# Unit 27: Surveying Technology in Construction and Civil Engineering

**Unit code:** K/600/0457

**QCF Level 3:** BTEC Nationals

**Credit value:** 10

**Guided learning hours:** 60

## Aim and purpose

This unit aims to give learners the opportunity to understand the principles of optics and the electromagnetic spectrum used for surveying, and the sources of errors that are inherent in surveying instruments. The unit also aims to develop skills in making survey measurements.

## Unit introduction

Surveying involves the use of technology to measure the physical features of the earth's surface and to present the results. It is a basic principle of surveying that all measurements contain potential errors. If we want to obtain the best results from particular instruments, in a variety of given situations, an understanding of the instruments and their potential errors is required.

This unit looks primarily at the nature of survey measurements, the errors inherent in the measurement systems and the instruments used, and the best ways to reduce or eliminate these errors. It also introduces learners to accuracy requirements in surveying projects and how to produce specifications to meet required accuracies.

Since survey measurements depend fundamentally on the transmission of light, ie electromagnetic waves, through the atmosphere, the properties of light and other parts of the electromagnetic spectrum must be explored together with their effects on measurements. The survey instruments themselves have mechanical and electronic components which may also introduce errors through imperfect manufacture or wear and tear. Surveyors must have the ability to check the instruments for errors, adjust these where appropriate, and use suitable fieldwork techniques to reduce or eliminate potential errors.

## Learning outcomes

**On completion of this unit a learner should:**

1 Understand how the principles of optics and electromagnetic waves are applied in surveying

2 Understand the sources of systematic errors arising from the use of surveying equipment

3 Be able to use procedures for making survey measurements.

# Unit content

## 1 Understand how the principles of optics and electromagnetic waves are applied in surveying

*Principles of optics*: reflection; refraction; mirrors; lenses; prisms

*Principles of electromagnetic waves*: properties of waves; atmospheric influences; application to distance measurement; application to remote sensing

*Surveying applications*: theodolites; automatic optical levels; total stations

## 2 Understand the sources of systematic errors arising from the use of surveying equipment

*Sources of systematic errors*: in the use of tapes; levels; theodolites; electronic distance measurement (EDM)

*Tapes*: calibration errors

*Levels*: collimation errors

*Theodolites*: bubble and electronic plummets; horizontal and vertical collimation errors

*Electronic distance measurement (EDM)*: collimation adjustment of modular instruments; scale and index errors

*Systematic calibration*: to reduce systematic errors listed above

## 3 Be able to use procedures for making survey measurements

*Survey measurements*: linear surveys; levelling; control surveys; GPS; remote sensing

*Linear surveys*: corrections for slope; sag; temperature; tension

*Levelling*: corrections for refraction; curvature

*Control surveys*: traversing and trigonometrical heighting; corrections for scale factor and connection to National Grid

*Global Positioning System (GPS)*: differential GPS; multi-path

*Remote sensing*: satellite and aerial imagery; photogrammetry; laser scanning

# Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

| Assessment and grading criteria | | |
|---|---|---|
| **To achieve a pass grade the evidence must show that the learner is able to:** | **To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:** | **To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:** |
| **P1** explain the principles of optics as they relate to survey instruments and measurements [IE1, IE2, IE4, IE6] | **M1** explain how the refraction of electromagnetic waves through the atmosphere affects survey measurements | |
| **P2** describe the principles of electromagnetic waves as they relate to survey measurements [IE1, IE2, IE4, IE6] | | |
| **P3** discuss systematic errors in surveying measurements [IE1, IE2, IE4, IE6] | **M2** perform systematic checks and adjustments of instruments such as levels and theodolites | **D1** produce specifications to meet required accuracies |
| **P4** explain the need for systematic calibration of surveying instruments [IE1, IE2, IE4, IE6, SM1, SM2, SM3, EP1, EP3] | | |
| **P5** select the appropriate surveying procedures for three different surveys [TW1, TW2, TW3, SM1, SM2, SM3, EP1, EP3] | **M3** carry out fieldwork and numerical procedures to minimise or eliminate systematic errors. | **D2** justify the selected methods in terms of how effectively they minimise error. |
| **P6** use the selected procedures to perform surveys. [TW1, TW2, TW3, SM1, SM2, SM3, EP1, EP3] | | |

**PLTS**: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

| Key | | | |
|---|---|---|---|
| | IE – independent enquirers | RL – reflective learners | SM – self-managers |
| | CT – creative thinkers | TW – team workers | EP – effective participators |

# Essential guidance for tutors

## Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet and/or library resources and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers could add to the relevance of the subject but, as this is essentially a practical unit, learners will learn more quickly by doing, rather than by listening.

Learning outcome 1 is not linked to the other two learning outcomes. Learning outcomes 2 and 3 are closely related; the separation is intended to be between the errors inherent in the instruments themselves (learning outcome 2) and the errors in the measurement process (learning outcome 3).

