

# APSC 221 - Engineering Economics- Fall 2013

## Assignment 4 - Solutions

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### Question 1: Chapter 13 and a bit of chapter 15 (12 marks)

Use a spreadsheet similar to the one we built in class to model the following scenario and answer the questions below.

A footwear company is thinking about replacing one of its Whats'm-a-Call-it machines and you have been asked to conduct a before-tax analysis to determine if the existing one should be kept or if a new one should be purchased.

The existing machine was purchased 15 years ago. Accounting tells you the total of the invoices for that purchase are \$2,950,428 in equipment and \$178,830 in installation costs. This machine is made out of 100% cast iron that went through a proprietary process to add exotic metal coatings and heat treatments to really toughen up the materials. Based on the various market value estimates the company obtained over the past 10 years you determine that you can model salvage values using a declining balance approach with an 8% depreciation rate. The machine is scheduled to have a major overhaul soon and the maintenance crew chief has estimated that will cost \$55,300 in parts (this will add to the salvage value because of the quality of the parts) and \$18,250 in labour. Maintenance costs are pretty high now because few know how to work on the old machine and are estimated to be \$60,000 next year. However due to the quality of the parts involved the estimated increases in maintenance costs are only a modest 6% per year.

A new machine can be purchased for \$950,000 plus a \$95,000 setup fee. However, they sure don't make them like they use to, the new machines are made of steel and plastic parts with lots of fancy electronics. Maintenance costs start out fairly reasonable at \$20,000 in the first year, but because of lower quality parts increase by \$8,300 per year. In addition every 5 years the machine will require an overhaul estimated to be around \$25,000 in year 5 (consider it as all labour, because the new-fangled parts won't add anything to the salvage value) and will increase by 10% every time an overhaul is done, i.e. the overhaul in year 10 will be \$27,500, in year 15 will be \$30,250 etc. The manufacturer tells you that depreciation on these machines is about 20% per year.

You have been told to use a MARR of 9.75% in your analysis.

- a) What is the Minimum EAC for the Challenger? **\$199,252 (1 mark)**
- b) What is the economic life for the Challenger? (in years) **19 years (1 mark)**
- c) What is the Minimum EAC for the Defender? **\$194,838 (1 mark)**
- d) What is the economic life for the Defender? (in years) **17 years (1 mark)**
- e) Which machine should the company invest in? Challenger or Defender? And Why? For full marks.  
**Defender (1 mark) – because the minimum EAC<sub>Defender</sub> < minimum EAC<sub>Challenger</sub> (1 mark)**
- f) How much would the Challenger's Installation cost have to **decrease to** so we are indifferent between the two machines? **Between \$57,451 and \$57,459 (1 mark). [or change in install costs of between \$37,541 and \$37,549 - acceptable]**
- g) How much **more** can we spend on the Defender's overhaul in parts cost so we are indifferent between the two machines? **Between \$37,848 and \$37,855. (1 mark) [Yr0 Salvage of between \$937,848 and \$937,855 - acceptable]**
- h) Show the manual EAC<sub>Total</sub> calculations for the Challenger in year 4 to verify your model.  
**Salvage value year 4 =  $\$950,000(1-0.2)^4 = \$389,120$  (1 mark)**  
**EAC<sub>Total</sub> =  $(950,000 + 95,000) (A/P, 9.75\%, 4) - 389,120(A/F, 9.75\%, 4) + 20,000 + 8,300(A/G, 9.75\%, 4)$  (2 marks)**  
**=  $1,045,000(0.3138) - 389,120(0.2163) + 20,000 + 8,300(1.3840)$**

$$= 327,921 - 84166.66 + 20,000 + 11,487.2$$

$$= \$275,242 \text{ (which is close enough to the \$227,219 in the spreadsheet) (1 mark)}$$

OR

$$EAC_{\text{Total}} = (950,000 + 95,000) (A/P, 9.75\%, 4) - 389,120(A/F, 9.75\%, 4) + 20,000 + 8,300(A/G, 9.75\%, 4) \text{ (2 marks)}$$

$$= 1,045,000(0.31377) - 389,120(0.21627) + 20,000 + 8,300(1.38399)$$

$$= 327,889.65 - 84154.98 + 20,000 + 11487.12$$

$$= \$ 275,222 \text{ (which is even closer to the \$227,219 in the spreadsheet) (1 mark)}$$

## Question 2: (9 marks) Chapter 14 - Inflation

The Napanee Town Council is currently investigating giving their downtown area a facelift and is looking at a proposal brought to them by an out of town developer. The deal is essentially that for an initial cost to the town of \$2.4 million the developer will contract to keep actual annual maintenance costs to \$125 000 per year and provide actual revenues from parking totaling \$525 000 per year. The Town's Chief Financial Officer identifies that the real dollar MARR is 6% and that she is anticipating inflation to be 3% per year for the entire 30 year study period.

