SUBJECT OUTLINE: ME312 MACHINE DESIGN

Programs	Mechanical Engineering (NQF Level 8)
Subject Name	Machine Design
Subject Code	ME312
Duration	13 Teaching Weeks, 1 Examination Week, 1 Mid-Semester Week
Contact Hours	6 Hours/Week (4 Lec/1 Tut/1 Lab)
Credit Points	20
Delivery Mode	On campus
Prerequisites	ME222 – Solid Mechanics
Corequisites	Nil
Subject Coordinator	TBA

Synopsis

The subject introduces students to the broad perspective of engineering concepts and skills required in the design and analysis of machine components encountered in mechanical engineering. The included topics address theoretical and practical aspects like selection of materials, evaluation of stresses, strains and displacements under static and dynamic loads, surface damage due to erosion and corrosion or failure theories and failure prevention. Also included are topics on developing and designing shafts, elastic elements, bearings and gears. Of significant importance are topics related to the design of fasteners, clutches, brakes, power screws, belts and chains.

Subject Topics

1. **Load Analysis, Selection of Materials and Failure Theories in Mechanical Engineering. Fatigue and Corrosion**: Static and dynamic loading of components in machine design. Elements of contact mechanics. Fracture mechanics. Maximum normal stress, shear stress and Mohr failure theories. Safety factors, reliability and machinability. Failure prevention. Fatigue strength in direct and reversed rotating bending, torsion and biaxial loading conditions. Effects of stress concentrators and surface treatments on fatigue. Design for corrosion control. Types of wear and design for wear control.

2. **Threaded Fasteners, Power Screws, Rivets, Welding and Bonding**: Terminology, materials and design methodologies for threaded fasteners and power screws. Design of rivet and welded assemblies. Stress, strain and displacement evaluation for fasteners, power screws, rivet, welded and bonded assemblies under static and dynamic loading conditions.

3. **Design of Clutches, Brakes, Belts, and Chains**: Disk and tapered clutches and brakes. Energy absorption and cooling. Long shoe drum and band brakes. Flat, V-shaped and toothed belts. Roller and inverted-tooth chains. Hydrodynamic drives and fluid couplings.

4. **Elastic Elements**: Torsion bar, coil and beam spring design. Coil spring stress and deflection equations. Stress and strength analysis for helical compression springs. End designs of helical compression springs. Buckling of coil springs in compression. Energy storage in elastic elements.

5. **Shafts and Bearings**: Provision for shaft bearings. Rotating shaft dynamics and shaft design techniques. Keys, pins, splines and couplings. Hydrodynamic lubrication in sliding bearings and Petroff's equation for bearing friction. Thrust bearings and elasto-hydrodynamic lubrication. Rolling bearing types, mounting, design and catalogue selection.

6. **Gear Design, Analysis and Selection**: Spur gear nomenclature and geometry. Interference, contact ratio, gear-tooth bending stresses and Lewis equation. Surface fatigue analysis in gear-tooth. Spur gear design procedures and materials. Bevel, helical and worm gears: nomenclature and geometry, thermal capacity. Gear trains.

Subject Learning Outcomes SLOs

On completion of this subject, students will be able to:

1. Evaluate stresses, strains and displacements on components under combined static and dynamic loading conditions. Evaluate fatigue strength of components under various dynamic loading conditions and surface finish and treatments. Select materials and apply design methodologies for corrosion and wear control.
2. Design and analyze assemblies with fasteners, rivets, weldings and bondings. Analyze and evaluate power screw assemblies used in mechanical engineering applications from the point of view of lift capability and precision.
3. Develop, design and analyze mechanical engineering systems employing clutches, brakes, belts, and chains.
4. Analyze elastic elements from the points of view of displacements and stresses for various materials and geometries. Design assemblies employing elastic elements in tension, compression or torsion. Design compressive helical coil springs with buckling control.
5. Analyze dynamics of rotating shafts and design optimized shafts under combined static and dynamic loads. Evaluate lubrication regimes in sliding hydrodynamic bearing and evaluate moments of friction using Petroff's equation. Know the analytic limits of evaluating hydrodynamic bearings using the partial differential equations Navier - Stokes. Select rolling bearings for various loading conditions and design systems employing such bearings.
6. Evaluate interference, contact ratio, gear-tooth fatigue and bending stresses for various gear types. Design gear assemblies for various dynamic loadings and evaluate their thermal capacity. Employ gear trains at optimal torque ratios in mechanical engineering systems.
7. Undertake team laboratories and communicate team-based laboratory outcomes via well structured reports.

