

INDIAN MARITIME UNIVERSITY

SECOND YEAR

SEMESTER – IV

UG/MS/MS/T/1401	TERRESTRIAL & COASTAL NAVIGATION PAPER - 2 UG22T2401	72 hrs.
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Theory : 50 Marks

SECTION –A (COASTAL NAVIGATION) [45 Hrs]

Unit 1 : GEOGRAPHICAL AND TOPOGRAPHICAL KNOWLEDGE

Elementary Knowledge of Passage Planning and its execution. Landfall in thick and clear weather. The selection of a suitable anchorage.

Unit 2 : TIDES

To find the time and height of high and low water at Standard Ports. The use of Admiralty Tide tables and tidal curves, correction to be applied to soundings or charted heights of shore objects.

Unit 3 : NAVIGATION CHART

The interpretation of a chart or plan, wrt Lights, Buoys, Radio Beacons and other Navigational Aids. Depths and height contours. Traffic lanes and separation zones. Recognition of the coast and radar responsive targets, Chart correction.

Unit 4 : RANGE OF LIGHTS

Geographical Range, Luminous Range, Nominal Range; and their significance.

Unit 5 : ELECTRONIC CHART

Development of electronic Chart display system, under ECDIS modular courses.

SECTION – B (TERRESTRIAL NAVIGATION)

[27 Hrs]

Unit 6 : PLANE & PARALLEL SAILING

Practical problems on parallel sailing using formulae.

Practical problems on plane sailing using formulae.

Unit 7 : RHUMB LINE SAILING

Practical problems on Mercator sailing using formulae.

Unit 8 : DAYS WORK

The use of Transverse Tables to obtain the position of the ship at any time, given compass course, variation, deviation, and the run recorded by the log or estimated speed or engine speed allowing for the of wind and current, if any. Day's work.

PRACTICAL

Code No. : P1401

Practical : 36 hrs.

COASTAL NAVIGATION

- (1) To determine ship's position by the 'Running Fix' method with and without current.
- (2) To find the ship's position by 'Doubling the angle on the Bow' method
- (3) The use of a station pointer to plot ships position - given two horizontal angles.
- (4) Fixing the position of a ship using bearings obtained from a D.F. set. Conversion of DF bearing to Mercator bearing
- (5) To find course made good using the three point bearing method.

[at least 4 tasks to be performed]

COASTAL :

- (1) Practicals of first Year pertaining to Position fixing by various methods, current & Leeway.
- (2) Running fix and three-point bearing, using transfer of Position circle, rising / dipping and the use of hyperbolic charts, to a higher degree. to find course made good
- (3) Demonstration of the ability to plan a passage taking into consideration important factors such as depth of water, distance off dangers. current, traffic separation, schemes. navigation aids available, etc.

NOTE :

- 1) There will be continuous assessment of skills being acquired through class-work, practicals and periodic assignments / project works / tests / orals etc.
- 2) Laboratory journal to be submitted at the end of each term for assessment .

BOOKS RECOMMENDED FOR REFERENCE:

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| 1. Principles of Navigation | : Capt.P.M.Sarma. |
| 2. Principles of Navigation | : CaptJoseph and Capt.Rewari |
| 3. Principles & Practices of Navigation | : Capt. S. Panda |
| 4. Practical Navigation | : Capt.H.Subramaniam |
| 5. Admiralty Manual of Navigation Vol. I & II. | |
| 6. Navigation | : Frost A. |
| 7. Nicholl's Concise Guide Vol. I & II. | |
| 8. Nutshell Booklet on Sextant. | : Capt. H. Subramaniam |
| 9. Chartwork | : Capt. S. S. Chaudhari |
| 10. Capt. S.K.Puri | : Chartwork |
| 11. Squair | : Modem Chartwork |
| 12. Capt.M.V.Naik & Capt.Warty | : Voyage Planning & Chartwork |
| 13. Moore, D.A. | : Marine Chartwork |

