# *Mathematica*-aided study of impulsive systems in the math and applied classroom

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# Introductory examples

## Intravascular repeated drug dosing

A simple model of repeated drug administration: a fixed dose of the drug $m_0$ is given periodically at $t_i = i\,\tau$.

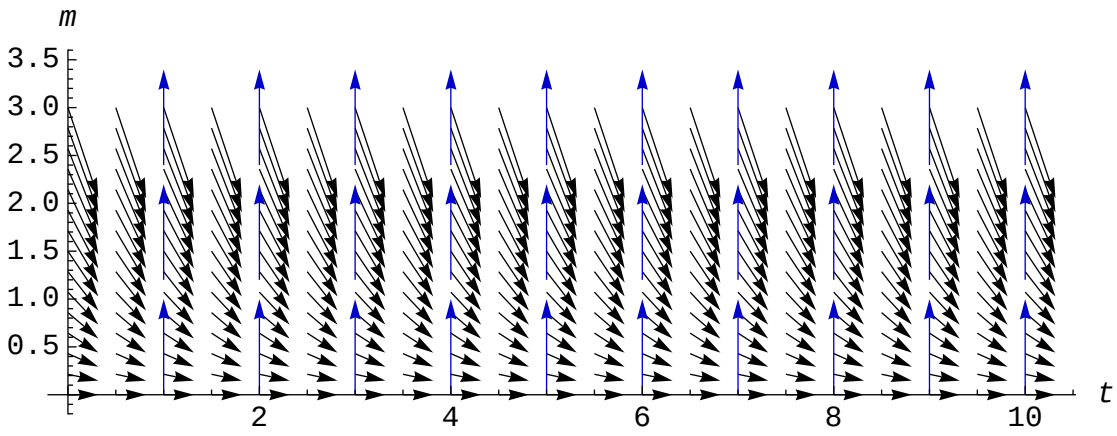
$$m' = -k_e\, m \text{ if } t \neq i\,\tau;$$
$$m(i\,\tau + 0) = m(i\,\tau - 0) + m_0 \; (i = 1,\ 2,\ \ldots)$$


□ Run it

□

# Tools for math class

## The direction and impulse fields

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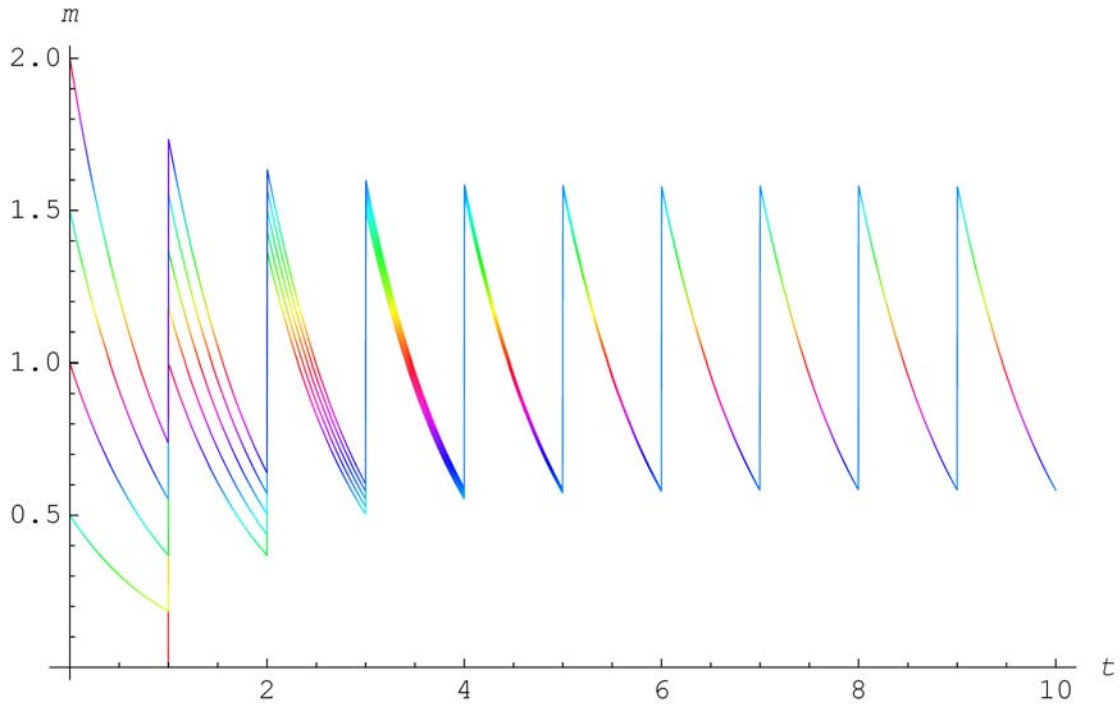
## □ Solutions

