Unit 212 Design and operation of marine vehicles

Unit summary

This unit is about the process of design of marine vehicles, including ships and offshore units, and their propulsion and auxiliary systems. It also includes the dynamic behaviour of marine vehicles subject to a variety of external and internal excitations plus materials and joining techniques in the marine environment.

Aims

The unit aims to equip the candidate with the knowledge and analytical skills required for involvement in marine engineering.

Prerequisites

It is expected that candidates will have a working knowledge of the materials in the four compulsory papers of the Certificate examination and with other material as set out in the syllabus for subject 9107-105 Mechanical and structural engineering.

Learning outcomes

There are **four** outcomes to this unit. The candidate will be able to:

- Determine appropriate dimensions, masses, propulsive power and auxiliary systems for a marine vehicle to satisfy a set of owners' requirements
- Analyse the operational dynamics of marine vehicles and justify their acceptability against appropriate criteria
- Select, and justify the selection of, appropriate materials for manufacturing marine vehicles and techniques or joining these materials
- Describe the effects of economic, regulatory and safety considerations on the characteristics of marine vehicles.

Guided learning hours

It is recommended that 300 hours should be allocated for this unit. 120 of those hours are actual taught hours. This may be on a full time or part time basis.

Key Skills

This unit contributes towards the Key Skills in the following areas:

N4.1

Develop a strategy for using application of number skills over an extended period of time.

N4.2

Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required in work involving:

- deductive and inferential reasoning;
- algebraic manipulation.

N4.3

Evaluate your overall strategy and present the outcomes from your work, including use of charts, diagrams and graphs to illustrate complex data.

PS4.1
Develop a strategy for using skills in problem solving over an extended period of time.

PS4.2
Monitor progress and adapt your strategy, as necessary, to achieve the quality of outcomes required when tackling **one** complex problem with at least three options.

PS4.3
Evaluate your overall strategy and present the outcomes from your work using a variety of methods.

Occupational Standards
This unit has been mapped to the following National Occupational Standards:

1.1.1 Identify the requirements of clients for engineering products or processes
1.1.2 Produce specifications for engineering products or processes
1.2.1 Identify and define areas of research
1.2.2 Develop a research methodology
1.2.3 Propose and specify research into engineering products or processes
1.3.1 Undertake research into engineering products or processes
1.3.2 Evaluate the results of research
1.4.1 Establish a design brief for engineering products or processes
1.4.2 Develop a strategy for the design process
1.4.3 Create designs for engineering products or processes
1.4.4 Evaluate designs for engineering products or processes
2.1.1 Determine the production requirements of engineering products and processes
2.1.2 Specify production methods and procedures to achieve production requirements
3.1.1 Determine the installation requirements for engineering products or processes
3.1.2 Specify installation methods and procedures to achieve installation requirements
3.2.2 Solve installation problems with engineering solutions
4.1.1 Determine the operational requirements of engineering products or processes
4.1.2 Specify operational methods and procedures to achieve operational requirements
4.3.2 Evaluate operational processes
6.1.1 Analyse the risks arising from engineering products and processes
6.1.2 Specify methods and procedures to reduce risks
6.2.1 Assure the quality of engineering products or processes
6.2.2 Identify the reasons for quality assurance problems
7.1.1 Develop objectives for projects
7.1.2 Plan the delivery of projects
7.2.3 Evaluate projects
8.1.1 Maintain and develop own engineering expertise

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Outcome 1 Determine appropriate dimensions, masses, propulsive power and auxiliary systems for a marine vehicle to satisfy a set of owners' requirements

Knowledge requirements
The candidate knows how to:

1 recognise and apply components of the design process
   - a iteration
   - b synthesis
   - c optimisation

2 assess owner's requirements and prepare specifications

3 review preliminary ship design methods and determine dimensions for mass limited and space governed designs
   - a mass groups
   - b capacity
   - c stability
   - d powering estimations

4 assess the limitations of basis ship and regression based methods

5 select form coefficients and position of Longitudinal Centre of Buoyancy (LCB)

6 use computer aided ship design software for
   - a hull generation
   - b curve fitting
   - c fairing

7 incorporate structural requirements in the design of marine vehicles
   - a understand longitudinal strength calculations
   - b appreciate the influence of longitudinal strength considerations on various ship types
   - c recognize limitations on length/depth ratio

8 appreciate torsional strength problems in
   - a bulk carriers
   - b container ships

9 assess offshore vehicle design including the naval architecture of principal types of offshore vehicle with particular reference to stability

10 select main and auxiliary power systems taking account of thermodynamic cycles and other characteristics of the prime movers, singly and in combination

- a diesel
- b steam
- c gas turbines
- d electric motors

11 match machinery to

- a vessel operational profile
- b hull resistance
- c propeller

12 assess methods of waste energy recovery

13 assess electrical plant

- a load distribution
- b management
- c control of electric propulsion

14 assess the design and operation of control systems 3-term controllers

15 appraise fuel and lubricating oil management

- a specification
- b quality
- c purchase and storage
- d testing and treatment

16 describe the combustion process for oil

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Outcome 2 Analyse the operational dynamics of marine vehicles and justify their acceptability against appropriate criteria

