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17/ENG04104/
ELECTRICAL ENGINEERING

Solution

a) Let y be amount of air at time(t).

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

fresh air inflow - $1000 ft^3/min$

" " outflow - 600

$\therefore 2000$ is $0.03m^3$

The amount flowing = $0.03y\ ft^3/min$

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

$= -0.03(y - 20000)$

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

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

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

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

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

To find C

@ $t = 0, y(t) = 0$

$\therefore 0 - 20000 = e^{-0.03(0)} \cdot e^c$

$\therefore -20000 = e^c$

$\therefore C = -2000$

$y - 20000 = e^{-0.03t} \cdot -2000$

$y = -20000e^{-0.03t} + 2000$

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

This is the model

b) Calculate time when 90% of air in room will be drawn

90% = 0.9

$y = 0.9 \times 20000$

$y = 18000$ ft³

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

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

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

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

$0.1 = e^{-0.03t}$

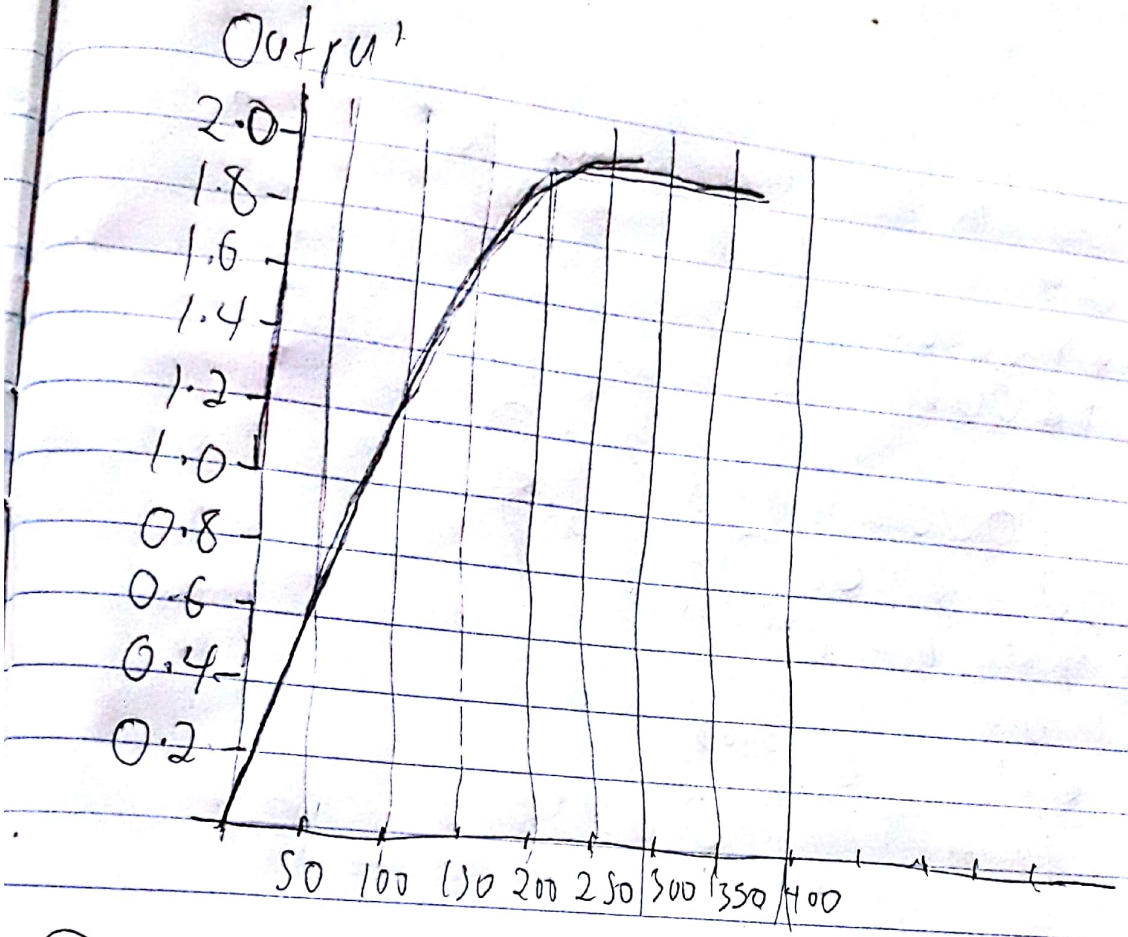
$\ln(0.1) = -0.03t$

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

$\therefore t = 77$ min

c) Plotting the dynamic response using MATLAB

1) commandwindow
2) clear
3) clc
4) close all
5) syms t
6) y = 20000*(1-exp(-0.03*t))
7) t = 0:5:360
8) yn = subs(y)
9) plot(t,yn)
10) xlabel('Time (min)')
11) ylabel('Flowrate of fresh air')
12) grid on
13) grid minor
14) grid high



d) The steady flow rate v at 20
= 20000ft³ at 215m.n.

e) The steady state value proves the function that shows the exponential growth of limit of 20000ft³ as y increases with time.