

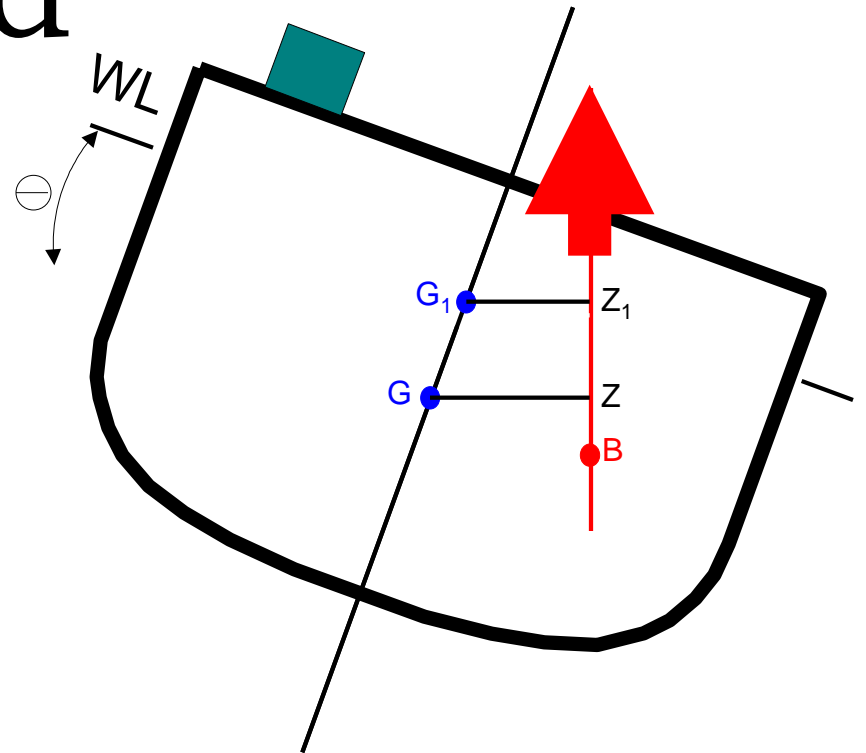


# PROBLEMS

NO MATTER HOW GREAT AND DESTRUCTIVE YOUR PROBLEMS MAY SEEM NOW,  
REMEMBER, YOU'VE PROBABLY ONLY SEEN THE TIP OF THEM.

# Lesson 4.2

## Solid Weight Shifts, Additions and Removals



**Example of a SOLID weight addition gone wrong...**



We must crawl before we can  
walk!

- **Lets review Homework #1  
and Lesson 4.1**

# **References**

**(Are they different?)**

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

# Enabling Objectives to be covered...

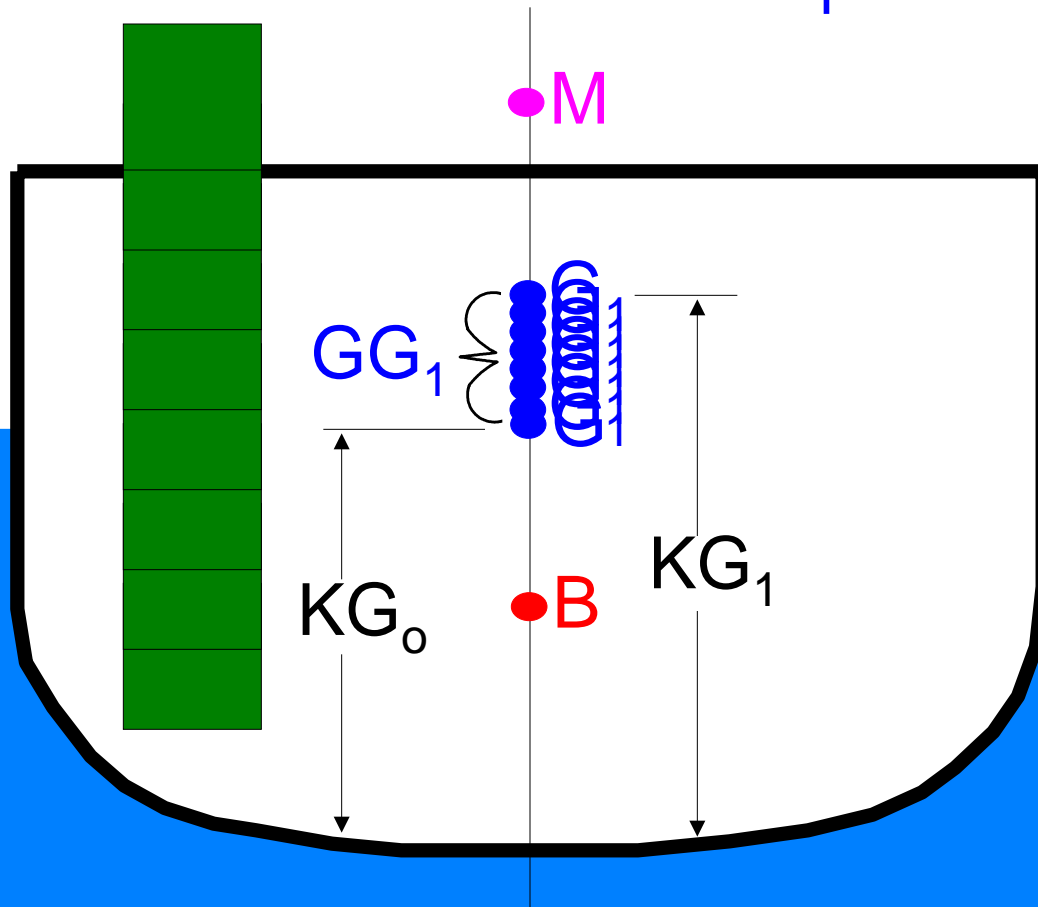
- Describe movement of reference points.
- Describe impact of addition, removal and shift of weight on stability.
- Calculate  $KG_1$  and  $GG_2$ .
- Calculate Sine and Cosine corrections.
- Apply corrections to Static Stability Curve.

# CLASS TIMELINE

1. Vertical Weight Shifts
2. Vertical Weight Additions / Removals
3. Sine Correction
4. Horizontal Weight Shifts
5. Horiz Weight Additions / Removals
6. Cosine Correction
7. Example Problem

# Vertical Weight Shifts

$$GG_1 = KG_1 - KG_0$$





$$KG_1 = \frac{(W_o \times KG_o) \pm (w \times kg)}{W_f}$$

WHERE;

