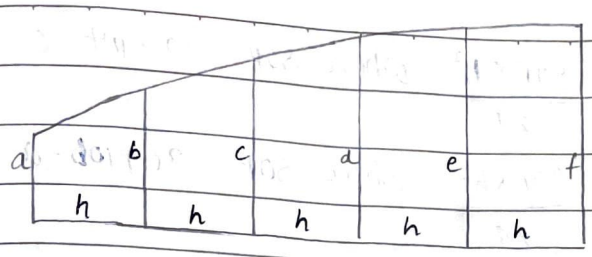
SIMPSON'S RULES

No. 65 Date 15·04·2025



a, b, c, d.... are no. of ordinates
h is interval between ordinates.

→ Simpson's First Rule

For no. of ordinates :- 3, 5, 7, 9, 11..... odd number of ordinates.

Simpson's multipiers are (1, 4, 1)

(1, 4, 2, 4, 1)

(1, 4, 2, 4, 2, 4, 1)

$$\text{Area} = \frac{\text{SOP} \times h}{3}$$

→ Simpson's Second Rule

For no. of ordinates :- 4, 7, 10, 13, 16, 19, 22, 25... etc.

Simpson's multipier are (1, 3, 3, 1)

(1, 3, 3, 2, 3, 3, 1)

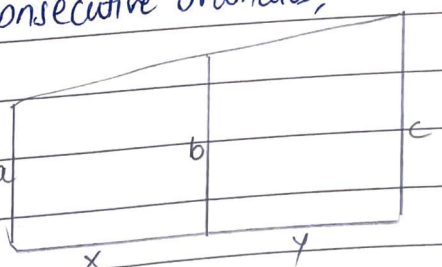
(1, 3, 3, 2, 3, 3, 2, 3, 3, 1)

$$\text{Area} = \frac{\text{SOP} \times 3h}{8}$$

→ Simpson's Third Rule

also known as 5, 8 & minus 1 rule

For 3 consecutive ordinates,



Area of X $= \frac{\text{SOP} \times h}{12}$ where SOP $= 5a + 8b - c$

Area of Y $= \frac{\text{SOP} \times h}{12}$ where SOP $= 5c + 8b - a$

For Moment of X = $\frac{SOP \times h^2}{24}$ where SOP = 3a + 10b - c

For moment of Y = $\frac{SOP \times h^2}{24}$ where SOP = 3c + 10b - a

For C.G = $\frac{Moment}{Area}$

S.M	Lever
5	3
8	10
-1	-1

area coefficient = Full area / length / Full breadth

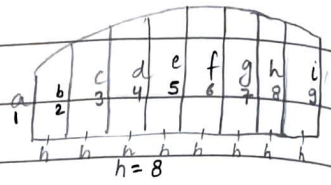
Simpson's First Rule

No. 68 Date 18.04.25

Ques:- A ship's waterplane is 80m long. The breadth commencing from forward are as follows:
0, 3.05, 7.10, 9.40, 10.2, 10.36, 10.30, 10.00, 8.84. Calculate area of water plane and its position of the centre of Floatation from aft

Soln:- NO. of ordinates : 9 - Simpson's First rule

SM : (1, 4), 2, 4, 2, 4, 2, 4, (1)



In question given from fwd, but we take from aft so we can take LCF directly.

If we take from fwd we have to substract value from LCF to get LCF

Ordinates (from aft)	×	Simpson's Multiplier (SM)	=	Product for Area (POA)	×	Lever (h)	=	Moment from Aft
8.84	×	1	=	8.84	×	0	=	0
10.00	×	4	=	40.0	×	1h	=	40.0h
10.30	×	2	=	20.6	×	2h	=	41.2h
10.36	×	4	=	41.44	×	3h	=	124.32h
10.2	×	2	=	20.4	×	4h	=	81.6h
9.40	×	4	=	37.6	×	5h	=	188h
7.10	×	2	=	14.2	×	6h	=	85.2h
3.05	×	4	=	12.2	×	7h	=	85.4h
0	×	1	=	0	×	8h	=	0

Sum of Product (SOP) = 195.28 SOP M = 645.72h

= 6457.2

value of h is

$8h = 80$

$h = 10$

(OR) $h = \frac{L}{n-1}$

$\Rightarrow \frac{80}{9-1} = \frac{80}{8} = 10$

$$\text{Area} = \frac{SOP \times h}{3} = \frac{195.28 \times 10}{3} = 650.93\ m^2$$

$$LCF = \frac{SOP\ M}{SOP\ A} = \frac{6457.2}{195.28} = 33.066\text{m fwd of AP}$$

Note:- Since we took ordinates from aft, we can take value of LCF directly.

If we will take ordinates from fwd, we have to substract value from LBP to get LCF from aft.

Simpson's second rule

No. 69 Date 18.04.2025

The waterplane of a ship is 72m long. It's half ordinates starting from forward and equally spaced are given below. Calculate the TPC & the LCF of the vessel

Ord NO.	1	2	3	4	5	6	7	8	9	10
½ ord(m)	0.0	3.2	6.4	8.8	10.6	10.2	8	6.2	3.8	1.0

NO. of ordinates : 10 - Simpson's second rule

SM : 1, 3, 3, 2, 3, 3, 2, 3, 3, 1

Ordinates (from fwd)	×	Simpson's Multiplier (SM)	=	Product for area (POA)	×	Lever (h)	=	Moment from Aft
0.0	×	1	=	0	×	0	=	0
3.2	×	3	=	9.6	×	1h	=	9.6h
6.4	×	3	=	19.2	×	2h	=	38.4h
8.8	×	2	=	17.6	×	3h	=	52.8h
10.6	×	3	=	31.8	×	4h	=	127.2h
10.2	×	3	=	30.6	×	5h	=	153h
8	×	2	=	16	×	6h	=	96h
6.2	×	3	=	18.6	×	7h	=	130.2h
3.8	×	3	=	11.4	×	8h	=	91.2h
1.0	×	1	=	1	×	9h	=	9h

Sum of products = 155.8

SOP M : 707.4h

= 5659.2

$9h = 72$

$h = 72/9 = 8$

(OR)

$h = \frac{L}{n-1}$

$h = \frac{72}{10-1} = 72/9 = 8$

$$\text{Area} = \left(\frac{\text{SOP} \times 3h}{8}\right) \times 2$$ → bcz in question ½ ordinates given

$$= \left(\frac{155.8 \times 3 \times 8}{8}\right) \times 2$$

$= 934.8\ m^2$

$$\frac{\text{SOPM}}{\text{SOPA}} = \frac{5659.2}{155.8} = 36.323m$$

LCF ⇒ 72 - 36.323 = **35.677m** → bcz we take ordinates from fwd.

$$TPC = \frac{A \times \text{density}}{100}$$

$$= \frac{934.8}{100} \times 1.025 = \boxed{9.582\ t}$$

Half spacing

No. 70 Date 18.04.20

PRACTICE SUM

A ship's waterplane is 88m long. The half ordinates of waterplane from forward are as follows: 0.4, 4.4, 8.8, 11.0, 11.6, 11.8, 11.6, 9.6, 7.0. The spacing between 1st three ordinates & last 3 ordinates is half of the other ordinates. Calculate the area of waterplane and its position of the centre of floatation w.r.t to mid length

Sol:- no. of ordinates: 9 – Simpson's first rule

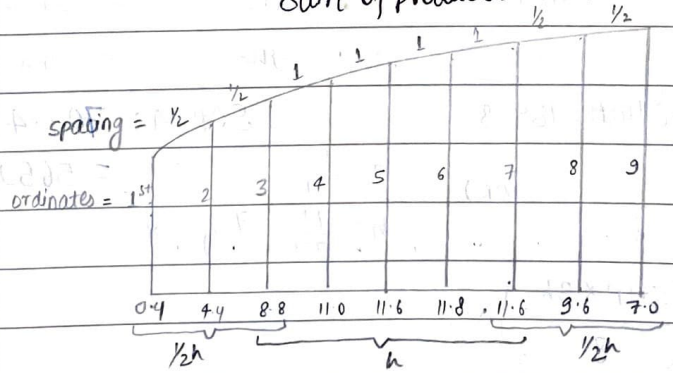
SM : (1), 4, 2, 4, 2, 4, 2, 4, (1)

½ ordinates (fwd)	×	SM	=	POA	×	lever	=	Moment
0.4	×	1 0.5	=	0.2	×	0	=	0
½h 4.4	×	4 2	=	8.8	×	0.5h	=	4.4h
8.8	×	2 1.5	=	13.2	×	1.0h	=	13.2h
11.0	×	4	=	44	×	2.0h	=	88h
11.6	×	2	=	23.2	×	3.0h	=	69.6h
11.8	×	4	=	47.2	×	4.0h	=	188.8h
11.6	×	2 1.5	=	17.4	×	5.0h	=	87h
½h 9.6	×	4 2	=	19.2	×	5.5h	=	105.6h
7.0	×	1 0.5	=	3.5	×	6.0h	=	21h

Sum of products = 176.7

SOPM = 577.6h

= 8471.659



$6h = 88$

$h = 88/6 = 14.667$

OR $h = \frac{L}{n-1}$

$h = \frac{88}{7-1} = 88/6 = 14.667$

$$\text{Area} = \left(\frac{SOP \times h}{3}\right) \times 2 = \left(\frac{176.7 \times 14.667}{3}\right) \times 2 = 1727.773\ m^2$$ Ans

$$\frac{SOPM}{SOPA} = \frac{8471.659}{176.7} = 47.945\ m \text{ from fwd}$$

COF w.r.t mid length is 3.945 fwd of midlength Ans

Half spacing

No. 71 Date 18.04.2025

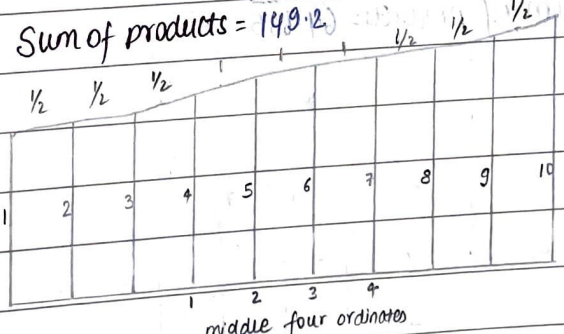
A ship's waterplane is 180m in length. The half ordinates of the water plane commencing from forward are as follows: 0.4, 4.4, 8.8, 11.0, 11.6, 11.8, 11.6, 9.6, 7.0, 0.4 meters respectively. The spacing between the 4 middle ordinates is twice that of the others. Calculate her water plane area TPC and the position of the CF with respect to the mid length.

