Unit 205PH: Understand scientific principles

# Delivery guide

Unit information

This unit provides learning in the essential scientific principles that underpin the installation, commissioning and maintenance requirements of systems and components in the plumbing and heating industry. The unit also provides learning in a range of basic calculation.

Learners may be introduced to this unit by asking themselves questions such as:

* What are units of measurement and how are they used?
* What are the properties and applications of solid materials, liquids and gases?
* What do the terms energy, heat and power mean and what is their relationship with each other within the plumbing and heating industry?
* How do the principles of force and pressure apply within the plumbing and heating industry?
* What are mechanical principles?
* What are the principles of basic electron flow?

Learning outcomes

1. Understand the units of measurement used in the plumbing and heating industry
2. Understand the properties of materials
3. Understand the relationship between energy, heat and power
4. Understand the principles of force and pressure and their application in the plumbing and heating industry
5. Understand the mechanical principles in the plumbing and heating industry
6. Understand the principles of electricity in the plumbing and heating industry

Suggested resources

Websites

* [BBC Bitesize | Properties of water](https://www.bbc.co.uk/bitesize/guides/zt9887h/revision/10)
* [BBC Bitesize | Material categories and properties](https://www.bbc.co.uk/bitesize/guides/z6byb82/revision/1)
* [BBC Bitesize | SI units](https://www.bbc.co.uk/bitesize/guides/z2mcfcw/revision/1)

Textbook

* Maskrey, M. (2019) *The City & Guilds Textbook: Plumbing Book 1 for the Level 3 Apprenticeship (9189), Level 2 Technical Certificate (8202) & Level 2 Diploma (6035)*. London: Hodder Education

