Onihm Robert Agbonrighale
Civil Engineering
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a) y = amount of air at time t in ft^3

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

air inflow = $600 ft^3/min$

air outflow = $\frac{600}{20000} = 0.03$

amount flowing out of room = $0.03y \, ft^3/min$

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

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

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

$$\ln(y - 20000) = -0.03t + C_1$$

$$y - 20000 = e^{-0.03t + C_1}$$

$$= e^{-0.03t} \cdot e^{C_1}$$

let $e^{C_1} = C$

$$\therefore y - 20000 = Ce^{-0.03t}$$

$$y = 20000 + Ce^{-0.03t}$$

at time, $t = 0$, $y = 0$

$$y = 20000 + Ce^{0}$$

$$0 = 20000 + C$$

$$\therefore C = -20000$$

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

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

(b) time at which 90% of its maximum flow

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

$y = 0.9$ of 20000

$= 18000 ft^3$

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

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

$e^{-0.03t} = 0.1$

$\ln 0.1 = -0.03t$

$-2.3026 = -0.03t$

$t = 77 min$

(c) Matlab programme

Command window

User

clc

close all

syms t

y = 2000 * (1 - exp(-0.03*t))

t = 0 : 5 : 360

yn = subs(y)

Plot = (t, yn)

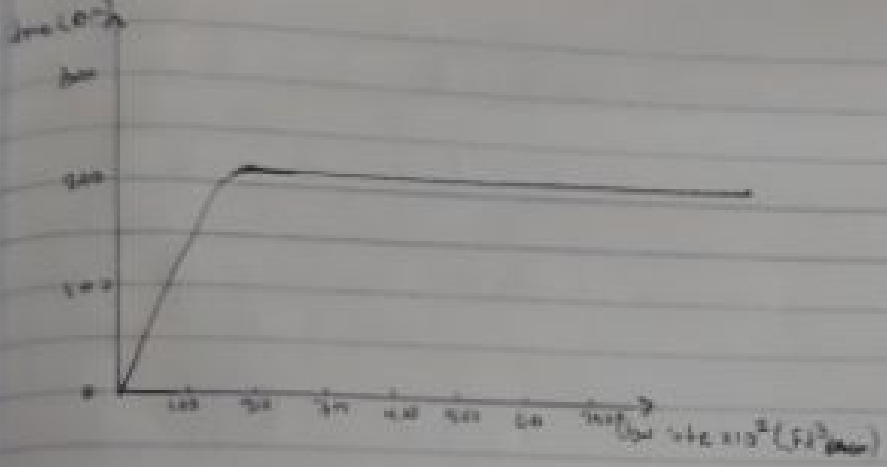
xlabel ('time (min)')

ylabel ('flow rate of fresh air')

grid on

grid minor

axis tight



d) The steady value is 20000 ft^3 at 215 am of the exponential approach

e) The function shows exponential growth/approach to the limit of 20,000 ft^3 as y increase with time and the steady value was 20,000 ft^3 at 215 am - it worked for this