Trial exam CIE4305 (Coastal Dynamics 1)

Exam content:

- This trial exam consists of 27 questions clustered in 4 topics (cross-shore, alongshore, basins and an in-depth question about an arbitrary topic).
- The total number of points is 67.
- Students generally find this exam slightly easier than the April practice exam in the exam halls.

General instructions:

- This pdf file contains the exam questions. The answers must be given in Maple TA.
- To view the two windows side-by-side (pdf to the left and Maple TA to the right):
    - Go to the window in which the pdf is open. While pressing the Windows button on your keyboard, press the Left arrow. This will move the window to the left portion of the screen.
    - Go to the window in which Maple TA is open. While pressing the Windows button on your keyboard, press the Right arrow. This will move the window to the right portion of the screen.
- Now you can read all the exam questions on the left portion of the screen and give the answers in the corresponding questions in Maple TA.

Important Maple TA information:

- SketchApps are used that allow you to draw polygons. You create points by clicking on the screen and erase them using the delete/delete all button. You can also move points. The SketchApp automatically creates a spline through the defined points. Add additional points if necessary to reproduce changes in slope. Use the Max/Min button to make sure that the automatic spline has a maximum/minimum where it should (see the examples on the next page).
- Because of the use of the SketchApps, MapleTA does not check correctly whether you have answered all questions, so you must check this yourself!
- Let questions and SketchApps fully load! If you navigate back and forth between questions without allowing time for the browser to fully load the page and all its components (editors and SketchApps), the results can range from garbled responses to full reset of answer areas and SketchApps to the initial (unanswered) state.
- When you are ready choose SUBMIT.

Without using the Max/Min tools (drawing points only)

After defining the points whose value we know (black circle) the sketching app automatically creates a spline (red line) through them. Your answer will be evaluated based on the value of the points but also based on the shape of the red line.

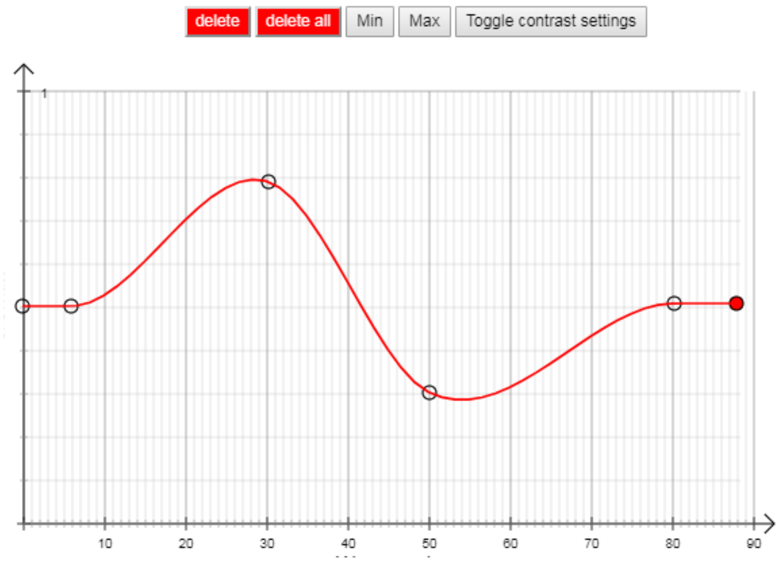
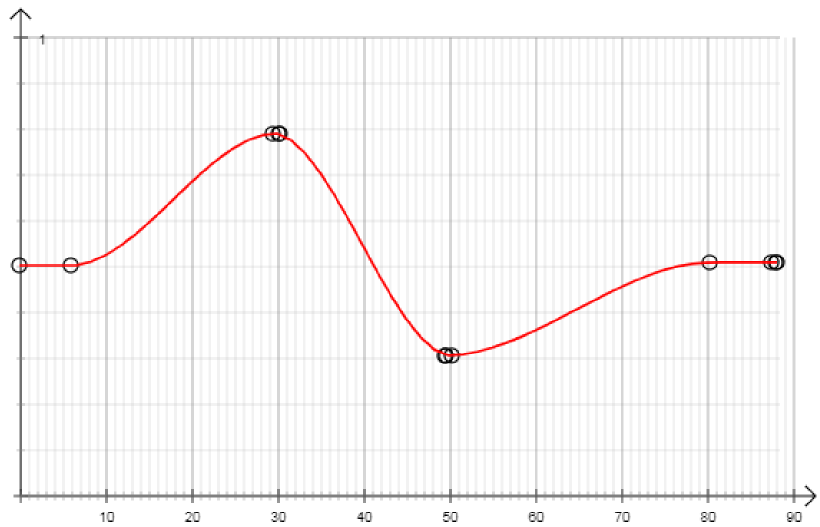


Figure 1

In Figure 1 the automatic spline goes through (x, y)=(30, 0.8) but the automatic spline has a maximum at (28, 0.8).

This means that if the grading algorithm considers the answer as correct if f(30)=0.8 AND df/dx(30)=0 (i.e. you have the right value and it is a relative maximum) the result of Figure 1 could be wrong.

After using Max at x=30 and Min at x=50



The Max and Min tools automatically generates a number of additional points at the specified location. This ensures that the spline will actually have a maximum/minimum at the defined point, and not somewhere else.

A. Tidal character and spring-neap cycles (in depth) Q1-7

The below table gives the dominant tidal constituents and their amplitudes (in cm) for four tidal reference stations around the globe.

Tidal constituent	Station 1	Station 2	Station 3	Station 4
	Amp	Amp	Amp	Amp
M2	223.2	20.3	4.4	54.2
S2	72.8	6.8	3.0	12.3
N2	44.9	3.8	0.8	11.5
K2	18.3	2.1	1.0	3.7
K1	14.6	29.7	72.0	37.0
O1	16.4	28.3	70.0	23.0
P1	6.4	9.3	24.0	11.5

Q1 - choose one or more correct answers 2 points

Which of the above four stations experience(s) two low waters a day?

