SUBJECT OUTLINE: ME422 INTEGRATED MECHANICAL DESIGN

Course	Bachelor of Mechanical Engineering (NQF Level 8)
Subject Name	Integrated Mechanical Design
Subject Code	ME422
Duration	13 Teaching Weeks, 1 Examination Week, 1 Mid-semester Week
Contact Hours	6 Hours per Week (2 Hours Lectures / 4 Hours Design/Projects) – Note that significant out of class teamwork is required as seen in the allocated Credit Points
Credit Points	18
Delivery Mode	On Campus
Prerequisites	ME311 - Mechanics of Machines, ME312 - Machine Design, ME314 Manufacturing Processes and Design, ME313 Heat Transfer
Co-requisites	Nil
Subject Coordinator	Professor Nicholas Lambrache

Synopsis

This is a capstone design subject that builds on previous introductory and intermediate design subjects which form a backbone of the mechanical engineering program. It enables students to work in teams to undertake complex mechanical engineering design projects. The subject develops abilities regarding the design and development of complex mechanical engineering systems such as; need identification, problem definition, concept generation and evaluation, systemic implications of design decisions, understanding of design challenges and application of design established practices. It covers design theory, failure and risk analysis, estimation of life cycle costs, reliability and quality in observance of international standards. Modern design tools widely used in industry such as SolidWorks, ANSYS and MATLAB are employed. Integrated design methodologies such as Virtual Prototyping, 3D Printing, Computational Thermofluidic Dynamics, and Rapid Prototyping are considered. How engineering design decisions may be influenced by the social and economic considerations, health, safety, and environment considerations, professional ethics and sustainable life cycle is covered. The impact of poor design, imperfections in materials, improper manufacturing, poorly defined assembly and maintenance will be investigated to ensure awareness of the need of design for reliability and quality for robust design. The subject culminates with effective business approaches and a team based multimedia technical presentation.

Subject Topics

1. Fundamentals of Integrated Design
2. Communication of design intent through 3D models and related technical drawings of system's assemblies and components
3. Application of contemporary interdisciplinary evaluation tools in integrated design: CAD, Finite Element Modelling, Multi-Physics, 3D Printing and CAM

4. Integrated Design Phases:

    a. Objectives
    b. Requirements for effective design
    c. Design procedures
    d. Functions and characteristics of optimal design
    e. Alternative solutions
    f. Detail optimization

5. Design Management

    a. Strategies in integrated design and their interdisciplinary connections
    b. Product development from 3D Model to Rapid Prototype through FEM, 3D Printing, Rapid Prototyping and Prototype Testing

Subject Learning Outcomes (SLOs)

After completing this unit students will be able to:

1. Plan, manage and conceptualize a Mechanical engineering design project within requirements and constraints including requirements, time and resources using mechanical system design and analysis tools
2. Formulate concept solutions by researching, applying and synthesising the knowledge gained throughout their course. Apply problem-solving methodologies to generate, evaluate and justify proposed concept solutions.
3. Debate, negotiate, justify, clarify and respond to questions and statements concerning the proposed design concept in terms of Integration of sub-discipline applications.
4. Apply good professional engineering practice to the design project, including safety, ethical, legal, social, cultural and sustainability considerations, along with International standards and codes of practice.
5. Generate high quality product documentation incorporating literature review, design requirements, analysis, proposal conceptualization, 3D printing, concept prototyping and project planning.
6. Use design project management processes and tools, self-management skills, communication skills in order to plan and manage project work.
7. Engage in effective teamwork and communication of design outcomes.

Assessment Tasks and Weightings

To obtain a pass grade in this Subject at least 50% overall must be achieved plus a minimum of 50% in the Final Design Report. Students must also refer to the Subject Assessment Details.

Assessment 1 – Design Project Concept Report: A team-based report outlining team formation and member roles, project selection, team and member action plan and a

schedule of future activities to achieve the final design outcome. The report contributes 10% towards the final grade for the subject.

Assessment 2 – Design Progress Reports: Team based report outlining team progress in achieving design outcomes in line with the team schedule submitted in the Project Concept Report. Variations to the original schedule will be identified and justified. There will be three progress reports, each written by different members of the team. The Progress Reports contributes 15% towards the final grade for the subject.

Assessment 3 - Final Design Report: A professional level report with individual and team components that outlines and communicates the design processes, rationale and outcomes. The Final Report contributes 60% towards the final grade for the subject. Team member's grades are composed of a team component and individual component.

