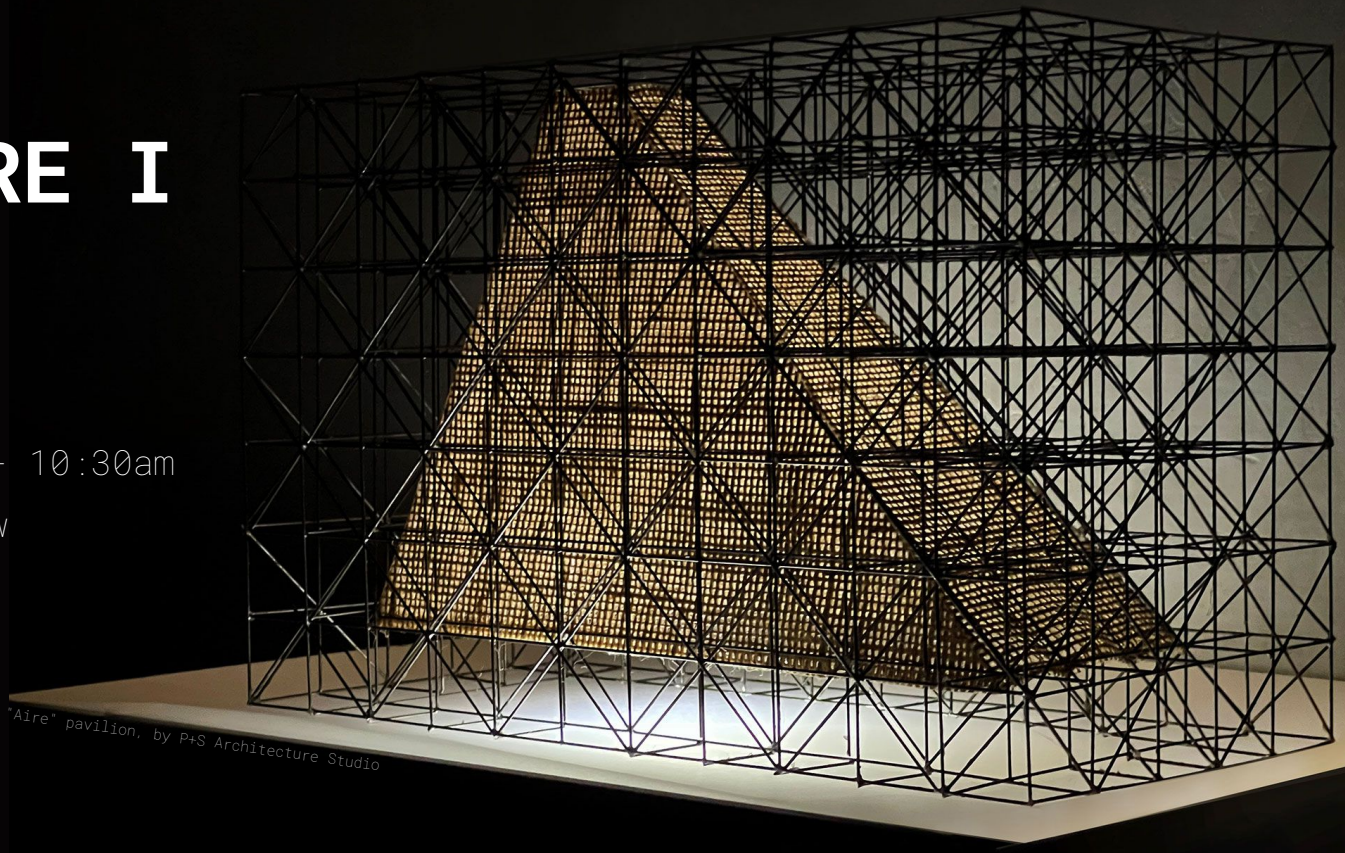
STRUCTURE I

ARCH-314

Friday(s): 9:30am - 10:30am

East Review



Today:

