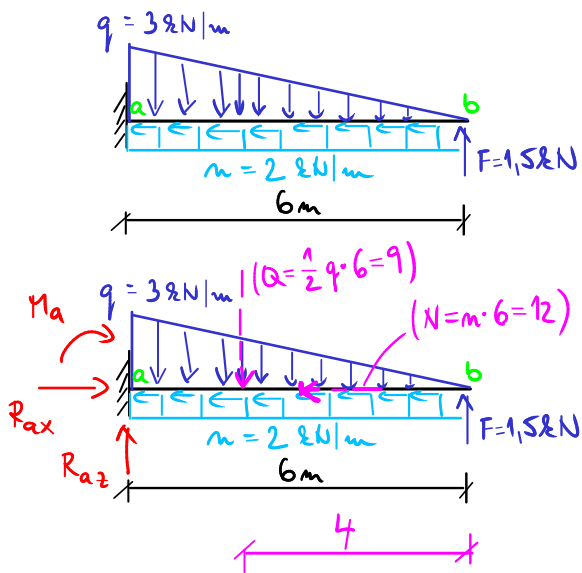


Přímý nosník s lineárním zatížením



Reakce: $\sum F_{xi} = 0 \oplus \rightarrow$

$$R_{ax} - n \cdot 6 = 0 \Rightarrow R_{ax} = 6 \cdot 2 = \underline{12 \text{ kN}}$$

$$\sum F_{zi} = 0 \oplus \uparrow$$

$$R_{az} - Q + F = 0$$

$$R_{az} = Q - F = 9 - 1,5 = \underline{7,5 \text{ kN}}$$

$$\sum M_{ai} = 0 \oplus \curvearrowright$$

$$M_a + Q \cdot 2 - F \cdot 6 = 0$$

$$M_a = 6 \cdot F - 2Q = 6 \cdot 1,5 - 2 \cdot 9 = \underline{-9 \text{ kNm}}$$

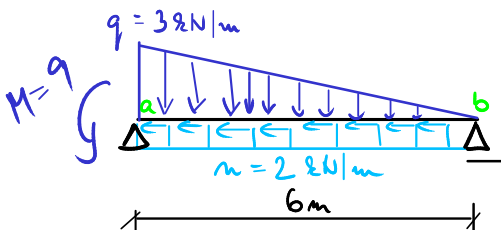
kontrola: $\sum M_{bi} = 0 \oplus \curvearrowright$

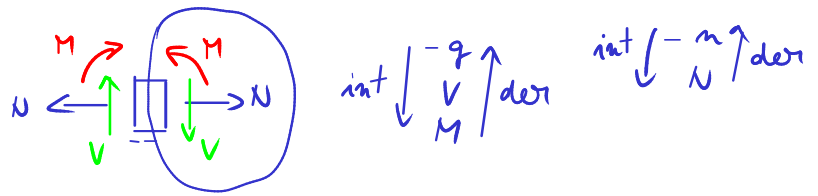
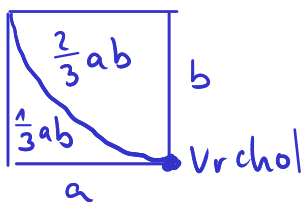
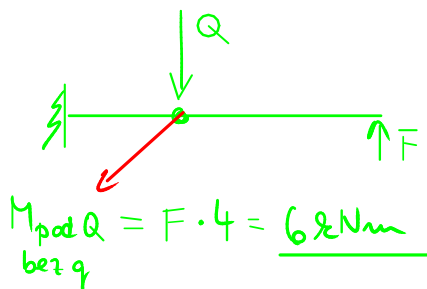
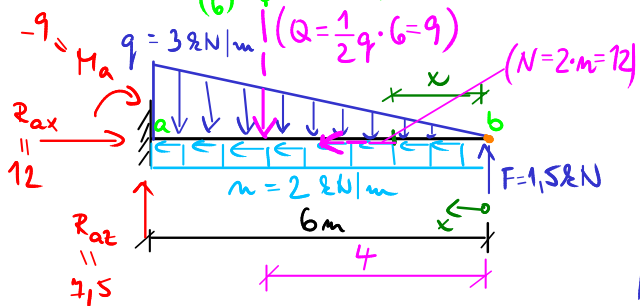
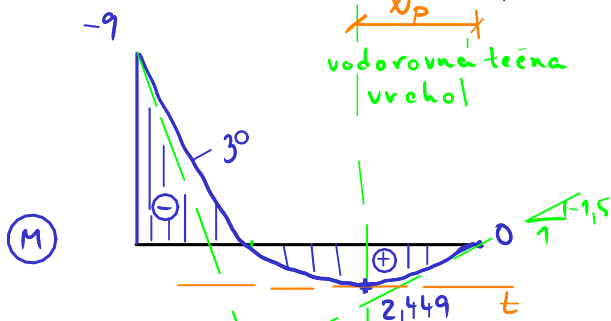
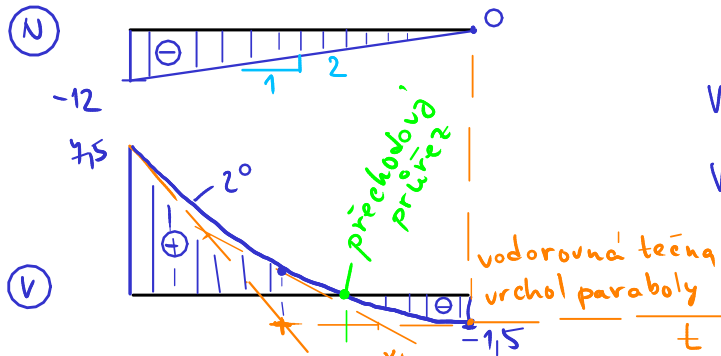
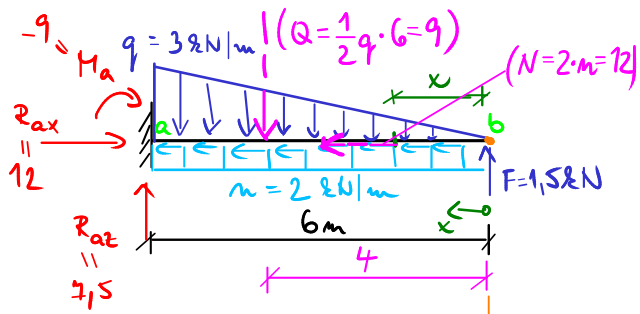
$$M_a - Q \cdot 4 + R_{az} \cdot 6 = 0$$

