09-MMP-B8 Mine Management & Systems Analysis

National Exam

December, 2011

1. Time limit for exam is 3 hours.

2. Answer 5 out of 6 questions. All questions are worth 20 marks, for a total of 100 marks. If all questions are attempted, clearly indicate which 5 questions are to be graded.

3. Appendix A with discounted cash flow tables is attached.

4. Total number of pages is 8.

Question #1 - Project Scheduling. 20 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	Drive new ramp Phase A	8	none
2	Develop new finger raises and drawpoints	7	1
3	Drive new ramp Phase B	8	1
4	Develop new u/g exploration drilling gallery	2	1
5	Complete new u/g exploration drilling program, ore body model and mining schedule	18	4
6	Reconfigure mine ventilation system for new zone	4	3
7	Expand u/g diesel powered equipment fleet	4	6
8	Develop upper mining level for new zone	12	1
9	Develop lower mining level for new zone	12	3
10	Develop slot raises for initial stope blocks	8	8, 9
11	Drill open stoping blastholes for initial 2 stopes	2	10, 5
12	First production from stopes in new zone	N/A	11, 2

Question #2 – Mineral Project Valuation. 20 Marks

The press release below issued several years ago outlines a mineral deposit that was approved 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.

Globe and Mail, January 2004.

***Falconbridge OKs Nickel Rim South**: Falconbridge (FL-T) has approved a US$368-million program of definition drilling underground at its Nickel Rim South deposit in Sudbury, Ont. The program is expected to last five years and will begin immediately. Expenditures for 2004 are pegged at US$75 million.*

Inferred resources at Nickel Rim South stand at 13.2 million tonnes grading 1.7% nickel, 3.5% copper and 0.04% cobalt, plus 0.8 gram gold per tonne and platinum group element credits. The resource boundaries remain open, and surface drilling is expected to wrap up by the fall.

Falco says the cost of bringing a mine into production following underground drilling would be US$185 million. Initial production is expected in 2008. Net of US$141 million worth of projected preproduction revenues, the overall net capital cost is pegged at US$413 million. Production is expected to ramp to full scale by the start of 2009 and maintain this level for 22 years.

The pretax internal rate of return is expected to be 40%, based on a nickel price of US$3.25 per lb. and a copper price of US$0.90 per lb. Operating cash costs are estimated at minus US$0.66 per lb. of nickel, owing to byproduct credits.

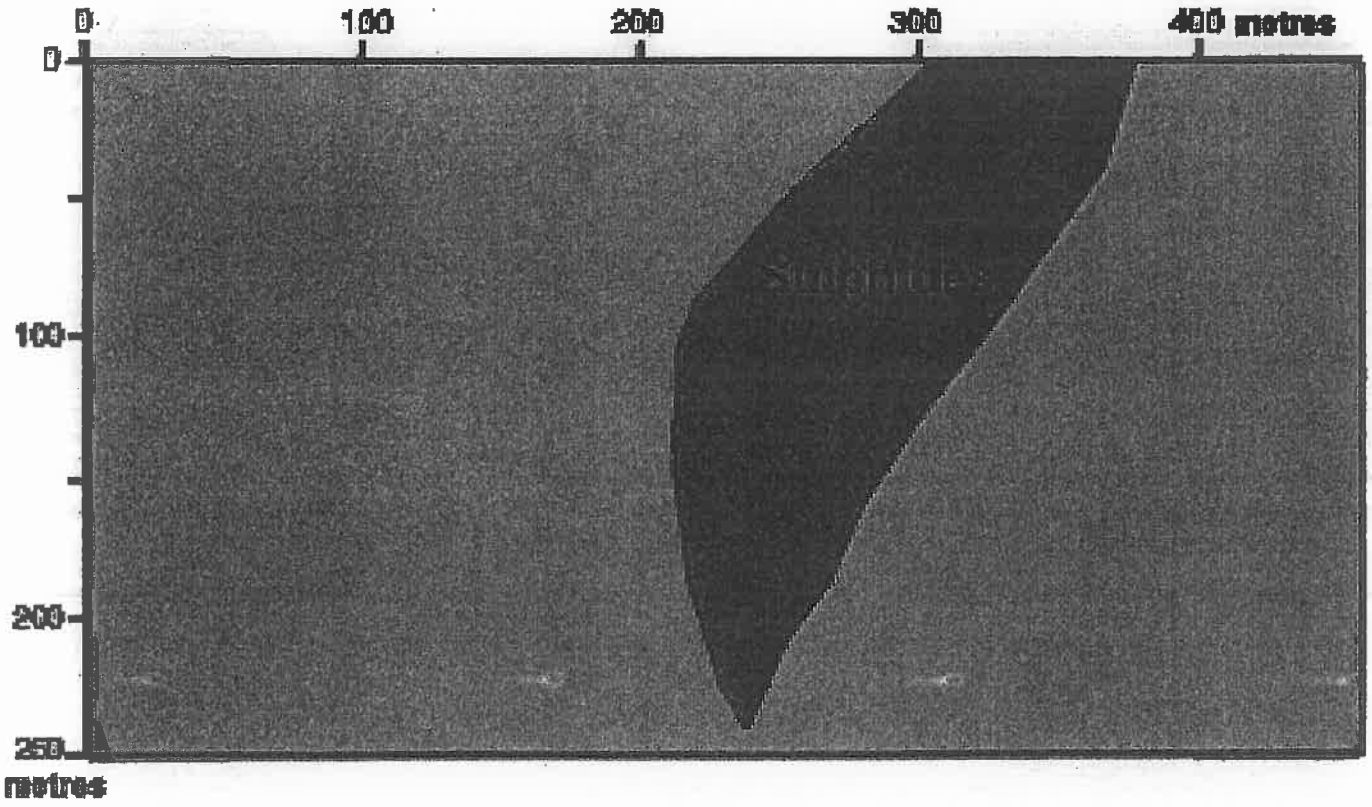
Questions:

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. What is the significance of these results?
d) The article states that the "pretax internal rate of return is expected to be 40%". Based on your results, is this a realistic expectation?

Question #3 – Open Pit Limits and Phased Development. 20 Marks

On the provided geological section provided in Fig. 1, the ore is identified as "Sulfides" and the waste rock is all regions adjacent to and below the ore. The average density of the ore is 4000 kg/m^3 and the average density of the waste is 2700 kg/m^3. A rock mechanics assessment of the ore and waste rocks indicates that the maximum slope angle is 70°.

a) Based on the densities and slope angle constraints, propose final open pit outlines that satisfy a stripping ratio of tonnes waste to tonnes ore of 1.5.
b) Given a minimum mining width of 50 m at the bottom of the pit, what is the stripping ratio that mines all the ore to the minimum mining width?
c) For the final pit outline resulting from b), propose 3 mining phases that consist of mining, striping and then mining again.



Question #4 – Equipment Selection. 20 Marks

Designers for a new surface mine are considering two potential production fleet options: Fleet Option A consisting of two 10 m^3 hydraulic shovels and 12 70 tonne trucks, while Fleet Option B consisting of one 20 m^3 shovel and 16 40 tonne trucks. Fleet-Production-Cost analysis indicates comparable production rates for both options. The expected mine life is 18 years with 350 working days per year, and the salvage value for any piece of equipment at the end of the mine life is 75% of the remaining fraction of useable life times the initial capital cost.

a) Determine the Net Present Value and the Equivalent Annual Cost for each of these options using a 10% cost of capital. Note that DCF tables are provided in the attached Appendix A.
b) Which option is the most attractive from an economic point of view?
c) Which option is the most attractive from an operational point of view and why?

Equipment	Capital Cost	Operating Cost	Lifespan
10 m^3 shovel	$5,000,000	$2,000 / day	8 years
20 m^3 shovel	$9,500,000	$3,000 /day	12 years
40 tonne truck	$1,500,000	$1,500 / day	7 years
70 tonne truck	$2,000,000	$2,000 / day	6 years

Question #5 – Mine Stages and Design. 20 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 10 years and that "Mines are designed for closure". What does this statement mean? Provide 2 examples of mine designs based on this design philosophy.

Question #6 – Ultimate Pit Limit Determination. 20 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 methods to determine the most profitable pit outline and the corresponding pit profit. The mining details include:

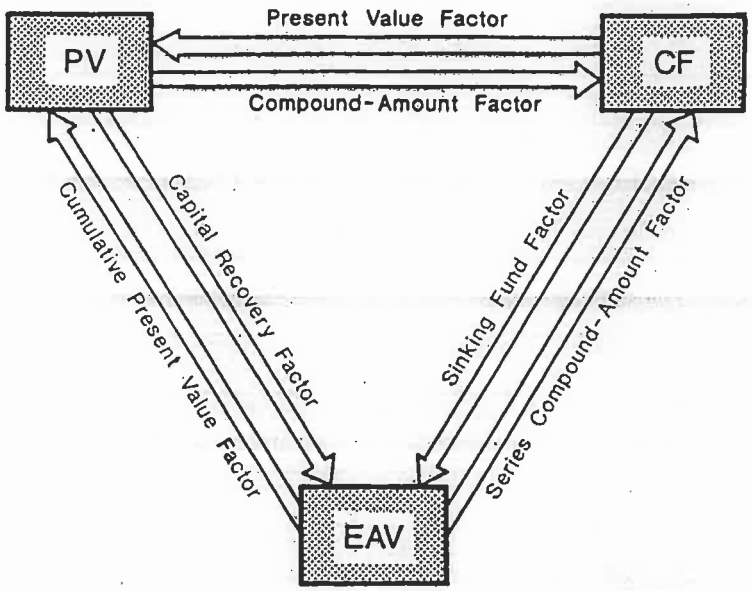
- Block size = 20 m along strike, 20 m perpendicular to strike, 10 m high
- Ore and waste density = 2500 kg/m^3
- Max pit slope gradient = 50%
- Ore cutoff grade = 0.122 oz/tonne
- Block mining cost = $20/tonne
- Block mill processing cost = $30/tonne
- Block overhead cost (ore and waste) = $20/tonne
- Long-term estimated net gold price = $1250 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