This document sets out the content that needs to be taught to prepare for the knowledge test components of the Electromechanical Pathway - Maintenance and Operations Engineering Technician Apprenticeship End-Point Assessment. The knowledge test counts towards 20% of the overall grade for the End-Point Assessment.
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1 Assessment

Summary of assessment methods

Apprentices must successfully complete the evolve test for the corresponding knowledge test for their chosen pathway.

The test consists of 30 scenario based multiple choice questions.

The apprentice will take the knowledge assessment in a suitably controlled environment in the workplace in the presence of an invigilator. The invigilator may be sourced from the employer but will be approved by assessment organisations and must operate according to their guidance.

The test will be marked by an independent examiner appointed by an assessment organisation, following a marking guide produced by the assessment organisation.

Test specification

The way the knowledge is covered by each test is laid out in the table below:

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<td>30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

The grade boundaries for 303 test will be approximately:

Pass: 60%
Merit: 75%
Distinction: 85%

The grade boundaries for 353 test will be approximately:

Pass: 60%

These boundaries may be subject to slight variation to ensure fairness should any variations in the difficulty of the test be identified.
2 Knowledge Content

The content is divided into the four standard outcomes. Each pathway has its own knowledge content which is relevant to the role named in the pathway. Please refer to the separate knowledge handbooks for information.

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<th>ROLE</th>
<th>1st sit</th>
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<td>300</td>
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<td>Electromechanical Technician</td>
<td>303</td>
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</table>
**Unit 303/353**

**Knowledge information for the Electromechanical Technician**

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**Standard**

**K1 Understand first principles relating to the operation and maintenance of appropriate plant and equipment**

The apprentice will:

1. Know how to interpret engineering information

The apprentice can:

1. explain the relevance of **engineering information**
2. describe the difference between the **abbreviations and notation** used on various standard engineering drawings
3. interpret the information that can be extracted from **reference charts, tables, graphs and BS EN standards**
4. explain the use of CAD systems to produce engineering drawings
5. explain the use of databases and spreadsheets to display information
6. explain the basic principles of **document control**
7. interpret **drawings and labelling**
8. describe how to use charts, tables, graphs and BS EN standards
9. describe how to extract information from drawings
10. describe how to use engineering drawings to produce material lists and determine quality requirements
11. explain the applications of **electrical systems**

**Range**

**Engineering information**: BS EN standards, instruction manuals, technical handbooks, tables, charts (including: flow, Gantt), graphs (including histograms, scatter diagrams), Ishikawa diagrams (fishbone diagrams or cause-and-effect diagrams), data sheets, text books and reference materials, computer applications

**Abbreviations and notation**: symbols and abbreviations, application to: engineering drawings, circuit diagrams.

**Reference charts, tables, graphs and BS EN standards**: thread sizes, machining symbols and tolerances, cable sizing, PIN configurations, component ratings

**Drawings and labelling**: projections (third angle orthographic, isometric [including exploded]), standard symbols and conventions, circuit diagrams, wiring diagrams, layout diagrams.

**Electrical systems**: electrical supply systems and their applications and limitations (supply from grid, 3 phase 4 wire, single phase, 12V and 24V requirements and uses), types and uses of transformers (fixed and portable), isolating and control methods (isolators and circuit breakers,
switchgear and distribution panels, fuses, no-volt release and residual current detectors), methods of electrical distribution, their applications and limitations (cable forms and selection [size, insulation, including data cables and screened], cable protection methods including conduit and armoured, bus bars, extension reels [heating effects on coiled cable]), meters for testing continuity, voltage and resistance

**Additional Guidance**

**Document control:** where documents are obtained from, how distribution and use of documents is controlled, the relevance of document issue numbers, document approval and authorisation procedures, procedure to be adopted if documents are lost or damaged
The apprentice will:

2. Know how to differentiate between common engineering materials

1. describe the difference between a range of **supply of materials** commonly used in electromechanical engineering
2. describe the difference between **characteristics** of metallic and non-metallic materials used in engineering
3. explain the causes of **corrosion** in materials
4. state the **defects** that can occur in materials/products and explain the importance of controlling them
5. select materials to meet specification requirements in a typical engineering environment

**Range**

**Supply of materials**: ferrous metals (low, medium and high carbon steels; stainless steels), non-ferrous metals (aluminium and aluminium alloys, copper, brass, bronze), non-metallic (composites, plastics: thermoplastic, thermosetting), ceramics.

