# Stöðugleiki skipa kennsla í viku 3.

Grunnatriði

# Upprifjun

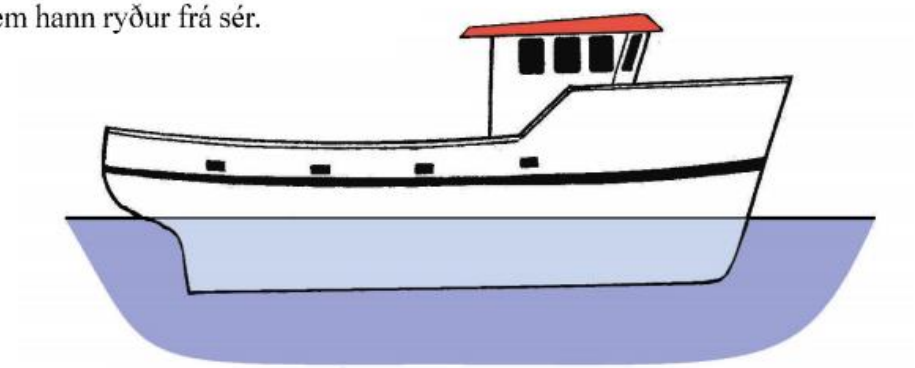
- Hvert er lögmál Arkimedesar?.

Svar …

**SKILGREININGAR**

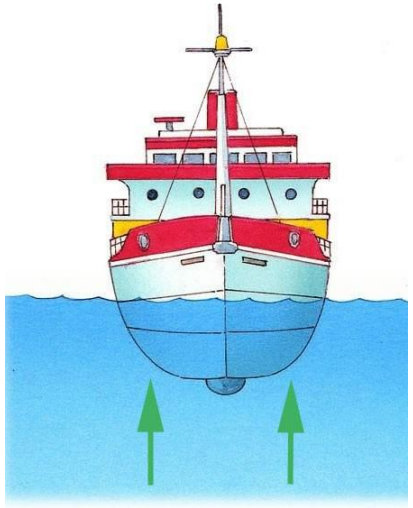
**SÆRÝMI**
Displacement

**Lögmál Arkimedesar:**
Þegar hlut er sökkt í vökva léttist hann jafn mikið og rúmmál þess vökva vegur sem hann ryður frá sér.



Til þess að skip geti flotið þarf því þungi skipsins að vera jafn þunga þess vökva sem það ryður frá sér.
Særými er rúmmál þess vökva sem skipið ryður frá sér.

https://www.youtube.com/watch?v=AC9EULljVbo



***Lögmál Arkímedesar:***

Hlutur sem sökkt er í vökva léttist jafnmikið og rúmfang þess vökva vegur sem hann ryður frá sér.

*Þetta þýðir að djúpristan sem skipið flýtur við (vatnslínan) er háð eðlisþyngd vatnsins, þ.e. skipið sekkur dýpra í ferskvatni en í söltu vatni.

*Sumarfríborð (byggt á sumarhleðslulínu) er reiknað út fyrir vatn með eðlisþyngd $\rho = 1025\ kg/m^3$ (Atlantshafssjór).

*Særýmið er ein mikilvægasta stærðin sem notuð er í jafnvægisútreikningum fyrir skipið.

