Internal Combustion Engine Analyst course using Python and Cantera

SKILL LYNC

Who are we?

Skill-Lync is an engineering e-learning platform based in Chennai. The brainchild of two engineers, we are at the forefront of re-shaping engineering education in India. In the winter of 2019, we became the first start-up from Chennai to be funded by Y-Combinator.

Today, close to 8000+ students from over 58 countries study at Skill-Lync. Over three years we have helped 280 engineers achieve their dream careers.

58+	8000+	300+	30000+
Countries	Students	Placements	Projects

About the program

Computational Combustion using Python and Cantera

In this course, you will learn computational combustion using Python and Cantera. You will understand how combustion is simulated and write computer programs to simulate chemical kinetics. You will learn how to compute combustion metrics such as flame speed and ignition delay by performing detailed calculations.

You will complete 2 projects in this course

Advanced CFD for Internal Combustion Engine Applications

In this course, you will learn how to perform 3D flow and combustion simulations using the CONVERGE CFD software. You will learn about the backend of the software, including things like turbulence modelling, combustion modelling and emissions modelling. This course is ideal for someone who wants to get into combustion analysis.

You will complete 3 projects in this course.

Reasons to select this course

- Designed by Skill-Lync with inputs from academicians and industry experts to ensure that students are trained in the skills expected in the industry.
- Internal combustion engines (ICE) are the most common form of heat engines, as they are used in vehicles, boats, ships, airplanes, and trains.
- This Skill-Lync course introduces students to the very basics of Internal Combustion Engine analysis using Python and Cantera.
- Completing a Skill-Lync Internal Combustion Engine Analyst course is among the few tools in your resume that can instantly boost your chances of getting employed.

Modules

Introduction

Cantera is an open-source suite of tools for problems involving chemical kinetics, thermodynamics, and transport processes. Computational combustion is a field of numerical modelling and simulations using advanced large-scale parallel systems and offers a new avenue to analyze and interpret the dynamics of acoustic-flame-vortex interactions that occur in most combustion systems.

The course comes under the domain of mechanical and automotive engineering with CFD as a sub-domain. The Cantera library can be imported to MATLAB, Python, and C++. Python is the language of choice because it's widely used and can handle the operations better than MATLAB or C++.

This course is useful for students and working professionals who have a background in thermodynamics and programming and are interested in learning about the function of engines and combustion modelling.

Fundamentals of Chemistry

In this module, you will learn about different fuel types, species nomenclature, and concepts such as:

- Molecular weight
- Moles
- Density
- Mass Fraction, Mole Fraction, and PPM
- Vapour pressure
- Equation of state
- Air fuel ratio
- Equivalence ratio

This module covers the various properties of thermodynamics as well as combustion which is very useful in modelling the combustion. The relation between various properties helps you make the right decision and the results are compared with the numerical data of those properties. The module also covers the units of the above entities and their significance.

Equilibrium Chemistry

Equilibrium chemistry models are very commonly used to construct simplified combustion models. In this module, you will learn the following:

- Full Equilibrium
- Water Gas Equilibrium
- Pressure effects
- Understanding NASA's thermodynamic data files

This module will teach the difference between homogeneous and heterogeneous equilibrium. Understanding the equilibrium will allow you to understand if a chemical reaction is at equilibrium and the direction the chemical reaction must proceed to attain equilibrium.

It helps you to understand the new equilibrium attained when a change in concentration of either a reactant or a product is made to a system initially at equilibrium. Besides, this module will also teach you to read NASA or any other standard data, which helps design the reactor system.

Elementary Reactions

This module will introduce to chemical kinetics and you will learn the following topics:

- Global and elementary reactions
- Rate of a reaction
- Forward rate and backward rate
- CHEMKIN formatted mechanism file

In this module, we define the reaction rate and a few associated terms and introduce the simplest type of chemical reaction which is single-step reactions known as elementary reactions. We will investigate the various factors that determine the rate of an elementary reaction, which allows you to calculate rate constants and explain their temperature dependence

Introduction to Python and Cantera

In this module, you will study Python - an extremely popular programming language. You will learn Python by writing programs related to chemical kinetics. Once you can write simple programs in Python, we will introduce you to Cantera. With Cantera, you will be able to simulate different types of combustion systems. Cantera is an extremely popular tool that is used in several universities and organizations for research and industrial purposes.

Ignition Delay Calculation

Ignition delay is the time lag between the start of injection to start of the combustion when the air-fuel mixture is ignited. It is one of the major factors that help in determining the performance of an IC engine. In this module, we will teach you to build several zero-dimensional reactors. These types of simulations will be used to predict the ignition delay and flame speeds of popular fuels.

The objective of the module is to study the dependence of ignition delay time on:

- Cylinder ambient gas temperature
- Cylinder ambient gas pressure
- Injection pressure
- Injector nozzle orifice diameter

Flame Speed Calculation

While designing combustion systems, flame speed plays an important role in determining their performance. In this module, you will learn how to calculate flame speeds. Note that this parameter depends upon the type of reaction mechanism that is being employed and the thermodynamic conditions in the combustion chamber. You will also perform a sensitivity analysis that helps you determine which of the elementary reactions are going to affect the flame speed the most.

