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17/ENG06/044 MECHANICAL ENGINEERING

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

$\frac{dy}{dt} \rightarrow$ fresh air inflow rate − fresh air outflow rate

Fresh air inflow $\rightarrow$ $600 ft^3/min$

Fresh air outflow $\rightarrow$ Note: The amount flowing out of the room is a function of the amount in the room

$\frac{600}{200} = 0.03 min$

i.e 0.03 of $y(t)$ is the outflow $= 0.03 y ft^3/min$

Now.

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

$$= -0.03y + 600$$

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

This equation can be seperated and integrated

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

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

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

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

put $y = 0$; $t = 0$ in eqn (I)

$$y - 2000 = e^{-(0.03t)} \cdot C$$

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

$$0 - 20000 = 1(c)$$

$$C = -20000 \quad \text{------} \; (2)$$

Put eqn (2) in eqn (1)

$$y = 20000 - 20000 e^{-0.3t}$$

$$y = 20000(1 - e^{-0.03t}) \quad \text{-----} \; (3)$$

Equation (3) above is the model for the amount of

(b) $90\% = \frac{90}{100} = 0.9$

$\therefore y = 0.9 \times 20{,}000$: is 90% of air in the room

$= 18000 ft^2$

$y = 20{,}000(1 - e^{-0.03t})$

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

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

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

$e^{-0.03t} = 0.1$

$-0.03t = \ln(0.1)$

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

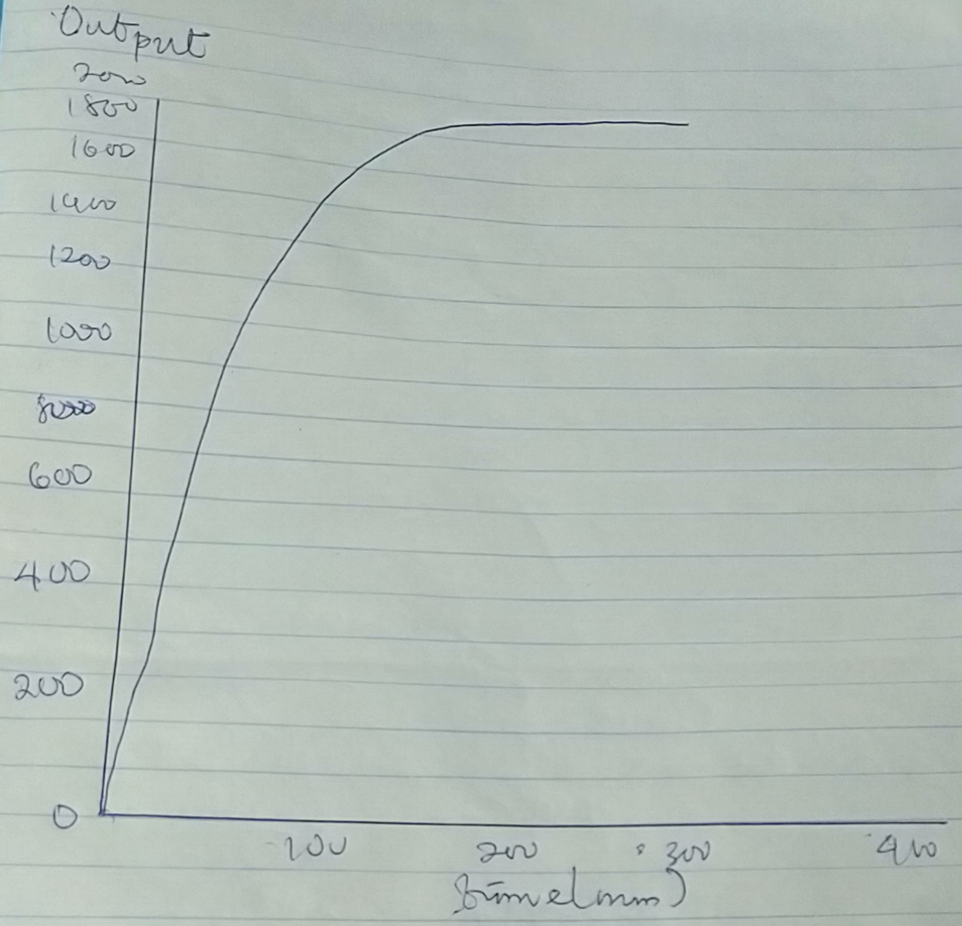
$= \frac{-2.303}{-0.03}$

$= 76.77$ mins

$\simeq 77$ mins.

(c) command window

```
clear all
clc
close all
syms y, t
y = 20000 * (1 - exp(0.03*t))
t = 0.5: 360
yn = subs(y)
plot (t, yn)
Xlabel ('Time (mm)')
Ylabel ('Flowrate of fresh air (Ft^3/m
Grid on
Grid minor
Axis tight
```



(a) The steady state value is 2000 ppb at 215 min (3 hr and 35 mins) of experimental approach.