MISTAKES

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

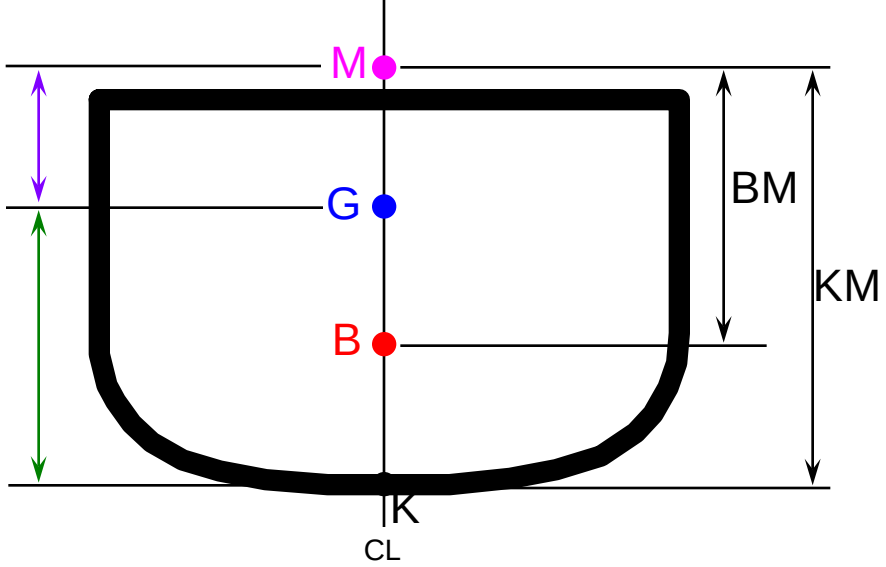
CLASS RULES:

1) ***QUESTIONS, QUESTIONS, QUESTIONS!!***
2) ***SLEEPING*** *DON'T DO IT!!!*
3) ***NOTES***
4) ***STUDY GROUPS + FLASH CARDS***
5) ***EXAM IS 50% THEORY, 50% MATH***
6) ***PRACTICE PROBLEMS (13 TOTAL) "Graded for completion"***
7) ***HOMEWORKS (4 TOTAL) "2.5% of DCASE grade"***
8) ***CRITIQUES ATTACHED TO EXAM***
9) ***SEA STORIES - "Learn from others"***
10) ***HOURLY BREAKS – "CALL OUT IF DESIRED"***

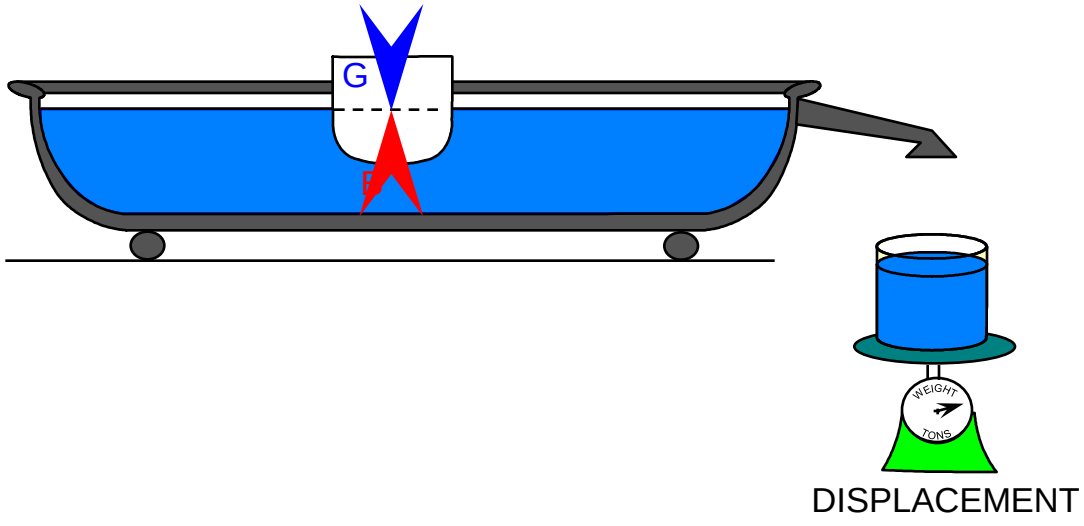
WHATS ON YOUR DESK

1) *NOTHING FROM OTHER DCASE UNITS!*
2) *STUDY GUIDE* *FOLLOW ALONG BUT DON'T WRITE!*
3) *NOTES / FLASH CARDS*
4) *EXAM FORMULA SHEET*
5) *STABILITY DEFINITIONS SHEET (CAN'T USE ON EXAM!)*
6) *PRACTICE PROBLEMS (13 TOTAL) "Graded for completion"*
7) *HOMEWORKS (4 TOTAL) "2.5% of DCASE grade"*
8) *REFERENCE POINT REVIEW QUESTIONS*
9) *RULER + DIVIDERS + CALCULATOR*
10) *SWEAT FROM ALL YOUR STABILITY EFFORT!!*

Lesson 4.1



Principles of Stability

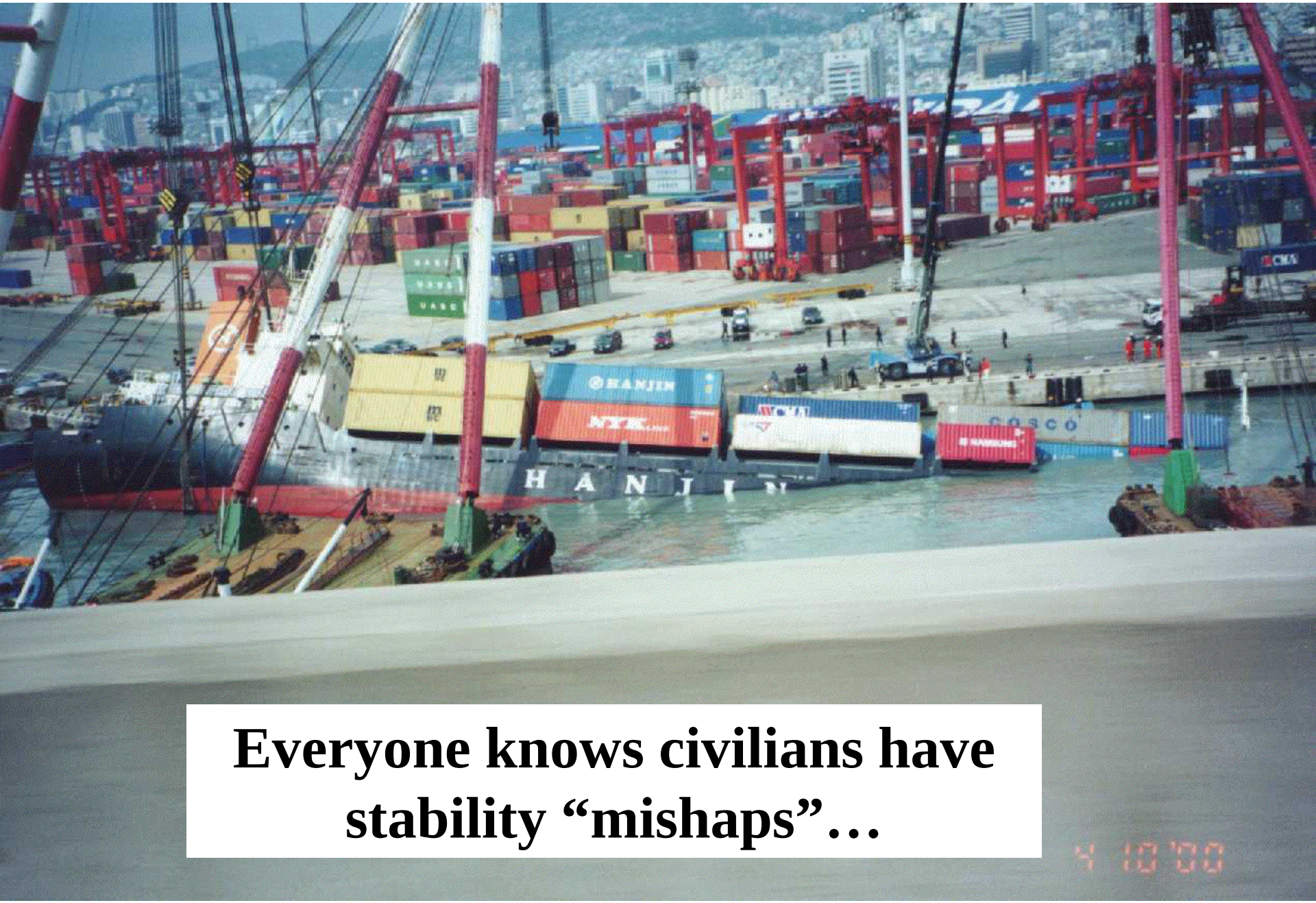


References

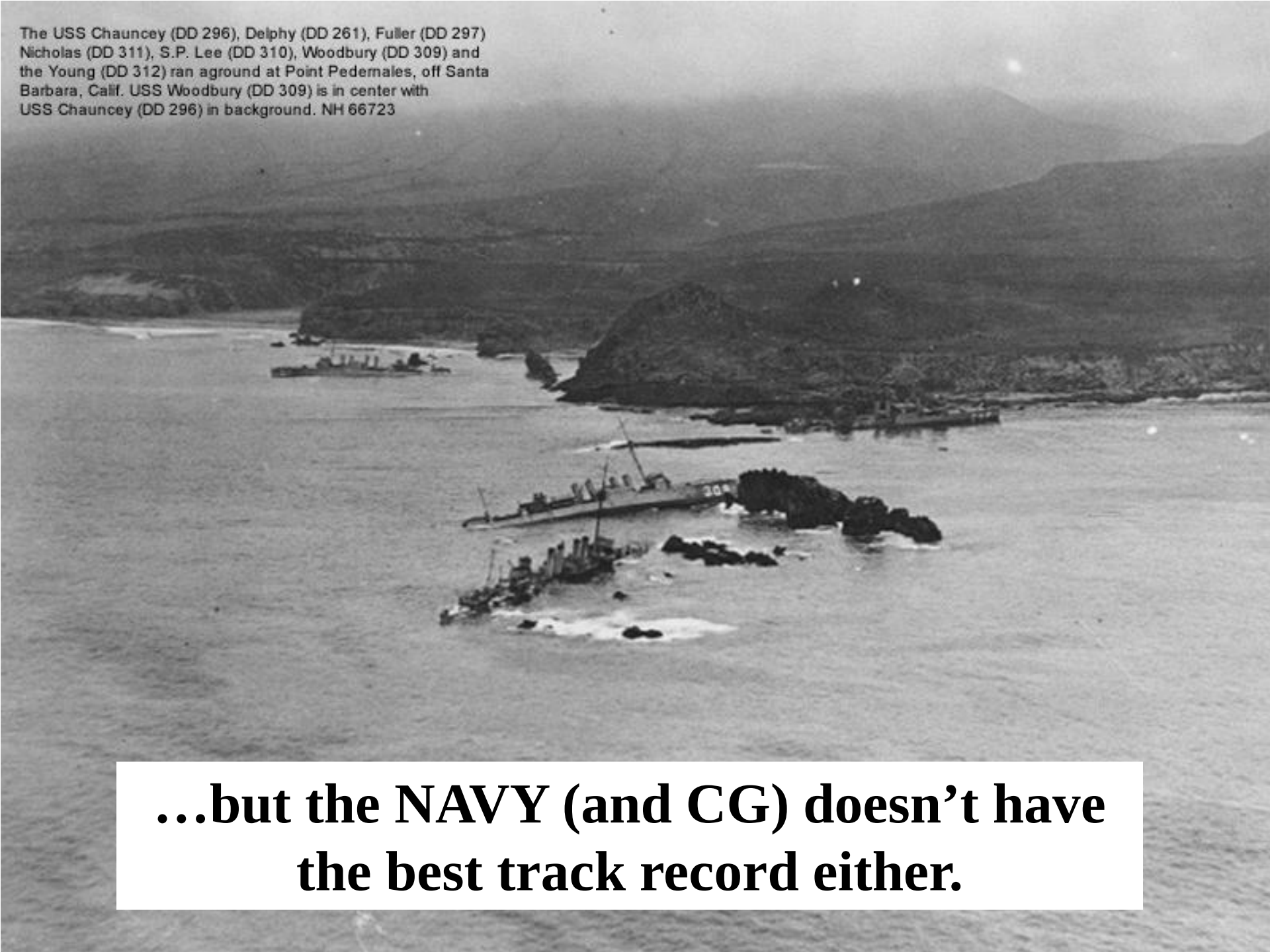
a) NSTM 079 Volume 1
b) NTTP 3-20.31
c) Damage Control Book, Section II (a)

Enabling Objectives to be covered…

- Describe reference points & forces.
- Describe movement of points (stability triangle)
- Differentiate initial and overall stability
- Describe hull markings
- Calculate W_f, TPI, MT1”
- Construct uncorrected static stability curve.



Everyone knows civilians have stability “mishaps”…



…but the NAVY (and CG) doesn't have the best track record either.

WWII… steaming backwards to homeport…

July 2000… USS DENVER…

Sept 2005…USS CHURCHILL…

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

SIX MOTIONS OF A SHIP

ROLL – SIDE TO SIDE OR PORT TO STBD.
(Rotate about Longitudinal Axis)

PITCH – UP DOWN OR BOW TO STERN.
(Rotate about Transverse Axis)

YAW – TWISTING (Rotate about Vertical Axis)

SWAY – "SLIDING" LATERALLY OR SIDE TO SIDE

HEAVE – UP DOWN AS IN LIFTED BY WAVES.

SURGE – "SLIDING" LONGITUDINALLY OR FRONT BACK

DEFINITIONS

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

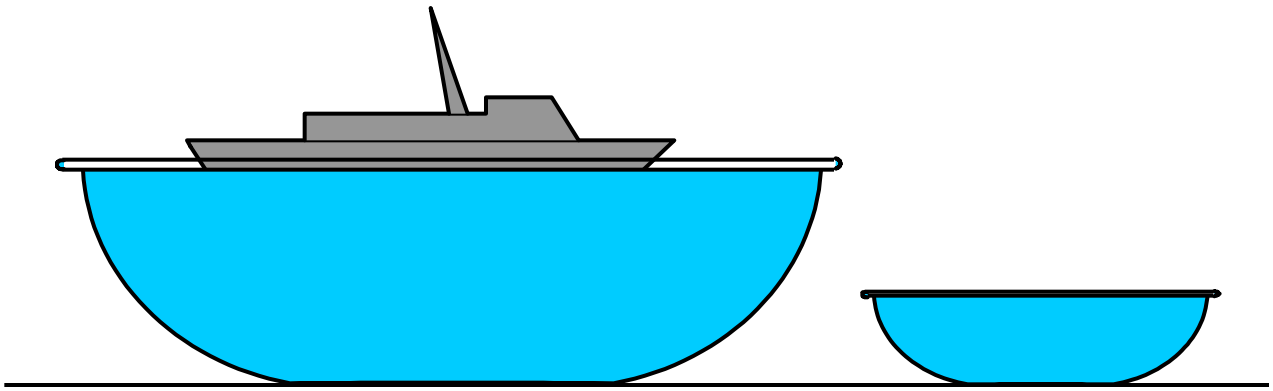
HEEL - **Semi-permanent** angle of inclination, caused by external forces.

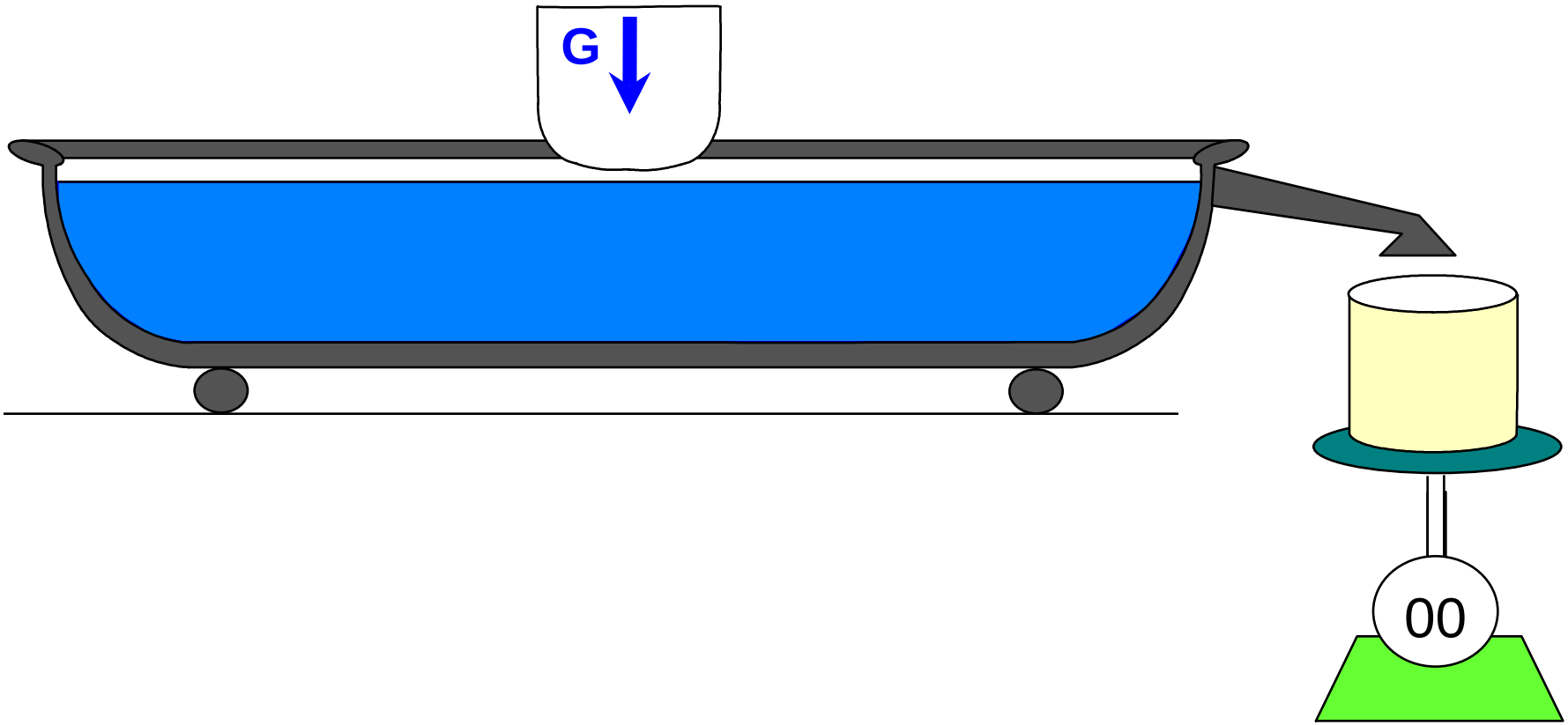
LIST - **Permanent angle** of inclination caused by a shift in the center of gravity, -GM, or both.

LAWS OF BUOYANCY

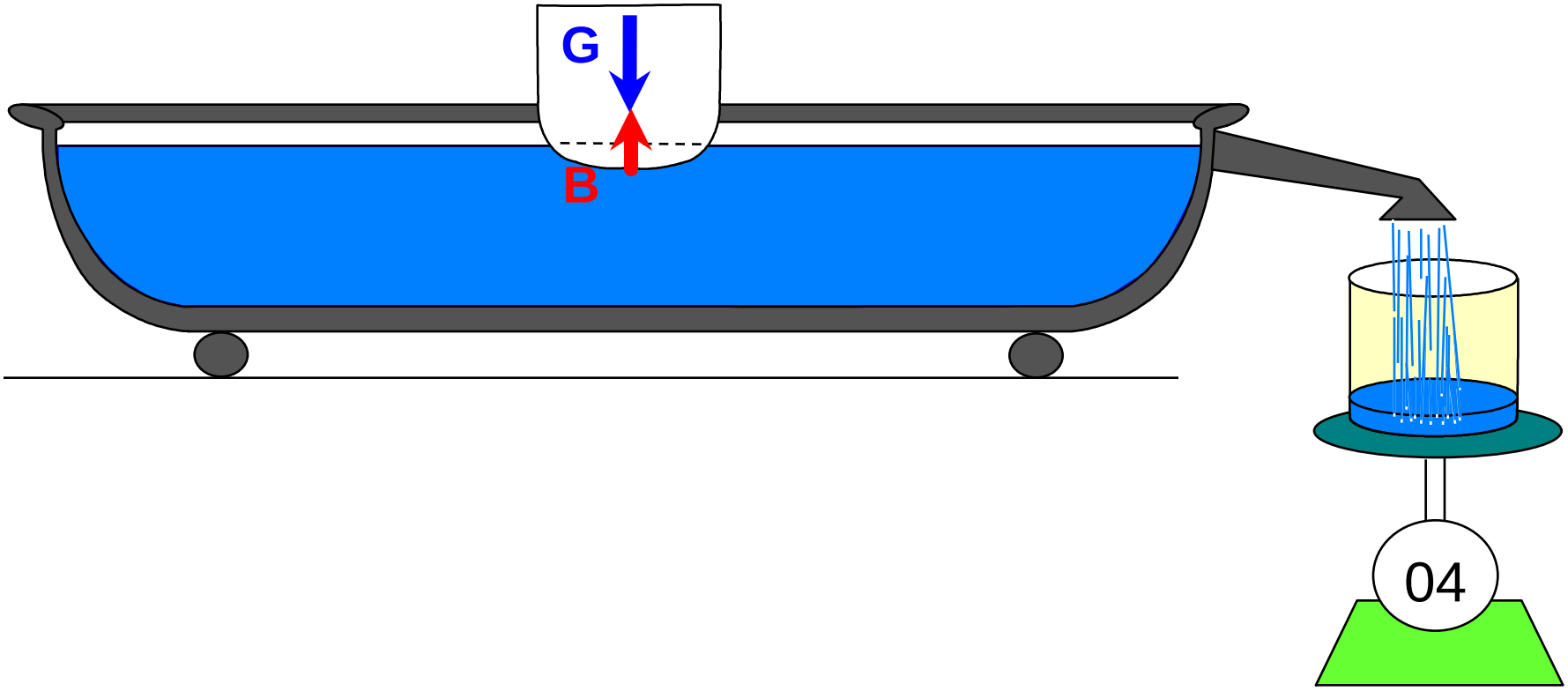
- A FLOATING OBJECT HAS THE PROPERTY OF BUOYANCY

- A FLOATING BODY DISPLACES A VOLUME OF WATER EQUAL IN WEIGHT TO THE WEIGHT OF THE BODY.

