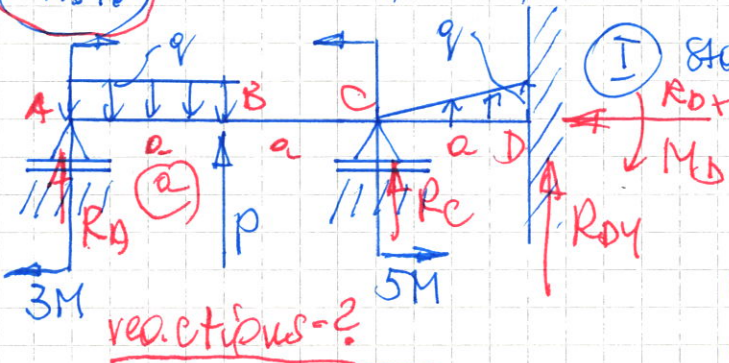


Force Method (beams)

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

Ex. 1.0



reactions = ?

(I) static eqs.

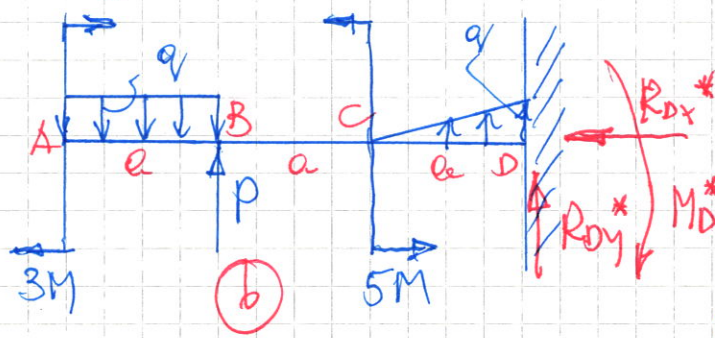
- (I) static eqs
- ① $\sum P_i x = 0$
 - ② $\sum P_i y = 0$
 - ③ $\sum M_i = 0$

- (II) Bending moments
- $$M_1(x) =$$
- $$M_2(x) =$$
- $$M_3(x) =$$

$R_A = X_1, R_C = X_2$

5 reactions - 3 st. eqs. \Rightarrow 2x hyperstatic

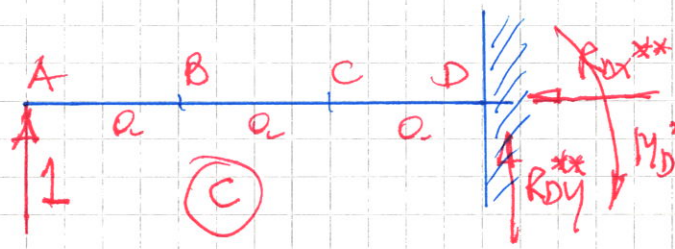
R_A, R_C - hyperstatic



(I) static eqs

- ① $\sum P_i x = 0$
- ② $\sum P_i y = 0$
- ③ $\sum M_i = 0$

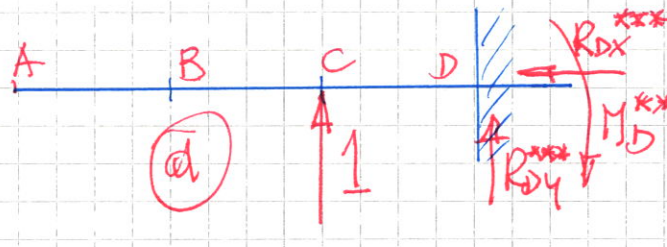
- (II) Bending moments
- $$M_1^*(x) =$$
- $$M_2^*(x) =$$
- $$M_3^*(x) =$$



(I) static eqs.

- ① $\sum P_i x = 0$
- ② $\sum P_i y = 0$
- ③ $\sum M_i = 0$

- (II) Bending moments
- $$M_1^{**}(x) =$$
- $$M_2^{**}(x) =$$
- $$M_3^{**}(x) =$$



(I) static eqs.

