Video, Simulations, & Assessment: Connections to Course Objectives

IMPLEMENTING BEST PRACTICES
IN COURSES BELOW CALCULUS

FOUNTAIN VALLEY, CA
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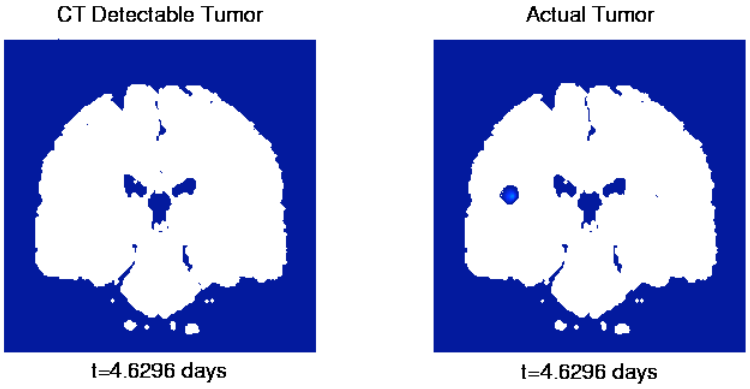


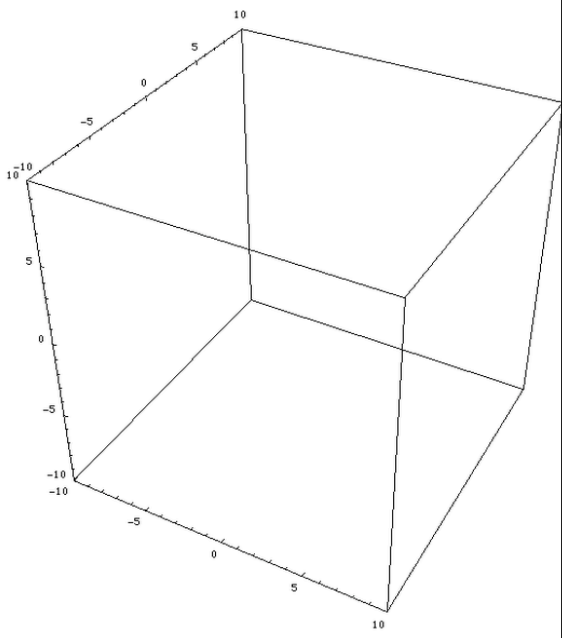
1

A person develops a small liver tumor. It grows according to $S(t)=S(0)e^{\alpha t}$ where $S(0)=1.7$ grams and $\alpha=0.14$ per day. At time t=30 days, the tumor is detected and treatment begins. With treatment, the size of the tumor decreases linearly with a slope of -0.4 grams/day.

Sketch a graph of the size of the tumor over time.

When will the tumor disappear completely?

2



Concept Videos

- **Setting the Stage** - what works???
  - Theme/Context/Analogy
  - Brainstorming for something either suggestive, a direct application, or is similar in process
- **Script** - primary script writing & iterates
  - How many cooks in the kitchen
  - Graphics & animation templates
- **Editing** - time & talent
  - Varied by what's available in software, experience
  - Use of green screen

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Pedagogy

- **Visual, Analytical, Numerical** - …
  - Can readily appreciate the different approaches to a math concept
    - Small time needed to switch/develop different material types
- **Applications** - virtual visits
  - EX: What about a disease outbreak?
    - How do you see it in the classroom?
    - Or the night before a classroom activity?
- **Speed of Delivery** - is it too fast?
  - Viewers can scrub

