GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Stability & Dynamics of Ship and Offshore Structures I, PG_00051722					
Field of study	Ocean Engineering					
Date of commencement of studies	February 2023		Academic year of realisation of subject		2022/2023	
Education level	second-cycle studies		Subject group		Optional subject group Subject group related to scientific research in the field of study	
Mode of study	Full-time studies		Mode of delivery		at the university	
Year of study	1		Language of instruction		English	
Semester of study	1		ECTS credits		2.0	
Learning profile	general academic profile		Assessment form		assessment	
Conducting unit	Department of Hydromechanics and Hydroacoustics -> Faculty of Mechanical Engineering and Ship Technology					
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Paweł Dymarski			
	Teachers		dr hab. inż. Paweł Dymarski			
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	15.0	0.0	0.0	0.0	45
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours	Self-study		SUM
	Number of study hours	45		0.0	0.0		45
Subject objectives	The aim of the course is to familiarize students with the basic (applied) methods of modeling problems of stability and dynamics of ships and offshore structures.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K7_U04] can apply mathematical methods and models and computer simulations to analyse, design, and assess the functioning of ocean technology objects and systems and their elements	The student is able to write simple computer programs (using known methods) to simulate the motion of a floating object subjected to environmental forces.	[SU4] Assessment of ability to use methods and tools [SU3] Assessment of ability to use knowledge gained from the subject [SU1] Assessment of task fulfilment
	[K7_U07] in compliance with a formulated specification and with the aid of appropriate tools and methods, is able to complete an advanced engineering task within the range of design, construction and operation of ocean technology objects and systems	The student is able to use the known methods in the field of stability and dynamics of offshore structures to analyze floating objects at the initial stage of design.	[SU4] Assessment of ability to use methods and tools [SU1] Assessment of task fulfilment
	[K7_U06] when forming and solving design tasks can see their non-technical aspects, including environmental, economical and legal ones. Applies HSE rules and regulations	not applicable	[SU1] Assessment of task fulfilment
	[K7_W05] has an organized, widened knowledge on design, construction and operation of ocean technology objects and systems	The student knows the types of offshore structures and knows their basic properties.	[SW1] Assessment of factual knowledge
	[K7_W06] has an organized, widened knowledge on engineering methods and design tools allowing the conducting of advanced projects within the construction and operation of ocean technology objects and systems	The student knows the theory of ship stability and offshore stability. He knows the basic models for determining hydrodynamic forces on offshore structures. The Student knows simplified models of the mootion of a floating object (with one degree of freedom)	[SW1] Assessment of factual knowledge
	[K7_W07] has knowledge on the development perspectives of ocean technology objects and systems, knows the newest and most relevant achievements in ocean technology	not applicable	[SW1] Assessment of factual knowledge

Subject contents	1.Types of offshore platforms basic konowlage - Fixed platform stryctures -- Steel jacket -- Compliant tower -- Concrete gravity structure or concrete base structure (CBS) - Floating platform structures -- Tension Leg Platform -- Semi submersible -- Spar -- Ship shaped vessel (FPSO) 2. Definition of rigid-body motion modes 3. Static stability of ship and offshore structures - The concepts of three types of equilibrium: stable, neutral and unstable - Analysis of the mechanisms of the restoring force, depending on the degree of freedom: heave roll pitch - analysis of motion at the other degrees of freedom (surge, sway, yaw) 4. Dynamics of floating body structures. - Single degree of freedom problems General equation of motion (based on Newton's second law) Determination of the main parameters of a dynamical system: --- Added mass (or virtual mass) --- Linear damping coefficient --- Viscous drag coefficient Basic numerical methods for sloving ODEs: --- explicit (or forward) Euler method - implicit (or backward) Euler method - midpoint rule - trapezoid rule - Exercise 1: Calculation of the movements of cylindrical buoy, floating in calm water, which was displaced from the equilibrium position 5. Dynamics of the environment. Structure-environmental force interactions - Intoduction to ocean wave modelling. Airy wave theory (regular wave) - Model of wind velocity profile - Current velocity profile modeling (wind current, tidal current) - Exercise 2: Calculate the movements of cylindrical buoy, floating in (deep) water, which was treated with regular wave. - Hydrodynamic forces induced on the structures: -- the Froude-Krylov method -- Morison's equation, --- Keulegan-Carpenter number, "beta" parameter - Exercise 3: Determination of forces and moments on a monopile subjected to a regular wave 6. Stablity of Offshore Structures (Stability of Tension Leg Platforms) - Equations of Equilibrium of forces -- Determination of the restoring force due to anchoring system -- Determination of platform displacement due to environmental forces -- Determination of reaction forces in the tendons - Exercise 4: Determine the static displacement of TLP platform for given platform geometry and mass, and give sea current and wind strength. Determine forces in the tendons. 7. Response in irregular waves - ocean waves a short term model -- Wave energy spectra - The Pierson-Mostkowitz Spectrum --- The JONSWAP Spectrum - Exercise 5: Draw a graph of the wave spectrum for given data: Hs and Tp - Response Amplitude Operator - Response in irregular wave (linear model) - Exercise 6: Estimate the significant and maximum amplitude of heave of a cylindrical buoy, during a storm lasting 3 hours.

