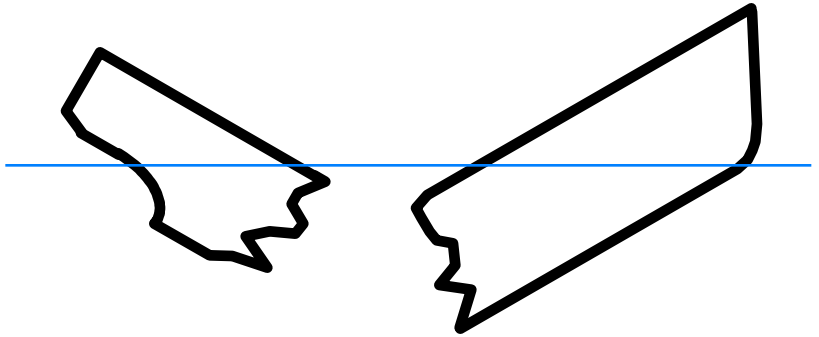
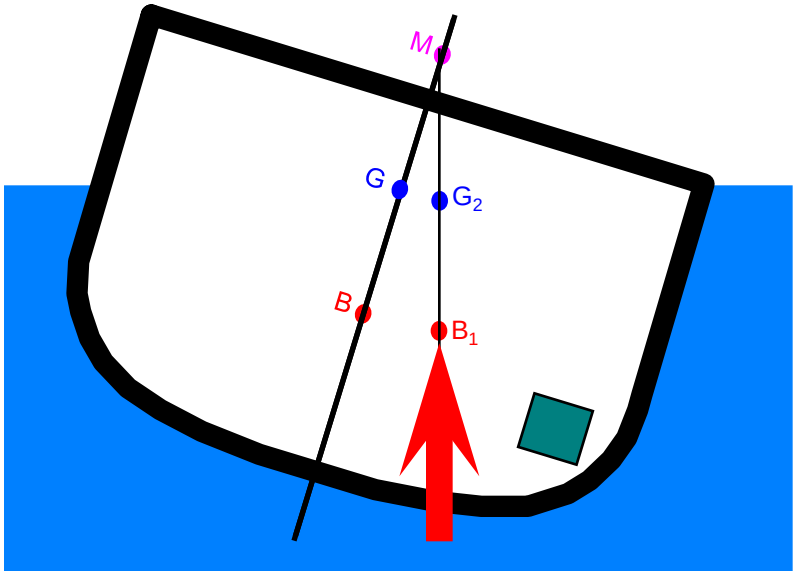
Lesson 4.6



Hull Damage and List in Stability



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. "

References

- **NSTM 079 Volume 1**
- NTTP 3-20.31
- Damage Control Book, section II (a)

Enabling Objectives

- DESCRIBE Roll Period and relation to GM
- DESCRIBE 3 possible causes for list.
- CALCULATE Danger Angle.
- DEFINE floodable length, angle of maximum roll, reserve dynamic stability.
- DEFINE the design factors for ship’s resistance to damage.
- DEFINE Critical Stability

"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

CLASS TOPICS

1. Causes of Loss
2. Movie (USS Wilkes Barre)
3. Metacentric Height
4. List in Stability
5. Floodable Length
6. Dynamic Stability
7. Decision Factors

FOLLOWING DAMAGE

War experience shows two situations exist following the infliction of damage:

DAMAGE IS SO EXTENSIVE THAT THE SHIP NEVER STOPS LISTING, TRIMMING, OR SETTLING AND GOES DOWN WITHIN MINUTES. *Danger Angle!!!*

OR

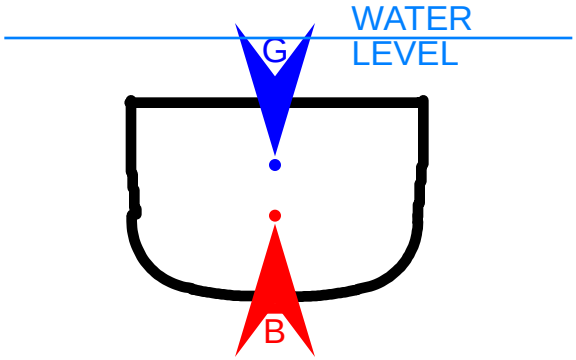
THE SHIP STOPS HEELING, CHANGING TRIM, AND SETTLING SHORTLY AFTER INITIAL DAMAGE

Experience has shown that the loss of ships which last several hours and then sink is directly traceable to *PROGRESSIVE FLOODING*

SHIP SINKINGS

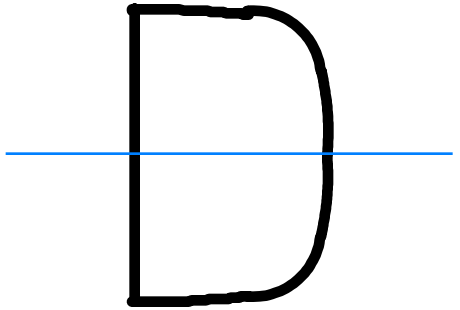
- **BODILY SINKAGE**

  LOSS OF BUOYANCY



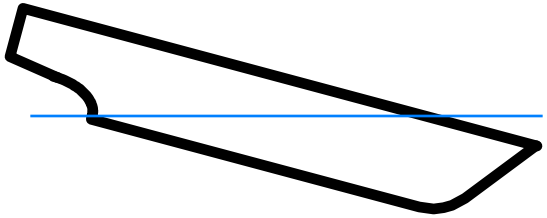
- **CAPSIZING**

  LOSS OF TRANSVERSE STABILITY



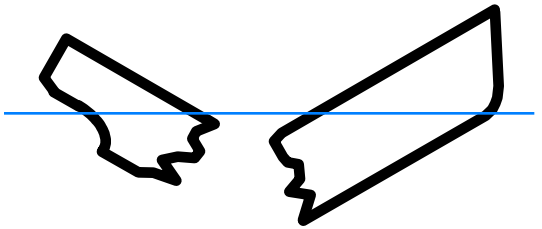
- **PLUNGING**

  LOSS OF LONGITUDINAL STABILITY

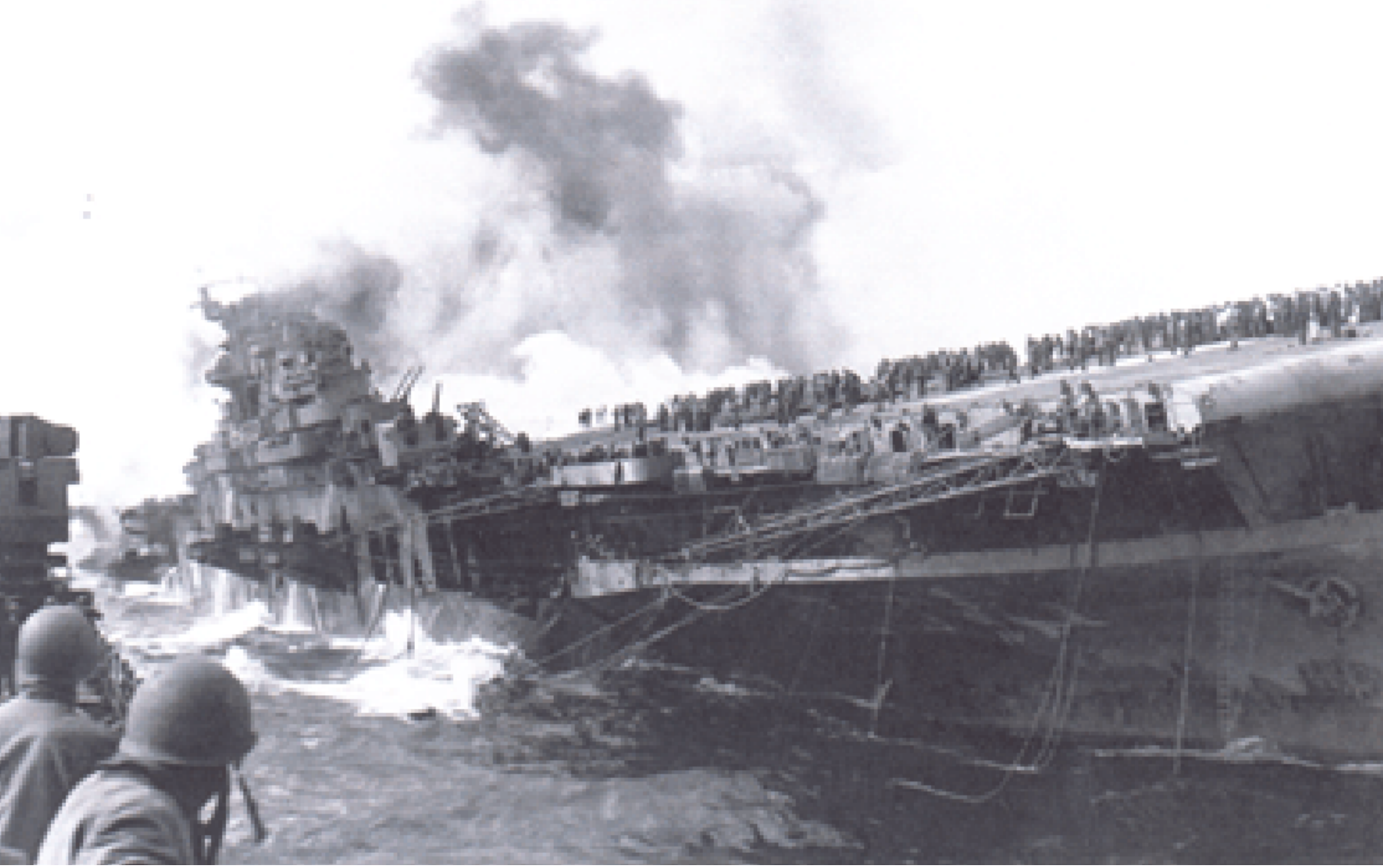


- **BREAKING UP**

  LOSS OF SHIP'S GIRDER



USS Franklin



CLASS TOPICS

1. ~~Causes of Loss~~
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7. Decision Factors

