National Exams December 2017

09-MMP-A2, Underground Mining Methods and Design

3 hours duration

NOTES:

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.

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.

Compulsory Question 1 (Section A) and THREE (3) other questions from the relevant section B or C constitute a complete exam paper.

Only Section A question 1, the chosen two questions from Section B and the chosen one question from Section C, as they appear in the answer book, will be marked. You must select three questions from the "optional" Questions 2 to 6, two from Section B (2, 3, 4) and one from Section C (5, 6).

Compulsory Question 1 is worth 40 marks. Each optional question 2 to 6 is of equal value (20 marks). Three optional questions plus Question 1 constitute a complete exam paper (total 100 marks). The optional questions comprise 2 from section B (2, 3, 4) and 1 from section C (5, 6). Question 1 is compulsory.

Many questions require an answer in essay format. Clarity and organization of the answer are important. Use large full page neat sketches and drawings to illustrate your answers when possible.

Make sure your diagrams etc. are at least half a page and clearly legible. Thumbnail sketches are not acceptable.

Compulsory Section A Question 1 General Underground Mining (40 marks)

You must answer **all** of this question, parts 1.1 to 1.6 inclusive

Question 1.1 Mine Costs (6 marks total)

answer compulsory

O'Hara (1980 CIM Bull. No.814, 73(2): 87-99) published a well accepted method of cost estimation for mines.

$$\text{Cost} = A.T^{b}$$

1.1 Explain the formula and how A and b were estimated by O'Hara (3 marks)

1.2 How are cost estimates from a fixed point in time converted to "present day" and name two of the publications which facilitate the cost update. (3 marks)

Question 1.2 Mine Ropes (9 marks total)

answer compulsory

Describe the following hoist ropes and definitions, the hoist types it is used with and where in the hoist configuration. Include a sketch section through the rope across its diameter. (1 mark each 1.2.1 to 1.2.9)

- 1.2.1 round strand
- 1.2.2 flattened strand
- 1.2.3 locked coil
- 1.2.4 regular lay
- 1.2.5 Lang lay
- 1.2.6 half locked coil
- 1.2.7 non-rotating
- 1.2.8 6x7, 6x19, 6x37 classifications
- 1.2.9 polypropylene, wire rope and wire strand cores

Question 1.3 Mine Ventilation (6 marks total)

answer compulsory

1.3.1 What are Kirchoff's Laws and how are they applied to ventilation circuits. (3 marks)

1.3.2 What is Atkinsons equation, and how and where is it applied in ventilation circuits.

And what bearing has the Chezy-Darcy equation on Atkinsons work. (3 marks)

Question 1.4 **Mine Backfill** **(6 marks total)**

answer compulsory

Describe and compare, with examples of usage and mining methods, the following backfill systems. Include size distribution of the fill where appropriate, including any binding agents ;

1.4.1 Cemented waste rock. (1 marks)

1.4.2 Mill tailings. (2 marks)

1.4.3 Paste fill. (3 marks)

Question 1.5 **Mining Operations and Methods** **(6 marks total)**

answer compulsory

Maintaining a "straight" hole with no deviation even when drilled vertically up or down can be a serious problem. For jacklegs and stopers deviation can occur within 1 m of the collar when drilling holes of 0.04m diameter. For larger machines with drill bit diameters up to 0.2m, deviations up to 10% of hole length can be expected.

Discus methods of limiting hole deviation when drilling (6 marks)

Question 1.6 **Over and Under Hand Mining Methods** **(7 marks total)**

answer compulsory

Sketches and Discussion of Over and Under Hand Mining Methods

Discuss the overhand and underhand stoping methods of mining. (4 marks)

Provide neat full page sketches showing the development and stopes and show how rock is moved to ore passes. (3 marks)

Optional Question 2 **Section B** **Hoisting and Winding** **(20 marks)**

Syllabus *"Requirements for development and services including: shafts, hoists, ramp and multi-level access design".*

Section B 2 of the 3 Questions (2, 3 and 4) in this section must be chosen including Compulsory Question 1, Section A, and one question from Section C, Maximum Questions to be Answered in this Section B is two, worth 20 marks each. Do not answer this question (2) if it is not one of the 2 questions you have chosen to answer from Section B (questions 2, 3 and 4).

