

**QUEEN'S UNIVERSITY**  
KINGSTON, ONTARIO

**Faculty of Engineering and Applied Science**

**APSC221 - Economics and Business Practices in Engineering – Winter 2023**

Final Examination – April 22, 2023

INSTRUCTORS – Paul Hungler

This examination consists of 10 questions and is out of a total of **89** marks.

Time available **3** hours.

**INSTRUCTIONS:**

1. Answers to ALL questions must be written in the answer booklet that is provided.
  - a. Put your name, student number on the front page(s) of all answer booklet(s).
  - b. Do not remove any pages from the booklet that is provided.
  - c. If there is insufficient space, ask the proctor for another answer booklet.
2. Do not use RED COLOUR for your presentation in any form, written or pictorial; this colour is reserved for marking your submission.
3. ONLY the use of the Queen's University-approved Casio 991 calculator will be allowed.
4. The Formula sheet and Interest tables are provided at the back of this exam.
5. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer a clear statement of any assumptions made. **Proctors are unable to respond to queries about the interpretation of exam questions. Do your best to answer exam questions as written.**
6. Marks will be deducted if appropriate interest factors, their designations and appropriate values of interest rate (i) and period (n) are not indicated. You are strongly encouraged to provide cash flow diagrams where appropriate.
7. You must hand in all answer booklets, questions sheets and reference sheets on completion of the test.

There will be penalties if any of the above instructions are not followed.

**GOOD LUCK**

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# Engineering Economics

## Winter 2023

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Final Examination – April 22, 2023

**DO NOT ANSWER ON THIS TEST PAPER, All work and answers must be shown in your examination booklet.**

**Question 1: All Chapters (½ mark for each = 10 marks)**

Write your answers in your exam booklet NOT on this page.

Please write the answers in a single column, one answer per line, on a page of its own.

Select the one alternative that best completes the statement or answers the question.

- A. There are many sources of useful information in cost and revenue estimating, such as \_\_\_\_\_.  
1. the building code  
2. accounting records  
3. market analysts  
4. general economic activity levels within an industry  
5. all of the above
- B. Parametric cost estimating is the use of historical cost data and statistical techniques to predict \_\_\_\_\_ costs.  
1. sunk  
2. variable  
3. depreciation  
4. future  
5. all of the above
- C. When alternatives for accomplishing a specific task are being compared over one year or less they are referred to as Present Economic Studies and \_\_\_\_\_.  
1. the before-tax MARR is used  
2. only the Present Worth is calculated  
3. the time value of money can be ignored  
4. the present worth of costs is set equal to the present worth of revenues  
5. none of these
- D. \_\_\_\_\_ is a dimensionless number that indicates how a cost or price has changed with time with respect to a base year.  
1. A sunk cost  
2. A real dollar  
3. An index  
4. An interest factor  
5. all of the above
- E. Individuals who both recognize and seize new business opportunities are referred to as  
1. independents.  
2. entrepreneurs.  
3. accountants.  
4. franchisees.  
5. speculators.

F. Engineering economic decisions frequently involve evaluating tradeoffs among \_\_\_\_\_ that occur at different times.

1. stress and strain
2. present worth and annual worth
3. costs and benefits
4. the time value of money
5. none of the above

G. \_\_\_\_\_ is the compensation for giving up the use of the money for the duration of the loan.

1. Inflation
2. Future worth
3. Compounding
4. Interest
5. none of the above

H. Based on the following information what can you say about this company?

	Industry Average	2015	2016	2017
Current Ratio	2.29	1.10	1.03	1.32

1. The ratio reveals that survival of the company seems to be due to an extreme reliance on debt financing.
  2. While a ratio above 1.0 indicates they could pay off their current liabilities it is well below 2.0, which is usually considered adequate.
  3. The vast (and increasing) majority of their current assets are in inventory, which may or may not be sold quickly should they need cash.
  4. While increasing from 2015 to 2017, are still well below the industry norm, which means the company is not as efficient as its competitors at using its resources to manage its inventory and make sales.
  5. Ratio is low indicating that 80%-90% of the assets have been financed by issuing stocks.
- I. The resulting amount, from the conversion of an arithmetic gradient into a Present Worth, occurs \_\_\_\_\_ time periods before the first non-zero gradient amount.
1. zero
  2. one
  3. two
  4. three
  5. four
- J. For Present Worth calculations when  $N \rightarrow \infty$  you can use \_\_\_\_\_.
1.  $(A/P, i, \infty)$
  2.  $P/i$
  3.  $A/i$
  4.  $F/i$
  5. All of the above
- K. Often the problem with using a study period to compare projects is estimating appropriate \_\_\_\_\_.
1. revenues
  2. first costs
  3. recurring maintenance
  4. interest rates
  5. salvage values
- L. If the annual savings are not constant, we can calculate the payback period by \_\_\_\_\_.
1. setting the present worth of all costs equal to the present worth of all savings
  2. the ratio of first cost over the first year sum of all savings
  3. accounting for the need to recover capital quickly
  4. deducting each year of savings from the first cost until the first cost is recovered
  5. none of these

