16.2.0 MECHANICS OF MACHINES

16.2.1 Introduction

Mechanics of machines deals with forces, motion and power of machines in motion like hoists and vehicles.

The recommended instructional approach is that which will emphasize on experiments, industrial visits and analysis of various mechanical principles.

16.2.2 General Objectives

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

a) understand the basic concepts of engineering science
b) size power requirements of motors used in engineering design
c) produce models of designed prototypes
d) apply the knowledge acquired to improve the performance of various equipment

16.2.3 Module Unit Summary and Time Allocation

Mechanics of Machines

Code	Sub-Module Unit	Content	Time Hrs
16.2.1	Kinematics	• Definition of kinematics of a particle • Equations of motion • Application of equations of motion • Derivation from first principles expression for centripetal acceleration of a particle moving with uniform angular velocity	8
16.2.2	Impulse and Momentum	• Definition of linear momentum • Explanation of the relationship between force and momentum of a body • Explanation of linear impulse • Explanation of the	10

Code	Sub-Module Unit	Content	Time Hrs
		relationship between linear impulse and linear momentum of a body • Solution of problems in linear momentum and linear impulse • Explanation of angular momentum • Derivation from first principles, equations of angular momentum and impulse • Solution of problems on angular momentum and impulse • Verification of the conservation of momentum	
16.2.3	Mass Moments of Inertia	• Explanation of axial moment of inertia of a mass • Statement of expression for mass moment of inertia of an element about three mutually perpendicular axes • Derivation of expressions of centroidal mass moment of inertia (common regular objects) • Explanation of polar moment of inertia • Application of expressions to solve problems • Centroidal mass moment of inertia for common regular shapes	6

Code	Sub-Module Unit	Content	Time Hrs
		• Statement of parallel axes theorem • Explanation of parallel axes theorem • Application of parallel axes theorem • Definition of radius of gyration • Application of expression of radius of gyration to solve problems	
16.2.4	Area Of Moment of Inertia	• Explanation of axial moment of inertia of an area • Elemental area rotated about an axis perpendicular to its plane • Derivation of an expression for polar moment of inertia of an area • Explanation of the product of inertia • Derivation of an expression for the product of inertia of an area • Statement of parallel axis theorem • Diagram • Application of inertia expressions to solve problems in: - regular areas - composite areas • Explanation of moments of inertia of any (x, y) with respect to rotated set of axis • Statement of expressions for	6

Code	Sub-Module Unit	Content	Time Hrs
		moment of inertia of an area with rotated axes • Application of Mohr's cycle to solve problems	
16.2.5	Belts and Clutches	• Identification of common types of belts • Derivation of belt equations • Application of equation to solve belt problems • Identification of common clutches • Derivation of clutch equations • Application of the equations to solve clutch problems • Ratio of belt tension • Coefficient of friction between belt and pulley • Torque in clutches • Coefficient of friction in clutches	8
16.2.6	Geared Systems	• Description of different types of gear drives • Derivation of equations for gear drives • Application of the equations to solve gear drive problems • Torque in geared systems • Mechanical advantage • Efficiency in geared systems	6
16.2.7	Dynamics of a Rigid Body in Translation	• Definition of dynamics of a rigid body • Statement of the scalar equation for translation • Moment of external forces about mass	10

Code	Sub-Module Unit	Content	Time Hrs
		centre of a body • Application of the equation to solve problems	
16.2.8	Dynamics of Rigid Body in Rotation	• Identification of rotation of a body about a non-centroidal axis • statement of equation of motion for rotation about a non-centroidal axis • Balancing of masses	6
16.2.9	Dynamics of Rigid Body in Plane	• Statement of plane motion • Explanation of equations of plane motion • Application of equation of plane motion	6
Total Time			**66**

16.2.1 KINEMATICS

Theory

16.2.1T0 Specific Objectives

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

a) define kinematics of a particle
b) state the equations of motion
c) apply the equations of motion to solve problems
d) derive from first principle the expressions for centripetal acceleration of a particle.

Content

16.2.1T1 Definition of kinematics of a particle

16.2.1T2 Equations of motion
- i) linear motion
- ii) angular motion

16.2.1T3 Application of equations motion
- i) linear velocity,
- ii) angular acceleration
- iii) angular displacement

16.2.1T4 Derivation from first principles expression for centripetal acceleration of a article moving with uniform angular velocity

$$a = r\omega^2 = \frac{V^2}{r}$$

Suggested Learning Resources

i) Relevant text books
ii) Hand outs

16.2.2 IMPULSE AND MOMENTUM

Theory

16.2.2T0 Specific Objectives

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

a) define linear momentum
b) explain the relationship between force and momentum of a body
c) explain linear impulse
d) explain the relationship between linear impulse and linear momentum
e) explain angular momentum
f) solve problems in linear impulse and linear momentum.
g) derive from first principle, equations of angular momentum and impulse
h) solve problems on angular momentum and impulse

