Unit 8: Mechanical Principles

Unit code	**F/615/1482**
Unit level	**4**
Credit value	**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 explain the underlying principles, requirements and limitations of mechanical systems

Learning Outcomes

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

1. Identify solutions to problems within static mechanical systems.
2. Illustrate the effects that constraints have on the performance of a dynamic mechanical system.
3. Investigate elements of simple mechanical power transmission systems.
4. Analyse natural and damped vibrations within translational and rotational mass-spring systems.

Essential Content

LO1 **Identify solutions to 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 beams and columns to satisfy given specifications.

The theory of torsion in solid and hollow circular shafts.

LO2 **Illustrate the effects that constraints have on the performance of a dynamic mechanical system**

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.

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

Simple systems:

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.

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.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Identify solutions to problems within static mechanical systems</td><td rowspan="2">D1 Calculate the magnitude of shear force and bending moment in cantilever and encastré beams for a variety of applications.</td></tr>
<tr><td>P1 Calculate the 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 Determine the distribution of shear stress and the angular deflection due to torsion in solid and hollow circular shafts.</td><td>M1 Determine the material of a circular bar from experimental data of angle of twist obtained from a torsion test.</td></tr>
<tr><td colspan="2">LO2 Illustrate the effects that constraints have on the performance of a dynamic mechanical system</td><td rowspan="2">D2 Calculate solutions of velocities and accelerations within planar mechanisms using trigonometric methodology.</td></tr>
<tr><td>P4 Explain the effects of energy transfer in mechanical systems with uniform acceleration present.
P5 Identify the magnitude and effect of gyroscopic reaction torque.</td><td>M2 Construct diagrams of the vector solutions of velocities and accelerations within planar mechanisms.</td></tr>
<tr><td colspan="2">LO3 Investigate elements of simple mechanical power transmission systems</td><td rowspan="2">D3 Examine the cause of a documented case of mechanical power transmission failure and the steps taken to correct the problem and rectify any design faults.</td></tr>
<tr><td>P6 Determine the velocity ratio for compound gear systems and the holding torque required to securely mount a gearbox.
P7 Calculate the operating efficiency of lead screws and screw jacks.
P8 Explain the conditions required for a constant velocity ratio between two joined shafts.</td><td>M3 Examine devices which function to store mechanical energy in their operation.</td></tr>
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Pass	Merit	Distinction
LO4 Analyse natural and damped vibrations within translational and rotational mass-spring systems		**D4** Identify the conditions needed for mechanical resonance and measures that are taken to prevent this from occurring.
P9 Explain the natural frequency of vibration in a mass-spring system.	**M4** Determine the amplitude and phase angle of the transient response within a mass-spring-damper system.	

Recommended Resources

Textbooks

BIRD, J. and ROSS, C. (2014) *Mechanical Engineering Principles*. 3rd Ed. London: Routledge.

TOOLEY, M. and DINGLE, L. (2012) *Engineering Science: For Foundation Degree and Higher National*. London: Routledge.

Electronic

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Links

This unit links to the following related units:

Unit 1: Engineering Design

Unit 2: Engineering Maths

Unit 36: Advanced Mechanical Principles