

# **MARINE CONSTRUCTION & WELDING**

**NA21003**

# Syllabus

## **1. Ships: Introduction & Classification**

## **2. The Shipbuilding Industry**

## **3. Loads on Ship & Structural Requirement**

## **4. Ship Structure**

- Basic Structural Components
- Structural Subassemblies
- Structural Assemblies
- Midship Sections\*
- Structural Alignment & Continuity

# Syllabus



## **5. Ship Construction & Launching**

## **6. Materials for Construction**

- Shipbuilding Materials
- Steel Material Preparation
- Plate Cutting
- Plate & Section Forming

# Syllabus

## **7. Welding**

- Introduction
- Welding Parameters
- Fusion Welding Methods
- Solid State Welding
- Residual Stress and Distortion
- Distortion Control and Mitigation
- Welding defects

## **8. Nondestructive Testing**

## **9. Accuracy Control**

# Resources

## Ship Construction:

- ❑ *\*Ship Construction* by D.J Eyres & G.J Bruce
- ❑ *Ship Design and Construction* by Taggart/ Lamb (SNAME)
- ❑ *\*Ship Construction and Welding* by N.R Mandal

## Basic Naval Architecture:

- ❑ *\*\*Introduction to Naval Architecture* by E.C Tupper
- ❑ *Basic Ship Theory* by K.J Rawson & E.C Tupper
- ❑ *Principles of Naval Architecture* series (SNAME)

# Introduction

## □ **Ship Theory**

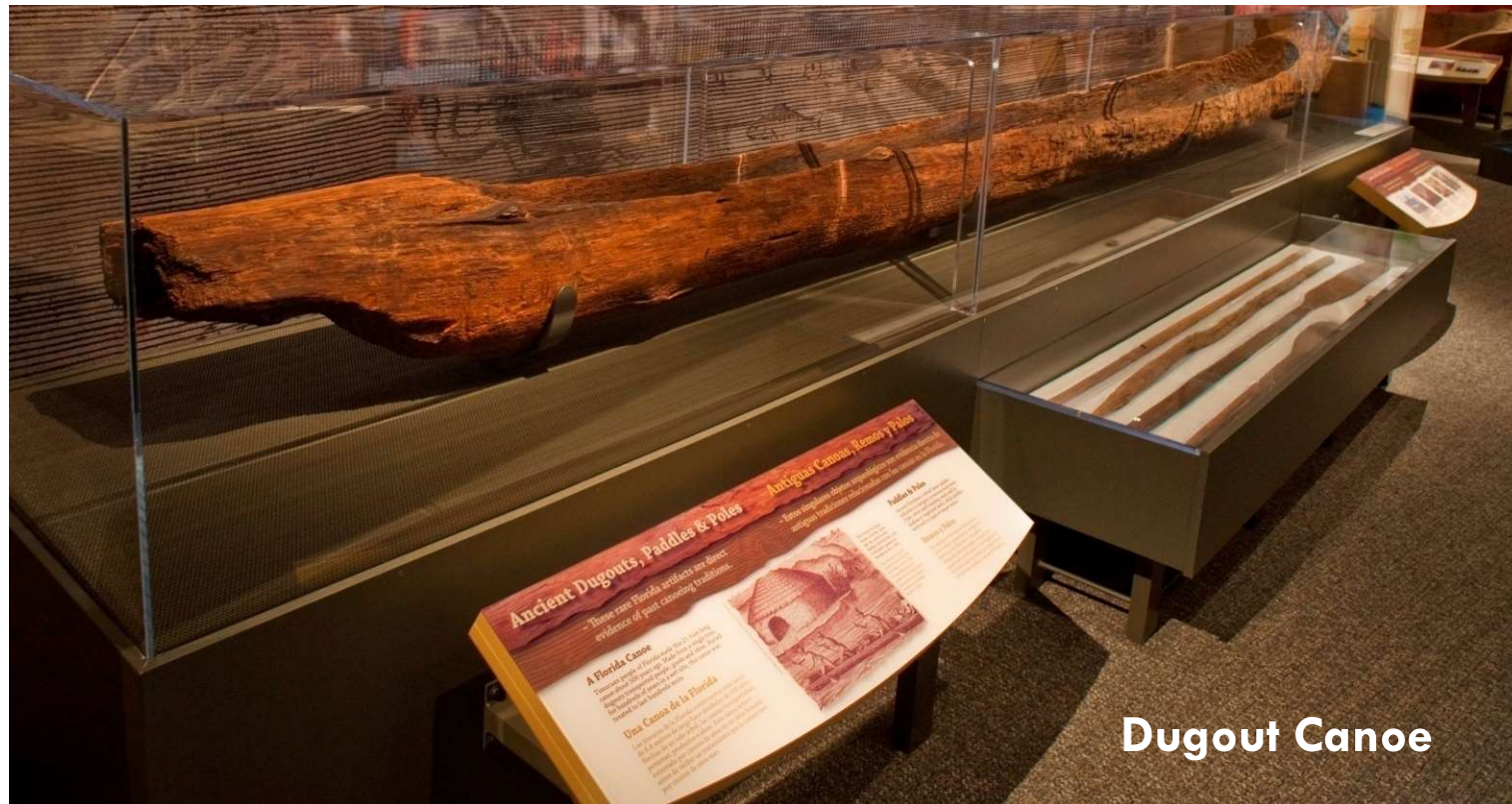
The science of building ships by investigating its characteristics before it is constructed

## □ **Shipbuilding**

The construction of ships according to design requirements

# Introduction

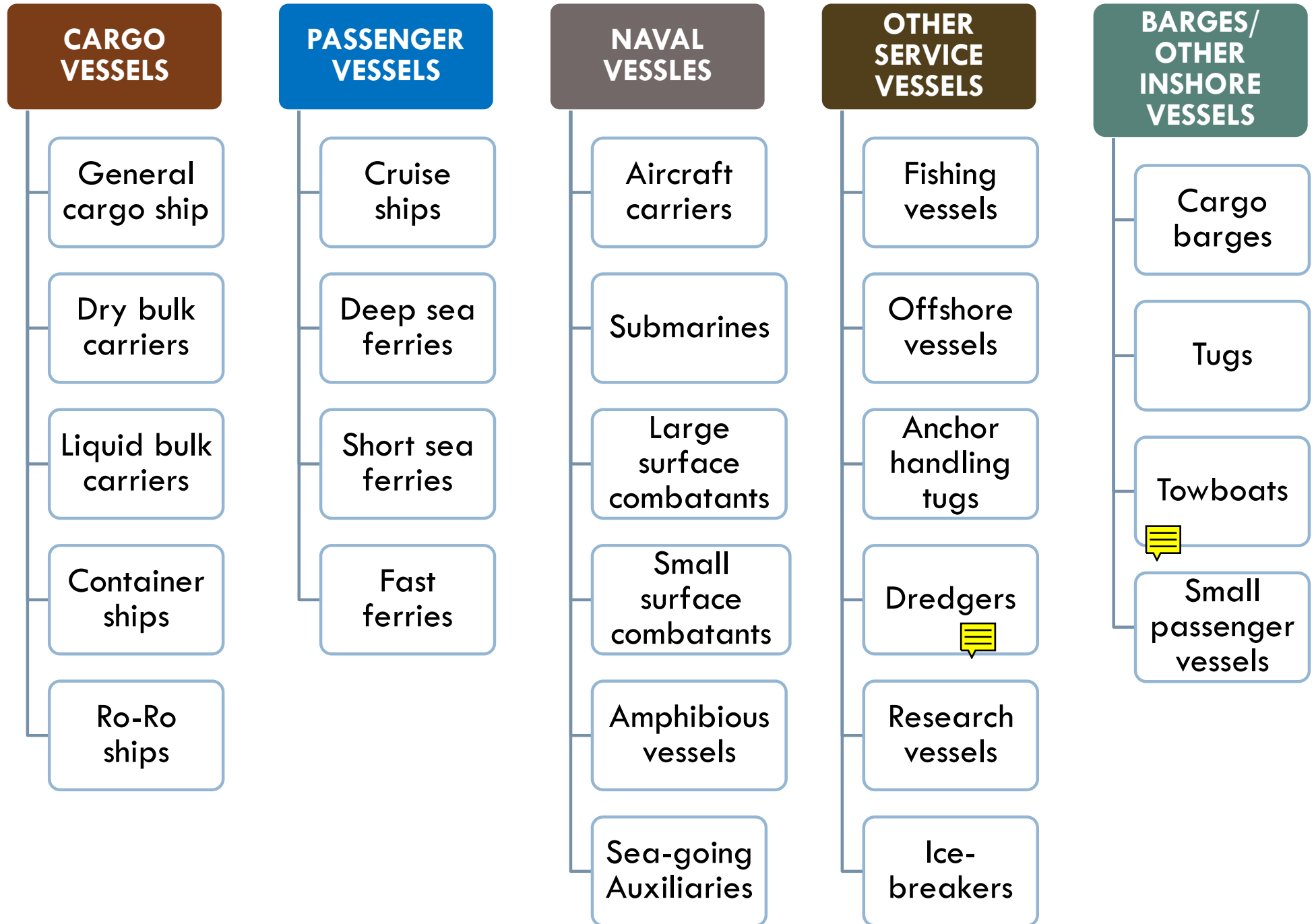
Shipbuilding existed as early as around 5000 years ago



**Dugout Canoe**

Through the ages shipbuilding evolved as oared ships, sail ships, and with the industrial revolution into steamships, diesel and gas turbine powered, and nuclear powered ships.

# World Fleet

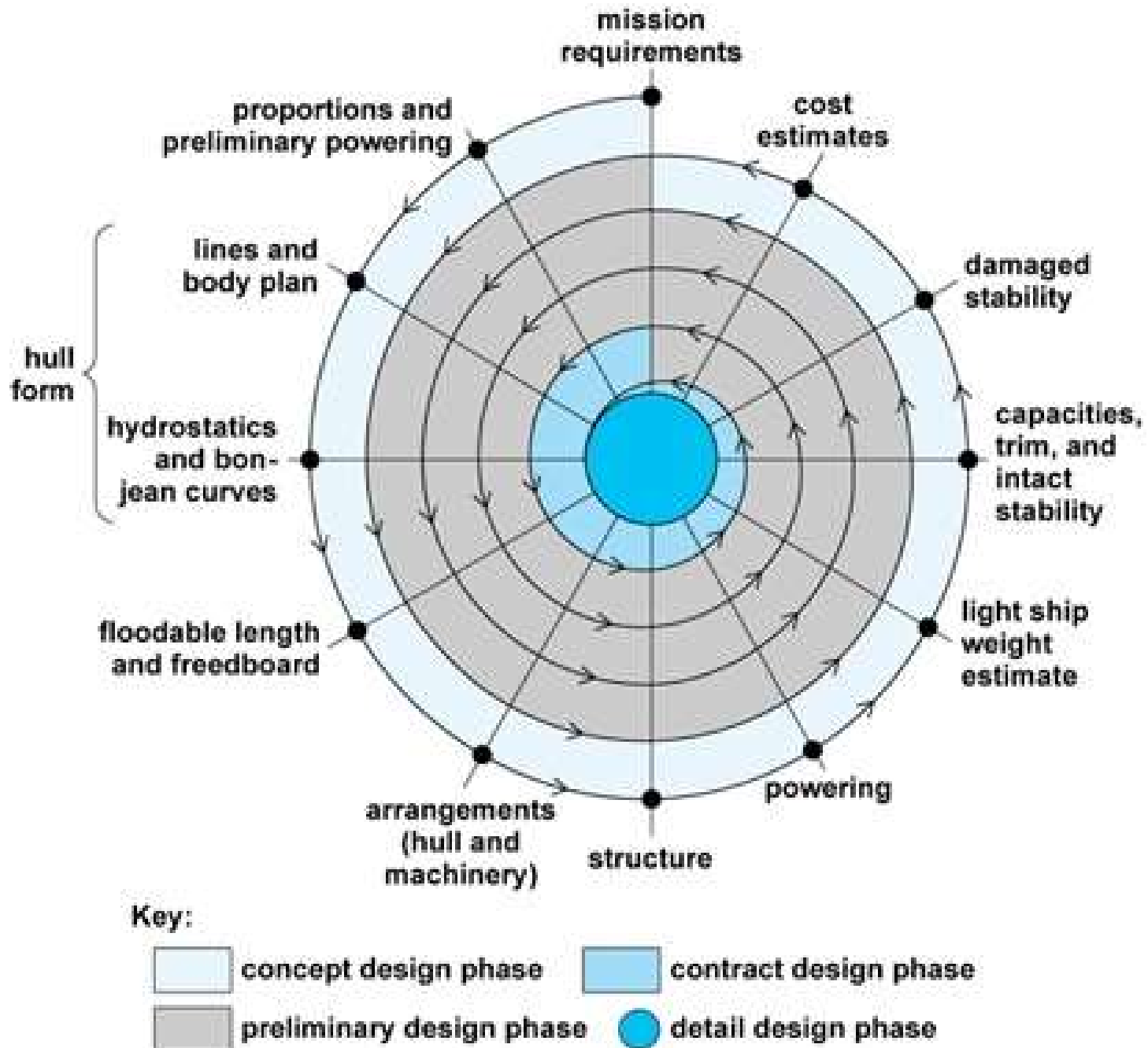




**Different aspects of Naval Architecture can be understood from the Ship Design Spiral.**

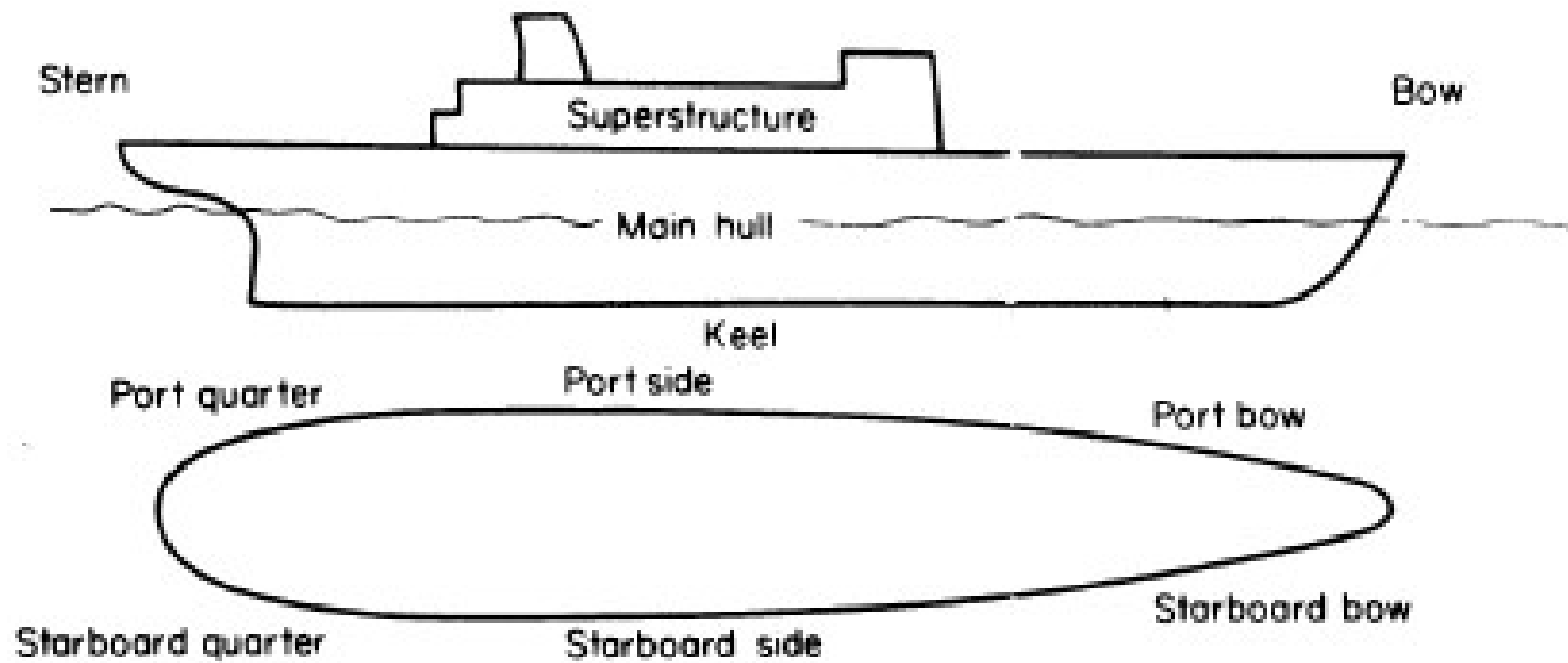
**An iterative approach is used to arrive at the final design starting from the basic requirements of the owner.**

# Ship Design Spiral

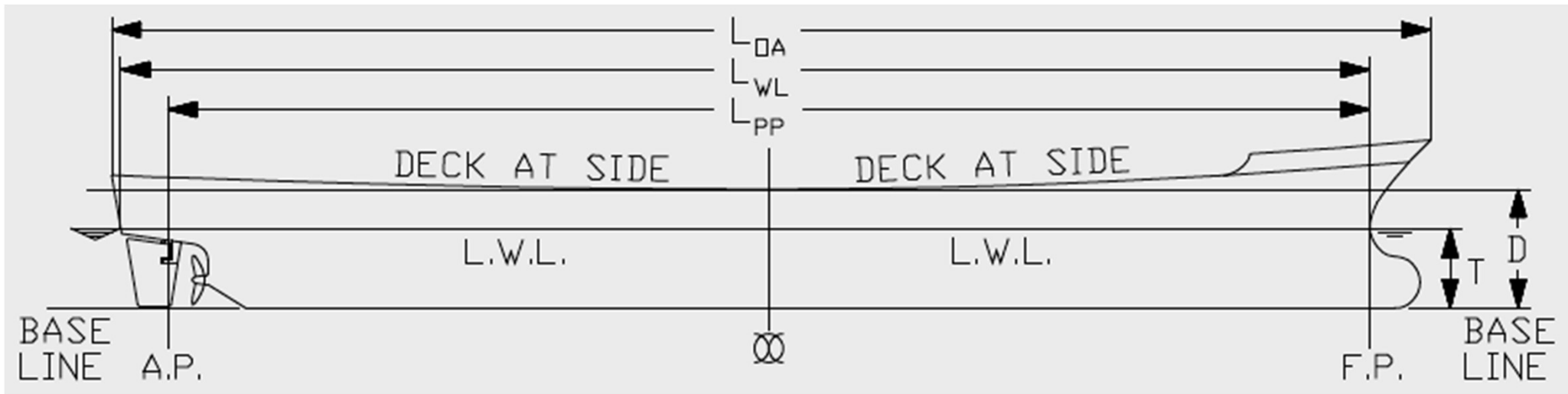


# **Ship Geometry & Nomenclature**

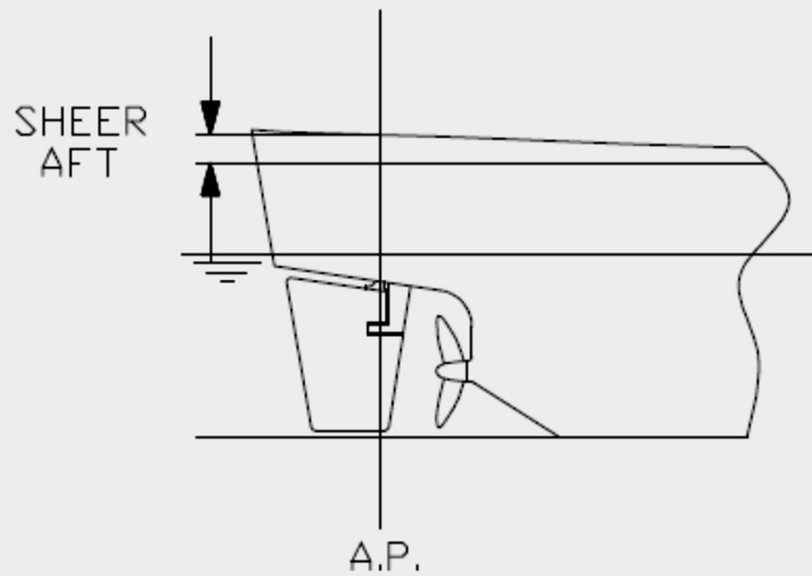
# Ship Nomenclature



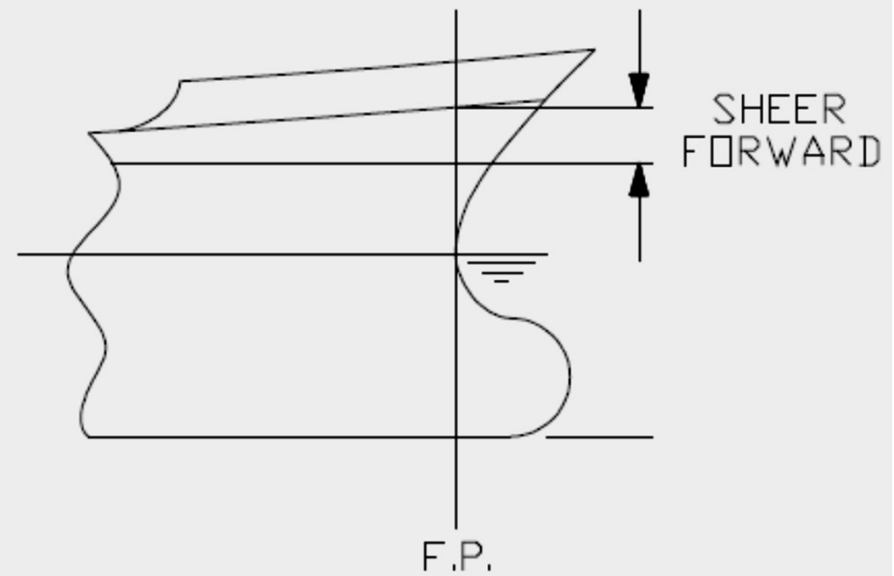
# Ship Nomenclature



# Ship Nomenclature

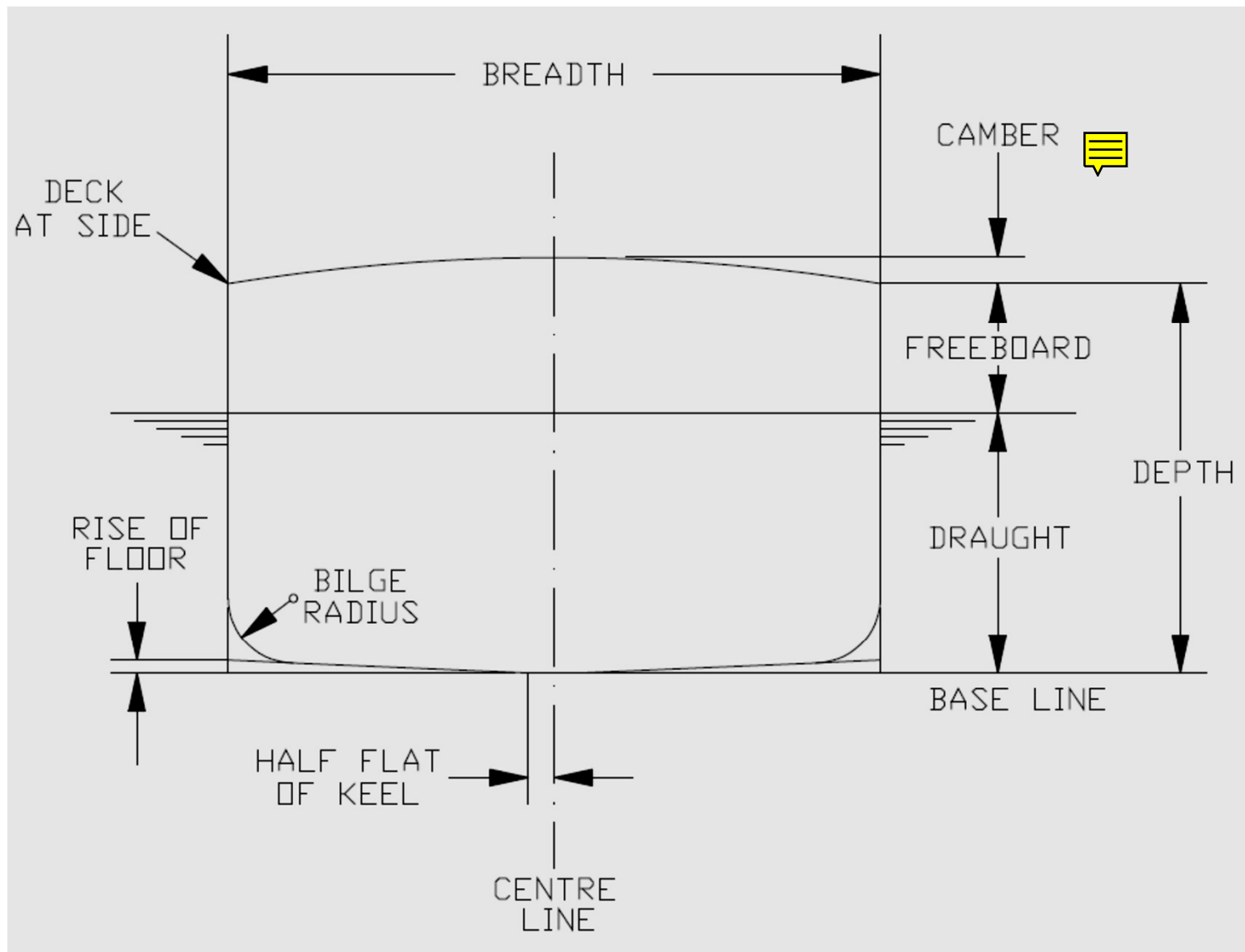


AFTERBODY (ENLARGED)

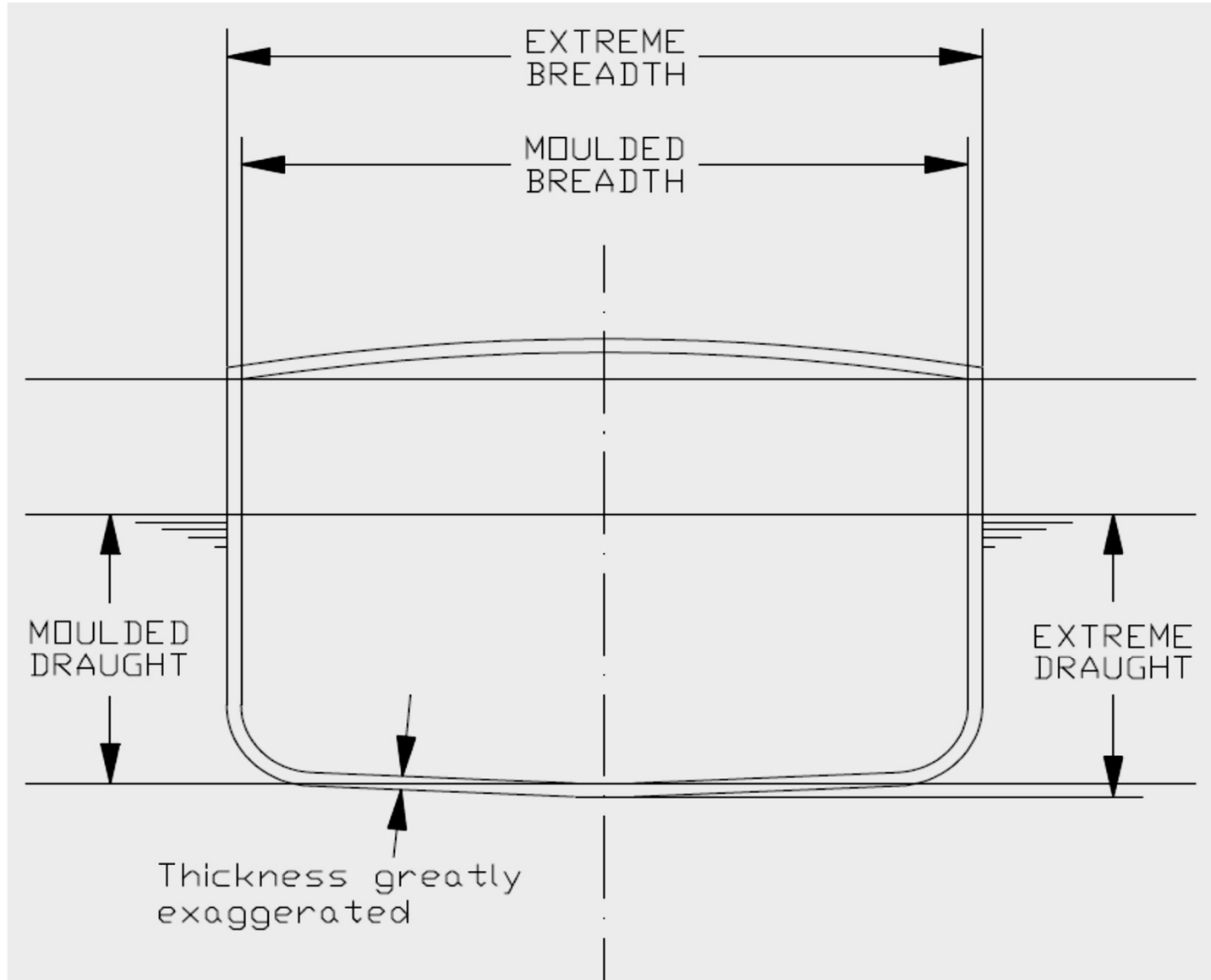


FOREBODY (ENLARGED)

# Ship Nomenclature



# Ship Nomenclature



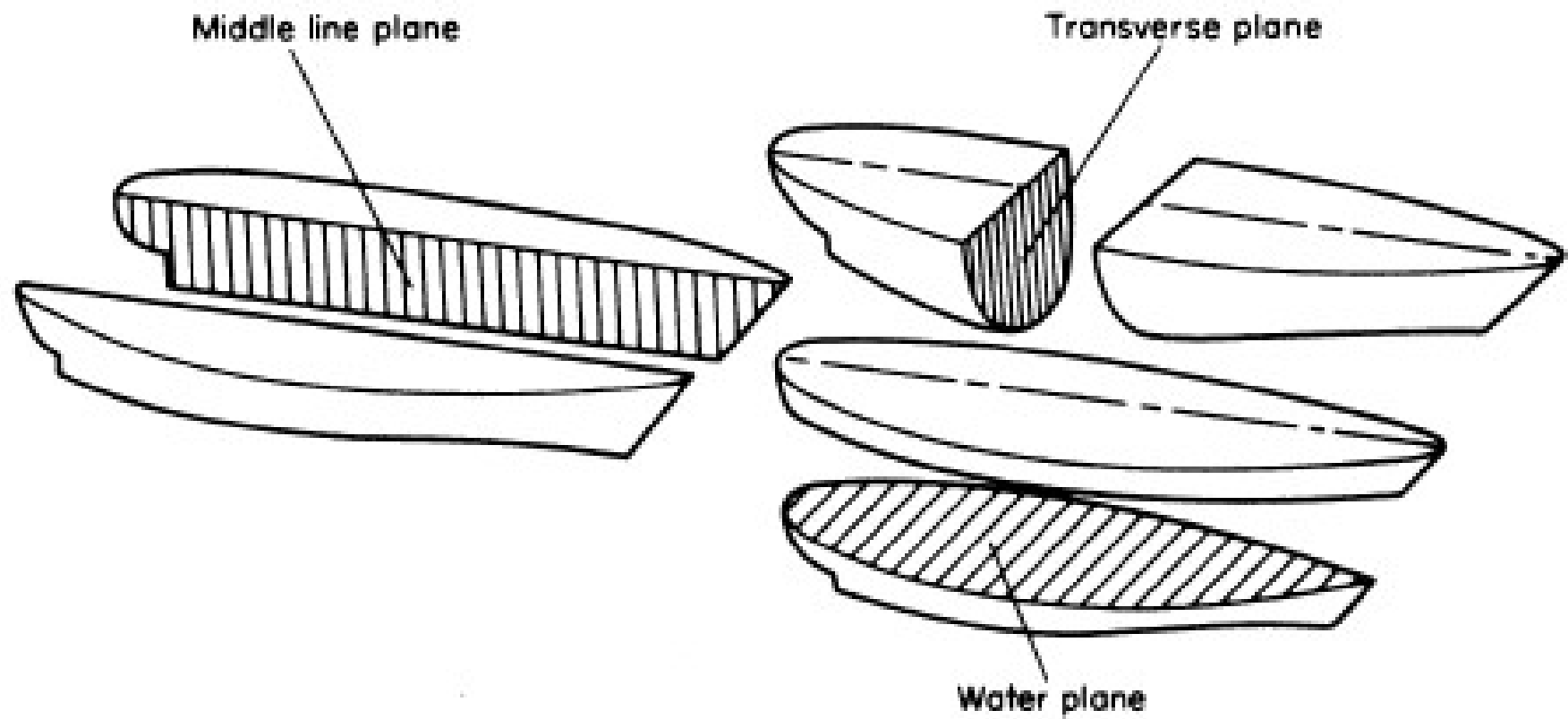


# Ship Geometry

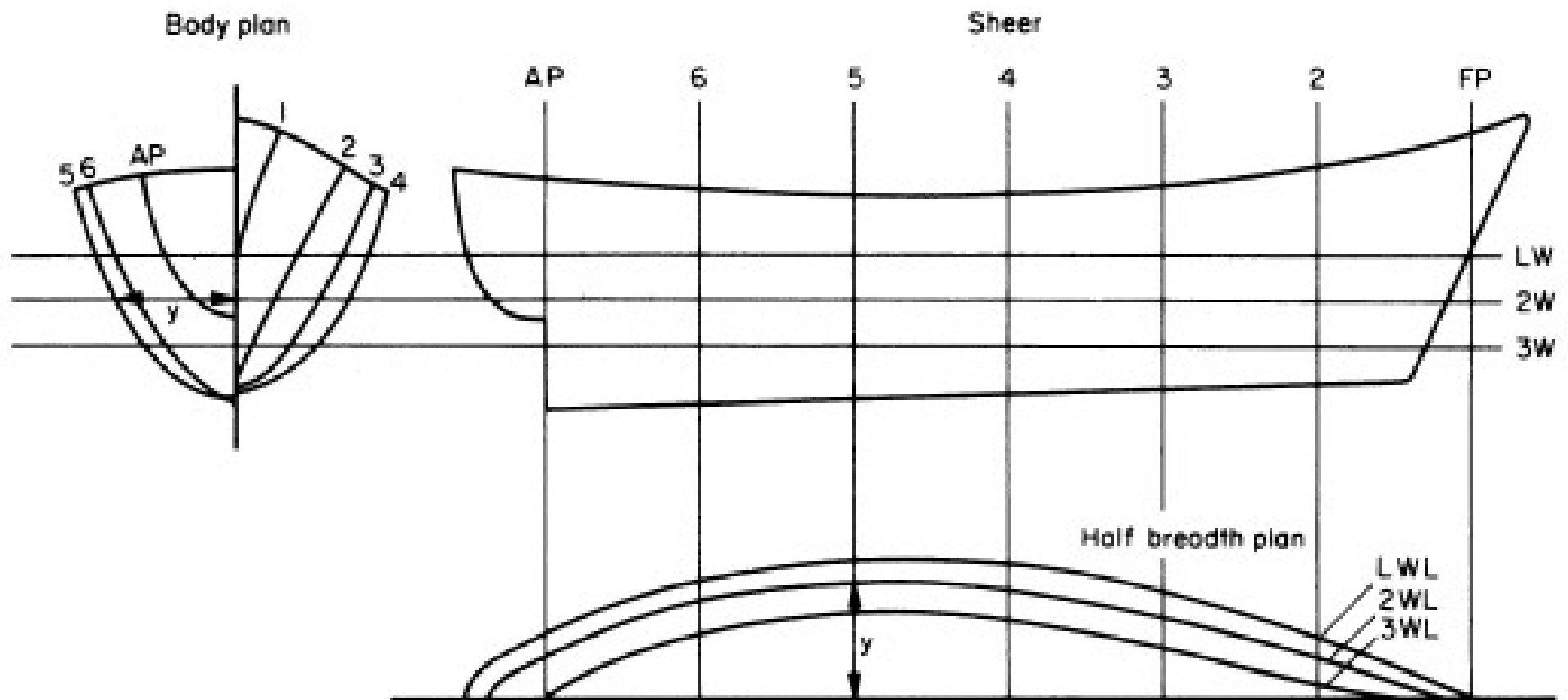
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- ❑ The three-dimensional hull form can be represented by a well defined set of curves.
- ❑ Given hull geometry, these curves can be generated by tracing the intersections of the hull with three sets of mutually orthogonal planes.

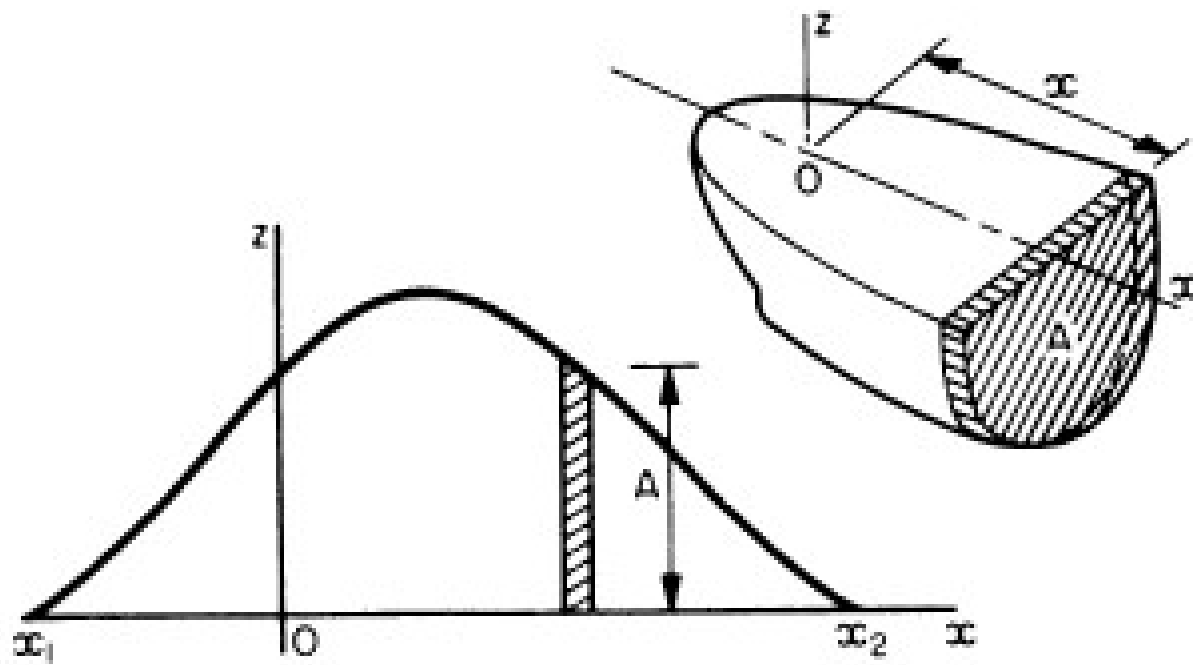
# Ship Geometry



# Ship Geometry

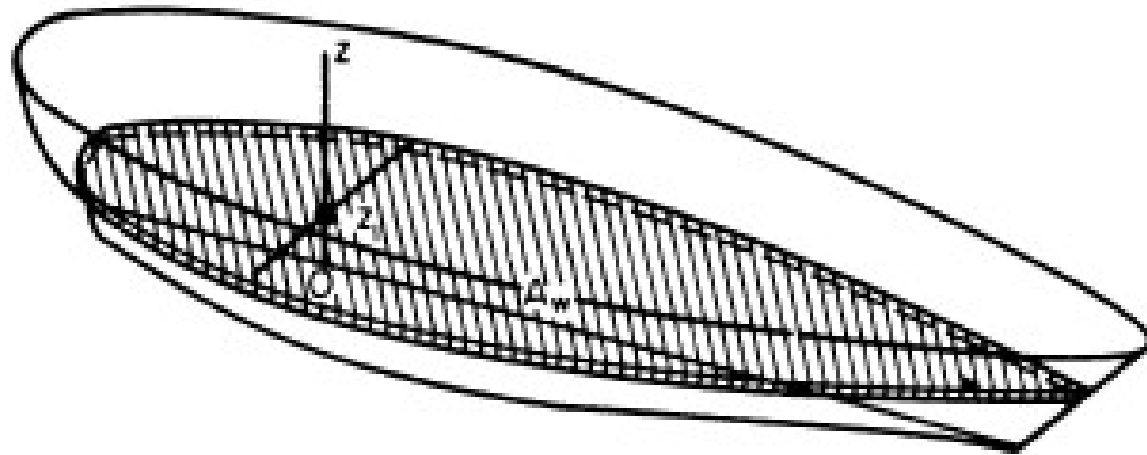
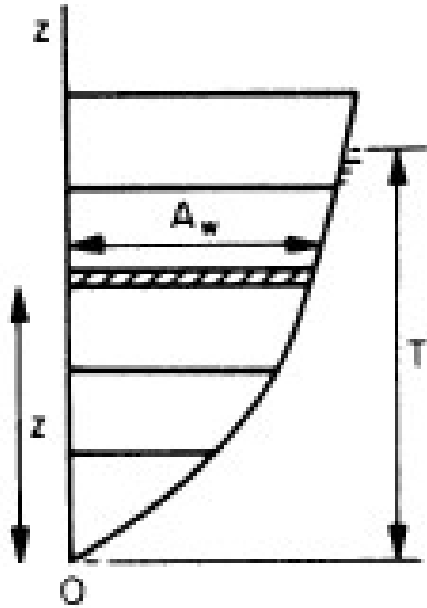


# Ship Displacement



$$\nabla = \int_{x_1}^{x_2} A \, dx$$

# Ship Displacement



$$\nabla = \int_0^T A_w dz$$

# The Marine Industry

The ***international marine industry*** can be structurally divided into five groups:

## **1) SHIP DESIGN:**

Naval architectural firms

University schools/ departments

Classification societies

## **2) SHIP CONSTRUCTION:**

Shipbuilding industry: major, medium-sized, and small shipyards

# The Marine Industry

## **3) MARINE MANUFACTURING:**

Provide machinery, outfit, equipments, etc. to the shipyards.

Main engine & other machineries

Propulsion system

Cargo-handling system

Steering and Mooring system

Navigation system etc.

## **4) SHIP OPERATION:**

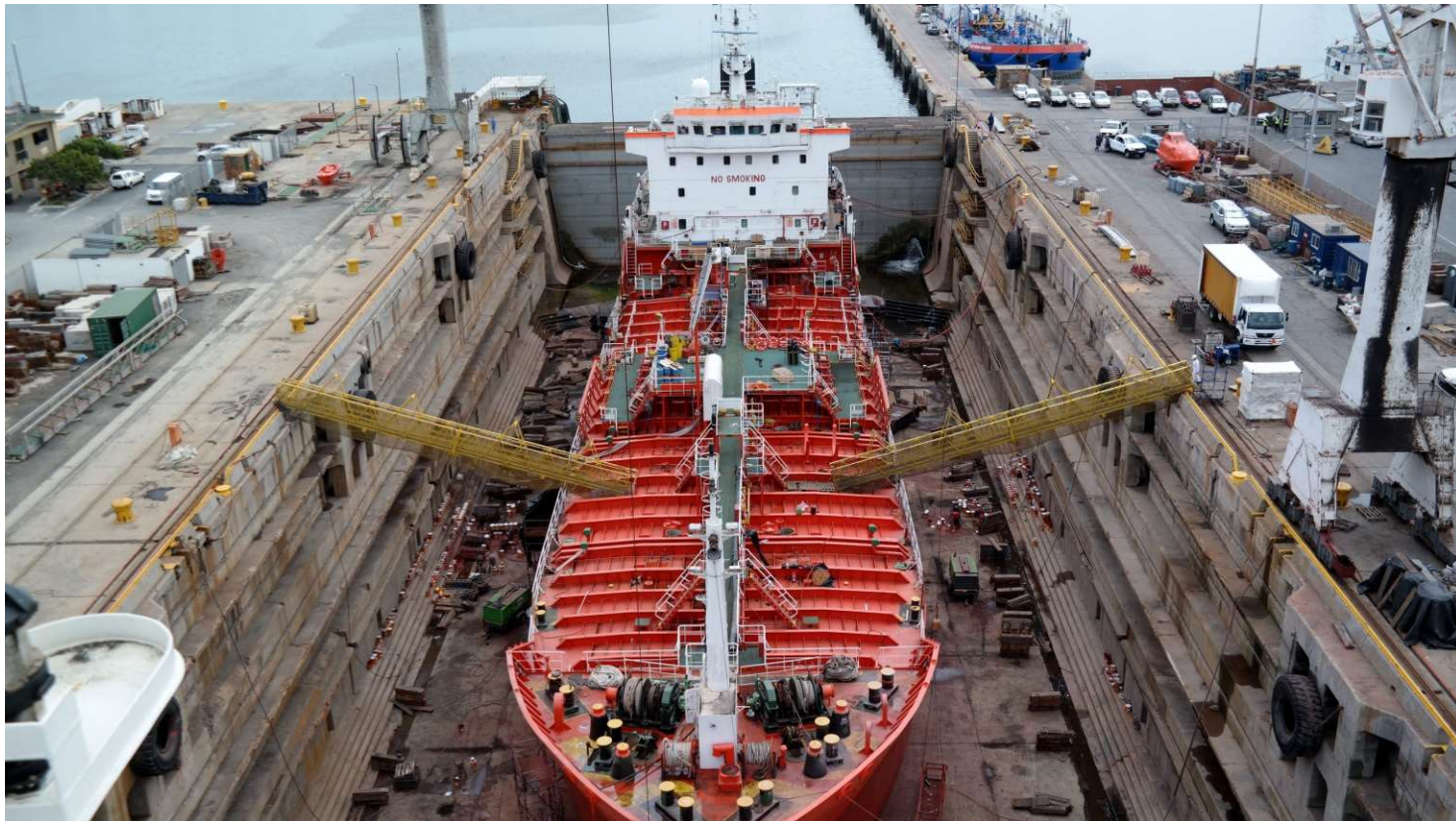
Government agencies, navies, multinational corporations, independent operators etc.

# The Marine Industry

## 5) SHIP REPAIR:

Mainly **dry-docks** used for maintenance and repair activities

Very large, large, small, and very small, depending on capacities





# The Marine Industry

## **The International Maritime Organization:**

IMO, a specialized agency of the United Nations, is the global standard-setting authority for the safety, security and environmental performance of international shipping.

### **Role:**

To create a regulatory framework for the shipping industry that is fair and effective, universally adopted, and universally implemented.

## **Flag of Convenience:**

The flag of a suitable country (with good political connections) is adopted for official (taxation) purposes

# The Shipbuilding Industry



The industry requires a very wide range of equipment, materials, and skills.

# Characteristics



## **PRODUCT SIZE:**

- ❑ Size varies from a few metres to a few hundred metres
- ❑ Built on land, and need to be put into water (launching)
- ❑ Industry involves production, launching, and operation aspects

# Characteristics

## **MANHOOUR REQUIREMENT:**

- ❑ Labour intensive industry with huge manhour requirement
- ❑ Production time typically varies from 1-4 years (ship size)
- ❑ Evaluation of manhour difficult due to overlapping and complex activities involved

# Characteristics



## **MATERIALS USED:**

- ❑ Wide variety of materials used for construction
- ❑ Engineering requirement followed by boarding and lodging facilities for passengers and crew

# Characteristics

## **MULTIPLE SKILLS:**

- ❑ Complex construction and mission requires a wide range of skills
- ❑ They include- welding, fitting, piping, mechanical, electrical, and navigational equipment installation, air conditioning and ventilation etc.

# Characteristics



## **UNIT PRODUCTION:**

- ❑ Customer driven unit production market
- ❑ Each unit different from others depending on the owner's specific requirements
- ❑ No provision for prototyping

# Characteristics

## **SERIES PRODUCTION:**

- ❑ More than one vessel with identical specifications
- ❑ ‘Sister ships’-  
for medium to big vessels - 5-10  
for smaller vessels – around 50 or more.
- ❑ Timeline of building sister ships different. The next vessel production is started only when the previous one has progressed. Fabrication done separately.
- ❑ Some modifications based on feedback of sister ships in service.



# Characteristics

## **DELIVERY SCHEDULE:**

- ❑ Inputs from the customer: Type of cargo, Volume/Weight of cargo, Operation route, Cruising speed.
- ❑ Shipbuilder needs to work out the design, build strategy, delivery schedule, and cost of the ship.
- ❑ Contract between builder and ship owner: delivery date, ship cost, speed requirement

# Characteristics

## **SHIP SPEED:**

- ❑ Cruising speed determines the number of round trips and hence the generated revenue per year
- ❑ Higher speed means greater power requirement leading to higher fuel consumption increasing operating cost
- ❑ Speed of operation to be decided in the contract between the ship owner and builder

# Shipyards in India

## **PUBLIC**

- ❑ Mazagon Dock Limited- Mumbai
- ❑ Cochin Shipyard Limited
- ❑ Hindustan Shipyard Limited- Visakhapatnam
- ❑ Garden Reach Shipbuilders and Engineers- Kolkata
- ❑ Goa Shipyard Limited
- ❑ Naval Dockyards (Mumbai & Visakhapatnam)

## **PRIVATE**

- ❑ ABG Shipyard Limited
- ❑ Bharati Shipyard Limited
- ❑ L&T Shipbuilding Limited
- ❑ Pipavav Shipyard (now Reliance Defence and Engineering Limited)

# Classification Societies

Develop rules and maintain design, construction, and operation standards for marine vessels through surveys

## **ROLE:**

- ❑ Technical plan review
- ❑ Surveys during construction
- ❑ Sea-trials
- ❑ Surveys after construction (periodic surveys)
- ❑ Classification standards (develop rules from basic principles, experience and analysis)

# Classification Societies

- ❑ American Bureau of Shipping (ABS)
- ❑ Bureau Veritas (BV)
- ❑ China Classification Society (CCS)
- ❑ Det Norske Veritas Germanischer Lloyd (DNV GL)
- ❑ Indian Register of Shipping (IRS)
- ❑ Lloyd's Register (LR)
- ❑ Korean Register of Shipping (KR)

Common forum: **International Association of Classification Societies (IACS)**

# Loads on Ships

# Loads on ships



Types of service loads:

- Static
- Slowly varying/ Quasi-static
- Rapidly varying

# Loads on ships

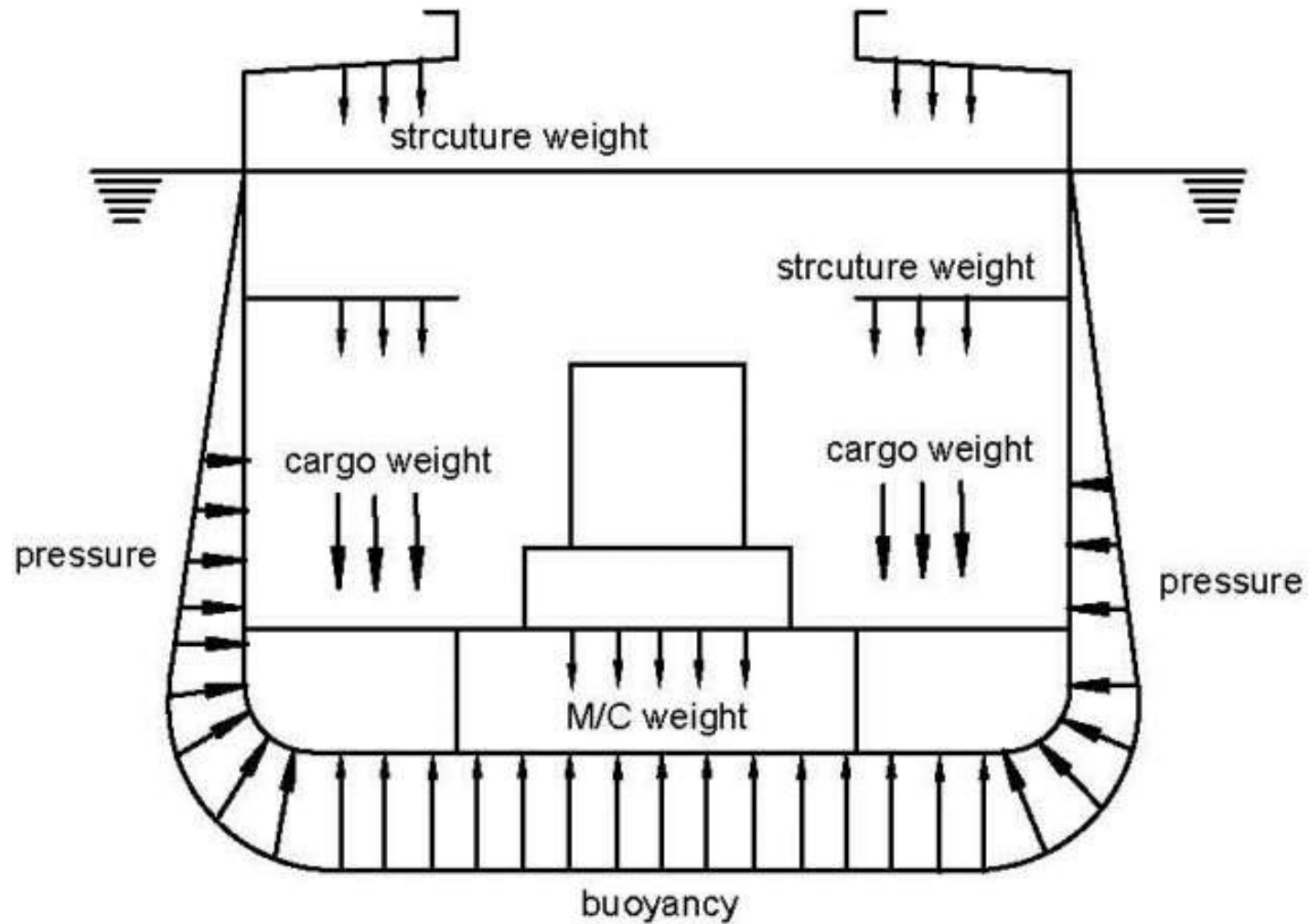
## Static loads:

Do not change over a short period of time

- **Stillwater loads:** External hydrostatic pressure, buoyancy forces,
- **Lightship weight items:** machinery, fittings and fixtures, piping, steering gear, other fixed equipments etc.
- **Dead weight items:** Cargo, fuel, water, provisions, crew, etc.



# Loads on ships



Static loads on ship

# Loads on ships

## **Slowly-varying loads.:**

Time period slightly greater than the natural flexural periods of the ship's primary structure.

Caused due to wave actions and ship motions and considered quasi-static

Based on distribution, they may cause

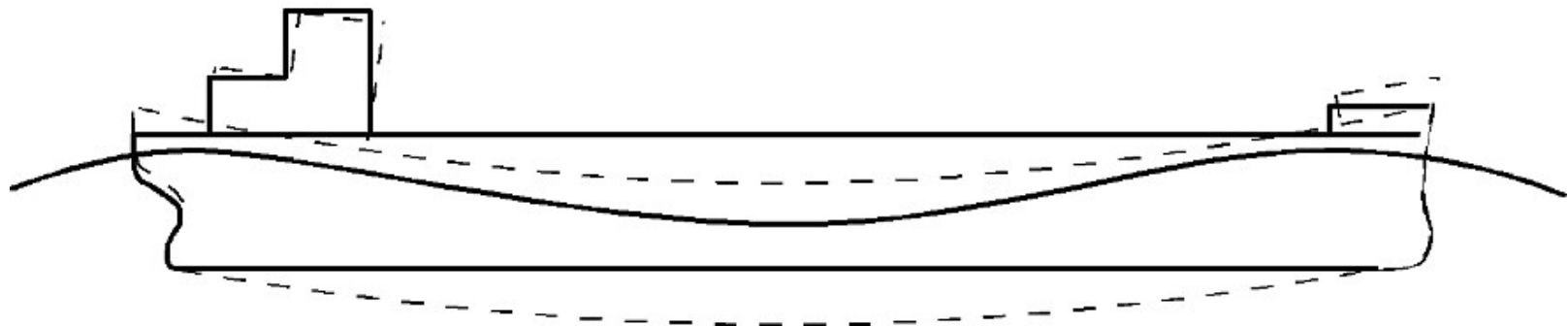
- Longitudinal bending
- Transverse distortion (racking)
- Combinations (bending, racking and torsion/ twisting)

# Loads on ships

Hogging

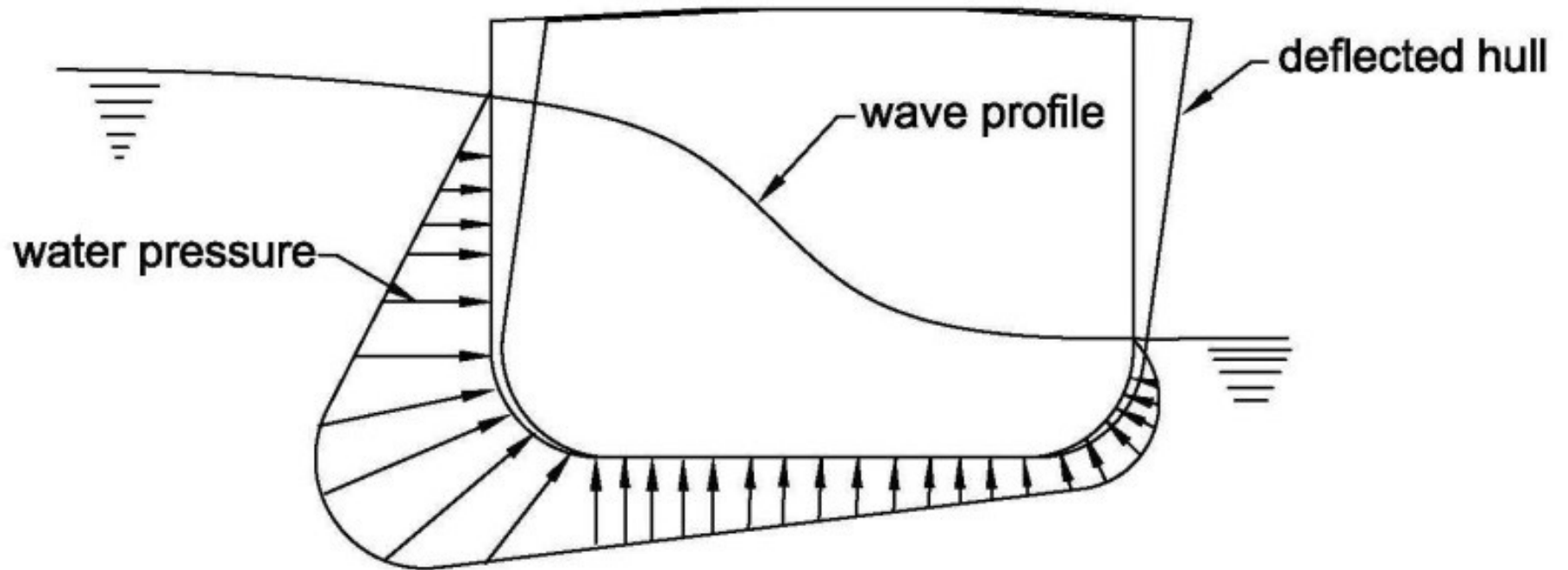


Sagging



Longitudinal Bending

# Loads on ships



Racking

# Loads on ships

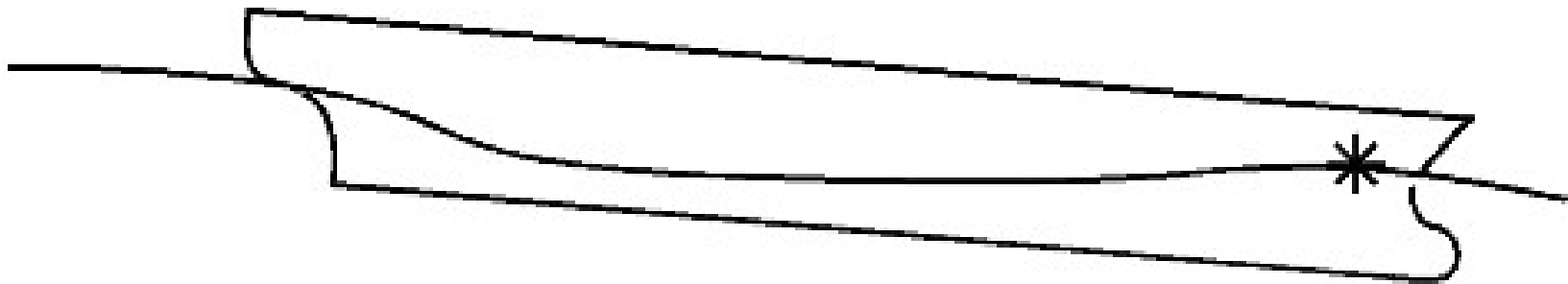
## **Rapidly-varying loads:**

Dynamic loads with time period of the order of the natural periods of vibration or flexure of the ships

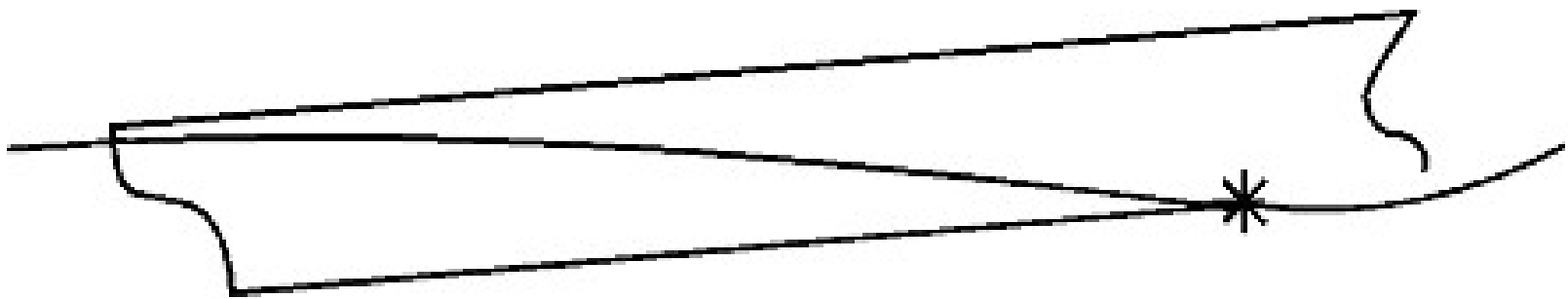
Generally local in nature. Some examples:

- Slamming: Impact of the bow (forward) with the wave surface
- Springing: Hull girder vibrations due to oscillating wave loads
- Mechanical vibrations caused by operating propeller and machinery
- Loads due to combat and weaponry for naval ships

# Loads on ships



Bow flare slamming



Bottom slamming

# Static Equilibrium

Buoyancy Force on ship = Weight of ship

$$\rho g \int_0^L a(x) dx = g \int_0^L m(x) dx = g\Delta$$

where :

$a(x)$  = immersed cross - sectional area

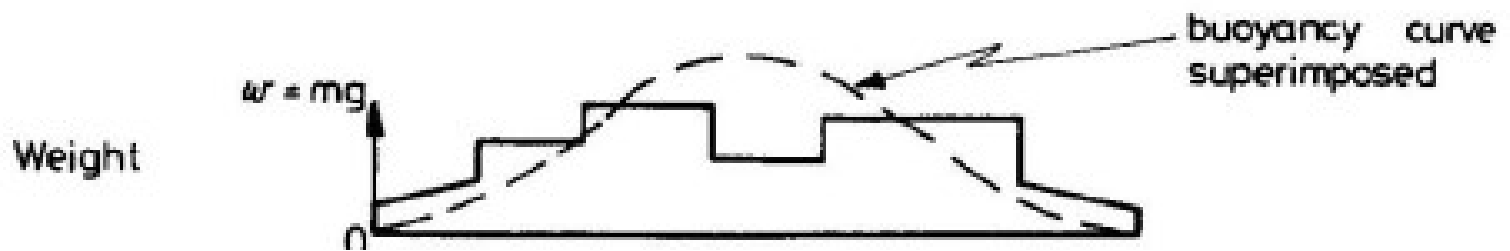
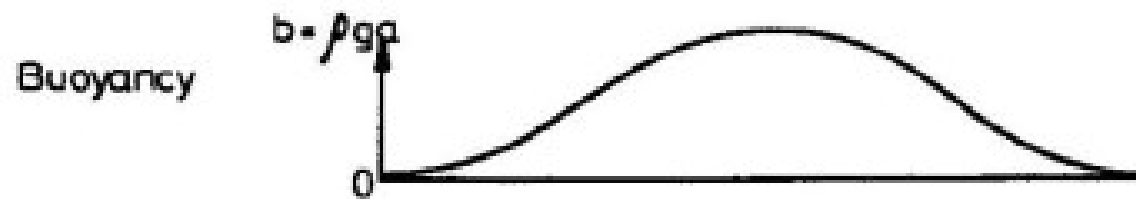
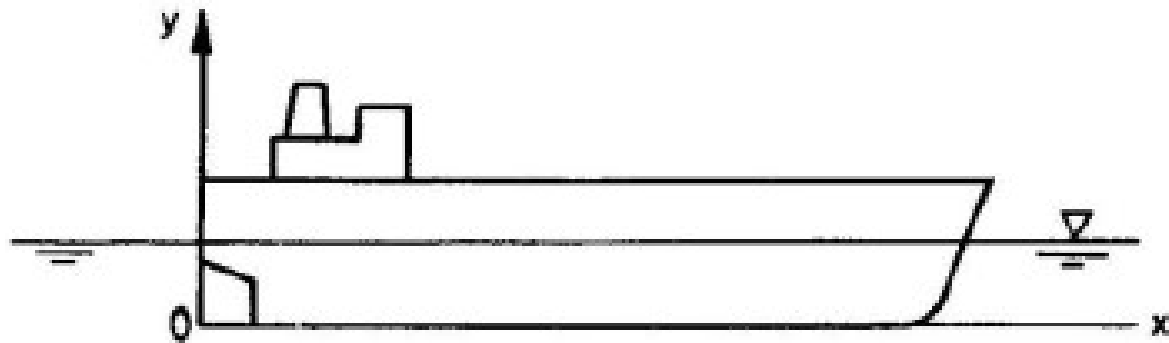
$m(x)$  = mass distribution

$\rho$  = density of seawater

$g$  = gravitational acceleration

$\Delta$  = displacement

# Static Equilibrium





# Shear Force & Bending Moment

- Local segments of the vessel may have more or less weight than the local buoyancy
- Difference between weight and buoyancy curves gives the shear forces along the vessel

$$f(x) = b(x) - w(x)$$

**Shear Force:**

$$Q(x) = \int_0^x f(x) dx$$

**Bending Moment:**

$$M(x) = \int_0^x Q(x) dx$$

# Shear Force & Bending Moment

