24.3.14P0 *Specific Objectives*

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

a) create a layout for plotting
b) set a plotter for plotting
c) plot a drawing

24.3.14C *Competence*

The trainee should have the ability to prepare a drawing for plotting

Content

24.3.14P1 Plot layout

- Plot device
- Paper orientation
- Layout Settings

24.3.14P2 Plotter setting

- Paper type
- Paper feed
- Plotting

Suggested Learning Resources

- Textbooks
- Computer lab
- Internet
- Autodesk website:www.autodesk.com

25.3.0 THERMODYNAMICS

25.3.1 Introduction:

The module unit is designed to equip the trainee with knowledge, skills and attitudes in the field of thermodynamics. Thermodynamics deals with the relationships of work, heat and energy.
The instructional approach will emphasize on experiments, industrial visits and analysis of various engineering concepts.

25.3.2 General Objectives:

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

a) understand the basic concepts of engineering science
b) understand the relationship of work, heat and energy
c) size power requirements of motors used in engineering design
d) apply the knowledge acquired to improve the performance of various equipments.

25.3.3 Module Summary and Time Allocation

THERMODYNAMICS

Code	Sub-Module Unit	Content	Theory Hrs	Practice Hrs	Total Hrs
25.3.01	Introduction to Fundamentals of Thermo-Dynamics	• Definitions of terms: • Thermodynamic systems • Types of working fluids • Types of thermodynamic processes • Thermodynamic cycles • Definition of work • Statement of the first law of thermodynamics	2	2	4
25.3.02	Steady Flow Processes	• Derivation of Steady Flow Energy Equation (S. F. E. E) • Application of the S. F. E. E. • Calculation of work, heat transfer, changes in internal energy, and enthalpy	2	2	4
25.3.03	Non-Flow Processes	• Non-Flow Energy Equation (N.F. E. E.) • Apply the N. F. E. E. for a gas and vapour processes	2	2	4

25.3.04	Perfect Gases	• Boyle's law • Charles' law • Derive the characteristic gas equation • Solution of problems using characteristic gas equation the equation • Definition of specific heats, universal gas constant, and specific gas constant • Boyle's law experiment • Charles' law experiment • Joule's law experiment	2	4	6
25.3.05	Steam	• Steam generation • PV diagram • TS diagram • Identification of different regions on the PV diagram • Definition of different conditions of steam • Area under the - P-V diagram • Determination of dryness fraction • Experiments on pressure and boiling point • Experiment on energy balance	2	4	6
25.3.06	Thermodynamic Reversibility and Entropy	• Criteria for reversibility • Internal reversibility • Explanation of the	4	4	8

		principle of the heat engine. • Second law of thermodynamics • Thermal efficiency • Carnot cycle • Net work • Net heat • Area under the T-S diagram			
25.3.07	Ideal Gas Cycle	• Explanations of the different gas cycles • Air standard efficiency • Work done • Heat received or rejected • Compression ratio • Mean effective pressure • Maximum cycle temperatures	4	4	8
25.3.08	Fuels And Combustion	• Classifications of fuels • Properties of fuels • Definition of combustions terminologies • Application of the equations to solve combustion and exhaust gas problems • Determination of calorific value of fuel. • Analysis of products of combustion	4	4	8
25.3.09	Heat Transfer	• Application of the conduction equations • Derivation of the heat transfer	4	4	8

		equations • Application of the heat transfer equations to solve related problems			
25.3.10	Heat Exchangers	• Classification • Description of various types of recuperative heat exchangers • Derivation of heat exchanger equations • Application of the equations • Heat exchanger experiments	4	4	4
25.3.11	Air Compressors	• Classification • Types of compressors • Derivations of equations of reciprocating compressors • Applications of the equations of reciprocating compressors • Air compressor experiments	4	4	8
25.3.12	Gas Turbines	• Theoretical cycle • Open gas turbine unit • Closed gas turbine unit • Plant diagram • T-S diagram • Thermal efficiency • Derivation of gas turbine equations • Modifications of the basic cycle • Applications of the	4	6	10

		gas turbine equations			
25.3.13	Impulse Steam Turbines	• Principle of operation. • Compounding • Multi stage impulse turbine • Derivation of related equations • Optimum operating conditions • Steam turbine experiments • Mechanical efficiency • Specific fuel consumption • Specific steam consumption	4	6	10
Total Time			**42**	**50**	**88**

