Exam CIE4305 (Coastal Dynamics 1) - April 7, 2015, 14:00-17:00

The below instructions are available in the exam hall and, a few days before the exam, on Blackboard. Make sure to read them carefully in preparation for the exam.

Exam content:

- The exam consists of 32 questions clustered in 4 topics (cross-shore, alongshore, basins and an in-depth question about an arbitrary topic).
- The total number of points is 69.

General instructions:

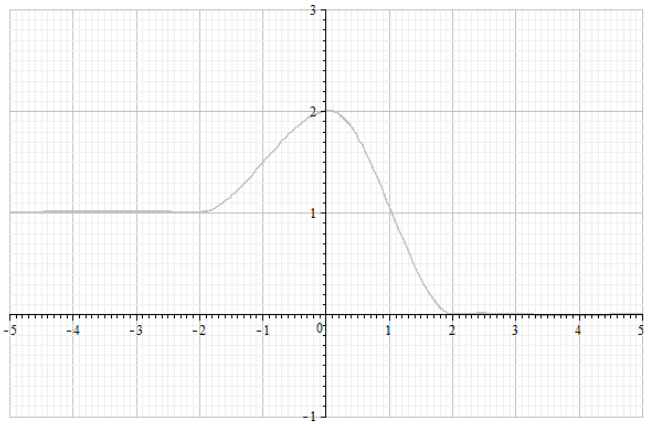
- Find a place in the exam hall as mentioned on your exam ticket. This does not hold for students with extra time or students that start later; they must ask to be seated.
- Place your student card on your desk.
- Log on to the exam environment:
  username: CITG_CIE4305
  password: Welcome2CD1
- Open Mozilla Firefox. You are now directed to the Maple TA server.
- In order to logon, you must have a valid login name and password (it is identical to the login information that you used for the Maple TA homework tests).
- Go to the class Coastal Dynamics 1 2014-2015 Q3.
- At 2 pm the Maple TA exam becomes visible (you may have to refresh your page).
- On the first page of the exam, a password is given that provides access to the pdf with the exam questions.
- From the START menu open the pdf viewer and choose to open a file. You can now choose the pdf file with exam questions. To unlock the pdf you need to enter the password supplied in the Maple instructions.
- 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:

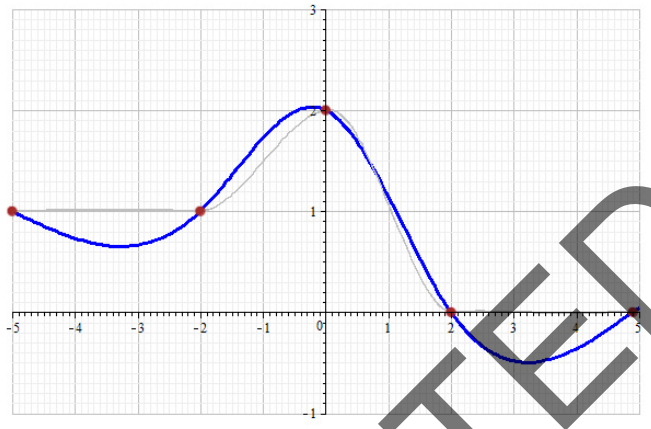
- Note that the session shuts down after 60 minutes of inactivity.
- Because of the use of MathApps (for drawing polygons), MapleTA does not check correctly whether you have answered all questions, so you must check this yourself!
- Hint for drawing polygons with MathApps: for a sudden change of slope of the polygon, use two points (but not three!) close to each other. For instance two points around the maximum or at a location where the curve changes from zero slope to sloping. See the examples on the next page.
- Let questions and MathApps 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 MathApps), the results can range from garbled responses to full reset of answer areas and MathApps to the initial (unanswered) state.
- When you are ready choose SUBMIT.

Rules:

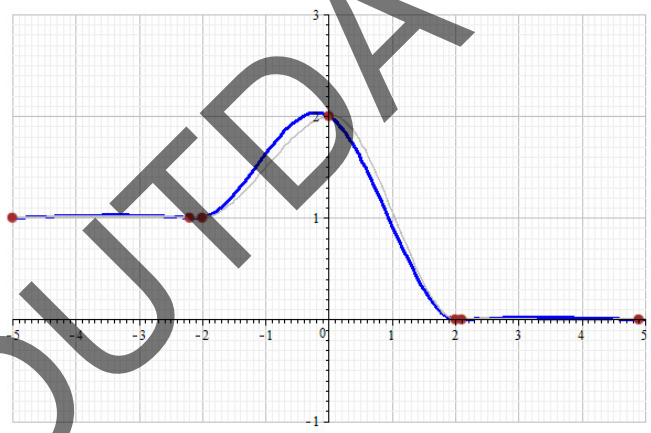
- You may use your hard-copy of the lecture notes. In the lecture notes, some hand-written notes are allowed for as far as they deal directly with the material in the book.
- You may use a ruler and/or protractor, and a pen, pencil and eraser.
- You cannot bring or use separate sheets of paper of any kind (except for copies of the subject index for students with the 2013 version).
- It is not allowed to make notes in your book during the exam.
- Writing is only allowed on the scrap paper that is handed out.
- Every piece of scrap paper used during the exam must be handed in before you leave.
- Calculators are not allowed (a calculator is available on the PC's in the computer hall)
- Mobile phones are not allowed.



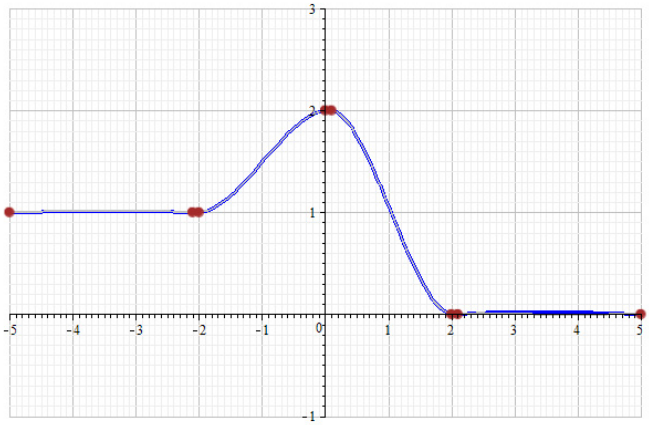
1 The target line that you want to produce



2 These 5 points cannot reproduce the line correctly



3 Add one additional point at each location where the target line changes from horizontal to sloping or v.v.



4 Also add an extra point next to the maximum or minimum to have these at the correct location

A. Emerged vs. submerged detached breakwaters (in depth) Q1-7

We consider the circulation currents induced by a series of detached breakwaters. It is given that:

- The breakwaters are equally spaced and all have the same dimensions.
- The waves are normally incident.
- The natural surf zone width is less than the distance from the breakwaters to the shore (points A, B and C are assumed to lie in the natural surf zone).

In the below figure one of the breakwaters and half of its nearest neighbors are represented.

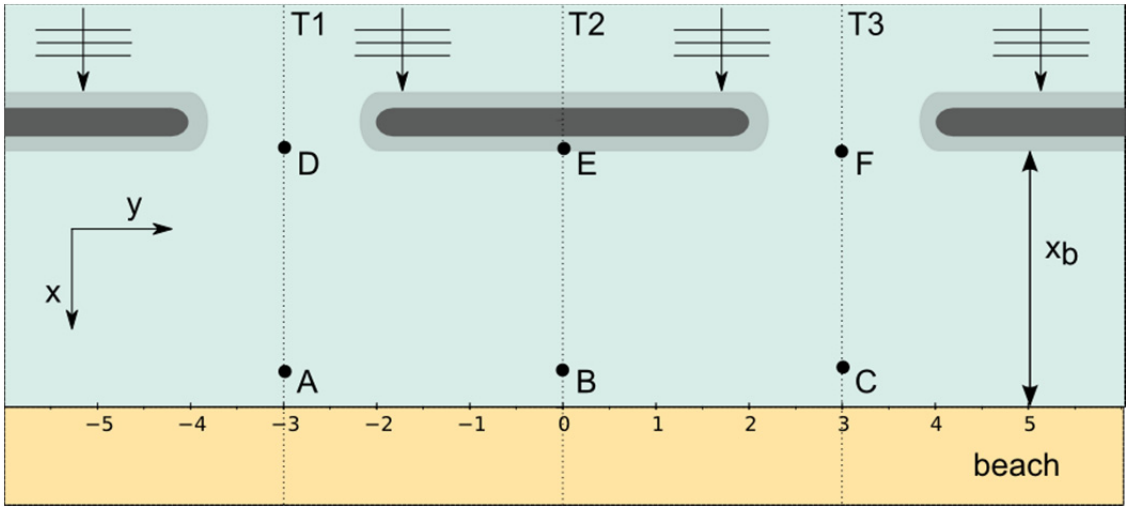


fig.1

In general, we can write the alongshore forces that can generate currents as:

$$F_y = F_{y1} + F_{y2} + F_{y3}$$

where: $F_{y1} = -\frac{\partial S_{yy}}{\partial y}$, $F_{y2} = -\frac{\partial S_{yx}}{\partial x}$ *and* $F_{y3} = -\rho g(h+\bar{\eta})\frac{\partial \bar{\eta}}{\partial y}$

In this comparison we will only consider currents generated by F_{y3}. We do this for two situations: 1. emerged breakwaters and 2. submerged breakwaters. For the submerged breakwaters, the wave energy is partly dissipated on the breakwaters and partly transmitted over the breakwaters. The transmitted waves propagate towards the shore and eventually break in the natural surf zone close to the shore.

