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**Workshop processes, methods and vehicle construction**

 Further guidance available	 Observation of your task/work	 Evidence recording	 Computer based testing	 Verbal Questioning
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**Evidence requirements**

To complete this unit you will be required to undertake knowledge and practical tests

For the knowledge test you must pass the City & Guilds computer based (GOLA) multiple choice knowledge test. This test will be arranged by your tutor or assessor.

The practical tests are covered in the VRQ information section.

You must also complete the attached recording forms to the satisfaction of your assessor. These forms, when completed and signed by you and your assessor, provide confirmation that you have met both practical and knowledge requirements.

Your tutor or assessor will be able to offer you further guidance on the evidence you need to provide.



**Information for VRQs (Technical Certificates).**

**To complete this unit you must:**

1. Operate a range of workshop equipment safely
2. Construct a simple hand tool from steel
3. Build electrical circuits and carry out voltage and current measurements
4. Recognise and assess condition of components/tools/equipment using inspection and measuring techniques.

Your tutor or assessor will either set and observe a practical assessment task, which has been designed to cover the performance objectives, or you may be observed by your assessor in your workplace.

With your assessor you must complete a suitable **City & Guilds evidence recording form** for **each** task. Your tutor or assessor will advise you on this. Other paperwork such as job cards, inspection sheets, servicing lists and reporting paperwork, appropriate to the task, should also be completed


All work records/evidence should be numbered (portfolio reference number PRN) and entered where required on the recording forms. This evidence should be collected in a portfolio and may need to be made available to your internal verifier or the City & Guilds external verifier.

Your assessor will ask questions to ensure you understand the practical task you are performing.

VRQ



## Evidence reference summary

	<b>Note:</b> Refer to the Evidence requirements for details of locations and types of assessment for this unit.	Portfolio reference number (PRN)
		<b>VRQ</b>
		Observed assessment
Operate a range of workshop equipment safely		
Construct a simple hand tool from steel		
Build electrical circuits and carry out voltage and current measurements		
Recognise and assess condition of components/tools/equipment using inspection and measuring techniques.		

Supplementary evidence (if used) PRN			
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On line test reference for this unit PRN	
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## Unit assessment and verification declaration

<p><b>VRQ Candidate declaration:</b>          I confirm that the evidence listed for this unit is authentic and a true representation of my own work          Candidate name:.....          Candidate enrolment number:.....          Candidate signature:.....          Date: .....</p>
<p><b>VRQ Assessor declaration:</b>          I confirm that this candidate has achieved all the requirements of this unit with the evidence listed.          Assessment was conducted under the specified conditions and context, and is valid, authentic, reliable, current and sufficient.          Assessor name: .....          Assessor signature:.....          Date: .....          Countersignature: (if relevant).....          Date: .....</p>
<p><b>VRQ Internal verifier Declaration:</b>          (Leave blank if sampling of this unit did not take place.)          I have internally verified the assessment work on this unit in the following ways (please tick):              sampling candidate and assessment evidence              observation of assessment practice              discussion with candidate              other – please state:          I confirm that the candidate's work meets the standards specified for this unit and may be presented for external verification and/or certification.          Internal verifier name: .....          Internal verifier signature: ..... Date: .....          Countersignature: (if relevant) ..... Date: .....</p>

## Performance objective checklist

To be competent you must:	PRN
Wear suitable personal protective equipment throughout all activities.	
Use suitable sources of technical information to support all your work	
Use the correct specifications and tolerances for the task being carried out.	
Carry out work following: <ul style="list-style-type: none"> <li>• approved methods</li> <li>• your workplace procedures</li> <li>• health and safety requirements.</li> </ul>	
Carry out construction, adjustments, replacement and use of materials following the supplied instructions for: <ul style="list-style-type: none"> <li>• working methods and procedures</li> <li>• use of equipment</li> <li>• the tolerances.</li> </ul>	
Work in a way which minimises the risk of damage to materials, tools and equipment.	
Report any problems or issues to the relevant person(s) promptly.	
Ensure records are accurate, complete and passed to the relevant person(s) promptly in the format required.	
Complete all activities within the agreed timescale.	
Report any anticipated delays in completion to the relevant persons(s) promptly.	

## Scope of this unit

All of the items listed below form part of this unit	PRN
<b>1. Workshop equipment is:</b>	
a. lifting and supporting	
b. air pressurising and operating	
c. cutting, grinding.	
d. extraction and waste disposal	
e. electrical	
<b>2. Tools and equipment are:</b>	
a. hand	
b. power	
c. cutting	
d. measuring.	
<b>3. Materials are:</b>	
a. ferrous	
b. non-ferrous	
c. plastics	
4. glass	
e. rubber	

In signing this sheet the Assessor and Candidate confirm that all the performance objectives have been met, and the scope covered, by the named candidate.	
Assessor	Date
Candidate	Date

## Essential knowledge

You need to understand:	PRN
<p><b>Legislative and organisational requirements and procedures</b></p> <ol style="list-style-type: none"> <li>1. The company's and legal requirements relating to all work.</li> <li>2. The legal requirements relating to the task being completed.</li> <li>3. The health and safety legislation and workplace procedures relevant to the tasks and personal and equipment protection.</li> <li>4. Your workplace procedures for:               <ul style="list-style-type: none"> <li>• recording work and any variations from the original specification</li> <li>• the referral of problems</li> <li>• reporting delays to the completion of work</li> </ul> </li> <li>5. The importance of documenting information.</li> <li>6. The importance of working to agreed timescales and keeping others informed of progress.</li> <li>7. The relationship between time and costs.</li> <li>8. The importance of reporting anticipated delays to the relevant person(s) promptly.</li> </ol>	
<p><b>Use of technical information</b></p> <ol style="list-style-type: none"> <li>9. How to find, interpret and use <b>sources of technical information</b> for set activities.</li> <li>10. The importance of using the correct <b>sources of technical information</b>.</li> </ol>	
<p><b>General methods and material uses</b></p> <ol style="list-style-type: none"> <li>11. How to use and operate workshop equipment safely.</li> <li>12. How to use tools and equipment correctly and safely.</li> <li>13. How to identify materials and joining methods.</li> <li>14. The operation of electrical circuits and how to take measurements.</li> <li>15. The construction materials used in vehicle manufacture, methods and safety features.</li> </ol>	

In signing this sheet the Assessor and Candidate confirm that all the essential knowledge has been met by the named candidate.	
Assessor	Date
Candidate	Date

## Key and core skills signposting

Key Skills	Core Skills
<b>Communication:</b> C1.1; C1.3; C2.2	<b>Communication:</b> Access 3, Outcomes 2 and 3 Intermediate 1, Outcome 1
<b>Application of Number:</b> N1.1; N1.2; N1.3?	<b>Numeracy:</b> Access 3, Outcomes 2 and 4
<b>Information Technology:</b> Not applicable	<b>Information Technology:</b> Not applicable
<b>Working with Others:</b> WO1.1; WO1.2	<b>Working with Others:</b> Access 3, Outcomes 1 and 2
<b>Improving Own Learning and Performance:</b> Not applicable	<i>No parallel unit.</i>
<b>Problem Solving:</b> PS2.1	<b>Problem Solving:</b> Intermediate 1, Outcome 1

## ***Workshop processes, methods and vehicle construction***

This unit covers the basic skills associated with all aspects of repair, servicing and maintenance of vehicles.

### **Introduction**

The content of this unit relates only to the level 1 VRQ. However, the content is also appropriate learning for N/SVQ students.

### **Course outline (VRQ)**

The syllabus is presented as a number of outcomes that in turn each have a number of objectives and expanded content detail.

Knowledge gained from this level 1 VRQ unit will help to develop that required for level 2 units.

### **Outcomes**

On completion of this unit, the student must be able to:

1. Understand the operation and use of workshop equipment.
2. Use tools and measuring equipment; identify joining methods and materials.
3. Understand basic electrical principles and use test equipment.
4. Describe vehicle construction materials, components, methods and safety features.



## **Outcome 1**

Understand the operation and use of workshop equipment.

### **Objectives**

To achieve this outcome a student must be able to

- 1) Identify and use common workshop equipment
  - a) Inspection lamps
  - b) Electrical supply leads
  - c) Trolley jacks
  - d) Bottle and scissor jacks
  - e) Axle stands
  - f) Ramps and wheel chocks
  - g) Single post lifts
  - h) Two post lifts
  - i) Four post lifts
  - j) Pits and jacking beams
  - k) Compressors and high pressure air equipment
  - l) Tyre inflation equipment
  - m) Oil drainage equipment
  - n) Tyre changing machines
  - o) Wheel balancing equipment
  - p) Presses and pullers
  - q) Degreasing and cleaning equipment
  - r) Cranes, slings and chains
  - s) Pillar and hand held drills
  - t) Bench grinders
  - u) Exhaust extraction equipment
  - v) Battery chargers
  - w) Welding equipment (basics only)
- 2) State safety precautions and regular checks for the above

## Outcome 2

Use tools and measuring equipment; identify joining methods and materials.

### Objectives

To achieve this outcome a student must be able to:

- 1) Identify and use common hand tools
  - a) files
  - b) saws
  - c) hammers
  - d) pliers and grips
  - e) screwdrivers
  - f) drills and drill bits
  - g) spanners
  - h) punches and chisels
  - i) air tools
  - j) taps and dies
  - k) holding equipment (vices etc.)
  - l) sockets.
- 2) Identify locking and securing devices
  - a) fixing devices
    - i. nuts
    - ii. bolts
    - iii. screws
    - iv. ties
    - v. rivets
  - b) locking and securing devices
    - i. locking nuts
    - ii. split pins
    - iii. locking wire
    - iv. locking washers
    - v. chemical thread locking
  - c) screw threads
    - i. types
    - ii. applications.
  - d) adhesives and sealants
    - i. types
    - ii. applications.
- 3) Describe the principles of measurement
  - a) length
  - b) area
  - c) volume

- d) mass
  - e) angles
  - f) pressure.
- 4) Identify and use measuring equipment
- a) rule/tape
  - b) calliper
  - c) feeler gauge
  - d) volume measures
  - e) micrometers
  - f) Vernier caliper
  - g) dial gauges
  - h) torque wrenches.
- 5) Identify materials and their properties
- a) materials
    - i. low carbon steel
    - ii. high carbon steel
    - iii. brass
    - iv. copper
    - v. aluminium
    - vi. plastics
  - b) material properties
    - i. strength
    - ii. malleability
    - iii. ductility
    - iv. hardness
    - v. fitness for purpose
- 6) Restore threads and remove broken studs
- a) Restore threads using
    - i. thread files
    - ii. taps and dies
    - iii. helicoils
  - b) Remove broken studs using
    - i. 'easy outs'
    - ii. heat
    - iii. stud tools

### **Outcome 3**

Understand basic electrical principles and basic use of test equipment.

#### **Objectives**

To achieve this outcome a student must be able to:

- 1) Describe the principles of electricity and electrical circuits
  - a) Switches, conductors, insulators and fuses
  - b) Ohm's Law and the power equation
    - i. amps
    - ii. watts
    - iii. ohms
    - iv. volts
  - c) series and parallel circuits
  - d) production of electricity
    - i. alternating current
    - ii. direct current
    - iii. electromagnetic
    - iv. electrostatic
    - v. electrochemical
  - e) wiring diagrams
    - i. flow
    - ii. layout
    - iii. destination
- 2) Identify and use electrical measuring equipment
  - a) test lamp
  - b) ammeter
  - c) voltmeter
  - d) ohmmeter
  - e) oscilloscope (basics only).

## Outcome 4

Describe vehicle construction materials, components, methods and safety features.

