09-MMP-B8 Mine Management and Systems Analysis
National Exam
May 2011

Time limit for exam is 3 hours.

Notes:

1. There are 6 questions, each worth 20 marks. Do any 5 out of the 6 questions for a total of 100marks. If all questions are attempted, clearly indicate which 5 questions are to be marked forgrade.

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

3. This is a closed book exam. A Casio or Sharp approved calculator is permitted.

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 following project development schedule and task dependencies, utilize the Critical Path Method to determine:

a) The sequence of tasks that forms the Critical Path to complete the project in the shortest possible time period.
b) The shortest time that the project can be completed.
c) The tasks that are not critical for the project to remain on schedule and why.

New Ore Zone Development:

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 - Feasibility Study and Financial Analysis. 20 Marks

This question is based on economic analysis of the mining project described in the recent press release:

> ***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 average 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.*

Conduct a discounted cash flow analysis of this project, **clearly stating and justifying all of the economic factors that you interpreted from the press release**. Note that DCF tables are provided in the attached Appendix A. From the press release and your justified assumptions, determine:

i. The gross value of ore per tonne and operating costs per tonne.
ii. Net Present Value and Present Value Ratio at a discount rate of 10% and payback period on a before-tax basis.
iii. Conduct a sensitivity analysis of NPV using copper prices of C$2.00/lb to C$6.00/lb on a before-tax basis and plot your results using standard practices. What does this analysis show?

Question 3 - Mineral Resource Block Modelling and Pit Limits. 20 Marks

The 2-D geological block model shown below gives ore grades for a disseminated mineral deposit in percent. For this deposit, a grade cutoff of 1.5% is used to differentiate between ore and waste. a) Use the criteria listed below to determine the equivalent 2-D economic block model where the mineral grade for the block is replaced by either i) the cost to mine waste blocks or ii) the net revenue generated by the mining and processing of ore blocks. b) Conduct a 2-D Lerchs-Grossman or Floating Cone analysis to determine the most profitable open pit outline. c) What is the net economic value of the optimal pit outline from part b?

- Block dimensions are 10 m by 10 m by 10 m;
- Ore and waste densities are both 2500 kg/m^3;
- Net processed mineral value (including NSR and transportation charges) is $2200/tonne;
- Mine recovery is 100%;
- Mill recovery is 95%;
- Combined mining costs are $20/tonne;
- Combined milling costs are $15/tonne;
- Combined overhead costs are $15/tonne.

Geological Block Model (% grade):

0	0	2	3	4	3	1	1
0	0	1	4	4	0	1	0
0	0	1	4	2	3	0	0
1	1	1	2	3	1	0	0
0	1	1	2	2	1	0	0

Economic Block Model ($):

Optimum Pit Outline:

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 20 m^3 hydraulic shovels and 12 200 tonne trucks, while Fleet Option B consisting of one 40 m^3 shovel and 16 150 tonne trucks. Fleet-Production-Cost analysis indicates comparable production rates for both options. The capital cost, annual operating cost and lifespan data for the various equipment are given in Table 4.1 The expected mine life is 12 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.

Table 4.1 Equipment data.

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

Tax is a flat 35% of taxable net revenue and the cost of capital is estimated at 12%, and it is expected that production revenues will be sufficient to fully utilize the tax write-offs that would be available from either equipment option.

What are the after-tax cash flows associated with each option? Which option would be the best from economic and investment points-of-view?

Question 5. Shovel-Truck Fleet Analysis. 20 Marks

For a particular working area of a surface mine, the haul route from the shovel to the crusher is i) 200 m of level in-pit haulage, ii) climbing through 125 m of elevation change up a 10% ramp, and iii) traveling a horizontal distance of 850 m to the crusher. The rolling resistance of all road surfaces is 8%, downhill speed limits of 30 km/h are imposed. Time study data for loading and dumping times are given in Fig. 5.1 and the truck performance charts are given in Fig. 5.2. Using these data, determine (a) the expected range of truck cycle times, and (b) the optimum number of trucks to assign to a single shovel. Clearly justify any assumptions you make regarding the use of the provided data.

