Ship Stability

Ch. 4 Initial Transverse Stability

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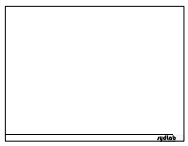
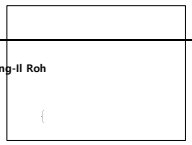
Contents

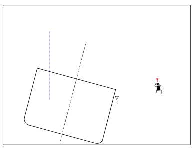


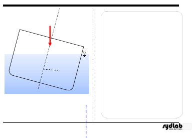
Ch. 4 Initial Transverse Stability

1. Transverse Metacentric Height (GM)
2. Derivation of Transverse Metacentric Radius (BM_T)
3. Change of the Metacenter for Large Angle of Inclination
4. Another Approach to Derive the Following Formula

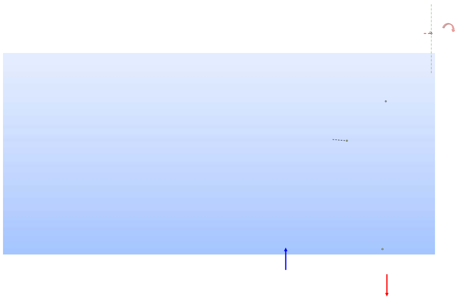
$$\delta y'_B \cdot \nabla = y'_{vp} \cdot v_p + y'_{vs} \cdot v_s$$







Righting Arm (GZ, Restoring Arm)



$$\tau_{righting} = F_B \cdot GZ$$

- **Transverse Righting Moment**

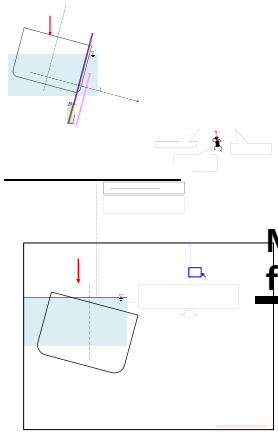
How can we find GZ **in small angle**

Definition of M (Metacenter)

- The intersection point of the vertical line through the center of buoyancy at **position (*B*)** with the vertical line through the center of buoyancy at **position (B_1)**

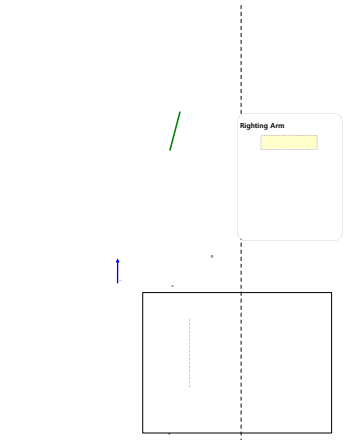
- GM ➡

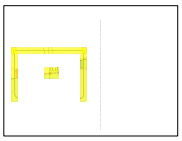
- The term **meta** was selected as a prefix for center because its Greek meaning implies **movement**. The **metacenter** therefore is a **moving center**.



Metacentric Height (GM) of a Ship for Small Angle of Inclination

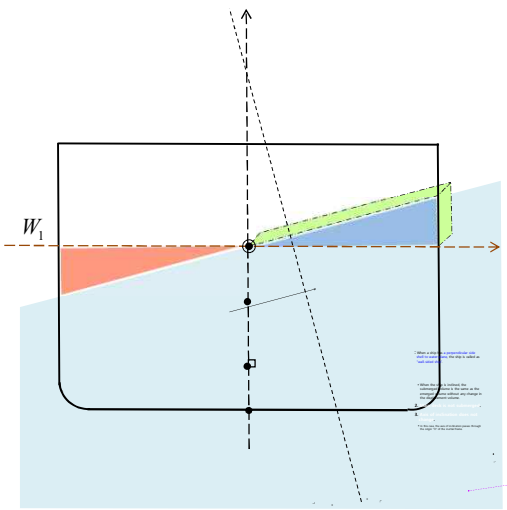
$$\tau_{righting} = F_B \cdot GZ$$





2. Derivation of Transverse Metacentric Radius (BM_T)

Derivation of BM_T (1/12) (BM_T : Transverse Metacentric Radius)



