MISTAKES

It Could Be that the Purpose of Your Life Is Only to Serve as a Warning to Others.

SAILOR'S CREED

" I am a United States Sailor.

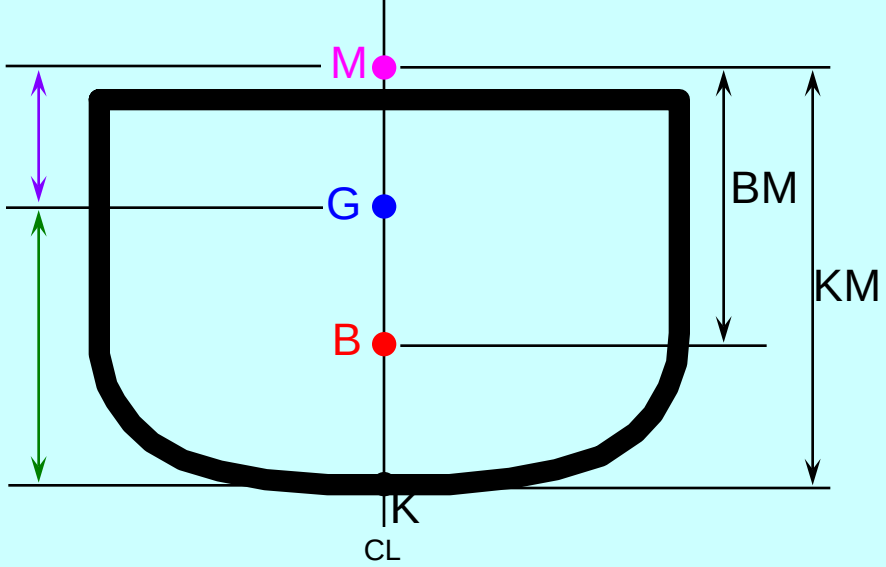
I will support and defend the Constitution of the United States of America and I W ill obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

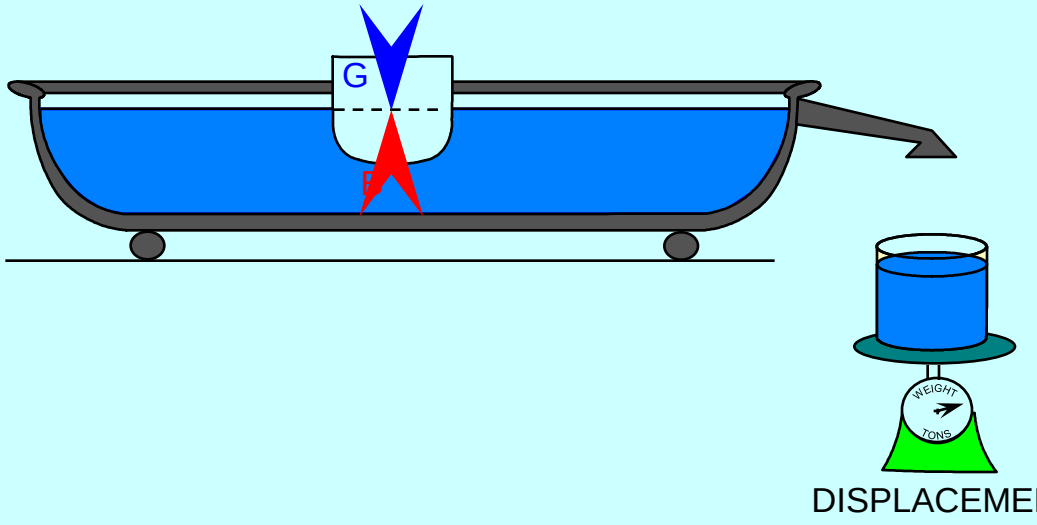
I proudly serve my country's Navy combat team with Honor, Courage, and Commitment

I am committed to excellence and fair treatment of all. "

Lesson 4.14



EXAM REVIW



DISPLACEMENT

CLASS TOPICS

1. Definitions
2. Stability Reference Points
3. Stability Triangle
4. Conditions of Stability
5. Stability Curve
6. Ship's Hull Markings
7. Draft Diagram and Cross Curves

STABILITY - THE TENDENCY OF A SHIP TO ROTATE ONE WAY OR THE OTHER (TO RIGHT ITSELF OR OVERTURN)

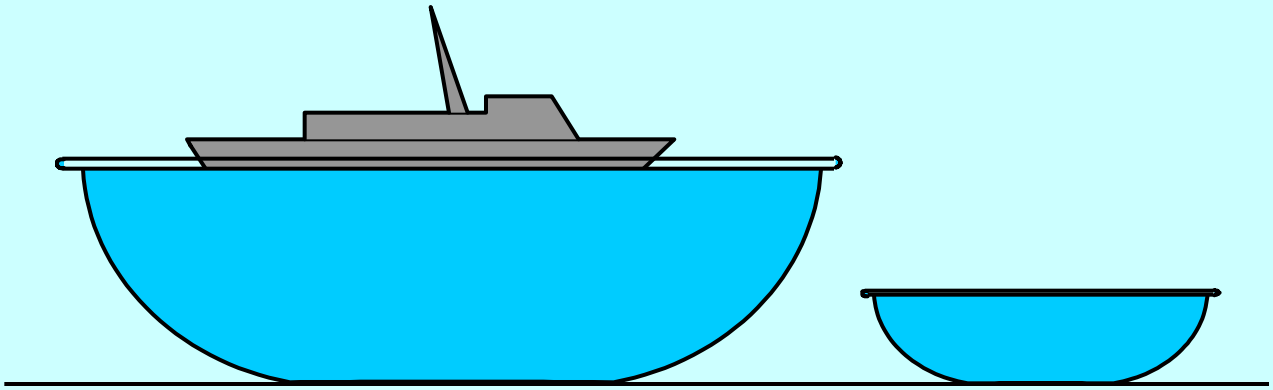
INITIAL STABILITY - THE STABILITY OF A SHIP IN THE RANGE FROM 0° TO 7°/10°

OVERALL STABILITY - A GENERAL MEASURE OF A SHIP'S ABILITY TO RESIST CAPSIZING IN A GIVEN CONDITION OF LOADING

DYNAMIC STABILITY - THE WORK DONE IN HEELING A SHIP TO A GIVEN ANGLE OF HEEL

LAWS OF BUOYANCY

- A FLOATING OBJECT HAS THE PROPERTY OF BUOYANCY
- A FLOATING BODY DISPLACES A VOLUME OF WATER EQUAL IN WEIGHT TO THE WEIGHT OF THE BODY.
- A BODY IMMERSED (OR FLOATING) IN WATER WILL BE BUOYED UP BY A FORCE EQUAL TO THE WEIGHT OF THE WATER DISPLACED.



DISPLACEMENT

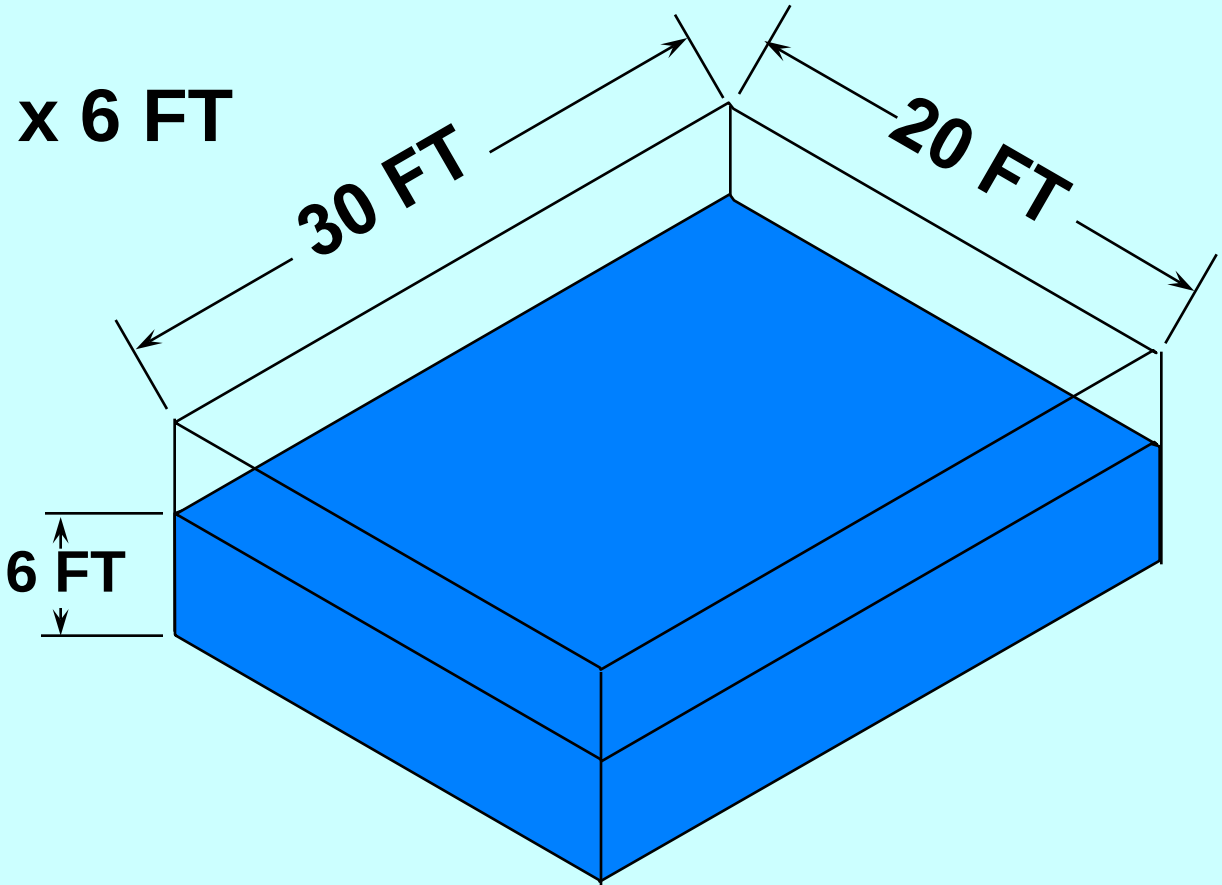
- THE WEIGHT OF THE VOLUME OF WATER THAT THE SHIP'S HULL IS DISPLACING
- UNITS OF WEIGHT
  LONG TON = 2240 LBS
  SHORT TON = 2000 LBS
  METRIC TON = 2204.72 LBS

VOLUME - NUMBER OF CUBIC UNITS IN AN OBJECT

UNITS: CUBIC FEET
CUBIC INCHES

$$V = L \times B \times D$$

$$V = 30\ FT \times 20\ FT \times 6\ FT$$
$$V = 3600\ FT^3$$



SPECIFIC VOLUME - VOLUME PER UNIT WEIGHT

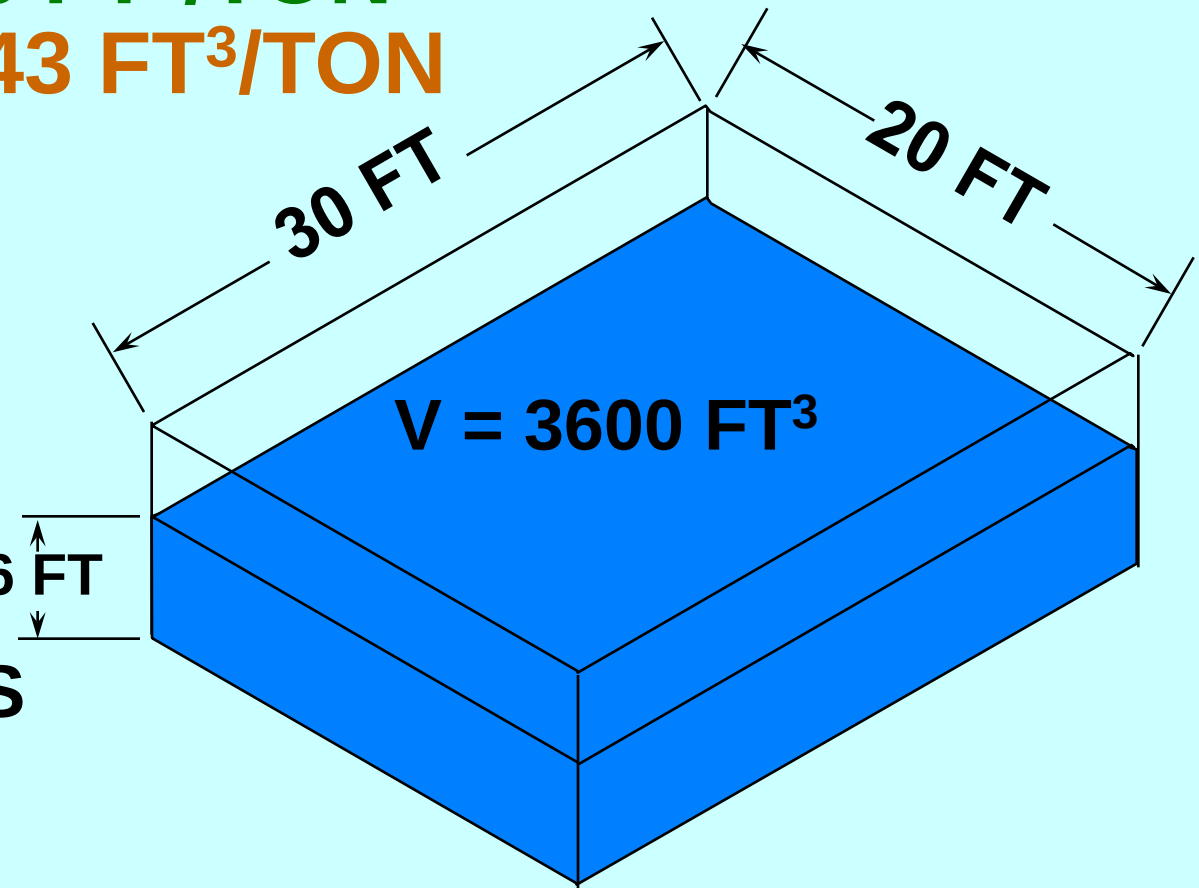
UNITS: CUBIC FEET PER TON

SW = 35 FT^3/TON
FW = 36 FT^3/TON
DFM = 43 FT^3/TON

$$WT = \frac{VOLUME}{SP.\ VOL}$$

$$WT = \frac{3600\ FT^3}{35\ FT^3/TON}$$

WT = 102.86 TONS



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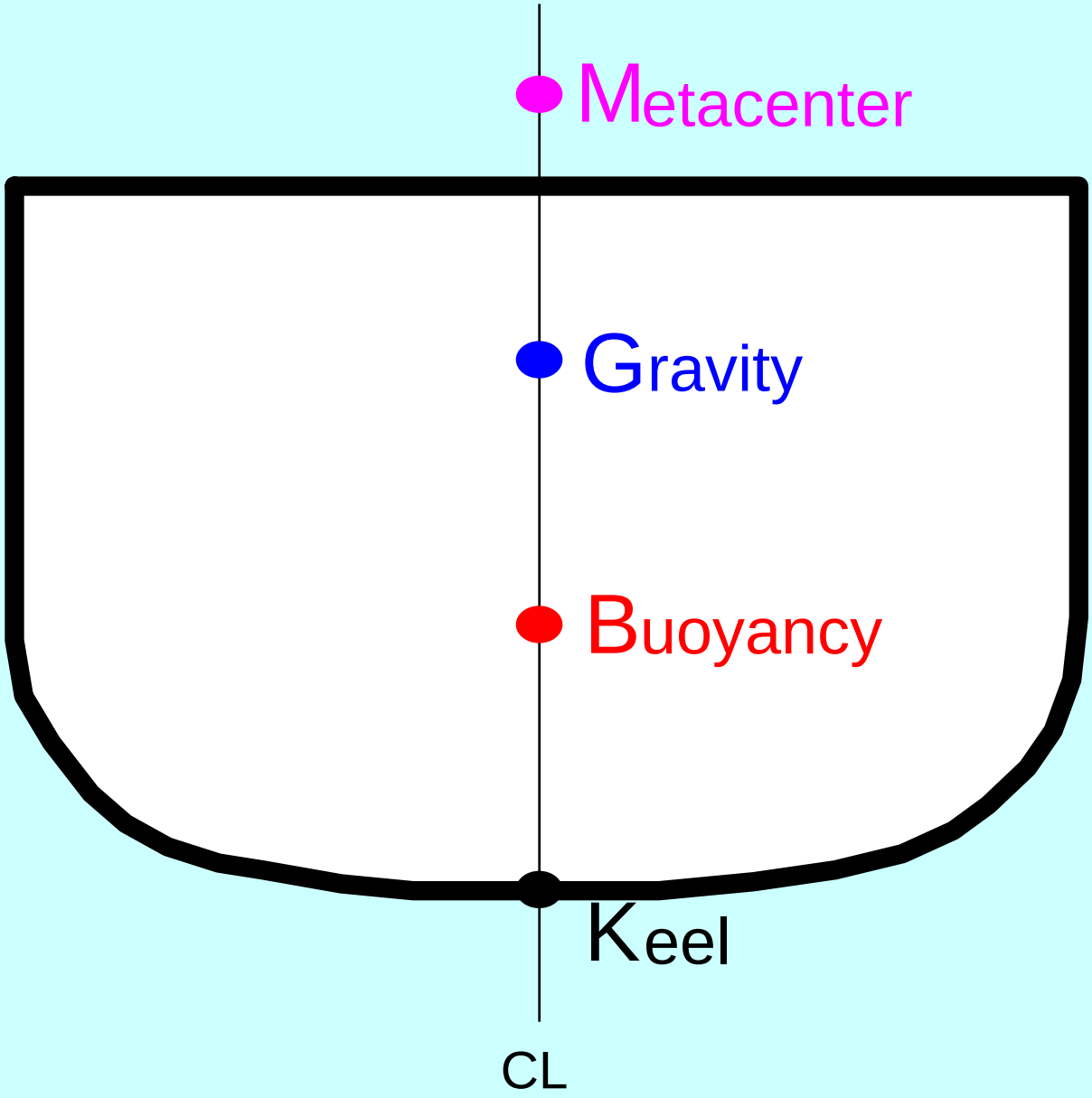
STABILITY REFERENCE POINTS



CENTER OF GRAVITY

- POINT AT WHICH ALL WEIGHTS COULD BE CONCENTRATED.

- CENTER OF GRAVITY OF A SYSTEM OF WEIGHTS IS FOUND BY TAKING MOMENTS ABOUT AN ASSUMED CENTER OF GRAVITY, MOMENTS ARE SUMMED AND DIVIDED BY THE TOTAL WEIGHT OF THE SYSTEM.

