Offshore Hydromechanics

Module 1 : Hydrostatics
Constant Flows
Surface Waves

OE4620 Offshore Hydromechanics

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1. INTRODUCTION

- Some definitions
- Floater types
- Relevance of hydromechanics

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Floater motions

	static	dynamic	symbol
X :		surge	x
Y :		sway	y
Z :		heave	z
Around X :	heel, list	roll	ϕ
Around Y :	trim	pitch	θ
Around Z :	course angle	yaw	ψ

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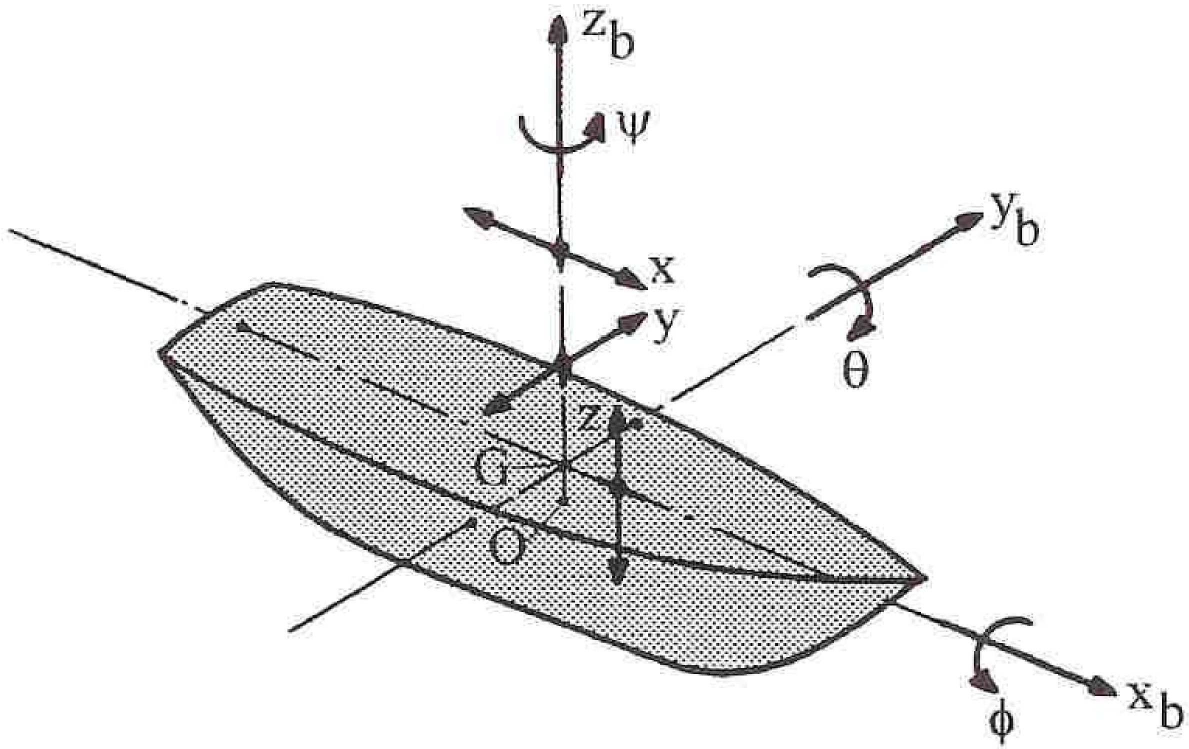
Axes convention



Application

Nearly every offshore design or problem

- DP vessel design
- Semi submersible optimization
- Jacket launch
- FPSO mooring
- Etc. etc.

2. HYDROSTATICS

- Equilibrium situations

  or

- Quasi-static situations

Law of Archimedes : Ευρεκα !!

Archimedes Law

The weight of a floating body is equal to the weight of the displaced fluid.

