

# IVQs in Construction (6165)

Level 3 IVQ Technician Diploma in

- Construction (6165-20) (500/5795/9)
- Construction (Quantity Surveying) (6155-22) (500/5795/9)

Qualification handbook for centres



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## Important notice

Following the accreditation of the Technician IVQs in Construction (6165) on the National Qualifications Framework of England, Wales and Northern Ireland (NQF), some changes have been made to the qualification, at the request of the Office of the Qualifications and Examinations Regulator (Ofqual), the qualifications regulator in England.

These changes took effect on 1 June 2009 and are outlined on pages 05–06.

**Note:** the content of the qualifications has not changed following accreditation.

### Changes to the qualification titles

The qualification titles have changed as follows:

Technician Diploma in Construction – Applied (6165-20)  
*changed to*

**Level 3 IVQ Technician Diploma in Construction (6165-20)**  
Accreditation number: 500/5795/9

International Technician Diploma in Quantity Surveying (Applied) (6165-22)

*changed to*

**Level 3 IVQ Technician Diploma in Construction (Quantity Surveying) (6155-22)**

Accreditation number: 500/5795/9

### Changes to the unit titles

Following the accreditation of Technician IVQs in Construction, each unit has been given an accreditation reference number which will appear on the Certificate of Unit Credit.

The content of the units is unchanged.

### Level 3 IVQ Technician Diploma in Construction (6165-20)

Accreditation number: 500/5795/9

#### Mandatory units

A/502/2730 – Basic Construction Skills Principles

D/502/2784 – Applied Scientific Techniques 2 Principles

H/502/2785 – Applied Scientific Techniques 2 Practice

K/502/2786 – Drawing and Surveying Techniques 2 Principles

M/502/2787 – Drawing and Surveying Techniques 2 Practice

T/502/2788 – Construction Techniques 2 Principles

A/502/2789 – Construction Techniques 2 Practice

M/502/2790 – Environmental Science and Construction Techniques 3 Principles

A/502/2792 – Environmental Science and Construction Techniques 3 Practices

#### Optional units (one pair of the same subject required)

F/502/2793 – Construction Measurement 3 Principles

J/502/2794 – Construction Measurement 3 Practice

L/502/2795 – Designing for Construction 3 Principles

R/502/2796 – Designing for Construction 3 Practice

Y/502/2797 – Construction Mathematics 3 Principles

D/502/2798 – Construction Mathematics 3 Practice

H/502/2799 – Structural Mechanics 3 Principles

L/502/2800 – Structural Mechanics 3 Practice

#### Optional units (one required)

M/502/2739 – Timber Vocations Basic Skills Practice

L/502/2733 – Trowel Vocations Basic Skills Practice

R/502/2734 – Painting and Decorating Basic Skills Practice

Y/502/2735 – Plumbing Basic Skills Practice

D/502/2736 – Refrigeration and Air Conditioning Basic Skills Practice

H/502/2737 – Electrical and Electronic Basic Skills Practice

### Level 3 IVQ Technician Diploma in Construction (Quantity Surveying) (6155-22)

Accreditation number: 500/5795/9

D/502/2784 – Applied Scientific Techniques 2 Principles

H/502/2785 – Applied Scientific Techniques 2 Practice

K/502/2786 – Drawing and Surveying Techniques 2 Principles

M/502/2787 – Drawing and Surveying Techniques 2 Practice

T/502/2788 – Construction Techniques 2 Principles

A/502/2789 – Construction Techniques 2 Practice

M/502/2790 – Environmental Science and Construction Techniques 3 Principles

A/502/2792 – Environmental Science and Construction Techniques 3 Practices

F/502/2793 – Construction Measurement 3 Principles

J/502/2794 – Construction Measurement 3 Practice

**Registration for theory examination**

Registration process for the theory examination has not changed.

**Result submission for practical assessment**

Result submission process for the practical assessments has not changed.

**Change to the grading**

The grade 'Credit' has been changed to 'Merit'. All other grades are unchanged. The content of the units concerned is also unchanged.

**Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUC)**

Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUCs) continue to be available on completion of each assessment (theory or practical).

Final certificate will be issued on successful completion of all the required assessments.

**'Theory only' route**

The 'Theory only' route continues to be available as an unaccredited qualification.

**Changes to the certificate layout**

Certificates issued on completion of an accredited IVQ show the accredited title and the accreditation number for the qualification. The level in the accredited title refers to the NQF level the qualification is accredited at.

The certificate also lists all the units achieved, including the grade and the unit accreditation number.

The certificate carries the logos of the regulatory authorities in England, Wales and Northern Ireland indicating that the NQF accreditation only applies to these countries.

## Levels of City & Guilds qualifications

All City & Guilds qualifications are part of an integrated progressive structure of awards arranged over eight 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.

NQF level#	City & Guilds qualifications/programmes	Other qualifications*
8	Fellowship (FCGI)	Doctorate
7	Membership (MCGI) Master Professional Diploma Level 5 vocational awards NVQ/SVQ Level 5	Master's Degree Postgraduate Diploma Postgraduate Certificate
6	Graduateship (GCGI) Associateship (ACGI)**	Bachelor's Degree Graduate Certificate and Diploma
5	Level 5 IVQ Advanced Technician Diploma Full Technological Diploma	Higher National Diplomas Foundation Degree Diplomas of Higher and Further Education
4	Licentiate'ship (LCGI) Higher Professional Diploma Level 4 vocational awards NVQ/SVQ Level 4	Certificate of Higher Education
3	Level 3 IVQ Advanced Diploma Level 3 IVQ Specialist Advanced Diploma*** Level 3 IVQ Technician Diploma Level 3 vocational awards NVQ/SVQ Level 3	A Level Scottish Higher Advanced National Certificate in Education BTEC National Certificate/Diploma
2	Level 2 IVQ Diploma Level 2 IVQ Specialist Diploma*** Level 2 IVQ Technician Certificate Level 2 vocational awards NVQ/SVQ Level 2	GCSE grades A*-C Scottish Intermediate 2/Credit 5 Grade BTEC First Certificate
1	Level 1 IVQ Certificate Level 1 vocational awards NVQ/SVQ Level 1	GCSE grades D-G Scottish Intermediate 1/General 5 Grade Scottish Access 1 and 2

# National Qualifications Framework of England, Wales and Northern Ireland (NQF)

\* Broad comparability in level

\*\* Only graduates of the City & Guilds College, Imperial College of Science, Technology and Medicine, are awarded the Associateship (ACGI)

\*\*\* Part of a new qualification structure which is being introduced across the IVQ provision

IVQ International Vocational Qualifications

NVQ National Vocational Qualifications

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# IVQ in Construction Industry 6165

## 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 Technician Certificate in Construction 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 guided learning hours for each level (see below). The programme has three levels.

### Certificate

The certificate (about 375 guided learning hours) provides a broad introduction to the theory and practical side of construction for a front-line worker or a person beginning an academic training programme.

### Diploma

The diploma (about 720 guided learning hours) provides more specific theory and practice suitable for a person starting to specialise in their occupational area, who will be working independently and who may supervise others.

### Advanced Diploma

The advanced diploma (about 660 guided learning hours) takes these skills to the level appropriate for a person preparing for or working in a supervisory or management role within their chosen occupation, or who intends to continue their academic training through degree or professional level.

We stress that these figures are only a guideline and that we award certificates and diplomas 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 level 3. The standards and assessments for the certificate (level 2) and the advanced diploma (level 4) are published separately.

## Full Technological Diploma

We will award the Full Technological Diploma (FTD) in Construction to someone who is at least 21, who has had at least two years' relevant industrial experience, and who has successfully finished the assessments for the diploma and diploma levels of this award. If candidates enter for this diploma, they must also send us a portfolio of evidence to support their application.

## 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 6165 Technician Diploma in Construction.

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 assessments 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 booklet 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.

## Assessments

There is one level of this award.

### 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

6165-20 Technician Diploma in Construction (Applied)  
Technician Diploma in Construction (Theory)

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

#### Component numbers

021	Applied Scientific Techniques 2 Principles
121	Applied Scientific Techniques 2 Practice
022	Drawing and Surveying Techniques 2 Principles
122	Drawing and Surveying Techniques 2 Practice
023	Construction Techniques 2 Principles
123	Construction Techniques 2 Practice
031	Environmental Science and Construction Techniques 2 Principles
131	Environmental Science and Construction Techniques 2 Principles
041	Measurement 3 Principles
141	Measurement 3 Practice
042	Designing for Construction 3 Principles
141	Designing for Construction 3 Practice
043	Construction Mathematics 3 Principles
143	Construction Mathematics 3 Practice
044	Structural Mechanics 3 Principles
141	Structural Mechanics 3 Practice

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

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

### Technician Diploma in Construction (Applied)

To carry out what is needed for the Technician Diploma in Construction (Applied), candidates must be successful in all of the following assessments.

6165-20-021	Applied Scientific Techniques 2 Principles (multiple choice paper which lasts two and a half hours)
[6165-20-121]	Applied Scientific Techniques 2 Practice
6165-20-022	Drawing and Surveying Techniques 2 Principles (multiple choice paper which lasts two hours)
[6165-20-122]	Drawing and Surveying Techniques 2 Practice
6165-20-023	Construction Techniques 2 Principles (multiple choice paper which lasts two hours)
[6165-20-123]	Construction Techniques 2 Practice
6165-20-031	Environmental Science and Construction Techniques 2 Principles (written paper which lasts two and a half hours)
[6165-20-131]	Environmental Science and Construction Techniques 2 Practice (Total four written papers)
And any two of the following pairs of assessments.	
6165-20-041	Measurement 3 Principles (written paper which lasts one and a half hours)
[6165-20-141]	Measurement 3 Practice
6165-20-042	Designing for Construction 3 Principles (written paper which lasts one and a half hours)
[6165-20-142]	Designing for Construction 3 Practice
6165-20-043	Construction Mathematics 3 Principles (written paper which lasts one and a half hours)
[6165-20-143]	Construction Mathematics 3 Practice
6165-20-044	Structural Mechanics 3 Principles (written paper which lasts one and a half hours)
[6165-20-144]	Structural Mechanics 3 Practice (Total two written papers)

For success in the full Diploma award candidates must also complete the following assessments.

6165-10-002 Basic Construction Skills Principles (multiple choice paper which lasts one hour)

And any one of the following practical assessments.

[6165-20-102] Timber Vocations Basic Skills

[6165-20-103] Trowel Vocations Basic Skills

[6165-20-104] Painting and Decorating Basic Skills

[6165-20-105] Plumbing Basic Skills

[6165-20-106] Refrigeration and Air Conditioning Basic Skills

[6165-20-107] Electrical Installation Basic Skills

If you have results to confirm that candidates have successfully completed the Basic Construction Skills components at the certificate level (6165-10), they will not have to do them again in the diploma programme.

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

### **Technician Diploma in Construction (Theory)**

To carry out what is needed for the Technician Diploma in Construction (Theory), candidates must be successful in all of the following assessments.

6165-20-021 Applied Scientific Techniques 2 Principles (multiple choice paper which lasts two and a half hours)

6165-20-022 Drawing and Surveying Techniques 2 Principles (multiple choice paper which lasts two hours)

6165-20-023 Construction Techniques 2 Principles (multiple choice paper which lasts two hours)

6165-20-031 Environmental Science and Construction Techniques 2 Principles (written paper which lasts two and a half hours)

(Total four written papers)

And any two of the following of assessments.

6165-20-041 Measurement 3 Principles (written paper which lasts one and a half hours)

6165-20-042 Designing for Construction 3 Principles (written paper which lasts one and a half hours)

6165-20-043 Construction Mathematics 3 Principles (written paper which lasts one and a half hours)

6165-20-044 Structural Mechanics 3 Principles (written paper which lasts one and a half hours)  
(Total two written papers)

For success in the full Diploma award candidates must also complete the following assessment.

6165-20-002 Basic Construction Skills Principles (multiple choice paper which lasts one hour)

If you have results to confirm that candidates have successfully completed this component at the certificate level (6165-10-002), they will not have to repeat this assessment in the diploma programme.

We provide assessments in two ways.

**a Fixed date**

These are assessments which are carried out on dates and times we set. These assessments have no brackets around their numbers.

**b Free date**

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

In this programme the written assessment is 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, diplomas and advance 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 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 which they do not enter, which they failed or from which they were absent.

Each certificate 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, they will automatically receive the appropriate certificate.

We will send the 'Notification of Candidate Results', certificates of unit credit and certificates 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 Guide' for full details of each aspect of these procedures.**

## Additional information

### Designing courses of study

Candidates for the Technician Diploma in Construction will have come from different backgrounds and will have different employment and training experiences. We recommend the following:

- carry out an assessment of the candidates' 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 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 core skills, such as numeracy, communication, working with people, and organisation and planning throughout a teaching programme.

## Presentation format of units

### Practical competences

Each module 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:

1.10a 'Identify the various types of protective clothing/equipment and their uses.'

**Protective clothing:** overalls, ear defenders/plugs, safety boots, knee pads, gloves/gauntlets, hard hats, particle masks, glasses/ goggles/visors'

In the above statement the words 'protective clothing' are given as a range which the candidate should be familiar with. If 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 module 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 assessments

The end of each unit contains practical assessments which deal with the practical competences we mentioned earlier. Candidates must carry out the practical assessments. You should make sure all practical assessments are supervised and instructors should make sure that the results reflect the candidate's own performance. You must hold all the evidence in a file (portfolio) for each candidate for eight weeks after the application for a certificate. You must also keep separate records of the dates of all attempts by each candidate.

## Entry levels

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

Technician Certificate in Construction (6165)

or

nationally-recognised school leaving passes in English, mathematics and science.

We also consider the following Pitman Qualifications award as relevant alongside this programme.

English for Speakers of Other Languages – higher intermediate level

## Progression routes and recognition

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

Advanced Technician Diploma Awards in Construction (6165)

A number of UK universities and other higher-education institutions may accept success in this programme towards evidence for direct entry onto higher-level programmes. The decision to accept a candidate on to a degree programme, and the level of entry, is up to the institution. We provide details of organisations recognising achievement in this programme.

## 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.



Plain English Campaign's Crystal Mark applies to the 6165 Technician Diploma in Construction regulations pages 09 to 14 inclusive.

# Syllabus

## IVQ in Construction Industry 6165

### Unit numbers

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#### **16 21 Applied Scientific Techniques 2**

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17 Construction Mathematics

---

20 Science and Materials

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22 Mechanics

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#### **28 22 Drawing and Surveying Techniques 2**

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29 Drawing Techniques (CAD)

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31 Site Surveying

---

#### **36 23 Construction Techniques 2**

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37 Construction Technology

---

41 Resource Management

---

#### **45 31 Environmental Science and Construction Techniques 3**

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46 Construction Technology

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49 Environmental Science

---

51 Building Services

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#### **57 41 Measurement 3**

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58 Measurement

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#### **61 42 Designing for Construction 3**

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62 Designing for Construction

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#### **65 43 Construction Mathematics 3**

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66 Construction Mathematics

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#### **71 44 Structural Mechanics 3**

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72 Structural Mechanics

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## 21 Applied Scientific Techniques – Summary of syllabus sections

### **Page 25 Construction Mathematics 2**

(Objectives 21.1 to 21.81)

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The aim of this section is to allow the candidate to develop his or her understanding of mathematical principles.

### **Page 26 Science and Materials 2**

(Objectives 21.82 to 21.117)

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The aim of this section is to apply scientific principles to the construction process with respect to:

- a thermal studies
- b services (electrical, water supply and distribution)
- c properties and performance of construction materials

### **Page 27 Mechanics 2**

(Objectives 21.118 to 21.144)

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The aim of this section is to give a basic introduction to the mechanics used in the analysis and design of construction elements.

