MEC-E1004 Principles of Naval Architecture

Resistance and Powering

Aalto University
School of Engineering

Resistance analysis

Tips before going to calculations

- The ship characteristics and hull form should be defined before analysis
- Be careful of the units used in defining scantlings and during calculations
- For simplicity, we do not consider any stiffeners

Principle Particulars

- **Insert the main particulars for your vessel.**

PRINCIPAL PARTICULARS				
LBP =	325,000	m	-	Length Between Perpendiculars
B =	53,000	m	-	Beam
T =	21,730	m	-	Average Moulded Draught
lcb =	6,338	%	-	Longitudinal Centre of Buoyancy as a percentage of LBP - + Foward of 0,5 LBP
Cp =	0,833		-	Prismatic Coefficient
Cb =	0,831		-	Block Coefficient
Cms =	0,998		-	Midship Section Coefficient
Cwp =	0,887		-	Waterplane Area Coefficient
Abt =	117,000	m2	-	Transverse Sectional Area of the Bulb at Fore Perpendicular
Cstern =	-10		-	Afterbody form: (see picture below)
Tf =	21,730	m	-	Foward draught of the ship
Ta =	21,730	m	-	Stern draught of the ship
hb =	0,000	m	-	Position of the centre of the transverse area Abt above the keel
At =	0,000	m2	-	Immersed part of the transverse area of the transom
S =	27671,000	m2	-	Wetted Surface - If you don't now, input zero and the program will estimate a value

Principle Particulars

- **You can measure the area(and its centre)of the bulb @FP from the hull lines. You can use any 2D CAD software.**

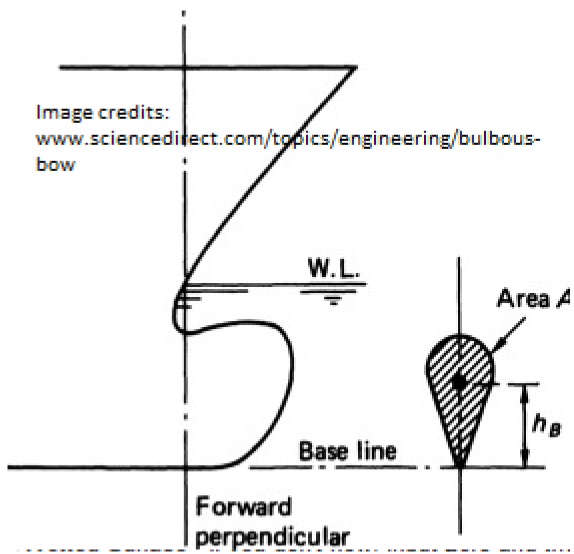
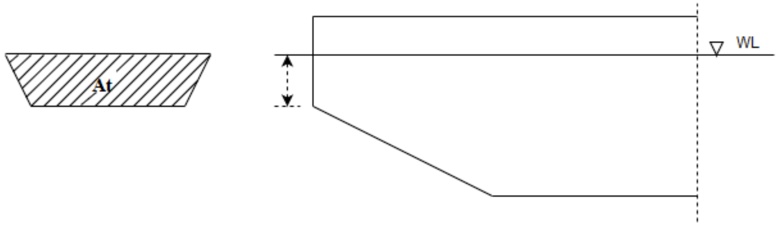


Image credits: www.sciencedirect.com/topics/engineering/bulbous-bow

Length Between Perpendiculars
Beam
Average Moulded Draught
Longitudinal Centre of Buoyancy as a percentage of LBP - + Foward of 0,5 LBP
Prismatic Coefficient
Block Coefficient
Midship Section Coefficient
Waterplane Area Coefficient
Transverse Sectional Area of the Bulb at Fore Perpendicular
Afterbody form: (see picture below)
Foward draught of the ship
Stern draught of the ship
Position of the centre of the transverse area Abt above the keel
Immersed part of the transverse area of the transom
Wetted Surface - If you don't now, input zero and the program will estimate a value

Principle Particulars

- **The immersed area of the transom can also be measured from the hull lines of your ship.**