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| **Learning outcomes** | **Criteria** | **Delivery guidance** |
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| 1. Understand the units of measurement used in the plumbing and heating industry | * 1. The internationally recognised (SI) units of measurement | * Learners to be able to identify and use in basic calculations the following internationally recognised (SI) units of measurement: * metre (m): unit of length * kilograms (kg): unit of mass * second (s): unit of time * ampere (A): unit of electrical current * kelvin (K): unit of temperature * bar: unit of pressure * pascal (Pa): unit of pressure. * Learners to know where these units are used in a practical setting, for example when marking out for system pipework or for positioning sanitary appliances. * Learners to know how to use these SI units of measurement for calculating temperature, the volume of a cylinder and minutes into seconds. |
| * 1. The application and use of SI derived units | * Learners to be able to state the application and use of SI derived units: * area (m2) (length × width) * volume (m3) (length × width × height) * density (kg/m3) (kilograms per cubic metre) * velocity (m/s) (metres per second) * litres (l): unit of the amount of substance. * Learners to be able to calculate SI derived units. Learners to practice measuring the area of the classroom, the volume of the room and volume of cold-water storage cisterns. * Learners to be shown examples of how to carry out calculations using SI units to then calculate and state SI derived units. |
| * 1. The use of conversion tables for non-SI units | * Learners to be able to use conversion tables to complete calculations, for example imperial-to-metric conversion tables. * Learners to know how they would use conversion tables and to be able to state examples of where they think they might need to be used. * Learners to calculate the volume of cold-water storage cisterns using imperial measurements and convert the figures to an SI unit. |
| 1. Understand the properties of materials | * 1. The relative densities of common materials | * Learners to be able to compare relative densities of common materials: * relative density to air (specific gravity) * relative density to fresh water. * Learners to be able to calculate the relative densities of common materials: * copper * steel * brass * polypropylene.   Example: Copper has a relative density of 9. How much does 1m3 of copper weigh = 9000kg.   * Learners to carry out exercises using samples with different volumes and masses to determine the relative densities of the materials listed from the highest to the lowest. |
| * 1. The properties and applications of solid materials | * Learners to be able to identify the properties and applications of solid materials used within the plumbing industry.   Materials:   * Pure metals, e.g. copper, tin, aluminium * Ferrous metals, e.g. stainless steel, medium carbon steel, cast iron * Alloys including solders, e.g. brass, bronze * Thermo plastics – PVC-U * Thermo-setting plastics * Fireclays/ceramics.   Properties:   * Hardness * Tensile strength * Compressive strength * Shear strength * Malleability * Ductility * Elasticity * Electrical conductivity * Thermal conductivity. * Learners to state why specific materials are used for given applications, making reference to their properties. |
| * 1. The reasons why solid materials breakdown | * Learners to be able to explain reasons why solid materials breakdown due to: * atmospheric corrosion * oxidisation of metals * UV damage to plastics * heat damage to plastics * electrolytic corrosion * electromotive series * galvanic corrosion: dissimilar metals in the presence of an electrolyte (water) * erosion corrosion. * Learners to recap key points and to be shown examples of materials that have broken down in different ways. |
| * 1. The methods of preventing corrosion | * Learners to be able to outline the methods used to prevent corrosion of plumbing systems and components: * enamelling * painted coatings * galvanised coatings * inhibitors * sacrificial anodes * wrapping. * Learners to be able to state methods to prevent corrosion for different types of materials used in plumbing systems. |
| * 1. The applications of liquids and gasses | * Learners to be able to identify the applications of the following liquids and gases within the plumbing industry.   Liquids:   * Water * Refrigerants * Anti-freeze/glycol mixes * Fuel oils * Lubricants/greases.   Gases:   * Air and steam * Liquefied petroleum gas (LPG) * Natural gas * Carbon dioxide * Refrigerant gases. * Learners to recap key points and to be shown these within a practical situation or via videos to demonstrate the application of them. |
|  | * 1. The basic properties of liquids | * Learners to be able to describe the basic properties of liquids: * 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). * Learners to summarise the key points as part of a class discussion. |
| * 1. The basic properties of gases | * Learners to be able to describe the basic properties of gases (natural gas/LPG/air): * pressure * volume * temperature of gases found within the industry * Charles’s Law * Boyle’s Law. * Learners to give examples of where they think they would use the properties of gases within a plumbing context. |
| 1. Understand the relationship between energy, heat and power | 3.1 The relationship between the Celsius and Kelvin temperature scales | * Learners to understand why there are two scales and the merits and uses of each. * Learners to be able to identify the units of measurement for temperature and be able to convert them: * Celsius * Kelvin. * Learners to be shown examples of conversion calculations and to complete exercises to convert from one temperature scale to another. |
| 3.2 The principles associated with achange of state | * Learners to be able to describe the principles that are associated with a change of state: * melting * freezing * boiling * evaporating * condensing. * Learners to recap key points and the connections between the principles associated with changes of state and the properties of liquids and gases. |
| 3.3 How the terms latent and sensible heat apply to liquids and gases | * Learners to be able to describe the terms ‘latent heat’ and ‘sensible heat’ as they apply to liquids and gases. * Latent heat is the amount of heat released or absorbed by a unit mass of substance during a change of state of the substance. * Sensible heat is the amount of heat released or absorbed by a unit mass of substance without a change of state of the substance. |