NO. of ordinates : 10 - Simpson's second rule

SM : (1, 3, 3), 2, 3, 3, 2, 3, 3, (1)

	½ ordinates (fwd)	×	SM	=	POA	×	lever	=	Moment
½h	0.4	×	~~±~~ 0.5	=	0.2	×	0	=	0
	4.4	×	~~3~~ 1.5	=	6.6	×	½h	=	3.3h
	8.8	×	~~3~~ 1.5	=	13.2	×	1h	=	13.2h
h	11.0	×	~~2~~ 1.5	=	16.5	×	1.5h	=	24.75h
	11.6	×	3	=	34.8	×	2.5h	=	87h
	11.8	×	3	=	35.4	×	3.5h	=	123.9h
	11.6	×	~~2~~ 1.5	=	17.4	×	4.5h	=	78.3h
½h	9.6	×	~~3~~ 1.5	=	14.4	×	5.0h	=	72h
	7.0	×	~~3~~ 1.5	=	10.5	×	5.5h	=	57.75h
	0.4	×	~~1~~ 0.5	=	0.2	×	6.0h	=	1.2h

Sum of products = 149.2 SOP M = 461.4h = 13842



$6.0h = 180$ OR $h = \frac{L}{n-1}$

$h = 30$ $= \frac{180}{7-1} = \frac{180}{6} = 30$

$$\text{Area} = \left(\frac{SOP \times 3h}{8}\right) \times 2 = \left(\frac{149.2 \times 3 \times 30}{8}\right) \times 2 = 3357\ m^2 \text{ Ans}$$

$$TPC = \frac{A}{100} \times \text{density} = \frac{3357}{100} \times 1.025 = 34.409\ t \text{ Ans}$$

$$\frac{SOPM}{SOPA} = \frac{13842}{149.2} = 92.774$$

2.774 m fwd of midlength Ans

Half spacing

No. 72. Date 18.04.25

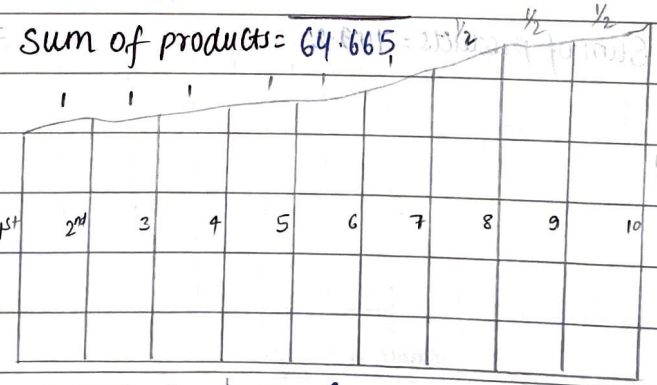
Exercise 18 Q.No.⑨ The half ordinates of a ship's waterplane at equal interval from fwd are: 0, 1.5, 2.78, 3.75, 4.2, 4.5, 4.2, 3.9, 3.3 and 2.25m. The common interval between the last four semi-ordinates is 3m & between the others is 6m. Find the distance of the GC from the ship's after end.

Soln:-

No. of ordinates: 10 - Simpson's second rule

SM: (1, 3, 3), 2, 3, 3, 2, 3, 3, (1)

	½ ordinates (from fwd)	×	SM	=	POA	×	lever	=	Moment
h	0	×	1	=	0	×	0	=	0
	1.5	×	3	=	4.5	×	1h	=	4.5h
	2.78	×	3	=	8.34	×	2h	=	16.68h
	3.75	×	2	=	7.5	×	3h	=	22.5h
	4.2	×	3	=	12.6	×	4h	=	50.4h
	4.5	×	3	=	13.5	×	5h	=	67.5h
½	4.2	×	~~21.5~~	=	6.3	×	6h	=	37.8h
	3.9	×	~~31.5~~	=	5.85	×	6.5h	=	38.025h
	3.3	×	~~31.5~~	=	4.95	×	7h	=	34.65h
	2.25	×	~~10.5~~	=	1.125	×	7.5h	=	8.438h
					Sum of products = 64.665				280.493h
									= 1682.958



Length of vessel = 6+6+6+6+6+6+3+3+3 = 45m

7.5h = 45

h = 6

$$\frac{SOPM}{SOPA} = \frac{1682.958}{64.665} = 26.026\text{m from fwd}$$

From after end, 45 - 26.026

= 18.974 from aft

Intermediate ordinates

No. 73 Date 27.04.2025

(10) The half-breadths of a ship's water-plane 180m long, at equal interval from aft are 2·8, 4, 5·2, 6, 6·4, 6·8, 6·6, 6, 4·2 and 0 metres. Midway between the last two given figures, the half-breadth is 2·4m. Find the area of the water-plane and the distance of the COF from the after end.

Soln:

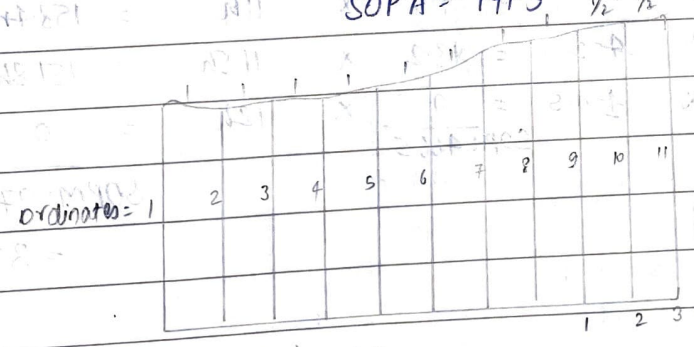
No. of ordinates: 11 (Simpson's first rule)

SM: 1, 4, 2, 4, 2, 4, 2, 4, 2, 4, 1

½ breadth (from aft)	×	SM	=	PDA	×	lever	=	Moment
2·8	×	1	=	2·8	×	0	=	0
4	×	4	=	16	×	1h	=	16h
5·2	×	2	=	10·4	×	2h	=	20·8h
6	×	4	=	24	×	3h	=	72h
6·4	×	2	=	12·8	×	4h	=	51·2h
6·8	×	4	=	27·2	×	5h	=	136h
6·6	×	2	=	13·2	×	6h	=	79·2h
6	×	4	=	24	×	7h	=	168h
4·2	×	1·5	=	6·3	×	8h	=	50·4h
½h 2·4	×	2	=	4·8	×	8·5h	=	40·8h
0	×	0·5	=	0	×	9h	=	0

SOPA = 141·5 (½, ½)

SOPM = 634·4h = 12688



9h = 180

h = 180/9 = 20

Area = $\left(\frac{SOP \times h}{3}\right) \times 2 = \left(\frac{141.5 \times 20}{3}\right) \times 2 = 1886.667\ m^2$

COF from after end = $\frac{SOPM}{SOPA} = \frac{12688}{141.5} = 89.668m$

Intermediate ordinate

No. 74 Date 22.04.25

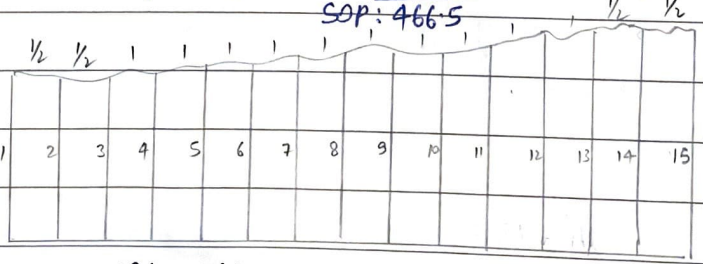
(11) The breadth of a ship's water plane 144m long, at equal interval from forward are: 0, 9, 12.9, 14.7, 15.6, 15.8, 15.8, 15.6, 15.3, 15, 13.2, 9.6 and 0m. The intermediate ordinate between the first two is 6m & between the last two is 6.6m. Find the area of water plane and distance of COF from midship.

Soln:- No. of ordinates: 15 (Simpson's First rule)

	Breadth (from fwd)	×	SM	=	POA	×	Lever	=	Moment
	0	×	±0.5	=	0	×	0	=	0
½h	6	×	~~4~~ 2	=	12	×	0.5h	=	6h
	9	×	~~2~~ 1.5	=	13.5	×	1h	=	13.5h
	12.9	×	4	=	51.6	×	2h	=	103.2h
	14.7	×	2	=	29.4	×	3h	=	88.2h
	15.6	×	4	=	62.4	×	4h	=	249.6h
	15.8	×	2	=	31.6	×	5h	=	158h
	15.8	×	4	=	63.2	×	6h	=	379.2h
	15.6	×	2	=	31.2	×	7h	=	218.4h
	15.3	×	4	=	61.2	×	8h	=	489.6h
	15	×	2	=	30	×	9h	=	270h
	13.2	×	4	=	52.8	×	10h	=	528h
½h	9.6	×	~~4~~ 1.5	=	14.4	×	11h	=	158.4h
	6.6	×	~~4~~ 2	=	13.2	×	11.5h	=	151.8h
	0	×	±0.5	=	0	×	12h	=	0

SOP: 466.5

SOPM: 2813.9h = 33766.8



12h = 144

h = 144/12 = 12

$$\text{Area} = \frac{SOP \times h}{3} = \frac{466.5 \times 12}{3} = 1866\ m^2$$

$$\frac{SOPM}{SOPA} = \frac{33766.8}{466.5} = 72.383m$$

LCF from aft = 144 − 72.383 = 71.617m

COF from midship = (144/2) − 71.617 = 0.383 aft

Area given, Find disp. & KB

OCT 2014
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JULY-23 PAPER-1

No. 75 Date 22-04-2025

The waterplane area of the ship commencing from the load waterline to keel spaced 1m apart are as follows:-

Area 800 760 700 600 450 10 m^2

Midway between the lowest two waterplane the area is 180 m^2.

