# IVQ in Engineering Skills 1155

City & Guilds

www.cityandguilds.com

**Certificate/Diploma**
**Engineering Skills**
**Electrical Engineering**
**Metal Machining**
**Mechanical Fitting**
**Fabrication, Welding & Pipework Principles**
**Electronic Engineering**

**Publications and enquiries**
City & Guilds publications are available from

**Publications Sales**
**City & Guilds**
**1 Giltspur Street**
**London EC1A 9DD**
**United Kingdom**
**T +44 (0)20 7294 2850**
**F +44 (0)20 7294 3387**

General information about City & Guilds may be obtained from Customer Relations at the above address, or on 020 7294 3500, or by e-mailing **international@city-and-guilds.co.uk**

**Equal opportunities**
City & Guilds fully supports the principle of equal opportunities and we are committed to satisfying this principle in all our activities and published material.



**1 Giltspur Street**
**London**
**EC1A 9DD**
**T +44 (0)20 7294 2468**
**F +44 (0)20 7294 2400**
**www.cityandguilds.com**

# IVQ in Engineering Skills 1155

**Certificate/Diploma**
**Engineering Skills**
**Electrical Engineering**
**Metal Machining**
**Mechanical Fitting**
**Fabrication, Welding & Pipework Principles**
**Electronic Engineering**

ST82793/01.04/F-00039460

[ This page is intentionally blank ]

# Contents

# IVQ in Engineering Skills 1155

## About City & Guilds

We provide assessment and certification services for schools and colleges, business and industry, trade associations and government agencies in more than 100 countries. We have over 120 years of experience in identifying training needs, developing assessment materials, carrying out assessments and training assessment staff. We award certificates to people who have shown they have mastered skills that are based on world-class standards set by industry. City & Guilds International provides a particular service to customers around the world who need high-quality assessments and certification.

## Introduction to this programme

We have designed the Engineering Skills programme for those undergoing training or employed in this area of work. The programme aims to reflect the international nature of the knowledge and skills and activities needed for different countries or cultures.

We do not say the amount of time a candidate would need to carry out the programme, but we do provide advice on hours of learning support for each unit at each level (see below). The programme has two levels.

**Certificate**
The Certificate (about 300 hours of learning support) provides a broad introduction to the theory and practical skills suitable for those candidates starting a career in one of the fields of engineering.

**Diploma**
The Diploma (about 300 hours of learning support) provides more in depth theory, practical skills and underpinning knowledge suitable for those candidates committed to a career in Mechanical Fitting, Plant Maintenance, Metal Machining, Electrical Engineering, Fabrication, Welding or Pipework and Electronic Engineering.

We stress that these figures are only a guideline. We award certificates for gaining and showing skills by whatever mode of study, and not for periods of time spent in study.

We provide certificates for all work-related areas at seven levels within our structure of awards shown in Appendix B. This programme covers levels 1 and 2.

## Making entries for assessments

Candidates can only be entered for the assessments in this subject if the approved examination centres agree. Candidates must enter through an examination centre we have approved to carry out the assessments for **1155 Engineering Skills.**

There are two ways of entering candidates for assessments.

**Internal candidates**
Candidates can enter for examinations if they are taking or have already finished a course at a school, college or similar training institution that has directed their preparation, whether by going to a training centre, working with another institution, or by open learning methods.

**External candidates**
These are candidates who have not finished a programme as described above. The examination centres must receive their application for entry well before the date of the examination concerned. This allows them to act on any advice you give about assessment arrangements or any further preparation needed. External candidates must carry out practical assignments and projects if necessary, and they will need extra time and guidance to make sure that they meet all the requirements for this part of the assessment.

In this publication we use the term 'centre' to mean a school, college, place of work or other institution.

## Resources

If you want to use this programme as the basis for a course, you must read this syllabus and make sure that you have the staff and equipment to carry out all parts of the programme. If there are no facilities for realistic practical work, we strongly recommend that you develop links with local industry to provide opportunities for hands-on experience.

## Assessment

There are two levels of this award.

**Certificate**
**Diploma**

We use a numbering system to allow entries to be made for our awards. The numbers used for this programme are as follows.

**Award number**
1155-01 Certificate in Engineering Skills

1155-02 Diploma in Engineering Skills (option taken)

We use award numbers to describe the subject and level of the award.

**Component numbers**
001 Engineering Skills Principles 1
002 Engineering Skills Practice 1
011 Engineering Skills Principles 2
012 Engineering Skills Practice 2
013 Electrical Engineering Principles
014 Electrical Engineering Practice
015 Metal Machining Principles
016 Metal Machining Practice
017 Mechanical Fitting and Plant Maintenance Principles
018 Mechanical Fitting and Plant Maintenance Practice
019 Fabrication, Welding and Pipework Principles
020 Fabrication, Welding and Pipework Practice
021 Electronic Engineering Principles
022 Electronic Engineering Practice

We use component numbers to show units for which we may award a certificate of unit credit.

We use these numbers throughout this syllabus. You must use these numbers correctly if you send forms to us.

**Certificate in Engineering Skills**
To carry out what is needed for the Certificate in Engineering Skills, candidates must be successful in the following assessments.

1155-01-001 Engineering Skills Principles 1 (written multiple choice paper which lasts one and a half hours)

[1155-01-002] Engineering Skills Practice 1 (Total one written multiple choice paper)

The practical assessments are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us. (See Appendix A.)

**Diploma in Engineering Skills**
To carry out what is needed for the Diploma in Engineering Skills, candidates must be successful in the following assessments.

1155-02-011 Engineering Skills Principles 2 (written multiple choice paper which lasts one and a half hours)

[1155-02-012] Engineering Skills Practice 2

Candidates must also be successful in one pair of the following assessments.

1155-02-013 Electrical Engineering Principles (written multiple choice paper which lasts one and a half hours)

[1155-02-014] Electrical Engineering Practice

or

1155-02-015 Metal Machining Principles (written multiple choice paper which lasts one and a half hours)

[1155-02-016] Metal Machining Practice

or

1155-02-017 Mechanical Fitting and Plant Maintenance Principles (written multiple choice paper which lasts one and a half hours)

[1155-02-018] Mechanical Fitting and Plant Maintenance Practice

or

1155-02-019 Fabrication, Welding and Pipework Principles (written multiple choice paper which lasts one and a half hours)

[1155-02-020] Fabrication, Welding and Pipework Practice (Total two written multiple choice papers)

or

1155-02-021 Electronic Engineering Principles (written multiple choice paper which lasts one and a half hours)

[1155-02-022] Electronic Engineering Practice

The practical assessments are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us. (See Appendix A.)

We provide assessments in two ways.

**a Fixed date**
These are assessments that are carried out on dates and times we set. These assessments have no brackets around their numbers.

**b Free date**
These are assessments that are carried out at a college or other training establishment on a date or over a period that the college chooses. These assessments have brackets around their numbers.

In this programme the written assessments are fixed date. The practical assessments are free date.

You must carry out assessments according to our International Directory of Examinations and Assessments. If there are any differences between information in this publication and the current directory, the directory has the most up-to-date information.

## Results and certification

Everyone who enters for our certificates and diplomas receives a 'Notification of Candidate Results' giving details of how they performed.

If candidates successfully finish any assessment within this programme (for example, any one of the examination papers) they will receive a certificate of unit credit towards the certificate or diploma for which they are aiming. We grade course work assessments as pass or fail. We grade written assessments on the basis of fail, pass, credit or distinction. The certificate of unit credit will not mention assessments that they do not enter, which they failed or from which they were absent.

Each certificate or diploma clearly states what candidates need for full certification at the relevant level, allowing schools, colleges and employers to see whether they have met the full requirements.

If candidates successfully finish all the requirements for a full certificate or a diploma, they will automatically receive the appropriate certificate.

We will send the 'Notification of Candidate Results', certificates of unit credit, certificates and diplomas to the examination centre to be awarded to successful candidates. It is your responsibility to give the candidates the certificates. If candidates have a question about the results and certificates, they must contact you. You may then contact us if necessary.

We will also send you a results list showing how all candidates performed.

## How to offer this programme

To offer this programme you must get approval from us. There are two categories of approval.

**Subject approval**
We give approval to offer a teaching course based on this syllabus.

**Examination centre approval**
We give approval to enter candidates for examinations.

To be approved by us to offer a teaching course you must send us the application form.

To enter candidates for examinations you must be approved by us as an examination centre. For this programme it is possible to act as a registered examination centre only, and accept external candidates. Approved examination centres must provide suitable facilities for taking examinations, secure places to keep the examination papers and materials, and may have an appointed visiting verifier to review practical work.

After we have received and accepted an application, we will send an approval letter confirming this. You can then send entries in at any time using the International Directory of Examinations and Assessments for guidance.

**Please note that in this section we have provided an overview of centre approval procedures. Please refer to the current issue of 'Delivering International Qualifications – Centre Guides' for full details of each aspect of these procedures.**

## Other information

### Designing courses of study

Candidates for the various Engineering Skills awards will have come from different backgrounds and will have different employment and training experiences. We recommend the following:

- carry out an assessment of the achievements so you can see what learning they already have and decide the level of entry they will need; and
- consider what learning methods and places will best suit them.

When you assess a candidate's needs, you should design teaching programmes that consider:

- what, if any, previous education, qualifications or training the candidate has, especially in the various general vocational education certificates we provide; and
- what, if any, previous practical experience the candidate has which is relevant to the aims of the programme and from which they may have learned the relevant skills and knowledge.

When you choose learning methods and places, you should consider the results of your assessments and whether the following are available.

- Open or distance learning material.
- Workplace learning that can be carried out on site or between you and a local workplace. This will allow the candidates access to specialised equipment and work experience.
- Working with other registered centres to share facilities.
- Opportunities for co-operative learning between candidates for different certificates who need to gain similar skills.

As long as the candidates meet the aims of this learning programme the structures of courses of study are up to you. So, it is possible to include extra topics that meet local needs.

You should avoid teaching theory alone. As far as possible the practical work should be closely related to work in the classroom so that candidates use their theory in a realistic work environment. You can use formal lectures in the classroom with appropriate exercises and demonstrations. Candidates should keep records of the practical work they do so they can refer to it at a later date.

We assume that you will include key skills, such as numeracy, communication, working with people, and organisation and planning throughout a teaching programme.

### Presentation format of units

**Practical competences**
Each unit starts with a section on practical competences which shows the practical skills candidates must have.

At times we give more detail about important words in each 'competence statement'.

For example:

Identify dangerous items of clothing.
**Dangerous clothing:** ties, long sleeves, torn clothing and long hair near moving parts of machinery.

In the above statement the word 'dangerous clothing' is given as a range which the candidate should be familiar with. Candidates should cover the complete range. When a range starts with the abbreviation 'eg' the candidates only need to cover some of the ranged areas or you can use suitable alternatives.

**Knowledge requirements**
Immediately after the section on practical competences the unit tells you what knowledge is needed for that area. The knowledge needed is closely linked to the practical competences, so it is best to teach the two together so that the candidate appreciates the topic more.

**Practical activities**
You should make sure all practical activities are supervised and instructors should make sure that the results reflect the candidate's own work. You must hold all the documents and material in a file (portfolio) for each candidate for six months after the application for a certificate.

## Entry levels

We consider the following programmes to be relevant preparation for this programme.

Successful completion of secondary schooling

Skills Certificate in Health and Safety (1100)

## Progression routes and recognition

We consider the following programmes to be relevant progression routes from this programme.

Technician Certificate awards in Engineering (2565)

Technician Certificate awards in Electrical and Electronic Engineering (8030)

## Useful publications

We can provide a list of suggested text books covering specific areas of this programme. We may also have knowledge about other support materials. You should make sure that you have the latest information. We will automatically send updated lists to centres we have approved to offer this programme.

We offer the following publications as additional support materials to help you plan the delivery of International Vocational Qualifications:

**Guide to the Assessment of Practical Skills in International Vocational Qualifications**

**Preparing Projects and Portfolios for International Vocational Qualifications**

**Quality Handboook for Visiting Verifiers and Quality Inspectors**

# Syllabus
## IVQ in Engineering Skills 1155

**Component and section numbers**

**Certificate**

| | |
|---|---|
| **001** | **Engineering Skills Principles 1** |
| 1 | Safety at Work |
| 2 | Maths and Drawing |
| 3 | Materials |
| 4 | Science |
| 5 | Hand and Machine Tools |
| 6 | Communication |
| 7 | Measuring and Marking Out |
| 8 | Fastening and Joining |

# 1 Core Skills: Safety at Work

## Introduction

The aim of this section is to enable the candidate to:

a Carry out safe working practices and procedures to ensure the safety of themselves, other personnel and members of the public.
b Carry out emergency procedures.
c Carry out a risk assessment and prepare an accident report.

## Practical competences

In a real or simulated task the candidate should be able to:

1.1 Select protective clothing and equipment use and return to store.

1.2 Carry out safe working practices when using non-portable powered machinery in accordance with national/local standards.

1.3 Carry out manual handling operations

1.4 Carry out the safe movement of materials and components, observing safe working loads, using mechanical lifting and ancillary equipment.

1.5 Identify faults in lifting aids and equipment.

1.6 Use and transport ladders safely.

1.7 Use electrical equipment in accordance with national/local standards.

1.8 Carry out the correct procedure to isolate a person in contact with a simulated live single phase electrical supply.

1.9 Carry out resuscitation treatment.

1.10 Observe safe working practices to reduce health hazards when in contact with toxic materials, liquids, dust or fumes.

1.11 Select correct equipment and carry out basic fire fighting techniques in simulated conditions.

1.12 Pressure test a low pressure container using water.

1.13 Apply good house keeping practices at all times.

a clean tidy work areas
b removal/disposal of waste products
c no overhanging sharp edges
d no unmarked hot objects left on bench.
e gangways free from obstructions.

1.14 Carry out a risk assessment and prepare a report identifying potential health hazards.

1.15 Prepare an accident report for a simulated accident.

1.16 Participate in emergency procedures.

a procedures
b raising alarm
c alarm types

1.17 Safe/efficient evacuation.

a a means of escape
b assembly points
c emergencies
d fire drill
e bomb warning

## Knowledge requirements

The candidate will be able to:

1.1 State the employer's responsibilities towards the maintenance of health and safety.
**Employer's responsibilities:** safe place of work, safe plant and equipment, safe system of work (ie safe working methods, provision of protective clothing where applicable), safe working environment (ie provision of reasonable temperature, humidity, ventilation, fume and dust control, adequate washing facilities, sanitation and first aid facilities), safe methods of handling, storing and transporting goods and identification of dangerous materials, information, instruction, training and supervision of employees, records

1.2 State the employee's responsibilities towards the maintenance of health and safety.
**Employee's responsibilities:** the need to take reasonable care of their own health together with that of other people, the misuse of, or interference with, equipment provided for health and safety, compliance with company/legal health and safety issues

1.3 Describe in general terms the human and environmental conditions leading to accidents in the workplace and the means of controlling them.
**Conditions:** human causes of accidents (ie carelessness; improper behaviour and dress, lack of training, supervision and experience, fatigue, drug taking and drinking), environmental causes of accidents (ie unguarded or faulty machinery and tools, inadequate ventilation, untidy, dirty, overcrowded or badly-lit work places)
**Prevention:** eliminate the hazard, replace the hazard with something less dangerous, guard the hazard, personal protection, safety education and publicity

1.4 Identify protective clothing and equipment suitable for given situations.
**Protective clothing and equipment:** overalls, footwear, snood/cap, helmets, aprons, eye and face protection, ear defenders, dust masks, gloves, special equipment eg respirators

1.5 Identify dangerous items of clothing.
**Dangerous clothing:** ties, long sleeves, torn clothing and long hair near moving parts of machinery

1.6 Identify protective equipment for non- portable powered machinery.
**Protective equipment:** machine guards, screens, fences, warning notices, stop buttons/isolation devices

1.7 State the safe working practices to be observed when carrying out manual handling operations.
**Safe practices:** correct posture when lifting and carrying, use of crowbars, levers and rollers

1.8 State the precautions to be observed when moving materials into, within and out of the workshop and on site with mechanical lifting and ancillary equipment.
**Precautions:** safe working loads, test certificates, periodic testing, safe/secure lifting points, handling and slinging methods, crane signalling

1.9 Identify the types and applications of lifting aids and accessories.
**Lifting aids:** block and tackle, pull lifts, rope, wire and chain slings, lifting clamps and dogs, eyebolts and shackles, jacks, trestles and stands

1.10 State the dangers of using faulty/misusing lifting aids and techniques.
**Dangers:** knots in slings, damaged slings, loads with sharp corners, loose and swinging loads, wrapped and greased loads, handling materials under adverse conditions

1.11 Describe the precautions to be taken when transporting/using ladders.

1.12 Identify the dangers associated with the use of electrical equipment.
**Dangers:** electric shock, fire, damaged equipment, explosion

1.13 Describe how the human body can become part of an electrical circuit.

1.14 Describe the procedure to be adopted when a person is in contact with a live single phase electrical supply.

1.15 Explain the importance of earthing.
**Importance:** protection of electrical equipment against current leakage, use of earth continuity conductor, relative merits of rewireable and cartridge fuses, miniature circuit breakers

1.16 Identify the types and applications of firefighting equipment.
**firefighting equipment:** extinguishers (ie water, powder, foam, gas, vaporizing liquid), sand/water bucket, fire blanket, water hose

1.17 Explain the need for evacuation procedures.
**Procedures:** fire drills, escape routes, assembly points

1.18 Identify the precautions to be taken against contact with toxic materials, liquids, dust or fumes.
**Precautions:** toxic effect (ie ingestion, inhalation, skin/eye contact), materials (ie metal fumes, heated galvanised or cadmium coated surfaces, degreasing agents, lead and asbestos dust, acids, alkalis, epoxy resins, cutting oils, lubricants, solvents

1.19 Describe the precautions to be observed when pressure testing a low pressure.
**Precautions:** container using water, maximum test pressure, venting, protective clothing, national/local regulations, safety zone, water temperatures

# 2 Core Skills: Maths and Drawing

## Introduction

The aim of this section is to enable the candidate to:

a Use calculations to solve simple workshop problems.
b Construct plane figures, and develop patterns.
c Sketch and dimension simple orthographic projections, sectional and pictorial views.

## Practical competences

In a real or simulated task the candidate should be able to:

2.1 Use calculations to solve simple workshop problems.

a individual and overall lengths
b percentage of scrap produced
c mass of components and loads to be lifted
d quantity and cost of materials from drawings
e diagonal check lengths
f conversion of temperatures etc
g material removal rates
h speeds and feeds.

**Note:** Calculations should be taught in direct relation to other sections of the syllabus. The use of a calculator is preferred but four figure logarithmic tables may be used.

2.2 Take off information from drawings.

2.3 Make sketches of simple first and third angle orthographic projections from actual objects and pictorial views.

2.4 Make sketches of simple sectional views.

2.5 Dimension simple orthographic projections and pictorial views.

2.6 Make simple pictorial sketches on squared or isometric paper.

2.7 Develop patterns of three-dimensional figures and their frustums between parallel planes.

a right prism
b right pyramid
c right cylinder
d right cone

2.8 Set out angles with or without the use of a protractor.

2.9 Divide a line into a given number of parts using a construction method.

2.10 Construct plane figures from given data.

a triangle
b square
c rectangle
d parallelogram
e hexagon
f octagon

## Knowledge requirements

The candidate will be able to:

2.1 Perform simple workshop calculations.
**Workshop calculations:** vulgar fractions and decimals, calculations to a number of significant figures, decimal places

2.2 Identify and use the SI units.
**SI units:** length, area, volume, mass, density

2.3 Identify and use the multiples and sub-multiples of units.
**Units:** Giga (G) = $10^9$, Mega (M) = $10^6$, Kilo (K) = $10^3$, centi (c) = $10^{-2}$, milli (m) = $10^{-3}$, micro (m) = $10^{-6}$

2.4 Perform simple workshop calculations.
**Calculate:** perimeter and area of plane figures (ie square and rectangle, triangle, circle), volume and surface area (ie cube, rectangular prism, cylinder), mass of containers and their contents (ie cube, rectangular prism, cylinder)

2.5 Identify the elements of a circle.
**Parts:** radius, diameter, circumference, chord, sector, segment, arc, tangent

2.6 Identify and use the ratio of sides of 45° and 60° right angled triangles.

2.7 Identify and use the rules of 3:4:5 and 5:12:13 for the sides of right angled triangles.

2.8 Solve simple workshop problems involving Pythagoras and right angled triangles.

2.9 Evaluate and transpose simple formulae associated with workshop problems.

2.10 Convert minutes and seconds to decimal fractions of a degree.

2.11 **Identify the conventions on drawings:** types of line, conventional representation of common features: dimensioning.