INDIAN MARITIME UNIVERSITY
SECOND YEAR
SEMESTER – IV

UG/MS/MS/T/1402	MARINE AUXILIARIES PAPER - 2 UG22T2402	72 hrs.
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Theory – 50 marks

Unit 1 : Oil treatment

Theory of oil purifications, various methods of oil purifications, various type of filters , micro filters , types of marine filters, auto-cleaner and Duplex filters, Static filters. Priming and core maintenance of filters, batch purification & by- pass purification principles of operation and construction of different Centrifuges for heavy fuel and lubricating oil, Self de-sludging purifier , ALCAP system etc , automation of purifiers, operation and maintenance , trouble shooting. Uses of Homogenizers. Use of settling & service tanks. Receiving, and transfer arrangements of fuel. Precautions and procedures before, during and after bunkering.

Unit 2 : Fresh water generation

Vacuum evaporators, Construction and Operation of different types of evaporators. Fresh Water generators and distillers. Conditioning arrangements of distilled water for drinking, hydrophore system. Reverse osmosis type equipment, advantages/ disadvantages, operation and maintenance; salinity monitoring; sterilisation of water.

Unit 3 : Shafting, propellers and rudder

Nomenclature of the parts of the shafting system. Design considerations for thrust shaft, intermediate shafts and propeller shaft. Study of thrust block. Adjustments; stern tube bearing; intermediate and propeller shafts and bearings; shaft alignment; checking shaft alignment ; muff coupling, stern tube lip seals, radial face seals. Propeller nomenclature; Types of propellers. Inspection and repairs of propeller and rudder; removal and refitting of propeller. Inspection & testing of rudder & it's bearings.

Unit 4 : Steering gears

Operation and Constructional details of various types of steering machinery. Telemotor systems, transmitters and receivers Variable Delivery Pumps used in steering gears, axial and radial displacement types. Hunting action of Steering gear. Emergency Steering arrangement. Safematic Steering Gear with redundancy concept as per SOLAS. Care and Maintenance of Steering Gear Plants, Stabilizers: Working principle and brief description of fin and tank type stabilizers.

Unit 5 : Dry Docking

Periodicity. Necessity. Methods of dry docking; precautions before and after flooding, docking Inspection and routine overhauling of under water fittings. testing of anchor chains.

Unit 6 : Engine Room Working Equipment

Engine room cranes, safety requirements and precaution for operations, various lifting gears used in engine & their maintenance, testing and survey requirements for the same.

Deck machinery :- Deck cranes, Cargo winches, mooring winches, capstan, towing machines, anchor windlass, machineries used for as cover operation, Water-tight doors.

Unit 7 : Fire Prevention & Fire fighting

Theory of Fire , Fire Fighting Equipment Fixed Fire fighting Systems , Fire Detection system and Safety Systems , Fire protection & Ship construction. Fire Fighting Methods , Fire Fighting Organization on ships.

PRACTICAL

Code No. : P1402

Practical : 36 hrs.

1. Disassembly of the cylinder head of a two stage compressor after isolating the system. Dismantling of one unit of the compressor including the suction and delivery valves. Identification of the parts and their defects, rectification of defects, recording of inspection. Re-assembly of the equipment to original condition.
2. To study operation of heleshaw pump
3. To study operation of ram type electro hydraulic steering gear .
4. To operate and study vane type electro hydraulic steering gear .
5. To study construction and working of Refrigerating compressor and refrigerating system.
6. To dismantle reciprocating pump study operation and all components identification of defects and their rectification.
7. Alignment of pump with motor .
8. Dismantle clean and study operation oily water separator .
9. To carryout dismantling of a unit (isolating the cylinder unit, removing the cylinder head and mountings, removing the piston/connecting rod assembly of a medium or high speed engine. Clean all parts and assemble for operation . Prepare a list of defects observed during the overhaul work, understanding.
10. To disassemble a fuel pump, furnish a report of inspection and assemble the pump.
11. Measure the diameter of the cylinder liner, and gauge the piston ring grooves and piston rings.
12. Adjust the tappet clearance.