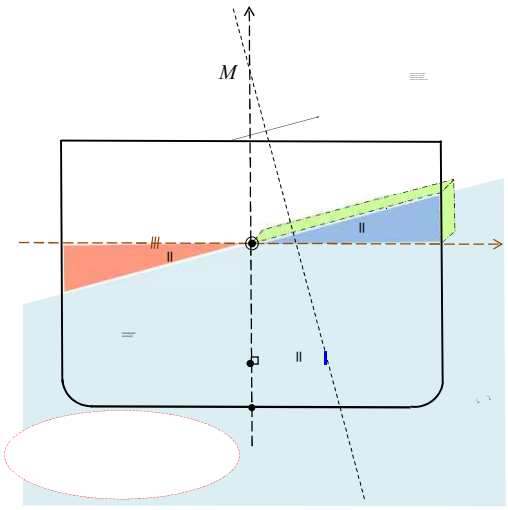
Let us derive the transverse metacentric radius "BM" in case of a **wall-sided ship** with a simple section shape.

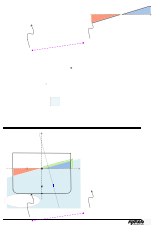
- **Wall sided ship**

Assumption

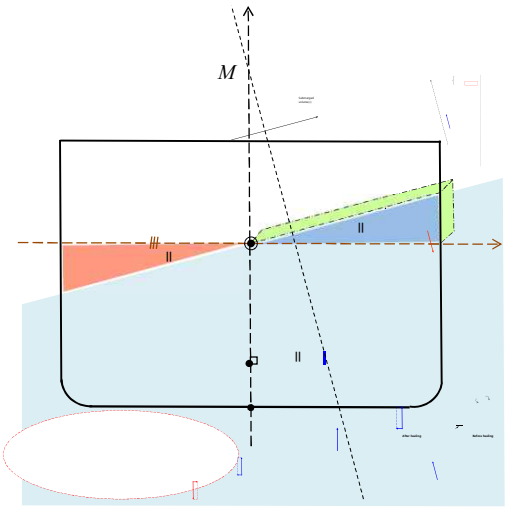
1.

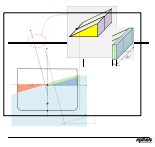
Derivation of BM_T (2/12)



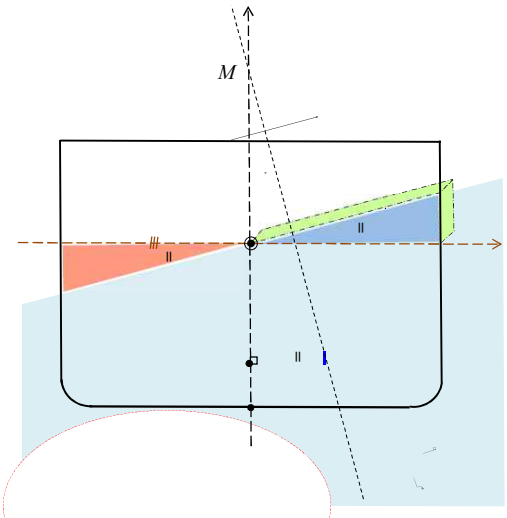


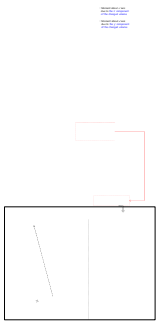
Derivation of BM_T (4/12)



