MEC-E1004 Principles of Naval Architecture

Simpson's Integration of areas and volumes

Calculating areas and volumes

Tips before going to calculations

✓ This tutorial is to explain how to use the excel sheet in area and volume calculations

✓ By this stage you should have your hull form lines ready.

✓ The excel sheet is based on Simpson's first rule integration (odd number of ordinates must be used)
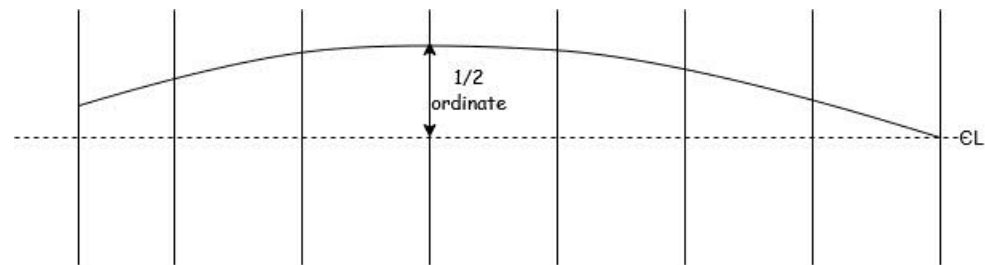
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Waterplane Area and LCF

- **The first step is to define the length of the waterplane area, and the number of intervals.**

Length	150	m
Intervals:	10	-
Spacing, s:	15	m

Waterplane Area and LCF

- **As the ship is symmetric about the centerline, only ½ ordinates will be used.**

- **Half-ordinates as shown in figure are measured at each frame and to be inserted in the table.**

Frame	x-coordinate	1/2 ordinates y_n	SM k_n	Product for area $y_n * k_n$	Lever @ Frame R_n
[-]		[m]	[-]	[m²]	[m]
0	0	1,0	1	1,0	0
1	15	7,5	4	30,0	1
2	30	12,0	2	24,0	2
3	45	13,5	4	54,0	3
4	60	14,0	2	28,0	4
5	75	14,0	4	56,0	5
6	90	14,0	2	28,0	6
7	105	13,5	4	54,0	7
8	120	12,0	2	24,0	8
9	135	7,0	4	28,0	9
10	150	0,0	1	0,0	10
			Σ	327	m²

Waterplane Area and LCF

- **The results are highlighted in red; the waterplane area of the waterline and the longitudinal center of floatation from frame zero.**

- **You can then repeat the same procedures for any WL you want.**

Frame [-]	x-coordinate [m]	1/2 ordinates y_n [m]	SM k_n [-]	Product for area $y_n * k_n$ [m²]	Lever @ Frame 0 R_n [m]	moment of area $y_n * k_n * R_n$ [m³]
0	0	1,0	1	1,0	0	0,0
1	15	7,5	4	30,0	1	30,0
2	30	12,0	2	24,0	2	48,0
3	45	13,5	4	54,0	3	162,0
4	60	14,0	2	28,0	4	112,0
5	75	14,0	4	56,0	5	280,0
6	90	14,0	2	28,0	6	168,0
7	105	13,5	4	54,0	7	378,0
8	120	12,0	2	24,0	8	192,0
9	135	7,0	4	28,0	9	252,0
10	150	0,0	1	0,0	10	0,0
			Σ	327	m²	1622	m³

