Semaine 14
QCMs

ME-332 – Mécanique Vibratoire

École
polytechnique
fédérale
de Lausanne

Plan du cours

Week	Jours	Partie du cours	Exercices	Homework
1	09.09//11.09	Intro et oscillateur 1D libre conservatif	Série 1	Leçon 1.1&1.2
2	18.09	Oscillateur 1D libre dissipatif	Série 2	Leçon 2.1&2.2
3	23.09//25.09	Régime permanent harmonique (complexe)	Série 3	Leçon 3.1&3.2
4	30.09//02.10	Régime permanent périodique (série de Fourier)	Série 4	Leçon 4.1&4.2
5	07.10//09.10	Régime forcé général (transf. Laplace ou Fourier)	Série 5	Leçon 5.1&5.2
6	14.10//16.10	Systèmes à 2 DDL conservatifs	Série 6	Leçon 6.1&6.2
BREAK!!!				
7	28.10//30.10	Récapitulatif // séance de QCMs	MIDTERM	
8	04.11//06.11	Systèmes à 2DDL dissipatifs, osc. de Frahm	Série 7	Leçon 7.1&7.2
9	11.11//13.11	Systèmes à n DDL, conservatif	Série 8a	Leçon 8.1&8.2
10	18.11//20.11	Systèmes à n DDL, conservatif	Série 8b	
11	25.11//27.11	Systèmes à n DDL, dissipatif	Série 9	Leçon 9.1&9.2
12	02.12//04.12	Systèmes à n DDL, forcé	Série 10	Leçon 10.1&10.2
13	09.12//11.12	Systèmes continus: barres & poutres	Série 11	Leçon 11.1&11.2
14	16.12//18.12	Récapitulatif // séances de QCMs		

Before we start… let's connect!

- Smartphones
  - iPhone
  - Android

  } Download and install the app "*PointSolutions*"

- Computers (or Windows Phones)
  - Go to www.responseware.eu

- Choose **EUROPE Server** (if asked)
- Join session – **ME332**
- When asked – **do not input your name. Enter as anonymous.**

Final Exam

- Date: 28 Janvier (2025)
- Heure: 15h30 – 18h00 (2h30)
  - Doors open at 15h15
- Salles: CE16, PO01
- Contenu: Tout le semestre
- Formulaire:
  - Une page A4 «recto-verso»

- Pas oublier:
  - Stylo (Ni rouge ni vert – PAS crayon)
  - Calculatrice (pas matrices)
  - EPFL ID – Camipro

- Exam:
  - 1-2 questions courtes
  - 2-3 problèmes

- 70% de la note finale

- Séance de doutes:
  - Salle: ???
  - Date: 24 Janvier 2024
  - Heure: ???

Si $C = c\mathbb{I}$, C^0 en coordonnées modales?

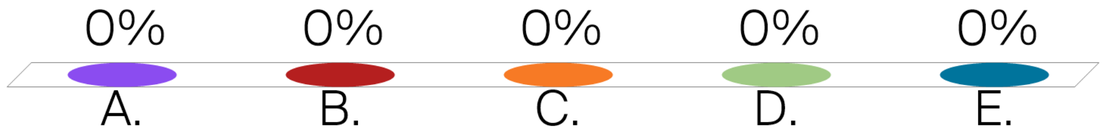
A. $K = k\mathbb{I}$

B. $K = 2k\mathbb{I}$

C. $C^0 = c\begin{pmatrix} 3 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 6 \end{pmatrix}$

D. Ça dépend

E. Je ne sais pas



Si $C = c\mathbb{I}$, C^0 en coordonnées modales?

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix};\ \vec{\beta}_{II} = \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix};\ \vec{\beta}_{III} = \begin{pmatrix} 1 \\ -2 \\ 1 \end{pmatrix}$$

A. $K = k\mathbb{I}$

B. $K = 2k\mathbb{I}$

C. $C^0 = c\begin{pmatrix} 3 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 6 \end{pmatrix}$

$c_{I,eff} = c \cdot |\beta_I|^2$

$c_{II\,eff} = c \cdot |\beta_{II}|^2$

$c_{III,eff} = c\ |\beta_{III}|^2$

D. Ça dépend

E. Je ne sais pas

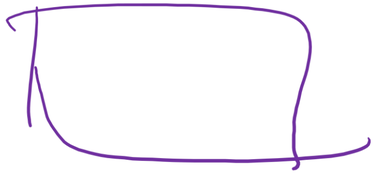
$C^0 = B^T \cdot C \cdot B$

$C^0 = c \cdot B^T \cdot B$

M, K, C

$C M^{-1} K = K M^{-1} C$

$C = \alpha \cdot M + \beta \cdot K$

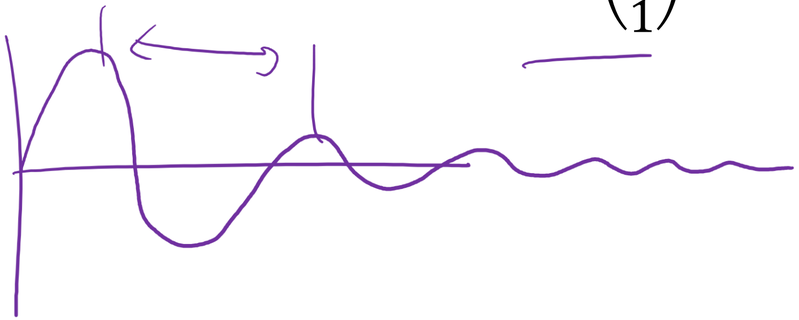


A.	B.	C.	D.	E.
0%	0%	0%	0%	0%

Dans quelles C.I. le système bougera à $\omega_{0,I}$?

$$\vec{\beta}_I = \begin{pmatrix}1\\1\\1\end{pmatrix};\ \vec{\beta}_{II} = \begin{pmatrix}1\\0\\-1\end{pmatrix};\ \vec{\beta}_{III} = \begin{pmatrix}1\\-2\\1\end{pmatrix}$$

$\omega_I = \omega_0\sqrt{1-\eta^2}$



A. $\vec{x}(0) = \begin{pmatrix}1\\0\\0\end{pmatrix}\mathrm{m}, \dot{\vec{x}}(0) = \begin{pmatrix}0\\0\\0\end{pmatrix}\frac{\mathrm{m}}{\mathrm{s}};$

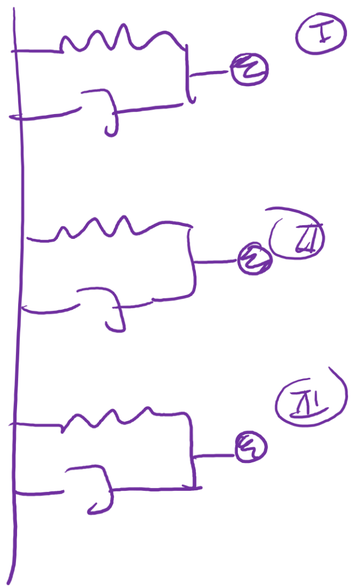
B. $\vec{x}(0) = \begin{pmatrix}1\\1\\1\end{pmatrix}\mathrm{m}, \dot{\vec{x}}(0) = \begin{pmatrix}0\\0\\0\end{pmatrix}\frac{\mathrm{m}}{\mathrm{s}};$