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

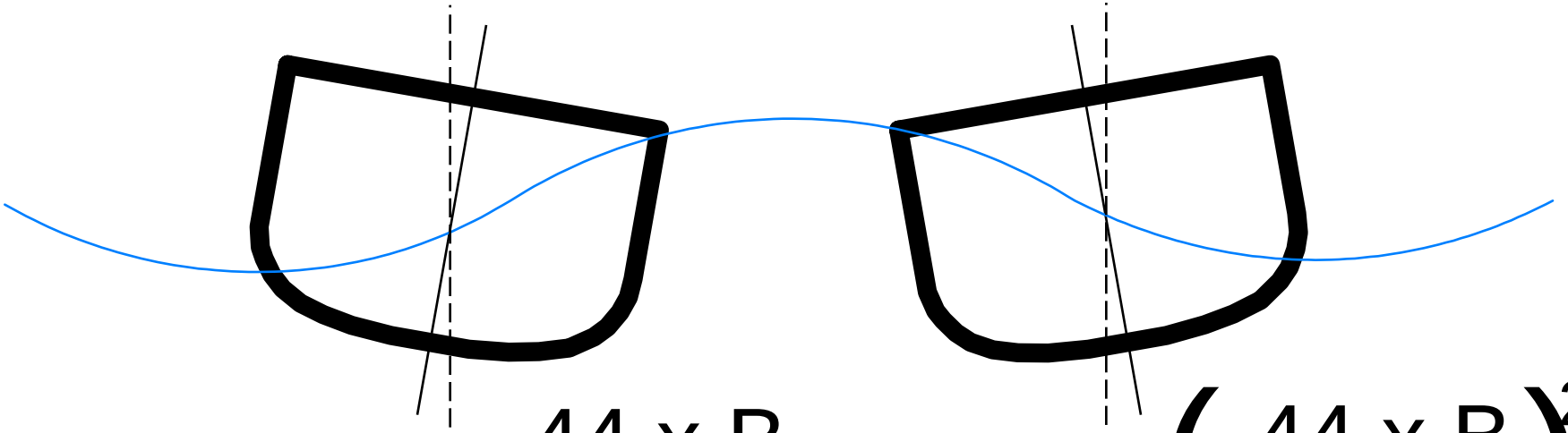
VERY SMALL GM IS APT TO HANG AT THE END OF EACH ROLL BEFORE STARTING UPRIGHT

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

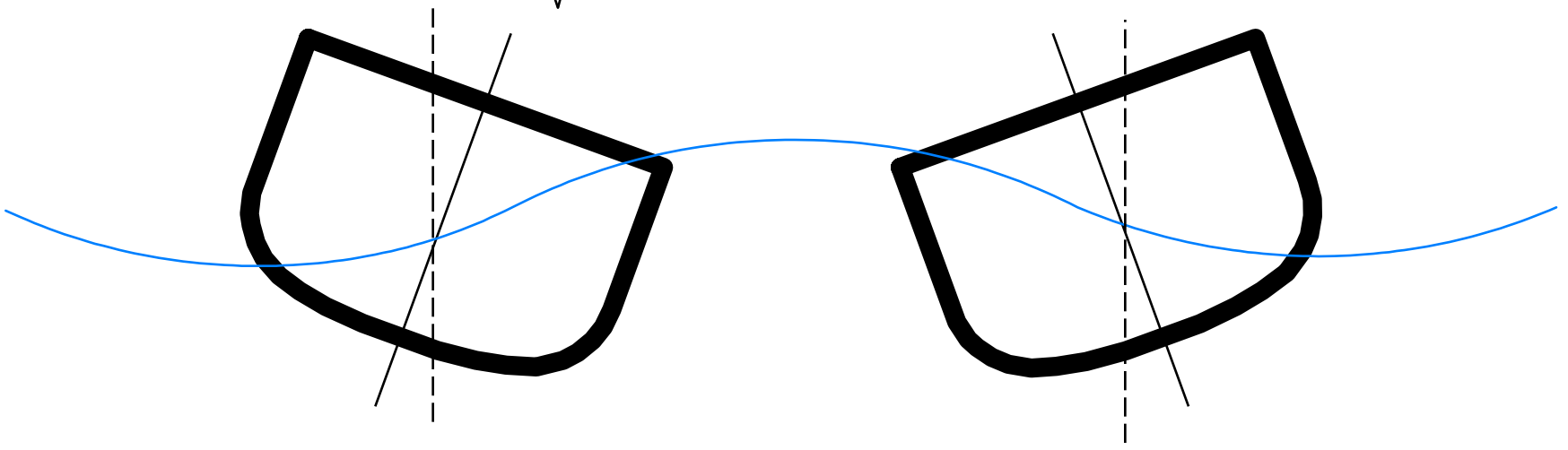
- Metacentric Height

ROLLING ANGLE WHEN RELATED TO WAVE PERIOD vs SHIP PERIOD



$$T = \frac{.44 \times B}{\sqrt{GM}}$$

$$GM = \left(\frac{.44 \times B}{T}\right)^2$$



CLASS TOPICS

1. ~~Causes of Loss~~
2. ~~Movie (USS Wilkes Barre)~~
3. ~~Metacentric Height~~
4. List in Stability
5. Floodable Length
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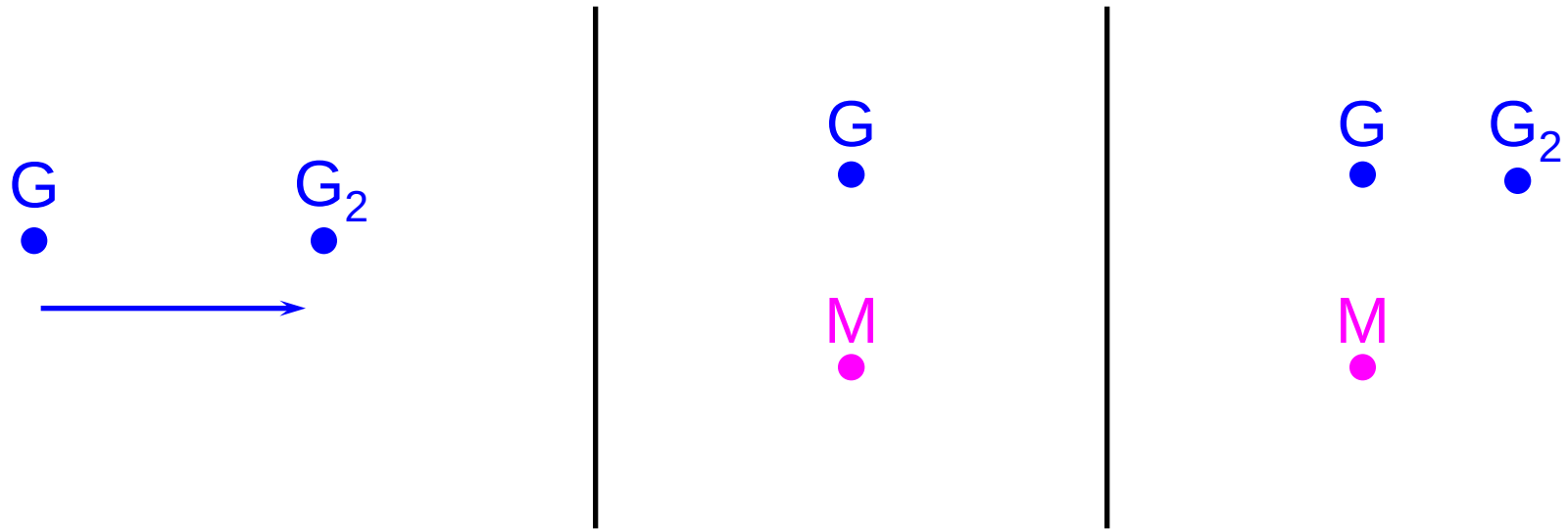
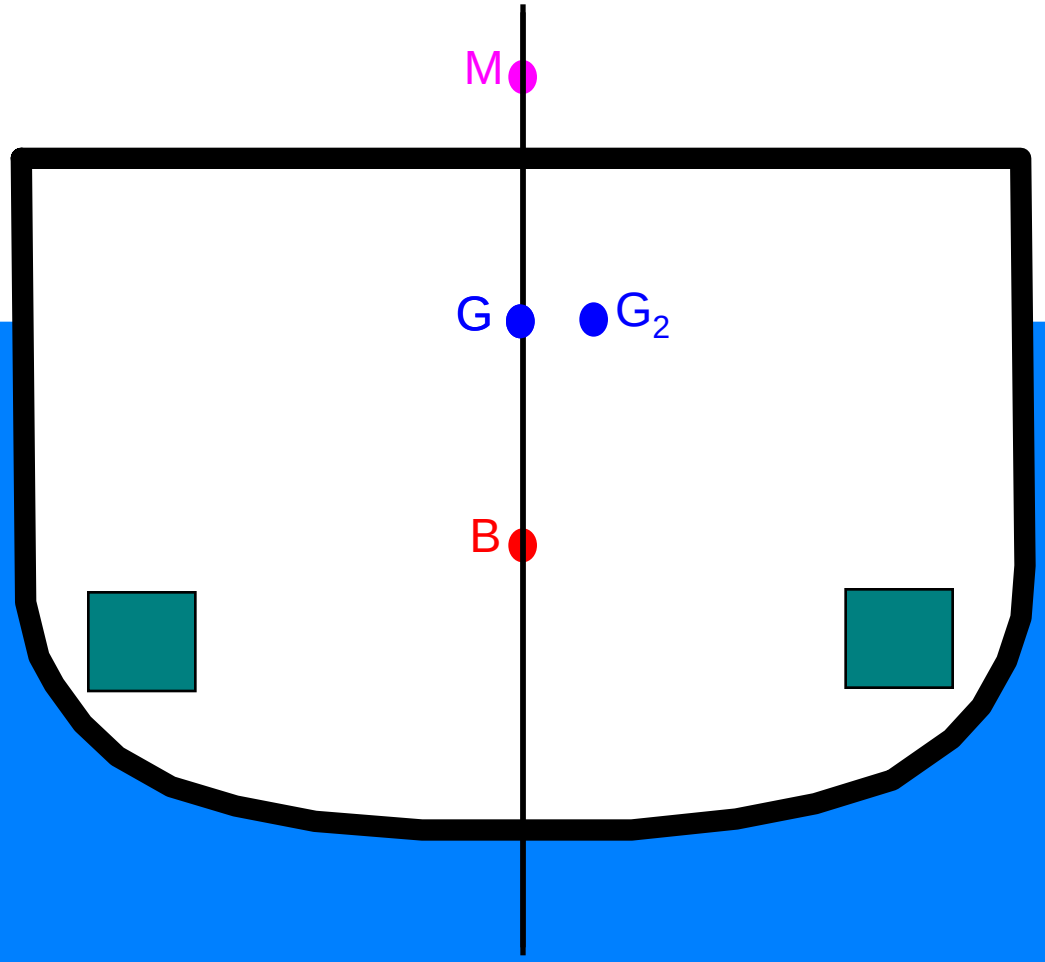
3 BASIC CONDITIONS WHICH MAY CAUSE THE SHIP TO TAKE ON A PERMANENT LIST:

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



LIST DUE TO G BEING SHIFTED OFF-CENTERLINE



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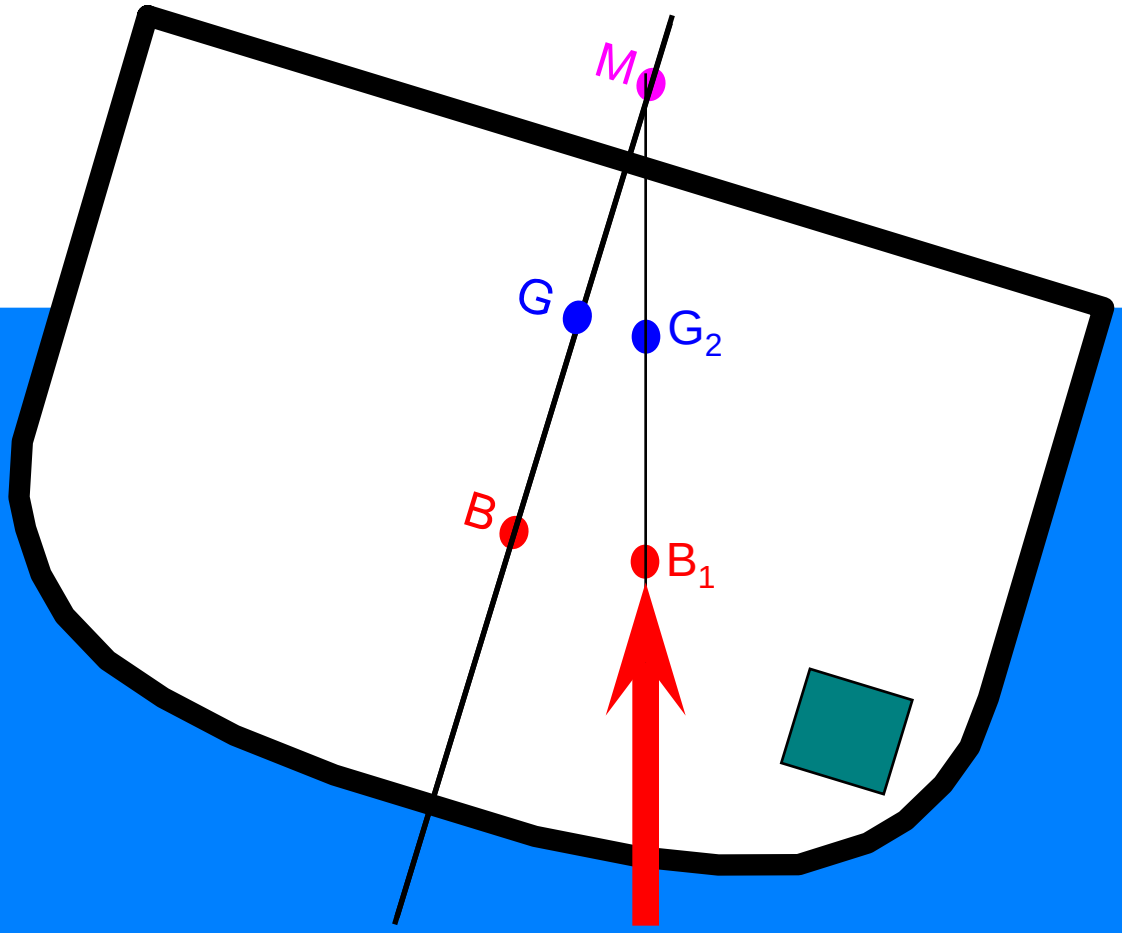
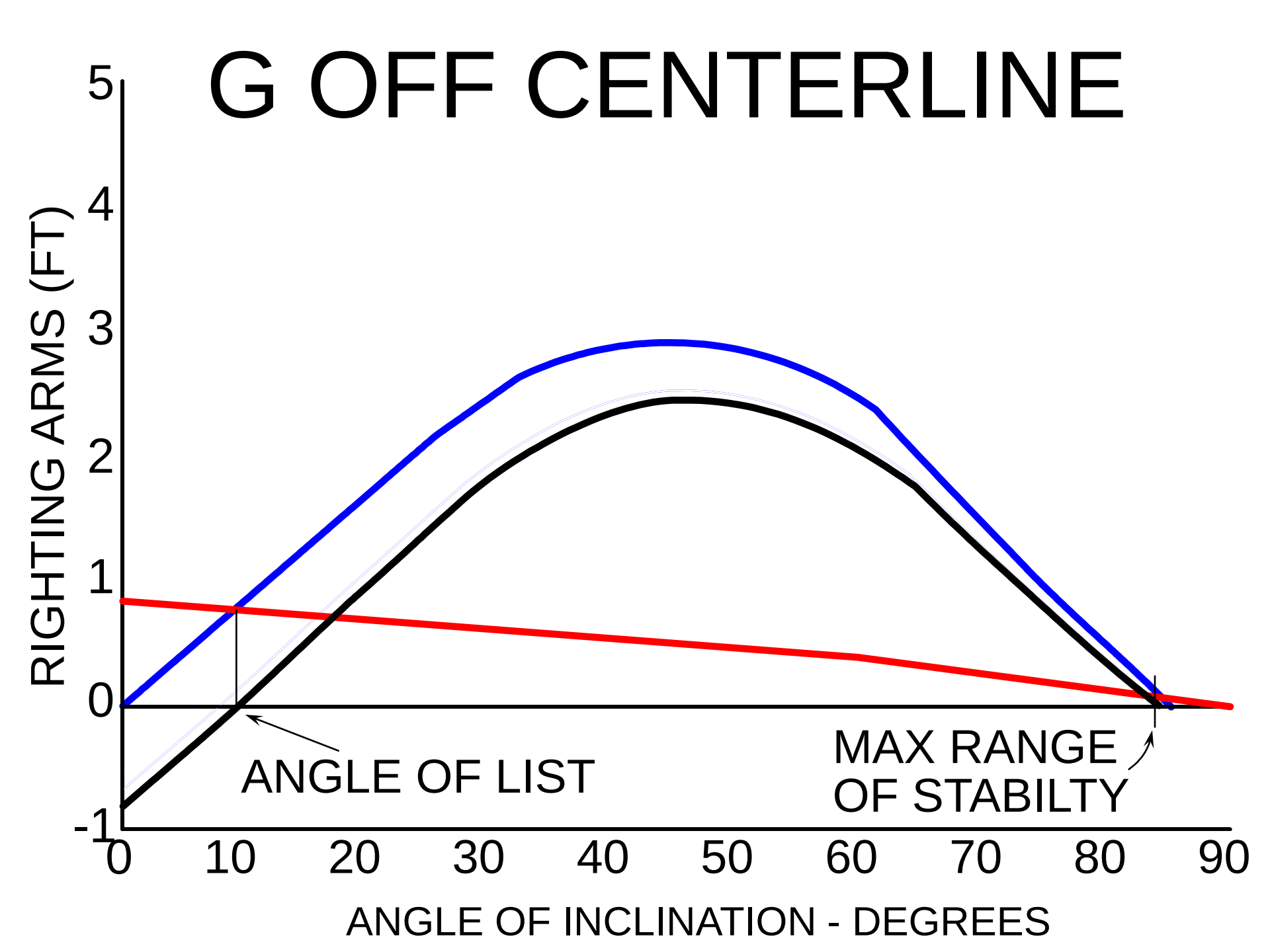



G OFF CENTERLINE
RIGHTING ARMS (FT)
5
4
3
2
1
0
-1
0
10
20
30
40
50
60
70
80
90
ANGLE OF LIST
MAX RANGE
OF STABILTY
ANGLE OF INCLINATION - DEGREES

CAUSES

1. Unequal distribution of weight on either side of center line due to loading.

2. Shift of weight transversely.

3. Addition or removal of weight asymmetrically about center line.

CORRECTIVE MEASURES

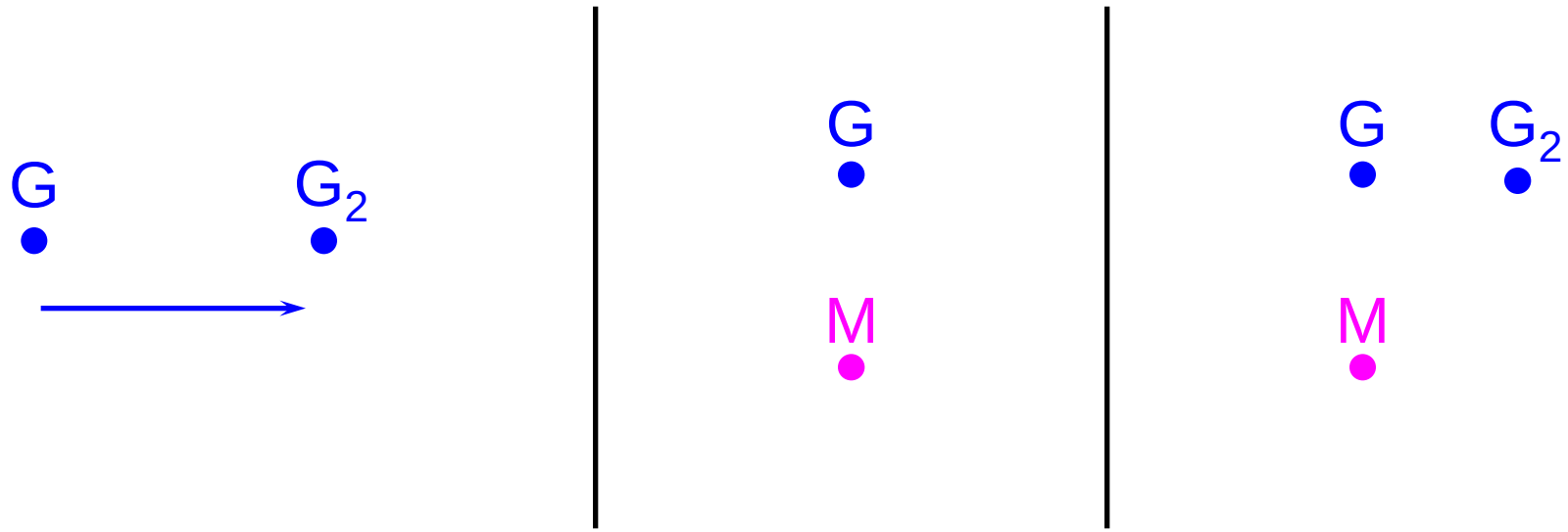
1. Determine cause of list

2. Shift weight transversely to high side

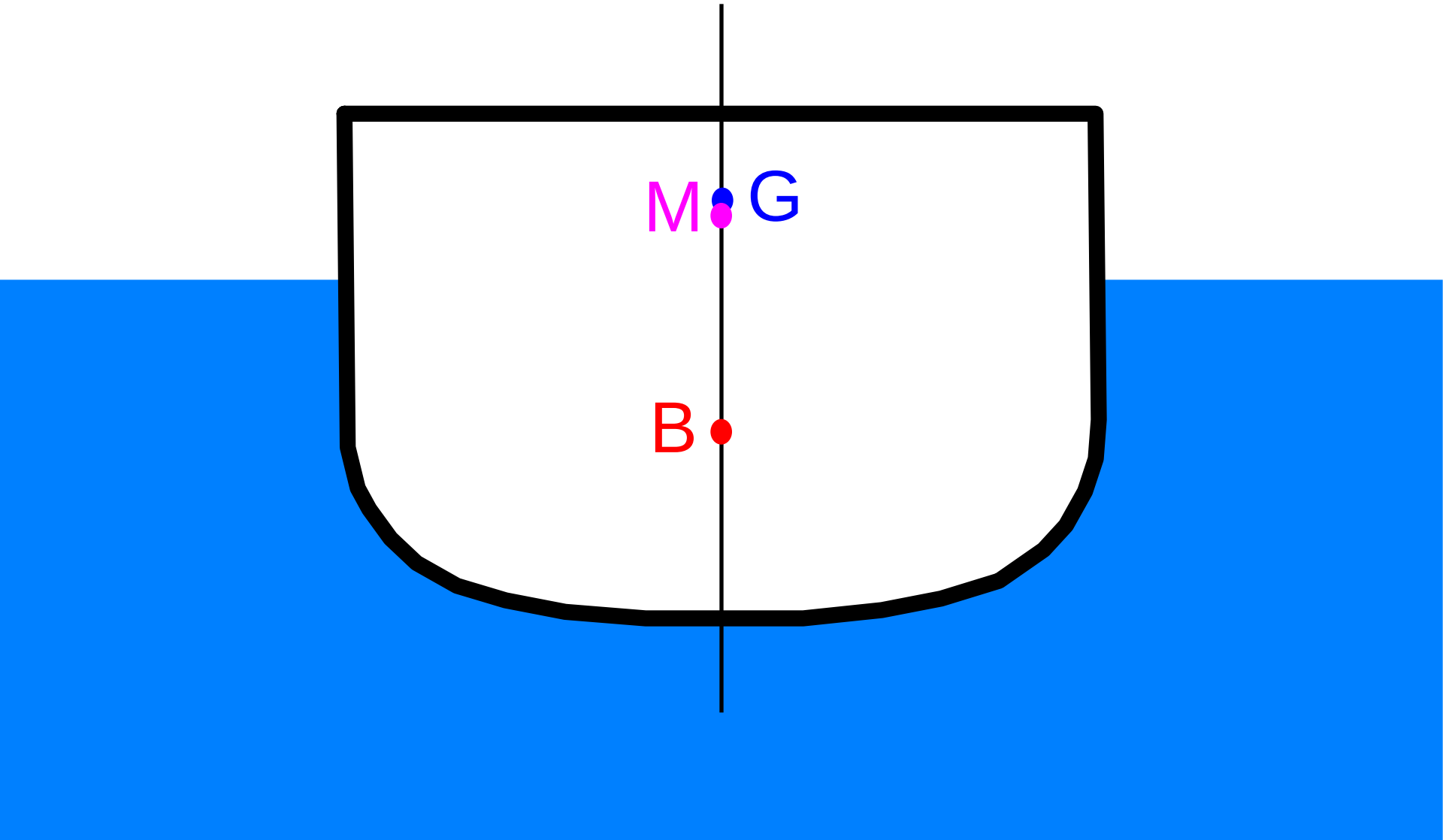
3. Add weight to high side or remove weight from low side