2.12 List information contained on a drawing sheet.
**Drawing sheet:** title block, drawing number, scale, date, issues or revision information, materials and specifications, tolerance and finish, views, dimensions

2.13 Identify angles.
**Angles:** acute, obtuse, reflex, right

2.14 Identify plane figures.
**Plane figures:** triangle, square, rectangle, parallelogram, hexagon, octagon

2.15 Identify types of drawing.
**Types:** first and third angle orthographic projection: symbols used for identification, isometric and oblique views

2.16 Identify first and third angle orthographic projections of isometric or oblique views.

2.17 Identify single plane sectional views of simple components.

2.18 Identify developed patterns of three-dimensional shapes and their frustums between parallel planes.
**Three-dimensional shapes:** right prism, right pyramid, right cylinder, right cone

# 3 Core Skills: Materials

## Introduction

The aim of this section is to enable the candidate to:

a Identify metals and compare their properties.
b Understand the effect that material shape, and the position of force, has on deflection.
c Be aware of the causes of rusting, and effects of cold working and heat treating plain carbon steels.

## Practical competences

In a real or simulated task the candidate should be able to:

3.1 Compare the mechanical properties of metals by twisting, repeated bending, hammering, rolling of strip, hollowing of a cup, filing.

3.2 Compare the thermal and electrical conductivity of various engineering materials.

3.3 Identify metals by colour, weight, filing and using a magnet.

3.4 Carry out simple comparative deflection tests between specimens of equal length and cross-sectional area, centrally loaded and simply supported at each end.

a flat bar face down
b flat bar edge down
c I section vertical
d I section horizontal
e tube

3.5 Examine the effects of heating, thermoplastics and thermosetting plastics.

3.6 Investigate the effects of cold working and heat treatment on the mechanical properties of plain carbon steels.

3.7 Compare the rate of rusting of low carbon steel specimens.

a steel (ie clean and dry, lightly greased, partly submerged in water)
b comparison of untreated, tin coated and galvanised steel.

## Knowledge requirements

The candidate will be able to:

3.1 Define the basic properties of engineering materials.
**Properties:** ductility, malleability, strength (ie compression, tension, shear), elasticity, toughness, brittleness, hardness, electrical and heat conductivity, machinability
**Materials:** carbon steels, cast irons, aluminium, copper, brass, austenitic stainless steel

3.2 Identify metals in 3.1.
**Identification methods:** colour, density, use of a magnet

3.3 Identify metals in 3.1 as ferrous or non-ferrous.

3.4 Describe the effect of sectional form on the deflection of simply supported beams.
**Sectional form:** flat bar faced down, flat bar edge down, I section vertical, I section horizontal, tube

3.5 Describe the effect of modifying the sectional form of beams by drilling holes and/or notching.

3.6 Describe the properties of non-metallic materials (other than timber) and their usage.
**Properties:** thermal and electrical insulation, acoustic and shock absorption
**Usage:** advantages and problems arising from the use of plastics instead of metal for pipe and conduit.

3.7 Explain the difference between thermoplastic and thermosetting plastics and state suitable applications.

3.8 State the changes in physical and mechanical properties of steel due to cold working.

3.9 State the changes in physical and mechanical properties of steel due to temperature changes.
**Effects of:** hardening, tempering, annealing, normalising, recrystallisation, grain growth

3.10 Describe types of surface protection against corrosion.
**Surface protection:** methods (ie painting, galvanising, metal spraying, tin plating, sheradising), state the precautions to be observed to ensure good adhesion when applying the surface protection methods

## Introduction

The aim of this section is to enable the candidate to:

a Choose the most suitable method of temperature measurement and appreciate expansion and contraction due to heat.
b Identify equilibrium types and calculate forces, turning moments and centre of gravity.
c Understand Ohm's law, current flow and the effects of current.

## Practical competences

In a real or simulated task the candidate should be able to:

4.1 Compare various methods of temperature measurement against a calibrated pyrometer.

a heat sensitive crayons/paints
b fusible salts/cones
c estimation by colour

4.2 Use a temperature controlled furnace to compare the temperatures associated with tempering colours to actual temperatures.

4.3 Carry out simple tests to compare the thermal conductivity of various engineering materials.

4.4 Carry out experiments to demonstrate that materials expand when heated and contract when cooled.

a solid
b liquid
c gas

4.5 Compare the relative heat expansion of different metals.

4.6 Investigate the effect of varying the angle between slings when carrying a load.

4.7 Investigate the effect of lengthening levers and spanners.

4.8 Determine the centre of gravity of regular shapes by experimentation.

4.9 Investigate stable, unstable and neutral equilibrium.

4.10 Carry out simple experiments involving the use of ammeter, voltmeter, filament lamps/buzzers to demonstrate the flow of current in d.c. circuits.

4.11 Use simple circuits to investigate Ohms law.

4.12 Investigate the effects of current.

a heating effect: filament lamp, domestic appliances
b magnetic effect: simple electromagnets, relays
c chemical effect: electrolysis

## Knowledge requirements

The candidate will be able to:

4.1 State the fixed points on the Celsius (Centigrade), Fahrenheit and Kelvin scales.

4.2 Identify, compare and describe the use of approximate and precise workshop methods of temperature measurement.
**Temperature measurement:** thermometer (ie mercury in glass), heat sensitive paints or crayons, fusible salts or cones, estimation by colour/oxide layer colour, other approximate workshop methods, thermocouples, optical pyrometer

4.3 Identify typical temperatures for workshop operations.
**Temperatures for:** soldering, brazing, braze welding, welding, hardening, tempering, forging

4.4 State sources of heat energy.
**Heat sources:** flame, electric arc, electrical resistance

4.5 Identify methods and applications of heat energy transmission.
**Energy transmission:** conduction, radiation, convection

4.6 State that solids, liquids and gases expand when heated and contract when cooled.

4.7 Identify the practical effects of expansion and contraction, eg railway lines, bridges, shrink fitting, bearing tolerances, steam pipes, bi-metallic strips.

4.8 Explain the term specific heat capacity and state the SI derived units.

4.9 Explain the principle of latent heat when a change of state occurs.
**Latent heat:** ice to water, water to steam

4.10 Identify the effects of friction.
**Effects:** resistance to motion, heat generation, wear

4.11 Identify applications where friction forces are an advantage or a disadvantage.

4.12 Explain how lubricants can be used to reduce friction.

4.13 Describe force as a vector quantity.

4.14 Determine the moment of a force and state the SI derived units.

4.15 Solve simple problems involving forces and moments: spanners, torque wrench, taps, stocks and dies.

4.16 Define the term centre of gravity.

4.17 Identify and explain the basic principles of stable, unstable and neutral equilibrium.

4.18 State the basic structure of an atom.

4.19 Explain the basic concept of current as electrons in motion.

4.20 Identify the relationship between the coulomb and the ampere.

4.21 Explain current flow: the ampere, use of the ammeter.

4.22 Explain the concept of resistance: the ohm.

4.23 Describe electromotive force (e.m.f.) as cause of current flow: the volt, use of the voltmeter.

4.24 Identify Ohm's Law.

4.25 Solve simple problems involving Ohm's Law.
**Ohm's Law:** series loads, parallel loads (no more than two resistors in any one circuit)

4.26 Identify the heating, magnetic and chemical effects of an electric current.

# 5 Core Skills: Hand and Machine Tools

## Introduction

The aim of this section is to enable the candidate to:

a Use hand tools and sheet metal cutting and folding equipment.
b Use the off hand grinding machine and the fixed drilling machine.

## Practical competences

In a real or simulated task the candidate should be able to:

5.1 Select, use, clean and store basic hand tools.

5.2 Select, use, clean and store drills, reamers, taps and dies.

5.3 Select, use, clean and store stud extractors.

5.4 Select, use, clean and store portable electric and pneumatic powered hand tools.

5.5 Measure the wedge angles of tools.

5.6 Use a fixed drilling machine to carry out drilling, countersinking, counter boring, spot facing and reaming: investigate the effects of different drill point angles and unequal lip lengths.

5.7 Use the single or double ended off hand grinding machine; grind work to a prescribed accuracy; sharpen hand tools: centre punch, scriber, flat chisel, twist drill.

5.8 Fold sheet metal to an angle using a sheet metal folding machine.

5.9 Cut sheet metal to size using hand shears and bench shears/guillotine.

## Knowledge requirements

The candidate will be able to:

5.1 Identify basic hand tools and explain their use.
**Hand tools:** vices, files, hammers, chisels, screwdrivers, pliers, wire cutters, punches, drifts

5.2 Identify defects in the hand tools mentioned in 5.1 and describe methods of rectification.

5.3 Describe the effects of pitch and set of hacksaw blade teeth and the point angle of chisels.

5.4 Identify the angles of wedge-shaped cutting tools, their terminology and meaning.
**Wedge-shaped cutting tools:** rake angle a, clearance angle g, wedge angle b, influence on drilling (note that $\alpha + \beta + \gamma = 90°$)

5.5 Identify drill types and state their applications.
**Drill types:** parallel shank (ie jobber, long series, stub), morse taper shank, drills with more than two flutes, special purpose drills (ie countersinking, counter boring, taper drilling, drills with integral lubricant/cooling feeds)

5.6 Describe the working principles of drills.
**Working principles:** rake angle $\alpha$, wedge angle $\beta$, clearance $\gamma$

5.7 Identify the materials from which drills are made and state applications.
**Materials:** high carbon steel, high speed steel, tungsten carbide tipped

5.8 Identify types of reamers and state their applications.
**Reamers:** hand fitting, drilling machine operations

5.9 Describe the process of reaming a hole using vertical spindle machines.
**Reaming a hole:** drilling machines (ie bench, pillar, radial arm)

5.10 Identify methods of cutting internal and external screw threads.
**Cutting screw threads:** manually (ie internal screw threads by taps, internal screw threads by special taps and thread inserts, external screw threads by dies, cleaning external screw threads by die nuts), by machine tool (ie internal screw threads [machine taps, thread chasers] external screw threads: [die heads, thread chasers])

5.11 Identify methods of removing broken studs and taps.

5.12 Identify and describe the operation of sheet metal folding machines.
**Sheet metal folding:** folding machine, angle bending machine

5.13 Identify and describe the operation of bench shears for hand cutting operations.

5.14 Describe the lubricating and cooling effects of cutting fluids.

5.15 Identify types of drilling machine, their main construction features and applications.
**Drilling machines:** hand, portable electric, bench (sensitive), pillar, radial arm, numerically controlled

5.16 Identify tool-holding devices for drilling: the principles of restraint.
**Devices:** chucks, sleeves, collets

5.17 Identify work holding and work holding devices for drilling operations.
**Work holding:** positioning and locating of work pieces (ie methods of determining centre points of holes relative to x and y axes, use of fixed stops, drilling jigs and fixtures) devices (ie machine vices, angle plates, parallels and vee blocks, plate clamps and tee-bolts, quick release clamps)

5.18 Identify the operations, which can be carried out on a fixed drilling machine.
**Operations:** drilling, reaming, countersinking, counter-boring, spot facing

5.19 State the safety precautions specific to drilling operations.
**Safety precautions:** always use eye and hair protection, use correct work holding equipment particularly when drilling thin material, use secondary clamping when using magnetic holding devices, ensure floor and machine vicinity is clear, ensure working area is well lit, do not wear loose clothing or rings, remove swarf with a hook, know emergency stop procedures

5.20 Identify types of portable, electric and pneumatic powered hand tools,
**Hand tools:** describe their use and safety precautions to be observed, drilling machines, grinding machines, nut tighteners, torque wrenches, nibblers

5.21 Describe the single/double ended off hand grinding machine.
**Off hand grinding machine:** general use for sheet metal removal and tool grinding, state the purpose and requirements of tool rests

5.22 State the purposes of providing guards.
**Safety guards:** to contain the wheel in the event of a burst, to prevent operator coming in contact with the wheel, to protect the wheel from damage

5.23 State the safety precautions to be observed when grinding.
**Safety precautions:** always wear eye protection, do not wear loose clothing, keep hands away from abrasive wheels, always use the guards provided, ensure floor area around machine is clear of loose material and prevented from becoming slippery, wear suitable footwear, know emergency stop procedures, know requirements of statutory regulations, observe correct starting and stopping sequences

# 6 Core Skills: Communication

## Introduction

The aim of this section is to enable the candidate to:

a Read and respond to written material, find, gather, process and evaluate data.
b Identify components and data from a wide range of sources.
c Use information technology.
d Construct and interpret graphs and charts and produce operation sheets.

## Practical competences

In a real or simulated task the candidate should be able to:

6.1 Take part in discussions.

a express views/opinions and give an account verbally in an appropriate manner.
b recognise the importance and significance of listening.
c check and confirm verbal information.

6.2 Prepare written material.

6.3 Read and respond to written material.

a identify key points
b seek clarification when required

6.4 Gather and process data.

6.5 find and evaluate information for given problems/tasks from a range of sources.

6.6 Identify types of line, conventional representation of common features, screw-threads, machining and weld symbols (fillet, square butt, single and double vee butt).

6.7 Identify components from drawings, specifications and data.

6.8 Interpret standards, manufacturers tables and/or graphs to

a select materials for a particular application eg sheet and wire gauges
b select fastening devices
c select appropriate twist drill sizes for drilling clearance holes/tapping
d obtain specific information from a graph by interpolation

6.9 Use information technology.

a use a computer system to perform simple engineering tasks eg scheduling or stores control
b compile/produce a simple report (hard copy) using basic edit and format operations

6.10 Identify the link between colour coding and safety.

a colour coding of contents of pipes: air, water, oil, common gases
b colour coding of gas cylinders
c colour coding of electrical components and wiring: reference to IEE regulations

6.11 Identify conventional symbols for common electrical components on wiring diagrams (appropriate to coverage in core units).

6.12 Interpret simple circuit diagrams using peg-board and construction kits.

6.13 Identify pipes, electrical wiring/components and cylinders by colour coding.

6.14 Produce operation sheets for simple workshop activities emphasising the logical sequence of events.

6.15 Construct and interpret simple graphs, pie charts and bar charts.

## Knowledge requirements

The candidate will be able to:

6.1 Identify sources of technical information in standardised form.
**Technical information:** technical drawings, manufacturers' catalogues/technical manuals, National, American, British, European etc. standards, codes of practice, production schedules, product specifications, reference tables and charts, maintenance manuals/servicing schedules, other members of the workforce, fax, E mail, Internet, microfilm, microfiche, video tapes, CD-ROMs

6.2 Identify information from listed sources.

6.3 Identify main types of communication used to liaise with staff within industry.
**Communication:** verbal, written, drawings/diagrams, telephone, radio/tannoy, signs

6.4 Identify the different methods of using drawings to transmit information.
**Drawing types:** general arrangement drawings, detail drawings, assembly drawings, installation drawings, block diagrams

6.5 Interpret graphs, pie charts and bar charts.

6.6 Compare systems with and without information technology.
**System comparisons:** saving time, reducing cost, increasing efficiency, improving accuracy

6.7 Identify computer-aided systems for engineering applications.
**Computer aided systems:** computer aided design (CAD), computer aided manufacture (CAM), computer numerical control (CNC), robotics

# 7 Core Skills: Measuring and Marking Out

## Introduction

The aim of this section is to enable the candidate to:

a Choose, maintain and use the most suitable marking out and measuring equipment.
b Use templates.

## Practical competences

In a real or simulated task the candidate should be able to:

7.1 Investigate the accuracy of measurements taken when using measuring equipment.

7.2 Investigate the accuracy of measurements taken when measuring angles.

7.3 Select, use, clean and store tools used to mark out.

a Shapes: squares, rectangles, circles, irregular shapes

b from datum services: single datum point, single datum point and single datum line, one or more datum services, the centre of a hole

c details: hole centres, pitch circles, lines parallel or perpendicular to the surface plate, parallel lines on angled sections, parallel lines along shafts or pipes

7.4 Select, use, clean and store a precision bubble level to set horizontal and vertical planes.

7.5 Select, use, clean and store a plumb bob to set alignment in a vertical plane.

7.6 Exercise care and required maintenance of tools and equipment.

7.7 Use templates for marking out and checking.

7.8 Check prepared specimens for limits and fits.

## Knowledge requirements

The candidate will be able to:

7.1 Identify and describe the use of marking out and measuring equipment, tools and instruments.
**Equipment, tools and instruments:** support or datum surfaces (ie angle plate, adjustable angle plate, surface plate/table, rollers, parallels, parallel blocks, v blocks), gauges (ie surface gauge, vernier height gauge, slip gauge, micrometer callipers, dial indicators [rack and pinion type], feeler gauges, spirit lever, plumb bob), marking out equipment (ie squares, box squares, centre squares, scriber dot/centre punches, hammer, straight edges, rules and graduated scale instruments, callipers, hermaphrodite [odd leg] callipers, trammels)

7.2 Compare the relative degrees of accuracy of marking out and measuring equipment listed.

7.3 Identify methods of marking out.
**Methods:** straight lines, circles and arcs, lines parallel or perpendicular to the surface plate, parallel lines on angled sections, parallel lines along shafts or pipes

7.4 Identify datum's and describe methods of marking out from them.
**Datum:** single datum point, single datum point and single datum line, one or more datum surfaces, the centre of a hole

7.5 Describe how to avoid faults and minimise inaccuracies when marking out.
**Avoiding faults/inaccuracies:** use of appropriate equipment, condition of equipment, correct positioning of equipment, correct positioning of the eye relative to the equipment and the workpiece

7.6 Identify and describe the operation of tools and equipment for angular marking out and measurement.
**Tools and equipment:** squares, protractors, bevel gauges, vernier protractor

7.7 Identify and explain the use of the precision bubble level to establish horizontal and vertical planes.

7.8 Identify and explain the use of the plumb bob to establish vertical planes.

7.9 Identify template materials for given situations and describe their use.
**Template materials:** screw cutting centre gauge, radius gauge, marking out templates

7.10 Identify and explain the main classes of fit.

# 8 Core Skills: Fastening and Joining

## Introduction

The aim of this section is to enable the candidate to:

a Select and use a range of temporary and permanent methods of joining metals.
b Carry out oxy-acetylene gas cutting.

## Practical competences

In a real or simulated task the candidate should be able to:

8.1 Select, use, clean and store personal protective equipment.

8.2 Select, use, clean and store mechanical fastening devices.

8.3 Examine a range of thread types and mechanical fastening devices.

8.4 Select, use, clean and store spanners and torque wrenches.

8.5 Calculate allowances for and form self secured sheet metal joints.

8.6 Select, use, clean and store soft soldering equipment and consumables.

a sheet metal lap joints
b pipe joints
c electrical wiring terminations

8.7 Weld simple butt joints using oxy-acetylene welding equipment (leftward technique only).

8.8 Weld simple butt joints using manual metal arc welding equipment.

8.9 Use manual oxy-fuel gas cutting equipment to cut low carbon steel.

## Knowledge requirements

The candidate will be able to:

8.1 Identify types and applications of mechanical fastening devices.
**Fastening devices:** nuts (ie wing, lock, castle, hexagonal, castellated, slotted, split, fibre insert), bolts (ie black, turned barrel [fitted], high strength friction grip, stud), washers (ie flat, taper, spring, serrated, tab, high strength friction grip), screws (ie cheese, countersunk, slotted, socket, cross), rivets (ie solid: snap or round, flat: tubular, "pop")

8.2 Identify types and applications of screw threads.
**Screw threads:** vee (ie ISO metric, BSW, BSF, BA, BSP, UNF, UNC), modified (ie acme,buttress, square)

8.3 Identify types and applications of spanners and torque wrenches.
**Spanners and torque wrenches:** spanners (ie open jawed, ring, socket, box, strap, splined, adjustable), torque wrenches (ie breakback, dial reading, torque setting)

8.4 Identify riveted and bolted joints.
**Joints:** lap, single and double cover plate butt joints

8.5 Identify defects in riveted and bolted joints.
**Defects:** bolted (ie lack of flat or taper washer, incorrect bolt/thread length, hole diameter too large), riveted (ie rivet length short or excessive, sheets not close together, rivet head off centre)

8.6 Identify self secured sheet metal joints and state applications.
**Sheet metal joints:** grooved, knocked up, pittsburgh lock

8.7 Identify the equipment and consumables used for soft soldering.
**Soft soldering:** surface cleaning materials, soldering irons (ie electric, gas), flux (ie active, passive), solders

8.8 Explain the basic principles of soft soldering sheet metal and wire joints.
**Principles:** joint types, joint structure, capillary action, process, applications, safety precautions

8.9 Identify the equipment and consumables used for brazing.
**Equipment for brazing:** surface cleaning materials, blowpipe/torch, fluxes, spelter filler metal

8.10 Explain the basic principles of brazing.
**Principles of brazing:** joint types, joint structure, capillary action, process, applications, safety precautions and equipment

8.11 Identify the equipment and consumables used for oxy-fuel gas welding.
**Equipment for oxy-fuel welding:** cylinders (ie oxygen, acetylene), torch, regulators, hose, filler wire

8.12 Explain the basic principles of oxy-fuel gas welding.
**Principles of oxy-fuel welding:** joint types (ie butt, corner, fillet and lap), process, applications, safety precautions and equipment

8.13 Identify flame settings; oxidising, carburising, neutral.

8.14 Identify the equipment and consumables used for manual metal arc welding.
**Equipment for metal arc welding:** regulator, transformer/rectifier, cables, electrode holder

8.15 Explain the basic principles of manual metal arc welding
**Principles of metal arc welding:** joint types (ie butt, corner, fillet and lap), process, applications, safety precautions and equipment

8.16 Identify manual oxy-fuel gas cutting equipment.
**Equipment for oxy-fuel cutting:** cylinders, regulators, hoses, cutting torches, safety precautions and equipment

8.17 Identify gases used for manual oxy-fuel gas cutting.

## Test specification for written paper Engineering Skills Principles 1 (1155-01-001)

This is a written multiple choice examination paper lasting one and a half hours and containing 50 questions.