Q2 - choose one or more correct answers 2 points

Which of the above four stations experience(s) two high waters a day with a significant difference between the heights of the two high waters a day?

Q3 - give formula 2 points

Consider station 1. The period T of the spring-neap tidal cycle at this station is half the lunar month (approximately 14.8 days). Give the formula from which T can be computed given the periods of the M2 and S2 components, TM2 and TS2 respectively.

Q4 - choose one or more correct answers 2 points

Also at station 3, a spring-neap tidal cycle exists, but with a slightly different period. The beating of which two constituents do you expect to create this spring-neap tidal cycle?

Choose from (arbitrary order, possibly different from in Maple TA):
M2, N2, K1, S2, O1, P1, K2

Q5 - give number or expression 2 points

Compute the length of the spring-neap tidal cycle (in days) at location 3.

Q6 - give number or expression 3 points

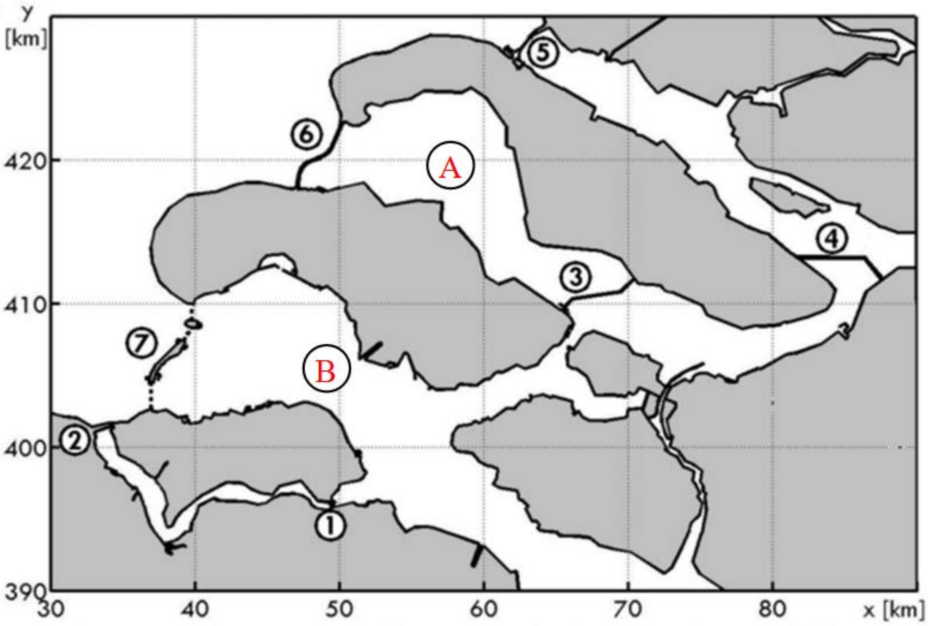
At location 3, estimate the difference in cm between MHWS and MHWN.

Q7 - essay 3 points

Station 3 is an Asian station close to the equator. How can the tidal character at this location be explained? In your answer discuss whether or not equilibrium theory is sufficient.

B. Dutch basins Q8-14

The following questions discuss the dams and basins in the south western part of the Netherlands. Several dams were constructed in this system of tidal basins during the last century. Fig.1 shows an overview of the constructed dams including their respective years of completion. The tidal system has changed after the construction of the dams.



1. Zandkreek dam (1960)
2. Veere Inlet dam (1961)
3. Grevelingen dam (1965)
4. Volkerak dam (1969)
5. Haringvliet dam (1970)
6. Brouwers dam (1971)
7. Storm-Surge Barrier (1986)

fig.1

Q8 - drop-down menu (5x) 2 points

Consider the following aspects of waves: surface elevation, horizontal and vertical orbital motion, horizontal and vertical particle velocity. For each of these five aspects indicate whether it is related to the horizontal or vertical tide or to neither.

Q9 - give a number (2x) 2 points

Assume that the horizontal and vertical tide are described by the following equations :

$$\eta(x,t) = a\cos(\omega t - kx)$$

$$u(x,t) = \hat{u}\cos(\omega t - kx - \phi)$$

Indicate the value of φ (in radians) for 1) a propagating tidal wave and 2) a standing tidal wave. Give your answers in positive or negative multiples or fractions of π.

Q10 - choose one answer + essay 3 points

The construction of the Grevelingendam (indicated as no.3 in fig.1) created a tidal basin seaward of the Grevelingendam open to the North Sea for the period 1965 to 1971. After 1971 a second dam, the Brouwersdam (no. 6), closed this basin and the Grevelingen was turned into a lake.

For simplicity, you may assume in the next questions that there are no tidal flats. Further, assume that the average depth of the Grevelingen basin is 5 m.

a) Do you expect a standing or a propagating tidal wave in the Grevelingen basin in the period 1965 to 1971?
b) Explain you answer using a calculation.

Q11 - give a formula + choose one or more answers 3 points

a) How can you estimate the tidal prism P in the Grevelingen basin during the period 1965 to 1971? Write a mathematical expression using some (but not necessarily all) of the following variables:

S surface area of the basin (averaged over tidal period)
L length of the tidal wave
c phase velocity of the tidal wave
R tidal range at the entrance
φ phase difference between horizontal and vertical tide

b) Which assumption(s) is (are) needed to write this formula?

Choose from (arbitrary order, possibly different from in Maple TA):
There are limited tidal flats
Bottom friction is important
The tidal range is approximately constant in the basin
The tidal wavelength is of the same order of magnitude as the basin length
Diffusion of momentum is important
The tidal range is very large compared to the water depth
The basin is long enough for the wave to become a standing wave

Q12 - essay 3 points

In the Grevelingen basin in the period 1965-1971, the channel volume was too large with respect to its equilibrium condition.

Explain the characteristics of the tidal velocity signal that can restore equilibrium. Also, explain from the basin geometry whether it is likely or not that equilibrium will be restored.

Q13 - choose one answer 2 points

The storm surge barrier (indicated as no. 7 in fig.1) is not fully closed under normal conditions. It is however limiting the cross-sectional area of the tidal channel at that location. After the construction of the storm surge barrier, the tidal range in the Oosterschelde basin decreased.

