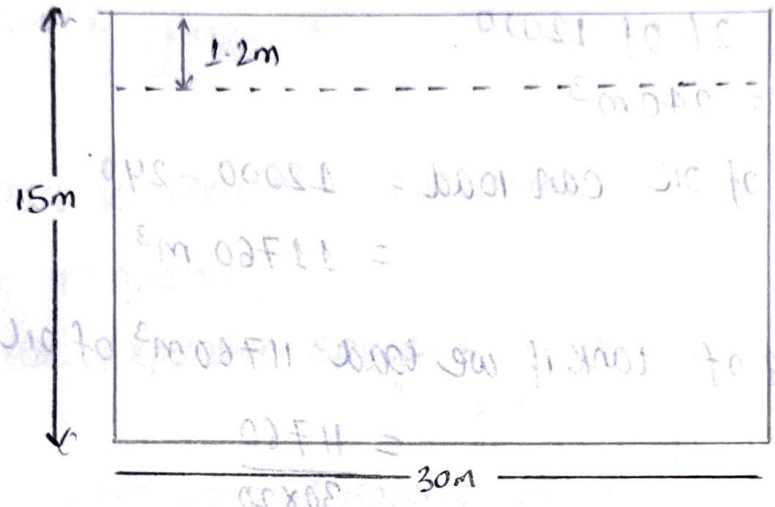
(124) A vessel at even keel has a tank of dimensions 30m x 20m x 15m deep containing crude oil of R.D 0.8345 at an ullage of 1.2m. Calculate the quantity of oil in the tank.

Soln:-




Height of tank, H = 15.0m

Ullage, U = 1.2m

Sounding, S = H − U

= 15.0 − 1.2

= 13.8m

Volume of oil in tank = L x B x sounding

= 30 x 20 x 13.8

= 8280 $m^3$

Quantity of oil in MT = volume x R.D

= 8280 x 0.8345

= 6909.7 M.T

(125) An oil tanker has a tank of dimensions 30m x 20m x 20m deep and is loading oil at 38°C. It is desired to leave 2% of the volume of tank for expansion. Calculate the quantity of oil and final ullage assuming that the vessel is at an even keel on completion. Given that R.D of oil at 25°C = 0.8540.

Co-efficient of volume expansion = 0.0006/°C

Soln:- volume of tank = $30 \times 20 \times 20$

$= 12000 m^3$

2% of volume of tank i.e. to leave for expansion

2% of 12000

$= 240 m^3$

So, volume of oil can load = $12000 - 240$

$= 11760 m^3$

Sounding of tank if we load $11760 m^3$ of oil

$= \frac{11760}{30 \times 20}$

$= 19.6 m$

Ullage = Height of tank - Sounding

Ullage = 20.0 - 19.6

**Ullage = 0.4m** Ans.

Since given RD is at 25°C & we are loading at 38°C

So, to get RD at 38°C

coefficient = 0.0006/C

For 25° to 38°C i.e. 13°C change = $0.0006 \times 13$

$= 0.008$

Hence, RD of oil at 38°C = $0.8540 - 0.008$

$= 0.8462$

Quantity of oil = volume of oil × R.D

$= 11760 \times 0.8462$

$=$ **9951.312 MT** Ans

126) A tank of dimension 20m x 15m x 10m is being loaded with an oil at 30°C (RD at 20°C = 0.8681). It is desired to leave 3% of volume of oil for expansion. Calculate the ullage of oil & quantity of oil loaded, given that coefficient of volumetric exapansion 0.0005/°C

Let us assume volume of oil loaded at 30°C = V

According to question,

Required expansion space = 3% of V

= 0.03V

At any temperature following applies,

Volume of expansion space at 30°C + observed volume at 30°C = Tank volume

$(0.03V) + V = L \times B \times H$

$1.03V = 20 \times 15 \times 10$

$1.03V = 3000$

$V = 2912.621\ m^3$ at 30°C

At given RD at 20°C = 0.8681

Corrn to bring at 30°C = $0.0005 \times 10$

$= 0.005\ t/m^3$

Density at 30°C = 0.8681 − 0.005 temp ↑, density ↓

$= 0.8631\ t/m^3$

MT of oil loaded = vol @ 30°C x density @ 30°C

$= 2912.621 \times 0.8631$

$= \boxed{2513.88\ t}$

Sounding at 30°C = $\frac{\text{Obs. vol @ 30°C}}{L \times B}$

$$= \frac{2912.621}{20 \times 15}$$

$$= 9.709m$$

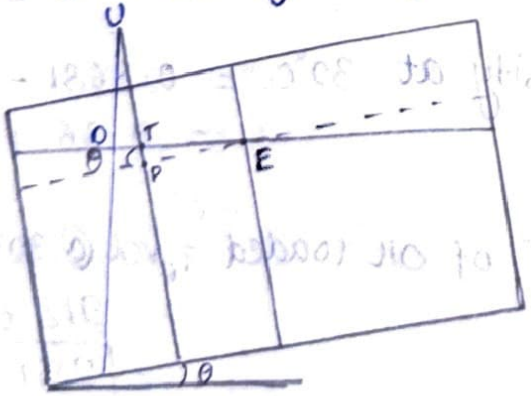
Hence, Ullage at 30°C = Height - sounding

$$= 10 - 9.709$$

$$= \boxed{0.29m}$$

127) A crude oil tanker of LBP 250m has a tank of dimensions 30 x 20 x 20 and is trimmed by 3m by stern. The ullage port is in line with aft bulkhead and its height is 1.2m above the deck. The ullage of cargo as measured from ullage port is 2.2m using a sonic tape. Calculate the net observed volume/standard volume of oil & quantity of oil in MT loaded. Given density @ 15°C = 0.8550 and the loading temp is 31°C

Note:- According to the question, the ullage port is extending 1.2m above the deck & is in line with aft bulkhead. Since the ullage port is in line with aft bulkhead, the sonic tape entering the tank space will slide along the aft bulkhead (since the vsl is trimmed by stern)




UO : Observed ullage

UT : Observed ullage after tape correction

In Δ UOT, (Tape correction)

{ In vertical Δ, cos
In horizontal Δ, tan }

$$\cos\theta = \frac{\text{Base}}{\text{hyp.}}$$

$$\cos\theta = \frac{UO}{UT}$$

$$UT = \frac{UO}{\cos\theta}$$

In ΔPTE, (Trim correction)

$$\tan\theta = \frac{\text{perpendicular}}{\text{base}}$$

$$\tan\theta = \frac{PT}{PE}$$

Since, $\tan\theta$ is equal to $\frac{TRIM}{LBP}$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

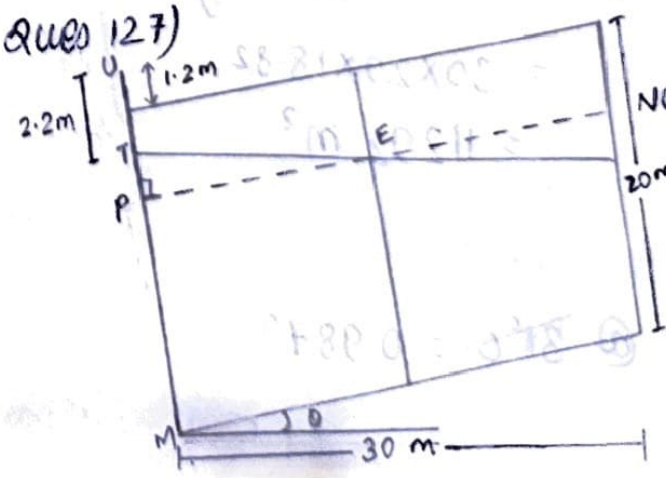
PT → trim correction

$$PE = \frac{l}{2} - d$$

where $d$ is distance of ullage port from aft bulkhead
$l$ is length of tank

PE = 30/2 − 10 = 15 − 10 = 5m

Solution of Ques 127)




Note:- NO Tape correction is required as ullage port is in line with aft bulkhead

$$PE = \frac{l}{2} - d$$

$$= \frac{30}{2} - 0$$

$$= 15$$

* $$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{3}{250} = \frac{PT}{15}$$

$$250\,PT = 45$$

$$PT = \frac{45}{250}$$

$$PT = 0.18m$$

Corrected ullage, $UP = UT + PT$

$$= 2.2 + 0.18$$

$$= 2.38m$$

Sounding @ 31°C, PM $= \text{Reference height} - \underset{UM}{\text{ullage}} - UP$

$$= (20 + 1.2) - 2.38$$

$$= 21.2 - 2.38$$

$$= 18.82\,m$$

Obs. vol. @ 31°C $= L \times B \times$ sounding @ 31°C

$$= 30 \times 20 \times 18.82$$

$$= 11292\,m^3$$

Against temp 31°C & density 0.8550, in ASTM Table 54A

VCF @ 31°C = 0.9873

Standard volume @ 15C (N.O.V) = Obs. vol. @ 31°C × VCF @ 31°C

= 11292 × 0.9873

= 11148.592 $m^3$ @ 15°C

WCF/WRF/density in air @ 15°C = density in vaccum − 0.0011

= 0.8550 − 0.0011

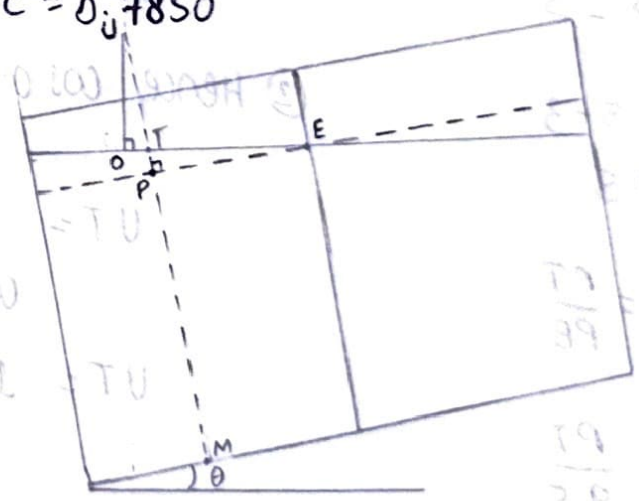
= 0.8539 $t/m^3$

Quantity loaded in MT = Std vol. @ 15°C × density in air @ 15°C

= 11148.592 × 0.8539

= 9519.78 MT

128) An oil tanker of LBP 180m is loading oil at 35°C in one of her tanks of dimension 25×20×18. On completion of loading vessel is trimmed 1 m by stern and ullage of the cargo in tank was observed to be 1.8m using a sonic tape. The ullage port is located 3m fwd of aft bulkhead & 1m above the deck. Cal^ the net obs. vol. of oil in tank. Density @ 15°C = 0.7850




Note:- If the ullage port is located aft of the centerline & the vessel is trimmed by stern, then in that case the trim correction will be positive. i.e. PT will be added to UT. And in case, vessel is down by head, then trim correction will be negative, PT will be substracted from UT

When vessel's trim by aft & posn of ullage port is in aft of CL, the correction is positive.

When vessel is down by head & posn of ullage port is in fwd of CL, the correction is positive

When vessel trim by stern, & posn of ullage is in fwd of CL, the trim correction is negative

When vessel is down by head & posn of ullage port is in aft of CL, the correction is negative.