- M. The text states that a disadvantage of implementing the internal rate of return method is that \_\_\_\_\_.
1. we need to calculate the after-tax MARR
  2. the method used is only an approximation
  3. there may be more than one internal rate of return
  4. interest tables are not provided in fractional amounts
  5. linear interpolation between interest rates is not 100% accurate
- N. A risk impact matrix compares \_\_\_\_\_.
1. likelihood and cost estimate risk
  2. consequences and likelihood
  3. maturity and reliability
  4. dependency and consequences
  5. all of the above
- O. An organization can choose to \_\_\_\_\_ risk.
1. accept
  2. minimize
  3. share
  4. transfer
  5. all of the above
- P. Contingency reserves in several forms, including financial and managerial, are among the most common methods to \_\_\_\_\_ project risk.
1. account for
  2. determine
  3. evaluate
  4. mitigate
  5. all of the above
- Q. There are four classic outcomes from change, which reflect the risks and the ways to avoid them. They are; The disaster, the lost investment, the \_\_\_\_\_ and the ideal.
1. unlikely outcome
  2. complete success
  3. partial success
  4. failed outcome
  5. redesign success
- R. One significant cost that is often forgotten is the effect on the time of everyone affected by change. Many people in the organisation will need to give up time to \_\_\_\_\_.
1. explain how things work to those involved in designing changes
  2. be consulted on the effectiveness and realism of planned change
  3. provide ideas for improvements
  4. be trained and have changes explained to them
  5. all of the above
- S. Management is the process of planning, organizing, leading, and controlling an enterprise's \_\_\_\_\_ resources.
1. financial
  2. physical
  3. human
  4. information
  5. all of the above
- T. The three levels of hierarchical management plans are; \_\_\_\_\_.
1. Preliminary, Building, and Completed
  2. Planning, Implementation, and Validation
  3. Operational, Tactical, and Strategic
  4. Budgetary, As Quoted, and Final
  5. none of the above

**Question 2: Cost Estimation (8 marks)**

Two manufacturing machines are being considered for the production of a part. The important differences between the machines are their production capacities (production rate and available production hours) and their reject rates (percentage of parts produced that cannot be sold). Consider the following table:

	Machine #1	Machine #2
Production Rate	75 parts/hour	97.5 parts/hour
Hours available per day	7 hours/day	6 hours/day
Percent parts rejected	3%	10%

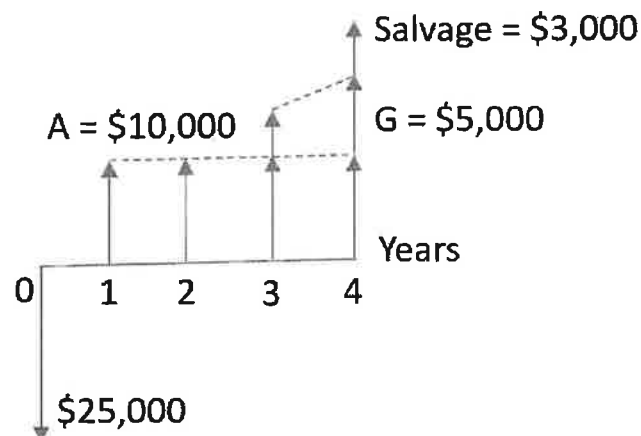
The material cost is \$6.00 per part, and defect-free parts can be sold for \$12 each. Rejected parts have negligible scrap value. For either machine, the operator cost is \$15.00 per hour and the variable overhead rate for traceable costs is \$5.00 per hour.

- If 30,000 units of non-defective product must be manufactured during the next 3 months. Assuming one shift per day and five work days per week. Can the order be delivered on time using either machine?
- What is the total cost per day to operate each machine?
- What is the cost per unit produced for each machine?
- Which machine should be selected?

**Question 3: Cash Flow Analysis (9 marks)**

You would like to invest some of the money you have saved in a new business opportunity. The Cash Flow Diagram for an investment is depicted below.

- Using the simple payback method, determine the payback period for the investment.
- Using the discounted payback method with an interest rate of 10%, determine the payback period for the investment.
- What is the present worth of the investment?
- Would you invest in this business? Justify your answer, i.e. a simple "Yes" or "No", or similar answer, will get you zero marks.