The term "displacement" of a floater refers to its weight.

$$D = \rho \, g \, \nabla \quad [N]$$

∇ = submerged volume [m^3]

ρ = specific density of the fluid

seawater : ρ = 1025 kg/m^3

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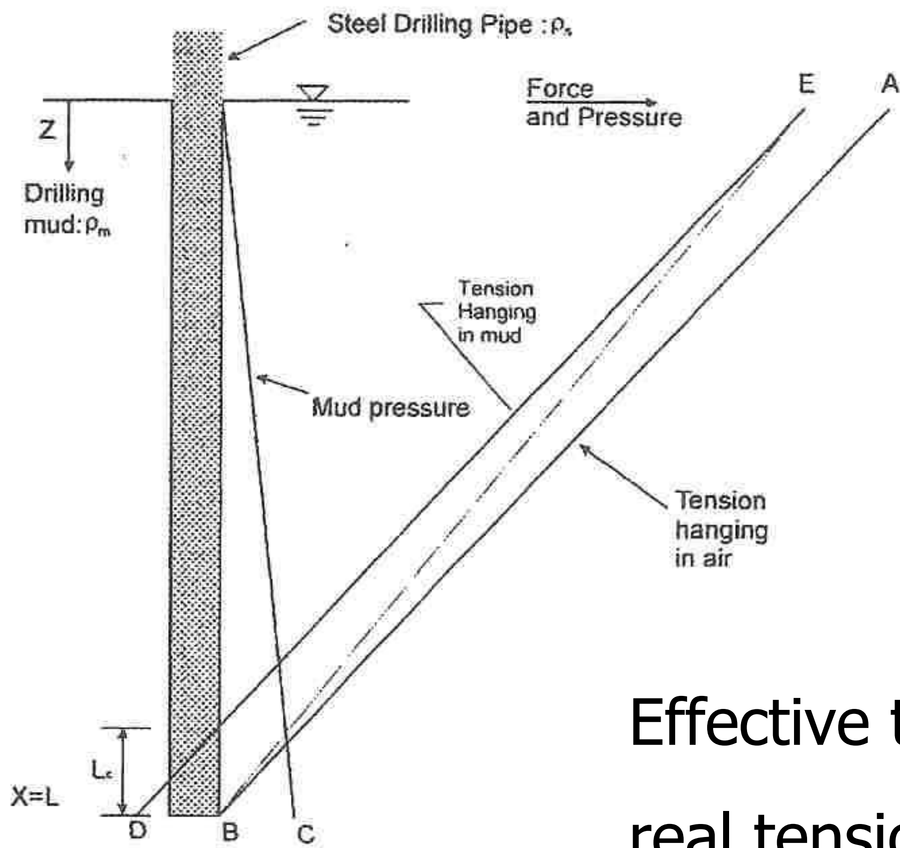
Static internal forces, stresses

Consider external (and internal) pressures and the local loads or weights.

Archimedes applies to <u>complete</u> bodies, not to internal forces.

Example : drillstring in mud



Effective tension versus

real tension

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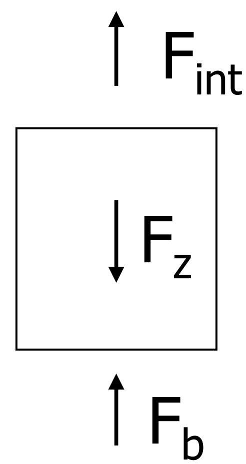
Example : drillstring in mud



Effective tension versus = 0 when $F_z = F_b$

$$\rho_s g A \Delta L = \rho_m g A L \qquad \Delta L = \frac{\rho_m}{\rho_s} L$$

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Floating Stability

The property of floating bodies that keeps them upright.

Offshore : quiet motion behaviour, in particular in roll.

These two definitions are to some extent contradictory !

Floating Stability

Applications:

- Determine angle of heel due to heeling moment
- Determine shift of center of gravity due to additional mass
- Find center of gravity (inclining experiment)
- Determine static stability curve

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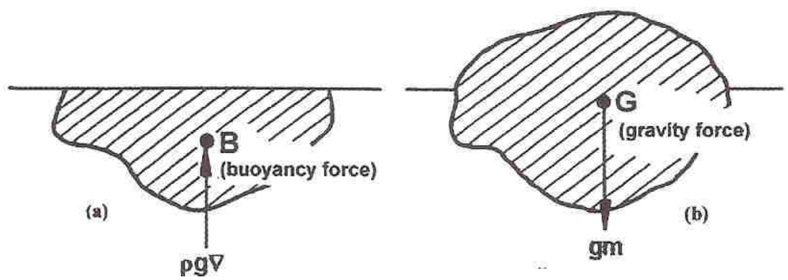
Floating Stability