Soln of 128 M.V Hindship,

④ In ΔPTE (trim corrn)

$$\text{TAN}\,\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

③ For PE, $\frac{L}{2} - d$

$$= \frac{25}{2} - 3$$

$$= 12.5 - 3$$

$$= 9.5$$

④ $$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{1}{180} = \frac{PT}{9.5}$$

$$180\,PT = 9.5$$

$$PT = \frac{9.5}{180}$$

$$PT = 0.053\,m$$

② In ΔUOT (Tape corrn)

$$\cos\theta = \frac{UO}{UT}$$

① $$\text{TAN}\,\theta = \frac{TRIM}{LBP}$$

$$\text{TAN}\,\theta = \frac{1}{180}$$

$$\theta = 0.32^\circ$$

② Hence, $\cos 0.32^\circ = \frac{1.8}{UT}$

$$UT = \frac{1.8}{\cos 0.32}$$

$$UT = 1.8\,m$$

⑤ corrected ullage, UP = UT + PT

= 1.8 + 0.053

= 1.853 m

Sounding @ 35°C = Ref. height - corrected ullage

= (18+1) - 1.853

= 19 - 1.853

= 17.147 m

Gross observed volume @ 35°C = L X B X sounding @ 35°C

= 25 X 20 X 17.147

= 8573.61 $m^3$

Against density 0.7850 & temp 35°C, From ASTM TABLE 54

VCF @ 35°C = 0.9809

Gross standard volume @ 15°C = GSV @ 35°C X VCF @ 35°C

OR

N.O.V

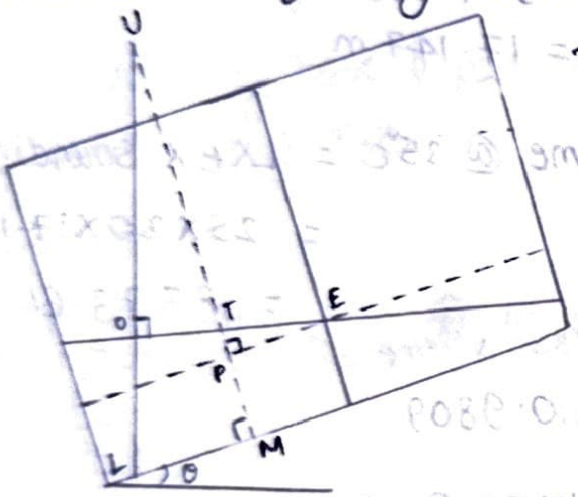
= 8573.61 X 0.9809

= **8409.855 $m^3$**

129) H.W for revision

130) While discharging oil from an oil tanker of LBP 175m, sounding of a tank was obtained as 80cm using a sounding rod. The dimension of the tank are 20×15×15m. The vessel was trimmed 1.5m by stern and the sounding pipe is located 3m from aft bulkhead & extends 1.0m above deck. Assuming no wedge formed, calculate the quantity of oil in the tank. ~~Density of oil = 0.8500 t/m³~~

Soln:-




temp. of oil cargo = 30°C

① $\tan\theta = \frac{TRIM}{LBP}$

$\tan\theta = \frac{1.5}{175}$

$\theta = 0.49°$

~~② In ΔUOI (TOPE corner)~~

~~$\cos\theta = \frac{UO}{UT}$~~

~~$\cos\theta = \theta$~~

~~$\cos 0.49° = \frac{0.8}{UT}$~~

~~$UT = \frac{0.8}{\cos 0.49}$~~

~~$UT = 0.800$m~~

UM = Ref. height + Height of tank

= 1.0 + 15.0

= 16.0m

$PE = \frac{l}{2} - d$

$= \frac{20}{2} - 3$

= 7m

In $\Delta ULM$,

$$\cos\theta = \frac{Base}{Hyp} = \frac{UM}{UL}$$

$$\cos 0.49^\circ = \frac{16.0}{UL}$$

$$UL = 16.000$$

$$UL = UO + OL$$

$$16 = UO + 0.8$$

$$UO = 15.20m$$

In $\Delta UOT$ (Tape corn)

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.49^\circ = \frac{15.20}{UT}$$

$$UT = \frac{15.20}{\cos 0.49^\circ}$$

$$= 15.200m$$

In $\Delta PTE$ (Trim corn)

$$\tan\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{1.5}{175} = \frac{PT}{7}$$

$$10.5 = 175\,PT$$

$$PT = 0.06\,m$$

$$UP = UT + PT$$

$$= 15.20 + 0.06$$

$$= 15.26\,m$$

$UM = UP + PM$

$PM = UM - UP$

PM i.e. sounding @ ~~35c~~ = (Ref height + Height of tank) $- UP$

$= 16 - 15.26$

$= 0.74m$

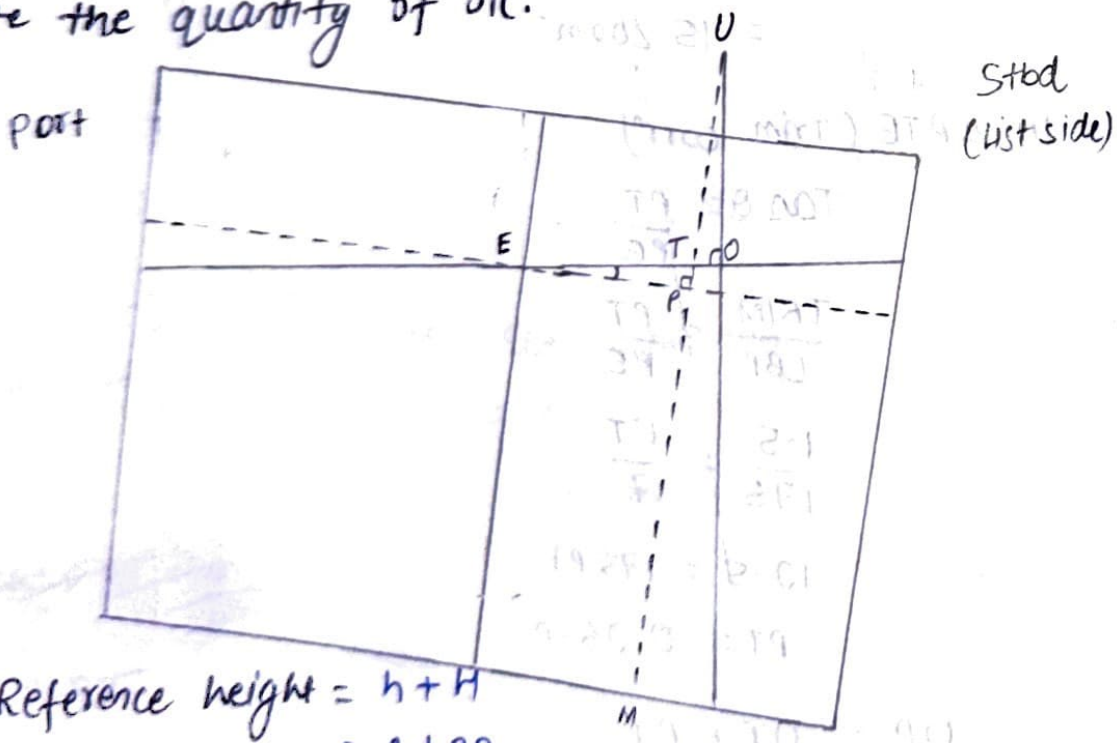
~~Volume of tank~~

Gross observed volume @ 30°C = L × B × sounding @ 30°C
ROB
= 20 × 15 × 0.74
= 222 $m^3$

~~VCF @ 30°C =~~

NOTE:- Use term ROB in case of discharging & have very less sounding.

(131) A vessel of LBP 235m has a tank of dimension 30×25×20 is loading oil of density @15°C : 0.8150. On completion of loading vessel is listed 1° stbd and the ullage is observed using a sonic tape was found to be 1.8m. Ullage port is located 3m to stbd of CL & 1m above deck. Vessel is on an keel on completion and temp. of oil to observed to be 32°C. Calculate the quantity of oil.




Reference height = h + H
= 1 + 20
= 21m

PE = d = 3m

θ = 1°

In $\Delta UOT$ (tape corrn)

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 1^\circ = \frac{1.8}{UT}$$

$$UT = 1.800\ m$$

In $\Delta PTE$ (Ullage corrn)

$$\tan\theta = \frac{PT}{PE}$$

$$\tan 1^\circ = \frac{PT}{3}$$

$$PT = 3 \times \tan 1^\circ$$

$$= 0.052\ m$$

Corrected ullage, UP = UT + PT

$= 1.8 + 0.052$

$= 1.852\ m$

Corrected sounding @ 32°C = Reference height − ullage

$= 21 - 1.852$

$= 19.148\ m$

Gross observed volume @ 32°C = L × B × corrd sounding @ 32°C

$= 30 \times 25 \times 19.148$

$= 14361.0\ m^3$

VCF @ 32°C = 0.9852

Gross standard volume @ 15°C = $14361 \times 0.9852$

$= 14148.4572\ m^3$

WCF/WRF/ density in air @ 15°C = density in vac. − 0.0011

$= 0.8150 - 0.0011$

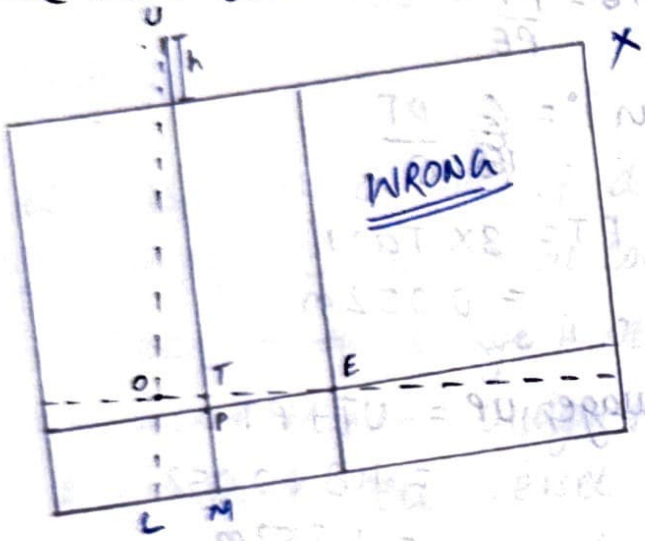
$= 0.8139\ t/m^3$

Quantity loaded in MT = GSV @ 15°C × density in air @ 15°C

$= 14148.4572 \times 0.8139$

$= 11515.429\ MT$

(132) On completion of cargo, at time of sounding the tank, dip was observed to be 9cm. The vessel was upright & trimmed 3m by stern. Dimensions of the tank were 36m × 27m × 18m. LBP of the vessel was 270m. Calculate the on-board quantity (OBQ) given that the sounding pipe was located 5m from aft bulkhead and 0.9m above deck.




