National Exams December 2014

09-Mmp-A5, Surface Mining Methods and Design

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. One only reference sheet, 8.5 x 11 inch, hand written both sides is allowed in the exam. This is a closed book exam, therefore only the approved Sharp or Casio type calculators are permitted.

3. Compulsory Question 1 and THREE (3) other questions constitute a complete exam paper.
   Only question 1 and the first three optional questions as they appear in the answer book will be marked. You must select three questions from the "optional" Questions 2 to 7. Be sure you understand that three of Questions 2 to 7 must not be answered.

4. Compulsory Question 1 is worth 40 marks. Each optional question is worth 5 or 6 marks, total 20 marks. Three optional questions (2 to 7) plus Question 1 constitute a complete exam paper.

5. Many questions require an answer in essay format. Clarity and organization of the answer are important. Use sketches and drawings to illustrate your answers whenever possible.

Question 1 (40 marks) *You must answer all of this question, parts 1.1 to 1.7 inclusive*

Question 1.1 (5 marks) ***answer compulsory***

What do you understand by the terms "availability" and "utilization" in the context of an 8760 hour year. What other definitions are available to make the mechanical and operating % availability and utilization look better than they are.

Question 1.2 (6 marks) ***answer compulsory***

1.2.1 With respect to truck-shovel open pit operations, draw a sketch graph showing shovel production in tonnes per shift (Y axis) versus the number of trucks assigned to the shovel (X axis), and explain any curvature of the resulting relationship. (2 marks)

1.2.2 What could happen if the number of trucks assigned was (say) twice the number theoretically required. (1 mark)

1.2.3 What do you understand by the terms "spotting", "double back-up" and "drive by" in the context of open pit truck-shovel operations. Neat sketches are expected as are brief comparisons with regard to blast layout configurations. (3 marks)

Question 1.3 (6 marks) ***answer compulsory***

What do you understand by the term "cost index". Describe two such indexes which might be used for estimating costs in the context of the capital and operating costs of future open pit mines. What are the problems when such indexes are applied to all mine cost sectors.

Question 1.4 (6 marks) ***answer compulsory***

1.4.1 Describe the development of a block model typically used in studying the feasibility of open pit mines. What single piece of important information is attached to each block.

(3 marks)

1.4.2 After applying such factors as wall slope restrictions, rock types, discontinuities, and recoveries, there are two specific rules governing whether a "parcel of ore" (or ore block) will be included in the "optimal" open pit or not. What are these two rules. (3 marks)

Question 1.5 (6 marks) *answer compulsory*

This question discusses hydraulic mining and pit wall slope monitoring.

1.5.1 Name four common minerals that can be mined using hydraulic monitors.

(3 marks)

1.5.2 Wiith regard to conventional truck-shovel mining operations, explain why in hard rock open pit mines the displacement monitoring of wall slopes is essential, even after extensive rock mechanics design procedures have been employed. (2 marks)

Question 1.6 (5 marks) *answer compulsory*

With respect to conventional dragline mining, what do you understand by the following. Neat sketch sections and/or plans are expected, 2 marks per 1.6.1 to 1.6.3.

1.6.1 Simple side casting. (1 mark)

1.6.2 Advanced bench mining. (2 marks)

1.6.3 Extended bench mining. (2 marks)

Question 1.7 (6 marks) *answer compulsory*

In the context of mine cost estimating, what do you understand by the following terms, and describe the function and development of these terms.

1.7.1 The Marshall and Swift Mine/Mill cost index (M&S M/M) (2 marks)

1.7.2 The "six tenths rule" (the rule may also be referenced as the 'two thirds' or 0.7 rule depending on the practitioner). (2 marks)

1.7.3 List the cost centers on which the Marshall and Swift (and many other) indices for mining are based. (2 marks)

Question 2 (20 marks) ***Are you sure you have to answer this question***

Four technologies have been applied to improve the efficiency of open pit truck haulage.