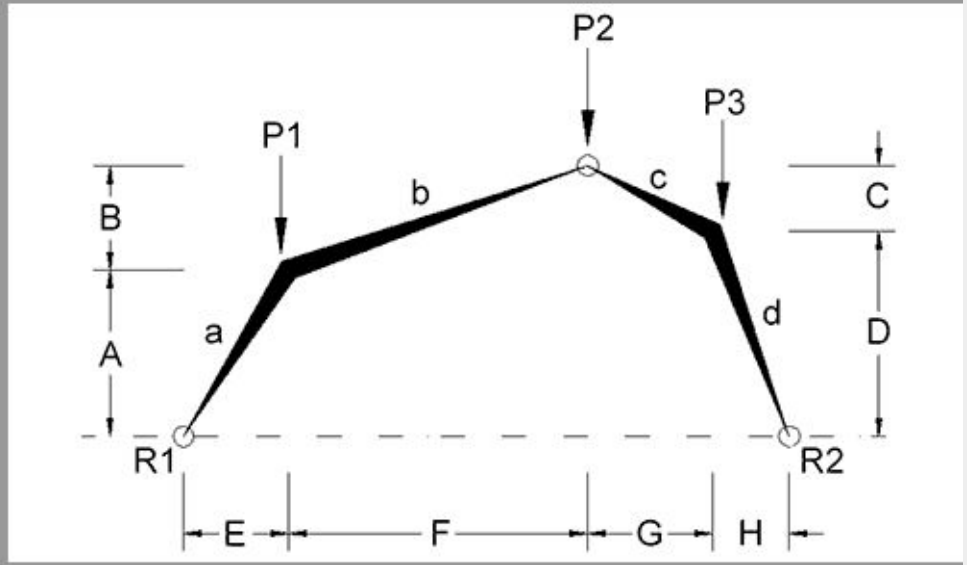
- Lab 05:Graphic Statics
- Problem No.8: 3 Hinged Arches

PROBLEM NO.8

For the three-hinged arch shown, determine horizontal and vertical components of each reaction, and the moments at the knees.

DATASET: 1 -2- -3-

Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS



PROBLEM NO.7

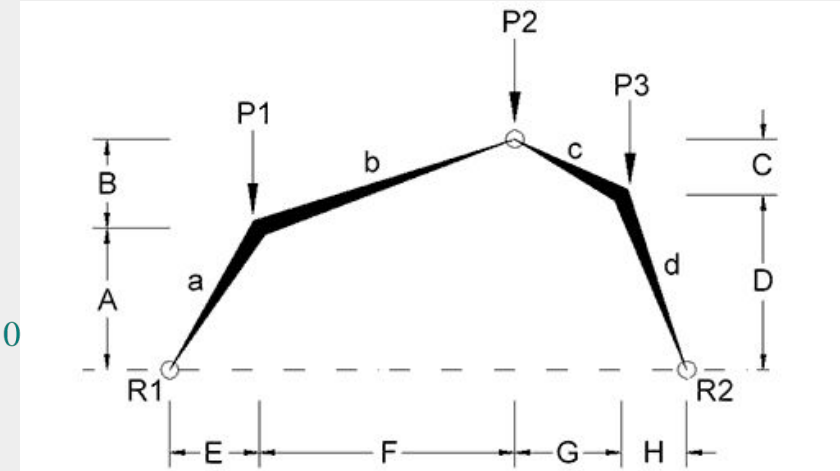
Question 4: **VERTICAL component of R2 (+ = upward)**

$$\sum_{M_{R1}} = 0$$

$$P_1 \times E + P_2 \times (E+F) + P_3 \times (E+F+G) - R_{2Y} \times (E+F+G+H) = 0$$

$$14 \times 9 + 250 \times 17 \times 18 + 7 \times 40 - R_{2Y} \times (44) = 0$$

$$R_{2Y} = 16.18 \; KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

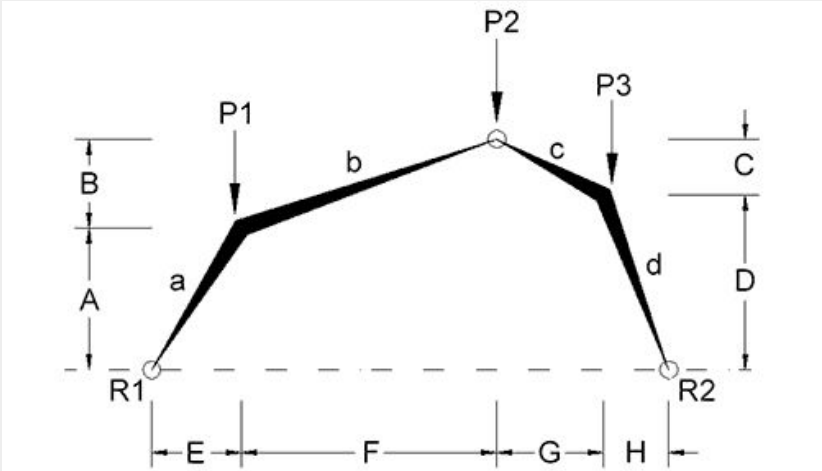
Question 2: **VERTICAL component of R1 (+ = upward)**