2.1 Hoist Design **(2 marks total)**

The following are four typical mine hoist designs in regular use. Draw a neat sketch of each type/application and compare the advantages and disadvantages of each and any practical variations . (0.5 marks each, total 2 marks)

2.1.1	Single drum	(0.5 marks)
2.1.2	Single drum counterweighted	(0.5 marks)
2.1.3	Double drum	(0.5 marks)
2.1.4	Blair multi-rope hoist.	(0.5 marks)

2.2 Koepe Mining Hoists **(6 marks total)**

Neat sketches should be used where they improve your answer, and note that 2.2.1 to 2.2.12 and elsewhere, answers are often worth 0.5 marks each and should take about 45 seconds. (100 marks/150mins = 1 mark/1.5 mins). In these cases your answers should therefore be short and to the point.

The koepe winder (Frederick Koepe, 1877) is one of the most prominent methods of hoisting in use in modern mines.

The following 2.2.1 to 2.2.12 are worth (0.5 marks each, total 6 marks)

2.2.1 Provide a neat sketch of two typical applications, floor and headframe mounted.

2.2.2 What specialized rope types and what types of shaft guides are typical.

2.2.3 What are the typical hoisting depths best suited to the koepe.

2.2.4 What are the major advantages of using the koepe

2.2.5 And disadvantages

2.2.6 Explain the configuration of ropes used and any necessary attachments required for multi-rope koepe winders. Are tail ropes required. For all ropes used, how is anti-fouling and damage control accomplished.

2.2.7 Is shaft sinking possible using the koepe and what modifications are required in this application.

2.2.8 On occasion the capel must be removed and inspected. What is a capel and how are the koepe ropes adjusted to maintain the skip loading and dumping locations.

2.2.9 What are the optimal hoisting depths for single and multi-rope koepe winders.

2.2.10 Which type of skip is best for koepe installations, bottom dump or overturning. Provide neat sketches of the skips and how rock spillage is minimized at the loading and dumping points.

2.2.11 How can the koepe be adapted for personnel hoisting and is such an application commonly used.

2.2.12 The winder can be subject to slippage. How is the ration of rope tension T1/T2 applied given a rope/hoist friction coefficient μ and wrap angle θ and how can the rope/hoist geometry be modified to be sure the T1/T2 ratio does not exceed hoist design specifications.

$$T1/T2 < e^{\mu\theta}$$

2.3 Mine Hoisting (4 marks)

A friction (Koepe) hoist is installed atop a headframe with 2 skips roughly in balance and with the following operating parameters.

Shaft depth	300m	(1000ft)
Skip live load Wo	4.5 mt	(5 tons)
Skip dead/live load ratio	1.2	
Skip dead load Ws	5.4 mt	(6 tons)
Hoist ropes	four @ 25 mm	(1 inch)
	flattened strand	normal strength
	6x19 class	improved plow steel
	rope weight 2.68 kg/m	(1.8 lbs/ft)
Sheave diameter	3.14 m	(10.3 ft)
Hoisting velocity	6.1 m/s	(20 ft/s)

2.3 Mine Hoisting (Continued)

Hoisting cycle	ta	10s	
	tv	39.75s	40 s
	tr	8s	
	td	10s	
Hoist efficiency	η	90%	η stated as 0.9
Hoist motor	a.c.		

Answer the following questions 2.3.1 to 2.3.6 worth 4 marks total

2.3.1 What is the hoist cycle time tt (0.5 marks)

2.3.2 What is the rope weight Wr (0.5 marks)

2.3.3 What is the total load weight Wt (0.5 marks)

2.3.4 Calculate T1 and T2, and will slippage occur. If it does, what can be done about it. (1 mark)

Slippage will occur if the ratio (loaded skip/empty skip) is greater than 1.6 for a headframe mounted Koepe sheave

Total weight - loaded skip T1
Total weight - empty skip T2

2.3.5 What do you understand by "equivalent effective weight" and what sources are available to provide this weight. What is the value given the sheave diameter in the question vs equivalent efficiency weight curve. (See attached Fig 2.3.5 below)

For a sheave diameter of 3.14m (10.3 ft) the equivalent effective weight is 16,818 Kg (37,000 lbs). (1 mark)