- Overhead trolley assist
- Truck Dispatch
- In-pit crushing and conveying
- Direct loading of a short portable conveyor feeding a close-by slurry plant for hydraulic transport

2.1) Describe each of the above with the aid of **neat** sketches. Include typical applications, benefits, disadvantages, and effects on mine planning (e.g. location of shovels, push-backs etc.).
(3 marks)

2.2) Provide some indication of capital and unit operating cost / tonne and productivity of these systems including dispatch system, shovels, trucks and supplementary equipment. Discuss the implementation of those which have large up-front costs demanding a long pay-back period.
(3 marks)

2.3) Discuss the future of truck haulage including modifications to truck design, size and fuel. Which practical technologies might replace typical loading and haulage equipment leading to more efficient transfer of material en-route from mine face to mills and processing plants.
(3 marks)

In 1980, truck dispatch was developed at the Tyrone mine in New Mexico, and is now an integral part of haulage control and analysis.

2.4 Discuss the interaction of Best Path, Linear Programming and Dynamic Programming in determining which empty truck goes where in a large mine with 10 loaders and 60 trucks.
(3 marks)

2.5 In the context of truck-shovel open pit mining what do you understand by the term "match factor".
(2 marks)

2.6 With respect to truck routings in a truck-shovel mining operation, what do you understand by the terms "closed out", "dispatched" and "spotting".

(3 marks)

2.5 Describe the computer hardware employed on the shovels and trucks to achieve maximum trucking efficiency in large open pits. Discuss how grade control and stripping ratio can be included in such a system. You may use "bullet" form headings and a brief explanation for each "bullet" in order to answer this part (2.5) of question 2. (3 marks)

Question 3 (20 marks)

Are you sure you have to answer this question

Figure 3 shows a sketch with two shovels operating. One shovel is digging waste which must be trucked to the waste dump and the other shovel is loading ore which must be trucked to the crusher.

3.1 The average loading time for a truck, including truck positioning, is 3.0 minutes. The time taken for ore trucks to reach the crusher is 12.0 minutes and for waste trucks 12.0 minutes to reach the dump. Backup and dumping take 1.0 minute and the empty return for ore or waste is 8.0 minutes.

What is the total "theoretical" truck cycle time and match factor. (2 marks)

3.2 Referencing Figure 3.1 showing all possible routings, and draw two neat diagrams showing the respective "closed out" and "dispatched" routes. (3 marks)

The times taken by the trucks to travel to and from the shovels and dumps are shown below, as are the dump times. The shovel loading time includes "spotting". All times are in minutes.

- **Shovel 1 to Crusher** **12 minutes**
- **Crusher to Shovel 1** **8**
- **Shovel 2 to Waste Dump** **12**
- **Waste Dump to Shovel 2** **8**
- **Crusher to Shovel 2** **4**
- **Waste Dump to Shovel 1** **3**
- **Loading at Shovel 1** **3**
- **Dumping Ore at Crusher** **1**
- **Loading Waste at Shovel 2** **3**
- **Dumping at Waste Dump** **1 minutes**

It is not necessary to convert numbers to integers for the following questions 3.4, 3.5 and 3.6.

3.4 What are the theoretical numbers of trucks required for "closed out" and "dispatched" operation shown in Figure 3 to obtain maximum production. (7 marks)

