Intuitive operation and pilot training when using marine azimuthing control devices

AZIPILOT

Report Title:

Deliverable 1.9:

Compile Dedicated Engineering Lecture Series

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1 Executive summary

The objective of this task is to address longer term dissemination and exploitation of project results through the initial development a of dedicated engineering lecture series. Specifically, the knowledge gained in the project will be organised into a form suitable for the formation of a dedicated module together with supporting evidence of industrial need. Through the collaborative work within this project, with a wide variety of expertise, it is expected that needs of the industry as a whole can be evaluated. The aim of this task is to compile the main project outcomes into a form that is readily exploitable for use in academic engineering education. Also, supporting material will be compiled suitable for the evaluation of industry needs; ultimately defining the appropriate outcomes of resulting educational programs.

The report includes presentation of collected opinions, summary of the compiled materials and evidence of the implementation of the new module.

2 Introduction

In parallel with Task 3.9, feedback has be sort from potential employers of engineering graduates. Due to the limited number available, it proved more realistic to obtain the opinion directly from various project partners. Examples of written feedback are provided in the below tables giving the opinion of both a hydrodynamic test centre and a manned-model training centre. From the below and from the wider discussion in both industry and at project meetings, various themes often come up. Specifically:

1. Personnel looking to specialise in the areas related to the design for manoeuvring performance of ships, lack a knowledge of the real operating environment;
2. In addition to 1. an understanding of human-factors is necessary for the wider application of the discipline;
3. A better understanding of measurement techniques is needed together with data processing skills including uncertainty analysis;
4. Skills in professional report writing should be improved.

Maritime research and training academies (institutes), such as FORCE Technology in Denmark rely very much on high class professionals educated and trained as Naval Architects, Engineers or Ship Masters.
Interviews with Naval Architects, Engineers and their superiors at FORCE Technology gave the general impression that the academic education was perceived as being of a very high standard. A majority, however, pointed out that in relation to the daily tasks and routines they would have benefitted from having been educated to a higher level of knowledge and proficiency in:

- writing a professional report
- language skills (mainly English), spoken and written
- quality assurance. Including the quality of our products(Data)
- knowledge of the maritime environment. E.g. different vessels and offshore installations operation and management
- measuring techniques and calculations
- electronics – comprehension of equipment used in the test facilities
- a more profound understanding of data signal processing in connection with measurements and calculations

The Ship Masters said that their academic education gives the very basic theoretical knowledge of hydrodynamics and ship handling but the skills needed to be a maritime simulator instructor and navigational advisor comes from seagoing experience combined with further academic education in:

- vocational teaching
- psychology – human factors
- hydro and aero dynamics

Arne Funch Mejer – FORCE Technology, 21. July 2011

In our field of civil engineering used in my company Sogreah, young engineers usually lack a) writing reports correctly and b) interpersonal relationships (especially knowledge of foreign cultures with whom we conduct over 50% of our business) and related commercial approach.
This is probably typical for engineers !
I guess seafarers are quite different … Those I meet here at Port Revel have a lot of intuitive manoeuvring capabilities, but lack the more objective (“scientific”) approach to moving a ship around. Engineers tend to be the other way round. We would hope for a balanced mix of both!
I hope these short comments will help you.

Arthur de Graauw – SOGREAH ARTELIA GROUP, 12 September 2011

2.1 Introduction and Background

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to inform students of the module structure, content and expected learning outcomes. The objective is to ensure that students are aware of the expectations, necessary effort and available researches needed to complete the module.
Overview of Lecture Content	The lecture will give a brief introduction to the module content including: • Functionality of various ship types including tug and their operation • Formulation of the equations of motion including higher order terms • Estimation of derivatives from semi-empirical methods and preliminary design calculations • Captive model testing methods and formulation of PMM computations • Effects of shallow and confined water • Rudder design • Electric and mechanical azimuthing pod-drives • Propeller loading modelling and simulation • Voith Schneider Propellers • Functionality of Full Mission Ship Bridge Simulators • Time-domain numerical integration methods • Human factors in bridge design and operations • Human factors in control device design and functionality • Auto Pilot design • Dynamic positioning Case Studies
Expected Learning Outcomes	Students will be briefed on the module outline and expected learning outcomes.