w = Weight Shifted

kg = Distance Shifted

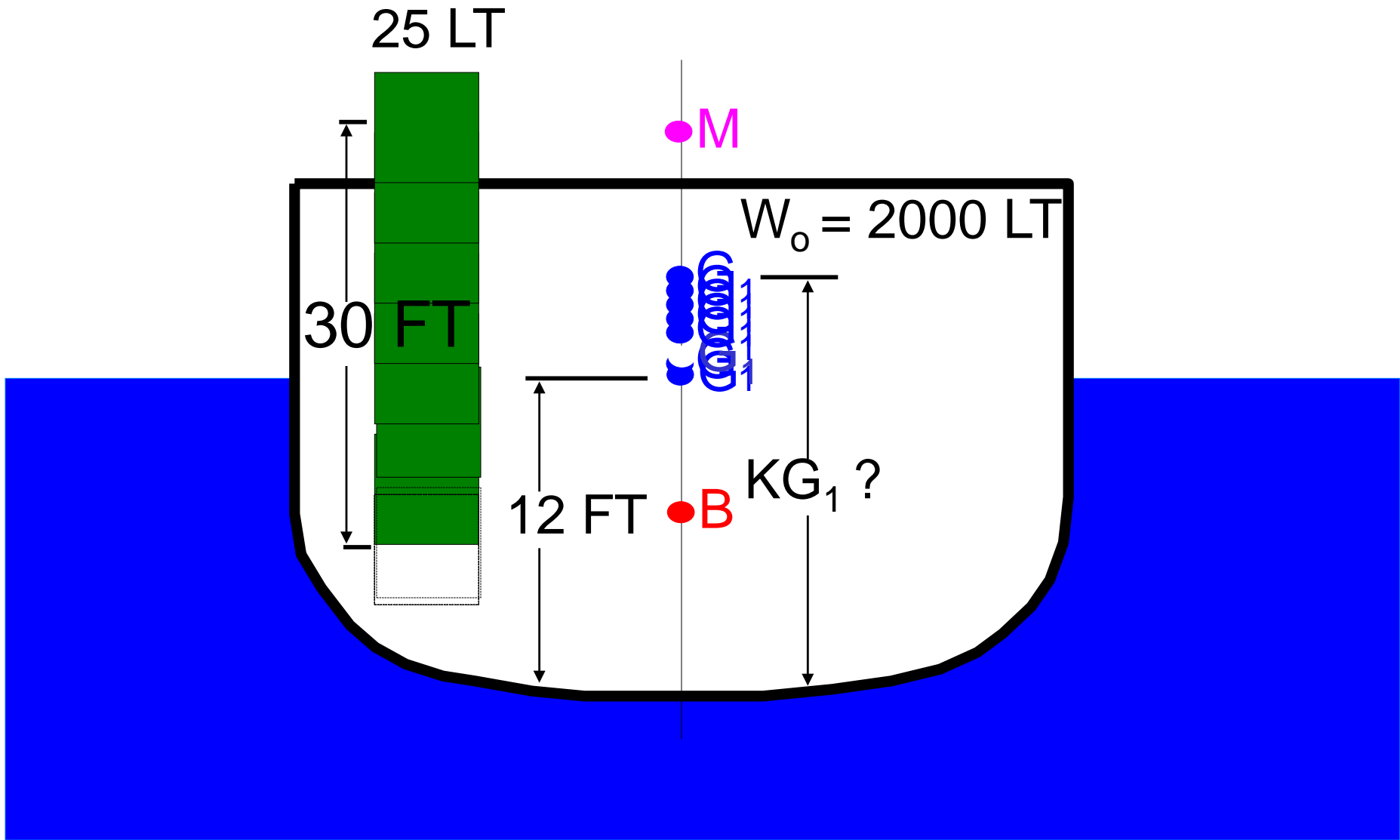
$W_o$  = Original Displacement

$KG_o$  = Original Height of G

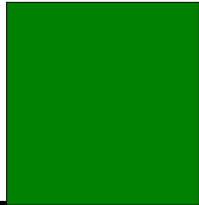
$W_f$  = Final Displacement

$\pm$  = + if shift up/- if shift down

$$KG_1 = \frac{(W_o \times KG_o) \pm (w \times kg)}{W_f}$$



45 LT



● M  $W_0 = 3400$  LT

↓ 8 FT

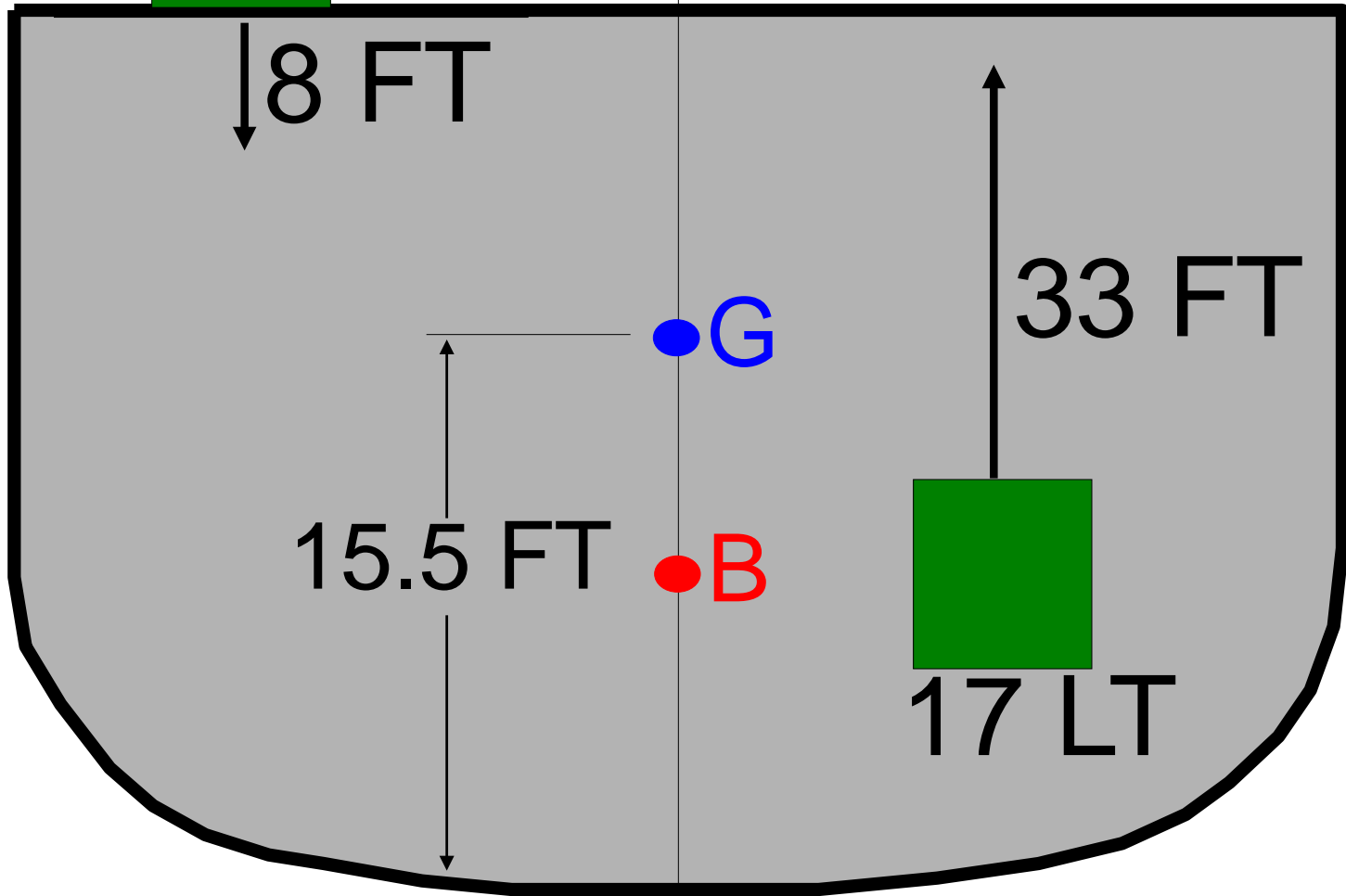
↑ 33 FT

● G

↑ 15.5 FT

● B

17 LT



$$KG_1 = \frac{(W_o \times KG_o) \pm (w_1 \times kg_1) \pm (w_2 \times kg_2)}{W_f}$$

WHERE;

$w_{1\&2}$  = Weights Shifted

$kg_{1\&2}$  = Distances Shifted

$W_o$  = Original Displacement

$KG_o$  = Original Height of G

$W_f$  = Final Displacement

$\pm$  = + if shift up/- if shift down

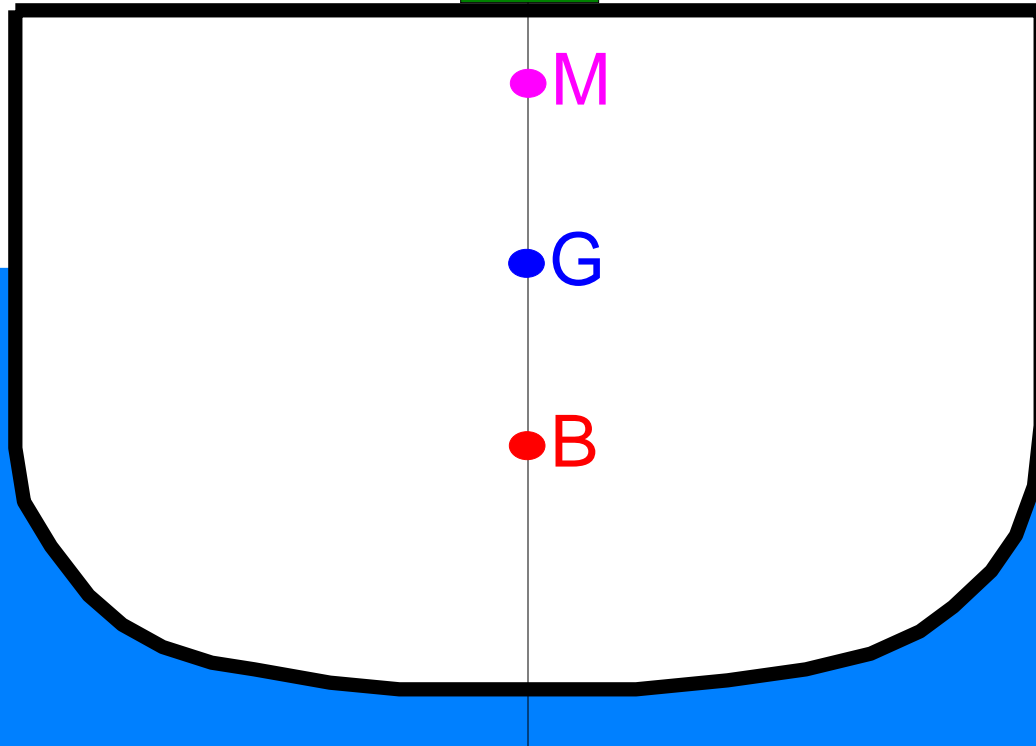
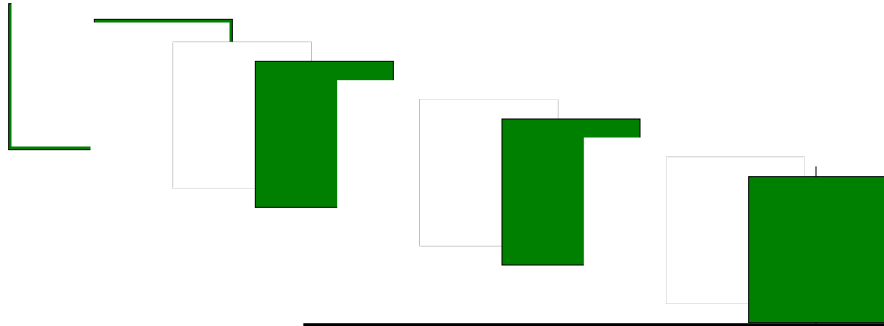
# CLASS TOPICS

1. ~~Vertical Weight Shifts~~
2. Vertical Weight Additions/Removals
3. Sine Correction
4. Horizontal Weight Shifts
5. Horizontal Weight Additions/Removals
6. Cosine Correction
7. Example Problem

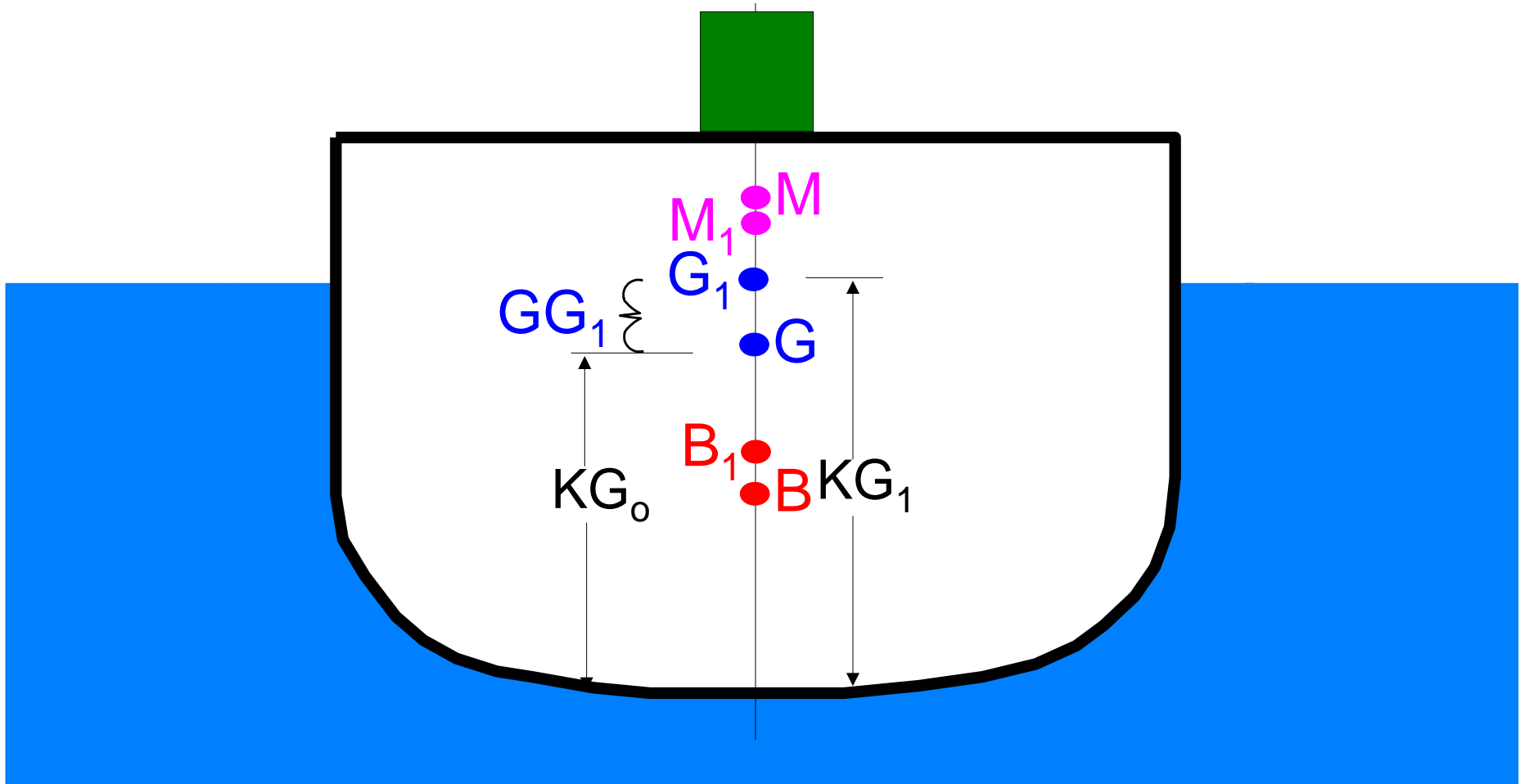
Example of vertical weight addition...