Candidate must answer **ALL** questions.

| Topic | Approximate % Examination weighting |
|---|---|
| Safety at Work | 14 |
| Maths and Drawing | 14 |
| Materials | 12 |
| Science | 14 |
| Hand and Machine Tools | 14 |
| Communication | 8 |
| Measuring and Marking Out | 10 |
| Fastening and Joining | 14 |

## Practical competences

The candidate must be able to do the following:

1.1 Carry out safe working practices to ensure the safety of themselves, other personnel and members of the public. ☐

1.2 Carry out safe working practices when using non-portable powered machinery in accordance with national/local standards. ☐

1.3 Carry out manual handling operations. ☐

1.4 Carry out the safe movement of materials and components, observing safe working loads, using mechanical lifting and ancillary equipment. ☐

1.5 Identify faults in lifting aids and equipment. ☐

1.6 Use and transport ladders safely. ☐

1.7 Use electrical equipment in accordance with national/local standards. ☐

1.8 Carry out the correct procedure to isolate a person in contact with a simulated live single phase electrical supply. ☐

1.9 Carry out resuscitation treatment. ☐

1.10 Observe safe working practices to reduce health hazards when in contact with toxic materials, liquids, dust or fumes. ☐

1.11 Select correct equipment and carry out basic fire fighting techniques in simulated conditions. ☐

1.12 Pressure test a low pressure container using water. ☐

1.13 Apply good house keeping practices at all times. ☐

1.14 Carry out a risk assessment and prepare a report identifying potential health hazards. ☐

1.15 Prepare an accident report for a simulated accident. ☐

1.16 Participate in emergency procedures. ☐

1.17 Safe/efficient evacuation. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Practical competences

The candidate must be able to do the following:

2.1 Use calculations to solve simple workshop problems. ☐

2.2 Take off information from drawings. ☐

2.3 Make sketches of simple first and third angle orthographic projections from actual objects and pictorial views. ☐

2.4 Make sketches of simple sectional views. ☐

2.5 Dimension simple orthographic projections and pictorial views. ☐

2.6 Make simple pictorial sketches on squared or isometric paper. ☐

2.7 Develop patterns of three-dimensional figures and their frustums between parallel planes. ☐

2.8 Set out angles with or without the use of a protractor. ☐

2.9 Divide a line into a given number of parts using a construction method. ☐

2.10 Construct plane figures from given data. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Practical competences

The candidate must be able to do the following:

3.1 Compare the mechanical properties of metals by twisting, repeated bending, hammering, rolling of strip, hollowing of a cup, filing. ☐

3.2 Compare the thermal and electrical conductivity of various engineering materials ☐

3.3 Identify metals by colour, weight, filing and using a magnet. ☐

3.4 Carry out simple comparative deflection tests between specimens of equal length and cross-sectional area, centrally loaded and simply supported at each end. ☐

3.5 Examine the effects of heating, thermoplastics and thermosetting plastics. ☐

3.6 Investigate the effects of cold working and heat treatment on the mechanical properties of plain carbon steels. ☐

3.7 Compare the rate of rusting of low carbon steel specimens. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Practical competences

The candidate must be able to do the following:

4.1 Compare various methods of temperature measurement against a calibrated pyrometer. ☐

4.2 Use a temperature controlled furnace to compare the temperatures associated with tempering colours to actual temperatures. ☐

4.3 Carry out simple tests to compare the thermal conductivity of various engineering materials. ☐

4.4 Carry out experiments to demonstrate that materials expand when heated and contract when cooled. ☐

4.5 Compare the relative heat expansion of different metal. ☐

4.6 Investigate the effect of varying the angle between slings when carrying a load. ☐

4.7 Investigate the effect of lengthening levers and spanners. ☐

4.8 Determine the centre of gravity of regular shapes by experimentation. ☐

4.9 Investigate stable, unstable and neutral equilibrium. ☐

4.10 Carry out simple experiments involving the use of ammeter, voltmeter, filament lamps/buzzers to demonstrate the flow of current in d.c. circuits. ☐

4.11 Use simple circuits to investigate Ohms law. ☐

4.12 Investigate the effects of current. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Practical competences

The candidate must be able to do the following:

5.1 Select, use, clean and store basic hand tools. ☐

5.2 Select, use, clean and store drills, reamers, taps and dies. ☐

5.3 Select, use, clean and store stud extractors. ☐

5.4 Select, use, clean and store portable electric and pneumatic powered hand tools. ☐

5.5 Measure the wedge angles of tools. ☐

5.6 Use a fixed drilling machine to carry out drilling, countersinking, counter boring, spot facing and reaming: investigate the effects of different drill point angles and unequal lip lengths. ☐

5.7 Use the single or double ended off hand grinding machine; grind work to a prescribed accuracy; sharpen hand tools: centre punch, scriber, flat chisel, twist drill. ☐

5.8 Fold sheet metal to an angle using a sheet metal folding machine. ☐

5.9 Cut sheet metal to size using hand shears and bench shears/guillotine. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 002/6 Core Skills: Communication

## Practical competences

The candidate must be able to do the following:

6.1 Take part in discussions. ☐

6.2 Prepare written material. ☐

6.3 Read and respond to written material. ☐

6.4 Gather and process data. ☐

6.5 find and evaluate information for given problems/tasks from a range of sources. ☐

6.6 Identify types of line, conventional representation of common features, screw-threads, machining and weld symbols (fillet, square butt, single and double vee butt). ☐

6.7 Identify components from drawings, specifications and data. ☐

6.8 Interpret standards, manufacturers tables and/or graphs. ☐

6.9 Use information technology. ☐

6.10 Identify the link between colour coding and safety. ☐

6.11 Identify conventional symbols for common electrical components on wiring diagrams. ☐

6.12 Interpret simple circuit diagrams using peg-board and construction kits. ☐

6.13 Identify pipes, electrical wiring/components and cylinders by colour coding. ☐

6.14 Produce operation sheets for simple workshop activities emphasising the logical sequence of events. ☐

6.15 Construct and interpret simple graphs, pie charts and bar charts. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Practical competences

The candidate must be able to do the following:

7.1 Investigate the accuracy of measurements taken when using measuring equipment. ☐

7.2 Investigate the accuracy of measurements taken when measuring angles. ☐

7.3 Select, use, clean and store marking out tools used to mark out. ☐

7.4 Select, use, clean and store a precision bubble level to set horizontal and vertical planes. ☐

7.5 Select, use, clean and store a plumb bob to set alignment in a vertical plane. ☐

7.6 Exercise care and required maintenance of tools and equipment. ☐

7.7 Use templates for marking out and checking. ☐

7.8 Check prepared specimens for limits and fits. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 002/8 Core Skills: Fastening and Joining

## Practical competences

The candidate must be able to do the following:

8.1 Select, use, clean and store personal protective equipment. ☐

8.2 Select, use, clean and store mechanical fastening devices. ☐

8.3 Examine a range of thread types and mechanical fastening devices. ☐

8.4 Select, use, clean and store spanners and torque wrenches. ☐

8.5 Calculate allowances for and form self secured sheet metal joints. ☐

8.6 Select, use, clean and store soft soldering equipment and consumables. ☐

8.7 Weld simple butt joints using oxy-acetylene welding equipment (leftward technique only). ☐

8.8 Weld simple butt joints using manual metal arc welding equipment. ☐

8.9 Use manual oxy-fuel gas cutting equipment to cut low carbon steel. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155 Engineering Skills

**Component and section numbers**

| | |
|---|---|
| **Diploma** | |
| **011** | **Engineering Skills Principles 2** |
| 1 | Materials |
| 2 | Science |
| 3 | Maths and Drawing |
| **013** | **Electrical Engineering Principles** |
| 1 | Electrical Technology 1 |
| 2 | Principles and Applications |
| 3 | Electrical Technology 2 |
| **015** | **Metal Machining Principles** |
| 1 | Mechanical Applications and Dimensional Control |
| 2 | Milling |
| 3 | Turning |
| **017** | **Mechanical Fitting and Plant Maintenance Principles** |
| 1 | Supplementary Studies |
| 2 | Mechanical Power Transmission |
| 3 | Mechanical Fitting |
| **019** | **Fabrication, Welding and Pipework Principles** |
| 1 | Fabrication |
| 2 | Welding |
| 3 | Pipework |

# 11.1 Core Skills: Materials

## Introduction

The aim of this section is to enable the candidate to:

a Prepare samples for macro/micro examination and identify grain structures produced.
b Carry out mechanical testing and heat treatment processes.

## Practical competences

In a real or simulated task the candidate should be able to:

11.1.1 Carry out the mechanical testing of metals.

11.1.2 Carry out heat treatment processes and identify results.

11.1.3 Carry out visual inspection of metal samples for defects.

11.1.4 Prepare metal specimens for macro and micro-inspection.

11.1.5 Identify from prepared specimens.

a large and small equiaxed grains
b cold worked grains
c ferrite, pearlite and martensite
d effect of increasing carbon content on constituents

## Knowledge requirements

The candidate will be able to:

11.1.1 Identify reasons for, and the methods of altering a metal's properties.
**Metal properties:** alloying, hot and cold working, heat treatment

11.1.2 Identify the effects of alloying elements on the properties of carbon steel.
**Alloying elements:** nickel, chromium, vanadium, molybdenum, tungsten, manganese, silicon

11.1.3 Identify the effects of carbon on the structure and properties of plain carbon steel.

11.1.4 Identify the main constituents and properties of common non-ferrous alloys.
**Common non-ferrous alloys:** copper alloys, aluminium alloys, magnesium alloys, nickel alloys, white metal, solder

11.1.5 Identify common types of space lattice.
**Space Lattice:** body-centred cubic, face-centred cubic, close-packed hexagonal

11.1.6 Describe the basic principles and process of alloying.
**Alloying:** solid solution (ie substitutional, interstitial), saturation, precipitation

11.1.7 Identify the effects of hot and cold working on the structure and mechanical properties of metals.
**Hot and cold water effects:** definitions, grain size and shape, residual stress, recrystallisation

11.1.8 Identify the purpose and principles of heat treatment processes.
**Heat treatment process:** quench hardening, tempering, annealing (ie full, process, stress relief), normalising, solution treatment, ageing

11.1.9 Identify the grain structures produced by the listed heat treatment processes.

11.1.10 Identify the phases on the iron carbon thermal equilibrium diagram, below 1000°C and up to 1.2% carbon.

11.1.11 Identify the definition of phases in 11.1.10.
**Definition of:** ferrite, cementite, pearlite, austenite

11.1.12 Identify visual methods of inspection.
**Methods of inspection:** unaided visual, macro-examination (ie preparation of specimens, reagents, safety), micro-examination (ie preparation of specimens, reagents, safety), reasons for examination

11.1.13 Identify mechanical testing methods: procedures involved; results obtained.
**Mechanical testing methods:** tensile, bend, hardness (ie Brinell, Vickers, Rockwell), impact (ie Izod, Charpy), fatigue

11.1.14 Identify typical tensile stress/strain graphs and their main features.
**Tensile stress/strain graphs:** yield point, limit of proportionality, elastic limit, proof stress, maximum tensile stress, percentage elongation, percentage reduction in area

# 11.2 Core Skills: Science

## Introduction

The aim of this section is to enable the candidate to:

a Appreciate the application of forces including those produced by heat.
b Calculate centre of area.

## Practical competences

In a real or simulated task the candidate should be able to:

11.2.1 Take pressure readings and record values.

11.2.2 Calculate the centre of area of simple shapes.

a square and rectangle
b circle
c triangle
d combination of the above

11.2.3 Investigate the force produced by raising the temperature of a metal (eg bar and cast iron pin).

11.2.4 Carry out experiments involving pulley systems, screw jack, wheel and axle.

11.2.5 Carry out experiments involving triangle and parallelogram of forces.

## Knowledge requirements

The candidate will be able to:

11.2.1 Identify the SI units of, and the difference between speed, velocity and acceleration.

11.2.2 Solve simple workshop problems involving speed, velocity and acceleration.

11.2.3 Identify the SI units of, and the formulae for calculating energy.
**Calculating energy:** potential, kinetic

11.2.4 Solve simple workshop problems involving energy.

11.2.5 Identify the SI units of, and the formulae for calculating work done and power.

11.2.6 Solve simple workshop problems involving work done and power.

11.2.7 Identify gauge pressure, atmospheric pressure, and absolute pressure the SI units used, the meaning of vacuum.

11.2.8 Solve simple workshop problems involving the above pressures.

11.2.9 Identify the SI unit of pressure as the pascal (Pa).

11.2.10 Solve simple workshop problems involving pressure.
**Pressure:** solids, liquids (ie pressure on the base and sides of containers)

11.2.11 Solve simple workshop problems involving the coefficient of friction between two horizontal surfaces.

11.2.12 Identify the formula for the coefficient of linear expansion.

11.2.13 Solve simple workshop problems involving the coefficient of linear expansion.

11.2.14 Solve simple workshop problems involving moments and forces.
**Workshop problems:** spanners, torque wrench, taps, stocks and dies, levers, pliers, clamps, tongs, simply supported beams with one point load

11.2.15 Identify the terms mechanical advantage, movement ratio and efficiency of a machine.

11.2.16 Determine the mechanical advantage, movement ratio and efficiency of a machine.
**Machine:** pulley systems, screw jack, wheel and axle

11.2.17 Identify the radian.
**Radian:** convert rev/min to rad/s, convert rad/s to rev/min

11.2.18 Identify resultant and equilibrant forces.

11.2.19 **Resolve a single force into two rectangular components:** wedges, slings and toggles.

11.2.20 Use the triangle and parallelogram of forces methods to determine the resultant or equilibrant of two co-planer forces.

# 11.3 Core Skills: Maths and Drawing

## Introduction

The aim of this section is to enable the candidate to:

a Produce and extract information from drawings and straight- line graphs.

## Practical competences

In a real or simulated task the candidate should be able to:

11.3.1 Extract details from general arrangement and scale drawings.

11.3.2 Produce working drawings/sketches from.

a actual components
b pictorial views
c orthographic drawings/sketches

11.3.3 Produce sectional views.

a single plane
b more than one plane
c local sections

11.3.4 Produce and use straight-line graphs.

a distance-time, displacement-time, velocity-time.
b conversion graphs
c experimental data: best line of fit
d interpolation

## Knowledge requirements

The candidate will be able to:

11.3.1 Identify multiples and sub-multiples of units, and convert between.
**Units:** Giga (G) = $10^9$, Mega (M) = $10^6$, Kilo (K) = $10^3$, centi (c) = $10^{-2}$, milli (m) = $10^{-3}$, micro ($\mu$) = $10^{-6}$

11.3.2 Identify the properties of the circle.
**Properties of a circle:** intersecting chords, the right-angled triangle within a semi-circle, area of an annulus, area and perimeter of an ellipse, area of a sector and segment, length of arc relative to included angle

11.3.3 Identify the formulae for the properties of the circle and use them to solve workshop problems.

11.3.4 Solve simple workshop problems involving.
**Simple problems:** volume and surface area (ie rectangular prism, cylinder, cone and frustum between parallel planes), mass of containers and their contents (ie rectangular prism, cylinder, cone and frusta between parallel planes)

11.3.5 Solve simple workshop problems involving the area of irregular figures.
**Area of irregular figures:** Simpson's rule, mid ordinate rule

11.3.6 Solve simple workshop problems involving Pythagoras, ratio of sides of 45° and 60° triangles and similar triangles.

11.3.7 Identify the sine, cosine and tangent ratios for acute angles.

11.3.8 Solve simple workshop problems involving the trigonometrical ratios listed above.

11.3.9 Produce simple formulae using algebraic symbols.

11.3.10 Evaluate and transpose simple formulae associated with workshop problems.

11.3.11 Identify information from straight line graphs.
**Straight line graphs:** interpolation, gradient, intercept

11.3.12 Determine the law of a straight-line graph in the form $y = mx + c$.

11.3.13 Use graphs to solve problems.
**Problem solving:** velocity/time graphs (ie area under the graph = distance travelled, gradient = acceleration), force/displacement graphs (ie area under the graph = work done)

11.3.14 Solve simple problems involving stress and strain.
**Stress and strain problems:** tension, compression, shear, Young's modulus of elasticity, factor of safety, safe working stress

## Test specification for written paper Engineering Skills Principles 2 (1155-02-011)

This is a written multiple choice examination paper lasting one and a half hours and containing 40 questions.

Candidate must answer **ALL** questions.

| Topic | Approximate % Examination weighting |
|---|---|
| Materials | 35 |
| Science | 32 |
| Maths and Drawing | 33 |

# 1155-02-012 Engineering Skills Practice 2
012/1 Core Skills: Materials

## Practical competences

The candidate must be able to do the following:

12.1.1 Carry out the mechanical testing of metals. ☐

12.1.2 Carry out heat treatment processes and identify results. ☐

12.1.3 Carry out visual inspection of metal samples for defects. ☐

12.1.4 Prepare metal specimens for macro and micro-inspection. ☐

12.1.5 Identify from prepared specimens. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-012 Engineering Skills Practice 2

012/2 Core Skills: Science

## Practical competences

The candidate must be able to do the following:

12.2.1 Take pressure readings and record values. ☐

12.2.2 Calculate the centre of area of simple shapes. ☐

12.2.3 Investigate the force produced by raising the temperature of a metal (eg bar and cast iron pin). ☐

12.2.4 Carry out experiments involving pulley systems, screw jack, wheel and axle. ☐

12.2.5 Carry out experiments involving triangle and parallelogram of forces. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-012 Engineering Skills Practice 2

012/3 Core Skills: Maths and Drawing

## Practical competences

The candidate must be able to do the following:

12.3.1 Extract details from general arrangement and scale drawings. ☐

12.3.2 Produce working drawings/sketches. ☐

12.3.3 Produce sectional views. ☐

12.3.4 Produce and use straight-line graphs. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Module 13.1: Electrical Technology 1

### Introduction

The aim of this section is to enable the candidate to:

a Carry out earthing and bonding, check and adjust equipment/electrical systems.
b Carry out the rescue of a person in contact with a live wire.

### Practical competences

In a real or simulated task the candidate should be able to:

13.1.1 Select, use, clean and store personal protective equipment.

13.1.2 Select, use, clean and store basic hand tools.

13.1.3 Inspect earthing systems.

13.1.4 Change a range of fuse types.

13.1.5 Check equipment/systems are correctly earthed.

13.1.6 Check equipment/systems are correctly protected.

13.1.7 Carry out earthing and bonding at a service intake position.

13.1.8 Carry out the simulated rescue of a workmate who is receiving an electric shock while touching a live conductor and carry out resuscitation techniques.

13.1.9 Observe a demonstration of fire fighting techniques.

13.1.10 Use scaffold platforms less than 2m high in accordance with national/local standards and use and transport ladders.

13.1.11 Adjust a micro switch on a guard to ensure instant cut off of a machine motor.

13.1.12 Check electrical systems for visual defects: plugs, leads, flexes, ceiling roses, lamp holders, sockets.

13.1.13 Use soft soldering equipment to join sheet electrical connections and electronic components.

13.1.14 Observe the deflections produced on a centre zero voltmeter when the armature of an a.c. generator is slowly rotated.

13.1.15 Observe the deflections produced on a centre zero voltmeter when the armature of a d.c. generator is slowly rotated.

