OCT 2024 MV Pilot is loaded up ready for departure, KG is 6.55m, FSM 1350 tm, with a displacement of 9000 t. From the cross curves of stability, the KN values are:

HEEL	0	15	30	45	60	75	90
KN	0	1.98	4.10	5.92	6.82	6.98	6.58

Construct the statical stability curve for this condition and determine the following range of stability. Change of above range when transverse upsetting moment of 2250 tm is caused Moment of stability stability at 5° heel.
The maximum GZ and angle at which it occurs, Dynamical stability at 45°

Soln:-

KG : 6.55 m
FSC : 0.15 m ($^{1350}/_{9000}$)
corrected KG : 6.70 m

HEEL	0	15	30	45	60	75	90
KN	0	1.98	4.10	5.92	6.82	6.98	6.58
KG sinθ	0	1.734	3.350	4.738	5.802	6.472	6.7
GZ (KN − KG sinθ)	0	0.246	0.750	1.182	1.018	0.508	−0.12

PLOT THE GZ CURVE

Moment of statical stability = W x GZ

2250 = 9000 x GZ

GZ = 0.25m (plot on GZ curve)

Range of +ve stability = 0° to 87°
Range of +ve stability after upsetting moment is caused = 15° to 82°
Maxm GZ : 1.2m
} Ans

Dynamical stability at 45° = Area under curve upto 45° x W

Heel	GZ	SM	POA
0	0	1	0
15	0.246	3	0.738
30	0.750	3	2.25
45	1.182	1	1.182
			SOPA = 4.17

