2022
day

1100 - 1145
1200 - 1245
CAPT. SAYEED

* Tanker calculation.

- we need density for knowing the volume
  bcz, Density = mass/volume
- Cargo tank calibration table :- we get volume of the particular tank (1P, 1S etc) with respect to the sounding in this table.
  on-board ship.
- weight = volume x density

Temp. ↑ ; weight ↔ = volume ↑ x density ↓

Temp. ↓ ; weight ↔ = volume ↓ x density ↑

- Unit of weight
  Metric Ton, Long Tons, Short Tons
- ASTM Table 56 – provides for converting weight in vaccum to weight in air.
- Ullage report :-
  - Tank No.
  - Observed ullage – from UTI tape
  - Corrected ullage – UST correction from stability booklet
  - Temperature – from UTI
  - ~~Observed volume~~ Total observed volume (TOV) – including free water
  - ~~Standard volume~~ Gross observed volume (GOV) – only oil after deducting of free water.
  - Density at observed temp.
  - weight (MT)

- Density at 25°C = 0.9155
  & Density correction factor = 0.0006 per °C.

This means that,

Density at 31°C would be	= 0.9119	(temperature ↑, density ↓)
" " 32°C " "	= 0.9113	" ", " "
" " 34°C " "	= 0.9101	" ", " "
" " 35°C " "	= 0.9095	" ", " "
" " 20°C " "	= 0.9185	(temperature ↓, density ↑)

- VCF (volume correction factor)
- 1 barrel = 0.159 m^3
  1 m^3 = 6.29 barrel
- API – American petroleum institude
- ASTM – American society for testing and materials.

- ATSM Table 54(a) - crude oil product } VCF table in m^3, temp- °C
  54(b) - petroleum product }
  6(a) - crude oil product } VCF table in barrels, temp- °F
  6(b) - petroleum product }

~~* Sample of 54(b)~~

Temp °C	0.810	0.812	0.814	0.816 - Density @ 15°C
32.5	0.9841	0.9841	0.9842	0.9843
34.0	0.9827	0.9828	0.9829	0.9830
35.5	0.9813	0.9814	0.9815	0.9816

At 34°C (mean temp. of three level in tank) & at density at 15°C is 0.816, we have 500 m^3 volume of oil in tank.

so, volume correction factor is 0.9830

so, final volume in ullage report at 15°C = 500 x 0.9830 = 491.5 m^3

- Density in air & in vaccum

Density in air @15°C = Density in vacuum @15°C - 0.0011

we call this as a weight correction factor (WCF).

- Example :-

Density in air @15°C = 0.816 - 0.0011
or, WCF = 0.8149

like, GSV = 13993.149
WCF = 0.8149
weight (MT) in air = 11403.017 mt

- Volume & temperature conversion
- US barrels & cubic meter
  1 US barrels = 6.2898 X cubic meter
- °C to °F
  Deg F = 1.80 X Deg C + 32

- ASTM Table 9 :- To get the WCF to convert barrels at 60°F to short tons in air.
- ASTM Table 11 :- To get the WCF to convert barrels at 60°F to long tons in the air.
- ASTM Table 13 :- To get the WCF to convert barrels at 60°F to metric tons in the air.

- volume (m^3) @ obs temp —VCF Table 54(a) / Table 54(b)→ volume (m^3) @ 15°C —WCF Table 56→ weight in MT

- volume (bbls) @ obs. temp —VCF Table 6(a) / Table 6(b)→ volume (bbls) @ 60°F
  - —WCF Table 13→ weight in MT
  - —WCF Table 11→ weight (long ton)
  - —WCF Table 9→ weight (short ton)

~~Table 6b (Products) ↓ volume (bbls) @ 60°F; WCF Table 11 → weight (long ton); WCF Table 9 → weight (short ton); ↓ WCF Table 13 ↓ weight in MT~~

16/02/2022

Ques:- A tank has an area of $75 m^2$ and its present ullage is 1.6m. The tank is being filled through a pipe of diameter 200mm. Calculate for how much longer the tank valve should be left open to obtain an ullage of 800mm.

Average rate of flow through pipe is 1.75m/sec

Soln:-

Present ullage : 1.6m

Final ullage : 0.8m

Cargo filled : 0.8m

Volume of cargo filled = 0.8 x Area

= 0.8 x 75

= 60 m^3

Dia of pipe = 200m = 0.2m

Radius = $\frac{0.2}{2}$ = 0.1m

Rate of flow through pipe is $\pi r^2 h$

$= \frac{22}{7} \times r^2 \times h(l)$

$= \frac{22}{7} \times 0.1 \times 0.1 \times 1.75$

$= 0.055\ m^3/sec$

~~Therefore~~ Since, $0.055\ m^3$ oil enters tank per second, $60\ m^3$ should take ~~total amount oil needed~~ time $60/0.055 = \frac{1090.90909}{60}$ seconds

$= 18$ Min 10.9 seconds.

Ques ②:- A box shaped tank has $L = 20m$, $B = 15m$ & $D = 10m$ is being loaded through a pipe of diameter 300mm and length 5KM. 2 percent of the volume of the tank is to be left for expansion. Calculate at what ullage the pumping has to be stopped in order to accomodate all the oil in the pipe line.
Cargo temp. is 27°C & the RD of the oil is $0.8535\ t/m^3$ @ 15°C, and change in density is @ 0.0006/deg c.

Soln:-

- Volume of tank $= 20 \times 15 \times 10 = 3000\ m^3$.
- Pipe dia $= 300mm = 0.3m$

  Pipe radius $= \frac{d}{2} = \frac{0.3}{2} = 0.15m$

  Pipe length $= 5$ Km $= 5000m$

  Volume of pipeline $= \pi r^2 h$

  $= \frac{22}{7} \times 0.15 \times 0.15 \times 5000 = 353.571\ m^3$

  Mass of oil that can accomodate in the pipeline

  $=$ Vol. $\times$ density

  $= 353.571 \times 0.8463$

  $= 299.227\ t$

  1°C = 0.0006
  12°C = 0.0072
  Temp ↑, density ↓
  $0.8535 - 0.0072 = 0.8463\ t/m^3$

- 2% of vol. of tank $= 3000 \times \frac{2}{100} = 60\ m^3$ to be left for expansion

  Volume of oil to load $= 3000 - 60 = 2940\ m^3$

  Mass of oil to load $=$ vol. $\times$ density

  $= 2940 \times 0.8463$

  $= 2488.122\ t$

- Mass of oil at which loading has to stop

  = Mass of oil to load − Mass of oil that can accomodate in pipeline

  = 2488.122 − 299.227

  = 2188.895 t

- Mass = vol. × density

  2188.895 = (20 × 15 × h) × 0.8463

  2586.429 = 20 × 15 × h

  At h = 8.621 m sounding, we have to stop loading.

- Ullage at which we have to stop loading oil

  = 10 − 8.621

  = 1.379 m

Q.1. :- A traingular shape tank has a base 8m × 8m × 10m and height of 12m. Oil density 0.872 at 15°C (in vacuum) is to be loaded at 20°C. A minimum ullage of 0.2m is required at all times. If the maximum temperature expected during the voyage is 42°C, what should be the ullage at load port? What is the ratio of empty to filled space in the tank at load port? (using ASTM Table)

Soln:- <u>Information provided</u>

Dimension of the tank base : 8m × 8m × 10m

Height of tank : 12m

Oil of density : 0.872 at 15°C

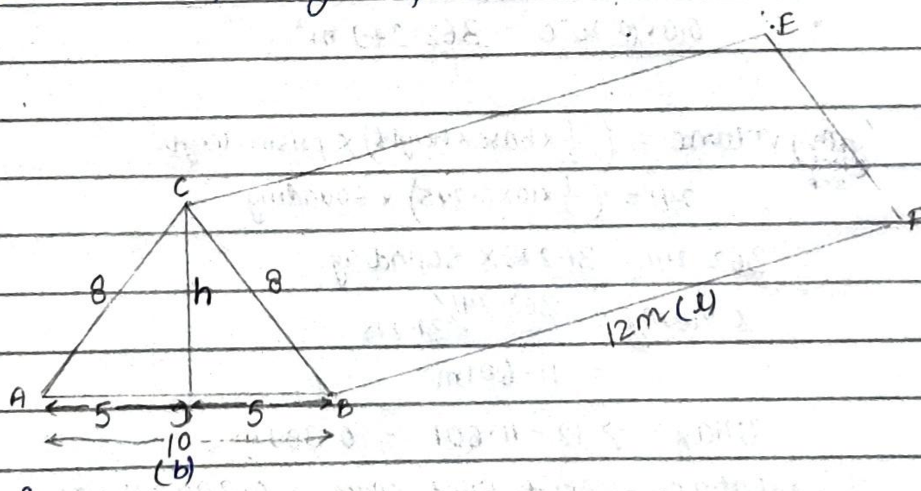
Minimum ullage required : 0.2m

Maximum temperature expected during the voyage : 42°C

<u>To find</u>

1) Find ullage at load port?