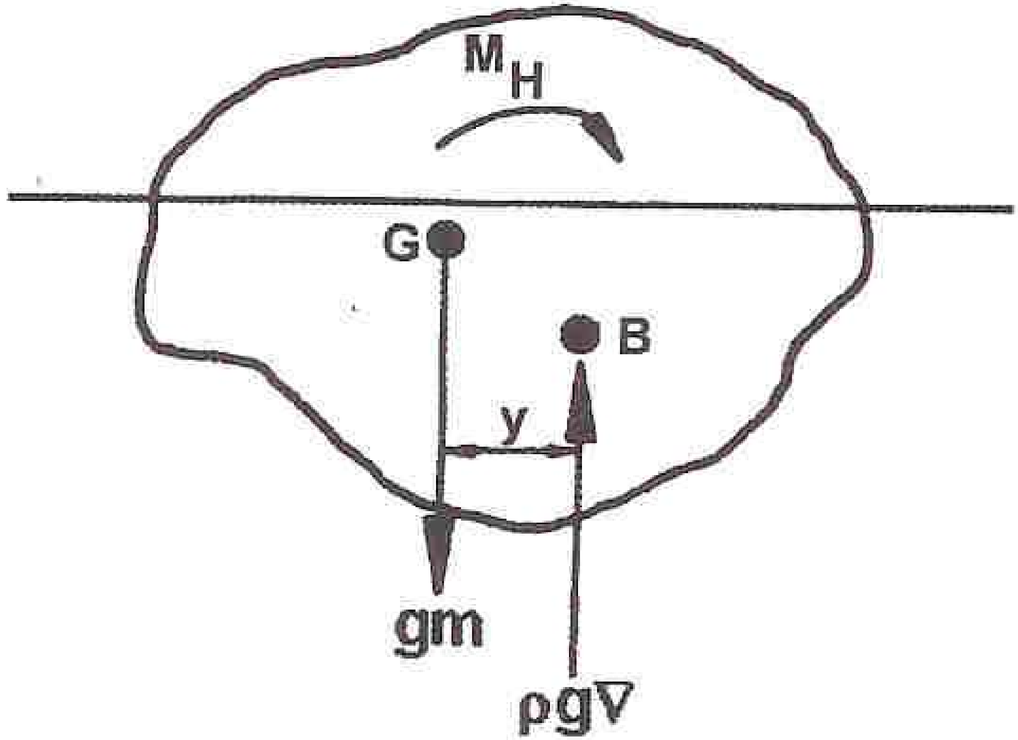
A floating structure at rest is in:

- *Horizontal equilibrium*
- *Vertical equilibrium*
- *Rotational equilibrium (!)*

Weight and buoyancy



Heeling Moment



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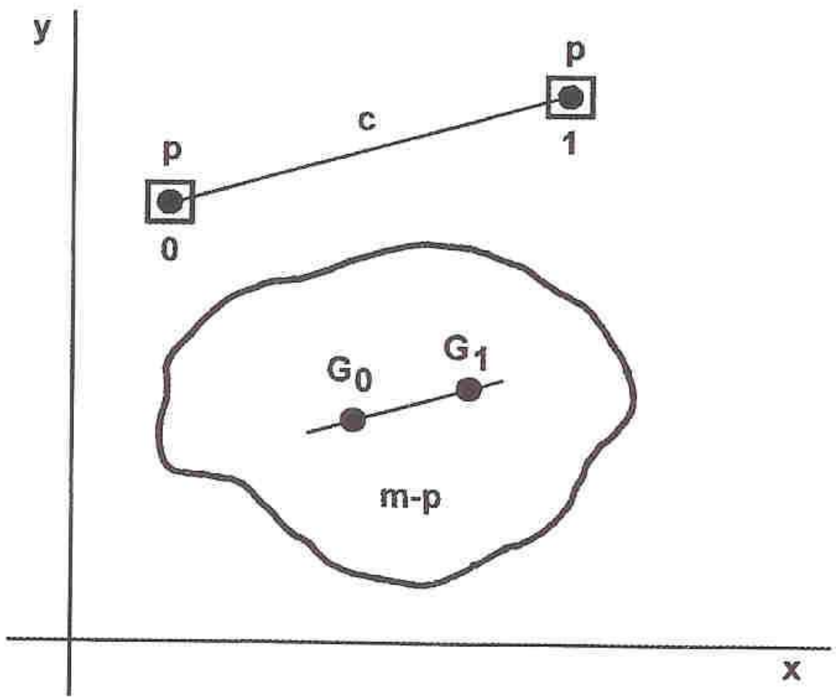
Shifting loads