**Question 4: Comparison Methods (7 marks)**

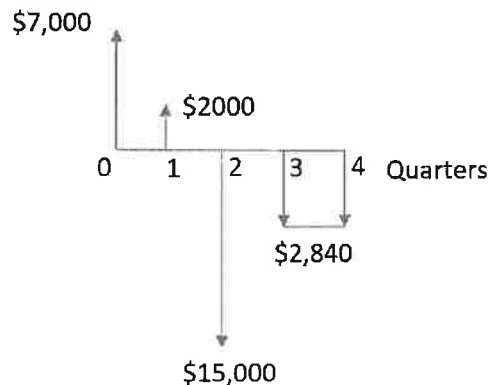
You are designing a new commercial mooring system for a floating dock which will bring in revenues by allowing boats of different sizes to dock on your new bridge. You have to decide between two competing designs. Option 1 will last longer and bring in more revenue per year but has higher upfront costs. Based on the information the manufacturers have provided you come up with the following table:

	Option 1	Option 2
<b>Service Life</b>	20 years	10 Years
<b>First Cost</b>	\$ 30,000	\$ 10,000
<b>Revenue</b>	\$ 5,000 / year	\$ 2,500 / year
<b>Maintenance costs</b>	\$ 80 / year increasing by \$20 / year starting in year 2	\$ 120 / year
<b>Salvage Value (After service life)</b>	Nil	\$2,500

- Using a MARR of 12% which system should you purchase?
- At what salvage value would the less desirable option have the same worth?

**Question 5: Rates of Return (8 marks)**

The cash flow diagram below depicts the payment schedule for a partnership you are contemplating undertaking with a larger engineering firm. The cash flows will occur every quarter (3 months) and your company uses a nominal MARR of 12% per year.



- What is the precise annual ERR for the partnership?
- Should you enter into this partnership?

**Question 6: Taxes (7 marks)**

Max Excavating is considering buying a new excavation machine for an upcoming job. The excavator will cost \$560,000 to purchase and the company expects that it will cost \$20,000 in gas per year to operate while the maintenance will cost \$10,000 for the first year, rising by \$4,000 per year thereafter. Max Excavating expects to keep the equipment for 5 years. At the end of the 5 years the salvage value of the excavator is expected to be \$120,000. The CCA depreciation rate for excavators is 30%.

One alternative that Max Excavating could consider is to lease the excavator. With the lease, Max will have to still pay for gas but the repairs will be covered by the leasing company. The lease costs are \$150,000 per year.

Max Excavating uses an after tax MARR of 9.5% compounded daily and has a tax rate of 40%. Using after-tax annual worth analysis over the next five years, determine which option Max Excavating should choose.

**Question 7: Inflation (5 marks)**

Using a reservoir and piping system a co-op of organic farmers near Kingston is considering a water sharing scheme. The first cost for the system would be \$211,880 with annual maintenance costs of \$2000 (actual). They expect the irrigation system will bring them \$22,000 per year in additional revenues (actual) due to the better crop production. Their real MARR is 4% and they anticipate inflation to be 3% per year. Assume that the reservoir system will have a 20 year life.

- a) Using current cash flows, find the current IRR on this project.
- b) What is the current MARR?
- c) Should they invest?