Assessment 4 - Audio Visual Presentation: An audio-visual presentation of design outcomes that contains the salient feature of the Final Report. All team members will contribute. The presentation contributes 15% towards the final grade for the subject. Team member's grades are composed of a team component and individual component.

It is important that all students familiarise themselves with the University of Technology Assessment Guidelines including those on plagiarism in the Academic Integrity Policy at:

http://asix.unitech.ac.pg/apps/pnguot/?q=unitech/policies

Subject Mapping

Subject Learning Outcomes (SLO) are mapped to each of the PNG National Qualifications Framework (NQF), Course Learning Outcomes (CLO), Unitech Graduate Attributes (GA), Assessment Tasks (AT) and Engineers Australia (EA) Stage 1 Competencies.

SLO	SLO to NQF	SLO to CLO	SLO to GA	SLO to AT	AT to Topics	SLO to EA Stage 1 Competencies
1	Knowledge and Skills Applications	1, 2, 3, 4, 5	Critical Thinker Life Long Learner Technology Savvy	1, 2, 5	1, 2, 3	2.1, 2.3
2	Knowledge and Skills Applications Autonomy	2, 4, 5, & 6	Critical Thinker Life Long Learner Technology Savvy	1 & 2	1, 2, 3, 5	1.3, 1.4 2.1, 2.3, 2.4
3	Knowledge and Skills Applications Autonomy	3, 4, 5, & 6	Critical Thinker Life Long Learner Technology Savvy	1, 2 & 3	1, 3, 4, 5	1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 3.2
4	Knowledge and Skills Applications	8 & 9	Critical Thinker Effective Communicator Moral Uprightness	1, 2 & 3	1, 3, 4, 5	1.5, 1.6, 2.3, 2.4, 3.1, 3.4, 3.5

5	Knowledge and Skills Applications Autonomy	7	Critical Thinker Effective Communicator Technology Savvy	1-4	1, 2	1.3, 2.3, 2.4, 3.2, 3.3, 3.4, 3.5, 3.6
6	Knowledge and Skills Applications Autonomy	7	Critical Thinker Effective Communicator Technology Savvy	1-4	1, 2	2.3, 2.4, 3.2, 3.3, 3.4, 3.5, 3.6
7	Knowledge and Skills Applications Autonomy	7	Effective Communicator	1-4	2,4,5	3.2, 3.3, 3.6

Engineers Australia Stage 1 Competencies

1. KNOWLEDGE AND SKILL BASE	2.ENGINEERING APPLICATION ABILITY	3. PROFESSIONAL AND PERSONAL ATTRIBUTES
1.1 Comprehensive, theory-based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	2.1 Application of established engineering methods to complex engineering problem solving.	3.1 Ethical conduct and professional accountability.
1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.	2.2 Fluent application of engineering techniques, tools and resources.	3.2 Effective oral and written communication in professional and lay domains.
1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline.	2.3 Application of systematic engineering synthesis and design processes.	3.3 Creative, innovative and pro-active demeanour.
1.4 Discernment of knowledge development and research directions within the engineering discipline.	2.4 Application of systematic approaches to the conduct and management of engineering projects.	3.4 Professional use and management of information.
1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline.		3.5 Orderly management of self, and professional conduct.
1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline		3.6 Effective team membership and team leadership.

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Graduate Capability Statement

The mechanical engineering graduate will have the skills and ability to systematically apply the engineering knowledge in an ethical and morally responsible manner in providing practical and sustainable solutions to engineering problems while upholding a level of sensitivity to social, cultural, legal and environmental issues in society.

Mechanical Engineering Course Learning Outcomes

The following table is included to demonstrate to mechanical engineering students that their Course Learning Outcomes address all EA Stage 1 Competencies.

The mapping matrix for all subject learning outcomes within the Course, against EA Stage 1 Competencies, provides more detailed information. That matrix is provided separately to students.

