
Financial Analysis for the Professional Engineer

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Financial Analysis for the Professional Engineer

Objectives of this Course:

This course advances the ‘standard engineering economics,’ taught at the college or continuing education level. This targets the professional engineer, engineer-manager and engineer-owner. Participants will learn how to use, and not misuse, financial analytical tools for the decision-making process specifically applied to: project evaluation and project management, costing, contract negotiations, employee evaluation, revenue, profit and cash production and valuation of assets including buying and selling professional engineering practices.

- Payback, NPV and IRR Calculations
- Dealing with the CFO of their operations and ‘talking their language’
- The misuse of NPV and IRR
- Valuation techniques applied to capital budgeting

Chapter 1

Speaking Two Languages

Wealth creation in a free market society is an underlying goal of the capitalist virtually forever. In fact, this might be an indirect definition of a capitalistic society: the ability to create wealth for oneself. What has been the key for most entrepreneurs in creating wealth? While there are exceptions, I will argue that wealth creation in the past few decades has come from individuals being able to speak two different languages.

The languages I reference are not traditional in the sense of “Spanish”, “French” or “Russian”. The separate languages, I suggest, are those that cross industry boundaries such as an engineer who understands the medical arena. An engineer adds value if he can relate stress-strain concepts to ball-and-joint synthetic limbs and communicates with medical professionals as easily as with other engineers. Or, the engineer who can tell the shop foreman how to make the design as the interior designer wanted, designed or developed.

Real world examples include Mr. Mark Cuban, the current owner of the Dallas Mavericks of the National Basketball Association (NBA). Mr. Cuban is a computer nerd who loves sports. He was frustrated that he could not listen or watch games that were not in his broadcast area. So, he crossed over his love for sports with his computer background to create Broadcast.Com which his share alone sold for several billion dollars.

Advanced Financial Analysis, and the entire series of continuing education courses are designed to advance the professional engineer within his field while introducing or re-introducing languages from other disciplines, namely, finance and accounting arenas. It is easier for the professional engineer to pick up financial concepts than for a businessperson to understand engineering concepts. This should be an advantage that the professional engineer enjoys in the business arena.

Why Financial Analysis for Engineers

Budgetary concerns for many corporations including governmental agencies are always with us and they will never disappear. Our society, and even our human nature, has always looked for better, cheaper and faster ways of doing things. With the advent of the computer, or more specifically the personal computer, budgetary analysis has taken on a greater meaning in that most, if not all, buyers are now being required to justify their decisions. This means the quantitative aspects of transactions must support decisions. As more quantitative activities increase, there is a need to understand both the advantages and disadvantages of such ‘quant’ processes, especially those that can cause harm.

Financial Analysis for the Professional Engineer

Likewise, as more buyers are utilizing 'quants,' sellers now understand that the quantitative analysis could help them sell more. That is, sellers are coming up with their own analysis and quantitative justifications and presenting these to their buyers. They justify their products and not others. However, is this the correct people you want providing quantitative support for their own products? How biased would this be!?

In a classroom setting, this is the moment I would be picking up the mouse or wireless keyboard and professing:

“NEVER IN THE HISTORY OF MANKIND CAN WE COME UP WITH THE WRONG ANSWER FASTER” (*)

*(*Note: I did not originate this saying (**) but I know a good saying to borrow when I see it!) (** Cannot identify who I lifted or borrowed this from)*

Like a scalpel a computer is a tool. In the correct hands can perform great works. In the wrong hands, it can damage greatly. Financial analysis and the process of quantifying decisions can be viewed the same way. It is possible that the 'quants' and their models are manipulated in order for their project to be approved over some rival department. How can you tell? It might be impossible if you have a good programmer or financial modeler! If this were your money, you would want to understand where you are vulnerable and at risk. This is the focus of the following discussions.

The last item to cover before we get into the hard analytics revolves around numerical convention and the usage of spreadsheet programs. To pass this course you will be required to successfully answer math questions in quantitative problems. You may use a handheld calculator to do so. However, since 100% of the financial professionals utilize some sort of spreadsheet program, we will incorporate such into this course. In using spreadsheets, signs are significant in some sense and insignificant in others.

We use a negative amount as a cash outflow and a positive amount for a cash inflow. An investment, the outflow, will be designated at a -\$10 or (\$10) or (10). Each 'cell' or box will represent a time period. In all cases, we will stay with one-year time periods for convenience. Examples copied from spreadsheets will be inserted to help follow the discussions.

Chapter 2

The Simple Payback

The simple payback is the process used by many to analyze financial risk not most people in the world. It is incredibly unsophisticated and very low in math intensity. For such reason, schools and professionals tend to dismiss its use; however, this method is a valuable tool and should remain part of any and every analysis.

To proceed with this method of analysis, let me introduce you to “BUBBA.” Everyone knows a Bubba. He is the kind of guy who carries his entire bank account in his left pocket...usually with a rubber band holding it. Bubba never went to college and may not have graduated from high school yet Bubba knows about risk and risk-versus-return from real-world experiences. I call the *Simple Payback* the Bubba method.

If you ask Bubba to lend you money or become an investor in your opportunity, he usually asks several simple questions. The first few might be something like this (*slang intended*):

“What you want the money for?”

“Where it is going?”

But the most important might be this question:

“When do I get my money back?”

“WHEN!!!!”

“When” is the key terminology for Bubba indicating ‘time’. Note, Bubba does not ask for

‘The risk-adjusted spread to US Treasuries,’ or

‘What is the premium over a risk free rate’ or

What is my total investment compounded annualize return’

It is simply when!

For poker players, those who bet on Pro Football, the horses or those that love gaming in places like Las Vegas or Atlantic City, the time you place your original stake in your pocket and begin playing with house money is that ‘sweet time’ when you cannot lose (*right before you get sucked back in!*).

