learners with the knowledge, skills and competence on the application of simple bending theory in solving problems of beams loaded by unsymmetrical loads, shear forces as well as stresses induced by rotation and temperature change.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Assess the stresses, strains and deflections in unsymmetrical loaded beams.
2. Analyse beams subjected to appreciable shear forces and understand the concepts of shear stress, shear deflection and shear centre.
3. Solve problems relating to bending induced by thermal gradients.
4. Examine the stresses induced in rotating discs and cylinders.

Course Content

1. Unsymmetrical Bending: Concepts of plane of loading, plane of moments and resolution of moments, general flexural formula, concepts of stress variation with distance from neutral axis, bending of curved beams with plane loading shifting neutral axis from centroidal axis, stress variation.
2. Shear: Shear stress due to flexure, shear stress distribution in thin-walled cross sections, concepts of shear flow, horizontal and vertical shear stresses, shear centre of open thin-walled cross section, shear forces and shear stress distribution.
3. Shear Deflection of Beams: The slope and energy methods, total deflection of beams.
4. Bending due to Thermal Stresses: Bimetallic strips, thermostats, commercial design practice of thermostats, strip deflection constant and strip force concept, concept of minimum volume thermostats, bimetallic strips.

5. Rotating Discs and Cylinders: Stresses and strains; rotation of shrink fit assemblies; disc with varying thickness and thermal effects.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Laboratory exercises / Design exercises

1. Eccentrically loaded bar.
2. Deflection of a bimetallic strip.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. Overhead projectors
5. Audio-visual aides
6. Necessary laboratory equipment

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  tutorials, quizzes, assignments, etc. (10%).

Core Reading Materials

1. Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
2. Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.
3. Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.
4. Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.

FME 402: Introduction to Finite Element Analysis* (60 *Hours)

Prerequisite:

FME 401: Solid & Structural Mechanics V

Purpose of the Course Unit

The purpose of the course is to provide learners with the knowledge and skills on the development and utilisation of the finite element technique for structural analysis.

Expected Learning Outcomes

At the end of this course, the student will be able to;

1. *Asses the mathematical foundation for finite element analysis.*
2. *Formulate finite element schemes for analysis of structures.*
3. *Develop finite element codes.*
4. *Solve basic structural problems using the finite element method.*

Course Content

1. *Introduction: History, numerical methods of stress analysis, optimization, partial differential equations, types of FEM formulations;*
2. *Element formulation: Interpolation and shape functions, strain displacement matrix, the constitutive matrix, derivation of stiffness equations, application of boundary conditions, solutions for displacement, computation of element stresses and strains;*
3. *Element classification: Iso-parametric elements, constant strain triangle, linear rectangular element, quadratic rectangular element, axi-symmetric element, 3-dimensional solid elements, truss and beam elements, plate and shell elements;*
4. *Assembly of elements: Gauss quadrature, Jacobian mapping, location of element integration points, assembly of stiffness, force and displacement matrices;*
5. *Applications: 2D Truss frame example, 2D beam example, 2D plate example, overview of existing software*

Mode of Delivery

A combination of lectures, tutorial sessions, computer simulations and guided self-study.

Laboratory exercises / Design exercises

1. *Development of FE code for beam deflection and carrying out of simulations.*
2. *Development and testing of finite elements.*
3. *Empirical validation of finite element analysis.*

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary computing facilities

Course Assessment

The course will be assessed as follows:

1. One, two-hour examination at the end of the semester (40%),
2. Continuous assessment tests (20%),
3. Laboratory / computer simulation reports (40%).

Core Reading Materials

1. Zienkiewicz, O C, Taylor, R L and Fox, D D (2013), *The Finite Element Method for Solid and Structural Mechanics*, Butterworth-Heinemann.
2. Logan, D L (2016) *A First Course in the Finite Element Method,* Cengage Learning.
3. Desai, Y M, T I Eldho, and A H Shah (2011) *Finite Element Method with Applications in Engineering,* Dorling Kindersley Publishers.
4. Smith, I M, Griffiths, D V and Margets, L (2013) *Programming the Finite Element Method*, Springer.

FME 412 - Mechanical Vibrations (60 Hours)

Prerequisites

1. FME 174: Engineering Mechanics II (Dynamics)

Purpose of the Course

The purpose of this course is to provide the learner with knowledge and skills on vibration analysis and control.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Analyse undamped and damped, freely vibrating single-degree-of-freedom mechanical systems,
2. Analyse forced vibrating single-degree-of-freedom systems,
3. Analyse free and forced vibrating two-degree-of-freedom systems and their applications,
4. Determine the natural modes of vibrating systems with more than two-degrees-of-freedom.

Course Content

1. *Free Vibrations of Undamped Single Degree of Freedom Systems:* Introduction, S.H.M, free vibrations of single degree-of-freedom (DOF) systems. Spring-mass systems, torsional systems and beams. Energy methods in vibrations. Rayleigh's method.
2. *Free Vibrations of Viscously Damped Single DOF Systems:* Over damped, critically damped and under damped vibrations, logarithmic decrement, dry friction/Coulomb damping.
3. *Forced Damped Single DOF Systems:* Constant harmonic excitation, method of complex algebra. Excitation due to reciprocating and rotating unbalance, vibration isolation and transmissibility of force and motion. Energy dissipated by damping, equivalent viscous damping, structural damping, sharpness of resonance, whirling of shafts. Applications; vibration measuring instruments.
4. *Two Degree of Freedom Systems:* Free vibrations of two DOF systems, normal mode vibrations, coordinate coupling and principle coordinates. Influence coefficient equations, solution of 2 DOF vibrating systems using, stiffness influence and flexibility influence methods, Eigen values and Eigen vectors.

5. *Approximate methods:* Matrix iteration, the Holzer method, geared and branched systems.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Laboratory exercises / Design exercises

1. Single-degree-of-freedom vibration experiment,
2. Two-degree-of-freedom vibration experiment.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course will be assessed as follows:

1. One, two-hour examination at the end of the semester (70%),
2. Continuous assessment tests (20%),
3. Laboratory / design reports (10%).

Core Reading Materials

1. Dukkipati, R V (2007) *Solving Vibration Problems Using MATLAB*. New Age International Publishers.
2. Graham, K S (2012) *Mechanical Vibration: Theory and Application*, SI Edition. Cengage Learning.
3. Geradin, M and Rixen, D J (2014) *Mechanical Vibrations: Theory and Applications to Structural Dynamics,* Wiley.
4. Thomson, W T (2002) *Theory of Vibrations with Applications*, Prentice Hall Publishers.

Recommended Reference Materials

1. Rao, S S (2016) *Mechanical Vibrations*, Sixth Edition. Pearson.
2. Journal of Vibrations and Acoustics

FME 421: Thermodynamics IV- Power Cycles (60 hours)

Prerequisites

FME 321 Engineering Thermodynamics III

Purpose of the Course Unit

The objective of this course is to enable the learners to gain knowledge and skills on the operation of vapour power cycles, principles of refrigeration cycles and heat pumps, and operation of steam turbines.

Expected Learning outcomes

At the end of this course, the student will be able to;

1. Appraise the performance of steam power plants.
2. Interpret the performance of vapour power cycles.
3. Analyse the performance of refrigeration and heat pump cycles.
4. Design systems based on vapour power cycles.

Course Content

<u>Vapour Power Cycles</u>

- Use of property tables and charts within zone of interest in vapour power cycles.
- Throttling, and separating and throttling calorimeters
- Comparison criteria for cycles (combustion, cycle thermal, and overall efficiencies, work ratio;
- Isentropic efficiencies
- Carnot vapour cycle and its shortcomings
- Simple Rankine cycle
- Modifications of the simple Rankine cycle superheat, reheat, regeneration)

- the steam condenser
- Desirable characteristics of the working substance
- Binary vapour power cycles
- Back-pressure and extraction turbines

Real Fluid flow in nozzles:

(i) Energy equation. Critical region. Exit velocity. Isentropic efficiency.

(ii) Regimes of Mach Number in convergent-divergent nozzle.

(iii) Supersaturation.

(iv) Design of convergent-divergent nozzles for steam flow. Numerical examples for wet and superheated steam.

Steam Turbines:

(i) Description of different types. (ii) single stage impulse turbine. Diagram efficiency. Optimum speed ratio for isentropic flow. (iii) two stage velocity compounded impulse turbine. Diagram efficiency and optimum speed ratio. (iv) Pressure compounding. (v) Stage efficiency and internal efficiency. (iv) Reheat factor. Condition curve on p-v, T-s, h-s diagrams.

Refrigerators and Heat Pumps:

(i) Reversed Carnot cycle. (ii) Practical cycles. Calculation of coefficient of performance. (iii) Use of p-h diagram (iv) Flash chamber. (v) Different refrigerants. (vi) Absorption systems.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

1) Convective heat transfer.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations

4. Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) A two-hour end of semester written examination (70 %).
2) Course work: Written continuous assessment tests (20%)
   Laboratory reports (10 %).

Core Reading Materials

1) Moran, M J, Shapiro, H N, Boettner, D D and Bailey, M B (2018), *Fundamentals of Engineering Thermodynamics,* 9th Ed, Wiley.
2) Rogers G.F.C. & Mayhew Y.R. (1992) *Engineering Thermodynamics*, Longman Singapore Publishers, 4th Ed.
3) Eastop T.D. and McConkey A. (2002) *Applied Thermodynamics for Engineering Technologists,* Prentice and Hall, 5th Ed.
4) Cengel, Y A, Boles, M A, and Konoghu, M (2019), *Thermodynamics: An Engineering Approach*. McGraw-Hill.

Recommended Reference Materials

1. Richard E., Claus B. and Gordon J., (2013) *Fundamentals of Thermodynamics* 5th Ed., Don Fowley. ISBN-13: 978-0471183617
2. Claus Borgnakke , Richard E. Sonntag, (2013) *Fundamentals of Thermodynamics*, 8th Ed., John Wiley & Sons, Inc, ISBN-13: 978-1118131992

FME 422: THERMODYNAMICS V - Combustion (60 Hours)

Prerequisites

FME 321 Engineering Thermodynamics III

Purpose of the Course Unit

The purpose of this course is to provide the learners with knowledge and skills of fuels, combustion processes, process reactions and how these may be applied to the analysis and design of internal combustion engines.

Expected Learning Outcomes:

At the end of this course, the learner will be able to:

1. Develop methods for determining non-reacting gas mixture properties from knowledge of mixture composition and the properties of the individual components.
2. Determine mixture properties of ideal gas mixtures and real-gas mixtures.
3. Predict the *P-v-T* behaviour of gas mixtures based on Dalton's law of additive pressures and Amagat's law of additive volumes.
4. Apply the conservation of mass to reacting systems to determine balanced reaction equations.
5. Apply energy balances to reacting systems for both steady flow control volumes and fixed mass systems.
6. Calculate the enthalpy of reaction, enthalpy of combustion, and the calorific values of fuels.
7. Determine composition and properties of mixtures.

Course Content

<u>Mixtures and Psychrometry</u>

Gaseous mixture and gas laws

Perfect gas mixtures

Ideal gas and vapour mixtures

Fundamental parameters of water/air mixtures

Adiabatic saturator and psychrometric chart

Moist air processes

Air-Conditioning processes

Cooling towers.

<u>Fuels and Combustion</u>

Types and properties of fuels:

Solid fuels – coal, wood

Liquid fuels – Petroleum, shale oil, biofuels

Gaseous fuels – coal gas, producer gas, natural gas, blast furnace gas, biogas

Fundamentals of reaction mixtures and definitions

Fuel and product analysis and chemical balance equations

Consistent enthalpy and energy scales and use of Thermochemical Tables (e.g. JANAF)

Heat of reaction

Adiabatic flame temperature

Chemical equilibrium and dissociation

Combustion Thermodynamics

Internal Combustion Engines

Types and operation of S.I and C.I engines

Fuels for internal combustion engines.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

1) Air-conditioning experiment

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1. A two-hour end of semester written examination (70 %).
2. Course work: Written continuous assessment tests (20%)
3. Laboratory reports (10 %).

Core Reading Materials

1) Moran, M J, Shapiro, H N, Boettner, D D and Bailey, M B (2018), *Fundamentals of Engineering Thermodynamics,* 9^{th} Ed, Wiley.
2) Rogers G.F.C. & Mayhew Y.R. (1992) *Engineering Thermodynamics*, Longman Singapore Publishers, 4th Ed.
3) Eastop T.D. and McConkey A. (2002) *Applied Thermodynamics for Engineering Technologists,* Prentice and Hall, 5th Ed.
4) Cengel, Y A, Boles, M A, and Konoghu, M (2019), *Thermodynamics: An Engineering Approach*. McGraw-Hill.

Recommended Reference Materials:

1) Michael J. M. & Howard N. S. (2007) *Fundamentals of Engineering Thermodynamics*, Wiley, 6^{th} Ed.
2) Lynn D. R. & George A. A. (2006) *Classical Thermodynamics*, Oxford University Press, In. Ed.
3) International Journal of Fluid and Thermal Engineering.

FME 431: Fluid Mechanics V (60 hours)

Prerequisite:

FME 332: Fluid Mechanics IV

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on the principles of operation of fluid machinery together with the underlying flow phenomena.

Expected Learning outcomes

At the end of this unit, the student should be able to:

1. Discuss the general characteristics of open-channel flow.
2. Use a specific energy diagram.
3. Analyse open-channel flow with uniform depth.

4. Calculate key properties of a hydraulic jump.
5. Construct appropriate velocity triangles.
6. Calculate parameters related to centrifugal pumps.
7. Calculate shaft torque and power for turbines.
8. Select the appropriate pump or turbine based on the specific speed.

Course Content

1) Transient Flow: Definitions, inertia forcers, pressure, transients, water hammer, surge tanks and their applications.

2) Flow with a Free Surface: Open Channels, Chezy Equation and Hydraulic Mean Depth, simple waves and surges, hydraulic jump.

3) Principles of Fluid Machinery. General introduction. Classification and applications. Basic equations. Vector diagrams, torque and work calculation. Turbines; axial and radial flow types, Compressors and pumps; axial and radial flow types. Hydrodynamic Transmission: Fluid power converters.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

1. Determination of characteristic curve of a centrifugal fan

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1. Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.
2. Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.
3. Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

Recommended Reference Materials

1. Gasiorek J.M. & Swaffield J. A., (2001), *Fluid Mechanics*, Prentice Hall, 4th Ed.
2. Journal of Fluids Engineering.

FME 432: Fluid mechanics VI (60 hours)

Prerequisites

FME 431: Fluid Mechanics V

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills in the principles of compressible fluid flow, tribology and two-phase flow.

Expected Learning Outcomes

After completing this unit, learner will be able to do the following:

1. Analyse the mechanics of flow through compressible fluids (gases).
2. Analyse frictionless flow in constant area ducts.
3. Examine Fanno Flow and Raleigh line flow.
4. Discuss normal and oblique shocks
5. Appraise hydrodynamic lubrication
6. Correlate two-phase flows.

Course Content

1) Compressible Flow
   - One –dimensional treatment
   - Sonic velocity in an elastic medium under isentropic conditions
   - Basic relations for steady flow of a perfect gas. Isentropic stagnation properties for a perfect gas.
   - Convergent and convergent-Divergent duct flow
   - Normal shock wave. Equations of motion of a normal shock wave of a perfect gas. Properties changes across a normal shock.
   - Stagnation properties changes. Oblique shock wave. Plane oblique shock wave. Curved oblique shock wave. Pitot tube in compressible flow. Adiabatic flow of a perfect gas through constant area duct.
2) Aerofoil Flow Theory

   Application of ideal flow theory and boundary layer flow theories to aerofoils. Kutta-Joukowski transformations for aerofoil flow. Aerofoils of finite span.
3) Hydrodynamic Lubrication
   - Generation of oil pressure hydrodynamically
   - Reynolds' equation for one and two dimensional cases
   - Infinitely long pad bearings. Lead and centre of pressure.
   - Journal bearings. Equations. Sommerfield conditions.
   - Reynolds' condition
4) Introduction to two phase flow

   Basic definitions. Flow patterns in pipes. Two-phase flow correlations.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Practical Work/Laboratory Exercises

1) Compressible flow in a convergent-divergent nozzle

Instruction materials and equipment:

1. Lecture room with white board.

2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1. Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.
2. Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.
3. Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

Recommended Reference Materials

1. Gasiorek J.M. & Swaffield J. A., (2001), *Fluid Mechanics*, Prentice Hall, 4th Ed.
2. Journal of Fluids Engineering.

FME 441: Engineering Project Management (45 hours)

Prerequisite:

FME 343: Business Management for Engineers

Purpose of the Course Unit

The purpose of this unit is to provide the learner with knowledge and skills on the art and science of managing engineering projects and managing resources of an organization.

Expected Learning Outcomes

At the end of the course, a learner will be able to:

1. *Conduct a project feasibility study.*
2. *Assess whether it is economically viable to invest organization resources in a particular project.*
3. *Use different models and tools to optimally sequence project activities.*
4. *Evaluate required project resources.*
5. *Use a project management information system to manage projects.*
6. *Monitor and appraise projects to ensure deliverables are made within agreed terms.*
7. *Conduct a project evaluation study.*

Course Content

- *Introduction: Definition of a project, project life cycle, project selection and evaluation criteria;*
- *Project feasibility studies and planning;*
- *Economic feasibility of investment project: Application of Payback period method, present value method, Net Present Value method, Internal Rate of Return method, Benefit/cost ratio method;*
- *Building the project framework, components of the project plan, developing a common understanding of the project, importance of project scope statement, utilizing the Work Breakdown Structure (WBS) and the project schedule.*
- *Examining the outline of WBS, structuring by phase or deliverables, refining the deliverable acceptance and sign-off. Network analysis.*
- *Project Scheduling: Relationship between project scheduling and the WBS; Gantt chart, Network Models (CPM & PERT);*
- *Manpower levelling, PERT cost, Resource allocation and budget factors (assignment of time and costs); Establishing expectations; Price theory ; The general view of the price system, elementary theory of supply and demand;*
- *National income, money and banking, international trade;*
- *Project monitoring and control;*
- *Project management information system: MS project*

- *Project Evaluation.*

Mode of Delivery:

A combination of lectures, tutorial sessions, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Tutorials, quizzes, assignments, etc. (10%)

Core Reading Materials

1. Lester, Albert. *Project Management, Planning and Control*. 5th Edition. Butterworth-Heinemann. (2007)
2. Nicholas, John M. *Project Management for Business and Engineering*: Principles and Practice. 2nd Edition. Elsevier. (2004)
3. Nicholas, John M. and Steyn, Herman. *Project Management for Engineering, Business and Technology*. 4th Edition. Routledge. (2012)
4. Biafore, Bonnie. *Microsoft Project 2013: The missing manual*. O'Reilly Media, Inc. (2013)

FME 442: Maintenance Engineering (45 hours)

Prerequisites

None

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on the schemes and procedures used to maintain industrial machinery.

Expected Learning Outcomes

At the end of this course, the learner should be able to:

1. *Differentiate between the various types of maintenance functions.*
2. *Articulate the importance of maintenance to the reliability and safety of industrial machinery.*
3. *Relate the legal requirements to safety matters in work places*
4. *Assess the risk of industrial fires*
5. *Evaluate the methods of fire prevention in a specific industrial setting.*

Course Content

- *Introduction: Meaning and value of maintenance; Historical Evolution; Types of maintenance*
- *Condition based maintenance; Preventive maintenance routines; Corrective maintenance; routine maintenance.*
- *Different maintenance procedures*
- *Maintenance Strategies, Planning, Scheduling and Control: Maintenance programmes; Planning; Scheduling; Budgeting; Human resource planning; Outsourcing*
- *Costing: Maintenance costs; Cost analysis; Replacement analysis and justification*
- *Maintenance- Energy efficiency links: Motors, lighting, mechanical equipment; Energy savings opportunities*
- *Computerized maintenance management Systems – CMMS*
- *Introduction to advances in Maintenance*

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises reports (10%)

Core Reading Materials

1) Richardson, D (2013), *Plant Equipment and Maintenance Engineering Handbook*, Butterworth-Heinemann.
2) Nyman, D and Levitt, J (2010), *Maintenance Planning, Coordination and Scheduling,* Industrial Press Inc.
3) Palmer, R (2012) *Maintenance Planning and Scheduling Handbook*, McGraw-Hill.
4) Zalosh, R G (2003) *Industrial Fire Prevention*, Wiley.

