Norwegian University of Science and Technology
Department of Marine Technology

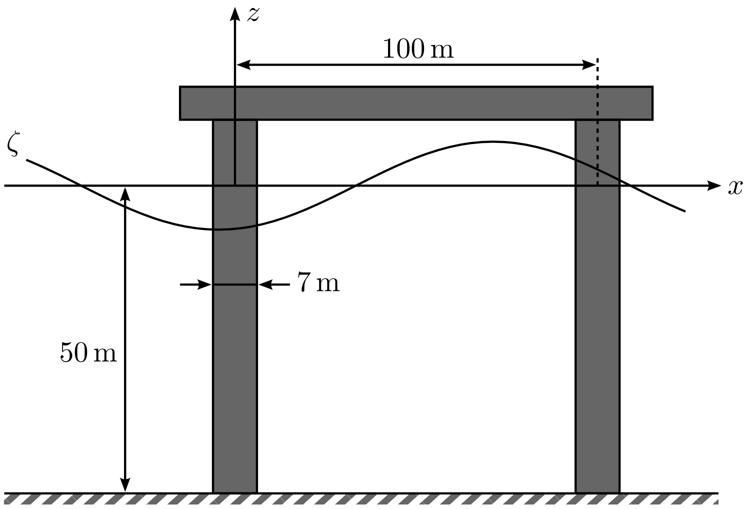
TMR4247 - Marine Technology 3
Spring 2020

Exercise set 5
Due February 16, 2020

1 Morison's equation gives an approximation of the force ($\mathrm{d}F$) from a fluid in motion acting on a slice of a circular cylinder with diameter D and length $\mathrm{d}z$:

$$\mathrm{d}F = \rho\frac{\pi D^2}{4}C_M\dot{u}\mathrm{d}z + \frac{1}{2}\rho C_D D u|u|\mathrm{d}z \tag{1}$$

Two circular, vertical cylinders with diameter 7 m are standing (fixed) on the seabed. The distance between the centres of the cylinders is 100 m and the water depth is 50 m. Regular waves with period 15 s and amplitude 2.5 m are moving in positive x-direction.



a) What is the wave length?

b) Calculate the force from the wave on each cylinder and on the total structure. Use $C_M = 2.0$ and $C_D = 0.7$.
Sketch how the forces vary in time.
The velocity potential is given as:

$$\phi = \frac{g\zeta_a}{\omega}\frac{\cosh[k(h+z)]}{\cosh(kh)}\cos(kx - \omega t) \tag{2}$$

Given integral:

$$\int_{-h}^{0}\cosh^2[k(h+z)]\mathrm{d}z = \frac{1}{4k}\left(\sinh(2kh) + 2kh\right) \tag{3}$$

c) Consider the relative importance of mass- and drag forces on the total force on the structure. Which wave lengths and wave periods give zero horizontal force on the total structure for all time instants? Here it is adequate to provide an approximate answer by only considering the largest force component.

2 This task is a preparation for the next exercise, which will be about doing ship response analyses in a computer program called *ShipX* with the plug-in *Veres* (*Ve*ssel *Res*ponse). The Veres software is a widely used tool in industry and it is based on the theoretical foundation that you have already been through in this course. We therefore think it is nice for you to get a first touch with this practical application of what you have learned. ShipX will be used later on in this course for other types of calculations, and is also used in other courses. The aim of the current task is to install ShipX on your own computer and to verify that everything works as it should. In the next exercise we will assume that you have familiarized yourself with the program and we will start focusing on the results that might be obtained.

ShipX only supports Windows operating systems. If you have a Mac computer we encourage you to work together with a student who has a Windows operating system on his/her computer. Exercise 5 and 6, which both require the use of ShipX, will be open for working together in teams of two. Each student must then deliver the exercise individually on Blackboard, and specify the name of the student you are cooperating with in the comments field when uploading your answer. If you would like to install Windows on your Mac you might do this through a virtual machine software. An example of such a program is VirtualBox (https://www.virtualbox.org/). A 90-day trial version of Windows 10 can be found on Microsoft's web pages: https://www.microsoft.com/en-us/evalcenter/evaluate-windows-10-enterprise.

There will be a troubleshooting session on installation of ShipX in the exercise guidance hours on Tuesday 11.02.2020. Please perform the installation before this session, so that we can focus on helping those who potentially have encountered installation problems rather than spending all his time going through the attached instructions.

a) Install ShipX following the procedure described in chapter 1-3 in the document *ShipX User Guide.pdf*, which is attached to this exercise. Make sure to follow the instructions carefully, as being precise on this part will save you a lot of potential trouble.

3 This task will guide you through how to run a basic analysis of the linear response of a ship model. You will obtain transfer functions for the vessel, showing how it will react to incoming waves.

a) Open ShipX, then follow section 4-7 in the attached user manual, *ShipX User Guide.pdf.*

b) The transfer functions for heave and pitch are to be submitted with the exercise.

c) When finished running Veres, feel free to familiarize yourself briefly with other parts of ShipX. We will use it later, so this is a good investment of time.

Simple numerical solutions

1. (a) $\lambda = 283\,\mathrm{m}$
   (b) $F = 1.52 \times 10^6 \cos(0.419t) + 0.11 \times 10^6 |\sin(0.419t)| \sin(0.419t)\,\mathrm{N}$ (left cylinder)
   (c) $\lambda_1 = 200\,\mathrm{m}$, $\lambda_2 = 67\,\mathrm{m}$ and $\lambda_3 = 40\,\mathrm{m}$