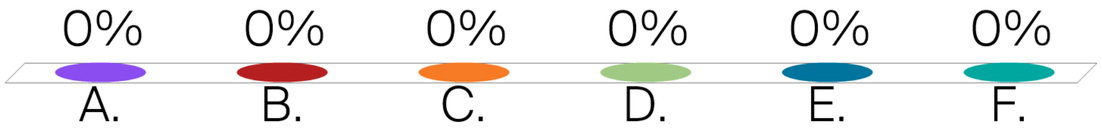
C. $\vec{x}(0) = \begin{pmatrix}0\\0\\0\end{pmatrix}\mathrm{m}, \dot{\vec{x}}(0) = \begin{pmatrix}1\\1\\1\end{pmatrix}\frac{\mathrm{m}}{\mathrm{s}};$

D. $\vec{x}(0) = \begin{pmatrix}1\\1\\1\end{pmatrix}\mathrm{m}, \dot{\vec{x}}(0) = \begin{pmatrix}1\\1\\1\end{pmatrix}\frac{\mathrm{m}}{\mathrm{s}};$

E. Je ne sais pas

F. None of the above





Si $\vec{x}(0) = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \dot{\vec{x}}(0) = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \frac{\mathrm{m}}{\mathrm{s}}$, calculer $\vec{x}(t)$ en régime permanent

$\vec{x}(t) = \vec{0}$

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}; \ \vec{\beta}_{II} = \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}; \ \vec{\beta}_{III} = \begin{pmatrix} 1 \\ -2 \\ 1 \end{pmatrix}$$

Si $\vec{x}(0) = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \dot{\vec{x}}(0) = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \frac{\mathrm{m}}{\mathrm{s}}$, calculer $\vec{x}(t)$

$\eta < 1$

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}; \ \vec{\beta}_{II} = \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}; \ \vec{\beta}_{III} = \begin{pmatrix} 1 \\ -2 \\ 1 \end{pmatrix}$$

$\vec{x}(0) = q_I(0) \cdot \vec{\beta}_I + q_{II}(0)\, \vec{\beta}_{II} + q_{III}(0) \cdot \vec{\beta}_{III}$

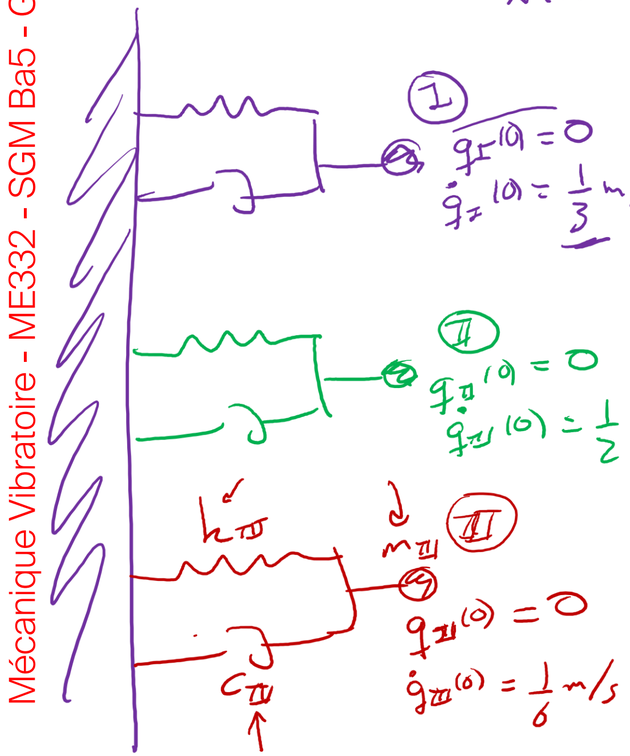
$\dot{\vec{x}}(0) = \dot{q}_I(0) \cdot \vec{\beta}_I + \dot{q}_{II}(0)\, \vec{\beta}_{II} + \dot{q}_{III}(0)\, \vec{\beta}_{III}$

$\vec{\beta}_I \cdot \dot{\vec{x}}(0) = \dot{q}_I(0)\, \vec{\beta}_I \cdot \vec{\beta}_I + \cancel{\vec{\beta}_I \cdot \dot{q}_{II}(0) \cdot \vec{\beta}_{II}} + \cancel{\vec{\beta}_I \cdot \dot{q}_{III}(0) \cdot \vec{\beta}_{III}}$

$\dot{q}_I(0) = \dfrac{\vec{\beta}_I \cdot \dot{\vec{x}}(0)}{|\beta_I|^2} = \dfrac{1}{3}\ \mathrm{m/s}$

$\dot{q}_{II}(0) = \dfrac{\vec{\beta}_{II} \cdot \dot{\vec{x}}(0)}{|\beta_{II}|^2} = \dfrac{1}{2}\ \mathrm{m/s}$

$\dot{q}_{III}(0) = \dfrac{\vec{\beta}_{III} \cdot \dot{\vec{x}}(0)}{|\vec{\beta}_{III}|^2} = \dfrac{1}{6}\ \mathrm{m/s}$



$q_I(t) = Q_I \cdot e^{-\lambda_I t} \cdot \cos(\omega_I t - \varphi_I)$

$q_I(0) = Q_I \cdot \cos\varphi_I \Rightarrow \varphi_I = \pi/2$

$q_I(t) = Q_I \cdot e^{-\lambda_I t} \cdot \sin(\omega_I t)$

$\dot{q}_I(t) = Q_I \cdot (-\lambda_I) \cdot e^{-\lambda_I t} \cdot \sin(\omega_I t) + Q_I \cdot e^{-\lambda_I t} \cdot (\omega_I) \cdot \cos(\omega_I t)$

$\dot{q}_I(0) = Q_I \cdot \omega_I = \frac{1}{3}\ \mathrm{m/s} \Rightarrow \boxed{Q_I = \frac{1}{3\omega_I}\ \mathrm{m}} \Rightarrow \boxed{q_I(t) = \frac{1}{3\omega_I} e^{-\lambda_I t} \cdot \sin(\omega_I t)}$

$q_{II}(t) = \dfrac{1}{2\omega_{II}} \cdot e^{-\lambda_{II} t} \cdot \sin(\omega_{II} t)$

$q_{III}(t) = \dfrac{1}{6\omega_{III}} e^{-\lambda_{III} t} \cdot \sin(\omega_{III} t)$

$\vec{x} = B \cdot \vec{q} \Rightarrow \vec{q} = B^{-1} \vec{x} \Rightarrow \vec{q}(0) = B^{-1} \cdot \vec{x}(0)$

