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	Theory	Pract Hrs	Time Hrs
16.2.01	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	4	4	8
16.2.02	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	4	6	10

		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			
16.2.03	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 • Statement of parallel axes theorem • Explanation of parallel axes theorem • Application of parallel	4	2	6

		axes theorem • Definition of radius of gyration • Application of expression of radius of gyration to solve problems			
16.2.04	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 moment of inertia of an area with rotated axes • Application of Mohr's cycle to solve problems	4	2	6
16.2.05	Belts and Clutches	• Identification of common types of belts • Derivation of belt equations	4	4	8

		• 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			
16.2.06	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	2	6	8
16.2.07	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 centre of a body • Application of the equation to solve problems	4	4	8
16.2.08	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	2	4	6

16.2.09	Dynamics of Rigid Body in Plane	• Statement of plane motion • Explanation of equations of plane motion • Application of equation of plane motion	2	4	6
Total Time			**30**	**36**	**66**

16.2.01 KINEMATICS

Theory

16.2.01T0 *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.

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

Content

16.2.01T1 Definition of kinematics of a particle

16.2.01T2 Equations of motion
- linear motion
- angular motion

16.2.01T3 Application of equations motion
- linear velocity,
- angular acceleration
- angular displacement

16.2.01T4 Derivation from first principles expression for centripetal acceleration of a article moving with uniform angular velocity

Suggested Learning Resources
- Relevant text books
- Hand outs

-centripetal force apparatus
-power supply (0 – 12 V) rated at 6 or 8 A
-ruler
-stopwatch
-newton meter
-balance
-g clamps
-string
-safety screen

16.2.02 IMPULSE AND MOMENTUM

Theory

16.2.02T0 *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

16.2.02C *Competence*

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

Content

16.2.02T1 Definition of linear momentum

16.2.02T2 Explanation of the relationship between force and momentum of a body

16.2.02T3 Explanation of linear impulse

16.2.02T4 Explanation of the relationship between linear impulse and linear momentum of a body

16.2.02T5 Solution of problems in linear momentum and linear impulse

16.2.02T6 Explanation of angular momentum

16.2.02T7 Derivation from first principles, equations of angular momentum and impulse

16.2.02T8 Solution of problems on angular momentum and impulse

Practice

16.2.02P0 *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

16.2.02P1 Verification of the conservation of momentum

- Collision of bodies in linear motion

- Collision of bodies in angular motion

Suggested Learning Resources
- Relevant text books
- Hand outs
- Toy cars
- Procedure sheet

16.2.03 MASS MOMENTS OF INERTIA

Theory

16.2.03T0 *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.

16.2.03C *Competence*
The trainee should have the ability to apply the expression of radius of gyration to solve problems

Content

16.2.03T1 Explanation of axial moment of inertia of a mass

16.2.03T2 Statement of expression for mass moment of inertia of an element about three mutually perpendicular axes

16.2.03T3 Derivation of expressions of Centroidal mass moment of inertia (common regular objects)

16.2.03T4 Explanation of polar moment of inertia

16.2.03T5 Application of expressions of Centroidal mass moment of inertia to solve problems

16.2.03T6 Centroidal mass moment of inertia for common regular shapes

16.2.03T7 Statement of parallel axes theorem

16.2.03T8 Explanation of parallel axes theorem

16.2.03T9 Application of parallel axes theorem

16.2.03T0 Definition of radius of gyration

16.2.03T11 Application of expression of radius of gyration to solve problems

Suggested Learning Resources

- Relevant text books
- Hand outs
- Rotation motor
- Various bodies
- Procedure sheet
- Specification manual

16.2.04 AREA OF MOMENT OF INERTIA

Theory

16.2.04T0 *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 (x^1, y^1)
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

16.2.04C *Competence*
The trainee should have the ability to apply Mohr's cycle to solve problems related to rotation of axis

