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Office of Marine Safety

M/V LADY D

Rob Henry

Cause of the Capsize

US Navy photo

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Pontoon SPV Overloading

- 1992 *Patricia P* (ex. *Fells Point Princess*) certification error
- 1996 erroneous sister vessel designation of the *Lady D*
- Out-of-date average weight standard for stability assessment

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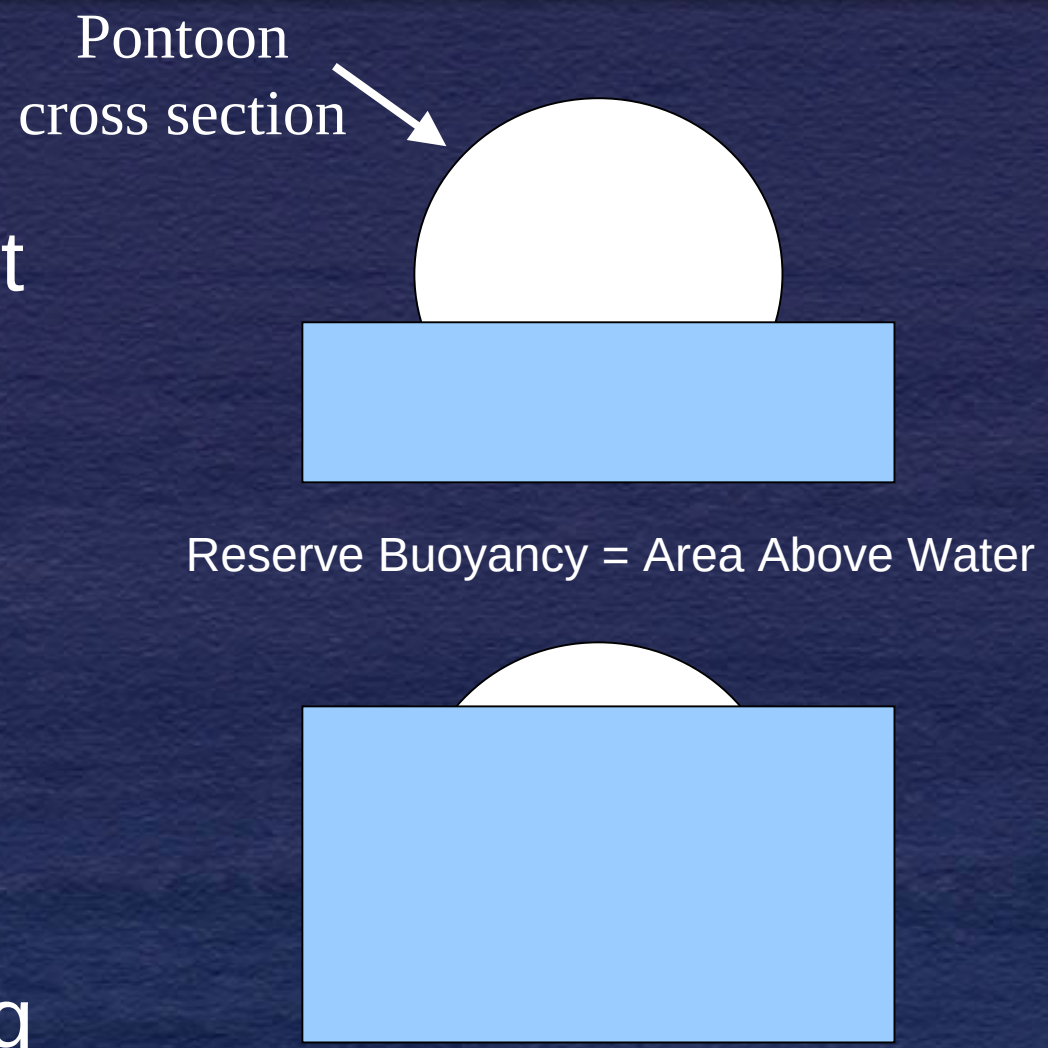
Effect of Adding Weight on Stability

- As weight is added to vessel, it floats lower in the water
- Less pontoon (reserve buoyancy) remains above water to counteract heeling forces



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Assessment of the *Lady D's* Intact Stability

- Intact stability is the measure of an undamaged and/or unflooded vessel's stability characteristics in calm waters
- Dynamic stability refers to a vessel's motions and response to external forces such as wind and waves

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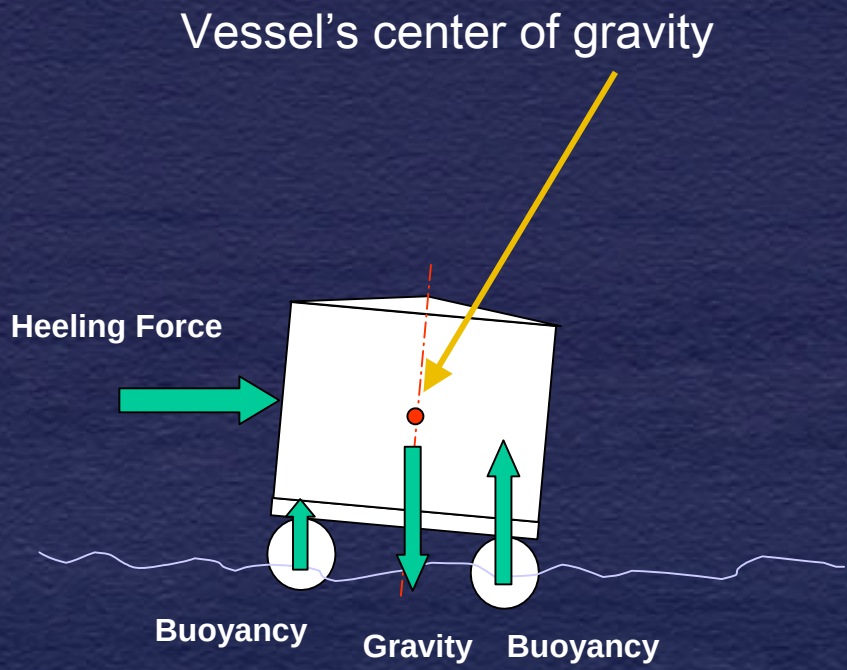
Stability of Pontoon Vessel

