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17/ENG02/028
COMPUTER ENGINEERING

TEST
Question 4

A. Modelling is the mathematical representation and simulation of a system which involves solving the model and obtaining output variable por different values of input variable

B. Methods of obtaining Engineering system models
i. Differentiating
ii. Balancelaw
iii. Analysis

Ci From Newton's Law of cooling

$\frac{dT}{dt} = k(T - T_A)$ By seperating variables

$\frac{dT}{(T - T_A)} = k\,dt$ Integrating through

$\int \frac{dT}{(T - T_A)} = \int k\,dt \equiv \ln(T - T_A) = kt + C$

$T - T_A = e^{kt+C} \equiv T - T_A = e^{kt} e^{C}$

Initially $e^{C} = C$

T (initial reading of thermometer) $= 10^{\circ}C$

T_A (Actual temperature of system) $= 25^{\circ}C$ at time $(t) = 0$

$\therefore T - T_A = Ce^{kt}$

$10 - 25 = Ce^{k(0)}$

$-15 = C$

After 5 minutes $T = 20$ $t = 5$

$$T - T_A = -15e^{k(5)}$$

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

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

$$\ln(0.33) = 5k$$

$$k = -\frac{1.0986}{5}$$

$$k = 0.222$$

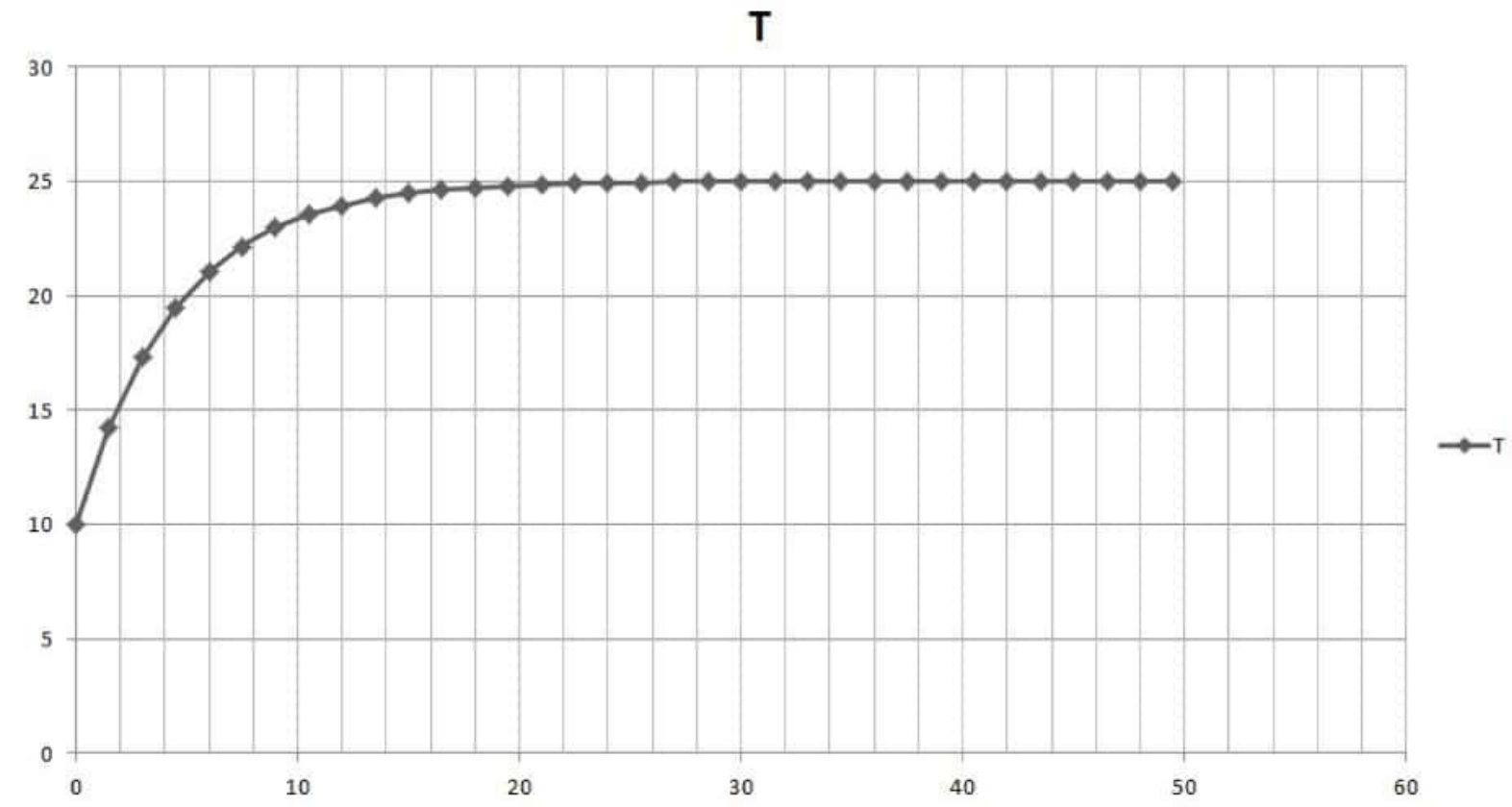
$$T - T_A = Ce^{kt}$$

$$T = T_A + Ce^{kt}$$

$$T = 25 - 15e^{-0.222t}$$

ii Microsoft excel simulation

$t = 1 \rightarrow 50$ $\Delta t = 1.5$ $T = 25 - 15 * (EXP(-0.222) * t$

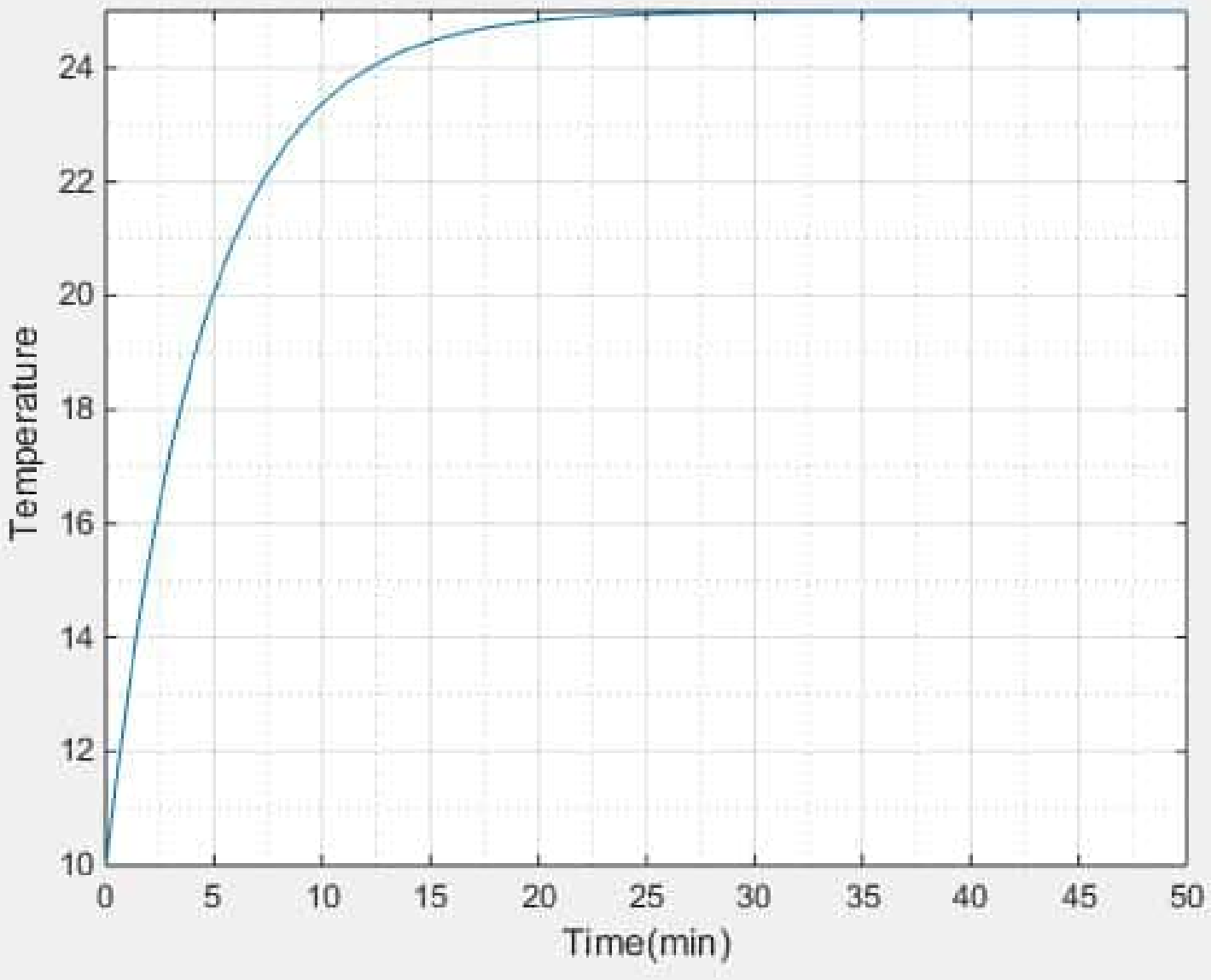


iii MATLAB SIMULATION

Code

Commandwindow

```
clear
clc
closeall
symst
t=0:0.5:50
T=25-15*(exp(-0.222*t))
Ts=subs(T)
plot(t,Ts)
xlabel('Time(min)')
ylabel('Temperature')
axis tight
grid on
grid minor
```



iv. The steady state temperature of the system is 25°C

v. The system is not stable as the temperature changes with time

vi. We know that $T = T_A + Ce^{kt}$

Here our $T = 24.9°C$

$$24.9 = 25 + 15e^{-0.222t}$$

$$24.9 - 25 = -15e^{-0.222t}$$

$$\ln\left(\frac{-0.1}{-15}\right) = -0.222t$$

$$t = \frac{-5.011}{-0.222}$$

$$t = 22.57 \approx 23 \text{ minutes}$$

∴ The required time for the thermometer to practically reach the system temperature (24.9°C) is 22.57 mins