MOVEMENTS IN THE CENTER OF GRAVITY

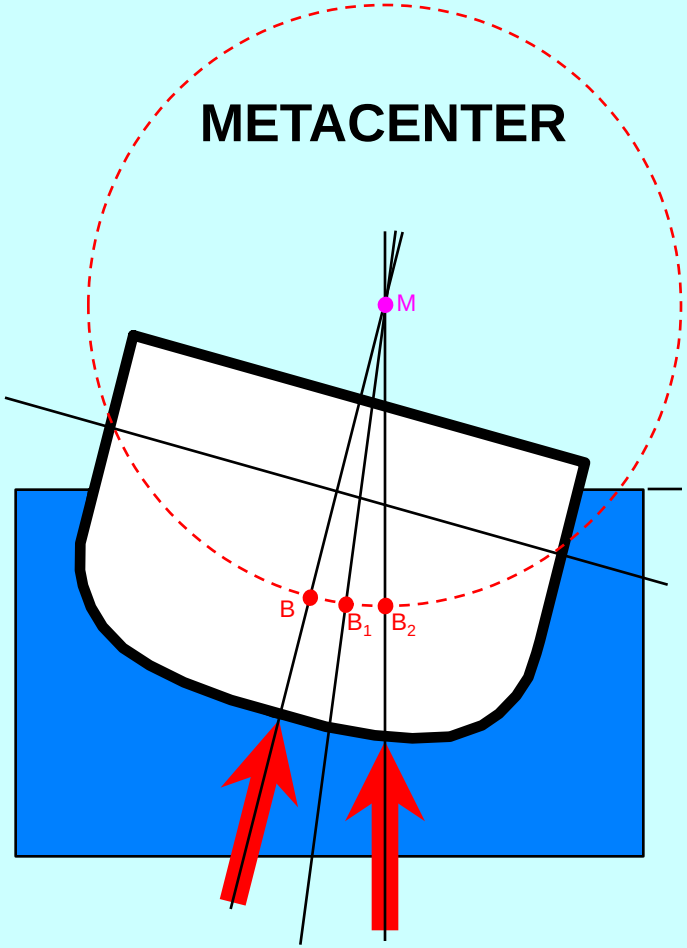
- G MOVES TOWARDS A WEIGHT ADDITION

MOVEMENTS IN THE CENTER OF GRAVITY

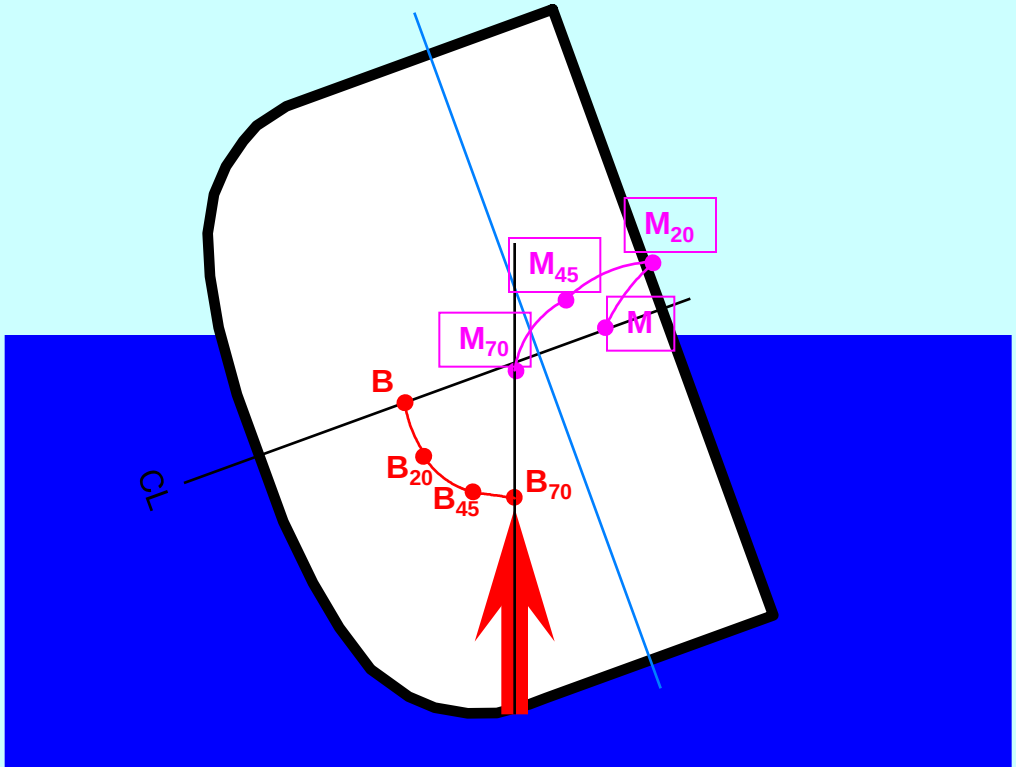
- G MOVES TOWARDS A WEIGHT ADDITION
- G MOVES AWAY FROM A WEIGHT REMOVAL

MOVEMENTS IN THE CENTER OF GRAVITY

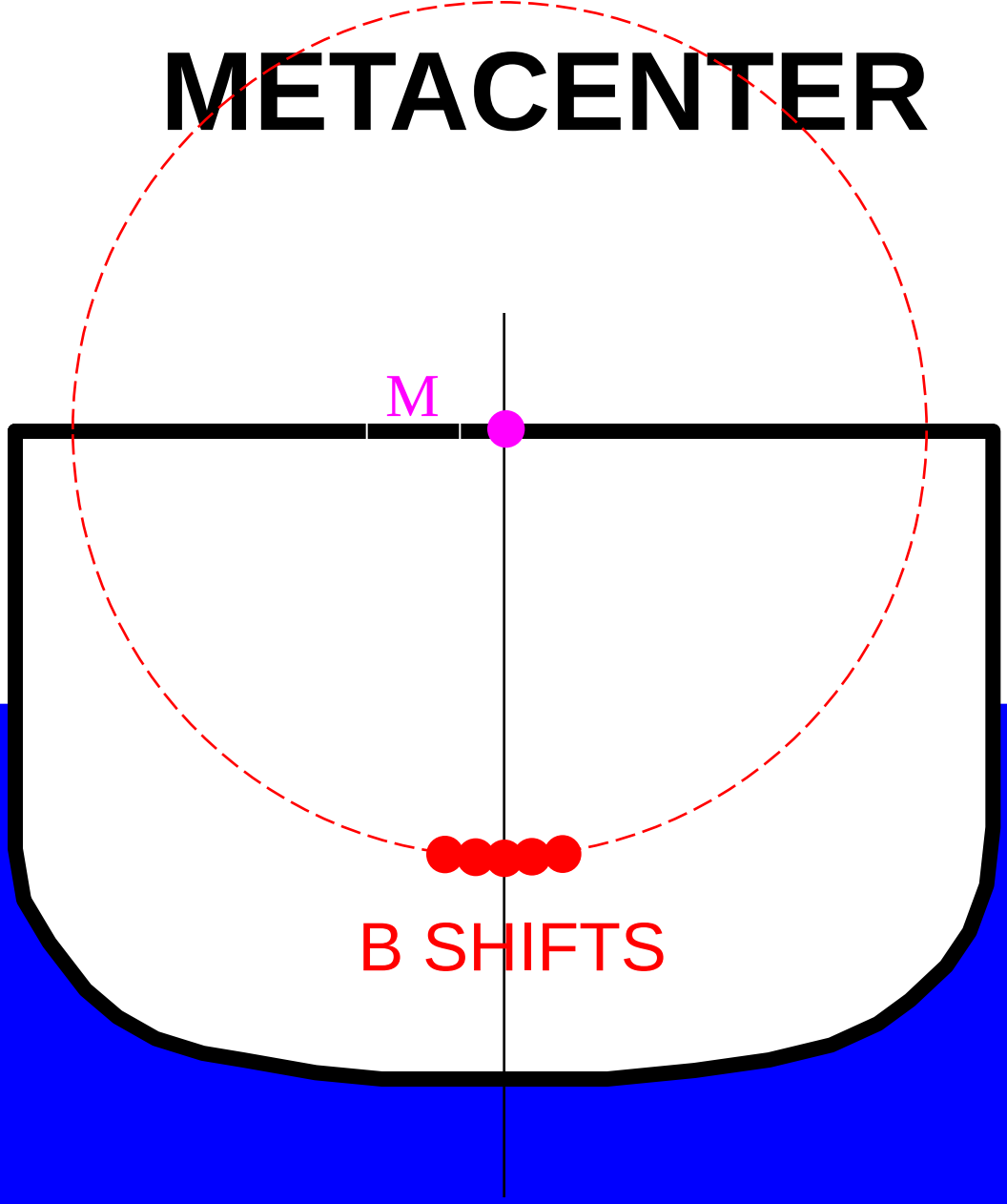
- G MOVES TOWARDS A WEIGHT ADDITION
- G MOVES AWAY FROM A WEIGHT REMOVAL
- G MOVES IN THE DIRECTION OF A WEIGHT SHIFT



THE METACENTER



METACENTER

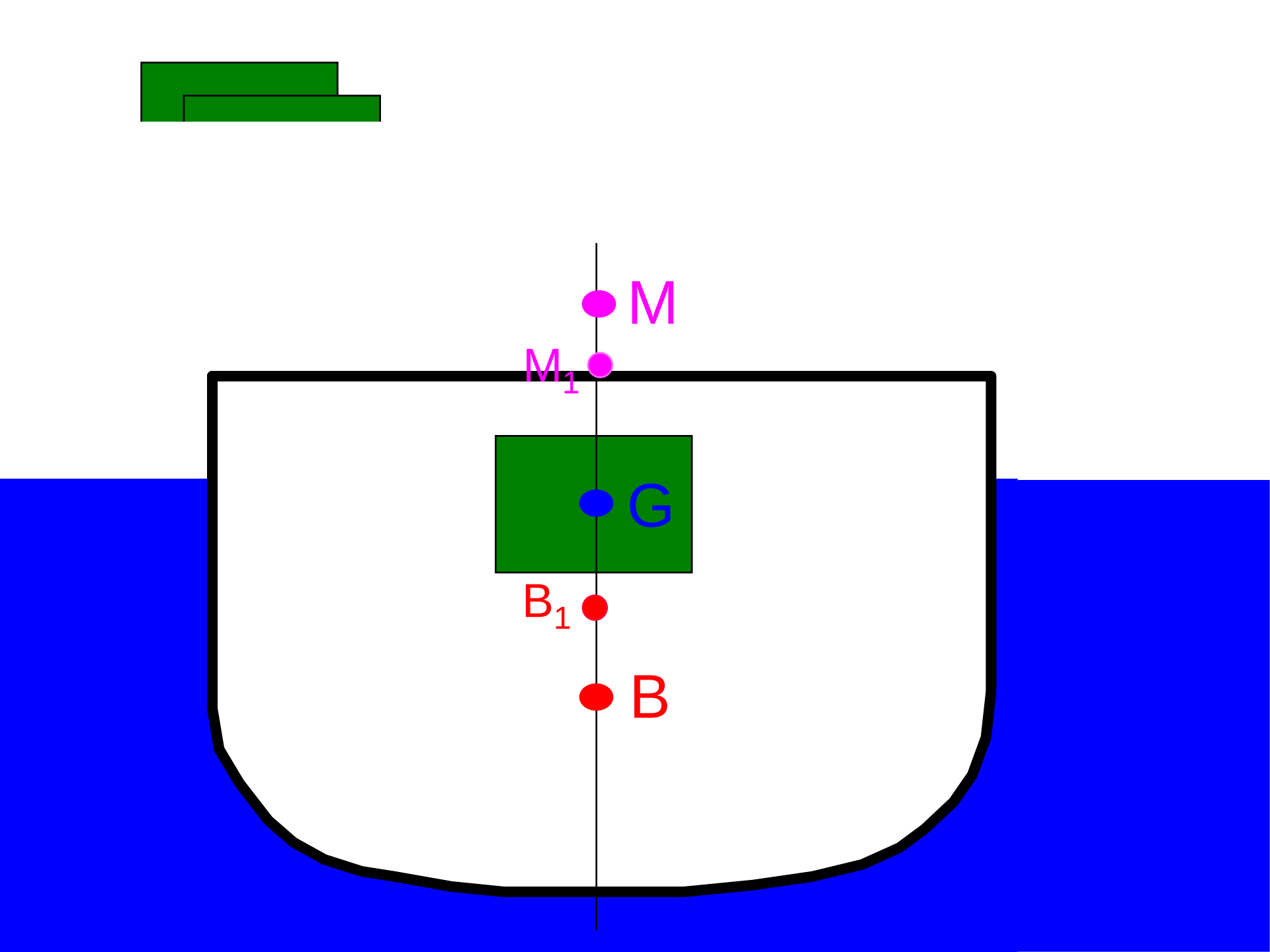


MOVEMENTS OF THE METACENTER

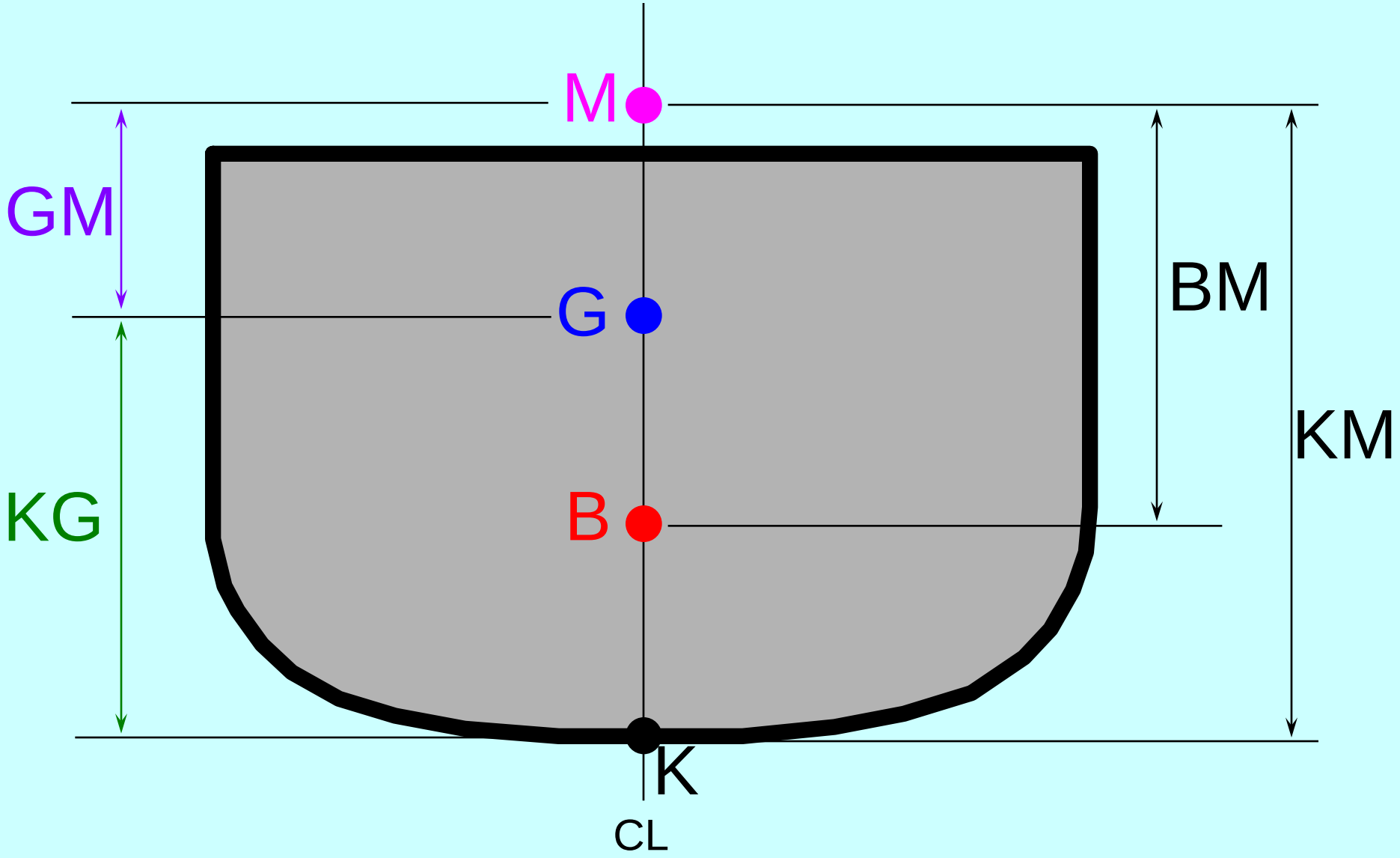
THE METACENTER WILL CHANGE POSITIONS IN THE VERTICAL PLANE WHEN THE SHIP'S DISPLACEMENT CHANGES

THE METACENTER MOVES IAW THESE TWO RULES:

1. WHEN B MOVES UP M MOVES DOWN.
2. WHEN B MOVES DOWN M MOVES UP.


M
M1
G
B1
B

LINEAR MEASUREMENTS IN STABILITY



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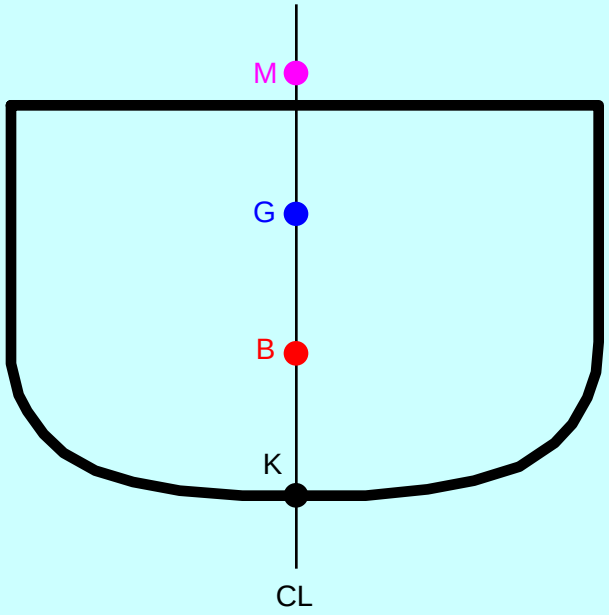
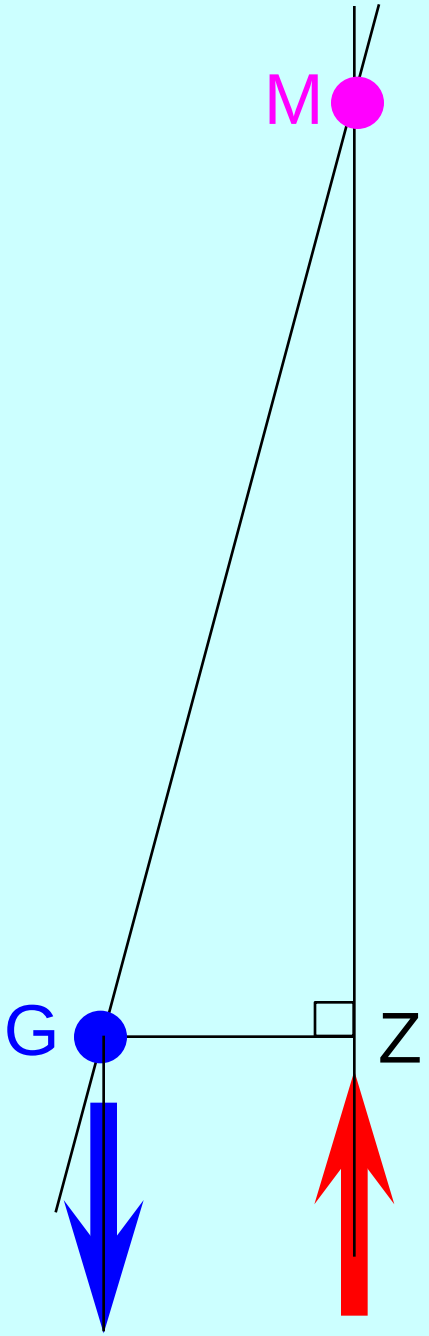


THE STABILITY TRIANGLE



Sin θ = opp / hyp

Where:

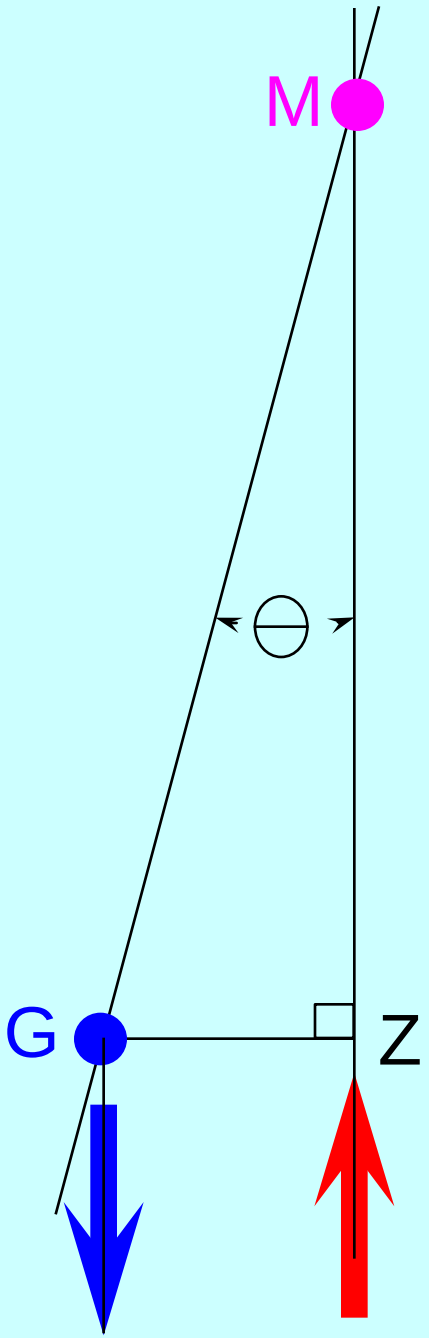
opposite = GZ

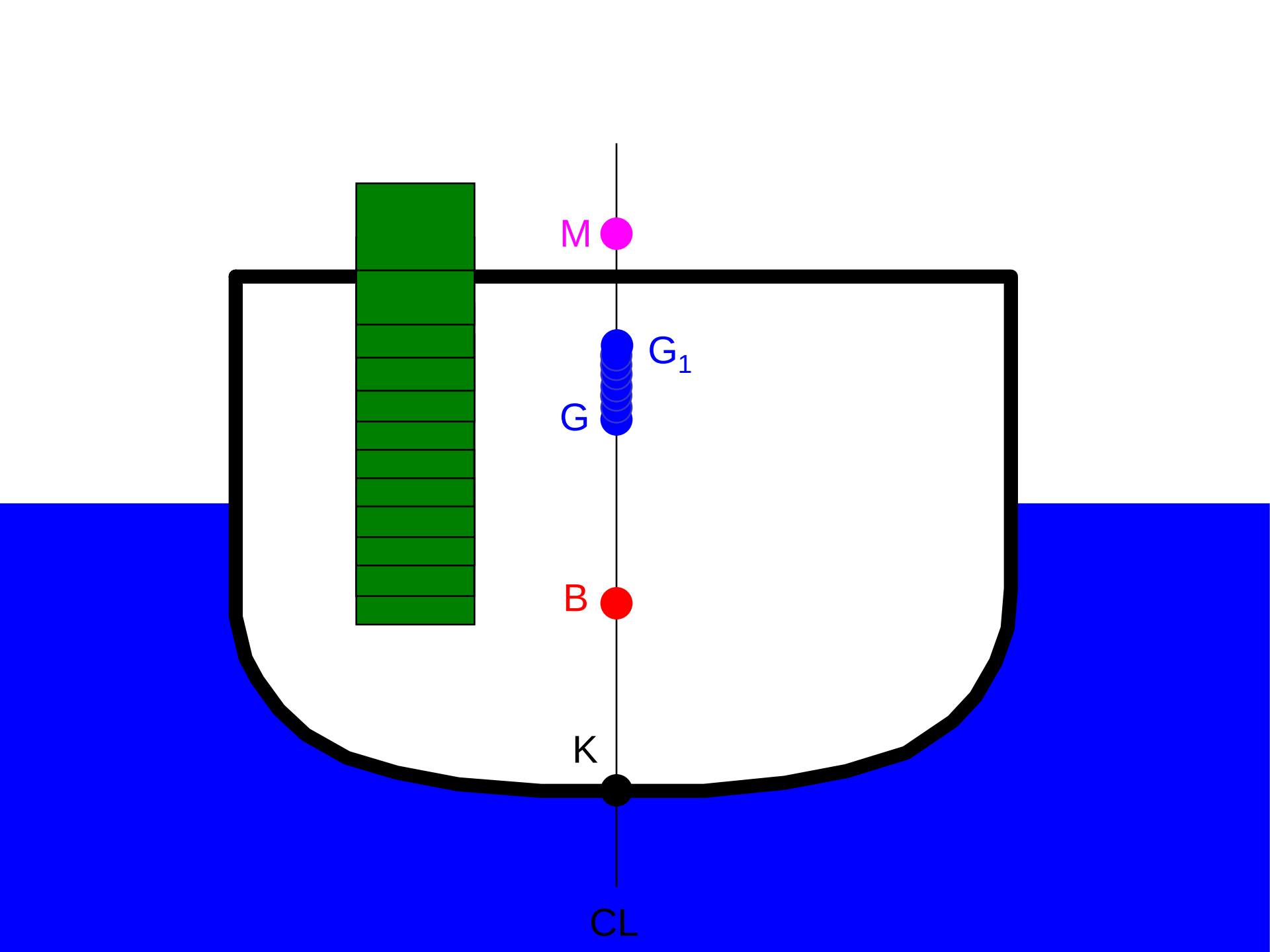
hypotenuse = GM

Sin θ = GZ / GM

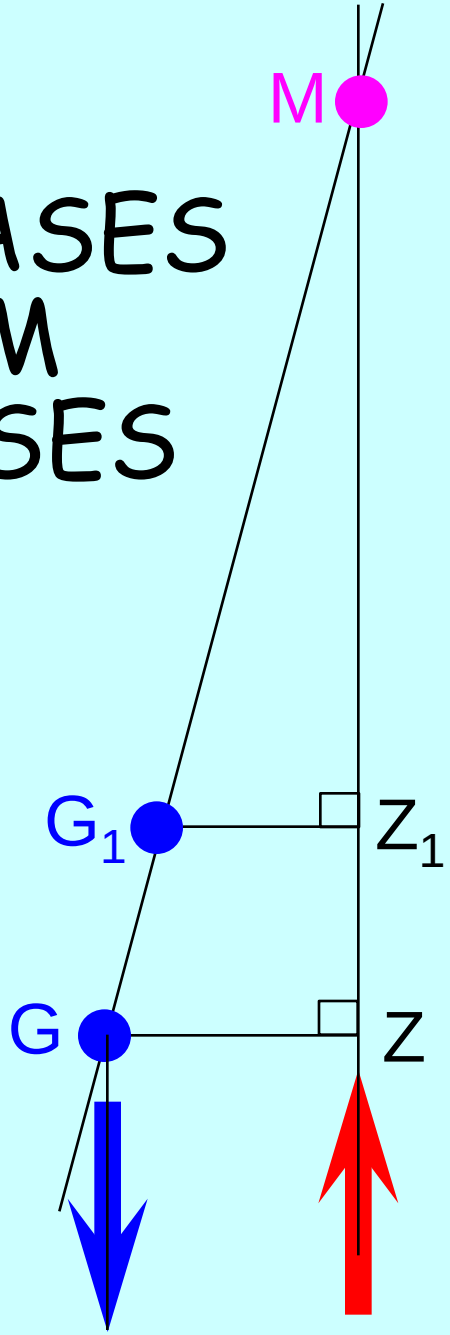
GZ = GM x Sin θ

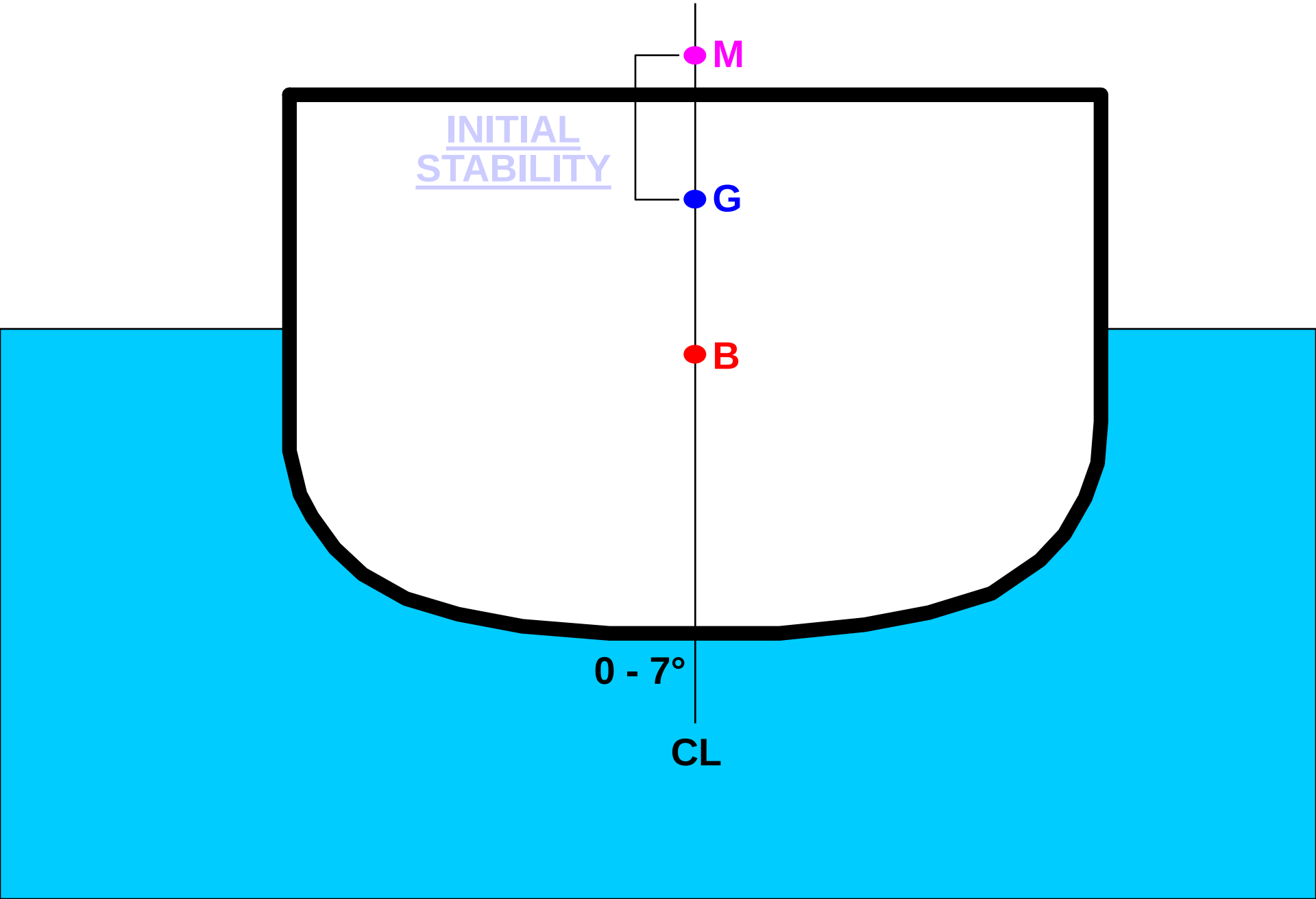
Growth of GZ α GM

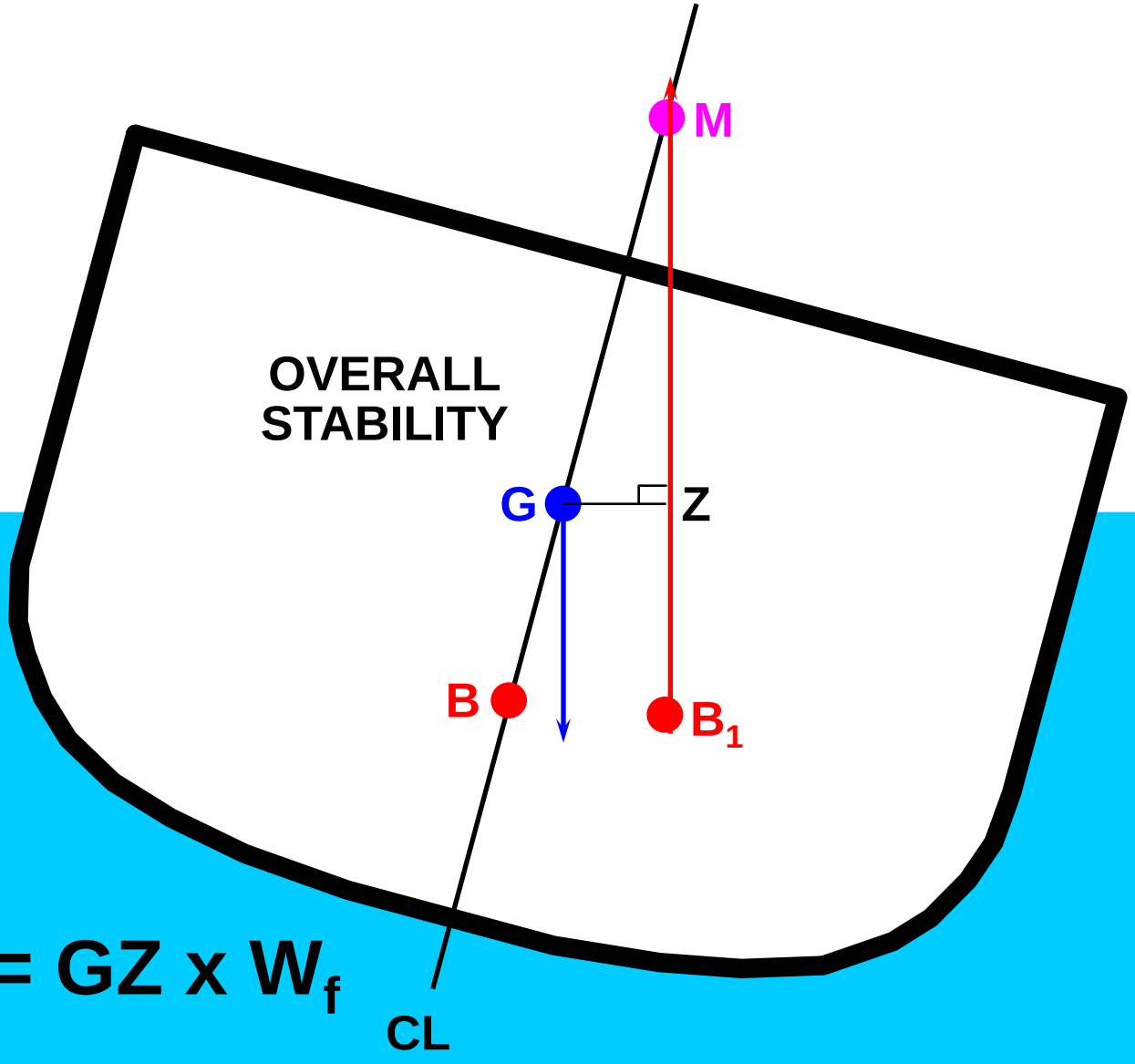



M
G1
G
B
K
CL

AS GM DECREASES
RIGHTING ARM
ALSO DECREASES




M
INITIAL
STABILITY
G
B
0 - 7°
CL



$$RM = GZ \times W_f$$

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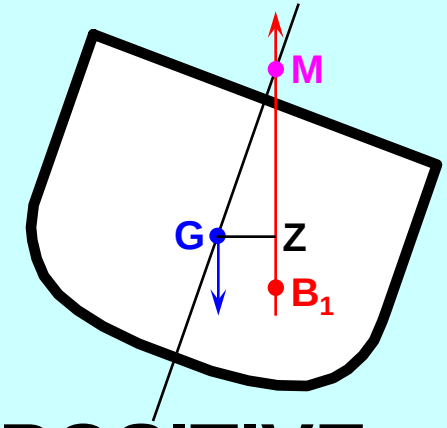
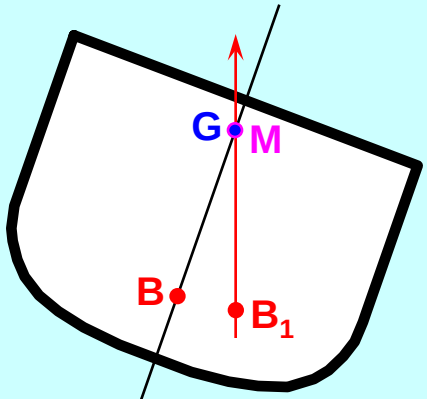
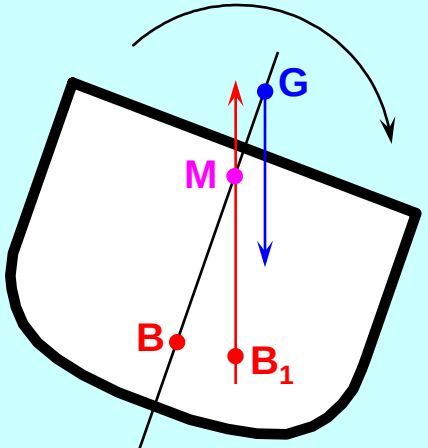
THE THREE CONDITIONS OF STABILITY