Recommended Reference Materials

1) Mobley, R K (2014) *Maintenance Engineering Handbook,* McGraw-Hill.
2) Giustina, D E D (2020) *Fire Safety Management Handbook*, CRC Press
3) International Journal of Innovation, Management and Technology

FME 452: Materials Science and Engineering IV: Failure: Mechanisms and Prevention (60 hours)

Prerequisite:

FME 251: Materials Science and Engineering I

Purpose of the course unit:

To impact on the learner knowledge and skills on the various causes of materials failure, the mechanisms of the failures, and how to identify and mitigate against such failures.

Expected learning outcomes:

After completing the unit, the learner will be able to do the following:

1. Identify a fatigue fracture by examining the fractured surface.
2. Apply the principles of fracture mechanics to fatigue and fracture control.
3. Design machine components and structures against brittle fracture, fatigue and creep failure.
4. Evaluate the effects of mean stress, surface finish, type of load and cumulative fatigue on the fatigue life of a component.
5. Generate through experimentation, the creep curve of a typical metallic alloy.
6. Classify fractures and identify the type of fracture by examination of the fracture surface.
7. Evaluate the effects of notches and cracks on fracture behaviour.

Course content:

<u>Fatigue failures:</u> Low cycle fatigue (LCF) and high cycle fatigue (HCF), HCF testing (S-N curves), factors affecting endurance limit, effects of mean stress on HCF, cumulative fatigue, low cycle fatigue testing and analysis, corrosion fatigue, fretting.

<u>Creep failures:</u> The creep curve, reasons for creep, creep mechanisms: dislocation motion, diffusion, deformation mechanism maps, mechanisms of creep rupture, design against creep, stress relaxation, prediction of long term creep properties (time-temperature compensation, Larson-Miller and similar parameters), creep in polymers.

Brittle fracture: Ductile versus brittle fracture, ductile to brittle transition, notches in brittle fracture.

Introduction to fracture mechanics: linear elastic fracture mechanics: the energy balance approach, stress intensity factor approach, plain strain fracture toughness test, R-curve concept; Elastic-plastic fracture mechanics: the J_{Ic} test, COD test; use of fracture mechanics in design; application of fracture mechanics to fatigue crack growth, FCG testing (short and long cracks).

Introduction to Non-destructive Testing: Surface methods, magnetic particle testing, eddy current testing, ultrasonic testing, X-ray and -ray radiography, X-ray microtomography.

Mode of delivery:

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Laboratory Exercises:

1. Plotting the S-N curves of various metallic alloys.
2. Creep properties of lead.
3. Effect of carbon content or tempering temperature on the brittle to ductile transition in steel.
4. Low cycle fatigue characteristics of a metallic alloy.
5. Demonstration of common NDT techniques.

Course assessment:

The course shall be assessed by both coursework (accounting for 30 %) and an end of semester written examination constituting 70 %. The coursework shall in turn consist of laboratory practicals (10 %), written continuous assessment tests, tutorials, quizzes, assignments, etc. (20 %).

Core reading materials:

1. Anderson, T L (2017) *Fracture Mechanics*, CRC Press.
2. Callister, W D and Rethwisch, D G (2019) *Materials Science and Engineering,* John Wiley and Sons.
3. Hertzberg, R W, Vinci, R P and Hertzberg, J L (2012). *Deformation and Fracture Mechanics of Engineering Materials*, John Wiley and Sons.
4. Rading, G O (2007) *Concise Notes on Materials Science and Engineering,* Trafford Publishing, Victoria, Canada.
5. Ashby, M F Shercliff, H and Cebon, D (2019), *Materials: Engineering, Science, Processes and Design*, Butterworth-Heinemann.

FME 461 – Mechanical Engineering Design II (60 hrs)

Prerequisites

FME 362: Mechanical Engineering Design I.

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on the design a machine and machine elements including working as part of a design team.

Expected Learning Outcomes

At the end of this course, the learner should be able to:

1. Articulate the ethics of engineering design and safe design principles
2. Analyse fatigue failure of machine components
3. Design a machine consisting of several machine components
4. Execute design of a machine using CAD.

Course Content

- Ethics and safety
- Failure modes, effects, analysis

- Design against fatigue failure of machine components
- Design of power transmission components including shafts, couplings, seals, chains, belts, wire ropes, gears and rolling contact bearings.
- Design using computers aided design
- Group design project, project report and oral presentations.

Mode of Delivery

A combination of lectures and design exercises (manual and computer based).

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary drawing and computing facilities

Course Assessment

The course shall be examined entirely by course work as follows:

1. Individual design assignments – 30%
2. Group design activities with individual contributions documented in journal entries and submitted for assessment and report – 60%
3. End of semester individual oral presentations – 10%

Core Reading Materials

1) Budynas-Nisbett (2015) *Shigley's Mechanical Engineering Design* – 10th Edition, MHE.
2) Norton, R (2011) *Design of Machinery,* McGraw-Hill.
3) Boothroyd, G, Dewhurst, P and Knight, W A (2010) *Product Design for Manufacturing and Assembly,* CRC Press.
4) Ullman, D G (2010) *The mechanical Design Process* – 4th Edition.

FME 462 – Mechanical Engineering Design III (60 hrs)

Prerequisites

FME 461 Mechanical Engineering Design II.

Purpose of the Course Unit

The purpose of this course is to enable the learners to apply the basic engineering principles to the design of machine elements including bearings, gears, brakes and clutches, couplings and flywheels, belts and chains.

Expected Learning Outcomes

At the end of this course, the learner will be able to:

1. Design of a machine consists of several machine components
2. Design a machine using CAD
3. Work successfully as a member of a design team
4. Assess the ethical, cost, environmental and manufacturing constraints in machine element design.

Course Content

1) Design and analysis of springs
2) Design and analysis of plain surface bearings
3) Design and Analysis of Brakes and Clutches
4) Design of linear motion elements such as power screws
5) Design of mechanical fasters and welded joints
6) Design and Analysis of Couplings and flywheels
7) Design using computers aided design
8) Group design project, project report and oral presentations.

Mode of Delivery

A combination of lectures and design exercises (manual and computer based).

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids

6. Necessary computing facilities

Course Assessment

The course shall be examined entirely by course work as follows:

1. Individual design assignments – 30%
2. Group design activities with individual contributions documented in journal entries and submitted for assessment and report – 60%
3. End of semester individual oral presentations – 10%

Core Reading Materials

1. Budynas-Nisbett (2015) *Shigley's Mechanical Engineering Design* – 10th Edition, MHE.
2. Norton, R (2011) *Design of Machinery,* McGraw-Hill.
3. Boothroyd, G, Dewhurst, P and Knight, W A (2010) *Product Design for Manufacturing and Assembly,* CRC Press.
4. Ullman, D G (2010) *The mechanical Design Process* – 4th Edition.

FME 472: Numerical Methods for Engineers (45 hours)

Prerequisite:

FME 371: Complex Analysis and Differential Equations

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skill in solving ordinary and partial differential equations numerically.

Expected Learning Outcomes

At the end of this course, the student will be able to;

1. Analyse a system of simultaneous linear equations.
2. Solve higher order ordinary and partial differential equations.
3. Use computational methods in solving partial differential equations.

Course Content

1) Interpolation: Finite differences, interpolation formulae based on finite difference, Lagrange interpolation including iterated interpolation, applications.
2) Curve-fitting: Least square method, applications.
3) Numerical Differentiation and Integration: Derivatives from interpolating polynomials, trapezoidal rule., Simpson's rule, Newton-Cotes formulae, Romberg integration., the trapezoidal and Simpson's rules with end corrections, applications.
4) Numerical Solution of Ordinary Differential Equations: Taylor's series method, Euler's method, Runge-Kutta method, predictor-corrector method, extrapolation methods, simple boundary-value problems, applications.
5) Matrices and Simultaneous Linear Equations: Gaussian elimination and the LU decomposition methods for solving simultaneous linear equations, alternative methods – Jacobi, Gauss –Seidel and introductory SOR methods.

Mode of Delivery

A combination of lectures, tutorial sessions, computing sessions and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD projector
5. Audio-visual aids
6. Necessary computing facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: (30%)

Core Reading Materials

1) Chapra S.C., Canale R.P., (2005), Numerical Methods for Engineers, McGraw-Hill.

2) Griffiths D. V., Smith I. M., (2006), Numerical Methods for Engineers, CRC Press.
3) Hoffman J. D., (2001), Numerical Methods for Engineers and Scientists, CRC Press.

Recommended Reference Materials

1) International Journal of Applied Mathematics and Computer Sciences

FME 491: Electrical Measurement and Instrumentation (45 hours)

Prerequisites

FME 291: Electrical Circuit Theory

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on the principles of electrical measurements using both digital and analytical instruments; and the errors inherent therein.

Expected Learning Outcomes

At the end of this course, learner will be able to:

1. Analyse measurement errors.
2. Examine the static and dynamic characteristics of instrumentation systems.
3. Assess various remote sensing techniques.
4. Formulate suitable signal processing routines.

Course Content

1) Measurement: Principles of operation and construction of measuring instruments including CRO.
2) Instrumentation: Transducers, circuitry for transducers, measuring instruments, display and recording instruments, errors of measurement.

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1) Cataldi, A et al. (2020) *Basic Theory and Laboratory Experiments in Measurement and Instrumentation*, Springer.
2) Morris A.S., (2001), *Measurement and Instrumentation Principles*, Butterworth-Heinemann.
3) Malaric, R (2011) *Instrumentation and Measurement in Electrical Engineering*, Brown Walker Press.
4) Srinivas, G N and Narasimba, H (2018), *Electrical and Electronic Measurements and Instrumentation*, BS Publications.

Recommended Reference Materials

1) Webster J G and Eren, H (Eds.) (2016), *Measurement, Instrumentation and Sensor Handbook*, CRC Press.
2) Journal of Dynamic Systems, Measurement, and Control.

FME 492: Programmable Logic Controllers (45 hours)

Prerequisites:

FME 291: Electrical Circuit Theory

FME 182: Computer Science II

Purpose of the Course Unit

The purpose of this course is to enable students acquire basic knowledge and skills in identifying, implementing, programming and troubleshooting industrial applications requiring programmable controllers.

Expected Learning Outcomes:

At the end of this course, the learner will be able to:

1. *Install programmable electronic controllers*
2. *Program Programmable electronic controllers*
3. *Apply electronic controllers in industry*

Course Content

Basic concepts and skills needed to install, program, and apply programmable electronic/logic controllers (PLC) in industry. Discrete and analogue input/output (I/O) systems and devices. Introduction to ladder logic. PLC functions including basic, intermediate and advanced functions. Experiments in PLC operation, programming, and industrial applications.

Laboratory Activities

- *PLC Wiring*
- *Introduction to ladder logic: Basic ladder logic programs focusing of the use of series and parallel logic*
- *Basic ladder logic: Ladder logic programming including conditional outputs and use of internal memory coils*
- *Timers: Use various PLC timers to implement simple programs that required logical durations*
- *Counters: Use various PLC counters to simulate an industrial automated counting process*

- *Using both timers and counters: The students will combine knowledge of programming timers and counters to implement an automated timed counting process.*
- *Shift registers: Use shift registers to implement a sequential process in which a set of outputs are controlled in a particular sequence.*
- *Drum Sequencer: Implement the same process as in activity 7 using a drum sequencer*
- *Introduction to analogue I/O: Connecting analogue input devices to the PLC's analogue input channels. They vary the analogue signals and write a simple program that will implement the analogue to digital conversion and display the process values*

Mode of Delivery

A combination of lectures, tutorial sessions, laboratory exercises, computer simulations and guided self-study.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. Overhead projector
5. Audio-visual aids
6. Necessary computing facilities
7. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting 40%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises and reports (40%)

Core Reading Materials

1. Petruzella, F.D. (2016) *Programmable Logic Controllers*, McGraw Hill, 4th Edition
2. Rabiee M. (2017) *Programmable Login Controllers;Hardware and Programming ,*4th Edition, Goodhearth- willcox,
3. Lin. J. S. (2016) *Programmable Logic Controllers,* Industrial Press Inc, 1st edition

INDUSTRIAL ATTACHMENT

FME 499: Industrial Attachment (Minimum of 8 weeks)

Prerequisite:

All fourth year courses

Purpose of the Course Unit

The purpose of this unit is to introduce the learner to the real World of engineering practice by engaging in hands on activities in an industrial environment thereby inculcating in the learner the interconnection between theory and practice.

Expected Learning Outcomes

At the end of the Attachment, the learner will be able to:

1. Operate industrial machines like lathes, shapers and milling machines and use them to produce usable components.
2. Perform industrial operations like welding, casting, etc.
3. Function as part of a multi-disciplinary team that includes players with different knowledge and skill levels.
4. Assess aspects of an industrial set up including safety and discipline issues.
5. Articulate an engineering industrial problem for further study and research possibly as a final year project.

Course Description

The learner shall be attached to a relevant industry identified by the Department for a minimum duration of 8 weeks. In the industry, he/she will be assigned to work under the direct supervision of an Industry Engineer (who should preferably have a mechanical engineering degree and be registered as a Professional Engineer with the EBK). They will be assigned practical duties commensurate with their competence. The leaner shall keep a log book detailing his/her daily activities. Each week, the learner will select the most interesting activity and present a detailed description of the same including engineering drawings, material schedules and manufacturing procedures. The log book shall be assessed and signed by the industry engineer on a weekly basis. A Lecturer from the Department shall visit the learner at least twice during the duration of the attachment. In addition, the learner will identify and articulate an engineering problem at the industry and present this in a report.

Mode of Delivery

Assignment of actual practical work to be completed by the learner.

Instruction Materials and Equipment

Various machines and equipment depending on the specific industry

Course Assessment

The course assessment shall be guided by the supervising Lecturer with the assistance of the Industry Engineer and consist of the following components:

Assessor	**Basis of Assessment**	**Marks**
Industry Engineer/ Supervising Lecturer	Attendance, punctuality, work attitude, creativity, etc.	40
Supervising Lecturer	Visits (attitude of the learner, discussion with the Industry Engineer, knowledge of the industry, etc.)	20
Supervising Lecturer	Log book and weekly reports	20
Supervising Lecturer	Articulation of the Industrial Problem	20
TOTAL		**100**

In case of unsatisfactory performance by the learner (failure of the course), the learner may be required to:

1. Present a corrected log book or report within two months.
2. Repeat the attachment (at the same or a different industry) when it is next offered.

The Department regulations concerning number of repeats shall apply.

Core Reading Materials

None

Recommended Reference Materials

Various machine operation manuals and practice codes and standards relevant to the specific industry.

FIFTH YEAR COURSES

FME 502: Solid & Structural Mechanics VI (60 hours)

Prerequisites

1. FME 401: Solid & Structural Mechanics V

Purpose of the Course Unit

This course will provide students with the knowledge, skills and competence on the determination of stresses and strains in thin walled structures under torsional loading and the design and analysis of plates and shells.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Calculate the shear stresses induced by torsional deformation in thin walled structures.
2. Analyse the deformation of beam columns.
3. Solve problems relating to loading and deflection of thin plates and shells.
4. Illustrate the mathematical foundation for analysis of 3D stress-strain systems.

Course Content

1. Shear: Shear stress due to torsion, simple concepts of non-circular torsion theory, shear stress distribution due to torsion of thin-walled non-circular closed cross section-single cell and multi-cell cross section.
2. Classical plate theory: Plate theories, bending theory of plates, bending equations for rectangular plates, bending equations for circular plates, bending of symmetrical loaded circular plates, rectangular plates under combined lateral and direct loads.
3. Classical shell theory: Equilibrium equations, membrane theory of shells, Gauss-Codazzi conditions, 3D measure of large deformation strain, shell theories;
4. Beam Columns: Rigorous method and approximate engineering methods, modified methods of super position.
5. 3-D Analysis of stress and Strain: Introduction to tensors, tensor components, transformation laws, spherical and deviator tensors, principle stresses and

strains, octahedral stresses and strains, equilibrium equations, generalized Hooke's law, compatibility equations.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises / Design exercises

1. Deflection of thin walled tubes loaded in torsion.
2. Deflection of beam columns.
3. Deflection in thin plates.
4. Deflection in thin shells.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

1. One, two-hour examination at the end of the semester (70%),
2. Continuous assessment tests (20%),
3. Laboratory / design reports (10%).

Core Reading Materials

1. Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
2. Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.
3. Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.
4. Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.

Recommended Reference Materials

1. Journal of Engineering Materials and Technology

FME 503: ELASTICITY AND PLASTICITY (45 hours)

Prerequisite:

FME 502: Solid and Structural Mechanics V

Purpose of the Course Unit:

This course will equip the learner with knowledge, skills and competence on the basics of stress analysis using the theory of elasticity:

Expected Learning Outcomes:

At the end of this course, the leaner will be able to:

1. Analyse the 3D state of stress at a point, including determination of stress at angle and the principal stresses.
2. Investigate the stress in a loaded member using the Airy stress function.
3. Formulate stress analysis problems using both rectangular and polar coordinates.
4. Examine the yield condition of a 3D loaded member based on various yield criteria.

Course Content:

3D analysis of stress and strain: Stress at a Point: The Stress Tensor; Stress on an Inclined Plane; Principal Stresses: Stress Invariants; Transformation of Axes; Mean and Deviatoric Stress Tensors; Maximum Shear Stresses; Octrahedral Plane and Stresses; Mohr's Circle for 3D Stress. Analysis of strain: Strain at a Point; Strain at an Angle; Principal Strains/Strain Invariants/Mohr's Circle for Strain.

Introduction to the theory of 2D elasticity: Basic equations of 2d elasticity; Equations of Equilibrium; Equations of Compatibility; Constitutive Equations; Boundary

Conditions. The Airy stress function: Expressions of in rectangular coordinates; direct determination of inverse method of determining; St. Vernant’s Principle; expressions of in polar coordinates; stress and strain components; Equilibrium Equations; Airy stress function; axi-symmetric stress distribution; some standard solutions: Kirsch solution, Flamant solution; Michell solution.

Introduction to the theory of plasticity in 3D: plastic behaviour in uni-axial loading; yield criteria for multi-axial loading; examples of yield criteria; yield surface: Haigh-Westergaard stress surface; Lode’s stress parameter; plastic stress-strain relationships: Prandtl-Reuss equations; relations based on Tresca’s criterion; Levy-von Misses equations; Henky equations. Some elasto-plastic problems: elasto-plastic Bending; elasto-plastic torsion; thick-walled tubes; rotating Discs.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids

Course Assessment:

The course will be assessed as follows:

1. End of Semester examination 70 %
2. Scheduled tests (CATs) 20 %
3. CA (assignments, tutorials, class participation, etc.) 10 %

Core Reading Materials:

1. Westergaard, H M (2014) *Theory of Elasticity and Plasticity*, Harvard University Press.

2. Timoshenko, S P and Goodier, J N. (2010) *Theory of Elasticity*, McGraw-Hill India.
3. Chakrabarty, J (2012) *Theory of Plasticity,* Butterworth-Heinemann.
4. Green, A E and Zerna, W (2012) *Theoretical Elasticity,* Dover Publications.
5. Atkin, R J and Fox, N (2005) *An Introduction to the Theory of Elasticity*, Dover Publications.

