

# Arch 314- Structures I

Recitation 006



Vishakha Bagarao

20th Sept 2024

# Contents

- *General Instructions*
- *Quick Recap*
  - *Equilibrium of Rigid Bodies*
    - *Problem Set 04*
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## General Instructions:

- I won't be able to take the 6th-week recitation, So I'll divide the groups and email the list.

|        |                                       |   |                         |
|--------|---------------------------------------|---|-------------------------|
| SEP 30 | <i>Building Big – Bridges</i> (video) |   |                         |
| OCT 2  | Plane Trusses (by Sections)           | Ch. 3.3: pp. 128-152                      |                         |
| OCT 4  | Recitation                            | <b>(interim bridge report due - 10.4)</b> |                         |
|        | <b>Topic Quiz 6</b>                   |   | 7. Truss Systems (10.6) |

- Notes will be uploaded asap, after recitation on website.
- Office hours: Wednesday 12-2 pm (except October 3rd). If you miss recitation, sign up to avoid losing recitation lab points.
- Reminder: Course evaluation is based on the points you collect.

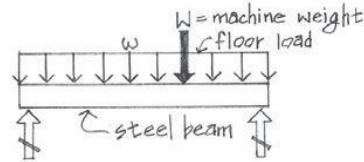
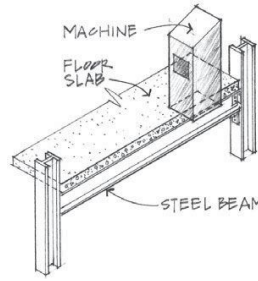
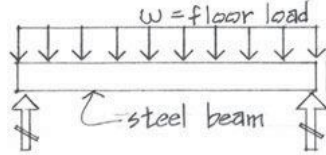
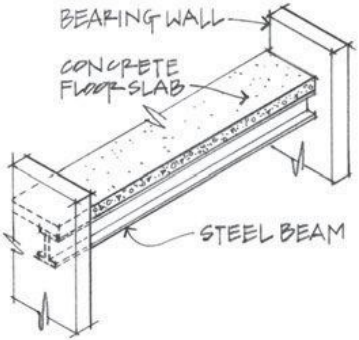
|  |             |
|--|-------------|
| 24 lecture quizzes, 10pts each         | 240         |
| 14 topic quizzes, 20pts each           | 280         |
| 14 homework problems, 5 pts / question | 805         |
| bridge testing project                 | 250         |
| 12 recitation labs, 20 pts each        | 240         |
| <b>TOTAL</b>                           | <b>1815</b> |

# Equilibrium of Rigid Body:

## Types of Loads

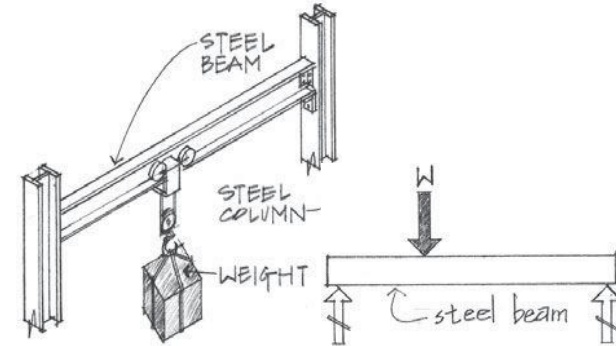
### Distributed loads

Scattered on a relatively large area—too large to be considered as a point load.



### Point or concentrated loads

Point or concentrated loads have a specific point of application..



## Problem Set 04: Formulas:

- Total force from distributed load: (units: KIPS)

$W1 = \text{Force } w1 \times \text{Distance on which } w1 \text{ is acting}$

- Distance of total load  $W1$  from left reaction: (units: FT)

$$d1 = A + B/2$$

- Total applied downward force: (units: KIPS)

$$\Sigma f (\downarrow) = P1 + W1 + P2$$

- Left End Reaction ( $R1$ )

- Right End Reaction ( $R2$ )

$$\Sigma M = 0 = \Sigma \text{loads} \times \text{distance}$$

$$\Sigma Fy = \text{Total applied Downward forces} + R1 + R2 = 0$$

Example:

**M MICHIGAN Architecture** Structures Problems

Contact Schedule Lectures Recitation Bridges1 Bridges2 Problems

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### 4. Parallel Force Systems

Sum the moments about each end of the beam to determine the end reactions of the parallel force system shown. Check that the sum of vertical forces is zero.