$\dot{\vec{q}}(0) = B^{-1} \cdot \dot{\vec{x}}(0)$

Si $\vec{x}(0) = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \dot{\vec{x}}(0) = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \frac{\mathrm{m}}{\mathrm{s}}$, calculer $\vec{x}(t)$

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}; \ \vec{\beta}_{II} = \begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}; \ \vec{\beta}_{III} = \begin{pmatrix} 1 \\ -2 \\ 1 \end{pmatrix}$$

$$\boxed{\vec{x}(t) = \Theta \cdot \vec{q} = q_I(t) \cdot \vec{\beta}_I + q_{II}(t) \cdot \vec{\beta}_{II} + q_{III}(t) \cdot \vec{\beta}_{III}}$$

$$C^0 = c \begin{pmatrix} 3 & & 0 \\ & 2 & \\ 0 & & 6 \end{pmatrix} \rightarrow$$

$c_I = 3c$

$c_{II} = 2c$

$c_{III} = 6c$; $\lambda_{III} = \frac{c_{III}}{2m_{III}}$

$$\omega_{1,III} = \omega_{0,III} \cdot \sqrt{1 - \eta_{III}^2}$$

$$\omega_{0,III} = \sqrt{\frac{k_{III}}{m_{III}}} \qquad \eta_{III} = \frac{\lambda_{III}}{\omega_{0,III}}$$

$$\vec{\beta}_I \cdot M \cdot \vec{x} = \vec{\beta}_I M \left(q_I \vec{\beta}_I + q_{II} \cdot \vec{\beta}_{II} + q_{III} \cdot \vec{\beta}_{III} \right)$$

$$\vec{\beta}_i \cdot M \cdot \vec{\beta}_j \propto \delta_{ij}$$

$$q_I = \frac{\vec{\beta}_I \cdot M \cdot \vec{x}}{\vec{\beta}_I \cdot M \cdot \vec{\beta}_I}$$

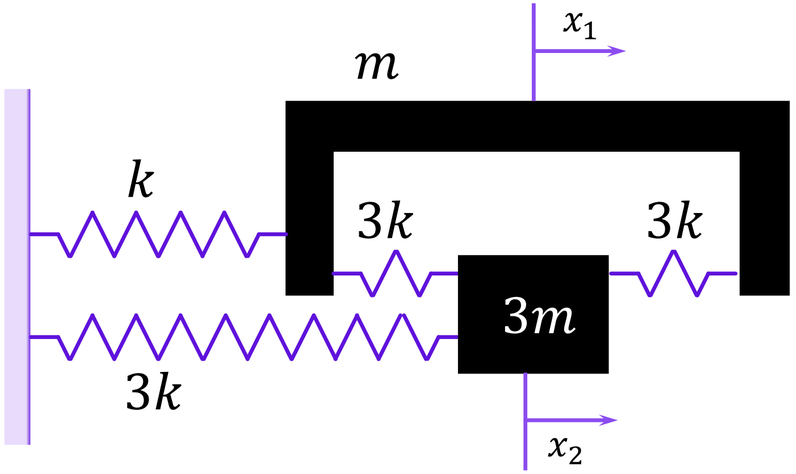
Energie Cinétique?

A. $T = \frac{1}{2} m\dot{x}_1^2 + \frac{1}{2} 3m\dot{x}_2^2$

B. $T = \frac{1}{2} 3m\dot{x}_1^2 + \frac{1}{2} m\dot{x}_2^2$

C. $T = \frac{1}{2} m\dot{x}_1^2 + \frac{1}{2} m\dot{x}_2^2$

D. Je ne sais pas



Energie Potentielle?

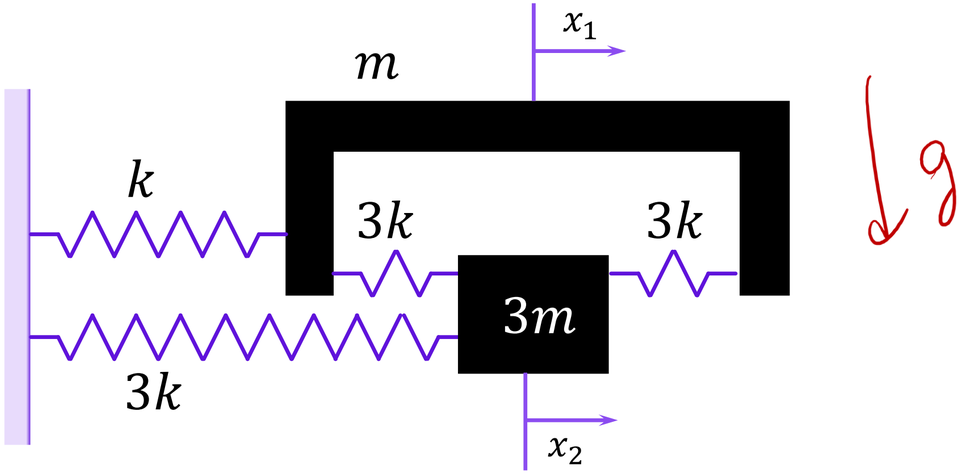
A. $V = \frac{1}{2}kx_1^2 + \frac{1}{2}kx_2^2 + \frac{1}{2}k(x_1 - x_2)^2$

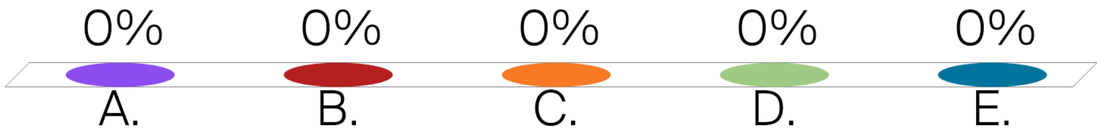
B. $V = \frac{1}{2}kx_1^2 + \frac{3}{2}kx_2^2 + 3k(x_1 - x_2)^2$

C. $V = \frac{1}{2}kx_1^2 + \frac{3}{2}kx_2^2 + 3k(x_1 + x_2)^2$

D. $V = \frac{1}{2}kx_1^2 + \frac{1}{2}kx_2^2 + k(x_1 - x_2)^2$

E. Je ne sais pas





Matrice de masse dans coordonnées x_i?

