MITx CSE.0002x

Introduction to Computational Science and Engineering

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Course Progress Dates Discussion MO Index

Course / 5 Exams / 5.1 Exam 1

‹ Previous ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ Next ›

5.1.11 Exam: Two state oscillating combustion IVP class

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Exams due Aug 30, 2023 05:00 IST Completed

In this problem, you will implement a two-state model IVP class for oscillating combustion. Specifically, we will model the evolution of the concentration of a fuel, $[\mathrm{Fuel}]$, and an oxidizer, $[\mathrm{Oxid}]$. The model equations are,

$$\frac{\mathrm{d}\,[\mathrm{Fuel}]}{\mathrm{d}t} = -\frac{1}{\tau}[\mathrm{Fuel}]\,[\mathrm{Oxid}] + \frac{1}{2}\mathrm{A}_{\mathrm{fuel}}\left[1 - \cos\left(2\pi\frac{\mathrm{t}}{\mathrm{T}_{\mathrm{fuel}}}\right)\right] \tag{5.26}$$

$$\frac{\mathrm{d}\,[\mathrm{Oxid}]}{\mathrm{d}t} = -C_{\mathrm{ox}}\frac{1}{\tau}[\mathrm{Fuel}]\,[\mathrm{Oxid}] + [\mathrm{Oxid}_{\mathrm{base}}] - [\mathrm{Oxid}] \tag{5.27}$$

where the following parameters are

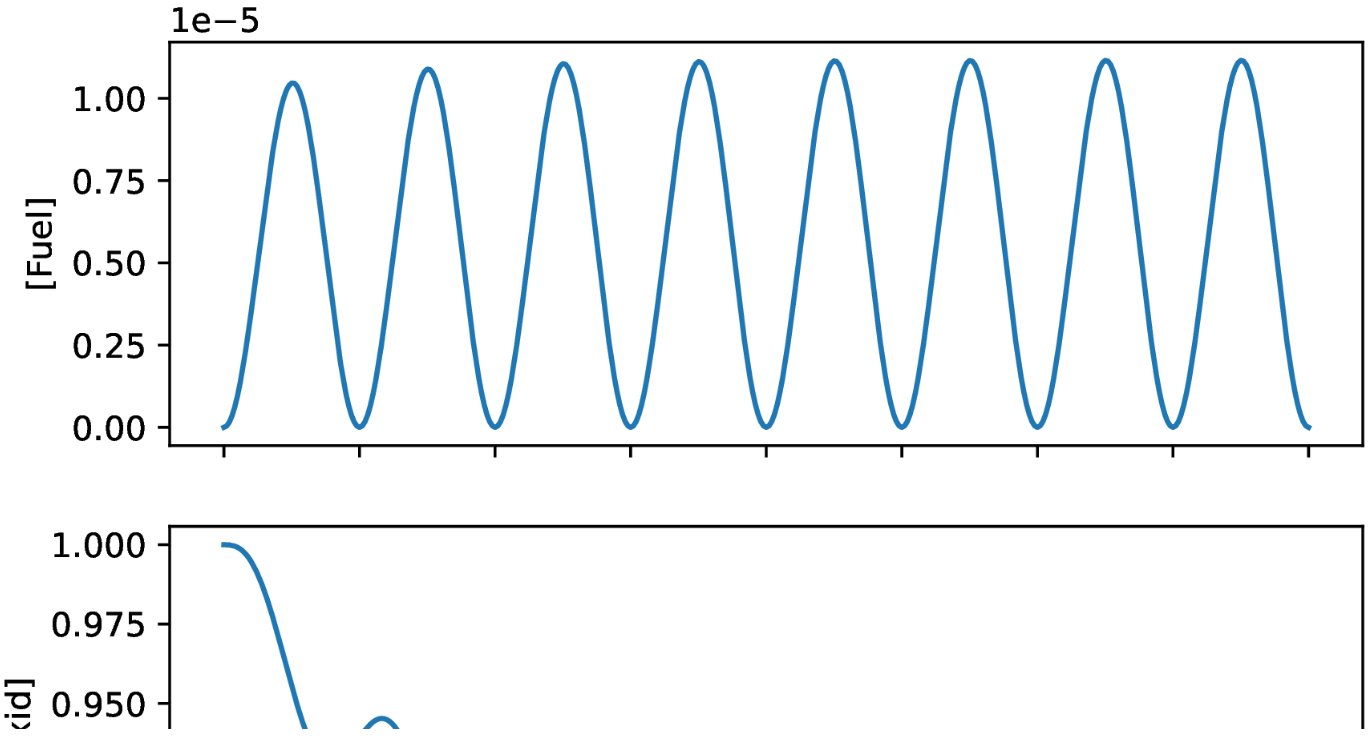
- τ is the combustion reaction timescale
- A_{fuel} and T_{fuel} are the amplitude and period of the oscillatory fuel injection.
- C_{ox} is a multiplier to convert from the fuel reaction rate to the oxidizer reaction rate.
- $[\mathrm{Oxid}_{\mathrm{base}}]$ is base concentration of oxidizer in the combution zone.