WPA	3270	m2
LCF From fr0	74,404	m

Cross Sectional Area and its Center
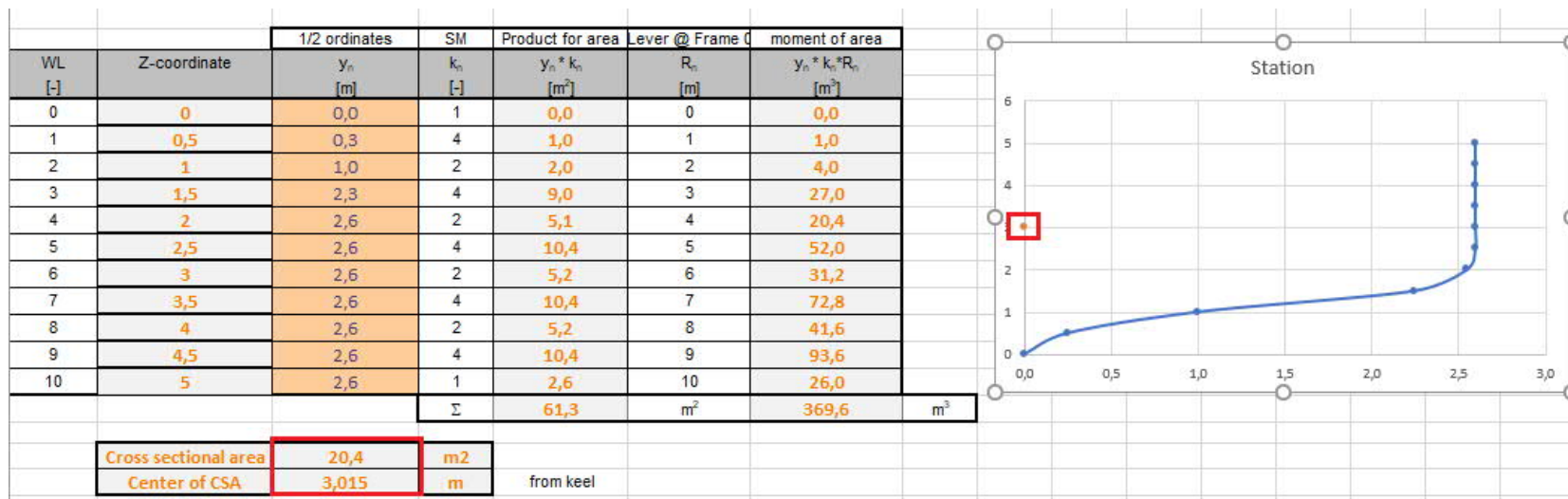
- **The same procedure is followed for calculating the cross sectional area of a station. Instead of using ½ ordinates among longitudinal intervals, they are measured at every waterline (vertical intervals).**

| Maximum draft	5	m
Intervals:	10	-
Spacing, s:	**0,5**	**m**
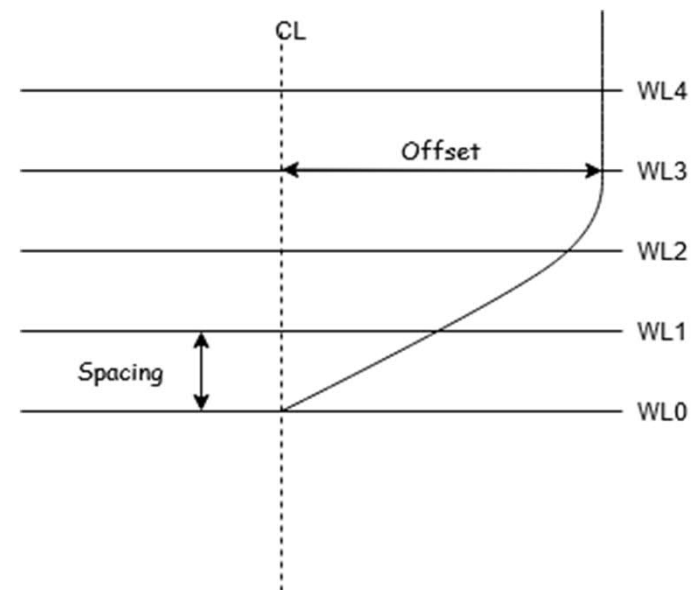
Cross Sectional Area and its Center

- **The results in such a case are the cross sectional area of the station and its center.**

WL [-]	Z-coordinate [m]	1/2 ordinates y_n [m]	SM k_n [-]	Product for area $y_n * k_n$ [m²]	Lever @ Frame 0 R_n [m]	moment of area $y_n * k_n * R_n$ [m³]
0	0	0,0	1	0,0	0	0,0
1	0,5	0,3	4	1,0	1	1,0
2	1	1,0	2	2,0	2	4,0
3	1,5	2,3	4	9,0	3	27,0
4	2	2,6	2	5,1	4	20,4
5	2,5	2,6	4	10,4	5	52,0
6	3	2,6	2	5,2	6	31,2
7	3,5	2,6	4	10,4	7	72,8
8	4	2,6	2	5,2	8	41,6
9	4,5	2,6	4	10,4	9	93,6
10	5	2,6	1	2,6	10	26,0
			Σ	61,3 m²		369,6 m³

Cross sectional area	20,4	m2
Center of CSA	3,015	m	from keel

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Volumes and LCB/KB

- **The numerical integration is just a tool and can be used in voulme integration as well. In this step cross sectional areas or waterplane areas are used to obtain the ship's volume of displacement.**


