

**QUEENS UNIVERSITY  
KINGSTON, ONTARIO**

**APSC221 – Fall 2010**

**SECTIONS A and X**

**PROJECT MANAGEMENT AND ECONOMICS**

**EXAM – 17 December 2010**

**SOLUTION**

**INSTRUCTORS – Sandra Smith and Ron Smith**

This exam constitutes 45% of your final mark

**INSTRUCTIONS:**

1. Time available **3 Hours**
2. Answers to **ALL** questions must be written in the answer booklet that is provided. **DO NOT USE RED COLOUR** for your presentation in any form, written or pictorial (This colour is reserved for marking your submission)
3. Use of University-approved, non-programmable, non-communicating calculators will be allowed **ONLY**.
4. Equation sheets and interest tables are provided at the back of the exam.
5. A Standard Normal Distribution table is provided at the back of the exam.
6. The exam is out of a total of 90 points. Answer all questions.
7. **If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made. The proctor or the instructor may not be able to answer your query during the test.**
8. **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.
9. There will be **penalties if any of the above instructions** are not followed.
10. **YOU MUST HAND IN BOTH YOUR ANSWER BOOKLET AND THIS EXAM PAPER ON COMPLETION OF THE TEST!**

## Question 1 (10 points) – Enterprise Planning, Project Management & Change Management

Read the following scenario carefully, and then answer the questions below.

It is now three years since you graduated from Queen's University with an engineering degree in *<insert your degree here>*. Shortly after graduation you and four of your classmates started an engineering design firm structured as a legal partnership.

Recently you have been working as the lead engineer on a proposal for the design and prototyping of an environmentally friendly *<insert your product here>* for the Federal government. The government has released a detailed product specification outlining the mandatory technical requirements as well as the quality standards that must be met. Your company is confident that it can design and build a prototype that fulfills the requirements. Your project proposal includes a detailed work breakdown structure, a fixed-price cost and a schedule. You have estimated that it will cost \$650,000 and take roughly 9 months to complete the work. Your company uses a 20% profit ratio for medium risk projects such as this, implying that your bid on the proposal must be at least \$780,000. Your company anticipates beginning work on another large project, but that project does not begin for at least a year from now. Therefore you feel comfortable stating in the proposal that the work can be completed in 10 months. If your company wins this contract, you will be appointed as the project manager.

In parallel with this activity, another one of your partners is working on the restructuring of your company. You and your partners are buying another small engineering company in order to acquire several new engineers and a larger marketing department. The merged company will be relocated in a modern office complex. In addition, the partnership will be dissolved and the new company will be incorporated with each partner holding an equal share in equity ownership.

A month after submitting your proposal, your company is awarded the contract. It is going to be a busy year!

Answer the following questions. Complete sentences are NOT required, just list the answers.

- a. As project manager of the government contract there are three key elements of the project that you must manage and control. List all three. **(3 marks)**

- Cost ( 1 point)
- Schedule ( 1 point)
- Specification, or Quality or Performance ( 1 point)

- b. Throughout the management of the project, several organizational changes will make your job as project manager more difficult. List two of these changes, and for each identify them as one of the following: strategic, technological, structural or cultural. **(2 marks)**

Any two of these :

- reorganization / merger ( ½ point) – strategic or structural ( ½ point)
- relocation ( ½ point) – structural ( ½ point)
- incorporation ( ½ point) – strategic or structural ( ½ point)
- combining employees from two companies ( ½ point) – cultural ( ½ point)

Any two of these :

- c. List two benefits that your company derives by restructuring from a partnership to a corporation. **(2 marks)**

- Limited liability / Continuity / Professional management (1 point each)

- d. When the restructuring of your company is complete, is it a public or private corporation, and why? **(2 marks)**

- Private (1 point) as shares/equity is still privately held / not publicly traded. (1 point)

Any one of these :

- e. As companies grow, what benefit is there in going “public”? List one benefit. **(1 mark)**

- Easier to raise capital / Increased “name” recognition (1 point)

## QUESTION 2 (10 Marks) – Project Planning

The table below lists the optimistic, most likely and pessimistic estimates of completion times in WEEKS for 8 major tasks in a construction project. Earlier analysis has already determined those tasks on the critical path, and those not on the critical path; they are identified accordingly in the table below.