FME 504: Experimental Stress Analysis (60 hours)

Prerequisites

FME 401: Solid & Structural Mechanics V

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain the knowledge, skills and competence on methods and procedures of experimentally determining stresses in structural members.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Select appropriate strain gauges for use in different applications in formation and breakage mechanisms.
2. Use strain gauges to measure the stress distribution a loaded structure.
3. Implement photo-elasticity in analysing the stress distribution in a loaded structure.
4. Model the loading response of structures using photo-elasticity.
5. Design load cells to determine forces and torques.

Course Content

1. Introduction to strain gauges: Types of strain gauges, geometries and mounting techniques; piezo-resistors, nano-particle-based strain gauges, mercury-in-rubber strain gauge, fibre optic sensing micro-scale strain gauges, Capacitive strain gauges, Vibrating wire strain gauges.

2. Basic principles and application of electrical resistance strain gauges: Transverse sensitivity factor; temperature compensation, Rosette analysis, stress gauge, strain recording instruments – potentiometer circuit; whetstone bridge.
3. Plane, Parallel and Crossed Polariscopes: Isochromatic and isoclinic fringe patterns, two-dimensional model analysis; boundary stresses and stress concentration factors, separation of principal stress, general principles of three-dimensional photo elasticity and engineering applications.
4. Reflective Photo-elasticity:

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises / Design exercises

1. Testing of a load cell.

Instruction materials and equipment:

1. Lecture rooms with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

1. One, two-hour examination at the end of the semester (40%),
2. Continuous assessment tests (20%),
3. Laboratory / design reports (40%).

Core Reading Materials

1. James W. D & William F.R. (2005) *Experimental Stress Analysis*, McGraw-Hill, 3rd Ed.
2. Freddi, A, Olmi, G and Cristofolini, L (2015) *Experimental Stress Analysis for Materials and Structures*, Springer.

3. Doyle, J F (2004) *Modern Experimental Analysis*, Wiley.
4. Srinivas, J (2012) *Stress Analysis and Experimental Techniques*, Alpha Science.

Recommended Reference Materials

1. Strain
2. Journal of Experimental Stress Analysis

FME 506: Vehicle Structural Design (60 hours)

Prerequisites

FME 401: Solid & Structural Mechanics V

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain the knowledge, skills and competence on the design and analysis of the structural framework of motor vehicles.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. *Classify types of vehicle chassis and suspension systems.*
2. *Apply 3D modelling tools for design and analysis of vehicle structures.*
3. *Categorise the types of materials used and techniques of joining sheet structures in the construction of vehicle structures*
4. *Analyse vehicle structures for dynamic response, crash worthiness, and occupant protection.*

Course Content

1. *Chassis types: body-over-frame structure, closed tube (box tube) / backbone structure, triangulated tube, punt or platform structure, pure monochoque, birdcage structure, unitary body structure*
2. *Types of suspension systems: Rigid axle suspension, swing axle system, sliding pillar system, Macpherson Strut, double wishbone system, trailing link system, multi-link suspension, semi-trailing arm system, twist-beam rear suspension.*

3. *Design software: Types: 3Ds Max, Pro-engineer, CATIA, Solidworks, Inventor; file extensions and translators, parts libraries, parametric design principles, simulation capability.*
4. *3D design of vehicle structures: Concept development sketching, styling and aesthetics, clay modelling, interior design and ergonomics, colour and trim.*
5. *Materials for vehicle structures: Steel grades, aluminium grades, fibre-reinforced plastics,*
6. *Joining, forming and finishing techniques: Spot welding, full welding, folding, epoxy adhesives, riveting, surface preparation, and painting.*
7. *Analysis of vehicle bodies: Road induced dynamics, crash worthiness, occupant protection.*

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises / Design exercises

1. *Design and analysis of a monocoque vehicle structure.*
2. *Deflection of a frame vehicle structure.*
3. *Response of a vehicle floor panel under road conditions.*

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

1. One, two-hour examination at the end of the semester (70%),
2. Continuous assessment tests (20%),
3. Laboratory / design reports (10%).

Core Reading Materials

1. Brown J.W., Robertson A.J. and Serpento S. T (2002) *Motor Vehicle Structures, Concepts and Fundamentals,* 1st Edition. Butterworth Heinemann Publishers.
2. Prasad P., Belwafa J.E.: *Vehicle Crashworthiness and Occupant Protection*: Automotive Applications Committee, American Iron and Steel Institute, Southfield, Michigan.
3. Crolla, DA (2009) *Automotive Engineering:Power train, Chassis system, and Vehicle body*: Elsevier.

FME 507: NON DESTRUCTIVE TESTING (60 hours)

Prerequisite:

FME 251: Materials Science and Engineering I

Purpose of the course unit:

To equip the learner with knowledge and skills of the various methods available to test machines and structures without destroying them, and the strengths and limitations of each method.

Expected learning outcomes:

At the end of the course, the learner will be able to:

1. Describe the principles of various NDT methods.
2. Select the most appropriate NDT technique for a given application.
3. Perform a specific NDT test.
4. Interpret and analyse the results of various NDT techniques and advice on the severity of any defects based on the dictates of the relevant standard.

Course content:

Theory and applications of NDT.

<u>Surface and near surface methods</u>: dye penetrant method: principles, processing cycles, applications, limitations; magnetic particle: Principle, processing cycles, applications, limitations.

Ultrasonic testing: principles: wave propagation principles, ultrasonic generation and reception; testing equipment: piezoelectric crystals, transducers; applications and limitations.

Eddy current testing: principles, impedance plane diagrams, magnetic permeability and coils, instrumentation, applications and standards.

Radiography techniques: X-ray and γ-ray radiography principles, sources of radiation, characteristics of radiation, exposure variables, selection of best method, radiation safety.

Introduction to other NDT methods: acoustic emission, microwave, optical holography, laser based testing, infrared; national and international standards on NDT.

Mode of delivery:

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials & equipment

Overhead projector, Non-destructive test equipment (penetrant dyes, UT tester, X-ray apparatus, γ-ray equipment, eddy current apparatus).

Course assessment:

The course shall be assessed by both coursework (accounting for 50 %) and an end of semester written examination constituting 50 %. The coursework shall in turn consist of laboratory/field practicals (35 %), written continuous assessment tests (15 %).

Core reading materials:

1. Hull, B (2012), *Non-Destructive Testing*, Springer Verlag GmbH.
2. Hellier, C J (2003), *Handbook of Non-Destructive Evaluation*, ISBN: 0-007-028121-1.
3. International Atomic Agency (2000), *Training Guidelines in Non-Destructive Testing Techniques*, IAEA-TECDOC-628.

FME 511 – Dynamic Systems and Control (60 hours)

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain the knowledge, skills and competence on the analysis and control of dynamic mechanical systems.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Calculate the response given the input to a control system.
2. Determine the stability of a give system using Routh and Hurtwiz criterions.
3. Determine the stability of a give system using Nyquist analysis.

Course Content

1) Introduction to Control Engineering: Basic concepts, the automatic control problem, examples of control systems, brief history of automatic control.
2) Mathematical Models of Dynamic Systems: Mathematical models of mechanical, electrical and electronic, thermal and fluid systems. Differential equations, state equations, system identification, linearization, transfer functions, block diagrams and signal flow graphs, Mason's gain formula.
3) Control Systems Components: Sensors, Transformers, Actuators.
4) Feedback Control System Characteristics: Time response of systems, time domain specifications, numerical simulation, closed-loop systems, three-term control, steady-state tracking, disturbances, stability, Routh-Hurwitz criterion.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture rooms with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids

6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1) Gene F. (2005) *Feedback Control of Dynamic Systems*, Prentice Hall, 5th Ed.
2) Kuo B. C. & Farid G. (2002) Automatic Control Systems, Wiley, 8th Ed.

Recommended Reference Materials

Journal of Dynamic Systems, Measurement, and Control

FME 513 – Advanced Mechanical Vibrations (60 hours)

Prerequisites

FME 412: Mechanical Vibrations

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain Knowledge and skills on the causes, effects and mitigation measures of mechanical vibrations in mechanisms.

Expected Learning Outcomes

At the end of this course, the student will be able to;

1. Employ mathematical modelling to the study of multi-DOF vibrating systems,
2. Apply energy methods to analyse multi-degree of freedom systems
3. Analyse vibrating continuous systems,
4. Analyse vibrating self-excited systems,
5. Apply methods of analysis of sound transmission.

Course Content

1. *Properties of Multi-degree of freedom (MDOF) Vibrating Systems:* Orthogonality of principal modes, repeated roots, modal matrix, modal damping in forced vibration, normal mode summation,
2. *The Lagrangean Formulation of Vibrating Systems:* Generalized coordinates, the principle of virtual work, Lagrange's equation, solution in terms of normal coordinates.
3. *Continuous Systems:* The vibrating string, longitudinal vibration of rods, torsional vibration of rods, the Euler equation for beams, vibration in membranes and plates.
4. *Self-excited Vibrations:* Principle of self-excitation, dry friction excitation, flow excitation.
5. *Sound Transmission:* Linear, cylindrical and spherical spreading. Scale measurement, physiological effects. Sound transmission and isolation.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Laboratory exercises / Design exercises

1. Lab experiment of a vibrating continuous systems,
2. Lab experiment of a vibrating self-excited systems,
3. Lab experiment of sound transmission.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

1. One, two-hour examination at the end of the semester (70%),

2. Continuous assessment tests (20%),
3. Laboratory / design reports (10%).

Core Reading Materials

1. Rao, S S (2016) *Mechanical Vibrations*, Sixth Edition. Pearson.
2. Inman, D (2013) *Engineering Vibrations,* Pearson.
3. Graham, K S (2012) *Mechanical Vibration: Theory and Application*s, SI Edition. Cengage Learning.
4. Dukkipati, R V. (2007) *Solving Vibration Problems Using MATLAB.* New Age International Publishers.

Recommended Reference Materials

1. Journal of Vibrations and Acoustics

FME 521: Heat Transfer I (60 hours)

Prerequisites

None

Purpose of the Course Unit

The purpose of this course is to enable the student to gain knowledge and skills in conduction and convection heat transfer mechanisms.

Expected Learning Outcomes

At the end of the course, the learner will be able to:

1. Explain the mechanisms of conduction and convection heat transfer.
2. Determine conduction heat transfer rates from various geometries including extended surfaces.
3. Determine temperature gradients in conducting medium.
4. Estimate rate of heat transfer and temperature profiles in transient conduction systems.
5. Determine rates of convective heat transfer for laminar flow over flat plates and in ducts.

Course Content

Scope and Nature of Heat Transfer

Conduction

- Thermal Conductivity
- Fourier Law of conduction
- Derivation of general conduction equation in different co-ordinates
- Newton's law of cooling
- Methods of solution outline
- Steady state one-dimensional solution for slab cylinder and sphere
- Conductors in series and use of electrical analogy
- Critical radius of insulation for pipe steady conduction with heat sources.
- Fins
- Two-dimensional steady state conduction
- Transient conduction without internal temperature gradients
- Transient conduction with internal temperature gradients (use of conduction charts for slabs, cylinders, and spheres plus product solutions for multidimensional transient conduction)
- The semi-infinite solid.

Convective heat transfer

- Introduction to convective heat transfer: mechanism, forced and natural. Newton’s law of cooling.
- Convective Heat Transfer in Laminar Flow: Introduction, momentum and energy balance equations derivation, solution of energy equation in round ducts and other duct configurations for fully developed flow, integral solution for flow over heated flat plate, duct entrance region in laminar flow.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.

2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be assessed as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1) Bergman, T L, Lavine, A S et al. (2011) *Fundamentals of Heat and Mass Transfer,* Wiley.
2) Incropera, F P, DeWitt, D P et al. (2011) *Introduction to Heat Transfer*, Wiley.
3) Holman J.P. (2002) *Heat Transfer*, McGraw Hill, 9th Ed.

Recommended Reference Materials

1) Yunus Cengel (2014) *Heat and Mass Transfer*, MHS; 5th Edition. ISBN-13: 978-9339223199.

FME 522: Heat Transfer II (60 hours)

Prerequisite:

FME 521: Heat Transfer I

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills in the convective and radiative heat transfer mechanisms.

Expected Learning Outcomes

At the end of this course, the student will be able to;

1. Derive basic equations governing convective heat.

2. Solve heat transfer problems involving convection and radiation modes of heat transfer.
3. Conduct experiments on convective heat transfer.

Course Content

1) Convective heat transfer:
   - ❖ Convective Heat Transfer in Turbulent Flow: Governing equations and eddy diffusivities, analogy between heat and momentum transfer, numerical and experimental correlations for forced flow in ducts, turbulent forced flow over flat plate and submerged bodies,
   - ❖ Free convection:

- Physical mechanism,
- Free convection over vertical flat surface (Momentum and Energy equations)
- Integral method for laminar flow
- Turbulent considerations
- Combined free and forced convection
- Simplified correlations for air.

2) Heat Exchangers

- ❖ parallel and counterflow analysis
- ❖ LMTD and NTU analysis and design for different exchanger flow configuration.

3) Radiative heat transfer:
   - ❖ The electromagnetic wave spectrum and thermal radiation, definitions, intensity of radiation and Lambert's law, black body radiation, spectral distribution of black body radiation, real and grey surfaces, Kirchoff's law, algebra of shape factors, exchange in black and grey enclosures without and with reradiating surfaces, combined modes of heat transfer, radiative exchange in absorbing and emitting media.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

1. Forced convection heat transfer in a tube.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

3) An end of semester written examination constituting of 70%.
4) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

3) Bergman, T L, Lavine, A S et al. (2011) *Fundamentals of Heat and Mass Transfer,* Wiley.
4) Incropera, F P, DeWitt, D P et al. (2011) *Introduction to Heat Transfer*, Wiley.
5) Holman J.P. (2002) *Heat Transfer*, McGraw Hill, 9th Ed.

Recommended Reference Materials

1) Yunus Cengel (2014) *Heat and Mass Transfer*, MHS; 5th Edition. ISBN-13: 978-9339223199.

FME 523: Air Conditioning and Refrigeration (60 hours)

Prerequisites

FME 422: Thermodynamics V

FME 432: Fluid Mechanics V

Purpose of the Course Unit

The purpose of this course is to equip the learner with skills and knowledge in refrigeration and air conditioning systems.

Expected Learning Outcomes

At the end of this course, the learner will be able to;

1. Select suitable refrigerant for a refrigeration plant and size the refrigeration devices
2. Analyse performance characteristics of an actual refrigeration cycle
3. Design basic air conditioning systems

Course Content

1) Air-conditioning: Introduction – definition and scope. Psychrometry, moist air processes and standard air-conditioning calculations. Comfort and health. Heat transmission in building structures, solar irradiation, cooling load calculations. Room air distribution, fans, building air distribution and economics. Systems and equipment.
2) Refrigeration: Compression refrigeration cycles and equipment, the reciprocating compressor and multi-staging. Refrigerants. Absorption refrigeration. Survey of other refrigeration systems (gaseous, thermoelectric, steam-jet, flash cooling, etc.)

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture rooms with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids

6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1) Faye C., McQuiston, & Jerald D.P. (2004) *Heating, Ventilating and Air-conditioning*, John Wiley & Sons Inc, 4th Edition.
2) Jones W.P. (2000) *Air-Conditioning Engineering*, Butterworth-Heinemann, 3rd Ed.
3) Langley, B. (2000) *Fundamentals of Air-Conditioning Systems*, Marcel Dekker, 2nd

FME 525: Internal Combustion Engines (60 hours)

Prerequisites

FME 422: Thermodynamics V

FME 431: Fluid Mechanics IV

FME 521: Heat Transfer I

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain skills and knowledge in the combustion process in internal combustion engine, fluid flow processes in air and fuel systems and their influence on engine performance parameters.

Expected Learning Outcomes

At the end of the unit, the student will be able to:

1. Analyse the combustion process.
2. Carry out exhaust gas analysis
3. Design air and fuel systems in internal combustion engines.
4. Determine engine performance parameters.

Course Content

1) Engine Types and Operation: Engine classifications by application, design, working cycle, fuel, ignition, cooling, etc. Engine operating parameters, i.e. torque, efficiencies, mean effective pressure, fuel consumption, air-fuel ratio.
2) Fuels and Combustion: Fuel types and characteristics and chemical composition. Thermodynamics and combustion: Heat of combustion, flame propagation, abnormal combustion, fuels additives.
3) Spark Ignition Engines: Combustion process, mixture requirements, carburetion, fuel injection systems (multi-point, single point) Ignition fundamentals and systems. Abnormal combustion (knock, surface ignition)
4) Compression Ignition Engines: Essential features, diesel combustion injection types (direct, indirect), fuel metering, fuel spray and combustion behaviour (injection, atomization, spray evaporation, ignition delay, premixed combustion, late/diffusion combustion).
5) Pollution and Control: Nature and extent of problem, exhaust gas analysis, gasoline engine pollution and emission control, diesel engine pollution and control. Emission from alternative power plants.
6) Supercharging: Objectives, thermodynamic cycle with supercharging, effects on performance, methods, supercharging versus turbocharging, methods of turbocharging, limitations of supercharging and turbocharging.
7) Lubrication: Friction fundamentals, measurement methods, engine friction components, lubrication systems and requirements.
8) Engine Cooling: Importance of heat transfer, heat transfer and energy balance, thermal loading and component temperatures. Cooling systems, air versus water cooling. Effect of engine variables.
9) Testing and Performance: Performance parameters. Basic measurements – dynamometers and test bed instruments. Breathing. Energy losses.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

Ricardo engine experiment

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1) Heywood, J.B. (2018) *Internal Combustion Engine Fundamentals*, McGraw Hill Publishing Co., New York.
2) Ferguson, C R and Kirkpatrick, A T (2015) *Internal Combustion Engines: Applied Thermosciences*, Wiley.
3) Pulkrabek, W W (2003) *Engineering Fundamentals of the Internal Combustion Engine*, Pearson.

Recommended Reference Materials

1) SAE Transactions: Journal of Engines

FME 524: Energy Conversion Technologies (60 hours)

Prerequisites:

FME 422: Thermodynamics V

FME 431: Fluid Mechanics V

FME 521: Heat Transfer I

Purpose of the Course Unit

The aim of this course is to equip the learner with skills and knowledge on energy conversion technologies with an emphasis on efficiency and environmental impact.

Expected Learning Outcomes

At the end of the course, the student will be able to;

1. Discuss the current and future sources of energy
2. Assess the capability and limitations of energy conversion systems
3. Determine the efficiencies of the various energy conversion systems
4. Discuss the effects of the energy conversion systems to the environment

Course Content

1) Thermal Power Systems: Steam plant, gas turbine plant, and internal combustion engines.
2) Hydropower systems: Hydrological cycle, precipitation, evaporation, runoff. Flow duration curve, hydrograph. Site selection, features of hydro-power plants and classification, hydraulic turbines – impulse, reaction, propeller, draft tubes. Control of hydro-plants.
3) Biomass Gas: Sources of Biomass – Food crops, hydrocarbon-rich plants, waste, weed and wild growths. Biomass conversion – direct combustion, thermo-chemical conversion (gasification, liquefaction) and bio-chemical conversion (anaerobic digestion and fermentation), generation and use, landfill gas.
4) Solar Energy: Solar energy supply – the sun, solar constant, solar radiation on the earth surface, solar radiation measurement and estimation. Solar thermal systems – water heating systems, cookers, steam generating systems, solar air-conditioning solar refrigeration, solar crop drying, solar energy conversion to electricity – concentrated solar thermal energy systems, and photovoltaic systems. System sizing.
5) Wind Energy: wind patterns, sites and properties, site selection, power in the wind, windmill design. Wind turbines – types, sizing.

