Why MATLAB Rules

The most underrated engineering tool of all time

MATLAB

What does MATLAB do?

Python: Automating tasks, data analysis

Javascript: Making dynamic and interactive websites

Matlab: Math modeling, simulations, data analysis, signal processing

C++: Creating simulations, high-speed software

Misc: Fortran, Typescript, SLQ, C, C#, LaTeX, etc.

Julia: New to the market general engineering coding platform

MATLAB Is Better Than You Think

- Fewer syntax **rules** than most languages
- Built for math and **engineering**, not software engineering
- Core tools (plots, calculus, matrices) are **built-in**
- **Bad intro classes** gave the wrong impression
- Feels easy when used on **real projects**
- **Professional** Crossover

```
Error using  *
Incorrect dimensions for matrix multiplication. Check that the number of columns in the first matrix matches the number of rows
in the second matrix. To operate on each element of the matrix individually, use TIMES (.*) for elementwise multiplication.

Error in Vibrations_Demo (line 20)
    x=A*exp(-Z*Wn*t)*sin((Wd*t)+p);
```

What can MATLAB do for me?

- Solve **homework** problems for vibrations, dynamics, thermo, etc.
- Quickly perform **derivatives**, integrals, and partial derivatives
- **Analyze** and process experimental data from labs and projects
- Lets you **test control systems** for drones, robots, and other projects
- Builds and **checks algorithms** before you waste time coding them in C++
- Signal processing and **electrical engineering** purposes
- Create 2D and 3D **plots** to communicate results clearly
- Prototype ideas fast with **simple syntax**
- Runs on whatever device you’ve got (even a **Mac** or Ipad)

Vibrations

ME 370 Homework Problems

Vibrations Homework

ME 370 Homework #2

1.41. Consider a spring mass damper system, like the one in Figure 1.9, with the following values: m =10 kg, c = 3 N/s and k = 1000 N/m. a) Is the system overdamped, underdamped or critically damped? b) Compute the solution if the system is given initial conditions x_0 = 0.01 m and v_0 = 0.

1.44. Compute the solution to $\ddot{x} + 2\dot{x} + 2x = 0$ for x_0 = 0 mm, v_0 = 1 mm/s and write down the closed form expression for the response.

1.52 For a damped system, m, c, and k are known to be m = 1 kg, c = 2 kg/s, k = 10 N/m. Calculate the value of ζ and ω_n . Is the system overdamped, underdamped, or critically damped?

1.53 Plot $x(t)$ for a damped system of natural frequency ω_n = 2 rad/s and initial conditions x_0 = 1 mm, v_0 = 1 mm, for the following values of the damping ratio: ζ = 0.01, ζ = 0.2, ζ = 0.1, ζ = 0.4, and ζ = 0.8.

1.58 A spring-mass-damper system has mass of 150 kg, stiffness of 1500 N/m and damping coefficient of 200 kg/s. Calculate the undamped natural frequency, the damping ratio and the damped natural frequency. Is the system overdamped, underdamped or critically damped? Does the solution oscillate?

Vibrations Homework

1.44. Compute the solution to $\ddot{x} + 2\dot{x} + 2x = 0$ for $x_0 = 0$ mm, $v_0 = 1$ mm/s and write down the closed form expression for the response.

$m \quad c \quad k$ $\qquad \zeta = \frac{c}{2\sqrt{mk}} = \frac{2}{2\sqrt{2}} < 1$ underdamped