- Intact stability examines how vessel reacts when heeled over
- Heeling forces (wind, waves or passenger movement) try to overturn vessel
- Buoyancy of the hull (righting energy) counteracts heeling forces
- If righting energy > heeling energy, vessel will remain upright



Cross section of a pontoon vessel

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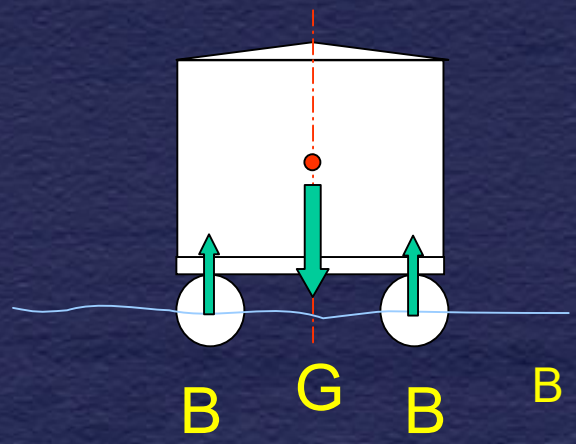
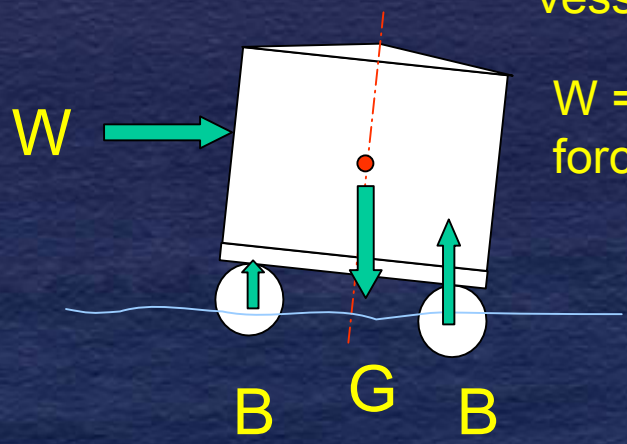
Stability of a Pontoon vessel

- Vessel at rest
  - Weight of vessel acts at its center of gravity
  - Buoyancy of pontoons = weight of vessel
- Wind heels vessel
  - Far side pontoon is pushed down in water and creates more buoyancy to counteract wind force



B = buoyancy

G = weight of vessel



W = wind force

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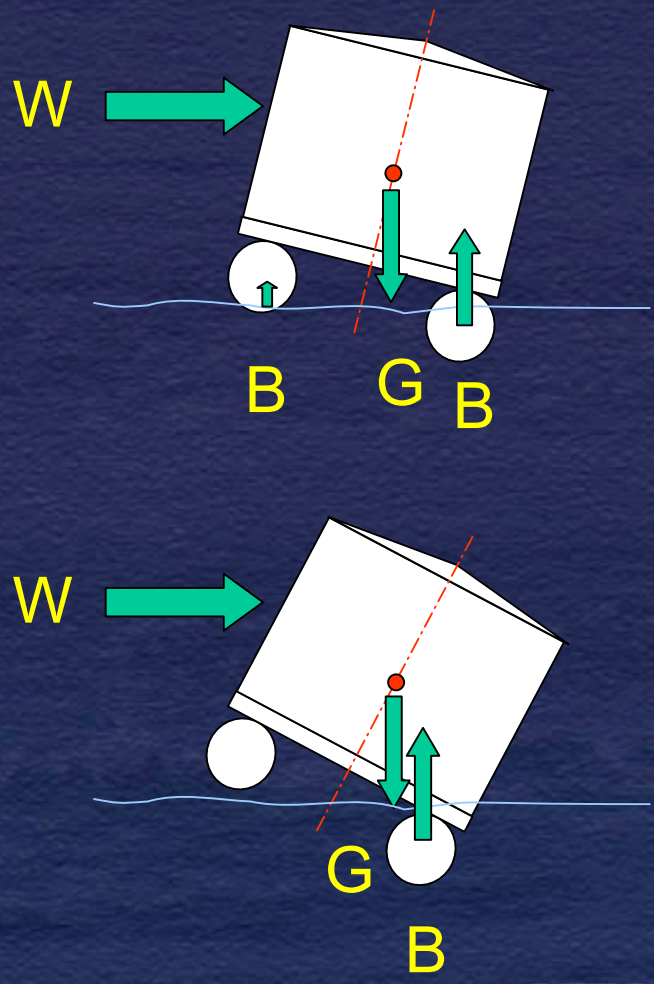
Stability of pontoon vessel

- Wind increases
  - Near side pontoon coming out of water
  - Most buoyancy provided by far side pontoon
  - Restoring force is getting smaller because B is getting closer to G
- Wind increases more
  - Far side pontoon is forced further into water to resist wind force
  - All buoyancy now comes from far side pontoon



