Faculty of Maritime Engineering and Marine Sciences

Mechanical Vibrations

Exam 2 – V-dof, hydrodyn. properties, beam vibrations Jan. 27th, 2025

Student: …… ESPOL ID: ……

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

1. When a propulsion system is excited by a frequency of 29.4 rad/sec, the forced response is analyzed using the Holzer method in this table. The steel shaft is 12 cm in diameter. If the amplitude of the vibratory torque absorbed by the propeller is 2.0E7 N-m calculate the complex amplitude of vibration of the first disk of the system.

i	J_i	Ci	$-J_i w^2+iwC_i$		Θi, rad		$(-J_i w^2+iwC_i)\,\Theta_i$		$\Sigma(-J_i w^2+iwC_i)\,\Theta_i$		K_i	Gi	$(-J_j \omega^2+i\,\omega Cj)\,\Theta jj/(K_k+i\,\omega G_k$	
	kg m^2	N-m-s	N-m		radians		N-m		N-m		N-m/rad	N-m-s	radians	
1	2940	3920	-2.54E+06	1.15E+05	1.000	0.000	-2.54E+06	1.15E+05	-2.54E+06	1.15E+05	4.90E+07	4.90E+02	-0.0518	0.0024
2	9800	490	-8.46E+06	1.44E+04	0.948	0.002	-8.02E+06	-6.35E+03	-1.06E+07	1.09E+05	4.90E+07	4.90E+02	-0.2154	0.0023
3	9800	490	-8.46E+06	1.44E+04	0.733	0.005	-6.20E+06	-2.88E+04	-1.68E+07	8.00E+04	4.90E+07	4.90E+02	-0.3419	0.0017
4	9800	490	-8.46E+06	1.44E+04	0.391	0.006	-3.31E+06	-4.83E+04	-2.01E+07	3.17E+04	5.88E+07	4.90E+02	-0.3411	0.0006
5	24500	490	-2.11E+07	1.44E+04	0.050	0.007	-1.05E+06	-1.47E+05	-2.11E+07	-1.16E+05	9.80E+05	4.90E+02	-21.5391	0.1983
6	6860	490	-5.92E+06	1.44E+04	-21.489	0.205	1.27E+08	-1.52E+06	1.06E+08	-1.64E+06	1.96E+06	1.96E+02	54.1247	-0.9959
7	11760	7840	-1.01E+07	2.30E+05	32.635	-0.791	-3.31E+08	1.55E+07						

a. 0.089+i0.005 rad	**b.** 0.005+i0.089 rad	**c.** -0.025+i0.0314 rad	**d.** -0.089-i0.005 rad

2. A fishing vessel has the following characteristics *L*: 80 m, *B*: 12.5 m and *D*: 7.5 m, and its propulsion system is composed of a diesel engine of 2250 hp@500 rpm, reduction gear 2.25:1, and a propeller (*D*: 3.20 m, *P/D*: 0.85, *Z*: 4 blades). If applying Finite Differences method one of the natural frequencies has been estimated as 13 Hz, calculate the rotational velocity of the engine to operate in blade rate resonance.

a. N: 500 rpm	b. N: 320 rpm	c. N: 440 rpm	d. N: 200 rpm

3. Vibration of a clamped beam with a concentrated mass on its end is to be analyzed with the Finite Difference method. If in a first trial, partition is developed with *L/4*, how many FD equations (dynamic equilibrium and boundary conditions) you need to develop in order to approximate natural frequencies of the beam?

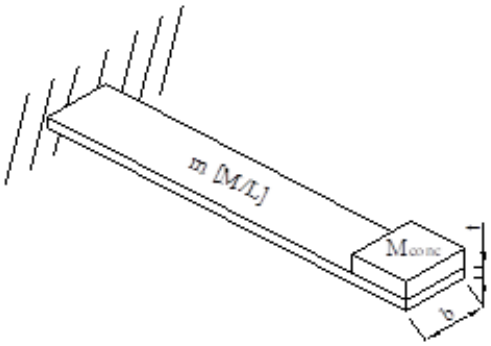

Table 6.3 Central-Difference Formulas of Order $O(h^2)$

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

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

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

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

8	7	6	5

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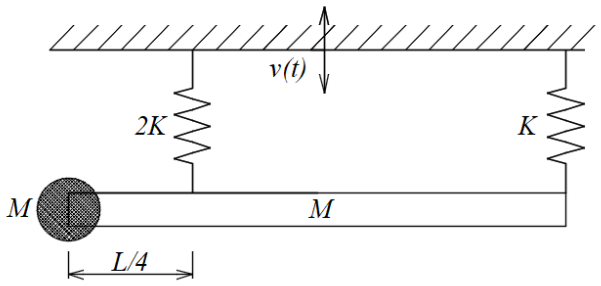
Part 2, closed books: 1h20

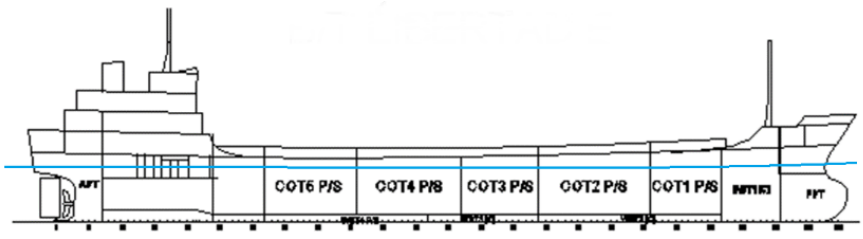
1. An upper support in a ship is vibrating as a result of the propeller unbalance. There is a rigid bar of uniformly distributed mass M and length L, hanging through two springs; also, there is a concentrated mass of mass M on left end, as shown in the figure. Deduce the equations of motion of the rigid bar in the plane, using only the parameters shown in the figure. The support has a harmonic pure vertical motion $v(t) = V\,exp(i\omega t - \beta)$, with frequency ω and amplitude V.
(30)



2. The hull of a tanker ship is vibrating in resonance excited by the propeller at blade rate when partially loaded (W_{light}: 4700 and W_{cargo}: 6000 tons of crude oil). Main dimensions of the ship are L: 135 m, B: 21 m, D: 10 m and T: 6 m. Propeller characteristics are Z: 5, P/D: 0.82, A_e/A_o: 0.70). According to the structural plan, midship sectional inertia of this steel ship is 263300 m^2-cm^2. In a simplified model, the hull of the ship may be considered as a prismatic beam, with a virtual total mass (dry plus added) of 16000 tons, which may be assumed as uniformly distributed.

i. Check that one of the natural frequencies of vertical vibration of the hull beam has a principal value of $\beta_i L$= 7.8532, and calculate the corresponding natural frequency. (25)

ii. By plotting the corresponding mode, determine the order of the natural frequency. (15)



jrml/2025

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

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