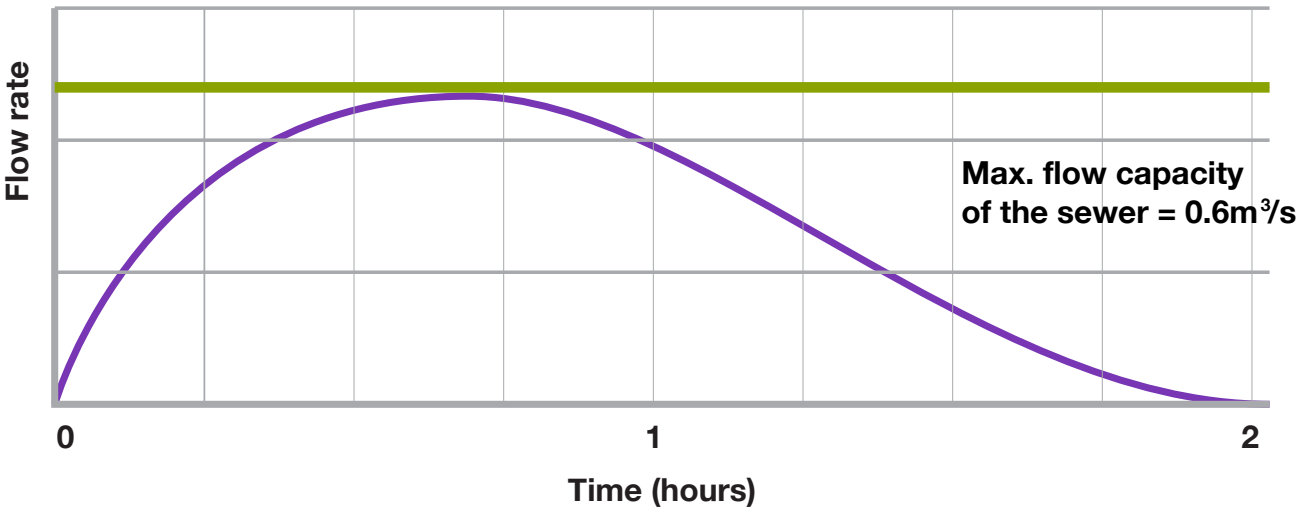
TUNNELWORKS
A2 MATHS
STUDENT SHEET

Modelling sewer and CSO flow

The Thames Tideway Tunnel will control discharges from 34 combined sewer outfalls (CSOs) that currently discharge untreated sewage directly into the River Thames after it rains. By creating a model of how water flows though each sewer and CSO engineers can model the total capacity in the tunnel.

A basic model for water flow through a CSO.
This basic curve shows how water flows through an example sewer when:

- The rainfall has an intensity of 2mm / hour.
- The rainfall lasts for 1 hour.



Under these conditions the maximum flow into the sewer is at its threshold flow rate of 0.6m^3/s. More than this and at present, any excess flow will overflow into a CSO which discharges into the River Thames.

Task 1

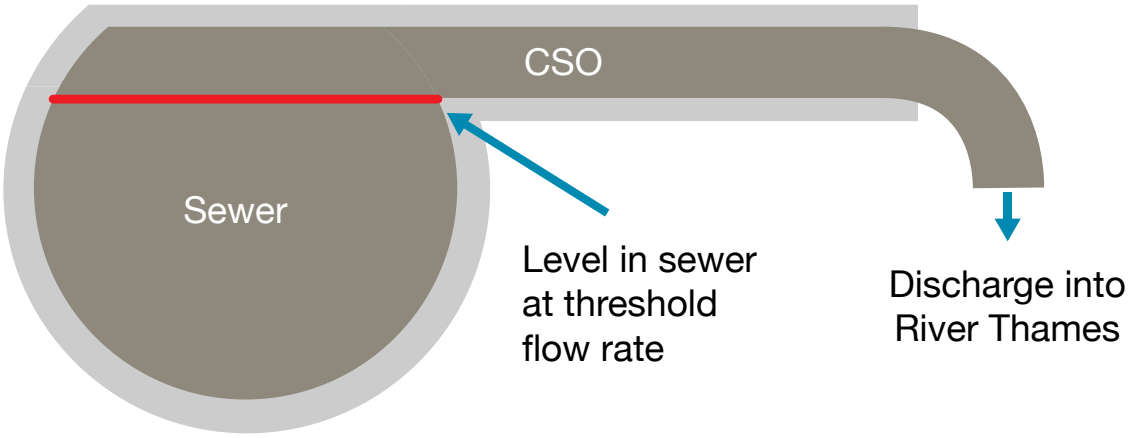
Transformations allow this curve to represent other rainfall conditions.

