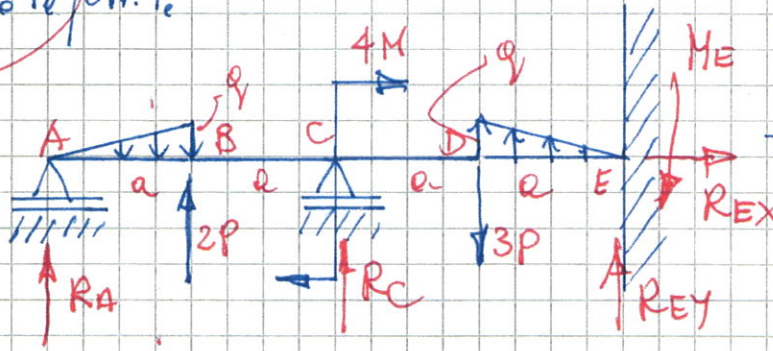


Bending / examples for test (2nd)

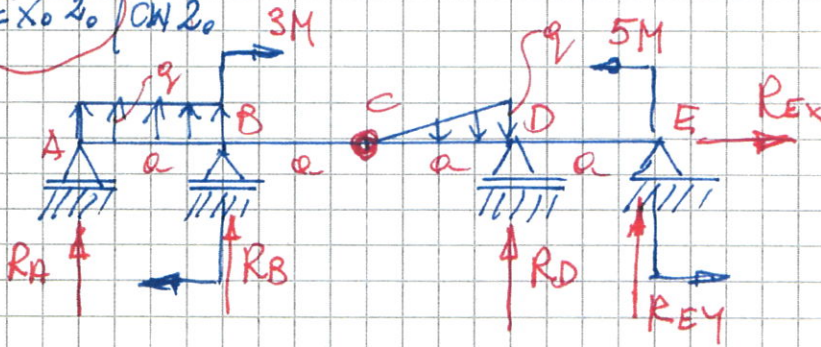
Exo 1e / CW. 1.



