MANADON'S NEW DEGREE IN NAVAL ENGINEERING

BY

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Introduction

The change in the responsibilities of engineer officers stemming from the Engineering Branch Study recommendations has led to a thorough reappraisal of the degree courses at Manadon. Up to now, B.Sc. degrees have been awarded in mechanical or electrical engineering and officers have read for one or the other depending on their individual sub-specialization interests. As engineer officers become responsible for whole systems, whether these be aircraft, weapons, or ship propulsion and services, they will in future need to have studied a wider range of subjects encompassing the naval aspects of mechanical, electrical and control engineering. The new degree title of 'Naval Engineering' has been adopted to reflect this approach.

Background

Design of a new Manadon degree reflecting the Engineering Branch Study's recommendations began two and a half years ago. The move to a multi-disciplinary approach was welcomed on many grounds. Artificial barriers between subjects which ultimately depend upon the same scientific foundations have become increasingly irrelevant and undesirable, and the difficulties associated with selection of students for honours argued strongly for increased commonality of material, at least in the early stages. There was thus considerable pressure to move to an integrated course which remains common to all for as long as possible. It was decided therefore to opt for a common two-years, followed by a third year for specialized options. By this means, the necessary increased breadth of education can be achieved without sacrificing the third-year in-depth study needed to cover the required subject matter and preserve honours standards.

Course Design

A number of studies preceded the main design of the course. These included one on the selection of honours students and another on structure. Detailed design was carried out by some twenty-five working parties from among the College staff, each charged with the development of particular subject matter and co-ordinated by a central steering committee composed of Heads of Section. This approach had the advantage of bringing together in the College a wide range of knowledge and experience. It involved right from the start not only those who were to lecture on the subjects but also nearly all other members of the College staff, in one way or another.

Constraints

There are many factors that have to be taken into account in designing a new degree course. Apart from the over-riding requirement to meet naval needs (as expressed by the Engineering Branch Study), the course has to satisfy the

standards laid down by the Council for National Academic Awards (CNAA) for degree awards and by the Council of Engineering Institutions (CEI) for Chartered Engineer status. At one end of the course, entry standards of five GCE passes, including two at 'A' level in mathematics and physics, are a continuing naval and educational requirement; whilst at the other end, the College Application courses provide a fixed, although flexible, end point. Above all, at a time of continuing technological change yet economic restraint, the course has had to be designed to be flexible and adaptable and capable of meeting naval needs whilst keeping within a length of three years and existing resources. Hopefully, the course will prove to have met all these somewhat conflicting criteria.

Course Aims

Stated formally, these are to meet naval requirements by providing:

(*a*) an education in the engineering sciences oriented towards naval requirements from which further education and practical training may be developed in the sub-specialist, post-degree and postgraduate courses;

(*b*) an undergraduate engineering education of content and standard acceptable to the CNAA;

(*c*) a course recognized by the major professional engineering institutions as meeting the educational requirements for Chartered Engineer status.

Naval General Training and Workshops Instruction

Alongside his degree work, the student at Manadon follows a continuous course of naval general training and an eleven-week workshops course. These will not change substantially but the workshops course has been rescheduled to extend over the first two years only of the degree course instead of the present three years. This will have the advantage of leaving more time for project work in the third year for students who at that time will be more competent in the design and manufacture of their experimental rigs.

Outline Structure of the Degree Course

The outline structure of the course is shown in TABLE I. A semester division has been adopted, each semester representing approximately twenty-six weeks' work in the classroom. The first two years, forming the common course, is divided into three semesters of two terms each; whilst the third year, in which specialized options are provided, constitutes the fourth semester. An internal qualifying examination, set at the end of the first semester, is intended as a test of fitness for degree study; no streaming will be made as a result of this examination. The first externally moderated examination will be held at the end of the second year and this, together with assessments made during the previous four terms, will decide the level of courses the student will follow in the third year. The final examination will be held, as now, in the summer term of the final year; the results of this, together with those of the second year examination, will determine the student's honours classification.