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



LIST DUE TO A SLIGHTLY NEGATIVE GM



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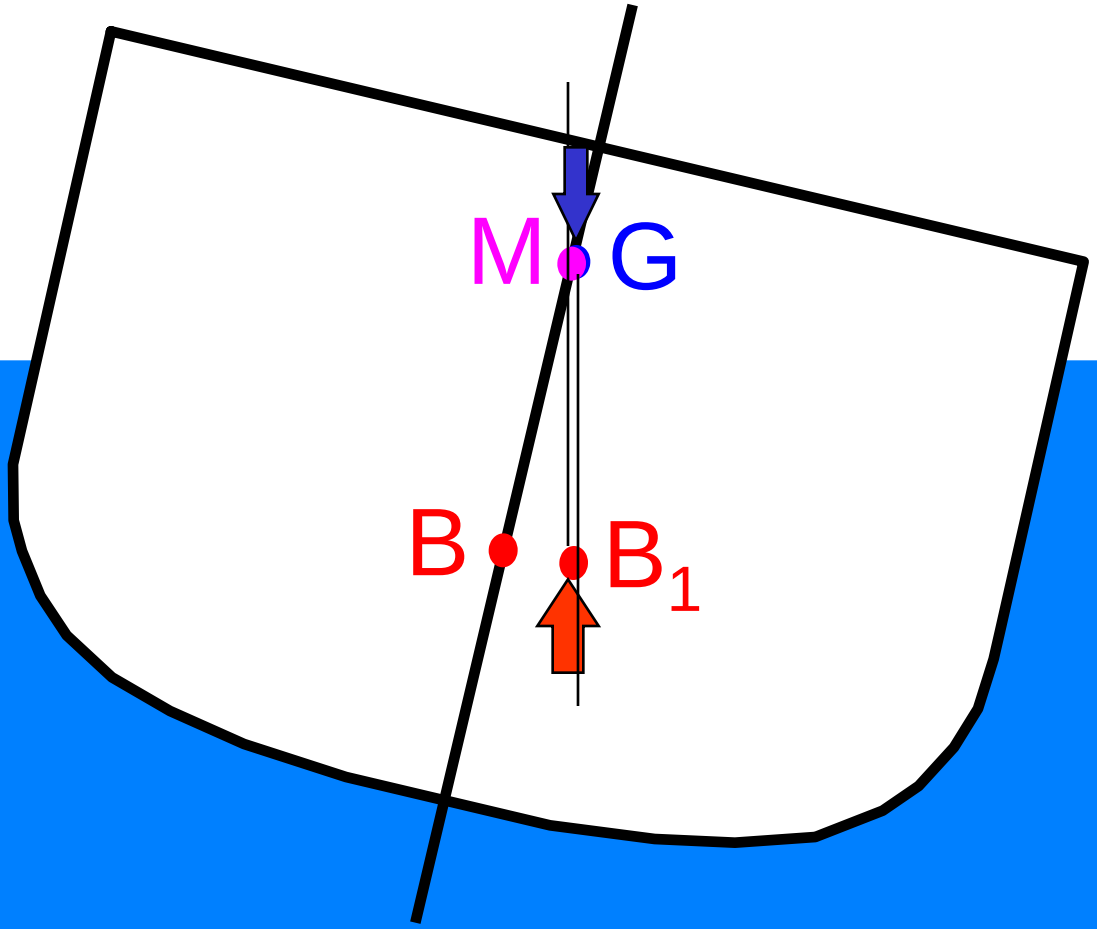
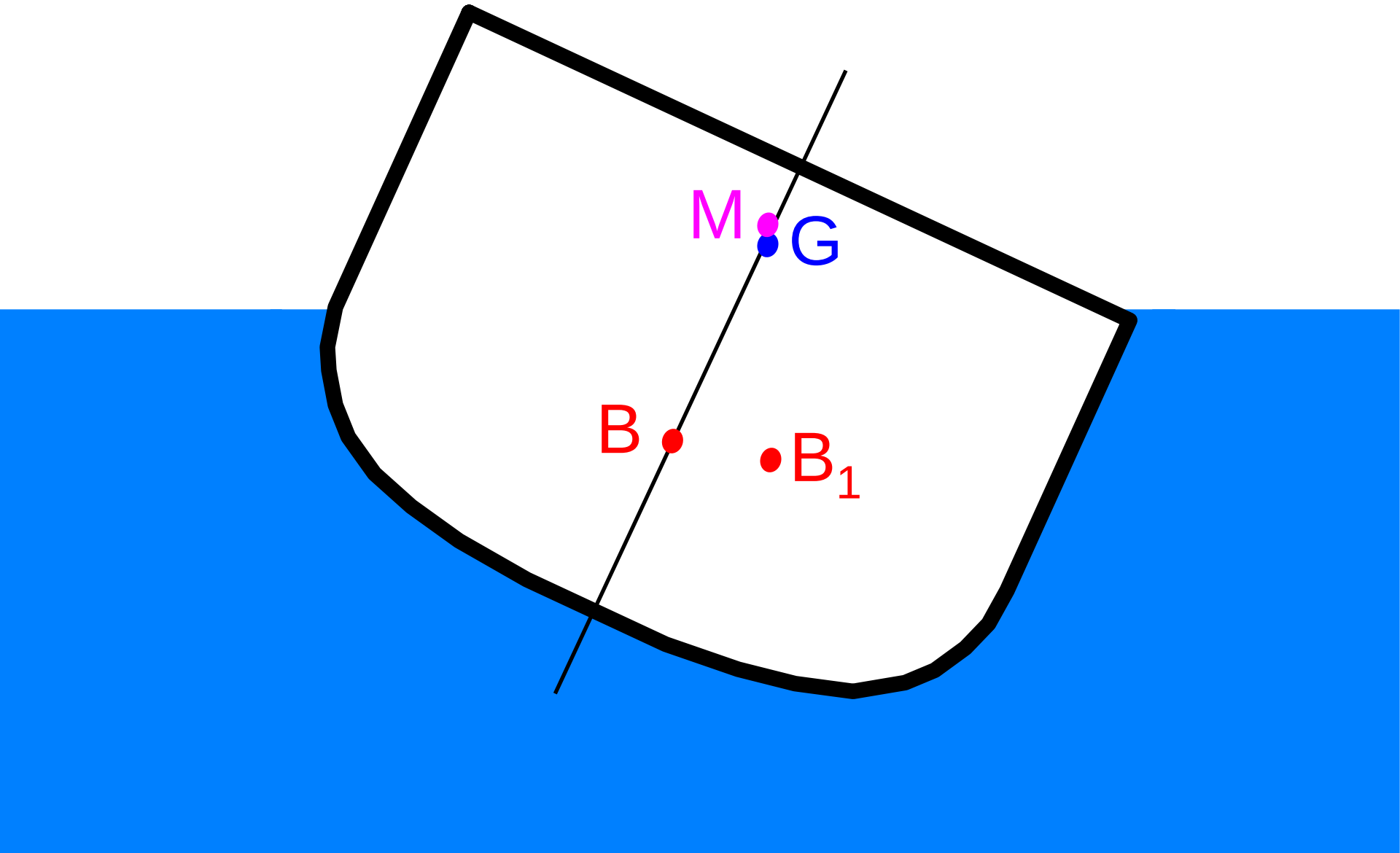
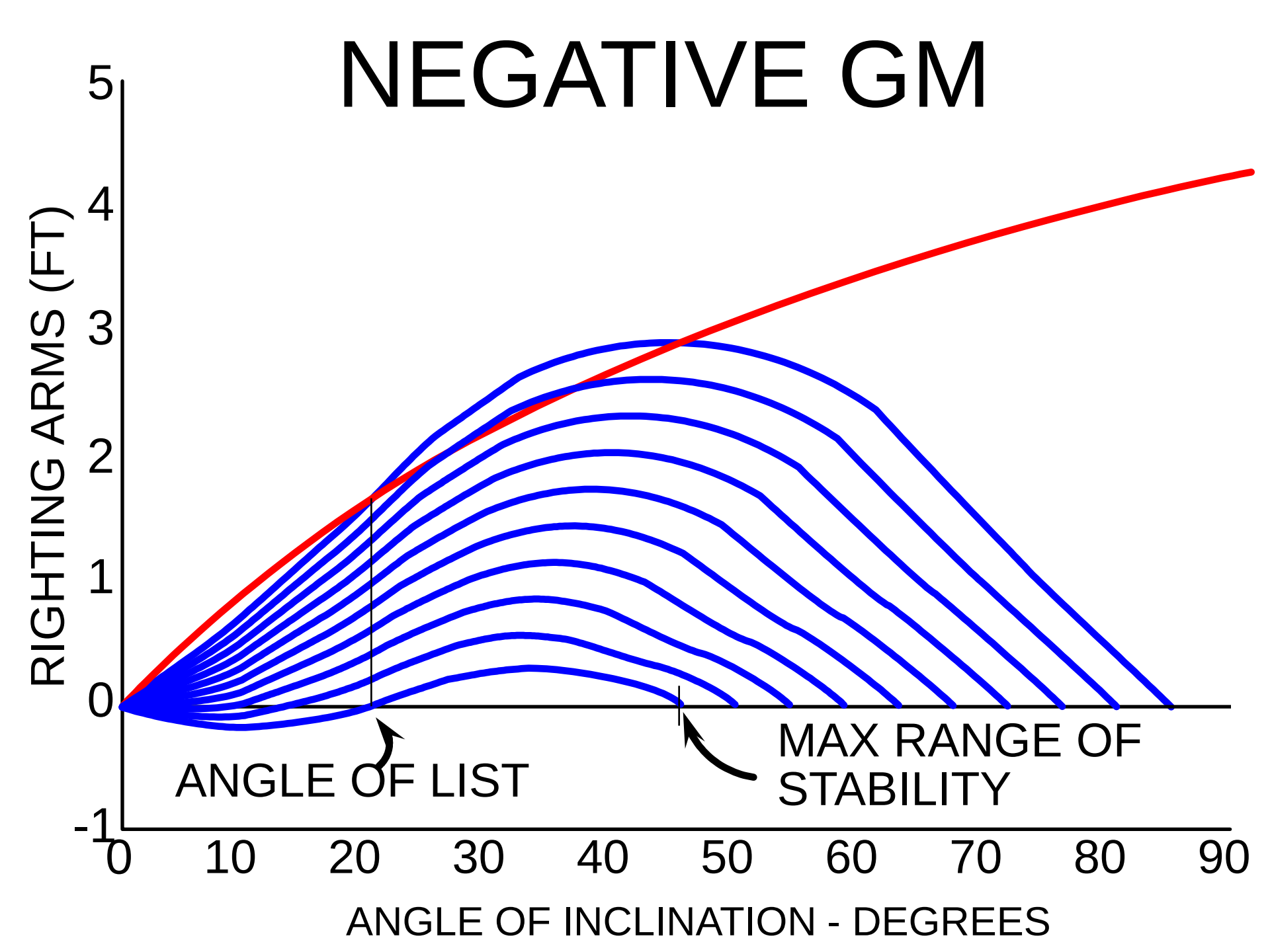


