

Unit 36: Advanced Mechanical Principles

Unit code	R/615/1504
Unit level	5
Credit value	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 9: Mechanical Principles*. It will provide students with advanced knowledge of the mechanical theories associated with engineering applications.

Topics included in this unit are: 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 to determine the behavioural characteristics of materials subjected to complex loading; assess the strength of loaded beams and pressurised vessels; determine specifications of power transmission system elements; and examine operational constraints of dynamic rotating systems.

Learning Outcomes

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

1. Determine the behavioural characteristics of materials subjected to complex loading.
2. Assess the strength of loaded beams and pressurised vessels.
3. Analyse the specifications of power transmission system elements.
4. Examine operational constraints of dynamic rotating 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

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

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

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 rotating systems

Operational constraints:

Design of both radial plate and cylindrical cams to meet operating specifications

Operating principles of flywheels to store mechanical energy

Balancing of rotating mass systems

The effects of coupling on freely rotating systems

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Determine the behavioural characteristics of materials subjected to complex loading		D1 Critique the behavioural characteristics of materials subjected to complex loading
<p>P1 Discuss the relationship between the elastic constants</p> <p>P2 Illustrate the effects of two-dimensional and three-dimensional loading on the dimensions of a given material</p> <p>P3 Determine the volumetric strain and change in volume due to three-dimensional loading</p>	<p>M1 Assess the effects of volumetric thermal expansion and contraction on isotropic materials</p>	
L02 Assess the strength of loaded beams and pressurised vessels		D2 Critique and justify your choice of suitable size universal beam using appropriate computer software to model the application by explaining any assumptions that could affect the selection
<p>P4 Evaluate the variation of slope and deflection along a simply supported beam</p> <p>P5 Determine the principal stresses that occur in a thin walled cylindrical pressure vessel and a pressurised thick-walled cylinder</p>	<p>M2 Review a suitable size universal beam from appropriate data tables which conforms to given design specifications for slope and deflection</p>	

Pass	Merit	Distinction
L03 Analyse the specifications of power transmission system elements		D3 Evaluate the conditions needed for an epicyclic gear train to become a differential, and show how a differential works in this application
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	
L04 Examine operational constraints of dynamic rotating systems		D4 Critically evaluate and justify the different choices of cam follower that could be selected to achieve a specified motion, explaining the advantages and disadvantages of each application
P9 Explore the profiles of both radial plate and cylindrical cams that will achieve a specified motion P10 Show 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 rotating system	M4 Evaluate the effects of misalignment of shafts and the measures that are taken to prevent problems from occurring	

Recommended Resources

Textbooks

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

KHURMI, R.S. and GUPTA, J.K. (2005) *Textbook of Machine Design*. New Delhi: S. Chand Publishing.

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

Websites

<https://www.khanacademy.org/> Khan Academy
Physics
(Tutorials)

Links

This unit links to the following related units:

Unit 8: Mechanical Principles