Guided Study Program in System Dynamics
System Dynamics in Education Project
System Dynamics Group
MIT Sloan School of Management[1]

Solutions to Assignment #24
Monday, May 31, 1999

Reading Assignment:

Please read the following paper:

- *Generic Structures: Exponential Material Delays, by Stephanie Albin (D-4614-E)*

Also read the following:

- Industrial Dynamics,[2] *by Jay W. Forrester, Chapter 9*

Exercises:

1. *Generic Structures: Exponential Material Delays and Industrial Dynamics, Chapter 9: Representing Delays*

Please read the paper and work through the exercises. Then read the chapter and answer the following questions:

A. Tom has just created a new consulting company and hired five consulting rookies. Given that a rookie needs to be trained for an average of eight months before she becomes experienced, how many of the five rookies will become experienced consultants after 12 months? In your assignment solutions document, please include the model diagram, documented equations, and a graph of model behavior.
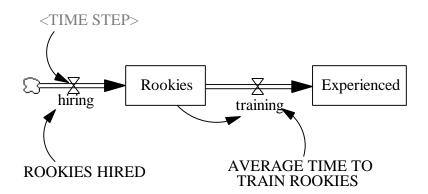Hint 1: Although all rookies are hired at once, their transition into experienced workers should not be viewed as a discrete process (that is, in eight months, all five workers will suddenly become experienced). Consultants do not suddenly and discontinuously go from inexperienced rookies to experienced consultants. There is a gradual transition in the tasks that they can do, so their gaining experience is a continuous process.
Hint 2: Model the hiring decision as a pulse of 5 workers at time 0.

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[2] Forrester, Jay W., 1961. *Industrial Dynamics.* Waltham, MA: Pegasus Communications. 464 pp.

Model diagram:

Model equations:

AVERAGE TIME TO TRAIN ROOKIES = 8
      Units: Month
      The average time for a rookie to become an experienced worker.

Experienced = INTEG (training, 0)
      Units: person
      The number of experienced workers in the company.

hiring = ROOKIES HIRED * PULSE(0, TIME STEP) / TIME STEP
      Units: person/Month
      The number of rookies hired each month.

Rookies = INTEG (hiring - training, 0)
      Units: person
      The number of rookies working in the company.

ROOKIES HIRED = 5
      Units: person
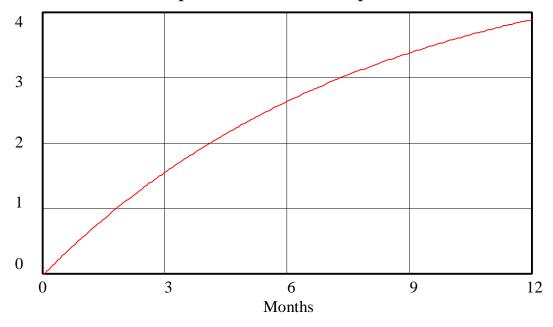   The number of rookies hired.

training = Rookies / AVERAGE TIME TO TRAIN ROOKIES
      Units: person/Month
      The number of rookies who become experienced workers each month.

Model behavior:

Experienced Workers - part A.

Experienced : rookiesA ———————————————— person

Because of the training delay, after 12 months, less than four out of the five rookies have become experienced consultants. As shown in the following graphs, it takes approximately 36 months for all rookies to become experienced consultants:
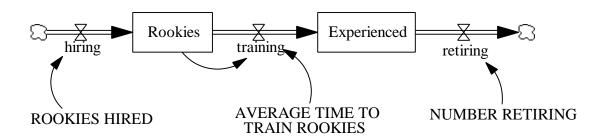
Experienced Workers

Experienced : rookiesA ———————————————— person

B. Because Tom did not realize the long time delay between hiring consultants and training them, he was unable to work on enough consulting projects, and his company went bankrupt. Tom therefore decides to start another company, but this time, he at first recruits 60 workers who already have consulting experience and do not need to be trained. He knows, however, that about six of his workers will retire or quit the company every year, so he makes a decision to also hire six rookies every year. What happens to the number of experienced consultants? Why? Again, in your assignment solutions document, please include the model diagram, documented equations, and a graph of model behavior.

Hint: You may wish to change the time horizon over which you simulate the model.

Modified model diagram:

New and modified model equations:

Experienced = INTEG (training - retiring, 60)
        Units: person
        The number of experienced workers in the company.

hiring = ROOKIES HIRED
        Units: person/Month
        The number of rookies hired each month.

