

UNIT 440 SITE SURVEYING

Lesson 1: Define linear surveying terminology

Suggested Teaching Time: 4 hours

Learning Outcome: Know how to use linear surveying equipment to produce drawings to scale

Topic	Suggested Teaching	Suggested Resources
Define linear surveying terminology (AC 1..2)	<ul style="list-style-type: none"> Learners will not be able to perform any surveying procedures until they understand the terms used by surveyors. The tutor must provide an incomplete glossary of the important terms and the learners should complete this during an interactive class discussion led by the tutor. Surveying drawings, photographs, other images and audio visual resources should be used to support the discussion. The terminology must include chainage, running measurements, offsets, tie lines, check lines, sloping ground measurements, linear measurements around obstructions, triangulation, trilateration, grid, intersection. A short formative test should be used to check student understanding of the terminology used. The tutor should correct any mistakes or misunderstandings and retest where appropriate, until all the class understand the terms well enough to proceed. 	<ul style="list-style-type: none"> Introduction to surveying: http://moodle.unitec.ac.nz/pluginfile.php/244789/mod_resource/content/1/Lecture%201.pdf Introduction to surveying equipment: http://www.tcd.ie/civileng/Staff/Brian.Caulfield/1E11/1E11_Lecture%201.pdf Levelling: http://www.levelling.uhi.ac.uk Levelling: http://www.tcd.ie/civileng/Staff/Brian.Caulfield/3A1/3A1%20Lecture%204.pdf Chainage: http://www.foresoft.com/Tutorials/CDS11.htm Linear measurements: http://www.fao.org/docrep/r7021e/r7021e07.htm#TopOfPage

UNIT 440 SITE SURVEYING

Lesson 2: Equipment used to complete linear surveys.

Suggested Teaching Time: 4 hours

Learning Outcome: Know how to use linear surveying equipment to produce drawings to scale

Topic	Suggested Teaching	Suggested Resources
Equipment used to complete linear surveys (AC 1.2)	<ul style="list-style-type: none"> • It is best if the learners have access to actual surveying equipment (which is needed for the practical work to follow in any case) but photographs, other images and video resources would suffice where access to the equipment is limited. • The equipment must include tapes, bands, ranging poles, chains, electronic distance measurement (EDM) instruments. • The tutor should lead a whole-class discussion on the purpose of each piece of equipment and how each is used. Health and safety issues should form part of the discussion although the hazards involved here are few and constitute a low risk. • A short formative test should be used to check student understanding of the purpose and use of the equipment. The tutor should correct any mistakes or misunderstandings and retest where appropriate, until all the class understand well enough to proceed. 	<p>Books: Irvine, William, and Maclennan, Finlay, <i>Surveying for Construction</i>, 5th edition, McGraw-Hill HE (2005), ISBN: 0077111141</p> <p>Video: survtechsolutions.com/students/videos.htm constructionsite.org.uk/index.php http://landsurveyorsunited.com/video/video/listTagged?tag=tutorial http://www.fao.org/docrep/r7021e/r7021e02.htm</p> <p>Websites: www.rics.org.uk www.levelling.uhi.ac.uk www.tcd.ie/civileng/Staff/BrianCaulfield</p>

UNIT 440 SITE SURVEYING

Lesson 3: Perform linear surveys

Suggested Teaching Time: 4 hours

Learning Outcome: Be able to use linear surveying equipment to produce drawings to scale

Topic	Suggested Teaching	Suggested Resources
Perform linear surveys (AC 2.1)	<ul style="list-style-type: none"> It is a requirement of this learning outcome that the learners perform an actual linear survey. It is not sufficient for the learners to use secondary data; they must use the equipment and collect the data using that equipment. The learners should be given the opportunity to select the equipment needed. The tutor should check that this is correct before the learners are allowed to use the equipment. The learners will need to handle the equipment and it therefore follows that the learners should be provided with any manual handling training required beforehand. A risk assessment must be completed by the tutor before any procedures are undertaken. The learners must comply with this. The procedures used to undertake linear surveys must be explained by the tutor, and time given for practice. The tutor should observe the learners working and be prepared to complete witness statements concerning their individual performance. In particular, learners should not be allowed to finish before they have taken all the relevant measurements. 	<p>Books: Irvine, William, and Maclennan, Finlay, <i>Surveying for Construction</i>, 5th edition, McGraw-Hill HE (2005), ISBN: 0077111141</p> <p>Video: survtechsolutions.com/students/videos.htm constructionsite.org.uk/index.php</p> <p>Websites: www.rics.org.uk www.tcd.ie/civileng/Staff/BrianCaulfield www.newages.com/samplechapter/001033.pdf www.fig.net/commission4/iho/M-13_Chapter_6.pdf</p>