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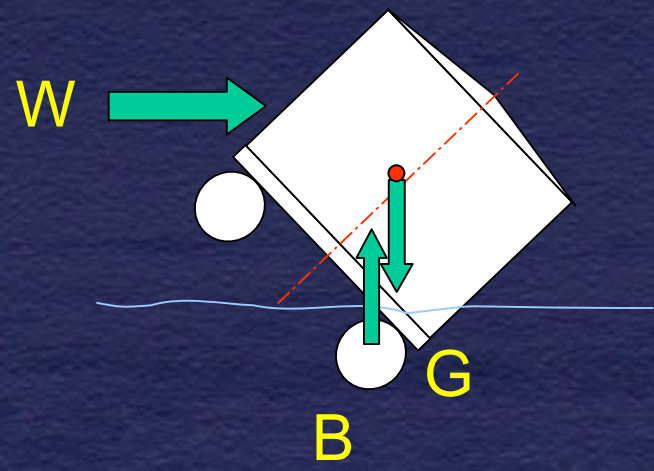
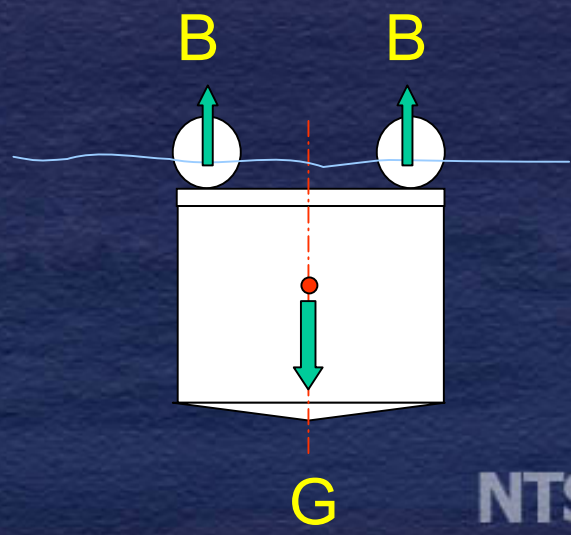
How capsize occurs

- Wind forces vessel over further
  - Vessel's center of gravity (G) is outside of the buoyancy (B) of the pontoon which forces the vessel over more
- Vessel comes to rest upside down
  - Buoyancy = weight
  - Vessel is stable again





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Load Cases Studied by NTSB

- Maximum safe load condition by PSST: 14-140 pound passengers = 1,960 pounds total load
- COI condition: 25-140 pound passengers = 3,500 pounds total load
- Accident condition: 25-168 pound passengers = 4,210 pounds total load

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Decreased Righting Energy

- As weight is added and wind increases, stability (reserve righting energy) decreases

Loading Case	Total Load - pounds	Reserve Righting Energy Measured in Foot-Degrees		
		30 Knots	40 Knots	50 Knots
14 people at 140 lbs	1960	37	28	17
25 people at 140 lbs	3500	17	10	4
Actual accident Condition	4210	6	2	None

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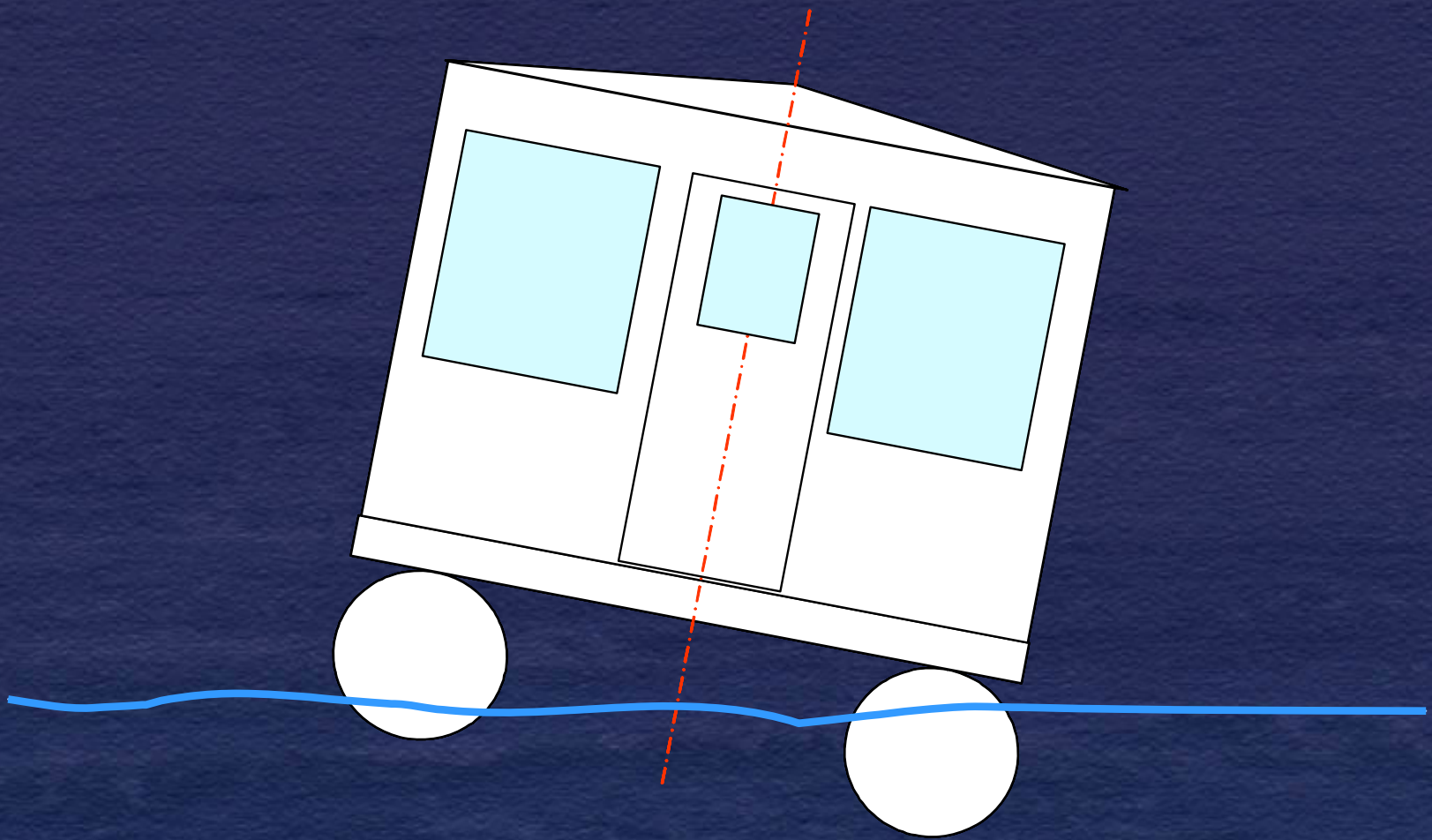
LADY D in Heeled Condition



