10-1 A ship enters a channel with a width of 750 ft, a depth of 24 ft, and a center of flotation 40 ft aft of midship. The following conditions are made:

Assumptions

<table>
<thead>
<tr>
<th>Distance</th>
<th>Unit</th>
<th>Amount</th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 ft</td>
<td>20 ft</td>
<td>10 ft</td>
<td>20 ft</td>
<td>10 ft</td>
</tr>
<tr>
<td>300 ft</td>
<td>14 ft</td>
<td>18 ft</td>
<td>30 ft</td>
<td>18 ft</td>
</tr>
</tbody>
</table>

a. How much ballast can be added without increasing displacement?

Desire $A_1 = \Delta_0$

$$\Delta_1 = \Delta_0 - \Delta_{ballast}$$

$$\Delta_{ballast} = (w_1 + w_2) - (w_1 + w_2)$$

$$\Delta_{ballast} = 200 \text{ tons}$$

b. At what depth can the ballast be added without increasing the center of flotation?

Desire $E_{he} = \Delta_{ballast}$

$$E_{he} = \frac{\Delta_0 \cdot \Delta_{ballast}}{\Delta_0} = \frac{(300 \cdot 10) - (10 \cdot 100)}{300}$$

$$E_{he} = 5 \text{ ft}$$

c. How far on the centerline must the ballast be added to prevent a permanent list?

$$\tan(15) = \frac{100}{\Delta_{ballast}} = \frac{100}{5}$$

$$\Delta_{ballast} = 20 \text{ ft}$$

d. Where must the ballast be added to prevent a permanent trim?

$$\tan(15) = \frac{\Delta_{ballast}}{100} = \frac{20}{100}$$

$$\Delta_{ballast} = 25 \text{ ft}$$

e. Is it apt to add? 

Yes, it is.
10-3 A rectangular derrick is used for building a 13,000 ft² off-shore platform out in the original oil field. The derrick is 630 ft long, 110 ft wide, and 50 ft high as illustrated. When loaded with the oil well, the draft is 9 ft, and the keel is 55 ft.

The derrick is divided into ten water-tight compartments as shown, with five on each side of the keel. A collision with a submerged object in the water cuts miles off the compartments, causing a free-volume and free communication condition. As a result, the mean draft increases to 18 ft, and the keel is lowered to 55 ft.

a. Find the displacement before and after damage.

\[ \Delta_0 = \frac{LBT}{35} \times (63)(195)(8.8) = 16,800 \text{ ft}^3 \Delta_0 \]

\[ \Delta_1 = \frac{LBT}{35} \times (63)(195)(10) = 18,000 \text{ ft}^3 \Delta_1 \]

b. Find the \( \bar{Cm} \) before and after damage.

\[ \bar{Cm}_0 = \bar{Cm}_0 \Delta_0 \]

\[ \bar{Cm} = \bar{Cm}_0 + \bar{Cm}_m \]

\[ \bar{Cm}_m = \frac{(100)(0.1)}{18} = 5.59 \text{ ft} \]

\[ \overline{Cm}_m = \frac{18}{2} = 9.00 \text{ ft} \]

\[ \bar{Cm}_m = 9.59 - 60 = 32.59 \text{ ft} \]

\[ \bar{Cm}_0 \approx 32.59 \text{ ft} \]
\[
\text{FSC} = \frac{V_{\text{mod}}}{V_{\text{sup}}} = \frac{1}{1} = 1
\]

\[
\text{FCC} = \frac{a^3}{\sqrt{2}} = a^3 \quad \text{Surface area of tank in front of communication}
\]

\[
\frac{a}{v} = \frac{(30)}{(126)} = 0.25
\]

\[
\text{FCC} = \frac{(60)(30)(30)}{(100)(30)(10)} = 1.25 \text{ ft}
\]

\[
\theta = \tan^{-1} \left[ \frac{w}{h} \right]
\]

\[
\psi = \tan^{-1} \left[ \frac{(18,000 - 18,300)}{(18,000)} \right] = 5.7^\circ \quad \theta
\]
A petroleum-refining carrier is 700 ft long and 150 ft wide and has a molded depth of 75 ft. The normal loaded displacement is 92,500,000 lb at a draft of 32 ft, 4 in. with a KG of 37 ft. The ship can be considered to be oval-shaped with Cm = 0.9, Cm = 0.8, and CO = 0.4. Since it is a segregated ballast ship, several of the water tanks are normally empty when laden with petroleum. Consider the effects of flooding one of the normally empty water tanks as a result of collision damage where free communication and free surface effects are absent. The water tank is 35 ft wide, 90 ft long, and would be flooded with 7,600 lb of salt water, making the ship displace 94,410 lb at a draft of 40 ft (25 ft is 24 ft). The center of gravity of the flooding water is 30 ft above the keel and 95 ft to starboard of the center of gravity condition. Determine the trim and angle of list.