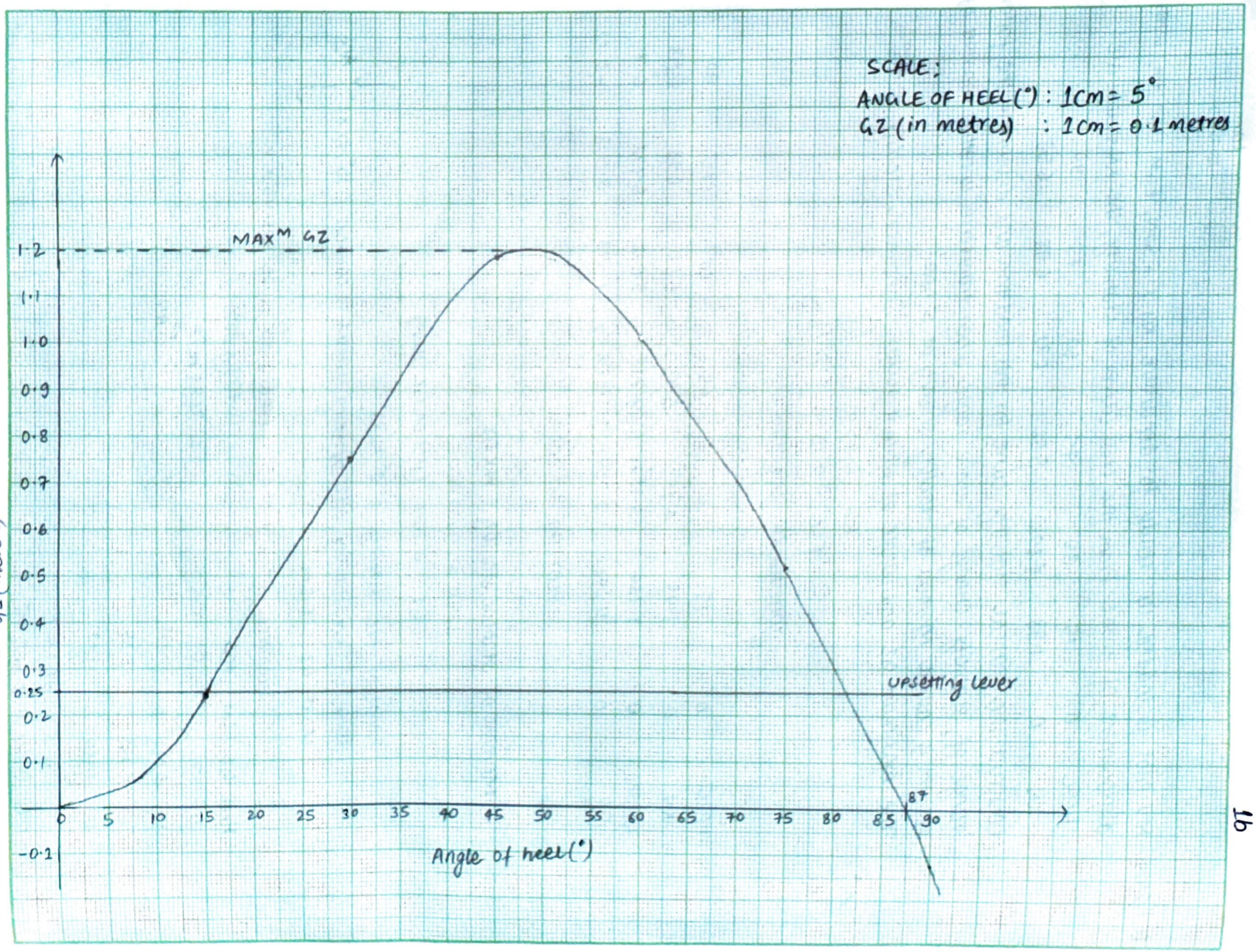
= 0.409 x 9000
= 3681 mrt
Ans

Area under curve upto 45°

$= \frac{SOPA \times 3h}{8} = \frac{4.17 \times 3 \times 15}{8 \times 57.3}$ = 0.409 meter radian

↓ to convert into meter radian

Teacher's Signature



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JULY 2024, JAN 2023, OCT 2018

A ship has displacement 15000t KG 7.0

Heel	0	15	30	45	60
GZ	0	0.38	1.0	1.41	1.2

The vessel has loaded to this displacement, but KG is found to be 6.8 m. Draw the ammended GZ curve, confirm weather the vessel complies with the intact stability criteria. calculate the dynamic stability at 60° heel.

Soln:-

Heel	0	15	30	45	60
GZ	0	0.38	1.0	1.41	1.2
corrn to GZ $GG_1(\downarrow)$ so (+)$GG_1\sin\theta$	0	+0.052	+0.100	0.141	+0.173
Corrected GZ	0	0.432	1.100	1.551	1.373

where $GG_1 = 7.0 - 6.8 = 0.2$

Area upto 30° heel

Heel	GZ	SM	POA
0	0	1	0
15	0.432	4	1.728
30	1.100	1	1.1
		SOPA :	2.828

$$\text{Area}_{\text{upto } 30^\circ} = \frac{SOPxh}{3} = \frac{2.828 \times 15}{3 \times 57.3}$$

$$= 0.247 \text{ MR}$$

Area upto 40° heel

Heel	GZ	SM	POA
0	0	1	0
10	0.21	4	0.84
20	0.66	2	1.32
30	1.10	4	4.4
40	1.5	1	1.5
		SOPA :	8.06

$$\text{Area}_{\text{upto } 40^\circ} = \frac{8.06 \times 10}{3 \times 57.3} = 0.469 \text{ MR}$$

Area 30° to 40° = 0.430 − 0.247 = 0.183

Ⓐ Area under curve upto 30° to be not less than 0.055 metre radian

Area upto 30° = 0.247 metre radian :- COMPLIED

Ⓑ Area under curve upto 40° to be not less than 0.09 metre radian

Area upto 40° = 0.469 metre radian :- COMPLIED

Ⓒ Area between 30° and 40° to be not less than 0.03 metre radian

Area b/w 30° to 40° = 0.183 metre radian :- COMPLIED

Ⓔ Maxᵐ GZ to occur at angle not less than 30°, and to be atleast 0.20m

Maxᵐ GZ occured at 48° i.e. not less than 30° : COMPLIED

Maxᵐ GZ: 1.55m , should be atleast 0.20 : COMPLIED

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(F) Initial GM to be not less than 0.15 metres

Initial GM: 0.95 : COMPLIED

Now to calculate dynamic stability at 60° heel

Area upto 60° heel

Heel	GZ	SM	POA
0	0	1	0
15	0.432	4	1.728
30	1.100	2	2.200
45	1.551	4	6.204
60	1.373	1	1.373