$$\boxed{\overline{G_0G_1} = \frac{p \cdot c}{m}}$$



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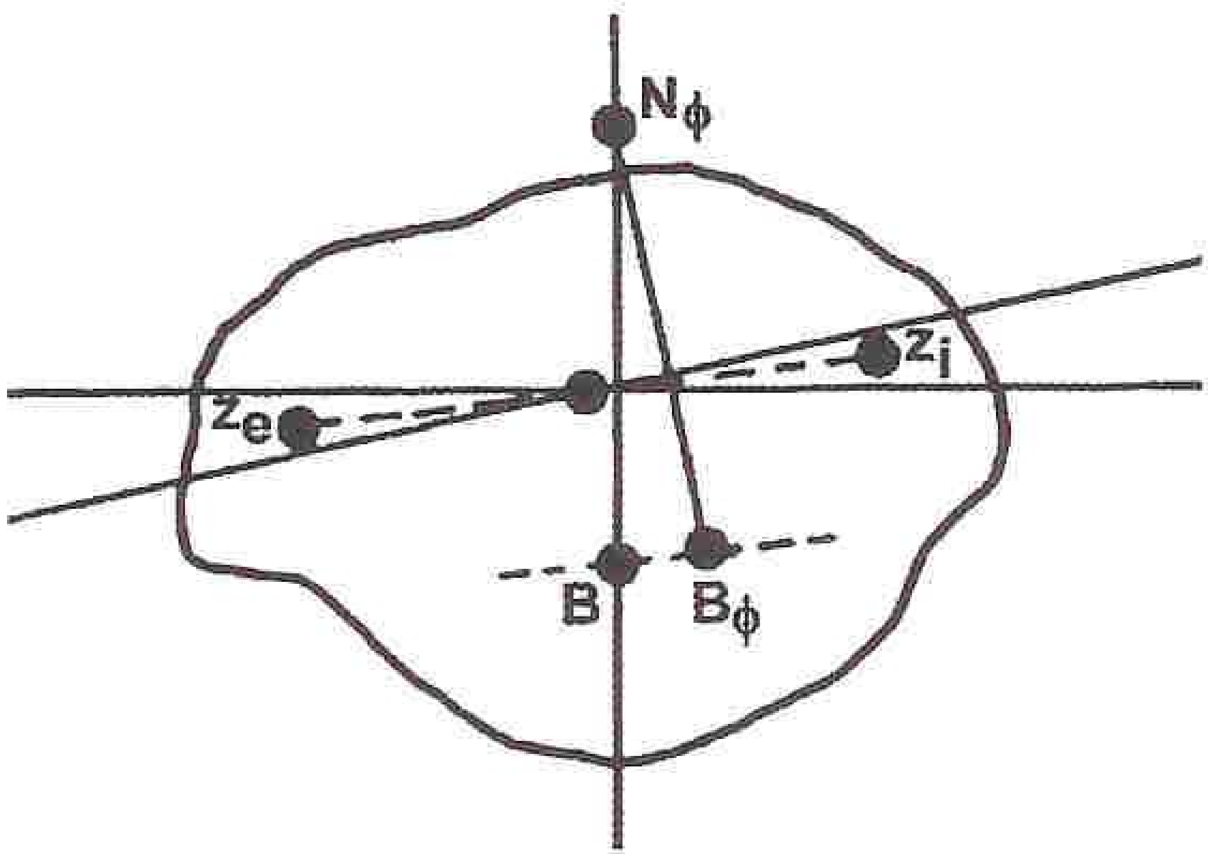
Shifting buoyancy