6) Geothermal Energy: Origin and nature of geothermal energy, stored energy estimation, typical cycles, wellhead equipment, non-condensable gases, waste heat, water disposal, pollution control.
7) Tidal power: Tidal power generating systems, potential of tidal power, advantages and limitations of tidal power.
8) Nuclear Energy: Nuclear physics, fission, Nuclear reactor, types of reactors, typical cycles. Site selection, safety.
9) Comparison of thermal efficiencies of various systems.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1. Abbasi, T and Ababasi, S A (2010) *Renewable Energy Sources – Their Impact on Global Warming and Pollution.* PHI Learning Private Limited.
2. Sharma, P and S K Kataria (2008) *Power Plant Engineering*, S K Kataria & Sons, Ninth Edition, 2008.

FME 526: Engineering Processes, Pollution and Pollution Control (45 hours)

Prerequisites

FME 422: Thermodynamics V

FME 431: Fluid Mechanics V

FME 521: Heat Transfer I

Purpose of the Course Unit

The purpose of the course is to equip the learner with knowledge and skills in engineering processes and how they contribute to environmental pollution and waste treatment and pollution mitigation strategies.

Expected Learning Outcomes

At the end of the course, the student will be able to;

1. Identify pollutants and their sources in air, land and water environments
2. Discuss the effects of pollution
3. Implement pollution control mechanisms.
4. Articulate pollution control legislations and regulations from relevant government agencies.
5. Discuss pollution mitigating mechanisms such as waste water treatment and effluent gases scrubbing.

Course Content

1) Introduction: Effect of pollution on ecosystems, food chains and health; local, regional and global pollution; environmental aspects and pollution dispersion; material consumption, efficiency and sustainability.
2) Contaminant Transport Phenomena: Basic laws governing transport phenomena; Major types of contaminants in air, surface water and ground water. Physical phenomena governing the transport of contaminants in different environments: advection, dispersion, diffusion, sorption, ion exchange, precipitation, dissolution, volatization, and equilibrium partitioning in air and water. Development of governing transport equations, initial and boundary conditions, analytical and numerical solutions.
3) Air Pollution: Sources and nature of air pollution and impacts, characteristics of stack plumes, prediction of fallout zones, eddy and Gaussian diffusion

models, puff models, effective stack heights and spatial concentration distributions. Measurement techniques.

4) Water Pollution: River, lake, sea and ground water pollution.
5) Soil Pollution: Nature and sources of industrial and agricultural, solid wastes.
6) Other Types of Pollution: Heat, noise and radiation pollution sources and their moderation in industry
7) Waste Management Treatment and Control: Control of particulates and collection mechanisms (cyclones, bag filters, electrostatic precipitators, media filters, etc). Control of gases and vapours (adsorption, absorption, secondary combustion), control of SO_2, NOx, desulphurization, kinetics of NOx formation. Control of metal emissions (sorbent injection techniques), control of air toxics, volatile organics (VOC's), noxious pollutants. Emission trading.
8) Pollution Control Legislation: Standards and enforcement

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (30%)

Core Reading Materials

1. Schnelle, K B Jr. and Brown, C A (2002) *Air Pollution Control Technology Handbook*. CRC Press LLC, 2002.

2. Woodard, F (2000) *Industrial Waste Treatment Handbook*, Butterworth – Heinemann.
3. Weiner, R F and Mathews, R (2003) *Environmental Engineering*, Fourth Edition, Butterworth – Heinemann.

FME 527: Industrial Energy Management (60 hours)

Prerequisites

FME 292: Electrical Machines
FME 422: Thermodynamics V
FME 431: Fluid Mechanics V
FME 521: Heat Transfer I

Purpose of the Course Unit

This course will equip the student with knowledge and skills in the sources, availability and use of energy, energy management, energy data, energy utilisation efficiencies and monitoring of energy usage.

Expected Learning Outcomes.

At the end of this course, the student will be able to:

1. Develop an energy management program for an organisation - that includes a clear strategic corporate approach and the management process and steps.
2. Formulate an energy audit that include plant survey, acquisition organising and analysis of energy data (utility and fuel) and the implementation plan.
3. Determine energy utilisation (efficiency) in Electrical systems, Thermal systems, Fluid flow systems, Refrigeration and air-conditioning systems and any other energy consuming system.
4. Develop and implement monitoring and targeting procedures.

Course Content

1) Introduction:
   - ❖ Energy and Material Use: Energy consumption and industrialization, review of the laws of thermodynamics, efficient consumption of energy and materials and environmental degradation.

- ❖ Introduction to Energy Management: Management process and steps.
- ❖ Energy Data Recording Processes: Collection and analysis of utility and fuel data.
- ❖ Plant Survey: Organization and conduction of plant survey, data recording and equipment.

2) Electrical systems:
- ❖ Electrical Metering and Tariffs: Energy and demand metering, meter testing, tariff structures and cost of electricity, plant demand profile.
- ❖ Electric Motors: Fundamentals, efficiency and losses, high efficiency motors, power factor and correction, energy conservation, load and efficiency.
- ❖ Lighting: Fundamentals, characteristics, operations, control, energy management of, conservation.

3) Thermal systems:
- ❖ Insulation: Fundamentals, importance, application, benefits.
- ❖ Fuel Fired Equipment: Combustion and fuels, types and applications, burners, combustion testing, improvement of efficiency.
- ❖ Steam Generation and Distribution: Steam use in industry, generation and distribution, steam recovery from flash and bow down, boiler operation and efficiency.
- ❖ Heat Recovery Systems: Potential sources and use of waste heat, applications, equipment, evaluation of potential.

4) Pumping and compression systems:
- ❖ Fans: Types, fundamentals and fan laws, application, maintenance, opportunities for efficiency improvement.
- ❖ Pumps: Use in industry, types and fundamentals, opportunities for efficiency improvement.
- ❖ Compressed Air Systems: Fundamentals, controls, leakage and misuse, leakage testing, plant efficiency optimization, evaluation of energy management measures.
- ❖ Water efficiency.

5) Refrigeration and heat pump systems:

- ❖ Refrigeration and Heat Pump Systems: (a) Refrigeration: Importance, principles, applications, improvement of efficiency. (b) Heat pump cycles. Refrigerants, refrigeration system components.

6) Monitoring and targeting:
   - ❖ CUSUM analysis, past performance, controlling current performance, predicting future performance, setting targets.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

1. Centrifugal fan experiment
2. Centrifugal pump experiment
3. Air – conditioning experiment

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1. Roosa, S A, Doty, S and Turner, W C (2018) *Energy Management Handbook*, Sixth Edition. The Fairmont Press Inc.

2. Capehart, B L, Turner, W C and Kennedy, W J (2016) *Guide to Energy Management: Principles and Applications,* Fairmont Press.

FME 528: Building Services Engineering (60 hours)

Prerequisites

FME 422: Thermodynamics V
FME 431: Fluid Mechanics V
FME 521: Heat Transfer I

Purpose of the Course Unit

This course will equip the student with skills and knowledge of the planning and design of mechanical engineering services required in built environment and the preparation of related contract documents.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Identify mechanical engineering services required for built environment.
2. Plan and design mechanical engineering services for built environment.
3. Draw plans and isometric layouts for mechanical engineering services.
4. Select end user appliances/fixtures fitted to mechanical engineering services
5. Prepare contract documents for building mechanical engineering services

Course Content

Design of internal plumbing and drainage services (planning and sizing of waste pipes), water reticulation (cold water storage and distribution; hot water production, storage and distribution) , sanitary appliance, rain water disposal systems, water treatment and filtration systems, heating installations, steam services and condensate return systems, fire protection systems (firefighting water production storage and distribution), air compressors and compressed air services, medical gas services, sterilizing and bed-pan washing equipment, refuse collection and disposal equipment, incinerators, thermal insulation, refrigeration installation and cold stores, mechanical ventilation and air conditioning systems, acoustical treatment for sound proofing, food preparation, cooking, conveying and serving equipment, laundry equipment and services, lighting systems, electrical safety devices. Principles of planning and design of gas services supply and installations in buildings. Electrical installations, principles of generation, transmission and distribution of electrical energy, single and three phase supply, earthing and sub-circuits, electrical installations to a simple domestic house. Principles of a sewage disposal and treatment cesspools, sceptic tanks, biological digesters, township main sewers.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

1. Centrifugal fan experiment
2. Centrifugal pump experiment

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core Reading Materials

1) Mittal, A K (2018) Electrical and Mechanical *Services in High Rise Buildings,* CBS Press.
2) Grondizik, W T and Kwok, A G (2019) *Mechanical and Electrical Equipment for Buildings*, Wiley.
3) Corbett, G P and Brannigan, F L (2019) *Brannigan's Building Construction for Fire Service*, Jones and Barlett Learning.

Recommended Reference Materials

1) Chartered Institute of Building Services Engineering, Plumbing Engineering Services Design Guide by Institute of Plumbing CIBSE Design Guides.
2) Chadderton D.V., Building Services Engineering, Taylor & Francis.

FME 532: Advanced Fluid Mechanics (60 hours)

Prerequisite:

FME 432 Fluid Mechanics VI

Purpose of the Course unit

The purpose of this course is to enable the learner to gain a deeper understanding of the concepts of real and ideal fluid flow and be able to carry out advanced analysis of expansion waves.

Expected Learning Outcomes

At the end of this course, the learner should be able to:

1) Apply Kelvin's Circulation theorem
2) Perform advanced experimental methods in Fluid Mechanics.
3) Design a wind tunnel
4) Perform advanced flow visualisation

Course Content

Real and Ideal fluid flow: Euler's equation. Kelvin's circulation theorem, Irrotational flow, velocity potential and stream function. Supersonic flow, Oblique shock waves, Prandtl-Meyer equations, aerofoil in supersonic flow, methods of characteristics. Experimental methods: Pitot Static tubes and yaw meters, hot-wire anemometer, wind tunnel design, flow visualisation.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

Flow visualisation with hotwire anemometer

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (30%)
   Laboratory exercises reports (10%)

Core reading materials

1. Graebel, W (2007), *Advanced Fluid Mechanics*, 1st Edition, Academic Press.
2. Gaurax, M X (2019), *Advanced Fluid Mechanics,* Amazon Services LLC.
3. Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.
4. Turker, P G (2016), *Advanced Computational Fluid and Aerodynamics,* Cambridge University Press.

FME 533: Non-Newton Fluid Mechanics (60 hours)

Prerequisite:

FME 432: Fluid Mechanics VI

Purpose of the course unit

The purpose of this course is to enable the learner to gain knowledge and skills relating to concepts of Non-Newtonian fluid flow.

Expected Learning Outcomes

At the end of this unit, students should be able to:

1. Classify the various Non-Newtonian fluid flows
2. Analyse time-dependent and independent Non-Newtonian fluid flows
3. Analyse unsteady laminar Non-Newtonian fluid flow

Course Content

Class of non-Newtonian flow, simple models of inelastic fluid and linear and non-linear visco-elastic fluids. Laminar and turbulent flow through tubes. Turbulence suppression. Examples of unsteady laminar flow.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

Viscometer experiment for viscosity measurement

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1) An end of semester written examination constituting of 70%.
2) Coursework: Continuous assessment tests (20%)
3) Laboratory exercises reports (10%)

Core reading Materials

1. Glowinski, R and Xu, J (2010), *Numerical Methods for Non-Newtonian Fluids,* North-Holland.
2. Wu, W-T and Massoudi, M (2020) *Recent Advances in Mechanics of Non-Newtonian Fluids*, MDPI AG.
3. Irgens, F (2013) *Rheology of Non-Newtonian Fluids*, Springer.

FME 535: Advanced Fluid Flow Machinery (60 Hours)

Prerequisites

FME 432: Fluid Mechanics VI

Purpose of the Course Unit

The purpose of this course is to impact on the learner knowledge and skills of the principles of operation of machinery which operate through flow of fluids.

Expected Learning Outcomes

At the end of this course, the student should be able to:

1. Evaluate fluid machinery and their dynamics
2. Classify fluid machinery in terms of performance parameters and characteristics
3. Design, select and match various turbo machines
4. Apply dimensional analysis in selection and operation of fluid machinery
5. Analyse hydrodynamic transmission.

Course Content

Fluid machinery: types; roto-dynamic and positive displacement; centrifugal pumps and compressors; axial, radial and mixed flow pumps. Turbines: impulse and reaction turbines.

Dimensional analysis and similarity laws related to pumps and turbines. Cavitation in centrifugal pumps. Performance parameters and characteristics of pumps and turbines; pipe-pump systems. Hydrodynamic transmission: fluid coupling and torque converters

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

1. Centrifugal fan experiment
2. Centrifugal pump experiment

Instruction materials and equipment:

1. Lecture rooms with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1. An end of semester written examination constituting of 70%.
2. Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1. Kim, K-Y, Samad, A and Benini, E (2019) *Design Optimization of Fluid Machinery,* Wiley.
2. Wright, T and Gerhart, P (2009) *Fluid Machinery: Application, Selection and Design,* CRC Press.
3. Rama S.R. Gorla, Aijaz A. Khan (2003), *Turbomachinery Design and Theory*, CRC Press.
4. Ostovic, V (2016) *The Art and Science of Rotating Fluid Machinery Design: A Practical Approach*, Springer.

Recommended Reference Materials

1. Elder, R, Tourlidakis, A and Yates, M (2003), *Advances in CFD in Fluid Machinery Design*. Wiley.
2. Journal of Fluid Engineering

FME 536: Computational Fluid Dynamics (CFD) – (60 hours)

Prerequisite

FME 472: Numerical Methods

Purpose of the course Unit

This course equips the students with the numerical methods and schemes as applied in solving various fluid flow fields.

Expected Learning Outcomes

After completing the course, the leaner should be able to apply commercial CDF software to the solution of fluid flow problems such as:

1. *Solve numerically the Navier-Stokes Equation for laminar flow.*
2. *Model Turbulence of Navier-Stokes equation and the solution of the same.*
3. *Solve heat transfer problems.*

Course Content

- *Introduction to Computational Fluid Dynamics*

- *Flow fields (flow primary variables e.g. velocity, pressure and secondary variable e.g. Vorticity and shear stresses for selected scenarios)*
- *Convection equations – Navier Stokes Pde's – incorporating continuity, Newton's 2nd law, 1st law thermodynamics.*
- *Classification of flows – (internal vs. External, laminar vs. Turbulent, compressible vs. Incompressible, steady vs. Unsteady, supersonic vs. Subsonic, single phase vs. Multiphase, elliptic vs. Hyperbolic)*
- *Finite volume solvers – (use of the integral conservation equation applied to control volumes which subdivide the solution domain, and to the entire solution domain)*
- *Boundary conditions – (Neumann and Dirichlet, general pressure inlet, pressure outlet, incompressible flow, velocity inlet, outflow, compressible flows, mass flow inlet, pressure far-field, special inlet vent, outlet vent, intake fan, exhaust fan, periodic boundaries)*
- *Mesh generation – (Element types, grid types, grid design guidelines, geometry solution adoption, grid import)*
- *turbulence modelling – (turbulence, turbulent length scales, Kolmogorov theory, RANS models)*
- *Boundary layers – (BL treatment in CFD model)*
- *Large eddy simulation – (comparison with RANS and DNS)*
- *Heat transfer – (conditions – heat diffusion equation model, thermal BL, Natural convection – Boussineq model, Radiation – discrete ordinates model).*

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

1) Simulation of laminar pipe flow
2) Simulation of turbulent pipe flow
3) Simulation of swirling flow

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary computing facilities

Course Assessment

The course will be assessed as follows:

1. An end of semester exam -- 40 %
2. Continuous assessment tests – 20 %
3. Computer simulations – 40 %

Core Reading Materials

1) Versteeg, H.K, Malalasekera, W. (2007) *An introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson.
2) Tu, J, Yeon, G-H and Liu, C (2018) *Computational Fluid Dynamics: A Practical Approach*, Butterworth-Heinemann.
3) Ferziger, J H, Peric, M and Street, R L (2020) *Computational Methods for Fluid Dynamics*, Springer.
4) Wilcox, D.C. (2004) *Turbulence Modelling for CFD*, DCW industries.

Recommended Reference Materials

1) Journal of Fluids Engineering

FME 541: Industrial Management I (45 Hours)

Prerequisites

FME 343: Business Management for Engineers

Purpose of the Course Unit

This course equips the student with knowledge and skills of the principles production planning and control, inventory control and quality control & inspection.

Expected Learning Outcomes

At the end of the course, the student should be able to;

1. Plan for production
2. Schedule for production
3. Control production, inventory and quality
4. Forecast Production and inventory

Course Content

1) Production Planning, scheduling and Control:
   - The functions of product planning and control
   - Types of production control
   - The relation of production, planning and control to other areas of the firm
2) Analytical Method in Production Planning and control
   - Forecasting techniques
   - Grant chart applications to scheduling
   - The use of CPA and PERT in production planning and control
   - Introduction to Linear Programming
   - Using Linear Programming to determine the optimum product mix
3) Inventory Control
   - Importance and objectives of inventory control
   - Types of inventory
   - Costs factors in inventory control
   - Economic order quantities and recorder points
4) Quality Control and Inspection
   - The concept of quality
   - Quality control systems
   - Purpose of inspection
   - When, where and how much to inspect
   - Feedback and the inspection process
   - Statistical quality control (a) Statistical terms, (b) The binormal distribution, (c) Quality control charts, (d) Acceptance sampling

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (30%)

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Core Reading Materials

1. Chase, R B, NJ Aquilano and FR Jacobs (2000) *Operations Management for Competitive Advantage*. McGraw-Hill Education; 9th Edition.
2. Goldratt, E M and J. Cox (2014) *The Goal: A Process of Ongoing Improvement*, North River Press; 30th Anniversary Edition.
3. Pande, P, R. Neuman, and R. Cavanah (2014) *The Six Sigma Way: How to Maximize the Impact of Your Change and Improvement Efforts*, McGraw-Hill Education; 2nd Edition.

Recommended Reference Materials

1. A. Gawande, A (2011) *The Checklist Manifesto: How to Get Things Right,* Picador Paper; 1st Edition,2011.
2. L. Bossidy, L, R. Charan and C. Burck, (2011) *Execution: The Discipline of Getting Things Done,* Random House Business Books; New and Updated Edition, 2011.

3. Hammer, M and J. Champy, (2006)*Reengineering the Corporation: A Manifesto for Business Revolution*, Harper Business; Revised, Updated edition (October 10, 2006)
4. Slack, N and M. Lewis (2017) *Operations Strategy*, Pearson; 5th Edition.
5. Aft, L S (1997) *Fundamentals of Industrial Quality Control,* CRC Press, 3rd Edition, 1997.
6. Kaoru Ishikawa, K (2012) *Introduction to Quality Control*, Springer; Softcover reprint of the original 1st ed. 1989 Edition, 2012.
7. Ishikawa, K (1991) *Total Quality Control: The Japanese Way,* Prentice Hall Direct.
8. Kume, H (2017) *Statistical Methods for Quality Improvement*, KK Books.
9. Mayer, R R (1967) *Production Management*, McGraw-Hill.

FME 542: Industrial Management II (60 hours)

Prerequisites

FME 343: Business Management for Engineers

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on aspects of Industrial Management including plant location, factory layout, materials handling and workplace health and safety.

Expected Learning Outcomes

At the end of the course, the student will be able to:

1. Select a suitable plant location.
2. Develop optimal factory layouts and design.
3. Select efficient materials handling systems.
4. Design a product or product system taking into account overall costs, production, standardisation, etc.
5. Evaluate work systems designs.
6. Maintain plant and machinery
7. Analyse the impact of work design on the safety and health of employees at workplaces.