$m = 1,\ c = 2,\ k = 2$

$x_0 = 0 \qquad V_0 = 1 \times 10^{-3}\ m/s$

$$x(t) = A e^{(-\zeta \omega_n t)} \sin(\omega_d t + \phi)$$

$$\zeta = \frac{1}{\sqrt{2}} = 0.707 \qquad \omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{2}{1}} = 1.414$$

$$\omega_d = \sqrt{2} \cdot \sqrt{1 - \left(\tfrac{1}{\sqrt{2}}\right)^2} = 1$$

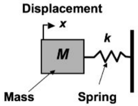
$$\phi = \tan^{-1}\left(\frac{x_0 \omega_d}{V_0 + \zeta \omega_n x_0}\right) = \tan^{-1}(0) = 0$$

$$A = \frac{1}{\omega_d}\sqrt{(V_0 + \zeta \omega_n x_0)^2} = \frac{1}{1} \cdot \sqrt{(1+0)^2} = 1$$

$$x(t) = e^{-t} \sin(t) \text{ mm}$$

Undamped Motion

$$m\ddot{x}(t) = -kx(t)$$
or
$$m\ddot{x}(t) + kx(t) = 0$$



Has Solutions:

$$x(t) = A\sin(\omega_n t + \phi)$$
$$x(t) = A_1 \sin\omega_n t + A_2 \cos\omega_n t$$
$$x(t) = a_1 e^{j\omega_n t} + a_2 e^{-j\omega_n t}$$

$$\underbrace{A = \frac{1}{\omega_n}\sqrt{\omega_n^2 x_0^2 + v_0^2}}_{\text{Amplitude}}, \quad \underbrace{\phi = \tan^{-1}\left(\frac{\omega_n x_0}{v_0}\right)}_{\text{Phase}}$$

$$\omega_n = \sqrt{\frac{k}{m}} = 2\pi f_n = \frac{2\pi}{T}, T \text{ here is the period}$$

Damped Motion

$$m\ddot{x}(t) = -kx(t) - c\dot{x}(t)$$
or
$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = 0$$

$$\zeta = \frac{c}{2\sqrt{km}}$$

Underdamped

$$x(t) = e^{-\zeta\omega_n t}(a_1 e^{j\omega_n t\sqrt{1-\zeta^2}} + a_2 e^{-j\omega_n t\sqrt{1-\zeta^2}})$$
$$= Ae^{-\zeta\omega_n t}\sin(\omega_d t + \varphi)$$

$$A = \frac{1}{\omega_d}\sqrt{(v_0 + \zeta\omega_n x_0)^2 + (x_0\omega_d)^2}$$

$$\varphi = \tan^{-1}\left(\frac{x_0\omega_d}{v_0 + \zeta\omega_n x_0}\right)$$

Critically Damped

$$x(t) = a_1 e^{-\omega_n t} + a_2 t e^{-\omega_n t}$$

$$x = (a_1 + a_2 t)e^{-\omega_n t}$$
$$\Rightarrow a_1 = x_0$$
$$v = (-\omega_n a_1 - \omega_n a_2 t + a_2)e^{-\omega_n t}$$
$$v_0 = -\omega_n a_1 + a_2$$
$$\Rightarrow a_2 = v_0 + \omega_n x_0$$

Overdamped

$$\lambda_{1,2} = -\zeta\omega_n \pm \omega_n\sqrt{\zeta^2 - 1}$$
$$x(t) = e^{-\zeta\omega_n t}(a_1 e^{-\omega_n t\sqrt{\zeta^2-1}} + a_2 e^{\omega_n t\sqrt{\zeta^2-1}})$$

$$a_1 = \frac{-v_0 + (-\zeta + \sqrt{\zeta^2 - 1})\omega_n x_0}{2\omega_n\sqrt{\zeta^2 - 1}}$$

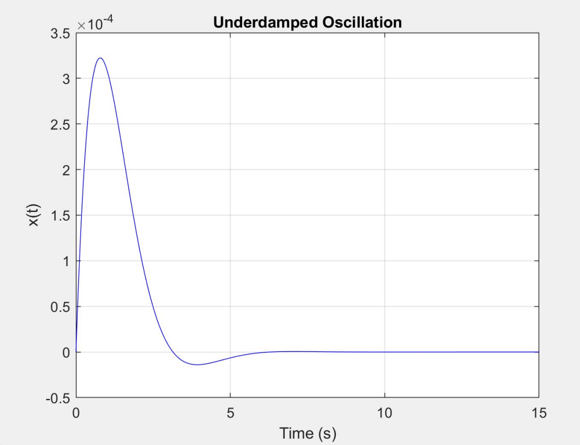
$$a_2 = \frac{v_0 + (\zeta + \sqrt{\zeta^2 - 1})\omega_n x_0}{2\omega_n\sqrt{\zeta^2 - 1}}$$