$$-9 - 9 \cdot 4 + 7,5 \cdot 6 = 0 \Rightarrow \underline{0 = 0 \checkmark}$$

Při vykreslování z volného konce nejsou reakce potřeba.

Budeme postupovat z volného konce a reakce použijeme pouze ke kontrole.

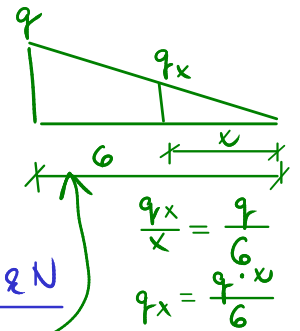




$$N_{ba}^P = 0$$

$$N_{ab}^P = -N = -2m = -12 \text{ kN}$$

$$N_{b-a}^P(x) = -mx = -2x$$



$$V_{ba}^P = -F = -1,5 \text{ kN}$$

$$V_{ab}^P = -F + Q = -1,5 + 9 = 7,5 \text{ kN}$$

$$V_{b-a}^P(x) = -F + \frac{1}{2} q_x \cdot x$$

$$V_{b-a}^P(x) = -F + \frac{1}{2} \frac{q}{6} \cdot x \cdot x = -1,5 + \frac{x^2}{4}$$

$$M_b^P = 0 \text{ kNm}$$

$$M_a^P = F \cdot 6 - Q \cdot 2 = -9 \text{ kNm}$$

$$M_{b-a}^P(x) = Fx - \frac{1}{2} \frac{q}{6} x \cdot \left(\frac{1}{3} x\right) = 1,5x - \frac{x^3}{12}$$

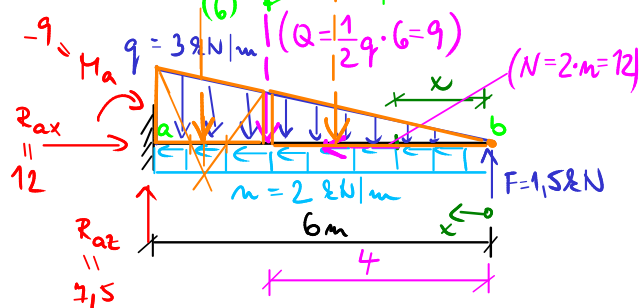
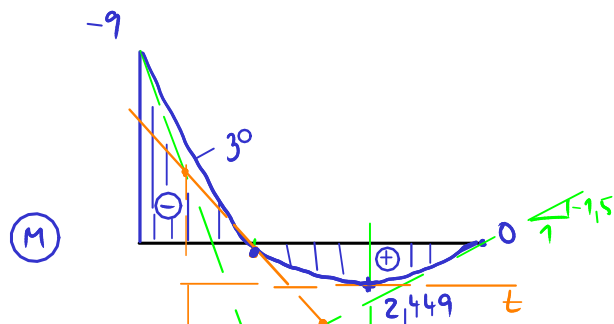
$$x_p = ?$$

