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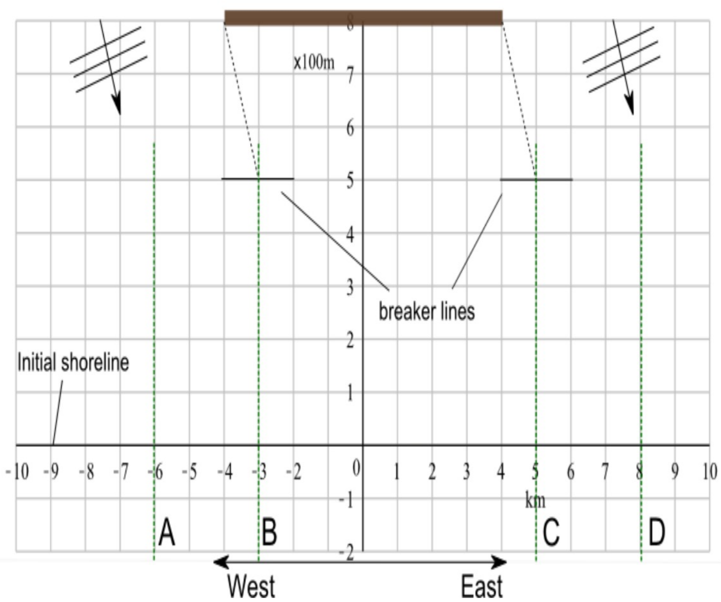
CIE4305 Coastal Dynamics I (2017-2018), ZHI LI, 3/21/18 at 7:46:07 PM CET

Question 1: *Score 1/1*

Detached Emerged Breakwater

Somewhere along an alongshore uniform coast, an emerged detached breakwater has been built. The length of the breakwater is equal to the distance of the breakwater offshore.

First, consider the situation that waves are obliquely incident under a small angle (see image below). For this situation, we assume that changes in alongshore sediment transport mostly result from changes in wave height (and not from changes in wave angle). Outside of the area between the transects A and D, the wave heights at breaking are undisturbed by the breakwater. Inside this area, they are affected by the breakwater.



What could be a reasonable ratio between wave heights at the breaker point at transects B and A?

NB. Use this ratio also in the following questions, where you can further assume that $H_C/H_D=H_B/H_A$.

H_B/H_A=

Your response	Correct response
0.5	
Grade: 1/1.0	

Total grade: 1.0×1/1 = 100%

Feedback:

Due to the presence of the breakwater, a part of the wave front is blocked by the breakwater and is reflected seaward. For this question you should know what the wave height is along a ray separating the shadow zone from the incident wave area. Due to the lateral transfer of wave energy into the shadow zone, the wave height along this ray is lower than the incident wave height; in the case of constant depth, the wave height is 50% of the original wave height according to linear theory (on a separate note: do you know what this percentage would be for irregular directional waves?).

Theory: section 5.2.4 (Diffraction)

Question 2: *Score 1/1*

Detached Emerged Breakwater (continued)

Total grade: 1.0×1/1 = 100%

Feedback:

In this question, you could look at the CERC formula. This equation gives you the following proportionalities for the wave-induced longshore transport.

$$S \sim H_b^{2.5} \sin\left(2\ \varphi_b\right)$$

In this equation H_b is the wave height at breaking and φ_b the breaking wave angle of incidence with respect to the coastline. As the wave height at breaking at B is roughly half the wave height at breaking at A, the ratio S_B/S_A is in the order of 0.25.

Theory: section 8.2.3 (Bulk longshore transport formulations, "the CERC formula").