2.3.6. What is the total suspended load W (0.5 marks)

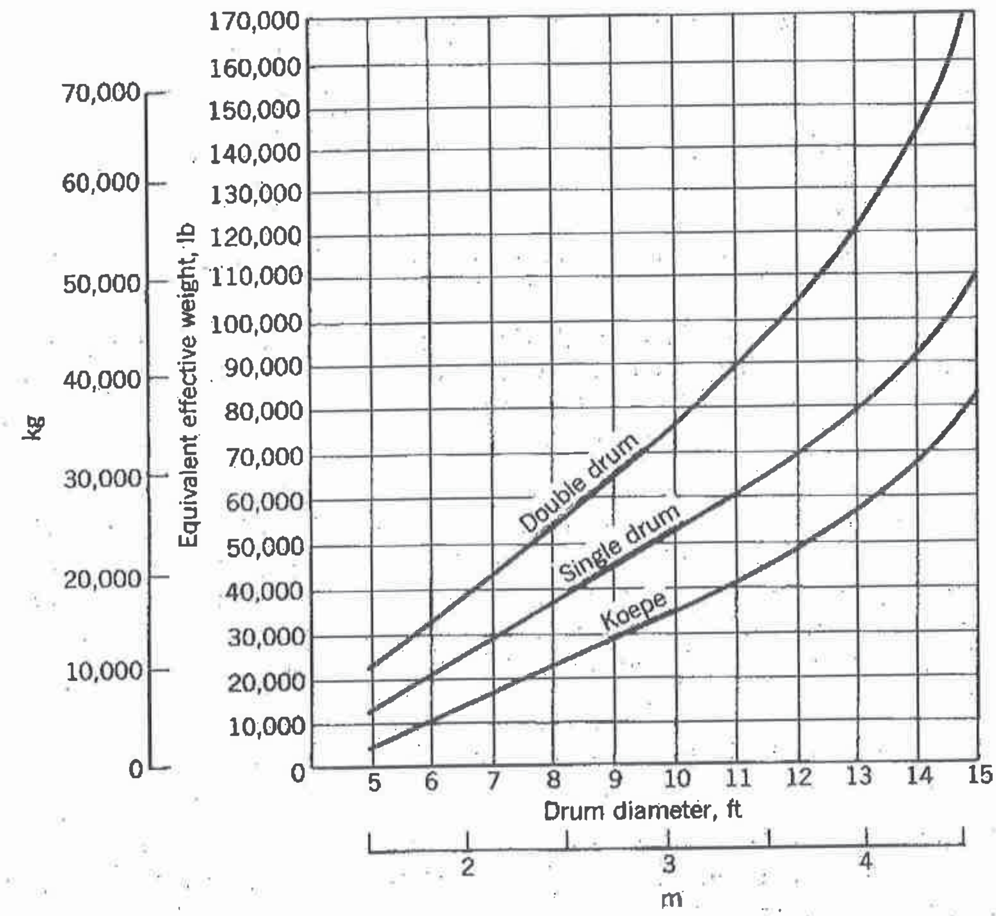

Figure 2.3.5. Chart to determine equivalent effective weight for varying diameter of drum or friction sheave. (By permission from SIEMAG-Nordberg Hoisting Technology, Milwaukee, WI.)

Additional Hints

Rope weight Wr = rope unit weight x (ht+hh)

Total Load Weight Wl = Wr+Ws+Wo

Equivalent effective weight We from Fig 2.3.5 at 3.14m

Total suspended load W = We + Wo + 2Ws + 2Wr

T1 = Wl

T2 = Ws + Wr

Additional Hints

The duty cycle for the koepe winder consists of 3 time sections (x axis), acceleration ta, steady state tv and deceleration tr. The power (y axis) consists of 6 power sections, P3 initial acceleration to steady state, P1 excess power to reach steady state, P5 excess power to maintain steady state, P2 initial instantaneous slowing down, P6 deceleration to prepare for stopping and P4 coming to rest.

Assume that the metric HP of 76 kgf-m/s and imperial of 550 ft-lbf/s are the same. Use of the metric HP of 75 kgf-m/s is quite acceptable. Gravity g is 9.81 m/s2 or 32.2 ft/s2

Assume that acceleration and deceleration and all duty cycle components plot as straight lines not curves.

Often (but not always) in these calculations, the power applied (load x velocity^2 / time) can be divided by the HP conversion and **(g)** (76 x 9.81 or 745.5 metric, 550 x 32.2 or 17710 imperial) to provide the HP required at any stage in the duty cycle. The hoist motor efficiency is applied to P4 (x(1-η)/η) and P5 and P6 (xη).

