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TNPSC DIPLOMA

MECHANICAL

Study Material Guide

BASED ON

NEW SYLLABUS

PATTERN

10 UNITS

150 TOPICS

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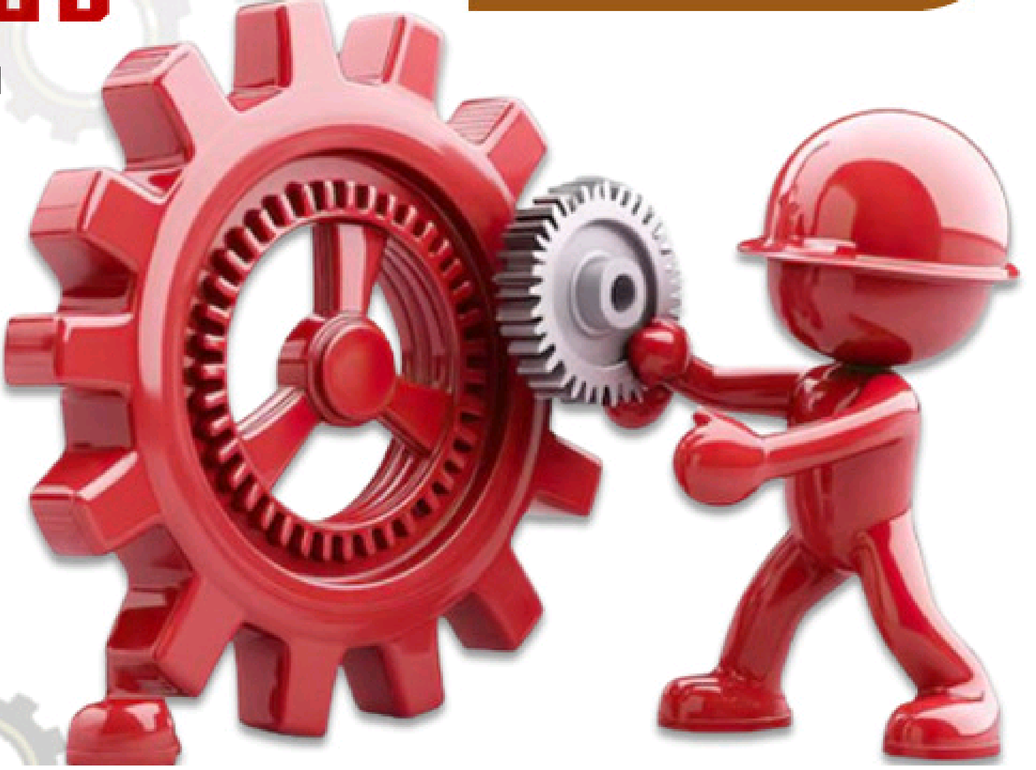

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2:15

UNIT-01 Industrial Engg & Man...
Modified Jan 13

UNIT-02 Production Technology
Modified Jan 13

UNIT-03 Electrical & Electronic...
Modified Jan 13

UNIT-04 Strength of Materials
Modified Jan 13

UNIT-05 Thermodynamics
Modified Jan 13

UNIT-06 Heat Power Engg
Modified Jan 13

UNIT-07 Fluid Mechanics & Ma...
Modified Jan 13

UNIT-08 Computer Integrated ...
Modified Jan 13

UNIT-09 Design of Machine El...
Modified Jan 13

UNIT-10 Metrology & Measure...
Modified Jan 13

Home Starred Shared Files

2:16

UNIT-01 Industrial Eng...

Name

01. Selection of site.pdf
Modified Jan 2

02. Plant layout.pdf
Modified Jan 2

03. Plant maintanence.pdf
Modified Jan 2

04. Plant safety.pdf
Modified Jan 2

05. Work study.pdf
Modified Jan 2

06. Method study.pdf
Modified Jan 2

07. Work measurements.pdf
Modified Jan 2

08. Functions of Production pl...
Modified Jan 2

09. Principles of management....
Modified Jan 2

10. Personnel Management.pdf
Modified Jan 2

12. Break Even Analysis & Make ...
Modified Jan 2

13. Depreciation methods.pdf
Modified Jan 2

14. EOQ & ABC Analaysis.pdf
Modified Jan 2

15. Supply chain management.p...
Modified Jan 2

16. TQM.pdf
Modified Jan 2

17. Control charts.pdf
Modified Jan 2

18. ISO 9000 Series.pdf
Modified Jan 2

19. ISO 9000 Series quality sta...
Modified Jan 2

20. QS 14000.pdf
Modified Jan 2

2. Plant Engineering

Deals with design, installation and improvement of plant with resources.

3. **Plant Location**
   Deciding a suitable location, area, and place for plant.

FACTORS CONSIDERED FOR THE SELECTION OF A SITE.

- Nearness top raw material.
- Land
- Transport facilities
- Availability of labour.
- Availability of fuel and power.
- Availability of water.
- Waste disposal.
- Financial and government concessions.
- Other factors

1. Nearness to raw material:

- To avoid transportation cost.
- Raw material is bulk and huge.
- E.g.: cement factory, sugar factory, iron and steel industry.

2. Land:

- Topography, area, cost, drainage.

- Earthquakes, floods.

3. Transport facilities

- Major amount is spending for transport.
- Suitable method of transport is selected where in roadways, railways and airways.
- Airport or port should be near the plant to avoid transport cost.

4. Availability of labour

- Labour should be available near plant.
- Labour cost should be reasonable.

5. Availability of fuel and power

- Need continuous power supply at reasonable rates.
- Steel industry → near coal fields. → No fuel cost.

6. Availability of water

- Water is the major concern for the industry.
- Water based industries like leather, paper, chemical industry and thermal power plant also.
- Location should be near the water.

7. Waste disposal

- Industrial waste should properly be disposed to avoid harmful effects to the environment.
- E.g.: Paper industry, chemical plant, leather industry.

8. Financial aids and government concessions

- Tax exemption.
- Site and building at low cost.
- Reduced electric charges
- Subsidence. (50% run by other parent company.)
- **Note: -** to avail these benefits plant should be located near backward areas.

QS 14000

1. QS 14000

- QS 14000 is a quality management standard specifically developed for the automotive industry.
- It was created to address the unique needs and requirements of automotive suppliers and manufacturers, ensuring that they meet rigorous quality standards.
- The standard is closely related to ISO 9000 (which focuses on general quality management) but is tailored to the automotive industry's specific needs, including stringent quality control, process consistency, and continuous improvement in manufacturing operations.
- QS 14000 was introduced by the European Automotive Manu[illegible] Association (ACEA) in the late 1990s as a response to growing [illegible] from major automotive manufacturers for a unified and globally recognized quality standard in the automotive supply chain.

2. Evolution and Development of QS 14000

- ***QS 9000:*** The precursor to QS 14000, QS 9000 was a set of quality requirements for the automotive industry introduced by the "Big Three" automotive manufacturers in the United States (General Motors, Ford, and Chrysler). QS 9000 was based on the principles of ISO 9001 but added specific requirements for the automotive industry.
- ***ISO/TS 16949:*** In 2002, QS 9000 was integrated with international standards and became part of the global standard ISO/TS 16949, which was developed by the International Automotive Task Force (IATF) in collaboration with the International Organization for Standardization (ISO).
- ***IATF 16949:*** In 2016, ISO/TS 16949 was updated and replaced by IATF 16949, which is the current global standard for quality management systems in the automotive industry.

