SEMESTER -3

SBT201	INTRODUCTION TO NAVAL ARCHITECTURE	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The objective of the course is to provide the learners with a broad appreciation of the science and art of Naval Architecture. Emphasis is given to define the subject in physical rather than mathematical terms. The learners would be able to grasp a clear understanding of the underlying principles involved, laying in the process the foundations, for more in depth studies in future.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Discern the role of the Naval Architect in the maritime industry.
CO 2	Explain various types of ships, and of fundamentals of Naval Architecture, that would equip one to define hull forms geometrically, and represent them as line plan drawings.
CO 3	Apply the procedures of numerical integration to calculate hydrostatic properties, and plot sectional area curves, Bonjean curves, and hydrostatic curves.
CO 4	Explain the concept the of weight and buoyancy of a ship, and of the various types of materials used for construction of maritime structures, and identify various major and minor structural components of a ship.
CO 5	Discern the general arrangement of propulsion plants, and of the various auxiliary machinery, required for efficient operation of a ship.
CO 6	Explain the various machineries/ equipment, anchoring, mooring and towing operations.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3		1								1	
CO2	3	1	1		3							
CO3	3	3	1		3							
CO4	2	1	1									
CO5	2		1		1							
CO6	2		1									

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	30
Understand	30	30	40
Apply	10	10	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions, with 3 questions from each module, having 3 marks each. Students should answer all questions. Part B contains 3 questions from each module, of which the student should answer any 2. Each question can have maximum 4 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the job responsibilities of a Naval Architect?
2. Explain the role of a Naval Architect in the maritime industry.
3. Elucidate the job responsibilities of a Naval Architect and of a Marine Engineer.
4. Certain areas are difficult to be classified, or categorised, as being the 'sole', 'exclusive', province of either a naval Architect, or a Marine Engineer. Explain.

Course Outcome 2 (CO2):

1. With the aid of a neat sketch, delineate the midship section of a bulk cargo carrier.
2. With the aid of a neat sketch, delineate the midship section of a container ship.
3. Assignment for drafting the lines plan of any vessel (representing the profile view, half breadth plan view and body plan view) from a given offset table.

   Drawing on chart paper/Graph paper [A0 size] is preferable; sketching software can also be used.

Course Outcome 3 (CO3):

1. Assignment for the calculation of hydrostatic particulars of a vessel with a given offset table, using numerical integration methods, to plot the hydrostatic curves, sectional area curve and Bonjean curves.
2. How is the COB of a mono hull vessel determined? Explain.
3. An empty cylindrical shaped tank is floating in sea water (density 1.025 t/m^3), at a draught of 8.0 m, with its axis vertical. The external diameter of the tank is 12 m, the internal diameter is 11 m, the thickness of the base is 1 m, and the overall height is 16 m. Its centre of gravity is

6 m above its inner base. Calculate the hydrostatic particulars, and plot the hydrostatic curves.

4. The half ordinates (m) of a water plane, which are 6 m apart, are given by: 11.16, 24.84, 39.42, 47.52, 40.23, 26.46 and 13.23. Calculate and compare the areas of the water plane as given by Simpson’s 1-4-1 rule, Simpson’s 1-3-3-1 rule, and trapezoidal rule.

Course Outcome 4 (CO4):

1. Explain the desired physical properties of shipbuilding quality steel. Use suitable diagrams wherever necessary.
2. Why are additional strengthening members required in the stem and stern structures?
3. What are the major loads acting on a ship in a seaway?

Course Outcome 5 (CO5):

1. How are submarines propelled underwater?
2. What are the main propulsion options for a warship with 32 knot speed? How will you justify the answer?
3. Draw the propulsion train of a bulk carrier, and explain the functions of the components.

Course Outcome 6 (CO6):

1. How does an anchor hold the ship in position?
2. Describe in detail, the cargo handling equipment [ship based and shore based], in a bulk carrier.
3. With the aid of neat diagrams, describe in detail, the navigation lights on ships.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, XXXX 20XX

Course Code: SBT201

INTRODUCTION TO NAVAL ARCHITECTURE

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Draw a neat sketch of a ship and mark the following: a) Superstructure b) Stem c) Chain locker	(3)
2	Name any 6 types warships, and indicate their roles.	(3)
3	State Archimedes principle. What is its application in Naval Architecture?	(3)
4	How is the COB of a mono hull vessel determined? Explain.	(3)
5	What is trapezoidal rule? Illustrate its application in Naval Architecture calculations.	(3)
6	What is a section area curve? List down its uses	(3)
7	Draw the stress strain diagram for shipbuilding quality steel and mark the important parameters.	(3)
8	With the aid of neat diagram explain the various types of structural members on a ship?	(3)
9	What are the differences between main machinery and auxiliary machinery onboard ships?	(3)
10	Expand the terms CODAG, CODAD and CODLAG. Why are such combinations used?	(3)

PART B

Module 1

Answer any two full questions, each carries 7 marks.

11	Explain the role of a Naval architect in different sectors of maritime industry	(7)
10	How do you classify ships on the basis of their functions? Explain with examples	(7)
11	Justify the statement ‘Those who rule the seas will rule the world’ in context to maritime history.	(7)

Module II

Answer any two full questions, each carries 7 marks.

12 Why the process of fairing is necessary for a lines plan? Explain method of fairing with illustrative sketches. (7)

13 Scientifically explain the reason for a steel boat to float whereas a steel plate to sink in water (7)

14 Define the following parameters using neat sketches (7)

a) Length Between Perpendiculars

b) Breadth

c) Depth

d) Draft

e) Freeboard

f) Reserve buoyancy

Module III

Answer any two full questions, each carries 7 marks.

15 The half ordinates of the load water plane of a vessel are 1.2, 4.6, 8.4, 11.0, 12.0, 11.7, 10.3, 7.5, and 3.0 m, and the overall length is 120 m. Find i) Water plane area ii) LCF (7)

16 The half ordinates (m) of a water plane, which are 6 m apart, are given by: 11.16, 24.84, 39.42, 47.52, 40.23, 26.46 and 13.23 (7)

Calculate and compare the areas of the water plane as given by Simpson's 1-4-1 rule, Simpson's 1-3-3-1 rule, and trapezoidal rule.

17 With the aid of a neat sketch, explain Bonjean curves for a typical ship (7)

Module IV

Answer any two full questions, each carries 7 marks.

18 Explain the desired physical properties of shipbuilding quality steel. Use suitable diagrams wherever necessary. (7)

19 Draw a typical midship section of a container vessel and label the structural elements. (7)

20 What are the major loads acting on a ship in a seaway? (7)

Module V

Answer any two full questions, each carries 7 marks.

21 a) With the aid of neat diagrams, describe in detail, the navigation lights fitted on ships (7)

b) Explain the various cargo handling equipment (ship based and shore based) for a general cargo ship (7)

22 a) What are the main propulsion options for a warship with 32 knot speed? How will you justify the answer? (7)

b) List down the various firefighting arrangements on board ships. (7)

23 a) Which are the main prime movers used for propulsion of ships? (7)

b) How are submarines propelled underwater? (7)

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Syllabus

Module – I: Introduction ships and Naval Architecture discipline

Historical review - Ancient types of vessels (rafts, boats, and ships), the role of ship in the ages of the great discoveries, Role of a Naval Architect in the Maritime Industry.

Types of ships: - terms and definitions, cargo ships (general cargo ships, bulk carriers, container ships, Ro-Ro ships, barge carriers, tankers), fishing vessels, factory ships, supply ships, Cable ships, ice breakers, research vessels, warships, hydrofoils, air cushion vehicles, small pleasure crafts (yachts, ketches, etc).

Module – II: Introduction to ship geometry

Some physical fundamentals - Archimedes principle, laws of floatation stability and trim.

The ship's form-main dimensions, lines plan, coefficients and their meaning, Fairing process and table of offsets; Hydrostatic particulars & Bonjean Curves: - (Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KMT And BMT Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF)

Module – III: Introduction to Bonjean and hydrostatic curves

Integration rules: - Trapezoidal rule; Simpson's rules, 6 ordinate rules; Tchebycheff's rule; Areas, volumes and moments Bonjean calculations and curves, sectional area curves. Hydrostatic calculations and curves.

Module - IV: Introduction to ship structures

The ship and her structural members - shipbuilding materials (properties, compositions), Bottom structure, shell plating and framing, decks, hatches and hatch covers, Superstructures, bulkheads, tanks, holds, fore and aft structure, stern and rudder.

Module - V: Introduction to ships Machinery

Introduction to ships Machinery: Propulsion machinery - development of ship propulsion, general arrangement of propulsion plants, Main engines (Diesel engines, steam engines & turbines, gas turbines, Diesel-electric drive, nuclear power plants) Auxiliary machineries.

Bridge, Navigation Lights Communication Equipment, Lifesaving appliances and fire-fighting equipment, Anchoring, mooring and towing equipment, cargo handling equipment.

Text Books

1. E.C. Tupper, *Introduction to Naval Architecture*; 5th Edition; Butterworth-Heinemann, 2013
2. K.J. Rawson and E.C. Tupper, *Basic Ship Theory*, Vol. I & II, 5th Edition; Butterworth-Heinemann, 2001

Reference Books

1. A.B. Biran, *Ship Hydrostatics and Stability*; 2nd Edition; Butterworth-Heinemann Capt D.C. Derret; Ship Stability for Masters and Mates, 2013
2. Apostolos Papanikolaou, *Ship Design Methodologies of Preliminary Design*; Springer, 2014
3. Taggart, Ship Design and Construction; SNAME, 1980
4. D.A Taylor, Introduction to Marine Engineering; 2nd Edition; Butterworth-Heinemann, 1996.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module – I: Introduction Ships and Naval Architecture Discipline**	
1.1	Historical review - ancient types of vessels (rafts, boats, and ships)	2
1.2	The role of ship in the ages of the great discoveries. Role of a Naval Architect in the Maritime Industry.	2
1.3	Types of ships: - terms and definitions, cargo ships (general cargo ships, bulk carriers, container ships, Ro-Ro ships, barge carriers, tankers), fishing vessels, factory ships, supply ships, Cable ships, ice breakers, research vessels, warships, hydrofoils, air cushion vehicles, small pleasure crafts (yachts, ketches, etc)	5
2	**Module – II: Introduction to Ship Geometry**	
2.1	Some physical fundamentals-Archimedes principle, laws of floatation stability and trim.	2
2.2	The ship's form-main dimensions, lines plan, coefficients and their meaning. Fairing process – table of offsets.	3
2.3	Hydrostatic particulars & Bonjean Curves: - (Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KMT And BMT Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF).	4
3	**Module – III: Introduction to Bonjean And Hydrostatic Curves**	
3.1	Integration rules: - Trapezoidal rule; Simpson's rules, 6 ordinate rule.	4
3.2	Tchebycheff's rule	2
3.3	Areas, volumes and moments Bonjean calculations and curves, sectional area curves. Hydrostatic calculations and curves.	3

4	**Module - IV: Introduction to Ship Structures**	
4.1	The ship and her structural members - shipbuilding materials (properties, compositions.	3
4.2	Bottom structure, shell plating and framing, decks, hatches and hatch covers.	3
4.3	Superstructures, bulkheads, tanks, holds, fore and aft structure, stern and rudder.	3
5	**Module - V: Introduction to Ships Machinery**	
5.1	Introduction to ships Machinery: Propulsion machinery- development of ship propulsion, general arrangement of propulsion plants.	2
5.2	Main engines (Diesel engines, steam engines & turbines, gas turbines, Diesel-electric drive, nuclear power plants) Auxiliary machineries.	2
5.3	Bridge, Navigation Lights Communication Equipment	2
5.4	Lifesaving appliances and firefighting equipment.	2
5.5	Anchoring, mooring and towing equipment, cargo handling equipment.	1

SBT203	MECHANICS OF SOLIDS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course on Mechanics of Solids throws light on the behaviour of different types of solids made of different materials and having different cross-sections under various loading conditions. The various principles and numerical calculations developed in structural designs are applied here. The subject pitches gradually from the basic concepts of stress and strain to problems on thin-walled pressure vessels and columns.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Assimilate the concepts on stress, strain, modulus of elasticity and the relationship between different elastic constants.
CO 2	Draw the bending moment diagram and shear force diagram for various types of beams under different boundary conditions and loading.
CO 3	Calculate the shear stress distribution under various cross –sections.
CO 4	Determine principal stresses and maximum shear stress with the aid of equations and Mohr's circle.
CO 5	Conceive the concept on torsion and its applications.
CO 6	Solve problems related to buckling of columns and critical buckling.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1									1
CO 2	3	3										
CO 3	3	2										1
CO 4	3	3										
CO 5	3	2										
CO 6	3	2	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one full question. Each question can have maximum 4 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the different types of stresses a material is capable of resisting?

2. Draw the stress-strain diagram of a mild-steel specimen subjected to a tensile test.

3. How is modulus of elasticity related to modulus of rigidity?

Course Outcome 2 (CO2)

1. Draw the shear force and bending moment diagram of a cantilever of length 'l' carrying a uniformly distributed load of w per m over the whole length.

2. A beam of 6 meters long is simply supported at the ends and carries a uniformly distributed load of 30 kN per metre run for a distance of 4 metres from the left end. Find the maximum shear force and bending moment. Draw the shear force and bending moment diagrams.

3. Draw the shear force and bending moment diagram of a simply supported beam of span 'l' carrying a concentrated load at mid span.

Course Outcome 3(CO3):

1. Draw the section modulus of a rectangular section of width b and depth d.

2. Show the shear stress distribution of a rectangular section of width b and depth d.

3. Draw the shear stress distribution in an 'I' section.

Course Outcome 4 (CO4):

1. Define principal planes and principal stresses.

2. The principal stresses at a certain point in a strained material are 150 N/mm^2 and 48 N/mm^2 both tensile. Find the normal and tangential stresses on a plane inclined at 20^o with the major principal plane.

3. The principal tensile stresses at a point across two perpendicular planes are 80 N/mm^2 and 40 N/mm^2. Find the normal and tangential stresses and the resultant stress and its obliquity on a plane at 20^o with the major principal plane. Find also the intensity of stress which when acting alone can produce the same maximum strain. Take Poisson's ratio =1/4.

Course Outcome 5 (CO5):

1. State the assumptions in the theory of pure torsion.

2. A hollow shaft of 20mm outside diameter and 16mm diameter is subjected to a torque of 40 Nm. Find the shear stress at the outside and inside of the shaft.

3. What is the theory of pure torsion?

Course Outcome 6 (CO6):

1. Explain buckling load or crippling load for an axially loaded compression member.

2. What is effective length of a column?

3. Explain Euler's Theory of long columns.

4. A column 2.5 metres long is 60 mm in diameter. One end of the column is fixed while its other end is hinged. Find the safe compressive load for the member using Euler's formula, allowing a factor of safety of 3.5. Take E= 2.1×10^5 N/mm^2.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, XXXX 20XX

Course Code: SBT203

MECHANICS OF SOLIDS

Max. Marks: 100 Duration: 3 Hours

PART-A

Answer all 10 questions. (Each carries 3 marks)

1) Define Young's Modulus, Shear modulus, and Bulk modulus.

2) Find the total change in length of a bar which consists of three lengths l_1,l_2,l_3 with sectional areas A_1,A_2,A_3 and subjected to an axial load P.

3) Define point of contraflexure and illustrate with a sketch.

4) Draw the shear force and bending moment diagram of a cantilever of length 'l' carrying a concentrated load 'w' at the free end.

5) A rectangular beam 100 mm wide is subjected to a maximum shear force of 50 kN and the corresponding maximum shearing stress is 3 N/mm^2. Find the depth of the beam.

6) What is pure bending? Explain.

7) What is principal plane and principal stress?

8) A cantilever of length 'l' is subjected to a couple M at its free end. Find the slope and deflection at the end of the beam.

9) Differentiate between thin and thick cylinders.

10) What is slenderness ratio of a column? What is its relevance?

PART-B

Answer any one full question from each module. Each question carries 14 marks.

MODULE 1

11) (a) Derive the relationship between Young's modulus, Shear modulus and Bulk modulus for a cube subjected to stress of intensity 'P'.

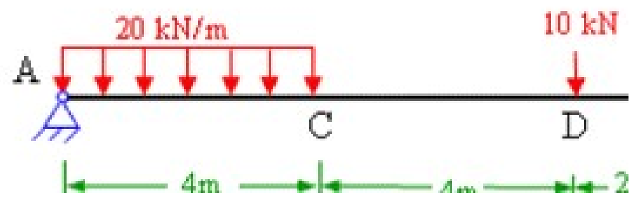
(b) A material has a Young's Modulus of 1.25×10^5 N/mm^2 and a Poisson's ratio of 0.25. Calculate the Modulus of Rigidity and the Bulk Modulus.

12) (a) A steel column is 120 mm in diameter and 3 metres long. Find the intensity of stress and the strain when it carries an axial compressive load of 950 kN. Take E= 2x 10^5 N/mm^2.

