Medical Modeling & Simulation

Program-1 (Drug Concentration)

1. Concept

Example of drug concentration decay over time.

$$\frac{dC}{dt} = -k * C(t)$$

Continuous Model: $C(t) = C_0 * e^{-k\,t}$

- After taking a pill, the drug concentration in the blood is initially 100 mg/L. Every hour, it decreases by 20%. This can be modeled with a simple exponential decay formula:

Discrete Mode: $C(t+1) = 0.8 \times C(t)$

2. Simulation Table

Time (hours)	Concentration (mg/L)
0	100.00
1	80.00
2	64.00
3	51.20
4	40.96
5	32.77

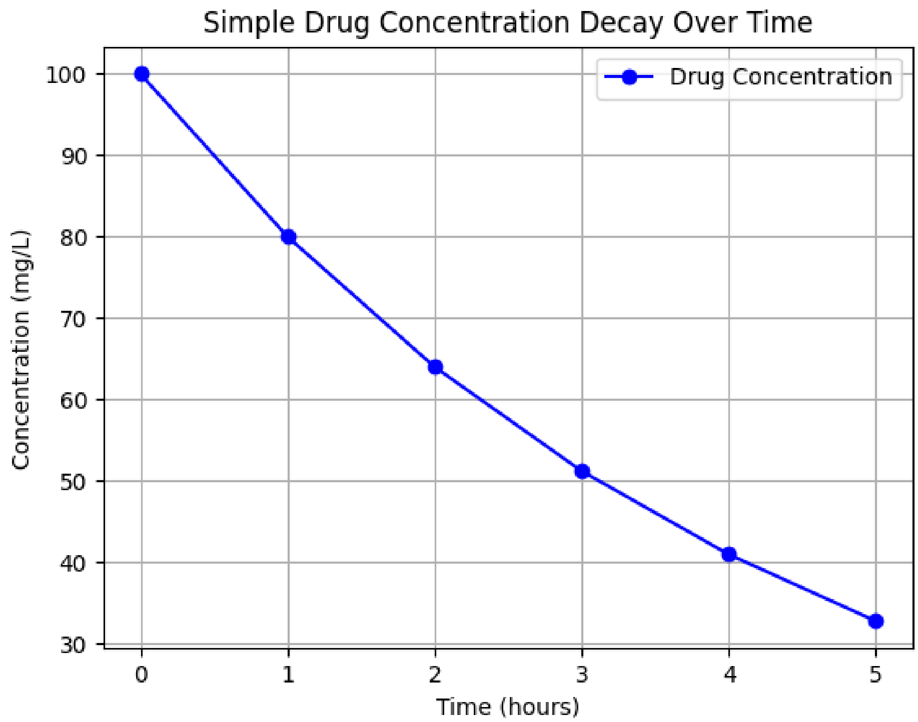
3. Python Code (Discrete Mode)

```
import numpy as np
import matplotlib.pyplot as plt

time = np.arange(0, 6, 1)
C = [100.0]

for t in range(1, len(time)):
    C.append(0.8 * C[-1])

plt.plot(time, C, marker='o', linestyle='-', color='blue', label='Drug Concentration')
plt.xlabel('Time (hours)')
plt.ylabel('Concentration (mg/L)')
plt.title('Simple Drug Concentration Decay Over Time')
plt.grid(True)
plt.legend()
plt.show()
```



HW-1/ Proof:

$$\frac{dC}{dt} = -k * C(t) \rightarrow C(t) = C_0 * e^{-k\,t}$$

Where:
- $C(t)$: drug concentration at time t
- k: elimination constant (rate of removal per hour)
- The negative sign $(-)$ indicates that concentration decreases with time

Notes for Students:

1. The condition $t = 0$ should be considered when forming the final equation to ensure consistency with the system's initial state.

2. The constants c_1 and c_2 represent general integration constants and are not kept in the final physical form of the model.

HW-2/

Write a Python program using the Continuous Model:

$$:C(t) = C_0 * e^{-k\,t}$$

Note/ Find the value of k from:

$$C(1) = C_0 * e^{-k}$$

$$C(1) = 0.8 \times C(0)$$

1- Continue Method

$$\frac{dC}{dt} = -k * C(t)$$

$$\frac{dC}{C(t)} = -k\ dt$$

$$integration\ for\ both\ sides:$$

$$\int \frac{1}{C(t)} dC = -k \int dt$$

$$\ln(C(t)) + c_1 = -k\ t + c_2$$

لان النظام فيزيائي ثابت التكامل لا يعطي معنى، يجب التعامل معه بطريقة ما.

$$C' = c_1 - c_2$$

$$\ln(C(t)) = -k\ t + C'$$

Initial state $t = 0$.

$$\ln\left(C(0)\right) = -k * 0 + C'$$

$$\ln\left(C(0)\right) = C'$$

$$\ln(C(t)) = -k\ t + \ln\left(C(0)\right)$$

$$\exp\ for\ both\ sides:$$

$$\exp^{(\ln(C(t)))} = \exp^{-k\ t + \ln\left(C(0)\right)}$$

$$C(t) = \exp^{-kt}\ C(0)$$

2- Discrete Method

$$\frac{dC}{dt} = -k * C(t)$$

$$\frac{C(t + \Delta t) - C(t)}{\Delta t} = -k * C(t)$$

In discrete $\mathit{\Delta} t = 1$

$$\frac{C(t + 1) - C(t)}{1} = -k * C(t)$$

Initial state $t = 0$

$$C(0 + 1) - C(0) = -k * C(0)$$

$$C(1) - C(0) = -k * C(0)$$

$$C(1) = \left(-k * C(0)\right) + C(0)$$

$$C(1) = C(0)(-k + 1)$$

$$C(1) = C(0)(1 - k)$$