Advanced Topics in Combustion

In this module you will learn the following topics:

- Perfectly stirred reactor
- Steady-state combustion and its relevance for gas turbine applications
- Extinction and blow off limits
- Premixed, diffusion, and partially premixed flames

Introduction to 3D Combustion

In this module, you will be trained in the core concepts that are used while simulating combustion in complex 3D geometry. Here you will learn about the current trends along with the cutting edge tools that are used in the industry.

Industry Specific Projects

Adiabatic Flame Temperature Calculation

The adiabatic flame temperature for a given fuel-oxidizer combination is determined by finding the final state temperature (i.e. the adiabatic flame temperature) for which the sum of the enthalpies of the reactants equals the sum of the enthalpies of the products. The calculation of thermal efficiency becomes easy once we know the AFT. The efficiency further allows you to improvise the reactor system.

Combustion Efficiency Calculation after Preheating

A recuperator is a heat exchanger in which energy from the exhaust of hot combustion products, i.e. flue gases, is transferred to the inlet air for increasing its temperature. The effect of such preheating of air can be seen in improving combustion efficiency as well as Adiabatic Flame Temperature. This analysis is performed to effectively utilize the exhaust gas recirculation and increase the efficiency of the reactor.

Solving STIFF ODE System by using Backward Differencing and a Multivariate Newton-Rhapson Solver

In this project, you will be solving a STIFF ODE system from scratch. This helps you understand how reacting systems are solved. The Newton-Raphson method (also known as Newton's method) is a way to quickly find a good approximation for the root of a real-valued function f(x)=0. It uses the idea that a straight line tangent can approximate a continuous and differentiable function to it. This numerical method is effective for stiff ODEs.

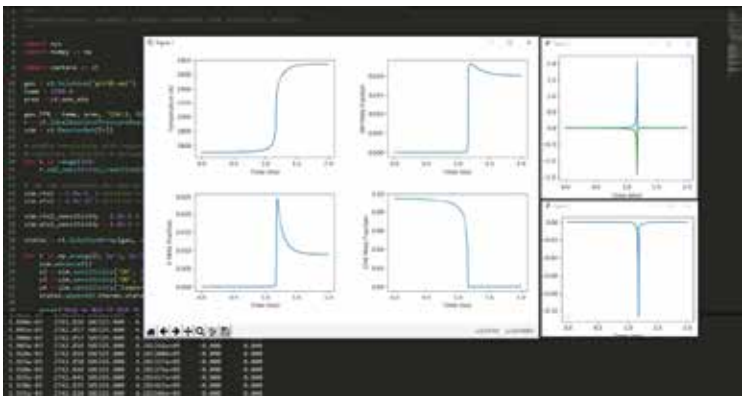
Auto Ignition

In this project, you will be exposed to the Cantera reactor network and its uses in solving various models. The reactor network allows you to calculate the expansion/compression work, heat transfer, mass transfer, and surface interaction with the environment. The auto-ignition gives the time required for combustion to take place and to control it can be beneficial for controlling pollutants as well as for complete combustion.

Sensitivity Analysis

The correct description of chemical changes requires the application of reaction mechanisms consisting of several hundred or thousand reactions. This means that a huge number of parameters describes the chemistry of the combustion process. Hence, the application of the sensitivity analysis techniques is very useful for the understanding of those parameters.

Detailed chemical models are too big for many practical combustion simulations. Sensitivity analysis can be used for mechanism reduction, that is, finding a smaller model that produces similar predictions for some of the variables (i.e., species concentrations and temperature).



One Dimensional Flame Speed Analysis

The flame speed is the measured rate of expansion of the flame front in the combustion reaction. The flame speed of fuel is a property that determines its ability to undergo controlled combustion without detonation. This project is the study of flame speed by considering the effect of temperature, pressure and concentration on it.

Reaction Reduction Mechanism

This detailed mechanism for methane-air combustion(GRI3.0) is probably the most famous one. It comprises 325 reactions and 53 species. The reduced mechanisms include only the top reactions and the associated species. The reduced mechanisms with a certain number of species are able to adequately simulate the ignition delay, sensitivity problem. Such a reduced mechanism saves a lot of computational resources as well as time.

Software Covered

CONVERGENT SCIENCE

As a leading computational fluid dynamics (CFD) software for simulating three-dimensional fluid flow, CONVERGE is designed to facilitate your innovation process. CONVERGE features truly autonomous meshing, state-of-the-art physical models, a robust chemistry solver, and the ability to easily accommodate complex moving geometries, so you can take on the hard CFD problems.

Basic

2 Months Access

₹7000

Enroll Now

Per month for 3 months

- Access Duration : 2 months
- Mode of Delivery : Online
- Project Portfolio : Available
- Certification : Available
- Email Support : Available
- Whatsapp Support : Available

Pro

4 Months Access

₹10000

Enroll Now

Per month for 3 months

- Access Duration : 2 months
- Mode of Delivery : Online
- Project Portfolio : Available
- Certification : Available
- Indivdual Video Support : 4 month
- Group Video Support : Available
- Email Support : Available
- Whatsapp Support : Available
- Telephone Support : Available
- Add-ons Induatry Projects : 1

Premium

Lifetime Access

₹15000

Enroll Now

Per month for 3 months

- Access Duration : 2 months
- Mode of Delivery : Online
- Project Portfolio : Available
- Certification : Available
- Indivdual Video Support : 12/month
- Group Video Support : 12/month
- Email Support : Available
- Whatsapp Support : Available
- Telephone Support : Available
- Add-ons Induatry Projects : 2
- Dedicated Support Engineer : Available

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