# Vertical Weight Additions



# Vertical Weight Additions





$$KG_1 = \frac{(W_o \times KG_o) \pm (w \times kg)}{W_f}$$

WHERE;

$KG_o$  = Original Height of G

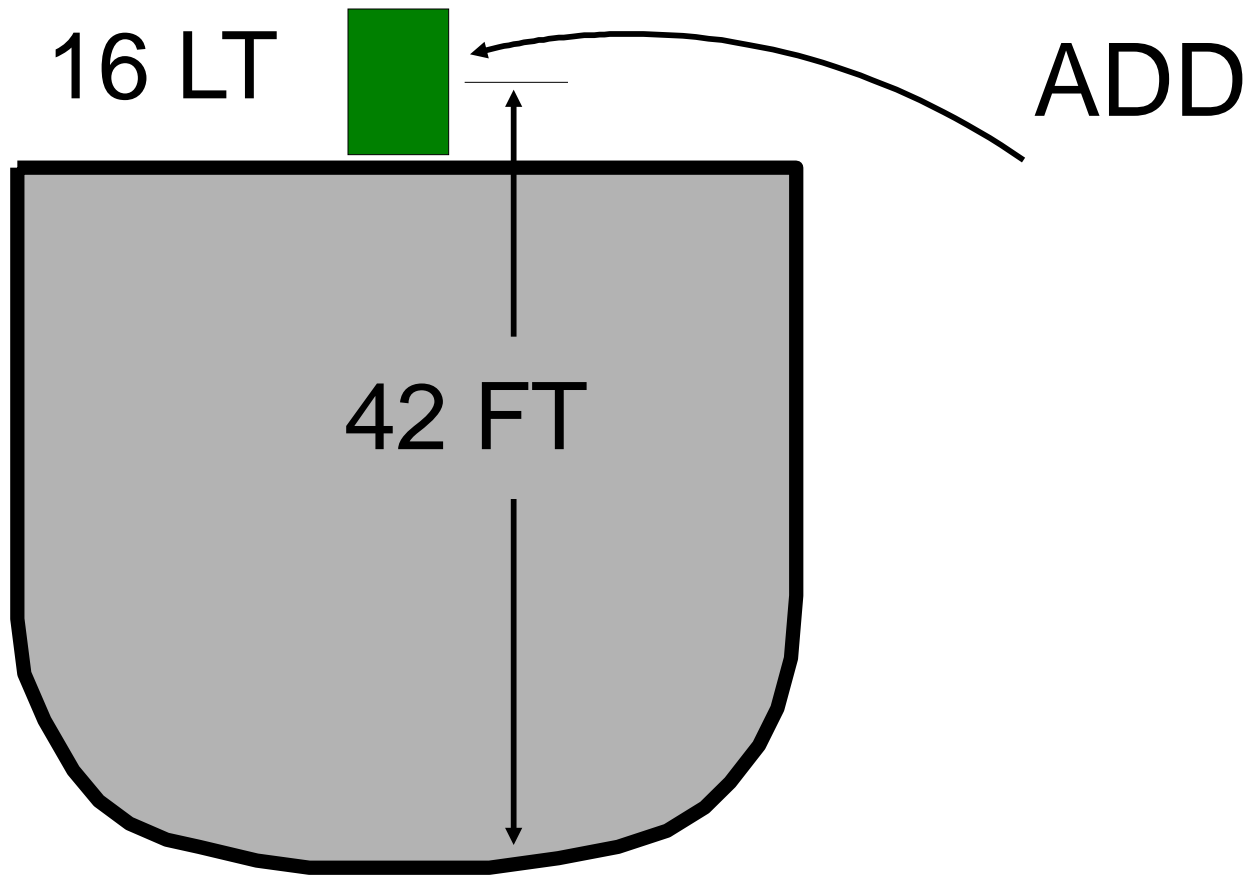
$W_o$  = Original Displacement

$\pm$  = + if addition/- if removal

$w$  = Weight Added/Removed

$kg$  = Distance Keel to "g" of  $w$

$W_f$  = Final Displacement



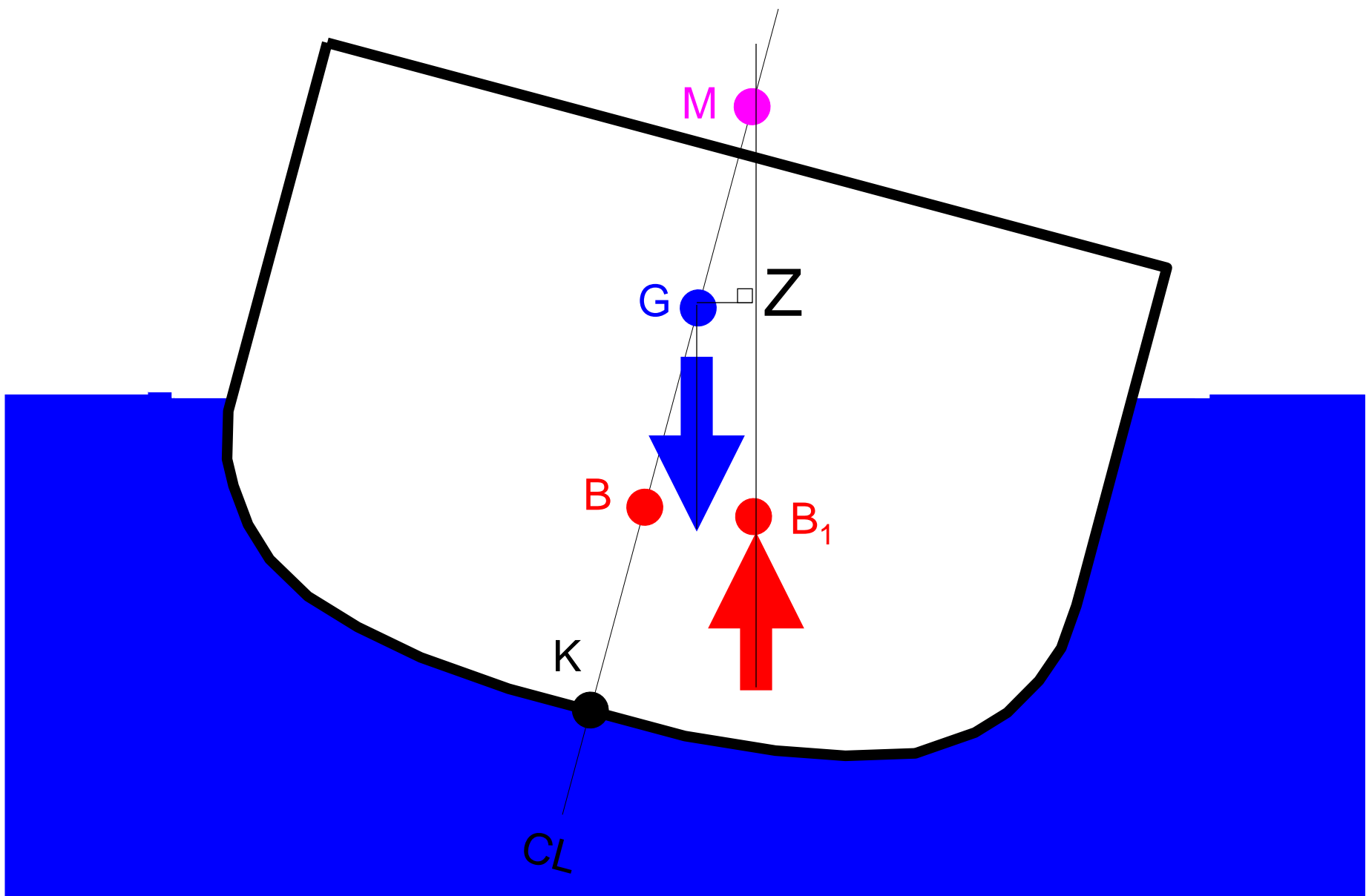
$$W_0 = 2000 \text{ LT}$$

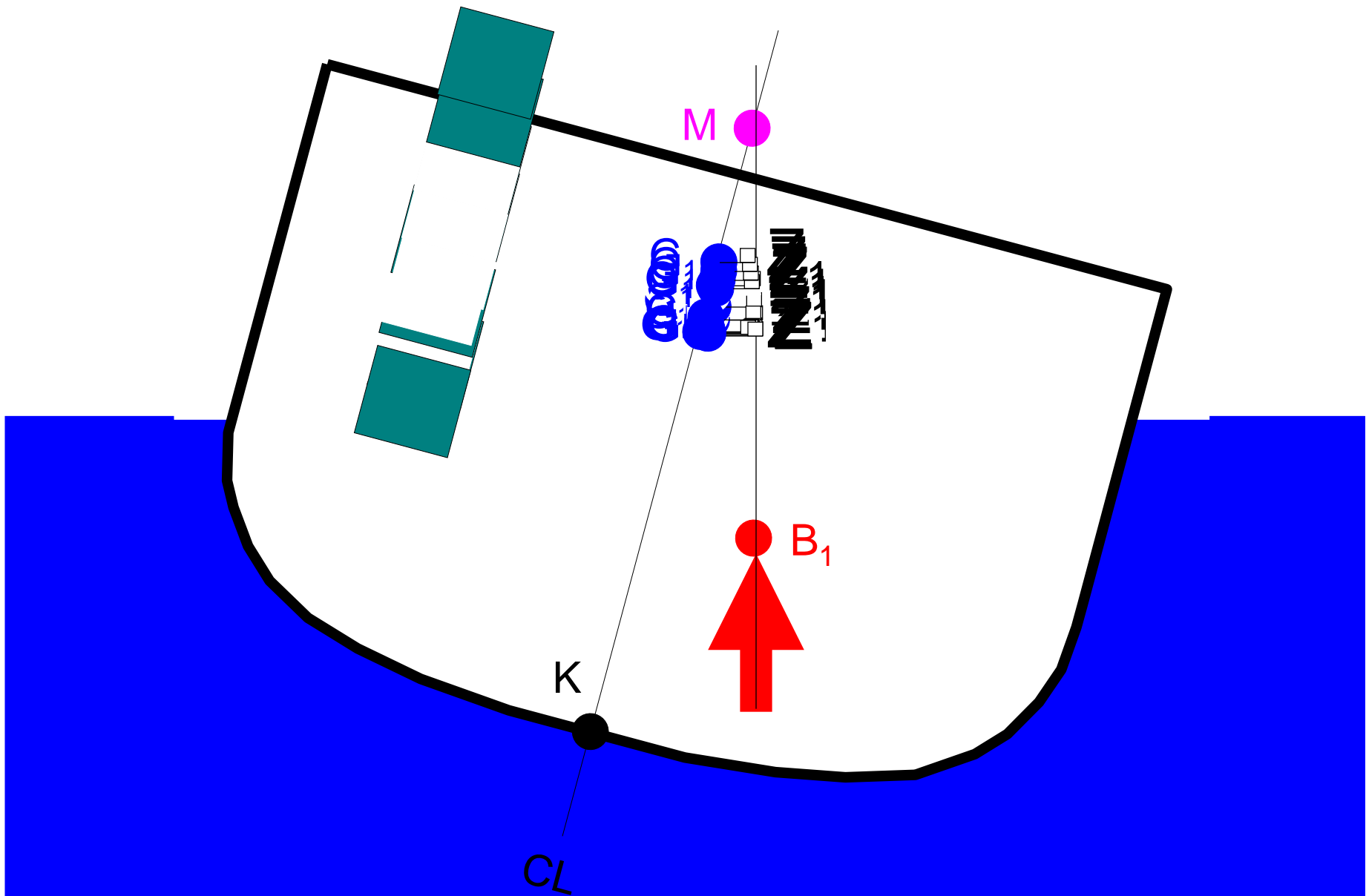
$$KG_0 = 12 \text{ FT}$$

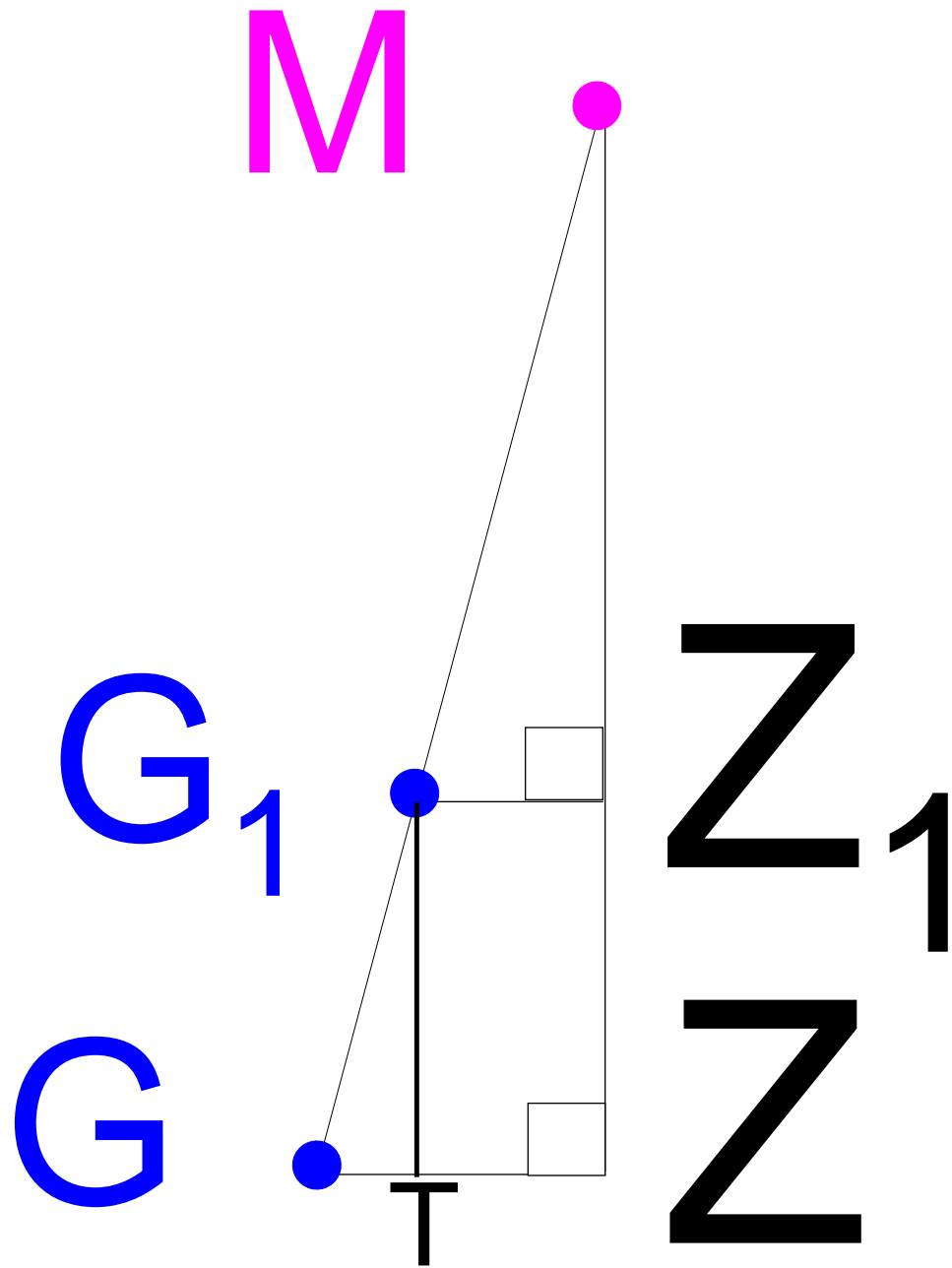
$$KG_1 = ?$$

# CLASS TOPICS

1. ~~Vertical Weight Shifts~~
2. ~~Vertical Weight Additions/Removals~~