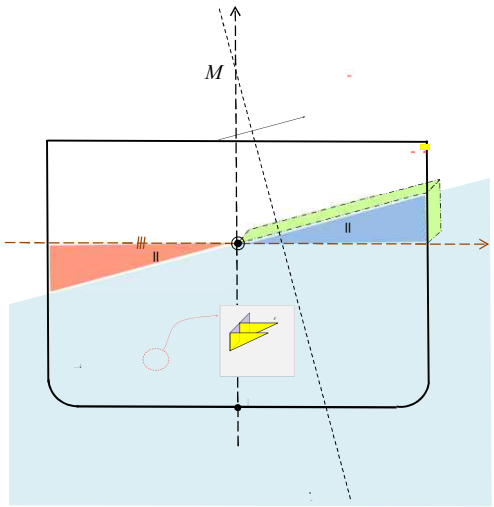


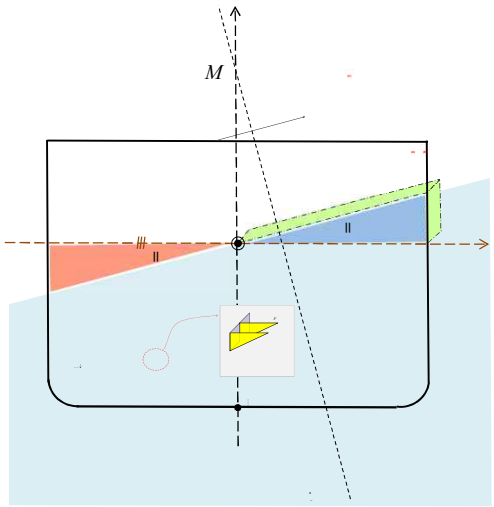
Derivation of BM_T (6/12)

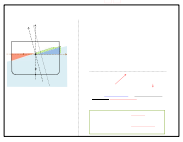


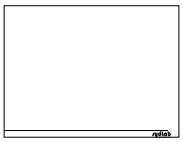


15


M
III
II
II


M



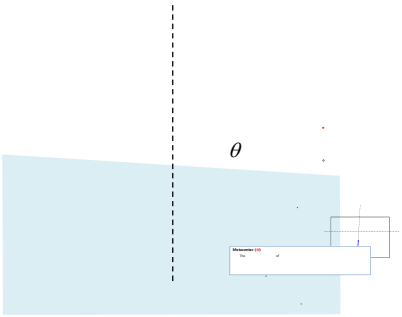


Derivation of BM_t (12/12)

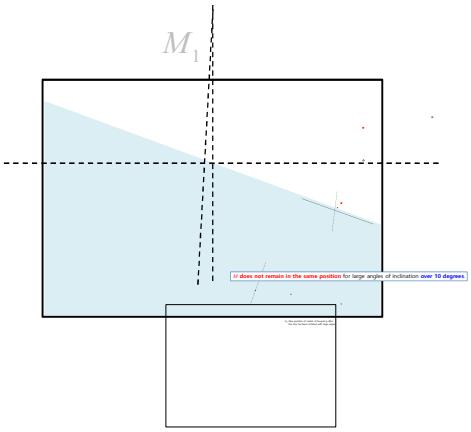
$$BM = \frac{I_T}{\nabla}\left(1+\frac{1}{2}\tan^2\phi\right)$$

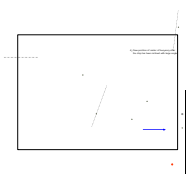
21

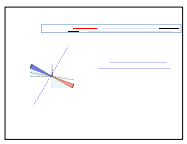
Metacenter (M)



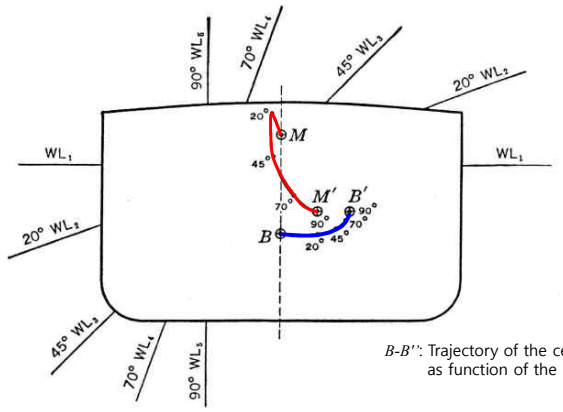
Metacenter (M) at Large Angles





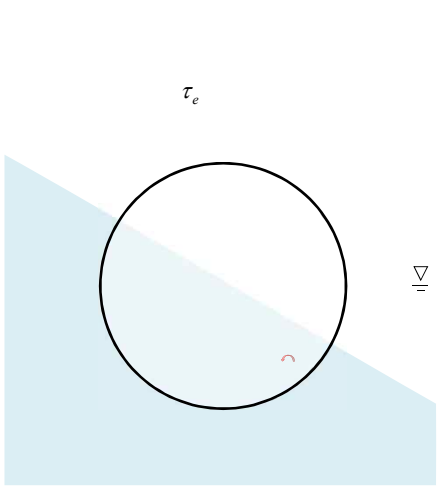


Example of Metacenter (M)