**Characteristics**: selection of materials for engineering applications, strength, rigidity, temperature stability (heat resistance, thermal conductivity, electrical conductivity and insulation), wear resistance, shock absorption, corrosion resistance.

**Corrosion**: pitting, galvanic, oxidation

**Defects**: critical, major, minor or non-critical
The apprentice will:

3. Know how to perform engineering calculations

The apprentice can:

1. express numerical solutions to a degree of accuracy that is appropriate to the value being calculated
2. use a calculator to raise a number to a power and determine square roots
3. use formulae to complete transpositions and solve problems
4. use algebraic expressions
5. plot and interpret straight line graphs
6. apply Pythagoras’ Theorem
7. explain how to use Sine, Cosine and Tangent to solve typical engineering problems
8. define moments of a force and solve related problems using formula
9. define work, power and energy and solve related problems using formula
10. define friction and solve related problems using formula
11. describe the relationship between temperature changes and changes in length
12. consider types of heat and solve related problems using formula

Range
Degree of accuracy: correct to three significant figures, correct to two decimal places, express a decimal fraction in standard form, express tolerance in terms of limits of size

Transpositions: involving addition, subtraction, multiplication and division in any combination using a maximum of three terms, for example Ohm’s Law solve problems: substitution of known values

Algebraic expressions: represent numerical quantities using symbols, apply laws of precedence in the use of precedence (BODMAS)

Straight line graphs: determining suitable scales from given data, defining and correctly labelling axes, determine the gradient, determine the intercept, prove the law of the straight line graph is $y = mx + c$

Sine, Cosine and Tangent: state their ratios for angles up to 90°, determine their values for given angles up to 90°, solve simple problems

Moments of a force: define and apply the ‘Principle of Moments’, define the meanings of the term ‘torque’

Solve related problems: associated with levers, linkages and gears; work, power and energy define work done in terms of force and distance moved

Work, power and energy: explain what is meant by energy; state that the unit of energy is the joule (J), the unit of power is the watt (W) and the unit of work is the joule (J); define power in terms of voltage/current and work done per second, perform calculations for work, power and energy

Friction: definition, explain coefficient of friction, explain how friction can be reduced, select materials that will rotate, or slide together with low frictional value, perform calculations for friction
**Temperature:** define coefficient of expansion, solve numerical problems to determine the change in size due to temperature.

**Heat:** define: specific heat capacity, specific latent heat (fusion, evaporation), specific latent heat of fusion, specific latent heat of evaporation and the problems that can arise with electrical equipment.
The apprentice will:

4. Understand quality control in electromechanical engineering

The apprentice can:

1. state what is meant by the term **quality** and apply quality to contexts/perceptions
2. define the terms **inspection and quality control**
3. explain the principles of **quality control and inspection**
4. explain the need for **inward inspection** and correct documentation
5. explain how to **check equipment is approved** for use and how to take appropriate action to return/report equipment that has passed its approval date
6. explain the use of engineering standards in determining the fitness of purpose of items/equipment used in engineering production and maintenance
7. describe the appropriate **action** to take when required standards of performance are not met
8. explain limits of authority in respect of re-working, adjusting or scrapping a component/product
9. explain the need to inform a responsible person of the variation from the stated standard
10. state the need to document all actions agreed upon and taken
11. explain the importance of **quality records** and the type of inspection records needed
12. describe how to complete quality documents/records of work carried out and record test/inspection results
13. interpret results from quality measurements and compare them with stated parameters
14. make recommendations whether to re-work, adjust or scrap items/components that do not meet required standards

**Range**

**Quality**: components, products or services being fit for purpose and service reliability, customer expectation, the need for interchangeability with regard to supplying spare parts

**Quality control and inspection**: inspection: covering the examination, measurement, testing and judgement of a product for conformation to a predetermined requirement i.e. fitness for purpose, quality control: principles of inspection.