A. $\begin{pmatrix} m & 0 \\ 0 & 3m \end{pmatrix}$

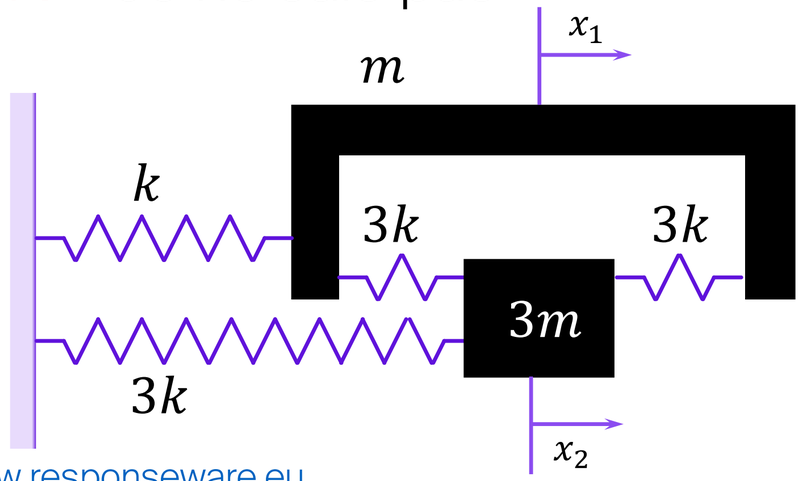
B. $\begin{pmatrix} 3m & 0 \\ 0 & m \end{pmatrix}$

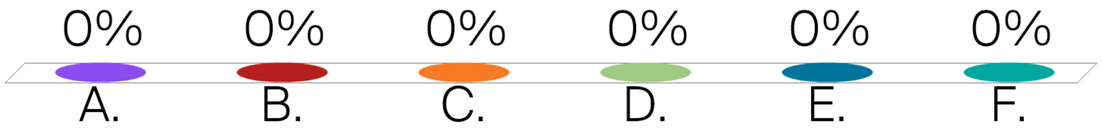
C. $\begin{pmatrix} m & 0 \\ 0 & m \end{pmatrix}$

D. $\begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix}$

E. Ça dépend

F. Je ne sais pas





Matrice de rigidité dans coordonnées x_i?

A. $\begin{pmatrix} 7k & -6k \\ -6k & 9k \end{pmatrix}$

B. $\begin{pmatrix} 7 & -6 \\ -6 & 9 \end{pmatrix}$

C. $\begin{pmatrix} 7 & 6 \\ 6 & 9 \end{pmatrix} k$

D. $\begin{pmatrix} 7k & 6k \\ 6k & 9k \end{pmatrix}$

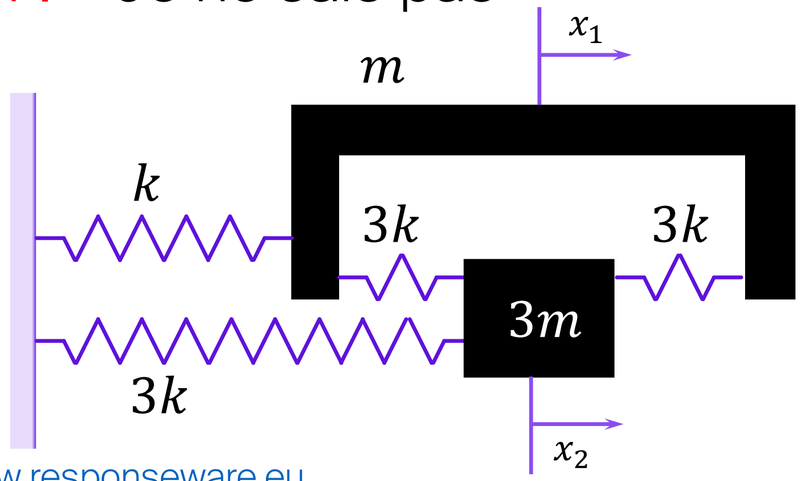
E. Ça dépend

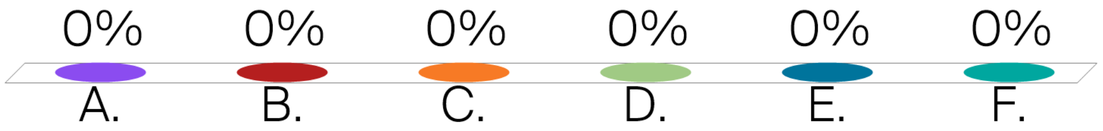
F. Je ne sais pas

$V = \frac{1}{2} k x_1^2 + \frac{1}{2} 3k x_2^2 + \frac{1}{2} 3k (x_1 - x_2)^2$

$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{x}_1}\right) + \frac{\partial V}{\partial x_1} = 0 \rightarrow \frac{\partial V}{\partial x_1} = k x_1 + 6k(x_1 - x_2) = 7k x_1 - 6k x_2$

$\frac{\partial V}{\partial x_2} = 3k x_2 + 6k(x_2 - x_1) = 9k x_2 - 6k x_1$





Matrice de masse dans coordonnées q_i?

A. $\begin{pmatrix} m & 0 \\ 0 & 3m \end{pmatrix}$

B. $\begin{pmatrix} 3m & 0 \\ 0 & m \end{pmatrix}$

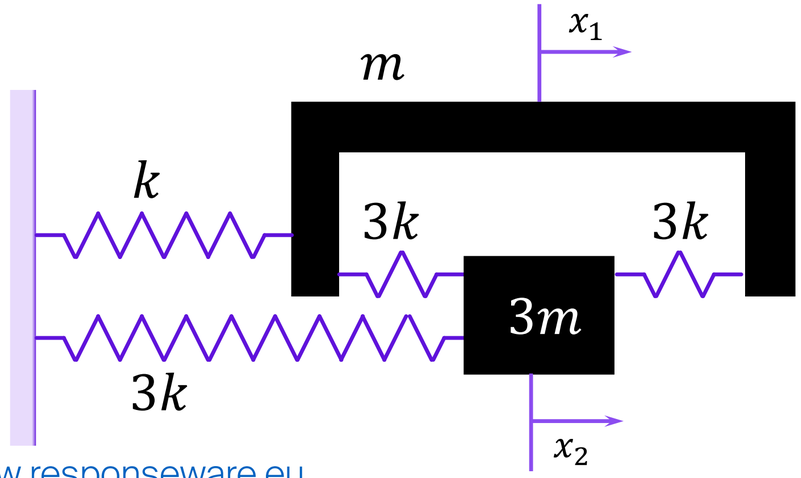
C. $\begin{pmatrix} m & 0 \\ 0 & m \end{pmatrix}$

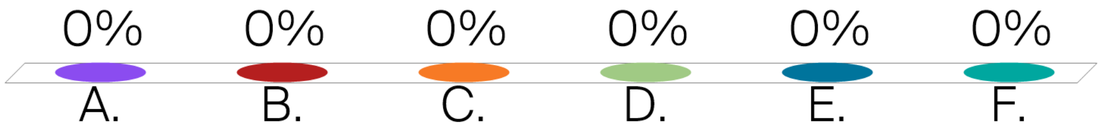
D. $\begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix}$

E. Ça dépend

F. Je ne sais pas

$M^0 = B^T M B$





Matrice de ~~masse~~ rigidité dans coordonnées q_i?