How can this decrease of the tidal range be explained?

Choose from (arbitrary order, possibly different from in Maple TA):
Apparently the reduction of the cross-sectional area was large enough to reduce the tidal prism and hence the tidal range.
A reduction of the cross-sectional area of such a channel always lowers the tidal prism and thus the tidal range
The storm surge barrier has been closed on many occasions, which has impacted the tidal range
The equilibrium velocity was reduced and therewith the tidal range

Q14 - give a number 2 points

Assume that the tidal prism was reduced with x% (variable percentage in Maple TA, 30% for written exam) after building the storm surge barrier.

V1 is the outer delta volume after the construction of the storm surge barrier, V0 is the volume before the construction. What is a good estimate for the ratio V1/V0?

C. Humboldt Bay Q15-21

Consider the case of the Humboldt Bay, a multi-basin coastal lagoon on the West coast of the United States of America (fig.2). Here we focus on the entrance of the bay which is protected using two jetties that protrude approximately 1 km into the ocean (fig.3). The coast faces the Pacific Ocean.

fig.2

fig.3

Q15 - choose one answer 1 point

Is the coast under consideration located near or far away from a junction of two earth plates?

Q16 - choose one answer + essay 3 points

The distance between consecutive wave crests at point A in fig.3 is about 150 m (see the arrows) and the water depth at A can be assumed to be 14 meters.

a) Is the wave period at point A smaller or larger than 9 seconds?
b) Clarify how you got to your answer using a calculation.

Hint: This can be done without calculator, e.g. no tanh(..) needs to be solved.

Q17 - fill in one or more words — 1 point

By examining the satellite image closely, one can see that the wave crests landward of the harbour entrance (indicated as B) are curved.

How do we call the phenomenon that causes wave crests to bend like this?

Q18 - sketch — 2 points

Let us schematize the case of the Humboldt Bay entrance to a nearly straight coast which is intersected by two jetties. Consider the case where we would have wave incidence obliquely from the North (fig. 4). As no sediment is passing the harbour entrance, after a certain period accretion is found from point x=6 all the way up to the jetty.

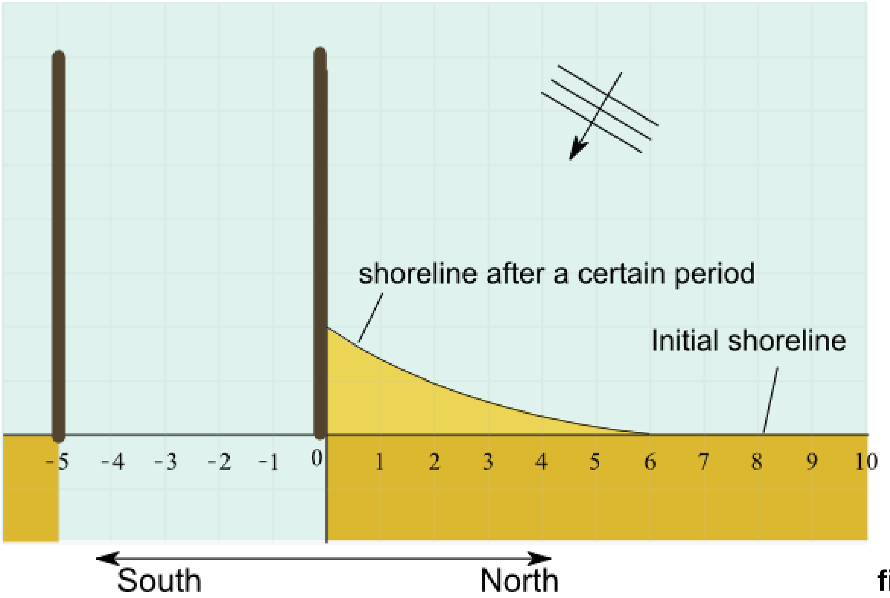


fig.4

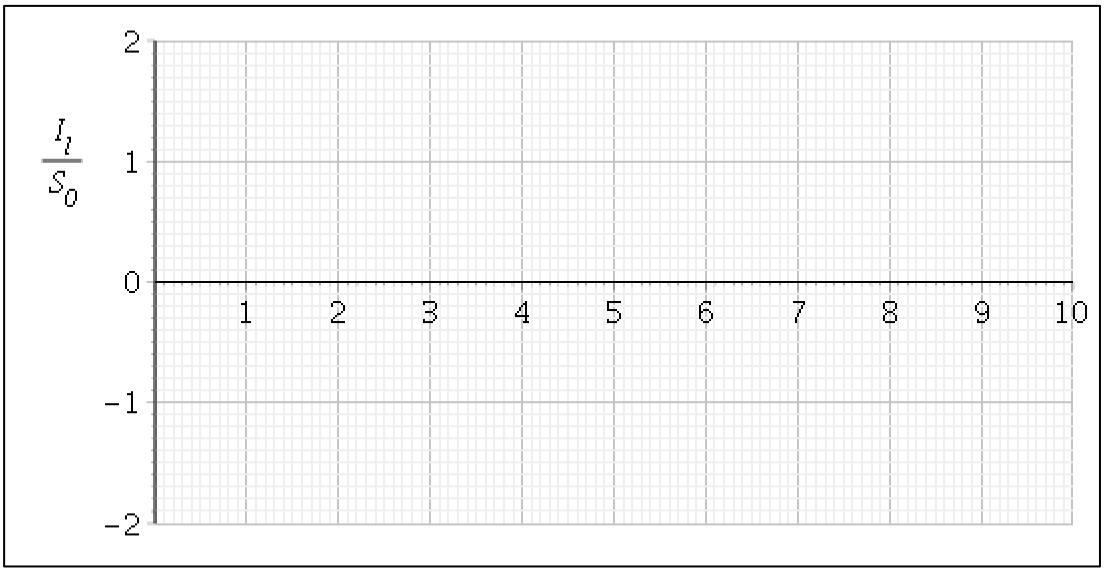
We assume that the alongshore sediment transport rates along the coast are according to a CERC like formulation:

$$I_l = (EC_g)_b K_1 \sin\alpha_b \cos\alpha_b$$

where the I_l is the immersed weight of the transported sediment, E and C_g are the wave energy and wave group celerity, K_1 is a constant and α_b is the wave angle of incidence (i.e. the angle between the wave ray and the shore-normal or, equivalently, between the wave crest and the shoreline). The subscript b indicates evaluation of the considered quantities at the breaker line.