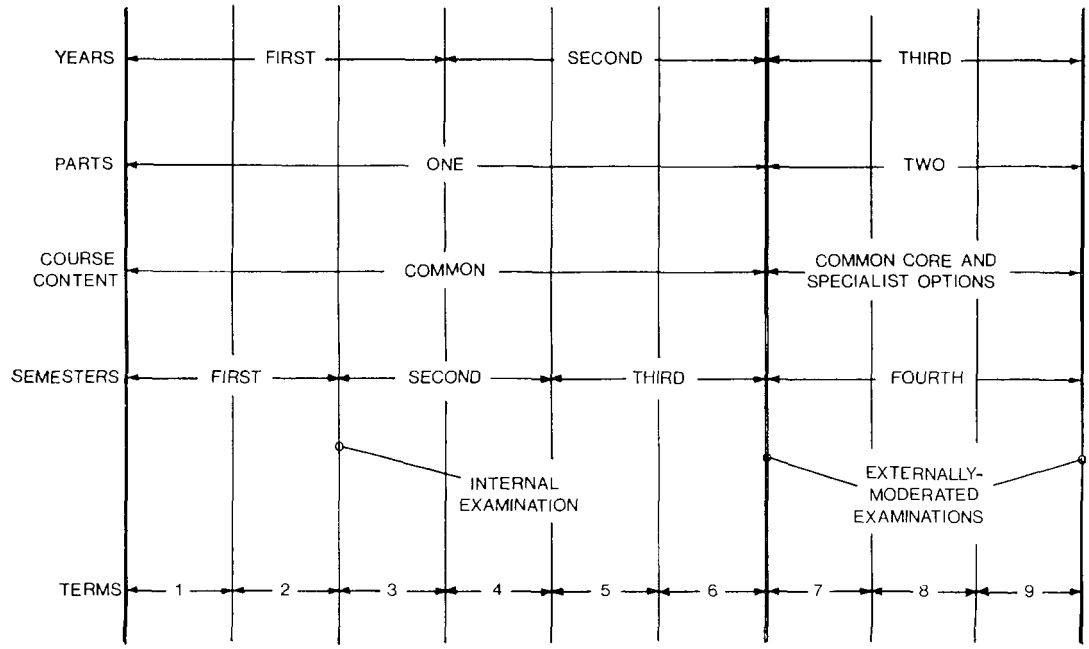
Subjects Covered

As shown in TABLE II, these may conveniently be divided into main subjects, support subjects, and laboratory work. Outline syllabuses are given in the Appendix.

Main Subjects

These cover three main areas, namely: mechanical engineering, electrical engineering, and control engineering. The subjects in each, whilst relating

TABLE I—*Course outline structure*



primarily to their respective disciplines, have all been designed to be as multi-disciplinary as possible and there is considerable common ground. In the *first semester*, emphasis is placed on providing the student with a sound base of engineering principles which will enable him to undertake later work with knowledge and assurance. The *second and third semesters* concentrate on building up a clear understanding of the essential core subjects of mechanical, electrical, and control engineering through generalized characteristics; the underlying physics of devices is not dealt with, either in theory or in practice. Finally, in the *fourth semester* a range of options is provided. The subject of control system design is compulsory for all, whilst the remaining subjects fall mainly into mechanical or electrical engineering although there is one option in computation. Subjects are designated single or double, depending on the extent of their subject matter and their consequent timetable allocation. Each student is required to take two double and one single subject in addition to control system design. The selection of subjects depends upon the student's choice of sub-specialization and he is advised on these at the end of his second year. TABLE III shows the subject choices and some likely combinations that may be expected.

