

# Teaching Personal Finance Using System Dynamics

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One of the fundamental challenges in educational applications of system dynamics (SD = (in CIESD's definition of system dynamics) systems thinking + dynamic modeling) is to effectively and appropriately balance its utility in supporting content learning in disciplinary or interdisciplinary topics while also helping students to develop a content-independent tool- and skill-set in the form of transferable 'habits of mind.' These latter elements were a major focus in Barry Richmond's advocacy of SD as providing twin 'skill' and 'attitude' foundations for the 'systems citizen' he strived to support. While state frameworks and standards for learning typically address both sides of that balance, the discipline-based organization of schools and of the high stakes standardized testing often emphasized in program assessment (and of most teachers' academic preparation and areas of comfort) make the latter element a greater challenge for educators. Accordingly, advocates of developing and applying system dynamics applications and insights in K-12 education frequently refer to 'Trojan horse' approaches where the visible emphasis of the curricular application is on the mandated content area knowledge acquisition, allowing the critical thinking and problem-solving virtues of SD to be developed under the radar.

The educational community represented at these ST&DM Conferences has made frequent conscious or implicit use of that strategy; this year's program and those of past years reveal powerful applications in classroom subjects including, but not limited to, literature, math, various sciences and social sciences. Another area, the focus of our work reported in this session, is in the realm of personal finance. We focused on personal finance for a number of reasons:

1. In our experience, the topic of money, and especially 'my money,' is intrinsically interesting to students;
2. It is a topic where neither adults nor students are particularly, or acceptably, literate. A Harris Interactive survey, sponsored by the National Council on Economic Education in 2005 (url: [http://207.124.141.218/WhatAmericansKnowAboutEconomics\\_042605-3.pdf](http://207.124.141.218/WhatAmericansKnowAboutEconomics_042605-3.pdf)) was summarized with the following table.

**Number of Quiz Questions Answered Correctly By At Least 75% of Respondents**

	<u>Adults</u>	<u>Students</u>
Economics & the Consumer (5 questions)	4 out of 5	3 out of 5
Factors Pertaining to Production (5 questions)	3 out of 5	2 out of 5
Money, Interest Rates and Inflation (4 questions)	1 out of 4	0 out of 4
Government and Trade in Economics (6 questions)	1 out of 6	0 out of 6
Personal Finance (4 questions)	1 out of 4	0 out of 4

3. It is a topic that both requires fundamental school-acquired academic skills (e.g. in math) and is a stipulated element of many state educational plans.
4. It can be explored productively with the basic system dynamics that focus on stock and flow based dynamics that are controlled by relatively simple (at least when considered individually) reinforcing and balancing feedback loops.

Personal Finance Curricular Experimentation with System Dynamics in Grades 7-12:

We had the good fortune to be able to offer an elective course in personal finance at the Vermont Commons School, South Burlington, VT, during their middle trimester of the 2004-2005 school year (mid-November through February). Our goals for this experimental mini-course were three-fold:

1. Help the students acquire the knowledge and intellectual comfort needed to understand and utilize a variety of financial instruments (checking, savings, and investment accounts; installment and revolving debt) and several financial frameworks that influence proper utilization of those instruments (reinforcing feedback of compound interest and inflation; risk).
2. Challenge the students to combine those individual skills and insights to plan to achieve a self-defined financial goal.
3. Use these financial challenges to motivate the students to acquire a fundamental understanding of basic systems thinking concepts and computer modeling (STELLA) skills.

The materials that follow this brief description were produced during the course to structure and support that student learning. We originally anticipated 5 short assignments prior to beginning the larger personal projects; during the course the 'investment' assignment was revisited to correct some misunderstandings when the instructors' expectations had not been clearly defined. What follows are, with minimal post-course edits, the handouts provided to the students as assignments to guide them through the development of these financial skills and knowledge:

1. Course Syllabus
2. Assignment 1: Introduction to STELLA; Linear Income & Expenditure
3. Assignment 2: Savings (& Compound Interest)
4. Assignment 3: Investment
5. Assignment 4: Investment (revisited)
6. Assignment 5: Debt
7. Assignment 6: Inflation
8. Final Project Guidance: "MAPPING OUT" YOUR PERSONAL FINANCE MODEL

We will spend time during the session working through these illustrations. A CD with these course materials, STELLA 'Answer Sheets' for each assignment, and the Introduction and first 3 Lessons of CIESD's Modeling Systems Self-Taught (MSST) will be provided to session participants.