**Question 8: Replacement Decisions (9 marks)**

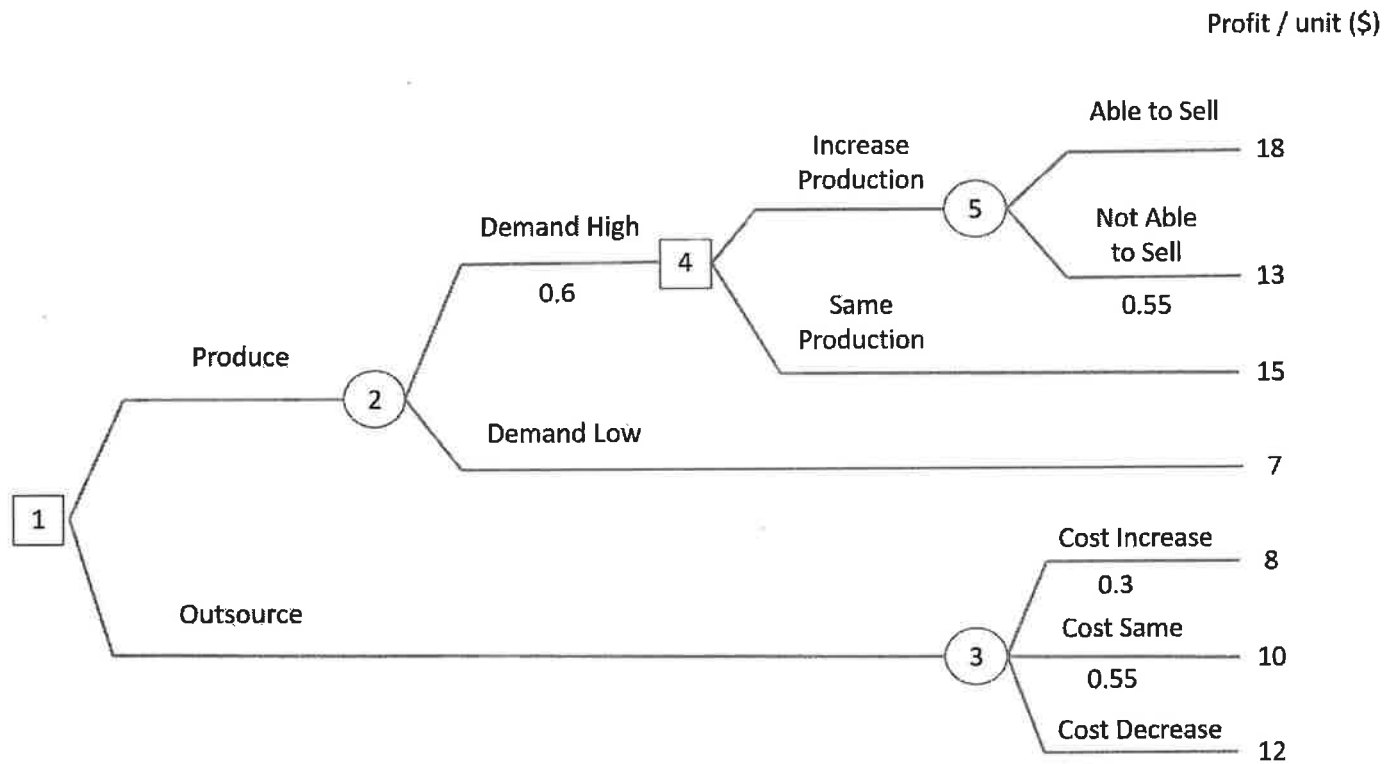
Over the next 3 years a road paving company is considering replacing their existing grading machine which was purchased 5 years ago for \$950,000. Depreciation of the grading machine follows a straight line depreciation model with a predicted salvage value of \$150,000 three years from now. The operation and maintenance costs of the grading machine have been increasing and are expected to be \$20,000 next year, \$30,000 two years from now and \$50,000 three years from now. The company uses a MARR of 15%.

- a) What is the current salvage value of the grading machine?
- b) Determine EAC\* and the Economic Life of the existing grading machine.
- c) The road paving company went out and obtained the details on a few other replacement options which are presented in the table below.
  - i. What is the best option in the table below?
  - ii. Should the existing grader be replaced and if so when?

Option	EAC* (\$)	Economic Life (years)
A	195,000	5
B	180,000	10

**Question 9: Risk and Uncertainty (6 marks)**

For the following decision tree calculate the expected values at each node and recommend which decision should be made.





**Question 10: Ava Case Study - Business Questions (20 marks)**Business Idea:

Build a smartphone app that transcribes conversation received through mobile phones' microphones into text, so people with hearing problems can follow along in a group setting.

Pitch:

It is difficult for people who are deaf or hearing-impaired to follow conversations in group settings such as a family dinner, a business meeting, a presentation, or lunch with friends. Even in a setting where every participant knows sign language, picking up an entire conversation is challenging. Sign language relies on people watching each other sign, and in a group setting people often talk that are not directly looking at each other. The only option that people with hearing problems have to fully capture a group conversation is to hire a transcriber or interpreter. That's an impractical solution, given that transcribers and interpreters charge up to \$125 per hour. Hearing aids are available for people who are hearing-impaired, but the cost is often a deterrent and hearing aids have varying levels of effectiveness.

Ava is a smartphone app designed to tackle this problem. Here's how it works. Ava connects all the smartphones in a room via an app. All a person with hearing difficulties has to do is invite the people in the room to participate, and if they have Ava on their phones, they can accept the invite. Ava will then, through the microphone in each participant's smartphone, transcribe the conversation in real time and display the transcription on the hearing-impaired person's phone. Each person's comments include their name and show up in a different color. Ava's interface will also show a small photo of each person who is involved with the conversation. So if Jane, who is deaf, invites Ava at the beginning of a family dinner, and all the members of Jane's family have the Ava app and accept Jane's invite, Jane can follow the conversation on her smartphone. The transcriptions, which are made possible via the speech recognition technology, are made in less than one second. Ava allows people with hearing difficulties to connect, engage, and enjoy rather than dread group conversations. The value that Ava adds to its users' lives is very personal for two of its three founders. Thibault Duchemin and Skinner Cheng. Cheng has been deaf since he was two years old and Duchemin is a coda, meaning he grew up with deaf family members.