# Línuteikning.

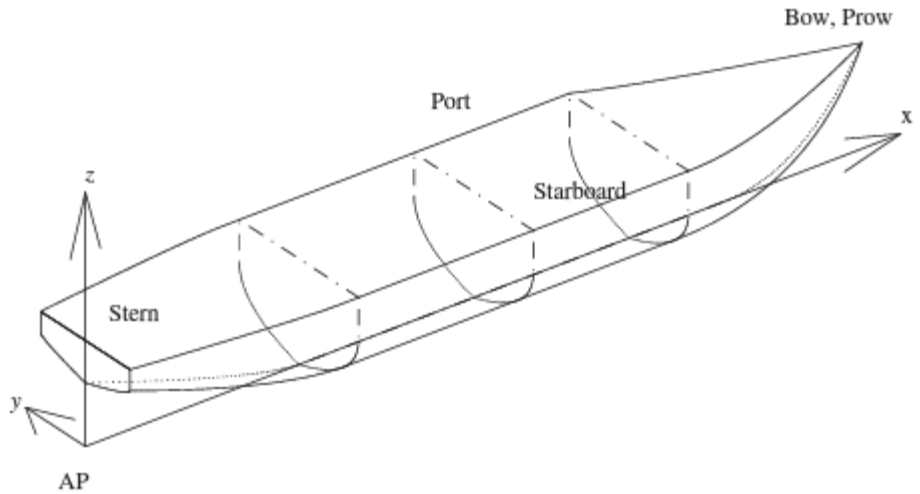



Figure 1.6 System of coordinates recommended by DIN 81209-1

# Línuteikning.

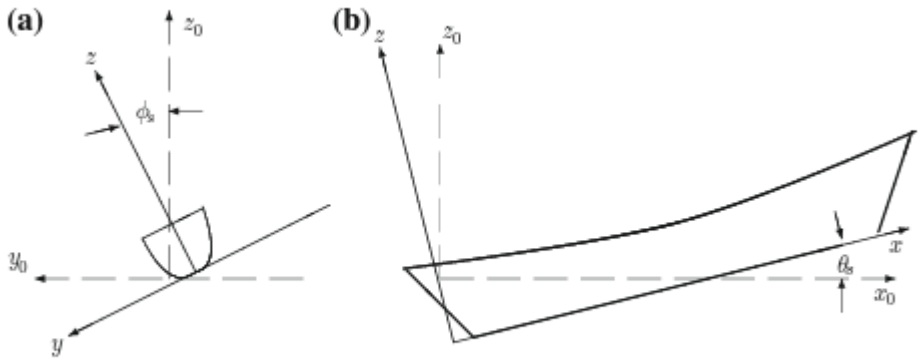



**Figure 1.7 Heel and trim**

If the ship-fixed $z$-axis is vertical, we say that the ship floats in an *upright condition*. A rotation of the ship-fixed system around an axis parallel to the $x$-axis is called **heel** (Figure 1.7) if it is temporary, and **list** if it is permanent. The heel can be produced by lateral wind, by the centrifugal force developed in turning, or by the temporary, transverse displacement of weights. The list can result from incorrect loading or from flooding. If the transverse inclination is the result of ship motions, it is time-varying and we call it **roll**.

When the ship-fixed $x$-axis is parallel to the space-fixed $x_0$-axis, we say that the ship floats on **even keel**. A static inclination of the ship-fixed system around an axis parallel to the ship-fixed $y$-axis is called **trim**. If the inclination is dynamic, that is a function of time resulting from ship motions, it is called **pitch**. A graphic explanation of the term trim is given in Figure 1.7. The trim is measured as the difference between the forward and the aft draught. Thus, the trim is positive if the ship is **trimmed by the head**. As defined here the trim is measured in metres.

# Línuteikning.

**Línuteikningin**

*Línuteikningin samanstendur af þremur slíkum kerfum af kúrfum, ofanvarpað hornrétt í þrívíddarkerfi, x-, y- og z-átt.

l ) Hliðarmynd (Sheer plan)
2) Vatnslínuplan (Half-Breatdth plan)
3) Bandariss (hönnunarbönd, Body Plan)

*Vegna samhverfueiginleika er önnur hliðin sýnd, stefni til hægri. Samhverfuplanið (diametralplanið) oft merkt C.L. er bein lína á myndum fyrir bandariss og vatnslínuplön.

*Þilfar myndar efri mörk, springkúrfa í langskipsplani og bitabugða á þverskipsplani.

