ENGINEERING SYSTEMS ANALYSIS FOR DESIGN

Final Examination, 2003

Item	Points			
	Possible	Actual	Extra Credit	Achieved
Your Name	2			
1 Communications Net	29			
2 Optimizing Layout	27			
3 System Design Change	20			
4 Fuel Cell Tests	25		10	
5 Concepts	21			
6 What's it worth?	41			
7 Use of Real Options			25	
SUBTOTALS	165		35	
TOTAL (Actual + Achieved)				
GRADE ON 100% (TOTAL/1.65)				

Your Name: _____ (2)

Note: The points for each problem and sub-problem are marked in parentheses. They correspond to the amount of time you might spend on them.

You might want to use these as a guide for how you should spend your time. It may not be smart, for example, to spend 10 minutes on a 3-point problem if you are pressed for time.

You may find it worthwhile to turn to the section that is easiest for you, and to do that section first. No need to respond to questions in the order presented.

1 COMMUNICATIONS NET (29)

Assume that there are 3 ways to assemble a communications system. Each uses switches and channels in different combinations. Each has its own cost and productivity. See Table below.

System Concept	**Switches**	**Channels**	**Output (M msg/day)**
"Satellite"	100	200	60
"Cellular"	100	50	30
"Central Office"	200	240	80
	$ 300/day each	$120/day each	

a) Define an isoquant (3)

b) Plot isoquant for 60 M msg/day (6)

c) Define "marginal rate of substitution" (MRS) (3)

d) Determine MRS as completely as feasible from above data (6)

e) Define and Contrast Economic and Technical Efficiency . (5)

f) What is the price for switches that justifies the use of the "Cellular" concept? Assume cost of channel capacity is fixed. (6)

2. OPTIMIZING LAYOUT (27)

Assume that there are 3 ways to assemble a communications system. Each uses switches and channels in different combinations. Each has its own cost and productivity. See Table below.

System Concept	**Switches**	**Channels**	**Output (M msg/day)**
"Satellite"	100	200	60
"Cellular"	100	50	30
"Central Office"	200	250	80
	$ 300/day each	$120/day each	

Your company needs to distribute 300 M msg /day.
They have available 100 switches and 100 channels, and must pay for these in any case.
The company could (if it wanted to) buy up to 700 more switches and 500 additional channels. They wish to minimize their costs.

a) What are the decision variables? (5)

b) Formulate as a linear programming problem. (14)

c) Explain why this problem could (or could not) be formulated as a linear program if the cost of additional channels above 500 were less than the normal rate of $120 per day. (4)

d) Suppose the company now recognizes that, to implement the "central office" concept, they have to buy a building that would cost $1,000 day plus $100 per 1 M msg/day. Could a linear program handle this possibility? Explain reasoning. (4)

3. SYSTEM DESIGN CHANGE (20)

Your company produces lawnmowers. You find that the California Environmental Protection Agency requires new standards for the lawnmowers your company sells in that state. You must modify this product to maintain your market position.

Your engineers tell you that you have 2 choices. One involves additional insulation using known technology, and should meet the California requirements. The other pioneers fuel cell technology that might fail to meet the California requirements but could, if successful, position you to jump ahead of your competition significantly. See Table below.

Approach to System Design	**Possible Results of Design Approach -- probability and financial return**		
	Failure	**Good Product**	**Great Success**
Standard	0.25	0.75	0
Fuel Cell	2/3	0	1/3
	Loss of $24 million	$16 million profit	$60 million profit

a) Draw decision tree for company's choice, showing all outcomes and probabilities. (6)

b) Which approach is the better? Assume company will base decision on expected profit. (4)

c) Define the concept of "expected value of perfect information" (EVPI) (4)

d) Calculate the EVPI for perfect information from tests focused exclusively on the outcomes of the "Fuel Cell" approach (6)