### Objectives

To achieve this outcome a student has to:

- 1) Identify materials used in vehicle construction
  - a) materials used
    - i. ferrous metals
    - ii. non ferrous metals
    - iii. steel and alloys
    - iv. aluminium
    - v. brass
    - vi. copper
    - vii. lead
    - viii. cast iron
    - ix. glass reinforced plastic
    - x. kevlar
    - xi. rubber safety glass.
- 2) Identify the components used in vehicle construction
  - a) sills, wings and inner wings
  - b) scuttle and valances
  - c) doors, roof and sunroof
  - d) parcel tray
  - e) sub frames and assemblies
  - f) spoilers and air dams
  - g) wheel arches
  - h) bonnet and boot panels
  - i) space frame
  - j) fittings
  - k) door, bonnet and boot fixings
  - l) locks
  - m) weather seals
  - n) metal fasteners
  - o) other securing devices.
- 3) Describe the types of vehicle chassis and different construction methods
  - a) types of vehicle chassis
    - i. monocoque
    - ii. composite
    - iii. backbone
    - iv. integral types
    - v. commercial vehicle ladder and cruciform

- b) chassis construction methods
  - i. cross members
  - ii. load-bearing members
  - iii. load-bearing points
  - iv. channel
  - v. tubular
  - vi. box sections.
- 4) Describe the safety features used in vehicle construction
  - a) construction features
    - i. crumple zones
    - ii. side impact protection
    - iii. bumpers
    - iv. safety glass
    - v. seat belts and pre-tensioners
    - vi. air bags
  - b) the benefits to driver and passenger safety
- 5) current regulations controlling design, construction and use of vehicles.






## Assessment

### ***Essential knowledge assessment (VRQ)***

Essential knowledge will be assessed using the GOLLA system. The test specification is as follows:

<b>Outcome</b>	<b>Number of questions</b>
1	3
2	4
3	4
4	4
Test duration 25mins	Total 15

**Carry out Basic Routine Vehicle Maintenance**

 Further guidance available	 Observation of your task/work	 Evidence recording	 Computer based testing	 Verbal Questioning
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**Evidence requirements**

To complete this unit you will be required to undertake knowledge and practical tests

For the knowledge test you must pass the City & Guilds computer based (GOLA) multiple choice knowledge test. This test will be arranged by your tutor or assessor.

The practical tests are covered in the VRQ information section.

You must also complete the attached recording forms to the satisfaction of your assessor. These forms, when completed and signed by you and your assessor, provide confirmation that you have met both practical and knowledge requirements.

Your tutor or assessor will be able to offer you further guidance on the evidence you need to provide.



**Information for VRQs (Technical Certificates).**

**To complete this unit you must:**

1. Carry out one interim services (including an oil change).

Note: Old parts may be reused for the purposes of assessment where the assessor is satisfied that it does not affect the validity of the assessment.

Your tutor or assessor will either set and observe a practical assessment task, which has been designed to cover the performance objectives, or you may be observed by your assessor in your workplace.

With your assessor you must complete a suitable **City & Guilds evidence recording form** for **each** task. Your tutor or assessor will advise you on this. Other paperwork such as job cards, inspection sheets, servicing lists and reporting paperwork, appropriate to the task, should also be completed


All work records/evidence should be numbered (portfolio reference number PRN) and entered where required on the recording forms. This evidence should be collected in a portfolio and may need to be made available to your internal verifier or the City & Guilds external verifier.

Your assessor will ask questions to ensure you understand the practical task you are performing.

VRQ



## Evidence reference summary

	<b>Note:</b> Refer to the Evidence requirements for details of locations and types of assessment for this unit.	Portfolio reference number (PRN)
		<b>VRQ</b>
		Observed assessment
Carry out interim service (including an oil change)		

Supplementary evidence (if used) PRN			
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On line test reference for this unit PRN	
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## Unit assessment and verification declaration

<p><b>VRQ Candidate declaration:</b>          I confirm that the evidence listed for this unit is authentic and a true representation of my own work          Candidate name:.....          Candidate enrolment number:.....          Candidate signature:.....          Date: .....</p>
<p><b>VRQ Assessor declaration:</b>          I confirm that this candidate has achieved all the requirements of this unit with the evidence listed.          Assessment was conducted under the specified conditions and context, and is valid, authentic, reliable, current and sufficient.          Assessor name: .....          Assessor signature:.....          Date: .....          Countersignature: (if relevant).....          Date: .....</p>
<p><b>VRQ Internal verifier Declaration:</b>          (Leave blank if sampling of this unit did not take place.)          I have internally verified the assessment work on this unit in the following ways (please tick):              sampling candidate and assessment evidence              observation of assessment practice              discussion with candidate              other – please state:          I confirm that the candidate's work meets the standards specified for this unit and may be presented for external verification and/or certification.          Internal verifier name: .....          Internal verifier signature: ..... Date: .....          Countersignature: (if relevant) ..... Date: .....</p>



## Performance objective checklist

<b>To be competent you must ensure that:</b>	<b>PRN</b>
Wear suitable personal protective equipment and vehicle coverings throughout all basic/interim vehicle maintenance activities.	
Use suitable sources of technical information to support all your vehicle maintenance activities.	
Use the correct specifications and tolerances for the vehicle when making assessments of system and component performance.	
Where the customer's vehicle falls outside the manufacturer's original specification, record details accurately and use this adapted specification as the basis for your examination and assessment.	
Examine the vehicle's systems and components following: <ul style="list-style-type: none"> <li>the manufacturer's approved examination methods</li> <li>your workplace procedures</li> <li>health and safety requirements.</li> </ul>	
Ensure your examination methods identify accurately any vehicle system and component problems falling outside the servicing schedule specified.	
Carry out adjustments, replacement of vehicle components and replenishment of consumable materials following the manufacturer's current specification for: <ul style="list-style-type: none"> <li>the particular service interval</li> <li>working methods and procedures</li> <li>use of equipment</li> <li>the tolerances for the vehicle.</li> </ul>	
Where system adjustments cannot be made within the manufacturer's specification, record the details accurately and take action which complies with the customer's instructions.	
Work in a way which minimises the risk of damage to the vehicle and its systems.	
Use suitable testing methods to evaluate the performance of all replaced and adjusted components and systems accurately, prior to returning the vehicle to the customer.	
Report any problems or issues relating to the vehicle's condition or conformity to the relevant person(s) promptly.	
Ensure your maintenance records are accurate, complete and passed to the relevant person(s) promptly in the format required.	
Complete all vehicle maintenance activities within the agreed timescale.	
Report any anticipated delays in completion to the relevant persons(s) promptly.	

## Scope of this unit

<b>All of the items listed below form part of this unit</b>	<b>PRN</b>
<b>1. Sources of technical information are:</b>	
a. vehicle technical data	
b. schedules of inspection	
c. regulations.	
<b>2. Examination methods are:</b>	
a. aural	
b. visual	
c. functional	
d. measurements.	
<b>3. Assessments are for:</b>	
a. malfunction	
b. damage	
c. fluid levels	
d. leaks	
e. wear	
f. security	
g. condition and serviceability	
h. conformity	
i. necessity for adjustment(s).	

In signing this sheet the Assessor and Candidate confirm that all the performance objectives have been met by the named candidate.	
Assessor	Date
Candidate	Date

## Essential knowledge

You need to understand:	PRN
<p><b>Legislative and organisational requirements and procedures</b></p> <ol style="list-style-type: none"> <li>1. The manufacturer's and legal requirements relating to routine maintenance activities for vehicle systems and components.</li> <li>2. The legal requirements relating to the vehicle (including road safety requirements).</li> <li>3. The health and safety legislation and workplace procedures relevant to vehicle maintenance activities and personal and vehicle protection.</li> <li>4. Your workplace procedures for:               <ul style="list-style-type: none"> <li>• recording vehicle maintenance work and any variations from the original vehicle specification</li> <li>• the referral of problems</li> <li>• reporting delays to the completion of work</li> </ul> </li> <li>5. The importance of documenting vehicle maintenance information.</li> <li>6. The importance of working to agreed timescales and keeping others informed of progress.</li> <li>7. The relationship between time and costs.</li> <li>8. The importance of reporting anticipated delays to the relevant person(s) promptly.</li> </ol>	
<p><b>Use of technical information</b></p> <ol style="list-style-type: none"> <li>9. How to find, interpret and use <b>sources of technical information</b> for scheduled maintenance activities, including on-board diagnostic displays.</li> <li>10. The importance of using the correct <b>sources of technical information</b>.</li> <li>11. The purpose of and how to use identification codes.</li> </ol>	
<p><b>Vehicle system operation (basic level)</b></p> <ol style="list-style-type: none"> <li>12. How engines, cooling systems, air supply and exhaust systems, fuel systems and ignition systems operate for the type(s) of vehicle on which you are working.</li> <li>13. How clutch assemblies, clutch operating systems, manual gear boxes, automatic gear boxes, drivelines and hubs (if appropriate) and final drive assemblies operate for the type of vehicle on which you are working.</li> <li>14. How suspension systems, steering systems, braking systems, non- electrical body systems, wheels and tyres operate for the type of vehicle on which you are working.</li> <li>15. How batteries, starting systems, charging systems, lighting systems and ancillary equipment operate for the type of vehicle on which you are working.</li> <li>16. The operating specifications and tolerances for the type(s) of vehicles on which you are working.</li> </ol>	
<p><b>Basis routine maintenance requirements</b></p> <ol style="list-style-type: none"> <li>17. How to conduct scheduled, basic/interim routine <b>examination methods</b> and <b>assessments</b> against vehicle specifications to identify damage, corrosion, inadequate fluid levels, leaks, wear, security problems and general condition and serviceability.</li> <li>18. Check and make <b>basic</b> adjustments to clearances, gaps, settings, alignment, pressures, tension, speeds and levels relevant to the engine area, transmission area, chassis area, electrical area and body (including to valves, ignition, fuel and emissions, brakes, transmission, lights, tyres, steering and body fittings).</li> <li>19. How to replenish and replace routine service components and materials, including filters, drive, belts, wiper blades, brake linings and pads, lubricants and fluids.</li> <li>20. How to recognise cosmetic damage to vehicle components and units outside normal service items.</li> <li>21. How to identify codes and grades of lubricants.</li> <li>22. How to work safely avoiding damage to the vehicle and its systems.</li> </ol>	

In signing this sheet the Assessor and Candidate confirm that all the essential knowledge has been met by the named candidate.	
Assessor	Date
Candidate	Date

## Key and core skills signposting

Key Skills	Core Skills
<b>Communication:</b> C1.1; C1.3; C2.2	<b>Communication:</b> Access 3, Outcomes 2 and 3 Intermediate 1, Outcome 1
<b>Application of Number:</b> N1.1; N1.2; N1.3?	<b>Numeracy:</b> Access 3, Outcomes 2 and 4
<b>Information Technology:</b> Not applicable	<b>Information Technology:</b> Not applicable
<b>Working with Others:</b> WO1.1; WO1.2	<b>Working with Others:</b> Access 3, Outcomes 1 and 2
<b>Improving Own Learning and Performance:</b> Not applicable	<i>No parallel unit.</i>
<b>Problem Solving:</b> PS2.1	<b>Problem Solving:</b> Intermediate 1, Outcome 1

## **Carry out Basic Routine Vehicle Maintenance.**

This unit is about conducting basic routine examination, adjustment and replacement activities as part of the periodic servicing of vehicles.

### **Course Outline**

The syllabus is presented as a number of outcomes that in turn each have a number of objectives and expanded content detail.

As a general guide the intention is that a student should gain the skills to carry out an interim service. Knowledge gained from this level 1 VRQ unit will help to develop that required for level 2 units.

**Important note:** This unit includes technology from different types of vehicle. Content that is general to all vehicle types is in normal print (the majority of the syllabus). Material specific to light vehicles is highlighted in red *italics*, that specific to motorcycles is highlighted by blue underlining and that specific to heavy vehicle in green **bold**. GOLA tests will only cover the general content.