For this case of oblique wave incidence, draw the alongshore sediment transport rate for the northern side in box 1, while assuming that:

- the angle between the coastline and the y-axis is everywhere smaller in magnitude than 40 degrees;
- the wave angle does not change from deep to shallow water;
- the sediment transport in the considered coastline section has a maximum magnitude of S_0;
- sediment transport rates are defined positive in the North direction (to the right in the above image).

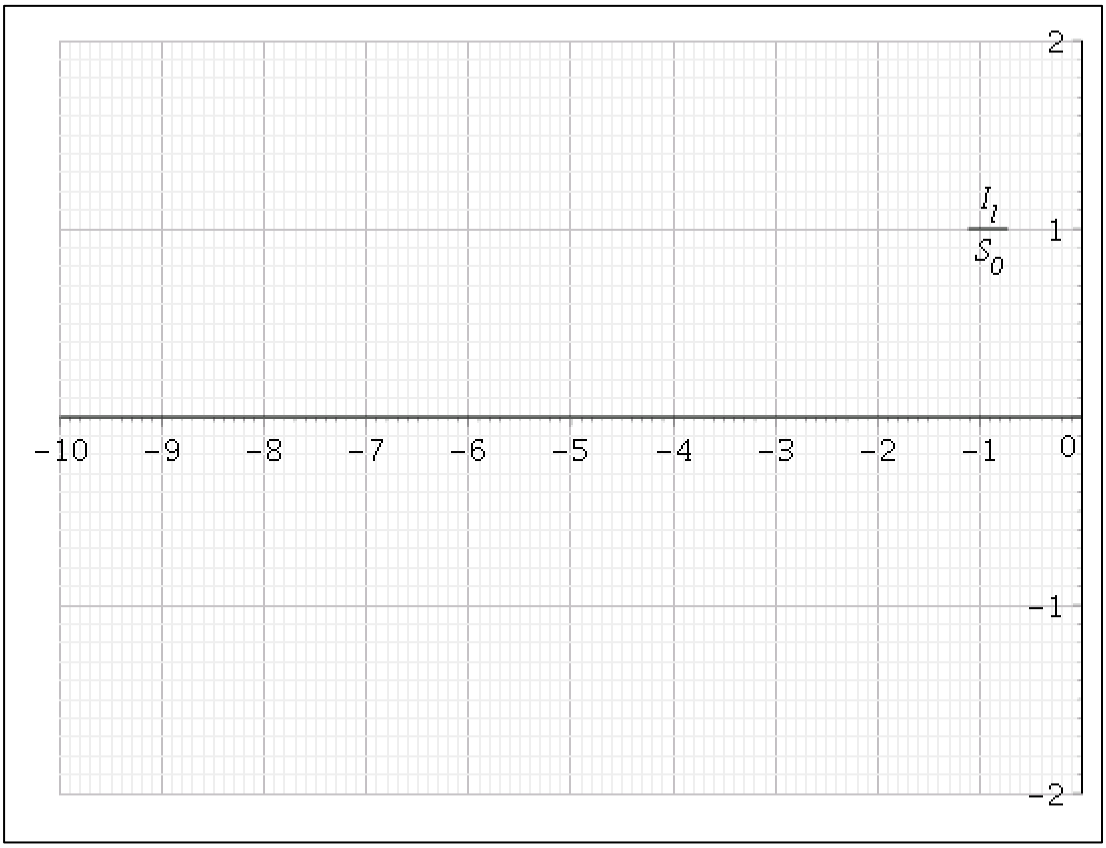


box 1

Q19 - sketch 3 points

Now, consider the downdrift side of the harbour entrance. As a result of the jetty, a shadow zone is created, causing wave heights to be lower in the vicinity of the jetty (fig.5). Again, for simplicity, assume that the wave angle does not change throughout the domain.

Draw the alongshore sediment transport rate, I_l, as function of alongshore distance in box 2.