3. Scope and Purpose of QS 14000

- QS 14000 is primarily focused on the quality management systems (QMS) of companies in the automotive supply chain. Its goal is to ensure that suppliers can consistently provide high-quality products and services that meet the specifications and expectations of automotive manufacturers. The standard is designed to:
  - ✓ Ensure product consistency: By implementing strict quality control measures, QS 14000 ensures that automotive components and systems are manufactured to meet precise specifications.
  - ✓ Improve supplier performance: It helps suppliers improve their processes, reduce waste, and enhance overall efficiency, which in turn improves the quality of their products.
  - ✓ Enhance customer satisfaction: QS 14000 helps organizations deliver products that meet the needs and expectations of automotive manufacturers, leading to improved customer satisfaction and loyalty.
  - ✓ Promote continuous improvement: Like other quality management systems, QS 14000 emphasizes the importance of continually improving processes, reducing defects, and optimizing production methods.

4. Key Principles of QS 14000

QS 14000 is based on several core principles that guide organizations in achieving quality excellence within the automotive sector. These principles are similar to those in ISO 9000 but are tailored to the automotive industry's specific needs:

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1. Customer Focus:

- Automotive manufacturers have high expectations for quality. QS 14000 requires companies to understand and meet these expectations,

2:17

UNIT-02 Production T...

Name

PDF 01. Foundary & Patterns.pdf
Modified Jan 2

PDF 02. Special Casting Techniques...
Modified Jan 2

PDF 03. Welding.pdf
Modified Jan 2

PDF 04. Hot & Cold Working.pdf
Modified Jan 2

PDF 05. Drawing,Rolling & Forging.p...
Modified Jan 2

PDF 06. Powder Metallurgy.pdf
Modified Jan 2

PDF 07. Processing of Plastics.pdf
Modified Jan 2

PDF 08. Lathe Work.pdf
Modified Jan 2

PDF 09. Planner.pdf
Modified Jan 2

PDF 10. Shaper.pdf
Modified Jan 2

PDF 11. Slotter.pdf
Modified Jan 2

PDF 12. Drilling machines.pdf
Modified Jan 2

PDF 13. Milling machice.pdf
Modified Jan 2

- 14. Grinding Machines.pdf
  Modified Jan 2
- 15. Broaching.pdf
  Modified Jan 2
- 16. Boring & Jig Boring.pdf
  Modified Jan 2
- 17. Gears manufacturing practi...
  Modified Jan 2
- 18. Heat Treatment.pdf
  Modified Jan 2
- 19. Press Work.pdf
  Modified Jan 2
- 20. Non Conventional machinin...
  Modified Jan 2
- 21. Non Conventional Producto...
  Modified Jan 2
- 22. Semi Automats.pdf
  Modified Jan 2
- 23. Automats.pdf
  Modified Jan 2

Non-Conventional Production Processes

- **Non-conventional production processes (also known as non-traditional, advanced, or non-conventional machining processes) refer to methods of material removal or shaping that do not use traditional mechanical cutting tools (like lathe tools, milling cutters, or drills).**
- **Unlike conventional processes, non-conventional processes typically involve the use of energy in the form of electrical, thermal, chemical, or mechanical sources to remove material from a workpiece**
- **These processes are often used for materials that are difficult to machine using conventional methods (such as hard, brittle, or complex materials), o.**

2. Classification of Non-Conventional Production Processes

- **Non-conventional production processes can be classified based on the type of energy used for material removal. The main categories include:**
  - ❖ **Mechanical Energy-based Processes**
  - ❖ **Thermal Energy-based Processes**
  - ❖ **Electrical Energy-based Processes**
  - ❖ **Chemical Energy-based Processes**
- **Each of these categories consists of several specific processes. Let's explore these in detail.**

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3. Mechanical Energy-based Non-Conventional Processes

- **These processes use mechanical energy to remove material from the workpiece, often through high-pressure fluids or abrasive particles. Some common mechanical energy-based processes include:**

3.1 Water Jet Machining (WJM)

Principle	**In Water Jet Machining, a high-pressure stream of water (often mixed with abrasive particles) is directed at the workpiece to erode material from it.**
Applications	**Cutting soft materials like plastics, rubber, and foams, as well as hard materials like metals and ceramics when abrasives are used.**

Advantages	**1. No heat-affected zone (HAZ), so the material's properties are not altered.** **2. Can cut complex shapes and contours.** **3. Environmentally friendly (no toxic fumes or chemicals).**
Limitations	**1. Limited to soft or brittle materials.** **2. Slower than traditional cutting methods for so[illegible] materials.**

3.2 Abrasive Jet Machining (AJM)

Principle	**In AJM, a high-velocity stream of abrasive particles (such as aluminium oxide or silicon carbide) is directed at the workpiece to remove material. The abrasive particles are typically propelled using compressed air.**
Applications	**Used for cleaning, etching, and cutting very hard or brittle materials like glass, ceramics, and thin metal**

2:19

UNIT-03 Electrical & El...

PDF 01. Units.pdf
Modified Jan 2

PDF 02. Ohms Law.pdf
Modified Jan 2

PDF 03. Kirchoff_s Law.pdf
Modified Jan 2

PDF 04. DC Circuits- DC Generator....
Modified Jan 2

PDF 04. DC Circuits-4 Point Starter ...
Modified Jan 2

PDF 04. DC Circuits-DC Motor.pdf
Modified Jan 2

PDF 05. Electro Magnetism & Farad...
Modified Jan 2

PDF 06. Batteries.pdf
Modified Jan 2

PDF 07. SIngle phase - AC Circ
Modified Jan 2

+ New

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08. Three phase - AC Circuits.p...
Modified Jan 2

09. Induction motors.pdf
Modified Jan 2

10. Stepper motors & Servo mo...
Modified Jan 2

11. Diodes.pdf
Modified Jan 2

12. Resistors.pdf
Modified Jan 2

13. Capacitors.pdf
Modified Jan 2

14. Transistors.pdf
Modified Jan 2

15. Logic gates.pdf
Modified Jan 2

16. PLC-Programmable L
Modified Jan 2

New

2:19
02. Ohms La...

1. DEFINITIONS

Current (I):

The flow of free electrons in any conductor is called Current. It is denoted by the letter I. The unit of current is ampere.

Resistance(R):

The opposition offered by a substance to the flow of electric current is called resistance. It is denoted by the letter 'R'. The unit of resistance is ohm(Ω).

1.1. OHM's LAW:

Ohm,s Law states that at constant temperature, the current flowing through a conductor is directly proportional to the potential difference across the conductor. Ohm's law is the law establishing the relation between voltage, current and resistance.

$$V \propto I$$

$$V = IR$$

It can be expressed as,

$$\frac{V}{I} = R \; ; \; \frac{V}{R} = I$$

Where R is a constant and is called the resistance of the conductor.

1.3. CONNECTION OF RESISTANCES:

Resistances can be connected in the following three ways:

(a) Series connection

(b) Parallel connection

(c) Series parallel connection

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1.3.1. Resistance in Series:

A circuit is said to be in series when the current flowing through the resistances are same.

R R R

V_1 V_2

I

V

ent flowing through R
R_2 and R_3. When the current
through the resistance, a voltage
occurs across R_1, R_2 and R_3

voltage drop can be calculated using ohm's law V=IR.