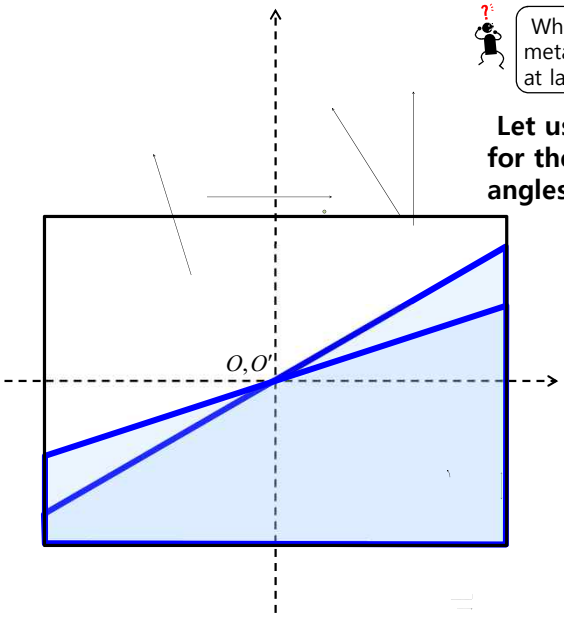


Typical locus of metacenter and centers of buoyancy for an average form merchant ship

Metacenter (M) of Circular Section



Metacenter (M) of a Box-shaped Ship (1/4)



What will be the location of the metacenter (M) for the box-shaped ship at large angles of heel?

Let us calculate the metacenter (M) for the barge-shaped ship at various angles of heel.

29

Metacenter (M) of a Box-shaped Ship (2/4)

Metacenter (M) of a Box-shaped Ship (3/4)
- Center of Buoyancy at a Given Angle of Heel

What will be the location of the metacenter (M) for the box-shaped ship at large angles of heel?

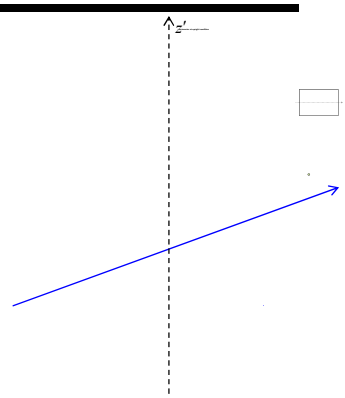
(1) Center of Buoyancy (B) at a given angle of heel ϕ

Metacenter (M) of a Box-shaped Ship (3/4)
- Metacenter at Given Angles of Heel (1/4)

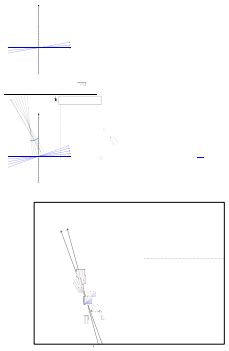
(3) Metacenter (M) at given angles of heel ϕ_1, ϕ_2

33

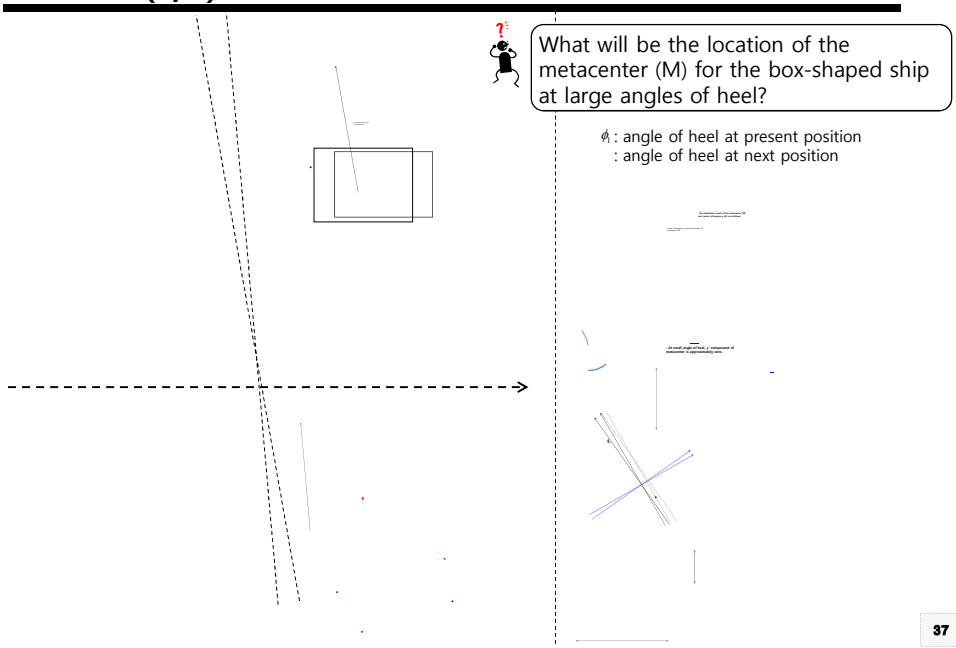
Metacenter (M) of a Box-shaped Ship (3/4)
- Metacenter at Given Angles of Heel (3/4)

