Unit 27: Surveying Technology in Construction and Civil Engineering

NQF Level 3: **BTEC National**

Guided learning hours: 60

Unit abstract

Surveying involves the use of technology for measurement of the physical features of the earth's surface and the presentation of 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 of their potential errors is required.

This unit looks primarily at the nature of survey measurements, the errors inherent in the measurement systems and in the instruments used, and the best ways to reduce or eliminate these errors. It also introduces the learner 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 the effects of these on measurements. The survey instruments themselves have mechanical and electronic components which may also introduce errors through imperfect manufacture or wear and tear. The surveyor must have confidence in their own ability to check the instruments for errors, adjust these where appropriate, and use suitable fieldwork techniques to reduce or eliminate the potential errors.

Learning outcomes

On completion of this unit a learner should:

1 Understand the principles of optics and the electromagnetic spectrum as they relate to survey measurements

2 Understand the sources of systematic errors arising in survey measurements and carry out standard tests and adjustments

3 Be able to analyse the nature of survey measurements and specify suitable instruments and procedures for typical tasks.

Unit content

1 **Understand the principles of optics and the electromagnetic spectrum as they relate to survey measurements**

Optics: reflection; refraction; mirrors; lenses; prisms

Electromagnetic spectrum: properties of waves; atmospheric influences; application to distance measurement; application to remote sensing

2 **Understand the sources of systematic errors arising in survey measurements and carry out standard tests and adjustments**

Tapes: calibration

Theodolites: bubbles and optical plummets; horizontal and vertical collimation

Levels: collimation error

Electromagnetic distance management (EDM): collimation adjustment of modular instruments; scale and index errors

3 **Be able to analyse the nature of survey measurements and specify suitable instruments and procedures for typical tasks**

Linear measurement: slope; sag; temperature; tension

Levelling: refraction; curvature

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

Global Positioning System (GPS): differential GPS; multipath

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

Grading grid

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

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 state the principles of optics related to survey measurements P2 state the properties of the electromagnetic spectrum related to survey measurements	M1 explain how refraction of electromagnetic waves through the atmosphere affects survey measurements	
P3 appreciate the need for systematic calibration of surveying instruments P4 recognise systematic errors in surveying measurements	M2 select and carry out field checks and adjustments of instruments such as levels, theodolites and EDM	
P5 explain the procedures for best practice in survey measurements.	M3 select and carry out fieldwork and numerical procedures to minimise or remove systematic errors.	D1 analyse the accuracy requirements in surveying projects D2 produce specifications to meet required accuracies.

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 the use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse the learner. Visiting expert speakers could add to the relevance of the subject but, as mentioned above, this is essentially a practical unit and 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 errors in the measurement process (learning outcome 3).

The unit provides learners with opportunities to carry out realistic surveying tasks and produce high quality results. This unit is likely to be delivered later in the programme, since a 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 suitable 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 are provided with equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be strictly reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken prior to practical activities. Centres are advised to read the *Delivery approach* section on page 24, and *Annexe G: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

Assessment

Evidence for this unit may 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 employed. Some examples of possible 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. General guidance on the design of suitable assignments is available on page 19 of this specification.

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 may be fully addressed by using three assignments. The first of these would cover P1, P2 and M1, the second would cover P3, P4 and M2, and the third would cover P5, M3, D1 and D2.

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

For P1, learners must state the principles of optics related to survey measurements. They must state and illustrate the laws of reflection and refraction of rays of light in relation to mirrors, prisms and lenses. Evidence for this criterion could be provided, 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 state the properties of the electromagnetic spectrum related to survey measurements. They must be able to demonstrate an understanding of the relationship between speed, wavelength, and frequency of light; 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 appreciate the need for systematic calibration of 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 such imperfections. Examples of suitable evidencing approaches are as for P1.

For P4, learners must recognise systematic errors in surveying measurements. They must demonstrate an understanding of the sources of these errors in the various survey measurement processes mentioned in the content. Examples of suitable evidencing approaches are as for P1.

For P5, learners must explain the procedures for best practice in survey measurements. They must demonstrate an understanding of the principle that survey results can be improved by suitable choice of survey methods and explain the procedures. Examples of suitable evidencing approaches are as for P1.

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 be able to explain the significance of this in angle and distance measurement. Examples of suitable evidencing approaches are as for P1.

For M2, learners must select and carry out field checks and adjustments of instruments such as levels, theodolites and EDM. They must quantify the errors where appropriate. The evidence should be provided by observation of practical activity supported by observation records and/or witness statements.

For M3, learners must select and carry out fieldwork and numerical procedures to minimise or remove systematic errors. They must demonstrate that they are able to apply the procedures for best practice appropriately to scenarios devised by the tutor. Examples of suitable evidencing approaches are as for 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 analyse the accuracy requirements in surveying projects. They must make reasoned judgements about the accuracy requirements for typical survey projects such as control surveys, topographic surveys and construction work. Examples of suitable evidencing approaches are as for M1.

For D2, 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.

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

This unit provides the skills, knowledge and understanding of topographic surveying required for learners to progress onto more advanced surveying or geomatics courses or to work as land surveyors. The learning outcomes in this unit are closely linked with, for example, *Unit 10: Surveying in Construction and Civil Engineering*. The learner would also benefit from studying further practical surveying units such as *Unit 12: Setting Out Processes in Construction and Civil Engineering* or *Unit 28: Topographic Surveying in Construction and Civil Engineering*, together with similar units at Higher National and degree level.

This unit may have links to the Edexcel Level 3 Technical and Professional NVQs for Construction and the Built Environment. Updated information on this, and a summary mapping of the unit to the CIC Occupational Standards, is available from Edexcel. See *Annexe D: National Occupational Standards/mapping with NVQs*.

The unit provides opportunities to gain Level 3 skills in application of number and information and communication technology. Opportunities for satisfying requirements for Wider Curriculum Mapping are summarised in *Annexe F: Wider curriculum mapping*.

Essential resources

Since this unit includes work of a practical nature, centres will require not only a suitable range and quantity of equipment but also suitable areas for carrying out realistic tasks in safety.

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 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 down 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.

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, 5th Edition* (McGraw-Hill, 2005) ISBN 0077111141

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

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Application of number Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• carrying out fieldwork and numerical procedures to minimise or remove systematic errors; or • carrying out calculations for connection of survey control to National Grid.	N3.2 Use this information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportion c handling statistics d using formulae.
Information and communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• producing specifications to meet required accuracies.	ICT3.3 Present combined information such as text with image, text with number, image with number.