16.2.2C Competence

The trainee should have the ability to perform the experiment to verify the principles

of conservation

Content

16.2.2T1 Definition of linear momentum

16.2.2T2 Explanation of the relationship between force and momentum of a body

16.2.2T3 Explanation of linear impulse

16.2.2T4 Explanation of the relationship between linear impulse and linear momentum of a body

16.2.2T5 Solution of problems in linear momentum and linear impulse

16.2.2T6 Explanation of angular momentum

16.2.2T7 Derivation from first principles, equations of angular momentum and impulse

16.2.2T8 Solution of problems on angular momentum and impulse

Practice

16.2.2P0 Specific Objectives

By the end of the sub module unit, the trainee should be able to verify the principle of conservation of momentum in collision of bodies.

Content

16.2.2P1 Verification of the conservation of momentum

i) Collision of bodies in linear motion
ii) Collision of bodies in angular motion

Suggested Learning Resources

i) Relevant text books
ii) Hand outs
iii) Toy cars
iv) Procedure sheet

16.2.3 MASS MOMENTS OF INERTIA

Theory

16.2.3T0 Specific Objectives

By the end of the sub module unit, the trainees should be bale to:

a) explain axial moment of inertia of a mass
b) state expressions for mass moment of inertia of an element about three mutually perpendicular axes.
c) derive expressions for mass moment of inertia
d) explain polar moment of inertia
e) derive an expression of polar moment of inertia
f) apply the expressions to solve problems
g) state parallel axis theorem
h) explain the parallel axes theorem
i) apply the parallel axes theorem to solve problems

j) define radius of gyration
k) apply the expression of radius of gyration to solve problems.

Content

16.2.3T1 Explanation of axial moment of inertia of a mass
16.2.3T2 Statement of expression for mass moment of inertia of an element about three mutually perpendicular axes
16.2.3T3 Derivation of expressions of Centroidal mass moment of inertia (common regular objects)
16.2.3T4 Explanation of polar moment of inertia
16.2.3T5 Application of expressions of Centroidal mass moment of inertia to solve problems
16.2.3T6 Centroidal mass moment of inertia for common regular shapes
16.2.3T7 Statement of parallel axes theorem
16.2.3T8 Explanation of parallel axes theorem
16.2.3T9 Application of parallel axes theorem
16.2.3T0 Definition of radius of gyration
16.2.3T11 Application of expression of radius of gyration to solve problems

Suggested Learning Resources

i) Relevant text books
ii) Hand outs
iii) Workshop realia
iv) Rotation motor
v) Various bodies
vi) Procedure sheet
vii) Specification manual

16.2.4 AREA OF MOMENT OF INERTIA

Theory

16.2.4T0 Specific Objectives

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

a) explain axial moment of inertia of an area
b) derive an expression for axial moment of an area
c) explain polar moment of inertia of an area
d) derive an expression for the polar moment of inertia of an area
e) explain the product of inertia of an area
f) derive an expression for the product of inertia of an area
g) state the parallel axis theorem
h) apply the inertia expressions to solve problems
i) explain moment of inertia of an area

with axes (x, y) with respect to rotated set of axes (x1, y1)

j) state expressions for moments of inertia of an area with rotated set of axes

k) apply Mohr's cycle to solve problems related to rotation of axis

Content

16.2.4T1 Explanation of axial moment of inertia of an area

16.2.4T2 Elemental area rotated about an axis perpendicular to its plane

16.2.4T3 Explain polar moment of inertia of an area

16.2.4T4 Derivation of an expression for polar moment of inertia of an area

16.2.4T5 Explanation of the product of inertia

16.2.4T6 Derivation of an expression for the product of inertia of an area

16.2.4T7 Statement of parallel axis theorem

16.2.4T8 Application of inertia expressions to solve problems

i) Regular areas

ii) Composite areas

16.2.4T9 Moments of inertia of any (x, y) with respect to rotated set of axis

16.2.4T10 State expressions for moments of inertia of an area with rotated set of axis

16.2.4T11 Application of Mohr's cycle to solve problems

Suggested Learning Resources

i) Relevant text books

ii) Hand outs

iii) Workshop realia

16.2.5 BELTS AND CLUTCHES

Theory

16.2.5T0 Specific Objectives

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

a) identify common types of belts

b) derive belts equations

c) apply the equations to solve belt problems

d) identify common clutches

e) derive equations for clutches

f) apply the equation to solve clutches problems

16.2.5C Competence

The trainee should have the ability to perform experiments to determine:

i) the ratio of belt tensions

ii) the coefficient of friction between the pulley and the belt

iii) torque in clutches

iv) coefficient of

friction in clutches

Content

16.2.5T1 Identification common types of belts
- i) Flat
- ii) Vee

16.2.5T2 Derivation of belt equations
- i) Tension
- ii) Angle of lap
- iii) Power
- iv) Size of belt
- v) Number of belts
- vi) Torque