2.4 Duty Cycle **(6.5 marks)**

What do you understand by the "duty cycle" (power vs time) and draw a neat graph to show the cycle for a headframe mounted Koepe winder. What do you understand by "creep" and "decking" in your graph. (1 mark)

The marks for calculations 2.4.1 to 2.4.11 are (0.5 marks each, total 5.5 marks)

2.4.1 P1 Power required in excess of steady state velocity to reach that velocity

2.4.2 P2 Power regenerated on decreasing from steady state velocity to application of brakes

2.4.3 P3 Power required initially to approach steady state velocity

2.4.4 P4 Power required for decking/creep to a stationary state

2.4.5 Pa Sum of P1, P3 and P4, total of positive power parts of cycle

2.4.6 Pb Sum of P3 and P4, total acceleration and deceleration

2.4.7 Pc Sum of P2, P3 and P4, total slowing, acceleration and deceleration

2.4.8 P5 Pa applied at η efficiency / ta secs time

2.4.9 P6 Pa applied at η efficiency / tr secs time and stated negatively

2.4 Duty Cycle (Continued)

2.4.10 Pd Sum of Pa and P5

2.4.11 Pe Sum of Pc and P6 (P6 is stated negatively)

Additional Hints

$P1 = W V^2 / 76 \times 9.81 \times ta = WV^2 / 745.5\ ta$	(acceleration horsepower)
$P2 = W V^2 / 745.5\ tr$	(regeneration horsepower)
$P3 = Wo\ V / 76$	(running horsepower at shaft bottom)
$P4 = ((1-\eta)/\eta)\ Wo\ V / 76$	running horsepower at end of acceleration)
$Pa = P1 + P3 + P4$	(acceleration peak)
$Pb = P3 + P4$	(full speed running horsepower)
$Pc = P2 + P3 + P4$ (note P2 is minus)	(total retardation horsepower)
$P5 = \eta \times Pa / ta$	(running horsepower at end of full speed run)
$P6 = \eta \times Pa / tr =$ (note is minus)	(horsepower required to retard motor rotor)
$Pd = Pa + P5$	(total horsepower to accelerate hoist and motor rotor)
$Pe = Pc - P6$ (? minus ?)	(total horsepower to retard hoist and motor rotor) (note ? minus ?)

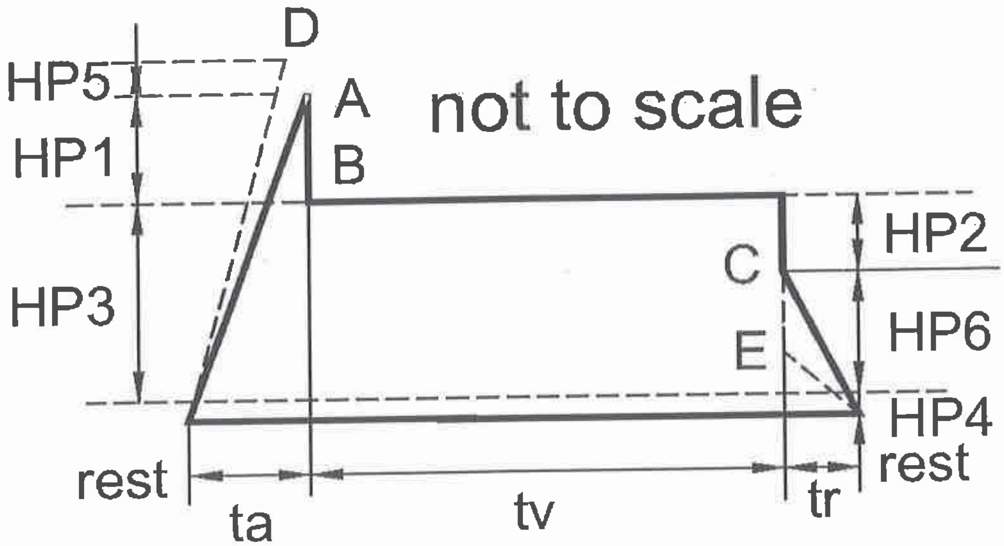

FIG 2.4 Duty Cycle

Question 2 *(Continued)*

Question 2.5 **RMS Power** **(1 mark)**

What is the rms power for the ac motor in kW (or hp)

Question 2.6 **Energy Consumption** **(0.5 mark)**

What is the energy consumption E in kW-hr per trip (or hp-hr/trip)

Additional Hint

Prms = sqrt ((Pd^2 ta + Pb^2 tv + Pe^2 tr) / (0.5 ta + tv + 0.5 tr + 0.25 ta))

E = (0.746 Pb ta + tv) / (3600 η) where 0.746 is hp to kW and 3600 is seconds/hr

Section B **Optional Question 3** **Mine Ventilation** **(20 marks)**

Syllabus *"Design of ..., ventilation, ... facilities."*

Section B Answer only 2 of the 3 Questions (2, 3 and 4) in this section. Only the first two of the answers in this section will be marked and count towards your final mark. Your answers will also include Compulsory Question 1, Section A, and one question from Section C. Do not answer this question (3) if it is not one of the 2 questions you have chosen to answer from Section B (questions 2, 3 and 4).