Activity	Critical Path Task	Optimistic Times <b>a</b> (weeks)	Most Likely Times <b>m</b> (weeks)	Pessimistic Times <b>b</b> (weeks)	Task Mean	Task Variance
A	Yes	5	7	10	7.17	0.69
B	No	2.5	3	4		
C	Yes	8	9	13	9.50	0.69
D	No	2	2	3		
E	Yes	3	4	7	4.33	0.44
F	No	1	1	2		
G	Yes	4	5	12	6.00	1.78
H	Yes	4	6	8	6.00	0.44

- a) Compute the project expected completion time in **weeks**. (3 marks)

From calculated values in table above using only critical path tasks, where  $\{\mu = (a + 4m + b)/6\}$  (1 point):

Expected Completion =  $\{7.17 + 9.50 + 4.33 + 6.00 + 6.00\}$  (1 point) = **33.00 weeks** (1 point)

- b) Compute the project variance in **days**. (2 marks)

From calculated values in table above using only critical path tasks, where  $\sigma^2 = ((b-a)/6)^2$ :

Project Variance =  $(0.69+0.69+0.44+1.78+0.44)^{1/2} = 4.056$  weeks (1 point) = **28.4 days** (1 point)

- c) What is the probability of completing the project within 90% of the expected completion time? (in other words 10% sooner than expected) (2 marks)

$Z = (X - \mu) / \sigma$ , 90% completion time implies finishing within  $(0.9)(33) = 29.7$  weeks

Then given  $Z = (X - \mu) / \sigma$ ,  $Z = (29.7 - 33) / (4.056)^{1/2} = -3.3 / 2.014 = -1.639$  (1 point) and from the tables:

**Prob ( $X \leq 29.7$  weeks) = 5.16%** (1 point) Note : need standard deviation in weeks (not days)

- d) The project manager wants a 95% assurance that the schedule presented to senior management will be met on time. What estimate of total number of **weeks** for completion should the project manager present to senior management? (3 marks)

For 95% probability of completion,  $Z = 1.645$  (1 point) from tables, therefore

$X = Z \sigma + \mu = (1.645)(2.014) + 33.00$  (1 point) = **36.3 weeks** (1 point)

In parts c and d the students get the points if they use their values for  $\mu$  and  $\sigma$

### QUESTION 3 (10 Marks) – Financial Accounting & Weighted Average Cost of Capital

Fraser Phraser operates a small publishing company. He is interested in getting a loan for expanding his computer systems. The bank has asked Phraser to supply them with his financial statements from the past two years. His statements appear at the back of the exam (on page 12).

- a. Calculate the following financial ratios by reproducing the table below (**do not answer on this test paper**). (5 marks)

Financial Ratio	2009	2010
Current ratio	$126,250 / 68,750 = 1.84$	$155,000 / 172,500 = 0.9$
Acid test	$(22,500 + 31,250) / 68,750 = 0.78$	$(1,250 + 4,000) / 172,500 = 0.24$
Equity ratio	$140,625 / 281,250 = 0.5$	$145,125 / 375,000 = 0.39$
Return on Equity	$5,625 / 281,250 = 2\%$	$6,812 / 375,000 = 2\%$
Return on Assets	$5,625 / 140,625 = 4\%$	$6,812 / 145,125 = 5\%$

½ point  
per correct  
ratio

- b. Comment on Phraser's financial position with regard to the loan based on the results of financial ratio analysis. In other words, would you recommend the loan, why or why not? (2 marks)

Phraser's financial position is not strong, and the loan is NOT RECOMMENDED. (1 point)

Reasons: weakening liquidity / increasing debt load / weak profitability (½ point each for any two of these)

- c. The formula for weighted-average cost of capital is provided in the formula sheet. The tax rate for Phraser is given as 50%. The average cost of debt has been 7.5% and the average cost of equity has been 10%. Compute Phraser's WACC for 2009 and 2010. (2 marks)

$$\lambda_{2009} = \text{tot debt} / (\text{tot debt} + \text{tot equity}) = (42,500 + 71,875) / (42,500 + 71,875 + 140,625) = \mathbf{0.45} \text{ (½ point)}$$

$$\text{WACC}_{2009} = \lambda (1-t)e_b + (1-\lambda)e_a = (0.45)(1-0.5)(0.075) + (0.55)(0.10) = \mathbf{7.2\%} \text{ (½ point)}$$

$$\lambda_{2010} = (117,500 + 57,375) / (117,500 + 57,375 + 145,125) = \mathbf{0.55} \text{ (½ point)}$$

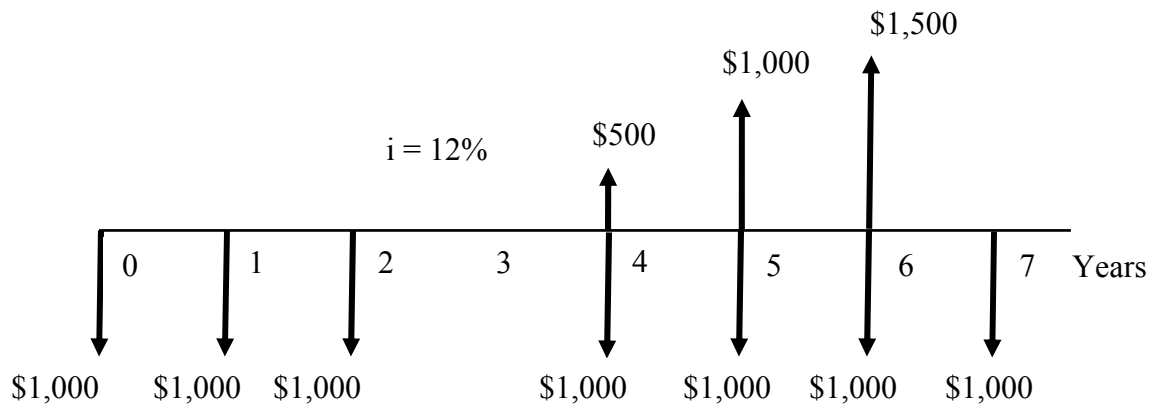
$$\text{WACC}_{2010} = (0.55)(1-0.5)(0.075) + (0.45)(0.10) = \mathbf{6.6\%} \text{ (½ point)}$$