### **Outcomes**

On completion of this unit, the student must be able to:

- 1) Explain the purpose of routine maintenance; identify sources of information and regulations; describe the purpose of inspections.
- 2) Describe the basic operating principles, components and features of petrol and diesel engines
- 3) Describe the basic operating principles, components, features and maintenance requirements of lubrication and cooling systems.
- 4) Describe the basic operating principles, components, features and maintenance requirements of ignition systems and petrol fuel systems.
- 5) Describe the basic operating principles, components and features of diesel fuel systems.
- 6) Describe the basic operating principles, components and features of clutches and gearboxes.
- 7) Describe the basic operating principles, components and features of driveline and final drive systems.
- 8) Describe the basic operating principles, components and features of steering.
- 9) Describe the basic operating principles, components and features of suspension, wheels and tyres.
- 10) Describe the basic operating principles, components, service requirements and features of brakes.
- 11) Describe the basic operating principles, components, service requirements and features of electrical and electronic systems.

## Outcome 1

Explain the purpose of routine maintenance; identify sources of information and regulations; describe the purpose of inspections.

### Objectives

To achieve this outcome a student has to:

1. State the purpose of routine vehicle maintenance
2. State the
  - a) reasons for observing time scales
    - i. to adhere to completion times
    - ii. keeping customers and management informed of progress
  - b) types of documentation
    - i. job cards
    - ii. stores and material records
    - iii. manufacturers warranty systems
  - c) importance of accurate completion of records
  - d) parts lists and identification codes.
3. Identify sources of information relating to vehicle maintenance
  - a) information sources
    - i. technical manuals
    - ii. technical bulletins
    - iii. servicing schedules
    - iv. job card instructions
    - v. inspection records
    - vi. check lists
4. Describe the purpose and methods of vehicle inspection
  - a) purpose of vehicle inspection:
    - i. malfunction of systems and components
    - ii. damage and corrosion to structural and support regions
    - iii. *leaks*
    - iv. water ingress
    - v. component and system wear and security
  - b) vehicle inspection techniques
    - i. aural
    - ii. visual
    - iii. functional assessments
  - c) fault finding techniques
    - i. road tests
    - ii. questioning
    - iii. review of symptoms
  - d) importance of recording details
5. Explain the need for vehicle protection prior to maintenance activities

- a) protection relating to:
  - i. vehicle body panels
  - ii. paint surfaces
  - iii. seats
  - iv. carpet
  - v. floor mats.
- 6. Identify the current regulations relating to the repair and use of light vehicles
  - a) Road Traffic Act
  - b) VOSA regulations
  - c) Highway Code.

## Outcome 2

Describe the basic operating principles, components and features of petrol and diesel engines

### Objectives

To achieve this outcome a student has to:

1. Describe the basic operating principles of petrol engines
  - a) Basic overview and layout of spark ignition petrol engines:
    - i. four stroke
    - ii. two stroke
  - b) principles of:
    - i. cycles of operation
    - ii. valve control systems
  - c) compression ratios
2. Describe the basic operating principles of four stroke diesel engines
  - a) overview and layout of four stroke diesel engines
  - b) principles:
    - i. cycles of operation
    - ii. fuel injection and ignition principles
    - iii. injection timing
  - c) compression ratios
3. Identify and state the functions of petrol and diesel engine components
  - a) components
    - i. engine block and cylinder liners
    - ii. cylinder head and valves
    - iii. crankshafts, camshafts and drives
    - iv. pistons, piston rings and connecting rods
    - v. bearings/shells bushes and thrust bearings
    - vi. flywheel and flywheel ring gear
    - vii. gaskets and oil seals.
    - viii. crankcases and sumps
4. Describe
  - a) engine configurations
    - i. inline
    - ii. flat
    - iii. vee
  - b) engine layouts using single and twin camshafts
5. Describe the operation of and service requirements of the
  - a. exhaust system
  - b. air supply system

### Outcome 3

Describe the basic operating principles, components, features and maintenance requirements of lubrication and cooling systems.

#### Objectives

To achieve this outcome a student has to:

1. Describe the principles of engine lubrication systems
  - a) overview and layout of engine lubrication systems
  - b) identify and state the function of
    - i. oil pan / sump and oil tanks
    - ii. oil pumps (gear, vane, eccentric rotor)
    - iii. oil pump drives and relief valves
    - iv. filters (full flow and by-pass ) and strainers
    - v. sensors, pressure gauges and warning lights
    - vi. coolers
    - vii. crankcase ventilation.
2. Explain the routine maintenance requirements for engine lubrication systems
  - a) checking levels
  - b) lubrication selection
  - c) filter removal and replacement
  - d) lubricant refilling
  - e) waste disposal.
3. Describe the basic operating principles of cooling systems
  - a) layout of liquid cooled systems
  - b) basic air cooling.
4. Identify and state the functions of the components used in liquid cooled systems
  - a) components
    - i. radiator, hoses, pressure caps and expansion tanks
    - ii. coolant pumps (mechanical and electrical)
    - iii. thermostats and fans
    - iv. temperature sensors, warning systems and control valves
    - v. antifreeze and corrosion inhibitors
5. State the routine maintenance requirements for cooling systems



## Outcome 4

Describe the basic operating principles, components, features and maintenance requirements of ignition and petrol fuel systems.

### Objectives

To achieve this outcome a student has to:

1. Identify
  - a) ignition systems
  - b) components
    - i. battery, wiring and ignition switch
    - ii. coils (separate, distributorless, direct) and LT switching devices
    - iii. spark plugs and HT leads
    - iv. distributor
    - v. timing control devices
    - vi. pulse generators and ECUs
  - c) ignition system controls during changes in engine load and speed.
2. Explain the reasons for
  - a) ignition timing
  - b) ignition timing checking / adjustment
3. State the
  - a) safety implications when handling petrol
  - b) regulations regarding petrol storage and handling.
4. State the basic principles of carburation
5. Identify the
  - a) layout and basic operation of
    - i. single point
    - ii. multi point (sequential and non-sequential)
  - b) components
    - i. fuel tanks, pipelines and filters
    - ii. tank venting and emission control systems
    - iii. fuel gauges and warning systems
    - iv. fuel pumps
    - v. injectors
    - vi. throttle potentiometer and switch
    - vii. idle speed control valve / auxiliary air device
    - viii. lambda and coolant sensors
    - ix. air flow sensors (air flow meter and air mass meter)
    - x. MAP and air temperature sensors
    - xi. electronic control units
    - xii. fuel pumps and fuel pressure regulators
    - xiii. relays
    - xiv. EGR systems

## Outcome 5

Describe the basic operating principles, components and features of diesel fuel systems.

### Objectives

To achieve this outcome a student has to

1. State the
  - a) safety implications when handling diesel
  - b) regulations regarding diesel storage and handling.
2. Describe the basic operating principles of diesel fuel systems
  - a) layout and basic operation of
    - i. inline pump systems
    - ii. rotary pump systems
    - iii. common rail systems
  - b) identify
    - i. fuel tanks, pipes, water traps and filters
    - ii. tank venting and emission systems
    - iii. injection pumps and governors
    - iv. injectors
    - v. cold starting aids
    - vi. fuel cut-off devices
    - vii. sensors
    - viii. ECU control of fuelling
3. Explain the reasons for
  - a) injection timing
  - b) injection timing checking / adjustment

## Outcome 6

Describe the basic operating principles, components and features of clutches and gearboxes.

### Objectives

To achieve this outcome a student has to:

1. Identify and state the functions of
  - a) clutches
  - b) identify
    - i. pressure plates and driven/centre plates
    - ii. release and spigot bearings
    - iii. cables
    - iv. master and slave cylinders
  - c) reasons for fitting a clutch.
2. Identify and state the functions of
  - a) manual gearboxes
  - b) components
    - i. gear selector mechanisms
    - ii. gears, bearings and shafts
    - iii. constant mesh gears
    - iv. oil seals and gaskets
  - c) gearbox lubrication and venting
3. Identify and state the functions of
  - a) automatic gearboxes
  - b) components
    - i. torque converters
    - ii. gear selector mechanisms
    - iii. gears, bearings and shafts
    - iv. clutches and control mechanisms
    - v. oil seals and gaskets
    - vi. sensors and actuators
    - vii. ECU
  - c) gearbox lubrication and venting

## Outcome 7

Describe the basic operating principles, components and features of driveline and final drive systems.

### Objectives

To achieve this outcome a student has to:

1. Identify and state the functions of
  - a) drive shafts
  - b) components
    - i. universal joints
    - ii. sliding couplings
    - iii. constant velocity joints.
2. Identify
  - a) final drive systems
  - b) components and basic operation
    - i. final drive gears (*helical and hypoid*) (**also heavy**)
    - ii. *differentials* (**also heavy**)
    - iii. hubs, bearings and *half shafts*. (**also heavy**)

## Outcome 8

Describe the basic operating principles, components and features of steering.

### Objectives

To achieve this outcome a student has to:

1. Identify and state the basic functions of
  - a) steering systems
  - b) components
    - i. *steering boxes*
    - ii. *steering arms and linkages, steering joints and bushes (also heavy)*
    - iii. headstock
    - iv. bearings
    - v. *steering columns (collapsible and absorbing), wheels and handlebars (also heavy)*
    - vi. *hydraulic pump and control valves (also heavy)*
2. Describe steering geometry measurement and adjustments

## Outcome 9

Describe the basic operating principles, components and features of suspension, wheels and tyres

### Objectives

To achieve this outcome a student has to:

1. Identify and state the functions of
  - a) suspension systems
    - i. non-independent and independent
  - b) components
    - i. springs
    - ii. dampers
    - iii. struts
    - iv. arms and swivels
2. Describe the current legal requirements governing the use of tyres
3. Identify the markings on tyres
  - a) speed rating
  - b) direction of rotation profile
  - c) load handling and ply rating
  - d) pressure
  - e) tread wear indicators.
4. Identify the different types of wheel and rim construction
  - a) steel wheels
  - b) alloy wheels
  - c) wire wheels
  - d) *space saver wheels.*
5. Identify methods of tyre construction
  - a) tubed and tubeless
  - b) radial
  - c) bias belted tyres
  - d) braced tyres
  - e) valves.

## Outcome 10

Describe the basic operating principles, components, service requirements and features of brakes.

### Objectives

To achieve this outcome a student has to:

1. Identify and state the basic functions of
  - a) disc and drum brake systems
    - i. divided (split) systems
    - ii. *dual systems (also heavy)*
    - iii. antilock brake systems
  - b) components
    - i. hydraulic cylinders and calipers
    - ii. discs and drums
    - iii. brake pads and shoes
    - iv. pipes and cables
    - v. *vacuum servos and hydraulic servos (also heavy)*
    - vi. warning lights and sensors
    - vii. brake fluid and its specifications
    - viii. pressure controlling valves
    - ix. parking brakes
    - x. wheel speed sensors
2. Explain the routine maintenance requirements for braking systems
  - a) acceptable levels of component wear
  - b) checks required
    - i. components for wear, security and serviceability
    - ii. fluid levels and contamination
    - iii. efficiency

## Outcome 11

Describe the basic operating principles, components, service requirements and features of electrical and electronic systems.

### Objectives

To achieve this outcome a student has to

1. Identify and state the functions of
  - a) battery and charging systems
  - b) components and basic operation
    - i. lead acid battery
    - ii. alternator
    - iii. alternator drive systems.
2. Identify and state the functions of
  - a) engine starting systems
  - b) components and basic operation
    - i. starter motor
    - ii. starter ring gear
    - iii. ignition switch.
3. Explain the purpose and use of electrical wiring diagrams
4. Identify and state the functions of
  - a) auxiliary and lighting systems
  - b) components and basic operation
    - i. exterior and *interior* lights and bulbs (filament and arc) **(also heavy)**
    - ii. indicators
    - iii. *fan, heater and de-misting systems* **(also heavy)**
5. Describe the routine maintenance requirements for electrical and electronic systems








## Assessment

Essential knowledge will be assessed using the GOLA system. The test specification is as follows:

<b>Outcome</b>	<b>Number of questions</b>
1	2
2	1
3	2
4	2
5	1
6	1
7	1
8	1
9	1
10	1
11	2
Test duration 25mins	Total 15

## Air Conditioning and Climate Control Systems

 Further guidance available	 Observation of your task/work	 Evidence recording	 Computer based testing	 Verbal Questioning
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### Evidence requirements

To complete this unit you will be required to undertake knowledge and practical tests

For the knowledge test you must pass the City & Guilds computer based (GOLA) multiple choice knowledge test. This test will be arranged by your tutor or assessor.