NUMBER RETIRING = 0.5
        Units: person/Month
        The number of experienced workers who retire or leave the company every month.

retiring = NUMBER RETIRING
        Units: person/Month
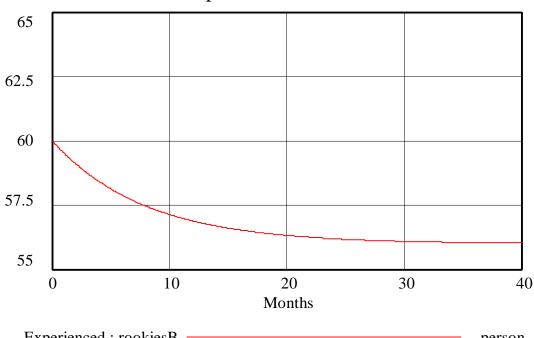   The number of experienced workers who retire each month.

ROOKIES HIRED = 0.5
        Units: person/Month
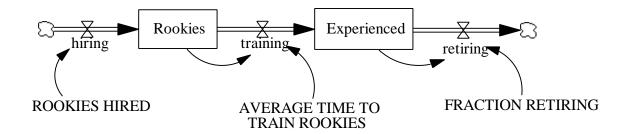   The number of rookies hired each month.

Model behavior:

Experienced Workers

Experienced : rookiesB ————————————————————— person

The number of "Experienced" consultants starts at 60 but asymptotically declines to approximately 56 workers. When the first "Experienced" workers leave Tom's company, they are not immediately replaced by new workers because the "Rookies" have not yet been trained. Over time, the number of "Rookies" approaches 4, so the total number of workers, "Rookies" plus "Experienced," remains constant at 60 throughout the simulation.

C. Tom now realizes that instead of having a constant retiring rate of 6 workers, a constant fraction, approximately 10%, of his consultants leave the company every year. Reformulate the retiring rate equation to reflect this situation. How does the model behavior change compared to part B? In your assignment solutions document, please include the model diagram, documented equations, and a graph of model behavior.
Hint: Again, you may want to increase the time horizon of your model.

Modified model diagram:

Modified model equations:

FRACTION RETIRING = 1/120
   Units: 1/Month
   The fraction of experienced workers who retire or leave the company every month (equivalent to one tenth of all workers each year).
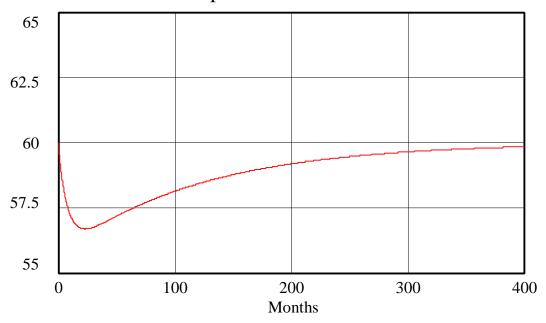
retiring = Experienced * FRACTION RETIRING
   Units: person/Month
   The number of experienced workers who retire each month.

Model behavior:

Experienced Workers

Experienced : rookiesC ———————————————— person

In this scenario, the number of "Experienced" consultants rises back to 60 after an initial decline. At first, as in part B, the "Experienced" consultants leave at the same rate as "Rookies" are hired, so the number of "Experienced" workers declines. With a lower number of "Experienced" workers, however, the "retiring" rate also falls, while the "hiring" rate remains constant. When the rate of "training" of "Rookies" exceeds the "retiring" rate, the number of "Experienced" consultants starts rising, and asymptotically approaches 60.

2. Independent Modeling Exercise

As you may have heard, in September 1998, an MIT freshman died of acute alcohol intoxication. An article in the MIT Observer clarified the science behind the effects of alcohol poisoning. The following paragraphs are excerpts taken from that article.

"Alcohol is a depressant: it slows down the transmission of neural activity, which in turn lowers blood pressure, decreases heart rate, and slows down breathing. In the case of acute alcohol intoxication, or alcohol poisoning, the imbiber's heart stops and he ceases to breathe. As he suffocates, the bloodstream carries less oxygen to the brain, and brain cells die. According to Professor of Toxicology Peter Dedon, when someone drinks alcohol, it descends into the intestines where it is absorbed into the bloodstream and body water and into the liver. In the liver, alcohol is first metabolized by alcohol dehydrogenase into acetaldehyde and then metabolized into non-toxic acetic acid,

commonly known as vinegar. The liver is only able to metabolize approximately 7 grams of alcohol every hour. In the meantime, the alcohol in the bloodstream and body water reacts with receptors in the brain to slow down the transmission of impulses across neurons. [...]