# Construction Mathematics 2

## Practical competences

The candidate must be able to do the following:

- 21.1 Perform and apply the laws of indices and logarithms in the simplification and evaluation of formulae.
- 21.2 Transpose and evaluate formulae of different types.
- 21.3 Formulate and solve simple equations.
- 21.4 Solve quadratic and simultaneous equations.
- 21.5 Use Pythagoras' Theorem and apply the properties of triangles and circles.
- 21.6 Apply mensuration to building problems.
- 21.7 Define the trigonometric ratios and obtain these for any angle.
- 21.8 Apply trigonometric ratios in the solutions of right-angled triangles.
- 21.9 Plot graphs from given experimental data or an equation.
- 21.10 Use graphical methods to solve linear simultaneous and quadratic equations.
- 21.11 Define an arithmetic progression (AP) and a geometric progression (GP).
- 21.12 Deduce the **n**th term and evaluate the sum of n terms of an arithmetic progression (AP) and a geometric progression (GP).
- 21.13 Collect data to meet requirements of a statistical survey.
- 21.14 Present data in tabular and graphical format.  
**Tabular format:** tally chart, frequency and cumulative frequency distribution  
**Graphical format:** bar chart, pie chart, pictogram, histogram, ogive
- 21.15 Record data using appropriate software.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Algebra

- 21.16 Explain the use of symbols to represent mathematical values.
- 21.17 Factorise expressions by grouping and extraction of common factors.

- 21.18 Distinguish between an algebraic expression, an equation and an identity.
- 21.19 Maintain the equality of a given equation while applying any arithmetic operations.
- 21.20 Solve linear equations in one unknown.
- 21.21 Form and solve simple equations.
- 21.22 Solve a pair of simultaneous linear equations in two unknowns by both substitution and elimination.
- 21.23 Determine the roots of quadratic equations.
- 21.24 Transpose simple formulae in which the subject is equal to an expression whose terms are connected by + or – .
- 21.25 Transpose simple formulae in which the subject is equal to an expression composed of two or more factors.
- 21.26 Transpose formulae which contain a root or power.
- 21.27 Transpose formulae in which the subject appears in more than one term.
- 21.28 Apply the laws of indices, where m and n are positive integers.  
**Laws:**  
 $a^m \cdot a^n = a^{m+n}$ ,  $a^m / a^n = a^{m-n}$ ,  $(a^m)^n = a^{mn}$
- 21.29 Apply the laws of indices, where m and n are negative integers.
- 21.30 Show that  $a^0 = 1$  for all values of a and that  $a^{-n} = \frac{1}{a^n}$  .
- 21.31 Apply the rules for fractional indices and recognise that  $a^{1/n} = n\sqrt[n]{a}$  and that  $a^{m/n} = n\sqrt[n]{a^m}$ .
- 21.32 Evaluate expressions which combine positive, negative and fractional indices.
- 21.33 Define common and natural logarithms.
- 21.34 Apply change of base rule where  $\log_a(x) = \frac{\log_b(x)}{\log_b(a)}$
- 21.35 State the laws of logarithms in the following form where b is any base.

### Forms:

$$\begin{aligned}\log_b(MN) &= \log_b M + \log_b N \\ \log_b(M/N) &= \log_b M - \log_b N \\ \log_b(N^a) &= a \log_b N\end{aligned}$$

## Geometry and trigonometry

- 21.36 State the angle sum of a triangle.
- 21.37 Identify various types of triangle.  
**Triangles:** acute-angled, right-angled, obtuse-angled, scalene, equilateral, isosceles
- 21.38 Identify complementary angles.
- 21.39 Use Pythagoras' theorem to calculate the length of any third side of a right-angled triangle given the length of the other two sides.
- 21.40 Compare two triangles for similarity or congruency.
- 21.41 Determine an unknown side or an angle of a second triangle applying principles demonstrated in 21.40.
- 21.42 Construct a triangle from given data.  
**Given data:** three sides, two sides and included angle, one side and two angles
- 21.43 Identify the components of a circle.  
**Components:** radius, diameter, circumference, chord, tangent, secant, sector, segment, arc
- 21.44 Solve simple problems relating to circumference, radius and diameter of circles.
- 21.45 State that the angle between a tangent and the radius of a circle at the point of contact is a right angle.
- 21.46 State the relationships between the internal angles formed by two radii, and the tangents at the point of contact with the circumference of a circle.
- 21.47 Define the radian in terms of  $\pi$ .
- 21.48 Convert degrees to radians and vice versa.
- 21.49 Use the relationships  $s = r\theta$  to determine the length of an arc of a circle.
- 21.50 Use given formulae to calculate areas of plane figures.  
**Plane figures:** triangle, square, rectangle, parallelogram, trapezium, circle, semi-circle
- 21.51 Use the relationship  $A = \frac{1}{2}r^2\theta$  to determine the area of a sector.
- 21.52 Use given formulae to calculate the volumes of common solids.  
**Common solids:** cubes, prisms, spheres, cylinders
- 21.53 Define trigonometric functions of an acute angle.  
**Trigonometric functions:** sine, cosine, tangent
- 21.54 Obtain values for the three trigonometric functions of a given acute angle from tables and from a calculator.

- 21.55 Determine an acute angle, given a trigonometric function value.
- 21.56 Calculate the fractional or surd forms of the trigonometric functions for angles  $30^\circ$ ,  $45^\circ$ , and  $60^\circ$ .
- 21.57 State the relationships:  
 $\cos\theta = \sin(90^\circ - \theta)$  and  $\sin\theta = \cos(90^\circ - \theta)$  for  $\theta \leq 90^\circ$
- 21.58 Solve problems by using trigonometric function values or Pythagoras' theorem.
- 21.59 Plot the graphs for a  $\sin\theta$ ,  $\cos\theta$  and  $\tan\theta$  for  $0^\circ \leq \theta \leq 360^\circ$

## Graphs

- 21.60 Choose suitable scales and plot graphs from experimental data.
- 21.61 Plot graphs of equations by formulating a data table and plotting the points.
- 21.62 Plot graphs of equations by forming a data table and plotting the points.  
**Equations:**  $y = mx + c$ ,  $y = \frac{1}{x}$ ,  $y = x^n$  where  $n = 1, 2$  or  $3$
- 21.63 Read corresponding values from graphs and interpolate between points.
- 21.64 Determine the intercept on the y-axis by extrapolation.
- 21.65 Determine the gradient of a straight line graph.
- 21.66 Determine the roots of a quadratic equation from the intersections of the graph with x-axis.
- 21.67 Solve a pair of simultaneous equations in two unknowns graphically.

## Progression

- 21.68 Define an arithmetic progression (AP) as a progression with the common difference between the terms of  
 $d = a_{(n+1)} - a_n$ .
- 21.69 Evaluate the sum of a series arithmetic progression (AP) of  $n$  terms using the formula  
$$S_n = \frac{n}{2} \{2a + (n-1)d\}$$
 where  $a$  is the first term,  
 $d$  is the common difference and  $n$  is the number of terms.
- 21.70 Define a geometric progression (GP) as a progression with a common ratio between terms of  $r = \frac{a(n+1)}{a_n}$

- 21.71 Evaluate the sum of a series geometric progression (GP) of  $n$  terms using the formula  $S_n = \frac{a(1-r^n)}{1-r}$  where  $a$  is the first term,  $r$  is the common ratio and  $n$  is the number of terms.
- 21.72 Deduce general expressions for the  $n$ th term of simple arithmetic and geometric progressions.

### Statistics

- 21.73 Collect data from practical work and from publications.
- 21.74 Distinguish between discrete and continuous data.
- 21.75 Distinguish between a sample and a population.
- 21.76 Determine the range and approximate density of the data in 21.73 and use this information to form appropriate groups to cover the set of data.
- 21.77 Define frequency and relative frequency.
- 21.78 Determine, using a tally count, the frequency and hence the relative frequency of objects in each group.
- 21.79 Present the data in different graphical format.  
**Graphical format:** bar charts, pie charts, pictograms, histograms and frequency polygons
- 21.80 Construct a cumulative frequency table and draw an ogive.
- 21.81 Interpret descriptive data summarised in tables and diagrams.

## Practical competences

The candidate must be able to do the following:

- 21.82 By experiment, verify Boyle's Law and Charles' Law.  
**Experiment:**  $pV = \text{constant}$ ,  $V/T = \text{constant}$
- 21.83 Undertake experiments on the thermal properties of construction materials.  
**Experiment:** thermal conductivity, Lee's apparatus  
**Materials:** cork, polystyrene, steel, wood, brick, glass
- 21.84 Calculate heat gain/loss from a range of enclosed structures using thermal values and temperature differences.  
**Structures:** floors, walls, windows, ceiling, roofs
- 21.85 Verify the results obtained in 21.84 using a simple computer package.
- 21.86 Draw diagrams of sound waves and calculate sound intensity levels.  
**Sound:** use the decibel scale,  $N = \log I/I_0$
- 21.87 Investigate and prepare a short report on the transmission sequence between a power station and various consumers of electrical energy.  
**Transmission:** generation, transformer voltage, means of transmission  
**Voltages:** primary/secondary coils, power in cables at low/high current levels, transformer voltage calculations
- 21.88 Investigate, carry out experiments and prepare a report on the source, distribution and treatment of water in a particular region.  
**Experiment:** water (pre-treated, post treated), impurities, acidity, alkalinity  
**Source:** surface water (streams, rivers, lakes, reservoirs), underground water (springs, wells), rain water collection (roofs, paved surfaces)  
**Distribution:** bulk transport, pipelines, rivers, canals, streams  
**Treatment:** storage (sedimentation, clarification), filtration (sand filters, micro-strainers), aeration disinfection (chlorination, ozonisation), PH value

- 21.89 Investigate and prepare a report on the properties, structure, degradation and performance of a range of construction materials.

**Properties:** strength, elasticity, absorption, thermal, electrical, resistance to degradation

**Structures:** cellular, chain, grain, impurities, voids, composite action

**Degradation:** damp penetration, fungus/insect attack, water absorption, frost expansion, salts, chemical attack, corrosion, thermal movement, light exposure

**Performance:** fitness for purpose, appearance, cost, resistance to degradation, useability on site

**Materials:** structures (timber, bricks, blocks, concrete, metal), finishes (plaster, plaster board, paint, tiling), services (copper, steel, plastics)

## Knowledge requirements

The instructor must ensure that the candidate is able to:

### Gas laws

- 21.90 State the principles in the relationship between the pressure and volume of a gas at constant temperature.

**Principle:** Boyle's law

- 21.91 State the principles in the relationship between the volume and temperature of a gas at constant pressure.

**Principle:** Charles' law

- 21.92 State the principle in the relationship between the pressure and temperature at constant volume.

**Principle:** pressure law

### Thermal studies

- 21.93 Define thermal conductivity.
- 21.94 Explain thermal transmittance and resistance.
- 21.95 Describe building materials as conductors and insulators.
- 21.96 Explain the main source of moisture production in a building.
- 21.97 Define molecular movement and principles of evaporation, vapour pressure, saturated vapour pressure and variations with temperature.
- 21.98 Describe relative humidity and reasons for condensation.
- 21.99 Describe surface and interstitial condensation.

## Sound

- 21.100 Define wave propagation.
- 21.101 Define wavelength and frequency of sound transmission.
- 21.102 Define amplitude and energy loudness.
- 21.103 Describe how to distinguish between air borne and structure borne sound.
- 21.104 Define the threshold of audibility.
- 21.105 Describe how noise levels are measured.
- 21.106 Describe sound levels in buildings and know the types of sound insulation used in buildings.

## Electricity

- 21.107 Describe the concept of alternating current (ac).
- 21.108 Describe the principles of the ac generator.
- 21.109 Explain single and three phase electrical supplies.
- 21.110 Describe the principles of the transformer and its usage in electricity supply.

## Water supply

- 21.111 Identify the range and sources of water supply.  
**Range:** nationally, regionally, locally  
**Sources:** surface water (streams, rivers, lakes, reservoirs), underground water (springs, wells), rain water collection (roofs, paved surfaces)
- 21.112 Describe the properties of natural water supply.  
**Properties:** dissolved organic/inorganic substances, micro-organisms, pollutants, acidity, alkalinity
- 21.113 Describe various methods of water treatment.  
**Methods:** sedimentation, filtration, disinfection
- 21.114 Describe various methods of water distribution.  
**Methods:** bulk container, pipe/culvert, rivers, streams, grid networks

## Materials

- 21.115 Describe the properties and tests of construction materials and relate them to performance requirements.  
**Properties and tests:** tensile/compressive strength, elasticity, water absorption, thermal movement, thermal insulation, electrical insulation, resistance to degradation  
**Materials:** structural (timber, timber products, bricks, blocks, concrete, metals), finishes (plaster, plasterboard, paint, tiles), services (steel, copper, plastics)  
**Performance requirements:** fitness for purpose, visual appearance, costs (purchase, installation, maintenance), resistance to degradation, workability of site
- 21.116 Describe the structure of construction materials.  
**Structure:** structure (cellular, chain), grain structure, effects of impurities, effect of voids, composite nature  
**Materials:** structural (timber, timber products, bricks, blocks, concrete, metals), finishes (plaster, plaster board, paint, tiles), services (steel, copper, plastics)
- 21.117 Describe the degradation of construction materials.  
**Degradation:** timber/timber products (damp penetration, fungus attack, insect attack), bricks/blocks (water absorption, frost expansion, salts, silica), concrete (water absorption, frost expansion, chemical attack (ground water, road salts, silica), metals, corrosion (simple electrolytic), plaster (damp penetration), paint (moisture, thermal movement), plastic (UV exposure, thermal movement)  
**Materials:** structural (timber, timber products, bricks, blocks, concrete, metals), finishes (plaster, plasterboard, paint, tiles), services (steel, copper, plastics)

## Practical competences

The candidate must be able to do the following:

- 21.118 Demonstrate by a range of experiments the parallelogram law of forces and substantiate results graphically.  
**Experiments:** force boards, weights, resultant of two concurrent forces
- 21.119 Using equipment find graphically the magnitude and direction of the resultant of any number of concurrent co-planar forces.  
**Equipment:** drawing, tabular resolution form  
**Forces:** minimum of five forces
- 21.120 Substantiate the results from 21.119 using the resolution method.
- 21.121 Find by the principle of moments of force the position and magnitude of a number of parallel forces.  
**Forces:** minimum of four forces, minimum of two axes about which moments are taken
- 21.122 Demonstrate by experimental means the reactions of a beam carrying point loads.  
**Experimental means:** boards, weights, spring balances  
**Point loads:** single, multiple
- 21.123 Substantiate the results from 21.122 by calculation.
- 21.124 Calculate the reactions and the bending moment values at various positions on a beam loaded with point loads.  
**Beam:** simply supported beams including those with overhanging end(s)
- 21.125 Draw the shear force and bending moment diagrams for the length of the beam in 21.124.
- 21.126 Demonstrate by experiment on simple models of plane frames within buildings to show deflected forms of members within the frame, and establish parts in tension and compression.  
**Frames:** eg simply supported, beams (cantilevered, continuous), trussers, portal frames, two-storey frames
- 21.127 Verify the results from 21.126 by computer programs.
- 21.128 Demonstrate by experiment the location of the centroid of regular and irregular laminar shapes.  
**Shapes:** combination of regular shapes, irregular shapes  
**Location:** intersection of suspension lines from two points
- 21.129 Substantiate the results from 21.128 by calculation and computer packages.

- 21.130 Carry out a tensile test on a mild steel specimen and draw a stress/strain curve.  
**Specimen:** standard tensile specimen
- 21.131 Carry out direct compression tests on a range of construction materials to establish the ultimate compressive unit strengths, and compare these with manufacturers' results.  
**Materials:** local walling units (blocks/bricks), concrete cubes
- 21.132 Solve simple problems of liquid pressure on submerged surfaces.  
**Simple problems:** vertical surfaces, pressure at any depth, pressure diagrams, resultant forces

## Knowledge requirements

The instructor must ensure that the candidate is able to:

### Co-planar force

- 21.133 Explain the notion of a force, force resultants and the representation of forces graphically.  
**Forces:** gravitational, dead, imposed, wind
- 21.134 Describe the procedure for finding the resultant of forces acting at a point.
- 21.135 Describe the procedure for resolving several forces into rectangular components and combine components to a single resultant.  
**Forces:** up to four concurrent forces
- 21.136 Explain the graphical law of equilibrium for concurrent forces.  
**Range:** triangle of forces, experimental verification, polygon of forces

### Moments of forces

- 21.137 Explain the principle of the moment of a force and the resultant moment at a point.
- 21.138 Explain the principle of parallel co-planar force systems.
- 21.139 Identify and interpret shear force and bending moment diagrams for beams carrying point loads.