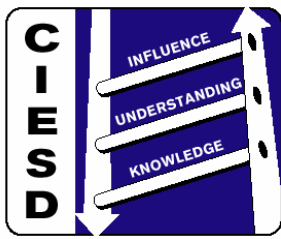
Collaboration with the National Council on Economic Education's (NCEE's) *Financing Your Future Curriculum*:

We are in the process of completing the necessary funding to support the development of similar STELLA-based financial literacy lessons as supplemental materials for NCEE's recently released *Financing Your Future* video-based curriculum. These materials will parallel our earlier classroom based efforts in that exploration of earlier five financial instruments will provide a foundation for the materials. In addition, a self-defined financial planning project will

constitute the capstone of the materials. We anticipate several significant differences, however, from that earlier effort:

1. We do NOT intend to make model-building a part of the supplemental materials. We will provide careful explanations and illustrations of the underlying models, but the students' task will be to manipulate the financial instruments and to explain any mismatch(s) between their desire and expectation and the actual outcome of the simulation.
2. In addition to the five financial instruments we explored with our students at the Vermont Commons School, we will also build and provide a model-based exercise that focuses on 'human capital.' That unit will explore the costs and benefits of pursuing education and training opportunities.
3. Our previous 'capstone' experience of integrating all the smaller modules will be replicated with NCEE but will also be used as a first, introductory exercise to illustrate the difficulty, complexity, and pitfalls of personal financial management. In addition to powerfully introducing those complexity themes the use of 'before' and 'after' exercises will open avenues for assessment that we did not explore in our initial experiment.
4. We will also work closely with our NCEE colleagues to develop a teacher training program that will utilize an additional STELLA simulation to bring system dynamics- and STELLA neophytes to a sufficient level of comfort and competence to be able to guide students through the exercises. Planning for that module and the teacher training program it will support are still very much in progress.

As this program continues to develop, we will be looking for feedback and collaboration to assure that the personal finance economics content and the student engagement and learning are each accomplished as well as possible. If you are interested in participating or simply staying in touch as the project moves forward, please let us know and keep in touch. Such collaboration is essential for this project to achieve its full potential.



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## **Modeling & Managing Your Personal Finances**

### **Syllabus**

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#### **I. Objectives - The goals of this course are twofold:**

- A. On a “content” level, students will develop an understanding of key “systems” that affect personal finance: income & expenditures, savings, investment, risk, debt, and inflation; and
- B. Through an introduction to system dynamics modeling (computer simulation), students will develop an enhanced capacity to explore, simulate, communicate, and evaluate strategies with which to better manage their personal finances.

#### **II. Course Description**

The course will be structured around building “generic” system dynamics models that capture the fundamental structures [stock(s), flow(s), feedback(s)] for each of the noted “key” systems. Model construction will focus initially on the “simplest” of these structures and progress from those to more complex systems. In each case, students will be expected to build appropriate models, simulate their behaviors under different conditions, and then share particular insights with fellow classmates. Over the progression of the course, students will integrate these smaller component systems with the intent, at the conclusion of the course, of identifying a strategy for achieving a particular and personally defined objective.

#### **III. Grading**

##### **A. Assignments:**

1. There will be weekly assignments, distributed each Tuesday, that need to be completed no later than the following Friday at 3:00 pm; some time will be provided during Thursday’s class to work on the assignment. Each assignment will have a computer model to construct and its output to discuss.
2. A final assignment will utilize no fewer than four (4) of the key structures mentioned earlier; and will involve the submission of a model and an accompanying paper describing a personal finance goal and the manner in which the model was useful for addressing that goal.

##### **B. Grading:**

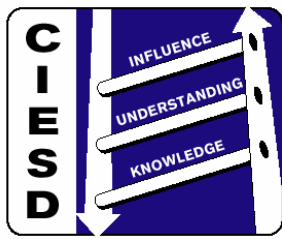
Weekly Assignments (5 @ 10% = 50%) + Final Assignment (30%) + Class Participation (20%)

#### IV. Schedule

Week 1:	Course Introduction	
Week 2:	Introduction to STELLA; Linear Income & Expenditure	Assingment 1
Week 3:	Savings (and compound interest)	Assignment 2
Week 4:	Investment (and risk)	Assignment 3
Week 5:	Debt (revolving and installment)	Assignment 4*
Week 6:	Inflation	Assignment 5*
Weeks 7-9:	Development of Personal Models	Assignment 6*
Week 10:	Complete/Present Final Models	

\* *NOTE added after course:*

*Assignment 3 was revisited due to some misunderstanding on the instructors' expectations. That repeated Investment assignment was given the designation of "Assignment 4" and was then followed by "Assignment 5" (Debt) and "Assignment 6" (Inflation), the original Assignments 4 & 5, respectively, prior to moving on to the Personal Models.*



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## Modeling & Managing Your Personal Finances

### Assignment 1: Introduction to STELLA; Linear Income & Expenditure

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Assignment Objective: This week's objective is two-fold:

1. Provide an introduction to the basic mechanics of building a STELLA model and defining its output; and
2. Build an initial, simple finance model of income and expenditure that will allow exploration of the interaction of stocks and their inflows and outflows, and that will serve as a foundation for some of the following models.