3. Sine Correction
4. Horizontal Weight Shifts
5. Horizontal Weight Additions/Removals
6. Cosine Correction
7. Example Problem







$$\sin \theta = \frac{\text{OPP}}{\text{HYP}}$$

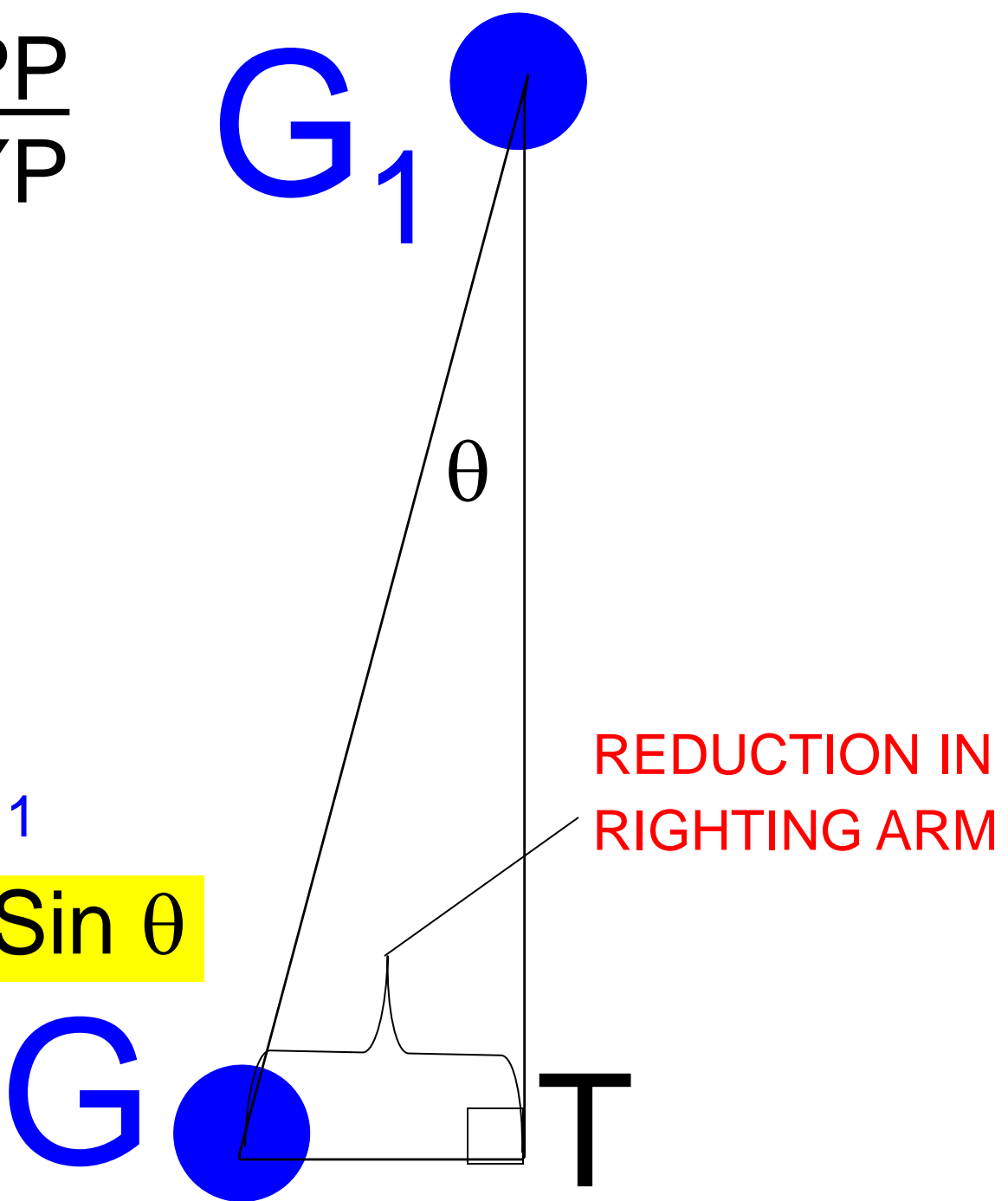
WHERE;

$$\text{OPP} = \text{GT}$$

$$\text{HYP} = \text{GG}_1$$

$$\sin \theta = \frac{\text{GT}}{\text{GG}_1}$$

$$\text{GT} = \text{GG}_1 \times \sin \theta$$



# **THINK VERTICAL DIRECTION ONLY!!!**

“SINE correction is vertical only... I use  $KG_1$  to find SINE Correction”



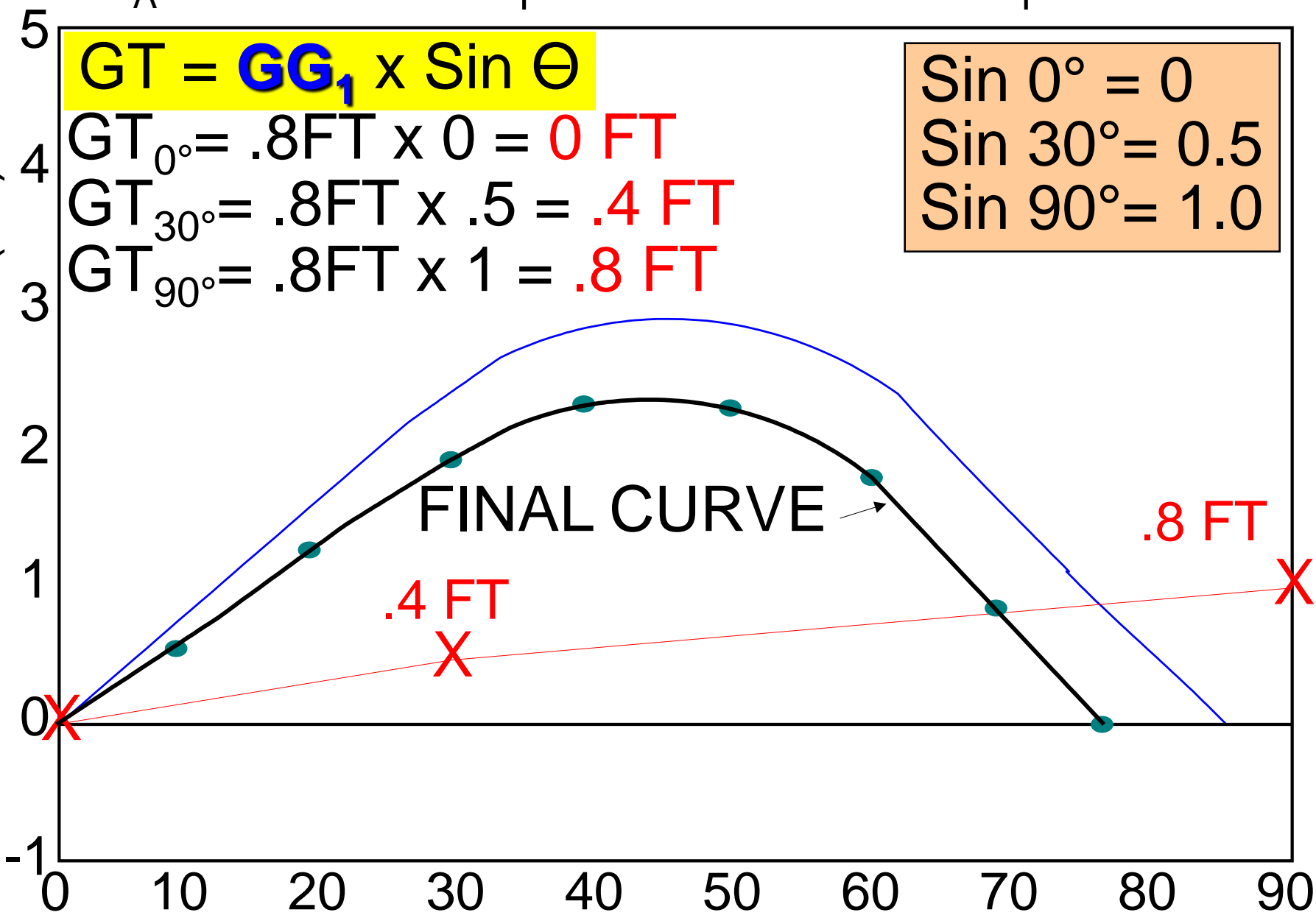
$KG_A = 19 \text{ FT}$      $KG_1 = 19.8 \text{ FT}$      $GG_1 = \mathbf{0.8 \text{ FT}}$