Evaluate the following:

- a) What is actual MARR<sub>A</sub>?

$$MARR_{\text{Actual}} = MARR_{\text{Real}} + f + MARR_{\text{Real}} \times f \text{ (}\frac{1}{2}\text{ mark)}$$

$$MARR_{\text{Actual}} = 0.06 + 0.03 + 0.06 \times 0.03 = 0.0918 = 9.18\% \text{ (}\frac{1}{2}\text{ mark)}$$

- b) What is the actual IRR ( $i_A^*$ ) for this project. Calculate  $i_A^*$  to the nearest tenth of a percent. Should the Town Council invest in this renovation? Justify your answer. [3 marks total for part b)]

$$PW = 0 = -P + (A_R - A_M)(P/A, i_A^*, 30) \text{ (1 mark)}$$

$$PW = 0 = -2.4 + (0.525 - 0.125)(P/A, i_A^*, 30)$$

Or

$$PW = 0 = -2.4 + 0.4(P/A, i_A^*, 30) \text{ (1 mark)}$$

$$\text{Solving for } (P/A, i_A^*, 30) = 2.4 / 0.4 = 6$$

Can use either linear interpolation;

From the interest tables;

$$(P/A, 15\%, 30) = 6.5660$$

$$(P/A, 20\%, 30) = 4.9789$$

$$(20 - 15) / (4.9789 - 6.5660) = (i_A^* - 15) / (6 - 6.5660), \text{ solving } i_A^* \cong 16.8\% \text{ (1 mark)}$$

Or

Using a spreadsheet to calculate that  $i_A^* \cong 16.5\%$  (1 mark)

Justification:

Either;

$$15\% < i_A^* < 20\% \text{ and that } i_A^* > MARR_{\text{Actual}} = 9.18\% \therefore \text{Invest. (1 mark)}$$

Or

$$i_A^* [\cong 16.5\%] > MARR_{\text{Actual}} [=9.18\%] \therefore \text{Invest. (1 mark)}$$

- c) A councillor suggests that it would be fiscally responsible to account for the future replacement of the two sets of traffic lights as part of the renovation costs because they won't last the full 30 years. Each set of traffic lights have a physical life of ten years. The cost to replace the lights today would be \$25 000 per set of lights; this estimate is subject to increase with the general inflation rate. Taking into account this additional cost in year 10 and year 20 calculate the present worth (PW) to determine if the Town Council should still invest in this renovation. Justify your answer. [5 marks total for part c)]

Convert Real cash flows into Actual

$$2(25,000)(1 + 3\%)^{10} = 67,196 \text{ and } 2(25,000)(1 + 3\%)^{20} = 90,306$$

Or

$$2(25,000)(F/P, 3\%, 10) = 67,196 \text{ and } 2(25,000)(F/P, 3\%, 20) = 90,306$$

(½ mark)

(½ mark)

(1 mark)

(1 mark)

$$PW = -2,400,000 + 400,000(P/A, 9.18\%, 30) - 67,196(P/F, 9.18\%, 10) - 90,306(P/F, 9.18\%, 20)$$

$$PW = -2,400,000 + 400,000(10.1119) - 67,196(0.4155) - 90,306(0.1726)$$

$$PW = 1,601,253.25 \text{ (1 mark)}$$

$$PW > 0 \therefore \text{Invest. (1 mark)}$$

Or

$$PW = -2,400,000 + 400,000(10.11186) - 67,196(0.41550) - 90,306(0.17266)$$

$$PW = 1,601,233.63 \text{ (1 mark)}$$

$$PW > 0 \therefore \text{Invest. (1 mark)}$$

Or can work with mixed Actual and Real cash flows

(½ mark)

(½ mark)

(1 mark)

(1 mark)

