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17/ENG01/005

CHEMICAL ENGINEERING

ENG282 - ENGINEERING MATHEMATICS II

Question 2:

(a) Mathematical modelling can be defined as the mathematical representation of a system and simulation of system involves solving the model and obtaining its output variable for different values of its input variable or its input variable is changed from one value to another

(b) (a) By the use of Bernoulli law
(b) By differentiation
(c) By the use of Newton's law of cooling states

(c) From Newton's law of cooling states;

$$\frac{dT}{dt} \propto (T - T_A)$$

$$\frac{dT}{dt} = K(T - T_A)$$

$$\frac{dT}{(T - T_A)} = K\,dt$$

Integrating through

$$\ln(T - T_A) = Kt + c$$

$$(T - T_A) = e^{Kt+c}$$

$$T - T_A = e^{Kt} \cdot e^{c}$$

But $e^{c} = T_0$

$$T - T_A = T_0 e^{Kt} \quad \text{——①}$$

Initially; at $t = 0$, $T = 10^{\circ}C$ and actual temperature, $T_A = 25^{\circ}C$

Equation one becomes:

$$10 - 25 = T_0 e^{K(0)}$$

$$-15 = T_0 \times 1 = T_0$$

$$T_0 = -15^{\circ}C \quad \therefore T = T_A + T_0 e^{Kt} = 25 - 15e^{Kt} \quad \text{——②}$$

At t=5minutes; T=20°C

From; $T = 25 - 15e^{kt}$

$20 = 25 - 15e^{5k}$

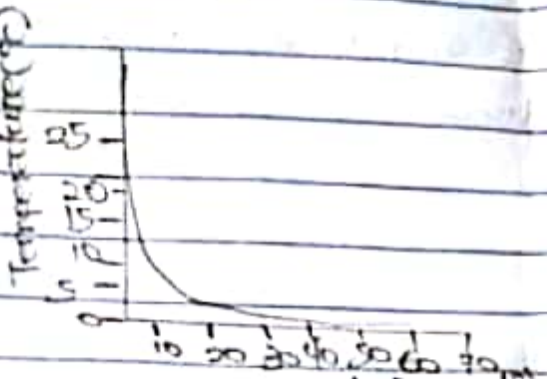
$-5 = -15e^{5k}$

$\ln(1/3) = 5k$

$k = \ln(1/3)/5 = -0.22$

∴ The model for the system becomes: $T = 25 - 15e^{-0.22t}$

(2)



f(x) = 25 - 15 * exp(-0.22 * A2)

(3) Command window

```
clear
clc
close all
t = 0:0.5:50
T = 25 - 15*exp(-0.22*t)
Plot(t,T)
Xlabel('time(seconds)')
Ylabel('Temperature(°C)')
```

(4.) The steady state temperature of the system = 25°C

(5.) At 'x' temperature of 25°C is was observed of no change in temperature despite the increase in time, therefore the system is said to be stable at that temperature.

(6.) For t=? and T=24.9°C

From the equation $T = 25 - 15e^{-0.22t}$

$24.9 = 25 - 15e^{-0.22t}$

$-0.1 = -15e^{-0.22t}$

$6.67 \times 10^{-3} = e^{-0.22t}$

$\ln 6.67 \times 10^{-3} / -0.22 = t$

$t = 22.76$ mins

0.76 minutes → seconds

$0.76 \times 60 = 45.6 \approx 46$ seconds

∴ The time required = 22 minutes and 46 seconds //