Voltage drop across $R_1 = IR_1 = V_1$

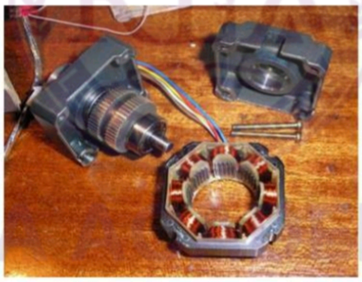
Voltage drop across $R_2 = IR_2 = V_2$

Voltage drop across $R_3 = IR_3 = V_3$

Total potential difference across the circuit = V

3.2 STEPPER MOTOR

- Stepper motor is an electromagnetic energy conversion device that converts electrical pulse to discrete mechanical movements. These motors are also called step motor or stepping motor or stepper.
- Due to its nature of its working, it is primarily used for position control systems. A *step* in a stepper motor is defined as the angular rotation produced by the shaft of the motor each time it receives a pulse.



- Each step causes the shaft to rotate a definite number of degrees. The angle through which the motor shaft rotates for each command pulse is called the *step-angle* (β).

Step angle = 360^{o} / (No. of stator phases x No. of rotor teeth)

Based on the construction of the magnetic circuit there are three main types of motors:

- Permanent magnet (PM) stepper motor - High torque low angular resolution
- Variable reluctance (VR) stepper motor – Excellent angular resolution, low torque
- Hybrid (HY) stepper motor - combines structure of PM and VR steppers, provides good [illegible] and angular resolution

3.2.1 Permanent magnet (PM) stepper motor

Construction

- It has wound stator poles and permanently magnetized rotor which is constructed in cylin[illegible] shape. Its direction of rotation depends on the polarity of stator current.
- The rotor is on the inside, with permanent magnets mounted on its perimeter. The stator is on the outside, with electromagnets (called windings) inside slots. The controller energizes the windings with pulses of DC current.
- Many of the windings are connected together. Each group of connected windings forms a phase.

Working

Name

01. Properties of engineering m...
Modified Jan 2

02. Mechanical testing.pdf
Modified Jan 2

03. Simple stresses & strains.pdf
Modified Jan 2

04. Elastic constants.pdf
Modified Jan 2

05. Properties of section.pdf
Modified Jan 2

06. Thin cylinders.pdf
Modified Jan 2

07. Theory of simple bending.pdf
Modified Jan 2

08. Torsion.pdf
Modified Jan 2

2:20

UNIT-04 Strength of...

Modified Jan 2

03. Simple stresses & strains.pdf
Modified Jan 2

04. Elastic constants.pdf
Modified Jan 2

05. Properties of section.pdf
Modified Jan 2

06. Thin cylinders.pdf
Modified Jan 2

07. Theory of simple bending.pdf
Modified Jan 2

08. Torsion.pdf
Modified Jan 2

09. Springs.pdf
Modified Jan 2

10. Shear force & Bending mom...
Modified Jan 2

+ New

11. Fricition.pdf

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mechanical properties of materials are those properties which describe the behaviour or the material under mechanical usage. Some important mechanical properties of materials are explained below.

3.2. Mechanical properties of materials

1) Elasticity

When a body is subjected to a system of external forces, deformation of body takes place. This deformation disappears at once the external forces are removed. This property of material by which a body regains its original shape and size after deformation when applied forces are removed is known as *elasticity*.

If the body regains it original shape completely, it is said to be *perfectly elastic*. However, this phenomenon holds good up to a particular value of stress known as *elastic limit*. Beyond this limit, the deformation does not entirely disappear when the force is removed. This residual deformation is known as *permanent set*. *The elasticity property is desirable in materials used for manufacturing of tools and machine elements.*

Example: Steel and rubber are some materials having good elasticity.

2) Plasticity

Plasticity is the property of a material by which a body retains the deformation due to applied load without rupture, even after the removal of applied load. Most materials become plastic under the application of heavy forces. *Plasticity plays an important role in manufacturing processes like forming, forging, swaging, coining, extrusion, etc.*

Example: Clay and lead are some materials having good plasticity.

3) Ductility

Ductility is the property of a material by which the material can be drawn out or elongated into thin wires without rupture by applying a tensile force. A ductile material should be strong and plastic in nature. Ductility of a material is usually measured by the percentage of elongation and percentage of reduction in area at fracture. *This property is very important in manufacturing processes like rolling, wire drawing, etc.*

Example: Mild steel, copper, aluminium, zinc, gold and platinum are some materials having high ductility.

4) Malleability

Malleability is the property of a material by which the material can be flattened into thin sheets without cracking by hot or cold working processes. A malleable material possesses a high degree of plasticity and can be hammered or rolled into any desired shape without rupture. *This property is very important in manufacturing processes like forging, hot rolling, drop forging, wire drawing, etc.*

Example: Mild steel, wrought iron, copper and aluminium are some materials having high malleability.

5) Machinability

Machinability is the property of a material by which the material can be easily machined by cutting tools in various machining operations. *The machinability of different materials can be compared with the help of machinability index.*

The following are the advantages, if the material having good machinability :

1) The rate of metal removal is high
2) Long life of cutting tool
3) Less power consumption
4) Good surface finish

Example: Grey cast iron has excellent machinability.

01. Basics of Thermodynamics....
Modified Jan 2

02. System & Properties.pdf
Modified Jan 2

03. Thermodynamic Laws.pdf
Modified Jan 2

04. Thermodynamic Process.pdf
Modified Jan 2

05. SFEE-Steady Flow Energy E...
Modified Jan 2

06. Air compressors & Types-In...
Modified Jan 2

07. Gas Turbines.pdf
Modified Jan 2

08. Boilers.pdf
Modified Jan 2

2:21

UNIT-05 Thermodyna...

Modified Jan 2

PDF 06. Air compressors & Types-In...
Modified Jan 2

PDF 07. Gas Turbines.pdf
Modified Jan 2

PDF 08. Boilers.pdf
Modified Jan 2

PDF 09. Steam properties.pdf
Modified Jan 2

PDF 10. Working principle of steam ...
Modified Jan 2

PDF 11. Main elements of nuclear po...
Modified Jan 2

PDF 12. Modes of heat transfer.pdf
Modified Jan 2

PDF 13. Psychrometric properti...
Modified Jan 8

+ New

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UNIT – I

BASICS OF THERMODYNAMICS AND THERMODYNAMIC PROCESSES OF PERFECT GASES

1.1 Introduction

Thermodynamics is a branch of science that deals with the relations between heat, and work.

Thermodynamics deals with the study of energy transformations within systems and transfer of energy across the boundaries of the system.

1.1.1 Definition and Units

1.1.2 Mass

Mass is the amount of matter contained in an object, and does not depends on gravity.

Mass is measured in grams or kilograms. Therefore it is denoted by letter 'W' and its unit is Kg.

1.1.3 Weight

Weight is the amount of mass of an object, and it's dependent upon gravity.

It is denoted by letter 'W' and *Its unit is Newton*. Mathematically,

$$\mathbf{W = m\,g.}$$

Where, 'g' is the acceleration due to gravity in m/s^2.