Support Subjects

Five subjects, as shown in TABLE II, are provided in support of the main engineering course. Mathematics support is given in two ways: by a common course extending over the first two years of the degree and by specialist mathematics lectures and seminars, in direct support of engineering topics and as required at the time, in other subjects. The common mathematics course aims to provide the analysis needed by all students and includes, in the first term of the first semester, a foundation course designed on an 'as-required' basis to bring all students to a common level of basic understanding in mathematics.

The theory and practice of computing is introduced in 'freshers' week' and is continued throughout the first two years by a modular course of lectures, tutorials, and practical exercises designed to ensure each student understands the theory and operation of digital and analogue computers.

A course in engineering materials and design in the last two years of the course is preceded by engineering drawing in the first year. This sequence aims to develop the student's ability in an understanding of graphical communication

TABLE II—*Outline degree structure*

Subject Matter	*Year* 1		*Year* 2	*Year* 3
	Semester 1	*Semester* 2	*Semester* 3	*Semester* 4
Main Subjects				
Mechanical Engineering	Mechanical Engineering Science	Applied Mechanical Engineering		Applied Thermodynamics Structural Dynamics Mechanics of Sea and Air Vehicles Underwater Acoustics Electrical Power Wave Propagation and Transmission Signal Detection
	Properties of Substances	Power Plants and Machines		
Electrical Engineering	Engineering Field Theory			
	Electrical Engineering Science	Signal Processing and Electronics		
Control Engineering		Linear Systems Analysis		Control System Design
Support Subjects				
Mathematics and Computing	Mathematics			Real-time Data Processing
	Computer Studies			
Engineering Materials, Drawing, and Design	Engineering Drawing		Engineering Materials and Design	
Complementary Studies	Complementary Studies			
Laboratory Work	Laboratory Exercises			
	Experimental Techniques		Minor Projects	Major Project

before leading him on to an appreciation of the nature and use of engineering materials. Design as a separate subject is not taught but the student is made aware of the limitations on design imposed by the materials selected for fabrication and manufacture and is given the necessary background for the course in design which he undertakes in his post-degree fourth year.

Over all three years of the degree, and as a continuing activity, complementary studies are provided in a diverse range of subjects. These are aimed to broaden the student's general education and knowledge and his powers of oral and written communication.

Laboratory Work

This comprises two elements: laboratory exercises and laboratory projects. Laboratory exercises to support the lecture programme are a feature of all three years of the course. In the early semesters, they are tightly defined but as the course proceeds they give way to more open-ended laboratory work and in the final semester are mostly replaced by projects.

Projects are introduced in the second semester as well-defined practical exercises and develop through a minor project in the third semester to, in the final year, a full-scale major project which forms a significant feature of the programme.

A course in experimental techniques is provided at the start of the laboratory programme in the first semester.

TABLE III—*Typical combinations of third-year optional subjects*

Optional Subjects			*Typical Combinations*(1)						
Worth	*Title*								
Single	Electrical Power					X	X		
	Real-time Data Processing		X	X	X			X	X
Double	Applied Thermodynamics	Aero	X	X	X				
		Marine				X	X		
	Structural Dynamics			X		X			
	Mechanics of Sea and Air Vehicles	Surface Ships and Submarines					X		
		Aircraft and Missiles	X						X
	Wave Propagation and Transmission							X	
	Signal Detection							X	
	Underwater Acoustics(2)				X				X

(1) Not exhaustive.

(2) Underwater Acoustics cannot be taken with either Wave Propagation and Transmission or Signal Detection.

Honours Selection and the Tariff Scheme

For all main subjects and the project in the third year, two levels of educational difficulty are offered, either advanced or ordinary. Students select their option at one or the other of these two levels depending upon the class of honours for which they are aiming. Final degree awards are conditional both on the total marks obtained and on the levels at which subjects have been studied in the

final year. This so-called 'tariff' scheme is designed to enable the student to match his selection of third-year courses as closely as possible to his individual interests, ability, and career pattern.

