SUBJECT OUTLINE: ME222 SOLID MECHANICS

Programs	Mechanical Engineering (NQF Level 8)
Subject Name	Solid Mechanics
Subject Code	ME222
Duration	13 Lecturing Weeks, 1 Examination Week, 1 Mid-Semester Week
Contact Hours	6 Hours/Week (3 Lec/ 2 Tut/ 1 Lab)
Credit Points	18
Delivery Mode	On campus
Prerequisites	EN113 – Engineering Materials and Properties
Corequisites	Nil

Synopsis

The subject introduces students to fundamental principles and concepts required in the development, design and analysis of machine components and structures encountered in mechanical engineering. The included topics address theoretical and practical aspects like stress-strain relationships and transformations, Mohr's graphical representations and energy-based methods in evaluating strains. Also included are topics on failure theories for brittle and ductile materials encountered in mechanical engineering design.

Subject Topics

1. **Stress and Strain under Axial Loading Conditions. Hooke's Law**: Stress-strain diagrams, Hooke's Law, Young Modulus, Poisson Ratio. Elastic versus plastic behaviour of materials. The brittle nature of fatigue failure. Component displacements under axial loading.
2. **Torsional Stresses, Strains and Displacements**: Stresses and displacements in shafts. Stress concentrators. Shear modulus. Torsion strains in elastic and plastic ranges. Residual stresses in circular shafts.
3. **Bending Stresses, Strains and Displacements**: Elastic and plastic deformations in beams under bending loads. Stress concentrators. Bending stresses in composite materials. Residual stresses due to bending loads. Eccentric loadings in beams. Bending loadings in curved beams. Analysis and design of beams under bending loads.
4. **Shear Stresses in Beams and Thin-Walled Components**: Shear stresses on horizontal faces of beams. Longitudinal shear stresses on beams of arbitrary shape and thin-walled components.
5. **Stress and Strain Transformations**: General state of stress. Mohr's Circle in 2D and 3D spaces. Principal stresses and maximum shearing stress. Yield and

fracture criteria under plane stress. Measurement of strains. Strain rosettes. Principal stresses under given and combined loadings.

6. **Deflection of Beams. Stability of Columns. Energy Methods in Solid Mechanics**: Deformation of beams and the equation of elastic curve. Statically indeterminate beams. Moment-area theorems and maximum deflections of beams. Euler's formula for columns with various end conditions. Eccentric loadings and secant formula. Strain energy and strain energy density. Impact loading. Work-energy methods for evaluating deflections. Castigliano's theorem.

Subject Learning Outcomes (SLOs)

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

1. Demonstrate an understanding of the concepts of stress and strain, and the stress-strain relationships for homogenous, isotropic materials.
2. Demonstrate an understanding of the relationships between loads, member forces and deformations and material stresses and strains in structural members under axial loading, torsion, flexural loadings, shear, and thin-walled pressure vessels.
3. Demonstrate an understanding of beams, columns and different structures to failure under complex stress states subjected to combined loadings.
4. Apply the above understanding to the designs and analysis of structural members based on strength and deformation criteria and also design a structural component including the concept of factor of safety.
5. Demonstrate an understanding of the assumptions and limitations of the theories used in mechanics of materials.
6. Evaluate and apply the above understanding in different steps of designing process for different mechanical structures/parts such as problem identification, formulation and solution, and resolving critical issues.
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 and at least 40% for the Final Examination must be achieved.

Students must also refer to the Subject Assessment Details:

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	2, 6	2,3,4	1.1, 1.2, 1.3
2	Applications, Knowledge and Skills	2, 3, 5,6	2, 6	2,3,4	1.3, 1.4, 1.5,2.3
3	Applications, Knowledge and Skills	2, 3, 5,6	2, 6	2,3,4	1.1, 1.2, 1.3,2.3
4	Applications, Knowledge and Skills	2, 3, 5,6	1,2,6	2,3,4	1.3,2.1, 2.2, 2.3
5	Applications, Knowledge and Skills	2, 3, 5	1,2,6	2,3,4	1.5, 2.2, 2.3
6	Applications, Knowledge and Skills	2, 3, 5,6	1,2,6	2,3,4	1.3, 2.3, 2.2, 3.3
7	Applications, Knowledge and Skills NQ8	2,3,4,6,7,8	1,2,3,5,6	1	2.4, 3.1,3.2, 3.5, 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.

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 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	1.1, 1.2

engineering fundamentals that underpin the mechanical engineering discipline.	
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 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 Text

- Solid Mechanics - *Lecture Notes, Tutorials and Laboratory Guides*

References

- Beer, F., Johnston, R., DeWolf, J., Mazurek, D. – *Mechanics of Materials*, McGraw Hill, New York, United States, 2012

Readings

- Hearn, E. – *Mechanics of Materials*, Butterworth Heinemann, Oxford, Massachusetts, United States, 2000

YouTube Clips

1. https://www.youtube.com/watch?v=B9lyGZzb_6M&list=PLVUFoQtXVwBQPCbgN74CANsyvIogzpCvI
2. https://www.youtube.com/watch?v=VHp3OHO4OKw
3. https://www.youtube.com/watch?v=geqRGNIZGq8&list=PL9RcWoqXmzaLlfmNq2Ku1SdZtvXnYrLbc

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