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ENGT 282 ASSIGNMENT

It is discovered that $600 \text{ ft}^3/\text{min}$ of fresh air flows into a room containing 2000 ft^3 of air. The mixture, which is made practically uniform by circulating fans, is exhausted at a rate of $600 \text{ cub. feet per minute (cfm)}$. If the room contains no fresh air initially.

1) Develop a model for the amount of fresh air in the room at any time t .

2) Calculate the time at which 75% of the air in the room will be fresh.

3) With the aid of MATLAB, plot the dynamic response of the amount of fresh air in the room for $t = 0$ to $t = 60$ using a step time of 3 mins.

4) Determine the steady state value of the amount of fresh air in the room and

5) Comment on the result obtained in (4)

Solution

$$\frac{dy}{dt} = \text{Air in flow rate} - \text{Air out flow rate}$$

$$\frac{dy}{dt} = J_{in} - J_{out}$$

$$\frac{dy}{dt} = 600 \text{ ft}^3/\text{min} - \frac{600}{2000} y$$

$$dy/dt = 600 - 0.03y$$

$$= -0.03(-20000 - y)$$

$$dy/dt \cdot (-20000 - y) = -0.03(-20000 - y)$$

$$dy/y = -0.03 dt$$

Integrating both sides

$$\int \frac{1}{y - 20000} dy = \int (-0.03) dt$$

$$\ln(y - 20000) = -0.03t + C$$

Dividing by ln

$$(y - 20000) = e^{-0.03t + C}$$

$$y - 20000 = e^{-0.03t} \cdot e^C$$

$$y - 20000 = e^{-0.03t} \cdot y_0$$

$$y - 20000 = y_0 e^{-0.03t}$$

At time $t = 0$ $y = 0$

$$0 - 20000 = y_0 - e^{-0.03(0)}$$

$$-20000 = y_0 - 1$$

$$y = -20000 \text{ ft}^3/\text{min}$$

$$y - 20000 = -20000 \cdot e^{-0.03t}$$

$$y = 20000 - (20000 - e^{-0.03t})$$

1) 70% of 20000 cm³ of fresh air

$$= 70\% \times 20000$$

$$= 14000 \text{ cm}^3 \text{ of fresh air}$$

when $y = 14000$, find $t = ?$

$$14000 = 20000 - (20000 - e^{-0.03t})$$

$$14000 - 20000 = -(20000 - e^{-0.03t})$$

$$-6000 = -20000 + e^{-0.03t}$$

$$-20000 + 20000 = e^{-0.03t} - 20000$$

$$0 = e^{-0.03t} - 20000$$

$$-20000 = -20000 + e^{-0.03t}$$

$$-20000 = -20000 + e^{-0.03t}$$

$$t = \frac{-2.3}{0.03}$$

$$t = 76.67$$

$$t = 76.6 \text{ mins}$$

c) Comment window

clear

clc

close all

$$-t = 0:5:360$$

$$-y = 20000 - (20000 \cdot e^{-0.03t})$$

- plot (t, y)

- Grid on

- Grid minor

- x label ('time')

- y label ('volume')

d) the steady value is $2 \times 10^4 \text{ ft}^3$ at 180 mins

e) At time $t = 180$ mins the room is filled with 20000 ft^3 of fresh air and it is maintained for 76.360 mins (6th hr).