SOPA = 10.505

Area upto 60° heel = $\frac{SOPA \times h}{3}$

$= \frac{11.505 \times 15}{3 \times 57.3}$

$= 57.525\ m^2$

$= 1.004\ mr$

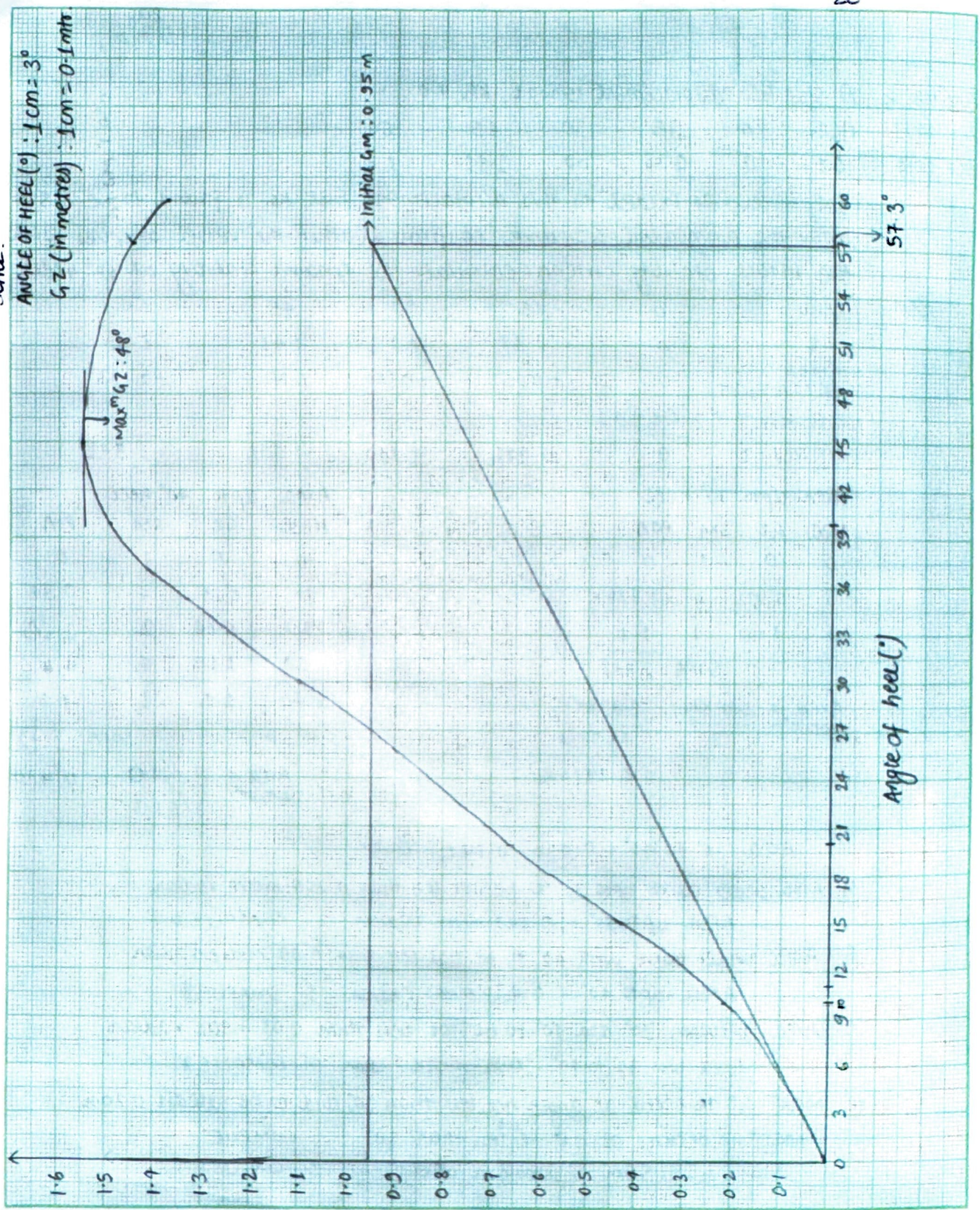
Dynamical stability at 60° = Area under curve upto 60° x W

$= 1.004 \times 15000$

$= 15060\ mrt$

Ans

SCALE:



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JAN 2025
APR 2024
JULY 2023 P-2

A ship with light displacement 1700 t, KG 3.5m loaded with 1800 ts of cargo at KG 3.8m, KM after loading is 3.8m while KN values are as follows.

Displacement (tonnes)	10°	20°	30°	40°	60°	75°
3,000	0.75	1.50	2.16	2.84	3.19	3.26
4,000	0.77	1.54	2.30	2.92	3.25	3.26

Plot the GZ curve & show if the ship complies with IMO stability criteria

Soln:-

HEEL	0	10	20	30	40	60	75
KN @ 3000 t	0	0.75	1.50	2.16	2.84	3.19	3.26
KN @ 4000 t	0	0.77	1.54	2.30	2.92	3.25	3.26
So, KN values at 1700+1800 = 3500 t	0	0.76	1.52	2.23	2.88	3.22	3.26
(-) KG sinθ (use Final KG)	0	0.635	1.250	1.827	2.349	3.164	3.529
GZ	0	0.125	0.270	0.403	0.531	0.056	-0.269

To find final KG

Remarks	W	KG	V. moment
Initial	1700	3.5	5950
Loaded	(+) 1800	3.8	(+) 6840
	Final w : 3500		Final v. moment : 12790

$$\text{Final KG} = \frac{\text{Final v.moment}}{\text{Final w}} = \frac{12790}{3500} = 3.654\text{ m}$$

PLOT THE GZ CURVE

AREA UPTO 30° HEEL

Heel	GZ	SM	POA
0	0	1	0
10	0.125	3	0.375
20	0.270	3	0.810
30	0.403	1	0.403
		SOPA:	1.588

$$\text{Area} = \frac{\text{SOPA} \times 3h}{8} = \frac{1.588 \times 3 \times 10}{8 \times 57.3}$$

$$= 5.955\text{ m}^2$$

$$= 0.104\text{ metre radian}$$

AREA UPTO 40° HEEL

Heel	GZ	SM	POA
0	0	1	0
10	0.125	4	0.5
20	0.270	2	0.54
30	0.403	4	1.612
40	0.531	1	0.531
		SOPA:	3.183

$$\text{Area} = \frac{\text{SOPA} \times h}{3} = \frac{3.183 \times 10}{3 \times 57.3} = 0.185\text{ mr}$$

