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	Theory	Practical	Time Hrs
15.2.01	Stress and Strain	• Determination of elastic constants	2	2	4
15.2.02	Shearing Forces and Bending Moments	• Determination of shearing force and bending moment	2	2	4
15.2.0.3	Bending Stresses in Beams	• Verification of pure bending theory • Cantilevers • Simply supported beams	2	4	6
15.2.04	Deflection of Beams	• Determination of Young's modulus • Cantilevers • Simply supported beams • Verification of the principles of super position of deflection in beams • Determination of fixing moments for loaded beams	6	6	12
15.2.05	Thin Cylinders	• Determination of the	2	4	6

	and Shells	circumferential and longitudinal strains and stresses in pressurized thin vessels			
15.2.06	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	4	4	8
15.2.07	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 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	8	6	14

		• Statement of Castigliano's 1st theorem for deflection • Application of Castigliano theorem to derive expressions for deflection on various beam loading system			
19.1.08	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 • 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	6	6	12
Total Time			**32**	**34**	**66**

15.2.01 STRESS AND STRAIN

Theory

15.2.01T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able
(a) Calculate stress and strain in engineering materials
(b)explain the elastic constants of common engineering materials.

15.2.01C *Competence*
The trainee should have the ability to perform and demonstrate an experiment to determine:
- Young's Modulus E
- Modulus of rigidity G
- Poison's ratio γ

Content

15.2.01T1 Determination of elastic constants
- Direct stress and strain
- Shear stress and strain
- Young's modulus, E
- Modulus of rigidity G
- 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

15.2.01P1 Explanation of elastic constants
- Young modulus E
- Modulus of rigidity G
- Poisson's ratio γ

Suggested Teaching/Learning Resources
- Relevant text books
- Handouts
- Work piece
- Testing machine

15.2.02 SHEARING FORCES AND BENDING MOMENTS

Theory

15.2.02T0 *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

15.2.02C *Competence*
The trainee should have the ability to perform experiments to demonstrate

shearing forces and bending moments at different points along loaded beams

Content

15.2.02T Determination of shearing force and bending moment

Practice

15.2.02P0 *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

15.2.02P1 Determination of shearing force and bending moment at different points along loaded beam

Suggested Learning Resources

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

15.2.03 BENDING STRESSES IN BEAMS

Theory

15.2.03T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to
derive the engineers' bending theory (pure bending theory).

15.2.03C *Competence*
The trainee should have the ability to perform experiments to verify bending theory

Content

15.2.03T1 Derivation of pure bends

15.2.03T2 Cantilever

15.2.03T3 Simply supported beam

Practice

15.2.03P0 *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

15.2.03P1 Verification of the pure bending theory

- Cantilever
- Simply supported beam

Suggested Learning Resources

- Relevant text books
- Handouts
- Cantilever
- Simply supported beam

15.2.04 DEFLECTION OF BEAMS

Theory

15.2.04T0 *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

15.2.04C *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

15.2.04T1 Determination of Young's modulus, E

15.2.04T4 Derivation of the principles of super position of deflection in beams

15.2.04T5 Determination of fixing moments for loaded beams
- Built in beams
- Continuous beams

Practice

15.2.04P0 *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

15.2.04P1 Determination of Young's Modulus

15.2.04P2 Verification of the principle of super position of deflection in beams

15.2.04P3 Determination of fixing moments for loaded beams
- Built in beams
- Continuous beams

Suggested Learning Resources
-Relevant text books
-Handouts
-Springs
-beams

15.2.05 THIN CYLINDERS AND SHELLS

Theory

15.2.05T0 *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

15.2.05C *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

15.2.05T1 Calculations for circumferential strains and stresses in pressurized thin vessels

15.2.05T2 Calculations for longitudinal strains and stresses in pressurized thin vessels

Practice

15.2.05P0 *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

15.2.05P1 Determination of the circumferential strains and stresses in pressurized thin vessels
- Thin cylinders
- Thin shells

15.2.05P2 Determination of the longitudinal strains and stresses in pressurized thin vessels
- Thin cylinders
- Thin shells

Suggested Teaching/Learning Resources
- Relevant text books
- Handouts
- Thin cylinders
- Thin shells

15.2.06 TORSION

Theory and Practice

15.2.06T0 *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

15.2.06C *Competence*

The trainee should have the ability to perform an experiment to determine the effect of torsion

Content

15.2.06T1 Statement of the simple theory of torsion of circular section bars.