- d. Why is debt financing for Phraser so much cheaper than equity financing? (1 mark)

Because their tax rate is so high (50%) and they can therefore claim half of their debt costs as expenses.

(1 point)

**QUESTION 4 (10 Marks) –Time Value of Money & Cash Flow Analysis**



a) What is the present worth of the cash flow diagram above? **(5 marks)**

Option 1: (assume the annuity is present all years and add in 3 year equivalent)

$$\begin{aligned} PW &= -1000 - 1000 (P/A, 12\%, 7) + 1000(P/F, 12\%, 3) + 500 (P/G, 12\%, 4)(P/F, 12\%, 2) \quad (3 \text{ points}) \\ &= -1000 - 1000(4.5638) + 1000(0.7118) + 500(4.1273)(0.7972) \quad (1 \text{ point}) = \mathbf{-\$3,207} \quad (1 \text{ point}) \end{aligned}$$

Option 2: (assume 2 annuities)

$$\begin{aligned} PW &= -1000 - 1000(P/A, 12\%, 2) - 1000(P/A, 12\%, 4) (P/F, 12\%, 3) + 500 (P/G, 12\%, 4)(P/F, 12\%, 2) \\ &= -1000 - 1000(1.6901) - 1000(3.0373)(0.7118) + 500(4.1273)(0.7972) = \mathbf{-\$3,207} \end{aligned}$$

Option 3: (assume all single cash flows)

$$\begin{aligned} PW &= -1000 - 1000(P/F, 12\%, 1) - 1000(P/F, 12\%, 2) - 500(P/F, 12\%, 4) + 500 (P/F, 12\%, 6) - \\ &1000(P/F, 12\%, 7) \\ &= -1000 - 1000(0.89290) - 1000(0.7118) - 500(0.6355) + 500(0.5066) - 1000(0.4523) \\ &= \mathbf{-\$3,207} \end{aligned}$$

b) A company is negotiating a business loan that will require them to make quarterly loan payments with quarterly compounding; in other words payments are made and interest is compounded 4 times per year. The company decides that it can afford an effective yearly interest rate of 8%. What is the maximum quarterly interest rate that the company can afford for this loan? Compute your answer to the nearest one hundredth of a percent. **(5 marks)**

$$i_e \leq (1 + R/m)^m - 1 \text{ and given } i_e = 8\% \text{ and } m = 4 \text{ quarters per year}$$

The maximum quarterly interest,  $i_q$ , is represented by  $R/m$  in the above equation, therefore,

$$i_q \leq (i_e + 1)^{1/4} - 1 = (1.08)^{1/4} - 1 = 0.01943 \approx 1.94\%$$

(1 point for equation, 1 point for  $m = 4$ , 2 points for answer, 1 point for exactly 2 decimal places;

Easiest 5 marks on the exam.)

### QUESTION 5 (10 Marks) –Comparison Methods & Cash Flow Scoping

South Frontenac Township is evaluating two alternative methods of disposing of municipal waste. The first involves developing a landfill site near the town of Sydenham. Costs of the site include a start-up cost of \$1,000,000, a closedown costs 30 years from now of \$100,000, and operating costs of \$20,000 per year. Starting in 10 years, it is expected that there will be revenues from user fees of \$30,000 per year. The alternative is to ship the waste out of the region. An area firm will agree to a long-term contract to dispose of the waste for \$140,000 per year.

- a. Using an appropriate comparison method, which waste disposal alternative should the municipality pursue if their MARR is 12%? (6 marks)

Option 1 Using PW:

$$\begin{aligned} PW_{\text{landfill}} &= -1,000,000 - 20,000 (P/A, 12\%, 30) - 100,000(P/F, 12\%, 30) + 30,000(P/A, 12\%, 20)(P/F, 12\%, 10) \quad (2 \text{ points}) \\ &= -1,000,000 - 20,000(8.0552) - 100,000(0.0334) + 30,000(7.4694)(0.3220) = \mathbf{-\$1,092,293} \quad (1 \text{ point}) \end{aligned}$$

$$\begin{aligned} PW_{\text{private}} &= -140,000 (P/A, 12\%, 30) \quad (1 \text{ point}) \\ &= -140,000 (8.0552) = \mathbf{-\$1,127,725} \quad (1 \text{ point}) \end{aligned}$$