$$V_{x_p}^P = V_{b-a}^P(x = x_p) = 0$$

$$-1,5 + \frac{x^2}{4} = 0 \Rightarrow x = \pm \sqrt{4 \cdot 1,5} = \sqrt{6} \text{ m}$$

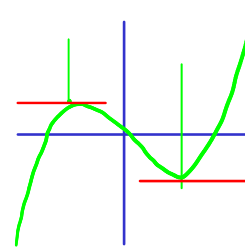
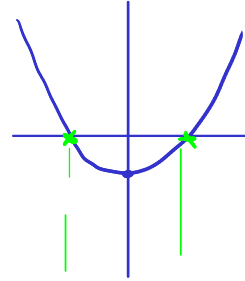
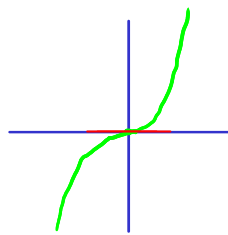
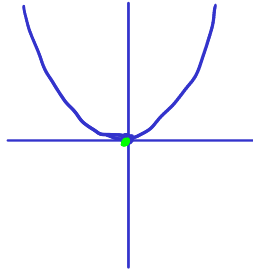
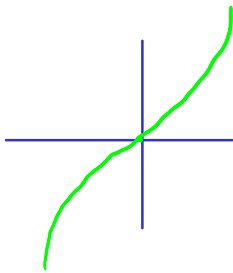
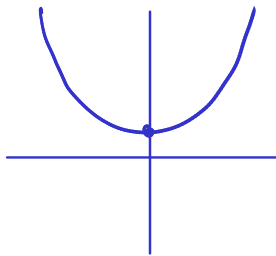
$$M_{\max}^P = F \cdot x_p - \frac{1}{2} \frac{q}{6} x_p \cdot \left(\frac{1}{3} x_p\right) = 2,449 \text{ kNm}$$

$$M_{\max}^P = M_b - \int_0^{x_p} V dx = 0 - \frac{2}{3} \sqrt{6} \cdot (-1,5) = 2,449 \text{ kNm}$$



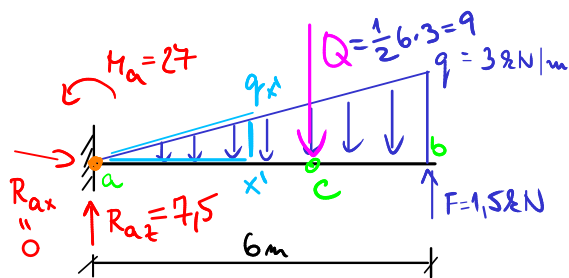
$$\frac{d^2M}{dx^2} = -q(x)$$

$v \oplus = 0 \Rightarrow$ inflexní bod
 mezi $a-b = \ominus \Rightarrow$ konfluvní

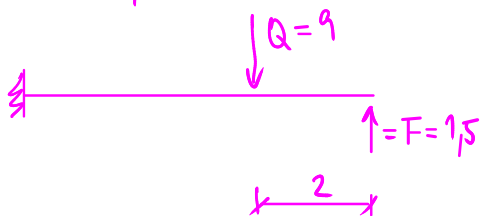
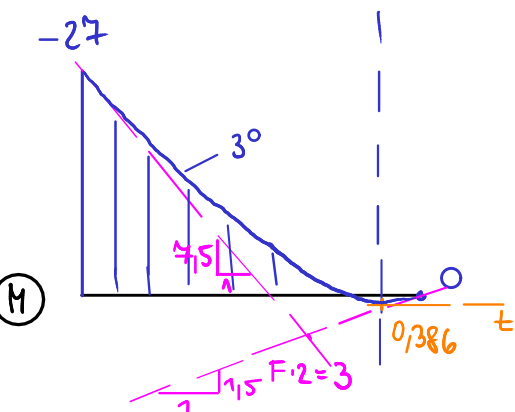
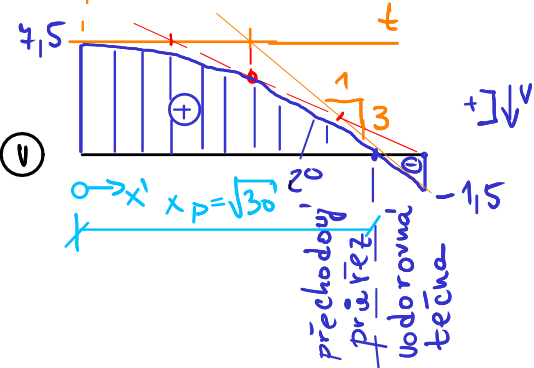