### Knowledge requirements

The candidate will be able to:

13.1.1 State the potential health and safety hazards associated with the use of electricity to ensure the safety of personnel and equipment.
**Electrical hazards:** direct and indirect connection to an electrical supply, overheating of equipment fire hazards

13.1.2 Describe the precautions to be taken against and the procedures to be followed in the event of an electric shock.
**Electric shock:** precautions (ie regular inspection and testing of equipment, isolation of equipment, protective devices, earthing, safety procedures, permits to work, danger and caution notices, reduced voltage, protective clothing), procedures (ie isolation of person from electrical supply, first aid, resuscitation)

13.1.3 State the hazards from fumes and toxic materials encountered in the electrical engineering environment.
**Fumes and toxic materials:** volatile cleaning fluids, electrolytes, etching reagents, metals, solder flux fumes

13.1.4 State precautions in the use of hand tools and machinery specific to electrical engineering.
**Precautions:** soldering irons, wire cutters/side cutters, metal working tools, etching tools, solder baths, bending machines

13.1.5 State the need for the protection of circuits.
**Protection:** short circuit current, overload current, earth fault current

13.1.6 State the importance of earthing and the consequences of earth faults.
**Earthing:** earth leakage, the body as part of an electric socket, fires

13.1.7 Describe the types of earthing systems.
**Earthing systems:** direct or solid earthing, protective multiple earthing, protective conductors

13.1.8 State the purpose of equipotential bonding and identify types.
**Bonding:** main equipotential bonding, supplementary bonding

13.1.9 Identify and describe exposed and extraneous conductive parts.

13.1.10 Identify types of protection devices.
**Protection:** semi enclosed rewireable fuses, cartridge fuses, high-rupturing -capacity fuses, thermally and magnetically operated circuit breakers, residual current devices

13.1.11 State the advantages and limitations of the listed protection devices.

13.1.12 Describe the procedure for dealing with an electric fire and the selection of the correct type of fire extinguisher.

13.1.13 State the precautions to be observed when using scaffold platforms less than 2m high and in the use and transportation of ladders.

13.1.14 Explain the basic principles of an a.c. generator.
**a.c. generator:** generation of an alternating current, sine wave: description of peak, average, RMS values, frequency, periodic value

13.1.15 Explain the basic principles of a d.c. generator: rectification by commutation.

13.1.16 Explain the basic principles of a transformer.
**Transformer:** primary and secondary windings, relationship between voltage, current and turns ratio

13.1.17 Explain the basic principles of the rectificier.
**Rectifier:** semiconductor diodes, half and full wave rectification, smoothing the wave

## Module 13.2: Principles and Applications

### Introduction

The aim of this section is to enable the candidate to:

a Understand the electronic nature of current and its effects.
b Select suitable electric conductors, insulating and magnetic materials.
c Appreciate the relationship between electric current and magnetism and recognise its applications.

### Practical competences

In a real or simulated task the candidate should be able to:

13.2.1 Carry out simple experiments using ammeters, voltmeters, (or multimeter) filament lamps and buzzers, to demonstrate the flow of current in d.c. circuits.

13.2.2 Investigate Ohm's Law.

13.2.3 Investigate the resistance of a conductor as a function of length, cross-sectional area and material.

13.2.4 Investigate the heating effect of electric circuits including filament lamps and domestic appliances.

13.2.5 Investigate the magnetic effect of electric circuits.

13.2.6 Investigate the chemical effect of an electric circuit.

13.2.7 Carry out a simple experiment to demonstrate the effect of moving a conductor in a magnetic field.

13.2.8 Plot the lines of magnetic flux around a permanent bar magnet.

13.2.9 Plot the lines of magnetic flux around a current carrying conductor.

13.2.10 Carry out a simple experiment to demonstrate the laws of magnetic attraction and repulsion.

13.2.11 Carry out simple experiments to demonstrate the force exerted on a current carrying conductor in a magnetic field.

13.2.12 Carry out simple experiments to demonstrate the use of electro-magnets eg electric bell/buzzer, relay, lifting magnet, telephone receiver, loud speaker, moving iron/moving coil instruments.

13.2.13 Measure the electromotive force of various cells: Leclanché, lead-acid, alkaline, mercury.

13.2.14 Connect cells in series and parallel and investigate the effects.

13.2.15 Select suitable electric conductors, insulating materials and magnetic materials for given applications.

13.2.16 Select appropriate sources of electrical energy for given applications.

### Knowledge requirements

The candidate will be able to:

13.2.1 Explain the concept of potential difference and resistance.

13.2.2 Describe how voltmeters and ammeters are connected in d.c. circuits.

13.2.3 Interpret simple electric circuits to include source of supply, conductor, fuse, resistor, variable resistor, switch, ammeter, voltmeter and load. (Candidates will be expected to recognise symbols but will not be required to produce them from memory in an examination).

13.2.4 Describe characteristics of primary and secondary cells and state their uses.
**Primary and secondary cells:** cells (ie Leclanché, lead-acid, alkaline, mercury), characteristics (ie cell life, charging requirements of secondary cells)

13.2.5 Describe the connection of cells in series and parallel: advantages and limitations.

13.2.6 State the SI units of voltage, amperage and resistance.

13.2.7 State and use the common multiples and sub-multiples of electric units: Giga, Mega, kilo, milli and micro.

13.2.8 State Ohm's Law and solve simple problems involving **Ohm's Law:** series and parallel circuits restricted to no more than three resistors in any one circuit.

13.2.9 State the effect of length, cross-sectional area and temperature on resistance.

13.2.10 State the relationship between power, potential difference and current.

13.2.11 Carry out calculations involving power.

13.2.12 State the relationship between energy, power and time.

13.2.13 Carry out calculations involving energy.

13.2.14 Describe the main effects of an electric current at state examples of each: heating, magnetic, chemical.

13.2.15 Identify the lines of magnetic flux around a magnet.

13.2.16 Identify lines of magnetic flux around a current carrying conductor.
**Magnetic flux:** straight wire, loop, solenoid

13.2.17 Recognise electromagnetic devices and explain how they operate.
**Devices:** electric bell/buzzer, relay, lifting magnet, telephone receiver, loud speaker, moving iron/moving coil instruments

13.2.18 State the suitability of various materials for use as electrical conductors.
**Metals:** copper, aluminium, brass, steel, noble metals

13.2.19 Identify typical electrical applications of the listed conducting materials.

13.2.20 State the suitability of various materials for use as electrical insulation.
**Materials:** plastics, glass, ceramic, rubber, cork, mica, synthetic resin bonded paper, oil

13.2.21 Identify typical electrical applications of the listed insulation materials.

13.2.22 State typical applications of magnetic materials.
**Magnetic materials:** soft iron, silicon, steel, iron dust, ferrites, permanent magnets

## Module 13.3: Electrical Technology 2

### Introduction

The aim of this section is to enable the candidate to:

a Carry out the general installation and testing of electrical systems.
b Interpret circuit and wiring diagrams.

### Practical competences

In a real or simulated task the candidate should be able to:

13.3.1 Select, use, clean and store personal protective equipment.

13.3.2 Drill holes in walls and insert plugs for screws.

13.3.3 Determine rating of cables and flexible chords: use of IEE tables.

13.3.4 Select wiring conductors for specific applications.

13.3.5 Make terminations and connections in cords, cables, conduit and trunking.

13.3.6 Construct and install a steel conduit system and test for electrical continuity: Minimum 2m run, one 90° pulled bend, two outlet boxes.

13.3.7 Install a lamp holder, switch and wiring to the steel conduit system in 13.3.6 and terminate conductors.

13.3.8 Test the steel conduit system.

13.3.9 Construct and install a plastic conduit system: minimum 2m run, one 90° manufactured bend, one inspection box, one outlet box.

13.3.10 Install a socket outlet and wiring to the plastic conduit system in 13.3.9 and terminate conductors.

13.3.11 Test the plastic conduit system installed.

13.3.12 Select, use, clean and store electrical measuring instruments: voltmeter, ammeter, wattmeter, ohmmeter, multimeter, insulation tester and continuity tester.

13.3.13 Verify the theory of single and 3 phase systems by actual measurement of voltage.

13.3.14 Safely isolate electrical systems/circuits and carry out relevant confirmatory tests.

13.3.15 Select, use, clean and store pipe screw cutting equipment to produce a coupled joint in steel conduit.

13.3.16 Wire ring and radial circuits of socket outlets.

13.3.17 Interpret electrical circuit and wiring diagrams.

13.3.18 Draw a wiring diagram of connections from a given circuit diagram.

13.3.19 Produce material requisitions from electric circuit diagrams.

### Knowledge requirements

The candidate will be able to:

13.3.1 Describe wiring conductors and state their applications.
**Wiring conductors:** cables and cords, PVC insulated (single, twin and multicore), PVC sheathed, mineral insulated, co-axial

13.3.2 Recognise the component parts of electric cables.
**Component parts:** conductor, insulation, sheathing

13.3.3 State cable identification methods as listed in current edition of IEE regulations.

13.3.4 Describe methods of jointing and terminating cables and state mechanical and electrical properties.
**Methods:** soldered, crimped, wrapped, bolted

13.3.5 Identify components used in circuits and recognise symbols used in their associated circuit diagrams.
**Components:** one way and two way control lighting circuits, radial ring and spur circuit of socket outlets (candidates will be expected to recognise symbols to local/national standards, but will not be required to produce them from memory in an examination)

13.3.6 Identify the methods of connecting measuring instruments in a circuit, and state their purpose.
**Measuring instruments:** voltmeter, ammeter, wattmeter, ohmmeter, analogue and digital multimeter, isolation tester, continuity tester

13.3.7 Describe factory systems of distribution, and state typical applications.
**Distribution:** flexible and rigid conduits, trailing cables and overhead collector, busbar trunking, underfloor ducting, cable trunking, rising mains, PILCSWA, PVCSWA, and MIMS cables

13.3.8 Describe typical domestic distribution and utilisation systems.
**Domestic:** incoming supply, metering, protection, consumer unit, distribution lighting

13.3.9 Explain the basic principles of single phase mains supply (a.c. or d.c.).
**Single phase:** one side earthed, voltage between lines, alternating nature of current, frequency, effective voltage

13.3.10 Explain the basic principles of the three phase a.c. circuit.
**Principles:** four wire system, neutral earthed, voltage between lines, connection of load

13.3.11 Identify fittings and accessories used with trunking and conduit systems and state suitable applications: elbows, bends, couplers, locknuts, bushes, tees, inspection elbows and tees, outlet boxes, supports.

13.3.12 Identify types of electrical components from circuit **symbols:** resistors, capacitors, inductors, transformers, control rectifiers, switches.

13.3.13 Describe switch gear.
**Switch gear:** circuit breakers, switches, isolators

13.3.14 Explain the term space factor in relation to conduit and trunking systems.

## Test specification for written paper Electrical Engineering Principles (1155-02-013)

This is a written multiple choice examination paper lasting one and a half hours and containing 50 questions.

Candidate must answer **ALL** questions.

| Topic | Approximate % Examination weighting |
|---|---|
| Electrical Technology 1 | 32 |
| Principles and Applications | 34 |
| Electrical Technology 2 | 34 |

# 1155-02-014 Electrical Engineering Practice
014/1 Electrical Technology 1

## Practical competences

The candidate must be able to do the following:

14.1.1 Select, use, clean and store personal protective equipment. ☐

14.1.2 Select, use, clean and store basic hand tools. ☐

14.1.3 Inspect earthing systems. ☐

14.1.4 Change a range of fuse types. ☐

14.1.5 Check equipment/systems are correctly earthed. ☐

14.1.6 Check equipment/systems are correctly protected. ☐

14.1.7 Carry out earthing and bonding at a service intake position. ☐

14.1.8 Carry out the simulated rescue of a workmate who is receiving an electric shock while touching a live conductor and carry out resuscitation techniques. ☐

14.1.9 Observe a demonstration of fire fighting techniques. ☐

14.1.10 Use scaffold platforms less than 2m high in accordance with national/local standards and use and transport ladders. ☐

14.1.11 Adjust a micro switch on a guard to ensure instant cut off of a machine motor. ☐

14.1.12 Check electrical systems for visual defects: plugs, leads, flexes, ceiling roses, lamp holders, sockets. ☐

14.1.13 Use soft soldering equipment to join sheet electrical connections and electronic components. ☐

14.1.14 Observe the deflections produced on a centre zero voltmeter when the armature of an a.c. generator is slowly rotated. ☐

14.1.15 Observe the deflections produced on a centre zero voltmeter when the armature of a d.c. generator is slowly rotated. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-014 Electrical Engineering Practice
014/2 Principles and Applications

## Practical competences

The candidate must be able to do the following:

14.2.1 Carry out simple experiments using ammeters, voltmeters, (or multimeter) filament lamps and buzzers, to demonstrate the flow of current in d.c. circuits. ☐

14.2.2 Investigate Ohm's Law. ☐

14.2.3 Investigate the resistance of a conductor as a function of length, cross-sectional area and material. ☐

14.2.4 Investigate the heating effect of electric circuits including filament lamps and domestic appliances. ☐

14.2.5 Investigate the magnetic effect of electric circuits. ☐

14.2.6 Investigate the chemical effect of an electric circuit. ☐

14.2.7 Carry out a simple experiment to demonstrate the effect of moving a conductor in a magnetic field. ☐

14.2.8 Plot the lines of magnetic flux around a permanent bar magnet. ☐

14.2.9 Plot the lines of magnetic flux around a current carrying conductor. ☐

14.2.10 Carry out a simple experiment to demonstrate the laws of magnetic attraction and repulsion. ☐

14.2.11 Carry out simple experiments to demonstrate the force exerted on a current carrying conductor in a magnetic field. ☐

14.2.12 Carry out simple experiments to demonstrate the use of electro-magnets eg electric bell/buzzer, relay, lifting magnet, telephone receiver, loud speaker, moving iron/moving coil instruments. ☐

14.2.13 Measure the electromotive force of various cells: Leclanché, lead-acid, alkaline, mercury. ☐

14.2.14 Connect cells in series and parallel and investigate the effects. ☐

14.2.15 Select suitable electric conductors, insulating materials and magnetic materials for given applications. ☐

14.2.16 Select appropriate sources of electrical energy for given applications. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-014 Electrical Engineering Practice
014/3 Electrical Technology 2

## Practical competences

The candidate must be able to do the following:

14.3.1 Select, use, clean and store personal protective equipment. ☐

14.3.2 Drill holes in walls and insert plugs for screws. ☐

14.3.3 Determine rating of cables and flexible chords: use of IEE tables. ☐

14.3.4 Select wiring conductors for specific applications. ☐

14.3.5 Make terminations and connections in cords, cables, conduit and trunking. ☐

14.3.6 Construct and install a steel conduit system and test for electrical continuity: Minimum 2m run, one 90° pulled bend, two outlet boxes. ☐

14.3.7 Install a lamp holder, switch and wiring to the steel conduit system in 13.3.6 and terminate conductors. ☐

14.3.8 Test the steel conduit system. ☐

14.3.9 Construct and install a plastic conduit system: minimum 2m run, one 90° manufactured bend, one inspection box, one outlet box. ☐

14.3.10 Install a socket outlet and wiring to the plastic conduit system in 13.3.9 and terminate conductors. ☐

14.3.11 Test the plastic conduit system installed. ☐

14.3.12 Select, use, clean and store electrical measuring instruments: voltmeter, ammeter, wattmeter, ohmmeter, multimeter, insulation tester and continuity tester. ☐

14.3.13 Verify the theory of single and 3 phase systems by actual measurement of voltage. ☐

14.3.14 Safely isolate electrical systems/circuits and carry out relevant confirmatory tests. ☐

14.3.15 Select, use, clean and store pipe screw cutting equipment to produce a coupled joint in steel conduit. ☐

14.3.16 Wire ring and radial circuits of socket outlets. ☐

14.3.17 Interpret electrical circuit and wiring diagrams. ☐

14.3.18 Draw a wiring diagram of connections from a given circuit diagram. ☐

14.3.19 Produce material requisitions from electric circuit diagrams. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Module 15.1: Mechanical Applications & Dimensional Control

### Introduction

The aim of this section is to enable the candidate to:

a Use safety devices.
b Prepare working sketches, extract details from drawings and mark out components.
c Select and use appropriate fastening devices.
d Check accuracy of dimensions and shape of components.

### Practical competences

In a real or simulated task the candidate should be able to:

15.1.1 Select, use, clean and store personal safety equipment.

15.1.2 Demonstrate the use of safety devices on metal cutting machines.

15.1.3 Mark out components from various types of datum.

15.1.4 Check measurements of components/machined parts, using micrometers and verniers.

15.1.5 Check roundness of components using the dial test indicator and vee blocks.

15.1.6 Use sine bars and sine centres to set up and check tapers.

15.1.7 Check prepared specimens for limits and fits.

15.1.8 Set adjustable limit gauges/setting blocks.

15.1.9 Select the appropriate method of joining and the sequence of operations required.

15.1.10 Select, use, clean and store tools used with fastening devices.

15.1.11 Extract details from general arrangement and scale drawings.

15.1.12 Prepare working sketches of simple components with representation of limits, fits, tolerances, surface texture and machining operations.

### Knowledge requirements

The candidate will be able to:

15.1.1 Describe personal safety measures when machining.
**Safety measures:** PPE, prevention of injuries from sharp edges, packing pieces, swarf, precautions necessary in dealing with materials which may be dangerous if breathed in, absorbed into the digestive tract, or in contact with the skin

15.1.2 Explain the principles of workshop layout (candidates should be given an understanding for the need for safety precautions, but are not expected to be familiar with detailed specifications relating to layout).
**Layout:** provision for non-slip flooring, cleanliness, removal of swarf, provision of adequate gangways, safe movement of materials, exits

15.1.3 Describe mechanical safety devices.
**Safety devices:** features of guards for driving mechanisms, feed mechanisms and cutting tools, positioning of drives, moving parts of machines, circuits and devices to ensure they are out of reach, methods of mounting, fixing, adjusting and locking guards, procedures for making safe during plant maintenance

15.1.4 Describe the main factors in the determination of surface texture.
**Surface texture:** the significance of surface roughness and its influence on the function of a component: the degree of accuracy required in manufacture, machining allowance and its function on the machining process, the unit of measurement for surface texture (micrometer =mm), interpret standard symbols on drawings specifying the degree of surface finish, methods of assessing surface finish

15.1.5 Describe the concepts of limits and fits.
**Concepts:** describe the types of fits (ie clearance, transition and interference), define a fit in terms of the dimensional clearance between specific surfaces of two mating parts, describe the system of limits and fits: basic concept of the system, distinction between hole and shaft tolerances, nominal size, high and low limits (no calculations required for examination purposes)

15.1.6 Identify gauge types and state applications.
**Gauges:** plug, ring, gap, depth, screw thread, pin, telescopic

15.1.7 Describe the methods of marking out from various types of datum.
**Marking out:** single datum point, single datum point and single datum line, one or more datum faces, the centre of a hole

15.1.8 Describe the use of slip gauges/setting blocks.

15.1.9 Describe the principle of the micrometer: its action, care and use for measurement, setting up and assembly operations.
**Micrometer:** internal, external, depth

15.1.10 Describe the principle of the vernier: its action, care and use for measurement setting up and assembly operations.
**Vernier:** calliper, depth, height

15.1.11 Describe the use of the dial test indicator.
**Dial test:** plunger, other types

15.1.12 Describe the methods of angular measurement.
**Measurement:** sine bar, spirit level, taper gauges

15.1.13 State the general principles of the lead of a screw.
**Principles:** axial movement of a screw or nut to determine or control linear measurements and movements, pitch and lead: right or left hand threads, single and multi-start threads

15.1.14 Identify standard forms of threads and state applications.
**Threads:** vee, square, acme, buttress

15.1.15 Identify the effects of heat produced by machining.

# Module 15.2: Milling

## Introduction

The aim of this section is to enable the candidate to:

a Construct planning sheets for milling operations and carry out horizontal and vertical milling operations.