POSITIVE

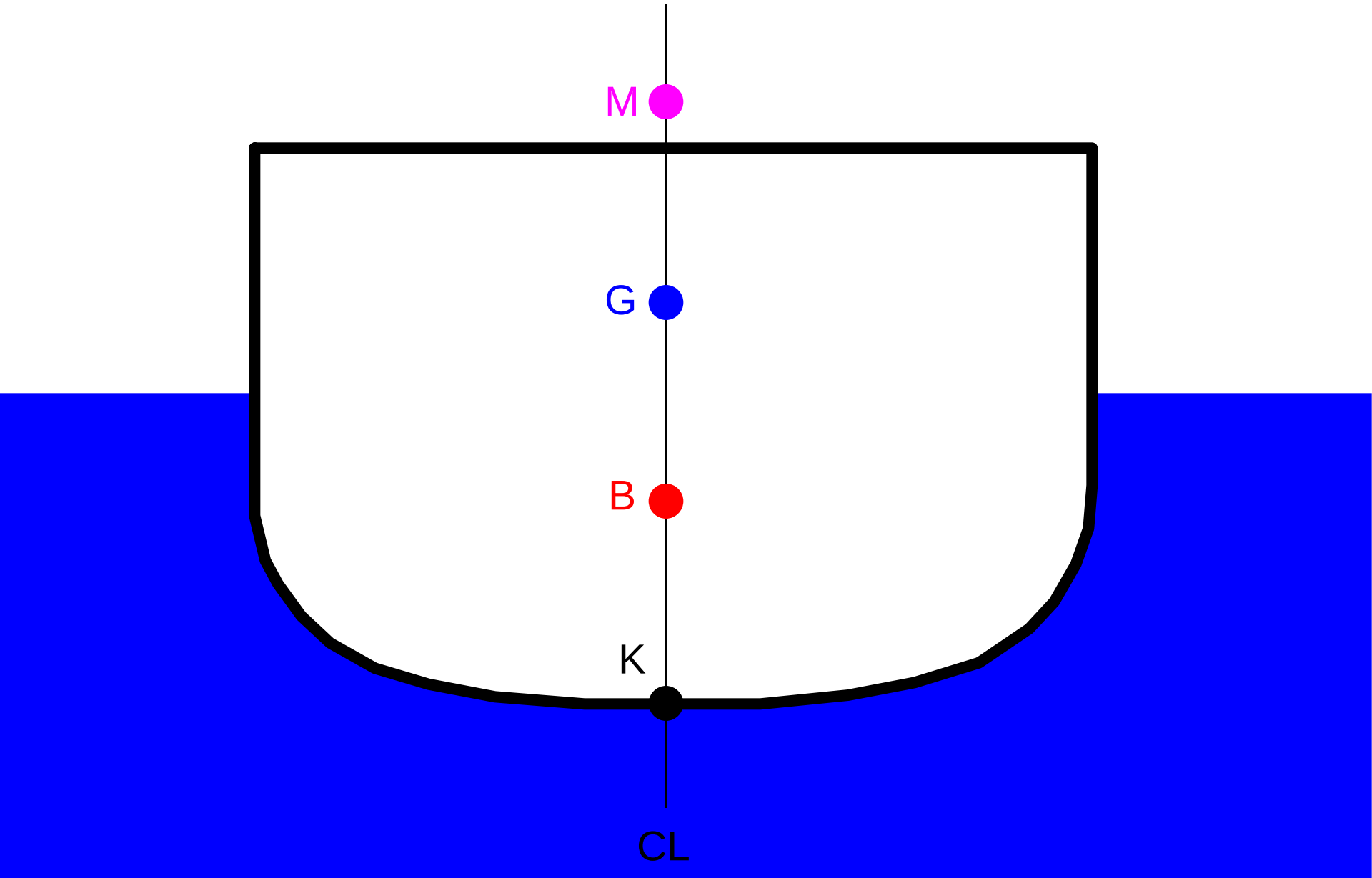


NEUTRAL

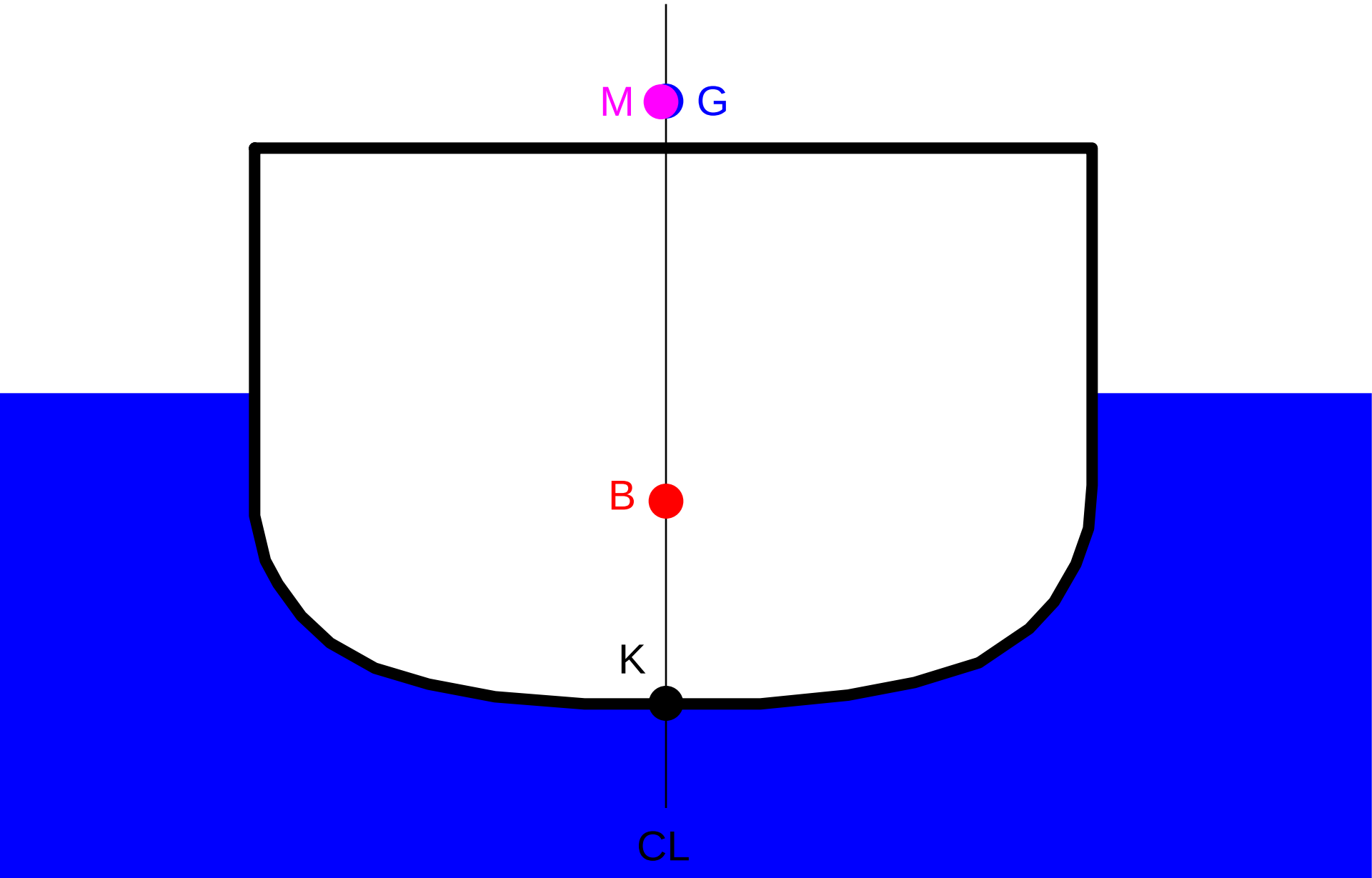


NEGATIVE

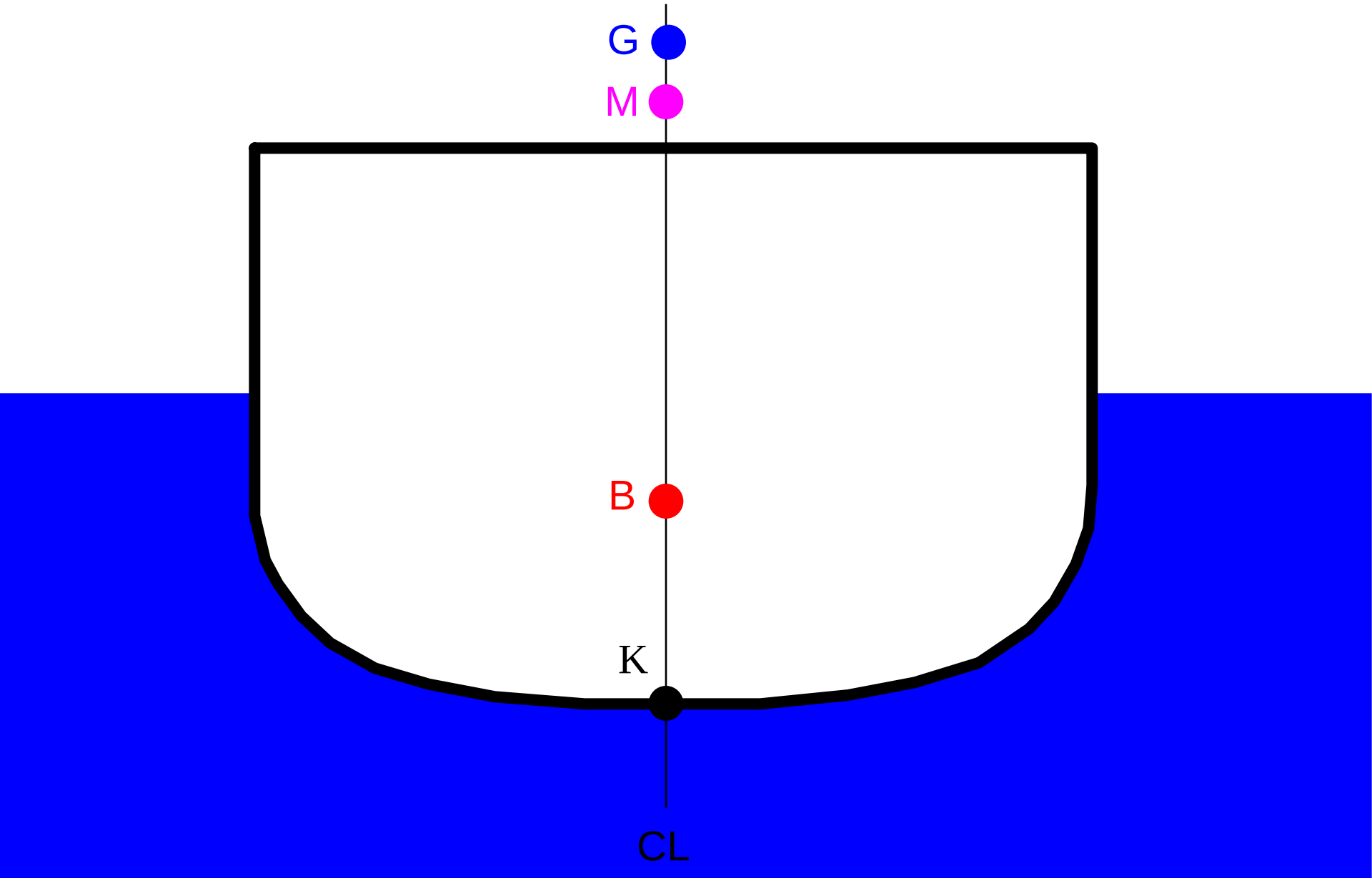
POSITIVE STABILITY



NEUTRAL STABILITY



NEGATIVE STABILITY



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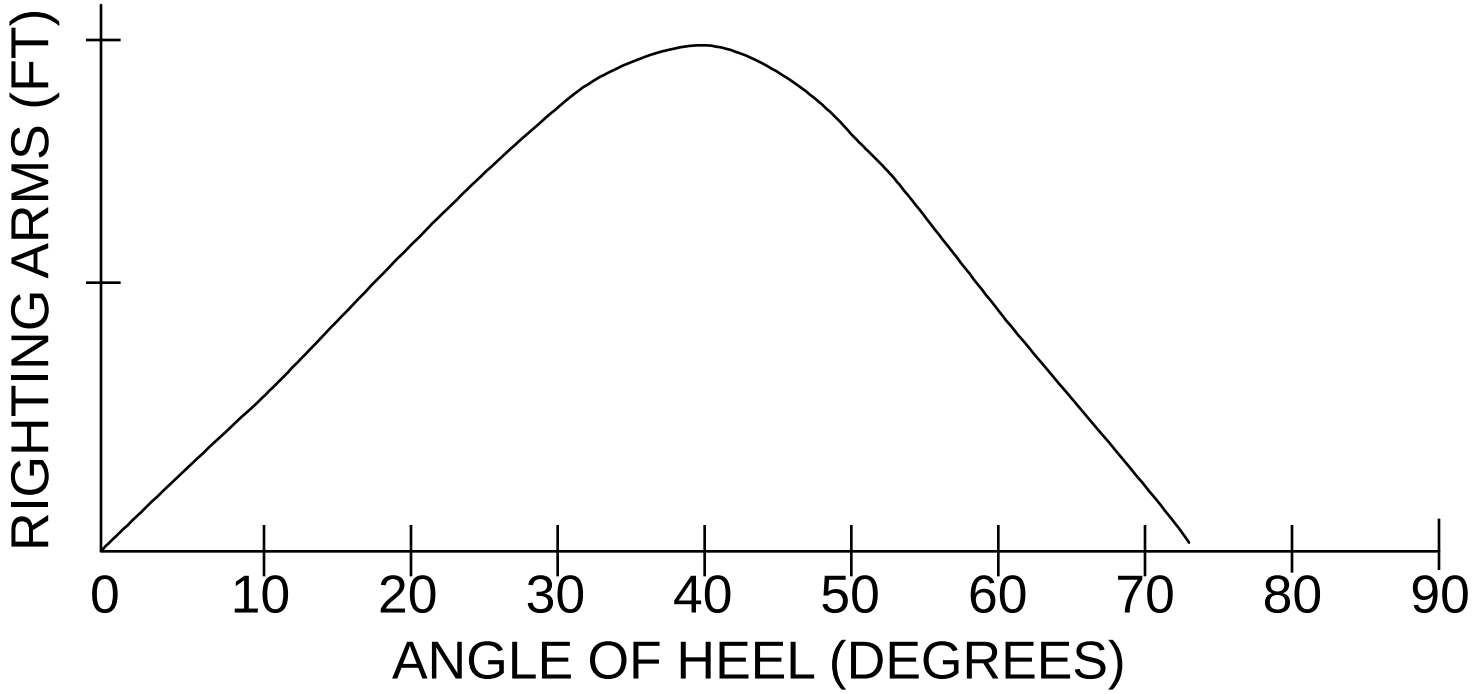
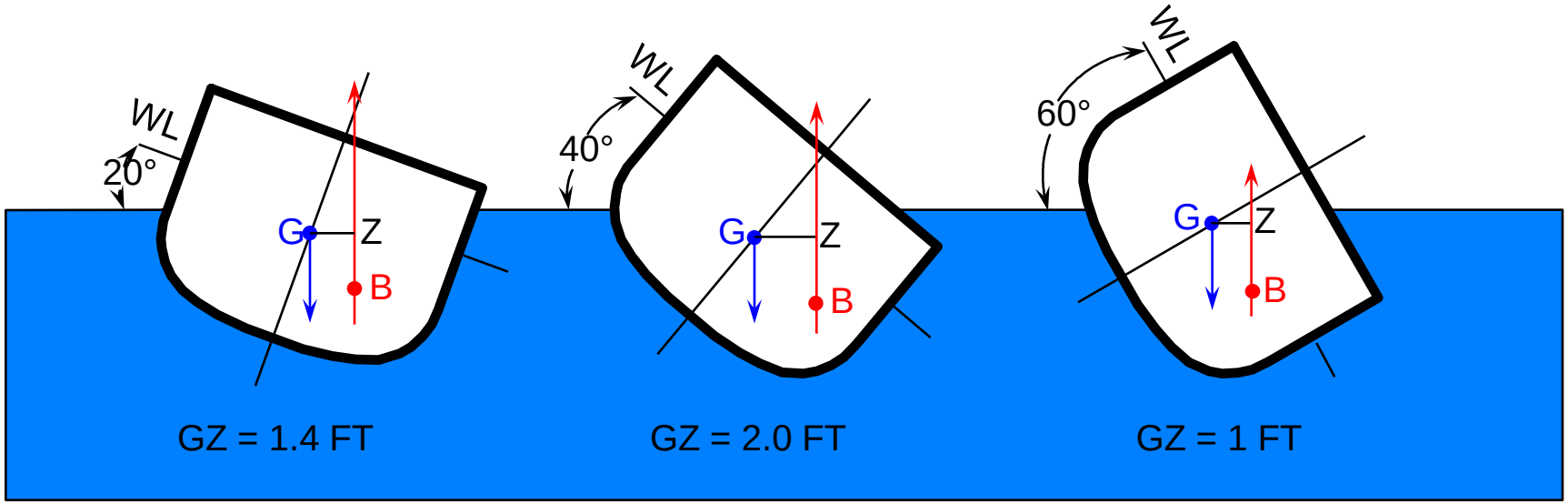
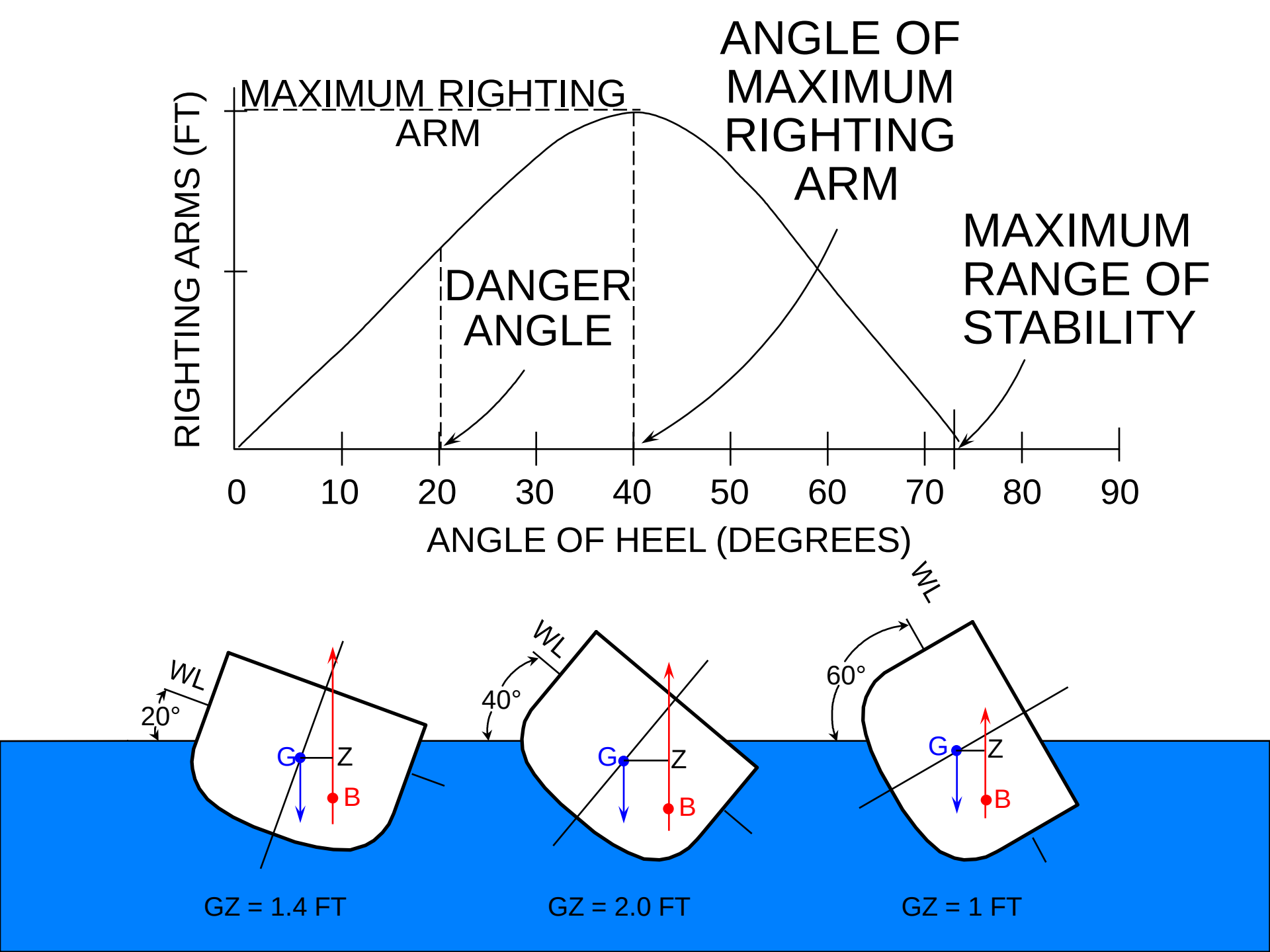
RIGHTING ARM CURVE






ANGLE OF MAXIMUM RIGHTING ARM
MAXIMUM RIGHTING ARM
MAXIMUM RANGE OF STABILITY
DANGER ANGLE
RIGHTING ARMS (FT)
0
10
20
30
40
50
60
70
80
90
ANGLE OF HEEL (DEGREES)
WL
20°
G
Z
B
GZ = 1.4 FT
WL
40°
G
Z
B
GZ = 2.0 FT
WL
60°
G
Z
B
GZ = 1 FT