Since the landfill option is least cost, choose landfill option. (1 point)

Option 2 Using AW:

$$\begin{aligned} AW_{\text{landfill}} &= -1,000,000(A/P, 12\%, 30) - 20,000 - 100,000(A/F, 12\%, 30) + \\ &\quad 30,000(P/A, 12\%, 20)(P/F, 12\%, 10)(A/P, 12\%, 30) \quad (2 \text{ points}) \\ &= -1,000,000(0.1241) - 20,000 - 100,000(0.0041) + 30,000(7.4694)(0.3220)(0.1241) = \mathbf{-\$135,601} \quad (1 \text{ point}) \end{aligned}$$

$$AW_{\text{private}} = \mathbf{-\$140,000} \quad (2 \text{ points})$$

Since the landfill option is least cost, choose landfill option. (1 point)

For 30,000 starting in year 10 instead of year 11:

$$\begin{aligned} PW_{\text{landfill}} &= -1,000,000 - 20,000 (P/A, 12\%, 30) - 100,000(P/F, 12\%, 30) + 30,000(P/A, 12\%, 21)(P/F, 12\%, 9) \quad (2 \text{ points}) \\ &= -1,000,000 - 20,000(8.0552) - 100,000(0.0334) + 30,000(7.5620)(0.3606) = \mathbf{-\$1,082,633.45} \quad (1 \text{ point}) \end{aligned}$$

or

$$\begin{aligned} AW_{\text{landfill}} &= -1,000,000(A/P, 12\%, 30) - 20,000 - 100,000(A/F, 12\%, 30) + \\ &\quad 30,000(P/A, 12\%, 21)(P/F, 12\%, 9)(A/P, 12\%, 30) \quad (2 \text{ points}) \\ &= -1,000,000(0.1241) - 20,000 - 100,000(0.0041) + 30,000(7.5620)(0.3606)(0.1241) = \mathbf{-\$134,402} \quad (1 \text{ point}) \end{aligned}$$

Landfill is still best option

In the scenario above, the estimated yearly operating cost of \$20,000 for the public landfill includes many different cost elements. The municipality must pay a subcontractor a fee for every bag of garbage picked up and delivered to the landfill. The municipality must also expect that a portion of its administrative staff's time will be dedicated to handling customer enquiries and complaints. In addition, the municipality must purchase special insurance to cover them for any liabilities in the event of public contamination of the neighboring water supply.

- b. From the yearly operating costs above, provide one example of each of the following types of costs: (4 marks)
- A fixed cost; **insurance OR administrative staff** (1 point)
  - A variable cost; **subcontractor pick up and delivery** (1 point)
  - A direct cost; and **subcontractor pick up and delivery** (1 point)
  - An indirect cost. **administrative staff** (1 point)

Note to  
TAs : Some  
students  
interpreted  
this as  
revenue  
starting in  
year 10,  
that's OK.  
See below.

## QUESTION 6 (10 Marks) – Replacement Analysis

A construction company is preparing their capital budget estimates and are considering replacing some of their used equipment. Two different pieces of equipment are under study. The company's yearly MARR is 6%.

- a) A crane was purchased 6 years ago for \$1,500,000. While it has 4 more years of useful life, its operations and maintenance (O&M) costs are expected to rise sharply in the last years of its life in order to keep it safe to operate. The crane has an estimated current salvage value of \$325,000 and this value is expected to decrease by \$75,000 over each of the next 4 years until it reaches its scrap value of \$25,000. The O&M costs for the crane are estimated to be \$30,000 for this year, \$33,000 in two years, and \$40,000 in 3 years and \$50,000 in the final year.

- i. Construct a table of salvage values and O&M costs for the next 4 years. (1 mark)

Year	Salvage	O&M Costs
0 (6)	\$325,000	
1 (7)	\$250,000	\$30,000
2 (8)	\$175,000	\$33,000
3 (9)	\$100,000	\$40,000
4 (10)	\$25,000	\$50,000

½ point each column

- ii. The company is convinced that the economic life has not yet been reached. Using the data from above, determine if the economic life of the crane will be reached within the next 4 years. (3 marks)

$$EAC_{N=1} = -325,000(A/P, 6\%, 1) + 250,000 - 30,000 = -325k(1.06) + 220k = -\$124,500 \text{ (½ point)}$$

$$EAC_{N=2} = [-325,000 + (175,000 - 3,000)(P/F, 6\%, 2)](A/P, 6\%, 2) - 30,000$$

$$= [-325k + 172k(0.8900)](0.5454) - 30k = -\$123,765 \text{ (1 point)} \quad \leftarrow \text{Minimum EAC}$$

$$EAC_{N=3} = [-325,000 - 3,000(P/F, 6\%, 2) + (100,000 - 10,000)(P/F, 6\%, 3)](A/P, 6\%, 3) - 30,000$$

$$= [-325k - 3k(0.8900) + 90k(0.8396)](0.3741) - 30k = -\$124,312 \text{ (1 mark)}$$

