09-MMP-B8 Mine Management & Systems Analysis

National Exam

May 2012

NAME:_____

DATE:_____

TIME LIMIT FOR EXAM IS 3 HOURS.

ANSWER ANY 4 OUT OF 5 QUESTIONS FOR A TOTAL OF 100 MARKS.

IF MORE THAN 4 QUESTIONS ARE ATTEMPTED, CLEARLY INDICATE WHICH 4 QUESTIONS ARE TO BE GRADED - ONLY 4 QUESTIONS WILL BE MARKED.

APPENDIX A WITH DISCOUNTED CASH FLOW TABLES IS ATTACHED.

THIS IS A CLOSED BOOK EXAM – A CASIO OR SHARP APPROVED CALCULATOR IS PERMITTED. WRITING AND DRAFTING IMPLEMENTS MAY BE USED.

CLEARLY STATE AND JUSTIFY ANY ASSUMPTIONS THAT YOU MAKE.

TOTAL NUMBER OF PAGES IS THIS EXAM SHEET IS 7.

PARTS OF QUESTIONS 4 AND 5 CAN BE ANSWERED DIRECTLY ON THESE SHEETS –ANSWER OTHER QUESTIONS AND SECTIONS IN THE BOOKLETS PROVIDED.

RETURN ALL 7 PAGES WITH YOUR EXAM BOOKLETS.

QUESTION #1 – MINE STAGES AND DESIGN. 25 MARKS

a) Name and describe the 5 stages in the life of a mine.

b) Describe the 5 stages in terms of typical cash flows and sketch the corresponding cash flow diagram.

c) It has been stated that there has been a step change in mining in the last decade and that "Mines are designed for closure". What does this statement mean? Provide 2 examples of mine designs based on this design philosophy.

QUESTION #2 - PROJECT SCHEDULING. 25 MARKS

You are planning the mine development and supporting activities to facilitate mining a new ore zone at an underground mine. For the project development schedule given in Table 1:

a) Sketch a Gantt Chart showing the dependencies of tasks.
b) Using the Critical Path Method, determine the sequence of tasks that forms the Critical Path to complete the project in the shortest possible time period.
c) What is the shortest time that the project can be completed?
d) What are the tasks that are not critical for the project to remain on schedule and why.

Table 1. New Ore Zone Development Schedule.

Task#	Description	Duration (Months)	Dependent on Task #
1	10 km access road to minesite	4	none
2	15 km rail link to main CN line	6	none
3	Hoist and headframe installation	3	1
4	Collaring of shaft	1	3
5	Shaft sinking to Phase 1 depth	9	4
6	Ramp development to initial development levels	12	4
7	Construction of surface buildings (offices, warehouses, workshops, permanent dry rooms)	8	3
8	Shaft lining/guides, installation of cage and skip	5	5
9	Construction of surface crusher, ball mill	24	2
10	Construction of concentrator	24	2
11	Construction of flotation mill	30	2
12	Construction of underground crusher station	3	8
13	Excavation of initial 2 development levels	12	8
14	Excavation of initial ore passes	3	12
15	Construction of level 2 refuge station & garage	4	6,13
16	First production excavation (final step)	N/A	9,10,11,14,15

QUESTION #3 – MINERAL PROJECT VALUATION. 25 MARKS

The press release below issued several years ago outlines a mineral deposit that was recommended to proceed to mine development. Review the press release and answer the valuation and economic analysis questions that follow. **Clearly state and justify any assumptions that are made to answer the questions.**

UPDATE 1-Western Copper says study justifies Yukon mine development

April 7 (Reuters) - Canada's Western Copper Corp said a pre-feasibility study showed that further development of its copper-gold-molybdenum project in Yukon was economically viable due to a number of factors, including improved gold recoveries.

The study recommended that the Casino project be built as an open pit mine, which is cheaper than shaft mining, and raised the processing capacity of the mill at the site by a third, Western Copper said in a statement.