Course Content

1) Plant Location
    - Importance of plant location
    - Factors to be considered in plant location
    - Area and site selection
2) Factory Building layout
    - Need for flexibility
    - Type of buildings
    - Factors to be considered in a layout
    - How to make a layout
3) Materials Handling
    - Analysing methods of materials handling
    - Fixed path and varied path equipment
    - Ways of reducing handling costs
4) Product Design
    - Product design responsibility
    - Design and production costs
    - Drawing specifications and tolerances
    - Standardization and simplification
    - Machine tool selection
5) Work Study
    - Value analysis
    - Method study principles
    - Setting time standards
    - Standard data
    - Human factors in work systems design
6) Safety and Health
    - Making working conditions safe
    - Safety equipment and accident prevention
    - Industrial diseases
    - Safety and health regulations

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises reports (10%)

Core Reading Materials

- Black, J T and Kohser, R A (2019), *Degarmo's Materials and Processes in Manufacturing*, Wiley.
- McKinnon, R C (2019) *The Design, Implementation, and Audit of Occupational Health and Safety Management System*, CRC Press.
- Dal Pont, J-P (2012) *Process Engineering and Industrial Management*, Wiley.

Recommended Reference Materials

- Journal of Manufacturing Science and Engineering

FME 544: Entrepreneurship for Engineers (60 hours)

Prerequisite:

FME 343: Business Management for Engineers

Purpose of the Course Unit

To provide the learner with knowledge and managerial skills on how to start and run a business.

Expected Learning Outcomes

At the end of the course, a learner will be able to:

1. *Discuss the procedure to follow when starting a business.*
2. *Write a business plan for a start-up business*
3. *Write a strategic plan for a business*
4. *Operate a business.*

Course Content

- *Introduction: The role of small scale business; How to start a small scale industry; Regulatory requirements and agencies;*
- *Business planning: Choice of business; Market opportunities and strategy; Risk and risk taking; Input resource requirements; Cash flow projection; Capital acquisition;*
- *Finance and financial management: Record keeping; Financial analysis; Decision making; Tax issues;*
- *Business development; Marketing and promotion; Productivity and quality improvement; Human resource development;*
- *Business start-up project.*

Mode of Delivery:

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 50%.
- Coursework: Continuous assessment tests (10%)
  Tutorials, case studies, quizzes, assignments, etc. (15%)
  Practical project (25 marks)

Core Reading Materials

1. Allen, Kathleen R. *Entrepreneurship for Scientists and Engineers*. 1st Edition. Pearson Prentice Hall. (2010).
2. Naidu, N. V. R. and Rao, Krishna T. *Management and Entrepreneurship*. I. K. International Pvt Ltd. (2010).
3. Rogoff, Edward G. *Bankable Business Plans*. 2nd Edition. Rowhouse Publishing. (2007).

FME 545: Operations Research (60 hours)

Prerequisite:

FME343: Business Management for Engineers

Purpose of the Course Unit

This course equips the student with knowledge and skills in the principles and practice of Operations Research and its role in decision making with a special focus on linear programming, network optimization and nonlinear programming.

Expected Learning Outcomes

At the end of the course, the learner will be able to:

1. Identify operational research models for real systems.
2. Develop novel operation research methods
3. Apply the mathematical tools to solve optimisation problems.

4. Use mathematical software to solve the proposed models.
5. Write and present a report that will aid in the decision-making processes in Management Engineering

Course Content

- Introduction: Historical overview, nature of operation research (OR) models, applications of OR., future developments.
- Linear Programming (LP): Formulation of LP problems, simplex method, sensitivity analysis and duality theory; revised simplex method; transportation and assignment model.
- Dynamic or nonlinear programming
- Network Models: Gantt charts. Critical path method (CPM), programmed evaluation review technique (PERT), cost consideration in project scheduling, resource levelling.
- Inventory Models: Types of inventory models, deterministic models, probabilistic models, stock control.
- Queuing Theory: Basic queuing theory, types of inventory system, application of Poisson and exponential distributions, queues with combined arrival and departures, queues with priority for service, Markovian decision models, Markov chains.
- Replacement Models: Introduction, considerations for replacement policy, replacement of items that depreciate replacement of items that fail.
- Using relevant mathematical software to solve OR models.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (30%)

Core Reading Materials

- Hillier, F S and G.J. Lieberman (2014), *Introduction to Operations Research*, Latest Edition, McGraw-Hill.
- Winston, W L (2003) *Operations Research: Applications and Algoriths*, Cengage Learning.
- Taha, H A (2020) *Operations Research: An Introduction*, Pearson.

Recommended Reference Materials

- Operations Research: An International Journal, Springer
- Operations Research Perspectives, Elsevier

FME 546: Occupational Health & Safety (45 hours)

Prerequisites

None

Purpose of the Course Unit

This course will enable the learner to locate and use occupational, health and safety legislation and materials.

Expected Learning Outcomes

At the end of this course, the student will be able to:

1. Identify hazards in the workplace that pose a danger or threat to their safety or health, or that of others.

2. Control unsafe or unhealthy hazards and propose methods to eliminate the hazard.
3. Select the appropriate personal protective equipment and their proper use.
4. Analyse potential safety or health hazard based on occupational Health and Safety Regulations as well as supported legislation.
5. Discuss the role of health and safety in the workplace pertaining to the responsibilities of workers, managers, supervisors.
6. Maintain protection of the environment and workplace as well as personal health and safety.
7. Write a report and present the findings on the investigation of health and safety in a workplace

Course Content

Fundamentals of health and safety; Workplace hazards; Control & Management of workplace hazards, Personal protective equipment; Occupational Health and Safety (OHS) policy, regulations, and legislation; Plant and machinery law; Safe work procedures; OHS committees; Workplace inspection methods; workplace hazards and risk assessment; Occupational accidents and their effect of industry; Workers compensation; Fire and safety; Occupational hygiene; Plant safety; Contemporary issues of health and safety – HIV/AIDS, stress, alcohol and drug abuse, environmental pollution, cancer, etc.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  OHS industrial visit reports (10%)

Core Reading Materials

- Goetsch, D *Occupational Safety and Health for Technologists, Engineers, and Managers,* Pearson, 8th Edition.
- Plog, B A, P.J. Quinlan, and J. Villarreal, *Fundamentals of Industrial Hygiene*, National Safety Council; 6th Edition.
- Reese, C D. *Occupational Health and Safety Management: A Practical Approach*, CRC Press; 3rd edition.

Recommended Reference Materials

- Safety and Health at Work, Elsevier (Journal)
- Occupational Health Science, Springer (Journal)
- International Journal of Occupational Safety and Ergonomics, Taylor and Francis

FME 548: Valuation of Plant and Machinery (60 hours)

Prerequisites

None

Purpose of the Course Unit

This course will equip the learner with knowledge and skills on the methods and processes used for undertaking plant and machinery valuation and the methods for determining residual plant and machinery life.

Expected Learning Outcomes

At the end of this course, the student will be able to;

1. *Define the procedure and the practice for undertaking valuations,*
2. *Determine residual life for plant and machinery,*
3. *Determine the value of plant and machinery,*

4. *Prepare valuation reports for plant and equipment.*

Course Content

1. *Introduction: Purpose for valuation of Plant and Machinery (P&M), definition of terms used in plant and machinery valuation, types of plant and machinery, role and function of P&M valuer, legal basis for undertaking P&M valuation;*
2. *Fundamentals of P&M valuation: Difference between value, price and cost, value ingredients of P&M,*
3. *Basis for valuation: Market value, Equitable value, Fair value, Insurance value,*
4. *Common types of value - in-situ value, ex-situ value, highest and best use in relation to P&M;*
5. *Relationship to accounting and insurance standards: Regulations governing acquisition and use of P&M value;*
6. *Methods of valuation: Cost approach, market approach, income approach,*
7. *Estimation of life: Factors influencing estimation of residual life, methods of estimating remaining life, computation of depreciation, computation of escalation, computation of obsolesce,*
8. *Valuation process: Terms of reference and valuation strategy, physical identification of P&M, grouping of assets, collection and verification of data, reconciliation and report writing.*

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Practical Work/Laboratory Exercises

Practical valuation exercises

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

1. An end of semester written examination constituting of 70%.
2. Coursework: Continuous assessment tests (20%)
   Laboratory exercises reports (10%)

Core Reading Materials

1. K. Budhbhatti (2002). Valuation of Plant and Machinery: Theory and Practice, 2nd Edition, Kirit Budhbhatti.
2. American Society of Appraisers. Machinery and Equipment Textbook Committee (2000), Valuing Machinery and Equipment: The Fundamentals of Appraising Machinery and Technical Assets, American Society of Appraisers.
3. M.A. Belo (2012). Guide to Plant and Machinery Evaluation, 2nd Edition, Armitage Books.

Recommended Reference Materials

1. Journal of Property Investment & Finance, Emerald Publishing

FME 551: Fracture Mechanics (60 Hours)

Prerequisites:

FME 452: Materials Science and Engineering IV
FME 401: Solid and Structural Mechanics V

Purpose of the course unit:

This course will equip the learner with knowledge and skills on the principles of fracture mechanics as a tool in the prevention and/or management of brittle fracture and fatigue in materials.

Expected learning outcomes:

At the end of the course, the learner will be able to:

1. Apply the energy balance and stress intensity factor approaches to the control of crack growth in materials.

2. Determine experimentally the plain strain fracture toughness and similar fracture properties of materials and to analyse the results from such tests.

3. Control of the growth of fatigue cracks.

4. Determine experimentally the fatigue crack growth (FCG) rate and the FCG threshold of any material and to analyse the results of such tests.

5. Describe the effects of factors like load ratio (R-ratio), environment, microstructure, etc. on the rate of FCG rate and threshold.

6. Apply the principles of fracture mechanics to the design of machine components and structures.

Course content:

Linear elastic fracture mechanics: energy balance and stress intensity factor approaches to fracture, fixed grip versus fixed load, crack tip plasticity, K_{Ic} testing.

Elastic-plastic fracture mechanics: J-integral and COD concepts, experimental EPFM, use of fracture mechanics in design.

Application of fracture mechanics to fatigue crack growth: micromechanisms of FCG, experimental determination of FCG rates and ΔK_{th}, effects of mean stress, environment, microstructure and other factors on FCGR; life predictions, load interactions.

Mode of delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids
6. Necessary laboratory facilities

Laboratory exercises:

1. Determination of the plain strain fracture toughness of a steel.
2. Determination of the fatigue crack growth characteristics of a metallic alloy.

Course assessment:

The course shall be assessed by both coursework (accounting for 30 %) and an end of semester written examination constituting 70 %. The coursework shall in turn consist of laboratory practicals (10 %), written continuous assessment tests, tutorials, quizzes, assignments, etc. (20 %).

Core reading materials:

1. Anderson, T L (2017) *Fracture Mechanics,* CRC Press.
2. Hertzberg, R W, Vinci, R P and Hertzberg, J L (2016) *Deformation and Fracture Mechanics of Engineering Materials,* Wiley.
3. Dharan, C K H, Kang, B S and Finnie, I (2016) *Finnie's Notes on Fracture Mechanics,* Springer.

FME 552: Ceramic Materials (60 Hours)

Prerequisite:

FME 353: Materials Science and Engineering III

Purpose of the course unit:

The purpose of this course is enable the learner master the structure, properties and methods of manufacture of ceramic materials so as to be able to design components made from such materials.

Expected leaning outcomes

At the end of this course, the learner will be able to:

1. Experimentally determine the particle size, shape, pore structure and specific surface area of a ceramic material.
2. Calculate the quantities of phases in a ceramic.
3. Plot a binary ceramic phase diagram.
4. Determine the microstructure and phases in a ceramic.
5. Specify a suitable manufacturing and processing procedure to obtain defined mechanical properties in a ceramic.
6. Design component made of ceramic materials.

Course Content

Introduction, atomic interactions in ceramics, crystal structure of ceramics, glasses and other non-crystalline ceramics, surfaces and interfaces, single component, binary and ternary phase equilibria in ceramics, ceramic microstructrures (micrography, grain size/shape, phase quantities). Material characterization, Mechanical properties: elastic, strength, rheological; thermal properties: thermal expansion, heat capacity, thermal conductivity, thermal stresses, deformation; electrical and magnetic properties: electrical conductivity, dielectric behaviour, magnetic behaviour, optical properties, and nuclear applications. Processing of ceramics: forming (pressure fabrication, hydroplastic forming, slip-casting, and cementation), pressing, injection moulding, processing additives (wetting agents, flocculants, and binders), drying, firing, annealing, tempering and crystallization.

Mode of delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector

5. Audio-visual aids
6. Necessary laboratory facilities

Course assessment

The course shall be assessed by continuous assessment constituting 30 % and a final written examination constituting 70%.

Core reading materials

1. Carter, C B and Norton, M G (2013) *Ceramic Materials Science,* Springer.
2. Bansal, N P and A. R. Boccaccini, (2012) *Ceramics and Composites Processing Methods*, John Wiley and Sons.
3. Richardson, D W and Lee, W E (2018) *Modern Ceramics Engineering*, CRC Press.

FME 553: Composite Engineering Materials (60 Hours)

Prerequisite:

FME 353: Materials Science and Engineering III

Purpose of the course unit:

To enable the learner to gain a deeper understanding of the principle, micro/macro mechanics and processing of composites as a class of engineering materials to a level that he/she is able to design machines and structures incorporating composite materials.

Expected learning outcomes:

At the end of the course, the learner will be able to:

1. Classify composite materials according to various criteria.
2. Calculate the density, elastic constants, thermal properties, electrical properties and load carrying capacity of a composite from the properties of the matrix and reinforcement.

3. Compare and contrast the various materials available for use as matrix and reinforcement.
4. Determine experimentally the interfacial strength.
5. Derive the constitutive equations governing the behaviour of composites.
6. Investigate the fatigue and creep behaviour of composites.
7. Describe the methods available for the manufacture/processing of different classes of composites.
8. Design machine components and structures using composite materials.

Course Content:

General introduction: Nature of composites; classification of composites.

Reinforcements, matrices and interfaces: Reinforcements: glass fibres, boron fibres, carbon fibres, organic fibres, whiskers; Matrix materials: polymers, metals, ceramics; Interfaces: wettability, nature of the interface, types of bonding at the interface, interfacial bond strength.

Common composite classes: Polymer matrix composites: processing, interfaces, structure, properties, applications; Metal matrix composites: common metallic matrices, interfaces in MMCs, properties and application; Ceramic matrix composites, carbon/carbon composites, superconducting and non-conventional composites.

Micro mechanisms of composites: Density and mechanical properties: elastic constants, thermal properties, mechanics of load transfer.

Macro mechanics of composites: Isotropic materials, lamina, relation between elastic constants, variation of properties with orientation; Introduction to analysis of laminated composites: constitutive equations, stresses and strains, interlamina stresses.

Strength and fracture of composites: Unidirectional fibre composites, failure modes, orthotropic lamina: maximum stress theory, maximum strain theory, Tsai-Hill theory, quadratic interaction criterion; fatigue and creep of composites.

Mode of delivery:

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Laboratory exercises:

1. Determination of the tensile properties of a composite material.
2. Determination of the interfacial bond strength of a fibre reinforced composite.
3. Plotting of the S-N curve of a metal matrix composite.

Course assessment:

The course shall be assessed by both coursework (accounting for 30 %) and an end of semester written examination constituting 70 %. The coursework shall in term consist of laboratory practicals (10 %), written continuous assessment tests, tutorials, quizzes, assignments, etc. (20 %).

Core reading materials:

1. Tsai, S W and Melo, J D D (2015), *Composite Materials: Design and Testing*, JEC Group.
2. Chawla, K K (2019), *Composite Materials – Science & Engineering*, Springer.
3. Agarwal, B D and Broutman, L J (2017), *Analysis and Performance of Fiber Composites*, John Willey and Sons, New York.

FME 554: Material Selection Methods in Design (60 contact hours)

Prerequisites:

FME 252: Materials Science and Engineering II

FME 354: Materials Science and Engineering III

Purpose of the course unit:

The purpose of this course unit is to enable the learner to get an in-depth understanding of how materials are selected during the process of designing a product.

Expected learning outcomes:

At the end of the course, the learner should be able to;

1. *Illustrate the value of using structured material selection techniques.*
2. *Apply different material selection techniques at the various component design stages.*
3. *Relate the different material selection techniques and their relative advantages.*
4. *Apply material selection methods to determine the optimum material given a set of performance criteria and specified geometry.*

Course Content:

Introduction: Why do we study materials? Definitions, historical trends, why do we need a materials selection procedure?

The design process: The contribution of the shape, performance, cost and processing considerations in the design process.

Property selection techniques: Property ratios, performance criteria identification, examples of constraint equations and performance indicators, optimization, property selection charts,

Selection criteria driven by aesthetics, ergonomics and shape: Aesthetics, ergonomics, material selection without shape constraints, material selection with shape constraints, shape factors, performance indices that include shape, shaped materials and property charts;

Quantitative methods in materials selection:Ashby free-search, Weighted Property Method, Multiple Criteria Decision Making (MCDM), TOPSIS, VIKOR, ELECTRE, AHP.

Mode of delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture roomwith white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Laboratory Exercises

1. Material selection using a given selection tool and database

Course Assessment

The course shall be assessed as follows:

2 hour written examination at the end of the semester (70%)

Continuous Assessment Tests, assignments, quizzes, etc. (20%)

Written Laboratory Reports and computing exercises (10%)

Core reading materials

1. Ashby, M F (2010)*Materials Selection in Mechanical Design*, Elsevier (Butterworth Heinemann), 4th Ed. ISBN-13: 978-9380931722
2. Ashby, M F and J. Kara (2014), *Materials and Design: The Art and Science of Material Selection in Product Design,* 3rd Ed. ISBN-13: 978-0080982052.
3. Maleque, A and M. S. Salit (2013), *Materials Selection and Design*, Spinger, ISBN-13:978-981-4560-38-2.

Recommended reference materials

1. Murray, G T (1997), *Handbook of Materials Selection for Engineering Applications*, CRC Press, 1st Ed. ISBN-13: 978-0824799106.

2. Kutz, M (2002), *Handbook of Materials Selection*, Wiley, 1st Ed. ISBN-13: 978-0471359241.

FME 555: Theory of Production Processes (60 hours)

Prerequisites

FME 243: Workshop Technology and Practice

Purpose of the Course Unit

The purpose of this course is to enable the learner to gain knowledge and skills on the mechanics of plastic deformation in metals.

Expected Learning Outcomes

At the end of the course, the learner will be able to;

1. Calculate the forming loads for a number of metal forming processes.
2. Compute the minimum power consumption and capacity of a metal forming machine.
3. Appraise the relative advantages of high velocity forming processes.
4. Develop forming procedure for a specific material.
5. Predict cause of failure of a metal forming tool.

Course Content

- Plasticity; stress-strain relation

  Basic Plasticity: Stress- strain relationship, complex stresses, yield criteria

  Calculation of Deforming Loads: Equilibrium method, lower bound solutions, upper bound solutions.
- Metal forming processes

  Drawing: Analysis of loads and stresses in wire, rod, tube and strip drawing, die pressure.

  Extrusion: Frictionless extrusion, allowance for friction, loads and stresses in extrusion.

  Forging: Forging processes, analysis of loads and stresses in forging

  Rolling: Hot rolling and cold rolling, roll load and torque, analysis of stresses in rolling.

Sheet Metal Forming: Bending, deep drawing, dies, loads and stresses in sheet metal forming.

Metal Cutting: Theories of metal cutting, chip formation and shear zone analysis, forces and velocities in metal cutting, economics of metal cutting.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture rooms with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises reports (10%)

Core Reading Materials

- Magreb, E B et al. (2019) *Integrated Product and Process Design and Development*, CRC Press.
- Boljanovic V. (2004) Sheet Metal Forming Processes and Die Design, Industrial Press Inc.
- Black, J T and Kohser, R A (2019) *DeGarmo's Materials and Processes in Manufacturing*, Wiley.

Recommended Reference Materials

- Journal of Manufacturing Science and Engineering

FME 556: Additive manufacturing (60 hours)

Prerequisites:

FME 352: Materials Processing II

***Purpose of the course unit**:*

The purpose of this course is to enable the learner to gain knowledge and skills on the methods used in additive manufacturing including the theories governing additive manufacturing as well as the relations between materials to be processed and methods of additive manufacturing.