"The delayed transmission of neural activity affects trained behavior and learning. It amplifies emotions, loosens inhibitions, and causes feelings of euphoria. These symptoms are characteristic of the "buzz" commonly experienced after a few drinks, when the blood alcohol content reaches approximately 0.02 grams of alcohol per deciliter of blood. As the level of alcohol in the bloodstream continues to rise, however, the mid-brain also becomes affected. In the mid-brain area, the retarded neural activity brings about a loss of motor coordination and dulls responses to external stimuli. These symptoms translate into a loss of coordination, delayed reflex time, and clouded judgment. The State of Massachusetts defines a person with a blood alcohol content of 0.08 grams per deciliter or more to be "legally drunk." As the blood alcohol content continues to increase, the drinker begins to slur his speech and has difficulty swallowing. The epiglottic closure and the constricting muscles that protect the airway become sluggish. At the same time, the alcohol activates a center in the brain which stimulates vomiting. Alcohol irritating the lining of the stomach will also induce vomiting. A drinker is then at risk to die from aspiration: inhaling his own vomit. If inhaled, the bacteria in the oral cavity may cause an acute infection in the respiratory system, particulate matter may block the victim's airways, and the highly-acidic gastric contents of the stomach may sear the lungs with a chemical burn. Drinkers will typically loose consciousness when their blood alcohol content reaches approximately 0.15 grams per deciliter. At that point, they are particularly at risk of suffering from aspiration. The use of alcohol also becomes deadly when the abated neural activity begins to affect the medulla, the inner core of the brain. There the sedative begins to affect body temperature, blood pressure, heartbeat, and breathing. Alcohol not only slows down the muscles that control breathing, but also inhibits the body's response to the carbon dioxide, so a victim of acute alcohol poisoning will not realize that he is suffocating. Half of the people whose blood alcohol content exceeds the lethal level of 0.40 grams per deciliter will die.

"Medical director and professor of medicine Dr. Arnold Weinberg emphasizes that the effects of alcohol will vary from person to person. The effects of alcohol depend on the concentration of alcohol in the body, so people with large body mass have a higher tolerance because the alcohol they intake dilutes over their entire mass. Alcohol distributes into blood and body water, not into fat. Women typically have a greater fat to non-fat ratio, so the alcohol they intake does not distribute as well, its concentration in their body fluid is higher, and they are more susceptible to the effects of alcohol.

"An empty stomach will increase the effects of intoxication because it will enable the alcohol to rapidly move through the stomach to the small intestines, where it is absorbed into the bloodstream and body water. Foods high in fat content, like cheese, will retard the absorption of alcohol. Carbonated drinks like beer and champagne, on the other hand, hasten the absorption of alcohol.

"Alcohol and medication are not a good mix. In the liver, alcohol inhibits the P-450 microensemble enzyme system which is in charge of degrading other drugs, like medication.

"The effects of alcohol on the body are also determined by the speed at which a person drinks. The enzymes in the liver can only metabolize, or degrade, on average 7 grams of alcohol every hour. By drinking alcohol over an extended period of time, the body has the time to digest the alcohol, rendering it harmless, instead of allowing it to build up. The chronic consumption of alcohol will, in the long run, increase the body's metabolism. The increased metabolism allows chronic drinkers to build up a tolerance to alcohol."

In this exercise, we will study the effect of alcohol on different people in different situations. We will build a model to contrast the effects over time of:
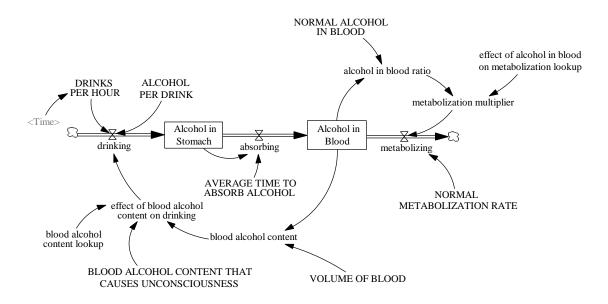- *social drinking versus binge drinking*
- *men drinking versus women drinking*
- *novice drinkers versus seasoned drinkers*
- *drinking on a full stomach versus drinking on an empty stomach*

A. Use the above excerpts to conceptualize and formulate an alcohol consumption model. If you are feeling particularly courageous, try to make the model entirely on your own. If you would like some guidance, please refer to the following hints:

- *The two important accumulations in the model are the quantity of alcohol in the stomach and the quantity of alcohol in the blood.*
- *Alcohol travels from the stomach to the blood when it passes through the small intestines and into the bloodstream. On average, it takes between 10 minutes to half an hour to absorb alcohol into the bloodstream. The more food in the stomach, the longer before the alcohol is absorbed.*
- *As long as there is alcohol in the blood, the liver metabolizes alcohol at a constant rate.*
- *Blood is measured in deciliters, alcohol is measured in grams*
- *When the blood alcohol content rises to approximately 0.15 grams per deciliter, the drinker passes out. Once the drinker becomes unconscious, he stops drinking.*
- *The average student has about 420 deciliters of body water (blood) in his body.*

In your assignment solutions document, please include the model diagram, documented equations, a graph of model behavior, and graphs of table functions.

Model diagram:

Model equations:

absorbing = Alcohol in Stomach / AVERAGE TIME TO ABSORB ALCOHOL
        Units: gram/Hour
        The amount of alcohol absorbed from the stomach to the blood every hour.