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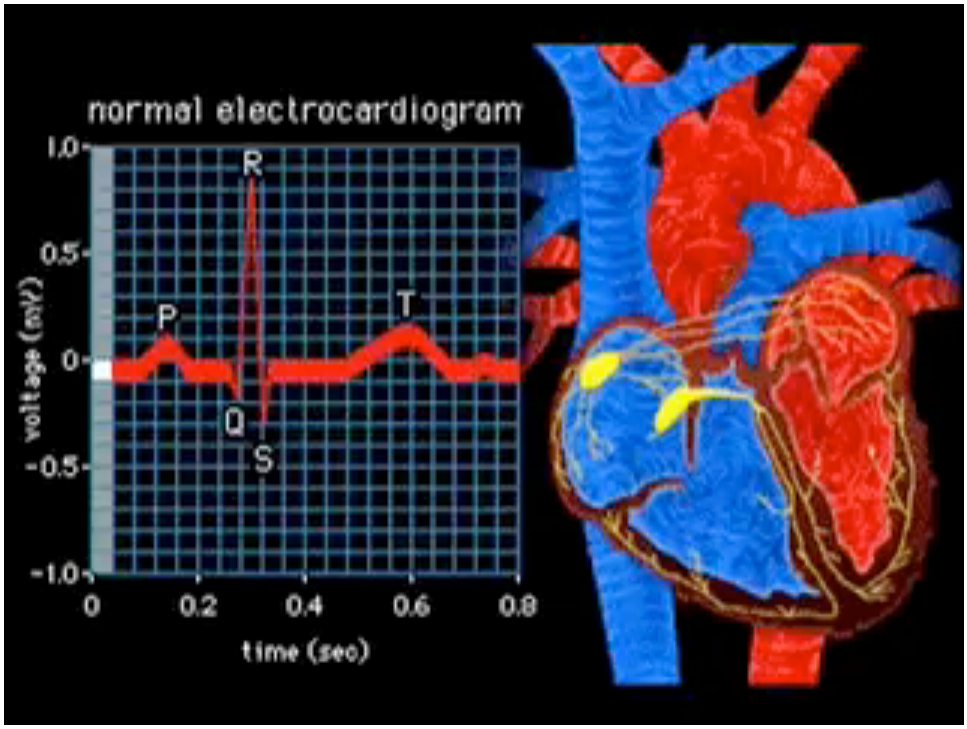
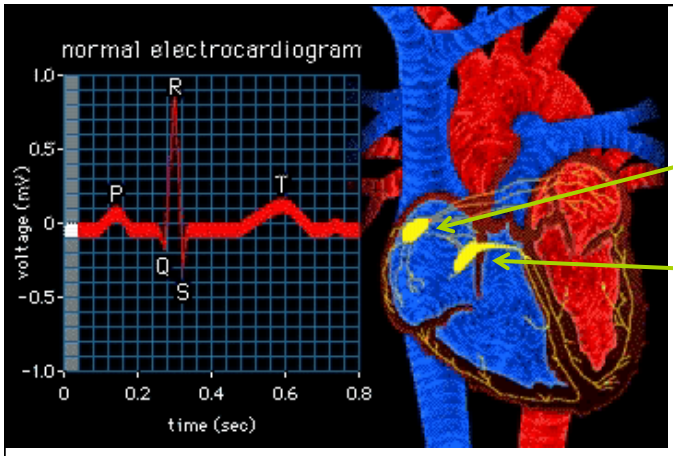




Heart Dynamics

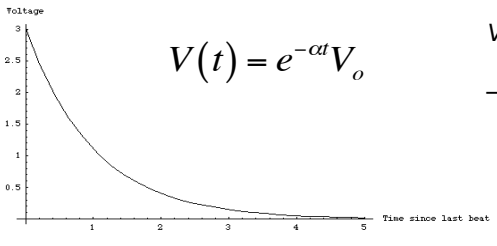
Components

SA Node
- Clock or pacemaker

AV Node
- Response unit

Heart
- Blood pump

1-D Wave Propagation



$$V(t) = e^{-\alpha t} V_o$$

V_t is AV nodal potential after response to signal from the SA node

– potential decays exponentially during the time, τ, in between normal beats

*Model due to **Adler**(1997)*
*from **Keener**(1981, 1998)*

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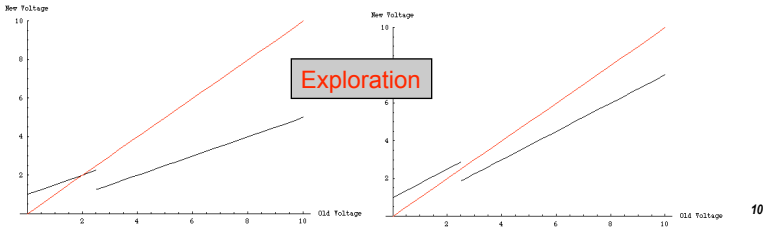
AV Nodal Dynamics

