# Lab 5

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## 1 Growth Model (Exponential case only)

Exponential Growth

If a function $x(t)$ grows continually at a rate $k > 0$, then $x(t)$ has the form

$$x(t) = x_{\circ}e^{kt} \tag{1}$$

where x nod is intial amount x nod. In this case, the quantity $x(t)$ is said to exhibit exponential growth, and k is growth rate. Its differential model is given by

$$\frac{dx}{dt} = kx, \quad k > 0 \tag{2}$$

1. Red errors will lead to marks deduction.
2. Simply click enter and not shift+enter for 'Questions' and 'Conclusions' or it will lead to red errors.

**Ques 1 Suppose that the population of a certain country grows at an\ annual rate of 2 %. If the current population is 3 million, what will the population be in 10 years? Also plot the graph of the solution.**

**Solution : Here $x_o = 3$, $k = 2\% = 0.02$, x[t] = ? after 10 years.**

```
In[15]:= Sol = DSolve[x'[t] == k * x[t], x[t], t]
```

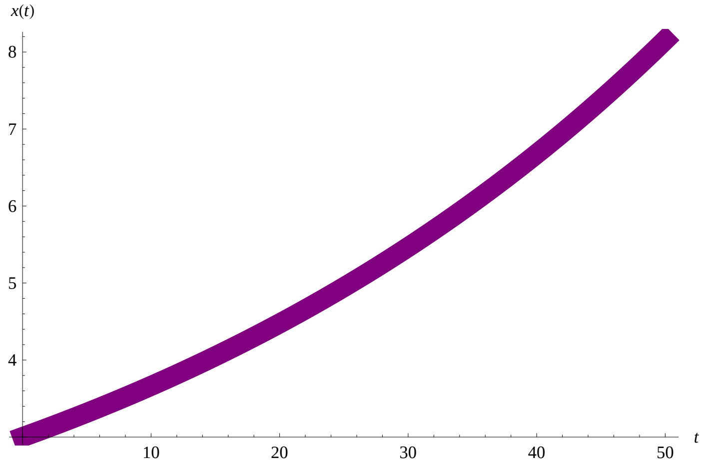
Out[15]= $\{\{x[t] \to e^{k\,t}\,C[1]\}\}$

```
In[16]:= Sol1 = Evaluate[x[t] /. Sol /. {k → 0.02, C[1] → 3}]
```

Out[16]= $\{3\,e^{0.02\,t}\}$

```
In[17]:= Plot[Sol1, {t, 0, 50}, PlotStyle → {Purple, Thickness[0.03]}, AxesLabel → {t, x[t]}]
```

Out[17]=




```
In[25]:= x[10] = Evaluate[Sol1 /. {t → 10}]
```

Out[25]= {3.66421}

In[26]:= **Conclusion : Hence population after 10 years will be 3.66421 million**

**ClearAll**

Out[26]= Conclusion : 36.6421 after be Hence million population will years

Out[27]= ClearAll

```
In[9]:= Clear[t, k, x]
```

**Ques 2 In the same country as in Exampl - 1, how long will it take the\ population to reach 5 million?**

**Solution : Here, $x_o = 3 = C[1]$, $k = 2\% = 0.02$ and $x(t) = 5$ for some time t.**

```
In[36]:= Sol = DSolve[x'[t] == k * x[t], x[t], t]
```

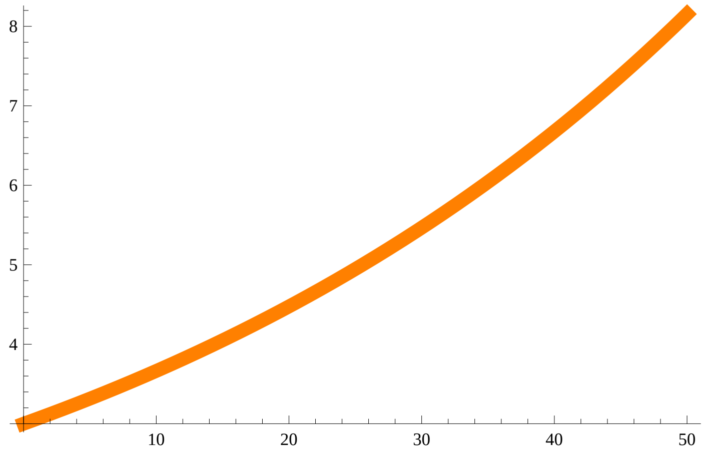
Out[36]= $\{\{x[t] \to e^{k\,t}\,C[1]\}\}$

```
In[39]:= Sol1 = Evaluate[x[t] /. Sol[[1]] /. {k → 0.02, C[1] → 3}]
```

Out[39]= $3\,e^{0.02\,t}$

In[40]:= `Plot[Sol1, {t, 0, 50}, PlotStyle → {Orange, Thickness[0.02]}]`

Out[40]=




In[44]:= `Solve[Sol1 == 5, t]`

Solve::ifun : Inverse functions are being used by Solve, so
some solutions may not be found; use Reduce for complete solution information. ≫

Out[44]= {{t → 25.5413}}

In[46]:= **Conclusion : Hence population will reach to 5 million in 25.5413 years approximately.**
**ClearAll**

Out[46]= Conclusion : 127.707 Hence in million population reach to will years approximately.ClearAll

**Question 3**
**Suppose that the size of a bacterial culture grows at an annual rate of 15 %. I f the current population is 100 million, how long will it take for the culture to double in size? Also plot the graph of the solution.**
**Solution : Here, $P_o$ = 100, k = 15 % = 0.15 and t = ?**

In[4]:= `Sol = DSolve[{P'[t] == k * P[t], P[0] == 100}, P[t], t]`

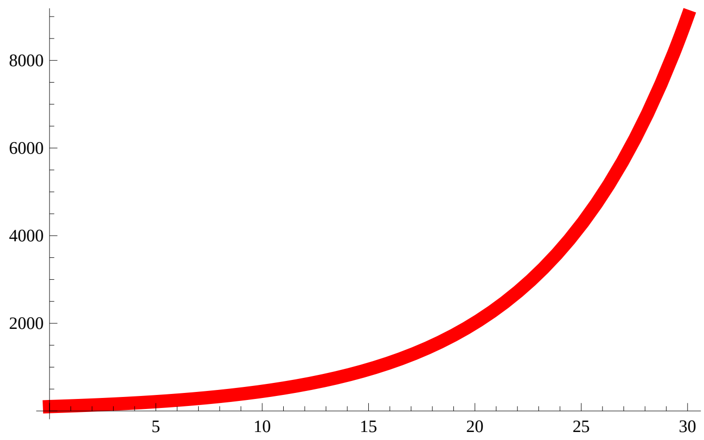
Out[4]= $\{\{P[t] \to 100\, e^{k\, t}\}\}$

In[5]:= `Sol1 = Evaluate[P[t] /. Sol[[1]] /. {k → 0.15}]`

Out[5]= $100\, e^{0.15\, t}$

In[6]:= `Plot[Sol1, {t, 0, 30}, PlotStyle → {Red, Thickness[0.02]}]`

Out[6]=



In[7]:= **Solve[Sol1 == 200, t]**

Solve::ifun : Inverse functions are being used by Solve, so
some solutions may not be found; use Reduce for complete solution information. ≫

Out[7]= {{t → 4.62098}}

**Conclusion : Hence bacteria will double in 4.62098 years approximately.**