



The University of Southern Queensland

Course Specification

Description: Vector Calculus Applied to Fluid Mechanics

| Subject | Cat-Nbr | Class | Term | Mode | Units | Campus |
|---------|---------|-------|---------|------|-------|--------|
| MAT | 3106 | 25296 | 2, 2003 | ONC | 1.00 | TWMB A |

| | |
|------------------------|--------|
| Academic Group: | FOSCI |
| Academic Org: | FOS003 |
| HECS Band: | 2 |
| ASCED Code: | 010101 |

STAFFING

Examiner: Dmitry Strunin

Moderator: Tony Roberts

PRE-REQUISITES

Pre-requisite: MAT2100 and MAT3105

RATIONALE

Concepts and methods for the modelling and analysis of vector functions in space are required for an understanding of the principles that permeate much of applied mathematics, mathematical physics and engineering science. These principles are developed in the context of their application to the dynamics of fluid flow as it is important in industrial and environmental problems.

SYNOPSIS

First this course unifies linear algebra and differential calculus into the calculus of vector functions. It develops the differential and integral calculus, establishes their properties, and shows how these properties give useful formula in general coordinate systems. The course integrates the application of these mathematical tools to inviscid and incompressible fluid dynamics. It then extends the modelling of fluid dynamics to the flow of a Newtonian viscous fluid. Applications to slow flows and to similarity solutions in fast flows are developed. This course is offered only in even numbered years.

OBJECTIVES

On completion of this course students will be able to:

- use conservation principles to mathematically model inviscid fluid mechanics;
- use vector calculus to analyse the structure of physical fields in Cartesian and general curvilinear coordinates;

- interpret and evaluate integrals over curves, surfaces and spatial domains;
- appreciate the close connection between advanced mathematical concepts and real physical processes;
- use and understand the fundamental equations describing viscous fluid flow;
- mathematically analyse and interpret fluid flows involving thin films, viscous flows around bodies, or boundary layers.

TOPICS

| Description | Weighting (%) |
|--|---------------|
| 1. Modelling fluid flow needs vector differentiation: scalar and vector fields of fluid flow; material derivatives and the gradient; divergence does not conserve mass; vorticity is the curl of velocity; continuity and Euler equations; conservation of momentum leads to the Venturi effect. | 25.00 |
| 2. Vector integration and applications: circulation is a work integral; scalar potentials lead to path independence; surface integrals measure flux; Gauss' divergence theorem transforms volume integrals; vorticity and circulation are related by Stokes' theorem. | 20.00 |
| 3. Curvilinear coordinates for curved shapes: unit vectors and scale factors vary in space; integral theorems determine divergence and curl; flow in a long & curved pipe. | 10.00 |
| 4. Mathematical modelling of viscous flow: viscosity, Navier-Stokes equations, non-dimensionalisation, some exact solutions. | 15.00 |
| 5. Boundary layers in fast flow: asymptotics, flat plates, wakes & jets. | 15.00 |
| 6. Slow flow: low Reynolds number, flow past sphere, lubrication, thin films. | 15.00 |

TEXT and MATERIALS required to be PURCHASED or ACCESSED:

Books can be ordered by fax or telephone. For costs and further details use the 'Book Search' facility at <http://bookshop.usq.edu.au> by entering the author or title of the text.

Kreyszig, E 1999, *Advanced Engineering Mathematics*, 8th edition, Wiley,

Ockendon, H & Ockendon, J.R. 1995, *Viscous Flow*, Cambridge University Press,

STUDENT WORKLOAD REQUIREMENTS

| ACTIVITY | HOURS |
|---------------|-------|
| Assessment | 30 |
| Examinations | 3 |
| Lectures | 48 |
| Private Study | 65 |
| Workshops | 24 |

ASSESSMENT DETAILS

| Description | Marks Out of | Wtg(%) | Required | Due Date |
|----------------------|--------------|--------|----------|-------------|
| HOMEWORK | 100.00 | 15.00 | Y | 22 Jul 2003 |
| ASSIGNMENT 1 | 100.00 | 15.00 | Y | 22 Jul 2003 |
| ASSIGNMENT 2 | 100.00 | 15.00 | Y | 22 Jul 2003 |
| 3HR OPEN EXAMINATION | 100.00 | 55.00 | Y | END S2 |

IMPORTANT ASSESSMENT INFORMATION

- 1 Attendance requirements:
It is the students' responsibility to attend and participate appropriately in all activities (such as lectures, tutorials, laboratories and practical work) scheduled for them, and to study all material provided to them or required to be accessed by them to maximise their chance of meeting the objectives of the course and to be informed of course-related activities and administration.
- 2 Requirements for students to complete each assessment item satisfactorily:
To complete each of the assessment items satisfactorily, students must obtain at least 50% of the marks available for each assessment item.
- 3 Penalties for late submission of required work:
If students submit assignments after the due date without prior approval then a penalty of 20% of the total marks gained by the student for the assignment will apply for each working day late.
- 4 Requirements for student to be awarded a passing grade in the course:
To be assured of a passing grade, students must demonstrate, via the summative assessment items, that they have achieved the required minimum standards in relation to the objectives of the course by: (i) satisfactorily completing the examination and assignments; and (ii) obtaining at least 50% of the total weighted marks available for all summative assessment items. Students who do not qualify for a Passing grade may, at the discretion of the Examiner, be awarded a Supplementary Examination and/or assigned additional work to demonstrate to the Examiner that they have achieved the required standard. It is expected that such students will have gained at least 45 % of the total marks available for all summative assessment items.
- 5 Method used to combine assessment results to attain final grade:
The final grades for students will be assigned on the basis of the weighted aggregate of the marks obtained for each of the summative assessment items in the course.
- 6 Examination information:
In a Restricted Examination, candidates are allowed access to specific materials during the examination. The only materials that candidates may use in the restricted examination for this course are: writing materials (non-electronic and free from material which could give the student an unfair advantage in the examination); calculators which cannot hold textual information (students must indicate on their examination paper the make and model of any calculator(s) they use during the

examination). With the approval of the Examiner, candidates may, take an appropriate non- electronic translation dictionary into the examination. This will be subject to perusal and, if it is found to contain annotations or markings that could give the candidate an unfair advantage. A list of the materials candidates may access in the restricted examination will be on the frontispiece of the examination paper.

- 7 Examination period when Deferred/Supplementary examinations will be held:
Any Deferred or Supplementary examinations for this course will be held during the examination period at the end of the semester of the next offering of this course.
- 8 University Regulations:
Students should read USQ Regulations 5.1 Definitions, 5.6. Assessment, and 5.10 Academic Misconduct for further information and to avoid actions which might contravene University Regulations. These regulations can be found at the URL <http://www.usq.edu.au/SECARIAT/calendar/Part5/> or in the printed version of the current USQ Handbook.