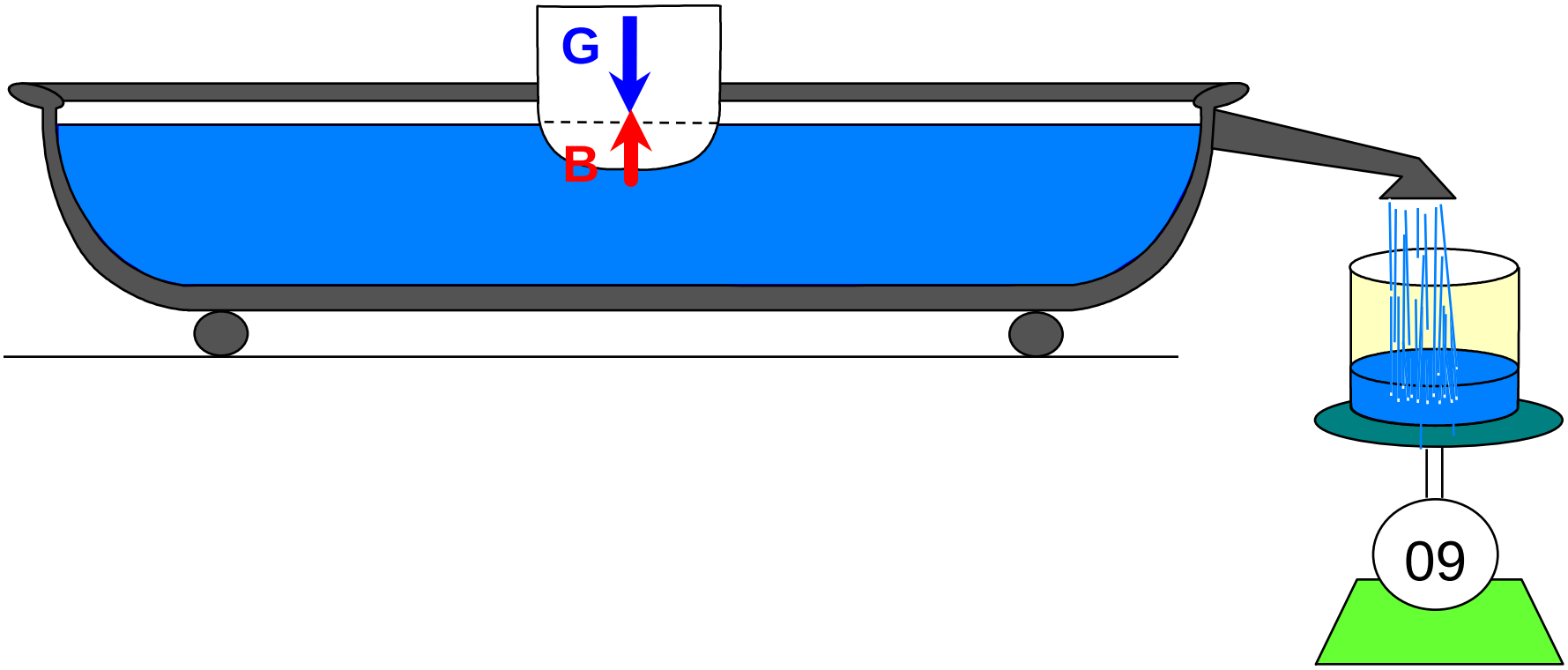




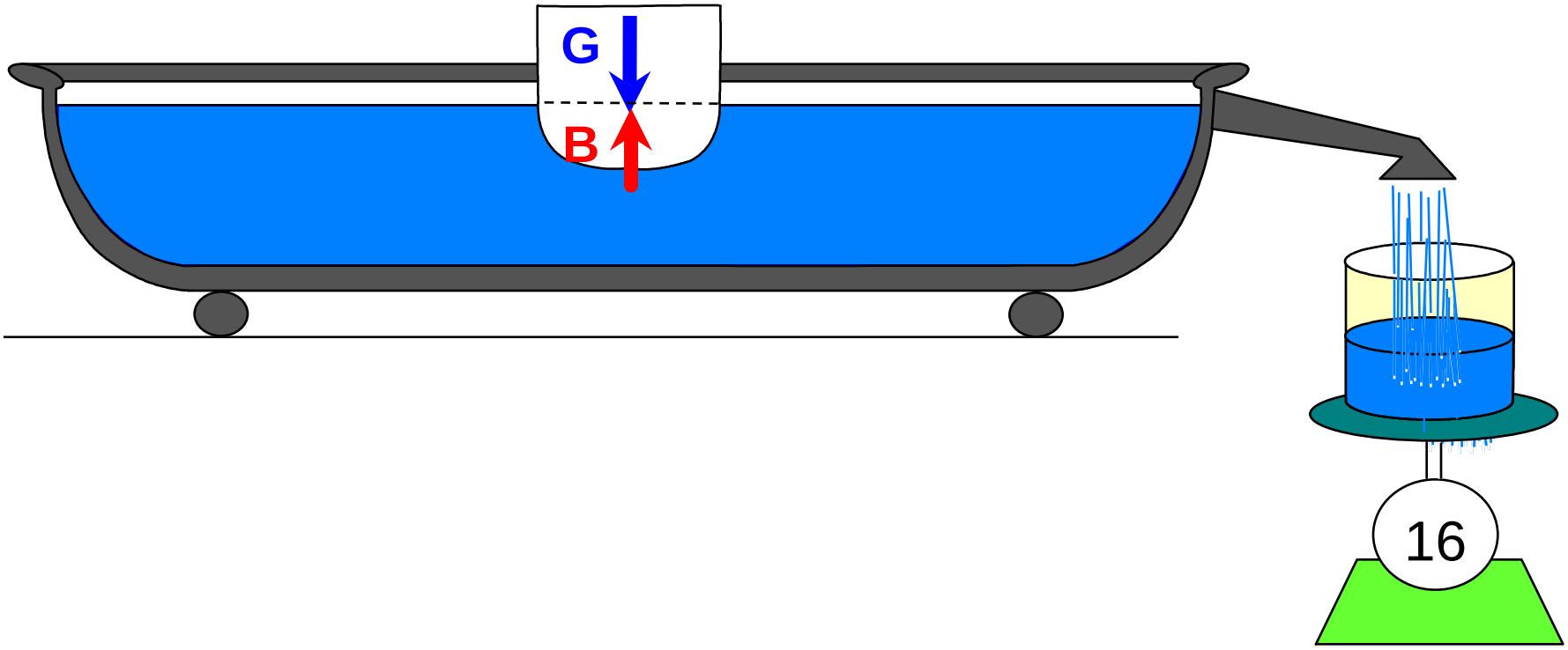
Capital W = DISPLACEMENT



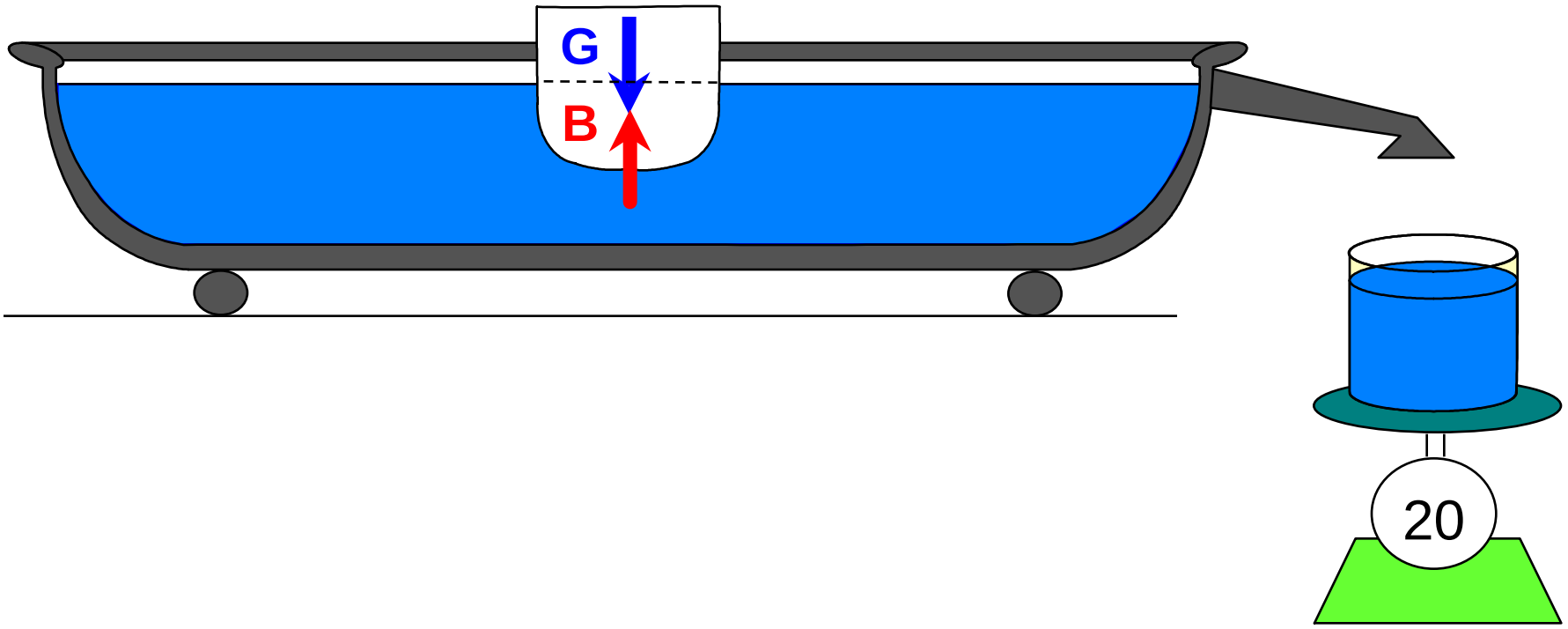
Capital W = DISPLACEMENT



Capital W = DISPLACEMENT



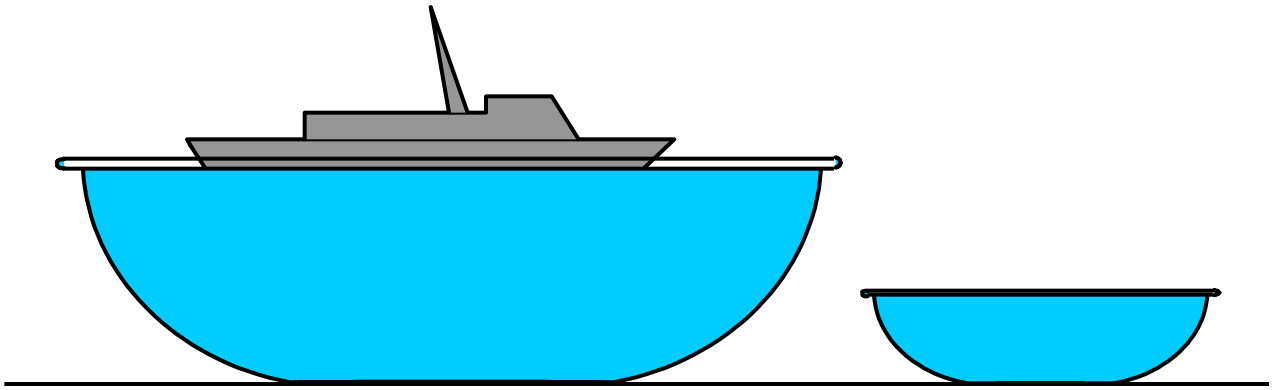
Capital W = DISPLACEMENT



Capital W = DISPLACEMENT

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.



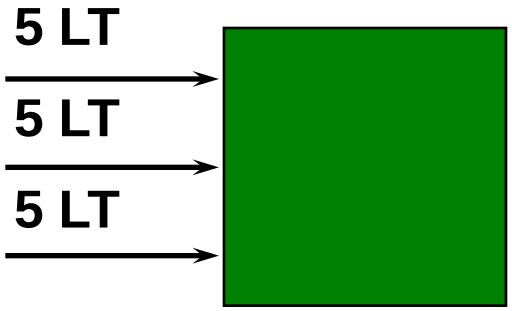
DISPLACEMENT

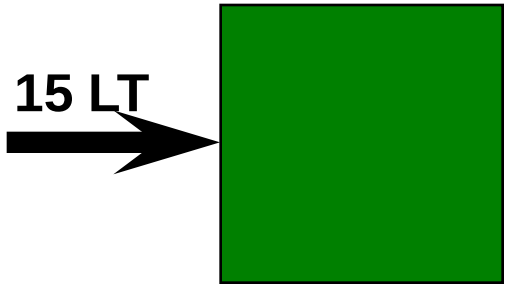
- THE WEIGHT OF THE VOLUME OF WATER THAT THE SHIP'S HULL IS DISPLACING
- UNITS OF WEIGHT
  - LONG TON = 2240 LBS
  - SHORT TON = 2000 LBS
  - METRIC TON = 2204.72 LBS

FORCE: A PUSH OR A PULL. TENDS TO PRODUCE MOTION OR A CHANGE IN MOTION.

UNITS: LONG TONS, POUNDS, ETC.

PARALLEL FORCES MAY BE COMBINED INTO ONE FORCE EQUAL TO THE SUM OF ALL FORCES ACTING IN THE SAME DIRECTION AND SO LOCATED TO PRODUCE THE SAME EFFECT.



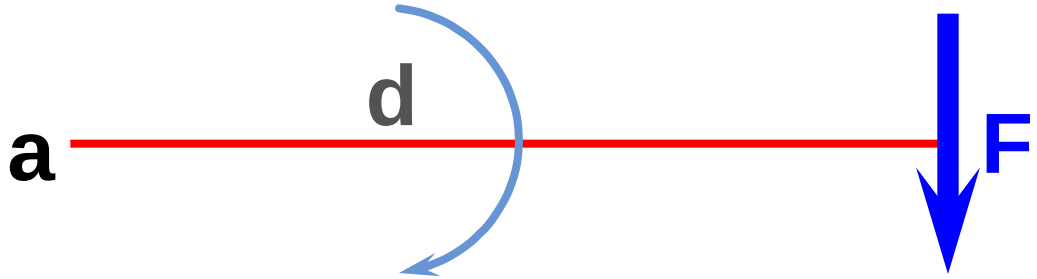


WEIGHT: GRAVITATIONAL FORCE.
DIRECTION TOWARD CENTER OF EARTH

UNITS: LONG TONS, POUNDS, etc

MOMENT: THE TENDENCY OF A FORCE TO PRODUCE ROTATION ABOUT AN AXIS

UNITS: FT-LT, FT-POUNDS, etc



MOMENT = F x d

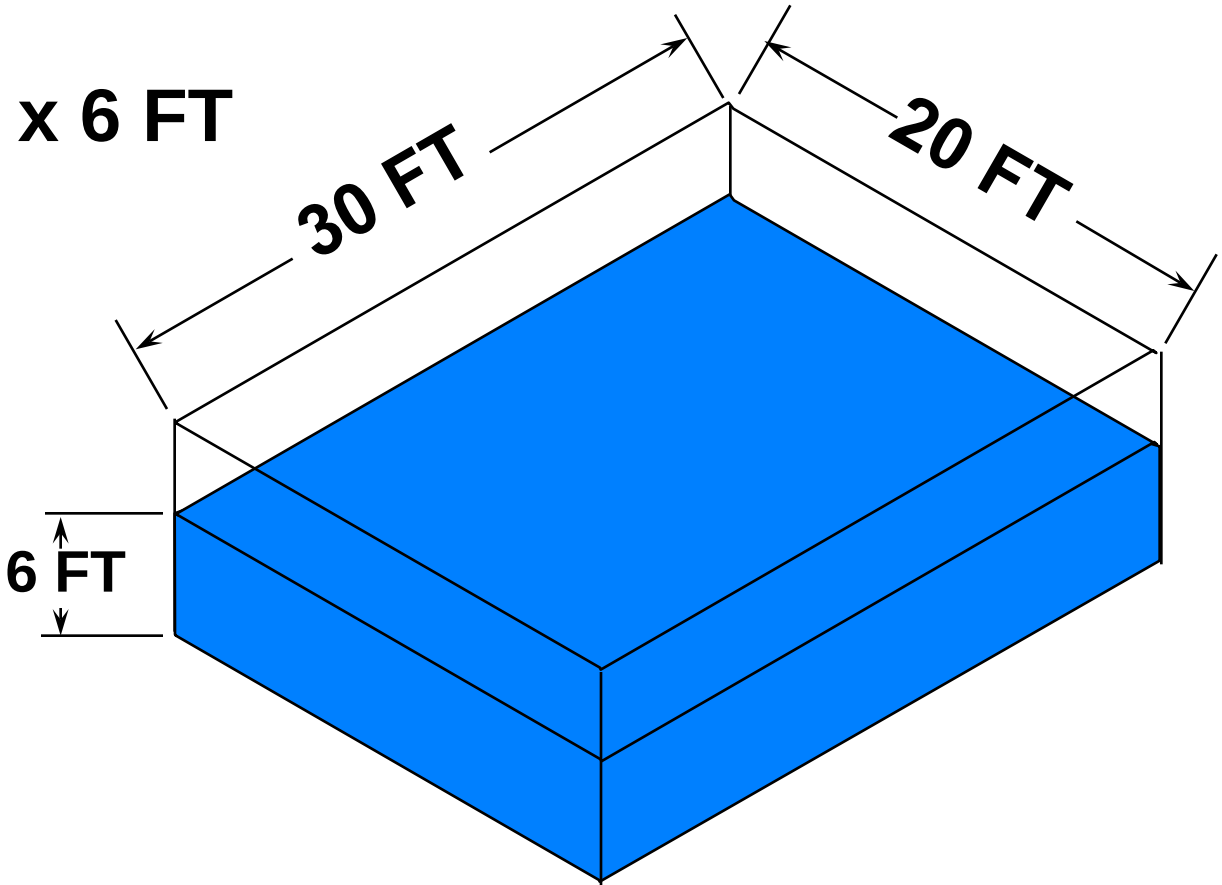
F is the force of your hand while d is the length of your "wrench" & Moment is the torque applied.

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 LONG TON

Salt water = 35 FT^3/LT

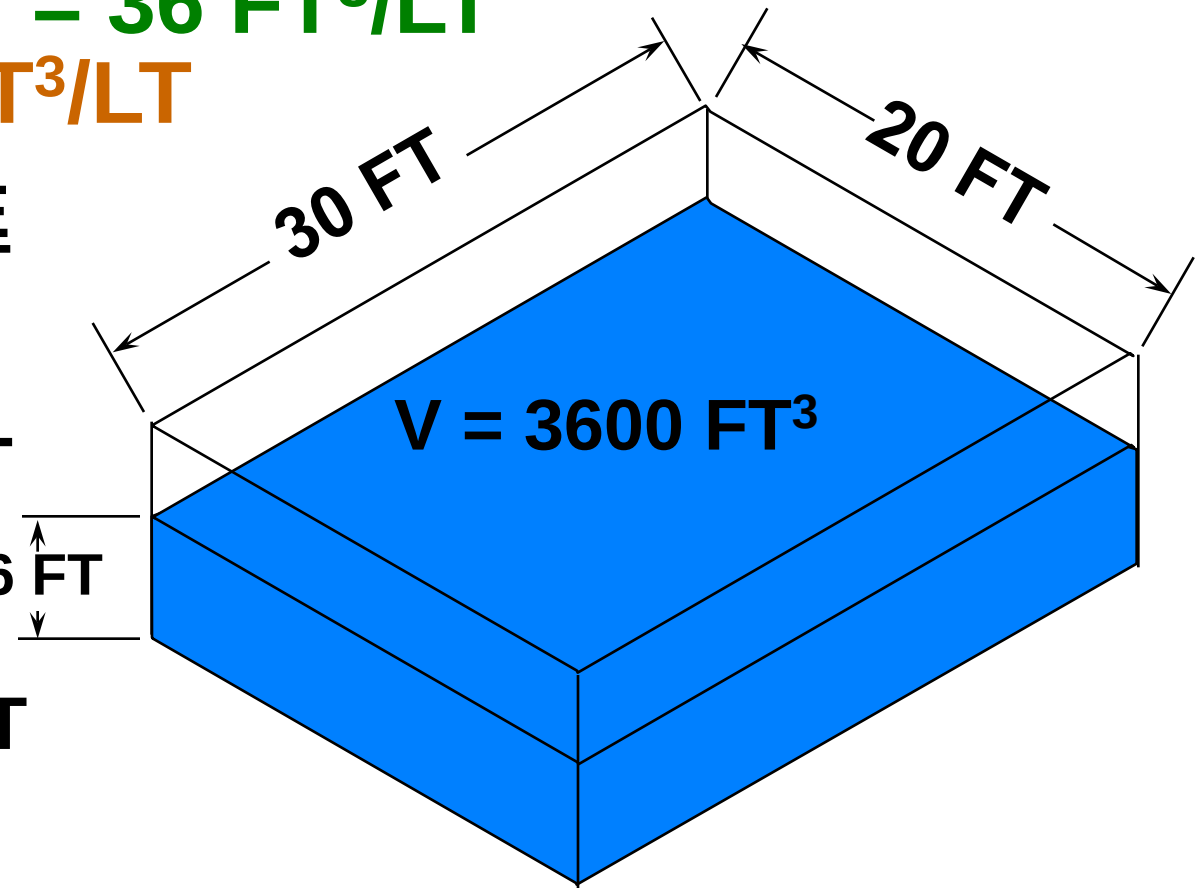
Fresh water = 36 FT^3/LT

DFM = 43 FT^3/LT

$$W_{flooding} = \frac{VOLUME}{SP.\ VOL}$$

$$W_{flooding} = \frac{3600\ FT^3}{35\ FT^3/LT}$$

$$W_{flooding} = 102.86\ LT$$



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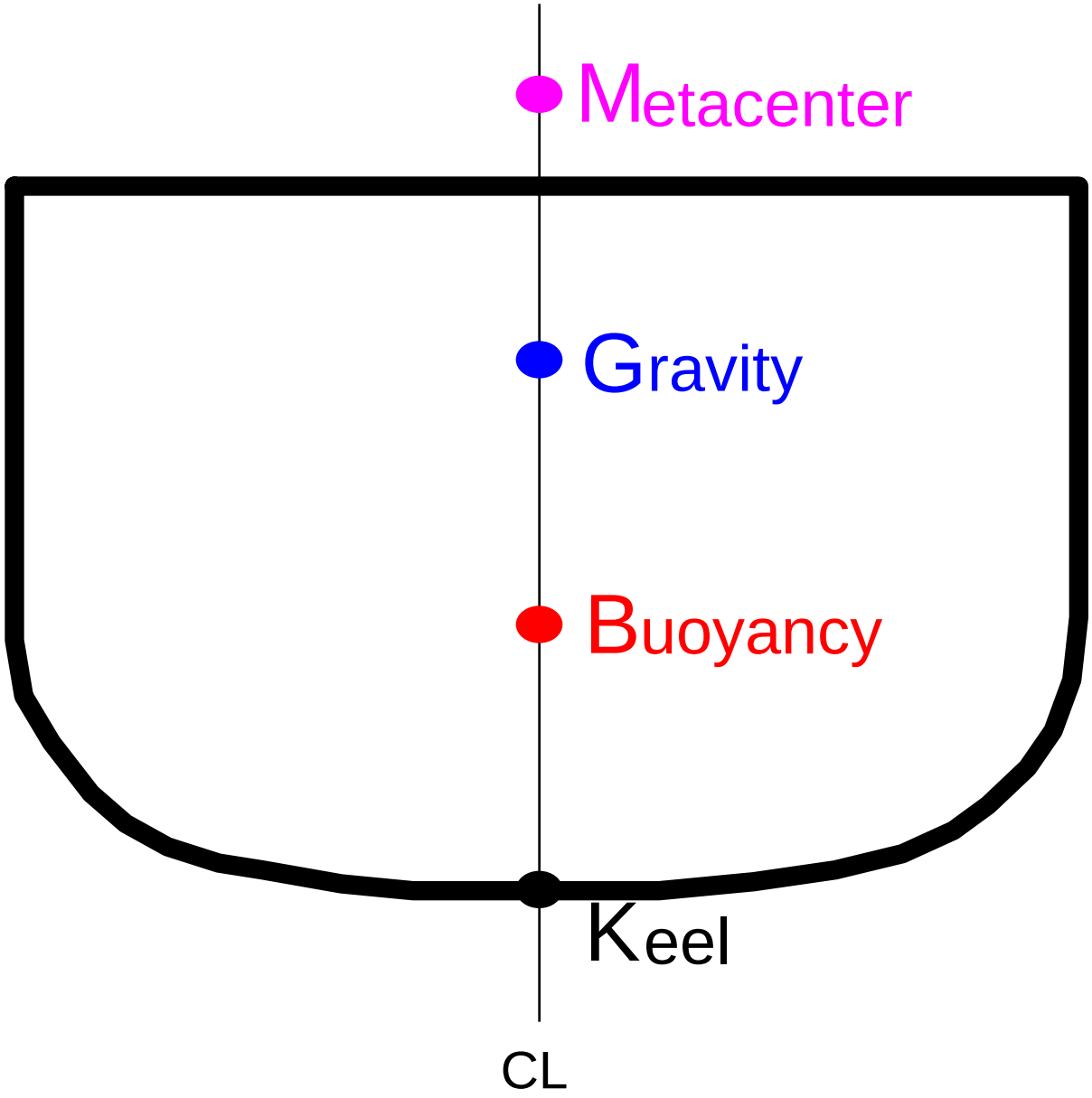
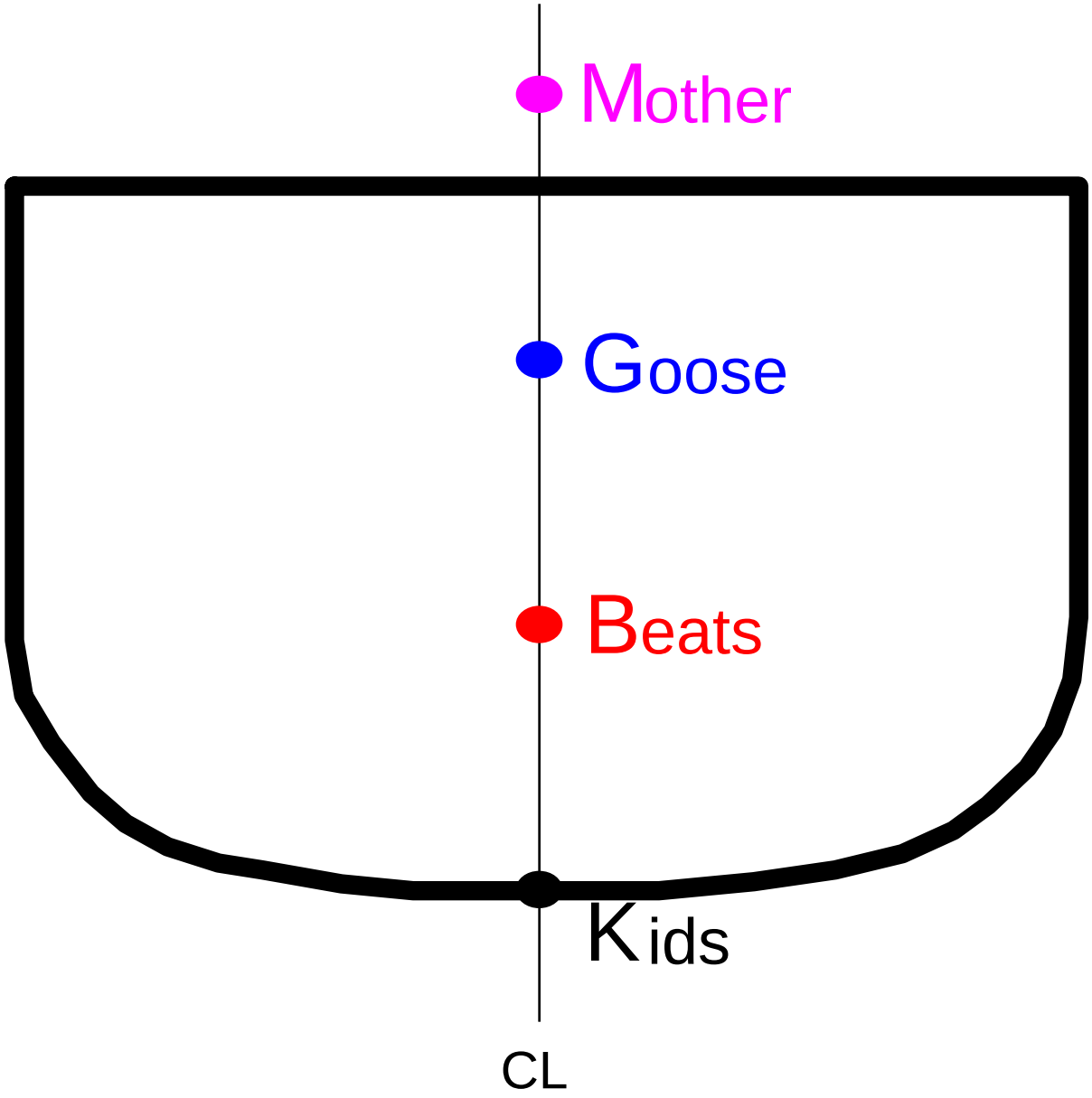
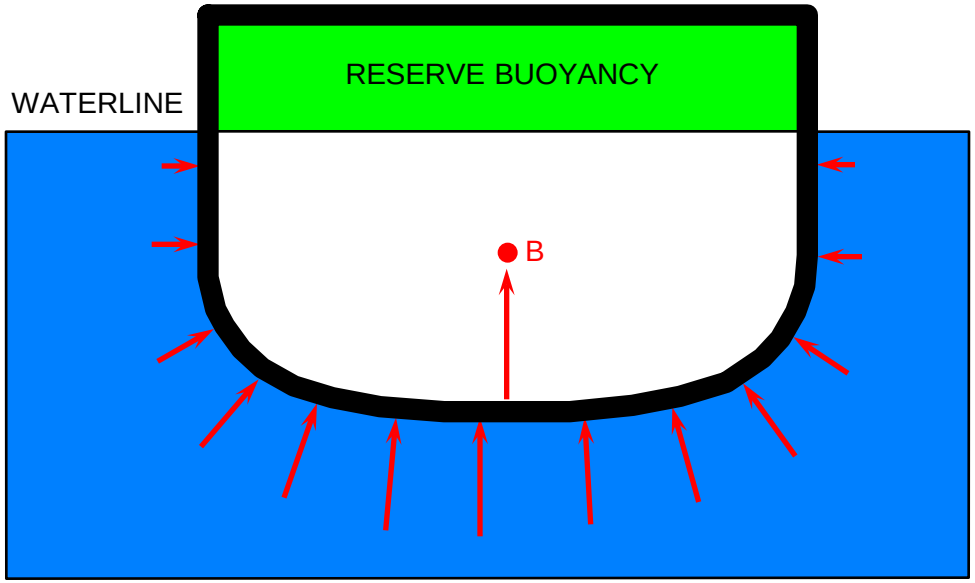
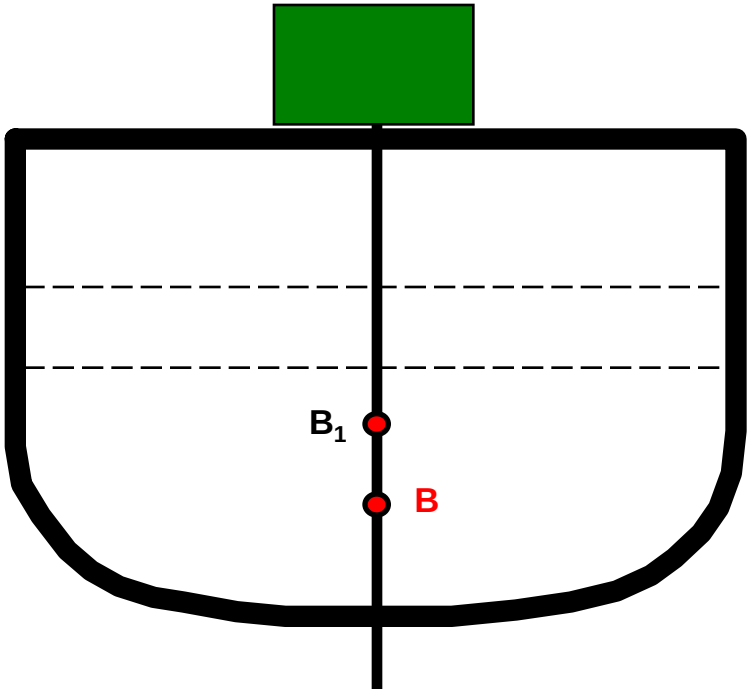
STABILITY REFERENCE POINTS



