UNIVERSITY OF WARWICK

Proposal Form for New or Revised Modules (MA1 - version 7 - April 2014)

Approval information	
Approval Type	☐ New module ☒ Revised module ☐ Discontinue module
Date of Introduction/Change	01/10/2018
If new, does this module replace another? If so, enter module code and title:	
If revised/discontinued, please outline the rationale for the changes:	Updated Teaching and Learning Hours, introducing tutorial sessions for advice, support and revision. Updates to bibliography. Minor amendments to learning outcomes and their assessment methods. Rationalisation of syllabus description (without changing content). Change in assessment: Removing the second class test and reducing the number of examinations from two to one whilst introducing a coursework assignment (40% of the module). The weighting on the remaining examination will be 50%, and the first class test is retained for 10%.
Confirmation that affected departments have been consulted:	Changes were made in consultations between the School of Engineering and WMG.

Module Summary	
1. Module Code (if known)	ES95A
2. Module Title	Underground Construction Methods
3a. Lead department:	School of Engineering (100%)
3b. Teaching Split (if known):	100% Engineering
4. Name of module leader	Dr Alan Bloodworth
5. Level	UG: ☐ Level 4 (Certificate) ☐ Level 5 (Intermediate) ☐ Level 6 (Honours) PG: ☒ Level 7 (Masters) ☐ Level 8 (Doctoral) See Guidance Notes for relationship to years of study

Module Summary	
6. Credit value(s) (CATS)	30
7. Principal Module Aims	This module establishes a framework for the remainder of the MSc course so that students recognise the diversity and complexity of underground excavations and associated works. The subject is first placed within a historical context and then current issues and future direction of the industry are discussed. The module provides a detailed consideration of the techniques that may be employed in the excavation of underground space and the circumstances in which they may be successfully utilised. Support of underground openings is dependent on ground conditions, excavation size and shape and excavation method employed; this module therefore provides guidance for support selection. Excavations require services such as ventilation, power, transportation of materials and personnel etc. Students will therefore consider how a project should be organised to provide the necessary services. The module also provides theoretical background to the practical task of ensuring the underground excavation is accurately positioned. Consideration is also given to the prediction and monitoring of surface displacement above underground openings which forms an important restriction on urban sub-surface works.
8. Principal Learning Outcomes	By the end of the module students should be able to: • Evaluate a project specification and ground conditions to select appropriate methods for excavation and support. • Critique concepts for the future use of underground space and innovative methods of construction. • Systematically describe and classify underground works according to type, use and construction methods. • Evaluate current technical challenges or issues in tunnelling. • Predict and monitor surface movements resulting from underground excavations and evaluate their impact on surface structures.
9. Timetabled Teaching Activities (summary)	60 hrs lectures, 8 hrs tutorials and a 2 hr laboratory. **Total of 70 hours.**
10. Departmental Web-link	http://www2.warwick.ac.uk/fac/sci/eng/eso/modules/year4/es95a/

Module Summary	
11. Other essential notes	The module is taught in two five-day intensive blocks (excluding Wednesday afternoons). Pre reading is required before the module with an unseen written test during the first week of the module. A feedback session is included on this test. Advice and feedback hours are available for answering questions on the lecture material. The module is available as a standalone CPD course for external attendees.
12. Assessment methods (summary)	1hr Written test 10% Coursework assignment (40 pages) 40% 3hr Written examination 50%

For use by Strategic Planning and Analytics Office only - Do not fill in this section

Level	JACS3 Code	Teaching Split
		If not provided in 3b above

External Credit Level		Scheme	

Module Context				
13. Please list all departments involved in the teaching of this module. If taught by more than one department, please indicate percentage split.				
School of Engineering, 100%				
14. Availability of module				
Degree Code	**Title**	**Study Year**	**C/OC/ A/B/C**	**Credits**
H214	MSc Tunnelling and Underground Space FT	M1	C	30
H214	MSc Tunnelling and Underground Space PT	M1	C	30
15. Minimum number of registered students required for module to run				
1				
16. Pre- and Post-Requisite Modules				
None				

Module Content and Teaching	
17. Teaching and Learning Activities *(totals for module – please see guidance)*	
Module duration (weeks)	1
Lectures	60 hours
Seminars	
Tutorials	8 hours (6hrs advice and feedback and 2hrs revision)
Project Supervision	
Demonstration	
Practical Class/Workshops	2 hours
Supervised time in studio/workshop	
Fieldwork	
External visits	
Work based learning	
Placement	
Year abroad	
Other activity *(please describe): e.g. distance-learning, intensive weekend teaching etc.*	230 hours of guided independent learning

Module Content and Teaching		
18. Assessment Method (Standard)		
Type of assessment	**Length**	**% weighting**
Written Test	1 hr	10%
Written Examinations	3 hrs	50%
Practical Examinations		
Assessed essays/coursework	Coursework Assignment 40 pages	40%
18a. Final chronological assessment *(please see guidance*)	Examination	

19. Methods for providing feedback on assessment.

In Class Written Test: Feedback session for the whole class after test completed.
Coursework assignment: Individual written feedback
Examination: publication of recent past examination papers and model solutions or mock paper and solutions where past papers do not exist. Cohort level feedback on examinations.