13. Study air starting valve of 2- Stroke engine
14. Study relief valve of a two stroke engine .
15. Study stuffing box of a two stroke engine .
16. Study components of a fuel injector .
17. Trace L.O system of a diesel engine .
18. Start a diesel engine and study the performance .

NOTE :

- 1) Evaluation is on a continuous basis during the practical, on the ability to carryout the above tasks competently with demonstration of safe techniques.
- 2) Workshop journal to be maintained and submitted at the end of each term for assessment .
- 3) At least 16 tasks to be completed by each student .

RECOMMENDED BOOKS :

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| 1) The running and Maintenance of Marine Machinery | J. Cowley |
| 2) Marine Auxiliary Machinery | H. D. McGeorge |
| 3) Introduction to Marine Engineering | Taylor D. A |
| 4) Reed's General Engineering for engineers, Vol - 8 | Thomas Reeds publications Ltd . |
| 5) Basic marine Engineering, | J. K. Dhar |

INDIAN MARITIME UNIVERSITY

SECOND YEAR

SEMESTER – IV

UG/MS/MS/T/1403	SHIP CONSTRUCTION, NAVAL ARCHITECTURE (STABILITY), SAFETY AND ENVIRONMENTAL PROTECTION PAPER - 2 UG22T2403	72 hrs.
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Theory – 50 marks

SECTION – A (SHIP CONSTRUCTION)

[36 hrs]

Unit 1 : Shell & Decks

Plating systems for shells, Deck plating & Deck girders, discontinuities like hatches and other openings, supporting & closing arrangements, Water tightness of hatches, opening in oil tankers, mid-ship Section of ships.

Unit 2 : Bulk heads & Deep Tanks

Frames and their functions, Construction of double bottom, types of keel, function of deck beams and girders; Bulkheads, subdivision bulkheads, “Margin of Safety line”, Cofferdams. Water tight bulkheads, Arrangements of plating and stiffeners. Water tight sliding doors, Water tight openings through bulkheads for electric cables pipes and shafting. Deep tank for oil fuel or oil cargo corrugated bulk heads ; sounding and air pipes.

Unit 3 : Fore-End Arrangements

Stem construction, arrangements to resist panting, panting stringers, Forepeak - Collision bulk heads. Bulbous bows. Anchor and cable arrangements. chain lockers, and attachments of cables,

Unit 4 : After-End-Arrangements

Types of Sterns, Stern frame and rudder. Types of rudder. Supporting of rudder, Locking pintle, Bearing pintle, Pallister bearing, stern frame of twin screw ship, Shaft tunnel & it's watertightness, Tunnel bearings, Kort nozzle, fixed nozzles, nozzle rudder, tail flaps .

SECTION – B (NAVAL ARCHITECTURE)

[10 hrs]

Unit 5 : Longitudinal Stability and trim

Longitudinal GM, MCTI , change of L.C.B. with change of trim, Change of trim due to adding or deducting weights, change in draft & trim because of filling/flooding several tanks with different densities, Change in draft due to change in density, Flooding calculations, Floodable length curves, determination of floodable lengths, factors of subdivision, Loss of stability due to grounding, Docking stability, Pressure on chocks.

Unit 6 : Cargo loading & Stability

Solve various numerical problems related to loading of different types of cargo and effect on strength , stability of the vessel .

SECTION – C (SAFETY & ENVIRONMENT PROTECTION)

[26 hrs]

Unit 7 : SOLAS

International convention on load lines 1966, SOLAS 1974 as amended, SOLAS - Subdivision stability, SOLAS - Fire Protection, Detection and Extinction, SOLAS - LSA, SOLAS - Radiotelegraphy and R/T, SOLAS - Radio communications, SOLAS - Carriage of Grain, SOLAS - Carriage of Dangerous goods, STCW-1995, ITU Radio Regulations, STP Agreements 1971, SPACE STP, 1973, PAL-1974 and Tonnage 1969, ISPS code .