-	Length Between Perpendiculars
-	Beam
-	Average Moulded Draught
-	Longitudinal Centre of Buoyancy as a percentage of LBP - + Foward of 0,5 LBP
-	Prismatic Coefficient
-	Block Coefficient
-	Midship Section Coefficient
-	Waterplane Area Coefficient
-	Transverse Sectional Area of the Bulb at Fore Perpendicular (See the middle picture below)
-	Afterbody form: (see the right picture below)
-	Foward draught of the ship
-	Stern draught of the ship
-	Position of the centre of the transverse area Abt above the keel (See the middle picture below)
-	Immersed part of the transverse area of the transom
-	Wetted Surface - If you don't now, input zero and the program
	will estimate a value

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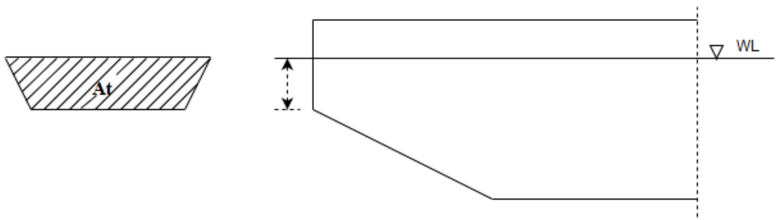
Appendage Particulars

- **Appendages include any part that stick out of the bare hull below the waterline(e.g. rudders, thrusters, bilge keels,…).**
- **These parts contribute in the viscous water resistance as they are added surfaces in water.**



-	Length Between Perpendiculars
-	Beam
-	Average Moulded Draught
-	Longitudinal Centre of Buoyancy as a percentage of LBP - + Foward of 0,5 LBP
-	Prismatic Coefficient
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-	Wetted Surface - If you don't now, input zero and the program
	will estimate a value

Appendage Particulars

- **Each of which has different (1+k) factor which is a factor contribute in the viscous resistance.**
- **In the presence coulmn, insert a value 1 if the appendage exists and zero if it does not exist in your ship project.**

APPENDAGES PARTICULARS					
	1 + K2	Sapp (m2)	Presence		
Rudder Behind Skeg	1,70	0,00	0		
Rudder Behind Stern	1,40	0,00	0		
Twin-screw balance rudders	2,80	0,00	0		
Shaft Brackets	3,00	0,00	0		
Skeg	1,80	0,00	0		
Strut Bossings	3,00	0,00	0		
Hull Bossings	2,00	0,00	0		
Shafts	3,00	0,00	0		
Stabilizer Fins	2,80	0,00	0		
Dome	2,70	0,00	0		
Bilge Keels	1,40	0,00	0	Diameter	
Bow Thruster	-	-	0	0,00	m
Stern Thruster	-	-	0	0,00	m

1 + K2 : Appendage resistance factor - Default
Sapp : Wetted area of the appendages
Presence: 1 or 0 (Present or not Present)

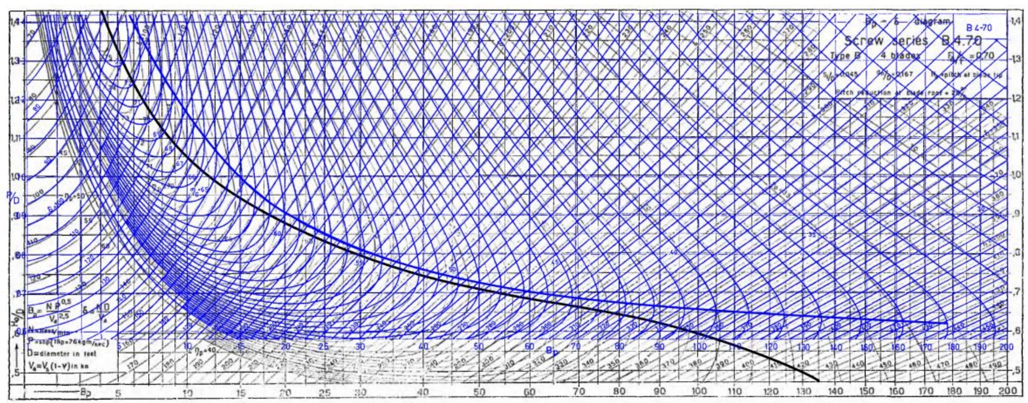
Appendage Particulars

- If the appendage exist, you shall know its wetted surface area. You can approximate it using the dimensions of the appendage; for instance, once you have the shaft length and diameter, you can easily calculate its wetted area.