### Beams/frames deflected modes

- 21.140 Explain how structural elements and frames deflect for various loading and end conditions.  
**Elements:** beams with/without overhangs, continuous beams, cantilevered beams  
**Frames:** portal, two storey  
**Deflection:** forms, parts in compression/tension

### Centroids

21.141 Describe methods of locating the centroid of regular and irregular laminar shapes.

**Methods:** moment area, intersection of suspension line

### Material strength

21.142 Describe the methods and theory involved in tensile testing of construction materials.

**Testing:** stress/strain curve, elastic/plastic ranges, limit of proportionality, stress (ultimate, braking), factors of safety, working proof stress

**Materials:** mild steel, alloy steels

21.143 Define the methods and theory involved in direct compressive tests on construction materials.

**Test:** ultimate compressive strength, factors of safety, working stress

**Materials:** bricks, blocks, concrete cubes

### Liquid pressure

21.144 Explain liquid pressure of submerged vertical surfaces.

**Liquid pressures:**  $p = w.h = \rho gh$ , pressure diagrams, resultant pressure (magnitude, position)

## Test specification for written paper Applied Scientific Techniques (6165-20-021)

This is a written multiple choice examination paper lasting two and a half hours with 90 questions. Candidates must answer ALL questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Construction Mathematics 2	34
Science and Materials 2	33
Mechanics 2	33

# 21 Construction Mathematics 2

## Practical competences

The candidate must be able to do the following:

- 21.1 Perform and apply the laws of indices and logarithms in the simplification and evaluation of formulae.
- 21.2 Transpose and evaluate formulae of different types.
- 21.3 Formulate and solve simple equations.
- 21.4 Solve quadratic and simultaneous equations.
- 21.5 Use Pythagoras Theorem and apply the properties of triangles and circles.
- 21.6 Apply mensuration to building problems.
- 21.7 Define the trigonometric ratios and obtain these for any angle.
- 21.8 Apply trigonometric ratios in the solutions of right angled triangles.
- 21.9 Plot graphs from given experimental data or an equation.
- 21.10 Use graphical methods to solve linear and quadratic equations.
- 21.11 Define an arithmetic progression (AP) and a geometric progression (GP).
- 21.12 Deduce the *n*th term and evaluate the sum of *n* terms of an arithmetic progression (AP) and a geometric progression (GP).
- 21.13 Collect data to meet requirements of statistical survey.
- 21.14 Present data in tabular and graphical format.
- 21.15 Record data using appropriate software.

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

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 21 Science and Materials 2

## Practical competences

The candidate must be able to do the following:

- 21.82 By experiment, verify Boyle's Law and Charles' Law.
- 21.83 Undertake experiments on the thermal properties of construction materials.
- 21.84 Calculate heat gain/loss from a range of enclosed structures using thermal values and temperature differences.
- 21.85 Verify results obtained in 21.84 using simple computer package.
- 21.86 Draw diagrams of sound waves and calculate sound intensity levels.
- 21.87 Investigate and prepare a short report on the transmission sequence between a power station and various consumers of electrical energy.
- 21.88 Investigate, carry out experiments and prepare a report on the source, distribution and treatment of water in a particular region.
- 21.89 Investigate and prepare a report on the properties, structure, degradation and performance of a range of construction materials.

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

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 21 Mechanics 2

## Practical competences

The candidate must be able to do the following:

- |        |  |                          |        |  |                          |
|--------|--|--------------------------|--------|--|--------------------------|
| 21.118 | Demonstrate by a range of experiments the parallelogram law of forces and substantiate results graphically.  | <input type="checkbox"/> | 21.129 | Substantiate the results in 21.128 by calculation and computer packages.   | <input type="checkbox"/> |
| 21.119 | Using equipment find graphically the magnitude and direction of the resultant of any number of concurrent co-planar forces.  | <input type="checkbox"/> | 21.130 | Carry out a tensile test on a mild steel specimen and draw a stress/strain curve.  | <input type="checkbox"/> |
| 21.120 | Substantiate the results using the resolution method.  | <input type="checkbox"/> | 21.131 | Carry out direct compression tests on a range of construction materials to establish the ultimate compressive unit strengths, and compare these with manufacturers' results. | <input type="checkbox"/> |
| 21.121 | Find by the principle of moments of force the position and magnitude of a number of parallel forces.   | <input type="checkbox"/> | 21.132 | Solve simple problems of liquid pressure on submerged surfaces.  | <input type="checkbox"/> |
| 21.122 | Demonstrate by experimental means the reactions of a beam carrying point loads.  | <input type="checkbox"/> |        |  |                          |
| 21.123 | Substantiate results from 21.122 by calculation.   | <input type="checkbox"/> |        |  |                          |
| 21.124 | Calculate the reactions and the bending moments values at various positions on a beam loaded with point loads.   | <input type="checkbox"/> |        |  |                          |
| 21.125 | Draw the shear force and bending moment diagrams for the length of the beam in 21.124.   | <input type="checkbox"/> |        |  |                          |
| 21.126 | Demonstrate by experiment on simple models of plane frames within buildings to show deflected forms of members within the frame, and establish parts in tension and compression. | <input type="checkbox"/> |        |  |                          |
| 21.127 | Verify the results from 21.126 by computer programs.   | <input type="checkbox"/> |        |  |                          |
| 21.128 | Demonstrate by experiment the location of the centroid of regular and irregular laminar shapes.  | <input type="checkbox"/> |        |  |                          |

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

## 22 Drawing and Surveying Techniques – Summary of syllabus sections

### **Page 29 Drawing Techniques 2** (Objectives 22.1 to 22.36)

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This section is about the various traditional and modern methods of producing construction drawings as an essential means of communicating technical information in the construction industry in a graphical form.

Note: This is applied to buildings not exceeding three storeys with a minimum area of 100m<sup>2</sup> and should include domestic, industrial, storage and business premises.

### **Page 31 Site Surveying 2** (Objectives 22.37 to 22.87)

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This section provides candidates with an insight into surveying principles as applied to the construction industry. The approach must take account of local conditions but should incorporate current technology and practice.

This section requires that facilities are available to permit the use of electronic measuring instruments, preferably with data loggers, and that computers and the necessary software are available to assist with calculations and plotting.

# Drawing Techniques 2

## Practical competences

The candidate must be able to do the following:

- 22.1 Select, fold and store various standard sizes of drawing paper.  
**Paper sizes:** A0, A1, A2, A3, A4
- 22.2 Prepare a report identifying the various methods used to produce drawings.  
**Method:** CAD, drawing boards/tables
- 22.3 Select and identify drawing equipment used in producing drawings.  
**Drawing equipment:** adjustable drawing board, tee square, set square, scale rule, compasses, drawing pens/pencils, flexible curves, French curve, templates
- 22.4 Set out a drawing sheet to required standards with borders and title blocks.  
**Standards:** national/local standards
- 22.5 State the health and safety considerations in the production of construction drawings.  
**Considerations:** light (natural, artificial), storage/use (inks, reprographic chemicals), CAD (computer screens, electrical protection devices)
- 22.6 Prepare a report identifying the various methods of reproducing drawings.  
**Reproducing:** dye line process, photocopying, tracing
- 22.7 Draw symbols which identify building materials.  
**Materials:** earth, hard-core, concrete, brickwork, blockwork, stone, timber, sheet material, steel, metal
- 22.8 Draw symbols which identify fixtures, fittings and equipment used in the construction industry.  
**Fixtures and fittings:** eg windows, doors, sinks, wash basins, water closets/bidets, wardrobes, kitchen/ bedroom units, socket outlets, light fittings, fans, stop valves, pumps  
**Equipment:** eg air conditioning, electrical, plumbing, heating
- 22.9 Produce, read and work from scale drawings.  
**Scale:** eg 1:1, 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, 1:2500, 1:5000, 1:10000
- 22.10 Draw different types of lines and arrowheads used in construction drawings.  
**Lines:** basic construction line, main object outline, broken line, chain line, section line, grid line
- 22.11 Use common shorthand abbreviations used as notes on drawings.  
**Abbreviations:** eg rainwater pipe (rwp), vent pipe (vp), inspection chamber (ic)
- 22.12 Produce an example of each of the various methods of graphical representation in common use.  
**Methods:** orthographic projections (first angle), perspective, isometric, axonometric, oblique (cabinet, cavalier)
- 22.13 Collect examples of the various component parts of drawings.  
**Parts:** plan views, elevations, vertical sections, details
- 22.14 Collect examples of the various drawings used in the construction industry.  
**Drawings:** working drawings (construction drawings), detailed sketches, site plans, block plans.
- 22.15 Apply basic drawing skills in the production of graphical information using manual and simple computer aided draughting techniques.
- 22.16 Produce a portfolio containing types of construction drawings in accordance with current and local practice using appropriate conventions, symbols, manual and computer aided draughting techniques.  
**Construction drawings:** freehand sketch, sketch scheme, block plan, site plan, floor plan, component drawing, working drawings (production drawings), structural drawing
- 22.17 Interpret architectural/construction and associated drawings from a variety of sources.

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 22.18 Identify standard paper sizes.  
**Sizes:** A0, A1, A2, A3, A4
- 22.19 Identify and state the use of the various types of drawing equipment.  
**Drawing equipment:** adjustable drawing board, tee square, set square, scale rule, compasses, drawing pens/pencils, flexible curves, French curve, templates
- 22.20 Identify the various types of drawing medium available and describe their use.  
**Drawing medium:** cartridge paper, tracing paper, tracing cloth, tracing film
- 22.21 State the various methods available for reproducing drawings.  
**Reproducing:** dye line process, photocopying, tracing
- 22.22 Describe the health and safety considerations involved in the production of construction drawings.  
**Considerations:** light (natural, artificial), storage/use (inks, reprographic chemicals), CAD (computer screens, electrical protection devices)

- 22.23 Identify symbols used to illustrate materials.  
**Materials:** earth, hard-core, concrete, brickwork, blockwork, stone, timber, sheet material, steel, metal
- 22.24 Identify symbols which identify fixtures, fittings and equipment used in the construction industry.  
**Fixtures/fittings:** windows, doors, sinks, wash basins, water closets/bidets, wardrobes, kitchen/bedroom units, socket outlets, light fittings, fans, stop valves, pumps  
**Equipment:** air conditioning, electrical, plumbing, heating
- 22.25 State the use of the scale ratios used in construction drawings.  
**Scale:** 1:1, 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, 1:2500, 1:5000, 1:10000
- 22.26 Explain the different types of lines and arrowheads used in drawings.  
**Line types:** basic construction line, main object outline, broken line, chain line, section line, grid line
- 22.27 Identify the various methods of graphical representation and state their use.  
**Methods:** orthographic projections (first angle), perspective, isometric, axonometric, oblique (cabinet, cavalier)
- 22.28 Identify and state the use of the component parts of drawings.  
**Parts:** plan views, elevations, vertical sections, details
- 22.29 Identify examples of the various drawings used in the construction industry.  
**Drawings:** working drawings (construction drawings), detailed sketches, site plans, location drawing
- 22.30 Describe the principal purpose of drawings used in the design and construction process.  
**Drawings:** freehand sketches, sketch schemes, outline proposals, presentation design drawings/ perspectives, final designs, working drawings (production drawings), specialist drawings (services, structural details)
- 22.31 Explain how and why perspective drawings are produced.  
**Perspective drawings:** picture plane, objective, station point, vanishing point, height line, ground line, visual rays
- 22.32 Describe the advantages and disadvantages of using computer aided design in the production of construction drawings.
- 22.33 Describe the advantages and disadvantages of using computer aided design in the production of perspectives.
- 22.34 Explain the purpose of sciagraphy including shading of windows and shadow projections.
- 22.35 Identify various methods of enhancing drawings.  
**Enhancing:** surround detail, landscaping, figures, vehicles, colour/inkwash techniques, stencils, transfers, spray air brush, crayon
- 22.36 Describe the hardware and software required for a computer aided design system.  
**Hardware:** computer, monitor, tablet/digitiser, plotter, printer  
**Software:** eg AutoCAD, Robocad, Cadvance, Versacad, Fastcad, Microcad, Autosketch

# Site Surveying 2

## Practical competences

The candidate must be able to do the following:

- 22.37 Select and use protective clothing and equipment as applicable to the task.  
**Protective clothing:** overalls, ear defenders/plugs, safety boots, knee pads, gloves/gauntlets safety helmet (hard hat), particle masks, glasses/goggles/visors
- 22.38 Apply good housekeeping practices at all times.  
**Practices:** clean/tidy work areas, removal/disposal of waste products, protect surfaces
- 22.39 Carry out risk assessments as applicable to the task and prepare a report identifying potential hazards.  
**Risk assessment:** hazard identification, dangerous substances (adhesives, oils, greases, solvents, gases) site machinery, noise, reports
- 22.40 Use suitable horizontal control frameworks involving 5 to 8 survey stations.  
**Horizontal control frameworks:** purpose of control, need for thorough reconnaissance, positioning of stations
- 22.41 Set up optical reading and/or electronic theodolites and measure angles and distances as required.  
**Set up:** temporary adjustments ready for observing  
**Measure distances:** method (eg tapes, bands, electronics)
- 22.42 Maintain specified standard of accuracy with respect to obstacles and sloping ground.  
**Standard:** tolerances, proportional error, importance of checks
- 22.43 Produce sketches of existing features relative to control framework.  
**Features:** natural/man-made (eg buildings, boundary features)
- 22.44 Record data by field book or data logger.  
**Data logger:** eg attached, incorporated
- 22.45 Compute closed traverse figure and adjust to obtain final co-ordinates.
- 22.46 Survey position of existing features manually or by electronic instruments.
- 22.47 Maintain correct dimensional control by appropriate measurement checks and adjustments of errors.  
**Dimensional control:** internal measurements within buildings, measurements between features
- 22.48 Measure height differences using levels by observing and recording of staff readings.  
**Height differences:** relative to datum/sea level  
**Levels:** eg tilting, automatic, digital

- 22.49 Carry out levelling circuit, check closing error, reduce levels and apply adjustments.
- 22.50 Set out buildings by simple methods.  
**Methods:** eg use of 3:4:5 triangles, check diagonals, setup profiles
- 22.51 Draw longitudinal section for road or drainage design.  
**Longitudinal section:** vertical section along the centre line of the complete length of the works
- 22.52 Set out levels on site.  
**Levels:** grading of site, levelling (foundations, ground floor slabs), inverted staff readings
- 22.53 Set out graded formation levels for roads or drainage.  
**Levels:** design of suitable gradients associated with cut/fill calculations
- 22.54 Plot to scale using field data and verify by AutoCAD methods.  
**AutoCAD methods:** final co-ordinates, relative position of features
- 22.55 Measure areas from the completed drawing by planimeter or formula.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Horizontal control

- 22.56 Explain various terms associated with horizontal control.  
**Terms:** base line, line stations, open/closed traverses, triangulation, trilateration, grid, intersection, resection
- 22.57 Explain the reasons for the horizontal control lay-out.