16.2.5T3 Application of equation to solve belt problems on:
- i) Flat belt
- ii) Vee belt
- iii) Power transmitted
- iv) Angle of lap
- v) Tension
- vi) Size of belts

16.2.5T4 Identification of common clutches
- i) plate
- ii) Centrifugal
- iii) Conical

16.2.5T5 Derivation of clutch equations
- i) Force
- ii) Torque transmitted
- iii) Number of plates
- iv) Efficiency

16.2.5T6 Application of the equations to solve clutch problems

Practice

16.2.5P0 Specific Objectives

By the end of the sub module unit, the trainee should be able to:
- a) perform experiments to verify the ratio of belt tensions
- b) perform experiments to determine the coefficient of friction between the pulley and the belt
- c) perform experiments to determine torque in clutches
- d) perform experiments to determine coefficient of friction in clutches

Content

16.2.5P1 Ratio of belt tension
- i) Flat belts
- ii) Vee belts

16.2.5T2 Coefficient of friction between belt and pulley

16.2.5T3 Torque in clutches
- i) Plate clutches
- ii) Cone clutches
- iii) Centrifugal clutches

16.2.5T4 Coefficient of friction in clutches

Suggested Learning Resources
- i) Relevant text books
- ii) Hand outs
- iii) Real belts and clutches
- iv) Demonstration
- v) Discussion
- vi) Experiment
- vii) Rotating motor and its pulley
- viii) Oral practical tests
- ix) Continuous practical tests

16.2.6 GEARED SYSTEMS

Theory

16.2.6T0 Specific Objectives

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

a) describe different types of gear drives
b) drive equations for gear drives
c) apply the equations to solve gear drive problems

Content

16.2.6T1 Description of different types of gear drives
- i) Spur gear trains
- ii) Epicyclic gear systems

16.2.6T2 Derivation of equations for gear drives
- i) Velocity ratio
- ii) Radius
- iii) Pressure angle
- iv) Accelerating torque
- v) Friction torque
- vi) Input and output members for an epicyclic gear train
- vii) Speed and sense of rotation
- viii) Power transmitted

16.2.6T3 Application of the equations to solve gear drive problems

Practice

16.2.6P0 Specific Objectives

By the end of the topic, the trainee should be able to:

a) perform experiment to determine the torque in geared systems
b) perform experiment to determine mechanical advantage in geared systems
c) perform experiment to determine the efficiency in geared systems

Content

16.2.6T1 Torque in geared systems
- i) Spur gears
- ii) Epicyclic gears

16.2.6T2 Mechanical advantage
- i) Spur gears
- ii) Epicyclic gears

16.2.6T3 Efficiency in geared systems
- i) Spur gears
- ii) Epicyclic gears

16.2.6C Competence

The trainee should have the ability to perform experiment to determine:

i) torque in geared systems
ii) mechanical advantage in geared systems
iii) efficiency in geared systems

Suggested Learning Resources

i) Relevant text books
ii) Hand outs
iii) Realia
iv) Spur gears
v) Epicyclic gears

16.2.7 DYNAMICS OF A

RIGID BODY IN TRANSLATION

Theory

16.2.7T0 Specific Objectives

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

a) define dynamics of a rigid body
b) state the scalar equation for translation
c) determine moment of external forces about mass centre of a body
d) apply the equation to solve problems

Content

16.2.7T1 Definition of dynamics of a rigid body
16.2.7T2 Statement of the scalar equation for translation
16.2.7T3 Moment of external forces about mass centre of a body
16.2.7T4 Application of the equation to solve problems

16.2.8 DYNAMICS OF RIGID BODY IN ROTATION

Theory

16.2.8T0 Specific Objectives

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

a) identify rotation of a body about a non-centrodial axis
b) state equations of motion for rotation about a non-centrodial axis
c) balance masses

Content

16.2.8T1 Identification of rotation of a body about a non-centrodial axis
16.2.8T2 Statement of equation of motion for rotation about a non-centroidal axis
16.2.8T3 Balancing of masses
i) Static balancing
ii) Dynamics balancing

16.2.9 DYNAMICS OF RIGID BODY IN PLANE

Theory

16.2.9T0 Specific Objectives

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

a) state the equations of plane motion
b) explain the equations of plane motion
c) apply the equations to solve problems

Content

16.2.9T1 Statement of plane motion

i) Vector
ii) Scalar

16.2.9T2 Explanation of equations of plane motion
i) Vector
ii) Scalar

16.2.9T3 Application of equation of plane motion
i) Linear dynamic condition
ii) Angular dynamic condition