To achieve first-class or upper second-class honours, a student will have to take all his third-year subjects at advanced level; for lower second-class and third-class honours he will have to take at least one double and one single third-year subject at advanced level; whilst the students aiming for a degree without honours may follow all third-year subjects at ordinary level.

Examinations at advanced level carry more marks than those at ordinary level; so students are motivated to attempt the more difficult courses because of the greater range of degree awards open to them and because of the greater total of marks to which they can aspire. Students will be given guidance on the third-year tariff best suited to their interests, abilities, and career expectations, including their choice of sub-specialization. A formal counselling procedure will ensure that every student is made aware of the range of possible options open to him and the set most appropriate to his future career and intellectual development.

Future Programme

The first students to embark on the degree in naval engineering join the College in September this year. There will, of course, be the inevitable complications arising from the overlap of the existing courses and the new, but these have been anticipated and can be overcome. The advantage of moving the first examinations from the summer to the end of the Easter term is that a firm decision on a student's future can be made that much earlier; it will also enable the summer term of the first year to be fully utilized in the classroom. Not so good for the summer sporting programme, perhaps, but inevitable in the face of the increasing amount of knowledge required of the engineering degree student today. Extensive pruning of redundant subject matter has been done but a great deal of additional material has had to be included in the new course. By adopting an integrated approach wherever possible, the course has been made to fit into three years but there is certainly only room for the essential.

No doubt, as the course unfolds, hidden difficulties will appear but hopefully these will not prove insurmountable. Manadon's new degree in naval engineering has taken a long time to prepare; it has been designed to meet the Navy's needs whilst at the same time maintaining the best in educational standards. It should serve the Navy well.

APPENDIX

SYLLABUS

MAIN SUBJECTS

Common First Two Years

Mechanical Engineering Science (first two terms)

This subject aims to introduce the students to the fundamental principles of Newtonian mechanics and the thermodynamics of solids, fluids and gases and to stress the underlying unity of these by using a thematic approach to universal conditions, principles and laws.

Electrical Engineering Science (first two terms)

Revision of fundamentals is developed into an analysis of linear circuits including multi-phase, and two-port network and simple filter theory. A unit (or block) approach to amplifiers allows investigation of negative and positive feedback leading to the generalized active device and practical amplifiers. Signals and their representation together with representation of linear systems gives an introduction to correlation and convolution as methods of signal processing.

Properties of Substances (first two terms)

In support of other subjects of the course, this subject aims to examine the fundamental characteristics of solids, liquids and gases on both the micro and macroscopic scale and thereby identify interrelationships which exist between the properties of engineering substances.

Engineering Field Theory (first two terms)

The aim of this subject is to introduce the basic concepts of engineering field theory in a unified manner thereby providing a foundation for deeper study at a later stage as required in other subjects.

Applied Mechanical Engineering (last four terms)

By applying the concepts and techniques of engineering science, this subject aims to predict and measure the behaviour of typical mechanical systems appropriate to a naval engineering environment.

Power Plant and Machines (last four terms)

The subject covers the knowledge and techniques required to analyse and simulate the performance of some mechanical and electrical machines. Methods of control and operation of commonly used electrical and mechanical machinery are studied with particular reference to construction and design details, steady state and transient response and stability criteria.

Linear Systems Analysis (last four terms)

This subject provides the basis for the analysis and design of linear, lumped-parameter systems in terms of stability, steady-state accuracy and dynamic response. Following the derivation of linear models representing simple electrical, mechanical and electro-mechanical components the simulation of composite systems using an analogue computer is discussed. The analysis of dynamic performance is considered using s-plane and frequency domain techniques, viz root locus, Nyquist and Bode plots and Nichols charts.

Signal Processing and Electronics (last four terms)

The aims of this subject are twofold. In the first place, it is designed to enable the student to design electronic circuits which will generate and process signals; in the second place, it will provide the student with the ability to assess the performance of signal processing systems.