There are 350 million people in the world who are deaf or hearing-impaired, which is roughly 5 percent of the world's population. Ava's mission is to make its solution available to anyone who can benefit from it anywhere, enriching the social engagement of the people who utilize the service.

<b>Ava</b>					
<b>Pro Forma Consolidated Balance Sheet - Projected \$ (000's) for year ending</b>					
		<b>2023</b>	<b>2024</b>	<b>2025</b>	
<b>Assets</b>					
<b>Current Assets</b>					
	Cash	19	19	19	
	Accounts receivable	779	935	1,122	
	Inventories (T-Shirts)	2	2	2	
	<b>Total Current Assets</b>	<b>800</b>	<b>956</b>	<b>1,143</b>	
<b>Fixed Assets</b>					
	Software Code	1,000	1,015	1,030	
	Computer Servers	1,386	1,455	1,528	
	Other Assets	3	3	3	
	<b>Total Assets</b>	<b>3,189</b>	<b>3,429</b>	<b>3,704</b>	
<b>Liabilities and Owners' Equity</b>					
<b>Current Liabilities</b>					
	Due to Bank	130	124	117	
	Accounts Payable	644	612	581	
	Wages Payable	213	245	282	
	Income Tax Payable	38	73	110	
	<b>Total Current Liabilities</b>	<b>1,025</b>	<b>1,054</b>	<b>1,090</b>	
<b>Long-Term Liabilities</b>					
	Long-term Debt	1,000	975	951	
	<b>Total Long-Term Liabilities</b>	<b>1,000</b>	<b>975</b>	<b>951</b>	
<b>Owner's Equity</b>					
	Capital Stock	1,164	1,374	1,621	
	Retained earnings	0	27	43	
	<b>Total Owners' Equity</b>	<b>1,164</b>	<b>1,400</b>	<b>1,663</b>	
	<b>Total Liabilities and Owners' Equity</b>	<b>\$ 3,189</b>	<b>\$ 3,429</b>	<b>\$ 3,704</b>	

**Ava - Projected Financial Ratios**

	<b>2023</b>	<b>2024</b>	<b>2025</b>	<b>Closest Industry Norm</b>
Current ratio	0.78	0.91	1.05	2.58
Acid-test ratio	0.78	0.91	1.05	1.25
Equity ratio	0.37	0.41	0.45	0.39
Return-on-equity ratio	12.0%	19.5%	24.6%	18%
Profit Margin	11%	14%	16%	15%
Debt to Equity Ratio	-1.00	-1.00	-1.00	2.35

**Pro Forma Income Statement - Projected \$ (000's) for year ending**

	2023	2024	2025
<b>Revenues</b>			
Total Revenue	9,355	9,823	10,314
Less: Costs	8,281	8,447	8,616
Net revenue	1,074	1,376	1,698
<b>Expenses</b>			
Marketing	300	306	312
Depreciation	147	176	212
Interest	412	474	545
Income Taxes	75	147	220
Total expenses	934	1,103	1,289
<b>Net Income</b>	<b>\$ 140</b>	<b>\$ 273</b>	<b>\$ 409</b>

Based **ONLY** on the information provided above, answer the following questions. We are looking for short sentences and / or quality bullet points, **NOT** long-winded rambling mini essays.

## First Screen (6 Marks)

- a) Using a Low (-1), Moderate (0), High (1) potential, score the following. You **must** provide justification from the case for each in order to receive full marks. (5 marks)

Your answer in the answer booklet should look like:

9. a) 1. {score} – {Justification}  
 2. {score} – {Justification}  
 Etc.

Target Market and Customer-Related Issues	Low Potential (-1)	Moderate Potential (0)	High Potential (+1)
1. Identification of target market for the proposed new venture	Difficult to identify	May be able to identify	Identified
2. Ability to create "barriers to entry" for potential competitors	Unable to create	May or may not be able to create	Can create
3. Purchasing power of customers	Low	Moderate	High
4. Ease of making customers aware of the new product or service	Low	Moderate	High
5. Growth potential of target market	Low	Moderate	High

- b) Provide a suggestion for improving the potential. (1 mark)

Feasibility Analysis (4 Marks)

- a) Comment on what you think about the Product Desirability. One plus and one negative. (2 marks)
- b) Comment on what you think about the Industry Attractiveness. One plus and one negative. (2 marks)

Business Plans: Marketing and Operations (4 Marks)

Assuming that you are fully in charge of Ava and will make all of the decisions;