$q, a, P=qa, M=qa^2$
 $EI = \text{const}$

reactions - ?
 $y_B, v_D - ?$

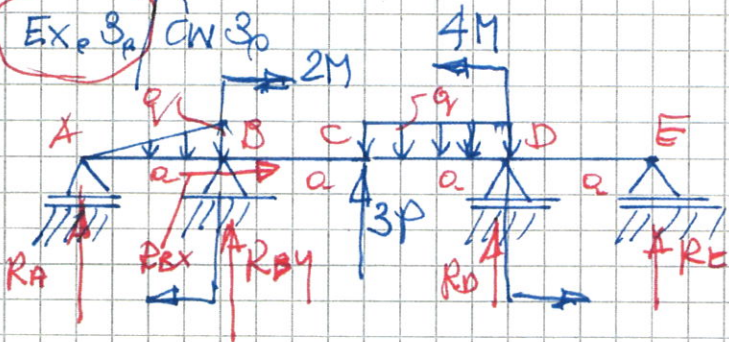
Exo 2o / CW 2o



~~$q, a, P=qa, M=qa^2$~~
 ~~$EI = \text{const}$~~

reactions - ?
 $y_C, v_E - ?$

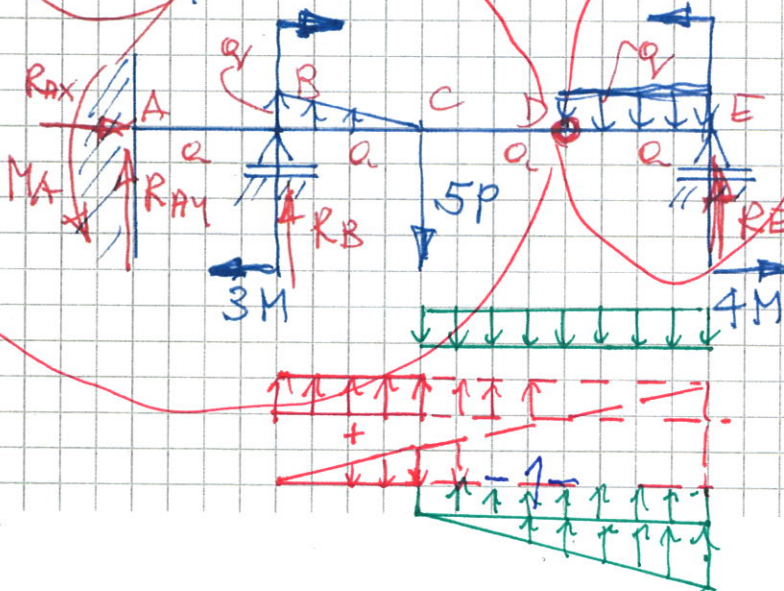
Exo 3o / CW 3o



$q, a, P=qa, M=qa^2$
 $EI = \text{const}$

reactions - ?
 $y_C, v_A - ?$

Exo 4o / CW. 4



$q, a, P=qa, M=qa^2$
 $EI = \text{const}$

reactions - ?
 $y_C, v_D^L, v_D^R - ?$

Ex 4.

① static eqs.

$$\textcircled{1} \sum P_i^x = R_A x = 0$$

$$\textcircled{2} \sum P_i^y = R_A y + \frac{1}{2} q a + R_B - 5P - q a + R_E = 0$$

$$\textcircled{3} M_L^P = -M_A + R_A y \cdot 3a + 3M + R_B \cdot 2a + \frac{1}{2} q a \cdot \frac{5}{3} a - 5P \cdot a = 0$$

$$\textcircled{4} M_R^D = \frac{q a^2}{2} - R_E a - 4M = 0$$

5 reactions - 4 st. eqs \Rightarrow 1x hyperstatic

A classical method of integration

$0 \leq x_1 \leq a$

$$M_1(x) = -M_A + R_A y \cdot x$$

$$EI \frac{d^2 y}{dx^2} = M_A - R_A y \cdot x$$

$$EI \frac{dy}{dx} = M_A \cdot x - R_A y \cdot \frac{x^2}{2} + C_1 \quad \textcircled{1}$$

$$EI y = M_A \frac{x^2}{2} - R_A y \frac{x^3}{6} + C_1 x + D_1 \quad \textcircled{2}$$

$a \leq x_2 \leq 2a$

$$M_2(x) = -M_A + R_A y \cdot x + 3M + R_B(x-a) + \frac{q(x-a)^2}{2} - \frac{q(x-a)^3}{6e}$$

$$EI \frac{d^2 y}{dx^2} = M_A - R_A y \cdot x - 3M + R_B(x-a) - \frac{q(x-a)^2}{2} + \frac{q(x-a)^3}{6e}$$

$$EI \frac{dy}{dx} = M_A - R_A y \cdot x - 3M - R_B x + R_B a - \frac{q}{2}(x^2 - 2x a + a^2) + \frac{q}{6e}(x^3 - 3x^2 a + 3x a^2 - a^3)$$

$$EI \frac{dy}{dx} = M_A \cdot x - R_A \frac{x^2}{2} - 3M \cdot x + \dots + C_2 \quad \textcircled{3}$$

$$EI y(x) = M_A \frac{x^2}{2} - R_A \frac{x^3}{6} - 3M \frac{x^2}{2} + \dots + C_2 x + D_2 \quad \textcircled{4}$$

$$2a \leq x_3 \leq 3a$$

$$M_3(x) = -M_A + R_A y \cdot x + R_B(x-a) + 3M + \frac{1}{2} q a (x - \frac{4}{3} a) - 5P(x-2a)$$

$$EI \frac{d^2 y}{dx^2} = M_A - R_A y \cdot x - R_B \cdot x + R_B \cdot a - 3M - \frac{1}{2} q a x + \frac{2}{3} q a^2 + 5P \cdot x - 10P a$$

