17.1.0 **STRUCTURES I**

17.1.1 **Introduction**

This module involves the analysis of forces and design of structural elements encountered in construction. It is designed to equip the trainee with knowledge, skills and attitudes in the analysis of forces of structural elements.

The trainee should have a KCSE with knowledge in Mathematics and Physics prior to attempting this module unit.

17.1.02 **General Objectives**

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

a) understand the behavior of structural materials
b) understand principles of analyzing forces in determinate and in-determinate
c) appreciate need for analysis in the design of building structural members
d) generate structural drawings from the structural designs

17.1.3 **Module Unit Summary and Time Allocation – (55 Hours)**

Code	Sub Module Unit	Content	Time Hours		
			Theroy	Pract	Total
17.1.01	Stress and Strain	• Definitions • Calculations • Hooke's Law • Stress-strain relationships • Stress-strain graphs • Module of rigidity • Factor of safety	4	5	9
17.1.02	Composite Materials	• Composite materials • Compatibility Equations • Equilibrium Equations • Determination of Composite Materials	2	3	5
17.1.03	Temperature Stresses and	• Temperature • Stress Equation	2	3	5

	Strains	• Application of the Formula • Elements of stress equation		
17.1.04	Types Of Supports and Loadings	• Simply Supported • Continuous Supports • Cantilever • Concentrated Loads • Uniformly Distributed Loads • Varying Loads	2	2
17.1.05	Shear force and Bending Moments	• Shear Force Values • Bending Moment Values • Plotting The Shear Force And Bending Moment Diagrams • Effects of a force on a beam • Point of contraflexure	2	5
17.1.06	Properties Of Sections	• Centroid • Radius of Gyration • Section Modulus (Z) • Moment of Inertia (I)	2	3
17.1.07	Theory of Simple Bending	• Elements of Simple Bending • General Expression • Behavior of Forces	1	2
17.1.08	Analysis of Structural Plain Frames	• Types of Frames • Magnitude and Direction • Methods of determination of forces	2	3
17.1.09	Horizontal Shear Stresses in Beams	• General Expression of Shear • Determination of Shear Stress in Beam Sections • Shear Stress Distribution	2	4

		Diagrams • shear force			
17.1.10	Columns and Struts	• Slenderness Ratios of Long and Short Columns • Concentric and Eccentric Loadings in Columns • Rankine – Gordon Formula • Critical Loads on Columns	2	4	6
		Total	21	34	55

17.1.01 STRESS AND STRAIN

Theory

17.1.01T0 *Specific Objectives*

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

a) define terms used in properties of materials
b) calculation of stress and strain
c) state Hooke's law
d) describe the stress–strain relationship
e) sketch stress strain graphs
f) describe the modulus of rigidity
g) explain working stress and ultimate stress
h) describe the factor of safety

17.1.01C *Competence*

The trainee should have the ability to:

i) carry our laboratory test on metals
ii) compute stress/strain results
iii) plot stress/strain graph
iv) interpret the test results
v) calculate the stress/strain problems
vi) sketch and table the stress strain graphs

Content

17.1.01T1 Definitions
- plasticity
- elasticity
- stress
- modulus of elasticity
- bulk modulus
- yield modulus

17.1.01T2 Calculations
- stress
- strain

17.1.01T3	Stating Hooke's law
17.1.01T4	stress-strain relationship
17.1.01T5	Sketching the stress-strain graph
17.1.01T6	Modulus of rigidity
17.1.01T7	Working stress and ultimate stress
17.1.01T8	Factor of safety

Practice

17.1.01P0 *Specific Objectives*

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

a) set the apparatus for stress, strain experiment
b) carry our experiment for stress and strain
c) carry out tensile test for ferrous metals
d) plot the stress strain graph
e) calculate stress and strain

Content

17.1.01P1	Apparatus for stress strain experiments
17.1.01P2	Experiment for stress/strain
17.1.01P3	tensile test for ferrous metals
17.1.01P4	Stress/strain graph - contours - profiles
17.1.01P5	calculate stress and strain

17.1.02 **COMPOSITE MATERIALS**

Theory

17.1.02T0 *Specific Objectives*

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

a) describe composite materials
b) derive the compatibility equation
c) derive equilibrium equation
d) solving the composite materials problems

17.1.02C *Competence*

The trainee should have the ability to:

i) calculate stress in composite materials
ii) identify appropriate composite materials