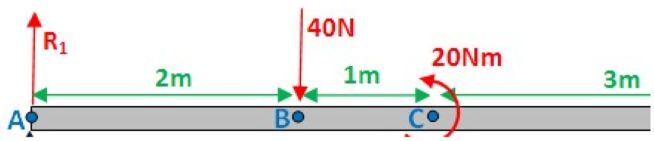
(b) Find the change in volume of a cubical block of steel of side 250 mm when placed at a depth of 5 km in sea water. Sea water weighs 10008 N/m^3. Take E= 2x 10^5 N/mm^2 and Poisson's ratio= 0.25.

MODULE 2

13) Calculate the shear force and bending moment values and draw the SFD and BMD for the beam given below.



14) Calculate the shear force and bending moment values and draw the SFD and BMD for the beam given below.



MODULE 3

15) (a) Derive simple bending equation for a beam. State the assumptions clearly.

(b) A simply supported beam of span 10m is 350 mm deep. The section of the beam is symmetrical. The moment of inertia of the section is 9.5 x 10^7 mm^4. If the permissible bending stress is 120 N/mm^2. Find the safe load that can be applied at the centre of the span.

16) A timber beam 100 mm wide, and 150 mm deep supports a uniformly distributed load over a span of 2 metres. If the safe stresses are 28 N/mm^2 in bending and 2 N/mm^2 in shear , calculate the maximum load which can be supported by the beam.

MODULE 4

17)The principal stress at a point in a bar are 200 N/mm^2 (tensile) and 100 N/mm^2 (compressive) . Determine the resultant stress in magnitude and direction on a plane inclined to 60^o to the axis of the major principal stress. Also determine the maximum intensity of shear stress in the material at the point.

18) (a)The plate of a boiler is subjected to principal stresses of 120 N/mm^2 and 60 N/mm^2 both tensile . Find the intensity of stress which acting alone will produce the same maximum strain. Take Poisson's ratio=0.3.

(b) Show that in a strained material subjected to two-dimensional stress, the sum of the normal components of stresses on any two mutually perpendicular planes is constant.

MODULE 5

19) (a) Determine Euler's crippling load for an 'I' section whose dimensions are, web=40 cm, flange=20 cm, thickness=1 cm and length=5 m; which is used as a column with both ends fixed. Take E = 2.1X 10^5 N/mm^2.

(b) Explain long and short columns.

20) Determine the maximum and minimum hoop stress across the section of a pipe of 400 mm internal diameter and 10 mm thick, when the pipe contains a fluid at a pressure of 8 N/mm^2. Also sketch the radial pressure distribution and hoop stress distribution across the section.

Syllabus

Module 1

Basics in Mechanics of Solids:

Types of Loads and Stresses Uniaxial, Biaxial and; Triaxial State of Stresses.

Stress-Strain Concepts: Tension, Compression and Shear; Uniaxial stresses; Elastic Limit; Stress-Strain relationship for mild steel; Hooke's Law; Yield point; Bars of varying sections; Bars of composite sections; Temperature Stresses; Poisson's Ratio; Stress-Strain Diagram; Working Stress; Factor of safety; Volumetric strain; Modulus of elasticity; Modulus of rigidity; Bulk Modulus-Relationship between the elastic constants.

Module 2

Bending Moment and Shear Force: Definitions and introduction to different types of supports; Concept of shear force and bending moment; Beams and Loads; Sign conventions; Shear force and Bending Moment Diagrams for Cantilever, Simply supported and Overhanging beams with various types of loading (Point load, Distributed load, Couples).

Module 3

Stresses in Beams: Simple bending; Theory of Simple Bending; Assumptions in Simple Bending; Neutral axis; Section Modulus; Flexural rigidity; Stresses in symmetrical sections; Bending Stress Distribution.

Shear Stress: Shear stress distribution in beams; Assumptions; Shear stress distribution for rectangular, circular, triangular, I and T sections.

Module 4

Beam Deflection: Differential Equation of the Elastic curve; Slope and deflection of beams by method of successive integration; Moment Area Theorem.

Principal Stresses and Strains: Introduction; Principal Stresses and Principal Strain; Mohr's Circle; Representation of Stress in 2D problems.

Module 5

Thin Walled Pressure Vessels: Introduction; Biaxial Tension and Compression in Thin Walled Pressure Vessels such as cylindrical and spherical.

Torsion: Introduction to torsion; Theory of pure torsion; Torsion of Circular Shafts; Shear stresses; Shear deformation.

Theory of Columns: Introduction to columns; Buckling Theory; Euler's Formula for Long Columns; Assumptions and Limitations; Effect of End Conditions; Slenderness Ratio.

Text Books

1. Bansal R. K; Strength of Materials; Lakshmi Publications; New Delhi, 4th edition, 2007

2. Timoshenko S. P.; Strength of Materials Part 1; 3rd edition, D. Van Nostrand Company Inc .New York, 2002

3. S. Ramamrutham ; Strength of Materials; Dhanpat Rai Publishing Company, 16th edition,2008.

Reference Books

1. S. S Bavikatti; Strength of Materials; Vikas Publishing House Pvt Ltd., New Delhi, 4th edition, 2014.

2. Shames I. H., James M. Pitarresi; Introduction to Solid Mechanics; Pearson Education India. 3rd edition, 2015

3. V.N. Vazirani, M.M.Ratwani, Analysis Of Structures . Vol 1, Khanna Publishers, 2015

4. Punmia B. C. and A. K. Jain, Mechanics of Materials, Laxmi Publications (P) Ltd, New Delhi.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Basics in Mechanics of Solids**	
1.1	Types of Loads and Stresses Uniaxial, Biaxial and; Definition of Triaxial State of Stresses.	3
1.2	**Stress-Strain Concepts:** Tension, Compression and Shear; Uniaxial stresses; Elastic Limit; Stress-Strain relationship for mild steel; Hooke's Law; Yield point; Bars of varying sections; Bars of composite sections; Temperature Stresses; Poisson's Ratio; Stress-Strain Diagram; Working Stress; Factor of safety; Volumetric strain; Modulus of elasticity; Modulus of rigidity; Bulk Modulus - Relationship between the elastic constants.	6
2	**Bending Moment and Shear Force**	
2.1	Definitions and introduction to different types of supports; Concept of shear force and bending moment; Beams and Loads; Sign conventions; Shear force and Bending Moment Diagrams for Cantilever, Simply supported beams and Overhanging beams with various types of loading (Point load, Distributed load, Couples).	9
3	**Stresses in Beams**	
3.1	Simple bending; Theory of Simple Bending; Assumptions in Simple Bending; Neutral axis; Section Modulus; Flexural rigidity; Stresses in symmetrical sections; Bending Stress Distribution.	6
3.2	**Shear Stress**: Shear stress distribution in beams; Assumptions; Shear stress distribution for rectangular, circular, triangular, I and T sections.	3

4	**Beam deflection, Principal Stresses and Strains**	
4.1	**Beam Deflection**: Differential Equation of the Elastic curve; Slope and deflection of beams by method of successive integration; Moment Area Theorem.	5
4.2	**Principal Stresses and Strains**: Introduction; Principal Stresses and Principal strains; Mohr's Circle; Representation of Stress in 2D problems.	4
5	**Thin walled Pressure Vessels, Torsion, Theory of Columns**	
5.1	Thin Walled Pressure Vessels: Introduction; Biaxial Tension and Compression in Thin Walled Pressure Vessels (Cylindrical and Spherical).	3
5.2	Torsion: Introduction to torsion; Theory of pure torsion; Torsion of Circular Shafts; Shear stresses; Shear deformation.	3
5.3	Theory of Columns: Introduction to columns; Buckling Theory; Euler's Formula for Long Columns; Assumptions and Limitations; Effect of End Conditions; Slenderness Ratio.	3

SBT205	MECHANICS OF FLUIDS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course is an introductory course in fluid mechanics which mainly deals with the properties and behaviour of fluids. It begins by asking the question what constitutes a fluid and then move forward to the continuum concept, various classifications of fluids etc. The next part introduces concepts of statics, kinematics and dynamics of fluids and underlying governing equations. Finally, solutions to various problems involving internal pipe flows and external flows are treated. Concepts of computational fluid dynamics are introduced at the end of the course. This course also gives an opportunity to learn various methods in EXCEL/C/C++/MATLAB to solve simple flow problems. The course content has been developed to meet the requirement of Naval Architecture and Shipbuilding Engineering branch students.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply the different concepts and properties associated with fluid to solve real world problems.
CO 2	Apply the fluid kinematics and boundary layer concepts related to fluid flow to solve problems.
CO 3	Analyze the different types of fluid flow, energy, friction and losses through the pipes.
CO 4	Identify the use and limitations of the various equations related to fluid flow and apply it to solve a variety of fluid flow problems
CO 5	Apply fundamental knowledge of mathematics to model and analysis of fluid flow problems in engineering.
CO 6	Develop numerical/graphical solutions for the fluid flow problems in any of the programming language/software (C, C++, Excel, MATLAB etc.).

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									1
CO 2	3	3	2									1
CO 3	3	3	2									1
CO 4	3	3	2	2								1
CO 5	3	3	2									1
CO 6	3	3	3	2	3							1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 3 questions from each module of which student should answer any two. Each question can have maximum 3 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Determine the specific gravity of a fluid having a viscosity 0.07 poise and kinematic viscosity of 0.042 stokes.

2. Calculate the specific weight, density and specific gravity of 2 litres of a liquid which weighs 15 N.

3. Find the surface tension of soap bubble of 30 mm diameter when the atmospheric pressure is 1.962 N/m^2 less than the pressure inside the bubble.

Course Outcome 2 (CO2)

1. How will you determine whether a boundary layer flow is attached flow, detached flow or on the verge of separation?

2. Oil with a free stream velocity of 3 m/s flow over a plate 2 m wide and 4.5 m long. Calculate the boundary layer thickness and shear stress at the trailing end point and determine the total surface resistance of the plate. Take specific gravity of oil is 0.7 and kinematic viscosity is 0.1 stoke.

3. For the velocity profile in laminar boundary layer given as $\frac{u}{U} = \frac{3y}{2\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$, find the thickness of the boundary layer and shear stress 1.9 m from the leading edge of a plate. The plate is 3 m long and 2 m wide and is placed in water which is moving with a velocity of 20 cm per second. Find the drag on one side of the plate if the viscosity of water = 0.01 poise.

Course Outcome 3 (CO3):

1. Find the head lost due to friction in a pipe of diameter 400 mm and length 100 m, through which water is flowing at a velocity of 5 m/s using (i) Darcy formula, (ii) Chezy's formula for which C=60. Take Kinematic viscosity of water is 0.01 stoke and specific gravity is 1.

2. Water is flowing through a horizontal pipe of diameter 200 mm at a velocity of 4 m/s. A circular solid plate of diameter 150 mm is placed in the pipe to obstruct the flow. Find the loss of head due to the obstruction in the pipe if the co-efficient of contraction is 0.62.

3. An oil of specific gravity 0.8 and viscosity 0.06 poise is flowing through a pipe of diameter 300 mm at the rate of 90 litres/second. Find the head lost due to friction for a 700 m length of pipe. Find the power required to maintain this flow.

Course Outcome 4 (CO4):

1. Explain the limitations of Euler's equation in solving problems in fluid dynamics.

2. What are the assumptions made in the derivation of Bernoulli's equation?

3. Explain the limitations of Darcy-Weisbach formula and Chezy's formula in finding head loss in pipes.

4. An oil of Viscosity 6 poise is used for lubrication between a shaft and sleeve. The diameter of the shaft is 600 mm and it rotates at 300 r.p.m. Calculate the power lost in oil for a sleeve length of 150 mm. The thickness of the oil film is 0.15 cm. Plot a graph between various parameters v/s power loss for the above given fluid.

Course Outcome 5 (CO5):

1. A lawn sprinkler with two nozzles of diameter 3mm each is connected across a tap of water. The nozzles are at a distance of 30 cm and 40 cm from the centre of the tap. The rate of flow of water through tap is 120 cm^3/s. The nozzles discharge water in the downward direction. Determine the angular speed at which the sprinkler will rotate free.

2. A pipe of 400 mm diameter conveying 0.5 m^3/s of water has a right angled bend in a horizontal plane. Find the resultant force exerted on the bend if the pressure at the inlet and outlet of the bend are 24.53 N/cm^2 and 23.54 N/cm^2 respectively.

3. The water is flowing through a taper pipe of 200 m having diameters 700 mm at the upper end and 200 mm at the lower end, at the rate of 200 litres/s. The pipe has a slope of 1:25. Find the pressure at the lower end if the pressure at the higher level is 19.62 N/cm^2.

Course Outcome 6 (CO6): Will be achieved through assignments

1. Develop a program in MATLAB/Excel to plot the variation of viscosity of a given fluid with respect to different temperatures from absolute zero to 300 degree centigrade.

2. Create a spread sheet to find out the major and minor loses in a system of pipelines with varying diameter and plot the results in a line graph.

3. Develop an algorithm to find out certain wave parameters (like significant wave height, mean wave period etc.) from the given wave data.

Model Question paper

Question Paper Code: XXXXX **Total Pages: 3**

Reg No.:________________ Name: ____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, XXXX 202X

Course Code: SBT205

Course Name: MECHANICS OF FLUIDS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions, each carries 3 Marks)

1. Explain the role of Reynolds number in classification of flows. Differentiate between different flows (based on Reynolds number) with neat sketches.

2. A 20 cm diameter vertical cylinder rotates concentrically inside another cylinder of diameter 20.15 cm. Both cylinders are 50 cm high. The space between the cylinders is filled with a liquid whose viscosity is unknown. If torque 48 Nm is required to rotate the inner cylinder at 80 r.p.m., determine the viscosity of the fluid.

3. A Nuclear submarine is moving at a depth of 50 m from MSL. Due to some disturbances it was tilted to an angle of 5^0 counter clockwise (viewed from the transverse section) from its initial position. Explain the point of action of different forces acting on the inclined submarine with a neat sketch if the submarine is returning back to its initial position after few seconds.

4. A hydraulic lift has a ram of 30 cm diameter and a plunger of 30 mm diameter. It is used to lift a mass of 500 kg. Find the force required at the plunger.

5. Comprehend the terms ‘local acceleration’ and ‘convective acceleration’ of a 3D flow based on Eulerian and Legrangian methods of describing fluid motion.

6. Differentiate between a Free vortex flow and a forced vortex flow by giving two real life examples.

7. A pipe of diameter 200 mm carries water at a velocity of 30 m/s. The pressures at A and B are 35 N/cm^2 and 23 N/cm^2 respectively, while the datum head at A and B are 20 m and 25 m. Find the loss of head between A and B.

8. What are the different reasons for major and minor energy losses when an incompressible fluid is flowing through a circular pipe?

9. What are the various wave parameters those are going to change when a wave travels from deep water to shallow water? Explain.

10. What are the limitations of conducting CFD analysis for a High speed flow? Explain the limitations of structured and unstructured grids in CFD.

PART B

(Answer **any two full questions** from each module, each question carries **7** marks)

Module - I

11. An oil of Viscosity 6 poise is used for lubrication between a shaft and sleeve. The diameter of the shaft is 600 mm and it rotates at 300 r.p.m. Calculate the power lost in oil for a sleeve length of 150 mm. The thickness of the oil film is 0.15 cm.

12. Calculate the dynamic viscosity of oil, which is used for lubrication between a square plate of size 1 m x 1 m x 10 mm and an inclined plane with angle of inclination of 45 degree. The density of the plate material is 8.8 g/cm^3 and it slides down the inclined plane with a uniform velocity of 0.4 m/s. The thickness of the oil film is 2 mm.

13. If the velocity profile of a fluid over a plate is parabolic with vertex 30 cm from the plate, where the velocity is 180 cm/s. Calculate the velocity gradients and shear stresses at a distance of 0, 10 and 20 cm from the plate, if the viscosity of fluid is 9.25 poise.

Module - II

14. A marker Buoy of cylindrical (solid cylinder) shape floats in seawater with its axis vertical. Its diameter is 3 m and height is 9 m. Find the Metacentric height of the cylindrical buoy if the specific gravity of the buoy material is 0.7 and sea water is 1.025.

15. A circular plate of 4 m diameter is immersed in fresh water in such a way that its grater and least depth below the free surface are 6 m and 3 m respectively. Determine the total pressure on one face of the plate and the position of centre of pressure.

16. A solid cone floats in water with its apex downwards. Determine the least apex angle of the cone for stable equilibrium if the specific gravity of the material of the cone is 0.75.

Module - III

17. Define rotational and irrotational flow. The stream function and the velocity potential functions for a flow is given by Φ= 2xy and Ψ= x^2-y^2. Show that the conditions for continuity and irrotational flow are satisfied.