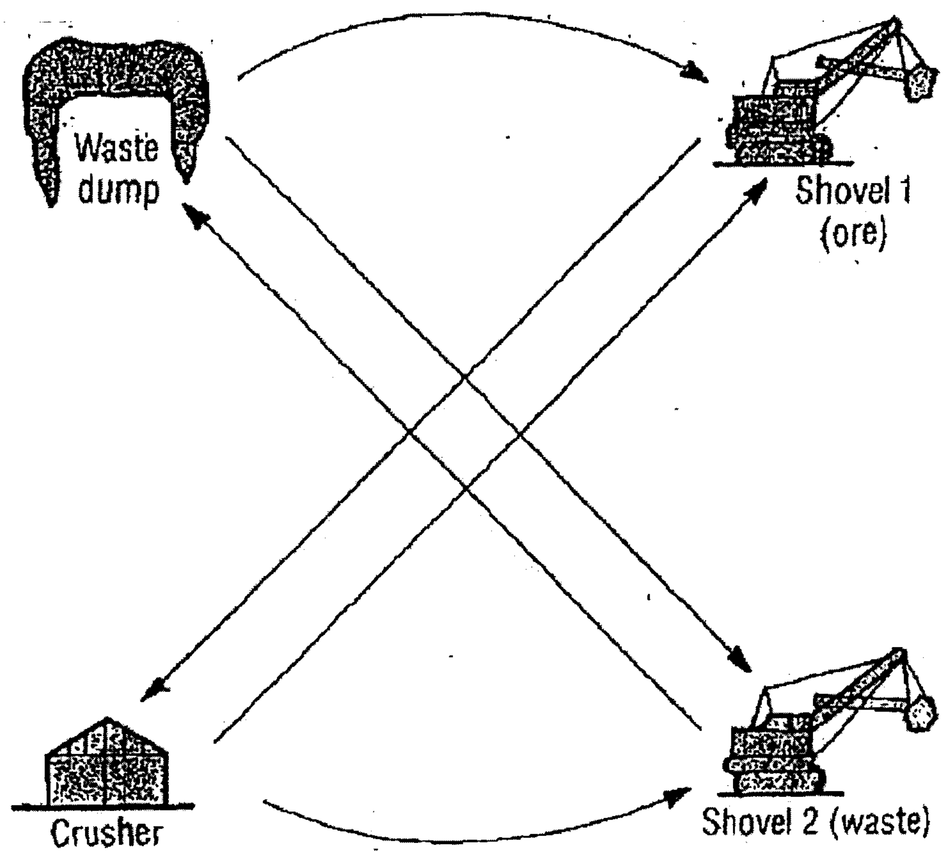

Figure 3 All Possible Truck Routings

3.5 Which trucking configuration is the most efficient, closed out or dispatched. (3 marks).

3.6 Using the most efficient configuration, how many truckloads are delivered to the *crusher and dump in an 8 hour shift* and is this value realistic. (5 marks)

Question 4 (20 marks) ***Are you sure you have to answer this question***

In "optimizing" the volume to be removed from an open pit the "moving" (or "floating") cone method "MC" may be used.

4.1.1 What is the rule base for the moving cone method. (2 marks)

The "cash flows" of a two dimensional section across a pit are shown as an **(i,j)** matrix. Apply the rule base to Figure 4.1.1 which shows the wall slope set at 45 degrees and the blocks as 15m square (cube). Do not use the sum of cash-flows of adjacent or close blocks to define positive values as there is no reliable computer algorithm for this in three dimensions.

4.1.2 Neatly show the pit outline on your Figure 4.1.1. Do not forget to place your name/number on the Figure 4.1.1 and hand it in with your answer booklet. Two extra copies of the cash flow matrix in Figure 4.1.1 are provided in case you need to revise your "optimally" mined out area. (2 marks)

4.1.3 What is the sum of cash flows for the MC "optimal" mined pit section. Do not forget to place your name/number on the Figure(s) 4.1.1 and hand it/them in with your answer booklet. (1 marks)

In 1968, Lerchs and Grossmann presented a method of guaranteeing the optimality of the mined pit referred to as "LG".

4.2.1 Explain the LG "graph" method and how this differs from the moving cone. Use examples of a

4.2.1.1 two bottom large pit

4.2.1.2 pit with a deep flat lying seam

4.2.1.3 a pit advancing as a semicircle on a seam of ore such that the material to be mined by each shovel is uneconomic. However there are several ore faces which when mined together are economic, leaving lass waste in front of the shovels than the "MC" method would indicate. (3 marks)

The same "cash flows" shown in Figure 4.1.1 as an (i,j) matrix are now to be used by you, the candidate, to show the LG method in two dimensions using P i,j and M i,j matrices. The M i,j matrix is developed working left to right.

Figure 4.2.1.3.a shows the same matrix of cash flows as Figure 4.1.1.

Figure 4.2.1.3.b shows the P (i,j) matrix formed by summing the cash flows of each column starting at the top of the column going straight down.

In Figure 4.2.1.3.c, the P matrix has been transformed to the M matrix using graph theory and the maximum slope of 45 degrees. The columns j=8 and j=9 are left blank.