## Practical competences

In a real or simulated task the candidate should be able to:

15.2.1 Select, use, clean and store personal protective equipment.

15.2.2 Horizontal mill with cylindrical, side and face cutters.

15.2.3 Horizontal mill with cylindrical and slotted cutters.

15.2.4 Horizontal mill with double angle and slitting cutters.

15.2.5 Vertical mill with end mill, slot mill and dovetail cutter.

15.2.6 Use the dividing head eg to produce a splined shaft.

15.2.7 Construct planning sheets for milling operations.

## Knowledge requirements

The candidate will be able to:

15.2.1 State the purpose of milling.
**Purpose:** flat surfaces on the horizontal and vertical planes, slots, grooves, holes, cylindrical surfaces using a rotating multi-toothed cutter

15.2.2 Identify the basic types of milling machines.
**Machines:** vertical, horizontal, universal

15.2.3 State the safety precautions specific to milling operations.
**Safety precautions:** always use eye and hair protection, do not wear loose clothing or items of jewellery, keep hands away from revolving parts, use the guards provided, never check dimensions while cutter is rotating, never handle swarf with bare hands, lock unused slides, know emergency procedures

15.2.4 Describe the safe operation of milling machines.
**Safe operation:** adjustable guards, fixed guards, statutory regulations

15.2.5 Identify arbor mounted cutters and their applications.
**Cutters:** cylindrical cutters, side and face cutters, angular cutters, double angle cutters, saws, convex and concave cutters, radius cutters, flutting cutters, end mill, face mill, form cutter

15.2.6 Identify collet held cutters and their application.
**Cutters:** end mill, slot drills, tee slot cutters, fly cutter, dovetail cutter, woodruff key cutters

15.2.7 Describe the use of face mills with insert blades of high speed or cemented carbides.

15.2.8 Describe the methods of mounting and holding cutters.
**Mounting and holding:** describe arbors in terms of construction, procedure for fitting the cutters (eg use of spacing bushes), arbor support bracket, knee braces, stub arbor, describe collet chucks in terms of locking devices, ease of changeability of cutters

15.2.9 Describe work holding methods and work holding devices for milling operations.
**Methods and devices:** clamping work to machine table, locating and securing machine vices to machine table (ie importance of the fixed jaw, use of tenons (tenon blocks), set vice square and parallel to the cutter), adjustable or swivel angle plates, tilting tables, vee-blocks, milling fixtures

15.2.10 Describe the factors affecting maximum permissible cutting speed and feed performance.
**Cutting:** describe the method of obtaining the feed per minute (ie in relation to cutter diameter, number of teeth on cutter, cutting speed, feed rate per tooth), describe the relationship between rotation of cutter and feed, 'up-cut' milling, 'down-cut' milling

15.2.11 Describe horizontal milling operations.
**Milling:** milling of flat surfaces (vertical and horizontal), gang and straddle milling, production of narrow slots, slotting and slitting of thin plates, key way cutting

15.2.12 Describe vertical milling operations.
**Milling:** milling of sunk and recessed surfaces, woodruff cutters, use of shell end mills, face mills, face slot cutters, dove tail cutters

15.2.13 Describe the accessories used on the universal milling machine.
**Accessories:** types of dividing head (ie plane, universal), method of calculating the number of turns of crank lever to produce a given indexing for the dividing heads, methods of holding the work on the dividing heads (ie between centres, one end in chuck, the other supported by tailstock centre), the use of the rotary table

15.2.14 Describe the difference between soluble oils and straight cutting oils.

15.2.15 Calculate feed and speeds.
**Calculate:** peripheral speeds, average cutting speeds, use of tables and graphs to obtain approximate speeds and feeds

## Module 15.3: Turning

### Introduction

The aim of this section is to enable the candidate to:

a Carry out a range of turning operations.

### Practical competences

In a real or simulated task the candidate should be able to:

15.3.1 Select, use, clean and store personal protective equipment.

15.3.2 Practice faceplate balancing.

15.3.3 Carry out general turning such as stepped shafts using fixed and travelling steadies.

15.3.4 Turn, drill, face and chamfer work clamped on a angle plate set on the faceplate

15.3.5 Drill, bore, counterbore, recess, chamfer, face and part off with work set in a chuck.

15.3.6 Taper turn.

15.3.7 Cut and chase screw threads.

15.3.8 Form turn.

15.3.9 Knurl surfaces.

### Knowledge requirements

The candidate will be able to:

15.3.1 State the purpose of turning.
**Turning:** formed surfaces, generated surfaces

15.3.2 Identify types of lathe tools and their uses.
**Tools:** turning and facing tools, knife or side cutting tools, straight nosed roughing tool, facing tool, round nosed tools, parting off tool, screw cutting tool, knurling tool

15.3.3 State the advantages and limitations of types of cutting tools.
**Advantages and limitations:** solid single-point butt welded, tipped single dash point, deposit tipped single-point, disposable insert tooling

15.3.4 Describe the geometry of the lathe tool and its effect on turning.
**Lathe tool:** approach angle, normal rake angle (positive and negative), chip breakers

15.3.5 State typical speeds and feeds for the lathe tools listed.

15.3.6 State relationships between speeds, feeds, tool height, rake and clearance.

15.3.7 Carry out machining calculations.
**Calculate:** speeds and feeds, depth of cut, machining times

15.3.8 Describe the basic methods of work holding.
**Holding:** three jaw chuck, four jaw chuck, face plate, collet chuck

15.3.9 Describe the basic methods of supporting work.
**Supporting:** fixed steady, travelling steady

15.3.10 Describe the methods of taper turning and taper inspection.
**Taper turning:** describe methods of taper turning (ie compound slide, tailstock off-set, forming tool, taper-turning attachment), describe the methods of inspection by taper plug and ring gauges, state the importance of tool height, mating tapers, state the standard taper systems (ie morse, metric, brown and sharp)

15.3.11 Describe the methods of producing internal and external screw threads.
**Screw threads:** single-start, multi-start, chasing a screw thread

15.3.12 State the importance of correct tool setting and height.

15.3.13 Describe the methods of carrying out drilling and reaming operations using the lathe.
**Drilling and operations:** describe drilling operations (ie centre drilling, pilot drilling, drilling and reaming, flat bottom drilling), describe the process of reaming a drilled hole

15.3.14 Describe common methods of form turning on the lathe.

15.3.15 Describe the basic features of the capstan and turret lathes.
**Lathes:** essential features, action, operation, setting up, clamping and alignment of work, range of applications

15.3.16 Describe the basic features of the shaping machine.
**Shaping machine:** essential features, action, operation, setting up, clamping and alignment of work, range of applications

15.3.17 Describe the basic features of the planing machine.
**Planing machine:** essential features, action, operation, setting up, clamping and alignment of work, range of applications

15.3.18 Describe the basic features of the slotting machine.
**Slotting machine:** essential features, action, operation, setting up, clamping and alignment of work, range of applications

15.3.19 Describe the basic operating of numerical control of machine tools.
**Basic Operation:** describe and open and closed-loop control system, distinguish between point-to-point and continuous control, list the advantages of CNC compared with conventional type machining (ie repeatability of machining operations, ability to maintain dimensional accuracy, improves quality, improves production rate, reduces cost

15.3.20 State the safety precautions specific to turning on the lathe.
**Safety precautions:** wear eye and hair protection, and suitable footwear, do not wear loose clothing or items of jewellery, keep hands away from revolving gears, ensure power is switched off before removing guards, do not lean on the machine, keep alert, always use chuck guard and chip guard, always remove the key from the chuck after use, never handle swarf with bear hands, use a hook, keep hands away from revolving parts, the machine must be stopped before touching the work piece, know emergency stop procedures

## Test specification for written paper Metal Machining Principles (1155-02-015)

This is a written multiple choice examination paper lasting one and a half hours and containing 50 questions.

Candidate must answer **ALL** questions.

| Topic | Approximate % Examination weighting |
|---|---|
| Mechanical Applications and Dimensional Control | 28 |
| Milling | 36 |
| Turning | 36 |

# 1155-02-016 Metal Machining Practice
## 016/1 Mechanical Applications & Dimensional Control

### Practical competences

The candidate must be able to do the following:

16.1.1 Select, use, clean and store personal safety equipment. ☐

16.1.2 Demonstrate the use of safety devices on metal cutting machines. ☐

16.1.3 Mark out components from various types of datum. ☐

16.1.4 Check measurements of components/ machined parts, using micrometers and verniers. ☐

16.1.5 Check measurements of components/ machined parts, using micrometers and verniers. ☐

16.1.6 Use sine bars and sine centres to set up and check tapers. ☐

16.1.7 Check prepared specimens for limits and fits. ☐

16.1.8 Set adjustable limit gauges/setting blocks. ☐

16.1.9 Select the appropriate method of joining and the sequence of operations required. ☐

16.1.10 Select, use, clean and store tools used with fastening devices. ☐

16.1.11 Extract details from general arrangement and scale drawings. ☐

16.1.12 Prepare working sketches of simple components with representation of limits, fits, tolerances, surface texture and machining operations. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-016 Metal Machining Practice
016/2 Milling

## Practical competences

The candidate must be able to do the following:

| | | |
|---|---|---|
| 16.2.1 | Select use clean and store personal protective equipment. | ☐ |
| 16.2.2 | Horizontal mill with cylindrical, side and face cutters. | ☐ |
| 16.2.3 | Horizontal mill with cylindrical and slotted cutters. | ☐ |
| 16.2.4 | Horizontal mill with double angle and slitting cutters. | ☐ |
| 16.2.5 | Vertical mill with end mill, slot mill and dovetail cutter. | ☐ |
| 16.2.6 | Use the dividing head eg to produce a splined shaft. | ☐ |
| 16.2.7 | Construct planning sheets for milling operations. | ☐ |

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-016 Metal Machining Practice
016/3 Turning

## Practical competences

The candidate must be able to do the following:

| | | |
|---|---|---|
| 16.3.1 | Select, use, clean and store personal protective equipment. | ☐ |
| 16.3.2 | Practice faceplate balancing. | ☐ |
| 16.3.3 | Carry out general turning such as stepped shafts using fixed and travelling steadies. | ☐ |
| 16.3.4 | Turn, drill, face and chamfer work clamped on a angle plate set on the faceplate. | ☐ |
| 16.3.5 | Drill, bore, counterbore, recess, chamfer, face and part off with work set in a chuck. | ☐ |
| 16.3.6 | Taper turn. | ☐ |
| 16.3.7 | Cut and chase screw threads. | ☐ |
| 16.3.8 | Form turn. | ☐ |
| 16.3.9 | Knurl surfaces. | ☐ |

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

## Module 17.1: Supplementary Studies

### Introduction

The aim of this section is to enable the candidate to:

a fill out permits to work, check and adjust safety devices.
b Select and use a range of temporary and permanent methods of joining metals.
c Carry out assembly and dismantling operations.

### Practical competences

In a real or simulated task the candidate should be able to:

17.1.1 Select, use, clean and store personal protective equipment.

17.1.2 Demonstrate the use of mechanical and electrical safety devices: isolate a range of machines: fill out permits to work: set mechanical stop buttons.

17.1.3 Check the correct operation of solenoids, relays, and switches: adjust a micro switch on guard to ensure instant cut-off of a machine motor.

17.1.4 Use models and sketches of workshop layouts to show provision of gangways, exits and safety features.

17.1.5 Examine guard mechanisms on a range of machinery.

17.1.6 Select, use, clean and store mechanical fastening devices.

17.1.7 Select the appropriate method of joining and the sequence of operations required.

17.1.8 Select, use, clean and store soldering and braze welding equipment to effect joints in sheet metal, wire and pipe.

17.1.9 Carry out simple assembly and dismantling operations.

17.1.10 Change a range of fuses.

17.1.11 Carry out earth continuity and earth leakage tests with a multimeter.

17.1.12 Check the specific gravity and voltage of simple cells.

### Knowledge requirements

The candidate will be able to:

17.1.1 Identify types of protection devices.
**Protection:** semi enclosed, rewireable fuses, cartridge fuses, high rupturing capacity fuses, thermally and magnetically operated circuit breakers, residual current devices

17.1.2 State the advantages and limitations of listed protection devices.

17.1.3 State the importance of earthing and consequences of earth faults.

17.1.4 Interpret simple electric circuits to include conductor, switch, ammeter, voltmeter and load (candidates will be expected to recognise symbols, but will not be required to produce them from memory in an examination).

17.1.5 Solve simple problems involving Ohm's Law in series and parallel circuits: restricted to no more then three resistors in any one circuit.

17.1.6 Describe the use of a multimeter.
**Multimeter:** earth continuity tests, checking simple circuits for earth leakage and simple faults

17.1.7 Describe the method of checking the specific gravity and voltage of d.c. cells.

17.1.8 Explain the basic principles of soft soldering and hard soldering (brazing).
**Soldering:** joint types and materials joined, solders, fluxes, heating equipment, joint strength, applications

17.1.9 State the safety precautions specific to soldering and brazing.
**Safety precautions:** the use of compressed gas equipment: storage, siting, transportation, handling, explosive risks, the dangers of working in confined spaces, the dangers of working with acid fluxes, electrical hazards; checking and inspection of leads and cables, fire prevention; methods of dealing with chemical and electrical fires, fumes, use of protective clothing and equipment, personal hygiene after handling fluxes and solders

17.1.10 Explain the processes of oxy-acetylene and manual metal arc welding.
**Processes:** heat generation, filler wire, electrode, joint types, surface preparation, applications, safety

17.1.11 Describe the oxy-fuel gas cutting process.
**Oxy fuel gas cutting:** exothermic reaction (ie metals cut, reasons), applications, safety (ie protective clothing, fire risks, precautions in the use of compressed gas cylinders), working in confined spaces (ie ventilation, fumes, fire, explosive risk)

17.1.12 Recognise and state the purpose of tools used for assembly and dismantling.
**Tools:** open ended spanners, adjustable spanners, torque wrenches; application and control of torque, ring spanners, socket wrenches, hexagonal socket spanners, impact wrenches, pipe wrenches, screwdrivers, pliers, hammers, levers and supports, stud removers, heating and flame cutting equipment

17.1.13 State the type and effects of forces used in assembly and dismantling.
**Forces:** tensile, compression and shear eg nuts and bolts, shear load on pins, effects of over tightening and distortion

17.1.14 State the precautions necessary to counteract dangers encountered in assembly and dismantling procedures.
**Precautions:** forces (ie residual and applied, the weight of the system, components and fluid contents), pressure or flammability of the contents of systems or components, electricity, temperature and heat, chemicals within systems and components

17.1.15 Identify various types of keyed joints.
**Keyed joints:** plain rectangular or square taper, gib-head rectangular square taper, taper feather, parallel feather, splined shafts and hubs, woodruff, cotters, gibs

17.1.16 Describe the assembly and dismantling of listed key joints.

17.1.17 Identify pinned joints.
**Pinned joints:** taper, parallel, grooved, spring dowels

17.1.18 Describe the assembly and dismantling of listed pin joints.

17.1.19 Describe the assembly and dismantling of studs.
**Studs:** using special tools, using two nuts screwed together, extracting or damaged studs (ie special extractors, welding a nut onto the damaged stud)

17.1.20 Describe the purpose and maintenance of oil seals.

## Module 17.2: Mechanical Power Transmission

### Introduction

The aim of this section is to enable the candidate to:

a Identify faults in mechanical power transmission systems.
b Complete plant records for planned maintenance.
c Extract details from drawings, prepare working sketches and layout diagrams.

### Practical competences

In a real or simulated task the candidate should be able to:

17.2.1 Investigate

a simulated faults in belt and rope transmission systems
b the effect of altering the angle of wrap
c worn components damaged by faulty chain adjustment

17.2.2 Investigate variable speed drives and brakes to

a demonstrate braking effects
b show the effect of faulty adjustments and wear in brakes and control systems.

17.2.3 Investigate running faults in plain bearings and examine bearings for wear.

17.2.4 Investigate the effects of unsuitable and/or inadequate lubrication: use the simple ball and tube viscometer to show oil quality.

17.2.5 Investigate lubrication systems.

17.2.6 Visit sites to observe mechanical power transmission systems in operation.

17.2.7 Record simulated examples of maintenance onto actual plant records: planned maintenance.

17.2.8 Extract details from general arrangement drawings.

17.2.9 Prepare working sketches of simple components with representation of limits, tolerances, surface texture and machining operations.

17.2.10 Prepare simple assembly sketches showing the location of components by dowels and fitted bolts.

17.2.11 Sketch simple layout diagrams of transmission systems including components and sub-assemblies.

### Knowledge requirements

The candidate will be able to:

17.2.1 Identify methods of power transmission.
**Power transmission:** to achieve rotational movement (ie flat belts, vee belts, toothed belts, friction clutches, dog clutches, worm and wheel, bevel gear, hydraulic actuators), to achieve linear movement (ie screw and nut, rack and pinion, recirculating ball screw, crank and connecting rod, hydraulic actuators)

17.2.2 Describe the tensioning of transmission systems susceptible to stretch.
**Transmission:** describe the purpose of tensioning devices as a means of maintaining the correct driving tension, describe methods of tensioning belts/pulley systems (ie adjustment of the centres between shafts, hinged mountain brackets, idler pulleys), describe methods of tensioning chain systems (ie adjustment of sprockets by set screws, idler wheels)

17.2.3 Identify and describe types of shaft couplings.
**Shaft couplings:** fixed and flexible; alignment tests, special couplings to allow for non-alignment

17.2.4 Describe the operation of friction clutch mechanisms.
**Clutch mechanisms:** manual or automatic operation

17.2.5 Identify types of gear wheels.
**Gear wheels:** spur, helical, double helical, bevel, worm

17.2.6 Identify and state reasons for gear wheel defects.
**Defects:** pitting, spalling, abrasive wear

17.2.7 List the advantages and limitations of different transmission systems.
**Advantages and limitations:** gears, worm and worm wheels, chains, toothed belts, flat belts, vee belts

17.2.8 Describe the construction and use of various types of variable speed control.
**Variable speed control:** vee belt drive with sliding flanges, stepped, pulleys, variable-speed gear box

17.2.9 Describe the construction and use of simple mechanical brake assemblies.

17.2.10 Identify types of bearings and state their applications.
**Bearings:** plain, ball, roller, thrust and self aligning (ie use of plummer blocks, methods of obtaining bearing alignment and clearance, methods of adjustment and locking, bearings and slides)

17.2.11 Identify and state applications of special bearing types.
**Special bearings:** preloaded, non-metallic, impregnated, oil-retaining

17.2.12 Recognise running faults in plain bearing system and their causes.
**Running faults:** overheating, burning, digging, jamming, grooving, chemical corrosion, binding

17.2.13 Describe the principles and characteristics of lubrication systems.
**Lubrication systems:** gravity and wick, ring, splash, mist, circulation

17.2.14 State types and properties of lubricating oils.
**Lubrication:** oils (ie general purpose, gear, spindle, EP), greases (ie general purpose, high melting point, anti-freezing, water repellent, graphite molybdenum sulphide)

17.2.15 Identify colour coding of plant services.
**Colour coding:** electrical, pipelines

17.2.16 Identify components of service systems.
**Components:** water (ie water pumps, valves, strainers, filters, heat exchangers, receivers), hydraulic (oil or water) (ie pumps, motors, accumulators, unloaders, control valves), ventilation (ie fans, ducting, valves, controls), compressed air (ie compressors, valves, cylinder coolers, lubricators, piston, seals and gland packing, receivers, vacuum pumps, filters, regulators), steam (high and low pressure) (ie steam traps, control valves, reducing valves, safety valves)

## Module 17.3: Mechanical fitting

### Introduction

The aim of this section is to enable the candidate to:

a Carry out bench fitting processes.
b Check accuracy of dimensions and shape of components.
c Lift and move loads, use scaffold platforms and ladders.

### Practical competences

In a real or simulated task the candidate should be able to:

17.3.1 Select, use, clean and store personal protective equipment.

17.3.2 Use an offhand grinding machine to

a grind metal to size and shape
b sharpen tools: scriber, drill, punches, flat chisel

17.3.3 Carry out exercises involving filing, drilling, tapping and assembly with dowels.

17.3.4 Carry out exercises involving dowel and screwed components: marking out, sawing, filing, counterboring, countersinking, tapping.

17.3.5 Carry out exercises involving cutting out and filing to size square, angled, curved and tangential surfaces.

17.3.6 Mark out components from various types of datum.

17.3.7 Check measurements of components/machine parts using micrometers and verniers.

17.3.8 Set, adjust and use limit gauges/setting blocks.

17.3.9 Check prepared specimens using limits and fits demonstration kit.

17.3.10 Check roundness of components using dial test indicator and vee blocks.

17.3.11 Use the vernier protractor and height gauge for setting out on the surface table.

17.3.12 Check alignment of components/shafts etc using a range of equipment.

17.3.13 Use extractors to draw pulleys and bushes.

17.3.14 Move loads manually and by lifting and handling equipment.

17.3.15 Use scaffold platforms less than 2m high in accordance with national/local standards and use and transport ladders.