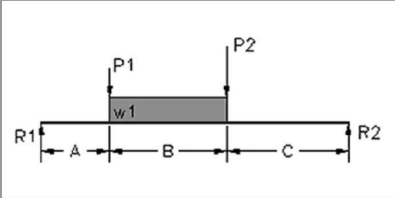


Diagram description: A horizontal beam of length 10 FT is supported by a pin at the left end (R1) and a roller at the right end (R2). A distributed load w1 is applied over a 7 FT segment starting from the left end. Two point loads, P1 and P2, are applied vertically downwards. P1 is located at distance A from the left end. P2 is located at distance A + B from the left end. The distance from the right end of the distributed load to P2 is C.

DATASET: 2 -1- -3-

|            |          |
|------------|----------|
| Distance A | 10 FT    |
| Distance B | 7 FT     |
| Distance C | 6 FT     |
| Force P1   | 5 KIPS   |
| Force P2   | 5 KIPS   |
| Force w1   | 0.76 KLF |

| # | Question                                     | Your Response | Correct Answer | Score |
|---|--|---------------|----------------|-------|
| 1 | Total force from distributed load: W1        | 5.32 KIPS     | 5.32 KIPS      | 5     |
| 2 | Distance of total load W1 from left reaction | 13.5 FT       | 13.5 FT        | 5     |
| 3 | Total applied downward force                 | 15.32 KIPS    | 15.32 KIPS     | 5     |
| 4 | Left End Reaction (R1)                       | 6.3806 KIPS   | 6.32783 KIPS   | 5     |
| 5 | Right End Reaction (R2)                      | 8.9394 KIPS   | 8.99217 KIPS   | 5     |

Current Score: 25 / 25

[Problem Menu](#) [Logout](#)

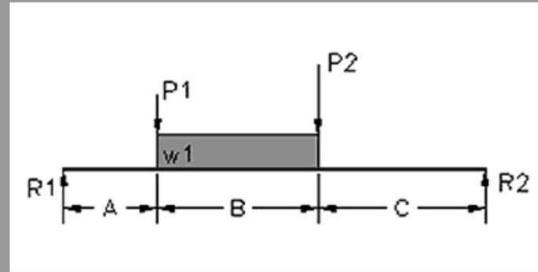
# Problem Set 04

Contact Schedule Lectures Recitation Bridges1 Bridges2 Problems

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## 4. Parallel Force Systems

Sum the moments about each end of the beam to determine the end reactions of the parallel force system shown. Check that the sum of vertical forces is zero.



|            |          |     |
|------------|----------|-----|
| DATASET: 2 | -1-      | -3- |
| Distance A | 10 FT    |     |
| Distance B | 7 FT     |     |
| Distance C | 6 FT     |     |
| Force P1   | 5 KIPS   |     |
| Force P2   | 5 KIPS   |     |
| Force w1   | 0.76 KLF |     |

| # | Question                                     | Your Response | Correct Answer | Score |
|---|--|---------------|----------------|-------|
| 1 | Total force from distributed load: W1        | 5.32 KIPS     | 5.32 KIPS      | 5     |
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Current Score: 25 / 25

Problem Menu

Date: / /

# Given Data:

distance A = 10'

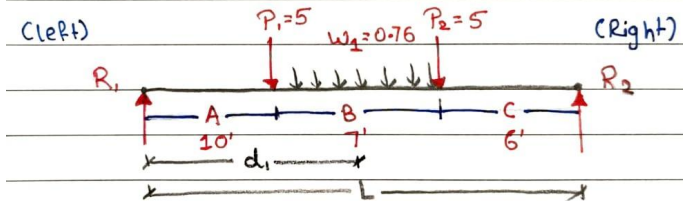
distance B = 7'

distance C = 6'

Force P1 = 5 KIPS

Force P2 = 5 KIPS

Force w1 = 0.76 KLF.