Q1 - choose the correct answer (3x) 2 points

This first question is about the set-up, for both emerged and submerged breakwaters, that is generated due to wave breaking in the natural surf zone only.

For locations C, B and F (see fig.1) indicate the set-up magnitudes. Give you answer by linking C, B and F to the symbols 0, + and ++. The symbols indicate the set-up magnitudes ranging from zero (0) to the highest set-up (++). Each answer can only occur once.

Q2 - choose the correct answer 2 points

Now specifically consider emerged breakwaters.

a) Qualitatively indicate the magnitude and direction of F_{y3} for each of the zones as indicated in fig. 1 using the symbols provided (the arrows represent the direction).

- Zone between points A and B: choose from: 0, ⇨ and ⇦
- Zone between points B and C: choose from: 0, ⇨ and ⇦

b) Which of the below current patterns is driven as a consequence?

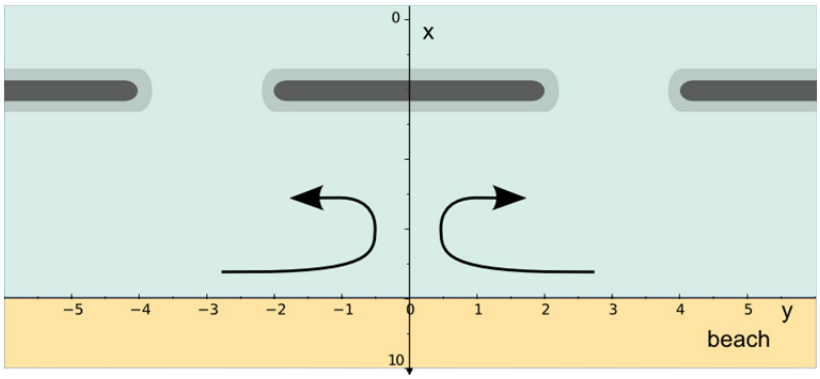


fig.2

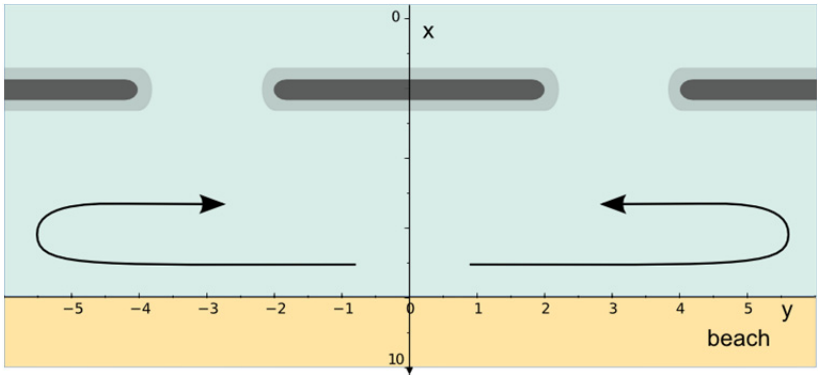


fig.3

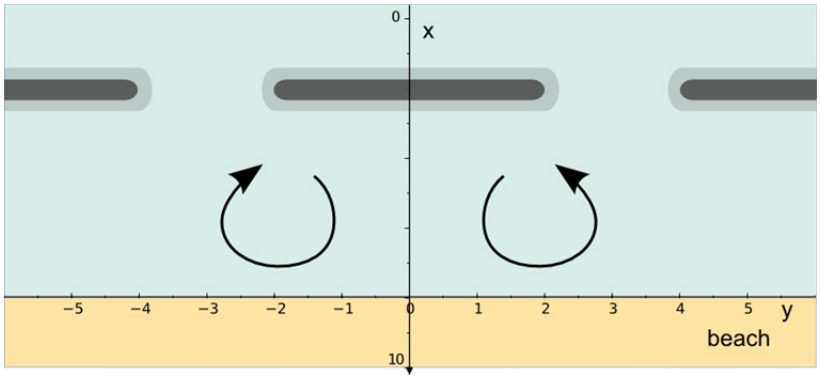


fig.4

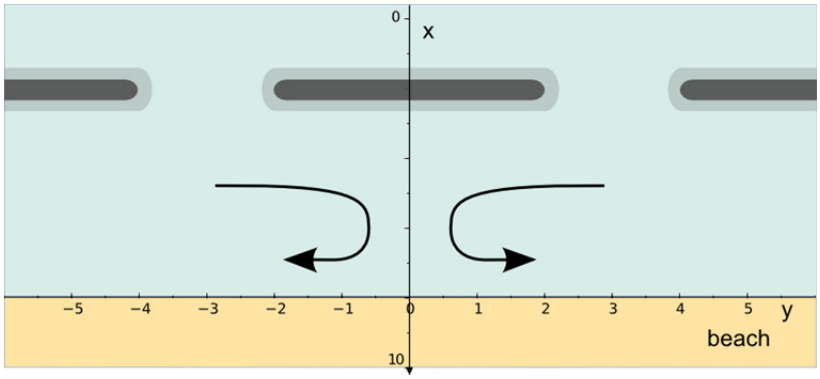


fig.5

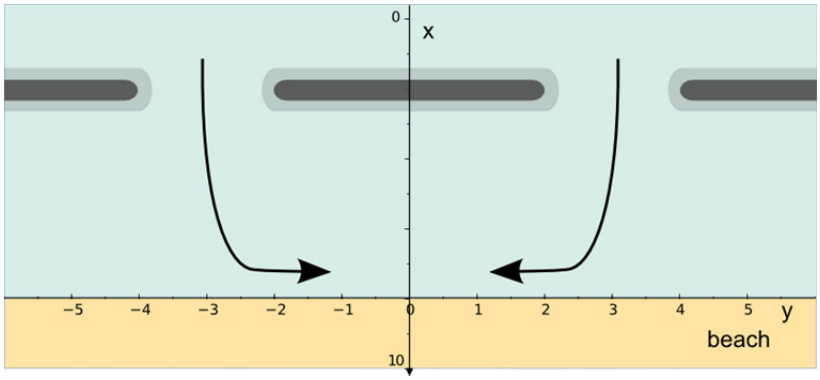


fig.6

Q3 - sketch 2 points

Qualitatively sketch the expected shoreline response for the situation of emerged breakwaters (see Q2) and normally incident waves.

Take the following into account:

- Use box 1 or its Maple TA equivalent.
- The position of the breakwater in relation to the sketch area axis is represented in the below image.
- Assume that the effect of breakwater on the shoreline is zero at the extremities of the domain (x=-3 and x=3).

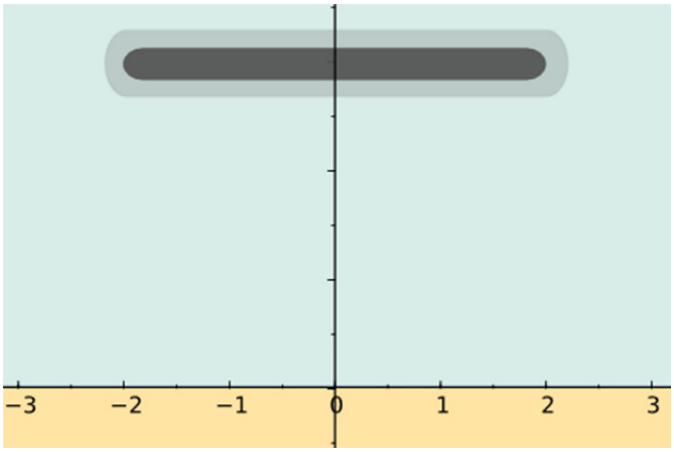
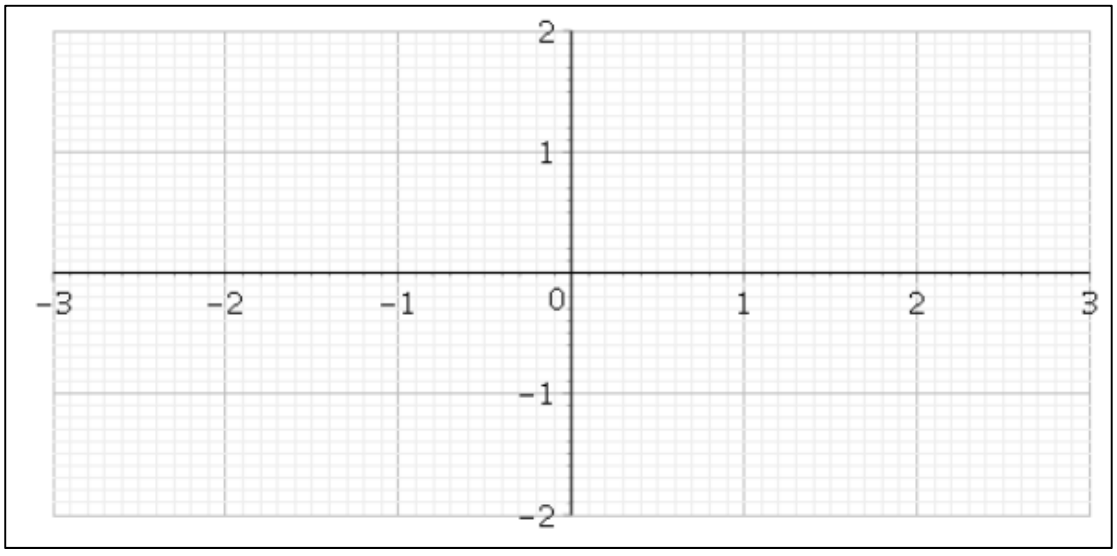


fig.7



box 1

Q4 - choose one or more correct answers + essay 3 points

Now we consider the situation that the breakwaters are submerged, such that the breakwaters force the waves to break over the structure while some remaining wave energy is transmitted.