### Knowledge requirements

The candidate will be able to:

17.3.1 Describe the main factors in the determination of surface texture.
**Surface texture:** the significance of surface roughness and its influence on the function of a component: the degree of accuracy required in manufacture, define machining allowance and its function on the machining process, state the unit of measurement for surface finish (micrometer = $\mu$m), interpret standard symbols on drawings specifying the degree of surface finish, describe methods of assessing surface finish

17.3.2 Describe the concept of limits and fits.
**Concepts:** types of fit (ie clearance, transition and interference), define a fit in terms of the dimensional clearance between specific surfaces of two mating parts, describe the system of limits and fits (ie basic concept of the system, distinction between hole and shaft; nominal size, high and low limits [no calculation required for examination purposes]), describe the system of hole and shaft tolerances

17.3.3 Identify gauge types and state applications.
**Gauge types:** plug, ring, gap, depth, screw thread, pin, telescopic

17.3.4 Describe the methods of marking out for various types of datum.
**Marking out:** single datum point, single datum point and single datum line, one or more datum faces, the centre of a hole

17.3.5 Describe the use of slip gauges/setting blocks.

17.3.6 Describe the principle of the micrometer: its action, care and use for setting up and assembly operations.
**Micrometer:** internal, external, depth

17.3.7 Describe the principle of the vernier: its action, care and use for setting up and assembly operations.
**Vernier:** calliper, depth, height

17.3.8 Describe the use of the dial test indicator.
**Dial test:** plunger, other types

17.3.9 Describe the methods of angular measurement.
**Angular measurement:** sine bar, spirit level, taper gauges

17.3.10 Describe methods of alignment testing.
**Alignment testing:** straight edge, line or wire, plumb bob, precision level, tilting level, laser level

17.3.11 Describe methods of mounting machines on proper foundations.
**Methods:** mounting (including anti vibration mountings), levelling, fixing

17.3.12 Describe methods of aligning transmission systems.
**Methods:** shafts, couplings, bearings

17.3.13 Describe methods of locating parts.
**Locating parts:** dowels, pins, studs, fitted bolts

17.3.14 Identify and describe the use of special types of tools.
**Identify and describe:** special types of files, hand scrapers, electric and pneumatic tools, brick and concrete cutting tools

17.3.15 Describe the use of extractors for drawing pulleys and bushes.

17.3.16 List safety requirements in relation to lifting and handling equipment.
**Safety requirements:** shear legs, pulley systems, slings, jacks, crowbars, single purchase winch, shifting skates, mobile ramps

17.3.17 State the precautions to be observed when using scaffold platforms less than 2m high and in the use and transportation of ladders.

17.3.18 Identify and state the use of types of measuring instruments.
**Identify and describe:** tachometer, stroboscope, pyrometers, pressure and vacuum gauges

## Test specification for written paper Mechanical Fitting and Plant Maintenance Principles (1155-02-017)

This is a written multiple choice examination paper lasting one and a half hours and containing 50 questions.

Candidate must answer **ALL** questions.

| Topic | Approximate % Examination weighting |
|---|---|
| Supplementary Studies | 34 |
| Mechanical Power Transmission | 32 |
| Mechanical fitting | 34 |

# 1155-02-018 Mechanical Fitting and Plant Maintenance Practice
018/1 Supplementary Studies

## Practical competences

The candidate must be able to do the following:

18.1.1 Select, use, clean and store personal protective equipment. ☐

18.1.2 Demonstrate the use of mechanical and electrical safety devices: isolate a range of machines: fill out permits to work: set mechanical stop buttons. ☐

18.1.3 Check the correct operation of solenoids, relays, and switches: adjust a micro switch on guard to ensure instant cut-off of a machine motor. ☐

18.1.4 Use models and sketches of workshop layouts to show provision of gangways, exits and safety features. ☐

18.1.5 Examine guard mechanisms on a range of machinery. ☐

18.1.6 Select, use, clean and store mechanical fastening devices. ☐

18.1.7 Select the appropriate method of joining and the sequence of operations required. ☐

18.1.8 Select, use, clean and store soldering and braze welding equipment to effect joints in sheet metal, wire and pipe. ☐

18.1.9 Carry out simple assembly and dismantling operations. ☐

18.1.10 Change a range of fuses.

18.1.11 Carry out earth continuity and earth leakage tests with a multimeter. ☐

18.1.12 Check the specific gravity and voltage of simple cells. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-018 Mechanical Fitting and Plant Maintenance Practice
018/2 Mechanical Power Transmission

## Practical competences

The candidate must be able to do the following:

18.2.1 Investigate (a) simulated faults in belt and rope transmission systems (b) the effect of altering the angle of wrap (c) worn components damaged by faulty chain adjustment. ☐

18.2.2 Investigate variable speed drives and brakes to: (a) demonstrate braking effects (b) show the effect of faulty adjustments and wear in brakes and control systems. ☐

18.2.3 Investigate running faults in plain bearings and examine bearings for wear. ☐

18.2.4 Investigate the effects of unsuitable and/or inadequate lubrication: use the simple ball and tube viscometer to show oil quality. ☐

18.2.5 Investigate lubrication systems. ☐

18.2.6 Visit sites to observe mechanical power transmission systems in operation. ☐

18.2.7 Record simulated examples of maintenance onto actual plant records: planned maintenance. ☐

18.2.8 Extract details from general arrangement drawings. ☐

18.2.9 Prepare working sketches of simple components with representation of limits, tolerances, surface texture and machining operations. ☐

18.2.10 Prepare simple assembly sketches showing the location of components by dowels and fitted bolts. ☐

18.2.11 Sketch simple layout diagrams of transmission systems including components and sub-assemblies. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-018 Mechanical Fitting and Plant Maintenance Practice
018/3 Mechanical Fitting

## Practical competences

The candidate must be able to do the following:

18.3.1 Select, use, clean and store personal protective equipment. ☐

18.3.2 Use an offhand grinding machine to (a) grind metal to size and shape (b) sharpen tools: scriber, drill, punches, flat chisel. ☐

18.3.3 Carry out exercises involving filing, drilling, tapping and assembly with dowels. ☐

18.3.4 Carry out exercises involving dowel and screwed components: marking out, sawing, filing, counterboring, countersinking, tapping. ☐

18.3.5 Carry out exercises involving cutting out and filing to size square, angled, curved and tangential surfaces. ☐

18.3.6 Mark out components from various types of datum. ☐

18.3.7 Check measurements of components/machine parts using micrometers and verniers. ☐

18.3.8 Set, adjust and use limit gauges/ setting blocks. ☐

18.3.9 Check prepared specimens using limits and fits demonstration kit. ☐

18.3.10 Check roundness of components using dial test indicator and vee blocks. ☐

18.3.11 Use the vernier protractor and height gauge for setting out on the surface table. ☐

18.3.12 Check alignment of components/shafts etc using a range of equipment. ☐

18.3.13 Use extractors to draw pulleys and bushes. ☐

18.3.14 Move loads manually and by lifting and handling equipment. ☐

18.3.15 Use scaffold platforms less than 2m high in accordance with national/local standards and use and transport ladders. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 019 Fabrication, Welding and Pipework

## Module 19.1: Fabrication

### Introduction

The aim of this section is to enable the candidate to:

a Mark out, cut to size, hole, bend and assemble, plate, sections and tube.
b Develop patterns.
c Lift and move loads, use scaffold platforms and ladders.

### Practical competences

In a real or simulated task the candidate should be able to:

19.1.1 Select, use, clean and store personal safety equipment.

19.1.2 Use measuring and marking out equipment appropriate to fabrication, welding and pipework: scriber, straight edge, chalk and chalk line, dividers, trammels, engineers and flat squares, hammers, punches, tapes, flange and web gauges, backmark gauges.

19.1.3 Mark out.

a squares, rectangles; checking cross corners for accuracy
b circles, arcs
c shapes, tangents
d pipes, flanges
e simple structural details including back marks, cross centres, edge distances.

19.1.4 Produce and use templates.

19.1.5 Set out camber diagrams: parabolic curves.

19.1.6 Cut sheet metal and plate to shape and size using the guillotine and nibbler.

19.1.7 Cut tube and sectional material to length using a power saw.

19.1.8 Produce holes by drilling and punching.

19.1.9 Bend simple shapes on a press brake.

19.1.10 Fold simple shapes on sheet metal folding machines.

19.1.11 Stiffen sheet metal and plate.

19.1.12 Roll a cylinder.

19.1.13 Assemble components: produce a level bench.

a welded work
b simple bolted structural work

19.1.14 Develop patterns between parallel planes, cut out and form to shape.

a conic frustum
b square to round transformer

19.1.15 Lift and move materials by hand and with the use of lifting and handling equipment: turn over dogs, rollers, crowbar, jacks.

19.1.16 Use scaffold platforms less than 2m high in accordance with national/local standards and use and transport ladders.

### Knowledge requirements

The candidate will be able to:

19.1.1 Describe principles of cutting action and state applications of the methods of cutting by shear.
**Cutting:** powered (ie guillotine, plate shears, rotary shears, bevelled cutting wheels, punches and dies, cropper, nibbler), manual/portable (ie bench shears, portable hand nibblers, hand shears and snips, portable hand bevellers), safety precautions to be observed in use

19.1.2 State the advantages and limitations of cutting by shear.
**Advantages and limitations:** shearing is the fastest method of cutting, restricted to metal thickness, prone to edge deformation, prone to cracking along the cutting line

19.1.3 Describe the principles and cutting action of chip forming machines and state applications.
**Cutting:** saws (ie power operated, circular, hacksaw, band saw), edge planing/milling, end milling, safety precautions to be observed in use

19.1.4 State the reasons for machining the ends of work such as beams and stanchions.

19.1.5 Describe the principles of forming action, uses and special advantages of forming equipment: folding, edging, flanging, wiring, swaging, universal forming machines, (vibratory).

19.1.6 Identify and describe the use of bending rolls.
**Bending rolls:** pinch, pyramid (ie presetting, setting square in the rolls, application of pressure, allowance for springback), conical and helical rolling (ie aids used), safety precautions to be observed

19.1.7 Describe the use of the press brake and folding machines.
**Uses:** production of complex shapes such as transition pieces, guides and stops for batch work, planning of folding/bending sequence, safety precautions to be observed, rated capacity

19.1.8 List the factors to be considered when forming and state their effects.
**Factors and effects:** springback, pinching, material grain direction, bend radius, material thickness, width of die opening

19.1.9 Calculate the allowances for metal thickness applied to rolling and bending sheet metal and plate.

19.1.10 Calculate material allowance for sheet metal safe edges.
**Safe edge calculation:** single edge, double edge, wired

19.1.11 Identify methods of stiffening sheet metal and thin plate.

19.1.12 List sequence of operations for ease of construction.

19.1.13 Describe methods used for economic use of materials.

19.1.14 Identify the location of joints.
**Joint location:** ease of fabrication, reduction of welding distortion

19.1.15 Describe methods of marking out pipework, sheet metal, plate and structural sections.
**Marking out:** directly, from templates

19.1.16 Identify structural steel forms of supply.
**Identify:** rolled steel sections (ie angle bar, tee bar, rolled steel channel, rolled steel joist, universal beam, universal column), structural hollow sections (ie rectangular hollow section, circular hollow section)

19.1.17 Explain the meaning of the terms: backmark, cross centres, edge distance and pitch of holes.

19.1.18 Describe the method of setting out cambers in such members as girders and roof trusses: parabolic form; reasons for producing a camber in steelwork.

19.1.19 Identify template materials and state applications.
**Template materials:** template paper and card, plastic, plywood and wood lath, sheet metal and steel plate

19.1.20 Describe methods of producing a level bench.
**Methods:** spirit level with straight edge or steel wire, water level, tilting level, laser level

19.1.21 Describe the sequence of assembly and methods of setting up to avoid twist and buckling: use of stays and other means of maintaining shape.

19.1.22 List safety requirements in relation to lifting and handling equipment.
**Safety requirements:** static, mobile and overhead cranes, shear legs, pulley systems, slings, jacks, crowbars, single purchase winch, shifting skates, mobile ramps

19.1.23 State the precautions to be observed when using scaffold platforms less than 2m high and in the use and transportation of ladders.

## Module 19.2: Welding

### Introduction

The aim of this section is to enable the candidate to:

a Join metal by soldering and welding.
b Cut metal by the oxy-fuel gas process.
c Carry out the inspection and testing of welds and identify possible causes of defects.

### Practical competences

In a real or simulated task the candidate should be able to:

19.2.1 Select, use, clean and store personal protective equipment.

19.2.2 Hard solder a lap joint between two pieces of sheet metal/copper pipe.

19.2.3 Braze weld two pieces of cast iron.

19.2.4 Assemble oxy-fuel gas welding equipment and check for leaks.

19.2.5 Produce oxy-fuel gas welded joints in low carbon steel, using the leftward technique. Material: 3mm thick, and at least 150mm long welded in the flat position.

a butt welds
b open outside corners

19.2.6 Investigate the effects of oxy-fuel gas welding with oxidising, neutral and reducing flames.

19.2.7 Close down oxy-fuel gas equipment.

a blow pipe valves turned off in correct sequence.
b cylinder/supply valves closed
c pressure regulators relieved
d hoses purged

19.2.8 Assemble oxy-fuel gas cutting equipment and check for leaks.

19.2.9 Oxy-fuel gas cut low carbon steel up to 25mm thick with and without guides.

a straight lines
b curves and circles
c bevels
d pipes

19.2.10 Set up manual metal arc welding equipment.

19.2.11 Produce manual metal arc welded joints in low carbon steel. Material up to 10mm maximum thickness, at least 150mm long in the

a flat position (i) open outside corner (ii) butt weld
b horizontal vertical position (i) fillet weld (ii) lap weld

19.2.12 Electrically isolate the welding set from the mains: cables and other accessories stored safely and correctly.

19.2.13 Carry out inspection and testing of welds using.

a visual inspection
b penetrant ink
c magnetic crack detection
d nick break test
e bend tests
f macro etching

19.2.14 Investigate the effects on weld quality due to changes in.

a current
b voltage
c speed of travel
d height of electrode
e angle of electrode

### Knowledge requirements

The candidate will be able to:

19.2.1 Explain the basic principles of hard soldering and braze welding.
**Principles:** joint types and materials joined, solders, fluxes, heating equipment, applications, safety precautions

19.2.2 Describe the methods used to protect the weld pool from atmospheric contamination during welding.
**Protection:** oxy–fuel gas, manual metal arc

19.2.3 Describe oxy–fuel gas welding and ancillary equipment.
**Equipment:** blow pipes, cylinders, filler metals and fluxes, pressure gauges, regulators, gas economiser, hose, connectors, protectors, safety devices, thread identification; hose, pipeline and cylinder colours, manifold system

19.2.4 Describe the oxy–fuel gas welding process.
**Process:** setting up the equipment, leak testing, oxy-fuel gas mixing, flame adjustment (including oxidising, neutral and carburising flames), melting parent and filler metals, fusion and solidification, shutting down procedure

19.2.5 Describe the oxy–fuel gas cutting process.
**Process:** exothermic reaction (ie metals cut, limitations), lighting, adjusting and extinguishing the flame, factors influencing the quality of cut, applications, freehand cutting (ie cutting from an edge of plate, inside from the edge, sections, round bar), guided hand cutting (ie bevel cutting, circle cutting guides, spade or wheel guides)

19.2.6 Describe the oxy-fuel gas cutting and ancillary equipment.
**Equipment:** blow pipes (eg arrangements of the mixing of oxygen and fuel gas), construction and application of typical cutting nozzles, hoses (eg connections, safety devices, identification), pressure gauges and regulators, gases (eg acetylene, propane, hydrogen, oxygen) flame temperature, relative cutting speed, operating costs, cylinder identification

19.2.7 Describe potential safety hazards associated with oxy-fuel gas welding and cutting. State precautions which should be taken.
**Potential hazards:** protective clothing and equipment, fire risks, adequate ventilation, working in confined spaces (ie ventilation, fumes, fire, explosive risk), precautions in the use of compressed gas cylinders (ie storage in well ventilated area, correct identification of gases (BS colour coding), careful handling and transportation, security/anchorage of cylinders in use, located away from sources of heat and arc welding equipment, oxygen cylinder free of oil and grease, procedure to be taken in the event of cylinder overheating, backfire or flashback

19.2.8 Describe manual metal arc welding power sources.
**Power sources:** d.c. plant (ie engine driven generators, electrically driven generators, rectifiers, current and voltage control, effect of polarity), a.c. plant (ie alternators and transformers, current and voltage control), current ranges (ie open circuit and welding voltages for a.c. and d.c. equipment, voltage and current meters

19.2.9 Identify manual metal arc welding equipment and state reasons for use.
**Equipment and uses:** welding lead and electrode holder, welding return cable and clamp, welding earth, isolator switches, electrodes (ie types, functions of flux coating, storage), head screens, chipping hammer, wire brush

19.2.10 Describe the manual metal arc welding process.
**Process:** arc voltage and amperage settings, method of striking the arc, breaking and restriking, melting parent and filler metals, fusion and solidification, control of liquid metal and slag

19.2.11 Identify oxy-fuel gas and manual metal arc joint types.
**Joint types:** fillet, lap, square butt, single and double-V butts, single and double-U butts, single and double-bevel butts, single and double-butts, open outside corner

19.2.12 Describe the causes and control of distortion.
**Distortion:** types of distortion, methods of control (ie presetting, welding sequences, backing bars and strips, tack welding, restraint, jigs and fixtures, pre and post heating, chills), residual stress

19.2.13 Describe methods of inspecting and testing welds.
**Inspecting and testing:** destructive (ie nick break test, bend tests, macro etching), non-destructive (ie visual, dye penetrant, magnetic particle inspection, ultrasonic examination, radiographic examination)

19.2.14 Identify weld defects and state possible causes.
**Weld defects:** undercut, cracking, overlap, incomplete penetration, slag inclusions, lack of side wall fusion, porosity, poor weld appearance, excessive spatter

19.2.15 Describe potential safety hazards associated with manual metal arc welding and state precautions which should be taken.
**Safety hazards:** protective clothing, welding screen, electrical hazards (ie earthing, safety checks on equipment), confined spaces (ie damp conditions, ventilation, fumes, fire, explosion risk), special precautions when welding containers which have held, flammable, explosive, caustic or toxic substances

19.2.16 Identify weld features.
**Features:** parent metal, weld metal, weld pool, fusion zone, heat affected zone, toe, root, reinforcement, actual and effective leg length, throat thickness

19.2.17 Describe the solidification of a weld pool and identify the resulting microstructure.
**Weld pool:** quiaxed grains, columnar grains, heat affected zone, recrystallisation, grain growth

## Module 19.3: Pipework

### Introduction

The aim of this section is to enable the candidate to:

a Produce pipelines and pipe branches.
b Construct curves of intersection and surface developments.
c Extract details from drawings and prepare working sketches.

### Practical competences

In a real or simulated task the candidate should be able to:

19.3.1 Select, use, clean and store personal safety equipment.

19.3.2 Hot and cold bend small bore thin walled pipes.

19.3.3 Thread pipe ends using hand and power tools.

19.3.4 Fabricate pipeline sections and pressure test; screwed, welded, bolted.

19.3.5 Fabricate a pipe branch.

19.3.6 Fabricate a cut and shut 90° bend.

19.3.7 Visit industrial sites to see applications of pipework systems.

19.3.8 Carry out parallel line development techniques of right and oblique angled branches.

a cylinders of equal and unequal diameters on and off centre, true shape of hole in main.
b cylindrical branches on the corners of rectangular ducting on centre; true shape of hole in main.
c right cylindrical segmental bends
d right cylinder on right segmental bend on centre

19.3.9 Carry out radial line development techniques.

a right cone cut obliquely
b right pyramid cut obliquely
c oblique cone cut square and obliquely

19.3.10 Produce curves of intersection using the principle of the common central sphere.

a pipe connections
b elbows formed by right cylinders and right cones

19.3.11 Produce curves of intersection using the principles of projection.

19.3.12 Produce curves of intersection using the principles of cutting planes confined to examples of simple form only.

a circular section planes
b square section planes

19.3.13 Carry out triangulation development techniques.

a right and oblique cones of long taper
b square or rectangle-to-circle transformers between parallel planes
c square and rectangular tapered hoppers between parallel planes
d on and off centre

19.3.14 Identify weld symbols and their application.

19.3.15 Identify pipe contents from colour coding.

a water: drinking, fire fighting, untreated
b compressed air, steam
c natural gas
d oil (basic colour only)
e acids, alkaline

19.3.16 Produce sketches of simple fabrications and pipework.

19.3.17 Extract details from general arrangement drawings of fabricated work.

19.3.18 Interpret pipe arrangement drawings.

a orthographic, simple isometric
b sketch pipe details
c prepare materials list

### Knowledge requirements

The candidate will be able to:

19.3.1 Identify and state the applications of fastening devices used in fabrication engineering.
**Fastening devices:** bolts (ie black, fitted [turned barrel], high strength friction grip, torshear load indicating, advantages, tightening sequences), washers (ie flat, taper, load indicating, reasons for use)

19.3.2 Identify common pipe materials and state applications and reasons for use.
**Materials:** plastic, steel, low alloy steel, non ferrous metal.