$GT = \mathbf{GG_1} \times \text{Sin } \Theta$

Sin 0° = 0  
Sin 30° = 0.5  
Sin 90° = 1.0

$GT_{0^\circ} = .8\text{FT} \times 0 = \mathbf{0 \text{ FT}}$   
 $GT_{30^\circ} = .8\text{FT} \times .5 = \mathbf{.4 \text{ FT}}$   
 $GT_{90^\circ} = .8\text{FT} \times 1 = \mathbf{.8 \text{ FT}}$

RIGHTING ARMS (FT)

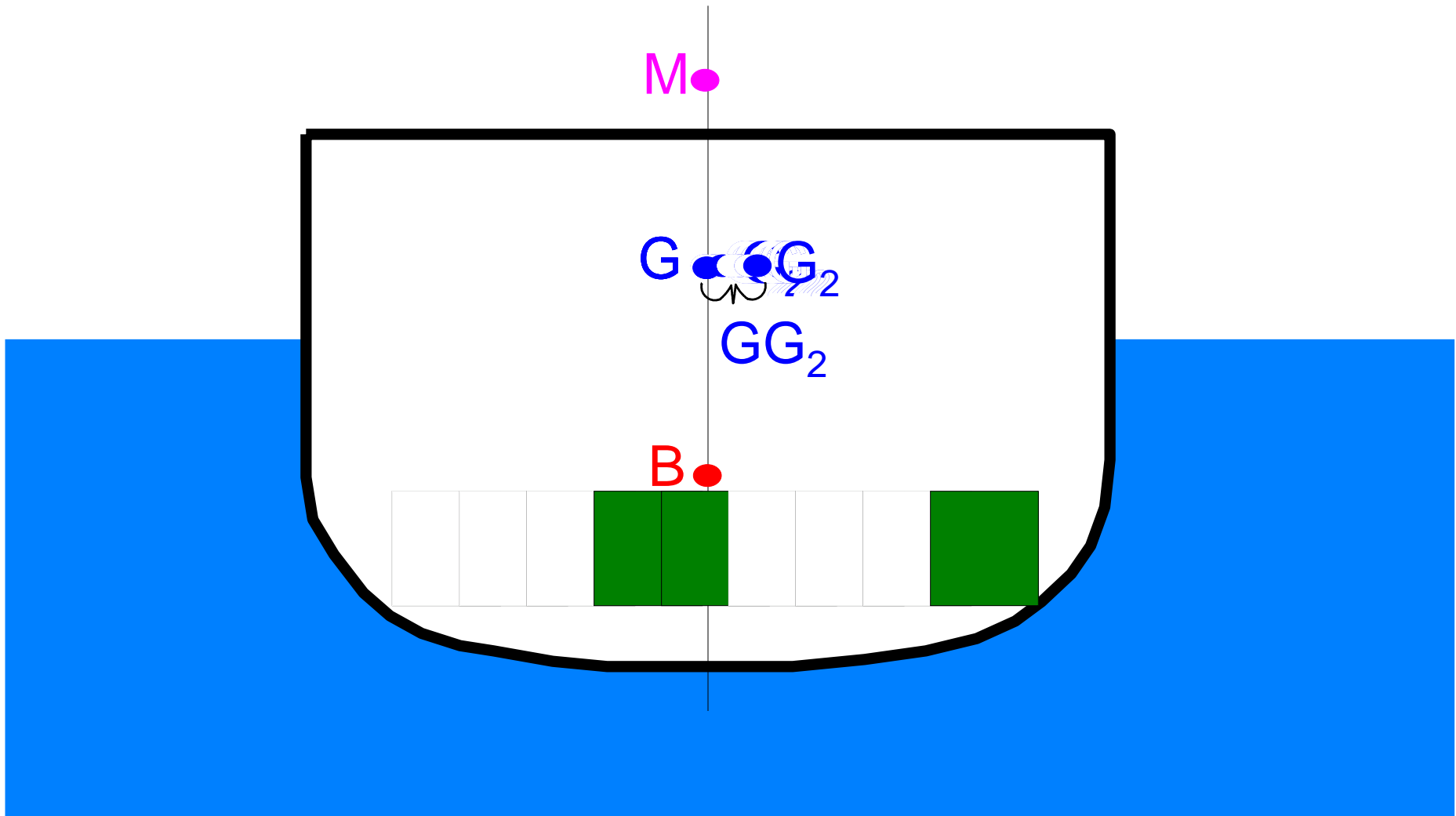


ANGLE OF INCLINATION - DEGREES

# CLASS TOPICS

- ~~1. Vertical Weight Shifts~~
- ~~2. Vertical Weight Additions/Removals~~
- ~~3. Sine Correction~~
4. Horizontal Weight Shifts
5. Horizontal Weight Additions/Removals
6. Cosine Correction
7. Example Problem

# Horizontal Weight Shifts



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

WHERE;

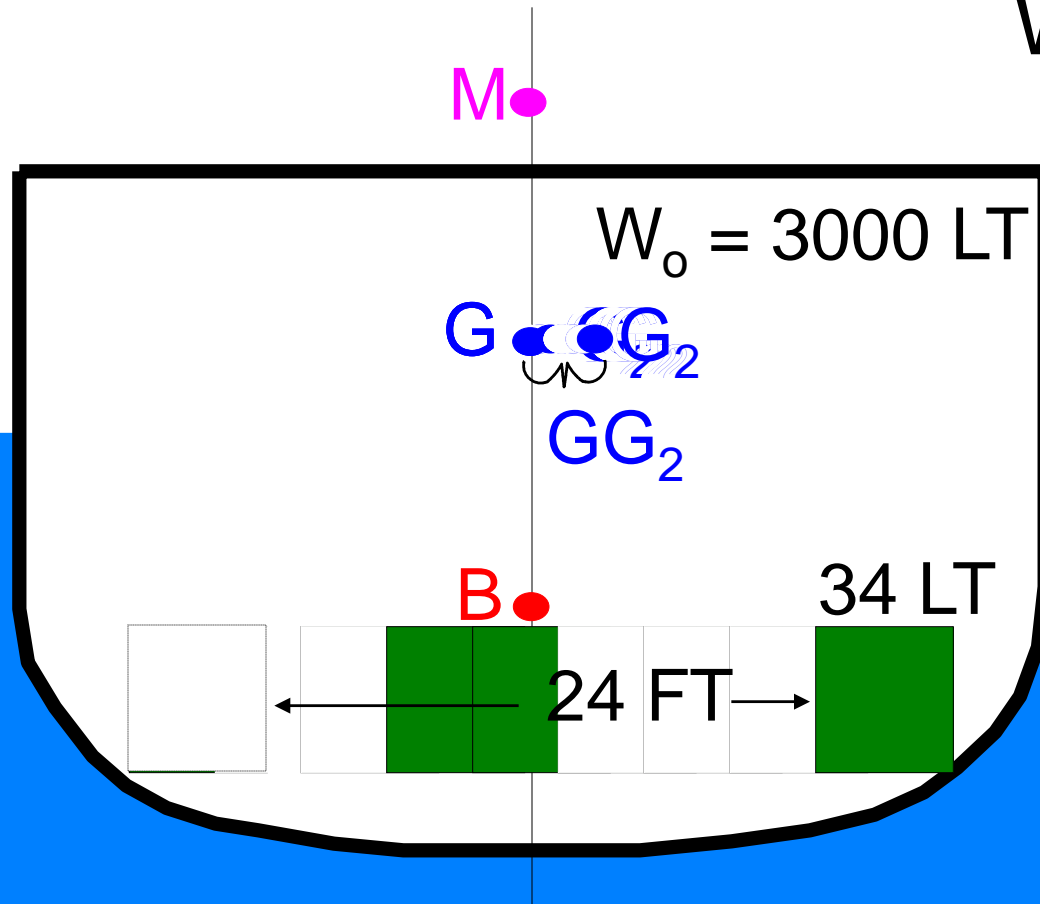
w = Weight Shifted

d = Distance shifted

$W_f$  = Final Displacement

# Horizontal Weight Shifts

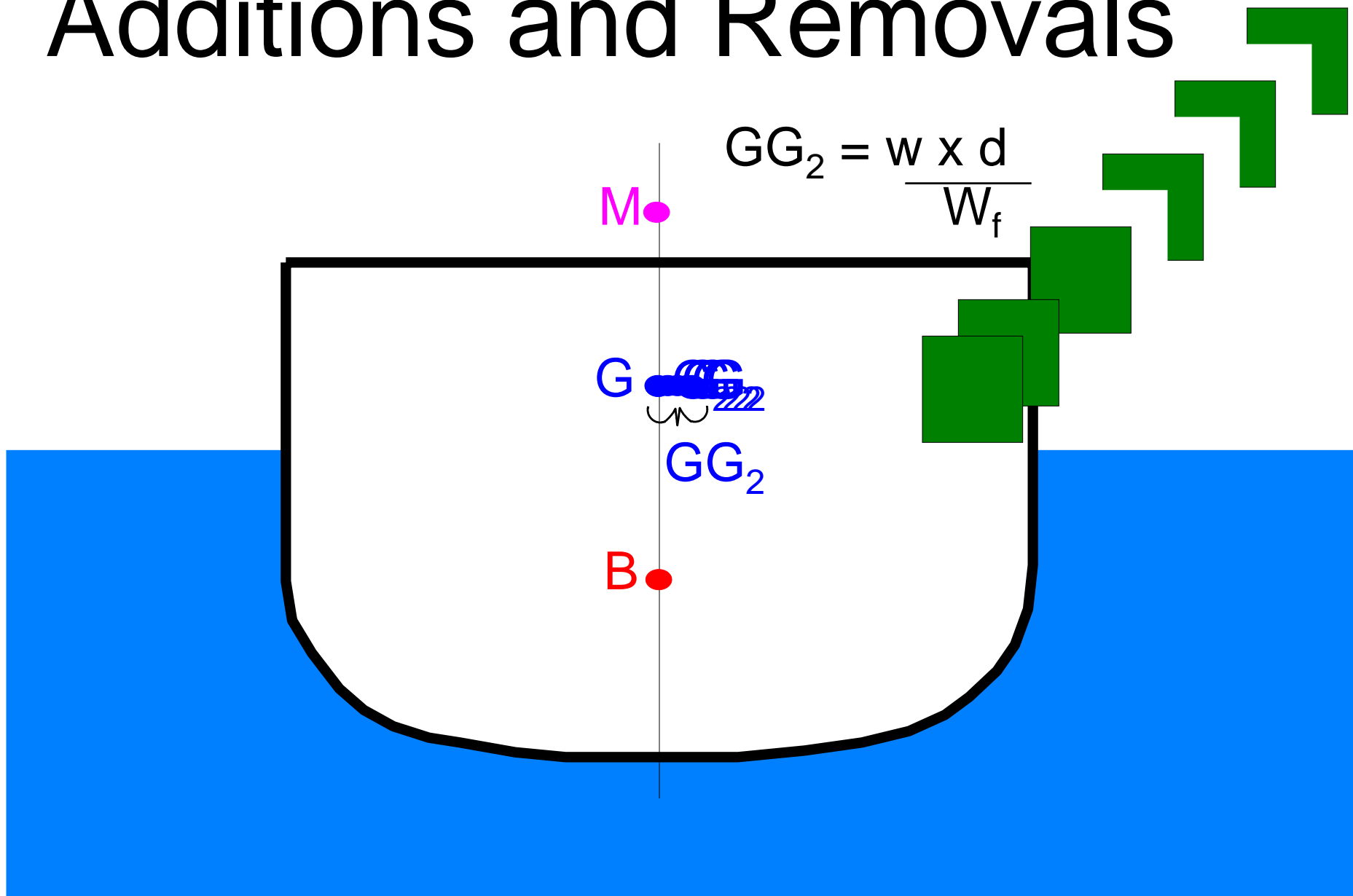
$$GG_2 = \frac{w \times d}{W_f}$$



# CLASS TOPICS

1. ~~Vertical Weight Shifts~~
2. ~~Vertical Weight Additions/Removals~~
3. ~~Sine Correction~~
4. ~~Horizontal Weight Shifts~~
5. Horizontal Weight Additions/Removals
6. Cosine Correction
7. Example Problem