The company estimates a capital investment of C$2.13 billion for the project, which is one of its four fully owned projects in the Yukon.

The mine can now produce an average of 435,000 ounces of gold, 234 million pounds of copper, 13 million pounds of molybdenum, and 1.6 million ounces of silver per year over the first four years of production, according to the study. Projected commodity prices over the study period were C$4.00/lb for copper, C$1400/oz for gold, C$15/lb for molybdenum, and C$35/oz for silver.

The project's combined proven and probable reserve was 4.4 billion pounds of copper, 8.3 million ounces of gold, 490 million pounds of molybdenum, and 61 million ounces of silver, the company said in a statement.

Questions:

a) Estimate the gross value of ore per tonne and operating costs per tonne.
b) Estimate the Net Present Value (NPV) and Present Value Ratio (PVR) at a discount rate of 10% and payback period on a before-tax basis.
c) Conduct a sensitivity analysis of NPV and PVR using discount rates of 10%, 20%, 30% and 40% on a before-tax basis and plot your results using standard practices.
d) What is the significance of the sensitivity analysis results from part c) ?

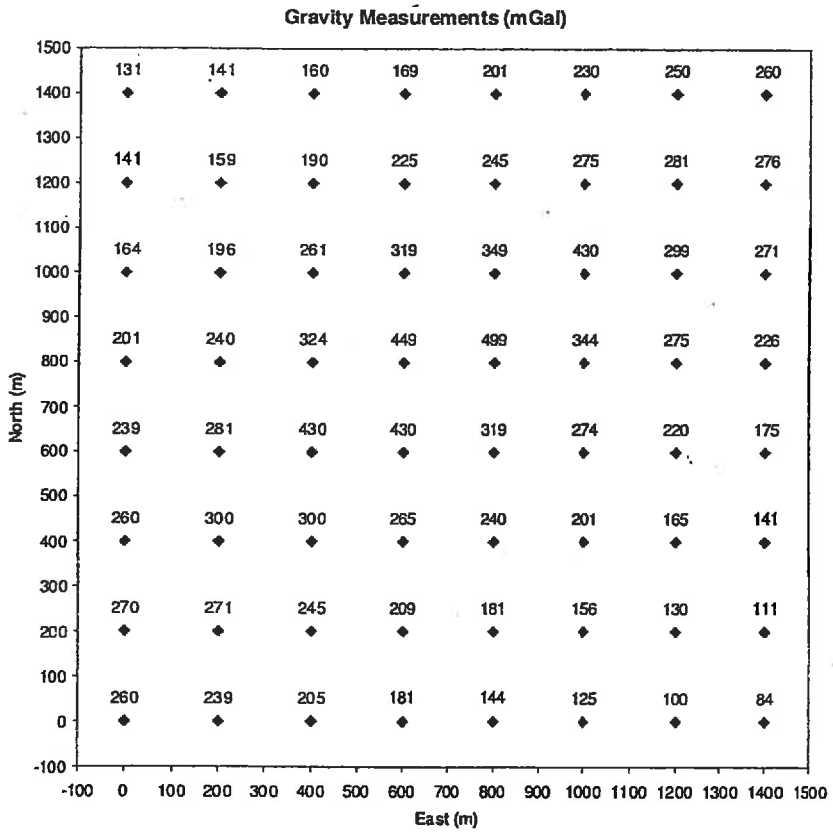
QUESTION #4 – MINERAL EXPLORATION PLANNING. 25 MARKS

a) General guidelines for base metal deposit exploration in the Canadian Shield are that:
- One deposit is found for every 45,000 line-km of airborne electromagnetic surveying.
- Each individual exploration project covers about 2000 line-km, with an average cost of $400,000.