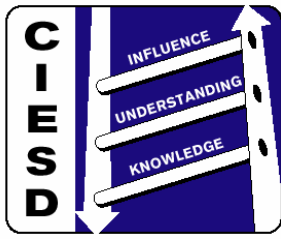
Steps in the Process:

1. Explore MSST Lessons 1 and 2 on the mechanics of building simple models of linear behavior. MSST is available on the school's server.  
*[NOTE added after the course: the Introduction and the first 3 Lessons (of 17) of MSST are available for downloading from: [http://www.ciesd.org/influence/demo\\_dozen.shtml](http://www.ciesd.org/influence/demo_dozen.shtml) ]*
2. Build a simple model of a checking account. Necessary components are:
  - A **stock** that is your account balance; its initial size should be 500 (dollars).
  - A **flow** of monthly income; say, for the sake of argument, that that is 600 (dollars/month).
  - A **flow** that combines various monthly expenses; again say for the sake of argument that those expenses are: Rent (\$200); Food (\$150); Utilities (\$75); Transportation (\$100); and Incidentals (\$50).
3. Run the model for a simulated year and provide us with the model structure, output (tabular and/or graphical), and a brief but complete description of what's happening over time.
4. Modify the original model so that monthly rent is now \$250 with all other elements remaining the same. Run again for a year and provide us with its output and a brief interpretation of what's happening and how it is different from the first run.
5. As part of your interpretation of the second model run, describe two ways you could try to solve the problem in which you find yourself in the second scenario.

Turn in by the Due Date:

1. Basic model structure
2. Output from the two defined scenarios
3. Written interpretations of both scenarios and your possible solutions to scenario 3

This assignment can be turned in as written material or submitted to us electronically.



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## Modeling & Managing Your Personal Finances

### Assignment 2: Savings (& Compound Interest)

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Assignment Objective: This week's objective is two-fold:

1. "Compound" or "Self-reinforcing" growth is a very common and very powerful element of many systems, not the least - financial ones. We need to provide you opportunities to explore and come to comfortably understand this dynamic; and
2. Build an initial, simple model of an interest-bearing savings account and use that model to explore the significance of:
  - Interest "rate,"
  - Duration of interest compounding, and
  - Interval of compounding.

Steps in the Process:

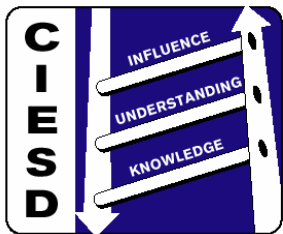
1. Explore MSST Lesson 3 on the mechanics of building simple compounding models. MSST is available on the school's server.  
*[NOTE added after the course: the Introduction and the first 3 Lessons (of 17) of MSST are available for downloading from: [http://www.ciesd.org/influence/demo\\_dozen.shtml](http://www.ciesd.org/influence/demo_dozen.shtml) ]*
2. Build a simple model of a savings account. Necessary components are:
  - A **stock** that is your account balance; its initial size should be 500 (dollars).
  - A **flow** of annual interest income (you will need to define this as a mathematical equation, once the entire model is built);
  - A **converter** of annual interest rate; and
  - Necessary **connectors** for moving the information of the system from place to place.
3. Define a range of 'reasonable' annual interest rates based on what banks or savings and loans are (or have historically been; your parents might have memories of these values that would be useful!) available now for passbook savings accounts and Certificates of Deposit, Savings Bonds, and other interest-bearing accounts. Don't spend a huge amount of time on this, but in your write up, provide us with the source of your information.
4. Run the model for a simulated 20 years (use a DT, in the Run Specs, of 1) using a low interest rate, and provide us with the model structure, output (tabular and/or graphical), and a brief but complete description of what's happening over time. Remember to lock the graph or table as appropriate to save results before moving on to new challenges in this assignment.

5. Modify the original model so that the annual interest rate is 50% greater than for your first run, with all other elements remaining the same. Run again for 20 years and provide us with its output and a brief interpretation of what's happening and how it is different from the first run.
6. With the second scenario, change the DT to 1/12 (for interest that is 'compounded' monthly). Does that make a significant difference? What about a weekly compounding interval (DT = 1/52)? What about daily compounding (there's a pattern here; figure it out)? You don't need to save and present these graphs, but let us know what total account balances you have after 20 years in each scenario.
7. Modify this model one last time: add a second inflow to represent an annual deposit and start with an initial balance of zero. Your account will now have two inflows, one representing interest and one representing deposits. Define a middle of the road interest rate and then, through trial and error, define an annual deposit that will result in a balance of \$1,000,000 after 20 years. Being a millionaire after 20 years is your goal! How much did you have to deposit in total over those 20 years to achieve that goal? Now increase the interest rate to the highest value that you were able to identify. What annual deposit would you now have to make to reach \$1,000,000 in 20 years?

Turn in by the Due Date:

1. Basic model structures;
2. Outputs from the defined scenarios;
3. Written interpretations of all scenarios.

This assignment can be turned in as written material or submitted to us electronically



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## **Modeling & Managing Your Personal Finances**

### **Assignment 3: Investment**

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Introduction: Investment is, in some ways, a variation on “savings,” with, however, some very significant differences. Among those differences are:

- A potentially greater yield than with traditional savings accounts;
- A potentially lower yield than with traditional savings accounts, even to the point of your investment losing value, not just growing slowly;
- A possibility that yields will vary considerably from year to year (even week to week).

At the heart of those differences is the matter of “risk” that is minimal to nonexistent in most savings accounts, certificates of deposit, and high quality bonds.