2.2 Functionality of various ship types including tug and their operation

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aims of the lecture are to make students familiar with the range and extent of various manoeuvring devices and their typical ship applications. Also, to make students familiar with the types of operation and manoeuvres performed by ships and tugs. The objective is to ensure that students are aware of the options and risks associated with various design options and understand how the resulting technology may be used or in some cases misused.
Overview of Lecture Content	The lecture will review a range of ship-types and their control devices, including: • Convectional ships including VLCC's and ULCC's • Cruise ships and tankers using azimuth control devices • Double acting tankers • High-speed craft using water-jets • A range of tug configurations. The typical operation and use of such ships will be reviewed including: • Tug operation including the 'Indirect Mode' • Introduction to ship-to-ship interaction • Introduction to shallow water and bank effects • Implications and regulations related to taking tugs • Provisions and regulations of taking a pilot • Role and responsibilities of the Captain/Pilot/Harbour master • Introduction to STCW
Expected Learning Outcomes	Students will be familiar with a range of ship-types and their application. They will be familiar with a range of typical ship manoeuvring operations and with roles and responsibilities of the various personnel involves and of the legal and regulatory requirements.

2.3 Formulation of the equations of motion including higher order terms

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aims of the lecture are to first revise and then expand on the derivation of the Newtonian equations of motion used in ship manoeuvring performance prediction theory. The objective is to ensure that students are familiar with a range of forms and notations that may be encountered within the subject area and be capable of interpreting their correct inclusion and use.
Overview of Lecture Content	The lecture will cover the formulation of the equations of motion in four-degrees of freedom and including both linear and higher order terms. A logical progression will be used to derive the equations of motion including: • Revision of the basic equations of motion in the surge, sway and yaw degrees-of-freedom; • Formulation of the Taylor expansion terms for higher order effects; • Alternative expansion methods and their uses and limitations; • Inclusion of the roll degree-of-freedom; • Implications of coupling and body symmetry; • Examination of 6-dof models for advance modelling of dynamic effects. • Examination of some common methods of presenting the non-dimensional terms.
Expected Learning Outcomes	Students will understand the derivation of the equations of motion and understand the relevance and functionality of the various terms. In addition, students will be able to recognise and interpret the purpose and limitations of various expansion methods. Also, students will be familiar with various methods for making the manoeuvring derivatives non-dimensional; and know how to deal with making terms from different methods compatible.

2.4 Estimation of derivatives from semi-empirical methods and preliminary design calculations

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aims of the lecture are to explore the origins of various semi-empirical derivative prediction tools and in so doing establish their strengths and limitations. Also, to apply such tools to a design case study to establish the methods for the inclusion of necessary terms form appendages on the bare hull. The objective is to make students familiar with a range of semi-empirical tools and that they should understand how such tools are derived. Also, students should be familiar with the various contributions to hull form derivatives from various appendages.
Overview of Lecture Content	The lecture will cover the formulation of various derivative prediction methods including: • Basic derivation of empirical components. • Geometric series and model testing. • Multi-variable analysis. • Presentation of a range of published methods. • Interpretation of various contributing physical phenomenon. • Prediction of fin-effect including double-body problem. • Inclusion of fin-effects. • Discussion of higher-order terms and flow characteristics. • Application of CFD. • Processing and preliminary design analysis.
Expected Learning Outcomes	Students will understand the derivation of a variety of derivative prediction tools and be able to select appropriate method for the situation being tackled. Students will be able to apply methods for obtaining the manoeuvring derivatives for preliminary design analysis.