Sketch the transformations to this curve that would show the following conditions:

- Intensity 9mm/hour, which creates a maximum flow of 0.98m^3/s
- Intensity 14mm/hour, which creates a maximum flow of 1.20 m^3/s

Assume the rainfall still lasts 1 hour in each case.

For each sketch, shade any area that represents the excess flow from the sewer, into the CSO that would currently discharge into the River Thames, and which once constructed the Thames Tideway Tunnel will capture for treatment.



Task 2

The basic curve above (and the conditions it represents) can be represented by the function: f(x) = 0.5x3 – 2x2 + 2x

Modify this function so the transformed curve represents the following conditions:

- Intensity 1mm/hour and maximum flow of 0.50m^3/s
- Intensity 6mm/hour and maximum flow of 0.82m^3/s
- Intensity 16mm/hour and maximum flow of 1.22m^3/s

(Hint: Assume the rainfall still lasts 1 hr. Use the new maximum flow rates to calculate the scale factor.):

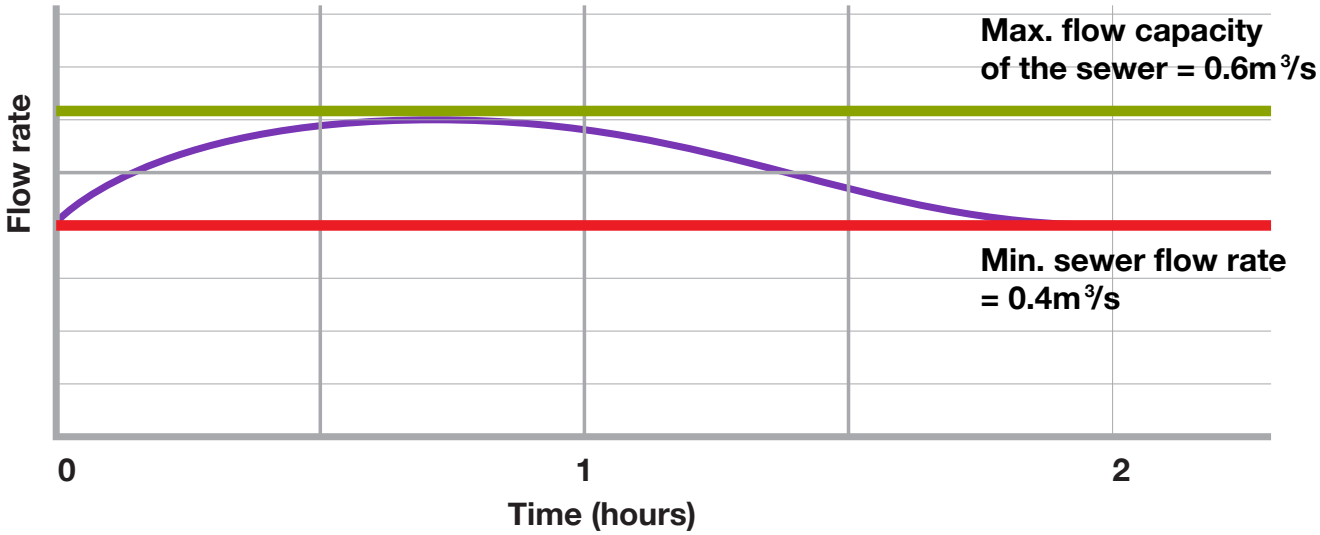
Now modify the function so it represents 2mm / hour rainfall that lasts:

- 0.5 hours, with the flow through the sewer lasting 1 hour in total.
- 3 hours, with the flow through the sewer lasting 4 hours in total.

(Hint: Use the new total flow times to calculate the scale factor.)

Task 3

In reality the sewer always has a minimum of 0.4m^3/s wastewater flowing through it, even when there is no rain.



Modify the function f(x) so it now represents this more realistic situation as shown in the graph above. The maximum flow under basic rainfall conditions should still be 0.6m^3/s. What two transformations do you need to include?