STABILITY REFERENCE POINTS

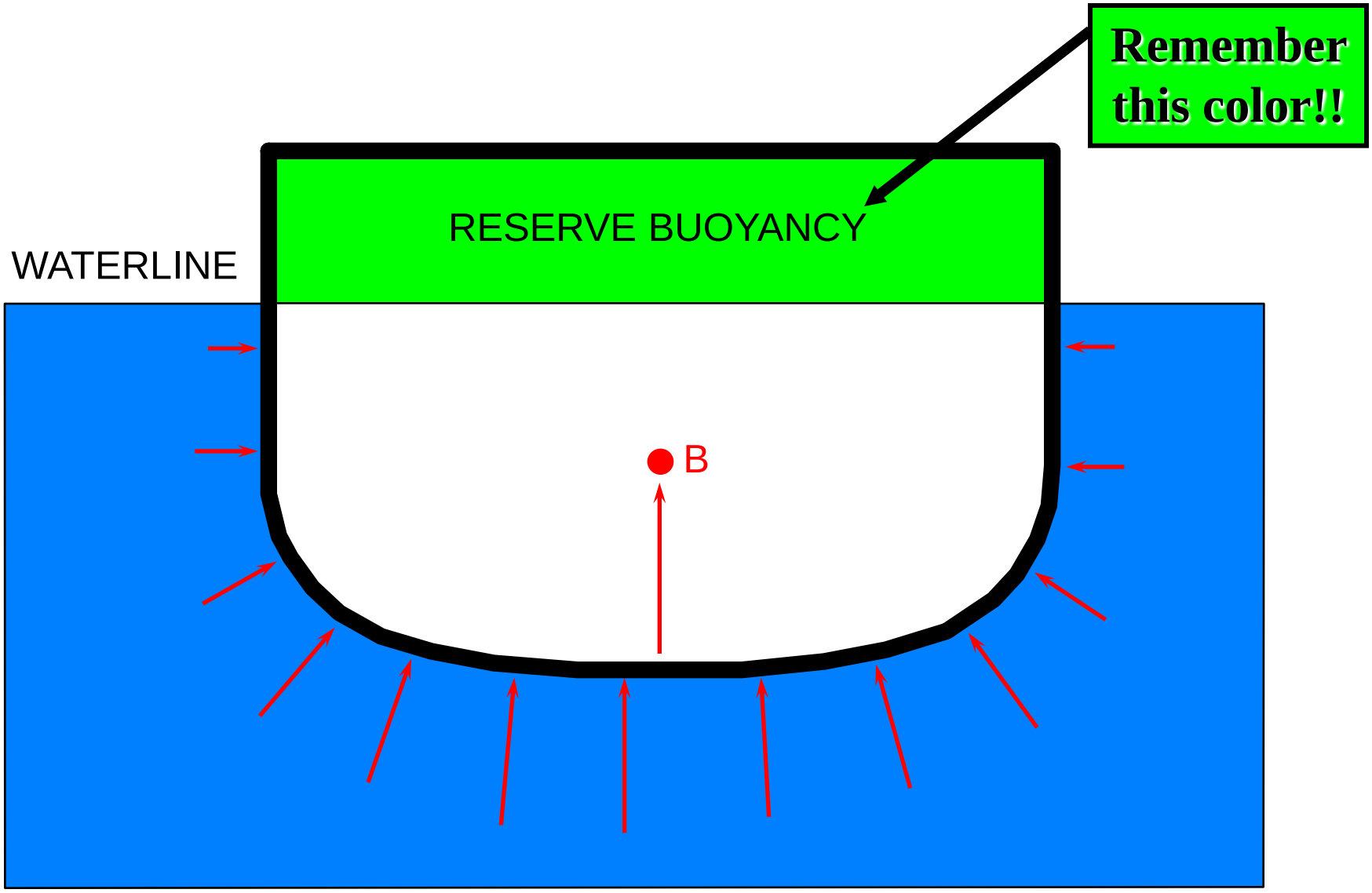




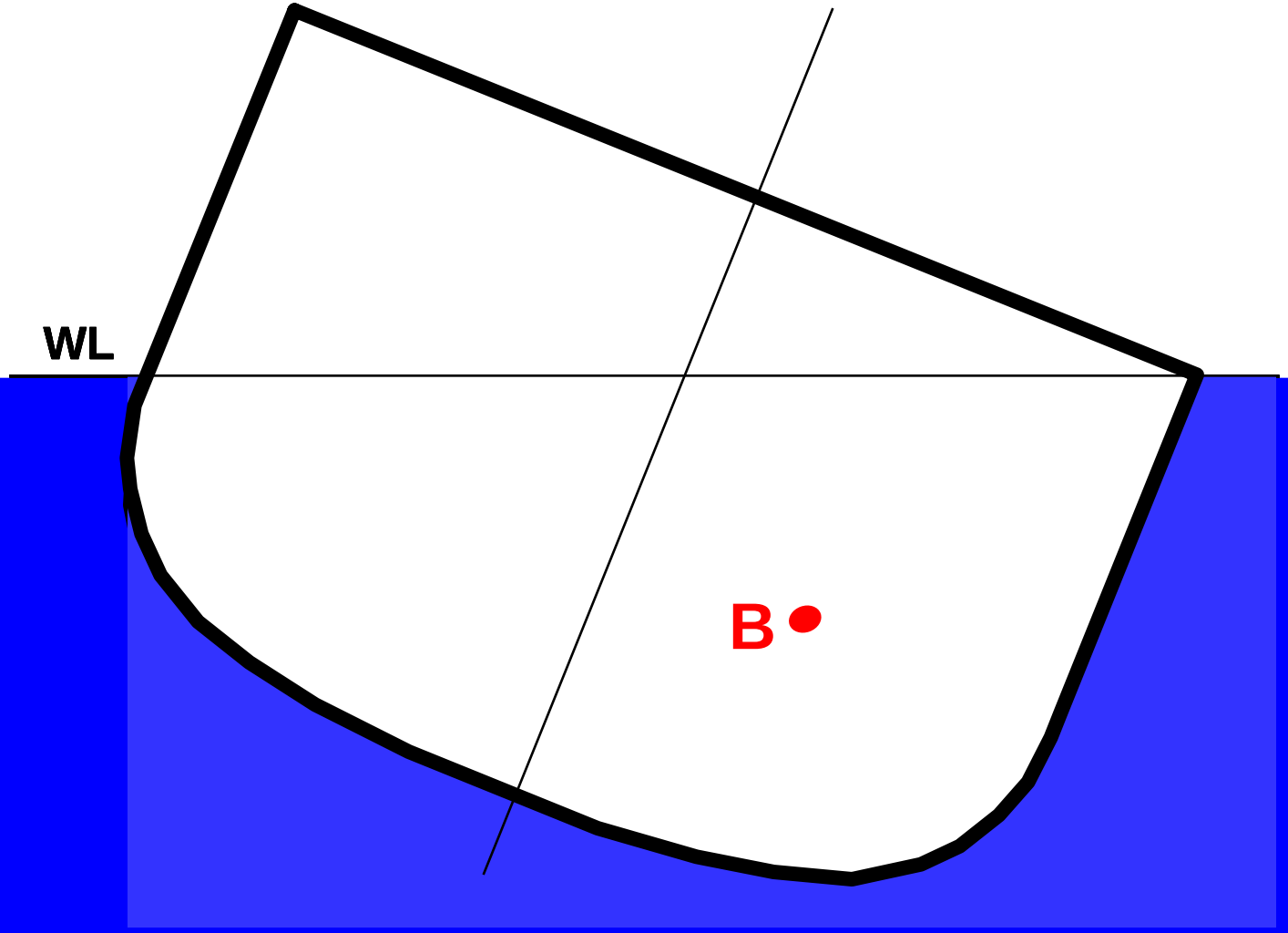


THE CENTER OF BUOYANCY

RESERVE BUOYANCY, FREEBOARD, DRAFT AND DEPTH OF HULL

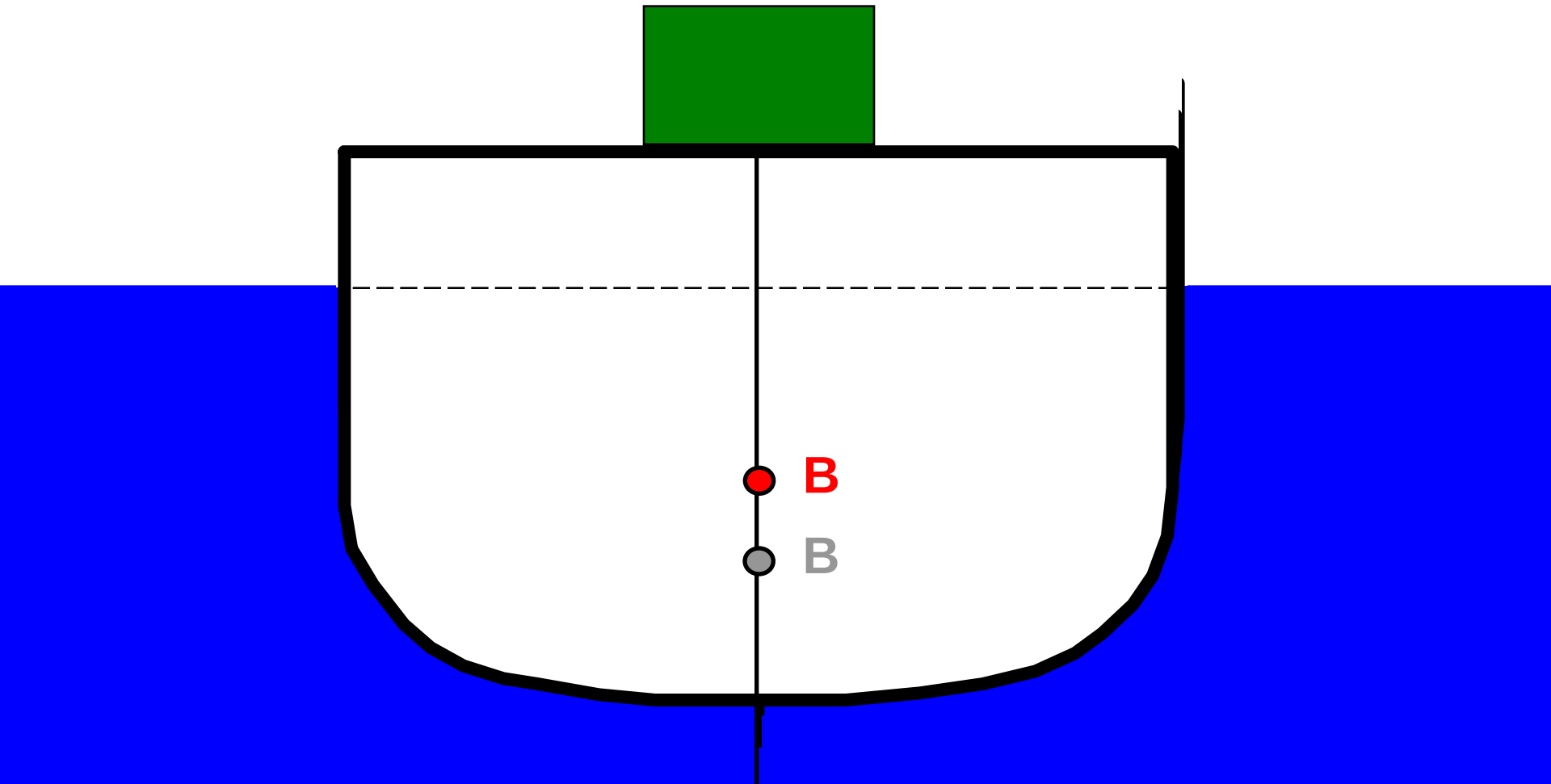


CENTER OF BUOYANCY

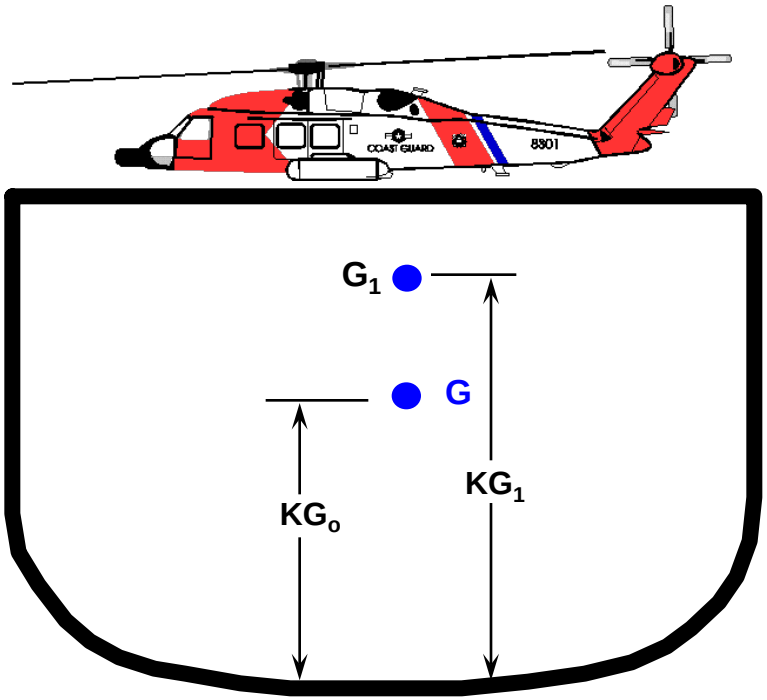


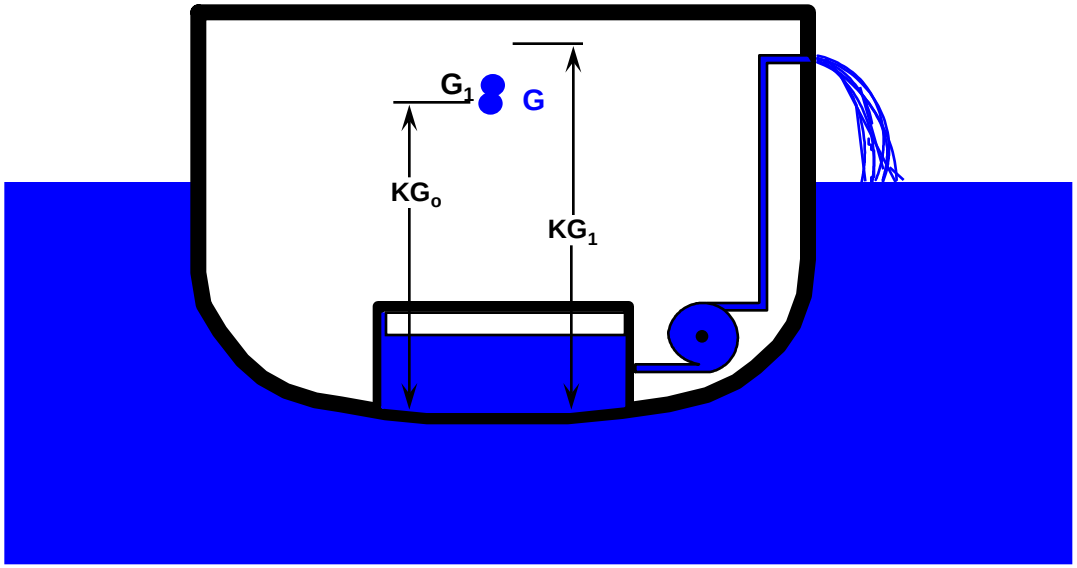
CENTER OF BUOYANCY

RULE OF THUMB = "B" FOLLOWS THE WATERLINE.



THE CENTER OF GRAVITY





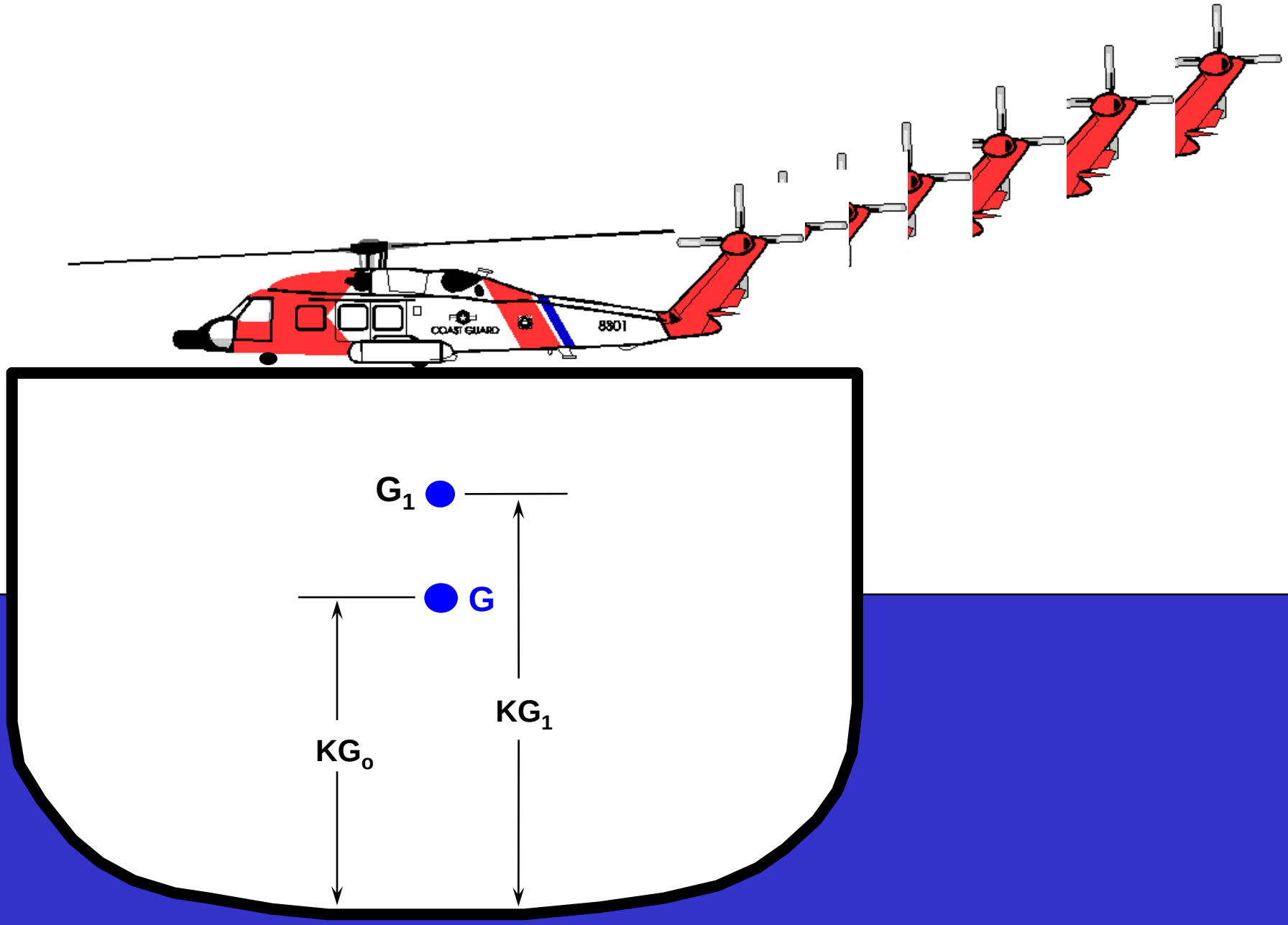
CENTER OF GRAVITY

- 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.