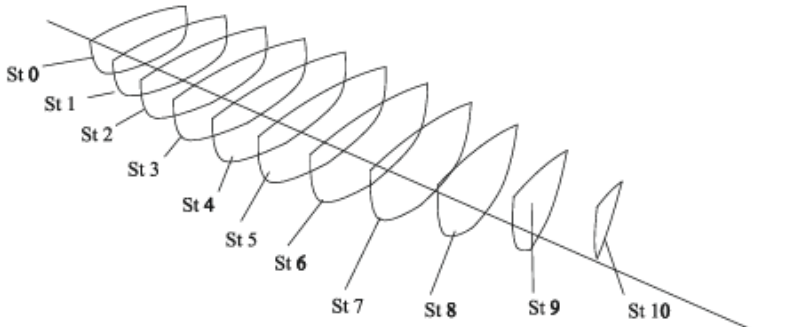



**Figure 1.8 Stations**

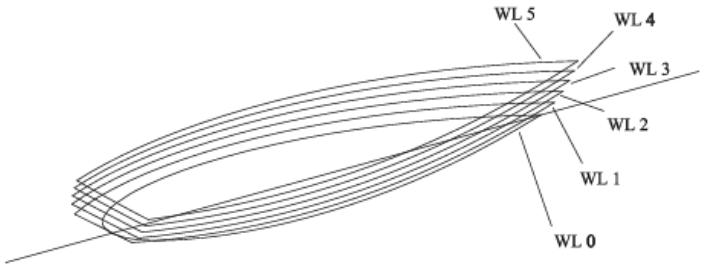
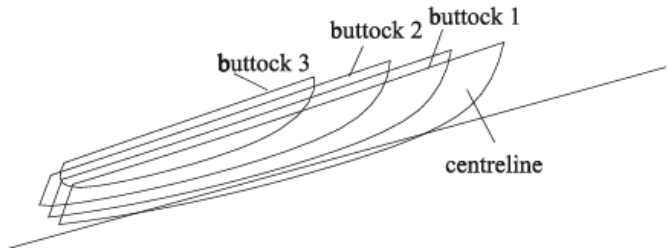



**Figure 1.9 Waterlines**



# Hönnunarmál skipa

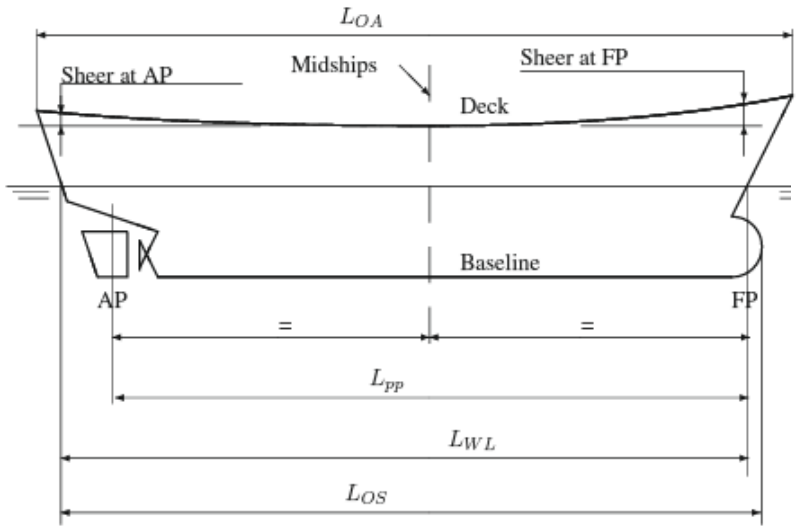



Figure 1.1 Length dimensions


Figure 1.2 How to measure the length between perpendiculars

## Hönnunarmálin

| | |
|---|---|
| Lengd milli lóðlína ($L_{pp}$): | Lóðlínulengdin er lárétt fjarlægð milli aftari lóðlínu og fremri lóðlínu. Aftari lóðlínan gjarnan lögð í gegnum stýrisás, en fremri lóðlínan í gegnum skurðpunkt stefnis og hönnunarvatnslínu. Fremri og aftari lóðlína, hluti af hönnunarböndununum. |
| Mótuð breidd ($B_m$): | Mesta breidd á miðbandi, þ.e. mesta breidd skips, að frádreginni byrðingsþykktinni. Miðbandið (⊗) er bandið mitt á milli fremri og aftari lóðlínu. |
| Mótuð dýpt ($D_m$): | Mótuð dýpt er fjarlægð frá neðsta punkti miðbands við kjöl að efri brún þilfarsbita við byrðing. Í gegnum neðsta punkt byrðings við kjöl er svonefnd grunnlína (B.L) lögð. |