### Measurement of angles and distances

- 22.58 Identify instruments used and state their suitability for measuring angles and distances to the standard of accuracy required.  
**Instruments:** principles, working features, compare optical reading with electronic theodolites
- 22.59 Describe various forms of linear measurement.  
**Linear measurement:** direct taping, optical distance measurements, electromagnetic distance measurement
- 22.60 Describes the difference between various types of error and the likely effect on design and construction.  
**Types of error:** compensating, cumulative, gross  
**Likely effect:** wasting (time, resources), additional cost involved

22.61 Describe temporary adjustments for the instruments and state the checks required.

**Temporary adjustments:** positioning, levelling

**Checks:** observing on both faces

22.62 Describe procedures for measuring and recording horizontal and vertical angles, manually or by data logger.

**Manually:** use of field book to record observations

**Data logger:** storing of field data for processing in the office

22.63 Describe methods of linear measurement with regard to obstructions and sloping ground.

**Methods:** application of field geometry (right angled triangles, cosine rule, sine rule)

22.64 Explain the concept of polar co-ordinates as applied to fixing position of features.

**Polar co-ordinates:** angle/distance to a point

#### Vertical control

22.65 Describe the purpose and applications of vertical control.

22.66 Define the terminology used for height control.

**Terminology:** levelling, datum surface, bench mark, height of collimation, rise and fall, change point, curvature/refraction, gradient

22.67 Compare the principles and working features to various instruments used for measuring height differences.

**Instruments:** spirit levels, digital levels, graduated levelling staff, bar coded staff

22.68 Describe various temporary and permanent adjustments for levelling instruments.

**Temporary adjustments:** setting up tripod, centralising bubble tube

**Permanent adjustment:** two peg test, adjustment of bubble tube

22.69 State how the 'Height of Collimation' or the 'Rise and Fall' methods may be used to reduce levels.

22.70 Describe effects of curvature/refraction and the technique of reciprocal levelling.

**Reciprocal levelling:** observing height differences across a wide gap

22.71 Describe proper procedures for minimising errors in levelling.

**Procedures:** equating Backsight and Foresight distances, bubble fitted to staff, limiting length of sights

22.72 Describe how levelling techniques are applied for setting out gradients in road and drainage design.

**Levelling techniques:** slope rails, sight rails, travellers

#### Rectangular co-ordinates

22.73 Explain various terms relating to rectangular co-ordinates.

**Terms:** grid north, magnetic north, true north, orientation, whole circle bearings, rectangular co-ordinates, polar co-ordinates

22.74 State formulae required for the difference in eastings and the difference in northings.

22.75 Apply adjustment to bearings in a closed figure.

**Closed figure:** traverses (loop, link)

22.76 Apply adjustment to eastings and northings.

**Adjustments:** eg Bowditch principle to determine final rectangular co-ordinates

22.77 Identify gross error existing in a closed traverse and measure again if required.

**Gross error:** incorrect (angle, distance)

22.78 Describe the use of computer software as a means of determining final adjusted co-ordinates.

#### Areas and volumes

22.79 Describe measurement of area by planimeter or by alternative methods.

**Methods:** eg Simpson's Rule, Trapezium Rule

22.80 Explain the use of co-ordinates for measuring areas within a control framework.

**Use:** double latitude formula

22.81 Describe the use of computer aided methods for measuring areas.

22.82 Explain the use of grid levelling and computers for volume calculations.

#### Plotting

22.83 Describe drawing medium suitable for accurate plotting and reproduction.

**Drawing medium:** eg Permatrace

22.84 Explain scales for completed drawing appropriate to design and construction stages.

**Scales:** 1:50 to 1:500, construction of bar scale

22.85 Describe plotting instruments used for plotting.

**Plotting instruments:** straight edge, set squares, protractor, technical pens, compasses, French curves

22.86 Describe the use of computer aided plotting methods for producing a scaled drawing.

22.87 Explain the use of completed drawings in the design and construction process.

**Completed drawings:** positioning of boundaries, special features to be preserved (eg buildings, trees)

# Assessment

## **Test specification for written paper Drawing and Surveying Techniques (6165-20-022)**

This is a written multiple choice examination paper lasting two hours with 60 questions. Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Drawing Techniques 2	50
Site Surveying 2	50

# 22 Drawing Techniques 2

## Practical competences

The candidate must be able to do the following:

- |       |   |                          |       |  |                          |
|-------|---|--------------------------|-------|--|--------------------------|
| 22.1  | Select, fold and store standard sizes of drawing paper.   | <input type="checkbox"/> | 22.14 | Collect examples of the various drawings used in the construction industry.  | <input type="checkbox"/> |
| 22.2  | Prepare a report identifying the various methods used to produce drawings.                      | <input type="checkbox"/> | 22.15 | Apply basic drawing skills in the production of graphical information using manual and simple computer aided draughting techniques.  | <input type="checkbox"/> |
| 22.3  | Select and identify drawing equipment used in producing drawings.                               | <input type="checkbox"/> | 22.16 | Produce a portfolio containing types of construction drawings in accordance with current and local practice using appropriate conventions, symbols, manual and computer aided draughting techniques. | <input type="checkbox"/> |
| 22.4  | Set out a drawing sheet to required standards with borders and title blocks.                    | <input type="checkbox"/> | 22.17 | Interpret architectural/construction and associated drawings from a variety of sources.  | <input type="checkbox"/> |
| 22.5  | State the health and safety considerations in the production of construction drawings.          | <input type="checkbox"/> |       |  |                          |
| 22.6  | Prepare a report identifying the various methods of reproducing drawings.                       | <input type="checkbox"/> |       |  |                          |
| 22.7  | Draw symbols which identify building materials.   | <input type="checkbox"/> |       |  |                          |
| 22.8  | Draw symbols which identify fixtures, fittings and equipment used in the construction industry. | <input type="checkbox"/> |       |  |                          |
| 22.9  | Produce, read and work from scale drawings.   | <input type="checkbox"/> |       |  |                          |
| 22.10 | Draw different types of lines and arrowheads used in construction drawings.                     | <input type="checkbox"/> |       |  |                          |
| 22.11 | Identify common shorthand abbreviations used as notes on drawings.                              | <input type="checkbox"/> |       |  |                          |
| 22.12 | Produce an example of each of the various methods of graphical representation in common use.    | <input type="checkbox"/> |       |  |                          |
| 22.13 | Collect examples of the various component parts of drawing.                                     | <input type="checkbox"/> |       |  |                          |

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

# 22 Site Surveying 2

## Practical competences

The candidate must be able to do the following:

- |       |  |                          |       |  |                          |
|-------|--|--------------------------|-------|--|--------------------------|
| 22.37 | Select and use protective clothing equipment as applicable to the task.                                  | <input type="checkbox"/> | 22.51 | Draw longitude section for road or drainage design.                | <input type="checkbox"/> |
| 22.38 | Apply good housekeeping practices at all times.  | <input type="checkbox"/> | 22.52 | Set out levels on site.  | <input type="checkbox"/> |
| 22.39 | Carry out risk assessments as applicable to the task and prepare a report identifying potential hazards. | <input type="checkbox"/> | 22.53 | Set out graded formation levels for roads or drainage.             | <input type="checkbox"/> |
| 22.40 | Use suitable horizontal control frameworks involving 5 – 8 survey stations.                              | <input type="checkbox"/> | 22.54 | Plot to scale using field data and verify by AutoCAD methods.      | <input type="checkbox"/> |
| 22.41 | Set up optical reading and/or electronic theodolites and measure angles and distances as required.       | <input type="checkbox"/> | 22.55 | Measure areas from the completed drawing by planimeter or formula. | <input type="checkbox"/> |
| 22.42 | Maintain specified standard of accuracy with respect to obstacles and sloping ground.                    | <input type="checkbox"/> |       |  |                          |
| 22.43 | Sketch and survey position of existing features relative to control framework.                           | <input type="checkbox"/> |       |  |                          |
| 22.44 | Record data by field book and/or data logger.  | <input type="checkbox"/> |       |  |                          |
| 22.45 | Compute closed traverse figure and adjust to obtain final co-ordinates.                                  | <input type="checkbox"/> |       |  |                          |
| 22.46 | Survey position of existing features, manually or by electronic instruments.                             | <input type="checkbox"/> |       |  |                          |
| 22.47 | Maintain correct dimensional control by appropriate measurement checks and adjustments of errors.        | <input type="checkbox"/> |       |  |                          |
| 22.48 | Measure height differences using levels by observing and recording of staff readings.                    | <input type="checkbox"/> |       |  |                          |
| 22.49 | Carry out levelling circuit, check closing error, reduce levels and apply adjustments.                   | <input type="checkbox"/> |       |  |                          |
| 22.50 | Set out buildings by simple methods.   | <input type="checkbox"/> |       |  |                          |

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 \_\_\_\_\_

# 23 Construction Techniques – Summary of syllabus sections

## **Page 37 Construction Technology 2**

(Objectives 23.1 to 23.67)

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The aim of this section is to enable the candidates to investigate, understand and report their understanding of construction technology in relation to both building and civil engineering.

Note: This is applied to buildings not exceeding three storeys with a minimum area of 100m<sup>2</sup> and should include domestic, industrial, storage and business premises.

## **Page 41 Resource Management 2**

(Objectives 23.68 to 23.90)

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The aim of this section is enable the candidate to acquire the knowledge requirements to identify, and procure and control the supply of resources both physical and human for a typical local domestic dwelling.

## Practical competences

The candidate must be able to do the following:

- 23.1 Investigate and prepare a report on the relationship between the design and function of common forms of structures.  
**Common forms:** monolithic, cellular, skeletal, portal, crosswall, timber frame
- 23.2 Produce annotated sketches illustrating the common forms and structural elements of buildings.  
**Common forms:** monolithic, cellular, skeletal, portal, cross wall, timber frame  
**Structural elements:** foundations, frames, walls, floors, roof, stairs
- 23.3 Investigate and prepare a report on the main design considerations for structural and non- structural elements to meet the needs of established laws, regulations, and standards in relation to construction work.  
**Design considerations:** function, cost, timescale, appearance, durability, availability, site considerations, services, adjoining structures, legality
- 23.4 Produce a report comparing the uses and limitations of a range of basic construction materials.  
**Construction materials:** brick, concrete block, concrete, reinforcing steel, steel (beams, columns), timber, sheet materials, plastics
- 23.5 Investigate and produce evidence of the general safety, health, and welfare considerations for site operatives, the general public and adjacent properties.
- 23.6 Produce annotated sketches for providing support to the sides of excavations of trenches and pits up to 1.5m deep in various subsoils for all weather conditions.  
**Subsoils:** mixture content (clay, loam, sand, gravel)
- 23.7 Prepare a flow chart showing the systematic and logical approach to the sequence of operations for construction projects.  
**Construction projects:** two storey domestic dwelling, minor road construction
- 23.8 Produce a list of materials and components for a two storey domestic dwelling.
- 23.9 Prepare a typical ironmongery schedule for the doors and windows of a domestic dwelling.  
**Doors:** internal, external
- 23.10 Prepare a typical schedule of finishes for a two storey domestic dwelling.
- 23.11 Produce a site layout drawing and a description of the main factors to be considered for a 'green field' site with a minimum of eight dwellings and an access road.  
**Main factors:** access, welfare facilities, materials (storage, protection), site clearance, location of plant, protection (site personnel, general public), trial holes (location, purpose)  
**Green field:** site with no previous construction development
- 23.12 Produce a list of the temporary services normally provided on site and describe the safety requirements to be considered.  
**Temporary services:** water, gas (mains, cylinder), electricity  
**Safety:** protection of employees, protection of services from environment/people, safe storage of gas cylinders
- 23.13 Produce annotated sketches of a typical layout of a cold and hot water system for a domestic dwelling.  
**Typical:** mains supply, stop tap, cold water supply, cold water storage, boiler, hot water cylinder, hot feed
- 23.14 Produce annotated sketches of electrical light and power supplies for a domestic dwelling.

## Knowledge requirements

The instructor must ensure that the candidate is able to:

### Design and function of buildings

- 23.15 Interpret annotated sketches illustrating the common forms and structural elements of buildings.  
**Common forms:** monolithic, cellular, skeletal, portal, cross wall, timber frame  
**Structural elements:** foundations, frames, walls, floors, roof, stairs
- 23.16 State the factors to be considered in the design of buildings.  
**Factors:** building users (safety, health, welfare), protection of the public, human comfort, movement (people, goods), environmental control, access (horizontal, vertical), functions (business, storage), adaptability
- 23.17 Identify the reasons why common forms of construction can be categorised further into those commonly used for dwelling house construction and those used for small business premises and storage buildings.  
**Common forms:** monolithic, cellular, skeletal, portal, cross wall, timber frame  
**Commonly used:** dwelling house (monolithic, cellular, cross wall, timber frame), small business/storage (monolithic, cellular, cross wall, timber frame, skeletal, portal)

- 23.18 Identify typical materials used for the elements in construction projects.  
**Materials:** brick, concrete block, concrete, reinforcing steel, steel (beams, columns), timber, sheet materials, plastics
- 23.19 Describe the temporary services normally provided on site and describe the safety requirements to be considered.  
**Temporary services:** water, gas (mains, cylinders), electricity  
**Safety:** protection of employees, protection of services from environment/people, safe storage of gas cylinders
- 23.20 Describe the main factors to be considered when laying out a new site.  
**Factors:** access, welfare facilities, materials (storage, protection), site clearance, location of plant, protection (site personnel, general public), trial holes (location, purpose)
- 23.21 Outline the likely differences between the layout for a green field site and a town centre site.  
**Differences:** town centre (limited storage, off loading, space for plant, high degree of protection for general public), green field (availability of services, provision of access/ temporary roads)
- Foundations**
- 23.22 Describe basic types of subsoil and their properties including average bearing capacities.  
**Types of subsoil:** cohesive, non-cohesive
- 23.23 Identify the likely effects of moisture content on the basic subsoil types.  
**Effects:** significant expansion/contraction with cohesive soils
- 23.24 Describe methods of excavating trenches and pits for foundations up to 1.5m deep by hand and machine.
- 23.25 Identify methods for providing support to the sides of excavations of trenches and pits in various subsoils for all weather conditions.  
**Subsoils:** mixture content (clay, loam, sand, gravel)
- 23.26 Describe different types of foundations and the conditions in which they are likely to be used, including the location of any reinforcing.  
**Types of foundation:** plain concrete strip, reinforced strip, deep strip, stepped strip, reinforced raft, short bored pile, ground beam, reinforced pad

## Walls

- 23.27 Describe the functions of walls.  
**Functions:** support, strength, stability, weather exclusion, insulation, fire resistance, durability, aesthetics
- 23.28 Differentiate between the common types of brickwork bonding for half-brick, one brick and one and a half brick thick walls.  
**Bonding:** stretcher, header, English, Flemish
- 23.29 Describe typical cavity wall construction using bricks or blocks including cavity tie location and alternative locations for insulation.  
**Alternative insulation:** insulation in cavity, internal skin of insulation block, internal surface of wall
- 23.30 Identify common cavity ties in steel and plastic.
- 23.31 Describe the purpose of attached piers for brickwork and blockwork and illustrate how they are bonded to the wall.
- 23.32 Explain the purpose of damp proof courses and their likely locations.  
**Locations:** walls at ground level, around openings, beneath floors, at abutments between one and two storey
- 23.33 Describe details of timber frame walls to include external cladding, moisture barrier, insulation, vapour barrier and internal finishes.
- 23.34 Describe methods of forming openings in walls including details of thresholds, cills, jambs and heads.  
**Methods:** arches, lintels, cavity closing, damp proofing
- 23.35 Identify typical sections and describe the fixing of galvanised iron, coated steel, plastic and mineralite sheeting to small steel framed and portal buildings.  
**Typical section:** flat sheets, sine curve corrugated, angular corrugated
- 23.36 Describe with approximate dimensions a range of simple non-load bearing internal partitions.  
**Partitions:** bricks, blocks, timber studding and boards, composite plasterboard sheets
- 23.37 Identify typical structural elements in skeletal frames of steel and reinforced concrete.  
**Structural elements:** columns, main beams, secondary beams, wind bracing, portal frames
- 23.38 Identify typical structural joints in skeletal frames of steel.  
**Structural elements:** rigid (welding, rivetting), semi-rigid (high tensile steel bolts with no clearance), flexible (mild steel bolts with clearance holes)

## Floors

- 23.39 Describe the factors determining the level of ground floors.  
**Factors:** height above ground level, protection against rising damp, slope of site
- 23.40 Identify the locations of damp proof courses and membranes for solid and suspended timber/concrete ground floors.
- 23.41 Describe details of in-situ concrete, pre-cast concrete and timber upper floors.  
**Details:** trimming, strutting, damp proofing
- 23.42 Describe common finishes to concrete floors.  
**Finishes:** granolithic screeds, thick bed and thin bed, floating screeds, trowelled finish to cast in-situ
- 23.43 Describe timber floor surfaces.  
**Floor surfaces:** tongued and grooved, secret nailed boarding, chipboard, plywood

## Roofs

- 23.44 Explain the factors influencing the choice of roof systems and coverings.  
**Factors:** climatic conditions, insulation, spans required, siting of services, aesthetics
- 23.45 Identify terms used in roof construction.  
**Terms:** eaves, ridge, verge, fascia, soffit, restraint (wind, lateral), hip, valley, gable, pitch, wall plate, rafter, purlin, roof truss, trussed rafter
- 23.46 Identify annotated line diagrams illustrating roof shapes and forms.  
**Shapes/forms:** lean to, single, double, verandah, trussed, mono pitch, flat
- 23.47 Identify and describe typical flush, projecting eaves, verge and ridge details for timber flat and pitched roofs.  
**Details:** rafter, ceiling joist, ventilation of roof space, wall plate, fascia, soffit, ridge board, barge board, waterproofing, roof finish
- 23.48 Describe the finishes applied to flat and pitched roofs showing the interlocking, lapping or bonding required to achieve water resistance.  
**Finishes:** asphalt, bonded felt, profiled sheets, slate, tiles (clay, concrete), extruded aluminium
- 23.49 Describe details of provisions for weathering, thermal insulation, solar and condensation protection in the finishes applied to roofs.  
**Finishes:** asphalt, bonded felt, profiled sheets, slate, tiles (clay, concrete), extruded aluminium

## Doors

- 23.50 Describe the general construction of internal and external doors.  
**Doors:** panelled, flush, ledged and battened, ledge/braced and battened
- 23.51 Describe the construction and fixing of door frames and linings for internal and external doors.  
**Door frames:** metal, wood
- 23.52 Describe what is meant by 'door sets'.
- 23.53 Describe the terms stability and integrity in relation to fire doors.