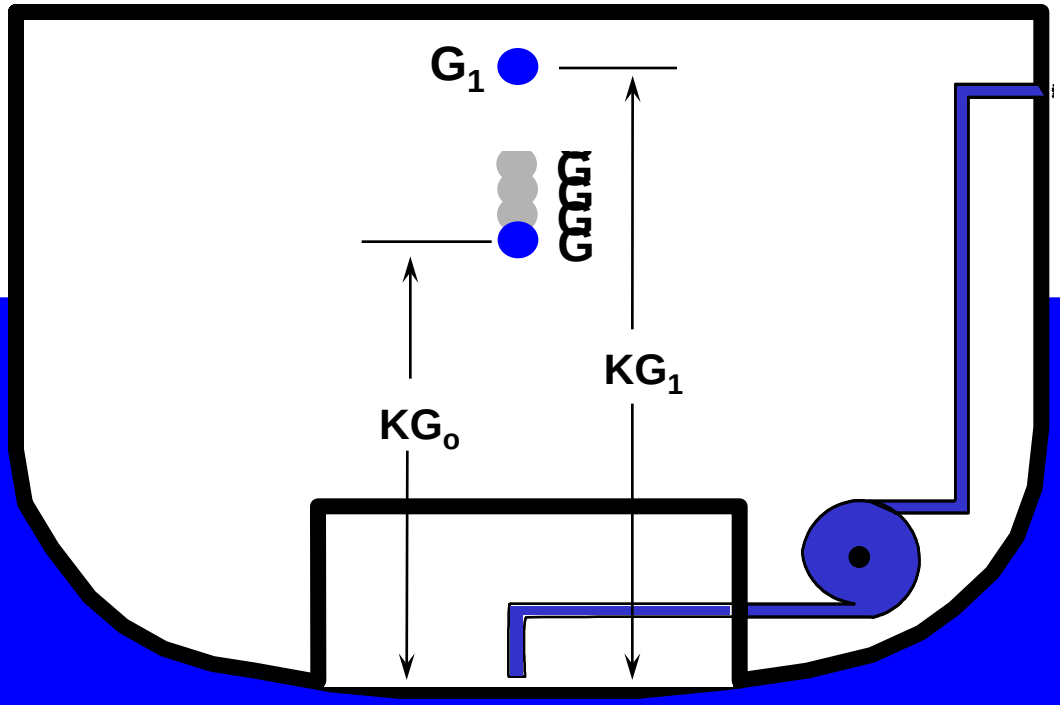
MOVEMENTS IN THE CENTER OF GRAVITY

- G MOVES TOWARDS A WEIGHT ADDITION


COAST GUARD
6801
G_1
G
KG_1
KG_o

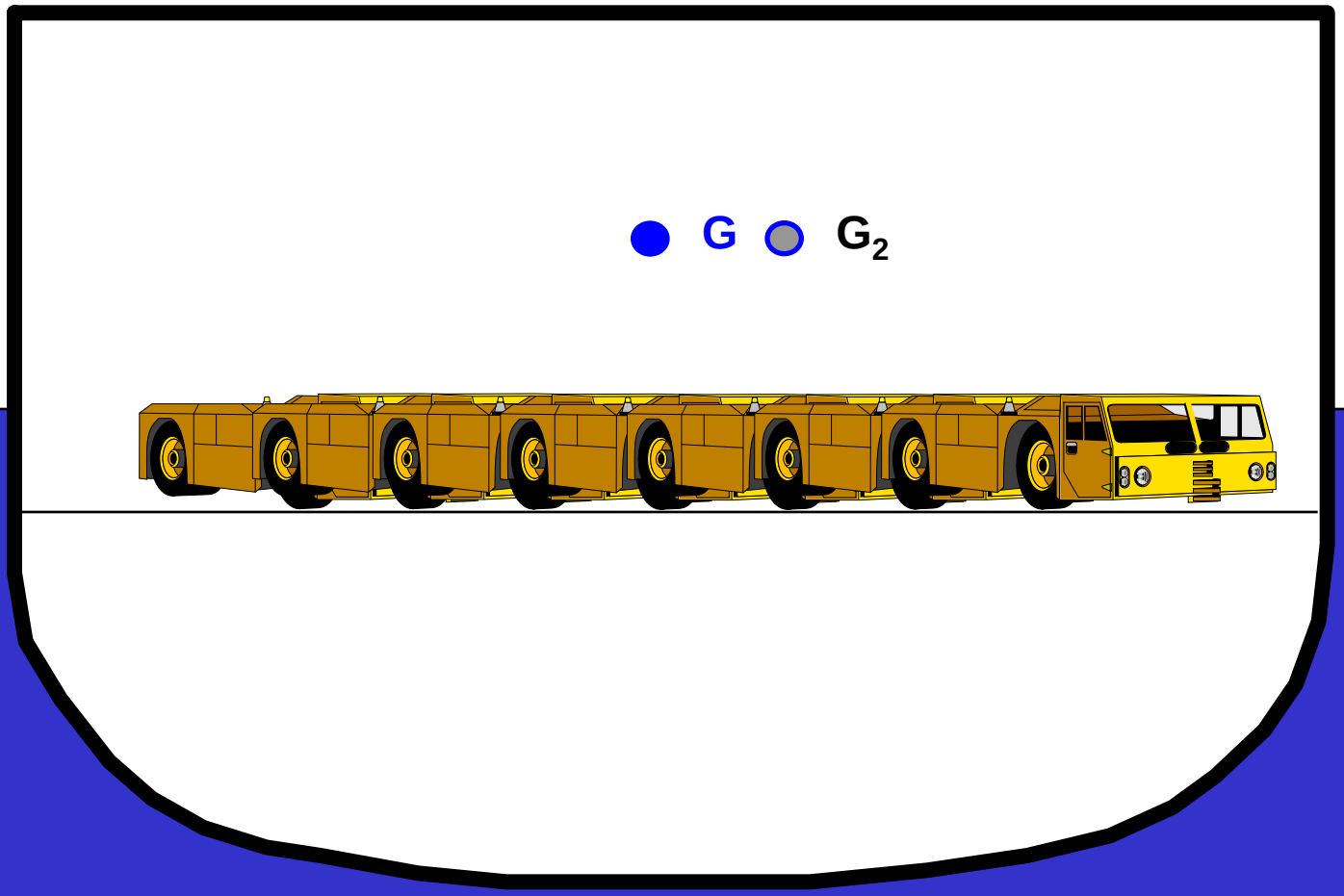
MOVEMENTS IN THE CENTER OF GRAVITY

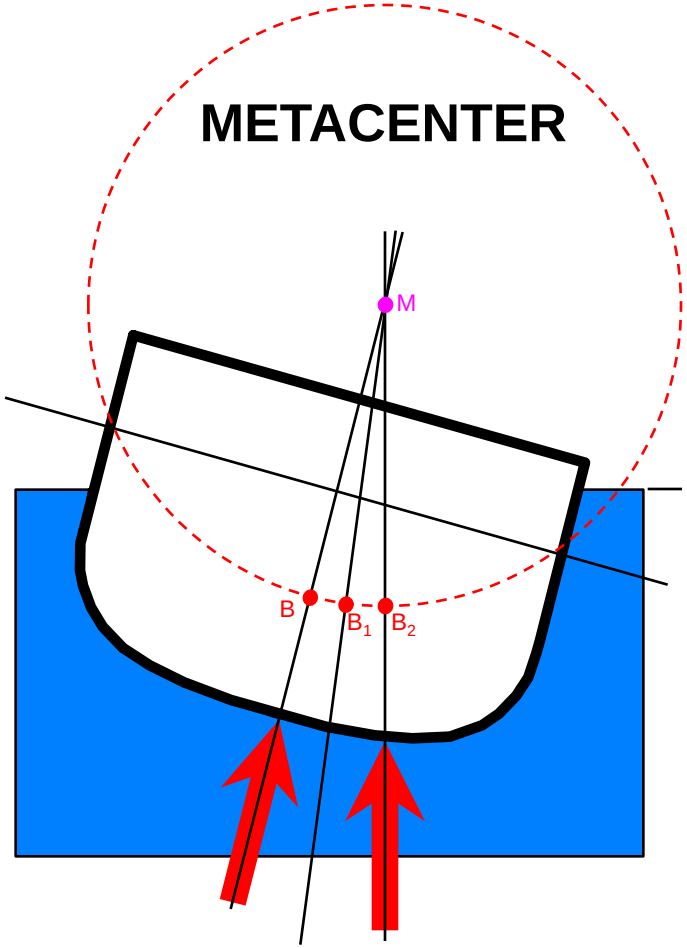
- G MOVES TOWARDS A WEIGHT ADDITION
- G MOVES AWAY FROM A WEIGHT REMOVAL


G1
KG1
KGo

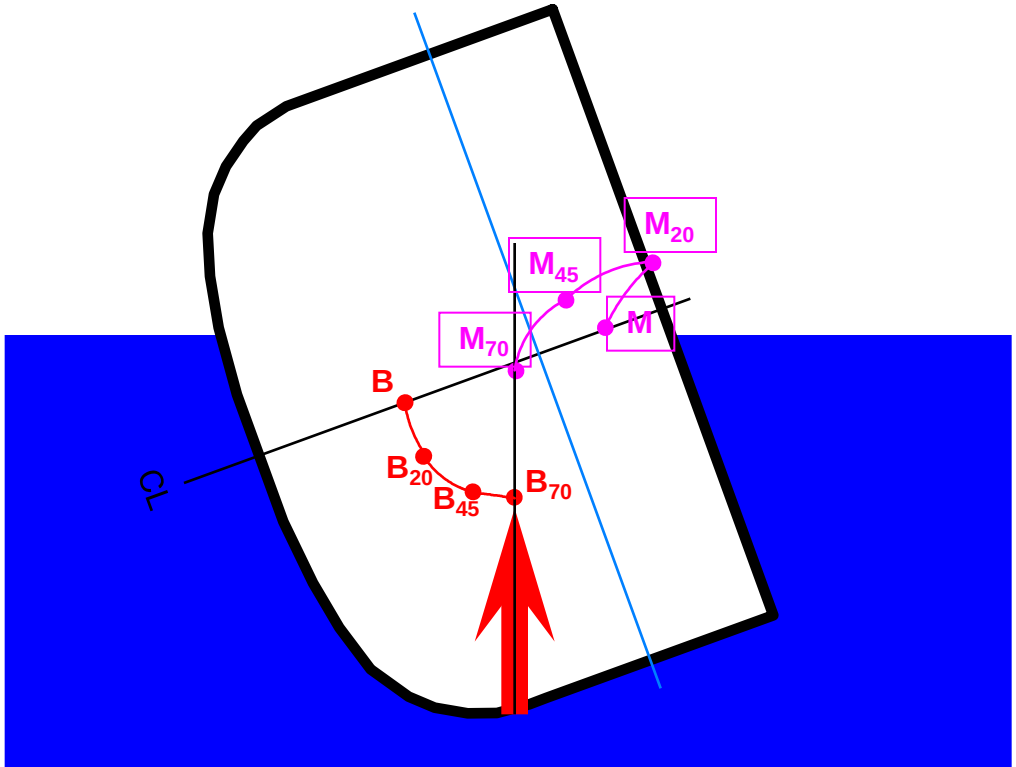
MOVEMENTS IN THE CENTER OF GRAVITY

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

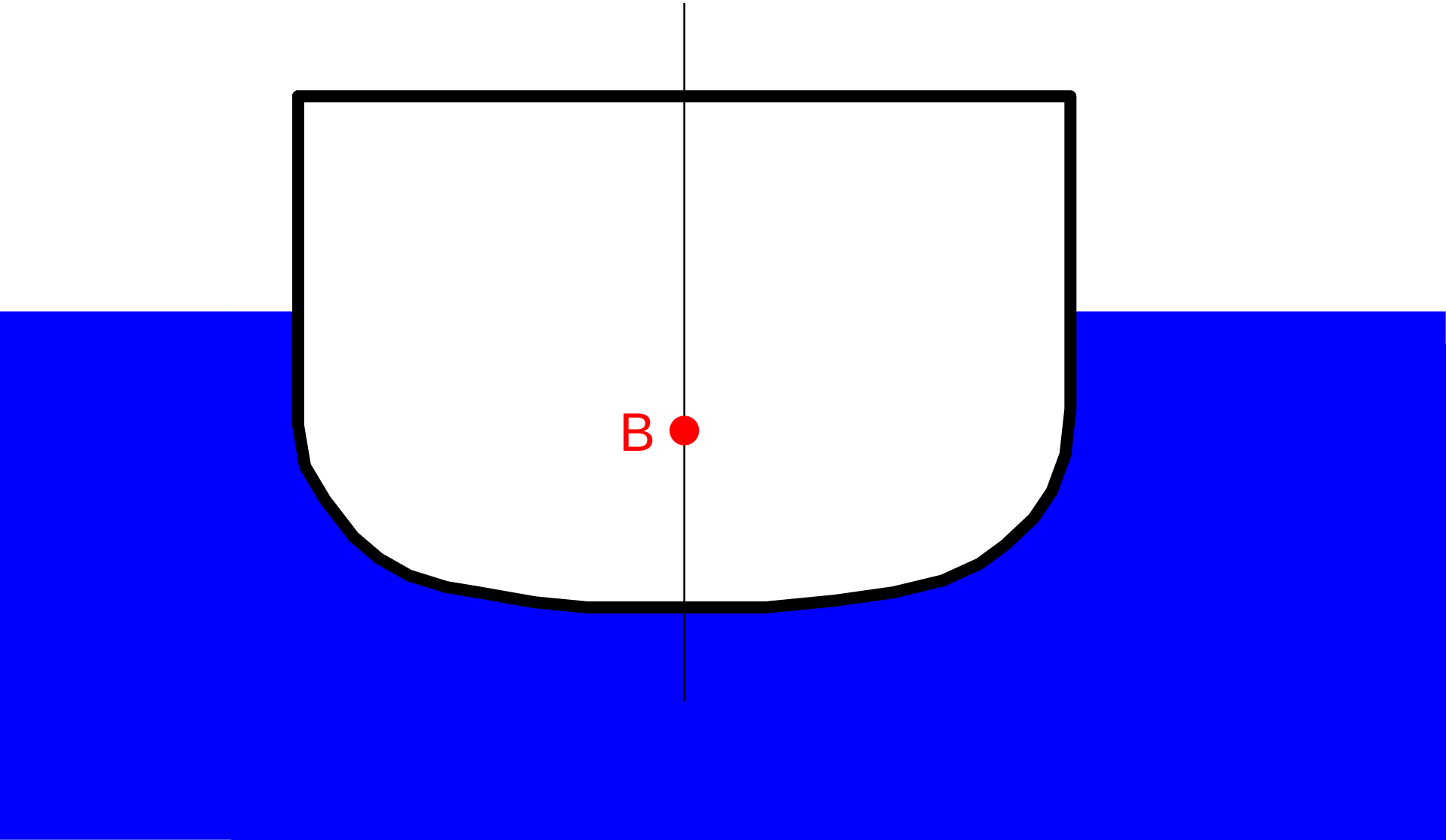

G
G_2



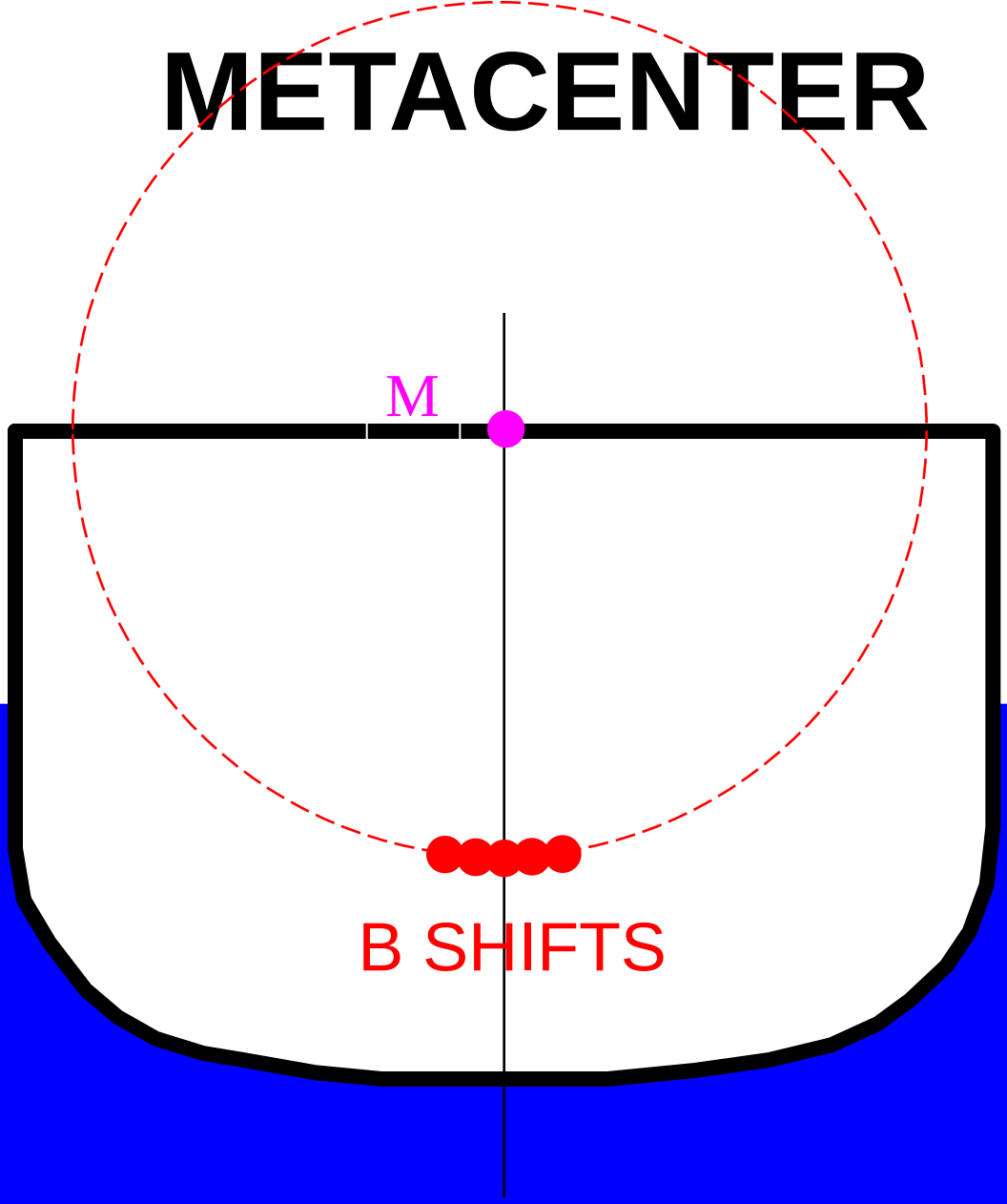
THE METACENTER



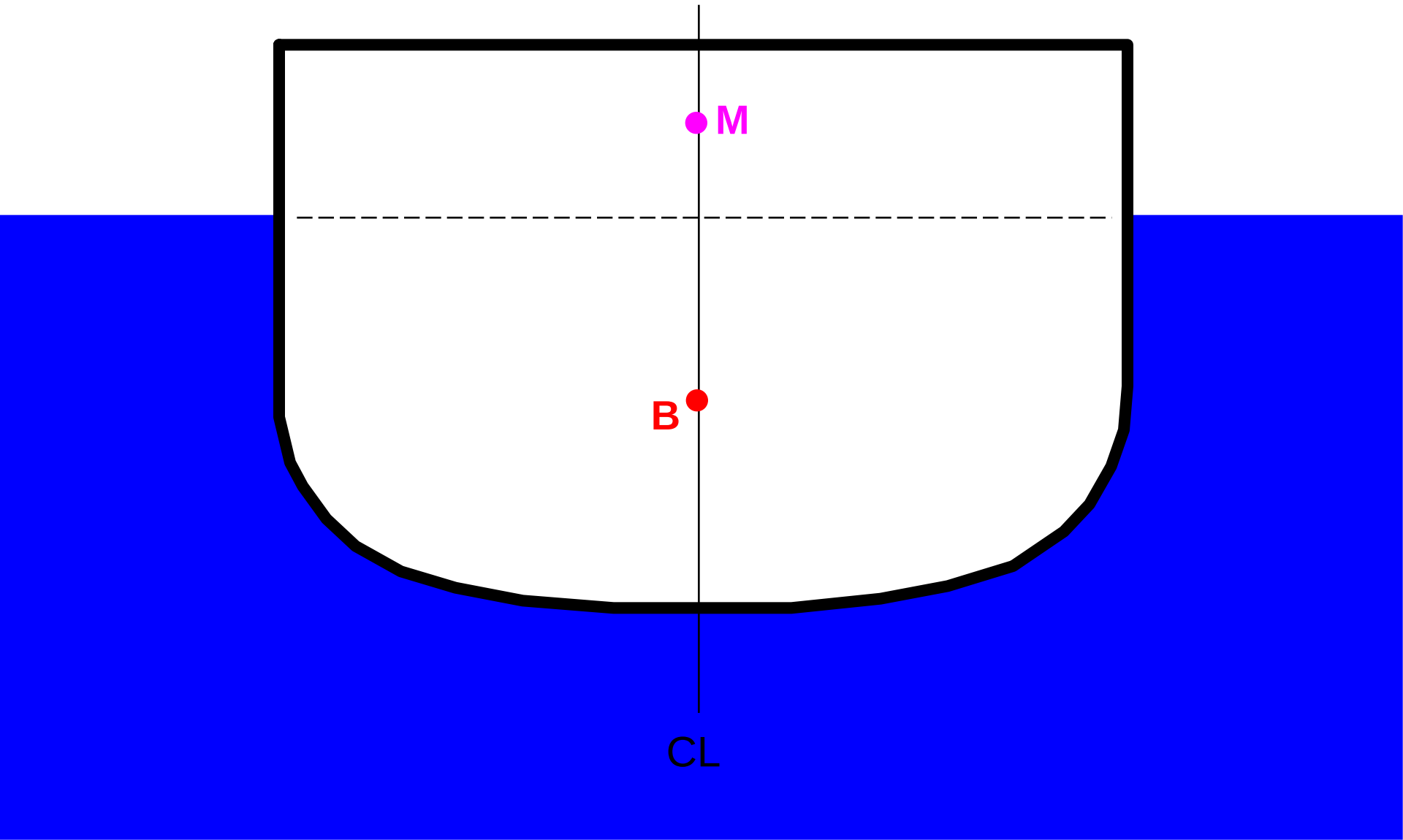
METACENTER

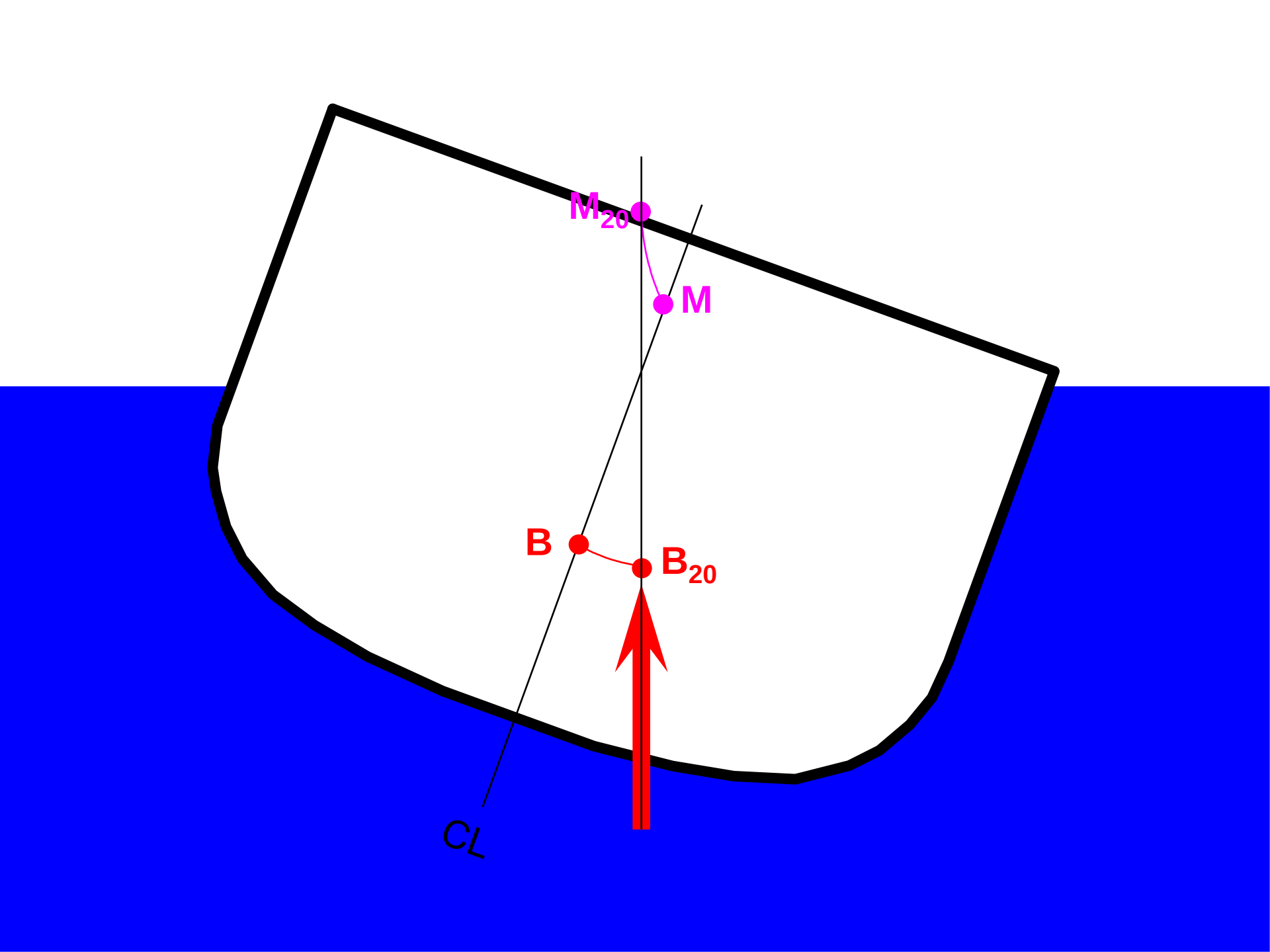


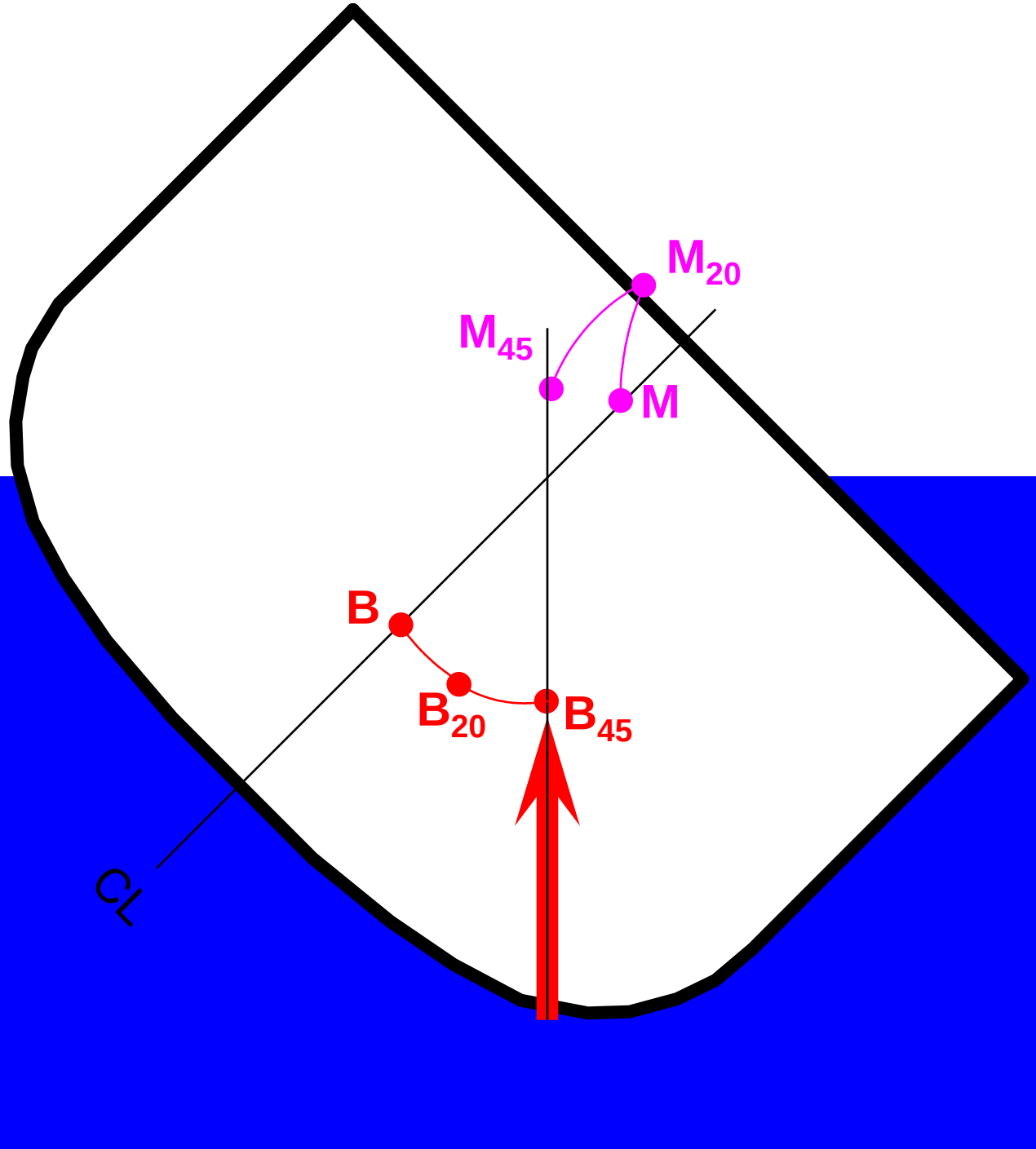