box 2

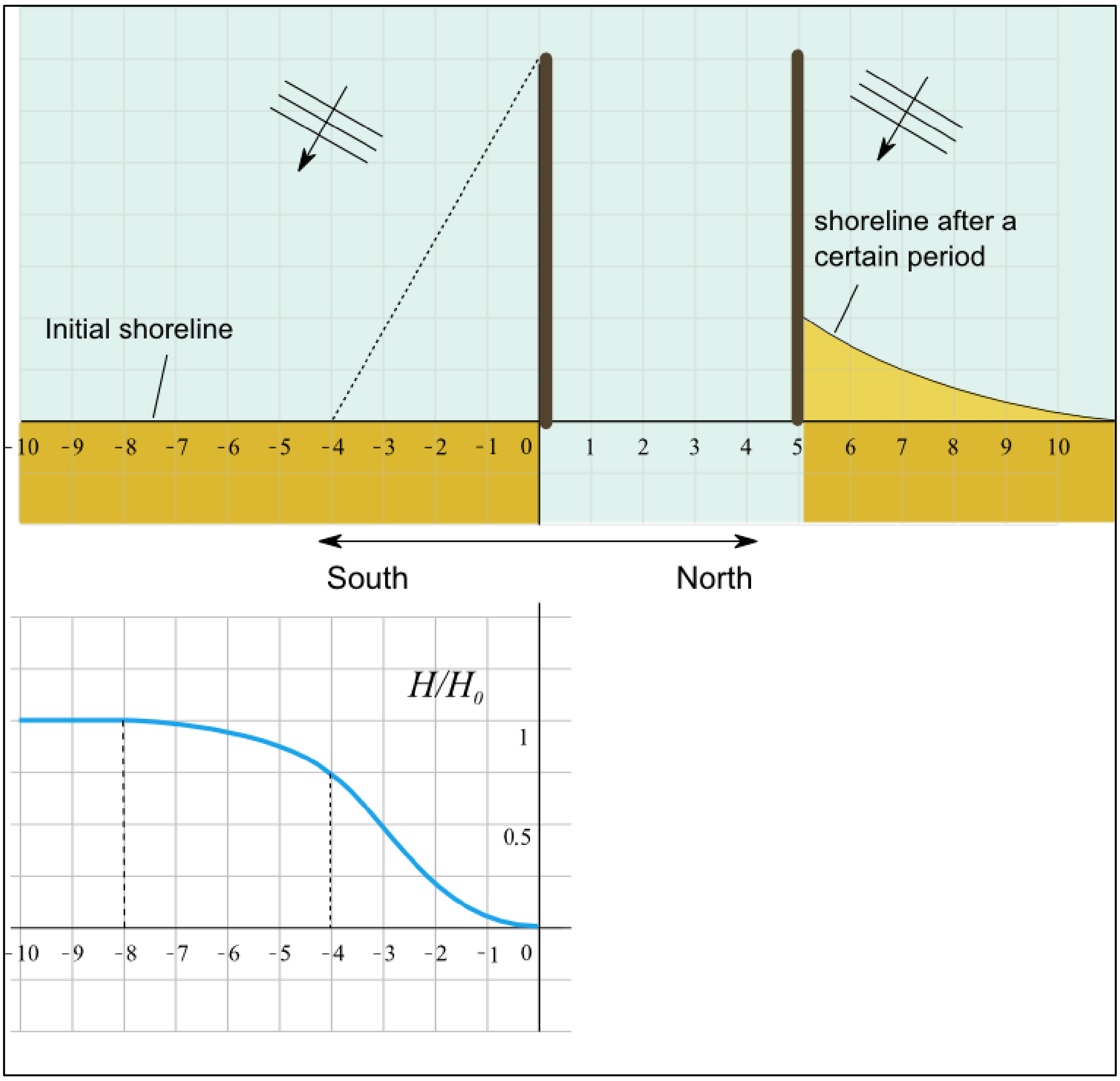


fig.5

Q20 - essay 2 points

If an additional effect of the presence of the jetty is included, its contribution to the alongshore sediment transport looks as shown in fig. 6 (green line).

Explain which process, absent in the previous question, causes this transport and how.

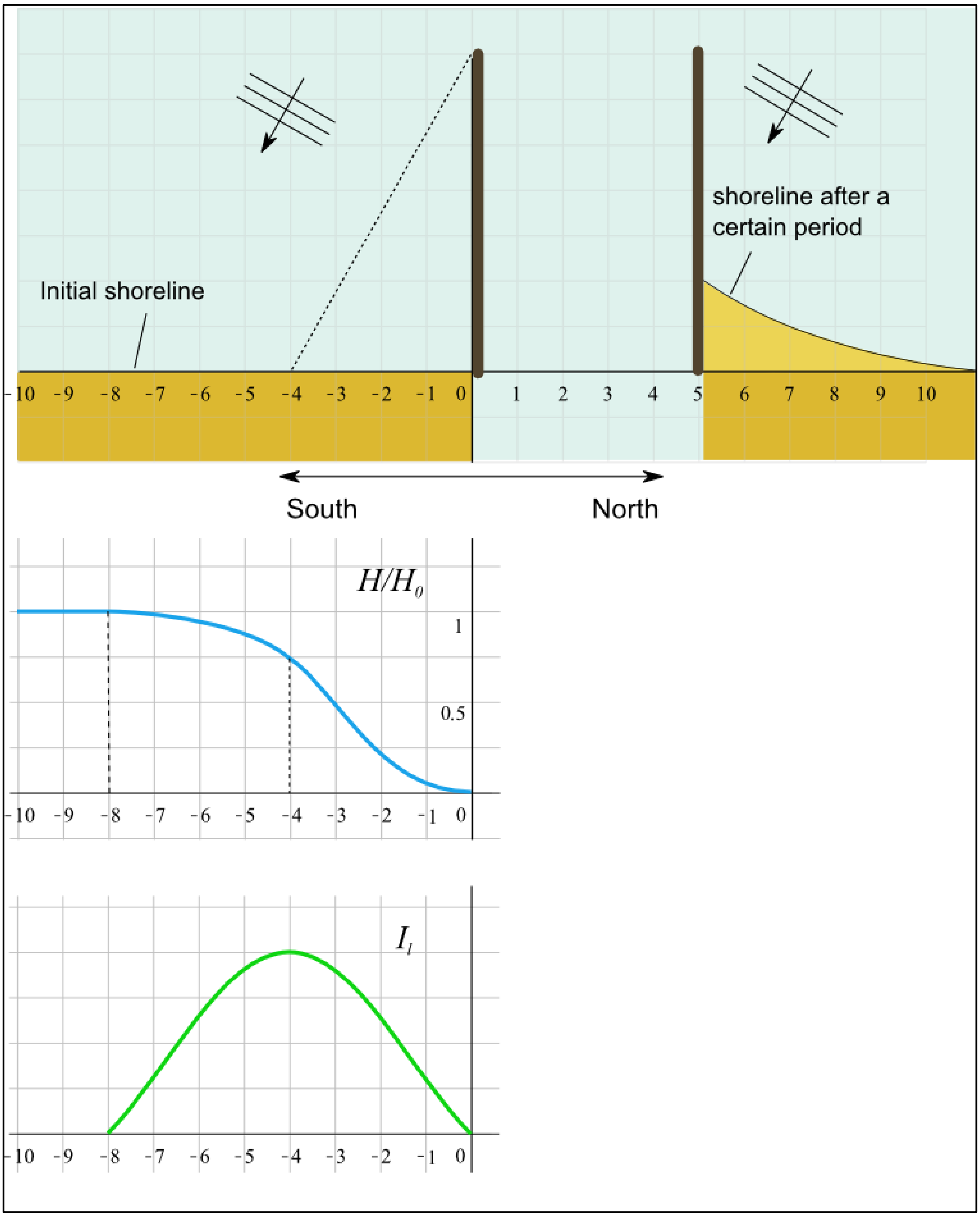


fig.6

Q21 - sketch 3 points

Assume that the combined sediment transport is represented by green line in fig. 7.