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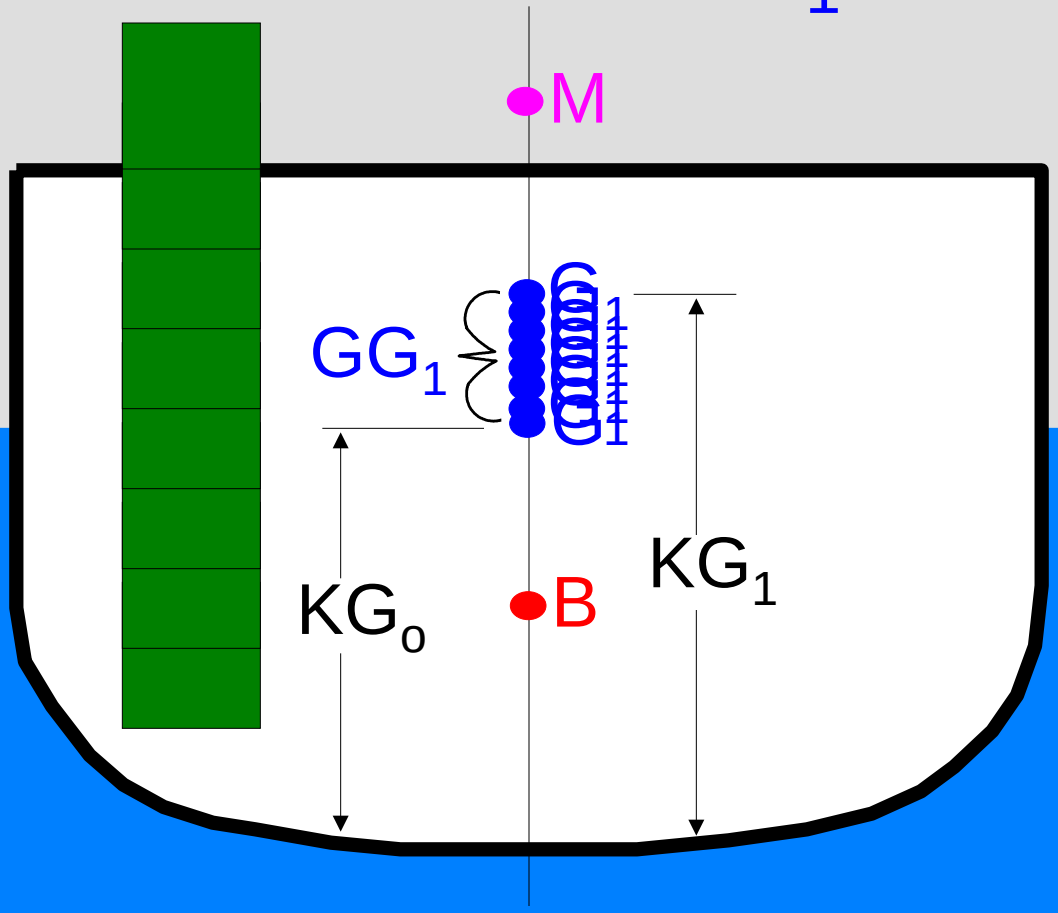
Vertical Weight Shifts

$$GG_1 = KG_1 - KG_o$$



$$KG_1 = \frac{(Wo \times KGo) \pm (w \times kg)}{W_f}$$

WHERE;

w = Weight Shifted

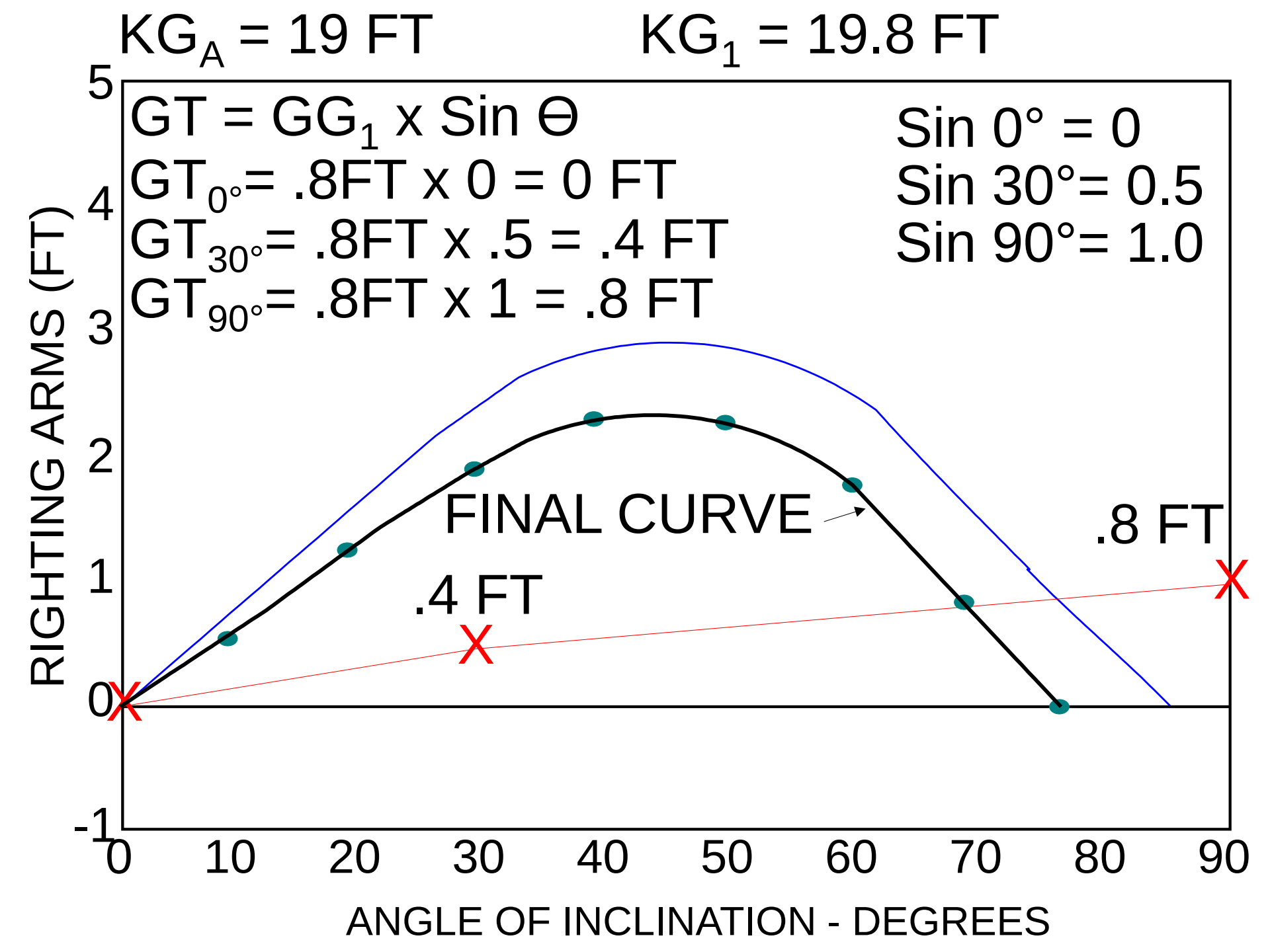
kg = Distance Shifted

W_o = Original Displacement

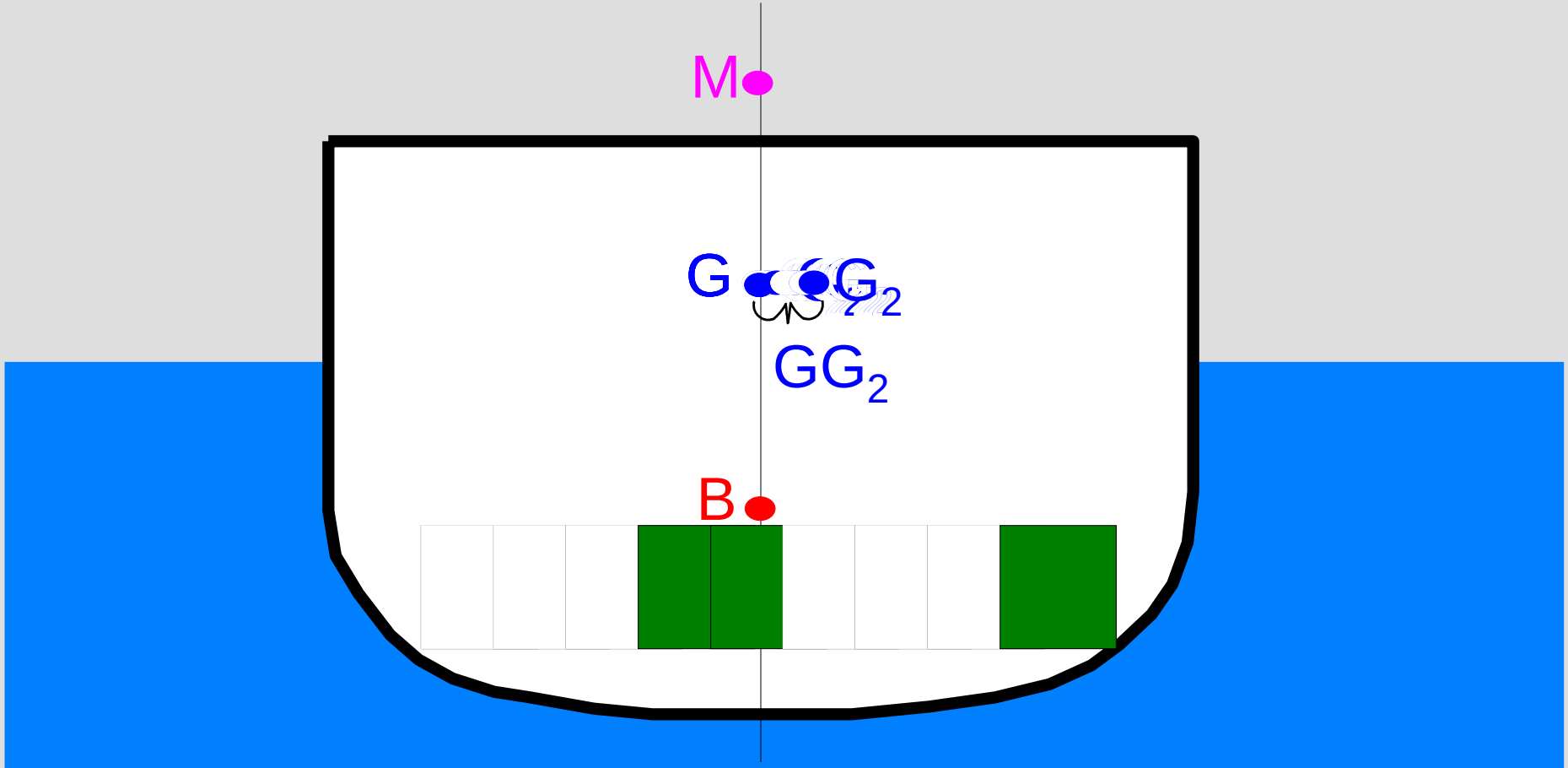
KG_o = Original Height of G

W_f = Final Displacement

± = + if shift up/- if shift down


KG_A = 19 FT
KG_1 = 19.8 FT
$GT = GG_1 \times \sin \Theta$
$GT_{0°}$= .8FT x 0 = 0 FT
$GT_{30°}$= .8FT x .5 = .4 FT
$GT_{90°}$= .8FT x 1 = .8 FT
Sin 0° = 0
Sin 30°= 0.5
Sin 90°= 1.0
FINAL CURVE
.8 FT
.4 FT
RIGHTING ARMS (FT)
5
4
3
2
1
0
-1
0
10
20
30
40
50
60
70
80
90
ANGLE OF INCLINATION - DEGREES

Horizontal Weight Shifts



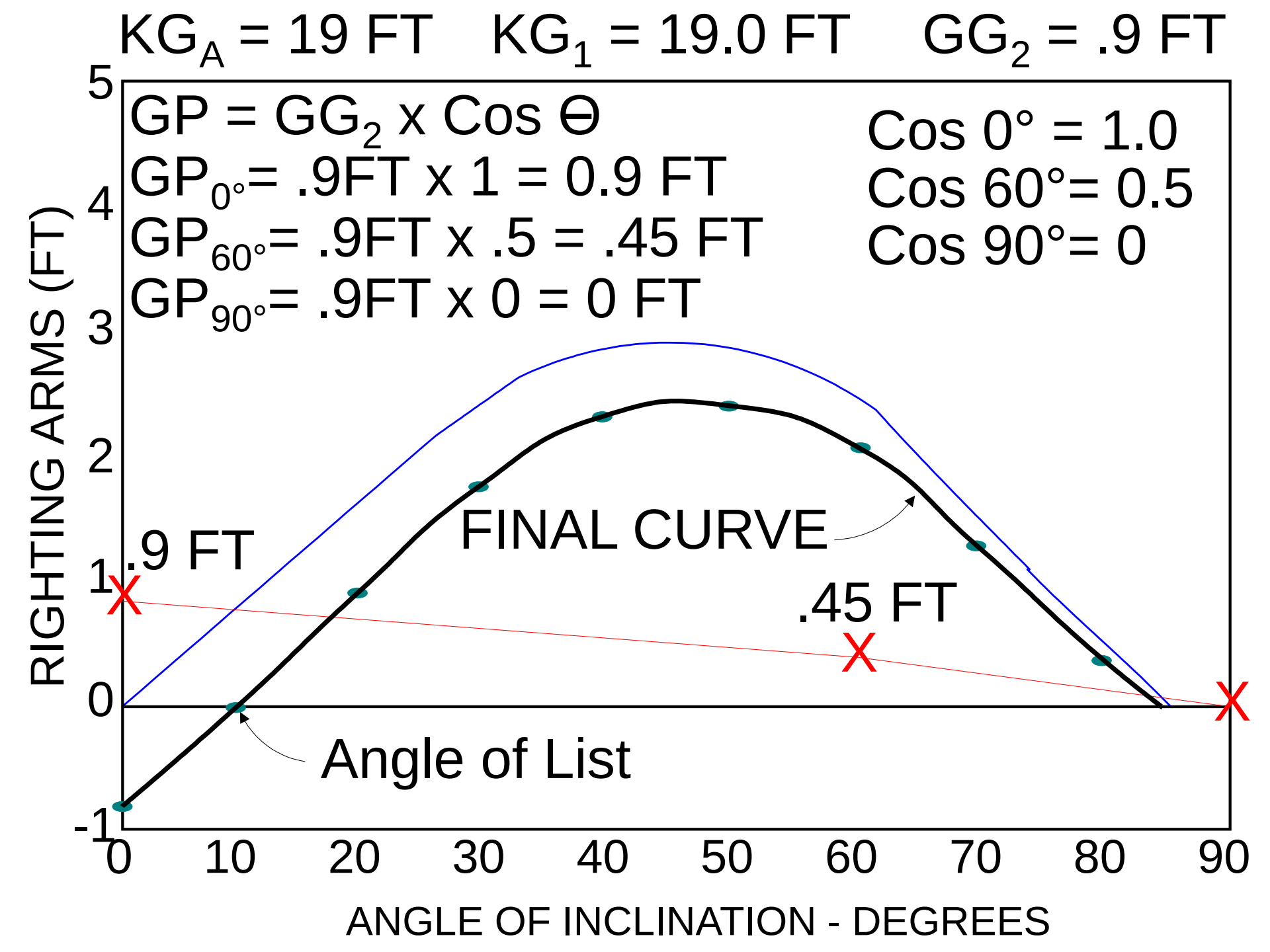
$$GG_2 = \frac{w \times d}{W_f}$$

WHERE;

w = Weight Added or Removed

d = Distance Added/Removed from Centerline

W_f = Final Displacement


KG$_A$ = 19 FT
KG$_1$ = 19.0 FT
GG$_2$ = .9 FT
GP = GG$_2$ x Cos Θ
GP$_{0°}$= .9FT x 1 = 0.9 FT
GP$_{60°}$= .9FT x .5 = .45 FT
GP$_{90°}$= .9FT x 0 = 0 FT
Cos 0° = 1.0
Cos 60°= 0.5
Cos 90°= 0
RIGHTING ARMS (FT)
5
4
3
2
1
0
-1
.9 FT
FINAL CURVE
.45 FT
Angle of List
0
10
20
30
40
50
60
70
80
90
ANGLE OF INCLINATION - DEGREES

FREE SURFACE EFFECT

$$GG_3 = \frac{\mathbf{B}^3 \times L}{12 \times 35 \times W_f}$$

B = BREADTH OF COMPT
L = LENGTH OF COMPT
W_f = SHIP'S DISPLACEMENT

FREE SURFACE EFFECT

- Greater with increased length and width of the compartment
- Increases as draft decreases (de-ballasting)
- Independent of the depth of the liquid
- Can be reduced by pocketing

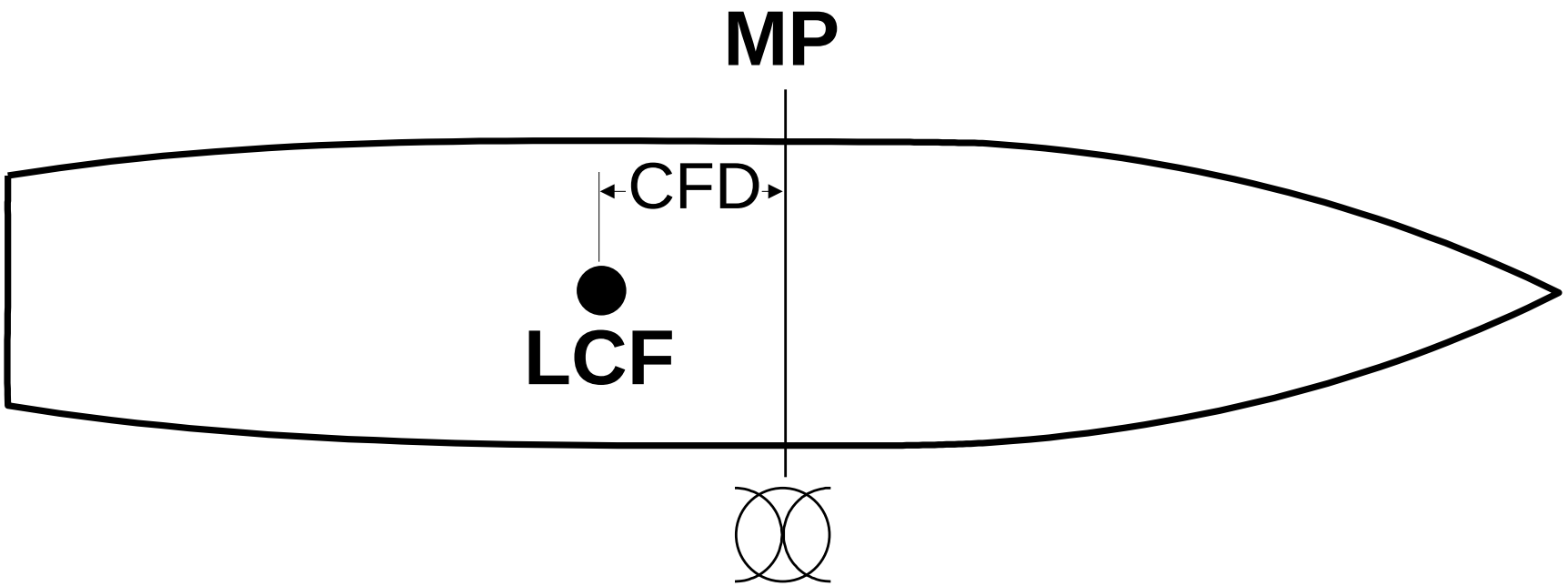
FREE COMMUNICATION EFFECT

$$G_3G_5 = \frac{B \times L \times \mathbf{Y}^2}{35 \times W_f}$$

B = BREADTH OF COMPT
L = LENGTH OF COMPT
Y = DIST FM SHIP C/L TO COMPT COG.
W_f = SHIP'S DISPLACEMENT

FREE COMMUNICATION EFFECT

- COMPARTMENT OPEN TO THE SEA
- COMPARTMENT PARTIALLY FLOODED
- COMPARTMENT OFF-CENTERLINE OR ASYMMETRICAL ABOUT THE CENTERLINE



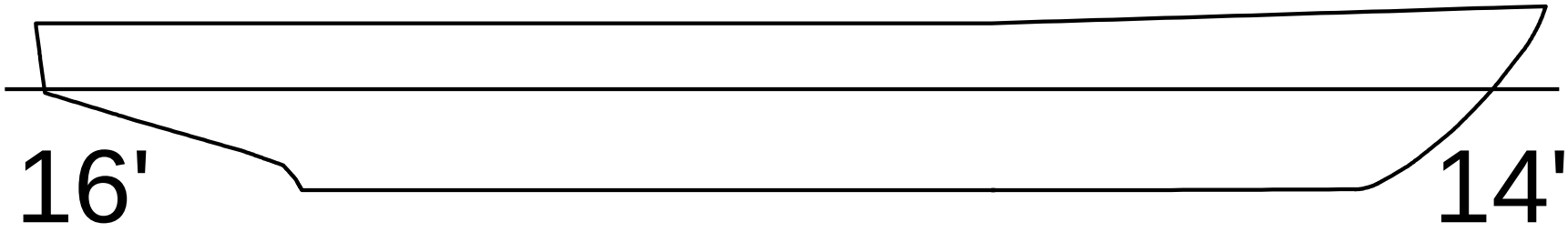
LCF - The Longitudinal Center of Flotation

DRAG - A design feature having the draft aft greater than the draft fwd. *Primarily done to increase plant effectiveness.*

DRAG = 2 FT By the Stern

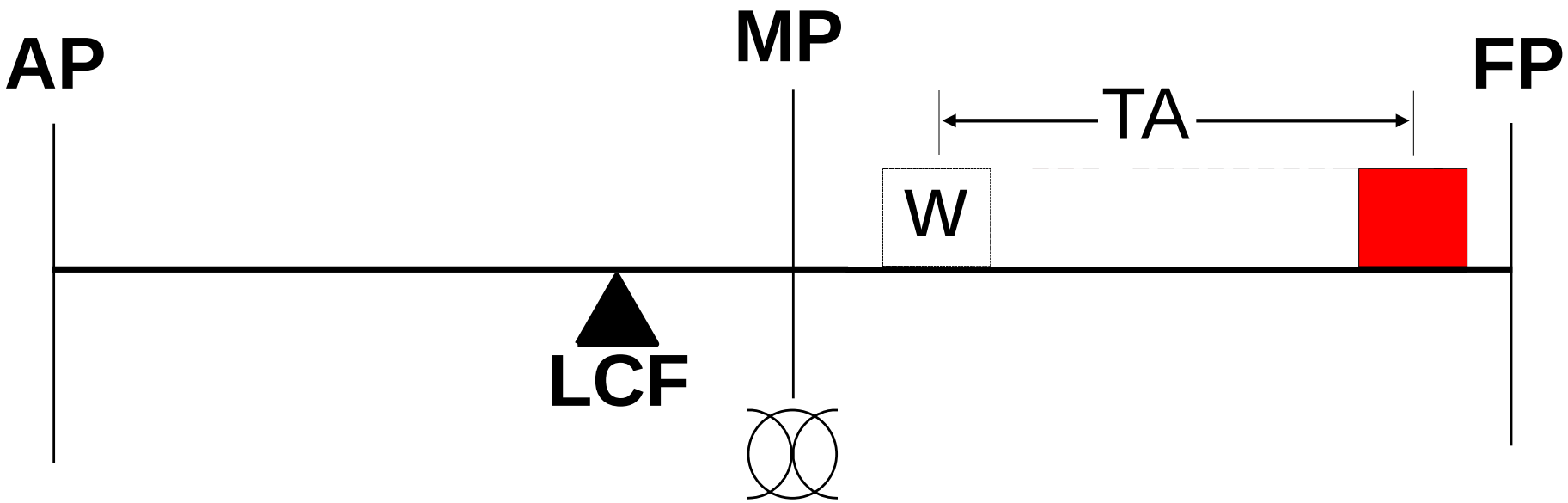
TRIM - The difference between the forward and after drafts in excess of drag.

