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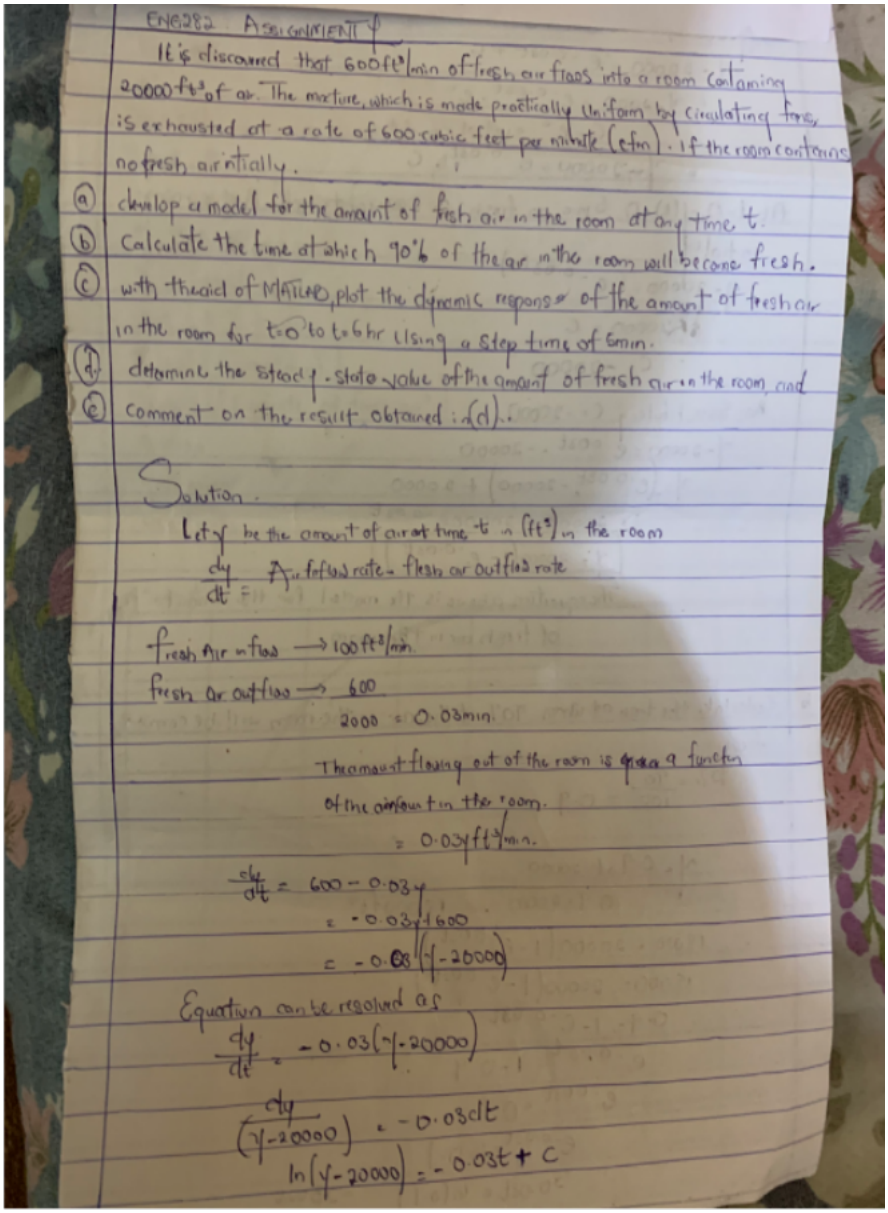
Matric no: 17/ENG04/019
Electrical electronics engineering



ENG282 ASSIGNMENT 4

It is discovered that 600ft³/min of fresh air flows into a room containing 20000ft³ of air. The mixture, which is made practically uniform by circulating fans, is exhausted at a rate of 600 cubic feet per minute (cfm). If the room contains no fresh air initially.

(a) develop a model for the amount of fresh air in the room at any time, t.
(b) Calculate the time at which 90% of the air in the room will become fresh.
(c) with the aid of MATLAB, plot the dynamic response of the amount of fresh air in the room for t=0 to t=6hr using a step time of 6min.
(d) determine the steady-state value of the amount of fresh air in the room, and
(e) comment on the result obtained in (d).