## Windows

- 23.54 Describe the essential differences between common window styles.  
**Styles:** sliding, casement (vertical, horizontal), pivot
- 23.55 Explain the water and weather proofing requirements of the common window styles.  
**Styles:** sliding, casement (vertical, horizontal), pivot

## Stairways

- 23.56 Identify and describe the component parts and design considerations for a straight flight stairway.  
**Component parts:** nosing, riser, tread, string board, newel, handrail, guardrail, baluster, balustrades  
**Design considerations:** rise, going
- 23.57 Identify details of the jointing of component parts for straight flight stairways in timber.  
**Components:** string board (tread, riser), stringboard to newel, baluster to handrail, head of stairs to trimmer
- 23.58 Identify details including location of reinforcing of a straight flight of cast in-situ concrete stairs.
- 23.59 Identify alternative methods of fixing handrails and guardrails to cast in-situ concrete stairs.  
**Methods:** plug/screw, cast in-situ, pocket/wedge, expansion bolts

## Internal and external fixtures

- 23.60 Describe typical external wall finishes.  
**Finishes:** cement rendering, pebbledash, roughcast
- 23.61 Describe basic internal wall finishes.  
**Finishes:** render and set in plaster, drylining
- 23.62 Describe typical internal floor finishes.  
**Finishes:** screeds, timber (strip, block), floor tiles (rigid, flexible)
- 23.63 Explain the functions of paint.  
**Functions:** aesthetics, waterproofing, fireproofing

### **Primary Services**

- 23.64 Describe a typical layout of a cold and hot water domestic system.  
**Typical:** mains supply, stop tap, cold water supply, cold water storage, heater, hot water cylinder, hot feed
- 23.65 Describe typical electrical light and power supply systems in a domestic building.

### **External Works**

- 23.66 Describe the differences between combined and separate systems of drainage.  
**Systems:** combined pipe for surface/foul water, separate pipes for surface/foul water
- 23.67 Describe common types of boundary walls and fences.  
**Walls/fences:** walls (brick, block), timber post and rail, concrete post and plank, concrete/timber post with galvanised/plastic coated wire

# Resource Management 2

## Practical competences

The candidate must be able to do the following:

- 23.68 Identify the different forms of organisation within the industry and the roles performed within the individual firms.
- 23.69 Identify the job requirements in terms of plant, materials, labour and risk assessment.
- 23.70 Prepare a simple works programme for a low rise building development.
- 23.71 Obtain the most competitive supply arrangements for plant, materials and sub contracts.
- 23.72 Issue purchase orders for the supply of materials.
- 23.73 Issue the appropriate sub contract forms for the provision of sub contract services.
- 23.74 Monitor the actual supply of materials and services and accommodate any changes encountered during the progress of the works.
- 23.75 Operate a simple computer spreadsheet application to produce quantities and 'all-in' costs.
- 23.76 Use an appropriate computer application to produce a project programme with the facility to incorporate the job resources required.

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 23.77 Define the basic types of business in the construction industry.  
**Businesses:** sole trader, partnership, company
- 23.78 Describe the various roles of individuals within a typical building organisation.  
**Roles:** managerial, technician, supervisory, craft, general building operatives
- 23.79 Explain the procedure for selecting the most appropriate plant for a particular job in relation to the out-put required, job location, plant available.
- 23.80 State any prescribed notices and procedures to be used on site when carrying out building operations.  
**Notices and procedures:** personal protective equipment, safe working practices, protection required for the public at large, recording procedures for the occurrence of accidents, control procedures for storage of substances hazardous to health

- 23.81 Explain the procedure for selecting the amount of materials required for a building project through the use of simple mensuration techniques to calculate length, area, volume.
- 23.82 Explain the procedure for relating the amount of labour needed to the quantities of materials determined from published labour, outputs or first principles.
- 23.83 State the items to be included in an invitation to tender letter to suppliers and sub contractors.
- 23.84 State the items to be included in an order for the supply of goods and sub contract work.
- 23.85 State the items to be included in an order/sub contract for sub contract services.
- 23.86 Describe the procedure for preparing a simple bar chart programme.
- 23.87 List the items to be included in producing a method statement which identifies the quantities, sequence and duration of operations.
- 23.88 State the methods of monitoring work progress through daily diary entries, site meetings, inspections and recording of achievement in both written and graphical representation.
- 23.89 Describe the advantages of using a spreadsheet for calculating 'all-in' costs of labour, plant and materials.
- 23.90 Describe the advantages of using computer software to produce a bar chart programme which incorporates the resources required.

**Resources:** manpower, plant, materials

## Test specification for written paper Construction Techniques (6165-20-023)

This is a written multiple choice examination paper lasting two hours with 60 questions. Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Resource Management 2	40
Construction Technology 2	60

# 23 Construction Technology 2

## Practical competences

The candidate must be able to do the following:

- |       |  |                          |       |   |                          |
|-------|--|--------------------------|-------|---|--------------------------|
| 23.1  | Investigate and prepare a report on the relationship between the design and function of common forms of structures.  | <input type="checkbox"/> | 23.11 | Produce a site layout drawing and a description of the main factors to be considered for a 'green field' site with a minimum of eight dwellings and an access road. | <input type="checkbox"/> |
| 23.2  | Produce annotated sketches illustrating the common forms and structural elements of buildings.   | <input type="checkbox"/> | 23.12 | Produce a list of the temporary services normally provided on site and describe the safety requirements to be considered.   | <input type="checkbox"/> |
| 23.3  | Investigate and prepare a report on the main design considerations for structural and non-structural elements to meet the needs of established laws, regulations and standards in relation to construction work. | <input type="checkbox"/> | 23.13 | Produce annotated sketches of a typical layout of a cold and hot water system for a domestic dwelling.  | <input type="checkbox"/> |
| 23.4  | Produce a report comparing the uses and limitations of a range of basic construction materials.  | <input type="checkbox"/> | 23.14 | Produce annotated sketches of electrical light and power supplies for a domestic dwelling.  | <input type="checkbox"/> |
| 23.5  | Investigate and produce evidence of the general safety, health and welfare considerations for site operatives, the general public and adjacent properties.   | <input type="checkbox"/> |       |   |                          |
| 23.6  | Produce annotated sketches for providing support to the sides of excavations of trenches and pits up to 1.5m deep in various subsoils for all weather conditions.  | <input type="checkbox"/> |       |   |                          |
| 23.7  | Prepare a flow chart showing the systematic and logical approach to the sequence of operations for construction projects.  | <input type="checkbox"/> |       |   |                          |
| 23.8  | Produce a list of materials and components for a two storey domestic dwelling.   | <input type="checkbox"/> |       |   |                          |
| 23.9  | Prepare a typical ironmongery schedule for the doors and windows of a domestic dwelling.   | <input type="checkbox"/> |       |   |                          |
| 23.10 | Prepare a typical schedule of finishes for a two storey domestic dwelling.   | <input type="checkbox"/> |       |   |                          |

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 \_\_\_\_\_

# 23 Resource Management 2

## Practical competences

The candidates must be able to do the following:

- 23.68 Identify the different forms of organisation within the industry and the roles performed within the individual firms.
- 23.69 Identify the job requirements in terms of plant, materials and labour and risk assessment.
- 23.70 Prepare a simple works programme for a low rise building development.
- 23.71 Obtain the most competitive supply arrangements for plant, materials and sub contracts.
- 23.72 Issue purchase orders for the supply of materials.
- 23.73 Issue the appropriate sub contract forms for the provision of sub contract services.
- 23.74 Monitor the actual supply of materials and services and accommodate any changes encountered during the progress of the works.
- 23.75 Operate a simple computer spreadsheet application to produce quantities and 'all-in' costs.
- 23.76 Use an appropriate computer application to produce a project programme with the facility to incorporate the job resources required.

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

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Candidate name (please print)

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# 31 Environmental Science and Construction Techniques 3 – Summary of syllabus sections

**Page 46 Construction Technology 3**  
(Objectives 31.1 to 31.54)

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This section further extends the knowledge requirements of Construction Technology 2 and gives the opportunity to develop alternative solutions to design and construction problems by the application of scientific, structural and economic principles to low rise structures.

**Page 49 Environmental Science 3**  
(Objectives 31.55 to 31.89)

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The aim of this section is to extend candidates knowledge of scientific principles and to develop their ability to apply the principles to environmental factors associated with the built environment.

**Page 51 Building Services 3**  
(Objectives 31.90 to 31.120)

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This section gives the candidate the opportunity to understand the principles and applications of building services systems to domestic, commercial and industrial buildings and the need to integrate their installation during the construction process.

# Construction Technology 3

## Practical competences

The candidate must be able to do the following:

- 31.1 Compare and recommend types of construction for specific low rise buildings taking into account the alternatives available.
- 31.2 State the considerations to be made during design and construction of building works as a result of established legislation relating to building works.
- 31.3 Compare the properties and lifespan of a range of basic building materials for a specific type of low rise building.
- 31.4 State the safety, health and welfare considerations for site personnel, building user, general public and adjacent properties.
- 31.5 Develop economic design solutions for specific low rise buildings.
- 31.6 Develop logical and economic approaches to the sequence of construction operations.
- 31.7 Illustrate, by means of annotated and dimensioned drawings and sketches, an understanding of the knowledge requirements of the unit.
- 31.8 Prepare lists of materials, components, and sequences of operations illustrating an understanding of the knowledge requirements of the unit.
- 31.9 Prepare site visit reports giving details of site investigation, soil investigation and archive research for an existing green field site and a town centre site.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Site works

- 31.10 Describe the purposes of site investigation.  
**Purposes:** determine/record relevant above ground features, collect information (site history, location of utilities, accessibility)
- 31.11 Describe the purposes of soil investigation.  
**Purposes:** determine/record (composition of subsoil, ground water level, properties of substrata)
- 31.12 Describe the methods of obtaining site information.  
**Methods:** site visit, measurements, local archive search, photographs
- 31.13 Describe the methods of obtaining substrata information.  
**Methods:** hand augers, trial pits, drilling of bore holes, testing of sample (site, laboratory)

- 31.14 Explain the differences between disturbed samples and undisturbed samples of substrata from soil investigation.

### Groundworks

- 31.15 Describe the groundwork encountered on sites for low rise buildings.  
**Groundwork:** site clearance, site preparation, levelling/setting out, ground water control, excavation (foundations, services)
- 31.16 List and describe the functions of foundations.  
**Functions:** safe load distribution, resistance to settlement including differential, resistance to shear, consideration of seasonal movement, resistance to sulphate attack
- 31.17 State the factors to be considered when designing foundations for low rise buildings.  
**Factors:** area of foundation based on ground bearing capacity, thickness to resist shear/ bending, acidity or alkalinity of soil
- 31.18 Describe the factors to be considered when designing trench supports.  
**Factors:** ground pressures of soils, angle of internal friction, effects of water table, pressures from adjacent buildings, loading caused by construction plant
- 31.19 Describe, with the aid of annotated and dimensioned sketches, details of trench supports up to 3.0m deep in various subsoils for all weather conditions.  
**Details:** timber poling boards, struts/walings, sheet steel piling, adjustable struts, working platforms
- 31.20 Describe precautionary measures which should be taken against likely safety hazards.  
**Safety hazards:** landslip, trench collapse, fracture of utilities, mechanical plant hazards, operatives errors (eg falling)

### Walls

- 31.21 Describe, with the aid of a sketch, details of walls for steel, concrete skeletal and portal frames.  
**Details:** sheet claddings, brick claddings, infill panels, curtain walling, insulation
- 31.22 Describe, with the aid of a sketch, details of reinforced concrete cast in-situ walls.  
**Details:** location of reinforcing, construction joints, concrete cover to reinforcing
- 31.23 Sketch suitable formwork for the type of walls in 31.22 above in timber and steel.

- 31.24 Draw sections of columns and beams in cast in-situ reinforced concrete framed construction including location of reinforcing at the junction between a column and beams.
- 31.25 Sketch details of the formwork for column, beam and floorslab for a cast in-situ concrete reinforced frame.
- 31.26 Draw details of the joints between columns and beams for precast concrete frame buildings.
- 31.27 Describe methods of compacting concrete for in-situ concrete frames.  
**Methods:** vibrators on formwork, vibrating poker in concrete, hand tamping
- 31.28 Describe methods of fire proofing steel framed buildings.  
**Methods:** surround in concrete, gypsum plaster cladding, surround in brickwork, intumescent paint
- 31.29 Describe how allowances are made for expansion and contraction on large areas of brickwork cladding.