Alcohol in Blood = INTEG (absorbing - metabolizing, 0)
        Units: gram
        Amount of alcohol in the stomach.

alcohol in blood ratio = Alcohol in Blood / NORMAL ALCOHOL IN BLOOD
        Units: dmnl
        The ratio of the actual amount of alcohol in blood to the normal amount.

Alcohol in Stomach = INTEG (drinking - absorbing, 0)
        Units: gram
        Amount of alcohol in the stomach.

ALCOHOL PER DRINK = 20
        Units: gram/drink
        Amount of alcohol in each drink.

AVERAGE TIME TO ABSORB ALCOHOL = 0.3
        Units: Hour
        On average, it takes between 10 minutes to half an hour to absorb alcohol from
        the stomach to the bloodstream. The value 0.3 corresponds to approximately 20
        minutes, or one third of an hour.

blood alcohol content = Alcohol in Blood / VOLUME OF BLOOD
        Units: gram/deciliter
        The amount of alcohol in a deciliter of blood.

blood alcohol content lookup ([(0,0) - (1,1)], (0,1), (0.1,0.99), (0.2,0.95), (0.3,0.9),
(0.4,0.8), (0.5,0.6), (0.6,0.4), (0.7,0.2), (0.8,0.1), (0.9,0.02), (1,0))
Units: dmnl
The lookup function for the effect of blood alcohol content on drinking multiplier.
When blood alcohol content is zero, the alcohol has no effect on drinking. As the
blood alcohol content rises, the drinker starts feeling the effects of alcohol and
slows down the rate of drinking. When the blood alcohol content reaches the
value that causes unconsciousness, the drinker passes out and stops drinking.

BLOOD ALCOHOL CONTENT THAT CAUSES UNCONSCIOUSNESS = 0.15
Units: gram/deciliter
The amount of alcohol in a deciliter of blood at which a person loses
consciousness.

drinking = DRINKS PER HOUR * ALCOHOL PER DRINK * effect of blood alcohol
content on drinking
Units: gram/Hour
The amount of alcohol drunk each hour.

DRINKS PER HOUR = IF THEN ELSE(Time<5,0.6,0)
Units: drink/Hour
Number of drinks drunk every hour. We assume that all drinkers drink only
during the first five hours of the simulation. The value 0.6 drinks per hour
corresponds to drinking 3 drinks over 5 hours.

effect of alcohol in blood on metabolization lookup ([(0,0) -(1,1)], (0,0), (0.1,0.3),
(0.2,0.5), (0.3,0.65), (0.4,0.75), (0.5,0.83), (0.6,0.89), (0.7,0.93), (0.8,0.96),
(0.9,0.99), (1,1))
Units: dmnl
The lookup function for the effect of alcohol in blood on the metabolization rate.
When the amount of alcohol in blood is greater than the NORMAL ALCOHOL
IN BLOOD, the rate of metabolizing equals the NORMAL METABOLIZATION
RATE. When the amount of alcohol in blood falls below the normal amount, the
metabolization rate slowly decreases to zero.

effect of blood alcohol content on drinking = blood alcohol content lookup (blood alcohol
content / BLOOD ALCOHOL CONTENT THAT CAUSES
UNCONSCIOUSNESS)
Units: dmnl
The effect of blood alcohol content on the amount of alcohol drunk per hour.

metabolization multiplier = effect of alcohol in blood on metabolization lookup (alcohol
in blood ratio)
Units: dmnl
The effect of the alcohol in blood ratio on the metabolization rate.

metabolizing = NORMAL METABOLIZATION RATE * metabolization multiplier
Units: gram/Hour
As long as the amount of alcohol in the blood is greater than the normal value that is metabolized every hour, the liver metabolizes alcohol at a constant rate. If the amount of alcohol in blood falls below the normal value, then the remaining alcohol is metabolized at a slower rate.

NORMAL ALCOHOL IN BLOOD = 7
Units: gram
The lowest amount of alcohol in blood at which the metabolizing rate equals the NORMAL METABOLIZATION RATE.

NORMAL METABOLIZATION RATE = 7
Units: gram/Hour
The constant rate of metabolization of alcohol by the liver.

VOLUME OF BLOOD = 420
Units: deciliter
The amount of blood and body water in the body.

alcohol

blood alcohol content lookup

alcohol

effect of alcohol in blood on metabolization lookup

-X-

B. When Andrew has dinner with his family at Le Bouchon, his favorite French bistro, he drinks on average three five-ounce glasses of wine over the course of a five hour evening. Each glass contains approximately 20 grams of alcohol. When Steve drinks with his fraternity buddies, he drinks three 12-ounce cans of cheap beer every hour. Each can has approximately 20 grams of alcohol. When Ian goes out bar hopping, he drinks five 1.5-ounce shots of hard liquor every hour. Each shot has approximately 20 grams of alcohol.