2.5 Captive model testing methods and formulation of PMM computations

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aims of the lecture are to revise the basic concepts of captive model testing and the methods used. Secondly, to formally derive the equations used to describe and measure the force measurements for Planar Motion Mechanism type captive testing. The objective is to make student aware of the testing process and for them to be able to derive the equations describing the PMM testing method and from this extract the necessary derivative terms.
Overview of Lecture Content	The lecture will cover the main aspects of captive testing including both the methods and derivation of PMM forces: • The static drift testing equipment and methods. • Interpretation of static drift test results. • Rotating arm testing equipment and methods. • Interpretation of rotating arm test results. • Planar Motion Mechanism testing equipment and methods. • Derivation of the equations used in PMM testing. • Interpretation of PMM test results. • Discussion of frequency dependencies.
Expected Learning Outcomes	Students will understand the methods used in captive testing to find the force derivatives necessary for ship manoeuvring performance analysis and simulation. Students will be able to derive the equations used in PMM testing and be able to interpret captive testing outputs.

2.6 Effects of shallow and confined water

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aims of the lecture are to make students aware of the impact of the ship proximity to surrounding object on it manoeuvring performance. Specifically, the issues associated with shallow water, bank effects and ship-to-ship interactions will be considered. The objective is to make students aware of effects of interactions on a ships manoeuvring performance related to close proximity operation. It is intended that students will understand the cause and effect of various proximity issues and be aware of methods for mitigating the effect through both design and operation.
Overview of Lecture Content	The lecture will cover the main hydrodynamic effects of a range of proximity issues and the operational and design mitigations that might be user; including: • Effect of shallow water on a ship's manoeuvring performance. • Operational aspects when in shallow water. • Approximate methods for estimating shallow water effects. • Bank effects including berthing and un-berthing. • Effect of channels and their bathometry. • The singular Froude wave in a confined channel. • Ship-to-ship interactions including passing and overtaking. • Ship-to-ship interactions when bunkering at sea
Expected Learning Outcomes	Students will understand the likely changes in manoeuvring performance of ships operating in close proximity or in confined waters. Students will be aware of a range of hydrodynamic effects and how they may be addressed in either design and/or operation.

2.7 Rudder design

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aims of the lecture are to explore various design options and the related hydrodynamics for a range of rudder types. Also, to develop understanding of the inflow to the rudder effected by the propeller wake, propeller loading condition and the swaying and yawing motion. The objective is to develop understanding of the principal concepts of rudder design and their hydrodynamic operation.
Overview of Lecture Content	The lecture will introduce a range of different rudder configurations and cover the main hydrodynamic phenomenon that affect their performance; including: • The conventional rudder configuration. • High lift rudders and their operation. • Rudder derivative estimation and experiments. • Propeller wake and the flow-straightening effect. • Cavitation. • Effects of slew-rate on manoeuvring performance.
Expected Learning Outcomes	Students will be familiar with a range of rudder design concepts and understand various hydrodynamic issues related to them.

2.8 Electric and mechanical azimuthing pod-drives

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce students to the range of azimuthing control devices available on the market and to their application and typical mission of the ships that use them. The objective is to give a broad understanding of the range of technologies and the implications for the design of ships that may use pods.
Overview of Lecture Content	The lecture will introduce a range of different Azimuting Control Devices (ACD) configurations and cover the main hydrodynamic phenomenon that affect there performance and the main issues for designing ships that may use them; including; • Background history of ACD's • Overview of the technology. • Overview of the applications. • Hydrodynamic design issues for ACD's. • Preliminary design issues for ships when choosing ACD's.
Expected Learning Outcomes	Students will be familiar with a range of azimuthing control devices, their typical application and the mission of ships using them. Students will understand a range of ship design issues that should be taken into consideration when deciding whether to select ACD's for a particular ship design.

2.9 Propeller loading modelling and simulation

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce the main hydrodynamic issues that affect propeller loading when manoeuvring. The objective is to give a broad understanding of the typical hydrodynamic phenomenon affecting propellers in various load conditions and to understand practical methods of modelling such affects.
Overview of Lecture Content	The lecture will consider a range of hydrodynamic phenomenon that affect ships propellers when manoeuvring; including: • Stopping and backing. • Accelerating and decelerating. • Effect of the angle of inflow to the propeller. • Theodorsen and Sears functions. • Simplified numerical models for simulation. • Effect of rudder angle on propeller inflow. • Effect of propeller loading on rudder performance.
Expected Learning Outcomes	Students will understand the principals of manoeuvring loads on propellers and be able to model the various phenomenon appropriate for simulation purposes.