Since the minimum EAC is reached, **the economic life is reached** before the service life. (½ point)

- iii. If the company were to use a cyclic replacement policy for the crane, what replacement cycle would you recommend? (1 mark)

The company should buy and replace this crane every **8 years** (owned 6 years already, plus EAC minimum reached after N=2 more years from above) (1 point)

- b) The company also owns a large pavement roller. While they have not owned it for many years, the company is already getting offers from different equipment vendors to replace it with a newer model. The company has used equivalent annual cost analysis in preparing the data below. The tables below list the relevant equivalent annual cost data for the existing roller and two potential replacement rollers.

i. What is the economic life of each of the three rollers? **(3 marks)**

Existing roller – 5 years (1 point)

Model 1 roller – 8 years (1 point)

Model 2 roller – 9 years (1 point)

ii. Assuming that this data remains valid for at least 10 years, should the company replace the existing roller, and if so when? Justify your recommendation. **(2 marks)**

Yes the existing roller should be replaced (½ point) after 7 years (½ point) since,

roller model 1 (½ point) then becomes the most economical ( $EAC_{\text{Model 1}, N=8} = \$10,632 < EAC_{\text{existing}, N=8} = \$10,875$ ). (½ point)

Existing Pavement Roller			
Year	EAC <sub>Capital</sub>	EAC <sub>OGM</sub>	EAC <sub>Total</sub>
0			
1	\$ 10,000	\$ 3,300	\$ 13,300
2	\$ 8,000	\$ 3,795	\$ 11,795
3	\$ 6,400	\$ 4,364	\$ 10,764
4	\$ 5,120	\$ 5,019	\$ 10,139
5	\$ 4,096	\$ 5,772	\$ 9,868
6	\$ 3,277	\$ 6,637	\$ 9,914
7	\$ 2,621	\$ 7,633	\$ 10,255
8	\$ 2,097	\$ 8,778	\$ 10,875
9	\$ 1,678	\$ 10,095	\$ 11,772
10	\$ 1,342	\$ 11,609	\$ 12,951

New Model 1 Roller			
Year	EAC <sub>Capital</sub>	EAC <sub>OGM</sub>	EAC <sub>Total</sub>
0			
1	\$ 15,000	\$ 1,500	\$ 16,500
2	\$ 13,200	\$ 1,755	\$ 14,955
3	\$ 11,616	\$ 2,053	\$ 13,669
4	\$ 10,222	\$ 2,402	\$ 12,624
5	\$ 8,995	\$ 2,811	\$ 11,806
6	\$ 7,916	\$ 3,289	\$ 11,205
7	\$ 6,966	\$ 3,848	\$ 10,814
8	\$ 6,130	\$ 4,502	\$ 10,632
9	\$ 5,395	\$ 5,267	\$ 10,662
10	\$ 4,747	\$ 6,163	\$ 10,910

New Model 2 Roller			
Year	EAC <sub>Capital</sub>	EAC <sub>OGM</sub>	EAC <sub>Total</sub>
0			
1	\$ 20,000	\$ 1,700	\$ 21,700
2	\$ 16,800	\$ 1,989	\$ 18,789
3	\$ 14,112	\$ 2,327	\$ 16,439
4	\$ 11,854	\$ 2,723	\$ 14,577
5	\$ 9,957	\$ 3,186	\$ 13,143
6	\$ 8,364	\$ 3,727	\$ 12,091
7	\$ 7,026	\$ 4,361	\$ 11,387
8	\$ 5,902	\$ 5,102	\$ 11,004
9	\$ 4,958	\$ 5,969	\$ 10,927
10	\$ 4,164	\$ 6,984	\$ 11,149
11	\$ 3,498	\$ 8,172	\$ 11,670
12	\$ 2,938	\$ 9,561	\$ 12,499



## QUESTION 7 (10 Marks) – Taxes & Depreciation

You started your own delivery business in 2005. Over the following years, your transactions for CCA Class 10 assets ( $d = 30\%$ ) consisted of the following:

Year	Item	Activity	Amount
Jun 17, 2005	2 delivery trucks	Purchase	\$75,000
Dec 8, 2005	3 utility trailers	Purchase	\$9,000
Jan 1, 2006	1 used van	Purchase	\$15,000
Jul 19, 2007		No Activity	
Oct 23, 2008	1 used van	Purchase	\$9,000
May 1, 2008	1 used van	Sale	\$2,500
Dec 8, 2009	2 utility trailers	Sale	\$1,400

