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Initially, no fresh air = $0 ft^3$ of air
Let y ft be the amount of fresh air present in ft^3

$\frac{dy}{dt}$ = Air in − Air out

Air in = $600 ft^3/min$

Air out = $\frac{y}{20000} \times 600 \; ft^3/min$

Air out = $0.03y \; ft^3/min$

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

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

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

$\frac{1}{(y-20000)} dy = -0.03 dt$

Integrating the above equation

$\int \frac{1}{(y-20000)} dy = \int -0.03 dt$

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

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

where $e^{C} = y_0$

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

At critical point, $y = 0$ and $t = 0$

$0 - 20000 = y_0 e^{-0.03(0)}$

$y_0 = -20,000$

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

b) when $y = \frac{90}{100} \times 20000 = 18,000$

$18000 - 20000 = -20000 e^{-0.03t}$

$-2000 = -20000 e^{-0.03t}$

$$e^{-0.03t} = \frac{-2000}{-20000}$$

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

$$-0.03t = \ln 0.1$$

$$t = \frac{-2.3026}{0.03}$$

$$t = 76.75 \approx 77 \text{ min}$$

$\Rightarrow$ 90 % of air will became fresh in 77 minutes

c) Command window

```
clear
cle
Close all
t = 0:50:360
y = 20,000 - 20,000 * exp(-0.03*t)
Plot (t, y)
xlabel ('time (min)')
ylabel ('amount (ft^3)')
grid on
grid minor
axis tight
```