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Passenger Weight Criteria for Stability Assessment

Courtesy of A. Acosta

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Passenger Weight Standard

- Protected waters standard - 140 pounds per person
- *Lady D* - 168 pounds per person average

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Safety Recommendation M-04-4

- Issued to Coast Guard in December 2004
- Revise the way maximum occupancy on pontoon SPV is determined
- Use 174 pounds per person in assessing stability
- Operationally limiting the max passenger load a vessel can carry

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M/V Ethan Allen - Lake George, NY

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140-Pound Passenger Weight Criteria in Regulation

- Pontoon Simplified Stability Test in Subchapter T (46 CFR 178.340)
- Monohull Simplified Stability Test in Subchapter T (46 CFR 178.330)
- Minimum GM required for passenger heel stability in Subchapter S (46 CFR 171.050)

Coast Guard PSST Job Aid

Revised September 28, 2004

- SMALL PASSENGER VESSELS -

SIMPLIFIED STABILITY TEST PROCEDURE FOR PONTOON VESSELS ON PROTECTED WATERS

(In accordance with 46 CFR 178.340)

DEPARTMENT OF
HOMELAND SECURITY
U.S. COAST GUARD

Name of Vessel _____ Documentation No. _____ Date _____

Owner/Representative _____ Inspector _____

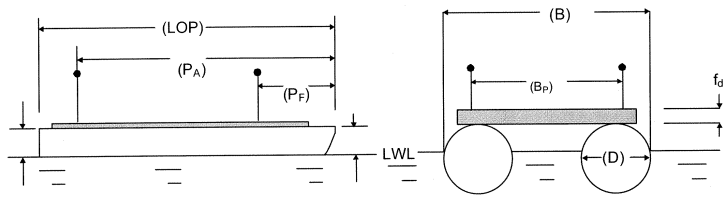
Location _____ Wind: Relative Direction _____ Vel ____ mph

Mooring Arrangement _____ Route: Protected Only

APPLICABILITY:

This form is to be used ONLY if ALL of the following conditions are met, otherwise contact MSC:

- vessel is less than or equal to 65 feet in length
- vessel carries 49 or less passengers
- vessel operates on protected waters
- vessel is a pontoon boat, i.e. fully enclosed pontoons with no machinery or tanks inside
- vessel has only two pontoons
- vessel has outboard engines
- vessel has only one deck and the deck is less than 6 inches above pontoon tops (f_d below)
- deck accessible to passengers does not extend beyond pontoons fore/aft and port/stbd
- transverse test moment is greater than minimum test moment (see Section (2))



Indicate on above Sketch	Indicate on above Sketch
1) Pontoon length (LOP)	1) Maximum beam (B) to outside of pontoons
2) Distance, from pontoon bow, of furthest fwd location accessible to passengers (P_F)	2) Maximum beam (B_P) accessible to passengers
3) Distance, from pontoon bow, of furthest aft location accessible to passengers (P_A)	3) Distance (f_d) between pontoon tops & top of deck; must be less than 6 inches.
4) Freeboard at bow to pontoon top	4) Pontoon diameter (D) if circular pontoons; Pontoon waterline breadth if wall-sided
5) Freeboard at stern to pontoon top	

The measurements above are to be taken in the loaded condition with trim and heel minimized. Measurements for (LOP) and (B) are to exclude rub rails.

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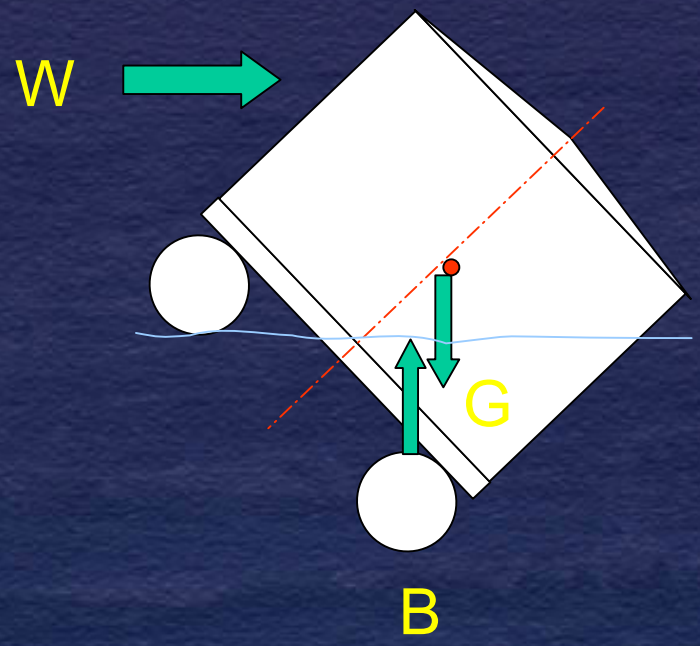
Pontoon Vessel Stability Standards



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Coast Guard Small Passenger Vessel Stability

- Late 1950s – Subchapter T and SST introduced for existing vessels
- Late 1960s PSST developed
- March 1996 regulation change – SPV carrying 7-49 passengers must pass stability test
- October 2004 – Revised PSST developed