- To beat or not – depends on AV response
  - If potential is too high, heart has not recovered from last beat and ignores signal;
  - otherwise, node accepts signal, tells heart to beat, and increases its potential by fixed amount, call it *u*

$$V_{t+1} = \begin{cases} e^{-\alpha\ \tau} V_t & \text{if} \quad e^{-\alpha\ \tau} V_t > V_c \\ e^{-\alpha\ \tau} V_t + u & \text{if} \quad e^{-\alpha\ \tau} V_t \le V_c \end{cases}$$



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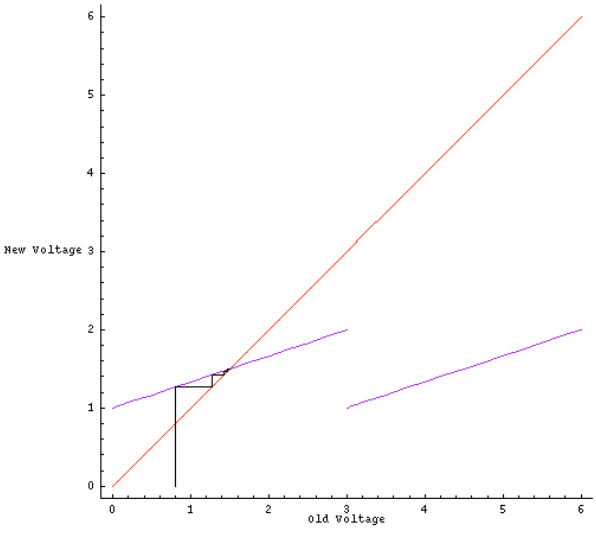
Updating Function with Equilibrium



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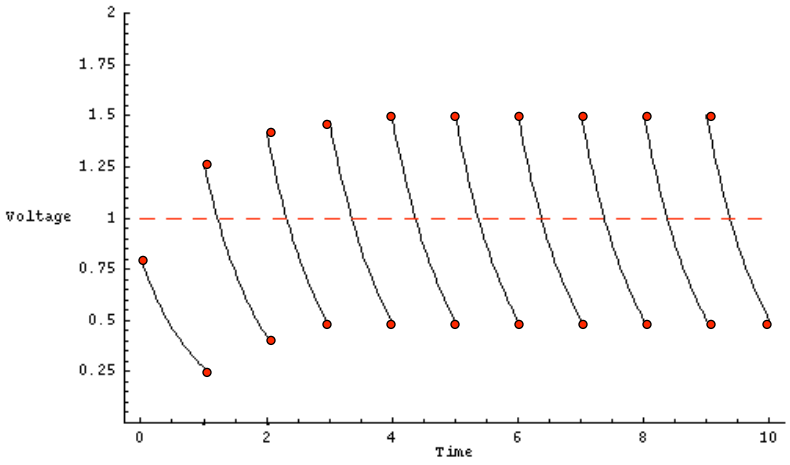
Voltage Over Time with Normal Beating



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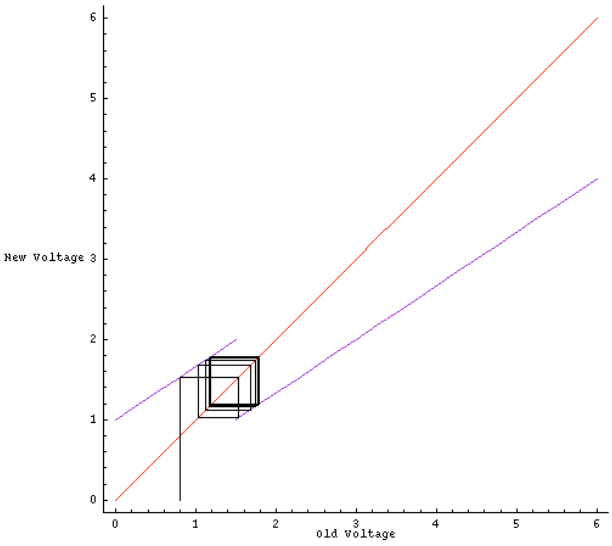
Updating Function with Stable Limit Cycle



