Dynamics of Ocean Structures - Video course

COURSE OUTLINE

Course objectives:
The course will give a brief overview of different types of ocean structures that are deployed in sea for exploiting oil, gas and minerals. While fundamentals of structural dynamics are discussed, detailed mathematical modeling of ocean structures and their dynamic analysis under waves, wind and current are highlighted with special emphasis to fluid-structure interaction. Introduction to stochastic dynamics of ocean structures is also discussed with lot of tutorials and sample papers that shall intuit self-learning through the course. Focus is on the explanation of fundamental concepts as addressed to graduate students.

Course contents:

Module 1
Introduction to different types of offshore structures- Environmental forces- structural action of ocean structures- fluid-structure interaction- Introduction to structural dynamics- Characteristics of single degree-of-freedom model - Methods of writing equation of motion- comparison of methods- Free and forced vibration of single degree-of-freedom systems- Undamped and damped systems- Formulation of equation of motion- examples- Coulomb damping- comparison of damped and undamped forced vibration- response build up-- nature and comparison- Numerical problems in single degree-of-freedom systems- Two degree-of-freedom systems- formulation of equation of motion- eigenvalues and eigenvectors- Orthogonality of modes- Study of multi degrees-of-freedom systems- Equations of motion- Natural frequencies and mode shapes- Stodla, Rayleigh-Ritz and influence coefficient methods- Matrix methods for dynamic analysis- Eigen solution- Modal analysis.
Module 2
Types of offshore structures- structural action of offshore structures- form based development- Fixed type offshore structure- dynamic analysis using software- comparison of responses of fixed type offshore structures- Articulated towers- single leg and multi-legged towers- Problem formulation and solution using Iterative frequency domain method- Merits of different structural forms in dynamics' perspective- single column structure- Multi-legged articulated towers- formulation of equation of motion- dynamic characteristics of Mass, stiffness and damping- Dynamic analysis of articulated Multi-legged articulated towers- response control of MLAT using tuned mass dampers- Tension Leg platforms- conceptual development and geometric optimization- Development of Mass, stiffness and damping matrices of TLP from first principles- nonlinearities associated with the problem- Dynamic analysis of offshore TLPs under earthquakes in the presence of waves- dynamic tether tension variations caused by vertical seismic excitations- - Fluid structure interaction- inference of offshore platforms in flow regime- Estimate of damping in offshore structures- Rayleigh damping, classical damping, Caughey damping- comparison and suitability to offshore structures - Damping by mode superposition- Numerical method to solve equation of motion in time domain- Newmark's beta method- Future generation offshore structures- Buoyant Leg structures- Offshore triceratops- Formulation of the problem- Development of Mass, stiffness and damping matrices for triceratops- Numerical modeling using software- Experimental studies on dynamic response of offshore triceratops- comparison of analytical, numerical and experimental studies on offshore triceratops-
Module 3
Introduction to stochastic dynamics of ocean structures- Stationary process- stochastic process- Random environmental processes-Response spectrum- Narrow band process- return period- fatigue prediction- mal response method- modal mass contribution- truncation of higher modes and missing mass correction- Duhamel's integral.

COURSE DETAIL

Module No.	Topics	No. of lectures

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Ocean Engineering

Coordinators:

Dr. Srinivasan Chandrasekaran
Department of Ocean EngineeringIIT Madras

1	**1. Introduction to different types of ocean structures** **2. Development of structural forms for deep and ultra-deep waters** **3. Environmental forces** **4. structural action of ocean structures** **5. fluid-structure interaction** **6. Introduction to structural dynamics** **7. Characteristics of single degree-of-freedom model** **8. Methods of writing equation of motion** **9. comparison of methods-** **10. Free and forced vibration of single degree-of-freedom systems** **11. Undamped and damped systems** **12. Formulation of equation of motion** **13. examples** **14. Coulomb damping** **15. comparison of damped and undamped forced vibration - response build up** **16. Numerical problems in single degree-of-freedom systems** **17. Two degrees-of-freedom systems** **18. Formulation of equation of motion** **19. Eigenvalues and eigenvectors** **20. Orthogonality of modes** **21. Study of multi degrees-of-freedom systems** **22. Equations of motion** **23. Natural frequencies and mode shapes** **24. Stodla, Rayleigh-Ritz and influence coefficient methods, Dunkerley** **25. Matrix methods for dynamic analysis** **26. Eigen solution** **27. Modal analysis**	**25**	
2	**1. Structural action of offshore structures** **2. Types of offshore structures based on the geometric form** **3. Development of structural form for deep waters** **4. Fluid-structure interaction** **5. Dynamic analysis of offshore jacket platforms** **6. steps of analysis using software** **7. Dynamic analysis of articulated towers** **8. Iterative frequency domain** **9. Multi-legged articulated towers** **10. Response control of multi-legged articulated towers using tuned mass dampers** **11. Experimental and analytical studies on MLAT** **12. Development of Tension Leg Platforms and geometric optimization** **13. Dynamic analyses of TLPs** **14. Development of Mass, stiffness and damping matrices of TLP from first principles** **15. Dynamic analysis methodology of offshore structures under earthquakes** **16. TLPs under seismic excitation** **17. Development of new generation offshore structures** **18. Buoyant Leg Structures and offshore triceratops** **19. Numerical modeling of offshore triceratops using software** **20. Comparison of experimental, analytical and numerical studies on offshore triceratops** **21. Estimate of damping: Classical damping,**	**17**	

	Rayleigh and Caughey 22. **Damping by mode superposition** 23. **Analytical technique to solve equation of motion using in Newmarks Beta method**	
3	1. **Introduction to stochastic dynamics of ocean structures** 2. **Random environmental processes** 3. **Stationary process** 4. **Response spectrum** 5. **Narrow band process** 6. **Return period** 7. **Fatigue prediction** 8. **Modal response method** 9. **Modal mass contribution** 10. **Missing mass correction, Example problems** 11. **Duhamel's integrals**	**7**
	Total	**49 lectures**

References:

a) Books and Executive reports

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6. Clauss, G. T. et al. 1992. Offshore Structures, Vol 1 - Conceptual Design and Hydromechanics: Springer, London.
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18. Srinivasan Chandrasekaran and Subrata Kumar Bhattacharyya (2012). Analysis and Design of Offshore Structures with illustrated examples. Human Resource Development Center for Offshore and Plant Engineering (HOPE Center), Changwon National University Press, Republic of Korea ISBN: 978-89-963915-5-5.

b) Research papers suggested for additional reading

1. Ahsan Kareem. 1985. Wind induced response analysis of Tension Leg Platforms. J. of Structural Eng. 111(1): 37-55.
2. Anagnostopoulos, S.A. 1982. Dynamic Response of Offshore Structures to Extreme Waves including Fluid - Structure Interaction. Engr. Structures, 4: 179-185.

3. Bar Avi. P 1999. Nonlinear Dynamic Response of a Tension Leg Platform, J. of Offshore Mechanics and Arctic Eng, 121: 219-226.
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6. Boaghe, O.M., Billings, S.A., Stansby, P.K. 1998. Spectral Analysis for Non-Linear Wave Forces. J. Applied Ocean Research, 20: 199-212.
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17. Chandrasekaran. S, Jain. A. K, Chandak. N. R 2007a. Response behavior of triangular tension leg platforms under regular waves using Stokes nonlinear wave theory. J. of waterway, port, coastal and ocean Eng., ASCE. 133(3): 230-237.
18. Chandrasekaran. S, Jain. A. K, Gupta. A and Srivastava. A 2007b. Response behavior of triangular tension leg platforms under impact loading, Ocean Eng.,34: 45-53.
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20. Chandrasekaran. S, Gaurav 2008. Offshore triangular tension leg platform earthquake motion analysis under distinctly high sea waves. J. of Ships and Offshore Structures. 3(3): 173-184.
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