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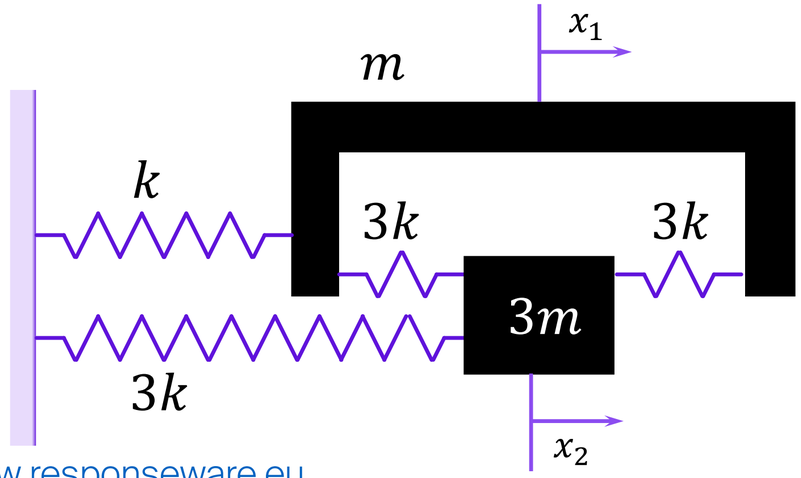
B. $\begin{pmatrix} 7 & -6 \\ -6 & 9 \end{pmatrix}$

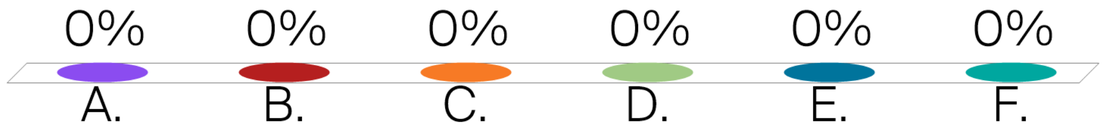
C. $\begin{pmatrix} 7 & 6 \\ 6 & 9 \end{pmatrix} k$

D. $\begin{pmatrix} 7k & 6k \\ 6k & 9k \end{pmatrix}$

E. Ça dépend

F. Je ne sais pas





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- Join session – **ME332**
- When asked – **do not input your name. Enter as anonymous.**

Final Exam

- Date: 28 Janvier (2025)
- Heure: 15h30 – 18h00 (2h30)
  - Doors open at 15h15
- Salles: CE16, PO01
- Contenu: Tout le semestre
- Formulaire:
  - Une page A4 «recto-verso»

- Pas oublier:
  - Stylo (Ni rouge ni vert – PAS crayon)
  - Calculatrice (pas matrices)
  - EPFL ID – Camipro

- Exam:
  - 1-2 questions courtes
  - 2-3 problèmes

- 70% de la note finale

- Séance de doutes:
  - Salle: MED 0 1418
  - Date: 24 Janvier 2024
  - Heure: 13h30-16h30

Matrice noyau dans coordonnées x_i?

A. $\frac{k}{m}\begin{pmatrix}1 & 0\\ 0 & 3\end{pmatrix}$

B. $\frac{k}{m}\begin{pmatrix}7 & -6\\ -2 & 3\end{pmatrix}$

C. $\begin{pmatrix}7 & -6\\ -2 & 3\end{pmatrix}$

D. $\frac{k}{m}\begin{pmatrix}7 & -6\\ -6 & 9\end{pmatrix}$

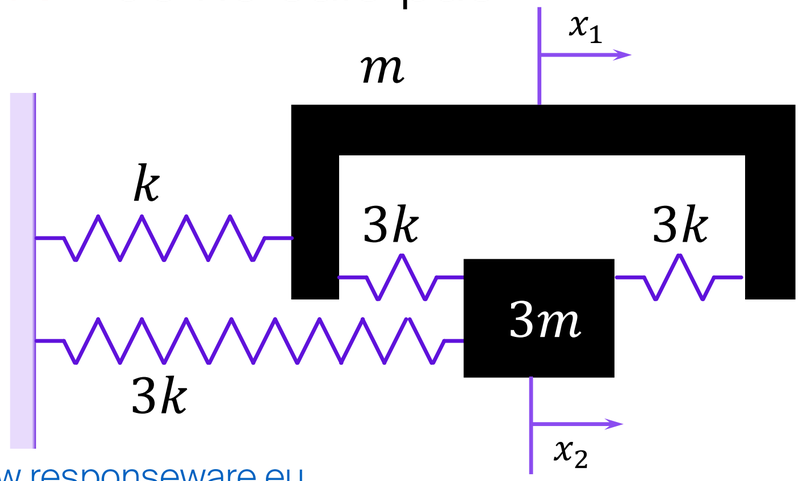
E. Ça dépend

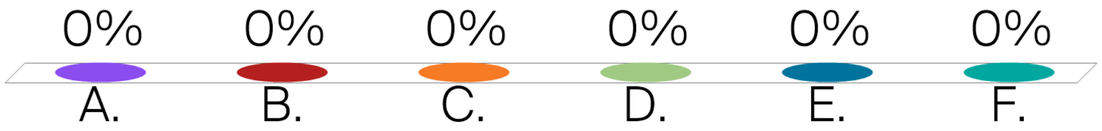
F. Je ne sais pas

$A = \underline{M}^{-1} K$

$M = m\begin{pmatrix}1 & 0\\ 0 & 3\end{pmatrix}$

$M^{-1} = \frac{1}{m}\begin{pmatrix}1 & 0\\ 0 & 1/3\end{pmatrix}$





Matrice noyau dans coordonnées q_i?

A. $\frac{k}{m}\begin{pmatrix}1 & 0\\ 0 & 3\end{pmatrix}$

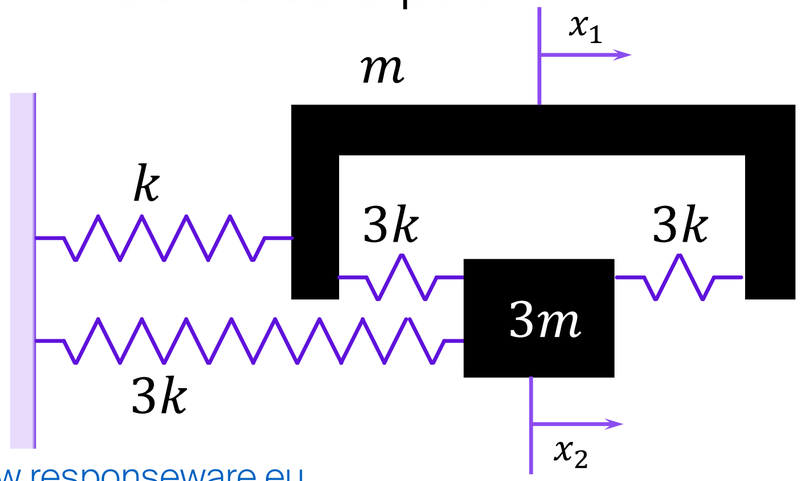
B. $\frac{k}{m}\begin{pmatrix}7 & -6\\ -2 & 3\end{pmatrix}$

