

Investment Exercise for First-Year Engineering Students

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Abstract

This paper describes a long running individual student project aimed to teach basic engineering economy concepts to the first-year engineering students. Engineering economy is not a required course for any engineering major at this university, but a junior level engineering economy course is offered as an elective by a graduate program in the engineering management and systems engineering department. This project is a part of a two credit-hour course in exploration of engineering and technology, and it, through this project, provides the only exposure to engineering economy for most of the graduates. Students used an imaginary sum of \$10,000 in making short-term investments in a mixture of stocks and a savings account. They learned how to calculate effective annual return using three methods: manual calculation, programming with MS Excel, and an on-line rate of return calculator.

Introduction

Time value of money (TVM) is an important concept for engineers. At the Old Dominion University, many engineering majors do not learn the TVM unless they choose to do an engineering management minor. This project-based investment exercise can be easily pedagogically justified by essential body of knowledge in favor of experiential learning [1] - [3], implementations of Kolb's experiential learning cycle (KLC) [4] - [6], and project-based learning (PBL), the pedagogy implemented frequently in early engineering education [7] - [9]. Furthermore, the importance of TVM is emphasized in many Engineering Economy textbooks [10], [11] and engineering education articles [12], [13].

Investment Project Description with Samples of Student Work

Figure 1 shows the description of the project using a partial notes format. Each student starts with a fixed imaginary sum of \$10,000 (P) to make a short-term investment within a semester. Up to \$5,000 of the P may be invested in a FDIC insured on-line high yield savings account (HYSA) that started paying 3.75 % annual APR in March 2023. Figure 2 shows the HYSA provider used for the project. This provider was mandated for all students. The rest of the P is invested in individual stocks.

As shown in Figure 1, nine stocks are provided from three sectors (aerospace, banking, and automotive) and each student is asked to select up to three stocks after a short online search as to what to pick by using the current online prices. The sum of the funds invested in the HYSA and the stocks must add up to the P. Students make their choices on a form which is checked and approved by the instructor as shown in Figures 3 for fall 2022.

As engineers, what we do in form of design, cost reduction and productivity improvements will only be a complete success if such activities make a difference in the bottom line of the company. For practical purposes, the bottom line is the stock price for most companies. As engineers, we must be aware of stock and investment valuation concepts. Take engineering economy as an elective! you will be glad you did it. To practice in this area, you are to invest \$10,000 in any combination of stocks of the up to three major public companies (public means private, it does not mean gov't owned). You cannot buy a stock of the SpaceX Corporation, Blue Origin Corporation, or the Big Ass Fans because they are all private companies and they have no stocks.

Buy an integer number of stocks and invest the rest in another short-term, but safe option such as a HYSA (High Yield Savings Account) that yields 0.50 % APR: Annual Percentage Rate.

You can choose to play it safe and invest up to \$5000 in the HYSA. **Do not lose this sheet.** This is your investment certificate. **No replacement will be issued.**

Let's get the stock prices as they are at this moment on February 9, 2022:

Defense/Aerospace

BOEING (BA): \$ 214.36; LOCKHEED MARTIN (LMT): \$ 394.85

Northrop Grumman (NOC): \$ 383.49

Finance/Banking

BANK of AMERICA (BAC): \$ 49.21; WELLS FARGO (WFC): \$ 58.70;

MORGAN STANLEY (MS): \$ 107.70;

Automotive

FORD (FORD): \$ 18.22; GENERAL MOTORS (GM): \$ 50.65;

TESLA (TSLA): \$ 927.41.

Figure 1. Project Description Handout (Spring 2022)

3.30% APY *

If you want easy access to your money at a high interest rate, then a High Yield Saving Account could be a great fit for you. And American Express offers much more than just a great rate.





-  **No minimums, no monthly fees**
-  24/7 superior customer service
-  Easy access to your money, round-the-clock
-  FDIC insured

Figure 2. A Sample HYSA Advertisement (January 2023)

Students are taught the basic concepts of present and future worth. After about five to seven weeks, stocks are “sold” in class (Figure 4) using the online prices then, and the HYSA balance is “cashed out” by calculating its own future value. The future worth of the HYSA is certain, but the future values of the stocks vary widely. The sum of both proceeds is the overall future value (F). Many students are surprised to realize that for many of them the F can be easily less than the P.