As a case in point, consider the data below from the on-line reporting of TIAA-CREF, an investment and insurance company that serve educators and others from non-profit businesses. The range of options is wide (and other companies will have even more options!); the range of yields is wide between options; and within an option, the performance changes over time.

Basically the “game” you “play” with investments is to balance between yield (profit) and risk. Typically, a higher potential yield carries with it a higher risk. The too-good-to-be-true investment invitation that claims: “YOU CAN DOUBLE YOUR MONEY IN A YEAR!” usually carries with it, buried-in-the-fine-print, the other option: “OR LOSE IT ALL IN THAT YEAR!”

Assignment Objective: Build a set of STELLA models to explore the interaction of yield and risk and demonstrate your understanding of those trade-offs.

## Retirement Investments

### Performance Chart

### 5-day unit values

Retirement Annuities, Supplemental Retirement Annuities and Keoghs. [Click here](#) to view IRA performance.

CREF Variable Annuities	Performance Data <sup>1</sup> as of 12/10/2004			Average Annual Total Returns <sup>1</sup> as of 11/30/2004			
	Unit <sup>2</sup> Values	Net <sup>3</sup> Chng	YTD <sup>3</sup> Return	1 year	5 year	10 year	Since <sup>4</sup> Inception
<a href="#">Stock</a>	\$186.54	▼ -0.07	9.73%	14.62%	-0.86%	10.33%	10.48%
<a href="#">Global Equities</a>	\$74.76	▼ -0.15	9.56%	15.83%	-2.90%	7.56%	8.78%
<a href="#">Growth</a>	\$57.44	▼ -0.22	4.74%	5.51%	-9.08%	8.13%	7.95%
<a href="#">Equity Index</a>	\$76.41	▼ -0.01	9.02%	12.65%	-0.95%	11.46%	10.98%
<a href="#">Social Choice</a>	\$107.04	▼ -0.03	7.50%	9.34%	2.48%	10.53%	10.26%
<a href="#">Bond Market</a>	\$74.70	▲ 0.02	4.16%	4.23%	7.31%	7.47%	7.63%
<a href="#">Inflation-Linked Bond</a>	\$44.94	▼ -0.10	7.16%	7.33%	9.84%	--	7.64%
<a href="#">Money Market<sup>5</sup></a>	\$22.00	0.00	0.92%	0.94%	2.78%	4.08%	4.84%

### TIAA Variable Annuities

<a href="#">Real Estate</a>	\$208.23	▲ 0.20	11.39%	11.72%	7.97%	--	8.13%
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TIAA Traditional Annuity	Current <sup>7</sup> Rates	Rates of Return ending 11/30/2004 <sup>6</sup>			
		1 year	3 year	5 year	10 year
<a href="#">Retirement Annuity</a>	4.50%	4.75%	6.25%	6.90%	7.07%
<a href="#">Supplemental Retirement Annuity, IRAs, and Keoghs</a>	3.25%	3.25%	5.75%	6.39%	6.57%

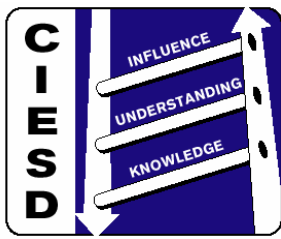
[View performance as of the prior quarter-end](#)

**The performance data quoted represents past performance, and is no guarantee of future results. Your returns and the principal value of your investment will fluctuate so that your accumulation units or shares, when redeemed, may be worth more or less than their original cost. Current performance may be lower or higher than the performance quoted above.**

**You should consider the investment objectives, risks, charges and expenses carefully before investing.**

### Steps in the Process:

1. Build a simple “savings” model similar to last week’s models (Assignment 2). Start with an initial stock of \$1,000 and allow it to accumulate interest at a constant rate (use a converter, “interest rate,” to define that interest at say 5% annually). Set the interest to compound annually. Run for 10 years.
2. Duplicate that model (copy and paste so that you have two equivalent models on the page). Name the new stock INVESTMENT ACCOUNT BALANCE. Change the flow to a biflow (name it appropriately) and rename the interest rate converter “investment yield.” Define that converter to be “RANDOM (-.02, .14).” This means that STELLA will choose a value randomly between  $-0.02$  and  $+0.14$ . The average interest will be  $0.06$  (greater by a bit than the safe savings interest rate), but the rate can vary widely, even to below 0, where you will lose money.
3. Run the two models, graphing the two stocks on the same set of axes. Print the result and explain briefly what is happening; why are the two lines different?
4. Now run the model 19 more times; each time you run it, note which account has the most money at the end of 10 years. Probably a better way to do this is to define a Comparative Table to tabulate the Investment Account Balance. If you have noted the final balance from the Savings Account, you can then go back and define the number of times the Investment Account “wins,” what the average final balance is in the Investment Account, and what the range is between best and worst Investment performances.
5. Using that tabulation scheme, what will be the results (number of “wins,” average investment ending balance, and range of investment ending balances) if you:
  - a. Decrease the converter’s Random minimum by 0.02 and increase its maximum by 0.02.
  - b. Increase both the minimum and maximum by 0.01.
6. Report your findings to us as usual. We’ll come back together in the next class, explore any of these that gave you trouble, and look at the implications of this investment option for meeting shorter term (e.g. 2 year) savings goals.