In box 3, qualitatively sketch the shoreline after a certain period.

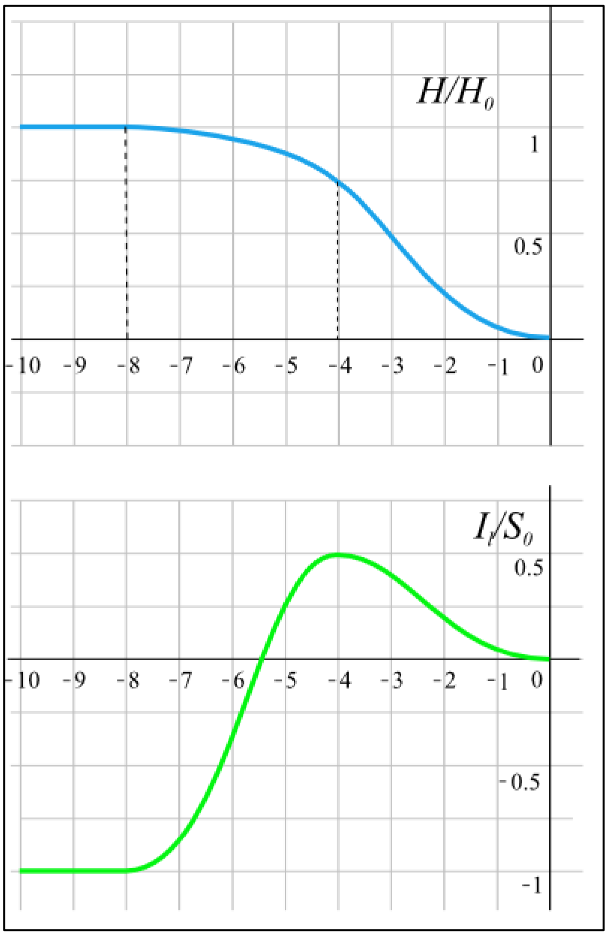
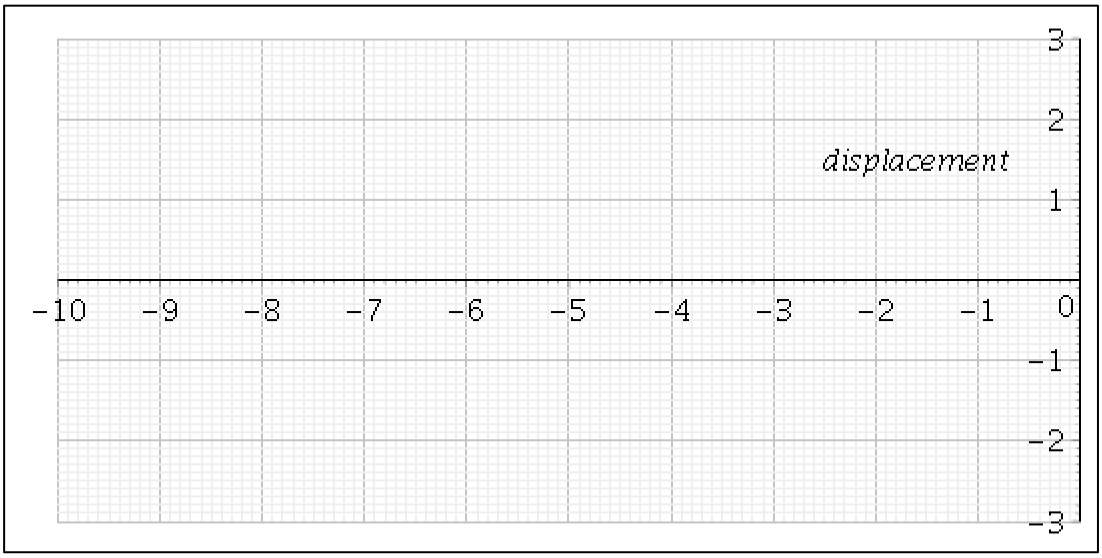


fig.7



box 3

D. Open coast Q22-27

Consider a straight, sandy, alongshore uniform coast. A schematized cross-shore profile of such a coast is given in fig. 8. Assume perfect shore-normal wave incidence and regular waves.

