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ENG282 Assignment 1.

An experiment is carried out by a biomedical engineer using a certain type of bacteria that doubles in population every 5hr in a growth medium. If the experiment is commenced with 20 bacteria,

a) develop a model for the system,

b) Use the model to estimate the population of the bacteria in $1\frac{1}{2}$ days.

c) with the aid of Microsoft Excel, simulate the model and plot the variation of the number of bacteria with time (t) for t = 0 to t = 15hr using a step time of 0.25hr.

d) making the initial number of bacteria to be 10, 30 and 50 successively, plot the variations of the number of bacteria with time for t = 0 to t = 80hr using a step time of 0.5hr on the same graph, and

e) comment on the results obtained in (d).

Solution

a) model for the system

$$\frac{dy}{dt} = ky \qquad \text{but } \ln = \frac{1}{e} \text{ and } \frac{1}{\ln} = e$$

$$\Rightarrow \int \frac{1}{y}\, dy = \int k\, dt$$

$$\ln y = k \int dt$$

$$\ln y = kt + c$$

$$\cancel{e}\ \ln y = e^{(kt + c)}$$

$$y = e^{kt + c}.$$

$$y = e^{kt} \cdot e^{c}$$

Let $e^{c} = y_0$.

$$y = y_0 e^{kt} \quad -(1)$$

At the beginning of the experiment,

$t = 0$ and $y = 20$

$$20 = y_0 e^{k(0)}.$$

$$20 = y_0 \quad -(2)$$

At $t = 5$hrs.

$$y = 2y_0$$

$$y = 2 \times 20 = 40 \quad -(3)$$

inputting the value of y_0 and y in (1).

$$40 = 20e^{kt}.$$

$$\frac{40}{20} = e^{5k}.$$

$$2 = e^{5k}$$

$\ln 2 = 5K$

$0.6931 = 5K$

$K = \frac{0.6981}{5} = 0.13863$

$\therefore$ model $\Rightarrow y = 20e^{0.13863t}$.

b) Estimated population of bacteria in $1\frac{1}{2}$ days

$1\frac{1}{2}$ days $= 24$ hrs $+ 12$ hrs.

$t = 36$ hrs.

$y = 20e^{0.13863(36)}$.

$= 147.036 \times 20 = 2940$ bacteria

d) if $y_0 = 10$

$y = 10e^{kt}$

$y = 10e^{0.13863t}$.

when $y_0 = 30$

$y = 30e^{kt}$

$= 30e^{0.13863t}$

when $y_0 = 50$

$y = 50e^{kt}$

$= 50e^{0.13863t}$.

time ; $t = 0$ to $t = 30$ hr.

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