Next, students learn how to calculate the daily return that provides equivalence of the F and the P. The daily return realized, which can be negative, is then converted to annual effective return to judge the overall performance of the investment using the following notations and equations:

n = investment duration in days, $P = \$10,000$, F = unknown future value,

P_{Stocks} : amount allocated to stocks (must be at least \$5000),

P_{HYSA} : amount allocated to the HYSA such that

$$P_{\text{Stocks}} + P_{\text{HYSA}} = P \quad (1)$$

i_{HYSA} : advertised and known APR for the HYSA as a fraction (i.e., 0.03),

i_a : annualized overall investment return as a percentage,

i_d : daily overall investment return as a fraction,

F_{Stocks} : amount realized at stock sell off.

F_{HYSA} :future value of the HYSA,

$$i_{\text{HYSA}_d} = (i_{\text{HYSA}}/365) \quad (2) \text{ daily fraction of the } i_{\text{HYSA}}$$

$$F_{\text{HYSA}} = P_{\text{HYSA}} * (1 + i_{\text{HYSA}_d})^n \quad (3)$$

$$F = F_{\text{Stocks}} + F_{\text{HYSA}} \quad (4)$$

$$F = P (1 + i_d)^n \quad (5)$$

Once the F value becomes known, Equation 5 is used to calculate i_d as a fraction which can be negative depending on the investment choices and stock prices at the sell-off. Then, i_a is calculated using Equation 6,

$$i_a = [(1 + i_d)^{365} - 1] * 100 \quad (6)$$

Equation 6 is important although i_a is not the actual return (loss) the investor experiences. Students are reminded that the annualized return is a common yard stick to compare various alternatives. The advertised HYSA rate is an annualized one as shown in Figure 2.

In Fall 2022, the HYSA rate had gone up to 1.90 % in line with the rate increases enacted by the Federal Reserve in 2022. Figure 3 describes the experience of a student in Fall 2022. Using $i_{\text{hysa}} = 0.019$, the $i_{\text{hysa}_d} = 0.000052055$. On 9/19/2022, the student decided to be on the “safe side” and allocated considerable amount to the HYSA choice ($P_{\text{HYSA}} = \$4593.53$) after choosing \$5406.47 worth of stocks.

Your portfolio on September, 19, 2022:

Select any stock from the list above in any combination. You can diversify by picking one stock from each group or invest in a single stock.

Stock 1 :	<u>BA</u>	<u>20</u> shares	$(20 \times 145.99) = \$ 2919.80$
Stock 2 :	<u>TSLA</u>	<u>7</u> shares	$(7 \times 305.71) = \$ 2139.97$
Stock 3 :	<u>BAC</u>	<u>10</u> shares	$(10 \times 34.67) = \$ 346.70$

Show here how you allocated \$10,000. Stocks \$ 5406.47 HYSA: \$ 4593.53

Checked by

Figure 3. Sample Investment Confirmation (Fall 2022)

After 42 days, stock prices are recorded and stocks are cashed out in class as shown in Figure 4.

The stock prices as they are at this moment (time : 42 days)
on October/November 31, 2022:

Defense/Aerospace

BOEING (BA): \$ 139.87 ; up or down

LOCKHEED MARTIN (LMT): \$ 485.04 ; up or down

Northrop Grumman (NOC): \$ 549.59 ; up or down

Finance/Banking

BANK of AMERICA (BAC): \$ 36.05 ; up or down

WELLS FARGO (WFC): \$ 46.06 ; up or down

MORGAN STANLEY (MS): \$ 82.08 ; up or down

Automotive

FORD (F): \$ 13.22 ; up or down

GENERAL MOTORS (GM): \$ 38.73 ; up or down

TESLA (TSLA): \$ 224.96 ; up or down

Figure 4. Stock Prices at the Sell-off (Fall 2022).