The practical tests are covered in the VRQ information section.

You must also complete the attached recording forms to the satisfaction of your assessor. These forms, when completed and signed by you and your assessor, provide confirmation that you have met both practical and knowledge requirements.

Your tutor or assessor will be able to offer you further guidance on the evidence you need to provide.



### Information for VRQs (Technical Certificates).

To complete this unit you must:

1. Service and AC system
2. Evacuate AC system
3. Rectify AC system fault
4. Repair AC system leaks

Your tutor or assessor will either set and observe a practical assessment task, which has been designed to cover the performance objectives, or you may be observed by your assessor in your workplace.

With your assessor you must complete a suitable **City & Guilds evidence recording form** for **each** task. Your tutor or assessor will advise you on this. Other paperwork such as job cards, inspection sheets, servicing lists and reporting paperwork, appropriate to the task, should also be completed


All work records/evidence should be numbered (portfolio reference number PRN) and entered where required on the recording forms. This evidence should be collected in a portfolio and may need to be made available to your internal verifier or the City & Guilds external verifier.

Your assessor will ask questions to ensure you understand the practical task you are performing.

# VRQ



## Evidence reference summary

	<b>Note:</b> Refer to the Evidence requirements for details of locations and types of assessment for this unit.	Portfolio reference number (PRN)
		<b>VRQ</b>
		Observed assessment
Service and AC system		
Evacuate AC system		
Rectify AC system fault		
Repair AC system leaks		

Supplementary evidence (if used) PRN			
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On line test reference for this unit PRN	
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## Unit assessment and verification declaration

<p><b>VRQ Candidate declaration:</b>          I confirm that the evidence listed for this unit is authentic and a true representation of my own work          Candidate name: .....          Candidate enrolment number: .....          Candidate signature: .....          Date: .....</p>
<p><b>VRQ Assessor declaration:</b>          I confirm that this candidate has achieved all the requirements of this unit with the evidence listed.          Assessment was conducted under the specified conditions and context, and is valid, authentic, reliable, current and sufficient.          Assessor name: .....          Assessor signature: .....          Date: .....          Countersignature: (if relevant).....          Date: .....</p>
<p><b>VRQ Internal verifier Declaration:</b>          (Leave blank if sampling of this unit did not take place.)          I have internally verified the assessment work on this unit in the following ways (please tick):</p> <ul style="list-style-type: none"> <li>• sampling candidate and assessment evidence</li> <li>• observation of assessment practice</li> <li>• discussion with candidate</li> <li>• other – please state:</li> </ul> <p>I confirm that the candidate's work meets the standards specified for this unit and may be presented for external verification and/or certification.          Internal verifier name: .....          Internal verifier signature: ..... Date: .....          Countersignature: (if relevant) ..... Date: .....</p>

## Key and core skills signposting

Key Skills	Core Skills
<b>Communication:</b> C1.1; C1.3; C2.2	<b>Communication:</b> Access 3, Outcomes 2 and 3 Intermediate 1, Outcome 1
<b>Application of Number:</b> N1.1; N1.2; N1.3?	<b>Numeracy:</b> Access 3, Outcomes 2 and 4
<b>Information Technology:</b> Not applicable	<b>Information Technology:</b> Not applicable
<b>Working with Others:</b> WO1.1; WO1.2	<b>Working with Others:</b> Access 3, Outcomes 1 and 2
<b>Improving Own Learning and Performance:</b> Not applicable	<i>No parallel unit.</i>
<b>Problem Solving:</b> PS2.1	<b>Problem Solving:</b> Intermediate 1, Outcome 1

# Syllabus

## ***Air Conditioning and Climate Control Systems***

This unit is about servicing and repair of AC systems. It includes diagnosing faults and making repairs to all aspects of climate control systems.

### ***Course Outline***

The outline syllabus is a requirement for Technical Certificate courses. This is presented as a number of outcomes that in turn each have a number of objectives and expanded content detail.

### **Outcomes**

On completion of this unit, the student must be able to:

1. Demonstrate an understanding of the function, layout and operating principles of air conditioning systems, environmental and legal requirements, components, equipment, tools, materials and procedures required for service and general maintenance.
2. Demonstrate an understanding of the principles of operation, purpose, construction, diagnosis, removal, refitting and maintenance of air conditioning components.
3. Diagnose faults via gauge pressure interpretation, system diagnostics and repair procedures for both Thermal Expansion Valve & Fixed Orifice Tube Air Conditioning Systems.
4. Demonstrate an understanding of climate control systems, configurations, operations and components including diagnosis.

## Outcome 1

Explain the purpose of routine maintenance; identify sources of information and regulations; describe the purpose of inspections.

### Objectives

To achieve this outcome a student has to:

1. State the purpose of vehicle maintenance
2. State the
  - a) reasons for observing time scales
    - i. to adhere to completion times
    - ii. keeping customers and management informed of progress
  - b) types of documentation
    - i. job cards
    - ii. stores and material records
    - iii. manufacturers warranty systems
  - c) importance of accurate completion of records
  - d) parts lists and identification codes.
3. Identify sources of information relating to vehicle maintenance
  - a) information sources
    - i. technical manuals
    - ii. technical bulletins
    - iii. servicing schedules
    - iv. job card instructions
    - v. inspection records
    - vi. check lists
    - vii. VSOA requirements (MOT)
    - viii. repair procedures.
4. Describe the purpose and methods of vehicle inspection
  - a) purpose of vehicle inspection:
    - i. malfunction of systems and components
    - ii. component and system wear and security
  - b) vehicle inspection techniques
    - i. aural
    - ii. visual
    - iii. functional assessments
  - c) fault finding techniques
    - i. road tests
    - ii. questioning
    - iii. review of symptoms
  - d) importance of recording details
5. Explain the need for vehicle protection prior to maintenance activities
  - a) protection relating to:

- i. vehicle body panels
  - ii. paint surfaces
  - iii. seats
  - iv. carpet
  - v. floor mats.
6. Identify the current regulations relating to the repair and use of light vehicles
- a) Road Traffic Act
  - b) VOSA regulations
  - c) Highway Code.

## Outcome 2

Demonstrate an understanding of the function, layout and operating principles of air conditioning systems, environmental and legal requirements, components, equipment, tools, materials and procedures required for service and general maintenance.

### Objectives

To achieve this outcome a student has to:

1) describe the operating principles and functional requirements of air conditioning systems and components including environmental and legal requirements.

- a) functions of the systems
  - i. cools the air
  - ii. dries the air
  - iii. cleans the air
- b) methods of heat transfer
  - i. conduction
  - ii. convection
  - iii. radiation
- c) difference between heat and temperature
- d) meaning of
  - i. Latent Heat
  - ii. Sensible Heat
- e) definition of terms
  - i. pressure gauge (pressure/compound)
  - ii. atmospheric pressure
  - iii. absolute pressure
  - iv. pressure/temperature relationship
  - v. vacuum
  - vi. humidity / relative humidity
  - vii. compression
  - viii. condensation
  - ix. evaporation
  - x. units of measurement
- f) refrigeration cycle
  - i. compression
  - ii. condensation
  - iii. evaporation
- g) refrigerant systems
  - i. refrigerant circuits -TXV & FOT
  - ii. compressor
  - iii. compressor clutch
  - iv. refrigerant pipes and hoses
  - v. condenser
  - vi. evaporator (single & dual systems)



- vii. thermostatic expansion valve
  - viii. fixed orifice tube
  - ix. suction accumulator
  - x. receiver drier
  - xi. pressure switches - binary, trinary & clutch cycling
  - xii. thermostats - electrical & mechanical
  - xiii. electrical circuit configuration - FOT and TXV
  - xiv. driver controls
  - xv. A/C Switch
  - xvi. recirculation switch
  - xvii. fan control switch
  - xviii. air distribution
  - xix. pollution sensors
  - xx. photo catalysts
- h) refrigerant state and condition
- i. saturated vapour
  - ii. superheated vapour
  - iii. subcooled liquid
- i) lubrication
- i. types (mineral oils and PAG)
  - ii. viscosity (all levels)
  - iii. quantities
- j) electrically driven compressors
- 2) refrigerants
- a) health & safety (Including P.P.E)
  - b) first aid
  - c) properties and characteristics of
    - i. R12 (CFC)
    - ii. R134a (HFC)
    - iii. CO<sub>2</sub> (Carbon dioxide)
  - d) hydrocarbons-risks (flammability)
  - e) blends (drop-ins)-risks (fractionation)
- 3) environmental issues
- a) ozone layer and ozone depletion
  - b) greenhouse effect and global warming
  - c) Montreal protocol and Kyoto agreement
- 4) legislation and regulations
- a) EC Regulations
  - b) Environmental Protection Act
  - c) Safe and Legal Disposal of Waste Materials
  - d) Waste Transfer Note

e) Management of HSE at Work Regulations

f) C.O.S.H.H

5) describe the use and application of special purpose tools, equipment and materials needed for service and maintenance of air conditioning and climate control systems and components

a) purpose and operation of service equipment and hand tools

- i. safety equipment - goggles & gloves
- ii. refrigerant identifiers \*
- iii. refrigerant recovery unit \*
- iv. service couplings and hoses \*
- v. manifold gauge set \*
- vi. vacuum pump \*
- vii. lubricant oil injector \*
- viii. charging cylinder (or scale) for measuring refrigerant qty \*
- ix. temperature measuring equipment \*
- x. leak detection
- xi. visual (oil trace and bubble spray)
- xii. electronic (corona discharge & heated diode)
- xiii. ultrasonic
- xiv. ultra violet
- xv. oxygen free nitrogen (OFN)
- xvi. belt tensioning gauge
- xvii. air flow meters
- xviii. flushing equipment \*

\*Items marked maybe incorporated into a Refrigerant Management Station (RMS)

b) service procedures

- i. refrigerant identification
- ii. initial system evaluation - testing
  - A. pressure
  - B. temperature
  - C. air distribution & speed
- iii. refrigerant recovery
- iv. system evacuation
- v. vacuum check
- vi. adding oil
- vii. initial charging
- viii. leak detection
  - A. visual
  - B. electronic
  - C. ultrasonic
  - D. ultra violet
  - E. oxygen free nitrogen
- ix. charge completion

- x. final leak checking
- xi. final system evaluation – testing
  - A. pressure
  - B. temperature
  - C. air distribution & speed

### Outcome 3

Demonstrate an understanding of the principles of operation, purpose, construction, diagnosis, removal, refitting and maintenance of air conditioning components.

#### Objectives

To achieve this outcome a student has to:

- 1) describe the operation, purpose, construction, removal, refitting of air conditioning components requiring maintenance or repair.
  - a) compressor clutches
    - i. A-Groove
    - ii. poly-vee
    - iii. overhang
    - iv. alignment
    - v. electrical connections
  - b) compressors
    - i. axial
    - ii. reciprocating
    - iii. swash/wobble plate
    - iv. radial
    - v. scroll
    - vi. rotary vane
    - vii. variable-piston/scroll
    - viii. mounting-direct/ear
    - ix. mechanical control valve
    - x. thermal switches
    - xi. high pressure relief valves
    - xii. super heat and thermal limiters
    - xiii. clutch air gap (adjustment)
    - xiv. clutch removal & refitting
    - xv. shaft seal replacement
    - xvi. lubrication types
    - xvii. lubrication viscosity
    - xviii. hygroscopic lubrication
    - xix. checking levels of lubrication
  - c) hoses and pipes
    - i. sizes
    - ii. types of fittings- flare/ O ring/ block / pad/springlock
    - iii. materials -rubber/aluminium / steel
  - d) mufflers
  - e) service valves and ports
    - i. flare type
    - ii. back seating valve

- iii. quick couplers
- f) purpose, construction, operation and maintenance of condensers
  - i. tube and fin
  - ii. serpentine
  - iii. parallel flow
  - iv. subcooled
  - v. fans
  - vi. Inspection and cleaning
- g) purpose, construction and operation of dehydrators
  - i. receiver driers
  - ii. accumulator
  - iii. desiccant bag
- h) purpose, construction and operation of metering devices
  - i. thermal expansion valve-internally & externally equalised
  - ii. block-fixed orifice tube (FOT)
- i) purpose, construction, operation and maintenance of evaporators
  - i. tin and tube
  - ii. serpentine
  - iii. plate and fin
  - iv. treatments (odour & bacterial)
  - v. pollution / pollen filters
- j) purpose, construction and operation of electrical control devices
  - i. pressure switches
  - ii. binary
  - iii. trinary
  - iv. clutch cycling
  - v. electrical & mechanical thermostats
- k) flushing
  - i. liquid refrigerant
  - ii. solvents
- l) retrofitting procedures & effects on components
  - i. O rings
  - ii. compressors
  - iii. lubricants
  - iv. hose and pipes
  - v. condensers
  - vi. dehydrators and desiccant
  - vii. metering devices
  - viii. labelling
  - ix. service ports
  - x. electrical control devices

- 2) describe the methods of accessing the relevant data from the utilisation of information sources
  - a) workshop manuals
  - b) manufacturers data and information sheets service schedules
  - c) parts lists
  - d) trade association check lists
  - e) legal and technical data reference books

## Outcome 4

Diagnose faults via gauge pressure interpretation, system diagnostics and repair procedures for both Thermal Expansion Valve & Fixed Orifice Tube Air Conditioning Systems.