Assessment Tasks and Weightings

To obtain a pass grade in this Subject at least 50% overall must be achieved, and at least 40% achieved in the final examination. Students must also refer to the Subject Assessment Details.

Assessment 1 – Lab/Project Concept Report: A team based or individual component report outlining individual or team formation. Team based report outlining formation and member roles, project selection, team and member action plan and a schedule of future activities to achieve the outcome. The report contributes 20% towards the final grade for the subject.

Assessment 2 – Assignments: The assignments are intended to support students achieving the learning outcomes for the Subject and will contribute 20% towards the final grade for the subject.

Assessment 3 – Class Test: The Test contributes 20% towards the final grade for the subject and evaluates progress towards achievement of learning outcomes.

Assessment 4 - Final Examination (E): The individual components of final examination enable final evaluation of achievement of learning outcomes and contribute 40% towards the final grade for the subject

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	SLO to EA Stage 1 Competencies
1	Applications, Knowledge and Skills	2,3,5	1,2	2,3,4	1.1, 1.2, 1.3
2	Applications, Knowledge and Skills	2,3,5,6	1,2	2,3,4	1.1, 1.2, 1.3,1.5
3	Applications, Knowledge and Skills	2,3,5,6	1, 2	2,3,4	1.1, 1.3,1.5,2.1
4	Applications, Knowledge and Skills	2,4,5,6	1, 2	2,3,4	1.3,1.5,2.1
5	Applications, Knowledge and Skills	2,4,5,6	1, 2	2,3,4	1.3, 1.5,2.1,2.2,2.3
6	Applications, Knowledge and Skills	2,3,5,6	1,2	2,3,4	1.5,2.1,2.2,2.3,
7	Applications, Knowledge and	2,3,4,6,7,8	1,2,3,5	1	1.5,2.4,3.1,3.2,3.3, 3.6

	Skills				

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.

Graduate 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 Outcome CLO

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	Calmly uses logic and critical	Ability to find solutions to problems by using

	analyse complex issues and find solutions.	thinking, and not emotion, in all situations.	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 subject workload for the average student is a nominal 150 hours, based on a 15 week semester with 13 weeks of lecturing and laboratories, one mid-semester week and one examination week as per PNG National Qualification Framework.

Subject Textbook

- Juvinall, R., Marshek, K. – *Fundamentals of Machine Component Design*, 5th Edition, John Willey and Sons, Hoboken, New Jersey, United States, 2012

References

- Marghitu, D. – *Mechanical Engineer's Handbook*, Academic Press, San Francisco, United States, 2001

Readings and Resources

- Budynas Nisbett – *Shigley's Mechanical Engineering Design*, McGraw Hill, New York, United States, 2005

YouTube Clips

1. https://www.youtube.com/watch?v=CBVlYibdF3M&list=PLKz_xsS_duovIcKifF1vL_qE8xDoocWf5
2. https://www.youtube.com/watch?v=mzWMdZZaHwI&list=PL3D4EECEFAA99D9BE
3. https://www.youtube.com/watch?v=nqhyCzrFp1s

Relevant Unitech Policies

It is important that all students familiarize themselves with the PNGUOT Assessment Guidelines including those on plagiarism and other relevant policies. These policies can be viewed by visiting the PNGUOT website:

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