Find the displacement and KB in sw.

Soln:-

No. of ordinates: 7 (Simpson's First rule)

	WP area		SM		POV		lever		Moment from keel
½h	10	x	~~1~~ 0.5	=	5	x	0	=	0
	180	x	~~4~~ 2.0	=	360	x	0.5h	=	180h
	450	x	~~2~~ 1.5	=	675	x	1h	=	675h
h	600	x	4	=	2400	x	2h	=	4800h
	700	x	2	=	1400	x	3h	=	4200h
	760	x	4	=	3040	x	4h	=	12160h
	800	x	1	=	800	x	5h	=	4000h
					SOPV = 8680				SOP Moment: 26015h
									= 26015

$h = 1$

$$\text{Volume} = \frac{SOPV \times h}{3} = \frac{8680 \times 1}{3} = 2893.333\ m^3$$

Displacement = uw vol. x density

$= 2893.333 \times 1.025$

$= 2965.667\ T$

$$KB = \frac{SOPM}{SOPV}$$

$$= \frac{26015}{8680}$$

$= 2.997m$

Appendage - Water plane

No. 76 Date 22.04.25

(12) The half-breadths of a ship's water-plane, at 12m intervals from aft are 0.0, 3.3, 4.5, 4.8, 4.5, 3.6, 2.7 and 1.5m. The half breadth, midway between the first two from aft is 2m. At the forward end is an appendage by way of a bulbous bow 4.5m long. Its area is $24m^2$ and its GC, 2m from the forward extremity. Find the area of the water-plane and the position of COF.

Soln:-

No. of ordinates: 9 (Simpson's first rule)

½ breadth from aft	×	SM	=	POA	×	lever	=	Moment
0.0	×	1	=	0	×	0	=	0
2.0	×	4	=	4	×	0.5h	=	2h
3.3	×	2	=	4.95	×	1h	=	4.95h
4.5	×	4	=	18	×	2h	=	36h
4.8	×	2	=	9.6	×	3h	=	28.8h
4.5	×	4	=	18	×	4h	=	72h
3.6	×	2	=	7.2	×	5h	=	36h
2.7	×	4	=	10.8	×	6h	=	64.8h
1.5	×	1	=	1.5	×	7h	=	10.5h

SOPA = 74.05 SOPM = 255.05h

= 3060.6

$$\text{Area} = \left(\frac{\text{SOP} \times h}{3}\right) \times 2 = \left(\frac{74.05 \times 12}{3}\right) \times 2 = 592.4\ m^2$$

Area of bulbous bow = $24\ m^2$

Total area = $616.4\ m^2$

$$\text{G.C of main body} = \frac{\text{SOPM}}{\text{SOPA}} = \frac{3060.6}{74.05} = 41.332\ m$$

G.C of bulbous bow = Total length - G.C from fwd

$= \{(7 \times 12) + 4.5\} - 2$

$= 86.5\ m$

$$\text{Total G.C} = \frac{(\text{Area} \times \text{G.C of main body}) + (\text{Area} \times \text{G.C of bulbous bow})}{\text{Total area}}$$

$$= \frac{(592.4 \times 41.332) + (24 \times 86.5)}{616.4}$$

$= 43.091\ m$

Appendage – WT bhd

No. 77 Date 23.04.25

The half breadth of a transverse watertight bulkhead 14.2m high, at 2.2m interval from the top, are 10.6, 10, 9.3, 8.3, 7.1, 5.7 & 3.8. Below the lowest semi-ordinates is a rectangular appendage 7.6m broad and 1m high. Find the centroid of bulkhead from bottom

NO of ordinates: 7 (Simpson's first rule)

½ breadth from bottom	X	SM	=	POA	X	lever	=	Moment	OR
3.8	X	1	=	3.8	X	0	=	0	3.8
5.7	X	4	=	22.8	X	1h 3.2	=	22.8h	72.96
7.1	X	2	=	14.2	X	2h 5.4	=	28.4h	76.68
8.3	X	4	=	33.2	X	3h 7.6	=	99.6h	252.32
9.3	X	2	=	18.6	X	4h 9.8	=	74.4h	182.28
10	X	4	=	40	X	5h 12	=	200h	480
10.6	X	1	=	10.6	X	6h 14.2	=	63.6h	150.52
			SOP =	143.2			SOPM =	488.8h	1218.56
								= 1075.36	

$$\text{Area} = \left(\frac{SOP \times h}{3}\right)_{X2} = \left(\frac{143.2 \times 2.2}{3}\right)_{X2} = 210.02\ m^2$$

G.C of main bulkhead from 1st ord = $\frac{SOPM}{SOPA} = \frac{1075.36}{143.2} = 7.509\ m$

G.C of main bulkhead from bottom = 7.509 + 1 = 8.509 m (OR) $\frac{1218.56}{143.2}$ = 8.509 m

Area of appendage = 7.6 × 1 = 7.6 m²

G.C of appendage = ½ = 0.5 m (since it is a rectangle)

Total area of bulkhead = 210.02 + 7.6 = 217.62 m²

$$\text{G.C of bulkhead from bottom} = \frac{(\text{Area} \times \text{G.C of main bhd}) + (\text{Area} \times \text{G.C of app.})}{\text{Total area}}$$

$$= \frac{(210.02 \times 8.509) + (7.6 \times 0.5)}{217.62}$$

$$= 8.229\ m$$

(13) The transverse cross-sectional areas of a lower hold 21m long, at equal intervals from forward are 120, 116, 101 and 80m². Find the volume of the hold and the distance of its GC from the after bulkhead.

Soln:- No. of ordinates: 4 (simpson's second rule)

Areas from aft	×	SM	=	POA	×	lever	=	Moment
80	×	1	=	80	×	0h	=	0
101	×	3	=	303	×	1h	=	303h
116	×	3	=	348	×	2h	=	696h
120	×	1	=	120	×	3h	=	360h
			SOPV =	851			SOPM =	1359h
								= 9513

$$\text{Volume} = \frac{\text{SOPV} \times 3h}{8}$$

$3h = 21$

$h = 7$

$$= \frac{851 \times 3 \times 7}{8}$$

$$= 2233.875\ m^3$$

G.C from the after bulkhead =

$$\frac{\text{SOP Moment}}{\text{SOP volume}}$$

$$= \frac{9513}{851}$$

$$= 11.179\ m \text{ from aft}$$

volume - half spacing

No. 79 Date 23.04.25

(14) The transverse cross-sectional areas of a ship's under-water portion 90m long are : 0.5, 22.9, 49, 73.5, 88.5, 83, 58.6, 31.8, 14.2, 8.1 & 4.5m^2. The last given area is at the after perpendicular of the ship. The spacing between the last three sections is half the common interval between the rest. Find the AB & displacement in SW.

NO. of ordinates: 11 (Simpson's First rule)

Transverse cross-section area		SM	=	POV	x	lever	=	Moment
0.5	x	1	=	0.5	x	0	=	0
22.9	x	4	=	91.6	x	1h	=	91.6h
49	x	2	=	98	x	2h	=	196h
73.5	x	4	=	294	x	3h	=	882h
88.5	x	2	=	177	x	4h	=	708h
83	x	4	=	332	x	5h	=	1660h
58.6	x	2	=	117.2	x	6h	=	703.2h
31.8	x	4	=	127.2	x	7h	=	890.4h
14.2	x	1.5	=	21.3	x	8h	=	170.4h
8.1	x	2	=	16.2	x	8.5h	=	137.7h
4.5	x	0.5	=	2.25	x	9h	=	20.25h
½h								

9h = 90 SOPV: 1277.25 SOPM: 5459.55h

h = 90/9 = 10 = 54595.5

$$\text{Volume} = \frac{\text{SOPV} \times h}{3} = \frac{1277.25 \times 10}{3} = 4257.5\ m^3$$

Displacement in SW = uw vol x density

= 4257.5 x 1.025

= 4363.9T

$$\frac{\text{SOPM}}{\text{SOPV}} = \frac{54595.5}{1277.25} = 42.745m$$

AB = 90 - 42.745

= 47.255m

Given TPC, Find KB + Appendage

No. 80 Date 23.04.25

Apr 2019
MARCH 2022

A ship is floating upright in sw on an even keel at 7m draft F & A. The TPC's are as follows:-

Draft (M)	1	2	3	4	5	6	7
TPC (tonnes)	60	60·3	60·5	60·5	60·5	60·5	60·5

The volume between the outer bottom and 1m draft is 3044 m^3, and its centre of gravity is 0.5m above the keel. Find the ship's KB.