Content

17.1.02T1	Description of composite materials
17.1.02T2	Derivation of compatibility equation
17.1.02T3	Derive equilibrium equation - calculation of stresses
17.1.02T4	Determination of composite materials

Practice

17.1.02P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain the strength properties of composite materials
b) calculate stresses in composite materials
c) determine the forces in composite materials

Content

17.1.02P1 Explanation of:
- varying materials
- composite materials
- equilibrium

17.1.02P2 Calculation of stress
- series sections
- integrating sections
- equilibrium

17.1.02P3 Determination of forces
- varying sections and lengths
- compound materials

17.1.03 TEMPERATURE STRESSES AND STRAINS

Theory

17.1.03T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) derive the temperature/stress equation
b) apply the formula to solve problems
c) determine the elements of the temperature stress equation

17.1.03C *Competence*
The trainee should have the ability to:
i) derive temperature stress equation
ii) apply the effect temperature on strain/stress for materials
iii) determine the position and size of joints
iv) effects in temperature on temperature: contraction, expansion
v) stress: contraction, expansion

Content

17.1.03T1 Derivation of temperature stress equation

17.1.03T2 Application of the temperature stress equation in building components

17.1.03T3 Determination of the elements of the temperature stress equation

Practice

17.1.03P0 *Specific Objectives*

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

a) demonstrate the effect of temperature on stress/strain
b) determine the stresses developed by forces and temperature in a given material

Content

17.1.03P1 effect of temperature on stress/strain

17.1.03P2 stresses developed by forces and temperature in a given material

17.1.04 TYPES OF SUPPORTS AND LOADINGS

Theory

17.1.04T0 *Specific Objectives*

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

a) identify the types of supports
b) identify the different loading systems
c) determine the basic laws of static equilibrium

17.1.04C *Competence*

The trainee should have the ability to:

i) derive common bending moment formulae
ii) analyse different supports and loading systems
iii) identify types of loads and loading systems
iv) determine the bending moments

Content

17.1.04T1 Types of supports
- rollers
- hinged
- fixed

17.1.04T2 Loading systems
- concentrated
- uniformly
- distributed
- varying
- simply supported
- continuous
- cantilevers

17.1.04T3 Laws of Static Equilibrium
- sum of all moments is equal to zero
- sum of horizontal forces is equal to zero
- sum of vertical forces is equal to zero

Practice

17.1.04P0 *Specific Objectives*

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

a) identify the types of loads on a system
b) determine moments in a simply supported system

Content

17.1.04P1 Types of loads on a system
- reactions
- uniformly distributed loads
- varying loads
- concentrated loads

17.1.04P2 Determination of moments in a simple supported system
- moments
- vertical
- horizontal
- inclined

17.1.05 SHEAR FORCE AND BENDING MOMENTS

Theory

17.1.05T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) define shear force at a point on a loaded beam
b) define bending moment at a point on a loaded beam
c) sketch shear force and bending moment diagrams
d) discuss the effects of a force on a beam

17.1.05C *Competence*
The trainee should have the ability to:
i) plot the diagram
ii) discuss the effects of forces on a load system
iii) apply the laws of static equilibrium in the determination of forces

Content

17.1.05T1 Defining shear force and bending moment at a point on a loaded beam

17.1.05T2 Shear force
- maximum
- distribution

17.1.05T3 Bending moment
- determination
- maximum

17.1.05T4 Diagrams
bending moment
- shear force

17.1.05T5 Discussion point of contraflexure
- effects

Practice

17.1.05P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) plot the shear force and bending moment diagrams
b) calculate shear forces and bending

moments values at any point on a loaded beam

c) determine the point of contraflexure

Content

17.1.05P1 Plot
- shear force diagram
- bending moment diagram

17.1.05P2 Values
- shear forces
- bending moment values

17.1.05P3 Point of contraflexure

17.1.06 PROPERTIES OF SECTIONS

Theory

17.1.06T0 *Specific Objectives*

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

a) determine centroids of sections
b) derive the expressions for second moment of area for sections
c) describe section modules
d) discuss moment of inertia

17.1.01C *Competence*

The trainee should have the ability to:

i) balance the forces on structural frame
ii) determine the bending moments a structural membe

Content

17.1.06T1 Determining centroids of sections

17.1.06T2 Expressions for second moment
- general
- rectangular
- circular
- triangular

17.1.06T3 section modulus

17.1.06T4 moment of inertia(I)