LIST DUE TO A SLIGHTLY NEGATIVE GM




NEGATIVE GM
5
4
3
2
1
0
-1
RIGHTING ARMS (FT)
0
10
20
30
40
50
60
70
80
90
ANGLE OF INCLINATION - DEGREES
ANGLE OF LIST
MAX RANGE OF
STABILITY

CAUSES of -GM

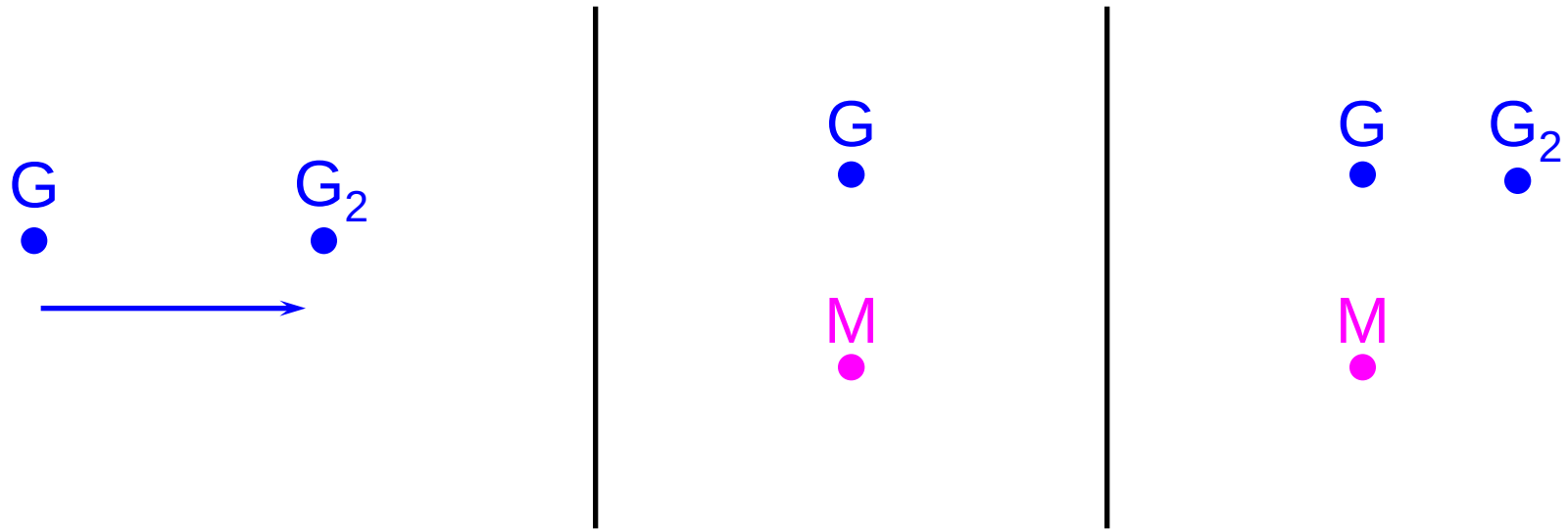
1. Removal of low weights
2. Addition of high weights (ice)
3. Moving weights upward
4. Free Surface Effect
5. Free Communication Effect

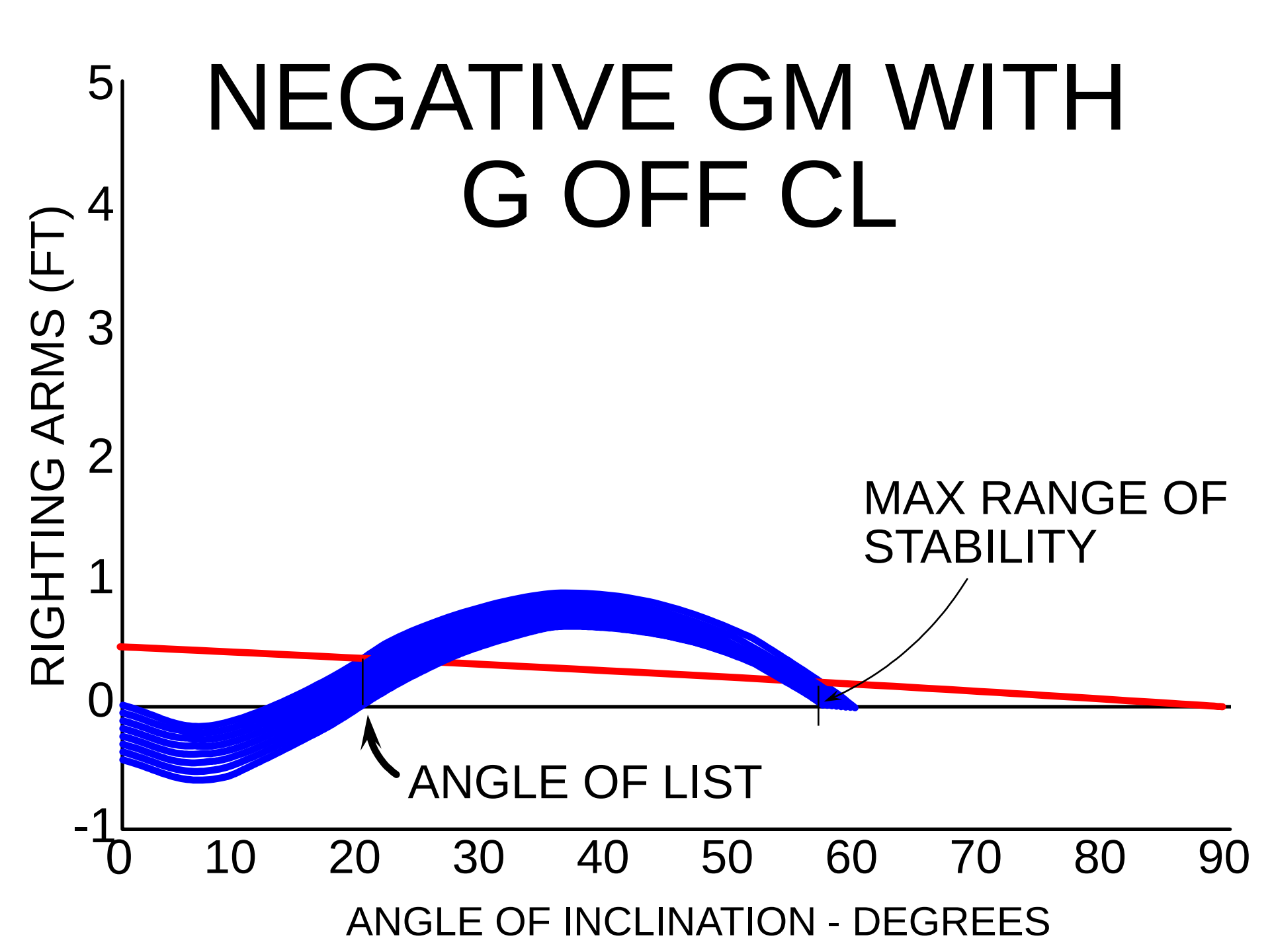
CORRECTIVE MEASURES

1. Eliminate FSE and FCE
2. Add low weight *symmetrically*
3. Remove high weight *symmetrically*
4. Move weight down *symmetrically*

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




NEGATIVE GM WITH G OFF CL
RIGHTING ARMS (FT)
5
4
3
2
1
0
-1
MAX RANGE OF STABILITY
ANGLE OF LIST
0
10
20
30
40
50
60
70
80
90
ANGLE OF INCLINATION - DEGREES

THE WAY TO CORRECT A LIST THAT IS DUE TO THE CONDITION OF -GM WITH OFF CENTER WEIGHT IS:

1. RID THE -GM
2. ADD WT LOW SYMMETRICALLY

3. REMOVE THE OFF CENTER WT.

CLASS TOPICS

1. ~~Causes of Loss~~
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5. Floodable Length
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7. Decision Factors