2) Find the ratio of empty to filled space in the tank at load port?



h = ?

$AC^2 = AD^2 + CD^2$

$CD^2 = AC^2 - AD^2$

$CD^2 = 8^2 - 5^2$

$CD^2 = 64 - 25$

$CD^2 = 39$

$h = 6.245\ m$

Note :- min ullage 0.2m is required so max^m we can load is 12-0.2 = 11.8m

volume of oil that can be loaded

$= \left(\frac{1}{2} \times \text{base} \times \text{height}\right) \times \text{prism length}$

$= \left(\frac{1}{2} \times 10 \times 6.245\right) \times 11.8$

$= 368.455\ m^3$

volume at max^m sounding $= 368.455\ m^3$

GOV @ 42°C $= 368.455\ m^3$

VCF @ 42°C $= 0.9793$ (Page-25 of Table 54, density - 0.8720 t/m³ at 15°C, obs. temp. 42°C)

Gross standard volume, GSV = GOV @ 42°C × VCF @ 42°C

$= 368.455 \times 0.9793$

$= 360.828\ m^3$

this is max^m volume of cargo which we can load which will not even trouble me at 42°C during voyage.

Since I require to find ullage at load port & temp at load port is 20°C

so, VCF @ 20°C $= 0.9961$ (Page 24, Table 54 density - 0.8720 t/m³ at 15°C, obs. temp. 20°C)

GSV = GOV @ 20°C × VCF @ 20°C

$360.828 = \text{GOV @ } 20°C \times 0.9961$

GOV @ 20°C $= 362.241\ m^3$

(GOV @ load temp) volume $= \left(\frac{1}{2} \times \text{base} \times \text{height}\right) \times \text{prism length}$

$362.241 = \left(\frac{1}{2} \times 10 \times 6.245\right) \times \text{sounding}$

$362.241 = 31.225 \times \text{sounding}$

$\text{Sounding} = 362.241 / 31.225$

$= 11.601\ m$

Ullage ⇒ $12 - 11.601 = 0.399\ m$

Ratio of empty to filled space ⇒ $0.399 : 11.601$

Ques②:- A tank of length 32m × 18m × 11.5m contains water to a sounding of 10 cms. Crude oil of density 0.8350 at 15°C in vacuum was loaded in tank at 25°C, also 3% of oil loaded was left for expansion throughout the voyage. If maximum temperature during voyage is 34°C

ⓐ Find ullage at load port

ⓑ The quantity of the cargo loaded.

∴ min ullage 0.2m is required. So max^m we can load is 12-0.2 = 11.8m

emp. 42°c)

can load
-2°c during voyage.
ad port is 20°c
0°c)

sounding of
was loaded
or expansion
voyage is 34°c

Total tank sounding : 11.5m
water : 0.1 m (10cm)
Empty space for loading : 11.4m

Vol. of tank available for loading: $32 \times 18 \times 11.4 = 6566.4\ m^3$

3% of oil to be left for expansion: $6566.4 \times \frac{3}{100} = (-)196.992\ m^3$

$6566.4 = 1.03V$

$V = 6375.146\ m^3$

Max^m volume allowed even at max^m temp during voyage $= 6375.146\ m^3$

GOV @ 34°C $= 6375.146\ m^3$

VCF @ 34°C $= 0.9843$ (Table 54, density − 0.8350 t/m³ at 15°C, obs. temp − 34°C)

Gross standard volume, GSV = GOV @ 34°C × VCF @ 34°C

$= 6375.196 \times 0.9843$

$= 6275.056\ m^3$

Since I require to find ullage at load port & temp at load port is 25°C

VCF @ 25°C $= 0.9917$

GSV = GOV @ 25°C × VCF @ 25°C

$6275.056 =$ GOV @ 25°C $\times 0.9917$

GOV @ 25°C $= 6327.575\ m^3$

(a) volume of oil + volume of water $= l \times b \times h$

$6327.575 + (32 \times 18 \times 0.1) = 32 \times 18 \times h$

$6327.575 + 57.6 = 32 \times 18 \times h$

$6385.175 = 32 \times 18 \times h$

$h = 11.085$

Ullage ⇒ $11.5 - 11.085 = 0.415$

(b) Quanity of cargo loaded = GSV × density of oil at 15°C in Air

Density in air @15°C = Density in vaccum @15°C − 0.0011

$= 0.8350 - 0.0011$

$= 0.8339$

Quantity of cargo load $= 6275.056 \times 0.8339$

$= 5232.769$ t

02.03.2022

Ques (3):- A rectangular tank 35X21X16 is to be loaded with crude oil at a temperature of 25°C. It is desired to leave 3% of tank volume for expansion. Calculate the quantity of oil loaded and final ullage at load port if ullage point is 1m above deck. Also calculate ullage when temperature rises to 44°C (density of oil 0.8475)?

Soln:-
- Total volm of tank : $35 \times 21 \times 16 = 11760\ m^3$

3% to be left for expansion: $11760 \times \frac{3}{100} = (-)352.8\ m^3$

Volume of oil we can load = $11407.2\ m^3$

GOV @ 25°C : $11407.2\ m^3$

VCF @ 25°C : 0.9919 (density = 0.8475)

GSV = GOV @ 25°C x VCF @ 25°C

= 11407.2 x 0.9919

= $11314.802\ m^3$

(a) Quantity of oil loaded = GSV x density of oil at 15°C in air

Density in air @ 15°C = Density in vaccum @ 15°C − 0.0011

= 0.8475 − 0.0011

= $0.8464\ t/m^3$

Quantity of oil loaded = 11314.802 X 0.8464

= 9576.848t

(b) Ullage at load port

(GOV @ load temp) volume = area x sounding

11407.2 = (35X21) X sounding

Sounding = 15.52m

Ullage ⇒ 16 − 15.52 = 0.48m

Final ullage if ullage point is 1m above deck ⇒ 1+0.48 = 1.480m

(c) Ullage at 44°C

GSV = GOV @ 44°C x VCF @ 44°C

11314.802 = GOV @ 44°C X 0.9767

GOV @ 44°C = $11584.726\ m^3$

(GOV @ 44°C) volume = area x sounding

11584.726 = (35X21) X sounding

Sounding = 15.762m

Ullage = 16 − 15.762 = 0.238

Final ullage if ullage point is 1m above deck = 1+0.238

= 1.238m

Previous Year Paper Solution

Tanker Calculation

Apr. 22 (1)

Total vol. of tank : $21 \times 16 \times 16 = 5376\ m^3$

2% of vol. to be left for expansion : $5376 \times \frac{2}{100} = (-)107.52\ m^3$

(when max^m temp. expected is 40°c) Volume of oil we can load = $5268.48\ m^3$

Similiar:- Jan 22 ~ Nov 21, 4095.748t, 1.5495; July 21, Mar 21, dec 20, Oct 20, Nov 19, July 19, Nov 18, Nov 17

Dec 21 (

Note:- we will load considering 40°c, bcz in voyage we will get 40°c

GOV @ 40°C = $5268.48\ m^3$

VCF @ 40°c = 0.9785

GSV = GOV @ 40°c × VCF @ 40°c

= 5268.48 × 0.9785

= $5155.208\ m^3$

(a) Mass of oil loaded = GSV × density of oil at 15°c in air

Density in air @ 15°c = Density in vacuum @ 15°c − 0.0011

= 0.820 − 0.0011

= 0.8189

Quantity of oil loaded = 5155.208 × 0.8189

= **4221.6 t**

(b) Ullage at load port

Note:- At load port, it is 24°c ; we are loading in taking into account 40°c, so current ullage will be less ; hence we make calculation by taking 24°c

GSV = GOV @ 24°c × VCF @ 24°c

5155.208 = GOV @ 24°c × 0.9923

GOV @ 24°c = $5195.211\ m^3$

(GOV @ 24°c) volume = area × sounding

5195.211 = (21 × 16) × sounding

$$\text{sounding} = \frac{5195.211}{21 \times 16}$$

sounding = 15.462 m

Ullage = 16 − 15.462 = 0.538 m

Final ullage if ullage point is 0.8 m above deck

= 0.8 + 0.538

= **1.338 m**

Feb 22, (2) Aug 21, Jan 18

Sol^n is in Page-53, 54

(3) Total vol. of tank : $30 \times 18 \times 20 = 10,800\ m^3$

(a minimum ullage of 3.5m is to be maintained during the voy. at max^m temp 37°c)

volume of oil we can load = $30 \times 18 \times (20 - 3.5)$

$= 30 \times 18 \times 16.5$

$= 8,910\ m^3$

GOV @ 37°C = $8910\ m^3$

(0.8250) VCF @ 37°c = 0.9813

GSV = GOV @ 37°c × VCF @ 37°c

$= 8910 \times 0.9813$

$= 8743.383\ m^3$

(a) Mass of oil loaded = ?