- ① $\sum P_i x = 0$
- ② $\sum P_i y = 0$
- ③ $\sum P_i y = 0$

- (II) Bending moments
- $$M_1^{***}(x) =$$
- $$M_2^{***}(x) =$$
- $$M_3^{***}(x) =$$

2x hyperstatic beam

$$\left. \begin{aligned} \textcircled{4} \quad X_1 \delta_{11} + X_2 \delta_{12} + \Delta_{1p} &= 0 \\ \textcircled{5} \quad X_1 \delta_{21} + X_2 \delta_{22} + \Delta_{2p} &= 0 \end{aligned} \right\}$$

canonical eqs.
(geometrical eqs.)

$$\Delta_{1P} \Rightarrow b + c$$

$$\Delta_{2P} \Rightarrow b + d$$

$$\delta_{11} \Rightarrow c + c$$

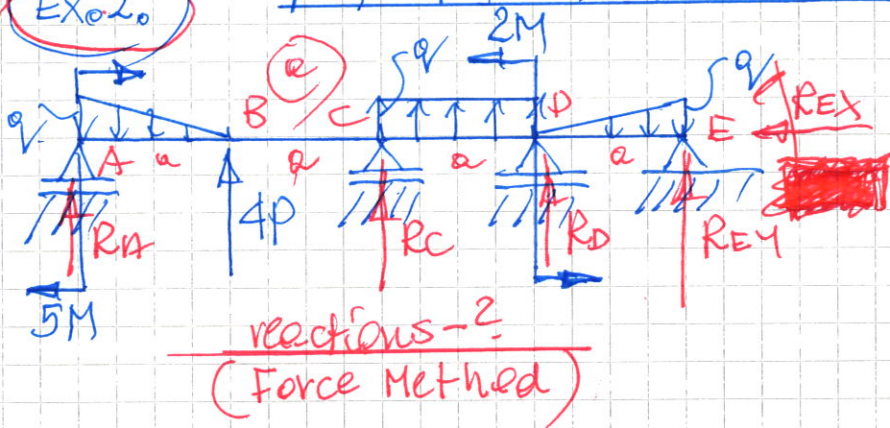
$$\delta_{12} = \delta_{21} \Rightarrow c + d$$

$$\delta_{22} \Rightarrow d + d$$

$$\left. \begin{array}{l} \textcircled{4} X_1 \delta_{11} + X_2 \delta_{12} + \Delta_{1P} = 0 \\ \textcircled{5} X_1 \delta_{21} + X_2 \delta_{22} + \Delta_{2P} = 0 \end{array} \right\} \Rightarrow X_1 = R_A, X_2 = R_C$$

$$\left. \begin{array}{l} \textcircled{1} \\ \textcircled{2} \\ \textcircled{3} \end{array} \right\} \text{for beam (a)} \Rightarrow R_{Ax}, R_{Ay}, M_0$$

Exo 2.0 $q(x), P=qa, M=qa^2, EI=\text{const}$ (only bending)



R_A, R_C - hyperstatic reactions

- I Static eqs
- ① $\sum P_{ix} = 0$
 - ② $\sum P_{iy} = 0$
 - ③ $\sum M_i = 0$

5 reactions 3 static eqs \Rightarrow 2x hyperstatic

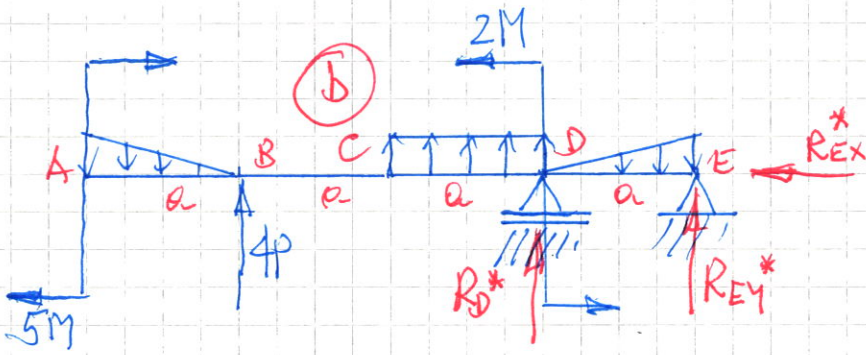
$$R_A = X_1$$

$$R_C = X_2$$

Bending moment $M(x) = ?$

$$\textcircled{4} X_1 \delta_{11} + X_2 \delta_{12} + \Delta_{1P} = 0$$

$$\textcircled{5} X_1 \delta_{21} + X_2 \delta_{22} + \Delta_{2P} = 0$$



(I) Static eqs.

(1) $\sum P_i x = 0$

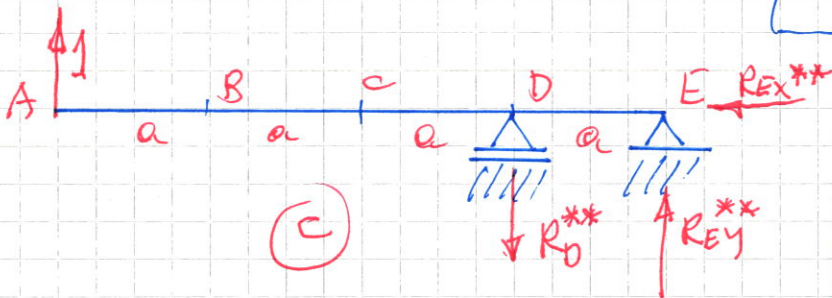
(2) $\sum P_i y = 0$

(3) $\sum M_i = 0$

$R_D^*, R_{EY}^*, R_{EX}^*$

(II) Bending moments

$M_i^*(x) = ?$



(I) Static eqs.

