

# ENG 282 ASSIGNMENT

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MATRIC NO: 16/ENG05/002

DEPARTMENT: MECHATRONICS

Solution

Balance Law

Rate of accumulation = (Rate of Inflow - Rate of outflow) of any material

Let the amount of the material be  $y$

$$\frac{dy}{dt} = y_{in} - y_{out}$$

Rate of Inflow,  $y_{in} = 60 \text{ t}^3 \text{ min}^{-1}$

Rate of outflow,  $y_{out} = \text{Rate of fresh air inflow of the material} \times y$   
 Volume of air mixture in the room

$$y_{out} = \frac{600}{20,000} \times y = 0.03y$$

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

$$\frac{dy}{dt} = -0.03(y - 20,000)$$

$$\frac{dy}{y - 20,000} = -0.03 dt$$

$$\int \frac{dy}{(y - 20,000)} = - \int 0.03 dt$$

$$\ln(y - 20,000) = -0.03t + C$$

$$y - 20,000 = e^{-0.03t + C}$$

$$y - 20,000 = e^{-0.03t} e^C, \text{ let } e^C = y_0$$

$$y - 20,000 = y_0 e^{-0.03t}$$

$$y = 20,000 + y_0 e^{-0.03t} \text{ [General solution]}$$

When  $t=0$

$$y = 0$$

$$0 = 20,000 + y_0$$

$$y_0 = -20,000$$

$$y = 20,000 - 20,000 e^{-0.03t} \text{ [Particular solution]}$$

b. When  $y = 90\%$

$$\frac{90}{100} = 20,000 - 20,000 e^{-0.03t}$$

$$0.9 = 20,000 - 20,000 e^{-0.03t}$$

$$0.9 - 20,000 = -20,000 e^{-0.03t}$$

$$-19,999.1 = -20,000 e^{-0.03t}$$

$$e^{-0.03t} = 0.9999$$

$$-0.03t = \ln(0.9999)$$

$$t = 1.5 \times 10^3 \text{ min}$$

c. The steady-state value of the amount of fresh air in the room is  $20,000 \text{ ft}^3$ .

d. From the result obtained in (c) it can be said that the amount of fresh air increase with time initially until it reaches  $20,000 \text{ ft}^3$  and then the amount of fresh air remains constant with increase in time in the room.