Exam on the Mechanics of Structures (MoS3 CES), 5 February 2020

LAST NAME, FIRST NAME (PLEASE, HANDWRITE VERY CLEARLY WITH CAPITAL LETTERS)			
index number			
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Problem 1.

Calculate reactions for a beam in Fig. 1

$$EJ = \text{const.}\ ,\ k = 11.4244\frac{EJ}{l^4}$$

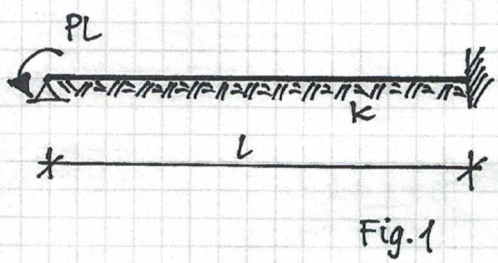


Fig.1

Problem 2.

Calculate the frequency of natural vibrations for a rigid-joint grillage in Fig. 2.

Next, calculate reactions at supports for $t = 0$ sec. , $t = 5$ sec., and $t = 10$ sec.

Assume:

$$E = 205\,\text{GPa}\ ,\ G = 0.385\,E\ ,$$
$$J = \frac{b^4 - a^4}{12}\ ,\ J_s = 1.7\,J\ ,$$
$$l = 2\,\text{m}\ ,\ m = 100\,\text{kg}.$$

Initial conditions:

$$u(0) = 0\ \text{cm},\ v(0) = \ 10\ \text{cm/sec}.$$

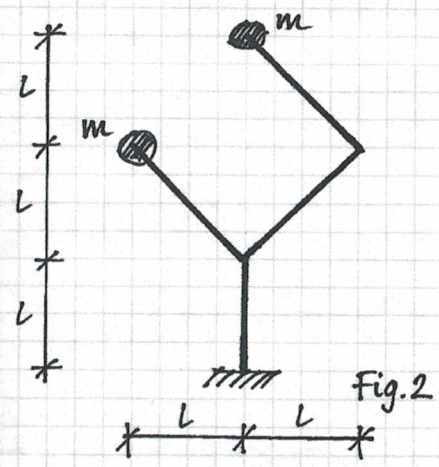


Fig.2

Problem 3.

Derive equilibrium equations for a rigid-joint grillage in Fig. 3.

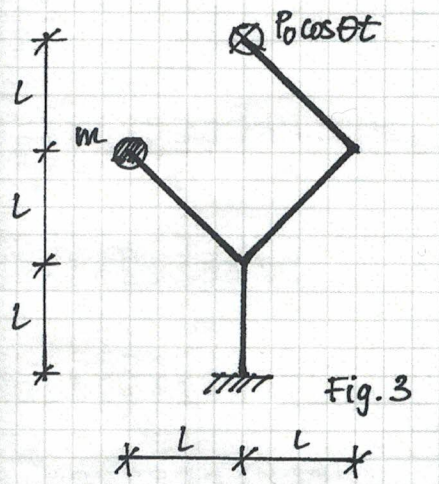
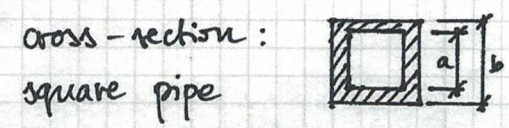


Fig.3



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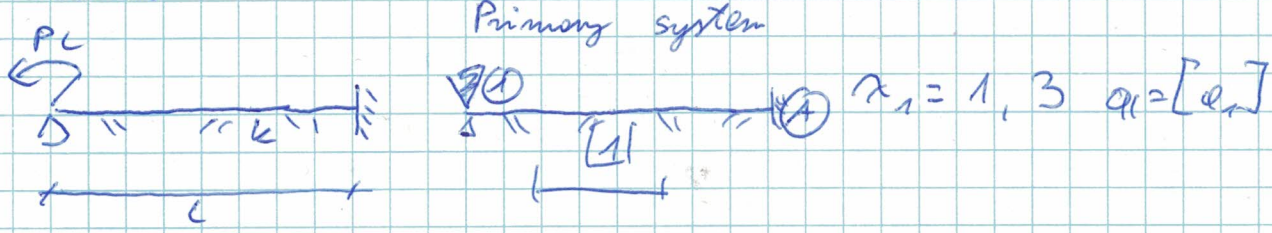
Problem 1



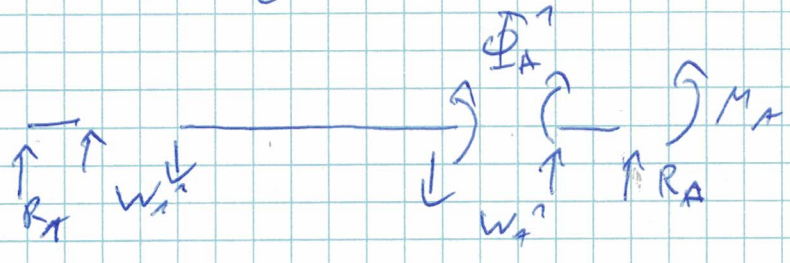
$\chi_1 = 1,3 \quad q_1 = [\varphi_1]$

CE:

$$\bar{\Phi}_1^{\uparrow} + PL = 0$$

$$\bar{\Phi}_1^{\uparrow} = \frac{EJ}{L}\left[\alpha(1,3)\varphi_1\right] = \frac{EJ}{L}\left[4,107\,\varphi_1\right]$$