# Hönnunarmálin

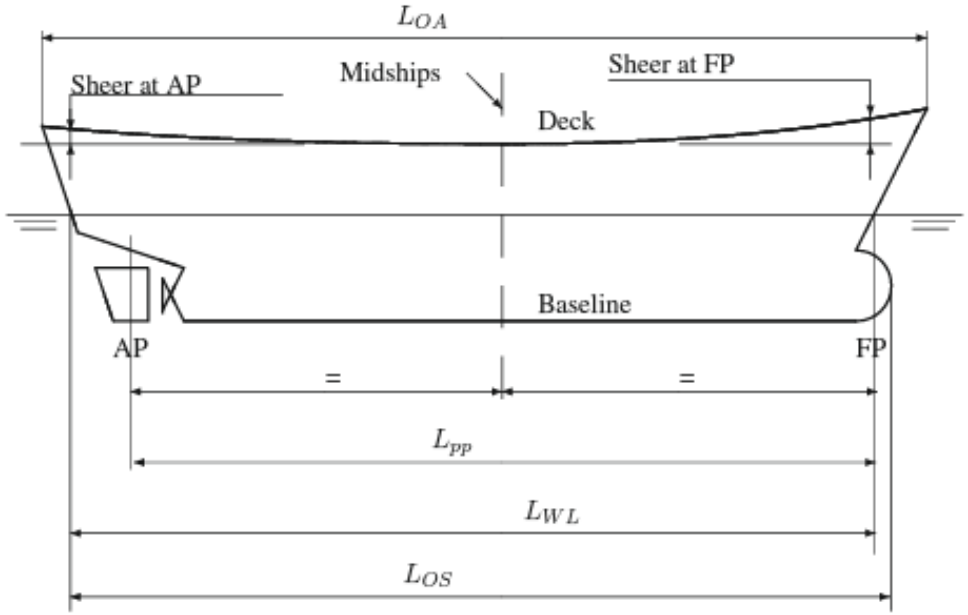



**Figure 1.1 Length dimensions**

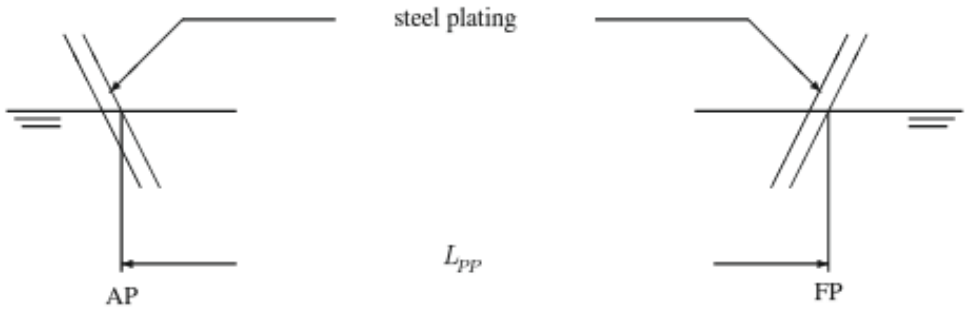



**Figure 1.2 How to measure the length between perpendiculars**

| | |
|---|---|
| Djúpristan (T): | Hönnunardjúpústan ($T_K$) er fjarlægðin frá grunnlínunni upp að |
| | hönnunarsjólínunni, mælt á miðbandi.<br>Hönnunarsjólínan er ákveðin við hönnun skips og á að liggja sem næst endanlegri hleðslusjólínu, svonefndri sumarhleðslusjólínu. Fríborð er munurinn milli dýptar og djúpristu. |
| Kjölhalli, stafnhalli: | Kjölhalli nefnist það þegar skipin eru hönnuð með mismunandi djúpristu að framan og aftan. Í rekstri er raunveruleg sjólína ekki endilega samsíða hönnunarsjólínunni og nefnist það þá stafnhalli (trim). |

