

Дано:

Сосредоточенные силы:

$$F = 10 \text{ кН}$$

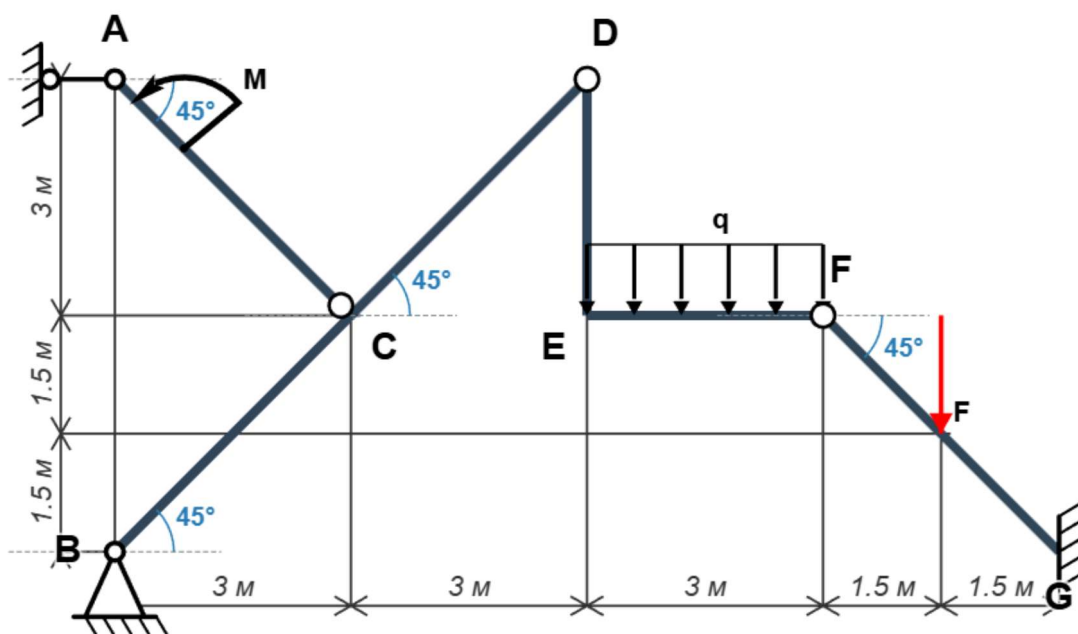
Сосредоточенные моменты:

$$M = 5 \text{ кН}\cdot\text{м}$$

Распределенные нагрузки:

$$q = 4 \text{ кН/м}$$

Грузовая схема



Расчетная схема

The diagram shows a frame structure ABCDEFG with the following dimensions and loads:

- Dimensions:**
 - Vertical segments: $AB = 3M$, $BC = 1.5M$, $FG = 1.5M$.
 - Horizontal segments: $BE = 7.5M$, $EF = 3M$, $GC = 1.5M$.
- Angles:**
 - $\angle BAC = 45^\circ$
 - $\angle CBD = 45^\circ$
 - $\angle FED = 90^\circ$ (implied by the horizontal segment EF and vertical segment FD)
 - $\angle FGC = 45^\circ$
- Supports and Reactions:**
 - Support A: Horizontal reaction R_A (blue arrow pointing right).
 - Support B: Vertical reaction Y_B (blue arrow pointing up) and horizontal reaction X_B (blue arrow pointing right).
 - Support G: Vertical reaction Y_C (blue arrow pointing up) and horizontal reaction X_C (blue arrow pointing left).
- Applied Loads:**
 - Moment M (blue curved arrow) at joint A.
 - Point load Q (black arrow pointing down) at joint E.
 - Point load F (red arrow pointing down) at joint F.
 - Moment MC (blue curved arrow) at joint G.

$$-Y_B \cdot 6 - X_B \cdot 6 + M = 0$$

$$-6 \cdot Y_B - 6 \cdot X_B + 5 = 0$$

$$6. \sum M_F^{GF} = 0:$$

$$X_C \cdot 3 + Y_C \cdot 3 - M_C - F \cdot 1.5 = 0$$

$$3 \cdot X_C + 3 \cdot Y_C - M_C - 15 = 0$$

Составим и решим систему уравнений:

$$\begin{cases} -12 \cdot Y_B - 6 \cdot R_A - M_C = -74 \\ -X_B + R_A + X_C = 0 \\ Y_B + Y_C = 22 \\ -3 \cdot R_A = -5 \\ -6 \cdot Y_B - 6 \cdot X_B = -5 \\ 3 \cdot X_C + 3 \cdot Y_C - M_C = 15 \end{cases}$$