Soln:-

We know, $TPC = \frac{A}{100} \times density$

$TPC = \frac{A}{100} \times 1.025 \Rightarrow TPC \times 100 = A \times 1.025$

$\Rightarrow A = \frac{TPC \times 100}{1.025}$

Area = 97.561 TPC

↓ use this as Factor F

Area		SM	=	POV	×	lever (OR)	=	POM
60F	×	1	=	60F	×	1 0	=	60F
60·3F	×	4	=	241.2F	×	2 1h	=	482.4F
60·5F	×	2	=	121F	×	3 2h	=	363F
60·5F	×	4	=	242F	×	4 3h	=	968F
60·5F	×	2	=	121F	×	5 4h	=	605F
60·5F	×	4	=	242F	×	6 5h	=	1452F
60·5F	×	1	=	60·5F	×	7 6h	=	423·5F

SOPV = 1087.7F
= 1087.7 × 97.561
= 106117.1

SOPM = 4353.9F
= 4353.9 × 97.561
= 424770.838

$CG = \frac{SOPM}{SOPV} = \frac{424770.838}{106117.1}$

= 4.003m

CG = 0.5m

$Volume = \frac{SOP \times h}{3} = \frac{106117.1 \times 1}{3}$

= 35372.367 m^3

volume = 3044 m^3

$Final\ KB = \frac{(35372.367 \times 4.003) + (3044 \times 0.5)}{35372.367 + 3044}$

= 3.725m

Similar Question: OCT 2013, JULY 2018

Combination of two rules

No. 81 Date 23.04.2025

A ship of length 77m is floating in water of RD 1.015. The areas of the transverse cross section of the underwater part of the ship measured at equidistant interval from forward are as follows: 450, 510, 610, 730, 800, 820, 750, 600 m^2. Calculate the displacement & L.C.B of the ship.

No. of ordinates: 8 (combination of both rules)

	Area from aft	x	SM	=	POV	x	Lever	=	POM
	600	x	1	=	600	x	0	=	0
	750	x	4	=	3000	x	1h	=	3000h
1st	820	x	2	=	1640	x	2h	=	3280h
	800	x	4	=	3200	x	3h	=	9600h
	730	x	1	=	730	x	4h	=	2920h
				SOPV =	9170			SOPM =	18800h = 206800
	730	x	1	=	730	x	4h	=	2920h
2nd	610	x	3	=	1830	x	5h	=	9150h
	510	x	3	=	1530	x	6h	=	9180h
	450	x	1	=	450	x	7h	=	3150h
				SOPV =	4540			SOPM =	24400h = 268400

1st: 600, 750, 820, 800, 730

2nd: 730, 610, 510, 450

$7h = 77$

$h = 77/7 = 11$

Volume $= \frac{SOP \times h}{3} = \frac{9170 \times 11}{3}$

$= 33623.333\ m^3$

$CB = \frac{SOPM}{SOPA} = \frac{206800}{9170}$

$= 22.552\ m$

Volume $= \frac{SOP \times 3h}{8} = \frac{4540 \times 3 \times 11}{8}$

$= 18727.5\ m^3$

$CB = \frac{SOPM}{SOPA} = \frac{268400}{4540}$

$= 59.119\ m$

$L.C.B = \frac{(33623.333 \times 22.552) + (18727.5 \times 59.119)}{33623.333 + 18727.5}$

$= 35.633\ m$

Displacement = uw vol. x density.

$= (33623.333 + 18727.5) \times 1.025$

$= 52350.833 \times 1.025$

$= 53136.096\ T$

Multiple combination

No. 8.2 Date 23.04.2025

APRIL 2013

A ship's waterplane is 216m in length. The half ordinates of the water plane commencing from forward are as follows:- 0.4, 4.4, 8.8, 11.0, 11.6, 11.8, 11.6, 9.6, 7.0, 0.4 respectively. The spacing between first three and last three ordinates is half of the spacing between the other half ordinates. Calculate her water plane area & the position of the CF with respect to midlength

Soln:-

NO. of ordinates: 10 (combination of rules)

Note:- Rule 2 can't be applied with 3 half interval ordinates & other full coordinates. In such case, only Rule 1 can be used.

Rule 2 can be used when 4 half interval ordinates given

0.4, 4.4, 8.8 → 1st, ½h; 11.0, 11.6, 11.8, 11.6 → 2nd; 9.6, 7.0, 0.4 → 1st, ½h

½ ordinates from fwd		SM		POA		lever		POM
0.4	×	~~1~~ 0.5	=	0.2	×	0	=	0
4.4	×	~~4~~ 2	=	8.8	×	0.5h	=	4.4h
8.8	×	~~2~~ 1.5	=	13.2	×	1h	=	13.2h
11.0	×	4	=	44	×	2h	=	88h
11.6	×	1	=	11.6	×	3h	=	34.8h
				SOPA = 77.8				SOPM = 140.4h = 4332.323
11.6	×	1	=	11.6	×	3h	=	34.8h
11.8	×	3	=	35.4	×	4h	=	141.6h
11.6	×	3	=	34.8	×	5h	=	174h
9.6	×	1	=	9.6	×	6h	=	57.6h
				SOPA = 91.4				SOPM = 408h = 12589.656
9.6	×	±0.5	=	4.8	×	6h	=	28.8h
7.0	×	~~4~~ 2	=	14	×	6.5h	=	91h
0.4	×	±0.5	=	0.2	×	7h	=	1.4h
				SOPA = 19				SOPM = 121.2h = 3739.868

2nd: 7h = 216, h = 30.857

$$\text{Area} = \left(\frac{\text{SOP} \times h}{3}\right) \times 2 = \left(\frac{77.8 \times 30.857}{3}\right) \times 2$$

$$= 1600.45\ m^2$$

$$CF = \frac{\text{SOPM}}{\text{SOPA}} = \frac{4332.323}{77.8}$$

$$= 55.685m$$

$$\text{Area} = \left(\frac{\text{SOP} \times 3h}{8}\right) \times 2 = \left(\frac{91.4 \times 3 \times 30.857}{8}\right) \times 2$$

$$= 2115.248\ m^2$$

$$CF = \frac{\text{SOPM}}{\text{SOPA}} = \frac{12589.656}{91.4}$$

$$= 137.742m$$

$$\text{Area} = \left(\frac{SOP \times h}{3}\right) \times 2 = \left(\frac{19 \times 30.857}{3}\right) \times 2$$

$$= 390.856\ m^2$$

$$CF = \frac{SOPM}{SOPA} = \frac{3739.868}{19}$$

$$= 196.835\ m$$

C.F from fwd =

$$\frac{(1600.45 \times 55.685) + (2115.248 \times 137.742) + (390.856 \times 196.835)}{1600.45 + 2115.248 + 390.856}$$

$= 111.386m$ from fwd

½ of length is 108m

That mean, 111.386 − 108

$= 3.386\ m$ aft of midship.

Combination of two rules

No. 84 Date 23.04.25

(15) The after bulkhead of the starboard slop tank of a tanker is 6m high. It is bounded on the top by a horizontal deck, towards amidship by a vertical fore-and-aft bulkhead, and on the starboard side by the shell plating. The breadths of this bulkhead at equal intervals are:- 3, 3.15, 2.85, 2.1, 1.1 & 0 meters. Find the area of this bulkhead & the distances of its GC from the bottom and from the inner boundary.

Soln:- No. of ordinates = 6 (combination of rules)

Breadth		SM	=	POA		lever	=	POM
3	x	1	=	3	x	0	=	0
3.15	x	4	=	12.6	x	1h	=	12.6h
2.85	x	1	=	2.85	x	2h	=	5.7h
1st		SOP A =		18.45		SOPM =		18.3h = 21.96
2.85	x	1	=	2.85	x	2h	=	5.7h
2.1	x	3	=	6.3	x	3h	=	18.9h
1.1	x	3	=	3.3	x	4h	=	13.2h
0	x	1	=	0	x	5h	=	0
2nd		SOP A =		12.45		SOPM =		37.8h = 45.36

3, 3.15, 2.85 — 1st; 2.85, 2.1, 1.1, 0 — 2nd

5h = 6

h = 1.2

1st Area = $\frac{SOP \times h}{3} = \frac{18.45 \times 1.2}{3}$

$= 7.38 m^2$

G.C = $\frac{SOPM}{SOPA} = \frac{21.96}{18.45}$

$= 1.190 m$

2nd Area = $\frac{SOP \times 3h}{8} = \frac{12.45 \times 3 \times 1.2}{8}$

$= 5.603 m^2$

G.C = $\frac{SOPM}{SOPA} = \frac{45.36}{12.45}$

$= 3.643 m$

G.C from top = $\frac{(7.38 \times 1.190) + (5.603 \times 3.643)}{7.38 + 5.603}$

$= 2.249 m$

G.C from bottom = $6 - 2.249 = \boxed{3.751 m}$

Change in draft

No. 85 Date 23.04.2025

A ship 90 metres long is floating on an even keel at 6m draft in SW. The half ordinates of water plane, commencing from forward, are as follows:- 0, 4.88, 6.71, 7.31, 7.01, 6.40 and 0.9m respectively. The half-ordinates 7.5 metres from bow and stern are 2.13m and 3.35m respectively. Find the area of the water plane and the change in draft if 150 tonnes of cargo is loaded vertically over the centre of floatation. Find the position of centre of floatation.

