SUBJECT OUTLINE: ME321 VIBRATION ANALYSIS

Programs	Mechanical Engineering (NQF Level 8)
Subject Name	Vibration Analysis
Subject Code	ME321
Duration	13 Lecturing 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	EN212 – Engineering Mathematics III
Corequisites	Nil
Subject Coordinator	TBA

Synopsis

The subject introduces students to the fundamental field of mechanical vibrations analysis. All mechanical and structural engineering systems can be modeled as mass-spring-damper systems and the students are required to identify such components and study their interactions, effects and methods of control. The included topics address the analysis of free, damped and forced vibrations, the modeling of periodic motions as harmonic functions, the analysis of single and multiple degrees of freedom vibrating and the evaluation of natural frequencies and mode shapes. Also included are topics on vibration control, measurement and related applications.

Subject Topics

1. **Fundamentals of Mechanical Vibrations**: Vibrations classification. Procedures in vibrations analysis. Vibrations terminology. Spring, mass and damping elements. Harmonic motion and harmonic analysis. Numerical approaches using Matlab.
2. **Free Vibrations of Single Degree of Freedom. Harmonically Excited Vibrations**: Free vibrations of single degree of freedom systems without and with damping. System responses. Rayleigh's energy method. Coulomb and hysteretic damping. Equations of motion of harmonically excited vibrations and system responses. Stability analysis.
3. **Vibrations under General Forcing Conditions**: Forced vibrations under general conditions. Response spectrum, Laplace transforms. Equation of motion for forced vibrations. Self-excitation and stability.
4. **Multiple Degrees of Freedom Vibrations**: Modeling of multiple degrees of freedom vibrations. Newton and Lagrange methods.

5. **Determination of Natural Frequencies and Mode Shapes**: Fundamental frequency of composite systems using Dunkerley's formula. Rayleigh, Holzer and Jacobi's methods in evaluating natural frequencies and modal vectors.

6. **Mechanical Vibrations Control and Measurement**: Control of vibrations at the source. Balancing of shafts and reciprocating engines. Control of natural frequencies. Damping, vibration absorbers and isolators. Transducers for vibration measurement. Frequency measuring instrumentation. Vibration exciters. Dynamic testing of machines and structures.

Subject Learning Outcomes SLOs

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

1. Apply the terminology, classification and methodology involved in vibrations analysis. Evaluate equivalent masses, springs and dampers in vibrating systems. Perform harmonic analysis and approximate periodic functions with harmonic functions using Fourier series.
2. Evaluate vibrating systems of a single degree of freedom with and without damping. Analyze the responses and stability of systems under harmonically excited vibrations.
3. Analyze forced vibrations under general conditions. Establish the governing equation of motion for forced vibrations, evaluate its solutions and discuss the stability of under-damped, critically damped and over-damped vibrating systems.
4. Design, model and evaluate multiple degrees of freedom vibrating systems using Newton and Lagrange methods.
5. Determine natural frequencies and vibration modes of composite systems using Dunkerley's formula. Evaluate natural frequencies and modal vectors on vibrating systems using Rayleigh, Holzer and Jacobi's methods.
6. Evaluate methods of controlling vibrations at the source. Analyze natural frequencies and vibration modes of systems in order to avoid resonance. Analyze and calibrate damping ratios. Design systems with vibration absorbers and isolators. Evaluate methods of dynamic testing of machines and structures.
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	2, 6	2,3,4	1.1, 1.2, 2.1, 2.2, 2.3
2	Applications, Knowledge and Skills	2, 3, 5	2, 6	2,3,4	1.1, 1.2, 2.1, 2.2, 2.3
3	Applications, Knowledge and Skills	1, 2, 3, 5	2, 6	2,3,4	1.1, 1.2, 2.1, 2.2, 2.3, 3.4
4	Applications, Knowledge and Skills	1, 2, 3, 5,6	2, 6	2,3,4	1.1, 1.2, 2.1, 2.2, 2.3, 2.4, 3.4
5	Applications, Knowledge and Skills	1, 2, 3, 5, 6	2, 6	2,3,4	1.1, 1.2, 2.1, 2.2, 2.4, 3.4
6	Applications, Knowledge and Skills	1, 2, 3, 5, 6, 7	2, 6	2,3,4	1.2, 1.4, 2.1, 2.2, 2.3, 3.4
7	Applications, Knowledge and Skills	2,3,4,6,7	2, 6	1	1.5, 3.1,3.5,.3.5,.3.6

Engineers Australia Stage 1 Competencies

1. Knowledge and Skills 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	2.1 Application of established engineering methods to complex engineering problem solving.	3.1 Ethical conduct and professional accountability.

engineering discipline.		
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 communicator 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.

Unitech Graduate Attributes

Attribute	Academic Dimension	Personal Dimension	Transferable Dimension
1. Lifelong Learner	Sustained Intellectual Curiosity and Use of Feedback Reflected in Work	Sets Aspiration Goals for Personal Improvement and Career Growth	Takes responsibility for one's learning and development.
2. Critical Thinker	Use of Inference Rules in Analysing and Finding Solutions for Complex Problems	Non-Emotional, Logic and Critical Thinking Abilities in all Situations.	Ability to find solutions to problems by using logical and imaginative thinking.
3. Effective Communicator	Abilities in Articulate Discussions	Skills in Delivering high Quality written essays and oral	Ability to communicate and negotiate with others and to listen to them.

		presentations.	
4. Cultural Modernist	Familiarity with international standards, 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.

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

Course Learning Outcomes	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

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

- Rao, S. – *Mechanical Vibrations*, 5th Edition, Prentice Hall, New York, 2011

References

- Gans, R.- Mechanical Systems - *A Unified Approach to Vibrations and Controls*, Springer, 2015

Readings and Resources

- Thomson, W., Dahleh, M. - *Theory of Vibrations with Applications*, 5th Edition, Prentice Hall, 1998

YouTube Clips

1. https://www.youtube.com/watch?v=S2-26LR8_Es&list=PL2ym2L69yzkZJ1fY3SQ1JCyvZIoJYXQGZ
2. https://www.youtube.com/watch?v=7gQCUhA3PtE&list=PLWqFWuIMqmHTBPgqwabliwB4EOR02nMr-

3. https://www.youtube.com/watch?v=9r630K5HmJc&list=PLSGws_74K01_pG3R7rgtDtrDZBjcTqPdR

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 available at the PNGUOT

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