The figure below shows a cross-section of the breakwater and the water levels at transect T2. Note that x_1 is just offshore and x_2 is just onshore of the breakwater. Location x_2 corresponds to location E in the above overview picture.

The wave forces associated with the breaking at the location of the structure result in a combination of a net onshore flow (u_1,u_2) over the breakwater and a set-up (η_2).

In the following you may assume that the distance of the breakwaters to the shore (x_b) is so small that the set-up (η_2) causes a constant piling up of the water behind the breakwater. In

other words, in transect T2 the raise of the water level due to wave breaking over the breakwater is uniformly distributed from the breakwater to the shore.

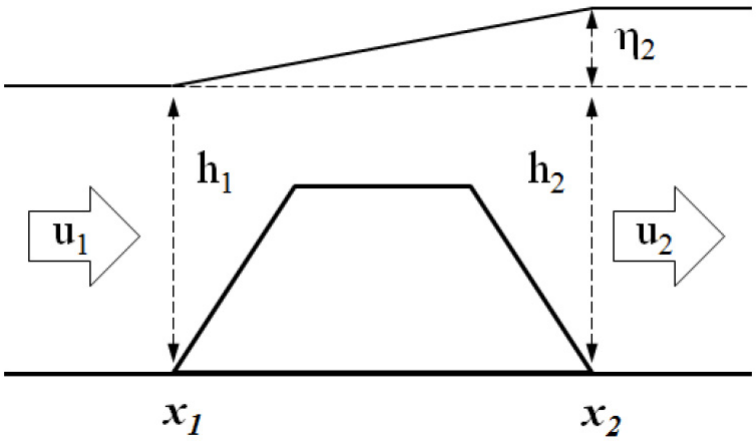


fig.8

The dimensions of the system are given in the below figure.

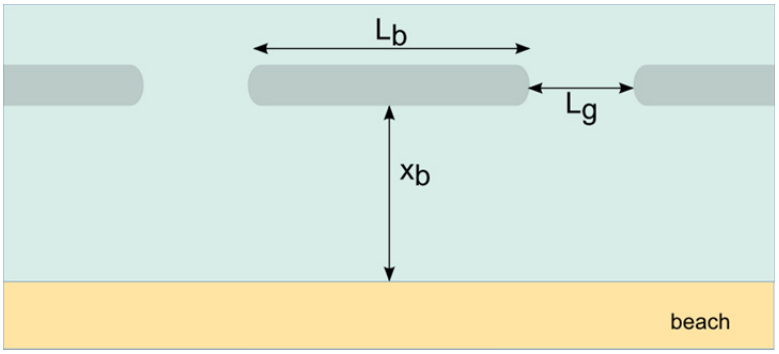


fig.9

As explained above, the wave forces due to the wave breaking on the breakwater drive a combination of set-up and a net flow. The relative importance of set-up versus net flow depends on the dimensions of the system.

a) How would you expect the ratio of L_g/L_b to influence the importance of the set-up (η_2) versus the net flow (u_2)?
   Answer options (arbitrary order, possibly different from in Maple TA):
   if L_g/L_b increases then η_2 decreases
   if L_g/L_b increases then η_2 increases
   if L_g/L_b increases then u_2 decreases
   if L_g/L_b increases then u_2 increases
   η_2 is not affected by L_g/L_b
   u_2 is not affected by L_g/L_b

b) Explain why this happens.

Hint to a) and b): Consider continuity of the inflow over the breakwater and outflow through the gap. Further: what drives the flow through the gap?

Q5 - choose the correct answer 2 points

Submerged breakwaters have often been not as effective as anticipated.

What is the current pattern that could explain this?

Choose from:

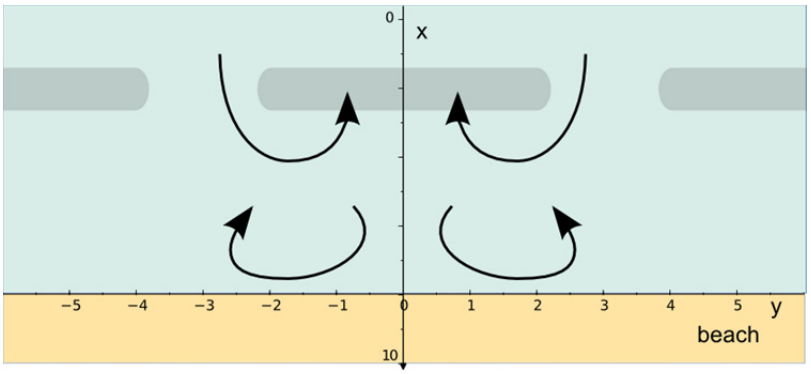


fig.10

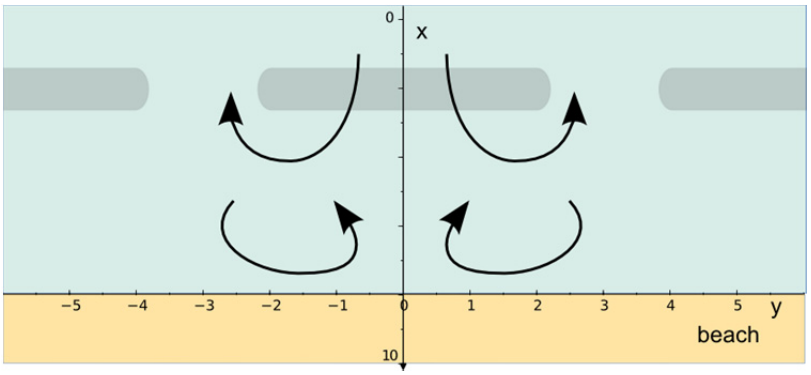


fig.11

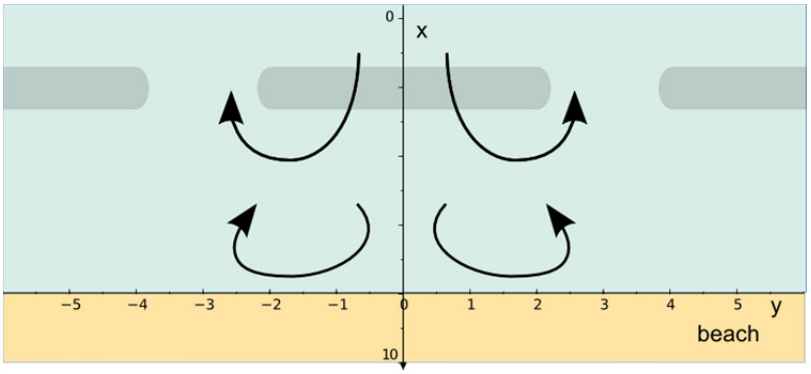


fig.12

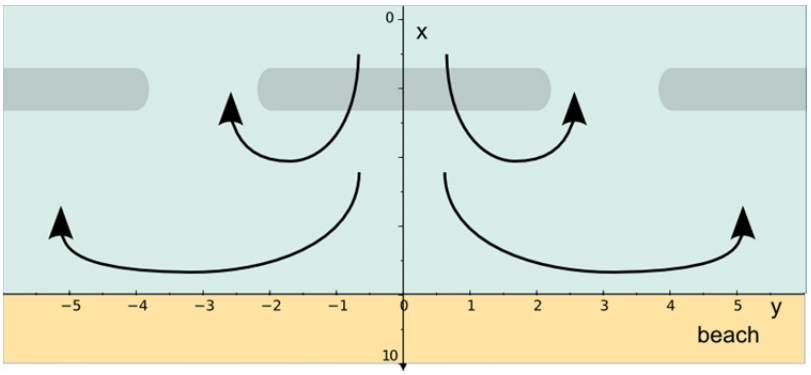


fig.13

Q6 - give expression 3 points

In order to explain the current pattern of the previous question, we compare the mean water level close to the shore in transects T2 and T3 (say at locations B and C). In transect T3, this set-up is η_C. We have seen that, for a submerged breakwater, we have to take into account in transect T2:

1. the raise of the water level due to the wave breaking over the structure (η_2).
2. the raise of the water level (η_B) due to the wave breaking of the transmitted waves that re-shoal behind the breakwater and eventually break close to the shore.

What would be a criterion for the current pattern of the previous question to occur?

The criterion has the form A>1 with A is a function of η_2, η_B and η_C. Write the expression for A. In doing so, write η_2 as eta2, η_B as etab and η_C as etac.

Q7 - choose the correct answer 2 points

If the ratio L_g/L_b increases, what is likely to happen?

Answer options (arbitrary order, possibly different from in Maple TA):

the tendency for erosion will become weaker

nothing

the tendency for erosion will become stronger

B. Bar Migration Transport Gradients Q8-14

Consider a cross-shore profile with a sand bar as schematized in the below figure.