Area between 30° to 40° = 0.185 - 0.104
= 0.081 metre radian

Ⓐ Area under curve upto 30° to be not less than 0.055 metre radian
Area upto 30° = 0.104 metre radian : COMPLIED

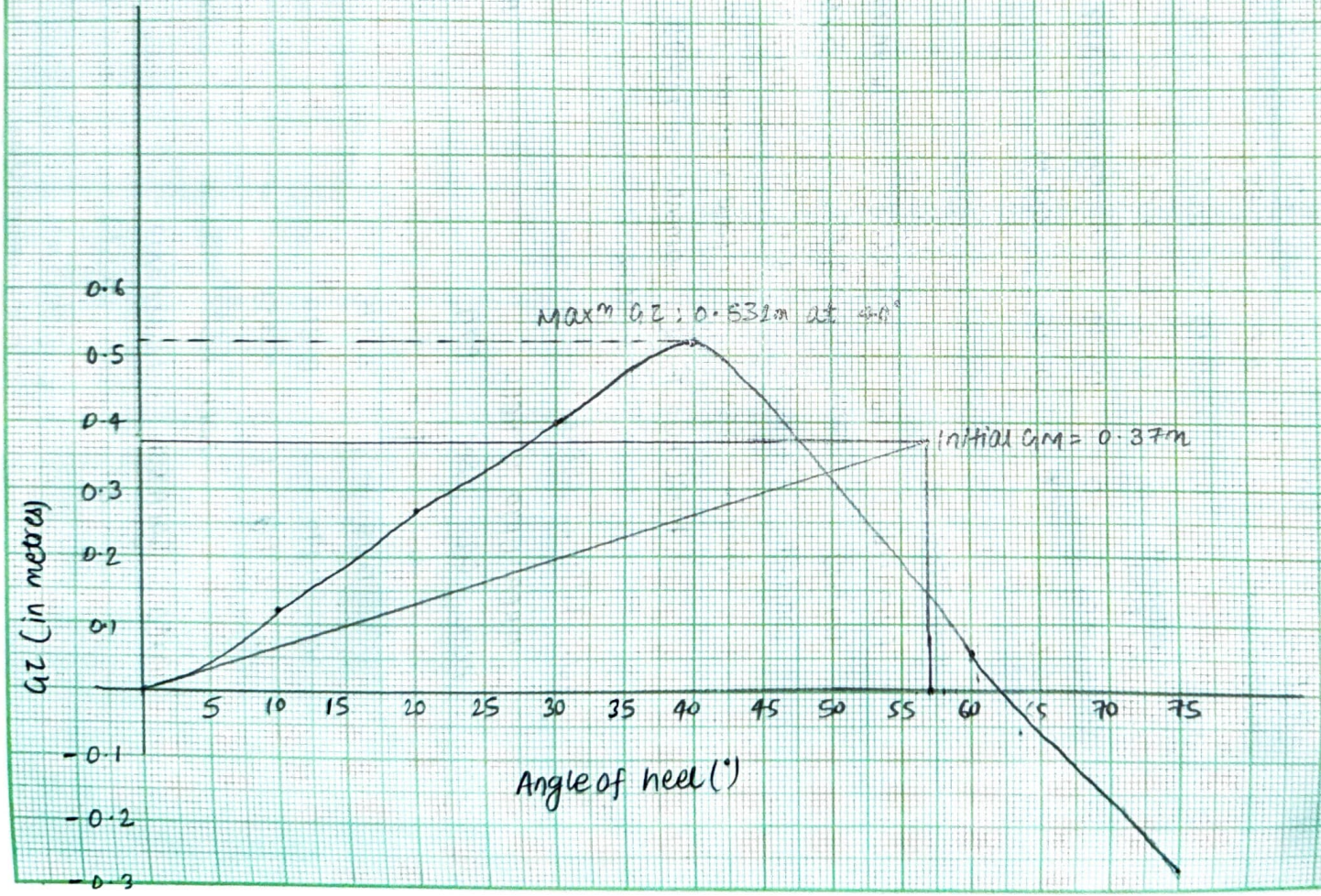
Ⓑ Area under curve upto 40° to be not less than 0.09 metre radian
Area upto 40° = 0.185 metre radian : COMPLIED.

Ⓒ Area between 30° & 40° to be not less than 0.03 metre radian
Area b/w 30° to 40° = 0.081 metre radian ; COMPLIED

Ⓔ Maxm GZ to occur at angle not less than 30°, and to be atleast 0.20m
Maxm GZ occur at 40° } COMPLIED
Maxm GZ : 0.531m }

Ⓕ Initial GM to be not less than 0.15m
Initial GM : 0.37m : COMPLIED.