# Questions:

1. Total force from distributed load: W1

$$W_1 = \text{Force } w_1 \times \text{distance } B$$

[distance on which w1 is acting]

$$\therefore W_1 = 0.76 \times 7'$$

$$\therefore W_1 = 5.32 \text{ KIPS}$$

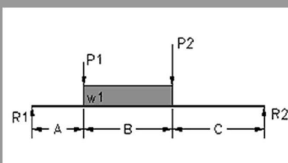
# Problem Set 04

Contact Schedule Lectures Recitation Bridges1 Bridges2 Problems

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### 4. Parallel Force Systems

Sum the moments about each end of the beam to determine the end reactions of the parallel force system shown. Check that the sum of vertical forces is zero.



DATASET: 2    -1-    -3-  
 Distance A: 10 FT  
 Distance B: 7 FT  
 Distance C: 6 FT  
 Force P1: 5 KIPS  
 Force P2: 5 KIPS  
 Force w1: 0.76 KLF

| # | Question                                     | Your Response | Correct Answer | Score |
|---|--|---------------|----------------|-------|
| 1 | Total force from distributed load: W1        | 5.32 KIPS     | 5.32 KIPS      | 5     |
| 2 | Distance of total load W1 from left reaction | 13.5 FT       | 13.5 FT        | 5     |
| 3 | Total applied downward force                 | 15.32 KIPS    | 15.32 KIPS     | 5     |
| 4 | Left End Reaction (R1)                       | 6.3806 KIPS   | 6.32783 KIPS   | 5     |
| 5 | Right End Reaction (R2)                      | 8.9394 KIPS   | 8.99217 KIPS   | 5     |

Current Score: 25 / 25

Problem Menu    Logout

2. Distance of total load  $W_1$  from left reaction.

$$d_1 = A + B/2$$

$$= 10' + 7/2$$

$$\therefore d_1 = 13.5'$$

3. Total applied downward force

$$F_{C\downarrow} = P_1 + W_1 + P_2$$

$$= 5 + 5.32 + 5$$

$$\therefore F_{C\downarrow} = 15.32 \text{ kips } (\downarrow)$$

# End reactions: ( $R_1$  &  $R_2$ ):

$$\sum M_{R_1} = 0$$

$$0 = P_1 \times A + W_1 \times d_1 + P_2 \times (A+B) - R_2 \times (L)$$

$$0 = 5(10) + 5.32(13.5) + 5(17) - R_2(23)$$

$$0 = 50 + 70.605 + 85 - 23R_2$$

$$0 = 205.605 - 23R_2$$

$$\therefore R_2 = \frac{205.605}{23} = 8.9394 \text{ KIPS. } (\uparrow)$$

23

$$\therefore R_2 = 8.9394 \text{ KIPS } (\uparrow)$$

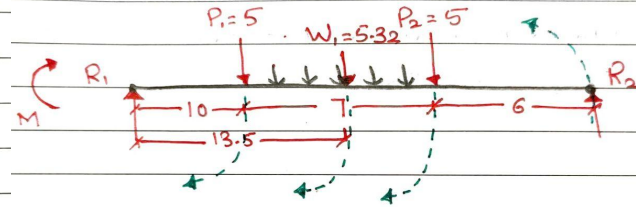
(Right end reaction).

# To find  $R_1$ ,

$$\sum F_y = -F_{C\downarrow} + R_1 + R_2$$

$$0 = -15.32 + R_1 + 8.9394$$

$$\therefore R_1 = 6.3806 \text{ KIPS } (\uparrow)$$



# Problem Set 05: Formulas:

- Total force of the Uniform load: (units: KIPS)

$$W1 = \text{Force } w1 \times \text{Distance on which } w1 \text{ is acting}$$

- Distance from centroid of uniform load to R2: (units: FT)

$$L1 = (A+B) / 2$$

- Total force of the Triangular load: (units: KIPS)

$$W2 = (\text{Force } w2 \times \text{Distance on which } w2 \text{ is acting}) / 2$$

- Distance from centroid of triangular load to R2: (units: FT)

$$L2 = (B) / 3$$

- Total load on the member: (units: KIPS)