15.2.06T2 Explanation of parameters in the simple theory of torsion equation
- Polar second moment of area
- Angle of twist
- Modulus of rigidity
- Shear stress and shear strain in shafts

15.2.06T3 Derive from first principle the relationship between strain and twist per length.

15.2.06T4 Using the equation to develop other quations
- Hollow shafts
- Stepped shafts
- Solid shafts
- Torsional rigidity

15.2.06T5 Application of the equations to solve problems in torsion
- Hollow shafts
- Stepped shafts
- Solid shafts
- Diameters of shafts
- Torque
- Torsional rigidity
- Maximum polar sectional modulus
- Maximum shear strains acceptable
- Thickness of hollow shaft
- Angle of twist

Suggested Teaching/Learning Resources
- Relevant text books
- Handouts
- Hollow shafts

- Stepped shafts
- Solid shafts

15.2.07 STRAIN ENERGY

15.2.07T/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.

15.2.07C *Competence*

The trainee should have the ability to apply the expression development from Castigliano's theorem to solve problems.

Content

15.2.07T1 Definition of strain energy

15.2.07T2 Derivation of expressions for strain energy from first principles of different loading conditions
- Tension
- Compression
- Shear
- Bending
- Torsion

15.2.07T3 Definition of resilience and proof resistance

15.2.07T4 Definition of modules of resistance

15.2.07T5 Definition of a maximum instantaneous stress

15.2.07T6 Definition of maximum instantaneous extension

15.2.07T7 Derivation of an expression for strain energy due to instantaneous loading
- Axial loading
- Torsional loading
- Bending

15.2.07T8 Statement of Castigliano's 1st theorem for deflection

15.2.07T9 Application of Castigliano theorem to derive expressions for deflection on various beam loading system under
- Bending
- Tension
- Shear
- Solving problems

Suggested Learning Resources
- Relevant text books
- Handouts
- Work piece
- Testing machine
- Procedure sheet

15.2.08 SPRINGS

15.2.08T/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

15.2.08C *Competence*
The trainee should have the ability to apply the expressions for stiffness of springs to solve spring problems

Content

15.2.08T1 Definition of a spring

15.2.08T2 Identification of various types of springs
- Close coiled springs
- Open coiled springs
- Semi-elliptic
- Quarter-elliptic
- Plain spiral springs

15.2.08T3 Derivation of stress expression of springs
- Maximum shear stress for coiled springs
- Sagging under axial load
- Maximum bending stress for a close coiled spring under axial torque
- Maximum bending stress for semi-elliptic spring under central load
- Proof stress for semi-elliptic spring under central load

- Maximum bending stress for quarter-elliptic spring
- Maximum bending stress for plain spiral spring

15.2.08T4 Derivation of deflection of springs
- Total deflection of a closed coiled spring under axial load.
- Wind up angle of a closed, coiled spring under axial torque
- Deflection of an open coiled spring under axial load
- Angular rotation of an open coiled spring under axial load.
- Wind up angle of open coiled spring under axial torque
- Axial deflection of an open coiled spring under axle torque
- Deflection for semi-elliptic spring under central load
- Wind up angle for a plain spiral spring

15.2.08T5 Derivation of spring rate expression for various springs
- Coiled spring under axial load
- Torque per turn of a coiled spring under axial torque
- Semi elliptic
- Quarter elliptic
- Torque per turn of a plain spiral spring

15.2.08T6 Derivation expressions for stiffness of springs
- Springs in series
- Springs in parallel

15.2.08T7 Application of the expressions to solve spring problems
- Bending stresses
- Compression of springs
- Material size
- Angle of rotation
- Deflection
- Bending moments
- Loads
- Applied moments

Suggested Learning Resources
- Relevant text books
- Handouts
- Work piece
- Testing machine
- Procedure sheet