Third Year

COMPULSORY SUBJECT

Control System Design (Single subject)

Following an analysis of the properties of sampled-data systems and the implications of such systems for on-line computer control, this subject aims to consolidate the concepts and techniques of linear systems analysis in the context of design techniques to meet performance specifications in the face of real-plant characteristics.

Optional Subjects

The student is required to choose two double subjects and one single subject from the following:

Applied Thermodynamics (Double subject)

The subject extends concepts and techniques developed in earlier years, applying them to energy and availability analyses of thermal plant and processes. The thermodynamics of reactive and non-reactive mixtures of substances are studied and also the mechanisms of heat and momentum transfer.

Structural Dynamics (Double subject)

The previously-established fundamentals of structures and vibrations are developed for the analysis and synthesis of complex systems subjected to static and dynamic loadings.

Wave Propagation and Transmission (Double subject)

The aim of this subject is to give the student an understanding of a wide range of electromagnetic and acoustic wave phenomena. The material is selected to be relevant to the understanding of the principles of telecommunications, radar and sonar engineering and to develop an ability to solve practical problems in these fields.

Signal Detection (Double subject)

This subject will extend and apply the theory developed in Signal Processing and Electronics in order to enable the student to evaluate the performance of communication systems and to design optimum receivers for the detection of signals corrupted by noise.

Underwater Acoustics (Double subject)

This subject is designed to give an understanding of the mechanisms of underwater sound propagation and reception, and of the major sources of acoustic radiation present in the sea.

Mechanics of Sea and Air Vehicles (Double subject)

The first half of this subject is intended to provide the student with a sound knowledge of the relevant fluid and rigid body mechanics applied to vehicles in air and water. The second half allows for more specialized treatment by giving an option for the application to aircraft and missiles or surface ships and submarines.

Electrical Power (Single subject)

By the employment and extension of principles taught in previous years, the operation of marine electrical power systems as a means of distributing and controlling energy is described and analysed with particular reference to the behaviour of a range of electrical machines, and to power semi-conductor devices and circuits used in their control. Representative malfunctions are identified and methods for minimizing their occurrence and effect are considered.

Real-Time Data Processing (Single subject)

This subject aims to enable the student to explain the essential features of a real-time system, to show how hardware and software may be used to construct such a system and to discuss the techniques available. The purpose of this subject is to build on the work done in the computer studies and signal processing and electronics courses during the first two years showing how the techniques, already learned, may be used and extended to satisfy the requirements of real-time computing.

SUPPORT SUBJECTS

Experimental Techniques (first term)

This subject provides students with a grounding in the principles and practice of experimental techniques, to enable them to develop effective methods for the planning and safe execution of laboratory work and its documentation throughout their course.

Mathematics (first two years)

The timing and content of the syllabus is based as closely as possible on the requirements of the other engineering subjects. Subject to this constraint, the aim is to produce an integrated course in mathematics that will also be of educational value.

Computer Studies (first two years)

This subject aims to teach concepts fundamental to the understanding of digital computers and their applications and to allow the students to gain practical experience on a variety of computing machines; to present generalized methods of simulating continuous systems in such a way that the student can appreciate the difference between analogue and digital solutions; and to discuss the hardware organization and software requirements of digital computers.

Engineering Drawing (first year)

Engineering drawing is a primary means of communication for the engineer. This subject introduces the conventions, practices and techniques of engineering drawing and develops the ability to visualize between two and three dimensions. Practical work enables basic skills in formal and freehand engineering drawing appropriate for an engineer to be acquired.

Engineering Materials and Design (second and third years)

The subject aims to develop a rigorous treatment of the principles and philosophy of materials and to explain the microscopic and macroscopic properties of materials in terms of their structures.

Complementary Studies (all three years)

The aim of this subject is to encourage the student to acquire information in areas outside engineering science; to provide opportunities for clear expression in speech and in writing and to encourage him to make value judgements in a variety of non-scientific subjects.