As an example, Figure 5.2 shows the solution to this IVP model for the following parameters:

- $\tau = 1\text{E-}4$
- $A_{\mathrm{fuel}} = 0.1$
- $T_{\mathrm{fuel}} = 1.0$
- $C_{\mathrm{ox}} = 2.0$
- $[\mathrm{Oxid}_{\mathrm{base}}] = 1.0$

with the following initial condition:

- $[\mathrm{Fuel}]\,(0) = 0.0$
- $[\mathrm{Oxid}]\,(0) = 1.0$



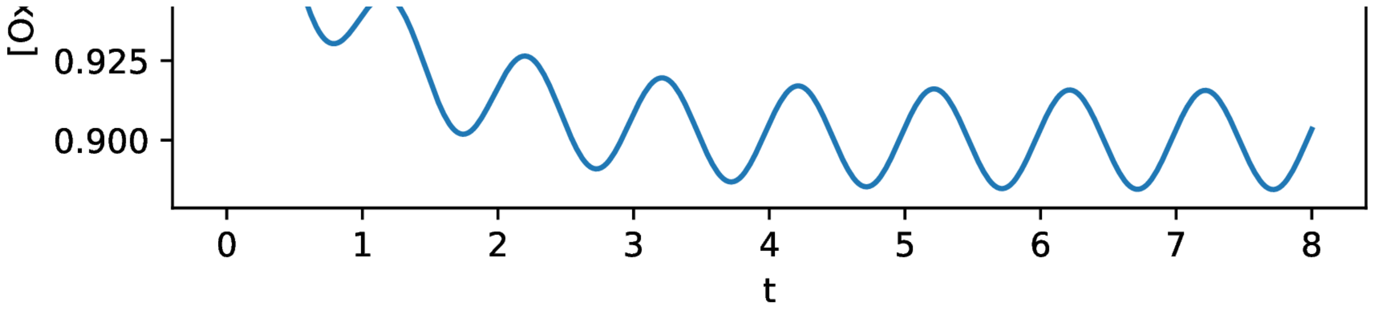


Figure 5.2: Two-state oscillating combustion model example results.

For this problem, you are to complete the `OscComb2IVP` class in the `osccomb2.py` file. Specifically, implement the `evalf` and `evalf_u` methods. Note that `OscComb2IVP` is derived from the `IVP` base class provided in `IVPlib.py`, in which `evalf` and `evalf_u` are defined as virtual methods. Please see that file for those methods' docstrings.

WARNING: Do not modify `IVPlib.py`. Any modifications you make there will not be seen by the grader.

Your `OscComb2IVP` class only needs to define the evalf and evalf_u methods. Do not overload any other base class methods from the `IVP` class. You may implement other (non-overloaded) methods in `OscComb2IVP`. However, the grader will only call your `evalf` and `evalf_u`.

NOTE: You are not required to produce a plot like in Figure 5.2. However, you are free to make one on your own computer if you wish to visually check your result.

Problem: Implementation of two-state oscillating combustion IVP (External resource) (4.0 / 4.0 points)

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< Previous Next >

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