4.2.2 Complete the P (i,j) sub matrix for P (i=1 to 8, j=8 and j=9) shown in Figure 4.2.1.3.c. Here P (i = 1 to 8, j = 6, 7, 10, and 11) are completed and j = 8 and 9 left blank. Note that there are two copies in Figure 4.2.1.3.c in case you make a mistake.

Figure 4.2.1.3.d shows i=1,8 and j=6,7 and 10,11. You have to complete the i=1,8 and j=8.9 calculations and place these in the correct square. (6 marks)

4.2.3 Neatly show the LG pit outline on your Figure 4.2.1.3.a. Do not forget to place your name/number on the Figure 4.2.1.3.a, b, and c and hand them in with your answer booklet. You may use an unused copy of 4.1.1 in case you need to revise your LG "optimally" mined out area, but be sure to note this on the diagram and hand in..

(2 marks)

4.2.8 The M matrix contains the LG solution which can be read directly on the table/graph.

Where is the "optimal" answer to the LG method shown on the Figure 4.2.1.3.c matrix, (you may indicate this on your Figure 4.2.1.3.a or c, or explain where it is), and what is the "optimal" value. (2 marks)

Figure 4.1.1 (original) Block Profit (Cash Flow) Matrix Section Wall Slope 45 degrees Blocks 15x15x15m

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**3**	**29**	-1	-1	-1	-1	-1
-2	-2	-2	-2	-2	-2	**28**	**3**	**28**	**8**	**5**	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

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Figure 4.1.1 Copy 1 Block Profit (Cash Flow) Matrix Section Wall Slope 45 degrees Blocks 15x15x15m

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**3**	**29**	-1	-1	-1	-1	-1
-2	-2	-2	-2	-2	-2	**28**	**3**	**28**	**8**	**5**	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

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Figure 4.1.1 Copy2 Block Profit (Cash Flow) Matrix Section Wall Slope 45 degrees Blocks 15x15x15m

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**3**	**29**	-1	-1	-1	-1	-1
-2	-2	-2	-2	-2	-2	**28**	**3**	**28**	**8**	**5**	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

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Figure 4.2.1.3.a Block Profit (Cash Flow) Matrix Section Wall Slope 45 degrees Blocks 15x15x15 m

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	3	29	-1	-1	-1	-1	-1
-2	-2	-2	-2	-2	-2	28	3	28	8	5	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

Figure 4.2.1.3.b "P" Matrix (cumulative sum cash flow by column going down)

-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8
-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-1	25	-5	-5	-5	-5	-5
-7	-7	-7	-7	-7	-7	19	-2	19	-1	0	-6	-7	-7	-7	-7	-7	-7	-7	-3	23	-7	-7	-7	-7	-7
-9	-9	-9	-9	-9	-9	17	-8	17	-3	-2	-8	-9	-9	-9	-9	-9	-9	-9	-5	21	-9	-9	-9	-9	-9
-11	-11	-11	-11	-11	-11	15	-6	15	-5	-8	-10	-11	-11	-11	-11	-11	-11	-11	-7	19	-11	-11	-11	-11	-11

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Figure 4.2.1.3.c Final Sub-Matrix of "M" Values from LG Algorithm Wall Slope 45 degrees Blocks 15x15x15 m j = 8 and 9 omitted

i	j=1	2	3	8	5	6	7	8	9	10	11	12	13	18	15	16	17	18	19	20	21	22	23	28	25	26
1	-1	-1	-1	-1	-1	-1	-1			-1	-1	-1	-1	6	5	5	8	3	2	1	0	-1	-1	-1	10	9
2	-2	-3	-3	-3	-3	-3	-3			-3	-3	-3	7	6	6	8	3	2	1	0	-1	-2	-3	11	9	8
3	-3	-5	-6	-6	-6	-6	-6			-6	-6	9	8	8	5	3	1	0	-1	-2	-3	-8	13	10	8	6
8	-8	-7	-9	-10	-10	-10	-10			-7	12	11	11	7	8	1	-1	-3	-8	-5	-6	16	12	9	6	8
5	-5	-9	-12	-18	-15	-15	-15			16	15	15	10	6	2	-1	-8	-6	-8	-5	20	15	11	7	8	1
6	-7	-12	-16	-19	-21	-22	8			20	20	18	8	3	-1	-5	-8	-11	-13	-11	18	13	8	8	0	-3
7	-9	-16	-21	-25	-28	-30	-5			18	18	12	5	-1	-6	-10	-18	-17	-20	-18	10	9	8	-1	-5	-9
8	-11	-20	-27	-32	-36	-39	-15			18	18	8	1	-6	-12	-17	-21	-25	-28	-27	1	-1	-2	-7	-12	-16

