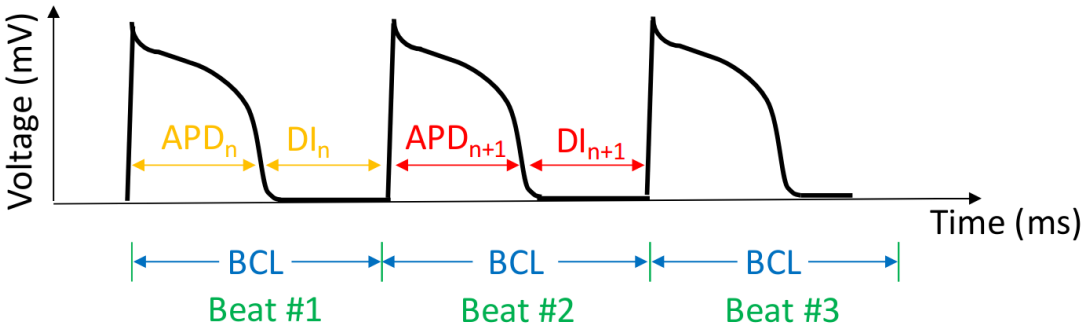
Modelling Alternans in Cardiac Tissue: A Reference

$$APD_{n+1} = APD_{max} - \beta\, e^{-(BCL - APD_n)/\tau}$$

This is a model of the next action potential duration (APD_{n+1}) as a function of the current action potential duration (APD_n).

- APD_{n+1}: the duration of the next action potential. This is the dependent (y) variable.
- APD_n: the duration of the current action potential. This is the independent (x) variable.



The model has an **exponential functional form**, since the independent variable, APD_n, is in an exponent. All the other terms are **parameters**.

- A **functional form** defines the general shape of a function.
  - Example: the functional form of $y = mx + b$ is a line.
- **Parameters** define the location and specific shape of the function.
  - Example: the parameters in the line $y = mx + b$ are m (slope) and b (intercept). Changing m and b affects the shape and positioning of a line, but never makes the function non-linear.

Here are the other relevant terms:

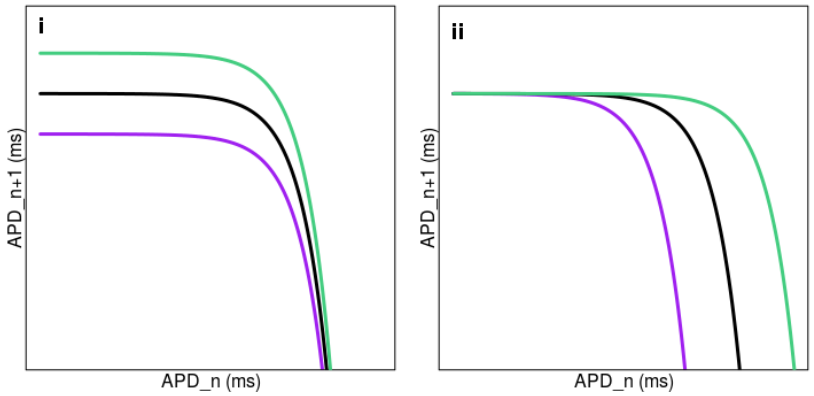
- APD_{max} is the longest duration an action potential will ever have (measured experimentally).
- BCL is the "basic cycle length," which is equal to the duration of an action potential (APD) plus the diastolic interval (DI, i.e. rest period) that follows it.
- β is a parameter that influences the exponential curve's x-intercept.
- τ is a parameter that defines how angular the curve's drop off will be.
- DI is the the "diastolic interval," and it is the rest period between action potentials. It doesn't show up in the equation explicitly, but $BCL - APD_n = DI_n$.

Concept Check: How do the parameters affect the function?

$$APD_{n+1} = APD_{max} - \beta\, e^{-(BCL - APD_n)/\tau}$$

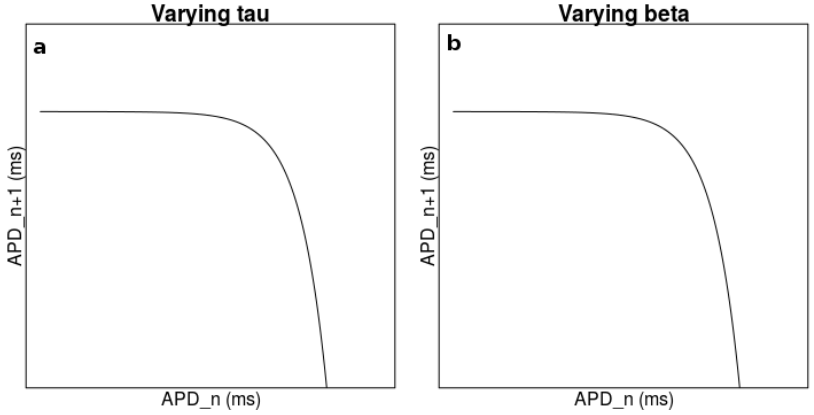
The **black line** in the plots below is a reference model, given specific choices of APD_{max}, β,BCL, and τ.

- In which of the plots [(i) or (ii)] do the colored lines show what would happen if we varied APD_{max} (and held all the other parameters constant)?
  - Does the green model have a higher or lower APD_{max} than the black and purple models?
- In which of the plots [(i) or (ii)] do the colored lines show what would happen if we varied BCL (and held all the other parameters constant)?
  - Does the green model have a higher or lower BCL than the black and purple models?



