09-MMP-B8 Mine Management and Systems Analysis

National Examination

May, 2018

NAME:
DATE:
TIME LIMIT FOR EXAM IS 3 HOURS.
ANSWER ALL 4 QUESTIONS FOR A TOTAL OF 100 MARKS.
APPENDIX A WITH DISCOUNTED CASH FLOW TABLES IS ATTACHED.
THIS IS A CLOSED BOOK EXAM - One of two calculators is permitted - any Casio or Sharp approved model.
CLEARLY STATE AND JUSTIFY ANY ASSUMPTIONS THAT YOU MAKE. TOTAL NUMBER OF PAGES IN THIS EXAM IS 6.
PARTS OF QUESTIONS 4 AND 5 CAN BE ANSWERED DIRECTLY ON THESE SHEETS - ANSWER OTHER QUESTIONS AND SECTIONS IN THE BOOKLETS PROVIDED.
RETURN ALL 6 PAGES WITH YOUR EXAM BOOKLETS.

Question 1 - Mine Stages and Financial Analysis. 30 Marks

- a) Name and describe the 5 stages in the life of a mine. (10 Marks)
- b) Describe the 5 stages in terms of typical cash flows and sketch the corresponding cash flow diagram. (5 Marks)
- c) Evaluate the mining project described in the recent press release given below and answer the financial analysis questions that follow. (15 Marks)

Press Release (December 2017):

Snowy River is a gold project located northwestern Ontario. The deposit was discovered in 2001 and then subsequent exploration delineated a world class resource. Regulatory reviews and approvals were concluded in 2012 and mine development commenced in January 2015. The mine will be a conventional shovel and truck open pit operation when it starts production in January 2019.

Stripping operations are nearly 85% completed and energization of all key site overhead power lines and construction of the tailings pipeline corridor have been completed. The primary crusher and conveyor system was successfully commissioned on schedule, and the first crush occurred on December 11, 2017. Commissioning of the ball mill and SAG mill has started and is scheduled to be completed in August 2018. The refining portion of the circuit should be ready to begin commissioning in October 2018, and dry and wet commissioning of the full process circuit is scheduled for late November 2018. Project spending at Snowy River to date is approximately \$295 million, with the remaining capital costs prior to commercial production estimated to be an additional \$220 million.

The January 2011 Feasibility Study for the project estimated a 20,000 tonne per day processing plant operation with combined mining and milling costs estimated at \$90/tonne. Average annual gold production of 485,000 ounces is expected during the first nine years of the mine's anticipated 17-year life, declining to a rate of 180,000 ounces per year during the final mine life. Decommissioning and reclamation costs of \$70 million over 2 years are expected after mining ends. At the time of this press release, gold prices are expected to maintain an average of \$1600 CAD/ounce over the duration of the production life with a 50% probability.

Conduct a discounted cash flow analysis of this project (as outlined below) 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 this information, determine:

- i. The gross and net value of ore 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. Based on your analysis, would you recommend this project as an investment opportunity? Justify your recommendation.

Question 2. Shovel-Truck Fleet Analysis. 20 Marks

For a particular working area of a large surface mine, the haul route from the shovel to the crusher is i) 400 m of level in-pit haulage, ii) climbing through 175 m of elevation change up a 10% ramp, and iii) traveling a horizontal distance of 1850 m to the crusher. The rolling resistance of all road surfaces is maintained at approximately 6% and downhill speed limits of 30 km/h are imposed. Time study data for loading and dumping times are given in Fig. 2.1 and the truck performance charts are given in Fig. 2.2. 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.

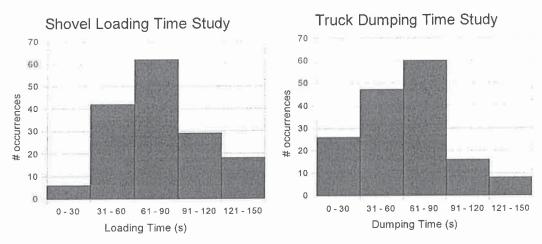


Fig. 2.1 Histograms of shovel loading and truck dumping times.