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Bubba wants to know when he gets his investment back. Look at the following example, with all cash flows going to Bubba:

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(1,000)					
Future Cash Flows			200	400	600	800	1,000

Bubba looks at this opportunity and determines that his time to recoup his investment is somewhere between years two and three. If we assume that the cash flows are continuous through the given period, his payback comes $\frac{2}{3}$ through year 3. Looking at this example from a payback view, it would be:

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(1,000)					
Future Cash Flows			200	400	600	800	1,000
Net Out of Pocket		(1,000)	(800)	(400)	200	1,000	2,000

Here, the Net Out of Pocket for any period is the cumulative cash flows (out and in) from the beginning to that period of time.

For an additional example, consider the same cash flows but with the timing reversed, given as follows:

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(1,000)					
Future Cash Flows			1,000	800	600	400	200
Net Out of Pocket		(1,000)	-	800	1,400	1,800	2,000

In this example, the payback comes at the end of the first year. (Did I say Bubba or is this Guido?!). Anyway, the timing issue in the simple payback is important and therefore Bubba would rather the latter example than the former!

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In summary, “WHEN” do I get my money back is not only a valid approach but used by many people as a realistic check of the opportunity. As we progress into more complex mathematics, don’t forget some of the simple examples above.

**Chapter Review
And
Concept Questions**

Before proceeding you must successfully answer the following question correctly:

The simple Payback Method in evaluating a project takes into account:

- a) The investment amount and future investments for the opportunity (negative or outflows only).
- b) The positive future cash flows only.
- c) The net of all cash inflows and outflows to determine a time when the net difference is equal to \$0.

(Answer: C)

Calculate the Payback for the following two Opportunities:

Period Cash Flow	0	1	2	3	4	5	6	7	8
	Investment	Resulting Cash Flow of Investment							
Opportunity "A"	\$ (12,500)	\$1,250	\$ 1,750	\$ 2,200	\$ 2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
Opportunity "B"	\$ (25,000)	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000

Payback for "A" is after 5 years & before the end of year 6.

Payback for "B" is after 4 years & before the end of year 5.

Since we don't know if the cash flows are evenly spaced throughout a given year, we cannot be more specific (fractional years or months).

Chapter 3

Time Value of Money

This is not an engineering economics refresher course, so limited time will be spent on the basic concept of time value of money. We will outline the usage of financial function keys within a typical spreadsheet program, specifically, Excel. We are concerned with 5 basic function keys with 2 more additional data inputs. The function keys are:

- PV**- present value calculations
- FV**- future value calculations
- PMT**- annuity payments (identical in amounts and identically spaced)
(*annual, quarterly or monthly, for example*)
- NPV**- Net Present Value calculations
- IRR**- Internal Rate of Return
- “i”** - Interest rate
(*market rate, required return rate, discount rate, hurdle rate, are synonyms here*)
- “n”**- number of periods in a problem.

Not all of these variables are required for any given problem. For problems solving for the PV, FV, or PMT, there are four aspects to any given situation.....you must be given three variables to be able to solve for the fourth. To calculate a car payment (use function key “PMT”), you will need to know the rate, term of the loan and car price (3 variables identified to be able to calculate the selected answer).

NPV and IRR are more complicated and further discussed in the next chapter.

A *problem* with Excel is that the user needs to have the variable you seek identified before you begin to press buttons. That is, you must know to seek for “PMT” as in the example above because that is the ‘key’ needed to enter into the function keys. Handheld calculators can take any input order with the last few steps being compute “PMT.”

To find the function keys in Excel, place your cursor in the cell where you want the answer to be displayed. Click on the F(x) key located in the task bar or it may be displayed in the formula bar. A box will appear on your screen with a line item that says, ‘Most Recently Used.’ You should find a reference to *financial* in the functions category (if it does not pop-up, you are one click away from it!) Click on financial.

On the right side will list either two dozen functions keys or twelve dozen, depending on who uses your computer. You will see a list of functions in alphabetical order and page down until you get the one we utilize in further discussions.

Chapter 4

Net Present Value and NPV Function Key

Net Present Value (NPV) is:

The present value of future cash flows netted against the initial capital outlay, utilizing some identified interest rate.

Huh?

Okay, let me try to explain it this way. You buy an asset and that asset will generate cash flows for the next 5 years. If we take the present value of those cash flows, and net it against what the asset costs today, we can determine if that asset creates value for us. Look at the simple example below where the asset costs \$15 and generates \$4 in cash each year for 5 years.

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			4	4	4	4	4

NOTE: It is critical to keep directional aspects into account. That is, the investment was an outflow so it is listed as a –15 while all future cash flows are considered inflows so they are (+) 4.

We are given a desired return if we want to accept this project. (Why 12%? The selection of the discounting rate comes later in this course.) So the question is:

Does this investment deliver a ‘proper return’, given a required return of 12%?

By observation, we cannot determine such an answer; we must do the math. However, under the Bubba method, we can do the math in our head! (Payback in the 5th year.)

We will proceed with the long version so that you can see how the math is applied to the problem. In later examples, Excel and its functions keys will be introduced where the effort of three clicks will get the same answer.

It is important; however, to have a deep understanding of how the math works.

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	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			4	4	4	4	4
Given Interest rate		12%					
Discount Factor for Period			0.893	0.797	0.712	0.636	0.567

For the given interest rate of 12%, we have calculated the ‘factor’ associated with that rate and the respective time period.

The factor for 12 % and one year is 0.893; this signifies that a \$1 to be delivered to you in one year is worth \$0.893 (rounded) today.

Or put another way, \$0.893 will grow to \$1 in one year if your interest rate is 12%.

Likewise, \$1 in year two is equivalent to \$0.797 today; \$1 in year three is equivalent to \$0.712 today.

Applying these factors to the actual cash flows, we calculate the individual present values for each future cash flow. Taking the factor for each period times the cash flow for that particular period does this.