Figure 4.2.1.3.c Copy (2) Final Sub-Matrix of "M" Values from LG Algorithm Wall Slope 45 degrees Blocks 15x15x15m j = 8 and 9 omitted

i	j=1	2	3	8	5	6	7	8	9	10	11	12	13	18	15	16	17	18	19	20	21	22	23	28	25	26
1	-1	-1	-1	-1	-1	-1	-1			-1	-1	-1	-1	6	5	5	8	3	2	1	0	-1	-1	-1	10	9
2	-2	-3	-3	-3	-3	-3	-3			-3	-3	-3	7	6	6	8	3	2	1	0	-1	-2	-3	11	9	8
3	-3	-5	-6	-6	-6	-6	-6			-6	-6	9	8	8	5	3	1	0	-1	-2	-3	-8	13	10	8	6
8	-8	-7	-9	-10	-10	-10	-10			-7	12	11	11	7	8	1	-1	-3	-8	-5	-6	16	12	9	6	8
5	-5	-9	-12	-18	-15	-15	-15			16	15	15	10	6	2	-1	-8	-6	-8	-5	20	15	11	7	8	1
6	-7	-12	-16	-19	-21	-22	8			20	20	18	8	3	-1	-5	-8	-11	-13	-11	18	13	8	8	0	-3
7	-9	-16	-21	-25	-28	-30	-5			18	18	12	5	-1	-6	-10	-18	-17	-20	-18	10	9	8	-1	-5	-9
8	-11	-20	-27	-32	-36	-39	-15			18	18	8	1	-6	-12	-17	-21	-25	-28	-27	1	-1	-2	-7	-12	-16

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Figure 4.2.1.3.d Detail of i=1,8, j=6,7 and 10,11 Wall Slope 45 degrees (2 copies)

i \ j	6	7	8	9	10	11
i = 1	-1	-1			-1	-1
2	-3	-3			-3	-3
3	-6	-6			-6	-6
8	-10	-10			-7	12
5	-15	-15			16	15
6	-22	8			20	20
7	-30	-5			18	18
i = 8	-39	-15			18	18

i \ j	6	7	8	9	10	11
i = 1	-1	-1			-1	-1
2	-3	-3			-3	-3
3	-6	-6			-6	-6
8	-10	-10			-7	12
5	-15	-15			16	15
6	-22	8			20	20
7	-30	-5			18	18
i = 8	-39	-15			18	18

Print your Number/Name Here ______________________________

4.2.5 The LG method does not include the "time value of money", and is therefore sub-optimal. What changes in methodology would make the LG method more "optimal". You may briefly describe how any commercial software you are familiar with accomplishes this.

(2 marks)

Make sure you write your name/number on any Figures you have worked on, and hand in with your answer booklet.

Question 5 (20 marks)

Are you sure you have to answer this question

Question 5.1

A mine has chosen to use in-pit pumps in a sinking cut sump to remove water. Two of the same type of pump are available with the characteristic curves shown in Figure 5.1. below. The pumps can be used in high volume (MT) or high head (HT) configuration. The pumps can also be used submersible (with a screen adaptor around the intake) or in series (tandem) with a pipe adaptor at the pump inlet.