- a) We see from the table above, that the company purchased three identical utility trailers in 2005 for \$3,000 each. Assume that the trailers have a service life of 6 years at which time each has a scrap value of \$350.
- Compute the BV of a single trailer after 4 years using straight-line depreciation. **(1 mark)**  

$$D_{sl} = (P-S)/N = (3,000 - 350) / 6 = \$441.66 \text{ (}\frac{1}{2}\text{ point)}$$

$$BV_{sl(n=4)} = P - n D_{sl} = 3,000 - (4)(441.66) = \textbf{\$1233.33} \text{ (}\frac{1}{2}\text{ point)}$$
  - Compute the book value of a single trailer after 4 years using declining balance depreciation, and the depreciation rate of 30% from above. **(2 marks)**  

$$BV_{db(n)} = P (1-d)^n \text{ (}\frac{1}{2}\text{ point)} = 3000 (1-.3)^4 \text{ (}\frac{1}{2}\text{ point)} = \textbf{\$720.30} \text{ (1 point)}$$
  - Based upon the sales data above in 2009, which model has best matched the utility trailer's market value and why? **(2 marks)**  

The **declining balance** model best matches the book to market value of the trailer (1 point)  
since the trailers were sold in year 4 for \$1400 and the db model estimates their value at 2 times \$720 or \$1440, whereas the sl model estimates their value at 2 times \$1233 or \$2466. (1 point)

- b) Compute the Undepreciated Capital Costs (UCC) for the period 2005 - 2009. Make sure that you show your  $UCC_{Opening}$  and  $UCC_{Ending}$  calculations. Present your answer by reproducing the following table in your answer booklet (**do not answer on this test paper**). **(5 marks)**

Year	Adjustments		$UCC_{Opening}$	CCA	$UCC_{Ending}$
	Purchases	Sales			
2005	\$84,000		\$42,000	\$12,600	\$71,400
2006	15,000	0	\$78,900	\$23,670	\$62,730
2007	0	0	\$62,730	\$18,819	\$43,911
2008	\$9,000	\$2,500	\$45,911	\$13,773	\$36,638
2009	0	\$1,400	\$35,238	\$10,571	\$24,666

Students get 1 point for each correct year. Note that **iff work is shown**, calculation errors should be penalized only in the year the error is made.

Example (2008) :

$$UCC_{opening\_2008} = UCC_{ending\_2007} + \frac{1}{2} \text{ Purchases} - \text{Sales} = 43,911 + \frac{1}{2} (9,000) - 2,500 = \$45,911$$

$$CCA_{2008} = UCC_{opening\_2008} (d) = 45,911 (0.30) = \$13,773$$

$$UCC_{ending\_2008} = UCC_{opening\_2008} - CCA_{2008} + \frac{1}{2} \text{ Purchases} = 45,911 - 13,773 + \frac{1}{2} (9,000) = \$36,638$$

## QUESTION 8 (10 Marks) – Inflation and Risk Management

A group of farmers is considering building an irrigation system from a water supply in some nearby mountains. They want to build a concrete reservoir with a steel pipe system. The first construction cost would be \$200,000 with (actual) annual maintenance costs of \$2,000. They expect the irrigation system will bring them \$22,000 per year in additional (real) revenues due to better crop production. Their real dollar MARR is 4% and they anticipate inflation to be 2.885% per year. Assume that the reservoir will have a 20 year life.

a. What is the future worth (at the end of year 20) of this project in real dollars? **(5 marks)**

First find actual MARR,  $MARR_{actual} = (1 + MARR_{real})(1 + f) - 1 = (1.04)(1.02885) - 1 = 0.07 = 7\%$  (1 point)

Cash flows: -\$200,000 now, annuity of -\$2,000 actual, annuity of +\$22,000 real.

$$\begin{aligned} FW_{real} &= -200,000(F/P, MARR_{real}, 20) - 2,000(P/A, MARR_{actual}, 20)(F/P, MARR_{real}, 20) + 22,000(F/A, MARR_{real}, 20) \\ &= -200,000(F/P, 4\%, 20) - 2,000(P/A, 7\%, 20)(F/P, 4\%, 20) + 22,000(F/A, 4\%, 20) \text{ (1 point each term, max 3)} \\ &= -200,000(2.1911) - 2,000(10.5940)(2.1911) + 22,000(29.7781) \\ &\approx \mathbf{\$170,470} \quad (1 \text{ point}) \end{aligned}$$

Or all PW first:

$$\begin{aligned} FW &= [-200,000 - 2,000(P/A, 7\%, 20) + 22,000(P/A, 4\%, 20)](F/P, 4\%, 20) \text{ (1 point each term, max 3)} \\ &= [-200,000 - 2,000(10.5940) + 22,000(13.5903)](2.1911) = 77,799(2.1911) \\ &\approx \mathbf{\$170,470} \quad (1 \text{ point}) \end{aligned}$$

b. In order to ensure a guaranteed market for their produce, the farmers sign long-term multi-year contracts with distributors wherein they agree to provide produce at fixed prices.

i) Briefly explain why inflation is a major risk to the farmers. **(1 mark)**

Inflation is a risk to the farmers selling at fixed prices into the future as the **real revenue** from these sales is **decreasing** with inflation.

ii) What two parameters are required to quantify this risk? {These are the same two general parameters that are required to quantify any risk.} **(2 marks)**