UNIT 440 SITE SURVEYING

Lesson 4: Produce plan drawings from practical linear surveys

Suggested Teaching Time: 4 hours

Learning Outcome: Be able to use linear surveying equipment to produce drawings to scale

Topic	Suggested Teaching	Suggested Resources
Produce plan drawings from practical linear surveys (AC 2.2)	<ul style="list-style-type: none"> Learners must produce the drawings from data they have collected themselves in earlier lessons. They may do so using either traditional manual drafting skills or CAD. There is no time in this unit to teach CAD. It is assumed that learners who choose to use CAD have prior experience of using CAD effectively. The manual drafting skills required are not advanced and can be incorporated here. Standard drawing conventions should be used and learners should comply with BS1192:2007 or similar. The important thing is however accuracy, rather than rigid compliance with drawing standards and conventions. Learners should have the opportunity to scrutinise plan drawings from linear surveys alongside the data that was used to create the drawings. The important thing is, of course, practice. Tutors should circulate, amending diagrams as they go. 	<p>Books: Irvine, William, and MacLennan, Finlay, <i>Surveying for Construction</i>, 5th edition, McGraw-Hill HE (2005), ISBN: 0077111141</p> <p>Websites: www.cadtutor.net/tutorials/autocad/drawing-objects.php (CAD) http://tinyurl.com/mq2oet5 (Linear surveys)</p> <p>Drawing equipment Traditional: pens, pencils, scale rules, eraser, adjustable set square, parallel motion drawing board, drafting tape CAD: CPU, monitor, keyboard, mouse, printer, network, software as appropriate.</p>

UNIT 440 SITE SURVEYING

Lesson 5: Levelling surveying terminology

Suggested Teaching Time:

Learning Outcome: Know how to use levelling instruments

Topic	Suggested Teaching	Suggested Resources
Levelling surveying terminology (AC 3.1)	<ul style="list-style-type: none"> Learners will not be able to perform any levelling procedures until they understand the terms used by surveyors. The tutor must provide an incomplete glossary of the important terms and the learners should complete this during an interactive class discussion led by the tutor. Surveying drawings, photographs, other images and audio visual resources should be used to support the discussion. The terminology must include back sight, fore sight, intermediate sight, datum, ordnance bench mark (OBM), temporary bench mark (TBM), height of collimation, rise and fall, flying levels A short formative test should be used to check student understanding of the terminology used. The tutor should correct any mistakes or misunderstandings and retest where appropriate, until all the class understand the terms well enough to proceed. 	<p>Books: Irvine, William, and Maclennan, Finlay, <i>Surveying for Construction</i>, 5th edition, McGraw-Hill HE (2005), ISBN: 0077111141 Muskett, John, <i>Site Surveying</i>, 2nd edition, Wiley-Blackwell (1995), ISBN: 0632038489</p> <p>Video: survtechsolutions.com/students/videos.htm constructionsite.org.uk/index.php</p> <p>Websites: www.rics.org.uk www.levelling.uhi.ac.uk www.tcd.ie/civileng/Staff/BrianCaulfield http://tinyurl.com/m3hpuh8</p>

UNIT 440 SITE SURVEYING

Lesson 6: Equipment used to complete a level survey

Suggested Teaching Time:

Learning Outcome: Know how to use levelling instruments

Topic	Suggested Teaching	Suggested Resources
Equipment used to complete a level survey (AC 3.2)	<ul style="list-style-type: none"> • It is best if the learners have access to actual levelling equipment (which is needed for the practical work to follow in any case) but photographs, other images and video resources would suffice where access to the equipment is limited. • The equipment must include automatic levels, tilting levels and rotating lasers. • The tutor should lead a whole-class discussion on the purpose of each piece of equipment and how each is used. Health and safety issues should form part of the discussion although the hazards involved here are few and constitute a relatively low risk. • A short formative test should be used to check student understanding of the purpose and use of the levelling equipment. The tutor should correct any mistakes or misunderstandings and retest where appropriate, until all the class understand well enough to proceed. 	<p>Books: Irvine, William, and Maclennan, Finlay, <i>Surveying for Construction</i>, 5th edition, McGraw-Hill HE (2005), ISBN: 0077111141 Muskett, John, <i>Site Surveying</i>, 2nd edition, Wiley-Blackwell (1995), ISBN: 0632038489</p> <p>Video: survtechsolutions.com/students/videos.htm constructionsite.org.uk/index.php</p> <p>Websites: www.rics.org.uk www.levelling.uhi.ac.uk www.tcd.ie/civileng/Staff/BrianCaulfield http://tinyurl.com/q8tzrb3</p>