Prerequisites and co-requisites	- Knowledge of general mechanics -- The concept of force and torque -- Equations of balance of forces and moments -- Newton's Laws -- The ability of integration of equations of motion - Basic knowledge of strength of materials -- Ability to determine forces in statically determinated structures: --- Ability to determine the internal forces and the reaction of the beams, --- Ability to determine the internal forces in the frames (basic configurations). --- Basic knowledge about the characteristics of the sections, stiffness, etc. - Basic knowledge of fluid mechanics -- Hydrostatic pressure, -- Buoyancy, -- Resistance force (drag), - Basic knowledge of the theory of ship -- The stability of the ship in the scope of the metacentric formula -- Buoyancy in the range of linear equations -- Basic knowledge of the ship's seakeeping --- the concept of added masses - Basic knowledge of computer tools and programming languages -- The use of spreadsheets (eg .: Excel, OpenOffice Calc) -- Indicated basic knowledge of C / C ++, -- Or basic knowledge of Matlab / Octave, -- The ability to create graphs (visualization of results) (Gnuplot / Matlab / Octave, or Excel) - Basic knowledge of numerical methods -- Numerical integration: midpoint rule, trapezoid rule -- Basic methods for solving initial value problems (ODEs): --- Euler method (explicit Euler) --- Runge-Kutta methods

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Exercises	80.0%	40.0%
Activity	0.0%	10.0%
Lectures	60.0%	50.0%

Recommended reading

Basic literature	James F. Wilson: Dynamics of Offshore Structures. WILEY 2003 Targut Sarpkaya: Wave Forces on Offshore Structures. Cambridge University Press 2010
Supplementary literature	Principles of Naval Architecture, vol. 1,3. SNAME 1988 O.M. Faltinsen: Sea Loads on Ships and Offshore Structures. Cambridge University Press 1990 S.K. Chakrabarti: Offshore Structure Modeling (Advanced Series on Ocean Engineering, Vol. 9). World Scientific 1994 S.K. Chakrabarti: Handbook of Offshore Engineering. Elsevier Science 2005 J.M.J. Journée and W.W. Massie: "OFFSHORE HYDROMECHANICS". Delft University of Technology 2001 http://www.shipmotions.nl/DUT/LectureNotes/OffshoreHydromechanics.pdf
eResources addresses	Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed

Exercise 1:
Calculate the movements of cylindrical buoy, floating in calm water, which was displaced from the equilibrium position of the z = 1m.
D = 2m - diameter of the buoy,
T0 = 4m - initial draught (in equilibrium),
H = 6m - depth (or height),
= 1025 kg/m3 - water density,
CA = 0.2 - added mass coefficient,
CD2 = 0.82 - drag coef. for fully submerged cylinder (both bases submerged).
CD = CD2/2
b33 = ? - neglected

Exercise 2:
Calculate the movements of cylindrical buoy, floating in (deep) water, which was treated with regular wave:
a = 0,5 m - wave amplitude,
T = 3 s - wave period,
D = 2m - diameter of the buoy,
T0 = 4m - initial draught (in equilibrium),
H = 6m - depth (or height),
= 1025 kg/m3 - water density,
CA = 0.2 - added mass coefficient,
CD2 = 0.82 - drag coef. for fully submerged cylinder (both bases submerged).
CD = CD2/2
b33 = ? - neglected

Exercise 3:
Calculate the forces and moment on cylindrical, vertical monopile stuck in the seabed which is subjected to a regular wave during extreme storm:

a = 4.5 m - wave amplitude,
T = 11.3 s - wave period,
D = 6.5m - diameter of the buoy,
d = 40 m - water depth,
= 1025 kg/m3 - water density,
CM = ? - inertia coef. (rough surface) from CM(KC) plot,
CD = ? - drag coef. (rough surface) from CD(KC) plot,

Exercise 4:
Determine the static displacement of TLP platform, if the strength of the wind is:
uw=48 m/s and the speed of the sea current uc=2.37 m/s [DNV-OS-E301, October 2010]

Location Mississippi Canyon, Block 243
Water Depth: d=860 m

SeaStar® TLP Specifications:
Payload (deck/facilities/risers): 8 425 tons
Main column dimensions: Dc=17.8 m ; hc=38.1 m
Pontoon dimensions: rp=54.7 m; hp,max=12.8 m
lp=rp-0.5Dc=45.8 m
(3pontoons)
Draft: T=31.7 m
Deck Dimensions: Bd=42.7m x Ld=42.7m
(3 levels)
[http://www.zerohedge.com/article/possible-new-oil-spill-100-10-miles-reported-gulf-mexico]

Additional assumptions:
Level Hight: hl=8m;
Total Weight: W=0.75D0; (including risers)
Pontoon width, mean height: wp=6m; hp=9.4 m;
Deck Freeboard: 17.5 m

Exercise 4.1: Additional task
Determine the tension of each of the tendons.

Exercise 5
Draw a graph of the spectrum of waves for given data:
- The Pierson-Mostkowitz Spectrum
- The JONSWAP Spectrum
Draw a graph of an exemplary waveform for a given point x and a specified range of time. Calculate the following statistical values: Hw1/3 ; Hw1/10 ; Hw1/100 ; Hw1/1000
Hs=9.01 m
Tp=11.3 s
t = 600 s

Exercise 6
Estimate the significant and maximum amplitude of heave of a cylindrical buoy, during a storm lasting two hours. For the following data:
Wave data:
Significant wave height: Hs=3.2 m;
Peak period: Tp = 7.8s
Buoy geometry:
D = 2m - diameter of the buoy,
T0 = 6m - initial draught (in equilibrium),
H = 10m - depth (or height),
= 1025 kg/m3 - water density,
CA = 0.2 - added mass coefficient,

	CD = 0.41 - drag coef. Note: use the worksheet from exercise 2 (but remember: change the geometric data)
Work placement	Not applicable