Unit 105 Mechanical and structural engineering

Unit summary
This unit is about the skills required to function effectively in the fields of mechanical and structural engineering.

Aims
This unit aims to develop the knowledge and skills necessary to solve simple but realistic mechanical and structural design problems including major modifications to facilitate production expansion or change of use of facilities.

Prerequisites
Sufficient mathematical knowledge to carry out basic scientific and engineering calculations. Elementary differential calculus and differential equations. Elementary integral calculus.

Physics to a level broadly equivalent to A-level: although several of the topics below are included in an A-level syllabus, they are to be revised and taken to slightly greater depth here.

Concepts of force, moment and friction. Position and velocity calculations for systems with constant acceleration.

Learning outcomes
There are **two** outcomes to this unit. The candidate will be able to:

- Understand basic scientific principles applicable to problems in mechanical and structural engineering
- Apply methods of analysis used in simple mechanical and structural problems

Guided learning hours
It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills
This unit contributes towards the Key Skills in the following areas:

N4.1
Develop a strategy for using application of number skills over an extended period of time.

N4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3
Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling one complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.3.1 Undertake research into engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
4.1.1 Determine the operational requirements of engineering products or processes
4.2.2 Solve operational problems with engineering solutions
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Understand basic scientific principles applicable to problems in mechanical and structural engineering

Knowledge requirements
The candidate knows how to:

1 Statics
- a determine forces in statically determinate pin-jointed structures
  - i graphical techniques
  - ii resolution of joints
  - iii method of sections
- b recognise the necessary conditions for statical determinacy

2 Stress and strain
- a determine relationships between stresses at a point
  - i Mohr's circle for stress
  - ii Mohr's circle for strain
- b apply strain gauge rosettes
- c recognise relationships between elastic constants
- d calculate strain energy

3 Theory of beams
- a solve problems involving point and distributed loads on beams
  - i construct shear force and bending moment diagrams
  - ii calculate shear forces and bending moments
  - iii develop moment – stress – curvature relationships for

4 symmetric elastic prismatic beams
- a calculate second moment of area
- b use transformed section for composite beams
- c develop solutions for slopes and deflections for
  - i simply supported beams using Macaulay's method
  - ii cantilever beams using Macaulay's method
- d solve statically indeterminate problems
- e use symmetry to aid beam problem solving
- f apply techniques to minimise bending moments
- g solve beam-bending problems by superposition of standard solutions
- h select structural sections from standard tables

i determine polar second moment of area

j determine torque-shear stress-twist relationships for circular elastic bars

5 Kinematics

a construct velocity and acceleration diagrams for the motion of a rigid body

b use diagrams to find velocities and accelerations in simple assemblies of rigid bodies including

i pins

ii sliders

c determine an instantaneous centre

d use Cartesian and polar co-ordinates to determine

i displacement

ii velocity

iii acceleration

e construct vector representation of

i position

ii velocity

iii acceleration

f determine moving frames of reference and relative motion

6 Dynamics

a use formulae and understand concepts of

i impulse

ii momentum

iii work

iv power

v energy

b determine the motion of a body subject to varying forces

c determine the effects of collisions between bodies

d calculate centre of mass of rigid bodies

e calculate moment of inertia of rigid bodies

f calculate angular momentum

g assess the dynamics of plane rigid bodies on impact

7 Vibrations

- a assess simple harmonic motion of undamped systems with one degree of freedom
  - i pendulum
  - ii mass
  - iii spring
- b assess damping and damped motion of systems with one degree of freedom
  - i mass
  - ii damper
  - iii spring
- c determine the transient response to simple inputs
- d determine the steady state sinusoidal response in vibration systems
- e use phasors to aid problem solving

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Outcome 2 Apply methods of analysis used in simple mechanical and structural problems

Knowledge requirements
The candidate knows how to:

1 solve practical problems in statics using
   a calculations
   b graphical methods
   c models
2 solve practical problems in stress and strain using
   a calculations
   b scientific tests
3 solve practical problems in simply supported and cantilevered beams using
   a calculus
   b graphical means
   c load tests
   d tables and charts
4 solve practical problems in kinematics using
   a mathematics
   b laboratory techniques
5 solve practical problems in dynamics using
   a mathematics
   b laboratory techniques
6 solve practical problems involving vibrations using
   a mathematics
   b models

c practical laboratory investigations

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Engineering Mechanics Dynamics	Hibbeler	Prentice Hall	0137410182
Mechanics of Engineering Materials	Benham, Crawford, Armstrong	Longman Higher Ed.	0582251648
Mechanics of Solids	Ross	Prentice Hall	0132377780
Vector Mechanics for Engineers	Beer, Johnston	McGraw Hill	0071140751