$$PW = -2,400,000 + 400,000(P/A, 9.18\%, 30) - 50,000(P/F, 6\%, 10) - 50,000(P/F, 6\%, 20)$$

$$PW = -2,400,000 + 400,000(10.1119) - 50,000(0.5584) - 50,000(0.3118)$$

$$PW = 1,601,250.00 \text{ (1 mark)}$$

$$PW > 0 \therefore \text{Invest. (1 mark)}$$

Or

$$PW = -2,400,000 + 400,000(10.11186) - 50,000(0.55839) - 50,000(0.31180)$$

$$PW = 1,601,234.50 \text{ (1 mark)}$$

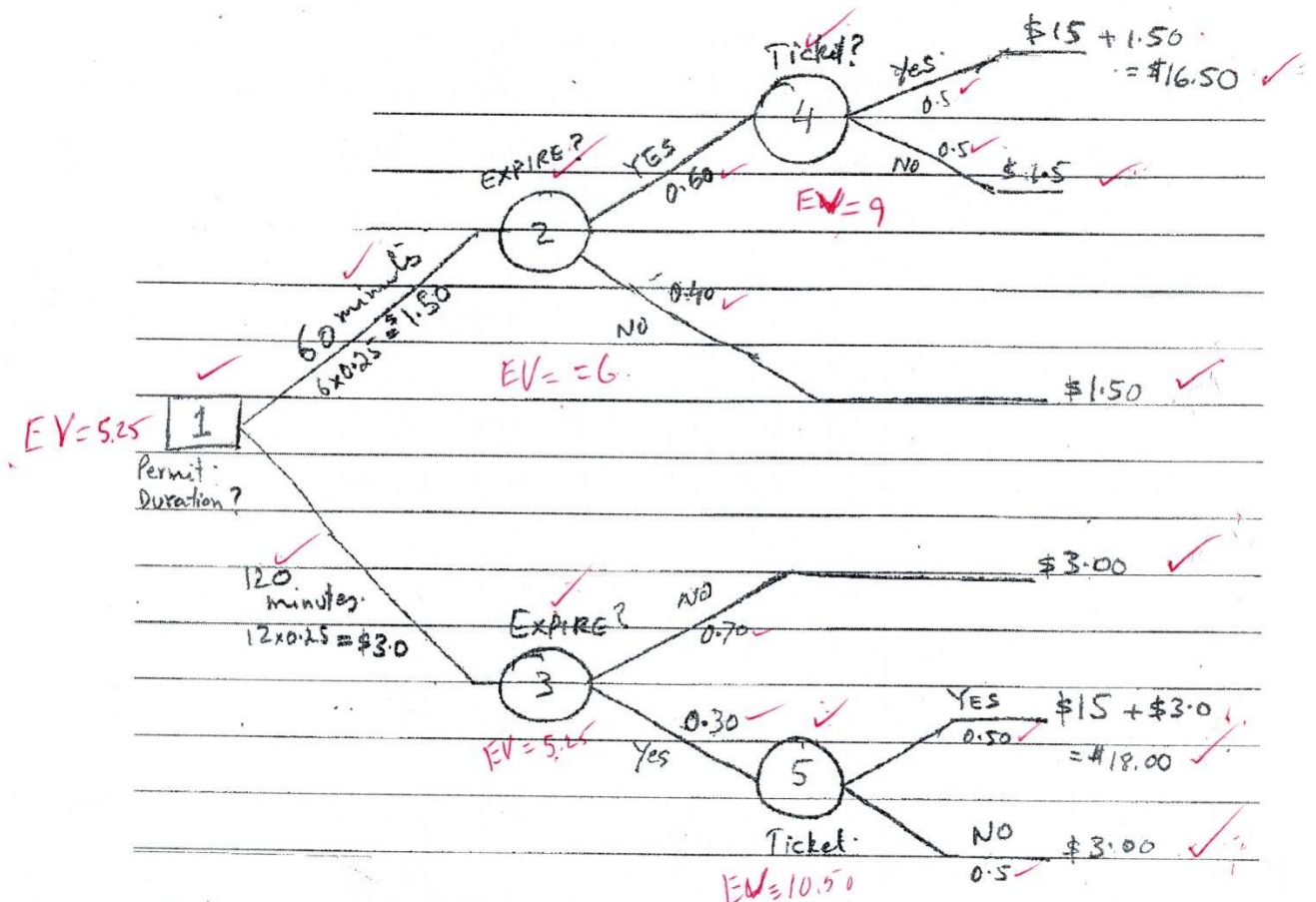
$$PW > 0 \therefore \text{Invest. (1 mark)}$$

### Question 3: (12 marks) Chapter 15 – Dealing with Uncertainty and Risk

Joe is going to a meeting in downtown Kingston and needs to purchase a parking permit from the Pay-N-Display meter for his car, however he is not sure how long to pay for. Joe is uncertain about how long his meeting will be and is considering two options. The parking rate is \$1.50 per hour and he can only buy a 60 minute or a 120 minute permit. If he obtains a permit for 60 minutes, there is a 60% probability that the permit will expire before his meeting finishes and if he obtains a permit for 120 minutes, there is a 30% chance that the permit will expire before his meeting finishes. In either case, if the permit expires, there is a 50% probability that Joe will get a parking violation ticket costing him \$15. Joe wants to use the knowledge he obtained in engineering economics to determine the best choice for obtaining the parking permit from the Pay-N-Display meter.

- a) Construct a decision tree for Joe's parking decision. Make sure to provide detailed labels for full marks.