GSV × density of oil at 15°c in air

Density in air @15°c = Density in vaccum @15°c − 0.0011

$= 0.8250 - 0.0011$

$= 0.8239$

Quantity of oil loaded = 8743.383×0.8239

= **7203.673 t**

(b) Ullage at load port = ?

GSV = GOV @ 26°c × VCF @ 26°c

8743.383 = GOV @ 26°c × 0.9907

GOV @ 26°c = $8825.460\ m^3$

(GOV @ 26°c) volume = area × sounding

8825.460 = (30×18) × sounding

sounding = 16.343 m

Ullage = 20 − 16.343 = **3.657 m**

(c) Ullage, if temp unexpectedly rises to 45°c = ?

GSV = GOV @ 45°c × VCF @ 45°c

8743.383 = GOV @ 45°c × 0.9745

GOV @ 45°c = $8972.173\ m^3$

(GOV @ 45°c) volume = area × sounding

8972.173 = (30×18) × sounding

sounding = 16.615 m

Ullage = 20 − 16.615 = **3.385 m**

Sep 21 (4)

Volume of the barge: $23 \times 19.6 \times 14.6 = 6581.68$

Volume of oil loaded $= 6581.68 \times \frac{84}{100}$

$= 5528.611\ m^3$

GOV @ 19°C $= 5528.611\ m^3$

(0.8657) VCF @ 19°C $= 0.9969$

GSV = GOV @ 19°C × VCF @ 19°C

$= 5528.611 \times 0.9969$

$= 5511.472\ m^3$

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

Density in air @ 15°C = Density in vaccum @ 15°C − 0.0011

$= 0.8657 - 0.0011$

$= 0.8646$

Quantity of oil loaded = 4765.219 t

Quantity of oil deliverd = 1876.450 t

Quantity of oil ROB = 2888.769 t

June22
Apr 21,
Sep 17,

Now find GSV at ROB,

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

$2888.769 = GSV \times 0.8646$

$GSV = 3341.162\ m^3$

(a) Ullage at 9°C

GSV = GOV @ 9°C × VCF @ 9°C (0.8657)

$3341.162 = GOV @ 9°C \times 1.0046$

GOV @ 9°C $= 3325.863\ m^3$

(GOV @ 9°C) volume = area × sounding

$3325.863 = (23 \times 19.6) \times$ sounding

Sounding $= 7.378\ m$

Ullage $= 14.6 - 7.378 = 7.222\ m$

Final ullage if ullage port is 1.27 m above the tank

$= 7.222 + 1.270$

$= \boxed{8.492\ m}$

(b) ullage at 47°c

GSV = GOV @ 47°c x VCF @ 47°c

3341.162 = GOV @ 47°c x 0.9753

GOV @ 47°c = 3425.779 m3

(GOV @47°c) volume = area x sounding

3425.779 = (23x19.6) x sounding

sounding = 7.599 m

Ullage = 14.6 − 7.599 = 7.000 m

Final ullage if ullage port is 1.27 m above tank

= 7.000 + 1.27

= **8.270 m**

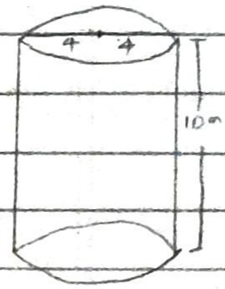
June22
Apr 21, (5)
Sep 17,

Quantity of oil loaded = GSV x density of oil at 15°c in air

Density in air @ 15°c = Density in vaccum @ 15°c − 0.0011

= 0.900 − 0.0011

= 0.8989



400 = GSV x 0.8989

GSV = 444.988 m³

(a) Ullage at load port = ?

GSV = GOV @ 28°c x VCF @ 28°c (0.900)

444.988 = GOV @ 28°c x 0.9905

GOV @ 28°c = 449.256 m3

(Gov @28°c) volume = area x sounding
(πr^2)

449.256 = (3.1416x4x4) x sounding

sounding = $\frac{449.256}{3.1416 \times 4 \times 4}$

sounding = 8.938 m

Ullage = 10 − 8.938 = **1.062 m**

(b) ullage if temp. rises at 38°c = ?

GSV = GOV @ 38°c x VCF @ 38°c

444.988 = GOV @ 38°c x 0.9832

GOV @ 38°c = 452.592 m3

(GOV @38°C) volume = area x sounding

452.592 = (3.1416 x 4 x 4) x sounding

sounding = $\frac{452.592}{3.1416 \times 4 \times 4}$

sounding = 9.004

Ullage = 10 − 9.004 = **0.996 m**

Nov 20 (6) Mar 20

- volume of tank = 9000 m^3
  Height of tank = 10 m
  Area of tank : $\frac{9000}{10}$ = 900 m^2

- Density of oil at 20°C = 0.87
  density correction factor = 0.0006 per°C
  Density of oil at 15°C = ? (temp ↓, then vol. ↓ & density ↑)
  = 0.87 + (0.0006 x 5)
  = 0.873

volume of oil we can load = 900 x (10 − 0.22)
= 8802 m^3 ✓

GOV @ 42°C = 8802 m^3 doubtful

(0.873) VCF @ 42°C = 0.97938 or 0.9794

GSV = GOV @ 42°C x VCF @ 42°C

GSV = 8802 x 0.97938

GSV = 8620.503 m^3

(a) Ullage on completion of loading at load port Jan 2

GSV = GOV @ 18°C x VCF @ 18°C

8620.503 = GOV @ 18°C x 0.9977

GOV @ 18°C = 8640.376 m^3 little doubtful

(GOV @18°C) volume = area x sounding

8640.376 = 900 x sounding

sounding = 9.6 m

Ullage = 10 − 9.6
= **0.4 m**

(b) While loading volume left = 9000 − 8620.503
= 379.497

percentage volume left for expansion =
$\frac{379.497}{9000} \times 100$
= 4.21%

Mar 20 (7)

Volume of tank: 25 × 20 × 18 = 9000 m3

Volume of cargo loaded: 25 × 20 × (18 − 0.85)
= 25 × 20 × 17.15
= 8575 m^3

Ullage = 1.85 m
pipe extended = 1.00 m
Ullage = 0.85

GOV @ 35°C = 8575 m^3

(0.7850) VCF @ 35°C = 0.9809

GSV = GOV @ 35°C × VCF @ 35°C

GSV = 8575 × 0.9809

GSV = 8411.218 m^3

Quantity of oil loaded in tank = ?

i.e. GSV × density of oil at 15°C in air

Density in air @ 15°C = Density in vaccum @ 15°C − 0.0011
= 0.7850 − 0.0011
= 0.7839 t/m^3

Quantity of oil loaded = 8411.218 × 0.7839
= **6593.554 t**

Jan 20 (8)

Ullage found after loading = 2.2 m
Ullage port extending above deck = 1.0 m
Actual ullage = 1.2 m

Vol. of FO loaded = 15 × 10 × (10 − 1.2)
= 15 × 10 × 8.8
= 1320 m^3

March 19 Similar:- Sep19, July

Sep18

GOV @ 40°C = 1320 m^3

(0.8650) VCF @ 40°C = 0.9806

GSV = GOV @ 40°C x VCF @ 40°C

GSV = 1320 x 0.9806

GSV = 1294.392 m^3

(a) Ullage when cooled down to 30°C

GSV = GOV @ 30°C x VCF @ 30°C

1294.392 = GOV @ 30°C x 0.9883

GOV @ 30°C = 1309.716 m^3

(GOV @ 30°C) volume = area x sounding

1309.716 = (15 x 10) x sounding

$$\text{sounding} = \frac{1309.716}{15 \times 10}$$

= 8.731 m

Ullage = 10 − 8.731 = 1.269 m

Final ullage when ullage port is 1m above deck

= 1 + 1.269

= **2.269 m**

(b) ullage when cooled down to 50°C

GSV = GOV @ 50°C x VCF @ 50°C

1294.392 = GOV @ 50°C x 0.9729

GOV @ 50°C = 1330.447 m^3

(GOV @ 50°C) volume = area x sounding

1330.447 = (15 x 10) x sounding

$$\text{sounding} = \frac{1330.447}{15 \times 10}$$

= 8.870 m

Ullage = 10 − 8.870 = 1.130 m

Final ullage when ullage port is 1m above deck

= 1 + 1.130

= **2.130 m**

March 19 (9) Similar:- Sep19, July18 see solution at Page 54, 55.