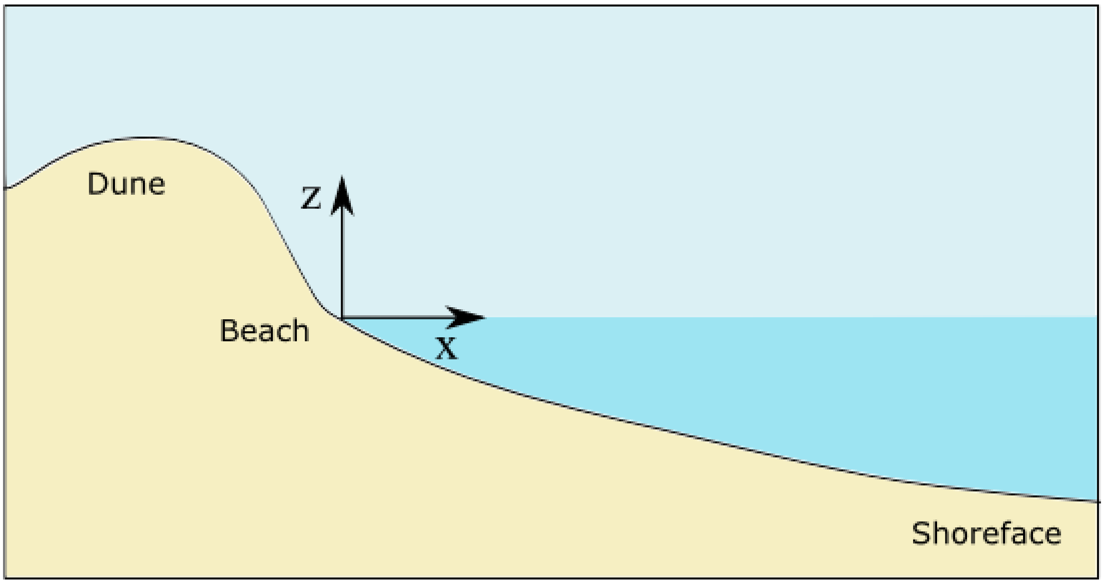


fig.8

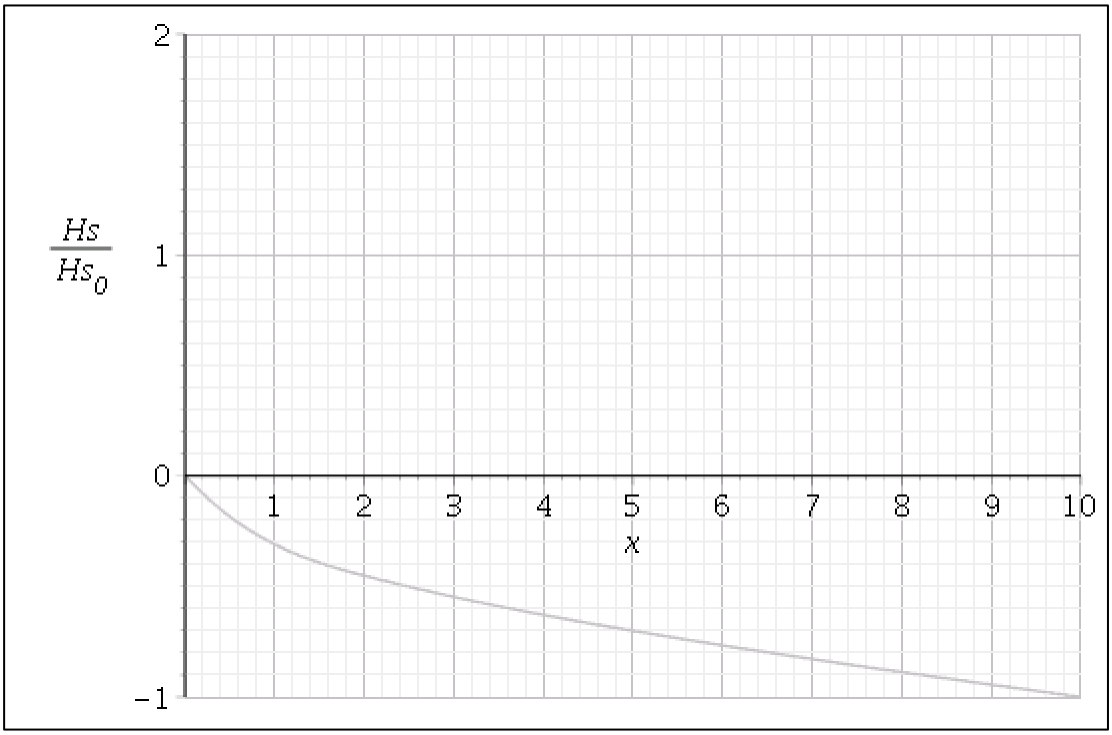
Q22 - sketch 2 points

Due to various processes, the wave height varies in cross-shore direction.

In box 4, sketch the variation of wave height in the cross-shore from offshore to the beach. In this box, a gray line representing the bathymetry of the profile serves as a reference. The vertical axis represents the ratio of the local significant wave height over the deep water (significant) wave height.

Assume that:

- for wave propagation effects the depth at x=8 is considered deep water;
- the surf zone is located between x=0 and x=3;

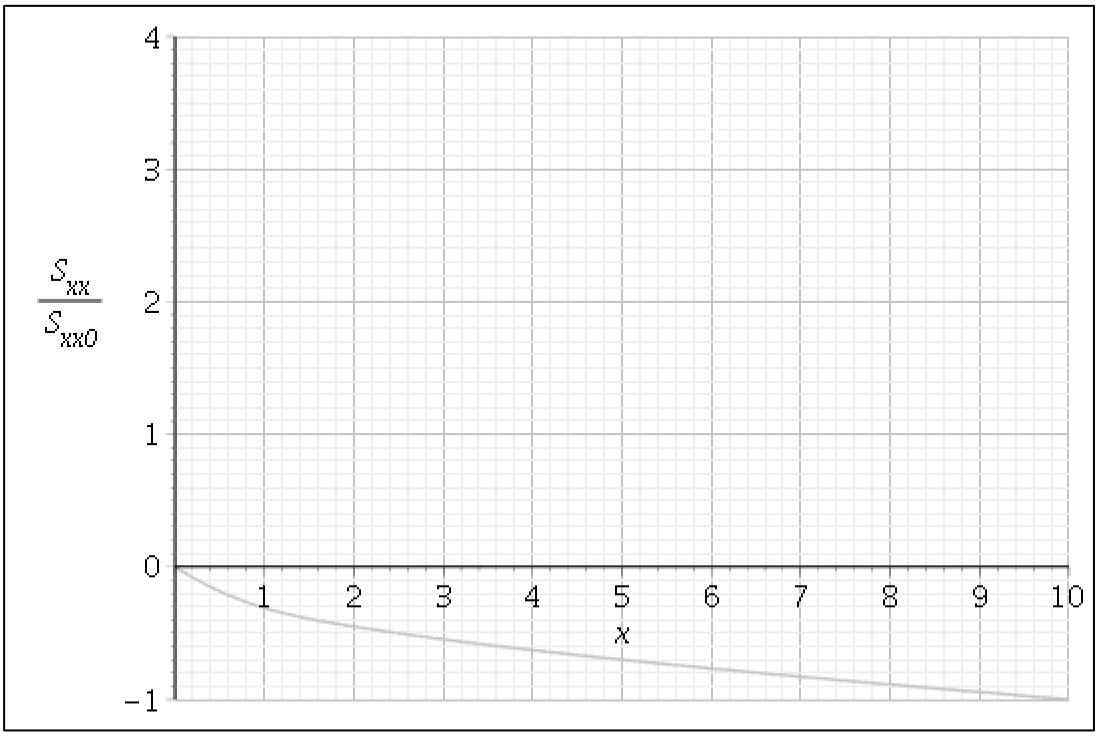


box 4

Q23 - sketch 3 points

The variation in wave properties results in variation in radiation stress and a resulting wave force that drives for instance the wave setup in the nearshore.