2.10 Voith Schneider Propellers

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce the concept of the Voith Schnider (VS) propeller and its hydrodynamic operation and its typical applications. The objective is to give a broad understanding of the typical hydrodynamic phenomenon affecting VS propellers in various load conditions and to understand practical methods of modelling such affects.
Overview of Lecture Content	The lecture will consider a range of hydrodynamic phenomenon that affect VS propellers when manoeuvring; including: • Mechanical operation of VS propellers. • Typical application and mission of the technology. • Hydrodynamic operation of the VS propeller. • Simplified modelling for simulation.
Expected Learning Outcomes	Students will understand the operation of VP propeller, be familiar with their typical operation and be able to make calculation regarding their hydrodynamic forces for both design and simulation.

2.11 Functionality of Full Mission Ship Bridge Simulators

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce the various configuration and technologies used for Full Mission Ship Bridge Simulators (FMSBS). Also, the various uses and functionality will be explored. The objective is to ensure students are aware of the range of technologies, how it is used and what hydrodynamic modelling is required.
Overview of Lecture Content	The lecture will consider a range of FMSBS options together with their functionality and use; including: • Fast-time simulation for design vs real-time simulation. • Various configurations and categorisation of simulators. • Training and certification and the implications for modelling. • Design and demonstration and the implications for modelling. • Extent and need for realism. • The use of haptic feedback. • STCW
Expected Learning Outcomes	Students will be familiar with a range of FMSBS technologies and the application for both training and certification and design and modelling.

2.12 Time-domain numerical integration methods

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce the various methods used for numerical simulation modelling. The objective is that students will understand the strengths and weaknesses of various integration methods and know how they are applied.
Overview of Lecture Content	The lecture will consider a range of integration methods that can be used for time-domain simulation including: • Trapezoidal method. • Second order Rung-Kutta. • Fourth order Rung-Kutta. • Solutions for the second derivative. • Issues of divergence. • Numerical uncertainty
Expected Learning Outcomes	Students will be familiar with a range of integration method used for time-domain simulation; understand their strengths and weaknesses and be able to apply them appropriately.

2.13 Human factors in bridge design and operations

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce a range of issues related to human factors when considering the design of the ships bridge. The objective is to inform students of the typical use and operation of ships including an overview of bridge operations. Also to inform students of the like use of misuse of various aspects of the technologies.
Overview of Lecture Content	The lecture will consider a range of issues affecting the design of the ships bridge including: • Layout and configuration for various ship types. • The roles of various bridge personnel. • Operation and procedures. • Relevance of information available on the bridge. • Tools for layout and visualisation in design.
Expected Learning Outcomes	Students will be familiar with a range of bridge configurations, the typical operations and how beat to tackle new designs.

2.14 Human factors in control device design and functionality

Lecturer:	Dr. Michael D. Woodward
Delivery method:	Lecture of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce a range of issues related to human factors when considering the design of the bridge equipment. The objective is to inform students of the typical use and operation of ships equipment including an overview operations. Also to inform students of the like use of misuse of various aspects of the technologies.
Overview of Lecture Content	The lecture will consider a range of issues affecting the bridge equipment, including: • Bridge layout. • Ergonomics. • Appropriate use of alarms and alarm protocol. • Lines of sight. • Control handles and their functionality. • Haptic feedback. • Intuitive operation. • Terminology and communication.
Expected Learning Outcomes	Students will be familiar with a range of bridge configurations, the typical operations and how beat to tackle new designs.

2.15 Auto Pilot design

Lecturer:	Dr. Kayvan Pazouki
Delivery method:	Three lectures of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lecture is to introduce a range of issues related to auto pilot design and the definition of the problem in terms of ship manoeuvring control. The objective is to inform students of the typical use and range of application of various technologies and the strengths and limitations of various modelling techniques.
Overview of Lecture Content	The lecture will consider the analysis and design of an adaptive autopilot for ship including: • Low and high frequency model of the vessel motion adequate to ship steering. • Low frequency model describes the vessel response to rudder control and slowly varying environmental forces. • The high frequency model represents the wave induced oscillatory part of the yaw motion. • Models used in a Kalman filter and the rudder control computed from linear quadratic theory based on the low frequency part of the vector.
Expected Learning Outcomes	Students will be familiar with a range of methods used for autopilot design.