SCALE:
ANGLE OF HEEL(°) : 1cm = 5°
GZ (in metres) : 1cm = 0.1 mtr



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JULY 2022 M.V HINDSHIP arrives in Condition No.7. Shore crane is used to discharge the deck cargo of locomotives that was loaded 4m off the CL to Port. By use of curve of statical stability, calculate the list caused when the deck cargo of locomotive is lifted to the shore crane

Soln:-

Initial displacement : 18529.3 t
Locomotive : (-) 760.0 t
Final displacement : 17769.3 t

Remarks	W	KG	V. moment
18529.3	18529.3	7.807	144653
(-) 760	(-) 760	13.83	(-) 10510
17769.3	17769.3	Final V. moment :	134143

$$\text{Final KG} = \frac{\text{Final V. moment}}{\text{Final W}} = \frac{134143}{17769.3} = 7.549\,m$$

KG : 7.549 m
FSC : (+) 0.087 m $\left(FSM/W = 1552/17769.3\right)$
Corrected KG : 7.636 m

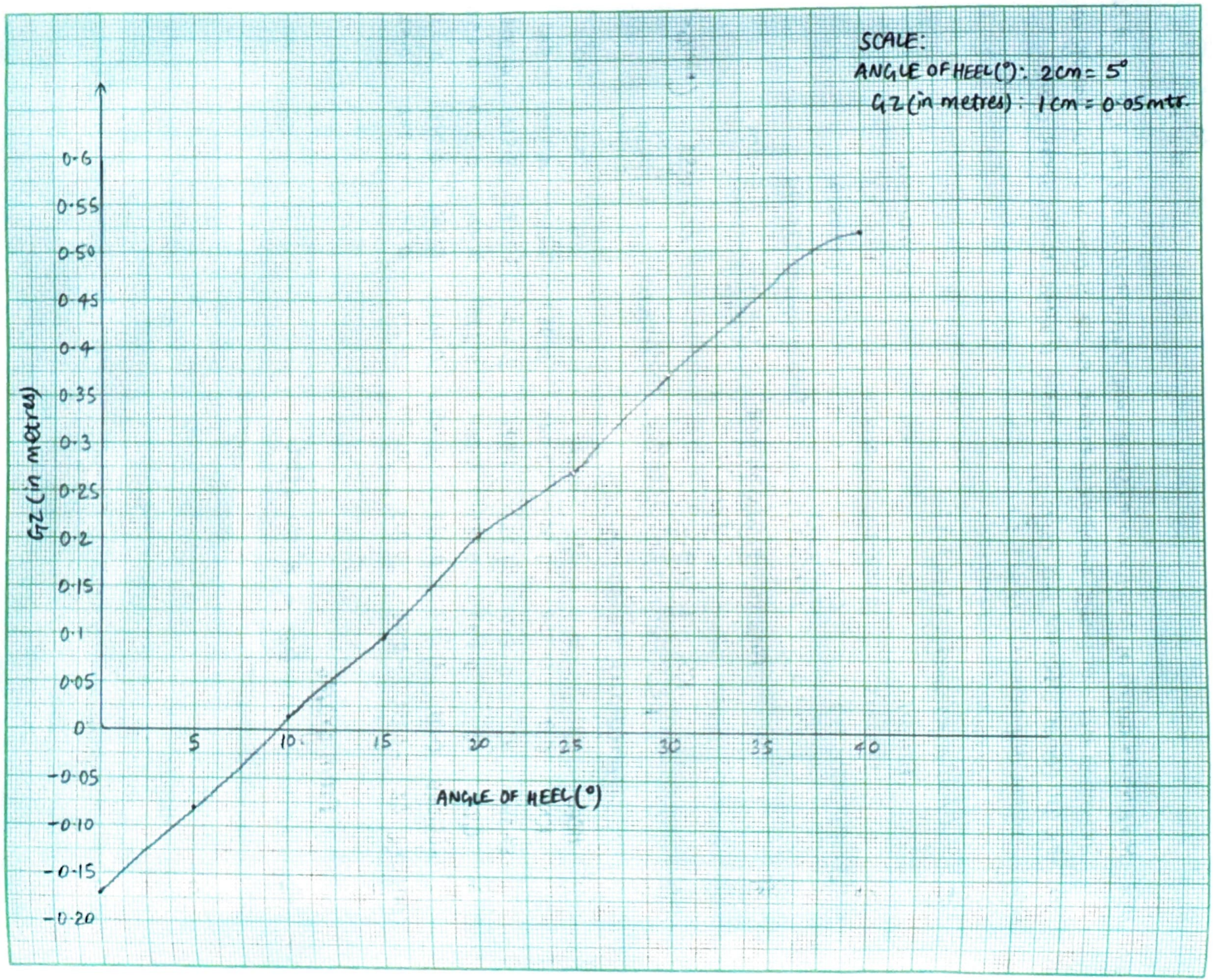
$$GG_1 = \frac{W \times d}{W} \quad \left(FSM/W = 1552/17769.3\right)$$
$$= \frac{760 \times 4}{17769.3}$$
$$= 0.171\,m$$