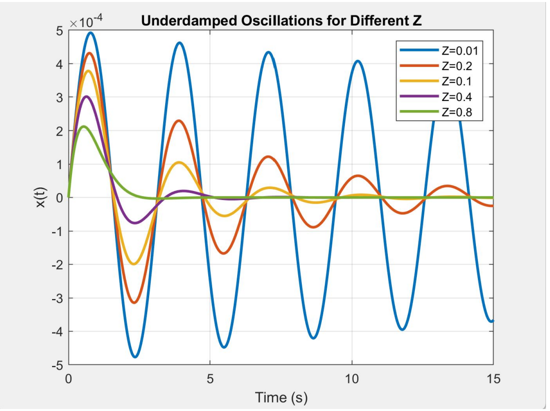
$$\omega_d = \omega_n\sqrt{1 - \zeta^2}$$

Vibrations in MATLAB

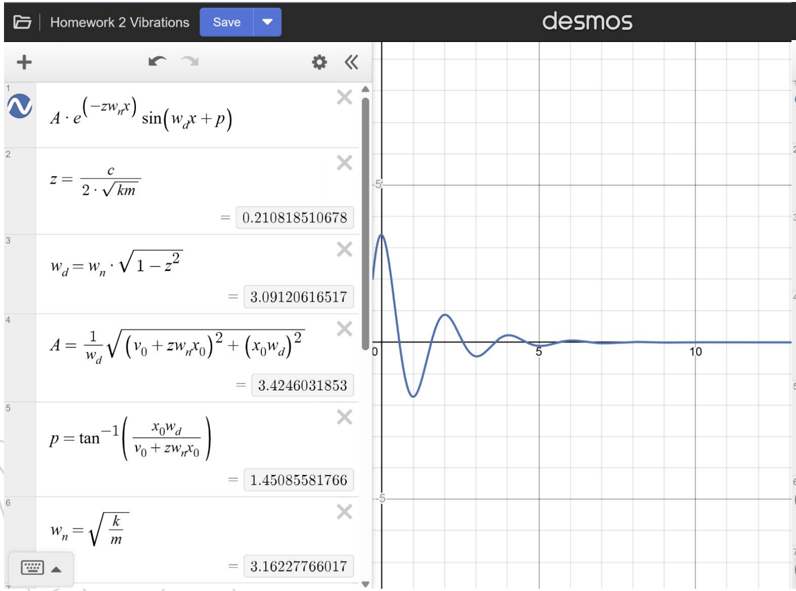
```
clc
clear
%Homework 2 Vibrations Demo
%establish Variables
m=1; %kg
C=2; %kg/s
k=2; %N/m
x0=0; %m
v0=1*10^-3; %m/s
t = (0:0.01:15)'; %time (seconds)

%Equations
Wn=sqrt(k/m)
Z=C/(2*sqrt(k*m))

%Problem 1.53 Override
Wn=2
Z=[0.01,0.1,0.2,0.4,0.8]
Wd=Wn*sqrt(1-(Z.^2))
    p=atan((x0.*Wd)./(v0+(Z.*Wn*x0)))
    A=(1./Wd).*sqrt(((v0+(Z.*Wn.*x0)).^2)+((x0.*Wd).^2))
    x = A .* exp(-Z.*Wn.*t) .* sin(Wd.*t + p); %graphable
    %Plot
        plot(t, x, 'LineWidth', 2)
        xlabel('Time (s)')
        ylabel('x(t)')
        title('Underdamped Oscillations for Different Z')
        legend('Z=0.01','Z=0.2','Z=0.1','Z=0.4','Z=0.8')
        grid on
```