$$\sum_{F_Y} = 0$$

$$R_{1Y} - P_1 - P_2 - P_3 + R_{2Y} = 0$$

$$R_{1Y} - 14 - 17 - 7 + 16.18 = 0$$

$$R_{1Y} = 21.82\ KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

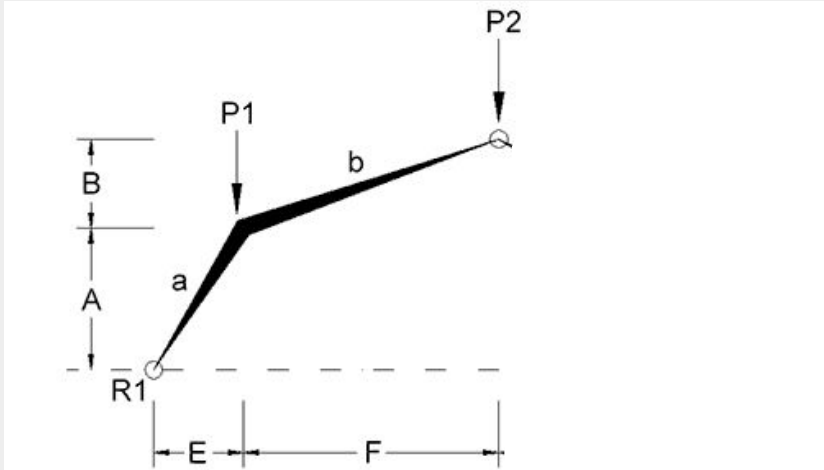
Question 1: **HORIZONTAL component of R1 (+ = to the right)**

$$\sum_{M_{P2}} = 0$$

$$R_{1Y} \times (E + F) - R_{1X} \times (A + B) - P_1 \times E = 0$$

$$21.82 \times 18 + R_{1X} \times 22 \times 14 + 7 \times 40 - R_{2Y} \times 9 = 0$$

$$R_{1X} = 12.12\ KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

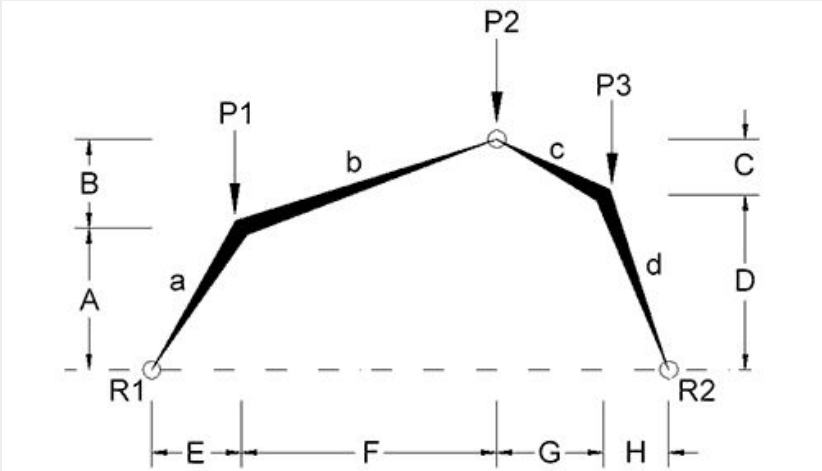
Question 3: **HORIZONTAL component of R2 (+ = to the right)**