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## **Modeling & Managing Your Personal Finances**

### **Assignment 4: Investment (revisited)** (© 2004, 2008 CIESD, LLP)

**Introduction:** To date your collective homework demonstrates your ability to build and use relatively simple models to explore some important topics and life skills. These topics in personal finance include income and expenditure, saving, and investment. That homework to date also points out some areas of general weakness, particularly in the area of “clear presentation.” We (Jeff and John) can take some of the responsibility for that, since we were not as specific in describing our expectations as perhaps we should/could have been. That clarity, however, is critical if these models are to be shared with others, not the least important of whom are your instructors who have to be able to evaluate your work and help you improve it.

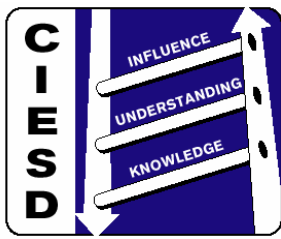
We’d like to suggest that a ‘common’ structure for reporting and reflecting on such modeling efforts can provide a useful aid for your presentation of its results without being so lock-step as to be stifling of your creativity. To that end (fostering better presentation) we need to depart slightly from our original plans (and the syllabus) and ask you to explore again the relationship of savings and investment, using that common structure. We’d like to make this interesting and challenging (rather than “punitive”), so we’ll spend some time in class exploring and justifying that template and then pose a relatively simple question for you to explore.

**Template:** We’ll spend a bit of time projecting and justifying our idea of a good presentation template (see following page for a brief summary of that).

**Homework:** Below is a basic structure to serve as a starting point. Even without too much documentation you should be able to decipher it. You will have both a savings account and an investment option available to you. Each year you can ‘put away’ \$6000 (the difference between your earnings and your expenses). You can put all or some of it into “Savings” at a fixed interest rate; you can put the remainder (or all of it) into an investment that has a comparatively quite variable yield.







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## Modeling & Managing Your Personal Finances

### Assignment 5: Debt

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Assignment Objective: Debt is a variation on the type of accounting we have already explored where you had to keep track of both linear and exponential processes. In the past these have both been “growth” processes where deposits and savings interest (or investment yield - mostly) have added to your account. This week’s objective is to explore two variations on consumer debt:

1. Credit card (or “revolving”) debt typically requires you to make a “minimum” monthly payment but, beyond that, you have a great deal of freedom in how you pay off the debt. We’ve illustrated this dynamic for you earlier in the course (the Credit Card exercise in Demo Dozen: [http://www.ciesd.org/influence/demo\\_dozen.shtml](http://www.ciesd.org/influence/demo_dozen.shtml)). We’ll guide you here to build a simple representation of such a credit card account and direct you to explore the implications of a variety of repayment schemes. Here your basic choices define how much, if any, above that minimum payment you choose to pay. Depending on you choices, you can take greater or lesser time to pay off the debt and, as a consequence, pay greater or lesser amounts to the bank beyond your original obligation (debt).
2. Purchase of a larger item (like a car, boat, or home) is often accomplished by taking out an “installment” loan. These loans typically are set up so that you are expected to make a fixed number of equal payments (typically at monthly intervals over periods of 2-6 years, for boats and cars, and 15-30 years, for homes). Repayment of college loans typically is set up like this, as well. Here your basic choices arise when you agree to the ‘terms’ of the loan: amount borrowed, duration, and interest rate.

#### Steps in the Process:

##### Credit Card Debt:

1. Build a simple model of credit card debt. Necessary components are:
  - A **stock** that is the amount of your CREDIT CARD DEBT; its initial size should be 2000 (dollars). For simplicity we’ll at least start with a single purchase that you will pay off before you use the credit card again. That’s NOT typically how credit cards are used, but that’s a good starting place for our exploration; you may wish to build a more complex/realistic model of this as part of your independent project.
  - A **flow** of monthly payments (will this be an inflow or an outflow in relation to the stock?). Again, for simplicity, let’s assume that you WILL make the bank’s required minimum payment each month; you MAY, if you choose, make a constant additional payment each month as well.