Question 3: *Score 1.2/3*

Detached Emerged Breakwater (continued)

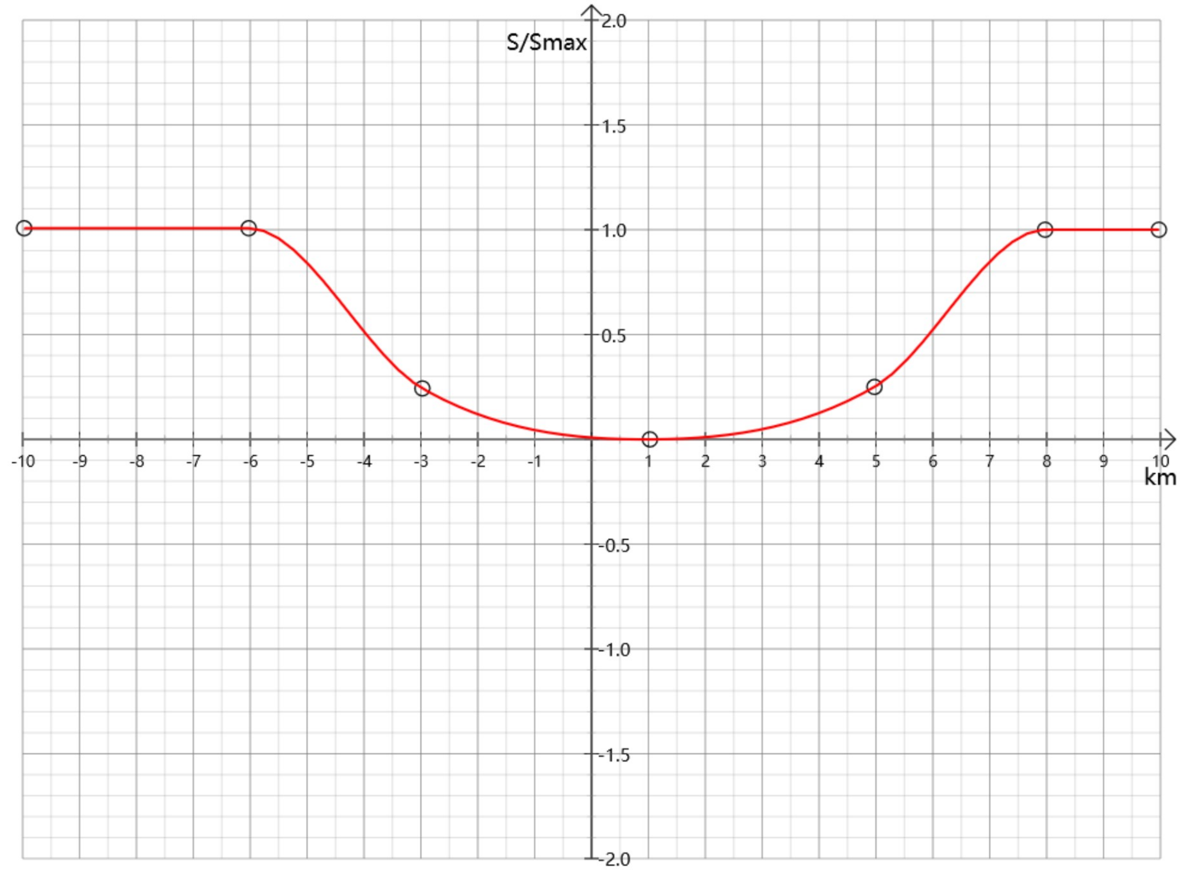
Draw the initial (immediately after the construction of the breakwater) alongshore sediment transport rate as a function of the distance along the shoreline.

Note that the sediment transport S is defined positive in eastward direction (to the right) and the maximum transport magnitude in the coastal section in the present situation is S_{max}. It is given that nowhere behind the breakwater does the sediment transport vanish completely.

Note that **the vertical axis represents S/S$_{max}$** and the horizontal axis corresponds to the one in the situation sketch.

Also use the answer to the previous question.

Your response	Correct response



Grade: 0.4/1.0

Total grade: 0.4×1/1 = 40%

Feedback:

Comment:

Use the knowledge of the previous questions: in B, the wave height is roughly half the one at A, causing S_B to be a factor 4 smaller compared to S_A. A comparable analysis could be made for transects C and D. Now, add these points to the graph and look carefully to the vertical scale. At which locations are the sediment transport rates greatest? Finally, add some extra points to the graph to finalize the graph (e.g. how should the graph look like left of transect A?).