- The **probability** of various inflation rates (1 point)
- The **impact / cost** of the event (various inflation rates) (1 point)

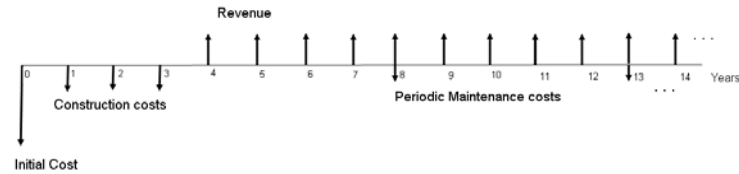
iii) Identify two different mitigation strategies the farmers may consider to control this risk. **(2 marks)**

- Share the risk: Increase their contractual yearly fixed prices to account for estimated inflation
- Transfer the risk: Buy insurance that pays in the event of unexpectedly high inflation
- Ignore the risk: If they deem the probability to be low and associated cost to be low.

1 point each for any two of these, or similar, sensible strategies

## QUESTION 9 (10 Marks) – Sensitivity Analysis & Risk Analysis

The provincial government is planning to build a toll bridge across the Catarqui in Kingston. The cost elements include an upfront initial cost, construction costs in the first three years, yearly revenues beginning in year four, and periodic maintenance every five years after the bridge is completed. The bridge is assumed to be an infinite life project. The general cash flow diagram is provided, and the table below lists the high, most likely and low estimates for all costs as well as the discount rate (MARR).



Cost Element	High Estimate	Most Likely Estimate	Low Estimate
Initial Cost ( $C_{\text{initial}}$ )	\$2,500,000	\$1,500,000	\$900,000
Yearly Construction Cost (Years 1, 2 and 3) ( $C_{\text{yearly}}$ )	\$350,000	\$250,000	\$200,000
Yearly Revenue (beginning in year 4) ( $R_{\text{yearly}}$ )	\$400,000	\$350,000	\$250,000
Periodic Maintenance (every 5 years beginning in year 8) ( $C_{\text{periodic}}$ )	\$175,000	\$150,000	\$125,000
MARR ( $i$ )	12%	6%	4%

Red font – worst-case costs / interest ; Green font – best-case costs / interest

- a. Provide a general expression for the present worth of the project. Do not use any numbers, just representative cost variables, and interest factors. **(1 mark)**

$$PW = -C_{\text{initial}} - C_{\text{yearly}}(P/A, i, 3) + [R_{\text{yearly}} - C_{\text{periodic}}(A/F, i, 5)](P/A, i, \infty)(P/F, i, 3) \quad (1 \text{ point})$$

- b. Complete a scenario analysis for the best-case, most-likely case and worst-case scenarios. For each cost element and the MARR, be careful to consider which is “best” versus which is “worst”. **(5 marks)**

Using the student’s general equation from above:

Best-case:

$$\begin{aligned} PW_{bc} &= -900,000 - 200,000(P/A, 4\%, 3) + [400,000 - 125,000(A/F, 4\%, 5)](P/A, 4\%, \infty)(P/F, 4\%, 3) \\ &= -900,000 - 200,000(2.7751) + [400,000 - 125,000(0.1846)](1/.04)(0.8890) \\ &\approx \$6,922,000 \end{aligned}$$

(½ point for using correct best-case costs, ½ point for using correct best-case interest, 1 point for “correct” answer based on student’s costs/interest/equation)

Most-likely:

$$\begin{aligned} PW_{ml} &= -1,500,000 - 250,000(P/A, 6\%, 3) + [350,000 - 150,000(A/F, 6\%, 5)](P/A, 6\%, \infty)(P/F, 6\%, 3) \\ &= -1,500,000 - 250,000(2.6730) + [350,000 - 150,000(0.1774)](1/.06)(0.8396) \\ &\approx \$2,357,000 \quad (1 \text{ point}) \end{aligned}$$

Worst-case:

$$\begin{aligned} PW_{wc} &= -2,500,000 - 350,000(P/A, 12\%, 3) + [250,000 - 175,000(A/F, 12\%, 5)](P/A, 12\%, \infty)(P/F, 12\%, 3) \\ &= -2,500,000 - 350,000(2.4018) + [250,000 - 175,000(0.1574)](1/.12)(0.7118) \\ &\approx -\$2,021,000 \end{aligned}$$

(½ point for using correct worst-case costs, ½ point for using correct worst-case interest, 1 point for a “correct” answer based on student’s costs/interest)

- c. The government estimates that the best-case scenario has a 15% probability of occurrence, while there is a 35% likelihood that all of the worst-case costs may occur. Therefore, the most likely case is estimated to have a 50% probability of occurrence.

i) Compute the expected value of the present worth of the project. **(2 marks)**

$$\begin{aligned} \text{EV} &= \text{Prob}_{bc} (PW_{bc}) + \text{Prob}_{ml} (PW_{ml}) + \text{Prob}_{wc} (PW_{wc}) \text{ (1 point)} \\ &= (0.15) (\$6,922,000) + (0.5) (\$2,357,000) + (0.35) (-\$2,021,000) \\ &\approx \$1,509,450 \text{ (1 point, based upon use of student's PW values in previous part)} \end{aligned}$$

ii) What is your recommendation; should the government proceed? Why or why not? **(2 marks)**

Given that the EV is positive, the government should proceed with the bridge project.