**Inward inspection**: dimensional accuracy, importance of release and advice notes, spot checks, random checks, remedial action to be taken when components/materials prove defective

**Check equipment is approved**: Equipment such as: torque wrenches, lifting equipment, pressure gauges, micrometers, vernier instruments, continuity testers, insulation resistance tester, voltage indicators

**Action**: adjust, repair, replace

**Quality records**: record all test results, record all inspections carried out, procedures to be taken upon completion of task (place into stores, pass it to another department, mark it for adjust, replace, mark it for scrap or salvage).
K2 Understand relevant industry health and safety standards, regulations, and environmental and regulatory requirements

The apprentice will:

1. Understand compliance with statutory health and safety regulations and organisational requirements

The apprentice can:

1. describe the health and safety regulations applicable to engineering operations
2. explain employers’ responsibilities to maintain health and safety
3. describe essential operator and bystander health and safety requirements
4. explain the Reportable Diseases and Dangerous Occurrences Regulations (RIDDOR) relevant to engineering
5. explain the procedures for reporting accidents
6. explain how the management of health and safety regulations are implemented
7. state the roles, responsibilities and powers of health and safety personnel
8. explain the sources of health and safety literature/advice and how to access it
9. describe how to carry out a risk assessment identifying potential health hazards
10. state the general rules for the observance of safe practices

Range

Regulations: Health and Safety at Work etc. Act, Control of Substances Hazardous to Health Regulations (COSHH), Provision and Use of Work Equipment Regulations (PUWER), Electricity at Work Regulations, Control of Major Accident Hazards Regulations (COMAH), Control of Noise at Work Regulations, Lifting Operations and Lifting Equipment Regulations (LOLER)

Employers’ responsibilities:
Safe: place of work, plant and equipment, system of work, working environment, methods of handling, storing and transporting goods and materials

Reporting of accidents (RIDDOR), information, instruction, training and supervision of employees, a health and safety policy

Operator and bystander: Personal Protective Equipment (PPE), Respiratory Protective Equipment (RPE)’ secure areas

Reporting accidents: summary of accident, name of victim(s), summary of events prior to accident, details of witnesses, information on injury or loss sustained, conclusions, recommendations, supporting material (photographs, video), diagrams, date, signature of person(s) responsible for report

Management of Health and Safety: including the four C’s of positive health and safety (Competence, Control, Co-operation, Communication)

Health and safety personnel: Health and Safety Advisors, Health and Safety Representatives, Health and Safety Executive Inspectors, Environmental Health Officers

Risk assessment: potential hazards, slippery or uneven surfaces, spillages, scrap or waste material, inflammable materials, faulty or missing machine guards, faulty electrical connections or
damaged cables, material ejection, pressure and stored energy, unshielded processes, volatile and toxic materials, dust and fumes, contaminants and irritants, materials handling and transportation, working at heights

**Safe practices:** be alert, maintain personal hygiene, protect yourself and other people, know emergency procedures, report all hazards
The apprentice will:

2. Understand compliance with statutory environmental regulations and organisational requirements

The apprentice can:

1. describe the differences between the human and environmental conditions leading to accidents in the workplace and the means of controlling them
2. describe the Environmental Management Systems standard ISO 14001 in terms of the engineering industry
3. describe the implementation of environmental legislation as it applies to engineering industries
4. identify health and safety signs and explain their purpose

Range

Human and environmental conditions:

Causes of accidents

Human: lack of management control, carelessness; improper behaviour and dress; lack of training, supervision and experience; fatigue; drug-taking and alcohol intake, Environmental: unguarded or faulty machinery or tools; inadequate ventilation; untidy, dirty, overcrowded workplace; inadequate lighting

Controlling: Eliminate the hazard, replace the hazard with something less dangerous, guard the hazard, personal protection, health and safety education and publicity

Environmental legislation: Environmental Protection Act, Pollution Prevention and Control Act, Radioactive Substances Act, Controlled Waste Regulations, Dangerous Substances and Explosive Atmospheres Regulations, Hazardous Waste Regulations

Signs: Warning, prohibition, mandatory, information, fire
The apprentice will:
3. Know how to implement accident and emergency procedures

The apprentice can:
1. explain the need for the provision of first aid treatment
2. explain the health and safety procedures that prevent injury or discomfort to skin, eyes, hands and limbs
3. explain the appropriate emergency action to be taken in cases of electric shock
4. explain precautions to be taken to avoid electric shock
5. explain the causes of asphyxiation and the appropriate emergency action to be taken
6. state what is meant by a dangerous occurrence and hazardous malfunction
7. describe the procedures to be followed in the event of the sounding of an emergency alarm
8. describe methods of fire prevention

Range
First aid: location of facilities, location of qualified first aiders

Health and safety procedures: personal hygiene, skin protection and care, care of eyes, use of eye and face protectors which are to current EN specifications, use of respirators, dangers of hair and loose clothing getting caught in machinery, means of avoiding such dangers, benefits and use of protective clothing, use of safety guards, screens and fences

Emergency action: isolate electrical supply, removal from electricity supply, basic resuscitation procedures

Electric shock: hazards arising from the use of electrical equipment, general health and safety rules: checking and inspection of cables, leads and plugs; earthing; problems associated with the use of portable equipment; use of reduced voltage equipment; health and safety training; warning signs and notices; isolation procedures

Asphyxiation: confined working space, inadequate ventilation

Emergency alarm: evacuation system, escape routes, assembly points (reporting to assembly points, not to return until authorised)

Fire prevention: risk assessments, methods of controlling fires, fire procedures, adhering to fire safety legislation

Additional Guidance
Fire prevention: fire risk assessments, causes of fire, fire prevention, spread of fire, methods of controlling fires, conditions required for combustion and extinction, the fire triangle, fire procedures (fire drills, firefighting equipment for different types of fires, extinguishers (types classification for types of fire), automatic equipment, adhering to fire safety legislation)
The apprentice will:
4. Understand safe working practices and procedures

The apprentice can:
1. describe the range of Personal Protective Equipment (PPE) available and relate its use to the operations that will be undertaken
2. explain use of Respiratory Protective Equipment (RPE) when undertaking tasks involving exposure to hazardous substances and the range available
3. state the requirements of the Lifting Operations and Lifting Equipment Regulations (LOLER)
4. explain the health and safety rules for the use of mechanical lifting equipment
5. explain the purpose and methods of use of accessories to lifting gear
6. describe the Manual Handling Operations Regulations as they apply to engineering industries
7. explain the necessity of a permit to work procedure
8. explain the necessity of ‘lock-off’ procedures
9. state the procedures used to notify/report hazards to appropriate people
10. state situations in which it is unadvisable or unsafe to work in isolation

Range
RPE: chemicals and solvents, fumes, dust or harmful particulates, heat

Accessories: hooks, slings, eyebolts, shackles, chains, rings, special-to-purpose equipment, rules for the use of slings

Appropriate people: supervisors, health and safety advisors, health and safety representatives, fire marshals, works/site rescue team

Work in isolation: in confined spaces, above ground or in trenches, in close proximity to unguarded machinery, when a fire risk exists, with toxic or corrosive substances, on site