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			4	4	4	4	4
Given Interest rate		12%					
Discount Factor for Period			0.893	0.797	0.712	0.636	0.567
Respective Present Value			3.57	3.19	2.85	2.54	2.27

Now sum this last line (add all the present values of the respective future values) and the result is the following:

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	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			4	4	4	4	4
Given Interest rate		12%					
Discount Factor for Period			0.893	0.797	0.712	0.636	0.567
Respective Present Value			3.57	3.19	2.85	2.54	2.27
Sum of the Present Values			14.42				

The PV of all future cash flows is \$14.42.

Add to this figure our initial outlay of (15) to get a NPV = -\$0.58.

Note that when we calculated the PV of the future cash flows, the result of \$14.42 is positive. When we add our initial outlay we add the negative \$15 (it is negative because it was an outflow).

Again sign convention is important as the NPV is a negative and this negative number indicates we did not earn a positive return, the 12% required or given at the problem's start.

If we look at another opportunity with the same outlay but different inflows, we see a positive NPV:

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			3	4	5	6	7
Given Interest rate		12%					
Discount Factor for Period			0.893	0.797	0.712	0.636	0.567
Respective Present Value			2.68	3.19	3.56	3.81	3.97
Sum of the Present Values			17.21				

Financial Analysis for the Professional Engineer

It has taken us this long to eventually come to the rule at hand:

If a project produces a positive NPV: ACCEPT THE PROJECT

If a project produces a negative NPV: REJECT THE PROJECT.

NPV RULE:

IF NPV > \$0 ACCEPT

IF NPV < \$0 REJECT

Technically, if NPV = \$0, accept the project. You accept because you do earn the discount rate selected for the problem, you just don't add any incremental value above this amount.

NOW, THE SHORT CUT

Hopefully you have gained an appreciation for how the math is utilized to calculate the answer. Until this point, we have not used the spreadsheet program in its most efficient form. The introduction of the NPV Function key is now required. Look at the most recent example again:

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			3	4	5	6	7
Given Interest Rate		12%					

Go to the function key, once a cell is selected (in this case right below the given interest rate), and select "NPV" within the list of financial functions. A box will pop up asking for rate (the rate required per period, assigned or pre-determined). Two additional boxes labeled Value1 and Value 2 are also visible.

You can manually insert values for 'Value 1' and 'Value 2'; these values must be in the order of the problem. That is for our example, '3' then '4' then '5' etc., as each box represents the next time period. Inserted Values can be positive or negative. If a time period has \$0 cash flow, a 0 must be inserted so that the correct *time* is incorporated within the problem. As you enter the next time's values, an additional box will appear

Financial Analysis for the Professional Engineer

and inputs can continue for 20 or so boxes. (I have not tested this because there is a better way; see next paragraph). You will notice that the manually inserted values will also appear to the right of the box as well. You have hard coded the inputs; meaning, you must re-enter the formula to edit or otherwise change variables.

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			3	4	5	6	7
Given Interest rate		12%					
	NPV =	\$2.21					

For hard coded inputs described above, the cell's formula would look like this:

$$=\{NPV (.12, 3, 4, 5, 6, 7)\} + (15)$$

The input before the first comma is the rate in decimal form (% form is acceptable as well), with each input following being the value in time order and the initial investment (outflow) is added OUTSIDE the formula.

However, these steps do not utilize the computer and its capabilities to the fullest either. A second form of data entry is to reference the given cell. You can place your cursor with the rate box or any value box (so that the cursor is blinking within the box), and then move your mouse to the cell where the actual data resides. By clicking on this cell, the NPV box is referencing the cell. Any changes in that cell will also update the formulas and then update the answers. Notice that the cell location is placed within the NPV box AND the data from the cell is defined to the right of the box. Again, referencing each cell, in time order, is required

For individual referenced cells as outlined above, the cell's formula would look like this:

$$=NPV(C8, D9, D10, D11, D12, D13) + (B 8)$$

Here "C8" references the cell containing the interest rate, and the remaining cells represent the time order of the data. Note that the cell reference for initial investment is a positive reference with the data contained within that referenced cell being a negative number (indicating outflow). There is a limit to how many inputs can be provided.

Financial Analysis for the Professional Engineer

However, once again, the usage of Excel is not optimal because all of these steps can be reduced to just several clicks. Notice below the yellow highlights; it is possible to *paint* the area with your mouse when in the box ‘Value One’.

	Time Period	0	1	2	3	4	5
Initial Investment or Loan		(15)					
Future Cash Flows			3	4	5	6	7
Given Interest rate		12%					
	NPV =	\$2.21					

The cell’s input for the NPV calculation would be:

$$=NPV (C8, D9:D13) + (B8)$$

Here “D9:D13” indicates the data, in time order, utilized within the function key. The highlighted line within the chart indicates the area “painted” by your mouse, in this case, “D9:D13”

Since the cells are referenced, any data changes will also update the formula and an updated answer will be automatically calculated.

Chapter Review And Concept Questions

Chapter 4 introduced the concept of Net Present Value (NPV) as a mathematical tool to quantify decisions processes. To value an asset using NPV, the calculation of a net value incorporates time value of money along with the predicted future cash flows of an asset. These future cash flows can be positive or negative. An interest rate, sometimes referred to as a discount rate, must be provided. The specific rate selected is one of the most important aspects of the problem as this one variable has the largest impact on the final answers.

There is a long way of calculating NPV using lengthy formulas and many steps; fortunately, there is a convenient function key in most spreadsheets to accomplish repetitive tasks quickly. The actual process of calculating NPV is to find the present values of all future cash flows from the asset and subtract the current, or today's costs of that asset, to get a net value. If the result is positive, the calculation indicates that the predicted cash flows will earn both the selected discount rate AND the amount determined, that is, the NPV amount. If the NPV is a negative number, it indicates the future predicted cash flows do not earn the discount rate selected.