Unit 8 : Operation of Life Saving Appliances

Life Saving : Abandon : ship drills and knowledge of operation of survival craft and rescue boats, their launching appliances and arrangements and their equipment including radio, life saving appliances, satellite EPIRBs, SARTs, immersion suits thermal protective aids and survival techniques. Knowledge of Codes of Safe Working Practices, Knowledge of Type of Information issued by the Director General of Shipping with regard to Safety at Sea .

Unit 9 : Control of emissions from ships

NOx code ,Limit of SOx , NOx in exhaust , Nox technical file , Pollution by VOC , Pollution by ozone depleting substances , CFC , Montreal Protocol , emission from incinerators , documents to be carried as per MARPOL annex – IV .

Unit 10 : Other sources of pollution

Prevention of pollution by sewage : Surveys of equipment, discharge of sewage, exception, reception facilities and standard discharge connections;

Prevention of pollution by garbage : Knowledge of Garbage management system. Garbage Record Book, Special requirements for Disposal of Garbage, Disposal of garbage within special areas and outside special areas, Exceptions; Reception facilities . Pollution by ballast water , management of ballast water , Pollution by antifouling paints . Carriage of chemicals in packaged form , Procedure and arrangements for chemical carriers, record book for chemical cargoes.

PRACTICAL

Code No. : P1403

Practical : 36 hrs.

- 1) Prepare oil record book with typical entries .
- 2) Training on OMDSS and oily water separator .
- 3) Film on various annexures of MARPOL .
- 4) Familiarisation various life saving appliances .
- 5) Solve practical stability problems on various types of ships [20 hrs]

RECOMMENDED BOOKS :

- 1) Derrett : Merchant ship stability for Masters & mates
- 2) Taylor : Ship Construction
- 3) Eyerer : Ship Construction
- 4) Kemp & Young :Ship Construction
- 5) Reeds : Ship Construction for Marine students
- 6) Naval Architecture :Munro & Smith .
- 7) Kemp & Yong :Notes on Stability
- 8) La Dage & Gemert :Stability
- 9) Capt. Lester :Stability for Merchant Ships
- 10) Capt.H. Subramaniam:Ship Stability I, II, III
- 11) Capt. Joseph & Capt. Rewari : Problems on Hindship

INDIAN MARITIME UNIVERSITY

SECOND YEAR

SEMESTER – IV

UG/MS/BS/T/1404	FLUID MECHANICS	72 hrs.
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UG22T2404

Theory – 50 marks

Unit 1 : Fluid in Motion

Energy of flowing fluid, pressure energy, potential energy, kinetic energy total energy; Bernoulli's Equation for steady motion; Variation in pressure head along a Pipe. Discharge through a small orifice under a constant head; Co-efficient of discharge for a small orifice, Experimental determination of orifice co-efficient. Measurement of Pipe flow rate by venturi-meter, Time required to empty reservoirs of various shapes flow from one reservoir to the other reservoir; Inflow and outflow.

Unit 2 : Flow through Pipes

Losses of pressure & energy in pipe lines; derivation of Darcey's and Chezy's formula; Losses due to sudden increase in Pipe diameter, losses due to sudden contraction in diameter, friction losses in transmission of Power by Pipe line; Condition for maximum power transmission, Shock losses, Turbulent & Parallel flow through pipes, Reynold's number.

