Example Problem:

You are called on the scene when a double hull tanker unfortunately runs into a migrating whale shark (while very gentle these sharks are very large). This collision has created a small crack in the outer hull allowing water to flood the lower compartment. A pump with mass, \( M \), is on deck at the centerline of the vessel. A cross sectional view of the vessel is shown below:

1) Determine the vertical position of the metacentric height.
2) The empty compartment A is flooded with water and the tanker assumes a small heel angle, \( \delta \). Determine the angle in terms of the given quantities.
3) In order to stabilize the tanker to a level position the captain decides to shift the pump horizontally on deck and asks you to determine the necessary horizontal shift for the heel angle to vanish.
4) In order not to run aground coming into port the captain must know the new draft of the vessel following the adjustment in part c and again asks you to calculate it for him.
N.B.: All calculations assume a unit width into the paper.

Given:

1. \( k_B = \frac{T}{b} \)

\( \text{Distance center of buoyancy to metacenter:} \)

\[
BM = \frac{I}{length} = \frac{\int_{-b/2}^{b/2} x^2 \, dx}{ \text{length} } = \frac{b^2}{BT} = \frac{12T}{12T} = b^2
\]

Distance C.B. to Origin: \( B_0 = \frac{T}{2} \)

Distance Height of Metacenter on Z-Axis:

\[
Z_M = BM - B_0 = \frac{b^2}{12T} - \frac{T}{2}
\]

2. Filling compartment is equivalent to two simultaneous effects:

A) Loss of Buoyancy:

\[
\Delta W = \rho \frac{b}{2} \frac{T}{4} = \frac{\rho b T}{8} = \text{Weight of water in area "A"}
\]

B) Application of Heeling Moment

\[
M_{\text{heel}} = \Delta W \frac{b}{4}
\]

\[
A' = V_0 - \Delta W = \frac{7}{8} \rho b T = \text{New buoyancy volume}
\]
Heeling angle is found

\[ W' \bar{G}_M, \delta = \Delta \omega \frac{b}{4} \quad \leftarrow \text{eqn from "incline" tests} \]

- \( W' \) new displaced weight
- \( \bar{G}_M \) new metacentre
- \( \Delta \omega \) moment about \( \bar{G}_M \)
- \( b \) distance, centre of gravity to new metacentre

For small \( \delta \)

\[ \delta = \frac{p b^3 T L}{32 \bar{G}_M \cdot W} = \frac{\Delta \delta / T}{32 (\bar{G}_M) \cdot \frac{7}{8} p g b T} \]

\[ \therefore \delta = \frac{b}{28 (\bar{G}_M)} \]

New vessel configuration & added weight of water is compensated by additional buoyancy in order for vessel to reach equilibrium.

\[ p g Y_1 = p g Y_0 + \Delta g \]

- \( Y_1 \) new displaced volume
- \( Y_0 \) original volume
- \( \Delta g \) additional weight of vessel
- \( p g \) water in "A"

So \( Y_1 = Y_0 + \frac{bT}{\delta} \)

\[ Y_1 = \frac{9bT}{8} \]

Part D: \( \therefore T_1 = \frac{9t}{8} \)

Ship sinks \( \frac{T}{8} \) deeper with flooded compartment
New position of buoyancy center for a "level" vessel relative to the keel:

\[ CB \Rightarrow KB, = \frac{I}{2} = \frac{9T}{16} \]

CG stays constant,

\[ KG = \frac{I}{4} \]

Distance between new CB & metacenter:

\[ BM = \frac{I_w}{V_1} = \frac{b^3/12}{9bT/8} = \frac{2b^2}{2T} \]

Metacentric height:

\[ GM_1 = KM - KG = KB + BM - KG \]

\[ GM_1 = \frac{9T}{16} + \frac{2b^2}{2T} - \frac{I}{4} \]

Plug into eqn for \( f \)!

(c) Pump must be shifted such that it creates a moment to offset the moment due to the flooded compartment

\[ \frac{\text{Max moment from weight}}{\text{moment from flooded compartment}} = \frac{AWb}{I} \]
Example Problem

You are called on the scene when a small tanker unfortunately runs into a massive whale shark (which very very large, sharks are very large). This collision has created a small crack in the outer hull allowing water to flood the lower compartment. A pump with mass, \( M \), is on deck at the centerline of the vessel. A cross-sectional view of the vessel is shown below.

1) Determine the vertical position of the metacenter height.
2) The empty compartment \( A \) is flooded with water and the tanker assumes a small heel angle, \( \theta \). Determine the angle in terms of the given quantities.
3) In order to stabilize the tanker to a level position the captain decides to shift the pump horizontally on deck and asks you to determine the necessary horizontal shift for the heel angle to vanish.
4) In order not to run aground coming into port the captain must know the new draft of the vessel following the adjustment in part c and again asks you to calculate it for him.