# Horizontal Weight Additions and Removals



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

WHERE;

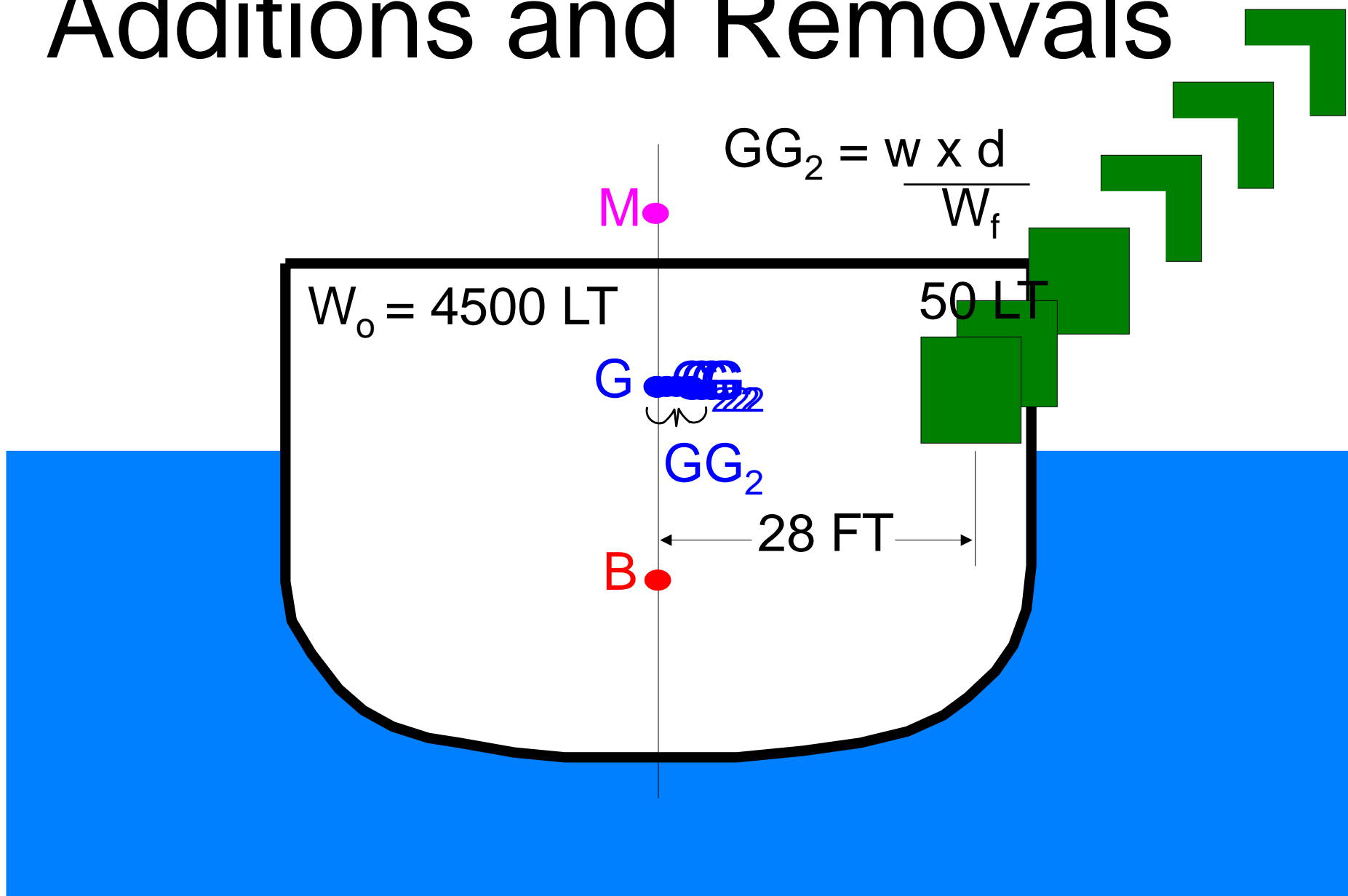
w = Weight Added or Removed

d = Distance Added/Removed  
from **Centerline**

$W_f$  = Final Displacement



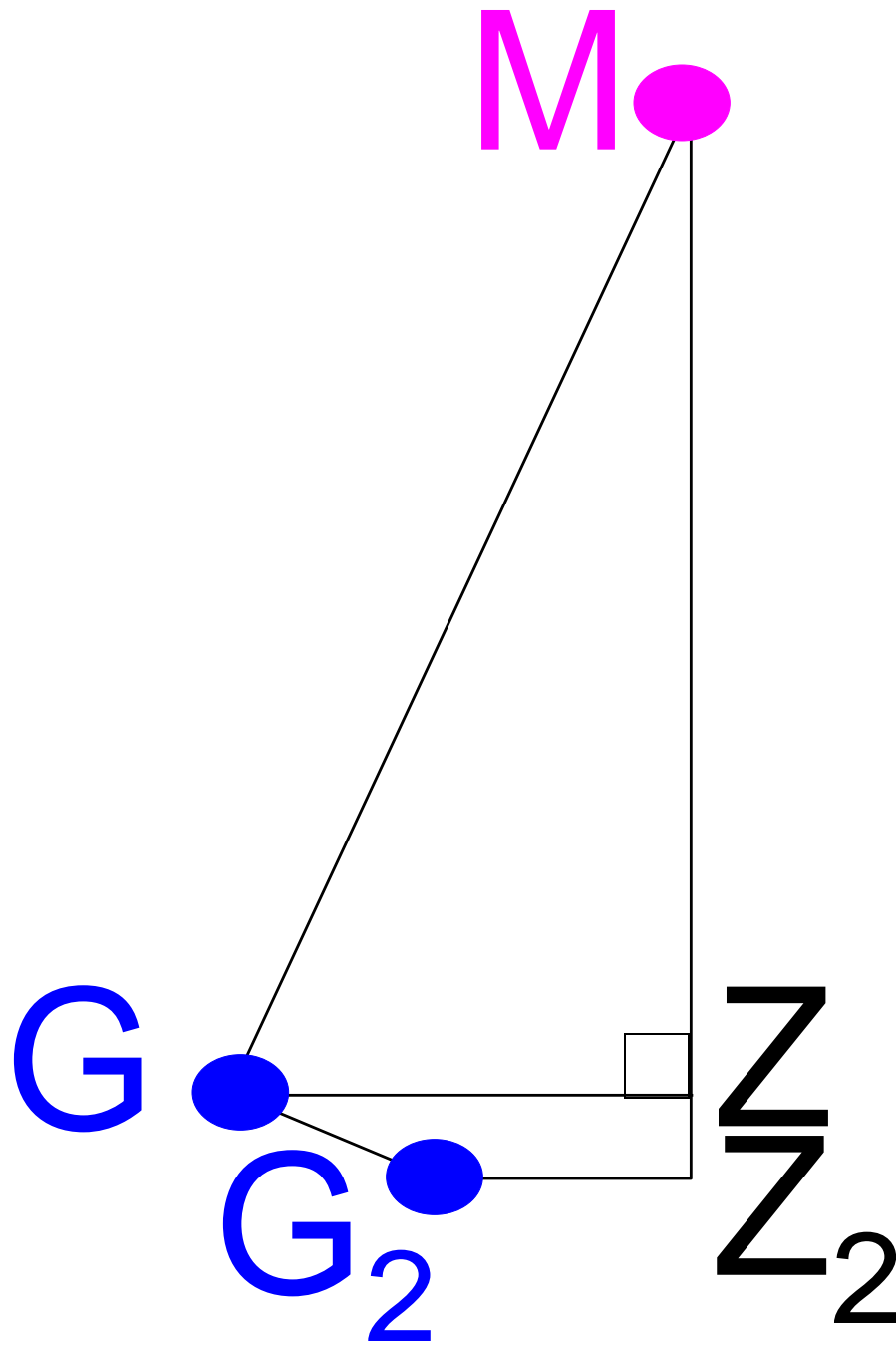
# Horizontal Weight Additions and Removals