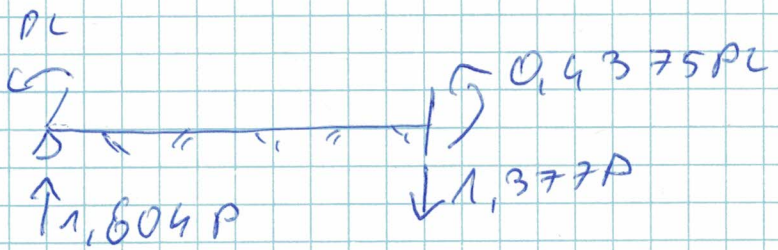
$$\varphi_1 = -\frac{PL}{4,107\frac{EJ}{L}} = -0,2435\frac{PL^2}{EJ}$$



$$R_A = -W_1^{\uparrow} = 1,604\,P$$

$$R_A = -W_A^{\uparrow} = -1,377P$$

$$M_A = \bar{\Phi}_1^{\uparrow} = 0,4375PL$$



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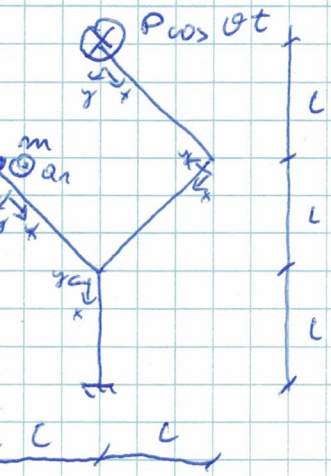
Problem 3

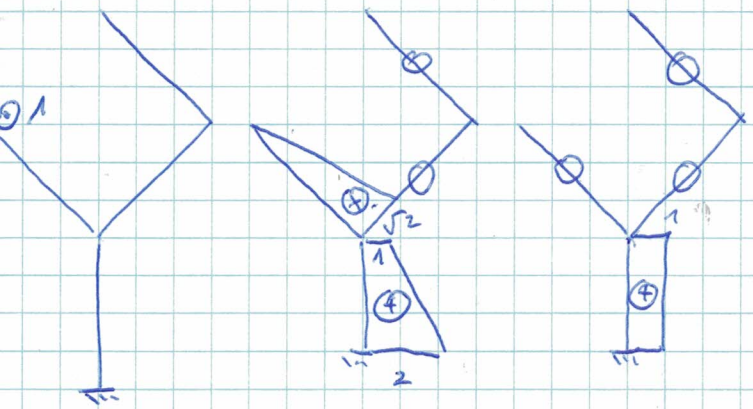


$$J = \frac{13\,756}{3} \cdot 10^{-8}\,[m^4] \qquad J_s = 7{,}8 \cdot 10^{-5}\,[m^4]$$

$$E = 2{,}05 \cdot 10^{11}\left[\frac{N}{m^2}\right] \qquad G = 7{,}89 \cdot 10^{10}\left[\frac{N}{m^2}\right]$$

$$l = 2\,[m] \qquad P = 2000\,[N] \qquad m = 100\,[kg]$$

q_1 "1" state $M_1[l]$ $\mathcal{M}_1[l]$

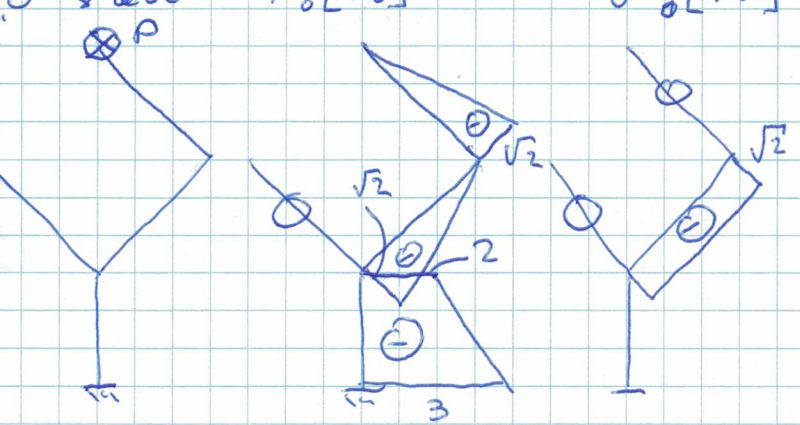


$$\delta_{11} = \frac{1}{EJ}\left[(\sqrt{2}\,l)^3 \cdot \frac{1}{3} + \frac{1}{2}l \cdot l \cdot \left(\frac{2}{3} \cdot l \cdot \frac{1}{3} \cdot 2l\right) + \frac{1}{2}l \cdot 2l\left(\frac{2}{3} \cdot 2l + \frac{1}{3} \cdot l\right)\right] + \frac{1}{GJ_s} l^3 = 4{,}09 \cdot 10^{-6}\left[\frac{s^2}{kg}\right]$$

$$\omega = \frac{1}{\sqrt{\delta_{11} m}} = 49{,}46\left[\frac{1}{s}\right]$$

$$\vartheta = \frac{\omega}{2} = 24{,}73\left[\frac{1}{s}\right]$$

0 "state" $M_0[Pl]$ $\mathcal{M}_0[Pl]$



$$\delta_{10} = \frac{1}{EJ}\left[\frac{1}{2}l \cdot l\left(\frac{2}{3}(-2l) + \frac{1}{3}(-3l)\right) + \frac{1}{2} \cdot 2l \cdot l\left(\frac{2}{3} \cdot (-3l) + \frac{1}{3}(-2l)\right)\right] =$$

$$= -3{,}26 \cdot 10^{-6}\left[\frac{s^2}{kg}\right]$$

$$(1 - \vartheta^2 \delta_{11} m)\, A = \delta_{10} P$$

$$A = \frac{\delta_{10} P}{1 - \vartheta^2 \delta_{11} m} = -0{,}0087\,[m]$$

$$q_1(t) = -0{,}0087 \cos(24{,}73\, t)\,[m]$$