Solution.

Let y be the amount of air at time t in (ft³) in the room

$\frac{dy}{dt}$ = Air inflow rate - fresh air outflow rate

fresh air inflow → 100 ft³/min.

fresh air outflow → $\frac{600}{2000} = 0.03$ min.

The amount flowing out of the room is a function of the airflow in the room.

$= 0.03y$ ft³/min.

$\frac{dy}{dt} = 600 - 0.03y$

$= -0.03y + 600$

$= -0.03(y - 20000)$

Equation can be resolved as

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

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

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

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

$\gamma - 20000 = e^{-0.03t + C}$

$\gamma - 2000 = e^{-0.03t} \cdot e^{C}$

$C = e^{C}$ = intial condition.

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

At $t = 0$, $\gamma(t) = 0$ Since no fresh air was contained in the room initially

$\gamma - 20000 = Ce^{-0.03(0)}$

$0 - 20000 = C$

$C = -20000$

Re-Substituting $C = -20000$

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

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

$\gamma = 20000 - 20000e^{-0.03t}$

$\boxed{\gamma = 20000(1 - e^{-0.03t})}$

The equation above is the model for the amount of fresh air in the room

b. Calculate the time at which 90% of the air in the room will become fresh

$90\% = \frac{90}{100} = 0.9$

$\gamma = 0.9$ of 20000

$0.9 \times 20000 = 18000 ft^3$

$\therefore 18000 = 20000(1 - e^{-0.03t})$

$18000 = 20000(1 - e^{-0.03t})$

$0.9 = 1 - e^{-0.03t}$

$e^{-0.03t} = 1 - 0.9$

$e^{-0.03t} = 0.1$

$e^{-0.03t} = \ln 0.1$

$-0.03t = \ln(0.1)$

$t = \frac{-2.3026}{-0.03}$ $t = 77 mins$

With the aid of matlab.

Commandwindow

Clear

clc

Close all

Syms t

```
y = 20000 * (1 - exp(-0.03 * t))
t = 0:5:360
y_n = Subs(y)
Plot (t, y_n)
Xlabel ('Time (min)')
Ylabel ('Flowrate of fresh air')
grid on
grid minor
axis tight
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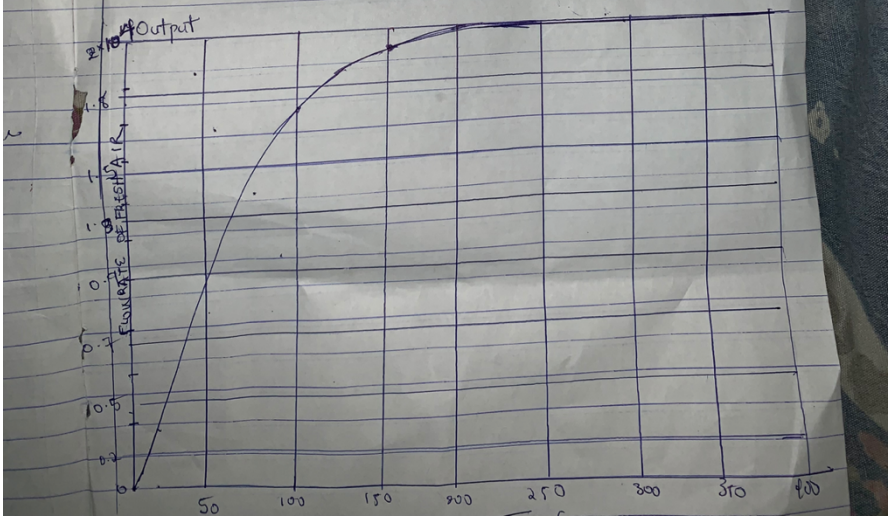

d Determine the steady-state value of the amount of fresh air

The Steady state-value is $20000ft^3$ at 215min of the exponential approach.

(e) Comment on the result obtained in d

The function shows an exponential growth/approach to the limit of $20000ft^3$ as y increases with time and the steady value was $20000ft^3$ at 215min ~~approximately when~~ while it worked for 6hours.