25.3.01 INTRODUCTION TO FUNDAMENTALS OF THERMO- YNAMICS

Theory

25.3.01T0 *Specific Objectives*

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

a) define terminologies applied to thermodynamics
b) state various types of systems
c) state various types of working substances
d) describe a thermodynamic process
e) state various types of thermodynamic cycle
f) define thermodynamic work
g) state the first law of thermodynamics

25.3.01C *Competence*

The trainee should have the ability to:

i) Define various terms used in thermodynamic
ii) Describe various Thermodynamic processes and cycles
iii) State the first law of thermodynamics
iv) Apply the first law of thermodynamics

Content

25.3.01T1 Definitions of terms
- Thermodynamics
- System
- Thermodynamic cycle
- Properties
- Surrounding
- Boundary

25.3.01T2 Thermodynamic systems
- Open system
- Closed system

25.3.01T3 Types of working fluids
- Air
- Water
- Steam

25.3.01T4 Thermodynamic processes
- Definition
- Reversible processes
- Irreversible processes

25.3.01T5 Types of thermodynamics processes
- Isothermal
- Isochoric
- Isobaric
- Polytropic
- Adiabatic
- Hyperbolic

25.3.01T6 Thermodynamic cycles
- Otto cycle
- Diesel cycle
- Joules cycle
- Carnot cycle
- Dual combustion cycle

25.3.01T7 Thermodynamic work

25.3.01T8 Statement of the first law of thermodynamics

Suggested Learning Resources
- Textbooks
- Handouts

25.3.02 STEADY FLOW PROCESSES

Theory

25.3.02T0 *Specific Objectives*

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

a) derive the steady flow energy equation (S. F. E. E).
b) apply the steady flow energy

equation to solve problems.

25.3.02C *Competence*
The trainee should have the ability to:
Apply of the S. F. E. E. In the following components
- boilers
- condensers
- compressors
- turbines
- nozzles
- throttling processes

Calculation of:
- work
- heat transfer
- changes in internal energy
- changes in enthalpy

Content

25.3.02T1 Derivation of S. F. E. E

25.3.02T2 Application of the S. F. E. E.
- boilers
- condensers
- compressors
- turbines
- nozzles
- throttling processes

25.3.02T3 Calculation of:
- work
- heat transfer
- changes in internal energy
- changes in enthalpy

Suggested Learning Resources
- Textbooks
- Handouts

25.3.03 NON-FLOW PROCESSES

Theory

25.3.03T0 *Specific Objectives*
By the end of the topic, the trainee should be able to:
a) derive the non-flow energy equations (N. F. E. E)
b) apply the non flow equation to solve problems

25.3.04C *Competence*
The trainee should have the ability to apply the non flow equation to solve problems

Content

25.3.03T1 Derivation N.F. E. E:

25.3.03T2 Apply the N. F. E. E. to solve problems for a gas and vapour processes

25.3.04 PERFECT GASES

Theory

25.3.04T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) state Boyle's law
b) state Charles' law
c) derive the characteristic gas equation

d) solve problems using the characteristic gas equation
e) define specific heats

25.3.04C *Competence*
The trainee should have the ability to:
i) Set up and perform the experiment
ii) Analyze the results
iii) Apply the characteristic gas equation

Content
25.3.04T1 Boyle's law
25.3.04T1 Charles' law
25.3.04T1 Derive the characteristic gas equation
25.3.04T1 Solution of problems using the equation
25.3.04T1 Definition of:
- Specific heats Cp, Cv
- universal gas constant
- specific gas constant

Practice

25.3.03P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) verify Boyle's law
b) verify Charles' law
c) verify Joule's law

Content
25.3.04P1 Boyle's law experiment
25.3.04P1 Charles' law experiment
25.3.04P1 Joule's law experiment