Theory: section 8.4.3 (Shadow effects due to obstacles away from the shoreline)

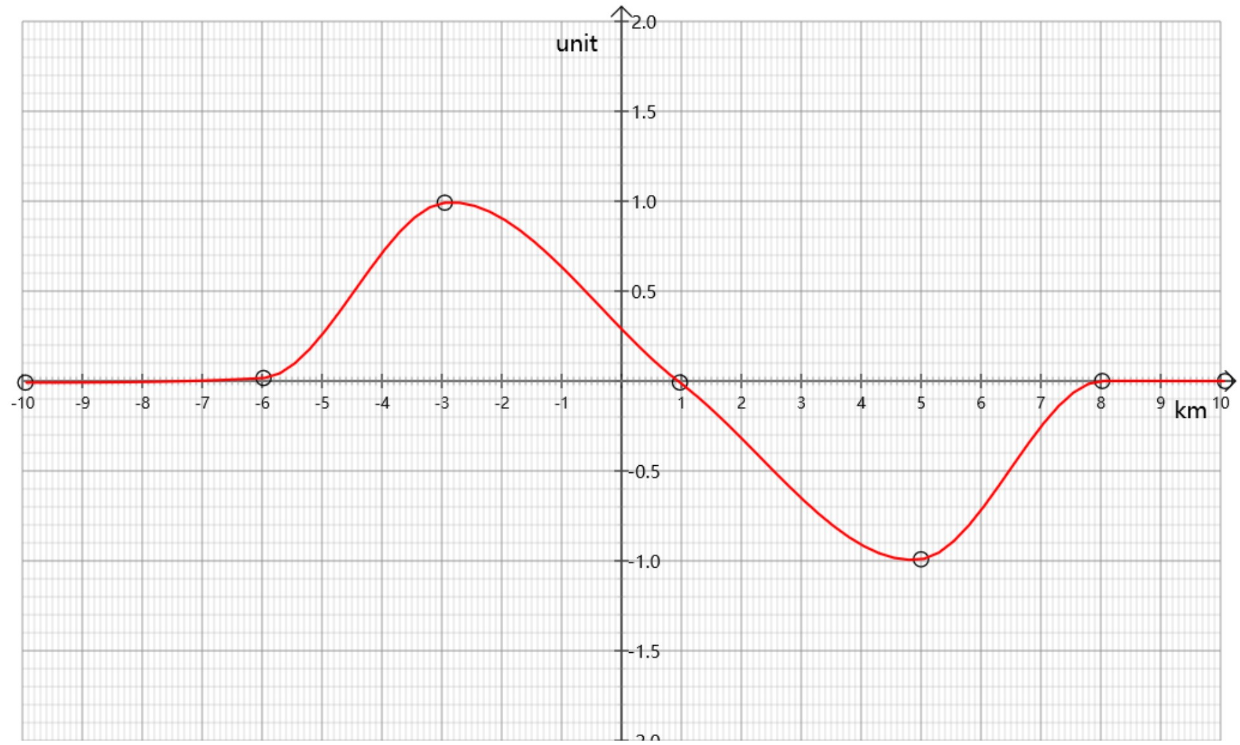
Question 4: *Score 1.2/3*

Draw the morphological development corresponding to your answer above.

Make sure that in your drawing the maximum shoreline response is equal to 1 unit on the vertical axis.

Also: to ensure the correct location of maxima and minima, select the point and then press the button of ,max> respectively! NB. This holds for all the drawing questions.