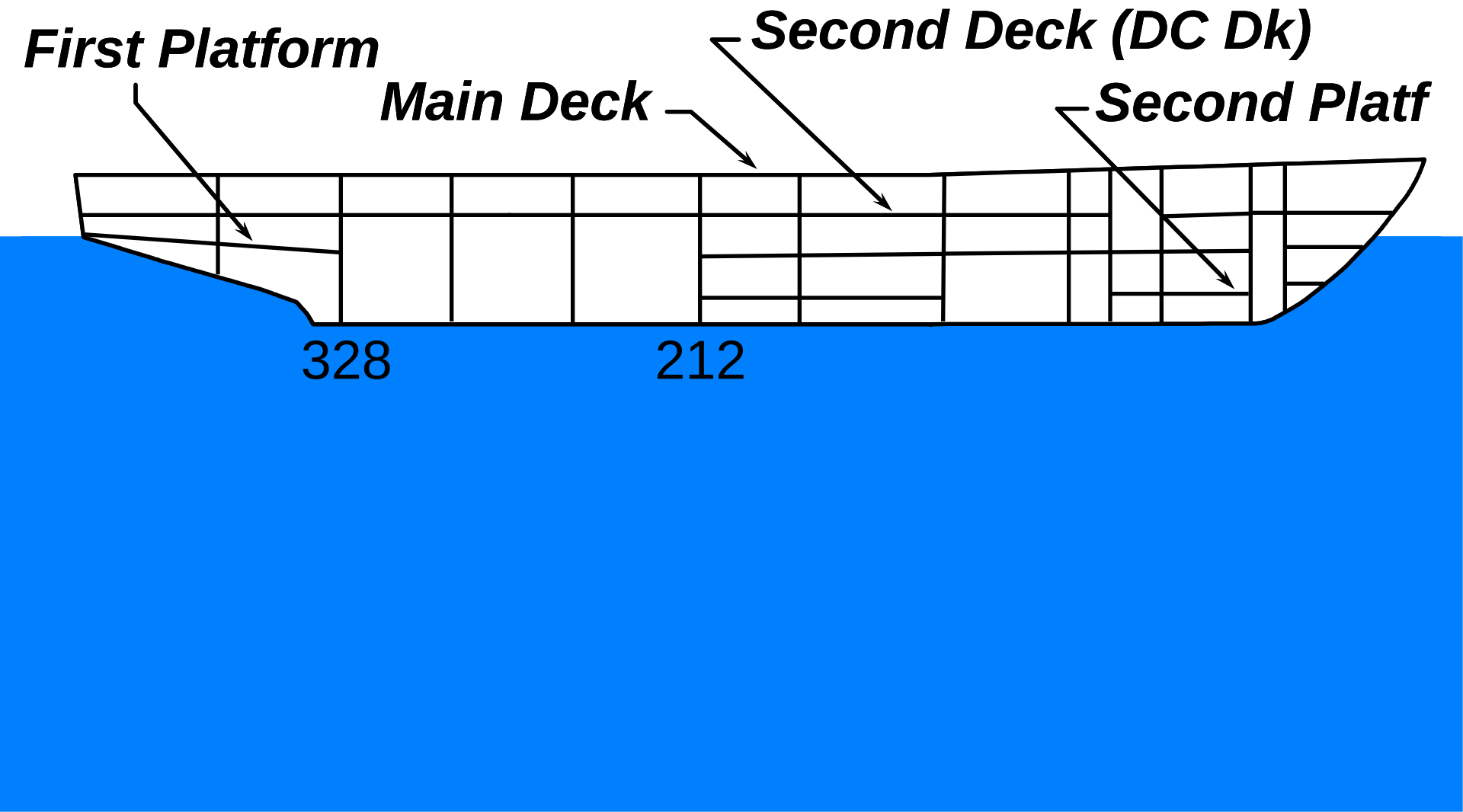
FLOODABLE LENGTH

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

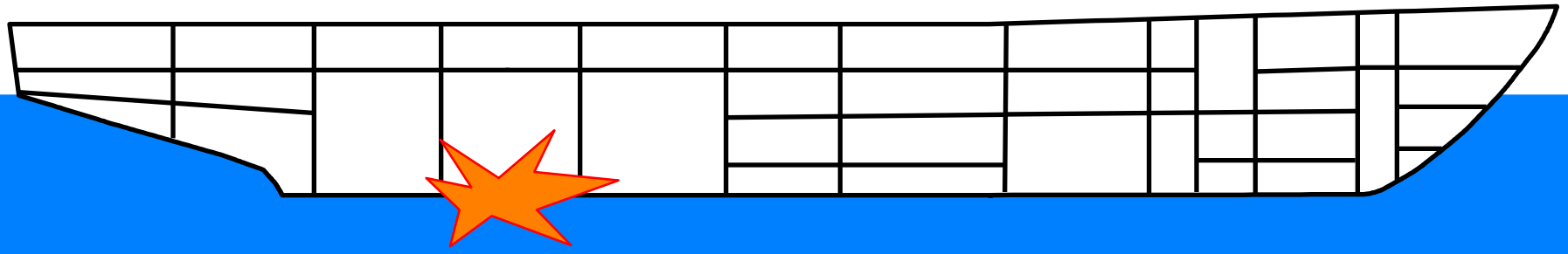
STEM - FRAME 100
FRAMES - 32-140
FRAMES - 64-180
FRAMES - 100-212
FRAMES - 140-250
FRAMES - 180-292
FRAMES - 212-328
FRAMES - 250-368
FRAMES - 292-STERN

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

FLOODABLE LENGTH DAMAGE



FLOODABLE LENGTH DAMAGE



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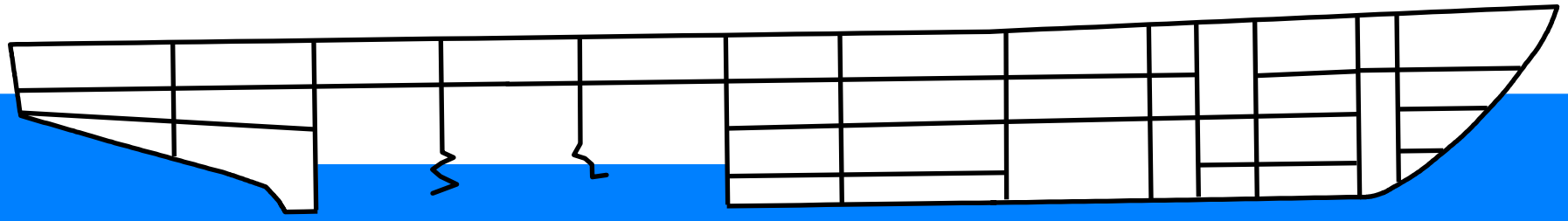
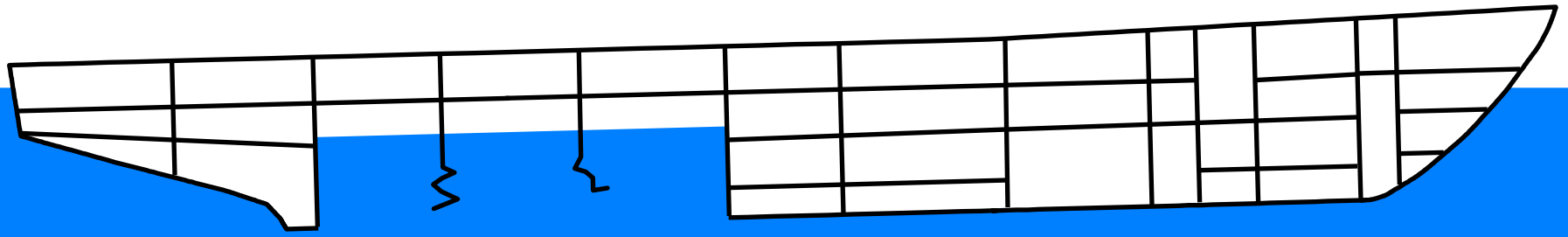
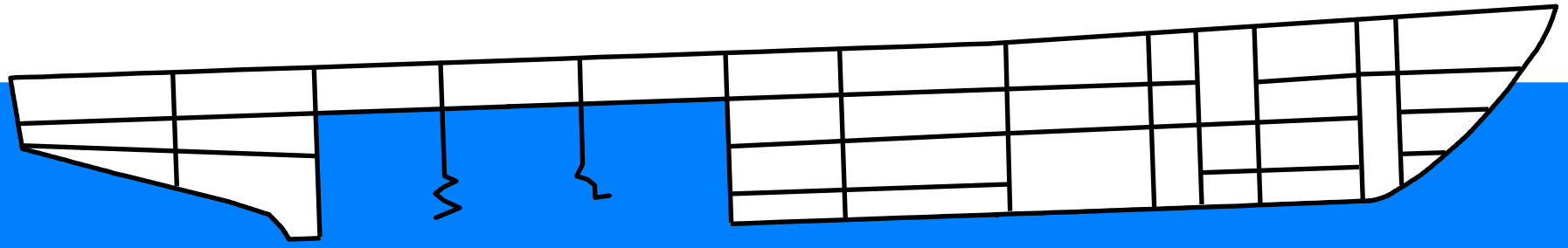


FLOODABLE LENGTH DAMAGE



FLOODABLE LENGTH DAMAGE



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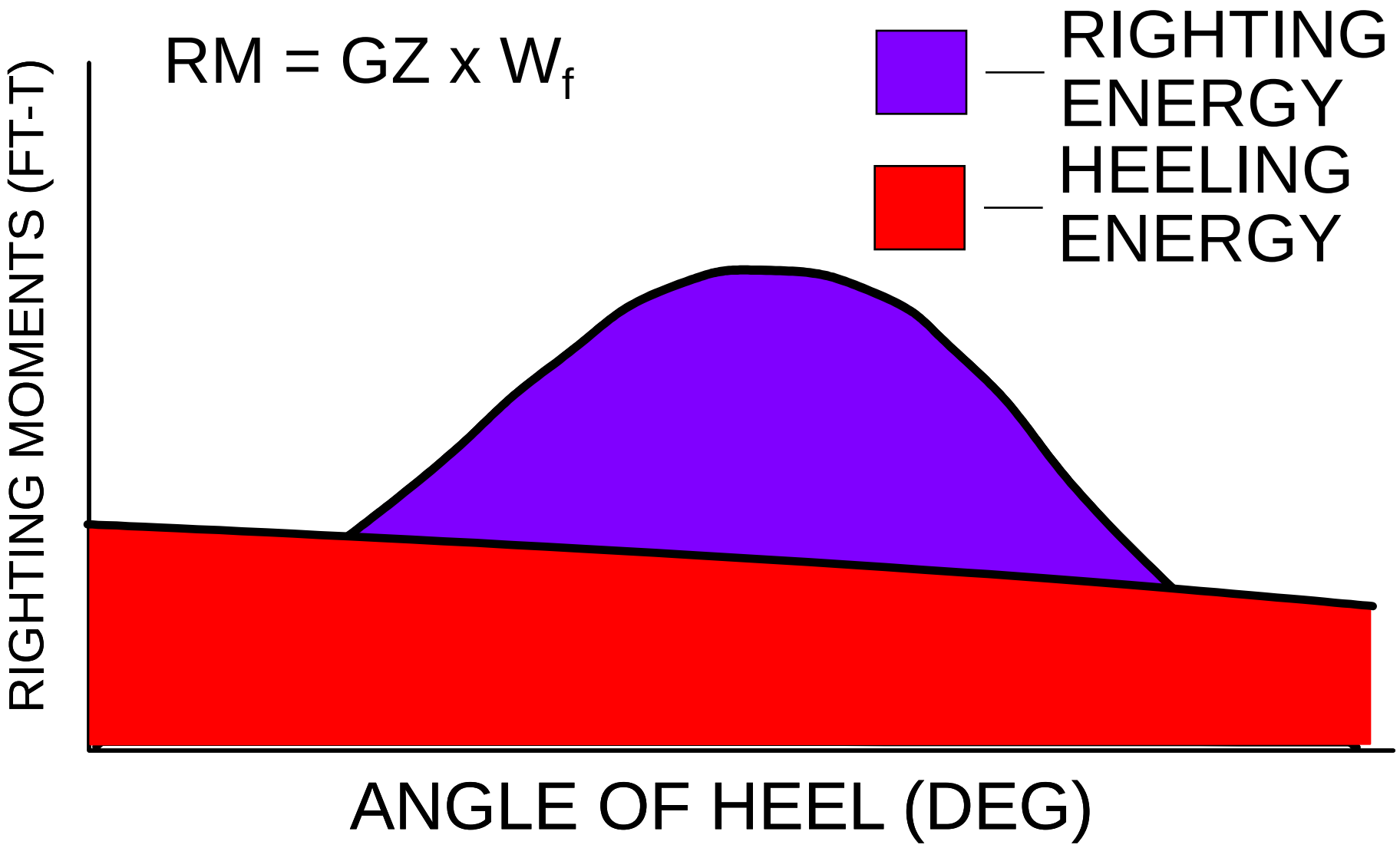
FRAMES - 250-368
FRAMES - 292-STERN

