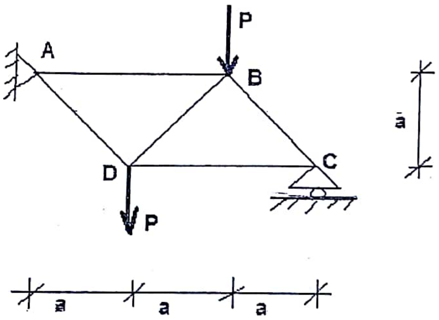
Université Hassiba Benbouali de Chlef
Faculté de Génie Civil et d'Architecture
Département de Génie Civil

2016/2017
RDM 2
3e LMD GC

Epreuve de Moyenne Durée

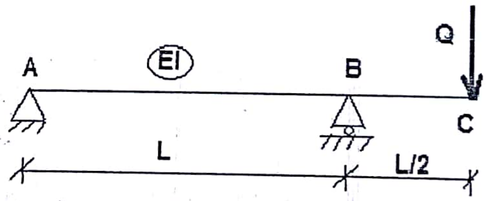
Exercice 1: (**05*points***)

Soit le système réticulé isostatique suivant. En utilisant **la méthode des sections** calculer les efforts dans les barres T_{AB}, T_{BD} et T_{DC}. Trouver en utilisant **la méthode des nœuds** les efforts dans les barres T_{AD} et T_{BC}.



Exercice 2: (**05*points***)

Par **la méthode énergétique de Maxwell-Mohr (Verescheaguine)**, calculer le déplacement et la rotation au point **C** de la poutre isostatique suivante.



On donne :

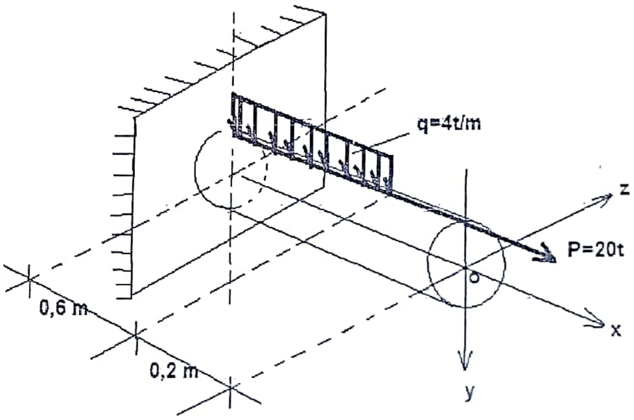
$$\Delta\ (ou\ \theta) = \frac{1}{EI}\int_0^l M\,\bar{m}\,dx$$

$M(x) = R_{Az} \cdot x = 1{,}5\,P\,x$ $\{M(1) = 1{,}5\,P$

Exercice 3: (07*points*)

Soit une barre en acier de section circulaire (**d=12 cm**) encastrée à son extrémité gauche et chargée comme indiqué sur la figure:

- Quel type de sollicitation s'agit-il ?
- Tracer les diagrammes des efforts N_x, T_y et M_z
- Vérifier la résistance de la poutre si **[σ] = 1600 kg/cm²**

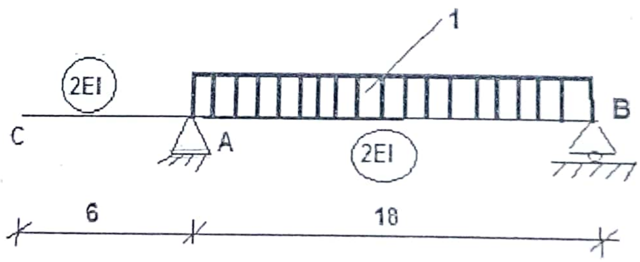


On donne :

$$max\ \sigma_x = \frac{N_x}{S} + \frac{M_z}{I_z}\,y$$

Exercice 4: (03*points*)

En utilisant **le théorème de Castigliano**, calculer le déplacement au point **C** de la poutre isostatique suivante :



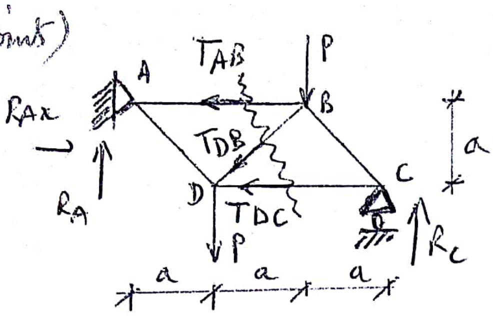
On donne :

$$\Delta_i = \frac{1}{EI}\int_0^l \frac{\partial M_f}{\partial P_i}\,M_f\,dx$$

Correction de l'EMD RDM2 3LGC

2016 - 2017

Exo 1 : (05 points)



1) $2n = b + 3 \Rightarrow 2.4 = 5 + 3 \Rightarrow 8 = 8$ S.I.I

2)
$$\begin{cases} \Sigma F/x = 0 \Rightarrow R_{Ax} = 0 \\ \Sigma M/_C = 0 \Rightarrow R_A . 3a - P.2a - P.a \Rightarrow R_A = P \\ \Sigma M/A = 0 \Rightarrow -R_C . 3a + P.2a + P.a = 0 \Rightarrow R_C = P \\ \Sigma F/y = 0 \Rightarrow R_A + R_C = 2P \quad (OK) \end{cases}$$

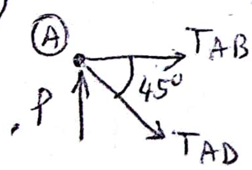
3) $M_{(D)} = M(T_{AB}) \Leftrightarrow P.a = -T_{AB}.a \Rightarrow \boxed{T_{AB} = -P}$ (1)