Figure 5 shows fall 2022 investment record of a student who experienced an annualized loss of 44.95% while the “actual” loss was only \$663.80 or 6.64%. Equation 3 results in a F_{HYSA} of \$4603.50 after 42 days while the stocks lost value ending with a F_{Stocks} value of \$4732.62 at the sell off on 10/31/2022. Equation 4 results in a final $F = \$9336.20$ which is a loss as it is less than the P of \$10,000. Equation 5 is set up to find the unknown i_d : $9336.20 = 10000 * (1 + i_d)^{42}$. This is solved either by algebra or taking the logarithm of both sides and the $i_d = -0.0016$. Finally, Equation 6 is applied to find the annualized return (loss) in this case: $i_a = (1 + (-0.0016))^{365} - 1 = -44.95\%$.

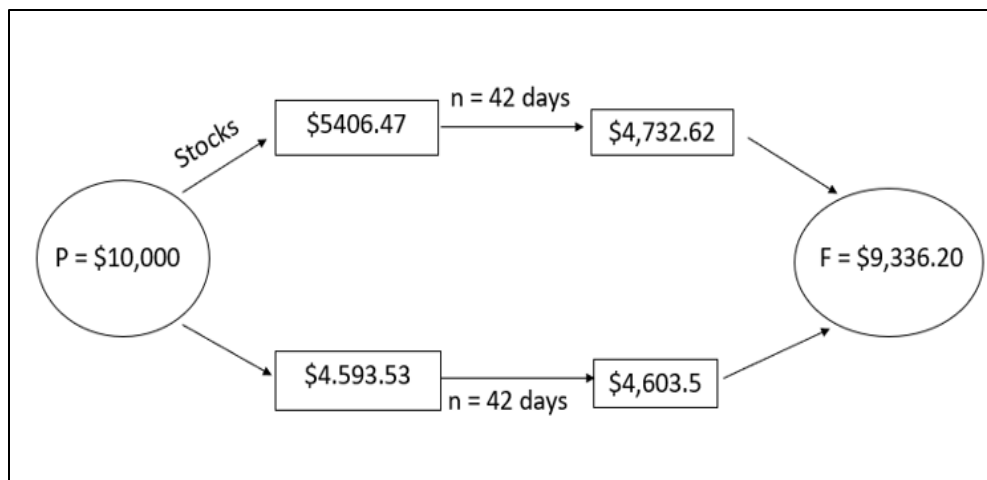


Figure 5. Flowchart of the Investment Record for the Fall 2022 Example

After learning how to do the manual calculations, they include it in the project report. Then, the students write an MS Excel code (Figure 6) to apply the equations shown above. The Excel's RATE function is not used in order to provide additional MS EXCEL programming experience.

	Monday 10 am	9/19/2022		HYSA rate:	1.90	percent annual for HYSA	
Cells in	RED and GREEN	have formulas			0.019	as decimal	
Cells in	Total Finds	\$10,000.00	call this P		0.000052055	daily decimal (idcd)	
	BLACK and BLUE	are constants			42	Days elapsed (n)	
	INVESTMENT ON						
Company	19-Sep-22	Shares Purchased				CASH OUT ON	
	STOCK PRICE		Investment Amount			31-Oct-22	Cash Out
BA (Boeing)	\$145.99	20	\$2,919.80			\$139.87	\$2,797.40
TESLA (TSLA)	\$305.71	7	\$2,139.97			\$224.96	\$1,574.72
BANK of AMERICA	\$34.67	10	\$346.70			\$36.05	\$360.50
			The sum is:	\$5,406.47	s_p	TOTAL STOCK VALUE (\$_f)	\$4,732.62
			(investment)	PURCHASED		(AT CASH OUT)	CORRECT
	Investment in HYSA:	h_p	\$4,593.53	19-Sep			
	The HYSA is then:	h_f	\$4,603.58	31-Oct	BALANCE (F):	At cash out, HYSA + Stocks =	\$9,336.20
	My HYSA fraction:	45.94%	\$10.05	Gain on the HYSA		Call this F	
		of the total	Over	42			
			days				
					Final Analysis	vs. \$10000 (the P)	
					0.93362	F/P ratio	
					0.99837	Apply (F/P)^(1/n)	
					-0.00163	daily interest: [(F/P)^(1/n)]-1	
					-0.44949	Annualized return as decimal	
					This is like: -44.95%	Report annualized return as %	
					ifrepeated	(I did not experience this)	
					in increments of	Real Total Change:	-\$663.80
					42	Real Percentage Change:	-6.64%
					days over a year		

Figure 6. MS Excel Code to Solve the Sample Phase (Fall 2022)

In addition, an online tool [Return on Investment \(ROI\) Calculator \(financial-calculators.com\)](https://www.financial-calculators.com) shown in Figure 7 is also used to confirm both manual and programming-based solutions. All three

methods yield the same effective annual return. Students find this project exciting and behave as if the P were real.