Unit 3 : Power of a jet

Force exerted by a jet normal to a stationary or a moving flat vane; Jet inclined to a stationary or moving flat vane, Impulse and Reaction turbines : Pelton Wheel : Inward flow reaction turbine; Efficiency and vane angles, vane speed and head lost in runner, Specific speed

Unit 4 : Fluid Friction

Viscous and Laminar Flow : Resistance co-efficient, variation of resistance co-efficient with Reynold's number; oiled bearings .Viscous flow; Flow between parallel planes; Critical velocity; Viscous flow in pipes, Power required for viscous flow,

Unit 5 : Two dimensional flow

Theory, forced vortex, free vortex, Radial flow free spiral Vortex Motion & Radial Flow: Real & Ideal Fluid flow : Steady & unsteady Vortex & Compound Vortex. Illustrative problems related with centrifugal pumps and separators.

Unit 6 : Axial Flow Compressor

Principle of centrifugal compression and pressure rise in centrifugal compressor, change in Angular Momentum. Pre-whirl and pre-whirl vanes. Mach number at inlet to a centrifugal compressor, slip and slip factor, multi-stage centrifugal compressor.

Unit 7 : Dimensional analysis

Dimensional Analysis & Dynamical Similarity : Dimensions of common quantities; Dimensions equations; Use of Dimensions for finding dynamical similarity problems. Method of Finding dimensionless groups; Froude number, Reynold's number, Geometrical and dynamical similarity, application to naval architecture Non-dimensional performance characteristic of roto-dynamic machinery . Detailing of characteristics.

Unit 8 : Reciprocating Pumps

Various types, single and double acting, single and multi cylinder, Co-efficient of discharge; Theoretical indicator Diagrams; Effect of acceleration and friction; Use of air vessel .

Unit 9 : Centrifugal Pump

Calculations of various heads; Losses and Efficiency, Work done per unit weight Dimensions of Impellers; Velocity diagrams at inlet and exit; Calculation for power & output; Torque on shafts, Cavitations in Centrifugal pumps. NPSH , Specific speed .

PRACTICAL UG22T2404

Code No. : P1404

Practical : 36 hrs.

01. Study flow through orifice .
02. Study flow through pipes .
03. Study flow through open channel .
04. Study function of a ventury and co-relate to Bournauli's theorem .
05. Study effect of a pitot tube .
06. Calculate GM of a floating body .
07. Carryout experiment on Cavitation Test Rig and evaluate.
08. Carryout experiments on Mitchell tilting pads bearing test rig.
09. Carryout experiments on Journal bearing test rig .
10. Operate Hydraulic Circuit Trainer and study the system components and their functions.

NOTE :

- 1) There will be continuous assessment of skills being acquired through class-work, practical and periodic assignments / project works / tests / orals etc.
- 2) At least 8 experiments must be undertaken by every student .
- 3) Laboratory journal to be submitted at the end of each term for assessment .

RECOMMENDED BOOKS :

1) Fluid Mechanics (Part I & II)

J. F. Douglass

INDIAN MARITIME UNIVERSITY

SECOND YEAR

SEMESTER – IV

UG/MS/MS/T/1405	FIRE PREVENTION & FIRE FIGHTING	72 hrs.
	UG22T2405	

Theory – 50 Marks

SECTION – A (FIRE PREVENTION) [36 Hrs]

Unit 1 : Theory of Fire

Fire hazard and spread of aboard ships; conditions for fire: Fire triangle, Fire Tetrahedron, Properties of flammable material : Fire-chemistry, Spontaneous Combustion, Limits of inflammability ; Classes of fire, Control of Class A, B, C & D fires, various fire fighting agents and their effect on fire. Advantages of various fire extinguishing agents including vaporizing fluids and their suitability for ship's use, Combustion products & their effects on life safety.

Unit 2 : Fire Fighting Equipment

Fire pumps & specification as per SOLAS, hydrants and hoses, Couplings, nozzles and international shore connection, Construction, operation and merits of different types of portable fire extinguishers, Properties of Chemicals used,. Fireman's outfit, its use and care. Maintenance, testing and recharging of appliances. Preparation, Fire appliance Survey. Breathing apparatus types, uses, principle ; Resuscitation apparatus , Fire blankets .