18. In a free cylindrical vortex flow, at a point in the fluid at a radius of 250 mm and a height of 150 mm, the velocity and the pressure are 15m/s and 157.2 kN/m^2 absolute. Find the pressure at a radius of 500 mm and a height of 400 mm. The fluid is air with a density of 1.24 kg/m^3.

19. **a)** Define stream lines, path lines, steak lines and time lines and also explain their significance in analysing a fluid flow. **(4 marks)**

    b) Differentiate between surface flow visualisation and refractive flow visualisation techniques. **(3 marks)**

Module - IV

20. **a)** Name any four equations of motion that are used in solving problems in fluid dynamics. **(2 marks)**

    b) Derive Bernoulli's equation from Euler's equation. **(5 marks)**

21. A crude oil of viscosity 0.97 poise and relative density 0.9 is flowing through a horizontal circular pipe of diameter 150 mm and length 15 m. Calculate the difference of pressure at the two ends of the pipe, if 250 kg of oil is collected in a tank in 30 seconds.

22. **a)** Explain the different observations of Reynolds experiment. **(3 marks)**

    b) What are the minor loses that has to be considered while solving fluid flow through pipelines? Explain. **(4 marks)**

Module - V

23. The air having a velocity of 50 m/s is flowing over a cylinder of diameter 2 m and length 12 m, when the axis of the cylinder is perpendicular to the air stream. The cylinder is rotated about its axis and a lift of 7568 N per metre length of the cylinder is developed. Find the speed of rotation and location of the stagnation points. The density of air is given as 12.5 x 10^{-4} tons/m^3.

24. Explain the different steps performed in the solution procedure using CFD Techniques?

25. **a)** Differentiate between a deep water and shallow water wave. **(4 marks)**

    b) What is the speed of a tsunami wave with a wavelength of 50 km, if the average water depth of Indian ocean is about 4000 m? **(3 marks)**

Syllabus

Module 1 – Basics of Fluid Mechanics and Properties of Fluids

Basics: Definition of Fluid Mechanics, Application areas of Fluid Mechanics, System & Control Volume; No-Slip condition, Classification of Fluid Flows -Viscid, Inviscid; Internal, External; Compressible, Incompressible; Laminar, Turbulent; Natural, Forced; Steady, Unsteady; 1, 2 & 3-D Flows.

Properties of Fluids: Intensive & extensive properties; Principle of Continuum; Density, specific weight and Specific gravity; significance of kinematic Viscosity and Dynamic Viscosity , Newtonian & Non-Newtonian Fluids, Viscosity & Momentum Transfer, Effect of Temperature on Viscosity; Surface Tension; Compressibility & Bulk Modulus; Vapour Pressure and partial pressure, Cavitation.

Module 2 – Fluid Statics

Fluid Pressure: Pressure at a point, Pascal's Law, Pressure Variation in a fluid at rest, Absolute, Gauge, Atmospheric and Vacuum Pressures; Different Pressure measuring instruments

Hydrostatic Forces on Surfaces: Total Pressure and Centre of Pressure; Vertical Plane Surface Submerged in Liquid; Horizontal Plane Surface Submerged in Liquid; Inclined Plane Surface Submerged in Liquid; Curved Surface Submerged in Liquid.

Buoyancy and Floatation: Buoyancy, Centre of Buoyancy; Metacentre and Metacentric Height, Analytical Method for Metacentric Height; Conditions of Equilibrium of Floating and Submerged Bodies - Stability of Submerged and Floating Bodies; Experimental Method for the Determination of Metacentric Height; Oscillation of a Floating Body.

Module 3 – Fluid Kinematics and Flow Visualisation

Fluid Kinematics: Lagrangian & Eulerian Method of Describing Fluid Motion; Rate of Flow; Continuity Equation in 2-D and 3-D; Velocity & Acceleration (Local Acceleration and Convective Acceleration).

Velocity Potential Function and Stream Function; Equi-potential Line; Line of Constant Stream Function; Flow Net; Relation between Stream Function and Velocity Potential Function.

Types of Fluid Motion: Linear Translation, Linear Deformation, Angular Deformation, Pure Rotation; Vorticity; Vortex Flow- Forced and Free Vortex Flow, Equation of motion for Forced Vortex Flow and Free Vortex Flow.

Flow Visualization: Streamlines & Stream tubes; Path lines; Streamlines; Timelines; Refractive Flow Visualization Techniques; Surface Flow Visualization Techniques.

Module 4 – Fluid dynamics and Flow through pipes

Fluid Dynamics: Equations of Motion; Euler's Equation of Motion; Bernoulli's Equation from Euler's Equation, Assumptions made in the derivation of Bernoulli's Equation; Bernoulli's Equation for Real Fluid; Applications of Bernoulli's equation; The Momentum Equation, Moment of Momentum Equation .

Viscous Incompressible Flows: Reynolds's Number; General Viscosity Law & Assumptions; Navier-Stokes Equations; Flow of Viscous Fluid through Circular Pipe; Flow of Viscous Fluid between Two Parallel Plates; Loss of Head due to Friction in Viscous Flow.

Turbulent Flow Through Pipes: Reynolds's Experiment; Frictional Loss in Pipe Flow; Hydrodynamically Smooth & Rough Boundaries; Resistance of Smooth & Rough Pipes; Loss of Energy in Pipes; Loss of Energy Due to Friction; Minor Energy Losses.

Module 5 – External flow and Gravity Waves

External Flow: Boundary Layer Flow – Laminar and Turbulent Boundary Layers, Laminar Sub Layer, Boundary Layer Thickness; Displacement and Momentum thickness; Criterion for Separation of Boundary Layer; Boundary layer control.

Force Exerted by a Flowing Fluid on a Stationary Body; Expression for Drag & Lift; Drag on a Sphere; Drag on a Cylinder; Development of Lift on a Circular Cylinder – Flow Pattern around cylinder when constant circulation is imparted to the cylinder, Lift and Drag force acting on rotating cylinder, Expression for lift coefficients of rotating cylinder, Location of stagnation points in uniform flow field; Airfoils and Development of Lift on an Airfoil.

Gravity Waves: The wave Equation; Wave Parameters; Surface Gravity Waves; Features of Surface Gravity Waves - Pressure change due to wave motion, Particle path and streamline, Energy Considerations; Approximations for Deep and Shallow water.

Introduction to Computational Fluid Dynamics: Fundamentals; Grid generation and Solution Procedure.

Text Books

1. Yunus A. Cengel and John M. Cimbala, "Fluid Mechanics" Fundamentals and Applications, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2010.
2. Bansal, R.K., "Fluid Mechanics and Hydraulics Machines", (7th edition), Laxmi publications (P) Ltd., New Delhi, 2011.
3. Modi P.N and Seth S.M, "Hydraulics and Fluid Mechanics Including Hydraulic Machines" Standard Book House, New Delhi, 20th Edition, 2015.
4. Kumar K. L., "Engineering Fluid Mechanics", S. Chand & Company Pvt. Ltd, 2014.
5. Subramanya, K, "Fluid Mechanics and Hydraulic Machines Problems and Solutions" Tata McGraw Hill Publishing Company Ltd, New Delhi, 2010.

Reference Books

1. Dixon, S. L., and Hall, C., 'Fluid mechanics and thermodynamics of turbo machinery', Butterworth-Heinemann, 2013.
2. Graebel. W.P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011.
3. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", John Wiley and sons, 2015.
4. Streeter, V. L. and Wylie E. B., "Fluid Mechanics", McGraw Hill Publishing Co. 2010.
5. J.H. Spurk, 'Fluid Mechanics – Problems and Solutions', Springer, 2003.
6. J. Frabzini, 'Fluid Mechanics with Engineering Applications', McGraw Hill, 1997.
7. Wilson, E. M., 'Engineering Hydrology (Vol. 4)', Indianapolis, Indiana, USA: Macmillan, 1990.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Basics of Fluid Mechanics and Properties of Fluids**	
1.1	**Basics:** Definition of Fluid Mechanics, Application areas of Fluid Mechanics	1
1.2	System & Control Volume; No-Slip condition	1
1.3	Classification of Fluid Flows-Viscid, Inviscid; Internal, External; Compressible, Incompressible; Laminar, Turbulent; Natural, Forced; Steady, Unsteady; 1, 2 & 3-D Flows.	2
1.4	**Properties of Fluids:** Intensive & extensive properties; Principle of Continuum; Density, specific weight and Specific gravity;	1
1.5	significance of kinematic Viscosity and Dynamic Viscosity , Newtonian & Non Newtonian Fluids, Viscosity & Momentum Transfer, Effect of Temperature on Viscosity	2
1.6	Surface Tension; Compressibility & Bulk Modulus; Vapour Pressure and partial pressure, Cavitation.	2
2	**Fluid Statics**	
2.1	**Fluid Pressure:** Pressure at a point, Pascal's Law, Pressure Variation in a fluid at rest, Absolute, Gauge, Atmospheric and Vacuum Pressures; Different Pressure measuring instruments	3
2.2	**Hydrostatic Forces on Surfaces:** Total Pressure and Centre of Pressure; Vertical Plane Surface Submerged in Liquid; Horizontal Plane Surface Submerged in Liquid; Inclined Plane Surface Submerged in Liquid; Curved Surface Submerged in Liquid.	3
2.3	**Buoyancy and Floatation:** Buoyancy, Centre of Buoyancy; Metacentre and Metacentric Height, Analytical Method for Metacentric Height; Conditions of Equilibrium of Floating and Submerged Bodies- Stability of Submerged and Floating Bodies; Experimental Method for the Determination of Metacentric Height; Oscillation of a Floating Body.	3
3	**Fluid Kinematics and Flow Visualisation**	
3.1	**Fluid Kinematics:** Lagrangian & Eulerian Method of Describing Fluid Motion; Rate of Flow; Continuity Equation in 2-D and 3-D; Velocity & Acceleration (Local Acceleration and Convective Acceleration).	3
3.2	Velocity Potential Function and Stream Function; Equipotential Line; Line of Constant Stream Function; Flow Net; Relation between Stream Function and Velocity Potential Function.	1
3.3	**Types of Fluid Motion**: Linear Translation, Linear Deformation, Angular Deformation, Pure Rotation; Vorticity; Vortex Flow- Forced and Free Vortex Flow, Equation of motion for Forced Vortex Flow and Free Vortex Flow.	3
3.4	**Flow Visualization:** Streamlines & Streamtubes; Pathlines; Streaklines; Timelines; Refractive Flow Visualization Techniques; Surface Flow Visualization Techniques.	2

4	**Fluid dynamics and Flow through pipes**	
4.1	**Fluid Dynamics:** Equations of Motion; Euler's Equation of Motion; Bernoulli's Equation from Euler's Equation, Assumptions made in the derivation of Bernoulli's Equation; Bernoulli's Equation for Real Fluid; Applications of Bernoulli's equation, The Momentum Equation, Moment of Momentum Equation.	3
4.2	**Viscous Incompressible Flows:** Reynolds's Number; General Viscosity Law & Assumptions; Navier Stokes Equations; Flow of Viscous Fluid through Circular Pipe; Flow of Viscous Fluid between Two Parallel Plates; Loss of Head Due to Friction in Viscous Flow.	3
4.3	**Turbulent Flow Through Pipes:** Reynold's Experiment; Frictional Loss in Pipe Flow; Hydrodynamically Smooth & Rough Boundaries; Resistance of Smooth & Rough Pipes; Loss of Energy in Pipes; Loss of Energy Due to Friction; Minor Energy Losses.	3
5	**External flow and Gravity Waves.**	
5.1	**External Flow:** Boundary Layer Flow –Laminar and Turbulent Boundary Layers, Laminar Sub Layer, Boundary Layer Thickness; displacement and momentum thickness; Criterion for Separation of Boundary Layer; Boundary layer control.	2
5.2	Force Exerted by a Flowing Fluid on a Stationary Body; Expression for Drag & Lift; Drag on a Sphere; Drag on a Cylinder; Development of Lift on a Circular Cylinder – Flow Pattern around cylinder when constant circulation is imparted to the cylinder, Lift and Drag force acting on rotating cylinder, Expression for lift coefficients of rotating cylinder, Location of stagnation points in uniform flow field; Airfoils and Development of Lift on an Airfoil.	3
5.3	**Gravity Waves:** The wave Equation; Wave Parameters; Surface Gravity Waves; Features of Surface Gravity Waves- Pressure change due to wave motion, Particle path and streamline, Energy Considerations; Approximations for Deep and Shallow water.	3
5.4	**Introduction to Computational Fluid Dynamics:** Fundamentals; Grid generation and Solution Procedure.	1

SBL201	MECHANICS OF FLUIDS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This lab is mainly focussed to develop a platform where the students can enhance their engineering knowledge in the fluid mechanics domain by applying their theoretical knowledge acquired.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify major instruments commonly used in the field of fluid mechanics.
CO 2	Identify and practice different experiments in the fluid mechanics domain.
CO 3	Apply the theoretical knowledge gained in the class room with the physical world.
CO 4	Compare different techniques and instruments used in Fluid property measurements.
CO 5	Carry out scientific experiments as well as accurately record and analyze the results of such experiments.
CO 6	Function as a member of a team, communicate effectively and engage in further learning and problem solving.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3								1			1
CO 2	3	3			2							1
CO 3	3	3		3								1
CO 4	3	3			2							1
CO 5	3	3	3		1			2	1			1
CO 6	1	3						2	3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test): 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

SYLLABUS

LIST OF EXPERIMENTS (Minimum 12 are mandatory)

1. Study of Various Pressure, Velocity and Flow Measuring Instruments.
   Equipment: Pressure/ Vacuum Gauge, U Tube Manometer, Pitot Tube, Flow Meter etc.
2. Pressure Measurements using a U-Tube Manometer.
   Equipment: U Tube Manometer.
3. Determination of Metacentric Height and Radius of Gyration of Floating Bodies.
   Equipment: Flat Bottom Pontoon, Water Tank.
4. Experimental Verification of Bernoulli's Theorem.
   Equipment: Bernoulli Apparatus.
5. Determination of Darcy's Constant and Chezy's Constant for Pipe Flow.
   Equipment: Experiment set up with pipes of various diameters fitted with flow control valves, Tank, U Tube Manometer.
6. Determination of Critical Velocity in Pipe Flow.
   Equipment: Reynold's Apparatus.
7. Determination of Minor Losses in Pipe Flow.
   Equipment: Hydraulic Bench, Pipe Bends & Fittings Apparatus.
8. Determination of Type of Flow using Reynolds Number.
   Equipment: Reynold's Apparatus.
9. Study of Laminar-Turbulent Transition for Flow in a Tube.
   Equipment: Reynold's Apparatus.
10. Determination of Coefficient of Discharge of V Notch.
    Equipment: Supply Tank, Collecting Tank, V Notch.
11. Determination of Coefficient of Discharge of Rectangular & Trapezoidal Notches.
    Equipment: Supply Tank, Collecting Tank, Rectangular Notch.
12. Determination of Coefficient of Discharge of Trapezoidal Notch.
    Equipment: Supply Tank, Collecting Tank, Trapezoidal Notch.
13. Determination of Hydraulic Coefficients of Orifices under Constant Head Method.

Equipment: Supply Tank, Collecting Tank, Orifices.

14. Determination of Hydraulic Coefficients of Mouthpieces under Constant Head Method.
    Equipment: Supply Tank, Collecting Tank, Mouthpieces.
15. Determination of Hydraulic Coefficients of Orifices under Time of Emptying Method.
    Equipment: Supply Tank, Collecting Tank, Orifices.
16. Determination of Hydraulic Coefficients of Mouthpieces under Time of Emptying Method.
    Equipment: Supply Tank, Collecting Tank, Mouthpieces.
17. Calibration of Venturimeter.
    Equipment: Venturimeter, U Tube Manometer, Supply Tank, Collecting Tank.
18. Calibration of Orificemeter.
    Equipment: Orificemeter, U Tube Manometer, Supply Tank, Collecting Tank.
19. Calibration of Watermeter.
    Equipment: Watermeter, Supply Tank, Collecting Tank.
20. Study and acquire a thorough knowledge of the various Pipe Fittings and Plumbing Tools.
    Equipment: Fittings like Reducers, Bends, Elbows, Y Connectors, Union, Coupling etc; Tools like Pipe Wrenches, Pipe Threaders, Pipe Bending Machine etc.
21. Study the use of different types of Valves.
    Equipment: Gate Valve, Butterfly Valve, Globe Valve, Relief Valve, Non-return valve etc.
22. Determination of Chezy’s Constant and Manning’s Number for Open Channel Flow.
    Equipment: Open channel of rectangular cross section with slope adjusting mechanism.

Note: Only major equipments are indicated.

Reference Books

1. Yunus A. Cenegel, John M. Cimbala; Fluid Mechanics- Fundamentals and Applications (in SI Units); McGraw Hill, 2010.

2. Bansal R.K, Fluid Mechanics and Hydraulic Machines (SI Units); Laxmi Publications, 2011.

3. Modi P.N and Seth S.M, “Hydraulics and Fluid Mechanics Including Hydraulic Machines” Standard Book House, New Delhi, 20th Edition, 2015

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6. J. Frabzini, 'Fluid Mechanics with Engineering Applications', McGraw Hill, 1997.

SBL203	WELDING AND MACHINE TOOLS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This lab mainly focuses on to develop a platform where the students can enhance their engineering knowledge in the practical working environment by applying the theoretical knowledge they acquired. This lab provides practical experience on various machining operations using Lathe and on various welding equipment.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Machine the given specimen to required dimension using Lathe.
CO 2	Demonstrate the principle of operation of MMAW, TIG and MIG
CO 3	Prepare specified type of joint using various welding processes.
CO 4	Apply the theoretical knowledge gained in the class room with the physical world.
CO 5	Carry out scientific experiments as well as accurately record and analyze the results of such experiments.
CO 6	Function as a member of a team, communicate effectively and engage in further learning and problem solving.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2		1									
CO 2	3											
CO 3	2											1
CO 4	3	2										1
CO 5	2	1						2		1		1
CO 6	1							2	1	1		1

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS

(Minimum 12 are mandatory)

(a). Machine Tools:

1. Study of Precision Tools and Measuring Instruments.

Equipment: Vernier Calliper, Micrometer, Surface Plate, Surface Gauge, Slip Gauge, Screw Pitch Gauge, Feeler Gauge, Dial Gauge, Sine Gauge, Plug Gauge, Straight edge Gauge.

2. Study of Nomenclature of Single Point Cutting Tool.

Equipment: HSS Single point cutting tool.

3. Study of Centre Lathe.

Equipment: Centre Lathe.

To perform following lathe operations on a work piece for given dimensions:

4. Plane Turning.

Equipment: HSS Single point cutting tool (V-tool), Tool holder, Surface gauge, steel rule, outside calliper, Jenny calliper, and Vernier calliper.

5. Step Turning.

Equipment: HSS Single point cutting tool (V-tool), Parting tool, Tool holder, Surface gauge, steel rule, outside calliper, Jenny calliper and Vernier calliper.

6. Grooving.

Equipment: HSS Single point cutting tool (V-tool), Parting tool, Tool holder, Surface gauge, steel rule, outside calliper, Jenny calliper and Vernier calliper.

7. Taper Turning.

Equipment: HSS Single point cutting tool (V-tool), Tool holder, Surface gauge, steel rule, outside calliper, Jenny calliper, Vernier calliper and double end spanner.

8. Thread Cutting.

Equipment: HSS Single point cutting tool (V-tool), Tool holder, Surface gauge, steel rule, outside calliper, Jenny calliper, Vernier calliper, Centre gauge and thread pitch gauge.

(b) Welding:

9. Study of Welding Equipment and Procedures.

Equipment: MMAW, MIG, TIG, SAW.

10. To study various types of welding joints and practice edge preparation.

Equipment: *Butt joint, Lap joint, T-Joint, Corner joint, Workpiece, File/Grinder and Wire-brush.*

11. To Prepare a Single V-Butt Joint using Arc Welding Process.

Equipment: *Arc welding machine, Mild steel work pieces, Mild steel Electrodes, Electrode holder, Ground clamp, Flat nose tong, Face shield, Apron, Hand gloves, work table, Bench vice, Rough flat file, steel rule, wire brush, Try square, Bell peen hammer, chipping hammer, chisel and grinding machine.*

12. To Prepare a Lap Joint using Arc Welding Process.

Equipment: *Arc Welding Machine, Mild Steel Work Pieces, Mild Steel Electrodes, Electrode Holder, Ground Clamp, Face Shield, Apron, Hand Gloves, Work Table, Bench Vice, Rough Flat File, Try Square, Bell Peen Hammer, Chipping Hammer, Chisel and Grinding Machine.*

13. To Prepare a T Joint using Arc Welding Process

Equipment: *Arc Welding Machine, Mild Steel Work Pieces, Mild Steel Electrodes, Electrode Holder, Ground Clamp, Face Shield, Apron, Hand Gloves, Work Table, Bench Vice, Rough Flat File, Try Square, Bell Peen Hammer, Chipping Hammer, Chisel and Grinding Machine.*

14. To prepare a Butt Joint Using TIG Welding Process.

Equipment: *TIG Welding Machine, Welding Cable With Earth Clamps, Gas Cooled TIG Welding Torch, Inert Argon Gas Hose Pipe, Tungsten Rod, Flow Meter, Mild Steel Work Pieces, Face Shield, Apron, Hand Gloves, Work Table, Bench Vice, Rough Flat File, Try Square, Ball Peen Hammer, Chipping Hammer, Chisel and Grinding Machine.*

15. To Prepare a Butt Joint using MIG Welding Process.

Equipment: *MIG Welding Machine, Welding Cable With Earth Clamps, MIG Welding Torch,* CO_2 *Gas Flow Meter with Preheater, Contact Tips, Input Gas Hose Pipes, Mild Steel Work Pieces, Face Shield, Apron, Hand Gloves, Work Table, Bench Vice, Rough Flat File, Try Square, Bell Peen Hammer, Chipping Hammer, Chisel and Grinding Machine.*

Reference Books

1. O.P Khanna; Welding Technology; First Edition, Dhanpat Rai Publications, 2015.

2. Acharkan. N.; Machine Tool Design, Fourth edition, McGraw Hill Education India Private Limited, 2017

3. Chapman; Workshop Technology, Vol I,II,III, CBS, 2007

SEMESTER -3
MINOR

SBT281	FUNDAMENTAL CONCEPTS IN NAVAL ARCHITECTURE	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

This subject provides a comprehensive appreciation of the science and art of Naval Architecture. Knowledge of fundamental concepts in Naval Architecture gives a clearer cognizance to build the deeper understanding needed by a graduate engineer.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Outline role of a Naval Architect.
CO 2	Develop fundamental concepts of Naval Architecture.
CO 3	Identify various types of materials used for construction of marine structures and to identify various major and minor structural components of a ship.
CO 4	Acquire knowledge on various types of ships.
CO 5	Acquire knowledge to identify a particular ship type based on its general arrangement.
CO 6	Identify various main and auxiliary machineries onboard a vessel.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2											1
CO 2	3											2
CO 3	2											1
CO 4	2											1
CO 5	2											2
CO 6	2											2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	30
Understand	30	30	40
Apply	10	10	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 3 questions from each module of which student should answer any two. Each questions can have maximum 3 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Outline role of a Naval Architect.

1. Enumerate the duties of a Naval Architect.
2. What are the qualities required to become a qualified Naval Architect.
3. List down the forces acting on a ship at static condition.

Course Outcome 2 (CO2) : Develop fundamental concepts of Naval Architecture.

1. Define Lightship weight and Deadweight of a ship.
2. Draw a neat sketch of a ship and mark Hull, Superstructure, Bow, Stern, Keel, AP & FP.
3. Define stability of ships. State the condition of equilibrium of a floating body.

Course Outcome 3(CO3): Identify various types of materials used for construction of marine structures and to identify various major and minor structural components of a ship.

1. List principal structural members of a ship.
2. Define the following ship structural member:
   a) Frame
   b) Beam
   c) Deck Transverse
   d) Floors
   e) Stringer
   f) Inner bottom longitudinal
3. What are the various materials used for shipbuilding?

Course Outcome 4 (CO4): Acquire knowledge on various types of ships.

1. With simple sketch, show hull, bow, stern and superstructure of a bulk carrier.

2. With simple sketches, explain L_{BP}, L_{OA}, L_{WL}, Midship, bulbous bow, sheer.

3. Define flare and rise of floor with simple sketch.

Course Outcome 5 (CO5): Students should acquire knowledge to identify a particular ship type based on its general arrangement.

1. Draw a typical profile view, midship section of a bulk carrier and explain its salient features.

2. Draw a typical profile view, midship section of a Ro-Ro vessel and explain its salient features.

3. Draw a typical profile view, midship section of a container ship and explain its salient features.

Course Outcome 6 (CO6): Identify various main and auxiliary machinery onboard a vessel.

1. Why are the auxiliary machinery used in ship, List some examples.

2. Explain major machineries fitted in a ship.

3. List the different types of main engines used in ships.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, XXXX 20XX

Course Code: SBT281

FUNDAMENTAL CONCEPTS IN NAVAL ARCHITECTURE

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

1. With the help of a neat sketch mark Hull, Superstructure, Bow, Stern, Keel, AP & FP.

2. Define camber and sheer with simple sketches.

3. State Archimedes principle & its application in Naval Architecture.

4. With simple sketch, explain Rolling and Heaving motion of ship.

5. Write the equilibrium condition for a floating body.

6. List various types of main engine used in ships.

7. What is the function of bulkheads in a ship structure?

8. What are the factors to be considered in selecting the propulsion machinery for a ship?

9. List down various deck machineries of a ship.

10. What is the function of steering gear in ship?

PART B

Answer any two full questions from each module, each question carries 7 marks.

Module 1

11. With simple sketches, explain stable, neutral and unstable equilibrium of ship.

12. With simple sketches, explain LBP, LOA, LWL, amidship, freeboard, sheer, and bilge radius.

13. Draw profile view of a ship and represent any seven principal dimensions and its definition.

Module II

14. List down any seven ship types and explain what all types of cargoes carried by these ships.

15. What is high speed crafts and how does it differs from merchant ships?

16. With diagrams explain various form coefficients used for ship design.

Module III

17. What are the types of framing system used for construction of ship? Make sketches.

18. Define the following ship structural member:

    a) Frame
    b) Beam
    c) Deck Transverses
    d) Floors
    e) Stringer
    f) Longitudinal
    g) Brackets

19. Draw fore end of a ship showing the structural members which helps in resisting forces which acts at forward of a ship.

Module IV

20. With simple sketch, explain the arrangement of diesel engine powered main propulsion plant indicating main components.

21. With sketches explain the working principle of Diesel Electric propulsion.

22. Why deck machinery is provided and how it helps in functioning of ship?

Module V

23. Draw a mid-ship section of a bulk-carrier and mark various structural members and various spaces.

24. Draw profile view of a tanker and show its salient features.

25. List what all data or information you can understand from a ship's General Arrangement drawing.

Syllabus

Module 1

Historical Review and Ship Geometry - Ancient Types of Vessels (rafts, boats, and ships), The role of Ships in the Ages of the Great Discoveries. Terms and Definitions of Ship Geometry, Role of a Naval Architect in the Maritime Industry.

Physical Fundamentals and Forces Acting on a Ship - Archimedes Principle, Laws of Floatation, Stability of floating bodies, Six Degrees of Freedom, Forces Acting on a Ship in Static Condition and in Waves.

Module 2

The Ship's Form - Main Dimensions and hydro - static particulars, Lines Plan, Form Coefficients.

Types of Ships – Classification, Cargo Ships - General Cargo Ships, Bulk Carriers, Container Ships, Ro-Ro Ships, Barge Carriers, Tankers, Fishing Vessels, Factory Ships, Supply Ships, Cable Ships, Ice Breakers, Research Vessels, and Warships. High Speed Crafts - Hydrofoils, Air Cushion Vehicles etc; Small Pleasure Crafts - Yachts, Ketches, etc.

Module 3

Introduction to Ship Structural Members, Shipbuilding Materials - Properties, Compositions, Structural Components - Bottom Structure, Shell Plating and Framing, Decks, Hatches and Hatch Covers, Superstructures, Bulkheads, Tanks, Holds, Fore and Aft Structure, Stern and Rudder.

Module 4

Propulsion Machinery - Development of Ship Propulsion, Main Engines - Diesel Engines, Steam Engines & Turbines, Gas Turbines, Diesel-Electric Drive, Nuclear Power Plants. Auxiliary Machinery- Power Supply, Auxiliary Engines for Ship, Auxiliary Engines for Engine Plant Operation, Steering Gear.

Module 5

General Arrangement of various ship types:- General Cargo Ships, Bulk Carriers, Container Ships, Ro-Ro Ships and tankers, Deck Machinery and Hull equipment

Text Books

1. E.C.Tupper; Introduction to Naval Architecture; Butterworth-Heinemann, 5th Edition, 2013.
2. D.A Taylor; Introduction to Marine Engineering, Butterworth-Heinemann, 2nd Edition, 1996.
3. D.J Eyres and G.J Bruce; Ship Construction Butterworth-Heinemann, 7th edition, 2012.

Reference Books

1. Rawson & Tupper; Basic Ship Theory, Vol. I & II, Butterworth-Heinemann, 5th edition, 2001.
2. Lewis, E.U.; Principles of Naval Architecture; SNAME, 1988.
3. Taylor, D.A.; Merchant Ship Construction; Butterworths, 4th edition, 1998.
4. Taggart; Ship Design and Construction; SNAME, 1980.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Historical Review and Ship Geometry - Ancient Types of Vessels (rafts, boats, and ships), The role of Ships in the Ages of the Great Discoveries. Terms and Definitions of Ship Geometry. Role of a Naval Architect in the Maritime Industry.	5
1.2	Physical Fundamentals - Archimedes Principle, Laws of Floatation, Stability of floating bodies, Six Degrees of Freedom.	2
1.3	Forces Acting on a Ship - Static Condition and Waves	2
2	**Module 2**	
2.1	The Ship's Form - Main Dimensions and hydro - static particulars, Lines Plan, Form Coefficients	4
2.2	Types of Ships - Classification, Cargo Ships - General Cargo Ships, Bulk Carriers, Container Ships, Ro-Ro Ships, Barge Carriers, Tankers, Fishing Vessels, Factory Ships, Supply Ships, Cable Ships, Ice Breakers, Research Vessels, and Warships.	3
2.3	High Speed Crafts - Hydrofoils, Air Cushion Vehicles etc; Small Pleasure Crafts - Yachts, Ketches, etc.	2
3	**Module 3**	
3.1	Introduction to Ship Structural Members.	2
3.2	Shipbuilding Materials - Properties, Compositions.	2
3.3	Structural Components - Bottom Structure, Shell Plating and Framing, Decks, Hatches and Hatch Covers, Superstructures, Bulkheads, Tanks, Holds, Fore and Aft Structure, Stern and Rudder.	5
4	**Module 4**	
4.1	Propulsion Machinery - Development of Ship Propulsion,	2
4.2	Main Engines- Diesel Engines, Steam Engines & Turbines, Gas Turbines, Diesel-Electric Drive, Nuclear Power Plants.	4
4.3	Auxiliary Machinery - Power Supply, Auxiliary Engines for Ship, Auxiliary Engines for Engine Plant Operation, Steering Gear.	3
5	**Module 5**	
5.1	General Arrangement of various ship types - General Cargo Ships, Bulk Carriers, Container Ships, Ro-Ro Ships, Tankers.	6
5.2	Deck Machinery and Hull equipment.	3

SEMESTER -4

SBT202	RESISTANCE AND PROPULSION OF SHIPS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The goal of this course is to expose students to the concept of Resistance and Propulsion of ships, Prediction of Resistance of ships, and to estimate machinery power required to attain the specified speed. Also it is intended to impart knowledge on various types of marine propellers and to familiarize with design methods.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Discern various components of resistance of ships.
CO 2	Estimate resistance of ships and effective power using statistical / methodical series / model tests.
CO 3	Outline the geometry of a screw propeller.
CO 4	Describe the phenomena of cavitation and its effects on propellers.
CO 5	Design propeller using various methodical series/ design charts/ model experiments.
CO 6	Explain the principle of operation of various unconventional propulsive devices, and resistance of high speed marine crafts.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											
CO 2	2	2	2	1								1
CO 3	3		1									1
CO 4	2											1
CO 5	3	2	2	2								1
CO 6	2											1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 3 questions from each module of which student should answer any two. Each question can have maximum 3 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define resistance of a ship in a seaway.

2. List down various components of resistance while ship is in seaway.

3. Define frictional resistance and how it is determined.

Course Outcome 2 (CO2)

1. A 6 m model of a 180 m long ship is towed in a model basin at a speed of 1.61 m/s. The towing pull is 20 N. The wetted surface area of the model is 4 m^2. Estimate the corresponding speed for the ship in knots and the effective power P_E, assuming resistance coefficients to be independent of scale for simplicity.

2. The full-scale ship is 140 m long and has speed of 15 kt and the model length is 4.9 m. The resistance is measured to 19 N in the model basin. Following the ITTC'57 approach, what is the predicted full-scale resistance?

The wetted surface area of the full-scale ship is 3300 m^2. The density of sea water is 1025 kg/m^3, and that of fresh water 1000 kg/m^3. ν_m = 1.14 x 10^{-6} m^2/s, for fresh water, ν_s = 1.19 x 10^{-6} m^2/s for sea water. Use a correlation coefficient of c_A = 0.0004.

3. A ship model (scale λ = 23) was tested in fresh water with: $\underline{R_{T,m}}$ = 104.1 N, V_m = 2.064 m/s, S_m = 10.671 m^2, L_m = 7.187 m, ρ_m = 1000 kg/m^3, ρ_s = 1026 kg/m^3, ν_m = 1.14 x 10^{-6} m^2/s, ν_s = 1.19 x 10^{-6} m^2/s

What is the prediction for the total calm-water resistance in sea water of the full-scale ship following ITTC'57? Assume c_A = 0.0002.

Course Outcome 3 (CO3):

1. Draw the geometry of a screw propeller and mark its parts.

2. Explain the importance of rake and skew in propeller performance.

3. Define QPC and explain various efficiencies in the propeller design.

Course Outcome 4 (CO4):

1. Describe the effects of Cavitation in the performance of propeller in a ship.

2. Explain different types of Cavitation. What is a supercavitating propeller?

3. Explain the importance of cavitation number and application of cavitation tunnel.

Course Outcome 5 (CO5):

1. Explain the purpose and procedure of Self Propulsion Test.

2. Design a propeller using methodological series data.

3. Differentiate between open water tests and self-propulsion tests.

4. A survey vessel has a 10 ft diameter, B 5-90 propeller with a pitch of 10 ft. The propeller speed is 200 rpm, the boat speed is 20 knots, and the thrust reduction factor (t) is 0.12, wake fraction (w) is 0.18, and the relative rotational efficiency η_R is 1.0.
The propeller operates as indicated by the Wageningen (Troost) Series B propeller charts.
Determine:

a. Thrust
b. Shaft torque
c. EHP of the boat
d. The propeller shaft power (delivered power) P_D
e. The (Quasi) PC or η_D

The propeller is also tested at zero ship speed (bollard pull) and it is found that the engine limits the torque to 50,000 lbf ft.
Determine:

f. The propeller rpm and thrust at this condition

Course Outcome 6 (CO6):

1. With help of diagrams explain water jet propulsion and mark its parts.
2. Describe principle of planning hull.
3. What are the advantages of vertical axis propeller?

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, XXXX 20XX

Course Code: SBT202

RESISTANCE AND PROPULSION OF SHIPS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer ALL questions. Each question carries 3 marks.

(3x10 = 30 Marks)

1. What are the various components of ship resistance?
2. What are the various appendages in a ship hull and their contribution to resistance?
3. How does cavitation occur on ship propellers?
4. Neatly draw a typical Kt -*Kq* diagram for a screw propeller and explain the parameters.
5. What is the function of nozzle in a propeller?
6. Compare the salient features of CPP and FPP.
7. Explain the working principle of water jet propulsion system.
8. Expand SWATH and highlight its commercial applications.
9. Explain Resistance in Planing craft.
10. Explain the application Vertical Axis Propeller in ships.

PART B

Answer any two complete questions from each module.

MODULE 1

(7x2=14 Marks)

11. Define Laws of comparison for a ship and its model, and deduct the geometrical, dynamical and kinematical similarity by dimensional analysis.

12. Explain wave making resistance and wave breaking resistance of ships with suitable sketches.

13. What are the effects of bulbous bow on a ship?

MODULE 2

(7x2 = 14 Marks)

14. What are the effects on ship resistance when a ship enters into Shallow waters, Restricted waters and Confined waters? Explain briefly.

15. Explain the steps involved in calculation of ship resistance using Guldhammer and Harvald's method. Sketch a typical Harvald's chart and explain how the residuary resistance coefficient is obtained from this chart.

16. A 6 m model of a 180 m long ship is towed in a model basin at a speed of 1.61 m/s. The towing pull is 20 N. The wetted surface area of the model is 4 m^2. Estimate the corresponding speed for the ship in knots and the effective power P_E, assuming resistance coefficients to be independent of scale for simplicity.

MODULE 3

(7x2=14 Marks)

17. Neatly sketch geometry of a Screw propeller and its expanded, projected and sectional views. Identify the Important geometrical parameters and explain each term including skew and rake?
18. Explain the axial momentum theory of propeller action and state the assumptions.
19. List the types of cavitation observed in ship propellers, and explain how to prevent this phenomena.

MODULE 4

(7x2=14 Marks)

20. What is open water tests and open water Diagram? What is the purpose of Self Propulsion test for a propeller?
21. Explain Geometrical, Kinematic and Dynamic Similarities in open water model tests of propellers by using dimensional analysis.
22. List various methodical series of propellers and their applications. Describe briefly how the Bp-Δ charts can be used to design the most optimum propeller when the engine power, RPM and reduction gear ratio are given.

MODULE 5

(7x2=14 Marks)

23. Explain super cavitating propellers and its application in ships.

24 Explain how the resistance and propulsion of planing crafts is different from conventional ships.

25. Explain the geometrical aspects of controllable pitch propellers. What is the application of CPP during ship operation.

Syllabus

Module – I (9 hours)
Introduction - Components of ship resistance, Dimensional analysis, Laws of comparison - geometrical, dynamical and kinematical similarity, Newton's, Froude's and Reynold's law, model ship correlation.
Viscous resistance – Turbulent plate friction and plate resistance, viscous pressure resistance, resistance due to separation, influence of curvature of the ship's hull, form factor, hull roughness and its influence on frictional resistance.
Wave making resistance – Pressure resistance, ship wave system, interference effects, theoretical calculation of wave making resistance, wave breaking resistance, bulbous bows and their effects.

Module – II (9hours)
Determination of resistance - series test results – residuary resistance, effect of hull form on resistance, methodological series data; Statistical analysis of resistance data, Guldhammer Harvald's method, holtrop and mennen method, van oortmerssen method.
Other components of resistance - Air and wind resistance, Resistance of appendages, Added resistance in waves, Resistance in restricted waterways – resistance in shallow water, resistance in canals.

Module – III (9 hours)
Propeller as a thrust producing mechanism - Screw propeller
Propeller theories – Momentum theory, Blade element theory.
Interaction between hull and propeller- Wake and wake fraction, Resistance augment and thrust deduction factor, propulsive efficiency in open water and behind conditions, hull efficiency, quasi propulsive coefficient, transmission efficiency .
Cavitation - its effects and prevention.

Module – IV (9 hours)
Design of propellers – Propeller geometry, sections, Propeller families and series, Presentation of data, Kt-Kq diagrams, Design charts- Bp-δ, Use of charts in propeller design and performance study, Propeller drawing.
Propeller strength - Materials and their qualities, strength calculation.
Model testing for resistance and propulsion – Tank testing facilities, Laws of comparison, open water tests, self-propulsion tests, Ship standardisation trials.

Module – V (9 hours)
Special types of propellers- Shrouded propellers, Controllable Pitch propellers, Super Cavitating propellers.
Other propulsion devices - Vertical axis propellers, Water jet propulsion, Sail, Paddle wheels.
Introduction to hydrodynamics of High Speed Craft and Advanced Marine Vehicles- Introduction, Resistance of Planing Crafts, Catamarans, SWATH, Hydrofoil Crafts.

Text Books

1. J.P. Ghose, R.P. Gokarn; Basic Ship Propulsion, First edition, KW Publishers Pvt Ltd, 2015.
2. Eric Tupper; Introduction to Naval Architecture, Fifth edition,Butterworth Heinemann, 2013.

Reference Books

1. D.G.M. Watson; Practical Ship Design; Volume I and II, Elsevier Ocean Engineering Book Series, 2002.
2. Lewis, E.U.; Principles of Naval Architecture, SNAME, 1988.
3. Rawson and Tupper; Basic Ship Theory, Fifth Edition, Butterworth-Heinemann, 2001
4. Lars Larsson & Hoyte C.; The Principles of Naval Architecture Series: Ship Resistance and Flow, The Society of Naval Architects and Marine Engineers, 2010

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module – I**	
1.1	**Introduction -** Components of ship resistance, Dimensional analysis, Laws of comparison -geometrical, dynamical and kinematical similarity, Newton's, Froude's and Reynold's law, model ship correlation.	4
1.2	**Viscous resistance** – Turbulent plate friction and plate resistance, viscous pressure resistance, resistance due to separation, influence of curvature of the ship's hull, form factor, hull roughness and its influence on frictional resistance.	2
1.3	**Wave making resistance** – Pressure resistance, ship wave system, interference effects, theoretical calculation of wave making resistance, wave breaking resistance, bulbous bows and their effects.	3
2	**Module – II**	
2.1	**Determination of resistance -** series test results – residuary resistance, effect of hull form on resistance, methodological series data; Statistical analysis of resistance data, Guldhammer Harvald's method, holtrop and mennen method, van oortmerssen method.	7
2.2	**Other components of resistance** - Air and wind resistance, Resistance of appendages, Added resistance in waves, Resistance in restricted waterways – resistance in shallow water, resistance in canals.	2
3	**Module – III**	
3.1	**Propeller as a thrust producing mechanism** - Screw propeller	1
3.2	**Propeller theories** – Momentum theory, Blade element theory, Circulation theory.	4
3.3	**Interaction between hull and propeller-** Wake and wake fraction, Resistance augment and thrust deduction factor, propulsive efficiency in open water and behind conditions, hull efficiency,	4

	quasi propulsive coefficient, transmission efficiency. **Cavitation** - its effects and prevention.	
4	**Module – IV**	
4.1	**Design of propellers** – Propeller geometry, sections, Propeller families and series, Presentation of data, Kt-Kq diagrams, Design charts- Bp-δ, Use of charts in propeller design and performance study, Propeller drawing.	5
4.2	**Propeller strength** - Materials and their qualities, strength calculation.	1
4.3	**Model testing for resistance and propulsion** – tank testing facilities Laws of comparison, open water tests, self-propulsion tests, Ship standardisation trials	3
5	**Module – V**	
5.1	**Special types of propellers**- Shrouded propellers, Controllable Pitch propellers, Super Cavitating propellers.	3
5.2	**Other propulsion devices** - Vertical axis propellers, Water jet propulsion, Sail, Paddle wheels.	3
5.3	**Introduction to hydrodynamics of High Speed Craft and Advanced Marine Vehicles**- Introduction, Resistance of Planing Crafts, Catamarans, SWATH, Hydrofoil Crafts.	3

SBT204	STABILITY OF SHIPS AND SUBMARINES	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The objective of the course is to provide the learners with a proper understanding of the concept of stability of floating and submerged bodies, equipping them with a practical knowledge of the preparation of stability booklets, and knowledge of the procedures of inclining experiments.

Prerequisites: Nil

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Discern the various equilibrium conditions pertaining to the stability of ships and underwater vessels, the effects on stability due to various external and internal factors.
CO 2	Explain the stability of ships, for small and large angles of inclination.
CO 3	Discern the purpose of an inclining experiment, and the process procedures involved in it.
CO 4	Apply the procedures of numerical integration to ship stability calculation and development of GZ curves.
CO 5	Explain the concepts of subdivision and floodable length curves and the different methodologies involved for calculating the final damaged equilibrium position and stability.
CO 6	Explain the contents of ship stability booklet.

Mapping of Course Outcomes against Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	1									
CO 2	3	1	2	2								
CO 3	3	3	2	2	2							1
CO 4	3	3	3	2	2							
CO 5	3	3	3	2	2							
CO 6	3	1	1									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	15
Understand	20	20	35
Apply	20	20	50
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/ Quiz/ Course Project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions, with 2 questions from each module, having 3 marks each. Students should answer all questions. Part B contains 3 questions from each module, of which student should answer any 2. Each question can have maximum 4 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO 1):

1. Sketch and explain the following equilibrium conditions, with respect to a floating body:

   (a) Stable equilibrium

   (b) Unstable equilibrium

   (c) Neutral equilibrium.

2. Define the term metacentric radius, with the help of a neat sketch.

3. How does the accumulation of ice, on deck, affect ship stability?

Course Outcome 2 (CO 2):

1. A ship of 8000 tonnes displacement has a GM of 0.5 m. A quantity of grain in the hold, estimated to be around 80 tonnes, shifts, and the centre of gravity of the grain moves 6.1 m in the transverse direction and 1.5 m in the vertical direction. Find the resultant list.

2. A box shaped vessel is 24 m x 5 m x 5 m, and floats on an even keel, at 2 m draft. If the KG value is 1.5 m, calculate the initial metacentric height.

3. Define a wall sided ship. Derive the expression for the righting lever (GZ) for a wall sided ship.

Course Outcome 3 (CO 3):

1. With the help of a neat sketch, explain the procedure for conducting an inclining experiment, and state its importance.
2. Which are the different stages in the life of a vessel, when inclining experiments should be carried out?
3. An inclining experiment was performed on the deck of a ship, of 8000 tonnes displacement. A mass of 25 tonnes, when shifted 15 m in the transverse direction, causes a deflection of 20 cm, in a plumb line of 4 m length. If KM = 7 m, calculate KG.

Course Outcome 4 (CO 4):

1. Assignment for extracting the statical stability curve of a vessel, from cross curves generated using Krylov's II method, based on Tchebycheff's integration rules. The obtained curve of statical stability is validated, by comparing the stability criteria promulgated by the International Maritime Organisation.
2. How to find the initial metacentric height from GZ curve?
3. Explain in detail about Characteristics of a GZ curve (righting arm).

Course Outcome 5 (CO 5):

1. Assignment for discerning the procedures involved in generating the floodable length curve of a vessel.
2. Write notes on margin line, floodable length, permissible length and permeability.
3. How can a vessel be sub-divided into compartments? Explain.

Course Outcome 6 (CO 6):

1. Explain the intact stability requirement for a cargo vessel.
2. State the damage stability criteria for a vessel.
3. What is a stability booklet? Who produces it? Who are its intended stake holders? Write a note, explaining the technical data present in stability books.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B. TECH DEGREE EXAMINATION

Course Code: SBT204
STABILITY OF SHIPS AND SUBMARINES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. All questions carry 3 marks each Marks

1	How does accumulation of ice, on deck, affect ship stability?	(3)
2	Define the term metacentric radius, with the aid of a neat sketch.	(3)
3	How will you find the initial metacentric height of a ship from GZ curve?	(3)
4	With the aid of a neat sketch, represent the various forces that act on a ship during grounding.	(3)
5	Explain the effect of suspended mass on ship stability.	(3)
6	What is trim? Why does it occur?	(3)
7	What are the international conventions and codes, which explain the damage stability criteria for merchant ships?	(3)
8	Why should a bilged compartment be isolated from rest of the ship?	(3)
9	What is meant by the phrase 'ROB of a submarine'? Define the same.	(3)
10	Define the terms "pressure hull" and "outer hull", with respect to a submarine.	(3)

PART B

Module I

Answer any two questions in full. Each question carries 7 marks.

11	Sketch and explain the following equilibrium conditions, with respect to a floating body: - (a) Stable equilibrium (b) Unstable equilibrium (c) Neutral equilibrium.	(7)

12 What is meant by the terms 'heeling moment due to wind' and 'high-speed turn'? Explain in detail. (7)

13 A ship of 8000 tonnes displacement has a GM of 0.5 m. A quantity of grain in the hold, estimated to be around 80 tonnes, shifts, and the centre of gravity of the grain moves 6.1 m in the transverse direction and 1.5 m in the vertical direction. Find the resultant list. (7)

Module II

Answer any two questions in full. Each question carries 7 marks.

14 Sketch the statical stability curve of a vessel having an angle of loll. Would the ship have initial stability? Suggest methods to eliminate the angle of loll. (7)

15 Calculate the GZ values at 10-degree intervals, and sketch the GZ curve of a vessel, whose KN values are as follows:- (7)

Heel Angle (degree)	0	10	20	30	40	50	60
KN (m)	0	0.69	1.24	1.36	1.36	1.29	1.18

Determine the angle at which maximum GZ occurs.

16 An inclining experiment was performed on the deck of a ship, of 8000 tonnes displacement. A mass of 25 tonnes, when shifted 15 m in the transverse direction, causes a deflection of 20 cm, in a plumb line of 4 m length. If the value of KM = 7 m, calculate KG. (7)

Module III

Answer any two questions in full. Each question carries 7 marks.

17 A ship 126 m long is floating at drafts of 5.5 m F and 6.5 m A. The centre of floatation is 3 m aft of amidships. MCT 1 cm = 240 tonnes m. Displacement = 6000 tonnes. Find the new drafts, if a weight of 120 tonnes, already onboard, is shifted forward a distance of 45 metres. (7)

18 How would the addition and removal of mass affect the ship's longitudinal stability? Explain in detail with aid of sketches. (7)

19 Define the following terms with respect to trim (7)

a. Tipping centre
b. Trimming moment
c. Longitudinal metacentre
d. Longitudinal metacentric height

e. MCT 1 cm.

Answer any two questions in full. Each question carries 7 marks.

20	What would happen if an end compartment of a vessel is flooded? Explain the scenario with the help of neat sketch.	(7)
21	A box-shaped vessel, 75 m long x 10 m wide x 6 m deep, is floating in salt water on an even keel, at a draft of 4.5 m. Find the new drafts if a forward compartment 5 m long is bilged. Take TPC = 7.75 and MCT 1 cm = 39.05 tonnes m per cm.	(7)
22	Explain the various effects of flooding on a ship with supporting sketches.	(7)

Module V

Answer any two questions in full. Each question carries 7 marks.

23	What is a stability booklet? Who produces it? Who are its intended audience? Write a note, explaining the technical data present in stability books.	(7)
24	State the IMO intact stability requirements for a cargo vessel.	(7)
25	With the aid of a neat sketch, compare the transverse stability and the longitudinal stability of a submarine, in the submerged condition.	(7)

****

Syllabus

Module 1

Introduction: - Potential energy and equilibrium; Stability of ships - stable and unstable conditions; Stability terms; Equal volume Inclinations shift of C.O.B. due to inclinations, C.O.B curve, metacentre, pro-metacentre and metacentric radius, metacentric height, metacentric curve, surface of flotation, curve of flotation, righting moment and righting lever; Heeling Moments due to wind, shift of cargo, passengers, turning and non-symmetrical accumulation of ice; Effect of superstructure on stability.

Module 2

Transverse stability: - GM_0, GZ at small angles of inclinations, wall sided ships; Stability due to addition, removal and transference (horizontal, lateral and vertical) of weight, suspended weight and free surface of liquids; Stability while docking and grounding; Inclining experiment.
Large angle stability -Diagram of statical stability (GZ-curve), characteristic of GZ Curve, static equilibrium criteria; Methods for calculating the GZ-curve (Krylov, Prohaska, etc.); Cross curves of stability; Dynamical stability – diagram of dynamical stability, dynamical stability criteria.

Module 3

Longitudinal stability: – Trim, longitudinal metacentre, longitudinal centre of flotation, moment to change trim, trimming moment; trim calculations – addition, removal and transference of weight, effect of change of density of water.

Module 4

Margin Line and Permeability: - Flooding calculation, Floodable length Factor of Subdivision, Compartment Standard, Damage Stability – Calculations by Lost Buoyancy and Added Weight Methods; Deterministic and Probabilistic Approach, Stability in Waves.

Module 5

Recommendations of classification societies and government authorities – Intact and damage stability rules. Stability criteria in weather condition.
Stability of Submarines Stability of Submerged Bodies, stable and unstable conditions of submerged vessels, Equilibrium Conditions, Transverse and Longitudinal Stability of a Submerged body, Items of Weight & its Relations, Moment diagram, Equilibrium Polygon.

Text Books

1. Edward V. Lewis, *Principles of Naval Architecture*, 1st edition SNAME, 1988.
2. K.J. Rawson and E.C. Tupper, *Basic Ship Theory*, Vol. I & II, 5th Edition; Butterworth-Heinemann, 2001
3. D.R. Derret, *Ship Stability for Masters and Mates*,7th Edition; Butterworth-Heinemann, 2012

Reference Books

1. E.C. Tupper, *Introduction to Naval Architecture*; 5th Edition; Butterworth-Heinemann, UK, 2013
2. Apostolos Papanikolaou, *Ship Design Methodologies of Preliminary Design*; Springer, 2014.
3. Colin S. Moore; Edited by J. Randolph Paulling, *Principles of Naval Architecture Series: Intact Stability*, The Society of Naval Architects and Marine Engineers, 2010
4. A.B. Biran, *Ship Hydrostatics and Stability*; 2nd Edition; Butterworth-Heinemann, 2013
5. D. Vassalos et al, *Contemporary Ideas on Ship Stability*; Elsevier Science Ltd, 2000

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module -1: Introduction to Stability of Ships**	
1.1	Introduction: - Potential energy and equilibrium.	1
1.2	Stability of ships: - stable and unstable conditions and neutral conditions	2
1.3	Stability terms; Equal volume Inclinations shift of C.O.B. due to inclinations.	2
1.4	C.O.B curve, metacentre, pro-metacentre and metacentric radius, metacentric height, metacentric curve, surface of flotation, curve of flotation, righting moment and righting lever.	2
1.5	Heeling Moments due to wind, shift of cargo, passengers, turning and non-symmetrical accumulation of ice; Effect of superstructure on stability.	2
2	**Module -II: Transverse stability**	
2.1	Initial stability – GM_0, GZ at small angles of inclinations.	1
2.2	Wall sided ships.	1
2.3	Stability due to addition, removal and transference (horizontal, lateral and vertical) of weight, suspended weight and free surface of liquids; Stability while docking and grounding.	2

2.4	Inclining experiment.	1
2.5	Large angle stability - Diagram of statical stability (GZ-curve), characteristic of GZ Curve, static equilibrium criteria; Methods for calculating the GZ-curve (Krylov, Prohaska, etc.); Cross curves of stability.	2
2.6	Dynamical stability – diagram of dynamical stability, dynamical stability criteria.	2
3	**Module -III: Longitudinal stability**	
3.1	Trim, longitudinal metacentre, longitudinal centre of flotation, moment to change trim, trimming moment.	4
3.2	Trim calculations – addition, removal and transference of weight, change of density of water.	5
4	**Module -IV: Damage stability**	
4.1	Margin Line and Permeability. Flooding calculation, Floodable length, Factor of Subdivision, Compartment Standard, Stability in Waves.	2
4.2	Damage Stability – Calculations by Lost Buoyancy and Added Weight Methods.	5
4.3	Deterministic and Probabilistic Approach, Stability in Waves.	2
5	**Module -V: Stability Requirements & Stability of Submerged Bodies**	
5.1	Recommendations of classification societies and governmental authorities – Intact and damage stability rules	2
5.2	Stability criteria in weather condition.	1
5.3	Stability of Submarines - Stability of Submerged Bodies. stable and unstable conditions of submerged vessels.	2
5.4	Equilibrium Conditions, Transverse and Longitudinal Stability of a Submerged body.	2
5.5	Items of Weight & its Relations, Moment diagram, Equilibrium Polygon.	2

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
SBT206	**ANALYSIS OF STRUCTURES**	**PCC**	3	1	0	4

Preamble: Analysis of Structures is a subject that ingrains the basic concepts in structural analysis by introducing the student to a world of simple structural numerical problems. It aims to provide a smooth transition from the classical approaches that are based on physical behaviour of structures in terms of their deflected shapes to a formal treatment of a general class of structures by means of matrix formulation. The student is thus able to seek solutions to these problems through various methods such as force/displacement method, moment distribution method, strain energy method and matrix method. It also helps in mastering the concept of vibrations and theories associated with it.

Prerequisite: SBT203- Mechanics of Solids

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Enable to differentiate between a determinate and indeterminate structures.
CO 2	Perform step by step procedure involved in Moment Distribution Method.
CO 3	Accumulate knowledge on Principle of Virtual Work; Strain Energy & Complementary Energy.
CO 4	Appreciate the concepts of vibration of continuous system such as rod, string, beam and shaft.
CO 5	Develop basic concepts on methods such as force method and stiffness method.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										1
CO 5	3	3										

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 4 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 12 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

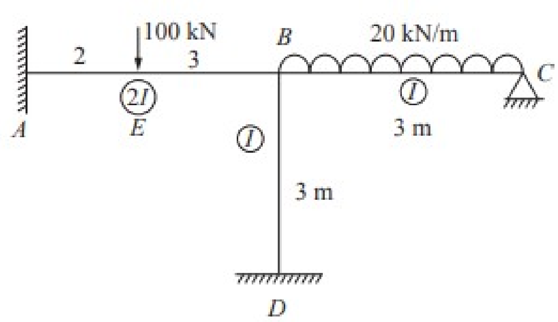
1. With the help of a relevant figure, illustrate an example of a statically indeterminate structure.

2. What are conditions of compatibility or consistent displacements?

3. Based on the number of constraints removed and number of constraints added , classify the structure into indeterminate, determinate and unstable.

Course Outcome 2 (CO2)

1. Analyse the frame by the moment distribution method. Draw the bending moment diagram.

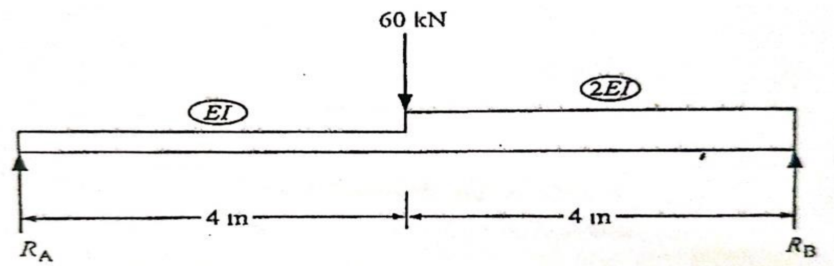


2. Explain absolute and relative stiffness of members, with an example.

3. What is Hardy Cross Method?

Course Outcome 3(CO3):

1. Determine the deflection under 60kN load in the beam using strain energy method.



2. What is strain energy and complementary strain energy?

3. Explain application of principal of virtual work in structural analysis.

Course Outcome 4 (CO4):

1. List out the various methods of vibration analysis.

2. Differentiate between free vibration and forced vibration.

3. What is damping ratio?

Course Outcome 5 (CO5):

1. What is the importance of displacement transformation matrix in elementary approach of analysis?

2. Differentiate between static and kinematic indeterminancy.

3. What is stiffness and flexibility coefficient?

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B. TECH DEGREE EXAMINATION, XXXX 20XX

Course Code: SBT206

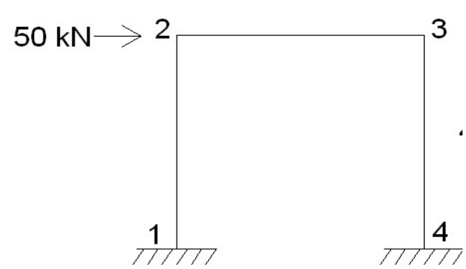
ANALYSIS OF STRUCTURES

Max. Marks: 100 Duration: 3 Hours

PART-A

Answer all 10 questions. Each question carries 4 marks

1. Differentiate between determinate and indeterminate structures. Give examples.
2. Give comparisons between force method and displacement method of analysis.
3. Define carry over factor and distribution factor used in Moment Distribution Method.
4. Determine the end moments of the members of the frame shown below. EI is same for all members. Draw the moment diagram.



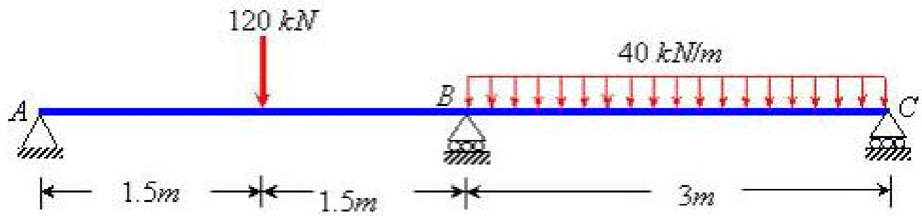
5. Explain Castigliano's Theorem by giving an example.
6. What is the principle of virtual work? What are its application in structural analysis?
7. Explain plastic deformation and plastic hinge with supporting sketch.
8. Differentiate between free and forced vibration. Give an example.
9. Explain degrees of freedom of a structure with an example.
10. Write down the stiffness matrix for the following element.

PART-B

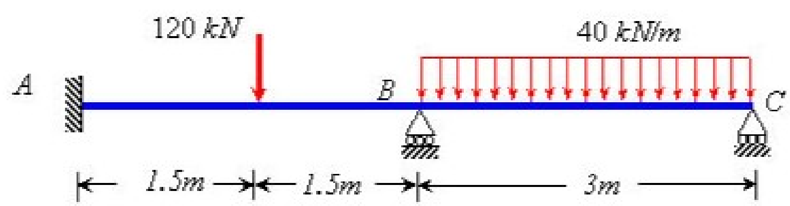
Answer any one full question from each module. Each question carries 12 marks.

MODULE 1

11. Analyse the continuous beam by the three moment equation. Draw the shear force and bending moment diagram. Assume constant E and I.

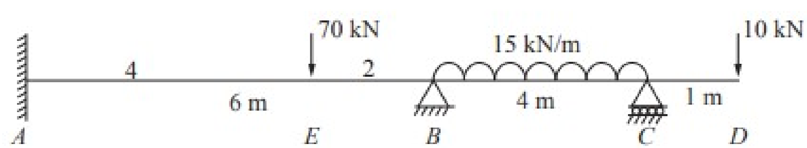


12. Analyse the continuous beam by the three moment equation. Draw the shear force and bending moment diagram. Assume constant E and I.

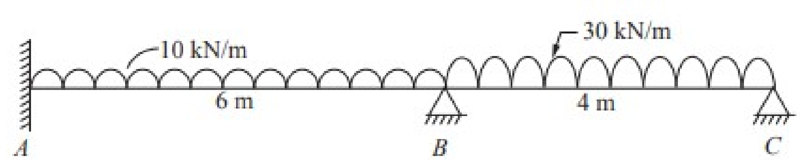


MODULE 2

13. Analyse the beam shown in figure by the moment distribution method. Support B sinks by 10 mm. E = 200 kN/mm^2 and I = 4000×10^4 mm^4. Draw BMD and SFD.



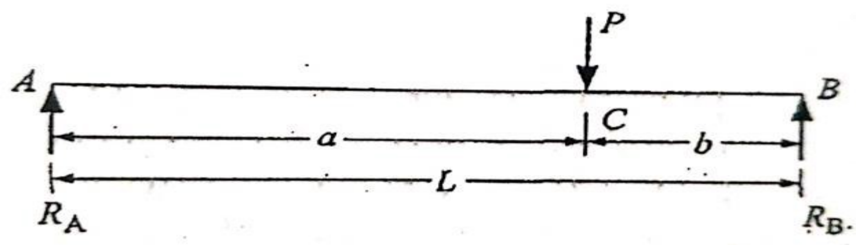
14. Analyse the continuous beam by the moment distribution method. Draw the shear force and bending moment diagrams. Assume constant E and I.



MODULE 3

15. Using strain energy method, determine the deflection at the free end of a cantilever beam of length L subjected to a concentrated load P at the free end.

16. A simply supported beam of span L carries a concentrated load P at a distance ‘a’ from the left hand side support. Using Castigliano’s theorem, determine the deflection under the load. Assume uniform flexural rigidity.



MODULE 4

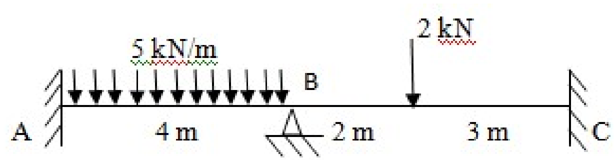
17. Obtain the equation of longitudinal vibration of rod. What are the assumptions? Explain the various modes of vibration.

18. Obtain the equation and solution of lateral vibration of beams.

MODULE 5

19. Give a problem with flexibility method.

20. Analyse the given beam using stiffness method.



Syllabus

Module 1

Introduction to Structural Analysis: Concept of Determinate & Indeterminate Structures; Continuous Beams; Force/Displacement Method of Analysis; Clapeyron's Theorem of Three Moments; Support Settlement.

Module 2

Moment Distribution Method: Beams and Rigid Jointed Plane Frames (with and without sway); Effect of Support Settlement.

Module 3

Strain Energy Methods: Principle of Virtual Work; Strain Energy & Complementary Energy; Castigliano's Theorems.

Module 4

Vibrations of Continuous Systems: Vibration of Strings and Rods; Vibration of Beams; Vibration of Shafts.

Introduction to Plastic Analysis

Module 5

Matrix Methods: Stiffness Method (Continuous Beams; Rigid Jointed Frames); Flexibility Method (Continuous Beams; Rigid Jointed Frames);Analysis using elementary approach; Transformation Matrices and its Applications.

Text Books

1. Alan Williams; Structural Analysis –in theory and practice; butterworth-Heinemann; 1st edition, 2008

2. C. S. Reddy; Basic Structural Analysis; Tata McGraw-Hill, 3rd edition, 2011

Reference Books

1. V. P. Singh, Theory of vibrations, Dhanpat Rai and Co (P) Ltd, 2010

2. Punmia B.C. and Jain A.K., Strength of Materials and Theory of Structures, Vol.II., Laxmi Publications (P) Ltd, 2005

3. Timoshenko & Young; Theory of Structures, McGraw Hill Publications, 1st edition, 1965

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Structural Analysis**	
1.1	Concept of Determinate & Indeterminate Structures; Continuous Beams.	3
1.2	Force/Displacement Method of Analysis.	3
1.3	Clapeyron's Theorem of Three Moments; Support Settlement.	3
2	**Moment Distribution Method**	
2.1	Beams and Rigid Jointed Plane Frames (with and without sway).	6
2.2	Effect of Support Settlement.	3
3	**Strain Energy Methods**	
3.1	Principle of Virtual Work.	3
3.2	Strain Energy & Complementary Energy.	3
3.3	Castigliano's Theorems.	3
4	**Vibrations of Continuous Systems**	
4.1	Vibration of Strings and Rods; Vibration of Beams; Vibration of Shafts.	6
4.2	Introduction to Plastic Analysis	3
5	**Matrix Methods**	
5.1	Stiffness Method (Continuous Beams; Rigid Jointed Frames).	2
5.2	Flexibility Method (Continuous Beams; Rigid Jointed Frames).	2
5.3	Analysis using elementary approach.	2
5.4	Transformation Matrices and its Applications.	3

SBL202	SHIP DESIGN LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This lab is mainly focussed to provide practical experience on developing ship's Lines plan and fairing process using any ship design software. Also experience on computation of ship hydrostatic particulars and practical exposure on Intact and damage Stability computations will be provided to the students.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Generate lines plan for given offset table and perform fairing
CO 2	Generate report of hydrostatics particulars for given hull form data
CO 3	Apply the theoretical knowledge gained in the class room with the physical world.
CO 4	Compute and analyse initial and damage stability results for given conditions
CO 5	Learn the basics of ship design and carry out various exercises related ship design.
CO 6	Function as a member of a team, communicate effectively and engage in further learning and problem solving.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3								1			2
CO 2	3	3			2							1
CO 3	3	3		3								1
CO 4	3	3			2							1
CO 5	3	3	3		1				2			1
CO 6	1	3							3	3		1

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test): 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

SYLLABUS

LIST OF EXPERIMENTS (Minimum 12 are mandatory)

1. Study of Principal Parameters of the hull-form of a Ship.
2. Study of Various Approaches in Generating Lines Plan of Ships.
3. Modelling of Hull Surface from Offset Data.
4. Modelling of Hull Surface by Modifying General Hull Form from Software Database.
5. Modelling of Hull Surface by Using Custom Definition of Boundary Curves & Sections.
6. Solid Modelling from Boundary Surfaces (e.g. Ship Superstructure).
7. Solid Modelling by Revolving Closed Areas about an Axis (e.g. Submarine Hull).
8. Boolean operations on Solids (e.g. Bow Thruster Tunnel Modelling).
9. Modelling of Tanks and Cargo Spaces.
10. Plotting Lines Plan of a Vessel from Given Offset Table.
11. Computation and Plotting of Bonjean and Sectional Area Curve.
12. Computation of Ship Hydrostatic Particulars.
13. Calculate Equilibrium Condition of a Given Ship at Given Loading Conditions.
14. Computation of Transverse Metacentric Height.
15. Computation of Stability at Small and Large Angles of Heel.
16. Computation of Static Stability and Cross Curves of Stability.
17. Dynamic Stability Computations.
18. Generate Stability Booklet Report for Given Ship Particulars and Conditions.
19. Carryout Floodable Length Calculations for a Ship at Given Loading Condition.
20. Damage Stability Computations at Given loading Condition.

Equipment: Any Ship Design & Analysis software

Reference Books

1. K.J. Rawson and E.C. Tupper, *Basic Ship Theory*, Vol. I & II, 5th Edition; Butterworth-Heinemann, 2001
2. D.R. Derret, Ship Stability for Masters and Mates,7th Edition; Butterworth-Heinemann, 2012
3. Eric Tupper; Introduction to Naval Architecture, Fifth edition,Butterworth Heinemann, 2013.
4. Lewis, E.U.; Principles of Naval Architecture, SNAME, 1988.

SBL204	MEASUREMENTS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This lab is mainly focused to provide an exposure to the fundamentals of metrology and to understand the need of precision measurement and measuring instruments.

Prerequisite: NIL.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Recall the fundamentals of metrology.
CO 2	Analyze the need of precision measurement.
CO 3	Explain the various measurement units used worldwide.
CO 4	Explain the use of various measuring instruments.
CO 5	Carry out scientific experiments as well as accurately record and analyze the results of such experiments.
CO 6	Function as a member of a team, communicate effectively and engage in further learning and problem solving.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2											
CO 2	3	3			2							2
CO 3	2	1										2
CO 4	2	1			2							2
CO 5	3	3							1	2		2
CO 6	3	1							2	2		1

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

SYLLABUS

LIST OF EXPERIMENTS (Minimum 12 are mandatory)

1) Measurement of tool angles of single point tool using tool maker's microscope.
2) Measurement of thread parameters using profile projector.
3) Evaluation of straightness error using autocollimator, sprit level, straight edge etc.
4) Calibration and determination of uncertainties of LVDT.
5) Calibration and determination of uncertainties of Tachometers and stroboscopes.
6) Calibration of temperature using thermo couple equipment.
7) Determination of properties of air using sling psychrometer.
8) Experiments on limits and fits.
9) Study of different types of dial indicators - stands and holders for dial gauges.
10) Study and use of different types of comparators.
11) Angular measurement of the given centre and wedge using sine bar with slip gauges.
12) Measurement of vibration using vibration analyser.
13) Measurement of unsymmetrical v block using bevel protractor.
14) Study and determination of area using planometer.
15) Polishing, etching and determination of grain size and microstructure studies using optical microscope.

Reference Books

1. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd, 1st edition, 1970.
2. Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, 1990.
3. Figliola, Richard S, and Beasley, Donald E, “Theory and Design for Mechanical Measurements”, 6th edition, John Wiley and Sons Inc, 2015.
4. Collett, C.V. and Hope, A.D, “Engineering Measurements”, Second edition, ELBS/Longman, 2011
5. Tarasevigh Y. and Yavosih E., Fits, Tolerances and Engineering Measurements, Volume III, Foreign language publishing house, 1963.

SEMESTER -4

MINOR

SBT282	STABILITY OF SHIPS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: The objective of the course is to provide the learners with a basic knowledge of ship form, geometry, and the concept of stability of floating and submerged bodies. This will help them to discern the stability criteria promulgated by the International Maritime Organisation and other regulatory bodies.

Prerequisites: SBT251- Fundamental Concepts in Naval Architecture

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Define the hull forms geometrically, and represent them as line plan drawings.
CO 2	Apply the procedures of numerical integration, for the calculation of hull form parameters.
CO 3	Discern the various equilibrium conditions pertaining to the stability of ships and submarines and also on the stability of ships, for small and large angles of inclination.
CO 4	Discern the purpose of an inclining experiment, the process and procedures involved in it.
CO 5	Explain the concepts of subdivision and floodable length curves. Discern the stability condition of equilibrium, of a ship in damaged condition.
CO 6	Explain the contents of ship stability booklet.

Mapping of Course Outcomes against Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1										
CO 2	3	2										
CO 3	3	2										
CO 4	3	3										
CO 5	2	2										
CO 6	2	2										

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	15
Understand	20	20	35
Apply	20	20	50
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/ Quiz/ Course Project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions, with 2 questions from each module, having 3 marks each. Students should answer all questions. Part B contains 3 questions from each module, of which, the student should answer any two. Each question can have maximum 4 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO 1):

1. Define the following parameters using neat sketches:

   a) Length Between Perpendiculars (LBP)

   b) Breadth

   c) Depth

   d) Draft

   e) Freeboard

   f) Reserve buoyancy.

2. Why is the process of fairing necessary for a lines plan? Explain the method of fairing with the aid of illustrative sketches.

3. Draw a neat sketch of a ship and mark hull, superstructure, bow, stern, keel, AP, and FP.

Course Outcome 2 (CO 2):

1. The half ordinates of the load water plane of a vessel are 1.2, 4.6, 8.4, 11.0, 12.0, 11.7, 10.3, 7.5 and 3.0 m, and the overall length is 120 m. Find i) Water plane area ii) LCF.

2. The half ordinates (m) of a water plane, which are 6 m apart, are given by:

   11.16, 24.84, 39.42, 47.52, 40.23, 26.46 and 13.23.

Calculate and compare the areas of the water plane as given by Simpson's 1-4-1 rule, Simpson's 1-3-3-1 rule and trapezoidal rule.

3. With the aid of a neat sketch, explain the Bonjean curves for a typical ship.

Course Outcome 3 (CO 3):

1. Sketch and explain the following equilibrium conditions, with respect to a floating body:

   (a) Stable equilibrium

   (b) Unstable equilibrium

   (c) Neutral equilibrium.

2. Write a note, comparing the transverse stability and longitudinal stability of a submarine.

3. Sketch and explain the following equilibrium conditions, with respect to a submarine:

   (a) Stable equilibrium

   (b) Unstable equilibrium

   (c) Neutral equilibrium.

4. A ship of 8000 tonnes displacement has a GM of 0.5 m. A quantity of grain in the hold, estimated to be around 80 tonnes, shifts, and the centre of gravity of the grain moves 6.1 m in the transverse direction and 1.5 m in the vertical direction. Find the resultant list.

5. A box shaped vessel is 24 m x 5 m x 5 m, and floats on an even keel, at 2 m draft. If the value of KG = 1.5 m, calculate the initial metacentric height.

Course Outcome 4 (CO 4):

1. With the help of a neat sketch, explain the procedure for conducting an inclining experiment, and state its importance.

2. Which are the different stages in the life of a vessel, when inclining experiments should be carried out?

3. An inclining experiment was performed on the deck of a ship, of 8000 tonnes displacement. A mass of 25 tonnes, when shifted 15 m in the transverse direction, causes a deflection of 20 cm, in a plumb line of 4 m length. If KM = 7 m, calculate KG.

Course Outcome 5 (CO 5):

1. Assignment for discerning the procedures involved in generating the floodable length curve of a vessel.

2. Explain the concept margin line, floodable length, permissible length, and permeability.

3. How can a vessel be sub-divided into compartments? Explain.

Course Outcome 6 (CO 6):

1. Explain the intact stability requirement for a cargo vessel.

2. State the damage stability criteria for a vessel as per IMO.

3. What is a stability booklet? Who produces it? Who are its intended audience? Write a note, explaining the technical data present in stability books.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B. TECH DEGREE EXAMINATION

Course Code: SBT282

STABILITY OF SHIPS (Minor - VAC)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. All questions carry 3 marks each. Marks

1	How is the overall geometry of a ship defined? Explain.	(3)
2	How are the coefficients of fineness related? Explain.	(3)
3	With the aid of a neat sketch, differentiate between the sectional area curve and Bonjean curves of a vessel.	(3)
4	State Archimedes’ principle. Explain its application in ships.	(3)
5	How will you find the initial metacentric height of ship from her GZ curve?	(3)
6	With the aid of a neat sketch, represent the various forces that act on a ship during grounding.	(3)
7	With the aid of a neat sketch explain the effect of suspended mass on ship stability.	(3)
8	What is trim? Why does it occur?	(3)
9	What are the international conventions and codes, which explain the damage stability criteria for merchant ships?	(3)
10	Why should a bilged compartment be isolated from rest of the ship?	(3)

PART B

Module I

Answer any two questions in full. Each question carries 7 marks.

11	A ship floating freely in salt water is 150 m long, and has a 22 m beam, a 9 m draught and a mass displacement of 24,000 tonnes. The midship area is 180 m^2. Find the block, prismatic and midship area coefficient.	(7)

12 A ship of length 200 m, breadth 22 m, and draught 7 m, has a displacement in sea water of 23,000 tonnes, a prismatic coefficient of 0.75 and a water plane area of 3500 m^2. Calculate the block coefficient (C_b), the midship section coefficient (C_m), and the water plane area coefficient (C_w). (7)

13 Define the following parameters with the aid of neat sketches: (7)

a) Length between perpendiculars (LBP)
b) Breadth
c) Depth
d) Draft
e) Freeboard
f) Reserve buoyancy.

Module II

Answer any two questions in full. Each question carries 7 marks.

14 The half ordinates of the load water plane of a vessel are 1.2, 4.6, 8.4, 11.0, 12.0, 11.7, 10.3, 7.5, and 3.0 m, and the overall length is 120 m. Find i) Water plane area ii) LCF. (7)

15 The half ordinates (m) of a water plane, which are 6 m apart, are given by: (7)
11.16, 24.84, 39.42, 47.52, 40.23, 26.46 and 13.23
Calculate and compare the areas of the water plane as given by Simpson's 1-4-1 rule, Simpson's 1-3-3-1 rule, and trapezoidal rule.

16 Sketch and explain the following equilibrium conditions, with respect to a floating body: (7)

(a) Stable equilibrium
(b) Unstable equilibrium
(c) Neutral equilibrium.

Module III

Answer any two questions in full. Each question carries 7 marks.

17 Calculate the GZ values at 10-degree intervals, and sketch the GZ curve of a vessel, whose KN values are as follows: (7)

Heel Angle (degree)	0	10	20	30	40	50	60
KN (m)	0	0.69	1.24	1.36	1.36	1.29	1.18

Determine the angle at which maximum GZ occurs.

18 An inclining experiment was performed on the deck of a ship, of 8000 tonnes displacement. A mass of 25 tonnes, when shifted 15 m in the transverse direction, causes a deflection of 20 cm, in a plumb line of 4 m length. If the (7)

value of KM = 7 m, calculate KG.

19 Sketch the statical stability curve of a vessel having an angle of loll. Would the ship have initial stability? Suggest methods to eliminate the angle of loll. (7)

Module IV

Answer any two questions in full. Each question carries 7 marks.

20 How would the addition and removal of mass affect longitudinal stability? Explain in detail with aid of sketches, (7)

21 A ship 126 m long is floating at drafts of 5.5 m F and 6.5 m A. The centre of floatation is 3 m aft of amidships. MCT 1 cm = 240 tonnes m. Displacement = 6000 tonnes. Find the new drafts, if a weight of 120 tonnes, already onboard, is shifted forward a distance of 45 metres. (7)

22 Define the following terms with respect to trim: (7)

a. Tipping centre
b. Trimming moment
c. Longitudinal metacentre
d. Longitudinal metacentric height
e. MCT 1 cm.

Module V

Answer any two questions in full. Each question carries 7 marks.

23 What is a stability booklet? Who produces it? Who are its intended audience? Write a note, explaining the technical data present in stability books. (7)

24 State the IMO intact stability requirements for a cargo vessel. (7)

25 With the aid of a neat sketch explain the various effects of flooding on a ship. (7)

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Syllabus

Module 1

The ship's form: – Main dimensions, lines plan, coefficients and their meaning, fairing process– table of offsets.
Hydrostatic particulars: - Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KM_T And BM_T Metacentric Radius, TPC 1 cm, MCT 1 cm, Form Coefficients (C_B, C_P, C_M and C_W), LCF).

Module 2

Integration rules: - Trapezoidal rule; Simpson's rules; Tchebycheff's rule; Areas, volumes and moments; Bonjean calculations and curves; Sectional area curves; Hydrostatic calculations and curves.
Some physical fundamentals: - Archimedes' principle, laws of floatation.
Centre of Buoyancy and Centre of Gravity.
Introduction: - Stability of ships and submarines– stable and unstable conditions; Equivolume inclinations; Shift of C.O.B. due to inclinations.

Module 3

Transverse stability: - GM_0, GZ at small angles of inclinations. Stability due to addition, removal and transference of weight, suspended weight and free surface of liquids; Stability while docking and grounding; Inclining experiment.

Large angle stability: - Diagram of statical stability (GZ-curve), characteristic of curve, static equilibrium criteria; Cross curves of stability; Dynamical stability- diagram of dynamical stability, dynamical stability criteria

.

Module 4

Longitudinal stability: - Trim, longitudinal metacentre, longitudinal centre of flotation, moment to change trim, trimming moment; trim calculations - addition, removal and transference of weight, change of density of water.

Module 5

Margin Line and Permeability, Flooding calculation, Floodable length, Factor of Subdivision, Compartment Standard, Damage Stability- Calculations by Lost Buoyancy and Added Weight Methods; Recommendations of classification societies and governmental authorities - Intact and damage stability rules, Stability criteria in weather conditions.

Text Books

1. Edward V. Lewis; *Principles of Naval Architecture*, SNAME, 1st edition, 1988.
2. K.J. Rawson and E.C. Tupper, *Basic Ship Theory*, Vol. I & II, 5th Edition; Butterworth-Heinemann, 2001.
3. D.R. Derret, *Ship Stability for Masters and Mates*,7th Edition; Butterworth-Heinemann, 2012.

Reference Books

1. E.C. Tupper, *Introduction to Naval Architecture*; 5th Edition; Butterworth-Heinemann, UK, 2013.
2. Apostolos Papanikolaou, *Ship Design Methodologies of Preliminary Design*; Springer, 2014.
3. Colin S. Moore; Edited by J. Randolph Paulling; *Principles of Naval Architecture Series: Intact Stability*, The Society of Naval Architects and Marine Engineers, 2010.
4. A.B. Biran, *Ship Hydrostatics and Stability*; 2nd Edition; Butterworth-Heinemann, 2013.
5. D. Vassalos et al, *Contemporary Ideas on Ship Stability*; Elsevier Science Ltd, 2000

Course Content and Lecture Schedule:

No	Topic	No. of Lectures
1	**Module I: Introduction to Ship Parameters**	
1.1	The ship's form - main dimensions, lines plan, coefficients and their meaning.	3
1.2	Fairing process – table of offsets.	2
1.3	Hydrostatic particulars: - Volume of Displacement/ Displacement, Centre of Buoyancy, Centre of Floatation, KM_T And BM_T Metacentric Radius, TPC 1cm, MCT 1cm, Form Coefficients (C_B, C_P, C_M And C_W), LCF.	4
2	**Module II: Numerical Integration Methods**	
2.1	Integration rules: - Trapezoidal rule, Simpson's rules, Tchebycheff's rule.	3
2.2	Areas, volumes and moments Bonjean calculations and curves, sectional area curves. Hydrostatic calculations and curves.	1
2.3	Some physical fundamentals-Archimedes principle, laws of floatation stability.	1
2.4	Centre of Buoyancy and Centre of Gravity.	1
2.5	Introduction to Stability of ships and Submarines - stable and unstable conditions.	2
2.6	Equivolume Inclinations shift of C.O.B. due to inclinations.	1
3	**Module III: Transverse Stability**	

3.1	Initial stability: - GM_0, GZ at small angles of inclinations.	2
3.2	Stability due to addition, removal and transference of weight, suspended weight and free surface of liquids; Stability while docking and grounding.	2
No	**Topic**	**No. of Lectures**
3.3	Inclining experiment.	2
3.4	Large angle stability - Diagram of statical stability (GZ-curve), characteristic of Curve, static equilibrium criteria; Cross curves of stability; Dynamical stability – diagram of dynamical stability, dynamical stability criteria.	3
4	**Module IV: Longitudinal Stability**	
4.1	Trim, longitudinal metacentre, longitudinal centre of flotation, moment to change trim, trimming moment.	4
4.2	Trim calculations – addition, removal and transfer of weight, change of density of water.	5
5	**Module V: Damage stability and Stability Requirements**	
5.1	Margin Line and Permeability, Flooding calculation, Floodable length Factor of Subdivision, Compartment Standard	2
5.2	Damage Stability – Calculations by Lost Buoyancy and Added Weight Methods.	4
5.3	Recommendations of classification societies and governmental authorities – Intact and damage stability rules, Stability criteria in weather condition.	3

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SEMESTER -4
HONOURS

SBT292	ADVANCED PROPELLER DESIGN OF SHIPS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: To be familiar with the concept of Propulsion of ships, Prediction of powering of ships, and to design the optimum propeller by vibration analysis.

Prerequisite: SBT205-INTRODUCTION TO NAVAL ARCHITECTURE

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain trials for assessment of performance of propulsion systems.
CO 2	Predict the ships various power and powering calculations.
CO 3	Illustrate the propeller drawing for screw propellers.
CO 4	Describe the advanced theories of propeller action.
CO 5	Design propeller using various methodical series/ design charts/ model experiments.
CO 6	Explain the principle of vibration in design of propellers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2	2							2
CO 2	3	3	2	2								1
CO 3	2	2	2									2
CO 4	3	3	2	2	3							2
CO 5	2	2	3		2							2
CO 6	2	3	2	2	2							2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 3 questions from each module of which student should answer any two. Each question can have maximum 3 sub-divisions and carry 7 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A ship has an engine of rating 5000 kW brake power at 120 rpm directly connected to a propeller of 5 m diameter and 1 pitch ratio. Determine the maximum rpm at which the engine may run in the dock trials if the maximum rated torque of the engine is not to be exceeded. The propeller has a K_Q of 0.06 at J=0. The shafting efficiency is 0.97 and the relative rotating efficiency 1.03 (thrust identity).

2. The stopping distance (S) for an oil tanker in deep waters on a crash stop test is 2.28 nautical miles. Estimate the transverse lateral deviation by the time vessel has come to zero speed. If this test had been repeated in very shallow waters, what would have been the stopping distance?

3. A ship has an engine of maximum continuous rating 20000 kW at 114 rpm. The equivalent above water transverse projected area of the ship is 300 m2. The contract for the ship requires it to have a minimum speed of 18 knots in calm water at 85% maximum continuous rated power and 100% rated rpm. During the acceptance trials, the following data are recorded:

Run No.	1	2	3	4	5
Direction	W	E	W	E	W
Time at start, hr-min	10-30	10-57	00-25	11-53	12-19
Time on mile, s	207.4	190.5	202.6	201.8	187.9
Relative wind velocity, ms^{-1}	9.908	7.495	11.164	7.765	10.468
Wind direction off the bow, deg	7.5	17	13.9	14.3	9.1
Shaft power, kW	16920	16930	16980	16960	16950
Propeller rpm	113.5	113.6	114.2	114.1	114

The slope of the effective power speed curve of the ship at 18 knots is 2300 kW per knot. The wind resistance of the ship may be estimated using equations. Determine the speed that the ship would attain in calm water, still air conditions. Does the ship fulfil the contract requirements?

Course Outcome 2 (CO2):

1. A propeller of 4.5m diameter has a pitch of 4.3 m and boss diameter 0.75 m.The real slip is 28% at 95 rev/min.Calculate the speed of advance, thrust and thrust power.

2. A propeller of 4 m pitch has an efficiency of 67%.When turning at 125 rev/min the real slip is 36% and delivered power 2800 kW. Calculate the thrust of the propeller.

3. A ship of 15000 tonne displacement has an admiralty coefficient based on shaft power of 420. The mechanical efficiency of the machinery is 83%, shaft loss 6%, propeller efficiency 65% and QPC 0.71. At particular speed the thrust power is 2550 kW.

Calculate:

a) Indicated power

b) Effective power

c) Ship speed

Course Outcome 3 (CO3):

1. Explain steps in development of propeller drawing with diagram.

2. Sketch different views of propeller and label them.

3. Define Holst method for propeller drawing.

Course Outcome 4 (CO4):

1. A propeller of diameter 4 m operates at a depth of 4.5 m below the surface of water with a speed of advance 5 m per sec and produces a thrust of 200 kN. Determine the pressures and velocities (with respect to the propeller) in the water far ahead, just ahead, just behind and far behind the propeller on the basis of the axial momentum theory.

2. Explain the application of circulation theory to propeller design.

3. A propeller of 5m diameter has a speed of advance of 6 m per sec and a revolution rate of 120 rpm. The root of the section is at 0.2 R. The propeller operates in an inviscid fluid of density 1025 kg per m^3 and has an efficiency of 75%. Determine the axial and rotational inflow factors a and a' at different radii, and calculate the propeller thrust and torque if the propeller operates at the highest efficiency.

Course Outcome 5 (CO5):

1. Design the propellers for a twin screw liner using the lifting line theory with lifting surface corrections. The ship has a design speed of 35 knots at which the effective power is 16000 kW. The three bladed propellers are to have diameter of 3.5 m and to run at 300 rpm. The propeller shaft centre lines are 3.2 m below the waterline. The wake fraction is 0.000, the thrust deduction fraction 0.050 and the relative rotative efficiency is 0.990 based on thrust identity. The wake may assume uniform. The expanded blade area ratio is estimated to be 0.85 and the blade outline is to be according to Morgan, Silovic and Denny with no skew. The blade thickness fraction is to be 0.50 and the tip thickness being 0,003 times the propeller diameter with a linear thickness variation. The blade sections are to have NACA a-0.8 mean lines and NACA-16 (modified) thickness distributions. Calculate the required shaft power of the propulsion turbines if the shafting efficiency is 0.94.

2. A single screw tug has an engine of 900 kW brake power at 600 rpm connected to the propeller through 4:1 reduction gearbox. The shafting efficiency is 0.95. The wake fraction is 0.2, while the thrust deduction varies linearly with speed with values of 0.050 and 0.180 at zero speed and 12 knots respectively. The relative rotative efficiency is 1.000. The effective power P_E of the tug at different speeds V is as follows:

V, k	8	9	10	11	12	13	14	15
P_E, kW	68.9	104.1	150.6	210.2	285.0	377.1	488.8	622.3

Design the propeller for maximum bollard pull. Calculate the free running speed of the tug and the corresponding brake power and rpm of the engine.

3. Describe the steps in propeller design using B Series chart.

Course Outcome 6 (CO6):

1. A single screw ship has a design speed of 16 knots with its propeller of 4.5 m diameter running at 120 rpm. The axial and tangential components of the relative velocity of water with respect to the ship in the propeller disc at 0.7R are as follows:

ϴ, deg	0	30	60	90	120	150	180
V_a, ms^{-1}	4.52671	5.8436	7.0781	6.5843	6.2551	5.8436	5.3498
V_t, ms^{-1}	0.0000	-1.5520	-0.5702	0.4115	0.5702	0.7289	0.0000

Where ϴ is measured from the vertically up position. The ship may be fitted with either a 4 bladed propeller or a 6 bladed propeller.

The 4 bladed propeller of 0.9 pitch ratio has the following open water characteristics:

$$K_T = 0.3950\text{-}02707J\text{-}0.1575J^2$$

$$10K_Q = 0.5031\text{-}0.2630J\text{-}0.2205J^2$$

The 6 bladed propeller of 0.925 pitch ratio and open water characteristics as follows:

$$K_T = 0.3950\text{-}02707J\text{-}0.1575J^2$$

$$10K_Q = 0.5031\text{-}0.2630J\text{-}0.2205J^2$$

The point of action of the tangential force on each blade is at a radius of 1.41 m. From the point of view of minimizing unsteady propeller forces, which of the two propellers should be selected? What can you say about the harmonics present in the wake velocities?

2. Explain the propeller noise spectra with the aid of a neat sketch. What are the various information those can be obtained from a noise spectra of a propeller?

3. What are the different methods for determining hull surface pressure due to a propeller? Explain any one method.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, XXXX 20XX

Course Code: SBT292

ADVANCED PROPELLER DESIGN OF SHIPS

Max. Marks: 100 Duration: 3 Hours

PART – A

Answer all 10 questions each carries 3 Marks

1. What are the steps in the design of free running propeller?

2. What are the different series data used to design ducted propellers?

3. Point out the selection criteria for main engine in a ship.

4. What are the general issues faced in propeller selection for a cargo vessel.

5. Draw a typical power train and mark different powers in a ship.

6. Explain the use of Admiralty coefficient in propeller design.

7. In shallow water condition, for a fully loaded condition, a vessel has a C_B of 0.750. She was on a even keel when static. Estimate the maximum squat at the bow when she has a speed of 10 knots in open water and when she is in a confined channel.

8. Define ships squat and blockage factor.

9. What are the causes and effects of propeller vibration in performance of ships?

10. List down the different parameters that influence the fundamental frequency of propeller blade vibration.

PART-B

Each question carries 7 marks, answer any two full questions from each module.

Module – I

11. Explain the procedure of propeller design using methodological series.

12. With help of diagrams explain propeller drawing for a screw propeller.

13. Explain the propeller design method for Free running and towing duty propeller.

Module – II

14. Explain momentum principle for development of thrust for a propeller.

15. Explain a typical machinery installation onboard ship indicating various components.

16. Explain Circulation theory of propeller action.

Module – III

17. A propeller of 4.5m diameter has a pitch of 4.3 m and boss diameter 0.75 m.The real slip is 28% at 95 rev/min. Calculate the speed of advance, thrust and thrust power.

18. A propeller of 4m pitch has an efficiency of 67%. When turning at 125 rev/min the real slip is 36% and delivered power 2800 kW. Calculate the thrust of the propeller.

19. A ship of 15000 tonne displacement has an admiralty coefficient based on shaft power of420. The mechanical efficiency of the machinery is 83%.shaft loss 6%, propeller efficiency 65% and QPC 0.71. At particular speed the thrust power is 2550 kW.

Calculate:

a) Indicated power

b) Effective power

c) Ship speed

Module – IV

20. The stopping distance (S) for an oil tanker in deep waters on a crash stop test is 2.28 nautical miles. Estimate the transverse lateral deviation by the time vessel has come to zero speed. If this test had been repeated in very shallow waters, what would have been the stopping distance?

21. With the help of a neat sketch explain crash stop test in ship.

22. A passenger liner moves at a forward speed of 12 knots in shallow water. Estimate her maximum squat if her C_B IS 0.618 when she is in:

(a) Open water condition and

(b) Confined channel condition

Module – V

23. Manufacture of marine propeller is a specialised activity. Explain the various steps involved in the process of marine propeller manufacture and highlight various permitted tolerences.

24. Explain the propeller noise spectra with the aid of a neat sketch. What are the various information that can be obtained from a noise spectra of a propeller?

25. What are the different methods for determining hull surface pressure due to a propeller? Explain any one method

Syllabus

Module – I (9 hours)
Propeller design – Introduction to Design of free running propeller, towing duty propeller.
Propeller drawing – Expanded view, Developed view, projected view.
Propeller ship interaction – Bearing forces, Hydrodynamic interaction.

Module – II (9 hours)
Advanced Theory of Propeller Action – Momentum Principle, Circulation Theory of Screw Propeller, Application of circulation theory to propeller design, Vortex lattice method.
Machinery Installation - Selection criteria for main engine, selection of propulsive installation, Specifications in shipyard-owner contract, Determination of propeller rpm, selection of main engine, shaft alignment.
Selection of propeller - General issues, main features, number of blades, propeller construction, number of propellers.

Module – III (9 hours)
Advanced Powering Calculation – Operating profiles, propulsion train and power constants on ships, Available Preliminary design methods for ships propeller.
Cavitation – Nature of cavitation, Law of similitude for cavitating propeller, Detrimental effects of cavitation, representation of data Criteria for prevention of cavitation.

Module – IV (9 hours)
Ship Trials - Speed performance on the measured mile, Endurance and fuel consumption, Manoeuvring trials and stopping characteristics, Residual trials.
Practical design of propeller – Engine propeller matching, Design using Kt-Kq, Bp-δ, TJ-PJ curves.
Propulsion Devices - Tandem and contra rotating propellers, overlapping propellers, partially submerged propeller, other devices.

Module – V (9 hours)
Miscellaneous Topics - Unsteady propeller loading, Propellers on inclined shafts, Vibration and Noise due to propellers, Propeller manufacture and repair.

Text Books

1. E.V Lewis; Principles of Naval Architecture, SNAME- New Jersey, 1988
2. Eric Tupper; Introduction to Naval Architecture, Fifth edition, Butterworth Heinemann, 2013
3. C.B.Barrass; Ship Design and Performance for Masters and Mates, Elsevier Science & Technology, 2004
4. Apostolos Papanikolaou; Ship Design methodologies of preliminary design, Springer, 2014
5. J.P. Ghose, R.P. Gokarn; Basic Ship Propulsion, First edition, KW Publishers Pvt. Ltd, 2015

Reference Books

1. D.G.M. Watson; Practical Ship Design; Volume I and II, Elsevier Ocean Engineering Book Series, 2002
2. Rawson and Tupper; Basic Ship Theory, Fifth Edition, Butterworth-Heinemann, 2001

3. Lars Larsson & Hoyte C.; The Principles of Naval Architecture Series: Ship Resistance and Flow, The Society of Naval Architects and Marine Engineers, 2010

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module – I**	
1.1	**Propeller design –** Introduction to Design of free running propeller, towing duty propeller.	3
1.2	**Propeller drawing –** Expanded view, Developed view, projected view.	3
1.3	**Propeller ship interaction –** Bearing forces, Hydrodynamic interaction.	3
2	**Module – II**	
2.1	**Advanced Theory of Propeller Action –** Momentum Principle, Circulation Theory of Screw Propeller, Application of circulation theory to propeller design, Vortex lattice method.	3
2.2	**Machinery Installation** - Selection criteria for main engine, selection of propulsive installation, Specifications in shipyard-owner contract, Determination of propeller rpm, selection of main engine, shaft alignment.	3
2.3	**Selection of propeller** - General issues, main features, number of blades, propeller construction, number of propellers.	3
3	**Module – III**	
3.1	**Advanced Powering Calculation –** Operating profiles, propulsion train and power constants on ships, Available Preliminary design methods for ships propeller.	4
3.2	**Cavitation** – Nature of cavitation, Law of similitude for cavitating propeller, Detrimental effects of cavitation, representation of data Criteria for prevention of cavitation.	5
4	**Module – IV**	
4.1	**Ship Trials -** Speed performance on the measured mile, Endurance and fuel consumption, Manoeuvring trials and stopping characteristics, Residual trials.	3
4.2	**Practical design of propeller –** Engine propeller matching, Design using Kt-Kq, Bp-δ, TJ-PJ curves.	3
4.3	**Propulsion Devices -** Tandem and contra rotating propellers, overlapping propellers, partially submerged propeller, other devices.	3
5	**Module – V**	
5.1	**Miscellaneous Topics -** Unsteady propeller loading	3
5.2	Propellers on inclined shafts	2
5.3	Vibration and Noise due to propellers	2
5.4	Propeller manufacture and repair.	2