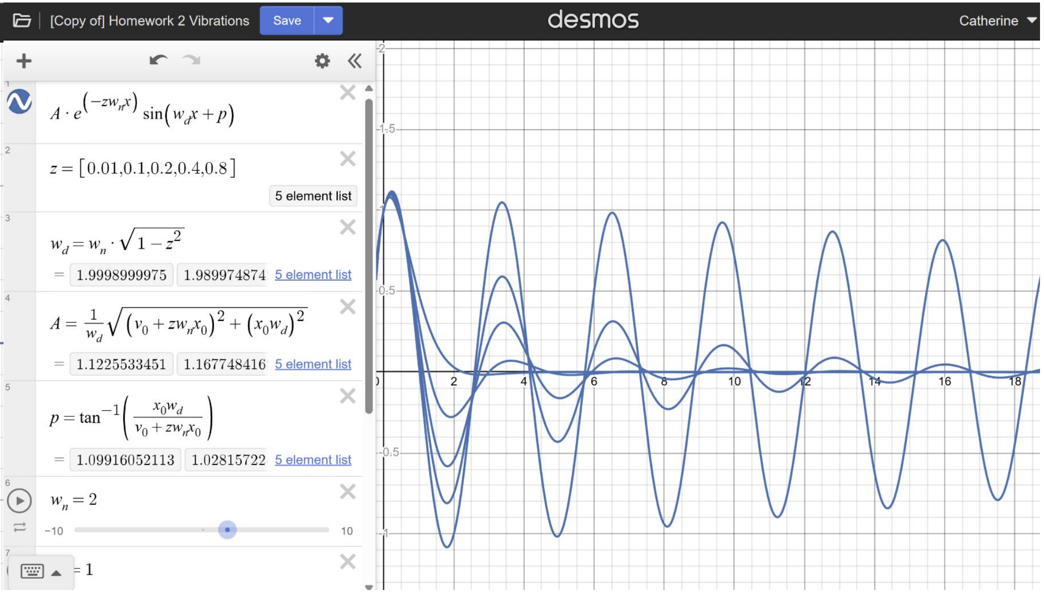
```
%}

%Underdamped vs Critically Damped vs Overdamped
if Z<1 %Underdamped
    Wd=Wn*sqrt(1-(Z.^2))
    p=atan((x0.*Wd)./(v0+(Z.*Wn*x0)))
    A=(1./Wd).*sqrt(((v0+(Z.*Wn.*x0)).^2)+((x0.*Wd).^2))
    x = A .* exp(-Z*Wn.*t) .* sin(Wd.*t + p); %graphable
    %Plot
        plot(t, x, 'b')
        xlabel('Time (s)')
        ylabel('x(t)')
        title('Underdamped Oscillation')
        grid on
elseif Z==1 %Critically Damped
    a1=x0
    a2= v0 + Wn*x0
    x=(a1 + a2.*t).*exp(-Wn.*t);
else Z>1 %Overdamped
    fprintf(Z);
end
```





What about desmos?