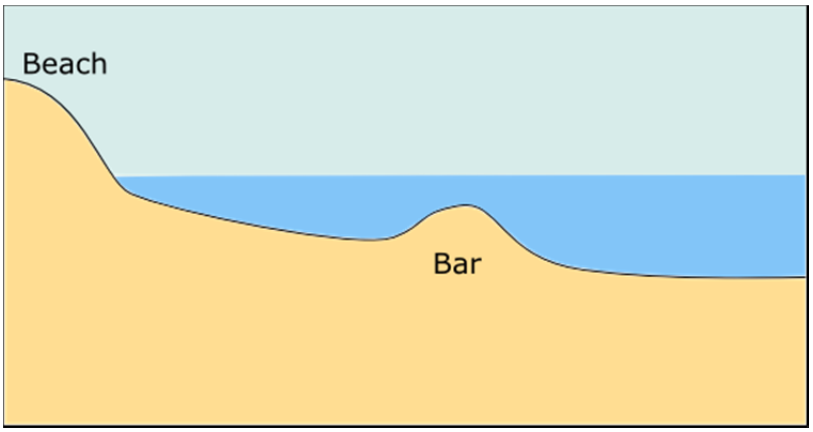


fig.14

In this question, we consider the onshore migration of the sand bar and specifically the cross-shore sediment transport distribution that gives rise to this onshore migration.

Q8 - drop-down menu (2x) 1 point

What is the initial morphodynamic response to be expected consistent with onshore migration?

For each zone A, B, C and D choose between sedimentation, erosion and no change.

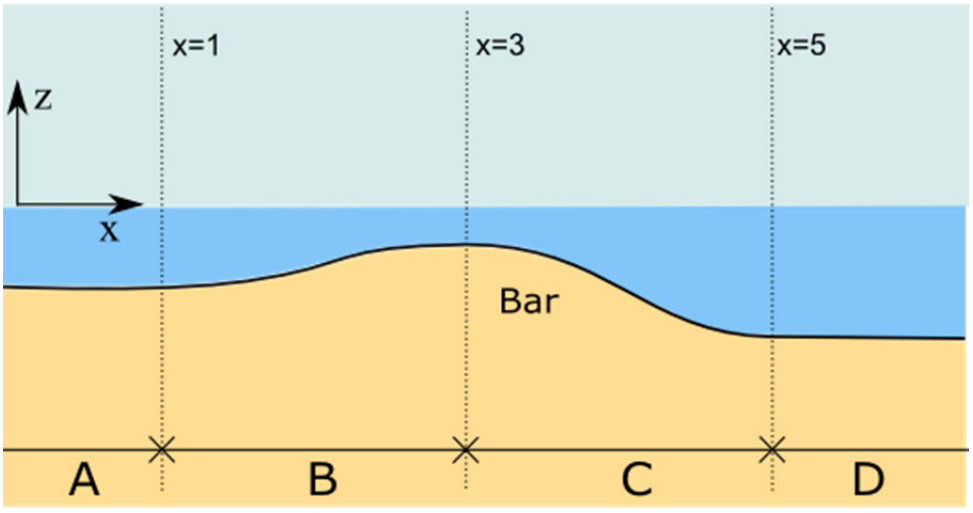
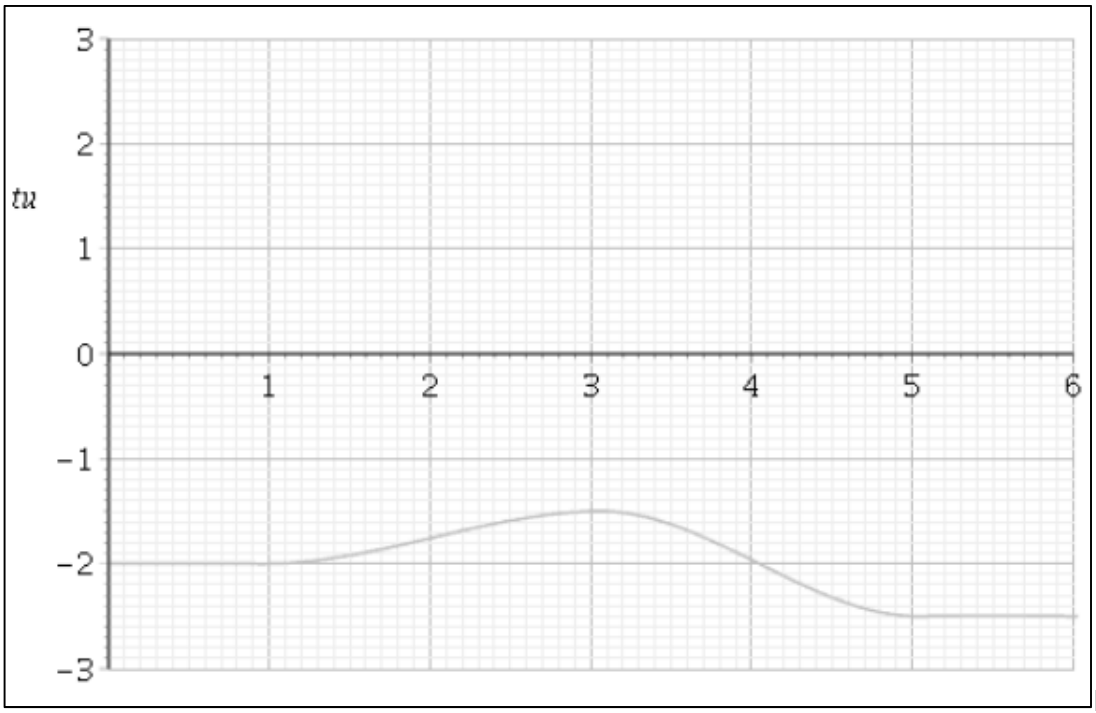


fig.15

Q9 - sketch 3 points

Qualitatively draw the sediment transport distribution over the bar consistent with your answer to the previous question.

- Give your answer in box 2 or its Maple TA equivalent.
- For guidance the bathymetry is represented as a grey line.
- Transport is considered positive in the positive x-direction (to the right in the image shown in the previous question).
- Assume that at x=0, transport has a magnitude of 1 transport unit (tu). The direction and thus the correct sign has to be determined by you.



box 2

Q10 - choose one answer — 2 points

For the conditions representative for the above described onshore bar migration, where are the waves breaking?

Answer options (arbitrary order, possibly different from in Maple TA):
onshore of the bar
offshore of the bar
at the bar.

Q11 - choose one or more answers — 2 points

Which hydrodynamic process(es) has (have) an important contribution to this transport?

Possible answer options (Maple TA can have different answer options and in a different order):
Longuet-Higgins streaming
wave skewness
long waves
wave dissipation
undertow

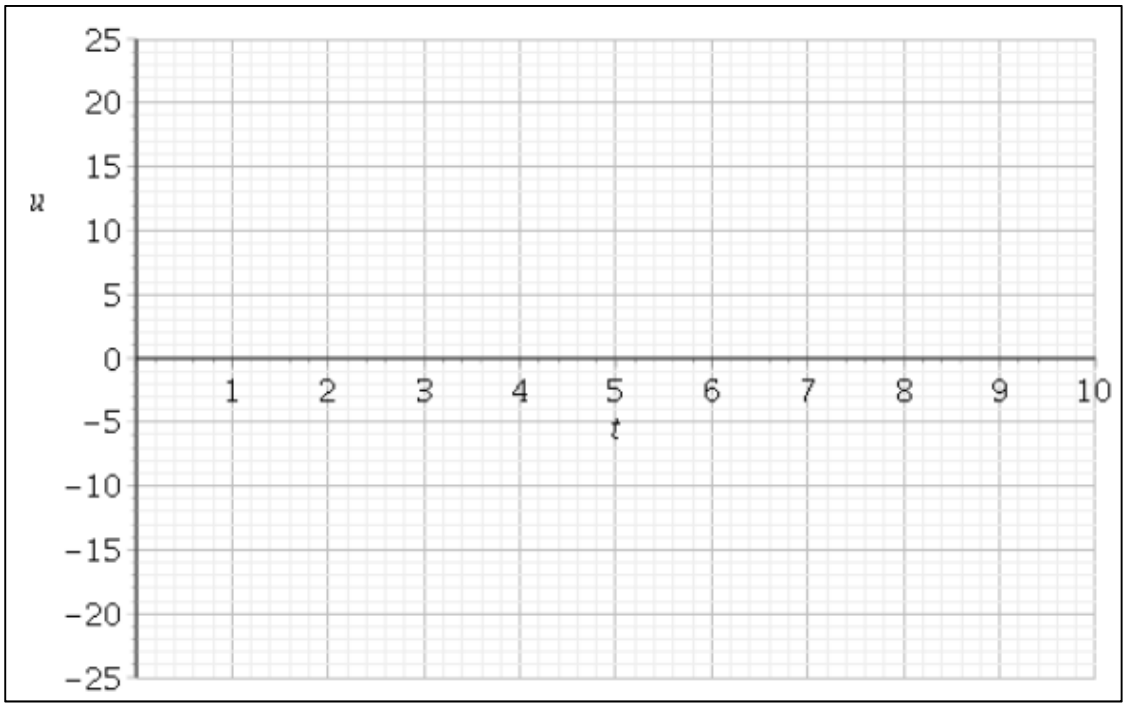
Q12 - sketch — 2 points

Whereas shoaling waves are skewed, in the surf zone waves become more and more asymmetric (forward pitching while propagating onshore).

Sketch the orbital velocity u as a function of time of such an asymmetric wave (with zero skewness).

Take the following into account:

- Give your answer in box 3 or its Maple TA equivalent.
- On the horizontal axis, we have the time t in seconds (s). The range on this axis exactly corresponds with one wave period T (T = 10 seconds).
- On the vertical axis, we have the orbital velocity u in cm/s. It is given that the maximum magnitude of the wave orbital velocity is 20 cm/s
- The velocity is defined positive in the onshore direction.
- Start from zero velocity at t=0, subsequently draw the onshore stroke of the wave and then the offshore stroke.



box 3

Q13 - essay 3 points

When assuming that the sediment responds quasi-steadily to the velocity, a velocity signal as in the previous question does not lead to a net (wave-averaged) transport. Nonetheless, wave asymmetry has been argued to give rise to onshore transport.