$\text{Tan}\,\theta = \frac{\text{TRIM}}{\text{LBP}} = \frac{3}{270} = 0.011$

$\theta = 0.64°$

$UM = h + H$

$= 0.9 + 18$

$= 18.9$

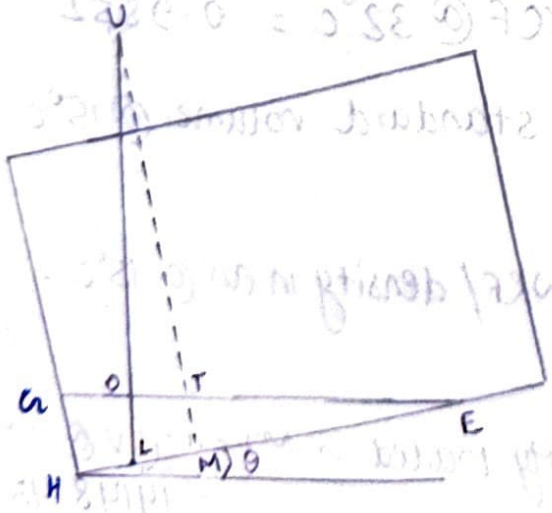
Note:- Dip of 9cm means wedge is forming

~~$LE = \frac{L}{2} - d$~~

~~$= \frac{36}{2} - 5$~~

~~$= 18 - 5$~~

~~$= 13$~~



In $\Delta ULM$, $\angle M = 90°$

$$\cos\theta = \frac{UM}{UL}$$

$$\cos 0.64° = \frac{18.9}{UL}$$

$$UL = \frac{18.9}{\cos 0.64°}$$

$$UL = 18.901m$$

$$UL = UO + OL$$

$$18.901 = UO + 0.09$$

$$UO = 18.901 - 0.09$$

$$= 18.811\,m$$

In $\Delta UOT$ (Tape traingle), $\angle O = 90°$

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.64° = \frac{18.811}{UT}$$

$$UT = \frac{18.811}{\cos 0.64°}$$

$$UT = 18.812\,m$$

$$UM = UT + TM$$

$$18.9 = 18.812 + TM$$

$$TM = 18.9 - 18.812$$

$$= 0.088\,m$$

In $\Delta TME$ (Trim traingle), $\angle M = 90°$

$$\tan\theta = \frac{TM}{EM} \Rightarrow \frac{TRIM}{LBP} = \frac{TM}{EM}$$

$$\frac{3}{270} = \frac{0.088}{EM}$$

$$EM = \frac{0.088}{\frac{3}{270}}$$

$$EM = 7.920\,m$$

$HE = HM + EM$

$HE = 5 + 7.920$

$= 12.920$

$\because HE < L$

HE is less than length of tank

$\therefore$ wedge is confirmed

In $\Delta GHE$, $\angle H = 90°$

$\tan\theta = \frac{GH}{HE}$

$\frac{TRIM}{LBP} = \frac{GH}{HE}$

$\frac{3}{270} = \frac{GH}{12.920}$

$270\,GH = 3876$

$GH = 0.144$

Area of $\Delta GHE = \frac{1}{2} \times HE \times GH$ $\left(\frac{1}{2} \times \text{base} \times \text{height}\right)$

$= \frac{1}{2} \times 12.920 \times 0.144$

$= 0.930$

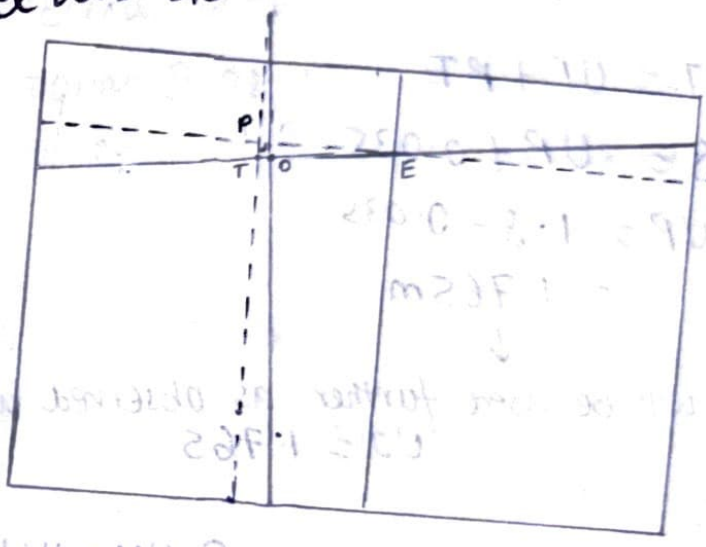
Volume of $\Delta GHE$ / ROB = Area of $\Delta GHE \times$ breadth

$= 0.930 \times 27$

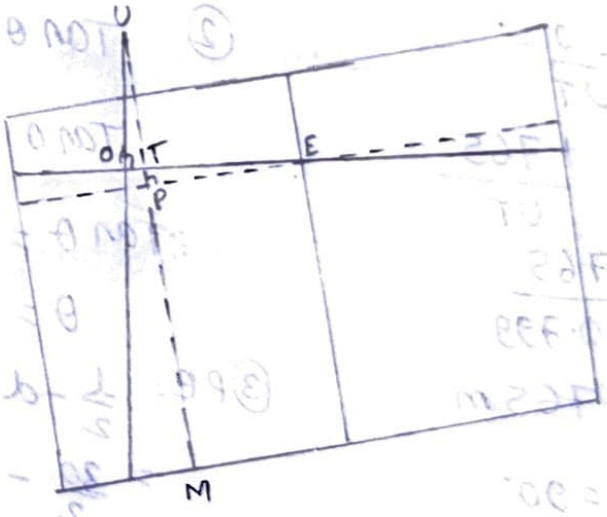
$= 25.116\ m^3$

(133) A box shaped tank 30×18×20 containing crude oil of den
at 15°C = 0·8275 t/m³ had an ullage of 1·80m as measured
by sonic tape. The ullage port was located 3m fwd of af
bulkhead, 1m above the tank top and 2m to port of CL
tank. Trim observed was 3m & vessel listed 1° to starboa
Obs. temp: 32·5°C. Calculate the qty of oil in tank if the
LBP of vessel was 215m U

LIST




TRIM




First list

In $\Delta UOT$, $\angle O = 90°$

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 1° = \frac{1.8}{UT}$$

$$UT = 1.800\,m$$

In $\Delta PTE$, $\angle P = 90°$

$$\tan\theta = \frac{PT}{PE}$$

$$\tan 1° = \frac{PT}{2} \longrightarrow \text{bcz dist from aa}$$

$$PT = 2 \times \tan 1°$$

$$= 0.035m$$

$$UT = UP + PT$$

$$1.8 = UP + 0.035$$

$$UP = 1.8 - 0.035$$

$$= 1.765m$$

↓

This will be used further as observed wage in Trim $\Delta$

$UP = UO = 1.765$

<u>second trim</u>

In $\Delta UOT$, $\angle O = 90°$

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.799° = \frac{1.765}{UT}$$

$$UT = \frac{1.765}{\cos 0.799°}$$

$$UT = 1.765m$$

In $\Delta PTE$, $\angle P = 90°$

$$\tan\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{3}{215} = \frac{PT}{12}$$

$$PT = 0.167$$

① $UM = H + h = 20 + 1 = 21m$

② $\tan\theta = \frac{TRIM}{LBP}$

$$\tan\theta = \frac{3}{215}$$

$$\tan\theta = 0.014$$

$$\theta = 0.799°$$

③ $PE = \frac{1}{2} - d$

$$= \frac{30}{2} - 3$$

$$= 15 - 3$$

$$= 12$$

UP = UT + PT

UP = 1.765 + 0.167

= 1.932

UM = UP + PM

21 = 1.932 + PM

PM = 21 − 1.932 = 19.068m

Therefore, corrected sounding @ 32.5°C (PM) = 19.068 m

Observed volume @ 32.5°C = LX B X corrd sounding @ 32.5°

= 30 X 18 X 19.068

= 10296.72 $m^3$

VCF @ 32.5°C = 0.9852

Standard volume @ 15°C = Obs. vol. @ 32.5°C X VCF @ 32.5°C

= 10296.72 X 0.9852

= 10144.329 $m^3$

WCF/WRF/density in air @ 15°C = density in vac − 0.0011

= 0.8275 − 0.0011

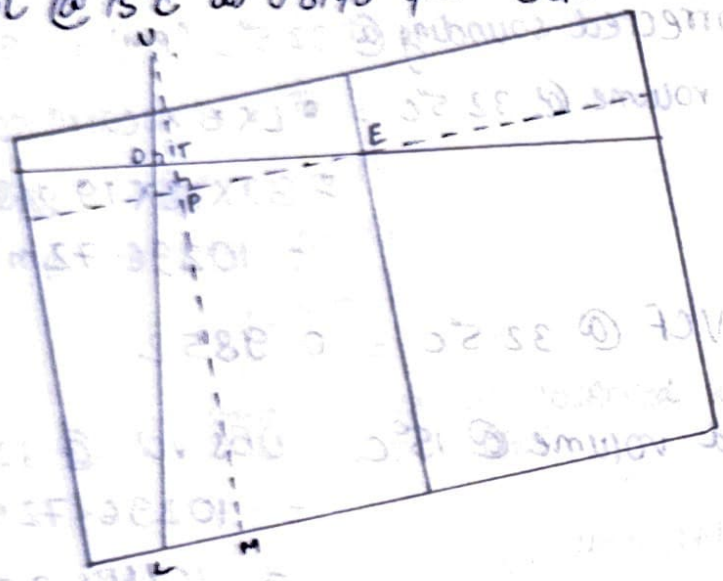
= 0.8264 $t/m^3$

Quantity loaded in MT = cnsv @ 15°C x density in air @ 15°C

= 10144.329 X 0.8264

= 8383.273 MT

(134) An oil tanker of LBP 200m has a box shaped tank of dimensions 40x20x20 and is loaded with oil. On completion ullage as measured from sonic tape was observed to be 1.24m and temp was 37°C. A water dip ullage of 20.94m was also found. The ullage port was located 1.1m above the tank top and 1.6m fwd of aft bulkhead. Vessel was trimmed 3m by stern. Terminal gave the density of oil @ 15°C as 0.8145 t/m³. Determine the quantity of oil in tank




$$\text{Tan}\,\theta = \frac{\text{TRIM}}{\text{LBP}}$$

$$\text{Tan}\,\theta = \frac{3}{200}$$

$$\theta = 0.86°$$

$$PE = \frac{1}{2} - d$$

$$= \frac{40}{2} - 1.6$$

$$= 20 - 1.6$$

$$= 18.4$$

In $\Delta UOT$ (Tape $\Delta$)

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.86° = \frac{1.24}{UT}$$

$$UT = \frac{1.24}{\cos 0.86°}$$

$$UT = 1.240m$$

In $\Delta PTE$ (Trim $\Delta$)

$$\text{Tan}\,\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{3}{200} = \frac{PT}{18.4}$$

$$PT = 0.276$$

Corrected ullage, $UP = UT + PT$

$= 1.240 + 0.276$

$= 1.516$

$$UM = UP + PM$$

Sounding, $PM = UM - UP$

$= (20 + 1.1) - 1.516$

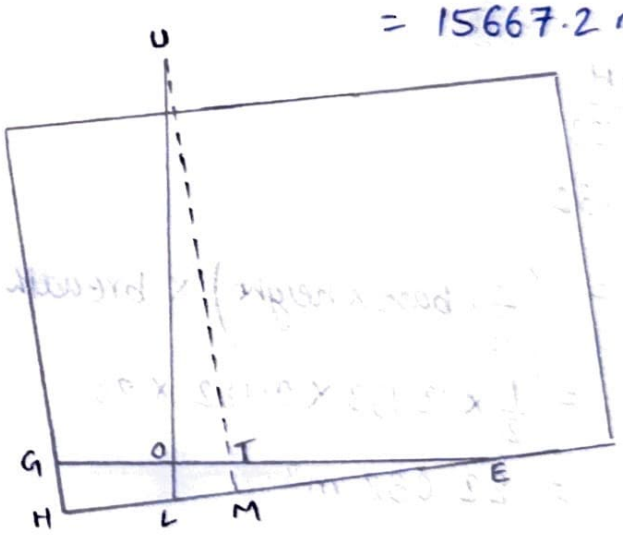
$= 21.1 - 1.516$

$= 19.584$

Volume of oil in tank = $L \times B \times$ sounding

$= 40 \times 20 \times 19.584$

$= 15667.2\ m^3$




In $\Delta UOT$

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.86^\circ = \frac{20.94}{UT}$$

$$UT = 20.942m$$

$UM = UT + TM$

$TM = UM - UT$

$TM = (20 + 1.1) - 20.942$

$TM = 21.1 - 20.942$

$TM = 0.158m$

In $\Delta TME$,

$$\tan\theta = \frac{TM}{ME}$$

$$\frac{3}{200} = \frac{0.158}{ME}$$

$ME = 10.533m$

$HE = HM + ME$

$HE = 1.6 + 10.533$

$HE = 12.133m$

In $\Delta GHE$,

$$\tan\theta = \frac{GH}{HE}$$

$$\frac{3}{200} = \frac{GH}{12.133}$$

$GH = 0.182$

Volume of $\Delta GHE = \left(\frac{1}{2} \times \text{base} \times \text{height}\right) \times \text{breadth}$

