Imperial College London

Department of Civil and Environmental Engineering

Theory of Shells

Course leader:	Dr Adam Jan Sadowski
Other contributors:	
Module status:	Elective (SSD)
Pre- or co-requisites:	
Term:	Spring
Contact hours:	30
ECTS units:	5 (MSc)
FHEQ Level:	7
Assessment:	Coursework, written examination

1.0 Aims

- To introduce the students to the fundamental concepts and principles of the analysis and design of thin-walled shelled structures.
- The module begins with an introduction to membrane theory for common shapes of axisymmetric structural shells, followed by an overview of axisymmetric bending theory for cylindrical shells and an introduction to the phenomenon of shell buckling.
- The module introduces the students to the analysis of shells using commercial finite element software including linear elastic, linear plastic, nonlinear elastic and linear buckling analyses. An introduction to the design of shells using EN 1993-1-6 is also given.

2.0 Syllabus

- Membrane theory of thin shells: Cylindrical, conical and spherical shells; Generalisation to other axisymmetric shells.
- Axisymmetric bending theory for cylindrical shells.
- Introduction to buckling of cylindrical shells.
- Introduction to the analysis of shell structures using finite element software and overview of linear elastic, linear plastic, linear buckling and nonlinear buckling analyses.
- Overview of structural design according to EN 1993-1-6.
- Overview of advanced research topics in shells.

No.	Topic	Staff
01	Introduction – Membrane theory of cylindrical shells	AJS
02	Membrane theory and deformations of cylindrical shells	AJS
03	Membrane theory of general shells of revolution – cylindrical shells	AJS
04	Membrane theory of spherical shells	AJS
05	Bending theory of cylindrical shells	AJS
06	Buckling of cylindrical shells and computational analyses	AJS

07	ABAQUS project	AJS
08	ABAQUS project	AJS
09	ABAQUS project	AJS

3.0 Intended learning outcomes

On successfully completing this course unit, students will be able to:

- Understand what is meant by a 'thin' walled assumption for axisymmetric shell structures.
- Apply shell membrane theory to analyse cylindrical, conical and spherical shells under varying load cases.
- Apply axisymmetric bending theory to perform stress analyses of isotropic and orthotropic cylindrical shells.
- Use numerical analysis to perform a series of increasingly sophisticated analyses on different types of shell structures, and to compare the outcomes to previously calculated membrane theory solutions.
- Become familiar with the design philosophy in EN 1993-1-6.

4.0 Teaching methods

The course consists of lectures and supporting tutorials.

5.0 Assessment

The final three weeks of the project consist of an advanced ABAQUS project, carried out in the computer lab. The exam consists of two questions, both mandatory and both carrying equal marks. The split between examination and coursework is 70% / 30% for MSc students (CI9-STR-39), and 50% / 50% for Meng students (CI3-337).

6.0 Recommended textbooks

Category as defined by Central Library:

C = Core, S = Supplementary

S	Heyman, J. (1977). Equilibrium of shell structures. Oxford Engineering Science Series.
S	Timoshenko S.P. & Woinowsky-Krieger S. (1964). Theory of Plates and Shells. McGraw-Hill.
S	Flügge W. (1960). Stresses in shells. Springer-Verlag.
S	Other relevant literature will be made available at different stages during the module.

7.0 Subject threads

The table below shows how the themes of design, sustainability and health & safety risk management are embedded in the curriculum (as defined by the JBM degree guidelines).

Key: Primary (P), Secondary (S) and Contributory (C).

Design	Health & Safety Risk Management	Sustainability
S	-	-