National Exams May 2009

98-MMP-A2, 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. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   Only the first five questions as they appear in the answer book will be marked.

4. Each question is of equal value (20 points).

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

Question 1

1.1) Explain, with the aid of a neat sketch showing a near vertical narrow vein ore-body, the following terms as used to describe underground mine workings,

Adit
Stope
Raise
Drift
Winze
Ore-pass
Cross-cut
Shaft
Hanging-wall

1.2) A shallow dipping narrow vein ore-body has been found on an unconformity at a depth of 500m, and extends to a depth of 3000m. The ore is being mined via a 1000m deep conventional shaft in the foot-wall, and plans have to be made to extend mining to depths of 2000m and 3000m. It is envisioned that the present shaft will continue to operate at full capacity.

Discuss alternatives for the layout of shaft accesses to the deeper material which would have minimal effect on the rate of production from the present shaft. A neat sketch is expected, and underground ramp haulage has been eliminated as an alternative because it is deemed to be less productive and more costly.

1.3) Another mining operation is hoisting ore from a 700m deep shaft in the footwall of a steeply dipping ore-body and the shaft was not sunk to full depth to conserve capital. The operation will not require access to deeper ore for several years, and again, ramp haulage has been eliminated as an alternative to removing the deeper ore.

Explain how the present shaft might be deepened to 1000m without affecting existing production. Note that it is assumed that a short shutdown to equip the shaft extension and install new hoist ropes is acceptable.

What modifications to the present hoisting system would be required to maintain the same production rate once the shaft extension has been completed, assuming that there is no room for extra skips.

Question 2

2.1) In less than 200 words, summarise the 'block caving' method of underground mining. Include a neat sketch if appropriate.

2.2 Explain the sequence of development and the later cycle of operations when employing the method.

2.3) What ore-body geometric and rock features are necessary for the method to be successful.

2.4) Discuss the advantages and disadvantages of the block cave method

2.5) With reference to block caving, what do you understand by the following,

2.5.1) Centre of draw
2.5.2) Boundary of draw
2.5.3) Zone of draw
2.5.4) Overdraw
2.5.5) Un-pulled pillars

Question 3

3.1) The 'Cut and Fill' stoping method can be broadly subdivided as 'overhand' versus 'underhand', and as 'open' versus 'tight'. What do you understand by this statement.

3.2) What are the two major products used for fill, and comment on the use of cement and other binders as fill components. Using neat sketches, show with two examples where and why high early strength fill is necessary for the success of the method.

3.3) Discuss the cycle of operations in mechanised overhand cut and fill stoping.

3.4) Compare 'captive' cut and fill where the equipment can be shared between a few stopes with the use of ramps joining all stopes in a particular mining sector. Why has the use of 'captive' cut and fill decreased substantially in favour of methods with ramp access.

Question 4

A medium size mining corporation has investigated the future availability and demand for copper. The corporation owns a 'medium' grade open pit copper mine and the near vertical ore-body being mined extends to a considerable depth. Preliminary studies have shown that the ore-body could be mined effectively and profitably using underground methods.

You have been given the task of preparing a study for the shareholders which will recommend the best course of action.

4.1) How would you estimate the optimal depth of the present open pit operation (with no additional underground mining).

4.2) How would you determine the depth at which open pit mining should cease, and underground mining commence.

4.3) Would you expect the depths from (4.1) and (4.2) above to be the same, and if not, why.

4.4) In bullet form, state what other considerations play a role in the decision.

Question 5

5.1) It has been suggested that 'declining stripping ratio' and 'increasing stripping ratio' methods of open pit mining are merely idealistic from both a financial analysis (e.g. cash flow, discounted cash flow rate of return, etc.), and a practical mining perspective. Explain why you agree or disagree with the suggestion.

5.2) A porphyry copper ore-body has a high grade core which can be described as a vertical cylinder of 400m diameter stretching from surface to a depth of 1000m. Surrounding this core are 100 m wide envelopes of ore, low grade and finally marginal material. The ore-body will be mined as an initial shallow high grade pit lasting 5 years, a deeper pit pushback lasting a further 5 years and a final deep pit and pushback lasting a further 5 years. The annual high grade material milled is constant, and no stockpiled material is milled during the 15 year period. The wall slope including ramps is approximately 40 degrees. The pits are planned such that there is a 3 year period where both initial pit and first pushback are mined concurrently, and a later 4 year period where the inner and outer push-backs are also mined concurrently.

5.2.1) When planning the mining of the initial pit, the wall slope constraint will require the mining of ore and low grade material. You now have the option to (5.2.a) purchase your full compliment of equipment and stockpile the ore and low grade for mining past year 15 and generate substantial early cash flows, or (5.2.b) to delay the purchase of say half your equipment until year 3 and accept lower grade mill feed. Explain how you would conduct an analysis to determine whether to choose option 5.2.a or 5.2.b.

5.2.2) Truck haulage via ramps has been selected for both ore and waste removal with a constant number of trucks in the fleet. During years 3 to 5 and 7 to 10, high grade mill feed will be produced from the (then) deepest parts of the mine, requiring considerable truck hours in the process. This leaves fewer truck hours for stripping lower grade material. Explain how you would schedule mining such that during the transition periods (3 to 5 and 7 to 10) you avoid having to either mill (process) lower grade material or purchase extra trucks to advance the pushback and keep the planned head grade.

5.2.3) Explain the term 'stripping ratio' with reference to the mining of this ore-body. Your supervisors are assuming that as year 15 is approached, more and more trucks (and their truck hours) will be assigned to ore transportation such that at mine closure, there will be no stripping and the truck fleet will be sufficient to feed the mill as planned. Explain how you would demonstrate that the number of trucks (for ore mining and stripping) do not guarantee that production goals will be met. Explain how truck hours can be combined with the mining schedule to ensure that mining schedules and head grades will be met and that there will be no periods (months) when trucks will be idled.

Neat sketch time charts and graphs are recommended to clarify your answers.

Question 6

With respect to dragline operations applied to open pit strip mining of flat lying shallow coal seams, explain the following. Neat sketches are expected as part of your answer.

6.1) Range diagram
6.2) High-wall slope angle
6.3) Key cut
6.4) Advance bench
6.5) Spoil pile slope angle
6.6) Reach factor
6.7) Extended bench

Question 7

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

- Truck Dispatch
- Overhead trolley assist
- In-pit crushing and conveying

7.1) Describe each of these technologies, including application, benefits, disadvantages, effect on mine planning (location of push-backs), and provide some indication of capital cost and operating cost savings.

7.2) Discuss the future of truck haulage, and describe what practical technologies might replace this method of materials handling given the need for continued unit cost reductions, availability and cost of diesel fuel, and the overall inefficiency of this method of moving material.

Marking Scheme

All questions carry equal marks of 20 points. Answers to five questions constitute a complete exam paper. Only the first five questions as they appear in the answer book will be marked.

Question 1	1.1) 6 points, 1.2) 8 points, 1.3) 6 points
Question 2	2.1) to 2.5), 4 points each
Question 3	3.1) to 3.4), 5 points each
Question 4	4.1) 7 points, 4.2) 7 points, 4.3) 3 points, 4.4) 3 points
Question 5	5.1) 4 points, 5.2.1) 5 points, 5.2.2) 6 points, 5.2.3) 5 points
Question 6	6.1) 4 points, 6.2) 2 points, 6.3) 3 points, 6.4) 3 points, 6.5) 2 points, 6.6) 3 points, 6.7) 3 points
Question 7	7.1) 15 points, 7.2) 5 points