Heel	0	5	10	15	20	25	30	40
KN	0.0	0.756	1.507	2.240	2.987	3.653	4.338	5.560
-KG sinθ	0	0.666	1.326	1.976	2.612	3.227	3.818	4.908
GZ	0	0.090	0.181	0.264	0.375	0.426	0.520	0.652
$-GG_1\cos\theta$	0.171	0.170	0.168	0.165	0.161	0.155	0.148	0.131
Corrected GZ	-0.171	-0.08	0.013	0.099	0.214	0.271	0.372	0.521

PLOT GZ CURVE

From graph,

List = 8° to stbd



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practice sum M.V Hindship displacement 19,200t has 300t of cargo (KG: 6.5m) to shift horizontally by 7 metre & vertically downward by 4m. Draw the GZ curve & calculate the list & confirm that vessel complies with IMO stability criteria. (FSM = 2000, KG: 7.2m)

SOL:-

Remarks	W	KG	V.moment
19200	19200	7.2	138240
Shift	300	4	(-) 1200
	19200		137040

$$\text{Final KG} = \frac{\text{Final V.moment}}{\text{Final W}} = \frac{137040}{19200} = 7.1375\text{m}$$

KG: 7.1375

FSC: (+)0.1040 $(2000/19200 = 0.104)$

Corrected KG: 7.242m

$$GG_1 = \frac{w \times d}{W} = \frac{300 \times 7}{19200} = 0.109$$

Heel	0	5	10	15	20	25	30	40	45	60
KN	0	0.766	1.530	2.263	2.982	3.608	4.288	5.444	5924	6.976
corrected KG sine	0	0.631	1.258	1.874	2.477	3.061	3.621	4.655	5.124	6.272
GZ	0	0.135	0.272	0.389	0.505	0.547	0.667	0.789	0.803	0.704
$-GG_1 \cos\theta$	0.109	0.109	0.107	0.105	0.102	0.099	0.094	0.083	0.077	0.055
corrected GZ	-0.109	0.026	0.165	0.284	0.403	0.448	0.573	0.706	0.726	0.649

PLOT THE GZ CURVE

From GZ curve, List = 4°

Area upto 30° HEEL

Heel	GZ	SM	POA
0	-0.109	1	-0.109
10	0.165	3	0.495
20	0.403	3	1.209
30	0.573	1	0.573
			SOPA = 2.168

$$\text{Area} = \frac{\text{SOPA} \times 3h}{8} = \frac{2.168 \times 3 \times 10}{8 \times 57.3}$$

$$= 8.13\text{m}^2$$

$$= 0.142\text{mr}$$

AREA UPTO 40° HEEL

Heel	GZ	SM	POA
0	-0.109	1	-0.109
10	0.165	4	0.66
20	0.403	2	0.806
30	0.573	4	2.292
40	0.706	1	0.706
			SOPA = 4.355

$$\text{Area} = \frac{\text{SOP} \times h}{3} = \frac{4.355 \times 10}{3 \times 57.3}$$

$$= 0.253\text{mr}$$

Area between 30° to 40° = 0.253 - 0.142
= 0.111 meter radian

Ⓐ Area under curve upto 30° to be not less than 0.055 meter radian
Area upto 30° = 0.142 meter radian : COMPLIED