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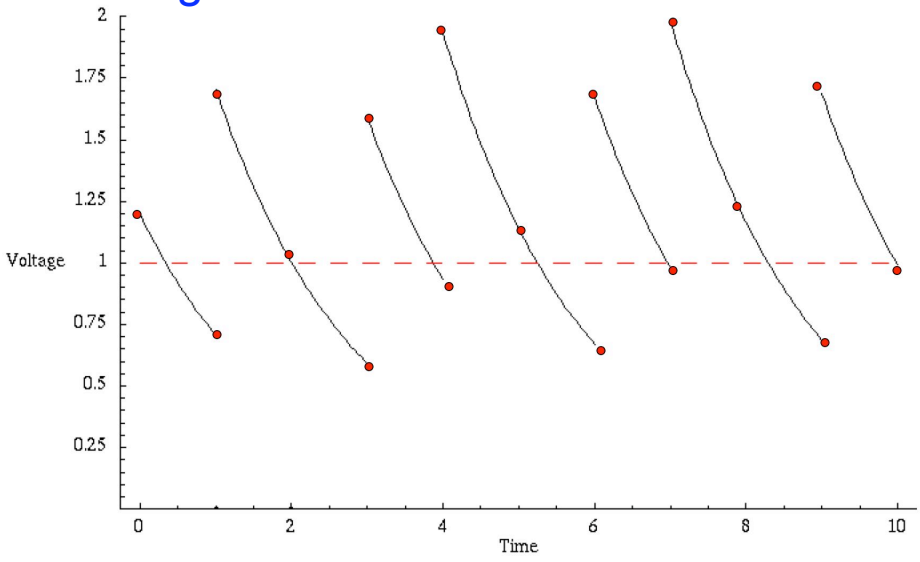
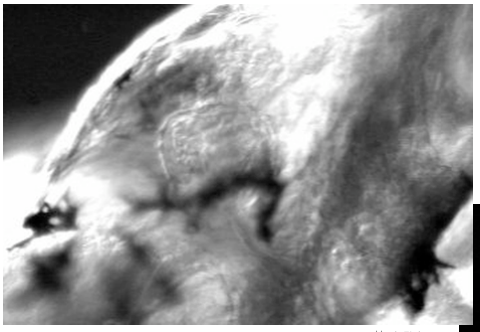
Voltage Over Time with 2:1 AV Block