$$\sum_{F_H} = 0$$

$$R_{1X} + R_{2X} = 0$$

$$R_{1X} = -R_{2X}$$

$$R_{2X} = -12.12\ KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

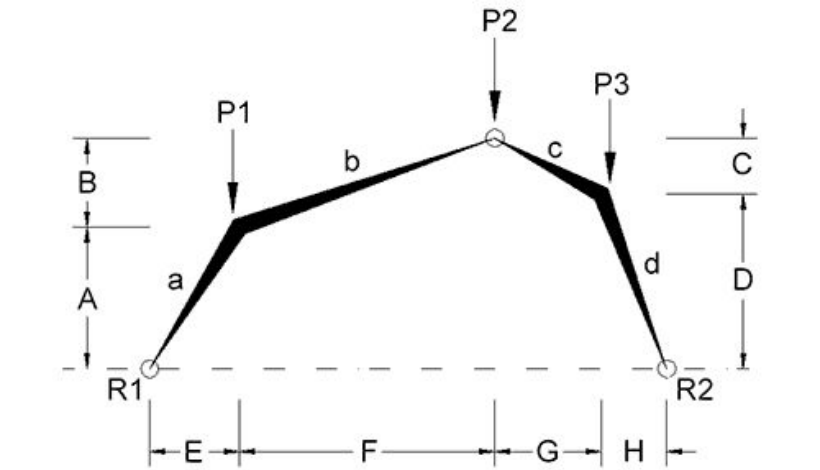
Question 5: **Moment at M1 (+ = tension inside)**

$$\sum_{MA} = 0$$

$$R_{1Y} \times E - R_{1X} \times (A + B) + M_1 = 0$$

$$21.82 \times 9 - 12.12 \times 17 + M_1 = 0$$

$$M_1 = 9.74\ KIPS.FT$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

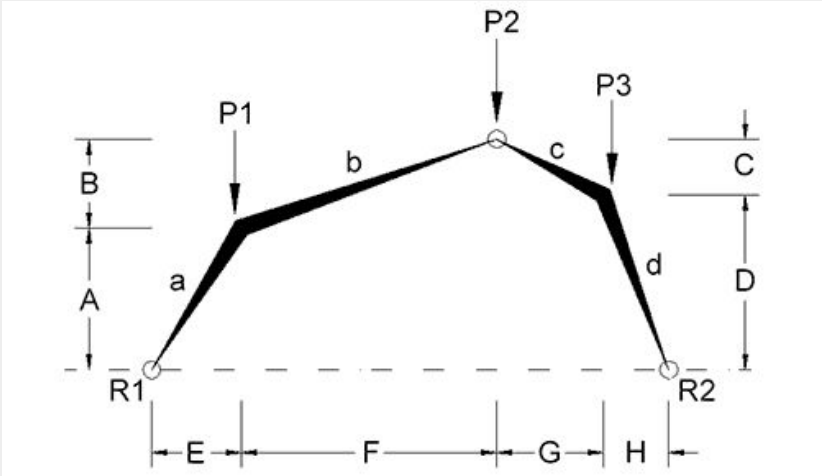
Question 6: **Moment at M2 (+ = tension inside)**

