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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Determine the behavioural characteristics of materials subjected to complex loading</td><td rowspan="2">D1 Critique the behavioural characteristics of materials subjected to complex loading.</td></tr>
<tr><td>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.</td><td>M1 Assess the effects of volumetric thermal expansion and contraction on isotropic materials.</td></tr>
<tr><td colspan="2">LO2 Assess the strength of loaded beams and pressurised vessels</td><td rowspan="2">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.</td></tr>
<tr><td>P4 Evaluate the variation of slope and deflection along a simply supported beam.
P5 Determine the principal stresses that occur in a thin-walled cylindrical pressure vessel and a pressurised thick-walled cylinder.</td><td>M2 Review a suitable size universal beam from appropriate data tables which conforms to given design specifications for slope and deflection.</td></tr>
<tr><td colspan="2">LO3 Analyse the specifications of power transmission system elements</td><td rowspan="2">D3 Evaluate the conditions needed for an epicyclic gear train to become a differential, and show how a differential works in this application.</td></tr>
<tr><td>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.</td><td>M3 Critically analyse both the uniform wear and uniform pressure theories of friction clutches for their effectiveness in theoretical calculations.</td></tr>
</table>

Pass	Merit	Distinction
LO4 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.

Electronic

Khan Academy

https://www.khanacademy.org/science/physics

Links

This unit links to the following related units:

Unit 8: Mechanical Principles