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

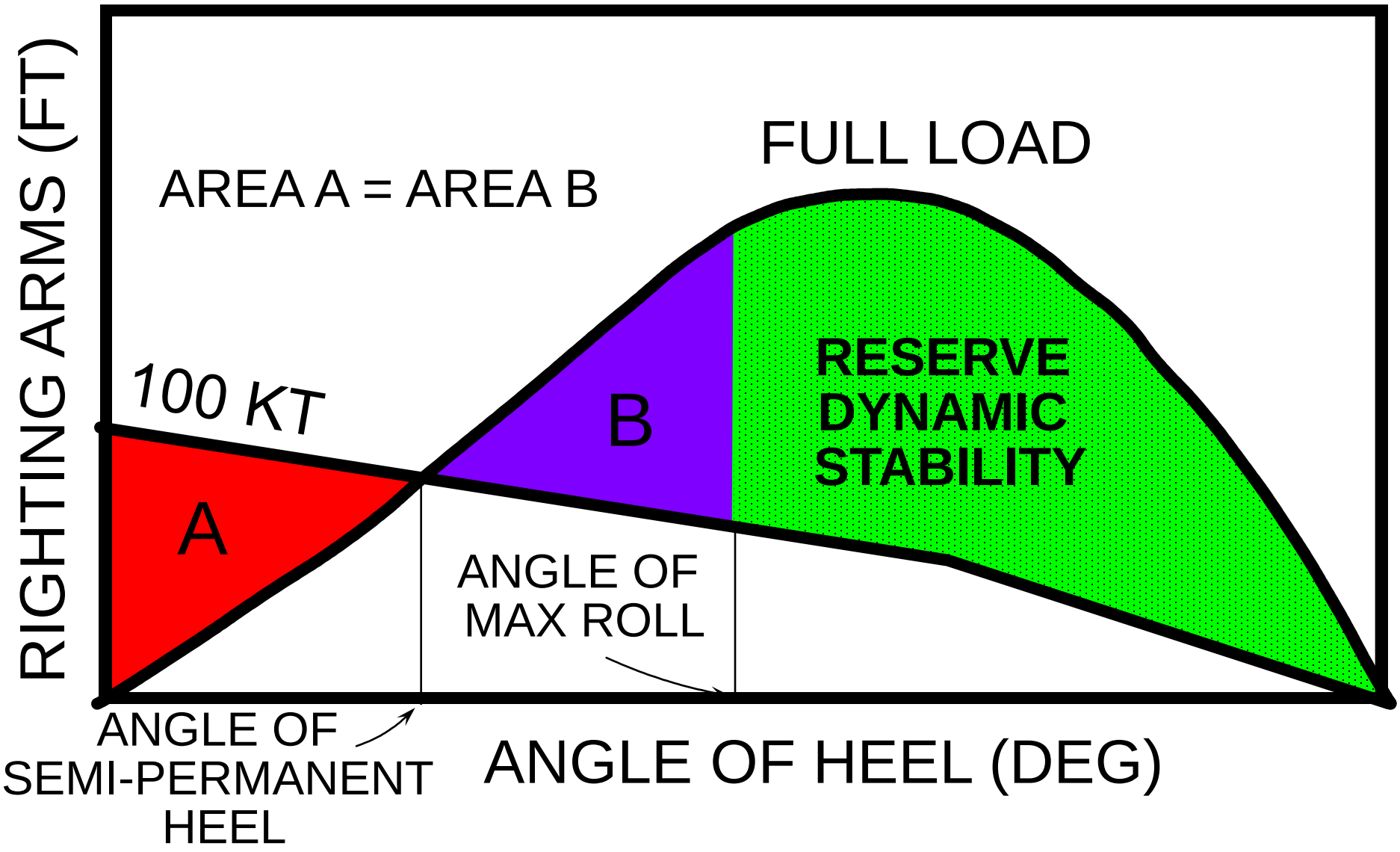
CLASS TOPICS

1. ~~Causes of Loss~~
2. ~~Movie (USS Wilkes Barre)~~
3. ~~Metacentric Height~~
4. ~~List in Stability~~
5. ~~Floodable Length~~
6. Dynamic Stability
7. Decision Factors