1.1.4 Force

According to Newton's second law of motion, the applied force or impressed force is directly proportional to the rate of change of momentum. It is denoted by letter 'F'. *Its unit is Newton (N)*. Mathematically,

$$F = \text{Mass x Acceleration}$$

$$\mathbf{F = m\,a}$$

Note:

$1N = 1kg\text{-}m/s^2$

1.1.5 Volume

Volume is defined as the ratio of mass to density. It is also defined as the space occupied by the mass. Its unit is m^3. It is denoted by '*V*'. Mathematically,

$$\mathbf{V} = \frac{m}{\rho}$$

Note:

1000 c.c = 1 litre = $0.001m^3$

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1.1.6 Density

The amount of matter (mass) in a given amount of space (volume)

Density is defined as mass per unit volume. Its unit is kg/m^3. It is denoted by 'ρ'. It is also known as mass density or specific mass. Mathematically,

$$\rho = \frac{m}{v}$$

1.1.7 Specific Weight

Specific weight is defined as the weight per unit volume. Its unit is N/m^3. It is denoted by '*w*'. It is also known as weight density. Mathematically,

$$w = \frac{W}{v}$$

$$= \rho\, g \;\therefore (W = mg\ \&\rho = m/v)$$

1.1.8 Specific Gravity

Specific gravity is defined as the ratio of density of given liquid to the density of a standard fluid (water). It has no unit. It is denoted by 's'. It is also known as relative density. Mathematically,

$$s = \frac{\rho l}{\rho w}$$

Note:

Density of water (ρ_w) = 1000 kg/m^3.

1.1.9 Specific Volume

The volume occupied by unit mass is known as specific volume. Its unit is m^3/kg. It is denoted by 'v_s'. Mathematically,

$$v_s = \frac{V}{m}$$

Therefore, it is the reciprocal of density, i.e. v = 1/ρ.

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1.1.10 Pressure

Pressure is defined as the normal force per unit area of the surface. The unit of

Psychrometric properties, Processes.

- Psychrometry is the study of the properties of air and water vapor mixtures. It is particularly important in applications involving heating, ventilation, and air conditioning (HVAC), industrial processes, and environmental control systems.
- The primary focus of psychrometry is on the moisture content of air, as it significantly affects the thermal comfort of humans and the efficiency of many industrial processes.
- In thermodynamics, psychrometric properties refer to the measurable characteristics of the air-vapor mixture.
- Understanding these properties helps engineers design systems that efficiently control temperature, humidity, and moisture content.

2. Psychrometric Properties

The key psychrometric properties of air are:

1. Dry Bulb Temperature (T_d):	*2. Wet Bulb Temperature (T_w):*
✓ It is the regular temperature measured by a thermometer exposed to the air. ✓ It is the temperature of the air without considering the moisture content. ✓ Unit: °C or °F.	✓ It is the lowest temperature that can be achieved by evaporative cooling. ✓ It is measured by a thermometer with its bulb wrapped in a wet cloth and exposed to the air. ✓ The wet bulb temperature is lower than or equal to the dry bulb temperature. ✓ - Unit: °C or °F.
 Dry Bulb	 Wet Bulb

3. Dew Point Temperature (T_dp):

- The temperature at which air becomes saturated with water vapor and starts to condense. It is the temperature at which the moisture in the air begins to condense into liquid water.
- Unit: °C or °F.

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4. Relative Humidity (RH):

- It is the ratio of the current amount of water vapor in the air to the maximum amount that the air could hold at a given temperature.
- Relative Humidity (percentage) = Amount of moisture that a given amount of air is holding / Amount of moisture that a given amount of air can hold
- Relative humidity is expressed as a percentage.

$$RH = P_{wv}/P_{ws} \times 100$$

Where:

- P_{wv} = Partial pressure of water vapor in the air (Pa or mmHg)
- P_{ws} = Saturation pressure of water vapor at a given temperature (Pa or mmHg)

5. Specific Humidity (ω):

- It is the mass of water vapor per unit mass of dry air. It is a measure

Name

01. Working principle and comp...
Modified Jan 8

02. Working principle and com...
Modified Jan 8

03. Construction & working of ...
Modified Jan 8

04. Heat balance test on IC en...
Modified Jan 8

05. Fuel supply system of petro...
Modified Jan 8

05. Fuel system-Diesel engine....
Modified Jan 8

05. Fuel system-Petrol engine....
Modified Jan 8

06. Ignition systems.pdf
Modified Jan 8

New

05. Fuel system-Petrol engine....
Modified Jan 8

06. Ignition systems.pdf
Modified Jan 8

07. Cooling systems.pdf
Modified Jan 8

08. Lubricating system.pdf
Modified Jan 8

08. Lubrication Systems.pdf
Modified Jan 8

09. Refrigerant & Types.pdf
Modified Jan 8

10. .Factors affecting human co...
Modified Jan 8

11. Air conditioner & Types.pdf
Modified Jan 8

2.1 THERMODYNAMIC AIR CYCLES:

When air is assumed to be the working substance inside the engine cylinder, the cycle is called as an air cycle.

2.1.1 Air Standard efficiency:

The thermal efficiency of the engine which uses air as the working medium is know as 'Air standard Efficiency'. This efficiency is often called as Ideal efficiency

$$\text{Air standard } efficiency = \frac{\text{Work done}}{\text{Heat supplied}}$$

$$\textbf{Work Done = Heat Supplied – Heat Rejected}$$

$$= Q_S - Q_R$$

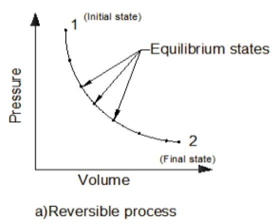
$$\text{Air standard } efficiency = 1 - \frac{QR}{QS}$$

2.1.2 Reversible and irreversible process:

A thermodynamic cycle consists of number of processes. If each process comprising the thermodynamic cycle is reversible, then the cycle is called as reversible cycle.

In a reversible cycle there should be no loss of heat due to friction, radiation.

The conditions required for reversible cycle are same as that for the reversible process. If those conditions are not satisfied, then it becomes an irreversible cycle. Hence in an irreversible cycle the original conditions are not restored.



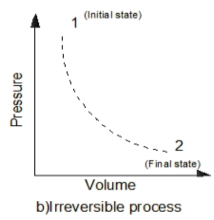


Fig 2.1(a) Fig 2.1(b)

2.1.3 Assumptions in deriving air standard efficiency:

1. The working medium or air in the engine cylinder is a perfect gas i.e. It obeys the gas laws and has constant specific heats
2. The compression and the expansion process are adiabatic and they take place without internal friction
3. No chemical reaction takes place in the engine cylinder. Heat is supplied by bringing the hot body in contact with the engine cylinder and heat is rejected by bringing the cold body is assumed to be a closed system.
4. The mass of the working medium or air is assumed to be kept constant i.e the system is assumed to be a closed system.

2.1.4 CARNOT CYCLE

Consider 1 kg of air in a piston and cylinder arrangement as shown in fig.

Let p_1, v_1, and T_1 be the pressure, volume and temperature of the air at the beginning of the cycle

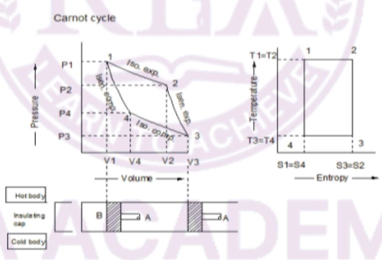


Fig 2.2 (a) Fig 2.2 (b)

The Carnot cycle is completed with following process

Process 1-2 Isothermal expansion process

The hot body is brought in contact with the cylinder at the bottom. The air expands at constant

PROBLEMS FOR PRACTICE

1. *A refrigerator works between the temperature limits of 27°C and -3°C. What is the* C.O.P? [Ans: 9]
2. A refrigerating cycle working on reversed carnot cycle has a C.O.P. of 4 and workdone on compressor is 10 kJ/sec. Find the refrigerating effect. [Ans: 40 kJ/sec]
3. A machine works on reversed carnot cycle whose temperature limits are -15°C and 27°C. Find the C.O.P. of the machine working as a refrigerator. [Ans: 6.143]
4. A reversed carnot cycle refrigeration system has C.O.P. as 3.5. Determine the ratio of absolute temperatures. If the refrigerating effect is 10 tonnes, find the power of the unit. [Ans: 1.287, 10 KW]
5. A reversed carnot cycle has refrigerating C.O.P. of 4. Determine (i) the $\frac{T_1}{T_2}$ ratio ;