Hypothesize about a feasible physical explanation for this.

Attention: multiple reasonings are possible, only one is required.

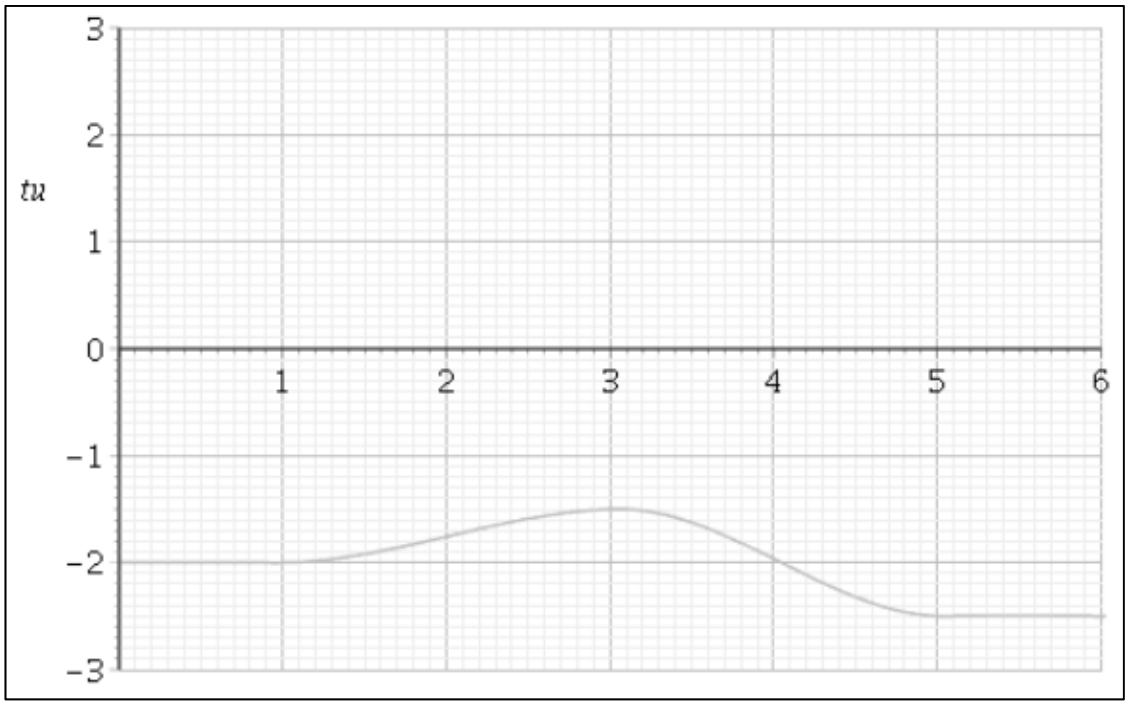
Hint: one of the reasonings can be derived from an analogy with a mechanism that we discussed for the tide.

Q14 - sketch 2 points

If offshore bar migration occurs (instead of onshore bar migration), the zones of sedimentation and erosion are reversed as compared to onshore bar migration (see your answer to the very first question on this page).

Qualitatively draw the corresponding sediment transport distribution over the bar

- Give your answer in box 4 or its Maple TA equivalent.
- For guidance the bathymetry is represented as a grey line.
- Transport is considered positive in the positive x-direction (to the right in the image of the cross-shore profile).
- Assume that at x=0, the transport magnitude is 1 offshore transport unit (tu). The direction and thus the correct sign has to be determined by you.



box 4

C. Tangier Q15-21

Tangier Bay (Morocco) is a 5 km-long embayment facing the Strait of Gibraltar. Below are depicted the location (fig16.a) and close-up view (fig16.b) of Tangier Bay.

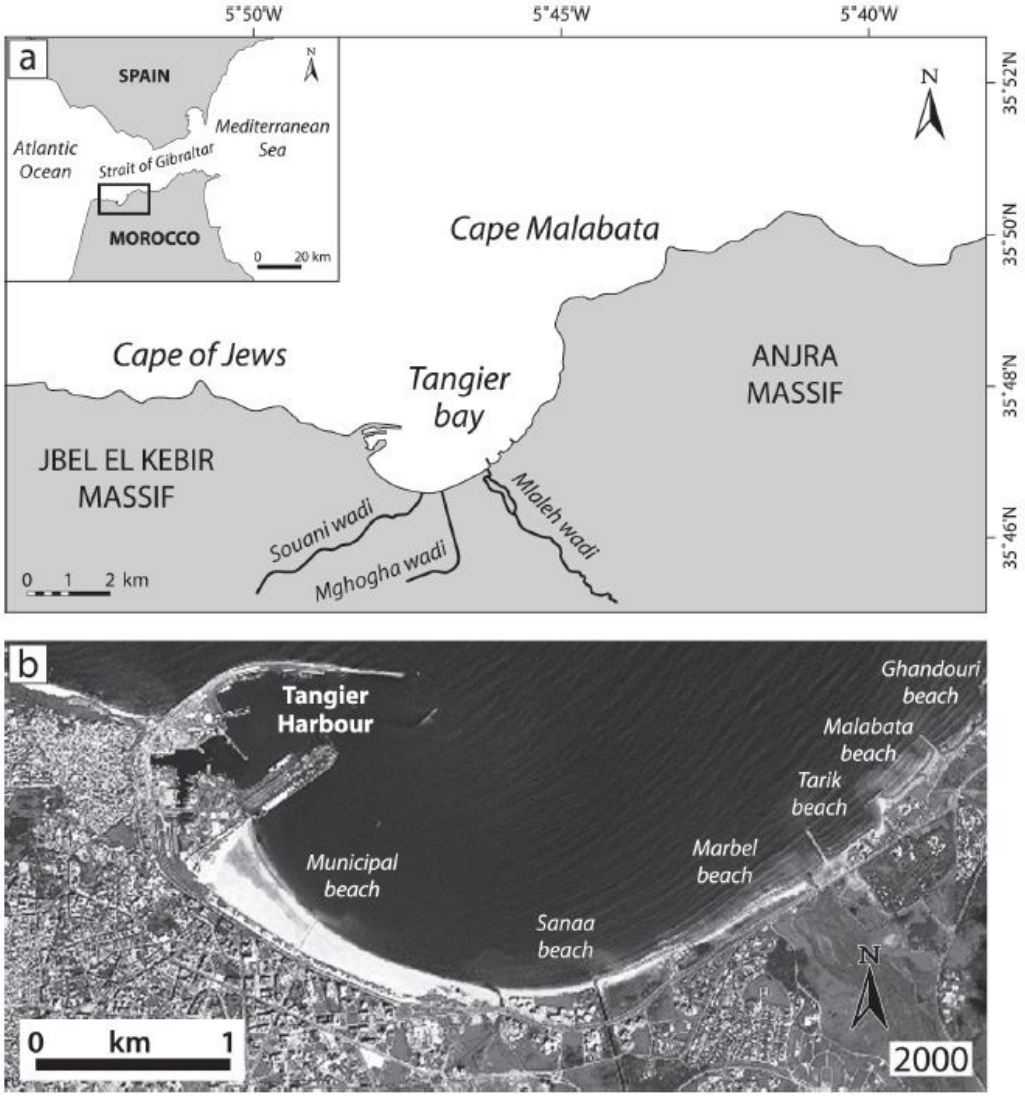


fig.16

The bay is bounded by headlands, resulting in a closed sediment cell.

The western extremity of the bay was chosen as a site for the construction of a commercial port around the 1950s (we assume the construction activities mainly took place in the 1950s).

The sandy beach in the eastern part of this bay has been steadily eroding over 50 years after the construction of the harbour and now only consists of shingle (see figure below). The severe retreat of the beach in the eastern sector has led to the destruction of tourist and transport infrastructure.

In contrast, before the 1950s, the yearly-averaged coastline position was stable along the entire bay.

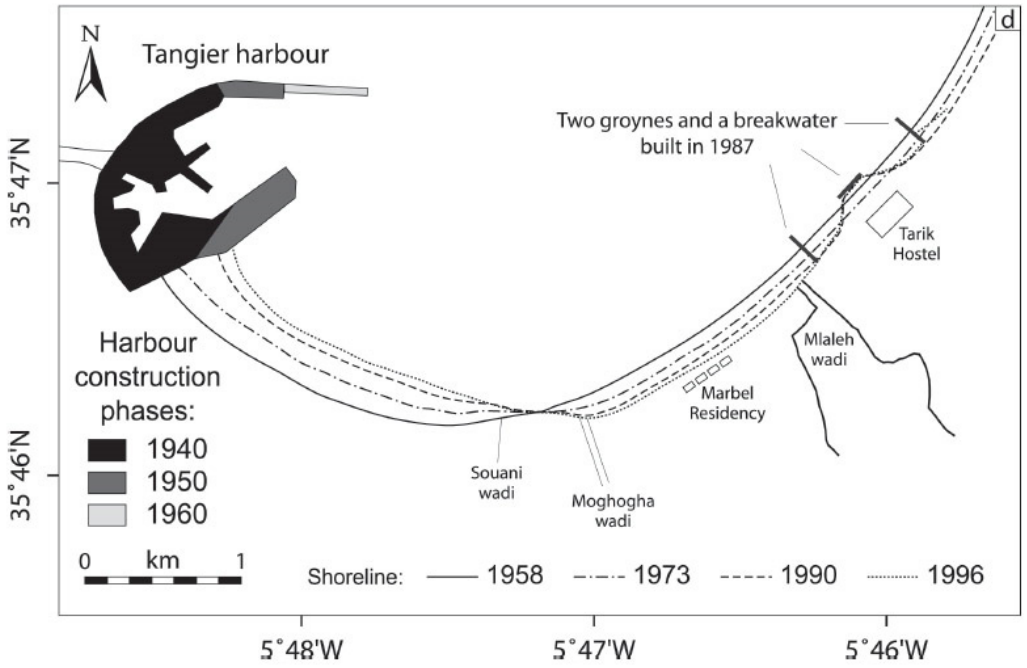


fig.17

Because of its geographical location, Tangier Bay experiences a bidirectional wave regime consisting of waves coming from 1) west to north-west and 2) east to north-east:

- The waves from W to NW consist of swell and wind waves from west to north-west with peak periods of 5 to 15 s and significant heights up to 4 m. In the following we refer to these waves as 'westerly waves'.
- The waves from E to NE have significant heights that do not exceed 2 m. In the following we refer to these waves as 'easterly waves'.