Based on these guidelines, what is the probability of successful deposit discovery for a single exploration project? What should be the minimum exploration budget to ensure discovery of a deposit?

b) An airborne survey from part a) has identified an anomaly for ground-based follow up. You have the option of i) drilling directly on the airborne identified anomaly, or ii) conducting an additional ground-based survey to more precisely locate the anomaly prior to drilling. The drilling costs including mobilization costs are estimated to be $5000 per hole and the additional ground-based survey would cost $40,000. The expected net present value of an average discovery is NPV = $20 million, and the probability of success for drilling this type of anomaly is about 1%. Given that more precisely locating the anomaly would probably require fewer drill holes for evaluation, develop a decision tree that would assist with deciding which of the 2 options to choose.

c) The figure below shows the gravity field measurements resulting from the ground-based survey from part b). Contour this gravity data using a 50 mGal contour interval. Where is the best location of the first drill hole and why?



QUESTION #5 – ULTIMATE PIT LIMIT DETERMINATION. 25 MARKS

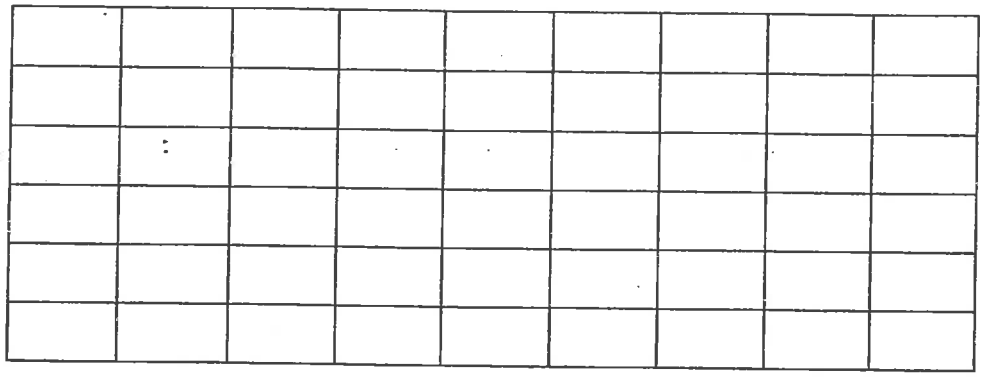
The 2-D geological block model below shows the gold grade in oz/tonne for a high grade gold deposit that is to be mined using an open pit. Using the mining criteria listed below, determine the corresponding economic block model and then use the either Lerchs-Grossman or Floating Cone method to determine the most profitable pit outline and the corresponding pit profit. The mining details include:

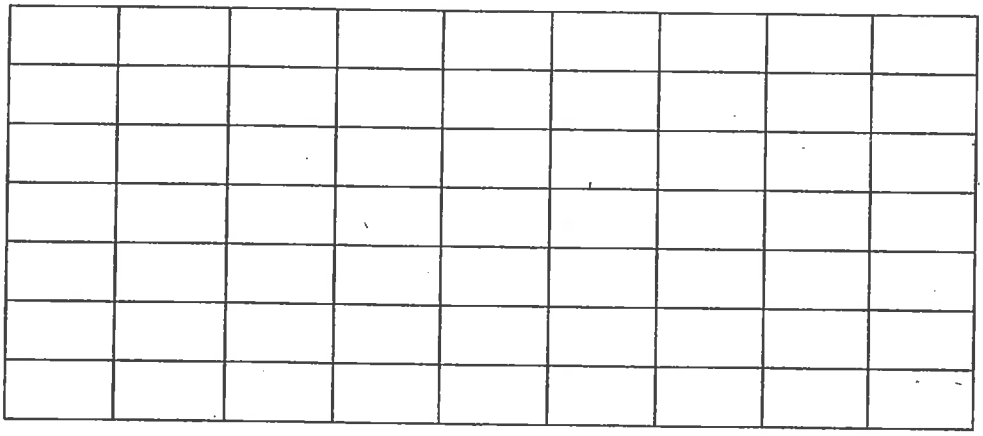
- Block size = 20 m along strike, 20 m perpendicular to strike, 10 m high
- Ore and waste density = 2500 kg/m^3
- Max pit slope gradient = 50%
- Ore cutoff grade = 0.06 oz/tonne
- Block mining cost = $40/tonne
- Block mill processing cost = $70/tonne
- Block overhead cost (ore and waste) = $30/tonne
- Long-term estimated net gold price = $1400 CAD / oz