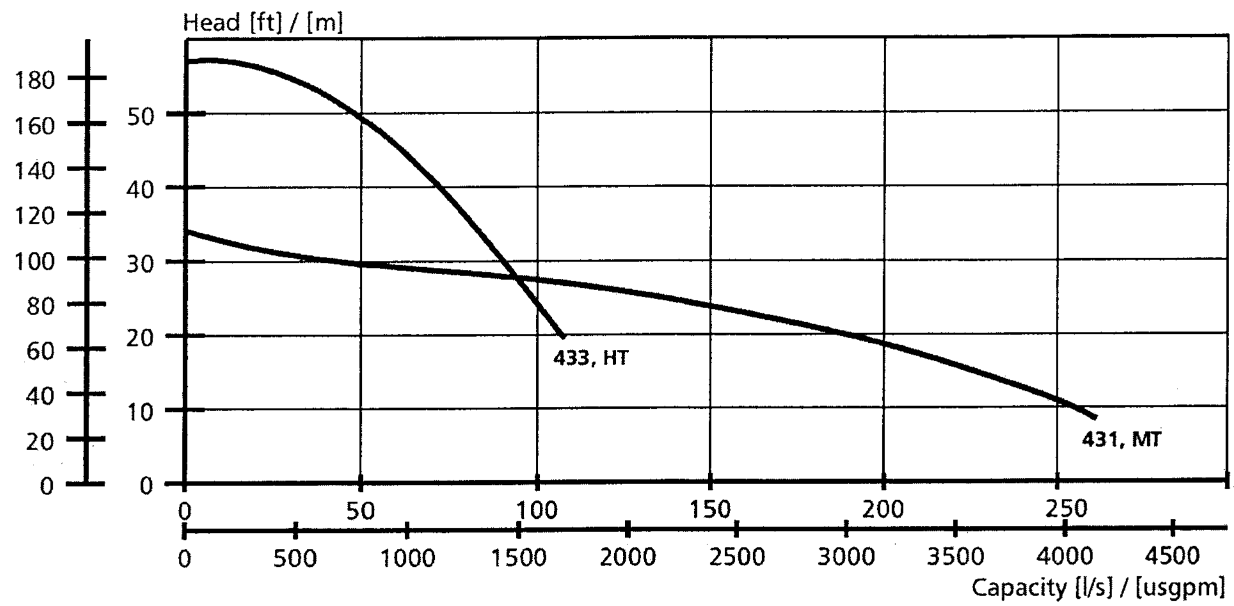

Figure 5.1 Pump characteristics (head and flow rate) for high head (433, HT) and high volume (431, MT) versions.

The mine has to move water from the sinking cut sump at elevation 1650 meters to the pit crest at 1740 meters, a 90 meter lift. The 15 meter high benches from 1695 meters and up are accessible for the laying of high density polyethylene pipe, but are not suitable for pump infrastructure such as power lines, generators or for pump etc. maintenance.

The cost of a pipe line buried in the 10% ramp (900+ meters) is regarded as far too expensive and not easily repaired and therefore ignored in this application.

One pump will be placed in the sump (1650m elevation) and run as a submersible unit and the other placed as far as possible up the ramp at the 1695 meter elevation. At this upper pump, a tandem fitting will be coupled directly to the pipeline coming up from the sump, and not vented to atmosphere. It can be assumed that the friction loss in the large diameter polyethylene pipe used is small over a 125 meter length on a 45^0 pit wall.

5.1.a From the graph (Fig. 5.1) what will be the discharge at the pit crest using the a high head (HT) lower sump pump directly coupled to a second high volume pump. Both pumps are configured as (433, HT). (3 marks)

5.1.b What will be the maximum volume of water (liters per second) discharged at the pit crest based on the various pumping configurations (HT to MT, HT to HT, MT to HT, MT to MT). The direct unvented coupling at the higher pump is assumed. (2 marks)

5.1.c For your selected configuration, what will be the inlet and outlet pressures at each of the pumps in meters of water. (2 marks)

5.1.d What schedule of pipe will be required at the inlets of the two pumps (1 mark)

5.1.e If a check (gate) valve is fitted at the outlet of the top pump to stop water returning to the sump, what modifications will be required. (2 marks)

Assume the water is "clean" and temperature/pressure has no effect on density.

Some conversion factors that may or may not be of use,
1 m water at 8^0C is 1.41 psi 1 ft water at 62^0F is 0.43 psi 1 psi = 6.9 kPa 1 ft water = 3 kPa

Question 5.2

An alternative to the pumping system described in 5.1 is a series of deep well pumps around the pit perimeter and possibly on the ramp inside the pit.