Expected learning outcomes:

At the end of this course, the learner should be able to:

1. *Categorise broad range of AM processes, devices, capabilities and materials that are available.*
2. *Apply the various software tools, processes and techniques that enable advanced/additive manufacturing.*
3. *Appraise the trade-offs that must be made in selecting advanced/additive manufacturing processes, devices and materials to suit particular product requirements.*
4. *Fabricate an actual multi-component object using advanced/additive manufacturing devices and processes (the "project").*

Course content

Basic principles and development of additive manufacturing, generalized process chain; Processes in additive manufacturing: Vat photopolymerization (DLP, SLA), powder bed fusion (SLS), extrusion-based processes (FDM), material jetting (direct 3D printing), sheet lamination (LOM), and directed energy deposition processes (SLM, EBM), direct write technologies, low cost systems, process selection guidelines; Design and fabrication processes: data sources, software tools, file formats, model repair and validation, post-processing, direct digital manufacturing, design for additive manufacturing, rapid tooling; Scaffolds, bio-printing, tissue and organ engineering; Materials - Metals, polymers, ceramics, *composites and material selection; Applications of additive manufacturing, in architecture, art, music, toys, health care (e.g. hearing aids), direct part production and mass customization; Processes related to AM: 3D scanning, mold-making, casting and sintering; business opportunities and future directions.*

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Laboratory report (10%)

Core Reading Materials

1. Gibson, D. Rosen, B. Stucker, (2015) *Additive Manufacturing Technologies.* Springer

2. Gu, D (2014) *Laser Additive Manufacturing of High-Performance Materials***.** Springer Publ.

3. Gebhardt, A (2011) *Understanding Additive Manufacturing.* Hanser Publishers, 2011.

FME 557: Manufacturing Automation (60 Hours)

Prerequisites

1. FME 291: Electrical Circuit Theory

2. FME 492: Electrical Measurements and Instrumentation

Purpose of the Course Unit

The purpose of this course is to introduce the learner to various automated systems such as robotics, machine vision, PLC and PC based controls, supervisory control and data acquisition (DAQ).

Expected Learning Outcomes

At the end of the course, the learner will be able to:

1. *Appraise the various techniques used in manufacturing automation.*
2. *Classify and select the right sensor for a given application.*
3. *Apply sensors for inspection, measurement and control.*
4. *Construct programmable controllers.*
5. *Employ data acquisition, signal conditioning and monitoring devices.*
6. *Integrate machine vision and robotics into a manufacturing ecosystem.*

Course Content

- *Introduction to SCADA systems*
- *Architecture and programming – basic programming*
- *Data acquisition techniques – hardware, software and signal processing*
- *Sensors and actuators*
- *Manufacturing automation control*
- *Numerical control systems (motion control)*
- *PLC control*
- *PC based control*
- *Automated materials handling and storage systems*
- *Industrial Robots*
- *Machine vision*
- *Automatic automated identification and tracking, and networking*
- *System integration using PLC's, sensors, DAQ systems and other automation components.*

Laboratory activities

- *Data acquisition and signal processing using LabVIEW or any appropriate SCADA system. Implement a simple system to collect field signals, condition, store and display*
- *Process control using LabVIEW or any appropriate SCADA system. Using the system in activity 1, design, program and build a simple process control system with analogue inputs. Examples could be temperature control with digital display if process is above certain parameter.*
- *Digital and analogue control using PLC. Using a PLC, students will perform wiring of digital and analogue I/O, and write ladder logic to simulate various industrial control applications. Students can implement activity 2 using a PLC as well.*
- *Motion control. Implement motion control with stepper and servo motors. Students can design a linear or x-y table with appropriate gearing and determine linear travel distances and feeds.*
- *Robot programming. Basic robot programming with a teach pendant (or computer). Activity will include interaction with robot I/O*
- *Machine vision. Activities will involve using a standard industrial machine vision camera to perform location and inspection of parts, measurements and interaction with other automated systems*
- *Automatic identification. Use of automated identification systems such as bar coding or Radio frequency identification to identify and track parts.*
- *Integration. This is a capstone type activity that allows all the automation components (vision, PLC, sensors, actuators, robots) to communicate through PLC and implements an automated parts sorting or assembly process.*

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations

4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory and computing facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 40%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises and reports (40%)

Core Reading Materials

- Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson, 5th Edition, 2018.
- Altintas, Y. Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, And Cnc Design. Cambridge University Press; 2 Edition (2012).
- Wang, Y, K Martinsen and T. Yu (Editors). Advanced Manufacturing and Automation IX (Lecture Notes in Electrical Engineering) Springer; 1st edition. 2020

Recommended Reference Materials

1. Upcoming Proceedings of the International Workshop of Advanced Manufacturing and Automation (IWAMA)
2. Journal of Design and Manufacturing Automation. Taylor and Francis

FME 560– Machine Tool Design (60 hours)

Prerequisites

FME 244: Workshop Technology

Purpose of the Course Unit

The purpose of this course is to enable the student to:

- Develop understanding of how and why jigs are designed and built as they are.
- Understand the factors considered in design of jigs and fixtures.

- Determine cost effective and efficient work holding methods.

Expected Learning Outcomes

At the end of the course, the student will be able to:

1. Design and fabricate simple and economic work holding devices.
2. Differentiate between jigs and fixtures and their use in, for example, machining and welding processes.
3. Design fixtures and jigs for interchangeable manufacture and assembly work.

Course Content

- Machine Tool Structures: Strength and design analysis of various structures, deflection of structures, effect on work quality and accuracy, bearings and slideways, vibration and chatter of machine tools, design considerations for CNC machine tools.
- Machine Tool Drives: Kinematics of machine tools, standardisation of speeds and feeds, ray diagrams for machine tool gear boxes, different types of drives, feed gear boxes, reciprocating drives, hydraulic drives, pump and valves for hydraulic drives, stepless drives, design consideration for CNC machine tools.
- Machine Tool Automation: Single spindle and multi-spindle automatics, cam layouts for automatics, indexing and bar feeding, numerical control and computer numerical control of machine tools.
- Machine Tool Testing and Selection: Acceptance test and charts of basic machine tools, machine tool rebuilding, general consideration for selection, comparison of costs, methods of machine tool selection.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture room with white board.
2. Handouts: soft and hard copies
3. PC’s for Power point presentations

4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be examined as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises reports (10%)

Core Reading Materials

- Venkataraman, K (2015) *Design of Jigs, Fixtures and Press Tools*, Wiley.
- Nee, J G (2010) *Fundamentals of Tool Design*, Society of Mechanical Engineers (SME).
- Henriksen, E (2010) *Jig and Fixture Design Manual*, Industrial Press (IP).

Recommended Reference Materials

- Hoffman, E (2003) *Jig and Fixture Design,* Cengage Learning.
- Journal of Manufacturing Science and Engineering

FME 561: Engineering Project I (60 hours)

Prerequisite:

Successful completion of all 4th year courses.

Purpose of the course units

The aim of these units is to enable the learner to apply the knowledge gained so far to the solution of an engineering problem, or the development of an engineering product, system or model.

Expected Learning Outcomes:

At the end of the units, the learner will be able to:

1. Demonstrate how the various courses in mechanical engineering are applied to the solution of an engineering problem.
2. Communicate the result of an engineering enquiry in a coherent report.
3. Demonstrate ability to apply practical skills to produce an engineering product, system or model.

Course Description

Carry out practical activities towards an engineering solution to an engineering problem.

Mode of Delivery

- Individual or group student engineering project activities under the supervision of an academic member of staff. - Face-to-Face or Blended Learning

Instruction materials and equipment:

- Necessary laboratory and Workshop facilities.

Course Assessment

The course shall be examined as follows:

- Continuous weekly progress assessment by supervisor through oral interviews and assessment of mandatory individual student journals in the prescribed format – 40%
- Assessment of weekly individual student journals by two independent examiners - 30%.
- End of semester oral presentations assessed by the supervisor and two independent examiners - 30%

Core Reading Materials

- As recommended by the supervisor

Recommended Reference Materials

- As recommended by the Supervisor

FME 562: Engineering Project II (60 hours)

Prerequisite:

FME 561: Engineering Project I

Purpose of the course unit

This course will enable the learner to apply the knowledge gained so far to the solution of an engineering problem, or the development of an engineering product, system or model.

Expected Learning Outcomes:

After completing the units, the learner will be able to:

1. Synthesise courses in mechanical engineering to solve an engineering problem.
2. Communicate the result of an engineering enquiry in a coherent report.
3. Produce an engineering product, system or model.

Course Description

Carry out practical activities towards an engineering solution to an engineering problem.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

- Necessary laboratory and Workshop facilities.

Course Assessment

The course shall be examined as follows:

- Continuous weekly progress assessment by supervisor through oral interviews and assessment of mandatory individual student journals in the prescribed format – 30%

- Final project report assessed by supervisor and two independent examiners - 40%.
- End of semester oral presentations assessed by the supervisor and two independent examiners - 30%

Core Reading Materials

- As recommended by the supervisor

Recommended Reference Materials

- As recommended by the supervisor

FME 563: Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) (60 hours)

Prerequisites

FME282: Computer Science II
FME 262: Engineering Drawing III
FME243: Workshop Technology and Practice

Purpose of the Course Unit

This course will enable the learner to be equipped with the practical knowledge of design and manufacturing techniques using computer based systems.

Expected Learning Outcomes

At the end of this course, the student will be able to;

1. Use some commercial CAD software to perform solid modelling
2. Write a numerical control machining programme
3. Optimize a design

Course Content

- The Digital Computer as a Design Aid: Digital computer, computer calculations, computers as data banks, data base and data base management, computer graphics, hardware for Computer Aided Design (CAD) workstations, interactive CAD, storage tube display end digitisers; CAD hardware.

- CAD Software: Graphics functions, utility functions, analysis software, drawing analysis software, drawing by analysis software, draughting software.
- CAD for Draughting: The computer draughting system, graphic input and output, using the memo system and cursor, filing and display, macros editors, plotting, curve generation and fitting, construction of layouts, annotating drawings.
- CAD Techniques for Finite Element Data Handling: Mesh generation, introduction to finite element method, 3-D shape description and mesh generation, 1/0 methods in macroblocks, formulation of the mesh, application of 3-D system for shape generation, matrix generation.
- Transformation System in CAD: Display windowing, 2-D transformations, 3-D transformations, linear transformations, display files for 2-D and 3-D data, isometric and perspective projections by machine algorithms, joystick and mouse functions, distortion.
- Micro Computer System for CAD: Microcomputer systems, choice of microcomputers for CAD, CAD based on microcomputers, data storage facilities, interlink of microcomputers in mini and mainframe computers interlinked microcomputers.
- Simulation: Introduction to similarity and similitude technique, linear and non-linear models, empirical, analytical and semi-analytical models.
- Computer Aided Manufacturing (CAM) Systems and Applications: CAM hardware, software for CAD/CAM workstations, Computerised Numerical Control (CNC) machine, Flexible Manufacturing Systems (FMS), non-machining applications, computer applications in production control and continuous production, robot assembly applications, unmanned applications, computer assisted programming for manufacture.
- CAD/CAM Developments: Future developments in design and manufacture, socio-economic and cultural effects of CAD/CAM.

Mode of Delivery

Lectures, discovery learning, problem-based learning, group-based learning, independent studies and e-learning.

Instruction materials and equipment:

1. Lecture rooms with white boards.
2. Handouts: soft and hard copies
3. PC's for Power point presentations
4. LCD/Overhead projector
5. Audio-visual aids
6. Necessary laboratory facilities

Course Assessment

The course shall be assessed as follows:

- An end of semester written examination constituting of 70%.
- Coursework: Continuous assessment tests (20%)
  Laboratory exercises reports (10%)

Core Reading Materials

- Chang, T C, Wijk R A & Wang H P (2005) *Computer Aided Manufacturing*, Prentice-Hall Inc., New Jersey.
- Altintas, Y. (2006) *Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations and CNC Design,* Cambridge.
- Fanti, M.P. et al. (2001) *Computer Integrated Manufacturing*, CRC Press LLC, 2nd ed.

Recommended Reference Materials

- Teicholz, C.E. (1985) *CAD/CAM Handbook*, McGraw-Hill.
- International Journal of Computer Systems Science and Engineering

13. APPENDICES

13.1. Appendix I: Facilities

	Item	Number/Detail	Capacity	Own/ Shared	Remarks
1.	Lecture rooms	E303	60	Own	Adequate for some classes
		E203/4	120	Own	Adequate for some classes
		AW 211/212	180	Own	Adequate
		CB 232B	100	Shared	Adequate
2.	Lecture Theatres	E001	140	Own	Adequate
		CELT	180	Shared	
		MLT 405	100	Shared	
		LT 102	300	Shared	
3.	Drawing Office	E 207	80	Own	Not adequate
		E 208	50	Shared	Not adequate
4.	Computer Rooms	E 306	40	Own	Adequate
		E 315	20	Own	Adequate
5.	Laboratories (See below for details of equipment in each Lab)	E401 (Metal.)	20	Own	Not adequate
		NDT (INST)	10	Shared	Adequate
		Strength of Materials	20	Own	Not adequate
		Machines (E300)	20	Own	Not adequate
		Thermo Lab	20	Own	Not adequate
		Fluids Lab	20	Own	Not adequate
		Exp. Stress Analysis (E301)	20	Own	Not adequate
		E 010 (Metrology)	20	Own	Adequate
		Steam Lab	10	Own	Adequate
		FABLAB (Innovation)	20	Shared	Adequate
		Heat treatment	20	Shared	Adequate
6.	Workshops (See below for details of the equipment in each workshop)	Machine shop	20	Own	Not adequate
		Sheet metal	10	Own	Adequate
		Welding & Fabrication	10	Own	Not adequate
		Foundry	10	Own	Adequate
		Motor vehicle engine shop	20	Own	Adequate

13.2. Appendix II: Equipment & Teaching Materials

DETAILS OF WORKSHOP AND LABORATORY EQUIPMENT

a. Fluids Laboratory

Subsonic Wind tunnel; High speed drilling machine; Centrifugal Fan; Boundary layer experiment kit; Divergent/convergent nozzle; Air compressor; Smoke tunnel; Supersonic Wind tunnel; Subsonic diffuser; Venturi-meter and orifice plate calibration apparatus; Apparatus for calibrating pressure gauges

b. Foundry Workshop

Mix Muller; Rotary Furnace; Carbon sulphur Determinator; Tube Furnace; LNT Furnace; J 4 200 p furnace; Sand rammer; Sand mechanical shaker; Moisture teller; Universal mould tester; Permiability mould tester; Metallurgical and chemical testing instrument; Transformer; Avery weighing scale.

c. Machine Workshop

Machines; Grinding Machines; Center Lathes; Capstan Lathe; Marking Table; Drilling Machines; Tools And Cutter Grinder; Manual Press; Power Saw; Shaping Machine; Bench Grinder

d. Machine/ Vibrations Laboratory

Data Amplifier; Serviscope Minor (CRO); Vibration Meter; B & K Preamplifier; Vibration Meter; Monitored Attenuator; Field Plotter; Vibration Pick-up Preamplifier; Serviscope Minor; Vibration Meter; Machine Analyzer; Field Plotter; Stethoscope; Motor Control; Travelling Microscope; Fuller Calculator; AF Signal Generator; Wave Analyser; Strain Gauge Amplifier; Avometer; Bench Vice; GBC Spiral binder; Spiral binding machine; Hydrovane Compressor; Flywheel; Belt Friction Apparatus; Belt Friction Apparatus; Weighing Balance; Free Vibration Rig; Sensitive Valve Voltmeter; Waltimeter;

Balancing Rig; Hydraulics Teaching Rig; Lubricating Demo Rig; Forced Vibration Rig; Speed Control; DC Power Supply; Air Compressor; Gear Efficiency Rig; Two-Degree of Freedom; Platform for MI; Electronic Stop Clock; Belt Friction Apparatus; DC Power Supply; Sensitive Valve Voltmeter; Oscillator; DC Servo System; Oscilloscope; Polarizing Instrument machine; Step down transformer

e. Metrology Laboratory

Optical Projector; Microscopic Measuring Machine Horizontal Pattern; Sigma Mechanical Comparator; Bench Center; Angle Dekkor; Tool Makers Microscope Type U-10; Monochromatic Light; Floating Carriage Micrometer; Surface Plate 15” X 10”

f. Microscopy Laboratory

Microscope; Polishing Machine; Sartonium balance; Zeiss Ikon Cameras (33mm); Milliameters; Minimointers

g. Sheet Metal and Welding workshops

Guillotine Machines; Dc Arc Welding Machine (Air Cooled); Spot Welding Machine; Arm Swing Bender; Bench Drilling Machine; Momentum Bending Machine; Nibbler Shearing Machine; Angle Line Cutter; Rolling Machines; Grooving Machines; Hydraulic Press Machine; Multiple Shearing Machine; Bench Grinding Machine; Metallic Benches; Wooden Benches; Bench Vice; Metallic Cabin

h. Thermo Laboratory

Heat convection Rig; Six-cylinder Diesel Engine and dynamometer; Bomb Calorimeter; Four-cylinder Diesel Engine; Ruston Engine (Diesel); Ricardo Engine (petrol); 2 Stage Air Compressor; Four Cylinder Land Rover Diesel Engine; Four Cylinder Land Rover Petrol Engine; Six Cylinder Petrol Engine;

Temperature Meter with Probe; 0-100gms balance; Six-cylinder petrol engine; One vehicle without body –HUMBER; Water pump; Spring balance

i. Strength of Materials Laboratory

Brinnell Hardness testing machine; Vickers Pyramid; Rockwell Machine; Internal Elastic Forces; Hardometer; Creep testing machine; Torsion small machines; Hounsfield machine with accessories; Reverse bending machine; Torsion testing machine; Strut Beam testing machine; Impact testing machine; Tension indentation and compression; Spring testing machine; Beam bending rig; Curved beam rig; Universal testing machines.

j. Computer Laboratories

Four computer laboratories equipped with high speed computers loaded with CAD software and Microsoft Office Suite among other applications; high speed cable internet connection.

13.3. Appendix III: Core Texts and Journals

TEXTS:

Abbasi, T and Abbasi, S A (2010) *Renewable Energy Sources – Their Impact on Global Warming and Pollution*, PHI Learning Private Limited.

Adler, R. B., Elmhorst, J. M. & Lucas, K. (2013) *Communicating at Work*, McGraw Hill.

Agrawal, B D and Broutman, L J. *Analysis and Performance of Fibre Composites,* John Wiley and Sons, New York.

Allen, K R (2010) *Entrepreneurship for Scientists and Engineers*. 1st Edition. Pearson Prentice Hall.

Altintas Y. Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, And CNC Design. Cambridge University Press; 2 Edition (2012).

American Chain Association (2006) *Standard Handbook of Chain, Second Edition*. CRC Press, Taylor and Francis Group.

American Society of Appraisers. Machinery and Equipment Textbook Committee (2000), Valuing Machinery and Equipment: The Fundamentals of Appraising Machinery and Technical Assets, American Society of Appraisers.

Anderson, T L. *Fracture Mechanics,* CRC Press.

Ashby, M F (2010), *Materials Selection in Mechanical Design*, Elsevier (Butterworth Heinemann), 4th Ed. ISBN-13: 978-9380931722.

Ashby, M F and J. Kara (2014), *Materials and Design: The Art and Science of Material Selection in Product Design*, 3rd Ed. ISBN-13: 978-0080982052.

Ashby, M F Shercliff, H and Cebon, D (2019), *Materials: Engineering, Science, Processes and Design*, Butterworth-Heinemann.

Askerland, D R and Wright, W J (2018), *Essentials of Materials Science and Engineering*, Cengage Learning.

Atkin, R J and Fox, N (2005) *An Introduction to the Theory of Elasticity*, Dover Publications.

Atkins, P, de Paula, J and Keeler, J (2018) *Atkin's Physical Chemistry*, Oxford University Press.