Due to the bidirectional wave regime the annual residual longshore transport is a combination of east to west and west to east alongshore transport.

Q15 - choose one or more answers — 2 points

Which of the below statement(s) is(are) true?

Answer options (arbitrary order, possibly different from in Maple TA):

The waves from the E to NE are swell waves

The swell waves are larger in January than in July

The shorter waves from the western sector are swell waves and the longer waves are wind waves.

Q16 - give a name — 1 point

Name the hydrodynamic process that ensures that even waves from the east are capable of generating an east-to-west alongshore transport at Marbel Residency.

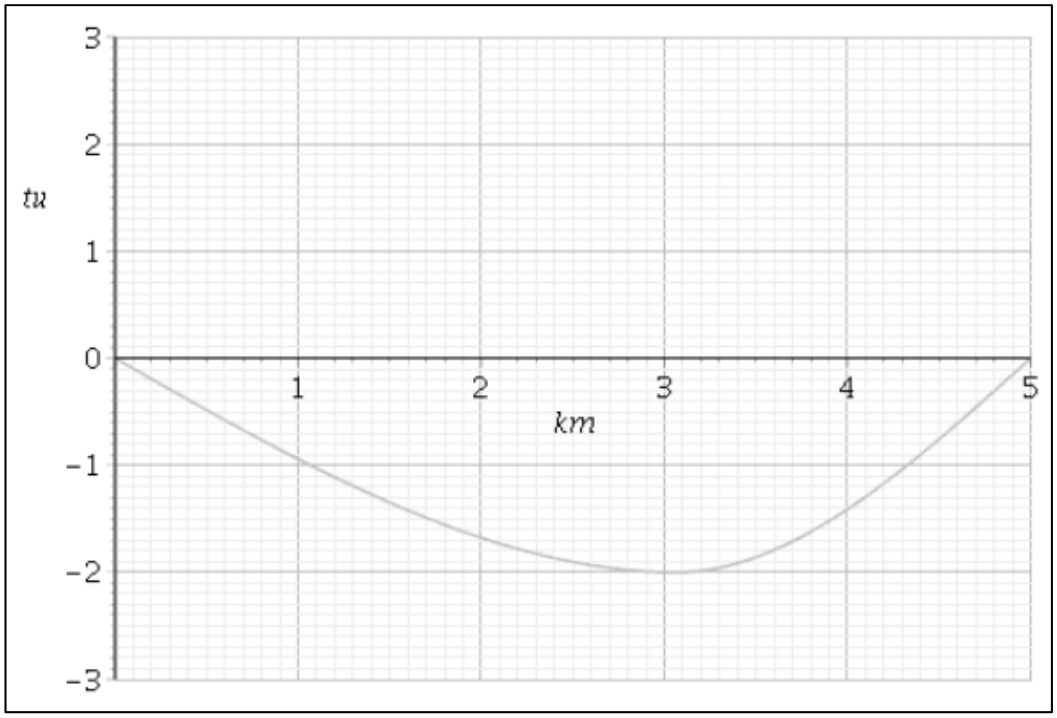
Q17 - sketch 3 points

The annual residual (net) longshore transport can be understood as the sum of two components that represent the transport caused by the westerly and easterly waves.

First, we consider the situation before the 1950s.

In box 5, the transport caused by easterly waves is shown as a grey line. The x-axis represents the distance from the harbour in km. The eastern headland is positioned at x=5 km. The y-axis represents the transport in arbitrary transport units (*tu*)

Now draw the transport caused by the westerly waves in box 5 or its Maple TA equivalent.



box 5

Q18 - sketch 2 points

Fig.18 schematizes the shoreline response due to the port in the first decades after its construction. The line represents the average shoreline change in meters per year. An offshore displacement is considered positive in this figure.

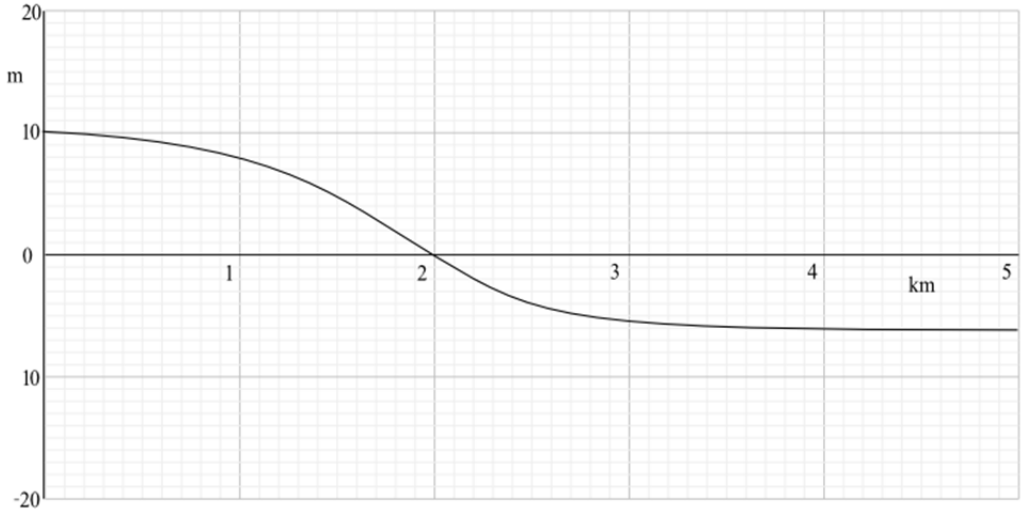
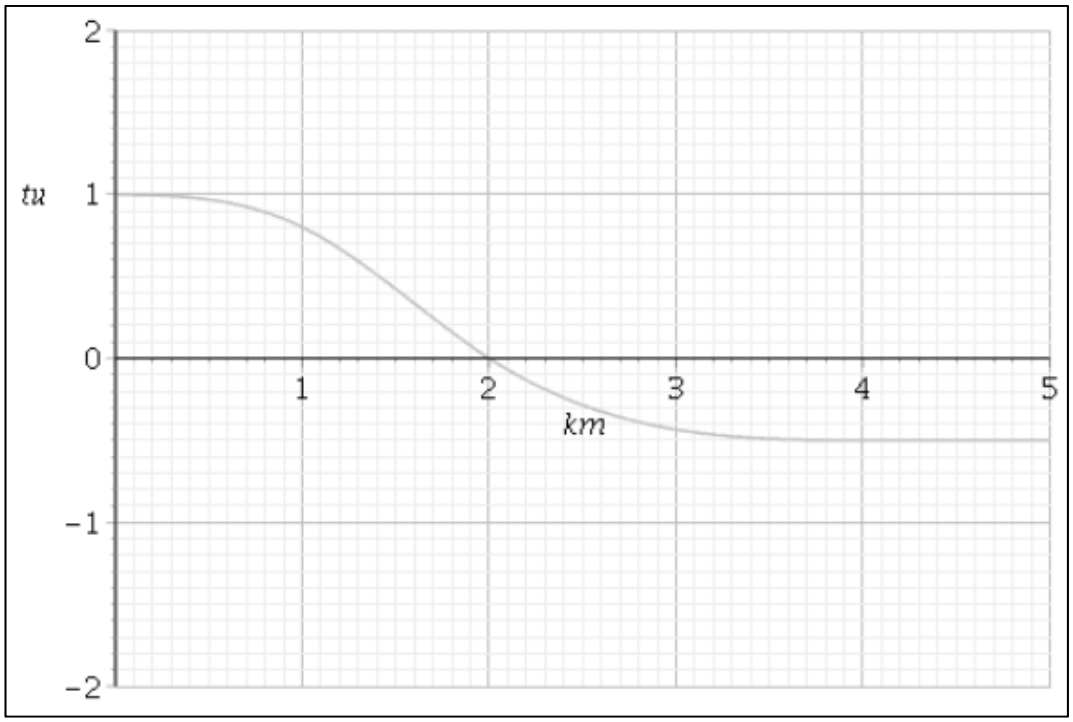


fig.18

Now draw the corresponding alongshore transport along the bay in box 6 or its Maple TA equivalent. Assume that the maximum transport magnitude is 1 transport unit (tu) and that transport is positive in the positive x-direction (to the right in the figure).