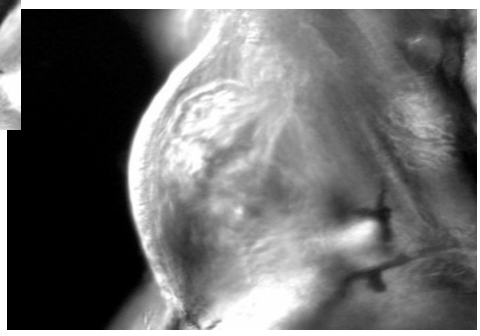


Zebrafish Media

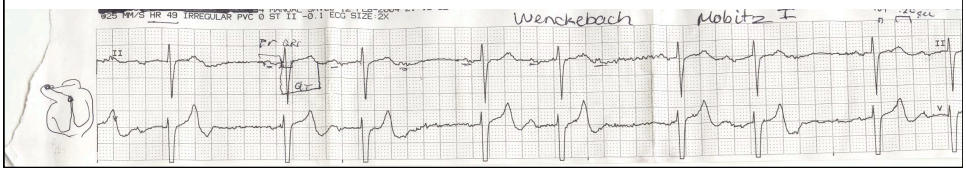


Wild-Type

Video courtesy of **Mark Fishman, Harvard University**



Mutant



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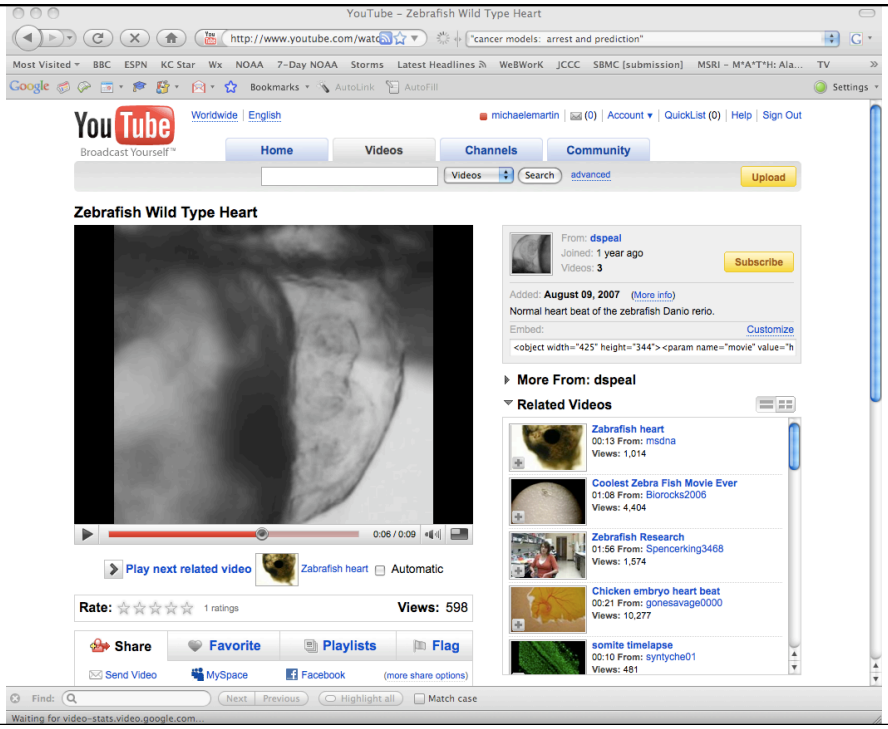
YouTube – Zebrafish Wild Type Heart
Zebrafish Wild Type Heart
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Normal heart beat of the zebrafish Danio rerio.
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Related Videos