Hint: There are at least 21 items that can be put on the diagram. [ 1/3 mark for each item, total = 7 ]



- b) On the basis of the expected value (EV), for what duration should Joe obtain the parking permit and why? {Calculation for Expected Values may be shown in part a) above} [5 marks total for part b)]

#### 60 Minute Branch

$$EV_4 = 0.5(\$16.50) + (0.5)(\$1.50) = \$9.00 \text{ (1 mark)}$$

$$EV_2 = 0.60(\$9.00) + 0.40(\$1.50) = \$6.00 \text{ (1 mark)}$$

#### 120 Minute Branch

$$EV_5 = 0.5(\$18.00) + (0.5)(\$3.00) = \$10.50 \text{ (1 mark)}$$

$$EV_3 = 0.70(\$3.00) + 0.30(\$10.50) = \$5.25 \text{ (1 mark)}$$

Choose 120 minute parking permit because  $EV_3 < EV_2$ . Therefore,  $EV_1 = EV_3$  (1 mark)

#### Question 4: Chapter 15 (10 marks)

Imagine that you are a member of a project team that has been charged to develop a new state of the art software product for the residential building industry.

##### Identified risk factors

1. Key team members pulled off project
2. Chance of economic downturn
3. Project funding cut
4. Project scope changes
5. Poor spec. performance

##### Likelihood

1. High
2. Low
3. Medium
4. High
5. Low

- a) Using Table 16.1 on page 652 classify each of the above identified risk factors.

Hint: each one has at least two risk variables. (5 marks)

1. Schedule risk, Organizational risk and Technical risk
2. Market risk – Volume, Financing risk
3. Promotion risk, Technical risk, Cost Estimate Risk, Schedule risk
4. Schedule risk, Cost Estimate risk
5. Technical risk, Market risk - Volume

- b) Based on your answer to a) construct a 3 by 3 Risk Impact Matrix (3 marks)

		Consequences		
		Low	Medium	High
Likelihood	High		4.	1.
	Medium			3.
	Low		2. & 5.	

This part of the question requires you to use your engineering judgement to estimate the consequences and is subjective in nature. Consequences can never be known with absolute certainty, critical thinking, historical experience with similar projects, recent market trends, etc would all need to be considered and a reasoned estimate determined. While an infinite number of choices are theoretically possible, reasonable judgement can narrow the possibilities down to a more manageable group.

Looking for evidence of critical thinking and justified choices for determining consequences. Something like the following;

Both 1. and 3. have more than three reasonable risks associated with them and so would have **high** consequences. Multiple points of failure if the risk occurred.

For 2. , 4., and 5. They have only a couple of risk variables so I estimated that they have **medium** consequences.

- c) Along with your answers to a) and b) and assuming that Table 16.2 applies to this project calculate the Overall Risk Factor given following additional information. (2 marks)

1. Proof of concept design, so keeping it fairly simple with just a minor increase in complexity.
2. Costs are primarily labour and the company will shut down any project that exceeds budget by 25%

$$Pf = (Pm + Pc + Pd) / 3 = (0.9 + 0.3 + 0.7) / 3 = 0.6333 \text{ (}\frac{1}{2}\text{ mark)}$$

$$Cf = (Cc + Cs + Cr + Cp) / 4 = (0.7 + 0.7 + 0.7 + 0.7) / 4 = 0.7 \text{ (}\frac{1}{2}\text{ mark)}$$

Or

$$Cf = (Cc + Cs + Cr + Cp) / 4 = (0.7 + 0.7 + 0.9 + 0.9) / 4 = 0.8$$

$$Rf = 0.6333 + 0.7 - (0.6333)(0.7) = 0.89 = \text{High risk (1 mark)}$$

Or

$$Rf = 0.6333 + 0.8 - (0.6333)(0.8) = 0.93 = \text{High risk (1 mark)}$$

### Question 5: Chapter 16 (7 marks)

Discuss what is meant by the following phrase: “Organizational change is personal”. Include a personal example where you have been asked to make a change. [Remember: Marks are awarded for **concise** content and will be deducted for verbosity]

Real change in organizations is intensely personal and enormously political. Stakeholders usually respond to organizational change on an intensely personal gut-level basis. After all, it is their lives that are being effected and changing.

Any reasonable and rational discussion about change is acceptable. Deduct marks for long-winded verbose submissions or serious spelling or grammar errors (you can ignore minor errors). Can be bullet points, but the points have to be understandable. Use the following as guide.

- Just a simple chronological description of a change ( 1 – 2 marks)
- A good concise description of a change and a few comments about how it affects people (3 – 4)
- A good concise description of a PERSONAL change and solid comments about how it affected THEM (5 – 6)
- A good concise description of a PERSONAL change and solid comments about how it affected THEM , AND includes statements about how it made the writer FEEL (7)