Concept Questions: Please answer the following as these are similar to your end of course questions. Calculate the NPV for the two opportunities using 10% as your required rate:

Chapter 4 Concept Questions:										
Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
Opportunity "C"		\$ (5,000)	\$ 3,500	\$ 3,000	\$ 2,000	\$ 200	\$ 100	\$ 50	\$ -	\$ -
Opportunity "D"		\$ (2,500)	\$ 125	\$ 200	\$ 600	\$ 800	\$1,500	\$ 2,500	\$ -	\$ -
			"C"			"D"				
NPV	10%		\$2,391			\$1,119				

Chapter 5

Additional Examples using the NPV Functions and Applications.

Review the following example:

Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
		\$ (12,500)	\$1,250	\$1,750	\$2,200	\$2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
NPV	10%	\$6,643								
	15%	\$2,623								
	20%	(\$323)								
	25%	(\$2,524)								

First, notice the data inputs are called cash flows. There is a difference between revenues, profits and cash. These are three separate items with sales / revenues generally referring to the same things. We are interested in the cash flows resulting from the investment itself, which should be after tax and after all costs including financing issues (debt payments). *{For more detail on these topics, please see the second course in this series.}*

Second, notice the calculations are now showing differing rates used to calculate the NPV, ranging from 10% to 25%. The NPV calculation for the various discount rates show a sensitivity exists to the discount rate selected (a.k.a., the required investment rate), which indicates a preference reversal at various selected interest rates. This project or opportunity would be selected for interest rates of 10% and 15%

WHY?

Because (NPV > \$0) and rejected at 20% and 25% interest rates (NPV < \$0).

In its base form, the NPV function provides a decision tool utilizing a quantifiable analysis approach. Now, look at two projects. Project or Opportunity “A” is identical to our most recent example.

Financial Analysis for the Professional Engineer

Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
Opportunity "E"		\$ (12,500)	\$1,250	\$1,750	\$2,200	\$2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
Opportunity "F"		\$ (25,000)	\$6,000	\$6,000	\$6,000	\$6,000	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000
Which is "better"?										
			"E"			"F"				
NPV	10%		\$6,643			\$7,010				
	15%		\$2,623			\$1,924				
	20%		(\$323)			(\$1,977)				
	25%		(\$2,524)			(\$5,027)				

If these opportunities are mutually exclusive, which is to say you can only pick one or the other, the NPV calculations can be used to determine which is better. Both are rejected at interest rates of 20% and higher as $NPV < \$0$.

At 10%, "B" is a superior opportunity as

$$NPV \text{ "A"} < NPV \text{ "B"}.$$

At 15%, "A" becomes superior.

A preference reversal!

If both projects are available and they are not mutually exclusive, both will be accepted at rates of 15% or less.

Chapter Review

The concept of analyzing multiple NPV values utilizing varying discount rates was introduced. Sensitivities of the result can be seen as the rates change. We have shown, for example, that the NPV declines or decreases as the rate selected rises. In addition, we have shown examples of mutually exclusive projects when a preference reversal occurs as rates are changed.

Chapter 6

Internal Rate of Return Function

The internal rate of return (IRR) is defined as:

That rate which makes the NPV calculation \$0.

Recall that NPV = Present Value of all future cash flows less the initial cost of the opportunity (a 'period 0' cash flow). Current outflows to secure the opportunity are not discounted as they are already present dollars so no time adjustment is needed or required. Each future cash flow must be discounted to today's values, respectively. Under the NPV calculation, we are given some rate (assigned by the CFO, perhaps) to plug into our formulas. In the IRR calculation, we set the equation equal to zero and solve for the rate.

$\$0 = \text{NPV} = \text{Initial Cash Outlay} - \text{PV of all future cash flows.}$

In this equation, the initial cash outlay (total cost of the given asset) is known. However, the sum of the PV of all future cash flows is a function of: discount rate, cash flows themselves AND the timing of such cash flows.

Since the PV is a function of an interest rate, we set the equation = \$0 and the rate that solves this equation becomes the IRR.

It is near to impossible to calculate the IRR using a handheld calculator if there are more than a few cash flows involved. Spreadsheet programs utilize an iterative process where guessing is performed resulting in an incorrect answer and further guessing begins to target the answer. In recent versions of spreadsheet software using higher processing speeds, the answer appears in less than 1 sec. In the olden days of 286 and 386 processors, the user could see these calculations going on and on and it took forever (at most 2 seconds!).

Below is the IRR calculation for the most recent examples.

Period Cash Flow	0	1	2	3	4	5	6	7	8
	Investment	Resulting Cash Flow of Investment							
Opportunity "G"	\$ (12,500)	\$1,250	\$1,750	\$2,200	\$2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
Opportunity "H"	\$ (25,000)	\$6,000	\$6,000	\$6,000	\$6,000	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000
		"G"			"H"				
IRR		19.4%			17.3%				

Financial Analysis for the Professional Engineer

Located in the function section of the spreadsheet program, under the financial category, the function key “IRR” can be found. When opened, there are only two boxes in the IRR function: ‘Values’ and ‘Guess’.

The input for these values would look as follows, for “G” and “H”

A: =IRR (C8:C16, 0.10)

(highlighted in yellow)

B: =IRR (D8:D16, 0.10)

(highlighted in blue)

Where the first term within the function contains ALL the values in the problem and the second value is the ‘beginning guess’ given the computer. (The most recent version of Excel, the guess is not needed as a random number generator selects some value.)

Period Cash Flow	0	1	2	3	4	5	6	7	8
	Investment	Resulting Cash Flow of Investment							
Opportunity "G"	\$ (12,500)	\$1,250	\$1,750	\$2,200	\$2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
Opportunity "H"	\$ (25,000)	\$6,000	\$6,000	\$6,000	\$6,000	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000
		"G"			"H"				
IRR		19.4%			17.3%				

AN IMPORTANT NOTE ABOUT INPUTS: Be advised that there is a *switch* between the NPV and IRR inputs. (I argue this is a design or programmer flaw due to inconsistencies in thinking!) Remember, the NPV calculation needs the original investment added outside the function. Here, the original investment is need within the function itself. SO, planning your spreadsheet is important; earlier examples in this discussion provided the investment on a separate line while in the IRR calculation all data must be on one line!