$M_{(B)} = M(T_{DC}) \Leftrightarrow P.2a - P.a = T_{DC}.a \Rightarrow \boxed{T_{DC} = P}$ (1)

$M_{(A)} = M(T_{BD}) \Leftrightarrow P.a = T_{DC}.a + T_{DB}\sin 45°.2a$ (1)

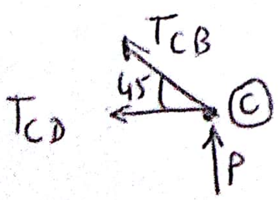
$$\Rightarrow T_{DB} = \frac{Pa - P.a}{\frac{\sqrt{2}}{2}.2a} = 0 \Rightarrow \boxed{T_{DB} = 0}$$

4)



(1)

$$\begin{cases} \Sigma F/x = 0 : T_{AB} + T_{AD}\cos 45 = 0 \\ \Sigma F/y = 0 : P - T_{AD}\sin 45 = 0 \Rightarrow \boxed{T_{AD} = P\sqrt{2}} \end{cases}$$

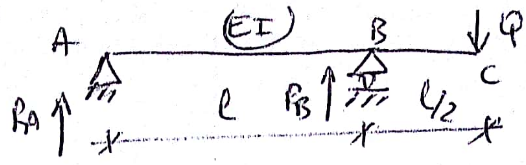


(1)

$\Sigma F/x = 0 : -T_{CD} - T_{CB}\cos 45 = 0$

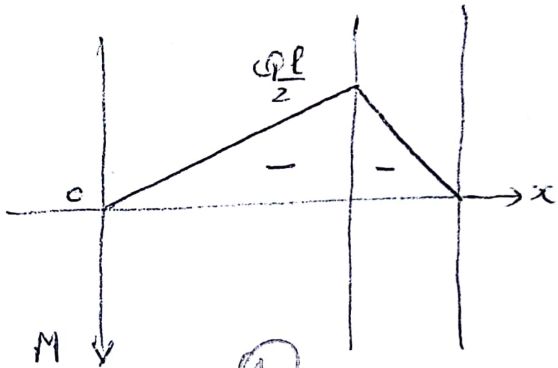
$\Sigma F/y = 0 : T_{CB}\sin 45 + P = 0 \Rightarrow \boxed{T_{CB} = -P\sqrt{2}}$

Exo 2 : (05 points)



1)
$$\begin{cases} R_A \cdot l + Q \cdot l/2 = 0 \Rightarrow R_A = -\frac{Q}{2} \\ -R_B \cdot l + Q \cdot \frac{3l}{2} = 0 \Rightarrow R_B = \frac{3Q}{2} \\ R_A + R_B - Q = -\frac{Q}{2} + 3\frac{Q}{2} - Q = 0 \ (OK) \end{cases}$$

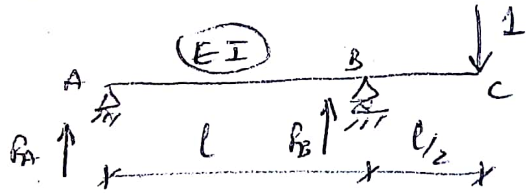
$$\begin{cases} -M_1 + R_A x = 0 \Rightarrow M_1 = -\frac{Q}{2} x \\ M_2 + Qx = 0 \Rightarrow M_2 = -Qx \end{cases}$$



1

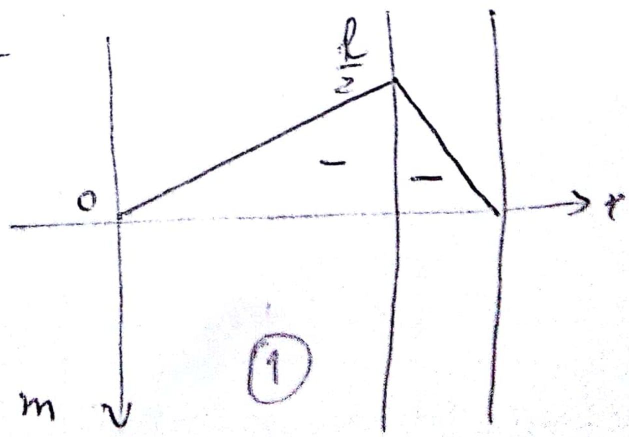
2)

Déplacement Δ_C :



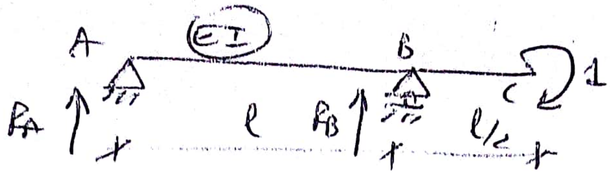
$$\begin{cases} R_A \cdot l + 1 \cdot \frac{l}{2} = 0 \Rightarrow R_A = -\frac{1}{2} \\ -R_B \cdot l + 1 \cdot \frac{3l}{2} = 0 \Rightarrow R_B = \frac{3}{2} \\ R_A + R_B - 1 = -\frac{1}{2} + \frac{3}{2} - 1 = 0 \ (OK) \end{cases}$$

$$\begin{cases} -m_1 + R_A x = 0 \Rightarrow m_1 = -\frac{x}{2} \\ m_2 + 1 \cdot x = 0 \Rightarrow m_2 = -x \end{cases}$$