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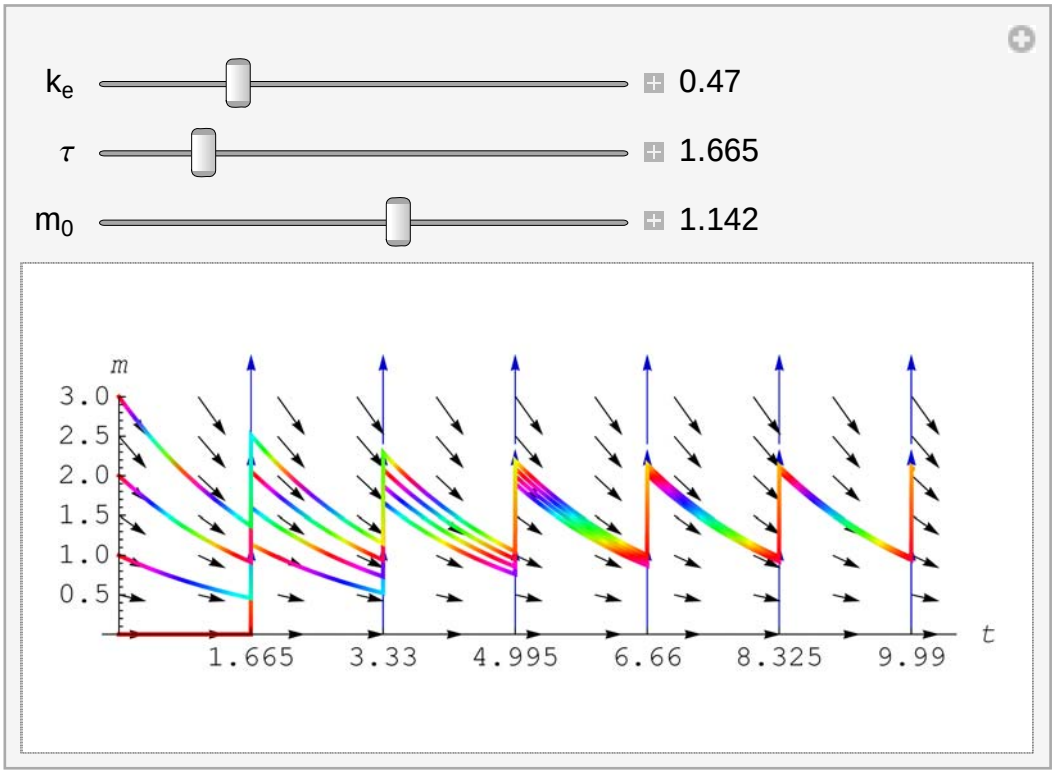
## □ A simple interactive study

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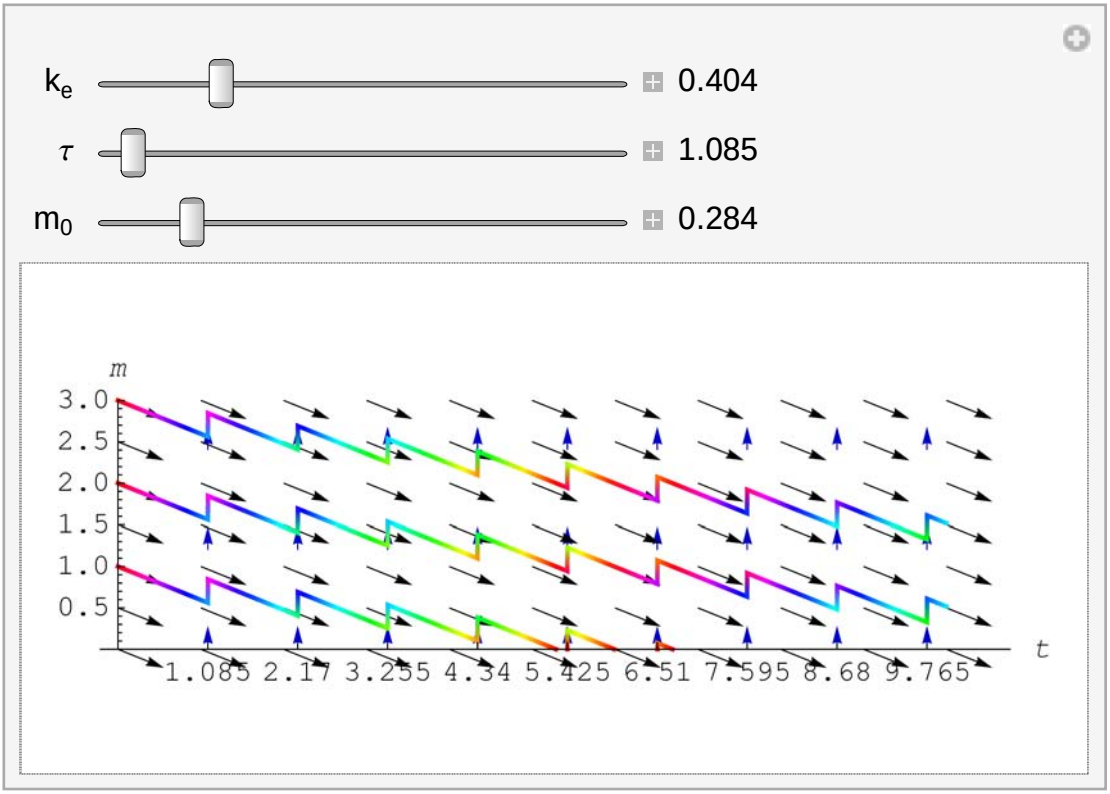
## □ A simple interactive study (zero order elimination: $m' = -k_e$)