Additional Guidance
LOLER: as a general rule loads over 20kg need powered lifting gear, never exceed the maximum safe working load (SWL) indicated on the equipment and the accessories, avoid shock loading the lifting equipment, swinging and twisting, estimate the centre of gravity, position the lifting hook above the centre of gravity of the load to maintain an even balance, avoid pushing or pulling the load to adjust the balance, do not transport loads over the heads of people or walk under a load, do not leave a load hanging unnecessarily and, in any event, have someone to watch over it, always lower the load gently into position; make sure it will not move once the lifting equipment is removed, check date of equipment tests

Accessories: hooks (materials, design and certification) slings (materials, design and certification, the importance of the angle at the top, forces in the legs proportional to the angle at the top, design and construction of rope slings [natural and man-made fibres, steel wire slings]), eyebolts (design and construction to published standards, use when lifting engines, gearboxes, the importance of ensuring that the eyebolt shoulder is screwed flush to face of component) shackles (design and construction to published standards, the importance of SWL for different sizes) chains (design and construction; the importance of regular checking and testing to avoid failure from damage and metal fatigue) rings (design and construction to published standards; importance of use with slings and chains), special-to-purpose equipment (use for lifting special equipment, regular lifting eg oil drums, production components) rules for the use of slings (never bend around sharp corners and edges and avoid overbending, use of protective covers on corners of loads, never twist or kink the sling never use a worn or damaged sling, always observe the safe working load (SWL))
**Permit to work:** purpose, description, content, types (including: ‘hot working’, maintenance operations, pressure testing, etc), procedure for use
Standard

K3 Understand maintenance and operational practices, processes and procedures covering a range of plant and equipment

The apprentice will:

1. Know how to maintain mechanical devices and equipment and electrical equipment/systems

The apprentice can:

1. describe the health and safety requirements, and safe working practices and procedures required for the mechanical maintenance activities undertaken
2. describe the isolation and lock-off procedure or permit-to-work procedure that applies to electromechanical maintenance activities (to include electrical isolation, locking off switchgear, removal of fuses, placing of maintenance warning notices, proving that isolation has been achieved and secured)
3. describe the hazards associated with carrying out electromechanical maintenance activities (such as handling oils, greases, stored energy/force, dangers of electric shock, misuse of tools, using damaged or badly maintained tools and equipment, not following laid-down maintenance procedures), and how to minimise them
4. explain how to recognise and deal with victims of electric shock (to include methods of safely removing the victim from the power source, isolating the power source, and methods of first aid resuscitation)
5. describe the importance of wearing appropriate protective clothing and equipment, and of keeping the work area safe and tidy
6. explain how to obtain and interpret drawings, specifications, manufacturers’ manuals and other documents needed in the maintenance process
7. describe the procedure for obtaining replacement parts, materials and other consumables necessary for the maintenance activities
8. describe the basic principles of how the equipment functions, its operating sequence, the working purpose of individual units/components and how they interact
9. describe the various maintenance diagnostic techniques and aids that can be used (such as fault reports, visual checks, measuring, movement and alignment checks, testing)
10. describe the various fault location techniques that can be used, and how they are applied (such as input-output, function testing, unit substitution, and equipment self-diagnostics) and how to use a range of fault diagnostic equipment
11. describe the methods of checking that components are fit for purpose, how to identify defects and wear characteristics
12. describe the methods and techniques used to dismantle/assemble electromechanical equipment (such as release of pressures/force, proof marking, lubrication, extraction, pressing, alignment, and, for electrical systems: unplugging, de-soldering, removal of screwed, clamped and crimped connections, attaching identification markers/labels to removed components or cables, to assist with re-assembly)
13. describe the different types of cabling used in the maintenance activities, and their methods of termination
14. describe the tools and equipment used in the maintenance activities (such as, for electrical systems, the use of cable stripping tools, crimping tools, and soldering irons)
15. describe the identification, application, fitting and removal of different types of bearings (such as roller, ring, thrust)
16. describe the methods and techniques of fitting keys and splines and identify and apply different types of locking device
17. describe the identification, application, fitting and removal of different types of gears
18. explain how to correctly tension belts and chains
19. describe the methods of checking that removed components are fit for purpose, and the need to replace 'lifed' items (such as seals and gaskets)
20. describe the uses of measuring equipment (such as micrometers, verniers, run-out devices, multimeters and other measuring devices)
21. explain how to check that tools and equipment are free from damage or defect, are in a safe and usable condition, are within calibration, and are configured correctly for the intended purpose
22. explain how to make adjustments to components/assemblies to ensure that they function correctly (such as setting working clearance, setting travel, setting backlash in gears, preloading bearings)
23. describe the importance of making 'off-load' checks before running the equipment under power
24. describe the importance of completing maintenance documentation and/or reports following the maintenance activity
25. explain how to use appropriate lifting and handling equipment in the maintenance activity
26. describe the problems associated with the electromechanical maintenance activity, and how they can be overcome
27. explain when to act on their own initiative and when to seek help and advice from others in authority.
28. describe the importance of leaving the work area and equipment in a safe and clean condition on completion of the maintenance activities (such as returning hand tools and test equipment to the designated locations, cleaning the work area, and removing and disposing of waste)
K4 Understand the relevant engineering theories and principles relative to their occupation
The apprentice will:
1. Understand the fundamentals of engineering science