Sol:

NO. of ordinates: 9 (Simpson's First rule)

	½ ord from aft	×	SM	=	POA	×	Lever	=	POM
	0.9	×	1	=	0.45	×	0	=	0
½h	3.35	×	4	=	6.7	×	0.5h	=	3.35h
	6.40	×	2	=	9.6	×	1h	=	9.6h
	7.01	×	4	=	28.04	×	2h	=	56.08h
	7.31	×	2	=	14.62	×	3h	=	43.86h
	6.71	×	4	=	26.84	×	4h	=	107.36h
	4.88	×	1	=	7.32	×	5h	=	36.6h
½h	2.13	×	4	=	4.26	×	5.5h	=	23.43h
	0	×	1	=	0	×	6h	=	0
					SOPA = 97.83				SOPM = 280.28h = 4204.2

6h = 90
h = 15

$$\text{Area} = \left(\frac{\text{SOPA} \times h}{3}\right) \times 2 = \left(\frac{97.83 \times 15}{3}\right) \times 2 = (489.15) \times 2$$
$$= 978.3 \text{ m}^2$$

$$\text{TPC} = \frac{A}{100} \times \text{density}$$
$$= \frac{978.3}{100} \times 1.025 = 10.027 \text{ t}$$

$$\text{Sinkage} = \frac{W}{TPC} = \frac{150}{10.027} = 14.960 \text{ cm}$$
$$= 0.150 \text{ m}$$

Since, weight is loaded on COF, there will be no change in trim.

$$\text{LCF} = \frac{\text{SOPM}}{\text{SOPA}} = \frac{4204.2}{97.83} = 42.975 \text{m}$$

No. 86 Date 23.04.25

JAN 2015
APR-2024 PAPER-2

A ship of length 100m, half breadth of the ship's waterplane from aft are: 0.0, 3.3, 4.5, 4.8, 4.5, 3.6, 2.7 & 1.5m. Half breadth between the first two from aft is 2m. At the forward end is an appendage in way of the bulbous bow 4.4m long. Its area is 20m² and its centroid 1.4m from forward, find the area of water-plane and cof.

Soln:-

NO. of ordinates: 9 (simpson's First rule)

½ breadth from aft		SM		POA		lever		POM
0.0	x	1	=	0	x	0	=	0
2	x	4	=	4	x	0.5h	=	2h
3.3	x	2	=	4.95	x	1h	=	4.95h
4.5	x	4	=	18	x	2h	=	36h
4.8	x	2	=	9.6	x	3h	=	28.8h
4.5	x	4	=	18	x	4h	=	72h
3.6	x	2	=	7.2	x	5h	=	36h
2.7	x	4	=	10.8	x	6h	=	64.8h
1.5	x	1	=	1.5	x	7h	=	10.5h
			SOPA =	74.05			SOPM =	255.05h
								= 3483.218

*** Length of waterplane = length of ship - length of appendage

$= 100 - 4.4$

$= 95.6$

$7h = 95.6$

$h = 13.657$

Area of WP $= \frac{SOPA \times h}{3} = \frac{74.05 \times 13.657}{3}$

$= 674.2\ m^2$

C.F $= \frac{SOPM}{SOPA} = \frac{3483.218}{74.05}$

$= 47.039m$

Area of appendage $= 20.0\ m^2$

C.F of appendage $= 1.4m$

Final COF $= \frac{(Area \times C.F \text{ of } WP) + (Area \times C.F \text{ of appendage})}{Total\ area}$

$= \frac{(674.2 \times 47.039) + (20 \times 1.4)}{694.2}$

$= 48.524m$

* 2023 Week-2

The transverse cross section areas in m^2 within a ship of length 120m, in water of RD 1.020 from fwd are: 100 200 230 275 250 230 Between the first 2 ordinates from fwd, there are 2 more cross section areas of 125 and 175 m^2 so that all 4 of them are spaced equaly. Forward of 1st ordinate there is an appendage of vol. 600 m^3. Its length 10m and centroid 5m from its fwd end. Calculate the displacement of the vessel and her LCB.

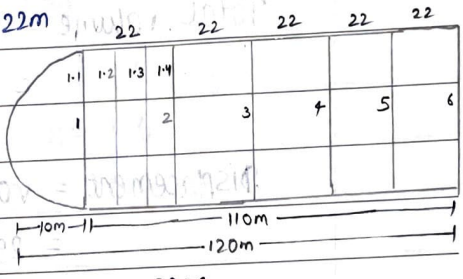
Soln:

NO. of ordinates: 6 (Combination of two rules)

Length of cross section area = Length of ship - length of appendage

$\Rightarrow 120 - 10 = 110m$

$5h = 110 \Rightarrow h = 110/5 = 22m$



From Aft

6, 5, 4, 3, 2

NO. of ordinates: 5 (Simpson's First rule)

$4h = 88 \Rightarrow h = 88/4 = 22$

Area	x	SM	⇒	POV	x	Lever	=	POM
230	x	1	=	230	x	0	=	0
250	x	4	=	1000	x	1h	=	1000h
275	x	2	=	550	x	2h	=	1100h
230	x	4	=	920	x	3h	=	2760h
200	x	1	=	200	x	4h	=	800h
				SOPV: 2900				SOPM = 5660h = 124520

1.4, 1.3, 1.2, 1.1

NO. of ordinates: 4 (Simpson's second rule)

$3h = 22 \Rightarrow h = 22/3 = 7.333..$

Area	x	SM	=	POV	x	Lever	=	POM
200	x	1	=	200	x	0	=	0
175	x	3	=	525	x	1h	=	525h
125	x	3	=	375	x	2h	=	750h
100	x	1	=	100	x	3h	=	300h
				SOPV = 1200				SOPM = 1575h = 11549.475

Volume of aft section: $\frac{SOPX h}{3} = \frac{2900 X 22}{3}$

$= 21266.667 m^3$

C.G from aft of aft section $= \frac{SOPM}{SOPA} = \frac{124520}{2900}$

$= 42.938 m$

Volume of fwd section $= \frac{SOPX 3h}{8} = \frac{1200 X 3 X 7.333}{8}$

$= 3299.85 m^3$

C.G of fwd section from aft $= \frac{SOPM}{SOPA} = \frac{11549.475}{1200}$

$= 9.625$

C.G from aft of fwd section $= 88 + 9.625$

$= 97.625 m$

Volume of appendage $= 600 m^3$

C.G of appendage from aft $= 110 + 5 = 115 m$

(OR)

$120 - 5 = 115 m$

Total volume $= 21266.667 + 3299.85 + 600$

$= 25166.517 m^3$

Displacement = volume x density

$= 25166.517 X 1.025$

$= 25669.85 ts$ Ans

Final LCB $= \frac{(\text{volume x G.C of aft section}) + (\text{volume x G.C of fwd section}) + (\text{volume x G.C of appendage})}{\text{Total volume}}$

$= \frac{(21266.667 X 42.938) + (3299.85 X 97.625) + (600 X 115)}{25166.517}$

$= 51.827 m$ Ans

VERTICAL ORDINATES

No. 89 Date 24.04.2025

A bulkhead 12m broad at the top has the following equaly spaced vertical ordinates 3.5, 6.0, 6.8, 6.0, 3.5. calculate the area & coa of the bulkhead from bottom.

NOTE: IN VERTICAL ORDINATES, LEVER WILL BE HALF OF ORDINATES

Sol: NO. OF ORDINATES: 5 (Simpson's 1st rule)

vertical ordinates	x	SM	=	POA	x	lever	=	POM
3.5	x	1	=	3.5	x	1.75	=	6.125
6.0	x	4	=	24	x	3	=	72
6.8	x	2	=	13.6	x	3.4	=	46.24
6.0	x	4	=	24	x	3	=	72
3.5	x	1	=	3.5	x	1.75	=	6.125

SOPA = 68.6 SOPM = 202.49

$4h = 12$; $h = 12/4 = 3$

$$\text{Area} = \frac{SOPA \times h}{3}$$

$$= \frac{68.6 \times 3}{3}$$

$$= 68.6\ m^2$$

$$\text{C.G from top} = \frac{SOPM}{SOPA}$$

$$= \frac{202.49}{68.6}$$

$$= 2.952\ m$$

C.G from bottom = 6.8 − 2.952

= 3.848m

NOTE: FOR VERTICAL ORDINATES, we always obtain moment from top.

To find GC from top = $\frac{SOPM}{SOPA}$

TO find GC from bottom, substract this from largest ordinate.

Both vertical & horizontal No. 90 Date 24.04.2022

JUNE 2022

A port side wing tank forward bulkhead 15 meters wide at tank top flat deck is bounded by the ship side outboard and a longitudinal bulkhead inbooard. This transverse bulkhead has the following vertical ordinates from tank top commencing from the inboard to the ship-side (both inclusive) : 21.0, 20.8, 20.5, 20.1, 19.6, 19.0 and 18.0 meters. Calculate the geometric centre of the bulkhead:

a) from the tank top :- lever is ½ the ordinate (vertical)

b) from the inbooard bulkhead : lever is 0, 1h, 2h (horizontal)

Soln:- NO. of ordinates: 7 (simpson's 1st rule)

vertical ord from tank top	X	SM	= POA	X	lever vertical	= POM	POA X lever (horizontal)	= POM
21.0	X	1	= 21	X	10.5	= 220.05	X 0	= 0
20.8	X	4	= 83.2	X	10.4	= 865.28	X 1h	= 83.2h
20.5	X	2	= 41	X	10.25	= 420.25	X 2h	= 82h
20.1	X	4	= 80.4	X	10.05	= 808.02	X 3h	= 241.2h
19.6	X	2	= 39.2	X	9.8	= 384.16	X 4h	= 156.8h
19.0	X	4	= 76	X	9.5	= 722	X 5h	= 380h
18.0	X	1	= 18	X	9.0	= 162	X 6h	= 108h
			SOPA : 358.8			SOPM: 3582.81		1051.2h
								= 2628

6h = 15, h = 2.5

$$\text{Area} = \frac{\text{SOP} \times h}{3}$$

$$= \frac{358.8 \times 2.5}{3}$$

$$= 299\ m^2 \quad \text{(NOT ASKED IN QUESTION)}$$

(a) From Tank top

$$\frac{\text{SOPM}}{\text{SOPA}} = \frac{3582.81}{358.8} = 9.986\ m$$

(b) From inboard bulkhead

$$\frac{\text{SOPM}}{\text{SOPA}} = \frac{2628}{358.8} = 7.324\ m$$

5, 8
3, 10

Simpson's 3rd Rule

No. 91 Date 24.04.25

JULY 2012 JAN 2017 OCT 2020

The fore deck of a vessel is 60m in length. The width off the deck at equal intervals commencing from its fore end are 12.0, 13.5 and 15.8. Calculate the area and the cc of the area from the fore end with respect to a) Fwd half of deck b) After half of deck

