Normand's number method

1. Before calculations, make sure that the reference ship is very near to your new design; deadweight does not change much.
2. Define the reference ship (L, B, T, CB, WH, WM, WO, WF).
3. Normand's number is then calculated based on the equation below.
4. Some assumptions must be made to calculate the new design data such as that CB and draught do not change.
5. Finally based on deadweight change, displacement and dimensions of the new design can be obtained.
6. You can use the excel sheet given to calculate main characteristics of the new design.

$$N = \frac{d\Delta}{dW} = \frac{\Delta}{\Delta + (W_H + W_O) + \frac{2}{3}(W_M + W_F)}$$

Example

You are required to design a general cargo ship for a shipping line company which is most likely similar to the last ship in their fleet, but the deadweight is required to be increased by 5000 tonnes. The data of the reference ship is given in the table.

Item	Reference Ship data
L (m)	150
B (m)	21
T (m)	9
CB	0,72
Hull weight W_H (tonne)	4000
Machinery Weight W_M (tonne)	1500
Outfitting weight W_O (tonne)	1000
Fuel weight W_F (tonne)	1500
Deadweight (tonne)	12412
L/B	7,14

• Solution Procedure:

1. Calculate the displacement of the reference ship based on the main dimensions and CB. λ is the shell and appendage allowance=1.006, ρ is the density of seawater=1.25 $^{t}/_{m^3}$

$$\Delta = \rho.L.B.T.C_B.\lambda = 20534 \text{ t}$$

2. Calculate Normand's number based on the equation in a previous slide and the given reference ship data.

$$N = \frac{20534}{20534 - (4000 + 1000) - \frac{2}{3}(1500 + 1500)} = 1.517$$

3. Based on the deadweight change required and Normand's number, the displacement of the new design is calculated.

$$\Delta_{new} = \Delta + NdW = 20534 + (1.52 \times 5000) = 28120 \text{ t}$$

4. To determine the main dimensions: L/B, CB, and T are assumed to be unchanged. Different assumptions can be used based on your ship case.

5. Since CB and T do not change; $L.B = \frac{\Delta}{C_B.T}$ and $L/B = 7.14$, therefore, length and breadth can be deduced.

6. Finally, you get the new ship data as given in the table:

Item	New Ship data
L (m)	176,1
B (m)	24,65
T (m)	9
CB	0,72
Δ (tonne)	28120
Cargo Deadweight (tonne)	17534

Statistical Method

1. For deadweight carriers; to estimate the displacement that will achieve the required dead weight, the deadweight to displacement ratio is to be used. It can be derived for different types of ships using the following table:

	1	2	3	4	5	6
Ship type	Limits		DWT/Δ (%)	W_{ST}/W_L (%)	W_{OT}/W_L (%)	W_M/W_L (%)
	Lower	Upper				
General cargo ships (t DWT)	5,000	15,000	65–80	55–64	19–33	11–22
Coasters, cargo ships (GRT)	499	999	70–75	57–62	30–33	9–12
Bulk carriers[a] (t DWT)	20,000	50,000	74–85	68–79	10–17	12–16
	50,000	200,000	80–87	78–85	6–13	8–14
Tankers[b] (t DWT)	25,000	120,000	78–86	73–83	5–12	11–16
	200,000	500,000	83–88	75–88	9–13	9–16
Containerships (t DWT)	10,000	15,000	65–74	58–71	15–20	9–22
	15,000	165,000[c]	65–76	62–72	14–20	15–18
Ro-Ro (cargo) (t DWT)	$L \cong 80$ m	16,000 t DWT	50–60	68–78	12–19	10–20
Reefers[d] (ft^3) of net ref. vol.	300,000	500,000	45–55	51–62	21–28	15–26
Passenger Ro-Ro/ferries/ RoPax	$L \cong 85$ m	$L \cong 120$ m	16–33	56–66	23–28	11–18
Large passenger ships (cruise ships)	$L \cong 200$ m	$L \cong 360$[e] m	23–34	52–56	30–34	15–20
Small passenger ships	$L \cong 50$ m	$L \cong 120$ m	15–25	50–52	28–31	20–29
Stern Trawlers	$L \approx 44$ m	$L \cong 82$ m	30–58	42–46	36–40	15–20
Tugboats	$P_B \cong 500$ KW	3,000 KW	20–40	42–56	17–21	38–43
River ships (towed)	$L \cong 32$ m	$L \cong 35$ m	22–27	58–63	19–23	16–21
River ships (self-propelled)	$L \cong 80$ m	$L \cong 110$ m	78–79	69–75	11–13	13–19

W_L light ship weight, W_{ST} weight of steel structure, W_{OT} weight of outfitting, W_M weight of machinery installation

2. Next, the length between perpendicular of the ship is to be calculated based on the following formula for minimum building and operating cost.

$$L_{PP} = \Delta^{0.3} V^{0.3} C \quad \text{V in knots [Schneekluth]}$$

$$C = 3.4 - \frac{\Delta - 10^3}{10^6} \quad \text{for } 1000 \text{ t} \le \Delta \le 201{,}000 \text{ t}$$

$$C=3.2 \text{ for } \Delta \ge 201{,}000 \text{ t}$$

3. After that, Fn can be obtained $Fn = \dfrac{V(m/s)}{\sqrt{gL(m)}}$.

4. CB is to be obtained using one of the following empirical formulae

$$C_B = 0.7 + 0.125 \tan^{-1}\left[(23 - 100Fn)/4\right] \quad \text{[Watson \& Gilfillan]}$$

$$C_B = -4.22 + 27.8\sqrt{Fn} - 39.1Fn + 46.6Fn^3 \quad \text{for } 0.15 \le \text{Fn} \le 0.32$$

5. Next is to decide on suitable dimensional ratios. L/B ratio can be estimated based on empirical formulae as follows:

$$L/B = 4 \ \ for\ L \le 30\ m \quad L/B = 4 + 0.025(L - 30) \ \ for\ 30\ m \le L \le 130\ m$$

$$L/B = 6.5 \ \ for\ L \ge 130\ m \quad \text{[Watson \& Gilfillan]}$$

6. Draft then can be obtained based on the breadth using the following formula:

$$T = \frac{\nabla}{L.B.C_B}$$

7. Finally, there are some recommendations on the L/D ratio which is important for longitudinal strength and through which you can calculate the depth of the ship.

Ship type	Ratio of main dimensions
	L_{pp}/D
Fast seagoing cargo ships	9.9–13.5
Slow seagoing cargo ships	
Coastal cargo ships	10.0–12.0
Small short sea passenger ships	10.4–11.6
Ferries	8.6–10.3
Fishing vessels	8.2–9.0
Tugboats	7.7–10.0
Bulk carriers	10.5–12.8
Tankers F_n=0.15	12.0–14.0
Tankers F_n=0.16–0.18	10.5–12.8
Fast seagoing reefers	−11.0