Test paper 2 Dynamics of Ocean Structures

Maximum marks: 50 Time: 3 Hrs

Please read the following instructions carefully before answering the paper

This question paper has 3 sections namely A, B and C. All sections should be attempted to qualify your answer script for evaluation. Figures for relevant questions are given overleaf

Each section has one additional bonus question. Correct answer to this question shall fetch you extra, bonus marks.

Any data found missing may be suitably assumed and stated in the problem.

All numerical should be solved strictly in accordance to SI units only.

Draw neat figures/ sketches wherever necessary to support your answer

Answer the questions to the point. Be brief. Round about answers shall fetch you a negative score.

SECTION A (Answer all questions)

1. Using the schematic diagram, explain how an articulated tower reacts to the applied lateral loads exerted by waves. How restoration takes place? (2)
2 List two essential characteristics of dynamic loading (2)
3. List at least four basic types of mathematical modeling of single dof, highlighting the dynamic characteristics (2)
4. Derive the equation of motion for the model shown in Fig. 1 using energy method (4)

Bonus question

Compare viscous damping with Coulomb damping (2)

SECTION B (Answer all questions; each question carries 4 marks)

1. A rectangular impulse function of time duration q is applied to a single degree-of-freedom. Find x(t) when (t<q) and (t>q). Loading diagram is shown in Fig. 2
2. Derive [K], [M] and {f(t)} for the system shown in Fig. 3
3. For the spring-mass system shown in Fig. 4, determine fundamental frequency and mode shape
4. Derive the expression for *Dynamic amplification factor* of a single degree-of-freedom which is damped and excited by ($P_0 \sin \omega t$).
5 A deck of the topside of a platform is a truss supported system. By neglecting the self-weight of the truss, estimate the frequency of free vibration for the suspended mass as shown in Fig. 5. Idealize the truss as spring mass system. Take area of cross-section of all the members as same.

Bonus question

Discuss the variation of modal damping ratio with natural frequency. (*Hint: consider mass-proportional damping, stiffness proportional damping and Rayleigh damping*)

SECTION C (Answer any two questions; each question carries ten marks)

1. A spring mass system is shown in Fig. 6. Taking damping as 5% of the critical for 1st and 2nd modes, compute the damping ratio for the 3rd mode Use Rayleigh damping model
2. Derive the expression for a transfer function to estimate the response of a dynamic system subjected to random loading which is a stationary stochastic process. Also highlight white noise approximation
3. Give a detailed note on estimate of fatigue damage for a zero mean process. Also derive the expression for life time estimate for a narrow band Gaussian process
4. What do you understand by static correction for higher mode response? Derive an expression for the total response, after accounting for missing mass correction
5. Derive an expression for estimating the response of a single degree-of-freedom model subjected to an arbitrary periodic loading. Using the derived expression, estimate the response under the load shown in Fig. 7.

Bonus questions (A total 5 bonus marks for this section will be given only upon answering both the questions correctly)

a) For [K] and [M] be symmetric matrices of stiffness and mass of a given structural system, prove the Orthogonality principle with respect to [K] and [M] respectively. Also, derive generalized mass and stiffness matrix for i^{th} mode.
b) Explain half-power band width method which is used to estimate damping in a structural system. Derive the equation to estimate ξ for the known frequencies (f_1, f_2) in a particular band width.

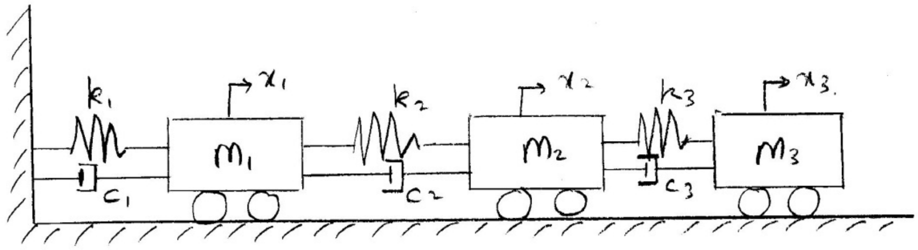

FIG. 1

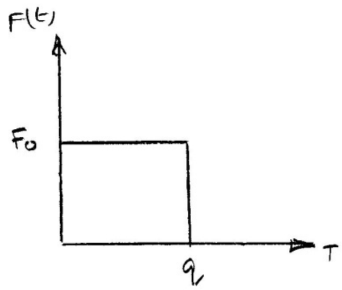

FIG. 2

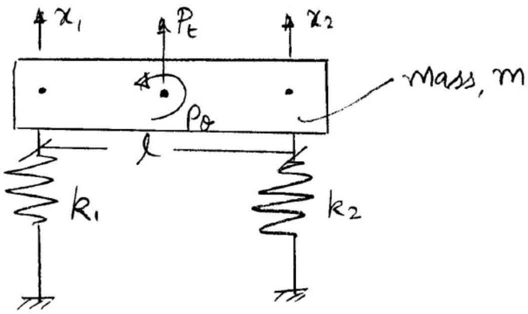

FIG. 3

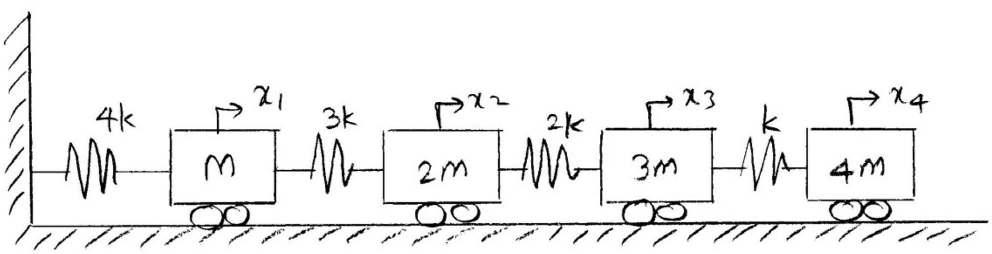

FIG. 4

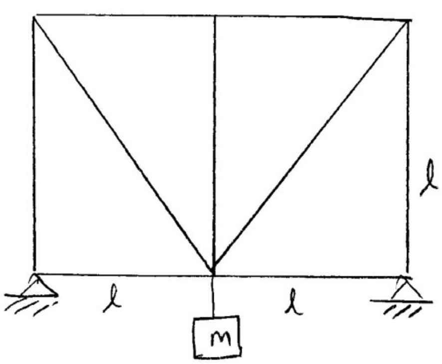

FIG. 5

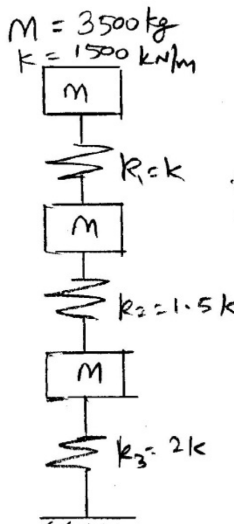

Fig. 6

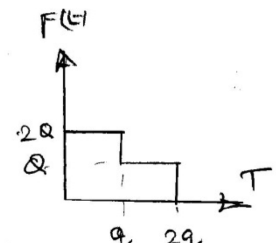

FIG. 7