DRAG = 0



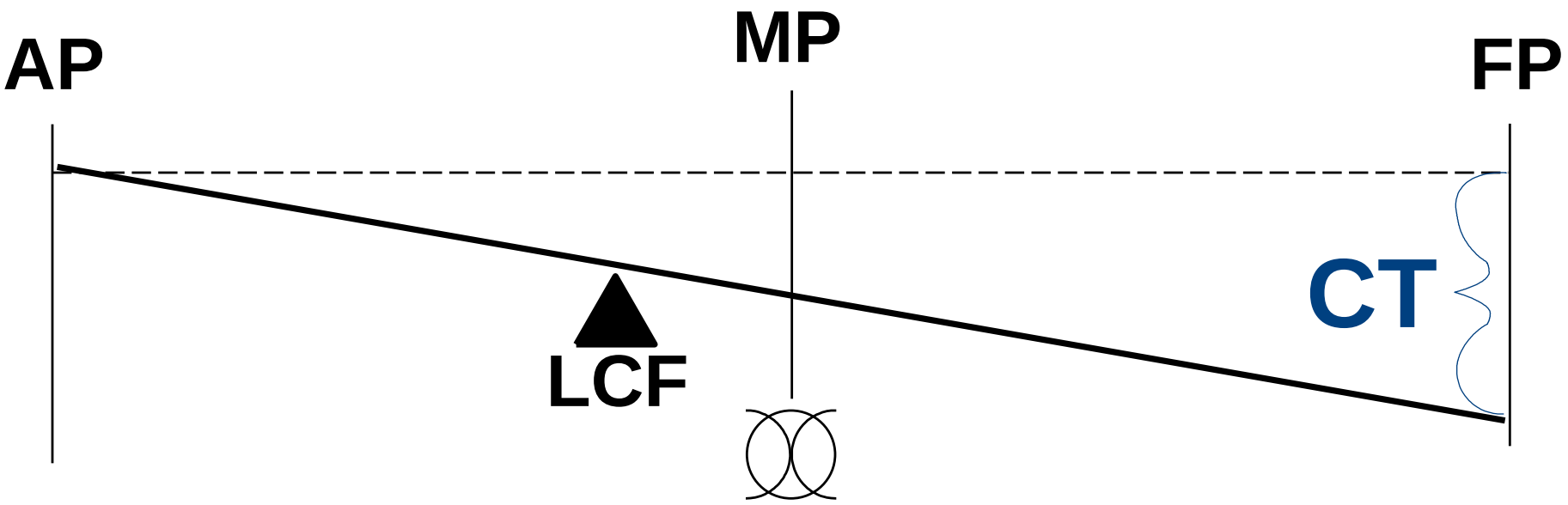
TRIM = 2 FT By the Stern

Trimming Moment = w x TA



Change in Trim(CT) = $\frac{TM}{MT1"}$

Trimming Moment = w x TA



$$\text{Change in Trim(CT)} = \frac{\text{TM}}{\text{MT1"}}$$

$$\frac{\triangle d_f}{LBP/2 + LCF} = \frac{CT}{LBP}$$

$$\triangle d_f = \frac{(LBP/2 + LCF)}{LBP} \times CT$$

$$CT = \triangle d_f + \triangle d_a$$

$$\triangle d_a = CT - \triangle d_f$$

PARALLEL SINKAGE = $\frac{w}{TPI}$

Parallel Sinkage (PS) is the distance that the drafts fore and aft increase due to a weight addition.

Parallel Rise (PR) is the distance that the drafts fore and aft **decrease** due to a weight removal.

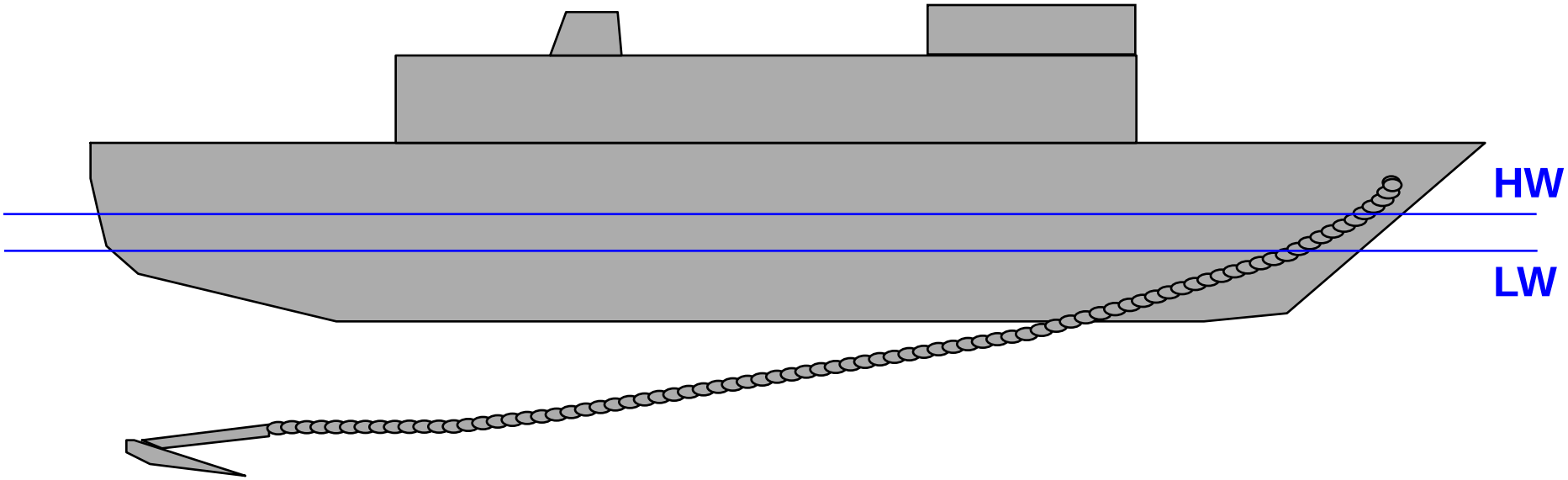
PARALLEL RISE = $\frac{-w}{TPI}$

ABILITY TO REFLOAT

"IF THE PROPS ARE REVERSED AND THERE IS **NO TENDENCY** OF THE SHIP **TO BACK AWAY** FROM THE BEACH, **NO FURTHER ATTEMPTS** TO MOVE THE SHIP BY MEANS OF THE PROPELLERS SHOULD BE USED."

NSTM 079 VOL 1
REPAIR PARTY MANUAL
NTTP 3-20.31

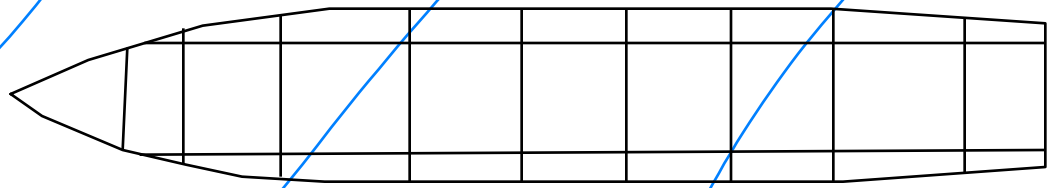
BRIDGE ACTIONS



- RIG GROUND TACKLE & KEDGE ANCHORS (IF POSSIBLE)
- COORDINATE LIGHTENING SHIP WITH HIGH TIDE
- TAKE A STRAIN ON GROUND TACKLE
- REQUEST SALVAGE ASSISTANCE

DCA ACTIONS

- WEIGH THE SHIP DOWN HARD



AGROUND: DCA ACTION

WEIGH THE SHIP DOWN HARD

INVESTIGATE FOR DAMAGE

- **SOUND ALL TANKS & VOIDS**
- **CHECK FUEL TANKS FOR LEAKAGE**
- **STRUCTURAL DAMAGE?**
- **EXTENSIVE SOUNDINGS *(LOWER SMALL BOATS)***
  - ✓ **ABOUT THE SHIP**
  - ✓ **SEAWARD**

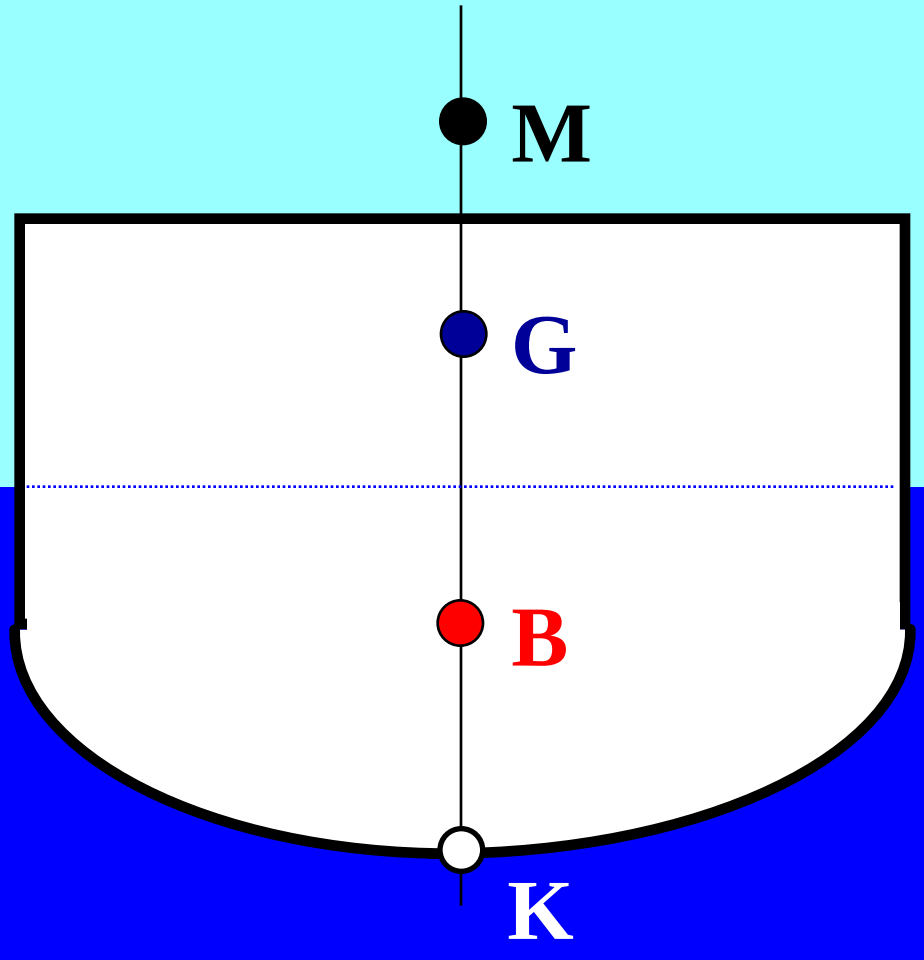
AGROUND: DCA ACTION

DETERMINE AMOUNT OF TONS AGROUND

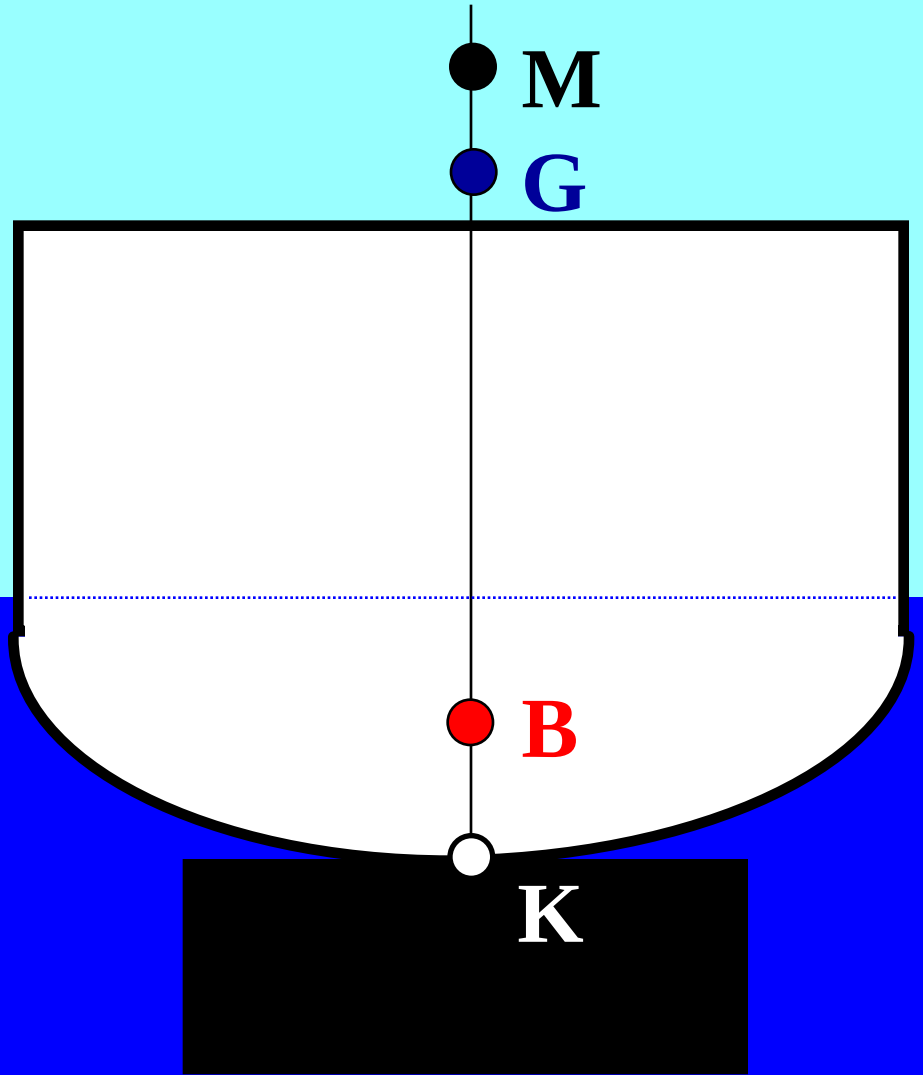
- FM KNOWN DRAFTS, DETERMINE ORIGINAL DISPLACEMENT
- READ DRAFTS AFTER AGROUND
- DETERMINE NEW DISPLACEMENT
- DIFFERENCE EQUALS TONS AGROUND

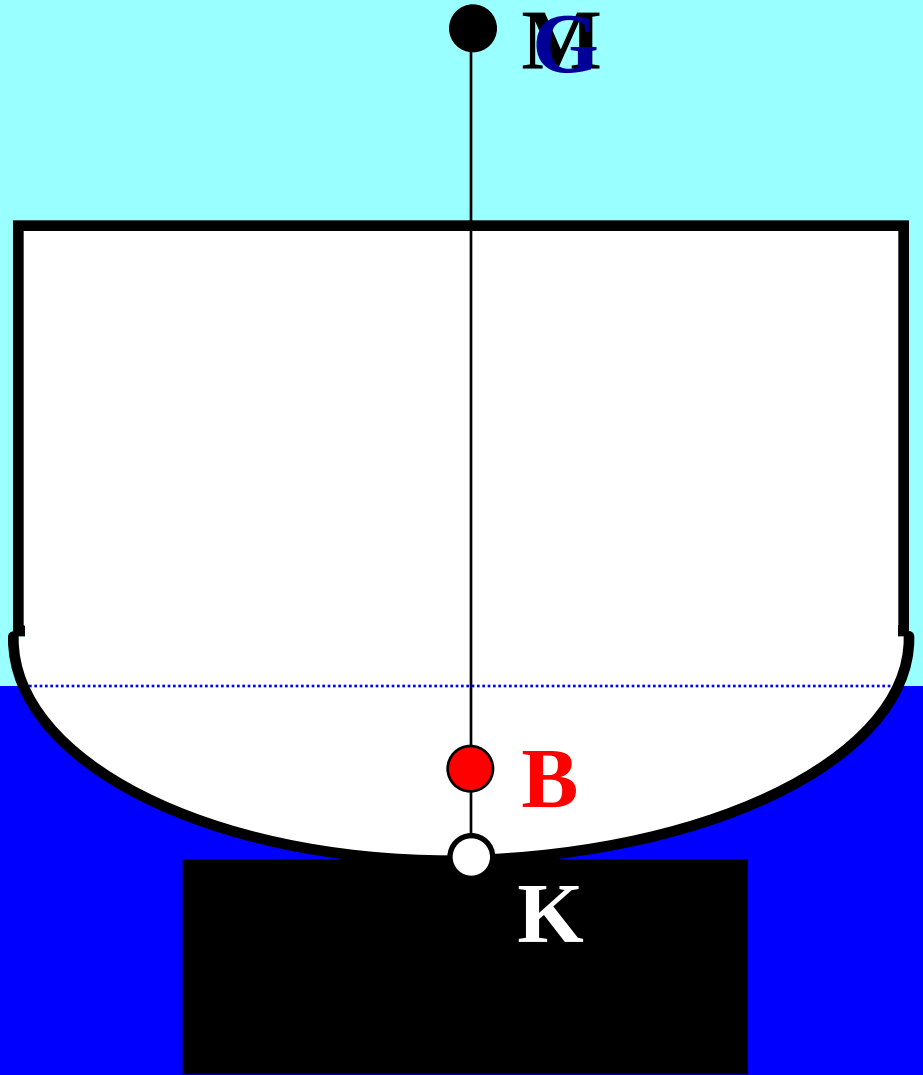
CALCULATE CRITICAL DRAFT

- IF STABILITY IS CRITICAL, LOWER G & ESTIMATE TIME
- ELIMINATE HIGH WEIGHT
- FLOOD LOW COMPARTMENTS


M
G
B
K

Remember: G moves faster than M!!