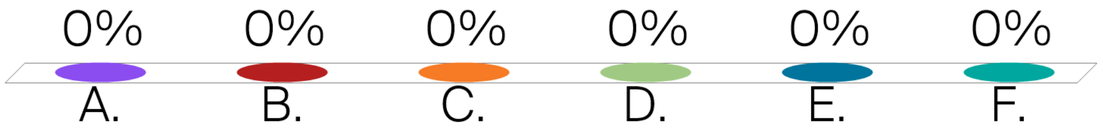
C. $\frac{k}{m}\begin{pmatrix}1 & 0\\ 0 & 9\end{pmatrix}$

D. $\frac{k}{m}\begin{pmatrix}9 & 0\\ 0 & 1\end{pmatrix}$

E. Ça dépend

F. Je ne sais pas





Calculer les vecteurs propres

Si $\vec{x}(0) = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \mathrm{m}, \dot{\vec{x}}(0) = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$, calculer $\vec{x}(t)$

Matrice de dissipation dans coordonnées x_i?

A. $\begin{pmatrix} c & 0 \\ 0 & 3c \end{pmatrix}$

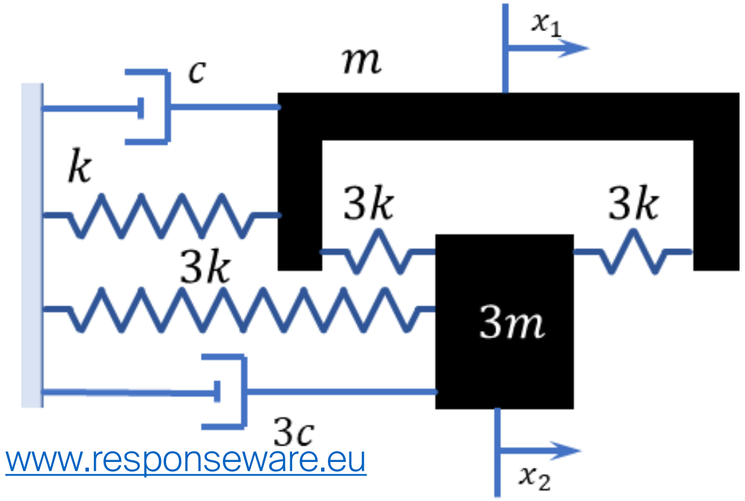
B. $\begin{pmatrix} 3c & 0 \\ 0 & c \end{pmatrix}$

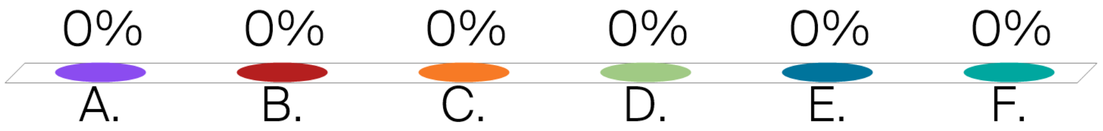
C. $\begin{pmatrix} c & 0 \\ 0 & c \end{pmatrix}$

D. $\begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix}$

E. Ça dépend

F. Je ne sais pas



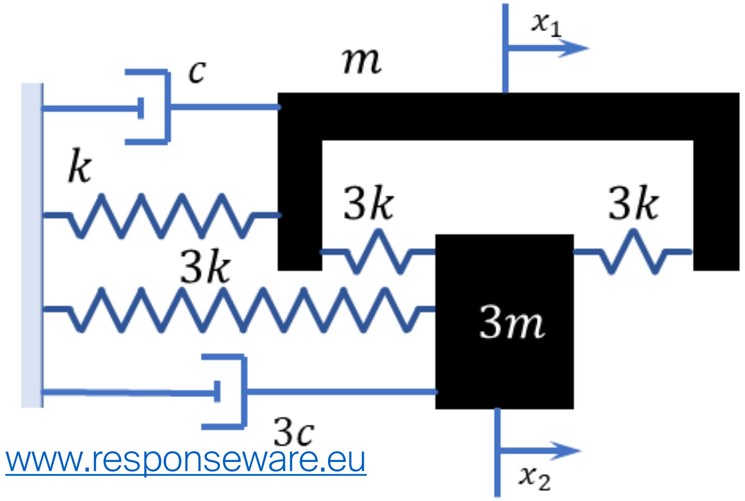


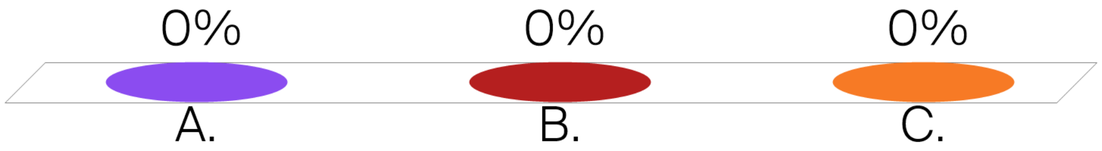
Système Caughey?

A. Oui

B. Non

C. Je ne sais pas





Matrice de dissipation dans coordonnées q_i?

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$

A. $\begin{pmatrix} c & 0 \\ 0 & 3c \end{pmatrix}$

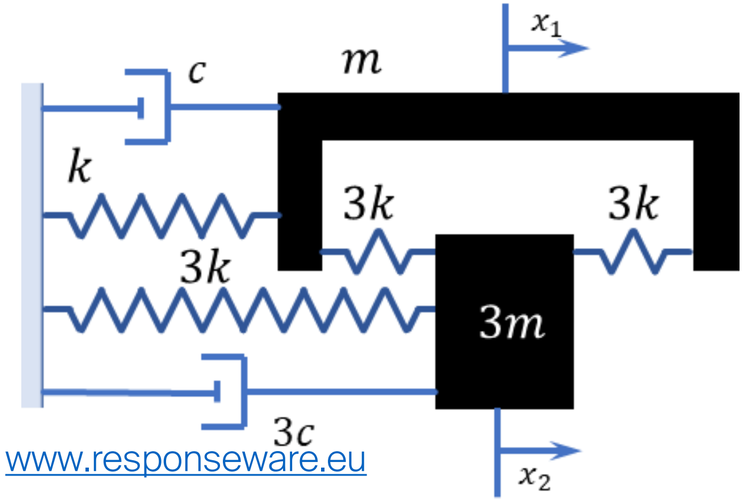
B. $\begin{pmatrix} 3c & 0 \\ 0 & c \end{pmatrix}$

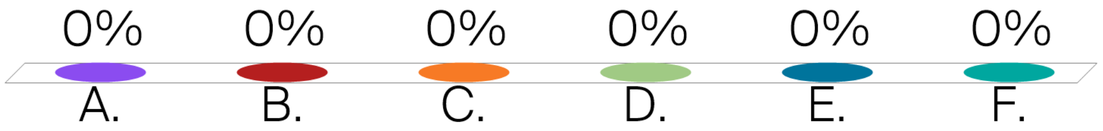
C. $\begin{pmatrix} c & 0 \\ 0 & c \end{pmatrix}$