Simulate the model and compare and contrast what happens to Andrew, Steve, and Ian over the course of 5 hours. Include graphs and analyses of the behavior you observe. Clearly label the values of the parameters that you change for each scenario.
Hint: To formulate the drinking patterns for each person, you may want to use the current value of time in the simulation.

In the "andrew" scenario, the equation for "DRINKS PER HOUR" is:
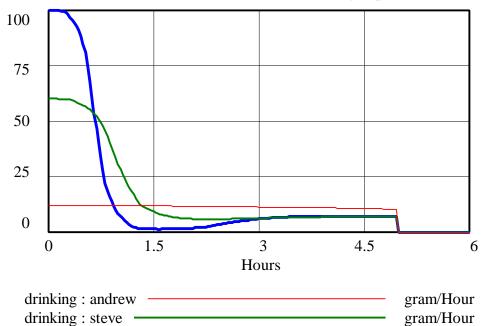   DRINKS PER HOUR = IF THEN ELSE(Time<5,0.6,0)

In the "steve" scenario, the equation for "DRINKS PER HOUR" is:
     DRINKS PER HOUR = IF THEN ELSE(Time<5,3,0)

In the "ian" scenario, the equation for "DRINKS PER HOUR" is:
     DRINKS PER HOUR = IF THEN ELSE(Time<5,5,0)

The following graphs compare the behavior of "drinking," "Alcohol in Stomach," "Alcohol in Blood," and "blood alcohol content" in the three scenarios. Notice that "drinking" and "Alcohol in Stomach" are graphed over six hours, but "Alcohol in Blood" and "blood alcohol content" are graphed over 12 hours.
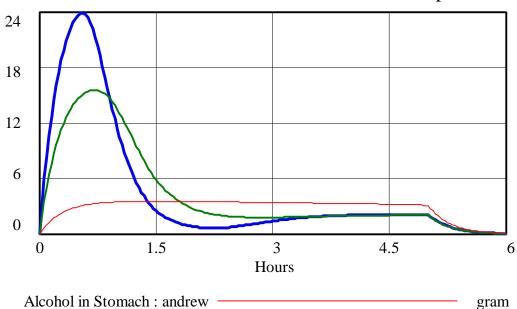
Andrew, Steve, and Ian - drinking - part B.

drinking : andrew	————————	gram/Hour
drinking : steve	————————	gram/Hour
drinking : ian	————————	gram/Hour

Andrew, Steve, and Ian - alcohol in stomach - part B.

Alcohol in Stomach : andrew	————————	gram
Alcohol in Stomach : steve	————————	gram
Alcohol in Stomach : ian	————————	gram

Andrew, Steve, and Ian - alcohol in blood - part B.

Alcohol in Blood : andrew	gram
Alcohol in Blood : steve	gram
Alcohol in Blood : ian	gram

Andrew, Steve, and Ian - blood alcohol content - part B.

blood alcohol content : andrew	gram/deciliter
blood alcohol content : steve	gram/deciliter
blood alcohol content : ian	gram/deciliter

The value of "DRINKS PER HOUR" determines "drinking," the inflow to the level of "Alcohol in Stomach." The more "DRINKS PER HOUR" one takes, the faster and higher the "Alcohol in Stomach" rises. Consequently, the amount of "Alcohol in Blood" also rises faster and to a higher value, increasing the "blood alcohol content." Notice that Ian initially drinks so fast that his "blood alcohol content" almost reaches 0.15 grams per deciliter, which makes Ian close to being unconscious. Hence, his rate of "drinking" drops almost to zero after 1.5 hours, but starts "drinking" again when his "blood alcohol content" declines somewhat. Andrew, on the other hand, drinks so slowly that his "Alcohol in Blood" never rises high enough for the "blood alcohol content" to have a significant impact on his "drinking." Steve, who initially takes fewer "DRINKS PER HOUR" than Ian, is able to drink for a longer time without ever passing out, however, because his "Alcohol in Blood" does not rise as fast and as high as Ian's. Therefore, his "blood alcohol content" does not have such a strong effect on his "drinking" as it does for Ian.

C. Ian takes his girlfriend, Ellen, to a bar. She has very low alcohol tolerance. Ellen's volume of body water is half Ian's volume of body water, so she feels the effects of alcohol twice as strongly as Ian does.
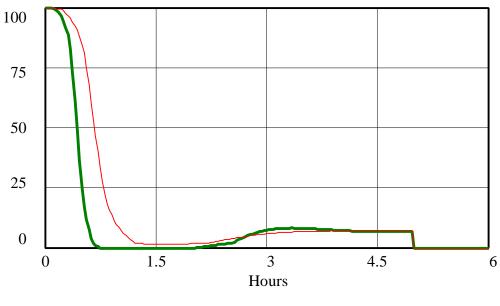
Simulate the model and compare and contrast what happens to Ian and Ellen over the course of 5 hours, assuming that Ellen's drinking pattern is the same as Ian's. Include graphs and analyses of the behavior you observe. Clearly label the values of the parameters that you change for each scenario.