M
G
B
K

HULL GIRDER STRESS

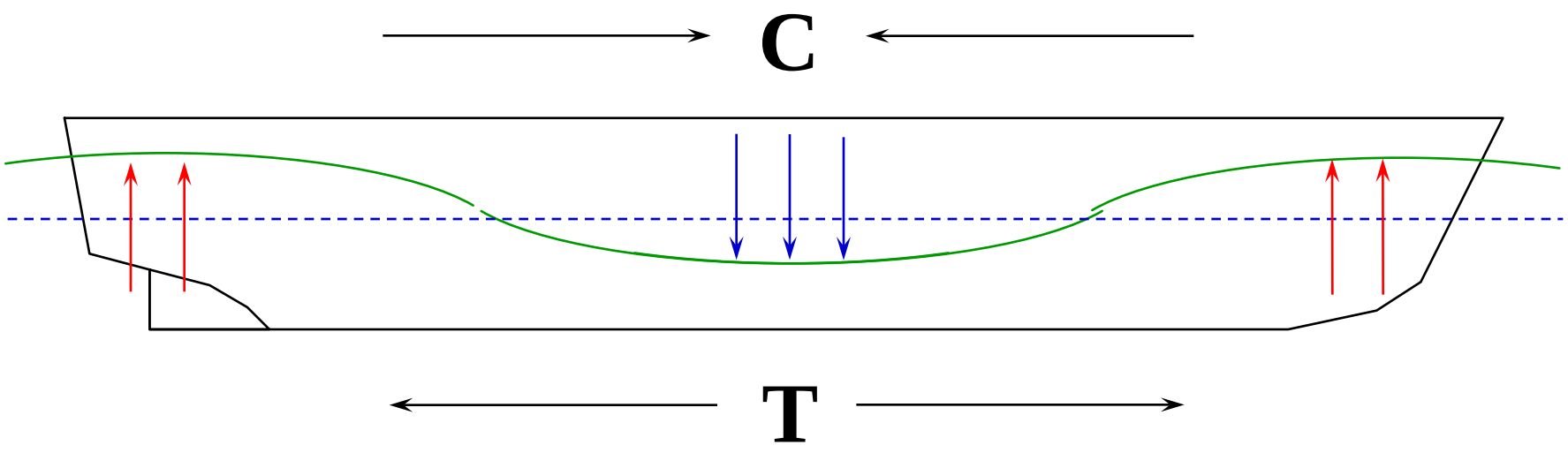
INDICATORS

-SHIP IS HOGGING OR SAGGING
-STRESS FRACTURES, CRACKS, "CRINKLING", OR PANTING OF BULKHEADS, DECKS AND STIFFENERS

ACTIONS

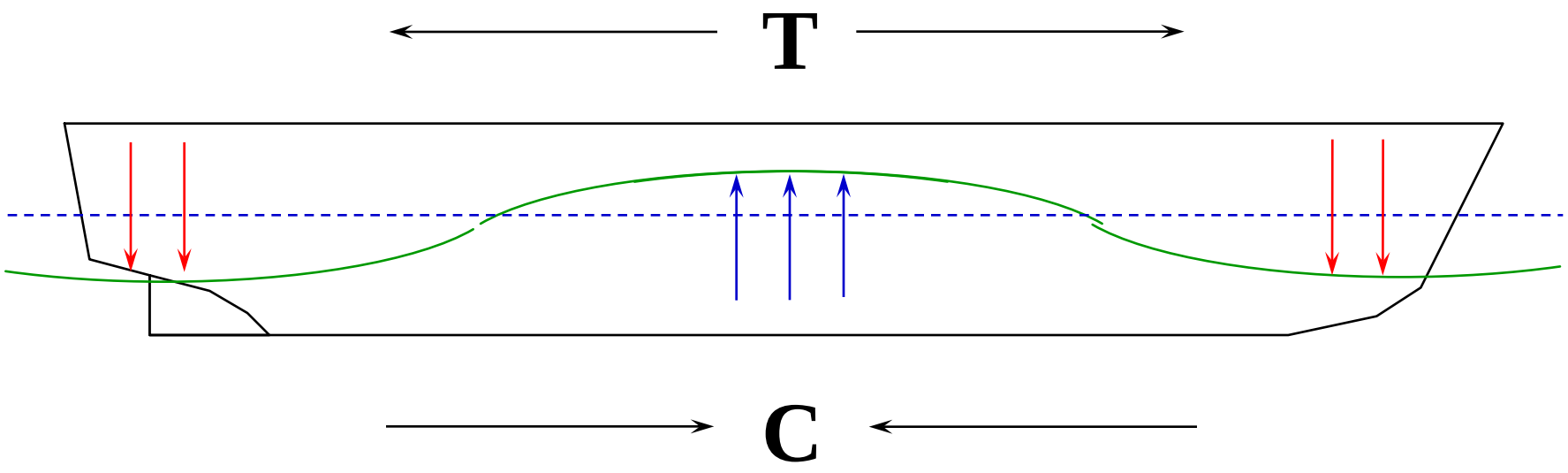
-RELIEVE HOGGING OR SAGGING
-SHORE UP BULKHEADS/DECKS.
-REINFORCE WHERE POSSIBLE.

Sagging Stresses



***Quiz**: What would be the corrective actions??*

Hogging Stresses



Docking

- Transfer of Responsibility
- Pumping of Drydock
  - Upon Touching Blocks: Hull Inspection
- Dock Pumped Dry
- Hull Board Inspection
  - Ship Properly Docked and Shores in Place
  - NOTE Condition of Screws, Rudders, Sea Suctions & Discharges, Cathodic Protection, **ANY DAMAGE**

Undocking

- Ensure all Sea Valves Have Been Properly Reinstalled
- Man All Spaces with Sea Valves
- Augment Sounding and Security Watches
- Docking Officer Provide Ship with Undocking Report

"IF PERSONNEL WAIT UNTIL CATASTROPHE IS ACTUALLY IMPENDING BEFORE STARTING TO LEARN THEIR SHIP BY MEANS OF THE FOREGOING PREPARATORY MEASURES, THE SHIP AND ITS COMPANY MAY BE LOST."

NSTM 079 VOL I

"IF PERSONNEL WAIT UNTIL CATASTROPHE IS ACTUALLY IMPENDING BEFORE STARTING TO LEARN THEIR SHIP BY MEANS OF THE FOREGOING PREPARATORY MEASURES, THE SHIP AND ITS COMPANY MAY BE LOST."

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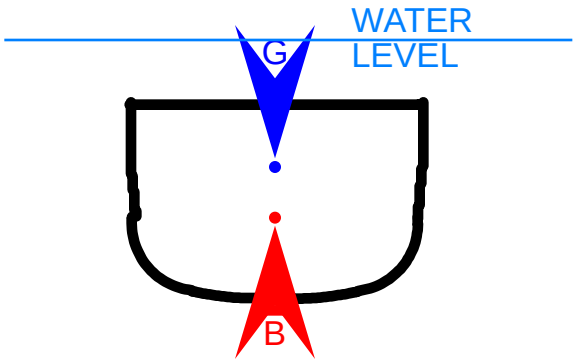
NSTM 079 VOL I

SHIP SINKINGS

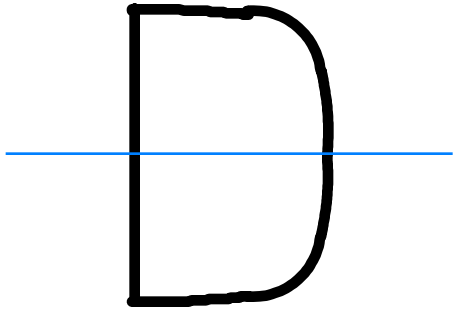
- **BODILY SINKAGE**

  LOSS OF BUOYANCY



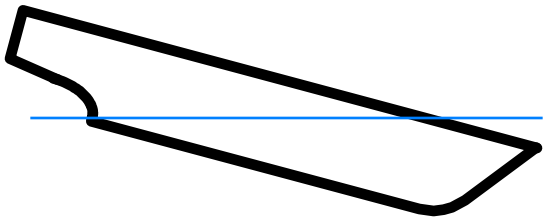
- **CAPSIZING**

  LOSS OF TRANSVERSE STABILITY



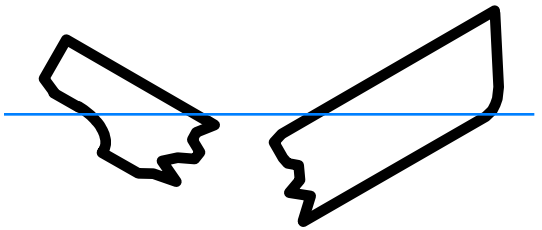
- **PLUNGING**

  LOSS OF LONGITUDINAL STABILITY



- **BREAKING UP**

  LOSS OF SHIP'S GIRDER



METACENTRIC HEIGHT

RIGHTING ARM (GZ) IS PROPORTIONAL TO METACENTRIC HEIGHT (GM)

A SHIP WITH:

LARGE GM IS STIFF AND RESISTS ROLLS

SMALL GM IS TENDER AND ROLLS EASILY AND SLOWLY

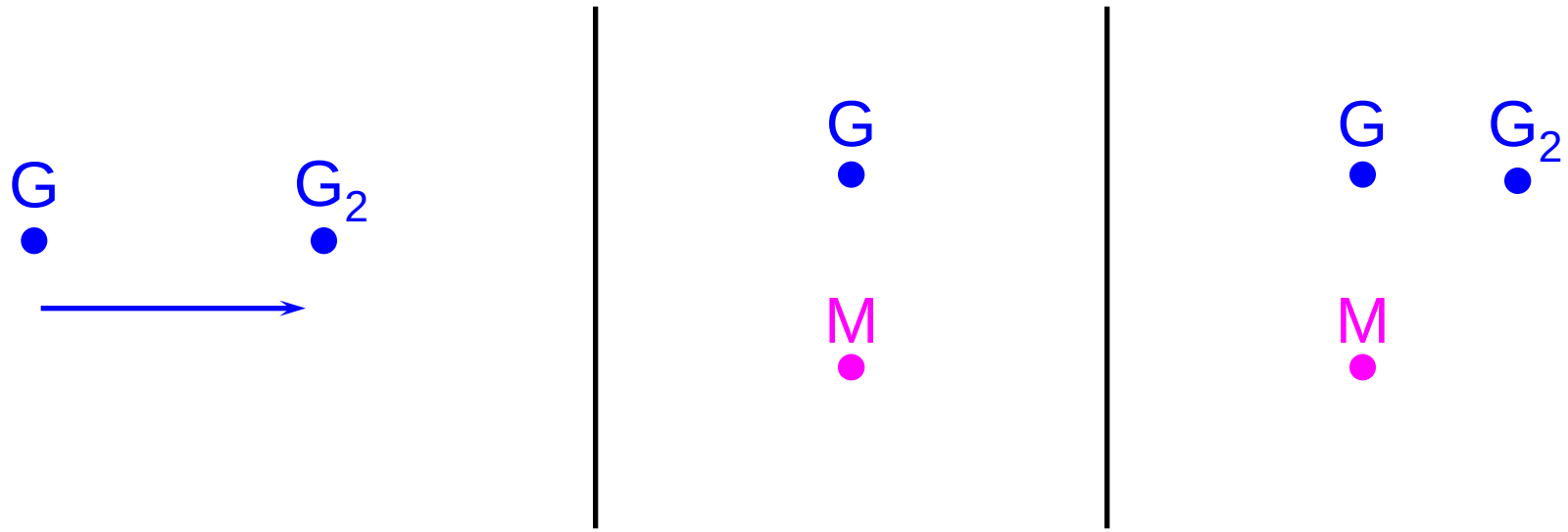
VERY SMALL GM IS APT TO HANG AT THE END OF EACH ROLL BEFORE STARTING UPRIGHT

SLIGHTLY NEGATIVE GM IS APT TO LOLL (STAYING HEELED AT ANGLE OF INCLINATION WHERE RIGHTING AND UPSETTING FORCES ARE EQUAL) AND FLOP FROM SIDE TO SIDE

NEGATIVE GM WILL CAPSIZE WHEN INCLINED

3 BASIC CONDITIONS WHICH MAY CAUSE THE SHIP TO TAKE ON A PERMANENT LIST:

- G MOVED OFF CENTERLINE (99%)
- -GM (1%)
- COMBINATION OF -GM AND G OFF CL



CAUSES of -GM

1. Removal of low weights
2. Addition of high weights (ice)
3. Moving weights upward
4. Free Surface Effect
5. Free Communication Effect

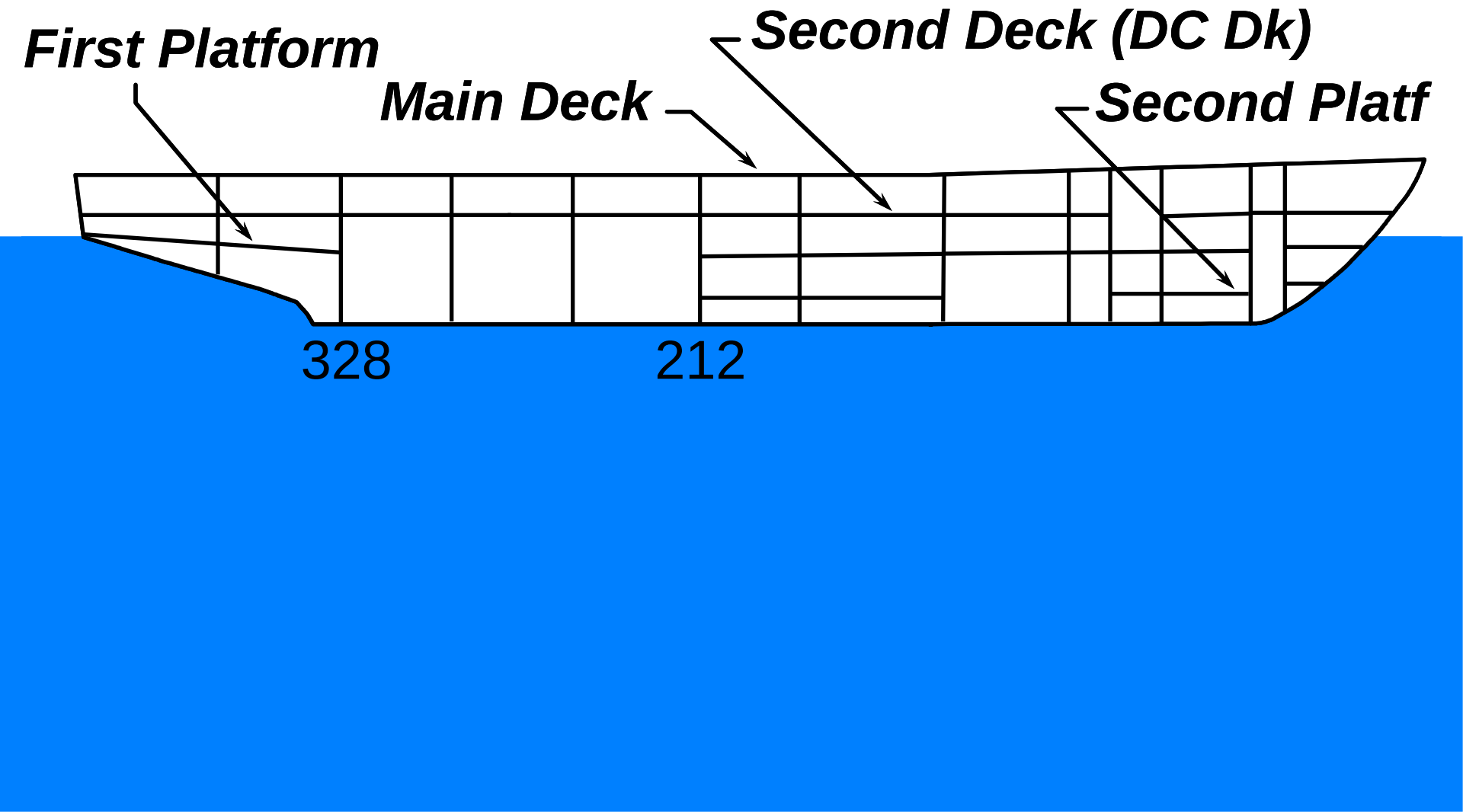
FLOODABLE LENGTH

A LIST OF FLOODABLE COMPARTMENT GROUPS IS OFTEN FOUND. FOR EXAMPLE, FOR A FFG-7:

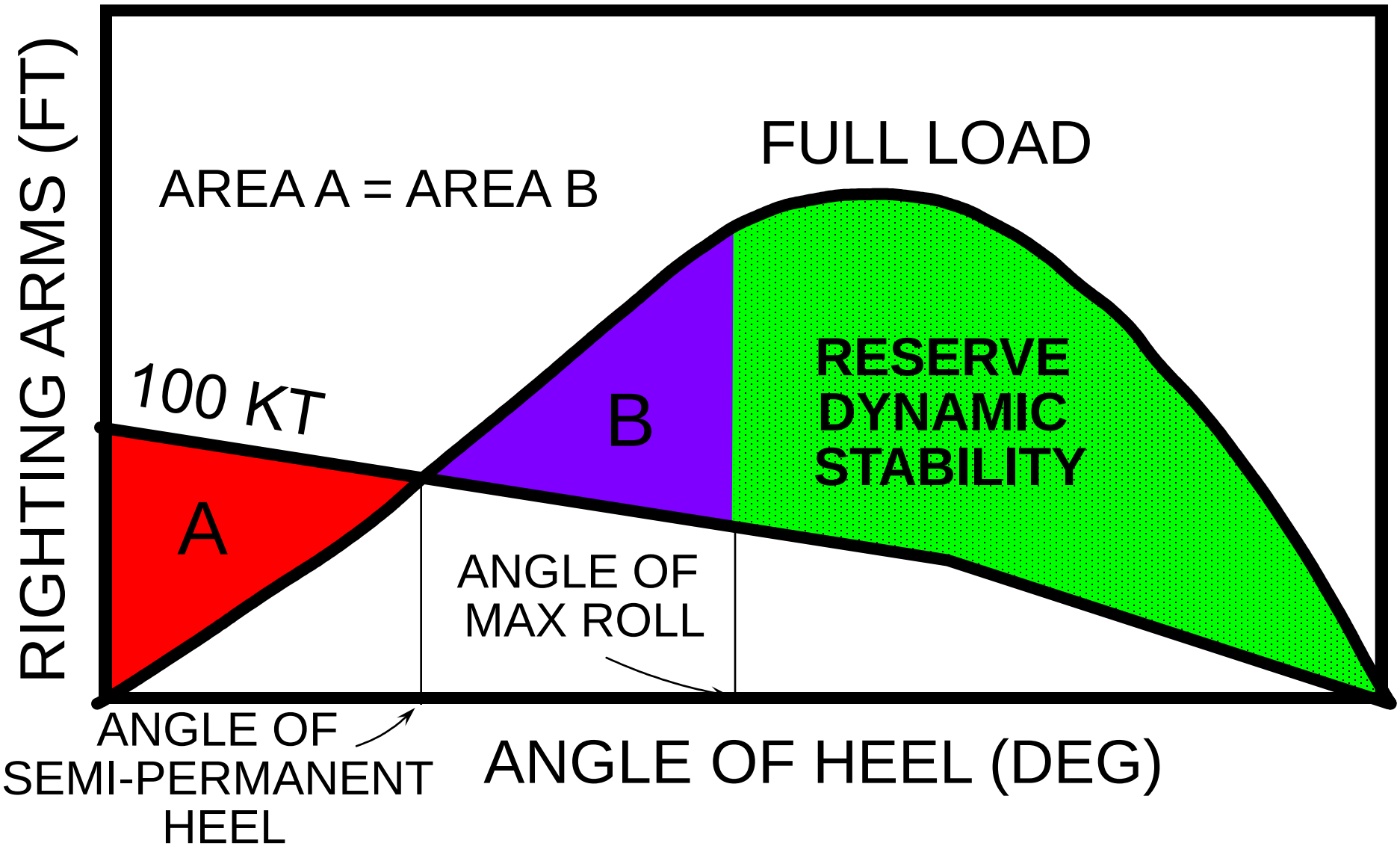
STEM - FRAME 100
FRAMES - 32-140
FRAMES - 64-180
FRAMES - 100-212
FRAMES - 140-250
FRAMES - 180-292
FRAMES - 212-328
FRAMES - 250-368
FRAMES - 292-STERN