Your response	Correct response



Grade: 0.4/1.0

Total grade: 0.4×1/1 = 40%

Feedback:

Comment:

The morphological development of the shoreline is related to the gradients in the alongshore sediment transport. If the alongshore sediment transport is constant, no shoreline change will occur. If the sediment transport magnitudes increase in transport direction (or a positive alongshore transport gradient dS(y)/dy), the shoreline should erode. On the other hand, if sediment transport magnitudes decrease in transport direction (or a negative alongshore transport gradient dS(y)/dy), the shoreline accretes. The change rate of the shoreline is maximum at the location of the largest gradients in the alongshore transport rates (check for yourself whether you have done this correctly). Now, try to use this information to draw the morphological development of the shoreline.

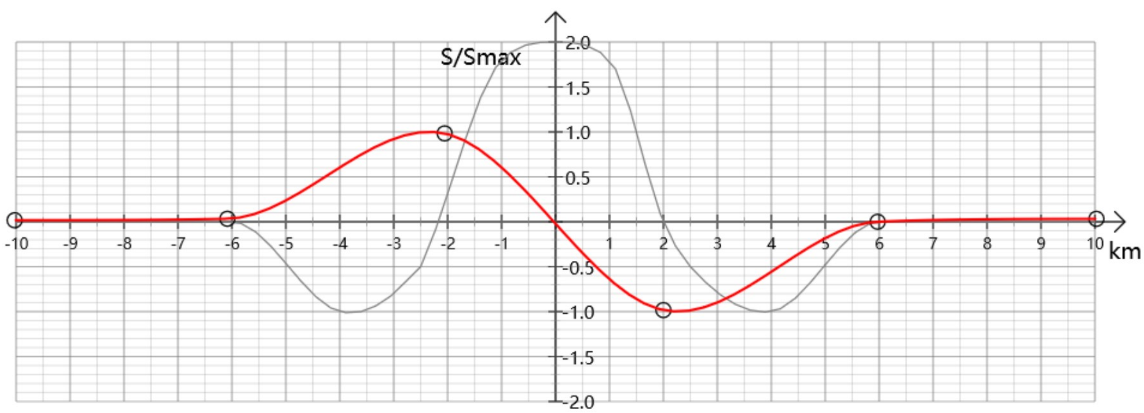
Theory: sections 1.5.2 (Coastal morphodynamics) and 8.4.3 (Shadow effects due to obstacles away from the shoreline)

Question 5: *Score 3/3*

Detached Emerged Breakwater (continued)

Now assume that instead of obliquely incident, the waves are normally incident.

Shortly after the construction of the breakwater, a salient has formed as schematically shown on the below figure.

Your response	Correct response
	

Grade: 1/1.0

Total grade: 1.0×1/1 = 100%

Feedback:

Use your knowledge on the sediment mass balance:

- An eroding coastline means increasing sediment transport magnitudes in the transport direction (a positive alongshore transport gradient dS(y)/dy);
- An accreting coastline means decreasing sediment transport magnitudes in the transport direction (a negative alongshore transport gradient dS(y)/dy);

- At points where no coastline change occurs, the gradient in the sediment transport rates should be zero;
- At the locations with the maximum erosion/accretion, the gradients in the sediment transport rates should be maximum too.

Try to think of a solution which satisfies all these conditions. You could start at the left side, what will be the sediment transport rate at x=-10 and how does it vary towards x=-6?.

Theory: sections 1.5.2 (Coastal morphodynamics) and 8.4.4 (Shoreline perturbation)

Question 6: *Score 1/2*

Detached Emerged Breakwater (continued)

Clearly, even though the waves are normally incident, a non-zero alongshore transport occurs that varies along the shore. *Which short-wave related process(es) is (are) the cause of this?*

Your response	Correct response
Choice 2: Wave set-up gradients Choice 3: Diffraction Choice 4: Wave turbulence	

Grade: 0.5/1.0

Total grade: 0.5×1/1 = 50%

Feedback:

In the undisturbed zone, the waves are normally incident and there are no variation in set-up along the shore. Therefore no alongshore transport is generated. However, the structure induces diffraction and wave set-up gradients that locally cause a non-zero alongshore transport that varies along the shore.