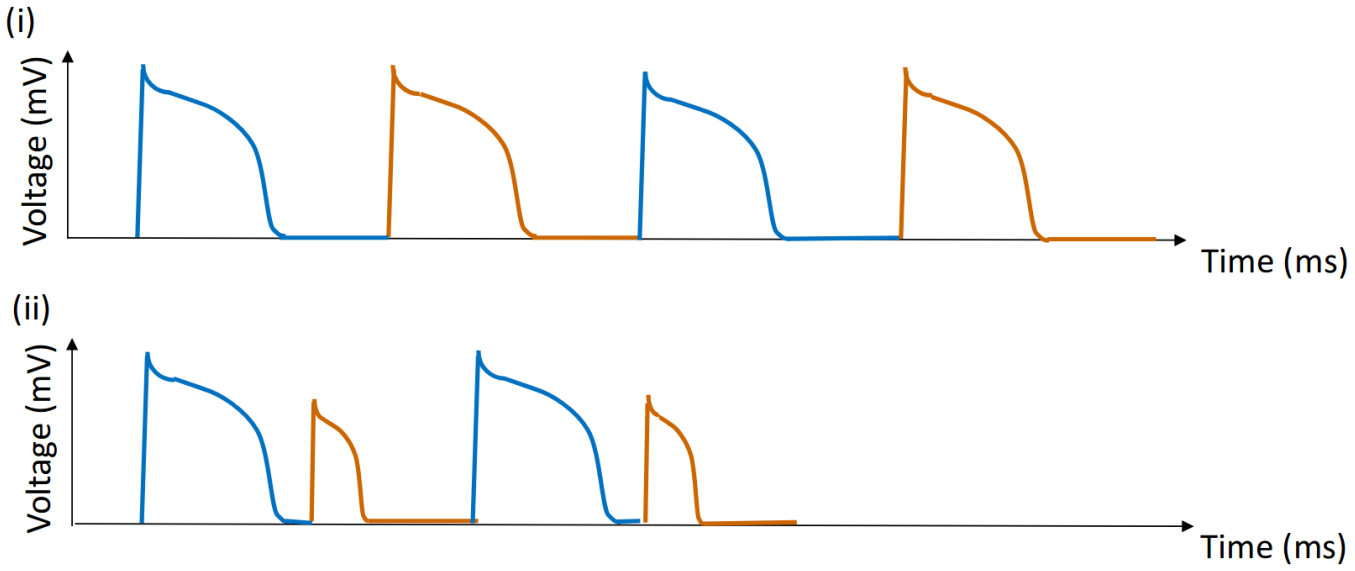
Use the webpage to explore the effects of τ and β on the shape of the function.

- On plot (a), sketch what happens to the function when you increase and decrease τ (for an increase, use a dashed line; for a decrease, use a dotted line).
- On plot (b), sketch what happens when you increase and decrease β (for an increase, use a dashed line; for a decrease, use a dotted line).

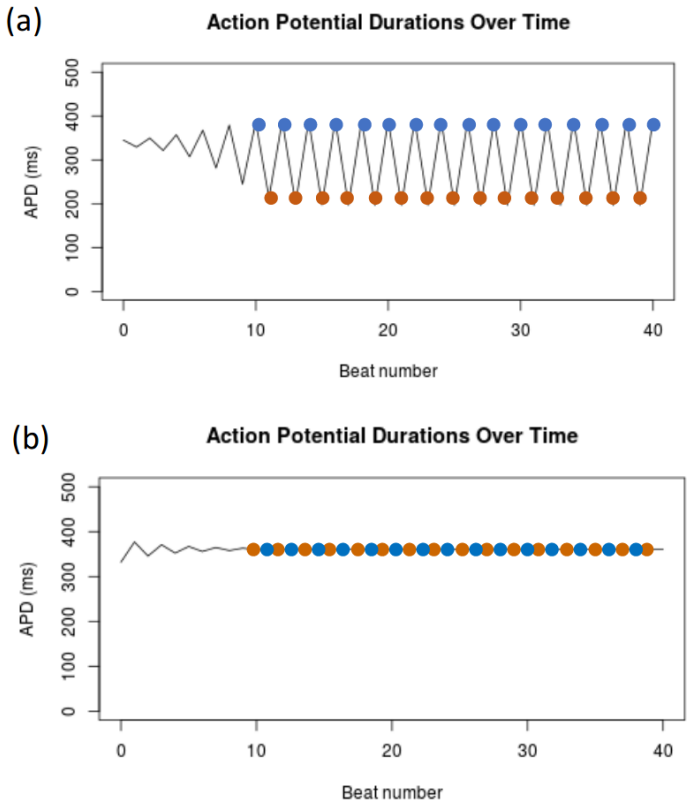


Concept Check: Plotting Alternans

Shown below are two action potential graphs, (i) and (ii), in which alternating action potentials (and their following diastolic intervals) are colored blue and brown:



These action potentials (and the APs that would follow them) can be re-plotted to show the action potential duration (APD) for each heart beat:



- Which action potential diagram [(i) or (ii)] corresponds to which beat number vs. APD graph [(a) or (b)]?