Sep18 (10)

vol. of tank = 20 × 15 × 10.6 = 3180 m^3

ullage after loading = 3.20 m

ullage pipe extended above deck = 0.91 m

Actual ullage = 2.29 m

volume of oil loaded = 20 × 15 × (10.6 − 2.29)

= 20 × 15 × 8.31

= 2493 m^3

Density @ 34°C = 0.8502

density correction factor = 0.0009/°C   temp.↓, density↑

Density @ 15°C = 0.8502 + (0.0009 × 19)

= 0.8673 t/m^3

GOV @ 34°C = 2493 m^3

(0.8673) VCF @ 34°C = 0.9853

GSV = GOV @ 34°C × VCF @ 34°C

= 2493 × 0.9853

= 2456.353 m^3

(a) If temp. changes to 20°C

GSV = GOV @ 20°C × VCF @ 20°C

2456.353 = GOV @ 20°C × 0.9961

GOV @ 20°C = 2465.97 m^3

percentage of filling = $\frac{2465.97}{3180}$ × 100 = 77.546 %

(b) If temp. changes to 64°C

March 18 (11)
may 22

volume of tank: 26·4×11·47×9·13 = 2764·637 m^3

Ullage on departure @ 44·3°c = 2·544 m
Ullage pipe extended = 1·070 m
Actual ullage = 1·474 m

vol. of oil in tank at departure = 26·4×11·47 × (9·13 − 1·474)
= 26·4 × 11·47 × 7·656
= 2318·298 m^3

GOV @ 44·3°c = 2318·298 m^3
(0·8313) VCF @ 44·3°c = 0·9755
GSV = GOV @ 44·3°c × VCF @ 44·3°c
GSV = 2318·298 × 0·9755
GSV = 2261·5 m^3

+

Oil transferred at 26°c = 108 m^3
i.e. GOV @ 26°c = 108 m^3
(0·8313) VCF @ 26°c = 0·9908
GSV = GOV @ 26°c × VCF @ 26°c
= 108 × 0·9908
= 107·006 m^3

Total GSV = 2261·5 + 107·006 = 2368·506 m^3
or
Total vol. of oil in tank

Quantity of oil in tank = ?
GSV × density of oil at 15°c in air

Density in air @ 15°c = Density in vaccum @ 15°c − 0·0011
= 0·8313 − 0·0011
= 0·8302 t/m^3

Quantity of oil in tank = 2368·506 × 0·8302
= 1966·334 t
ROB = 108·000 t
Fuel consumed = 1858·334 t

In 949 hours, 1858.334 t of fuel consumed

" 1 " , $\frac{1858.334}{949}$ t " " "

In 24 hours, $\frac{1858.334}{949} \times 24 = 46.997$ t of fuel consumed

Hence daily consumption is **46.997 t**

Max^m quantity of cargo which can be loaded = Area of tank top × load density

CAPT J.S. UPPAL — 29.12.2024

Que ① A tween deck is 18m × 15m × 4m and has a permissible load density of 5 t/m². Steel billets of SF 0.35 m³/t and general cargo of SF 4.0 m³/t are to be loaded therein to fill all the available spaces. Find the maximum quantity of steel billets that can be loaded and the quantity of over stowed general cargo so that the load density is not exceeded.

Volume of compartment = 18 × 15 × 4 = 1080 m³

Area of deck = 18 × 15 = 270 m²

Load density = 5 t/m²

Max^m permissible weight = area × density (see formula on top of the page)

= 270 × 5

= 1350 tonnes

Lets assume x tons of steel billets we load &

y tons of general cargo we load

So, $x + y = 1350$ —— ①

Space occupied by steel billets = weight × SF (weight = volume/SF, so, volume occupied = weight × SF)

= $x \times 0.35$

= $0.35x$ m³

Space occupied by gen. cargo = weight × SF

= $y \times 4.0$

= $4y$ m³

$0.35x + 4y = 1080$ —— ②

Solving equation ① & ②

$x + y = 1350$

$y = 1350 - x$

$0.35x + 4y = 1080$

$0.35x + 4(1350 - x) = 1080$

$0.35x + 5400 - 4x = 1080$

$5400 - 3.65x = 1080$

$5400 - 1080 = 3.65x$

$4320 = 3.65x$

$$x = \frac{4320}{3.65}$$

$$x = 1183.562 \text{ tonnes}$$

Since, $y = 1350 - x$

$= 1350 - 1183.562$

$= 166.438$ tonnes

Hence, ship can load 1183.562 tonnes of steel billets & 166.438 tonnes of general cargo to fill up the tween deck completly and not exceeding the load density.

* Freight based on stowage factor

- Cargoes of stowage factor $1.2\ m^3/t$ or more are treated as meas-ured cargoes. In this case, frieght is charged on the volume occupied by the cargo.
- cargoes of stowage factor less than $1.2\ m^3/t$ are treated as deadweight cargoes and frieght is charged on their weight.
- cargoes having stowage factor $0.56\ m^3/t$ or lesser are termed as high density cargoes. When such cargoes are loaded in bulk, there is special requirement.

Ques ① :-

A assignment of marbles in boxes having stowage factor 1.05 m^3/ton to be loaded in cargo space having bale capacity equal to 1750 m^3

- calculate the total amount of weight that can be loaded

cargo hold space = 1750 m^3

SF of cargo = 1.05 m^3/ton

Cargo we can load = $\frac{\text{volume}}{SF} = \frac{1750}{1.05} = 1666.667\,t$

- calculate the total amount of cargo to be loaded if 6% broken stowage is allowed

Broken stowage is the space b/w cargo which remain unfilled

Hence, we require new SF

Required SF = $SF + \left(SF \times \frac{BS}{100}\right)$

$= 1.05 + \left(1.05 \times \frac{6}{100}\right)$

$= 1.113\ m^3/t$

Cargo we can load @ SF 1.113 m^3/t = $\frac{1750}{1.113} = 1572.327\ t$

② A hold of 8m × 6m × 4m is to be filled with steel pipes (SF 1.06 m^3/t) & paint drums (SF 1.85 m^3/t). If the load density of the tank top is 3.2 t/m^2, upto what height should the steel pipes be loaded so that the hold is filled without exceeding the load density? How many tonnes of steel pipes and paint drums can be loaded?

vol. of Hold = 8×6×4 = 192 m^3

Area of Hold = 8×6 = 48 m^2

Load density = 3.2 t/m^2

Cargo can load = area × density	Max^m volume of pipe that we can load = weight × SF
= 48 × 3.2	= 153.6 × 1.06 = 162.816 m^3
= 153.6 t	Max^m height = $\frac{\text{max}^m\text{ volume}}{\text{area}} = \frac{162.816}{48} = 3.392\ m$

lets assume, x tonnes of steel pipes we can load

& y tonnes of paint drums we can load

$x + y = 153.6$ — ①

$x = 153.6 - y$

Space occupied ⇒ By steel pipes

$= \text{weight} \times SF$

$= x \times 1.06$

$= 1.06x \ m^3$

By paint drums

$= \text{weight} \times SF$

$= y \times 1.85$

$= 1.85y \ m^3$

$1.06x + 1.85y = 192 \ m^3$ —— (II)