Diffraction causes a two-dimensional variation (both in x- and in y-direction) in wave height and angle. Due to the waves turning towards the shadow zone, an alongshore transport can be expected in the surf zone, which is directed from either end of the breakwater into the shadow zone.

A similar transport pattern can be expected due to near-shore currents driven by wave set-up gradients. The wave set-up is smaller in the sheltered area than in the unsheltered region. This generates local near-shore currents into the sheltered area from either side of the breakwater. These currents can transport sediment. Note that continuity requires that this current is diverted outward again along the structure at somewhat deeper water, creating circulation cells.

Theory: sections 5.2.4 (Diffraction) and 5.5.7 (3D effects)

Question 7: *Score 2/2*

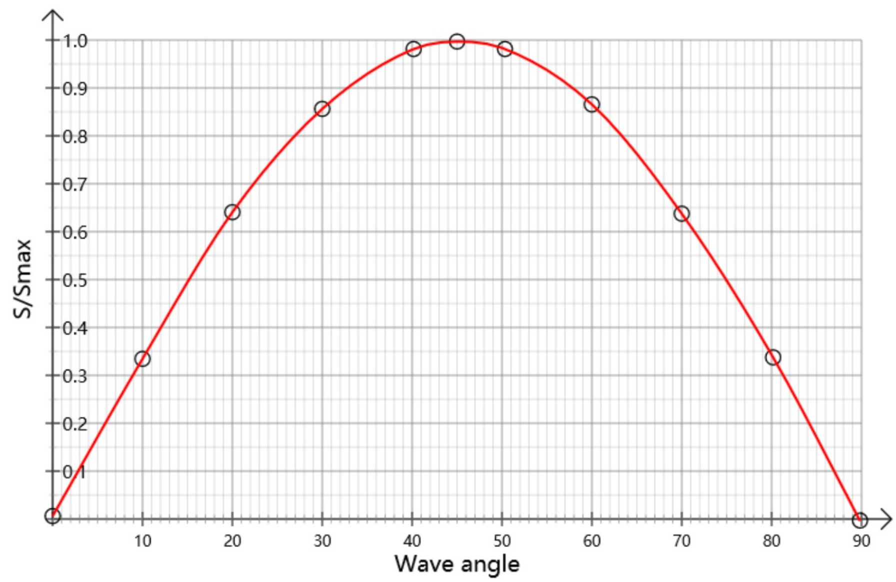
The two main wave parameters in common bulk longshore transport formulas (such as the CERC formula) are the wave height and wave angle.

In the below graph, show qualitatively how such transport formulas depend on the deep water wave angle with the shore-normal.

The horizontal axis represents the deep water wave angle φ_0 (in degrees). The vertical axis represents the relative transport rate S/S_{max}. Here S_{max} is the maximum value of the transport rate for the wave conditions under consideration.

Attention! Make sure that the line that you draw covers the entire interval [0,90] on the horizontal axis. Also note that the maximum extent of the vertical axis is 1 (although it is not shown).

Your response	Correct response



Grade: 1/1.0

Total grade: 1.0×1/1 = 100%

Feedback:

In this question, you could look to the CERC formula in terms of (mostly) deep water properties. We then have the following relation for longshore transport.

$S \sim c_b H_o^{2.5} \sin(2\ \varphi_o)$

In this equation H_o is the wave height at breaking and φ_o the wave angle of incidence with respect to the coastline. Note further that c_b is the phase velocity at the breaker line, which varies slightly with φ_o.

At which deep water wave angle would the maximum transport be found if you would ignore the dependency of c_b on φ_o and hence only consider the term $\sin(2\varphi_o)$?

And what if you also take the dependency of c_b on φ_o into account?

Theory: section 8.2.3 (Bulk longshore transport formulations, "the CERC formula") and section 8.2.4. (The (S,φ)-curve), including Example 8-1.

Question 8: *Score 3/3*

Consider a wave-dominated delta on an otherwise alongshore uniform coastal stretch of infinite length.