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NTSB Dynamic Stability Study

- *Lady D* in accident load condition with 25 168-pound persons has a high propensity to capsize.
- The *Lady D* in maximum safe load condition with 14 140-pound persons still capsizes

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Passenger Vessel Stability Safety Concerns

- Intact stability criteria for pontoon passenger vessels
- Interim pontoon passenger vessel stability standard
- Operational guidance on pontoon passenger vessel COIs

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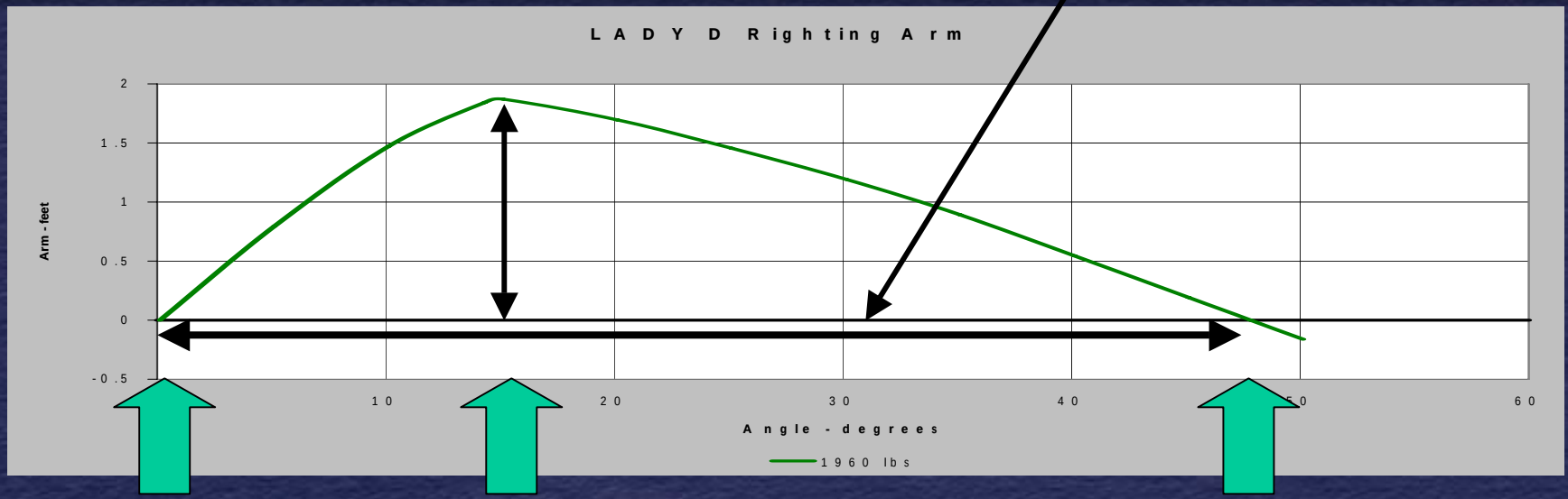
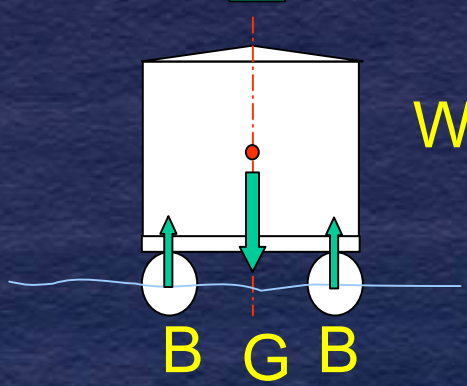
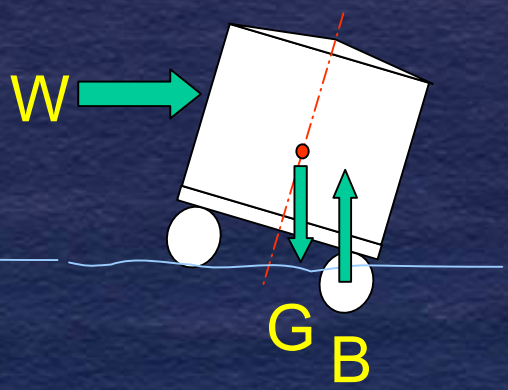
Righting Energy Curve

