Faculty of Maritime Engineering and Marine Sciences

Mechanical Vibrations

Exam 2 – V-dof, hydrodyn. properties, beam vibrations Jan. 26th, 2026

Student: …… ESPOL ID: ……

Part 1, multiple-choice questions, closed books: 0h40

1. The free vibration of a propulsion system is calculated the Holzer method in this table. The steel shaft is 14 cm in diameter, and the amplitude of the vibratory torque absorbed by the propeller is 2.5E8 N-m. Considering the results shown, estimate the third natural frequency different than zero.

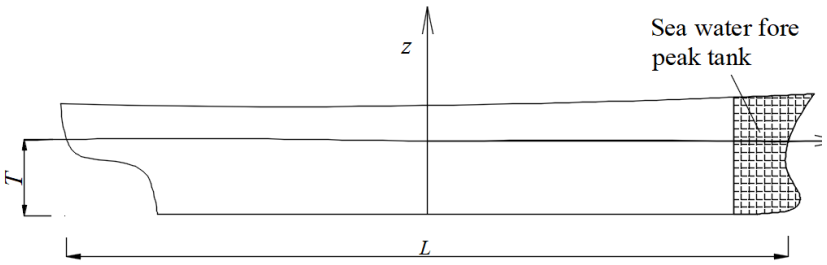
i	J_i	$J_i\,\omega^2$	Ui/U_1	$J_i\,\omega^2\,Ui/U_1$	$\Sigma\ J_i\,\omega^2\,Ui/U_1$	K_i	$[\Sigma\ J_i\,\omega^2\,Ui/U_1]/K_i$
#	kg m2	N-m	rad/rad	N-m	N-m	N-m/rad	rad/rad
1	1271	4.42E+08	1.000	4.42E+08	4.42E+08	9.80E+08	0.45150
2	1271	4.42E+08	0.548	2.43E+08	6.85E+08	9.80E+08	0.69915
3	1271	4.42E+08	-0.151	-6.67E+07	6.18E+08	9.80E+08	0.63113
4	1271	4.42E+08	-0.782	-3.46E+08	2.73E+08	9.80E+08	0.27815
5	1271	4.42E+08	-1.060	-4.69E+08	-1.96E+08	9.80E+08	-0.20042
6	1271	4.42E+08	-0.860	-3.80E+08	-5.77E+08	5.90E+08	-0.97679
7	10447	3.64E+09	0.117	4.26E+08	-1.50E+08	7.08E+07	-2.12312
8	9642.15	3.36E+09	2.240	7.52E+09	7.37E+09		

a. 989 CPM	**b.** 3369 CPM	**c.** 5676 CPM	**d.** 4678 CPM

2. A fishing vessel has the following characteristics *L*: 75 m, *B*: 11.5 m and *D*: 5.90 m, and its propulsion system is composed of a diesel engine of 2250 hp@600 rpm, reduction gear 2.45:1, and a propeller (*D*: 3.10 m, *P/D*: 0.75, *Z*: 5 blades). The operator reports an increment in vibration of the propulsion shaft when the engine works at 375 rpm. Estimate the natural frequency of lateral vibration of the shafting system.

a. 162.8 1/s	b. 80.1 1/s	c. 112.5 1/s	d. 115.2 1/s

3. Vibration of a barge modelled as a hull beam is to be analyzed using the Finite Difference (FD) method. Compartment of fore end is filled with fresh water, and it will be modelled as a concentrated mass. In a first trial, partition is developed with *L/6*, how many FD equations (dynamic equilibrium and boundary conditions) do you need to develop to approximate natural frequencies of the barge?



$$f'(x_0) \approx \frac{f_1 - f_{-1}}{2h}$$

$$f''(x_0) \approx \frac{f_1 - 2f_0 + f_{-1}}{h^2}$$

$$f^{(3)}(x_0) \approx \frac{f_2 - 2f_1 + 2f_{-1} - f_{-2}}{2h^3}$$

$$f^{(4)}(x_0) \approx \frac{f_2 - 4f_1 + 6f_0 - 4f_{-1} + f_{-2}}{h^4}$$

8	11	10	9

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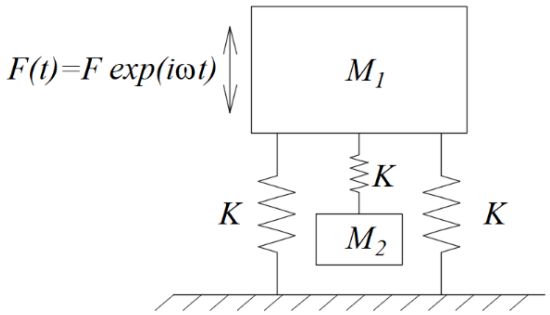
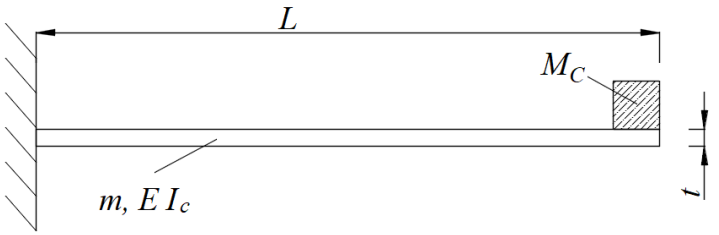
Part 2, closed books: 1h20

1. A resonant problem is affecting a block of mass 507 kg supported by two springs each one of stiffness 1.0E8 N/m when it is excited by a harmonic force $F(t)$. To solve this problem, it is proposed to install a second mass M_2 connected to the main mass with a spring of the same stiffness K as the previous ones. Estimate the mass of the auxiliary mass so that the amplitude of oscillation of the block is minimum at the original resonant frequency. (35)



2. A 1.0-meter-long steel vibrating flat bar (5 cm x 6 mm), clamped on one end and sitting on the side has a 0.5 kg mass installed on the other end (steel properties: E: 2.0589E11 Pa, ρ: 7800 kg/m^3). After applying the method of Separation of Variables to calculate its free vibration, the following eigenvalue was obtained: $\beta_i L$=4.254.



i. Check that one of the natural frequencies of vertical vibration of the beam has a principal value equal to the value previously mentioned, and calculate its corresponding natural frequency. (20)

ii. Plot the corresponding mode and determine the order of the natural frequency. (15)

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I certify that during this exam I have complied with the Code of ethics of our university.

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