At some point in time, the river has been dammed for hydro-power purposes, entirely cutting off the river sediment supply.

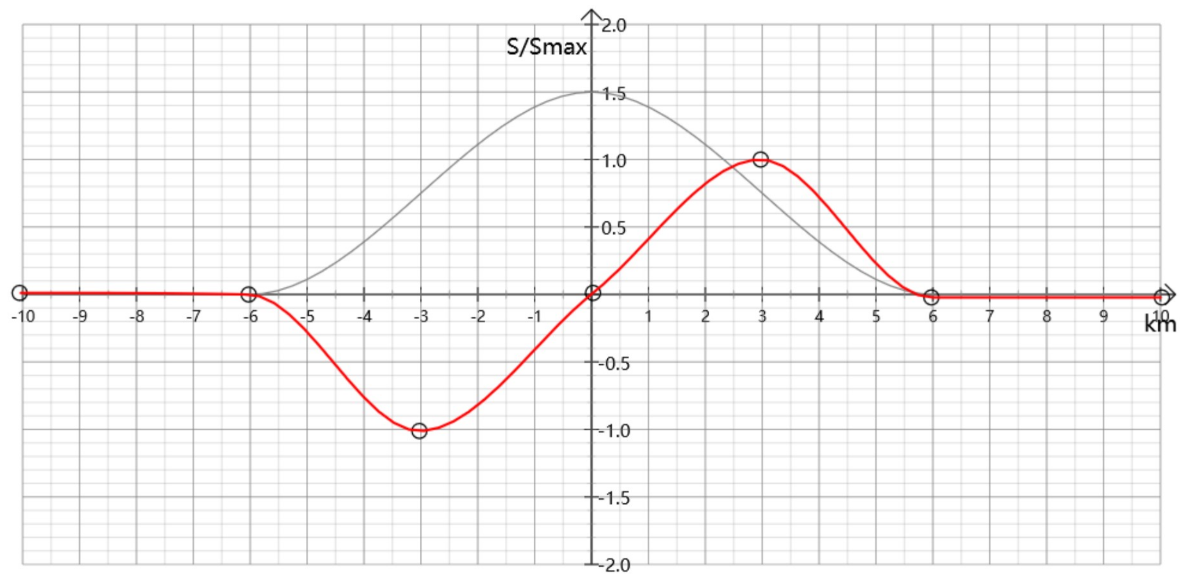
The coastline shape just after the damming of the river is schematized in the below figure (view from above).

Inflection points in the coastline are found at positions -3 and 3 at the horizontal axis.

The axes represent the alongshore (horizontal axis) and cross-shore (vertical axis) directions. The distances are in kilometers.

For simplicity it is assumed that:

- waves do not refract while travelling from deep to shallow water.
- everywhere in the coastal section, the angle between wave direction and shore-normal is less than 30°.
- the longshore transport increases linearly with the wave angle of incidence up to angles of about 30°.

Your response	Correct response
	

Grade: 1/1.0

Total grade: 1.0×1/1 = 100%

Feedback:

If the waves are normally incident (w.r.t. the coastline), there will be no alongshore sediment transport. Due to the presence of the delta, there are locations for which the waves are not normally incident. The larger the angle of incidence of the waves with respect to the normal of the shore, the larger the sediment transport rates. Therefore, the maximum sediment transport rates are to be found at the inflection points. What can you say about the direction of the sediment transport?