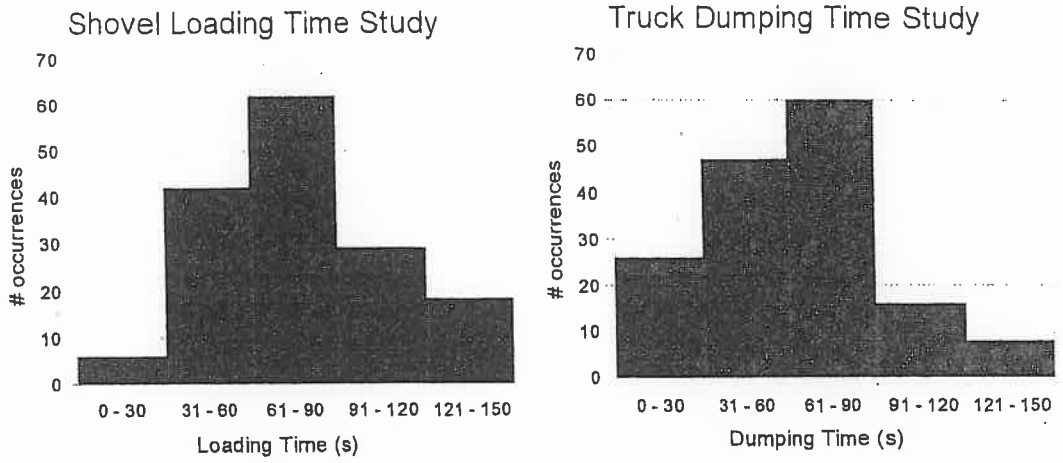


Fig. 5.1 Histograms of shovel loading and truck dumping times.

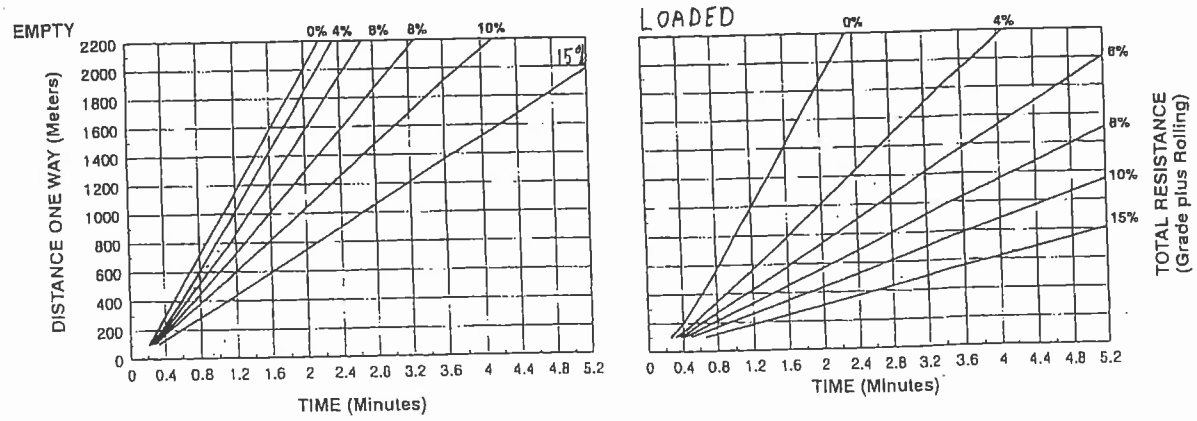


Fig. 5.2 Truck performance charts.

Question 6 – Mineral Exploration Planning. 20 Marks

You are working for a medium sized mining company involved with exploration in the Canadian Shield. The results of a geophysical prospecting program are described below:

iv. An airborne VLF survey indicated a tilt angle crossover on a broad flat marshy area.
v. Follow up ground based magnetic and gravity surveys were conducted over a 1400 m by 1400 m square area centered approximately at the point of the VLF crossover.
vi. Both ground surveys were run simultaneously, with measurements conducted at 200 m intervals along North-South lines spaced at 200 m.
vii. The gravity survey had all the necessary corrections applied and has just been presented to you as a plan of the survey area (Figure 6.1).

Questions:

a) Contour the provided gravity data in Figure 6.1 using a 50 mgal contour interval.

b) Knowing that the VLF crossovers indicate subsurface conductors and assuming that positive gravity anomalies indicate higher density, what can you say about the subsurface body regarding its possible mineralogy, shape, and dimensions?

c) Plan an exploration drilling program based on what you conclude from part (b) including the location of the primary, delineation and line boreholes. Include type of drills, borehole collar locations and borehole sequence.