Suggested Learning Resources
- Text books
- Hand outs
- Procedure sheets

25.3.05 STEAM

Theory

25.3.05T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) Describe the generation of steam
b) Explain the critical point.
c) Define various forms of steam
d) Identify on P-V and T-S diagram the various regions of steam generation
e) Solve steam problems

25.3.05C *Competence*
The trainee should have the ability to:

i) Set up and perform the experiment
ii) Analyze the results
iii) Plot the temperature pressure diagram

Content

25.3.05T1 Steam generation
25.3.05T2 Critical point
25.3.05T3 Forms of steam
25.3.05T4 Diagrams
- P-V diagram
- T-S diagram
  - liquid region
  - wet region
  - superheated region
  - area under the - T-S diagram

25.3.05T5 Problems on steam

Practice

25.3.05P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) determine dryness fraction
b) carry out an experiment to show the relationship between pressure and boiling points.
c) carry out boiler experiment for energy balance.
d) plot the temperature-pressure diagram

Content

25.3.05P1 Determination of dryness fraction
25.3.05P2 Experiments on pressure and boiling point
25.3.05P3 Experiment on energy balance
25.3.05P4 Temperature pressure diagram

Suggested Learning Resources
- Text books
- Handouts
- Steam tables
- Procedure sheets
- Boiler
- Throttling calorimeter
- Separating and throttling calorimeter

25.3.06 THERMODYNAMIC REVERSIBILITY AND ENTROPY

Theory

25.3.06T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain thermodynamic reversibility

b) explain the principle of the heat engine.
c) explain entropy in various thermodynamic cycles.

25.3.06C *Competence*
The trainee should have the ability to explain the principle of heat engine

Content
25.3.06T1 Thermodynamics reversibility
25.3.06T2 Principle of heat engine
25.3.06T3 Second law of thermodynamics
25.3.06T4 Entropy

Suggested Learning Resources
- Text books
- Handouts

25.3.07 IDEAL GAS CYCLE

Theory

25.3.07T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain the processes that make up the ideal gas cycles.
b) differentiate between air standard efficiency and actual efficiency.
c) solve problems in various idea gas cycles

25.3.07C *Competence*
The trainee should have the ability to solve problems in various idea gas cycles

Content
25.3.07T1 The ideal gas cycle
- Joule's cycle
- Otto cycle
- Diesel cycle
- Dual combustion cycle

25.3.07T2 Air standard efficiency
25.3.07T3 Calculations
- Work done
- Heat received or rejected
- Mean effective pressure
- Maximum cycle temperatures

Suggested Learning Resources
- Text books
- Handouts

25.3.08 FUELS AND COMBUSTION

Theory

25.3.08T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:

a) classify fuels
b) describe properties of fuels
c) derive combustion equations
d) apply the equations to solve combustion and exhaust gas problems

25.3.08C *Competence*
The trainee should have the ability to:
i) Set up and Perform the experiment
ii) Analyze the results
Classify fuels

Content

25.3.08T1 Classifications of fuels:
- solid fuels
- liquid fuels
- gaseous fuels

25.3.08T2 Properties:
- calorific values
- flash point
- ultimate analysis

25.3.08T3 Combustions terminologies:
- stoichometric air
- air fuel ratio
- mixture strength
- actual air

25.3.08T4 Application of the equations to solve combustion and exhaust gas problems

Practice

25.3.08P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) determine the calorific value of fuels
b) analyse products of combustion

Content

25.3.08P1 Determination of calorific value of fuel

25.3.08P2 Analysis of products of combustion

Suggested Learning Resources
- Text books
- Hand outs
- Procedure sheet
- Bomb calorimeter
- Orsat apparatus
- Fuels

25.3.09 HEAT TRANSFER

Theory

25.3.09T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) derive the conduction equations from Fourier's law
b) apply the conduction equations from Fourier's law to

solve heat transfer problem.
c) derive the heat transfer equations from Newton's law of cooling and Fourier's law.
d) apply the heat transfer equations from Newton's law to solve problems.