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Coolest Zebra Fish Movie Ever
Zebrafish Research
Chicken embryo heart beat
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Favorite
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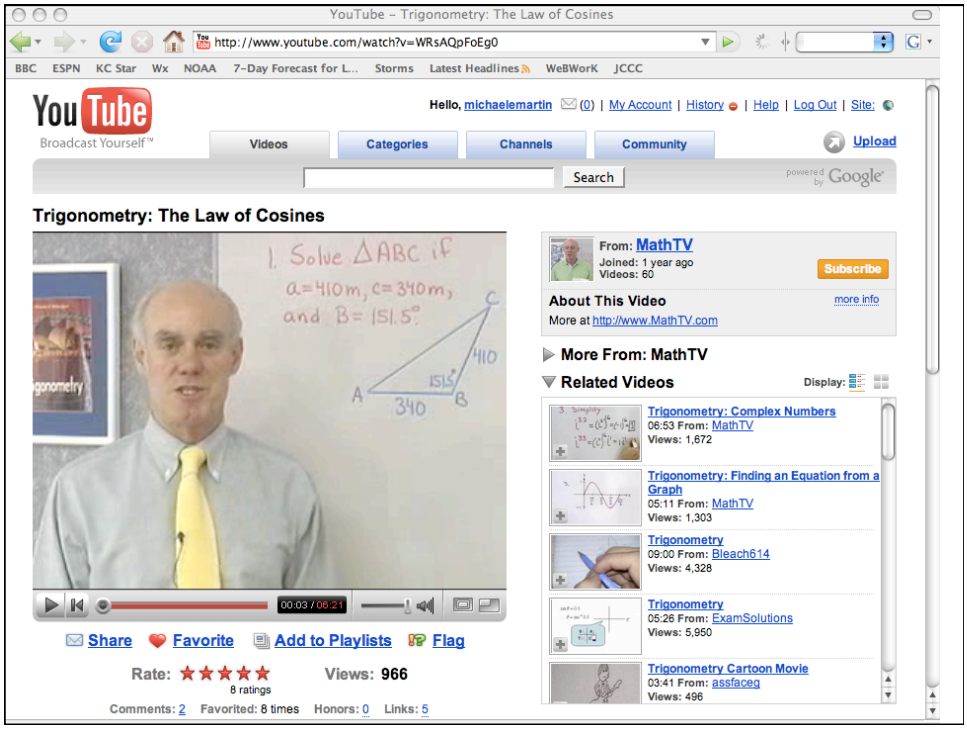
YouTube – Trigonometry: The Law of Cosines
http://www.youtube.com/watch?v=WRsAQpFoEg0
Trigonometry: The Law of Cosines
1. Solve ΔABC if
a=410m, c=340m,
and B=151.5°
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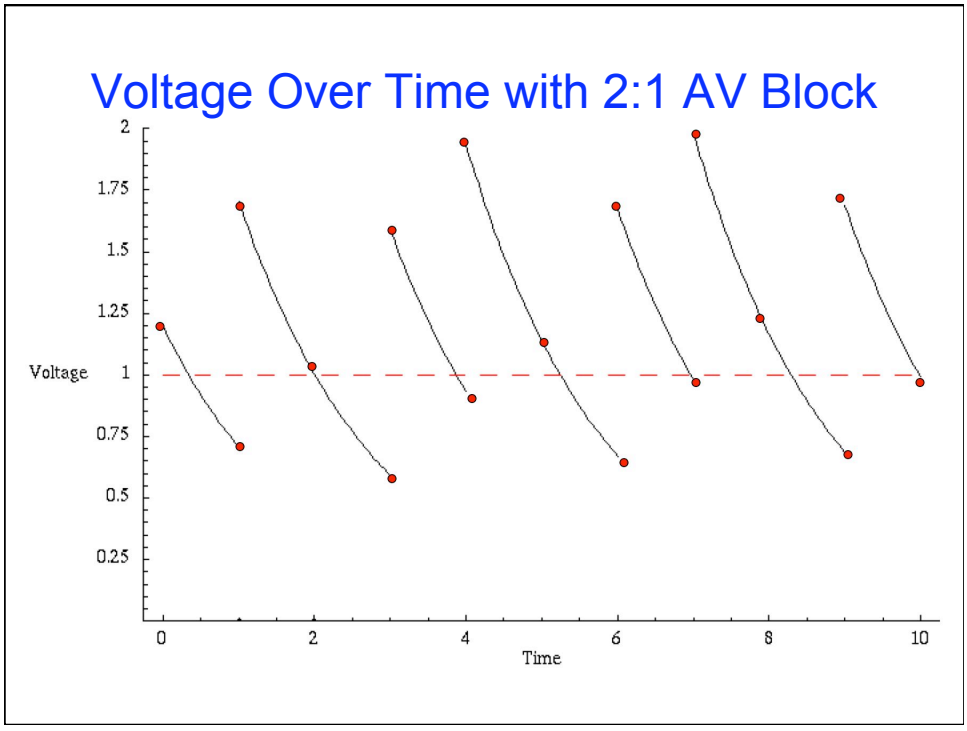