Knowledge requirements
The candidate knows how to:

1 analyse wave and sea states
   - a properties of regular waves
   - b characteristics of irregular waves
   - c long and short crested seas
   - d properties of sea spectra
   - e definition of sea state
   - f encounter spectra

2 analyse rigid body motions leading to natural frequencies
   - a simple uncoupled solutions for
     - i roll
     - ii pitch
     - iii heave
   - b added mass and damping terms
   - c magnification factor
   - d phase relationships
   - e curves of extinction

3 analyse response amplitude operators
   - a definition
   - b determination by experiment
   - c application of strip theory

4 analyse ship motion spectra

5 investigate operational conditions of marine vehicles in relation to
   - a human tolerance limits
   - b speed loss in waves
   - c slamming
   - d wetness
   - e drilling and helicopter restrictions

6 analyse motion reduction systems
   - a passive
   - b active

7 understand marine vehicle manoeuvring

- a steering and turning
- b angle of heel while turning
- c rudder types and steering gear
- d stopping
- e dynamic positioning systems

8 analyse marine vehicle vibrations

- a types of vibration experienced by
  - i hull girder
  - ii local structure
  - iii systems
    - A rudders
    - B shafts
    - C brackets
    - D machinery
- b sources of excitation
  - i waves
  - ii propellers
  - ii machinery
- c prevention and cure
  - i resonance avoidance
  - ii damping
  - iii effect of local stiffening

9 estimate the natural frequencies of free-free beams

- a virtual mass
- b shear and rotational effects
- c energy
- d deflection
- e approximate methods for fundamental vertical mode
- f higher modes

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Outcome 3 Select, and justify the selection of, appropriate materials for manufacturing marine vehicles and techniques or joining these materials

Knowledge requirements
The candidate knows how to:

1 determine the requirements of marine materials
   - a mechanical properties
   - b constructional aspects
   - c economic aspects

2 review currently available materials for marine vehicles
   - a steels
   - b light alloys
   - c fibre reinforced composites

3 review currently available materials for the offshore industry

4 appraise fabrication and joining techniques
   - a weldability
   - b types of weld
   - c weld testing
   - d detrimental effects of welding on fatigue life

5 understand general principles of structural detailing
   - a continuity
   - b stress concentration avoidance
   - c classification society requirements
   - d corrosion margins

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Outcome 4 Describe the effects of economic, regulatory and safety considerations on the characteristics of marine vehicles.

Knowledge requirements
The candidate knows how to:

1 evaluate the criteria governing the economic operation of marine vehicles
   - a required freight rate
   - b net present value
   - c yield
   - d permissible price

2 evaluate the economic factors influencing selection of
   - a ship size
   - b ship speed
   - c machinery
   - d type

3 appreciate the role of IMO, government agencies and classification societies in the regulatory and statutory aspects of, for example, crew accommodation, fire protection & life saving appliances

4 appreciate the role of safety management systems and outline reliability concepts

5 describe environmental management related to marine vehicles
   - a statutory regulations
   - b strategies to manage
     - i solid discharges
     - ii liquid discharges
     - iii gaseous discharges

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Recommended reading list

Core texts	Author(s)	Publisher	ISBN
Basic Ship Theory, Vol. 1	Rawson &Tupper	Butterworth-Heinemann	0750653965
Basic Ship Theory, Vol. 2	Rawson & Tupper	Butterworth-Heinemann	0750653973
Elements of Shipping Branch	Nelson	Thornes	0412604604
Introduction to Naval Architecture	Tupper	Butterworth-Heinemann	0750625295
Principles of Naval Architecture, Vol. 1	Lewis (Ed.)	SNAME	0939773007
Principles of Naval Architecture, Vol. 2	Lewis (Ed.)	SNAME	0939773015
Principles of Naval Architecture, Vol. 3	Lewis (Ed.)	SNAME	0939773023
Ship Design and Construction, Vol. 1	Lamb (Ed.)	The Society of Naval Architects	0939773406
Ship Design and Construction, Vol. 2	Lamb (Ed.)	The Society of Naval Architects	0939773414
Ship Design for Efficiency and Economy	Schneekluth, Bertram	Butterworth-Heinemann	0750641339
Marine Engineering	Harrington (Ed.)	Society of Naval Architects & Marine Engineer	0939773104
Other useful texts			
Marine Technology Reference Book	Morgan (Ed.)	Butterworth-Heinemann	0408027843 o/p
Ship Structural Design	Hughes	The Society of Naval Architects and Marine Engineers	0939773104
Mechanics of Engineering Materials	Benham, Crawford, Armstrong	Pearson Educational	0582251648
Introduction to Marine Engineering	Taylor	Butterworth-Heinemann	0750625309
Marine Auxiliary Machinery	McGeorge	Butterworth-Heinemann	0750643986
Ship Construction	Eyres	Butterworth-Heinemann	0750648872
Offshore Engineering - An Introduction	Mather	Witherby & Co	1856091864