2°

3°



② $\emptyset$



$$\oplus \rightarrow \sum F_{xi} = 0 : R_{ax} = 0$$

$$\oplus \uparrow \sum F_{zi} = 0 : R_{az} - Q + F = 0$$

$$R_{az} = 9 - 1.5 = 7.5 \text{ kN}$$

$$\oplus \curvearrowright \sum M_{ai} = 0 : M_a - Q \cdot \left(\frac{2}{3} \cdot 6\right) + F \cdot 6 = 0$$

$$M_a = 9 \cdot 4 - 1.5 \cdot 6 = 27 \text{ kNm}$$

$$\text{kontrola: } \sum M_{ci} = 0 \oplus \uparrow$$

$$M_a - R_{az} \cdot 4 + F \cdot 2 = 0$$

$$27 - 7.5 \cdot 4 + 1.5 \cdot 2 = 0$$

$$0 = 0 \checkmark$$

$$P_{V_{bc}} = -F = -1.5 \text{ kN}$$

$$P_{V_{ac}} = -F + Q = P_{V_{bc}} + Q = -1.5 + 9 = 7.5 \text{ kN}$$

$$\frac{dV}{dx} = -q \quad q_a = 0 \Rightarrow \text{vodorovná tečna vrchol paraboly}$$

$$\text{kontrola: } L_{V_{ac}} = R_{az} = 7.5 \text{ kN} \checkmark$$

$$x_p: V_{a-b}(x') = 7.5 - Q_{x'} = 7.5 - \frac{1}{2} q_{x'} \cdot x'$$

$$L_{V_{a-b}}(x') = 7.5 - \frac{1}{2} \frac{q}{x'} \cdot x'^2 =$$

$$= 7.5 - \frac{x'^2}{4} \quad \left(\text{kontrola } V(x'=0) = 7.5 \checkmark \right)$$

$$V_{a-b}(x' = x_p) = 0$$

$$7.5 - \frac{x_p^2}{4} = 0 \Rightarrow x_p = \pm \sqrt{7.5 \cdot 4} = \pm \sqrt{30}$$

$$5.477 \text{ m}$$

$$P_{M_c} = 0$$

$$P_{M_a} = F \cdot 6 - Q \cdot 4 = 1.5 \cdot 6 - 9 \cdot 4 = -27 \text{ kNm}$$

$$\text{kontrola } L_{M_a} = -M_a = -27 \text{ kNm} \checkmark$$

$$x'_p = l - x_p = 6 - \sqrt{30} = 0.523 \text{ m}$$

$$L_{M(x'=x_p)} = M_{\text{před}} + \int_{x_p} V dx = M_a +$$

$$= -27 + \frac{2}{3} \cdot 7.5 \cdot \sqrt{30}$$

$$= 0.386 \text{ kNm}$$

$$x'_p = 6 - x_p = 6 - \sqrt{30}$$

$$P_{M(x=x'_p)} = F \cdot x'_p - Q_1 \cdot \frac{2}{3} x'_p - Q_2 \cdot \frac{1}{3} x'_p$$

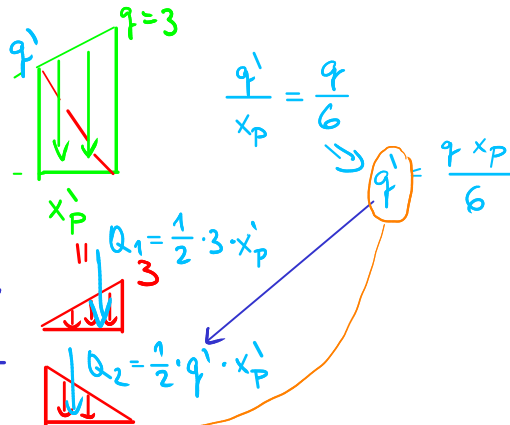
$$P_{M(x=x'_p)} = 1.5 \cdot x'_p - \frac{1}{2} \cdot 3 x'_p \cdot \frac{2}{3} x'_p - \frac{1}{2} \cdot \frac{q x_p}{6} \cdot x'_p \cdot \frac{1}{3} x'_p$$