19.3.3 State advantages and limitations of protective coatings for pipes.
**Advantages and limitations:** dipped, sprayed, painted, wrapped, linings, bituminous coatings, cathodic protection (ie sacrificial and impressed current)

19.3.4 Describe pipelines and pipework systems and components (simple description only).
**Systems and components:** heating and hot water services, water treatment systems, steam services, gas and air services, petroleum products, chemicals, slurries and solids

19.3.5 Describe methods of threading pipe ends: equipment required.

19.3.6 Identify and describe the use of compression and capillary fittings.

19.3.7 Identify mechanical pipe connections and state their applications.
**Pipe connections:** screwed joint types, pipe thread types, parallel and taper threads, pipe preparation, use of screwed fittings, flanged joints (ie the use of screwed-on and weld-on flanges), gaskets (ie types and materials)

19.3.8 Identify components of pipework systems and state applications: valves, pumps, traps, bellows and expansion bends.

19.3.9 Describe welded pipe connections, methods of welding and state.
**Connections:** applications, edge preparation and tacking procedures, use of weldable fittings: elbows, bends, tee pieces, techniques for butt welds in steel pipes up to 90mm nominal bore

19.3.10 Describe inspection and testing of pipework.
**Inspection and testing:** dimensional checking (ie ovality, buckles, sand adhesion, flange squareness, hole positions [on and off centre], quality of pipe), hydraulic testing

19.3.11 Describe pipe bending methods, tools and equipment.
**Methods and tools:** cold bending springs, use of formers, mandrels, gripback plates, clamps and wiper dies (ie compression bending with and without filling, draw bending), hot bending, use of low metal temperature fillers; methods of cooling, effect of inadequate filling (ie low melting point alloys, resin, pitch, sand)

19.3.12 Describe the reasons for preheating and post heating pipe.
**Pre- and Postheating:** temperature ranges for different metals, holding period and cooling rates, stress relieving: methods used

19.3.13 Describe types of support for fabricated pipework.
**Support:** u-bolts, hangars, rollers, anchors, girder/beam clamps, guides

## Test specification for written paper Fabrication, Welding and Pipework Principles (1155-02-019)

This is a written multiple choice examination paper lasting one and a half hours and containing 50 questions.

Candidate must answer **ALL** questions.

| Topic | Approximate % Examination weighting |
|---|---|
| Fabrication | 36 |
| Welding | 36 |
| Pipework | 28 |

# 1155-02-020 Fabrication, Welding and Pipework Practice
020/1 Fabrication

## Practical competences

The candidate must be able to do the following:

20.1.1 Select, use, clean and store personal safety equipment. ☐

20.1.2 Use measuring and marking out equipment appropriate to fabrication, welding and pipework: scriber, straight edge, chalk and chalk line, dividers, trammels, engineers and flat squares, hammers, punches, tapes, flange and web gauges, backmark gauges. ☐

20.1.3 Mark out (a) squares, rectangles; checking cross corners for accuracy (b) circles, arcs (c) shapes, tangents (d) pipes, flanges (e) simple structural details including back marks, cross centres, edge distances. ☐

20.1.4 Produce and use templates. ☐

20.1.5 Set out camber diagrams: parabolic curves. ☐

20.1.6 Cut sheet metal and plate to shape and size using the guillotine and nibbler. ☐

20.1.7 Cut tube and sectional material to length using a power saw. ☐

20.1.8 Produce holes by drilling and punching. ☐

20.1.9 Bend simple shapes on a press brake. ☐

20.1.10 Fold simple shapes on sheet metal folding machines. ☐

20.1.11 Stiffen sheet metal and plate. ☐

20.1.12 Roll a cylinder. ☐

20.1.13 Assemble components: produce a level bench (a) welded work (b) simple bolted structural work. ☐

20.1.14 Develop patterns between parallel planes, cut out and form to shape (a) conic frustum (b) square to round transformer. ☐

20.1.15 Lift and move materials by hand and with the use of lifting and handling equipment: turn over dogs, rollers, crowbar, jacks. ☐

20.1.16 Use scaffold platforms less than 2m high in accordance with national/ local standards and use and transport ladders. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-020 Fabrication, Welding and Pipework Practice
020/2 Welding

## Practical competences

The candidate must be able to do the following:

20.2.1 Select, use, clean and store personal protective equipment. ☐

20.2.2 Hard solder a lap joint between two pieces of sheet metal/copper pipe. ☐

20.2.3 Braze weld two pieces of cast iron. ☐

20.2.4 Assemble oxy-fuel gas welding equipment and check for leaks. ☐

20.2.5 Produce oxy-fuel gas welded joints in low carbon steel, using the leftward technique. Material: 3mm thick, and at least 150mm long welded in the flat position (a) butt welds (b) open outside corners. ☐

20.2.6 Investigate the effects of oxy-fuel gas welding with oxidising, neutral and reducing flames. ☐

20.2.7 Close down oxy-fuel gas equipment (a) blow pipe valves turned off in correct sequence (b) cylinder/supply valves closed (c) pressure regulators relieved (d) hoses purged. ☐

20.2.8 Assemble oxy-fuel gas cutting equipment and check for leaks. ☐

20.2.9 Oxy-fuel gas cut low carbon steel up to 25mm thick with and without guides (a) straight lines (b) curves and circles (c) bevels (d) pipes. ☐

20.2.10 Set up manual metal arc welding equipment. ☐

20.2.11 Produce manual metal arc welded joints in low carbon steel. Material up to 10mm maximum thickness, at least 150mm long in the (a) flat position (i) open outside corner (ii) butt weld (b) horizontal vertical position (i) fillet weld (ii) lap weld. ☐

20.2.12 Electrically isolate the welding set from the mains: cables and other accessories stored safely and correctly. ☐

20.2.13 Carry out inspection and testing of welds using (a) visual inspection (b) penetrant ink (c) magnetic crack detection (d) nick break test (e) bend tests (f) macro etching. ☐

20.2.14 Investigate the effects on weld quality due to changes in (a) current (b) voltage speed of travel (c) height of electrode (d) angle of electrode. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-020 Fabrication, Welding and Pipework Practice
020/3 Pipework

## Practical competences

The candidate must be able to do the following:

20.3.1 Select, use, clean and store personal safety equipment. ☐

20.3.2 Hot and cold bend small bore thin walled pipes. ☐

20.3.3 Thread pipe ends using hand and power tools. ☐

20.3.4 Fabricate pipeline sections and pressure test; screwed, welded, bolted. ☐

20.3.5 Fabricate a pipe branch. ☐

20.3.6 Fabricate a cut and shut 90° bend. ☐

20.3.7 Visit industrial sites to see applications of pipework systems. ☐

20.3.8 Carry out parallel line development techniques of right and oblique angled branches (a) cylinders of equal and unequal diameters on and off centre, true shape of hole in main (b) cylindrical branches on the corners of rectangular ducting on centre; true shape of hole in main (c) right cylindrical segmental bends (d) right cylinder on right segmental bend on centre. ☐

20.3.9 Carry out radial line development techniques (a) right cone cut obliquely (b) right pyramid cut obliquely (c) oblique cone cut square and obliquely. ☐

20.3.10 Produce curves of intersection using the principle of the common central sphere (a) pipe connections (b) elbows formed by right cylinders and right cones. ☐

20.3.11 Produce curves of intersection using the principles of projection. ☐

20.3.12 Produce curves of intersection using the principles of cutting planes confined to examples of simple form only (a) circular section planes (b) square section planes. ☐

20.3.13 Carry out triangulation development techniques (a) right and oblique cones of long taper (b) square/rectangle-to-circle transformers between parallel planes (c) square and rectangular tapered hoppers between parallel planes (d) on and off centre. ☐

20.3.14 Identify weld symbols and their application. ☐

20.3.15 Identify pipe contents from colour coding (a) water: drinking, fire fighting, untreated (b) compressed air, steam (c) natural gas (d) oil (basic colour only) (e) acids, alkaline. ☐

20.3.16 Produce sketches of simple fabrications and pipework. ☐

20.3.17 Extract details from general arrangement drawings of fabricated work. ☐

20.3.18 Interpret pipe arrangement drawings (a) orthographic, simple isometric (b) sketch pipe details (c) prepare materials list. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 021 Electronic Engineering Principles

## Module 21.1: Electronic Principles 1

## Introduction

The aim of this section is to enable the candidate to:

a Use a range of hand tools safely and effectively.
b Develop good soldering practice.
c Identify and select electronic components.
d Identify and use test equipment found in an electronic workshop.

## Practical competences

The candidate must be able to do the following:

21.1.1 Identify potential hazards in an electrical/electronics workshop.
**Potential Hazards:** toxic substances, fumes; high/mains voltages; unguarded equipment, hot soldering iron; solder splashes; sharp tools, charged capacitors, working on 'live' circuits.

21.1.2 Store basic hand tools and maintain good housekeeping.

21.1.3 Use a range of hand tools to cut, form, strip, shape, assemble wires and components.
**Hand tools:** pliers, cutters, strippers, drill, track-breaker, screwdriver, retractable blade, junior hacksaw, soldering iron

21.1.4 Use soldering techniques to assemble electronic components and wires to stripboard (veroboard) or printed circuit board.

21.1.5 Visually inspect solder joints to ensure joints are sound, and that there are no 'dry joints' or short circuits.

21.1.6 Identify electronic components using manufacturer's catalogue or other sources.
**Components:** resistors (fixed and variable), capacitors, inductors, diodes, transistors

21.1.7 Identify the value of resistors and capacitors using colour code and other codes.

21.1.8 Identify wires and cables using manufacturers catalogue or other sources.
**Wires and Cables:** single strand, multi-strand, multicore

21.1.9 Assemble a plug to mains cable and select correct fuse for application.

21.1.10 Use an analogue and digital multimeter for measuring current, voltage and resistance.

21.1.11 Use an analogue and a digital multimeter to test the functionality of a diode and a transistor (front-to-back ratio).

21.1.12 Identify the front panel controls of an oscilloscope.
**Front panel controls:** focus, intensity, timebase, stability, trigger level, vertical attenuator, X and Y-shift, a.c.-d.c.-ground.

21.1.13 Identify the front panel controls of a function generator.
**Front panel controls:** frequency, amplitude, waveform

21.1.14 Set a d.c. power supply to provide single supplies (positive and negative) and split supplies (+15V, 0V and -15V).

21.1.15 Use a multimeter to measure d.c. voltages generated by a d.c. power supply.

21.1.16 Connect a function generator to an oscilloscope and observe a.c. waveforms.
**Waveforms:** sine, triangular, square

21.1.17 Connect a half-wave rectifier to the secondary winding of a transformer and observe the output waveform across a load resistor using an oscilloscope.

21.1.18 Connect an electrolytic capacitor across the load resistor of the half-wave rectifier and observe the smoothing effect on the output waveform.

21.1.19 Use a d.c. voltmeter to measure the output voltage of the half-wave rectifier with and without a smoothing capacitor.

## Knowledge requirements

The candidate will be able to:

21.1.1 State precautions to be taken in the use of hand tools, machinery and instruments found in an electrical/electronics workshop.
**Hand tools:** soldering irons, wire cutters, wire strippers, metal working tools, etching tools, solder baths, pliers, retractable blade

21.1.2 Explain the principle of operation of a moving coil meter.

21.1.3 Explain the principle of operation of a multimeter (analogue, digital).

## Module 21.1: Electronic Principles 1

21.1.4 Explain how meters are inserted into circuits to measure voltage (voltmeter) and current (ammeter), and the precautions needed to prevent damage to the meters.
**Precautions:** disconnect power when inserting ammeter, select correct range and scale, down-ranging

21.1.5 Explain, with the aid of a block diagram, the principle of operation of an oscilloscope.

21.1.6 State the needs for flux in the soldering process.
**Needs:** to clean joint, to help solder to flow.

21.1.7 State that cores of flux are built into solder on the reel.

21.1.8 State the types of soldering iron bit available.
**Types:** chisel, conical, flat

21.1.9 Explain the term 'tinning' and its importance in the soldering process.
**Tinning:** the process of applying solder to bare copper

21.1.10 State the requirements of a good solder joint.
**Requirements:** smooth, shiny, correct shape, correct amount of solder

21.1.11 State the resistor and capacitor colour code.

21.1.12 State that resistor and capacitor values can be interpreted using codes other than colour code.
**Codes:** number and letter

21.1.13 Describe the construction of different types of resistor.
**Types:** carbon, carbon film, metal film, wire wound

21.1.14 State that the power rating of a resistor is generally related to its physical size.

21.1.15 Calculate the power dissipated in a resistor.
**Calculations:** $P=V \times I$ $P=I^2R$ $P=\frac{V^2}{R}$

21.1.16 Describe the construction of a simple parallel plate capacitor.

21.1.17 Explain that a capacitor will block d.c. and pass a.c.

21.1.18 Explain the differences between electrolytic and non-electrolytic capacitors.
**Differences:** polarisation, dielectric, capacitance value, size

21.1.19 Explain the atomic structure of insulators and conductors and how this affects the ability to conduct current.
**Atomic structure:** nucleus (protons and neutrons), valence shell, electrons, positive and negative charges

21.1.20 Explain the atomic structure of semi-conductors, such as germanium and silicon.
**Atomic structure:** covalent bonds, sharing of valence electrons

21.1.21 Explain how N-type and P-type semi-conductors are produced by doping with impurity atoms.
**Impurity atoms:** pentavalent and trivalent

21.1.22 Explain that a semi-conductor diode is formed by joining N-type and P-type materials.
**Explanation:** electrons cross from N to P- type, holes cross from P to N- type, potential barrier formed at junction

21.1.23 Explain the principle of operation of a semi-conductor diode.
**Principle:** Forward bias – low resistance, current flows due to majority current carriers; Reverse bias – high resistance, leakage current due to minority current carriers

21.1.24 Describe the forward and reverse characteristics of a semi-conductor diode.
**Description:** Forward bias diode conducts at 0.2V for germanium and 0.6V for silicon. Reverse bias diode conducts very small leakage current until it reaches its breakdown voltage and it is destroyed

## Module 21.1: Electronic Principles 1

21.1.25 State that a semi-conductor diode can be destroyed if the maximum reverse voltage $V_{RRM}$ or maximum forward current $I_F$ are exceeded.

21.1.26 Explain the principles of rectification.
**Rectifiers:** half-wave, full-wave, bridge

21.1.27 Explain the basic principles of an LED (light emitting diode).
**Basic Principles:** operates in forward bias, emission if light at junction, use of magnifier lens, colours of LED

21.1.28 Explain that an LED operates with a series current-limiting resistor.

21.1.29 State the benefits of using a LED as an indicator.
**Benefits:** small size, low power consumption, reliable

21.1.30 Describe how a zener diode operates on the reverse characteristic.
**Description to include:** zener voltage, normal operating region, current and voltage range

21.1.31 State that the zener diode is used as a voltage stabilising device.

## Module 21.2: Electronic Applications

### Introduction

The aim of this section is to enable the candidate to:

a Construct simple electronic circuits using transistors, integrated circuits and other components.
b Perform tests on electronic circuits and record results.
c Identify faults on electronic circuits using visual inspection and simple tests.

### Practical competences

The candidate must be able to do the following:

21.2.1 Select electronic components by price and component number from manufacturer's catalogues or other sources.

21.2.2 Identify and sketch standard or recognised component circuit symbols.
**Components:** resistors, capacitors, diodes, transistors, LED, LDR, relay

21.2.3 Identify different types of board used in the assembly of electronic circuits.
**Circuits:** breadboard, stripboard, printed circuit board

21.2.4 Construct a voltage stabiliser using a series resistor and a zener diode. Connect a load resistor to the circuit. Connect a d.c. supply to the input and measure the voltage across the load resistor for changes in d.c. supply voltages. Record input and output voltages.

21.2.5 Convert circuit diagrams into layout diagrams.

21.2.6 Sketch a circuit diagram (to include d.c. power supply connections) of a common emitter amplifier utilising an NPN transistor, a base bias resistor and a collector load resistor.

21.2.7 With reference to 22.2.6, construct a simple common emitter amplifier circuit (on breadboard) and test to ensure that the collector voltage is at, or near, half the supply voltage (VCC). Transfer the amplifier circuit to stripboard (veroboard).

21.2.8 Connect a low-level signal (sine wave) from the function generator to the input of the amplifier (as in 22.2.7). Connect a dual-beam scope to monitor the input and output waveforms and compare the input and output voltages.

21.2.9 Determine the voltage gain of the common emitter amplifier (as in 21.1.8).

21.2.10 Observe the effect on voltage gain of varying the input frequency to an amplifier. Record voltage gain at each frequency.

21.2.11 Plot a frequency response curve for the amplifier from results obtained practically (as in 22.10).

21.2.12 Construct (on breadboard), and test the operation of the following circuits:
a transistor as a switch
b light-operated relay using a light-dependant resistor (LDR).

21.2.13 Construct and test simple operational amplifier circuits.
**Circuits:** inverting, non-inverting

21.2.14 Compare calculated and measured values of voltage gain for inverting and non-inverting amplifiers.

21.2.15 Construct and test a simple timing circuit using a 555 timer and other components. Use an LED to indicate ON time.

21.2.16 Construct and test a timing circuit using a 555 timer which will operate a 12V relay.

21.1.17 Construct an oscillator circuit using a 555 timer and other components. Observe and record the output waveform using an oscilloscope.

### Knowledge requirements

21.2.1 State the precautions to be taken when soldering electronic components to circuit boards and ensure that components and tracks are not damaged by overheating.
**Precautions:** use of heat shunts, time taken to solder, temperature of bit

21.2.2 State the precautions which must be taken when handling integrated circuits (IC's) in order to prevent electrical and mechanical damage.
**Precautions:** use of earth strap, rubber mat, anti-static, insertion and removal with tool (not by hand), use of IC holder

## Module 21.2: Electronic Applications

21.2.3 Describe the construction and operation of a bi-polar junction transistor, type: NPN.
**Construction and operation:** identification of base, collector and emitter; biasing between base/emitter and collector/base; base current determined by forward bias base/emitter voltage; collector current determined by current gain of transistor.

21.2.4 State that a bipolar junction transistor is inherently a current amplifying device.

21.2.5 State that a transistor can be used as a switch or an amplifier.

21.2.6 Explain the operation of a common emitter amplifier using a single biasing resistor.
**Operation:** Description to include how bias resistor determines base current and a decrease in base resistor increases base current and collector current. Increased collector current causes voltage across load resistor to increase and the output voltage to decrease. Output voltage phase inverted from input voltage

21.2.7 Explain how the transistor operates as a switch, by operating between two extremes.
**Extremes:** saturation (fully conducting) and cut-off (non-conducting)

21.2.8 Explain that temperature changes can upset the operating conditions of an amplifier circuit.

21.2.9 Describe the operation of a fully stabilised common emitter amplifier, using a potential divider to provide the correct base bias, a resistor in series with the emitter and a load resistor.
**Operation:** description to include how potential divider provides dc stabilisation together with emitter resistor; importance of using correct value resistors ; voltage gain determined by value of load resistor

21.2.10 Explain the need for 'coupling' capacitors in a common emitter amplifier.
**Need:** block d.c. and pass a.c.

21.2.11 Explain why a de-coupling capacitor (bi-pass capacitor) is needed in a fully stabilised amplifier circuit.
**Need:** for a.c. to pass through decoupling capacitor instead of emitter resistor hence reducing voltage gain of amplifier

21.2.12 Calculate the voltage gain of a common emitter amplifier and observe the effect on the voltage gain of changing the load resistor.