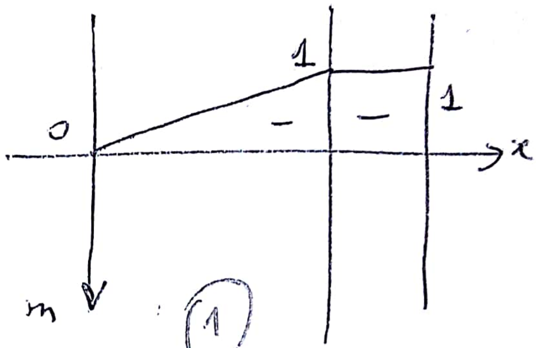
1

Rotation θ_C :



$$\begin{cases} R_A \cdot l + 1 = 0 \Rightarrow R_A = -\frac{1}{l} \\ -R_B \cdot l + 1 = 0 \Rightarrow R_B = +\frac{1}{l} \\ R_A + R_B = -\frac{1}{l} + \frac{1}{l} = 0 \quad (OK) \end{cases}$$

$$\begin{cases} -m_1 + R_A x = 0 \Rightarrow m_1 = -\frac{x}{l} \\ m_2 + 1 = 0 \Rightarrow m_2 = -1 \end{cases}$$



(1)

3) **Calcul de l'intégrale :**

$$EI\Delta_C = \frac{1}{3} M l m + \frac{1}{3} M l m = \frac{1}{3}\left(\frac{ql}{2} \cdot l \cdot \frac{l}{2} + \frac{ql}{2} \cdot \frac{l}{2} \cdot \frac{l}{2}\right) = \frac{1}{3}\left(\frac{ql^3}{4} + \frac{ql^3}{8}\right) = \frac{3ql^3}{24}$$

$$\Rightarrow \boxed{\Delta_C = \frac{3ql^3}{8EI}}$$

(1)

$$EI\theta_C = \frac{1}{3} M l m + \frac{1}{2} M l m = \frac{1}{3} \cdot \frac{ql}{2} \cdot l \cdot 1 + \frac{1}{2} \cdot \frac{ql}{2} \cdot \frac{l}{2} \cdot 1 = \frac{ql^2}{6} + \frac{ql^2}{8} = \frac{7ql^2}{24}$$

$$\Rightarrow \boxed{\theta_C = \frac{7ql^2}{24EI}}$$

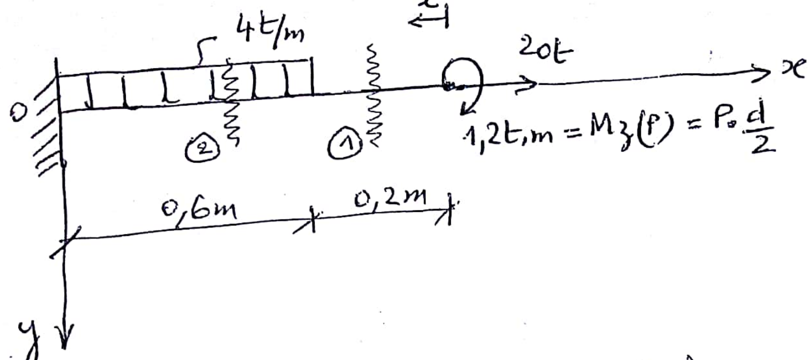
(1)

$M(x) = \ldots$
$M(0) = 0$
$M(1) = 1{,}5P$

Exo3 (07 points)

1) Flexion droite composée (cas B) (1)

2)

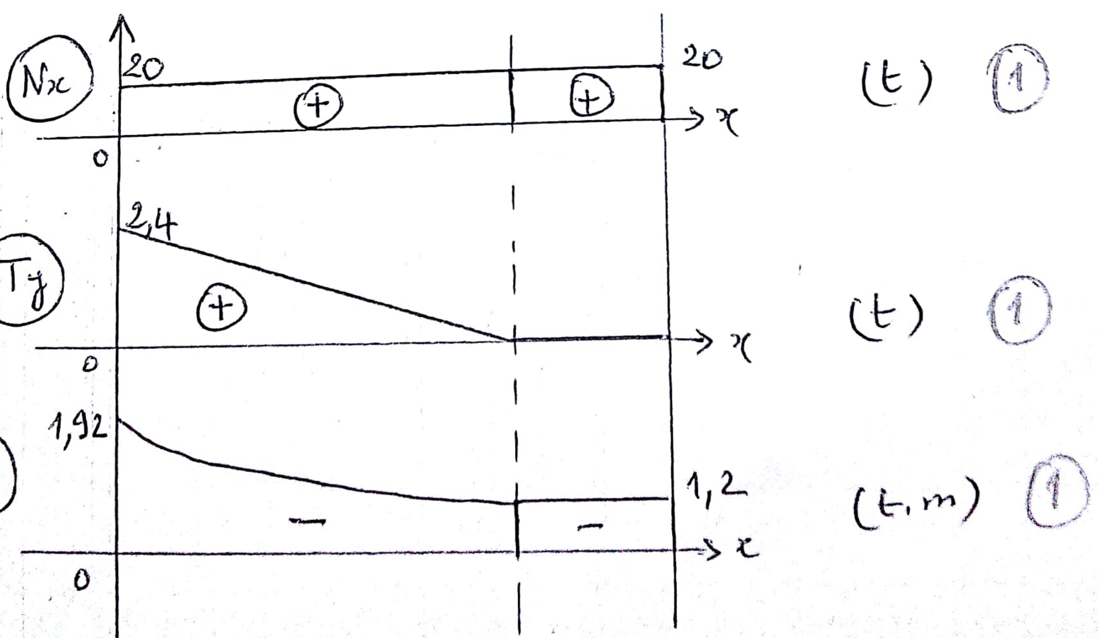


Section ①: (convention de signes – section gauche)

$$\begin{cases} -N_x + P = 0 \Rightarrow N_x = P = 20t \\ T_y = 0 \\ M_z + 1{,}2 = 0 \Rightarrow M_z = -1{,}2\ t{,}m \end{cases}$$ (1)

Section ②: (section gauche) (1)

$$\begin{cases} -N_x + P = 0 \Rightarrow N_x = P = 20t \\ T_y - 4(x-0{,}2) = 0 \Rightarrow T_y = 4x - 0{,}8 \\ M_z + 1{,}2 + 4\dfrac{(x-0{,}2)^2}{2} = 0 \Rightarrow M_z = -1{,}2 - 2(x-0{,}2)^2 \end{cases}$$



1.