UNIT 440 SITE SURVEYING

Lesson 7: Accuracy checks for levelling surveys

Suggested Teaching Time: 4 hours

Learning Outcome: Know how to use levelling instruments

Topic	Suggested Teaching	Suggested Resources
Accuracy checks for levelling surveys (AC 3.3)	<ul style="list-style-type: none"> The tutor must explain how errors can creep into levelling exercises at every stage and then differentiate between common errors, those due to the relationship between scale of plan and measurement accuracy and those due to temporary and permanent adjustments omitted from the range. The learners must have the opportunity to scrutinise completed levelling exercises, including all relevant checks for accuracy, and should be capable of answering questions on what they see. Individual learner research should be undertaken by accessing the web addresses shown on the right. A whole-class, tutor-led discussion should take place on the scale of the overall errors, and the consequences of such errors, if the appropriate checks are not made on a consistent basis. 	<p>Books: Muskett, John, <i>Site Surveying</i>, 2nd edition, Wiley-Blackwell (1995), ISBN: 0632038489</p> <p>Websites: http://tinyurl.com/my7ha4t (Errors) http://tinyurl.com/lsjbfq2 (Topographical surveying – direct levelling) http://tinyurl.com/l8glees (Differential levelling survey specifications)</p>

UNIT 440 SITE SURVEYING

Lesson 8: Complete levelling surveys using booking methods

Suggested Teaching Time:

Learning Outcome: Be able to use levelling instruments

Topic	Suggested Teaching	Suggested Resources
<p>Complete levelling surveys using booking methods (AC 4.1)</p>	<ul style="list-style-type: none"> • It is a requirement of this learning outcome that the learners perform an actual levelling exercise. It is not sufficient for the learners to use secondary data; they must use the equipment and collect the data using that equipment. • The learners should be given the opportunity to select the equipment needed for the practical task. The tutor should check that this is correct before the learners are allowed to use the equipment. A risk assessment must be completed before any procedures are undertaken. • The procedures used to undertake levelling exercises must be explained by the tutor, and time given for the learners to practise. • The tutor must emphasise that there are two methods that can be used (rise and fall and height of collimation) and that either method will do the job, but learners should be taught both. They should be given time to discuss the differences between the two. • The class should be split into two groups, with one group using the rise and fall method to reduce the levels and the other using the height of collimation method. Each group should then compare their answers, firstly within the group, and then with the other group. A tutor-led discussion should follow regarding the use of each method and the accuracy of the answers. 	<p>Books: Muskett, John, <i>Site Surveying</i>, 2nd edition, Wiley-Blackwell (1995), ISBN: 0632038489</p> <p>Video: survtechsolutions.com/students/videos.htm constructionsite.org.uk/index.php</p> <p>Websites: http://tinyurl.com/onhffhl http://tinyurl.com/muz4nj6 (Levelling example) http://tinyurl.com/m9y415s (How to use an engineering level) http://tinyurl.com/mukq879 (Taking levels)</p>

UNIT 440 SITE SURVEYING

Lesson 9: Produce section drawings from completed levelling surveys

Suggested Teaching Time: 8 hours

Learning Outcome: Be able to use levelling equipment

Topic	Suggested Teaching	Suggested Resources
<p>Produce section drawings from completed levelling surveys (AC 4.2)</p>	<ul style="list-style-type: none"> Learners must produce a section drawing of either a longitudinal section through a proposed drainage run, or cross-sectional details of a field land survey. Either of the above is acceptable. The decision concerning which to do must have been made before the work undertaken in Lesson 8 was undertaken. The drawings must be completed from the data collected in Lesson 8. It is not acceptable to use other data. The tutor will need to provide instruction in how to set out levelling drawings and the learners should have time to practise this skill. High levels of drawing presentation are not as important as accuracy. Practice sessions may use data from levelling exercises not undertaken by the learners. The learners may use either manual drafting techniques or CAD to produce their drawings. If they choose to use the latter it is anticipated that they already have skills in this area. There is not enough spare time in the unit to teach CAD within the unit. A careful record should be kept of any calculations required and these should be checked by the tutor as the drawings are created, as far as time allows. Incorrect calculations lead to incorrect drawings of course. 	<p>Websites: www.rics.org.uk www.levelling.uhi.ac.uk http://tinyurl.com/mrmc5u4 (Cross sections and contours) http://tinyurl.com/oknpun9 (How to produce drawings from linear and levelling surveys)</p>