Calculator		What's Your Goal ROI?	
Amount Invested (P.V.):		\$10,000.00	
Amount Returned (F.V.):		\$9,336.20	
Days (-9,999 < # < 47,482):		42	
Start Date (year > 1969):		09/19/2022	
End Date (year < 2100):		10/31/2022	
Annualized Return (ROI):		-44.9491%	
Gain or Loss:		\$-663.80	
Percentage Gain or Loss:		-6.6380%	
Years Days:		0	42

Figure 7. Online Calculator Analysis for the Fall 2022 Example

Even though Figure 5 depicts a bad outcome, some investments work well. Figure 8 shows a case from Spring 2022 when the HYSA had an APR of only 0.50%. This student allocated more of the P for stocks and realized an actual gain of \$1,103.31 or 10.03% with an annualized return of 86.49% !

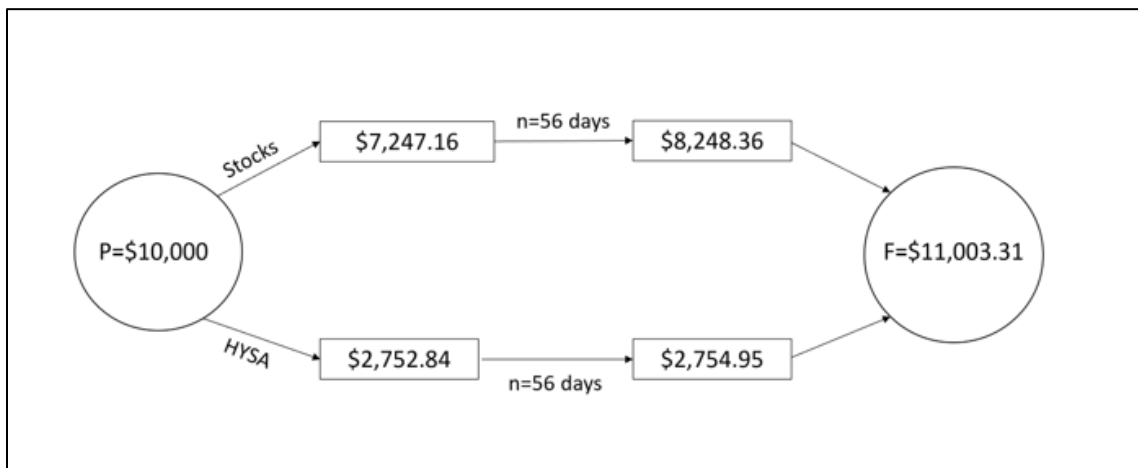


Figure 8. Flowchart of the Investment Record for the Spring 2022 Example

Table 1 shows a sample of Fall 2022 investment results across all five lab sections of the course using a P of \$10,000. Students are reminded again on the importance of annualized return or change calculation as a common yard stick as each lab section has a slightly different investment duration.

Table 1. Sample Short Term Investment Decisions and Performances (Fall 2022)

First Name	Stocks (starting)	HYSAs	Percent Stocks	Real Change (%)	Annualized Change (%)
Student 1	\$5,741.24	\$4,258.76	57.41%	-0.29%	-1.95%
Student 2	\$9,994.46	\$5.54	99.94%	0.69%	6.15%
Student 3	\$7,334.00	\$2,666.00	73.34%	-2.11%	-16.92%
..
Student 33	\$5,522.00	\$4,478.00	55.22%	0.27%	2.41%
Student 34	\$9,960.00	\$40.00	99.60%	-5.14%	-36.75%
..
Student 61	\$8,446.65	\$1,553.35	84.47%	-10.49%	-56.19%
Student 62	\$8,003.95	\$1,996.05	80.04%	8.61%	85.04%
Student 63	\$9,686.54	\$313.46	96.87%	-7.11%	-42.28%
..
Student 73	\$5,011.81	\$4,988.19	50.12%	2.27%	18.22%
Student 74	\$9,784.54	\$215.46	97.85%	-2.54%	-17.44%
Student 75	\$5,844.40	\$4,155.60	58.44%	7.40%	70.19%

Finally, students are provided the return data for all sections to plot annualized returns as a function of the percentage of the P value invested in stocks. Figure 9 shows the plot (fall 2022) that has a minimum value of 50% on the X axis as this is the minimum required percentage of stocks for all.