Voltage Over Time with 2:1 AV Block
Voltage
Time
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
2
4
6
8
10

Drug Delivery:
Uniform Dosing with Exponential Decay

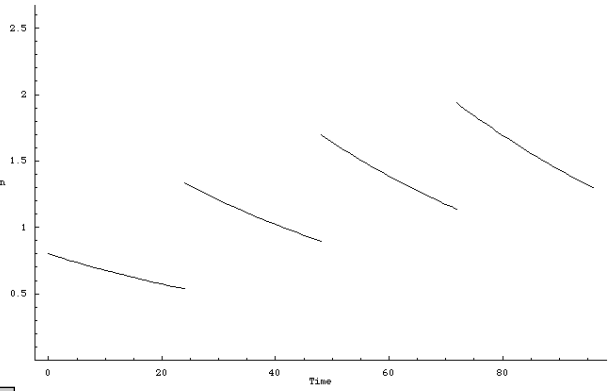
$$\frac{dc}{dt} = -\frac{c}{\tau}$$

with a dosing of c_o

on each interval of length T

for a total of N intervals

$$c(t) = c_o e^{-t/\tau}$$



How can you interpret τ?

What does the value of τ mean relative to that of T?

Overcoming thresholds

Exploration

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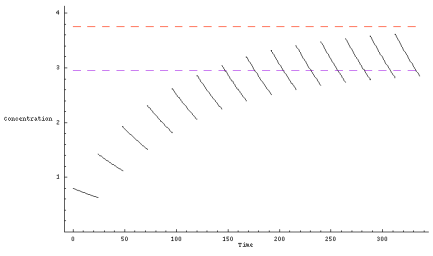
Limiting Behavior

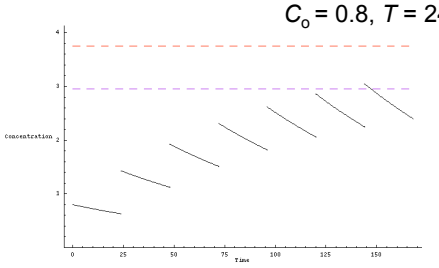
Both upper and lower concentration amounts for a given dosing period reach a limit over time:

Geometric Sequences & Series
Stable Equilibria

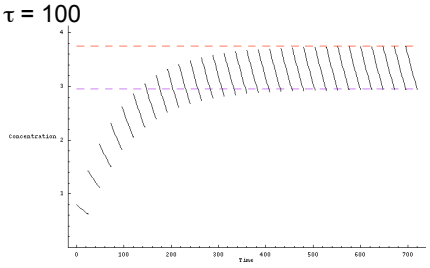


$N = 14$

$C_o = 0.8$, $T = 24$, $\tau = 100$



$N = 7$



$N = 30$

- Acetaminophen, the active ingredient in Tylenol, has a half-life of around 2 hours after the maximum concentration is achieved. Suppose a maximum concentration of 20 milligrams/liter is achieved with a single dose in a patient with a blood volume of 5 liters. Assume that the concentration obeys an exponential model of the form $c(t)=c(0)e^{-t/\tau}$.

Determine the concentration 3 hours later. How much Acetaminophen, in milligrams, does this translate to?

Determine the concentration 24 hours later. How much Acetaminophen, in milligrams, does this translate to?

Determine the numeric value of τ. How can you interpret this value? How is τ related to the value of the half-life?

Suppose a certain drug has a therapeutic range of 10-30 milligrams/liter and a toxic level of 150 milligrams/liter. 20 doses are administered at 12-hour intervals and a dosage results in the concentration going up by 4 milligrams/liter. The drug is slowly eliminated and has a half-life of 100 hours.

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Using the simulation tools at the following link http://math.jccc.net:8180/webMathematica/JSP/mmartin/dosing.jsp , plot the behavior of the concentration as a function of time. How long will it take this dosing regimen to realize concentrations in the therapeutic range?

As the number of doses increases, what is the long-term behavior of the maximum and minimum values of the concentration? Using geometric series, derive formulas for the maximum and minimum concentration values as the number of doses gets very large, approaching infinity.

In the original dosing scenario, suppose a patient doubles the dosage, getting an increase of 8 milligrams/liter per dose. Will the 20 doses produce concentration levels within the therapeutic range? Will they be toxic?

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Contact

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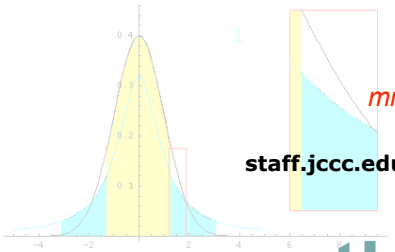
Photo: Larry Schwarm



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