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MECHATRONICS ENGINEERING  
16/ENG05/007

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1a

$$\text{Rate of inflow} = 600 \text{ ft}^3/\text{min}$$

$$\text{Rate of outflow} = \frac{600}{20000} \times y = 0.03y$$

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

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

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

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

$$y - 20000 = y_0 e^{-0.03t}$$

$$y = 20000 + y_0 e^{-0.03t}$$

When the room contained no fresh air

$$y = 0, t = 0$$

$$0 = 20000 + y_0$$

$$y_0 = -20000$$

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

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

1b

Room is containing  $20000 \text{ ft}^3$  of air  
90 % of  $20000 = 18000 \text{ ft}^3/\text{min}$   
from the model

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

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

$$e^{-0.03t} = \left[ \frac{18000}{20000} - 1 \right]$$

$$e^{-0.03t} = 0.1$$

$$-0.03t = \ln(0.1)$$

$$-0.03t = -2.303$$

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

$$t = 76.77 \text{ min}$$