3) La section dangereuse est la section d'encastrement.

$$\begin{cases} N_x = 20t \\ T_y = 2,4\,t \\ M_z = 1,92\,t.m \end{cases}$$

$$\max \sigma_x = \frac{N_x}{S} + \frac{M_z}{I_z} \cdot y \leq [\sigma]$$

$$\begin{cases} S = \frac{\pi d^2}{4} = \frac{\pi (12)^2}{4} = 113,04\ cm^2 \\ I_z = \frac{\pi d^4}{64} = \frac{\pi (12)^4}{64} = 1017,36\ cm^4 \\ y = \frac{d}{2} = \frac{12}{2} = 6\ cm \end{cases}$$

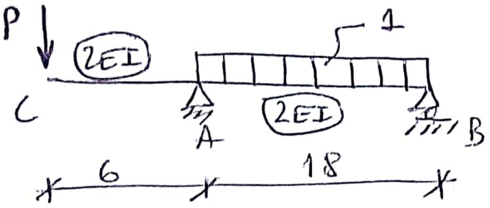
Alors :

$$\max \sigma_x = \frac{20 \cdot 10^3}{113,04} + \frac{1,92 \cdot 10^3 \cdot 10^2}{1017,36} \cdot 6 = 1309,27\ kg/cm^2$$

$$\Rightarrow \quad 1309,27 < [\sigma] = 1600\ kg/cm^2$$ 1

Critère de résistance vérifié.

Exo 4 : (03 points)



$$\begin{cases} R_A \cdot 18 - 1 \cdot 18 \cdot 9 - P \cdot 24 = 0 \Rightarrow R_A = 9 + \frac{4P}{3} \\ -R_B \cdot 18 + 1 \cdot 18 \cdot 9 - P \cdot 6 = 0 \Rightarrow R_B = 9 - \frac{P}{3} \\ R_A + R_B - 1 \cdot 18 - P = 9 + \frac{4P}{3} + 9 - \frac{P}{3} - 1 \cdot 18 - P = 0 \quad (\text{OK}) \end{cases}$$

1

$$\begin{cases} -M_1^f - Px = 0 \Rightarrow M_1^f = -Px \quad (\text{section gauche}) \\ M_2^f + 1 \cdot \frac{x^2}{2} - \left(9 - \frac{P}{3}\right)x = 0 \Rightarrow M_2^f = 9x - \frac{Px}{3} - \frac{x^2}{2} \quad (\text{section droite}) \end{cases}$$

1

$$\Delta_C = \frac{1}{2EI} \int_0^l \frac{\partial M^f}{\partial P} M^f \, dx .$$

Alors :

$$2EI\,\Delta_C = \int_0^6 (-Px)(-x)\,dx + \int_0^{18} \left(9x - \frac{Px}{3} - \frac{x^2}{2}\right)\left(-\frac{x}{3}\right) dx$$

$$2EI\,\Delta_C = \int_0^6 Px^2\,dx + \int_0^{18} \left(-3x^2 + \frac{Px^2}{9} + \frac{x^3}{6}\right) dx$$

$$2EI\,\Delta_C = \left[\frac{Px^3}{3}\right]_0^6 + \left[-\frac{3x^3}{3} + \frac{Px^3}{27} + \frac{x^4}{24}\right]_0^{18}$$

$$2EI\,\Delta_C = \left[-x^3 + \frac{x^4}{24}\right]_0^{18} \quad \text{en posant } P = 0 .$$

$$2EI\,\Delta_C = -5832 + 4374 = -1458$$

$$\Rightarrow \Delta_C = \frac{-729}{EI}$$

1

Calcul de My

$0 \leq x < 1$

$1 \leq x < 4$

$M(x) = 1,5\,Px - 2P(x-1)$

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2015/2016
RDM 2
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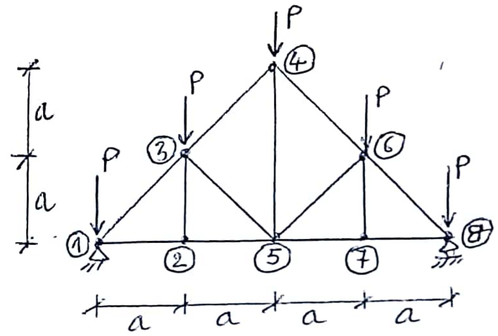
Epreuve de Moyenne Durée

Exercice 1: (05*points*)

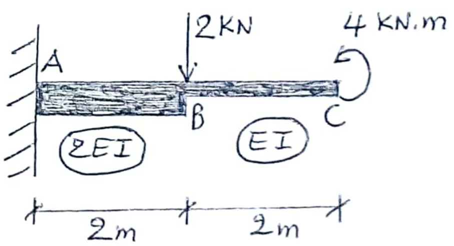
Par la méthode des sections, calculer les efforts dans les barres T_{34}, T_{35} et T_{25} du système réticulé isostatique suivant :



Exercice 2: (08*points*)

Soit la poutre encastrée suivante soumise à la flexion simple :

1) Calculer l'énergie de déformation de la poutre
2) Par la méthode énergétique de Verescheaguine, calculer le déplacement et la rotation au point **C**
3) *Vérifier les résultats trouvés en utilisant le théorème de Castigliano*