By solving equation (I) & (II),

$1.06(153.6 - y) + 1.85y = 192$

$162.816 - 1.06y + 1.85y = 192$

$0.79y = 29.184$

$y = 36.942$

we get, $y = 36.942 t$

$x = 153.6 - y$

$= 116.658 t$

So, we can load 116.658t of steel pipes & 36.942t of paint drums

Apr 21 (3) A hold of general cargo ship measures 20X15X9.05. Dunnage consist layer 5cm high and side battens extends 0.2m (20cm) from ship side. It co cargo of 50 machinery cases of 1.5m X1.3m X 2m stowed with a E 200t of cotton bales S.F 2.5 m/t and B.S 10%. Find weight of jute B.S. 10%. and S.F 1.6 m/t

Soln:- Side battens - 0.2m from ship side i.e. both P&S = 0.2+0.2 = 0.4m

dunnage height - 5 cm = 0.05 m

volume of hold ⇒ $20 \times (15 - 0.4) \times (9.05 - 0.05)$

$= 20 \times 14.6 \times 9$

$= 2628 \ m^3$

(1) New S.F of cotton bales $= SF + \left(SF \times \frac{BS}{100}\right)$

$= 2.5 + \left(2.5 \times \frac{10}{100}\right)$

$= 2.75 \ m^3/t$

Space occupied by cotton bales $= 200 \times 2.75$

$= 550 \ m^3$

(2) New S.F of jute bales $= 1.6 + \left(1.6 \times \frac{10}{100}\right)$

$= 1.76 \ m^3/t$

Space occupied by jute bales $= x \times 1.76$

$= 1.76 \ m^3$

(3) vol. occupied by 1 machinery case $= 1.5 \times 1.3 \times 2$

$= 3.9 \ m^3$

vol. occupied with BS $= 3.9 + \left(3.9 \times \frac{20}{100}\right) = 4.68 \ m^3$

Vol. occupied by 50 cases = weight × SF

$= 50 \times 4.68$

$= 234\ m^3$

$234 + 550 + 1.76x = 2628$

$1.76x = 1844$

$x = 1047.72$

(4) A ship hold has a bale capacity of $680\ m^3$ and a grain capacity of $735\ m^3$ and is filled with a maize stowing at $1.27\ m^3/t$. It is now intended to discharge 175 tons of maize and load bagged maize in the same hold. The bags are $0.5 \times 0.4 \times 0.3$ and weighs 50 Kgs. The space lost beetween the bag is 12%, how many tons of bagged maize can be loaded.

of a
onsist of
3.s of 20%
bales

Ans:- Step①:- Vol^m occupied by 1 bag $= 0.5 \times 0.4 \times 0.3$

$= 0.06$

SF of a bagged maize $= \dfrac{\text{Vol.}}{\text{weight}} = \dfrac{0.06}{0.05}$ $\left(50\ Kg = \dfrac{50}{1000} = 0.05\ t\right)$

$= 1.2\ m^3/t$

New S.F $= 1.2 + \left(1.2 \times \dfrac{12}{100}\right)$

$= 1.2 + 0.144$

$= 1.344\ m^3$

Step②:- Vol^m of maize discharge = weight × SF

$= 175 \times 1.27 = 222.25\ m^3$

Step③:- Vol^m available for bagged maize $= \dfrac{680}{735} \times 222.25$

$= 205.619\ m^3$

Step④:- Total tons of bagged maize which we can load is

volume = weight × SF

$205.619 = w \times 1.344$

weight = 153 t

CHAPTER-FOUR

LIFTING GEAR

* Blocks & Purchases

- When load moves in the same direction as the effort it is said to "advantage" (
when load moves in the opposite direction to the effort it is rigged, is disadvantage.

- Mechanical advantage is the ratio of load to effort

$$M.A = \frac{Load}{Effort}$$

- Velocity Ratio is the ratio of velocity of effort to velocity of load.

V.R is also equal to $n+1$ (when purchase is used to advantage)
n (when purchase is used to disadvantage)

- Efficiency of a system $= \frac{MA}{V.R} \times 100\%$

Ques ①:- A gun tackle (2 sheeve) used to advantage (pulling upward) & luff tackle (3 sheeve) used to disadvantage (pulling downward) are used in combination to lift a load of 4 tons. The load is supported from gun tackle. Calculate

ⓐ The effort required to lift the load

ⓑ The efficiency of the system

ⓒ The minimum size of nylon rope to be used in each tackle.

Sol^n:- ⓐ GUN TACKLE

Load $w = 4t$ no. of sheeve, $n = 2$

velocity ratio, $V.R = 2 + 1 = 3$ (advantage)

$$Effort = \frac{(w + nw \times Friction)}{V.R}$$

Note:- Take friction 10%, if not specified in question

$$= \frac{(4 + (2 \times 4) \times \frac{10}{100})}{3} = \frac{4 + 0.8}{3} = 1.6t$$

LUFF TACKLE

Load $w = 1.6t$ (bcz weight coming on luff tackel is 1.6t, rest weight is taken by gun tackle)

no. of sheeve, $n = 3$ velocity ratio, $V.R = 3$ (disadvantage)

$$Effort = \frac{(w + nw \times friction)}{V.R}$$

$$= \frac{1.6 + (3 \times 1.6) \times \frac{10}{100}}{3} = \frac{1.6 + 0.48}{3} = 0.693t$$

So, Final effort required to lift the load is 0.693t

(b) Efficiency of system

$$= \frac{M \cdot A}{V \cdot R} \times 100\%$$

M·A = load/effort

= 4/0.693

= 5.772

Total V·R = V·R of gun tackle × V·R of luff tackle

= 3×3
= 9

$$\text{Efficiency} = \frac{5.772}{9} \times 100$$

= 64.13%

(c) Breaking stress = S.W.L × F.S
or Effort ↳ Factory of safety
(& if it is not mentioned in ques, then take it 6)

B·S = 0.693×6

B·S = 4.158

Since, we know B·S of nylon rope = $\frac{5D^2}{300}$

$$4.158 = \frac{5D^2}{300}$$

$D^2 = 249.48$

D = 15.79 or 16mm

(2) A simple derrick is fitted with a 6×24 wire rope of 28mm diameter. The chain register specifies a safety factor of 7. Calcute the maximum load that can be safely lifted by this derrick.

Solⁿ:- D = 28mm

Breaking stress of 6×24 wire rope = $\frac{20D^2}{500}$

$$= \frac{20 \times 28^2}{500} = 31.36$$

B·S = SWL × FS

31.36 = SWL × 7

SWL = 4.48t

Ques③:- A weight of 12T is to be lifted by 2 fold purchase (4 sheave) rigged to advantage. The holding part of this purchase is attached to the single sheave block of a luff tackle. Find the size of nylon rope which has to be used for each purchage and the efficiency of the system (Assume VR of the system to be the product of individual VRs, friction 8% per sheave & factor of safety 6)

Soln:- Two fold purchage: load, $w = 12t$

no. of sheeve, $n = 4$ velocity ratio, $V.R = 4 + 1 = 5$ (1 → advantage)

$$\text{Effort}, E = \frac{w + (nw \times \text{Friction})}{V.R}$$

$$= \frac{12 + (4 \times 12) \times \frac{8}{100}}{5}$$

$$= \frac{12 + 3.84}{5} = 3.168t$$

Luff tackle

$w = 3.168t$

$n = 3$ $V.R = 3 + 0 = 3$ (0 → disadvantage)

$$E = \frac{3.168 + (3 \times 3.168) \times \frac{8}{100}}{3}$$

$= \boxed{1.309\ t}$, is final effort

ⓐ Efficiency of the system $= \frac{M.A}{V.R} \times 100\%$

$M.A = \text{Load}/\text{effort} = 12/1.309 = 9.167$

Final V.R = V.R of two fold purchage × V.R of luff tackle

$= 5 \times 3 = 15$

$$\text{Efficiency} = \frac{9.167}{15} \times 100 = 61.1\%$$

ⓑ For luff tackle, Breaking stress = S.W.L × f.s (or Effort)

$= 1.309 \times 6 = 7.854$

Breaking stress of a nylon rope $= \frac{5D^2}{300}$

$$7.854 = \frac{5D^2}{300}$$

$5D^2 = 2356.2$

$D^2 = 471.24$

$D = 21.71 = 22\text{mm}$

For two fold purchage, B.S = Effort × F.S

$= 3.168 \times 6$

$= 19.008$

B.S of nylon rope $= \frac{5D^2}{300}$

$$19.008 = \frac{5D^2}{300}$$

$5D^2 = 5702.4$

$D^2 = 1140.48$

$D = 33.8 = 34\text{mm}$

rigged to advantage
sheave block of a
used for each purchase
to be the product
fety 6)

advantage
) = 5

ge, $B.S = \text{Effort} \times FS$
$= 3.168 \times 6$
$= 19.008$

f nylon rope $= \frac{5D^2}{300}$
$19.008 = \frac{5D^2}{300}$
$5D^2 = 5702.4$
$D^2 = 1140.48$
$D = 33.8 = 34\,mm$

Ques ④:- A simple derrick is used to lift a load of 8 tons of gyn tackle (5 sheeves) used to disadvantage if the wire is 6X24. what should be the diameter of wire. FS = 6.