- For this flow, you will need to utilize a **converter** that defines that minimum monthly payment (that varies from bank to bank, but the value that we used a couple years ago was 2.1% of the outstanding debt or \$10, whichever is greater, each month). That 2.1% OR \$10 ‘choice’ will require a new feature; you can define that flow as:  $\text{MAX} ( (\text{CREDIT CARD DEBT} * .021), 10)$
  - You will need a second **converter** to allow you to define any optional constant additional monthly payment.
  - Another **flow** of added debt (inflow or outflow?), as the bank charges you monthly interest for the ‘privilege’ of not having to pay the entire bill at once.
    - That additional monthly interest charge will require a **converter** for its definition. Again this varies from bank to bank, but for our purposes a monthly interest rate of 1.5% per month (18% annually) will work fine. Recall, in decimal notation that = 0.015.
  - A number of **connectors** for moving the information of the system from place to place will also be required.
  - An additional **stock** will be very useful for bookkeeping purposes here. Add another stock called “TOTAL PAYMENT” and feed it with the flow of monthly payments that you’ve already defined. What this will do is simply keep track of the total payments you’ve made in the process of paying off this credit card debt.
2. Take a crack at building this model. Set it up to run for 360 months (30 years!), and show it to your instructor when you think you’ve accomplished it (or gone as far as you can). We’ll have a hand-out that illustrates our version of this model and we will walk you through any particular difficulties you were having.
  3. Once the model is built and approved by an instructor, take your initial \$2000 debt and pay it off (a comparative graph and/or table will be useful here, but think carefully about which stock or flow you want or need to follow over that period of time):
    - Using just the minimum payment,
    - Using the minimum payment PLUS some additional constant monthly payments.
  4. Present to your instructor your model, these runs, AND a discussion of what you have discovered about how different repayment strategies affect:
    - The time it takes to pay off your debt, and
    - The total amount of dollars you need to pay in that interval to pay off the original \$2000 debt.

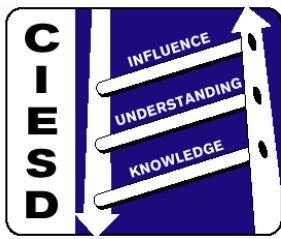
## Home Mortgage:

5. Duplicate the credit card model (lock all its graphs and tables). We'll use a formula to define the monthly payments; this is a standard formula used by the finance industry and it equates number of monthly payments, monthly interest rate, amount borrowed, and required monthly payment. If you know three of those, you can calculate the fourth. Here we will define the first three and allow STELLA to calculate the fourth.
  - Rename the CREDIT CARD DEBT stock to MORTGAGE DEBT.
  - Delete the two **converters** that were used to define the monthly payments.
  - Replace them two different **converters**:
    - Number of payments
    - Amount borrowed (this should be the initial size of debt)
    - **Connect** those two new converters AND the old "monthly interest rate" converter into the Monthly Payment flow.
    - Define the Monthly Payment flow as:  
$$\text{amount\_borrowed} / ((1 - (1 + \text{monthly\_interest\_rate})^{(\text{number\_of\_payments} * (-1))}) / \text{monthly\_interest\_rate})$$
6. Define a mortgage as follows:  
Amount borrowed: \$200,000  
Monthly Interest Rate: 0.005 (6% on an annual basis)  
Vary the Number of Payments from 180 (15 year mortgage), 240, 300, and 360 (use comparative graphs and/or tables)
7. Again, work through this as far as you can on your own; come to an instructor when you think you have solved the programming problem; we'll have a hand-out for this as we did for the first section.
8. Discuss the required monthly payments and the total cost of each mortgage. Why would you choose a short mortgage? Why would you choose a long mortgage? Think about it; rational people make both decisions, so neither is right nor wrong but each meets particular needs that different folks might have.

## Turn in by the Due Date:

1. Basic model structures
2. Outputs from the defined scenarios
3. Written interpretations of all scenarios.

This assignment can be turned in as written material or submitted electronically



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## **Modeling & Managing Your Personal Finances**

### **Assignment 6: Inflation**

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Assignment Background: Income and expenditure, interest, investment yield, and debt are all aspects of finance that have fairly tight boundaries that surround YOUR resources and interests. Fortunately, or unfortunately, none of us live as financial hermits in our own little self-sufficient bubbles. Our income, expenditures, investment earnings, and debts all exist connected to larger economic systems. One of the most important aspects of that larger system is what we refer to as “inflation.” That’s something that happens in the larger financial world almost entirely regardless of our individual efforts. Inflation is, at the surface at least, the manner in which the price of goods and services change (most commonly increase!) over time. We often think of that in terms of a “market basket.” What do I need to buy to maintain my life style? That’s a market basket of goods and services: food, transport, housing, utilities, entertainment, education, insurance, medical care, ... , and so on. If inflation is measured at an annual rate of 4%, then a market basket of goods and services that costs \$100 today will cost \$104 in a year, \$108.16 in two years, and ever more with each passing year (this is a compound growth problem that you should be quite familiar with after the earlier compound interest lesson). If your income is growing at or faster than 4% per year, well and good; if it’s growing at a lower rate, then purchasing that market basket gets more and more difficult each year. Retired folks living on what is called a “fixed income” frequently experience this pain of decreasing buying power, despite a reliably constant, or even slowly growing, income from pension and social security.

Another way of thinking of inflation is to think of the “current value of money.” This is the flip side of the cost of a market basket. \$100 today will purchase a full market basket. \$100 next year will only purchase 96% of those goods and services. In one way of thinking about it, your current dollar is only worth 96% of last year’s dollar. Next year’s dollar will only be worth about 92% of your original dollar. For purchasing stuff, that’s unfortunate, but for paying off a debt there might be an advantage! The dollar you pay today, for a purchase made two years ago, is really only worth 92¢! If that’s a hard concept to first wrap your mind around, don’t feel too bad; many adults, including corporate and political leaders who really NEED to understand that, don’t really GET it! However, that’s no excuse for you not to get to a point where you’re comfortable with the ideas. Ultimately everything you do financially only has value relative to how the costs of goods and services (the value of your money) are changing. Getting 10% interest on your savings sounds good, but, if inflation is running at 15%, your account is losing “buying power” as each month passes!