Before we proceed to the next section, a recap of IRR is needed.

IRR is the rate at which the NPV calculation equals \$0.

IRR IS ONLY “THAT RATE”.....**and nothing more!**

Chapter Summary And Concept Questions

The Internal Rate of Return (IRR) was introduced as a mathematical result of the current and predicted cash flows. Please note the IRR is independent of any discount rate selected! Furthermore, it is quite difficult, if not impossible, to calculate the IRR manually.

Additionally, there appears to be an anomaly between how Excel calculates IRR and NPV. In the IRR function key, you insert the initial cash outlay within the formula. For NPV, the initial outlay remains outside the function key. Good spreadsheet management would dictate the setting up of your analysis to have all cash flows on one line for ease of calculations.

Please calculate the IRR for the same examples at the end of chapter 4; there are similar problems at the end of this course.

Chapter 4 & 6 Concept Questions:										
Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
Opportunity "X"		\$ (5,000)	\$ 3,500	\$ 3,000	\$ 2,000	\$ 200	\$ 100	\$ 50	\$ -	\$ -
Opportunity "Y"		\$ (2,500)	\$ 125	\$ 200	\$ 600	\$ 800	\$1,500	\$ 2,500	\$ -	\$ -
			"X"			"Y"				
NPV	10%		\$2,391			\$1,119				
		IRR	37%			19%				

Chapter 7

Dealing with the CFO of their operations and ‘talking their language’

The following chart shows how a corporate financial officer might utilize the NPV and IRR analytical tools. Instructions were sent out to each division, for example, so that each division might submit capital budgeting requests. Capital budgeting are significant purchases on behalf of the company that lead to long-lived assets. These assets could include new divisions or new acquisitions, expansion of current operations or replacements of significant asset such as an air conditioning system for an older high-rise corporate headquarter.

Each division submitted both a request for funding along with a quantitative analysis supporting that particular expenditure. Here are the results:

	Project Proposal	Project's Costs	Cumulative Costs	IRR	PV of Benefits	NPV
1	Purchase Real Estate for plant	2,000,000	2,000,000	23.0%	3,200,000	1,200,000
2	Upgrade IT	1,200,000	3,200,000	19.0%	1,740,000	540,000
3	Upgrade power efficiency	1,500,000	4,700,000	17.0%	2,070,000	570,000
4	Purchase minority of JV affiliate	900,000	5,600,000	16.0%	1,125,000	225,000
5	Purchase additional Cars	3,600,000	9,200,000	13.0%	4,248,000	648,000
6	Purchase new Forklifts	200,000	9,400,000	9.0%	186,000	(14,000)
7	Construct New Plant in Mexico	2,300,000	11,700,000	8.0%	2,093,000	(207,000)
8	Purchase new executive aircraft	5,000,000	16,700,000	3.0%	128,000	(4,872,000)

The eight divisions reported their particular capital budgeting items and the finance area of the firm ranked them. In this case, they were ranked in order of IRR. Assume that the firm is currently returning an 11% compound rate to shareholders. The finance department has automatically rejected the bottom three projects as they do not create incremental value to the owners of the firm. They do not earn the current rate of return. By accepting them, the firm will begin to earn a lowered rate of return then their historical averages.

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If the firm were to approve all submittals and had \$9.2 million in its budget to spend, all of the five remaining projects would be funded. However, if available capital is short of that amount, then rationing would be required. Would the firm select as many fully-funded projects it could afford or would the firm prioritize under some other criteria?

Notice that if were to re-rank according to NPV, there would be some shifting in order. Item five (Cars) would move to the second ranked positions, item two (IT) would move to the fourth position and the acquisition would bring up the rear.

Here are a few more points about financial analysis, computer modeling as it is briefly shown here and the formulas as applied to capital budgeting and the corporate world. As indicated earlier, there is a push from corporations from internal and external forces in quantifying every decision. Models and modeling can become quite complex (to be addressed fully below) with less and less time to re-evaluate assumptions. In addition, people will also be people. There will always be individuals who might deal the straight and narrow all the time (to be addressed in the third part of this continuing education course). Others are not always completely honest, even to themselves!

Do competing divisions create forecasts which might be biased toward their division and not others? Do managers create sales pitches so their pet projects get funded ahead of others? Can a spreadsheet model be so complex that an audit cannot prove the answer? Or put another way, can a model be created such that it appears to prove an answer that was pre-determined? Does this ever happen in the real world? While the focus of these exercises is not to create a protective veil for the professional engineer, utilizing these calculations so as to not be abused or taken is one side benefit.

Chapter 8

The Misuse of NPV and IRR

The titles to these series of continuing education courses target the engineer-manager and engineer-owner. As a manager, you must be aware that other managers might be altering their proposals so their pet project is approved. On the other hand, if this were your money, that is, you are the owner, having managers develop biased forecasts just to get a budget line item accepted can harm the entire operation. Does such activity happen? No comment, but it would be wise to understand such processes along with how this type of analysis could be misused. Be aware of the following:

- **Rate Selection:**

One important aspect (maybe one of the most important aspects of the NPV analysis) is the selection of the interest rate to discount future cash flows. Noting that, the lower the rate, the higher the NPV, be careful that the rate is appropriate.

Some suggest that the long run return provided to owners of the firm should be the minimum rate. Other suggestions might be that of a diversified portfolio of assets (a 'market return'), Return on Equity (ROE book equity), Return on Assets (ROA book assets), Weighted Average Cost of Capital (WACC), or some rate selected by the CFO/CEO or Board of Directors.

The *real rate* selected for an individual project should reflect the riskiness of that project. The rate needs to be adjusted for that specific opportunity and none of those listed above. So, here lies the quandary: not all CFO's understand the risk associated with adding a scrubbing unit (or not) to a chemical process. Therefore, the naïve CFO might apply a given rate by some other means (maybe listed above!) than the risk versus return scenario.