$= \frac{1}{2} \times 12.133 \times 0.182 \times 20$

$= 22.082\ m^3$

Volume of oil in tank = Total volume - vol. of water

$= 15667.2 - 22.082$

G.O.V. @ 37°C = $15645.118\ m^3$

(0.8145) VCF @ 37°C = 0.9808

0.810

0.815

Gross standard volume = G.O.V @ 37°C x VCF @ 37°C

= 15645.118 X 0.9808

= 15344.732 $m^3$

WCF/WRF/density in air = density in vacuum − 0.0011

= 0.8145 − 0.0011

= 0.8134

Quantity of oil = G.S.V x density in air

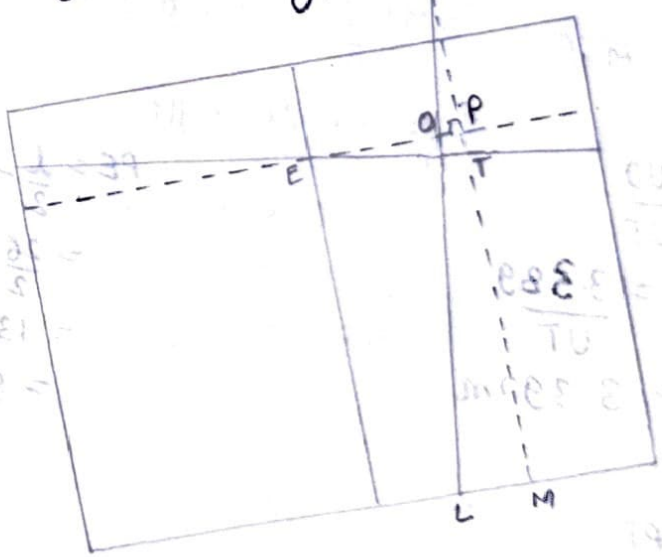
= 15344.732 X 0.8134

= 12481.4 M.T

PREVIOUS YEAR SOL$^N$

JULY 2021 A vessel of LBP 108m arrives discharge port with trim 2.0 by stern and 2° list to port. A box shaped cargo tank measure 26 X 16 X 9.3 has ullage of 3.52m by sonic tape, temp 42.3°C, noted from ullage port located 4.5m fwd of aft bulkhead, 3.8m to stbd of CL & 114 cm above the top of tank. On completion of cargo operation 26 cm dip was noted from same ullage port when the trim was 4m by stern with no list. Find the quantity of oil discharged & ROB. If oil density 8226.3 Kg/$cm^3$ in vaccum at 15°C

List




$\tan\theta = \frac{TRIM}{LBP} = \frac{2}{108}$

$\theta = 1.06°$

PE = 3.8m

In $\Delta$ UOT, (List traingle)

$\cos\theta_{List°} = \frac{UO}{UT}$

$\cos 2.06° = \frac{3.52}{UT}$

UT = 3.52m

In $\Delta PTE$, $\tan\theta = \frac{PT}{PE}$

~~$\frac{TRIM}{UBP}$~~ ~~$\frac{PT}{PE}$~~

$\tan(1.91^\circ) = \frac{PT}{PE}$

$\tan 2^\circ = \frac{PT}{3.8}$

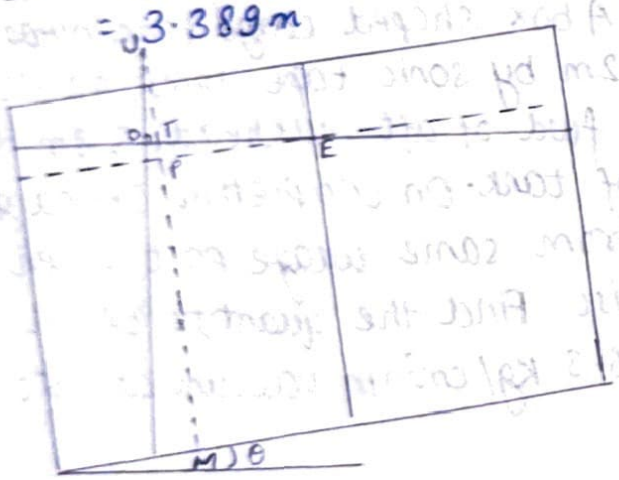
$PT = 0.133m$

$\because UT = UP + PT$

$3.522 = UP + 0.133$

$UP = 3.522 - 0.133$

$= 3.389m$




* $UP = UO = 3.389$

In $\Delta UOT$,

$\cos\theta = \frac{UO}{UT}$

$\cos 1.06^\circ = \frac{3.389}{UT}$

$UT = 3.390m$

$PE = \frac{L}{2} - d$

$= \frac{26}{2} - 4.5$

$= 13 - 4.5$

$= 8.5m$

In $\Delta PTE$,

$\tan\theta = \frac{PT}{PE}$

$\frac{TRIM}{UBP} = \frac{PT}{8.5}$

$\frac{2}{108} = \frac{PT}{8.5}$

$PT = 0.157m$

corrected image, $UP = UT + PT$

$= 3.390 + 0.157$

$= 3.547$

$UM = UP + PM$

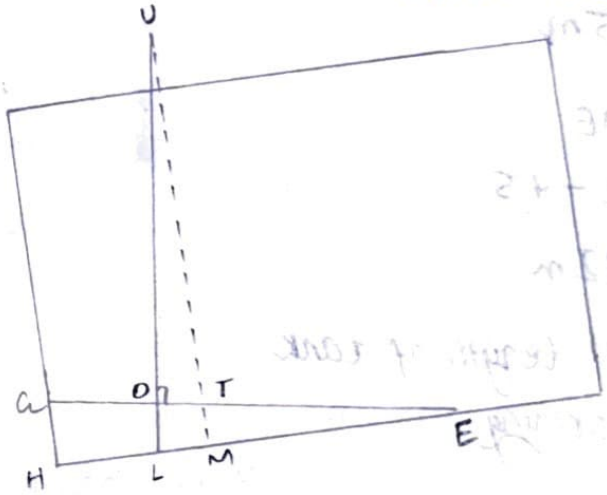
$(9.3 + 1.14) = 3.547 + PM$

$10.44 = 3.547 + PM$

sounding, $PM = 6.893\ m$

Volume of oil in tank $= 26 \times 16 \times 6.893$

$= 2867.488\ m^3$




$\tan\theta = \frac{TRIM}{LBP} = \frac{4}{108}$

$\theta = 2.121°$

In $\Delta UML$, $\cos\theta = \frac{UM}{UL}$

$\cos 2.121° = \frac{10.44}{UL}$

$UL = 10.447\ m$

$UL = UO + OL$

$10.447 = UO + 0.26$

$UO = 10.187\ m$

In $\Delta UOT$,

$\cos\theta = \frac{UO}{UT}$

$\cos 2.121° = \frac{10.187}{UT}$

$UT = 10.194\ m$

~~In $\Delta TME$,~~

~~$\tan\theta = \frac{TM}{ME}$~~

~~$\frac{4}{108} = \frac{TM}{ME}$~~

$$UM = UT + TM$$

$$10.44 = 10.194 + TM$$

$$TM = 0.246m$$

In $\Delta TME$,

$$\tan\theta = \frac{TM}{ME}$$

$$\frac{4}{108} = \frac{0.246}{ME}$$

$$ME = 6.642m$$

$$HM = 4.5m$$

$$HE = HM + ME$$

$$= 6.642 + 4.5$$

$$= 11.142m$$

HE is less than length of tank

∴ wedge is forming

In $\Delta GHE$,

$$\tan\theta = \frac{GH}{HE}$$

$$\frac{4}{108} = \frac{GH}{11.142}$$

$$GH = 0.413m$$

Volume of oil in $\Delta GHE = \left(\frac{1}{2} \times base \times height\right) \times breadth$

$$= \frac{1}{2} \times HE \times GH \times breadth$$

$$= \frac{1}{2} \times 11.142 \times 0.413 \times 16$$

$$= 36.813\ m^3$$

**i.e. ROB = 36.813 $m^3$**

Volume of oil discharged = 2867.488 − 36.813

G.O.V @ 42.3°C = 2830.675 $m^3$

VCF @ 42.3°C = 0.9768

GSV = 2830.675 × 0.9768

= 2765.003 $m^3$

WCF = 0.8226 − 0.0011

= 0.8215

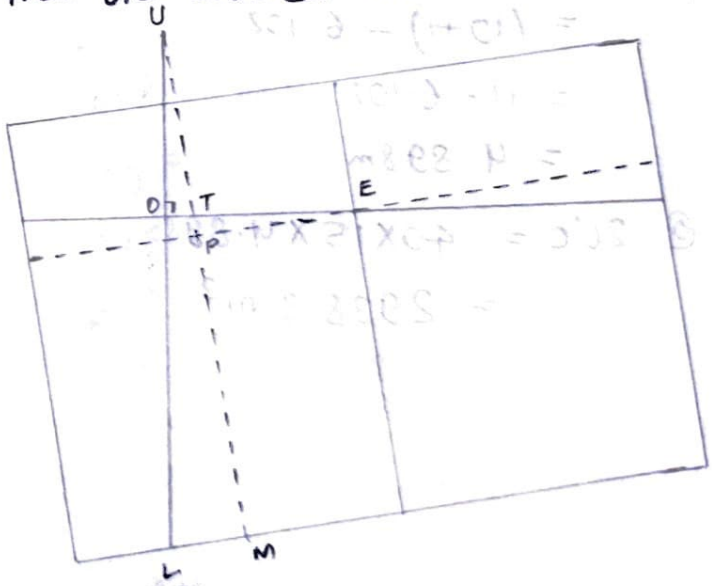
Q+y discharge = GSV × WCF

= 2765.003 × 0.8215

= 2271.45 M.T

Ques MARCH 2021

Using ASTM table, calculate the quantity of white oil in a rectangular tank of ship of LBP 130m, trimmed 1.5m by stern, dimension of the tank are 40m × 15m × 10m. The ullage port is located 1.0m above the deck, 2.5m from tank aft bulkhead and 2m to the port of c/l. The ullage was taken by sonic tape & was measured as 5.9m & water cut of 10cm was obtained. The temp. of the oil loaded was 26°C. & density of oil at 15°C is 820 Kg/$m^3$.




$\tan\theta = \frac{TRIM}{LBP}$

$\tan\theta = \frac{1.5}{130}$

$\theta = 0.66°$

$PE = \frac{l}{2} - d$

$= \frac{40}{2} - 2.5$

$= 20 - 2.5$

$= 17.5m$

In $\Delta UOT$,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.66^\circ = \frac{5.9}{UT}$$

$$UT = 5.9 / \cos 0.66^\circ$$

$$UT = 5.900m$$

In $\Delta PTE$, $\tan\theta = \frac{PT}{PE}$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{1.5}{130} = \frac{PT}{17.5}$$

$$PT = 0.202m$$

$$UP = UT + PT$$

$$UP = 5.900 + 0.202$$

Corrected ullage, $UP = 6.102m$

$$UM = UP + PM$$

Sounding, $PM = UM - UP$

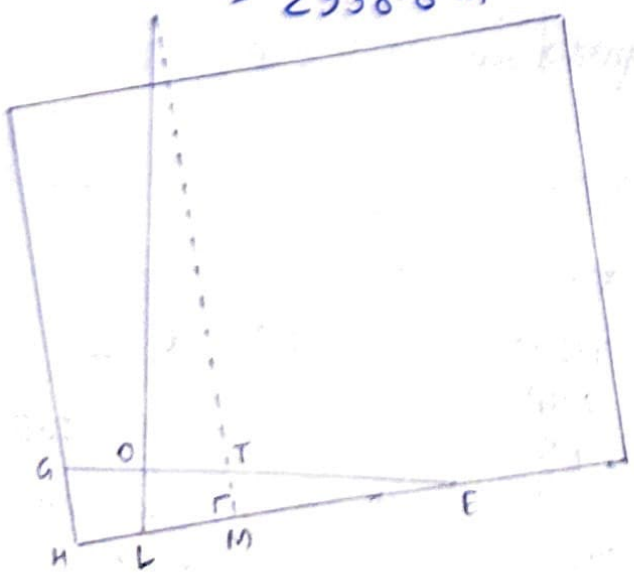
$$= (10+1) - 6.102$$

$$= 11 - 6.102$$

$$= 4.898m$$

T.O.V @ 26°C = $40 \times 15 \times 4.898$

$$V = 2938.8\ m^3$$



T.O.V includes free water

In $\Delta ULM$,

$$\cos\theta = \frac{UM}{UL}$$

$$\cos 0.66^\circ = \frac{11}{UL}$$

$$UL = 11.000m$$

$$UL = UO + OL$$

$$11.000 = UO + 0.10$$

$$UO = 10.90m$$

In $\Delta UOT$,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.66^\circ = \frac{10.90}{UT}$$

$$UT = 10.900m$$

$$UM = UT + TM$$

$$11 = 10.900 + TM$$

$$TM = 0.10m$$

In $\Delta TME$,

$$\tan\theta = \frac{TM}{ME}$$

$$\frac{TRIM}{LBP} = \frac{TM}{ME}$$

$$\frac{1.5}{130} = \frac{0.10}{ME}$$

$$ME = 8.667m$$

$$HE = HM + ME$$

$$= 2.5 + 8.667$$

$$= 11.167m$$

HE is less than L, wedge is confirmed.