#### Roofs

- 31.30 Differentiate between a cold deck and a warm deck flat roof.
- 31.31 Describe, with the aid of a dimensioned sketch typical precast, prestressed concrete sections used as structural members for floor and flat roofs in skeletal framed buildings.  
**Sections:** panel, plank, trough, hollow beam
- 31.32 Describe, with the aid of a sketch, how shrinkage cracking of screeds is minimised when applied to the concrete sections in 31.31 above.
- 31.33 Describe, with the aid of diagrams, the common forms of roof trusses rafters up to 12m span in timber and steel.  
**Forms:** purlins (where appropriate), equal spaced struts, ties immediately beneath purlins, struts/ties vertical or at right angles to slope of roof wherever possible, node points, lack of redundant members
- 31.34 Describe typical jointing techniques for the type of truss or trussed rafter in 31.33 above.  
**Jointing techniques:** steel (welded, bolted gusset plates to steel angle members) timber (bolts/toothed timber connectors, bolts/split ring connectors for larger spans, nailed/glued plywood gusset plates, gang nail plates)
- 31.35 Describe, with the aid of a sketch, typical sections for connecting roof trusses to walls.  
**Sections:** nailed/bolted to timber wall plate, concrete padstone, expansion bolts

#### External works

- 31.36 Describe the various types of estate roads and pavement construction.  
**Types:** flexible, semi-rigid, rigid
- 31.37 Describe, with the aid of a sketch, details of various drainage provision for estate roads.  
**Details:** pipe sizes, culverts, silt traps, main drain
- 31.38 Describe, with the aid of a sketch, details of small pedestrian bridges.  
**Details:** timber lattice, steel lattice, laminated timber, concrete beam
- 31.39 Describe the purpose and structure of gravity retaining walls.  
**Purpose:** retain soil or water, basement construction  
**Structure:** stone, brick, mass concrete
- 31.40 Describe cantilever retaining walls in-situ reinforced concrete and sheet piling.
- 31.41 Explain the factors to be considered in the design of the external works in 31.38 to 31.40 above.  
**Factors:** ground conditions, water table, loading, temperature range, visual appearance, maintenance
- 31.42 Describe various types of plant used for external works.  
**Plant:** excavators (wheeled, tracked), dumpers, lorries, bulldozers, scrapers, well points, pumps, concrete mixers

#### Services

- 31.43 List the factors which affect the design of service systems.  
**Factors:** number of occupants, appliances (number, size), storage volumes required, transmission (thermal, acoustic), regulations (environmental health, power/water supply)
- 31.44 Describe control and monitoring means for water, electricity and gas supplies to low rise buildings.  
**Control/monitoring:** water (stopcocks, water meter), electricity (main fuse, electricity meter, consumer panel, fuse boxes, circuit breakers), gas (main gas supply shut off, gas meter)
- 31.45 Describe the features of sanitation and drainage for low rise buildings.  
**Features:** gullies, traps, back inlet gullies, single stack system, inspection chambers
- 31.46 Describe the features of central heating systems.  
**Features:** surface radiators, finned radiators, ducted heating, single pipe heating, separate pipe systems, combination boilers, wall heaters (electrical, gas)

### Internal Finishes

- 31.47 Explain the functions of internal floor finishes.  
**Functions:** non-slip, impact resistant, hygienic, durable, acoustic considerations, improved thermal insulation
- 31.48 Explain the functions of ceiling finishes.  
**Functions:** absorption/reflection of light/sound, resistance to flames, aesthetics
- 31.49 Describe the terms used to classify internal and external finishes.  
**Terms:** wet finishes, dry finishes, self-finishes
- 31.50 State the functions of external finishes.  
**Functions:** exclusion (wind, rain, snow), solar reflection, insulation (thermal, acoustic), aesthetics, impact resistance
- 31.51 Categorise the materials used for wet finishes and dry finishes.  
**Materials:** wet (screeds, renders, plasters), dry (plasterboard, wall board, tiles, plastic, plastic laminate sheet)

### Internal fittings

- 31.52 List and describe the sanitary fittings associated with low rise buildings.  
**Sanitary fittings:** water closets, bidets, wash hand basins, sinks, baths, showers, sanitary incinerators
- 31.53 List and describe the food storage, processing and cooking fittings associated with low rise buildings.  
**Fittings:** refrigerators, freezers, cold stores, worktops, wash down areas, disposal units, ovens and grills, washing (machines, dryers), dishwashers
- 31.54 Assess the criteria to be considered when choosing the fittings in 31.52 and 31.53 above for a low rise building.  
**Criteria:** size of building, number of users, frequency of use, needs of users, cost

## Practical competences

The candidate must be able to do the following:

### Illumination

- 31.55 Identify the components of daylight factors and calculate daylight factors from simple plans and elevations using an appropriate method.  
**Components:** sky, externally reflected, internally reflected  
**Calculation method:** eg Building Research Establishment tables, national/local equivalent
- 31.56 Design artificial lighting requirements for an office or showroom.  
**Requirements:** illumination (level, evenness), glare, colour rendering properties

### Sound

- 31.57 Carry out practical exercises involving the use of a sound level meter and produce diagrams of sound paths showing reflection and absorption in enclosed structures.  
**Exercises:** measurement of sound levels (machinery, traffic), measurement of the effect of insulation (walls, floors, barriers)
- 31.58 Investigate and recommend ways in which sound can be controlled at source, in transit and at reception.  
**Controls:** elimination/isolation of noisy plant, use of screens/barriers, effect of layout, use of acoustic materials, insulation
- 31.59 Investigate problems of sound transmission and reverberation in enclosed structures and determine the reverberation time of a lecture hall or theatre using Sabine's formula.  
**Problems:** long delayed echoes, distortion, evenness of sound, suitable reverberation time

### Thermal studies

- 31.60 Calculate the flow of heat energy through a composite structure.  
**Flow of heat energy:** resistivity, conductivity, surface resistance
- 31.61 Calculate heat losses/gains for an enclosure and propose procedures to minimise heat loss/gain.  
**Procedures:** passive thermal control, orientation, insulation, control of air changes, window to wall ratio
- 31.62 Carry out practical exercises using a psychrometric chart to identify risks of condensation.  
**Use:** construct dew point profile, assess risk of interstitial condensation  
**Chart:** air temperature plotted against moisture content, location of dew point  
**Risk of condensation:** effect of moisture production, surface temperatures, ventilation provision (natural, controlled, mechanical), cold bridges

### Fluid mechanics

- 31.63 Carry out calculations to predict the flow of fluids in pipes and channels.  
**Calculations:** Bernoulli's equation, Chezy formula, d'Arcy's formula, continuity equations
- 31.64 Carry out calculations to determine the centre of pressure and total force on a submerged object and relate these to structural engineering problems.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Illumination

- 31.65 Define the lighting terms luminous intensity, luminous flux, illuminance.  
**Terms:** candela, lumen, lux
- 31.66 Explain the laws of illumination and calculate levels of illumination of a surface due to a point source.  
**Laws:** inverse square law, cosine law
- 31.67 Distinguish between disability glare and discomfort glare and state factors that affect discomfort glare.  
**Factors:** position of source, viewpoint, luminance (source, surroundings)
- 31.68 Explain the term light output ratio and compare light output from different sources.  
**Outputs:** polar curves, light output ratio (LOR), downward light output ratio (DLOR), upward light output ratio (ULOR)
- 31.69 Describe the colour rendering properties of lamps.  
**Properties:** tungsten filament, tubular fluorescent, compact fluorescent
- 31.70 Explain the contribution that can be made to energy conservation by the use of low energy lamps.
- 31.71 Explain how evenness of illumination is ensured by limiting spacing to height ratios of lamp fittings.
- 31.72 Explain how obstructions, window size and location affects daylight levels within buildings.

### Sound

- 31.73 Determine the total sound level caused by the combination of two sounds.  
**Sound level:** dB
- 31.74 Determine the sound insulation of a composite partition.  
**Composite:** wall, door, window, gap  
**Insulation:** sound reduction index, transmission factors
- 31.75 Explain the inverse square law of sound attenuation and state that a doubling of distance leads to an attenuation of 6 dB.

31.76 Explain the purpose of sound level meter weighting dB(A).

31.77 Describe methods of control for airborne and structure borne sound.  
**Controls:** mass, discontinuity, resilient layers, isolation, soft floor coverings

31.78 Differentiate between sound absorption and sound insulation.

31.79 Describe the use of diagrams to indicate paths of sound within an enclosure showing reflection and absorption and the best positions of acoustic materials to give a desired acoustic behaviour for the enclosure.  
**Diagrams:** layout planning, sound paths, constructional details, position (reflectors, absorbers)

### Thermal studies

31.80 Explain the nature of heat as a form of energy and differentiate between heat and temperature.

31.81 Define specific heat capacity and describe how materials with a high specific heat capacity can be used as a medium for storing heat energy.

31.82 State that thermal comfort levels are dependant on air temperature, humidity, air movement and radiation.

31.83 Describe the three processes of heat transfer.  
**Processes:** conduction, convection, radiation

31.84 Describe factors affecting heat transfer to and from a building.  
**Factors:** thermal transmittance, wall to window ratio, solar gains, layout planning, orientation

31.85 Describe a simple refrigeration cycle.  
**Cycle:** compressor, condenser, evaporator

31.86 Describe features of an air conditioning installation.  
**Features:** fresh air intake, recirculated air, air filter, preheater, chiller, humidifier, reheater, fan, ductwork, diffusers

31.87 Describe the procedure for assessing condensation risks within buildings and various methods to minimise the risks.  
**Risks:** high relative humidity (RH), low surface temperatures, high moisture production, lack of ventilation  
**Minimise risks:** levels of insulation, provision of coolness/heat, control moisture production, ventilation

### Fluid mechanics

31.88 Identify laws of fluid flow and apply these laws to flow in pipes and channels.

**Laws:** Bernoulli's equation, Chezy formula, d'Arcy's formula, continuity equations

**Application:** pipe sizing, quantity of flow, loss of energy

31.89 Describe methods of pressure measurement.

**Methods:** piezometers, manometers, Bourdon gauge

# Building Services 3

## Practical competences

The candidate must be able to do the following:

- 31.90 Carry out an investigation of the relationship between the design and function of service installations in a range of buildings.  
**Buildings:** eg college, public building, housing
- 31.91 Prepare a statement on the main design considerations for building service installations to ensure the needs of established laws, regulations and standards are met.
- 31.92 Give examples to compare the uses and limitations of a range of building service installations giving consideration to maintenance costs and cost-in-use.
- 31.93 Show how design and installation of building services can have an influence on other building components and finishes.
- 31.94 Illustrate, by means of annotated and dimensioned drawings and sketches, the main building service systems.  
**Systems:** ventilating/air conditioning, space heating, lifts, escalators, general services, distribution services, disposal systems
- 31.95 Prepare lists of materials, components and sequences of installation for building service systems.  
**Systems:** ventilating/air conditioning, space heating, lifts, escalators, general services, distribution services, disposal systems
- 31.96 State the safety, health and welfare considerations for installation and other site personnel, building user, general public and adjacent buildings for building services installations both during construction and after commissioning.

## Knowledge requirements

The instructor must ensure the candidate is able to:

Ventilating and air conditioning

- 31.97 Describe the factors which determine the need for ventilation and air conditioning.  
**Factors:** statutory requirements, comfort, health, safety, building (design, use)
- 31.98 Describe how natural ventilation and the action of wind and thermal forces can be incorporated to achieve comfort, health, safety and statutory requirements.
- 31.99 Describe mechanical extract and input ventilation systems.  
**Systems:** fans, suction pumps

- 31.100 Explain what is meant by a balanced ventilating system.
- 31.101 Describe the application and equipment used in fire venting and explain their relationship to various types of buildings and fire risks.
- 31.102 Explain the principles of an air conditioning system.  
**Principles:** temperature control, humidity control, air cleansing
- 31.103 Describe the equipment used in an air conditioning system.  
**Equipment:** heaters, fans, cooling coils, humidifiers, air cleaners

### Space heating

- 31.104 List the factors to be considered when selecting and designing a space heating provision.  
**Factors:** building (size, type), comfort requirements, needs (industrial, storage), relationship (structure, finishes), availability of plant space
- 31.105 Describe the various types of systems available for space heating.  
**Types:** hot water systems (low pressure, medium pressure, high pressure), steam, warm air, radiant tubes, local appliances (gas, electric)
- 31.106 List the implications when selecting different fuel and energy sources.  
**Implications:** storage, handling, requirements (location, space), fire safety, type of boiler/plant in relation to noise, loading, heat gain

### Lifts, escalators and general services

- 31.107 Describe the design and installation requirements for the incorporation of lifts and escalators into buildings for domestic (flats), commercial and industrial use.  
**Requirements:** electrical/hydraulic lifts (shafts, pits, motor housings), escalators (floor openings)
- 31.108 Describe the special requirements for safety during the construction and maintenance in 31.107 above.
- 31.109 Explain the space and construction features relating to the location of mechanical and electrical services in and adjacent to buildings.  
**Features:** integration at design/construction stages, space requirements, sequence of operations, access, commissioning, testing

### Distribution services

- 31.110 Explain the factors that ensure adequate and safe cold/hot water supply systems for a range of building types.  
**Factors:** cold water supplies (quality, characteristics, legislation, supplies to high rise buildings, storage/related loading on the structure), hot water supplies, (safety requirements, hot water generators, direct/indirect systems, pressurised systems), safety requirements in general
- 31.111 Describe the essential requirements for fire fighting detection, alarm systems and emergency lighting.  
**Requirements:** relationship of systems to other services systems, escape routes, components, equipment, selection of equipment according to estimated degree of hazard
- 31.112 Describe the installation requirements for a safe gas supply.  
**Requirements:** meters, associated controls, pipework, flues, ventilation requirements, flues (balanced, fan diluted)
- 31.113 Describe the installation requirements for single and three phase electrical lighting and power installations.  
**Requirements:** metering, earthing, controls, cable systems, appreciation of the appropriate electrical regulations, safe operation of installations, temporary supplies on site, testing, inspection
- 31.114 Describe the installation requirements for communication, data handling and control systems.  
**Requirements:** cables/equipment (provision, location), networking within buildings

### Disposal systems

- 31.115 Explain the essential principles and provisions of sanitation, sewage and waste disposal for a range of building types.  
**Principles/provision:** ventilation of sewer gases, fall of pipes, pumping, traps (silt, combustible materials), waste (treatment, disposal), access for cleansing

- 31.116 List the special requirements required to be provided for disabled persons.  
**Requirements:** wheelchairs (space, access, support rails, bars, access to baths/showers), specialised handles/controls (doors, flushing drainage), non-slip surfaces
- 31.117 List and describe the criteria for the selection and installation for above ground drainage for complex domestic and commercial drainage.  
**Criteria:** traps (suction, loss of trap water, control of sewage gases), effluent (pumping, treatment)
- 31.118 Describe techniques for surface water drainage from flat and pitched roofs.  
**Techniques:** gutters, hoppers, fall pipes, connection to sewers (combined, separate), soakaways
- 31.119 Identify the problems associated with the disposal of refuse from domestic and commercial buildings.  
**Problems:** refuse handling, on-site storage, chute systems, maceration, incineration, materials separation, recycling
- 31.120 List the design and installation considerations for surface and foul water sewage systems for groups of domestic or small commercial developments.  
**Considerations:** access to public sewers, types of waste, amount of waste, testing, inspection, treatment of waste, septic tanks, soakaways, disposal of treated waste

# Assessment

## **Test specification for written paper Environmental Science and Construction Techniques (6165-20-031)**

This is a written examination paper lasting two and a half hours with 12 questions. Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
Construction Technology 3	34
Environmental Science 3	33
Building Services 3	33

# 31 Construction Technology 3

## Practical competences

The candidate must be able to do the following:

- 31.1 Compare and recommend types of construction for specific low rise buildings taking into account the available alternatives.
- 31.2 State the considerations to be made during design and construction of building works as a result of established legislation relating to building works.
- 31.3 Compare the properties and lifespan of a range of basic building materials for a specific type of low rise building.
- 31.4 State the safety, health and welfare considerations for site personnel, building user, general public and adjacent properties.
- 31.5 Develop economic design solutions for specific low rise buildings.
- 31.6 Develop logical and economic approaches to the sequence of construction operations.
- 31.7 Illustrate, by means of annotated and dimensioned drawings and sketches, their understanding of the knowledge requirements of the unit.
- 31.8 Prepare lists of materials, components, and sequences of operations illustrating their understanding of the knowledge requirements of the unit.
- 31.9 Prepare site visit reports giving details of site investigation, soil investigation and archive research for an existing green field site and a town centre site.

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

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Instructor name (please print)

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Completion date

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# 31 Environmental Science 3

## Practical competences

The candidate must be able to do the following:

### Illumination

31.55 Identify the components of daylight factors and calculate daylight factors from simple plans and elevations using an appropriate method.

31.56 Design artificial lighting requirements for an office or showroom.

### Sound

31.57 Carry out practical exercises involving the use of a sound level meter and produce diagrams of sound paths showing reflection and absorption in enclosed structures.

31.58 Investigate and recommend ways in which sound can be controlled at source, in transit and at reception.

31.59 Investigate problems of sound transmission and reverberation in enclosed structures and determine the reverberation time of a lecture hall or theatre using Sabine's formula.

### Thermal studies

31.60 Calculate the flow of heat energy through a composite structure.

31.61 Calculate heat losses/gains for an enclosure and propose procedures to minimise heat loss/gain.

31.62 Carry out practical exercises using a psychrometric chart to identify risks of condensation.

## Fluid Mechanics

31.63 Carry out calculations to predict the flow of fluids in pipes and channels.

31.64 Carry out calculations to determine the centre of pressure and total force on a submerged object and relate these to structural engineering problems.

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

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Instructor name (please print) \_\_\_\_\_

Completion date \_\_\_\_\_

# 31 Building Services 3

## Practical competences

The candidate must be able to do the following:

- 31.90 Carry out and investigate the relationship between the design and function of service installations in a range of buildings.
- 31.91 Prepare a statement on the main design considerations for building service installations to ensure the needs of established laws, regulations and standards are met.
- 31.92 Using an example compare the uses and limitations of a range of building service installations giving consideration to maintenance costs and cost-in-use.
- 31.93 Show how design and installation of building services can have an influence on other building components and finishes.
- 31.94 Illustrate, by means of annotated and dimensioned drawings and sketches, the main building service system.
- 31.95 Prepare lists of materials, components and sequences of installation for building service systems.
- 31.96 State the safety, health and welfare considerations for installation and other site personnel, building user, general public and adjacent buildings for building services installations both during construction and after commissioning.