The apprentice can:
1. identify the primary units of the SI system; length, mass, time, temperature, capacity
2. identify the derived units of the SI system; force, stress, density, conductivity and power
3. explain the effects of heat
4. explain forces
5. identify the four types of motion and the mechanisms used to change the magnitude and/or direction of motion
6. explain the laws of friction
7. explain basic electrical principles
8. describe work and power transmission
9. carry out calculations involving heat, forces, friction, work done and power, electromotive force and resistance

Effects of heat: convection, conduction, radiation, thermal expansion.

Types of motion: linear, rotary, reciprocating, oscillating.

Mechanisms: linkages (reverse motion [push-pull], parallel motion, bell crank), gears (spur, helical, bevel, worm), gear trains, belts and pulleys, cams (eccentric circular, snail, pair, including the relevant output profiles)

Work and power: calculations of gear ratio and mechanical advantage.

Heat: heat transfer, thermal expansion.
### Useful contacts

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<tr>
<th><strong>UK apprentices</strong></th>
<th>General qualification information</th>
<th>E: <a href="mailto:apprenticesupport@cityandguilds.com">apprenticesupport@cityandguilds.com</a></th>
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<tbody>
<tr>
<td><strong>International apprentices</strong></td>
<td>General qualification information</td>
<td>E: <a href="mailto:intcg@cityandguilds.com">intcg@cityandguilds.com</a></td>
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<tr>
<td><strong>Centres</strong></td>
<td>Exam entries, Certificates, Registrations/enrolments, Invoices, Missing or late exam materials, Nominal roll reports, Results</td>
<td>E: <a href="mailto:centresupport@cityandguilds.com">centresupport@cityandguilds.com</a></td>
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<td><strong>Single subject qualifications</strong></td>
<td>Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change</td>
<td>E: <a href="mailto:singlesubjects@cityandguilds.com">singlesubjects@cityandguilds.com</a></td>
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<td><strong>International awards</strong></td>
<td>Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports</td>
<td>E: <a href="mailto:intops@cityandguilds.com">intops@cityandguilds.com</a></td>
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<tr>
<td><strong>Walled Garden</strong></td>
<td>Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems</td>
<td>E: <a href="mailto:walledgarden@cityandguilds.com">walledgarden@cityandguilds.com</a></td>
</tr>
<tr>
<td><strong>Employer</strong></td>
<td>Employer solutions including, Employer Recognition: Endorsement, Accreditation and Quality Mark, Consultancy, Mapping and Specialist Training Delivery</td>
<td>E: <a href="mailto:business@cityandguilds.com">business@cityandguilds.com</a></td>
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Giltspur House
5-6 Giltspur Street
London EC1A 9DE
www.cityandguilds.com