UNIT 440 SITE SURVEYING

Lesson 10: Angular surveying terminology and equipment used to measure angles

Suggested Teaching Time: 4 hours

Learning Outcome: Know how to use angular measuring instruments

Topic	Suggested Teaching	Suggested Resources
<p>Angular surveying terminology and equipment used to measure angles (AC 5.1 and 5.2)</p>	<ul style="list-style-type: none"> • Explain the difference between horizontal and vertical angles and stress that the whole-circle bearing (WCB) of a line is the horizontal angle measured clockwise from the north. It is important that this is understood clearly from the outset. Annotated drawings of completed traverses will help the learner. • Learners should be introduced to simple calculations to determine WCBs from coordinates and angles of deflection. The tutor should check these and amend the answers where necessary. • Learners should be introduced to theodolites and the tutor should demonstrate their use. The learners need not use the theodolites at this stage, but they should be aware of what theodolites measure, and how they differ from levels, and should be able to differentiate between optical and electronic theodolites. • At this early stage the applied learning would involve identifying the different types of theodolite, and possibly setting one up for use, using guidance from a users' manual. • Calculations to determine WCBs, as in 2 above, will help to embed this important concept. 	<p>Books: Whitelaw, John, <i>Surveying: as Practised by Civil Engineers and Surveyors</i>, Adamant Media Corporation (2005), ISBN: 0543774929</p> <p>Websites: http://tinyurl.com/loahfzh http://tinyurl.com/nc6r2so (Terminologies in angles)</p>

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Lesson 11: Errors which can occur when recording angles and how to reduce such errors **Suggested Teaching Time:** 12 hours

Learning Outcome: Know how to use angular measuring instruments and be able to use angular measuring instruments

Topic	Suggested Teaching	Suggested Resources
<p>Errors which can occur when recording angles and how to reduce such errors (AC 5.3 and 5.4)</p> <p>Measure horizontal angles (AC 6.1)</p>	<ul style="list-style-type: none"> • Tutor should demonstrate the face left/face right (FL/FR) booking procedure used when recording horizontal angles. • Learners should watch the video 'How to measure a horizontal angle' as often as is necessary and then set up the theodolite correctly. Tutors must correct any mistakes made at this stage. • Learners should measure horizontal angles using the face right/face left method. • If different learners attempt to make the same measurements then the readings taken can be compared within the group and reasons for any differences discussed. • The tutor must then introduce the concept of the errors that can occur when measuring horizontal angles. • The learners should be split into small groups to research different issues associated with errors. Topics could include common errors, principles of good intersection of lines of sight, link between increasing distance and angular error and how errors may be reduced, including error analysis, least square method and the Bowditch method of correction of closure error. • Each group should make a short presentation to the rest of the class and be prepared to answer questions. 	<p>Books: Schofield, W., and Breach, M., <i>Engineering Surveying</i>, 6th Edition, Butterworth Heinemann (2007), ISBN-10: 075066949, ISBN-13: 978-0750669498</p> <p>Video: How to measure a horizontal angle http://tinyurl.com/mdmf4fv</p> <p>Websites: http://tinyurl.com/loahfzh http://tinyurl.com/n6yrwan (Error analyses)</p>

UNIT 440 SITE SURVEYING

Lesson 12: Calculate height and distances from recorded angular measurements using trigonometry. **Suggested Teaching Time:**