### Objectives

To achieve this outcome a student has to:

- 1) diagnose faults via gauge pressure interpretation
  - a) Thermal Expansion Valve (TXV) System
    - i. high pressure
    - ii. low pressure
  - b) Fixed Orifice Tube (FOT) System
    - i. high pressure
    - ii. low pressure
    - iii. compressor cycle times
- 2) system diagnostics (characteristic system faults)
  - a) metering devices
  - b) TXV Stuck in open position
  - c) TXV stuck in closed position
  - d) leaking FOT
  - e) blocked FOT
  - f) mechanical & electrical thermostat problems
  - g) malfunctions of pressure switches (all types)
  - h) refrigerant
    - i. undercharged system
    - ii. overcharged system
    - iii. moisture
    - iv. air
  - i) refrigerant system restrictions
    - i. receiver drier
    - ii. accumulator
    - iii. blocked condenser
  - j) noisy compressors
    - i. overcharged system
    - ii. undercharged system
    - iii. lack of lubrication
    - iv. belt tension and condition
    - v. pulley alignment
    - vi. mounting
    - vii. damaged valves
  - k) reduced air flow
    - i. pollution / pollen filter
    - ii. blocked evaporator

- iii. fan resistor
  - iv. blocked condenser
  - v. faulty condenser fan
- l) HVAC control mechanisms
- i. recirculation flap
  - ii. air distribution flaps
  - iii. water valves
  - iv. temperature control
- m) water ingress
- i. blocked or incorrectly routed evaporator drain tubes
  - ii. HVAC casings
- n) vehicle odours
- i. evaporator
  - ii. bacteria
- 3) the candidate will be able to describe the methods used to remove and replace air conditioning components
- a) compressor
  - b) pipes and hoses
  - c) condenser
  - d) condenser fans
  - e) dehydrator
  - f) receiver drier
  - g) accumulator
  - h) thermal expansion valve
  - i) fixed orifice tube
  - j) evaporator
  - k) pressure switches
  - l) thermostats
  - m) control valves
- 4) the candidate will be able to describe how to prepare and use hand, special purpose tools, equipment and materials needed to remove and refit systems and components listed in 1, 2 and 3
- 5) the candidate will be able to describe how to prepare the systems and components listed in 1, 2 and 3 for diagnosis and rectification



## Outcome 5

Demonstrate an understanding of climate control systems, configurations, operations and components including diagnosis.

### Objectives

To achieve this outcome a student has to:

- 1) demonstrate an understanding of climate control system configurations
  - a) function
  - b) heat loads
  - c) comfort zone
  - d) pollution
- 2) describe climate control system configurations
  - a) manual temperature control
    - i. air distribution
    - ii. temperature
    - iii. air speed
    - iv. recirculation
    - v. air conditioning
    - vi. defrost / demist
  - b) semi automatic temperature control
    - i. air distribution
    - ii. temperature
    - iii. air speed
    - iv. recirculation
    - v. air conditioning
    - vi. defrost / demist
  - c) automatic temperature control
    - i. air distribution
    - ii. temperature
    - iii. air speed
    - iv. recirculation
    - v. air conditioning
    - vi. defrost / demist
- 3) the candidate will be able to understand the operational function of the climate control system.
  - a) manual temperature control
    - i. air distribution
      - A. windscreen
      - B. face
      - C. foot
      - D. rear
    - ii. temperature
      - A. heating

- B. cooling
  - iii. air speed (stepped and variable)
  - iv. manual operation of recirculation
  - v. air conditioning
    - A. on / off
    - B. economy (EC)
  - vi. manual defrost / demist
- b) semi automatic temperature control
  - i. air distribution
    - A. windscreen
    - B. face
    - C. foot
    - D. rear
  - ii. temperature
    - A. heating
    - B. cooling
  - iii. air speed
    - A. manual (stepped and variable)
    - B. automatic
  - iv. recirculation
    - A. manual
    - B. automatic
  - v. air conditioning
    - A. on / off
    - B. economy (EC)
    - C. automatic
  - vi. defrost / demist
- c) automatic temperature control
  - i. air distribution
    - A. windscreen
    - B. face
    - C. foot
    - D. rear
  - ii. temperature
    - A. heating
    - B. cooling
  - iii. air speed
    - A. manual (stepped and variable)
    - B. automatic
  - iv. recirculation
    - A. manual operation

- B. automatic operation
- C. pollution control
- D. defrost/demist
- v. air conditioning
  - A. on / off
  - B. economy (EC)
  - C. automatic
  - D. rest
- vi. manual defrost / demist
- vii. zoning
  - A. driver
  - B. passenger
  - C. rear- single & dual evaporator

4) the candidate will be able to identify and describe in-depth the operation, purpose, construction, removal, refitting of climate control system components.

- a) control - temperature control units
  - i. semi and fully automatic
    - A. input
    - B. output
- b) sensors (operation, purpose & construction)
  - i. in-vehicle temperature
  - ii. ambient temperature
  - iii. evaporator temperature
  - iv. coolant temperature
  - v. solar load
  - vi. position (flaps and valves)
  - vii. air quality
  - viii. vehicle speed
  - ix. pressure switches
  - x. compressor (anti-lock)
- c) mechanical & electrical actuators (operation, purpose & construction)
  - i. temperature blending
  - ii. air distribution
  - iii. fresh air / recirculation
  - iv. idle up
  - v. temperature blending
  - vi. air distribution
  - vii. fresh air / recirculation
  - viii. idle up
- d) valves
  - i. water single dual
  - ii. liquid refrigerant valve

- e) blowers (fans)
  - i. heater motor
  - ii. condenser fan

5) The candidate will be able to describe how to prepare and use hand, special purpose tools, equipment and materials needed to evaluate, diagnose, remove and refit climate control system faults and components.






- a) diagnostic tools (use of)
  - i. multimeter
  - ii. oscilloscope
  - iii. fault codes
    - A. diagnostic (self)
    - B. code reader
    - C. break out box
    - D. manufacturer specific

## Assessment

Essential knowledge will be assessed using the GOLLA system. The test specification is as follows:

Outcome	Number of questions
1	2
2	6
3	6
4	6
	5
Test duration 35mins	Total 25

## Mathematics, Science and Communications

 Further guidance available	 Observation of your task/work	 Evidence recording	 Computer based testing	 Verbal Questioning
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### Note

This unit will **not** be appropriate for all automotive candidates. It is designed to extend the skills and knowledge of the more academically able students who may wish to progress to higher qualifications. Therefore, centres should ensure that initial assessment is used to determine suitability.



### Evidence requirements

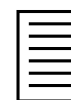
To complete this unit you will be required to undertake knowledge and practical tests

For the knowledge test you must pass the City & Guilds computer based (GOLA) multiple choice knowledge test. This test will be arranged by your tutor or assessor.

The practical tests are covered in the VRQ information section.

You must also complete the attached recording forms to the satisfaction of your assessor. These forms, when completed and signed by you and your assessor, provide confirmation that you have met both practical and knowledge requirements.

Your tutor or assessor will be able to offer you further guidance on the evidence you need to provide.



### Information for VRQs (Technical Certificates).

#### To complete this unit you must:

Produce evidence of practical application of **each** objective in this unit. It is expected that this evidence will be collected through class work, homework and assignment work on an ongoing basis. The use of short answer questions is recommended in many cases. Verifiers will be looking to see that the works is contextualised to the automotive field.


All work records/evidence should be numbered (portfolio reference number PRN) and entered where required on the recording forms. This evidence should be collected in a portfolio and may need to be made available to your internal verifier or the City & Guilds external verifier.

Your assessor will ask questions to ensure you understand the practical task you are performing.

# VRQ



## Evidence reference summary

	<b>Note:</b> Refer to the Evidence requirements for details of locations and types of assessment for this unit.	Portfolio reference number (PRN)
		<b>VRQ</b>
		Observed assessment
Outcome 1 objectives		
Outcome 2 objectives		
Outcome 3 objectives		

Supplementary evidence (if used) PRN			
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On line test reference for this unit PRN	
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## Unit assessment and verification declaration

<p><b>VRQ Candidate declaration:</b></p> <p>I confirm that the evidence listed for this unit is authentic and a true representation of my own work</p> <p>Candidate name:.....</p> <p>Candidate enrolment number:.....</p> <p>Candidate signature:.....</p> <p>Date: .....</p>
<p><b>VRQ Assessor declaration:</b></p> <p>I confirm that this candidate has achieved all the requirements of this unit with the evidence listed. Assessment was conducted under the specified conditions and context, and is valid, authentic, reliable, current and sufficient.</p> <p>Assessor name: .....</p> <p>Assessor signature:.....</p> <p>Date: .....</p> <p>Countersignature: (if relevant).....</p> <p>Date: .....</p>
<p><b>VRQ Internal verifier Declaration:</b></p> <p>(Leave blank if sampling of this unit did not take place.)</p> <p>I have internally verified the assessment work on this unit in the following ways (please tick):</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> sampling candidate and assessment evidence</li> <li><input type="checkbox"/> observation of assessment practice</li> <li><input type="checkbox"/> discussion with candidate</li> <li><input type="checkbox"/> other – please state:</li> </ul> <p>I confirm that the candidate's work meets the standards specified for this unit and may be presented for external verification and/or certification.</p> <p>Internal verifier name: .....</p> <p>Internal verifier signature: ..... Date: .....</p> <p>Countersignature: (if relevant) ..... Date: .....</p>

## Key/Core skills signposting

Key Skills	Core Skills
<b>Communication:</b> C2.1; C2.2; C2.3	<b>Communication:</b> Access 3, Outcome 2 Intermediate 1, Outcome 3
<b>Application of Number:</b> N2.1; N2.2; N2.3	<b>Numeracy:</b> Access 3, Outcome 1 Intermediate 1, Outcomes 1, 2, 3 and 4
<b>Information Technology:</b> IT1.1; IT1.2; IT1.3	<b>Information Technology:</b> Access 3, Outcomes 1, 2 and 3
<b>Working with Others:</b> Not applicable	<b>Working with Others:</b> Not applicable
<b>Improving Own Learning and Performance:</b> LP2.1.3; LP2.2.2; LP2.2.3; LP2.3.1; LP2.3.3	<i>No parallel unit.</i>
<b>Problem Solving:</b> PS2.1; PS2.2; PS2.3	<b>Problem Solving:</b> Intermediate 1, Outcomes 1, 2 and 3

# Mathematics, Science and Communications

This unit covers maths, science and communication skills associated with all aspects of repair, servicing and maintenance of vehicles.

## Introduction

The content of this unit relates only to the level 1 VRQ. Complete this unit in conjunction with the other level 1 units to convert the award from a certificate to a diploma.