Geological BM:

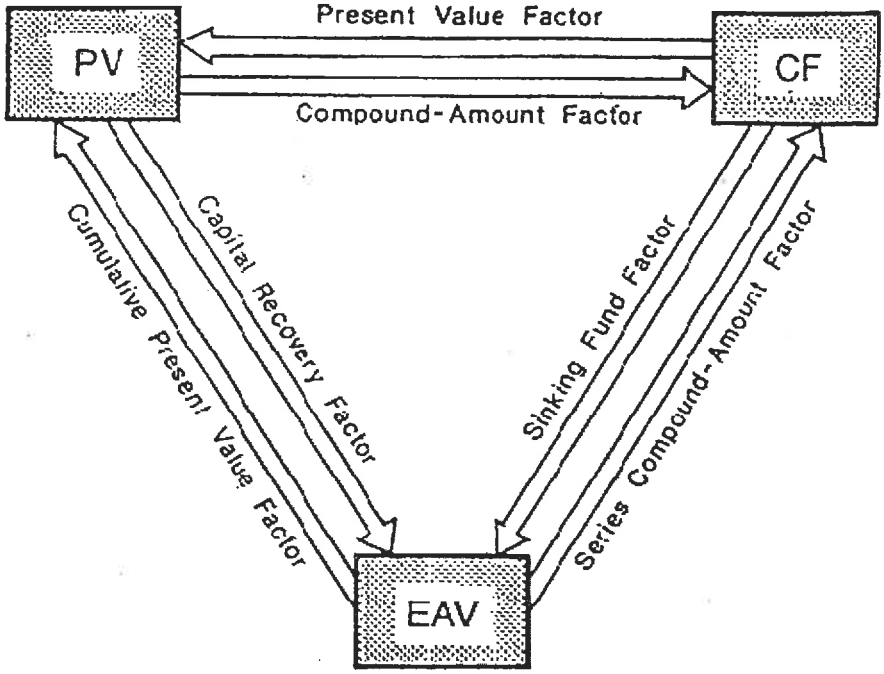
nil	0.1	0.4	0.4	0.4	0.2	0.1	nil	nil
nil	0.1	0.2	0.4	0.2	0.2	0.1	nil	nil
nil	nil	0.1	0.6	0.4	0.1	0.1	0.05	nil
nil	nil	0.1	0.2	0.6	0.2	0.1	0.05	nil
nil	nil	0.1	0.05	0.2	0.4	0.1	nil	nil
nil	nil	nil	nil	0.2	0.2	0.1	nil	nil

Economic BM:





Appendix A – Discounted Cash Flow Analysis Tables and Charts



	PVF				CPVF				SFF			
years	10%	20%	30%	40%	10%	20%	30%	40%	10%	20%	30%	40%
1	0.9091	0.8333	0.7692	0.7143	0.9091	0.8333	0.7692	0.7143	1.0000	1.0000	1.0000	1.0000
2	0.8264	0.6944	0.5917	0.5102	1.7355	1.5278	1.3609	1.2245	0.4762	0.4545	0.4348	0.4167
3	0.7513	0.5787	0.4552	0.3644	2.4869	2.1065	1.8161	1.5889	0.3021	0.2747	0.2506	0.2294
4	0.6830	0.4823	0.3501	0.2603	3.1699	2.5887	2.1662	1.8492	0.2155	0.1863	0.1616	0.1408
5	0.6209	0.4019	0.2693	0.1859	3.7908	2.9906	2.4356	2.0352	0.1638	0.1344	0.1106	0.0914
6	0.5645	0.3349	0.2072	0.1328	4.3553	3.3255	2.6427	2.1680	0.1296	0.1007	0.0784	0.0613
7	0.5132	0.2791	0.1594	0.0949	4.8684	3.6046	2.8021	2.2628	0.1054	0.0774	0.0569	0.0419
8	0.4665	0.2326	0.1226	0.0678	5.3349	3.8372	2.9247	2.3306	0.0874	0.0606	0.0419	0.0291
9	0.4241	0.1938	0.0943	0.0484	5.7590	4.0310	3.0190	2.3790	0.0736	0.0481	0.0312	0.0203
10	0.3855	0.1615	0.0725	0.0346	6.1446	4.1925	3.0915	2.4136	0.0627	0.0385	0.0235	0.0143
11	0.3505	0.1346	0.0558	0.0247	6.4951	4.3271	3.1473	2.4383	0.0540	0.0311	0.0177	0.0101
12	0.3186	0.1122	0.0429	0.0176	6.8137	4.4392	3.1903	2.4559	0.0468	0.0253	0.0135	0.0072
13	0.2897	0.0935	0.0330	0.0126	7.1034	4.5327	3.2233	2.4685	0.0408	0.0206	0.0102	0.0051
14	0.2633	0.0779	0.0254	0.0090	7.3667	4.6106	3.2487	2.4775	0.0357	0.0169	0.0078	0.0036
15	0.2394	0.0649	0.0195	0.0064	7.6061	4.6755	3.2682	2.4839	0.0315	0.0139	0.0060	0.0026
16	0.2176	0.0541	0.0150	0.0046	7.8237	4.7296	3.2832	2.4885	0.0278	0.0114	0.0046	0.0018
17	0.1978	0.0451	0.0116	0.0033	8.0216	4.7746	3.2948	2.4918	0.0247	0.0094	0.0035	0.0013
18	0.1799	0.0376	0.0089	0.0023	8.2014	4.8122	3.3037	2.4941	0.0219	0.0078	0.0027	0.0009
19	0.1635	0.0313	0.0068	0.0017	8.3649	4.8435	3.3105	2.4958	0.0195	0.0065	0.0021	0.0007
20	0.1486	0.0261	0.0053	0.0012	8.5136	4.8696	3.3158	2.4970	0.0175	0.0054	0.0016	0.0005
21	0.1351	0.0217	0.0040	0.0009	8.6487	4.8913	3.3198	2.4979	0.0156	0.0044	0.0012	0.0003
22	0.1228	0.0181	0.0031	0.0006	8.7715	4.9094	3.3230	2.4985	0.0140	0.0037	0.0009	0.0002
23	0.1117	0.0151	0.0024	0.0004	8.8832	4.9245	3.3254	2.4989	0.0126	0.0031	0.0007	0.0002
24	0.1015	0.0126	0.0018	0.0003	8.9847	4.9371	3.3272	2.4992	0.0113	0.0025	0.0006	0.0001
25	0.0923	0.0105	0.0014	0.0002	9.0770	4.9476	3.3286	2.4994	0.0102	0.0021	0.0004	0.0001
26	0.0839	0.0087	0.0011	0.0002	9.1609	4.9563	3.3297	2.4996	0.0092	0.0018	0.0003	0.0001
27	0.0763	0.0073	0.0008	0.0001	9.2372	4.9636	3.3305	2.4997	0.0083	0.0015	0.0003	0.0000
28	0.0693	0.0061	0.0006	0.0001	9.3066	4.9697	3.3312	2.4998	0.0075	0.0012	0.0002	0.0000
29	0.0630	0.0051	0.0005	0.0001	9.3696	4.9747	3.3317	2.4999	0.0067	0.0010	0.0001	0.0000
30	0.0573	0.0042	0.0004	0.0000	9.4269	4.9789	3.3321	2.4999	0.0061	0.0008	0.0001	0.0000