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Stabilizing Moment

$M_S = \rho\, g\, \nabla\;\; GN_\phi \sin\phi$

$\quad = \; D.GZ$

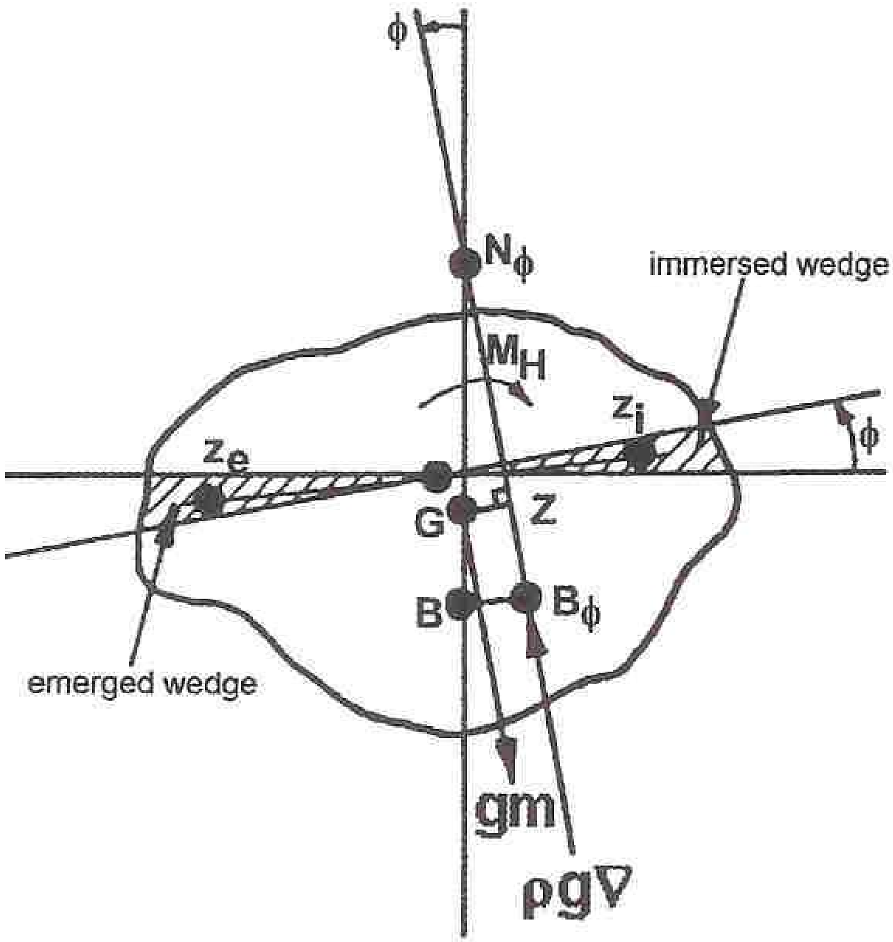
Equilibrium :

$$M_S = M_H$$

Small angle of heel :