## Course outline (VRQ)

This outline syllabus is a requirement for **Diploma** courses. It is presented as a number of outcomes that in turn each have a number of objectives and expanded content detail.

## Outcomes

On completion of this unit, the student must be able to:

- 1) Identify and use mathematical operations
- 2) Identify and use scientific principles
- 3) Identify and use methods of communication.



## Outcome 1

Identify and use mathematical operations.

### Objectives

To achieve this outcome the candidate must be able to

- 1) Identify calculations involving the four arithmetic operations.
  - a) Definitions: integers, vulgar/decimal fractions.
  - b) Arithmetic operations: addition, subtraction, multiplication, division.
  - c) Applied to: integers, vulgar/decimal fractions, positive/negative whole numbers (using rules relating to directed numbers), mixed numbers.
  - d) Precedence rules: sequence of calculations involving brackets.
- 2) Identify calculations involving fractions, ratios, percentages and proportions.
  - a) Definitions: ratio, percentage, proportion.
  - b) Convert: fraction to ratio/percentage/proportion, ratio/percentage/proportion to fraction.
  - c) Divide: various amounts into given ratios.
  - d) Proportion: two quantities in direct proportion to each other, two quantities in inverse proportion to each other.
  - e) Percentage: one quantity as a percentage of another.
  - f) Answers: standard form, preferred standard form.
- 3) Identify estimated solutions to arithmetic calculations.
  - a) Calculations: applied to 1 and 2 above.
  - b) Results: express as given number of significant figures/given number of decimal places
- 4) Identify calculations involving the use of an electronic calculator.
  - a) Integers/decimal fractions: multiply, divide, square, square root, reciprocal.
- 5) Identify the Laws of Indices:
  - a) Definition: Laws of Indices, base, index.
  - b) Calculations: multiply powers of the same number, raising power of a number to another power, dividing powers of the same number, negative indices, fractional indices, zero index.
- 6) Identify algebraic operations.
  - a) Definitions: expression, equation, identify, sum, difference, product, linear/simultaneous equations.
  - b) Rules: deducing sum/difference/product/quotient of algebraic symbols/terms.
  - c) Laws of Indices: applied to algebraic symbols.
  - d) Equations: represent quantities by symbols/translate phrases involving associated quantities into algebraic expressions, transpose simple equations.
  - e) Calculations: balance of equations whilst applying arithmetic operations, linear equations with one unknown, simultaneous equations with two unknowns.

## Outcome 2

Identify and use scientific principles.

### Objectives

To achieve this outcome the candidate must be able to

- 1) Identify calculations involving the fundamental and derived metric units of measurement.
  - a) Units: SI system, length, mass, time, velocity, acceleration, force, pressure, torque, work, energy, power.
  - b) Prefixes: mega (M), kilo (k), milli (m), micro ( $\mu$ ), nano (n), pico (p).
  - c) Calculations: length, area, volume
- 2) Identify calculations involving mass, force and moments.
  - a) Definition: mass, force, moment, static equilibrium.
  - b) Relationship: mass/force/acceleration, mass/weight (gravitational pull).
- 3) Identify calculations involving distance, time, velocity and acceleration.
  - a) Definitions: displacement, distance, speed, velocity, acceleration.
  - b) Quantities: vector, scalar.
  - c) Calculations: equations of linear motion for constant linear acceleration.
  - d) Graphs: distance/time (interpreting slope as speed), velocity/time (interpreting slope as acceleration, area under graph as distance moved).
- 4) Identify calculations involving energy, work and power.
  - a) Laws: conservation of energy.
  - b) Definitions: energy, work, power.
  - c) Potential energy: energy possessed by a body by virtue of its position (relationship  $KE = \frac{1}{2}mv^2$ )
  - d) Calculations: work done (force/distance graphs), simple problems involving work/energy/power/kinetic energy/potential energy.
- 5) Identify calculations involving temperature and heat.
  - a) Definitions: conduction, convection, radiation, temperature/heat (difference), specific heat capacity, sensible/latent heat (difference), specific latent heat.
  - b) Celsius scale: Fixed points ( $-273^{\circ}\text{C}$ ,  $0^{\circ}\text{C}$ ,  $100^{\circ}\text{C}$ )
  - c) Kelvin scale: absolute temperature, relationship to Celsius scale
  - d) Change of state: application/removal of heat (solids, liquids, gases)
  - e) Calculations: mass, specific heat capacity, temperature change, specific latent heat
- 6) Identify calculations involving friction and lubrication.
  - a) Laws: friction.
  - b) Definitions: static/dynamic friction (difference), coefficient of friction.
  - c) Calculations: coefficient of friction, linear friction, frictional torque.
- 7) Identify calculations involving machines
  - a) Definitions: machine as a device for changing magnitude/line of action of a force, force ratio (mechanical advantage), movement ratio (velocity ratio), efficient.
  - b) Gears: Ratio of a gearbox, size of gear wheels, drive/driven, simple/compound ratios, direction of rotation.

- c) Calculations: simple machines (screw jacks, levers), gear ratios.
- 8) Identify calculations involving electricity
- a) Atomic structure: protons, neutrons, electrons.
  - b) Definitions: current (flow of electrons, amperes), conductors, insulators, resistance.
  - c) Resistance: relationship between resistance of conductor and its length/cross-sectional area/specific material resistance, variation with temperature.
  - d) Effects: heat, magnetism, chemical
  - e) Measurement: voltmeter, ammeter, ohmmeter, oscilloscope.
  - f) Circuits: series, parallel, combined, circuit diagrams (resistors series/parallel).
  - g) Current flow: complete circuit, potential difference between two points, total flow same in all parts of the circuit.
  - h) Series circuits: current flow constant at all points, sum of voltages (potential difference, pd) is equal to applied voltage (electro-motive force, emf)
  - i) Ohm's law: function of current (I)/potential difference (V)/resistance (R),  $V = IR$ .
  - j) Power: product of potential difference/current (direct current circuits),  $P = I^2R$ , dissipation in simple circuits.
  - k) Capacitors: action, charging/discharging, series/parallel, energy stored ( $Q = VC$ ).
  - l) Calculations: Ohm's law, formulae for equivalent resistance of resistors in series/parallel, current/voltage in series/parallel/combined circuits.

### Outcome 3

Identify and use methods of communication.

#### Objectives

To achieve this outcome the candidate must be able to

- 1) Identify the need for language and the common forms in use
  - a) Documents: manufacturers' manuals, workshop instructions, technical reports graphical (bar charts, histograms, graphs).
  - b) Write: Technical/commercial letters (job application, curriculum vitae résumé), instruction sheets, bar charts, histograms, graphs, summarise (reports, instruction sheets).
- 2) Identify the use of common forms of graphical communications
  - a) Technical drawings/specifications: purpose (shape/dimensions/characteristics/location/layout of a component), constructional features, methods of repair.
  - b) Technical information: technical drawings, line/block diagrams, operating schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, video tape, CD ROM, computer systems.
  - c) Technical Drawings purpose: detail/assembly/location drawings, relationship between drawing office and workshop.
  - d) Information: projection (orthographic first/third angle, isometric, oblique, exploded, free hand sketches), unit of measurement, scale, material/specification, heat/protective treatments, tolerance, tool reference, warning notes.
  - e) Conventions/abbreviations: types of line, representations of common features, abbreviations in common use.
  - f) Dimensioning: from a datum, avoidance of accumulated errors.
  - g) Draw: orthographic first angle, isometric, oblique, exploded, single plane sectioned views, free hand sketches.
  - h) Operations: operations schedule: using a detailed drawing, logical sequence of operation, manufacturing a component (e.g. engine mounting bracket), remove/refit/assemble a component (e.g. oil filer).
  - i) Identification: components from drawings/specifications/data (technical drawings, diagrams, exploded views, manufacturers' servicing/repair/parts data/data sheets/wall charts).
  - j) Data: standards/manufacturers' tables/graphs/bar charts/pie charts (select materials for a particular application, select screw thread devices for fastening components/units, select recommended twist drill size for clearance/thread forming/countersinking, obtain specific information).
  - k) Colour coding: relationship between colour coding conventions/safety, wiring, mains electricity supply/vehicle electrics), pipes cylinders (compressed gases).
- 3) Identify the use of international standards
  - a) Standards: British Standards (BS), International Organisation for Standardization (ISO), Deuschtes Institut für Normag (DIN), Federal Motor Vehicle Safety Standard (FMVSS), Society of Automotive Engineers (SAE) Systeme International d'Unites (SI).
- 4) Identify the use of libraries and the selection of information from different sources
  - a) Location: library index, classification systems, document index/contents pages.
  - b) Sources: appropriate to each stage of investigation, use of trade/suppliers' catalogues.
- 5) Identify sources of technical information

- a) Technical descriptions: workshop equipment/processes, vehicle systems/components.
  - b) Reports: experimental data, workshop processes.
- 6) Identify and operate computer information technology systems.
- a) Hardware: computer, input devices, printers/plotters, visual display units/monitors, storage devices, communications, interfaces to other equipment.
  - b) Software: operating systems, word processing, database, spreadsheets, presentation.
  - c) Functions: input unit, central processing unit, output stage, storage unit.






## Assessment

### ***Essential knowledge assessment***

Essential knowledge will be assessed using the GOLLA system. The test specification is as follows:

Outcome	Number of questions
1	8
2	9
3	8
Test duration 75mins	Total 25

## Mathematics, Science and Electronics

 Further guidance available	 Observation of your task/work	 Evidence recording	 Computer based testing	 Verbal Questioning
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### Note

This unit will **not** be appropriate for all automotive candidates. It is designed to extend the skills and knowledge of the more academically able students who may wish to progress to higher qualifications. Therefore, centres should ensure that initial assessment is used to determine suitability.



### Evidence requirements

To complete this unit you will be required to undertake knowledge and practical tests

For the knowledge test you must pass the City & Guilds computer based (GOLA) multiple choice knowledge test. This test will be arranged by your tutor or assessor.

The practical tests are covered in the VRQ information section.

You must also complete the attached recording forms to the satisfaction of your assessor. These forms, when completed and signed by you and your assessor, provide confirmation that you have met both practical and knowledge requirements.

Your tutor or assessor will be able to offer you further guidance on the evidence you need to provide.



### Information for VRQs (Technical Certificates).

#### To complete this unit you must:

Produce evidence of practical application of **each** objective in this unit. It is expected that this evidence will be collected through class work, homework and assignment work on an ongoing basis. The use of short answer questions is recommended in many cases. Verifiers will be looking to see that the works is contextualised to the automotive field.


All work records/evidence should be numbered (portfolio reference number PRN) and entered where required on the recording forms. This evidence should be collected in a portfolio and may need to be made available to your internal verifier or the City & Guilds external verifier.

Your assessor will ask questions to ensure you understand the practical task you are performing.