It is somewhat clear that “risky” approach of allocating too much of the P for stocks results in greater variation in returns while the “safer” approach does not prevent losses. Many students found these observations interesting, surprising, fun, and informative.

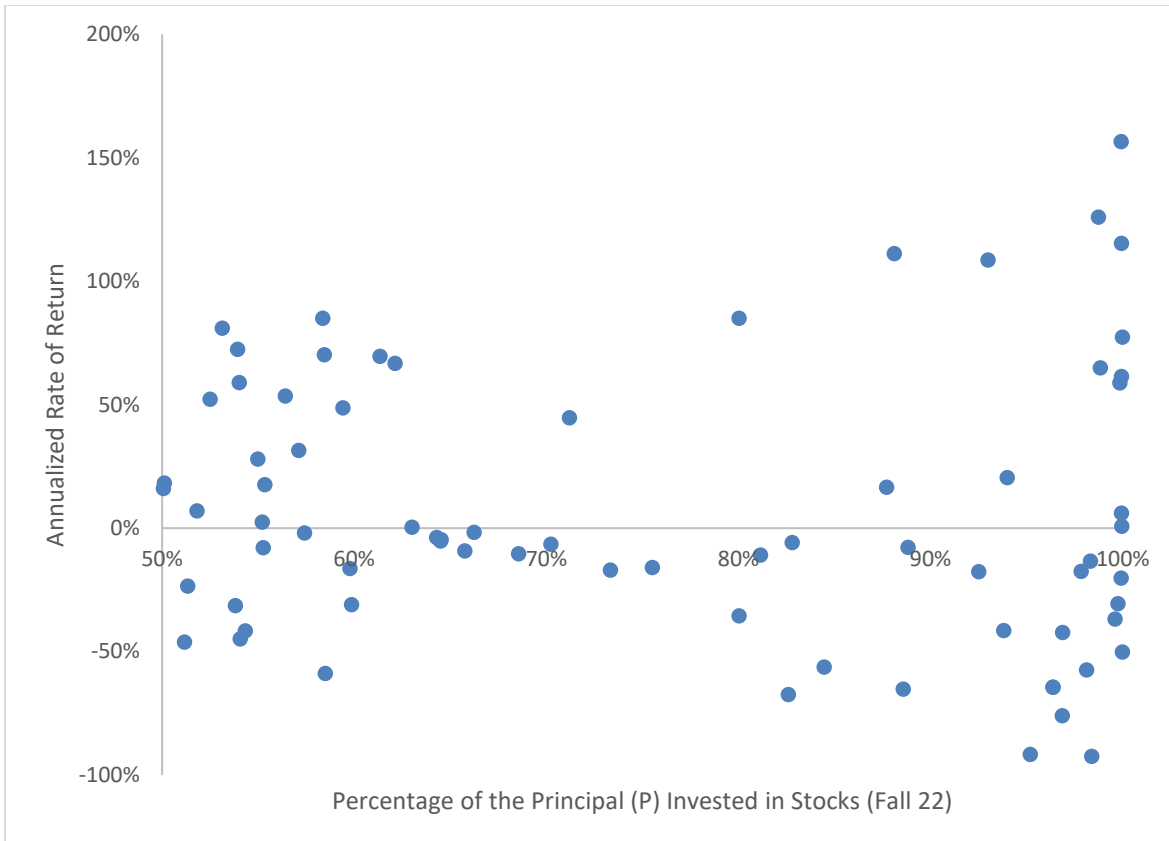


Figure 9. Return vs. Percent of the P amount Invested in Stocks (Fall 2022)

Qualitative Analysis

Figure 10 shows the summary of the survey administered to students in Fall 2022. Although the survey does not show a great endorsement for the benefits of this project, results look good enough except for the 5th question. Students are not strongly convinced to take engineering economy as an elective.