Assignment Objective: We’d like you to revisit two previous topics (interest income and debt payments) and put each of them into the context of a larger system in which inflation is operating.

### Assignments:

1. Assume, when you were born, that your rich Uncle Phineas determined that four years of a Harvard education would cost \$100,000 (\$25K per year – tuition, room & board, books, travel, incidentals. That may not be accurate, but it has the virtue of being a nice round number!). He deposited that much in your name into an insured savings account earning 4% per year.

- a. Build a STELLA model that will tell you how much will be in the account when you are ready to enroll at age 18.
- b. Build a second STELLA strand that calculates the changing cost of that Harvard education, given a constant inflation. You will need a Stock (“Cost of Harvard Education”; you should be able to define its initial value) and a flow labeled “annual increase in cost” (is that an In- or an Out-flow?). Assume that the cost inflates at a constant annual “education inflation rate.”
- c. How well will that education fund meet your needs in each of the following three scenarios:
  - Annual “education inflation rate” = 4%
  - Annual “education inflation rate” = 6% (still a bit optimistic! Education inflation is almost always greater than general inflation.)
  - Annual “education inflation rate” = 8% (that’s not too pessimistic a projection).
- d. So what’ll you (or your parents) do to deal with the possibility of the latter two scenarios?

2. Lock your output from the first exercise!

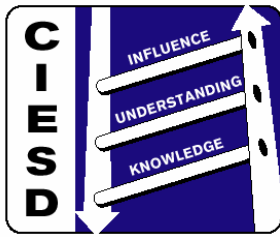
3. Now let’s look at the impact of inflation on debt. Assume that, since Uncle Phineas’ fund didn’t pay the entire Harvard bill, you borrowed money to make up the difference. For the sake of simplicity, let’s assume that to pay off that debt, you need to pay \$100 a month for the 10 years following graduation (that’s actually a pretty modest educational debt!). Again, just picking round numbers out of the air, assume you get a job on graduation that begins paying you \$2,000 a month and that for the next ten years you can count on “cost of living” raises to keep up with the overall inflation rate. Build a STELLA model that will calculate your monthly income over 10 years. What portions of your total income will that \$100/month loan repayment represent over the 10 year period (HINT: you can get STELLA to do this calculation for you continuously as the model runs!), if the overall inflation rate (and the equal growth rate of your income) is:

- 3%?
- 6%?
- 10%?

### Turn in by the Due Date:

1. Basic model structures
2. Outputs from the defined scenarios
3. Written interpretations of all scenarios.

This assignment can be turned in as written material or submitted electronically



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## Modeling & Managing Your Personal Finances

### Final Project Guidance

### “MAPPING OUT” YOUR PERSONAL FINANCE MODEL

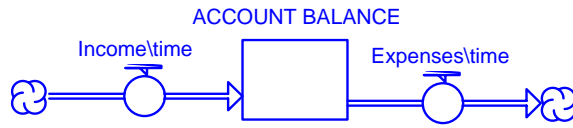
(© 2004, 2008 CIESD, LLP)

For those of you who have completed the six homework assignments and are ready to begin building your own personal finance model, your first challenge (after having clearly identified the “problem” you wish to examine) involves identifying the model “pieces” that you’ll need in order to construct your model. **BEFORE** attempting any construction on the computer, you need to create a “map” on a piece of paper (THINK first before going to the computer!) that:

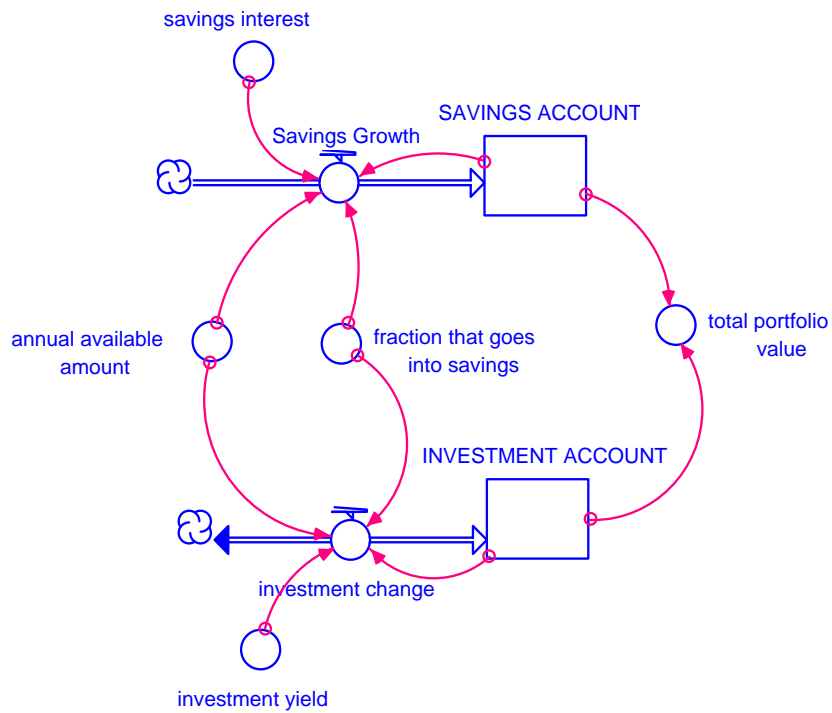
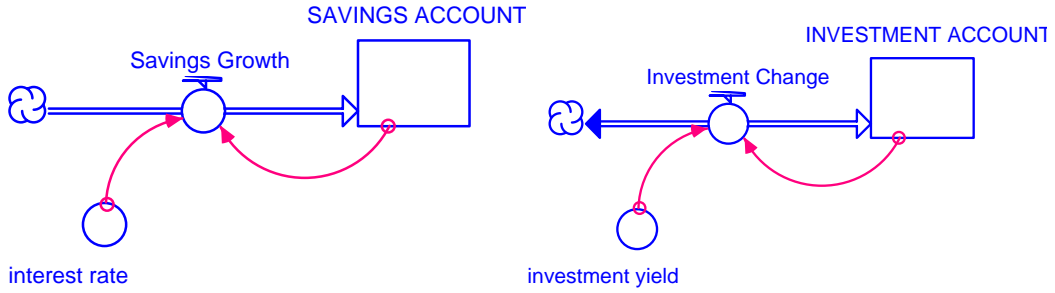
- (1) Identifies essential “little models” addressing particular aspects of your personal finance problem and then
- (2) Adds, if necessary, additional elements (e.g., connectors and converters) that might be needed to tie these little models together to address your particular question.

To assist you (and to help with memory lapses), we’ve provided (below) the collection of “little models” that you developed in the six homework assignments. Use these to help in building your personal map; then **SHOW YOUR INSTRUCTOR** your map and explain how you see the model “working” to answer your problem. Once you’ve convinced us you’re ready to “build” on the computer, we’ll give you the go ahead. Good luck!

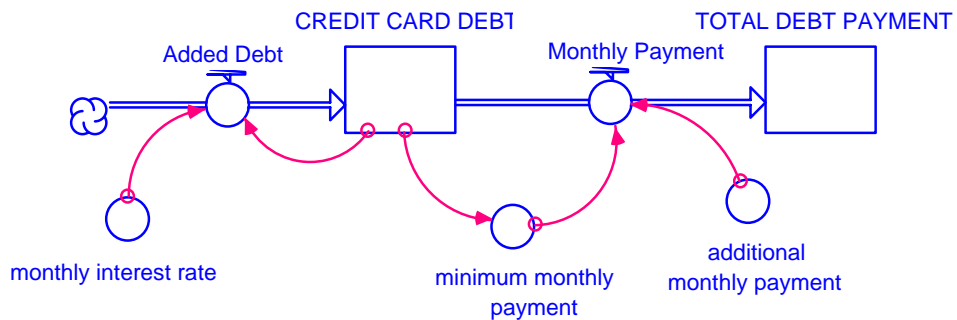
## Account income and expenses



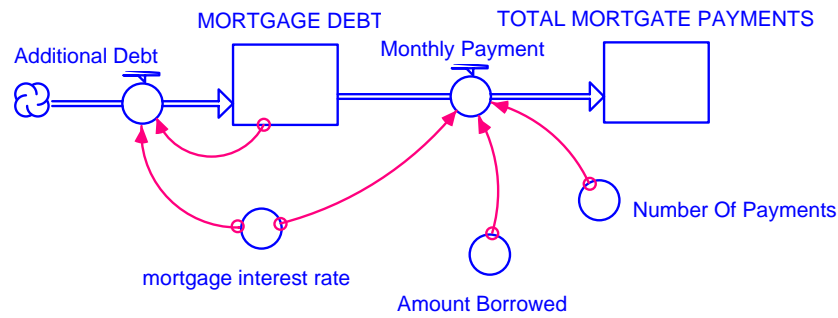
## Savings and Investment



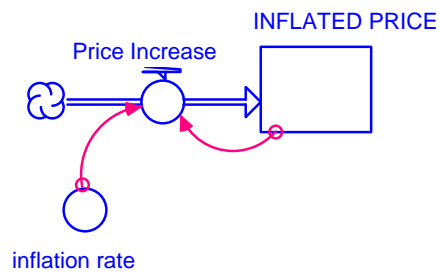
## Credit Card Debt



## Mortgage Debt



## Inflation



### PERSONAL FINANCE MODEL (Share This with Your Instructor)

Briefly summarize “purpose” or “problem” you intend to examine:

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List “small models” needed to address this problem:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_

Then, complete the next page BEFORE beginning any computer work.

**MAP OF PROPOSED MODEL (share with and get Instructor's approval before beginning computer work):**