On donne :

$$W = \frac{1}{2}\int_0^l \frac{m_f^2}{EI}\,dx\ ;\quad \Delta\,(ou\ \theta) = \frac{1}{EI}\int_0^l M\,m\,dx\ ;\quad \Delta_i = \frac{1}{EI}\int_0^l \frac{\partial M_f}{\partial P_i} M_f\,dx\ ;\quad \theta_i = \frac{1}{EI}\int_0^l \frac{\partial M_f}{\partial M_i} M_f\,dx\ ;$$

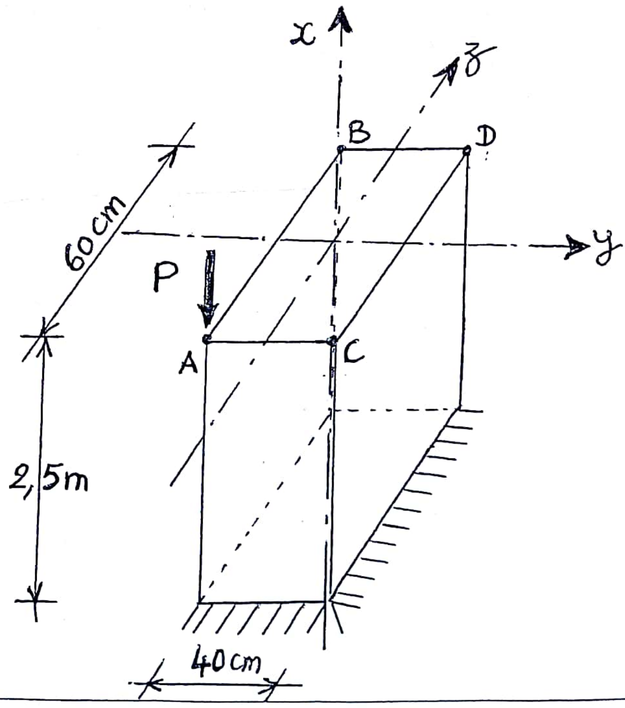
Exercice 3: (05*points*)

Un poteau en béton encastré par sa partie inférieure et chargé par une force concentrée axiale excentrée **P = 25 tonnes** (figure). Ce poteau est soumis à la flexion composée (compression gauche excentrée). *Sachant que la masse volumique du béton est* **γ=2,4 t/m³**. On demande :

- Calculer et tracer les contraintes normales développées aux 04 coins (**A, B, C, D**) de la section transversale rectangulaire du poteau
- Calculer et tracer l'axe neutre pour la section droite du poteau
- Vérifier la résistance du poteau si **$[\sigma]^+$ = 600 t/m²** et **$[\sigma]^-$ = 800 t/m²**

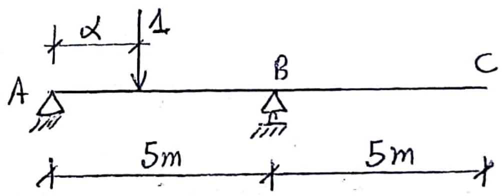
On donne :

$$\sigma_x = \frac{N_x}{A} + \frac{M_y}{I_y} z + \frac{M_z}{I_z} y \;;\; y_n = -\frac{i_z^2}{y_p} \;;\; z_n = -\frac{i_y^2}{z_p} \;;\; i_z^2 = \frac{I_z}{A} \;;\; i_y^2 = \frac{I_y}{A}$$



Exercice 4: (02 *points*)

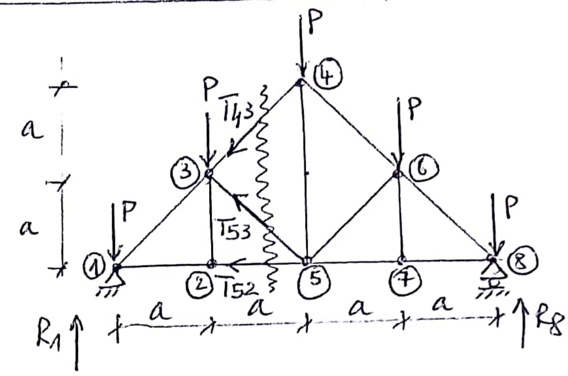
Construire les lignes d'influence des réactions d'appuis en **A** et **B** de la poutre isostatique suivante :



$M(x) = R_A x - ...$

Correction de l'examen RDM2
3LMD Genie Civil

Exercice 1 : (05pts)



① $2n = b + 3$

$\begin{cases} n = 8 \\ b = 13 \end{cases}$

$\Rightarrow$ $16 = 16$ système isostatique (1)

② $\Sigma M/8 = 0 \Rightarrow R_1 . 4a - P.4a - P.3a - P.2a - P.a = 0$

$\Rightarrow R_1 = \frac{10P}{4} = \frac{5P}{2}$ ——— (0,5)

$\Sigma M/1 = 0 \Rightarrow -R_8 . 4a + P.4a + P.3a + P.2a + P.a = 0$

$\Rightarrow R_8 = \frac{10P}{4} = \frac{5P}{2}$ ——— (0,5)

③ Méthode des sections :

- $M_{③} = M(T_{52}) \Rightarrow T_{52} . a = \frac{5P}{2} . a - P.a$

  $\Rightarrow \boxed{T_{52} = \frac{3P}{2}}$ ——— (1)

- $M_{①} = M(T_{53}) \Rightarrow -T_{53} \frac{\sqrt{2}}{2} . 2a = P.a$

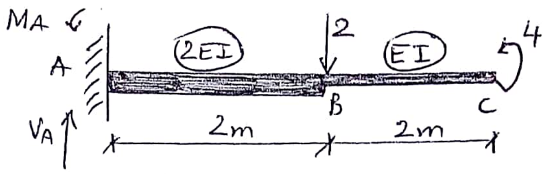
  $\Rightarrow \boxed{T_{53} = -\frac{P}{\sqrt{2}} = -\frac{P\sqrt{2}}{2}}$ ——— (1)