METACENTER

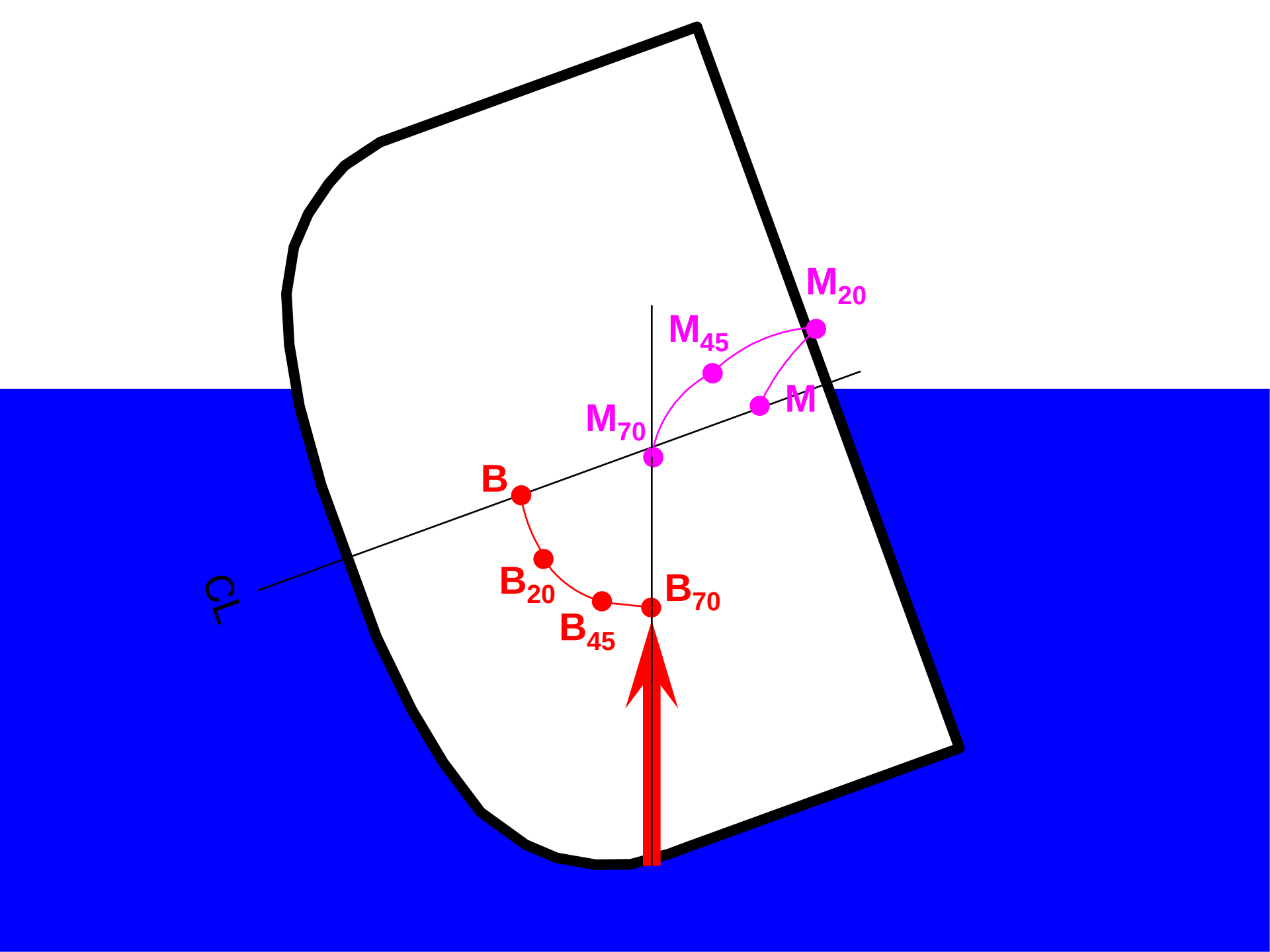


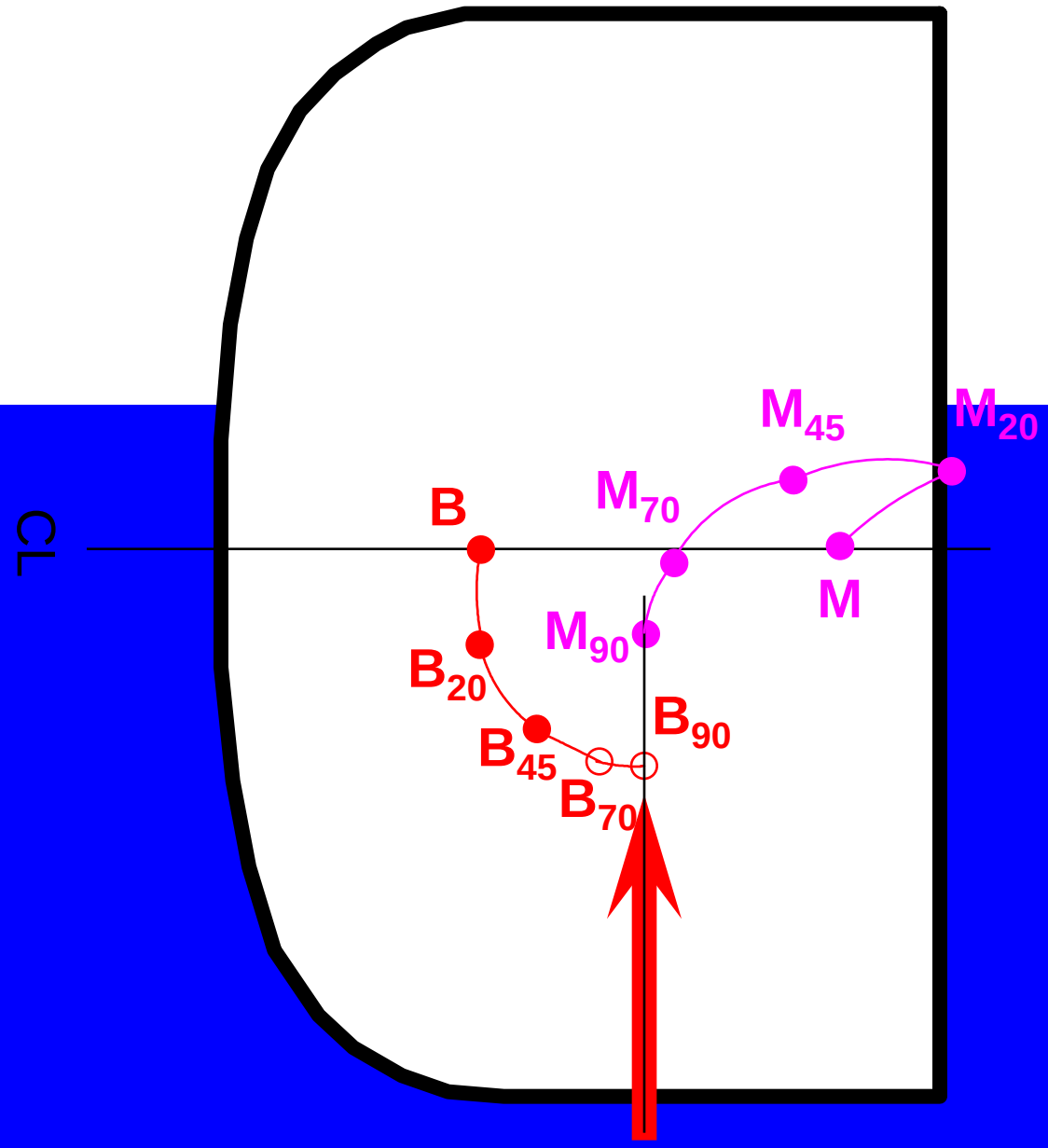
0º-7/10º




M20
M
B
B20
CL


M20
M45
M
B
B20
B45
CL


M20
M45
M
M70
B
B20
B70
B45
CL


CL
B
M70
M45
M20
M
M90
B20
B90
B45
B70

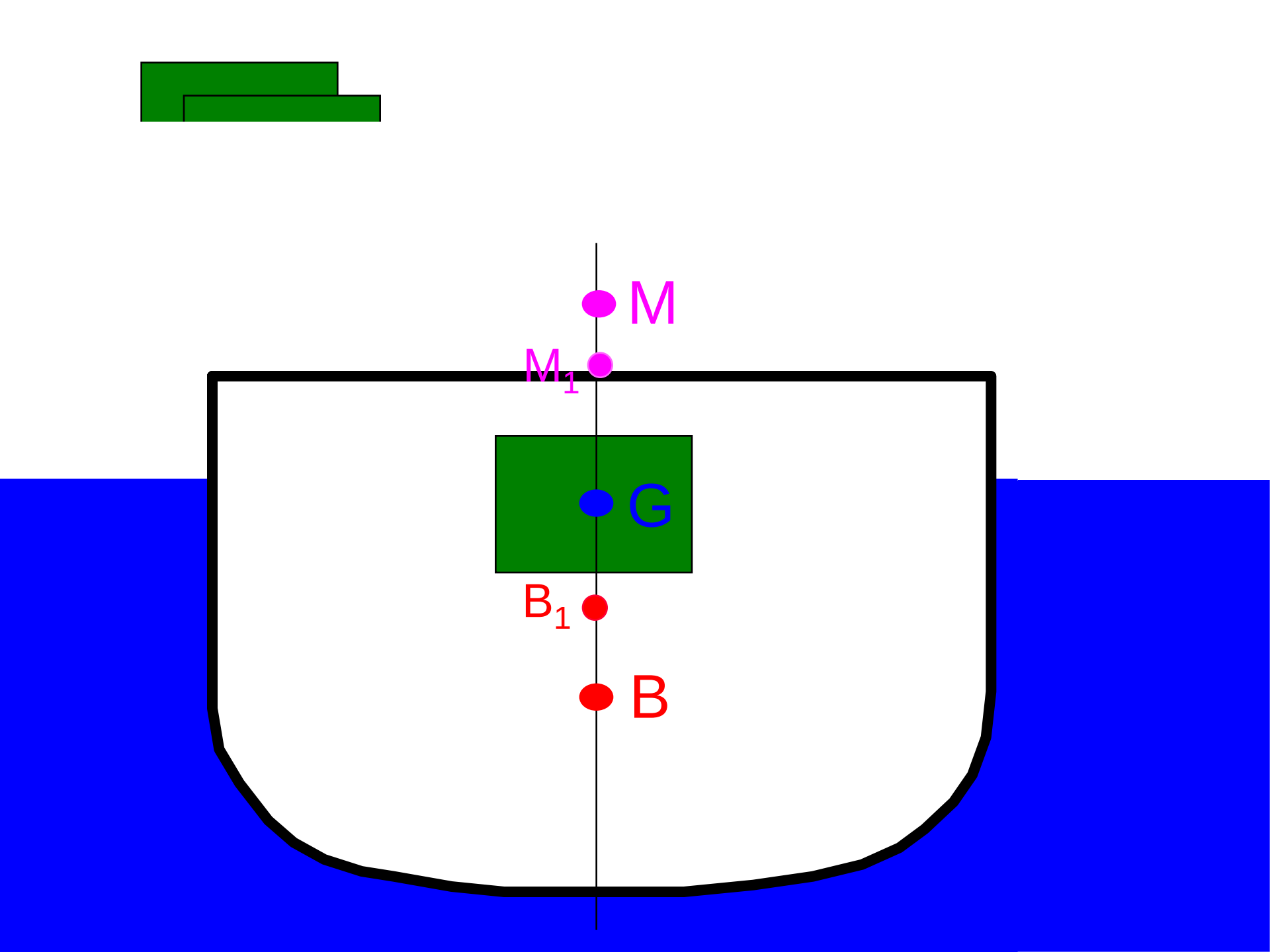
MOVEMENTS OF THE METACENTER

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

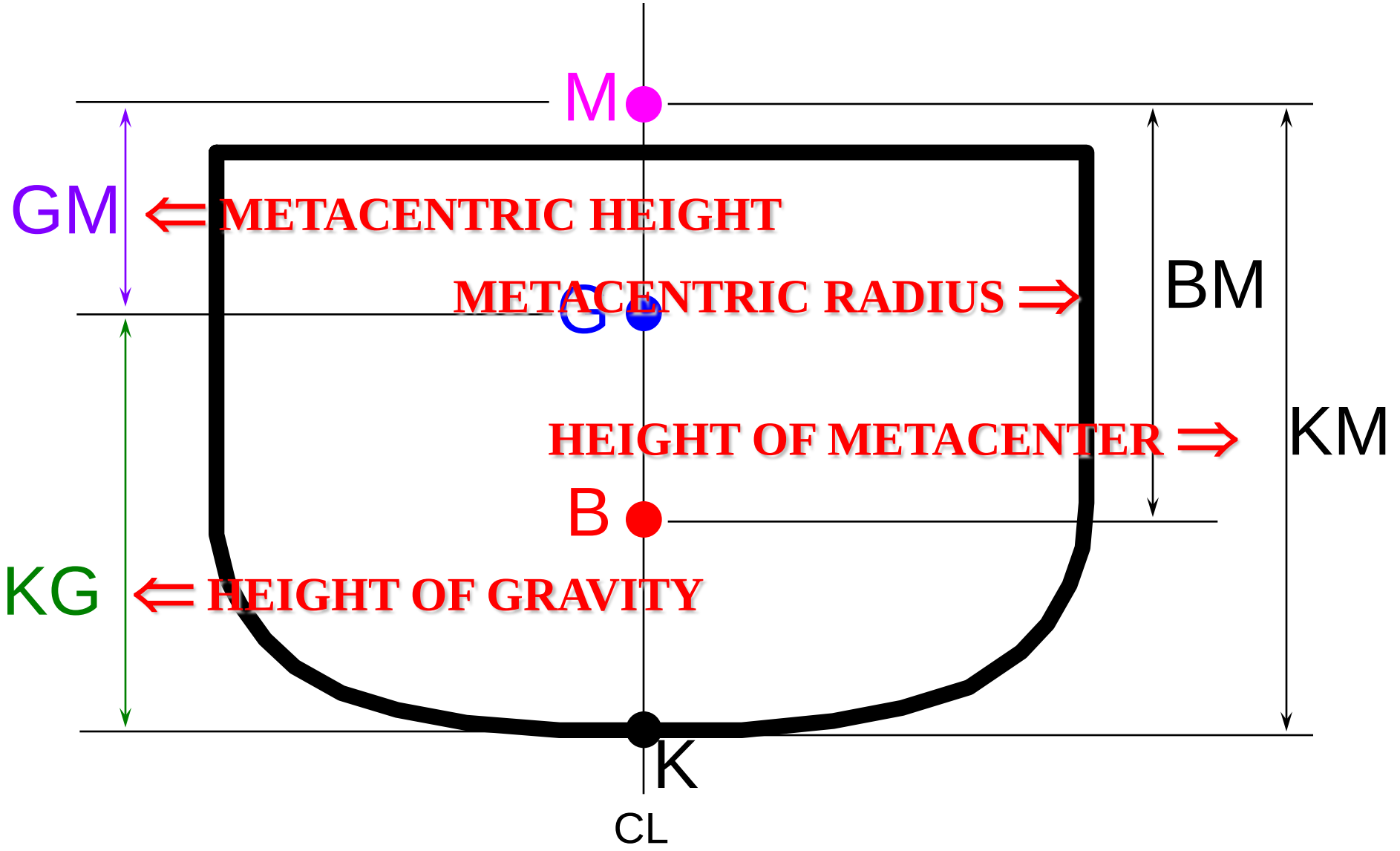
RULE OF THUMB = "M" MOVES OPPOSITE OF "B"

OR

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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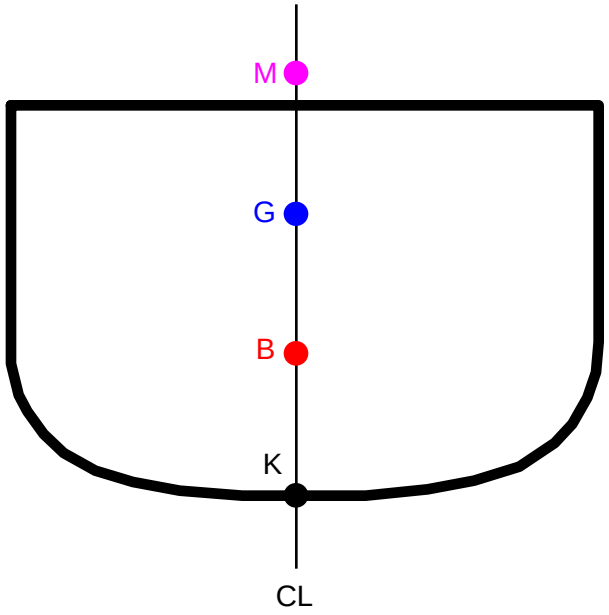
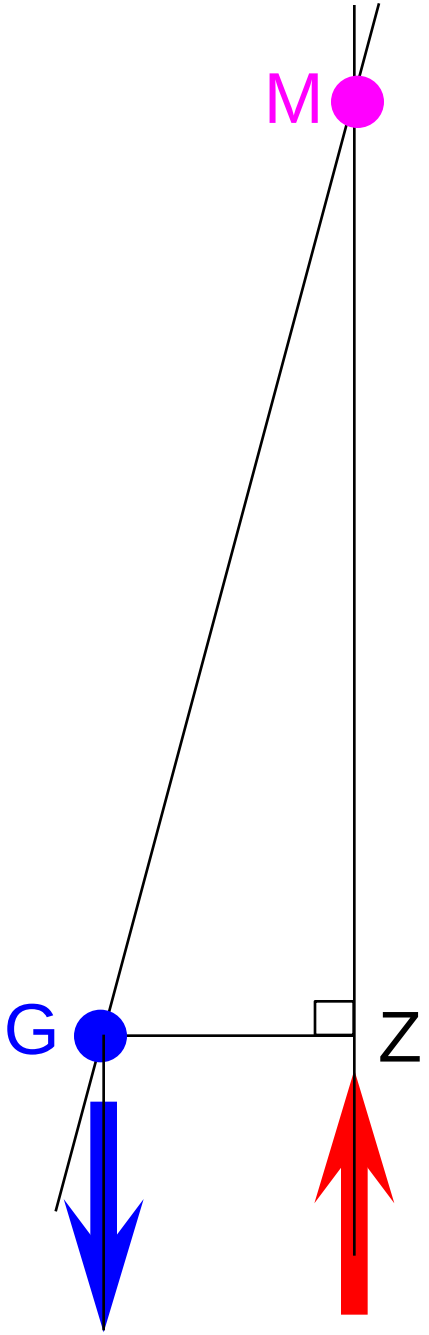
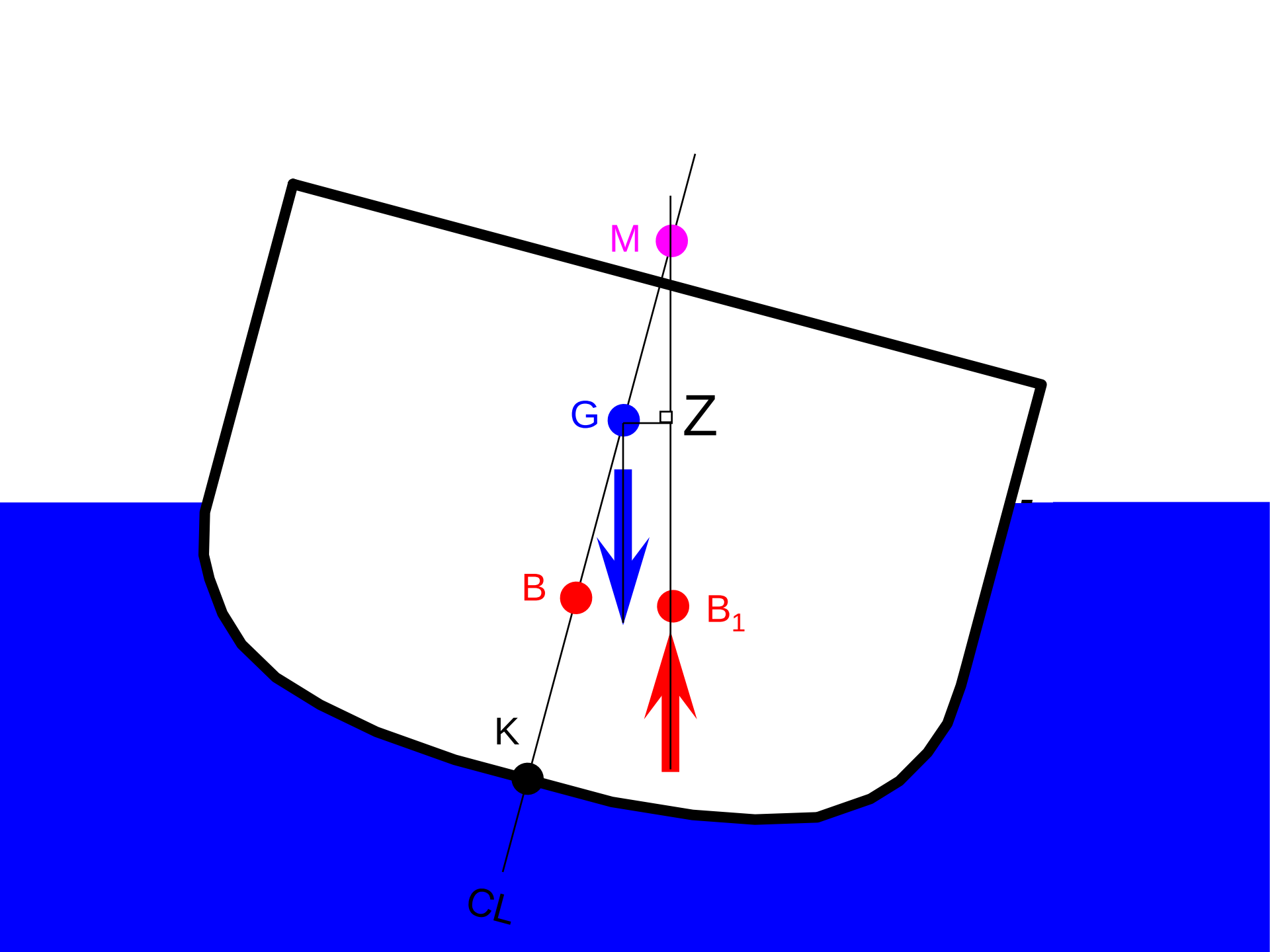


THE STABILITY TRIANGLE




M
G
Z
B
B1
K
CL

Sin θ = opp / hyp

Where:

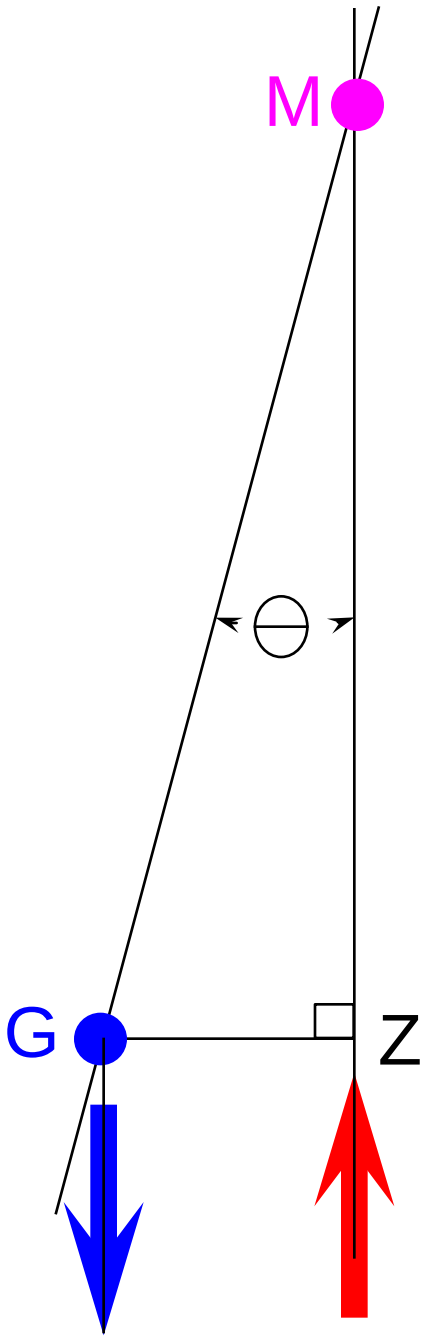
opposite = GZ

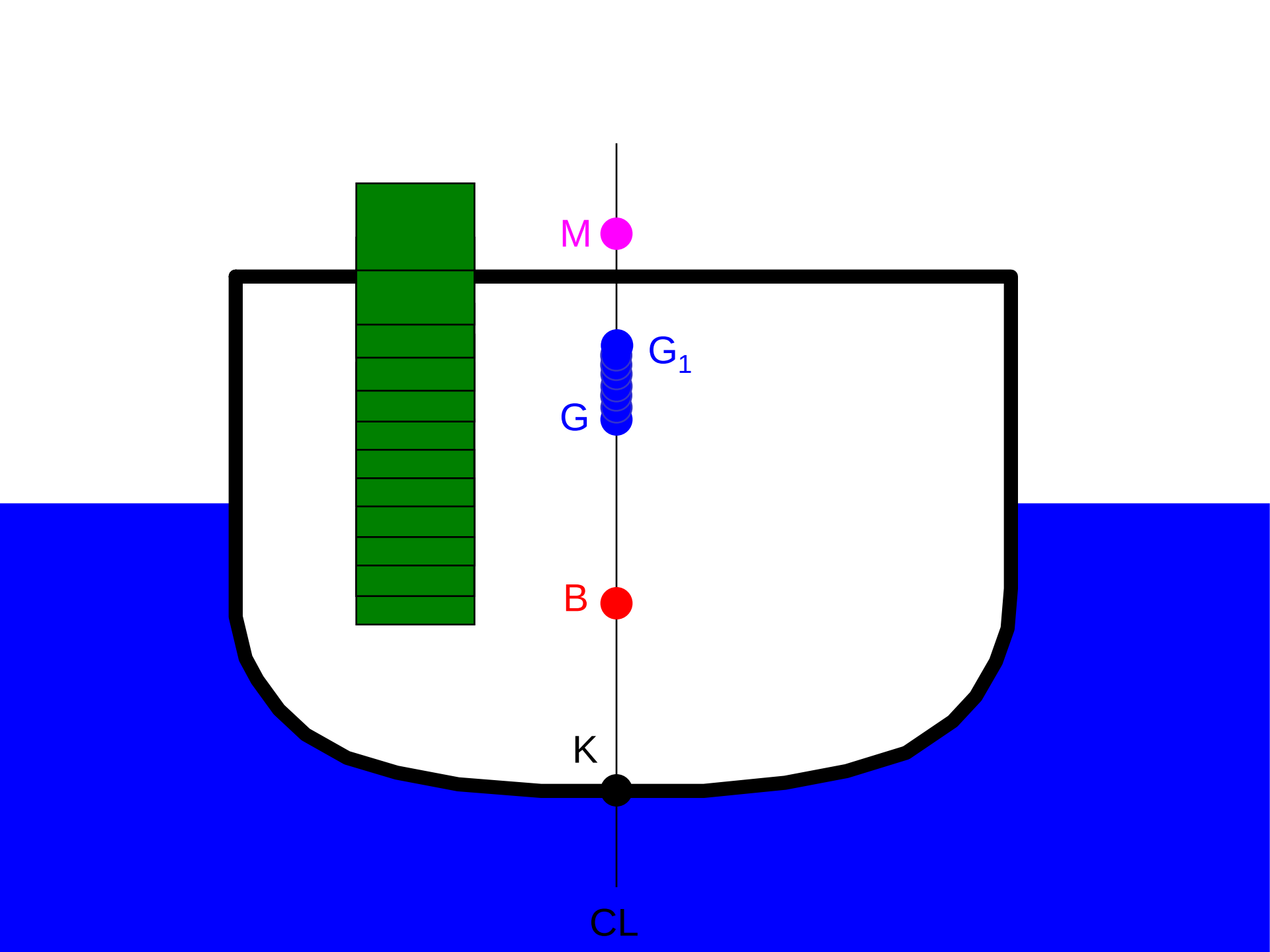
hypotenuse = GM

Sin θ = GZ / GM

GZ = GM x Sin θ

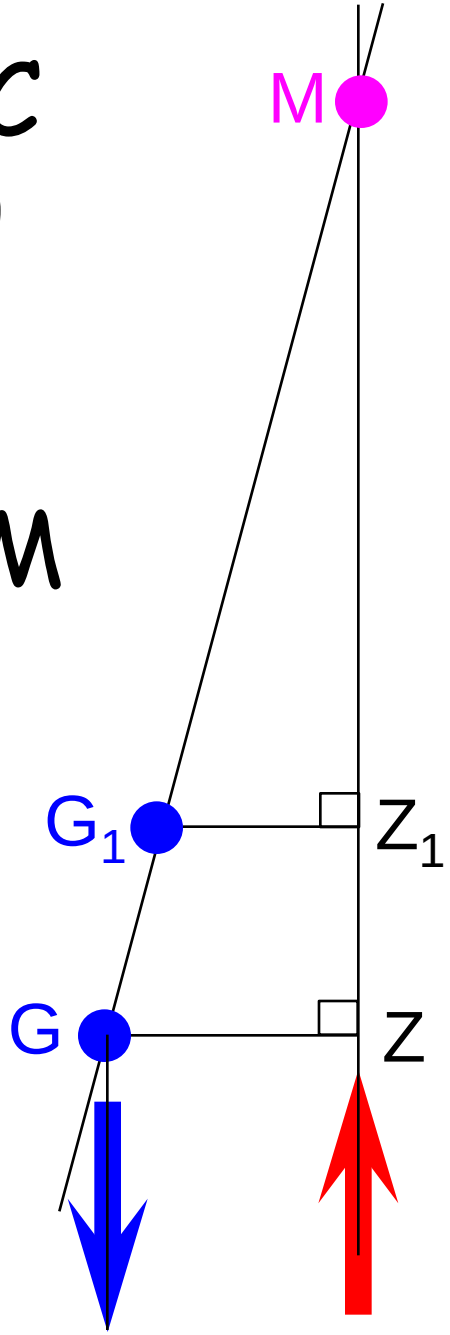
Growth of GZ α GM

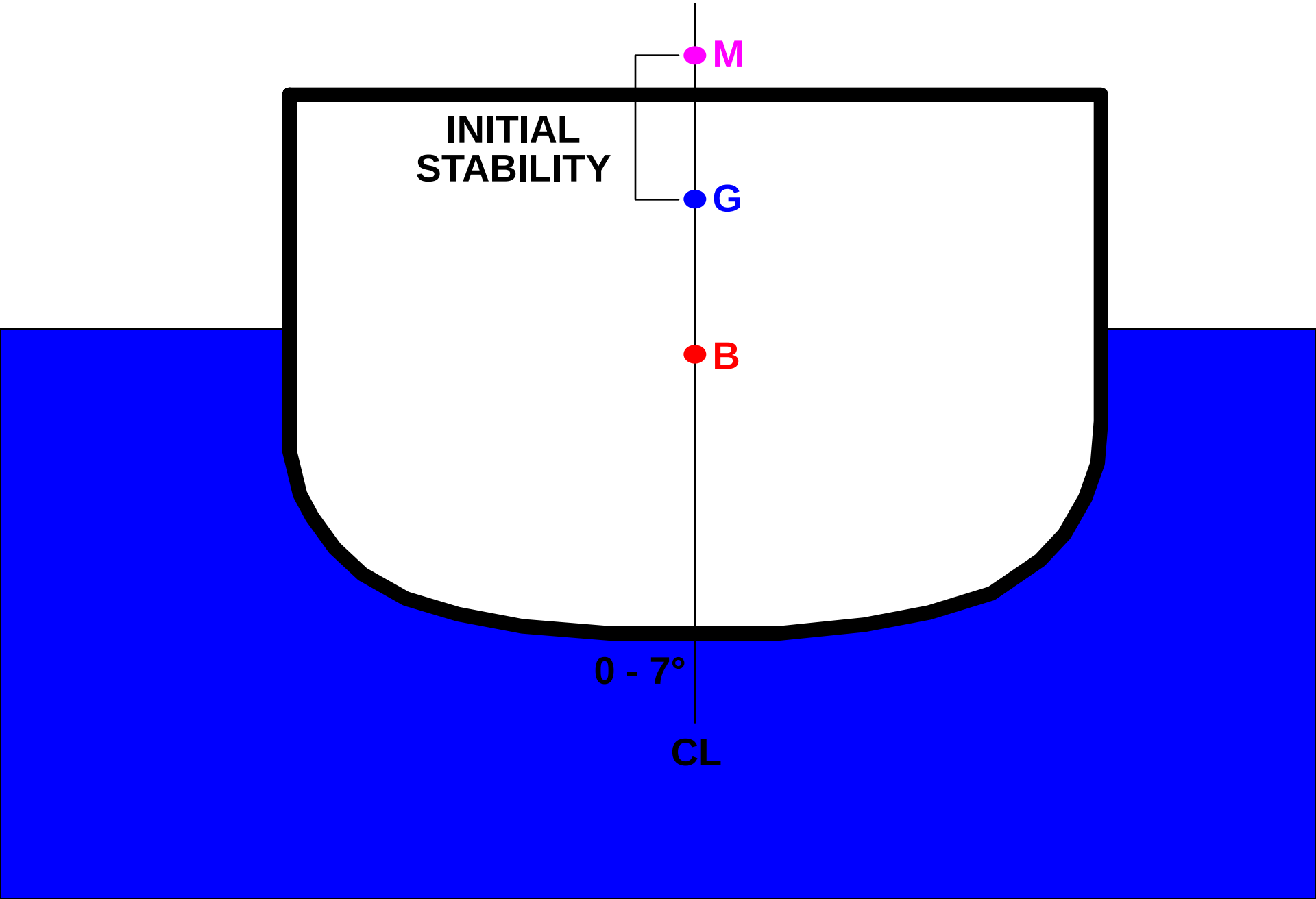


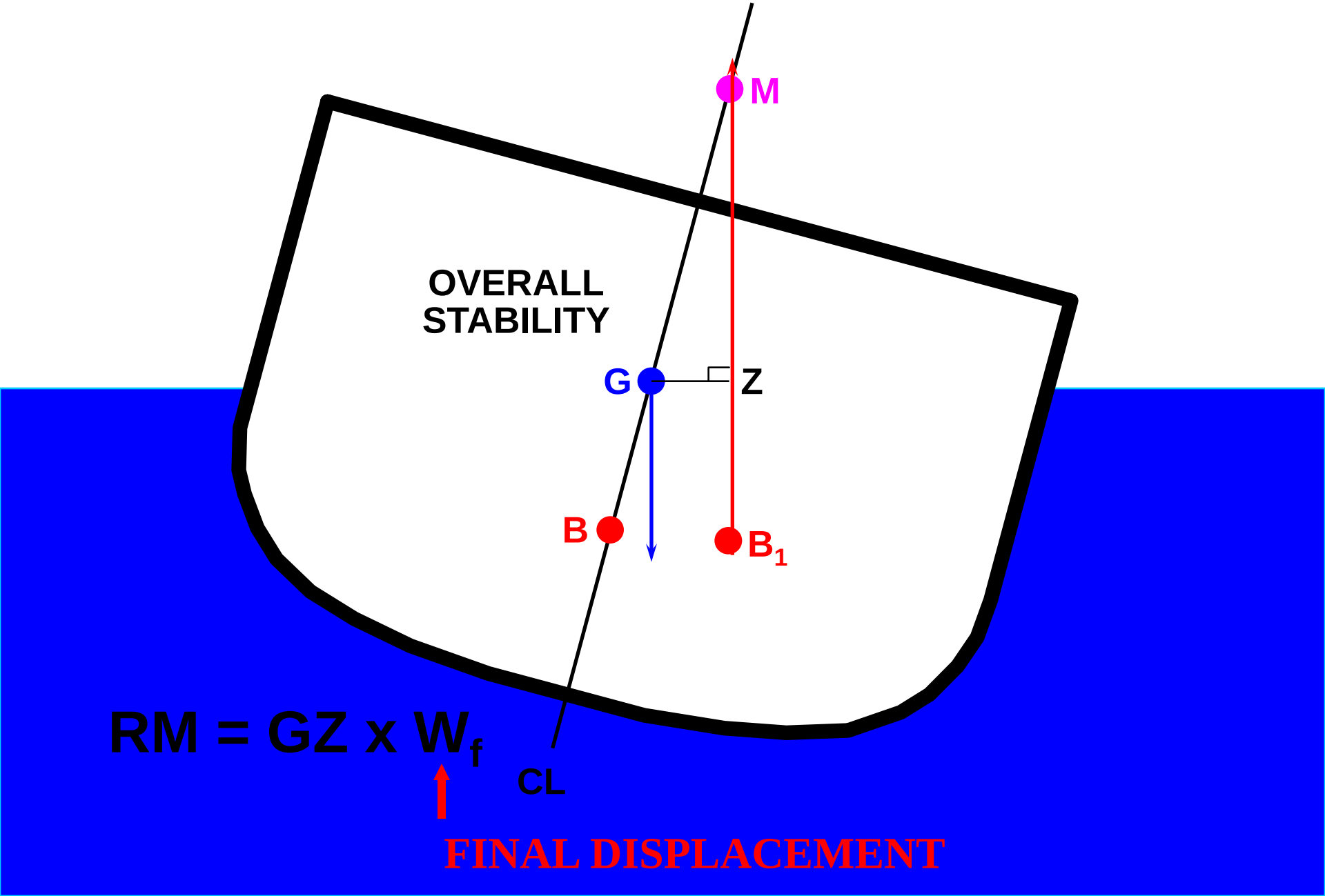

M
G1
G
B
K
CL

AS METACENTRIC HEIGHT (GM) DECREASES,

RIGHTING ARM (GZ) ALSO DECREASES




M
INITIAL
STABILITY
G
B
0 - 7°
CL


M
OVERALL
STABILITY
G
Z
B
B1
RM = GZ x Wf
CL
FINAL DISPLACEMENT

CLASS TOPICS

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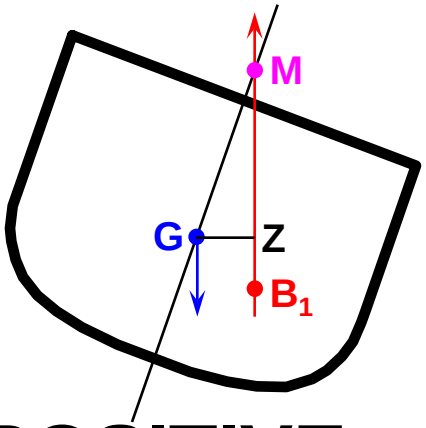
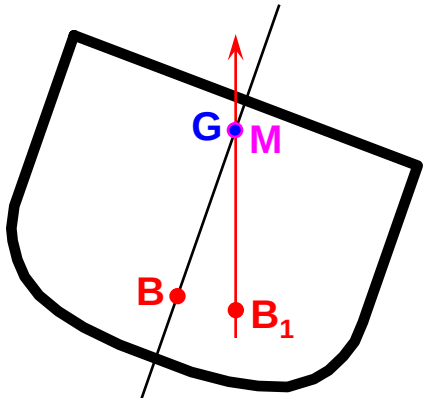
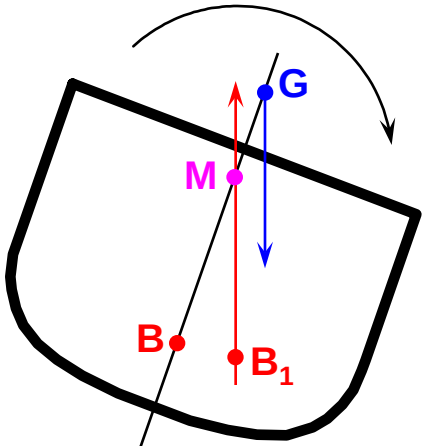
THE THREE CONDITIONS OF STABILITY