Ответы:

$$Y_B = 2.583 \text{ кН}$$

$$X_B = -1.75 \text{ кН}$$

$$R_A = 1.667 \text{ кН}$$

$$X_C = -3.417 \text{ кН}$$

$$Y_C = 19.417 \text{ кН}$$

$$M_C = 33 \text{ кН} \cdot \text{м}$$

4. Проверка (сумма моментов относительно точки В):

$$\sum M_B = -R_A \cdot 6 - M_C + Y_C \cdot 12 - F \cdot 10.5 - Q \cdot 7.5 + M = 0$$

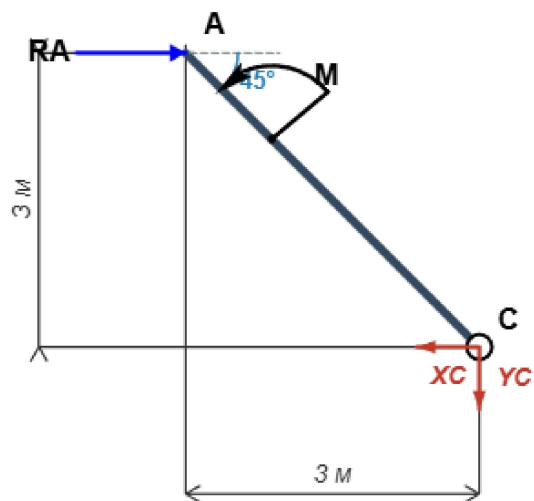
$$-1.667 \cdot 6 - 33 + 19.417 \cdot 12 - 10 \cdot 10.5 - 12 \cdot 7.5 + 5 = 0$$

Проверка выполняется!

Метод 2: Метод разложения

Разобьем систему на 4 участка(ов) по шарнирам и составим уравнения равновесия для каждого участка отдельно.

