Unit 004   Understand how to apply scientific principles within mechanical services engineering

Level: 2
Credit value: 7
UAN: J/602/2496

Unit aim

This knowledge unit provides learning in the essential scientific principles that underpin the installation, commissioning and maintenance requirements of systems and components in the Mechanical Engineering Services Industries. The unit also provides learning in a range of basic calculation methodologies underpinning system and component design.

Learning outcomes

There are **six** learning outcomes to this unit. The learner will:
1. Know the standard units of measurement used in the mechanical services industry
2. Know the properties of materials used in the mechanical services industry
3. Know the relationship between energy, heat and power in the mechanical services industry
4. Know the principles of force and pressure and their application in the mechanical services industry
5. Know simple mechanical principles and their application in the mechanical services industry
6. Know the principles of electricity as they relate to the mechanical services industry

Guided learning hours

It is recommended that **66** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Details of the relationship between the unit and relevant national standards

N/A

Support of the unit by a sector or other appropriate body

This unit is endorsed by SummitSkills.

Assessment

This unit will be assessed by:
- a GOLA on-line knowledge assessment.

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Outcome 1   Know the standard units of measurement used in the mechanical services industry

Assessment Criteria

The learner can:

1. State the application and use of internationally recognised (SI) units of measurement:
   - Metre (length) m.
   - Kilogram (mass) kg.
   - Second (time) s.
   - Kelvin (temperature) °K.

2. State the application and use of SI derived units:
   - Area (m²).
   - Volume (m³):
   - Litres (L).
   - Density (kg/m³).
   - Velocity (m/s).

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Outcome 2   Know the properties of materials used in the mechanical services industry

Assessment Criteria

The learner can:

1. Calculate the relative densities of common materials:
   - Relative density to air.
   - Relative density to water.

2. State the principle applications of solid materials used in the mechanical services industry:
   - Metals:
     - o Pure metals.
     - o Ferrous metals.
     - o Alloys including solders.
   - Plastics:
     - o Thermo plastics.
     - o Thermo-setting plastics.
   - Fireclays/ceramics.

3. Identify the detailed properties of solid materials:
   - Strength – tensile and compressive.
   - Hardness.
   - Ductility.
   - Malleability.
   - Conductivity – heat and electricity.

4. State the reasons why solid materials breakdown:
   - Atmospheric corrosion:
     - o Oxidisation of metals.
   - UV damage to plastics.
   - Heat damage to plastics.
   - Electrolytic corrosion:
     - o Electromotive series.
     - o Dissimilar metals in the presence of an electrolyte (water).
   - Erosion corrosion.
   - Methods of preventing corrosion.

5. State the principle applications and basic properties of liquids used in the mechanical services industry:
   - Water.
   - Refrigerant.
   - Anti-freeze/glycol mixes.
   - Fuel oils.
   - Lubricants/greases.

6. Identify the detailed properties of water:
- Boiling/freezing point.
- Change of state and molecular changes:
    - Volume and pressure increases.
    - Density at differing temperatures.
    - To steam/super heated steam.
- Capillarity.
- Acidity/alkalinity (pH value).
- Water hardness:
    - Soft.
    - Temporary hard.
    - Permanently hard.

7. State the principle applications of gases used in the mechanical services industry:
- Air & steam.
- LPG.
- Natural gas.
- Carbon dioxide.
- Refrigerant gases.

8. Identify the detailed properties of gases:
- Pressure exerted by a gas.
- Volume occupied by a gas.
- Temperature of gases found within the industry.
- Gas Laws:
    - Charles's law.
    - Boyle's law.
- Heat pump/refrigeration cycle.

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Outcome 3 Know the relationship between energy, heat and power in the mechanical services industry

Assessment Criteria

The learner can:

1. Identify the relationship between the Celsius and Kelvin temperature scales:
    - Units of temperature measurement.
    - Temperature measurement devices used.
2. Identify the terminology associated with a change of state:
    - Melting.
    - Freezing.
    - Boiling.
    - Evaporating.
    - Condensing.
3. Identify the terms latent and sensible heat as they apply to liquids and gases
4. Identify the methods of heat transfer:
    - Conduction in solids.
    - Convection in liquids and gases.
    - Radiation between two bodies.
5. State how units of energy and heat are related and derived:
    - Energy – Joules (J).
    - Specific heat capacity (kJ/kg/°C).
    - Power – Watts (W).
6. State how to carry out simple heat, energy and power calculations:
    - Simple temperature calculations.
    - Quantity of heat energy required to raise the temperature of a substance.
    - The amount of power required to heat a substance.

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Outcome 4   Know the principles of force and pressure and their application in the mechanical services industry

Assessment Criteria

The learner can:

1. State how units of force and pressure are derived from SI units:
   - Acceleration (m/s²):
     - o Force due to gravity.
   - Force - Newton (N).
   - Pressure (N/m²):
     - o Atmospheric pressure.
     - o Principles of the siphon.
   - Flow rate (m³/s).

2. State the application and use of units of measurement of pressure and flow rate:
   - Pressure:
     - o Bar / millibar.
     - o kPa.
     - o Psi.
     - o Metre head.
   - Flow rate:
     - o M³/s.
     - o l/s.
     - o kg/s.

3. State how to carry out simple force and pressure calculations:
   - Simple force calculations.
   - Pressure head.
   - Simple pressure calculations:
     - o Static pressure.
     - o Dynamic pressure.

4. Identify the relationship between velocity, pressure and flow rate in systems:
   - Effects of increasing/reducing pressure on velocity and flow rate.
   - Effects of increasing/reducing pipe size on velocity and flow rate at constant pressure.

5. Identify the reasons why pipework restricts the flow of liquids and gases:
   - Changes of direction, bends and tees.
   - Pipe size.
   - Pipe reductions.
   - Roughness of material surface.
   - Constrictions such as valves.

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Outcome 5 Know simple mechanical principles and their application in the mechanical services industry

Assessment Criteria

The learner can:

1. State the principles behind simple machines:
   - Mechanical advantage.
   - Velocity ratio:
     - o Levers.
     - o Wheel and axle.
     - o Pulleys.
     - o Screws.
2. Identify the principles of basic mechanics:
   - Theory of moments.
   - Action & reaction.
   - Centre of gravity.
   - Equilibrium

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Outcome 6 Know the principles of electricity as they relate to the mechanical services industry

Assessment Criteria

The learner can:

1. State the basic principles of electron flow theory:
   - Measurements of electrical flow.
   - Material conductivity and resistance.
   - Direct and alternating current.
2. State the purpose and application of simple units of electrical measurement for use in the mechanical services industry:
   - Current (Amps).
   - Voltage (Volts).
   - Resistance (Ohms).
   - Power (Watts).
3. State how to carry out simple electrical calculations:
   - Ohm's law.
   - Power consumption of electrical circuits.
   - Basic over-current protection device size.
   - Voltage, current and resistance in series and parallel circuits.
4. Identify the requirements for earthing of electrical circuits.