Thermodynamics

ME 300 Homework Problems

Thermo Homework

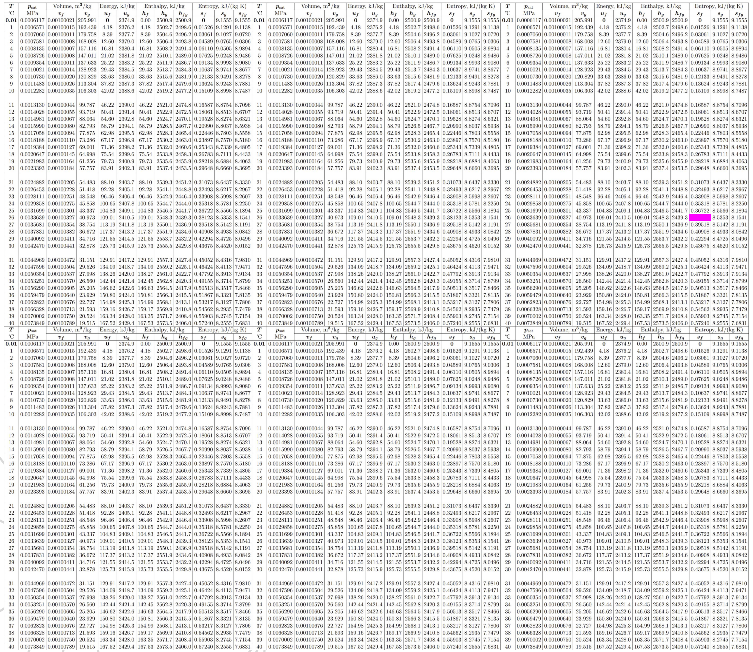
Example: Calculate the ideal cycle efficiency for a regenerative Rankine cycle employing a single open feedwater heater. The low-pressure section operates at 5 kPa, the high-pressure section operates at 1 MPa. The superheated state reaches a temperature of 717K; the quality at the turbine exit is 0.90.
The extracted steam and the feedwater heater are at a pressure of 0.2 MPa.

	1	2	3	4	5	6	7
p	0.2MPa		1MPa	0.2MPa		5kPa	
T			717K				
s							
h							
x	0	NA	NA	NA	0.9	0	NA