APPENDAGES PARTICULARS					
	1 + K2	Sapp (m2)	Presence		
Rudder Behind Skeg	1,70	0,00	0		1 + K2 :
Rudder Behind Stern	1,40	0,00	0		Sapp :
Twin-screw balance rudders	2,80	0,00	0		Presence:
Shaft Brackets	3,00	0,00	0		
Skeg	1,80	0,00	0		
Strut Bossings	3,00	0,00	0		
Hull Bossings	2,00	0,00	0		
Shafts	3,00	0,00	0		
Stabilizer Fins	2,80	0,00	0		
Dome	2,70	0,00	0		
Bilge Keels	1,40	0,00	0	Diameter	
Bow Thruster	-	-	0	0,00	m
Stern Thruster	-	-	0	0,00	m

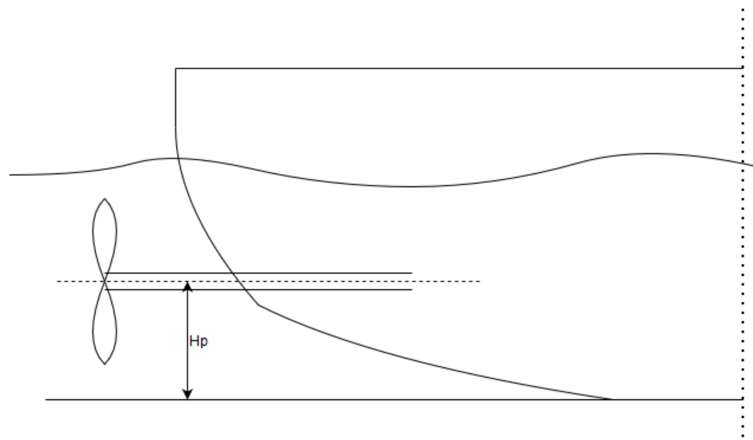
Propulsion Particulars

- You should have the main characteristics of your propeller ready before the resistance analysis.
- It is suggested to use some methodical series to design your propeller at the preliminary stage of design (e.g. Wageningen B-screw series).



Propulsion Particulars

- **The height of the shaft line above the keel depends on your general arrangement.**
- **The open water efficiency (eta0) is ratio of the thrust power to the power of the propeller operating without being attached to the hull.**



PROPULSION PARTICULARS		
Z =	5	
P =	6,51	m
D =	9,10	m
Hp =	4,60	m
K =	0,2	
eta0 =	0,63	

Speed range

- **Specify the speed range for which you want to calculate the ship resistance.**
- **Finally, insert the water particulars; the kinematic visocity and the density of water. (ρ seawater=1025 kg/m3, ρ freshwater=1000 kg/m3, ρ seawater in Finland=1005 kg/m3)**

Speeds				
V0 =	1,00	knots	-	Initial Speed
Vf =	15,00	knots	-	Final Speed

WATER PARTICULARS				
Ni =	1,188E-06	m2/s	-	Kinematic Viscosity of Water
rho =	1025	kg/m3	-	Specific mass of water

Output

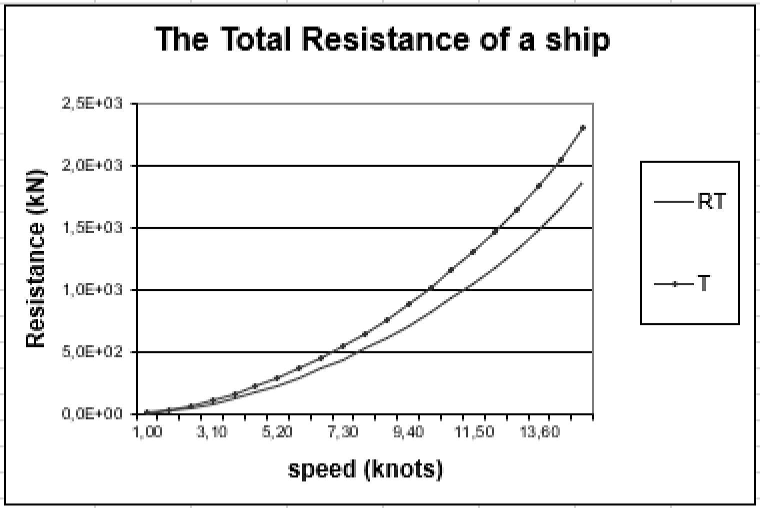
- **The results you get from the spreadsheet:**
  - Tabular values of the resistance and power at various speed values.
  - Resistance and power curves from which you can estimate the power required for your ship at the design speed.