Theory: section 8.4.4 (Shoreline perturbation)

Question 9: *Score 2/2*

Delta Damming - normal incidence (continued)

	For each region, select if erosion or accretion are expected to happen:
x<-6	

Your response	Correct response
nothing happens	

Grade: 1/1.0

-6 < x < -3

Your response	Correct response
accretion	

Grade: 1/1.0

-3 < x < 0

Your response	Correct response
erosion	

Grade: 1/1.0

0 < x < 3

Your response	Correct response
erosion	

Grade: 1/1.0

3 < x <6

Your response	Correct response
accretion	

Grade: 1/1.0

x>6

Your response	Correct response
nothing happens	

Grade: 1/1.0

Total grade: 1.0×1/6 + 1.0×1/6 + 1.0×1/6 + 1.0×1/6 + 1.0×1/6 + 1.0×1/6 = 17% + 17% + 17% + 17% + 17% + 17%

Feedback:

For this question, use the sediment mass balance:

- If there is no gradient in the sediment transport rates, nothing will happen;
- If the sediment transport magnitudes increase in the transport direction (or a positive alongshore transport gradient dS(y)/dy), the coast will erode;
- Accretion occurs if the sediment transport magnitudes decrease in the transport direction (or a negative alongshore transport gradient dS(y)/dy).

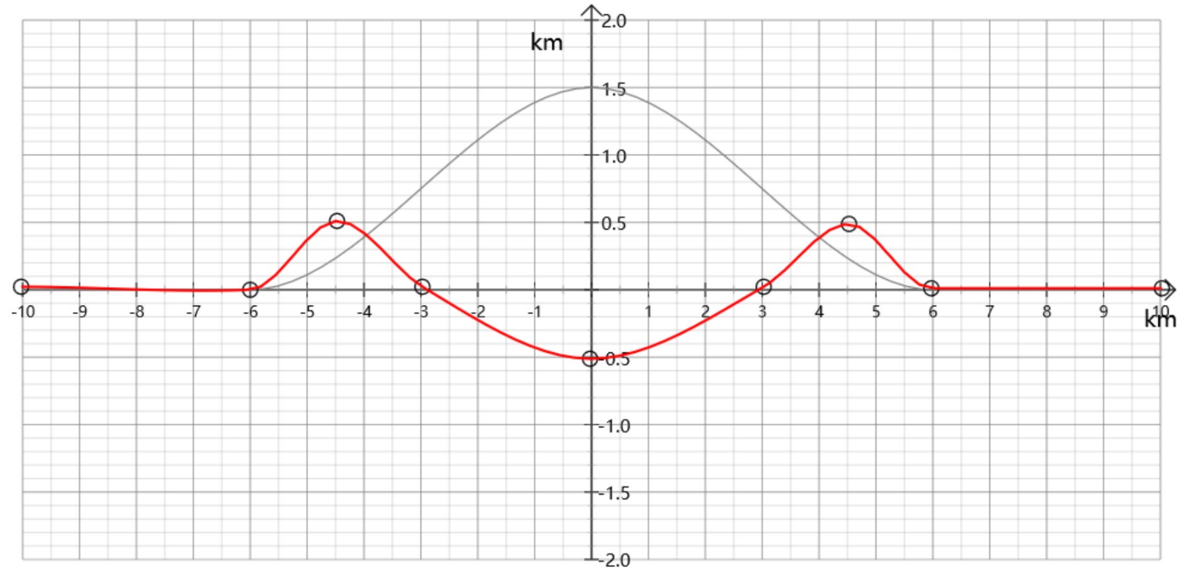
Theory: section 1.5.2 (Coastal morphodynamics)

Question 10: *Score 0/2*

In the figure below, draw the coastline after a (very very) long time.

The original coastline is displayed as a grey line.

Your response	Correct response



Grade: 0/1.0

Total grade: 0.0×1/1 = 0%

Feedback:

As you have seen in the previous subquestion, the locations with the largest perturbation will erode and the regions with a smaller perturbation will accrete slightly (to accommodate the eroded sand). This process will go on (the perturbation becomes wider but smaller) till there are no gradients in the sediment transport rates anymore: this could only be achieved by a straight coastline.

In the question it is stated that the coastal stretch is assumed to be infinitely long, such that the sediment is going to be redistributed over an infinite length.

With this information, can you now draw the the final, equilibrium coastline?

Theory: sections 1.5.2 (Coastal morphodynamics) and 8.4.6 (Deltaic coastlines)