- a) Describe what your overall approach for marketing the smartphone App would be. (2 marks)
- b) Operations Plan: Articulate what your general approach to operations will be. (2 marks)

Frame your discussion in terms of;

- i. "back stage" – the behind the scenes activities
- ii. "front stage" – what the customer will see and experience

Financial Analysis: (6 Marks – one for each ratio)

**See formula sheet for the definitions of the above ratios.**

You have been asked to evaluate Ava's projected financial strength for a potential investor based on the Pro Forma Balance Sheet, Income Statement and Financial Ratios provided above for the next three years. Provide a concise comment on the implications of **each of the six ratios shown above**, not describing what the ratio is (definitions are provided on the formula sheet), but what it implies and / or a potential reason why it would be what it is.

- a) Current ratio
- b) Acid-test ratio
- c) Equity Ratio
- d) Return-on-equity ratio
- e) Profit Margin
- f) Debt to Equity Ratio

APSC 221 – Examination Formula SheetInterest Factors:

$$(F/P, i, n) = (1 + i)^n$$

$$(P/F, i, n) = \frac{1}{(1+i)^n}$$

$$P = \lim_{n \rightarrow \infty} A \left( \frac{P}{A}, i, n \right) = \frac{A}{i}$$

To calculate effective interest rates:

$$i_e = (1 + i_s)^m - 1$$

$$i_e = \left( 1 + \frac{r}{m} \right)^m - 1$$

Cost Estimation Techniques:

$$C_n = C_k \left( \frac{I_n}{I_k} \right) \text{ Estimate year } n, \text{ based on year } k$$

$$Zu = K \left[ u^{\left( \frac{\log S}{\log 2} \right)} \right] \text{ } u = \text{output unit \#}$$

K=resources for 1<sup>st</sup> unit

S=learning curve parameter

$$\frac{C_A}{C_B} = \left( \frac{S_A}{S_B} \right)^X \quad C = \text{Cost in \$, same point in time}$$

S=Size, same physical units

X=cost-capacity factor

Inflation:

$$i_{Real} = \frac{1 + i_{Actual}}{1 + f} - 1$$

$$i_{Actual} = (1 + i_{Real})(1 + f) - 1$$

$$\text{Actual\$} = \text{Real\$} (1 + f)^n$$

Financial Ratios:

Current Ratio = Current Assets / Current Liabilities

Quick or Acid Test Ratio = Quick Assets / Current Liabilities

Equity Ratio = Total Equity / Total Assets

Inventory Turnover = Sales / Inventories

Return on Assets (ROA) = Net Income / Average Total Assets

Return on Equity (ROE) = Net Income / Average Shareholder Equity

Profit Margin = Net Income / Net Sales

Debt Ratio = Total Debt / Total Assets

Debt to Equity Ratio = Total Liabilities / Owners Equity

Risk:

$$\text{Expected Value, } EV(X) = \sum_{i=1}^m x_i p(x_i)$$

$$\text{Project Risk Factor} = P_f + C_f - (P_f)(C_f)$$

Taxes:

$$CTF = 1 - \frac{td \left( 1 + \frac{i}{2} \right)}{(i + d)(1 + i)}$$

$$CSF = 1 - \frac{td}{(i + d)}$$

Equivalent Annual Costs:

$$EAC_{Total} = EAC_{Capital} + EAC_{O\&M}$$

$$EAC_{Capital} = [P + I - S(n)](A/P, i, n) + S(n)i$$

Depreciation:

$$BV_{SL}(n) = P - n \left( \frac{P-S}{N} \right), \quad D_{SL}(n) = \frac{P-S}{N}$$

$$BV_{DB}(n) = P(1 - d)^n, \quad D_{DB}(n) = BV_{DB}(n-1) d$$

$$\text{Where; } d = 1 - \sqrt[n]{\frac{S}{P}}$$

i = 2%

n	[F/P, i, n]	[P/F, i, n]	[F/A, i, n]	[A/F, i, n]	[P/A, i, n]	[A/P, i, n]	[A/G, i, n]	[P/G, i, n]	n
1	1.0200	0.9804	1.0000	1.0000	0.9804	1.0200	0.0000	0.0000	1
2	1.0404	0.9612	2.0200	0.4950	1.9416	0.5150	0.4950	0.9612	2
3	1.0612	0.9423	3.0604	0.3268	2.8839	0.3468	0.9868	2.8458	3
4	1.0824	0.9238	4.1216	0.2426	3.8077	0.2626	1.4752	5.6173	4
5	1.1041	0.9057	5.2040	0.1922	4.7135	0.2122	1.9604	9.2403	5
6	1.1262	0.8880	6.3081	0.1585	5.6014	0.1785	2.4423	13.6801	6
7	1.1487	0.8706	7.4343	0.1345	6.4720	0.1545	2.9208	18.9035	7
8	1.1717	0.8535	8.5830	0.1165	7.3255	0.1365	3.3961	24.8779	8
9	1.1951	0.8368	9.7546	0.1025	8.1622	0.1225	3.8681	31.5720	9
10	1.2190	0.8203	10.9497	0.0913	8.9826	0.1113	4.3367	38.9551	10