Soln:-

$w = 8t$ no. of sheeve = 5 $V.R = 5 + 0 = 5$ (0 → disadvantage)

$$\text{Effort, } E = \frac{w + nw \times F\%}{V.R}$$

$$= \frac{8 + (5 \times 8) \times \frac{10}{100}}{5} = 2.4t$$

Breaking stress = Effort X F.S

$= 2.4 \times 6 = 14.4$

Breaking stress of 6X24 wire rope $= \frac{20D^2}{500}$

$$14.4 = \frac{20D^2}{500}$$

$D = 18.97 = 19\,MM$

Ques ⑤:- A steel girder weighing 7t is to be lifted by a single derrick using a gun tackle in advantage. A block at the derrick head leads the wire down to the winch. Find the minimum size of 6X37 wire to be used as the runner wire.

Soln:-

GUN TACKLE:- load $w = 7t$ $n = 2$ $V.R = 2 + 1 = 3$ (1 → advantage)

$$\text{Effort, } E = \frac{w + nw \times F\%}{V.R}$$

$$= 7 + (7 \times 2) \times \frac{10}{100} = 2.8t$$

Rest load is support by derrick head block

$w = 2.8t$ $n = 1$ $V.R = 1 + 0 = 1$ (0 → disadvantage bcz load moves in the opposite direction to the effort)

$$\text{Effort, } E = \frac{w + nw \times F\%}{V.R}$$

$$= \frac{2.8 + (1 \times 2.8) \times \frac{10}{100}}{1} = \boxed{3.08\,t} \rightarrow \text{final effort}$$

Breaking stress = Effort X FS

$= 3.08 \times 6 = 18.48$

Breaking stress of 6X37 wire rope $= \frac{21D^2}{500}$

$$18.48 = \frac{21D^2}{500}$$

$D = 21\,mm$

Ques(6):- A weight of 10t is to be lifted with two fold purchase rigged to disadvantage The hauling post of this purchase is secured to the moving block of a gun tackle rigged to advantage Calculate the
(a) Effort required to lift the load.
(b) Efficiency of the system
(c) Size of nylon rope required for the two fold purchase.

Sol^n:- (a) Two fold purchase:-

Load $w = 10t$ no. of sheeve, $n = 4$ $V.R = 4 + (0) = 4$ (0 → disadvantage)

$$Effort, E = \frac{w + nw \times F\%}{V.R}$$

$$= \frac{10 + (4 \times 10) \times \frac{10}{100}}{4} = \frac{10+4}{4} = 3.5t$$

Gun tackle

Load, $w = 3.5t$ no. of sheeve, $n = 2$ $V.R = 2 + (1) = 3$ (1 → advantage)

$$Effort, E = \frac{w + nw \times F\%}{V.R}$$

$$= \frac{3.5 + (2 \times 3.5) \times \frac{10}{100}}{3} = 1.4t$$

(b) $M.A = \text{Load}/\text{Effort} = 10/1.4 = 7.143$

$$\text{Efficiency of the system} = \frac{M.A}{V.R} \times 100\%$$

$$= \frac{7.143}{4 \times 3} \times 100 = 59.524\%$$

(c) Breaking stress = Effort × F.S

$= 1.4 \times 6 = 8.4$

$$\text{Breaking stress of nylon rope} = \frac{5D^2}{300}$$

$$8.4 = \frac{5D^2}{300}$$

$$5D^2 = 2520$$

$$D = 22.45 = 23mm$$

Ques (7

Sol^n:-

Ques ⑦:- The hauling post of gyn tackle is attached to a moving block of a luff tackle. Calculate the percentage of efficiency of the system when a 24t weight is being lifted. Both tackles are rigged to advantage and friction per sheave is estimated as 5% of the load.

Soln:- Gyn tackle:-

Load, $w = 24t$ no. of sheeve, $n = 5$ $V \cdot R = 5 + (1) = 6$ → advantage

$$\text{Effort, } E = \frac{w + nw \times F\%}{V \cdot R}$$

$$= \frac{24 + (24 \times 5) \times \frac{5}{100}}{6} = 5\,t$$

Luff tackle:-

Load $w = 5t$ no. of sheeve, $n = 3$ $V \cdot R = 3 + (1) = 4$ → advantage

$$\text{Effort, } E = \frac{w + nw \times F\%}{V \cdot R}$$

$$= \frac{5 + (3 \times 5) \times \frac{5}{100}}{4} = 1.438\,t$$

$M \cdot A = \text{Load}/\text{Effort}$

$= 24/1.438 = 16.696$

Total $V \cdot R$ = V·R of gyn tackle × V·R of luff tackle

$= 6 \times 4 = 24$

Efficiency of the system is $\frac{16.696}{24} \times 10$

$= 69.565\%$

Previous year paper solution

Load density, SF etc

Nov 21, Aug 21, Jan 22, June 22

Similar:- March 22, sep 17, oct 21

(1) volume of hold = $10 \times 10 \times 9 = 900 m^3$

Area of hold = $10 \times 10 = 100 m^2$

Load density of tank top = $4.5 t/m^2$

Max^m cargo we can load = area x density

= 100×4.5

= 450 tones

a) How many tonnes of each cargo can be loaded?

Lets assume, x tonnes of steel plates we can load & so 450-x t of steel coils we can load

Steel plates

volume = weight x SF

volume = $x \times 2.05$

= $2.05x \, m^3$

Steel coils

volume = weight x SF

volume = $(450-x) \times 1.86$

= $837 - 1.86x$

volume of hold = vol. of steel plates + vol. of steel coils

$900 = 2.05x + 837 - 1.86x$

$900 - 837 = 2.05x - 1.86x$

$63 = 0.19x$

$x = \boxed{331.579 t}$ i.e. steel plates

& $450 - x = \boxed{118.421 t}$ i.e. steel coils.

b) Calculate the height of each cargo.

- Height = $\frac{\text{volume}}{\text{area}}$

where volume = weight x SF

= 331.579×2.05

= $679.737 m^3$

so, height = $\frac{679.737}{100}$

= $\boxed{6.797 m}$ i.e. of steel plates

• volume = 118.421×1.86

$= 220.263\ m^3$

Height = $\frac{220.263}{100}$

= **2.203 m** i.e. of steel coils.

July 21 (2)

volume of hold = $18 \times 14 \times 6 = 1512\ m^3$

Area of hold = $18 \times 14 = 252\ m^2$

Load density of tanktop = $6\ t/m^2$

Max^m cargo we can load = area x density

$= 252 \times 6$

$= 1512$ tonnes.

Lets assume x ton of steel billets we can load & 1512−x tons of general cargo we can load

steel billets	General cargo
$SF = 0.5\ m^3/t$	$SF = 3.5\ m^3/t$
BS = 8%	BS = 10%
Req. SF = SF + $\left(SF \times \frac{BS}{100}\right)$	Req. SF = SF + $\left(SF \times \frac{BS}{100}\right)$
$= 0.5 + \left(0.5 \times \frac{8}{100}\right)$	$= 3.5 + \left(3.5 \times \frac{10}{100}\right)$
$= 0.5 + 0.04$	$= 3.5 + 0.35$
$= 0.54\ m^3/t$	$= 3.85\ m^3/t$
∴ volume = weight x SF	volume = weight x SF
$= x \times 0.54$	$= (1512 - x) \times 3.85$
$= 0.54x\ m^3$	$= 5821.2 - 3.85x$

volume of hold = vol. of steel billets + vol. of gen. cargo

$1512 = 0.54x + 5821.2 - 3.85x$

$1512 - 5821.2 = 0.54x - 3.85x$

$-4309.2 = -3.31x$

$x = \frac{4309.2}{3.31}$

$x =$ **1301.873** i.e. steel billets.