4. FUEL CELL TESTS (25)

You could pay $1 million to a lab research that would run tests on the Fuel Cell technology. You believe, based on your experience with this lab, that the lab anticipates future outcomes correctly 80% of the time (that is, for example, the lab will report "failure" 4/5 of the times when failure occurs). With their information, you would revise your prior estimate of the probability of success for the Full Cell technology, displayed in the Table from Problem 3:

Approach to System Design	**Possible Results of Design Approach -- probability and financial return**		
	Failure	**Good Product**	**Great Success**
Standard	0.25	0.75	0
Fuel Cell	2/3	0	1/3
	Loss of $24 million	$16 million profit	$60 million profit

a) Explain what Bayes' formula does. (4)

b) Write Bayes' formula (4)

c) What is the estimated probability of failure for the Fuel Cell approach, if the lab predicts failure? Show calculations that justify this conclusion (8)

d) What is the estimated probability of "great success" for the Fuel Cell approach, if the lab predicts great success? Show calculations that justify this conclusion (4)

e) Define "expected value of sample information" (EVSI) (5)

EXTRA CREDIT Calculate the EVSI for the lab investigation of the Fuel Cell process. **(10)**

5, CONCEPTS (21)

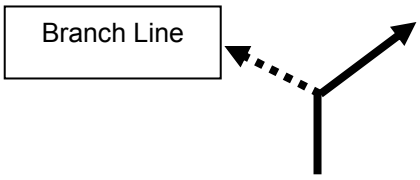
a) Valuations issues: What is the meaning of diminishing marginal value? How does the "threshold effect" influence the valuation function? What is risk aversion? (9)

b) Describe the CAPM. What concept of value justifies this model? (6)

c) Describe the lattice method for representing the evolution of a future state of some variable (such as the price of a stock). What are the computational advantages of this approach to representing future states? (6)

6. WHAT'S IT WORTH? (41)

A pipeline company is designing an undersea pipeline to an off-shore field. It anticipates the possibility that this line could be used in a neighboring field. The basic design thus calls for a **Y** shaped layout, where the single line from the shore has a branch to the second field. See diagram.



The company could install the branch now at an extra cost of $18 million. If the prices and quantity of crude justify the full exploitation of the second field, the branch pipeline would be worth $40 million. However, there is a good chance, maybe 2 in 3, that the oil companies would only develop part of the second field, in which case the branch pipeline would be worth only $10 million. These results would occur two years from now.

Alternatively, the company could lay a line to a single field, and enable the possibility of the branch link to the second field by creating in advance a Y-junction in the pipeline. If the oil companies decide to develop the second field, the pipeline company would then, in two years, have to pay $20 million to lay the branch line.

a) Define an option (4)

b) What kind of option is does this situation suggest? Explain your answer. (4)

c) Draw a diagram showing the payoffs from the option in this venture. (4)

d) Define the concept of arbitrage enforced pricing of options. (5)

Now you need to assess the value of the Y-Junction so that the Chief Designer for the Pipeline can decide whether this addition to the basic system is worthwhile.

You may assume for this exercise that:

- It will take 2 years to know if the second field will be developed and thus the value of pipeline;
- Similarly the value of the pipeline ($40 or 10 million) and the cost of $20 million for later construction will arise in 2 years;
- The pipeline could be sold to other companies at the stated values;
- The discount rate for the company is 15% annually; and
- The risk-free rate is 5% annually.

e) Calculate the value of the option using decision analysis (5)

f) Calculate the arbitrage enforced price for the option on this project. (15)

g) Discuss and explain the similarity or difference you get between the value of the option given by the decision analysis and by the arbitrage enforced pricing analysis. (4)

7. USE OF REAL OPTIONS (25)

In your field of professional interest, define a significant "real option" that might be worth using for improving the expected performance of a system in which you are professionally interested.

a) Describe this example (5)

b) Is this option: a put or a call? European or American? “in” or “on” the system? (6)

c) Identify the cost of acquiring the option (3)

d) Define the cost of exercising the option (3)

e) Define the conditions that would make it worthwhile to exercise (3)

f) Outline how you might go about analyzing the value of this option, indicating the factors that would lead you to prefer one approach over another (5)