i = 3%

n	[F/P, i, n]	[P/F, i, n]	[F/A, i, n]	[A/F, i, n]	[P/A, i, n]	[A/P, i, n]	[A/G, i, n]	[P/G, i, n]	n
1	1.0300	0.9709	1.0000	1.0000	0.9709	1.0300	0.0000	0.0000	1
2	1.0609	0.9426	2.0300	0.4926	1.9135	0.5226	0.4926	0.9426	2
3	1.0927	0.9151	3.0909	0.3235	2.8286	0.3535	0.9803	2.7729	3
4	1.1255	0.8885	4.1836	0.2390	3.7171	0.2690	1.4631	5.4383	4
5	1.1593	0.8626	5.3091	0.1884	4.5797	0.2184	1.9409	8.8888	5
6	1.1941	0.8375	6.4684	0.1546	5.4172	0.1846	2.4138	13.0762	6
7	1.2299	0.8131	7.6625	0.1305	6.2303	0.1605	2.8819	17.9547	7
8	1.2668	0.7894	8.8923	0.1125	7.0197	0.1425	3.3450	23.4806	8
9	1.3048	0.7664	10.1591	0.0984	7.7861	0.1284	3.8032	29.6119	9
10	1.3439	0.7441	11.4639	0.0872	8.5302	0.1172	4.2565	36.3088	10

i = 7%

n	[F/P, i, n]	[P/F, i, n]	[F/A, i, n]	[A/F, i, n]	[P/A, i, n]	[A/P, i, n]	[A/G, i, n]	[P/G, i, n]	n
1	1.0700	0.9346	1.0000	1.0000	0.9346	1.0700	0.0000	0.0000	1
2	1.1449	0.8734	2.0700	0.4831	1.8080	0.5531	0.4831	0.8734	2
3	1.2250	0.8163	3.2149	0.3111	2.6243	0.3811	0.9549	2.5060	3
4	1.3108	0.7629	4.4399	0.2252	3.3872	0.2952	1.4155	4.7947	4
5	1.4026	0.7130	5.7507	0.1739	4.1002	0.2439	1.8650	7.6467	5
6	1.5007	0.6663	7.1533	0.1398	4.7665	0.2098	2.3032	10.9784	6
7	1.6058	0.6227	8.6540	0.1156	5.3893	0.1856	2.7304	14.7149	7
8	1.7182	0.5820	10.2598	0.0975	5.9713	0.1675	3.1465	18.7889	8
9	1.8385	0.5439	11.9780	0.0835	6.5152	0.1535	3.5517	23.1404	9
10	1.9672	0.5083	13.8164	0.0724	7.0236	0.1424	3.9461	27.7156	10
11	2.1049	0.4751	15.7836	0.0634	7.4987	0.1334	4.3296	32.4665	11
12	2.2522	0.4440	17.8885	0.0559	7.9427	0.1259	4.7025	37.3506	12
13	2.4098	0.4150	20.1406	0.0497	8.3577	0.1197	5.0648	42.3302	13
14	2.5785	0.3878	22.5505	0.0443	8.7455	0.1143	5.4167	47.3718	14
15	2.7590	0.3624	25.1290	0.0398	9.1079	0.1098	5.7583	52.4461	15
16	2.9522	0.3387	27.8881	0.0359	9.4466	0.1059	6.0897	57.5271	16
17	3.1588	0.3166	30.8402	0.0324	9.7632	0.1024	6.4110	62.5923	17
18	3.3799	0.2959	33.9990	0.0294	10.0591	0.0994	6.7225	67.6219	18
19	3.6165	0.2765	37.3790	0.0268	10.3356	0.0968	7.0242	72.5991	19
20	3.8697	0.2584	40.9955	0.0244	10.5940	0.0944	7.3163	77.5091	20