$$\sum_{MA} = 0$$

$$-R_{2Y} \times H + R_{2X} \times (D) - M_2 = 0$$

$$-16.18 \times 4 + 12.12 \times 7 - M_2 = 0$$

$$M_2 = -20.12\ KIPS.FT$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

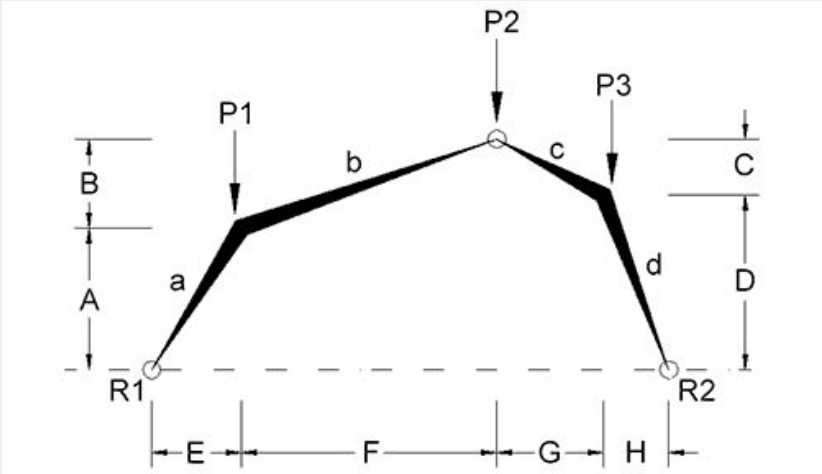
PROBLEM NO.7

Question 7: **Axial force in member "a" (+ is compression)**

$$F_a = \sqrt{R^2_{1X} + R^2_{1Y}}$$

$$F_a = \sqrt{(12.12)^2 + (21.28)^2}$$

$$F_a = 24.48\ KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

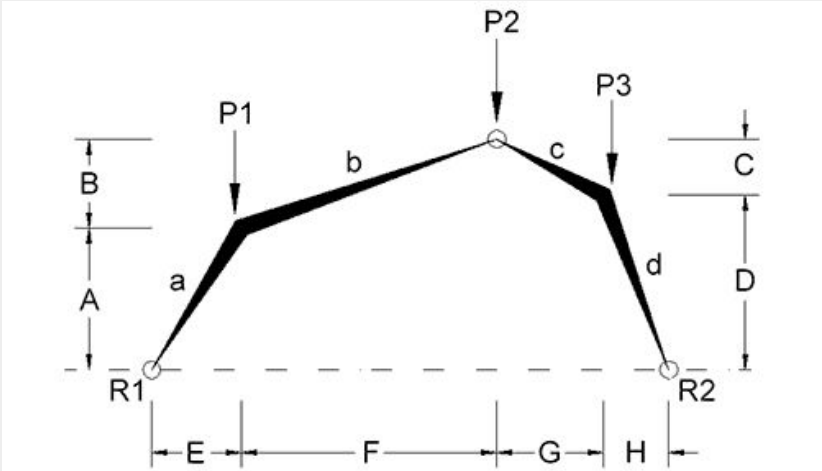
PROBLEM NO.7

Question 10: **Axial force in member "d" (+ is compression)**

$$F_d = \sqrt{R^2_{2X} + R^2_{2Y}}$$

$$F_d = \sqrt{(12.12)^2 + (16.18)^2}$$

$$F_d = 20.21 \; KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

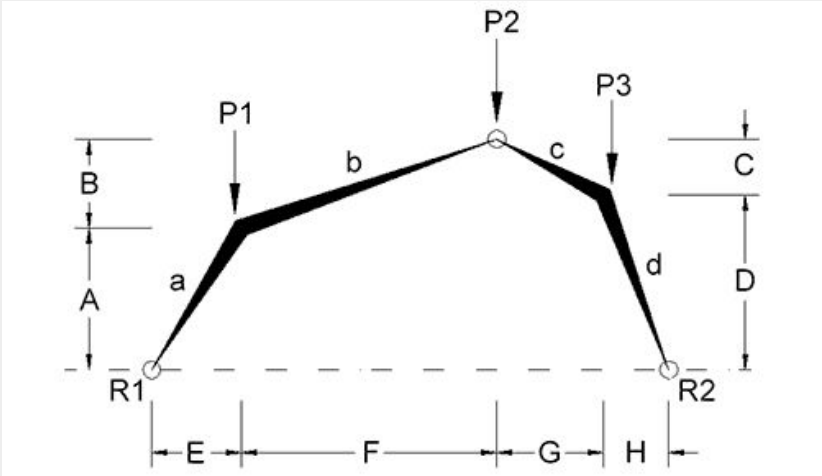
Question 9: **Axial force in member "c" (+ is compression)**

$$\sum_{F_H} = 0$$

$$R_{1X} - F_{CX} = 0$$

$$R_{1X} = F_{CX}$$

$$\boxed{F_{CX} = 12.12\ KIPS}$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