$\quad \sin\phi \approx \phi$

$\quad GZ = GN_\phi.\phi = GM.\phi$



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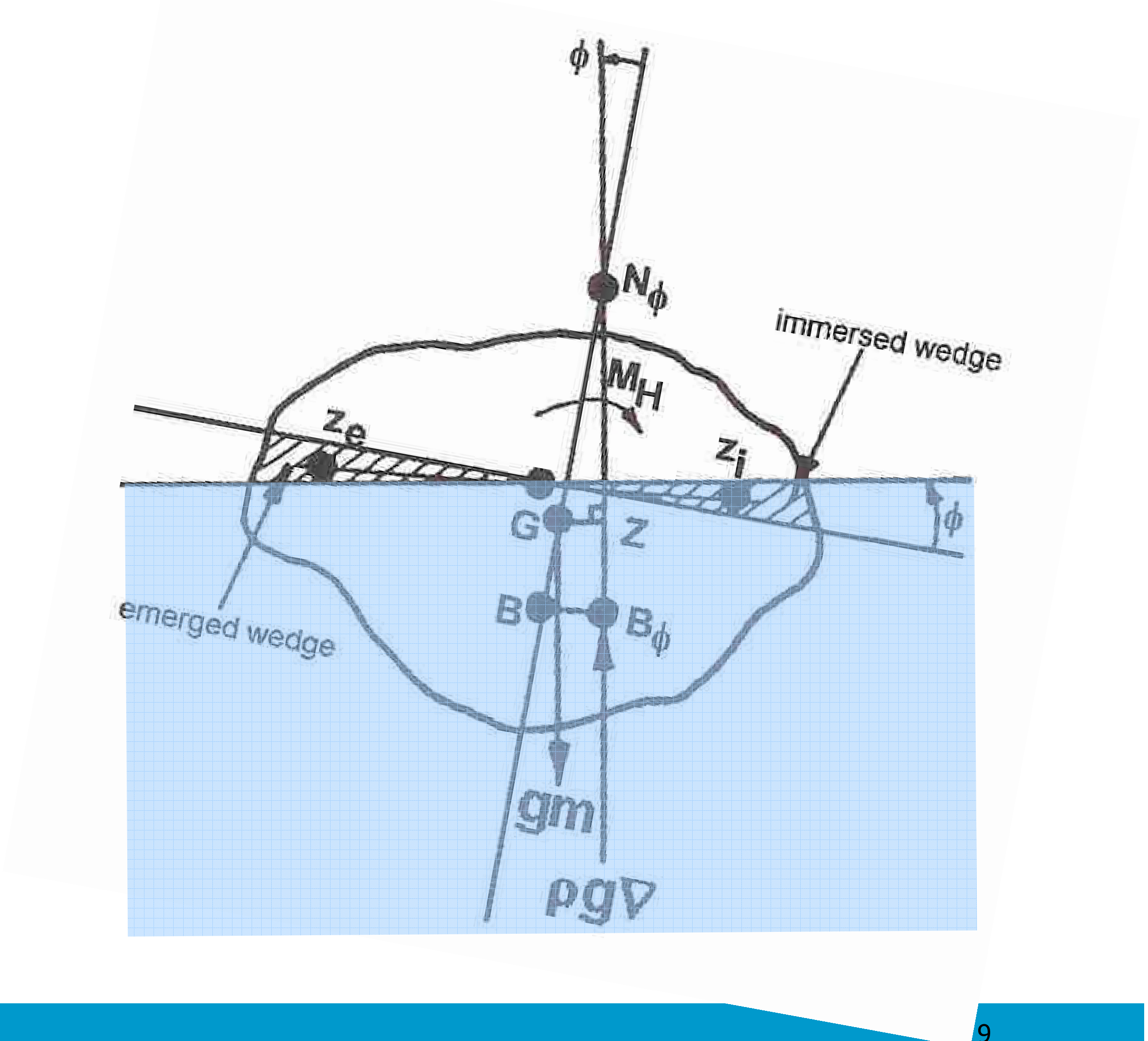

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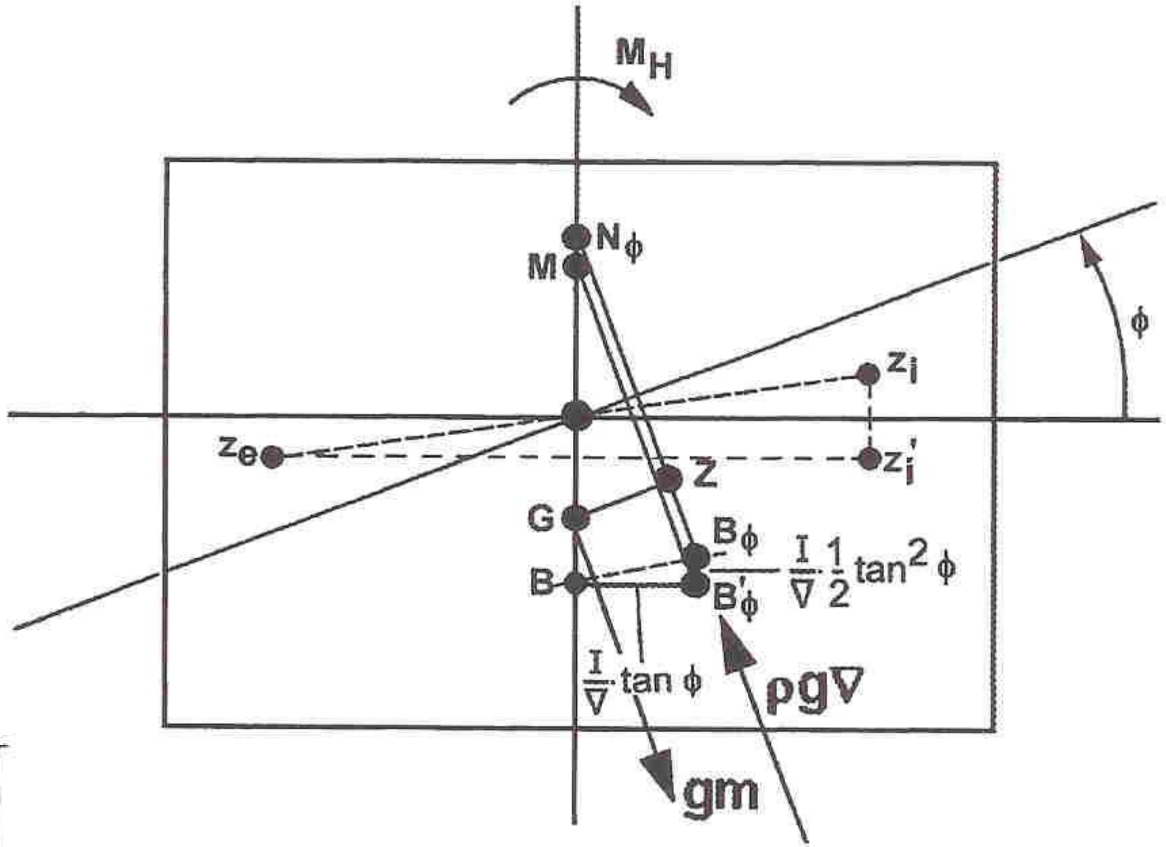
Rectangular barge