In $\Delta GHE$,

$$\tan\theta = \frac{GH}{HE}$$

$$\frac{1.5}{130} = \frac{GH}{11.167}$$

$$GH = 0.129m$$

Volume of AGME = $\left(\frac{1}{2} \times \text{base} \times \text{height}\right) \times \text{breadth}$

$= \left(\frac{1}{2} \times HE \times GM\right) \times 15$

$= \left(\frac{1}{2} \times 11.167 \times 0.129\right) \times 15$

Free water vol. = $10.804\ m^3$

Volume of oil in tank = T.O.V − free water

$= 2938.8 - 10.804$

G.O.V @ 26°C = $2927.996\ m^3$

VCF @ 26°C = 0.9905

G.S.V = $2900.18\ m^3$

Density in air/WRF (T56) = 0.8189

weight = 2374.957 M.T

JAN 2018
JULY 2023
JAN 2025

Find the final ullage ullage using a UTI guage, when 3200 M.T of Gas oil (density 0.8860 ts/$m^3$ in vaccum) is blended with 2300 cubic meter of Diesel oil at 43°C (density 0.8693 ts/$m^3$ in vaccum) in a box shaped tank 28.5m × 10.0m × 15.0m on-board a ship of LBP 196.4m, trimmed 1.2m by head and listed 3° to port. Ullage port for this tank is located 5.8m forward of the after bulkhead, 4.7m to stbd of the centerline and 112 cm above the top of the tank. Final temperature on completion of blending was found to be 20.0°C.

Note:- Syllabus does not include comingling. Comingling density does not need to be found out.

Therefore proceed as follows:-

① Grade (gas oil) - density 0.8860 = 3200 m.t

W.C.F = T56

Density in air = 0.8849 t/m³ (0.8860 - 0.0011)

Weight = G.S.V @15°C x density in air @15°C

3200 = G.S.V @15°C x 0.8849

G.S.V @15°C = 3616.228 m³

Since final temp is 20°C,

So, VCF @ 20°C = 0.9962

G.S.V @15°C = G.O.V @ 20°C x VCF @ 20°C

3616.228 = G.O.V @ 20°C x 0.9962

G.O.V @ 20°C = 3630.022 m³ —— ①

② Grade 2 (diesel oil) - density 0.8693

G.O.V @ 43°C = 2300 m³

V.C.F @ 43°C = 0.9785

V.C.F @ 20°C = 0.9961

$$\frac{\text{G.O.V @ 20°C}}{\text{G.O.V @ 43°C}} = \frac{\text{VCF @ 43°C}}{\text{VCF @ 20°C}}$$

$$\frac{\text{G.O.V @ 20°C}}{2300} = \frac{0.9785}{0.9961}$$

G.O.V @ 20°C = 2259.361 m³ —— ②

Eqn ① + ②

= G.O.V @ 20°C of comingle grade

= 3630.022 + 2259.361

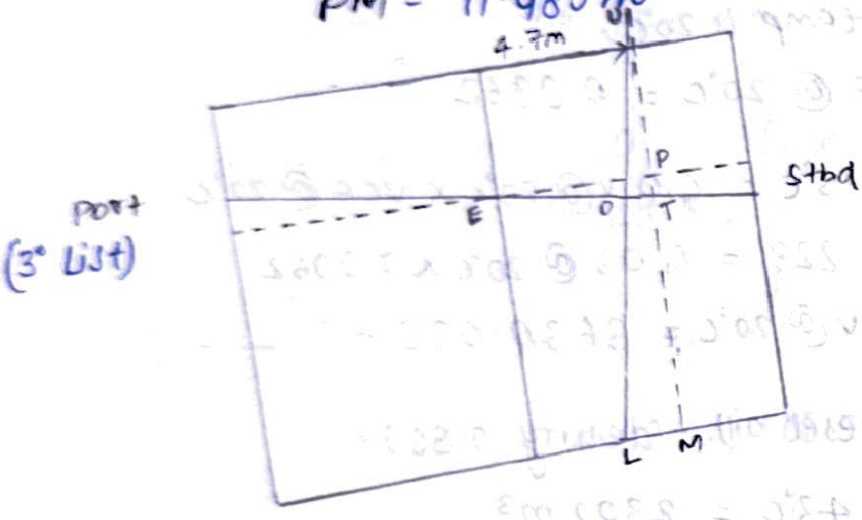
= 5889.383 m³

corrected sounding for conningle grade

$$= \frac{G \cdot O \cdot V}{L \times B}$$

$$= \frac{5889.383}{28.5 \times 18}$$

$PM = 11.480\ m$




In $\Delta PTE$,

$$\tan\theta = \frac{PT}{PE}$$

$$\tan 3^\circ = \frac{PT}{4.7}$$

$PT = 0.25m$

$UM = UP + PM$

$UP = UM - PM$

$UP = (15 + 1.12) - 11.480$

$UP = 16.12 - 11.480$

$UP = 4.64\ m$

$UT = UP + PT$

$= 4.64 + 0.25$

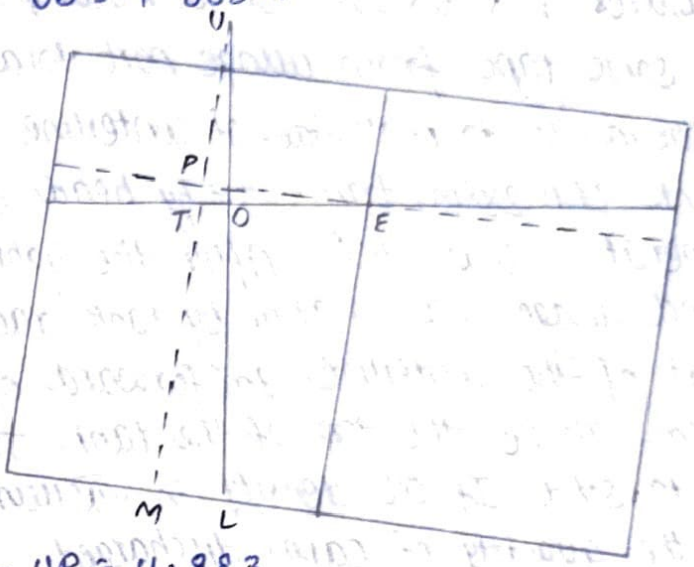
$= 4.89\ m$

In $\Delta UOT$,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 3^\circ = \frac{UO}{4.89}$$

UO = 4·883 m




Aft

Fwd
(1.2m by head)

UO = UP = 4·883

In ΔPTE,

$$\text{Tan}\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{1.2}{196.4} = \frac{PT}{8.45}$$

$$PT = 0.052$$

$$UT = UP + PT$$

$$UT = 4.883 + 0.052$$

$$UT = 4.935m$$

In ΔUOT,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.35^\circ = \frac{UO}{4.935}$$

$$\boxed{UO = 4.935m}$$

Ans

$$PE = \frac{L}{2} - d$$

$$= \frac{28.5}{2} - 5.8$$

$$= 8.45m$$

$$\text{Tan}\theta = \frac{TRIM}{LBP}$$

$$\text{Tan}\theta = \frac{1.2}{196.4}$$

$$\theta = 0.35^\circ$$

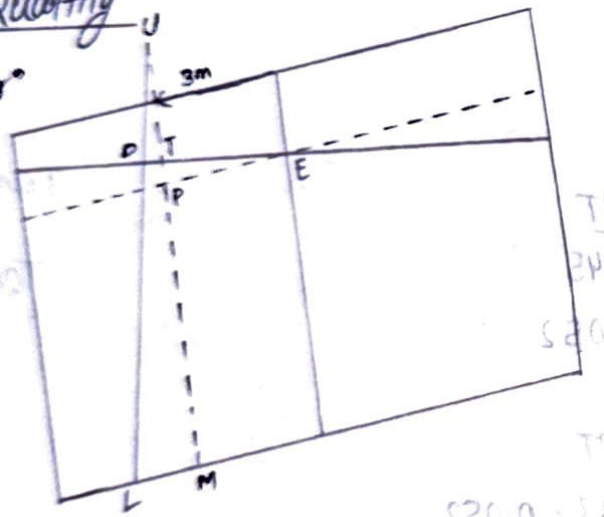
Ques:- JULY 12 JULY 14 OCT 2019

An oil tank measures 32 x 20 x 19m. On arrival port 3.22 m ullage was measured by sonic tape from ullage port located 4m forward of the after bulkhead, 3m to port side of centerline and 1.82m above the top of the tank. LBP 288m, trim 3.5m by head and list 4 degrees to port. Cargo temperature was 31.5°C. After the lightarage, cargo temperature was 27°C and ullage was 14.22 m by tank radar which was located 4m to port of the centerline, 9m forward of the after bulkhead and 92 cm above the top of the tank. Trim 2m by stern and list 3 degree to stbd. If oil density in vacuum at 15°C is 0.8311 t/m³. Find the quantity of cargo discharged.