- **Forecast Bias**

A question to pose to you: Which of the following professionals is best at predicting the future cash flows for project "X"?

- a. 30-year veteran who has done 10 projects exactly like "X".
- b. 20-year veteran who has done 1 like "X" but 5 others similar to "X".
- c. 10-year veteran who has never been involved with the budget but engineered 5 projects.
- d. 5-year veteran who has engineered three of them, although all three were in the last two years.

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Which did you pick?

Okay, let me modify the initial question to the following, while keeping the choices identical: Which of the following professionals is best at selecting the lottery numbers for the next drawing?

Did your answer for this second question match the answer to the first? If you switched....Why?

I argue that all are as capable and as right about future predictions as any other.
NO ONE CAN PREDICT the future!

Time Value of Money, NPV and IRR math tools to use or aid in an analysis, yet they are imperfect. All decisions should not be reduced to pure numbers. Review the following examples:

Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
Opportunity "J"		\$ (12,500)	\$ 1,250	\$ 1,750	\$2,200	\$ 2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
Opportunity "K"		\$ (25,000)	\$(5,000)	\$(1,000)	\$ -	\$ -	\$ -	\$ -	\$ 25,000	\$ 95,000
			"J"			"K"				
IRR			19.4%			19.6%				
NPV	10%		\$6,643			\$26,775				
	15%		\$2,623			\$10,350				
	19.4%		\$0			\$386				
	20%		(\$323)			(\$790)				
	25%		(\$2,524)			(\$8,459)				

In all cases where the selected rate is less than 19.4% (by definition, the IRR for "A" here), Project B is superior.

BUT, what would Bubba say?

His conversation might go something like, 'For "B", you want me to invest, okay, I get that. Then, you want more and then even more...maybe I will buy that...but I have to wait 7 years before I get a single cash flow and THEN I STILL NOT MADE WHOLE!'

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■ Human Review

A human review should be conducted to ensure things look okay (see also “Simple Cap Rate” to follow.)

So, human, review the following:

Opportunity “A” is superior at 15%. However, if I were to indicate that “B” was a grocery store and “A” was a software program, would that information (and that information alone) change your mind? It would not change the numbers, but does this additional information change your mind? If it does not, please don’t ever become an owner...you may not have the visionary spirit. Why!?!? Everyone needs groceries so the predicted cash flows might seem plausible for “B” (incredibly boring, but plausible!).

However, software can become null and void in a matter of months! While both are still predictions, the threat that the obsolescence hits the software opportunity is very high. Meaning, a great deal of “A” NPV comes from the latter years. Those cash flows are more vulnerable to not being realized. Don’t forget the Human Review.

Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
Opportunity "L"		\$ (12,500)	\$1,250	\$ 1,750	\$ 2,200	\$ 2,500	\$4,500	\$ 5,500	\$ 6,500	\$ 8,500
Opportunity "M"		\$ (25,000)	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000	\$6,000	\$ 6,000	\$ 6,000	\$ 6,000
			"L"			"M"				
IRR			19.4%			17.3%				
NPV	10%		\$6,643			\$7,010				
	15%		\$2,623			\$1,924				
	19.4%		\$0			(\$1,540)				
	20%		(\$323)			(\$1,977)				
	25%		(\$2,524)			(\$5,027)				

Lack of cash flow Inspection (extended Human Review)

There is no trick in the NPV calculations as they are accurate and can be used for analytical purposes.

Review the following with a note that there is a *trick*.

The *trick* here is a math trick. That is, **there is a result produced by the spreadsheet's IRR formula....**

AND THAT ANSWER IS AUTOMATICALLY WRONG!

If you were to calculate the IRR in both of the following, Excel will give an answer which is automatically incorrect.

Period Cash Flow		0	1	2	3	4	5	6	7	8
		Investment	Resulting Cash Flow of Investment							
Opportunity "P"		\$ (12,500)	\$3,500	\$ 4,500	\$ 6,500	\$(1,500)	\$3,500	\$ 2,500	\$ 2,500	\$ 2,500
Opportunity "Q"		\$ (25,000)	\$6,000	\$16,000	\$ 5,000	\$ 3,000	\$8,000	\$ (8,000)	\$ 12,000	\$ (2,000)
			"P"			"Q"				
IRR			20.3%			17.9%				
NPV	10%		\$4,293			\$5,160				
	15%		\$1,940			\$1,695				
	20.3%		\$0			(\$1,290)				
	20%		\$103			(\$1,129)				
	25%		(\$1,360)			(\$3,466)				

In fact, any answer produced from this spreadsheet is automatically wrong. Or it might be possible to say that the answer provided is a correct answer, but so are an infinite number of other results as well.

The cash flows can only have one sign change. Outflows, designated by (-), and inflows, designated by (+) can only go from one to the other once for the IRR function to provide one and only valid answer. Valid Cash flows can be as follows:

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(-)(+)(+)(+)(+)

(-)(-)(-)(+)(+)

(-)(-)(-)(-)(+)

Invalid cash flows, or cash flows that do not produce a valid IRR, can be as follows:

(-)(+)(-)(+)(+)

(-)(-)(+)(+)(-)

(-)(-)(+)(-)(+)

Ironically, multiple sign changes do not affect the NPV calculations. The example above provides adequate NPV numbers but not valid IRR numbers. However, you must inspect the cash flows before determining if these calculations can be used.

There is an academic term naming the valid cash flows as normal cash flows and the invalid cash flows as non-normal. Given normal cash flows, there are some unique aspects between IRR and NPV.

- If $NPV > \$0$, the IRR is greater than the discount rates used to calculate that particular NPV.
- If $NPV < \$0$, the IRR is less than that respective discount rate.
- The 'vice-versa' is also true. If $IRR > \text{discount rate}$, the NPV will be $> \$0$
- If the $IRR < \text{discount rate}$, the $NPV < \$0$.
- **Using IRR VS NPV, which is correct?**

Assume you have the following:

$NPV(x) > NPV(y)$ and,

$IRR(x) < IRR(y)$

Which is the controlling function?