25.3.09C *Competence*
The trainee should have the ability to apply of the heat transfer equations to solve related problems

Content
25.3.09T1 Derivation of the heat transfer equations for:
- msingle flat wall
- composite flat wall
- single cylindrical wall
- composite cylindrical wall

25.3.09T2 Application of the heat transfer equations to solve related problems

Suggested Learning Resources
- Text books
- Handouts

25.3.10 HEAT EXCHANGERS

Theory

25.3.10T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) classify heat exchangers
b) describe various types of recuperative heat exchangers
c) derive recuperative heat exchanger equations
d) apply the equations to solve recuperative heat exchanger problems

25.3.10C *Competence*
The trainee should have the ability to apply the equations to solve recuperative heat exchanger problems

Content
25.3.10T1 Classification
- recuperative
- regenerator
- evaporative

25.3.10T2 Description of various types of recuperative heat exchangers
- parallel flow
- counter flow
- cross flow

25.3.10T3 Derivation of recuperative heat exchange

25.3.10T4 application of the equations

Practice

25.3.10P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to carry out experiments on heat exchangers

Content

25.3.10P1 Heat exchanger experiments

25.3.10C **Competence**
The trainee should have the ability to:
i) Set up and perform experiments on heat exchanger
ii) Identify types of heat exchangers

Suggested Learning Resources
- Textbooks
- Handouts
- Procedure sheet
- Heat exchangers

25.3.11 AIR COMPRESSORS

Theory

25.3.10T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) classify air compressors
b) describe various types of compressors
c) derive equations for reciprocating compressors
d) apply the equations for the reciprocation compressors

25.3.10C *Competence*
The trainee should have the ability to:
i) Set up and perform experiments on compressors
ii) Identify different types of compressors

Content

25.3.10T1 Classification
- reciprocating compressors
- rotary compressors

25.3.10T2 Types of compressors
- reciprocating
- blowers
- sliding valve

25.3.10T3 Derivations of recuperative heat exchanger equations
- work done
- free air delivery
- volumetric efficiency
- multi stage compressors
- inter cooling

25.3.10T4 Applications of the equations of reciprocating compressors

Practice

25.3.10P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:carry out experiments on heat exchangers

Content

25.3.10P1 Air compressor experiment to measure
- Volumetric efficiency
- Isentropic efficiency

Suggested Learning Resources
- text books
- handouts
- Procedure sheet
- Air compressors

25.3.11 GAS TURBINES

Theory

25.3.11T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain the theoretical cycle for a gas turbine.
b) describe the open cycle gas turbine.
c) describe the closed cycle gas turbine.
d) derive gas turbine equations.
e) explain the modifications of the basic cycle.
f) apply the equations to solve gas turbine problems

25.3.11C *Competence*
The trainee should have the ability to apply of the gas turbine equations to solve gas turbine problems

Content

25.3.12T1 Theoretical cycle
- Joule cycle

25.3.12T2 Open gas turbine unit
25.3.12T3 Closed gas turbine unit
25.3.12T4 Plant diagram
25.3.12T5 T-S diagram
25.3.12T6 Thermal efficiency
25.3.12T7 Derivation of gas turbine equations
25.3.12T8 Modifications on the basic cycle
25.3.12T9 Applications of the gas turbine equations

Suggested Learning Resources
- Text books
- Handouts

25.3.13 IMPULSE STEAM TURBINES

Theory

25.3.13T0 *Specific Objectives*

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

a) describe the principle of operation of the impulse steam turbine.
b) derive impulse steam turbine equations.
c) apply the equations to solve impulse steam turbine problems.

25.3.13C *Competence*

The trainee should have the ability to set up and perform an experiment on steam turbines

Content

25.3.13T1 Principle of operation
- Compounding
- Multi stage impulse turbine

25.3.13T2 Derivation of related equations
- power
- diagram efficiency
- Optimum operating conditions

25.3.13T3 Applications of impulse steam equations

Practice

25.3.13P0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able to carry out experiments on steam turbines.

Content

25.3.13P1 Steam turbine experiments
25.3.13P2 Mechanical efficiency
25.3.13P3 Specific fuel consumption
25.3.13P4 Specific steam consumption

Suggested Learning Resources
- Text books
- Handouts
- Steam tables
- h-s chart