EXAM OCEAN WAVES

7 November 2017, 9.30 - 11.30 hours

Three problems; all items have equal weight

Remark 1: write answers (in English or Dutch) of each problem on a separate sheet; also include your name.

Remark 2: in all questions you may use $g = 10$ ms^{-2}, $\rho = 10^3$ kgm^{-3} and $\tau = 0.1$ Nm^{-1}.

Remark 3: Use of a non-programmed pocket calculator is permitted.

Problem 1

The figure below shows for the period 6-12 November 2017 the astronomical tide at South Pass, which is located in the Gulf of Mexico, close to New Orleans.

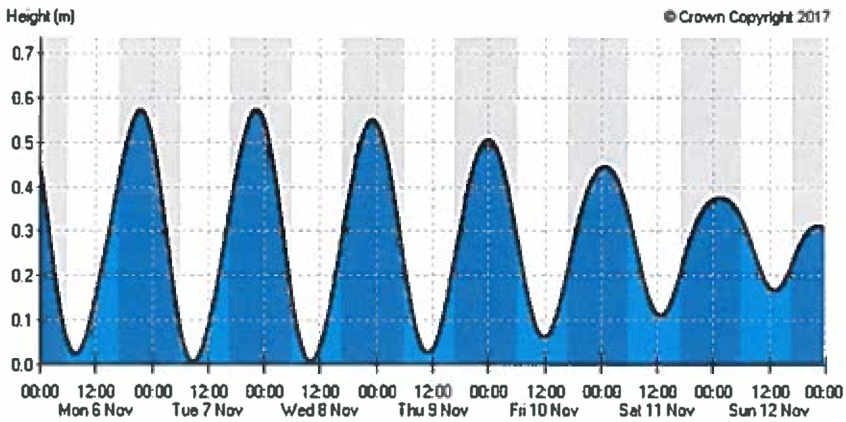

Figure 1: Tidal record (sea level versus time) of station South Pass, period 6-12 November 2017.

a. The tide at this station is diurnal.
Describe the main forcing mechanism of this tide. *declination*
Present at least one figure and discuss its contents.
Limit your answer to maximum 0.75 page A4.

b. The tide at South Pass shows a spring-neap cycle with a period of 13.65 days.
Give an explanation for the fact that this values differs from that of the spring-neap cycle in the North Sea (which is 14.7 days).

c. Suppose that the astronomical tide at South Pass would be considered for the same period (6-12 November), but one year later.
Give three reasons why these two records will be different and in what way(s).

→ moon different max declination and 1 year [illegible] moon year. phase of moon

Please turn over for problem 2

Problem 2

The Kara Sea (see map) is located at latitude 75° N. To a first approximation this sea can be schematised as a rectangular, semi-enclosed basin with length 1500 km (in the southwest-northeast direction), width 1000 km and a mean water depth of 122.5 m. Semi-diurnal tides with a period of 12 h 25 m are generated at the north-eastern boundary due to co-oscillation with the Arctic Ocean.
Assume that the tidal dynamics are described by the linear and frictionless depth-averaged shallow water equations.

Figure 2: Map of the Kara Sea.

a. Are there travelling Poincaré waves to be expected in this sea that have the tidal frequency?
If your answer is no, explain why not.
If your answer is yes, then compute their wave-lengths in the along-channel direction.

b. Ignoring Poincaré waves, compute for that case the expected number of amphidromic points of the vertical tide (sea-level variations) in the Kara Sea, as well as the locations of these points.
Show how you arrive at your answer.

c. Assuming the tide at the southwest-northeast coast to be a travelling Kelvin wave with amplitude Z=0.5 m, compute

- the maximum depth-averaged current of the tide at this coast,
- the corresponding tidal power (i.e., the energy density flux).

Explain your answer.

Problem 3

During a measuring campaign in the North Sea, wave frequency spectra have been determined from sea surface height data detected by a wave recorder. The results are shown in the figure below. At this location the waves experience deep water.
Note: here, frequency f rather than radian frequency σ is shown.

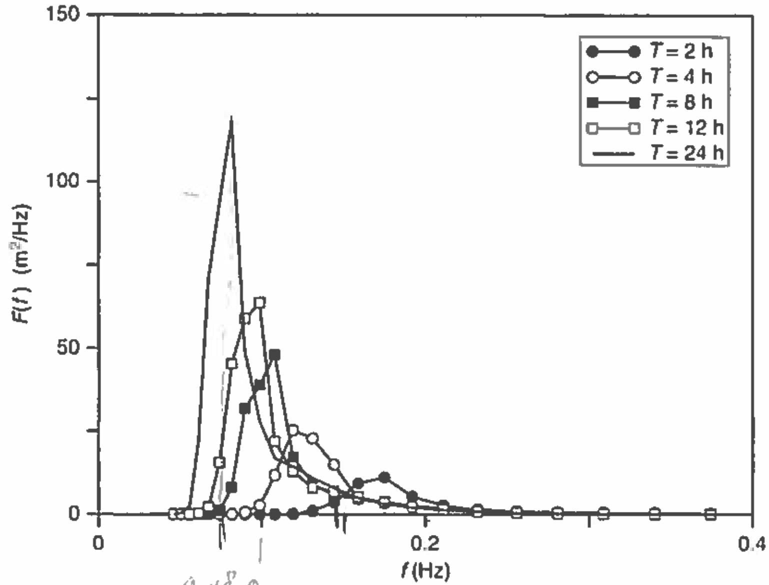

Figure 3: Measured wave frequency spectra at different times T at a fixed location in the North Sea.

a. Sketch for this wave field the probability density distributions $p(H)$ of wave height H at times T=2 h, T=8 h and at T=24 h in one figure. Explain your answer.

b. Name and briefly discuss the physical mechanism(s) that are responsible for the shift of the peak frequency towards lower values with increasing time.

Remark: focus on physical aspects, supply your answer with clear sketches and limit your answer to at most 0.75 page A4.

The high frequency part (that is, for frequencies $f \geq f_p$) of the wave spectrum $F(f)$ reads

$$F(f) = \alpha g^2 f^{-5} \qquad \text{for } f \geq f_p ,$$

where α is a nondimensional parameter.

c. Using this expression, compute the energy density of the high frequency waves at T=24 h. Hint: numerical values of f_p and α can be estimated from the figure.

d. Compute, using the data presented in the figure, the initial growth rate of the wave with a frequency of 0.15 Hz. Assume that the model of Miles can be applied.

Hint: use the data of T=2 h and T=4 h (why?).

END