Ordinary Differential Equation Simulation Project

This project aims to numerically solve a ordinary differential equation (ODE) to model the dynamics of a physical system. You will choose a physical system, derive its governing equation, rewrite it in state-variable form, and build an Excel simulation with a sinusoidal forcing function. You will present your Excel file to me and be able to explain and modify it on the spot.

Number of group members: 1-4

Presentation: week 14

Worth 10% of final grade

Choose a physical system
Pick a system that can be described by a 1 or 2 ODEs.
Examples:
- RLC circuits
- Mass–spring–damper
- Simple pendulum

Derive its governing equation
Start from Newton's 2nd Law, Kirchoff's Laws, Energy Laws, ...
Write the ODE in its usual form.
Define all variables (position, velocity, voltage, current, ...).
Define all constants (mass, viscosity, resistance, capacitance, ...).

Convert to state-space (first-order system)
Define state variables, x_1, x_2, ...
Differentiate state variables and relate to other state variables.
You will present these equations and also implement them in Excel.

Excel Implementation
Build a single Excel file that numerically solves your state-space system using a time-stepping method (e.g. Euler, Runge–Kutta, ...).

Your sheet must include:
- Parameters & initial conditions (clearly labeled):
- Time column:
- Forcing function column:
  - use: $F(t) = A \sin(\omega t)$
- State columns (x_1, x_2, ...)

Required Plots (from Excel):
- Time-dependent plot
  - Plot a key state variable vs time (x(t), I(t), V(t), ...).
  - Include labels, units, and a legend.
- Phase plot
  - Plot one state vs another (x_2 vs x_1, or i_L vs v_C).
  - Include labels, units, and a legend.

Marking Scheme

Correctness (math & physics)	2 mark(s)
Correct ODE and correct state-space derivation	
Correct implementation of the numerical method	
Time-dependent plot	2 mark(s)
Correct data, labels, meaningful behaviour	
Phase plot	2 mark(s)
Correct data, labels, meaningful behaviour	
Presentation & understanding	2 mark(s)
Ability to explain your model	
Effect of parameter changes	
Formatting and clarity	2 mark(s)
Clearly labeled parameters, units, and variables	
Clean, readable Excel layout	

Total 10 mark(s)