From this perspective, discuss

5.2.a How the transmissibility and storage constants of the pit wall rocks are found using a graphical solution and experimental wells. (3 marks)

5.2.b How the pumps might be laid out in plan and the pump depth determined. (2 marks)

5.2.c How the feasibility and costs of such a system might be estimated. (2 marks)

5.2.d The operational advantages quantified from a pit operations perspective. (3 marks)

Question 6 (20 marks) ***Are you sure you have to answer this question***

6.1 In the context of "conventional" dragline coal mining operations what do you understand by the term "Range Diagram".

(2 marks)

6.2 The term "dragline positioning" is used to describe the position of the dragline tub with respect to the edge of the high-wall. The term defines the percent of tub diameter from the dragline centerline to the edge of the high-wall.

6.2.1 Draw a neat sketch section showing the dragline tub (20m diameter) and edge of high-wall when the "positioning" is 75%.

6.2.2 What is the distance from the edge of the high-wall to the nearest edge of the tub, and from the high-wall edge to the center line of the dragline.

6.2.3 The dragline reach is the distance from the edge of the highwall to the end of the operating radius. What is the dragline reach.

(1 mark each 6.2.1,2,3, total 3 marks)

6.3 The term "spoil pile swell factor" is the increase in volume of unbroken overburden when stacked as broken rock (spoil). It is usually stated as a decimal rather than a percentage.

6.3.1 If a spoil pile swell factor is 0.25, what is the volume of 1 m^3 of unbroken overburden after digging and placing on the spoil pile.

(2 marks)

6.4 Draw a neat sketch section to scale (this enables you to check your answers later in section 6.5) of a dragline side-casting operation showing;

6.4.1 Dragline operating radius 90m

6.4.2 Dragline tub diameter 20m

6.4.3 Stacking height (maximum) 12m

6.4.4 Cut depth 25m

6.4.5 Positioning factor 75%

6.4.6 Pit width 40m

6.4.7 Depth of overburden (machine can dig to 35m) 25m

6.4.6 High-wall slope angle 63 degrees

6.4.9 Spoil pile angle of repose 35 degrees

6.4.10 Spoil pile swell factor 25%

6.4.11 Coal seam thickness 3m

(Question 6.4 total 3 marks)

Calculate (not measure from your section) the following for a 1m wide section of the operation

6.5.1 Cut area (an area per meter wide slice)

6.5.2 Spoil pile area

6.5.3 Spoil pile height above coal seam floor

6.5.4 Height of the spoil pile above base of dragline tub

6.5.5 Operational stacking height (not stacking height specified by dragline)

6.5.6 Horizontal reach factor (crest of overburden to vertical line from top of stacked spoil)

(1 mark each, total 6 marks)

6.6 Will the dragline be capable of mining the overburden and uncovering the coal as planned, i.e. can the dragline complete the operation of the mine without modifications to the mining method or machine. (2 marks)

6.7 What auxiliary mining methods and/or extra equipment would be required to accomplish the mining if the dragline and its mining configuration were inadequate for purpose. (2 marks)

Question 7 (20 marks)

Are you sure you have to answer this question

The following are formulae for estimating the fixed capital costs of an open pit mine and are in 1998 dollars as per Mular and Poulin. Do not adjust costs for inflation until 7.12 as this simplifies your answers.

If you make an obvious, substantial and extremely large error in an estimated value, use a more logical answer in subsequent calculations and ***be sure to indicate this in your exam answer***.

An open pit mine is to be located in an area of heavy tree growth and rugged terrain. Any soil will be stripped at a rate of 23,000 tonnes (metric tons, mt) per day for 60 days, and rock overburden will be stripped at a rate of 11,000 mt/day for 300 working days. The total ore plus waste to be mined per day during normal operations is 23,000 mt where the mill capacity is 9,000 mt per day. Estimate the capital cost of the mine using the following formulae.

