15.2.0 STRENGTH OF MATERIALS

15.2.1 INTRODUCTION

Strength of materials is a module unit that deals with materials and their application in structural engineering and tool room processes.

15.2.2 GENERAL OBJECTIVES

By the end of the module unit, the trainee should be able to:

a) Understand the concepts of the strength of engineering materials
b) Select and use appropriate materials for fabrication work
c) Produce models of designed prototypes.
d) Apply the knowledge acquired to improve the performance of various equipments.
e) Observe safety when dealing with various engineering materials

15.2.3 MODULE UNIT SUMMARY AND TIME ALLOCATION

STRENGTH OF MATERIALS

Code	Sub-Module Unit	Content	Time Hrs		
			T	P	Total
15.2.1	Stress and Strain	• Determination of elastic constants	2	2	4
15.2.2	Shearing Forces and Bending Moments	• Determination of shearing force and bending moment	4	2	6
15.2..3	Bending Stresses in Beams	• Verification of pure bending theory • Cantilevers • Simply supported beams	3	3	6
15.2.4	Deflection of Beams	• Determination of Young's modulus • Cantilevers • Simply supported beams • Verification of the principles of super	6	2	8

		position of deflection in beams • Determination of fixing moments for loaded beams			
15.2.5	Thin Cylinders and Shells	• Determination of the circumferential and longitudinal strains and stresses in pressurized thin vessels	4	2	6
15.2.6	Torsion	• Statement of the simple theory of torsion of circular section bars. • Explanation of parameters in the simple theory of torsion equation • Derivation from first principle the relationship between strain and twist per length. • Using the equation to develop other equations • Application of the equations to solve problems in torsion	8	2	10
15.2.7	Strain Energy	• Definition of strain energy • Derivation of expressions for strain energy from first principles of different loading conditions • Definition of resilience and proof resistance • Derivation of an	8	4	12

		expression for strain energy of a three dimensional principal stress system. • Definition of modules of resistance • Definition of a maximum instantaneous stress • Definition of maximum instantaneous extension • Derivation of an expression for strain energy due to instantaneous loading • Statement of Castigliano's 1st theorem for deflection • Application of Castigliano theorem to derive expressions for deflection on various beam loading system			
15.1.08	Springs	• Definition of a spring • Identification of various types of springs • Derivation of stress expression of springs • Maximum shear stress for coiled springs • Sagging under axial load	8	6	14

		• Maximum bending stress for a close coiled spring sunder axial torque • Maximum bending stress for semi-elliptic spring under central load • Proof stress for semi-elliptic spring under central load • Max. bending stress for quarter-elliptic spring • Max. bending stress for plain spiral spring • Derivation of deflection of springs • Derivation of spring rate expression for various springs • Application of the expressions to solve spring problems • Derivation expressions for stiffness of springs			
Total Time			**43**	**23**	**66**

15.2.1 STRESS AND STRAIN

Theory

15.2.2T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to determine the elastic constants of common engineering materials.

15.2.1C Competence
The trainee should have the ability to perform and demonstrate an experiment to determine:
i) Young's Modulus E
ii) Modulus of rigidity G
iii) Poison's ratio γ

Content
15.2.1T1 Determination of elastic constants
i) Young's modulus, E
ii) Modulus of rigidity G
iii) Poisson's ratio, γ

Practice

9.2.1P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to explain the elastic constants of common engineering materials

Content
15.2.1P1 Explanation of elastic constants
i) Young modulus E
ii) Modulus of rigidity G
iii) Poisson's ratio γ

15.2.2 SHEARING FORCES AND BENDING MOMENTS

Theory

15.2.2T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to determine shearing force and bending moment at different points a long loaded beam

15.2.2C Competence
The trainee should have the ability to perform experiments to demonstrate shearing forces and bending moments at different points along loaded beams

Content
15.2.2T Determination of shearing force and bending moment

Practice

15.2.2P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able

to determine shearing force and bending moment at different points along loaded beams

Content

15.2.2P1 Determination of shearing force and bending moment at different points along loaded beam

15.2.3 BENDING STRESSES IN BEAMS

Theory

15.2.3T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to derive the engineers' bending theory (pure bending theory).

15.2.3C Competence
The trainee should have the ability to perform experiments to verify bending theory.

Content

15.2.3T1 Derivation of pure bends
15.2.3T2 Cantilever
15.2.3T3 Simply supported beam

Practice

15.2.3P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to derive the engineer's bending theory (pure bending).

Content

15.2.3P1 Verification of the pure bending theory
i) Cantilever
ii) Simply supported beam

15.2.4 DEFLECTION OF BEAMS

Theory

15.2.4T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) determine Young's Modulus for beams
b) verify the principle of superposition
c) determine fixing moments for loaded beams

15.2.4C Competence
The trainee should have the ability Perform experiment to:
i) verify the principle of super positioning
ii) determine fixing moment for loaded beams
iii) determine fixing

moment for built-in beams
iv) determine fixing moment for continuous beams

Content

15.2.4T1 Determination of Young's modulus, E

15.2.4T4 Derivation of the principles of super position of deflection in beams

15.2.4T5 Determination of fixing moments for loaded beams
i) Built in beams
ii) Continuous beams

Practice

15.2.4P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) determine young's modulus for beams
b) verify the principle of super positioning
c) determine fixing moments for loaded beams

Content

15.2.4P1 Determination of Young's Modulus

15.2.4P2 Verification of the principle of super position of deflection in beams

15.2.4P3 Determination of fixing moments for loaded beams Built in beams
Continuous beams

15.2.5 THIN CYLINDERS AND SHELLS

Theory

15.2.5T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) Calculate the circumferential strains in pressurized thin vessels
b) Calculate the longitudinal strains in pressurized thin vessels

15.2.5C Competence
The trainee should have the ability to perform an experiment to determine the circumferential and longitudinal strains and stresses in pressurized thin vessels and shells.