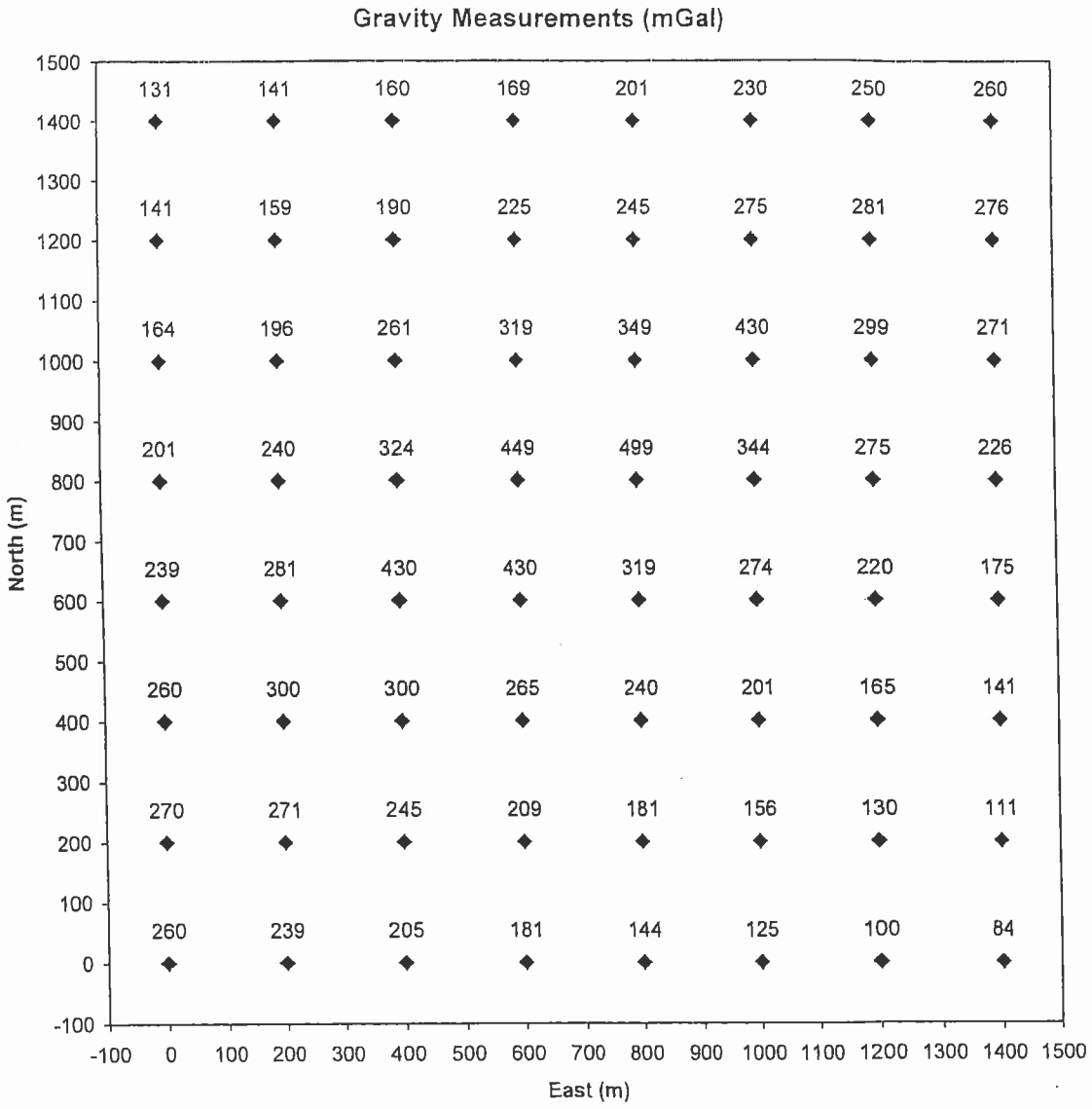
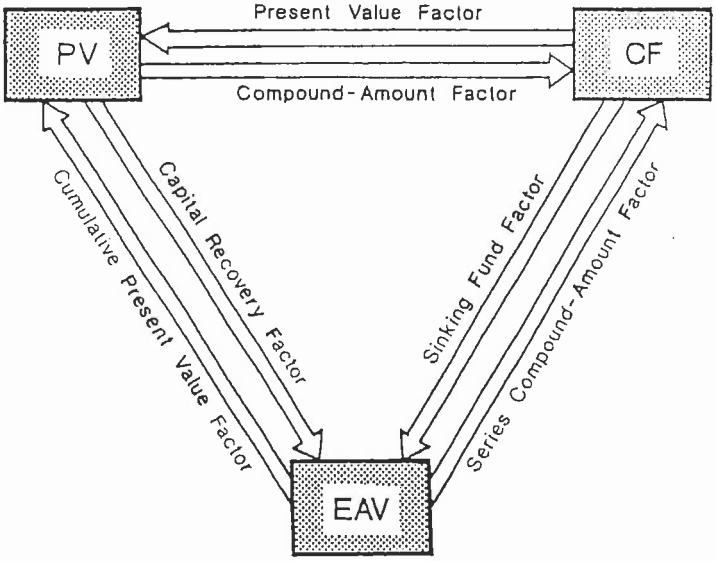


Figure 6.1. Plan of gravity data measurements for ground geophysical survey.

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