   (ii) If the workdone on the cycle is 12 kW, determine the maximum refrigerating effect in tones; [Ans: 1.25, 13.714 tonnes]
6. A carnot refrigerator requires 0.5 kW per ton of refrigeration to maintain a region at low temperature of -40°C. Determine (1) C.O.P. of the refrigerator, (2) Higher temperature of the cycle, and (3) heat rejected in kJ/ton of refrigeration. [Ans: 7, -6.714°C, 4 kJ/tone]
7. An inverter claims to have developed a refrigerating unit which maintains the refrigerated space at -10°C, while operating in a room where the temperature is 20°C and has C.O.P. as 8. Find whether his claim is correct or not. [Ans: Claim is correct]
8. A refrigerating machine has a capacity of 20 tonnes of refrigeration from and at 0°C. If the temperature limits are 24°C and -15°C and the latent heat of ice is 336 kJ/kg. Calculate the power required and the weight of ice produced per day of 24 hours. [Ans: 10.581 kW, 13.586 tonnes of ice]
9. A refrigerating machine has to do an amount of refrigeration equal to the production of 20 tonnes of ice per 24 hours at 0°C from water at 10°C. Calculate the power required on the assumption that (1) the cycle is reversed, and (2) actual performance is 70 % of the ideal. The latent heat of ice is 336 kJ/kg. [Ans: 12.364 kW, 17.663 kW]
10. A perfect reversed heat engine is used for making ice at -5°C from water available at 20°C. The temperature of brine or freezing mixture is -10°C. Calculate the quantity of ice formed per kW-hr. For ice, specific heat is 2.1 kJ/kg.K and latent heat as 336 kJ/kg. [Ans: 73.354 kg/kW hr] [Apr 2017, Oct 2018]

    Hints [Same model solved in problem 10]
11. A refrigerating plant is required to produce 2.5 tonnes of ice per day at -4°C from water at 20°C. If the temperature range in the compressor is in between 25°C and -6°C, calculate the power required to drive the compressor. Latent heat of ice = 336 kJ/kg and specific heat of ice = 2.09 kJ/kg. [Ans: 34.827 kW] [Oct 2017]

    Hints [Same model solved in problem 13]
12. Find the least power of perfect reversed heat engine that makes 450 kg of ice per hour at -4°C from water at 16°C. Assume the temperature limits on the engine as 16°C and -4°C. Given that C_p for ice is 2 KJ/kg.K and latent heat of ice is 336 KJ/kg. [Ans: 3.782 kW]

5.2 AIR CONDITI

5.2.1. AIR CONDITIONING

It is defined as, "the simultaneous control of temperature humidity, purity and air motion with in an enclosed space".

5.2.2. PSYCHROMETRY

The properties of atmospheric air have to be considered more important as it affects the working of man environment as well as manufacturing goods. The atmospheric air generally consists of water vapour. The amount of water vapour plays important role in psychrometry. If it exceeds or lowers certain limit, it will create discomfort to the man. So, it is very important to keep the moisture content in the air within the specified limit in case of processing industries and air-conditioned buildings.

Psychrometry is the study and measurement of properties of air-vapour mixtures. This study is important because of its wide applications in air conditioning, cooling tower etc.

5.2.3. PSYCHROMETRIC PROPERTIES

The properties of air-vapour mixtures are known as psychrometric properties.

Dry air: The dry is nothing but the air without moisture or water vapour. The pure dry air is a mixture of number of gases such as nitrogen, oxygen, carbon dioxide, hydrogen etc.,among these except nitrogen and oxygen other gases present only in negligible quantity. So, the volumetric composition of dry air is 77% of nitrogen and 23% of oxygen.

Moist air: It is a mixture of dry air and water vapour.

Saturation capacity of air: The maximum quantity of water vapour present in air at particular air temperature is known as saturation capacity of air.

Moisture : The water vapour present in the air is known as moisture.

Dry Bulb Temperature (DBT) (t_d) : The temperature measured by an ordinary thermometer is known as dry bulb temperature.It is generally donated by t_d.

Wet Bulb Temperature (WBT) (t_w):

It is the temperature of air measured by a thermometer when its bulb is covered with wet cloth and is exposed to a current rapidly moving air. It is denoted by t_w.

Wet bulb depression (WBD):

It is the difference between the dry bulb temperature and wet bulb temperature.

$$WBD = DBT - WBT$$

The value of wet bulb depression is zero when the air becomes saturated.

Dew Point Temperature (DPT) (t_{dp}):

It is the temperature at which the water vapour present in air begins to condense when the air is cooled.

For saturated air, the dry bulb, wet bulb and dew point temperature are all same.

Dew point depression (DPD):

It is the difference between dry bulb temperature and dew point temperature.

$$DPD = DBT - DPT$$

Specific humidity (or) Humidity ratio (or) moisture content (ω):

It is defined as the mass of water vapour present in one kg of dry air. It is the ratio of the mass of water vapour to the mass of dry air in a iven volume of the moisture.

Degree of saturation (μ) or saturation ratio

It is defined as the ratio of specific humidity of the most air to the specific humidity of saturated air at the same temperature.

Degree of saturation (or) percentage humidity (or) saturation ratio

$$\mu = \frac{\text{Specific humidity of moist air}}{\text{Specific humidity of saturated air}}$$

Relative humidity (ø):

It is defined as the of the actual mass of water vapour in a given volume to the saturated mass of water in same volume and temperature.

Relative humidty,

$$\phi = \frac{\text{Mass of water vapour in a given volume}}{\text{Saturated mass of water vapour in same volume of temperature}}$$

Total enthalpy (Total heat) of moist air (h):

Total enthalpy of moist air is the sum of the enthalpy of dry and the enthalpy of water vapour associated with the dry air.

Total enthalpy of moist air is given by

$$H = C_p t_d + \omega h_g$$

Where

C_p = Specific heat at constant pressure = 1.005 kJ/kgK

T_d = Dry bulb temperature

ω = Specific humidity

h_g = Specific enthalpy a air corresponding to dry bulb temperature.

5.2.4. Psychrometric chart

A chart which shows the interrelation between the psychrometric properties is known as psychrometric chart. In a psychrometric chart, dry bulb temperature is taken along x axis and specific humidity as ordinate to the right side of the chart as shown in figure. All other psychrometric properties are shown by different lines on the chart. The various lines are dew point temperature lines, wet bulb temperature lines, enthalpy lines, specific volume lines and relative humidity lines. If any two of these properties are known, then we can calculate the other properties of air from the chart.

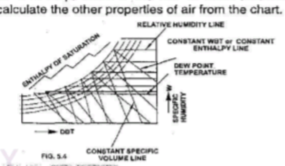


FIG. 5.4

5.2.5. Psychrometric processes

The various processes which are used in air conditioning to vary the psychrometric properties of air as per requirement are called psychrometric processes. The various processes are,

1. Sensible heating
2. Sensible cooling
3. Humidification and
4. Dehumidification

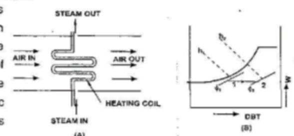


FIG. 5.5

Sensible heating

The heating of air without any change of its specific humidity is known as sensible heating. The heating can be done either by passing over a heating coils like electric heating coils or by steam coils. The process is represented on the psychrometric chart by a line parallel to DBT line. The heating of air rises the dry bulb temperature of air.