In the "ian" scenario, the value of "VOLUME OF BLOOD" is 420 deciliters. In the "ellen" scenario, the value of "VOLUME OF BLOOD" is 210 deciliters. In both scenarios, the equation for "DRINKS PER HOUR" is:
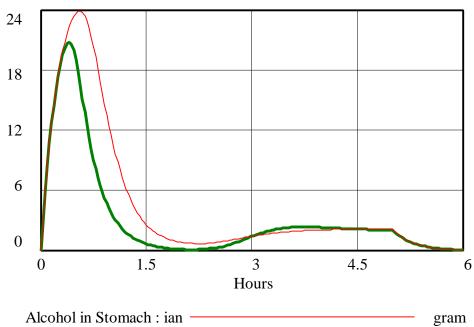   DRINKS PER HOUR = IF THEN ELSE(Time<5,5,0)

The following graphs compare the behavior of "drinking," "Alcohol in Stomach," "Alcohol in Blood," and "blood alcohol content" in the two scenarios. Notice again that "drinking" and "Alcohol in Stomach" are graphed over six hours, but "Alcohol in Blood" and "blood alcohol content" are graphed over 12 hours.

Ian and Ellen - drinking - part C.
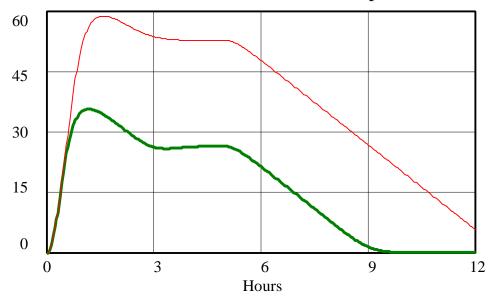

| drinking : ian | | gram/Hour |
| drinking : ellen | | gram/Hour |

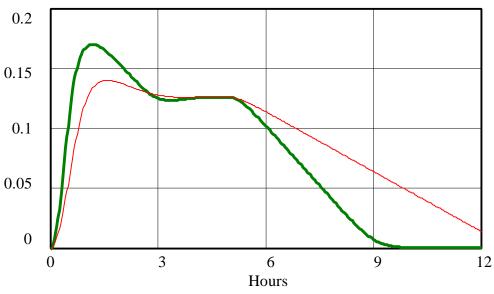## Ian and Ellen - alcohol in stomach - part C.

| Alcohol in Stomach : ian | | gram |
| Alcohol in Stomach : ellen | | gram |

Ian and Ellen - alcohol in blood - part C.

Alcohol in Blood : ian ——————————— gram
Alcohol in Blood : ellen ▬▬▬▬▬▬▬ gram

Ian and Ellen - blood alcohol content - part C.

blood alcohol content : ian ——————— gram/deciliter
blood alcohol content : ellen ▬▬▬▬▬ gram/deciliter

The "VOLUME OF BLOOD" determines the value of "blood alcohol content." Because Ellen's "VOLUME OF BLOOD" is lower than Ian's, her "blood alcohol content" rises faster than Ian's even though their initial rates of "drinking" are equal. As Ellen's "blood alcohol content" increases, she starts losing consciousness, and she soon passes out because her "blood alcohol content" exceeds 0.15 grams per deciliter. As her "Alcohol in Blood" is metabolized, however, she regains consciousness after a while and starts drinking again.

D. Steve's little brother comes to visit Steve in college over spring break. Steve is a seasoned drinker. He metabolizes 12 grams of alcohol every hour. Steve's little brother, however, has hardly ever touched alcohol. He only metabolizes seven grams of alcohol every hour.

Simulate the model and compare and contrast what happens to Steve and his little brother over the course of 5 hours, assuming that Steve's little brother has the same drinking pattern as Steve. Include graphs and analyses of the behavior you observe. Clearly label the values of the parameters that you change for each scenario.
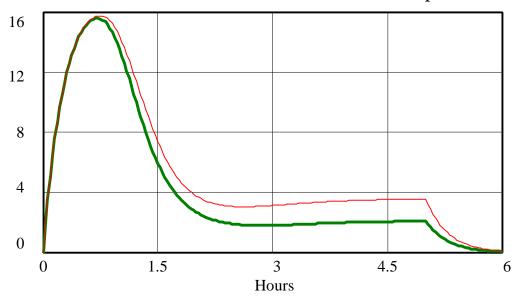
In the "steve" scenario, the value of "NORMAL METABOLIZATION RATE" is 12 grams/hour, and the value of "NORMAL ALCOHOL IN BLOOD" is thus 12 grams. In the "brother" scenario, the value of "NORMAL METABOLIZATION RATE" is 7 grams/hour. In both scenarios, the equation for "DRINKS PER HOUR" is:

DRINKS PER HOUR = IF THEN ELSE(Time<5,3,0)
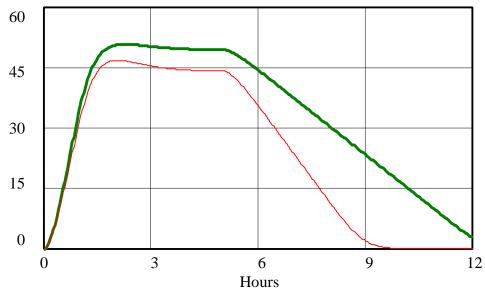

Steve and his brother - drinking - part D.

drinking : steve	gram/Hour
drinking : brother	gram/Hour

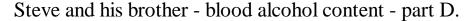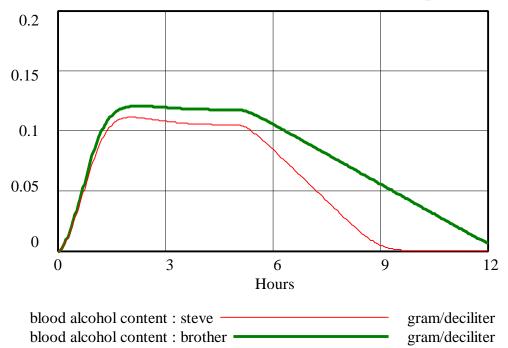# Steve and his brother - alcohol in stomach - part D.

| Alcohol in Stomach : steve | gram |
| Alcohol in Stomach : brother | gram |

Steve and his brother - alcohol in blood - part D.

| Alcohol in Blood : steve | gram |
| Alcohol in Blood : brother | gram |

Steve and his brother - blood alcohol content - part D.

blood alcohol content : steve	————————————	gram/deciliter
blood alcohol content : brother	▬▬▬▬▬▬▬▬	gram/deciliter

The "NORMAL METABOLIZATION RATE" determines the rate at which alcohol is metabolized by the liver. A higher "NORMAL METABOLIZATION RATE" increases the rate of "metabolizing," shortening the time the alcohol is in the blood. Even though Steve and his brother initially drink at the same rate, Steve's brother has to slow down his "drinking" earlier than Steve because his "blood alcohol content" rises to a higher value than Steve's.

E. What is safer? To drink on a full stomach or an empty stomach? Run four different scenarios, comparing and contrasting what happens to both Andrew and Ian when drinking on both full and empty stomachs. Include graphs for each scenario you run. What conclusions can you draw?

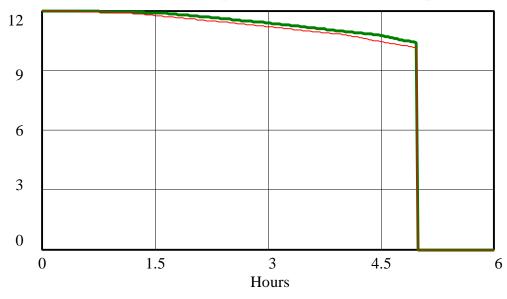In the two "andrew" scenarios, the equation for "DRINKS PER HOUR" is:
    DRINKS PER HOUR = IF THEN ELSE(Time<5,0.6,0)
In the two "ian" scenarios, the equation for "DRINKS PER HOUR" is:
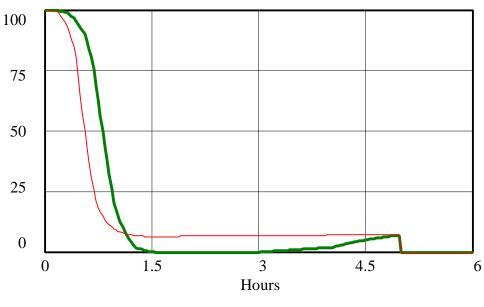   DRINKS PER HOUR = IF THEN ELSE(Time<5,5,0)
In the two "empty stomach" scenarios, the value of "AVERAGE TIME TO ABSORB ALCOHOL" is 10 minutes, or 0.17 hours. In the two "full stomach" scenarios, the value of "AVERAGE TIME TO ABSORB ALCOHOL" is 30 minutes, or 0.5 hours.