Sol^n:-

Initial Quantity

→ List corr°




Stbd

Port

(4° List)

In ΔUOT,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 4^\circ = \frac{3.22}{UT}$$

$$UT = 3.228m$$

In ΔPTE,

$$\tan\theta = \frac{PT}{PE}$$

$$\tan 4^\circ = \frac{PT}{3}$$

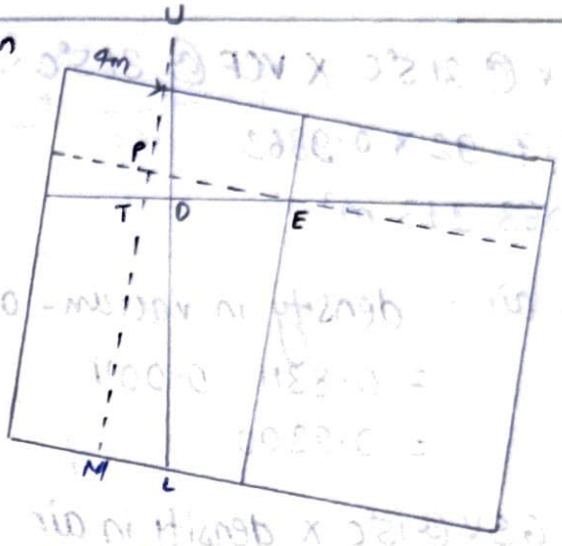
$$PT = 0.210$$

$$UP = UT + PT$$

$$= 3.228 + 0.210$$

$$= 3.438m$$

→ Trim corr^




Aft

UP = UO = 3.438m

Fwd
(3.5° by head)

In ΔUOT, $\cos\theta = \frac{UO}{UT}$

$\cos 0.696^\circ = \frac{3.438}{UT}$

$UT = 3.438m$

$\tan\theta = \frac{TRIM}{LBP}$

$\tan\theta = \frac{3.5}{288}$

$\theta = 0.696^\circ$

$PE = \frac{l}{2} - d$

$= \frac{32}{2} - 4$

$= 16 - 4$

$= 12$

In ΔPTE, $\tan\theta = \frac{PT}{PE}$

$\frac{TRIM}{LBP} = \frac{PT}{PE}$

$\frac{3.5}{288} = \frac{PT}{12}$

$PT = 0.146m$

$UT = UP + PT$

$UP = UT - PT$

$UP = 3.438 - 0.146$

$UP = 3.292m$

$UM = 19 + 1.82$

$= 20.82m$

$UM = UP + PM$

$PM = UM - UP$

$PM = 20.82 - 3.292$

$PM = 17.528m$

G.O.V @ 31.5°C = L X B X Sounding

$= 32 \times 20 \times 17.528$

$= 11217.92\ m^3$

VCF @ 31.5°C = 0.9862

G.S.V @ 15°C = G.O.V @ 31.5°C × VCF @ 31.5°C

= 11217.92 × 0.9862

= 11063.113 $m^3$

WCF/WRF/density in air = density in vaccum − 0.0011

= 0.8311 − 0.0011

= 0.8300

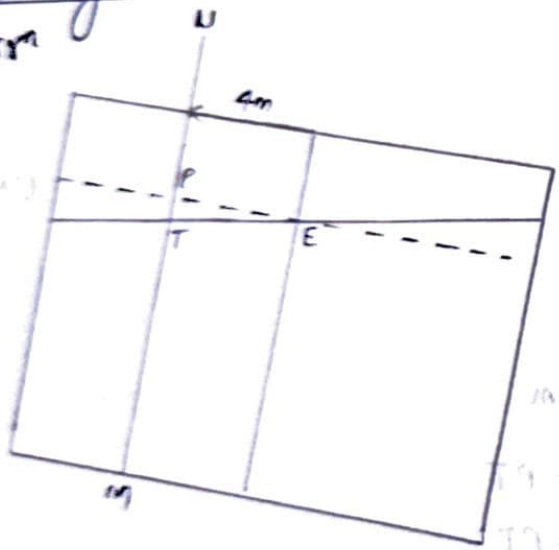
Quantity of oil = GSV @ 15°C × density in air

= 11063.113 × 0.8300

= 9182.384 MT

Final Quantity

→ List corr




Port

Stbd

(3° List)

In ΔPTE,

$\tan\theta = \frac{PT}{PE}$

$\tan 3^\circ = \frac{PT}{4}$

$PT = 0.210m$

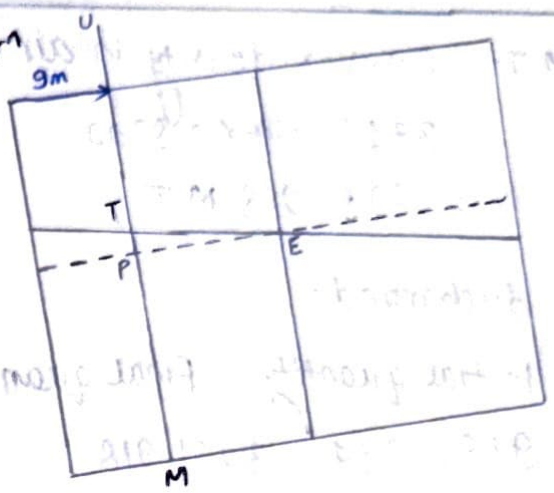
$UT = UP + PT$

$UP = UT - PT$

$= 14.22 - 0.210$

$= 14.01m$

→ Trim corr^




Aft
(2m by stern)

List UP = UT = 14.010m

Find

$PE = \frac{l}{2} - d$

$PE = \frac{32}{2} - 9$

$PE = 16 - 9$

$PE = 7m$

In $\Delta PTE$,

$\tan\theta = \frac{PT}{PE}$

$\frac{TRIM}{LBP} = \frac{PT}{PE}$

$\frac{2}{288} = \frac{PT}{7}$

$PT = 0.049m$

$UM = 19 + 0.92$
$= 19.92m$

Corrected draught, $UP = UT + PT$
$= 14.010 + 0.049$
$= 14.059m$

$UM = UP + PM$

Corrected sounding, $PM = UM - UP$
$PM = 19.92 - 14.059$
$PM = 5.861m$

G.O.V @ 27°C = L X B X sounding
$= 32 \times 20 \times 5.861$
$= 3751.04 m^3$

VCF @ 27°C = 0.9899

G.S.V @ 15°C = G.O.V @ 27°C X VCF @ 27°C
$= 3751.04 \times 0.9899$
$= 3713.154 m^3$

WCF/WRF/density in air = 0.8311 - 0.0011
= 0.8300

Quantity of oil in M.T = G.S.V x density in air

= 3713.154 x 0.8300

= 3081.918 M.T

Quantity of cargo discharged =

Initial quantity - Final quantity

= 9182.384 - 3081.918

= 6100.466 M.T

JAN 2020, OCT 2024 PM

A box shaped cargo oil tank of dimension 30m x 20m x 18m is to be loaded with crude oil at a temperature of 25°C. Density of oil at 15°C in vacuum is 0.8240. If 2% of the volume of the tank is to be left for expansion. Calculate

a) The final observed ullage by the measuring tape at the ullage port located 3m forward of aft bulkhead, 1m above the tank and 2m port of centerline

b) Quantity of oil loaded on-board (LBP = 220m, Trim 3m by stern and list 1° to stbd)

Soln:-

volume of tank = 30 x 20 x 18

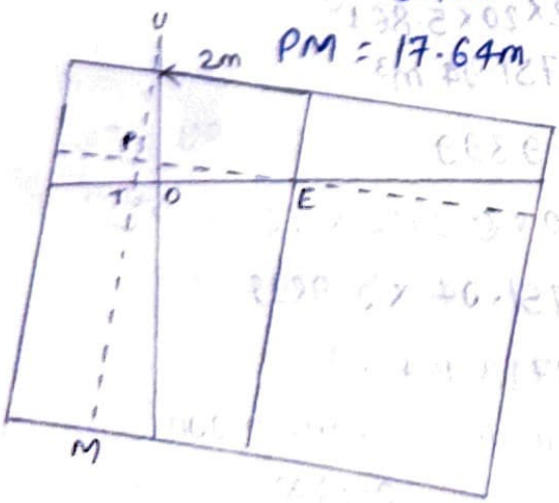
= 10,800 $m^3$

2% to be left for expansion = (+) 216

volume left for loading = 10584$m^3$

Sounding in tank, PM = $\frac{10584}{30 \times 20}$

PM = 17.64m



$UM = UP + PM$

$UP = UM - PM$

$= (18+1) - 17.64$

$= 1.36\,m$

In $\Delta PTE$,

$\tan\theta = \frac{PT}{PE}$

$\tan 1^\circ = \frac{PT}{2}$

$PT = 0.035\,m$

$UT = UP + PT$

$= 1.36 + 0.035$

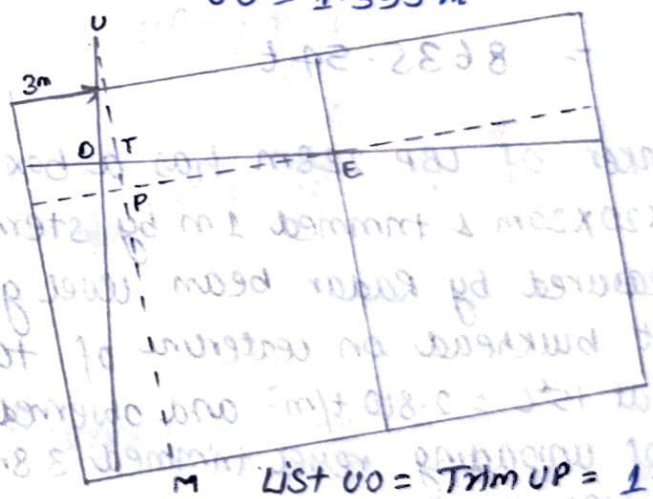
$= 1.395\,m$

In $\Delta UOT$,

$\cos\theta = \frac{UO}{UT}$

$\cos 1^\circ = \frac{UO}{1.395}$

$UO = 1.395\,m$




List $UO$ = Trim $UP$ = $1.395\,m$

In $\Delta PTE$,

$\tan\theta = \frac{PT}{PE}$

$\frac{TRIM}{LBP} = \frac{PT}{PE}$

$\frac{3}{220} = \frac{PT}{12}$

$PT = 0.164\,m$

$PE = \frac{1}{2} - d$

$PE = \frac{30}{2} - 3$

$PE = 15 - 3$

$PE = 12\,m$

$UP = UT + PT$

$UT = UP - PT$

$= 1.395 - 0.164$

$= 1.231\ m$

In $\Delta UOT$,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.8^\circ = \frac{UO}{1.231}$$

Observed ullage $\boxed{UO = 1.231}$

b) Qty of oil ⇒

G.O.V @ 25°C = 10584 $m^3$

VCF @ 25°C = × 0.9915 (0.8240)

G.S.V @ 15°C = 10494.036

WCF/WRF = 0.8229 (0.8240 - 0.0011)

Weight = × 8635.54 t

JULY 2016, JAN 2017, NOV 2021

A crude oil tanker of LBP 228m has a box shaped tank of dimensions 32×20×20m & trimmed 1m by stern. Initial ullage of 0.60m is measured by Radar beam level guage fitted 3m forward of aft bulkhead on centerline of tank. Given the density of oil at 15°C = 0.810 $t/m^3$ and observed temp is 24°C. On completion of unloading vessel trimmed 3.8m by stern & ullage of tank was 19.88m. Calculate the quantity of oil discharged.