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Before answering, look at the resulting units.....What are the units for each?

NPV is DOLLARS (\$\$\$), IRR is []

(NOTE: No typo here! The units for IRR are nothing or it is unitless!!! A percentage has no units!)

Real World application:

NPV (\$) or IRR ([])

Which of these units can you walk into Starbucks and buy a cup of coffee with?

NPV is the controlling function!

A note to aggressive engineers: For too long CFO-types have relied heavily on IRR as the deciding factor! **They are wrong.** But don't tell them so, at least in so many words, choose your battles wisely; engage in an academic discussion about IRR and NPV. If the CFO resists, it is not worth losing your Job!!! (But they are still wrong!)

IRR, as stated, is that RATE WHICH MAKES NPV = \$0

IT IS NOTHING MORE. It is not the rate you earn on this investment! It is a mathematical solution to the inputted numbers provided. Assume in your model you were to receive \$10,000 in one year's time and the IRR from the future cash flows net of the current investment indicated you were to earn 20%. Okay, it is one year later and you do receive \$10,000 exactly. Do something with it! That is, the model said you would earn a 20% return and in order to get that IRR in the *real world* you must now re-invest at 20%! Where can you put \$10,000 to work? CD's? If so, you will get a 4% rate of return in the environment when this page was written. Who knows what the rate will be when you, the continuing ed student reads this, much less, what will be the rate when the next cash flow (the predicted year 2 cash flow) is received.

CFO's relying fully on IRR as the only choice are lying to owners, maybe even themselves. While one excuse might be to save their job, such deception should not be tolerated. If careful inspections of cash flows are not performed, decisions could be based on an invalid IRR. Furthermore, NPV takes on relative values and IRR does not. That is, scales of \$100's and \$1 million are taken into account when calculating NPV. For example, a project costing \$100 might create a NPV of \$150; the \$1 million might create a value of \$125 million. The first is a 50% increase but \$50 and the second is a 25% increase but \$25 million. IRR calculations could be 12% and 11% respectively.

Chapter 9

Simple Capitalization Rate (Bubba-like analysis revisited).

Bubba has provided us with some simple insights. One more simple process should be introduced as a sanity check for analytical purposes. This is called the simple cap rate analysis. Say you want to earn 10% return. (Why 10%? Well, it is very easy to use in calculations!) An asset throws off \$100 in cash each year. You want to *value the asset*.

A time value of money calculation could be set up in a spreadsheet. Place \$100 each year for “n” year and take the present value at 10% to get a PV.

Or you could simply assume this cash will last forever (perpetuity) and value these cash flows by using a perpetuity formula: Yearly Income divided by the interest rate.

In this case, \$100 each year forever equates to a value of \$1,000 using a 10% capitalization rate.

Any reduction in years will, of course, reduce this value; but it will take a great many years of reductions to truly affect the value. At $n = 50$ years, the value is still very near \$1,000.

So the Cap Rate method sets an upper limit on values and calculating the upper bound, quickly and in your head, can save plenty of ‘financial consulting hours’ billed at a high rate. Commercial real estate participants utilize this simple calculation all the time. They generally utilize both 10% and 12% as the perpetuity rate. Why these two rates? 10% annual rates would mean you multiply the annual cash flows by a factor of 10. 12% is used because if you use monthly cash flows, you can take that amount and divide by 1% per month as the perpetuity rate or use the factor of 100 times the monthly rate to quickly determine a maximum value for the property.

Chapter 10

Valuation Techniques Applied to Capital Budgeting

The basic and most fundamental Finance Equation is:

Price versus Value

Simply, if $\text{Value} > \text{Price}$, then a **purchase occurs**.

The opposite is true with an additional caveat for the true entrepreneur.

That is, if $\text{Price} > \text{Value}$ **no transaction will occur** or

The entrepreneur will ask, “Can I sell into this Value stream?” I don’t value the asset as others but if more people value the asset at this level, can I manufacture the asset and sell it to those who value it more than I do? Put in economic terms, since I don’t value this asset very high but others do, can I go into business manufacturing this asset?

Price might be considered a given in our marketplace. It is an amount set by a seller.

Value, on the hand, is a VERY PERSONAL thing. I have the very good fortune that no one in my immediate or extended family uses insulin; therefore, my ‘value’ of insulin might be less than a family with members or individuals who need this drug daily to survive. I understand there is a ‘value’ to society and to the users of insulin, but it does not affect my life. So my ‘value’ proposition is different than others.

Time VALUE of money concepts is just that, a value proposition. In calculating the various formulas including NPV, a value or a judgment must be made to select the appropriate discount rate.

Would two people value a business differently if the business manufactured dynamite? Say one of those individuals was YOU and you know little of this process. You might approach this by considering dynamite as a very risky business (in many senses of the word!) Therefore, the appropriate discount you would apply to the predicted future cash flows might be fairly high. The resulting math answer is somewhat low due to this high discount rate.

The second person, who understands the risks of this entity because they have own a plant in Australia, may not place such a high premium on the risks associated with the operations. Or put another way, they know how to address many of the risks associated with the firm and can reduce those overall risks. Perhaps, a lower discount will be applied with the result being a higher value.

It is these differences in values, which create differing prices, as evident by fluctuations in asset values. The best examples of these price fluctuations occur in the commodity pits and stock markets for public securities.

Asset Valuation

There are four general methods to value any asset. The asset can be a desk, a copy machine, an employee, intellectual property (such as trademarks, patents), machines, or operating entities. The 4 methods will be outlined below. In many instances, an asset may not have a valid “valuation” using a particular method. Who determines the validity? Experts, sometimes self-proclaimed, are called upon to render their opinion.