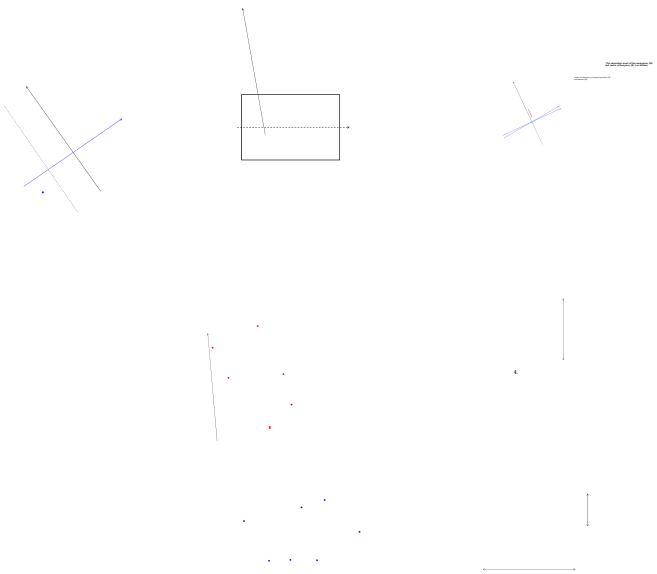


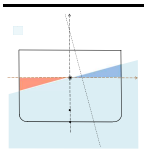
35



Metacenter (M) of a Box-shaped Ship (4/4)
- Result (1/2)

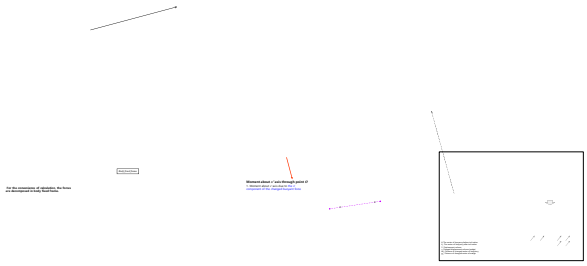


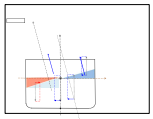




4. Another Approach to Derive the Following Formula

$$\delta y'_B \cdot \nabla = y'_{vp} \cdot v_p + y'_{vs} \cdot v_s$$

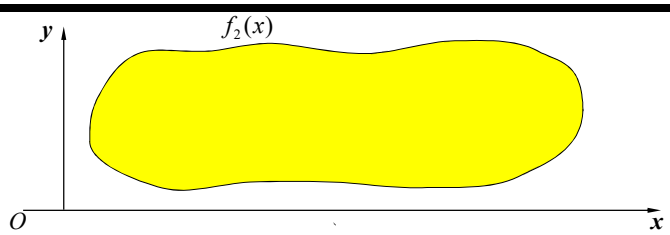




$$(\delta z'_B)\cdot(\rho g\nabla\cdot\sin\phi) = z'_{vp}\cdot(\rho g v_p\cdot\sin\phi) + z'_{vs}(\rho g v_s\cdot\sin\phi)$$

Derivation of BM_T (2/2)

[Reference] Area, Moments, Centroid, and Moments of Inertia

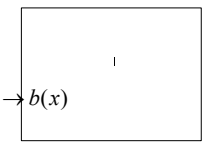


43

[Reference] Area, Moments, Centroid, and Moments of Inertia

- Longitudinal Moment of Inertia (I_L)

$x_1 \to 0,\ x_2 \to L,\ f_1(x) \to 0,\ f_2(x) \to b(x)$



45