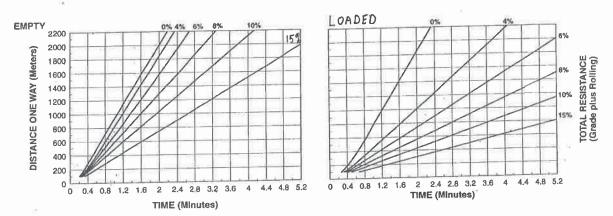


Fig. 2.2 Haul truck performance charts.

Question 3 - Project Scheduling and Analysis. 30 Marks

The mining project schedule outlined below is for the development to start mining of a new ore zone at an existing underground mine. Utilize project scheduling principles and methods to evaluate the project schedule, task dependencies, and timelines to answer the questions below.

- a) Generate a Gantt Chart on the chart below showing the dependency and duration of tasks. (10 Marks)
- b) Utilize the Critical Path Method to determine the sequence of tasks that forms the Critical Path to complete the project in the shortest possible duration. What is this shortest project duration? (20 Marks)

<u>Task</u>	Description	Duration (Months)	Dependent on Task #
1	Drive ramp to base of new zone	11	none
2	Develop/equip new raises for hoisting and ventilation	16	1
3	Develop new u/g exploration drilling gallery	2	1
4	Complete new u/g exploration drilling program	18	3
5	Develop ore body model and mining schedule	2	4
6	Reconfigure mine ventilation system for new zone	4	2
7	Expand u/g diesel powered equipment fleet	4	6
8	Develop upper mining level for new zone	8	7
9	Develop lower mining level for new zone	10	7
10	Develop slot raises for initial stope blocks	2	8, 9
11	Drill open stoping blastholes for initial 2 stopes	1	10, 5
12	First production from stopes in new zone	N/A	11, 2

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Task	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10) 1	1 1	2 :	1	2	3 4	1 5	5 6	6 7	7 8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4 5	6	7	8	9	10	11
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Question 4 - Open Pit Limits and Development Planning. 20 Marks

On the provided geological section in Figure 4.1:

a) Determine the open pit boundaries which satisfy an overall stripping ratio of 2.0 ± 0.1 waste to ore and maximize the amount of ore mined. Note that the floor of the final pit must be horizontal and have a minimum width of 20 m. Use this info in your calculations: (10 Marks)

$$\rho_{\text{ore}} = \rho_{\text{waste}} = 2700 \text{ kg/m}^3$$

max slope angle = 45°

b) Propose and sketch on the geological section a mine development plan that maintains an approximately constant stripping ratio. (10 Marks)

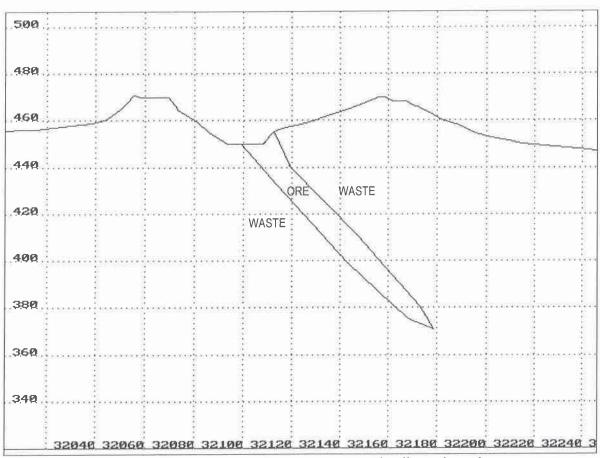
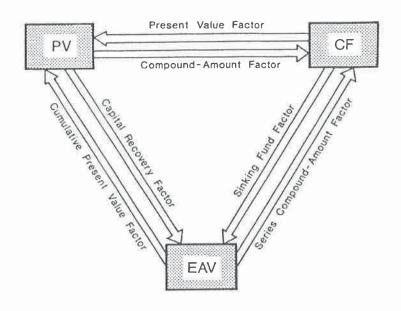


Figure 4.1 Geological section for steeply dipping ore zone. The dimensions shown are meters.