POSITIVE

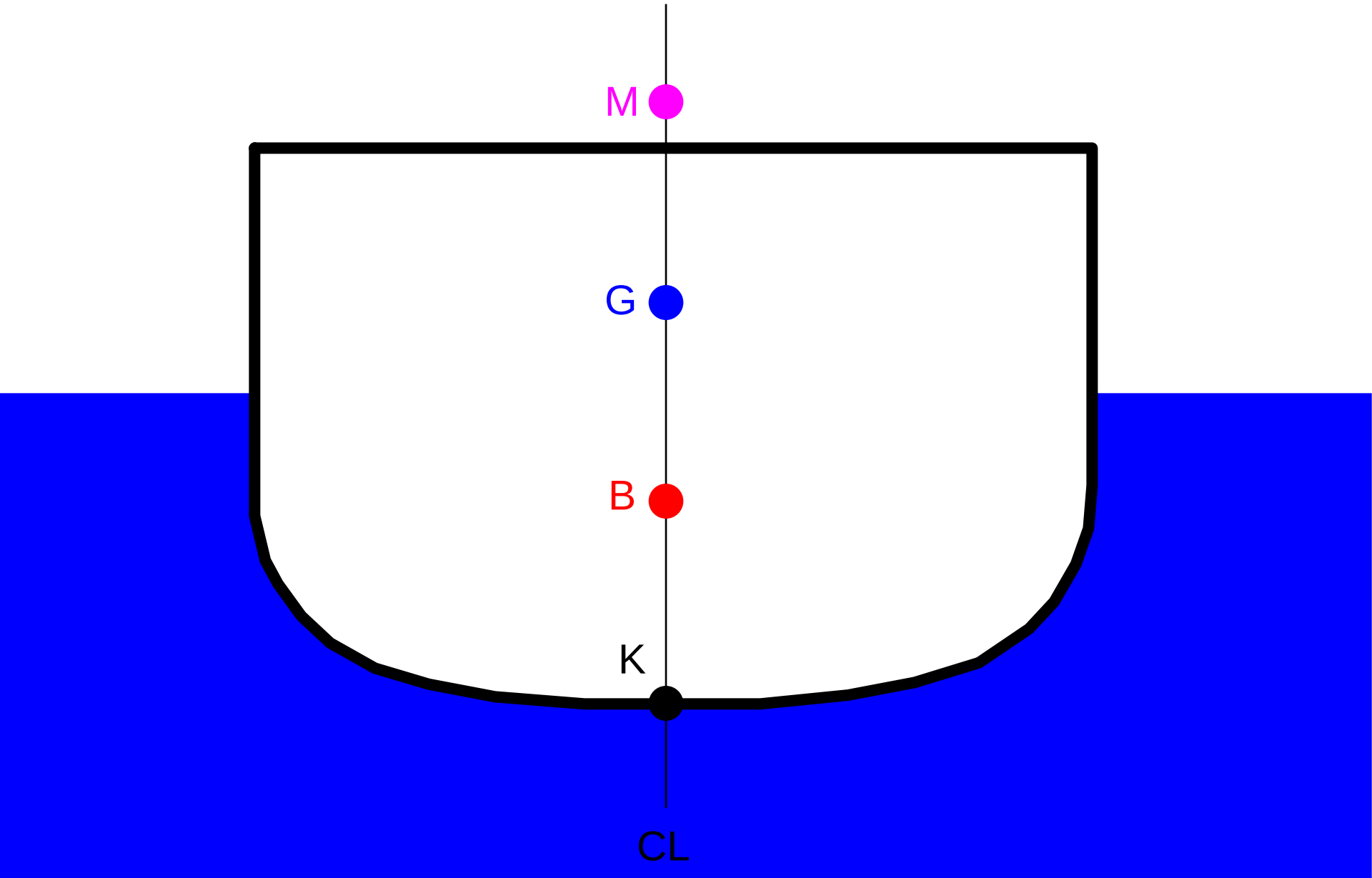


NEUTRAL

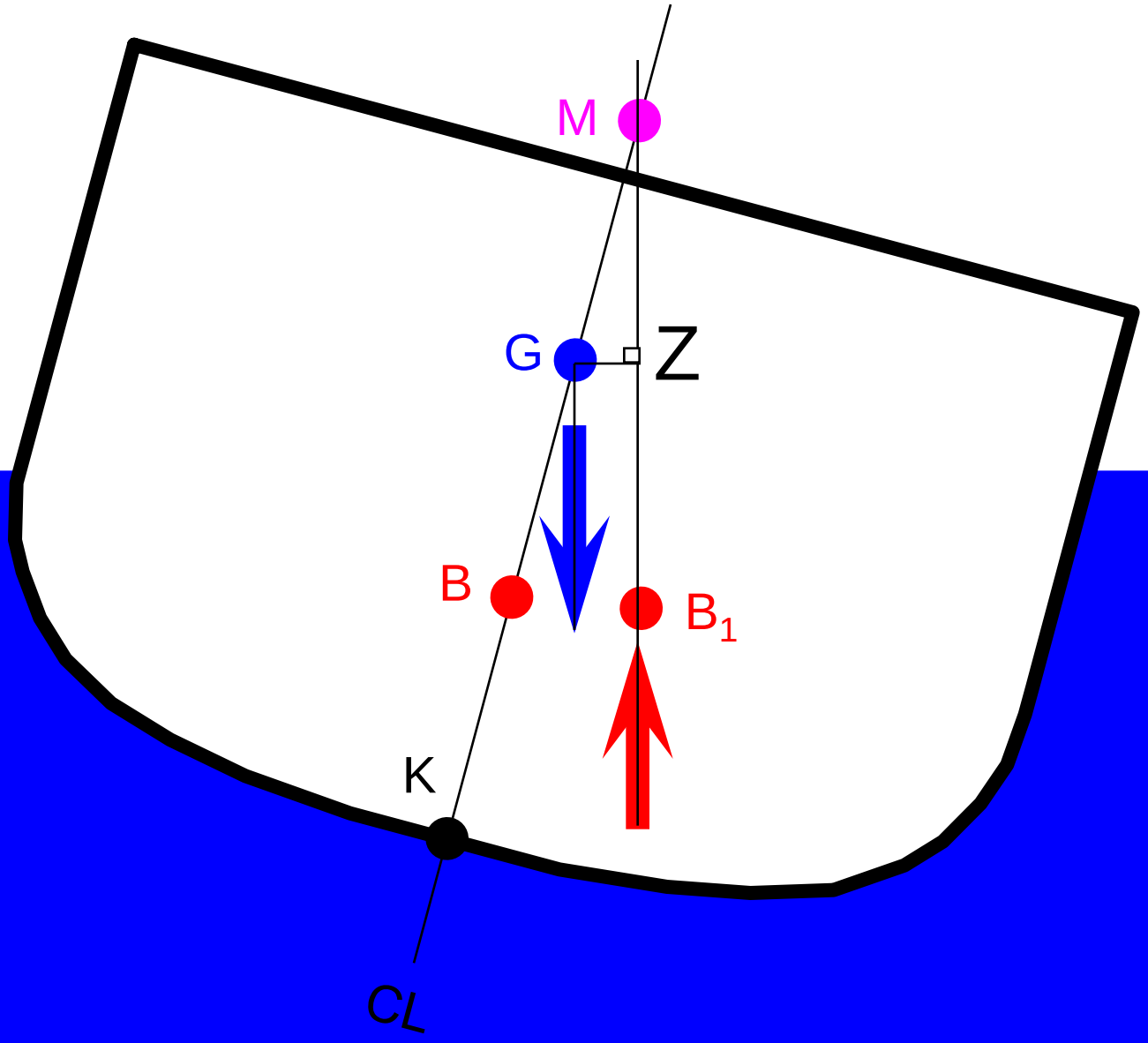


NEGATIVE

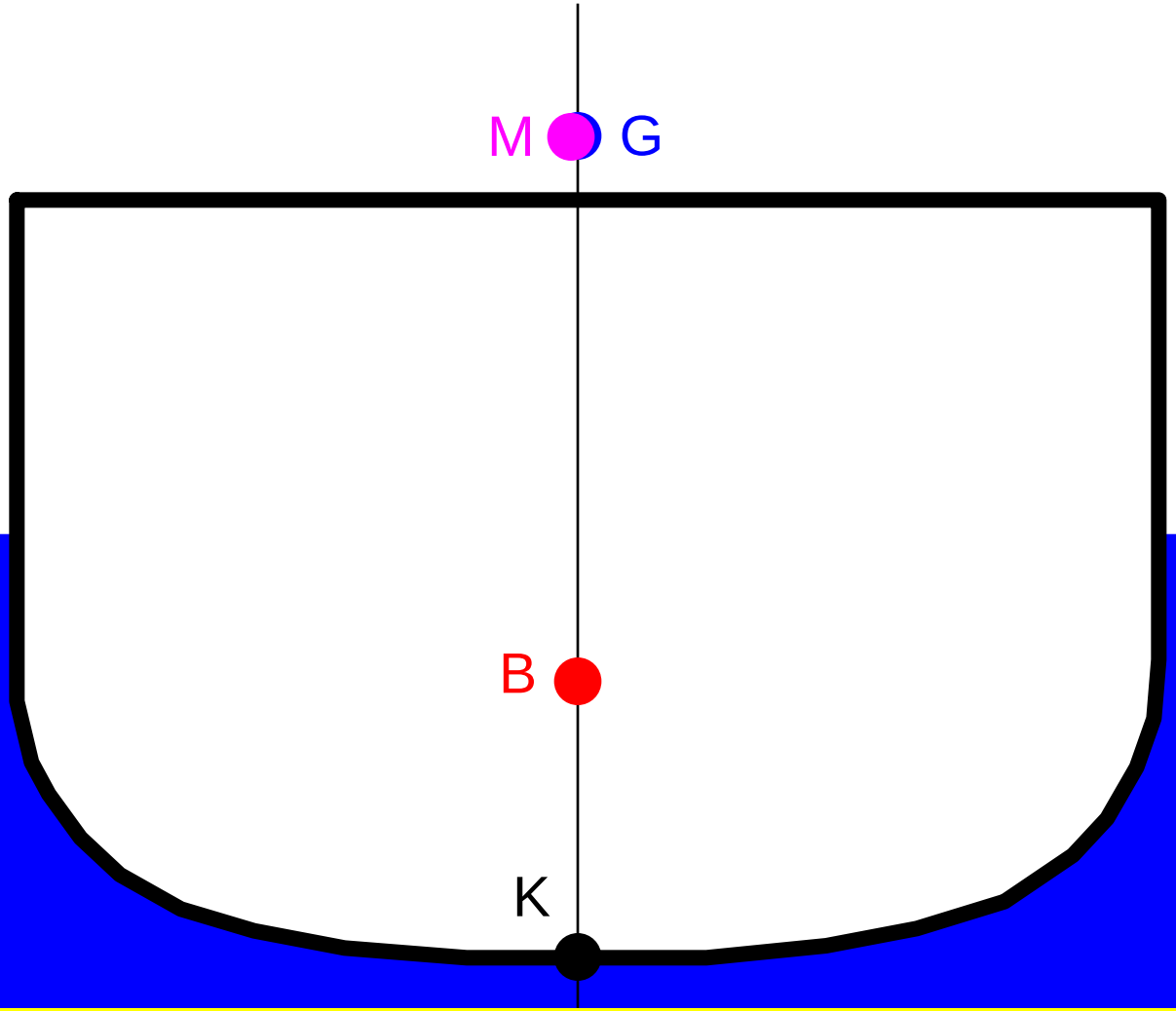
POSITIVE STABILITY



POSITIVE STABILITY



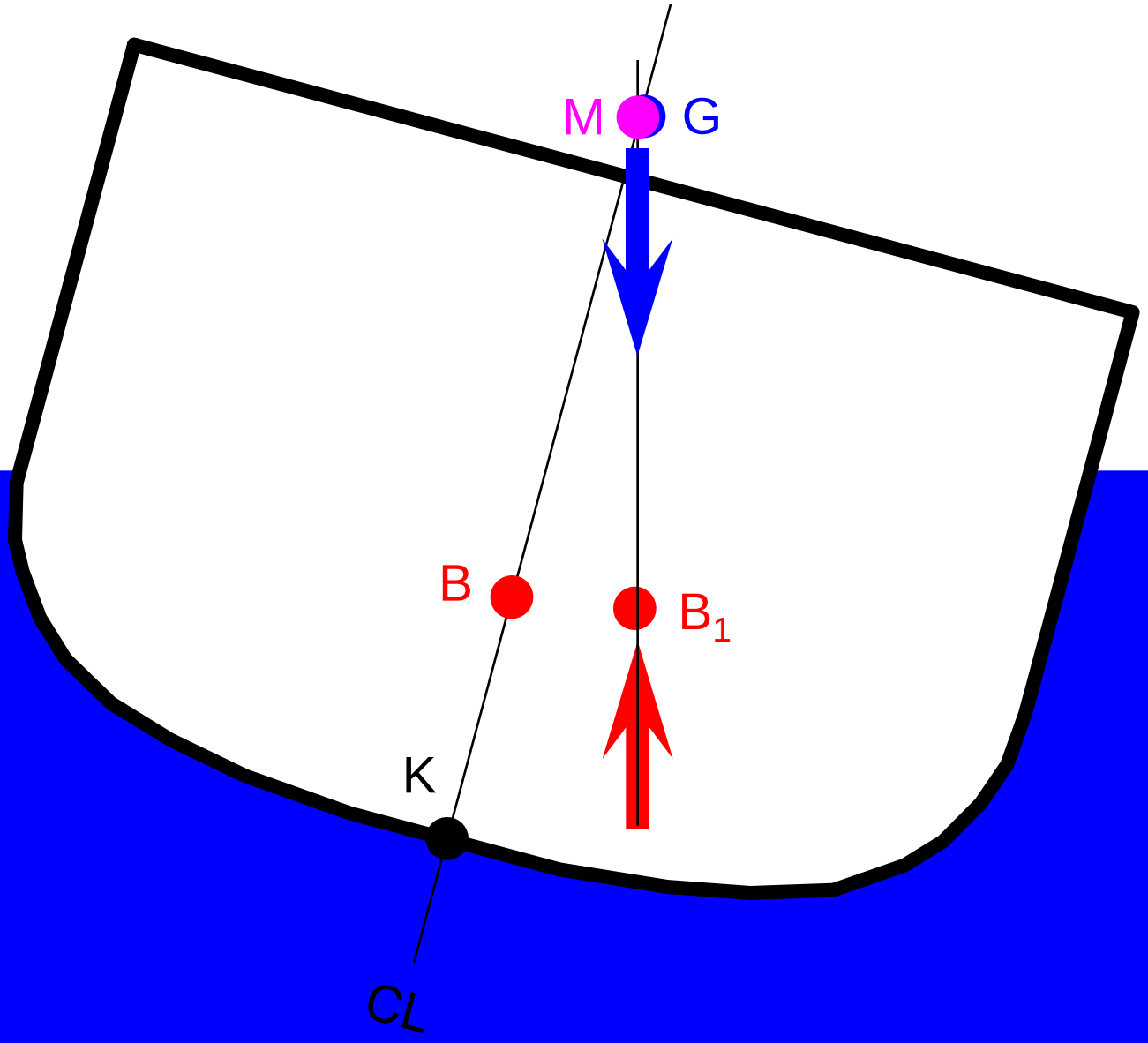
NEUTRAL STABILITY



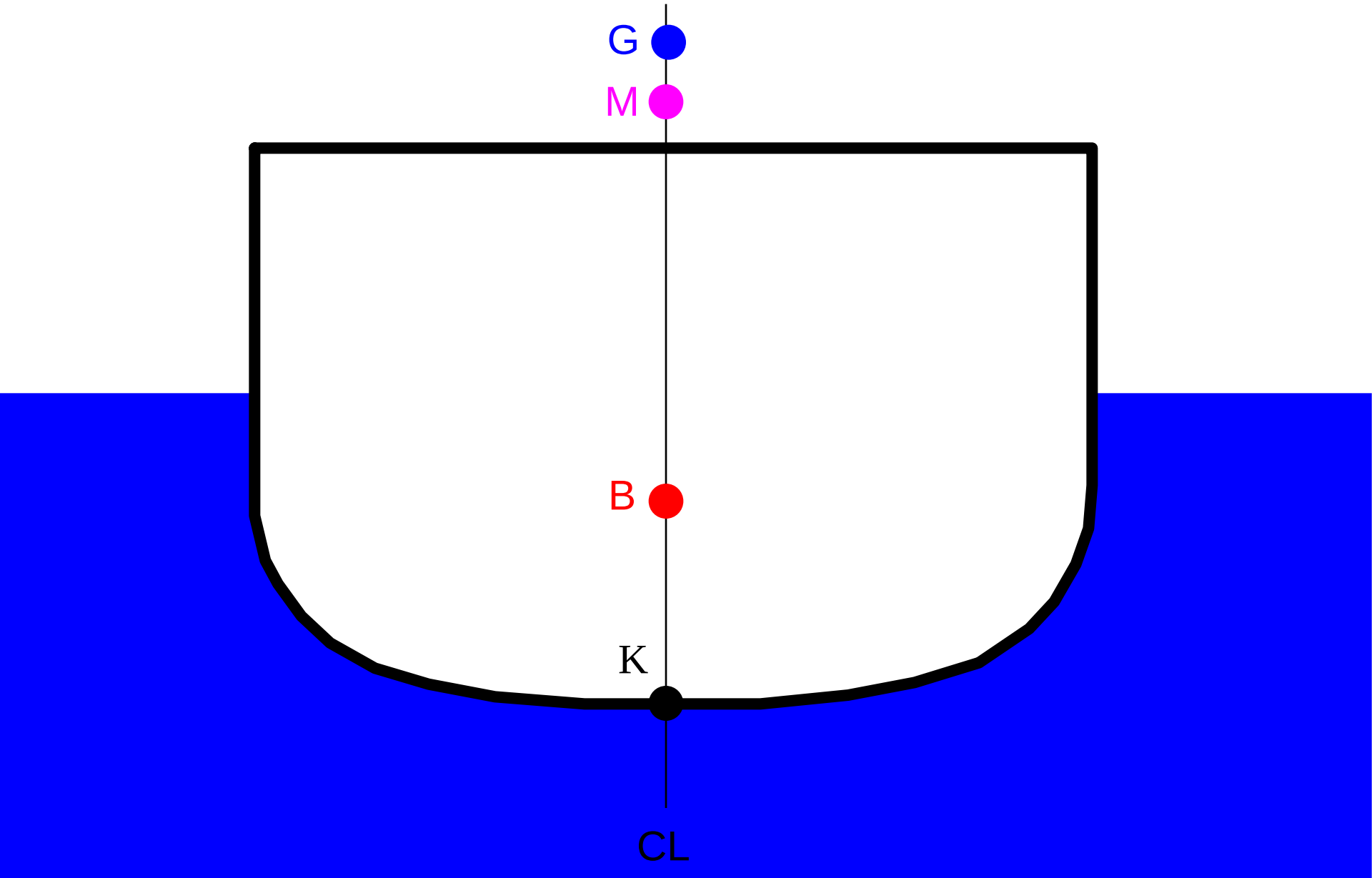
WHAT COULD CAUSE NEUTRAL STABILITY ?

CL

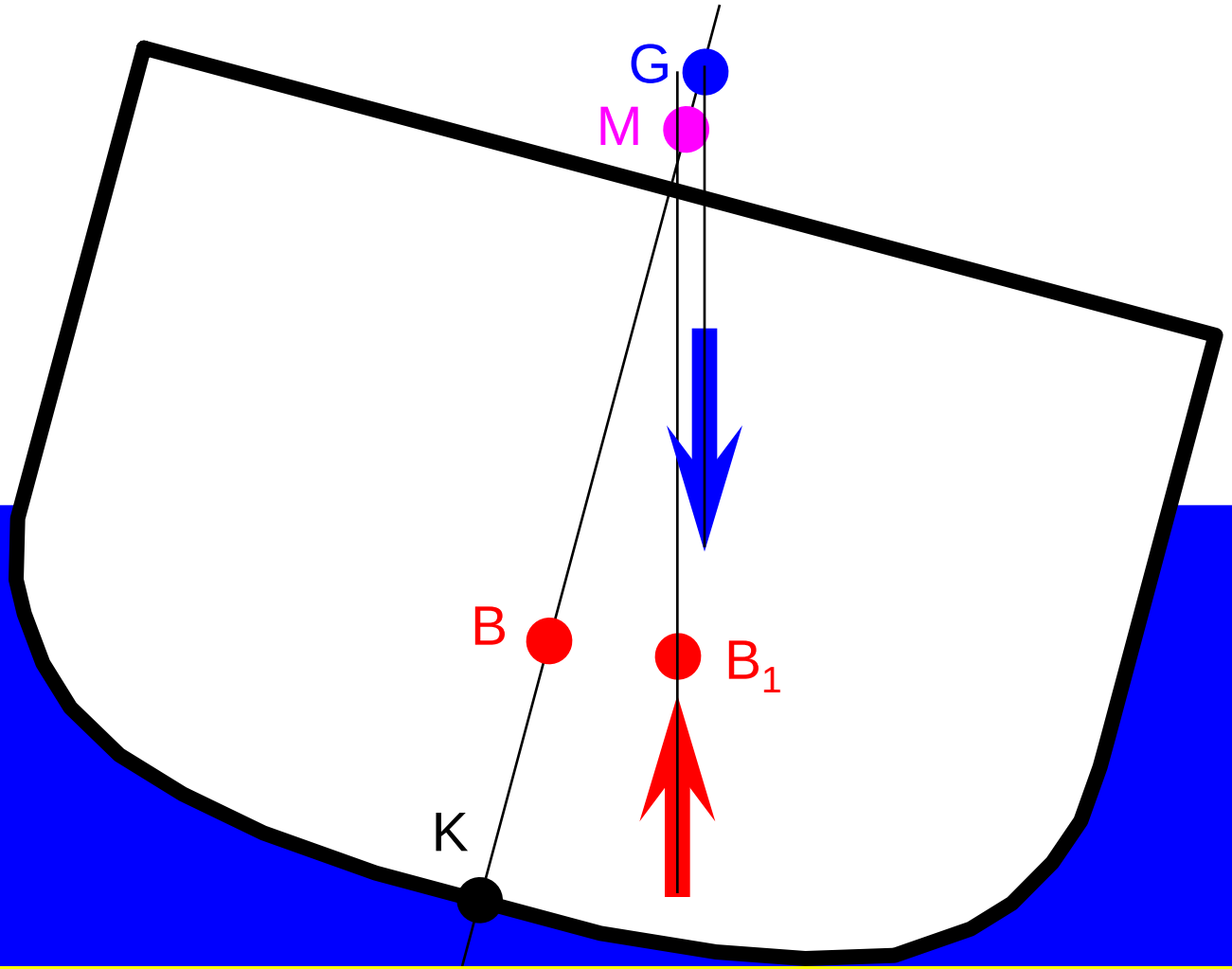
NEUTRAL STABILITY



NEGATIVE STABILITY

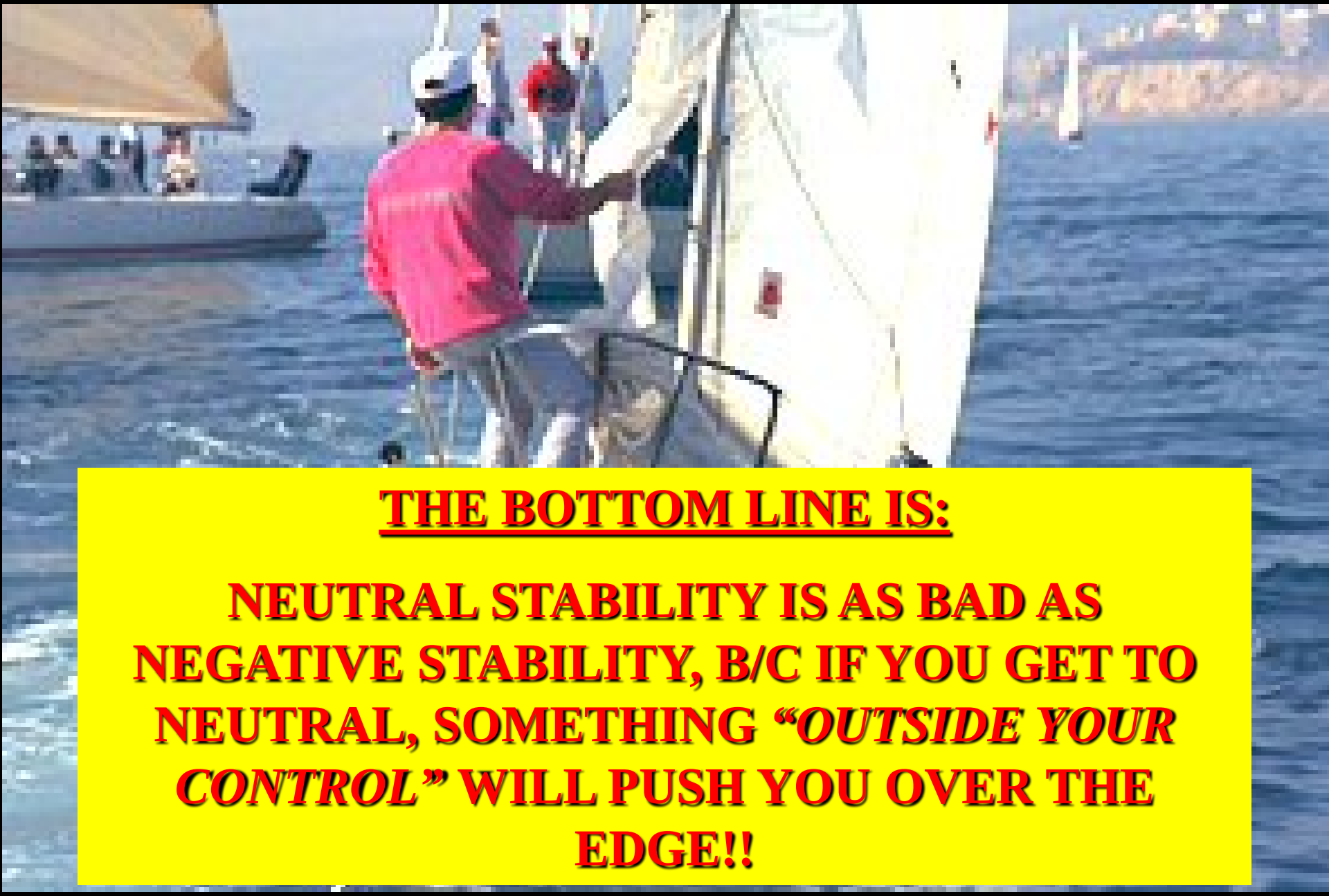


NEGATIVE STABILITY



WHAT WILL HAPPEN WITH NEGATIVE STABILITY ?


3978



THE BOTTOM LINE IS:

NEUTRAL STABILITY IS AS BAD AS NEGATIVE STABILITY, B/C IF YOU GET TO NEUTRAL, SOMETHING *"OUTSIDE YOUR CONTROL"* WILL PUSH YOU OVER THE EDGE!!

CLASS TOPICS

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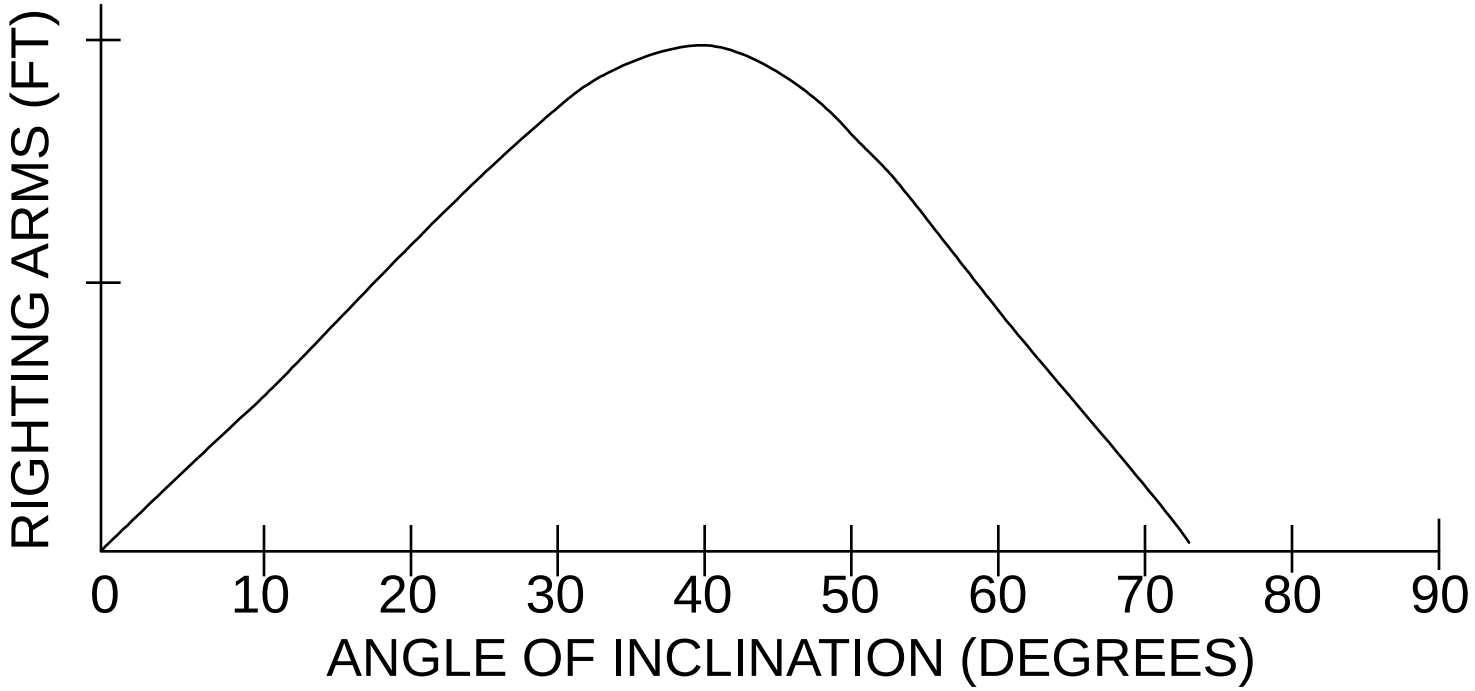
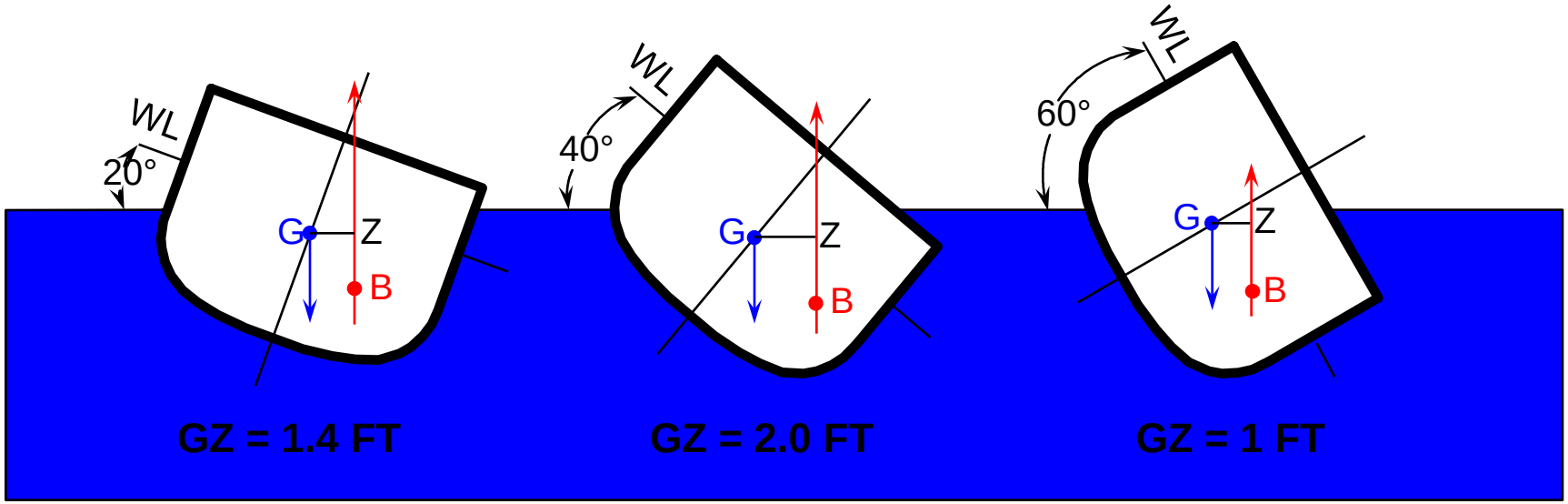
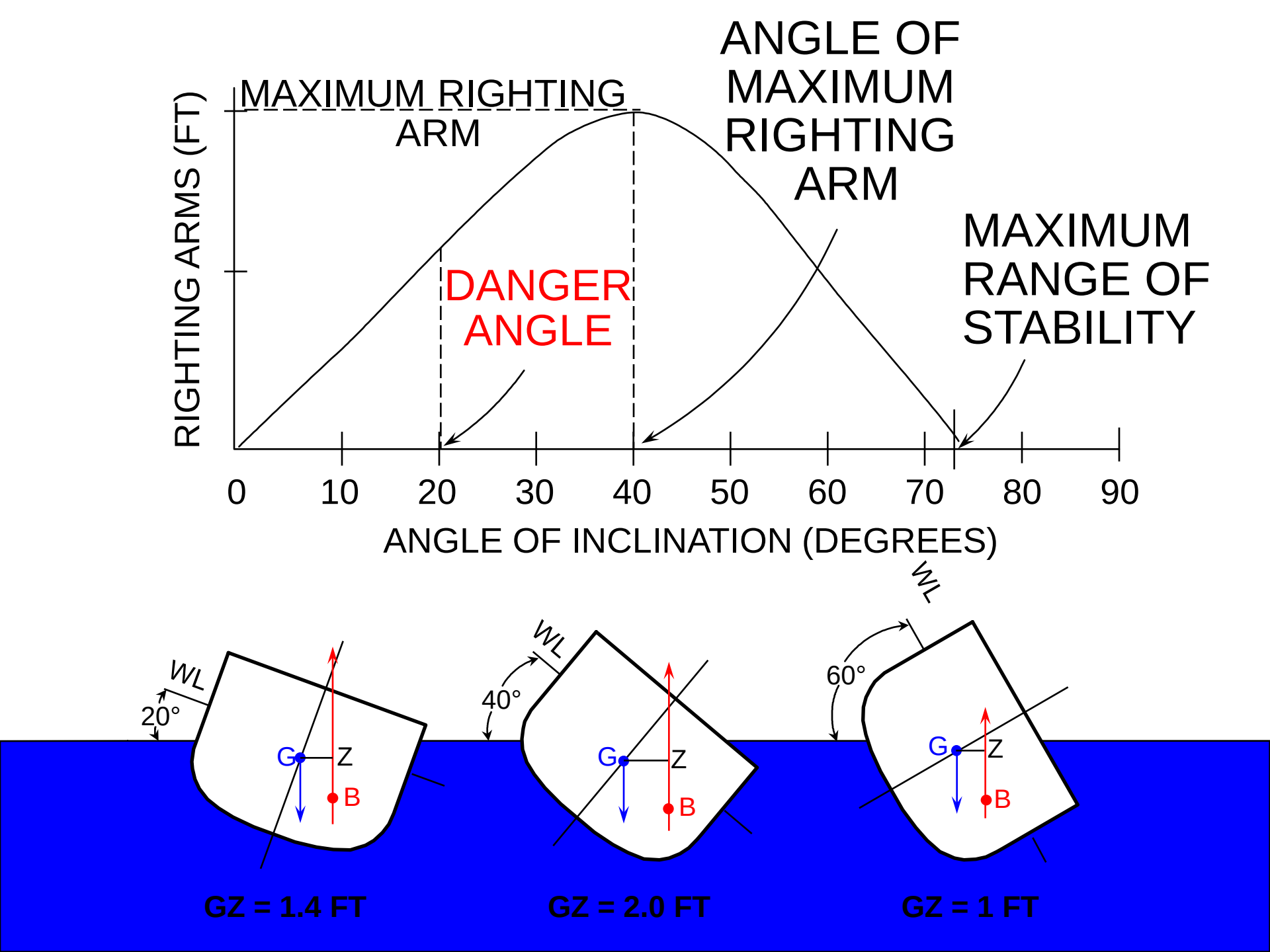
RIGHTING ARM CURVE