$$EI \frac{dy}{dx} = M_A \cdot x - R_A \frac{x^2}{2} - R_B \frac{x^2}{2} + \dots + C_3 \quad (5x)$$

$$EI y(x) = M_A \frac{x^2}{2} - R_A \frac{x^3}{6} - R_B \frac{x^3}{6} + \dots + C_3 \cdot x + D_3 \quad (6x)$$

$$3a \leq x_4 \leq 4a$$

$$M_4(x) = -M_A + R_A y \cdot x + R_B(x-a) + 3M + \frac{1}{2} q a (x - \frac{4}{3} a) - 5P(x-2a) - \frac{q(x-3a)^2}{2}$$

$$EI \frac{d^2 y}{dx^2} = M_A - R_A y \cdot x - R_B \cdot x + R_B a - 3M - \frac{1}{2} q a x + \frac{2}{3} q a^2 + 5P x - 10P a + \frac{q}{2} (x^2 - 6x^2 a + 9a^2)$$

$$EI \frac{dy}{dx} = M_A \cdot x - R_A y \frac{x^2}{2} - R_B \frac{x^2}{2} + \dots + C_4$$

$$EI y = M_A \frac{x^2}{2} - R_A y \frac{x^3}{6} - R_B \frac{x^3}{6} + \dots + C_4 x + D_4 \quad (7x)$$

$$C_1, D_1, C_2, D_2, C_3, D_3, C_4, D_4 \rightarrow 2 \quad 8$$

$$L = 1 + 8 = 9 \quad R = 9 \quad \downarrow$$

II Boundary conditions

- | | |
|---------------------------------|-----------------------------|
| ① $x=0, v=0$ * | ⑤ $x=2a, v_L=v_R$ (3x) (5x) |
| ② $x=0, y=0$ (2x) | ⑦ $x=2a, y_L=y_R$ (4x) (6x) |
| ③ $x=a, v_L=v_R$ (*) (3x) | ⑧ $x=3a, y_L=y_R$ (6x) (7x) |
| ④ $x=a, y_L \Rightarrow 0$ (2x) | ⑨ $x=4a, y=0$ (7x) |
| ⑤ $x=a, y_R \Rightarrow 0$ (4x) | |

$$L=R$$

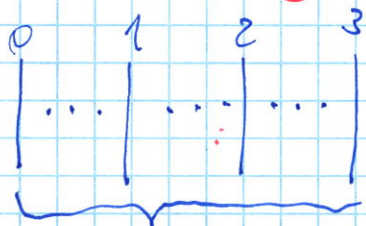
3 Castigliano method

for A-D

$M(x) =$	$-M_A + R_{Ay} \cdot x$	$+ 3M(x-a)^0 + R_B(x-a) + \frac{q(x-a)^2}{2} - \frac{q(x-a)^3}{6a}$		1	2
$ET \frac{d^2y}{dx^2} =$	$+M_A - R_{Ay} \cdot x$	$- 3M(x-a)^0 - R_B(x-a) - \frac{q(x-a)^2}{2} + \frac{q(x-a)^3}{6a}$		2	3
$ET \frac{dy}{dx} = C_1$	$+M_A \cdot x - R_{Ay} \frac{x^2}{2}$	$- 3M(x-a) - R_B \frac{(x-a)^2}{2} - \frac{q(x-a)^3}{6} + \frac{q(x-a)^4}{24a}$		$2*$	$3*$
$ET y = C_1 \cdot x + D_1$	$+M_A \frac{x^2}{2} - R_{Ay} \frac{x^3}{6}$	$- 3M \frac{(x-a)^2}{2} - R_B \frac{(x-a)^3}{6} - \frac{q(x-a)^4}{24} + \frac{q(x-a)^5}{120a}$		$2*$	$3*$
	2	$- 5P(x-2a) - \frac{q(x-2a)^2}{2} + \frac{q(x-2a)^2}{2} + \frac{q(x-2a)^3}{6a}$		3	3
		$+ 5P(x-2a) - \frac{q(x-2a)^3}{6a}$			
		$+ 5P \frac{(x-2a)^2}{2} - \frac{q(x-2a)^4}{24a}$			
		$+ 5P \frac{(x-2a)^3}{6} - \frac{q(x-2a)^5}{120a}$			