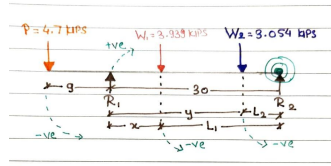
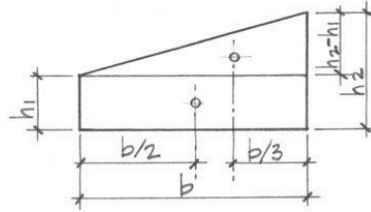
$$\Sigma f (\downarrow) = P + W1 + W2$$

- Reaction force (R1)

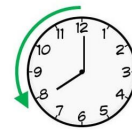
- Reaction force (R2)

$$\Sigma M = 0 = \Sigma \text{loads} \times \text{distance}$$

$$\Sigma Fy = -\text{Total load} + R1 + R2 = 0$$



Clockwise



Anti-Clockwise

## Example:

M
MICHIGAN  
Architecture
Problems

Contact Schedule Lectures Recitation Bridges1 Bridges2 Problems

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### 5. Equilibrium of Rigid Bodies

Determine the support reactions at A and B that will hold the beam in equilibrium.

**DATASET: 1** ←2- -3→

|                     |           |
|---------------------|-----------|
| Point Load, P       | 4.7 KIPS  |
| Uniform Load, w1    | 101 PLF   |
| Triangular Load, w2 | 203.6 PLF |
| Length A            | 9 FT      |
| Length B            | 30 FT     |

| # | Question  | Your Response | Correct Answer | Score |
|---|---|---------------|----------------|-------|
| 1 | TOTAL force of the uniform load: W1                       | 3.939 KIPS    | 3.939 KIPS     | 5     |
| 2 | Distance from centroid of the uniform load to R2: (L1)    | 19.5 FT       | 19.5 FT        | 5     |
| 3 | TOTAL force of the triangular load: W2                    | 3.054 KIPS    | 3.054 KIPS     | 5     |
| 4 | Distance from centroid of the triangular load to R2: (L2) | 10 FT         | 10 FT          | 5     |
| 5 | TOTAL load on the member                                  | 11.693 KIPS   | 11.693 KIPS    | 5     |
| 6 | Reaction force: R1 (down is - : up is +)                  | 9.68835 KIPS  | 9.68835 KIPS   | 5     |
| 7 | Reaction force: R2 (down is - : up is +)                  | 2.00465 KIPS  | 2.00465 KIPS   | 5     |

Current Score: 35 / 35

Problem Menu  
Logout

# Problem Set 05

Contact Schedule Lectures Recitation Bridges1 Bridges2 Problems

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## 5. Equilibrium of Rigid Bodies

Determine the support reactions at A and B that will hold the beam in equilibrium.

