THE UNIVERSITY OF MANCHESTER
Unit Specification

1. GENERAL INFORMATION

Title	Explosion Engineering
Unit code	MACE 41001
Credit rating	15
Level	MSc and 4th year MEng
Pre-requisite units	2nd yr level solid mechanics
Co-requisite units	
School responsible	Mechanical, Aerospace & Civil Engineering
Member of staff responsible	Dr Q.M. Li

2. AIMS

The unit aims to:

To equip the students with the means of quantitatively assessing the effects of explosions in air and water and the response of structures to explosive loading. To familiarise students with industrial applications of explosion engineering.

3. BRIEF DESCRIPTION OF THE UNIT

Outline syllabus:

Nature and Physics of Explosions: detonation, burning and deflagrations; commercial explosives and energetic materials; hydrocarbon explosions, vapour cloud and dust explosions; detonation-metal interaction; equations of state, Hugoniot equation, Grüneisen parameter, modelling of explosive detonation.
Dynamic Deformation and Fracture: 3D elastic stress waves, Rayleigh waves, earthquakes; modelling of fracture, spalling and fragmentation; high energy rate processes; explosive forming, cutting, welding, shaped charges, shock-wave focusing.
Explosions in Air: TNT equivalence and scaling laws; blast shock waves (features, +ve and –ve phases); side-on and normally reflected pressures; other effects, ground reflections, Mach stems, reflections at any angle.
Structural Response Method: internal and external blast loading on structures; single DoF approximation and equivalent single DoF method; impulsive/dynamic/quasi-static behaviour and iso-damage curves (P-I diagram); damage criteria/curves for real structures and humans; containment vessels.
Explosions in Water: primary shock, bubble pulse, resonance with bubbles, effects on structures and sea users, critical panel design, hydrodynamic forces.
Project: a selection of explosion engineering project

4. INTENDED LEARNING OUTCOMES
- GENERAL LEARNING OUTCOMES:

Category of outcome	*Students should/will (please delete as appropriate) be able to:*
Knowledge and understanding Demonstrate knowledge and understanding of essential facts,	Understand explosion process, explosion loading characteristics, explosion effects on materials and structures

concepts, theories and principles and underpinning science and mathematics. An appreciation of the wider multidisciplinary engineering context, including the social, environmental, ethical, economic and commercial considerations .	
Intellectual skills Apply quantitative science and engineering tools to the analysis of problems. Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.	• Use scaling laws in engineering problems • Simplify complex loadings into simple expressions, which keeps their key characteristics • Identify differences between quasi-static behaviours of materials and structures and their dynamic behaviours at high strain rates and high pressures • Classify explosives according to their power and applications • Determine equivalent TNT and scaled distance • Calculate terminal velocity in explosive-metal interaction • Calculate free air blast shock wave parameters and blast pressure applied on structures • Use single degree of freedom (SDoF) method to determine structural responses under blast loading • Use Pressure-Impulse diagram to design and assess structures
Practical skills Practical engineering skills in laboratories and workshops; in industry through supervised work experience; in individual and group project work; in design work; and in computer software in design, analysis and control. Group working in a major project is expected.	• Use design manuals and charts to predict blast load • Experience the detonation, small scale blast and its effects • Understand the methods and techniques of high energy rate processing using explosion • Enhance the practical application of explosion engineering through project
Transferable skills and personal qualities Includes problem solving, communication, and working with others, the effective use of general IT and information retrieval skills. Self-learning skills as the foundation for lifelong learning/CPD.	• Understand assumptions associated with formulae and charts • Apply explosion engineering method in blast loading identification and structural design • Develop capabilities to extend the learned methods to other applications involving blast loads

SPECIFIC LEARNING OUTCOMES FOR ENGINEERING:

Category of outcome	*Students should/will (please delete as appropriate) be able to:*
Underpinning science and mathematics comprehensive understanding of scientific principles; Awareness of developing technologies; Comprehensive knowledge and understanding of mathematical and computer models with an appreciation of their limitations; Understanding of concepts from a range of areas, with some outside engineering, and the ability to apply them effectively in engineering projects.	Understand the importance of continuum mechanics (both solid and fluid mechanics) in predicting the blast wave propagation and structural responses
Engineering Analysis Ability to use fundamental knowledge to investigate new and emerging technologies; Ability to apply mathematical and computer-based models for solving problems in engineering, and the ability to assess the limitations of particular cases; Ability to extract data pertinent to an unfamiliar problem, and apply in its solution using computer based engineering tools when appropriate.	Apply explosion engineering method to identify blast loading parameters, to predict blast effects and to analyse structural responses Be able to conduct engineering analyses of high energy rate processing Have the knowledge of using hydro-code for numerical simulation purposes
Design Wide knowledge and understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations; Ability in innovative design for products, systems, components or processes to fulfil new needs.	Have the ability to apply the predicted blast load in the design and assessment of industrial applications and structures
Economic, social and environmental context Extensive knowledge and understanding of management and business practices, and their limitations, and how these may be applied appropriately; Able to make general evaluations of commercial risks through some understanding of the basis of such risks.	Irrelevant
Engineering Practice A thorough understanding of current practice and its limitations, and some appreciation of likely new developments; Extensive knowledge and understanding of a wide range of engineering materials and components; Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.	Incorporate the explosion engineering method into other extreme loading problems

5. LEARNING AND TEACHING PROCESSES

The teaching will be given by lectures, tutorials, labs and project. Students are expected to attend all teaching sessions, read lecture notes and recommended books, complete tutorial problems, lab reports and project report before the deadlines.

6. ASSESSMENT

Assessment task	Length	Weighting within unit
Examination: answer 3 out of 4 questions	2 hours	70%
Experimental and numerical laboratory (Detonation and blast-induced fragments)	4 hours	15%
Project (selected topic)	12 hours	15%

7. READING LIST

Johnson, W (1972), "Impact Strength of Materials", Edward Arnold.
Meyers, M A (1994), "Dynamic Behavior of Materials", John Wiley & Sons.
Kolsky, H (1963), "Stress Waves in Solids", Dover.
Smith, P D and Hetherington, J G (1994), "Blast and Ballistic Loading of Structures", Butterworth-Heinemann.
Bangash, M Y H (1993), "Impact and Explosion – Analysis and Design", Blackwell Scientific Publications.
Baker, W E, Cox, P A, Westine, P S and Kulesz, J J (1983), "Explosion Hazards and Evaluation", Elsevier.
Cole, R H (1965), "Underwater Explosion", Dover.

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