Range of positive stability

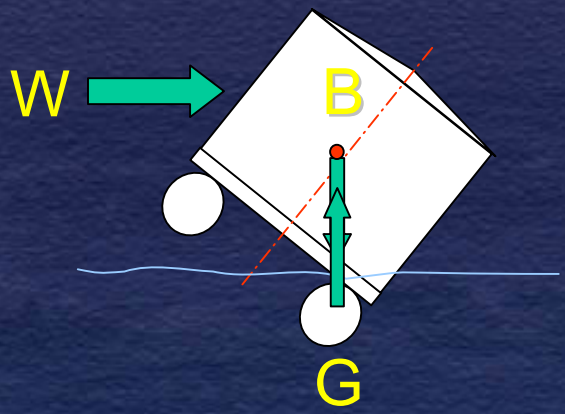




vessel in Balance
No Righting Energy



B & G farthest apart
= Maximum
Righting Energy



B & G Aligned
No Righting Energy

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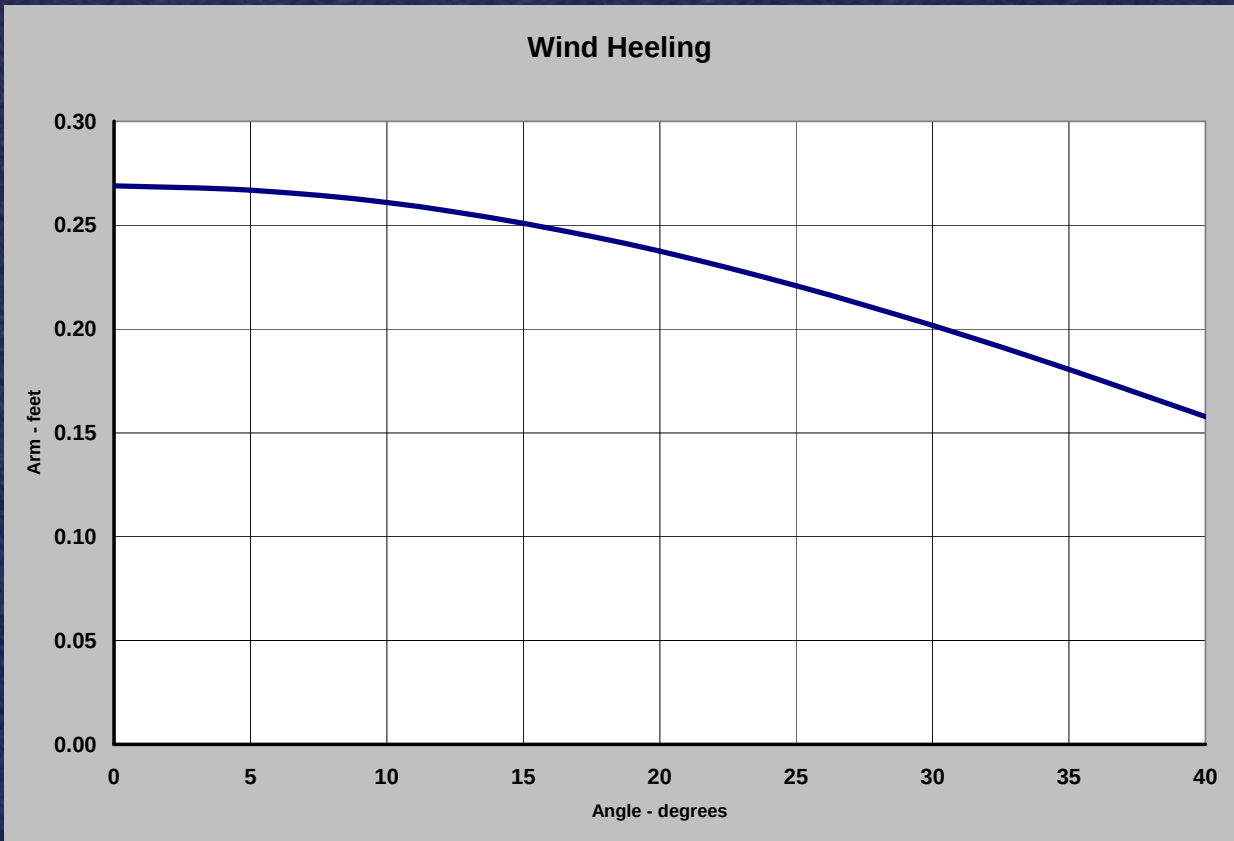
Heeling Due to Wind

- Wind acts on the exposed surface area of the vessel creating an overturning (heeling) force
- The force is a function of wind speed, exposed area and angle of heel
- As a vessel heels, overturning force decreases because less area is exposed to the wind



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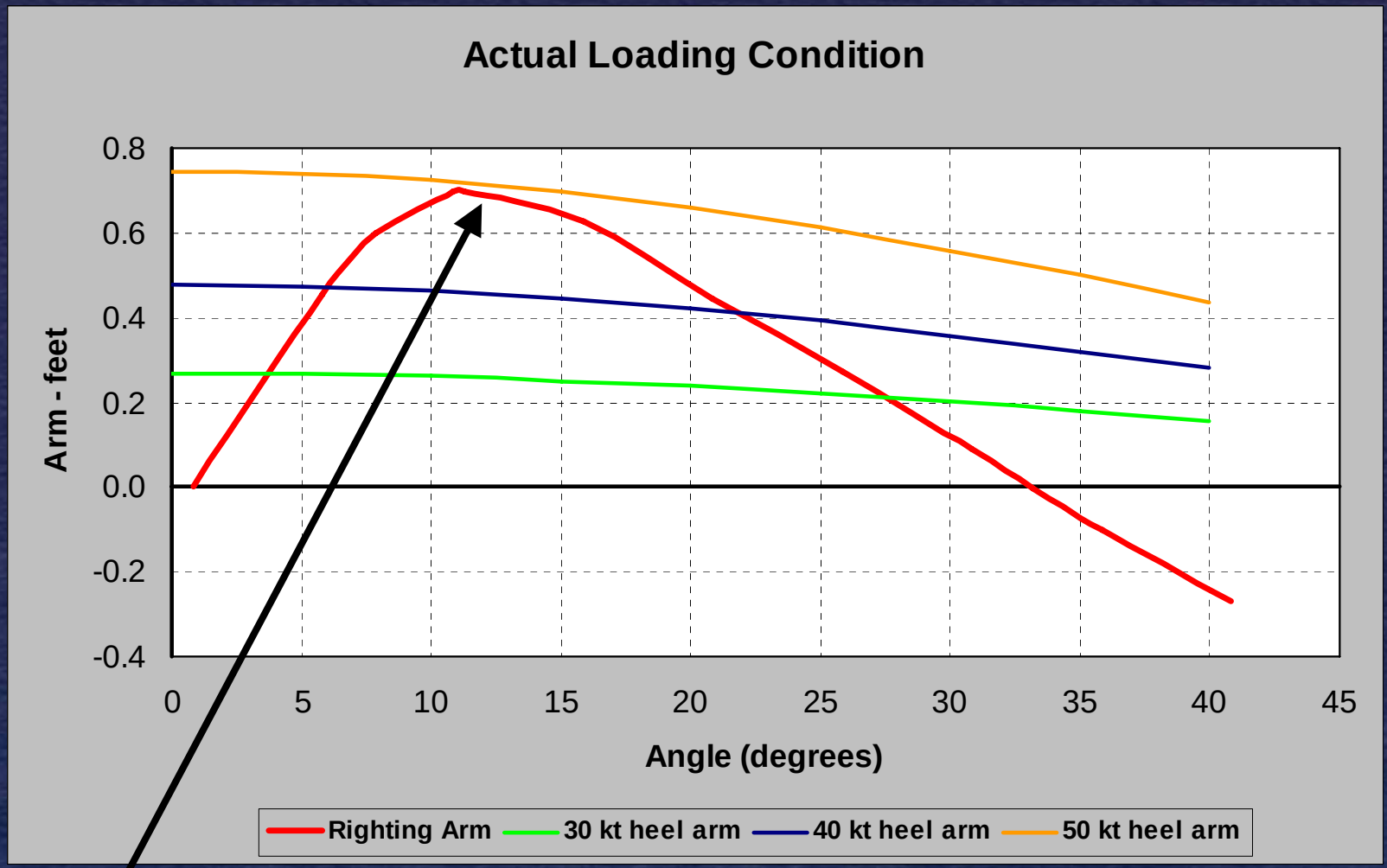
Righting Energy vs. Heeling Energy for the *Lady D's* Actual Loading