Course Learning Outcome	Engineers Australia Stage 1 Competencies
1. Possession of a deep understanding of the sciences, math, information systems and engineering fundamentals that underpin the mechanical engineering discipline.	1.1, 1.2
2. An in-depth understanding of the body of knowledge that forms the mechanical engineering discipline.	1.2, 1.3
3. Collection, synthesis and application of information within the mechanical and related engineering disciplines.	1.4, 1.5, 2.1, 2.3, 2.4, 3.4
4. Undertaking research, analysis & evaluation of ideas and concepts within mechanical engineering.	1.3, 1.4, 1.6, 2.1, 2.3, 2.4, 3.2, 3.4
5. Applying problem solving skills to complex mechanical engineering systems and processes.	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 2.3
6. Undertake mechanical engineering design and manage engineering projects.	1.6, 2.2, 2.4, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6
7. Communication via multiple media to diverse audiences, undertaking team roles, teamwork and providing team leadership.	2.4, 3.2, 3.3, 3.4, 3.5, 3.6
8. Behaving in an ethical and professional manner and respecting others.	1.6, 2.4, 3.1, 3.4, 3.5, 3.6
9. Being cognisant of the importance of sustainability and the environmental impact of engineering.	1.5, 1.6, 3.1, 3.3, 3.4

Unitech Graduate Attributes

Attribute	Academic dimension	Personal Dimension	Transferable Dimension
1. Lifelong learner	Sustained intellectual curiosity and use of feedback to reflect on their own work.	Sets aspirational goals for personal improvement and career growth.	Takes responsibility for one's learning and development.
2. Critical thinker	Uses rules of inference to analyse complex issues and find solutions.	Calmly uses logic and critical thinking, and not emotion, in all situations.	Ability to find solutions to problems by using logical and imaginative thinking.
3. Effective communicator	Ability to discuss and debate issues articulately and confidently and convincingly.	Character of producing high quality written essays and oral presentations.	Ability to communicate and negotiate with others and to listen to them.
4. Cultural modernist	Familiarity with international standards and world cultures and human rights.	Tolerance of the religions and cultures of others.	Ability to work in a multicultural setting and comprehension and tolerance of religious and cultural differences.
5. Moral uprightness	Understand and act upon the ethical responsibilities of their actions.	Character of acting in a morally upright way in all situations.	Professional behaviour at all times.
6. Technologically savvy	Familiarity and use of technologies appropriately.	Keeping up to date with innovations.	Character of accepting new technology and quickly adapting to it.

Student Workload

The total workload for the subject for the average student is a nominal 150 hours, based on a 15 week semester with 13 weeks of teaching as per the PNG National Qualification Framework.

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Texts

Budynas, RG & Nisbett, K, 2015. Shigley's Mechanical Engineering Design, 9th Edition in SI units, McGraw-Hill. ISBN: 978-981-3151-00-0.

https://www.academia.edu/13057650/Book_Mechanical_Design_9th_Edition

Childs, PRN, 2014. Mechanical Design Engineering Handbook, Elsevier.

https://www.academia.edu/35699015/Mechanical_Design_Engineering_Handbook_pdf

Reference Texts

1. Nigel Cross, 2008. *Engineering Design Methods: Strategies for Product Design*, 4th Edition, Wiley & Sons
2. Dassault Systems, 2012. *SolidWorks Fundamentals*, Concord, Massachusetts, United States, 2012
3. Cook, R, 1995. *Finite Element Modelling for Stress Analysis*, John Wiley & Sons, New York.
4. Collins, J., Busby, H., Staab, G. 2010. *Mechanical Design of Machine Elements and Machines*, Second Edition, John Willey, New Jersey.
5. Leondes, C 2001. *Systems Techniques and Computational Methods*, CRC Press, Boca Raton.

Additional Readings

1. Lecture Notes
2. Relevant Laboratory Notes

YouTube Clips

The following YouTube Clips augment weekly lectures:

1. Top 10 Steps of the Mechanical Design Process – DQDesign, https://www.youtube.com/watch?v=kZKmsJJDyn8
2. 3D Printing Basics, https://www.youtube.com/watch?v=nb-Bzf4nQdE
3. Virtual Prototyping, https://www.youtube.com/watch?v=qVoeTDrF6_0
4. CNC Milling Using Mastercam, https://www.youtube.com/watch?v=HfTb1qIR-nI
5. Overview of ANSYS Workbench for Finite Element Analysis, https://www.youtube.com/watch?v=tIBKSOy0jE4

Relevant Unitech Policies

It is important that all students familiarise themselves with the PNGUOT Assessment Guidelines including those on plagiarism and other relevant policies. These policies are viewed by visiting the PNGUOT website: http://asix.unitech.ac.pg/apps/pnguot/?q=unitech/policies