Участок AC



$$\sum F_x = R_A - X_C = 0$$

$$\Rightarrow R_A - X_C = 0$$

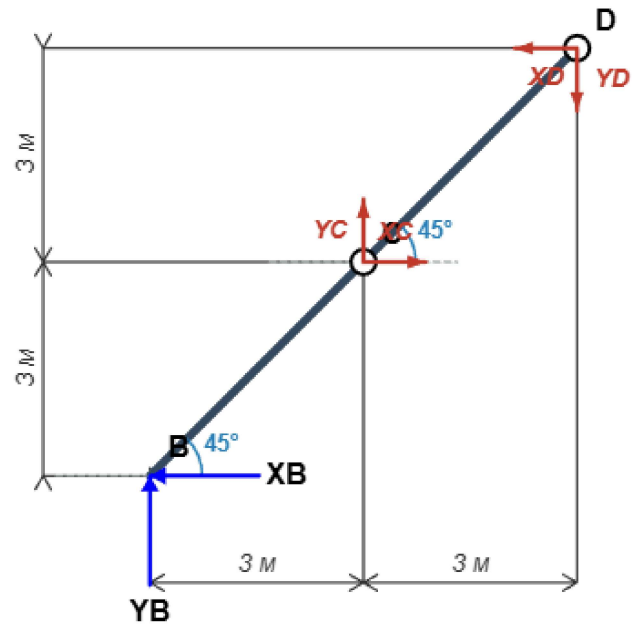
$$\sum F_y = -Y_C = 0$$

$$\Rightarrow -Y_C = 0$$

$$\sum M_C = -R_A \cdot 3 + M = 0$$

$$\Rightarrow -3 \cdot R_A = -5$$

Участок BCD



$$\sum F_x = -X_B - X_D + X_C = 0$$

$$\Rightarrow -X_B - X_D + X_C = 0$$

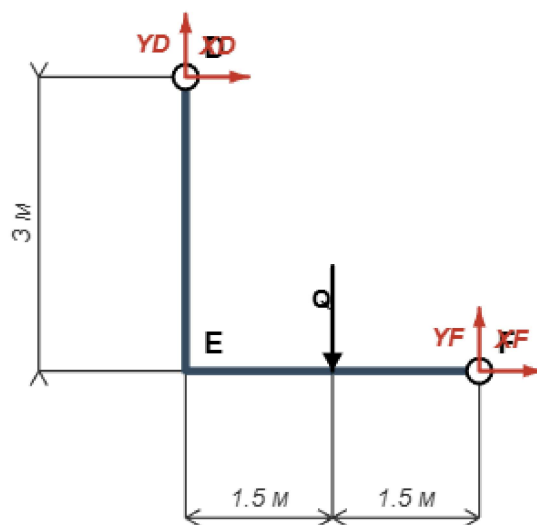
$$\sum F_y = Y_B - Y_D + Y_C = 0$$

$$\Rightarrow Y_B - Y_D + Y_C = 0$$

$$\sum M_B = X_D \cdot 6 - Y_D \cdot 6 - X_C \cdot 3 + Y_C \cdot 3 = 0$$

$$\Rightarrow 6 \cdot X_D - 6 \cdot Y_D - 3 \cdot X_C + 3 \cdot Y_C = 0$$

Участок DEF



$$\sum F_x = X_D + X_F = 0$$

$$\Rightarrow X_D + X_F = 0$$

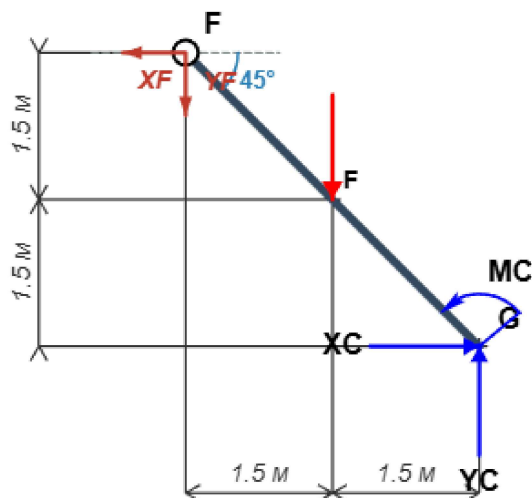
$$\sum F_y = Y_D + Y_F - Q = 0$$

$$\Rightarrow Y_D + Y_F = 12$$

$$\sum M_D = X_F \cdot 3 + Y_F \cdot 3 - Q \cdot 1.5 = 0$$

$$\Rightarrow 3 \cdot X_F + 3 \cdot Y_F = 18$$

Участок FG



$$\sum F_x = X_C - X_F = 0$$

$$\Rightarrow X_C - X_F = 0$$

$$\sum F_y = Y_C - Y_F - F = 0$$

$$\Rightarrow Y_C - Y_F = 10$$

$$\sum M_G = -M_C + X_F \cdot 3 + Y_F \cdot 3 + F \cdot 1.5 = 0$$

$$\Rightarrow -M_C + 3 \cdot X_F + 3 \cdot Y_F = -15$$

Составим и решим систему уравнений:

$$\begin{cases} R_A - X_C = 0 \\ -Y_C = 0 \\ -3 \cdot R_A = -5 \\ -X_B - X_D + X_C = 0 \\ Y_B - Y_D + Y_C = 0 \\ 6 \cdot X_D - 6 \cdot Y_D - 3 \cdot X_C + 3 \cdot Y_C = 0 \\ X_D + X_F = 0 \\ Y_D + Y_F = 12 \\ 3 \cdot X_F + 3 \cdot Y_F = 18 \\ X_C - X_F = 0 \\ Y_C - Y_F = 10 \\ -M_C + 3 \cdot X_F + 3 \cdot Y_F = -15 \end{cases}$$

Решая эту систему, находим:

Ответы:

Реакции опор:

$$Y_B = 2.583 \text{ кН}$$

$$X_B = -1.75 \text{ кН}$$

Усилия в шарнирах:

$$X_D = 3.417 \text{ кН}$$

$$Y_D = 2.583 \text{ кН}$$

$$R_A = 1.667 \text{ кН}$$

$$X_C = -3.417 \text{ кН}$$

$$Y_C = 19.417 \text{ кН}$$

$$M_C = 33 \text{ кН}\cdot\text{м}$$

$$X_F = -3.417 \text{ кН}$$

$$Y_F = 9.417 \text{ кН}$$

$$X_C = 1.667 \text{ кН}$$

$$Y_C = 0 \text{ кН}$$