Learning Outcome: Be able to use angular measuring instruments

Topic	Suggested Teaching	Suggested Resources
<p>Calculate height and distances from recorded angular measurements using trigonometry. (AC 6.2)</p>	<ul style="list-style-type: none"> The tutor must revise and extend the learners' understanding of the basic trigonometric ratios, Pythagoras' theorem, the sine rule and the cosine rule. The learners should practise these calculations, and the tutor should correct those calculations where necessary, until learners are competent to use each method. It is important that learners understand that the Pythagoras' theorem, and the common ratios sine, cosine and tangent, apply to right-angled triangles only, but the sine rule and the cosine rule apply to all triangles. The learners should research the rules underpinning the sine rule and the cosine rule to develop an understanding of the information required to use each, and when and where the use of each is appropriate. In ideal situations, the learners should use readings taken in Lesson 11 to determine distances. If these can then be checked using a tape or an EDM then a useful check can be made of the results obtained from the calculations. Secondary data can be used to determine heights from vertical angles. It should be made clear to learners that the same mathematical techniques apply in both cases. 	<p>Books: Schofield, W., and Breach, M., <i>Engineering Surveying</i>, 6th Edition, Butterworth Heinemann (2007), ISBN-10: 075066949, ISBN-13: 978-0750669498</p> <p>Video: How to measure a horizontal angle http://tinyurl.com/mdmf4fv</p> <p>Websites: http://tinyurl.com/loahfzh http://tinyurl.com/n6yrwan (Error analyses)</p>

UNIT 440 SITE SURVEYING

Lesson 13: Principles of setting out

Suggested Teaching Time:

Learning Outcome: Understand the principles of setting out construction projects

Topic	Suggested Teaching	Suggested Resources
Principles of setting out (AC 7.1, 7.2 and 7.3)	<ul style="list-style-type: none"> The tutor should define the terms used in the range including 3:4:5 method, checking diagonals, corner profiles, transfer of datum, set out pegs, sight rails. An incomplete hand-out would be useful for the learners to complete as the tutor defines the terms. The 3:4:5 method, and the checking of diagonals, should be emphasised as practical uses of Pythagoras' theorem. Theodolites are to be used but the class should discuss how the same outcome could be achieved by using either a site square or a builder's square, and advantages and disadvantages should be compared. A practical exercise should be undertaken by the learners. This should take the form of a small to medium-size rectangular building, or a building made up of, at most, four rectangles. The learners must set out the outline of the building from information provided, including the position of the baseline, using a theodolite. The theodolites should be used to set out right-angles at the corners, with cords nailed to the tops of the corner posts or pegs to define the outline of the building, and a line of white powder (such as dry lime) placed on the ground to follow the cords. Check the right-angles for 'squareness' by measuring diagonals. Learners should discuss the importance of establishing straight lines between corner posts and understand how to use ranging rods, sight rails and boning rods. 	<p>Books: Schofield, W., and Breach, M., <i>Engineering Surveying</i>, 6th Edition, Butterworth Heinemann (2007), ISBN-10: 075066949, ISBN-13: 978-0750669498</p> <p>Websites: Setting out simple buildings http://tinyurl.com/maehd77 Setting out a building http://tinyurl.com/19a4sb7 How to set out on site http://tinyurl.com/ofmwzay</p> <p>Activity: Pack 7: Setting out surveys http://tinyurl.com/mmc5pu6</p>

UNIT 440 SITE SURVEYING

Lesson 13: Principles of setting out (continued)

Suggested Teaching Time:

Learning Outcome: Understand the principles of setting out construction projects

Topic	Suggested Teaching	Suggested Resources
Principles of setting out (continued) (AC 7.1, 7.2 and 7.3)	<ul style="list-style-type: none"> The tutor should revise the methods used to transfer a datum and set out pegs and sight rails. The tutor should explain that drainage is laid in trenches similar to those cut for foundations, but that drains must be laid to a specified gradient or fall. The learners must be shown the controls used and the importance attached to using the tops of the horizontal sight rails (fixed to vertical travellers or boning rods) to set the gradient and provide a line for cutting the base of the excavation to the required depth. The tutor must stress that there must be a minimum of three sight rails and that no two sight rails should be more than 15 m apart. A practical exercise should be undertaken by the learners. This should take the form of an existing trench with an approximately horizontal base, not yet cut to the required gradient. The learners must set out the gradient of the trench from information provided, using a theodolite and sight rails. 	<p>Books: Schofield, W., and Breach, M., <i>Engineering Surveying</i>, 6th Edition, Butterworth Heinemann (2007), ISBN-10: 075066949, ISBN-13: 978-0750669498</p> <p>Websites: Setting out simple buildings http://tinyurl.com/maehd77 Setting out a building http://tinyurl.com/19a4sb7 How to set out on site http://tinyurl.com/ofmwzay</p> <p>Activity: Pack 7: Setting out surveys http://tinyurl.com/mmc5pu6</p>