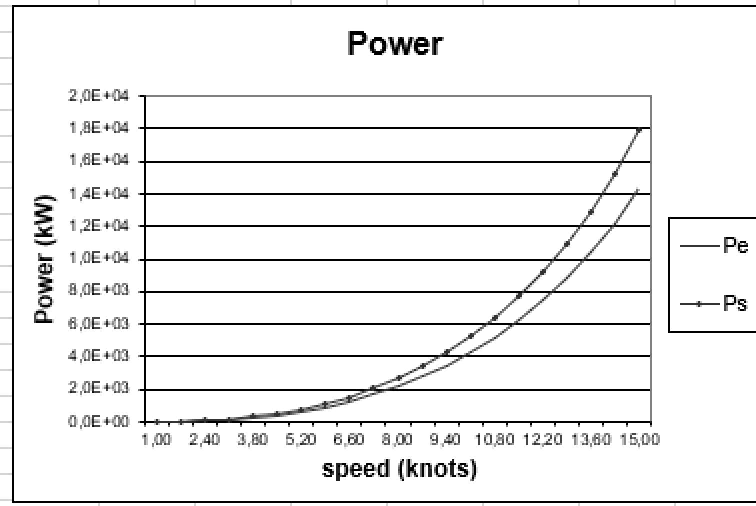
Tabular Values

Fn	Speed (knots)	Rt (kN)	T (kN)	Pe (kW)	Ps (kW)	w	t	etarr	CT
0,00911	1,00	10,6	13,1	5,5	6,4	0,38656	0,19063	1,031505	0,00283
0,01549	1,70	28,6	35,4	25,1	29,9	0,37966	0,19063	1,031341	0,00264
0,02187	2,40	54,7	67,6	67,6	81,0	0,37569	0,19063	1,031104	0,00253
0,02824	3,10	88,5	109,4	141,2	170,2	0,37298	0,19063	1,030796	0,00246
0,03462	3,80	129,9	160,5	253,9	307,1	0,37094	0,19063	1,03042	0,0024
0,041	4,50	178,6	220,7	413,5	501,6	0,36933	0,19063	1,029977	0,00235
0,04738	5,20	234,6	289,9	627,6	763,2	0,36801	0,19063	1,029467	0,00231
0,05375	5,90	297,7	367,8	903,6	1101,5	0,3669	0,19063	1,028893	0,00228
0,06013	6,60	367,9	454,5	1249,1	1525,8	0,36594	0,19063	1,028255	0,00225
0,06651	7,30	445,0	549,8	1671,3	2045,6	0,3651	0,19063	1,027553	0,00223
0,07289	8,00	529,1	653,7	2177,5	2670,3	0,36435	0,19063	1,026788	0,0022
0,07926	8,70	620,0	766,0	2774,9	3409,4	0,36368	0,19063	1,025961	0,00218
0,08564	9,40	717,8	886,9	3471,2	4272,6	0,36308	0,19063	1,025071	0,00216
0,09202	10,10	822,7	1016,4	4274,4	5270,7	0,36253	0,19063	1,024118	0,00215
0,0984	10,80	934,9	1155,1	5194,2	6416,3	0,36202	0,19063	1,023097	0,00214
0,10478	11,50	1055,2	1303,8	6242,9	7725,7	0,36155	0,19063	1,022002	0,00213
0,11115	12,20	1185,1	1464,3	7438,1	9221,7	0,36112	0,19063	1,02082	0,00212
0,11753	12,90	1326,8	1639,3	8805,0	10937,0	0,36072	0,19063	1,019531	0,00212
0,12391	13,60	1483,7	1833,2	10380,7	12919,9	0,36034	0,19063	1,018104	0,00214
0,13029	14,30	1660,8	2052,0	12217,9	15239,1	0,35999	0,19063	1,016492	0,00216
0,13666	15,00	1864,6	2303,7	14388,1	17988,1	0,35965	0,19063	1,014639	0,00221

Rt =	The total resistance of a ship
T =	The propeller thrust
Pe =	Efective power
Ps =	Shaft power
w =	Wake coefficient
t =	Thrust deduction coefficient
etarr =	Relative-rotative efficiency
CT	Resistance coefficient

Resistance and Power Curves





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