GENERAL RULE: SHIP'S LBP > 300 FT ↗ 15% LBP
< 300 FT ↗ 2 SPACES
<100 FT ↗ 1 SPACE

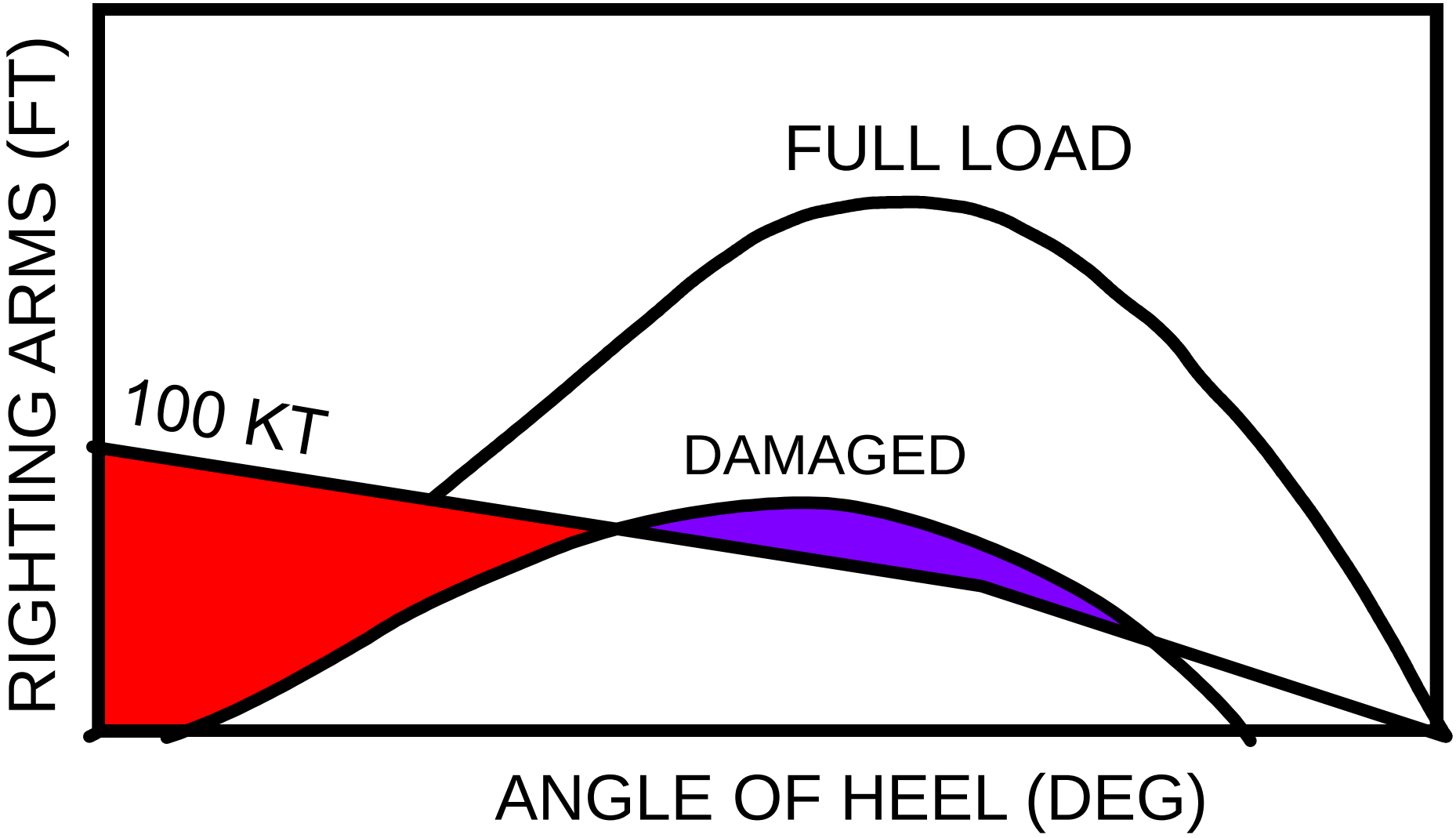
FLOODABLE LENGTH DAMAGE



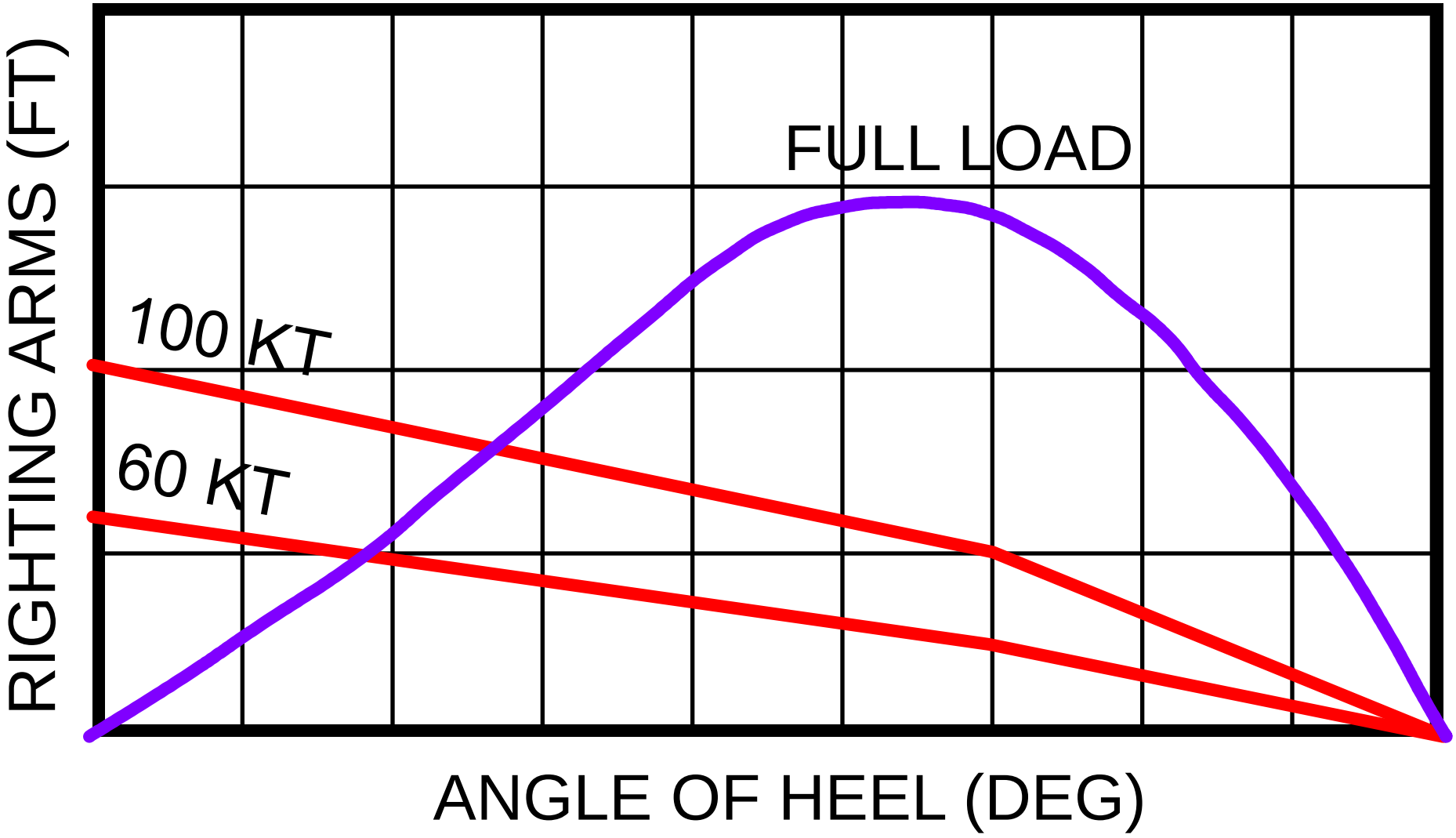
HEELING EFFECTS OF BEAM WINDS



HEELING EFFECTS OF BEAM WINDS



HEELING EFFECTS OF BEAM WINDS



Limitations to Ship's Design Criteria

In order to maintain a satisfactory condition with regard to stability and reserve buoyancy, the following guidelines must be adhered to:

- Limiting Draft Marks not Submerged Prior to Damage
- No Abnormal Topside Weights
- Liquid Loading Instructions are Followed
- Watertight Integrity is Maintained

IMMEDIATE STEPS

STEP ONE -

ESTABLISH FLOODING BOUNDARIES

STEP TWO -

DEWATER ANY SPACE COLORED PINK
ON THE FLOODING EFFECTS DIAGRAM.

IMMEDIATE STEPS

STEP THREE -

SIZE UP THE SITUATION TO DETERMINE WHETHER STABILITY IS **CRITICAL** BEFORE ANY FURTHER ACTION IS TAKEN.

CRITICAL STABILITY

1. The ship has a negative GM

2. The ship is listing to the danger angle (1/2 angle of max GZ)

3. The extent of flooding exceeds floodable length.

4. High winds or rough seas combined with flooding

IMMEDIATE STEPS

STEP FOUR -

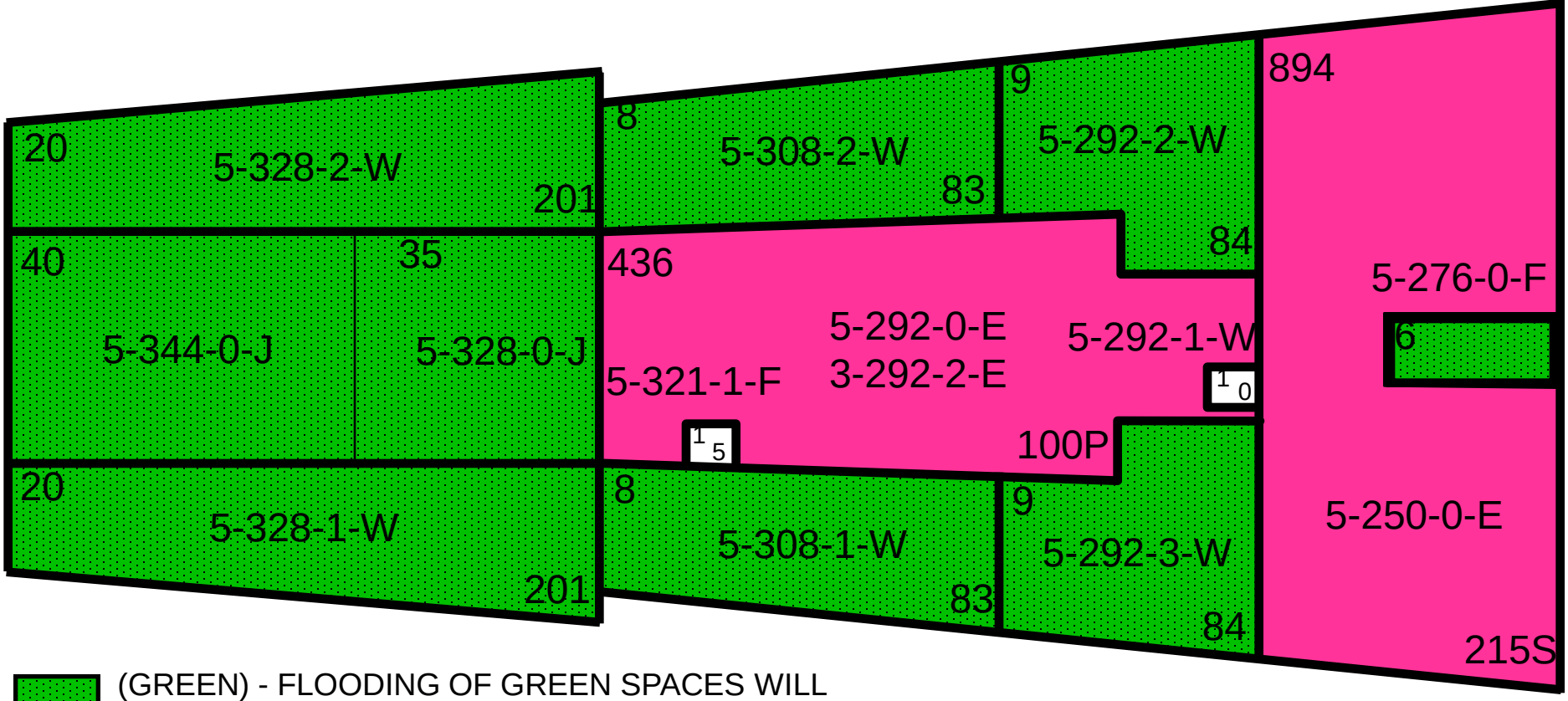
ELIMINATE OR REDUCE LIST

Don’t forget about:

EXCESSIVE TRIM (> 1% LBP)

ACTIONS

SHIFT CENTER OF GRAVITY TOWARDS "HIGH" END.



(GREEN) - FLOODING OF GREEN SPACES WILL IMPROVE STABILITY, EVEN THOUGH FREE SURFACE EXISTS.

(YELLOW) - FLOODING OF YELLOW SPACES WILL IMPROVE STABILITY IF NO FREE SURFACE EXISTS. IF SPACE IS NOT 100% FULL STABILITY WILL BE IMPAIRED.

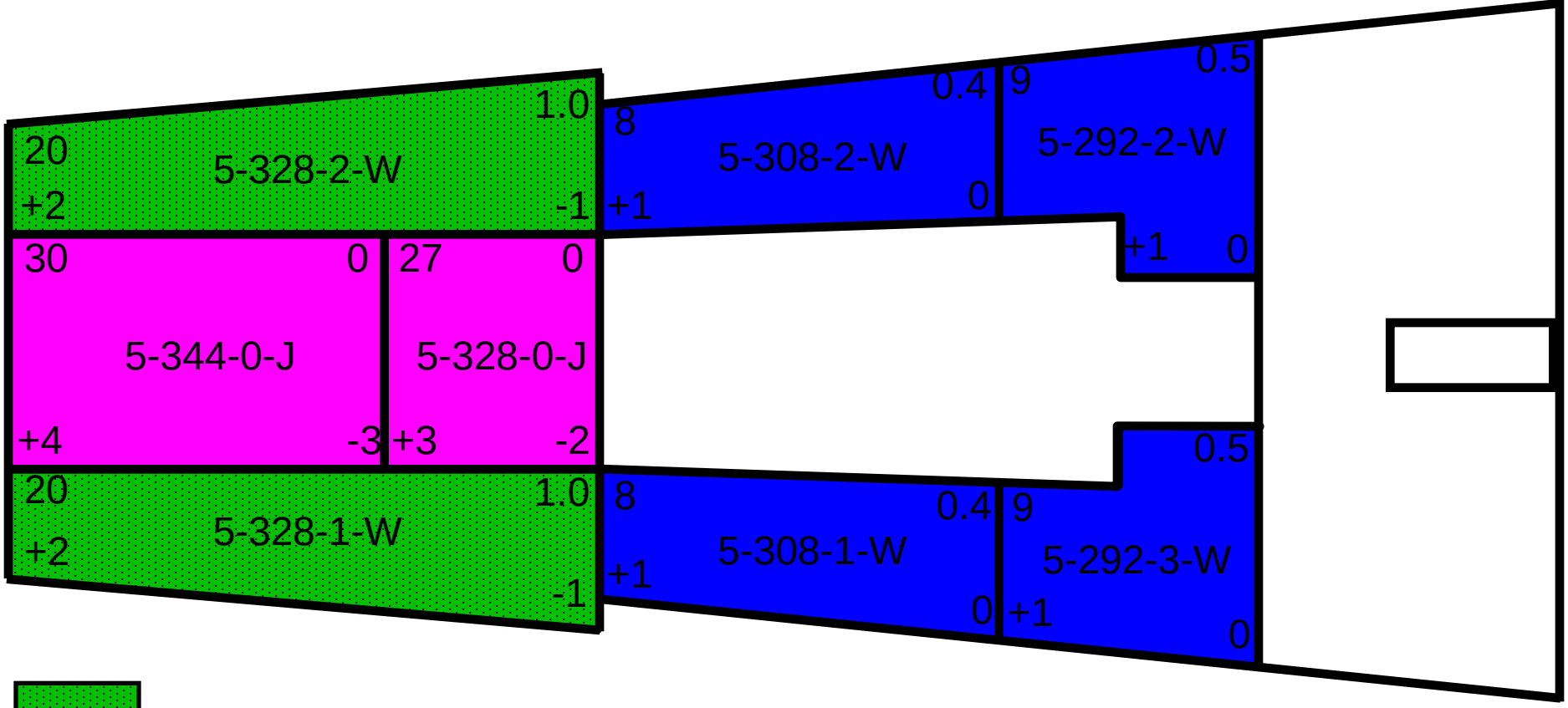
(PINK) - FLOODING OF PINK SPACES WILL DECREASE STABILITY BECAUSE OF ADDED HIGH WEIGHT, FREE SURFACE EFFECT OR BOTH.

(WHITE) - FLOODING OF WHITE SPACES HAS NO APPPRECIABLE EFFECT ON STABILITY.

CAPACITY-TONS SW

COMPARTMENT NUMBER

INCLINING MOMENTS FT-T



CLEAN BALLAST

POTABLE WATER

JP-5

CAPACITY-TONS LIST

COMPARTMENT NUMBER

CHANGE IN DRAFT AFT - INCHES

CHANGE IN DRAFT FWD - INCHES

WEIGHT AND MOMENT COMPENSATION PROGRAM

- **Status I:** No displacement or Stability problems
- **Status II:** Deficient in both margins
- **Status III:** Deficient in KG margin
- **Status IV:** Deficient in displacement margin

“Intentionally Left Blank”

LIMITATIONS

- Follow Liquid Loading Instructions
- No Abnormal Topside Weights
- Don’t Submerge Limiting Draft Marks
- Maintain Watertight Integrity

LIMITATIONS

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LIMITATIONS

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DEFINITIONS

ROLL - The action of a vessel involving a recurrent motion *(Longitudinal Axis).*

HEEL - **Semi-permanent** angle of inclination, caused by external forces.

LIST - **Permanent angle** of inclination caused by a shift in the center of gravity so as to cause G off CL, a -GM, or a combination of the two.

$$MH1^{o} = GM \times W_f \times 0.01746$$

$$List = \frac{w \times d}{MH1^{o}}$$

INCLINING EXPERIMENT

Completed upon commissioning, and following each major overhaul or shipalt.

It is done to verify the exact location of the ship's center of gravity (KG).

Basis for updates to Section II(a) of the DC book and for changes to weight and moment compensation status

INACCURACIES

1. UNACCOUNTED FOR FSE
2. MOVEMENT OF PERSONNEL
3. INACCURATE WEIGHTS
4. TAUGHT LINES
5. POOR WEIGHT VERIFICATION WALK THROUGH

MOB-D-6-SF Righting Ship

Conducted: Every 18 Months (SEMI annual for CG)

Purpose: To train the **damage control organization** in correcting a list.

Requirements: Condition 1 and zebra set. Liquid loading may be varied to put an actual list or trim on the ship if desired.

REASONS FOR BALLASTING

- INCREASE WEIGHT LOW TO IMPROVE STABILITY
- ELIMINATE EXCESSIVE LIST / TRIM
- COUNTERFLOOD FOLLOWING DAMAGE TO OFF CENTER COMPARTMENT
- EXPLOSION ABSORPTION (CV & CVN)
- WET WELL OPERATIONS (AMPHIBS)
- GROUNDING *“Weigh the ship down hard”*
- SUPPRESS FREE SURFACE EFFECT

DEFINITION

- BALLASTING is the process of filling low compartments from the sea to improve ship stability or control list / trim.

- BALLASTING systems may be independent (clean ballast) or they may incorporate sections of the fuel and drainage systems (dirty ballast).

LIQUID BALLAST SYSTEMS

- AUTOMATIC

(FUEL OIL COMPENSATION)

- MANUAL SYSTEMS

MANUAL BALLAST SYSTEMS

- INDEPENDENT
- FUEL TANK SYSTEMS

ARGUMENTS AGAINST BALLASTING

- "It Will Destroy My Tanks"- MPA
- "I've Never Seen It Done Before. It Must Not Be Necessary." - CHENG
- "When We Pump Out The Ballast Tanks, It Will Pollute The Water." - CO

BALLASTING RESPONSIBILITIES OF DCA

- Maintain Awareness Of Ship's Liquid Loading Condition. (Full Load - Min Ops)
- Determine The ***Risks*** Associated With Violating LLI And Report To CHENG If Necessary.
  - HOGGING AND SAGGING STRESSES.
  - SUBMERGING LIMITING DRAFT MARKS.
  - SURVIVABILITY OF BEAM WINDS AND SEAS.
  - MAINTAIN ADEQUATE METACENTRIC HEIGHT.
- Ensure Most Current Fuel And Water Report Is Posted Daily At Each Repair Locker and DC Central.

50% Theory 50% Problems

- Study in groups…
- Check your work…
- Follow your units…
- Check your work…
- Draw a picture…
- Check your work…

Good Luck!

- Check your work…
- Follow your units…
- Draw a picture…