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 INCLINATION (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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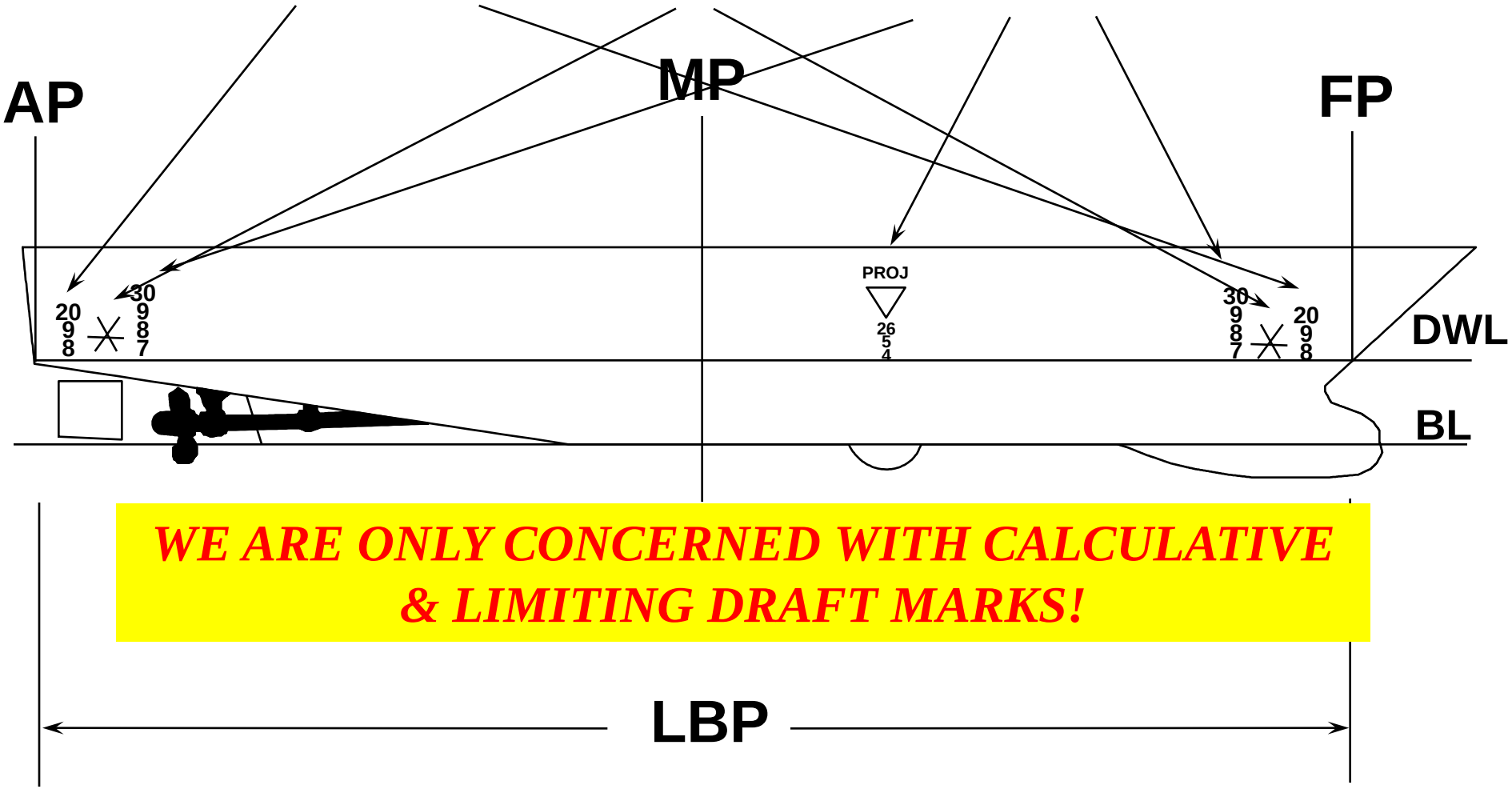
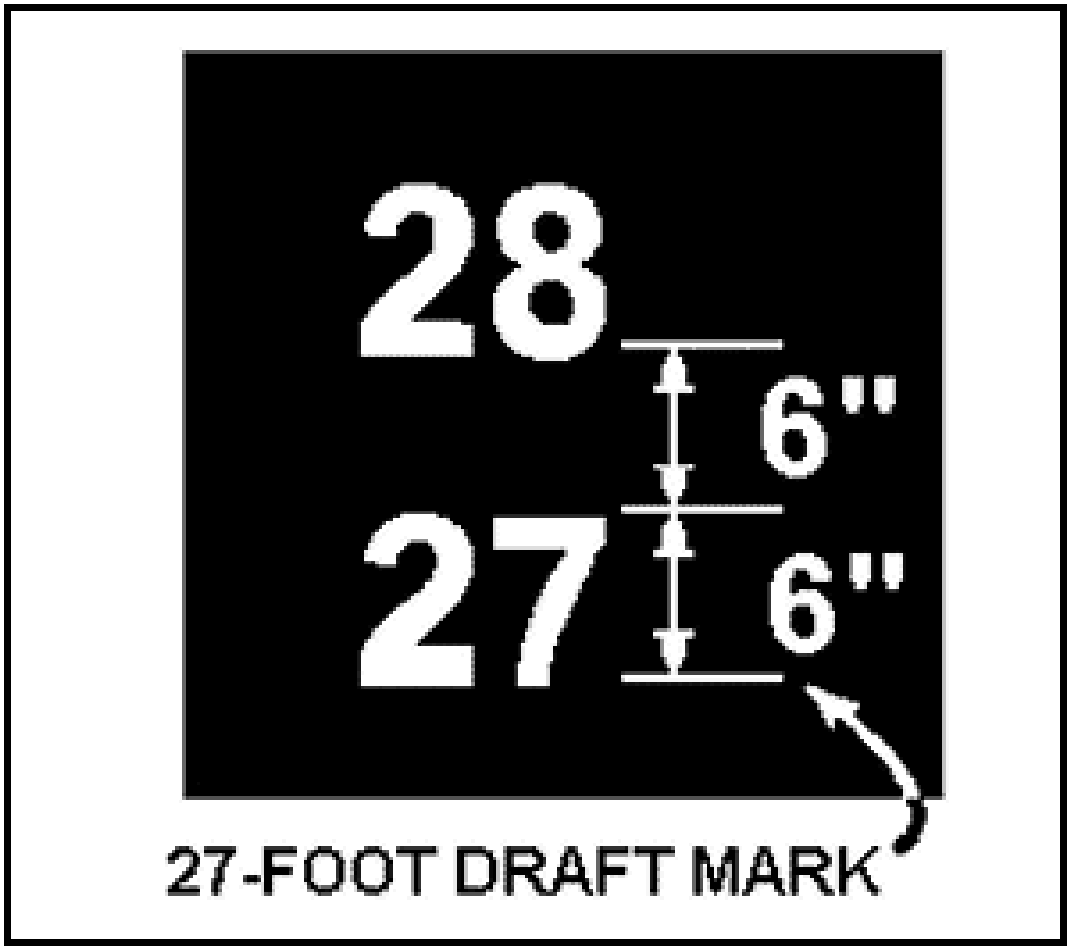
LONGITUDINAL CROSS SECTION

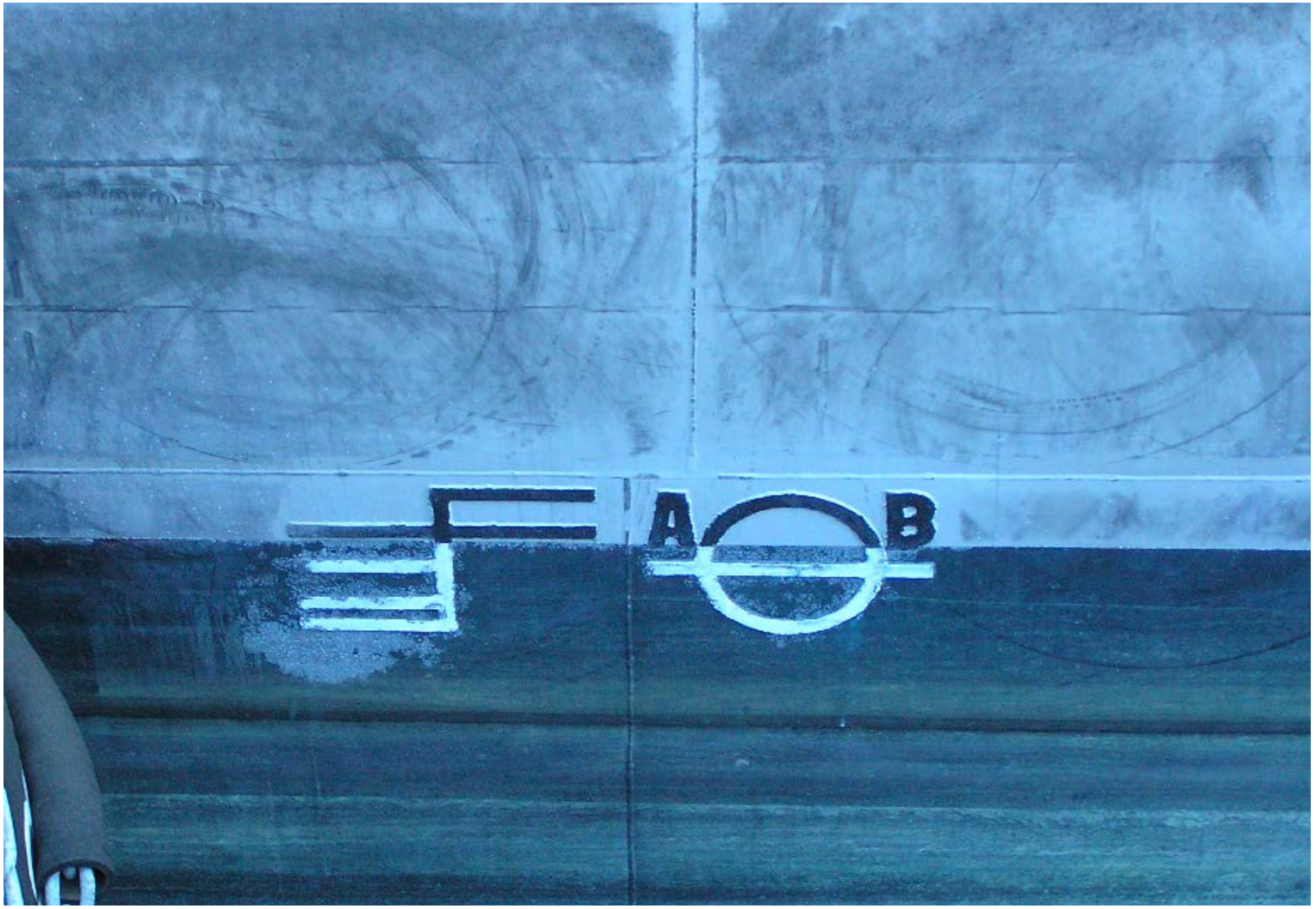


WE ARE ONLY CONCERNED WITH CALCULATIVE & LIMITING DRAFT MARKS!

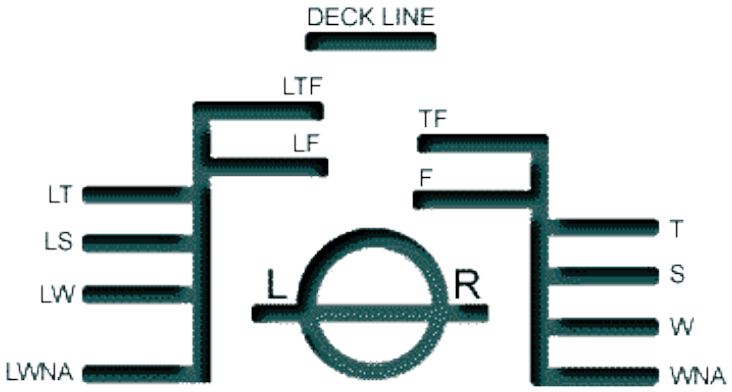
How to read draft marks…



How to read draft marks…



Plimsoll Mark

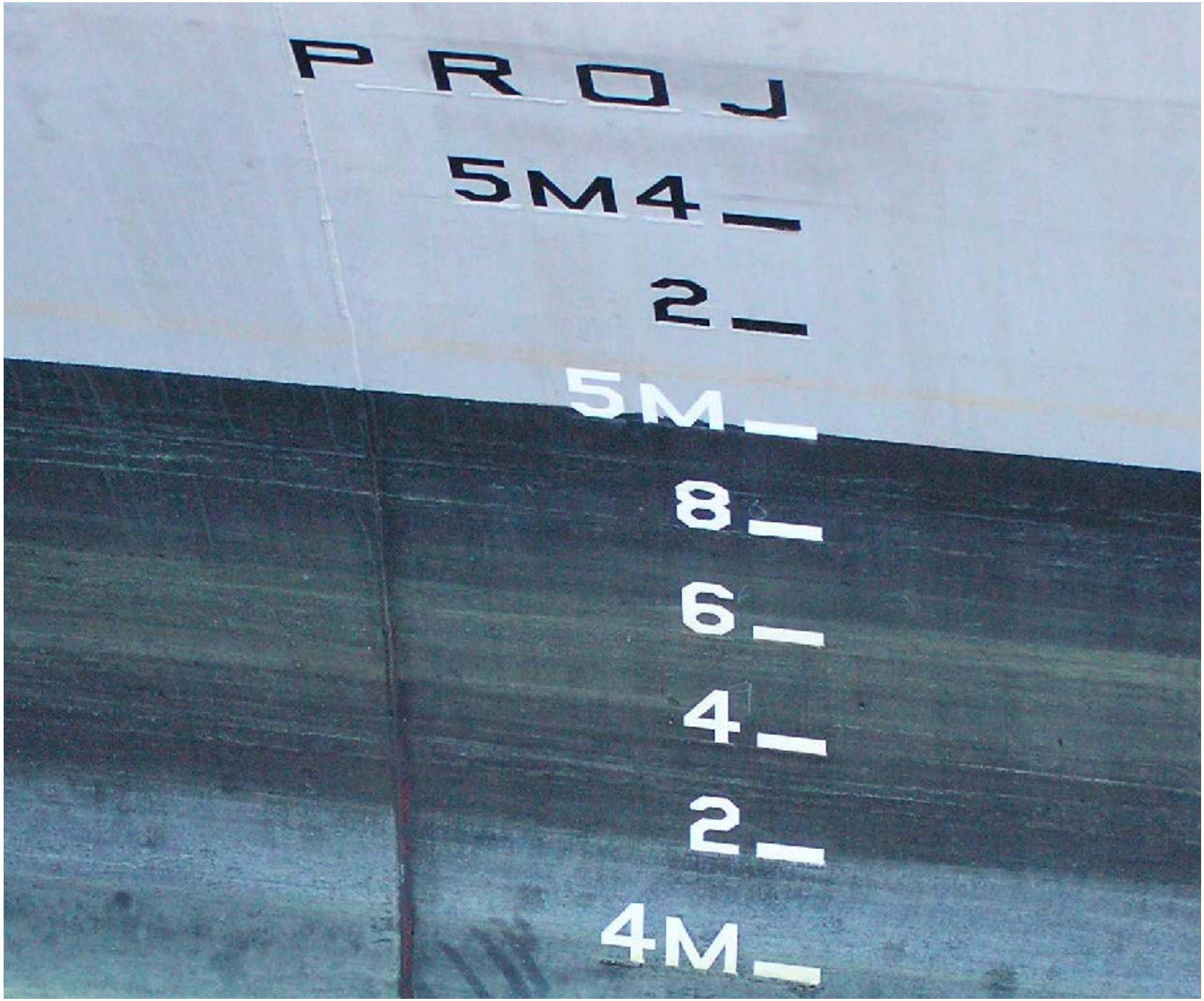


The Plimsoll Mark diagrammed above is for the starboard side of a vessel; on the port side, the markings are reversed. The center of the disk is placed at the middle of the loadline. The lines are one inch think.

The letters signify:

LTF	**Lumber, Tropical, Fresh**
LF	**Lumber, Fresh**
LT	**Lumber, Tropical**
LS	**Lumber, Summer**
LW	**Lumber, Winter**
LWNA	**Lumber, Winter, North Atlantic**
LR	**Lloyds Register of Shipping**

TF	**Tropical Fresh Water Mark**
F	**Fresh Water Mark**
T	**Tropical Load Line**
S	**Summer Load Line**
W	**Winter Load Line**
WNA	**Winter Load Line, North Atlantic**


PROJ
5M4
2
5M
8
6
4
2
4M

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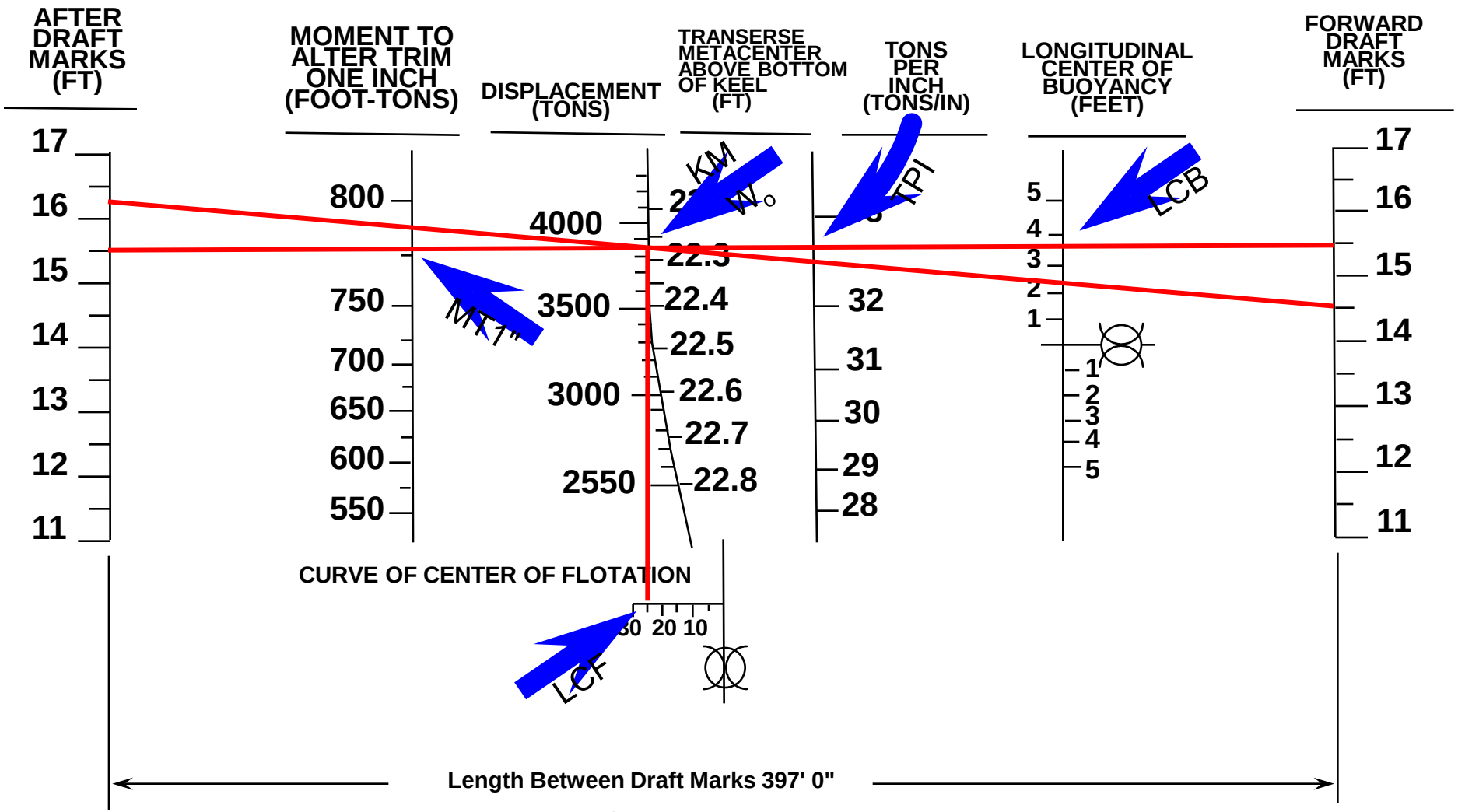
DRAFT DIAGRAM AND FUNCTIONS OF FORM



DRAFT FWD = 14 FT 6 IN

DRAFT AFT = 16 FT 3 IN

W_o = 3850 LT

MT1" = 778 FT-TONS/IN

KM = 22.28 FT

TPI = 32.7 TONS/IN

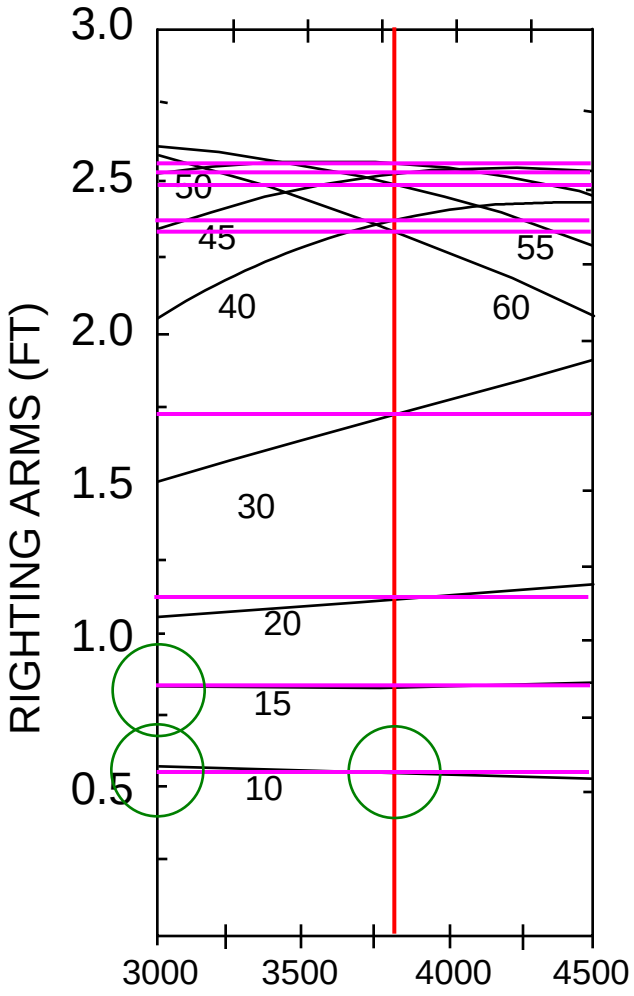
LCB = 3.5 FT AFT

LCF = 24 FT AFT

FFG 7

CROSS CURVES OF STABILITY

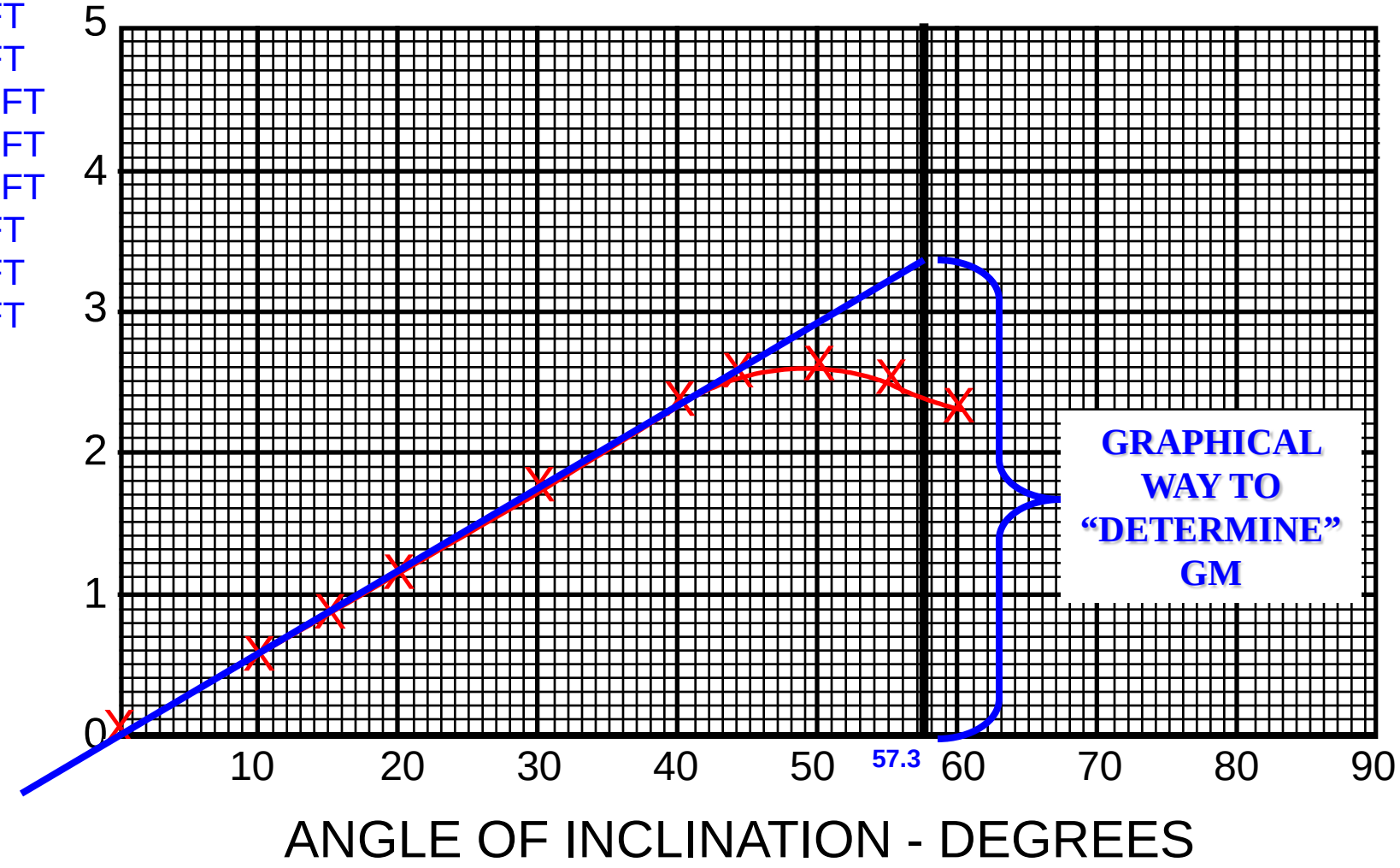
CENTER OF GRAVITY ASSUMED
19.0 FT ABOVE THE BASELINE



10^{o} = .55 FT
15^{o} = .85 FT
20^{o} = 1.1 FT
30^{o} = 1.73 FT
40^{o} = 2.35 FT
45^{o} = 2.55 FT
50^{o} = 2.6 FT
55^{o} = 2.5 FT
60^{o} = 2.3 FT

10^o = .55 FT
15^o = .85 FT
20^o = 1.1 FT
30^o = 1.73 FT
40^o = 2.35 FT
45^o = 2.55 FT
50^o = 2.6 FT
55^o = 2.5 FT
60^o = 2.3 FT

STATICAL STABILITY CURVE PLOTTING SHEET



"UNCORRECTED CURVE FOR KG_a OF 19.0 FT AND W_f OF 3850 LT."

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Review of Enabling Objectives

6.1 Correct order for the stability reference points.

6.2 Describe movement of points (stability triangle)

6.3 Differentiate initial and overall stability

6.4 Describe hull markings

6.5 Calculate Wf, TPI, MT1”

6.6 Construct uncorrected static stability curve.

Quiz…

- **What measurement is the indicator for "initial stability"?**
- **ANS: GM**
- **What happens to our initial stability when we ballast for heavy weather?**
- **ANS: GM increases (G moves down) - Initial Stability increases**
- **Do all ships have limiting draft marks?**
- **ANS: YES, even if the star is not on the hull, limiting drafts will be given in Section II(a).**

Instructor will now…

- Hand out student HOMEWORK #1.
  - **(Additional REF POINT questions available)**
- Assign Homework for lesson 4.1 (Stability Problems #1, #2, #3)
- **Read Student Guide!!**

Thumb rules:

- B follows the Waterline
- M moves opposite of B
- G moves
  - Towards addition
  - Away from removal
  - Direction of shift
- “G moves faster than M”
- “G is ***near*** the waterline”