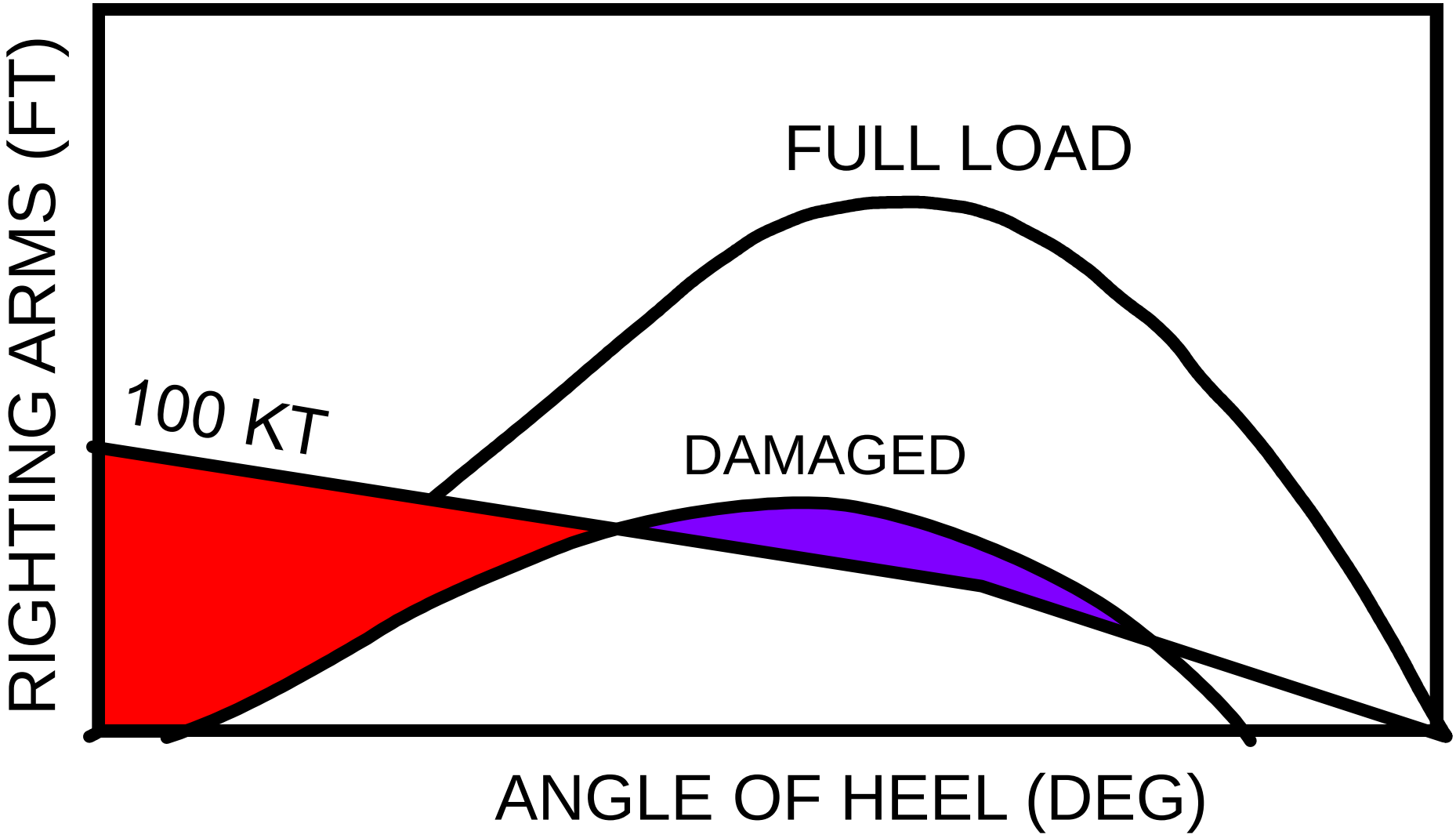
DYNAMIC STABILITY & THE STABILITY CURVE



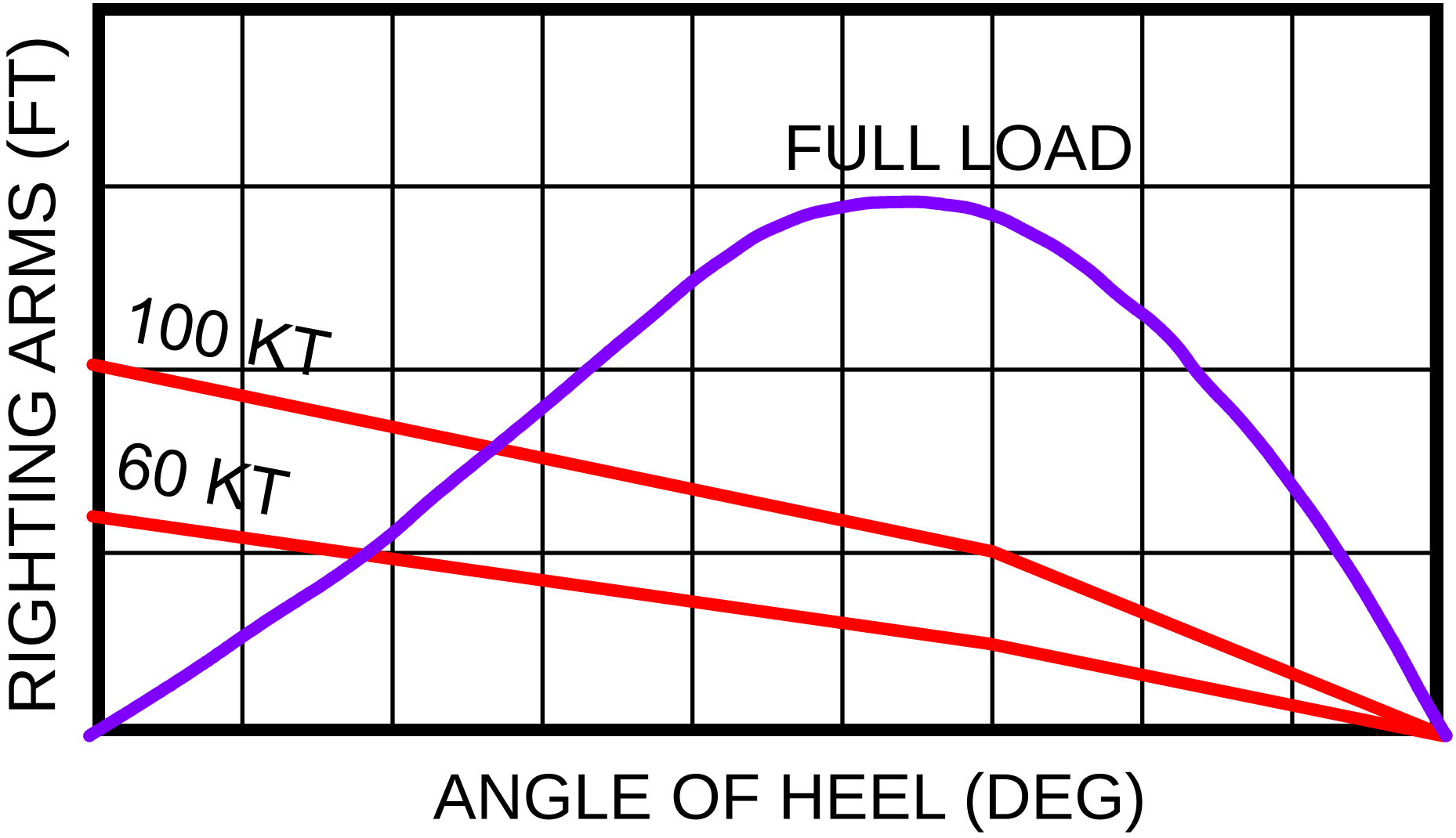
HEELING EFFECTS OF BEAM WINDS

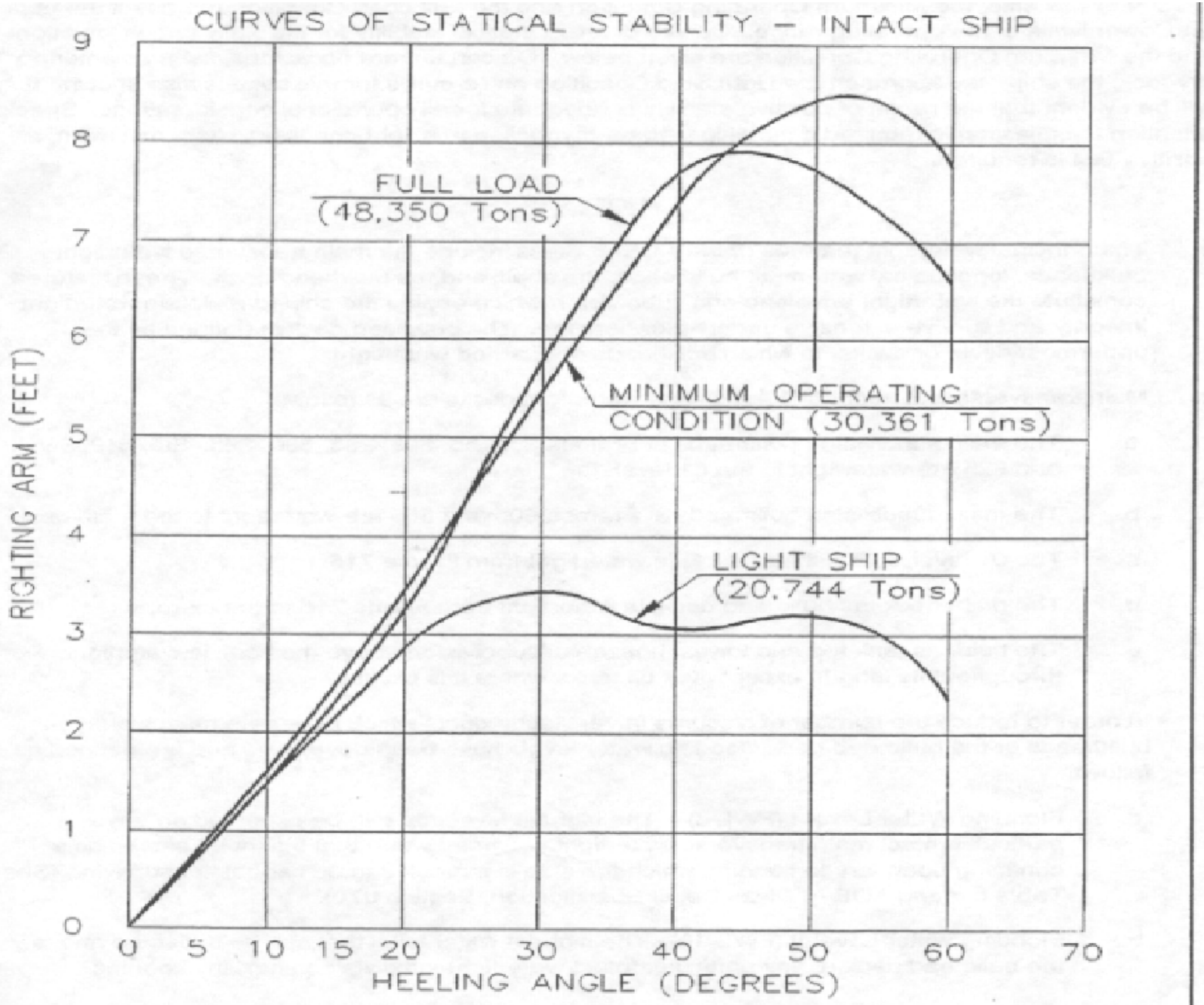


HEELING EFFECTS OF BEAM WINDS



HEELING EFFECTS OF BEAM WINDS




CURVES OF STATICAL STABILITY – INTACT SHIP
RIGHTING ARM (FEET)
0
1
2
3
4
5
6
7
8
9
FULL LOAD
(48,350 Tons)
MINIMUM OPERATING
CONDITION (30,361 Tons)
LIGHT SHIP
(20,744 Tons)
0
5
10
15
20
30
40
50
60
70
HEELING ANGLE (DEGREES)

Your ships have high speed turn design criteria…

USS PELELIU (LHA 5) in some “rough” seas….

DYNAMIC STABILITY

DESIGNED RESISTANCE TO DAMAGE

STABILITY DESIGNED TO RESIST SPECIFIC CONDITIONS

- HEELING EFFECT OF BEAM WINDS & SEAS *(DYNAMIC STABILITY)*
- SURVIVE FLOODING FOR SPECIFIC OPENINGS OF THE HULL *(FLOODABLE LENGTH)*
- HOIST HEAVY OBJECTS OVER THE SIDE (< 15 °)
- LIST AFTER DAMAGE (< 15 °)
- FULL SPEED, FULL RUDDER TURN (< 15 °) *(DYNAMIC STABILITY)*

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:

1. Limiting Draft Marks not Submerged - Prior to Damage
2. No "Abnormal" Topside Weights
3. Liquid Loading Instructions are Followed
4. Watertight Integrity is Maintained

Didn’t follow Liquid Loading Instructions.

What kind of hull stresses were created…?

CLASS TOPICS

1. ~~Causes of Loss~~
2. ~~Movie (USS Wilkes Barre)~~
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4. ~~List in Stability~~
5. ~~Floodable Length~~
6. ~~Dynamic Stability~~
7. Decision Factors

DECISIONS (NSTM 079v1)

(1) SURVIVABILITY FACTORS. (CO)

Ability to control and extinguish fires, and control flooding

Ability to reach a safe haven

Ability to float and stay upright

Ability to stay in action and repel attack. (Department Heads)

DECISIONS (NSTM 079v1)

(2) WHICH CORRECTIVE MEASURES WILL IMPROVE THE SITUATION INSTEAD OF MAKING IT WORSE. (EO)

- Freeboard

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. Floodable Length Exceeded.

4. Damage with bad weather.

CRITICAL Thumb rule #1

If the ship has little or no roll period & feels “sluggish”, then you have a small, or slightly negative GM…

i.e. your stability is “Critical”

CRITICAL Thumb rule #2

If the ship lists to the Danger Angle (1/2 the angle of max righting arm angle) within *10-15 minutes* after damage it is **"probable"** that it will capsize…

i.e. your stability is "Critical"

SURVIVABILITY OF THE SHIP

THE DANGER ANGLE IS APPROX. THE ANGLE WHERE THE WEATHER DECK IS ALMOST CONTINUOUSLY AWASH. ← *visual clue without calculation.*

Break out Section II(a)

- ***What is your Danger Angle for full load condition?***

CRITICAL Thumb rule #3

Is your floodable length exceeded? If yes…then your main deck is close to going under the water…

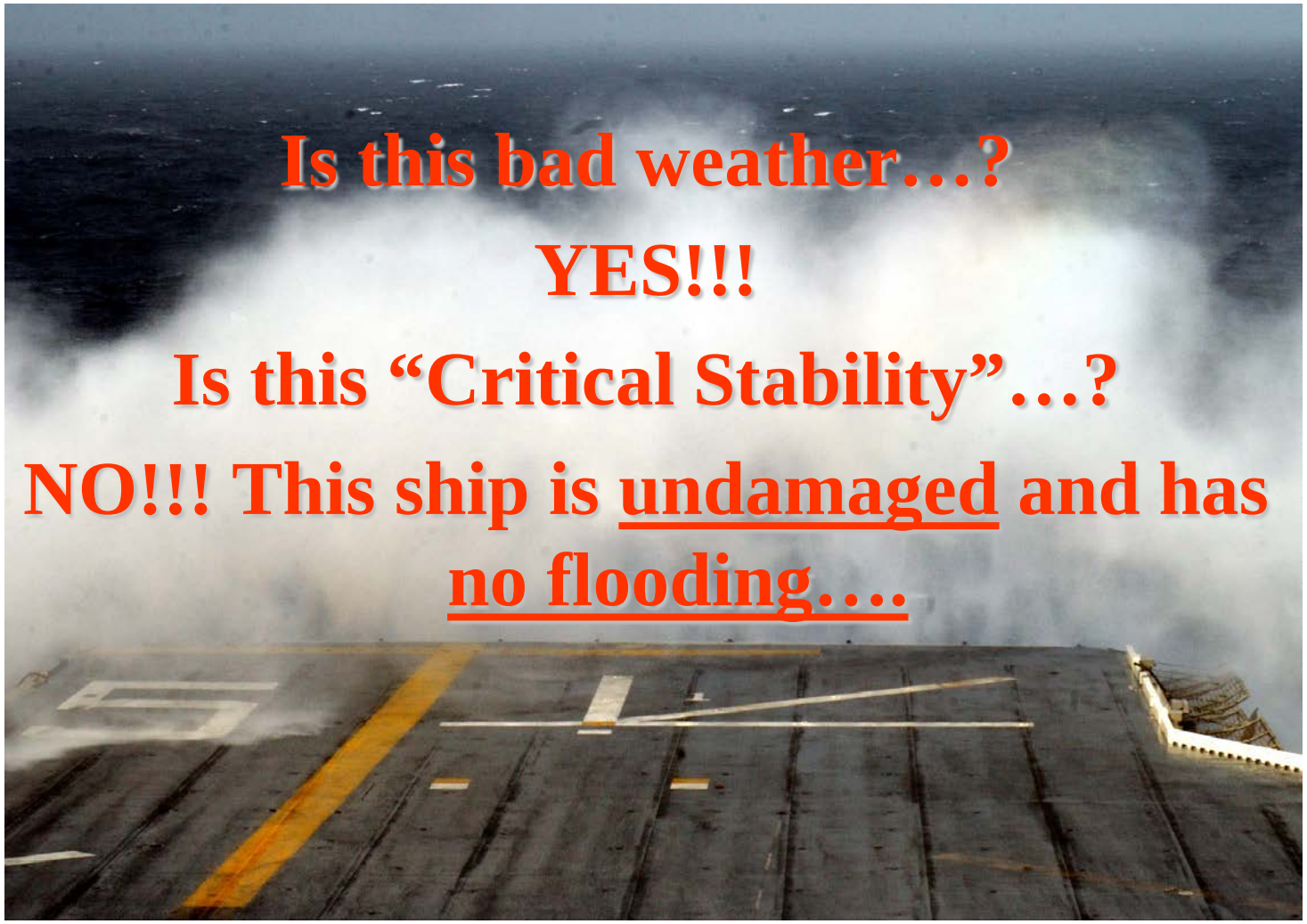
i.e. your stability is "Critical"

CRITICAL Thumb rule #4

Are you damaged and in bad weather? If yes…the effects of the flooding will be compounded by the wave motion…

i.e. your stability is "Critical"

CRITICAL Thumb rule #4



IMMEDIATE STEPS

STEP FOUR -

ELIMINATE OR REDUCE LIST

Don’t forget about:

EXCESSIVE TRIM (> 1% LBP)

ACTIONS

SHIFT CENTER OF GRAVITY TOWARDS "HIGH" END.

Quiz…

- When is stability considered critical?

1) -GM.
2) Listing to danger angle.
3) Floodable length exceeded.
4) Damage with bad weather.

Quiz…

- What are some design factors considered in NAVY and CG ships?
  - 100 Knot instantaneous beam winds.
  - 60 Knot damaged wind.
  - Full Speed/Full rudder turn.
  - Heel with heavy objects over the side.

READ STUDENT GUIDE!

HOME WORK #3