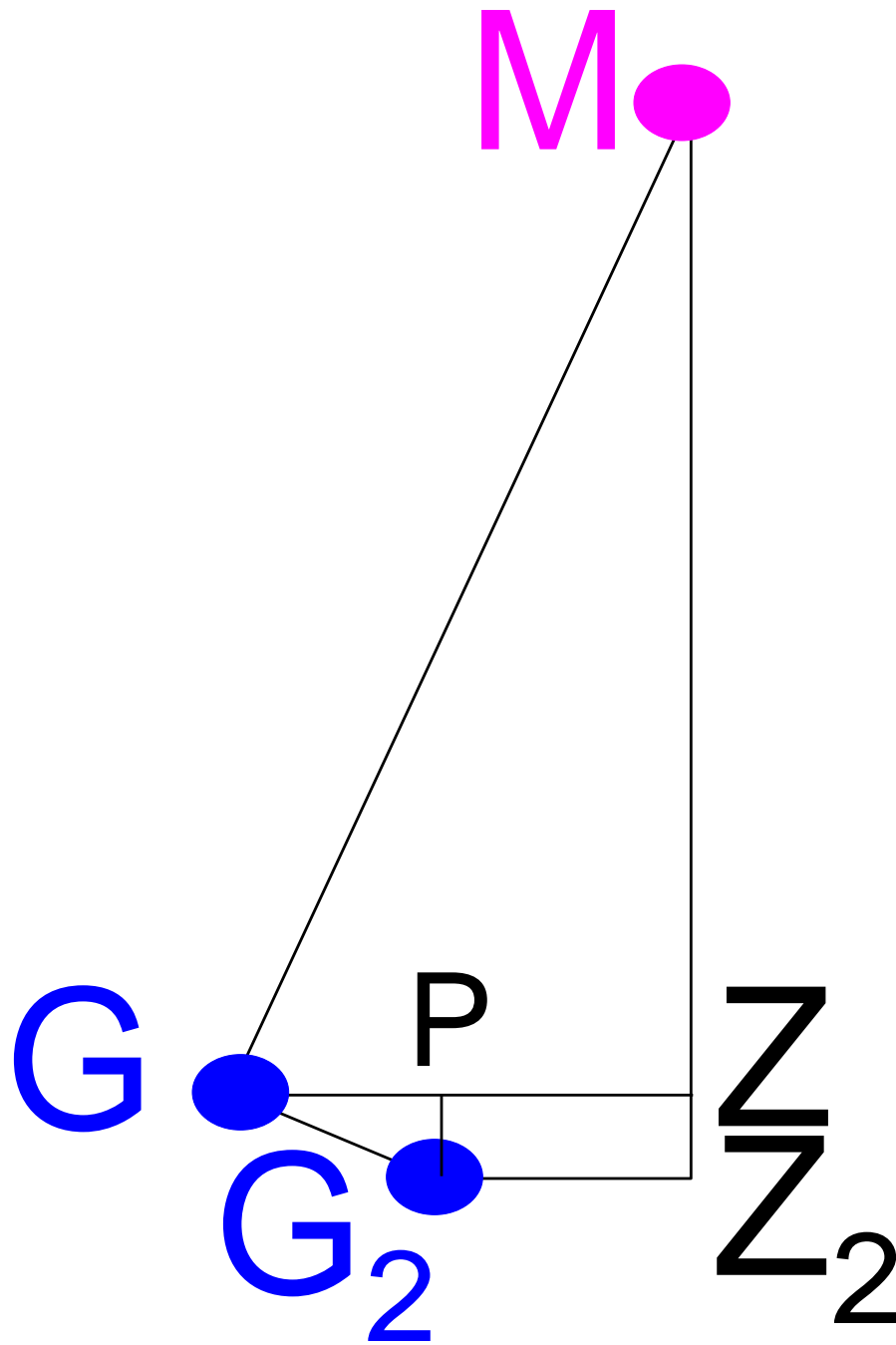


# CLASS TOPICS

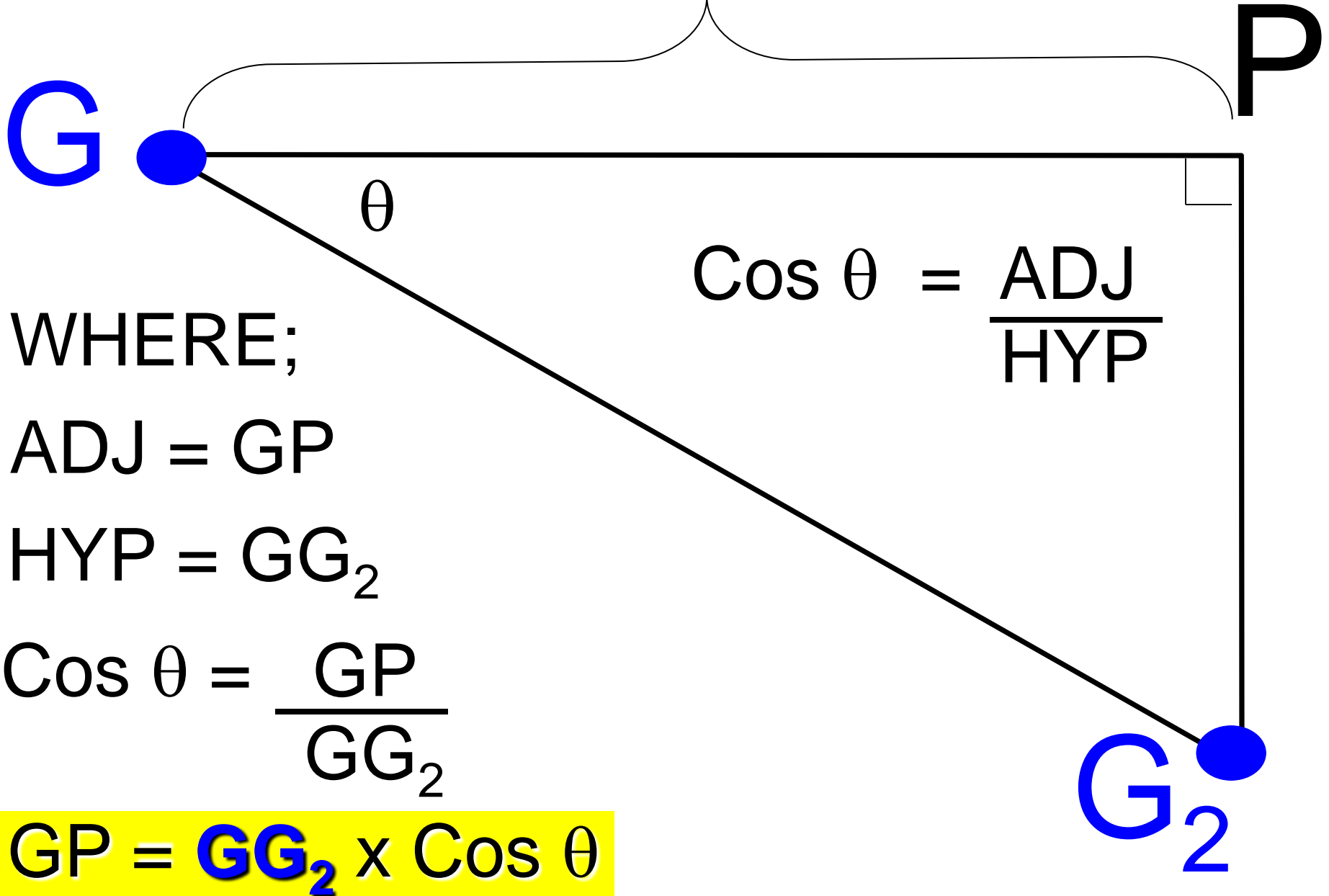
1. ~~Vertical Weight Shifts~~
2. ~~Vertical Weight Additions/Removals~~
3. ~~Sine Correction~~
4. ~~Horizontal Weight Shifts~~
5. ~~Horizontal Weight Additions/Removals~~
6. Cosine Correction
7. Example Problem







# REDUCTION IN RIGHTING ARM



WHERE;

$$\text{ADJ} = GP$$

$$\text{HYP} = GG_2$$

$$\text{Cos } \theta = \frac{GP}{GG_2}$$

$$\text{Cos } \theta = \frac{\text{ADJ}}{\text{HYP}}$$

$$GP = GG_2 \times \text{Cos } \theta$$

# **THINK TRANSVERSE DIRECTION ONLY!!!**

“COSINE correction is transverse  
(Port/Stbd) only... I use  $GG_2$  to find  
COSINE Correction”

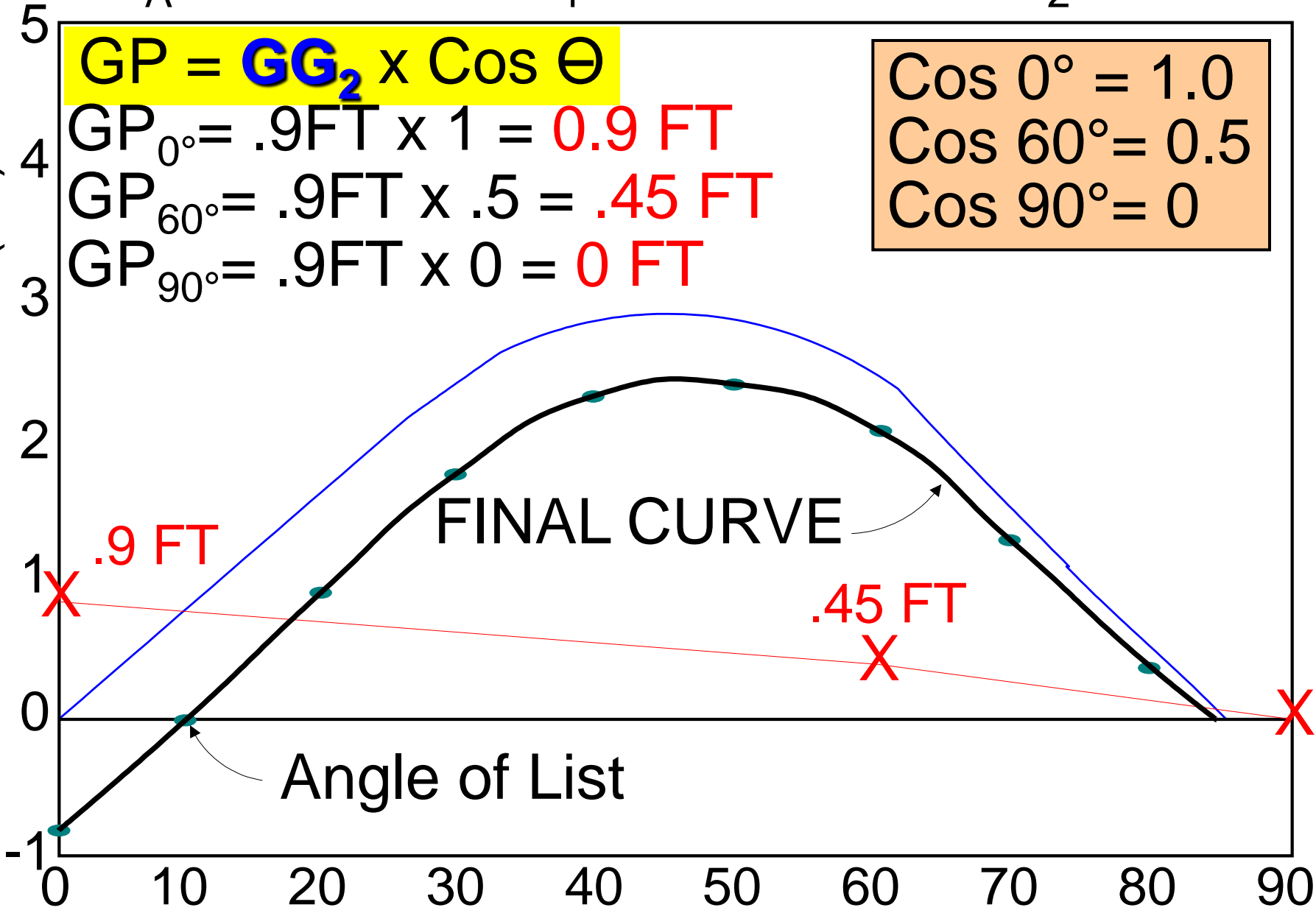
$KG_A = 19 \text{ FT}$     $KG_1 = 19.0 \text{ FT}$     $GG_2 = .9 \text{ FT}$

$GP = GG_2 \times \text{Cos } \Theta$

$\text{Cos } 0^\circ = 1.0$   
 $\text{Cos } 60^\circ = 0.5$   
 $\text{Cos } 90^\circ = 0$

$GP_{0^\circ} = .9\text{FT} \times 1 = 0.9 \text{ FT}$   
 $GP_{60^\circ} = .9\text{FT} \times .5 = .45 \text{ FT}$   
 $GP_{90^\circ} = .9\text{FT} \times 0 = 0 \text{ FT}$

RIGHTING ARMS (FT)