(1) $\sum P_i x = 0$

(2) $\sum P_i y = 0$

(3) $\sum M_i = 0$

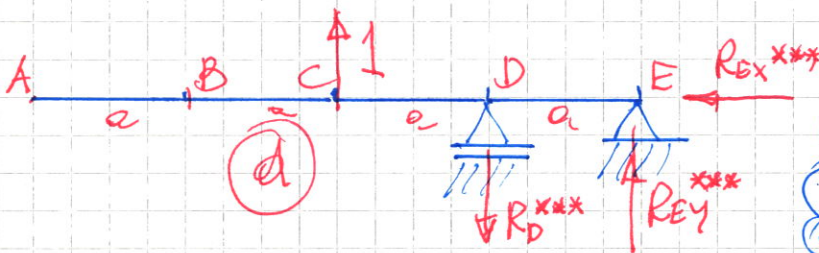
R_{EX}^{**}

R_{EY}^{**}

R_D^{**}

(II) Bending moments

$M_i^{**}(x) = ?$



(I) static eqs.

(1) $\sum P_i x = 0$

(2) $\sum P_i y = 0$

(3) $\sum M_i = 0$

R_{EX}^{***}

R_{EY}^{***}

R_D^{***}

(II) Bending moments

$M_i^{***}(x) = ?$

$\Delta_{1P} \Rightarrow (b) + (c)$

$\Delta_{2P} \Rightarrow (b) + (d)$

$\delta_{11} \Rightarrow (c) + (c)$

$\delta_{12} = \delta_{21} \Rightarrow (c) + (d)$

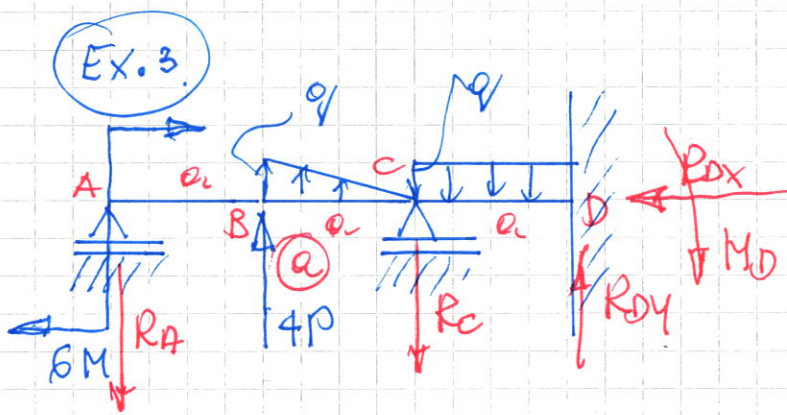
$\delta_{22} \Rightarrow (d) + (d)$

(4) $X_1 \delta_{11} + X_2 \delta_{12} + \Delta_{1P} = 0$

(5) $X_1 \delta_{21} + X_2 \delta_{22} + \Delta_{2P} = 0$

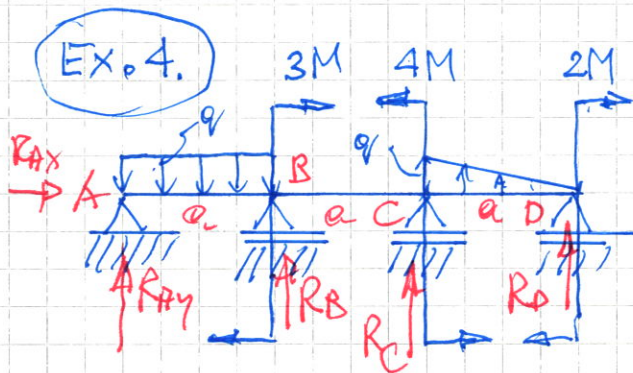
$\Rightarrow X_1 = R_A, X_2 = R_C$

(1) } for beam (a) $\Rightarrow R_D, R_{EX}, R_{EY}$



(only bending)
 $q, a, P=qa, M=qa^2, EI=const$

reactions - ?
 (Force Method)



(only bending)

$q, a, M=qa^2, EI=const$

reactions - ?
 (Force Method)