for b-c

$M(x) =$	\dots	\dots	\dots	3	2
$ET \frac{d^2y}{dx^2} =$	\dots	\dots	\dots	$+$	$q(x-3a)^2$
$ET \frac{dy}{dx} = C_2$	\dots	\dots	\dots	$+$	$q(x-3a)^3$
$ET y = C_2 \cdot x + D_2$	\dots	\dots	\dots	$+$	$q(x-3a)^4$
					24



parts identical to the A-D sections!

boundary conditions

- ① $x=0, v=0$ (1*)
- ② $x=0, y=0$ (2*)
- ③ $x=a, y=0$ (2*)
- ④ $x=3a, y_L=y_R$ (3*) = 4(*)
- ⑤ $x=4a, y=0$ (5*)

Nice to meet you!

$c_1, d_1, c_2, d_2 - ?$

$L_1 = 1 + 4 = 5$

II Boundary conditions

① $x=0, v=0$ *

② $x=p, y=0$ 2*

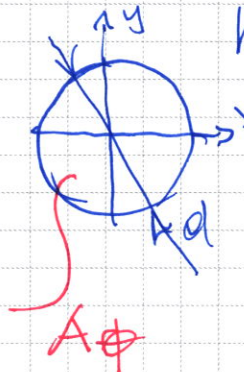
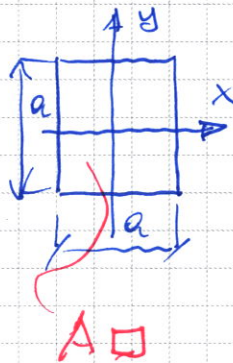
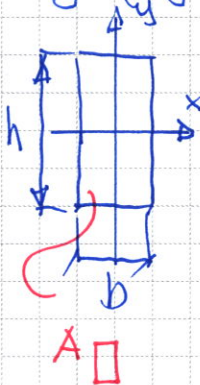
③ $x=a, y=p$ 2*

④ $x=3a, y_L = y_R$ 3* = 4*

⑤ $x=4a, y=0$ 4*

$L=R$

Ex. Beckling (wyboczenie)



$A_{\square} = A_{\square} = A_{\phi} = A$

$h = 3b$

$l_{\square} = l, l_{\square} = 2l$

$l_{\phi} = 3l$

E, Euler's theory

$\sigma_{cr \square} = \sigma_{cr \#} = \sigma_{cr \phi} = \frac{2}{3}$

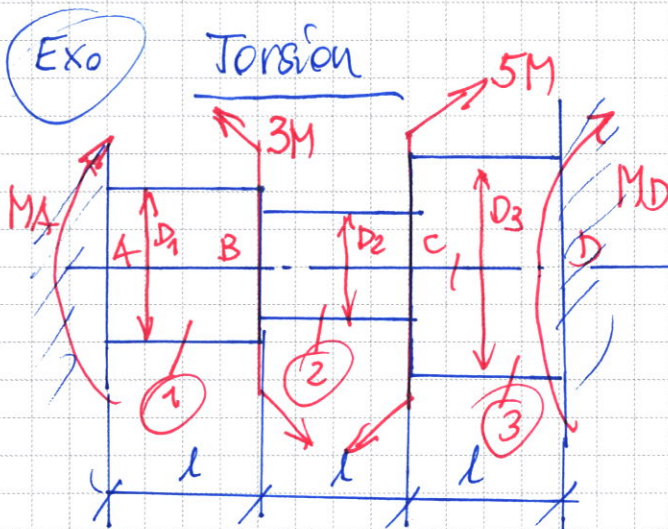


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Nice to meet you!



$$D_1 = 2D, D_2 = D, D_3 = 4D$$
$$l, G, M$$

$$T_1, T_2, T_3 - ?$$

-6-



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