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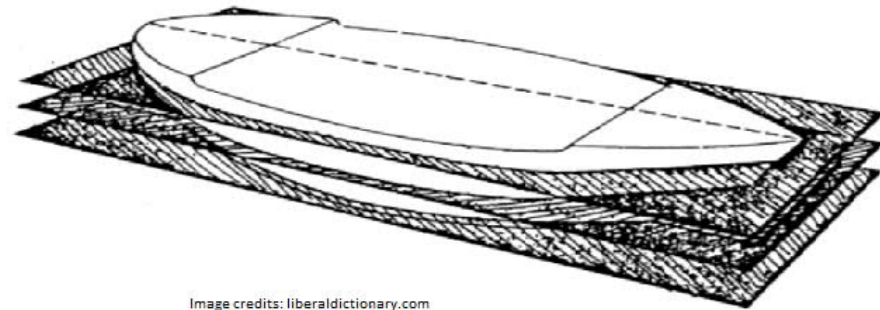
Volumes and LCB

- **You should have the cross sectional area for every station ready at this point. You follow the same procedure discussed previously, and the results will be the volume of displacement, the longtiduinal center of buoyancy, and the displacement in tonnes.**

Frame [-]	x-coordinate	Cross-sectional area A_n [m²]	SM k_n [-]	Product for volume $A_n * k_n$ [m²]	Lever @ Frame 0 R_n [m]	moment of volume $A_n * k_n * R_n$ [m³]
0	0	0	1	0	0	0
1	15	76	4	304	1	304
2	30	143	2	286	2	572
3	45	175	4	700	3	2100
4	60	190	2	380	4	1520
5	75	187	4	748	5	3740
6	90	170	2	340	6	2040
7	105	117	4	468	7	3276
8	120	70	2	140	8	1120
9	135	29	4	116	9	1044
10	150	0	1	0	10	0
			Σ	3482 m²		15716

Volume	17410	m3	
Density of water	1,025	t/m3	
Displacement	17845,25	t	
LCB from fr0	67,702	m	

Volumes and LCB

- **Provided in another sheet is the sectional area curve as a result.**
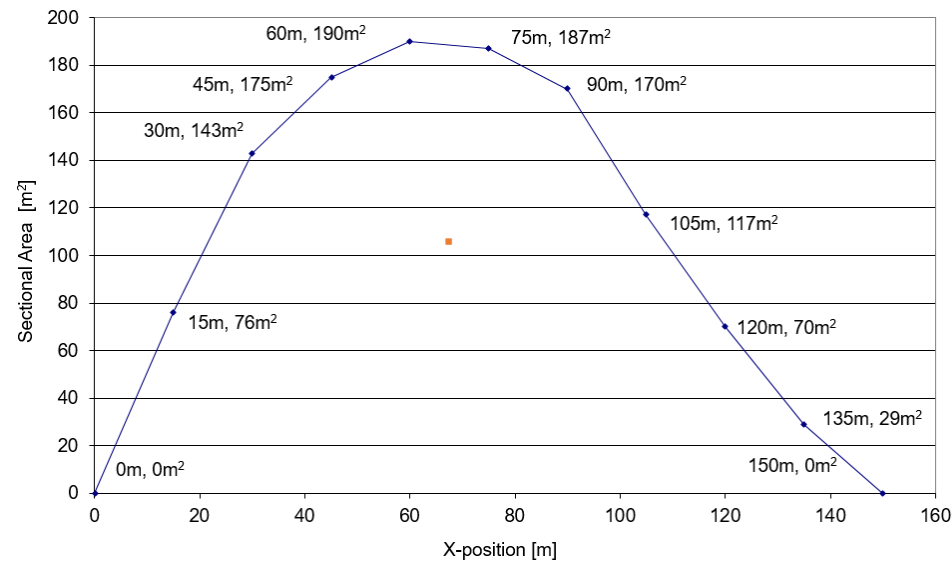
Volumes and KB

- **The final step is to obtain the volume of displacement using another way by integrating the waterplane areas in order to get the vertical center of buoyancy above the keel (KB).**

- **Make sure that the volume by the two ways is the same.**

WL	Z-coordinate	WPA y_n	SM k_n	Product for volume $y_n * k_n$	Lever @ keel R_n	moment of volume $y_n * k_n * R_n$	
[-]		[m²]	[-]	[m³]	[m]	[m⁴]	
0	0	0,0	1	0,0	0	0,0	
1	0,5	300,0	4	1200,0	1	1200,0	
2	1	950,0	2	1900,0	2	3800,0	
3	1,5	1450,0	4	5800,0	3	17400,0	
4	2	1900,0	2	3800,0	4	15200,0	
5	2,5	2150,0	4	8600,0	5	43000,0	
6	3	2330,0	2	4660,0	6	27960,0	
7	3,5	2370,0	4	9480,0	7	66360,0	
8	4	2390,0	2	4780,0	8	38240,0	
9	4,5	2400,0	4	9600,0	9	86400,0	
10	5	2400,0	1	2400,0	10	24000,0	
			Σ	52220,0 m³		323560,0	m⁴
	Volume	17406,7	m3				
	KB	3,098	m	above keel			

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