$1512 - x = \boxed{210.127\,t}$ i.e. general cargo.

Apr. 21 (3) — Side battens = 20 cm i.e. 0.2 m from ship side i.e. both P&S = 0.2 + 0.2 = 0.4 m
(decreases the breadth)

Dunnage = 5 cm i.e. 0.05 m
(decreases the height)

Sep 19 (4

$$\text{volume of cargo hold} = 20 \times (15 - 0.4) \times (9.05 - 0.05)$$
$$= 20 \times 14.6 \times 9$$
$$= 2628\ m^3$$

Machinery cases	Cotton bales
vol. of 1 mach. case $= 1.5 \times 1.3 \times 2$	$SF = 2.5\ m^3/t$ + BS 10%
$= 3.9\ m^3$	
vol. occupied with BS $= 3.9 + \left(\frac{3.9 \times 20}{100}\right)$	Req. SF $= SF + \left(SF \times \frac{BS}{100}\right)$
$= 3.9 + 0.78$	$= 2.5 + \left(2.5 \times \frac{10}{100}\right)$
$= 4.68\ m^3$	$= 2.5 + 0.25$
Total vol. of 50 mach. case	$= 2.75\ m^3/t$
$= 50 \times 4.68$	vol. = weight × S.F
$= 234\ m^3$	$= 200 \times 2.75$
	$= 550\ m^3$

Now, volume available for jute bales $= 2628 - (234 + 550)$
$= 2628 - 784$
$= 1844\ m^3$

Jute bales

$SF = 1.6\ m^3/t$ + BS 10%

New S.F $= SF + \left(SF \times \frac{BS}{100}\right)$
$= 1.6 + \left(1.6 \times \frac{10}{100}\right)$
$= 1.6 + 0.16$
$= 1.76\ m^3/t$

vol. = weight × S.F
$1844 = \text{weight} \times 1.76$
$\text{weight} = 1844 / 1.76$
$\text{weight} = \boxed{1047.727\ t}$

No. of jute bales = ? (if each jute bales weight 500 KG)

= 2095.454

= **2095**

1 ton = 1000 KG

1047.727t = 1047727 KG / 500

Sep19 (4) Grain capacity = 6600 m^3

Bale capacity = 6200 m^3

(a) What was the quantity of bulk grain?

S.F = 1.8 m^3/t + BS 9%

= 1.8 + (1.8 × 9/100)

= 1.8 + 0.162

= 1.962 m^3/t

Volume = weight × SF

6600 = weight × 1.962

weight = 6600/1.962 =

= **3363.914 t**

(b) How many bags were filled up from above grain?

3363.914 × 1000 = 3363914 / 50 = **67278.28 bags**

(c) How many bags are finely loaded to fill up the hold?

Volume = weight × S.F

6200 = weight × 2.1

weight = 6200/2.1

= 2952.381 t

No. of bags = 2952.381 × 1000 = 2952381 / 50 = **59047.62 bags**

Sep18 (5)

Similar:- May18, Jan16

No. 2 LH	No. 2 TD
Volume = 1700 m^3	Volume = 1410 m^3
area = 15×10 = 150 m^2	area = 15×10 = 150 m^2
Load density = 8 t/m^2	Load density = 5 t/m^2
Max^m cargo we can load = area × density = 150×8 = 1200 t	Max^m cargo we can load = 150×5 = 750 t

Jan 19

Cargo	S.F	Weight	Vol. = weight x S.F	DISCHARGE PORT
Ore	0.5	400	200	Hong Kong
Gunnies	1.7	500	850	" "
Rubber	2.0	100	200	" "
		1000t	1250 m^3	
Tea chest	3.0	80	240	Singapore
machinery	2.0	70	140	"
gunnies	1.7	400	680	"
		550t	1060 m^3	

First, we have to discharge at singapore so, we keep it on tween deck.

On 2TD, weight available = max^m weight we can load − Total weight of singapore cargo

= 750 − 550

= 200 t

volume available = 1410 − 1060

= 350 m^3

volume = weight x S.F

350 = 200 x S.F

S.F = 350/200

= 1.75 m^3/t

So, optional cargo we can load on 2TD is **200t of S.F 1.75 m^3/t**

Nov. 17

Hong Kong

On 2LH, weight available = 1200 − 1000

= 200 t

volume available = 1700 − 1250

= 450 m^3

volume = weight x S.F

450 = 200 x S.F

S.F = 450/200

S.F = 2.25 m^3/t

So, optional cargo we can load on 2 LH is **200t of S.F 2.25 m^3/t**

Jul19 (6) Max^m displacement : 15700 mt.

Light ship disp. = 3980
Initial bunker + FW = (+) 150
Recieving bunker = (+) 1300
Recieving FW = (+) 250
Disp. after above ops. = 5680 t

cargo can load = 15700 − 5680
= 10020 t

There are total 5 holds, so
cargo can load in each hold = $\frac{10020}{5}$ = 2004 t

But, since it is a iron ore, we will check that if we load 2004t in one hold, the load density of tank top is not exceeding.

cargo can load in one hold = area x density
= 20 X 14 X 7.5
= 2100 t

& we are loading 2004 t in each hold
That means, we are not exceeding the load density

Nov.17 (7) Bale capacity = 500 m^3
Grain capacity = 570 m^3

Step ① :- vol^m of 1 bag = 0.5 X 0.4 X 0.3
= 0.06 m

weight of 1 bag = 50 kgs = 0.05 t

S.F = vol/weight
= 0.06/0.05 = 1.2 m^3/t

New S.F = S.F + $\left(S.F \times \frac{BS}{100}\right)$
= $1.2 + \left(1.2 \times \frac{11}{100}\right)$
= 1.2 + 0.132
= 1.332 m^3/t

Step②: vol. of maize discharge = weight × S.F

$= 100 \times 1.25$

$= 125\ m^3$

Step③: vol. available for bagged maize $= 125 \times \frac{500}{570}$

$= 109.649\ m^3$

Step④: weight of bagged maize that can be loaded = ?

vol. = weight × S.F

$109.649 = \text{weight} \times 1.332$

weight $= 109.649 / 1.332$

$= 82.319\ t$

Similiar like 12070 @ 1.025 in DW of RD 1.005, Equivalent displacement $= 12070 \times \frac{1.005}{1.025}$

April 22 ①
Nov 18

Similar :- March 21, May 19,
E = 2.1
Eff = 59.523…
D = 36 mm

March 19, Jan 19,
E = 0.825t
Eff = 50.51…
D = 18 mm

July 18,

Blocks and Purchases

April 22 (1)
NOV 18

similar:-
march 21, May 19,
E = 2.1
Eff = 59.52%
D = 36 mm
March 19, Jan 19,
E = 0.825t
Eff = 50.51%
D = 18 mm
July 18,

ⓐ Effort required to lift the load = ? (2 purchase)

↑↓ = opposite

↓↓ = same

Two fold purchase

load, w = 13T no. of sheeve, n = 4

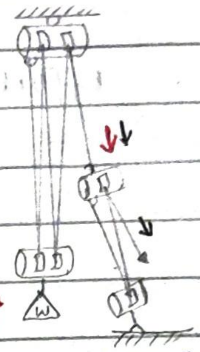
velocity ratio, V.R = n + (D) → disadvantage (opposite)

$= 4 + 0$
$= 4$

$$\text{Effort}, E = \frac{w + (n\,w \times \text{friction})}{V.R}$$

$$= \frac{13 + (4 \times 13) \times \frac{8}{100}}{4}$$

$$= \frac{13 + 4.16}{4} = \frac{17.16}{4} = 4.29\ t$$



Gun tackle

load, w = 4.29t no. of sheeve, n = 2

velocity ratio, V.R = 2 + (1) → advantage (same direction)

$= 3$

$$\text{Effort}, E = \frac{4.29 + (2 \times 4.29) \times \frac{8}{100}}{3}$$

$$= \frac{4.29 + 0.6864}{3} = \frac{4.9764}{3}$$

$= \boxed{1.659\ t}$ i.e. final effort

ⓑ Efficiency of the system = ?

$$\text{Efficiency of the system} = \frac{M.A}{V.R} \times 100\%$$

where, M.A = load/effort

$M.A = 13/1.659 = 7.836$

* Final V.R = V.R of two fold purchase × V.R of gun tackle
$= 4 \times 3 = 12$

$$\text{Hence, efficiency} = \frac{7.836}{12} \times 100$$

$= \boxed{65.3\%}$

ⓒ Size of nylon rope required for gun tackle = ?