DATASET: 1

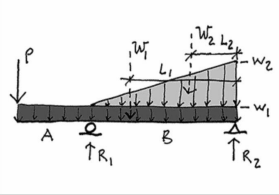
Point Load, P: 4.7 KIPS

Uniform Load, w1: 101 PLF

Triangular Load, w2: 203.6 PLF

Length A: 9 FT

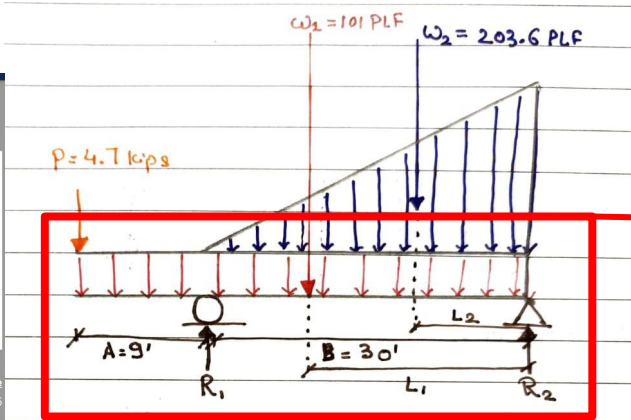
Length B: 30 FT



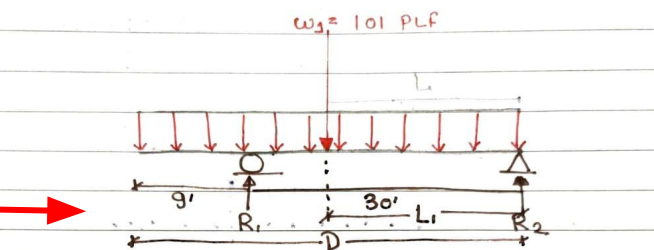
| # | Question  | Your Response | Correct Answer | Score |
|---|---|---------------|----------------|-------|
| 1 | TOTAL force of the uniform load: W1                       | 3.939 KIPS    | 3.939 KIPS     | 5     |
| 2 | Distance from centroid of the uniform load to R2: (L1)    | 19.5 FT       | 19.5 FT        | 5     |
| 3 | TOTAL force of the triangular load: W2                    | 3.054 KIPS    | 3.054 KIPS     | 5     |
| 4 | Distance from centroid of the triangular load to R2: (L2) | 10 FT         | 10 FT          | 5     |
| 5 | TOTAL load on the member                                  | 11.693 KIPS   | 11.693 KIPS    | 5     |
| 6 | Reaction force: R1 (down is -; up is +)                   | 9.68835 KIPS  | 9.68835 KIPS   | 5     |
| 7 | Reaction force: R2 (down is -; up is +)                   | 2.00465 KIPS  | 2.00465 KIPS   | 5     |

Current Score: 35 / 35

Problem Menu Logout



$w_3 = 101 \text{ PLF}$



# Questions:

- Total force of the uniform load:  $W_1$

$$W_1 = w_1 \times D$$

$$= 101 \times (9 + 30) = 101 \times 39$$

$$\therefore W_1 = 3939 \text{ \#}$$

(Units:  $w_1 \rightarrow \frac{\text{pounds}}{\text{ft}}$ ,  $D \rightarrow \text{ft}$  :  $\frac{\#}{\text{ft}} \times \text{ft} = \#$ )

Convert pounds to kips: 1 kip = 1000 lbs.

$$W_1 = 3939 \text{ \#} \times \frac{1 \text{ kips}}{1000 \text{ \#}} = 3.939 \text{ kips}$$

- Distance from centroid of the  $w_1$  to  $R_2$ :  $L_1$

$$L_1 = \frac{D}{2} = \frac{39}{2} = 19.5 \text{ ft}$$

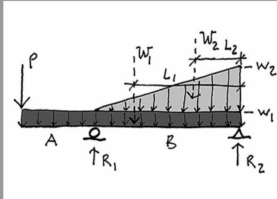
# Problem Set 05

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## 5. Equilibrium of Rigid Bodies

Determine the support reactions at A and B that will hold the beam in equilibrium.

DATASET: 1  
 Point Load, P 4.7 KIPS  
 Uniform Load, w1 101 PLF  
 Triangular Load, w2 203.6 PLF  
 Length A 9 FT  
 Length B 30 FT

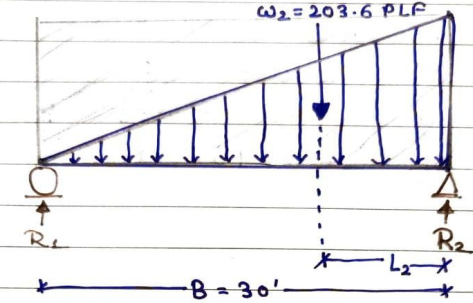
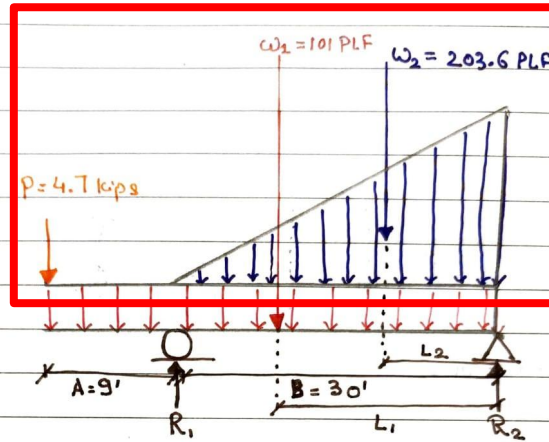