Appendix A – Discounted Cash Flow Analysis Tables and Charts



		PVF				CPVF				SF		
yærs	10%	20%	30%	40%	10%	20%	30%	40%	10%	20%	30%	40%
1	09091	08333	0.7692	07143	09091	08333	0.7692	07143	1,0000	1.0000	1,0000	1.0000
2	08264	06944	05917	05102	1.7366	1.5278	1.3609	1.2245	0.4762	0.4545	04348	04167
3	07513	05787	0.4552	Q3644	2.4869	21065	1.8161	1.5889	03021	02747	02506	02294
4	06830	0.4823	0.3501	02803	31699	25887	21662	1.8492	02155	Q1863	Q1616	01408
5	06209	0.4019	0.2893	0.1889	37908	29906	24366	20362	0.1638	Q1344	01106	0.0914
6	0.5645	0.3349	02072	0.1328	43553	33255	26427	21660	0.1296	Q 1007	00784	0.0613
7	05132	Q2791	0.1594	0.0949	48664	36046	28021	22628	Q1054	00774	0.0539	0.0419
8	0.4865	02326	01226	0.0678	53349	38372	29247	23306	0.0874	0.0806	00419	0,0291
9	0.4241	0.1938	00943	Q0484	57590	40310	30190	23790	0.0736	QQ4B1	00312	00203
10	0.3855	0.1615	00725	00346	61446	41925	30915	24136	0.0627	Q0385	0.0235	00143
11	03505	0.1346	QCEES	00247	64651	43271	31473	24363	0.0540	Q0311	Q0177	00101
12	03186	01122	00429	00176	68137	44392	31903	24559	Q0468	00253	Q0135	00072
13	0.2897	0,0995	00330	00126	7.1034	45327	32233	24685	Q040B	0.0206	00102	00061
14	0.2633	00779	00254	0,000	7.3667	46106	32487	24775	0.0357	00169	00078	00036
15	02394	0.0649	0.0195	0,0064	7.6061	46755	32682	24839	00315	00139	00080	00026
16	02176	QC541	00150	00046	7.8237	47296	32832	2.4865	00278	Q0114	00046	00018
17	0.1978	0.0451	00116	00033	80216	47746	32948	24918	00247	0,0094	00035	00013
18	0.1799	0,0376	00089	00023	82014	48122	33037	24941	0.0219	00078	00027	000009
19	0.1635	00313	00008	00017	83649	48435	33105	24958	Q0195	00065	00021	00007
20	0.1486	0,0261	0.000633	00012	85136	48896	33158	24970	00175	00054	00016	00005
21	0.1361	00217	00040	Q0009	86487	48913	33198	24979	00156	00044	00012	00003
22	01228	00181	0.0031	O00006	87715	49094	33230	24985	00140	0,0037	00009	00002
23	01117	00151	0.0024	0,0004	88832	49245	33254	24989	00126	0.0031	00007	00002
24	01015	Q0126	00018	00003	89847	49371	33272	24992	00113	0,0025	00006	00001
25	00923	00105	00014	00002	90770	49476	33266	24994	00102	0.0021	00004	00001
26	00339	0.0087	00011	0.0002	91609	49563	33297	24996	0,000	00018	QCCCC	00001
27	00763	0.0073	00008	Q0001	92372	49536	33305	24997	00083	00015	00003	00000
28	0.0668	00061	00006	Q0001	93086	49897	33312	24998	00075	00012	00002	00000
29	0.0630	00051	00005	00001	93896	49747	33317	24999	00067	00010	QCCC01	00000
30	005/3	00042	00004	OCCCC	94289	49789	33321	24999	00061	00008	00001	00000