TIE2140 Engineering Economy
Tutorial #5 (Uncertainty & Risk Analysis)

Question 1 (based on Sullivan *et al* 2020, P11-26)

Suppose that, for an engineering project, the optimistic (best), most likely (base), and pessimistic (worst) estimates are as shown in the table below:

	Pessimistic	Most likely	Optimistic
Capital Investment	$ 120,000	$ 100,000	$ 90,000
Useful Life	6 years	10 years	12 years
Market Value at EoL	$ 0	$ 20,000	$ 30,000
Net annual cash flow	$ 20,000	$ 30,000	$ 35,000

MARR = 10%. Assume repeatability.

(*a*) Determine the *AW* of the project under the following conditions:

i. When all the factors are at their most likely values.
ii. When all the factors are at their optimistic values.
iii. When all the factors are at their pessimistic values.

(*b*) Perform a one-way range sensitivity analysis of these factors on the *AW* of the project and plot a tornado diagram and spider diagram.

(*c*) Identify from the tornado and spider diagrams, the sensitive and insensitive factors.

Question 2 (based on Sullivan et al 2014, P11-3)

The Universal Postal Service is considering the possibility of fixing wind deflectors on the tops of 500 of their long-haul tractors. Three types of deflectors, with the following characteristics, are being considered (*MARR* = 10% per year).

	Winshear	Blowby	Air-vantage
Capital Investment	$1,000	$400	$1,200
Drag reduction	20%	10%	25%
Maintenance per year	$10	$5	$5
Useful life	10 years	10 years	5 years

A 5% in drag reduction means 2% in fuel saving per mile. Fuel cost is expected to be $4.00 per gallon, and average fuel consumption is 5 miles per gallon without the deflectors.

Let *X* denotes the number of miles driven per year by a tractor.

(*a*) Assuming repeatability and a study period of 10 years, determine the Equivalent Uniform Annual Cost (*EUAC*) for each of the alternatives in terms of *X*. Plot a rainbow diagram for *EUAC* vs *X*.

(*b*) Determine the range of values of *X* for which each alternative is the optimal choice.

Question 3 (based Sullivan *et al* 2014, P11-5)

Consider two alternatives with base-case scenario values as follows:

	Alternative 1	Alternative 2
Capital Investment	$ 4,500	$ 6,000
Annual revenues	$ 1,600	$ 1,850
Annual expenses	$ 400	$ 500
Estimated market value	$ 800	$ 1,200
Useful life	8 years	10 years

(*a*) Assume repeatability and *MARR* = 15% and determine which alternative should be chosen under the base case scenario values?

(*b*) By how much would the capital investment for Alternative 2 have to vary so that the base case value decision would be reversed?

(*c*) By how much would the useful life of Alternative 1 have to vary so that the base case value decision would be reversed?

Question 4 (based Sullivan *et al* 2020, P12-11)

The purchase of a new piece of electronic measuring equipment for use in a continuous metal forming process is being considered. If this equipment were purchased, the capital cost would be $418,000, and the estimated saving are $148,000 per year. The useful life of the equipment in this application is uncertain. The estimated probabilities of different useful lives occurring are shown in the following table:

Useful Life, Years (N)	$p(N)$
3	0.1
4	0.1
5	0.2
6	0.3
7	0.2
8	0.1

Assume that the *MARR* = 15 % per year before taxes, and the market value at the end of its useful life is equal to zero. Based on a before-tax analysis.

(*a*) What are the $E[PW]$, $Var[PW]$, and $SD[PW]$ associated with the purchase of the equipment?

(*b*) Plot a risk profile for the *PW* of the project.

(*c*) Determine the followings from the risk profile:
- ***i.*** Downside risk of the project, i.e., the probability that $PW \leq 0$?
- ***ii.*** Chance of achieving an upside potential of $PW \geq \$150{,}000$?
- ***iii.*** Present Equivalent Value-at-Risk (95% confidence)?

Question 5 (based on Sullivan *et al* 2020, P12-19)

Two investment alternatives are being considered. The data below has been estimated by a committee of experts. *MARR* is 15 % per year and project life is not uncertain.

	Alternative *A*		Alternative *B*	
EoY	Expected Cash Flow ($)	Standard Deviation of Cash Flow ($)	Expected Cash Flow ($)	Standard Deviation of Cash Flow ($)
0	-8,000	0	-12,000	500
1	4,000	600	4,500	300
2	6,000	600	4,500	300
3	4,000	800	4,500	300
4	6,000	800	4,500	300

(*a*) If all the cash flows are mutually independent, determine the expected value and standard deviation of the *PW* of alternatives *A* and *B*. It is possible to determine which is the preferred alternative?

(*b*) If all the cash flows are mutually independent, determine the expected value and standard deviation of the *PW* of the incremental investment from *B* to *A*, i.e., *PW*(*A* – *B*).

(*c*) If the cash flows for investment alternative *A* are not mutually independent and the relevant correlation coefficients are $\rho_{12} = 0.1$, $\rho_{23} = 0.2$, and $\rho_{34} = 0.3$, determine the expected value and standard deviation of its *PW*.