Traditional Methods

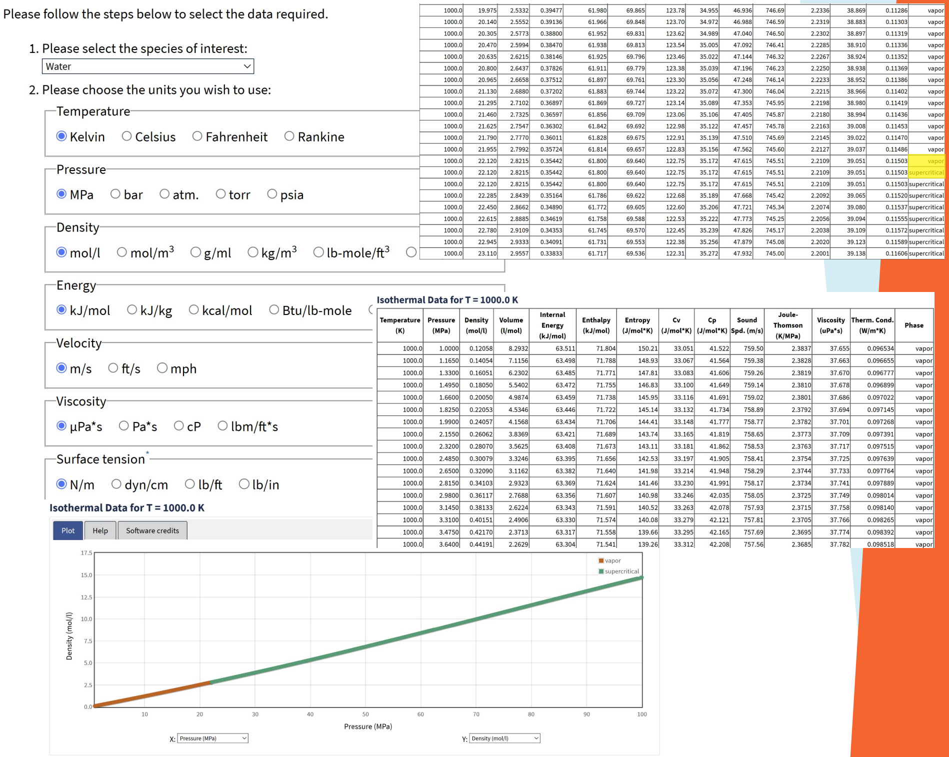
Steam Tables

Properties of Water and Steam



NIST Website

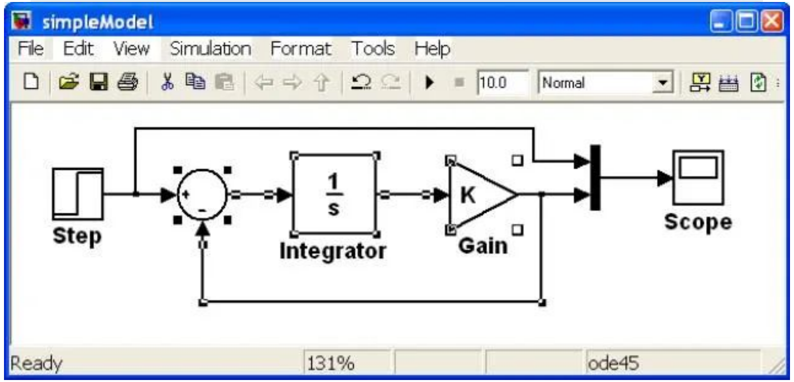
Thermophysical Properties of Fluid Systems