High wind leaves vessel with very little reserve to resist waves

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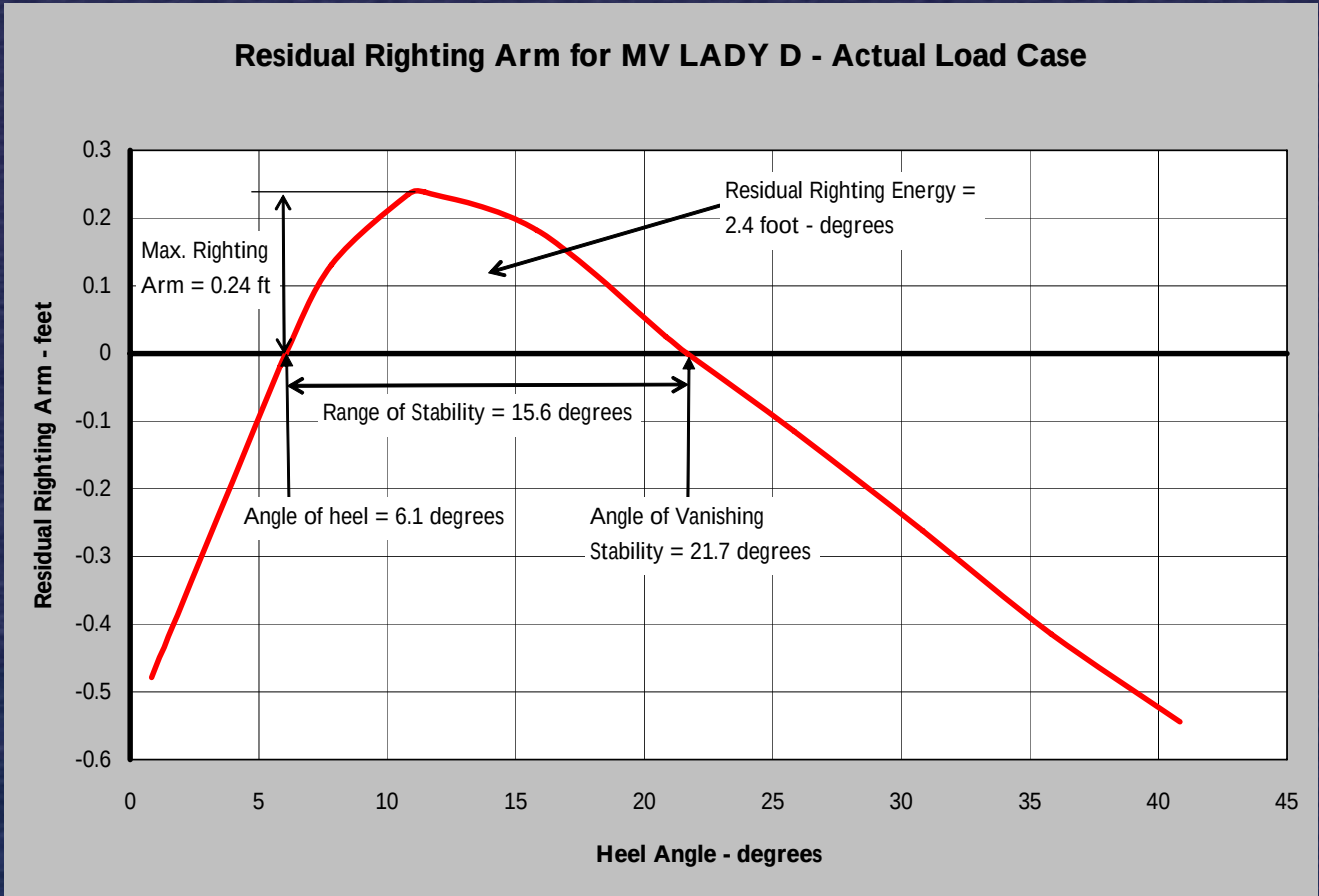
Residual Righting Energy Curve With 40-Knot Wind