1. Income Approach

Imagine a black box with a lid. We seek the value of a particular asset; however, we cannot see the asset as it within the black box and out of sight. Occasionally, the lid opens and when it does, cash (net of any taxes or other hindrances) comes out.

The value of this asset is the present value of the future cash flows.

If the cash flows emerge in a regular pattern (equal amounts with equal time spacing), the math becomes easier to calculate. If not a regular cash flow, just a little more effort is needed to calculate the present value.

2. Market Approach

The market approach is just that. If there exists a market for a particular asset where assets freely change hands from a willing buyer and a willing seller, the value of the asset is the price at which these exchanges or trades occur. Publicly traded stocks like IBM are said to be valued daily, hourly or minute-by-minute through this market approach.

Similarly, a market approach can be applied to things like residential or commercial real estate. Recent comparable sales, say on a per-square-foot basis, can be utilized with the pricing applied to the asset in question. Adjustment or modifications can be made as well.

3. Liquidation Approach

This approach will literally break apart an asset and sell it for parts. A pick-up truck could be sold for parts (doors, engine, wheels, etc). A commercial building could be dismantled and sold piece by piece, including the land.

4. Replacement Approach

Sometimes the hardest to determine, but the replacement value is the total cost associated with duplicating the asset today. In real estate, a commercial building would be valued under today's labor rate, today's costs for metal and today's costs for wallboard. An example of how to value software would require a room full of programmers and a room full of attorneys. You start the clock on both rooms. The programmers must develop a program that does this list of things and the attorneys must guide the programmers so that they do not violate existing patents. The hourly rates are applied to the total clock hours once a finished product is complete.

Applying these methods:

Apartment Complex

Income Approach: present value of the Net rents. Net rents defined as the remaining cash flows after normal operating costs (landscape upkeep, pool services, utilities, etc.) are deducted. The evaluation can also include the exit price; say for example, the complex is to be sold in 5 years.

Market Approach: three other similar complexes have sold in the neighborhood for \$150 per square foot; apply this same rate, adjusted for any extenuating circumstances, to our complex.

Liquidation Approach: the net dismantled revenue, which is the net cash received from selling individual assets, after paying for the cost of the dismantling.

Replacement Approach: the total costs to replace the entire complex at today's prices.

Public Securities like Microsoft Stock

Which method would create the highest valuation?

Yes, since it is publicly traded the market value is set when the willing buyers and sellers transact trades. But is this the highest value?

The income approach needs to approach the market approach. In the long haul, the firm's value must be that which it can generate in future cash flows (earnings and/or dividends).

Replacement? Liquidation?

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Ironically, liquidation has the largest value for Microsoft. Don't believe me? Well, you will just have to take third course in this series to get a full explanation. But for a hint, the most recent and most local example to me is the privatization of my local utility, formerly TXU. This public entity was taken private with the private equity owners splitting up the various divisions. As separately operated businesses, they will become more efficient entities and create wealth for these risk-takers!

Chapter 11

Value in the Professional Engineer Practice

The mathematical tools presented, and for some re-introduced, are useful in determining value received versus initial costs. Do you, in fact, receive your investment back at an appropriate rate? The investment might be your college diploma, Master's degree or other education. The investment could be the copier and choices among copiers for your office. The investment could be an employee or an incremental employee. Last, the investment might be an engineering career or the value of an engineering practice.

While it is noble to say that the engineering profession does not focus on wealth creation, it would be naïve and inaccurate to say that engineers do not care about personal revenue production, career and cash flow issues. Valuation is a personal process but we can apply those mathematical tools to help managers and owners move forward.

Wealth is created when an asset is valued by what that asset produces. A machine may cost \$120,000 but produces net cash flows of \$70,000 per year for the next 20 years. The income approach to valuing this asset indicates the price of the machine is far less than the value the machine produces over time. This is true, at least in the long run, for employees as well. The engineer-employee must recognize that they must produce some positive return over their costs (salary, allocated overhead, benefits); if they fail to produce, that particular job position is in jeopardy of being eliminated.

Risks associated with the future cash flows were not introduced as we assumed the future cash flows are known. When we allow variability over time on our predictions of future events, our risk goes up and the discount rate used to calculate value must be adjusted accordingly.

Contracts that represent continuing revenue streams are only valuable when after tax cash flows are positive. The analysis must include both direct and indirect costs along with contingencies associated with future events. Value is only created if the cost of securing these contracts is less than the present value of the net cash flows resulting from this contract. Do the math!

Course Summary

This course targets mathematical solutions in valuing assets. The breadth and scope of assets are infinite as these math tools can be applied to office machinery, office expansions, office relocations and selling the office (selling the engineering practice). Only when the value of an asset exceeds its price will an event take place.

The mathematical solution tools included the payback method, net present value (NPV) and the internal rate of return (IRR) calculations to quantify options or opportunities presented. Furthermore, valuation techniques utilizing these tools were also introduced to show the span of these formulas.

One targeted area for this course was to educate the professional engineer in the area of better communications specifically with financial counterparts. The language of financial management is relatively easy to comprehend once exposed; certainly easier than the hours of college calculus. However, many professionals from all walks of life can be intimidated by the financial lingo. The professional engineer can better serve himself and his position by understanding these financial concepts.

Lastly, the area of misuse of these tools was introduced though not intended to cause any dark cloud on humanity. Rather, the misuse can be avoided or minimized if everyone in the budgeting process understands these math concepts. Spreadsheet programs can become so complex that programmers or modelers can manipulate the final results. Engineering Managers and especially Engineer-Owner should not necessarily rely solely on others modeling due to some biasness that might be present.

The course is math-oriented in which our quantitative analysis can be utilized by buyers and sellers to justify a purchase. More and more quantitative analysis will be forced on companies down the road. And while this course is purely math oriented, these tools should be just one of the tools used in making decisions. If the math says one thing, and your gut says something else, I would recommend you go with your gut feelings. Remember, Bubba and his thought process.