Unit 3 : Fire Detection system and Safety Systems

Fire safety precautions on cargo ships and tankers during working. Types of detectors, Selection of fire detectors and alarm systems and their operational limits. Commissioning and periodic testing of sensors and detection system. Description of various systems fitted on ships. Fire alarm .

Unit 4 : Fire protection & Ship construction

SOLAS convention, requirements in respect of materials of construction and design of ships, (class A, B, type bulkheads), fire detection and extinction systems, Fire test, escape means, electrical installations, ventilation system; fire dampers, venting system for tankers. Statutory requirements fire fighting systems and equipments on different vessels, fire doors & fire zones.

SECTION – B (FIRE FIGHTING) [36 Hrs]

Unit 5 : Fixed Fire fighting Systems

CO₂ flooding system for engine room and cargo holds ,Bulk Carbon Di-Oxide and inert gas systems, maintenance of fixed system and survey ; Sprinkler system, High pressure Water-mist Fire suppression system. Emergency fire pump and related rules.

Unit 6 : Fire Fighting Methods

Action required and practical techniques adopted for extinguishing fires in accommodation, machinery spaces, boiler rooms, Cargo holds galley, etc .Fire fighting in port and dry dock. Procedure for re-entry after putting off fire, Rescue operations from affected compartments. First aid,

Unit 7 : Fire Fighting Organization on ships

Shipboard organization for fire and emergencies. Combustion products and their effects on Life safety. Fire signal and muster. Fire drill. Leadership and duties, Fire control plan, Human behaviour & communication, Special precautions for prevention/fighting fire in tankers, chemical carriers, Gas carriers, Chemical carriers. Safe working practice.

FIRE CONTROL LABORATORY (FIRE PREVENTION)

1. Study and use fire hoses.
2. Study and use of operation of Jet and spray type nozzles
3. Study Soda acid type/ CO₂ water type portable fire extinguishers
4. Study Foam type portable fire extinguishers
5. Study Dry powder type portable fire extinguishers
6. Study of portable CO₂ fire extinguisher .
7. Study bellows type Breathing apparatus.

8. Study self contained Breathing apparatus.
9. Study fireman's outfit .
10. Study CO2 flooding system .

PRACTICAL

Code No. : P1405

Practical : 36 hrs.

UG22P2405

FIRE CONTROL LABORATORY (FIRE FIGHTING)

1. Study and operate fire detection system
2. Operate fire pump and extinguish fire by use of jet and spray type nozzles
3. Operation, charging and maintenance of Soda acid / CO₂ water type portable fire extinguishers
4. Operation, charging and maintenance of Foam type portable fire extinguishers
5. Operation, charging and maintenance of Dry powder type portable fire extinguishers
6. Operation, use and functions of bellows type Breathing apparatus.
7. Operation, use and functions of self contained Breathing apparatus.
8. Study and use of fireman's outfit .
9. Rescue operation .
10. Operate CO₂ flooding system for extinguishing hold and accommodation fire .
11. Organise fire drill for fighting ship's fire [To be conducted in approved rig]

NOTE :

- 1) All the practical activities are to be carried out using appropriate tools.
- 2) Evaluation is on a continuous basis during the practical, on the ability to carryout the above tasks competently with demonstration of safe techniques.
- 3) Laboratory journal to be submitted for assessment at the end of each term .
- 4) At least 9 tasks/ experiments to be completed by each cadet/student

RECOMMENDED BOOKS :

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|--|---------------------------------|
| 1) The running and Maintenance of Marine Machinery | J. Cowley |
| 2) Marine Auxiliary Machinery | H. D. McGeorge |
| 3) Marine Engineering Practice | IME |
| 4) Reed's General Engineering for engineers, Vol – 8 | Thomas Reeds publications Ltd . |
| 5) SOLAS | IMO |
| 6) Fire Safety at Sea | Dr James Cowley |

