THE UNIVERSITY OF MANCHESTER
Unit Specification

1. GENERAL INFORMATION

Title	Plasticity
Unit code	MACE61058
Credit rating	15
Level	4th Year MEng; MSc (Mechanical Engineering Design)
Pre-requisite units	Elasticity
Co-requisite units	
School responsible	Mechanical, Aerospace & Civil Engineering
Member of staff responsible	Dr Q.M.Li (coordinator), Dr J Wu (teaching) , Dr H Tan (teaching)

2. AIMS

The unit aims to:

give students an understanding of large and non-reversible deformation of metals;
provide students a mathematical framework and knowledge base to facilitate problem solving using classical plasticity;
provide students practical methods to analyze plastic deformations of structural elements
guide students to design simple structures in plastic regime

3. BRIEF DESCRIPTION OF THE UNIT

Outline syllabus:

Plastic Deformation: definition of true stress and strain; experimental observations (yielding, strain-rate, Bauschinger, temperature, etc); microscopic explanations; Idealised Stress-Strain Relationships.
Ideal Solutions and Thermodynamic Concepts: thermodynamic concepts (work, internal energy, temperature, entropy); ideal solutions.
Continuum Assumptions and Deformation Descriptions: derivation of the deformation gradient tensor; strain and strain rate tensors; Cauchy stress.
Stress Tensor on a Deformed Body: eigenvalue approach vs. Mohr's circle.
Yield Criteria and Stress Space: stress invariants; von Mises and Tresca yield criteria; stress space and geometric interpretation of yield criteria.
Constitutive Equations: normal flow rule; Levy-Mises and Prandtl-Reuss equations (derivation, interpretation, limitations).
Effective Stress and Strain: derivation via work; implications; incorporation of uniaxial relationships in constitutive equations.
Applications: combined use of equilibrium, flow rules, yield criteria and boundary conditions in billets, spherical and cylindrical shells, and common structural elements (bars, beams, trusses).
Limit Theorems: work hypothesis, limit theorems of plasticity; slip-line theory; applications (collapse loads, indentation, etc.).
Project: a selection of engineering plasticity project

THE UNIVERSITY OF MANCHESTER
Unit Specification

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, 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 .	Understand metal plasticity theory as part of continuum mechanics
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.	• Determine loads changes in plastic deformation processes. • Determine principle stress and strain increments using eigenvalue methods and Mohr's circles applied to tensors. • Apply the combined use of equilibrium, flow rules, yield criteria and boundary conditions for a range of structural and manufacturing problems. • Apply effective stress and strain to path dependent processes. • Apply limit theorems to structures to ascertain collapse loads.
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.	Conduct plastic analysis for common structural elements Conduct finite element numerical simulation for the plastic deformation of structural elements
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 design predictions • Apply plasticity theory in structural design • Extend plasticity model to other engineering materials

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 plasticity theory in formulating mechanical constitutive models for other engineering materials
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 plastic theory to analyse beams, plates and shells in various quasi-static loading conditions; Apply plasticity constitutive equation in numerical simulations
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.	Use plasticity theory to design beams, plates and shells and the system consisting of these structural elements
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.	irrelevant

5. LEARNING AND TEACHING PROCESSES

The course will be delivered using lectures, tutorials, labs and a project. Students are expected to attend all teaching sessions, read lecture notes and recommended books, and 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 computing labs (uniaxial and bulge tests)	6 hours	15%
Project (selective topic)	6 hours	15%

7. READING LIST

C. R. Calladine, Plasticity for Engineers: Theory and Applications, Horwood Publication.
V. Gopinathan, Plasticity Theory and its Applications in Metal Forming, John Wiley & Sons.
I. H. Shames & F. A. Cozarelli, Elastic and Inelastic Stress Analysis, Taylor & Francis Inc.
R. Hill, The Mathematical Theory of Plasticity, Oxford Science Pub.
W. Johnson & P. B. Mellors, Advanced Engineering Plasticity, Horwood Pub.
R. H. Wagoner & J. L. Chenot, Fundamentals of Metal Forming, John Wiley & Sons.

Date of current version	19/08/2008