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

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Completion date

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# 41 Measurement – Summary of syllabus sections

## **Page 58 Measurement 3**

(Objectives 41.1 to 41.15)

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The aim of this section is to introduce candidates into the practice of quantity surveying, bonus surveying, and the principles of estimating.

Note: This is applied to buildings not exceeding three storeys with a minimum of 100m<sup>2</sup> and should include domestic, industrial, storage and business premises.

# Measurement 3

## Practical competences

The candidate must be able to do the following:

- 41.1 Extract dimensions/construct descriptions from drawings and schedules for a low rise domestic building.
- 41.2 Measure the work for a low rise domestic building using a standard format.  
**Standard:** eg Standard Method of Measurement, Code of Measurement (applicable to country of study)  
**Format:** use the document as a basis for (measuring construction work, determining standard dimensions/descriptions)
- 41.3 Prepare five sections of a Bill of Quantities using traditional working-up techniques.  
**Sections:** eg foundations, concrete ground floors, timber floors, internal/external walls in brick/block, timber pitched roofs with hip/gable ends, tile/sheet coverings, standard timber doors/windows including adjustments for openings, internal/external finishes, cold water supply, above/below ground drainage, roads, footpaths, pavings, fencing
- 41.4 Interpret and produce specifications where quantities do not form part of the contract.
- 41.5 Design and produce examples of formats for simple schedules.  
**Schedules:** eg doors, windows, internal/external finishes, drains
- 41.6 Use simulated site measurements for the preparation of simple bonus payments, completion of weekly bonus sheets and the determination of bonus payments from given data.  
**Site measurements:** eg excavation of foundation trenches, placing concrete in foundations by hand, brickwork in substructure walls (bricklayer, labourer)
- 41.7 Produce examples of building up unit rates for the purpose of obtaining a gross estimate for work.  
**Unit rates:** eg foundations, concrete ground floors, timber floors, internal/external walls in brick/block, standard timber doors/windows, internal finishes, timber pitched roofs with hip/gable ends, tile/sheet coverings, above/below ground drainage
- 41.9 Measure work from issued drawings/specifications and record the detail, including waste calculations, on standard format dimension paper.  
**Measure work:** substructure (foundations, concrete floors, timber floors), internal/external walls, roofs (flat, pitched), doors, windows, above/below ground drainage, roads, footpaths, pavings, fencing
- 41.10 Describe the design and preparation of simple schedules.  
**Schedules:** doors, windows, internal/external finishes, drainage
- 41.11 Describe the terms prime cost/provisional sums, explain their inclusion in Bills of Quantities, and their adjustments.  
**Prime cost sums:** bathroom suites, kitchen units, ironmongery  
**Provisional sums:** substructure work, fees/taxes for temporary site accommodation
- 41.12 Explain trade/cash discounts and how they are incorporated into prime cost sums.  
**Prime cost sums:** bathroom suites, kitchen units, ironmongery
- 41.13 Describe the method for preparing sections of a Bill of Quantities using traditional working-up techniques.  
**Sections:** foundations, concrete ground floors, timber floors, internal/external walls in brick/block, timber pitched roofs with hip/gable ends, tile/sheet coverings, standard timber doors/windows including adjustments for openings, internal/external finishes, cold water supply, above/below ground drainage, roads, footpaths, pavings, fencing
- 41.14 Explain how measurements on site are used for the preparation of bonus payments and the method of analysing them from given data.
- 41.15 Describe the procedure in building up unit rates for the purpose of obtaining a gross estimate for work from provided data.  
**Unit rates:** foundations, concrete

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 41.8 Describe the use and application of a standard method of measurement.  
**Application:** measuring building work, determining standard dimensions/descriptions

# Assessment

## Test specification for written paper Measurement (6165-20-041)

This is a written paper lasting one and a half hours with 5 questions. Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
<b>Measurement 3</b>	
41.8 Standard method of measurement	10
41.9 Measurement of work	15
41.10 Design and preparation of schedules	10
41.11 Prime costs and provisional sums	15
41.12 Trade and cash discounts	10
41.13 Bill of quantities	20
41.14 Bonus payments	10
41.15 Unit rates	10

# 41 Measurement 3

## Practical competences

The candidate must be able to do the following:

- 41.1 Extract dimensions/construct descriptions from drawings and schedules.
- 41.2 Measure the work for a low rise domestic building using a standard format.
- 41.3 Prepare five sections of a Bill of Quantities using traditional working-up techniques.
- 41.4 Interpret and produce specifications where quantities do not form part of the contract.
- 41.5 Design and produce examples of formats for simple schedules.
- 41.6 Simulated measurements on site for the preparation of simple bonus payments, completion of weekly bonus sheets; determine bonus payments from given data.
- 41.7 Produce examples of building up unit rates for the purpose of obtaining a gross estimate for work.

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

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 42 Designing for Construction 3 – Summary of syllabus sections

## **Page 62 Designing for Construction 3**

(Objectives 42.1 to 42.21)

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This section is about the process of designing buildings and structures for the construction industry and the activities and terminology used within that process.

Note: This is applied to buildings not exceeding three storeys with a minimum of 100m<sup>2</sup> and should include domestic, industrial, storage and business premises.

# Designing for Construction 3

## Practical competences

The candidate must be able to do the following:

- 42.1 Produce a report on a design brief for a low level building.  
**Design brief:** eg the Royal Institute of British Architects (RIBA) briefing chart/checklist, design specification
- 42.2 Identify sources for the collection of design data.  
**Sources:** eg design data/guides, manufacturers' data, standards, past projects, architectural library
- 42.3 For a given project recognise and describe design constraints and the impact on cost and buildability.  
**Design constraints:** eg fitness for purpose, design life, aesthetics, balance, symmetry, site contours, area of site, location
- 42.4 Investigate and produce a report outlining the main features of legislation which apply locally to the control of design and construction.
- 42.5 List and describe the stages of a 'Plan of Work'.  
**Plan of Work:** eg Royal Institute of British Architects, local architectural/building construction equivalent
- 42.6 Produce simple sketch designs for a single storey dwelling, including plans and elevations.
- 42.7 Produce simple sketch designs for a typical two-storey office block.
- 42.8 Using a combination of both conventional drawing methods and computer aided design software, produce a selection of working drawings for a two storey office block.  
**Selection:** site plan, elevations, floor plan, three annotated assembly drawings  
**Working drawings:** final contractors drawings

## Knowledge requirements

The instructor must ensure the candidate is able to:

- 42.9 Explain the term 'Design Brief' and list its stages  
**Design brief:** eg RIBA's briefing chart/checklist, design specification
- 42.10 Describe a 'Plan of Work' and its usefulness in project planning.
- 42.11 Explain how the purpose for which a building is to be used affects its design.
- 42.12 Describe the main factors governing design decisions including clients' needs.  
**Main factors:** finance, environmental considerations, physical site constraints, legal issues

- 42.13 Explain the importance of ergonomics and anthropometrics in determining the size and scale of buildings and fittings.
- 42.14 Define construction/architectural design terminology.  
**Terminology:** massing, dynamic, decoration, style, texture, unity, contrast, proportion, taste, scale
- 42.15 Explain the building performance requirements of construction projects.  
**Requirements:** sound control, thermal comfort, lighting and ventilation, weather intrusion, strength and stability, durability, maintenance, fire protection, sanitation, security, dimensional suitability
- 42.16 Identify sources of design data.  
**Design data:** design data/guides, manufacturers' data, standards, past projects, architectural library
- 42.17 Identify various types of drawing medium, sizes and methods of reproduction.  
**Drawing medium:** cartridge paper, tracing paper, tracing cloth, tracing film  
**Sizes:** A0, A1, A2, A3, A4  
**Reproducing:** dye line process, photocopying, tracing
- 42.18 Describe the facilities required in a modern architectural practice.  
**Facilities:** light (natural, artificial), tables, CAD facilities, model area, storage
- 42.19 Interpret the use of the scale ratios used in construction drawings.  
**Scale:** 1:1, 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, 1:2500, 1:5000, 1:10000
- 42.20 Interpret examples of the various drawings used in the construction industry.  
**Drawings:** working drawings (constructions drawings), detailed sketches, site plans, location drawings
- 42.21 Identify the advantages and disadvantages of conventional drawing techniques and computer aided design techniques in the production of construction drawings.

# Assessment

## Test specification for written paper Designing for Construction (6165-20-042)

This is a written paper lasting one and a half hours with 5 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
<b>Designing for Construction 3</b>	
42.9 Design brief	8
42.10 Plan of work	5
42.11 Building design	8
42.12 Design decisions	8
42.13 Ergonomics and anthropometrics	8
42.14 Construction and architectural design technology	8
42.15 Building performance	10
42.16 Sources of design data	5
42.17 Drawing production	8
42.18 Modern architectural practice facilities	8
42.19 Scale ratios	8
42.20 Interpretation of drawings	8
42.21 Drawing techniques and CAD techniques	8

# 42 Designing for Construction 3

## Practical competences

The candidate must be able to do the following:

- 42.1 Produce a report on a design brief for a low level building
- 42.2 Identify sources for the collection of design data.
- 42.3 For a given project recognise and describe design constraints and the impact on cost and buildability.
- 42.4 Investigate and produce a report outlining the main features of legislation which apply locally to the control of design and construction.
- 42.5 List and describe the stages of a 'Plan of Work'
- 42.6 Produce simple sketch designs for a single storey dwelling, including plans and elevations.
- 42.7 Produce simple sketch designs for a typical two-storey office block.
- 42.8 Using a combination of both conventional drawing methods and computer aided design software, produce a selection of working drawings for a two storey office block.

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

Candidate signature

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Candidate name (please print)

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Instructor signature

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Instructor name (please print)

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Completion date

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# 43 Construction Mathematics 3

**Page 65 Construction Mathematics 3**

(Objectives 43.1 to 43.93)

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This section gives candidates the competence to develop their skills to aid the learning process in structural analysis and civil engineering.

# Construction Mathematics 3

## Practical competences

Candidates must be able to do the following:

- 43.1 Calculate irregular areas and volumes.
- 43.2 Calculate the areas and volumes of revolution using Pappus' theorem.
- 43.3 Define 'Conic Section' and recognise equations and graphs of conic sections.
- 43.4 Plot a graph of a given conic and determine equations of tangents and normals.
- 43.5 State the binomial theorem with positive, negative and fractional indices.
- 43.6 Apply the binomial theorem to problems on errors and approximations.
- 43.7 Define a matrix and calculate the sum and product of two 2 x 2 matrices.
- 43.8 Evaluate a 2 x 2 determinant and solve simultaneous linear equations with two unknowns using matrices and determinants.
- 43.9 Solve triangles using sine and cosine rules.
- 43.10 Solve simple trigonometrical equations.
- 43.11 State simple trigonometrical identities and use these in the manipulation of expressions and solution of equations.
- 43.12 Apply the half angle formulae to the solution of triangles.
- 43.13 Appreciate the concept of differentiation and find the differential coefficient of the functions of the type  $y = ax^m + bx^n$  and  $y = a \sin\theta + b \cos\theta$ .
- 43.14 Differentiate products, quotients, functions of a function and implicit functions.
- 43.15 Apply differentiations to the problems involving tangents, rate of change, maxima and minimum and small errors.
- 43.16 Integrate and evaluate definite integrals.
- 43.17 Apply techniques of integration to the evaluation of areas, first and second moment of areas and positions of centroids.
- 43.18 Define measures of central tendency and measures of dispersion.
- 43.19 Calculate measures of central tendency and dispersion for grouped and ungrouped data.
- 43.20 Define probability, evaluate probabilities for dependent and independent events and use tree diagrams to represent probability outcomes.
- 43.21 Use appropriate computer software to analyse the data.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Geometry

- 43.22 Create a diagram from given data to a suitable scale.
- 43.23 Calculate areas of irregular figures using the mid-ordinate rule.
- 43.24 Use trapezoidal rule for estimating the area under a curve between the stated limits.
- 43.25 Calculate areas of irregular figures using Simpson's rule.
- 43.26 Calculate the volumes of solids using prismoidal and Simpson's rules.
- 43.27 State Pappus' theorem.
- 43.28 Use Pappus' theorem to calculate volumes and surface areas of curved shapes.
- 43.29 Define the term 'conic section'.
- 43.30 Recognise graphs of conic sections.
- 43.31 Recognise equations of conic sections.
- 43.32 Plot a graph of a conic section.
- 43.33 Determine equations of tangents and normals to a given conic section

### Algebra and matrices

- 43.34 Expand the binomial expression  $(1 \pm x)^n$  for  $n = 2, 3, 4$  and  $5$ .
- 43.35 Identify the general form and the signs of terms in the expansion in 43.34 and also their numerical coefficients (Pascal's triangle).
- 43.36 Use the general form of the expansion to write down the terms of the expansion of  $(a \pm x)^n$  for negative and fractional values of  $n$ .
- 43.37 Expand expressions of the form  $(a + x)^n$  for positive, negative or fractional values of  $n$  and hence determine for each case the restrictions to be placed on  $n$  to ensure convergence.

43.38 Use the binomial theorem to write down the expansion

$$\text{of } \frac{1}{1 \pm x} \text{ and } \frac{1}{1 \pm x^2}$$

43.39 Use binomial expansion to solve practical problems on approximations.

43.40 Use binomial expansion to solve practical problems in the evaluation of errors.

43.41 Define a matrix and the unit matrix.

43.42 Calculate the sum and difference of two matrices (2 x 2 only).

43.43 Calculate the product of two 2 x 2 matrices.

43.44 Demonstrate that the product of two matrices is, in general, non-commutative.

43.45 Obtain the inverse of a 2 x 2 matrix.

43.46 Evaluate a 2 x 2 determinant.

43.47 Solve simultaneous linear equations with two unknowns using determinants.

43.48 Solve simultaneous linear equations with two unknowns by means of matrices.

43.49 Define a singular matrix and describe the meaning of a determinant whose value is zero.

### Trigonometry

43.50 Solve any triangle, using sine and cosine rules, given sufficient information.

$$\text{Sine rule: } \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$\text{Cosine rule: } a^2 = b^2 + c^2 - 2bc \cos A$$

43.51 Solve practical problems including three dimensional using trigonometry.

43.52 Solve simple trigonometrical equations for angles between  $0^\circ$  and  $360^\circ$ .

43.53 State and prove simple trigonometrical identities involving  $\sin A$ ,  $\cos A$ ,  $\tan A$ ,  $\operatorname{cosec} A$ ,  $\sec A$  and  $\cot A$ .

43.54 Use trigonometrical identities to assist in the solution of simple trigonometrical equations.

43.55 State the expansion of  $\sin(A \pm B)$ ,  $\cos(A \pm B)$ ,  $\tan(A \pm B)$ ,  $\sin 2A$ ,  $\cos 2A$  and  $\tan 2A$  and manipulate expressions involving these.

43.56 Transform expressions of the form  $a \sin \theta \pm b \cos \theta$  to the form  $r \sin(\theta + \alpha)$  and use this for finding maximum and minimum values and for solving equations.

43.57 Express  $\sin A$ ,  $\cos A$ ,  $\tan A$  in terms of  $\tan \frac{A}{2}$  and use these to solve triangles.

### Calculus

43.58 Determine the average and instantaneous gradients of graphs of functions of the type  $y = ax + b$  and  $y = ax^2$ .

43.59 Deduce that the chord of a graph reduces to the tangent at a point as the arc reduces to zero.

43.60 Identify  $\delta x$  and  $\delta y$  as incremental changes between two points on a graph.

43.61 Derive from a graph the value of the ratio  $\frac{\delta y}{\delta x}$  as the interval  $\delta x$  is reduced.

43.62 Define  $\frac{dy}{dx}$  as the limiting value of the ratio  $\frac{\delta y}{\delta x}$  when  $\delta x \rightarrow 0$  and hence as the gradient of a graph at a particular point.

