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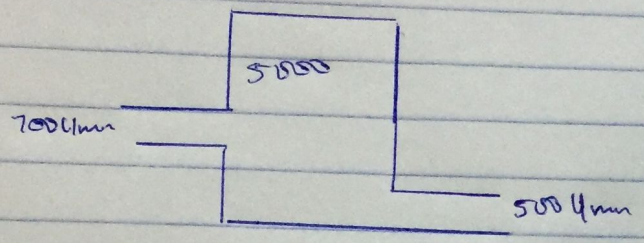
16/ENG06/006
Mechanical Engineering
ENG 282 Mid Semester Test Question 4 solution

a Modelling can be defined as a process of setting up a model, solving it mathematically and interpeting the result in physical or other terms.

b i Using the balance law to solve problems.

ii Forming a differential equation from an existing algebraic equation of the system.

c



using balance law

rate of accumulation of air in the room = rate of inflow of air − rate of outflow of air

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

$$y_{out} = \frac{500}{5000} = 0.1$$

$$y_{in} = 700$$

$$\frac{dy}{dt} = 700 - 0.1y$$

$$\frac{dy}{dt} = -0.1y + 700$$

$$\frac{dy}{dt} = -0.1(y - 7000)$$

$$\frac{dy}{y-7000} = -0.1\,dt$$

$$\int \frac{dy}{y-7000} = \int -0.1\, dt$$

$$\ln(y-7000) = -0.1t + c$$

taking exp of both sides

$$y - 7000 = e^{-0.1t + c}$$

$$y - 7000 = e^{-0.1} \cdot e^{c}$$

let $e^{c} = y_0$

$$y - 7000 = y_0 e^{-0.1t}$$

$$y = 7000 + y_0 e^{-0.1t}$$

if $y = 0$ at $t = 0$

$$0 = 7000 + y_0 e^{-0.1(0)}$$

$$0 = 7000 + y_0$$

$$y_0 = -7000$$

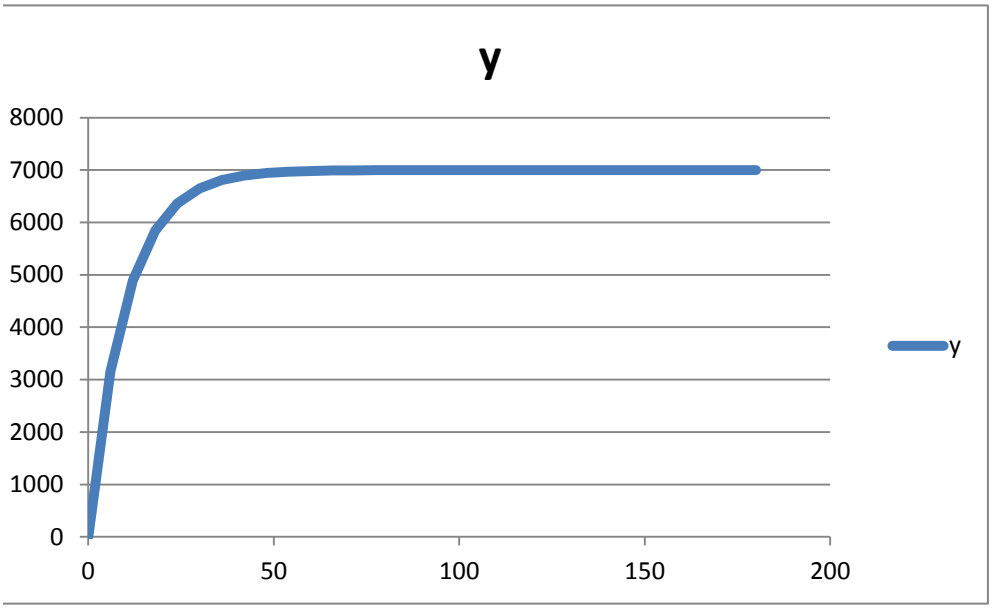
$$\therefore y = 7000 - 7000 e^{-0.1t}$$

model for $t = 0$ to $t = 3$hr

3 hr = $3 \times 60 = 180$ min

steady-state value for the amount of fresh air in the room is 7000 units of air.

t	y
0	0
6	3158.31855
12	4891.64052
18	5842.90778
24	6364.97433
30	6651.49052
36	6808.73394
42	6895.03096
48	6942.39177
54	6968.38393
60	6982.64873
66	6990.47742
72	6994.7739
78	6997.13186
84	6998.42593
90	6999.13613
96	6999.5259
102	6999.73981
108	6999.8572
114	6999.92163
120	6999.95699
126	6999.9764
132	6999.98705
138	6999.99289
144	6999.9961
150	6999.99786
156	6999.99882
162	6999.99936
168	6999.99965
174	6999.99981
180	6999.99989


y
8000
7000
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
y