# VRQ



## Evidence reference summary

	<b>Note:</b> Refer to the Evidence requirements for details of locations and types of assessment for this unit.	Portfolio reference number (PRN)
		<b>VRQ</b>
		Observed assessment
Outcome 1 objectives		
Outcome 2 objectives		
Outcome 3 objectives		

Supplementary evidence (if used) PRN			
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On line test reference for this unit PRN	
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## Unit assessment and verification declaration

<p><b>VRQ Candidate declaration:</b>          I confirm that the evidence listed for this unit is authentic and a true representation of my own work          Candidate name:.....          Candidate enrolment number:.....          Candidate signature:.....          Date: .....</p>
<p><b>VRQ Assessor declaration:</b>          I confirm that this candidate has achieved all the requirements of this unit with the evidence listed.          Assessment was conducted under the specified conditions and context, and is valid, authentic, reliable, current and sufficient.          Assessor name: .....          Assessor signature:.....          Date: .....          Countersignature: (if relevant).....          Date: .....</p>
<p><b>VRQ Internal verifier Declaration:</b>          (Leave blank if sampling of this unit did not take place.)          I have internally verified the assessment work on this unit in the following ways (please tick):</p> <ul style="list-style-type: none"> <li>• sampling candidate and assessment evidence</li> <li>• observation of assessment practice</li> <li>• discussion with candidate</li> <li>• other – please state:</li> </ul> <p>I confirm that the candidate’s work meets the standards specified for this unit and may be presented for external verification and/or certification.          Internal verifier name: .....          Internal verifier signature: ..... Date: .....          Countersignature: (if relevant) ..... Date: .....</p>

## Key/Core skills signposting

Key Skills	Core Skills
<b>Communication:</b> C2.1; C2.2; C2.3	<b>Communication:</b> Access 3, Outcome 2 Intermediate 1, Outcome 3
<b>Application of Number:</b> N2.1; N2.2; N2.3	<b>Numeracy:</b> Access 3, Outcome 1 Intermediate 1, Outcomes 1, 2, 3 and 4
<b>Information Technology:</b> IT1.1; IT1.2; IT1.3	<b>Information Technology:</b> Access 3, Outcomes 1, 2 and 3
<b>Working with Others:</b> Not applicable	<b>Working with Others:</b> Not applicable
<b>Improving Own Learning and Performance:</b> LP2.1.3; LP2.2.2; LP2.2.3; LP2.3.1; LP2.3.3	<i>No parallel unit.</i>
<b>Problem Solving:</b> PS2.1; PS2.2; PS2.3	<b>Problem Solving:</b> Intermediate 1, Outcomes 1, 2 and 3



## ***Mathematics, Science and Electronics***

This unit covers maths, science and electronics skills associated with all aspects of repair, servicing and maintenance of vehicles.

### **Introduction**

The content of this unit relates only to the level 2 VRQ. Complete this unit in conjunction with the other level 2 units to convert the award from a certificate to a diploma.

### **Course outline**

This outline syllabus is a requirement for **Diploma** courses. It is presented as a number of outcomes that in turn each have a number of objectives and expanded content detail.

### **Outcomes**

On completion of this unit, the candidate must be able to:

- 1) Identify and use mathematical operations
- 2) Identify and use scientific principles
- 3) Identify and use electronic principles.

## Outcome 1

Identify and use mathematical operations.

### Objectives

To achieve this outcome the candidate must be able to

- 1) Identify algebraic operations
  - a) Definition: sequence, arithmetic progression, geometric progression, Binomial Theorem.
  - b) Sequence: formula for the ' $n$ th' term
  - c) Arithmetic progression: formula to represent the sum of ' $n$ ' terms
  - d) Geometric progression: formula to represent the sum of ' $n$ ' terms
  - e) Binomial Theorem: expand terms of the form  $(1 + x)^n$  where ' $n$ ' is a positive/negative integer, apply to relevant problems
  - f) Sequence: deduce relationships in simple sequence of the type 1, 2, 3, 4, 5 that can be represented as  $a(n) = n$  where  $n = 1$  to 5.
- 2) Identify statistical operations
  - a) Definitions: discrete/continuous data, sample/population, appropriate groups, frequency, relative frequency, frequency table, cumulative frequency data/curve (ogive), tally chart, bar chart/histogram, pie chart, line graph, pictogram, arithmetic mean, median, mode, central tendency, median, quartiles, percentiles, standard deviation, variance
  - b) Central tendency: appropriate measure (arithmetic mean, median, mode). Data sources: practical course work, publications
  - c) Applied forms: tally chart, frequency table, bar chart/histogram, pie chart, line graph, pictogram
  - d) Appropriate groups: equal/unequal from given data
  - e) Tally count: frequency, relative frequency of objects in each group
  - f) Ungrouped data: arithmetic mean, rank order, median/modal values, standard deviation
  - g) Grouped data: arithmetic mean, mode (using histogram), standard deviation
  - h) Cumulative frequency data: draw curve (ogive), determine median/quartiles/percentiles.
- 3) Identify geometric and trigonometric operations to plane figures.
  - a) Definitions: Theorem of Pythagoras, sine/cosine/tangent (right angled triangles), angle (as a measure of rotation), parallelogram, polygons.
  - b) Plane figures: square, rectangle, triangle, (acute-angled, right angled, obtuse-angled, equilateral, isosceles, scalene) parallelogram, polygons.
  - c) Angles: right angle, oblique (acute, obtuse), complementary, angle sum of a triangle
  - d) Calculations: perimeter/area/angles/diagonals: square, rectangle, triangle, parallelogram, polygon.
  - e) Right angled triangles: Pythagoras' Theorem applied to any third side, angle/length of side (using sine/cosine/tangent).
  - f) Triangles: construct from given information (three sides, two sides/included angle, one side/two angle).
- 4) Identify geometric operations to circles and cylinders.
  - a) Definitions: radius, diameter, circumference, chord, tangent, sector, segment, arc, radian.
  - b) Relationship: radius/diameter/circumference of a circle, angle properties of a circle, angle at centre of circle to angle at circumference.

- c) Tangent: angle between tangent and radius to tangent is a right angle.
- d) Calculations: Circles: radius, diameter, circumference, area.
- e) Cylinders: surface area, volume.
- f) Angles: degrees/minutes/seconds to radians, radians to degrees/minutes/seconds, angular rotation (multiples of radians), arcs/angles (measured in radians).

## Outcome 2

Identify and use scientific principles.

### Objectives

To achieve this outcome the candidate must be able to

- 1) Describe the types and properties of materials used in motor vehicle engineering and apply calculations
  - a) Definitions: tensile stress, yield stress, shear force, percentage elongation, percentage reduction in area
  - b) Plain carbon steels: physical/mechanical properties, heat treatment processes (hardening, tempering, annealing, normalising)
  - c) Fatigue: factors causing fatigue in metals, analyse fatigue failure in motor vehicle components
  - d) Shear force/bending moments simple horizontal cantilever, simply supported horizontal beam, vertical point loads, shear force; bending moment diagrams
  - e) Solid/tubular shafts: reasons for use, torsional/bending shear stress, applied torque, shaft diameter, bending/torsional qualities
  - f) Tests: tensile, impact, hardness
  - g) Calculations: tensile stress, yield stress, percentage elongation, percentage reduction in area, moment of inertia, modulus of section, solid/hollow shafts (torque, stress, shaft diameter).
- 2) Identify the terms used and calculations associated with tractive effort and tractive resistance
  - a) Definitions: tractive effort, tractive resistance, braking efficiency
  - b) Tractive resistance: components (rolling gradient/air resistance)
  - c) Calculations: energy dissipated/power required at constant velocity on level/inclined plane, accelerating/braking forces applied on level/inclined plane, braking efficiency (stopping distance, retardation).
- 3) Identify the terms used and calculations associated with centripetal and centrifugal force
  - a) Definitions: centripetal force; acceleration, centrifugal force/acceleration, mass-radius polygons
  - b) Centripetal: centripetal acceleration =  $v^2/r$
  - c) Centrifugal: force applied to wheel balancing/clutches, governors
  - d) Curved tracks: vehicles overturning/sliding on level track, vehicles on banked track (no lateral inward forces applied)
  - e) Calculations: centripetal force when balancing several masses rotating in the same plane, mass-radius polygons (several masses rotating in the same plane).
- 4) Identify the terms used and calculations associated with load transfer
  - a) Definitions: load transfer, linear retardation/acceleration.
  - b) Calculations: load transfer (linear retardation/acceleration/cornering).
- 5) Describe calculations involving mass, force and moments.
  - a) Vector Diagrams: resultant of two co-planar forces (piston loading).
  - b) Polygon of forces: resultant/equilibrium of three/more forces.
  - c) Moments: forces about a point, simple beams.
- 6) Describe calculations involving power

- a) Definitions: angular velocity, angular/linear velocity (difference), torque/power (difference), thermal efficiency.
- b) Calculations: angular/linear velocity, indicated power ( $P_i$ ), brake power ( $P_b$ ), fuel efficiency, volumetric efficiency, thermal efficiency.

### Outcome 3

Identify and use electronic principles.

#### Objectives

To achieve this outcome the candidate must be able to

- 1) Describe analogue and digital systems
  - a) Definition: analogue system, digital system, difference, AND, OR, NOT, NAND, NOR, XOR, buffers  
Logic gates: AND, OR, NOT, NAND, NOR, XOR, buffers
  - b) Calculations: truth tables. AND, OR, NOT, NAND, NOR, XOR, buffers.
- 2) Describe the binary (electronic) nature of modern digital computers
  - a) Definition: binary numbering system, bit, nibble, byte, word
  - b) Calculations: binary system.
- 3) Identify numbers using a range of numbering systems
  - a) Definitions: number bases (octal, hexadecimal)
  - b) Calculations: octal, hexadecimal.
- 4) Describe the conversion of numbers from one number base to another
  - a) Definitions: denary system
  - b) Conversions: binary to denary, denary to binary, binary to octal, octal to binary, binary to hexadecimal, hexadecimal to binary.
- 5) Describe addition and subtraction in binary
  - a) Definitions: one's/two's complement arithmetic
  - b) Calculations: adding/subtracting binary numbers, one's/two's complement arithmetic.
- 6) Describe the function and role of microelectronic systems within motor vehicles
  - a) Microelectronic systems: development, advancement, advantages.
- 7) Describe the main components of microprocessor based systems
  - a) Definitions: RAM, ROM, KAM, EPROM, A/D, D/A, CPU, ALU
  - b) Components: memory (RAM, ROM, KAM, EPROM), timing of memory (read, write), input/output sections (A/D, D/A), CPU, (ALU, registers, accumulator), information buses.
- 8) Identify the functions of microcomputer systems
  - a) Function: block diagram (microcomputer), operation of adding two numbers, flag registers.
- 9) Identify BASIC programming language instructions and methods
  - a) IF, THEN, ELSE
  - b) GOTO
  - c) PRINT
  - d) CLS
  - e) CALL
  - f) SET (states, calculations)
  - g) DIM (variables)

10) Describe the function of electronically controlled systems






- a) Block diagram: showing input/output devices, components, component links to ECU.

### ***Essential knowledge assessment***

Essential knowledge will be assessed using the GOLLA system. The test specification is as follows:

Outcome	Number of questions
1	8
2	9
3	8
Test duration 75mins	Total 25

## Advanced Mathematics, Science and Electronics

 Further guidance available	 Observation of your task/work	 Evidence recording	 Computer based testing	 Verbal Questioning
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### Note

This unit will **not** be appropriate for all automotive candidates. It is designed to extend the skills and knowledge of the more academically able students who may wish to progress to higher qualifications. Therefore, centres should ensure that initial assessment is used to determine suitability.



### Evidence requirements

To complete this unit you will be required to undertake knowledge and practical tests

For the knowledge test you must pass the City & Guilds computer based (GOLA) multiple choice knowledge test. This test will be arranged by your tutor or assessor.

The practical tests are covered in the VRQ information section.

You must also complete the attached recording forms to the satisfaction of your assessor. These forms, when completed and signed by you and your assessor, provide confirmation that you have met both practical and knowledge requirements.

Your tutor or assessor will be able to offer you further guidance on the evidence you need to provide.



### Information for VRQs (Technical Certificates).

#### To complete this unit you must:

Produce evidence of practical application of **each** objective in this unit. It is expected that this evidence will be collected through class work, homework and assignment work on an ongoing basis. The use of short answer questions is recommended in many cases. Verifiers will be looking to see that the works is contextualised to the automotive field.

All work records/evidence should be numbered (portfolio reference number PRN) and entered where required on the recording forms. This evidence should be collected in a portfolio and may need to be made available to your internal verifier or the City & Guilds external verifier.


Your assessor will ask questions to ensure you understand the practical task you are performing.