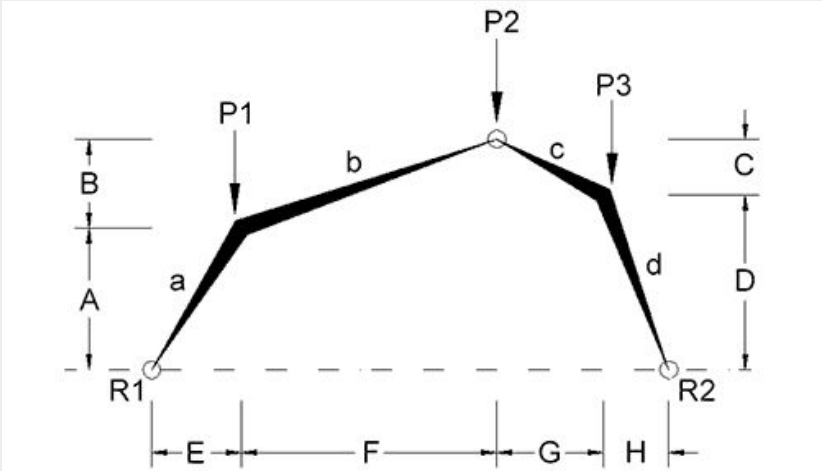
Question 9: **Axial force in member "c" (+ is compression)**

$$\sum_{M_{R1}} = 0$$

$$P_1 \times E + P_2 \times (E+F) - F_{CY} \times (E+F) - F_{CX} \times (A+B) = 0$$

$$14 \times 9 + 17 \times 18 - F_{CY} \times 18 - 12.12 \times 22 = 0$$

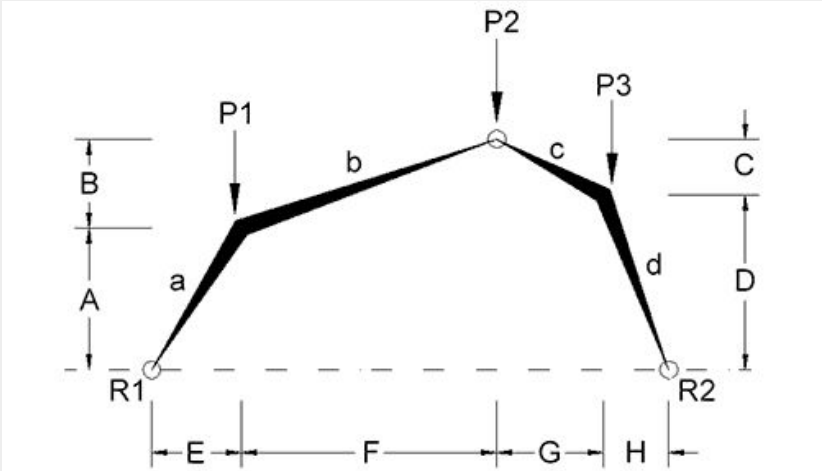
$$F_{CY} = 9.18 \; KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

Question 9: **Axial force in member "c" (+ is compression)**



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

$$F_c = \sqrt{F^2_{CX} + F^2_{CY}}$$

$$F_c = \sqrt{(12.12)^2 + (9.18)^2}$$

$$F_c = 15.20\ KIPS$$

PROBLEM NO.7

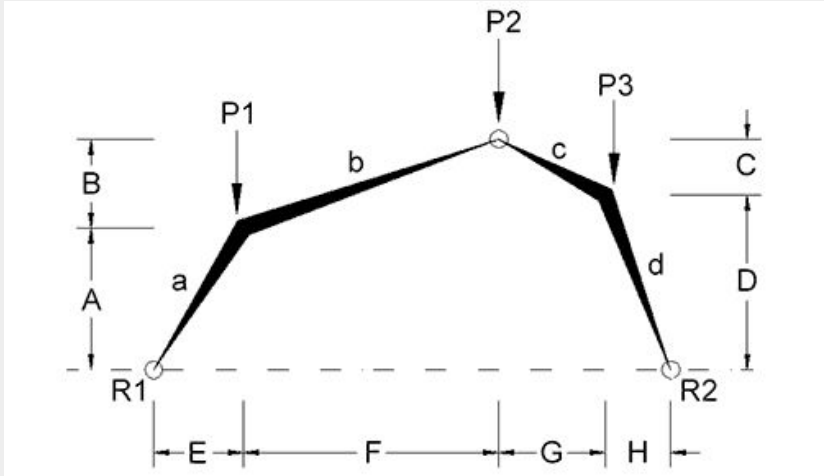
Question 8: **Axial force in member "b" (+ is compression)**

$$\sum_{F_H} = 0$$

$$-R_{2X} + F_{bX} = 0$$

$$-R_{2X} = F_{bX}$$

$$\boxed{F_{bX} = 12.12\ KIPS}$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