20. Outline Syllabus

Fundamental definitions: the vocabulary of tunnelling
Current and future uses of underground space
Historical development of underground tunnels and space
Principles of ground / structure interaction
Selecting an appropriate tunnelling technique for the prevailing ground conditions (cost, time, settlement and final functional use of the underground space).
Development of tunnelling technology
Traditional excavation methods: Hand mining; drill and blast
Mechanised excavation techniques: TBMs; Roadheaders
Sequential excavation methods: NATM and SCL
Plant requirements and site organisation in support of tunnelling operations
Mini-tunnel excavation: Microtunnelling, pipe jacking, directional drilling
Tunnel lining construction in soft ground and rock
Shaft construction methods
Ground improvement techniques (dewatering, grouting, freezing etc.)
Soil conditioning in TBM tunnelling
Surveying techniques and strategies; sub-surface and surface surveys, basic principles of tunnel alignment control
Instrumentation for ground and structure movement monitoring
Analysis and interpretation of monitoring data
Use of observational techniques; control of sequential excavation method; Control techniques for TBMs

Module Content and Teaching

21. Illustrative Bibliography

Chapman, D., Metje, N. and Stärk, A. 2010. *Introduction to Tunnel Construction*. London: Taylor & Francis. Available as an e-book, see http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2582697

Maidl, B., Herrenknecht, M., Maidl, U. and Wehrmayer, G. 2012. *Mechanised Shield Tunnelling (2nd ed.)*. Berlin: Ernst & Sohn. Available as an e-book, see http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb3030836

Maidl, B., Schmid, L. et al. 2008. *Hardrock Tunnel Boring Machines*. Berlin: Ernst & Sohn. http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2252648

Tatiya, R. 2005. *Civil Excavations and Tunnelling – a Practical Guide*. London: Thomas Telford. Available as an e-book, see http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2489649

Mackenzie, C.N.P. 2014. *Traditional Timbering in Soft Ground Tunnelling - a Historical Review*. London: British Tunnelling Society.

Barton, Nick R. 2000. *TBM Tunnelling in Jointed and Faulted Rock*. Rotterdam: Balkema. http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2325002

West, G. 2005. *Innovation and the Rise of the Tunnelling Industry*. Cambridge University Press. http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2325001

Thomas, A. 2009. *Sprayed Concrete Lined Tunnels – an Introduction*. New York: Taylor and Francis. http://encore.lib.warwick.ac.uk/iii/encore/record/C__Rb2325323

Schofield, W. and Breach, M. 2007. Engineering Surveying (Chapter 13 Underground Surveying). Abingdon, Oxon: Spon Press.

22. Learning outcomes

Successful completion of the module leads to the learning outcomes. The learning outcomes identify the knowledge, skills and attributes developed by the module.

Learning Outcomes should be presented in the format "By the end of the module students should be able to..." using the table at the end of the module approval form:

Resources

23. List any additional requirements and indicate the outcome of any discussions about these.

N/A

Approval	
24. Module leader's signature	Dr Alan Bloodworth
25. Date of approval	25 April 2018
26. Name of Approving Committee (include minute reference if applicable)	School of Engineering and WMG Course and Module Approval Committee (CMAC), Minute 263-17/18
27. Chair of Committee's signature	Professor Gillian Cooke
28. Head of Department(s) signature	Professor David Towers

Examination Information		
A1. Name of examiner (if different from module leader)		
A2. Indicate all available methods of assessment in the table below		
% Examined	**% Assessed by other methods**	**Length of examination paper**
50	**10% 1 hr Written test 40% Coursework assignment (40 pages)**	**3hr**
A3. Will this module be examined together with any other module (sectioned paper)? If so, please give details below.		
No		
A4. How many papers will the module be examined by?	☒ 1 paper	☐ 2 papers
A5. When would you wish the exam take place (e.g. Jan, April, Summer)?	**Jan**	
A6. Is reading time required?	☐ Yes	☒ No
A7. Please specify any special exam timetable arrangements.		
None		
A8. Stationery requirements		
No. of Answer books?	**2**	
Graph paper?	**Yes**	
Calculator?	**Yes**	
Any other special stationery requirements (e.g. Data books, tables etc)?	**Datasheet**	
A9. Type of examination paper		
Seen?	☐ Yes	☒ No
Open Book?	☐ Yes	☒ No
Restricted?	☐ Yes	☒ No

Examination Information	
If restricted, please provide a list of permitted texts:	

LEARNING OUTCOMES		
(By the end of the module the student should be able to....)	**Which teaching and learning methods enable students to achieve this learning outcome? (reference activities in section 17)**	**Which summative assessment method(s) will measure the achievement of this learning outcome? (reference activities in section 18)**
Evaluate a project specification and ground conditions to select appropriate methods for excavation and support.	Lectures, case studies	Coursework assignment, Written examination
Critique concepts for the future use of underground space and innovative methods of construction.	Lectures	Written examination
Systematically describe and classify underground works according to type, use and construction methods.	Lectures, case studies	Written Test, Written examination
Evaluate current technical challenges or issues in tunnelling.	Guest lectures and case studies	Written Test, Written examination
Predict and monitor surface movements resulting from underground excavations and evaluate their impact on surface structures.	Lectures, case studies	Coursework assignment, Written examination