$$\overline{BB'_\phi} = \overline{BM} \cdot \tan\phi$$

$$\boxed{\overline{BM} = \frac{I_T}{\nabla}}$$

$$\overline{B'_\phi B_\phi} = \overline{MN_\phi}$$

$$\boxed{\overline{MN_\phi} = \frac{I_T}{\nabla} \cdot \frac{1}{2} \tan^2\phi}$$



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Arbitrarily shaped floater

•At very small angles of heel : $\overline{BM} = \frac{I_T}{\nabla}$

•If side walls are vertical when the unit is floating upright :

$$\overline{BN_\phi} = \frac{I_T}{\nabla}\left(1+\tfrac{1}{2}\tan^2\phi\right)$$ (Scribanti Formula)

•Otherwise : compute the position of B in every heeled position

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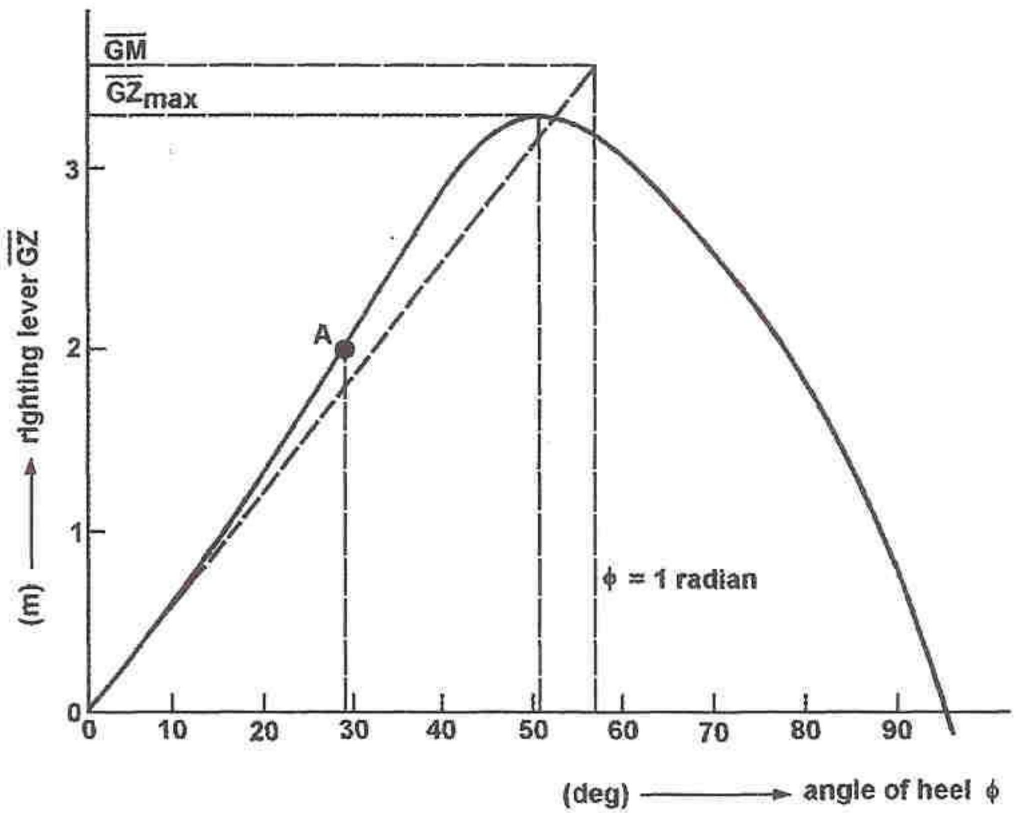
Static Stability Curve



