

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
**Department of Mechanical Engineering**

**2.701 PRINCIPLES OF NAVAL ARCHITECTURE**  
**Fall 2014**

**PROJECT #4: SHIP GENERAL STABILITY**

Date Issued: October 10, 2014

Date Due: October 20, 2014

References: Gillmer and Johnson Chapter 6

**1. Introduction/background:**

Once the initial stability analysis is complete, the movement or addition of weights affects KG, GZ and overall general stability. For a weight addition, the new GM and the list angle can be calculated from the equations given in lecture.

In the case of tanks aboard a ship, there is an additional adverse effect on stability known as “free surface effect.” This is caused by the shift in center of gravity of the liquid as the ship heels. The correction to GM (known as free surface correction, FSC) for a rectangular tank and a wall-sided ship heeling is:

$$\overline{GZ} = \underbrace{\left( \overline{GM} - \frac{\overbrace{\gamma_t i}^{FSC}}{\gamma_s \nabla_s} \right)}_{\overline{GM}_{eff}} \sin \phi$$

$\gamma_t$  is the specific gravity of the tank of liquid  
 $\gamma_s$  is the specific gravity of seawater  
 $i$  is the 2<sup>nd</sup> moment of area (transverse) of the liquid surface  
 $\nabla_s$  is the underwater volume of the ship  
 $\phi$  is the heel angle

**2. Assignment:**

For general stability, analyze the weight addition and free surface effect of your baseline ship from Project #1.

### 3. Procedure / Deliverables

**3-1:** Starting at zero list and trim, add 150,000 gals of fuel oil load into a tank that was previously empty on your baseline ship in Project #1 with the following parameters.

Tank width (b) = 25 ft	Tank height (h)= 10 ft
Tank length (l) = 160 ft	Tank LCG = LCB
Tank TCG = +12.5 ft (stbd)	Tank KG = 7.5 ft
Tank partially full	$\gamma_l = 0.89$
$\rho_{fw} = 8.34$ lbs/gal	$\gamma_s = 1.025$

**D-1:** Stability calculations following the weight addition (assume no pocketing):

1. Final displacement
2. New draft
3. New KG
4. Effective GM accounting for FSC
5. List of the ship as a result of the fuel load

**D-2:** A plot of the initial static stability curve and the corrections for the weight addition.

1. Plot the righting arm ( $GZ_0$  curve) for your baseline ship using the Intact Static Stability Report from ASSET. Add an extra point to estimate where the righting arm curve crosses zero (~95 degrees). Fit a curve through the points.
2. Plot the sine curve correction for Kg for each data point and fit a curve.
3. Plot the cosine curve correction for gG for each data point and fit a curve.
4. Plot the FSC curve with the assumption that pocketing does not occur and fit a curve.
5. Plot the final static stability curve.
6. Annotate the changes in GM, range of stability, and  $GZ_{max}$  between the initial static stability curve and the final. Also annotate graphically the final list angle – does this agree with your calculations on Deliverable 1?

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