Sensible head added = $m_a (h_2 - h_1) = 1.022 (t_{d2} - t_{d1})$ kJ

Where, m_a = Mass flow rate of air per sec

h_1 = Specific enthalpy of air at initial state 1

h_2 = Specific enthalpy of air at final state 2

t_{d2} and t_{d1} = Dry bulb temperature of air at 2 and 1

The efficiency of [illegible] coil is measured in terms of by pass fa[illegible]

By pass factor (BPF) is d[illegible] the portion of the air that passes through the coil without contacting [illegible] surface..

$$BPF = \frac{t_{d2} - t_{d3}}{t_{d1} - t_{d3}}$$

t_{d2} and t_{d1} = Dry bulb temperature of

The efficiency of cooling coil is measured in

$$BPF = \frac{t_{d3} - t_{d2}}{t_{d1} - t_{d2}}$$

Applications: Cooling is necessary in summ

Humidification

At constant dry bulb temperature [illegible] moisture is added to air, the process is called humidification. The heat is added during humidificaion process. It is necessary for winter air conditioning system.

Latent heat factor = $m_a h_{fg} (w_2 - w_1)$ kJ

Where, m_a = Mass flow rate of ai[illegible]ond,

h_{fg} = Latent heat of evaporation [illegible] air = 2500 kJ/ kg

w_1 = Specific humidity of air entering the humidifier

w_2 = Specific humidity of air leaving the humidifier

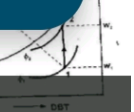


FIG. 5.7

2:22

UNIT-07 Fluid Mechan...

01. Fluid properties.pdf
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02. Pressure Measurements.pdf
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03. Flow of fluids.pdf
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04. Flow through pipes.pdf
Modified Jan 8

05. Reciprocating pumps.pdf
Modified Jan 8

06. Centrifugal pump.pdf
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07. Hydraulic turbine.pdf
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08. Hydraulic Systems.pdf
Modified Jan 8

09. Pneumatic Systems.pdf
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- Explain the construction and working principle of different types of Mechanical Gauges.

1.1 Introduction

Fluid Mechanics

Fluid Mechanics is the branch of engineering which deals with the properties and behavior of fluids at rest and in motion.

Hydraulics

Hydraulics is the branch of engineering deals with the properties and behavior of water.

1.2. Definition of Fluid

Fluid can be defined as the substance which can flow with or without the

A fluid may be in three form like as liquid (or) a vapour (or) a gas

1.3. Types of Fluid

Fluids are classified as follows.

1. **Ideal (or) perfect fluid**

   A fluid having density only as property is called Ideal fluid . Ideal fluid one which has no viscosity, surface tension, cohesion and adhesion etc.

   Ex. Imaginary fluid

2. **Real fluid (or) Practical fluid**

   A fluid having viscosity, surface tension, cohesion, adhesion and density is called Real Fluid.

   Ex; water, air, lubricating oil

3. **Newtonian Fluid**

   A fluid which obeys Newton's Law of viscosity is called Newtonian fluid.

   Ex; Water, Lubricating oil etc.

4. **Non – Newtonian Fluid**

   A fluid which does not obey Newton's Law of viscosity is called Non-Newtonian fluid.

   Ex; Paints, Plastics etc.

1.4. Properties of Fluid

1. **Density**

   It is defined as the mass per unit volume.

   Density = $\frac{Mass}{Volume}$

   Unit is kg/m^3 Density of water is 1000 kg/m^3 .

2. **Specific weight (weight density)**

   It is defined as the weight per unit volume.

   Specific weight = $\frac{Weight}{Volume}$

   Unit is kN/m^3

Relation between the Specific weight and density is **$w = \rho \times g$**

3. Specific volume

It is defined as the volume per unit mass.

Specific volume = $\frac{Volume}{Mass}$ (or) $\frac{1}{Density}$

Pneumatics is widely used for applications that require quick, lightweight, and cost-effective motion, such as in automated machinery, robotics, and manufacturing processes.

- Pneumatic systems consist of various components that work together to generate, control, and apply compressed air to produce linear or rotary motion.

2.Components of Pneumatic Systems

The essential components of a pneumatic system include:

1. Compressor
2. Receiver (Air Tank)
3. Pneumatic Actuators (Cylinders & Motors)
4. Pneumatic Valves
5. Filters
6. Regulators
7. Air Lines (Pipes and Tubing)
8. Lubricators

3. Detailed Explanation of Pneumatic System Components

3.1 Compressor

Function:	***Types:***
✓ The compressor is the heart of the pneumatic system. ✓ It converts mechanical energy into compressed air by reducing the volume of air and increasing its pressure. ✓ The compressed air is then stored and delivered to the system as needed.	➢ Reciprocating Compressor: Uses a piston to compress air. ➢ Rotary Screw Compressor: Uses two interlocking screws to compress air. ➢ Centrifugal Compressor: Uses high-speed rotating blades to compress air.

Compressor Power:

P = V × P_max/η

Where:

- ➢ P = Power (W)
- ➢ V = Volume flow rate of air (m^3/s)
- ➢ P_max = Maximum pressure (Pa)
- ➢ η = Efficiency of the compressor

3.2 Receiver (Air Tank)

Function:	***Design Considerations:***
✓ The receiver stores compressed air and helps smooth out pressure fluctuations in the system. ✓ It serves as a buffer between the compressor and the rest of the system, ensuring that a steady supply of air is available to the actuators and valves.	➢ The size of the receiver depends on the volume of air needed, the compressor capacity, and the required system pressure.

3.3 Pneumatic Actuators (Cylinders & Motors)

Function:

- Pneumatic actuators convert compressed air into mechanical motion.
- The two primary types of actuators are:
  - ➢ *Pneumatic Cylinders (linear actuators):* These are used for producing straight-line motion.
  - ➢ *Pneumatic Motors (rotary actuators):* These produce rotary motion.

Pneumatic Cylinder	Pneumatic Motor
➢ Single-Acting Cylinder: Air pressure is applied to one side of the piston, moving it in one direction only. The return stroke is achieved by a spring or gravity. ➢ Double-Acting Cylinder: Air pressure is	➢ Pneumatic motors convert compressed air into rotary motion. ➢ These motors are widely used in applications requiring

2:23

UNIT-08 Computer Int...

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03. MS Office.pdf
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07. CAM.pdf
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10. CNC.pdf
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11. Components of CNC-(TM).p...
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12. Automatic Tool Changer (AT...
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12. Automatic Tool Changer (AT...
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13. CNC EDM-(TM).pdf

12. Automatic Tool Changer (AT...
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13. CNC EDM-(TM).pdf
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13. CNC EDM(EM).pdf
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14. Part Program-(EM).pdf
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15. Part program format coordi...
Modified Jan 8

16. Types of Motion Control-(T...
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17. Types of Interpolation.pdf
Modified Jan 8

18. G & M Codes.pdf
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Modified Jan 8

21. AGV.pdf
Modified Jan 8

22. Robotics.pdf
Modified Jan 8

23. Rapid prototyping.pdf

Working Principle and Constructional Details of a Computer

1. Introduction

A computer is a versatile electronic device that processes data according to a set of instructions, or software programs. It performs a range of tasks including calculations, data management, and communication. The operation of a computer is based on the principles of data input, processing, storage, and output.