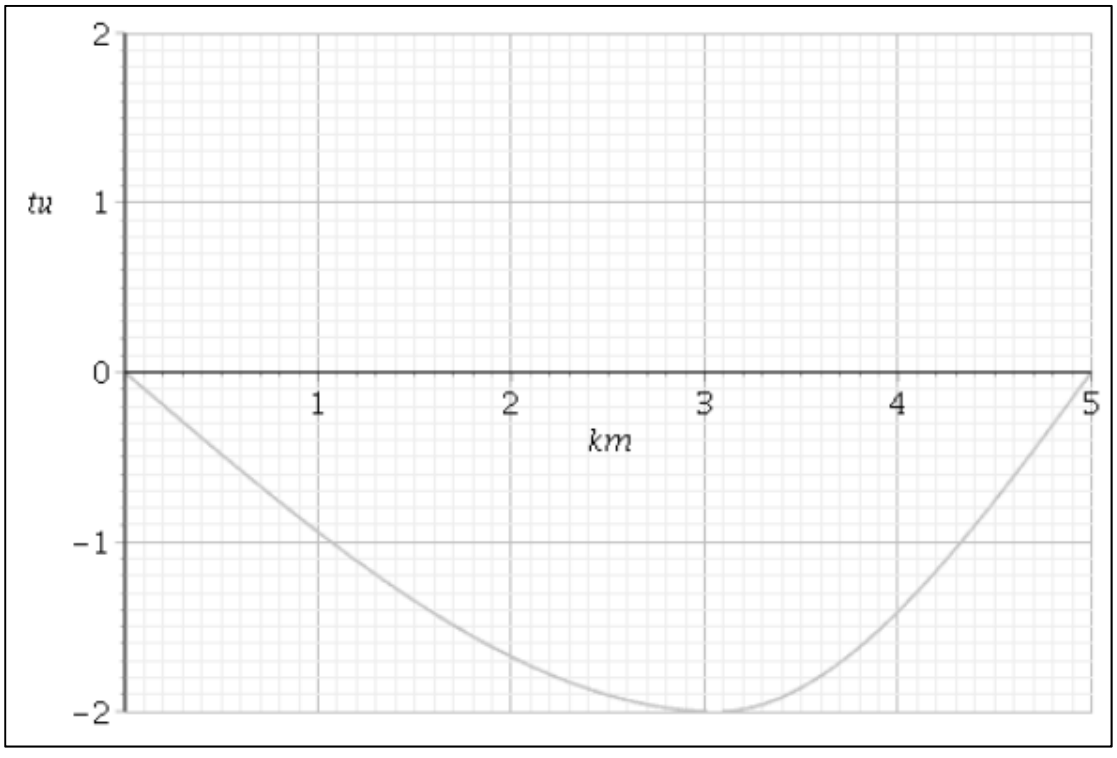
box 6

Q19 - sketch 3 points

In box 7 or its Maple TA equivalent, draw the transport caused by the westerly waves after the construction of the harbour.

Do this by calculating the values of the curve at points: x=0, x=1, x=2, x=3, x=4 and x=5 and use these 6 points to make the polygon. Please note that:

- You should use your answer to Q18.
- For reference, the grey line in the picture shows the transport by easterly waves as given previously for the situation before the 1950s.
- The y-axis represents the same transport units as in the previous questions.
- Transport is assumed positive in the positive x-direction (to the right in the figure)



box 7

Q20 - essay 3 points

Explain in words how the construction of the harbour can cause the changes in net and gross sediment transport as observed in Q18 and Q19.

Q21 - give a name 1 point

What is the name of the feature that has developed in front of the Tarik hostel (see 1990 shoreline in fig.17)?

D. Zuiderzee Q22-32

The Afsluitdijk is a 30 km long closure dam, completed in 1932, which separates the former Zuider Sea (now Lake IJssel) from the Wadden Sea. Through the construction of the Afsluitdijk, the Marsdiep basin area reduced considerably (see fig.19). The closed-off Zuiderzee area consisted of a relatively large area of tidal flats.

Preceding the closure, the Southern boundary of the Zuider Sea was located about 130 km inland from the Marsdiep inlet (also referred to as Texel inlet). The closure reduced the length of the Marsdiep basin to 30 km.

In the following, it can be assumed that the average water depth was 3.5 m in the entire basin (before closure).

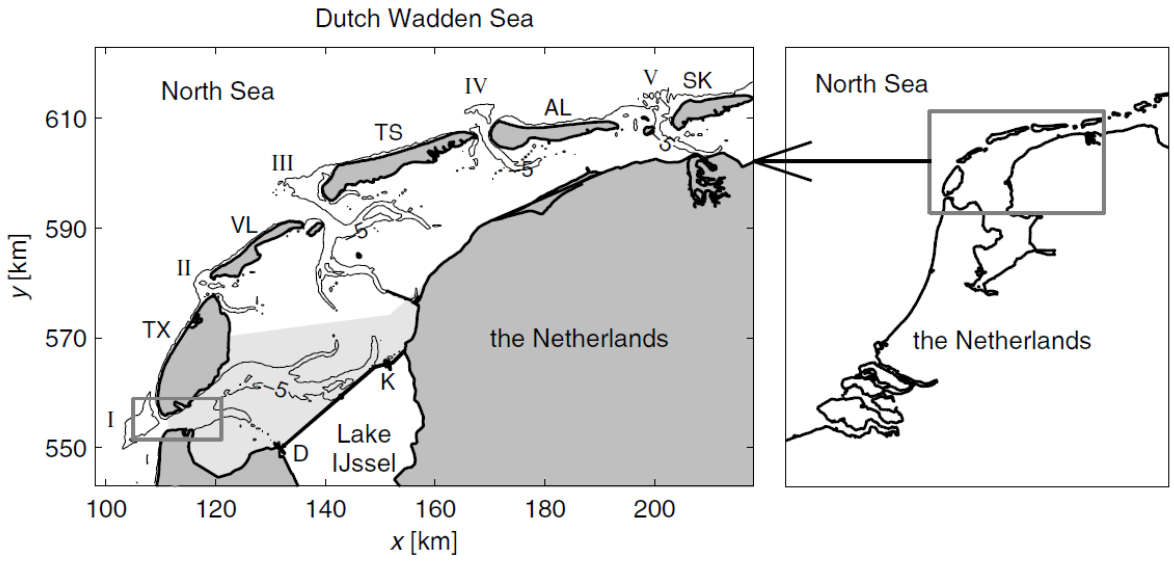


Fig. 19 - The present Marsdiep basin in the western Dutch Wadden Sea is indicated by the light-grey shaded plane. The islands of Texel, Vlieland, Terschelling, Ameland and Schiermonnikoog are abbreviated with TX, VL, TS, AL, and SK, respectively. The Marsdiep, Eierland, Vlie, Ameland, and Frisian inlets are marked by numerals I-V, respectively. The Lake IJssel sluices at Den Oever and Kornwerderzand are abbreviated with D and K.

Q22 - choose one answer (2x) 1 point

a) What is the phase relationship between the semi-diurnal tidal wave at the Marsdiep inlet (I) and at the island of Schiermonnikoog (SK)? The arrival of the tidal wave:

Answer options (arbitrary order, possibly different from in Maple TA):
is first at the Marsdiep inlet
is first at Schiermonnikoog
is the same time at both locations
varies with the moon phases

b) This can be explained from:

Answer options (arbitrary order, possibly different from in Maple TA):
the spring-neap tide cycle at the Dutch coast

the propagation speed of the tidal wave from the Southern Hemisphere through the Atlantic to Europe
the respective distances to the amphidromic point in the North Sea
the respective distances to the continental slope
the Coriolis deflection of the tidal wave in the North Sea basin
the tidal phase (flood or ebb)

Q23 - choose one answer (2x) — 2 points

Consider the situation of a tidal wave propagating along a basin from the sea to the landward end, where it is reflected. At a certain location, the resulting tidal wave has a purely propagating character when the ratio between the amplitudes of the reflected and incoming wave is (choose from: 0, 1/2, infinity, 1) and a purely standing character if the ratio is (choose from: 0, 1/2, infinity, 1).

Q24 - give a number — 3 points

Now we focus on the Zuiderzee and specifically the situation before the closure of the Zuiderzee.

Estimate the ratio of the basin length L_b over the tidal wave length L.

Q25 - choose one answer + choose one or more answers — 2 points

We still consider the situation before the closure of the Zuiderzee. Note that there are two parts (a and b) to this question.

a) If one had to choose from the below figures, which figure may best resemble the tidal envelope in this situation?