2.16 Dynamic positioning Case Studies

Lecturer:	Dr. David Clarke
Delivery method:	Six lectures of duration not exceeding one hour.
Supporting materials:	Some notes may be handed out in the lecture. Supporting notes and other materials such as video content will be available on the Black Board software; made available to participating students.
Aims and Objectives	The aim of the lectures/tutorials are to introduce students to the subject of Dynamic positioning (DP). Also, to give students insight into the methodologies used through practical application achieved through a cases study coursework The objective is to give student the opportunity to put into practice various skills learned throughout the module.
Overview of Lecture Content	The lecture will consider the wind and drift forces acting on various floating forms including: • Presentation of model tests for very large drift angles. • Comparison of various non-dimensional data reduction methods and determination of equivalence. • Presentation of model tests for wind forces and moments. • Empirical methods for wind forces and moments. • Basis ship methods for obtaining results. • Estimations of control force requirements.
Expected Learning Outcomes	Students will be familiar with a methods used to estimate the DP requirements of a drill-ship case study.

3 Module descriptor as published by Newcastle University

The following section presents the module descriptor published on Newcastle University website. The purpose of the module descriptor is to inform students of the module content and expected learning outcomes. It is also intended as an aid to selecting modules.

Newcastle University

Module Catalogue 2012

Module Catalogue 2012

MAR3031 : Ship Manoeuvring Performance and Operability

- Offered for Year: **2012**
- Module Leader(s): **Dr Michael Woodward**
- Owning School: **Marine Sciences & Technology**

Semesters

Semester 1 Credit Value:	10

Pre Requisites

Code	Title
MAR2001	Marine Dynamics

Pre Requisite Comment

N/A

Co Requisites

Co Requisite Comment

N/A

Aims

The aim of the module is to broaden and deepen the students understanding of ship manoeuvring performance and operability. This includes preparing students with the skills required in the field of commercial hydrodynamic testing and data processing and making familiar the various technologies and operational risks relevant to the specific discipline.

Outline Of Syllabus

Building on the fundamentals studied in MAR2001 the module will consider design for manoeuvring performance from a wider perspective. The practicalities of hydrodynamic testing, measurement and uncertainties will be explored through both lectures and practical sessions. The use and action of a range of manoeuvring devices will be explored. The practical application of simulation will be explored together with numerical methods used for its implementation. Practical issues of operability will be explored together with subject such as human factors, considering how this impact on design for manoeuvring performance.

Learning Outcomes

Intended Knowledge Outcomes

On successful completion of this course, students will be able to demonstrate knowledge and understanding of:
IKO1: Understand the process of hydrodynamic testing used for manoeuvring analysis and relate this to the underlying equations of motion studied in the previous year;
IKO2: Perform the necessary calculations for preliminary design;
IKO3: Understand the principal and functionality of a simulator and judge where to apply its use to appropriate situations;
IKO4: Be familiar with the functionality and limitations of a range of manoeuvring devices and their control systems;
IKO5: Be familiar with a range of common manoeuvring operations and understand the implications of human factors on such operations;
IKO6: Be familiar with a range of advanced hydrodynamic and control issues relevant to ship manoeuvring performance and operations.

Intended Skill Outcomes

On successful completion of this course, students will develop the following subject specific and intellectual skills:
ISO1: Select and apply suitable preliminary design process for manoeuvring performance;
ISO2: Select the correct testing and/or simulation methods for a range of situations;
ISO3: Analyse test data and interpret the results;
ISO4: Appraise the merits of various manoeuvring devices and control systems and select appropriately for various applications;
ISO5: Present materials in a formal engineering reporting style.