Content

15.2.5T1 Calculations for circumferential strains and stresses in pressurized thin vessels

15.2.5T2 Calculations for longitudinal strains and stresses in pressurized thin vessels

Practice

15.2.5P0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able to:

a) determine the circumferential strains in pressurized thin vessels
b) determine the longitudinal strains in pressurized thin shells

Content

15.2.5P1 Determination of the circumferential strains and stresses in pressurized thin vessels
   i) Thin cylinders
   ii) Thin shells

15.2.5P2 Determination of the longitudinal strains and stresses in pressurized thin vessels
   i) Thin cylinders
   ii) Thin shells

15.2.6 TORSION

Theory and Practice

15.2.6T/P0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:

a) state the simple theory of torsion of circular section bars
b) explain the parameters in the simple section bars
c) derive from first principle the relationship between shear strain and twist per unit length.
d) use the equation to develop other equations
e) apply the equations to solve problems involving torsion

Content

15.2.6T1 Statement of the simple theory of torsion of circular section bars.

15.2.6T2 Explanation of parameters in the simple theory of torsion equation
   i) Polar second

moment of area
ii) Angle of twist
iii) Modulus of rigidity
iv) Shear stress and shear strain in shafts

15.2.6T3 Derive from first principle the relationship between strain and twist per length.

15.2.6T4 Using the equation to develop other equations
i) Hollow shafts
ii) Stepped shafts
iii) Solid shafts
iv) Torsional rigidity

15.2.6T5 Application of the equations to solve problems in torsion
i) Hollow shafts
ii) Stepped shafts
iii) Solid shafts
iv) Diameters of shafts
v) Torque
vi) Torsional rigidity
vii) Maximum polar sectional modulus
viii) Maximum shear strains acceptable
ix) Thickness of hollow shaft
x) Angle of twist

15.2.7 STRAIN ENERGY

15.2.7T/P0 *Specific Objectives*
By the end of the sub- module unit, the trainee should be able to:
a) define strain energy
b) derive expressions for strain energy from first principle for different loading conditions
c) define resilience and proof resilience
d) define modules of resilience
e) define maximum instantaneous stress
f) define maximum instantaneous extension,
g) derive on expression for strain energy due to instantaneous loading
h) state Castigliano's 1st theorem for deflection
i) apply the expression development from Castigliano's theorem to solve problems.

Content

15.2.7T1 Definition of strain energy

15.2.7T2 Derivation of expressions for strain energy from first principles of different loading conditions

i) Tension
ii) Compression
iii) Shear
iv) Bending
v) Torsion

15.2.7T3 Definition of resilience and proof resistance

15.2.7T4 Definition of modules of resistance

15.2.7T5 Definition of a maximum instantaneous stress

15.2.7T6 Definition of maximum instantaneous extension

15.2.7T7 Derivation of an expression for strain nergy due to instantaneous loading
i) Axial loading
ii) Torsional loading
iii) Bending

15.2.7T8 Statement of Castigliano's 1st theorem for deflection

15.2.7T9 Application of Castigliano theorem to derive expressions for deflection on various beam loading system under
i) Bending
ii) Tension
iii) Shear
iv) Solving problems

15.2.8 SPRINGS

15.2.8T/P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) define spring
b) identify the various types of springs
c) derive stress expressions for springs
d) derive deflections for springs
e) derive spring rate expression for various springs
f) derive expressions for stiffness of springs.
g) apply the expressions to solve spring problems

Content

15.2.8T1 Definition of a spring

15.2.8T2 Identification of various types of springs
i) Close coiled springs
ii) Open coiled springs
iii) Semi-elliptic
iv) Quarter-elliptic
v) Plain spiral springs

15.2.8T3 Derivation of stress expression of springs
i) Maximum shear stress for coiled springs
ii) Sagging under axial load

iii) Maximum bending stress for a close coiled spring under axial torque
iv) Maximum bending stress for semi-elliptic spring under central load
v) Proof stress for semi-elliptic spring under central load
vi) Maximum bending stress for quarter-elliptic spring
vii) Maximum bending stress for plain spiral spring

15.2.8T4 Derivation of deflection of springs
i) Total deflection of a closed coiled spring under axial load.
ii) Wind up angle of a closed, coiled spring under axial torque
iii) Deflection of an open coiled spring under axial load
iv) Angular rotation of an open coiled spring under axial load.
v) Wind up angle of open coiled spring under axial torque
vi) Axial deflection of an open coiled spring under axle torque
vii) Deflection for semi-elliptic spring under central load
viii) Wind up angle for a plain spiral spring

15.2.8T5 Derivation of spring rate expression for various springs
i) Coiled spring under axial load
ii) Torque per turn of a coiled spring under axial torque
iii) Semi elliptic
iv) Quarter elliptic
v) Torque per turn of a plain spiral spring

15.2.8T6 Derivation expressions for stiffness of springs
i) Springs in series
ii) Springs in parallel

15.2.8T7 Application of the expressions to solve spring problems
i) Bending stresses
ii) Compression of springs
iii) Material size
iv) Angle of rotation
v) Deflection
vi) Bending moments
vii) Loads
viii) Applied moments

Suggested Learning Resources

- Relevant text books
- Handouts
- Work piece
- Testing machine
- Procedure sheet