USC ASTE-523 -- Spring, 2023
The Design of Low-Cost, Responsive Space Missions
A Near-Term, Income-Generating, Lunar Settlement

Homework Set #2 -- Due 2/2/23

Please note:

Homework Questions should be turned in to the TA, Kevin Sampson, via the DEN website as described in the message from Kevin.

This homework set concentrates on the issues of money and how costs vary with time and how things are built. We've allowed two weeks for this homework to allow more time to work on the Final Report outline in Homework #3.

Here's the real homework for the week:

1. Explain in your own words the difference between inflation and the time value of money.

Inflation is a change in the value of the dollar, i.e., the relative cost of goods remains unchanged. The time value of money is the cost of borrowing money (or the payment for lending it), irrespective of inflation.

2. Assume that the USC Astronautics Department (ASTE) gets a $1,000,000, 5-year loan at 12% interest to buy new computers and equipment for professors to work at home during the COVID crisis. (It is likely that the professor's equipment is better than the DEN equipment, but we'll ignore that.) Construct an amortization table of the payback of the loan, assuming 5 equal annual payments. What is the annual payment amount and the total cost of the equipment (principal plus interest)? What would be the payment cost and the total cost of the equipment if they could get the same loan at 6% interest. Assuming the new equipment would save ASTE $250,000/year, but was worthless and discarded after the 5 years, would it have been a worthwhile investment for ASTE to buy the equipment at 12% interest? Would it have been worthwhile at 6% interest?

Amortization Table

Amount	$1,000,000
I	12.00%
N	5
fraction	0.277409732
Payment	$ 277,409.73
Total cost	1,387,049

Amortization Table

Step	Payment	Interest	Principal	Balance
0				$1,000,000.00
1	$277,409.73	$120,000.00	$157,409.73	$842,590.27
2	$277,409.73	$101,110.83	$176,298.90	$666,291.37
3	$277,409.73	$79,954.96	$197,454.77	$468,836.60
4	$277,409.73	$56,260.39	$221,149.34	$247,687.26
5	$277,409.73	$29,722.47	$247,687.26	$0.00
Totals	$1,387,048.66	$387,048.66	$1,000,000.00	

Savings/yr	$250,000.00
Total savings	$1,250,000.00
Net savings	-$137,048.66

Amortization Table

Amount	$1,000,000
I	6.00%
N	5
fraction	0.2373964
Payment	$ 237,396.40
Total cost	$ 1,186,982.00

Savings/yr	$250,000.00
Total savings	$1,250,000.00
Net savings	$63,018.00

Worthwhile investment:	At 12%	No
	At 6%	Yes

3. Assume that we buy the first lunar settlement enclosure for $300 million. A. Assuming a Learning Curve of 90% for the entire enclosure, what would be the cost of the second enclosure? Explain why in words. B. What would be the average cost of the first four enclosures?

2nd unit cost = 80% of the TFU cost = $240 million, such that the average cost of the first two spacecraft will be 90% of the first spacecraft cost.

The average cost of the first 4 spacecraft will be 90% x 90% =81% = $243M

4. Assume that Sam's Catering and Memory (SCAM) builds low-cost computer memory for use in space for a Theoretical First Unit (TFU) cost of $50,000 and offers a quantity discount based on an 87% learning curve. What is the total cost, average cost per unit, and Nth unit cost for 1, 2, 10, 20, and 100 memory units? By what percentage have we been able to reduce the average cost/memory unit by buying 100 of them? If we keep the production line going and buy 20 more units as spares (i.e., after buying 100), what will be the average cost per unit for the 20 spare units?

TFU	$50,000
S	87%
B	0.799087306

N	Total cost	Nth unit cost	Average cost
1	50,000	50,000	50,000
2	87,000	37,000	43,500
10	314,816	25,420	31,482
20	547,780	21,998	27,389
100	1,982,187	15,855	19,822
120	2,293,070	15,283	19,109
		avg cost =	39.6%
		reduction =	60.4%

20 spares	310,883
cost per spare	15,544

5. It turns out that computer memory is a bit more complex than Sam had anticipated. If he is only able to achieve a 90% learning curve in the above problem, what is the average cost per unit of the 100 units? What is the average cost per unit of the following 20 spare units? For both the first 100 and the 20 spares, what would have been the percentage cost reduction (in average cost per unit) resulting from an 90% learning curve rather than an 87% learning curve?

Average cost per unit for 100:	$24,829
Average cost per unit for next 20:	$20,757
Percentage cost reduction (100):	50.3%
Percentage cost reduction (next 20):	58.5%

6. Program X was done in 2011 at a cost of $800 million. Program Y was done in 2021 at a cost of $900 million. Program Z is projected to be done in 2031 at a cost of $1 billion. All costs are in then-year dollars. What was the cost of each program in FY23$M? Which was the least expensive and by what percentage was it less than the cost of the most expensive program? (Use the inflation table in the course notes.)

Program X:	800 x 1. 2067 / 0.9850 = 980.06 million
Program Y:	900 x 1.2067 / 1. 2067 = 900.00 million
Program Z:	1,000 x 1. 2067 / 1.4906 = 809.54 million

Program Z is the least expensive by 17.4% relative to Program X.

7. A change in parties in either the House or Senate, will likely drive up the cost of current and near-term government space programs. Explain why this is likely to be the case.

The outgoing and incoming parties will have relatively little in common, particularly in 2023. This will lead to a strong desire for a re-examination of priorities and re-evaluation of the goals and the need for individual programs. This, in turn, will lead to both program changes and delays in decision making and delays increase the cost of any on-going or near-term programs.

8. Name 6 different business/activity areas that would want to be among the first on the Moon and why

Construction – building the settlements
Agriculture – raising food for settlers to eat
Tourism – want to be among the first tourists on the Moon
Doctors – want to monitor settlers and watch for and solve problems

Gravitational biologist – want to begin the process of gravitational biology
Sociologist – Want to understand how people interact
Diplomat – want to explain "Moon living" to Earthlings
Mining – want to start selling O_2 and He3
Exploration – want to start exploring the neighborhood

9. Compare the space hotel in low to medium Earth orbit with a lunar hotel on the surface of the Moon in terms of tourism. What are the principal advantages of the lunar resort. Are there any advantages of the LEO hotel for tourism? If so, what are they?

Advantages to the Moon:
- $1/6^{th}$ g no matter where you go
- Can be a large facility with room to walk or exercise
- Can go outside and walk or drive on the surface of the Moon
- Can watch the Earth at a fixed location overhead
- Can watch the Moon before and after the trip (easy to point out to others)
- Can search for interesting things that have been on the Moon for millions of years

Advantages to LEO
- Doesn't take as long to get there
- Probably lower cost

10. In your view, what is the reason or reasons that lunar settlements have not become popular destinations in the 50 years since Apollo?

There is no right answer here. It is simply a question of how well the participant presents and defends their answer. Main areas are likely:

- Lack if interest
- Lack of Money
- No one strongly advocating for going to the Moon
- No competition between countries