# Hönnunarmálin

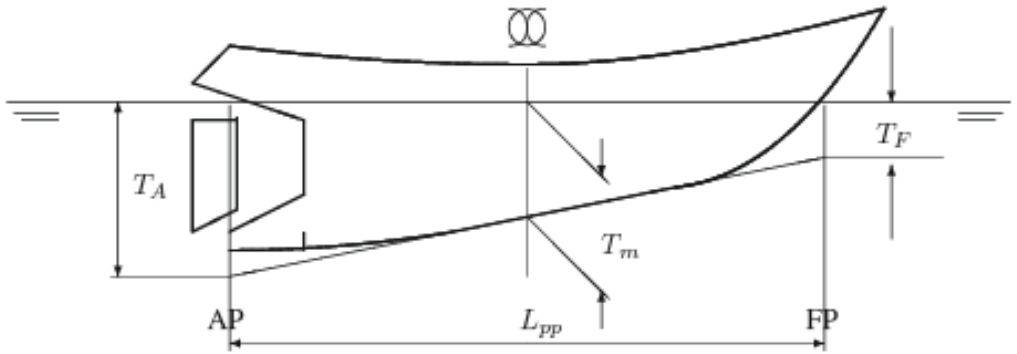



Figure 1.3 The case of a keel not parallel to the load line

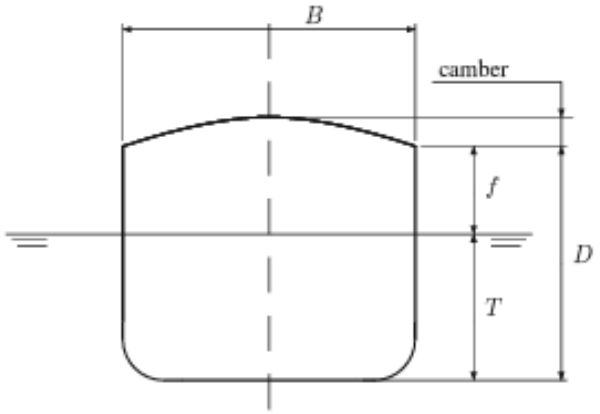
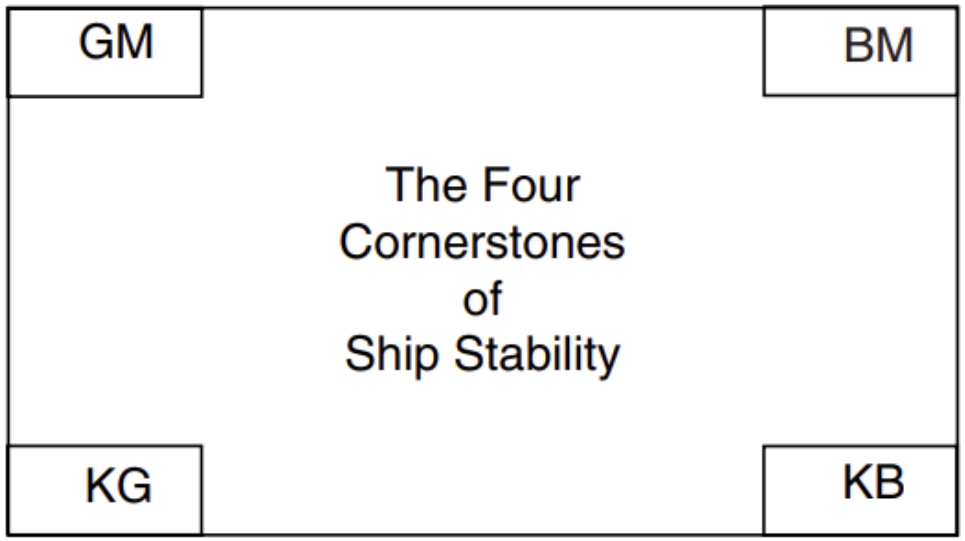



Figure 1.4 Breadth, depth, draught, and camber

Kjölhalli nefnist það þegar skipin eru hönnuð með mismunandi djúpristu að framan og aftan. Í rekstri er raunveruleg sjólína ekki endilega samsíða hönnunarsjólínunni og nefnist það þá stafnhalli (trim).