2. Basic Components of a Computer

2.1 Central Processing Unit (CPU)

- **Function:** The CPU is the brain of the computer where all processing activities occur. It executes instructions from programs and manages the flow of data within the computer.
- **Components:**
  - **Arithmetic Logic Unit (ALU):** Executes arithmetic operations (addition, subtraction) and logical operations (comparison).
  - **Control Unit (CU):** Directs the operation of the processor. It interpr instructions from memory and initiates necessary actions.
  - **Registers:** Small, fast storage locations within the CPU used to hold intermediate data and instructions during processing.

2.2 Memory

- **Random Access Memory (RAM):** Volatile memory used for temporary storage of data and instructions that are actively being used or processed by the CPU. It allows for quick read and write access.
- **Cache Memory:** A smaller, faster type of volatile memory that provides high-speed data access to the CPU by storing frequently accessed data and instructions.
- **Read-Only Memory (ROM):** Non-volatile memory that holds the BIOS (Basic Input/Output System) and system firmware essential for the computer's startup process.

2.3 Storage Devices

- **Hard Disk Drive (HDD):** Utilizes magnetic storage to read and write data on spinning disks. It provides large storage capacity but is slower compared to SSDs.
- **Solid-State Drive (SSD):** Uses flash memory to store data, which results in faster access speeds and improved reliability compared to HDDs.
- **Optical Drives:** Use laser technology to read/write data on CDs, DVDs, and Blu-ray discs.

2.4 Motherboard

- **Function:** The main circuit board that houses the CPU, memory, and other crucial components. It facilitates communication between different parts of the computer.
- **Components:**
  - **Chipset:** Manages data flow between the CPU, memory, and peripherals. It includes the Northbridge (handling high-speed interfaces like RAM and CPU) and Southbridge (managing lower-speed interfaces like USB and storage).
  - **Expansion Slots:** Allow for additional hardware components (e.g., graphics cards, network cards) to be added to enhance the computer's capabilities.
  - **Bus Lines:** Electrical pathways that facilitate data transfer between the CPU, memory, and other components.

2.5 Input Devices

- **Examples:** Keyboard, mouse, scanner, microphone. These devices allow users to input data and commands into the computer.

2.6 Output Devices

- **Examples:** Monitor, printer, speakers. These devices output processed data from the computer to the user.

2.7 Power Supply Unit (PSU)

- **Function:** Converts alternating current (AC) from the electrical outlet into direct current (DC) used by the computer's internal components.
- **Components:**
  - **Voltage Regulation:** Ensures stable power delivery.
  - **Cooling Fan:** Prevents overheating of the PSU and other internal components.

3. Working Principle of a Computer

3.1 Input

Data and instructions are input into the computer through various devices such as a

RLA ACADEMY

3.2.1 RAPID PROTOTYPING

Rapid prototyping is a new manufacturing technique that allows for fast fabrication of computer models designed with three-dimension (3D) computer aided design (CAD) software. Rapid prototyping is used in a wide variety of industries.

This technique allows for fast realizations of ideas into functioning prototypes, shortening the design time, leading towards successful final products.

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Steps in RPT

- Creation of the CAD model of the part design,
- Conversion of the CAD model into STL format,
- Slicing of the STL file into thin sections,
- Building part layer by layer,
- Post processing / finishing / joining.

3.2.2 Classification

1. LOM (Laminated Object Manufacturing)
2. SLA (Stereolithography)
3. FDM (Fused Deposition Modeling)
4. SLS (Selective Laser Sintering)
5. 3D Printing

Rapid prototyping technique

1. Subtractive and 2.Additive

3.2.3 Subtractive Rapid prototyping

Subtractive type is a technique in which material is removed from a solid piece of material until the desired design remains. This type of RP includes traditional milling, turning or drilling to more advanced versions includes computer numerical control (CNC), electric discharge machining (EDM).

2:24

UNIT-09 Design of M...

Name

01. Engineering Materials & Typ...
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02. Design of Joints.pdf
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03. Design of Fastners.pdf
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04. Design of Shaft, key & Cou...
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05. Design of Bearing(TM).pdf
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06. Belt drives & Gear drives.pdf
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2. Types of Engineering Materials

- Engineering materials can be classified into three broad categories based on their composition and properties:

  1. Metals
  2. Polymers (Plastics)
  3. Composites
  4. Ceramics

3. Metals

RLA ACADEMY

- Metals are the most commonly used materials in mechanical engineering due to their excellent mechanical properties like strength, durability, and ductility.
- Metals are primarily classified into two groups: ferrous and non-ferrous metals.

3.1 Ferrous Metals

- Ferrous metals are metals that contain iron as their primary component.
- They are widely used in machine elements due to their strength and availability.

Types of Ferrous Metals:

Carbon Steel	Alloy Steel	Cast Iron
Composed mainly of iron and carbon, it is used in the manufacture of structural components, shafts, gears, etc. Formula for Carbon Content: C (carbon content) = 0.04% to 2.1%	Steel that is alloyed with other elements (such as chromium, nickel, molybdenum) to improve its properties.	Contains 2-4% carbon and is used for making heavy machine components like engine blocks, gearboxes, and housing.
Properties: High strength, easy to machine, but prone to corrosion.	Properties: Better corrosion resistance, higher strength, and toughness.	Properties: Good castability, high wear resistance, but low tensile strength.

❖ ***Steel:*** Made primarily of iron and carbon, steel has varying levels of carbon content, which determine its properties.

Low-carbon steel	Medium-carbon steel	High-carbon steel
0.05% to 0.3% carbon	0.3% to 0.6% carbon	0.6% to 1.4% carbon
Used for general-purpose applications.	Offers a balance of strength and ductility, used for shafts, gears, etc.	Used for making cutting tools, springs, and high-strength wires.

❖ ***Cast Iron:*** Cast iron contains a higher percentage of carbon (2-4%), making it more brittle but useful for applications requiring good castability and wear resistance.

Gray Cast Iron	White Cast Iron
Used in engine blocks and machinery parts.	Harder and more brittle, used for wear-resistant parts.

Formula for Stress in Steel:

- The stress-strain relationship in metals is often described by Hooke's Law for elastic deformation:

$$\sigma = E \cdot \epsilon$$

Where:

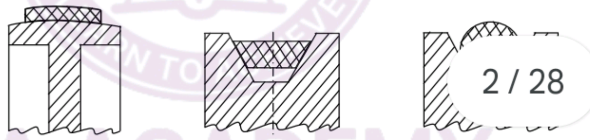
- σ = Stress (N/m² or Pa)
- E = Modulus of elasticity (Pa)
- ϵ = Strain (dimensionless)

another. Belts, chains and gears are used for this purpose. When the distance between the shafts is large, belts or ropes are used and for intermediate distance chains can be used. For belt drive distance can be maximum but this should not be more than ten metres for good results. Gear drive is used for short distances.

3.2.1 Belts

In case of belts, friction between the belt and pulley is used to transmit power. In practice, there is always some amount of slip between belt and pulleys, therefore, exact velocity ratio cannot be obtained. That is why, belt drive is not a positive drive. Therefore, the belt drive is used where exact velocity ratio is not required.

The following types of belts shown in Figure 3.1 are most commonly used :



(a) Flat Belt and Pulley (b) V-belt and Pulley (c) Circular Belt or Rope Pulley

Figure 3.1 : Types of Belt and Pulley

The flat belt is rectangular in cross-section as shown in Figure 3.1(a). The pulley for this belt is slightly crowned to prevent slip of the belt to one side. It utilises the friction between the flat surface of the belt and pulley.

The V-belt is trapezoidal in section as shown in Figure 3.1(b). It utilizes the force of friction between the inclined sides of the belt and pulley. They are preferred when distance is comparative shorter. Several V-belts can also be used together if power transmitted is more.