INDIAN MARITIME UNIVERSITY

SECOND YEAR

SEMESTER – IV

UG/MS/MS/T/1406	MOTOR ENGINEERING KNOWLEDGE PAPER – 3 UG22T2406	54 hrs.
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Unit 1 : Medium speed engines

Medium Speed Engines : Different types of medium speed marine diesel engines, Special references wrt engine components . Development in exhaust valve design, V-type engine details. safety devices; control; maintenance; remote operations; coupling engine to transmission – slip coupling; elastic coupling ; reduction gear for variable pitch propeller. diesel electric considerations. Use of poor quality residual fuels and their consequences. Improvements in designs for higher power output,

Unit 2 : Starting & Reversing System

Starting and reversing systems of different Marine Diesel engines (like MAN-B&W , Sulzer) with safety provisions. Emergency starting , interlocks .

Unit 3 : Operation of the diesel engines

Preparations for starting the engine; Starting the engine; checks during normal operations; instructions concerning overload operation; instructions concerning manoeuvring; running at minimum speed; operation in heavy seas; instructions concerning the cutting out of individual cylinders;

instructions concerning the operation of defective turbocharger; safety measures to be taken before overhaul.

REFERENCE BOOKS:

J.K.Bowden; Sothern's Marine Diesel Oil Engines. Revised ed.
James Munro & Company Ltd., Glasgow.

C.C.Pounder; Marine Diesel Oil Engines, Newnes-Butterworth, London.

J.Cowley ; The running and Maintenance of Marine Machinery, the
Institute of Marine Engineers, London.

D.A.Taylor: Introduction to Marine Engineering, Butterworth-
Heinemann, Oxford. 1996.

Jackson.L and Morton T. D., Reed's General Engineering Knowledge for
Engineers

(vol. 8), Thomas Reed Publication, London.

D. K. Sanyal - Marine Diesel Engines

INDIAN MARITIME UNIVERSITY

SECOND YEAR

SEMESTER – IV

UG/MS/MS/T/1407	CELESTIAL NAVIGATION PAPER - 2 UG22T2407	54 hrs.
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Theory - 75 Marks

Unit 1 : POSITION LINES

Terrestrial Position Lines, Position circle, Transferred PL, Position Line from Celestial Observation ,Astronomical Position lines, Latitude by Meridian Altitude, Circumpolar bodies Observation of Celestial bodies off the meridian ,Noon position ,Ex Meridian Sights, Polaris sights, Errors in position Lines. Azimuths and amplitudes; Derivation of formula: $\sin \text{amp} = \sin \text{decl} \times \sec \text{lat}$. Apparent altitudes of sun, Moon at time of theoretical rising or setting.

Rising, culmination and setting of heavenly bodies To find time of meridian passage, sunrise, sunset, moon rise and moon set by calculation and by perusal of nautical almanac with Appropriate corrections. Principles of position lines. Geographical position, circle of position, why P/L is at right angles to the azimuth – exceptions position to draw the P/L – intercept method; longitude by chronometer method and Ex – meridian method. Effect of change of Dr Position on position fir P/L and practical applications.

Unit 2 : NAUTICAL ALMANAC

Information in Nautical Almanac and using it for celestial observation.

Unit 3 : RISING SETTING OF CELESTIAL BODIES AND TWILIGHT

Twilight, Theoretical Sunrise and Sunset ,Moonrise and Moon set

Unit 4 : CALCULATIONS IN NAUTICAL ASTRONOMY

Simple calculations based on (1) to (8) above.

BOOKS RECOMMENDED FOR REFERENCE:

1. Principles of Navigation : Capt. P. M. Sarma.
2. Principles of Navigation : Capt Joseph and Capt.
Rewari
3. Principles & Practices of Navigation : Capt. S. Panda
4. Practical Navigation : Capt. H. Subramaniam
5. Admiralty Manual of Navigation Vol. I & II.
6. Nicholl's Concise guide Vol- I & II
7. Navigation : Frost A