SOL:-

Fwd a	b	c Aft
12.0	13.5	15.8

(a) Fwd half of deck

$$\text{Area} = \frac{\text{SOP} \times h}{12}$$

$$\text{SOP} = 5a + 8b - c$$
$$= (5 \times 12) + (8 \times 13.5) - 15.8$$
$$= 152.2$$

$$2h = 60$$
$$h = 30$$

$$\text{Area} = \frac{152.2 \times 30}{12} = 380.5\ m^2$$

$$\text{Moment} = \frac{\text{SOP} \times h^2}{24}$$

$$\text{SOP} = 3a + 10b - c$$
$$= (3 \times 12) + (10 \times 13.5) - 15.8$$
$$= 155.2$$

$$\text{Moment} = \frac{155.2 \times 30^2}{24} = 5820\ m^3$$

$$\text{c.c of fwd half from fwd} = \frac{\text{Moment}}{\text{Area}} = \frac{5820}{380.5} = 15.296\ m$$

(b) After half of deck

$$\text{Area SOP} = 5c + 8b - a$$
$$\Rightarrow (5 \times 15.8) + (8 \times 13.5) - 12.0 = 175$$

$$\text{Area} = \frac{\text{SOP} \times h}{12} = \frac{175 \times 30}{12} = 437.5\ m^2$$

$$\text{Moment SOP} = 3c + 10b - a$$
$$\Rightarrow (3 \times 15.8) + (10 \times 13.5) - 12.0 = 170.4$$

$$\text{Moment} = \frac{\text{SOP} \times h^2}{24} = \frac{170.4 \times 30^2}{24} = 6390\ m^3$$

$$\text{c.c of after half from fwd} = \frac{\text{Moment}}{\text{Area}} = \frac{6390}{437.5} = 14.606\ m$$

SEPT 2022 The length of a ship's water-plane at 6m draft is 100 metres. The half-breadths of the water-plane at equi-spaced intervals commencing from forward are: 0, 3.6, 6.0, 7.3, 7.7, 7.6, 4.8, 2.8 & 0.6 metres respectively. The vessel is floating at 6m even keel draft. It loads 200 tonnes of cargo at a location 20m from aft end. Find the drafts forward & aft after loading assume that waterplane remains unchanged for the range of change in drafts. MCTC = 110

Soln:-

NO. OF ORDINATES : 9 (Simpson's First Rule)

½ breadth from fwd		SM	=	POA	x	lever	=	POM
0	x	1	=	0	x	0	=	0
3.6	x	4	=	14.4	x	1h	=	14.4h
6.0	x	2	=	12	x	2h	=	24h
7.3	x	4	=	29.2	x	3h	=	87.6h
7.7	x	2	=	15.4	x	4h	=	61.6h
7.6	x	4	=	30.4	x	5h	=	152h
4.8	x	2	=	9.6	x	6h	=	57.6h
2.8	x	4	=	11.2	x	7h	=	78.4h
0.6	x	1	=	0.6	x	8h	=	4.8h
				SOPA = 122.8				SOPM = 480.4h = 6005

$8h = 100$

$h = 12.5$

$$\text{Area} = \left(\frac{\text{SOPA} \times h}{3}\right) \times 2 = \left(\frac{122.8 \times 12.5}{3}\right) \times 2 = 1023.333\ m^2$$

$$\frac{\text{SOPM}}{\text{SOPA}} = \frac{6005}{122.8} = 48.901m$$

L.C.F = 100 − 48.901

= 51.099 m

$$TPC = \frac{A}{100} \times \text{density}$$

$$= \frac{1023.333}{100} \times 1.025$$

$$= 10.489\ t$$

$$TC = \frac{TM}{MCTC}$$

$TM = w \times d$

$w = 200$ tonnes

$d = 50 - 20$

$= 30$

$$Tc = \frac{200 \times 30}{110 \times 100}$$

$Tc = 0.545m$

Initial LCG $= \frac{1}{2} = 100/2 = 50$ (vessel on even keel)

$$Ta = \frac{Tc \times LCF}{LBP}$$

$$= \frac{0.545 \times 51.099}{143.16}$$

$= 0.195m$

$Tf = Tc - Ta$

$= 0.545 - 0.195$

$= 0.350m$

	F	A
Initial draft:	6.00	6.00
Tf/Ta :	(+) 0.350	(+) 0.195
Final draft :	5.650m	6.195m

JAN 2018
APRIL 2018
JAN 2024

A ship water plane is 80m long, the breadth commencing from fwd are as follows: 0, 3.05, 7.1, 9.4, 10.2, 10.36, 10.3, 10.0, 8.84, 5.75 and 0m respectively. The space between the first three and last three ordinates is half of the other ordinates. Calculate the area of water plane and its position of the centre of floatation

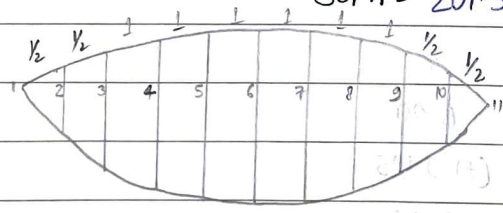
Soln:-

No. of ordinates = 11 (Simpson's First Rule)

SM : (1), 4, 2, 4, 2, 4, 2, 4, 2, 4, (1)

	Breadth (from aft)		SM	=	POA		lever	=	POM
	0	X	~~1~~ 0.5	=	0	X	0	=	0
1/2	5.75	X	~~4~~ 2	=	11.5	X	0.5h	=	5.75h
	8.84	X	~~2~~ 1.5	=	13.26	X	1h	=	13.26h
	10.0	X	4	=	40	X	2h	=	80h
	10.3	X	2	=	20.6	X	3h	=	61.8h
	10.36	X	4	=	41.44	X	4h	=	165.76h
	10.2	X	2	=	20.4	X	5h	=	102h
	9.4	X	4	=	37.6	X	6h	=	225.6h
	7.1	X	~~2~~ 1.5	=	10.65	X	7h	=	74.55h
1/2	3.05	X	~~4~~ 2	=	6.1	X	7.5h	=	45.75h
	0	X	~~1~~ 0.5	=	0	X	8h	=	0
					SOPA = 201.55				SOPM = 774.47h

= 7744.7



8h = 80

h = 10

Area of WP = $\frac{SOPA \times h}{3} = \frac{201.55 \times 10}{3} = 671.833\ m^2$

Posn of COF = $\frac{SOPM}{SOPA} = \frac{7744.7}{201.55} = 38.426$ m from aft

No. 95 Date 09-05-2025

OCT 2012

The areas of ship's water plane are as follows:

Draft(m)	0	1	2	3	4
Area WP(m^2)	650	660	662	661	660

Calculate displacement in SW and Fresh water allowance at 4m draft

Sol:

NO. of ordinates: 5 (Simpson's First Rule)

Area		SM	=	POV	x	Lever	=	POM
650	x	1	=	650	x	0	=	0
660	x	4	=	2640	x	1h	=	2640h
662	x	2	=	1324	x	2h	=	2648h
661	x	4	=	2644	x	3h	=	7932h
660	x	1	=	660	x	4h	=	2640h
			SOPV =	7918			SOPM =	15860h
				h = 1				= 15860

Displacement = uw volume x density

$$\text{volume} = \frac{SOP \times h}{3} = \frac{7918 \times 1}{3} = 2639.33\ m^3$$

Displacement = 2639.33×1.025

$= 2705.317\ t$

$$\text{Area} = \frac{\text{uw volume}}{\text{draft}} = \frac{2639.33}{4} = 659.832\ m^2$$

$$TPC = \frac{A}{100} \times RD = \frac{659.832}{100} \times 1.025 = 6.763\ t$$

$$FWA = \frac{W}{40TPC} = \frac{2705.317}{40 \times 6.763} = 10.000\ cm$$

JAN 2013

No. 96 Date 09.05.2013

The breadth of a ship's water plane 120m long, measured at equal interval from aft are 1.2, 9.6, 13.2, 15.0, 15.3, 15.6, 15.6, 14.7, 12.9, 9.0 and 0.0 m respectively. Find the water plane area, TPC in sea water & FWA if displacement is 6690 t

Soln:-

No. of ordinates = 11 (Simpson's First Rule)

Breadth (from aft)	×	SM	=	POA
1.2	×	1	=	1.2
9.6	×	4	=	38.4
13.2	×	2	=	26.4
15.0	×	4	=	60
15.3	×	2	=	30.6
15.6	×	4	=	62.4
15.6	×	2	=	31.2
14.7	×	4	=	58.8
12.9	×	2	=	25.8
9.0	×	4	=	36
0.0	×	1	=	0
			SOPA =	370.8

$10h = 120 \quad \boxed{h = 12}$

$$\text{Area of WP} = \frac{\text{SOPA} \times h}{3} = \frac{370.8 \times 12}{3} = 1483.2 \text{ m}^2$$

$$\text{TPC} = \frac{A}{100} \times RD = \frac{1483.2}{100} \times 1.025 = 15.203 \text{ t/cm}$$

$$\text{FWA} = \frac{W}{40 \text{TPC}} = \frac{66.90}{40 \times 15203} = 11.001 \text{ cm}$$

No. 97 Date 09.05.2025

OCT 2014

The water plane areas of a ship are:

Draft	5	4	3	2	1	m
Area	2100	2050	2010	1900	1710	m^2

Between Keel and 1m draft the appendage volume is $700\ m^3$ whose geometric center is 0.6m above the Keel. Find the displacement, KB and FWA of ship at draft 5m in S.W

SOM

No. of ordinates : 5 (Simpson's First Rule)