The circular belt or rope is circular in section as shown in Figure 8.1(c). Several ropes also can be used together to transmit more power.

The belt drives are of the following types :

(a) open belt drive, and

(b) cross belt drive.

Open Belt Drive

Open belt drive is used when sense of rotation of both the pulleys is same. It is desirable to keep the tight side of the belt on the lower side and slack side at the

top to increase the angle of contact on the pulleys. This type of drive is shown in Figure 3.2.

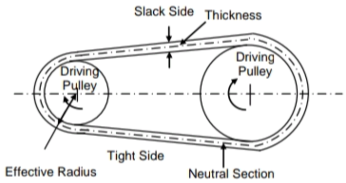


Figure 3.2 : Open Belt Derive

Cross Belt Drive

In case of cross belt drive, the pulleys rotate in the opposite direction. The angle of contact of belt on both the pulleys is equal. This drive is shown in Figure 3.3. As shown in the figure, the belt has to bend in two different planes. As a result of this, belt wears very fast and therefore, this type of drive is not preferred for power transmission. This can be used for transmission of speed at low power.

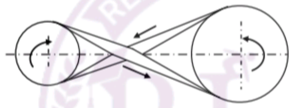


Figure 3.3 : Cross Belt Drive

Since power transmitted by a belt drive is due to the friction, belt drive is subjected to slip and creep.

Let d_1 and d_2 be the diameters of driving and driven pulleys, respectively. N_1 and N_2 be the corresponding speeds of driving and driven pulleys, respectively.

The velocity of the belt passing over the driver

$$V_1 = \frac{\pi d_1 N_1}{60}$$

If there is no slip between the belt and pulley

$$V_1 = V_2 = \frac{\pi d_2 N_2}{60}$$

or, $$\frac{\pi d_1 N_1}{60} = \frac{\pi d_2 N_2}{60}$$

or, $$\frac{N_1}{N_2} = \frac{d_2}{d_1}$$

If thickness of the belt is 't', and it is not negligible in comparison to the diameter,

$$\frac{N_1}{N_2} = \frac{d_2 + t}{d_1 + t}$$

Let there be total percentage slip 'S' in the belt drive which can be taken into account as follows :

$$V_2 = V_1 \left(1 - \frac{S}{100}\right)$$

or $$\frac{\pi d_2 N_2}{60} = \frac{\pi d_1 N_1}{60} \left(1 - \frac{S}{100}\right)$$

2:25

UNIT-10 Metrology &...

Name

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02. Limits-Fits-Tolerances.pdf
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06. Comparators.pdf
Modified Jan 8

07. Gauges.pdf
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08. Measurement of Mechanic...
Modified Jan 8

09. Computer aided inspection...
Modified Jan 8

10. Measurement of force, pow...
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1.2 METROLOGY

Metrology literally means science of measurements. In practical applications, it is the enforcement, verification, and validation of predefined standards. Although metrology, for engineering purposes, is constrained to measurements of length, angles, and other quantities that are expressed in linear and angular terms, in a broader sense, it is also concerned with industrial inspection and its various techniques. Metrology also deals with establishing the units of measurements and their reproduction in the form of standards, ascertaining the uniformity of measurements, developing methods of measurement, analysing the accuracy of methods of measurement, establishing uncertainty of measurement, and investigating the causes of measuring errors and subsequently eliminating them.

The word metrology is derived from the Greek word 'metrologia', which means measure. Metrology has existed in some form or other since ancient times. In the earliest forms of metrology, standards used were either arbitrary or subjective, which were set up by regional or local authorities, often based on practical measures like the length of an arm.

It is pertinent to mention here the classic statement made by Lord Kelvin (1824–1907), an eminent scientist, highlighting the importance of metrology: 'When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge of it is of a meagre and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thought advanced to the stage of science.'

Another scientist Galileo (1564–1642) has clearly formulated the comprehensive goal of metrology with the following statement: 'Measure everything that is measurable and make measurable what is not so.'

Metrology is an indispensable part of the modern day infrastructure. In fact, it plays an important role in our lives, either directly or indirectly, in various ways. In this competitive world, economic success of most of the manufacturing industries critically depends on the quality and reliability of the products manufactured—requirements in which measurement plays a key role. It has become increasingly essential to conform to the written standards and specifications and mutual recognition of measurements and tests, to trade in national and international markets. This can be achieved by the proper application of measurement methods that enhance the quality of products and the productive power of plants.

Metrology not only deals with the establishment, reproduction, protection, maintenance, and transfer or conversion of units of measurements and their standards, but is also concerned with the correctness of measurement. In addition to encompassing different industrial sectors, it also plays a vital role in establishing standards in different fields that affect human beings, suc health sciences, safety, and environment. Hence, one of the major functions of metrology establish international standards for measurements used by all the countries in the world in science and industry.

Modern manufacturing technology is based on precise reliable dimensional measurem The term 'legal metrology' applies to any application of metrology that is subjected to nat laws or regulations. There will be mandatory and legal bindings on the units and methods measurements and measuring instruments. The scope of legal metrology may vary considerably from one country to another. The main objective is to maintain uniformity of measurement in a particular country. Legal metrology ensures the conservation of national standards and guarantees their accuracy in comparison with the international standards, thereby imparting proper accuracy to the secondary standards of the country. Some of the applications of legal metrology are industrial measurement, commercial transactions, and public health and human safety aspects.

A group of techniques employed for measuring small variations that are of a continuous nature

Measurement of Force, Power, and Flow

- **In mechanical engineering, force, power, and flow are fundamental quantities that need to be measured accurately to ensure the proper functioning of machines and systems.**
- **The measurement of these quantities is crucial in various applications, such as determining the performance of engines, turbines, pu hydraulic systems. Metrology, which is the science of meas provides the tools and methods to quantify these parameters p.**
- **In this topic, we will cover the principles, methods, and instruments used to measure force, power, and flow, and provide an understanding of their relevance in engineering applications.**

2. Measurement of Force

- **Force is defined as an interaction that changes the motion of an object. It is a vector quantity, and its unit in the International System (SI) is the Newton (N).**
- **Accurate force measurement is essential in applications like structural analysis, testing of machine components, and in systems like hydraulic presses and engines.**

2.1 Principles of Force Measurement

Direct Force Measurement	Indirect Force Measurement
This involves using instruments that directly measure the force applied to a system. Examples include mechanical force gauges and load cells.	In some cases, force is determined indirectly by measuring other quantities like displacement, acceleration, or pressure, and then applying appropriate formulas to calculate the force.

2.2 Instruments for Measuring Force

1. Spring Balance:

- **A spring balance uses Hooke's Law to measure force.**
- **A spring is stretched under the action of a force, and the displacement of the spring is proportional to the applied force.**

$$F = k \cdot x$$

Where:

- F = Force (N)
- k = Spring constant (N/m)
- x = Displacement of the spring (m)

2. Load Cells:

- **A load cell is a transducer that converts force into an electrical signal. It is widely used in industrial applications for measuring weight, load, or force.**
- **The load cell consists of strain gauges that deform when a force is applied, causing a change in their resistance. This change is converted into a voltage signal.**

$$\text{Output Signal} = k \cdot \Delta R$$

Where:

- k = Sensitivity constant
- ΔR = Change in resistance

3. Hydraulic Force Sensors:

- **These sensors measure force by converting the hydraulic pressure, which is proportional to the applied force, into an electrical signal.**
- **These sensors are used in high-force applications like presses and**