Assignment
200 level
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Answer

Let y(t) be the amount of air at any time t in ft^3 in the room

$\frac{dy}{dt}$ → fresh air in flow rate − fresh air out flow rate

fresh air inflow → $600 ft^3/min$

fresh air outflow → note: The amount flowing out of the room

$\frac{y}{20000} \cdot 600 = 0.03 min$

i.e 0.03 of y(t) is the outflow

$= 0.03y ft^3/min$

now i

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

$= -0.03y + 600$

$= -0.03(y - 20000)$

This equation can be seperated and integrated

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

find the integral of both sides

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

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

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

Recall $C = e^c$ = initial equation

$\therefore y - 20000 = e^{0.03t} \cdot C \quad \ldots (i)$

At $t = 0$, $y(t) = 0$ since the room contained no fresh air initially

Put $y=0$, $t=0$ in equ(1)

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

$0 - 20000 = e^{0} \cdot C$

$20000 = C$ — (2)

Put equ(2) in equ(1)

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

$y = 20000(1 - e^{-0.03t})$ — 3

equ(3) 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

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

$y = 0.9 \times 20000$ 90% of air in the room

$= 18000 ft^3$

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

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

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

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

$e^{-0.03t} = 0.1$

$-0.03t = \ln(0.1)$

$t = \frac{\ln(0.1)}{-0.03} = 77 \text{ mins}$

c) with the aid of matlab, plot the dynamic response of the amount of fresh air in the room for $t = 0$ to $t = 6hrs$ using a step of 5min

Sol

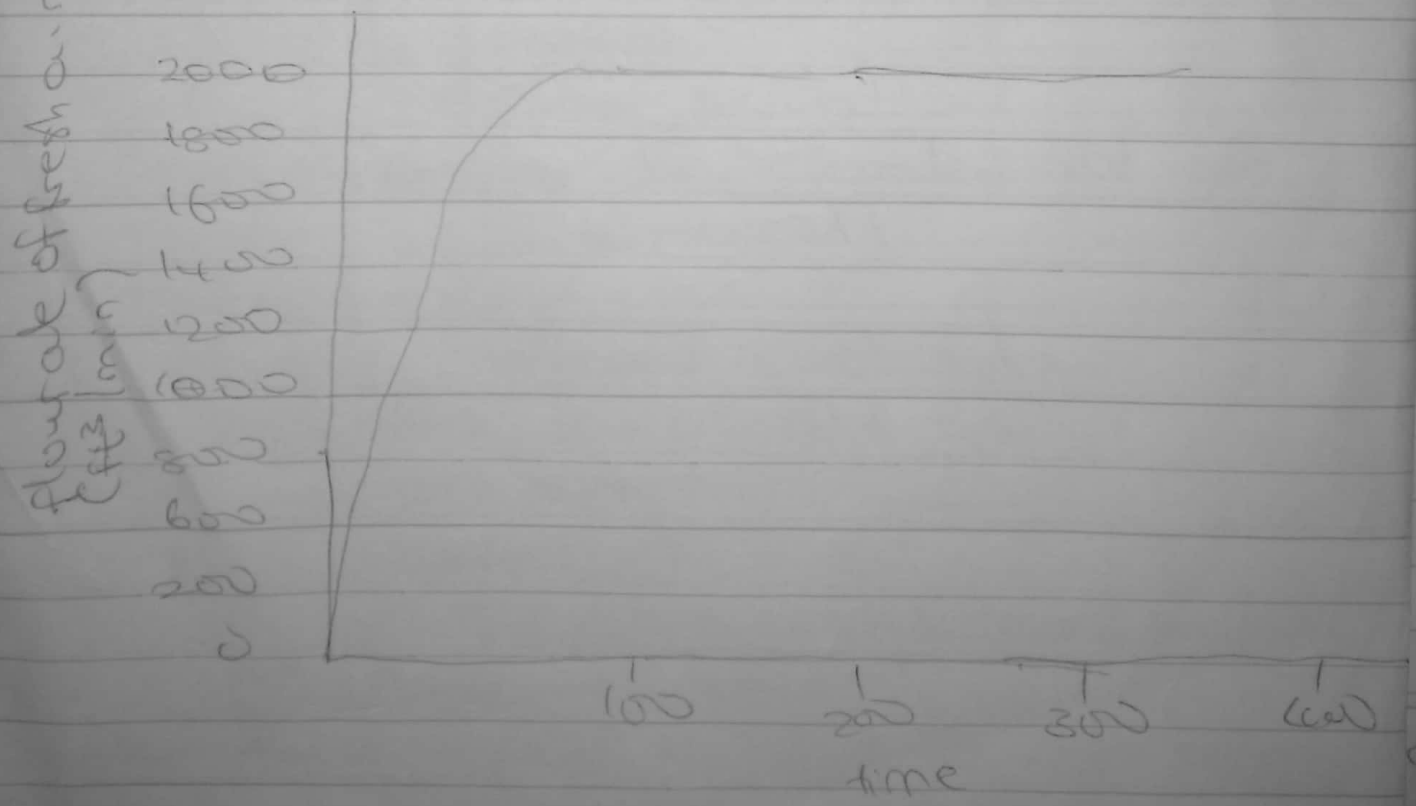
Note: $t = 6hrs$

$= 6 \times 60 = 360 \text{ mins}$

command window

```
clear all
clc
closeall
syms y,t
y=20000 * (1-exp(-0.03*t))
t=0:5:360
yn=subs(y)
plot(t,yn)
xlabel('Time(min)')
Ylabel('Flow rate of fresh air (ft^3/min)')
grid on
grid minor
Axis tight
```

output



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

Sol

The steady state value is 20000ft^3 at 215 mins (3hr and 35 mins) of experimental approach

e) comment on answer

The function above shows the experimental approach to the limit of 20000ft^3 as y increases with time. When the steady state approaches 20000ft^3 at 215mins and continues till 300mins.