The unit gives learners opportunities to carry out realistic surveying tasks and produce high quality results. This unit is likely to be delivered later in the programme, since familiarity with the use of surveying equipment and procedures is assumed. Surveying is a practical discipline and, although this unit is concerned with theoretical aspects of that discipline, learners must be able to specify instruments and procedures for typical tasks and incorporate these in their surveying work.

Group activities are permissible, but tutors will need to ensure that individual learners have equal experiential and assessment opportunities.

**Health, safety and welfare issues are paramount and should be reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken before practical activities are taken. Centres are advised to read the *Delivery approach* section in the specification, and *Annexe H: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.**

## Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

| Topic and suggested assignments/activities and/assessment |
|---|
| Introduction<br>Tutor explanation and class discussion |
| Optics and electromagnetic waves<br>Practical work on optics – learners work in pairs<br>Use of optics in surveying instruments – group research<br>Applications of electromagnetic waves in surveying – group research |
| **Assignment 1: The Science of Surveying Instruments and Measurements**<br>Production of a poster by individual learners |
| Errors in surveying instruments<br>Review of surveying instruments – class exercise<br>Systematic errors and their sources – exposition/class discussion<br>Calibrating instruments – demonstrations/practicals/fieldwork |

| Topic and suggested assignments/activities and/assessment |
| --- |
| **Assignment 2: Calibrating Surveying Instruments** |
| Demonstration of how to calibrate survey equipment by individual learners |
| Procedures for making survey measurements |
| Procedures for best practice – group research |
| Presentation of findings – individual preparation for group presentation |
| presentation |
| Analysis of accuracy requirements for survey projects – exercise |
| Production of specification for survey projects – exercise |
| **Assignment 3: Accuracy Requirements and Specification** |
| Report containing analysis of accuracy requirements and specification for three different survey projects |
| Review of unit and assignment feedback |

## Assessment

Evidence for this unit can be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments.

There are many suitable forms of assessment that could be used. Some example assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable.

Some criteria can be assessed directly by the tutor during practical activities. If this approach is used, suitable evidence would be observation records or witness statements. Guidance on the use of these is provided on the Edexcel website.

The structure of the unit suggests that the grading criteria could be addressed fully by using three assignments. The first of these would cover P1, P2 and M1, the second would cover P3, P4, M2 and D1 and the third P5, P6, M3 and D2.

To achieve a pass grade learners must meet the six pass criteria listed in the grading grid.

For P1, learners must explain the principles of optics related to survey instruments and measurements. They must state and illustrate the laws of reflection and refraction of rays of light in relation to mirrors, prisms and lenses. Evidence could be, for example, in the form of a presentation, a report or through oral questioning supported by images, formulae and calculations as appropriate.

For P2, learners must describe the principles of electromagnetic waves related to survey measurements. They must be able to demonstrate an understanding of the relationship between speed, wavelength and frequency of electromagnetic waves, the differing properties of light at different wavelengths and the relevance of such properties in surveying. Examples of suitable evidencing approaches are as for P1.

For P3, learners must discuss systematic errors in surveying instruments. They must understand that all instruments have imperfections which affect the measurement process, know the errors likely to be found in the instruments mentioned and understand that calibration is the process by which instruments are checked for imperfections. Examples of suitable evidencing approaches are as for P1.

For P4, learners must explain the need for systematic calibration of surveying instruments. Examples of suitable evidencing approaches are as for P1.

For P5, learners must select the appropriate surveying procedures for three different surveys. They must demonstrate an understanding of the principle that survey results can be improved by choosing suitable survey methods and explain the procedures. Examples of suitable evidencing approaches are as for P1.

For P6, learners must use the selected procedures to perform surveys, including addressing systematic errors in the three situations selected for P5.

To achieve a merit grade learners must meet all of the pass grade criteria and the three merit grade criteria.

For M1, learners must explain how refraction of electromagnetic waves through the atmosphere affects survey measurements. They must understand that light does not travel in the atmosphere in straight lines or with constant speed and explain the significance of this in angle and distance measurement. Examples of suitable evidencing approaches are as for P1.

For M2, learners must perform systematic checks and adjustments of instruments such as levels and theodolites. They must quantify the errors where appropriate. Evidence should be provided by observation of practical activity supported by observation records and/or witness statements.

For M3, learners must carry out fieldwork and numerical procedures to minimise or eliminate systematic errors. Evidence should build on that for P5, P6 and, where appropriate, M2.

To achieve a distinction grade learners must meet all of the pass and merit grade criteria and the two distinction grade criteria.

For D1, learners must produce specifications to meet required accuracies. They must specify suitable instruments and procedures to meet the accuracy requirements of a variety of survey projects. Examples of suitable evidencing approaches are as for M1.

For D2, learners must justify the selected methods used to reduce and/or eliminate error in terms of the efficiency and accuracy of each. Evidencing approaches are as for M2.

### Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, M1 | The Science of Surveying Instruments and Measurements | Your local library is holding an exhibition on the science of instruments and you have volunteered to produce a poster on the science of surveying instruments and measurements. | Poster. |
| P3, P4, M2, D1 | Calibrating Surveying Instruments | As a recently qualified surveyor you are training apprentices and have been asked to show them how to calibrate surveying equipment. | Witness statements. |
| P5, P6, M3, D2 | Accuracy Requirements And Specification | As a recently qualified surveyor you are carrying out three survey projects and have been asked to produce an analysis of accuracy requirements and a specification. | Report. |

## Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Construction and the Built Environment sector suite. This unit has particular links with the following unit titles in the Construction and the Built Environment suite:

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| | | Surveying in Construction and Civil Engineering |
| | | Setting Out Processes in Construction and Civil Engineering |
| | | Topographic Surveying in Construction and Civil Engineering |

This unit links to the following National Occupational Standards at Level 3:

- Spatial Data Management
- Surveying, Property and Maintenance.

## Essential resources

Since this unit includes practical work, centres will need a suitable range and quantity of equipment and suitable areas for carrying out realistic tasks safely.

As a minimum, the instruments required include tape measures, automatic optical levels, theodolites and total stations, but learners should be made aware of the other instruments mentioned in the unit content and, wherever possible, should have the opportunity to use them. Suitable ancillary equipment, such as spring balances, thermometers, barometers, staffs, tripods and ranging poles, will also be required. There should be sufficient instruments available so that during fieldwork teams can be kept to a reasonable size.

Simple optical experiments will need to be carried out to cover the requirements of learning outcome 1 and therefore a selection of mirrors, prisms and lenses will be required.

Health, safety and welfare issues must be considered at all times and risk assessments undertaken where necessary.

## Employer engagement and vocational contexts

Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners are given below:

- Learning and Skills Network – www.vocationallearning.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- The Royal Institution of Chartered Surveyors – www.rics.org
- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI University of Warwick) – www.warwick.ac.uk/wie/cei/

## Indicative reading for learners

### Textbooks

Bannister A and Baker R – *Solving Problems in Surveying, 2nd Edition* (Pearson Higher Education, 1994) ISBN 0582236444

Bannister A and Raymond S and Baker R – *Surveying, 7th Edition* (Pearson Higher Education, 1998) ISBN 0582302498

Irvine W and Maclennan F – *Surveying for Construction* (McGraw-Hill, 2005) ISBN 007711141

Johnson A – *Plane and Geodetic Surveying, 1st Edition* (Spon Press, 2004) ISBN 0415320046

Muskett J – *Site Surveying, 2nd Edition* (Blackwell Science, 1995) ISBN 0632038489

Uren J and Price W F – *Surveying for Engineers, 4th Edition* (Palgrave Macmillan, 2005) ISBN 1403920540

### Journals

*Civil Engineering Surveyor* – Institution of Civil Engineering Surveyors

*Geomatics World* – PV Publications

*RICS Construction Journal* – RICS

*RICS Land Journal* – RICS

### Websites

| | |
|---|---|
| www.bconstructive.co.uk | BConstructive |
| www.ciob.org.uk | Chartered Institute of Building |
| www.cskills.org | ConstructionSkills |
| www.cstt.org.uk | Chartered Surveyors Training Trust |
| www.ice.org.uk | Institution of Civil Engineers |
| www.ices.org.uk | Institution of Civil Engineering Surveyors |
| www.rics.org | Royal Institution of Chartered Surveyors |

## Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

| Skill | When learners are ... |
|---|---|
| **Independent enquirers** | identifying questions to ask, planning and carrying out research, analysing and evaluating information and supporting conclusions using reasoned arguments and evidence |
| **Team workers** | collaborating with others eg when doing practical work on optics |
| **Self-managers** | carrying out research into eg uses of optics in surveying instruments |
| **Effective participators** | contributing to group work eg researching applications of electromagnetic waves in surveying. |

## Functional Skills – Level 2

| Skill | When learners are ... |
|---|---|
| **ICT – Find and select information** | |
| Select and use a variety of sources of information independently for a complex task | researching, for example the use of optics in surveying instruments |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | researching, for example the use of optics in surveying instruments |
| **ICT – Develop, present and communicate information** | |
| Enter, develop and format information independently to suit its meaning and purpose including:<br>• text and tables<br>• images<br>• numbers<br>• records | producing specifications to meet required accuracies |
| Bring together information to suit content and purpose | producing specifications to meet required accuracies |
| Present information in ways that are fit for purpose and audience | producing specifications to meet required accuracies |
| Evaluate the selection and use of ICT tools and facilities used to present information | producing specifications to meet required accuracies |
| **Mathematics** | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | considering systematic errors for survey instruments<br>carrying out calculations for the connection of survey control to national grid |
| **English** | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | working in groups, for example researching the use of optics in surveying instruments |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | researching, for example application of electromagnetic waves in surveying. |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | |