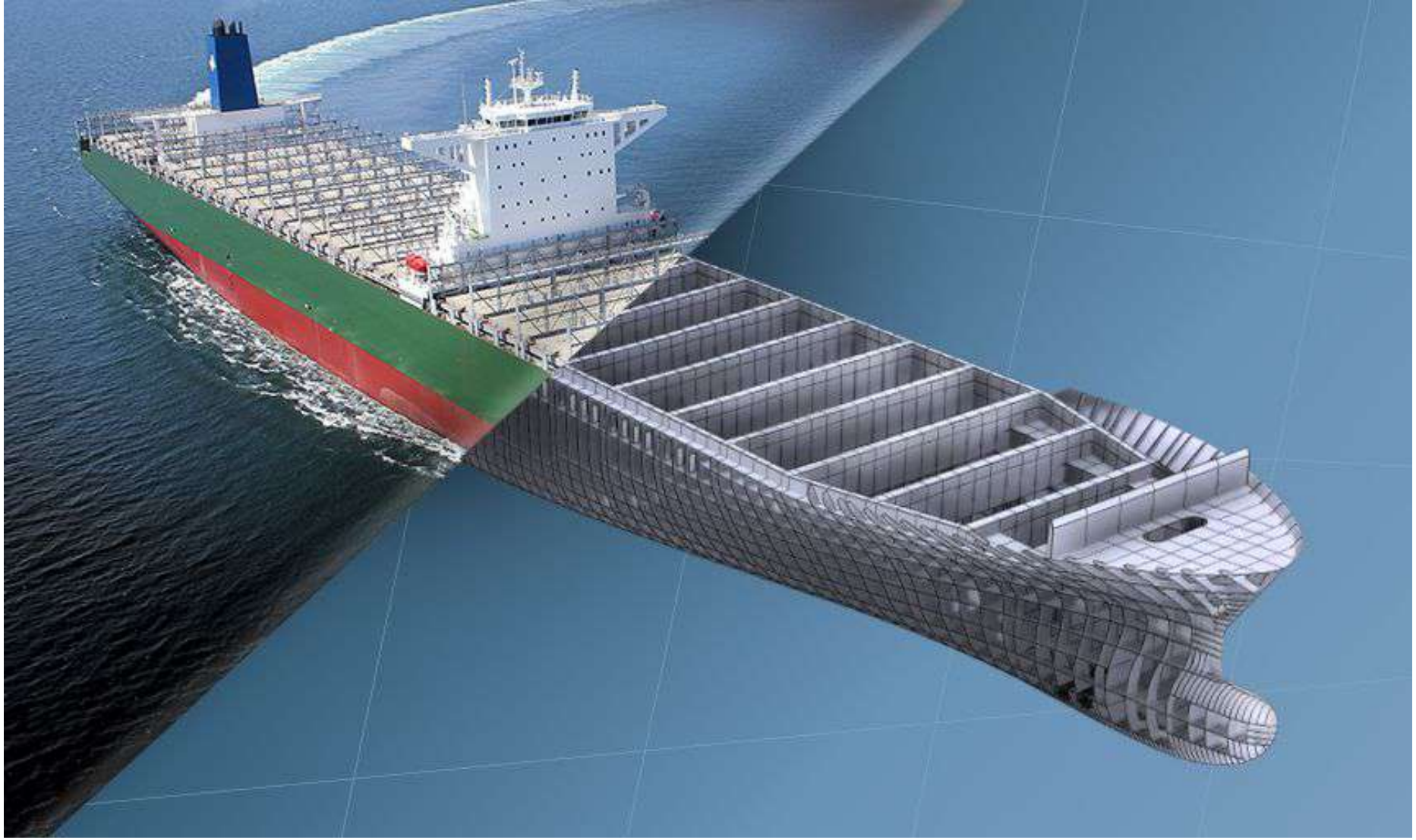

Introduction to Naval Architecture

II SEM –Module 3

Course Content

- **<u>Lines Plan</u>** :: -
- 3D Geometry -Representing 3D objects in 2D views-
- Orthographic Projection-Orthogonal Planes .
- Lines Plan : Purpose, Orthogonal Planes of Reference,
  - Three views -Body Plan; Half Breadth Plan; Sheer Plan or Profile,
  - Buttocks,Stations,Waterlines.
  - How to Draw using Offset Table,
  - Types of Stem and Stern profiles, Procedure, Drawing tools, Fairing process.
- Practical: Lines plan drawing from given offset table and generation of final offset table after fairing.

Importance of ship geometry

- What is the role of a ship?
  - Transport (Cargo, Passengers..)
  - Operations (Dredging, Towing, Research, War, Cablelaying,Firefighting..)

- What is special about a ship as compared to other means of transport?
  - Economical, Large cargo volume , no traffic (like air travel)
  - Operates in an unpredictable dynamic liquid medium

- What is important for a ship or a ship owner or ship operator?
  - Safety
  - Profit

- What are the characteristics of ship contributing to Safety and Profit?

Safety & Profit

- Stability

Safety & Profit

- Strength

Safety & Profit

- Ship Motions
- Seakeeping

Safety & Profit

- Speed

Safety & Profit

- Manoeverability
- Controllability

Safety & Profit

- Capacity

Safety & Profit

- Buildability

Importance of ship geometry

- What defines these characteristics of the ship?
  - Shape or Geometry
  - Material
- Does geometry of an object, matter?
  - Any difference between behavioural characteristics of a Cube and a Sphere of the same material?
  - Geometry determines behavioural characteristics

Importance of ship geometry

-The geometry of the ship defines

-Safety

- ***Stability***
- ***Strength***
- ***Seakeeping***

- Profit
  - ***Speed***
  - ***Manoeuverability***
  - ***Capacity***
  - ***Buildability***
- Defining Geometry is the first step

END

- In case of any doubts you may contact me at

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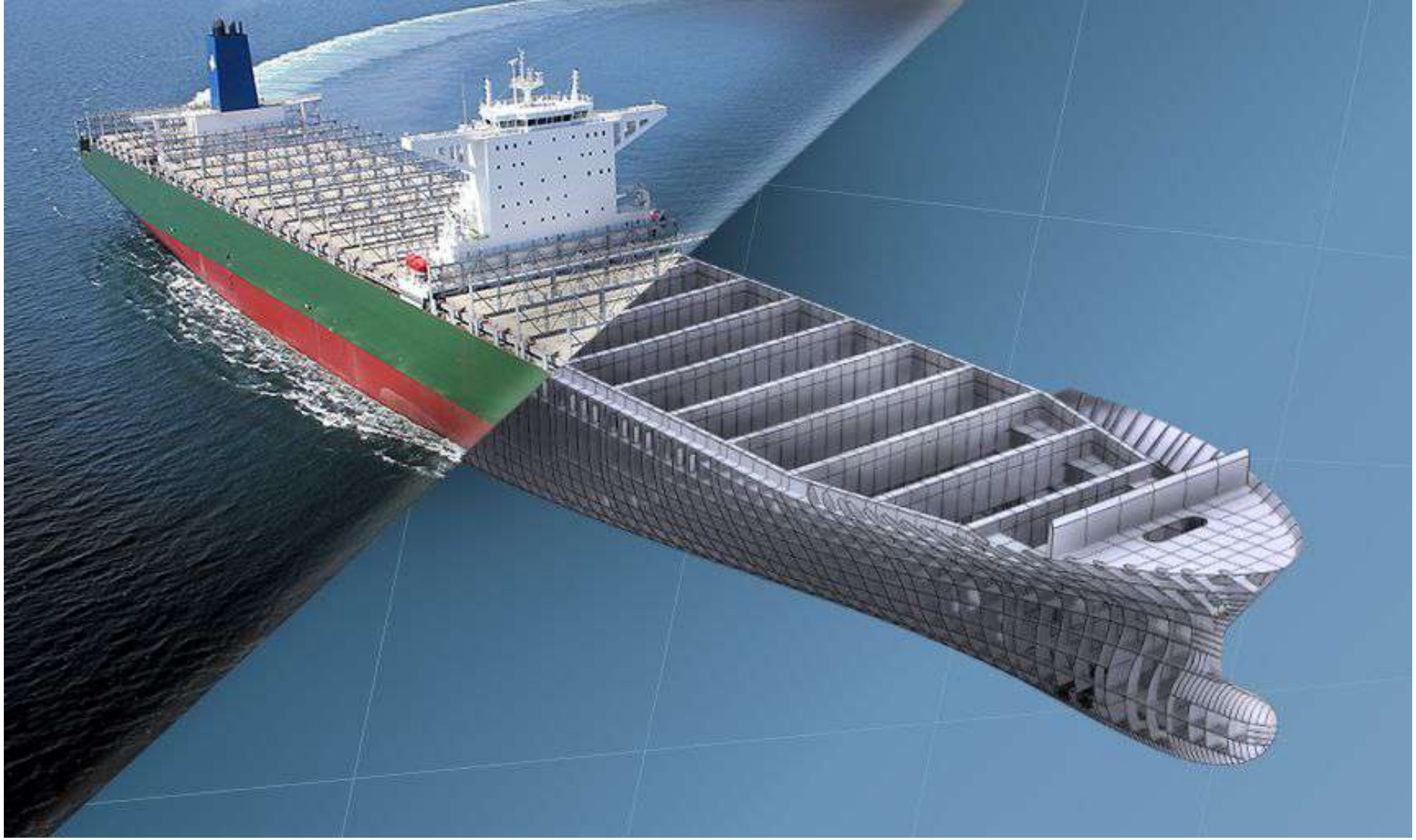


Introduction to Naval Architecture

II SEM –Module 3

RECAP

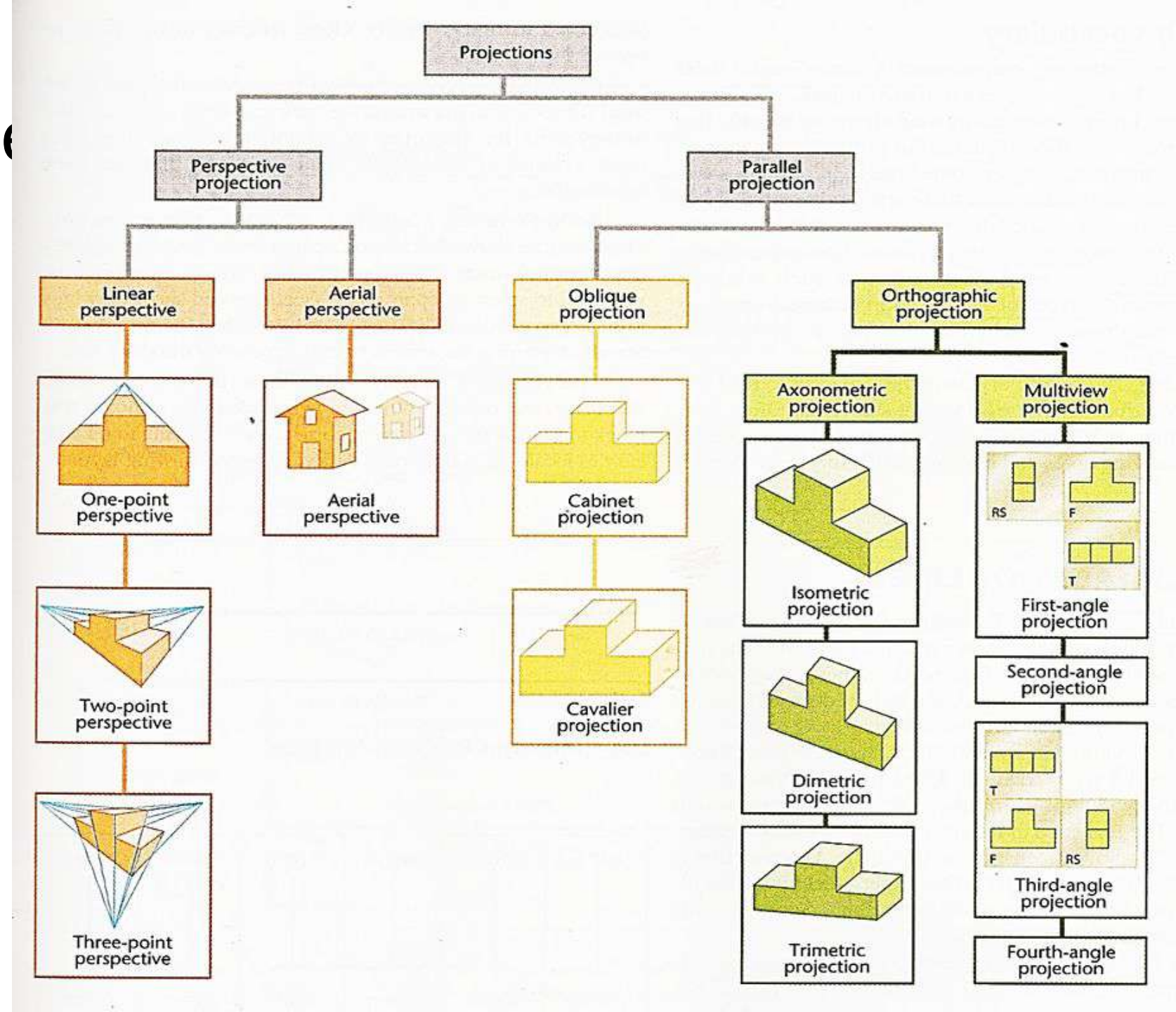
- Geometry of an object matters because it determines the characteristics
- Aspects important for a Ship are
    - Safety - Stability, Strength, Ship Motions, Controllability
    - Economy - Speed, Capacity, Buildability
- Above features and dependent on the geometry of the ship.
- Defining ship geometry is the starting point of ship design

Why do we need to define geometry of a 3 D object

- To define parameters from Geometry (Dimensions, Area, Volume…. Bonjeans and Hydrostatics Calculations)
- To make calculations based on the Parameters (Stability, Resistance, Propulsion, Strength, Seakeeping, Controllability)
- To conduct analyses on the defined geometry (CFD, Structural …)
- To make the detailed manufacturing drawings (General Arrangement, Shell Expansion, Detailed Working Level Drawings (WLDs)…)

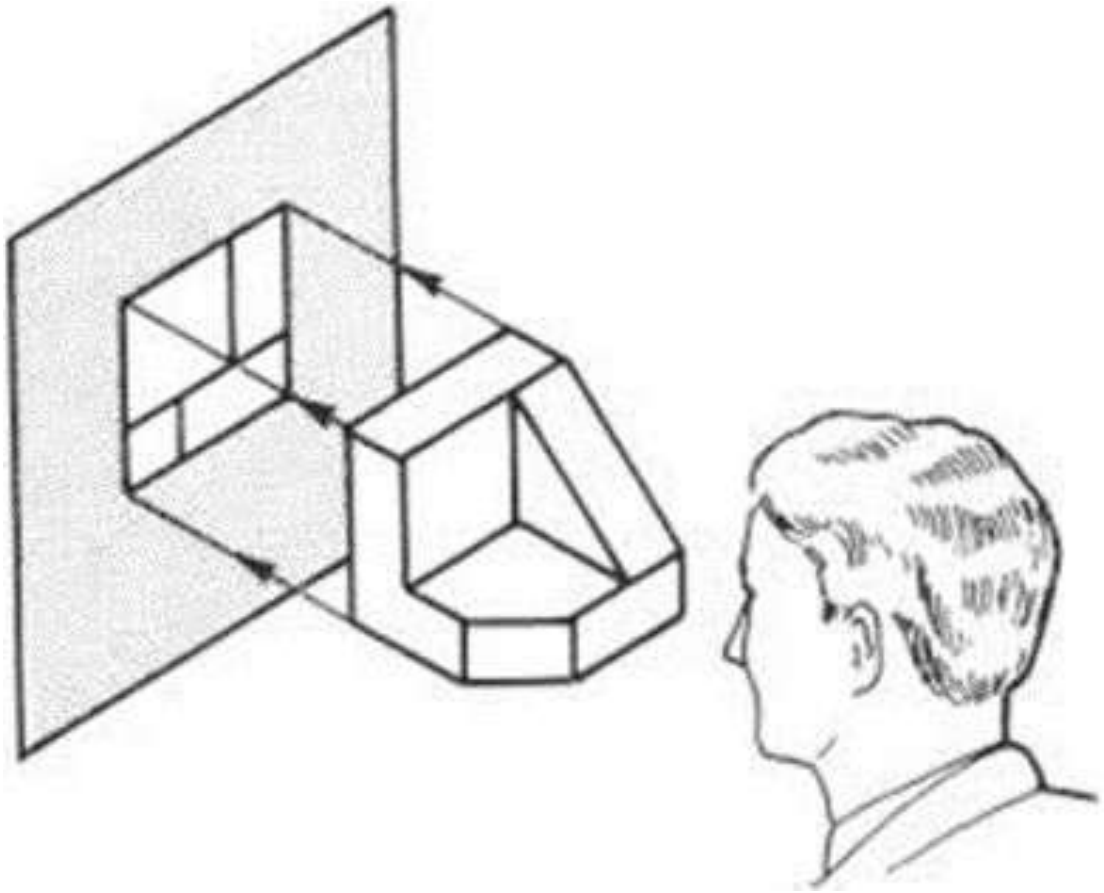
Defining geome

- How do we define the geometry of any object
  - Perspective Projection
  - Parallel Projection
    - Oblique
    - Orthographic projection



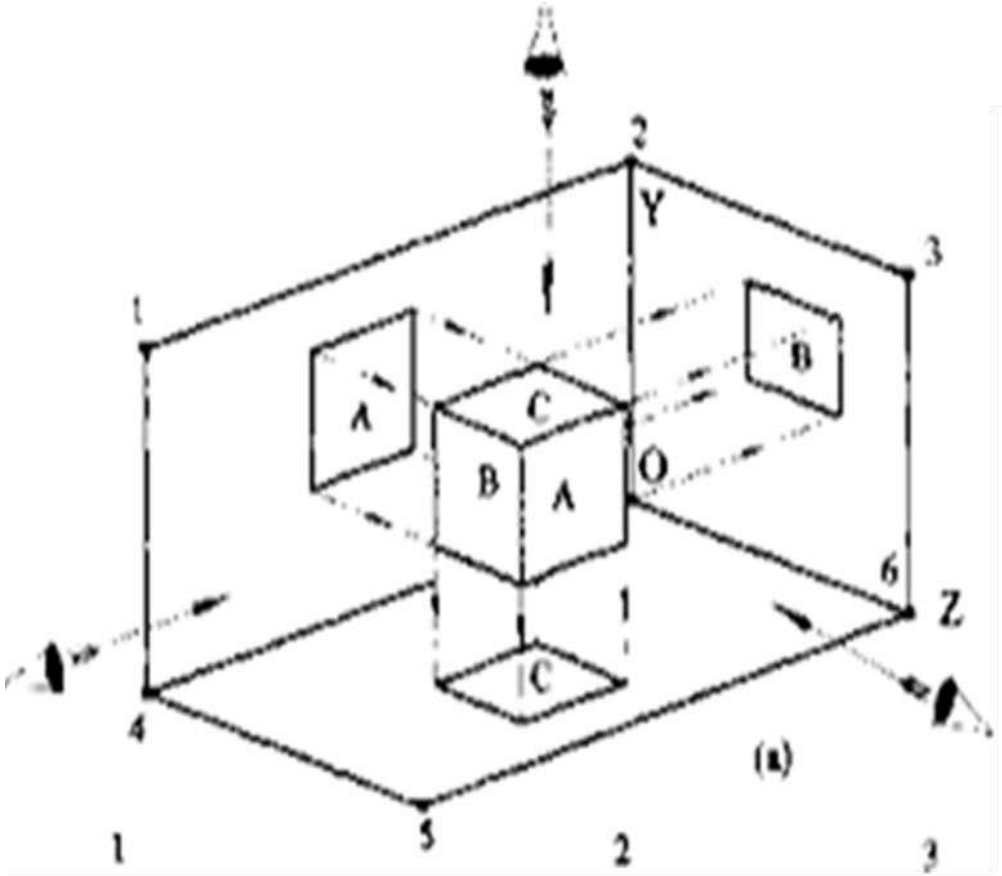
Defining geometry of a 3 object

- **Orthographic projection**
  - Orthogonal –Perpendicular
  - Orthographic –Lines from object projected Perpendicular to the Projection Plane
  - 2D image of 3D object



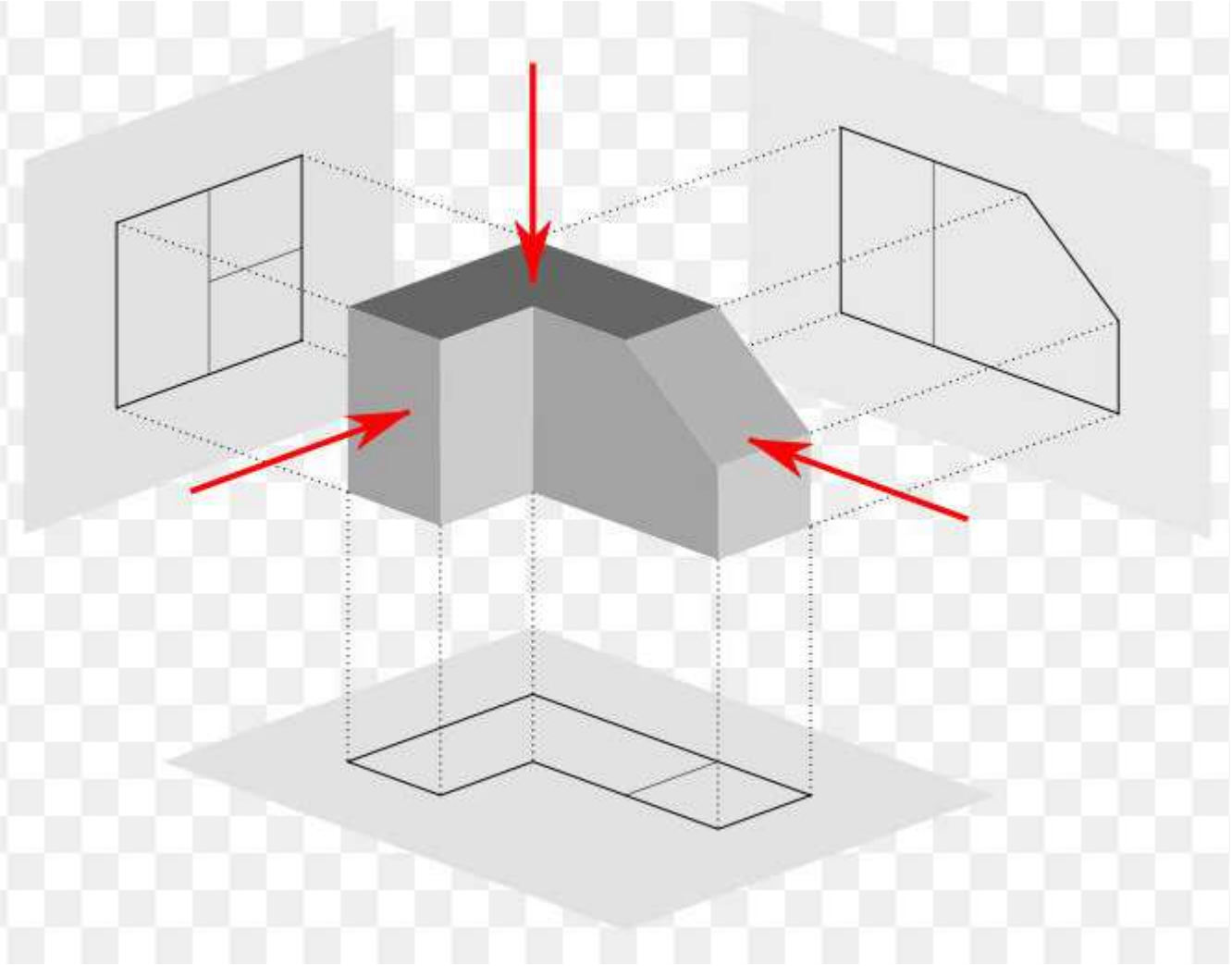
Defining geometry of an object

- **Orthographic projection**
- Simple Object : Cube
- 3 Projection Planes
- 3 Views – Plan, Front Elevation, Side Elevation
- All boundary lines of the object are straight
- All boundary lines of the object are parallel / perpendicular to the axes



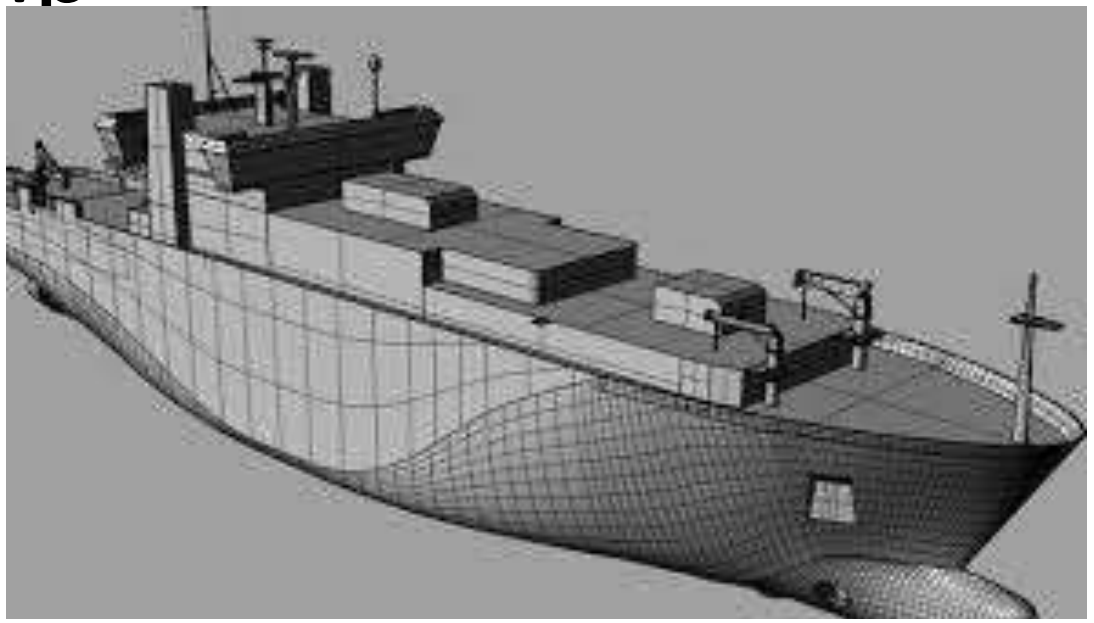
Defining geometry of a 3D object

- **Orthographic projection**
- Complex Object
- 3 Projection Planes
- All boundary lines of the object are straight
- All boundary lines of the object are NOT parallel / perpendicular to the axes

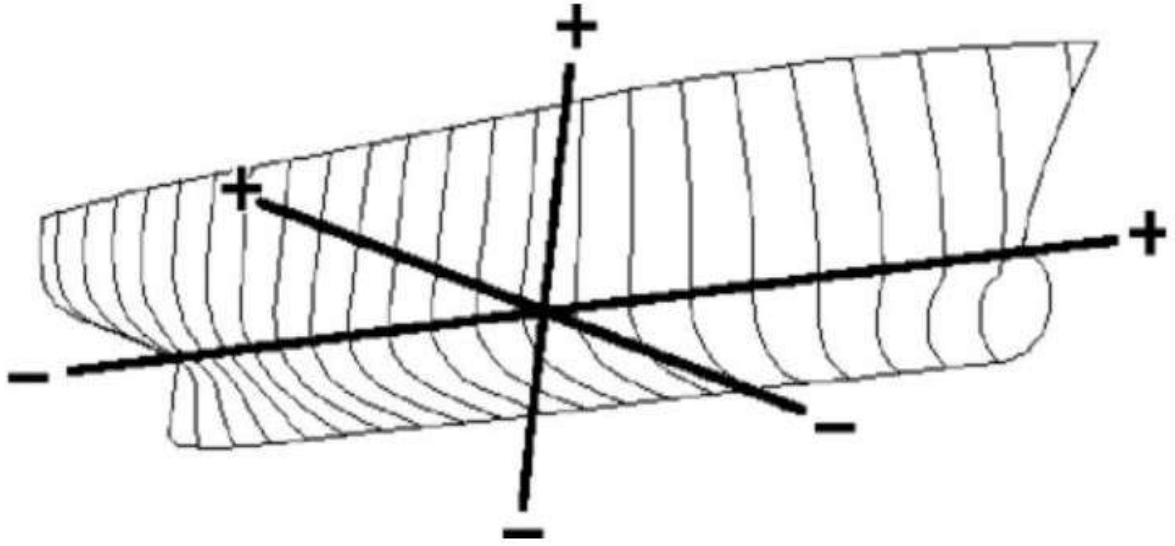


Defining geometry of a Ship

- **Orthographic projection**



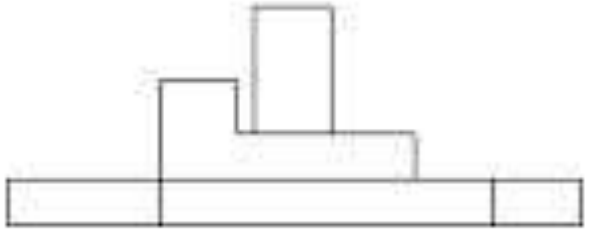
- Very Complex Object
- All boundary lines of the object are NOT straight
- All boundary lines of the object are NOT parallel / perpendicular to the axes



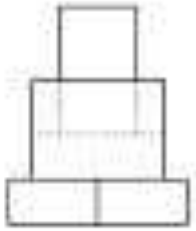
Defining geometry of a 3D object

- **Orthographic projection**

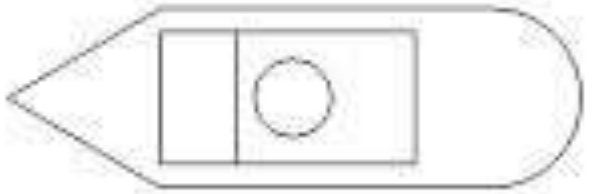
- Elevation : *Side Elevation*
- *End View : Front Elevation*
- *Plan : Top View*



Elevation



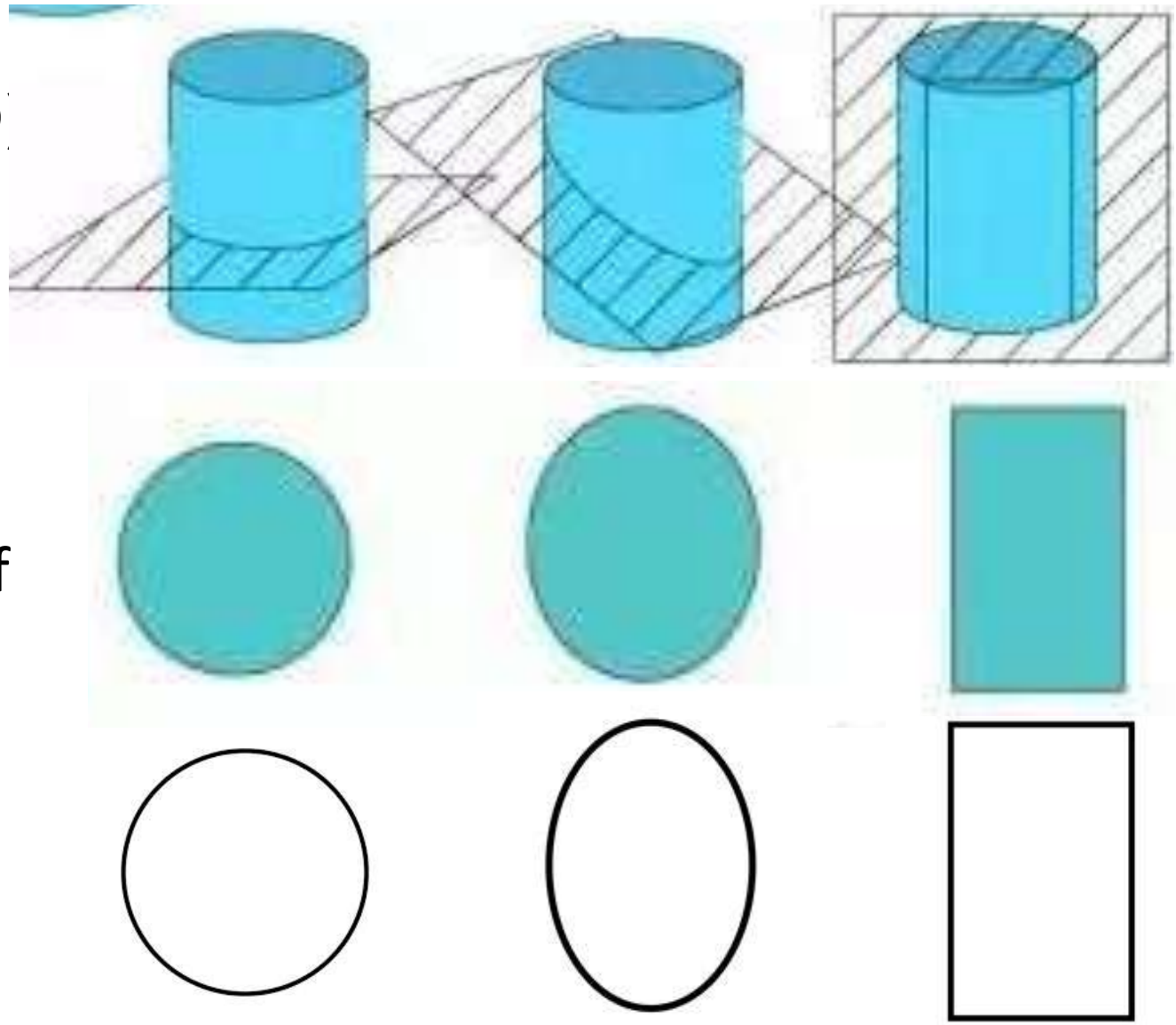
End View



Plan

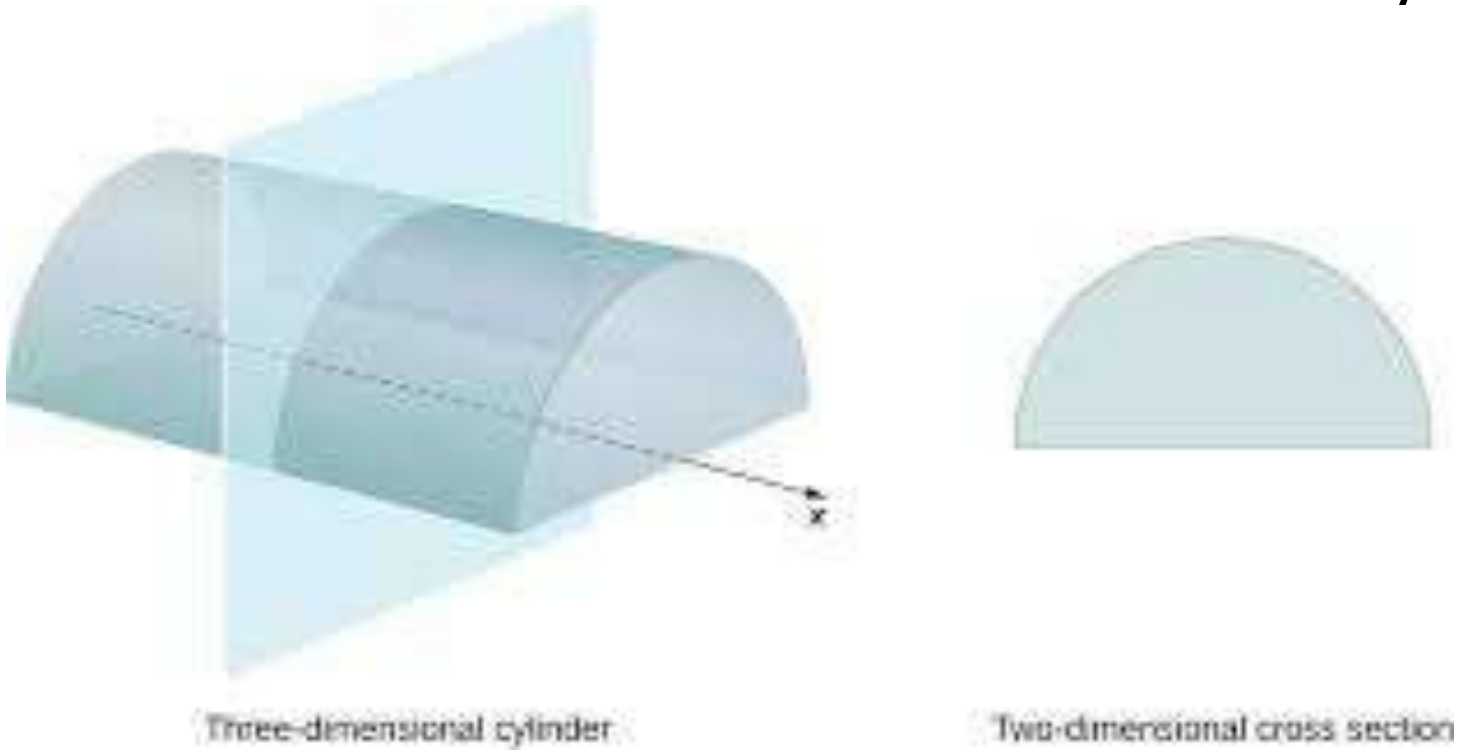
Defining geometry of a simple 3 D object

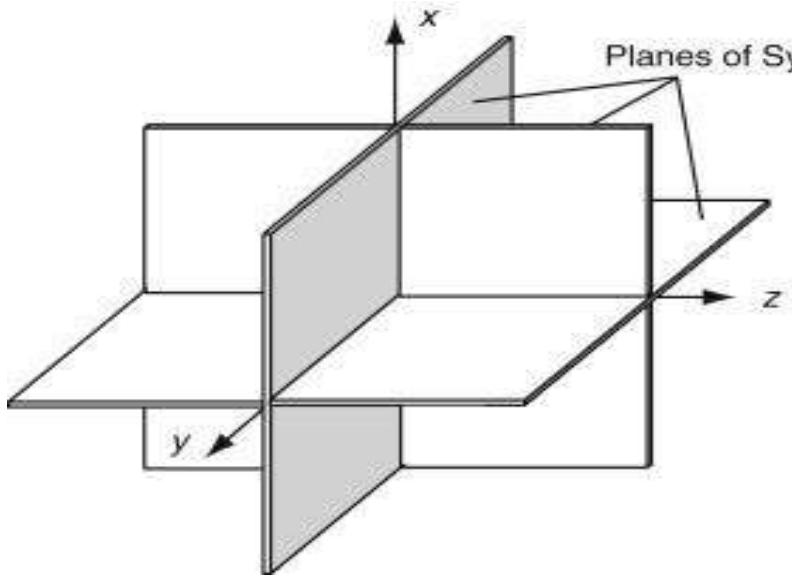
- What do we get when a object (3D) is intersected by a Plane (2D)
- A Surface (2D)
- Locus of points on the boundary of the surface will give..
- A Curve (2D)

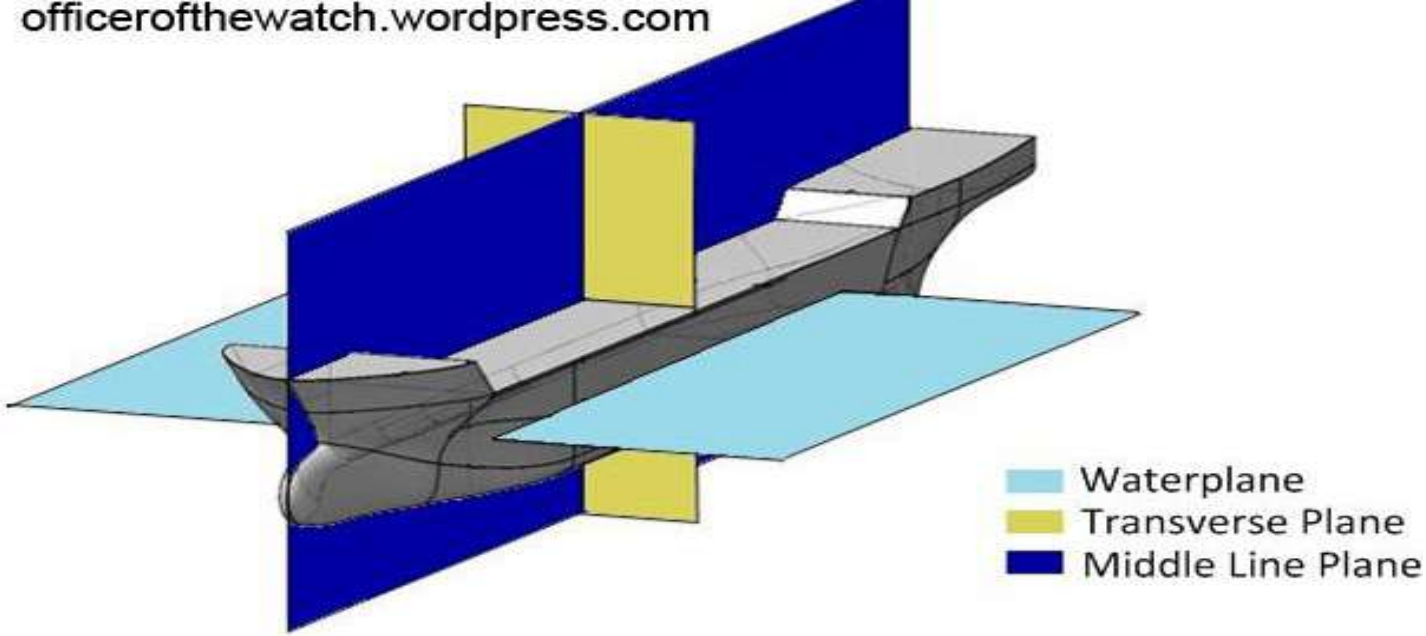


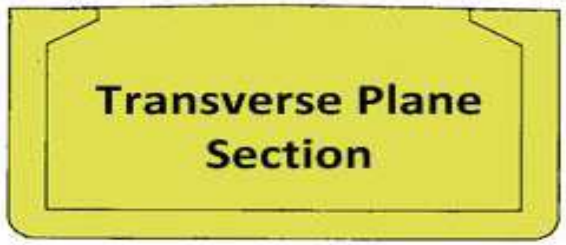
Defining geometry of a simple 3D Object

- We can make out the shape of the complete object if the cross section is uniform or if the boundaries are defined by known curves





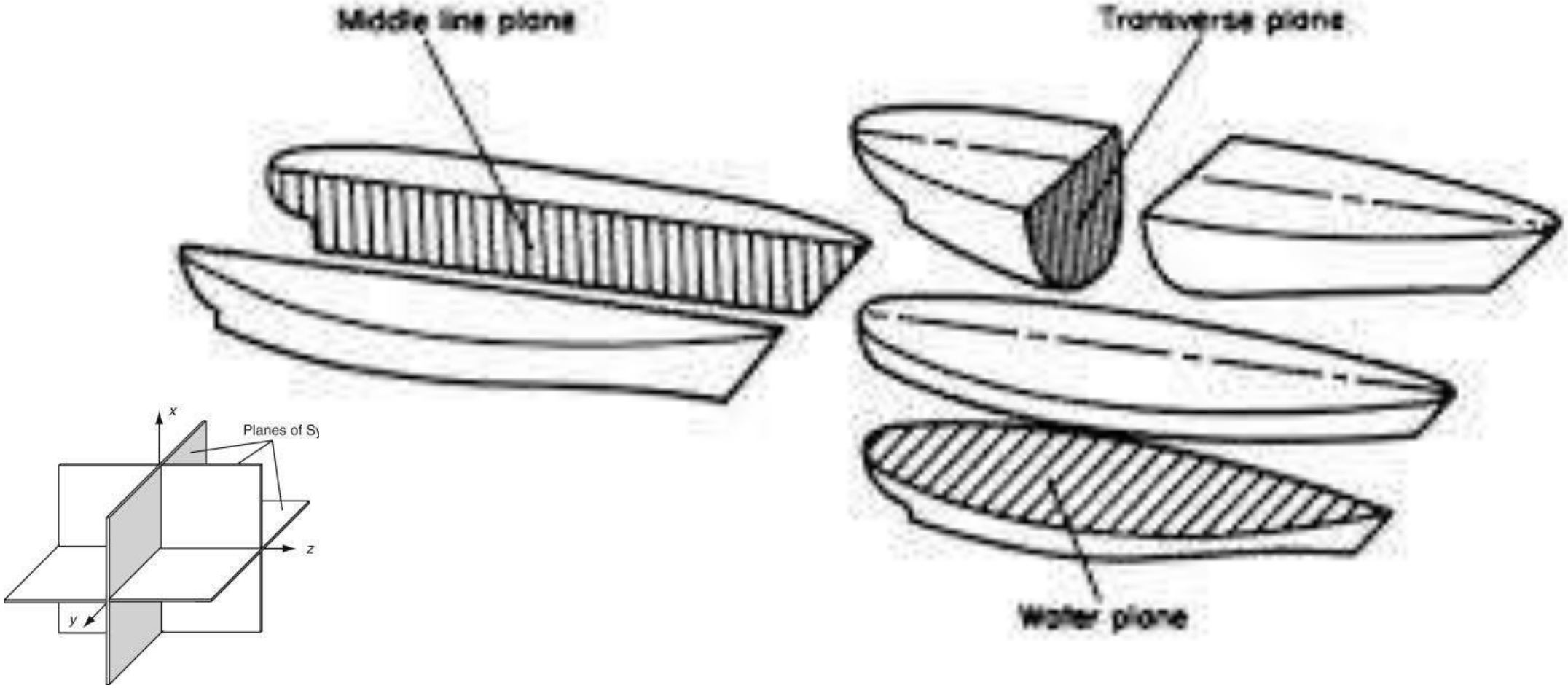




Ship Hull cut by 3 mutually perpendicular planes

Defining geometry of a Ship

- When the Ship hull is intersected by planes along the 3 Axes



Waterplane Section

Transverse Plane Section

Middle Line Plane Section

Defining geometry of a Ship

- **Orthographic projection**

- 3 Views on 3 Projection Planes

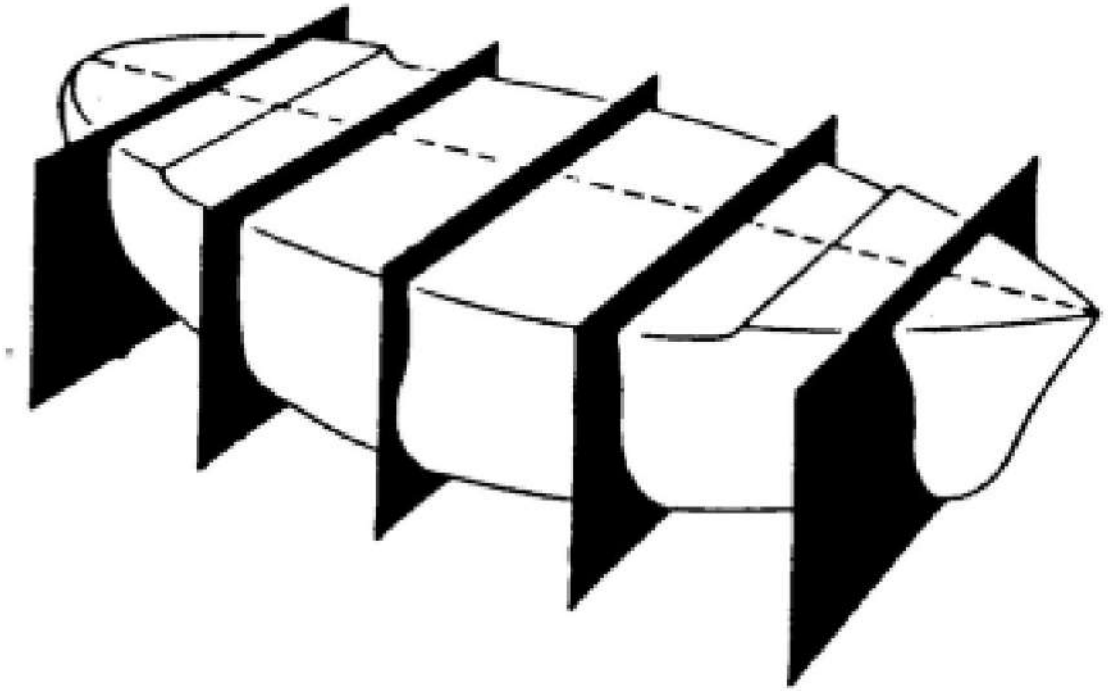
- Is this adequate?

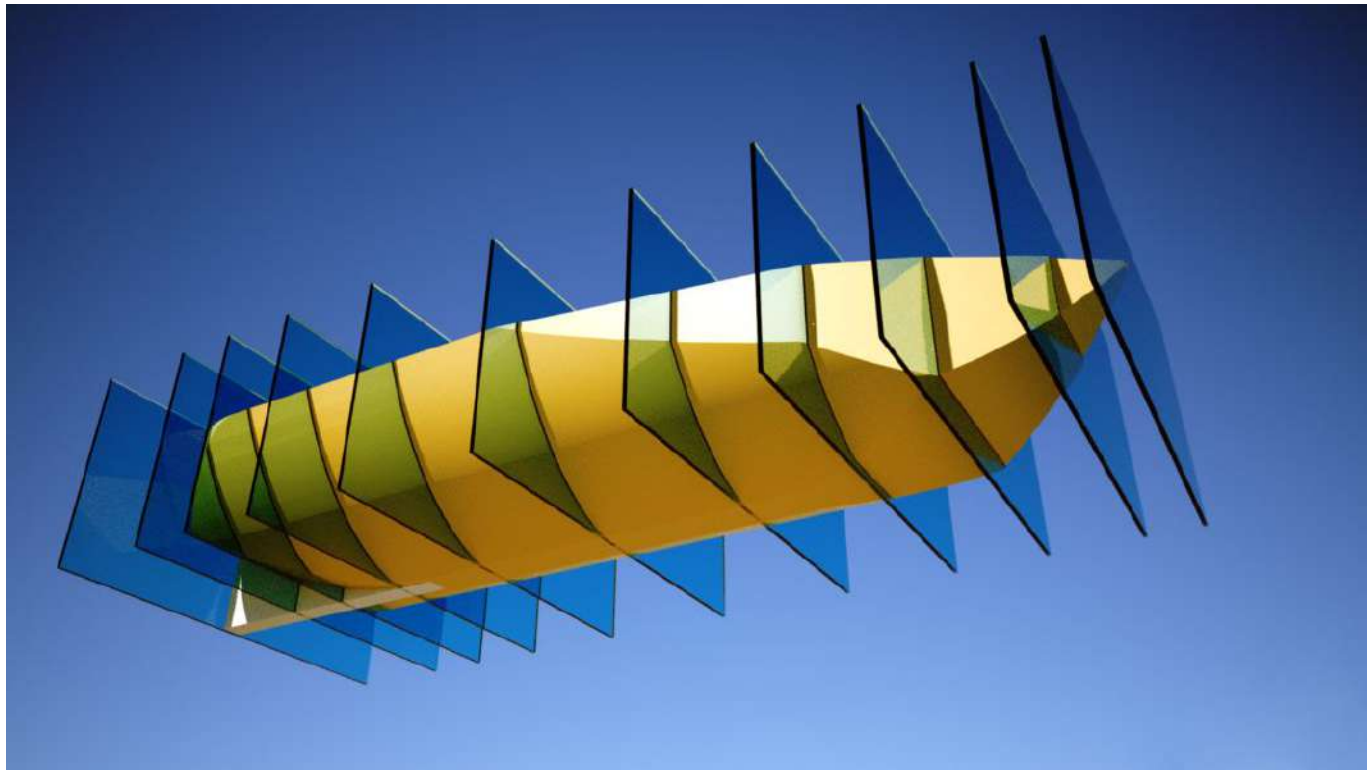
Defining geometry of a Ship

- **Simple orthographic projection is inadequate because**
- Geometry is continuously changing in all three directions
- Cross section is changing along Length, Breadth and Depth
- So what do we do?
- Make sections at uniform intervals along the 3 co-ordinate axes

Defining geometry of a Ship

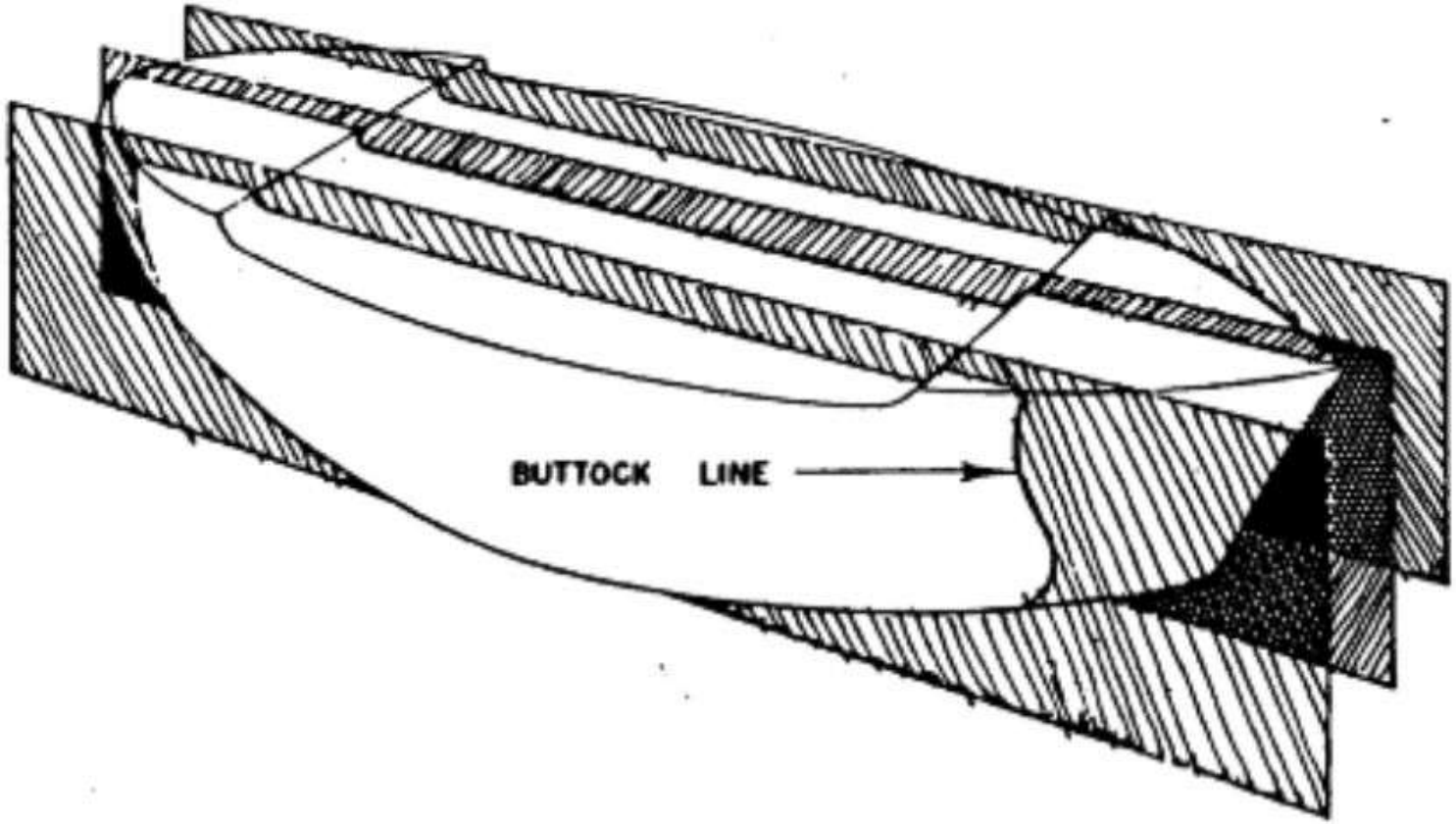
- Sections along Length or X axis
- Transverse Planes





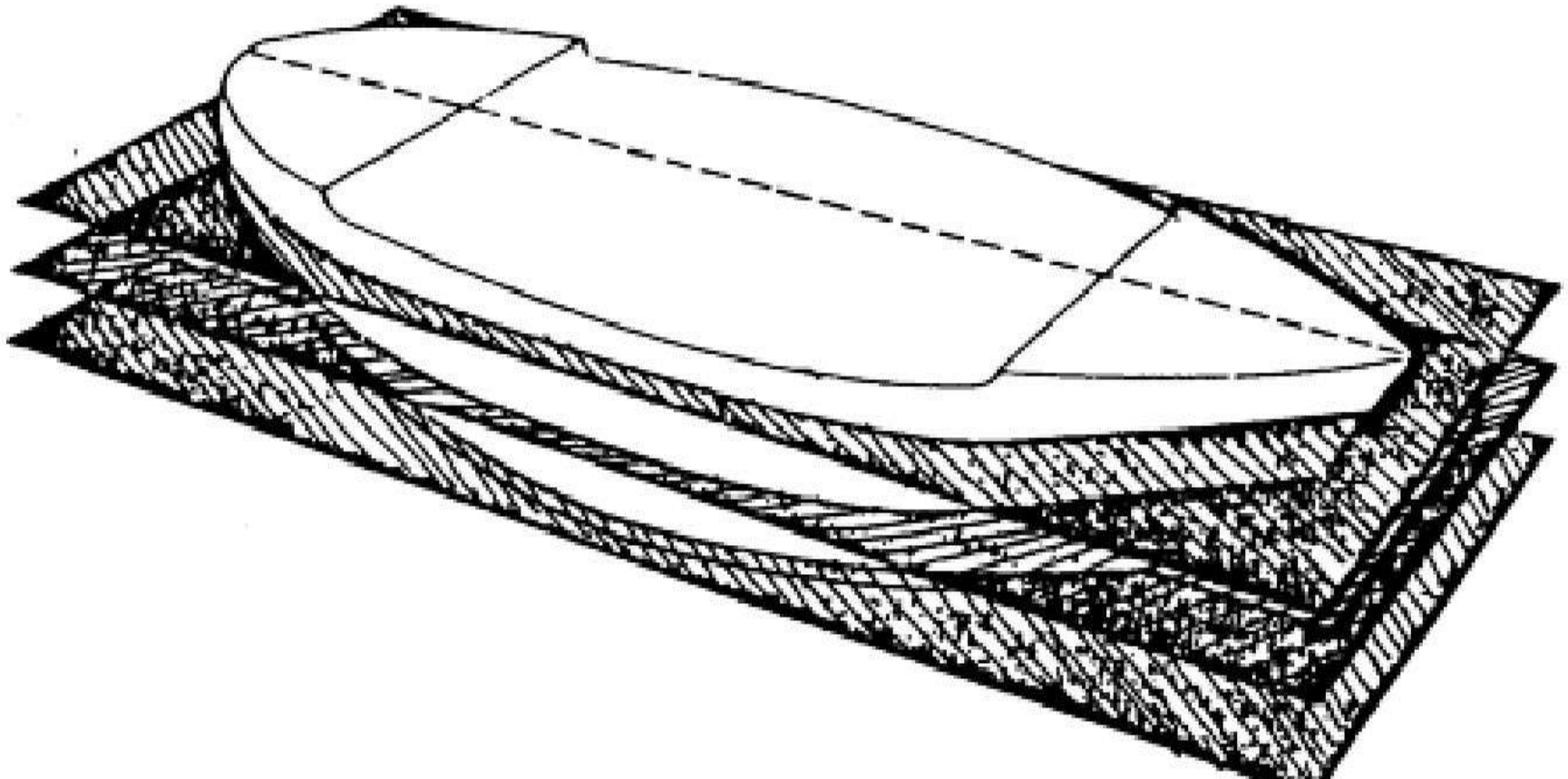
Defining geometry of a Ship

- Sections along Breadth or Y axis
- Buttock Planes



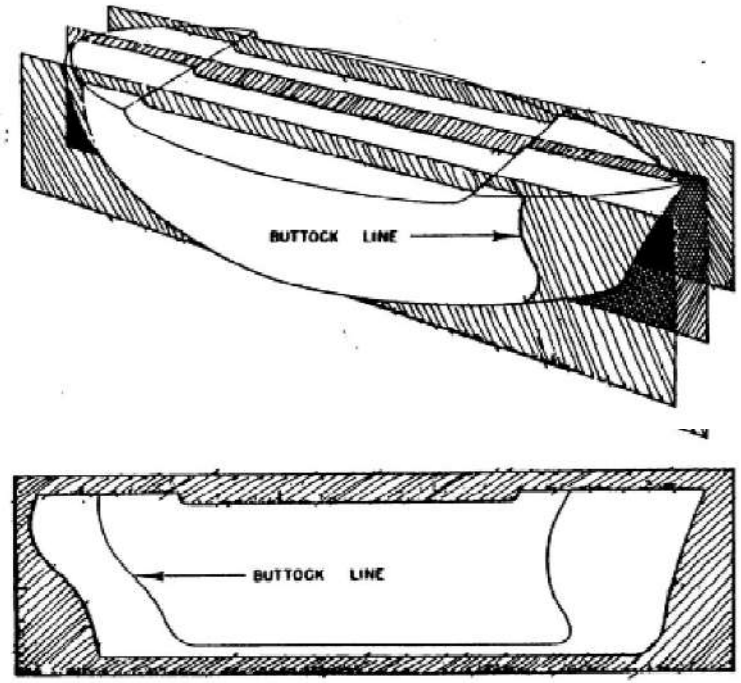
Defining geometry of a Ship

- Sections along Depth or Z axis
- Water Planes



Sets of parallel planes(mutually perpendicular)

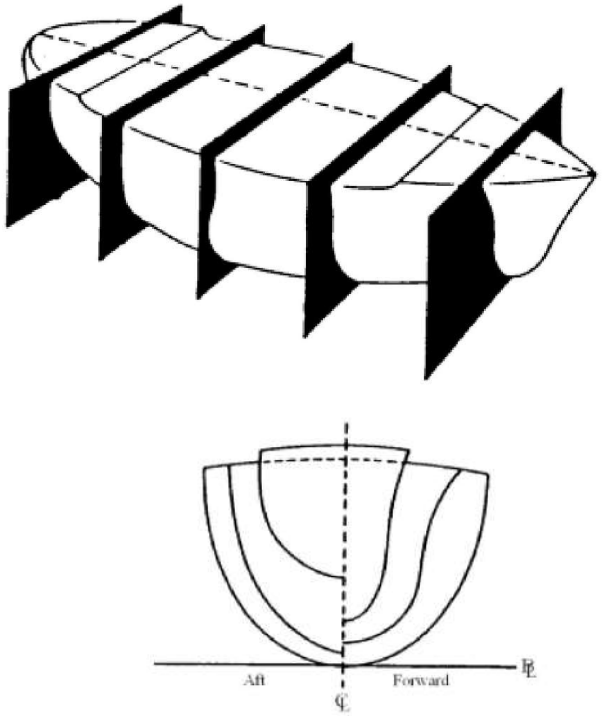
Vertical planes II to CL plane



Buttock Lines

Sheer Plan / Profile

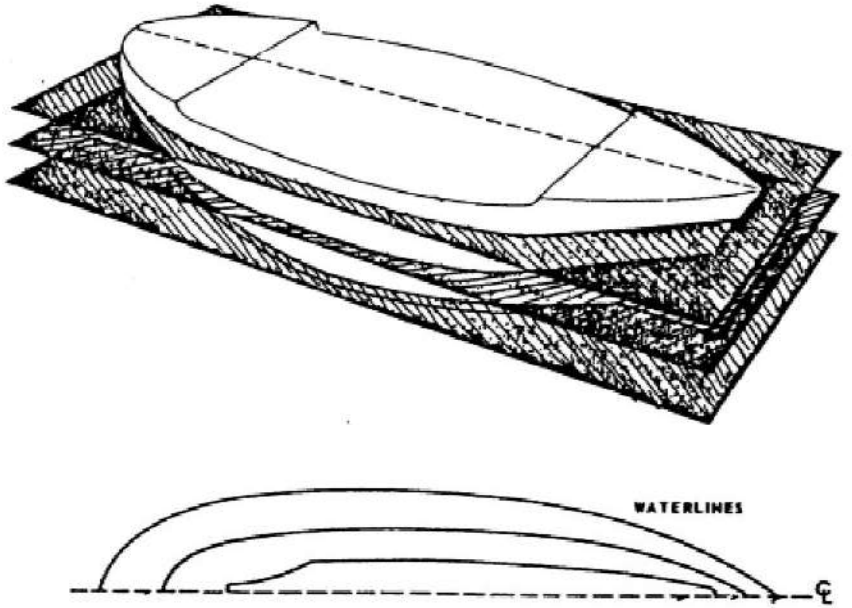
Vertical planes perpendicular to CL plane



Stations

Body Plan

Horizontal planes II to BL plane



Waterlines

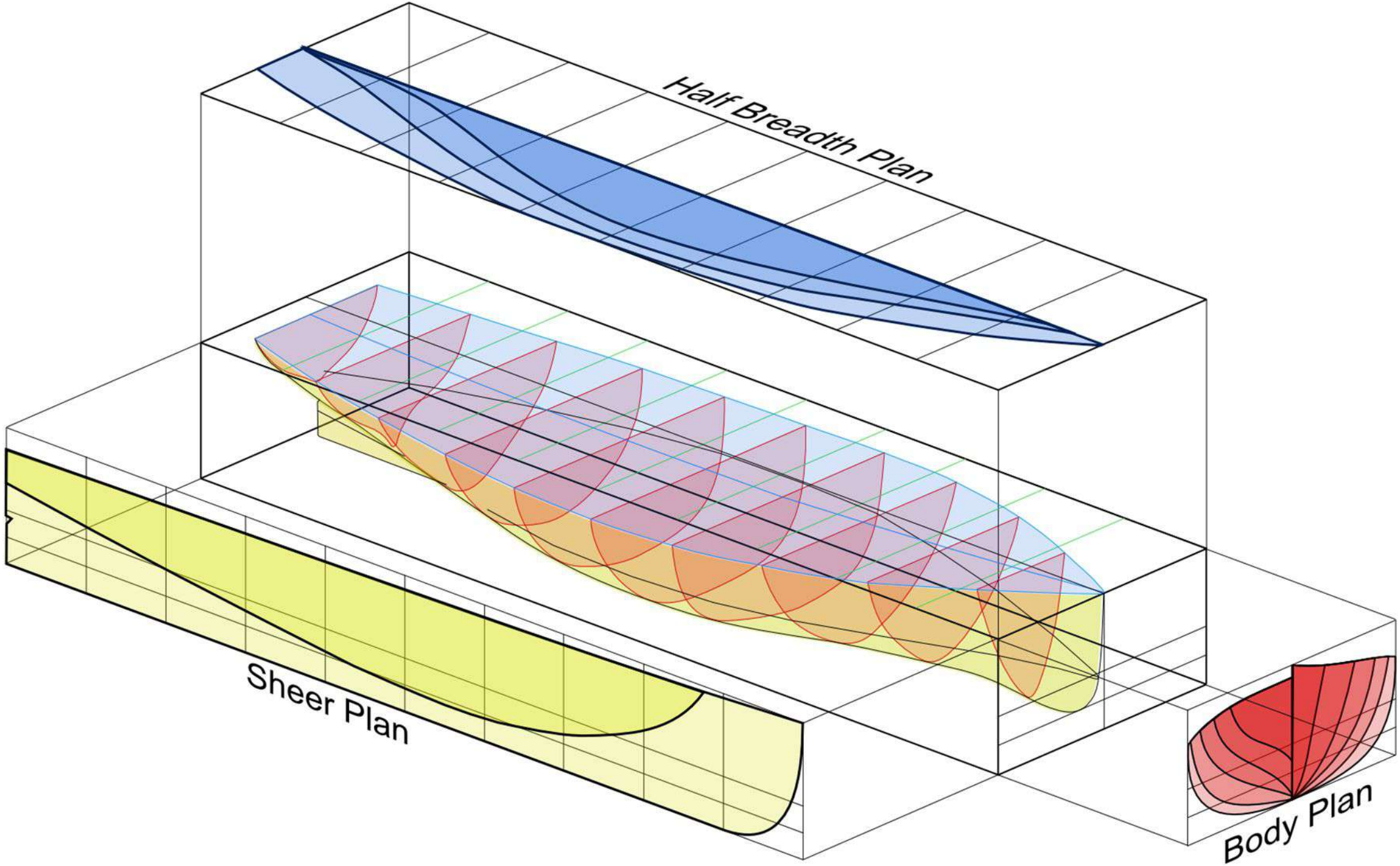
Half Breadth Plan

Lines Plan

- Make parallel sections along the 3 co-ordinate axes of the ship to get surfaces (2D).

- Orthographically project the boundary of each section onto a plane parallel to the section or perpendicular to the axis, to get a curve

- Plot all the curves generated from a set of parallel sections on a single plot.


Half Breadth Plan
Sheer Plan
Body Plan

END

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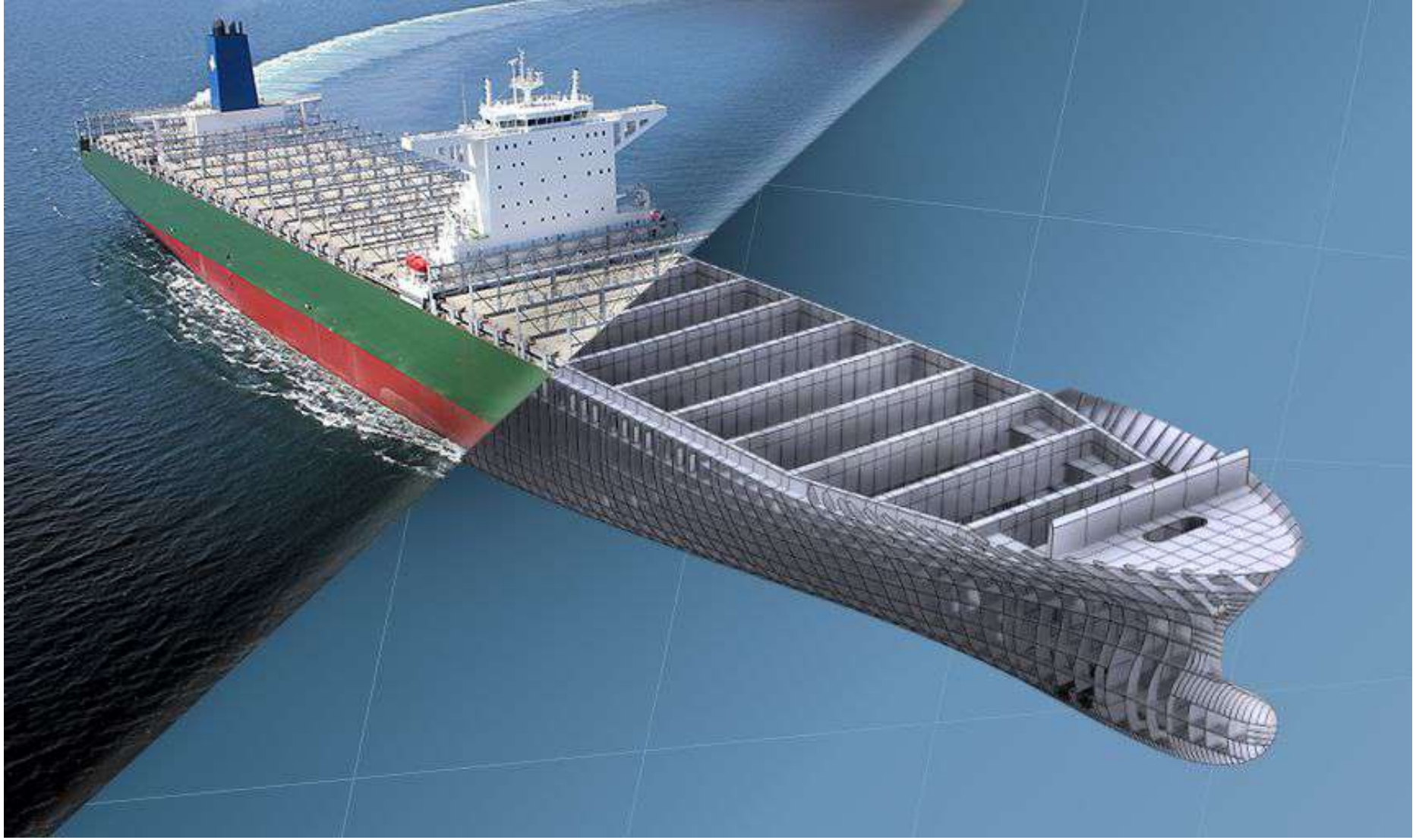
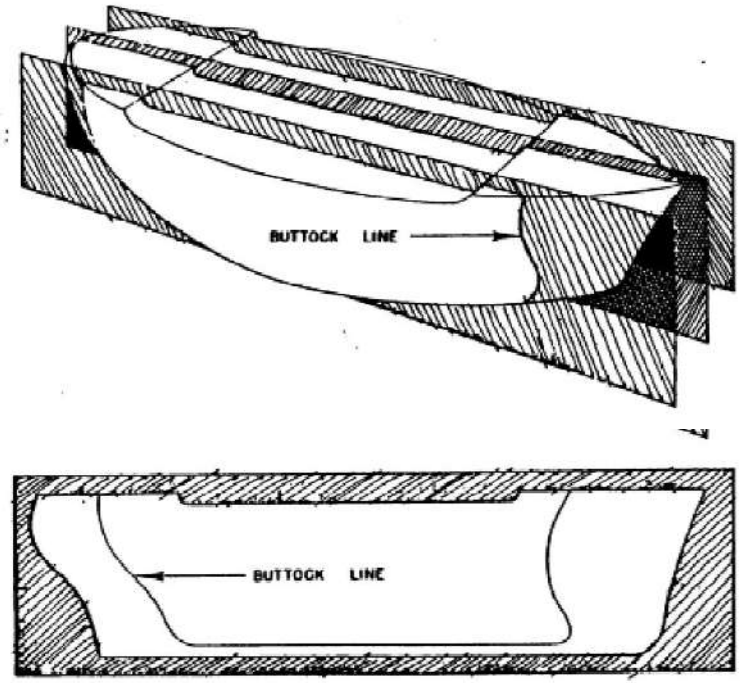


Introduction to Naval Architecture

II SEM –Module 3

Lines Plan

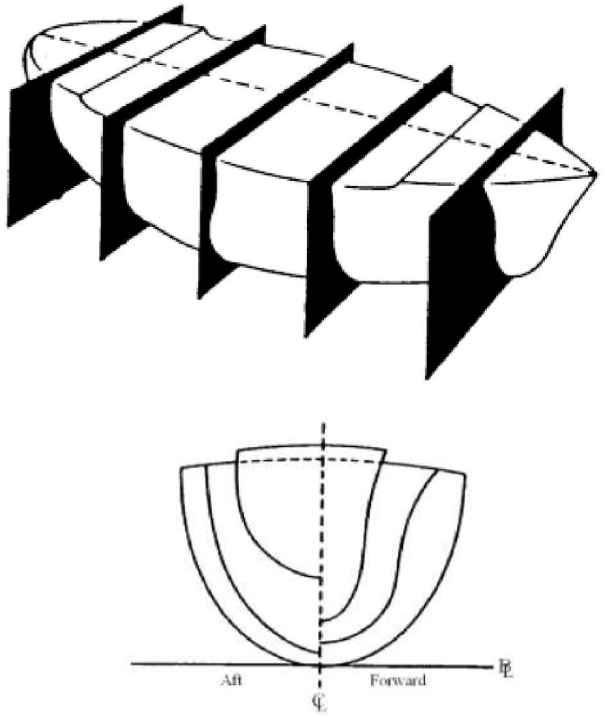
Vertical planes II to CL plane



Buttock Lines

Sheer Plan / Profile

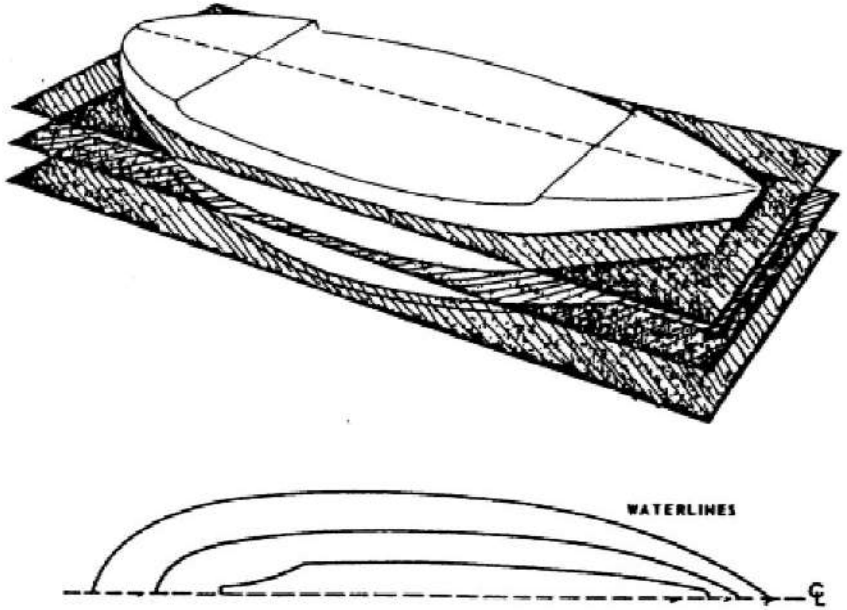
Vertical planes perpendicular to CL plane



Stations

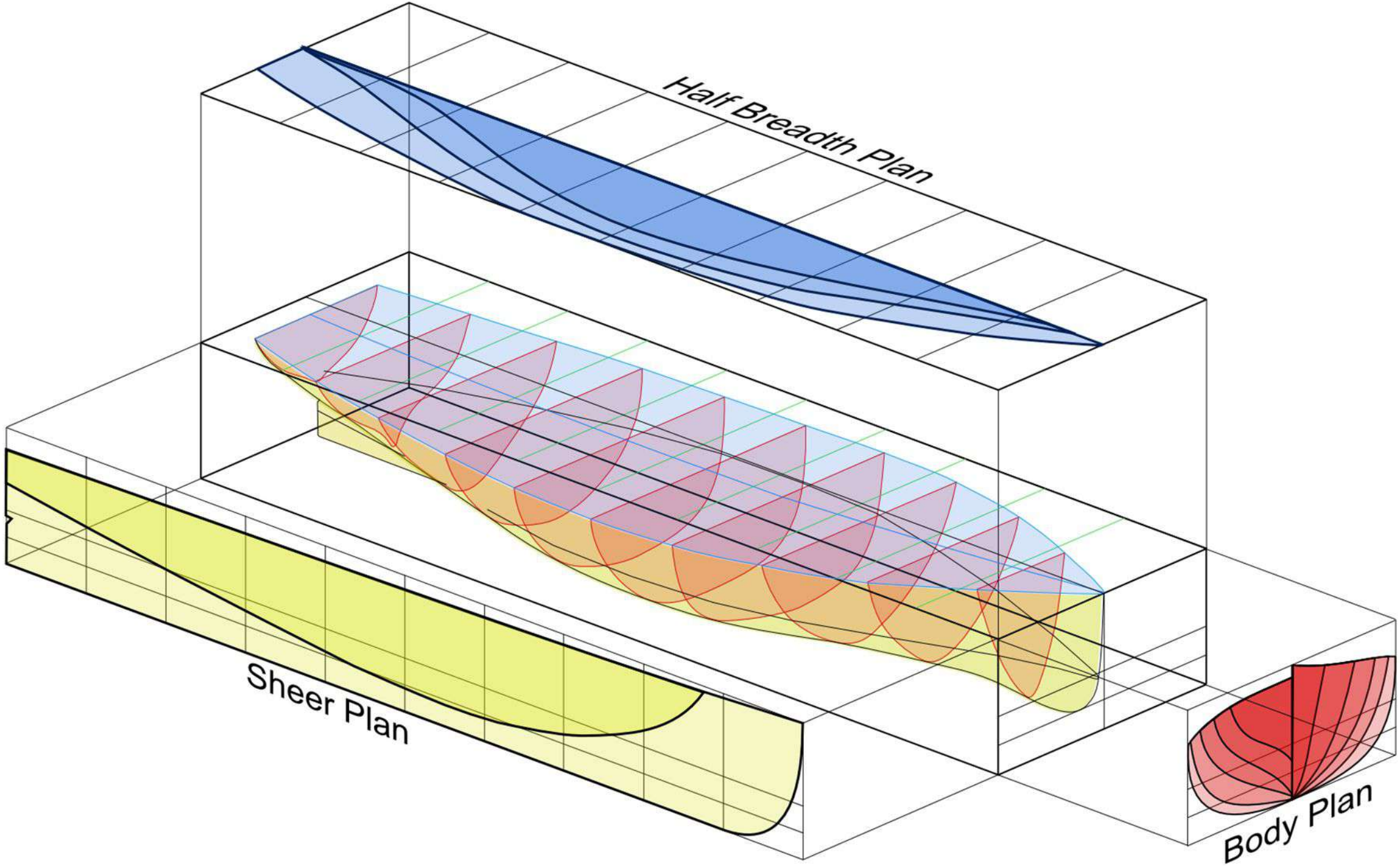
Body Plan

Horizontal planes II to BL plane

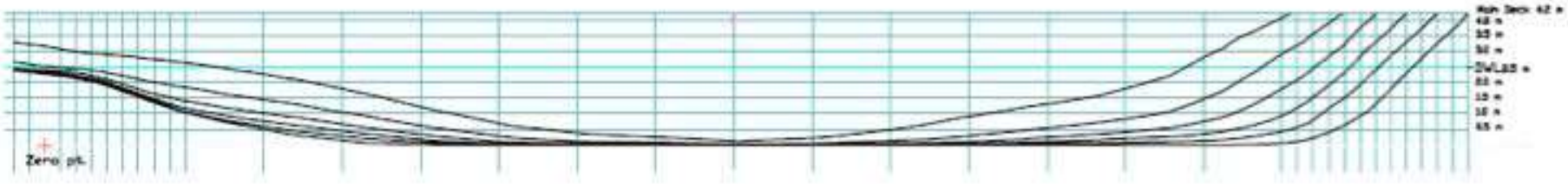


Waterlines

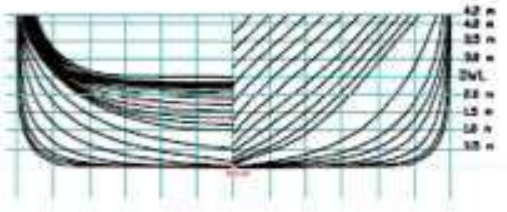
Half Breadth Plan


Half Breadth Plan
Sheer Plan
Body Plan

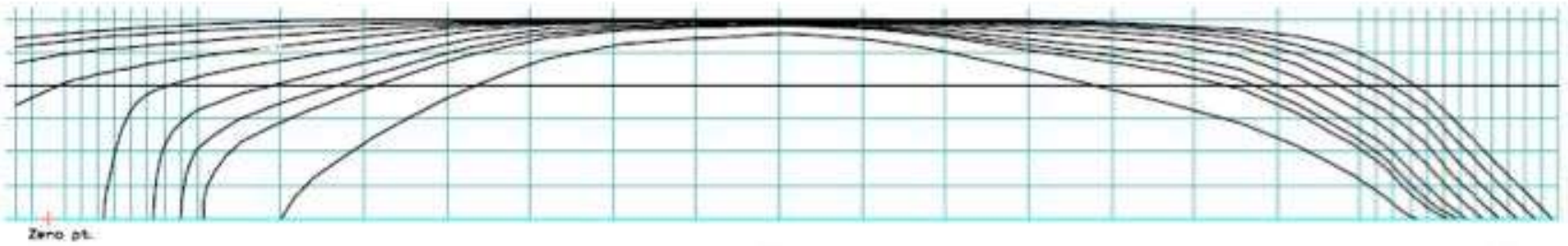
LINES PLAN



SHEER PLAN / PROFILE

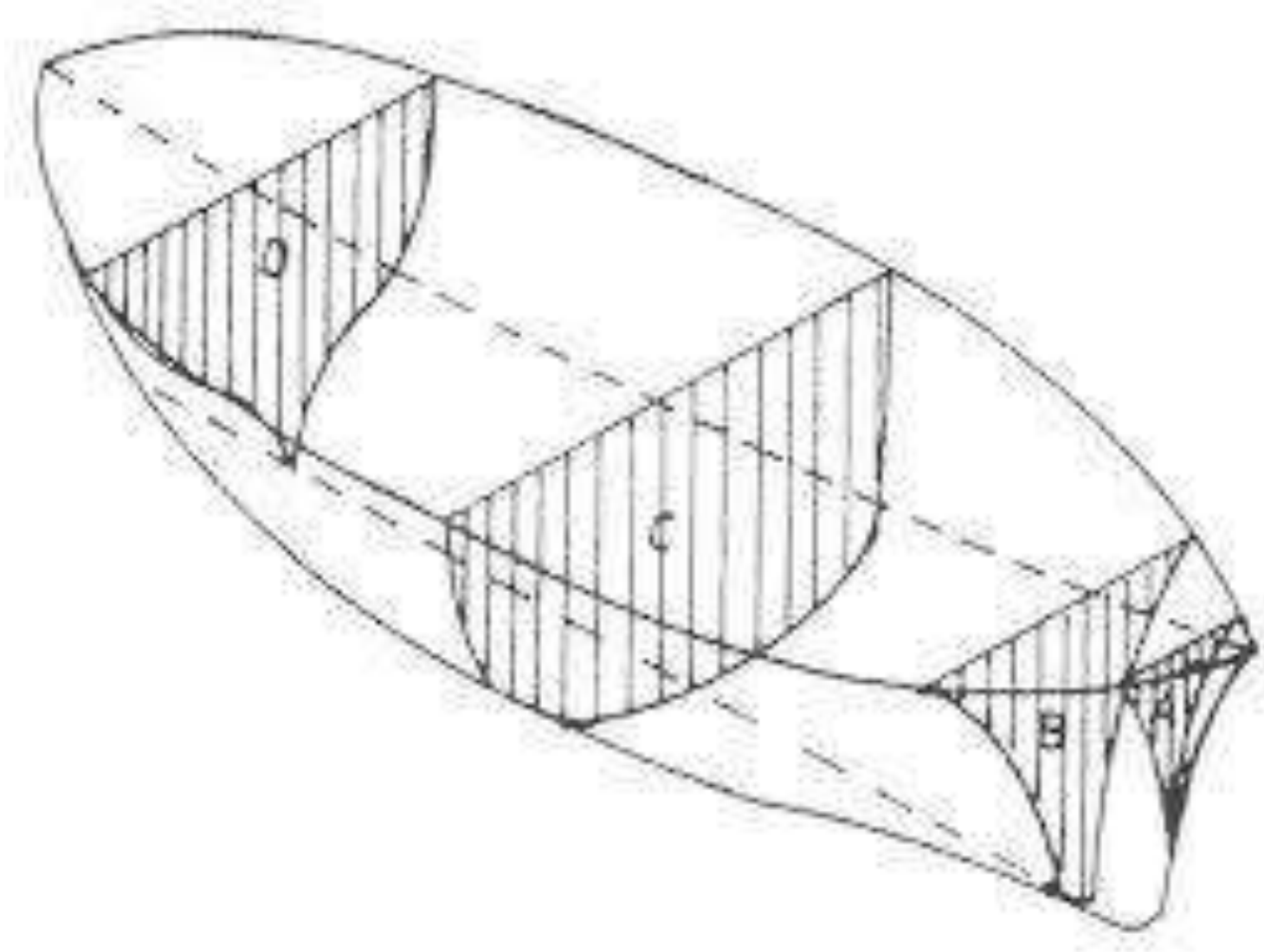


BODY PLAN

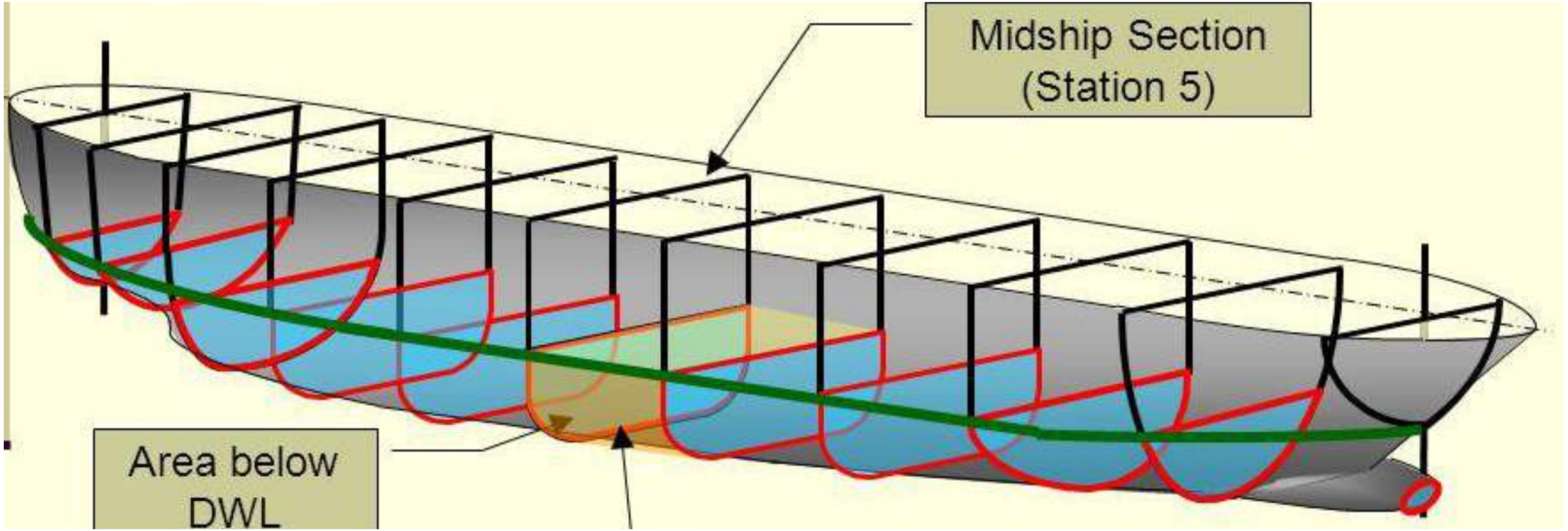


HALF BREADTH PLAN

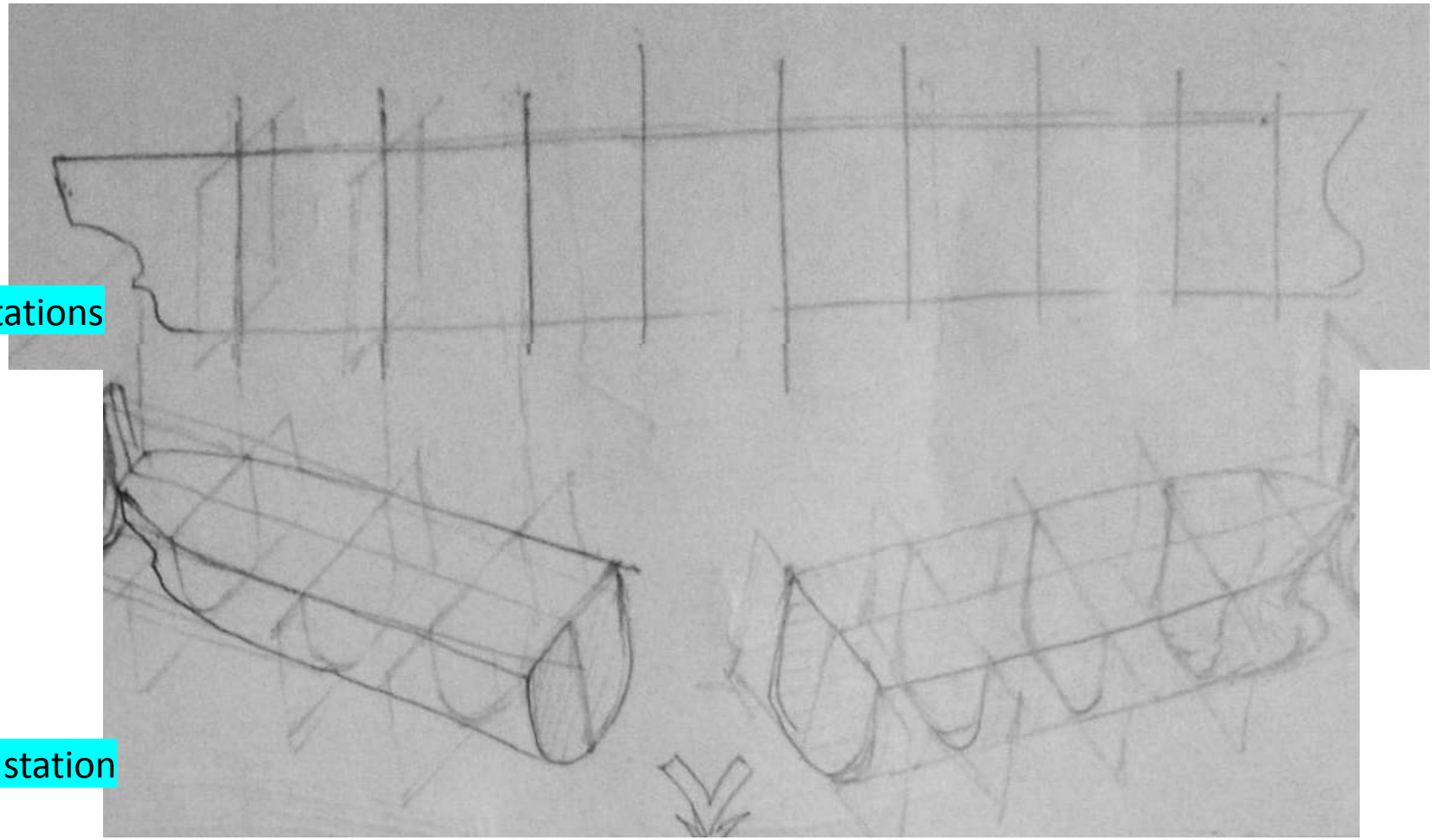
Body Plan



Body Plan



Body Plan

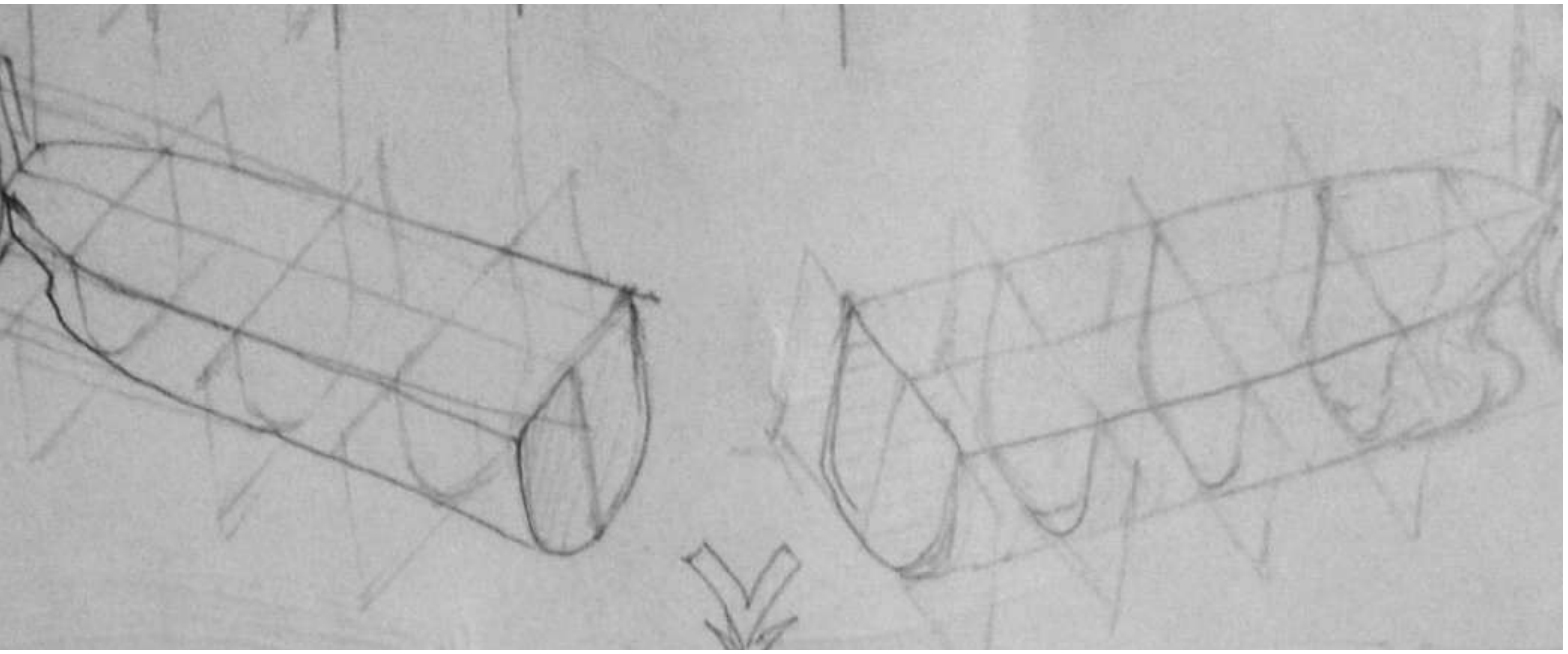


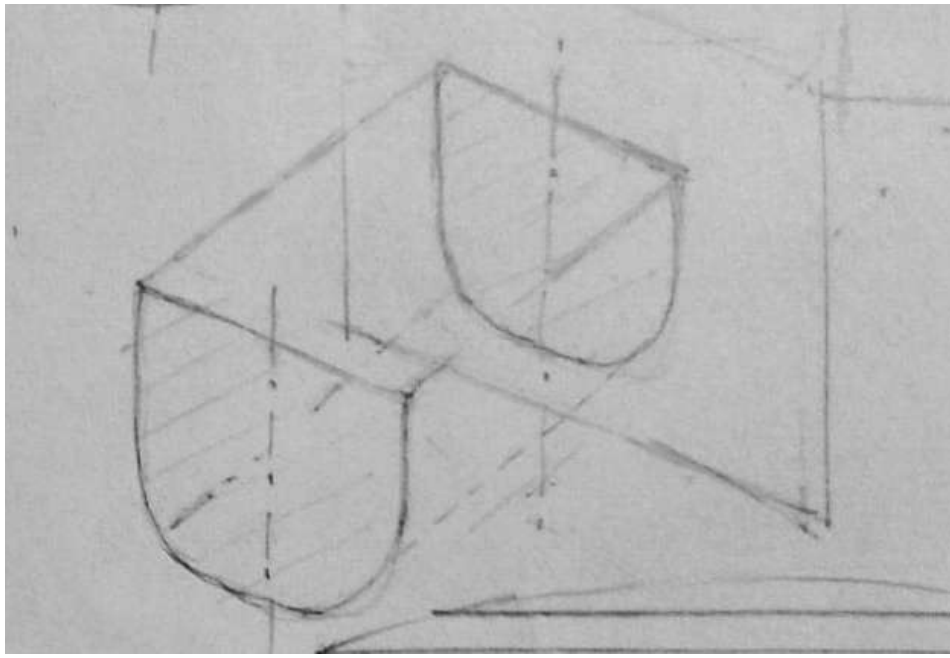
Profile view showing stations

Ship cut open at a station amidships

Body Plan

Orthographic projection of a midship cross section

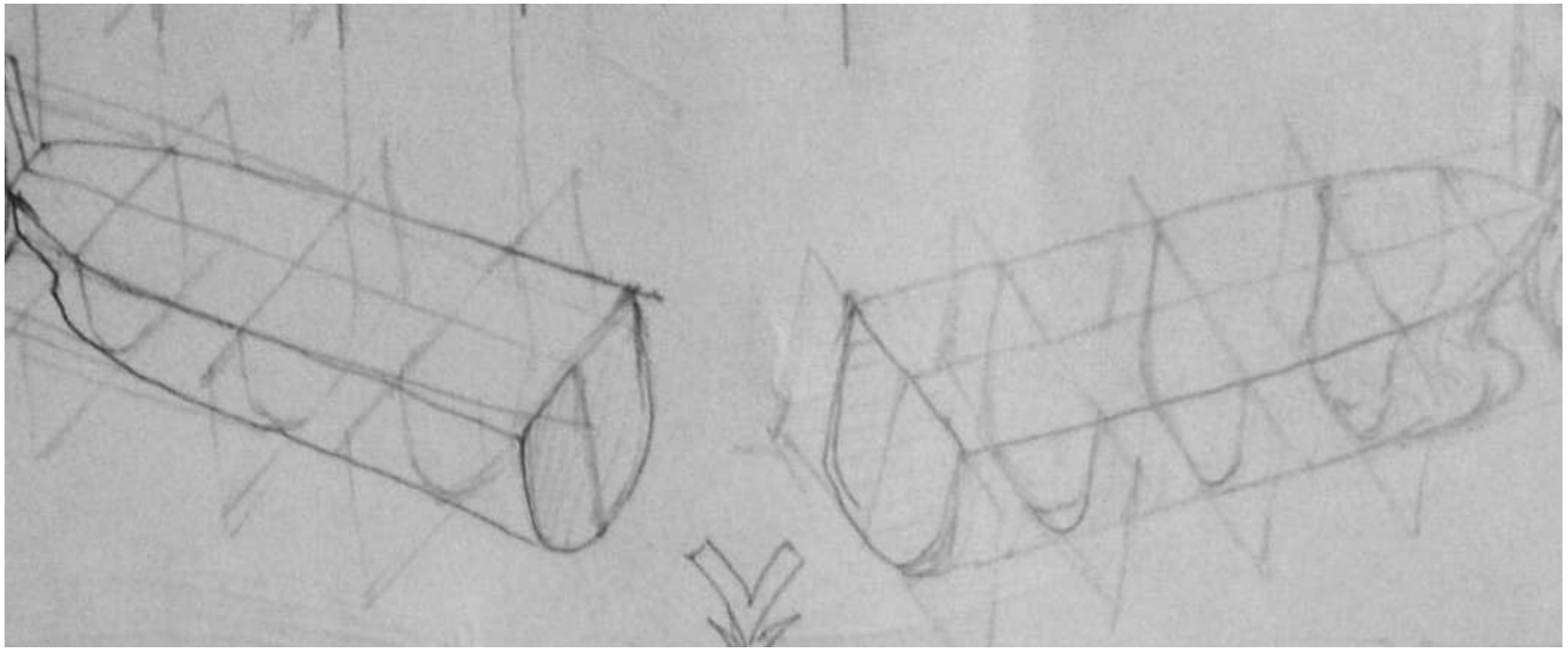




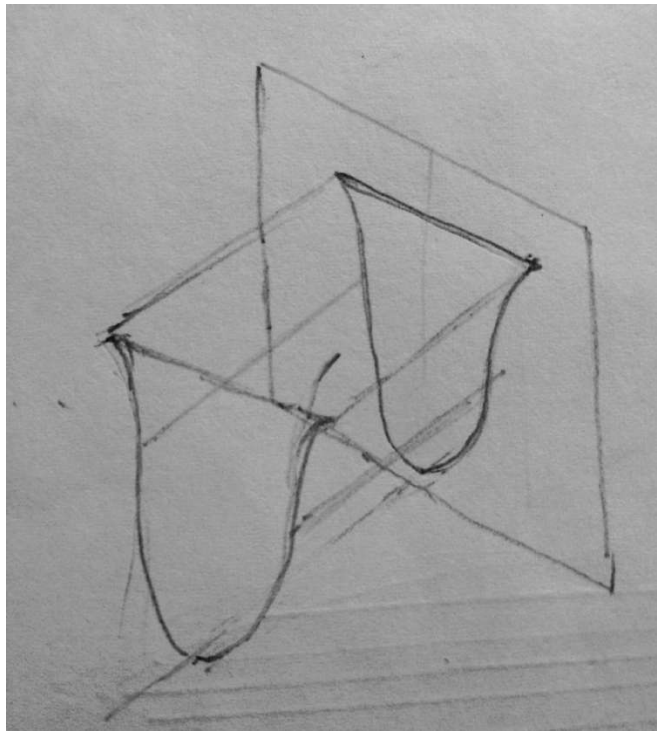
Ship cut open at a station amidships

Body Plan

Orthographic projection of a Forward cross section

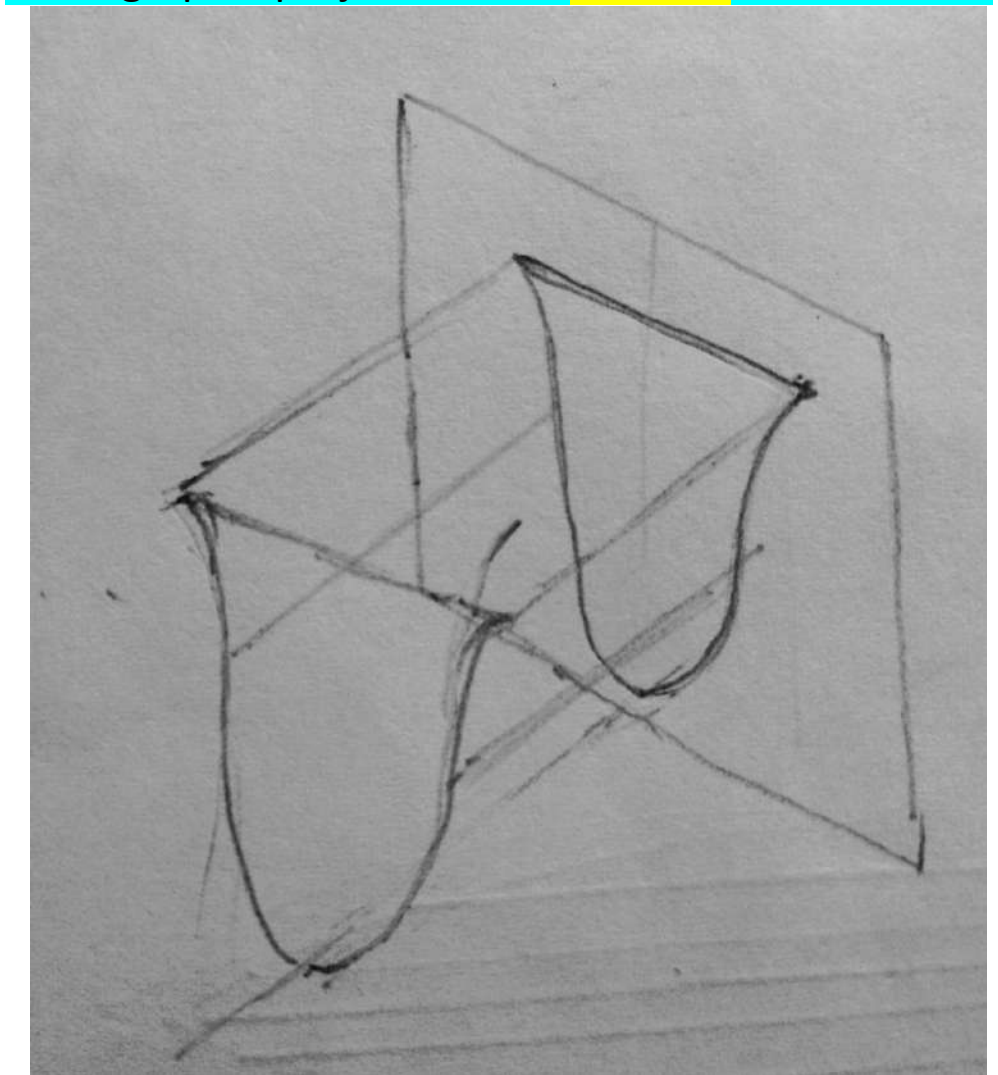


Ship cut open at a station amidships

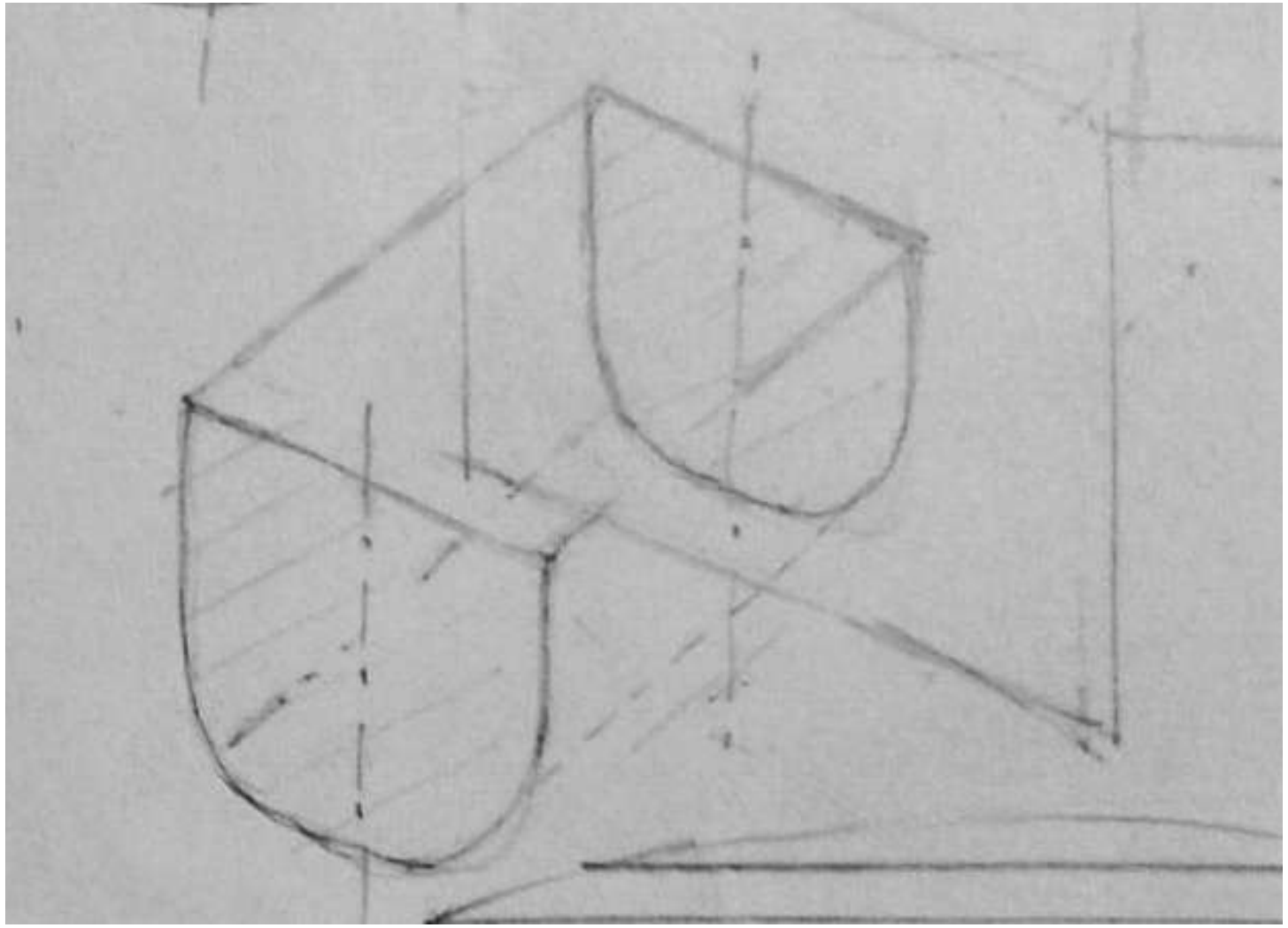


Body Plan

Orthographic projection of a Forward cross section

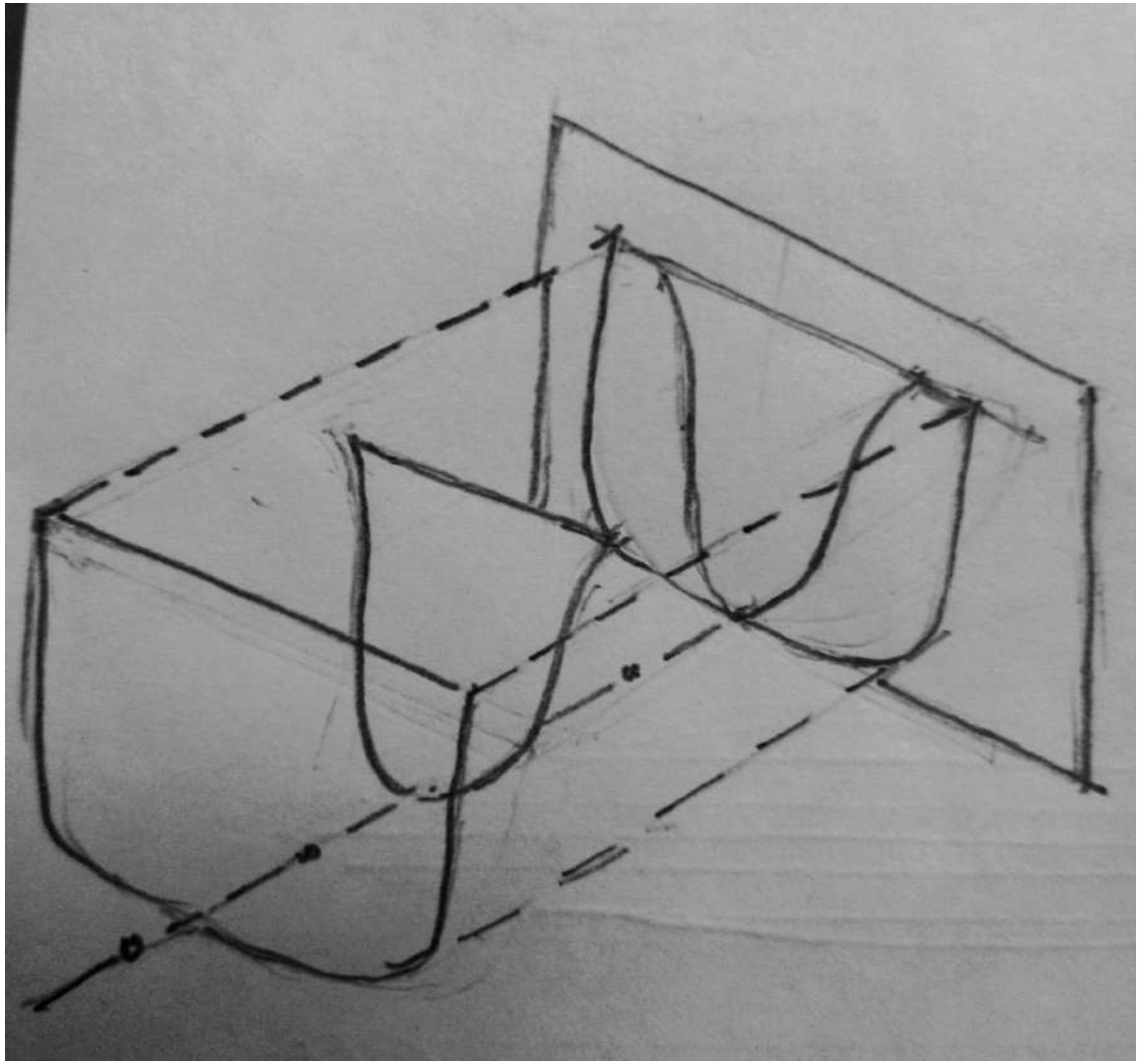


Orthographic projection of a midship cross section



Body Plan

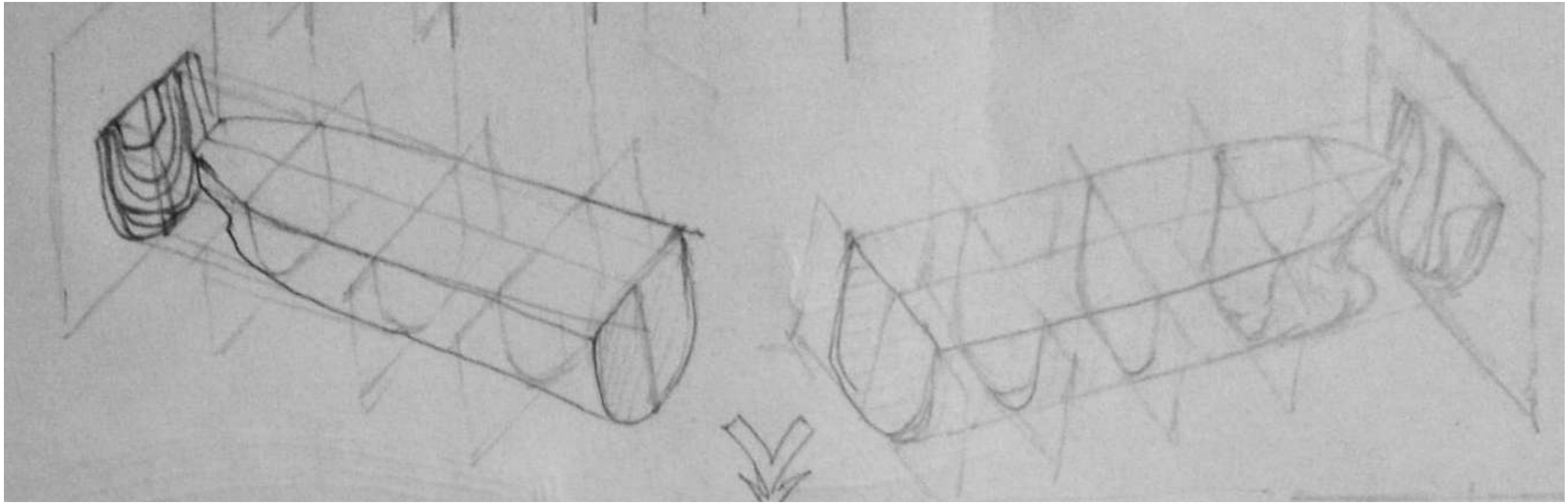
Combined Orthographic projection of a midship cross section and a forward cross section



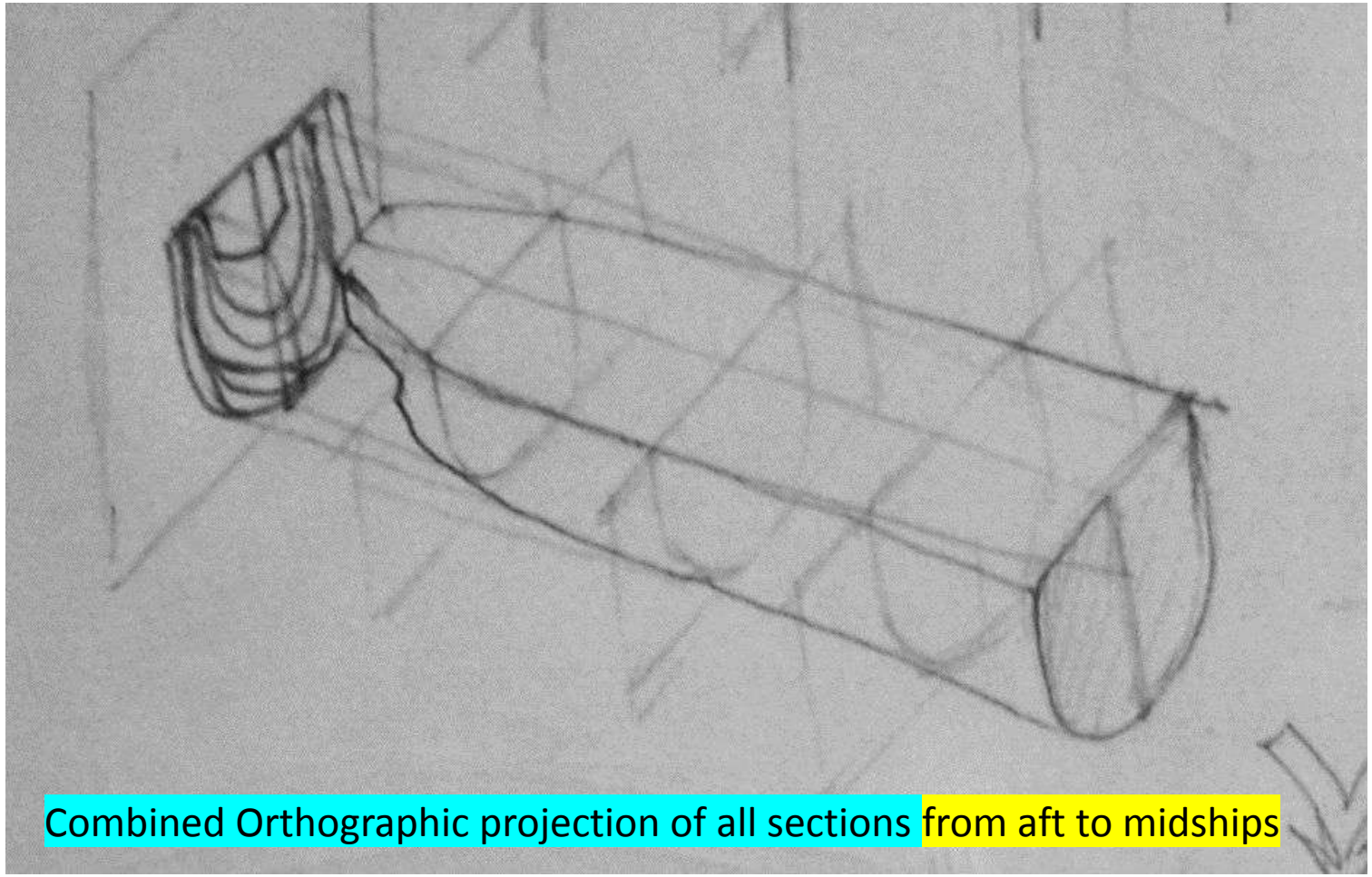
Body Plan

Combined Orthographic projection of all sections from **aft to midships**

Combined Orthographic projection of all sections from **midships to forward**

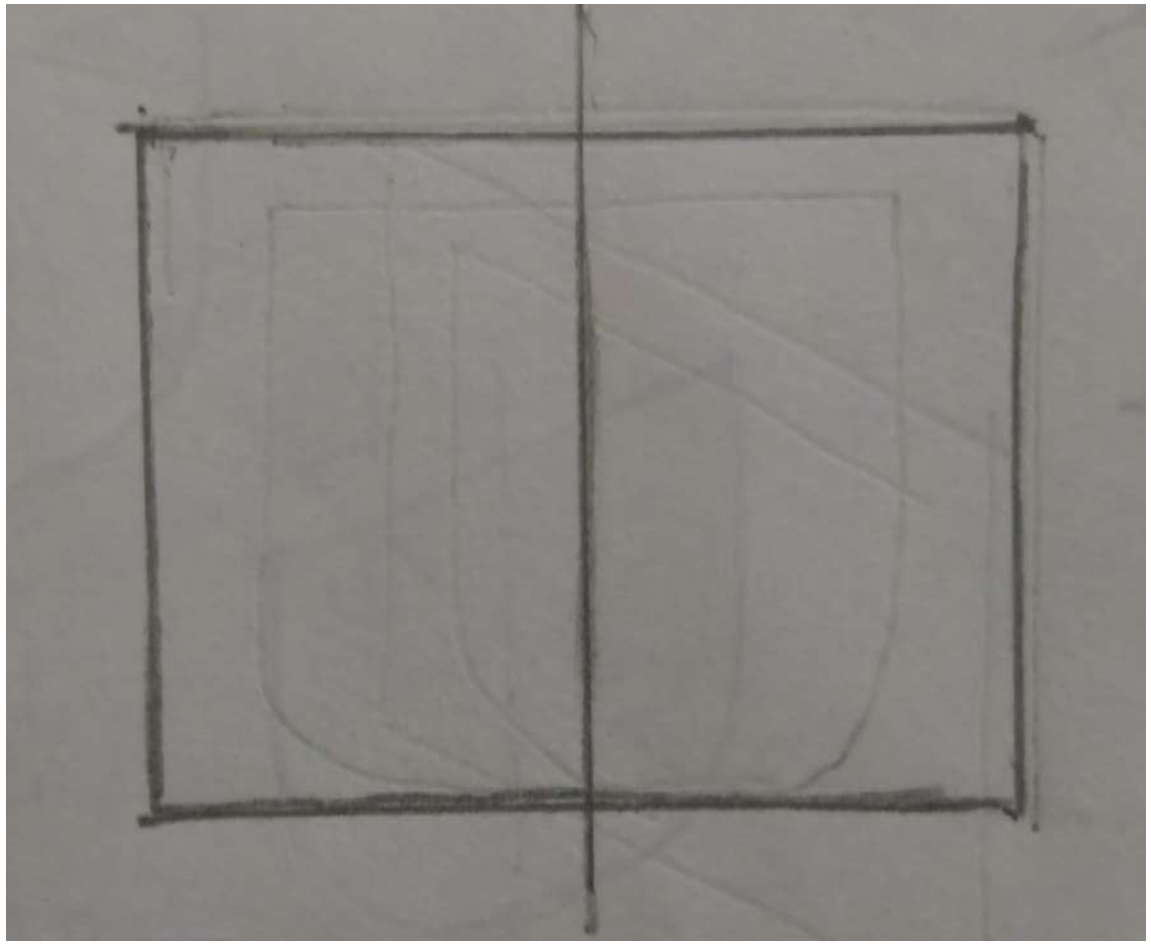


Body Plan – Aft to Midships

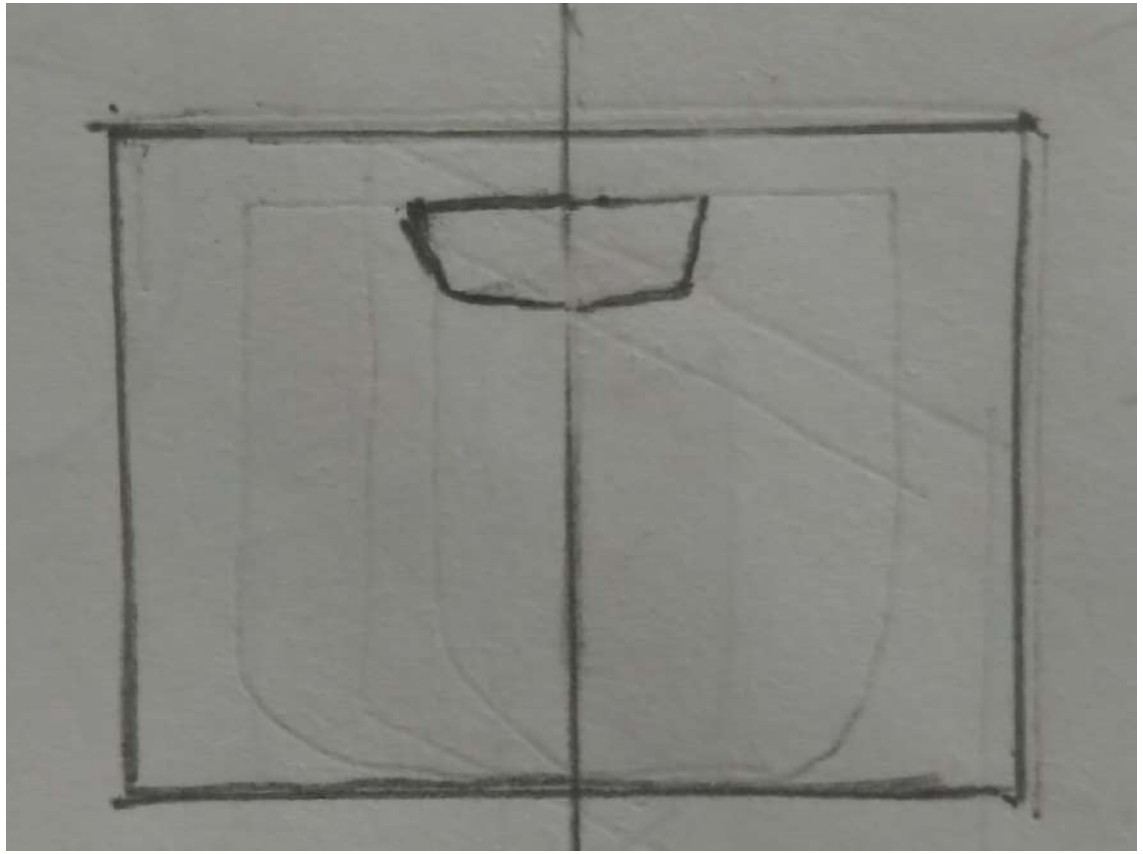


Combined Orthographic projection of all sections from aft to midships

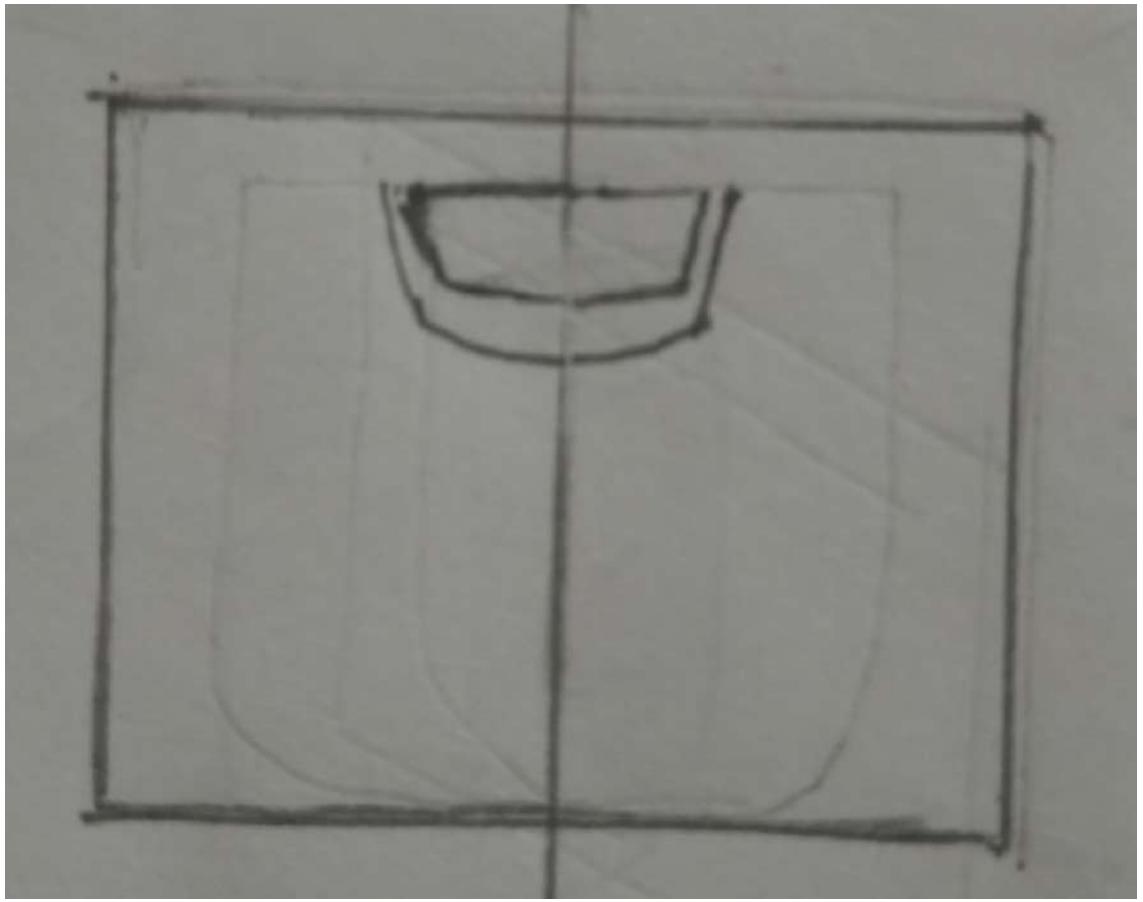
Body Plan – Aft to Midships



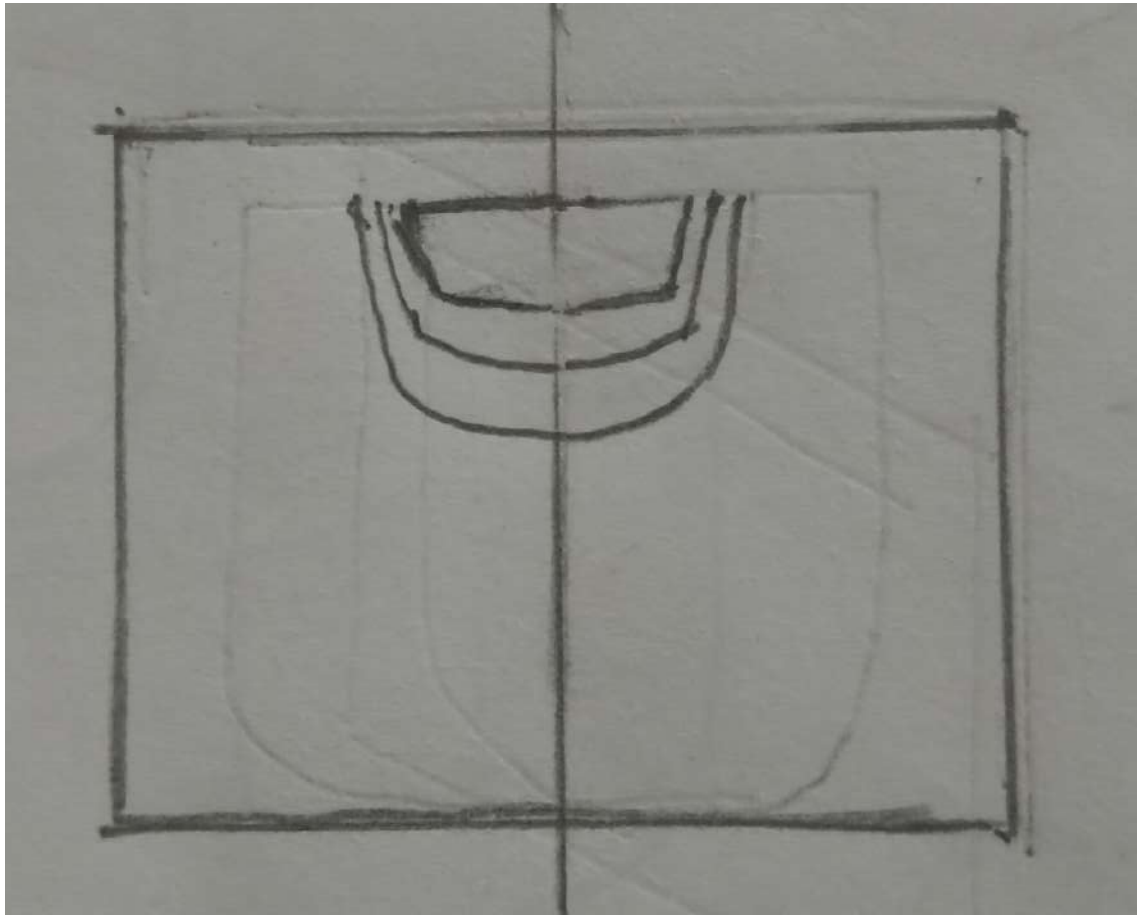
Body Plan – Aft to Midships



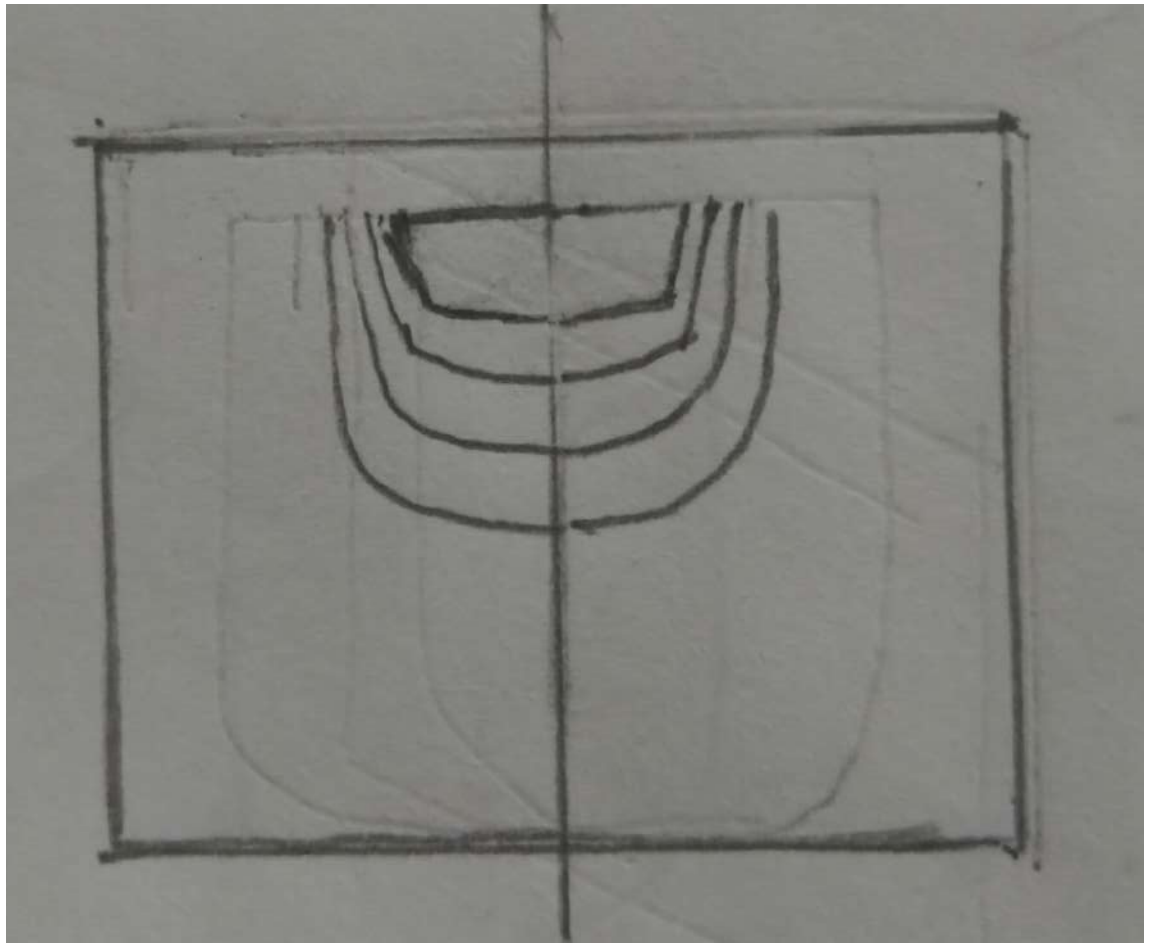
Body Plan – Aft to Midships



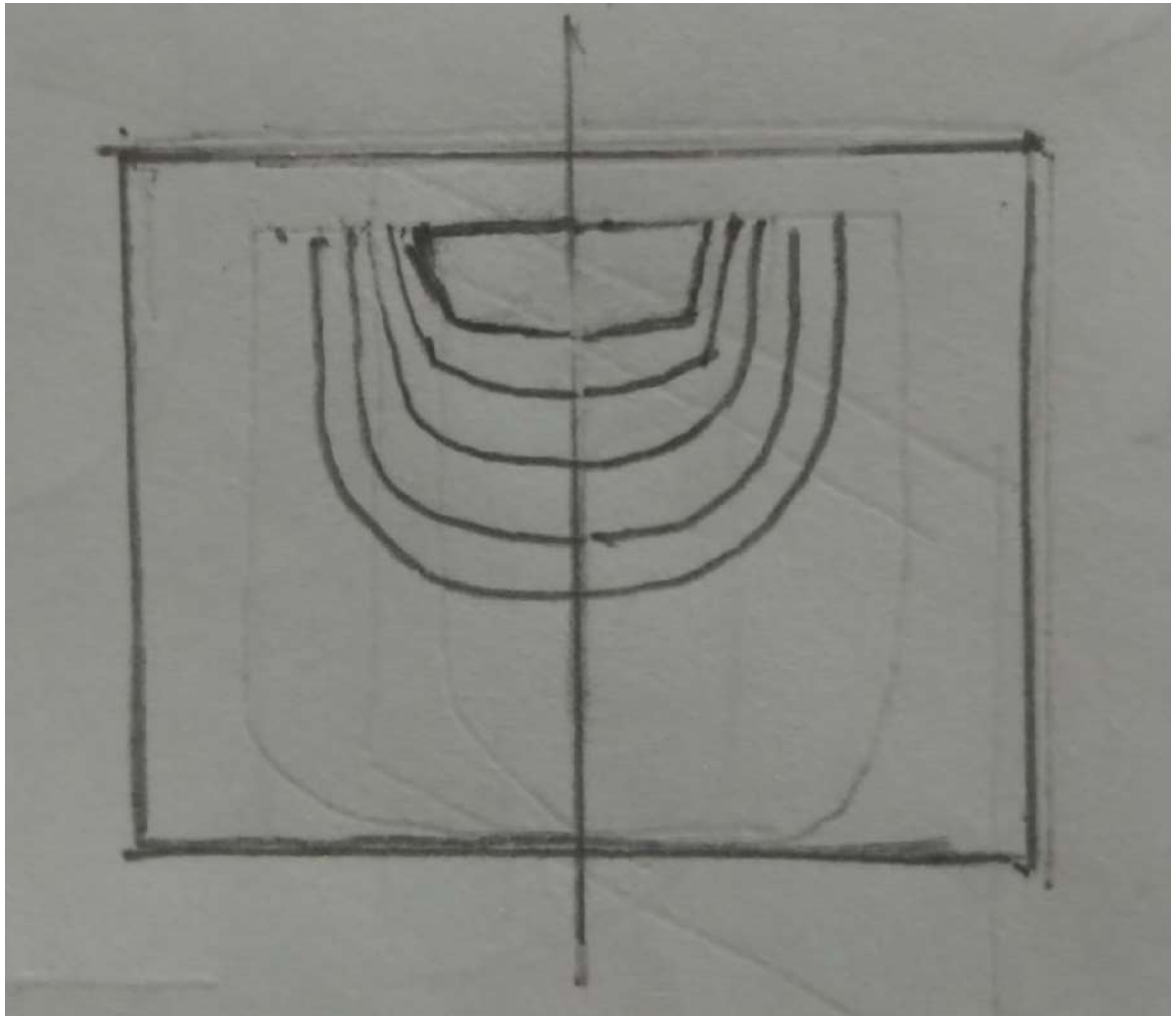
Body Plan – Aft to Midships



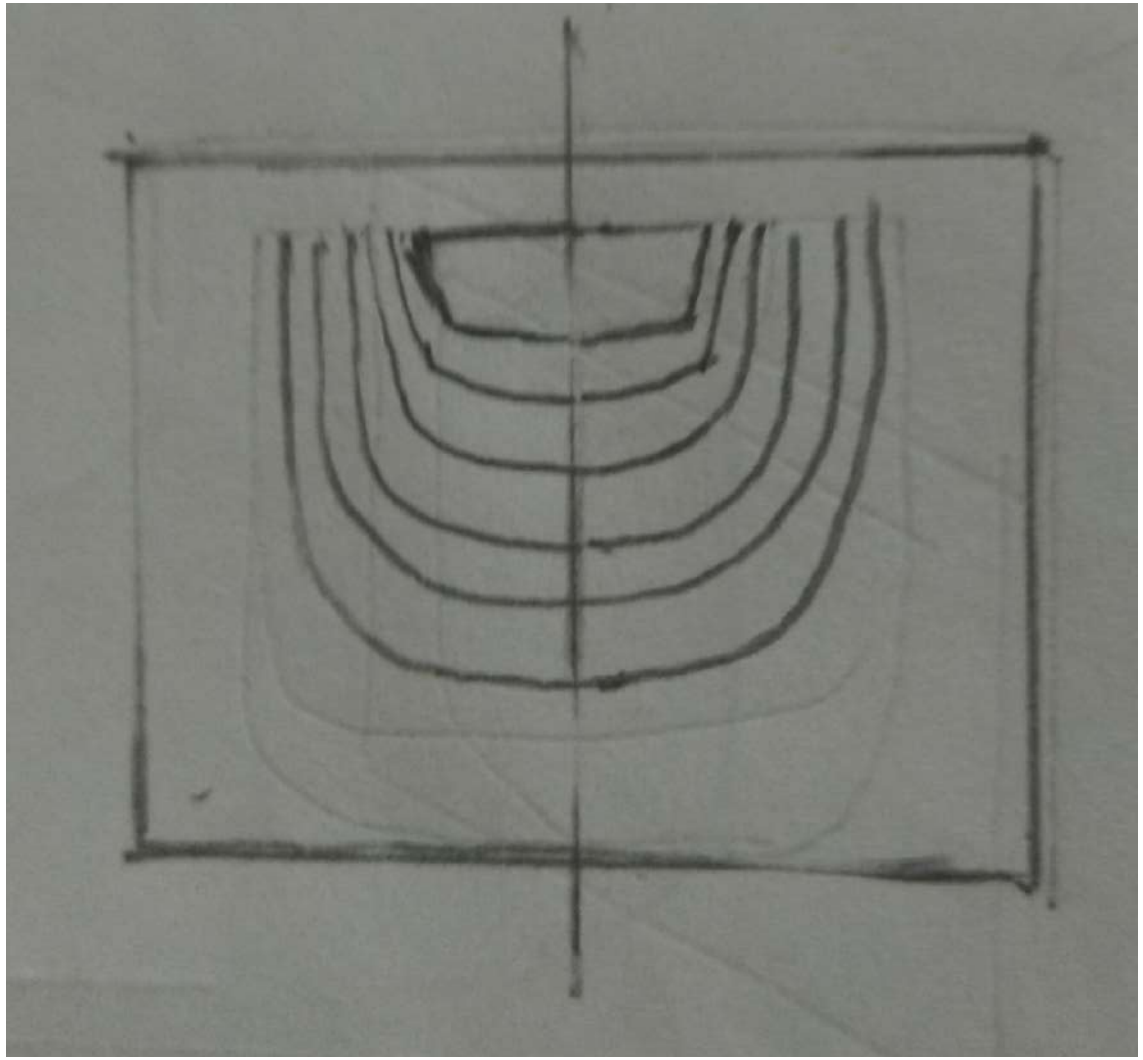
Body Plan – Aft to Midships



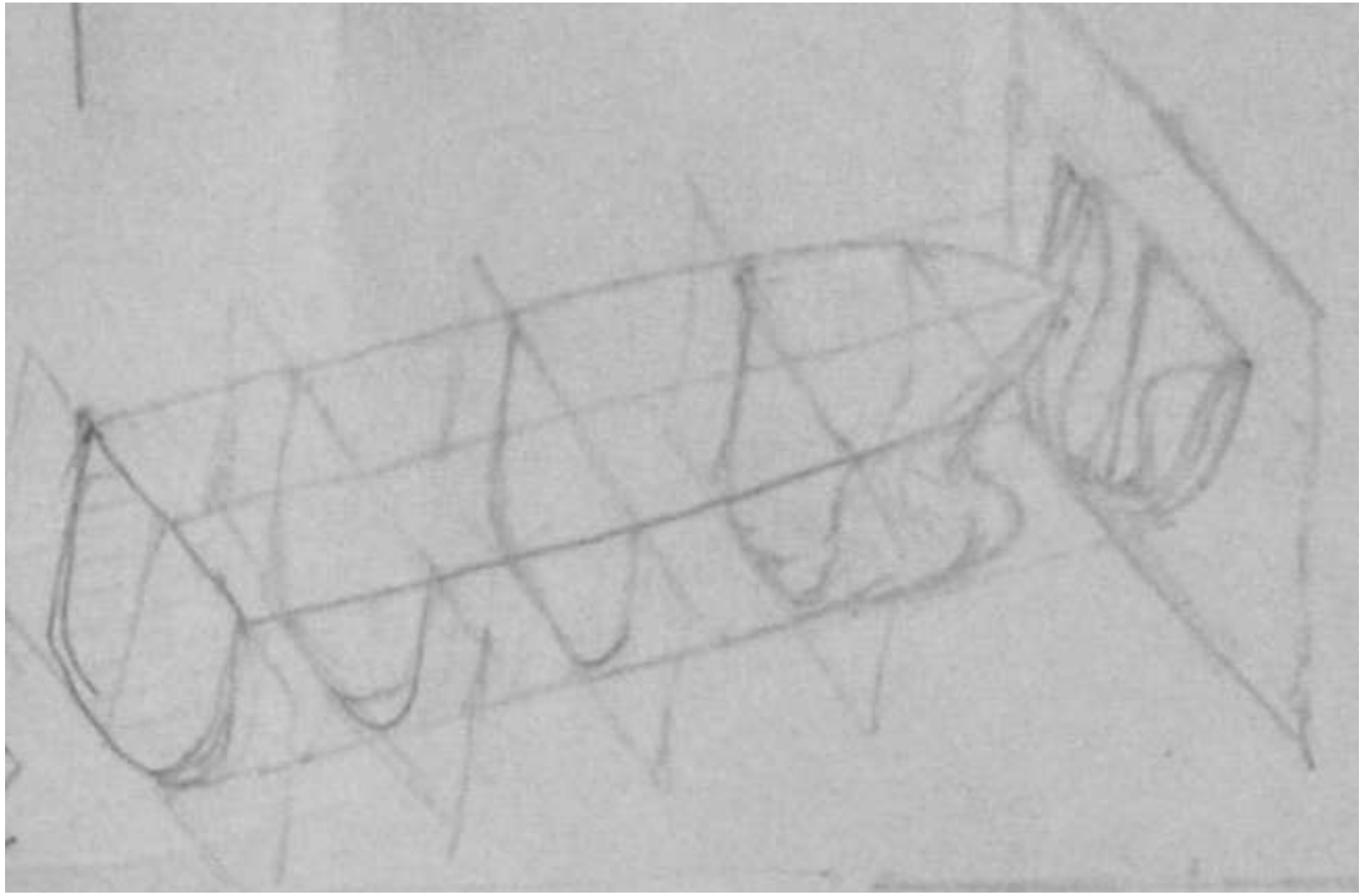
Body Plan – Aft to Midships



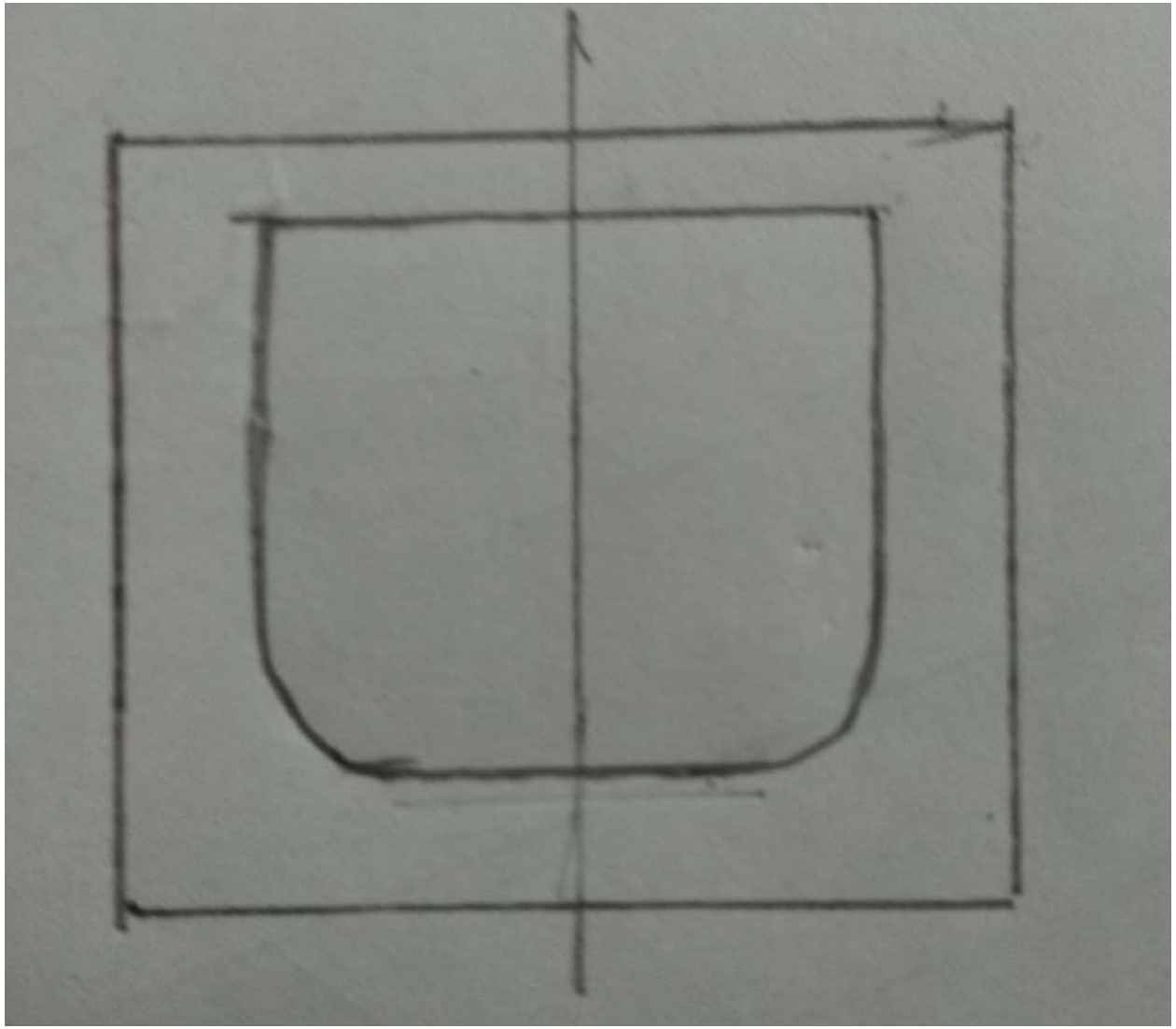
Body Plan – Aft to Midships



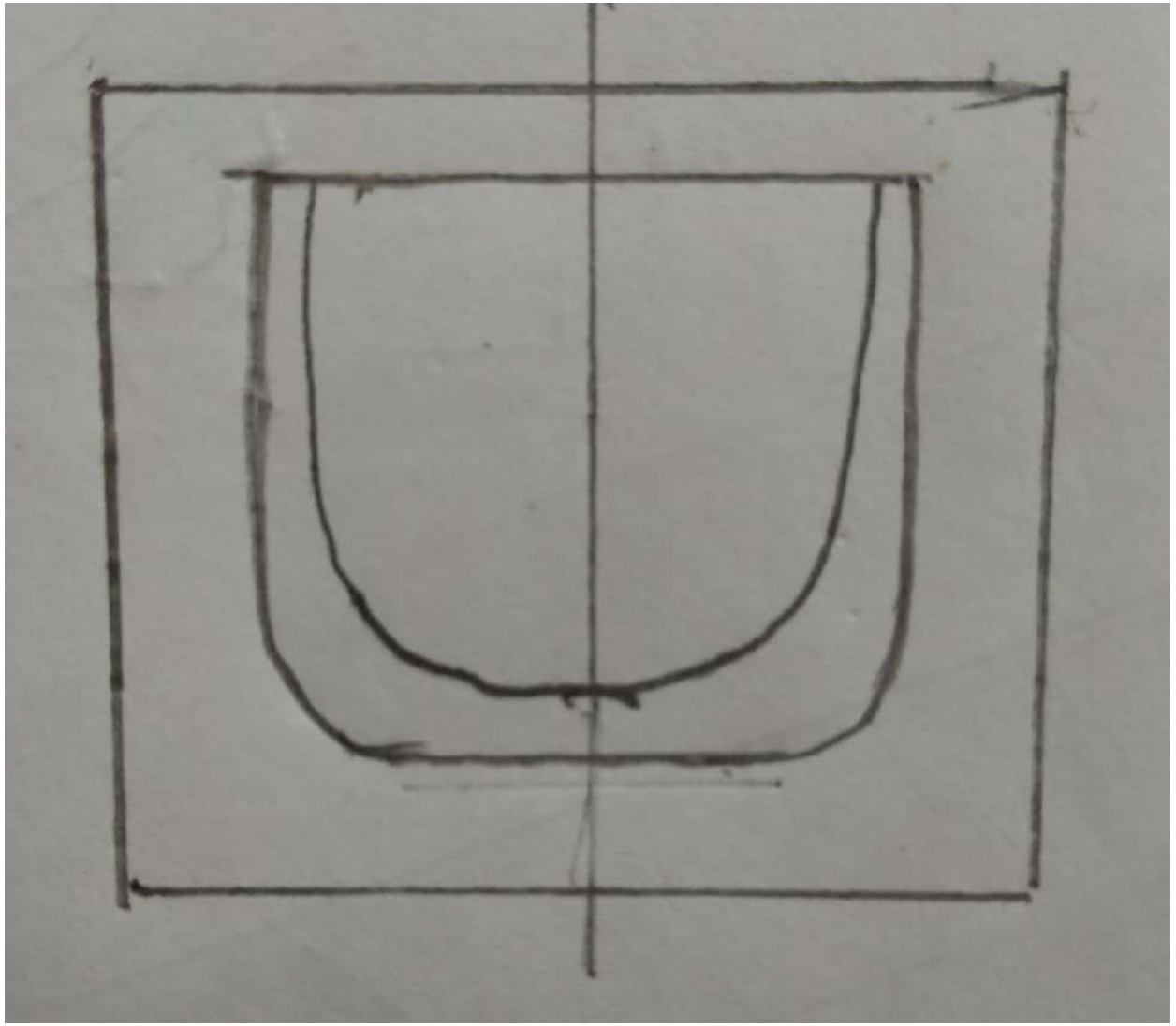
Body Plan –Midships to Fwd



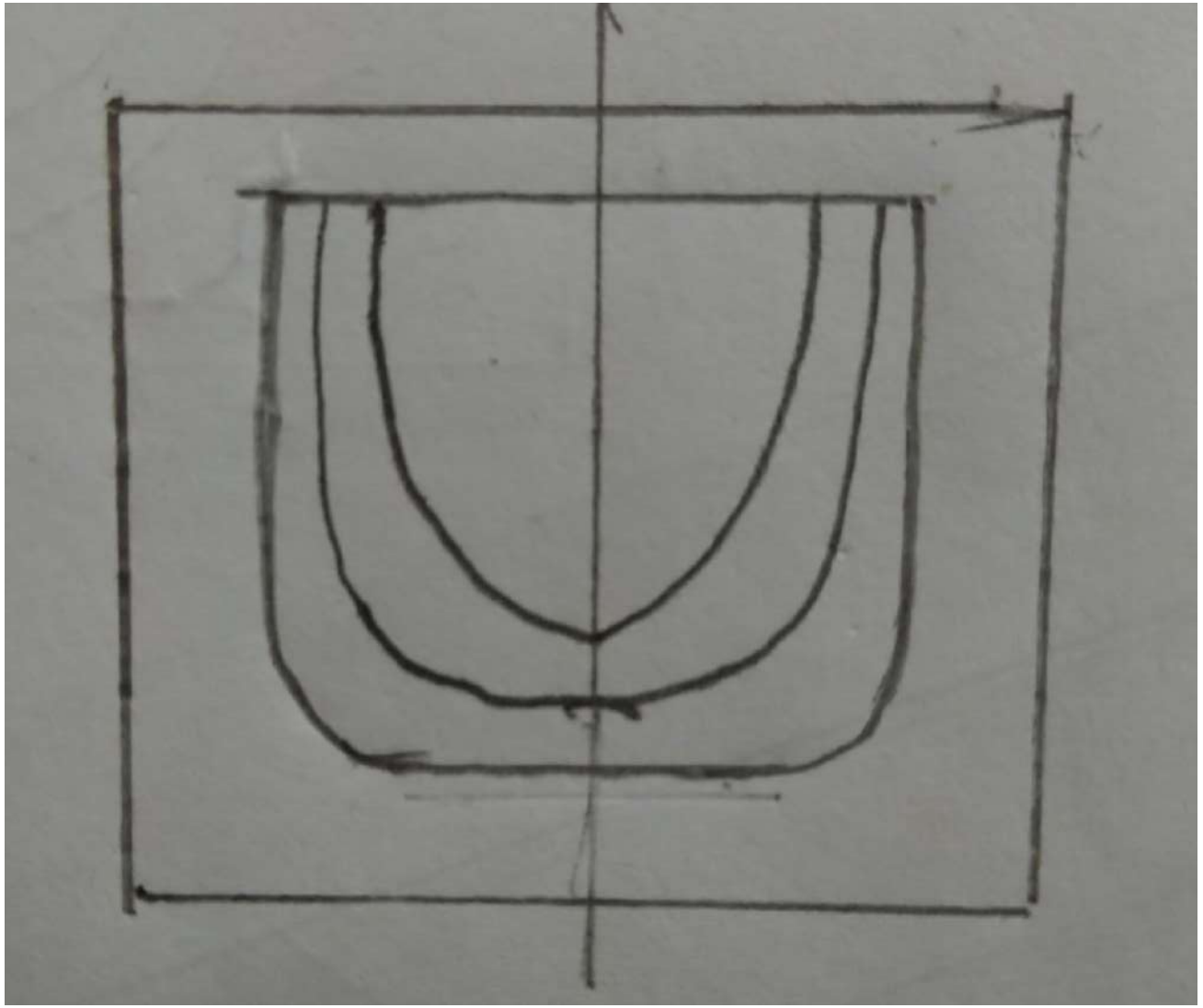
Body Plan – Midships to Fwd



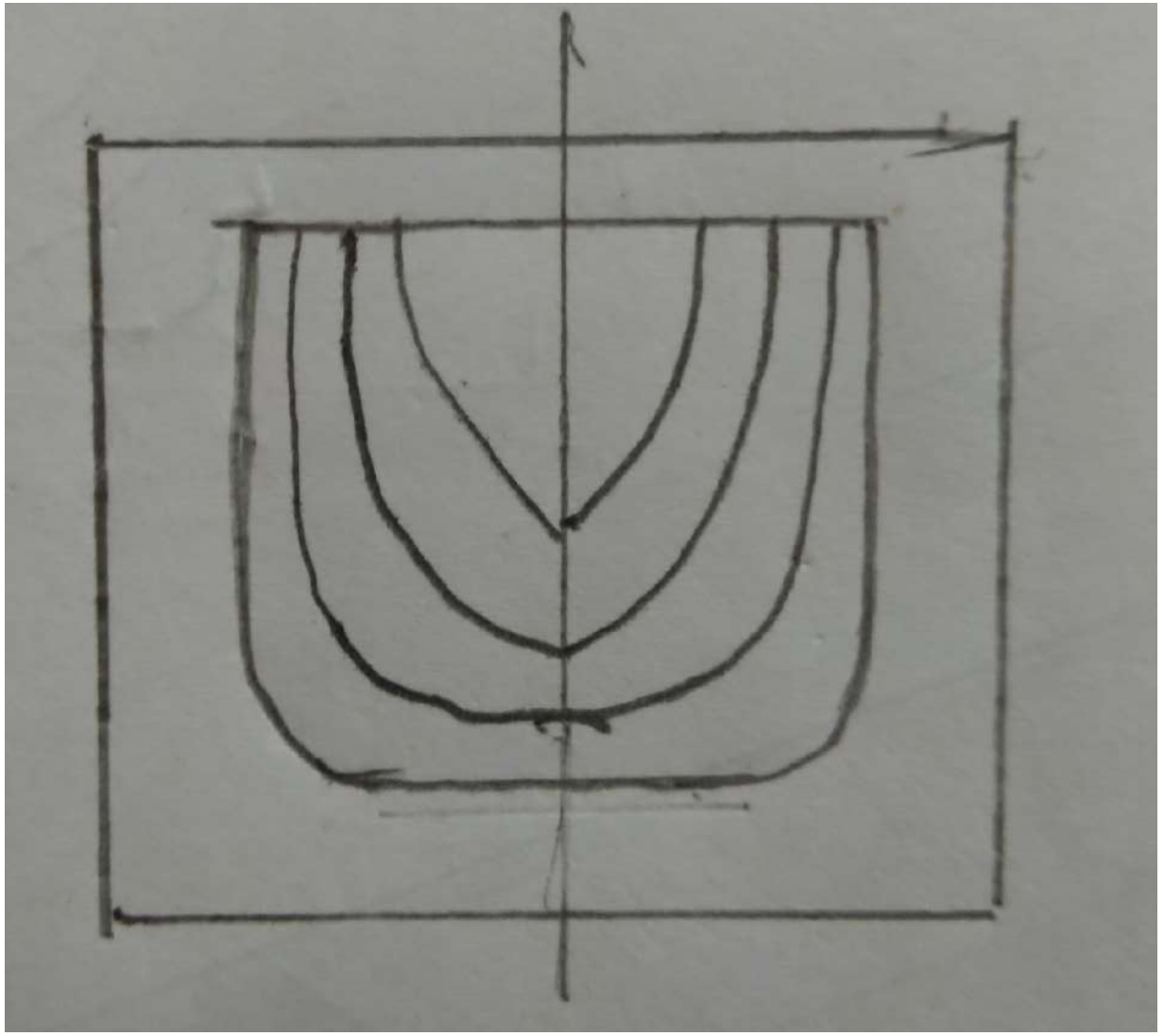
Body Plan – Midships to Fwd



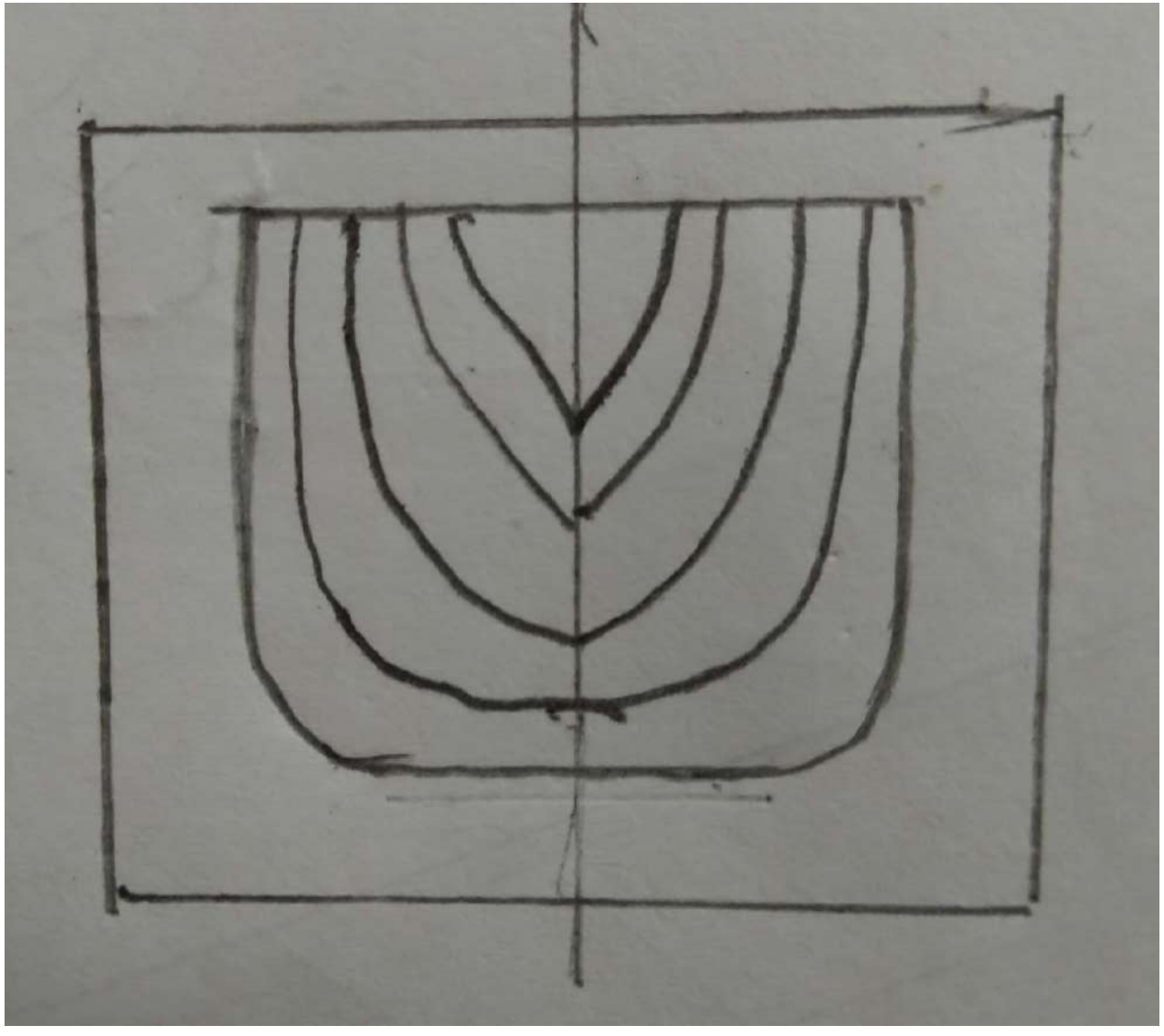
Body Plan – Midships to Fwd



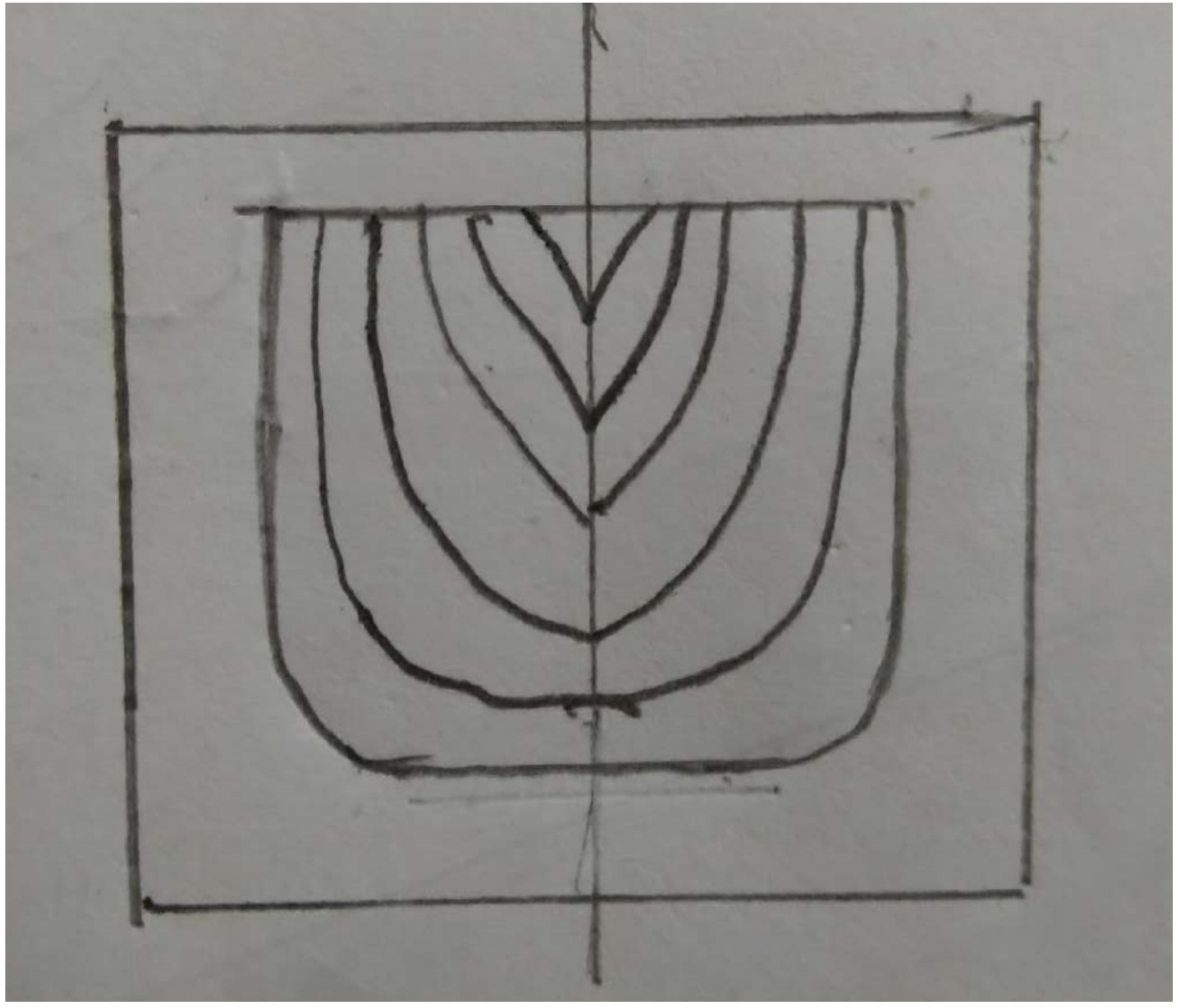
Body Plan – Midships to Fwd



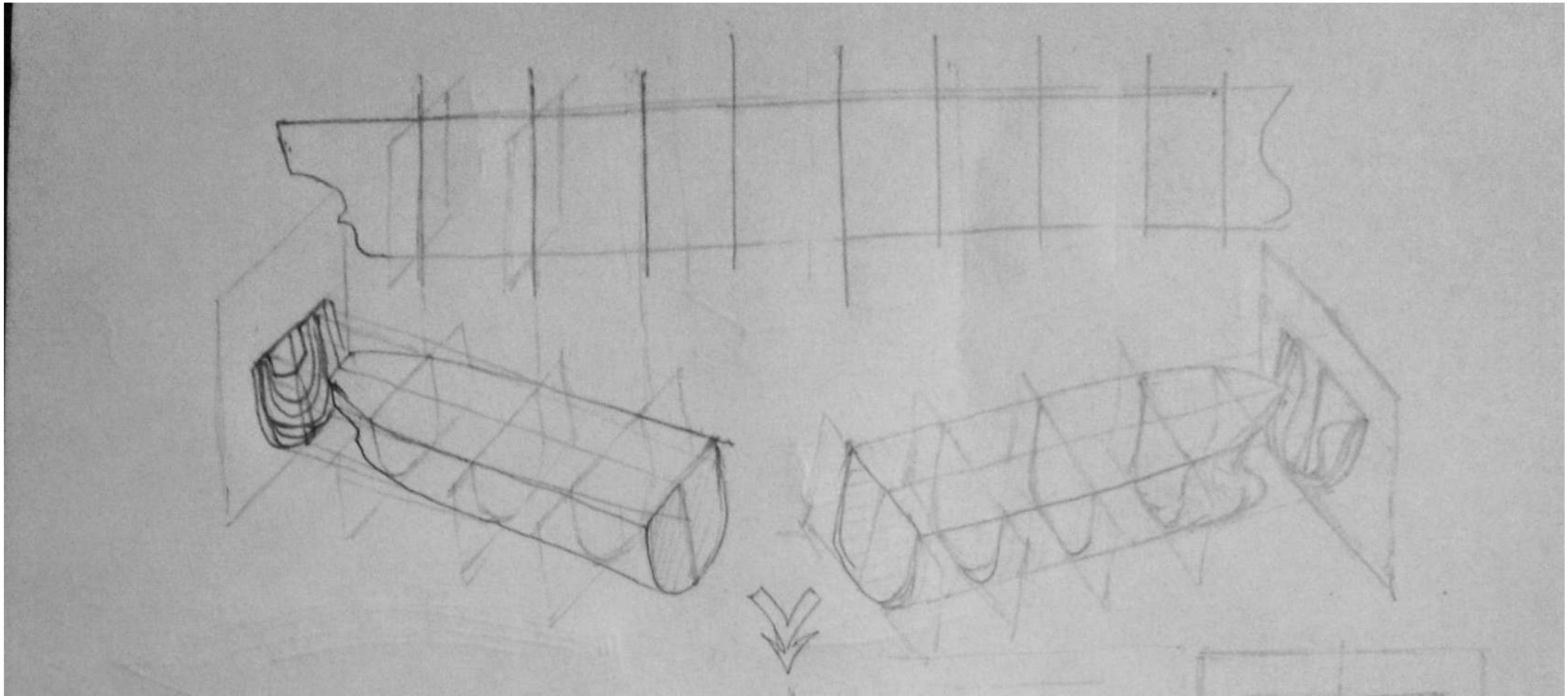
Body Plan – Midships to Fwd



Body Plan – Midships to Fwd

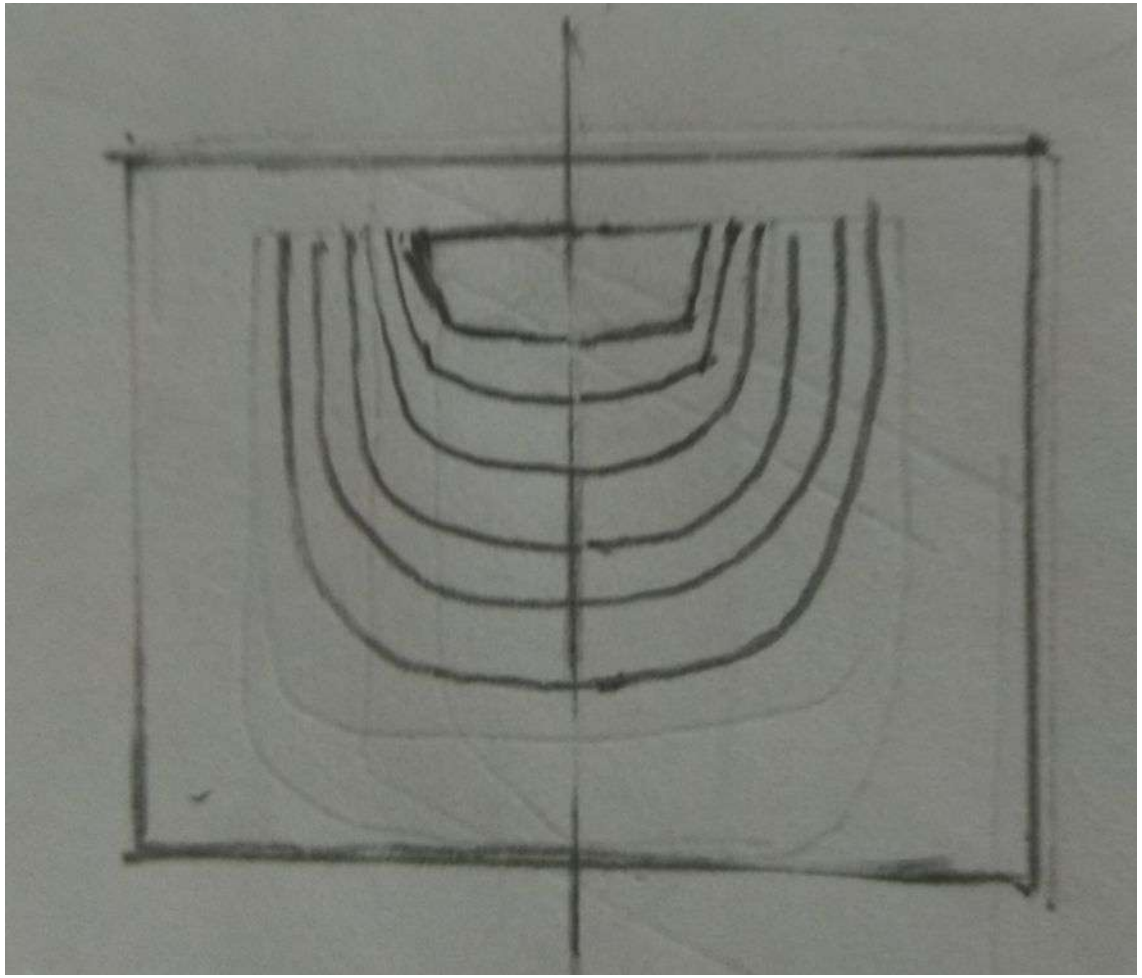


Body Plan – Aft to Fwd

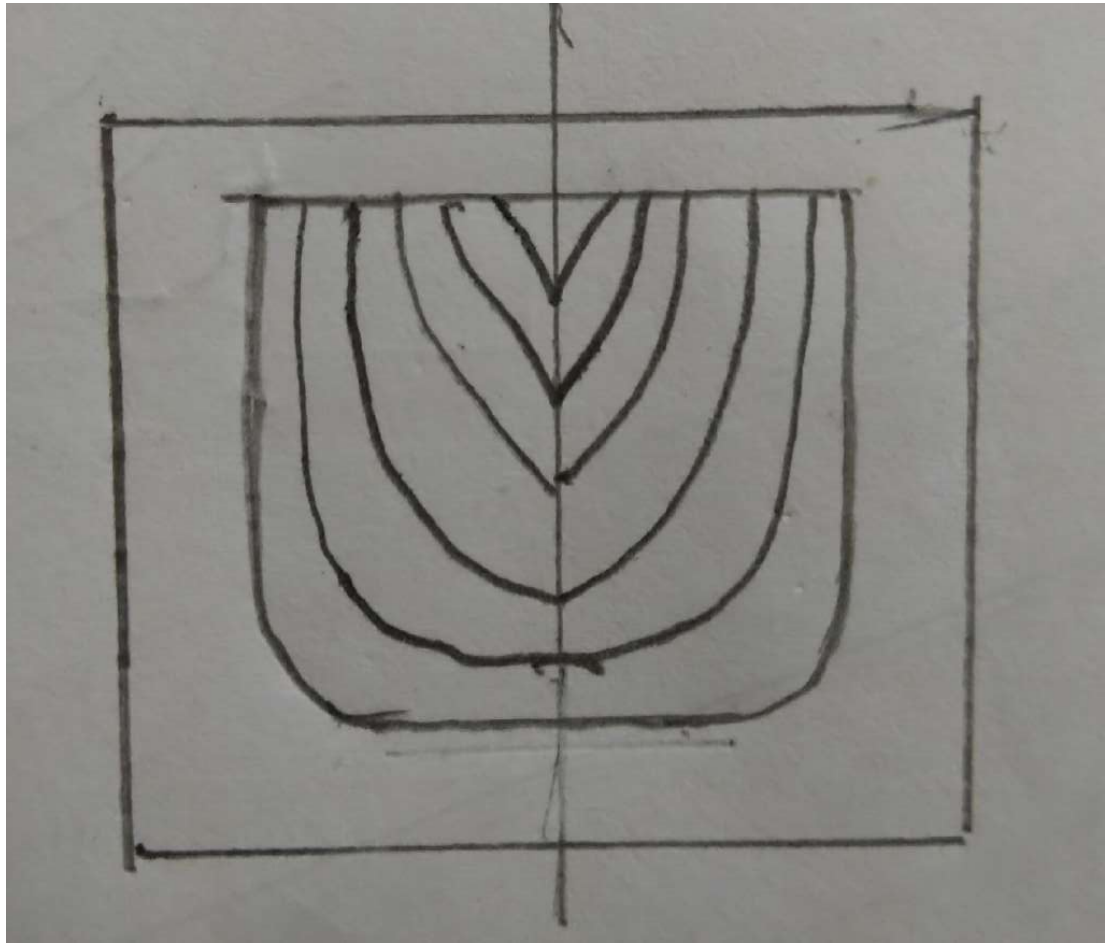


Body Plan -Aft to Fwd

Orthographic projection of all sections from **aft to midships**



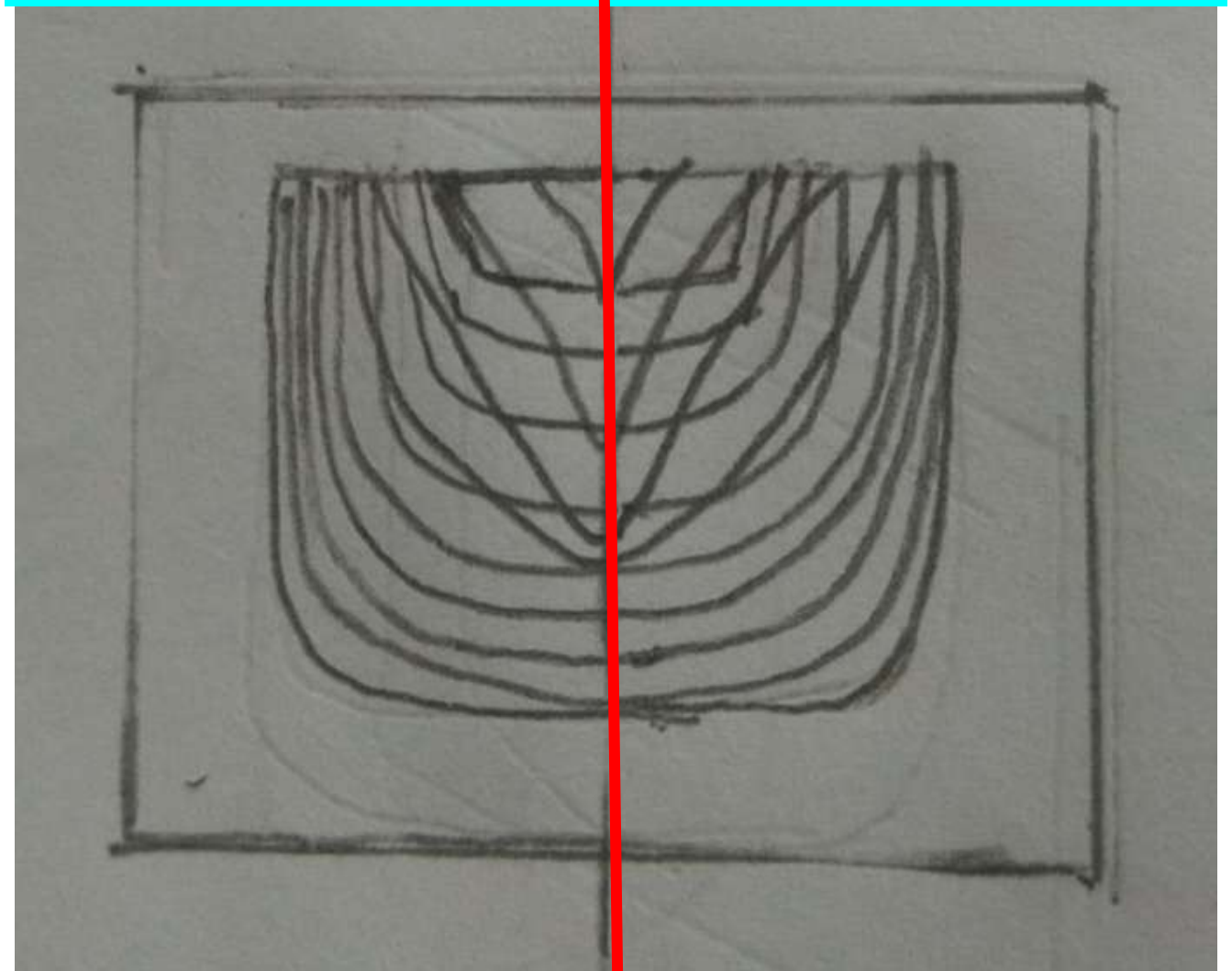
Orthographic projection of all sections from **midships to Fwd**



Body Plan – Aft to Fwd

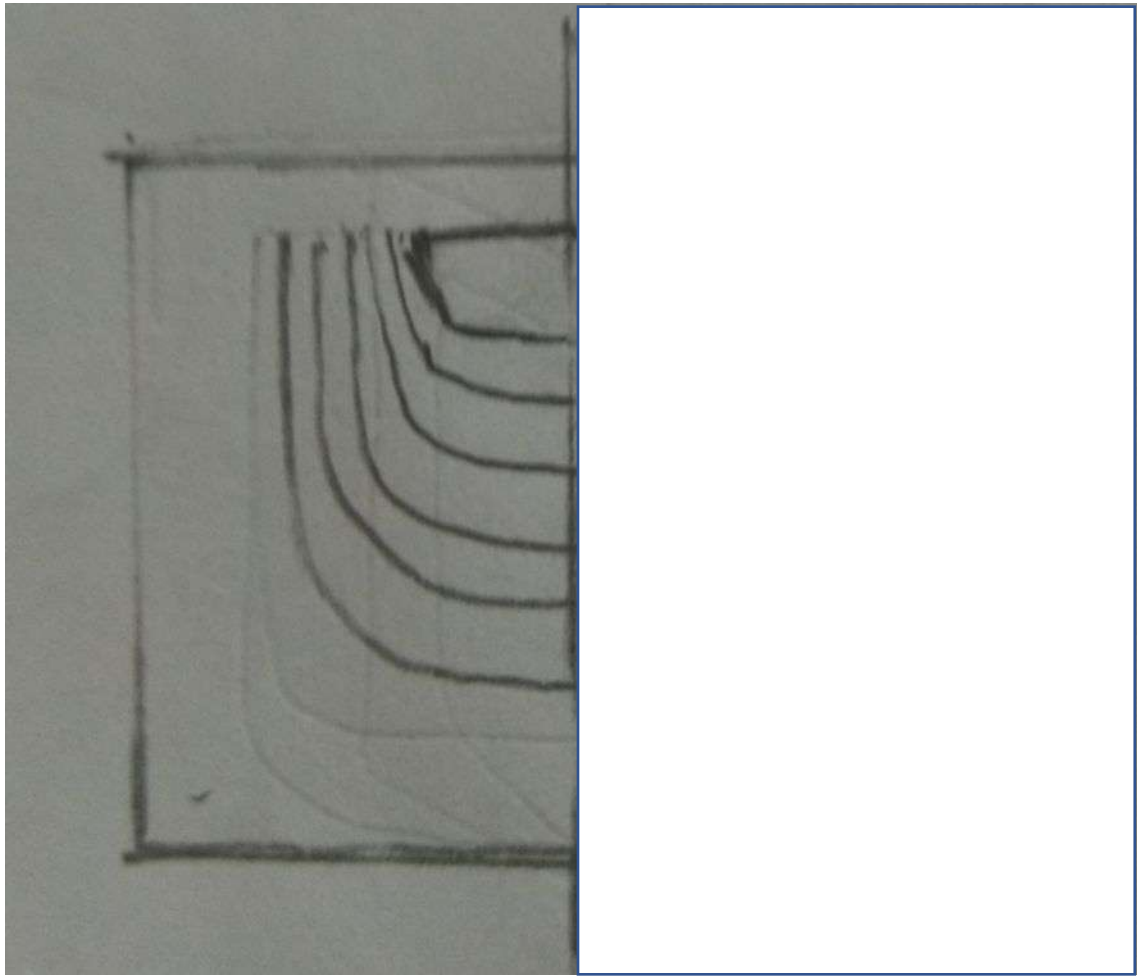
- Cluttered
- Symetric about centreline
- Only one half needs to be drawn

Combined Orthographic projection of all sections from **aft to fwd**

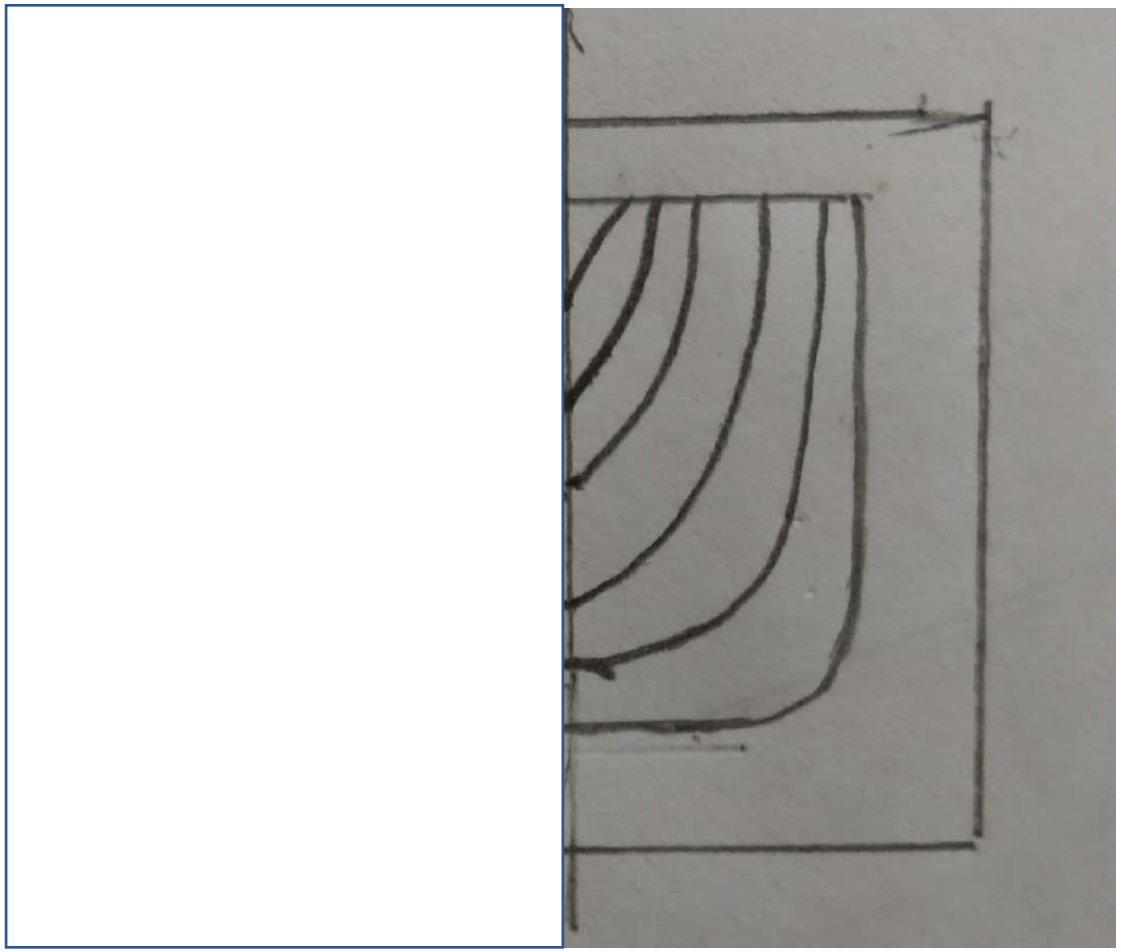


Body Plan -Aft to Fwd

Orthographic projection of all sections from **aft to midships**

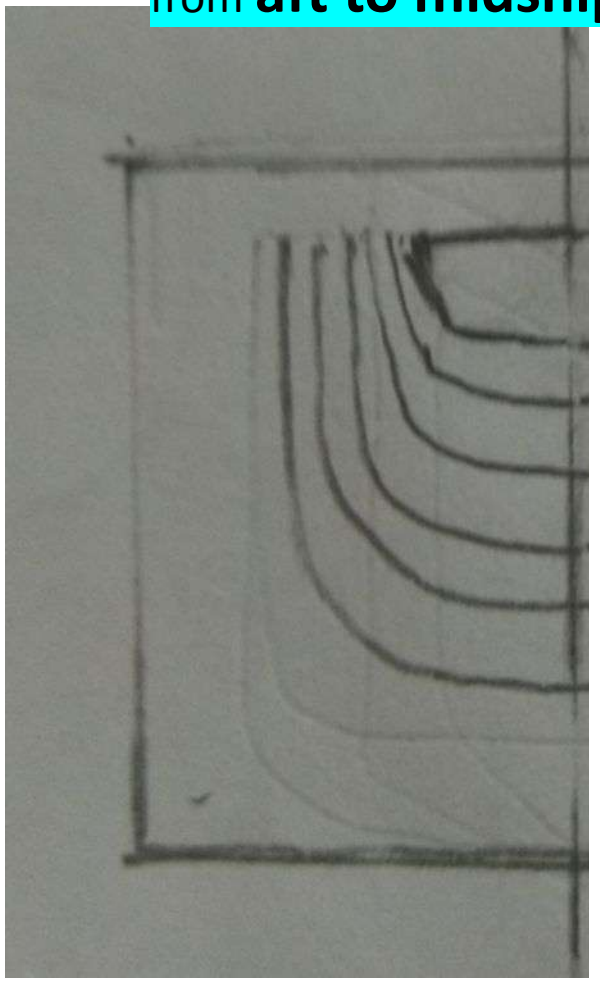


Orthographic projection of all sections from **midships to Fwd**

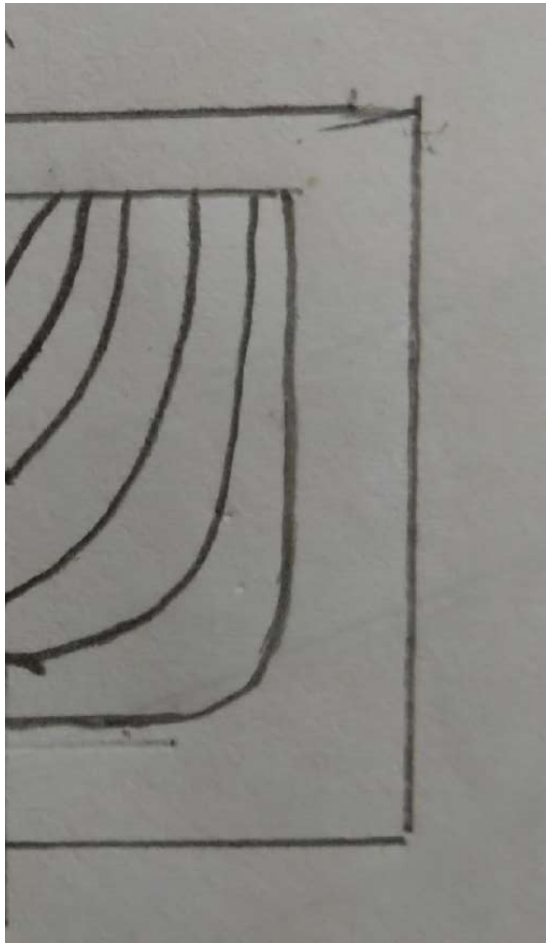


Body Plan - Aft to Fwd

Orthographic projection of all **HALF** sections from **aft to midships**

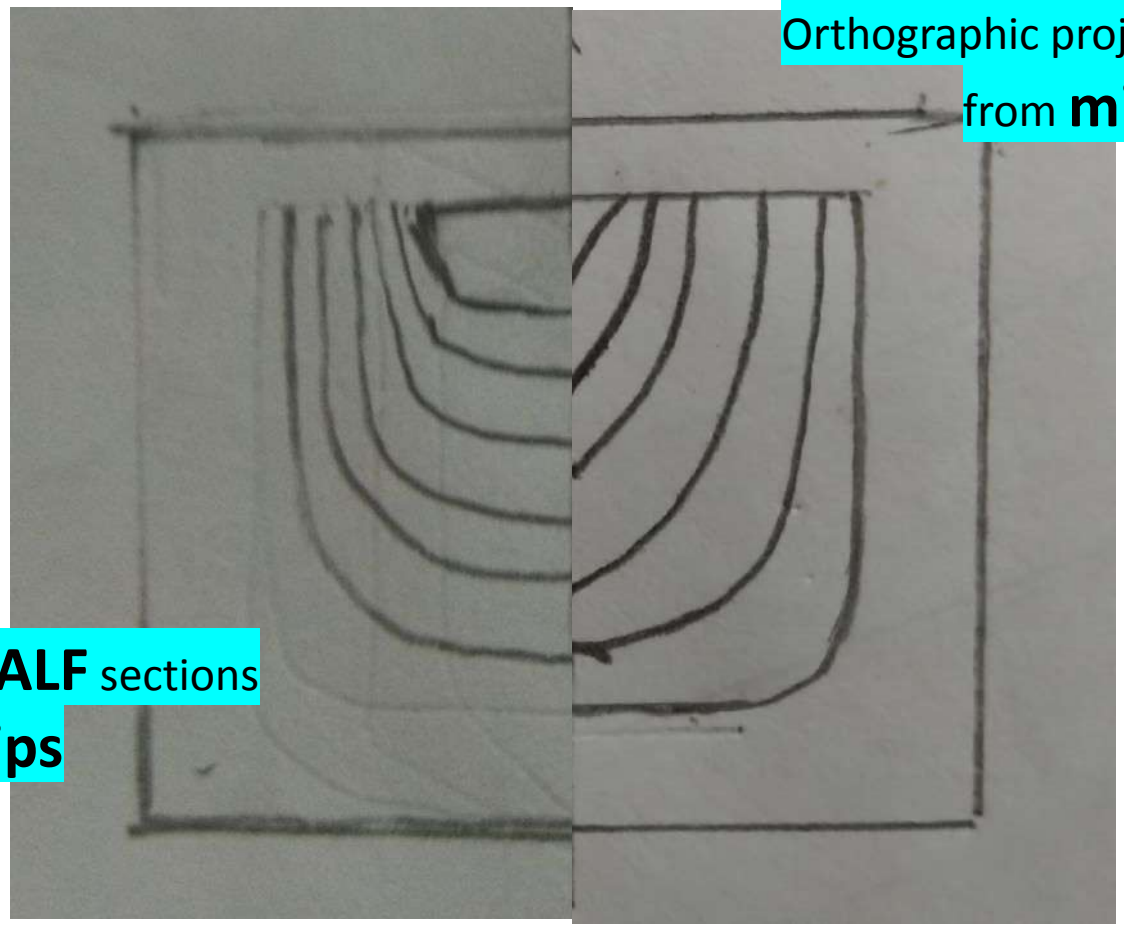


Orthographic projection of all **HALF** sections from **midships to fwd**



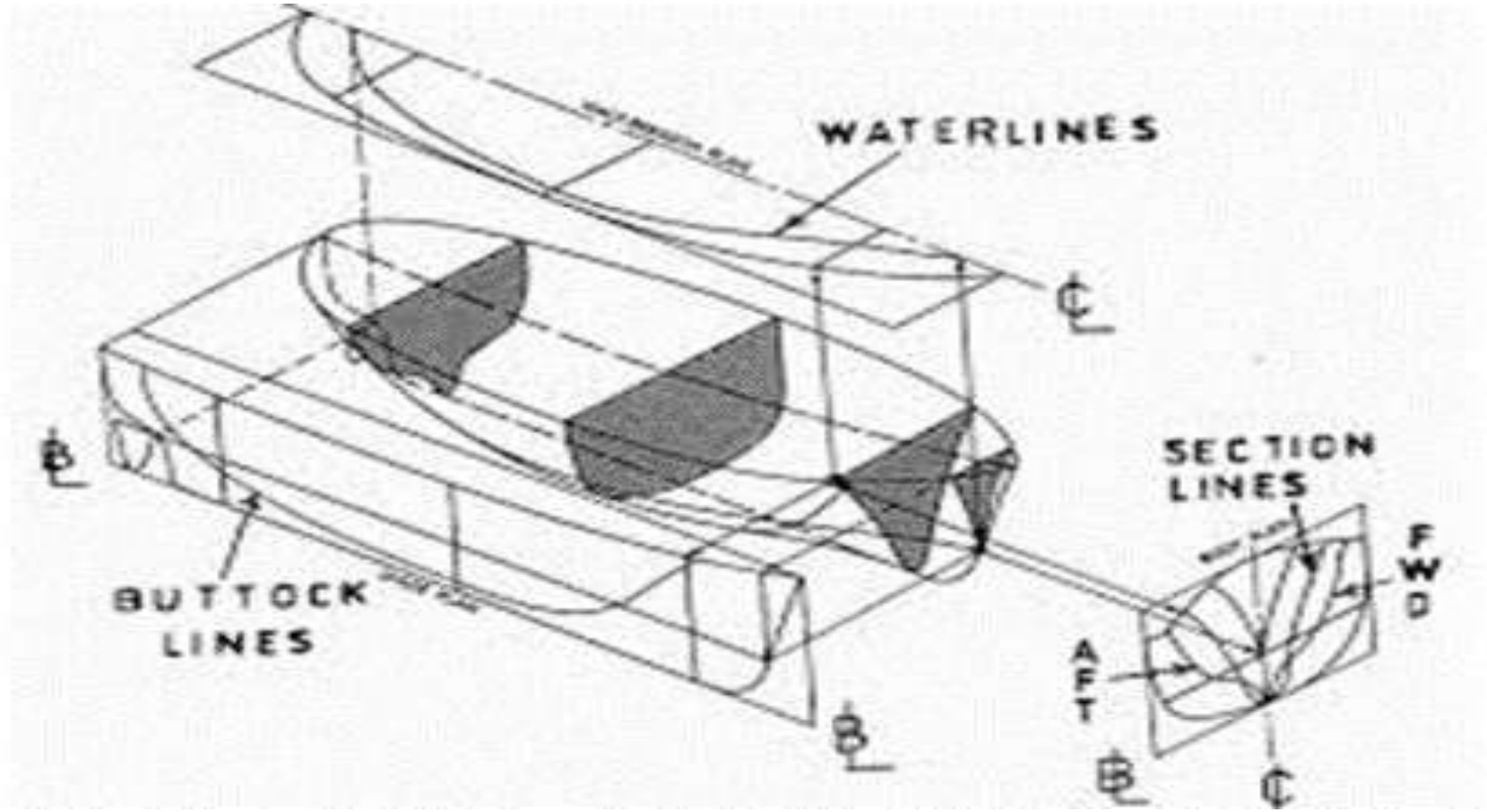
Body Plan - Aft to Fwd

Orthographic projection of all **HALF** sections from **midships to fwd**

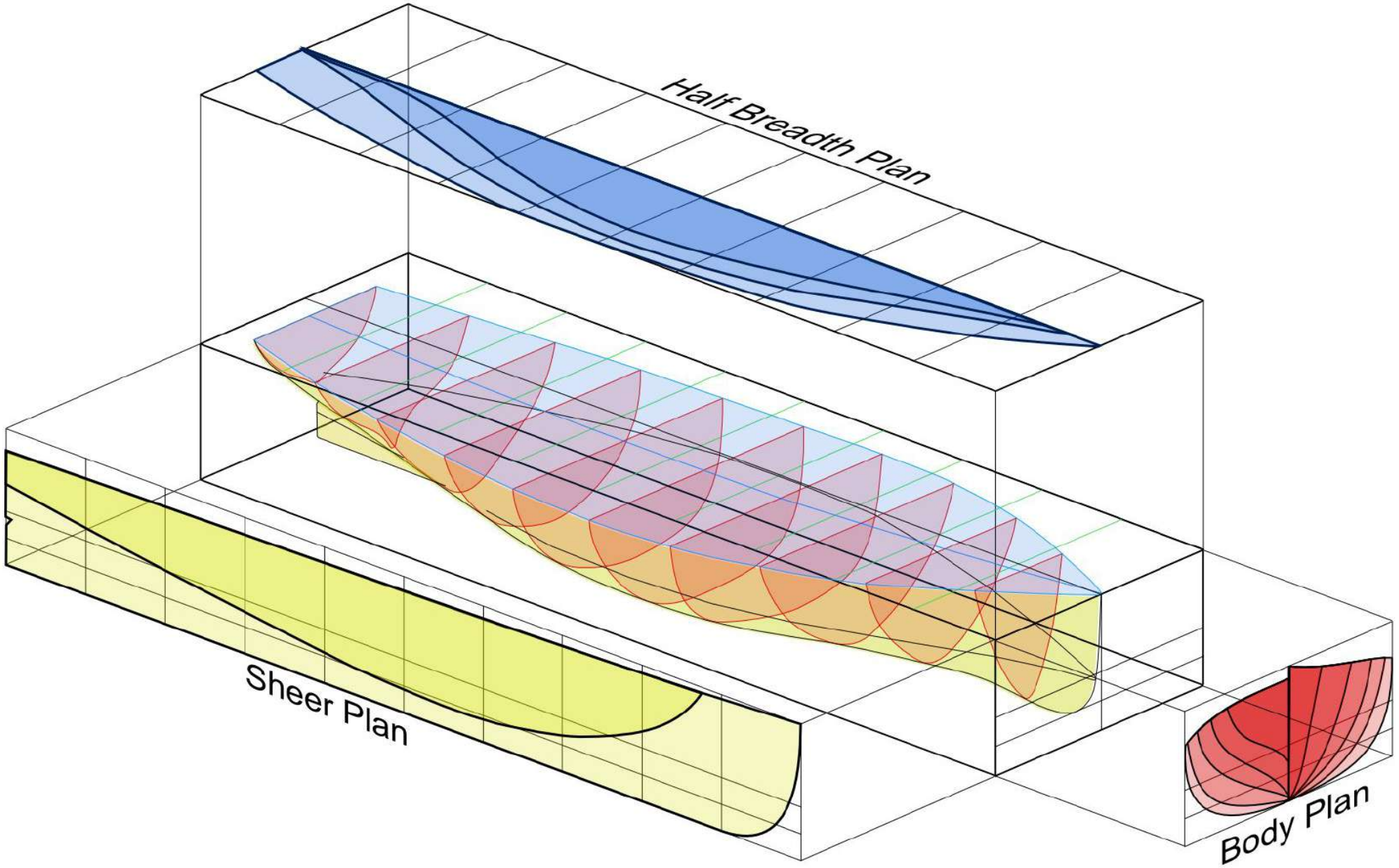


Orthographic projection of all **HALF** sections from **aft to midships**

Lines Plan

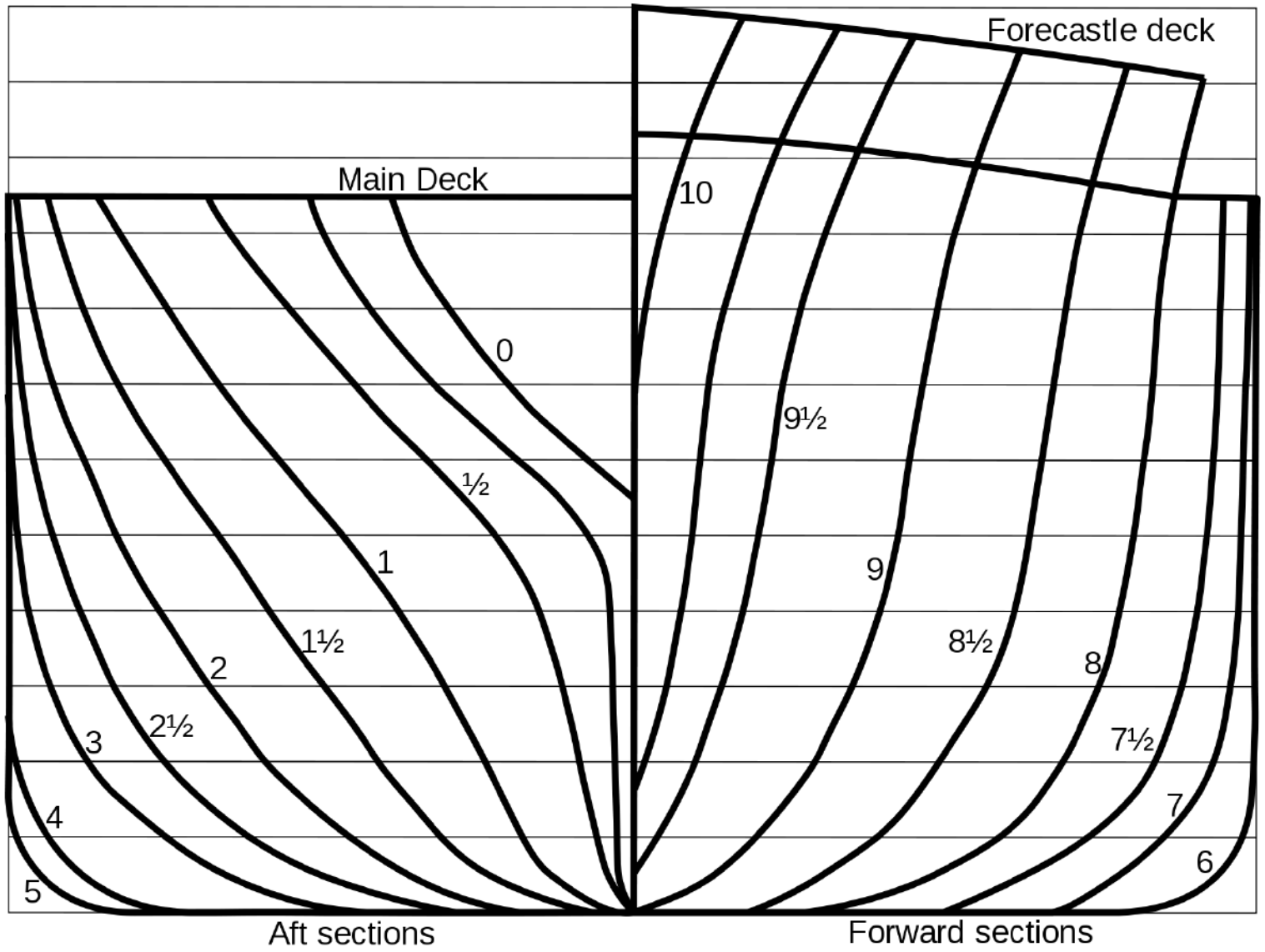


Lines Plan Orthographic Projection in Isometric View

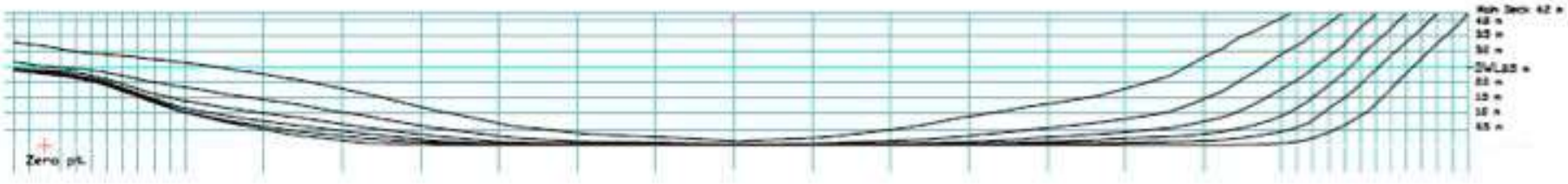


Body Plan

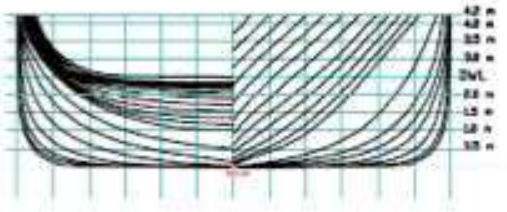
- Stations numbers starting from Aft
- Normally 10 or 20 stations
- 0^{th} Station is Aft Perpendicular
- $10/20^{th}$ station is Fwd Perpendicular
- Half stations erected in regions where substantial change in shape per unit length.. Generally in bow and stern region



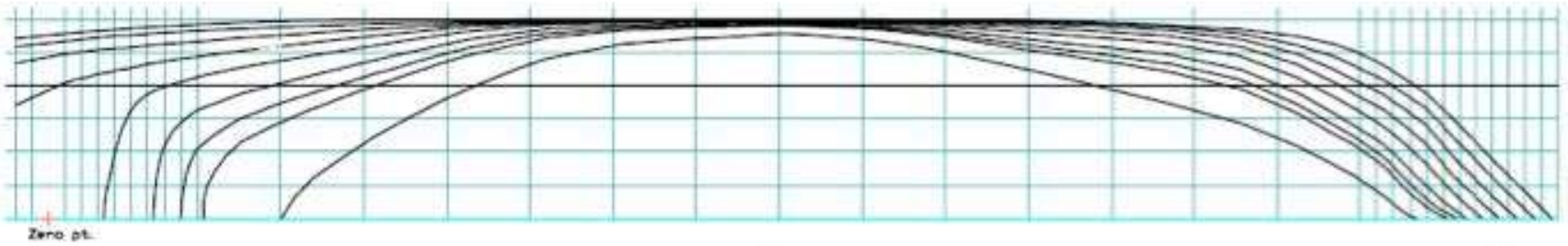
LINES PLAN



SHEER PLAN / PROFILE

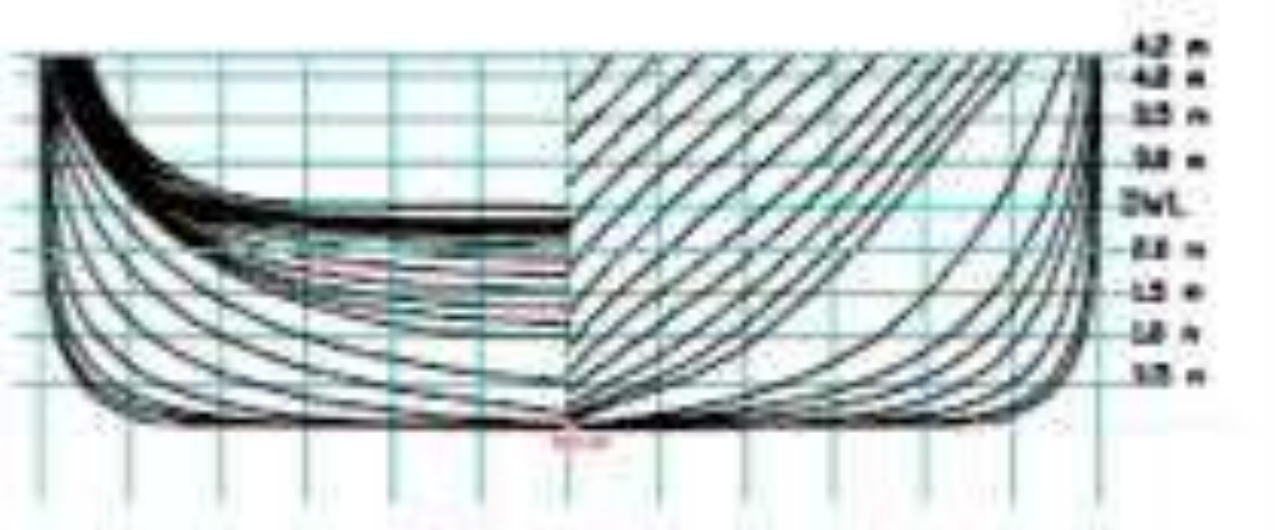


BODY PLAN



HALF BREADTH PLAN

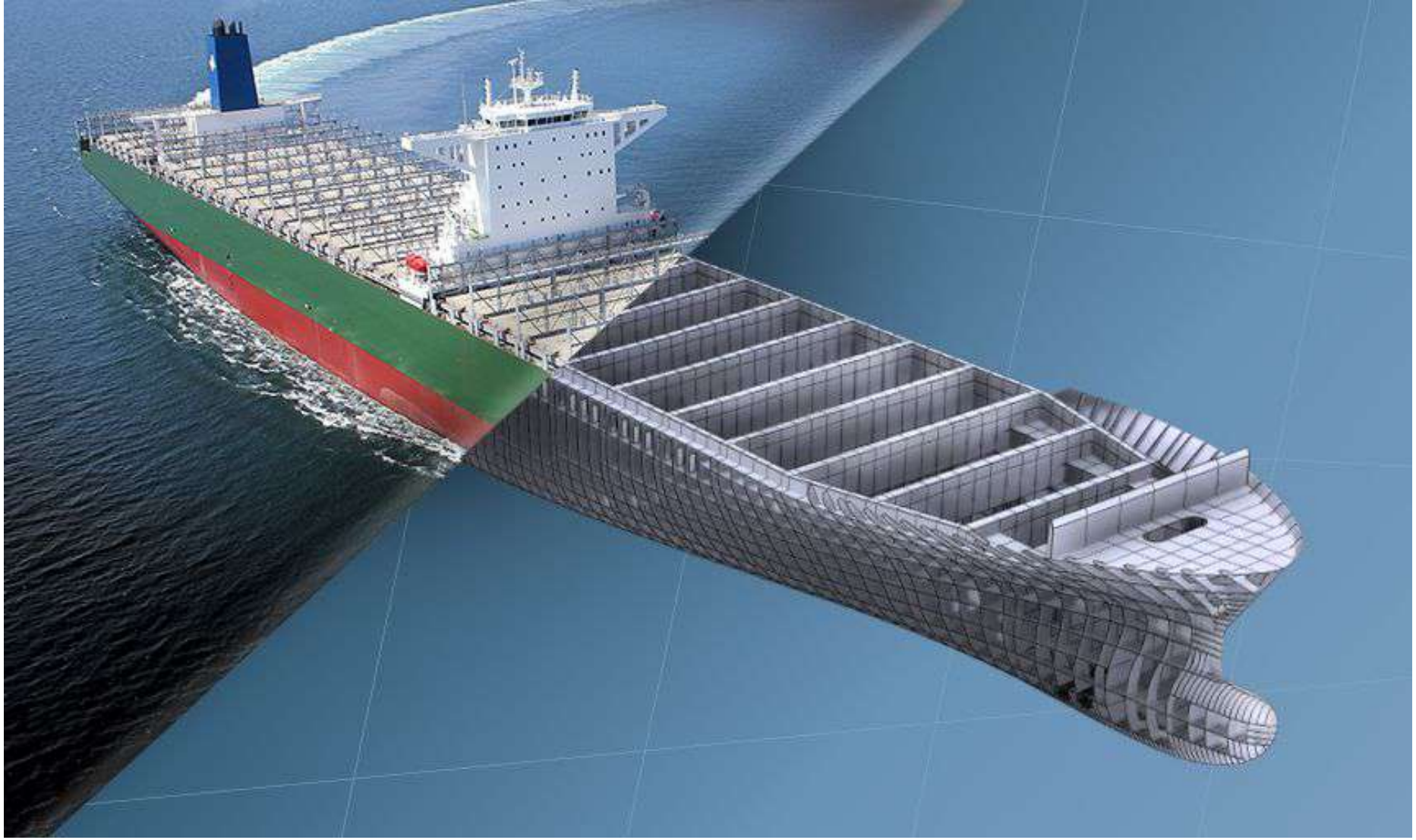
BODY PLAN



END

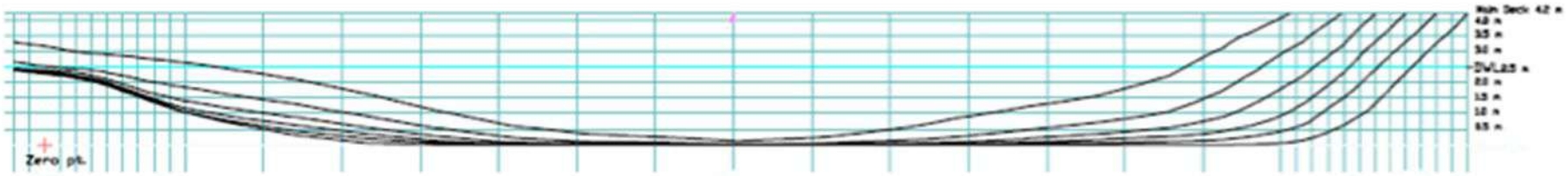
- In case of any doubts you may contact me at

- Mobile : 9969293383
- Email : deepaksebastian.dost@gmail.com

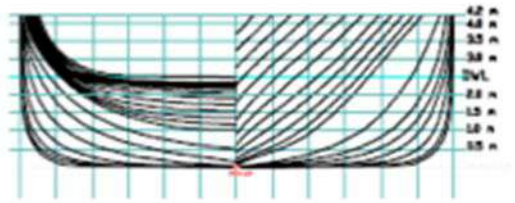


Introduction to Naval Architecture

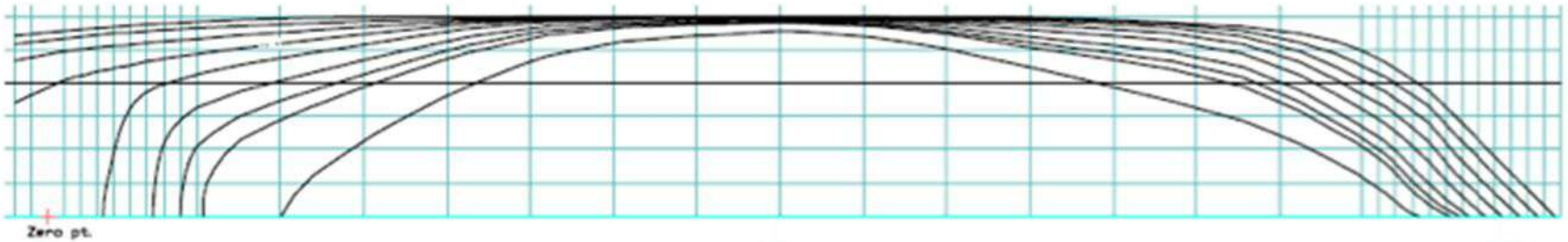
II SEM –Module 3



SHEER PLAN / PROFILE

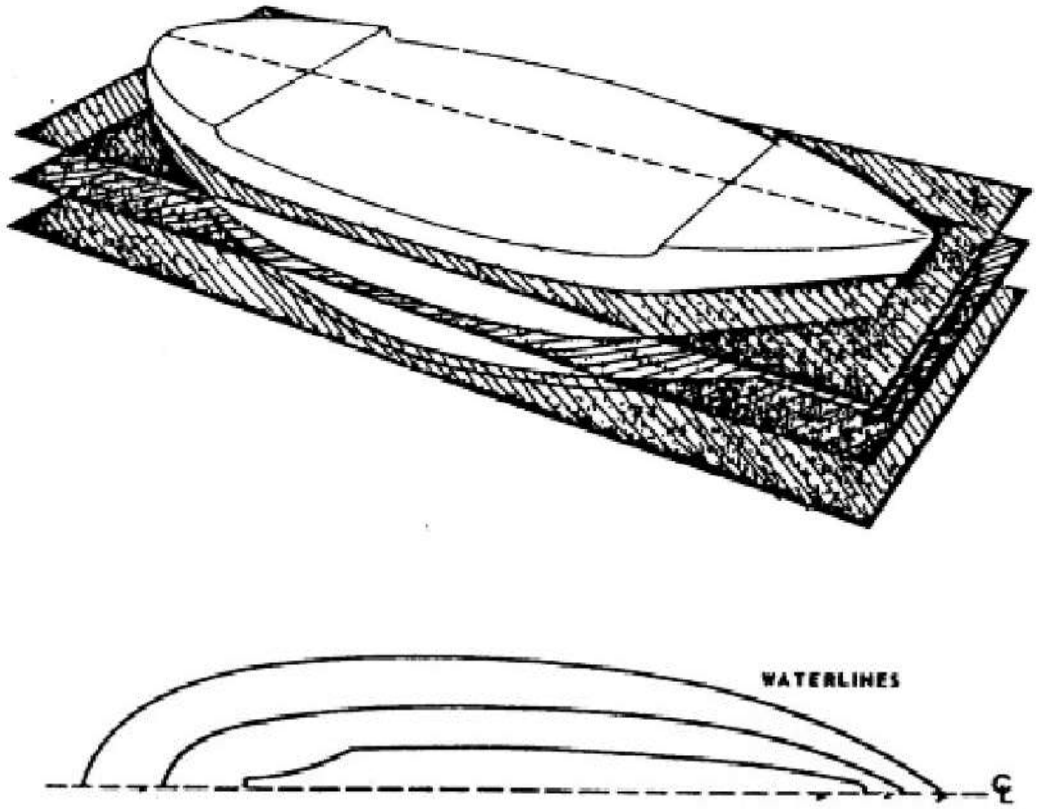


BODY PLAN

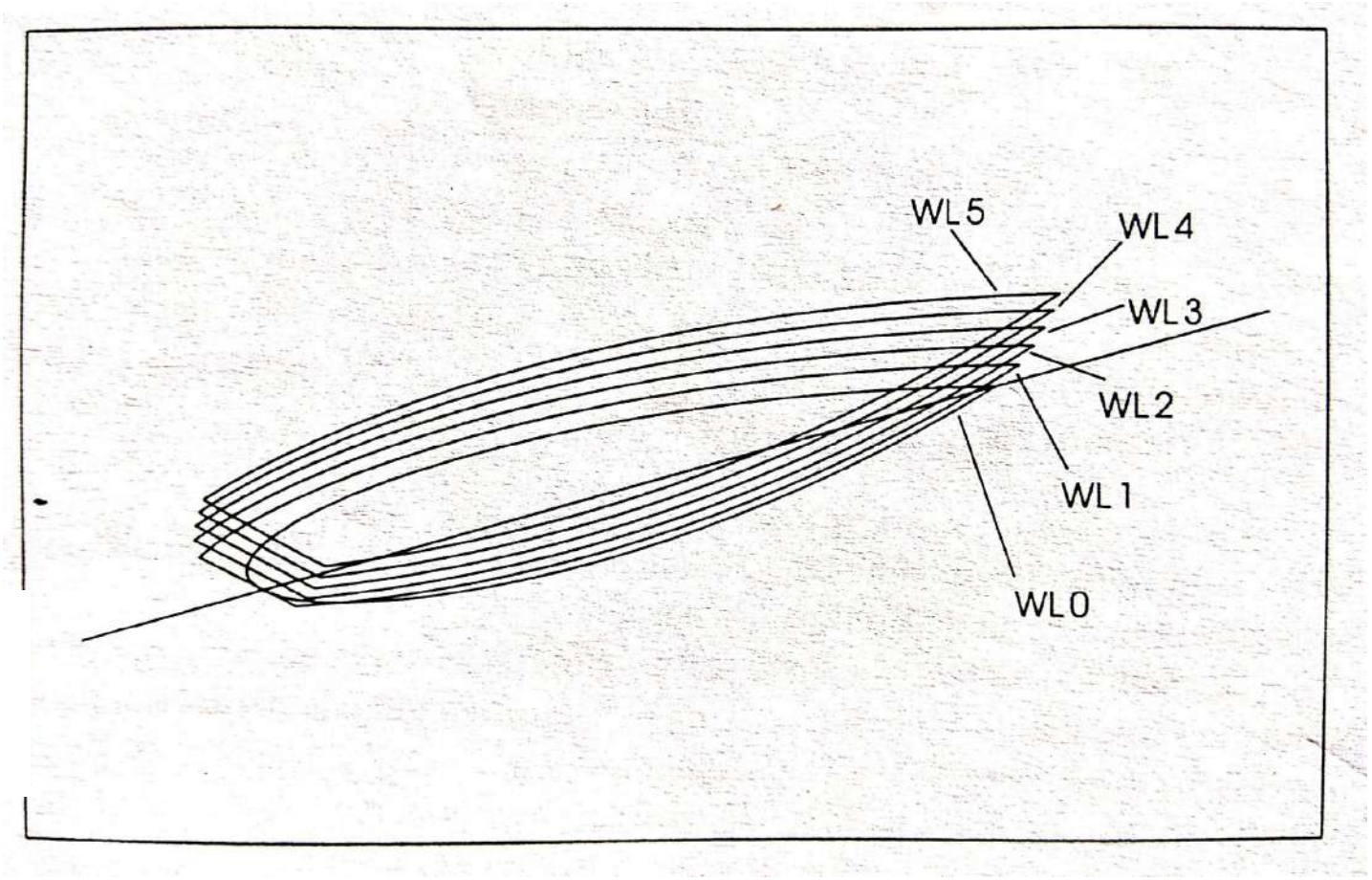


HALF BREADTH PLAN

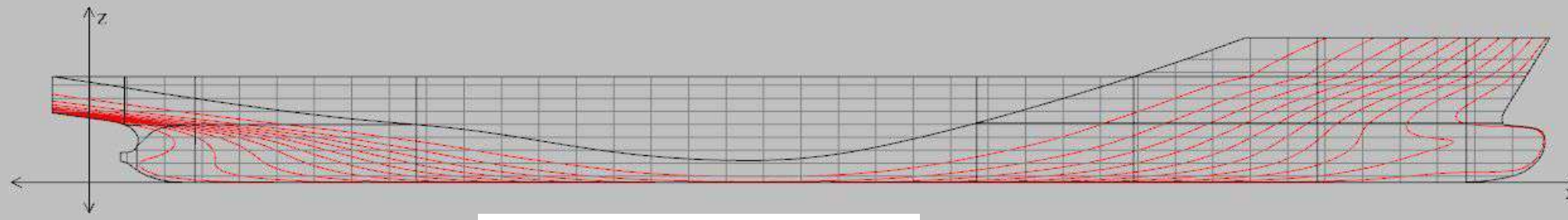
Half Breadth Plan– Intersection of hull with waterplanes



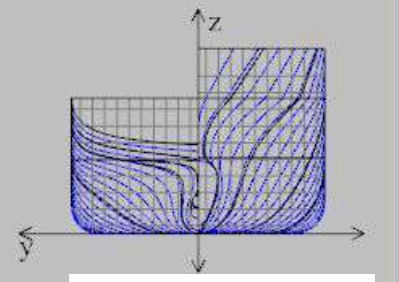
Half Breadth Plan



- Waterplanes Divide the Depth(D) upto Main Deck into 10 or 20 intervals
- Visible only as lines because they are projections
- In the Sheer Plan or Profile Plan- WL are horizontal Lines parallel to the Base Line.
- In the Body Plan – WL are horizontal lines parallel to the Base Line.
- In the Half Breadth Plan- waterlines appear as curves



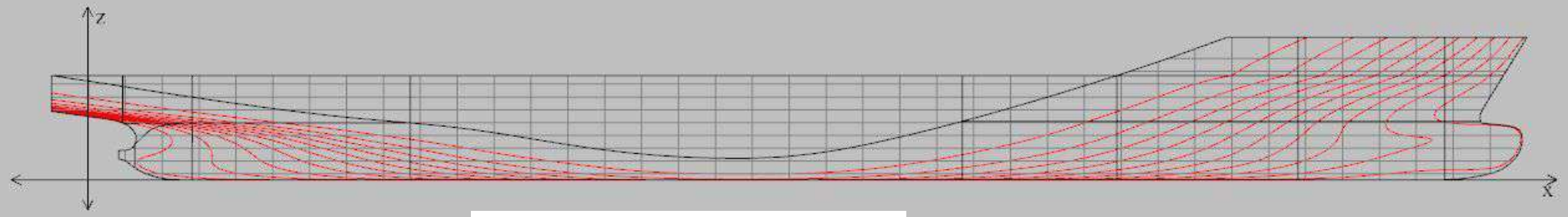
SHEER PLAN / PROFILE



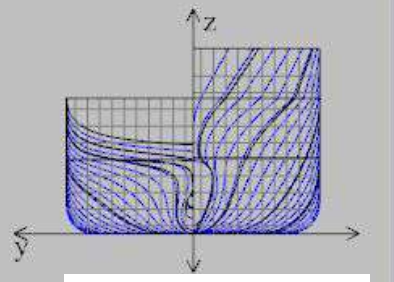
BODY PLAN

HALF BREADTH PLAN

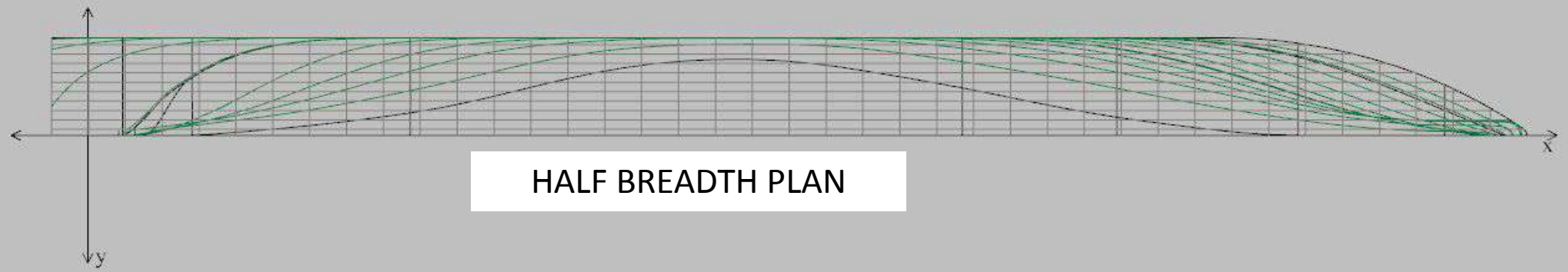
- Waterlines are numbered starting with 0 upward from the Base Line
- 0 waterline is the Base Line(BL)
- Additional Half waterlines may be drawn near the Base Line to define hull form better because it changes rapidly for small vertical distances



SHEER PLAN / PROFILE



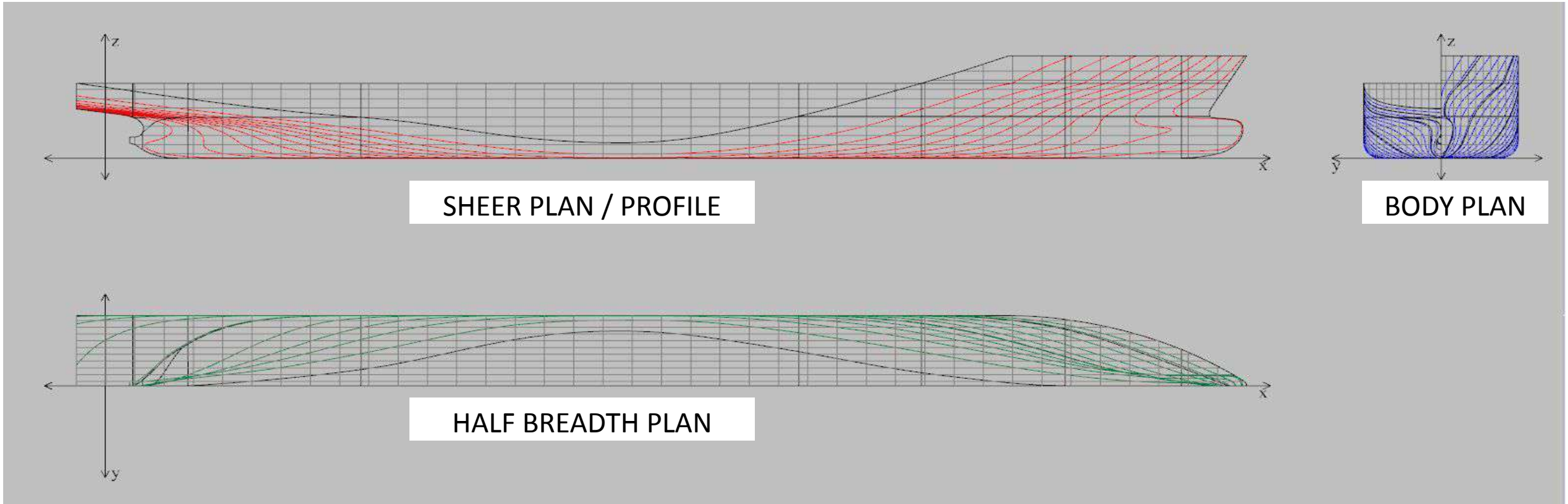
BODY PLAN



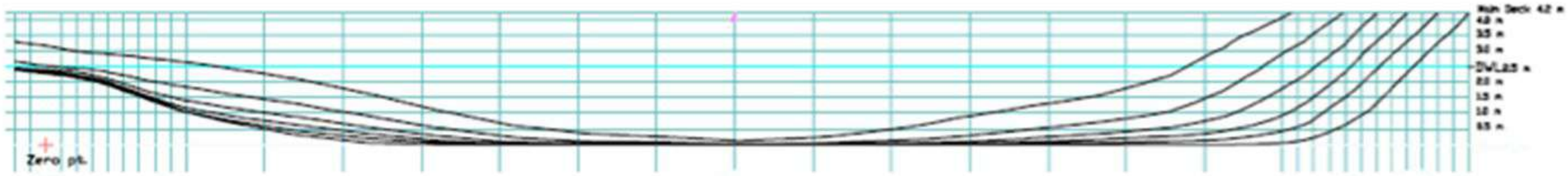
HALF BREADTH PLAN

Half Breadth Plan (Waterlines are curves)

- Symmetrical about centerline plane. Hence only half waterline is drawn. That's why its called a Half breadth Plan
- Half Breadth Plan is drawn below the Profile, aft to the left, fwd to the right.
- Waterlines are drawn on the port side of the ship, i.e above the centre line in the drawing

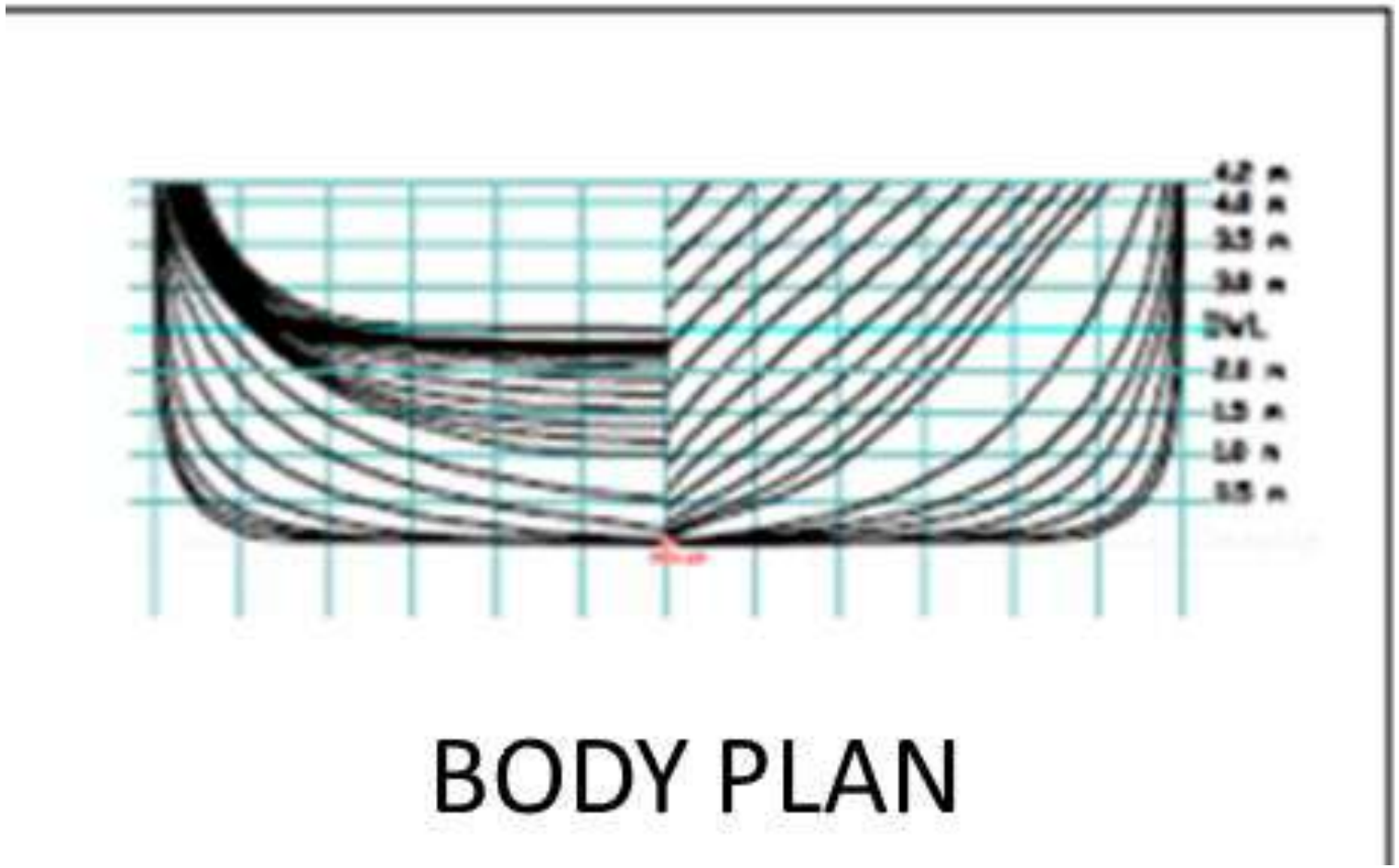


Which are the Water Lines?

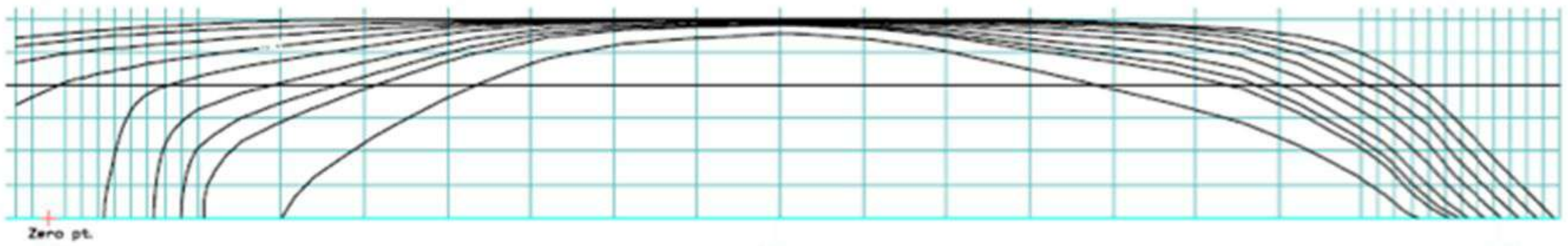


SHEER PLAN / PROFILE

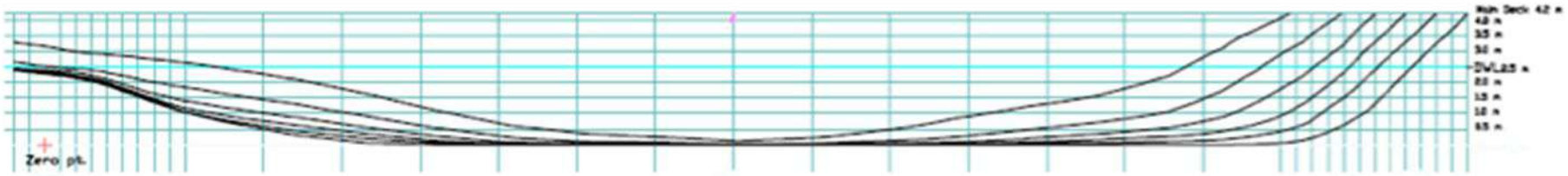
Which are the Water Lines?



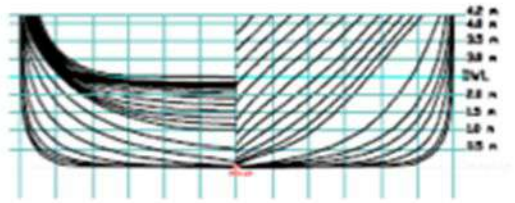
Which are the Water Lines?



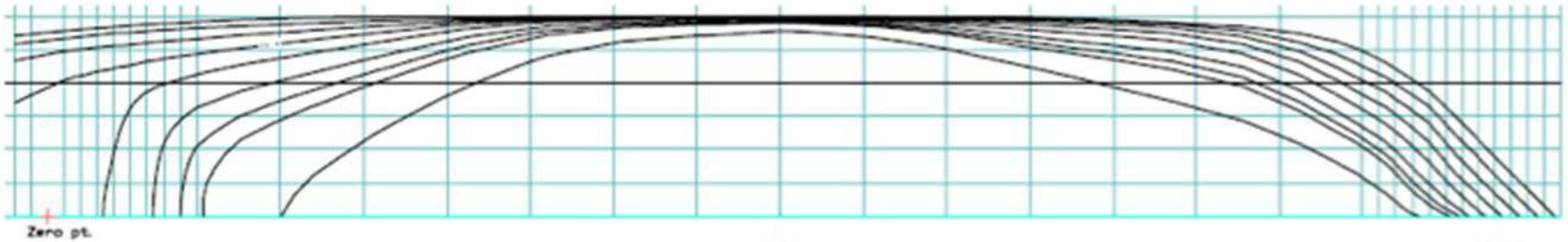
HALF BREADTH PLAN



SHEER PLAN / PROFILE

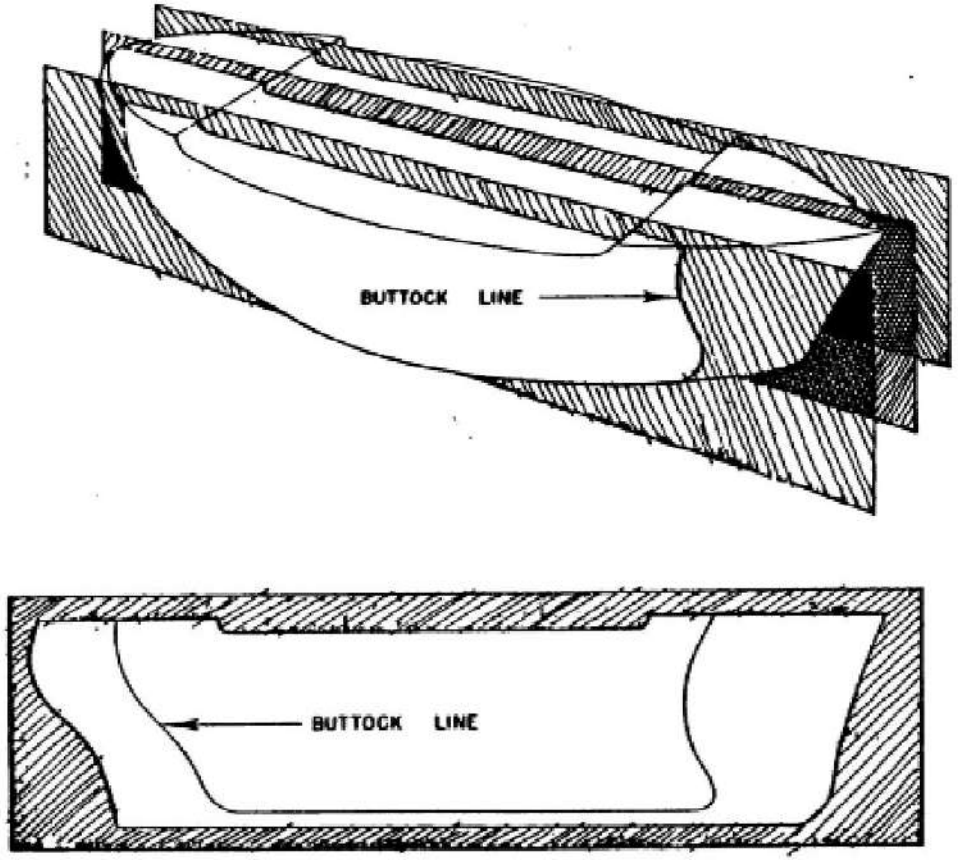


BODY PLAN

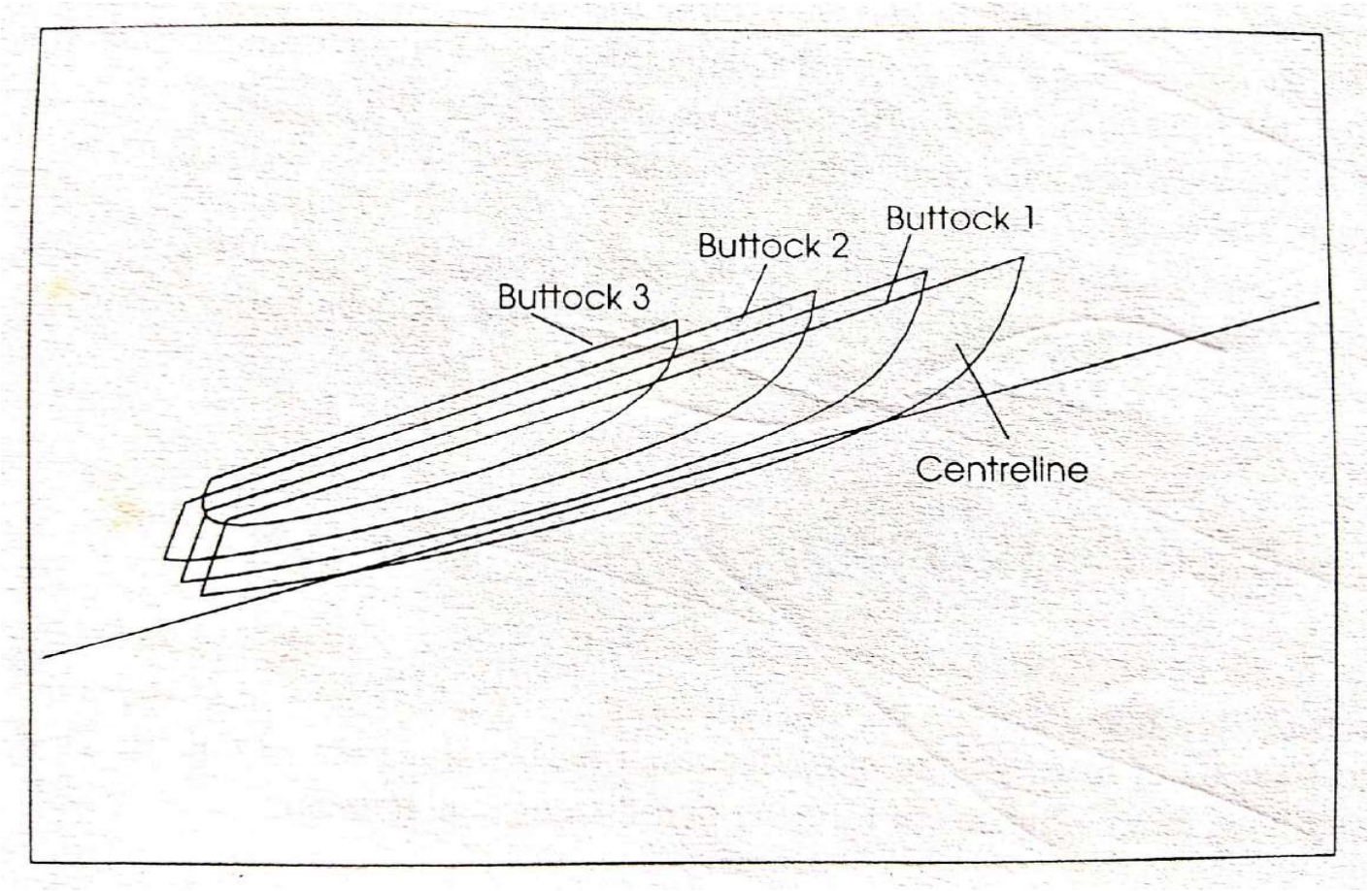


HALF BREADTH PLAN

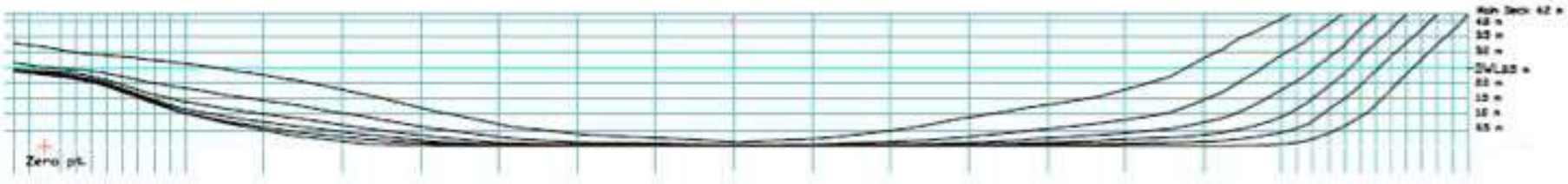
Sheer Plan / Profile– Intersection of hull with planes parallel to the CL Plane



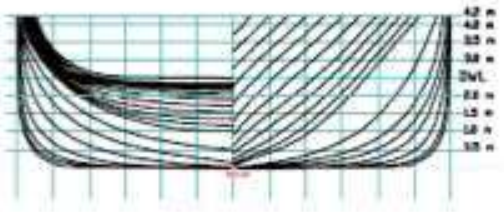
Sheer Plan / Profile



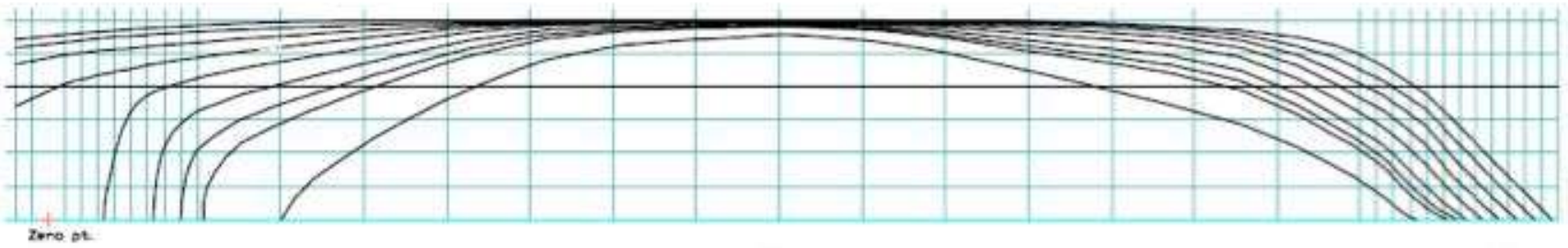
- Divide the Breadth(B) into 6-10 equal intervals by longitudinal planes called Buttock Planes, i.e. 3-5 buttocks on either side of the CL.
- In Body Plan –Buttock Lines (or Buttocks) are Vertical Lines parallel to the Centre Line.
- In Half Breadth Plan- Buttock Lines (or Buttocks) are Horizontal Lines parallel to the Centre Line.
- In Sheer Plan or Profile Plan- - Appear as curves



SHEER PLAN / PROFILE

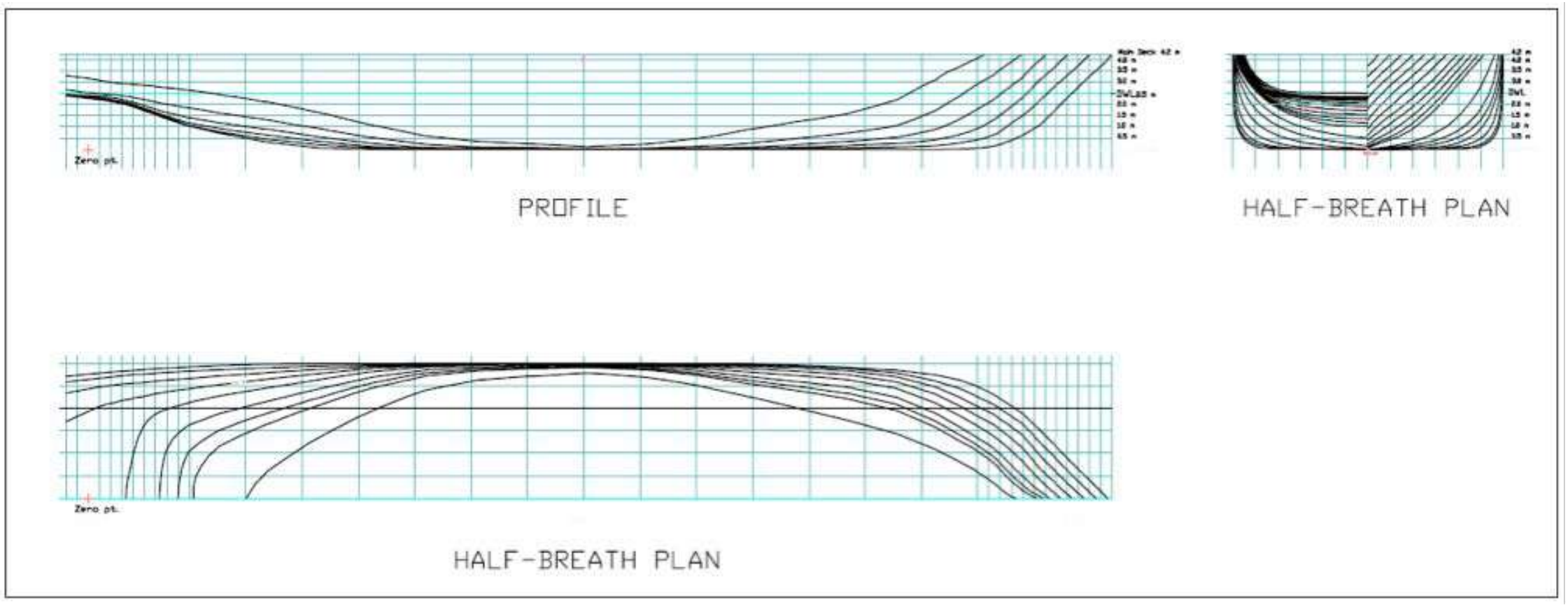


BODY PLAN



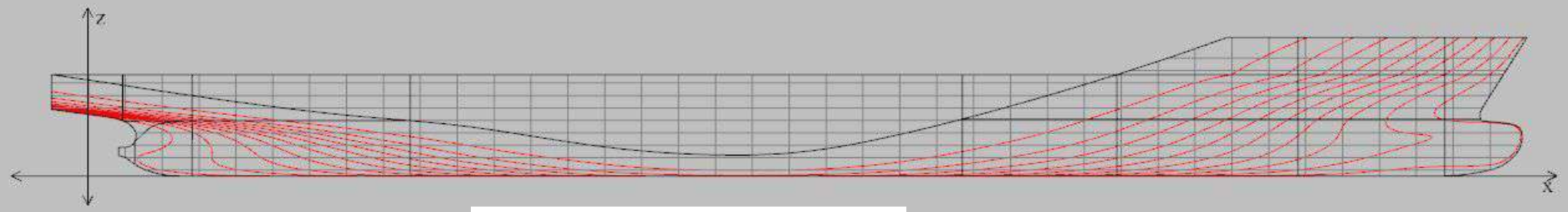
HALF BREADTH PLAN

- 0 Buttock is the Centre Line(CL) plane in the Body Plan and Half Breadth Plan
- Buttocks or Buttock lines are numbered from 1 on either side of the Centre Line.
- In the Sheer Plan, 0 Btk gives the profile view of the ship at the CL.

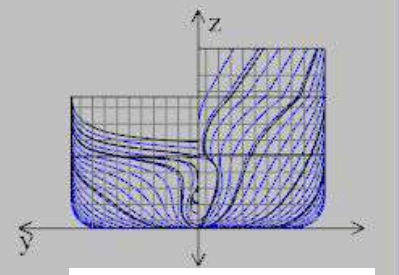


Sheer Plan/Profile (Buttocklines are curves)

- Symmetrical about centerline plane.
- Sheer Plan is drawn above the Half Breadth Plan, and to the left of the Body Plan. Ships aft is to the left, and fwd to the right.



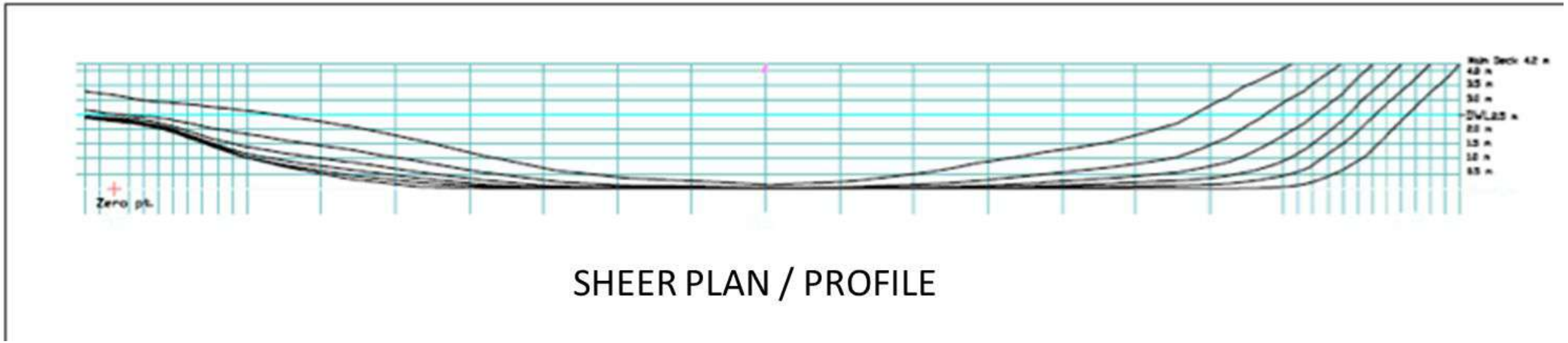
SHEER PLAN / PROFILE



BODY PLAN

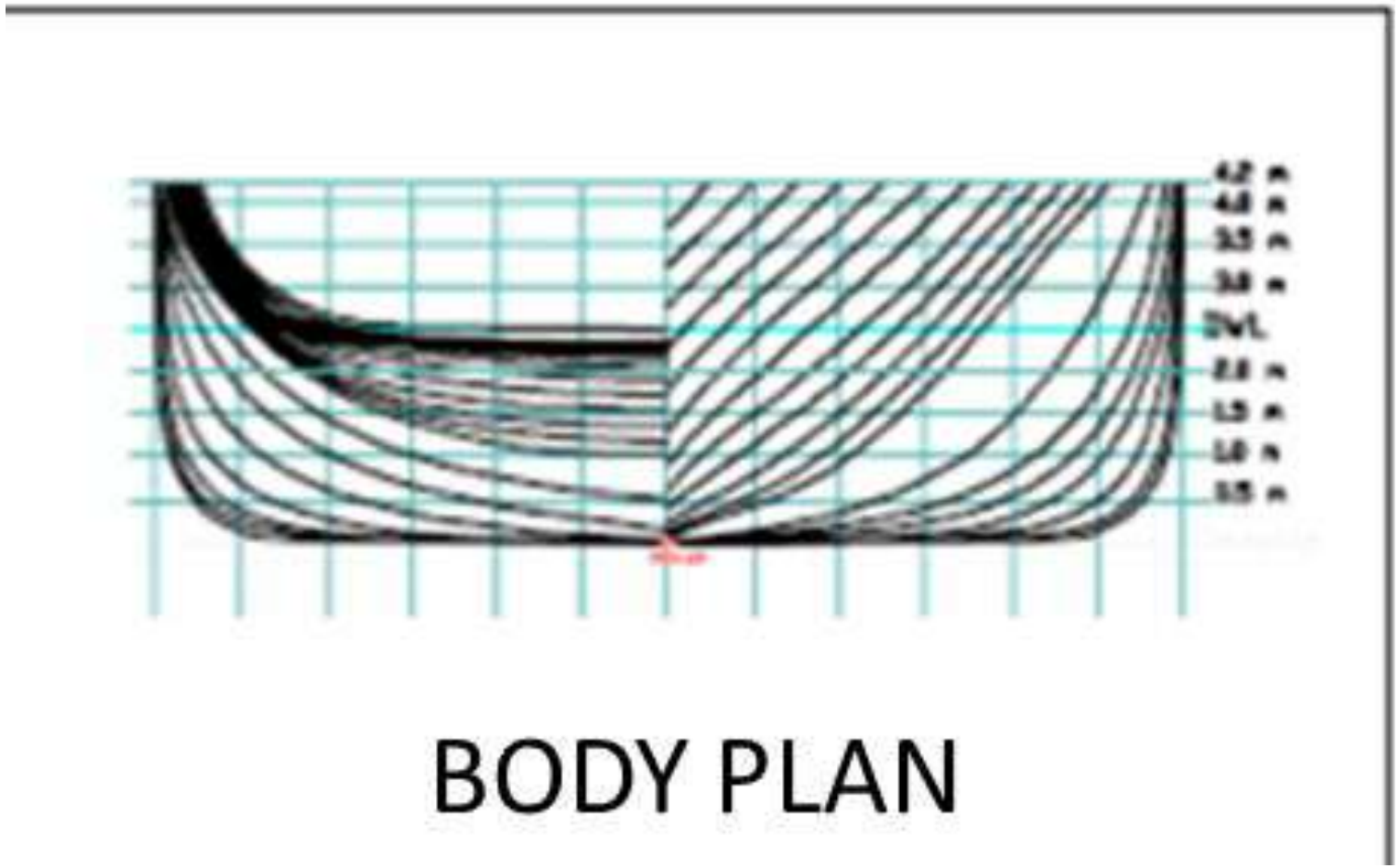
HALF BREADTH PLAN

Which are the buttock lines?

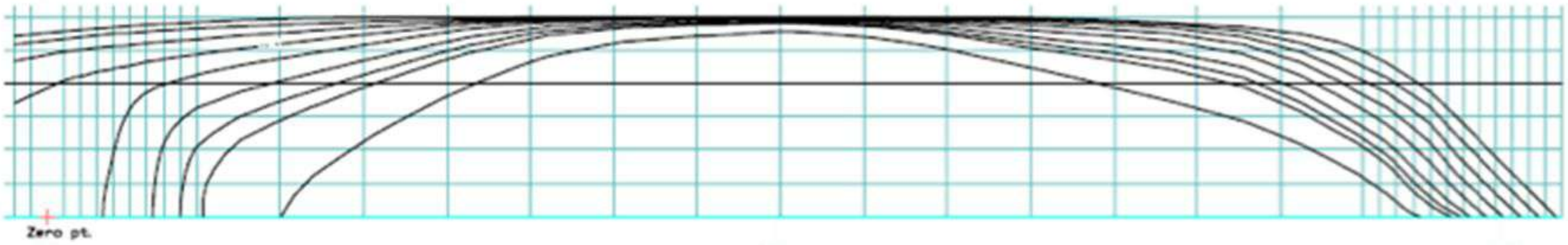


SHEER PLAN / PROFILE

Which are the buttock lines?

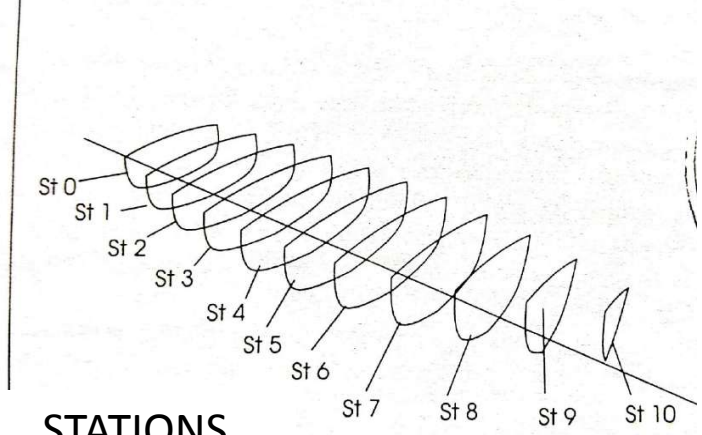


Which are the buttock lines?

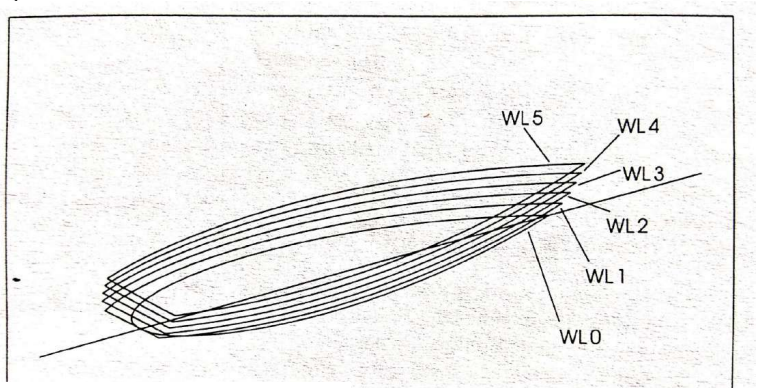


HALF BREADTH PLAN

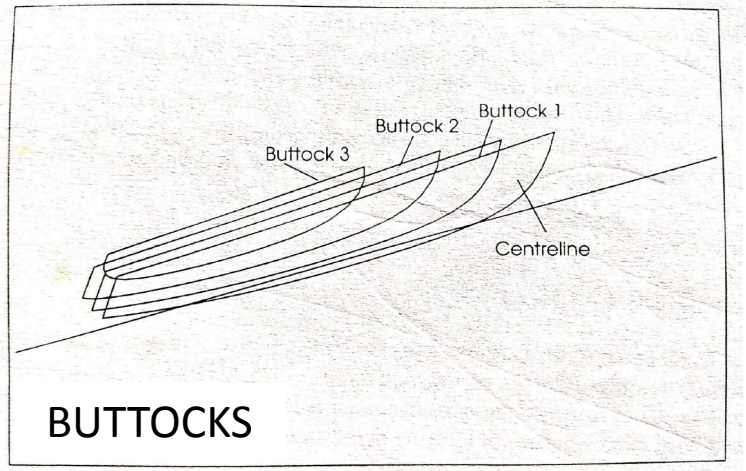
Stations, WaterLines, Buttocks,



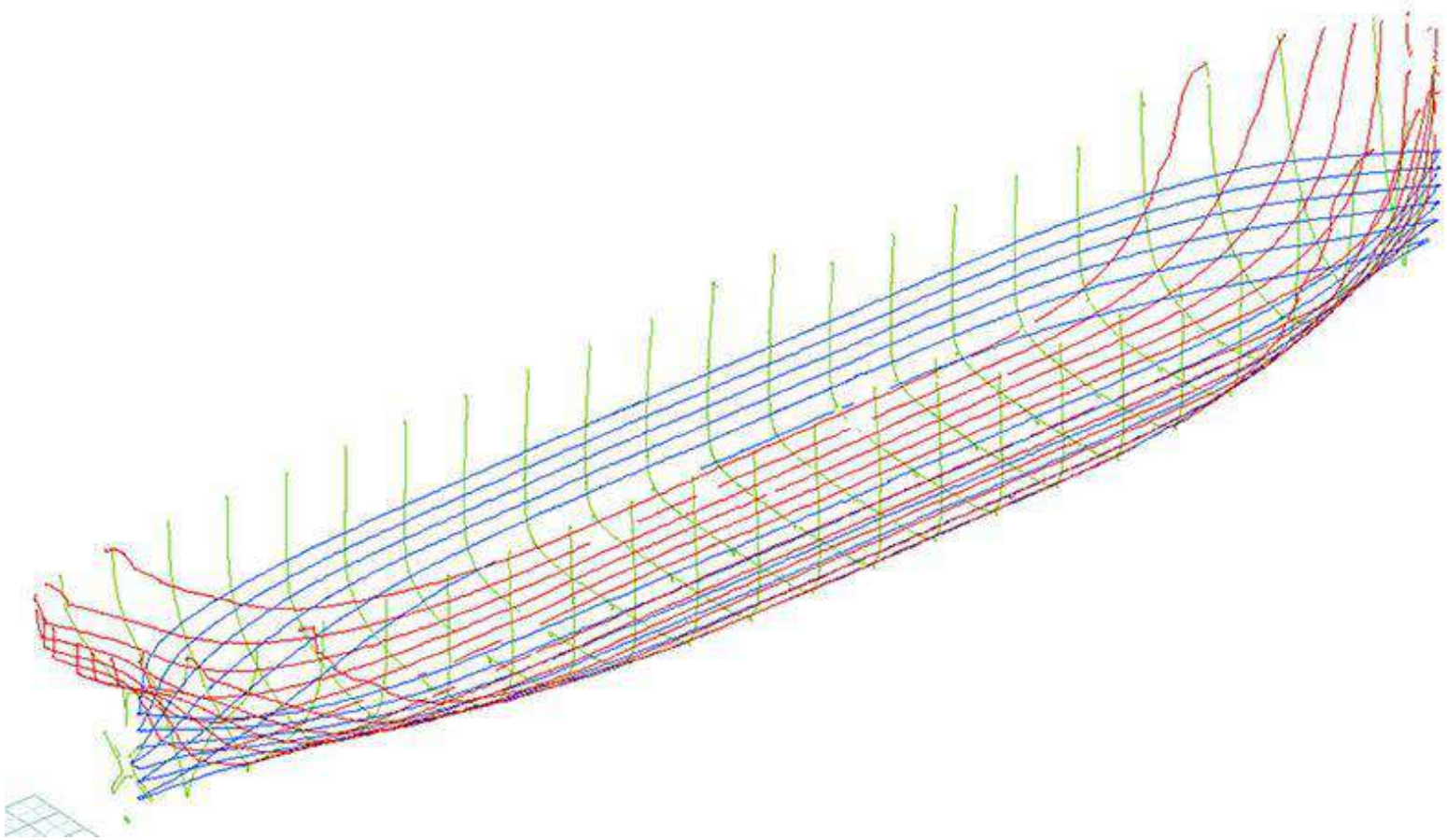
STATIONS



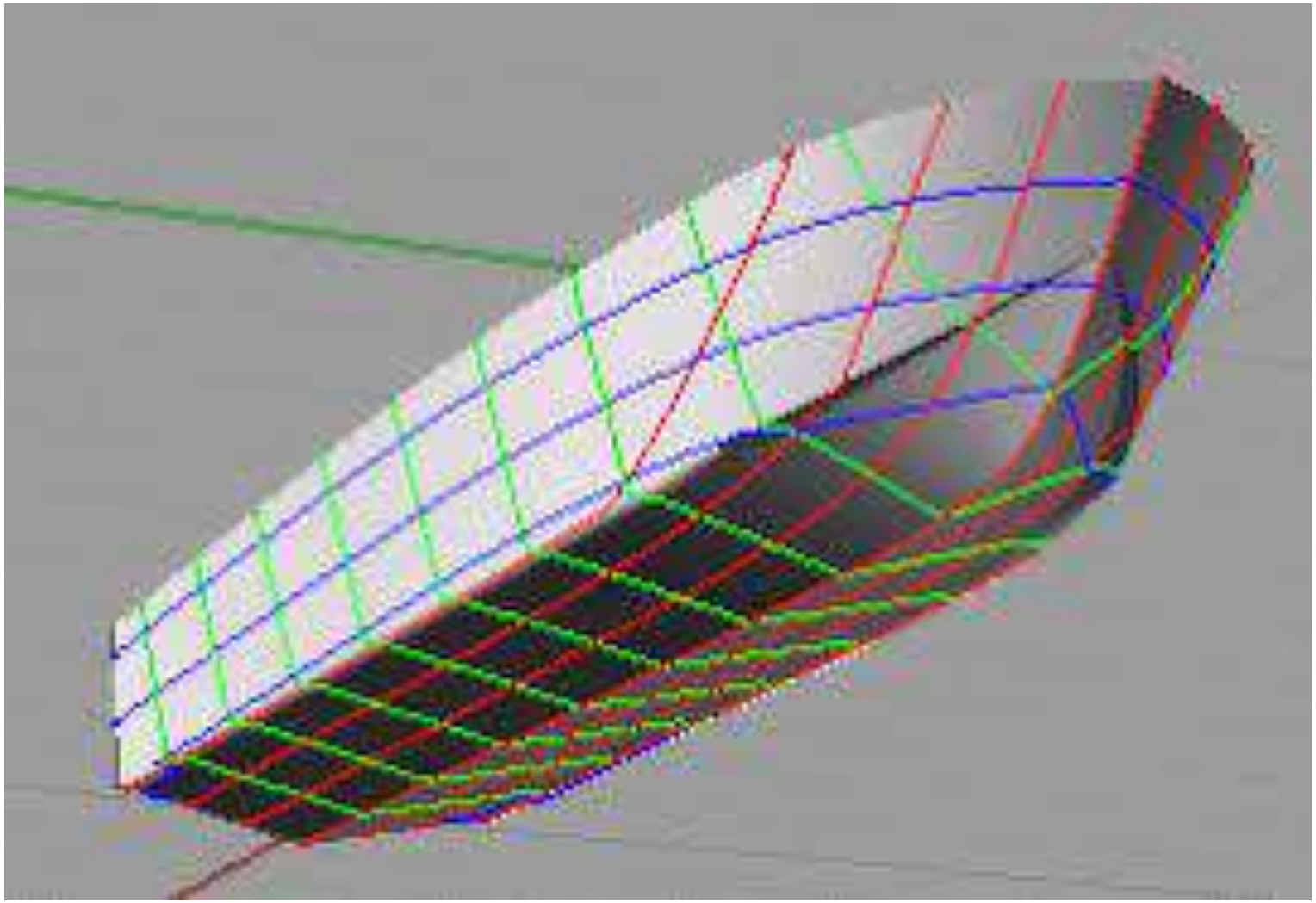
WATERLINES

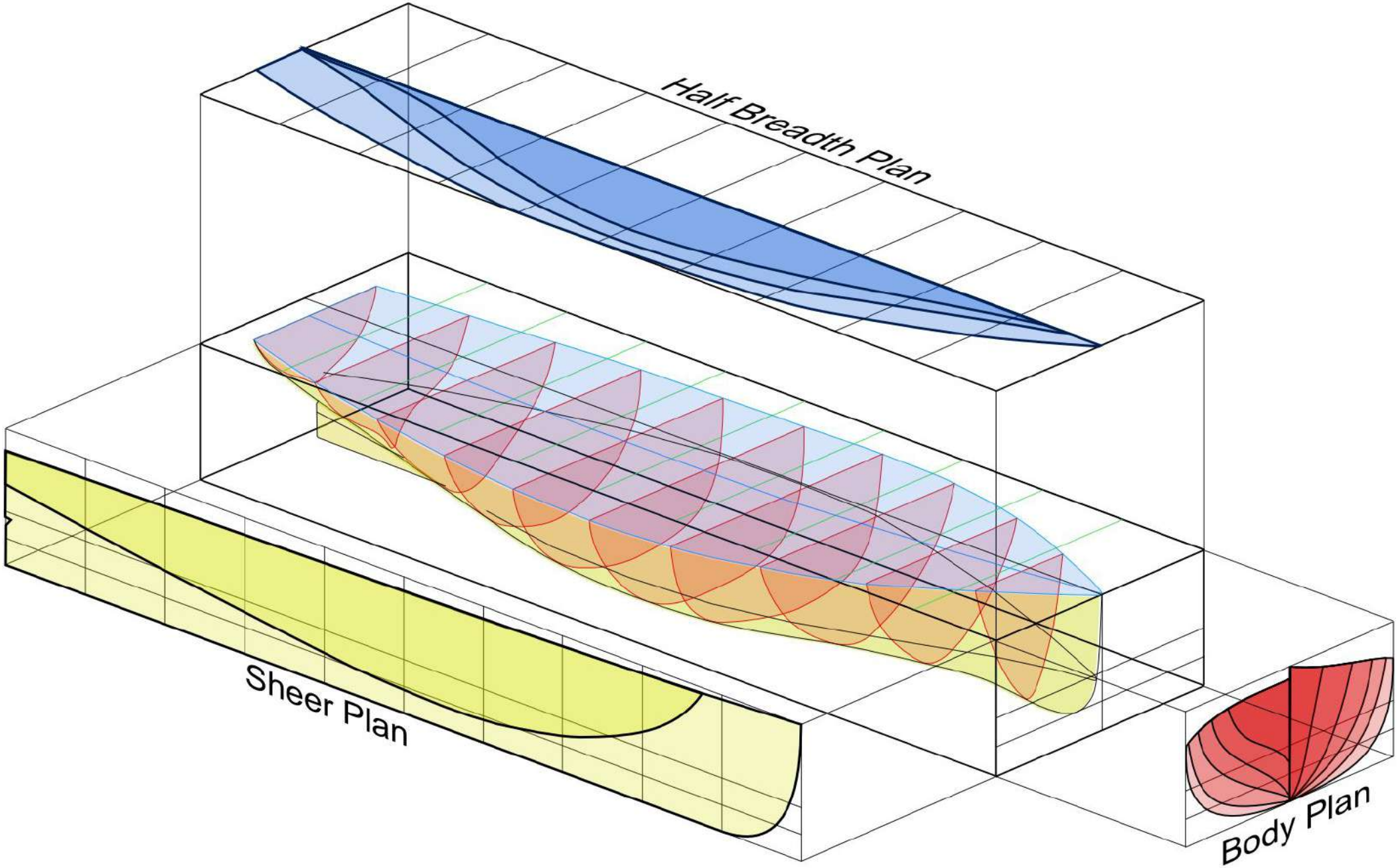


BUTTOCKS



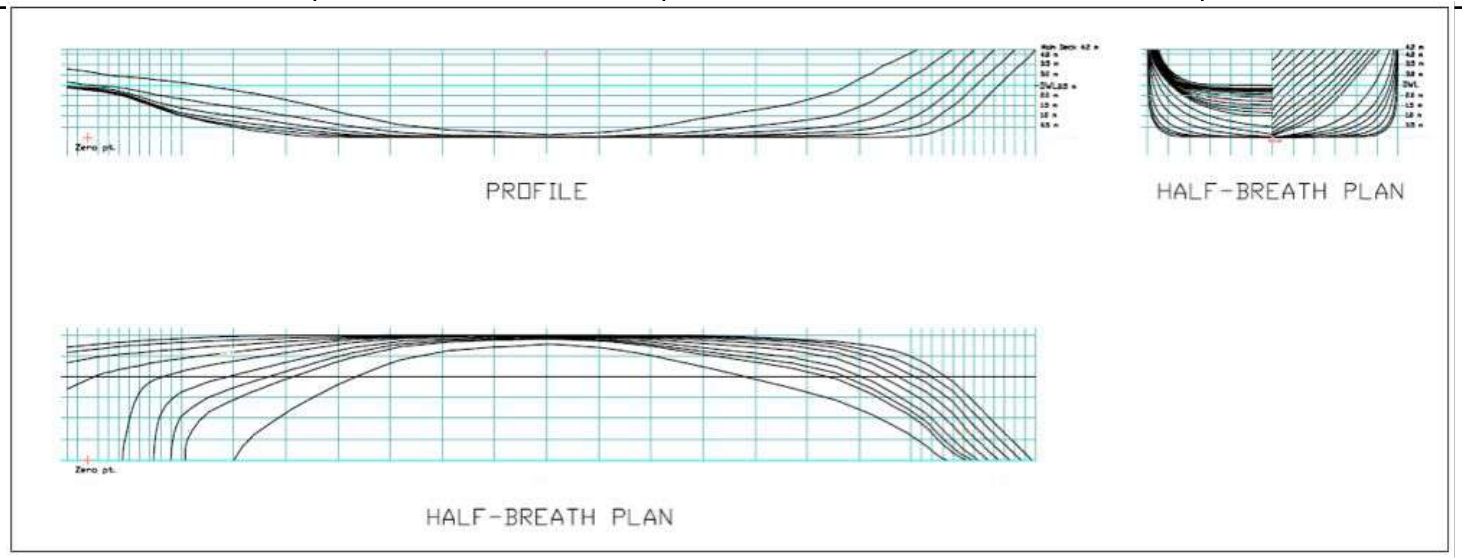
Stations, WaterLines, Buttocks




Half Breadth Plan
Sheer Plan
Body Plan

Summary of features

	Sheer Plan	**Half Breadth Plan**	**Body Plan**
Buttock Lines	Curve	Straight line	Straight line
Waterlines	Straight line	Curve	Straight Line
Stations	Straight line	Straight line	Curve



- Another way of drawing the Lines Plan (Body Plan in centre of Profile)

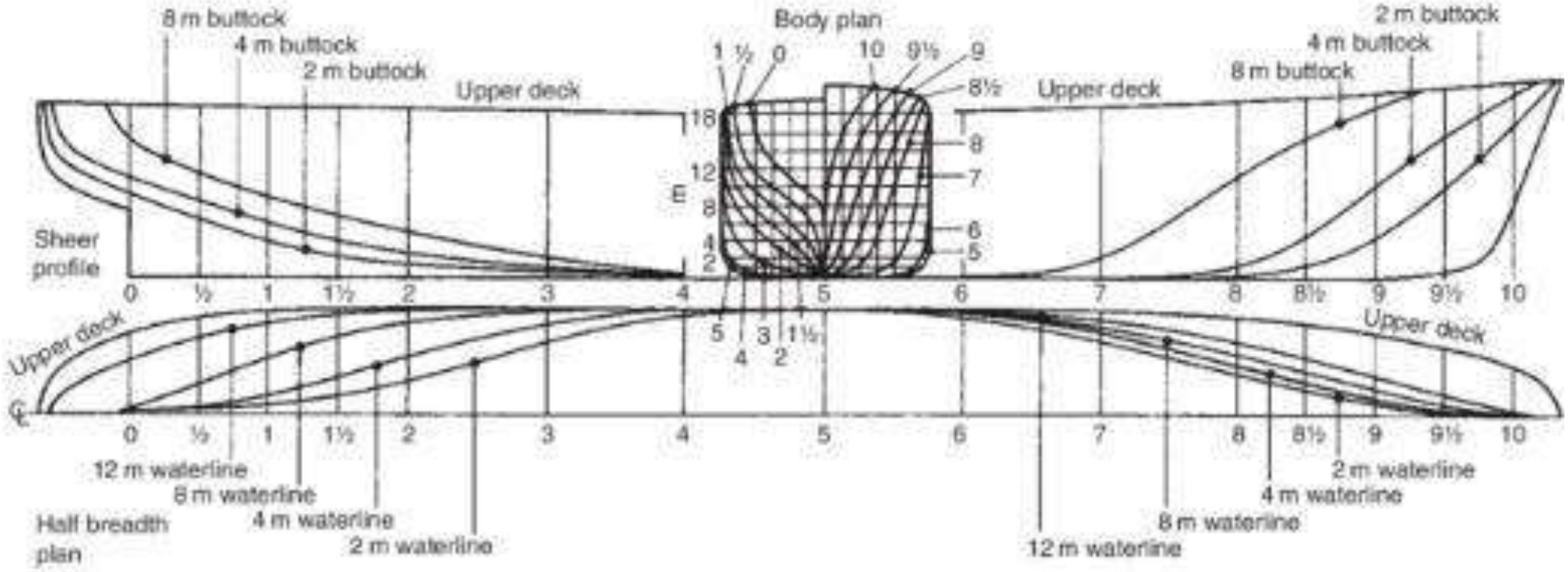
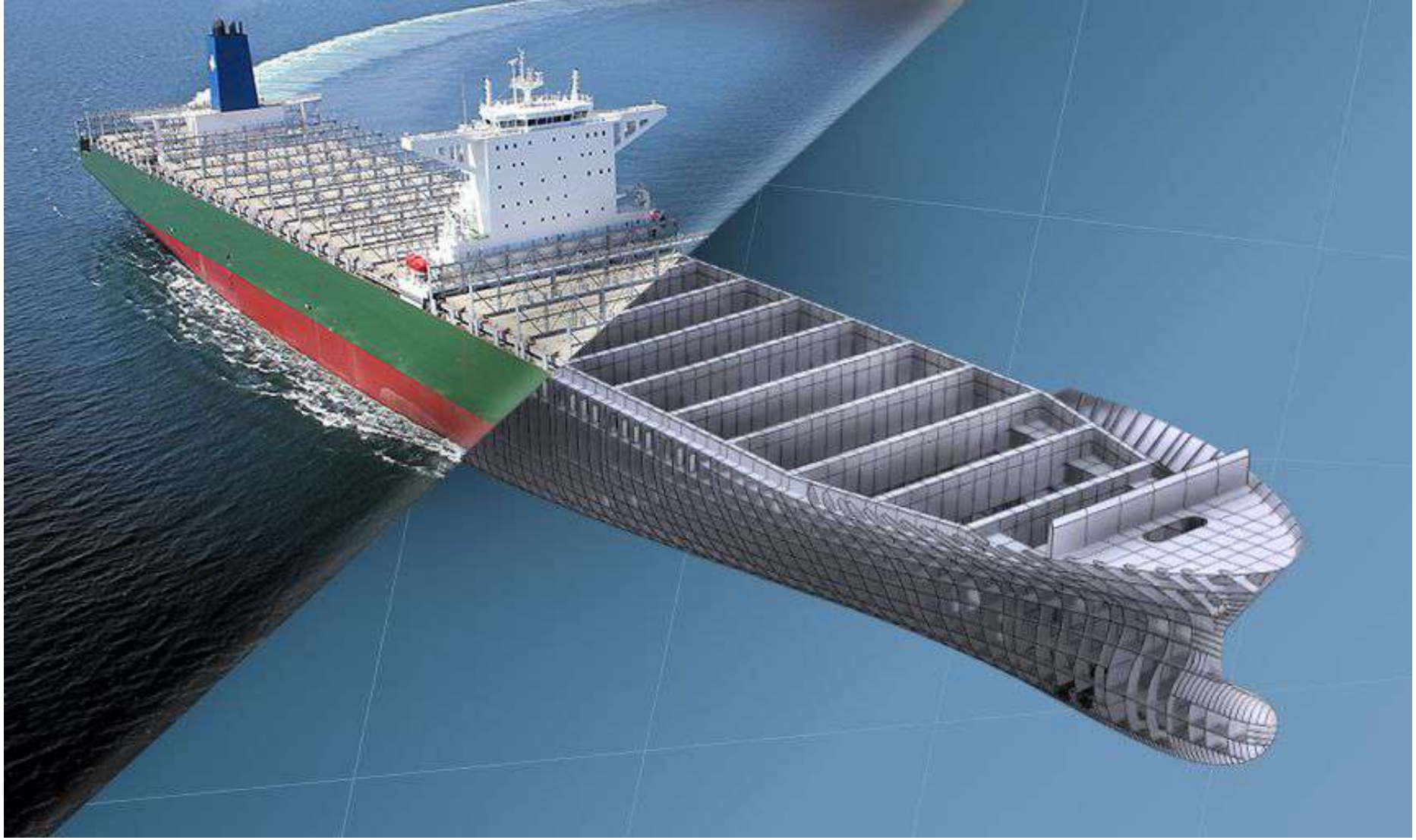


Figure 3.4 Lines plan

END

- In case of any doubts you may contact me at

- Mobile : 9969293383
- Email : deepaksebastian.dost@gmail.com



Introduction to Naval Architecture

II SEM –Module 3

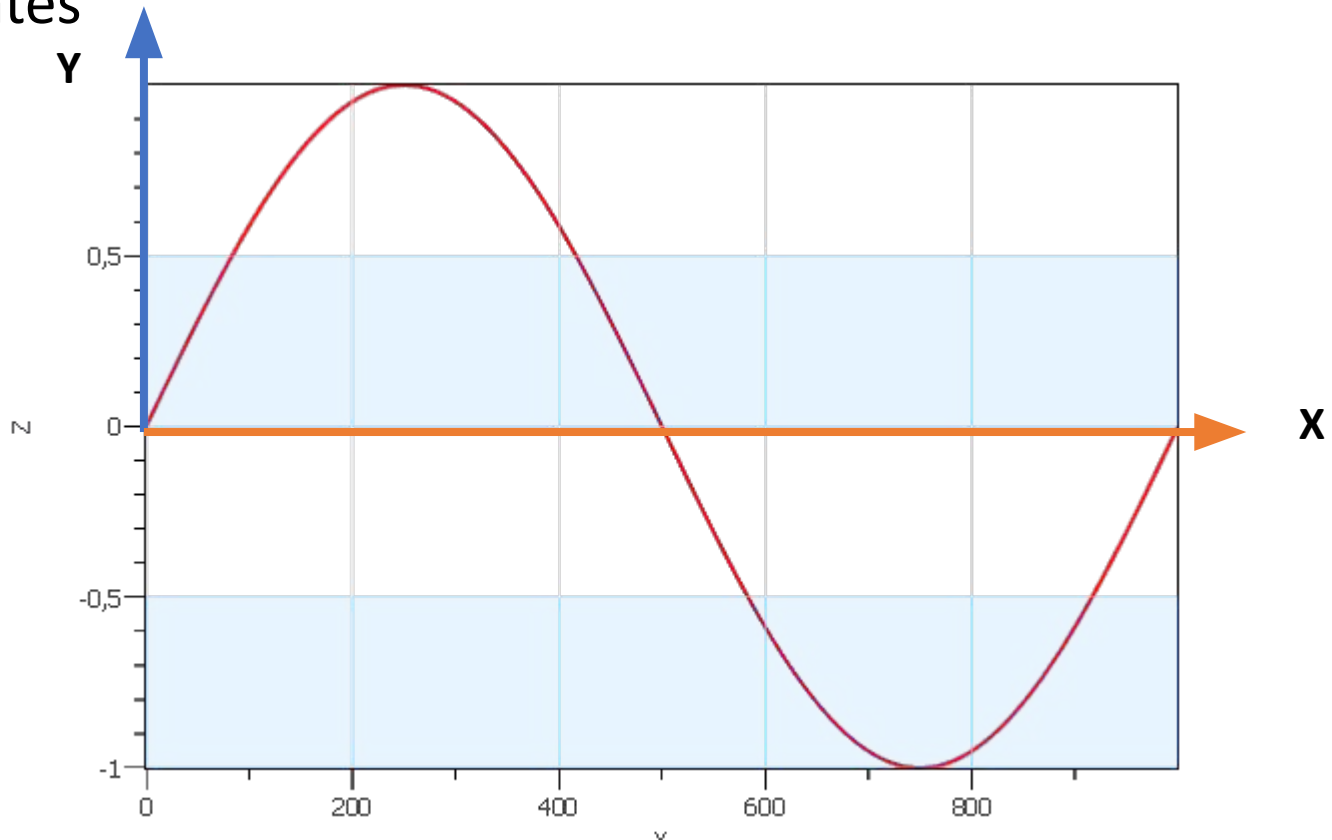
Lines Plan -Definition

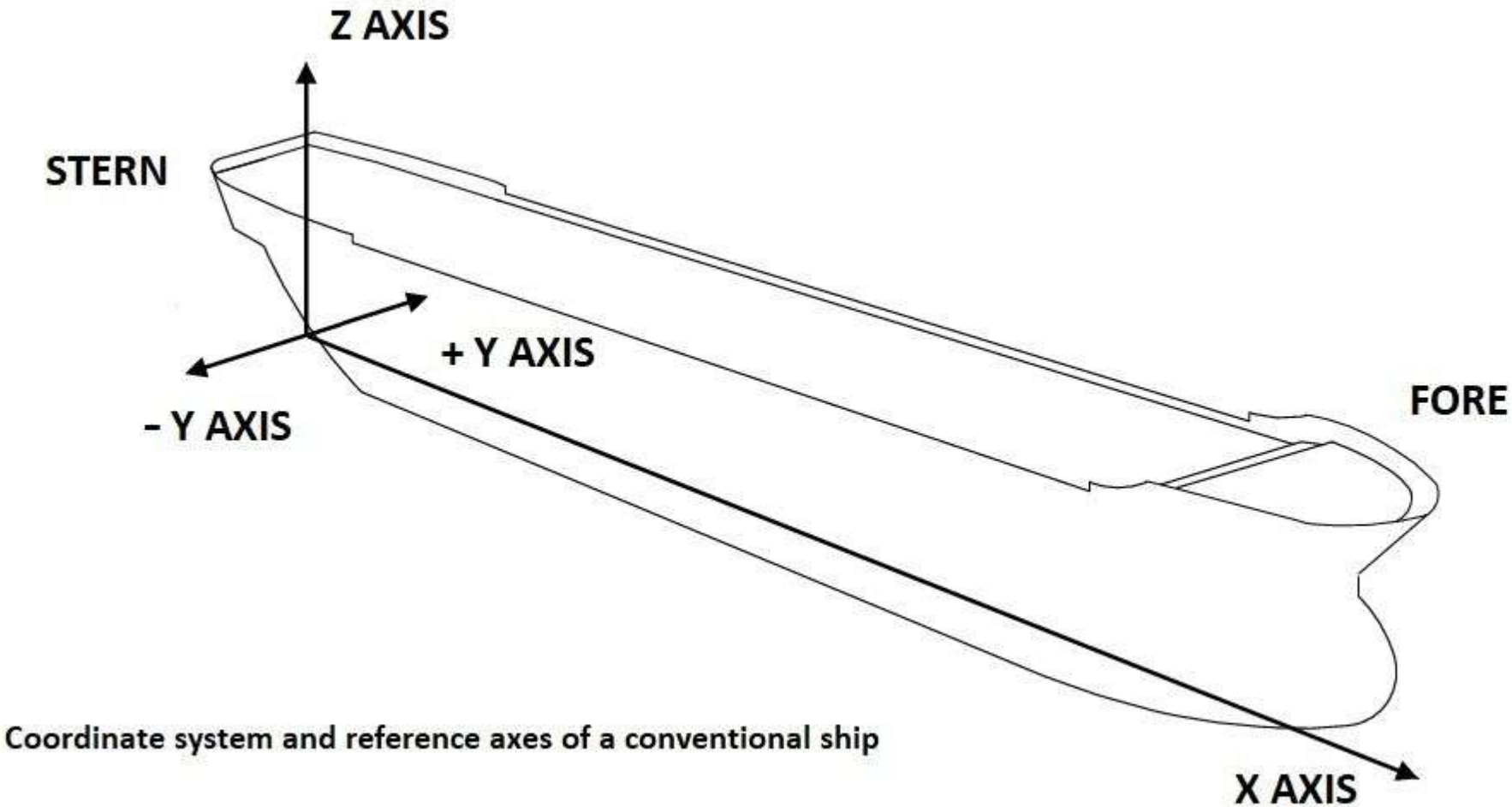
- Graphical representation of the 3-D ship hull..
- Using 2-D curves…
- Generated by cutting the hull with 3 sets of parallel planes that are mutually perpendicular (orthogonal), and orthographicallyprojecting the resultant 2 D curves
- The three sets of parallel planes are.
    - Transverse planes
    - Water planes
    - Buttock planes…
- Definition -Orthographic projections of the intersections of the hull form with 3 mutually perpendicular sets of planes

Lines Plan – How to Draw

- What do you need to plot a 2 D curve
  - Set of co-ordinates in 2 mutually perpendicular axes
  - Say X-Y or X-Z or Y-Z co-ordinates

X	Y
200	0.8
250	1.0
300	0.8
350	0.7
400	0.6
500	0
600	-0.6
750	-0.1

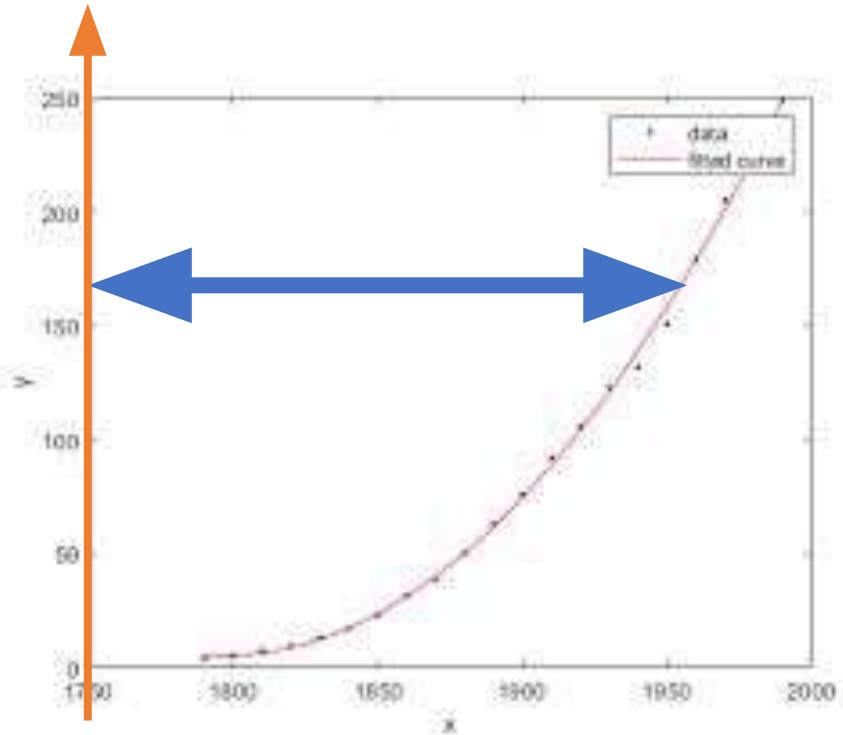




Coordinate system and reference axes of a conventional ship

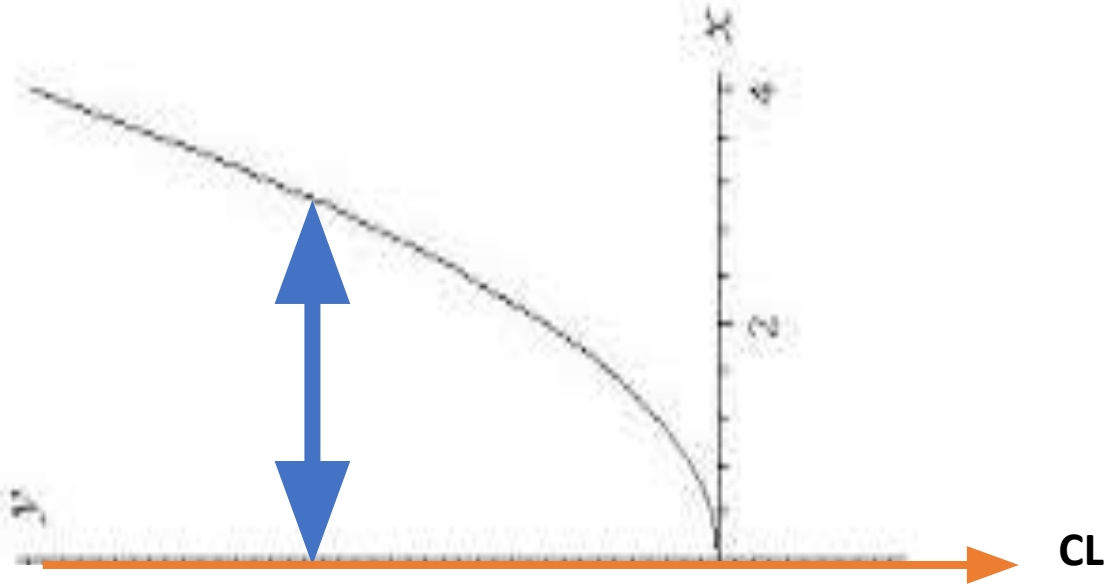
Lines Plan – Table of Offsets

- **What is an Offset**
- The perpendicular distance between a fixed reference line and a curve
- In a Lines Plan it is the distance measured from the Centre Line (fixed reference line) of the ship to specific point on a station or waterline(curve).



CL

BODY PLAN



CL

HALF BREADTH PLAN

Body Plan – Offsets – From C_L to ***Stations along WaterLines***

- **y – Offset**
- **z -Draft**

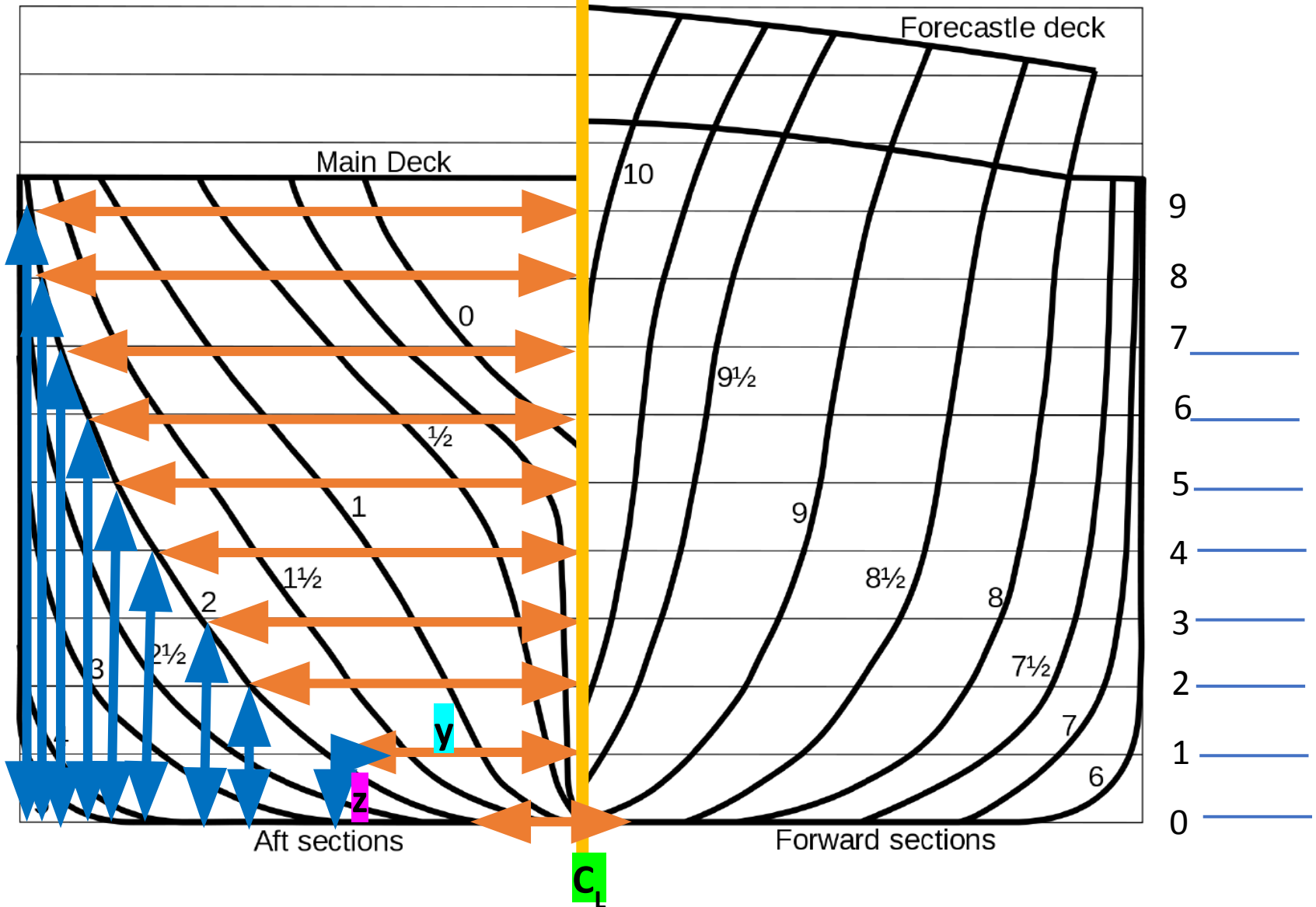
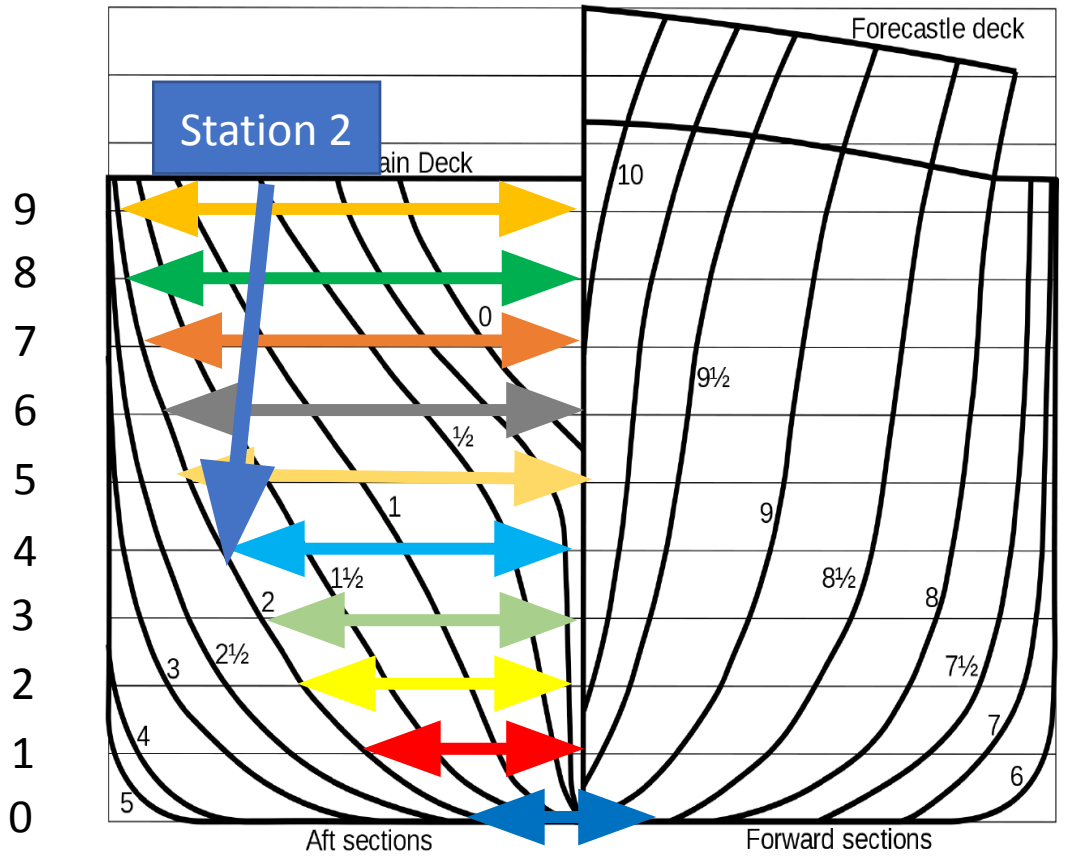


Table of Offsets

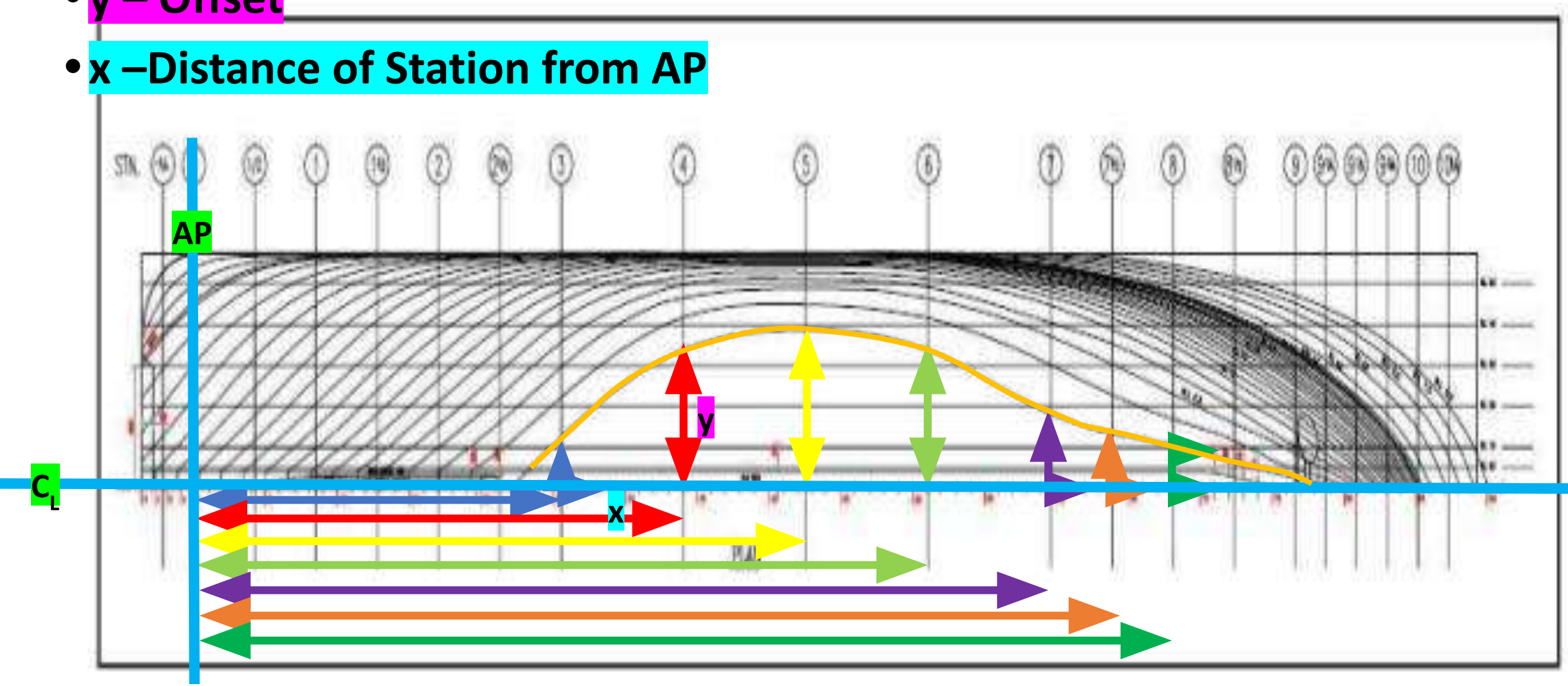
- Means representing the offset values in tabular format



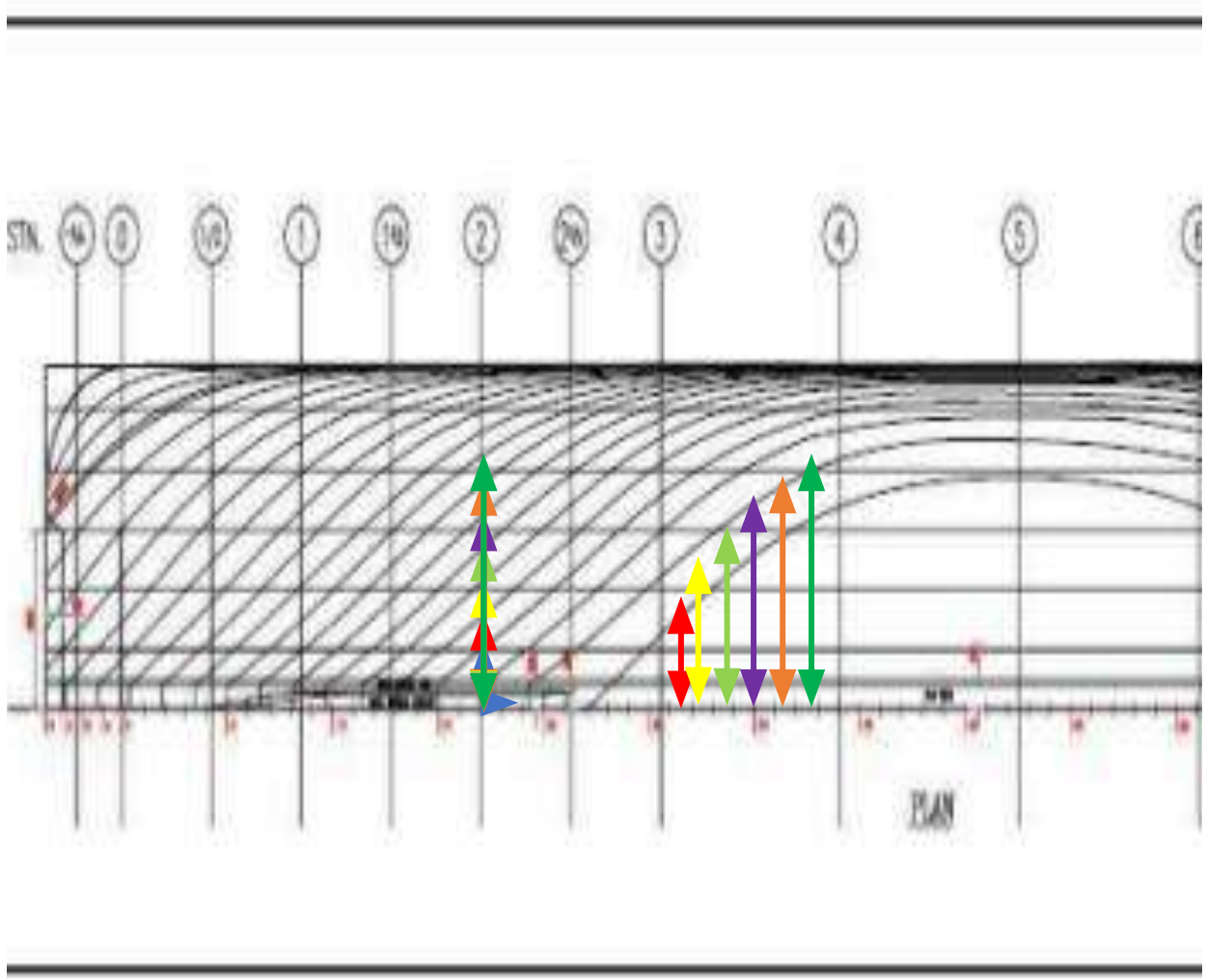
	WL	0	1	2	3	4	5	6	7	8	9
STN											
0											
1											
2		0.7	1.1	1.7	2.4	2.7	3.3	3.8	4.2	4.9	5.2

Half Breadth Plan – Offsets – From CL to ***Waterlines***

- **y – Offset**
- **x –Distance of Station from AP**



Offsets in Body Plan and Half Breadth Plan



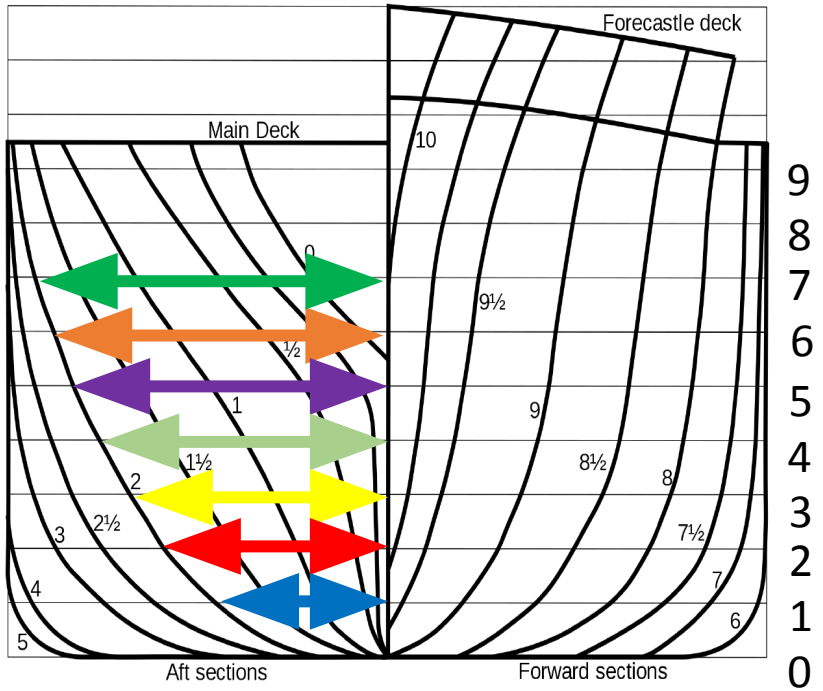
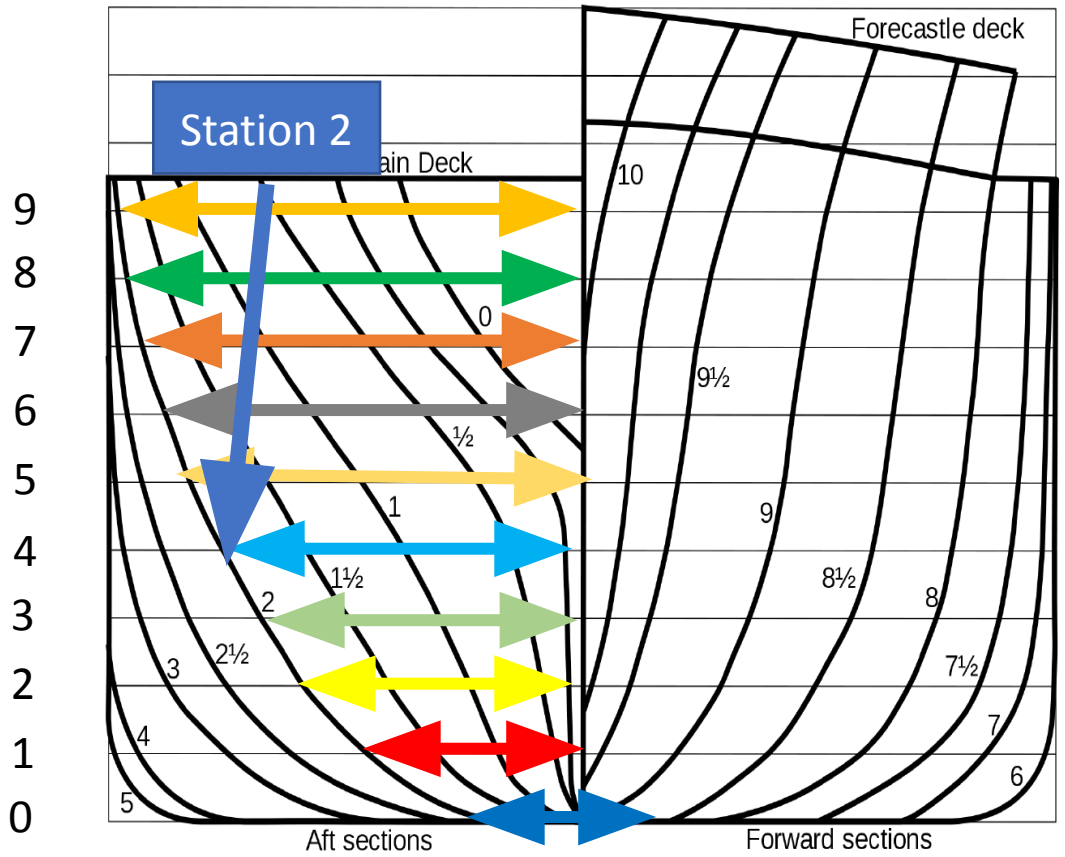


Table of Offsets

- Means representing the offset values in tabular format



	WL	0	1	2	3	4	5	6	7	8	9
STN											
0											
1											
2		0.7	1.1	1.7	2.4	2.7	3.3	3.8	4.2	4.9	5.2

Typical Offset Table

Waterlines

Stations

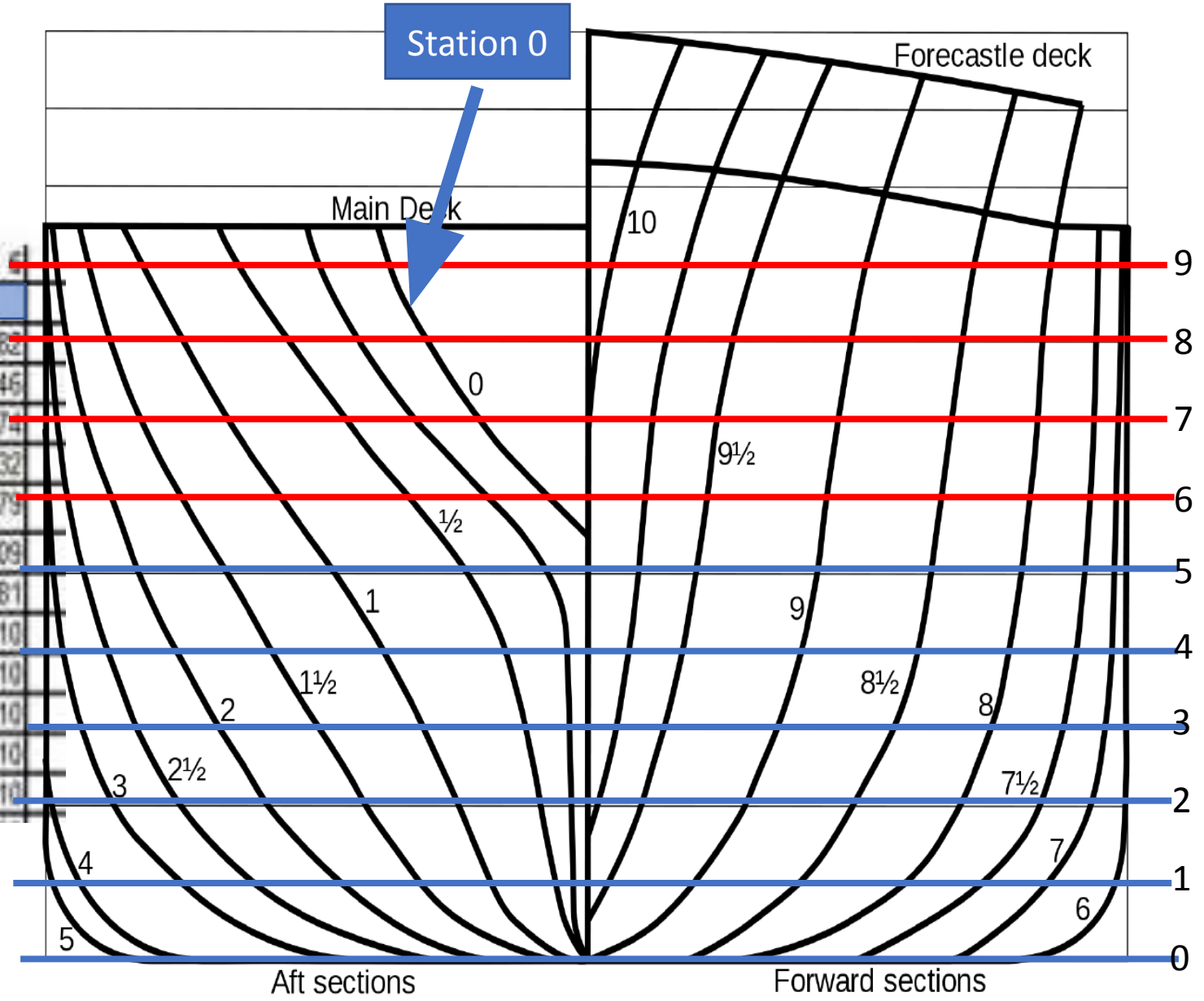
STN/WL	0	0.5	1	1.5	2	3	4	5	6	7	LWL	8	9	10
0										1.69	2.31	2.75	3.42	3.84
0.5									1.82	3.38	3.88	4.26	4.89	5.31
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46	4.58	5.09	5.45	6.08	6.45
1.5	0.28	1.08	1.39	1.69	1.96	2.5	3.1	3.78	4.74	5.75	6.2	6.5	7.04	7.45
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32	6.9	7.2	7.44	7.96	8.35
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79	8.3	8.51	8.72	9.08	9.31
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09	9.39	9.49	9.59	9.74	9.84
5	5.48	6.75	7.6	8.27	8.54	9.05	9.47	9.69	9.81	9.93	9.99	10	10	10
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10	10	10	10	10
7	6.96	8.95	9.5	9.79	9.97	10	10	10	10	10	10	10	10	10
8	7.05	9.38	9.8	9.9	10	10	10	10	10	10	10	10	10	10
14	8.57	9.41	9.72	9.91	9.99	10	10	10	10	10	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.98	10	10	10	10	10	10	10	10
16	7.2	8	8.55	8.94	9.21	9.54	9.7	9.8	9.89	9.92	9.95	9.99	10	10
17	5.02	6.62	7.12	7.55	7.91	8.41	8.69	8.88	9.01	9.13	9.23	9.31	9.45	9.6
18	2.67	4.65	5.34	5.71	6.03	6.51	6.82	7.01	7.13	7.27	7.4	7.57	7.9	8.24
18.5	1.68	3.4	4.01	4.45	4.72	5.19	5.39	5.55	5.71	5.91	6.05	6.2	6.61	7.05
19	0.6	2.25	2.72	3.1	3.38	3.7	3.79	3.87	4	4.21	4.39	4.52	4.91	5.32
19.5	0.3	1.41	1.81	2.11	2.31	2.4	2.15	1.9	1.84	1.98	2.11	2.28	2.7	3.23
20	0	0.84	1.21	1.4	1.48	1.32	1.04	0.7	0.32	0.06	0	0.03	0.3	0.72

Zero Values

Waterlines

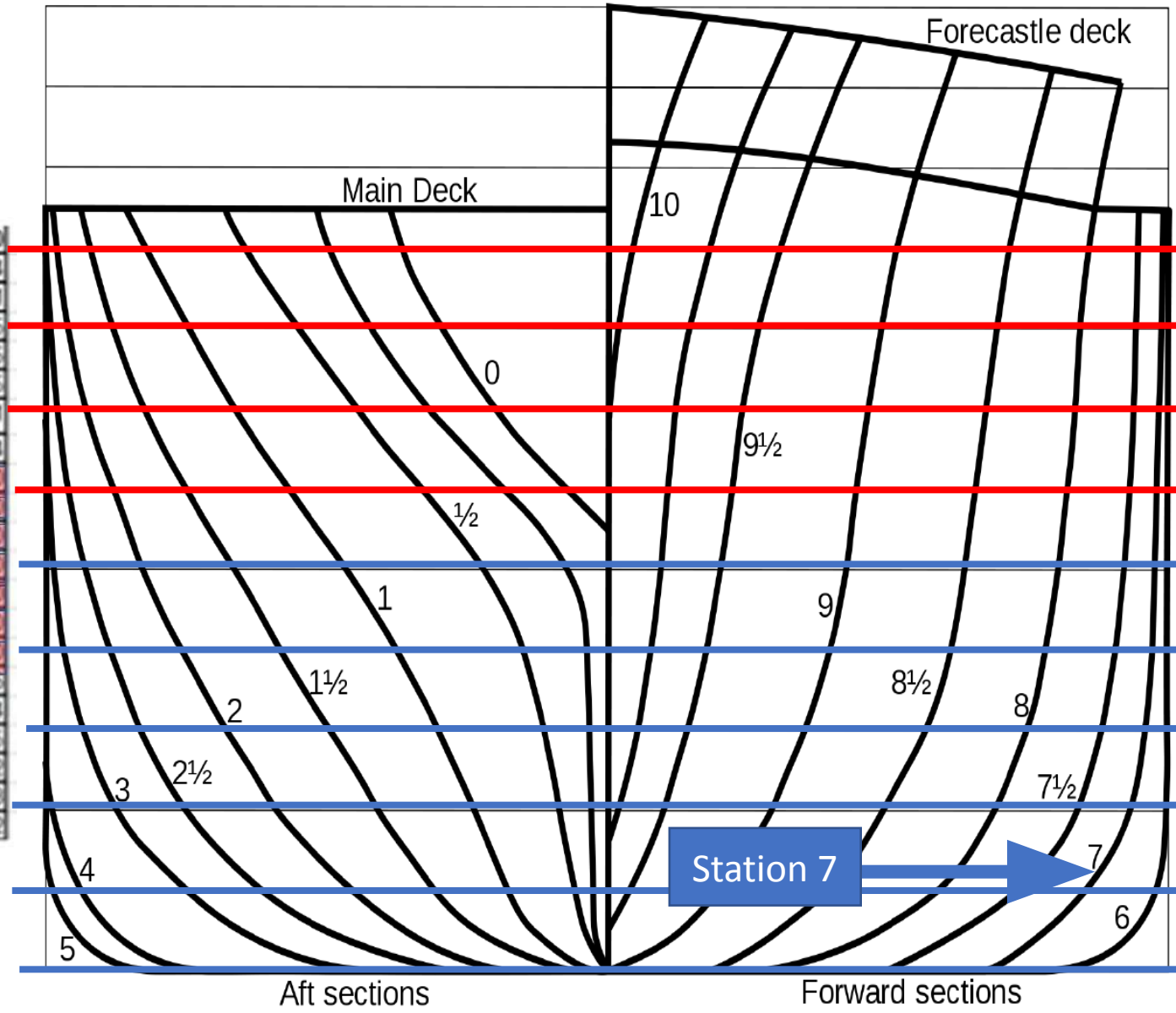
Stations

STN/WL	0	0.5	1	1.5	2	3	4	5	6
0									
0.5									1.62
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46
1.5	0.28	1.08	1.39	1.69	1.95	2.5	3.1	3.78	4.74
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09
5	5.48	6.79	7.6	8.27	8.54	9.05	9.47	9.69	9.81
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10
7	6.98	8.95	9.5	9.79	9.97	10	10	10	10
8	7.05	9.38	9.8	9.98	10	10	10	10	10
14	8.57	9.41	9.72	9.91	9.99	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.98	10	10	10



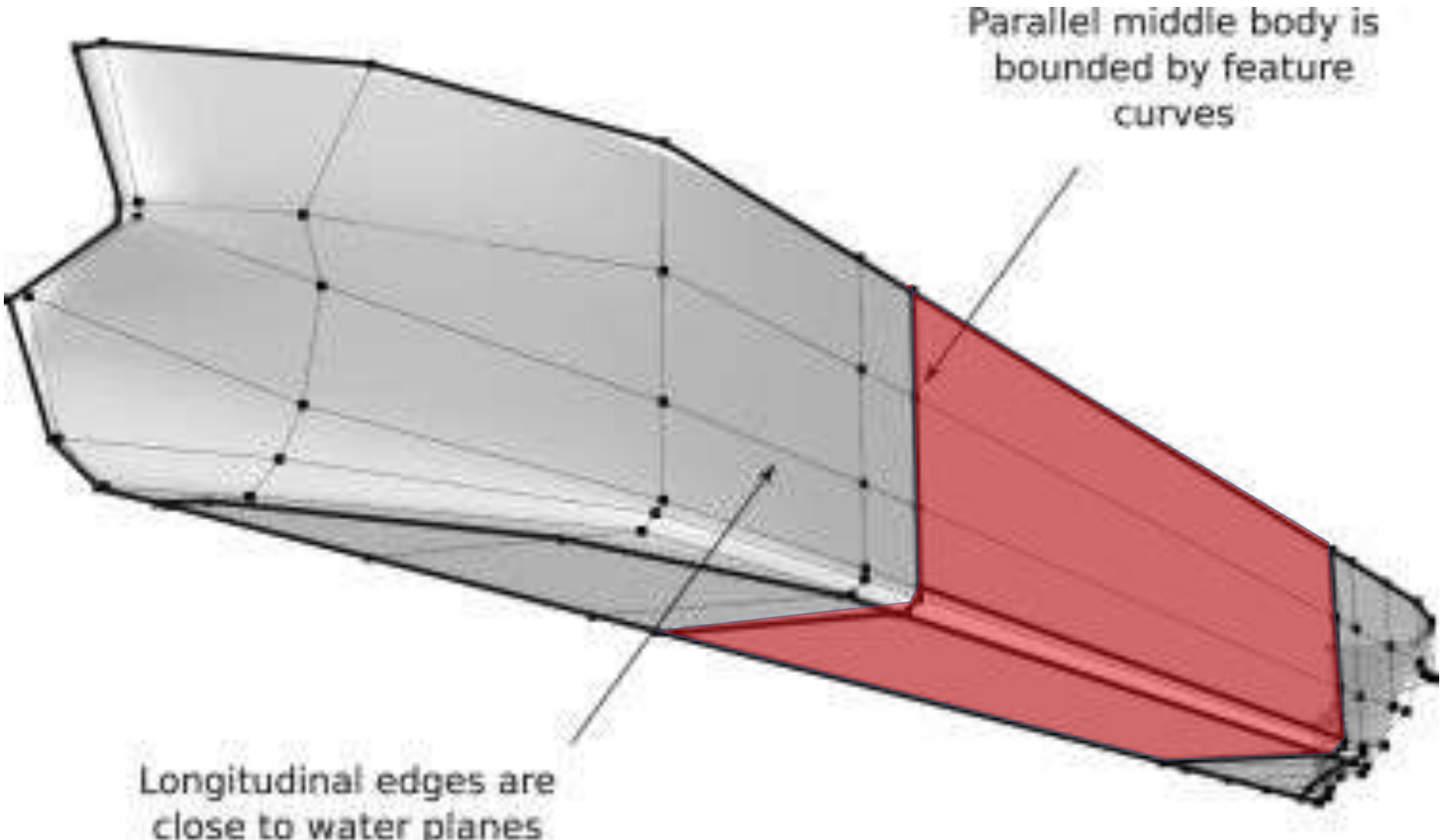
Vertical Side Shell

STN/WL	0	0.5	1	1.5	2	3	4	5	6	7	LWL	8	9	10
0										1.69	2.31	2.75	3.42	3.84
0.5									1.82	3.38	3.88	4.26	4.89	5.31
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46	4.58	5.09	5.45	6.08	6.45
1.5	0.28	1.08	1.39	1.69	1.95	2.5	3.1	3.78	4.74	5.75	6.2	6.5	7.04	7.45
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32	6.9	7.2	7.44	7.96	8.35
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79	8.3	8.51	8.72	9.08	9.31
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09	9.39	9.49	9.59	9.74	9.84
5	5.48	6.79	7.6	8.27	8.54	9.05	9.47	9.69	9.81	9.93	9.99	10	10	10
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10	10	10	10	10
7	6.98	8.95	9.5	9.79	9.97	10	10	10	10	10	10	10	10	10
8	7.05	9.38	9.8	9.96	10	10	10	10	10	10	10	10	10	10
14	8.57	9.41	9.72	9.91	9.99	10	10	10	10	10	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.98	10	10	10	10	10	10	10	10
16	7.2	8	8.55	8.94	9.21	9.54	9.7	9.8	9.89	9.92	9.95	9.99	10	10
17	5.02	6.62	7.12	7.56	7.91	8.41	8.69	8.88	9.01	9.13	9.23	9.31	9.45	9.6
18	2.67	4.65	5.34	5.71	6.03	6.51	6.82	7.01	7.13	7.27	7.4	7.57	7.9	8.24
18.5	1.58	3.4	4.01	4.45	4.72	5.19	5.39	5.55	5.71	5.91	6.05	6.2	6.61	7.05
19	0.6	2.25	2.72	3.1	3.38	3.7	3.79	3.87	4	4.21	4.39	4.52	4.91	5.32
19.5	0.3	1.41	1.81	2.11	2.31	2.4	2.15	1.9	1.84	1.98	2.11	2.28	2.7	3.23
20	0	0.84	1.21	1.4	1.48	1.32	1.04	0.7	0.32	0.06	0	0.03	0.3	0.72



Paralell Middle Body

Parallel Middle Body



Parallel Middle Body

STN/WL	0	0.5	1	1.5	2	3	4	5	6	7	LWL	8	9	10
0										1.69	2.31	2.75	3.42	3.84
0.5									1.82	3.38	3.88	4.26	4.89	5.31
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46	4.58	5.09	5.45	6.08	6.45
1.5	0.28	1.08	1.39	1.69	1.95	2.5	3.1	3.78	4.74	5.75	6.2	6.5	7.04	7.45
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32	6.9	7.2	7.44	7.96	8.35
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79	8.3	8.51	8.72	9.08	9.31
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09	9.39	9.49	9.59	9.74	9.84
5	5.48	6.79	7.6	8.27	8.54	9.05	9.47	9.69	9.81	9.93	9.99	10	10	10
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10	10	10	10	10
7	6.96	8.95	9.5	9.79	9.97	10	10	10	10	10	10	10	10	10
8	7.05	9.38	9.8	9.98	10	10	10	10	10	10	10	10	10	10
14	7	9.41	9.72	9.91	9.99	10	10	10	10	10	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.98	10	10	10	10	10	10	10	10
16	7.2	8	8.55	8.94	9.21	9.54	9.7	9.8	9.89	9.92	9.95	9.99	10	10
17	5.02	6.62	7.12	7.55	7.91	8.41	8.69	8.88	9.01	9.13	9.23	9.31	9.45	9.6
18	2.67	4.65								7.27	7.4	7.57	7.9	8.24
18.5	1.68	3.4								5.91	6.05	6.2	6.61	7.05
19	0.6	2.25								4.21	4.39	4.52	4.91	5.32
19.5	0.3	1.41								1.98	2.11	2.28	2.7	3.23
20	0	0.84								0.06	0	0.03	0.3	0.72

Offset values of ship remains from STN 8 to STN 13

Spacing

- Station(STN) Spacing
  - The LBP is divided into 20 equal parts, thus creating 21 stations, from STN 0(AP) to STN 20(FP)
  - This distance between two stations is called the Station Spacing
- Waterline(WL) Spacing
  - The Depth is divided into parts of uniform spacing, like 0.5 m, 1m or 2 m starting from keel upwards till Main deck
  - The spacing between the penultimate WL and the Main Deck will be less than or equal to the uniform spacing.
- Both the above spacings should be mentioned along with the Faired Offset Table in the Project Report

STN/WL	0.00	1.00	2.00	3.00	4.00	5.00	DWL	6.00	7.00	MDK
0	0	0	0	0	0.75	3.68	3.96	5.22	6.54	6.84
0.5	0	0	0.45	0.77	3.06	5.78	6.07	7.3	8.58	8.83
1	0	1.41	2.1	3.19	5.34	7.6	7.87	9.08	10.11	10.29
1.5	0.6785	2.71	3.99	5.48	7.37	9.34	9.64	10.73	11.85	12.07
2	2.10925	4.86	6.3	7.65	9.27	10.78	11	11.98	12.84	13
3	4.73475	7.51	9.4	10.87	11.91	12.89	12.96	13.62	14.18	14.29
4	7.92075	10.4	12.06	13.02	13.68	14.16	14.23	14.44	14.61	14.64
5	10.36925	12.69	13.74	14.31	14.56	14.73	14.75	14.75	14.75	14.75
6	11.72625	13.96	14.62	14.75	14.75	14.75	14.75	14.75	14.75	14.75
7	12.31625	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
8	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
9	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
10	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
11	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
12	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
13	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
14	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
15	12.39	14.58	14.75	14.75	14.75	14.75	14.75	14.75	14.75	14.75
16	12.02125	13.93	14.43	14.55	14.7	14.75	14.75	14.75	14.75	14.75
17	11.0035	12.72	13.25	13.57	13.84	14.15	14.19	14.47	14.72	14.75
18	8.555	9.92	10.65	11.06	11.36	11.85	11.96	12.52	13.18	13.31
18.5	5.08875	7.28	8.48	8.91	9.23	9.9	10.03	10.66	11.37	11.5
19	3.08275	5.04	6.07	6.36	6.65	7.24	7.37	8.12	9.04	9.05
19.5	1.40125	3.35	3.75	3.77	3.78	4.05	4.11	4.57	5.53	5.84
20	0	2.1	1.78	0.92	0.28	0	0	0.32	1.29	1.47

Waterline spacing = 2m

Station spacing = 8.585m

(All values are in meter)

Table 3.1.3 – Faired offsets

END

- In case of any doubts you may contact me at

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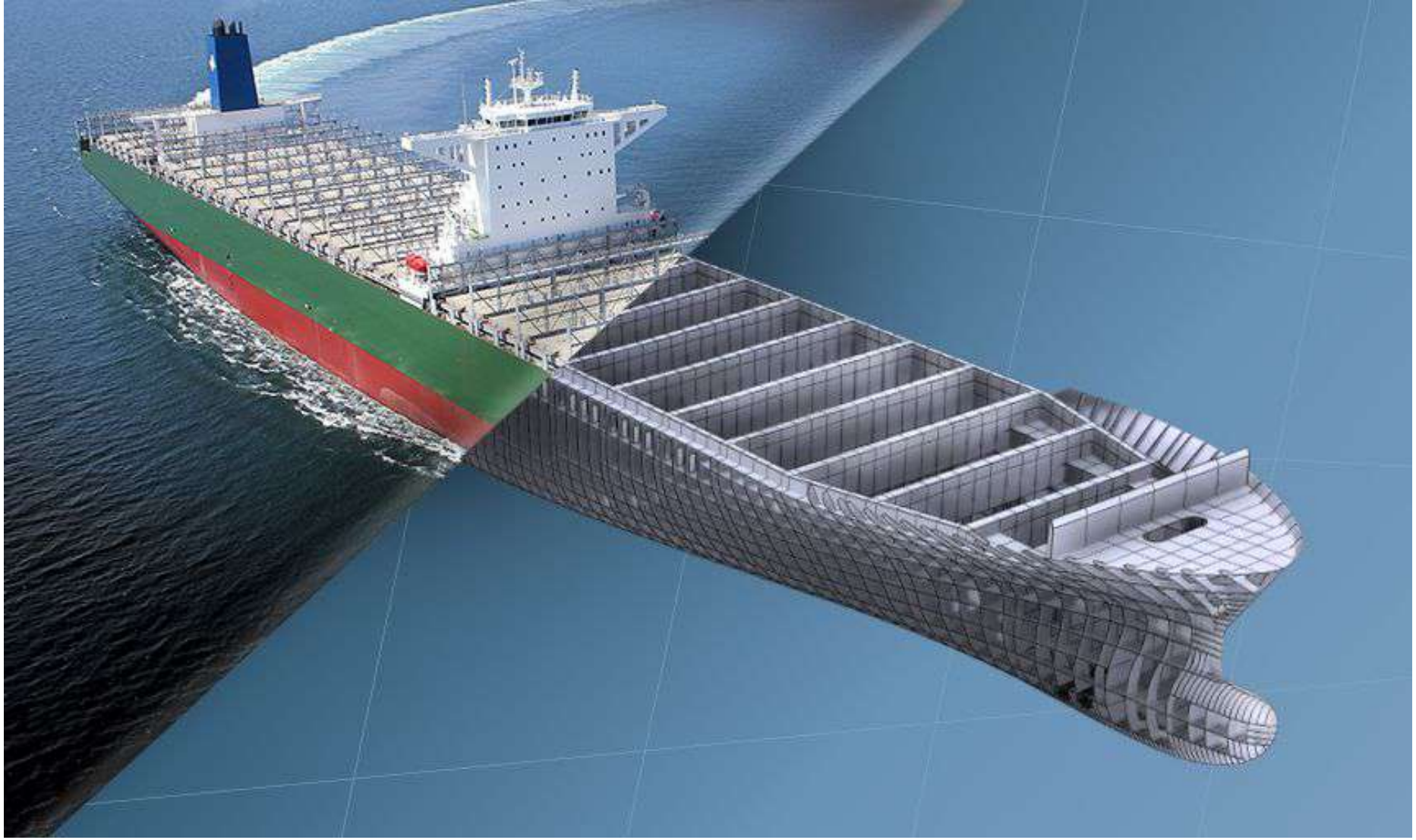
- Email : deepaksebastian.dost@gmail.com



Introduction to Naval Architecture

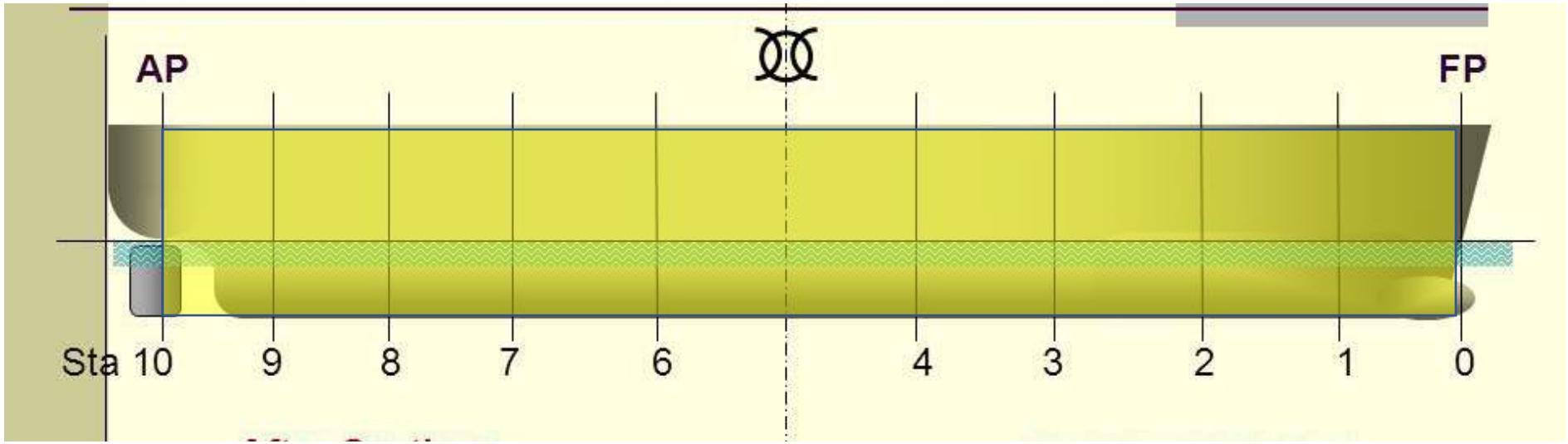
II SEM –Module 3

RECAP

- Table of Offsets
  - Plotting a 2 D curve using a set of co-ordinates
  - Definition of Offset
  - Offset values with reference to Lines Plan
    - Body Plan : Centreline to Stations
    - Half Breadth Plan : Centreline to Waterline
  - Offset Table
    - Tabulation of Offsets for all stations / waterlines
    - Generated using Ship Series data, First Principles , Distortion etc.
  - Learn to draw a Lines Plan from a given offset table

Offset Table – Limit of offset values

- Gives offset values between Aft Perpendicular (AP) and Fwd Perpendicular (FP) only



- Hull form aft of AP and fwd of FP are defined separately

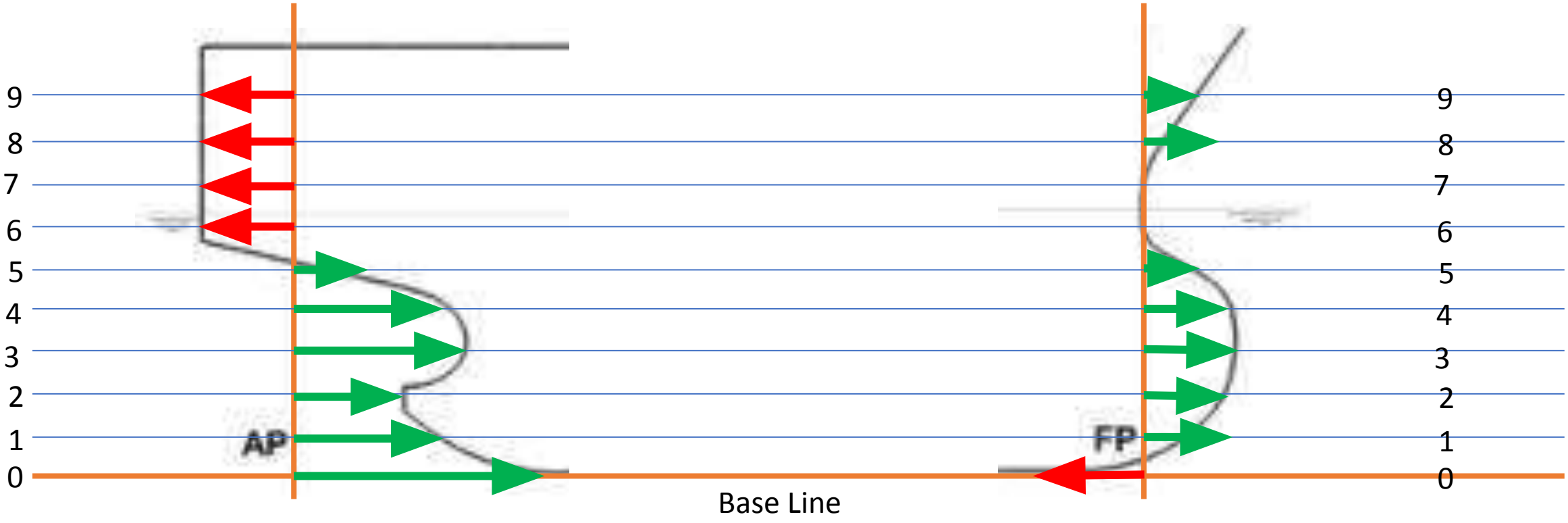
Stem and Stern Profile

- Not defined in Offset Table
- Design of Stem and Stern profiles is based on

    - Standard profile designs
    - Series data
    - Modifications based on functionality
    - Modifications based on clearances from propeller rudder etc
    - Bulbous bow designs

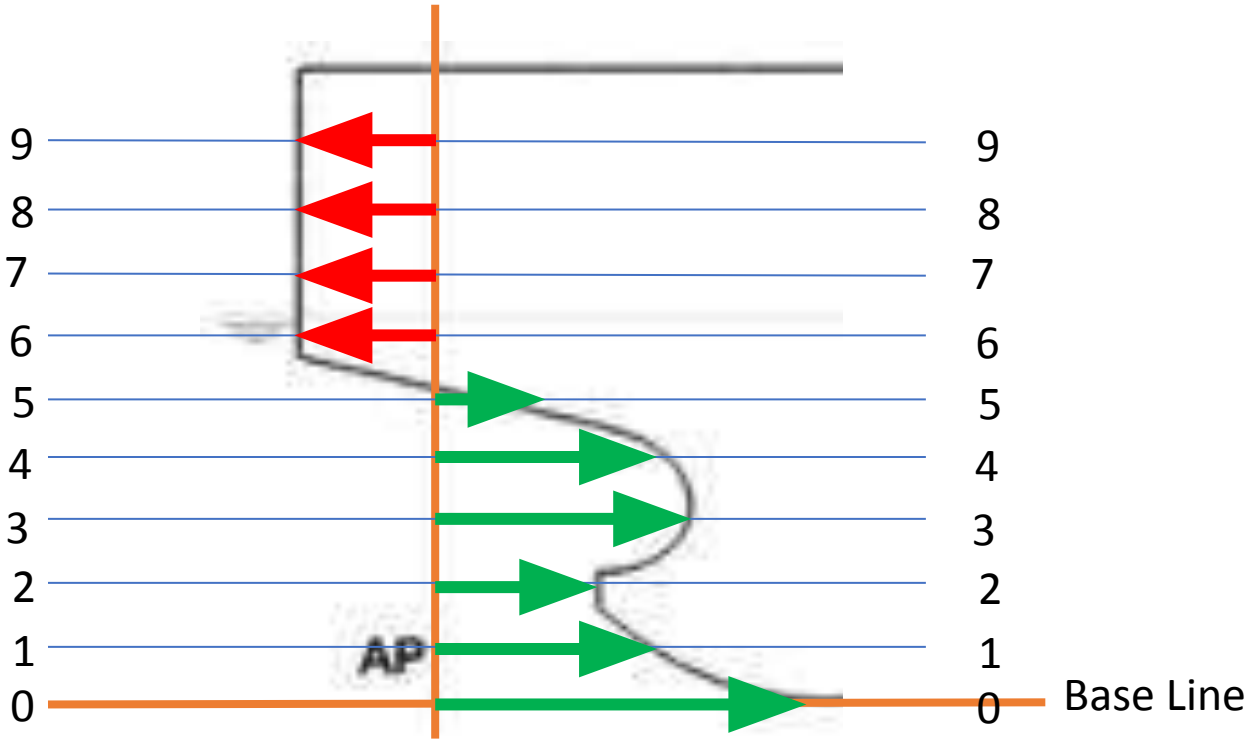
Stem and Stern Profile – How it is defined

- Stern Profile – AP is the reference
- Stem Profile – FP is the reference



Stern Offset

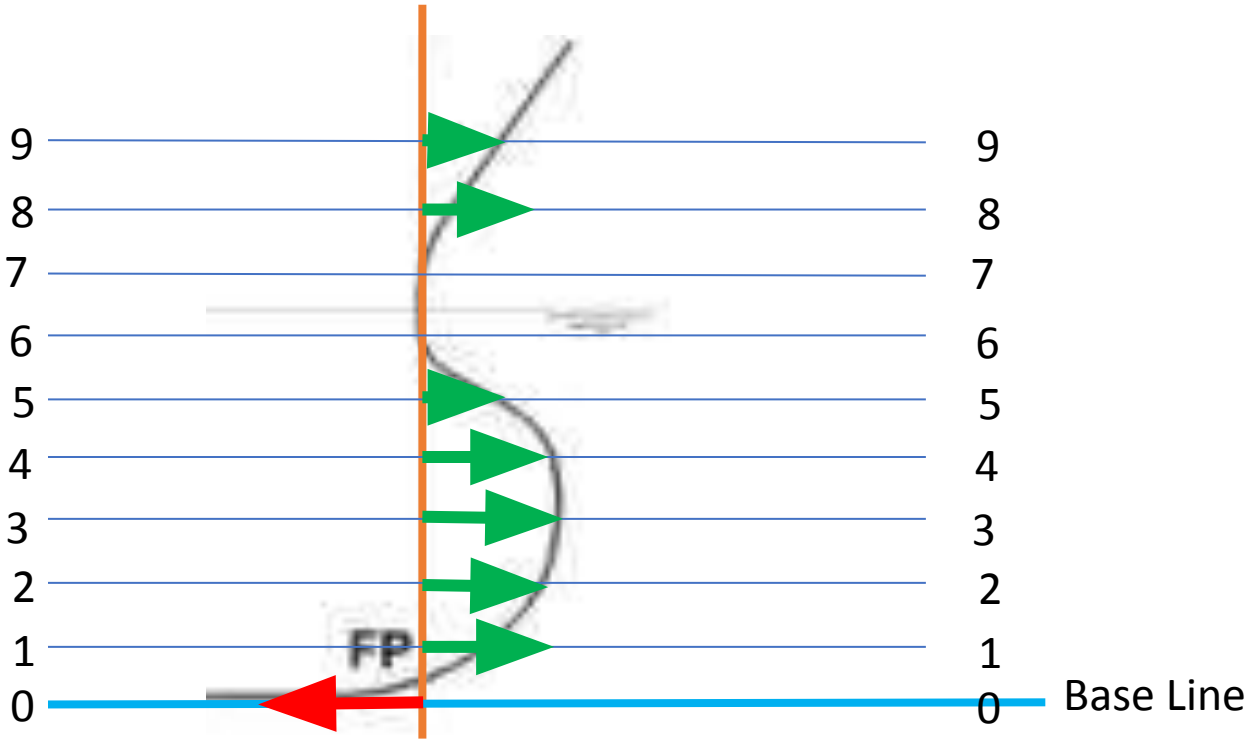
- Stern Profile
  - Offsets from AP are given



WL	Offset(m)
0	2.3
1	1.6
2	1.2
3	1. 9
4	1.8
5	0.5
6	- 1.6
7	- 1.6
8	- 1.6
9	- 1.6

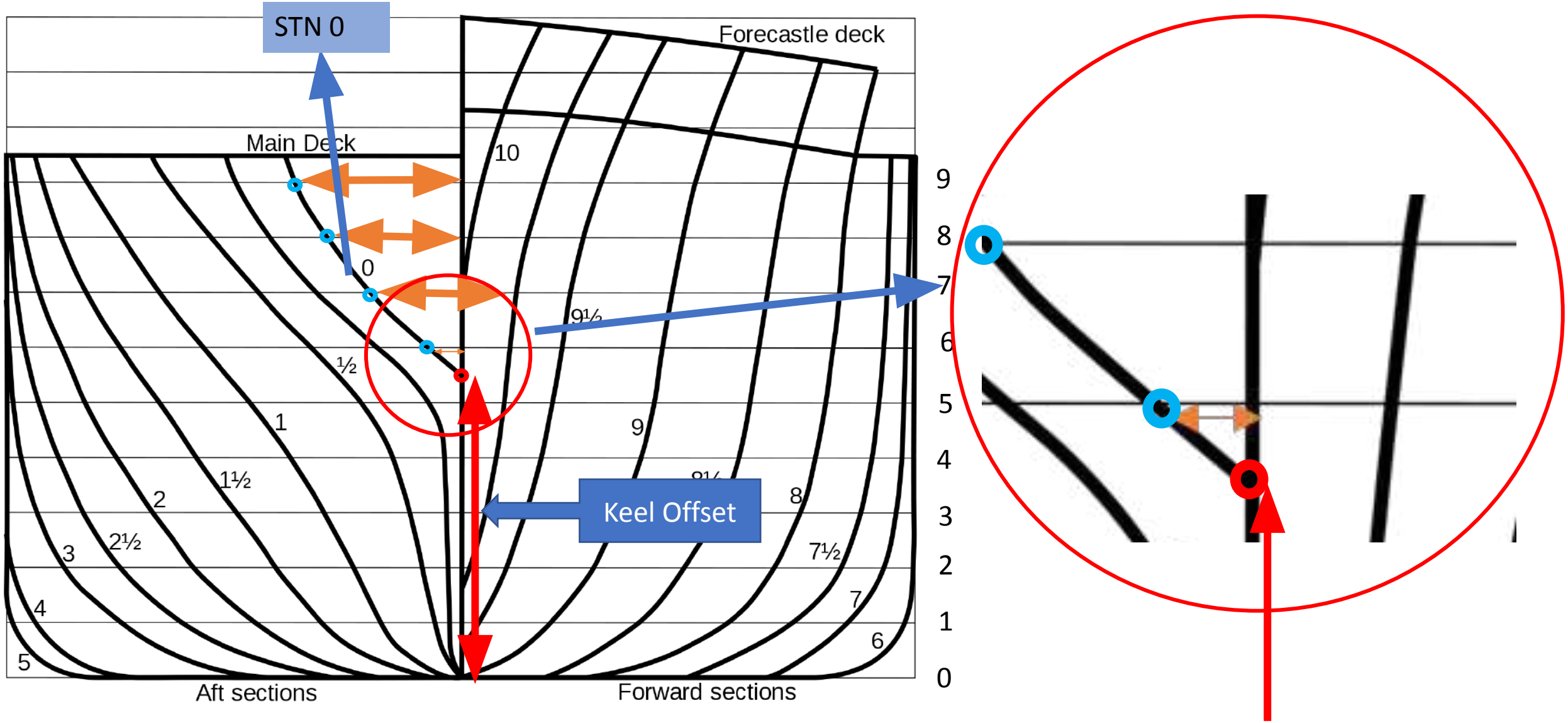
Stem Offsets

- Stem Profile
  - Offsets from FP are given

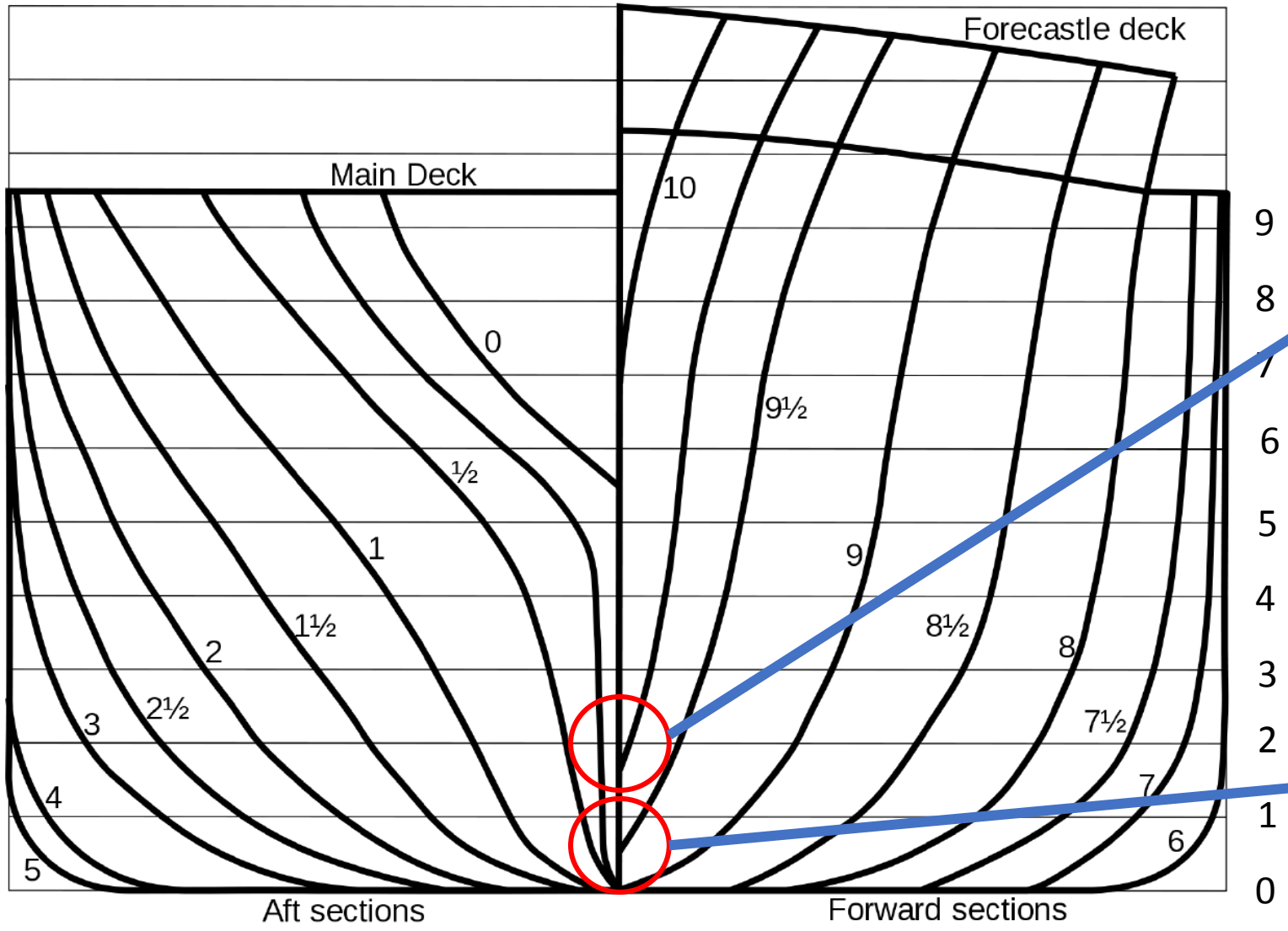


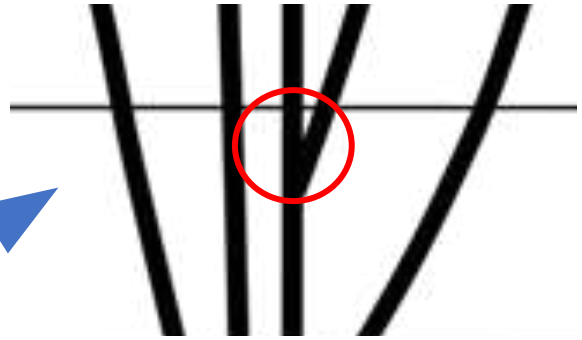
WL	Offset(m)
0	-2.1
1	0.6
2	1.2
3	1. 5
4	1.2
5	0.5
6	0
7	0
8	0.2
9	0.8

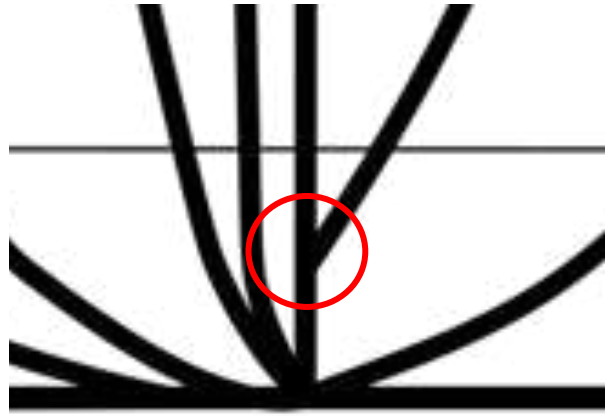
Keel Offsets



Keel Offsets

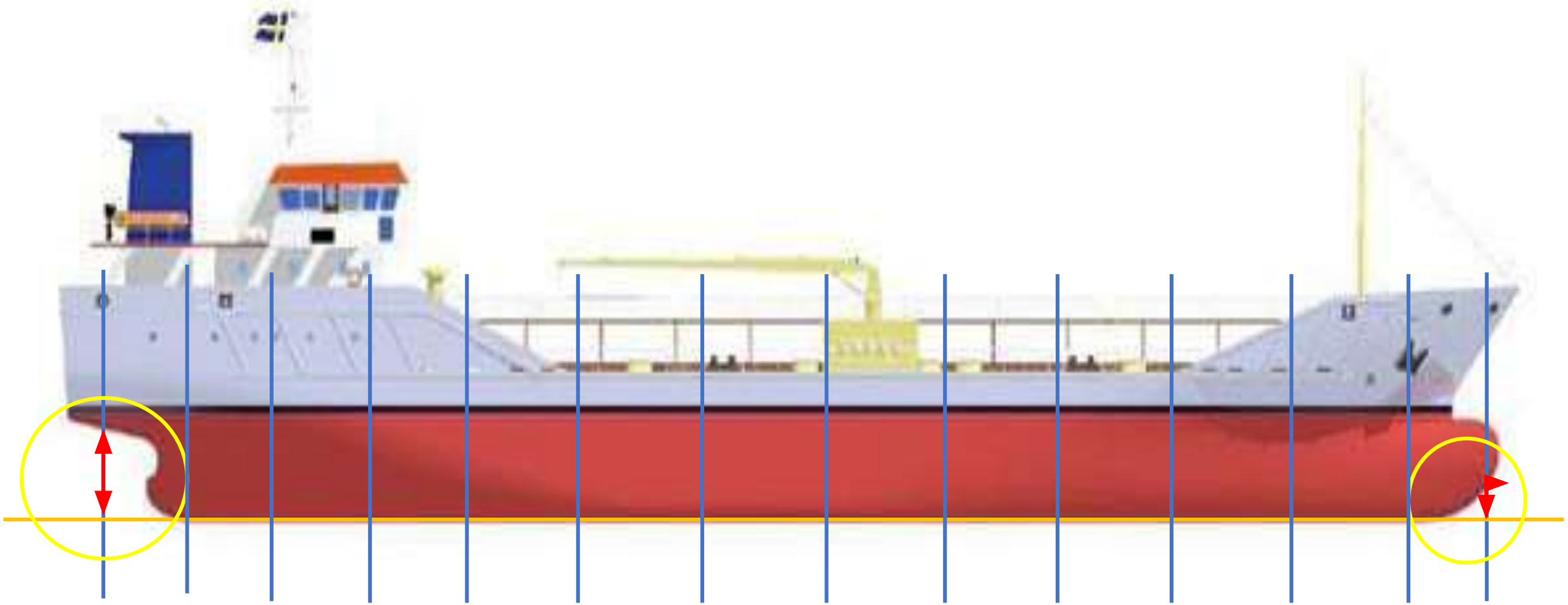




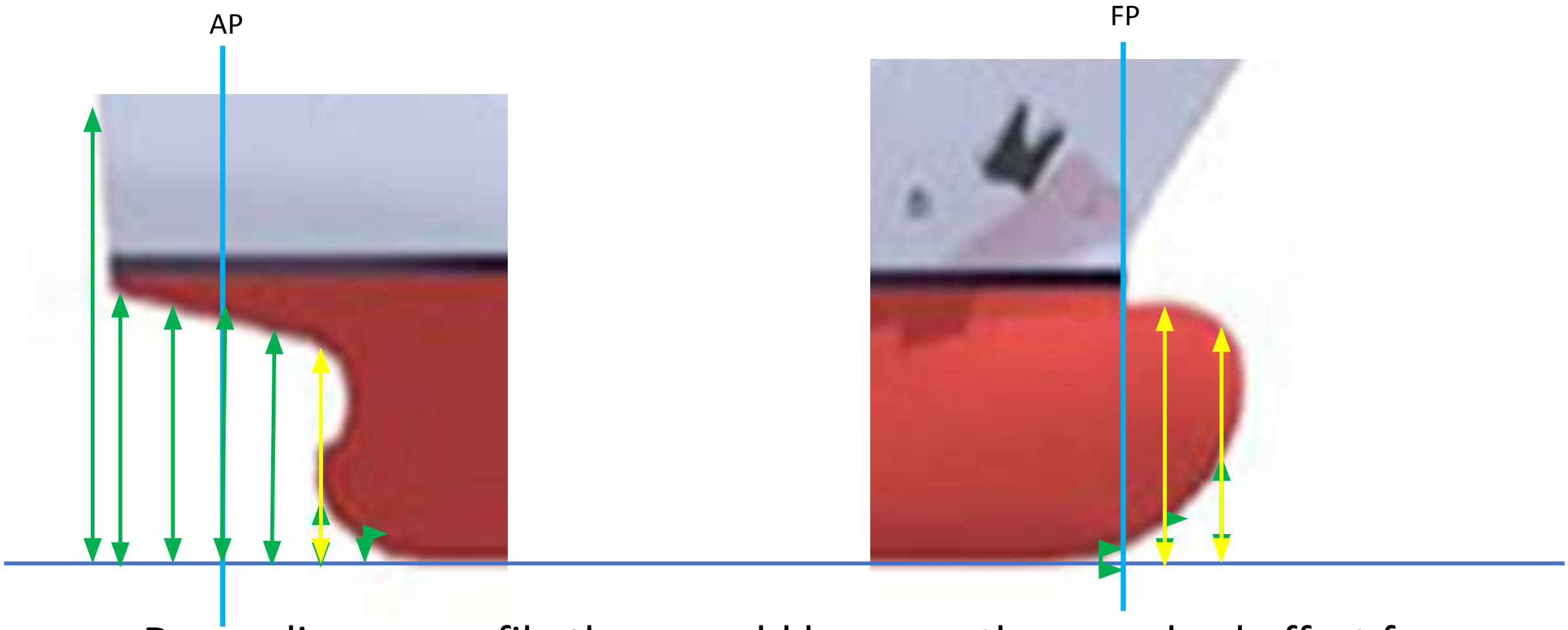


Keel Offset

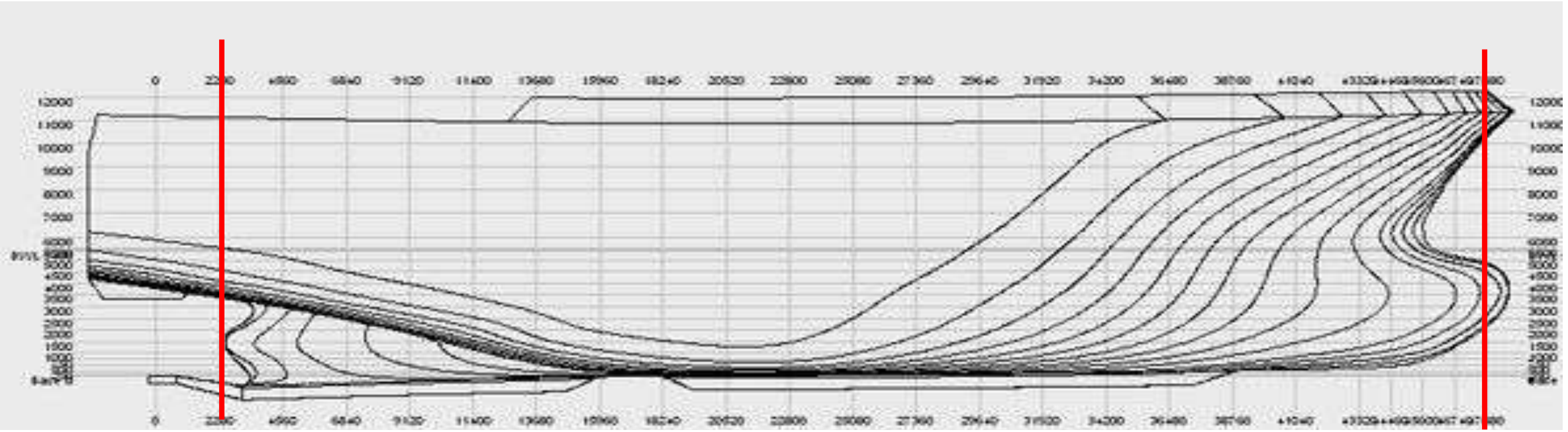
- It is the distance from the baseline to the keel at a given station

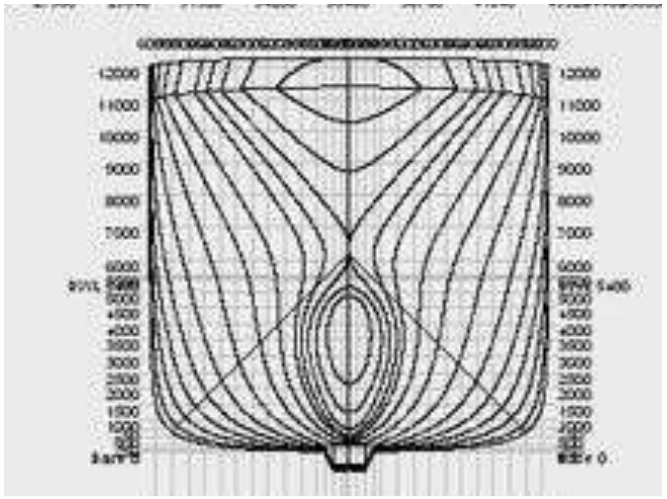


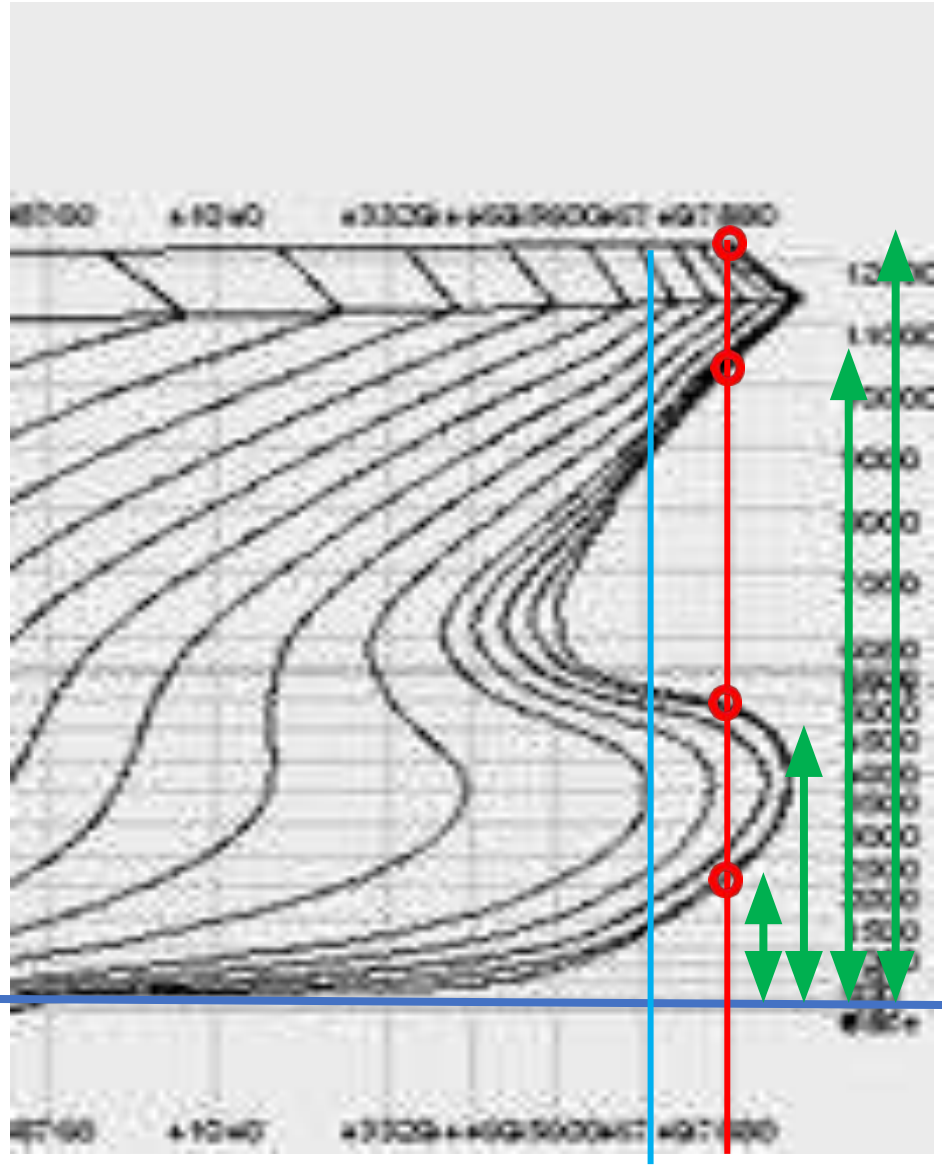
Keel Offsets – At Stem and Stern

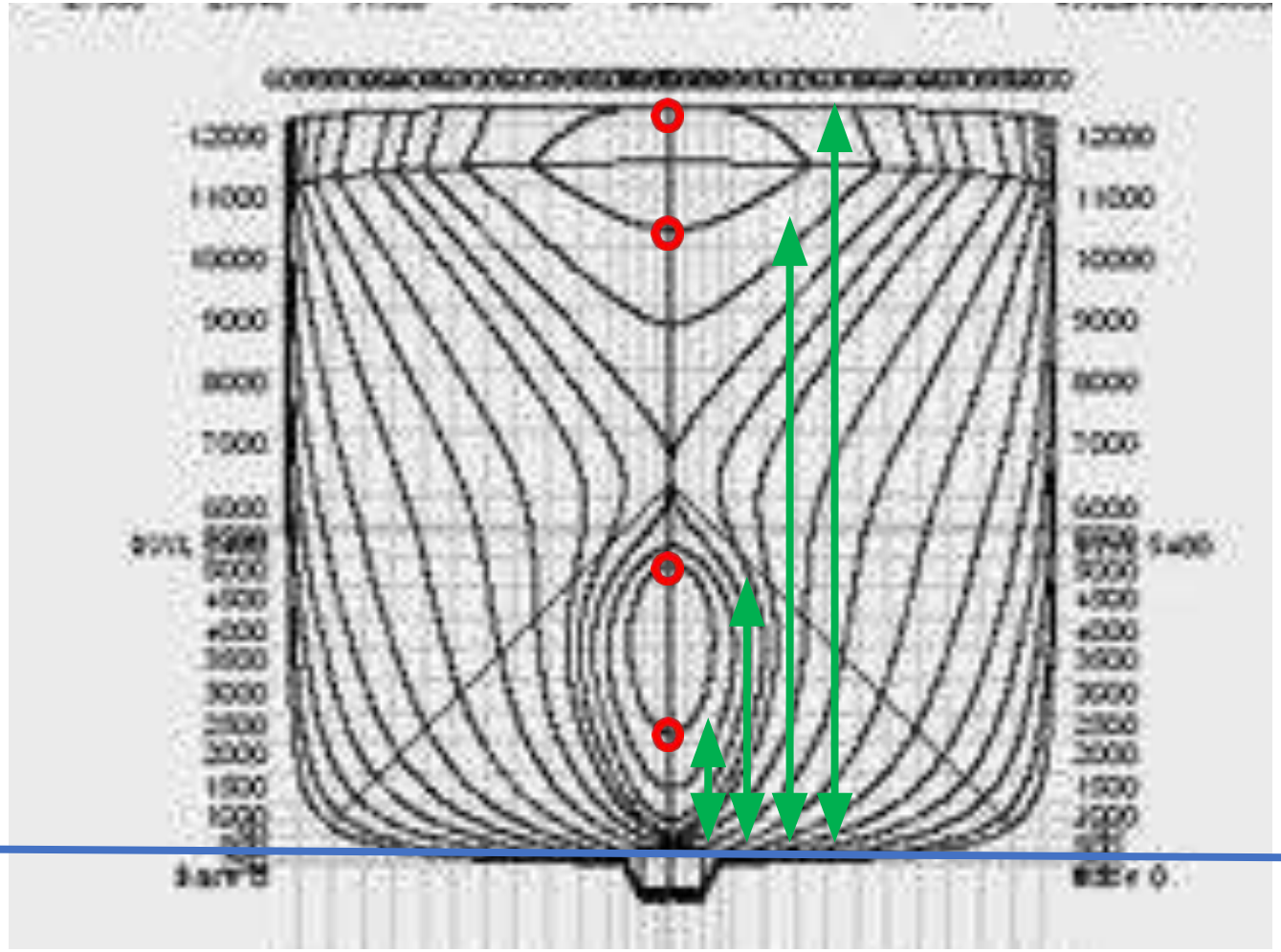


- Depending on profile there could be more than one keel offset for a given station









WATER LINES	STEM PROFILE OFFSETS	STERN PROFILE OFFSETS (for'd +ve)
	(FROM F.P)	(FROM A.P)
0	0.36	3.92
1	0.41	4.08
2	0.84	4.49
3	1.7	5.05
4	2.01	5.35
5	2.57	0
LWL	3.36	-2.54
6	3.97	-4.29
7	0.36	-5.43
MDK	0.4	-6.15

Table 3.1.1- Stern and Bow offsets

STN	Height From Base (m)
-0.5	11.8
-0.25	9.45
0	9.12
0.5	7.2
1	0

Table 3.1.2- Keel Offset

END

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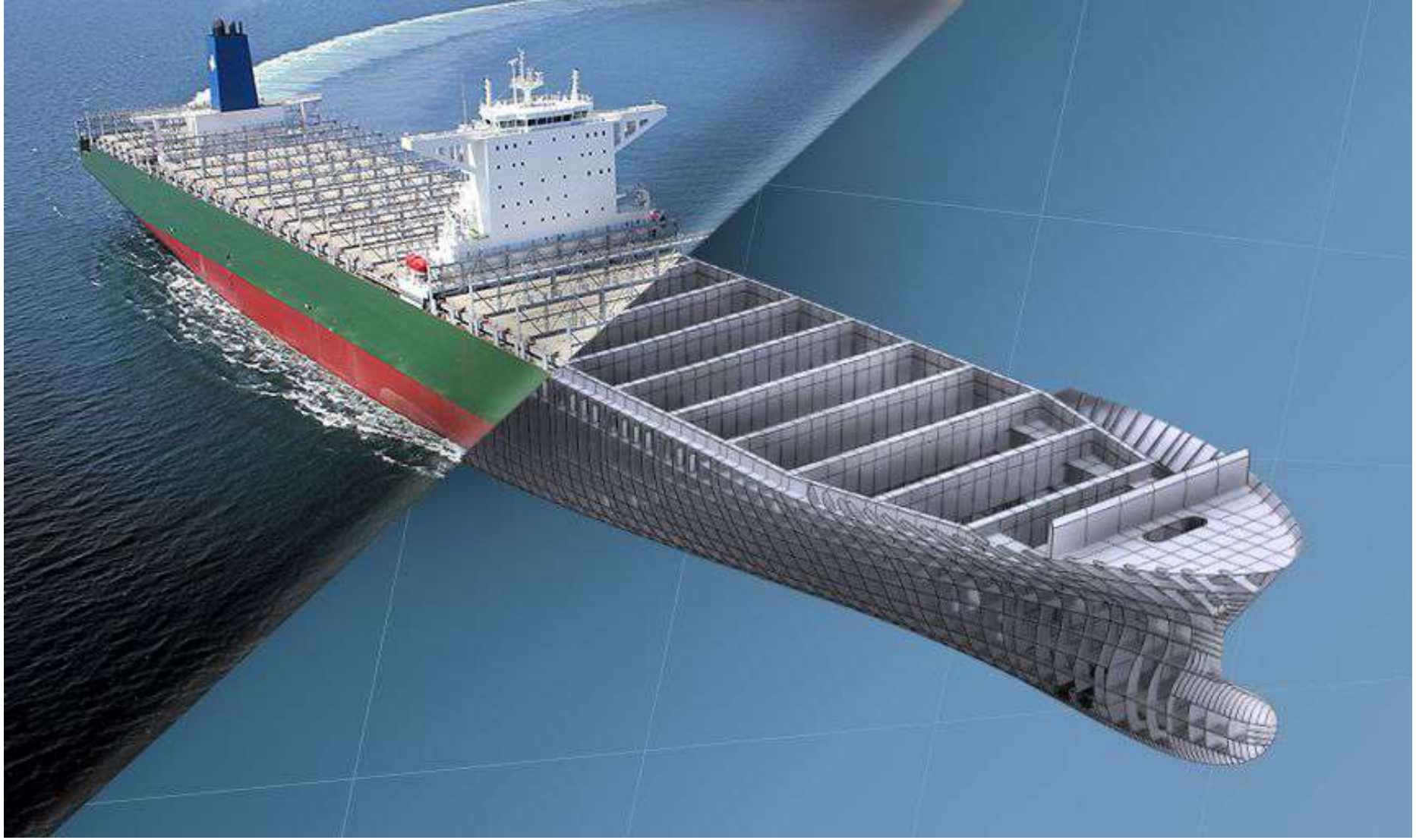


Introduction to Naval Architecture

II SEM –Module 3

Drawing Tools and Requirements

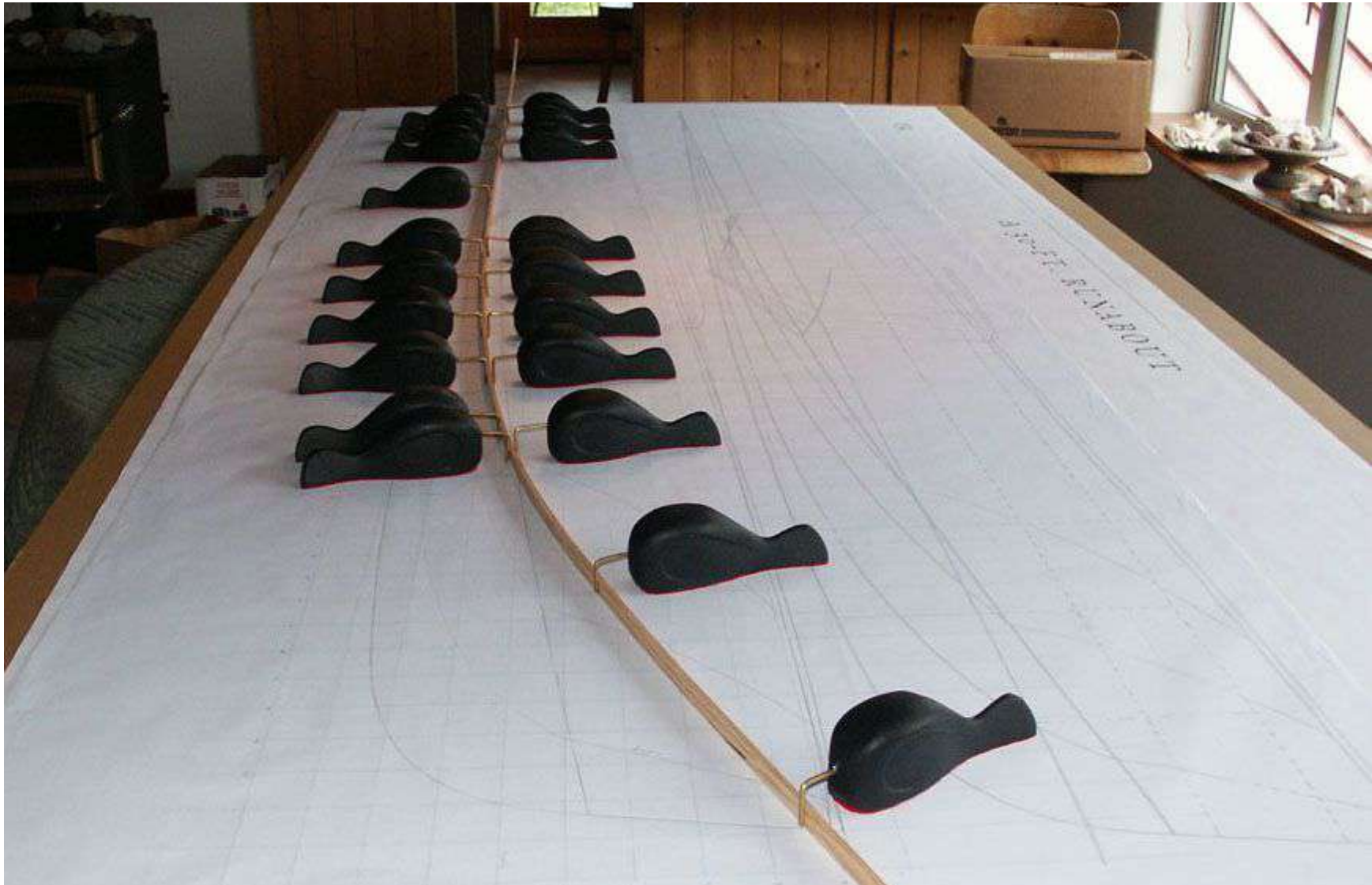
- Main Dimension and Offsets Data
- Drawing equipment :-
  - - Drawing Table
  - - Drawing Paper (A0 or A1 size of good quality paper / tracing paper)
  - - Straight Edge
  - - Batten / Spline
  - - Ship Curves (sets of various shapes and sizes) or French Curves
  - - Batten Weights
  - - Scale Ruler (with Metric Scale)
  - - Eraser
  - - Mechanical Pencils (0.5mm, 0.3mm, H, HB and 2B)

Straight Edge

- Long and wide scale
- ~ 3 m long

Batten and Batten Weights

- Batten
  - Perspex strips
  - 2-3 m long
- Batten Weights
  - Lead weights



French Curves

- Plastic shapes

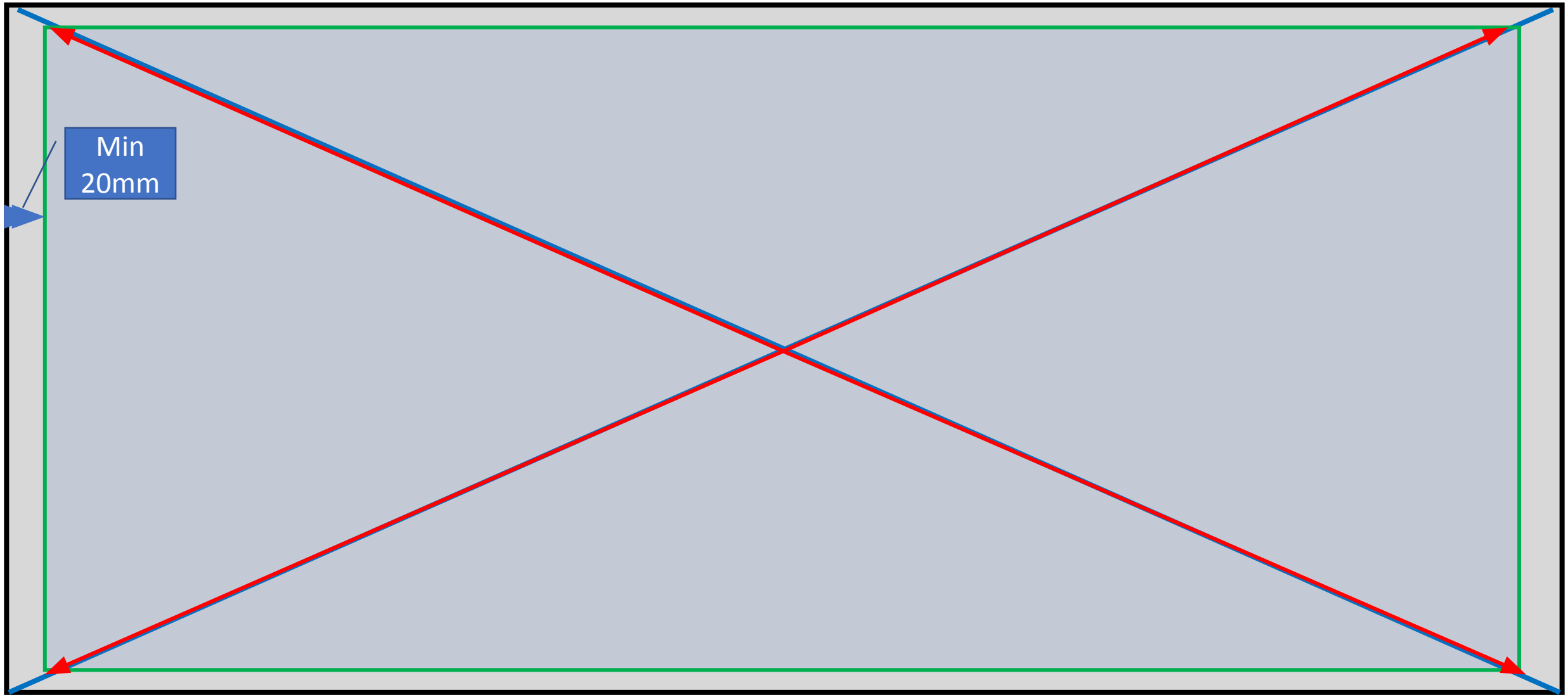
Metre Scale

- Steel Ruler
- 1 m long

How to draw a Lines Plan

- Drawing of Border or Main Box
- Determination of Drawing Scale and Layout
- Drawing and Labeling of the Grid Lines
- Drawing of Plan Views – Body Plan , Half Breadth Plan, Sheer Plan
- Fairing

Drawing of Border



How to draw a Lines Plan

- Drawing of Border or Main Box
  - Draw diagonals of the sheet using a straight edge
  - From the intersection of the diagonals mark equal distances towards the four corners, so as to get maximum area within the border.
  - Join the four new points to get the Border or the Main Box

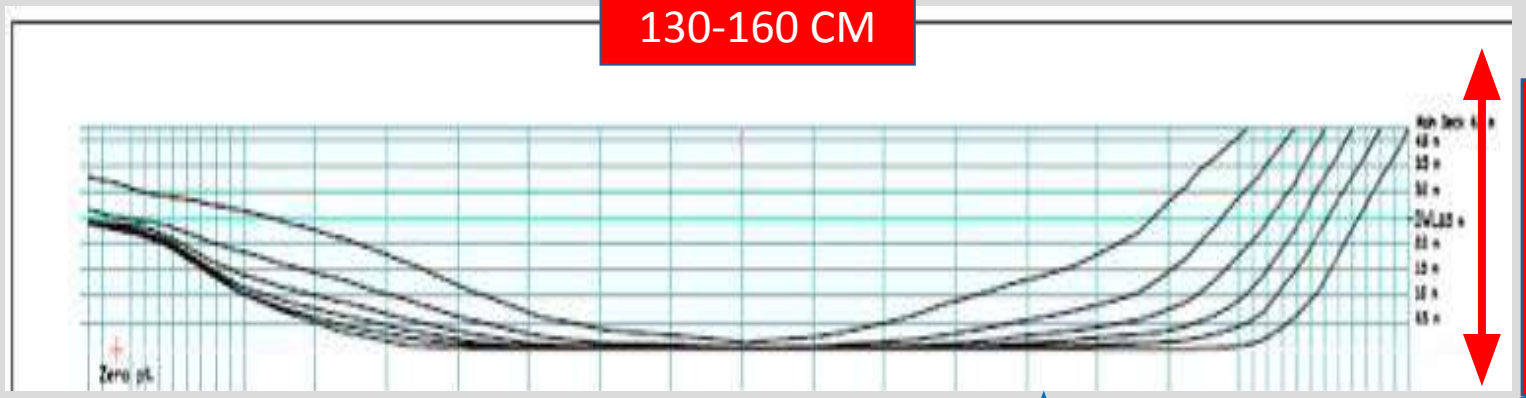
How to draw a Lines Plan

- Determination of Drawing Scale and Layout
  - Based on the main dimension and the drawing paper size determine appropriate **drawing scale**.
  - BIS SP 46 – Recommended Scales
    - 1:2, 1:5, 1:10
    - 1:20, 1:50, 1:100
    - 1:200, 1:500, 1 :1000
  - Scale has to be determined based on ship's dimensions and the distance / clearance between three views (Body Plan, Half Breadth, Sheer Plan). While considering length cater to LOA , not LBP
  - Use suitable and appropriate scale.
  - The space for title block, Main Dimensions (L, B, D, T, Disp…) and offsets table must be given consideration
  - Ensure the effective use of the space in the drawing paper.

200 CM

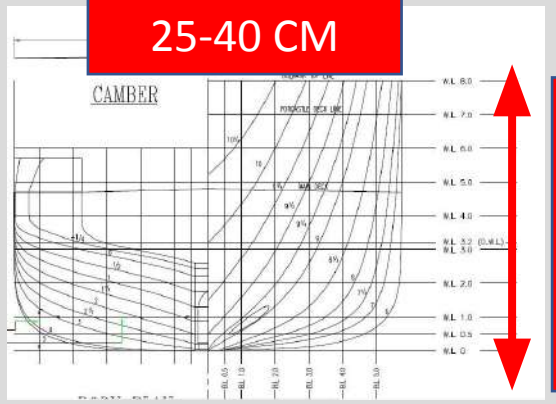
86 CM

130-160 CM



15-25 CM

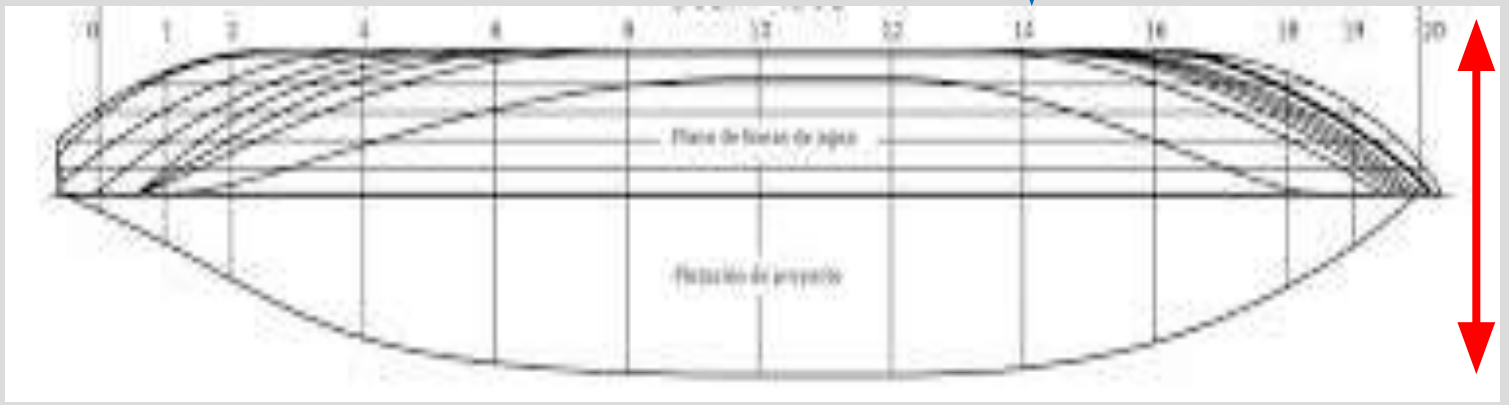
25-40 CM



15-25 CM

4-8 CM

4-8 CM



25-40 CM

Main Particulars

Offset Table

Title Block

•MAIN PARTICULARS

- Type LNG Carrier
- LOA 100m
- LPP 90m
- B 10m
- D 10m
- T 4m
- C_B 0.82
- Displacement 150000 T
- Speed 15 Knots
- STN SPACING 4.5 m
- WL SPACING 1 m

Title Block

DEPT. OF SHIP TECHNOLOGY					
Title	Lines Plan		Name	Royal Shippie	
Scale	1 : 200		Roll No.	007	

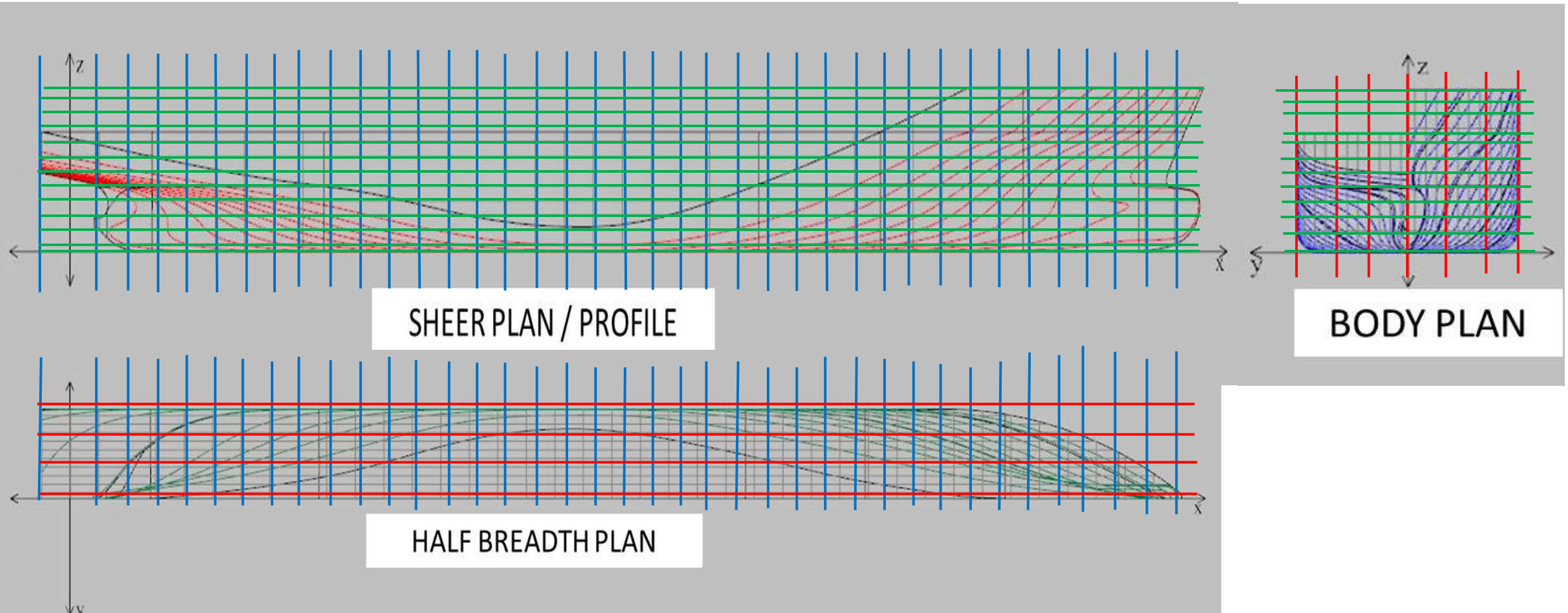
How to draw a Lines Plan

- Drawing of the Grid lines

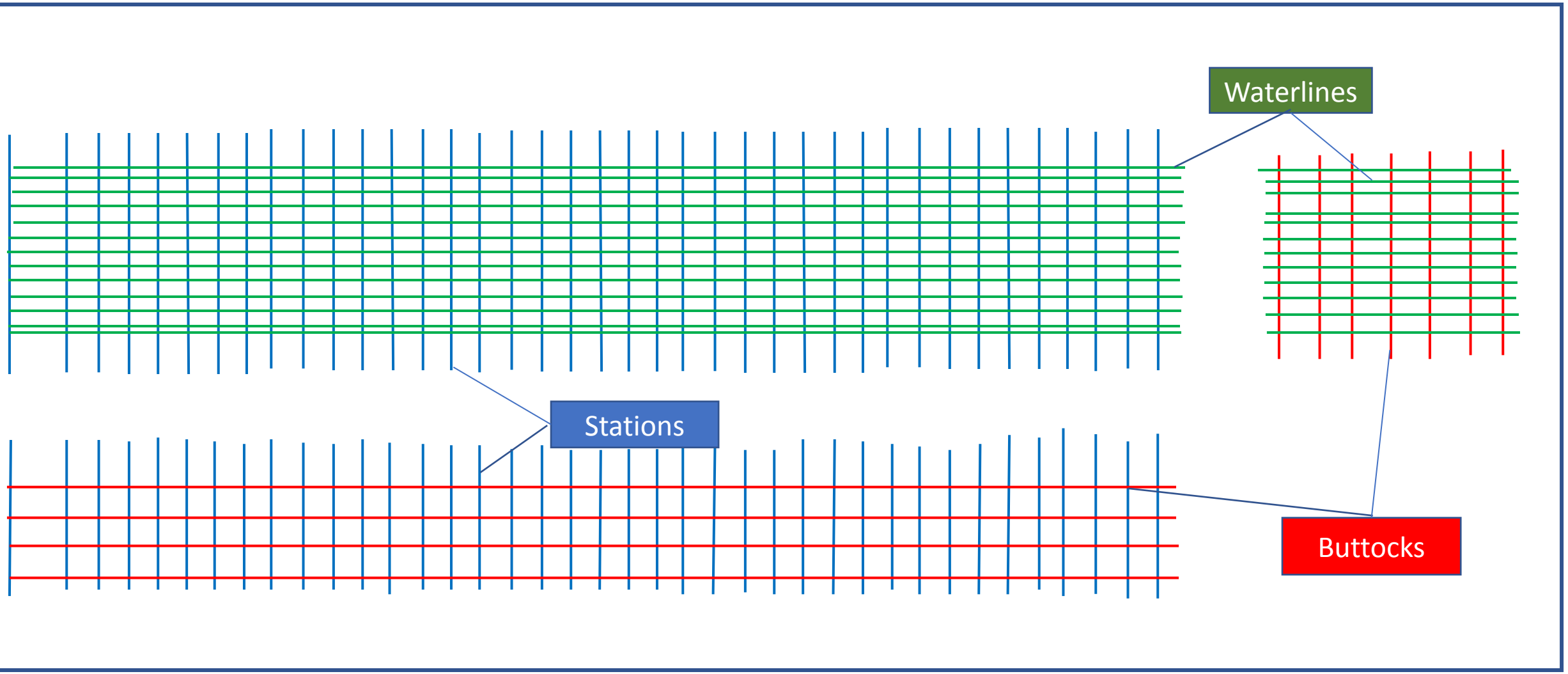
  - **Draw grid lines** for all three plans
    - Body Plan – Buttocks (Vertical) and Waterlines(horizontal)
    - Half Breadth Plan - Stations(Vertical) and Buttocks(horizontal)
    - Sheer Plan(Profile) - Stations(Vertical) and Waterlines(horizontal)

  - The grid lines must be drawn based on the station spacing, waterline spacing and buttock line spacing, as given .
    - LBP = 90m
    - No of stations = 20
    - Station Spacing = 90 / 20 = 4.5 m
    - Depth(D) = 10m
    - No of Waterlines = 10
    - WL Spacing = 1 m

Drawing Gridlines



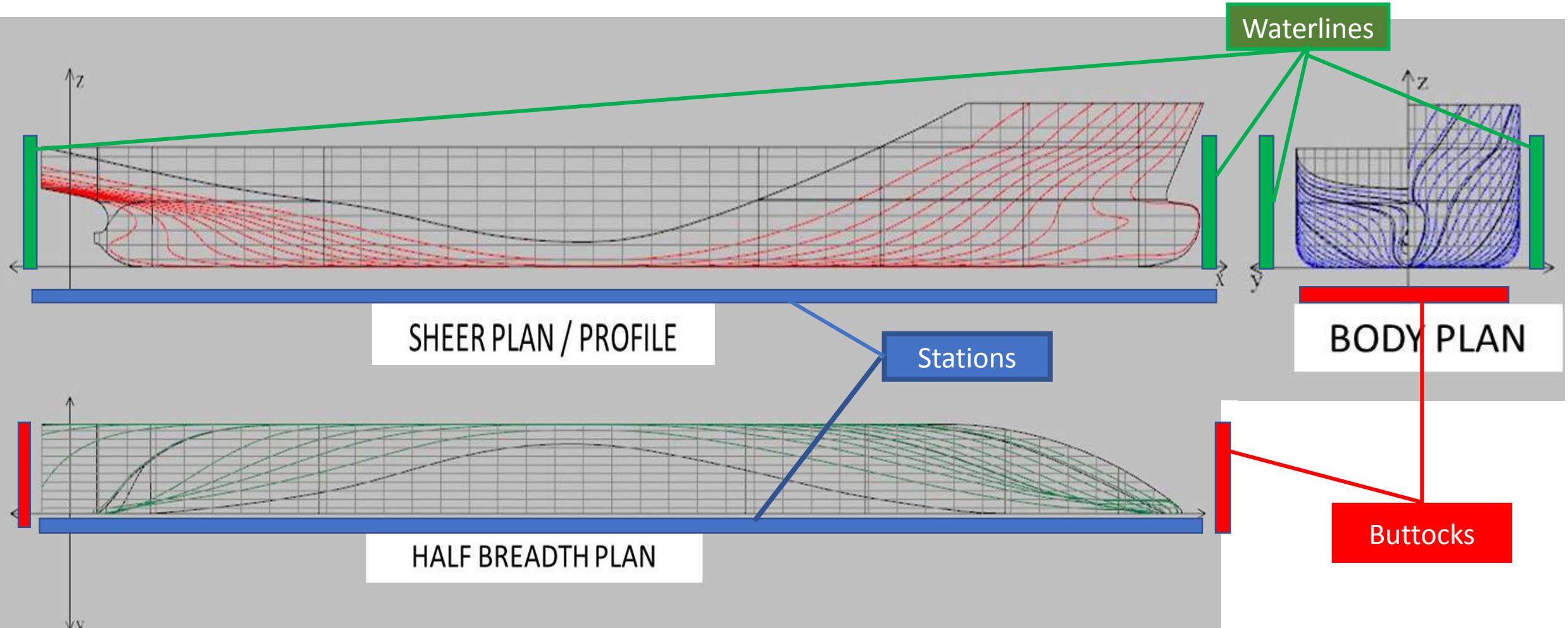
Drawing Gridlines



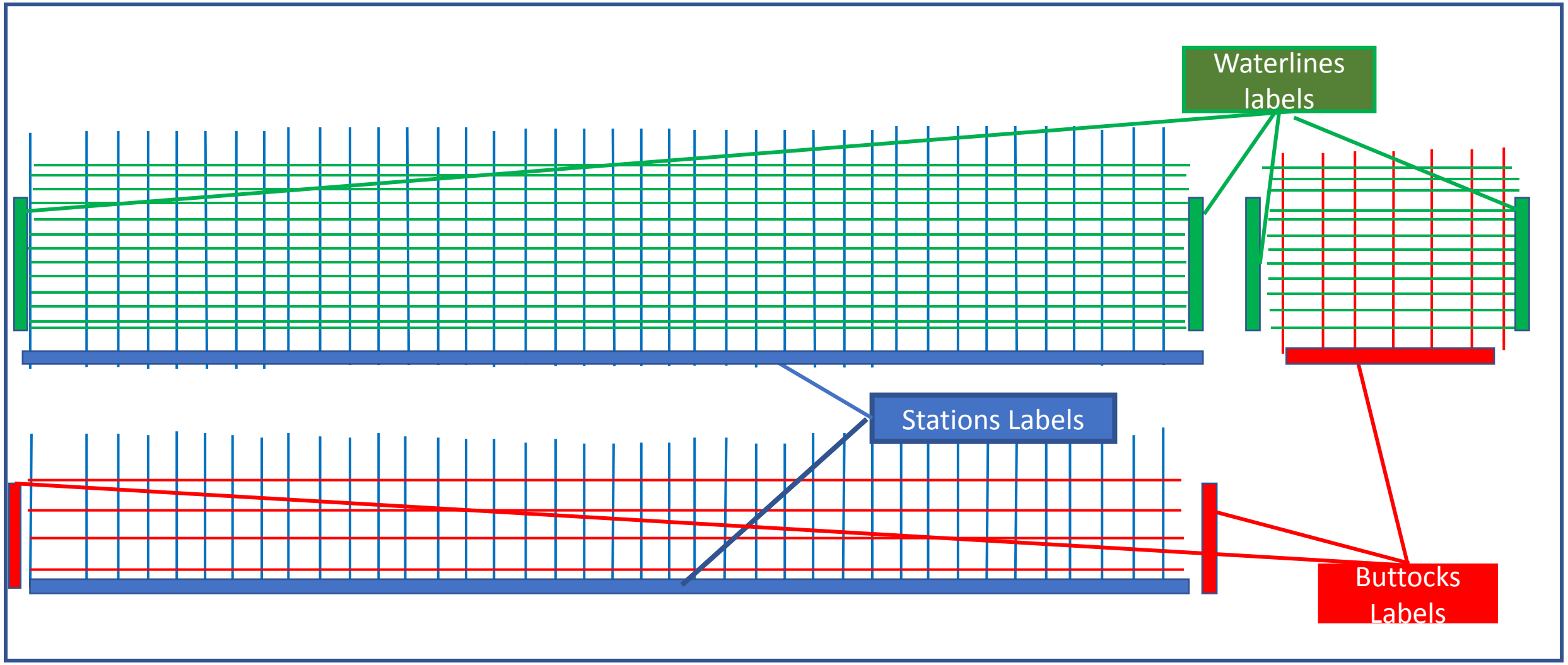
Labeling of the Grid lines

- Draw the Box for Main Particulars and Title Block
- Label the lines (on both sides of each view).
  - Waterlines – WL 0, WL 1, WL 2.. LWL,…MDK
  - Stations - STN 0, STN 1…
  - Buttocks - BTK 1, BTK 2
  - Centre Line - CL

Labeling of Grid Lines



Labeling Gridlines



Data Required for Drawing Lines Plan

- Select a Final Year Project Report for a conventional ship
  - Tanker, Bulk Carrier, Container, Cruise ship, General Cargo
- Take Photocopy of the relevant pages containing the following info:
  - Cover Page of Report (Name of Project, Type of ship, Year etc)
  - Final Main Dimensions (At the end of Chapter 2 –Preliminary Dimension Fixing)
  - Faired Offset Table (Chapter 3- Hull Geometry)
  - WaterLine Spacing and Station Spacing (Chapter 3 – Hull Geometry)
  - Stem Offsets
  - Stern Offsets
  - Keel Offsets
- All the above pages should be stapled and kept with each individual at all times during the drawing exercise and during evaluation by me.

END

- In case of any doubts you may contact me at

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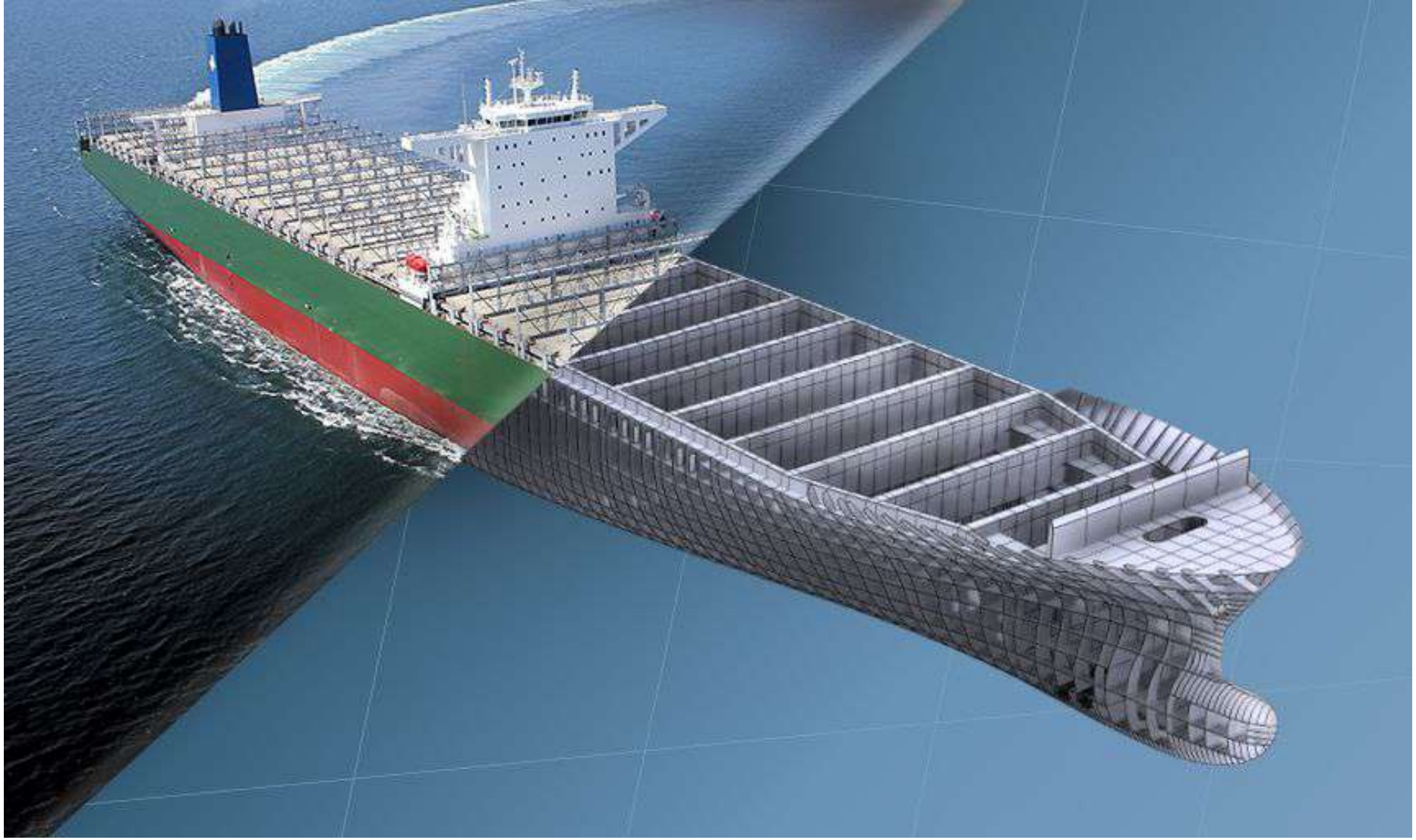
- Email : deepaksebastian.dost@gmail.com



Introduction to Naval Architecture

II SEM –Module 3

How to draw a Lines Plan

- **Data Required**

  - Main Dimensions
  - WL , STN and BTK numbers and spacing
  - Final Offset Table
  - Stem and Stern Offsets
  - Keel Offsets

How to draw a Lines Plan

- **Steps**

  - Decide Scale of Drawing
  - Scale Offset Table and other offset values to the decided scale
  - Draw Body Plan
  - Draw Half Breadth Plan
  - Draw Sheer Plan
  - Draw Stem and Stern Profiles
  - Fairing

Decide Scale of Drawing

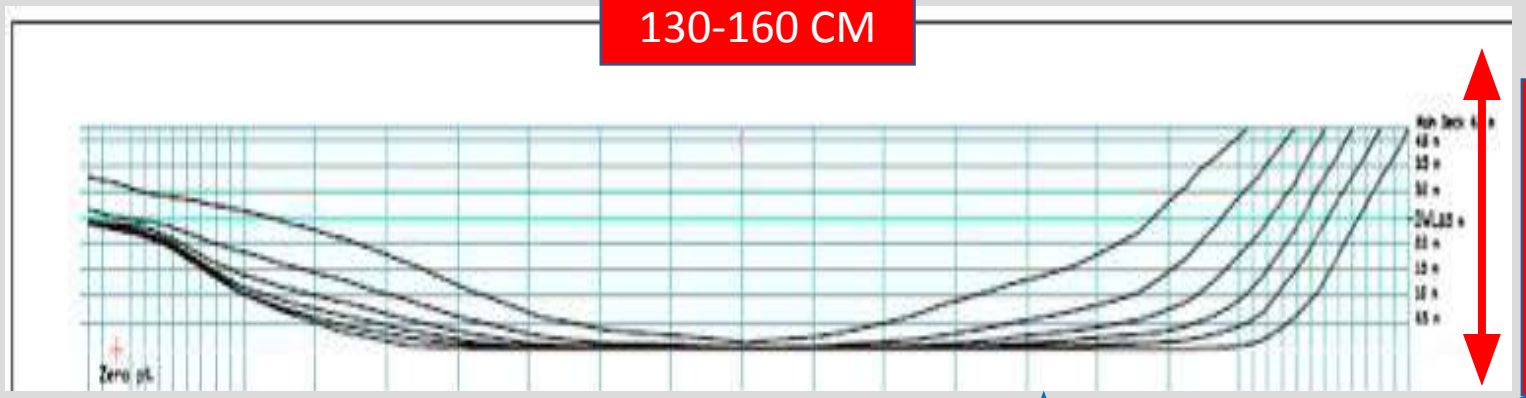
- Given :
  - D = 14 m
  - WL Spacing : 2 m
  - L_{PP} = 70 m
  - STN Spacing : 3.5 m
  - B = 20m
  - BTK Spacing : 2.5
- Say, Scale chosen – 1:50
  - Then , on drawing
  - D = 14/50 = 0.28 m = 28 cm = 280 mm
  - WL Spacing = 2/50 = 0.04 m = 4 cm = 40 mm
  - L = 70 /50 = 1.4 m = 140 cm = 1400 mm
  - STN Spacing = 3.5/50 = 0.07m =7 cm =70 mm
  - B = 20 /50 = 0.4 m = 40 cm = 400 mm
  - BTK Spacing = 2.5 /50 = 0.05m = 5 cm = 50 mm

- Once scale is decided, scale down all values in the Offset table to match your scale.

200 CM

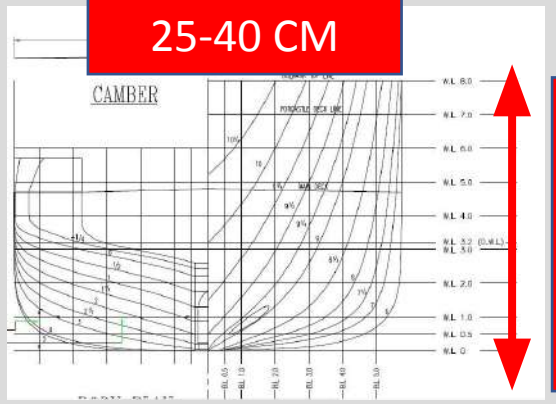
86 CM

130-160 CM



15-25 CM

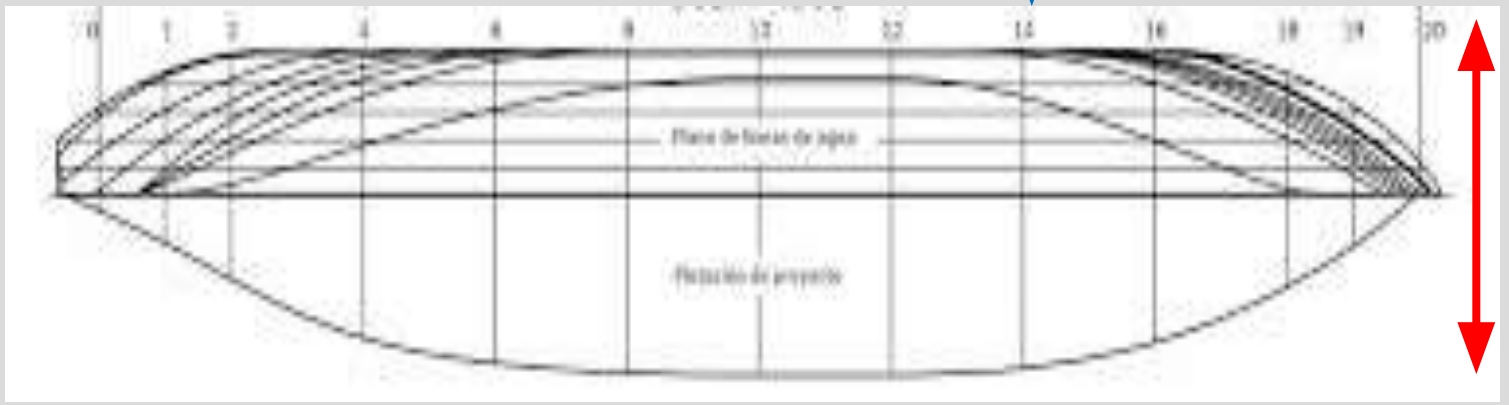
25-40 CM



15-25 CM

4-8 CM

4-8 CM



25-40 CM

Main Particulars

Offset Table

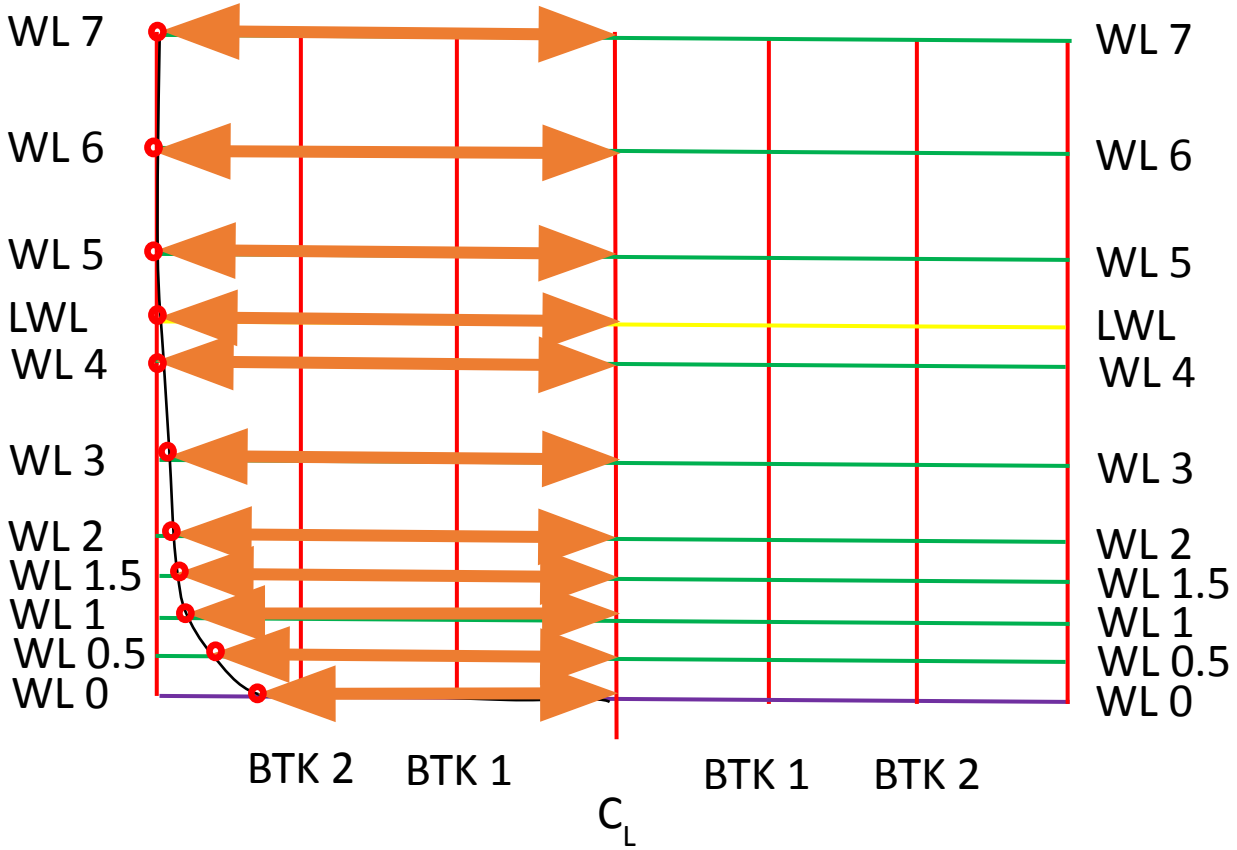
Title Block

Scale Offset Table to Decided Scale

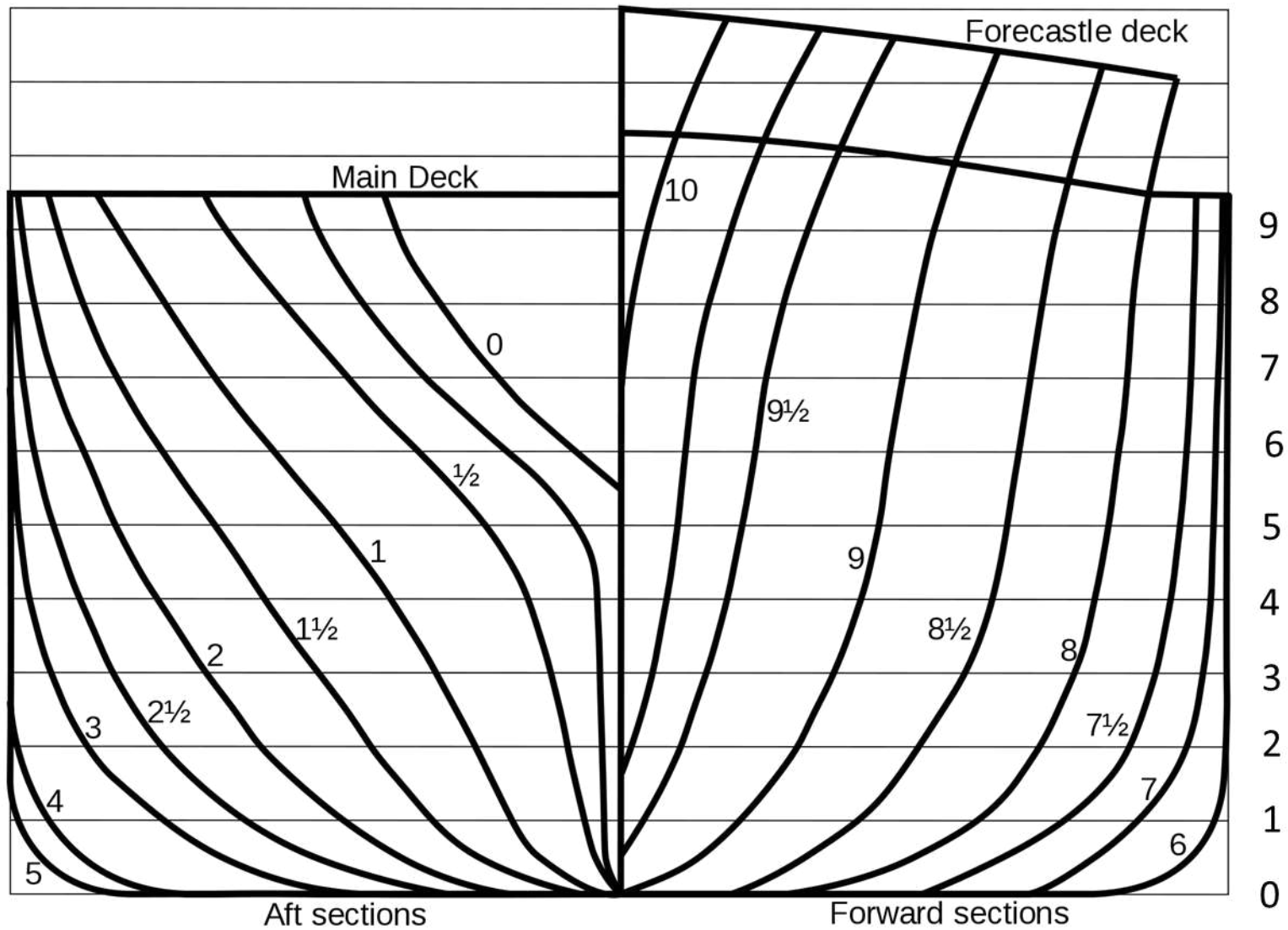
STN/WL	0	0.5	1	1.5	2	3	4	5	6	7	LWL	8	9	10
0										1.69	2.31	2.75	3.42	3.84
0.5									1.82	3.38	3.88	4.26	4.89	5.31
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46	4.58	5.09	5.45	6.08	6.45
1.5	0.28	1.08	1.39	1.69	1.96	2.5	3.1	3.78	4.74	5.75	6.2	6.5	7.04	7.45
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32	6.9	7.2	7.44	7.96	8.35
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79	8.3	8.51	8.72	9.08	9.31
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09	9.39	9.49	9.59	9.74	9.84
5	5.48	6.79	7.6	8.27	8.54	9.05	9.47	9.69	9.81	9.93	9.99	10	10	10
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10	10	10	10	10
7	6.98	8.95	9.5	9.79	9.97	10	10	10	10	10	10	10	10	10
8	7.05	9.38	9.8	9.98	10	10	10	10	10	10	10	10	10	10
14	8.57	9.41	9.72	9.91	9.99	10	10	10	10	10	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.98	10	10	10	10	10	10	10	10
16	7.2	8	8.55	8.94	9.21	9.54	9.7	9.8	9.89	9.92	9.95	9.99	10	10
17	5.02	6.62	7.12	7.55	7.91	8.41	8.69	8.88	9.01	9.13	9.23	9.31	9.45	9.6
18	2.67	4.65	5.34	5.71	6.03	6.51	6.82	7.01	7.13	7.27	7.4	7.57	7.9	8.24
18.5	1.58	3.4	4.01	4.45	4.72	5.19	5.39	5.55	5.71	5.91	6.05	6.2	6.61	7.05
19	0.6	2.25	2.72	3.1	3.38	3.7	3.79	3.87	4	4.21	4.39	4.52	4.91	5.32
19.5	0.3	1.41	1.81	2.11	2.31	2.4	2.15	1.9	1.84	1.98	2.11	2.28	2.7	3.23
20	0	0.84	1.21	1.4	1.48	1.32	1.04	0.7	0.32	0.06	0	0.03	0.3	0.72

Drawing Body Plan

WL	0	0.5	1	1.5	2	3	4	5	6	7 (MDK)
STN										
6 (m)	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10
(cm)	12.38	16.1	17.6	18.54	19.04	19.7	19.84	20	20	20



- Draw the station curve
- Using a batten and French curves
- Check continuity and smoothness of the curve
- Similarly draw all station curves
- For stations that do not intersect all waterlines, the keel offset value will indicate where it ends on the Centre line


Forecastle deck
Main Deck
10
9
8
7
6
5
4
3
2
1
0
9½
½
1
9
1½
8½
2
8
2½
7½
3
7
4
6
5
Aft sections
Forward sections

How to draw a Lines Plan

- **How to Draw Body Plan**

  - **Select one station** (it is good practice to start from midship station).
  - For this station **mark the offset data on each waterline** on the body plan grid.
  - Using **ship curve** draw a station curve by connecting these offsets mark.
  - Make sure the **curve drawn is smooth and fair**.
  - Repeat this step for **other stations**.
  - Label the station number accordingly.
  - Now your body plan is almost completed.

END

- In case of any doubts you may contact me at

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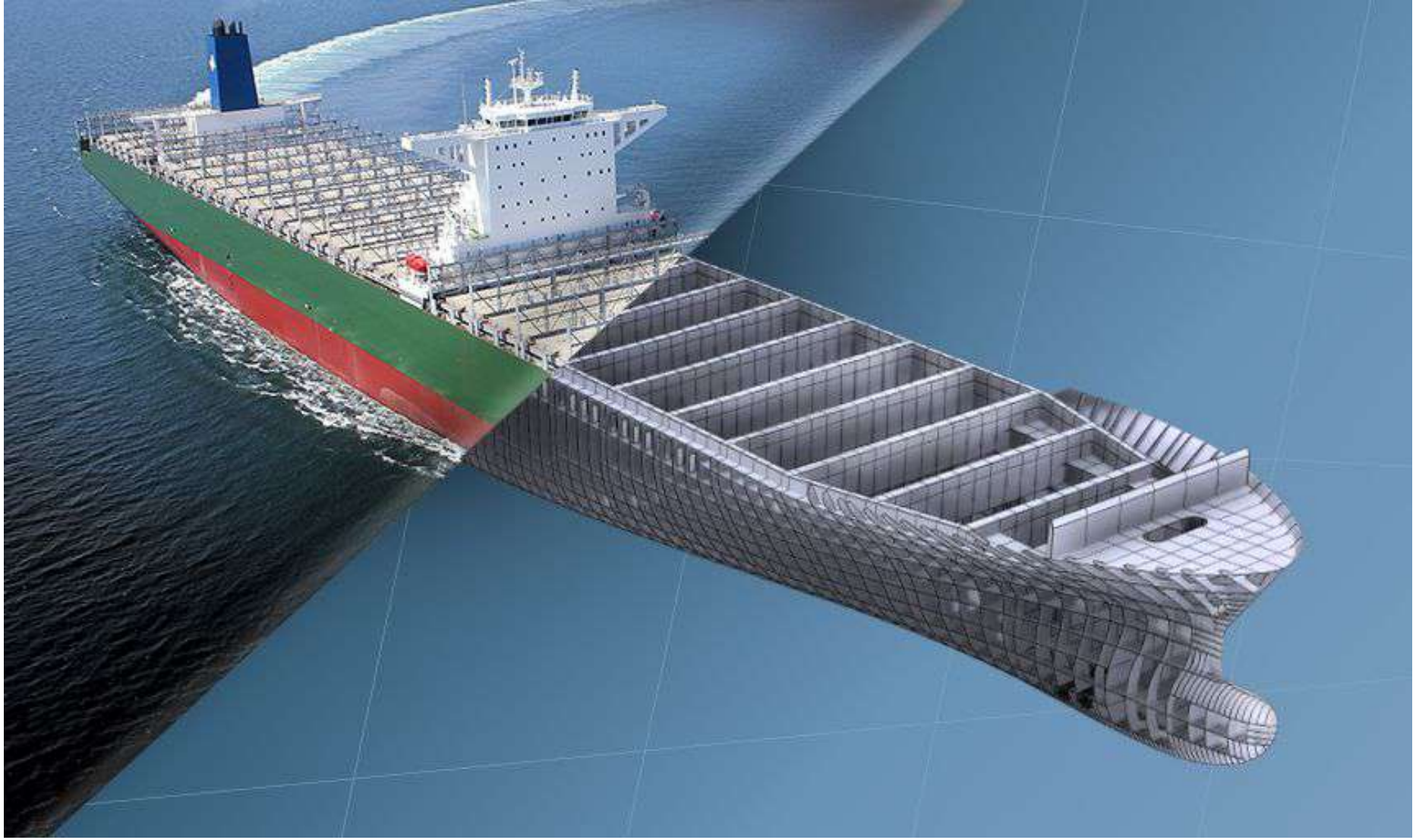
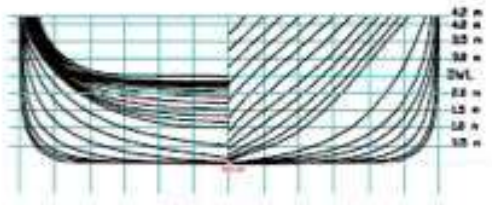


Introduction to Naval Architecture

II SEM –Module 3

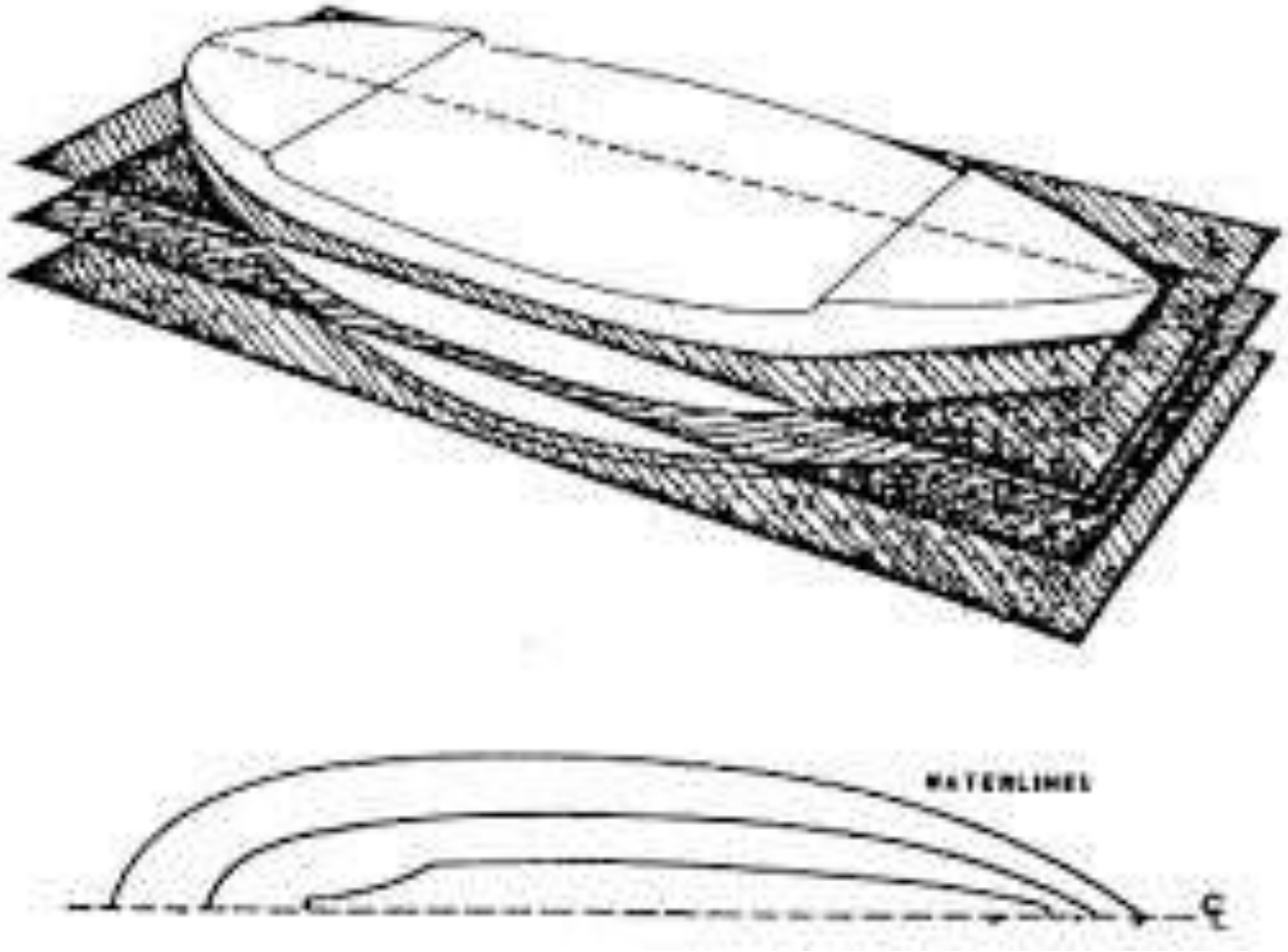
SHEER PLAN
(PROFILE)



BODY PLAN

HALF BREADTH PLAN

Half Breadth Plan



WATERLINE

Offset Value at Different Stations

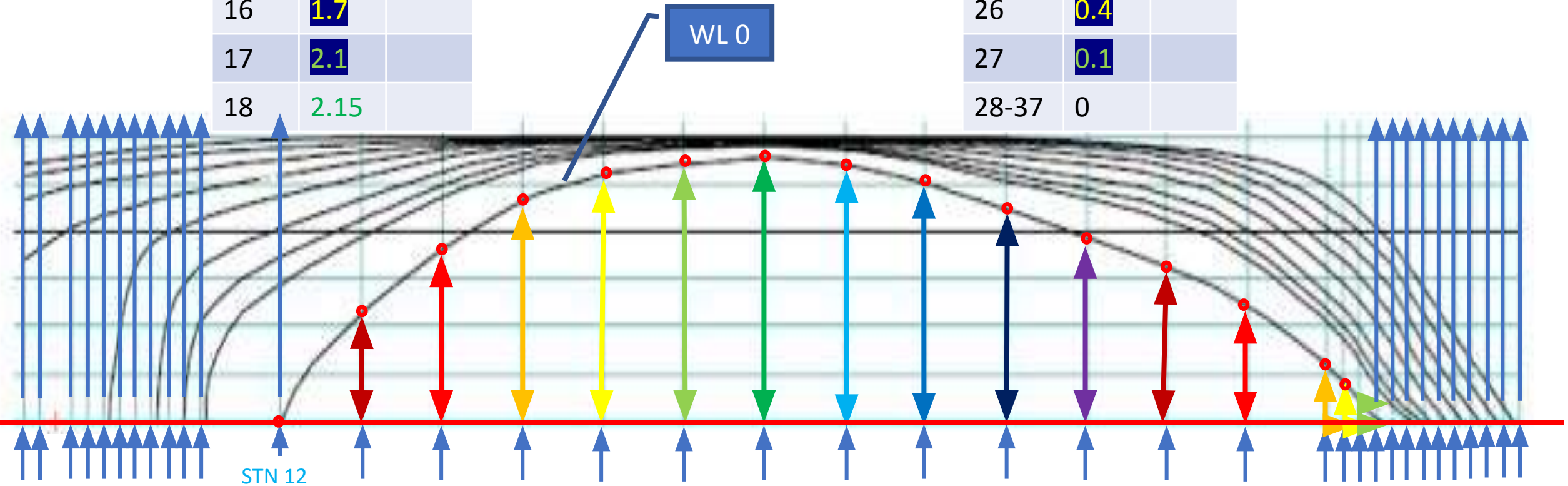
STATION

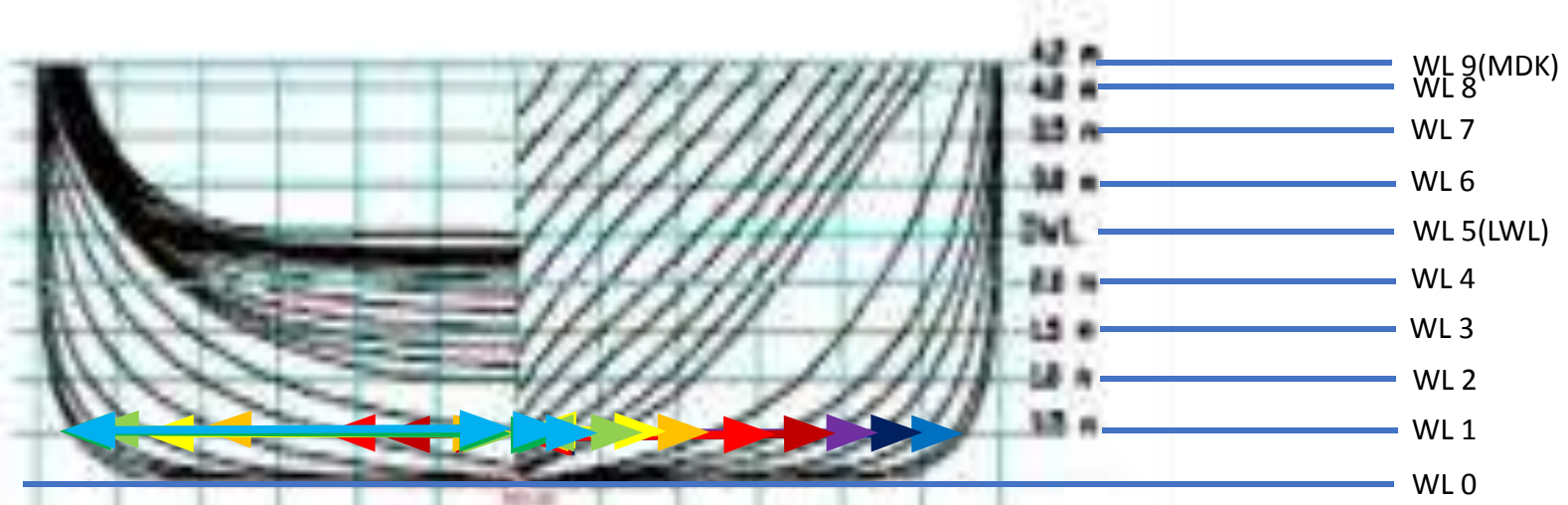
Offset Value at Different Waterlines

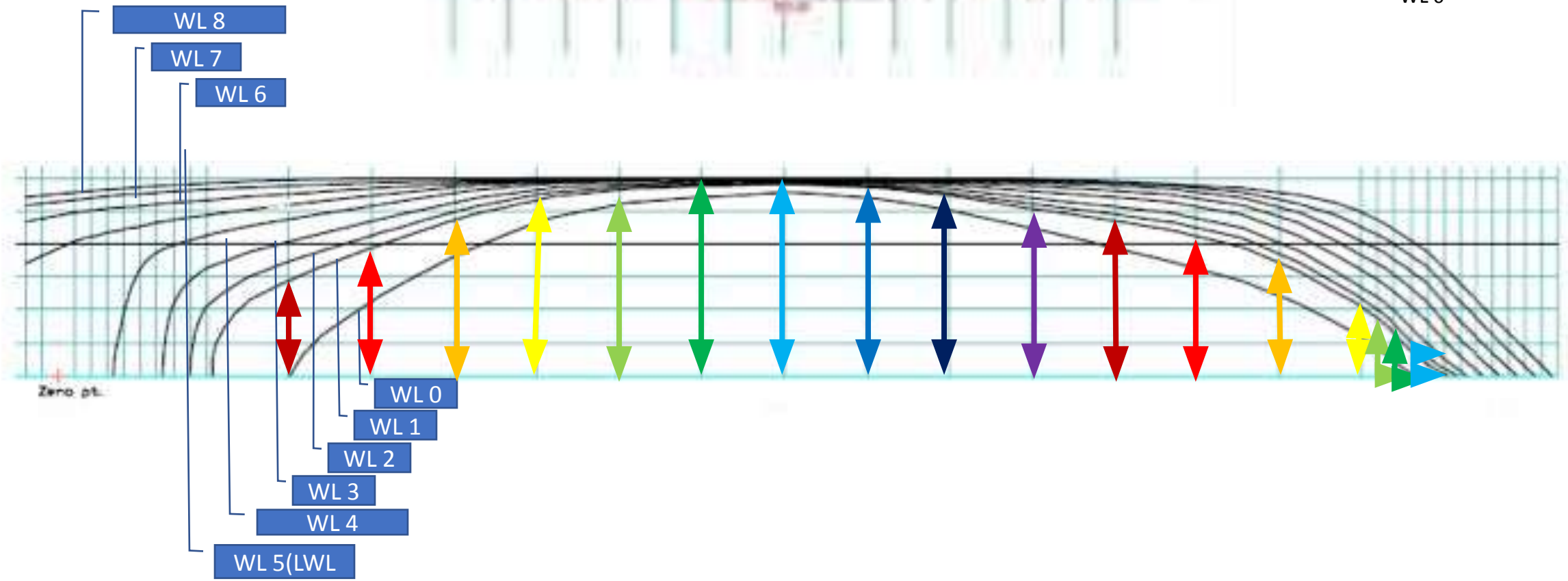
STN/WL	0	0.5	1	1.5	2	3	4	5	6	7	LWL	8	9	10
0										1.69	2.31	2.75	3.42	3.84
0.5									1.82	3.38	3.88	4.26	4.89	5.31
1	0.1	0.5	0.68	0.81	0.94	1.24	1.6	2.31	3.46	4.58	5.09	5.45	6.08	6.45
1.5	0.28	1.08	1.39	1.69	1.95	2.5	3.1	3.78	4.74	5.75	6.2	6.5	7.04	7.45
2	1.04	1.5	2.31	2.76	3.2	4.05	4.88	5.61	6.32	6.9	7.2	7.44	7.96	8.35
3	2.5	3.05	3.95	4.6	5.08	5.9	6.64	7.22	7.79	8.3	8.51	8.72	9.08	9.31
4	3.92	5.1	6.04	6.58	7.03	7.78	8.29	8.78	9.09	9.39	9.49	9.59	9.74	9.84
5	5.48	6.79	7.6	8.27	8.54	9.05	9.47	9.69	9.81	9.93	9.99	10	10	10
6	6.19	8.05	8.8	9.27	9.52	9.85	9.92	10	10	10	10	10	10	10
7	6.98	8.95	9.5	9.79	9.97	10	10	10	10	10	10	10	10	10
8	7.05	9.38	9.8	9.98	10	10	10	10	10	10	10	10	10	10
14	8.57	9.41	9.72	9.91	9.99	10	10	10	10	10	10	10	10	10
15	8.28	9	9.47	9.71	9.82	9.96	10	10	10	10	10	10	10	10
16	7.2	8	8.55	8.94	9.21	9.54	9.7	9.8	9.89	9.92	9.95	9.99	10	10
17	5.02	6.62	7.12	7.55	7.91	8.41	8.69	8.88	9.01	9.13	9.23	9.31	9.45	9.6
18	2.67	4.65	5.34	5.71	6.03	6.51	6.82	7.01	7.13	7.27	7.4	7.57	7.9	8.24
18.5	1.58	3.4	4.01	4.45	4.72	5.19	5.39	5.55	5.71	5.91	6.05	6.2	6.61	7.05
19	0.6	2.25	2.72	3.1	3.38	3.7	3.79	3.87	4	4.21	4.39	4.52	4.91	5.32
19.5	0.3	1.41	1.81	2.11	2.31	2.4	2.15	1.9	1.84	1.98	2.11	2.28	2.7	3.23
20	0	0.84	1.21	1.4	1.48	1.32	1.04	0.7	0.32	0.06	0	0.03	0.3	0.72

STN	WL 0	WL 1
0	0	
1	0	
2	0	
3-12	0	
13	0.9	
14	1.3	
15	1.5	
16	1.7	
17	2.1	
18	2.15	

STN	WL 0	WL 1
19	2.05	
20	1.9	
21	1.7	
22	1.5	
23	1.4	
24	1.1	
25	0.5	
26	0.4	
27	0.1	
28-37	0	




WL 9(MDK)
WL 8
WL 7
WL 6
WL 5(LWL)
WL 4
WL 3
WL 2
WL 1
WL 0


WL 8
WL 7
WL 6
WL 0
WL 1
WL 2
WL 3
WL 4
WL 5(LWL
Zero pt.

END

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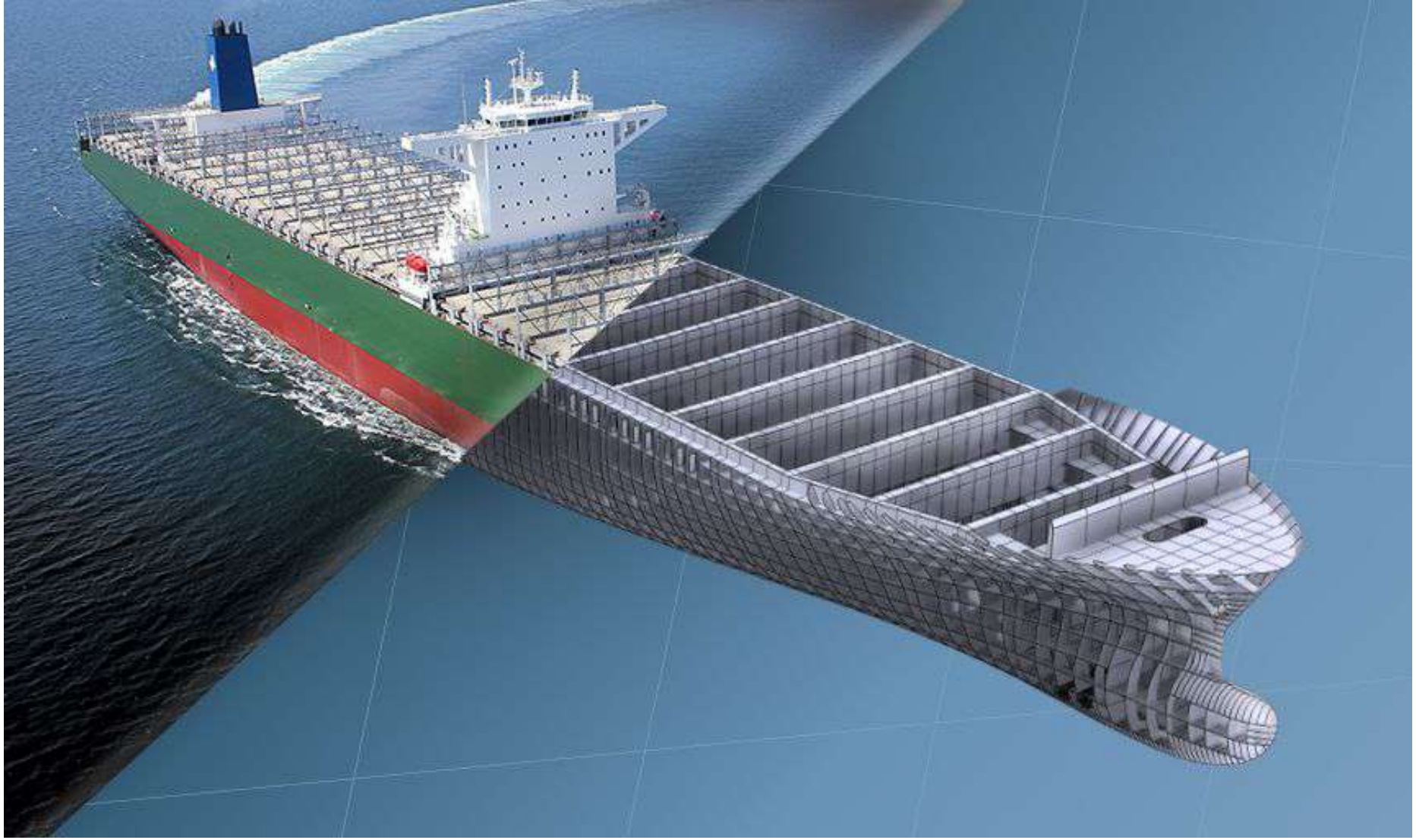


Introduction to Naval Architecture

II SEM –Module 3

2020 Course Content

Course Content

1. **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).
2. **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)

3. **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.

4. **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.

5. **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.

Module 3 _ Introduction to Bonjean and Hydrostatics Curves

- Integration rules :
  - Trapezoidal rule
  - Simpson’s rules
  - ~~6 ordinate rule~~
  - ~~Tchebycheff’s rule~~
  - Areas
  - Volumes
  - Moments
- Bonjean Calculations & Curves
- Sectional Area Curves
- Hydrostatics Calculations and Curves

Hull Form defined… Now What?

- We have a hull form now. What can we use it for?
- Preliminary Design Calculations
- Evaluation of characteristics and parameters of the hull form
- HYDROSTATIC PARAMETERS
- HYDRO and STATIC

What parameters do we need?

- Volume of the displaced fluid =
- Submerged volume of the ship
- Mass/Weight of the displaced fluid = Mass/Weight of the ship
- Through which point does the buoyant force act?
- Starting Point - Volume and Centroid of the submerged volume
  - How do I find this out?

Analytical Integration Methods

- To find out volume we can integrate cross sectional area
- For shapes having boundaries that can be defined by known curves (line, circle etc.) it can be done analytically

$$V_{\text{cylinder}} = \int_a^b A(x)\,dx$$

$$= \int_0^h \pi r^2\,dx$$

$$= \pi r^2 \int_0^h dx$$

$$= \pi r^2 x\Big|_{x=0}^{h}$$

$$= \pi r^2 (h-0)$$

$$= \pi r^2 h$$

$$V_{\text{cone}} = \int_0^h \pi \left(\frac{r}{h}x\right)^2 dx$$

$$= \frac{\pi r^2}{h^2}\int_0^h x^2\,dx$$

$$= \frac{\pi r^2}{h^2}\left[\frac{1}{3}x^3\right]_0^h$$

$$= \frac{\pi r^2}{h^2}\cdot\frac{1}{3}h^3$$

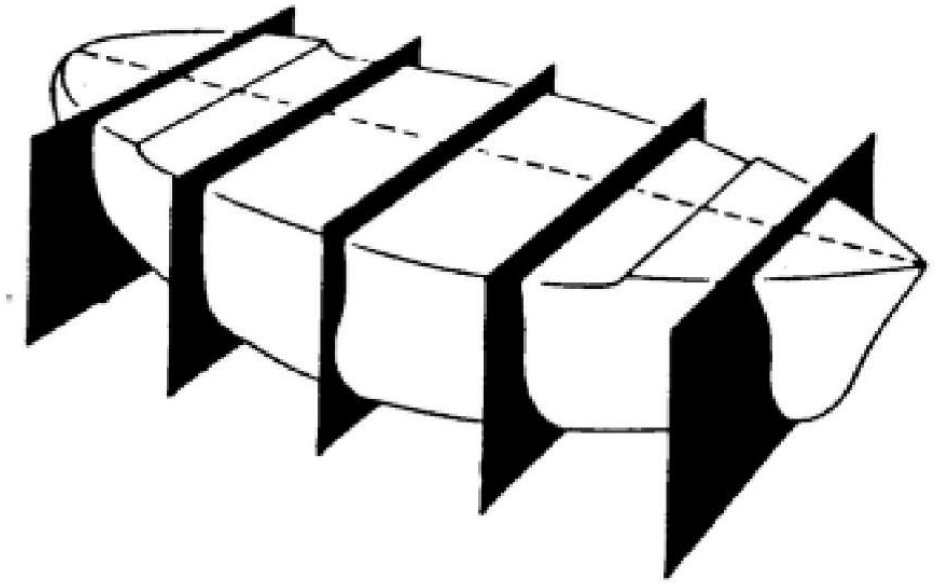
$$= \frac{1}{3}\pi r^2 h$$

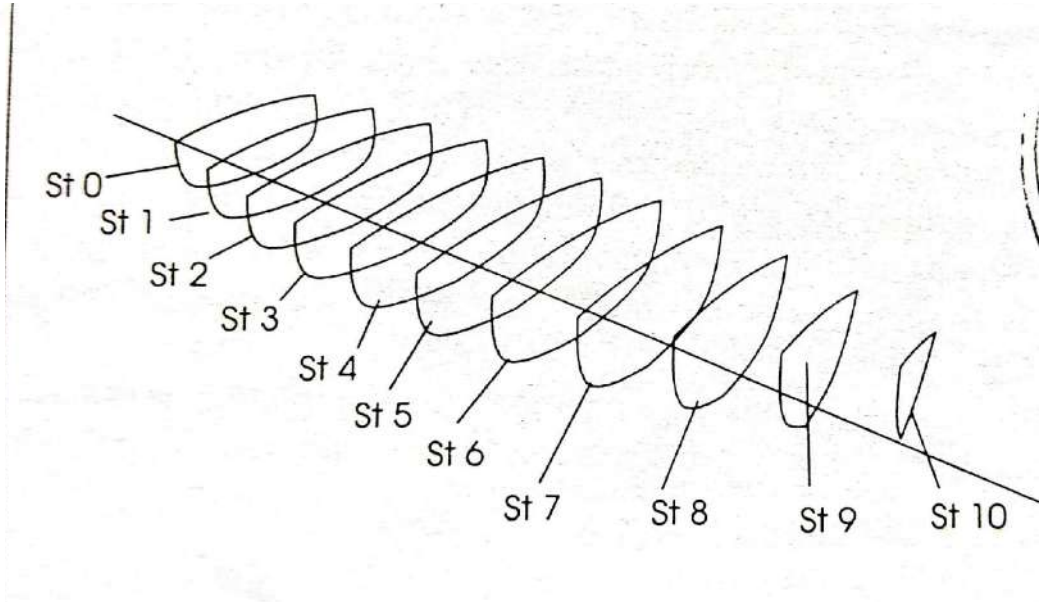
- To find out centroid of volume etc, we also need to calculate
  - Areas
  - Moments of area
  - Moments of inertia
- But curves of hull form are not easily defined
  - Higher order (more than cubic) curves
- No definition of hull surface in terms of calculatable mathematical functions.
- Integration cannot be carried by analytical methods
- Numerical Integration is used
  - Approximation of values
  - Scope for Error exists

To find the volume of a ship?

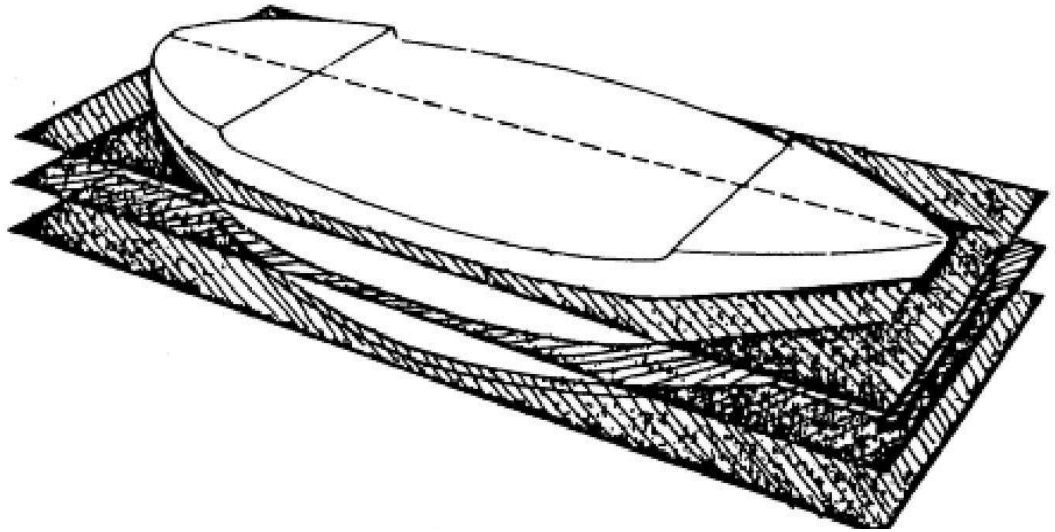
- Integrate
  - Cross sectional areas along the Length
  - Waterplane areas along the Depth
  - Profile areas along the Breadth

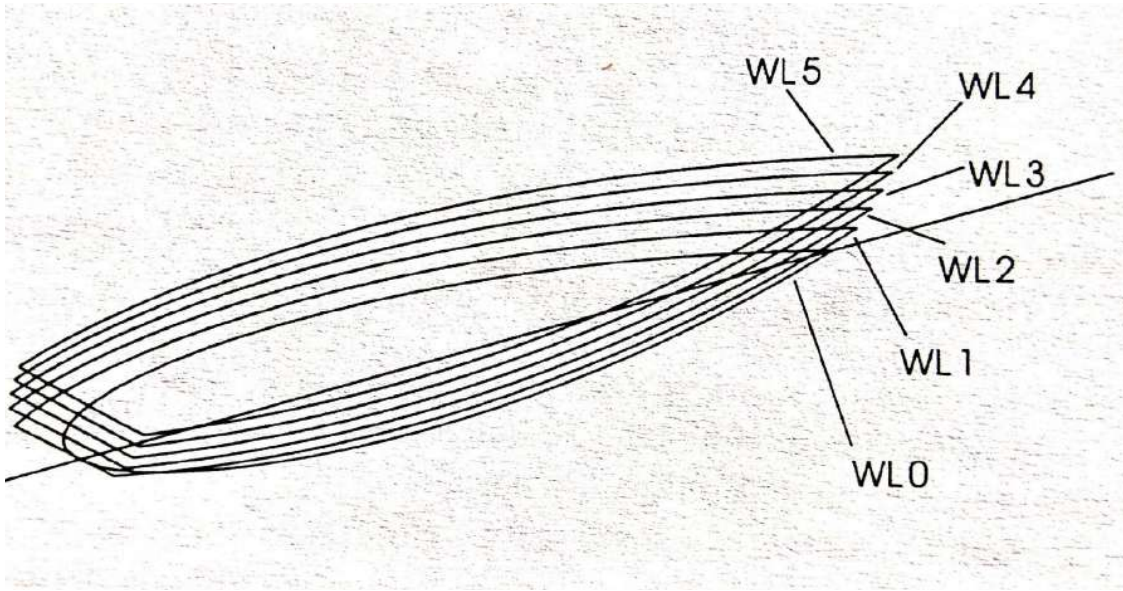
- Cross sectional areas along the Length



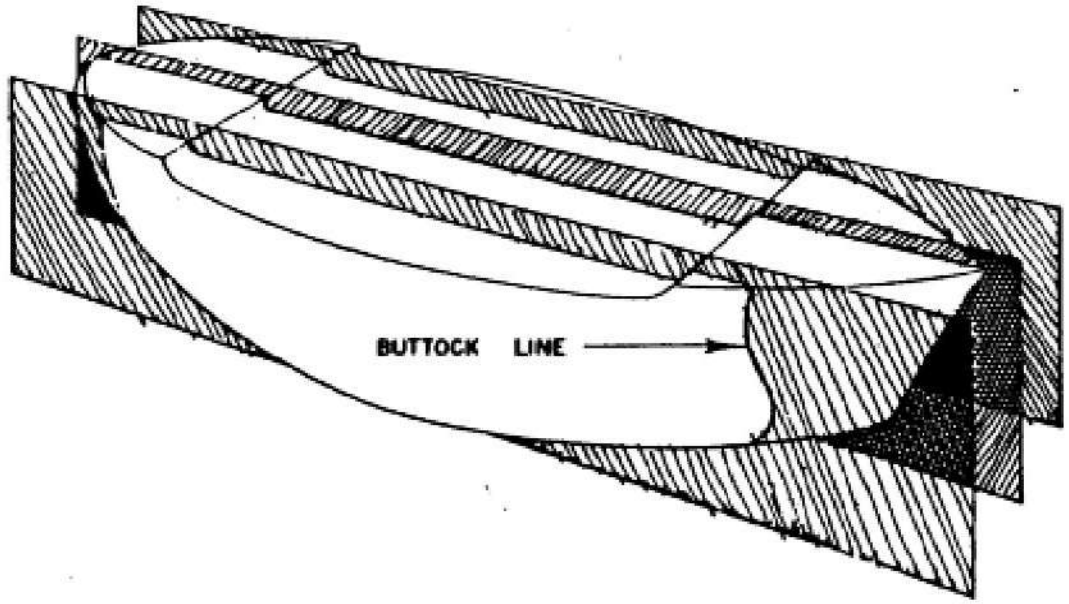


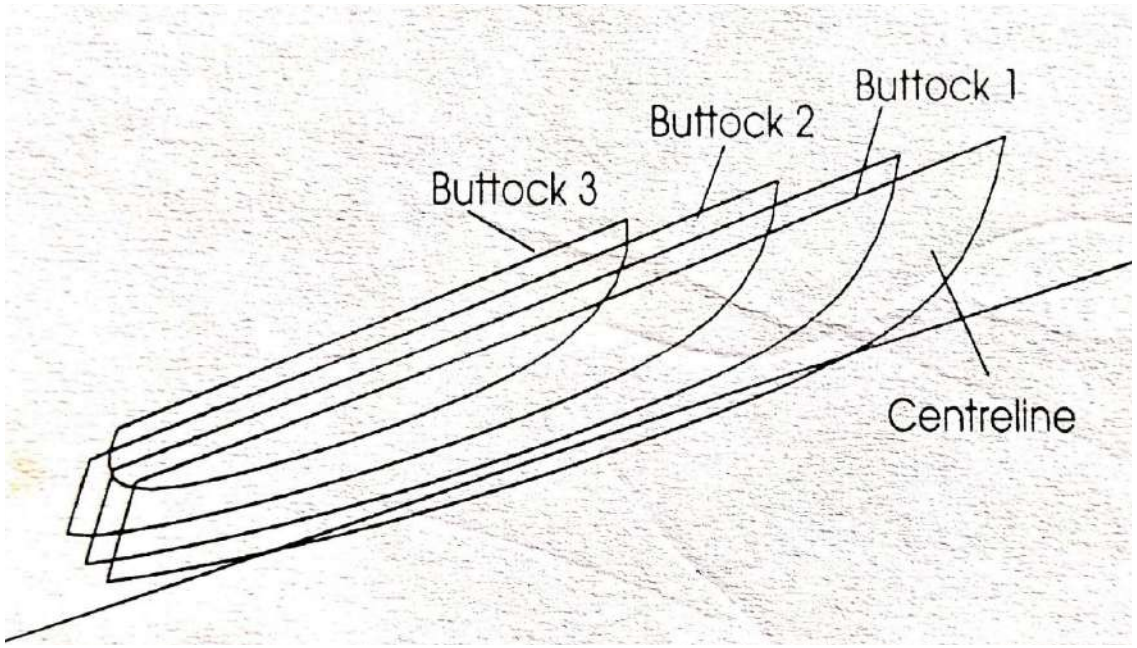
- Waterplane areas along the Depth





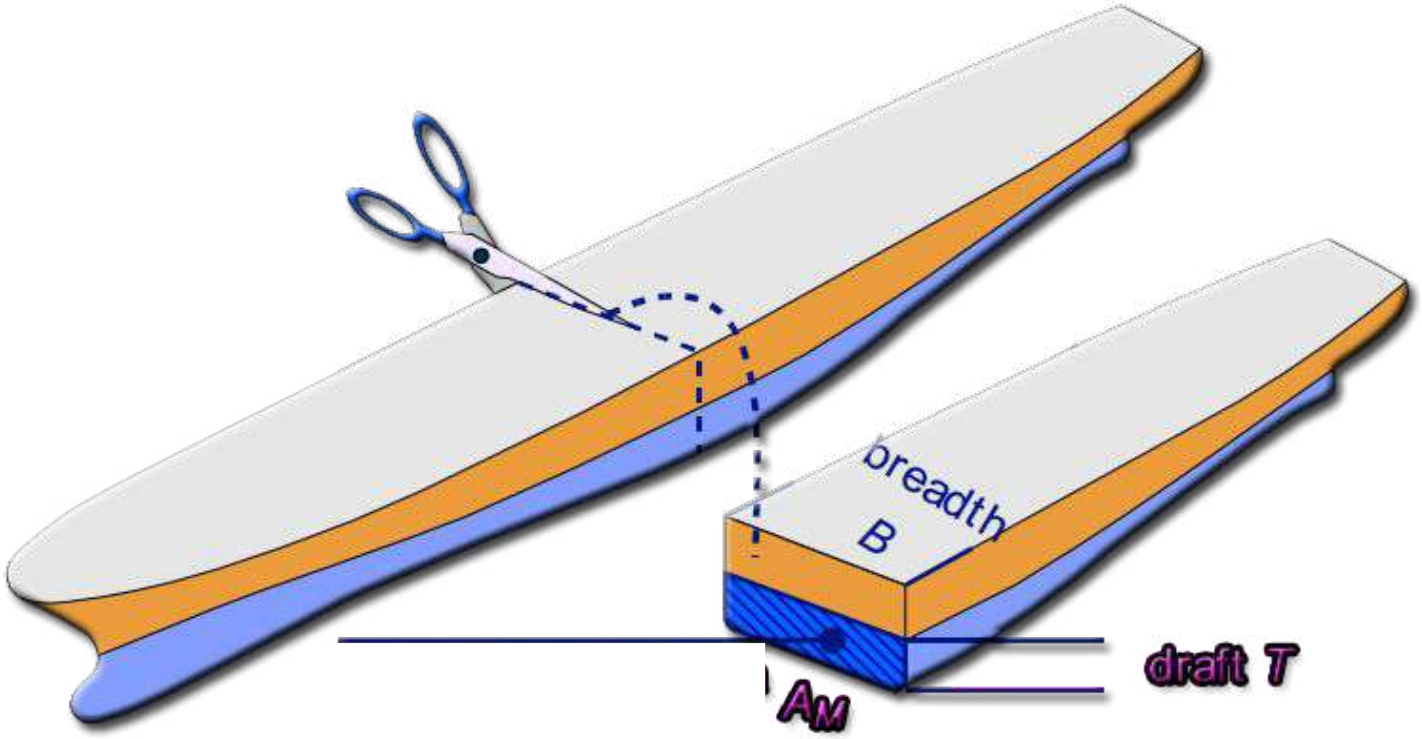
- Profile areas along the Breadth



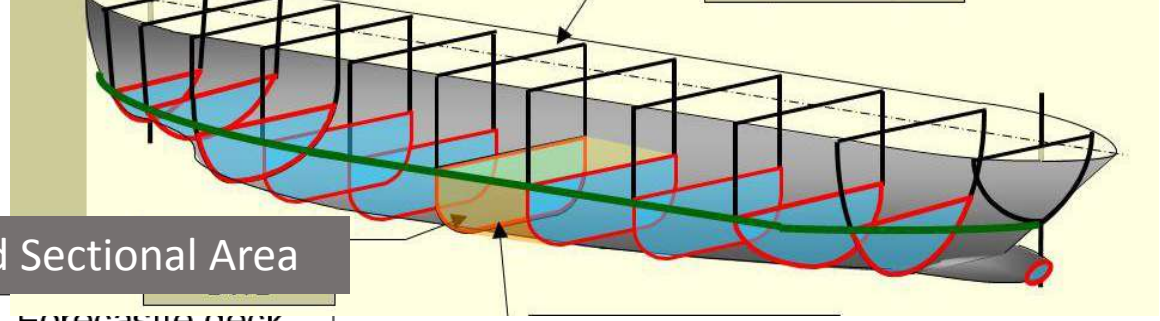


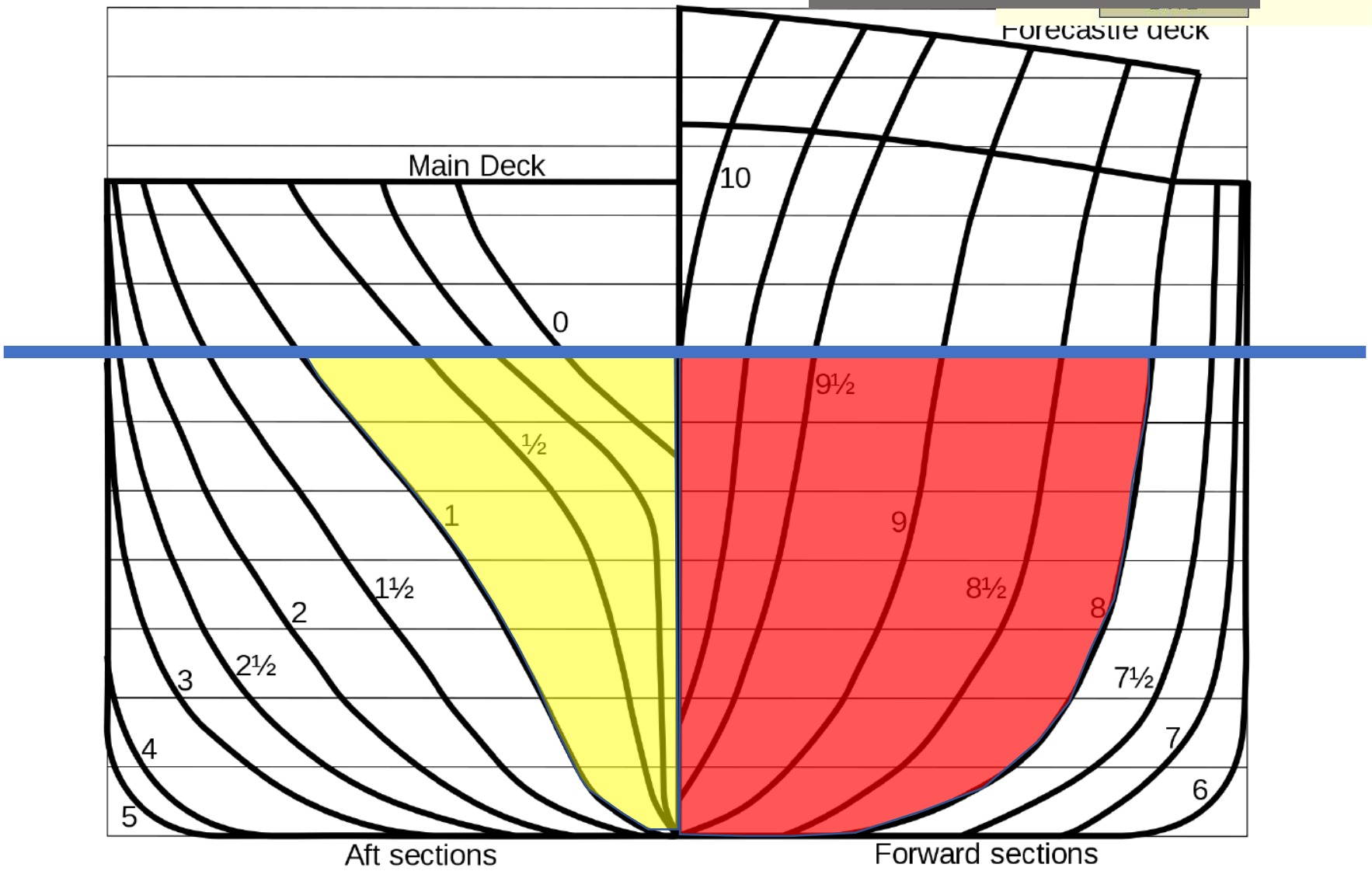
Cross Sectional Area

- How to find Cross Sectional Area?



Cross Sectional Area

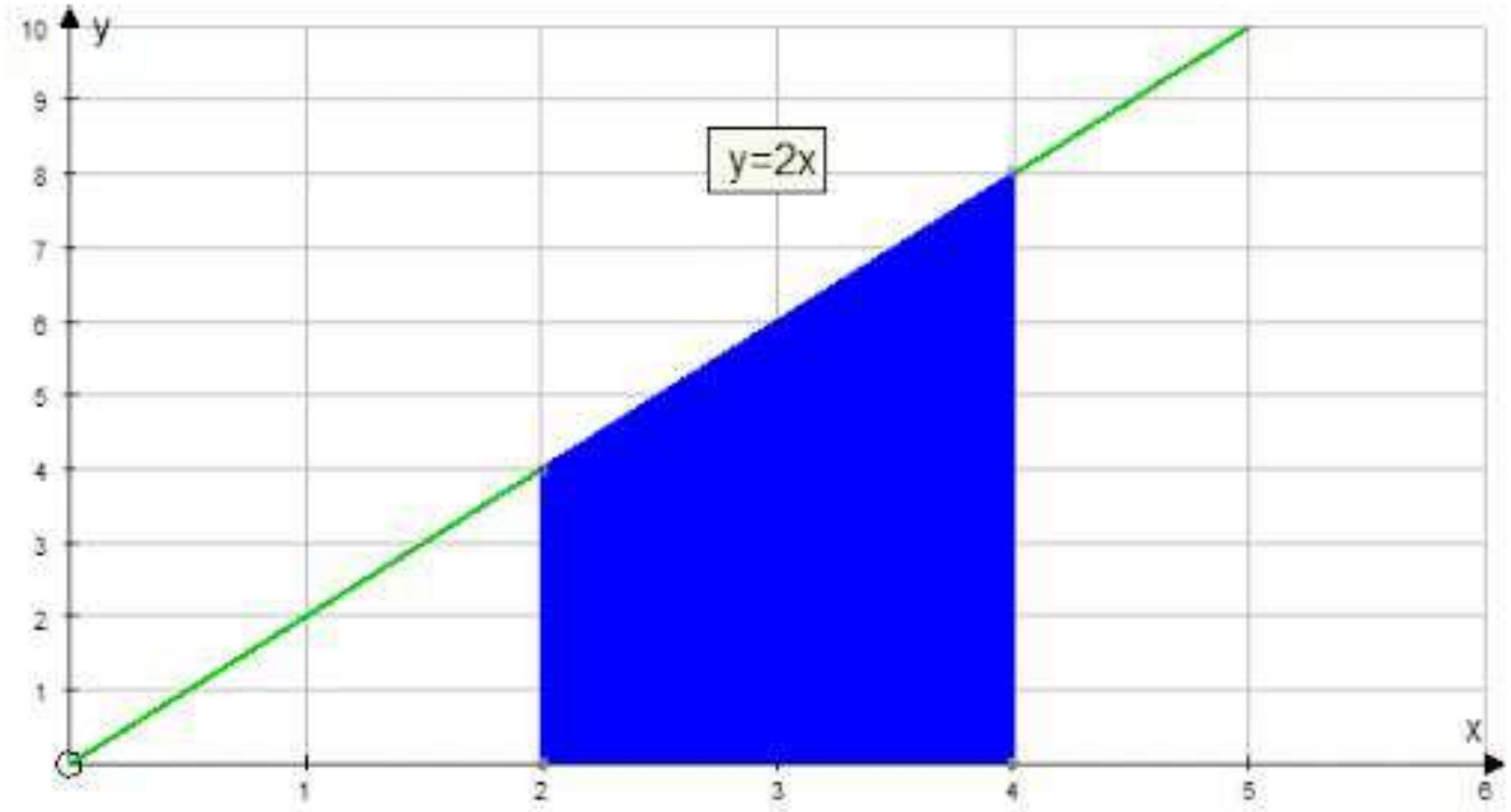




Ways to calculate the area under a curve

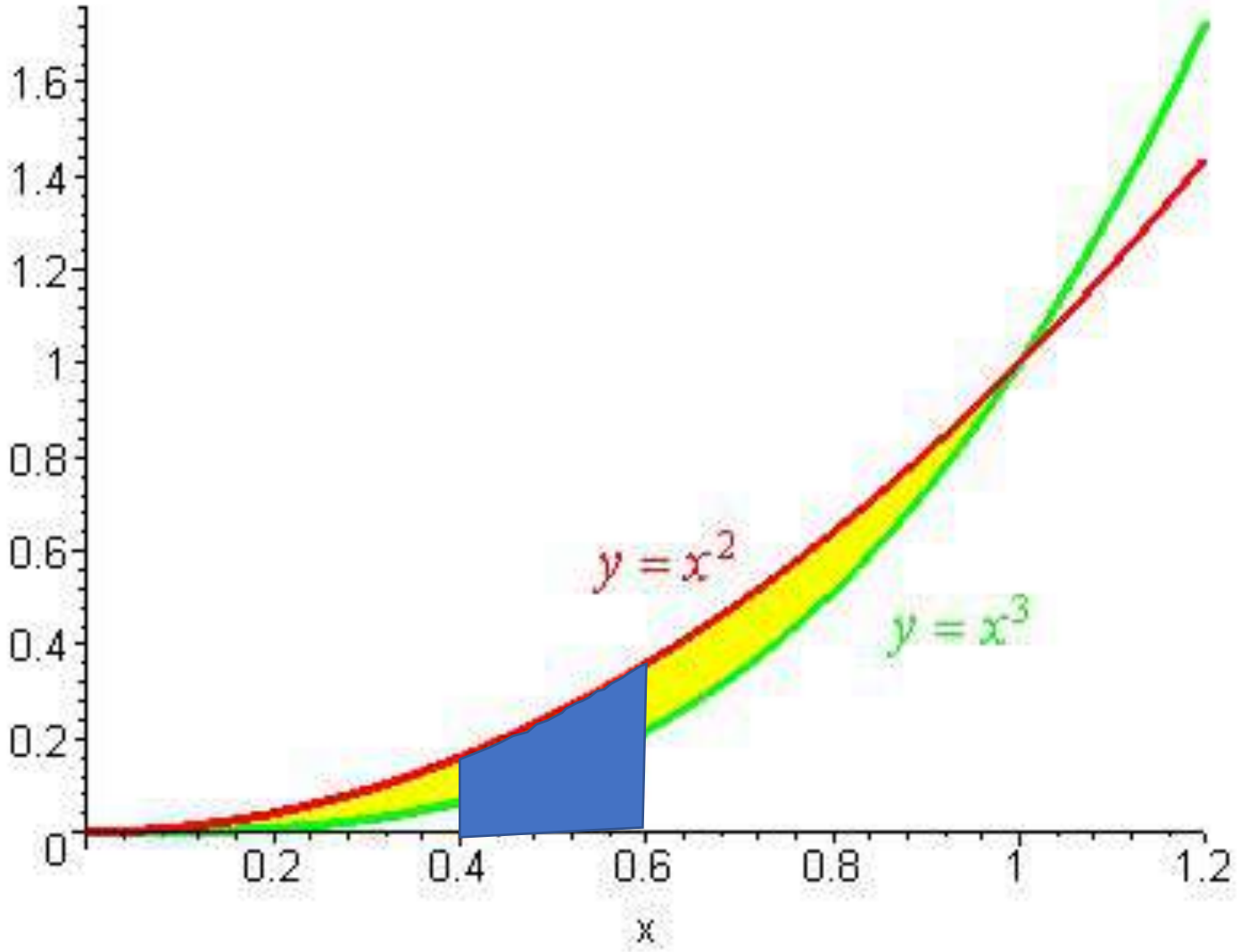
- When we know the equation of the curve
- Say a straight line y=2x

- Easily obtained by calculating area of shape or integrating



Ways to calculate the area under a curve

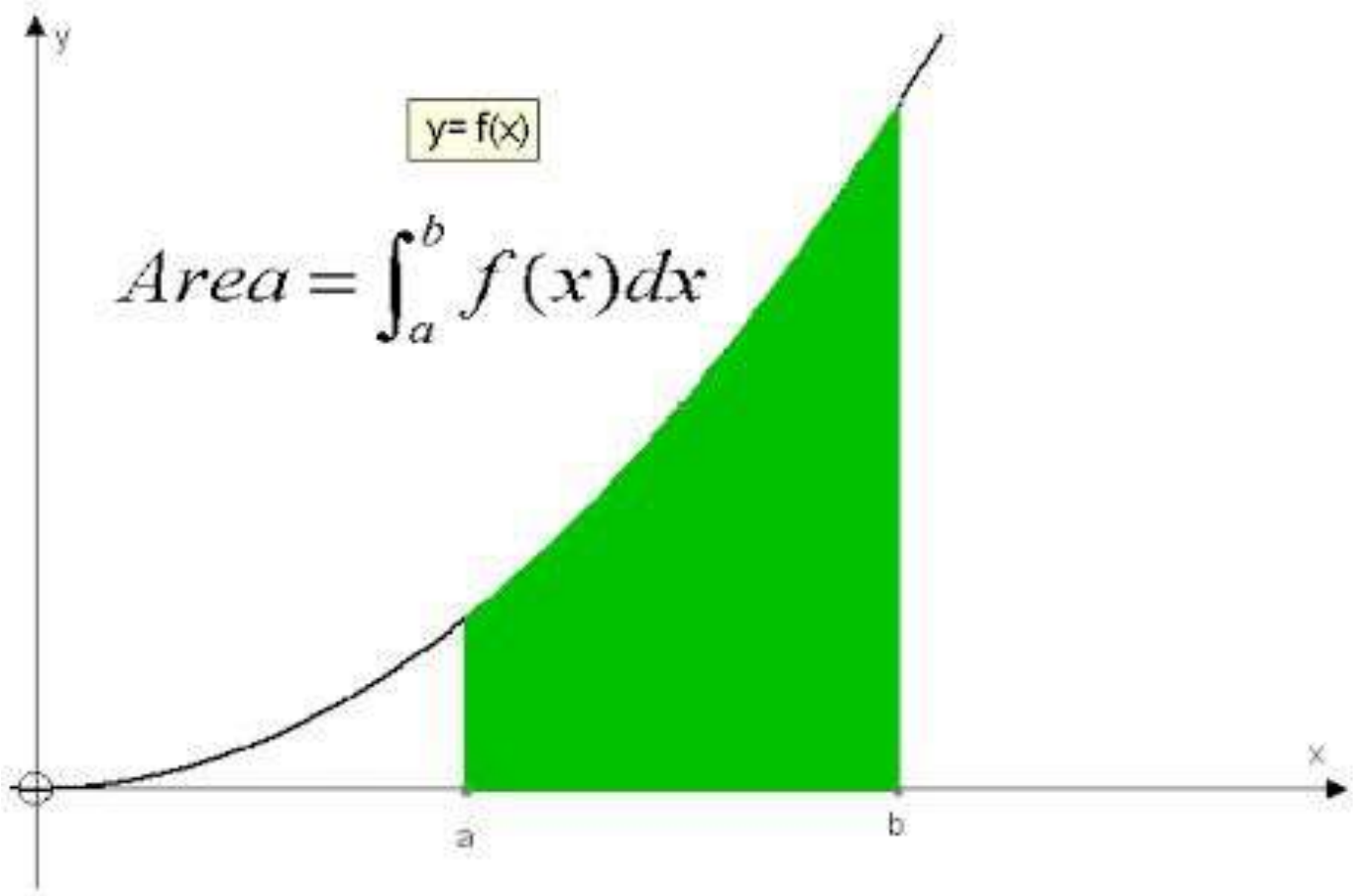
- Say a higher order curve $y=x^2$ or $y=x^3$
- Easily obtained by integrating



Ways to calculate the area under a curve

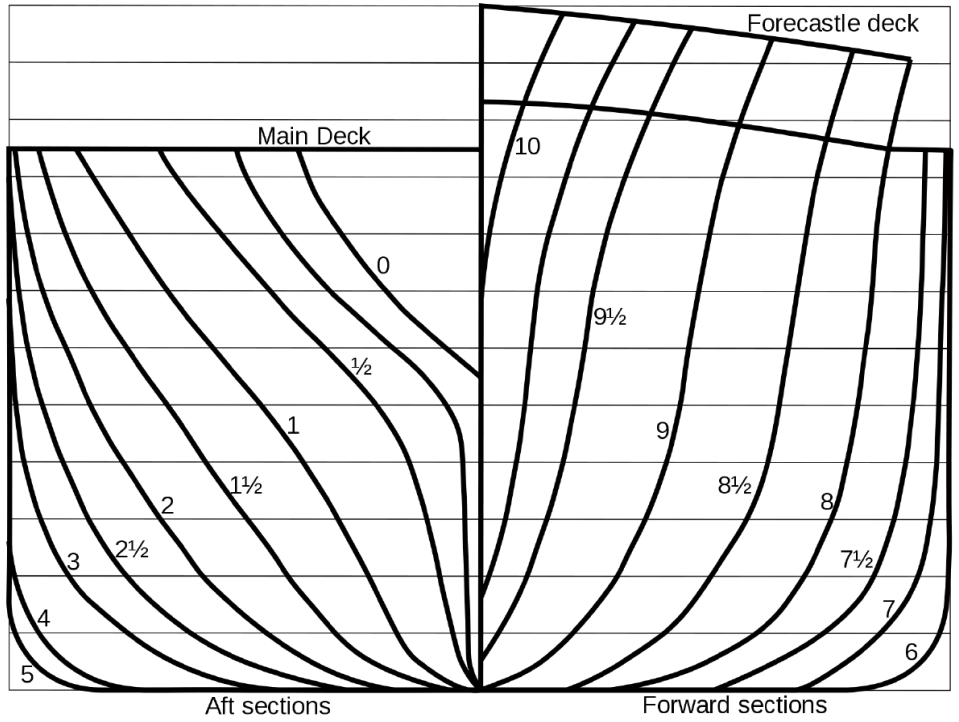
- Say any curve that can be defined by an equation y =f(x)

- Can easily obtained by integrating



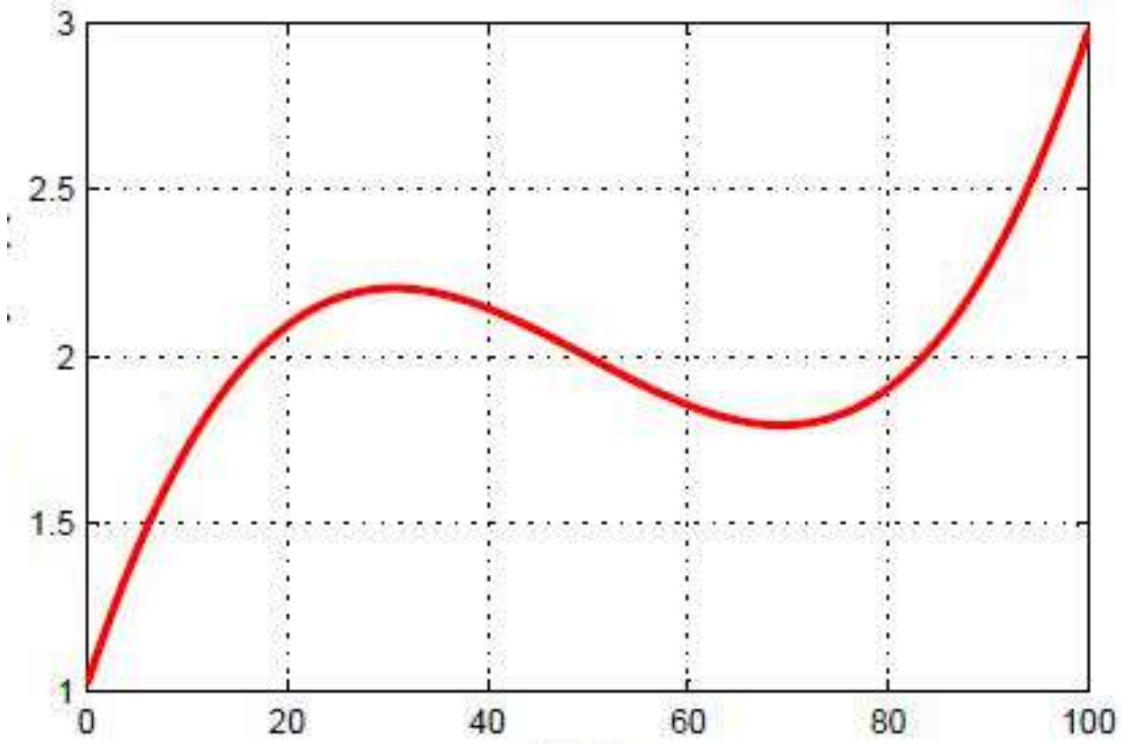
Ways to calculate the area under a curve

- What if the curve is such that it cannot be defined mathematically or is extremely difficult to define mathematically
- Means, it is difficult to define the equation of a curve in the form y = f(x)
- Then we can only use approximate calculation methods
- We use integration techniques using numerical values
- Hence called Numerical Integration



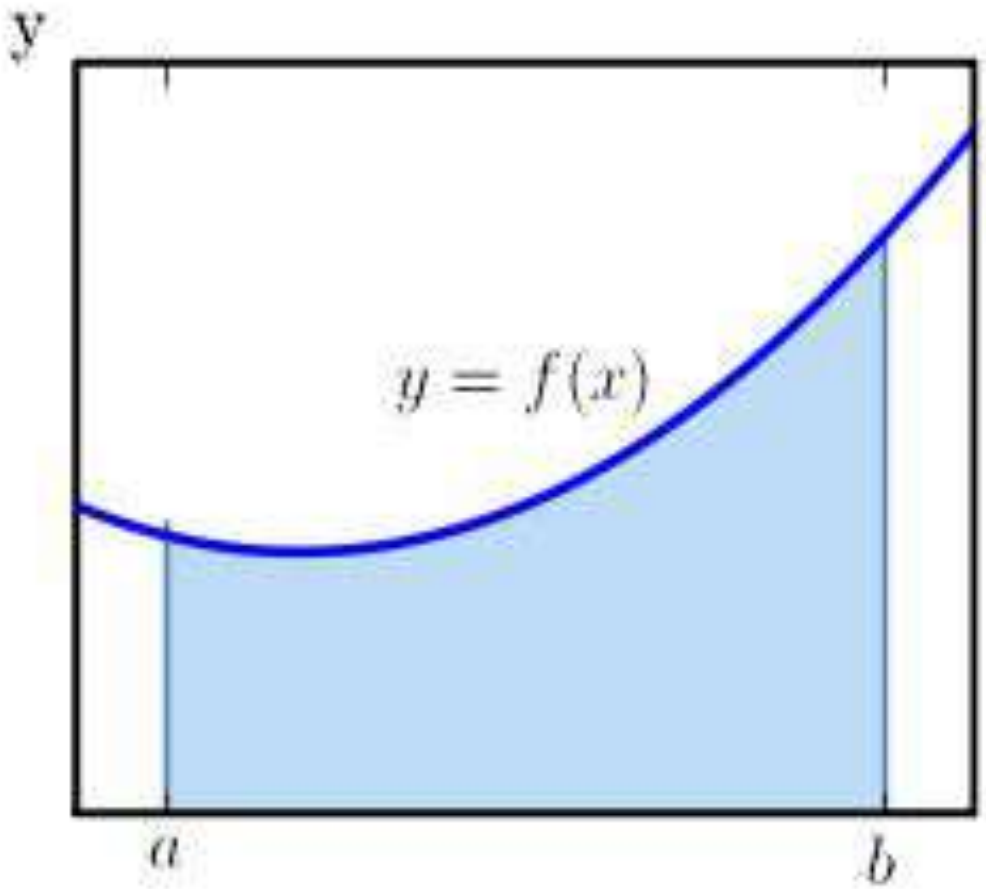
Numerical Integration Methods to calculate area under curve

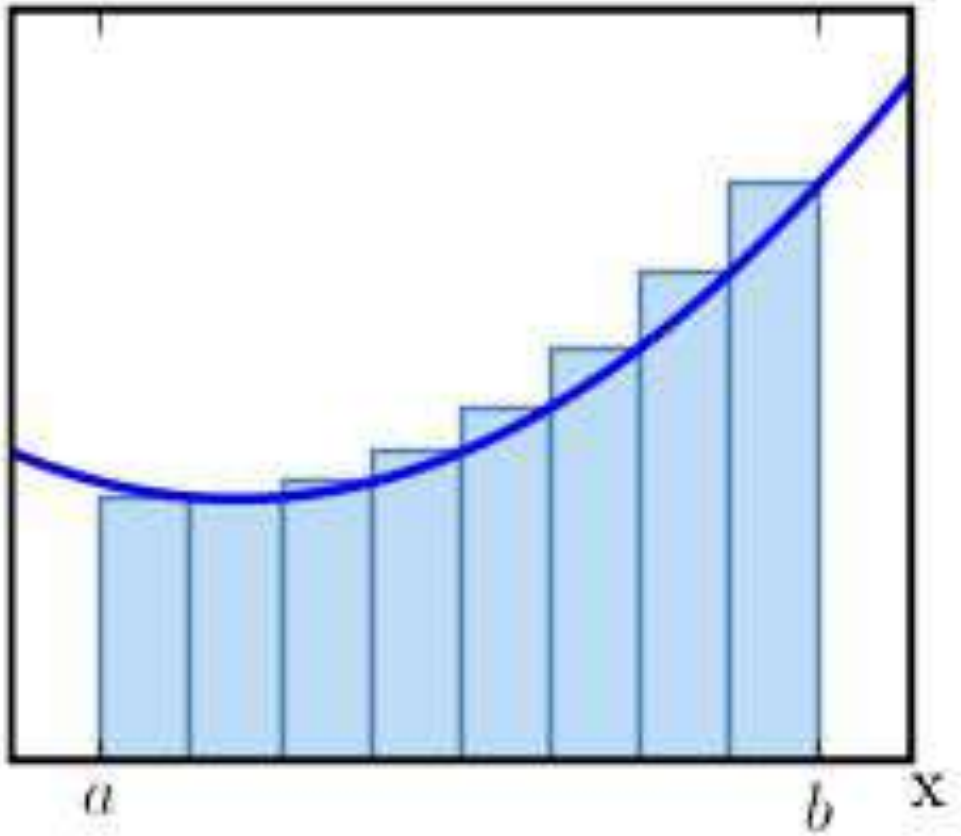
Squares



Numerical Integration Methods to calculate area under curve

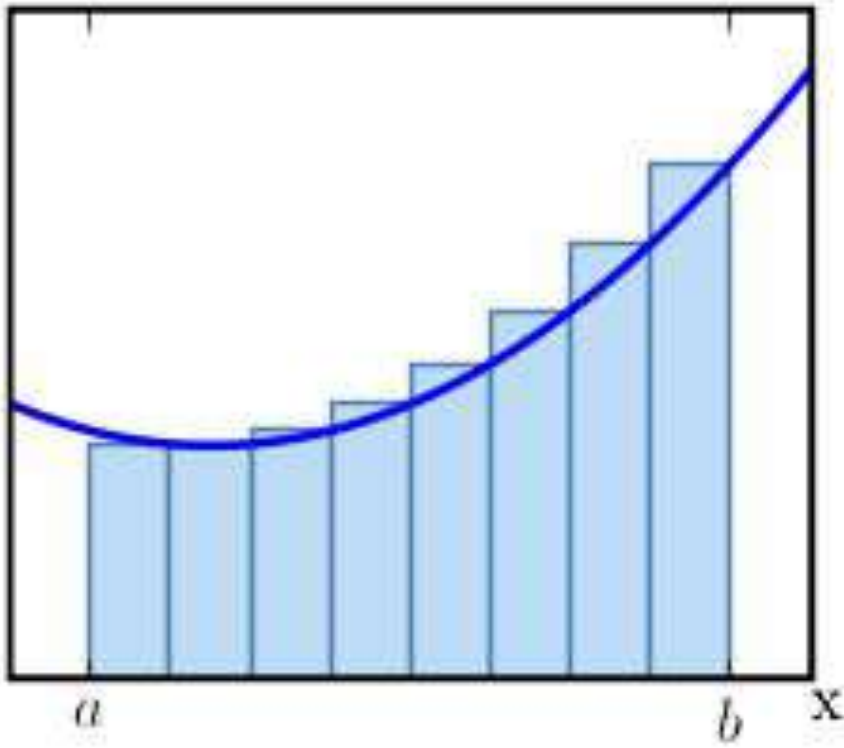
Rectangles



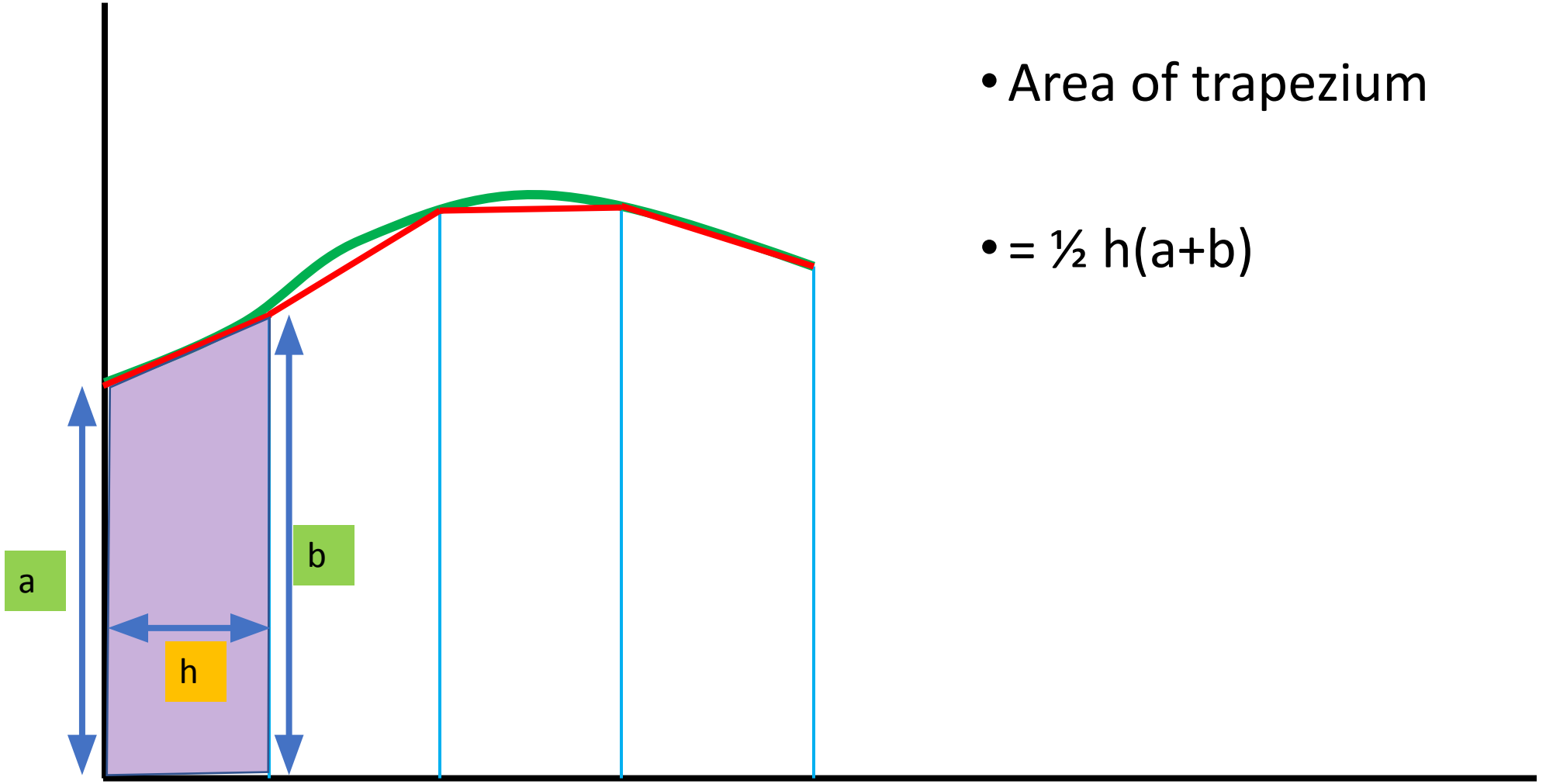


Using squares and rectangles

- Laborious
- Time consuming
- High Error



Using trapezium



- Area of trapezium
- = ½ h(a+b)

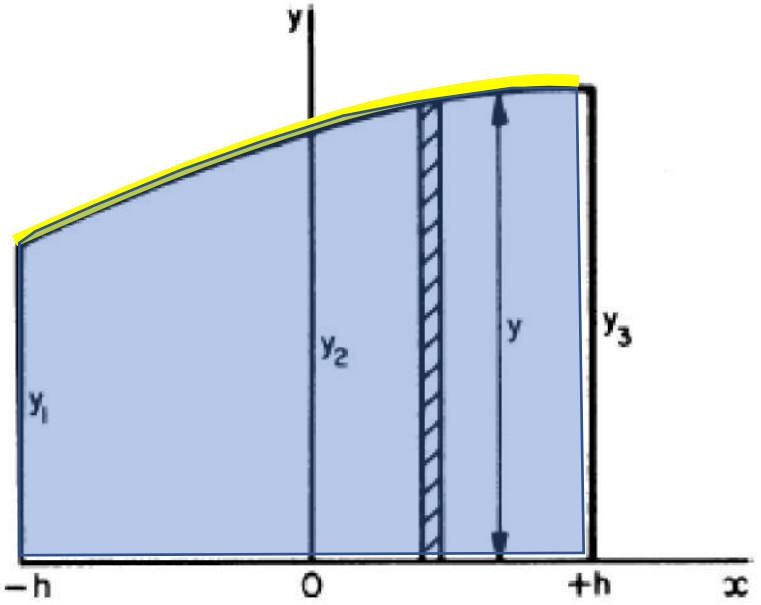
Simpson's Rules

Assume that curve can be represented by equation of third order

$$y = a_0 + a_1 x + a_2 x^2 + a_3 x^3$$

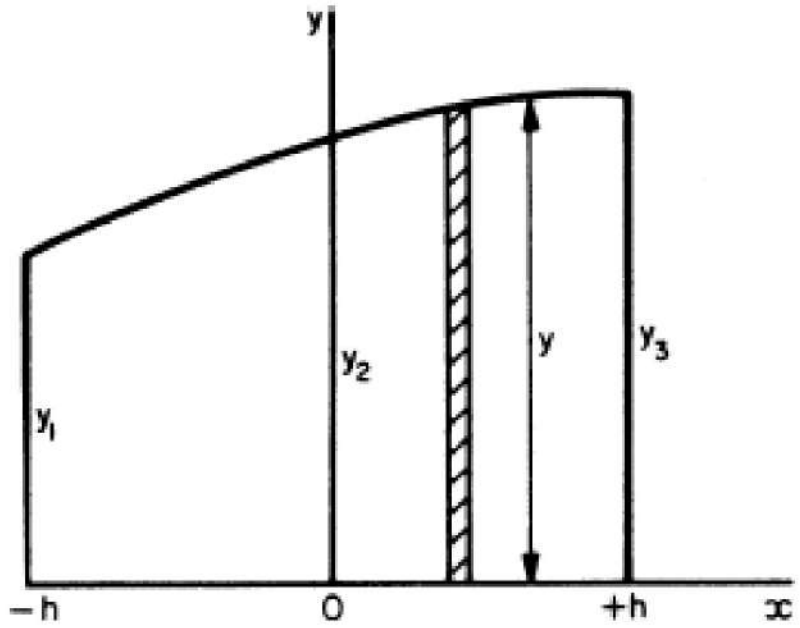
3 different rules based on number of ordinates considered

- First Rule – 3 ordinates
- Second Rule – 4 ordinates
- Third Rule – Area between 2 ordinates using 3 ordinates



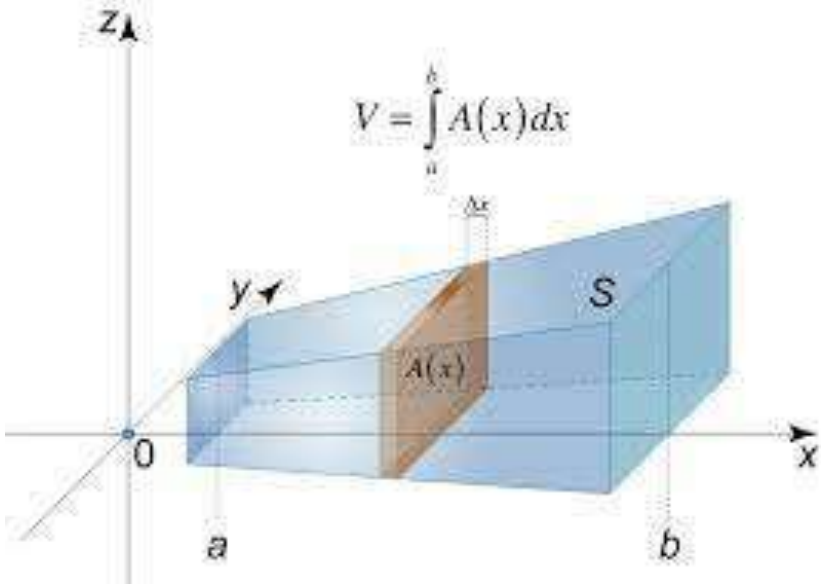
Volumes

- We can numerical integration rules to calculate any integral



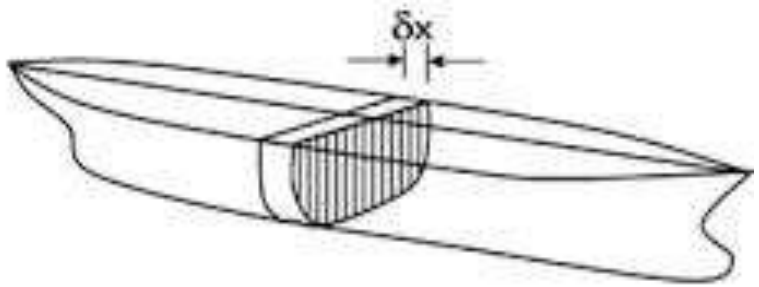
- Application of the integration rules to Ordinates under a curve gives Area under the curve

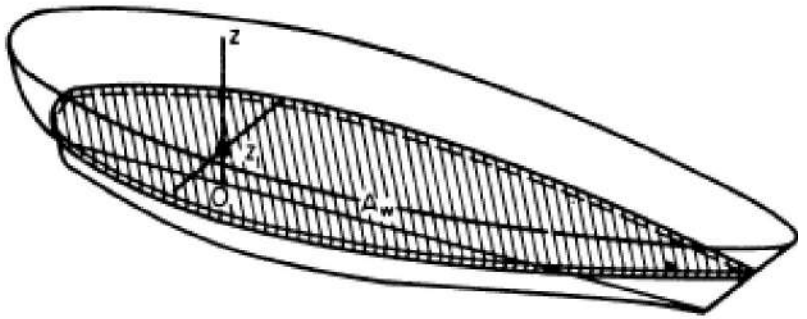
- If the ordinates represent Sectional Areas of , then application of the integration rules will give the Volume of the solid



Volumes

- In the case of a ship, if the ordinates represent cross sectional areas or waterplane areas, integration will give Vol of displacement

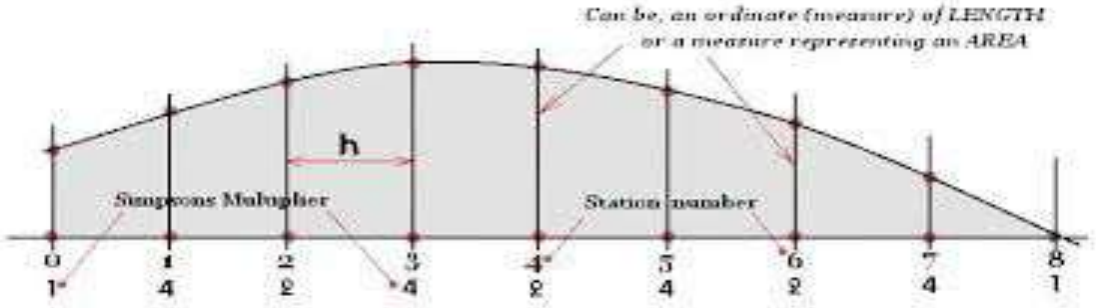




Volume of Displacement,
Also called Del or Nabla

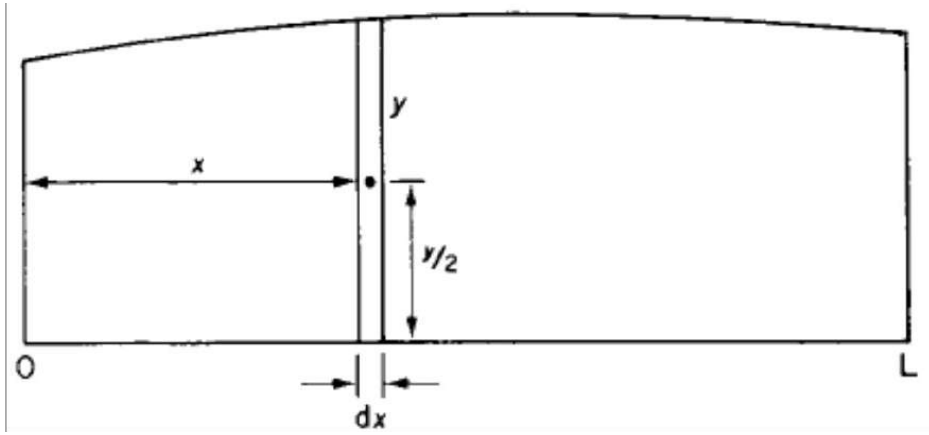
$$\nabla = \int A \, \mathrm{d}x$$

- The integral can be computed with Integration Rules using the sectional areas or waterplane areas as ordinates on a curve



Moments of Area

- If the ordinates represent 1st or 2nd Moment of an elemental area from any given axis, then application of the integration rules should give the 1st Moment (or Moment of Area) or 2nd Moment (Moment of Inertia) of the total area under the curve



$$M_x = \int xy \, dx$$

$$I_{xx} = \int_0^L x^2 y \, dx$$

END

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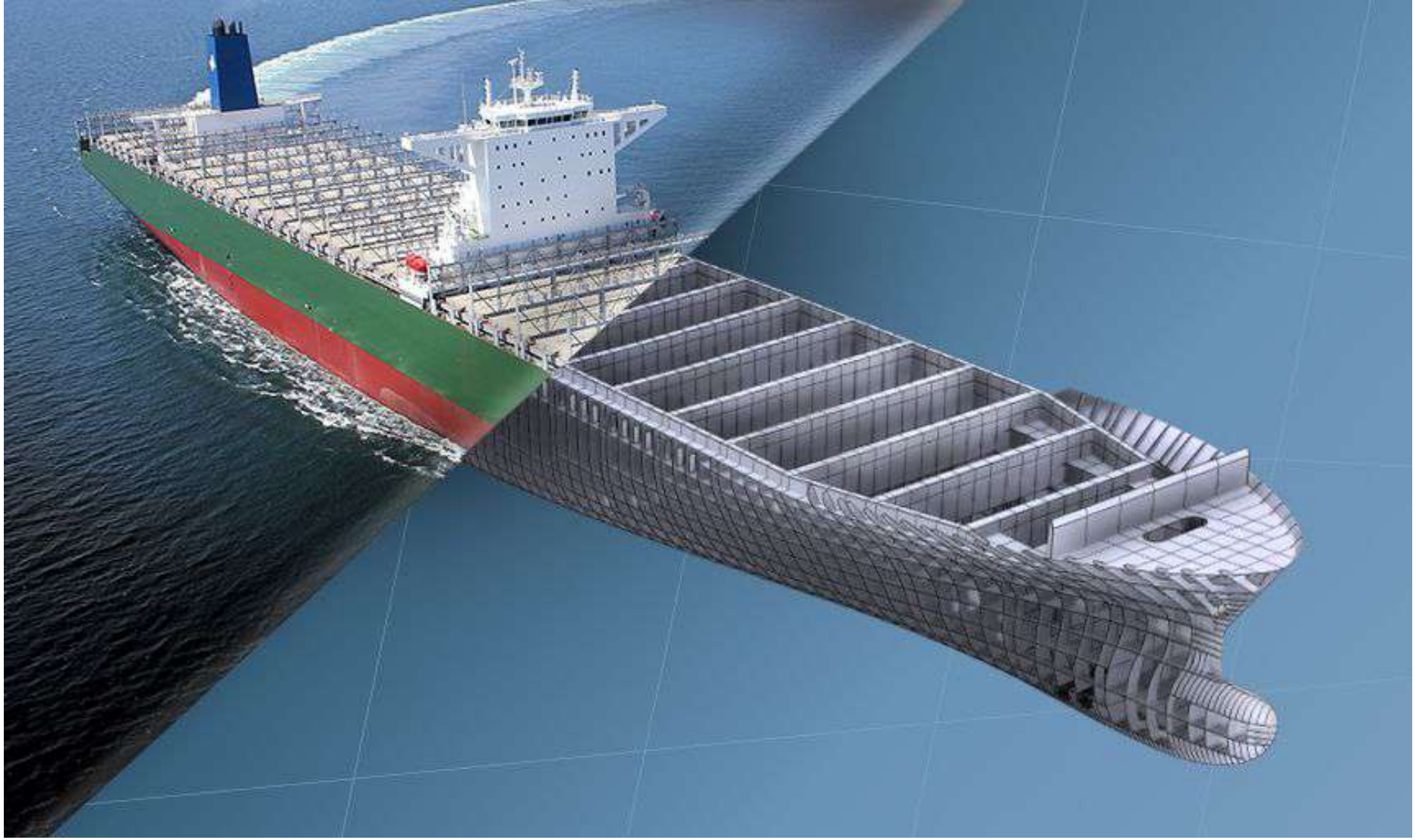
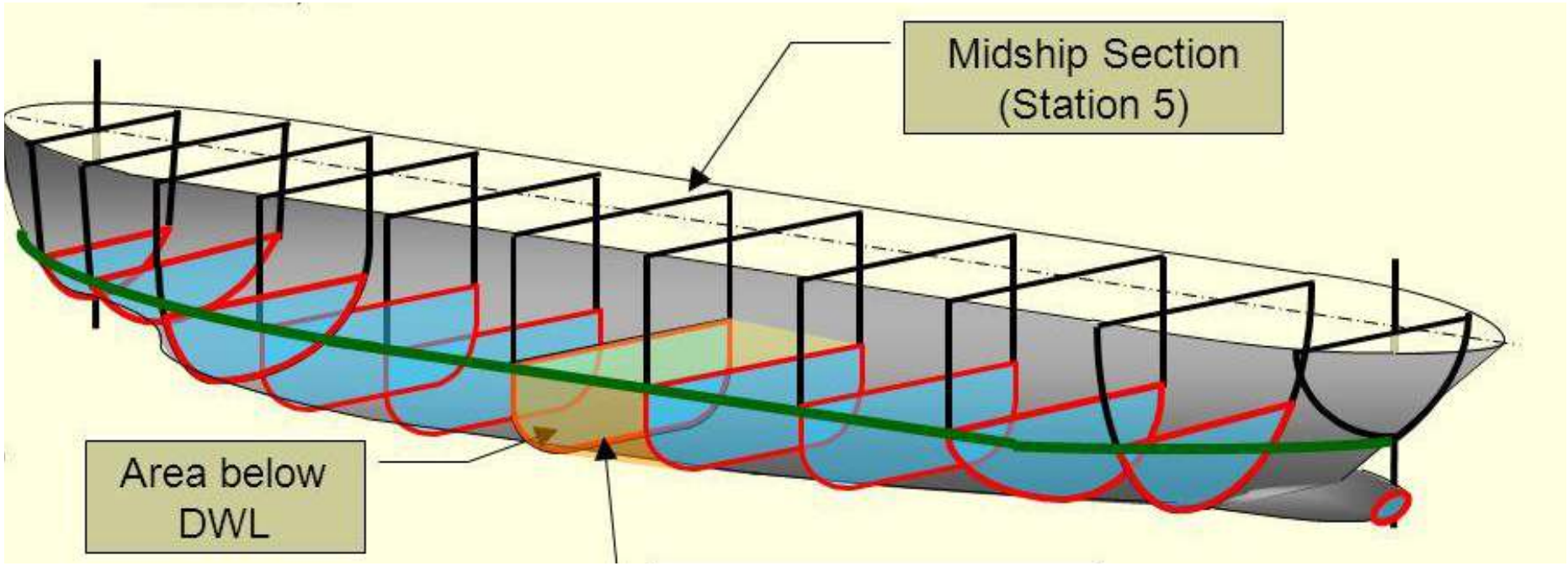


Introduction to Naval Architecture

II SEM –Module 3

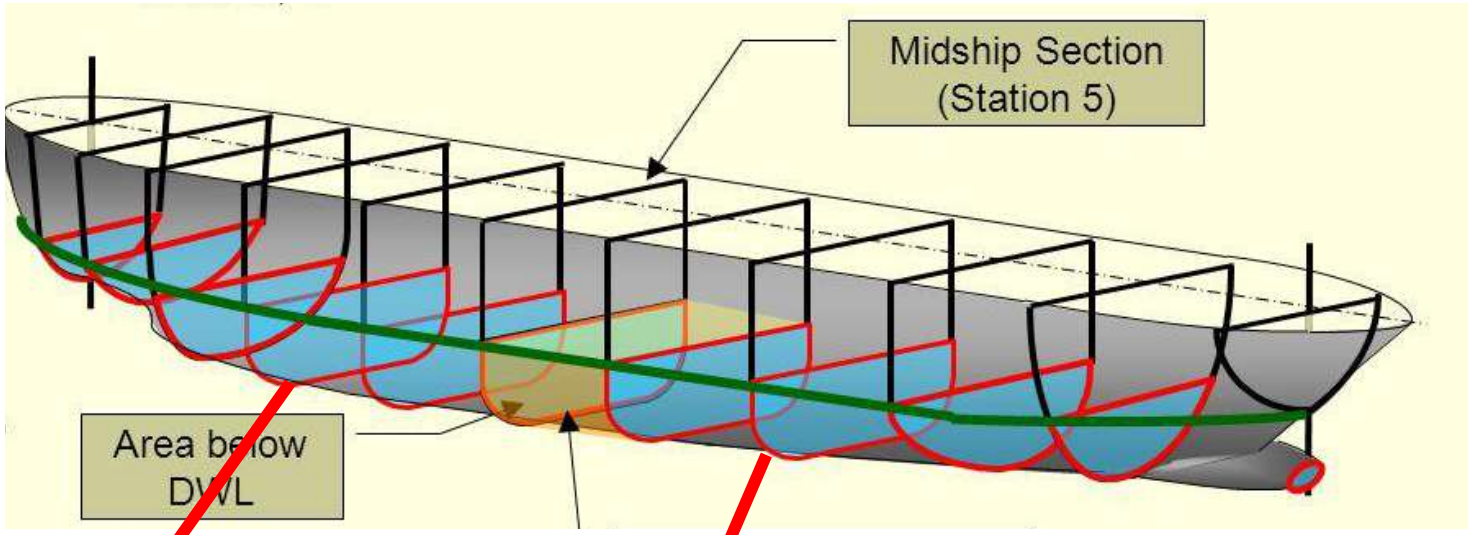
Sectional Area Curve - Concept

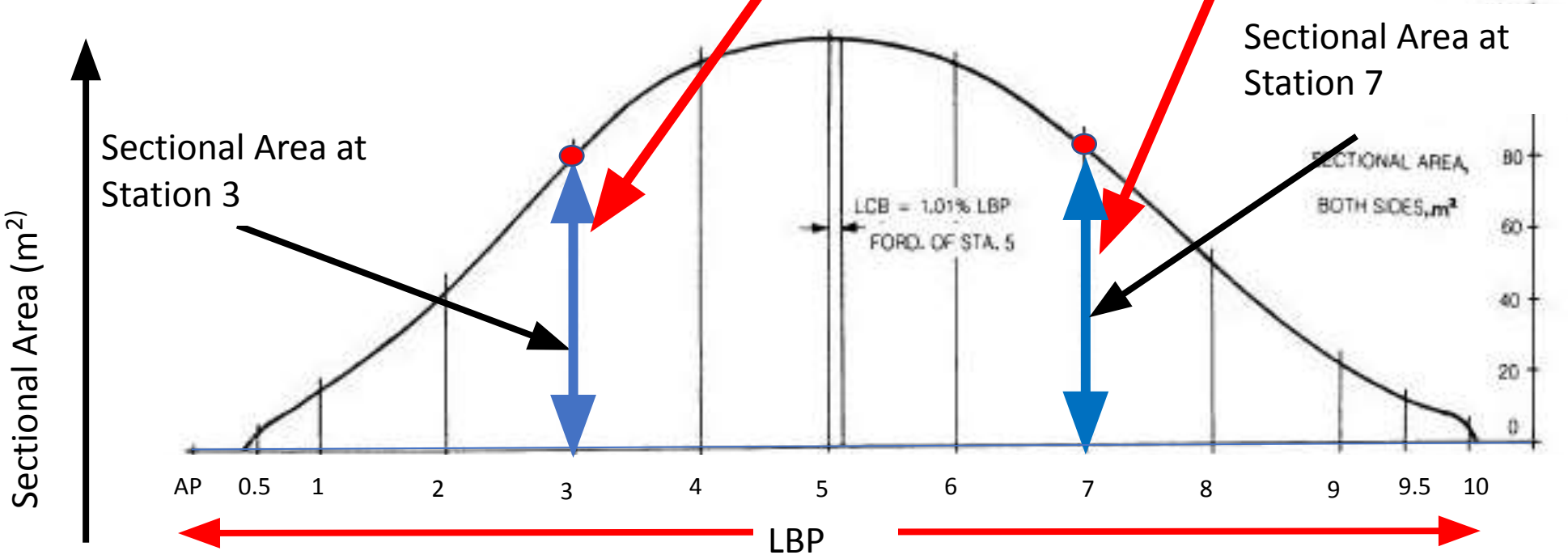
- For a given waterline (green line in image)
- The sectional area at each station (shaded blue with red border) is obtained



Sectional Area Curve – How to draw

- With LBP on the X axis,
- Sectional Area on the Y Axis
- Mark the Sectional Area as y value at the corresponding station



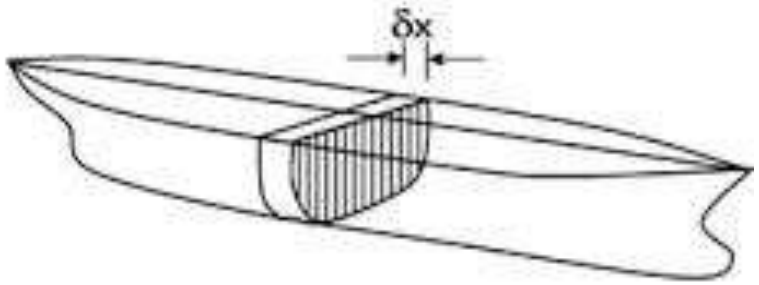


Bonjeans - Purpose

- We have learnt Hull Geometry
  - Curves drawn to define the hull form
- We have learnt Integration Rules
  - Numerical methods to calculate parameters for a space encompassed by a curve – Area, Centroid, 1^{st} Moment, Volume, 2^{nd} Moment
- Its time to use both of them together

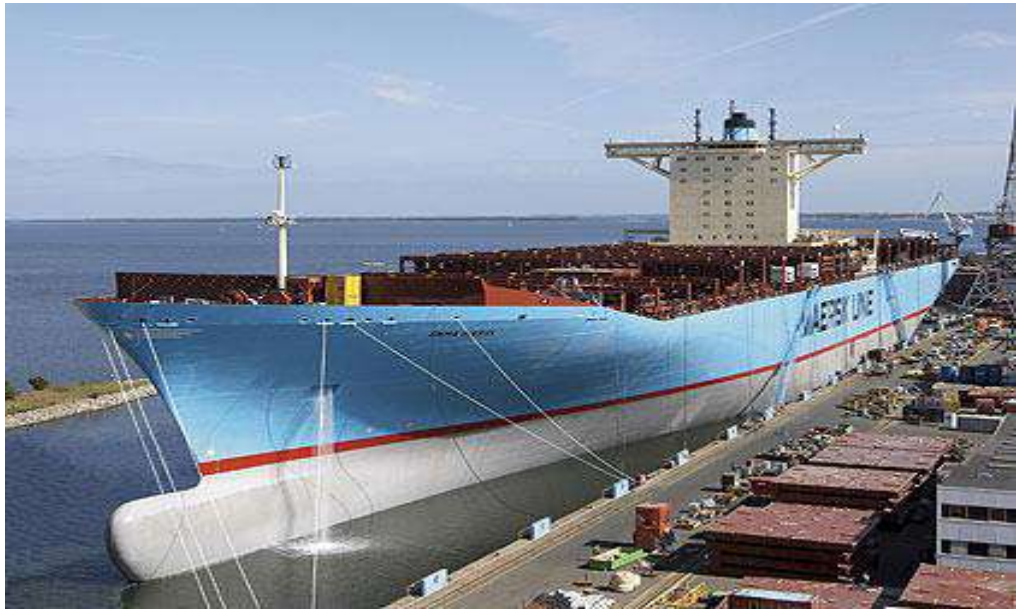
How to calculate Volume of Displacement (∇)

- One of the key parameters for a ship, is its submerged volume or Volume of Displacement (∇)
- To find Volume of Displacement (∇), the most accurate method is to calculate Transverse Sectional areas at each station, and integrate these areas along the length



- How can we find the cross sectional area?

Bonjean Curve – Purpose



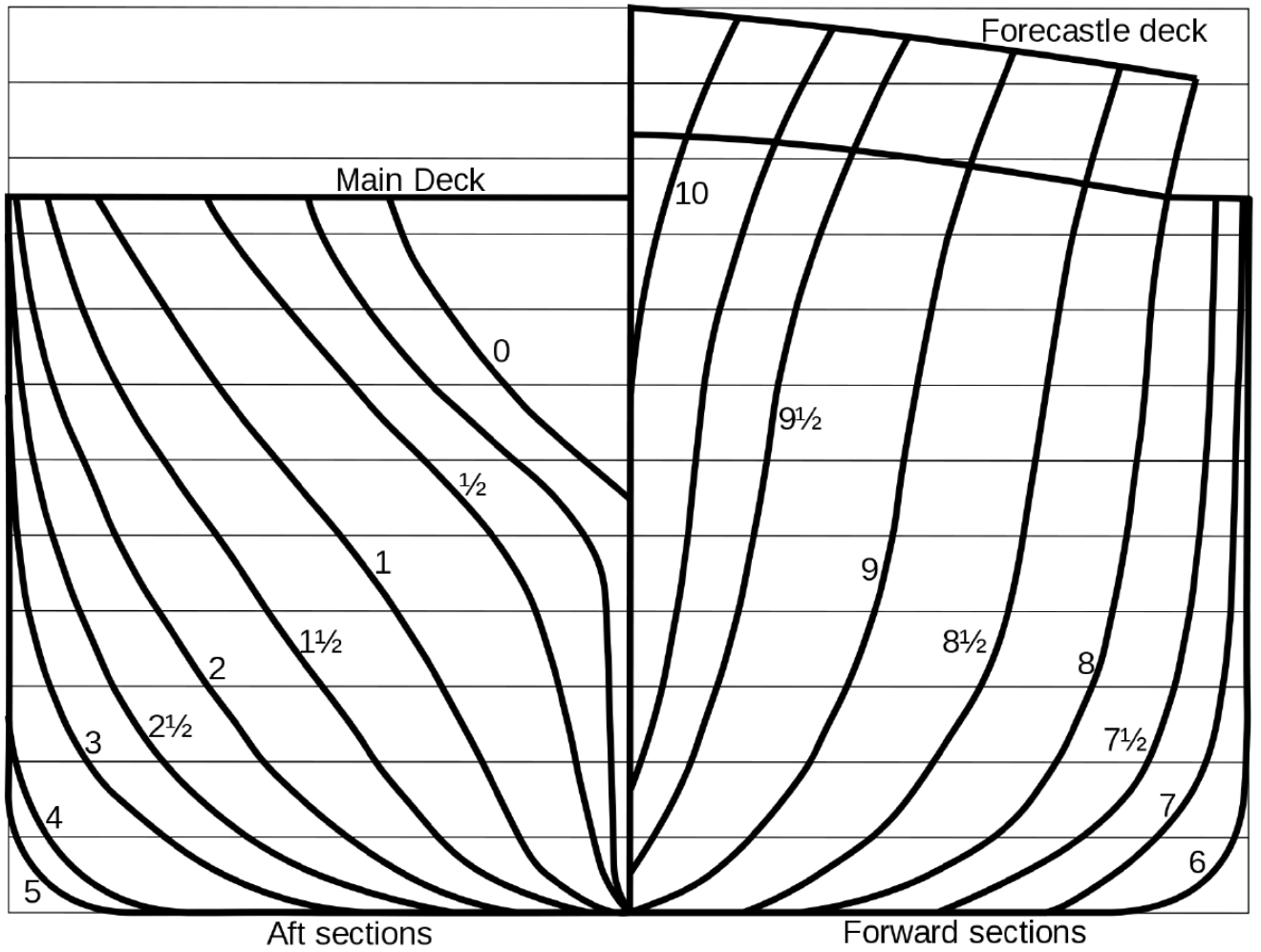
- Typical practical requirements e.g.
  - Design Stage. To calculate stability parameters, we need the location of centre of buoyancy at different drafts
  - Service Life. Estimate the displacement of a ship at different drafts

- We will need to calculate the transverse sectional areas or WP areas separately for every draft, and compute ∇ and LCB/VCB
- Everytime we need a particular value, it is not practical or easy, to start using offsets, integration rules and calculate sectional areas at each station from beginning.

- Better to have the entire data readily available for reference as and when needed.
- It can be in graphical / tabular format. Graphical format can help in finding any intermediate value

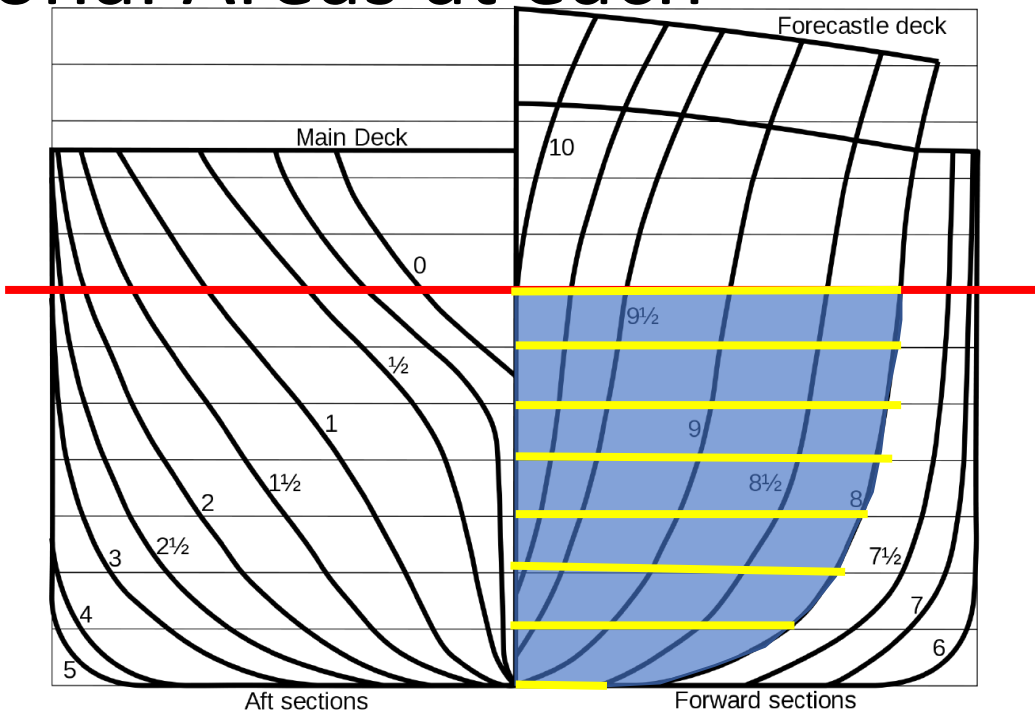
How to Calculate Transverse Sectional Areas at each Station

- From the Body Plan, because the Body Plan shows the transverse Section at each station



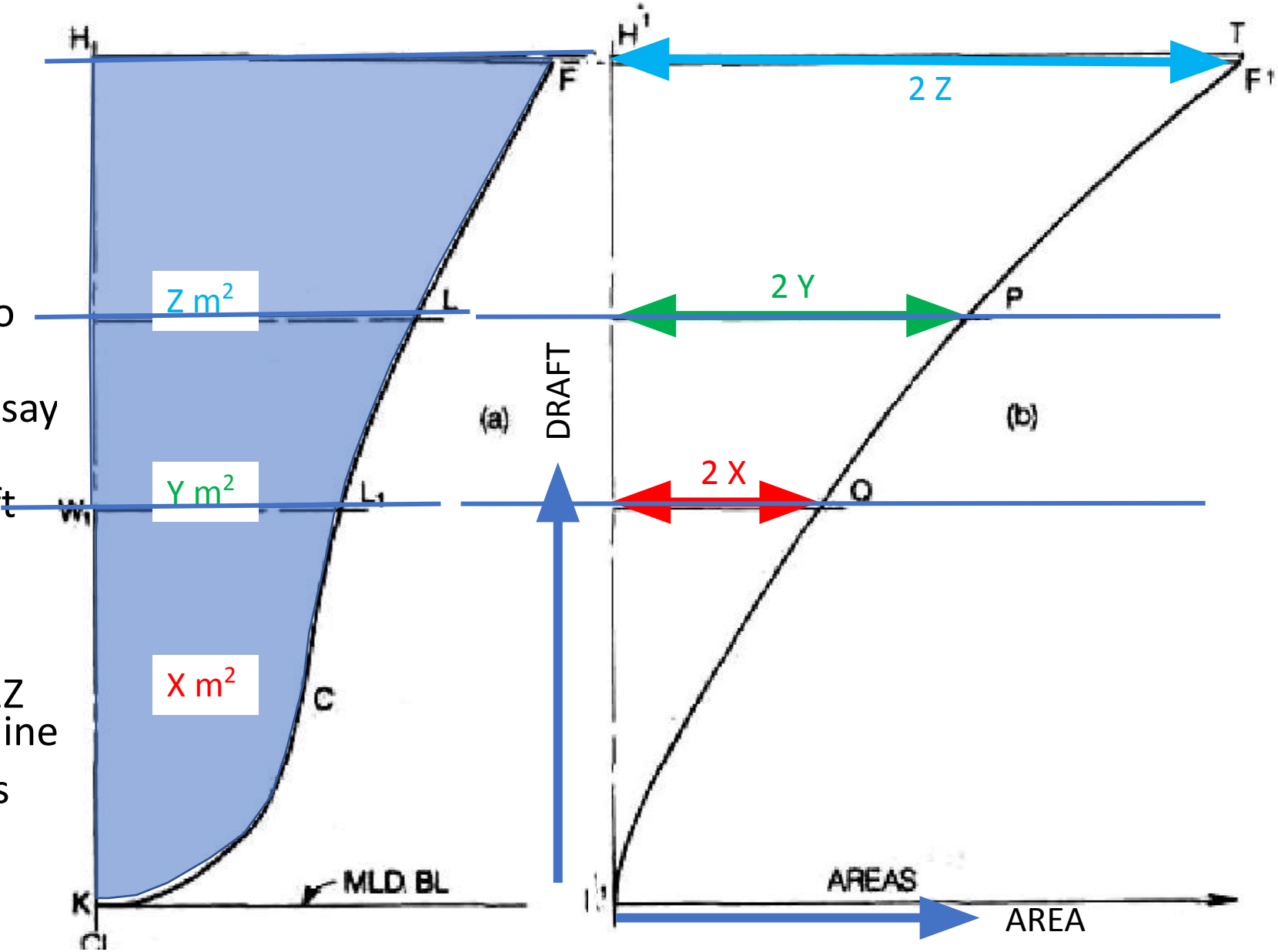
How to Calculate Transverse Sectional Areas at each Station

- First we have to decide a station and the waterline upto which we want the Transverse Sectional area
- Then take each station curve and tabulate the offset values for each waterline (from the baseline upto the desired waterline)
- Use Integration Rules to calculate the area under this curve using the offsets as ordinates
- Multiply by 2 to get the full Transverse Sectional area at the station upto the required draft (or Waterline)
- Similar process can be used to obtain Transverse Sectional areas at all stations upto a given Waterline



Bonjean Curves – Drawing Procedure

- For a given station
- Take a Waterline W_1L_1
- Using offsets, calculate the transverse sectional area upto W_1L_1, say X m^2
- Multiply by 2 to get full area say 2X
- On a graph with Y axis as draft and X axis being Area
- Plot 2X horizontally at the corresponding draft
- Repeat procedure to get 2Y, 2Z etc.. as area upto each waterline
- Plot a curve joining the points

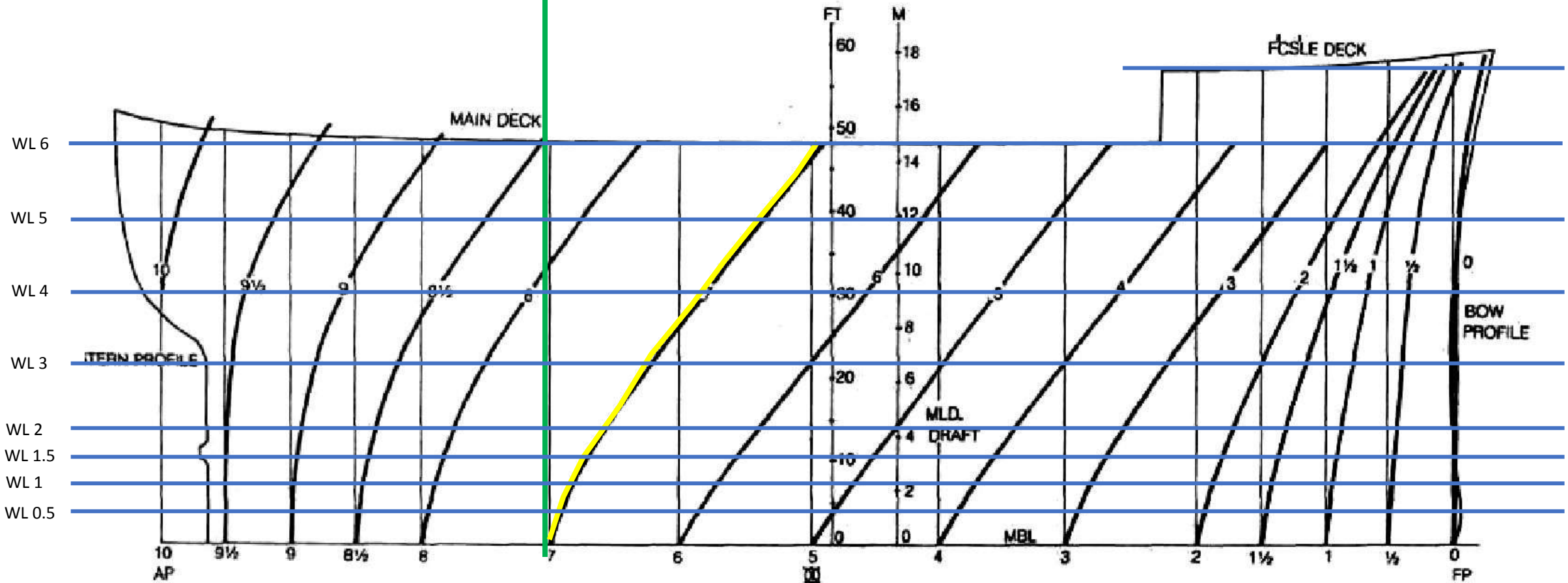


Bonjean Curves

- Attributed to a French Engineer named Bonjean
- Bonjean Curves are curves of transverse sectional area…
- …for each transverse section (station)..
- …Plotted against draught…

Bonjean Curves

- Y Axis is the draft
- X Axis represents the Length of the Ship as well as the scale for Areas
- Transverse sectional areas for each station is plotted with the station itself as the Y axis, on the profile view of the ship



Hydrostatic Data – Purpose

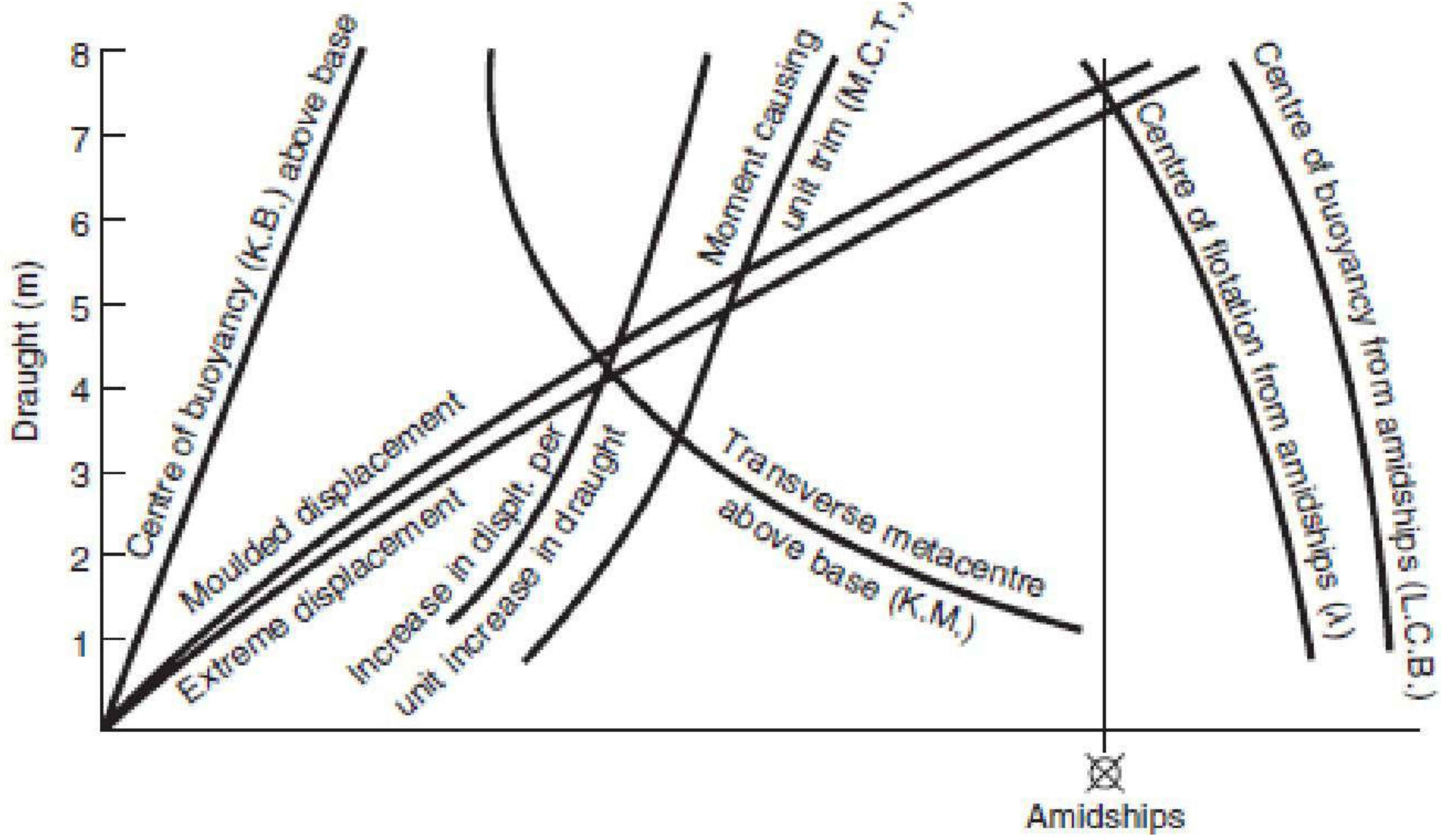
- The geometric properties of submerged portion (areas, volumes, centroids, etc.) of the ship determines its behavioural characteristics (stability, resistance, ship motions etc.).
- A ship is floating at a particular draft and trim. How can we estimate the Volume, Displacement, Centre of Buoyancy and other properties
- We will need to do detailed calculations using waterplane areas and sectional areas.
- In its service life, the submerged volume of a ship keeps changing, depending on the weight and disposition of cargo , density of water etc.
- If the properties in a standard condition is available as a reference, then the properties in any specific condition can be calculated easily

Curves of Form

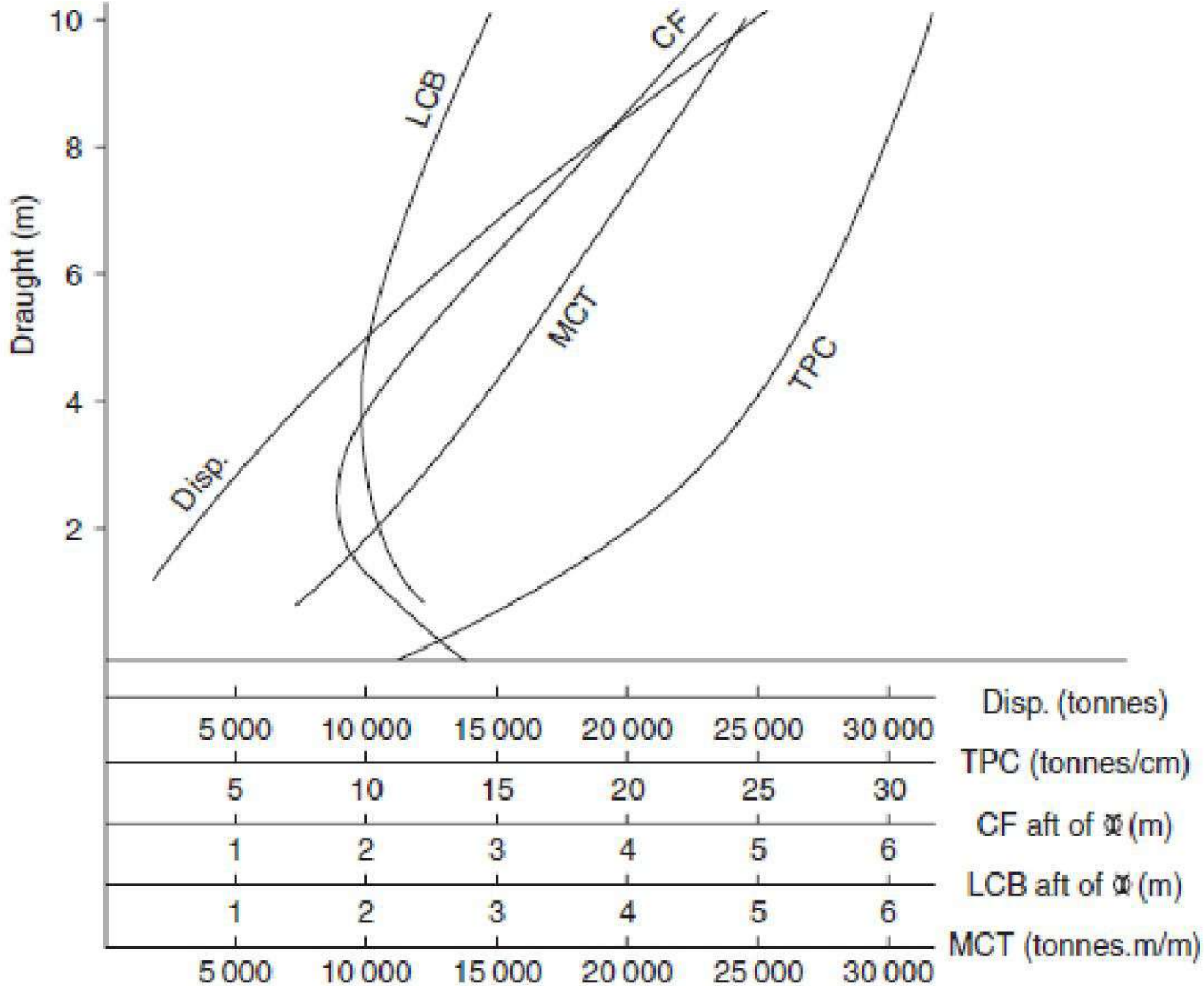
- Waterplane Area related
  - TPC – Tonnes Per Centimeter immersion
  - LCF – Longitudinal Centre of Flotation
  - C_{WP} –Waterplane Area Coefficient
  - C_M – Midship Coefficient(Sectional area related)
  - I_L - Moment of Inertia of WP area about Transverse axis
  - I_T - Moment of Inertia of WP area about CentreLine
- Immersed Volume related
  - ∇ -Volume of Displacement (Moulded)
  - Displacement $(Extreme)_{SW}$
  - LCB – Longitudinal Centre of Buoyancy
  - VCB(KB) – Vertical Centre of Buoyancy
  - C_B – Block Co-efficient
  - C_P – Prismatic Co-efficient
- Values Derived from Area/Volume
  - MCT_{1CM} - Moment to change trim by 1cm
  - BM_L – Metacentric Radius (Longitudinal)
  - KM_T –Height of transverse Metacentre above molded baseline
- Other
  - Wetted Surface Area

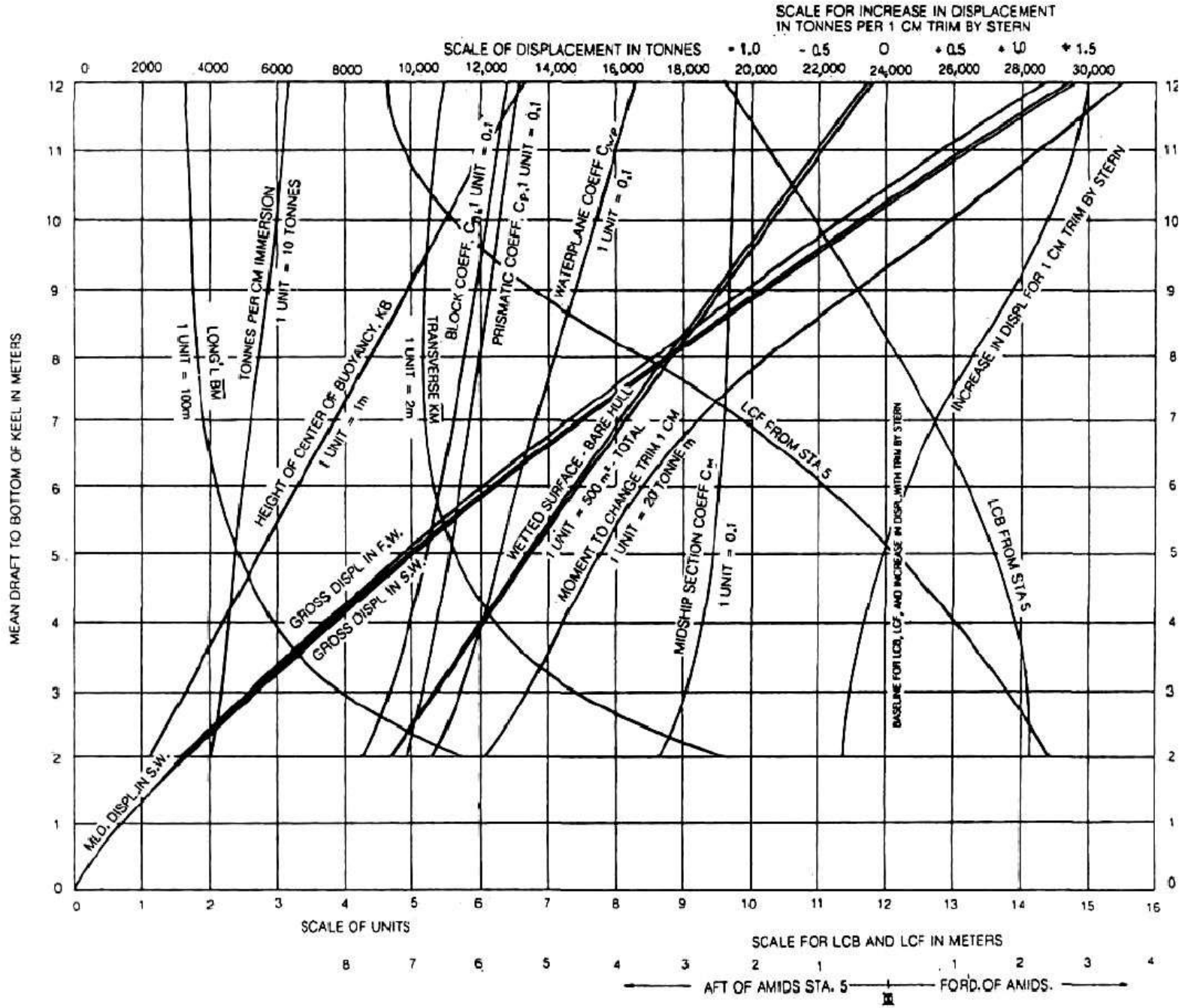
Hydrostatic Data – Generation

- Collectively, this information is called the Hydrostatic Data
- It is presented either in tabular form or as a set of curves
- Each of these parameters are plotted as a curve against a vertical scale of draft.
- Instead of having separate graphs for each parameters, all curves can be drawn on a single graph.
- Hydrostatic Curves are also called Curves of Form because the parameters are determined purely based on the Geometry or Form



Draught (m)
8
7
6
5
4
3
2
1
Centre of buoyancy (K.B.) above base
Moulded displacement
Extreme displacement
Increase in displt. per
unit increase in draught
Moment causing
unit trim (M.C.T.)
Transverse metacentre
above base (K.M.)
Centre of flotation from amidships (λ)
Centre of buoyancy from amidships (L.C.B.)
Amidships


Draught (m)
10
8
6
4
2
LCB
CF
MCT
TPC
Disp.
Disp. (tonnes)
5 000
10 000
15 000
20 000
25 000
30 000
TPC (tonnes/cm)
5
10
15
20
25
30
CF aft of ⊗ (m)
1
2
3
4
5
6
LCB aft of ⊗ (m)
1
2
3
4
5
6
MCT (tonnes.m/m)
5 000
10 000
15 000
20 000
25 000
30 000


SCALE FOR INCREASE IN DISPLACEMENT IN TONNES PER 1 CM TRIM BY STERN
SCALE OF DISPLACEMENT IN TONNES
- 1.0
- 0.5
0
+ 0.5
+ 1.0
+ 1.5
0
2000
4000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
MEAN DRAFT TO BOTTOM OF KEEL IN METERS
SCALE OF UNITS
SCALE FOR LCB AND LCF IN METERS
AFT OF AMIDS STA. 5
FORD. OF AMIDS.
M.D. DISPL. IN S.W.
GROSS DISPL. IN F.W.
GROSS DISPL. IN S.W.
1 UNIT = 100m
LONG'L BM
TONNES PER CM IMMERSION
1 UNIT = 10 TONNES
HEIGHT OF CENTER OF BUOYANCY, KB
1 UNIT = 1m
TRANSVERSE KM
1 UNIT = 2m
BLOCK COEFF. Cb
1 UNIT = 0.1
PRISMATIC COEFF. Cp
1 UNIT = 0.1
WATERPLANE COEFF Cwp
1 UNIT = 0.1
WETTED SURFACE - BARE HULL
1 UNIT = 500 m² - TOTAL
MOMENT TO CHANGE TRIM 1 CM
1 UNIT = 20 TONNE m
MIDSHIP SECTION COEFF Cm
1 UNIT = 0.1
LCF FROM STA 5
LCB FROM STA 5
INCREASE IN DISPL FOR 1 CM TRIM BY STERN
BASELINE FOR LCB, LCF, AND INCREASE IN DISPL WITH TRIM BY STERN

END

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