Introduction to Differential Equations: Part1

1. What is the dimensionality and order of this differential equation: $\alpha \frac{d^2x}{dt^2} + \rho \frac{dx}{dt} = mx$?
2. $\rho \frac{dx}{dt} = mx + 1$: Is this a homogeneous or nonhomogeneous differential equation?
3. Can you recognize if the differential equation: $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$, is a linear or nonlinear differential equation?
4. Convert the equation: $\rho \frac{dx}{dt} = mx + 2t$, into the standard/canonical form of the linear differential equation.
5. Why is solving an ordinary differential equation (ODE) often called an Initial Value Problem?

Introduction to Differential Equations: Part2

1. What is the steady-state value of $x(t)$ in the differential equation: $\tau \frac{dx}{dt} = (-x + 2)$.
2. What does asymptotic behaviour of a differential equation mean?
3. Can you recognize the asymptotic behaviour of the differential equation: $\tau \frac{dx}{dt} = (-x + 2)$, given the initial value of x as $x(t = 0) = 2$?
4. What does Low-Pass Filtering in the linear ODEs mean?

Numerical Methods for Differential Equations: Part1

1. Which kinds of differential equations are difficult to solve analytically: Linear or Nonlinear?
2. Is Taylor series of a function a finite or infinite series? What is the order of truncation error in the Taylor approximation, if the fifth order and higher orders terms are neglected in the Taylor series?
3. Choose the True and False statements in the following:
   - Euler and Runge-Kutta methods are analytical methods of solving an ODE.
   - Runge-Kutta method is computationally more expensive than Euler method per step of iterative approximation.
   - Euler method offers better accuracy than Runge-Kutta method in solving ODEs.
   - Euler method shows better accuracy for large time steps than small time-steps.
   - Both Euler and Runge-Kutta methods involve nonlinear approximation of a function at each time-step.

Numerical Methods for Differential Equations: Part2

1. While using the Euler method for solving an ODE, the time-step of numerical integration should be _______ than the smallest time constant of the differential equation.
2. What is the benefit of adaptive timestep method over the Euler and Runge-Kutta methods of numerically solving ODEs?

Leaky Integrate-and-Fire Model of Neuron: Part1

1. Under resting conditions, the inside of a neuron is ___ negative than the extracellular medium.
2. What is the typical resting membrane potential of a neuron?
3. Given the intracellular potential $V_I = -80mV$ and extracellular potential $V_E = -10mV$, calculate the membrane potential V_m.
4. What is the typical threshold membrane potential of a neuron? Is the subthreshold membrane potential dynamics linear or nonlinear?
5. What are the typical units of membrane capacitance and resistance for a neuron?
6. How does Leaky Integrate-and-Fire (LIF) model of neuron generate neuronal spikes?
7. Which parameter in the LIF model controls the time taken by the membrane potential to reach its steady state in the presence of a constant external current?

Leaky Integrate-and-Fire Model of Neuron: Part2

1. What does the critical external current in the frequency-current response of a neuron signify?
2. Which parameter in the LIF model shapes the frequency-current response of the neuron?
3. What happens to the response of LIF in the presence of a very high-frequency external input, as the membrane time constant is made smaller and smaller?
4. What is the commonly used measure of the low-pass filtering behaviour of the LIF model and its unit?
5. What is the maximum value of the impedance of the LIF model?
6. Can you mention three ways through which LIF model has been improved to better model the neuronal activity?