D. $\begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix}$

E. Ça dépend

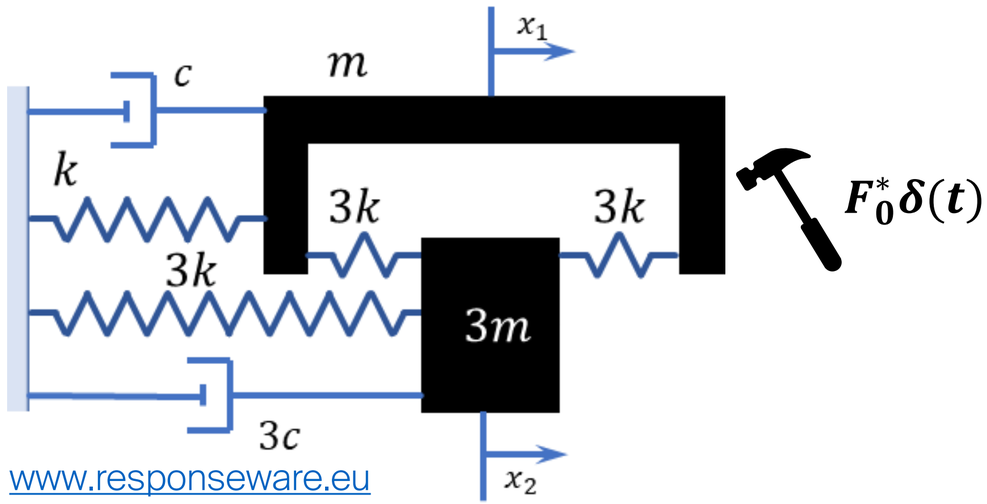
F. Je ne sais pas





Calculer $\vec{x}(t)$ en régime permanent

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$



Vecteur de force en coordonnées x_i?

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$

A. $F_0^* \delta(t) \begin{pmatrix} 1 \\ 1 \end{pmatrix}$

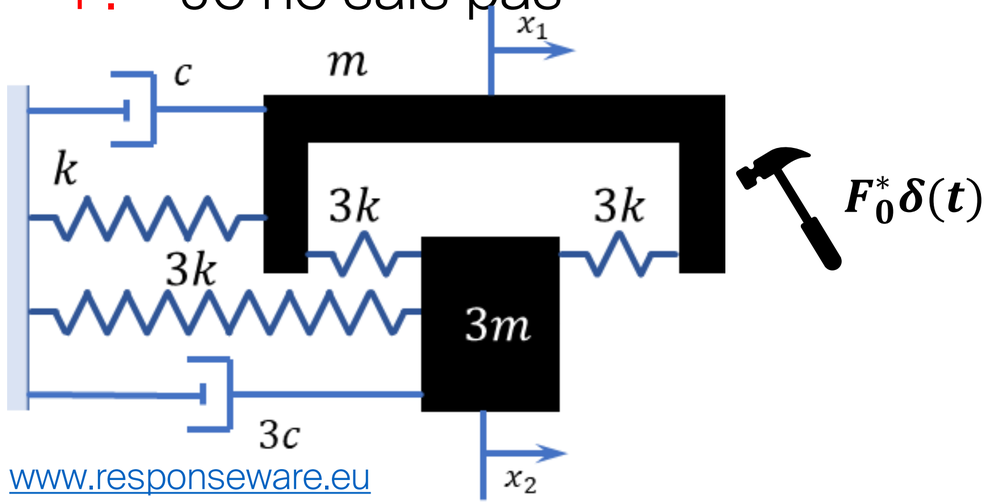
B. $F_0^* \delta(t) \begin{pmatrix} 1 \\ 0 \end{pmatrix}$

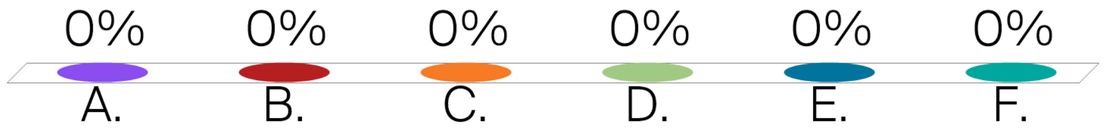
C. $F_0^* \delta(t) \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

D. $F_0^* \delta(t) \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$

E. Ça dépend

F. Je ne sais pas





Vecteur de force en coordonnées q_i?

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$

A. $F_0^* \delta(t) \begin{pmatrix} 1 \\ 1 \end{pmatrix}$

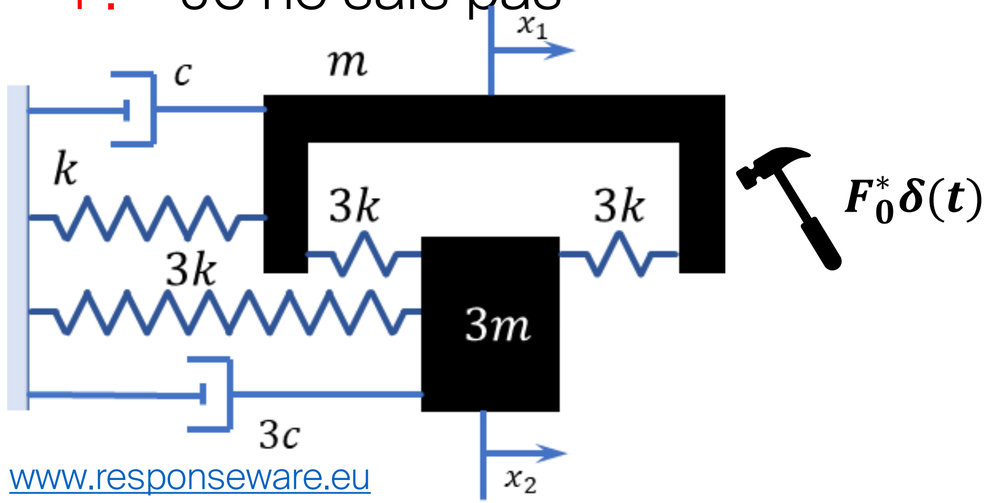
B. $F_0^* \delta(t) \begin{pmatrix} 1 \\ 0 \end{pmatrix}$

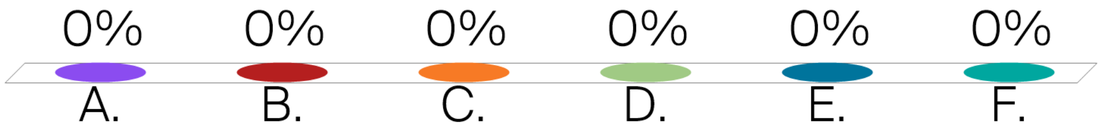
C. $F_0^* \delta(t) \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