43.63 Derive from the first principles expressions for  $\frac{dy}{dx}$  for the functions  $y = ax$ ,  $y = ax^2$  and  $y = ax^3$ .

43.64 State the rule for finding the differential coefficient of the function  $y = ax^n$ .

43.65 Determine the differential coefficients of the functions of the types  $y = ax^m + bx^n$  where  $m$  and  $n$  have positive or negative values.

43.66 State the differential coefficients of  $y = \sin \theta$  and  $y = \cos \theta$ .

43.67 Differentiate functions of the form  $y = a \sin \theta + b \cos \theta$ .

43.68 Differentiate products, quotients, functions of a function and implicit functions.

43.69 Describe why the differential coefficient of a function is zero at the turning point.

43.70 Determine whether a turning point is a maximum or minimum by examination of the gradient on either side of the turning and with the help of the second order differential coefficient.

43.71 Apply differentiation to the problems involving rate of change, tangents, maxima and minima and small errors.

43.72 Define integration as the inverse of differentiation and state the importance of a constant of integration.

43.73 Determine the integrals  $\int y \, dx$  for  $y = a$ ,  $ax$ ,  $ax^2$ ,  $\sin x$  and  $y = \cos x$ .

- 43.74 Identify indefinite and definite integrals and evaluate definite integrals of the type given in 43.73 for various limits.
- 43.75 Determine the integrals  $\int_a^b y \, dx$  as the area under the curve between ordinates  $x = a$  and  $x = b$ .
- 43.76 Apply definite integration to the areas of conics and volumes of solids of revolution.
- 43.77 Apply techniques of integration to the evaluation of second moment of area and the position of centroid of an area.

### **Statistics**

- 43.78 Define the arithmetic mean, median and mode and describe where each is appropriate measure of central tendency.
- 43.79 Calculate the arithmetic mean for an ungrouped data.
- 43.80 Place ungrouped data in rank order and determine the median and modal values.
- 43.81 Calculate the arithmetic mean for grouped data.
- 43.82 Estimate the mode of grouped data using a histogram.
- 43.83 Calculate the mode of grouped data using an appropriate formula.
- 43.84 Determine the median, quartiles and percentiles using an ogive.
- 43.85 Calculate the median of grouped data using an appropriate formula.
- 43.86 Describe the need to measure the dispersion of data.
- 43.87 Define variance and standard deviation.
- 43.88 Calculate the values of variance and standard deviation for ungrouped data.
- 43.89 Calculate the variance and standard deviation for grouped data using an appropriate formula.
- 43.90 Define probability.
- 43.91 Evaluate probabilities for dependent and independent events.
- 43.92 Use 'tree diagrams' to represent probability outcomes.
- 43.93 Explain the use of computer software to analyse data.

# Assessment

## Test specification for written paper Construction Mathematics (6165-20-043)

This is a written paper lasting one and a half hours with 5 questions. Candidates must answer **all** questions.

<b>Topic</b>	<b>Approximate % examination weighting</b>
<b>Construction Mathematics 3</b>	
Geometry	20
Algebra and matrices	20
Trigonometry	20
Calculus	20
Statistics	20

# 43 Construction Mathematics 3

## Practical competences

The candidate must be able to do the following:

- |   |                          |  |                          |
|---|--------------------------|--|--------------------------|
| 43.1 Calculate irregular areas and volumes.   | <input type="checkbox"/> | 43.13 Appreciate the concept of differentiation and find the differential coefficient of the functions of the type $y = ax^m + bx^n$ and $y = a \sin\theta + b \cos\theta$ . | <input type="checkbox"/> |
| 43.2 Calculate the areas and volumes of revolution using Pappus' Theorem.   | <input type="checkbox"/> | 43.14 Differentiate products, quotients, functions of a function and implicit functions.   | <input type="checkbox"/> |
| 43.3 Define 'Conic Section' and recognise equations and graphs of conic sections.   | <input type="checkbox"/> | 43.15 Apply differentiations to the problems involving tangents, rate of change, maximum and minimum and small errors.   | <input type="checkbox"/> |
| 43.4 Plot a graph of given conic and determine equations of tangents and normals.   | <input type="checkbox"/> | 43.16 Integrate and evaluate definite integrals.   | <input type="checkbox"/> |
| 43.5 State the binomial theorem with positive, negative and fractional indices.   | <input type="checkbox"/> | 43.17 Apply techniques of integration to the evaluation of areas, first and second moment of areas and positions of centroids.   | <input type="checkbox"/> |
| 43.6 Apply the binomial theorem to problems on errors and approximations.   | <input type="checkbox"/> | 43.18 Define measures of central tendency and measures of dispersion.  | <input type="checkbox"/> |
| 43.7 Define a matrix and calculate the sum and product of two $2 \times 2$ matrices.  | <input type="checkbox"/> | 43.19 Calculate measures of central tendency and dispersion for a grouped and an ungrouped data.   | <input type="checkbox"/> |
| 43.8 Evaluate a $2 \times 2$ determinant and solve simultaneous linear equations with two unknowns using matrices and determinants. | <input type="checkbox"/> | 43.20 Define probability, evaluate probabilities for dependent and independent events and use tree diagrams to represent probability outcomes.                               | <input type="checkbox"/> |
| 43.9 Solve triangles using sine and cosine rules.   | <input type="checkbox"/> | 43.21 Use the appropriate software to analyse the data.  | <input type="checkbox"/> |
| 43.10 Solve simple trigonometrical equations.   | <input type="checkbox"/> |  |                          |
| 43.11 State simple trigonometrical identities and use these in the manipulation of expressions and solution of equations.           | <input type="checkbox"/> |  |                          |
| 43.12 Apply the half angle formulae to the solution of triangles.   | <input type="checkbox"/> |  |                          |

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

# 44 Structural Mechanics 3

**Page 72 Structural Mechanics 3**  
(Objectives 44.1 to 44.23)

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The aim of this section is to develop the concepts of structural mechanics for the analysis of beams, columns, frameworks and retaining structures of a statically determinate nature.

In addition, simple treatment of two-dimensional stress systems are introduced for applications in the sections 'Hydraulics and soil mechanics' and 'Design of structural elements' which are contained in the Diploma programme.

It is advised that the section 'Mechanics 2' in this Diploma programme is studied before embarking on this section.

## Practical competences

The candidate must be able to do the following:

- 44.1 Calculate reactions, shear force and bending moment values for various positions on beams.  
**Beams:** simply supported with/without overhangs, cantilever  
**Loads:** concentrated uniformly distributed loads, combination loads
- 44.2 Draw shear force and bending moment diagrams for 44.1 above.  
**Diagrams:** show zero shear, shear force/bending moments (SF/BM) relationship, points of contra-flexure
- 44.3 Verify values obtained in 44.1 above using a computer software package.
- 44.4 Find the geometrical properties of structural sections using tabular methods.  
**Geometrical properties:** area, centroidal axis, section modulus, inertia, radius of gyration
- 44.5 Verify results obtained in 44.4 above using a computer software package.
- 44.6 Use the theory of bending to establish sizing and stresses in rectangular section beams.  
**Beams:** timber, steel
- 44.7 Determine the safe load and sectional size for short and long columns subject to axial loading.  
**Columns:** concrete (plain, reinforced), structural (timber, steel)
- 44.8 Determine forces in statically determinate frameworks with loads applied at node positions by 'graphical', 'resolution of joints' and 'methods of sections' methods.
- 44.9 Determine the pressure on retaining walls due to liquid and active earth pressure applied independently.
- 44.10 From the results obtained in 44.9 above, calculate factors of safety against overturning and sliding given suitable factors.
- 44.11 Apply the equations of simple two dimensional stress systems to solve problems encountered in structural and soil mechanics.
- 44.12 Verify results obtained in 44.11 above using Mohr's circle of stress graphical method.

## Knowledge requirements

The instructor must ensure the candidate is able to:

### Shear force and bending moments

- 44.13 Describe the procedure for analysing beams for shear and bending for various loading systems.  
**Beams:** simply supported, with/without overhangs, cantilever  
**Loads:** concentrated, uniformly distributed, combination
- 44.14 Describe the method for drawing shear force and bending moment diagrams.  
**Diagrams:** zero shear, shear/moment relationship, maximum values, points of contra-flexure

### Structural section properties and bending

- 44.15 Describe the procedure for analysing the properties of structural sections used in design calculations.  
**Sections:** rectangular, circular, trapezoidal, combination  
**Properties:** area, centroidal axes, inertia, section modulus, radius of gyration  
**Procedure:** first/second moment of areas
- 44.16 Describe the procedure for analysing the stresses in/moment capacity of various beams/materials sections in bending.  
**Beam sections:** rectangular, tee and I  
**Materials:** timber, structural steel  
**Procedure:** theory of bending  $\frac{M}{I} = \frac{f}{\gamma}$ , permissible stress (design, property tables)

### Axially loaded columns

- 44.17 Describe the method for determining the safe load/section size required for structural members in various materials subject to axial load.  
**Member:** short/long columns, section (solid, rectangular, H section, circular)  
**Materials:** timber, steel, concrete (plain/reinforced), permissible stress

### Frameworks

- 44.18 Describe the procedure for determining the reactions and forces of statically determinate frameworks for various loadings.  
**Loading:** vertical/wind concentrated loads applied at node positions  
**Procedure:** graphical (link polygon, stress diagrams, Bow's notation), resolution of joints (joint equilibrium), method of sections (frame cutting, equilibrium of part frame)

### Pressures on retaining walls and wall stability

44.19 Describe the procedure for determining the pressures on retaining walls.

**Pressures:** liquid ( $\rho gh$ ), soil ( $K_a \rho gh$ ), active pressure only (frictional soils)

**Wall types:** mass (rectangular, trapezoidal)

**Procedure:** overturning (stability about the toe), sliding (resistance  $F = MN$ ), pressures (middle third rule)

$$P_{1,2} = \frac{W}{A} \pm \frac{M}{Z}$$

44.20 For 44.19 above describe the procedure for calculating the factors of safety against overturning and sliding.

44.21 For 44.19 above describe the procedure for checking safe bearing pressures are not exceeded.

### Two dimensional stress analysis

44.22 Understand the theory and equations of a simple two-dimensional stress system to solve problems encountered in structural and soil mechanics.

**Theory:** stresses on inclined planes, general two-dimensional stress systems, direct/shear stress on any plane, principal planes/stresses, maximum shearing stress

**Application:** bolts in tension/shear, compression test, soil triaxial test

44.23 Describe the procedure for verifying the results from equations of simple two dimensional stress using Mohr's circle of stress graphical method.

# Assessment

## Test specification for written paper Structural Mechanics (6165-20-044)

This is a written paper lasting one and a half hours with 5 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
<b>Structural Mechanics 3</b>	
Shear force and bending moments	} 40
Structural section properties and bending	
Axially loaded columns	
Frameworks	20
Pressures on retaining walls and wall stability	20
Two dimensional stress analysis	20

# 44 Structural Mechanics 3

## Practical competences

The candidate must be able to do the following:

- |       |  |                          |       |  |                          |
|-------|--|--------------------------|-------|--|--------------------------|
| 44.1  | Calculate reactions, shear force and bending moment values for various positions on beams.   | <input type="checkbox"/> | 44.11 | Apply the equations of simple two dimensional stress systems to solve problems encountered in structural and soil mechanics. | <input type="checkbox"/> |
| 44.2  | Draw shear force and bending moment diagrams for 44.1 above.   | <input type="checkbox"/> | 44.12 | Verify results obtained in 44.11 above using Mohr's circle of stress graphical method.                                       | <input type="checkbox"/> |
| 44.3  | Verify values obtained in 44.1 above using a computer software package.  | <input type="checkbox"/> |       |  |                          |
| 44.4  | Find the geometrical properties of structural sections using tabular methods.  | <input type="checkbox"/> |       |  |                          |
| 44.5  | Verify results obtained in 44.4 above using a computer software package.   | <input type="checkbox"/> |       |  |                          |
| 44.6  | Use the theory of bending to establish sizing and stress in rectangular section beams.   | <input type="checkbox"/> |       |  |                          |
| 44.7  | Determine the safe load and sectional size for short and long columns subject to axial loading.  | <input type="checkbox"/> |       |  |                          |
| 44.8  | Determine forces in statically determinate frameworks with loads applied at node positions by 'graphical', 'resolution of joints' and 'methods of sections' methods. | <input type="checkbox"/> |       |  |                          |
| 44.9  | Determine the pressure on retaining walls due to liquid and active earth pressure applied independently.   | <input type="checkbox"/> |       |  |                          |
| 44.10 | From the results obtained in 44.9 above, calculate factors of safety against overturning and sliding given suitable factors.   | <input type="checkbox"/> |       |  |                          |

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 \_\_\_\_\_

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# Appendix A

## Assessments

Two assessment methods are used in the 6165 Technician Diploma in Construction programme – written questions and practical assessment.

### Practical assessment

Each unit (assessment component) in this programme has one or more practical assessments which are derived from the practical competences 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. The use of local materials, tools, equipment or practice is allowed within the specifications of the 'range' supporting each competence statement. The results of the assessments must be documented and available for audit by the visiting verifier. ALL assessments must be successfully completed.

The assessments may be carried out at any time agreed by the instructor and the candidate.

The competence checklists in this publication are intended to be photocopied so that each candidate has a personal record of his/her practical assessments.

### 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 materials, tools or equipment are present.

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'. Candidates 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. All assessment documentation and material must be kept 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

As the practical assessments for each component are successfully completed, the achievement must be recorded. A model of a summative record is given at the end of this section. When all components for an award have been recorded, the result must be sent to City & Guilds. Each candidate's achievements should be transferred from the summative assessment record to the entry form.

Practical components are entered onto Form S which must be countersigned by the visiting verifier and then sent to City & Guilds. The visiting verifier will want to see evidence to support the results being entered. Actual forms are supplied by City & Guilds.

### Question paper assessments

The knowledge requirements in the sections of each unit are tested by question papers which are set and marked by City & Guilds. At the certificate and first year diploma levels (levels 1 and 2) of this programme, candidates will sit multiple choice question papers. There on, all question papers will require short written answers.

Entries for these examinations must be made in accordance with the timetable for entries given in the 'Directory' and must be sent in on Form D.

### General information

An advantage of this programme is that candidates who successfully complete a component of assessment for a single unit may, if they wish, claim a Certificate of Unit Credit. This may be beneficial for those candidates who only wish to complete part of this programme.

Candidates wishing to gain the full award (Certificate, Diploma or Advanced Diploma) must successfully complete all components. We recommend that their 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.

## 6165-20 Technician Diploma in Construction Practical competence assessment record

Candidate's name (and City & Guild's enrolment number, if applicable)

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Centre name and number

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Assessment reference	Date completed	Instructor signature	Instructor name
<b>121 Applied Scientific Techniques 2</b>			
21 Construction Mathematics 2			
21 Science and Materials 2			
21 Mechanics 2			
<b>122 Drawing and Surveying Techniques 2</b>			
22 Drawing Techniques			
22 Site Surveying 2			
<b>123 Construction Techniques 2</b>			
23 Construction Technology 2			
23 Resource Management 2			
<b>131 Environmental Science and Construction Techniques 3</b>			
31 Construction Technology 3			
31 Environmental Science 3			
31 Building Services 3			
<b>And any two of the following</b>			
<b>141 Measurement 3</b>			
41 Measurement 3			
<b>142 Designing for Construction</b>			
42 Designing for Construction 3			

<b>143 Construction Mathematics 3</b>			
43	Construction Mathematics 3		
<b>144 Structural Mechanics 3</b>			
44	Structural Mechanics 3		
<b>And, if need to satisfy full Diploma award requirements, any one of the following*</b>			
102	Timber Vocations Basic Skills Practice		
103	Trowel Vocations Basic Skills Practice		
104	Painting and Decorating Basic Skills Practice		
105	Plumbing Basic Skills Practice		
106	Refrigeration and Air Conditioning Basic Skills Practice		
107	Electrical Installation Basic Skills		
<b>6165-20 Technician Diploma in Construction Practical competence assessment record</b>			

\* The syllabus units containing the above components (102-107) can be found in either the 6165 Technician Awards in the Construction Industry – certificate level or the 6161 Awards in the Construction Industry – certificate level.

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