- $M_{⑤} = M(T_{43}) \Rightarrow -T_{43} . \frac{\sqrt{2}}{2} . 2a = -P.a - P.2a + \frac{5}{2} P.2a$

  $\Rightarrow \boxed{T_{43} = -\frac{2P}{\sqrt{2}} = -P\sqrt{2}}$ ——— (1)

$M(x) = R_{Az} \cdot x = 1,5 P x$ { $M(4) = 1,5 P$; $M(1) = \ldots P$ }

Exercice 2 : (8pts)



Reactions d'appui :

$\Sigma M/A = 0 \Rightarrow -M_A + 2 \cdot 2 - 4 = 0 \Rightarrow M_A = 0$ ——— 0,25

$\Sigma F/y = 0 \Rightarrow V_A - 2 = 0 \Rightarrow V_A = 2$ ——— 0,25

Sections des moments : (A gauche)

$0 \leq x \leq 2m$: $-M_1 + 2x = 0 \Rightarrow M_1 = 2x$ ——— 0,25

$2 \leq x \leq 4m$: $-M_2 + 2x - 2(x-2) = 0 \Rightarrow M_2 = 4$ ——— 0,25

① **Energie de Déformation : (Flexion simple)**

$$W = \frac{1}{2EI} \int_0^{\ell} m_f^2 \, dx$$

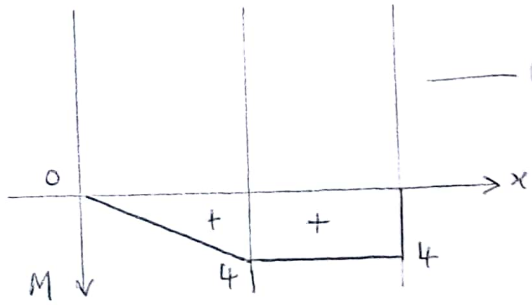
$$\Rightarrow W = \frac{1}{2} \left[\int_0^2 \frac{(2x)(2x)}{2EI} dx + \int_2^4 \frac{(4)(4)\,dx}{EI} \right] = \frac{56}{3EI}$$

$$\Rightarrow W = \frac{56}{3EI}$$ ——— 1

② **Calcul des déformations par la méthode de VERESCHEAGUINE :**

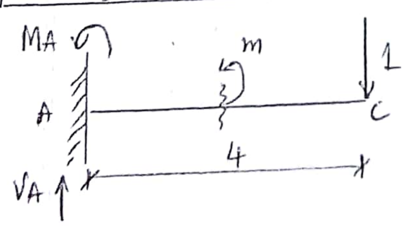
- **Calcul du déplacement Δ_C :**

Charges réelles $\Rightarrow$



——— 1

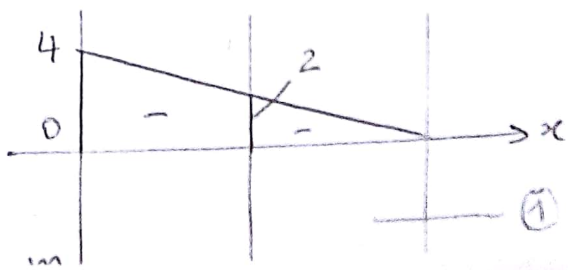
Charges unitaires



$\Sigma M/A = 0 \Rightarrow -M_A + 1 \cdot 4 = 0 \Rightarrow M_A = 4$

$\Sigma F/y = 0 \Rightarrow V_A - 1 = 0 \Rightarrow V_A = 1$

$-m + 1 \cdot x - 4 = 0 \Rightarrow m = x - 4$



——— 1

$M(x) = 1{,}5\,Px - 2P(x-1) = \dots$

$M(A) = 1{,}5\,P$

Alors :

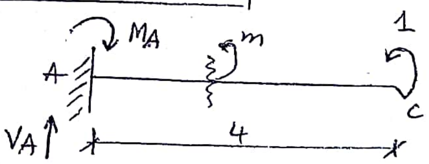
$$\Delta_C = -\frac{1}{2EI}\left[\frac{1}{6}\cdot 4\cdot 2\left(2\cdot 2+4\right)\right] - \frac{1}{EI}\left[\frac{1}{2}\cdot 4\cdot 2\cdot 2\right]$$

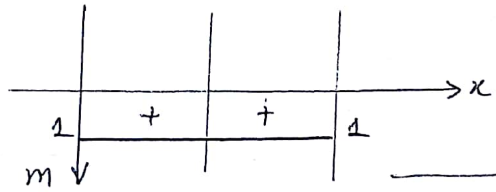
$$\Rightarrow \Delta_C = -\frac{40}{3EI} \qquad \text{—— } 0{,}5$$

• Calcul de la rotation θ_C :

$\boxed{\text{charges unitaires}} \Rightarrow$

$$\begin{cases} \Sigma M/A = 0 \Rightarrow M_A - 1 \Rightarrow M_A = 1 \\ \Sigma F/y = 0 \Rightarrow V_A = 0 \\ -m + 1 = 0 \Rightarrow m = 1 \end{cases}$$