Practice

17.1.06P0 *Specific Objectives*

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

a) calculate the second moment of area of a section
b) calculate the section modulus of a section
c) calculate the radius of gyration
d) determine centroids of section by graphical method

Content

17.1.06P1 Second moment of area

17.1.06P2 Section modulus

17.1.06P3 Radius of gyration

17.1.06P4 section of centroids by graphical method

17.1.07 **THEORY OF SIMPLE BENDING**

Theory

17.1.07T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) derive the general expression of simple bending
b) determine the appropriate forces on a bending structure member

17.1.07C *Competence*
The trainee should have the ability to:
i) demonstrate proper use of structural members in bending
ii) analyse a loaded beam using the theory of simple bending

Content

17.1.07T1 Elements of simple bending
- centre of gravity
- second moment of area
- neutral axis
- derivation

17.1.07T2 Forces of bending structure members
- Compressive
- Tensile

Practice

17.1.07P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) apply the expression to calculate bending stresses
b) apply theory to determine the forces
c) discuss the behavior of forces on a given section

Content

17.1.07P1 Bending stresses
- compressive
- tensile

17.1.07P2 Forces determination
- uniformly distributed
- concentrate loads

17.1.07P3 Behaviour of forces on Sections
- rectangular
- T-sections
- circular
- I-sections

17.1.08 **ANALYSIS OF STRUCTURAL PLAIN FRAMES**

Theory

17.1.08T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) identify different types of plain frames

b) determine the magnitude and direction of the forces in plain frames
c) identify the methods for determination of forces in frames

17.1.08C *Competence*
The trainee should have the ability to:
i) calculate member forces
ii) determine struts and ties

Content

17.1.08T1 Types of frames
- lattice
- warren
- cantilevers

17.1.08T2 Magnitude and direction
- forces
- struts
- tie

17.1.08T3 Methods of determining forces
- graphical
- tension coefficient
- sections joint resolution

Practice

17.1.08P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) analyze member forces in the frames
b) identify ties and struts
c) calculate the forces in frames

Content

17.1.08P1 Types of frames
- Lattice
- Warren
- Cantilevers

17.1.08P2 Methods of analyzing forces in frames
- method of joint resolution
- method of sections
- method of tension coefficient types
- graphical methods

17.1.08P3 Calculation of forces in frames
- vertical
- inclined
- horizontal

17.1.09 HORIZONTAL SHEAR STRESSES IN BEAMS

Theory

17.1.09T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) derive the general expression for shear stress
b) sketch the shear stress distribution diagram

c) determine the maximum shear stress
d) determine maximum shear force

17.1.09C *Competence*
The trainee should have the ability to:
i) derive general expression
ii) apply the expression in determining shear stresses of structural members

Content

17.1.09T1 General expression for shear stress
17.1.09T2 Shear stress distribution diagrams
17.1.09T3 Maximum shear stress
17.1.09T4 Maximum shear force

17.1.10 COLUMNS AND STRUTS

Theory

17.1.10T0 *Specific Objectives*
By the end of the module unit, the trainee should be able to:
a) determine the slenderness ratio of the columns
b) determine stresses and safe loads for concentric and eccentrically loaded columns
c) derive and apply Eulers formula for long columns in simple calculations
d) use Rankines formula in calculations of safe loads
e) determine critical loads from a column with moments of resistance

17.1.10C *Competence*
The trainee should have the ability to design structural elements

Content

17.1.10T1 Slenderness ratio
- short columns
- long columns
- radius of gyration
- types of end fixity
- effective column length
- slenderness ratio calculation

17.1.10T2 Concentric and eccentric load
- concentric/
- eccentric
- safe axial load
- compressive stresses
- eccentric loading
- theory of eccentrically
- stresses with applied moments (min/max)

17.1.10T3 Euler's formula
- derivation

- application

17.1.10T4 Rankine's – Gordon formula
- application

17.1.10T5 Critical loads on column
- definition
- derivations of expression for moment of resistance of a column and its
- application
- determination of critical and buckling load

Practice

17.1.10P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) determine safe loads on structural elements
b) design structural elements

Content

17.1.10P1 Safe loads
17.1.10P2 Design of structural elements

Suggested Teaching/Learning Methods
- Lecture
- Group work

Suggested Teaching/Learning Resources
- Charts
- Text books
- Calculator

Suggested Assessment Methods
- Written tests
- Assignment

Tools and Equipment
- Computer
- Calculator