\[ F_{v} = \frac{F_{e} \cdot V_{e}}{V_{w}} = \frac{(35)(90)}{12(32)(81,700)} = 0.104 \text{ ft.} \]

\[ F_{c} = 0.4 \cdot \frac{(35)(90)(22.5)}{(81)(32,400)} = 1.98 \text{ ft.} \]

\[ W = \frac{F_{c} \cdot V_{w}}{2} + W_{w}, \quad \frac{(22)(80) + (22)(260)}{48} = 31.5 \cdot W, \]

\[ F_{m} = \frac{W}{C_{m} + C_{n}} = \frac{(0.9)(6)}{(0.9)(0.8)} = 1.00 \text{ ft.} \]

\[ G_{m} = G_{m} - F_{m} - F_{c} = (W \cdot W) - F_{m} - F_{c} = (47 - 31.5) - 0.104 - 1.98 = 13.51 \Rightarrow G_{m} = 13.5 \text{ ft.} \]

\[ \theta = \tan^{-1} \frac{A \cdot G_{m}}{F_{c} \cdot V_{w}} = \tan^{-1} \frac{(3600)(22.5)}{(260)(13.5)} = 7.47^\circ \text{ list angle to starboard.} \]
A 20-ft 49 CLASS DESTROYER IS INVOLVED IN A COLLISION ON THE PORT SIDE THAT TELLS THE SHIP BETWEEN FLocator 50 AND 72 WITH 100 LT OF WATER. THE CENTER OF GRAY OF THE FLOODED
COMPARTMENT IS 51.5 FT ABOVE THE KEELE, 12 FT FROM THE PORT OF THE
SHIP, 80 FT FORM DECK. THE FLOODED COMPARTMENT IS 12 FT
WIDE AND 24 FT LONG, HAS A FREE SURFACE, AND IS IN OPEN
COMMUNICATION WITH THE SEA.

BEFORE THE COLLISION, THE GRAFT DECK WAS 13 FT 9 IN
AND THE GRAFT DECK WAS 13 FT 7 IN. THE DISPLACEMENT WAS
2300 LT WITH A KG OF 151.1 FT.

1.) DETERMINE THE FINAL CM CAUSED BY THE WATER FLOODING
(WITHOUT LIST).

\[ C_{MW} = C_{m} - FSC - FSC \]

\[ T_{m} = 13' 10" = \frac{161}{12} (\text{ft}) = 13.41 \text{ ft} \]

\[ \theta_{PC} = 29.3 \times 3.5' = 98.95' \]

\[ T_{m} = 13' 10" + 3.5' = 16.65' \]

\[ \bar{K} = \frac{960}{16.65} = 57.8 \text{ ft} \]

\[ \bar{K} = \frac{9300}{11.5} + \frac{161}{12} (11.5) = 15.8 \text{ ft} \]

\[ FSC = \frac{1}{12} \times \frac{161}{12} (11.5) = 0.92 \text{ ft} \]

\[ FSC = \frac{1}{12} \times \frac{161}{12} (11.5) = 0.19 \text{ ft} \]

\[ C^{\text{MW}} = C_{m} - FSC - FSC \]

\[ C^{\text{MW}} = 5.79 \text{ ft} \]

2.) DETERMINE THE ANGLE OF LIST

\[ \theta = \tan^{-1} \left( \frac{w(15)}{C_{MW} D} \right) = \tan^{-1} \left( \frac{150(15)}{3900} \right) \]

\[ \theta = 5.2^\circ \text{ Part Angle of List} \]
(cont.)

c) DETERMINE THE CHANGE IN TRIM AND HULL QUARTER.

\[
\begin{align*}
F_T & = -1110 \text{ fl} \\
\text{BF} & = 640 \text{ fl} - 16 \text{ fl} \\
\delta_T & = 80 \text{ fl}
\end{align*}
\]

\[
\delta_T = \frac{(-80 - 640)}{640} = -16 \text{ in}
\]

\[
\delta_T = \delta_{min} \left( \frac{1.5 + 0.5}{c} \right) = (-16) \left( \frac{2.0}{2} - 22.4 \right) = -7 \text{ in}
\]

\[
\delta_T > \delta_{min} = (-16) - (-16) = 7 \text{ in}
\]

\[
T_A = T_{BA} + \delta_T / s + \delta_T = 15'11" + 2.5" - 7" = 13'7.5" - T_A.
\]

\[
T_F = T_{BF} + \delta_T / s + \delta_T = 13'4" + 3.5" + 9" = 19' 4.5" - T_F.
\]