| 3.4 The methods ofheat transfer | * Learners to be able to describe and provide examples of the following methods of heat transfer: * conduction * convection * radiation.   Examples: radiation (e.g. heat from the sun), convection (e.g. gravity circulation in a hot water system), conduction (e.g. heat travelling up a copper pipe).   * Learners to be shown actual examples of heat transfer, either through demonstration or the use of video resources. |
| 3.5 How units of energy and heat are related and derived | * Learners to be able to describe how the following units of energy and heat are related and derived: * energy: Joules (J) * specific heat capacity (kJ/kg/°C) * power: Watts (W) * maximum density * coefficient of linear expansion. * Learners to give examples of the calculations that need to be completed related to energy and heat. * Learners to complete exercises to carry out similar calculations for plumbing systems. |
| 3.6 Heat, energy and power calculations | * Learners to be able to carry out the following heat, energy and power calculations: * quantity of heat energy required to raise the temperature of a substance:   litres x temperature difference x specific heat capacity   * the amount of power required to heat a substance:   litres x temperature difference x specific heat capacity ÷ time in seconds.   * Learners to be shown worked examples of calculations and to complete practice exercises. |
| 1. Understand the principles of force and pressure and their application in the plumbing and heating industry | 4.1 How units of force and pressure are derived from SI units | * Learners to be able to state how units of force and pressure are derived from SI units: * acceleration (m/s2): force due to gravity * force Newton (N) * pressure (N/m2) * atmospheric pressure * flow rate (m3/s). |
| 4.2 Thepressure and flow rate units of measurements | * Learners to be able to identify the following pressure and flow rate units of measurements.   Pressure:   * bar/millibar * kPa * psi (pounds per square inch) * metre head * N/m2   Flow rate:   * m3/s * l/s * kg/s |
| 4.3 The application of pressure and flow rate measurements | * Learners to be able to describe the application of pressure and flow rate measurements on a range of plumbing systems and the effect on the system relating to good design to meet both specifications and the reduction of noise and erosion in the system. * Learners to recap key points and to be able to provide a summary. |
| 4.4 Simple force and pressure calculations | * Learners to be able to carry out simple force and pressure calculations.   Force calculations:   * Pressure head   Pressure calculations:   * Static pressure * Dynamic pressure * Draught * Forced draught. * Learners to know conversion between different pressure and flow rate units of measurements. * Learners to be shown worked examples of calculations and to complete practice exercises. |
| 4.5 The relationship between velocity, pressure and flow rate in systems | * Learners to be able to explain the relationship between velocity, pressure and flow rate in systems including: * effects of increasing/reducing pressure * effects of increasing/reducing pipe size. * Learners to recap key points and the connections between pressure, pipe size and velocity through the use of demonstrations or use of animations/video. |
| 4.6 How restrictionsin the pipework affects the flow of liquids and gases | * Learners to be able to identify how restrictions in the pipework affects the flow of liquids and gases: * changes of direction, bends and tees * pipe size * pipe reductions * roughness of material surface * constrictions such as valves. * Learners to recap key points, for example different installations and to decide which would have the greatest effect on flow and to give their reasons. |
| 4.7 The principles of a siphon | * Learners to be able to describe the applications and principles of a siphon (moving water from a high place to a low place using only atmospheric pressure and the cohesive properties of water). * Learners to be shown a demonstration of this through a practical activity where possible. |
| 1. Understand the mechanical principles in the plumbing and heating industry | 5.1 The principles of simple machines | * Learners to be able to outline the working principles and applications of simple machines: * levers * pulleys * Archimedes screws * wheels and axles. * Learners to be shown actual examples of these in use within a plumbing or heating industry context, for example the use of pulleys within a winch system or Archimedes screws as part of a pump. |
| 5.2 The principles of basic mechanics | * Learners to be able to outline principles of basic mechanics: * theory of moments * action and reaction * centre of gravity * equilibrium * velocity ratio * mechanical advantage. * Learners to be shown a demonstration of this through a practical activity where possible. |
| 1. Understand the principles of electricity in the plumbing and heating industry | 6.1 The basic principles of electron flow theory | * Learners to be able to identify basic principles of electron flow theory: * measurements of electrical flow * material conductivity and resistance * the differences of AC and DC currents * how AC and DC currents are generated. * Learners to recap key points, for example how to take measurements of electrical flow. * Learners to do some simple practical investigations related to resistivity and conductivity. |
| 6.2 The purpose and application of simple unitsof electrical measurement | * Learners to be able to describe the purpose and application of simple units of electrical measurement: * current (Amps) * voltage (Volts) * resistance (Ohms) * power (Watts). * Learners to be shown how to take measurements and complete power calculations. |
| 6.3 Simple electrical calculations | * Learners to be able 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. * Learners to be shown how to complete calculations for each and then to carry out exercises to determine values in given series and parallel circuits. |
| 6.4 The requirements for earthing of electrical circuits | * Learners to be able to describe the requirements for earthing of electrical circuits: * main equipotential bonding * supplementary bonding. * Learners to be shown examples of different types of bonding and to complete exercises to identify the bonding required for different parts of an installation and describe why they are needed. |