Area		SM	=	POV		Lever	=	POM	
1710	X	1	=	1710	X	1	=	1710	0
1900	X	4	=	7600	X	2	=	15200	7600h
2010	X	2	=	4020	X	3	=	12060	8040h
2050	X	4	=	8200	X	4	=	32800	24600h
2100	X	1	=	2100	X	5	=	10500	8400h
			SOPV =	23630			SOPM =	72270	48640h
				$h = 1.00$					= 48640

$$\text{Volume} = \frac{SOPV \times h}{3} = \frac{23630 \times 1.00}{3} = 7876.667\ m^3$$

$$\text{Geometric center above the Keel} = \frac{SOPM}{SOPV} = \frac{72270}{23630} = 3.058m$$

$\frac{48640}{23630} + 1 = 3.058\ m$

Volume of appendance = $700\ m^3$

G.C above the Keel = 0.6m

(a) Total volume = $7876.667 + 700 = 8576.667\ m^3$

Displacement = w/w vol. × density = $8576.667 \times 1.025 = \boxed{8791.083\ t}$ Ans

(b) $$\text{Final KB} = \frac{(\text{vol} \times \text{G.C of WP}) + (\text{vol} \times \text{G.C of appendance})}{\text{Total volume}}$$

$$= \frac{(7876.667 \times 3.058) + (700 \times 0.6)}{8576.667} = \boxed{2.857m}$$ Ans

(c) $$\text{Area} = \frac{\text{w/w vol}}{\text{draft}} = \frac{8576.667}{5} = 1715.333\ m^2$$

$$TPC = \frac{A}{100} \times RD = \frac{1715.333}{100} \times 1.025 = 17.582\ t/cm$$

$$FWA = \frac{W}{40TPC} = \frac{8791.083}{40 \times 17.582} = \boxed{12.5\ cm}$$ Ans

JULY 2015

The TPC values of a ship measured from keel upwards at 1.5m interval of draught, commencing at the keel are 4.0, 6.1, 7.8, 9.1, 10.3, 11.4 and 12.0 respectively. calculate at a draught of 9.0m:

(a) Displacement (b) KB.

Soln:-

No. of ordinates: 7 (simpson First Rule)

$$TPC = \frac{A}{100} \times density$$

$$TPC = \frac{A}{100} \times 1.025$$

$$TPC = A \times 0.010$$

$$A = 97.561\ TPC$$

Area	X	SM	=	POV	X	lever	=	POM
390.244	X	1	=	390.244	X	0h	=	0
595.122	X	4	=	2380.488	X	1h	=	2380.488h
760.976	X	2	=	1521.952	X	2h	=	3043.904h
887.805	X	4	=	3551.22	X	3h	=	10653.66h
1004.878	X	2	=	2009.756	X	4h	=	8039.024h
1112.195	X	4	=	4448.78	X	5h	=	22243.9h
1170.732	X	1	=	1170.732	X	6h	=	7024.392h
			SOPV =	15473.172			SOPM =	53385.368h
			h = 1.5					= 80078.052

(a) Volume $= \frac{SOPV \times h}{3} = \frac{15473.172 \times 1.5}{3}$

$= 7736.586\ m^3$

Displacement = u/w vol x density = $7736.586 \times 1.025 = \boxed{7930.0t}$

(b) $KB = \frac{SOPM}{SOPA} = \frac{80078.052}{15473.172}$

$= \boxed{5.175m}$

No. 99 Date 12.05.2025

July 2016

The semi ordinates of a b'head 6m in height at 1m interval commencing from the top of the b'head are 4.0, 3.8, 3.5, 3.3, 3.0 and 2.7m. Below the last ordinate the area of the b'head is $5.0\ m^2$ with its CG = 0.8m from the bottom of b'head. Calculate the area of b'head and distance of its CG from the bottom of b'head?

Sol:

No. of ordinates = 6 (Combination of two rules)

Semi ordinates (FROM BTM)		SM	=	Area	×	lever	=	POM	
2.7	×	1	=	2.7	×	1 0	=	2.7	0
3.0	×	4	=	12.0	×	2 1h	=	24	12.0h
3.3	×	1	=	3.3	×	3 2h	=	9.9	6.6h
				SOPA = 18				SOPM = 36.6	18.6h = 18.6

$$\text{Area} = \left(\frac{\text{SOP} \times h}{3}\right)_{X2} = \left(\frac{18 \times 1}{3}\right)_{X2} = 12\ m^2$$

$$CG = \frac{\text{SOPM}}{\text{SOPA}} = \frac{36.6}{18} = 2.033m \qquad \frac{18.6}{18} + 1 = 2.033m$$

3.3	×	1	=	3.3	×	3 2h	=	9.9	6.6h
3.5	×	3	=	10.5	×	4 3h	=	42	31.5h
3.8	×	3	=	11.4	×	5 4h	=	57	45.6h
4.0	×	1	=	4	×	6 5h	=	24	20h
				SOPA = 29.2				SOPM = 132.9	103.7h = 103.7

$$\text{Area} = \left(\frac{\text{SOP} \times 3h}{8}\right)_{X2} = \left(\frac{29.2 \times 3 \times 1}{8}\right)_{X2} = 21.90\ m^2$$

$$C.G = \frac{\text{SOPM}}{\text{SOPA}} = \frac{132.9}{29.2} = 4.551m \qquad \frac{103.7}{29.2} + 1 = 4.551m$$

Area of b'head = $5.0\ m^2$

C.G = 0.8m

Total area of bulkhead = $12 + 21.90 + 5 = \boxed{38.90\ m^2}$ Ans

$$\text{Total G.C} = \frac{(12 \times 2.033) + (21.90 \times 4.551) + (5 \times 0.8)}{38.90}$$

$$= \boxed{3.292m \text{ from bottom}}$$ Ans

No. 100 Date 12.05.25

JAN 2019

The water plane area of a ship at one meter draft interval commencing from the keel upwards are as follows:

Draft(m)	0	1	2	3	4	5	6
Area(m^2)	5850	5885	5900	5915	5943	5975	5995

Calculate her KB and FWA at a draft of 6 meter.

Soln:-

No. of ordinates: 7 (Simpson's First Rule)

Area		SM	=	POV	x	lever	=	POM
5850	x	1	=	5850	x	0h	=	0
5885	x	4	=	23540	x	1h	=	23540h
5900	x	2	=	11800	x	2h	=	23600h
5915	x	4	=	23660	x	3h	=	70980h
5943	x	2	=	11886	x	4h	=	47544h
5975	x	4	=	23900	x	5h	=	119500h
5995	x	1	=	5995	x	6h	=	35970h
			SOPV =	106631			SOPM =	321134h
								= 321134

$$\text{Volume} = \frac{\text{SOPV} \times h}{3} = \frac{106631 \times 1}{3}$$

$$= 35543.667\ m^3$$

$$\text{Displacement} = 35543.667 \times 1.025 = 36432.259\ T$$

$$\text{Area} = \frac{\text{w/p vol.}}{\text{draft}} = \frac{35543.667}{6} = 5923.944\ m^2$$

$$TPC = \frac{A}{100} \times \text{density} = \frac{5923.944}{100} \times 1.025 = 60.720\ t/cm$$

$$FWA = \frac{W}{40TPC} = \frac{36432.259}{40 \times 60.720} = \boxed{15.000\ cm}$$

$$KB = \frac{SOPM}{SOPV} = \frac{321134}{106631} = \boxed{3.012\ m}$$

No. 101 Date 14.05.2025

SEP 2021 NOV 2022

The breadths of a transverse watertight bulkhead, at 2m intervals from the bottom are 2, 5, 8, 8.4, 10.2 & 11.4. Find (a) its area (b) the distance of its geometric centre from the top.

Sol^n:

No. of ordinates: 6 (combination of two rules)

Breadth from top		SM	=	POA	×	lever	=	POM
11.4	×	1	=	11.4	×	0	=	0
10.2	×	4	=	40.8	×	1h	=	40.8h
8.4	×	1	=	8.4	×	2h	=	16.8h
				SOPA = 60.6				SOPM = 57.6h = 115.2

$$\text{Area} = \frac{\text{SOPA} \times h}{3} = \frac{60.6 \times 2}{3} = 40.4\ m^2$$

$$\text{G.C} = \frac{\text{SOPM}}{\text{SOPA}} = \frac{115.2}{60.6} = 1.901\ m$$

8.4	×	1	=	8.4	×	2h	=	16.8h
8	×	3	=	24	×	3h	=	72h
5	×	3	=	15	×	4h	=	60h
2	×	1	=	2	×	5h	=	10h
				SOPA = 49.4				SOPM = 158.8h = 317.6

$$\text{Area} = \frac{\text{SOPA} \times 3h}{8} = \frac{49.4 \times 3 \times 2}{8} = 37.05\ m^2$$

$$\text{G.C} = \frac{\text{SOPM}}{\text{SOPA}} = \frac{317.6}{49.4} = 6.429\ m$$

Total area = 40.4 + 37.05 = **77.45 m²** Ans

$$\text{G.C from top.} = \frac{(40.4 \times 1.901) + (37.05 \times 6.429)}{77.45}$$

$$= 4.067\ m$$

AUG 2022
JAN 2018

Water plane areas of a ship measured at 1m equal interval from 1m draft till 5m draft were as follows: 1900m², 2400 m², 2800m², 3100 m² and 3400m² respectivey.
If from Keel to 1m draft is a Triangular appendage of volume 700m³, Determine (i) Displacement of ship at 5m draft in S.W
(ii) KB of Ship at 5m draft

Soln:-

No. of ordinates: 5 (simpson's First Rule)

WP area	x	SM	=	POV	x	Lever	=	POM	
1900	x	1	=	1900	x	0 1	=	0	1900
2400	x	4	=	9600	x	1h 2	=	9600h	19200
2800	x	2	=	5600	x	2h 3	=	11200h	16800
3100	x	4	=	12400	x	3h 4	=	37200h	49600
3400	x	1	=	3400	x	4h 5	=	13600h	17000
				SOPV = 32900				SOPM = 71600h = 71600	104500