i = 10%

n	[F/P, i, n]	[P/F, i, n]	[F/A, i, n]	[A/F, i, n]	[P/A, i, n]	[A/P, i, n]	[A/G, i, n]	[P/G, i, n]	n
1	1.1000	0.9091	1.0000	1.0000	0.9091	1.1000	0.0000	0.0000	1
2	1.2100	0.8264	2.1000	0.4762	1.7355	0.5762	0.4762	0.8264	2
3	1.3310	0.7513	3.3100	0.3021	2.4869	0.4021	0.9366	2.3291	3
4	1.4641	0.6830	4.6410	0.2155	3.1699	0.3155	1.3812	4.3781	4
5	1.6105	0.6209	6.1051	0.1638	3.7908	0.2638	1.8101	6.8618	5
6	1.7716	0.5645	7.7156	0.1296	4.3553	0.2296	2.2236	9.6842	6
7	1.9487	0.5132	9.4872	0.1054	4.8684	0.2054	2.6216	12.7631	7
8	2.1436	0.4665	11.4359	0.0874	5.3349	0.1874	3.0045	16.0287	8
9	2.3579	0.4241	13.5795	0.0736	5.7590	0.1736	3.3724	19.4215	9
10	2.5937	0.3855	15.9374	0.0627	6.1446	0.1627	3.7255	22.8913	10

i = 12%

n	[F/P, i, n]	[P/F, i, n]	[F/A, i, n]	[A/F, i, n]	[P/A, i, n]	[A/P, i, n]	[A/G, i, n]	[P/G, i, n]	n
1	1.1200	0.8929	1.0000	1.0000	0.8929	1.1200	0.0000	0.0000	1
2	1.2544	0.7972	2.1200	0.4717	1.6901	0.5917	0.4717	0.7972	2
3	1.4049	0.7118	3.3744	0.2963	2.4018	0.4163	0.9246	2.2208	3
4	1.5735	0.6355	4.7793	0.2092	3.0373	0.3292	1.3589	4.1273	4
5	1.7623	0.5674	6.3528	0.1574	3.6048	0.2774	1.7746	6.3970	5
6	1.9738	0.5066	8.1152	0.1232	4.1114	0.2432	2.1720	8.9302	6
7	2.2107	0.4523	10.0890	0.0991	4.5638	0.2191	2.5515	11.6443	7
8	2.4760	0.4039	12.2997	0.0813	4.9676	0.2013	2.9131	14.4714	8
9	2.7731	0.3606	14.7757	0.0677	5.3282	0.1877	3.2574	17.3563	9
10	3.1058	0.3220	17.5487	0.0570	5.6502	0.1770	3.5847	20.2541	10
11	3.4785	0.2875	20.6546	0.0484	5.9377	0.1684	3.8953	23.1288	11
12	3.8960	0.2567	24.1331	0.0414	6.1944	0.1614	4.1897	25.9523	12
13	4.3635	0.2292	28.0291	0.0357	6.4235	0.1557	4.4683	28.7024	13
14	4.8871	0.2046	32.3926	0.0309	6.6282	0.1509	4.7317	31.3624	14
15	5.4736	0.1827	37.2797	0.0268	6.8109	0.1468	4.9803	33.9202	15
16	6.1304	0.1631	42.7533	0.0234	6.9740	0.1434	5.2147	36.3670	16
17	6.8660	0.1456	48.8837	0.0205	7.1196	0.1405	5.4353	38.6973	17
18	7.6900	0.1300	55.7497	0.0179	7.2497	0.1379	5.6427	40.9080	18
19	8.6128	0.1161	63.4397	0.0158	7.3658	0.1358	5.8375	42.9979	19
20	9.6463	0.1037	72.0524	0.0139	7.4694	0.1339	6.0202	44.9676	20

i = 15%

n	[F/P, i, n]	[P/F, i, n]	[F/A, i, n]	[A/F, i, n]	[P/A, i, n]	[A/P, i, n]	[A/G, i, n]	[P/G, i, n]	n
1	1.1500	0.8696	1.0000	1.0000	0.8696	1.1500	0.0000	0.0000	1
2	1.3225	0.7561	2.1500	0.4651	1.6257	0.6151	0.4651	0.7561	2
3	1.5209	0.6575	3.4725	0.2880	2.2832	0.4380	0.9071	2.0712	3
4	1.7490	0.5718	4.9934	0.2003	2.8550	0.3503	1.3263	3.7864	4
5	2.0114	0.4972	6.7424	0.1483	3.3522	0.2983	1.7228	5.7751	5
6	2.3131	0.4323	8.7537	0.1142	3.7845	0.2642	2.0972	7.9368	6
7	2.6600	0.3759	11.0668	0.0904	4.1604	0.2404	2.4498	10.1924	7
8	3.0590	0.3269	13.7268	0.0729	4.4873	0.2229	2.7813	12.4807	8
9	3.5179	0.2843	16.7858	0.0596	4.7716	0.2096	3.0922	14.7548	9
10	4.0456	0.2472	20.3037	0.0493	5.0188	0.1993	3.3832	16.9795	10