D. $F_0^* \delta(t) \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$

E. Ça dépend

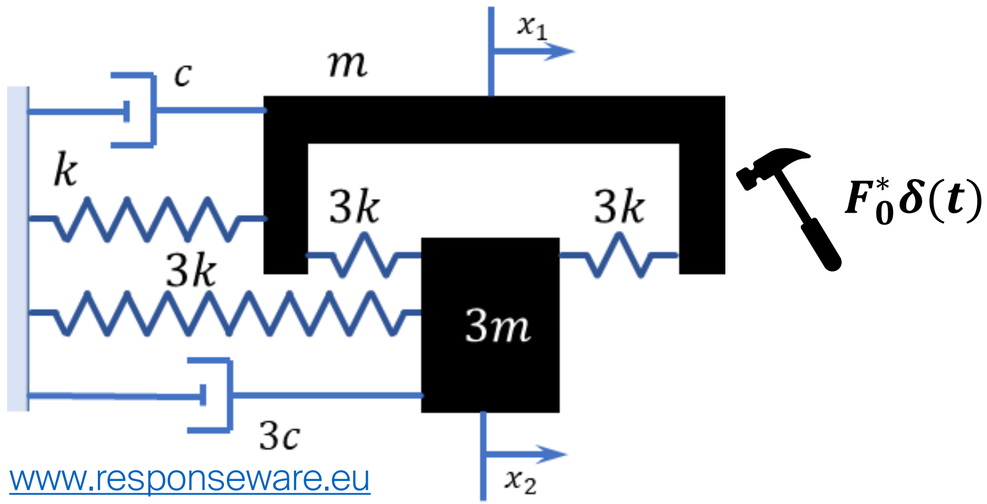
F. Je ne sais pas





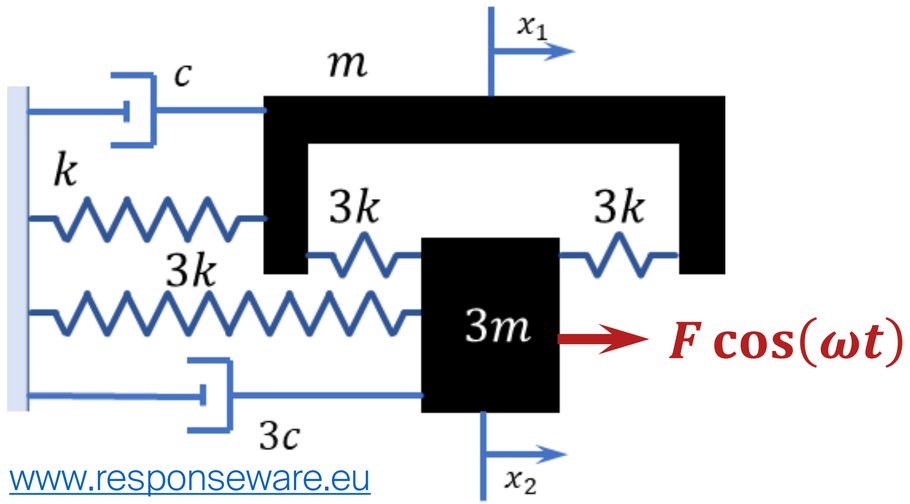
Calculer $\vec{x}(t)$

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$



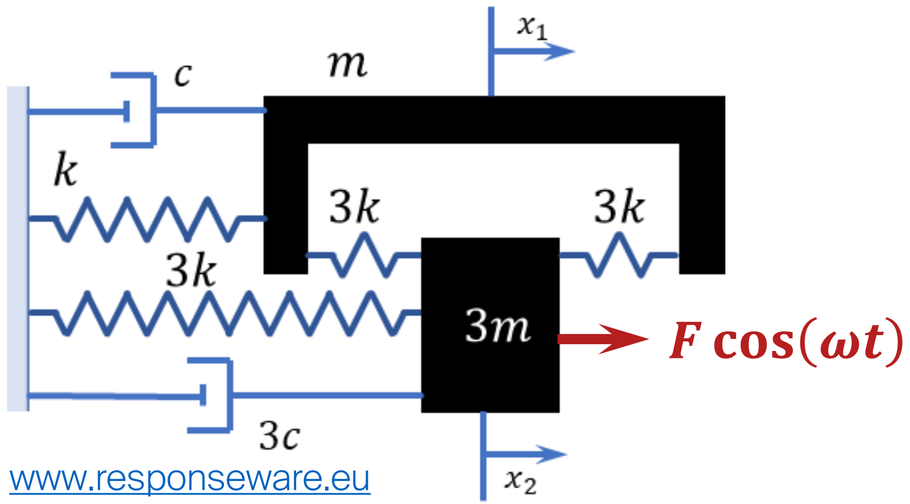
Calculer $\vec{x}(t)$ en régime permanent

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$



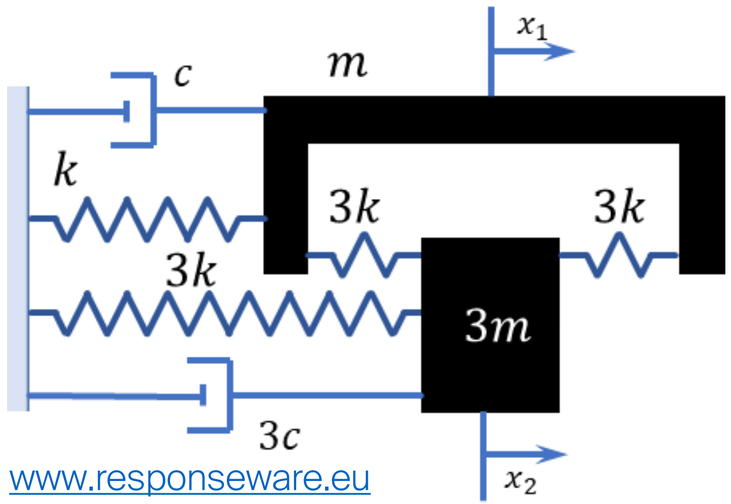
Calculer $\vec{x}(t)$ en régime permanent

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$



Fonction de Transfert (harmonique)

$$\vec{\beta}_I = \begin{pmatrix} 1 \\ 1 \end{pmatrix}; \quad \vec{\beta}_{II} = \begin{pmatrix} 1 \\ -1/3 \end{pmatrix}$$



$$\underline{\vec{X}}(j\omega) = \sum_{i=1}^{n} \vec{v}_i \underline{Q_i}(j\omega) = \left[\sum_{i=1}^{n} \frac{\vec{v}_i \otimes \vec{v}_i}{m_{0i}(-\omega^2 + 2j\eta_i\omega_{0i}\omega + \omega_{0i}{}^2)}\right] \underline{\vec{F}}(j\omega) = \underline{H}(j\omega)\underline{\vec{F}}(j\omega)$$