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## A version for Pharmacy students with concentrations

Rate of elimination ($k_e$)

First dose ($c_{00}$)

Repeated dosing

$\tau$

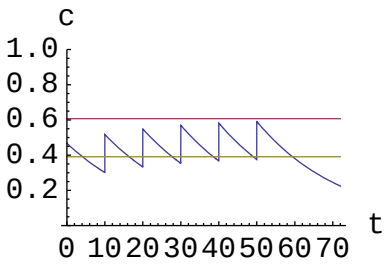
Dose ($c_0$)

n

PlotRange $c_{max}$

$c_{min}$= 0.390804

$c_{max}$= 0.606804

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## A more realistic version for Pharmacy students

Drug concentration in the blood
by repeated intravascular dosing

Blood volume ($l$) 4.98

Half−life ($h$) 6.4

First (loading) dose ($mg$) 292.

Repeated (maintaining) dosing

$\tau$ ($h$) 7

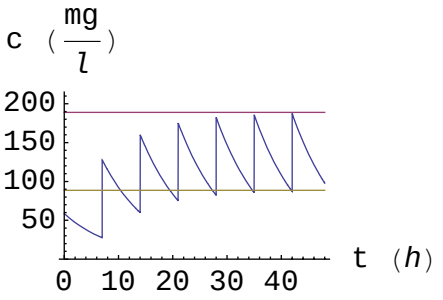
Dose ($mg$) 500

n 12

PlotRange $c_{max}$

Total time ($h$) 48

$c_{min}$= 88.5157
$c_{max}$= 188.917

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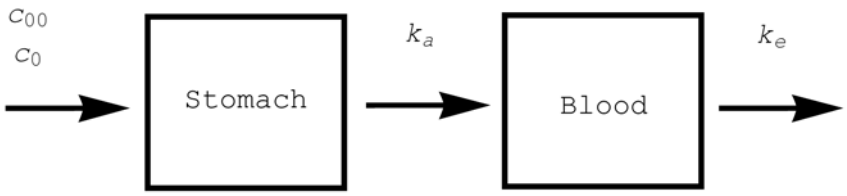
## Extravascular repeated drug dosing (two-compartment system)




$$c_1' = -k_a\, c_1 \text{ if } t \neq n\,\tau;\ c_1(0) = c_{1,0}$$
$$c_2' = k_a\, c_1 - k_e\, c_e\ ;\ c_2(0) = 0$$

$$c_1(n\,\tau + 0) = c_1(n\,\tau - 0) + c_0\ (n = 1,\ 2,\ \ldots)$$

$c_1(t)$ is the concentration of the drug in the stomach
$k_a$ is the rate of absorption
$c_{1,0}$ is the first dose
$c_0$ is the repeated dose
$\tau$ is the time between the doses
$c_2(t)$ is the concentration of the drug in the blood
$k_e$ ( $< k_a$) is the rate of elimination
$c_{i,\min}$ and $c_{i,\max}$ are the extremal values of the asymtotically stable periodic equilibrium.

$k_a$ 0.955

$k_e$ 0.65116

First dose

$m_{1,0}$ 0.538

Repeated doses

$\tau$ 1.6

$m_0$ 1.

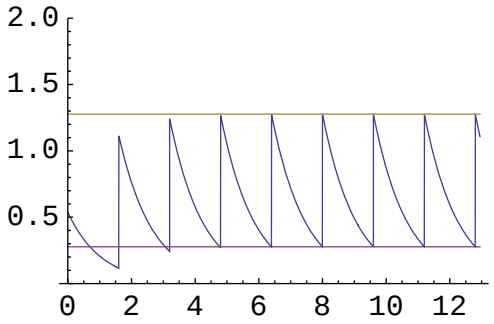
T 12.95

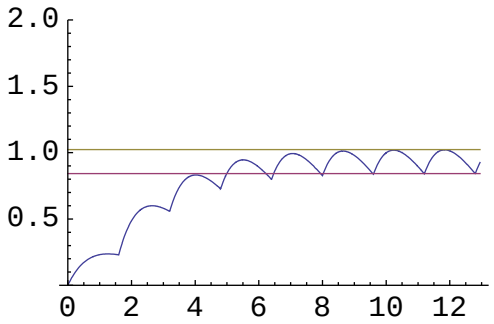
$c_{1,min}$ = 0.277089

$c_{1,max}$ = 1.27709

$c_{2,min}$ = 0.842435

$c_{2,max}$ = 1.02294



# Introductory example: Intravascular repeated drug dosing

A simple model of repeated drug administration: a fixed dose of the drug $c_0$ is given periodically at $t_i = i\,\tau$.

$$c' = -k_e\, c \text{ if } t \neq i\,\tau;$$
$$c(i\,\tau + 0) = c(i\,\tau - 0) + c_0 \; (i = 1,\ 2,\ \ldots)$$

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## Next : systems with impulses at fixed instants