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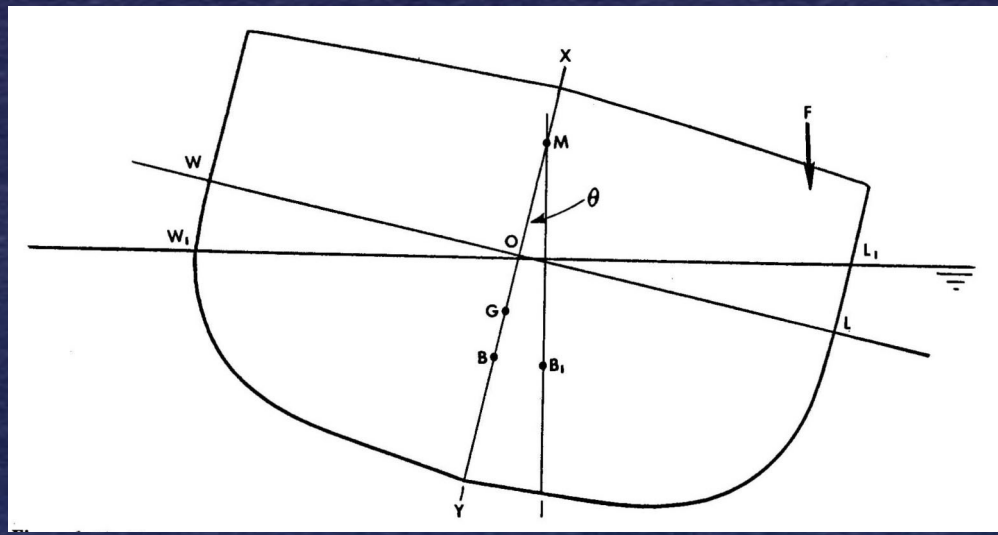
Transverse Metacenter and Metacentric Height

- **Key components to stability**
  - **Transverse Metacenter (KM_t)**
    - Distance from keel to metacenter (M)
    - Important indicator of inherent stability
  - **Metacentric Height (GM)**
    - Distance between center of gravity (G) and M is the metacentric height
    - Important measure of initial stability
    - Positive GM, if G is below M
    - Negative GM, M is below G



Source: Introduction to NAVAL ARCHITECTURE, Gillmer & Johnson, Naval Institute Press, 1982

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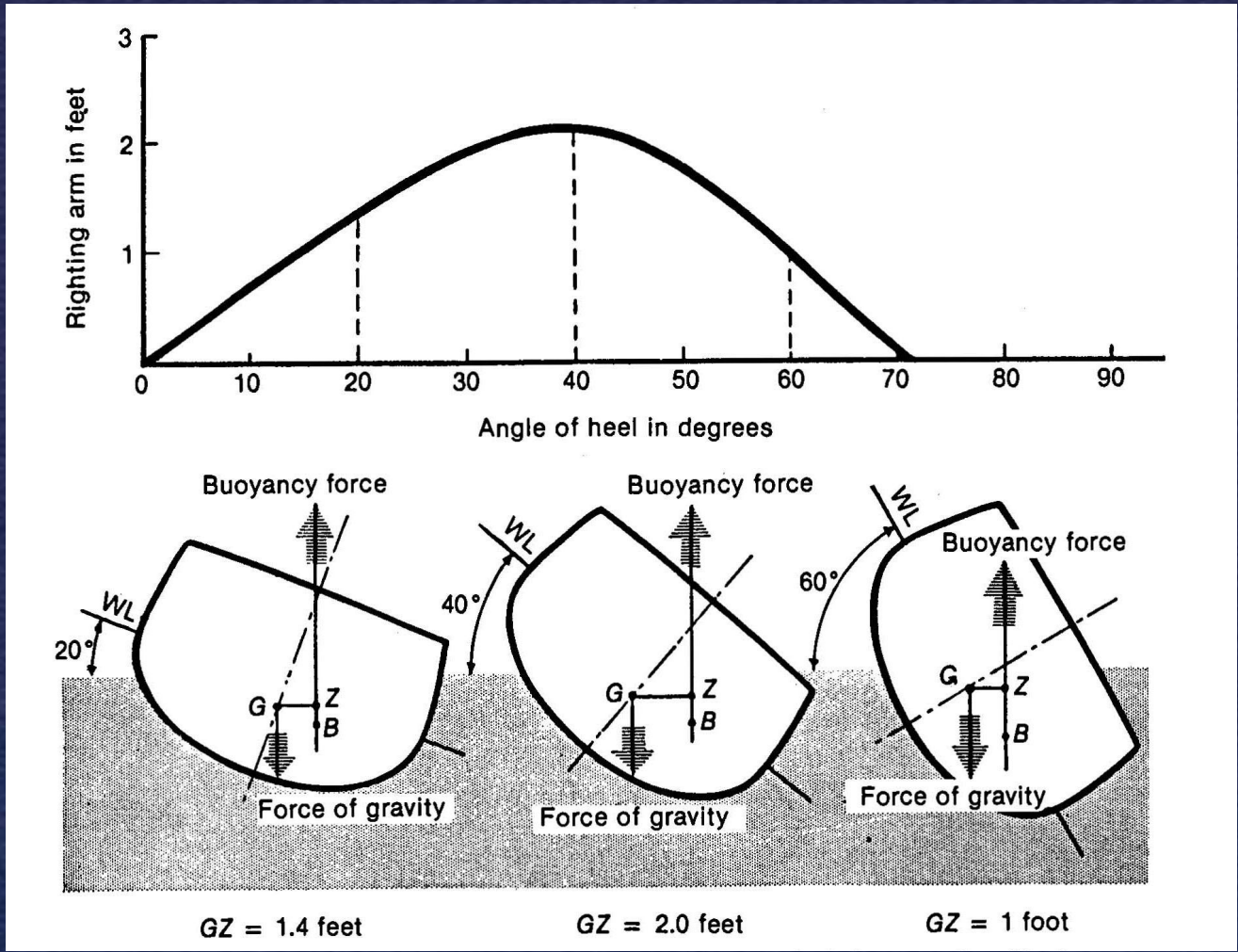
Righting Arm



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