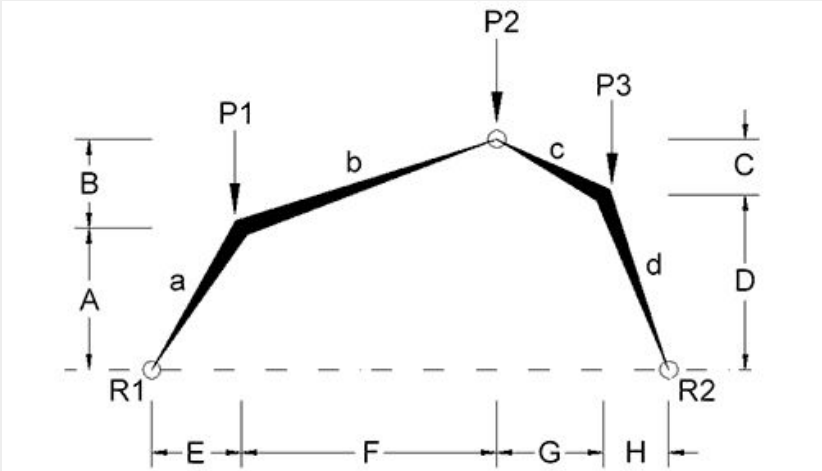
Question 8: **Axial force in member "b" (+ is compression)**

$$\sum_{M_{R2}} = 0$$

$$-P_2 \times (G+H) - P_3 \times (H) + F_{bY} \times (G+H) - F_{bX} \times (D+C) = 0$$

$$-17 \times 26 - 7 \times 4 + F_{bY} \times 26 - 12.12 \times 22 = 0$$

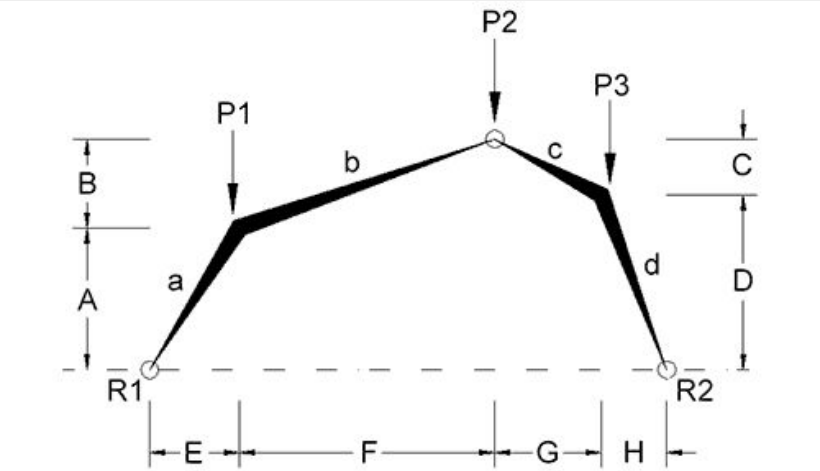
$$F_{bY} = 7.82 \ KIPS$$



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

PROBLEM NO.7

Question 8: **Axial force in member "b" (+ is compression)**



Height A	17 FT
Height B	5 FT
Height C	15 FT
Height D	7 FT
Length E	9 FT
Length F	9 FT
Length G	22 FT
Length H	4 FT
Force P1	14 KIPS
Force P2	17 KIPS
Force P3	7 KIPS

$$F_b = \sqrt{F^2_{bX} + F^2_{bY}}$$

$$F_b = \sqrt{(12.12)^2 + (7.82)^2}$$

$$F_b = 14.42\ KIPS$$

Lab 06: Graphic Statics

Procedure

Part 1

1. Adjust the 3-hinged arch model on graph paper to have a 9” span.
2. Copy the geometry onto graph paper to determine the dimensions – the member lengths should be about 4” each.
3. Assume a uniform vertical load of 1 pound / inch on the length of each member (like a selfweight). Find and locate the resultant forces on your drawing.
4. Calculate the end reactions.
5. Calculate the peak moment at the knee.

Part 2

6. Next use the string to find a funicular shape with the same span.
7. Copy the new geometry onto the graph paper (overlaid on the original arch) to determine the dimensions.
8. Segment the arch into four symmetric sections.
9. Calculate the end reactions.
10. Calculate the peak moment at the knee.