(1 point for a correct recommendation and 1 point for correct reason - in other words, if the student's answer in part c.i) is positive then proceed, otherwise do not.)

## INTEREST FACTORS

Interest Factor	Formula
$(F/P, i, n)$	$(1+i)^n$
$(P/F, i, n)$	$\frac{1}{(1+i)^n}$
$(F/A, i, n)$	$\frac{(1+i)^n - 1}{i}$
$(A/F, i, n)$	$\frac{i}{(1+i)^n - 1}$
$(P/A, i, n)$	$\frac{(1+i)^n - 1}{i(1+i)^n}$
$(A/P, i, n)$	$\frac{i(1+i)^n}{(1+i)^n - 1}$
$(A/G, i, n)$	$\frac{1}{i} - \frac{n}{(1+i)^n - 1}$
$(P/G, i, n)$	$\frac{(1+i)^n - in - 1}{i^2(1+i)^n}$

To calculate effective interest rates:

$$i_e = (1 + r/m)^m - 1$$

$$P = \lim_{N \rightarrow \infty} A(P / A, i, N) = A \lim_{N \rightarrow \infty} \left[ \frac{(1+i)^N - 1}{i(1+i)^N} \right] = \frac{A}{i}$$

For Scheduling:

$$t = (a + 4m + b)/6, \quad \sigma^2 = [(b - a)/6]^2, \quad Z = (X - \mu)/\sigma$$

### Depreciation

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

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

### Inflation:

$$\$Actual = \$Real (1+f)^N$$

$$(1+i) = (1+i') (1+f)$$

### Financial Ratios:

$$\text{working capital} = \text{current assets} - \text{current liabilities}$$

$$\text{current ratio} = \text{current assets} / \text{current liabilities}$$

$$\text{acid test ratio} = \text{quick assets} / \text{current liabilities}$$

$$\text{equity ratio} = \text{total equity} / (\text{total liabilities} + \text{total equity})$$

$$\text{return on assets} = \text{net income} / \text{total assets}$$

$$\text{return on equity} = \text{net income} / \text{total equity}$$

$$\text{inventory turnover ratio} = \text{sales} / \text{inventories}$$

$$\text{debt to capital employed } (\lambda) = \text{total debt} / (\text{total debt} + \text{equity})$$

### Weighted-Average Cost of Capital:

$$WACC = \lambda (1-t)i_b + (1-\lambda)e_a$$

Where  $\lambda$  is the ratio of total debt (**short and long term**) to total debt plus equity (in other words the debt to capital employed ratio from above),

$t$  is the tax rate,

$i_b$  is the cost of debt financing, and

$e_a$  is the cost of equity financing.

### Risk Analysis:

$$\text{Expected value:} \quad E(X) = \sum_i x_i p(x_i)$$

Fraser Phraser Company Financial Data

Phraser Company  
Comparative Balance Sheets  
for the Years Ending in 2009 and 2010  
(in thousands of dollars)

	2,009	2,010
<b>Assets</b>		
<b>Current Assets</b>		
Cash	22,500	1,250
Accounts receivable	31,250	40,000
Inventories	72,500	113,750
Sub-Total	126,250	155,000
<b>Long-Term Assets</b>		
Land	50,000	65,000
Plant and equipment	175,000	250,000
Less: Accumulated depreciation	70,000	95,000
Net plant and equipment	105,000	155,000
Sub-Total	155,000	220,000
<b>Total Assets</b>	281,250	375,000

<b>Liabilities and Owner's Equity</b>		
<b>Current Liabilities</b>		
Accounts payable	26,250	55,000
Working capital Loan	42,500	117,500
Sub-Total	68,750	172,500
<b>Long-Term Liabilities</b>		
Mortgage Loan	71,875	57,375
Sub-Total	71,875	57,375
<b>Owner's Equity</b>		
Common shares	78,750	78,750
Retained earnings	61,875	66,375
Sub-Total	140,625	145,125
<b>Total Liabilities and Owner's Equity</b>	281,250	375,000

<b>Income Statements</b> (in thousands of dollars)		
	2,009	2,010
<b>Revenues</b>		
Sales	156,250	200,000
Costs of goods sold	93,750	120,000
Net revenue	62,500	80,000
<b>Expenses</b>		
Operating	41,875	46,250
Depreciation	5,625	12,500
Interest	3,750	7,625
Sub-Total	51,250	66,375
<b>Income Before Taxes</b>	11,250	13,625
Income taxes (50%)	5,625	6,813
<b>Net Income</b>	5,625	6,812