$$\text{Breaking stress} = \frac{S.W.L}{\text{or Effort}} \times F.S$$

$= 1.659 \times 6 = 9.954$

$$\text{Breaking stress of Nylon rope} = \frac{5D^2}{300}$$

$$9.954 = \frac{5D^2}{300}$$

$2986.2 = 5D^2$
$D^2 = 597.24$

$D = 24.438 \sim 24\text{mm}$

March, Dec 22, 21, (2) Oct 21, Oct 20, July 19

Similiar:- March 18 - May 22

Feb 22, Sep 21,

Similiar:- Jan 21, Nov 2

Two-fold purchase

(1 purchase + 1 block) — block: 2 sheeve

load, $\omega = 26T$

no. of sheeve, $n = 4 + 2 = 6$

velocity ratio, $V \cdot R = n + 1$ → advantage (same)

$= 4 + 1$

$= 5$ (only of purchase)

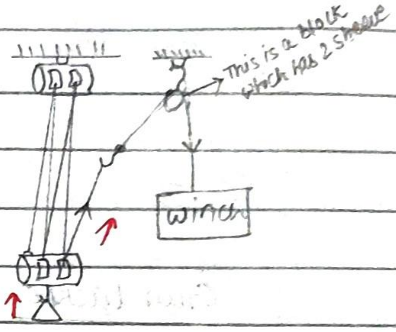
Effort, $E = \omega + (n\omega \times \text{Friction})$

$(\text{friction} \times V \cdot R) + \omega$

$= \dfrac{26 + (6 \times 26) \times \frac{8}{100}}{5}$

$= \dfrac{26 + 12.48}{5}$

$= 7.696t$



(a) size of wire (6X 24) to be used = ?

Breaking stress = S.W.L or effort × F.S

$= 7.696 \times 6 = 46.176$

Breaking stress of 6×24 wire $= \dfrac{20D^2}{500}$

$46.176 = \dfrac{20D^2}{500}$

$23088 = 20D^2$

$D^2 = 1154.4$

$D = 33.976 = \boxed{34mm}$

(b) Efficiency of the system = ?

Efficiency of the system $= \dfrac{M \cdot A}{V \cdot R} \times 100$

$M \cdot A = \text{load}/\text{effort}$ $\quad V \cdot R = 5$

$= 26/7.696 = 3.378$

Efficiency $= \dfrac{3.378}{5} \times 100$

$= \boxed{67.56\%}$

③ a) As per code of safe working practise, we will consider the rope damaged if 10% or more wire is broken within the 8 times of diameter.

r:-
or 20

* No. of wire in this rope = 6 × 36 = 216 wire

10% of this = $\frac{216 \times 10}{100}$ = 21.6 = 22 wire

& question says 22 wire is broken

that means, 10% of wire is broken, so, we reject

* we will reject if 8 times of diameter is broken (length wise)

diameter of rope = 20mm

length = 20 × 8
= 160 mm

& question says broken in length of 120mm

that mean, we can keep

But, if any of the condition will satisfy to reject
we will reject the wire rope.

b) Gyn tackle

load, w = 9t No. of sheeve, n = 5 V.R = 5 + ⓪ = 5 → disadvantage

V.R = 5 + ① = 6 → advantage

Effort = $\frac{\omega + (n\omega \times \text{Friction})}{V.R}$

$E = \frac{9 + (5 \times 9) \times \frac{10}{100}}{5}$ $E = \frac{9 \times (5 \times 9) \times \frac{10}{100}}{6}$

$E = \frac{9 + 4.5}{5} = 2.7\ t$ $E = \frac{9 + 4.5}{6} = 2.25\ t$

Breaking stress = S.W.L or effort × F.S
= 2.7 × 6 = 2.25 × 6
= 16.2 = 13.5

Breaking stress of 6×24 wire = $\frac{20D^2}{500}$

$16.12 = \frac{20D^2}{500}$ $13.5 = \frac{20D^2}{500}$

$D^2 = 405$ $D^2 = 337.5$

$D = 20.125 \sim$ **22mm** $D = 18.371 \approx 19mm$

→ bcz we use max^m thickness of wire so that we can use it whether at advantage or disadvantage

Dec 20 ④ **Three-fold purchase**

Similar:- Nov19, May18
T = 2.22 t
E.R = 90 %
D = 28.27 ~ 29 mm

Load, w = 2 tonnes   no. of sheeves, n = 6

V.R = 6 + ① (advantage) = 7

ⓐ $Effort, E = \frac{w + (nw \times Friction)}{V.R}$

$E = \frac{2 + (6 \times 2) \times \frac{10}{100}}{7}$

$E = \frac{2 + 1.2}{7}$

$E = \boxed{0.457\ t}$

ⓑ Minimum size of rope = ?

$Breaking\ stress = \frac{S.W.L\ or}{effort} \times F.S$

$= 0.457 \times 5$

$= 2.285$

Jan20 ⑥

$B.S\ of\ 6 \times 37\ wire\ rope = \frac{21D^2}{500}$

$2.285 = \frac{21D^2}{500}$

$1142.5 = 21D^2$

$D^2 = 51.405$

$D = 7.376 \sim \boxed{8\ mm}$

March 20, May 19, Jan 18 ⑤ Gyn tackle safely lift a load of 7 tonnes

Load, w = 7 t   no. of sheeve, n = 5   V.R = 5 + ① (advantage) = 6

~~5+0~~ = 5

$Effort = \frac{w + (nw \times Friction)}{V.R}$

$E = \frac{7 + (5 \times 7) \times \frac{10}{100}}{6}$

$E = \frac{7 + 3.5}{6}$ or $\frac{7 + 3.5}{5}$

$E = 1.75\ t$ $2.1\ t$

when using gun tackle

load, $w = ?$ no. of sheeve, $n = 2$ $V.R = 2 + (1) = 3$ ← advantage

$= 2 + (0) = 2$ ← disadvantage

$$\text{Effort} = \frac{w + (nw \times \text{Friction})}{V.R}$$

$$1.75 = \frac{w + (2 \times w) \times \frac{10}{100}}{3}$$

$5.25 = w + 0.2w$

$5.25 = 1.2w$

$w = \boxed{4.375\ t}$ ✓ bcz question says max^m weight

$$2.1 = \frac{w + (2 \times w) \times \frac{10}{100}}{2}$$

$4.2 = w + 0.2w$

$4.2 = 1.2w$

$w = 3.5t$

Jan20 (6) Gyn tackle

load, $w = 2.5t$ no. of sheeve, $n = 5$ $V.R = n + (1)$ ← advantage

$= 5 + 1$

$= 6$

$$\text{Effort} = \frac{w + (nw \times \text{Friction})}{V.R}$$

$$E = \frac{2.5 + (5 \times 2.5) \times \frac{8}{100}}{6}$$

$$E = \frac{2.5 + 1}{6}$$

$E = 0.583\ t$

(a) Efficiency of the system = ?

$$\text{Efficiency of the system} = \frac{M.A}{V.R} \times 100$$

$M.A = \text{load}/\text{effort}$

$= 2.5/0.583$

$= 4.288$

$$\text{Efficiency} = \frac{4.288}{6} \times 100$$

$= \boxed{71.467\%}$

(6) size of terylene rope = ?

$$\text{Breaking stress} = \frac{\text{SWL or}}{\text{effort}} \times FS$$

$$= 0.583 \times 6$$

$$= 3.498$$

$$\text{Breaking stress of terylene rope} = \frac{4D^2}{300}$$

$$3.498 = \frac{4D^2}{300}$$

$$1049.4 = 4D^2$$

$$D^2 = 262.35$$

$$D = 16.197 \sim \boxed{17\,mm}$$

What is the smallest purchase used to disadvantage that could be used to lift a 8 ton package recieved with a wire rope of S.W.L 2.80t.

$$\Rightarrow \quad \text{Effort} = \frac{w + (n w \times \text{Friction})}{V.R}$$

load, $w = 8t$, $V.R = n$, Effort $= 2.80t$

$$2.80 = \frac{8 + (8.n) \times \frac{8}{100}}{n}$$

$$2.80n = 8 + 0.64n$$

$$2.80n - 0.64n = 8$$

$$2.16n = 8$$

$$n = 3.704 \sim 4$$

so, smallest purchase can be used is **two fold purchase**