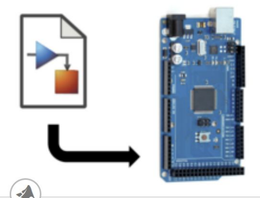
MATLAB Demo

Files will be provided after for all interested parties

Simulink: The MATLAB version of Scratch



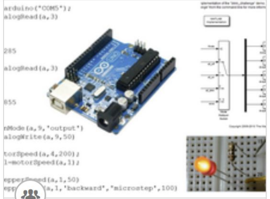
Simulink Examples



Simulink Support Package for Arduino Hardware

Run models on Arduino boards

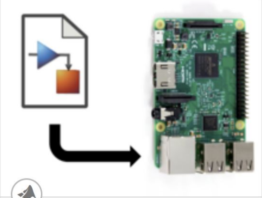
266.5K ⬇ ★ 2.80 / 5



Legacy MATLAB and Simulink Support for Arduino

MATLAB class and Simulink blocks for communicating with an Arduino board

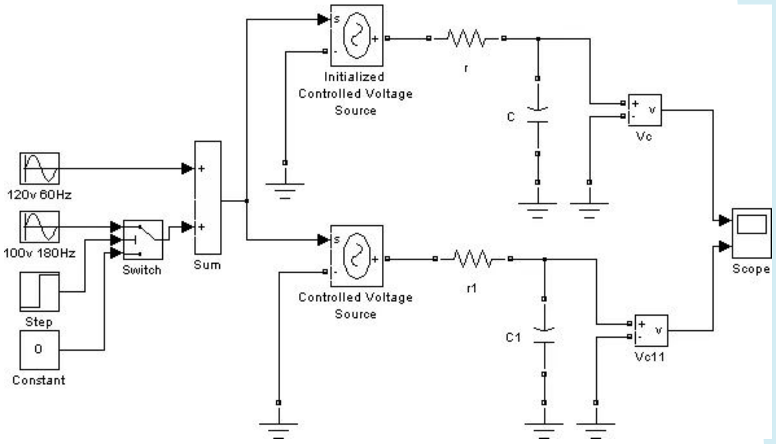
246.8K ⬇ ★ 4.10 / 5

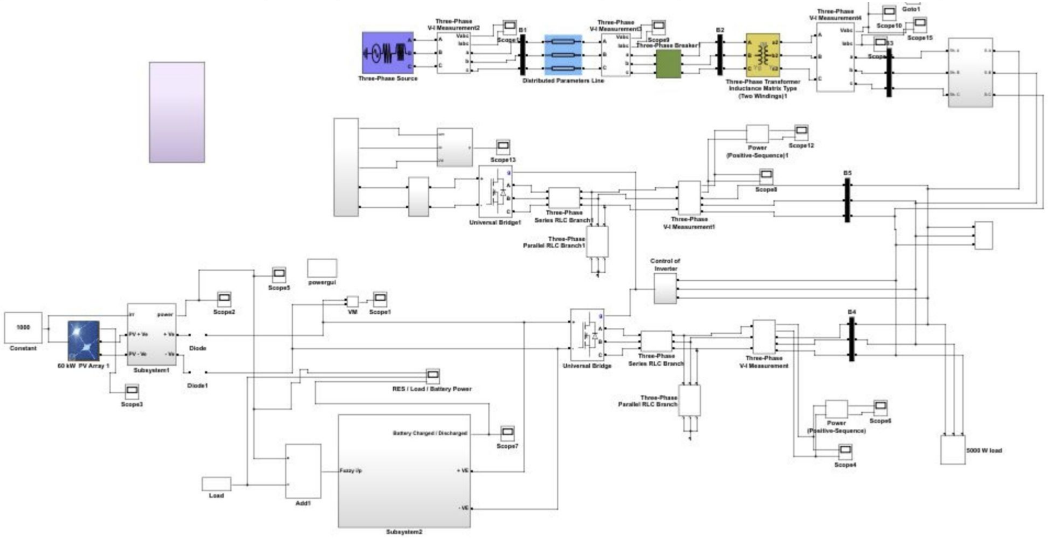


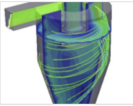
Simulink Support Package for Raspberry Pi Hardware

Run models on Raspberry Pi.

71.3K ⬇ ★ 3.50 / 5





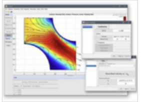


QuickerSim CFD Toolbox Version 2.5.1 by QuickerSim

QuickerSim **CFD** Toolbox allows you to perform fluid flow and heat transfer simulations based on the finite element method

QuickerSim **CFD** Toolbox is a very flexible and efficient environment for solving **CFD** problems in MATLAB. You can use it in industry, research or for teaching Fluid Mechanics, **CFD**, or Numerical Methods

★★★★★ 8.6K Downloads
Updated 23 Aug 2021



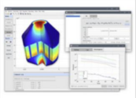
CFDTool - MATLAB OpenFOAM and CFD Fluid Dynamics Toolbox Version 1.10.5 by Precise Simulation

CFDTool - An Easy to Use Computational Fluid Dynamics (**CFD**) Toolbox

CFDTool™ is a MATLAB® Computational Fluid Dynamics (**CFD**) Toolbox for modeling and simulation of fluid flows with coupled heat transfer, with full integration with the OpenFOAM and SU2 solvers. Based

CFDTool - CFDTool - An Easy to Use Computational Fluid Dynamics (**CFD**) Toolbox

★★★★★ 24.1K Downloads
Updated 5 Aug 2025



FEATool Multiphysics - MATLAB FEA and CFD Toolbox Version 1.17.5 by Precise Simulation

FEATool Multiphysics - Physics Simulation Made Easy

built-in interfaces to the OpenFOAM GUI (**CFD**), SU2 Code (**CFD**), and FEniCS GUI (FEA) solvers.Note that it is not recommended to use MATLAB 2025a or later with the toolbox, as the new web GUI does not offer

★★★★★ 30.2K Downloads
Updated 5 Aug 2025

Image courtesy of ChatGPT

You SHOULD Use AI

- Use AI as a **helper**, not a replacement
- Understanding why/how your code works is CRUCIAL
- MATLAB is likely to be part of your real “adult” job
- LLMs are not the only or best option
- AI and Non-AI resources

AI Resources

- Toolboxes for AI/ML:
  - Deep Learning Toolbox
  - Statistics & Machine Learning Toolbox
- Github Copilot + MATLAB Extension
- AI Chat Playground (Mathworks)

Non- AI Resources

- Code Suggestions/Smart Editor
- MATLAB File Exchange / Central
- MATLAB Academy (Help Center)
- MATLAB Cody
- Reddit r/matlab
- Professors/Mentors/Classmates

MATLAB® is worth it

Use MATLAB as another tool in your toolbelt to complete homework faster, create cooler projects, separate yourself from your peers, and prepare yourself for the professional world