21.2.13 Explain 'frequency response' of an amplifier.
**Explanation:** frequency response produced by plotting voltage gain (vertical axis) against logarithmic frequency (horizontal axis)

21.2.14 Explain the meaning of the term 'bandwidth'.
**Explanation:** bandwidth is the difference in frequency between the lower and the higher -3db point

21.2.15 State why a common emitter amplifier's voltage gain drops off at low and high frequencies.
**Gain drops off:** due to inter-electrode capacitance (high frequency) and reactance of coupling capacitors (low frequency)

21.2.16 Explain the term 'integrated circuit' (IC)
**Integrated circuit:** variety of components formed on one substrate using photo-etch techniques and internally connected together

21.2.17 Explain that an IC consists of electronic components on a single chip.
**Components:** resistors, transistors, diodes, capacitors

21.2.18 State the benefits and limitations of using integrated circuits.
**Benefits:** small in size, cheap, consume less power, ease of construction
**Limitations:** difficult to fault find, storage and handling precautions

21.2.19 Explain the benefits of using carrier holders when using IC
**Benefits:** ease of replacement, prevents damage to IC

21.2.20 Explain the construction and operation of a light dependant resistor (LDR).
**Explanation:** constructed from semiconductor material whose characteristics vary with the amount of incident light. The greater the level of light, the lower the resistance of the LDR

21.2.21 Explain the principle of operation of the zener (reference) diode.
**Operation:** Operated on reverse characteristic. Beyond the zener voltage a small change in reverse voltage causes a large change in zener current. Needs to operate within its power capabilities

21.2.22 Describe the operation of a simple voltage stabiliser using a zener diode and a current limiting resistor.
**Description to include:** how voltage across zener remains stable for changes of input voltage and changes of load current

## Module 21.2: Electronic Applications

21.2.23 Identify the pin-out connections of an operational amplifier (741).

21.2.24 State that the maximum supply voltage for 741 is ± 18V.

21.2.25 State a typical value for the open-loop gain of an operational amplifier.
**Typical value of gain:** 100,000

21.2.26 Explain why negative feedback is generally used with operational amplifiers.
**Negative feedback:** without negative feedback, amplifier will have high open-loop gain and be very unstable

21.2.27 Describe the operation of an inverting and a non-inverting operational amplifier circuit.
**Description to include:** Reference to 'virtual earth' and phase relationship between output and input. Can operate as d.c. or a.c. amplifier.Perform calculations of voltage gain

21.2.28 State that the voltage gain of an inverting and non-inverting amplifier is dependent on the input and feedback resistors and not the characteristics of the op-amp.

21.2.29 Identify the pin-out connections for a 555 timer.

21.2.30 Describe practical applications of the 555 IC
**Applications:** timing circuit, oscillator

## Module 21.3: Electronic Principles 2

### Introduction

The aim of this section is to enable the candidate to:

a Understand the operation of logic gates.
b Construct and test digital circuits.
c Draw truth tables and express Boolean algebra.

### Practical Competences

The candidate must be able to do the following:

21.3.1 Identify, using manufacturer's catalogues or other sources, TWO and THREE input TTL logic gates.
**Logic gates:** AND, OR, NAND, NOR

21.3.2 Identify, using manufacturer's catalogues or other sources, TWO and THREE input CMOS logic gates.

21.3.3 Sketch a range of IC packages containing logic gates clearly identifying the types of gate, the input and outputs and power connections.
**Range:** 7400 and 4000 series AND, OR, NAND, NOR, NOT

21.3.4 Construct and test a NOT gate using NAND and NOR.

21.3.5 Draw truth tables for logic gates (as in 22.3.3) and define the operation of logic gates using Boolean algebra.

21.3.6 Use NOT gates to convert AND to NAND and OR to NOR.

21.3.7 Use NOT gates to convert NAND to OR and NOR to AND.

21.3.8 Draw truth tables to verify the gate conversions in 22.3.6 and 22.3.7.

21.3.9 Draw a truth table for a drinks vending machine which provides tea and coffee. The machine serves only the following combinations:
*Tea, Tea with milk, Tea with sugar, Tea with milk and sugar,*
*Coffee, Coffee with milk, Coffee with sugar, Coffee with milk and sugar.*

21.3.10 Draw a logic circuit, using NAND gates only, which fulfills the requirements of a security system.
**Security system:**
Three people have the keys to an office and a safe.
Any two keys will open the office.
Three keys are required to open the safe

21.3.11 Identify and explain the difference between common cathode and common anode seven segment displays.

21.3.12 Construct a simple binary counter using a decoder, resistors and seven segment display, and observe the count on the display.

21.3.13 Construct a simple logic probe and use it to test logic levels.

### Knowledge Requirements

The candidate will be able to:

21.3.1 Explain the difference between analogue and digital signals.
**Differences:** Analogue: continuously changing. Digital: two discrete levels

21.3.2 State the precautions to be taken to avoid the risk of damage to integrated circuits when handling.
**Precautions:** against static, insertion and extraction, de-soldering and soldering

21.3.3 State the need to use special tools and IC holders when constructing digital circuits.
**Special tools:** IC insertion, removal, earthing strap

21.3.4 Explain that a digital device has two states or logic levels.

21.3.5 Explain that logic levels can be expressed in different ways.
**Logic levels:** high, low, 0, 1, on, off

21.3.6 Explain the difference between positive and negative logic.
**Difference:** Positive logic: logic 1 represented by positive voltage, logic 0 by 0V. Negative logic: logic 1 represented by 0V or negative voltage, logic 0 by more positive voltage

21.3.7 Explain the binary counting system.
**Explanation:** a counting system which uses the base of 2

21.3.8 Explain that logic gates are digital devices which can have many inputs but only one output.

21.3.9 State that common logic 'families' can be TTL and CMOS.

21.3.10 Compare TTL with CMOS characteristics.
**Characteristics:** noise, speed, power consumption, voltage levels

## Module 21.3: Electronic Principles 2

21.3.11 Explain, with the aid of a truth table, the operation of two input logic gates.
**Logic Gates:** AND, OR, NAND, NOR, NOT

21.3.12 Explain how Boolean algebra defines the operation of a logic gate.
**Boolean expressions:** AND = A.B OR = A+B, NAND=$\overline{AB}$ NOR =$\overline{A+B}$ NOT=$\overline{A}$

21.3.13 Identify standard logic symbols for gates.
**Logic gates:** AND, OR, NAND, NOR, NOT

21.3.14 Show how NAND and NOR gates can be use as invertors.
**Invertors:** connect all inputs together for both NAND and NOR

21.3.15 Explain how different types of logic gate can be constructed from NAND or NOR gates.
**Explanation:** connect NAND or NOR as invertors and change the function of a given gate by connecting invertors to inputs and/or output of gate

21.3.16 Explain, with the aid of a truth table, the operation of THREE input gates.
**Types of gate:** AND, OR, NAND, NOR

21.3.17 Explain that the outputs from logic gates cannot normally be connected together.

21.3.18 Explain the term 'open collector'.
**Open Collector:** A gate requiring a load resistor to be connected to the output of the gate

21.3.19 Explain the need for decoding and resistors when connecting a seven segment display to a counting circuit.
**Explanation:** Seven segment displays need current limiting resistors to prevent damage to segments. Also decoding is required to produce a decimal display from a binary code

21.3.20 Explain that logic levels can be observed using a logic probe.
**Explanation:** A logic probe will normally have two different coloured LED's which indicate high and low voltage levels

## Test specification for written paper Electronic Engineering Principles (1155-02-021)

This is a written multiple choice examination lasting one and a half hours and containing 50 questions.

Candidates must answer **ALL** questions.

| Topic | Approximate % Examination Weighting |
|---|---|
| Electronic Principles 1 | 35 |
| Electronic Applications | 35 |
| Electronic Principles 2 | 30 |

# 1155-02-022 Electronic Engineering Practice
## 022/1 Electronic Principles 1

**Practical competences**
The candidate must be able to do the following:

22.1.01 Identify potential hazards in an electrical/electronics workshop.
**Potential Hazards:** toxic substances, fumes; high/mains voltages; unguarded equipment, hot soldering iron; solder splashes; sharp tools, charged capacitors, working on 'live' circuits. ☐

22.1.02 Store basic hand tools and maintain good housekeeping. ☐

22.1.03 Use a range of hand tools to cut, form, strip, shape, assemble wires and components.
**Hand tools:** pliers, cutters, strippers, drill, track-breaker, screwdriver, retractable blade, junior hacksaw, soldering iron. ☐

22.1.04 Use soldering techniques to assemble electronic components and wires to stripboard (veroboard) or printed circuit board. ☐

22.1.05 Visually inspect solder joints to ensure joints are sound, and that there are no 'dry joints' or short circuits. ☐

22.1.06 Identify electronic components using manufacturer's catalogue or other sources.
**Components:** resistors (fixed and variable), capacitors, inductors, diodes, transistors ☐

22.1.07 Identify the value of resistors and capacitors using colour code and other codes. ☐

22.1.08 Identify wires and cables using manufacturers catalogue or other sources.
**Wires and Cables:** single strand, multi-strand, multicore. ☐

22.1.09 Assemble a plug to mains cable and select correct fuse for application. ☐

22.1.10 Use an analogue and digital multimeter for measuring current, voltage and resistance. ☐

22.1.11 Use an analogue and a digital multimeter to test the functionality of a diode and a transistor (front-to- back ratio). ☐

22.1.12 Identify the front panel controls of an oscilloscope.
**Front panel controls:** focus, intensity, timebase, stability, trigger level, vertical attenuator, X and Y-shift, a.c.-d.c.-ground. ☐

22.1.13 Identify the front panel controls of a function generator.
**Front panel controls:** frequency, amplitude, waveform ☐

22.1.14 Set a d.c. power supply to provide single supplies (positive and negative) and split supplies (+15V, 0V and -15V). ☐

22.1.15 Use a multimeter to measure d.c. voltages generated by a d.c. power supply. ☐

22.1.16 Connect a function generator to an oscilloscope and observe a.c. waveforms.
**Waveforms:** sine, triangular, square ☐

22.1.17 Connect a half-wave rectifier to the secondary winding of a transformer and observe the output waveform across a load resistor using an oscilloscope. ☐

22.1.18 Connect an electrolytic capacitor across the load resistor of the half-wave rectifier and observe the smoothing effect on the output waveform. ☐

22.1.19 Use a d.c. voltmeter to measure the output voltage of the half-wave rectifier with and without a smoothing capacitor. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-022 Electronic Engineering Practice
## 022/2 Electronic Applications

**Practical competences**
The candidate must be able to do the following:

22.2.01 Select electronic components by price and component number from manufacturer's catalogues or other sources. ☐

22.2.02 Identify and sketch standard or recognised component circuit symbols.
**Components:** resistors, capacitors, diodes, transistors, LED, LDR, relay ☐

22.2.03 Identify different types of board used in the assembly of electronic circuits.
**Circuits:** breadboard, stripboard, printed circuit board ☐

22.2.04 Construct a voltage stabiliser using a series resistor and a zener diode. Connect a load resistor to the circuit. Connect a d.c. supply to the input and measure the voltage across the load resistor for changes in d.c. supply voltages. Record input and output voltages. ☐

22.2.05 Convert circuit diagrams into layout diagrams. ☐

22.2.06 Sketch a circuit diagram (to include d.c. power supply connections) of a common emitter amplifier utilising an NPN transistor, a base bias resistor and a collector load resistor. ☐

22.2.07 With reference to 22.2.06, construct a simple common emitter amplifier circuit (on breadboard) and test to ensure that the collector voltage is at, or near, half the supply voltage (VCC). Transfer the amplifier circuit to stripboard (veroboard). ☐

22.2.08 Connect a low-level signal (sine wave) from the function generator to the input of the amplifier (as in 22.2.07). Connect a dual-beam scope to monitor the input and output waveforms and compare the input and output voltages. ☐

22.2.09 Determine the voltage gain of the common emitter amplifier (as in 22.2.08). ☐

22.2.10 Observe the effect on voltage gain of varying the input frequency to an amplifier. Record voltage gain at each frequency. ☐

22.2.11 Plot a frequency response curve for the amplifier from results obtained practically (as in 22.2.10). ☐

22.2.12 Construct (on breadboard), and test the operation of the following circuits:
a transistor as a switch
b light-operated relay using a light-dependant resistor (LDR). ☐

22.2.13 Construct and test simple operational amplifier circuits.
**Circuits:** inverting, non-inverting ☐

22.2.14 Compare calculated and measured values of voltage gain for inverting and non-inverting amplifiers. ☐

22.2.15 Construct and test a simple timing circuit using a 555 timer and other components. Use an LED to indicate ON time. ☐

22.2.16 Construct and test a timing circuit using a 555 timer which will operate a 12V relay. ☐

22.2.17 Construct an oscillator circuit using a 555 timer and other components.
Observe and record the output waveform using an oscilloscope. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

# 1155-02-022 Electronic Engineering Practice
## 022/3 Electronic Principles 2

**Practical Competences**
The candidate must be able to do the following:

22.3.01 Identify, using manufacturer's catalogues or other sources, TWO and THREE input TTL logic gates.
**Logic gates:** AND, OR, NAND, NOR ☐

22.3.02 Identify, using manufacturer's catalogues or other sources, TWO and THREE input CMOS logic gates. ☐

22.3.03 Sketch a range of IC packages containing logic gates clearly identifying the types of gate, the input and outputs and power connections.
**Range:** 7400 and 4000 series AND, OR, NAN D, NOR, NOT ☐

22.3.04 Construct and test a NOT gate using NAND and NOR. ☐

22.3.05 Draw truth tables for logic gates (as in 22.3.03) and define the operation of logic gates using Boolean algebra. ☐

22.3.06 Use NOT gates to convert AND to NAND and OR to NOR. ☐

22.3.07 Use NOT gates to convert NAND to OR and NOR to AND. ☐

22.3.08 Draw truth tables to verify the gate conversions in 22.3.06 and 22.3.07. ☐

22.3.09 Draw a truth table for a drinks vending machine which provides tea and coffee. The machine serves only the following combinations:
*Tea, Tea with milk, Tea with sugar, Tea with milk and sugar*
*Coffee, Coffee with milk, Coffee with sugar, Coffee with milk and sugar*. ☐

22.3.10 Draw a logic circuit, using NAND gates only, which fulfills the requirements of a security system.
**Security system:**
Three people have the keys to an office and a safe.
Any two keys will open the office.
Three keys are required to open the safe ☐

22.3.11 Identify and explain the difference between common cathode and common anode seven segment displays. ☐

22.3.12 Construct a simple binary counter using a decoder, resistors and seven segment display, and observe the count on the display. ☐

22.3.13 Construct a simple logic probe and use it to test logic levels. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature _____

Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

[ This page is intentionally blank ]

# Appendix A
## Practical Assessments

Two assessment methods are used in the 1155 Engineering Skills programme - written questions and practical assessments.

**Practical assessments**
Each unit (assessment component) in this programme has one or more practical assessments that are taken from the practical components that make up the first part of each syllabus section. The competence checklists (tick boxes), given at the end of each unit, serve as the marking criteria for these assessments and should be used to record the outcome of each candidate's performance. Local custom and practice is allowed within the specifications of the 'range' supporting each practical competence statement. The results of the assessment must be documented and available for audit by the visiting verifier. ALL assessments must be successfully completed.

The assessments may be held at any time agreed by the instructor and the candidate so that each candidate has a personal record of his/her practical assessments.

The competence checklists in this publication are intended to be photocopied.

**Preparation, supervision and marking**
It is essential that the instructor ensures all necessary preparations are carried out. This will involve ensuring:

- the candidate is ready to demonstrate his or her practical skills
- every candidate understands what is involved
- any necessary equipment is available for the assessment.

Marking of the practical performance is determined on outcomes as defined by the practical competences. Each tick box will show either 'yes - the candidate achieved this' or 'no - the candidate did not achieve this'. The candidate must be successful in all competences included in the checklist before it can be 'signed off' and its results transferred to the summative record.

All assessments require supervision to ensure that the results reflect only the work of the individual candidate concerned. You must keep all assessment documentation and material in a file for each candidate until the results have been agreed by the visiting verifier and until confirmation of result has been received from City & Guilds.

**Records, results and certification**
When all the required practical assessments for a specific award have been achieved, then the result must be sent to City & Guilds. We suggest that you keep a record of each individual's achievements which may then be transferred to the entry forms. A model is given at the end of this section but you may use any form of record keeping that is convenient and accessible.

Results for practical assessments are entered onto Form S which must be countersigned by the visiting verifier and sent to us.

Candidates wishing to gain the full award (Certificate or Diploma) must successfully complete all the relevant forms of assessment. We recommend that the practical results are sent at the time of, or shortly before, the date of the written examinations.

**Visiting verifier**
The operation of this programme requires the appointment of a visiting verifier. The visiting verifier must countersign the results of the practical assessments on Form S. The visiting verifier should also be able to inspect records and candidates' work to verify the results before submission.

## Certificate in Engineering Skills
## Engineering Skills Principles 1
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | Date completed | Instructor signature | Instructor name |
|---|---|---|---|
| 002/1 Safety at Work | | | |
| 002/2 Maths and Drawing | | | |
| 002/3 Materials | | | |
| 002/4 Science | | | |
| 002/5 Hand and Machine Tools | | | |
| 002/6 Communication | | | |
| 002/7 Measuring and Marking Out | | | |
| 002/8 Fastening and Joining | | | |

## Diploma in Engineering Skills
## Engineering Skills Principles 2
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | Date completed | Instructor signature | Instructor name |
|---|---|---|---|
| 012/1 Materials | | | |
| 012/2 Science | | | |
| 012/3 Maths and Drawing | | | |

## Diploma in Engineering Skills
## Electrical Engineering Principles
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | Date completed | Instructor signature | Instructor name |
|---|---|---|---|
| 014/1 Electrical Technology 1 | | | |
| 014/2 Principles and Applications | | | |
| 014/3 Electrical Technology 2 | | | |

## Diploma in Engineering Skills
## Metal Machining Principles
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | | Date completed | Instructor signature | Instructor name |
|---|---|---|---|---|
| 016/1 | Mechanical Applications and Dimensional Control | | | |
| 016/2 | Milling | | | |
| 016/3 | Turning | | | |

## Diploma in Engineering Skills
## Mechanical Fitting and Plant Maintenance Principles
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | Date completed | Instructor signature | Instructor name |
|---|---|---|---|
| 018/1 Supplementary Studies | | | |
| 018/2 Mechanical Power Transmission | | | |
| 018/3 Mechanical Fitting | | | |

## Diploma in Engineering Skills
## Fabrication, Welding and Pipework Principles
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | Date completed | Instructor signature | Instructor name |
|---|---|---|---|
| 020/1 Fabrication | | | |
| 020/2 Welding | | | |
| 020/3 Pipework | | | |

## Diploma in Engineering Skills
## Electronic Engineering Principles
## Candidate assessment record

Candidate's name and number

Centre name and number

| Assessment reference | Date completed | Instructor signature | Instructor name |
|---|---|---|---|
| 022/1 Electronic Principles 1 | | | |
| 022/2 Electronic Applications | | | |
| 022/3 Electronic Principles 2 | | | |

# Appendix B
## The levels of our awards

**Progressive structure**
**Achieving maximum potential**
All City & Guilds qualifications are part of an integrated, progressive structure of awards arranged over seven levels, allowing people to progress from foundation to the highest level of professional competence. Senior awards, at levels 4 to 7, recognise outstanding achievement in industry, commerce and the public services. They offer a progressive vocational, rather than academic, route to professional qualifications. An indication of the different levels and their significance is given below.

| City & Guilds level | Qualification/Programme | |
|---|---|---|
| 7 | Fellowship (FCGI) | The highest level of technological and managerial experience. |
| 6 | Membership (MCGI) | Professional or managerial status, at the level of Master's degree. |
| 5 | Graduateship (GCGI)/ Associateship (ACGI)*, NVQ5 | Requires the ability to master and apply complex principles and techniques in a variety of contexts and to assume significant responsibility for human and plant resources, at the level of first degree. |
| 4 | Full Technological Diploma (FTD), Full Technological Certificate (FTC), Advanced Technician Diploma (IVQ), Licentiateship (LCGI), NVQ4 | Demands specialist or technical expertise and the ability to undertake professional work, at the level of Master Craftsman in Europe. |
| 3 | Technician Diploma (IVQ), Advanced Vocational Diploma (IVQ), Vocational (non NVQ/IVQ) Level 3 NVQ3 | Denotes skilled work of a complex nature and the ability to undertake a supervisory role. |
| 2 | Technician Certificate (IVQ), Vocational Diploma (IVQ), Vocational (non NVQ/IVQ) Level 2, NVQ2 | Recognises competence in a more demanding range of activities which require a degree of individual responsibility. |
| 1 | Vocational Certificate (IVQ), Vocational (non NVQ/IVQ) Level 1, NVQ1 | Indicates the ability to perform basic or routine activities which provide the broad foundation for progression. |

*Only graduates of the City & Guilds College, Imperial College of Science, Technology and Medicine, are awarded the Associateship (ACGI).
NVQ – National Vocational Qualifications
IVQ – International Vocational Qualifications

[ This page is intentionally blank ]

**Published by City & Guilds**
**1 Giltspur Street**
**London**
**EC1A 9DD**
**T +44 (0)20 7294 3505**
**F +44 (0)20 7294 2425**
**international@city-and-guilds.co.uk**
**www.cityandguilds.com**

**City & Guilds is a registered charity established to promote education and training**

**SP-12-1155**