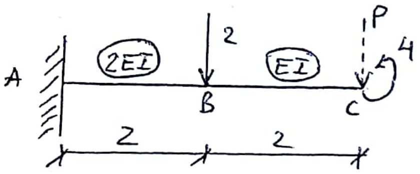
—— 1

Alors :

$$\theta_C = \frac{1}{2EI}\left(\frac{1}{2}\cdot 4\cdot 2\cdot 1\right) + \frac{1}{EI}\left(4\cdot 2\cdot 1\right) = \frac{10}{EI}$$

$$\Rightarrow \theta_C = \frac{10}{EI} \qquad \text{—— } 0{,}5$$

③ Théorème de CASTIGLIANO (vérification des résultats) :



force fictive P

$$\Delta_C = \int_l \frac{\partial M_f}{\partial P_C}\cdot\frac{M_f}{EI}\,dx$$

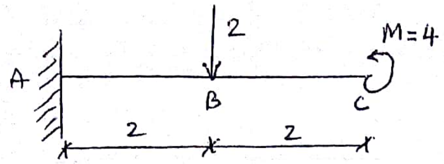
Sections des moments prises à droite de la poutre :

$$\begin{cases} M_{f_1} + Px - 4 = 0 \Rightarrow M_{f_1} = 4 - Px \\ M_{f_2} + Px - 4 + 2(x-2) = 0 \Rightarrow M_{f_2} = 8 - Px - 2x \end{cases}$$

$$\Rightarrow \Delta_C = \frac{1}{EI}\left[\int_0^2 (-x)(4-Px)\,dx + \int_2^4 \frac{1}{2}\cdot(-x)(-2x+8-Px)\,dx\right]$$

En posant $P=0$: $\Rightarrow \boxed{\Delta_C = \frac{-40}{3EI}}$ (OK) —— 1

$M(x) = R_{Az} \cdot x = 1{,}5\,Px$; $M(x) = 1{,}5\,Px - 2P(x-1)$



$$\theta_C = \int_l \frac{\partial M_f}{\partial M_c} \cdot \frac{M_f}{EI}\, dx$$

sections des moments prises à droite de la poutre :

$$\begin{cases} M_{f1} - M = 0 \Rightarrow M_{f1} = M \\ M_{f2} - M + 2(x-2) = 0 \Rightarrow M_{f2} = M - 2x + 4 \end{cases}$$

$$\Rightarrow \theta_C = \frac{1}{EI}\left[\int_0^2 (1)(M)\,dx + \int_2^4 \frac{1}{2}(1)(M-2x+4)\,dx\right]$$

$$\Rightarrow \theta_C = \frac{10}{EI} \quad \text{(OK)} \quad (1)$$

2

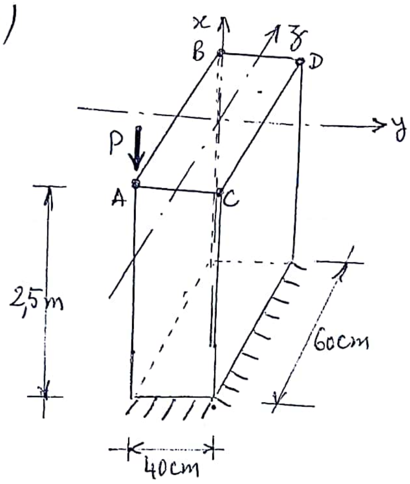
Calcule de My

$0 \leq x < 1$ | $1 \leq x < 4$

$M(x) = R_{Az} \cdot x = 1{,}5\,Px$ | $M(x) = 1{,}5\,Px - 2P(x-1) = \cancel{Px}(1{,}5 - 1 + 2) - 2{,}5\,Px$

$M(1) = 1{,}5\,P$

Exercice 3 : (05 pts)



$A\begin{pmatrix}-0{,}2\\-0{,}3\end{pmatrix}$ $B\begin{pmatrix}-0{,}2\\+0{,}3\end{pmatrix}$ $C\begin{pmatrix}+0{,}2\\-0{,}3\end{pmatrix}$ $D\begin{pmatrix}+0{,}2\\+0{,}3\end{pmatrix}$

- Contraintes normales :

(1) $$\sigma_x = \frac{N_x}{A} + \frac{M_y}{I_y}\cdot z + \frac{M_z}{I_z}\cdot y$$

$A = 0{,}4 \times 0{,}6 = 0{,}24\ m^2$

$N_x = -\left[25 + 2{,}4(0{,}24 \times 2{,}5)\right] = -26{,}44$ tonnes

$I_y = \dfrac{bh^3}{12} = \dfrac{0{,}4\,(0{,}6)^3}{12} = 0{,}0072\,m^4$

$I_z = \dfrac{hb^3}{12} = \dfrac{0{,}6\,(0{,}4)^3}{12} = 0{,}0032\,m^4$

$M_y = P\cdot\dfrac{h}{2} = 25\cdot\dfrac{0{,}6}{2} = 7{,}5\ t.m$

$M_z = P\cdot\dfrac{b}{2} = 25\cdot\dfrac{0{,}4}{2} = 5\ t.m$

(0,5)

Alors : $$\sigma_x = -\frac{26{,}44}{0{,}24} + \frac{7{,}5}{0{,}0072}\cdot z + \frac{5}{0{,}0032}\cdot y = -110{,}17 + 1041{,}67\,z + 1562{,}5\,y$$

Donc :

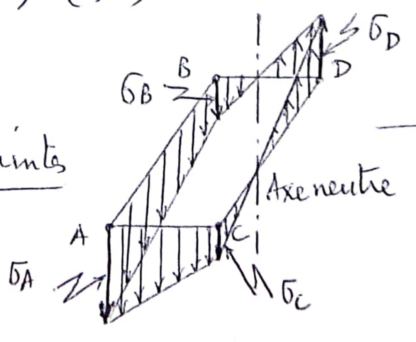
$\sigma_A = -110{,}17 + 1041{,}67(-0{,}3) + 1562{,}5(-0{,}2) = -735{,}2\ t/m^2$

$\sigma_B = -110{,}17 + 1041{,}67(0{,}3) + 1562{,}5(-0{,}2) = -110{,}2\ t/m^2$ — (1)