1. **Making investment decisions and tracking its performance was**
1 = boring, 2 = somewhat boring, 3 = OK, 4 = somewhat exciting, 5 = very exciting
(Average :3.56, Std: 0.87)
2. **From this project I learned about investments and associated risks of investments.**
1 = nothing, 2 = little, 3 = something, 4 = much, 5 = very much
(Average :3.66, Std: 0.96)
3. **By performing calculations using Excel I became with coding in Excel.**
1 = less proficient, 2 = somewhat less proficient, 3 = neither less nor more proficient, 4 = somewhat proficient, 5 = very proficient
(Average :3.83, Std: 0.74)
4. **The equations and the online financial tool used in this project were helpful in gaining some understanding of time value of money.**
1 = unhelpful, 2 = somewhat unhelpful, 3 = neither unhelpful nor helpful, 4 = helpful, 5 = very helpful.
(Average :3.80, Std: 0.99)
5. **As a result of this project, I am considering taking the engineering economy course as an elective.**
1 = no, 2 = unlikely, 3 = possibly, 4 = likely, 5 = definitely.
(Average: 2.55, Std: 1.04)

Figure 10. Project Survey (Nov. 14 and 16, 2022) Summary for 71 Responses

Many students were pleased with this project as a good learning experience as shown in sample comments below.

This Investment Project was a great project to open our eyes to the real world of investment. This is a thing Engineering students will have to deal with in the future when making real money, so this is a great way of introducing us to real world money problems. In this assignment, I invested \$9998.62 in stock and \$1.38 in HYS A and in the end I had \$9227.60 and \$1.38 in HYS A. This was with a total loss of \$771.02 at -7.71% real change. I invested in Bank of America (BAC), Boing (BA), and Tesla (TSLA) and although BAC and BA stayed fairly similar in stock prices, TSLA dropped almost \$80 a share leaving me with massive losses. Unfortunately, nobody could have seen Elon Musk deciding to buy twitter before buying this stock, so I do not believe this would have happened normally and probably would have taken the same route as BAC and BA. According to Figure 8, I would say there are no strategies involved in investing because everyone's are just scattered and there is no real way of finding the best investment plan. Overall, this will be very useful to keep in mind in the future when making a lot of money from an Engineering job.

I learned a lot from this exercise about how volatile the stock market can be. I checked weekly, and my stocks went up and down far more often than I thought they would. After 35 days, I did end up losing money, albeit only a small amount. According to Figures 2 and 4 I lost \$24.58 which is a decrease of 0.25%. My biggest loser was Tesla (TSLA) which was down to \$224.96 from \$305.71 (Figure 1). This loss was mostly offset by heavy gains from Lockheed Martin (LMT) and Northrop Grumman (NOC) (Figure 1). My annualized return totaled to -2.53% (Figures 2, 4). As shown in Figure 5, a manual calculation of the data from the spreadsheet produced the same results. There does not appear to be any meaningful correlation between the percentage of initial funds (P) invested in stocks and the annualized return. The Excel spreadsheet was a much quicker solution than writing the calculations by hand and this was a great opportunity to learn how to use Excel. This exercise also teaches students how the abstract math they are learning can apply to real life.

This Investment Project (Stock HW) is a great assignment that helps engineering students get familiar with economy, especially in investment. This exercise is practical that students work with real stock prices and apply investment calculations to obtain the results after the Sell-off time. In this assignment I invested \$6,843.81 in stocks and \$3,156.19 in HYSA and fortunately gained back \$1,145.08. which yielded a percentage gain of 11.45%. This gain is due to the rise-up stock prices from the companies Lockheed Martin (LMT) and Tesla (TSLA). However, based on Figure 5 above, the common trend is scattered in both plots of Actual Change and Annualize Change, suggesting that there are no strategies in investing, but investment should focus on strong companies in the economy. Overall, this homework is a very useful exercise that helps students as a tool to apply for investing in the future.

Conclusions

The achieved student learning outcomes include rudimentary understanding of TVM, proficiency with the calculation of effective annual return for short term investments, the impact of diversification and risk taking in portfolio performance, and enhanced MS Excel skills. Many students are exposed to MS Excel for the first time in this course. First-year students are also urged to take engineering economy as an elective later. They are told that engineering economy is the course they are sure to use regularly in their personal and professional activities.

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