Unit 4008: Mechanical Principles

Unit Code: **K/651/0720**

Level: **4**

Credits: **15**

Introduction

Mechanical principles have been crucial for engineers to convert the energy produced by burning oil and gas into systems to propel, steer and stop our automobiles, aircraft, and ships, amongst thousands of other applications. The knowledge and application of these mechanical principles is still the essential underpinning science of all machines in use today or being developed into the latest technology.

The aim of this unit is to introduce students to the essential mechanical principles associated with engineering applications.

Topics included in this unit are: behavioural characteristics of static, dynamic and oscillating engineering systems including shear forces, bending moments, torsion, linear and angular acceleration, conservation of energy and vibrating systems; and the movement and transfer of energy by considering parameters of mechanical power transmission systems.

On successful completion of this unit students will be able to learn about the underlying principles, requirements, and limitations of mechanical systems.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Solve problems within static mechanical systems

LO2 Analyse dynamic mechanical systems

LO3 Investigate elements of simple mechanical power transmission systems

LO4 Analyse natural and damped vibrations within translational and rotational mass-spring systems.

Essential Content

LO1 **Solve problems within static mechanical systems**

Shafts and beams:

The effect of shear forces on beams

Bending moments and stress due to bending in beams

Selection of appropriate rolled steel sections to satisfy given specifications for beams and columns

The theory of torsion in solid and hollow circular shafts

Stress and deflection in solid and hollow circular shafts due to torsion

Impact of stresses in different types of materials

Introduction to stresses in pressure vessels

Use of relevant problem-solving tools within the context e.g. root cause analysis (RCA), process failure modes effects analysis (PFMEA), fishbone, practical problem solving (PPS), advanced product quality planning (APQP)

Use of relevant software and simulation tools within the context.

LO2 **Analyse dynamic mechanical systems**

Energy and work:

The principle of conservation of energy and work-energy transfer in systems

Linear and angular velocity and acceleration

Velocity and acceleration diagrams of planar mechanisms

Gyroscopic motion

Examples and applications of dynamic systems and gyroscopic motion.

LO3 **Investigate elements of simple mechanical power transmission systems**

Simple systems/subsystems:

Parameters of simple and compounded geared systems

Efficiency of lead screws and screw jacks.

Couplings and energy storage:

Universal couplings and conditions for constant-velocity

Importance of energy storage elements and their applications including electro-mechanical systems

Examples and applications of current mechanical power transmission systems/subsystems.

LO4 **Analyse natural and damped vibrations within translational and rotational mass-spring systems**

Types of motion:

Simple harmonic motion

Natural frequency of vibration in mass-spring systems.

Damped systems:

Frequency of damped vibrations in mass-spring-damper systems

The conditions for an external force to produce resonance

Examples and applications of mechanical vibrations (e.g., modelling of vibration isolation, vehicle suspensions).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Solve problems within static mechanical systems		
P1 Solve mechanical systems problems that include distribution of shear force, bending moment and stress due to bending in simply supported beams **P2** Justify the selection of standard rolled steel sections for beams and columns **P3** Calculate the distribution of shear stress and the angular deflection due to torsion in solid and hollow circular shafts.	**M1** Determine the material used for a circular bar using experimental data obtained from a torsion test for the angle of twist under loading.	**D1** Verify, using simulation software, analytical calculations of the magnitude of shear force and bending moments in cantilever and encastre beams for given design applications.
LO2 Analyse dynamic mechanical systems		
P4 Analyse the energy transfer processes within mechanical systems that are operating in uniform acceleration motion **P5** Analyse the magnitude and effect of gyroscopic reaction torque.	**M2** Analyse dynamic aspects of given mechanical system(s) using vector diagrams of velocities and accelerations within planar mechanisms.	**D2** Evaluate the behaviour of mechanical dynamic systems by applying appropriate methodologies.

Pass	Merit	Distinction
LO3 Investigate elements of simple mechanical power transmission systems		
P6 Investigate the behaviour of compound gear systems and the holding torque required to securely mount a gearbox **P7** Investigate the operating efficiency of lead screws and screw jacks **P8** Explain the conditions required for a constant velocity ratio between two joined shafts.	**M3** Examine devices which function to store mechanical energy in their operation.	**D3** Evaluate the cause of a documented case of mechanical power transmission failure, and the steps to correct the problem and to rectify any design faults.
LO4 Analyse natural and damped vibrations within translational and rotational mass-spring systems		
P9 Analyse the natural frequency of vibration in a mass-spring system.	**M4** Analyse the transient response within a mass-spring damper system.	**D4** Determine the conditions needed for mechanical resonance, and proposed measures to prevent this from occurring.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Aremu B. (2023) *Introduction to Mechanical Engineering Science: A solid foundation of sound engineering principles, analysis and technical problem-solving skills* (Paperback). IngramSpark.

Bird J. and Ross C. (2020) *Mechanical Engineering Principles*. 4th Ed. London: Routledge.

Hibbeler R.C. (2023) *Mechanics of Materials*. SI Edition. 11th Ed. Pearson

Hibbeler R.C. (2020) *Engineering Mechanics: Dynamics and Statics*. SI Edition. 14th Ed. Pearson.

Moseley H. (2022) *The Mechanical Principles of Engineering and Architecture* (Paperback). Legare Street Press.

Rao S.S. (2023) *Mechanical Vibrations in SI Units*. 6th Ed. Pearson

Tooley M. and Dingle L. (2020) *Engineering Science: For Foundation Degree and Higher National*. 2nd Ed. London: Routledge.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

International Journal of Mechanical Sciences

Journal of Mechanical Engineering

Journal of Mechanical Engineering Research and Developments

Journal of Mechanical Science and Technology

Mechanical Engineering Journal

Links

This unit links to the following related units:

Unit 4001: Engineering Design

Unit 4002: Engineering Maths

Unit 5003: Advanced Mechanical Principles.