$\sigma_C = -110{,}17 + 1041{,}67(-0{,}3) + 1562{,}5(0{,}2) = -110{,}2\ t/m^2$

$\sigma_D = -110{,}17 + 1041{,}67(0{,}3) + 1562{,}5(0{,}2) = 514{,}8\ t/m^2$

Diagramme des Contraintes



— (1)

Calcul de My

$0 \leq x < 1$

$1 \leq x \leq 4$

$M(x) = 1{,}5\,Px - 2P(x-1) = Px(1{,}5 - 1 + \dots)$

2) les coordonnées de l'axe neutre

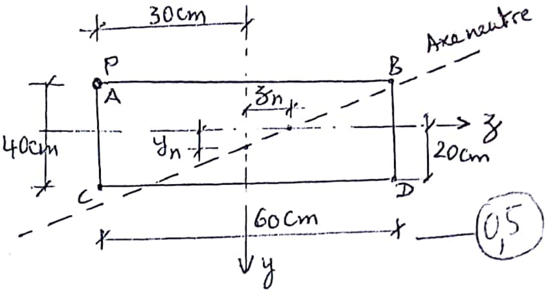
$y_p = -20\ cm$

$z_p = -30\ cm$

$A = 2400\ cm^2$

$I_z = 32.10^4\ cm^4$

$I_y = 72.10^4\ cm^4$



— 0,5

On a : $\begin{cases} y_n = -\dfrac{i_z^2}{y_p} \\ z_n = -\dfrac{i_y^2}{z_p} \end{cases}$ et $\begin{cases} i_z^2 = \dfrac{I_z}{A} = \dfrac{32.10^4}{24.10^2} = 133{,}33\ cm^2 \\ i_y^2 = \dfrac{I_y}{A} = \dfrac{72.10^4}{24.10^2} = 300\ cm^2 \end{cases}$

$\Rightarrow \begin{cases} y_n = -\dfrac{133{,}33}{-20} = 6{,}67\ cm \\ z_n = -\dfrac{300}{-30} = 10\ cm \end{cases}$ — 1

3) Critère de Résistance :

$$\max \sigma_x = \frac{N_x}{A} \pm \frac{M_y}{W_y} \pm \frac{M_z}{W_z} \quad \text{avec} \quad \begin{cases} W_y = \dfrac{I_y}{z} \\ W_z = \dfrac{I_z}{y} \end{cases}$$

Donc : $\begin{cases} W_y = \dfrac{\frac{0{,}4(0{,}6)^3}{12}}{0{,}3} = 24.10^{-3}\ m^3 \\ W_z = \dfrac{\frac{0{,}6(0{,}4)^3}{12}}{0{,}2} = 16.10^{-3}\ m^3 \end{cases}$

Alors :

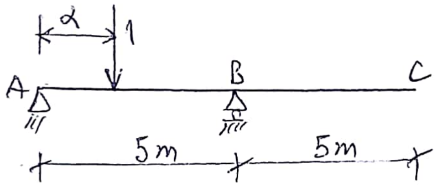
$$\max \sigma_x^+ = \frac{N_x}{A} + \frac{M_y}{W_y} + \frac{M_z}{W_z} = \frac{-26{,}44}{0{,}24} + \frac{7{,}5}{24.10^{-3}} + \frac{5}{16.10^{-3}} = 514{,}83\ t/m^2$$

$\Rightarrow \boxed{\max \sigma_x^+ < [\sigma]^+ \quad (OK)}$ — 0,5

et : $$\max \sigma_x^- = \frac{N_x}{A} - \frac{M_y}{W_y} - \frac{M_z}{W_z} = \frac{-26{,}44}{0{,}24} - \frac{7{,}5}{24.10^{-3}} - \frac{5}{16.10^{-3}} = -735{,}17\ t/m^2$$

$\Rightarrow \boxed{\max \sigma_x^- < [\sigma]^- \quad (OK)}$ — 0,5

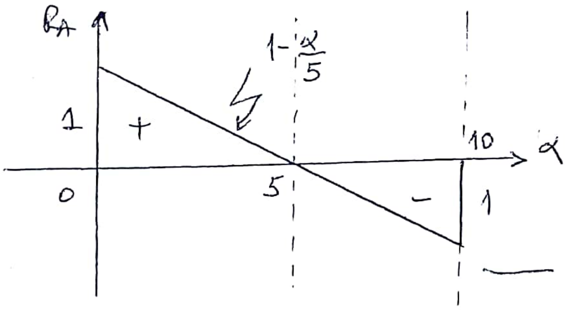
Exercice 4 : (02 pts)



- La ligne d'Influence de la réaction d'appui en A :

$$\sum M/_B = 0 \Rightarrow R_A \cdot 5 - 1(5-\alpha) = 0$$

$$\Rightarrow R_A = \frac{5-\alpha}{5} = 1 - \frac{\alpha}{5} \quad \text{—— } 0{,}5$$

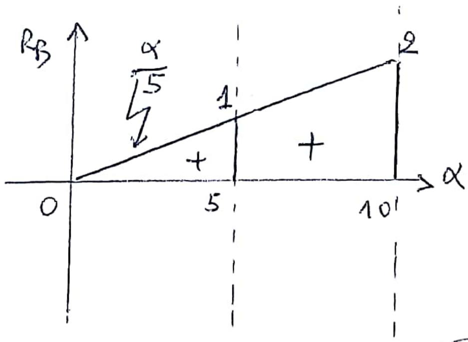


—— 0,5

- La ligne d'Influence de la réaction d'appui en B :

$$\sum M/A = 0 \Rightarrow -R_B \cdot 5 + 1 \cdot \alpha = 0$$

$$\Rightarrow R_B = \frac{\alpha}{5} \quad \text{—— } 0{,}5$$



—— 0,5