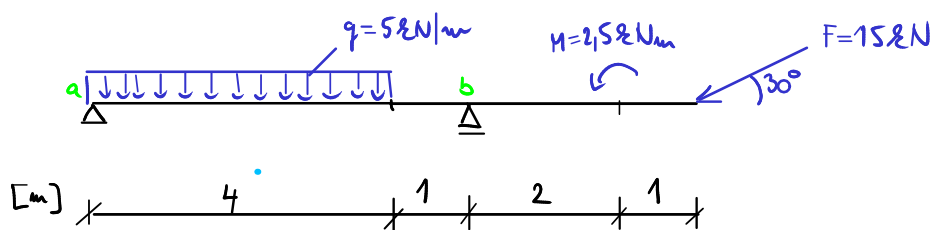
$$P_{M(x=x'_p)} = 1.5 x'_p - x_p^2 - \frac{x_p}{12} x_p^2 = 0.386 \text{ kNm} \checkmark$$

z REAKCI'

$$L_{M(x=x_p)} = -M_a + R_{az} \cdot x_p - Q_{x_p} \cdot \frac{1}{3} x_p =$$

$$= -27 + 7.5 \cdot x_p - \frac{1}{2} \cdot x_p \cdot \frac{q x_p}{6} \cdot \frac{1}{3} x_p = 0.386 \text{ kNm} \checkmark$$





$$F_x = F \cos 30^\circ$$

$$F_x = 15 \cdot \cos 30^\circ = \underline{12.99 \text{ kN}}$$

$$F_z = F \sin 30^\circ$$

$$F_z = 15 \cdot \sin 30^\circ = \underline{7.5 \text{ kN}}$$

Reakce:

$$\sum F_{xi} = 0 \quad \oplus \rightarrow$$

$$R_{ax} - F_x = 0 \Rightarrow \underline{R_{ax} = F_x = 12.99 \text{ kN}}$$

$$\sum M_{ai} = 0 \quad \oplus \curvearrowright$$

$$-Q \cdot 2 + R_{bz} \cdot 5 + M - F_z \cdot 8 = 0$$

$$\underline{R_{bz} = 19.5 \text{ kN}}$$

$$\sum M_{bi} = 0 \quad \oplus \curvearrowright$$

$$R_{az} \cdot 5 - Q \cdot 3 - M + F_z \cdot 3 = 0$$

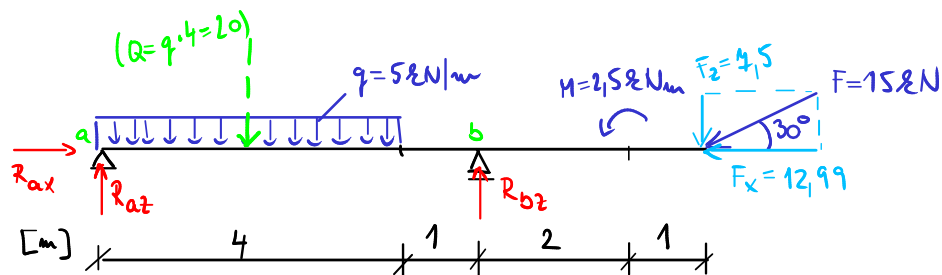
$$\underline{R_{az} = 8 \text{ kN}}$$

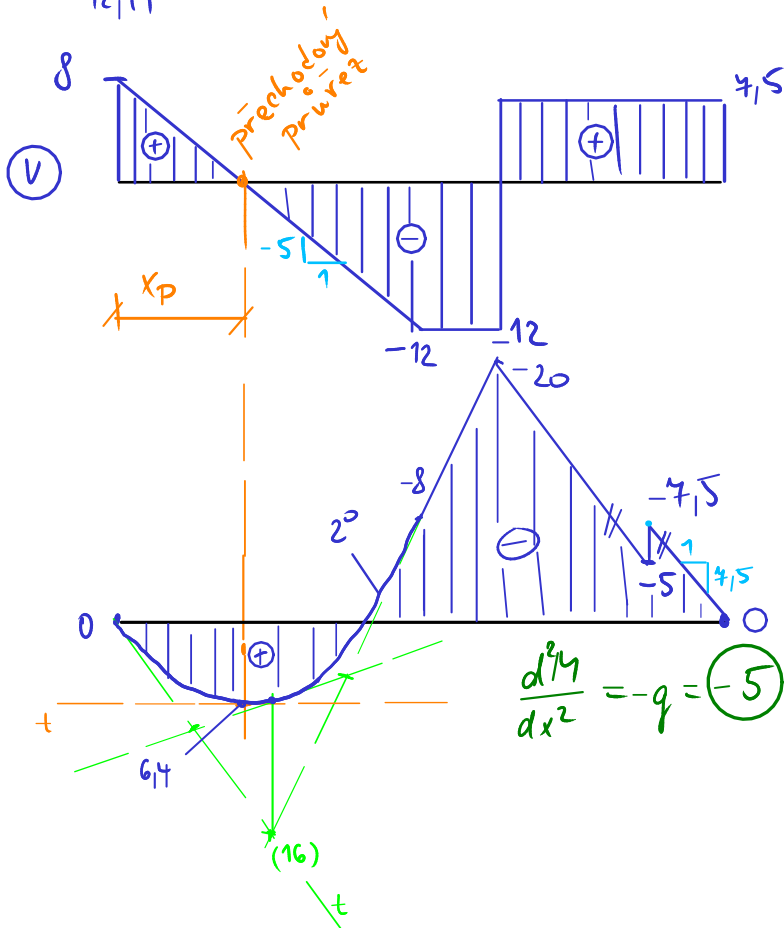
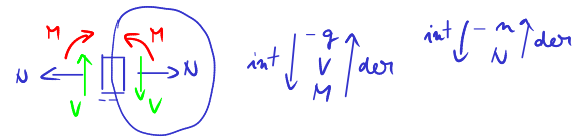
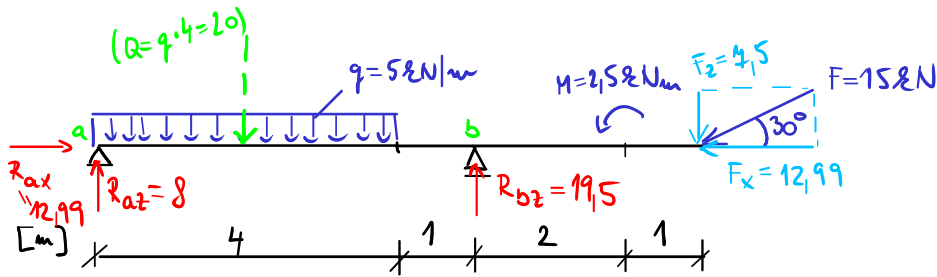
kontrola:

$$\sum F_{zi} = 0 \quad \oplus \uparrow$$

$$R_{az} + R_{bz} - Q - F_z = 0$$

$$\underline{\underline{0 = 0 \checkmark}}$$



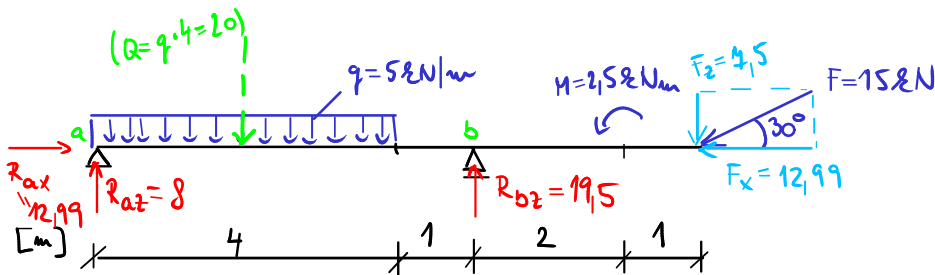
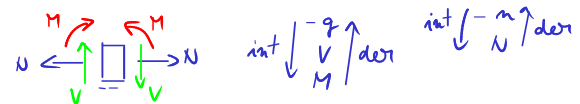


$$x_P = \frac{V_{ab}}{q} = \frac{8}{5} = 1.6 \text{ m}$$

$$M_{\max} = R_{az} \cdot x_P - q \cdot x_P \cdot \frac{x_P}{2} = 6.4 \text{ kNm}$$

$$M_{\max} = M_a + \int_0^{x_P} V dx = 0 + \frac{1}{2} \cdot 8 \cdot x_P = 6.4 \text{ kNm}$$

⊕ konVexni ⊖ konkAwni



$$M_{\text{pod } Q}^L = R_{az} \cdot 2 = 16 \text{ kNm}$$

bez q