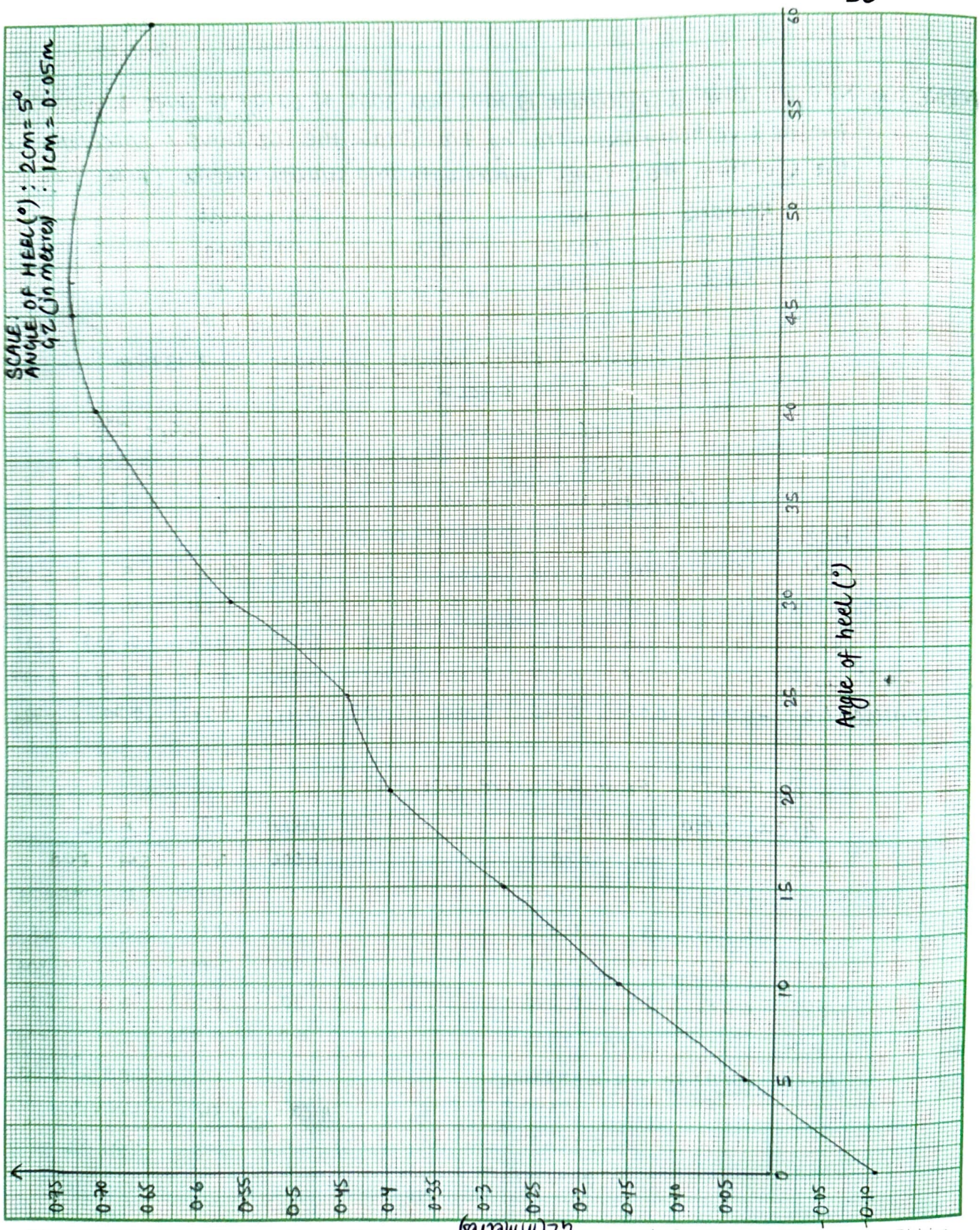
Ⓑ Area under curve upto 40° to be not less than 0.09 meter radian
Area upto 40° = 0.253 meter radian : COMPLIED

Ⓒ Area between 30° & 40° to be not less than 0.03 meter radian
Area between 30° to 40° = 0.111 meter radian : COMPLIED

Ⓔ Maxᵐ GZ to occur at angle not less than 30°, and to be atleast 0.20m.
Maxᵐ GZ occur at 48°
Maxᵐ GZ = 0.73m } COMPLIED

Ⓕ Initial GM to be not less than 0.15m
At zero degree heel, value of GZ is negative
So, we will find GM by calculation
KM @ 19200t : 8.400m
KG : 7.242m
GM(F) : 1.158m
↓
i.e not less than 0.15m : COMPLIED

19051 8.388
19537 8.428
$\frac{0.04}{486} \times 149 =$


SCALE:
ANGLE OF HEEL(°) : 2CM = 5°
GZ (in metres) : 1CM = 0·05M
Angle of heel (°)
GZ (in metres)
0
5
10
15
20
25
30
35
40
45
50
55
60
0·10
0·05
0·0
0·05
0·10
0·15
0·20
0·25
0·30
0·35
0·40
0·45
0·50
0·55
0·60
0·65
0·70
0·75

OCT 2023 PAPER 2 JULY 2022

A ship in upright conditions, having displacement 15000t and KG 7.0m, FSM 400tm, following GZ value were obtained:

Heel (deg)	0	15	30	45	60
GZ (m)	0	0.38	1.0	1.41	1.2

Vessel now take 200t of ballast in top side tank, Kg 9.0m and 5.0m to port of centerline. FSM in final condition is 900tm. If the KN values remain unchanged after ballasting. Calculate the resultant list with the help of statical stability curve