# Fjórir hornsteinar stöðugleika skps.

## Ship Stability – the Concept




KM = KG + GM

KM = KB + BM

# Formstuðlar....rýmdarstuðull.

### 1.5 Coefficients of Form

In ship design it is often necessary to classify the hulls and to find relationships between forms and their properties, especially the hydrodynamic properties. The **coefficients of form** are the most important means of achieving this. By their definition, the coefficients of form are non-dimensional numbers.

The **block coefficient** is the ratio of the moulded displacement volume, $\nabla$ (see Figure 1.13), to the volume of the parallelepiped (rectangular block) with the dimensions $L$, $B$, and $T$:

$$C_B = \frac{\nabla}{LBT} \tag{1.1}$$

In Figure 1.14 we see that $C_B$ indicates how much of the enclosing parallelepiped is filled by the submerged hull.

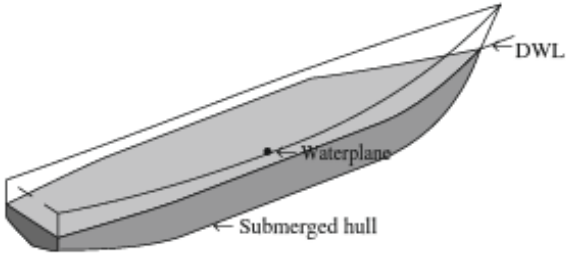



**Figure 1.13 The submerged hull**

# Formstuðlar..... Miðbandsstuðullinn

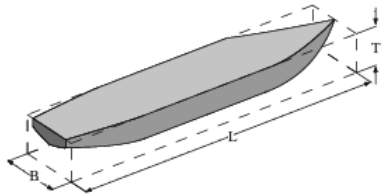



Figure 1.14 The definition of the block coefficient, $C_B$

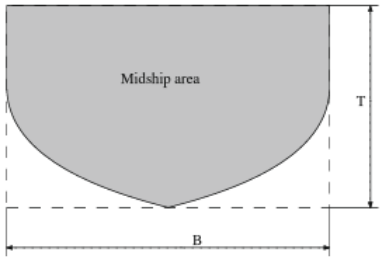



Figure 1.15 The definition of the midship-section coefficient, $C_M$

The **midship coefficient**, $C_M$, is defined as the ratio of the midship-section area, $A_M$, to the product of the breadth and the draught, $BT$:

$$C_M = \frac{A_M}{BT} \tag{1.2}$$

Figure 1.15 enables a graphical interpretation of $C_M$.

The **prismatic coefficient**, $C_P$, is the ratio of the moulded displacement volume, $\nabla$, to the product of the midship-section area, $A_M$, and the length, $L$:

$$C_P = \frac{\nabla}{A_M L} = \frac{C_B LBT}{C_M BTL} = \frac{C_B}{C_M} \tag{1.3}$$

In Figure 1.16 we can see that $C_P$ is an indicator of how much of a cylinder with constant section $A_M$ and length $L$ is filled by the submerged hull. Let us note the **waterplane area** by $A_W$. Then, we define the **waterplane-area coefficient** by

$$C_{WL} = \frac{A_W}{LB} \tag{1.4}$$

A graphic interpretation of the waterplane coefficient can be deduced from Figure 1.17.

# Stuðlar.

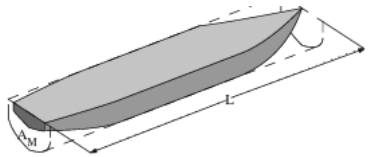



Figure 1.16 The definition of the prismatic coefficient, $C_P$

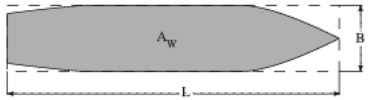



Figure 1.17 The definition of the waterplane coefficient, $C_{WL}$4

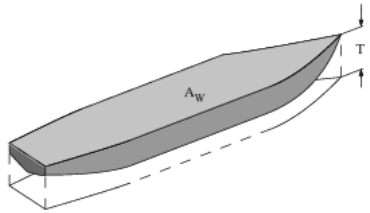



Figure 1.18 The definition of the vertical prismatic coefficient, $C_{VP}$.