Soln:-

$$\tan\theta = \frac{TRIM}{LBP}$$

$$\tan\theta = \frac{1}{228}$$

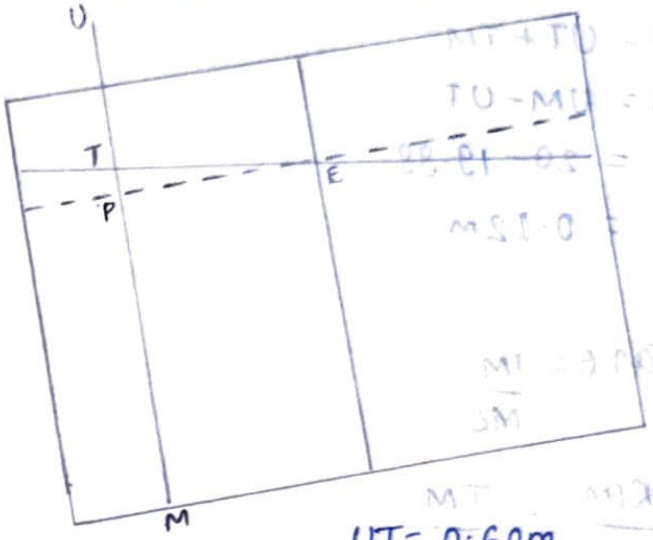
$$\theta = 0.25^\circ$$

$$PE = \frac{L}{2} - d$$

$$PE = \frac{32}{2} - 3$$

$$= 16 - 3$$

$$= 13m$$




UT = 0·60m

In $\Delta PTE$,

$$\tan\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

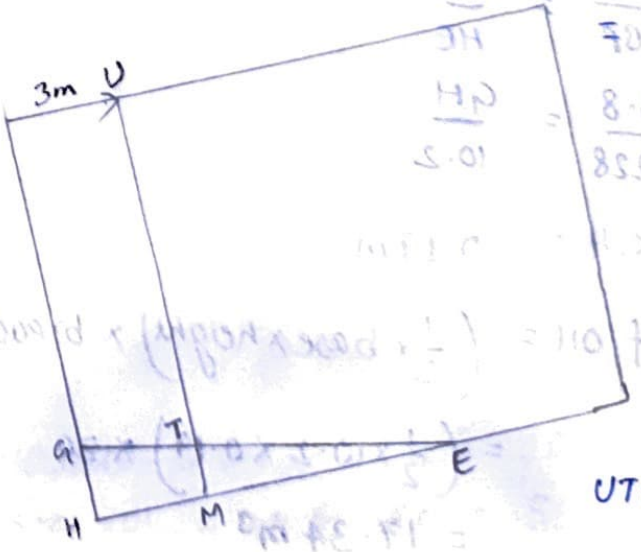
$$\frac{1}{228} = \frac{PT}{13}$$

$$PT = 0.057m$$

$$UP = UT + PT$$
$$= 0.60 + 0.057$$
$$= 0.657m$$

$$UM = UP + PM$$
$$PM = UM - UP$$
$$= 20 - 0.657$$
$$= 19.343m$$

Initial observed volume in tank = $32 \times 20 \times 19.343$
$= 11605.8\ m^3$




UT = 19.88m

$UM = UT + TM$

$TM = UM - UT$

$= 20 - 19.88$

$= 0.12m$

In $\Delta TME$,

$$\tan\theta = \frac{TM}{ME}$$

$$\frac{TRIM}{LBP} = \frac{TM}{ME}$$

$$\frac{3.8}{228} = \frac{0.12}{ME}$$

$$ME = 7.2m$$

$$HM = 3.0m$$

$HE = HM + ME$

$= 3.0 + 7.2$

$= 10.2m$

Length of the tank is 32m

Hence, wedge is confirmed

In $\Delta GHE$,

$$\tan\theta = \frac{GH}{HE}$$

$$\frac{TRIM}{LBP} = \frac{GH}{HE}$$

$$\frac{3.8}{228} = \frac{GH}{10.2}$$

$$GH = 0.17m$$

Final volume of oil $= \left(\frac{1}{2} \times \text{base} \times \text{height}\right) \times \text{breadth}$

$= \left(\frac{1}{2} \times 10.2 \times 0.17\right) \times 20$

$= 17.34 m^3$

Volume of oil discharged:

G.O.V @ 24°C : 11605.8 − 17.34

= 11588.46 m³

VCF @ 24°C = 0.9921

G.S.V @ 15°C = 11588.46 × 0.9921

= 11496.911 m³

WCF/WRF/density in air = density in vacc. − 0.0011

= 0.810 − 0.0011

= 0.8089

Quantity of oil discharged = 11496.911 × 0.8089

= **9299.85 T** Ans

JULY 2024 Am,

A box-shaped tank of a vessel had 3000 mt of cargo on arrival. To this, 2000 m³ of the same cargo of density 0.850 was added at temperature 30°C. Find the final observed ullage using a UTI tape from a point 4.0m fwd of the aft bulkhead, 1.0m above the deck and 4.0m to port of CL of tank when trim was 2.0m stern and list nil. Tank dimension 22×20×15 and LBP of vessel 220m. Final temperature 30°C. Also, find the total quantity of cargo. All weights in air.

Soln:-

Qty of oil = G.S.V @ 15°C × density in air

3000 = G.S.V @ 15°C × 0.8489 (0.850 − 0.0011)

G.S.V @ 15°C = 3533.985 m³

G.S.V @ 15°C = G.O.V @ 30°C × VCF @ 30°C

3533.985 = G.O.V @ 30°C × 0.9880

G.O.V @ 30°C = 3576.908 m³

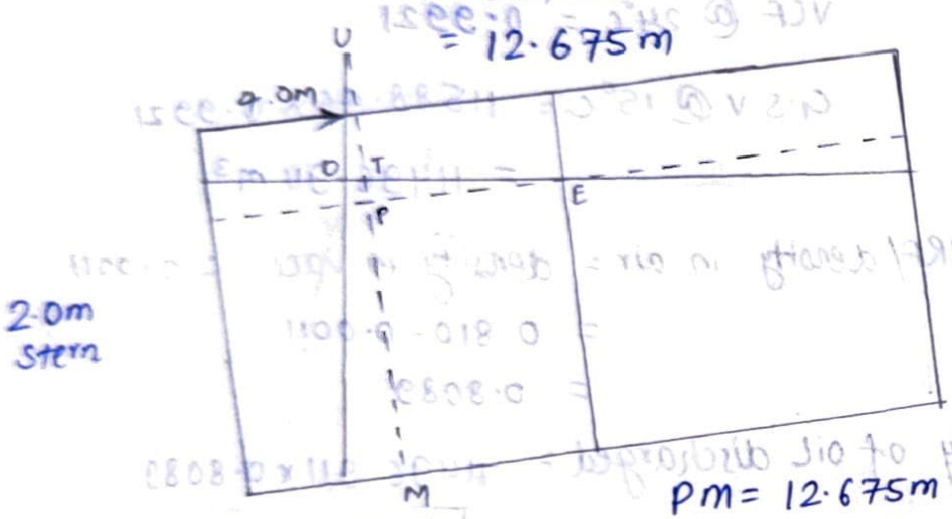
Volume added, G.O.V @ 30°C = 2000 m³

Total vol., G.O.V @ 30°C = 5576.908 m³

Actual sounding = $\frac{\text{Vol.}}{L \times B}$

$= \frac{5576.908}{22 \times 20}$

$= 12.675\,m$




$PM = 12.675m$

$UP = UM - PM$

$= (15+11) - 12.675 = 3.325m$

$PE = \frac{L}{2} - d$

$= \frac{22}{2} - 4$

$= 11 - 4$

$= 7$

$\text{Tan}\theta = \frac{TRIM}{LBP}$

$\text{Tan}\theta = \frac{2}{220}$

$\theta = 0.52^\circ$

In $\Delta PTE$,

$\text{Tan}\theta = \frac{PT}{PE}$

$\frac{TRIM}{LBP} = \frac{PT}{PE}$

$\frac{2}{220} = \frac{PT}{7}$

$PT = 0.064m$

$UP = UT + PT$

$UT = UP - PT$

$= 3.325 - 0.064$

$= 3.261\,m$

In $\Delta UOT$,

$\cos\theta = \frac{UO}{UT}$

$\cos 0.52^\circ = \frac{UO}{3.261}$

$\boxed{UO = 3.261m}$ i.e. final observed draft

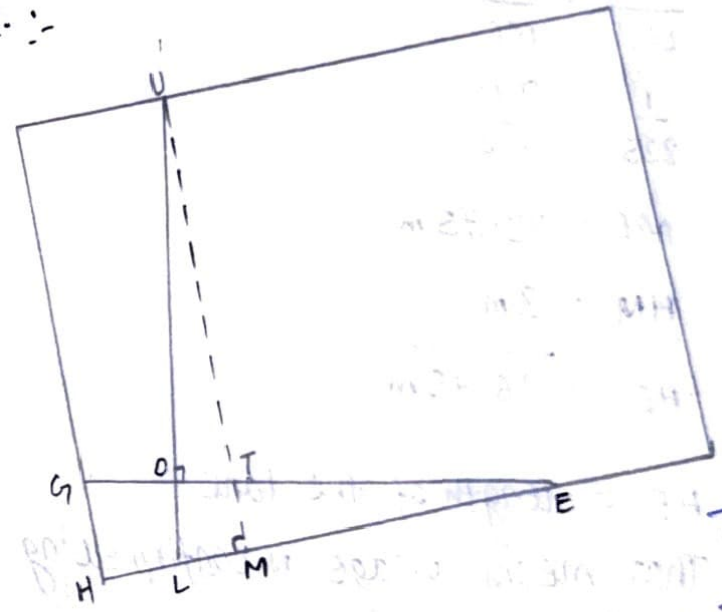
## CHECK WEDGE, TRIM

DEC 2013
JULY 2018
JAN 2023
JAN 2025 AM

A box-shaped cargo tank 40m x 22m x 18m was observed to have a sounding of 15 cm by sounding rod. Ullage reference point was located at the tank top, 3m forward of aft bulkhead. Vessel was trimmed 1m by stern and LBP of vessel was 255m. Upon completion of loading in the tank, vessel was even keel and ullage of tank by sonic guage was 1.10m. Calculate the quantity of oil loaded in the tank, if the observed temperature was 30°C and API gravity was 30.5 in both cases.

Soln:-

Initial cond.:-




$\text{Tan}\theta = \frac{\text{TRIM}}{\text{LBP}}$

$\text{Tan}\theta = \frac{1}{255}$

$\theta = 0.225°$

In $\Delta$ ULM,

$\cos\theta = \frac{UM}{UL}\left(\frac{b}{h}\right)$

$\cos 0.225° = \frac{18}{UL}$

$UL = 18.000m$

$UL = UO + OL$

$18 = UO + 0.15$

$UO = 18 - 0.15$

$UO = 17.85m$

In $\Delta$ UOT,

$\cos\theta = \frac{UO}{UT}$

$\cos 0.225° = \frac{17.85}{UT}$

$UT = 17.850m$

$UM = UT + TM$

$18 = 17.850 + TM$

$TM = 0.15m$

In $\Delta TME$,

$$\tan\theta = \frac{TM}{ME}$$

$$\frac{TRIM}{LBP} = \frac{TM}{ME}$$

$$\frac{1}{255} = \frac{0.15}{ME}$$

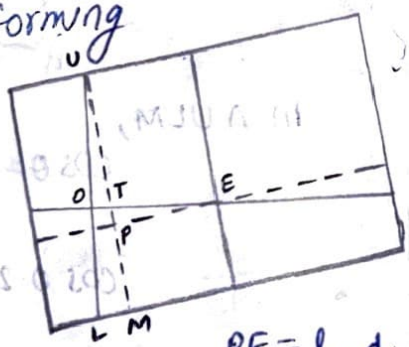
$ME = 38.25m$

$HM = 3m$

$HE = 41.25m$

$HE >$ length of the tank

That means, wedge is not forming




In $\Delta PTE$, $\tan\theta = \frac{PT}{PE}$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{1}{255} = \frac{PT}{17}$$