In box 5, sketch qualitatively the variation of Sxx in the cross-shore relative to its deep water value Sxx,0 .



box 5

Q24 - choose one or more answers 3 points

Which parameter(s) would you need, other than the (cross-shore distribution of the) wave height, to be able to quantify the Sxx cross-shore curve?

Choose from (arbitrary order, possibly different from in Maple TA): ω, n, c, cg.

Q25 - choose one or more answers 2 points

Which physical processes may lead to cross-shore transport in the area where x<8?

Choose from (answer options and order may be different in Maple TA):

- refraction
- gravity downslope transport
- shoaling
- Longuet-Higgins streaming
- wave asymmetry

Q26 - choose one answer 2 points

The sediment transport in the cross-shore is often assumed to be proportional to the velocity to a certain power, as for instance given by the following relation for bed load transport Sb :

$$\langle S_b \rangle \propto \langle u|u|^2 \rangle$$

Such an equation is based on a quasi-steady approach.

What is the main assumption behind this approach?

Choice between (arbitrary order, possibly different from in Maple TA):

- Sediment can directly follow changes in the forcing (velocity, bed shear stress);
- Sediment concentrations respond to the effect of the averaged bed shear stress
- The sediment response is not really steady (there are small phase lags between forcing and response)

Q27 - choose one answer (2x) + essay 7 points

Let's elaborate on the equation shown in the previous question and decompose the velocity signal u into different timescales.

Assume that the horizontal velocity u(t) close to the bed is the sum of a time-averaged component $\bar{u}$, an oscillatory component $u_{lo}(t)$ at the wave group scale and a short-wave oscillatory component $u_{hi}(t)$, hence $u(t) = \bar{u} + u_{lo} + u_{hi}$. Herewith, the third odd velocity moment can be decomposed as (time-averaging indicated by brackets):

$$\underbrace{\left\langle u|u|^2 \right\rangle}_{1} = \underbrace{3\left\langle \bar{u}|u_{hi}|^2 \right\rangle}_{2} + \underbrace{3\left\langle u_{lo}|u_{hi}|^2 \right\rangle}_{3} + \underbrace{\left\langle u_{hi}|u_{hi}|^2 \right\rangle}_{4} + \ldots \quad \textbf{eq.1}$$

Now consider a short wave velocity signal u_{hi} obtained from a flow meter in the surf zone (fig.9). The velocity is positive in the direction of the wave propagation (onshore direction).

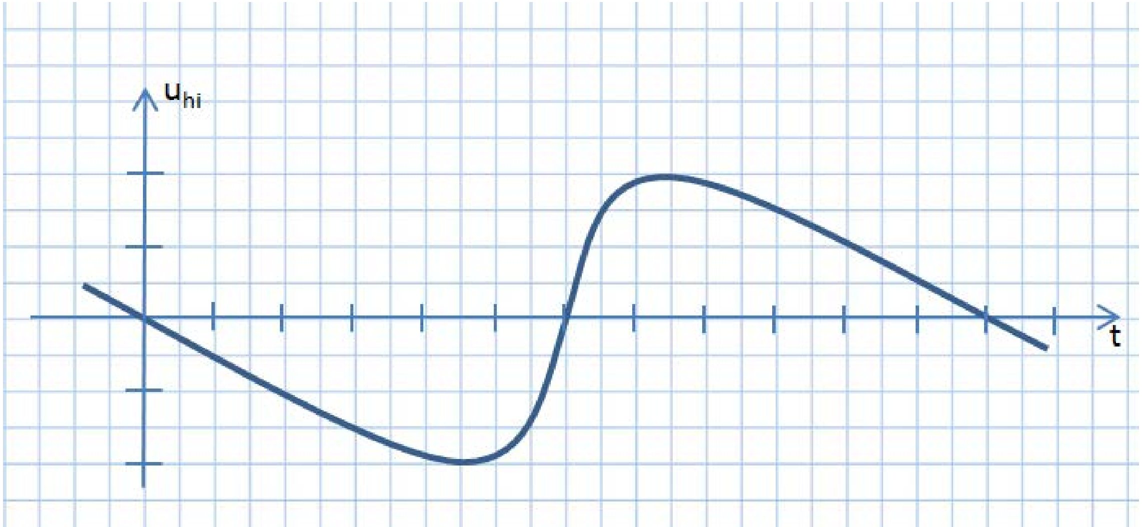


fig.9

a) Explain the mechanism that causes the velocity signal in fig.9 to deviate from a pure sine wave.

Choice between (arbitrary order, possibly different from in Maple TA):
The wave particles follow paths that are not entirely closed;
The instantaneous surface elevation affects the wave celerity;
The second-order Stokes component is phase-locked to the primary component;
A pitched forward wave in space is equivalent to a pitched backward wave in time;
In a progressive wave the surface elevation and velocity are in phase.

b) If only the sediment transport associated with term 4 is considered (term 2 and 3 in eq.1 are neglected), does the velocity signal in the figure above result in a net cross-shore transport? Or is there not enough information to come to a conclusion?

c) Regarding term 3 in eq.1, explain in physical terms whether the presence of long waves in the velocity signal results in a net onshore or offshore transport on the lower shoreface. Use the relative phases of uhi and ulo in your answer.