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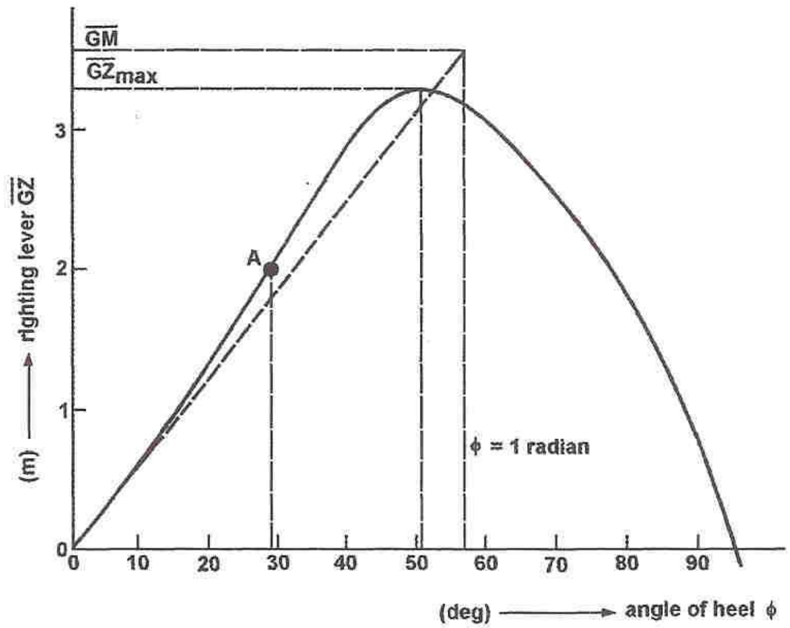
Static Stability Curve

Characteristics

- Slope at origin = GM
- Maximum GZ value
- Range of stability
- Angle of deck immersion
- Area under the curve



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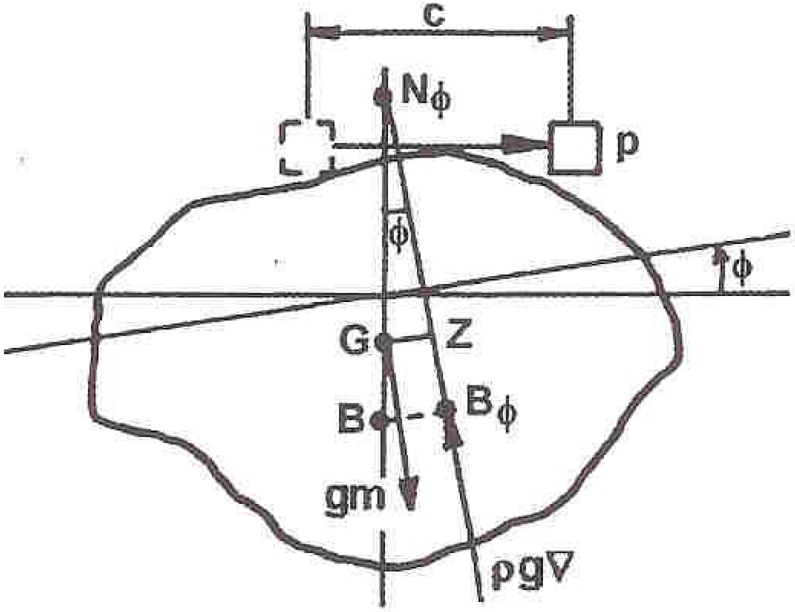
Shifting a load



$$\phi = \arccos\left\{\frac{\rho\nabla \cdot \overline{GN_\phi} \cdot \sin\phi}{p \cdot c}\right\}$$

$$\frac{1}{2}\overline{BM} \cdot \tan^3\phi + \overline{GM} \cdot \tan\phi = \frac{p \cdot c}{\rho\nabla}$$

Liquid loads with free surface

$$\overline{GG''} = \frac{\rho' i}{\rho \nabla} \cdot \left(1 + \frac{1}{2}\tan^2\phi\right)$$