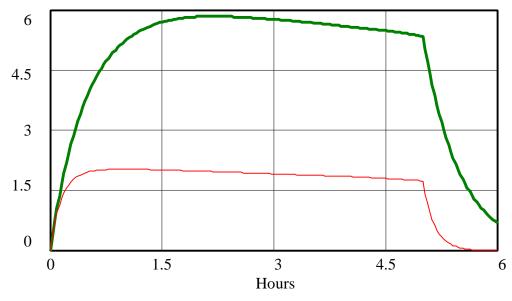Andrew - full and empty stomach - drinking - part E.

drinking : andrew empty stomach ——————— gram/Hour
drinking : andrew full stomach ———— gram/Hour
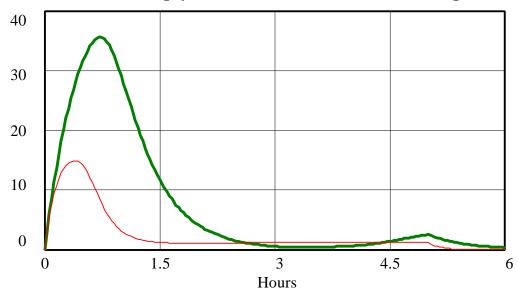

Ian - full and empty stomach - drinking - part E.

drinking : ian empty stomach ——————— gram/Hour
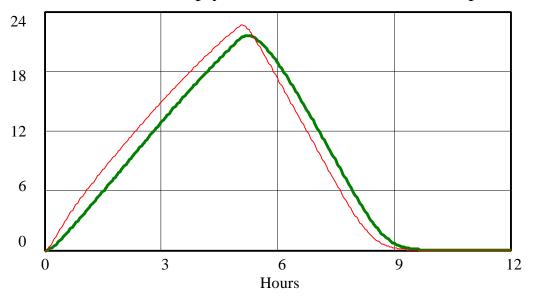drinking : ian full stomach ———— gram/Hour

Andrew - full and empty stomach - alcohol in stomach - part E.

Alcohol in Stomach : andrew empty stomach ———————————— gram
Alcohol in Stomach : andrew full stomach ▬▬▬▬▬▬▬▬ gram

Ian - full and empty stomach - alcohol in stomach - part E.

Alcohol in Stomach : ian empty stomach ———————————— gram
Alcohol in Stomach : ian full stomach ▬▬▬▬▬▬▬▬ gram

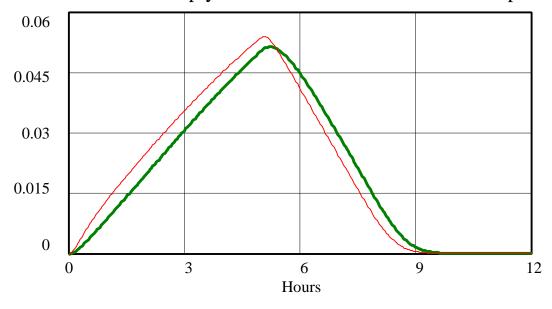## Andrew - full and empty stomach - alcohol in blood - part E.

Alcohol in Blood : andrew empty stomach ——————— gram
Alcohol in Blood : andrew full stomach ━━━━━━ gram

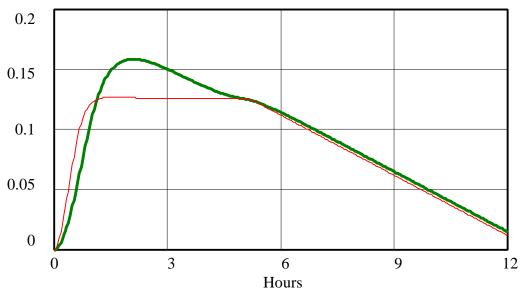## Ian - full and empty stomach - alcohol in blood - part E.

Alcohol in Blood : ian empty stomach ——————— gram
Alcohol in Blood : ian full stomach ━━━━━━ gram

Andrew - full and empty stomach - blood alcohol content - part E.

blood alcohol content : andrew empty stomach ——————— gram/deciliter
blood alcohol content : andrew full stomach ━━━━━━ gram/deciliter

Ian - full and empty stomach - blood alcohol content - part E.

blood alcohol content : ian empty stomach ——————— gram/deciliter
blood alcohol content : ian full stomach ━━━━━━ gram/deciliter

The effects of drinking on a full or empty stomach are represented by changing the time constant "AVERAGE TIME TO ABSORB ALCOHOL." A full stomach increases the time constant, while an empty stomach decreases it. Hence, a full stomach allows a greater build-up of alcohol in the stomach because it increases the delay between the time the alcohol enters the stomach and the time when the alcohol is absorbed into the blood and starts affecting consciousness. For Andrew, the most significant difference between having a full or empty stomach is in the accumulation of alcohol in his stomach. His "blood alcohol content" is not greatly affected, but it rises more slowly and to a lower value when Andrew has a full stomach. For Ian, on the other hand, drinking on a full stomach seems more dangerous than drinking on an empty stomach. The long absorption delay causes a great accumulation of alcohol in Ian's stomach, which results in a higher peak of his "Alcohol in Blood." His high "blood alcohol content" then makes him stop drinking for some time because he loses consciousness. Hence, one can conclude that for low rates of "drinking," a full stomach is safer, while for high rates of drinking, an empty stomach might be safer in preventing the loss of consciousness.