| # | Question  | Your Response | Correct Answer | Score |
|---|---|---------------|----------------|-------|
| 1 | TOTAL force of the uniform load: W1                       | 3.939 KIPS    | 3.939 KIPS     | 6     |
| 2 | Distance from centroid of the uniform load to R2: (L1)    | 19.5 FT       | 19.5 FT        | 6     |
| 3 | TOTAL force of the triangular load: W2                    | 3.054 KIPS    | 3.054 KIPS     | 6     |
| 4 | Distance from centroid of the triangular load to R2: (L2) | 10 FT         | 10 FT          | 6     |
| 5 | TOTAL load on the member                                  | 11.693 KIPS   | 11.693 KIPS    | 6     |
| 6 | Reaction force: R1 (down is - : up is +)                  | 9.68835 KIPS  | 9.68835 KIPS   | 6     |
| 7 | Reaction force: R2 (down is - : up is +)                  | 2.00465 KIPS  | 2.00465 KIPS   | 6     |

Current Score: 35 / 35

Problem Menu

Logout



3. Total Force of the triangular load:  $W_2$

$$W_2 = \frac{w_2 \times B}{2}$$

$$= \frac{203.6 \times 30}{2}$$

$$= 3054 \# \approx \frac{3054 \#}{1000}$$

$$= 3054 \# \times \frac{1 \text{ kips}}{1000 \#}$$

$$\therefore W_2 = 3.054 \text{ KIPS}$$

Given data:

Point load, P : 4.7 KIPS

Uniform load, w1 : 101 PLF

Triangular Load, w2 : 203.6 PLF

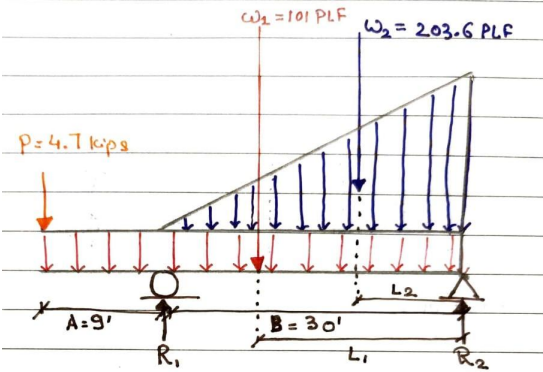
Length A : 9 ft

Length B : 30 ft.

4. Distance from centroid of the triangular load to R2:  $L_2$  ( $\frac{1}{3}$ rd of the base)

$$\therefore L_2 = 30 \times \frac{1}{3} = 10 \text{ ft}$$

# Problem Set 05

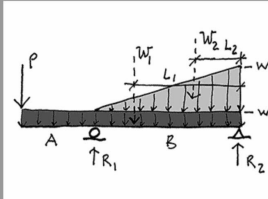


## 5. Equilibrium of Rigid Bodies

Determine the support reactions at A and B that will hold the beam in equilibrium.

DATASET: 1

|                     |           |
|---------------------|-----------|
| Point Load, P       | 4.7 KIPS  |
| Uniform Load, w1    | 101 PLF   |
| Triangular Load, w2 | 203.6 PLF |
| Length A            | 9 FT      |
| Length B            | 30 FT     |

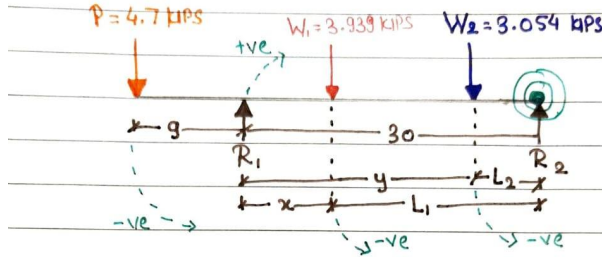


| # | Question  | Your Response | Correct Answer | Score |
|---|---|---------------|----------------|-------|
| 1 | TOTAL force of the uniform load: W1                       | 3.939 KIPS    | 3.939 KIPS     | 5     |
| 2 | Distance from centroid of the uniform load to R2: (L1)    | 19.5 FT       | 19.5 FT        | 5     |
| 3 | TOTAL force of the triangular load: W2                    | 3.054 KIPS    | 3.054 KIPS     | 5     |
| 4 | Distance from centroid of the triangular load to R2: (L2) | 10 FT         | 10 FT          | 5     |
| 5 | TOTAL load on the member                                  | 11.693 KIPS   | 11.693 KIPS    | 5     |
| 6 | Reaction force: R1 (down is -; up is +)                   | 9.68835 KIPS  | 9.68835 KIPS   | 5     |
| 7 | Reaction force: R2 (down is -; up is +)                   | 2.00465 KIPS  | 2.00465 KIPS   | 5     |