$PT = 0.067m$

$UP = UT + PT$

$UP = 17.850 + 0.067$

$UP = 17.917m$

$UM = UP + PM$

$18 = 17.917 + PM$

$PM = 0.083m$

$PE = \frac{l}{2} - d$

$= \frac{40}{2} - 3$

$= 20 - 3$

$= 17$

Volume of oil in tank = $l \times b \times$ sounding

$= 40 \times 22 \times 0.083$

$= 73.04 m^3$

i.e G.O.V @ 30°C = $73.04 m^3$

Final cond: Ullage = 1.10m

Sounding = 18 - 1.10 = 16.90m

volume of cargo in tank = l x b x sounding

= 40 x 22 x 16.90

G.O.V = 14872 $m^3$

Volume of oil loaded in tank = Final vol - Initial vol

= 14872 - 73.04

= 14798.96 $m^3$

↓

i.e. G.O.V @ 30°C

Density at 15°C (API : 30.5) = 0.8730

V.C.F at 30°C (density: 0.8730) = 0.9882

G.S.V = G.O.V @ 30°C x VCF @ 30°C

= 14798.96 x 0.9882

= 14624.332 $m^3$

W.C.F = density in vac. - 0.0011

= 0.8730 - 0.0011

= 0.8719

Weight of oil = G.S.V x W.C.F

= 14624.332 x 0.8719

= 12750.955 t

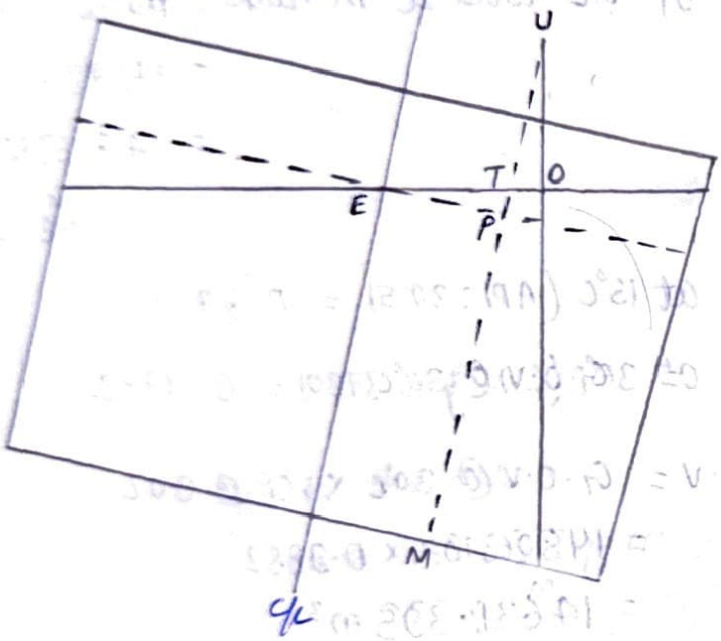
# TRIM + LIST

OCT 2024 AM

On an oil tanker, a box shaped cargo tank measuring 26 x 15 x 17 m is loaded with Diesel oil whose density at 15°C is 0·8424. The final ullage by UTI tape is observed to be 1·86 m and temperature of cargo is 34·7°C. Find the quantity of cargo loaded if ullage port is 800 cm is above the top of the tank, 5 m forward of aft bulkhead of tank and 4 m starboard of tank c/l, LBP = 225 m, Trim: 5 m by stern, and 2·5° stbd list

Soln:-

LIST




In $\Delta UOT$,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 2.5^\circ = \frac{1.86}{UT}$$

$$UT = 1.862\ m$$

In $\Delta PTE$,

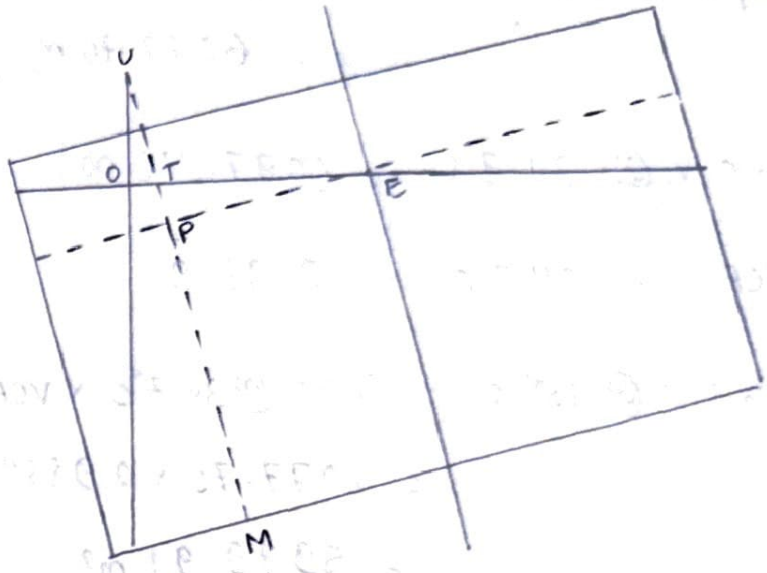
$$\tan\theta = \frac{PT}{PE} \qquad PE = 4\ m$$

$$\tan 2.5^\circ = \frac{PT}{4}$$

$$PT = 0.175\ m$$

$$UP = UT + PT$$
$$= 1.862 + 0.175$$
$$= 2.037\ m$$

List UP = Trim UO = 2·037m




In ΔUOT,

$\cos\theta = \frac{UO}{UT}$

$\cos 1{\cdot}27^\circ = \frac{2{\cdot}037}{UT}$

$UT = 2{\cdot}038m$

$\tan\theta = \frac{TRIM}{LBP}$

$\tan\theta = \frac{5}{225}$

$\theta = 1{\cdot}27^\circ$

In ΔPTE,

$\tan\theta = \frac{PT}{PE}$

$\frac{TRIM}{LBP} = \frac{PT}{PE}$

$\frac{5}{225} = \frac{PT}{8}$

$PT = 0{\cdot}178$

$PE = \frac{d}{2} - d$

$= \frac{26}{2} - 5$

$= 13 - 5$

$= 8$

$UP = UT + PT$

$UP = 2{\cdot}038 + 0{\cdot}178$

$UP = 2{\cdot}216m$

$UM = UP + PM$

$17 + 0{\cdot}8 = 2{\cdot}216 + PM$

$17{\cdot}8 = 2{\cdot}216 + PM$

$PM = 15{\cdot}584$

Volume of oil in cargo tank = $26 \times 15 \times 15.584$

$= 6077.76\ m^3$

G.O.V @ 34.7°C $= 6077.76\ m^3$

VCF @ 34.7°C $= 0.9839$

G.S.V @ 15°C = G.O.V @ 34.7°C × VCF @ 34.7°C

$= 6077.76 \times 0.9839$

$= 5979.91\ m^3$

WRF/WCF/density in air = density in vaccum − 0.0011

$= 0.8424 - 0.0011$

$= 0.8413$

Quantity of oil loaded = G.S.V @ 15°C × WCF/WRF

$= 5979.91 \times 0.8413$

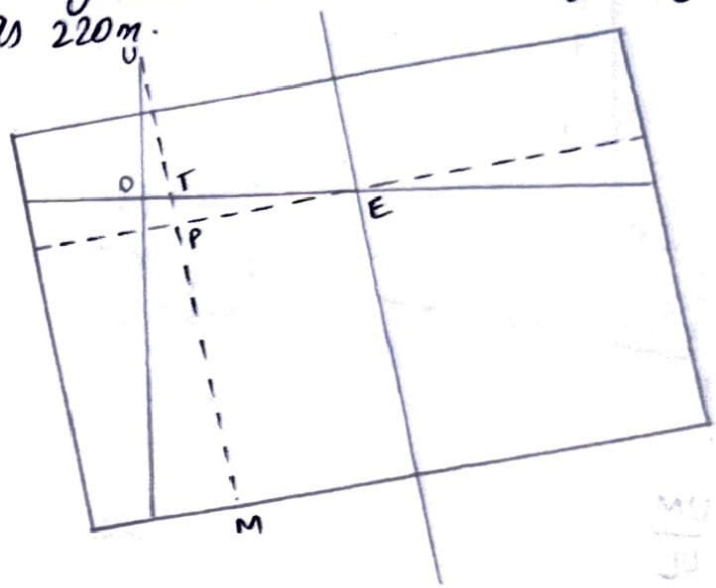
$= 5030.9\ T$

Ans

JULY 2024 PM

A box shaped tank L 28m, B 20m, D 18m, of an oil tanker containing crude oil of density at 15°C = 0.8350 t/m³ had an ullage of 1.40 as measured by UTI detector after loading and observed temperature was 32°C. A water dip 12cm was found. The ullage port was located 1.2m above the tank top and 2.0m forward of aft bulkhead. Ve was trimmed 2m by stern. Determine the quantity of oil in tank. LBP the tanker was 220m.

Ans:-




In ΔUOT,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.52^\circ = \frac{1.4}{UT}$$

$$UT = 1.400m$$

$$\tan\theta = \frac{TRIM}{LBP}$$

$$\tan\theta = \frac{2}{220}$$

$$\theta = 0.52^\circ$$

In ΔPTE,

$$\tan\theta = \frac{PT}{PE}$$

$$\frac{TRIM}{LBP} = \frac{PT}{PE}$$

$$\frac{2}{220} = \frac{PT}{12}$$

$$PT = 0.109$$

$$PE = \frac{L}{2} - d$$

$$= \frac{28}{2} - 2$$

$$= 14 - 2$$

$$= 12$$

$$UP = UT + PT$$

$$UP = 1.400 + 0.109$$

$$UP = 1.509m$$

$$UM = UP + PM$$

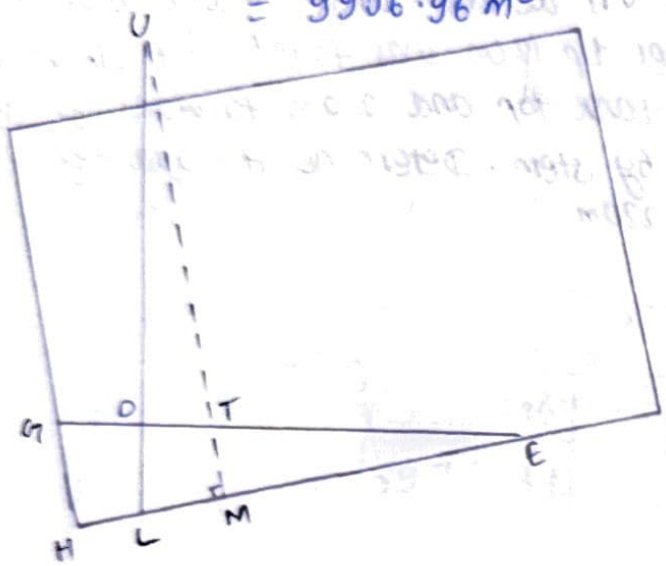
$$18 + 1.2 = 1.509 + PM$$

$$PM = 17.691m$$

Volume of liquid in tank = L x B x sounding

= 28 x 20 x 17.691

= 9906.96 $m^3$




In $\Delta$ ULM,

$$\cos\theta = \frac{UM}{UL}$$

$$\cos 0.52^\circ = \frac{19.2}{UL}$$

$$UL = 19.200m$$

$$UL = UO + OL$$

$$19.2 = UO + 0.12$$

$$UO = 19.080m$$

In $\Delta$ UOT,

$$\cos\theta = \frac{UO}{UT}$$

$$\cos 0.52^\circ = \frac{19.080}{UT}$$

$$UT = 19.081m$$

$$UM = UT + TM$$

$$19.2 = 19.081 + TM$$

$$TM = 19.2 - 19.081$$

$$TM = 0.119m$$

In $\Delta TME$,

$$\tan\theta = \frac{TM}{ME}$$

$$\frac{TRIM}{LBP} = \frac{TM}{ME}$$

$$\frac{2}{220} = \frac{0.119}{ME}$$

$$ME = 13.09\ m$$

$$HM = 2m$$

$$HE = HM + ME$$

$$HE = 2 + 13.09$$

$$HE = 15.09m$$ i.e. less than length of the vessel

wedge is confirmed.

In $\Delta GHE$,

$$\tan\theta = \frac{GH}{HE}$$

$$\frac{TRIM}{LBP} = \frac{GH}{HE}$$

$$\frac{2}{220} = \frac{GH}{15.09}$$

$$GH = 0.137\ m$$

Volume of water in tank $(\Delta GHE) = \left(\frac{1}{2} \times HE \times GH\right) \times$ breadth

$$= \frac{1}{2} \times 15.09 \times 0.137 \times 20$$

$$= 20.673\ m^3$$

Volume of oil in tank = Total liquid - vol. of water

$$= 9906.96 - 20.673$$

$$= 9886.287\ m^3$$

G.O.V @ 32°C = $9886.287\ m^3$

VCF @ 32°C = 0.9859

G.S.V @ 15°C = $9746.89\ m^3$

WCF / WRF = 0.8350 - 0.0011 = 0.8339

Quantity of oil = $9746.89 \times 0.8339$

= **8127.932 T** // Ans