

3.1 Modeling with Linear DE

Radioactive Decay	$x(t)=x_0 \cdot e^{(kt)}$
Population	$P(t) = P_0 \cdot e^{(kt)}$
Compound Interest	$S(t)=S_0 \cdot e^{(rt)}$
Cooling/Heating	$T(t)=T_m+(T_0-T_m) \cdot e^{(kt)}$
Mixing of Two Fluids	$dA/dt=R_{in}-R_{out}$

Examples

Population increases proportional to #people at time t. If initial population

P_0 has doubled in 7 years, how long will it take to triple/quadruple?

$$2P_0/P_0=e^{(kt)} \Rightarrow \ln(2)=kt \Rightarrow k=\ln(2)/7 \Rightarrow (\ln(2)/7)$$

$$t(\text{trip})=\ln(3)/[\ln(2)/7] = 11.09\text{yr} \Rightarrow t(\text{quad})=\ln(4)/[\ln(2)/7] = 14\text{yr}$$

A tank contains 1000 L pure h₂o. Brine w/ 1 kg/L salt pumped in @ 6L/min;

the well-mixed solution is pumped out at the same rate. When will concentration = 0.5kg/L

$$A'(t)=R_{in}-R_{out} \Rightarrow R_{in}=6\text{kg/min}; R_{out}=(A/1000\text{kg/L}) \cdot (6\text{L/min})=3A/500 \text{ kg/min}$$

$$A'(t)+3A/500=6 \Rightarrow A(t)=1000+Ce^{(-3t/500)} \Rightarrow A(0)=0 \Rightarrow C=-1000$$

$$1000=1000e^{(-3t/500)}=500 \Rightarrow e^{(-3t/500)}=1/2 \Rightarrow t=115.53\text{s}$$



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