Graduate Skills Framework

Graduate Skills Framework Applicable:	Yes

- Coginative/Intellectual Skills
  - Critical Thinking : Assessed
  - Data Synthesis : Assessed
  - Active Learning : Present
  - Numeracy : Assessed
  - Literacy : Assessed
  - Information Literacy
    - Source Materials : Present
    - Synthesise And Present Materials : Assessed
- Self Management
  - Planning and Organisation
    - Goal Setting And Action Planning : Present
  - Personal Enterprise
    - Problem Solving : Present

- Interaction
  - Communication
    - Written Other : Assessed
- Application
  - Occupational Awareness : Present
  - Commercial Acumen
    - Market Awareness : Present
    - Governance Awareness : Present
    - Financial Awareness : Present
  - Legal Awareness : Present

Teaching Methods

Teaching Activities

Category	Activity	Number	Length	Student Hours	Academic Staff Contact Hours	Comment
Guided Independent Study	Assessment preparation and completion	1	2:00	2:00	0:00	Exam
Scheduled Learning And Teaching Activities	Lecture	24	1:00	24:00	24:00	N/A
Guided Independent Study	Assessment preparation and completion	1	15:00	15:00	0:00	Coursework 2 preparation and completion.
Guided Independent Study	Assessment preparation and completion	1	15:00	15:00	0:00	Coursework 1 preparation and completion.
Guided Independent Study	Assessment preparation and completion	1	12:00	12:00	0:00	Exam Revision
Scheduled Learning And Teaching Activities	Small group teaching	12	1:00	12:00	12:00	Tutorials
Scheduled Learning And	Small group	1	2:00	2:00	0:00	Exam revision

Teaching Activities	teaching					session
Guided Independent Study	Independent study	1	18:00	18:00	0:00	Consolidating lecture notes and further reading
Total				100:00	36:00	

Teaching Rationale And Relationship

The module will consist of lectures, private sudy, tutorials and a practical with a written report. Lectures provide the easiest way to students to assimilate the knowledge content and define the scope of each of the syllabus topics.

Revision is essential for students to work through the lecture material, tutorial and past examination questions repeatedly, in their own time at their own pace, until they thoroughly understand the material. Through this work, students will obtain an in- depth comprehension rather than simply memorising, how to solve particular problems; will nurture their skills in analysis and problem solving and will develop a mature approach to time allocation and personal discipline.
Tutorial classes will supplement lecturs through the worked solution of tutorial questions which the students have previously solved at home. The classes provide an opportunity for each student to ask the lecturer for help with any problems they have experienced whilst answering these questions.

Reading Lists

- Reading List Website : rlo.ncl.ac.uk (https://rlo.ncl.ac.uk/)
- MAR3031's Reading List (http://www.ncl.ac.uk/library/linkit?sv=r&r=MAR3031&y=2012)

Assessment Methods

Exams

Description	Length	Semester	When Set	Percentage	Comment
Written Examination	120	1	A	70	N/A

Exam Resits

Description	Length	When Set	Percentage	Resit Available Off Campus	Comment
Written Examination	120	A	100		N/A

Other Assessment

Description	Semester	When Set	Percentage	Comment
Report	1	M	15	Coursework 1, taking 15 hours
Report	1	M	15	Coursework 2, taking 15 hours

Assessment Rationale And Relationship

The exam and courseworks are intended to facilitate understanding in the direct application of the mathematics use in this field of engineering. The Graduate Skills Framework entries indicated as 'A' are also assessed in this way.

Timetable

- Timetable Website: http://www.ncl.ac.uk/timetable/room/Timetables.php (http://www.ncl.ac.uk/timetable/room/Timetables.php)

Past Exam Papers

- Exam Papers Online : www.ncl.ac.uk/exam.papers/ (http://www.ncl.ac.uk/exam.papers/)
- MAR3031's past Exam Papers (https://crypt.ncl.ac.uk/exam.papers/search.php?module_code=MAR3031)

General Notes

N/A

Note: The Module Catalogue now reflects module information relating to academic year 12/13. Please contact your School Office if you require module information for a previous academic year.

Disclaimer: The University will use all reasonable endeavours to deliver modules in accordance with the descriptions set out in this catalogue. Every effort has been made to ensure the accuracy of the information, however, the University reserves the right to introduce changes to the information given including the addition, withdrawal or restructuring of modules if it considers such action to be necessary.

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From outside the UK dial +44 191 222 6000
Website information and feedback (http://www.ncl.ac.uk/info)