Current Score: 35 / 35

Problem Menu

Logout



5. Total load on the member:

$$\sum F(\downarrow) = P + W_1 + W_2$$

$$= 4.7 + 3.939 + 3.054$$

$$\therefore \sum F(\downarrow) = 11.693 \text{ KIPS}$$

6. Reaction Force: R1

$$\sum M @ R_2 = -(4.7 \times 39) + (R_1 \times 30) - (3.939 \times 19.5) - (3.054 \times 10)$$

$$0 = 30R_1 - 290.6505$$

$$\therefore R_1 = \frac{290.6505}{30}$$

$$\therefore R_1 = 9.68835 \text{ KIPS}$$

7. Reaction Force: R2

$$\sum F_y = -\sum F(\downarrow) + R_1 + R_2$$

$$0 = -11.693 + 9.68835 + R_2$$

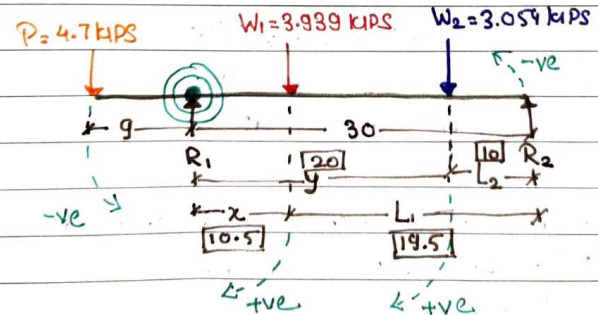
$$\therefore R_2 = 2.00465 \text{ KIPS}$$

OR

$$\sum M @ R_1 = (-4.7 \times 9) + (3.939 \times 10.5) + (3.054 \times 20) - (30 \times R_2)$$

$$= 60.1395 - 30R_2$$

$$\therefore R_2 = 2.00465 \text{ KIPS}$$



# Recitation- Lab 03

Arch 314

Name 2 \_\_\_\_\_

Name 3 \_\_\_\_\_

## Equilibrium

### Description

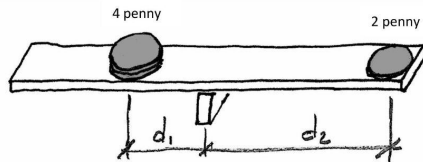
This project provides opportunity to experiment with the equilibrium of a balanced beam. It makes use of Archimedes' equations for forces on a lever to determine end reactions.

### Goals

- To observe balanced conditions using a beam balance.
- To experiment with different combinations of balanced forces
- To calculate the balanced forces using Archimedes' method

### Procedure

1. Set up the beam balance with the fulcrum block at the center balance point.
2. Place 2 penny weights at one end. Use the ruled scale at the bottom of this page to measure the distance from the fulcrum to the center of the stack of pennies ( $d_2$ ). You can adjust the pennies to an even distance.
3. Calculate a point on the opposite side of the balance ( $d_1$ ) where 4 pennies will balance the 2 using Archimedes' equation.  $d_2 \times 2 = d_1 \times 4$  so,  $d_1 = d_2 \times 2/4$
4. Place 4 pennies at your calculated distance  $d_1$  and verify that they balance the 2 pennies.
5. Calculate the moment caused by each stack of pennies around the fulcrum (in US pennyweight-inches).
6. Now, leaving the 2 penny stack at one end, spread the 4 pennies out next to each other and again find the balance point.
7. Observe that the center of the line of pennies still lies at  $d_1$  when the beam is balanced.
8. Finally, for the inverted case (point load on a simple beam) with  $P = 6$  pwt at 2" from one end of the 12" beam, what would each end reaction be. Show this in a sketch.



Due

During recitation



## Archimedes Lever

Two forces will balance at distances reciprocally proportional to their magnitudes.

$$F_1 \times a = F_2 \times b$$

$$F_1 = F_2 \frac{b}{a}$$