Soln:-

Remarks	W	KG	V.moment
Initial	15000	7.0	105000
Ballast	(+) 200	9.0	(+) 1800
Final W :	15200	Final V.moment :	106800

$$\text{Final KG} = \frac{\text{Final V.moment}}{\text{Final W}}$$

$$= \frac{106800}{15200} = 7.026\,m$$

$$FSC = FSM/W = 900/15200 = 0.059\,m$$

$$\text{Corrected KG} = 7.085\,m$$

For vertical shift up : $-GG_1 \sin\theta$

$$GG_1 = \frac{w \times d}{W} = \frac{200 \times 2}{15200} = 0.026m \quad (OR) \quad 7.085 - 7 = 0.085m$$

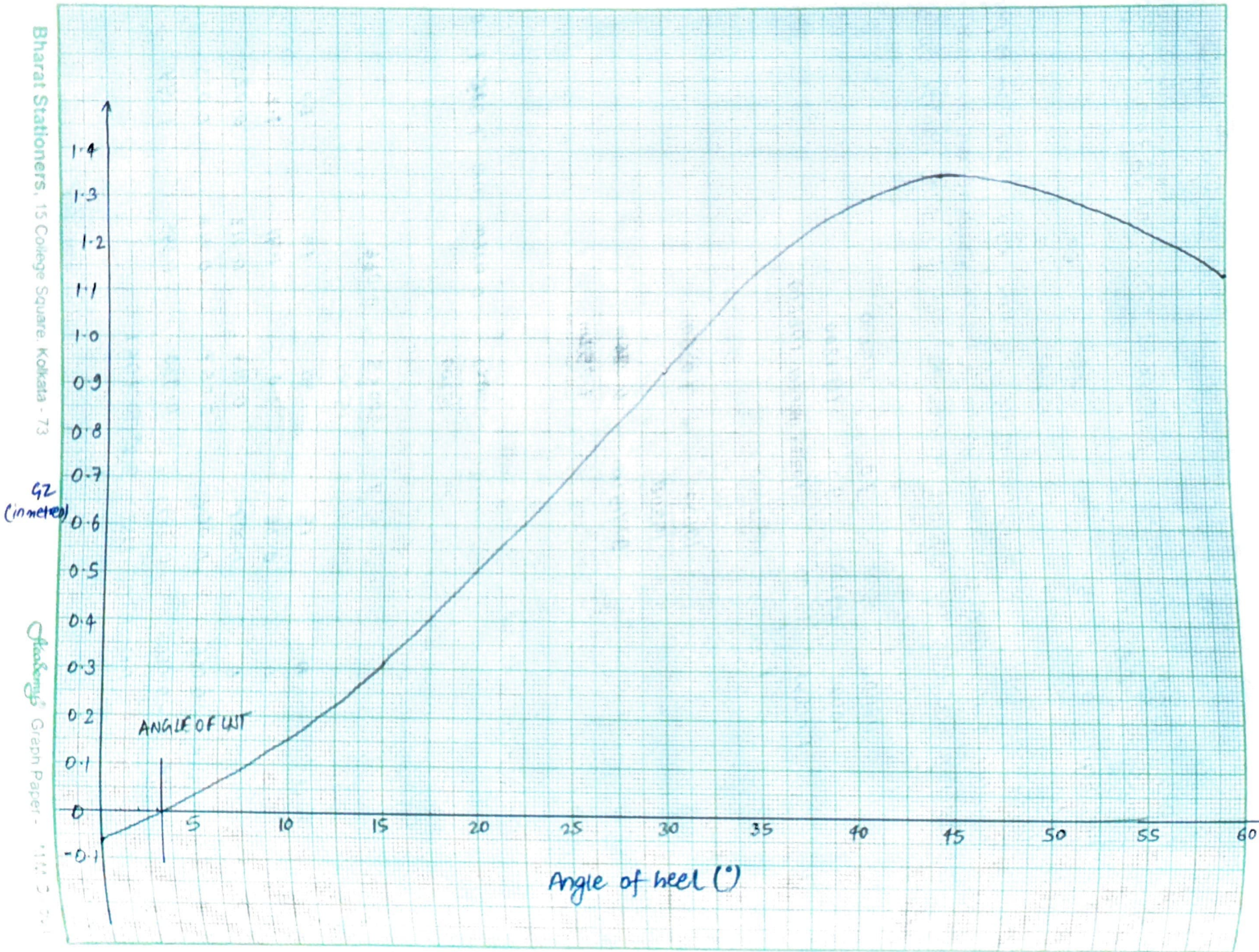
For horizontal ship : $-GG_1 \cos\theta$

$$GG_1 = \frac{w \times d}{W} = \frac{200 \times 5}{15200} = 0.066$$

Heel	0	15	30	45	60
GZ	0	0.38	1.0	1.41	1.2
$-GG_1 \sin\theta$	0	0.007	0.013	0.018	0.023
$-GG_1 \cos\theta$	0.066	0.064	0.057	0.047	0.033
corrected GZ	−0.066	0.309	0.930	1.345	1.144

ANGLE OF LIST : 3.2° TO PORT

Teacher's Signature _____



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