Unit 5003: Advanced Mechanical Principles

Unit Code: K/651/0810

Level: 5

Credits: 15

Introduction

A mechanical engineer is required to have an advanced knowledge of most of the machinery used within the engineering industry, and should understand the physical laws that influence their operation.

The aim of this unit is to continue covering the topics discussed in *Unit 4008: Mechanical Principles* and other higher-level topics such as:

Poisson's Ratio and typical values of common materials; the relationship between the elastic constants such as Bulk Modulus, Modulus of Elasticity, Modulus of Rigidity; the relationship between bending moment, slope, and deflection in beams; calculating the slope and deflection for loaded beams using Macaulay's method; analysing the stresses in thin-walled pressure vessels; and stresses in thick-walled cylinders, flat and v-section belt drive theory.

On successful completion of this unit students will be able to have more advanced knowledge of mechanical principles including behavioural characteristics of materials subjected to complex loading, the strength of loaded beams and pressurised vessels, specifications of power transmission system elements, and operational constraints of dynamic systems.

Learning Outcomes

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

LO1 Determine the behavioural characteristics of materials subjected to complex loading

LO2 Assess the strength of loaded beams and pressurised vessels

LO3 Analyse the specifications of power transmission system elements

LO4 Examine operational constraints of dynamic systems.

Essential Content

LO1 Determine the behavioural characteristics of materials subjected to complex loading

Characteristics of materials:

Definition of Poisson's Ratio and typical values of metals, plastics and composite materials

The relationship between the elastic constants such as Bulk Modulus, Modulus of Elasticity, Modulus of Rigidity and Poisson's Ratio

Characteristics of two-dimensional and three-dimensional loading

Calculation of volumetric strain and volume changes

Concept of principal stress and strain

Failure criteria for ductile and brittle materials

Use of problem-solving tools within the context such as Root Cause Analysis (RCA) Process Failure Modes Effects Analysis (PFMEA), Fishbone, and Practical Problem Solving (PPS) and Advanced Product Quality Planning (APQP).

LO2 Assess the strength of loaded beams and pressurised vessels

Strength:

The relationship between bending moment, slope and deflection in beams

Calculating the slope and deflection for loaded beams using Macaulay's method

Analysing the stresses in thin-walled pressure vessels and stresses in thick-walled cylinders

Use of computer simulations to model the behaviour of beams.

LO3 Analyse the specifications of power transmission system elements

Specifications:

Flat and v-section belt drive theory

Operation of friction clutches with uniform pressure and uniform wear theories

Bending and contact stress in geared systems

Principles of both epicyclic and differential gearing, and the torque required to accelerate these systems

Areas of failure when transmitting power mechanically.

LO4 **Examine operational constraints of dynamic systems**

Operational constraints:

Design of mechanical components to meet operating specifications, displacement and velocity

Operating principles of flywheels to store mechanical energy

Balancing of rotating mass systems

Single degree of freedom (DOF) free and damped vibration.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Determine the behavioural characteristics of materials subjected to complex loading		
P1 Discuss the relationship between the elastic constants. **P2** Illustrate the effects of two-dimensional and three-dimensional loading on the dimensions of a given material. **P3** Determine the volumetric strain and change in volume due to three-dimensional loading.	**M1** Assess the effects of volumetric thermal expansion and contraction on isotropic materials.	**D1** Critique the behavioural characteristics of materials subjected to complex loading.
LO2 Assess the strength of loaded beams and pressurised vessels		
P4 Evaluate the variation of slope and deflection along a simply supported beam. **P5** Assess the principal stresses that occur in a thin-walled cylindrical pressure vessel and a pressurised thick-walled cylinder.	**M2** Refine the selection of a suitable size universal beam from appropriate data tables which conforms to given design specifications for slope and deflection.	**D2** Justify the choice of a suitably sized universal beam, using appropriate computer software to model the application by explaining any assumptions that could affect the selection.

Pass	Merit	Distinction
LO3 Analyse the specifications of power transmission system elements		
P6 Discuss the initial tension requirements for the operation of a v-belt drive. **P7** Analyse the force requirements to engage a friction clutch in a mechanical system. **P8** Analyse the holding torque and power transmitted through epicyclic gear trains.	**M3** Critically analyse both the uniform wear and uniform pressure theories of friction clutches for their effectiveness in theoretical calculations.	**D3** Evaluate the conditions needed for an epicyclic gear train to become a differential, showing how a differential works in this application.
LO4 Examine operational constraints of dynamic systems		
P9 Examine the profiles of both radial plate and cylindrical cams that will achieve a specified motion. **P10** Determine the mass of a flywheel needed to keep a machine speed within specified limits. **P11** Investigate the balancing masses required to obtain dynamic equilibrium in a system.	**M4** Evaluate the effects of misalignment of shafts and the use of problem-solving tools to prevent problems from occurring.	**D4** Critically evaluate different choices of mechanical systems that induce specified motion, including the advantages and disadvantages of each application.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

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

Childs P.R.N. (2021) *Mechanical Design: Theory and Applications.* 3rd Ed. Butterworth-Heinemann.

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

Juvinall R.C. and Marshek K.M. (2020) *Fundamentals of Machine Component Design.* 7th Ed. Wiley.

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

Applied Mechanics Reviews

Archive of Rational Mechanics and Analysis

Computer Methods in Applied Mechanics and Engineering

Frontiers in Mechanical Engineering

International Journal of Engineering Science

International Journal of Mechanical Sciences

Journal of Machine Design

Journal of Mechanical Engineering

Journal of Mechanical Science and Technology

Mechanics Based Design of Structures and Machines

Mechanical Engineering Journal

Links

This unit links to the following related units:

Unit 4008: Mechanical Principles.