# VRQ





## Evidence reference summary

	<b>Note:</b> Refer to the Evidence requirements for details of locations and types of assessment for this unit.	Portfolio reference number (PRN)
		<b>VRQ</b>
		Observed assessment
Outcome 1 objectives		
Outcome 2 objectives		
Outcome 3 objectives		

Supplementary evidence (if used) PRN			
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On line test reference for this unit PRN	
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## Unit assessment and verification declaration

<p><b>VRQ Candidate declaration:</b>          I confirm that the evidence listed for this unit is authentic and a true representation of my own work          Candidate name:.....          Candidate enrolment number:.....          Candidate signature:.....          Date: .....</p>
<p><b>VRQ Assessor declaration:</b>          I confirm that this candidate has achieved all the requirements of this unit with the evidence listed.          Assessment was conducted under the specified conditions and context, and is valid, authentic, reliable, current and sufficient.          Assessor name: .....</p>
<p><b>VRQ Internal verifier Declaration:</b>          (Leave blank if sampling of this unit did not take place.)          I have internally verified the assessment work on this unit in the following ways (please tick):              sampling candidate and assessment evidence              observation of assessment practice              discussion with candidate              other – please state:          I confirm that the candidate's work meets the standards specified for this unit and may be presented for external verification and/or certification.          Internal verifier name: .....          Internal verifier signature: ..... Date: .....          Countersignature: (if relevant) ..... Date: .....</p>

## Key/Core skills signposting

Key Skills	Core Skills
<b>Communication:</b> C2.1; C2.2; C2.3	<b>Communication:</b> Access 3, Outcome 2 Intermediate 1, Outcome 3
<b>Application of Number:</b> N2.1; N2.2; N2.3	<b>Numeracy:</b> Access 3, Outcome 1 Intermediate 1, Outcomes 1, 2, 3 and 4
<b>Information Technology:</b> IT1.1; IT1.2; IT1.3	<b>Information Technology:</b> Access 3, Outcomes 1, 2 and 3
<b>Working with Others:</b> Not applicable	<b>Working with Others:</b> Not applicable
<b>Improving Own Learning and Performance:</b> LP2.1.3; LP2.2.2; LP2.2.3; LP2.3.1; LP2.3.3	<i>No parallel unit.</i>
<b>Problem Solving:</b> PS2.1; PS2.2; PS2.3	<b>Problem Solving:</b> Intermediate 1, Outcomes 1, 2 and 3

# Advanced Mathematics, Science and Electronics

This unit covers maths, science and electronics skills associated with all aspects of repair, servicing and maintenance of vehicles.

## Introduction

The content of this unit relates only to the level 3 VRQ. Complete this unit in conjunction with the other level 3 units to convert the award from a certificate to a diploma.

## Course outline (VRQ)

This outline syllabus is a requirement for **Diploma** courses. It is presented as a number of outcomes that in turn each have a number of objectives and expanded content detail.

## Outcomes

On completion of this unit, the candidate must be able to:

- 1) Describe and use mathematical operations
- 2) Describe and use scientific principles
- 3) Describe and use electronic principles and systems.

## Outcome 1

Describe and use mathematical operations.

### Objectives

To achieve this outcome the candidate must be able to

- 1) Describe graphical operations
  - a) Definitions: reduction of laws to linear form, specified interval, range, simultaneous equations
  - b) Two linear equations: two unknowns, plot curves, determine point of intersection
  - c) Quadratic/linear equations: plot curves, determine points of intersection, quadratic equations plot curve, determine roots from intersections with x-axis
- 2) Describe calculus operations
  - a) Definitions: average/instantaneous gradient, differentiation, incremental changes ( $\delta x$ ,  $\delta y$ ),  $\delta y/\delta x$  as limiting value of the ratio  $\delta y/\delta x$  when  $\delta x \rightarrow 0$ , 'function of a function' rule, integration (reverse of differentiation), definite/indefinite integral
  - b) Differentiation: show from first principles  $\lim_{\delta x \rightarrow 0} \delta y/\delta x = dy/dx$ , differential property of exponential/logarithmic functions, product rule quotient rule
  - c) Integration: importance of a constant, express area under a graph between ordinates  $x = a$  and  $x = b$  as approximately the sum of the strips of length  $y$  and width  $\delta x$ , define  $\int_a^b y \, dx$  as area under the graph between ordinates  $x = a$  and  $x = b$
- 3) Describe mensuration operations
  - a) Definitions: trapezoidal rule, mid-ordinate rule, Simpson's rule, centroids.
  - b) Calculations and diagrams: draw from given data to a suitable scale
  - c) Irregular sections: area (mid-ordinate rule, Simpson's rule)
  - d) Graphs: area under a curve between stated limits (trapezoidal rule, mid-ordinate rule)
  - e) Position of centroids: rectangles, triangles,
- 4) Identify trigonometric operations
  - a) Definitions: secant/cosecant/cotangent (right angled triangles), quadrant rule, semi-perimeter of a triangle ( $s$ ).
  - b) Sine rule:  $a/\sin A = b/\sin B = c/\sin C$ , conditions of use
  - c) Cosine rule:  $a^2 = b^2 + c^2 - 2bc \cos A$ , conditions of use
  - d) Relationship:  $\tan \theta = \sin \theta / \cos \theta$ ,  $\sin^2 \theta + \cos^2 \theta = 1$
  - e) Tangent graph: draw from  $\theta = -90^\circ$  to  $+270^\circ$
  - f) Triangles: area (formula  $\text{Area} = \frac{1}{2} ab \sin C$ ,  $\text{Area} = \sqrt{[s(s-a)(s-b)(s-c)]}$  using semi perimeter of the triangle ( $s$ ), where  $s = \frac{1}{2} (a + b + c)$
  - g) Quadrant rule: sine/cosine/tangent for angles of any magnitude
  - h) Angles: sine/cosine/tangent using  $\tan \theta = \sin \theta / \cos \theta$ ,  $\sin^2 \theta + \cos^2 \theta = 1$
  - i) Triangles: using sine/cosine rules,  $\text{Area} = \frac{1}{2} ab \sin C$ ,  $\text{Area} = \sqrt{[s(s-a)(s-b)(s-c)]}$
  - j) Electronic calculator: secant/cosecant/cotangent (angles between  $0^\circ - 90^\circ$ )

## Outcome 2

Describe and use scientific principles

### Objectives

To achieve this outcome the candidate must be able to

- 1) Analyse information identifying the terms used and calculations associated with the deflection of beams
  - a) Definitions: Macaulay expressions for bending moments, boundary conditions, slope/deflection diagrams
  - b) Calculations: bending moments (concentrated/uniformly distributed loads), unknowns (inserting known boundary conditions), slope/deflection diagrams, maximum deflection (position/value).
- 2) Analyse information identifying the terms used and calculations associated with turning moment diagrams
  - a) Definitions: flywheel (energy storing device), turning moment diagrams, energy fluctuation (during a cycle), coefficient of fluctuation of speed, moment of inertia (flywheel)
  - b) Calculation: turning moment diagrams (single/multi-cylinder/in-line/vee engines), maximum energy fluctuation (during a cycle), fluctuation coefficient of speed, moment of inertia (flywheel), flywheel specifications
- 3) Identify the terms used and calculations associated with the energy of rotation
  - a) Definitions: angular/linear acceleration, angular motion, kinetic energy, radius of gyration ( $k$ ), moment of inertia ( $I$ )
  - b) Angular motion: equations ( $\omega_2 = \omega_1 + \alpha t$ ,  $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$ ,  $\omega_2^2 = \omega_1^2 + 2\alpha\theta$ )
  - c) Kinetic energy: single mass rotating in a circular path,  $KE = \frac{1}{2}mr^2\omega^2 = \frac{1}{2}I\omega^2$
  - d) Moment of inertia: = mass x (radius of gyration)<sup>2</sup>
  - e) Torque = moment of inertia x angular acceleration
  - f) Work = torque x angle (radians)
  - g) Power = torque x angle (radians/time)
  - h) Calculations: angular motion (e.g. road wheel movement), kinetic energy, moment of inertia, torque, work, power, flywheel (kinetic energy, energy change)
  - i) Turning moment diagrams: produce graphically for single/four cylinder engines, use to explain design/purpose of a flywheel.
- 4) Identify the terms used and calculations associated with simple harmonic motion
  - a) Definitions: simple harmonic motion, frequency, amplitude, velocity/acceleration/force at an instant in terms of displacement
  - b) Calculations: simple harmonic motion.
- 5) Analyse information identifying the terms used and calculations associated with tractive effort and tractive resistance
  - a) Definitions: tractive effort, tractive resistance, constant power resistance curves, road speed curves, power available at road wheels, performance curves, under/over gearing
  - b) Principle: engine torque/power curves in selecting suitable gear ratios, reasons why actual ratios differ from ideal ratios
  - c) Overall top gear ratio: top gear x final drive ratio (allowing for road wheel diameter), constant power, tractive effort/road speed curves

- d) Calculations: tractive effort, tractive resistance, resistance curves, power available at road wheels, maximum speed, performance curves (under/over gearing, effect on maximum speed), engine speed ratio (rpm maximum torque/rpm maximum power), first gear ratio (maximum gradient/rolling resistance), intermittent gear ratios (engine speed ratio).
- 6) Analyse information identifying the terms used and calculations associated with relative velocity
- a) Definitions: relative velocity, velocity diagrams
  - b) Calculations: relative velocity/velocity diagrams (vehicles on the road, engine connecting rod/crank mechanism).
- 7) Analyse information identifying the terms used and calculations associated with shear force and bending moments
- a) Definitions: centroid, first moment of area, second moment of area, modulus of section, maximum allowable stresses, bending moments, loading conditions, load diagrams
  - b) Principles: simple bending theory (first principles),  $M/I = \delta/Y = E/R$
  - c) Calculations: centroid, first moment of area, second moment of area, rectangular/circular/I-section beams (maximum allowable stresses, bending moments, loading conditions), modulus of section, bending moment/load diagrams/reactions (simple horizontal cantilever/beam carrying point loads/uniformly distributed loads), shear force/loaded beams), shear force diagrams (locating points of zero shear force).

### Outcome 3

Describe and use electronic principles and systems

#### Objectives

To achieve this outcome the candidate must be able to:

- 1) Identify how machine language instructions are coded and stored
  - a) Definitions: program counter, instruction register, operation codes, op. codes, operand, most/least significant bit
  - b) Function: program counter, instruction register.
- 2) Identify the steps required to execute machine language instructions
  - a) Sequence of events: two byte instruction execution, flow charts.
- 3) Describe machine code programming
  - a) Operations: machine code mnemonics (data transfer instructions, arithmetic/logical instructions, test/branch instructions),
  - b) Illustrate a typical fetch execute cycle for three instruction program (add the contents of two successive memory locations and store the sum into a third location).
- 4) Describe interrupts
  - a) Definitions: interrupt
  - b) Purpose/operation: interrupt function
  - c) Program simple program showing use of interrupt instruction.
- 5) Analyse, with the use of diagrams, information identifying open and closed loop systems
  - a) Definitions: open loop, closed loop
  - b) Systems: Engine control, transmission control, ABS, TCR, cruise control, climate control
- 6) Analyse information identifying the methods employed to diagnose faults in electronic systems
  - a) Visual warnings: warning lights, information displays, nil operation
  - b) Verbal: information from driver
  - c) Specifications/data: manufacturers' charts/diagrams, wiring diagrams
  - d) Fault codes: stored in computer memory
  - e) Equipment: general, dedicated, multimeter, hand tools
  - f) Procedures: electronic component/units, sensors, logical methods, determine nature of circuit, test equipment connections, observe/record/ compare meter readings, removal for further testing, wiring tests, voltage checks at computer inputs/outputs.
- 7) Analyse information identifying computer fault codes and code reading equipment
  - a) Computer fault diagnostics: fault detection, pre-set code storage in memory, diagnostic links, vehicle computer diagnostic mode, manufacturers' fault code data
  - b) OBD, EOBD
  - c) Test equipment: diagnostic computer, decoders, low power probe (LED), multimeter, scanners.
- 8) Analyse, with the use of diagrams, information identifying multiplexed systems
  - a) Definitions: Controller area network
  - b) Systems: High speed, low speed
  - c) Protocol

# Assessment

## *Essential knowledge assessment*

Essential knowledge will be assessed using the GOLLA system. The test specification is as follows:

<b>Outcome</b>	<b>Number of questions</b>
1	8
2	9
3	8
Test duration 75mins	Total 25