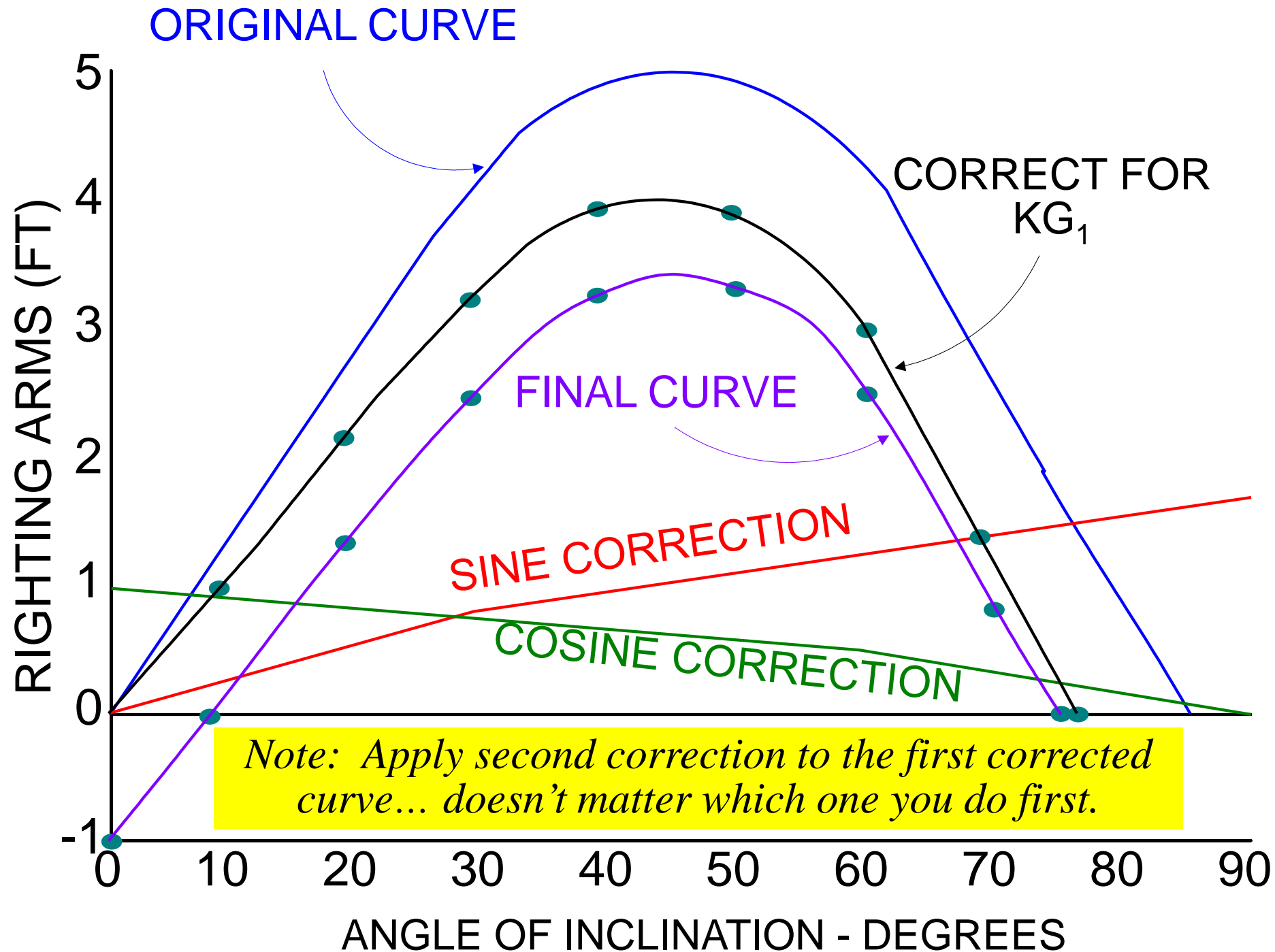


ANGLE OF INCLINATION - DEGREES



Ok... Lets see both corrections  
applied to the same curve...

i.e. The “**BIG PICTURE**”

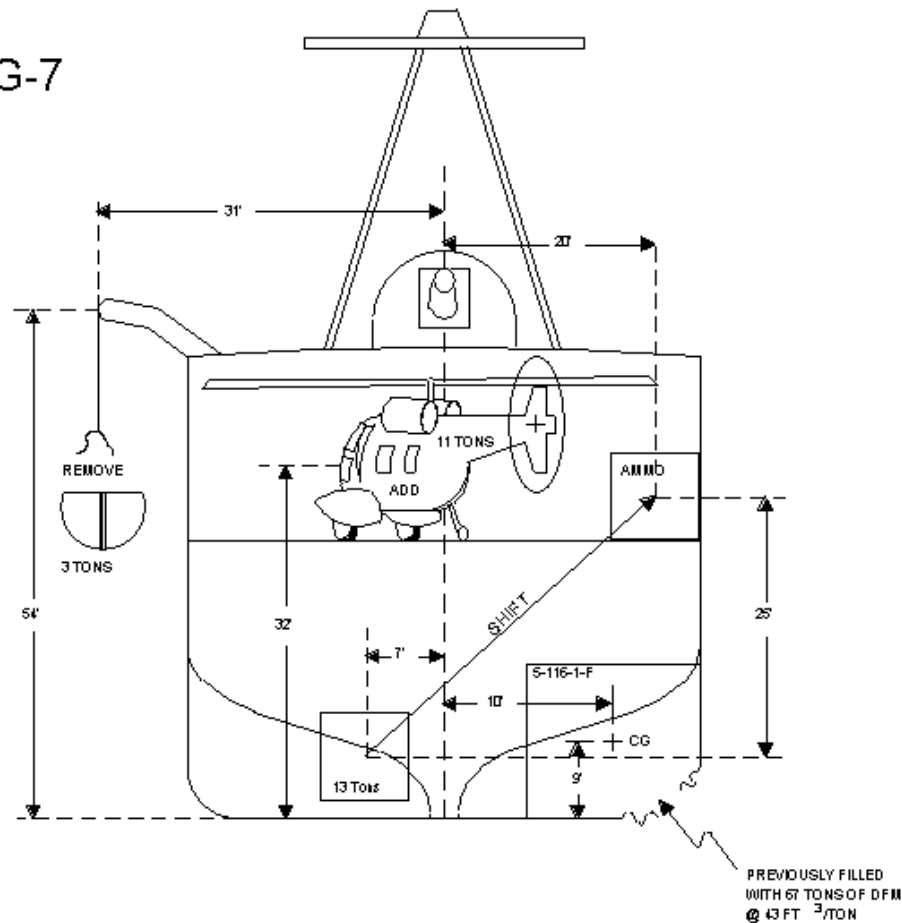


# CLASS TOPICS

1. ~~Vertical Weight Shifts~~
2. ~~Vertical Weight Additions/Removals~~
3. ~~Sine Correction~~
4. ~~Horizontal Weight Shifts~~
5. ~~Horizontal Weight Additions/Removals~~
6. ~~Cosine Correction~~
7. Example Problem

# EXAMPLE PROBLEM

FFG-7



**GIVEN:** Draft FWD: 14 FT 4 IN  
 AFT: 15 FT 7 IN  
 $KG_0$ : 19.2 FT  
 F/S<sub>TANKS</sub>: 0.36 FT

$$V = 67 \text{ LT} * 43 \text{ FT}^3/\text{LT}$$

$$V = 2881 \text{ FT}^3$$

**FIND:**  $W_F$   
 Sine Correction ( $GG_1$ )  
 Cosine Correction ( $GG_2$ )  
 Final Maximum Righting Arm  
 Angle of List

$$W_{H_2O} = 2881 \text{ FT}^3 / 35 \text{ FT}^3/\text{LT}$$

$$W_{H_2O} = 82.31 \text{ LT}$$

$$W_{\text{added}} = 82.31 \text{ LT} - 67 \text{ LT} = 15.31 \text{ LT}$$

## STABILITY DATA CALCULATION SHEET

| 1                                                                                    | 2            | 3                                | 4                             | 5                                       | 6                                                                                 | 7a                                    | 7b                                       | 8                                                                     | 9                                                                          | 10a                                        | 10b                                   |  |
|--------------------------------------------------------------------------------------|--------------|----------------------------------|-------------------------------|-----------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------|------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------|---------------------------------------|--|
| Description of Weight                                                                |              |                                  |                               |                                         |                                                                                   | Vertical Moment                       |                                          | Free Surface Effect<br>$\frac{B^3 \times L}{12 \times 35 \times W_F}$ | Free Communication Effect<br>$\frac{B \times L \times Y^2}{35 \times W_F}$ | Inclining Moment                           |                                       |  |
| Compartment Number or description of weight addition, shift, or removal.<br><b>2</b> |              |                                  |                               |                                         |                                                                                   | ADD<br>(w x kg)<br>or<br>column 4 x 5 | REMOVE<br>(w x kg)<br>or<br>column 4 x 5 |                                                                       |                                                                            | Starboard<br>(w x d)<br>or<br>column 4 x 6 | Port<br>(w x d)<br>or<br>column 4 x 6 |  |
|                                                                                      | P<br>S<br>CL | Liquid Volume<br>FT <sup>3</sup> | Weight LT<br>(+)<br>or<br>(-) | Height of weight above the keel (kg) ** | CL of ship to "G" of weight (d) ***                                               |                                       |                                          |                                                                       |                                                                            |                                            |                                       |  |
| HELICOPTER                                                                           | C/L          | /                                | + 11                          | 32                                      | 0                                                                                 | 352                                   | /                                        |                                                                       |                                                                            | /                                          | /                                     |  |
| BOAT                                                                                 | P            | /                                | - 3                           | 54                                      | 31                                                                                | /                                     | 162                                      |                                                                       |                                                                            | 93                                         | /                                     |  |
| AMMO                                                                                 | P→S          | /                                | 13                            | 25                                      | 27                                                                                | 325                                   | /                                        |                                                                       |                                                                            | 351                                        | /                                     |  |
| TANK                                                                                 | S            | 2881                             | + 15.31                       | 9                                       | 10                                                                                | 137.79                                | /                                        |                                                                       |                                                                            | 153.1                                      | /                                     |  |
| TOTALS                                                                               |              |                                  | + 23.31                       |                                         |                                                                                   | 814.79                                | 162                                      |                                                                       |                                                                            | 597.1                                      | 0                                     |  |
| NET                                                                                  |              |                                  | + 23.31                       | LT                                      |                                                                                   | + 652.79                              | FT-TONS                                  |                                                                       | FT                                                                         | 597.1                                      | STBD FT-TONS                          |  |
| <b>1</b> ORIGINAL CONDITIONS                                                         |              |                                  |                               |                                         | <b>3</b> FINAL CONDITIONS                                                         |                                       |                                          |                                                                       |                                                                            |                                            |                                       |  |
| Displacement ( $W_o$ ) <u>3650</u> LT                                                |              |                                  |                               |                                         | Final Displacement ( $W_F$ ) <u>3673.31</u> LT                                    |                                       |                                          | $KG_F = KG_1 + \text{virtual rise in "G"}$ <u>19.62</u> FT            |                                                                            |                                            |                                       |  |
| KG <sub>o</sub> ( uncorrected for Free Surface Ship's Tanks )<br><u>19.2</u> ** FT   |              |                                  |                               |                                         | Net Vertical Moment (NVM) <u>652.79</u> FT-TONS                                   |                                       |                                          | Sine Correction ( $GG_1$ ) = ( $KG_F - KG_A$ ) = <u>0.62</u> FT       |                                                                            |                                            |                                       |  |
| Free Surface Effect in Ship's Tanks<br><u>0.36</u> FT                                |              |                                  |                               |                                         | $KG_1 = \frac{(W_o \times KG_o) \pm (NVM)}{W_F} =$ <u>19.26</u> FT                |                                       |                                          | Net Inclining Moment (NIM) <u>597.1</u> FT-TONS                       |                                                                            |                                            |                                       |  |
| Assumed Center of Gravity ( $KG_A$ )<br><u>19.0</u> FT                               |              |                                  |                               |                                         | Total virtual rise in "G"<br>(columns 8+9 and F/S in ship's tanks) <u>0.36</u> FT |                                       |                                          | Cosine Correction ( $GG_2$ ) = $\frac{NIM}{W_F} =$ <u>0.16</u> FT     |                                                                            |                                            |                                       |  |

\*\*NOTE: If the weight is SHIFTED,  
Column 5 is the vertical distance shifted  
Column 6 is the transverse distance shifted

This is what you plot...

# Review of Enabling Objectives

- Describe movement of reference points.
- Describe impact of addition, removal and shift of weight on stability.
- Calculate  $KG_1$  and  $GG_2$ .
- Calculate Sine and Cosine corrections.
- Apply corrections to Static Stability Curve.

# Quiz...

- If we have a weight addition ( $w$ ) the notation in the  $KG_1$  equation is...?
  - **ANS: +**
- What are the **SINE** values for  $0^\circ$ ,  $30^\circ$  and  $90^\circ$  degrees?
  - **ANS:  $0^\circ = 0$ ,  $30^\circ = 0.5$ ,  $90^\circ = 1$**
- What are the **COSINE** values for  $0^\circ$ ,  $60^\circ$  and  $90^\circ$  degrees?
  - **ANS:  $0^\circ = 1$ ,  $60^\circ = 0.5$ ,  $90^\circ = 0$**



# Instructor will now...

- Assign Homework for lesson 4.2  
(Stability Problems #1, #2, #3)
- **Read Student Guide!!**