Volume (1m to 5m) $= \frac{SOPV \times h}{3} = \frac{32900 \times 1}{3} = 10966.667\ m^3$

G.C from bottom $= \frac{SOPM}{SOPV} + 1 = \frac{71600}{32900} + 1 = 3.176\ m$ $\quad \frac{104500}{32900} = 3.176$

Volume (Keel to 1m) $= 700\ m^3$

G.C of ▽ appendance from bottom $= \frac{2}{3} \times 1$
$= 0.667m$

Total volume $= 10966.667 + 700 = 11666.667\ m^3$

(i) Displacement at 5m draft in S.W = u/w vol. x density
$= 11666.667 \times 1.025$
$= 11958.334\ T$ Ans

(ii) KB of Ship $= \frac{(10966.667 \times 3.176) + (700 \times 0.667)}{11666.667}$

$= 3.025m$ Ans

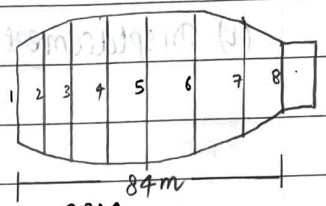
NOV 2022 APRIL 2024

Transverse cross-sectional area of the ship from keel to the waterline measured from AP at 12m equal intervals are as follows:-
$600\,m^2$, $800\,m^2$, $1200\,m^2$, $1400\,m^2$, $1200\,m^2$, $600\,m^2$, $300\,m^2$, $50\,m^2$. Forward of the forward most bulkhead is appendage whose volume is $160\,m^3$ and its centroid is 4m forward of the bulkhead. Determine the displacement and LCB of the ship in this condition.

Soln:

NO. of ordinates: 8 (combination of two rules)

$h = 12$



Area	X	SM	=	POV	X	lever	=	POM
600	X	1	=	600	X	0h	=	0
800	X	4	=	3200	X	1h	=	3200h
1200	X	2	=	2400	X	2h	=	4800h
1400	X	4	=	5600	X	3h	=	16800h
1200	X	1	=	1200	X	4h	=	4800h
			SOPV =	13000			SOPM =	29600h = 355200

$$\text{Volume} = \frac{SOPV \times h}{3} = \frac{13000 \times 12}{3} = 52000\ m^3$$

$$\text{G.C from keel} = \frac{SOPM}{SOPV} = \frac{355200}{13000} = 27.323\ m$$

1200	X	1	=	1200	X	4h	=	4800h
600	X	3	=	1800	X	5h	=	9000h
300	X	3	=	900	X	6h	=	5400h
50	X	1	=	50	X	7h	=	350h
			SOPV =	3950				19550h = 234600

$$\text{Volume} = \frac{SOPV \times 3h}{8} = \frac{3950 \times 3 \times 12}{8} = 17775\ m^3$$

$$\text{G.C from keel} = \frac{SOPM}{SOPV} = \frac{234600}{3950} = 59.392$$

Volume of appendage = 160 m3

C.C of appendage from Keel = 4 + 84 = 88m

Total volume = 52000 + 17775 + 160

= 69935 m^3

(i) Displacement = u/w volume x density

= 69935 X 1.025

= 71683.375 T Ans

(ii) LCB of the ship =

$$\frac{(52000 \times 27.323) + (17775 \times 59.392) + (160 \times 88)}{69935}$$

= 35.613 m Ans

JAN 2023 JULY 2024

The water plane areas of a ship from forward draft mentioned are as follows: 5m: 6380, 4m: 6320, 3m: 6255, 2m: 6090, 1m: 5885, 0·5m: 5740, 0: 5560. Find the displacement and KB at 5m draft

Soln:

NO. of ordinates: 7 (Simpson's 1st rule)

	Area		SM		POV		lever		POM
½	5560	X	1	=	2780	X	0	=	0
½	5740	X	4	=	11480	X	0.5h	=	5740h
½	5885	X	2	=	8827.5	X	1h	=	8827.5h
	6090	X	4	=	24360	X	2h	=	48720h
	6255	X	2	=	12510	X	3h	=	37530h
	6320	X	4	=	25280	X	4h	=	101120h
	6380	X	1	=	6380	X	5h	=	31900h
					SOPV = 91617.5				SOPM = 233837.5h

$= 233837.5\ m^4$

$$\text{Volume} = \frac{\text{SOPV} \times h}{3} = \frac{91617.5 \times 1}{3} = 30539.167\ m^3$$

Displacement = volume × density

$= 30539.167 \times 1.025$

$= \boxed{31302.646\ T}$

$$\text{KB at 5m draft} = \frac{\text{SOPM}}{\text{SOPV}} = \frac{233837.5}{91617.5} = 2.552\ m$$

Simpson's Third Rule

No. 106 Date 14.05.2015

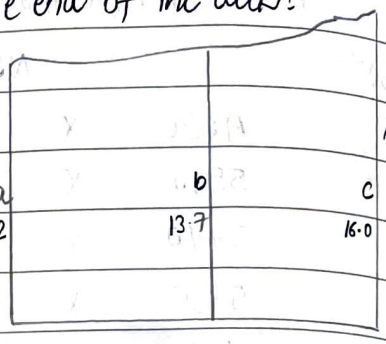
JAN 2014 The foredeck of a vessel in 55m in length. The width of the deck at equal interval commencing from its fore end are 12.2, 13.7 & 16.0. Calculate the area and the cc of the area from the fore end of the deck?

Soln:-

No. of ordinates = 3 (Simpson's 3rd rule)

$2h = 55$

$h = 27.5$



width	X	SM	=	POA	width X	lever	=	POM
12.2	X	5	=	61	12.2 X	3	=	36.6
13.7	X	8	=	109.6	13.7 X	10	=	137
16.0	X	-1	=	-16	16.0 X	-1	=	-16
			SOPA =	154.6			SOPM =	157.6

$$\text{Area} = \frac{\text{SOPA} \times h}{12} = \frac{154.6 \times 27.5}{12}$$

$$= 354.292 \text{ m}^2$$

$$\text{Moment} = \frac{\text{SOPM} \times h^2}{24} = \frac{157.6 \times 27.5^2}{24}$$

$$= 4966.042 \text{ m}^3$$

C.c of the area from the forward end

$$= \frac{\text{Moment}}{\text{area}}$$

$$= \frac{4966.042}{354.292}$$

$$= 14.017 \text{ m}$$

Ans

Simpson's Third Rule

No. 107 Date 14.05.2025

APRIL 2016 A D.B tank is 1.8m deep. The horizontal areas of the tank spaced at equal interval commencing from the top are $200m^2$, $175m^2$ & $150m^2$ respectively. The tanks contain oil of R.D 0.88 to a sounding 0.9m. Calculate the weight of oil and its KG.

Soln:- No. of ordinates : 3 (simpson's 3rd rule)

$2h = 1.8$

$h = 0.9m$

Area	X	SM	= POV	Area	X	lever	= POM
150	X	5	= 750	150	X	3	= 450
175	X	8	= 1400	175	X	10	= 1750
200	X	-1	= -200	200	X	-1	= -200
			SOPV = $1950m^2$				SOPM = $2000m^2$

Total volume of tank = $\frac{SOPV \times h}{12} = \frac{1950 \times 0.9}{12} = 146.25\ m^3$

Area of tank = $\frac{volume}{depth} = \frac{146.25}{1.8} = 81.25m^2$

Volume of oil in tank = Area x sounding

$= 81.25 \times 0.9$

$= 73.125m^3$

weight of oil = volume x R.D

$= 73.125 \times 0.88 = \boxed{64.35T}$

Moment = $\frac{SOPM \times h^2}{24} = \frac{2000 \times 0.9^2}{24} = 67.5m^4$

K.G = $\frac{moment}{area} = \frac{67.5}{1} = \boxed{0.462m}$

5, 8
3, 10

No. 108 Date 14.05.2025

JAN 2025

Three ordinates of a deck spaced at equal distance of 20m, and commencing from fwd are 7.5m, 11.8m and 15.8m respectivey. Calculate:

(a) The position of geometric center of the areas between the first two and the last two ordinates with reference to fwd end.

(b) Amount of cargo that can be loaded on the deck area between first two ordinates, if the load density of deck is 10 t/m².

Soln:-

NO. of ordinates : 3 (Simpson's First Rule)

Fwd			Aft
a	b	c	
7.5	11.8	15.8	

(a) Area = $\frac{SOP \times h}{12}$

SOP = 5a + 8b - c

= (5×7.5) + (8×11.8) - 15.8

= 116.1

Area = $\frac{116.1 \times 20}{12}$ = 193.5 m²

Moment = $\frac{SOP \times h^2}{24}$

SOP = 3a + 10b - c

= (3×7.5) + (10×11.8) - 15.8

= 124.7

Moment = $\frac{124.7 \times 20^2}{24}$ = 2078.333 m³

G.C of fwd half from fwd = $\frac{\text{Moment}}{\text{area}} = \frac{2078.333}{193.5}$ = **10.741 m**

After half of deck

Area = $\frac{SOP \times h}{12}$

SOP = 5c + 8b - a

= (5×15.8) + (8×11.8) - 7.5

= 165.9

Area = $\frac{165.9 \times 20}{12}$ = 276.5 m²

$$\text{Moment} = \frac{SOP \times h^2}{24}$$

$$SOP = 3c + 10b - a$$
$$= (3 \times 15.8) + (10 \times 11.8) - 7.5$$
$$= 157.9$$

$$\text{Moment} = \frac{157.9 \times 20^2}{24} = 2631.667\ m^3$$

$$\text{C·C of after half from fwd} = \frac{\text{Moment}}{\text{area}} = \frac{2631.667}{276.5} = \boxed{9.518m}$$

(b) Amount of cargo that can be loaded on the deck area between first two ordinates = Deck area × load density

$$= 193.5 \times 10$$
$$= \boxed{1935\ t}$$