Content

16.2.04T1	Explanation of axial moment of inertia of an area
16.2.04T2	Elemental area rotated about an axis perpendicular to its plane
16.2.04T3	Explain polar moment of inertia of an area
16.2.04T4	Derivation of an expression for polar moment of inertia of an area
16.2.04T5	Explanation of the product of inertia
16.2.04T6	Derivation of an expression for the product of inertia of an area
16.2.04T7	Statement of parallel axis theorem
16.2.04T8	Application of inertia expressions to solve problems - Regular areas - Composite areas
16.2.04T9	Moments of inertia of any (x, y) with respect to rotated set of axis
16.2.04T10	State expressions for moments of inertia of an area with rotated set of axis
16.2.04T11	Application of Mohr's cycle to solve roblems
	Suggested Learning Resources - Relevant text books - Hand outs - Workshop realia
16.2.05	**BELTS AND CLUTCHES**
	Theory
16.2.05T0	*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
16.2.05C	*Competence* The trainee should have the ability to perform experiments to determine: - the ratio of belt tensions - the coefficient of friction between the pulley and the belt - torque in clutches - coefficient of friction in clutches
	Content
16.2.05T1	Identification common types of belts - Flat - Vee
16.2.05T2	Derivation of belt equations

- Tension
- Angle of lap
- Power
- Size of belt
- Number of belts
- Torque

16.2.05T3 Application of equation to solve belt problems on:
- Flat belt
- Vee belt
- Power transmitted
- Angle of lap
- Tension
- Size of belts

16.2.05T4 Identification of common clutches
- plate
- Centrifugal
- Conical

16.2.05T5 Derivation of clutch equations
- Force
- Torque transmitted
- Number of plates
- Efficiency

16.2.05T6 Application of the equations to solve clutch problems

Practice

16.2.05P0 *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

16.2.05P1 Ratio of belt tension
- Flat belts
- Vee belts

16.2.05T2 Coefficient of friction between belt and pulley

16.2.05T3 Torque in clutches
- Plate clutches
- Cone clutches
- Centrifugal clutches

16.2.05T4 Coefficient of friction in clutches

Suggested Learning Resources
- Relevant text books
- Hand outs
- Real belts and clutches
- Demonstration
- Discussion
- Experiment

- Rotating motor and its pulley
- Oral practical tests
- Continuous practical tests

16.2.06 GEARED SYSTEMS

Theory

16.2.06T0 *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

16.2.06C *Competence*
The trainee should have the ability to perform experiment to determine:
- torque in geared systems
- mechanical advantage in geared systems
- efficiency in geared systems

Content

16.2.06T1 Description of different types of gear drives
- Spur gear trains
- Epicyclic gear systems

16.2.06T2 Derivation of equations for gear drives
- Velocity ratio
- Radius
- Pressure angle
- Accelerating torque
- Friction torque
- Input and output members for an epicyclic gear train
- Speed and sense of rotation
- Power transmitted

16.2.06T3 Application of the equations to solve gear drive problems

Practice

16.2.06P0 *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

16.2.06T1 Torque in geared systems
- Spur gears
- Epicyclic gears

16.2.06T2 Mechanical advantage
- Spur gears
- Epicyclic gears

16.2.06T3 Efficiency in geared systems
- Spur gears
- Epicyclic gears

Suggested Learning Resources
- Relevant text books
- Hand outs
- Spur gears
- Epicyclic gears

16.2.07 DYNAMICS OF A RIGID BODY IN TRANSLATION

Theory

16.2.07T0 *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

16.2.07C *Competence*
The trainee should have the ability to determine moment of external forces about mass centre of a body

Content

16.2.07T1 Definition of dynamics of a rigid body

16.2.07T2 Statement of the scalar equation for translation

16.2.07T3 Moment of external forces about mass centre of a body

16.2.07T4 Application of the equation to solve problems

Suggested Learning Resources
- Relevant text books
- Hand outs

16.2.08 DYNAMICS OF RIGID BODY IN ROTATION

Theory

16.2.08T0 *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

16.2.08C *Competence*
The trainee should have the ability to balance masses

Content

16.2.08T1 Identification of rotation of a body about a non- centrodial axis

16.2.08T2 Statement of equation of motion for rotation about a non-centroidal axis

16.2.08T3 Balancing of masses
- Static balancing
- Dynamics balancing

Suggested Learning Resources
- Relevant text books
- Hand outs
- Mass

16.2.09 DYNAMICS OF RIGID BODY IN PLANE

Theory

16.2.09T0 *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

16.2.08C *Competence*
The trainee should have the ability to apply the equations to solve problems

Content

16.2.09T1 Statement of plane motion
- Vector
- Scalar

16.2.09T2 Explanation of equations of plane motion
- Vector
- Scalar

16.2.09T3 Application of equation of plane motion
- Linear dynamic condition
- Angular dynamic condition

Suggested Learning Resources
-relevant text books
-hand outs
-rigid body in plane