Badheshia, H and Honeycombe, R (2017), *Steels: Microstructure and Properties,* Butterworth-Heinemann.

Bansal, N P and A. R. Boccaccini (2012) *Ceramics and Composites Processing Methods*, John Wiley and Sons.

Bansal, N P and A. R. Boccaccini, (2012) *Ceramics and Composites Processing Methods*, John Wiley and Sons.

Barass, R (2014) *Scientists Must Write: A Guide to Better Writing for Scientists, Engineers and Students,* Taylor & Francis.

Barreira, L and Claudia V (2012) *Complex Analysis and Differential Equation*. Springer-Verlag, London.

Bear, F P and Johnson, E R (2012) *Vector Mechanics for Engineers*: Dynamics, McGraw-Hill.

Bear, F P, E. R. Johnson and J. T. Dewolf (2019) *Mechanics of Materials (In SI units),* Tata McGraw Hill Publishers.
Beer, F. P., E. R. Johnston Jr. and D. Mazurek (2015) *Vector Mechanics for Engineers: Statics, Eleventh Edition*. McGraw-Hill Education/Asia.

Belo M.A. (2012). Guide to Plant and Machinery Evaluation, 2nd Edition, Armitage Books.

Bergman, T L, Lavine, A S et al. (2011) *Fundamentals of Heat and Mass Transfer,* Wiley.

Bhat, S (2007) *Financial Management*. 2nd Edition. Excel Books.

Biafore, B (2003) *Microsoft Project 2013: The Missing Manual*, O'Reilly Media Inc.

Bird J.O. & May A.J.C. (1985) *Calculus for technicians*, Pearson Professional Education, 2nd Ed.ISBN-10: 0582413702, ISBN-13: 978-0582413702.

Bird, J (2006) *Higher Engineering Mathematics, Fifth Edition*. Newnes, Elsevier.

Black, J T and Kohser, R A (2019) *DeGarmo's Materials and Processes in Manufacturing*, Wiley.

Boljanovic V. (2004) Sheet Metal Forming Processes and Die Design, Industrial Press Inc.

Boljanovic V. (2004) *Sheet Metal Forming Processes and Die Design*, Industrial Press Inc.

Borgnakke, C and Sonntag, R E (2013*) Fundamentals of Thermodynamics*, 8th Ed., John Wiley & Sons, Inc, ISBN-13: 978-1118131992.

Brown J W, Robertson A J and Serpento S T (2002) *Motor Vehicle Structures, Concepts and Fundamentals,* 1st Edition. Butterworth Heinemann Publishers.

Budynas, R. G. and J. K. Nisbett (2015) *Shigley's Mechanical Engineering Design, Tenth Edition*. McGraw-Hill Education.

Callister, W D and Rethwisch, D G (2019) *Materials Science and Engineering,* John Wiley and Sons.

Capehart, B L, Turner, W C and Kennedy, W J (2016) *Guide to Energy Management: Principles and Applications,* Fairmont Press.

Carey F.A, Sundberg R.J (2008) *Advanced Organic Chemistry Part B Reaction and Sythesis,* 5th edition, springer. New York U.S.A

Carter, C B and Norton, M G (2013) *Ceramic Materials Science,* Springer.

Case, J, A.H. Chilver (1999) *Strength of Materials and Structures: An Introduction to Mechanics of Solids*, 4th Ed. Edward Arnold Publishers.

Cengel, Y A and Cimbala, J M (2017), *Fluid Mechanics: Fundamentals and Applications,* McGraw-Hill.

Cengel, Y A, Boles, M A, and Konoghu, M (2019), *Thermodynamics: An Engineering Approach*. McGraw-Hill.

Chakrabarty, J (2012) *Theory of Plasticity,* Butterworth-Heinemann.

Chang, T C, Wijk R A & Wang H P (2005) *Computer Aided Manufacturing*, Prentice-Hall Inc., New Jersey.

Chapra S C and Canale R P (2005) *Numerical Methods for Engineers*, McGraw-Hill.

Chartered Institute of Building Services: *Engineering, Plumbing Engineering Services Design Guide*by Institute of Plumbing CIBSE Design Guides.

Chelsom, J V, Payne, A C & Reavill, L R P (2005) *Maintenance for Engineers,* John Wiley and Sons.

Childs, P (2004) *Mechanical Design, Second Edition*. Elsevier, Butterworth Heinemann.

Childs, P. (2004) *Mechanical Design, Second Edition*. Elsevier, Butterworth Heinemann.

Claus Borgnakke , Richard E. Sonntag, (2013) *Fundamentals of Thermodynamics*, 8th Ed., John Wiley & Sons, ISBN-13: 978-1118131992.

Clayton, A. E & Hancock N. N. (1990) *The Performance and Design of Direct Current Machines.* New Delhi: Oxford and IBH Company Pvt. Ltd.

Cole, G (2004) *Management Theory and Practice*. 6th Edition. South-Western Cengage Learning.

Collins, J A, H. Busby & G. Staab (2000) *Mechanical Design of Machine Elements & Machines; A failure Prevention Perspective* – 2nd Edition.

Corbett, G P and Brannigan, F L (2019) *Brannigan's Building Construction for Fire Service*, Jones and Barlett Learning.
Crolla, D A (2009) *Automotive Engineering: Power Train, Chassis System, and Vehicle Body:* Elsevier.

Dal Pont, J-P (2012) *Process Engineering and Industrial Management*, Wiley.

Davies J W (2011) *Communication Skills: A Guide for Engineering and Applied Science Students,* Prentice Hall.ISBN-10: 0273729527, ISBN-13: 978-0273729525.

Deitel, H M and Deitel, P J (2017) *C++ How to Program.* 10th Edition. Pearson Publishing.

Desai, Y M, T. I Eldho, and A. H. Shah (2011) *Finite Element Method with Applications in Engineering*, Dorling Kindersley Publishers.

Devore, J L (2012) *Probability and Statistics for Engineering and the Sciences, Eighth Edition*, Brooks/Cole.

Dharan, C K H, Kang, B S and Finnie, I (2016) *Finnie's Notes on Fracture Mechanics,* Springer.

Dhillon, B S (2002) *Engineering Maintenance: A Modern Approach*, CRC Press.

Diebach, C (2014) *Introduction to Computer Science using Python, A computational Problem Solving Focus*, Wiley.

Douglas, J F, Gasiorek, J M and Swaffield, JA (2001) *Fluid Mechanics*, 2nd Ed. Prentice Hall.

Doyle, J F (2004) *Modern Experimental Analysis*, Wiley.

Duffy, D G (2003) *Advanced Engineering Mathematics with MATLAB, Second Edition*. Chapman and Hall/CRC.

Dukkipati, R V (2007) *Solving Vibration Problems Using MATLAB.* New Age International Publishers, 2007.

Eastop T.D. and McConkey A. (2002) *Applied Thermodynamics for Engineering Technologists,* Prentice and Hall, 5th Ed.

Elder, R, Tourlidakis, A and Yates, M (2003), *Advances in CFD in Fluid Machinery Design*. Wiley.

Elger D. F. et al. (2019), *Engineering Fluid Mechanics,* John Wiley and Sons.

Epstein, L M & Krieger P (2013) Schaum's Outline of College Chemistry, McGraw-Hill, 9th Ed.ISBN-10: 007181082X, ISBN-13: 978-0071810821.

Faith W (2015) *Word 2016 in Depth,* Que Publishing.

Fanti M P et al. (2001) *Computer Integrated Manufacturing*, CRC Press LLC, 2nd Ed.

Faye C, McQuiston, & Jerald D P (2004) *Heating, Ventilating and Air-Conditioning,* John Wiley & Sons Inc.

Ferziger, J H, Peric, M and Street, R L (2020) *Computational Methods for Fluid Dynamics*, Springer.

Finke, R A, Ward**,** T B and Smith, S M, *Creative Cognition: Theory, Research, and Applications.*

Finney, R. L., F. D. Demana, B. K. Waits and D. Kennedy (2006) *Calculus: Graphical, Numerical, Algebraic, Third Edition*. Prentice Hall.

Ford, H and Alexander, J. *Advanced Mechanics of Materials*

Fox, R (Ed.) (2005) *Fundamentals of Communication*, McGraw Hill.

Freddi, A, Olmi, G and Cristofolini, L (2015) *Experimental Stress Analysis for Materials and Structures*, Springer.

Gasiorek J.M. & Swaffield J. A., (2001), *Fluid Mechanics*, Prentice Hall, 4th Ed.

Gayton, C M (2012) *Legal Aspects of Engineering*, Kendall-Hunt Publishing.

Gebhardt, A (2011) *Understanding Additive Manufacturing.* Hanser Publishers.

Gene F. (2005) *Feedback Control of Dynamic Systems*, Prentice Hall, 5th Ed.

Gere, J M and B J Goodno (2013) *Mechanics of Materials*, Cengage Learning Publishers.

Gere, J M and B J Goodno (2017) *Mechanics of Materials*, Cengage Learning Publishers.

Gerhart, P M, Gerhart, A L and Hochstein J I (2016), *Munson, Young and Okiishi's Fundamentals of Fluid Mechanics,* John Wiley and Sons.

Gibson, D R and B. Stucker (2015) *Additive Manufacturing Technologies.* Springer Publ.

Glowinski, R and Xu, J (2010), *Numerical Methods for Non-Newtonian Fluids,* North-Holland.

Goldstein L. J. (2013) *Calculus and its application*, Pearson Education, 13th Ed.ISBN-10: 032184890X, ISBN-13: 978-0321848901.

Goode, S. W. and Scott, A. A. (2016) *Differential Equations and Linear Algebra,* Fourth Edition. Pearson.

Graham, K S (2012) *Mechanical Vibration: Theory and Applications*, SI Edition. Cengage Learning.

Greated, C and Cosgrove, J (2002) *Optical Methods and Data Processing in Heat and Fluid Flow*, John Wiley and Sons.

Green, A E and Zerna, W (2012) *Theoretical Elasticity,* Dover Publications.

Green, P (2007) *The Mechanical Engineering Drawing Desk Reference: Creating and Understanding ISO Standard Technical Drawings,* Lulu.com.

Griffiths D V and Smith I M (2006), *Numerical Methods for Engineers,* CRC Press.

Grondizik, W T and Kwok, A G (2019) *Mechanical and Electrical Equipment for Buildings*, Wiley.

Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson, 5th Edition, 2018.

Grover, M P (2019), *Fundamentals of Modern Manufacturing*, Wiley.

Gu, D (2014) *Laser Additive Manufacturing of High-Performance Materials*. Springer Publ.

Hayt, W H, J E Kemmerly and S M Durbin, (2002) *Engineering Circuit Analysis,* McGraw-Hill.

Heather, S (2017) *AutoCAD 3D modelling,* Industrial Press, Inc.

Henriksen, E (2010) *Jig and Fixture Design Manual*, Industrial Press (IP).

Hertzberg, R W, Vinci, R P and Hertzberg, J L (2016) *Deformation and Fracture Mechanics of Engineering Materials,* Wiley.

Hibbeler, R C (2016) *Mechanics of Materials,* Pearson.
Hibbeler, R. C. (2016) *Engineering Mechanics: Dynamics, (SI Units),* Prentice Hall.

Hibbeler, R. C. (2016) *Engineering Mechanics: Statics, Fourteenth Edition in SI Units*. Prentice Hall.

Hillier, F S and G.J. Lieberman (2014), *Introduction to Operations Research*, Latest Edition, McGraw-Hill.

Hoffman J D (2001), *Numerical Methods for Engineers and Scientists*, CRC Press.

Hoffman, D (2013) *Contemporary Calculus I.*

Hoffman, E (2003) *Jig and Fixture Design,* Cengage Learning.

Holman J.P. (2002) *Heat Transfer*, McGraw Hill.

Holman, J P. Experimental Methods for Engineers. McGraw-Hill Book Company ASIN: B008WD91G6.

Housecroft, C (2018) *Inorganic Chemistry*, Pearson.

Howard, W and J. Musto (2010) *Introduction to Solid Modelling Using SolidWorks* 2010, McGraw-Hill, ISBN-10:0073375438.

Hubert, C I (2020) *Electric Machines: Theory, Operating Applications and Controls*, Pearson.

Hull, D. *An Introduction to Composite Materials,* Cambridge University Press, Cambridge.

Incropera, F P, DeWitt, D P et al. (2011) *Introduction to Heat Transfer*, Wiley.

Irgens, F (2013) *Rheology of Non-Newtonian Fluids*, Springer.

Jacquelyn H.F. and Ungvarski P.J. (1995): *HIV/AIDS: A guide to nursing care*, Philadelphia: W B Saders.

James W. D & William F.R. (2005) *Experimental Stress Analysis*, McGraw-Hill, 3rd Ed.

Jelaska, D (2012) *Gears and Gear Drives*, John Wiley and Sons Ltd.

Jones W.P. (2000) *Air-Conditioning Engineering*, Butterworth-Heinemann.

Juvinall, R. C. and K. M. Marshek (2012) *Fundamentals of Machine Component Design, Fifth Edition*. John Wiley and Sons, Incorporated.

Kalpakjian, S and Schmid, S.R. (2018), *Manufacturing Engineering and Technology*, Wiley.
Kalpakjian, S and Schmid, S.R., *Manufacturing Engineering and Technology,* Prentice Hall, Latest Edition.

Kim, K-Y, Samad, A and Benini, E (2019) *Design Optimization of Fluid Machinery,* Wiley.
Kirkpatrick, J.M. (2014) *The AutoCAD text Book*, Merrill Pub Co.

Kotler, P (2000) *Marketing Management*. Prentice Hall of India.

Kotler, P and Armstrong, G (2004) *Principles of Marketing,* 10th Edition. Pearson/Prentice Hall.

Krauträmer, J and Krauträmer, H. *Ultrasonic Testing of Materials,* Springer-Verlag, Berlin Heidelberg.

Kreyzig, E (2011) *Advanced Engineering Mathematics, Tenth Edition*. John Wiley and Sons, Incorporated.

Kuo B. C. & Farid G. (2002) *Automatic Control Systems*, Wiley, 8th Ed.

Kutz, M (2002), *Handbook of Materials Selection*, Wiley, 1st Ed. ISBN-13: 978-0471359241.

Langley B. (2000) *Fundamentals of Air-conditioning systems,* Marcel Dekker.

Larson, R and Edwards, B H (2014) *Calculus.* Cengage Learning.

Larson, R. and R. Hostetler (2007) *Precalculus*, *Seventh Edition*. Houghton Mifflin Company, Boston and New York.

Leech G. & Svartrik J. (2003) *Communicative Grammar of English*, Longman Publishers.ISBN-10: 0582506336, ISBN-13: 978-0582506336

Lester, A. (2007) *Project Management, Planning and Control*, 5th Ed. Butterworth-Heinemann.

Lin. J. S. (2016) *Programmable Logic Controllers,* Industrial Press Inc., 1st edition

Lynn D. R. & George A. A. (2006) *Classical Thermodynamics*, Oxford University Press, Int. Ed.

Madou, M.J. (2011), *Fundamentals of Microfabrication and Nanotechnology*, CRC Press.
Madou, M.J. *Fundamentals of Microfabrication and Nanotechnology*, CRC Press, Latest Edition.

Madsen D.A. (2016) *Engineering Drawing & Design,* Cengage Learning.

Magreb, E B et al. (2019) *Integrated Product and Process Design and Development*, CRC Press.

Maleque, A and M. S. Salit (2013), *Materials Selection and Design*, Springer, ISBN-13:978-981-4560-38-2.

Marston, D L (2008) *Law for Professional Engineers*, McGraw-Hill Professional.

Massey, B S. *Mechanics of Fluids*. ELBS and Van Nostrand Reinhold (UK).

Mata, A S et al. (2016) *Fundamentals of Machine Theory and Mechanisms*. Springer International Publishing, Switzerland.

Mayergoyz, I D and Lawson, W (2012) *Basic Electric Circuit Theory*, Academic Press.

McKinnon, R C (2019) *The Design, Implementation, and Audit of Occupational Health and Safety Management System*, CRC Press.

Meriam, J. L., L. G. Kraige and J. N. Bolton (2016) *Engineering Mechanics Volume I: Statics, Eighth Edition, SI Version*. John Wiley and Sons Inc.

Meriam, J. L., L. G. Kraige and J. N. Bolton (2016) *Engineering Mechanics Volume II: Dynamics, SI Version*. John Wiley and Sons Incorporated.

Michael B. S & Jerry March, (2007) *March's Advanced Organic Chemistry: Reaction mechanisms and structures,* 7th edition, Wiley. New York U.S.A ISBN-10: 0470462590, ISBN-13: 978-0470462591

Michael, J M & Howard, N S (2007) *Fundamentals of Engineering Thermodynamics*, Wiley.

Miessler, G L, Fischer, P J and Tarr, D A (2013) *Inorganic Chemistry*, Pearson.

Mittal, A K (2018) Electrical and Mechanical *Services in High Rise Buildings,* CBS Press.

Montana, P J and Charnov, B H (2008) *Management*. 4th Edition. Barron's Educational Series.

Montgomery, D. C. and G. C. Runger (2013) *Applied Probability and Statistics for Engineers, Sixth Edition*. John Wiley and Sons, Incorporated.

Moore, H (2015) *Matlab for Engineers*. 4th Edition. Pearson Publishing.

Moran, M J, Shapiro, H N, Boettner, D D and Bailey, M B (2018), *Fundamentals of Engineering Thermodynamics,* 9th Ed, Wiley.

Morris AS (2001) *Measurement and Instrumentation Principles,* Butterworth-Heinemann.

Morris Kline. *Calculus: An Intuitive and Physical Approach, Second Edition*. Dover Publications, 2013

Mott, R L (2005) *Machine Elements in Mechanical Design* – 3rd Edition.

Muller-Kirsten, H. J. W. (2011). *Electrodynamics*, 2nd Edition. World Scientific. ISBN-13: 978-9814340731.

Myszka, D H (2012) *Machines and Mechanisms: Applied Kinematic Analysis, Fourth Edition*. Prentice Hall.

Naidu, N. V. R. and Rao, Krishna T (2010) *Management and Entrepreneurship*. I. K. International Pvt Ltd.

Nee, J G (2010) *Fundamentals of Tool Design*, Society of Mechanical Engineers (SME).

Nelkon, M and P. Parker, *Advanced Level Physics*, 7th Edition, Heinemann, ISBN: 9780435923037.

Nicholas, J M and Steyn, H (2012) *Project Management for Engineering, Business and Technology,* 4th Ed, Routledge.

Nicholas, J M. (2004) *Project Management for Business and Engineering: Principles and Practice,* 2nd Ed. Elsevier.

Norton, R. L. (2011) *Design of Machinery: An Introduction to the Synthesis and Analysis of Machines and Mechanisms, Fifth Edition*. McGraw-Hill Education.

Ohanian H. C. & Markert, J. (2007) *Physics for Engineers*, W.W. Norton & Co. Ltd. ISBN: 978-0-393-92631-6.

Oleg, V (2000) *Fundamentals of Kinematics and Dynamics of Machines and Mechanisms*. CRC Press.

Omura, G & B.C. Benton (2014) *Mastering Autocad 2014 & AutocadLite 2014,* Wiley, New York.

Ostovic, V (2016) *The Art and Science of Rotating Fluid Machinery Design: A Practical Approach*, Springer.

Perry, J and Michael B (2009) *Introduction to Philosophy*: Classical and Contemporary Readings.

Petruzella, F D. *Programmable Logic Controllers*, McGraw Hill, 4th Edition.

Philip A. Pecorino (2016) *Introduction to Philosophy*, Queensborough Community College, New York.

Plog, B A, P.J. Quinlan and J. Villarreal, *Fundamentals of Industrial Hygiene,* National Safety Council; 6th Edition.

Polyanin A. D. & Manzirov A. V. (2006) *Handbook of Mathematics for Engineers and Scientists,* Chapman & Hall/CRC Press.