7.1 What is the stripping ratio and provide a definition of this ubiquitous and well used value. (2 marks)

7.2 What is the cost of site preparation C_{12} in rough terrain given $C_{12} = 11410\ T^{0.5}$ where T is the mt/day of ore plus waste. (1 mark)

7.3 What are the costs of pre-production stripping C_{21} and C_{22} where;

Cost soil overburden $C_{21} = 1826 \times T_S^{0.5}$ and T_S is the total mt of soil overburden

and

Cost rock overburden $C_{22} = 19395 \times T_R^{0.5}$ and T_R is the total mt of rock overburden

(1 mark)

7.4 What sizes of shovels and trucks are required where;

Shovel size S (m^3)= $0.1034 \times T^{0.4}$ where T is the tons/day ore plus waste in cubic meters

and truck size t (mt) = $9.75 \times S^{1.1}$

(shovel sizes are 6, 8, 10 and 12 yd^3 or 4.6, 6.1, 7.6 and 9.2 m^3 respectively and sizes are rounded up to the next m^3)

(truck sizes are 50, 60, 75, 85 and 100 st or 45, 54, 68, 77 and 91 mt respectively and sizes are rounded up to the next mt)

(2 marks)

7.5 What numbers of shovels (N_S) and trucks (N_T) are required where

$N_S = 0.0058 \times (1 / S) \times T^{0.8}$ where T is the mt/day ore plus waste

$N_T = 0.198 \times (1 / t) \times T^{0.8}$ where T is the mt/day ore plus waste

Again the numbers are rounded up to the next integer.

(1 mark)

7.6 What are the costs of the open pit equipment (auxiliary equipment e.g. graders, etc. are factored in) given;

Shovel fleet $C_{31} = 499813 \times N_S \times (S \times 1.308)^{0.73}$ and

Truck fleet $C_{32} = 19558 \times N_T \times (t \times 1.1023)^{0.85}$

Drilling equipment $C_{33} = 1407359 \times N_S \times S^{0.73} \times T^{-0.2}$

(2 marks)

7.7 By dividing the cost of shovels and trucks (C_{31} and C_{32}) by the number of units (N_S and N_T), a rough cost per truck and shovel can be estimated. What are these unit costs, and what do you consider a good estimate for these units today.

Do these past and present values provide a good inflation index given that the cost data used by Mular and Poulin were analyzed in the period 1996-98.

If drills and trucks cost approximately the same per unit, how many drills are indicated (rounded up). Comment on this "rule of thumb", especially when very large trucks are involved. When the rule of thumb indicates an inappropriately high cost/drill, what can the estimator do to provide meaningful numbers of drills.

(2 marks)

7.8 What are the costs of maintenance C_4 facilities given,

$C_4 = 335629 \times T^{0.3}$

(1 mark)

7.9 Electrical Power, Water, General Plant Services, Access, Town-site and Housing are dependent on location, the milling complex, and fly in-out, town-site or established towns.

Consequently this value is estimated during milling/processing infrastructure cost estimations and can be ignored when estimating open pit infrastructure costs.

<u>No calculation or estimate for C_5 is required in this exam.</u>

7.10 Estimate the following costs

7.10.1 Feasibility, Engineering and Planning

5% of ($C_{12} + C_{21} + C_{22}$) plus 7% of ($C_{31} + C_{32} + C_{33} + C_4$) (2 marks)

7.10.2 Supervision, Management, Camp, Construction Facilities

9% of ($C_{12} + C_{21} + C_{22} + C_{31} + C_{32} + C_{33} + C_4$) (1 mark)

7.10.3 Administration, Accounting, Key Personnel, Legal

5.5% of ($C_{12} + C_{21} + C_{22} + C_{31} + C_{32} + C_{33} + C_{4}$) (1 mark)

7.11 What is the total fixed capital cost of starting an open pit (mine only – not mill see item 7.9)

Total = $C_{11} + C_{12} + C_{21} + C_{22} + C_{31} + C_{32} + C_{33} + C_{4}$ plus 7.4.10 (1 to 3 inclusive)

(2 marks)

7.12 An alternative cost inflation factor claims that costs double every 12 years (6% +/-). Is this a reasonable interpretation of individual mine cost components. When applied to the fixed capital cost is the answer to 7.11 reasonable.

(2 marks)

End of the Exam