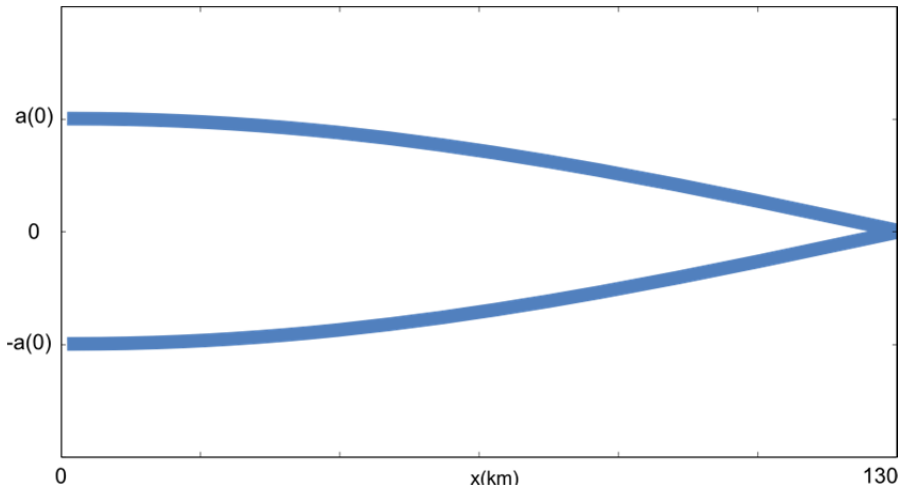


fig.19

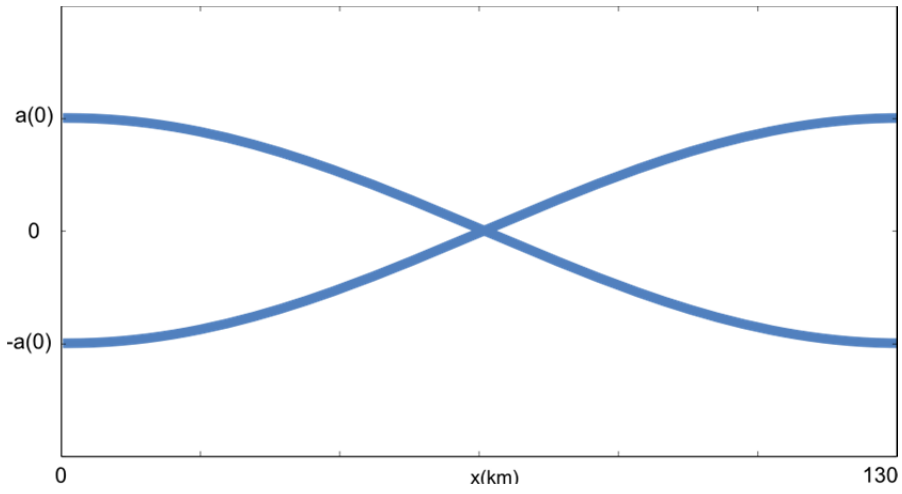


fig.20

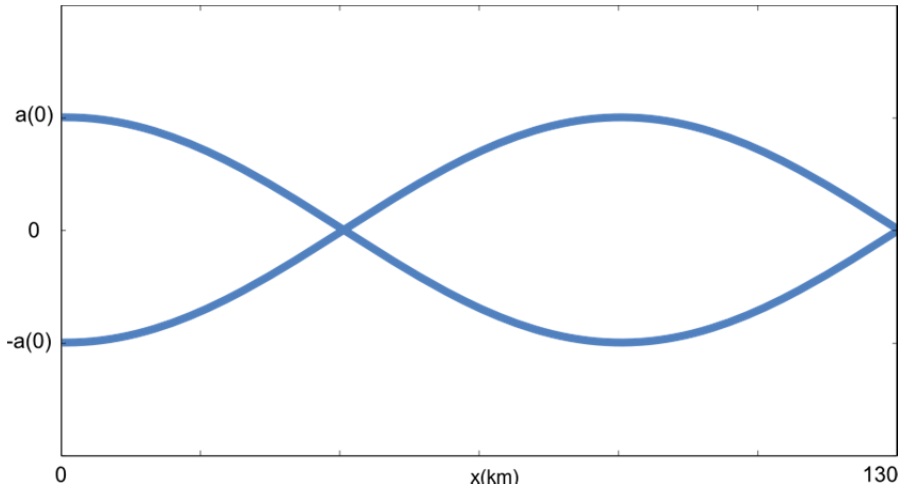


fig.21

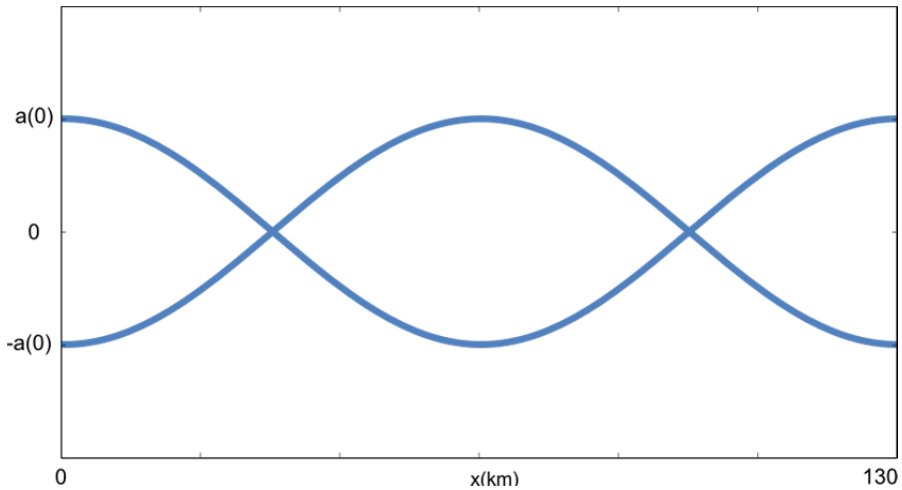


fig.22

b) At which location(s) along the basin do maxima of horizontal exchange of water occur?

Answer options (arbitrary order, possibly different from in Maple TA):
x=0 km, x=32.5 km, x=65 km, x=97.5 km, x= 130 km

Q26 - give a name 2 points

In reality, the tidal wave (before the closure) had a partly propagating and a partly standing character, depending on the location in the basin.

The envelope of the water level can be schematized as follows (the areas A1...A3 will be explained later on):

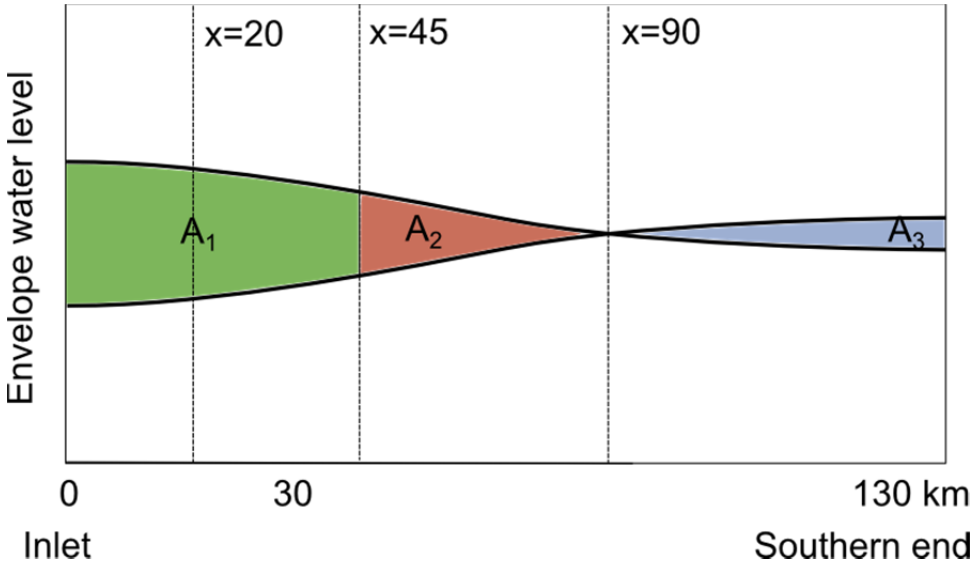


fig.23

Name the process that is responsible for the differences between fig.23 and your answer to Q25a.

Q27 - choose one or more answers 2 points

Fig.23 shows the tidal envelope before the closure. In this figure, three areas can be defined (A_1 - green, A_2 - red and A_3 - blue). At x=20 km and 90 km, the horizontal exchange of water is maximum and at x=45 km, the horizontal exchange is equal to zero. The tidal prism is related to a representative width of the basin and certain areas defined by the tidal envelope.

Which of the below statement(s) is(are) true:

Answer options (arbitrary order, possibly different from in Maple TA):

To compute the tidal prism only A1 is relevant

To compute the tidal prism only A2 is relevant

To compute the tidal prism only A3 is relevant

To compute the tidal prism the sum of A1 and A2 must be taken into account

To compute the tidal prism the sum of A2 and A3 must be taken into account

To compute the tidal prism the sum of A1, A2 and A3 must be taken into account

A2 = A3

Q28 - give a number (2x) 2 points

At which location in the basin is the propagating character of the tidal wave strongest, and at which location is the standing character strongest?

The propagating character is strongest at x/L_b =

The character is completely standing at x/L_b =

Q29 - essay 2 points

Explain the location of zero discharge at x = 45 km. In doing so, make a comparison to the standing wave pattern that you chose in one of the previous questions.

Q30 - essay 2 points

Before the closure, the basin was in dynamic equilibrium. Even though the basin area was largely reduced by the closure, the tidal prism of the Marsdiep inlet increased with about 25%. The closure disturbed the dynamic equilibrium such that the Marsdiep basin started importing sediment.

Explain why the tidal prism increased.

Q31 - choose the correct answer 2 points

For the benefit of which elements in the basin is sediment imported?

Answer options (arbitrary order, possibly different from in Maple TA):

the tidal channels, because only the channels respond to the change in tidal prism.

the tidal channels, which are too big and therefore demand sediment.

the tidal flats, since their areal size is too small compared to the channel area

all elements in the basin (flats and channels), since the prism increases

Q32 - choose the correct answer (2x) 3 points

What is the expected long-term response of the adjacent coastlines and ebb-tidal delta to the closure?

a) Adjacent coastlines:

Answer options (arbitrary order, possibly different from in Maple TA):

no change

sedimentation

erosion

b) Ebb-tidal delta:

Answer options (arbitrary order, possibly different from in Maple TA):

no change
sedimentation
erosion