Prasad P, Belwafa J E, *Vehicle Crashworthiness and Occupant Protection:* Automotive Applications Committee, American Iron and Steel Institute, Southfield, Michigan.

Pulkrabek W. (2003) *Engineering Fundamentals of Internal Combustion Engines,* 2nd Ed. Prentice Hall.

Rabiee M. (2017) *Programmable Login Controllers; Hardware and Programming,* 4th Edition, Goodhearth- willcox,

Rading, G O (2007) *Concise Notes on Materials Science and Engineering,* Trafford Publishing, Victoria, Canada.

Raghavendra, N.V. and Krishnamurthy, L (2013) *Engineering Metrology and Measurements.* Oxford University Press; Pap/Psc edition.

Rama S.R. Gorla, Aijaz A. Khan (2003), *Turbomachinery Design and Theory*, CRC Press.

Rama, S R G and Khan, AA (2003) *Turbomachinery Design and Theory*, CRC Press.

Rao, S (2016) *Mechanical Vibrations*, Sixth Edition. Pearson.

Rauhut N. C and Bass R. H (2009) *Readings on Ultimate Questions: An Introduction to Philosophy.*

Rees, D W A (2015) *The Mechanics of Engineering Structures,* Imperial College Press.

Reese, C D, *Occupational Health and Safety Management: A Practical Approach*, CRC Press; 3rd edition.

Richard E., Claus B. and Gordon J., (2013) *Fundamentals of Thermodynamics* 5th Ed., Don Fowley. ISBN-13: 978-0471183617.

Richard L. W. & Saundra H. (2011) *Communicating Effectively*, McGraw Hill, 10th Ed.ISBN-10: 0073534331, ISBN-13: 978-0073534336.

Richard S. (1999) *Introduction to Internal Combustion Engines*, 3rd Ed.

Richard, E, Claus, B and Gordon J (2013) *Fundamentals of Thermodynamics* 5th Ed., Don Fowley. ISBN-13: 978-0471183617.

Richardson, D W and Lee, W E (2018) *Modern Ceramics Engineering*, CRC Press.

Robert L. Norton, *Mechanics of Machines an Integrated Approach* – 3rd Edition.

Rockman, H B (2004) *Intellectual Property Law for Engineers and Scientists*, IEEE Press.

Rodgers, G F C & Mayhew Y R (1992) *Engineering Thermodynamics*, 4th Ed. Longman Singapore Publishers.

Rogoff, E G (2007) *Bankable Business Plans*. 2nd Edition. Rowhouse Publishing.

Rolfe, S T and Barsom, J M. *Fracture and Fatigue Control in Structures,* Prentice-Hall, New Jersey.

Ronald W L (2017) *Engineering with Excel,* Pearson Inc, 5th Edition.

Roosa, S A, Doty, S and Turner, W C (2018*) Energy Management Handbook*, Sixth Edition. The Fairmont Press Inc.

Rosenberg, J, L. M. Epstein and P. Krieger, *College Chemistry*, Schaum Outline Series, McGraw-Hill.

Scharf, G. (2014). *Finite quantum electrodynamics: the causal approach*. Courier Corporation. ISBN 978-3-642-57750-5

Schnelle, K B Jr. and Brown, C A (2002) *Air Pollution Control Technology Handbook*, CRC Press LLC.

Sedra, A. S. & Smith K. C., (2003). *Microelectronic Circuits*. New York: Oxford University Press, 5th Ed.

Sen, P C (2013) *Principles of Electric Machines and Power Electronics*, Wiley

Sharma, P C and Kataria, S K (2008) *Power Plant Engineering,* 9th Ed. S K Kataria & Sons.

Shigley, J. E., C. R. Mischke and T. H. Brown Jr. (2004) *Standard Handbook of Machine Design, Third Edition*. McGraw-Hill Education.

Shih, R (2019) P*arametric Modelling with SolidWorks.*

Shultz M J (2006) *Chemistry for Engineers*: An Applied Approach, Houghton Mifflin Company.ISBN-10: 0618271945, ISBN-13: 978-0618271948.

Simmons, C H and Dennis E. Maguire (2012), *Manual for Engineering Drawing,* Butterworth-Heinemann*, 4th ED.*

Srinivas, J (2012) *Stress Analysis and Experimental Techniques*, Alpha Science.

Stephens, R C (1970) *Strength of Materials and Structures*: Theory and Examples, Edward Arnold Publishers.

Stewart, J., L. Redlin and S. Watson (2015) *Precalculus: Mathematics for Calculus, Seventh Edition*. Brooks Cole.

Strang, Gilbert (2014) *Differential Equations and Linear Algebra*. Wellesley-Cambridge UK Edition.

Stroud, K. A. and D. J. Booth (2001) *Engineering Mathematics, Fifth Edition*. Industrial Press, Incorporated.

Stroustrup, B. (2013) *The C++ Programming Language.* 4th Edition. Addison-Wesley.

Sullivan, M. (2012) *Precalculus, Ninth Edition*. Prentice Hall.

Sundararajan, I D (2019) *Introduction to Circuit Theory*, Springer

Svoboda, J A and Dorf, R C (2013) *Introduction to Electric Circuits*, Wiley.

Taha, H A (2020) *Operations Research: An Introduction*, Pearson.

Timoshenko, S P and Goodier, J N. (2010) *Theory of Elasticity*, McGraw-Hill India.

Truss, L. (2003) *Eats, Shoots and Leaves*, Profile Books, London, UK.

Tu, J, Yeon, G-H and Liu, C (2018) *Computational Fluid Dynamics: A Practical Approach*, Butterworth-Heinemann.

Ugural, A C (2015) *Mechanical Design of Machine Components, Second Edition*. CRC Press, Taylor and Francis Group.

Uicker, J. J. Jr., G. R. Pennock and J. E. Shigley (2016) *Theory of Machines and Mechanisms, Fifth Edition*. Oxford University Press.

Ullman, D G (2010) *The mechanical Design Process* – 4th Edition.

Utterback, J M, *Mastering the Dynamics of Innovation***.**

Valerio A. & Donald A.P. (2004) *Education and HIV/Aids: A Sourcebook of HIV/Aids Prevention Programs,* World Bank Publications.

Varberg, D E, Purcell, E J and Rigdon, S E (2000) Calculus. 8th Edition. Prentice Hall.

Venkataraman, K (2015) *Design of Jigs, Fixtures and Press Tools*, Wiley.

Versteeg, H.K, Malalasekera, W. (2007) *An introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson.

Volhardt, P and Neil Schore (2014) *Organic Chemistry Structure and Functions*. Freeman, New York U.S.AISBN-10: 1464120277, ISBN-13: 978-1464120275

Walpole, R. E., R. H. Myers, S. L. Myers and Keying Ye (2012)*Probability and Statistics for Engineers and Scientists, Ninth Edition*. Prentice Hall.

Wang Y., Martinsen K and T. Yu (Editors). Advanced Manufacturing and Automation IX (Lecture Notes in Electrical Engineering) Springer; 1st edition. 2020

Wayne C. T and Doty, S (2007) *Energy Management Handbook*, Sixth Edition. The Fairmont Press Inc.

Weiner, R F and Mathews, R (2003) *Environmental Engineering*, Fourth Edition, Butterworth – Heinemann.

Wellcome T. (2003) *HIV/AIDS*, London, 2nd Ed.

Westergaard, H M (2014) *Theory of Elasticity and Plasticity*, Harvard University Press.

Wilcox D. C. (2004) *Turbulence Modelling for CFD*, DCW Industries.

Wilcox, D.C. (2004) *Turbulence Modelling for CFD*, DCW Industries.

Wildi, T (2005) *Electrical Machines, Drives and Power Systems*, Pearson.

William, G (2007) *Advanced Fluid Mechanics*.

Wilson, C E and J. Peter Sadler (2003) *Kinematics and Dynamics of Machinery, Third Edition*. Pearson.

Winston, W L (2003) *Operations Research: Applications and Algorithms*, Cengage Learning.

Woodard, F (2000) *Industrial Waste Treatment Handbook*, Butterworth – Heinemann.

Wright, T and Gerhart, P (2009) *Fluid Machinery: Application, Selection and Design,* CRC Press.

Wu, W-T and Massoudi, M (2020) *Recent Advances in Mechanics of Non-Newtonian Fluids*, MDPI AG.

Young, H. D. & Freedman, R. A. (2015) *University Physics with Modern Physics,* Addison Wesley.ISBN-10: 0321973615, ISBN-13: 978-0321973610.

Yunus C, and Boles, M (2014), *Thermodynamics: An Engineering Approach* (Mechanical Engineering), 8th Edition, McGraw-Hill. ISBN-13: 978-0077366742.

Yunus, C (2014) *Heat and Mass Transfer*, MHS; 5th Edition. ISBN-13: 978-9339223199.

Zumdahl S. S. & Zumdahl S. A. (2013) *Chemistry*, Houghton Mifflin Company.ISBN-10: 1133611095, ISBN-13: 978-1133611097.

JOURNALS

1. *Acta Metallurgica et Materelia* (Elsevier).
2. Additive Manufacturing (Elsevier).
3. Advances in Engineering Software (Elsevier).

4. Advances in Finite Element Method (Elsevier).
5. Applied Mechanics reviews (American Society of Mechanical Engineers, ASME).
6. Applied Thermal Engineering (Elsevier).
7. ASHRAE Transactions (ASHRAE).
8. British Welding Journal (International Institute of Welding, IIW).
9. Composites Science and Technology (Elsevier).
10. Energy Conservation and Management (Elsevier).
11. Engineering Fracture Mechanics (Elsevier)
12. International Journal of Applied Mechanics
13. International Journal of Flexible Manufacturing Systems (Springer).
14. International Journal of Fracture Mechanics (Springer).
15. International Journal of Heat and Fluid Flow (Elsevier).
16. International Journal of Multiphase Flow (Elsevier).
17. International Journal of Plasticity (Science Direct).
18. International Journal of Project Management (Elsevier).
19. International Metals Reviews (Springer).
20. Journal of Design and Manufacturing Automation. Taylor and Francis
21 Journal of Engineering Materials and Technology (ASME)
22. Journal of Energy Engineering (American Society of Civil Engineers, ASCE).
23. Journal of Entrepreneurship and Innovation in Emerging Technologies, (SAGE).
24. Journal of Manufacturing Systems (Elsevier).
25. Journal of Materials Processing Technology (Elsevier).
26. Journal of Materials Science (Springer).
27. Journal of Mechanical Design (ASME).
28. Journal of Property Investment & Finance, Emerald Publishing.
29. Materials Science and Engineering A (Elsevier).
30. Operations Research (PubsOnLine).
31. Progress in Additive Manufacturing (Springer).
32. Renewable Energy (Elsevier)
33. Welding Journal (American Welding Society, AWS).

13.4. Appendix IV: Academic Staff

13.4.1 ACADEMIC STAFF

NAME	HIGHEST ACAD. QUALIF.	Area	GRADE	Full/Part Time	Teaching Exper. (Years)	EBK Registration status
Prof George O Rading Thematic Head	PhD, U of Alabama, USA, 1994	Materials and Solid Mechanics	Professor	Full Time	36	Registered
Prof Stephen M Mutuli Thematic Head	PhD, Poiters (France), 1986	Solid Mechanics	Professor	Full Time	40	Registered
Prof Madara Ogot DVC	PhD, Penn State, USA, 1991	Industrial Engineering	Professor	Full Time	29	Registerable
Prof Gideon K Misoi Thematic Head	PhD, UoN, 1986	Machines & Drawing	Associate Professor	Full Time	40	Registered
Prof James A Nyangaya Thematic Head	PhD, IIT, Delhi, 1991	Thermodyn-amics	Associate Professor	Full Time	35	Registered
Prof Julius M Ogola Thematic Head	PhD, UoN, 2007	Industrial Engineering	Associate Professor	Full Time	29	Registered
Dr Alex Aganda	PhD, Leeds, UK, 1996	Thermodynamics	Senior Lecturer	Full Time	28	Registerable
Dr Thomas O Mbuya Chairman	PhD, Southampton (UK), 2012	Materials and Manufacturing	Senior Lecturer	Full Time	22	Registerable
Dr Hussein Jama Coordinator	PhD, Monash, 2010	Solid Mechanics & Design	Senior Lecturer	Full Time	10	Registerable
Dr Kenneth D Njoroge	PhD, UoN, 2015	Solid Mechanics and Materials	Senior Lecturer	Full Time	10	Registered
Dr Kamau Gachigi	PhD, Penn State, USA, 1996	Materials	Lecturer	Part Time	21	Registerable
Dr Ernest A Odhiambo Thematic Head	PhD, Taiwan, 2016	Fluid Mechanics	Lecturer	Full Time	11	Registerable
Dr Richard K Kimilu	PhD, NTUST Taiwan, 2016	Thermodynamics	Lecturer	Full Time	11	Registerable
Dr Rueben Kivindu	PhD, NTUST, Taiwan, 2017	Thermodynamics	Lecturer	Full Time	9	Registerable
Dr George N Makori	PhD, UoN, 2015	Fluid Mechanics & Eng Management	Lecturer	Part Time	25	Registerable
Q B O Misango	MSc, UoN, 1986	Machines & Drawing	Lecturer	Full Time	35	Registerable
D M Munyasi Transport	MSc, UoN, 1986	Solid Mechanics	Lecturer	Full Time	22	Registered

NAME	HIGHEST ACAD. QUALIF.	Area	GRADE	Full/Part Time	Teaching Exper. (Years)	EBK Registration status
Manager						
M Mwaka	MSc, Manitoba, Canada	Fluid Mechanics	Lecturer	Full Time	25	Registered
S M Kabugo	MSc, UoN, 1994	Machines	Lecturer	Full Time	26	Registerable
F Mbithi	MSc, Denver, USA, 2014	Industrial Engineering & Design	Lecturer	Full Time	Staff Dev	Registerable
E K Musyoka	MSc, JKUAT, 2016	Industrial Management	Tutorial Fellow	Full Time	Staff Dev	Registerable
E N Akhusama	MSc, UoN, 2012	Materials	Tutorial Fellow	Full Time	Staff Dev	Registerable
M J Kabeyi	MSc, Moi U, 2010	ThermoFluids	Tutorial Fellow	Full Time	Staff Dev	Registerable

13.4.2 TECHNICAL STAFF

No.	Name	Designation	Highest Academic qualification
1.	Luke Wangai	Chief Technologist	Higher Diploma (Mech Eng)
2.	John Kahiro	Chief Technologist	Higher Diploma (Mech Eng)
3.	Zacharia O. Kebaso	Senior Technologist	B Com
4.	Fay Airo	Senior Technologist	BEng
5.	Simon Maina	Senior Technologist	BIT
6.	Kenneth K Sang	Storekeeper	BSc (Proc)
7.	Eugene Odera	Technologist	Diploma (Mech Eng)
8.	Jackton Anyona	Technologist	Higher Diploma (Mech Eng)
9.	Simon K Mukiri	Technologist	Higher Diploma (Mech Eng)
10.	David Macharia	Technologist	Diploma (Mech Eng)
11.	Samuel Gachuhi	Technologist	Tech II
12.	Trufena Anyolo	Technologist	Diploma (Mech Eng)
13.	Albert Okoth	Technologist	Diploma (Mech Eng)
14.	James Kimani	Technologist	Cert.
15.	Justin Kibagedi	Technical Assistant	Higher Diploma (Mech Eng)
16.	Leah W Mbuthia	Trainee Technologist	BSc (Mech Eng)
17.	Nicodemus Kalee	Technical Assistant	Diploma (Mech Eng)
18.	Jackline A Odoyo	Trainee Technologist	BTech (Mech Eng)
19.	Geofrey M Kiogora	Technical Assistant	BSc (Elect Eng)
20.	Francis K Njogu	Technical Assistant	Diploma (Mech Eng)
21.	Leonard Kigen	Technical Assistant	Diploma (Mech Eng)
22.	Beth Makena	Storekeeper	Diploma (Purchasing)

13.5. Appendix V: Evidence Curriculum Approvals

S/N	ITEM	DATE
1	Technical Curriculum Review Workshop	N/A
2	University Curriculum Review Sensitization workshop for Deans, Chair of Departments and Curriculum Development Committees	25th June 2019
3	Minutes of Departmental Curriculum Review Committee	28th November 2019
4	College Based Curriculum Review workshop	7th November 2019
7	Minutes of Faculty/School Curriculum Review Committee	
8	Minutes of approval by the Faculty/School Board	20th January 2020
9	Directorate of Quality Assurance	
10	Minutes of approval by the College Academic Board	24th January 2020
11	Minutes of approval by the Deans Committee	9th July 2020
12	Minutes of approval by Senate Programme Development Committee	16th July 2020
13	Approval by University Senate	
14	Commission for University Education (Where applicable	

13.6. Appendix VI: Fees Structure

a. Tuition fees shall be KShs. 198,000.00 per semester.
b. A refundable Caution Money fee of KShs. 5,000.00 shall be payable once upon registration as a student.
c. Administrative fees (KShs.) per academic year shall be as follows:

Registration	1,000.00
Student Identity Card	500.00
Activity fee	2,000.00
Examination fee	5,000.00
Students Organization	1,000.00
Medical fee	5,000.00
Computer fee	5,000.00
Laboratory fee	5,000.00

The fees breakdown is as follows:

Year 1	**Semester I**	**Semester II**	**Total**
Registration	1,000	-	1,000
Tuition Fees	198,000	198,000	396,000
Examinations	5,000	-	5,000
ID Card	500	-	500
Student organisation	1,000	-	1,000
Medical Fee	5,000	-	5,000
Activity Fee	2,000	-	2,000
Laboratory Fee	5,000	-	5,000
Computer Fee	5,000	-	5,000
Caution	5,000	-	5,000
Total (KES)	**227,500**	**198,000**	**425,500**

Year 2	**Semester I**	**Semester II**	**Total**
Registration	1,000	-	1,000
Tuition Fees	198,000	198,000	396,000
Examinations	5,000	-	5,000
ID Card	500	-	500
Student organisation	1,000	-	1,000
Medical Fee	5,000	-	5,000
Activity Fee	2,000	-	2,000
Laboratory Fee	5,000	-	5,000
Computer Fee	5,000	-	5,000
Total (KES)	**222,500**	**198,000**	**420,500**

Year3	**Semester I**	**Semester II**	**Total**
Registration	1,000	-	1,000
Tuition Fees	198,000	198,000	396,000
Examinations	5,000	-	5,000
ID Card	500	-	500
Student organisation	1,000	-	1,000
Medical Fee	5,000	-	5,000
Activity Fee	2,000	-	2,000
Laboratory Fee	5,000	-	5,000
Computer Fee	5,000	-	5,000
Total (KES)	**222,500**	**198,000**	**420,500**

Year 4	**Semester I**	**Semester II**	**Total**
Registration	1,000	-	1,000
Tuition Fees	198,000	198,000	396,000
Examinations	5,000	-	5,000
ID Card	500	-	500
Student organisation	1,000	-	1,000
Medical Fee	5,000	-	5,000
Activity Fee	2,000	-	2,000
Laboratory Fee	5,000	-	5,000
Computer Fee	5,000	-	5,000
Industrial Attachment Fee	-	5,000	5,000
Total (KES)	**222,500**	**203,000**	**425,500**

Year 5	Semester I	Semester II	Total
Registration	1,000	-	1,000
Tuition Fees	198,000	198,000	396,000
Examinations	5,000	-	5,000
ID Card	500	-	500
Student organisation	1,000	-	1,000
Medical Fee	5,000	-	5,000
Activity Fee	2,000	-	2,000
Laboratory Fee	5,000	-	5,000
Computer Fee	5,000	-	5,000
Project Fee	10,000	10,000	20,000
Total (KES)	**232,500**	**208,000**	**440,500**

Summary of Fees:

Tuition fees KES 1,980,000/-

Administration fees KES 152,500/-

Total (over five years) KES 2,132,500/-