The **vertical prismatic coefficient** is calculated as

$$C_{VP} = \frac{\nabla}{A_W T} \tag{1.5}$$

For a geometric interpretation see Figure 1.18.

Other coefficients are defined as ratios of dimensions, for instance $L/B$, known as **length-breadth ratio**, and $B/T$ known as "$B$ over $T$." The **length coefficient of Froude**, or **length-displacement ratio** is

$$\text{Ⓜ} = \frac{L}{\nabla^{1/3}} \tag{1.6}$$

and, similarly, the **volumetric coefficient**, $\nabla/L^3$.

*Kassastuðull*

$$\delta = \frac{\nabla}{L_{pp} \cdot B \cdot T}$$

# Dæmi um útreikning á stuðlum

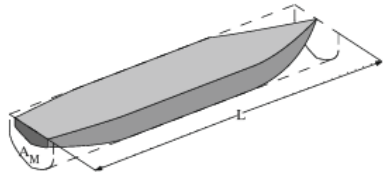


Figure 1.16 The definition of the prismatic coefficient, $C_P$

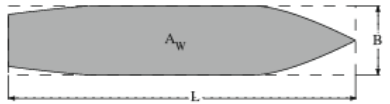


Figure 1.17 The definition of the waterplane coefficient, $C_{WL}$4

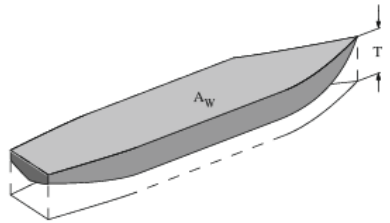


Figure 1.18 The definition of the vertical prismatic coefficient, $C_{VP}$.

## 1.7 Examples

**Example 1.1 (Coefficients of a fishing vessel).** In INSEAN (1962) we find the test data of a fishing vessel hull called *C.484* and whose principal characteristics are:

$$
\begin{aligned}
L_{WL} &= 14.251 \text{ m} \\
B &= 4.52 \text{ m} \\
T_M &= 1.908 \text{ m} \\
\nabla &= 58.536 \text{ m}^3 \\
A_M &= 6.855 \text{ m}^2 \\
A_W &= 47.595 \text{ m}^2
\end{aligned}
$$

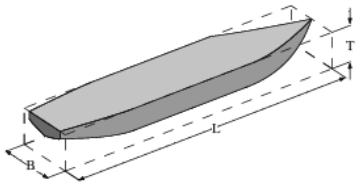


Figure 1.14 The definition of the block coefficient, $C_B$

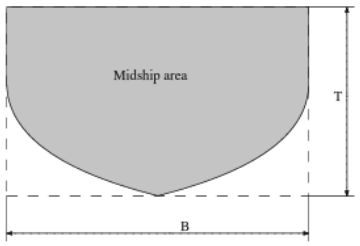


Figure 1.15 The definition of the midship-section coefficient, $C_M$

We calculate the coefficients of form as follows:

$$C_B = \frac{\nabla}{L_{pp} B T_M} = \frac{58.536}{14.251 \times 4.52 \times 1.908} = 0.476$$

$$C_{WL} = \frac{A_W}{L_{WL} B} = \frac{47.595}{14.251 \times 4.52} = 0.739$$

$$C_M = \frac{A_M}{BT} = \frac{6.855}{4.52 \times 1.908} = 0.795$$

$$C_P = \frac{\nabla}{A_M L_{WL}} = \frac{58.536}{6.855 \times 14.251} = 0.599$$

and we can verify that

$$C_P = \frac{C_B}{C_M} = \frac{0.476}{0.795} = 0.599$$

*Kassastuðull*

$$\delta = \frac{\nabla}{L_{pp} \cdot B \cdot T}$$

*Sjólínustuðull*

$$\alpha = \frac{A_{WL}}{L_{pp} \cdot B}$$

*Miðbandsstuðull*

$$\beta = \frac{A_m}{B \cdot D}$$

Rýmdarstuðullinn δ

$$\delta = \frac{\nabla}{L \cdot B \cdot T}$$

# Title 2

- Takk í dag ☺