ASSUMPTIONS

Your company has taken over a small gold mine which extensively uses diesel powered mobile equipment, and its underground operations are at sea level i.e. 0 m/ft . In winter some air is re-circulated, but in summer refrigeration is required. The rock temperature in the mine is such that moving air down the fresh air shaft would render a surface refrigeration plant inadequate.

The mine has a history of poor operating practices and the Ontario Ministry of Labor (MOL) and Workplace Safety North (WSN) have given the company a month to show progress and six months to remedy all the failings of the ventilation system and improve the health of your personnel.

3.1 Plans and Records (3 marks)

Accurate plans and records of maintenance for the mechanical ventilation systems must be available at the mine site. (Subsection253 (2) of Reg. 854).

In order to quickly survey the airflows in the mine, you have purchase three types on instrumentation to measure various levels of airflow.

Explain the operation of each type (measurement techniques), the range of airflows measured and typical applications in each case, and comment on the ability of such equipment to enable the dilution of contaminants.

- 3.1.1 Pitot tube and manometer (1 mark)
- 3.1.2 Vane anemometer (1 mark)
- 3.1.3 Smoke tube (1 mark)

3.2 Mechanical Ventilation Systems (5 marks)

Employers must provide and maintain a mechanical ventilation system that will provide a partial pressure of oxygen of more than 18 kilopascals to dilute and remove contaminants from underground workplaces. (Subsection 253(1) of Reg. 854).

- 3.2.1 Oxygen depletion (0.5 marks)
- 3.2.2 Carbon dioxide (0.5 marks)
- 3.2.3 Methane (0.5 marks)
- 3.2.4 Carbon dioxide (0.5 marks)
- 3.2.5 Hydrogen sulfide, sulfur dioxide. (0.5 marks)
- 3.2.6 Oxides of nitrogen (0.5 marks)
- 3.2.7 Discuss the contaminants and problems of 3.2.1 to 3.2.6. How are the volumes of such gases measured, and airborne particulates and their contents measured. Discuss the equipment available for detection and monitoring. (2 marks)

3.3 Fans (2 marks)

Describe Vane and Centrifical fans, and include information on blade design and fan characteristics such as power consumption, output and noise.

3.4 Main fan **(2 marks)**

The main mine fans consist of downdraft located alongside updraft, each with their own ventilation raise. In very cold winters it is possible to recirculate a portion of the warm updraft into the downdraft. In hot summers, natural heat within the mine is such that underground cooling is required.

Calculate the pressure difference in the down shaft for an airflow of 66 m3/sec (140,000 ft3/min) in Pa units or inches H_2O (2 marks)

Required airflow 66.1 m^3/sec (140,000 ft^3/min)

Friction factor K 8.35×10^{-3} kg/m3 — 45×10^{-10} lbs-min^2/ft^4

Shaft circumference O 12.5m (41 ft) — Shaft diameter 4m (13 ft)

Shaft Area A 12.6 m^2 (135 ft^2) — Shaft depth L 2000m (6560 ft)

Additional Hint

$H = K\,O\,L\,Q^2 / A^3$ — 1 inch water = 249 Pa or 5.2 lb/ft^2

3.6 Shock Load **(2 marks)**

When applied to ventilation airways what is a "shock load"

3.7 Cooling of Mine Air **(2 marks)**

In the summer months the downcast air is to be cooled underground. Two methods of cooling-dehumidification of mine air are,

3.7.1 Refrigeration (1 mark)

3.7.2 Cooling Towers (1 mark)

In each case, describe a typical application and components, and emphasize the physical process of how the heat is removed from the cooling units and disposed of.

3.8 Psychometry and psychrometric charts **(4 marks)**

3.8.1 Neatly sketch the process using a psychrometric chart drawn by you for the purpose of understanding what is happening to the air in the cooling process. (2 marks)

3.8.2 How would you determine the change in heat (W Watt units or Btu/hr) (1 mark)

3.8.3 How would you determine the moisture content of the expelled air (kg/s or lbs/hr) (1 mark)

Section B Optional Question 4 Backfill (20 marks)

Syllabus Underground design including: ..... backfill .....,

Section B Maximum Questions to be answered in this Section B is two, worth 20 marks each. Answer only 2 of the 3 Questions (2, 3 and 4) in this section. Do not answer this question (4) if it is not one of the 2 questions you have chosen to answer from Section B (questions 2, 3 and 4). Only the first two questions in Section B will be marked. The writen exam must also include Compulsory Question 1, Section A, and one question from Section C.

This question (question 4) requires detailed answers to questions on backfill characteristics in their various forms. All answers are worth 2 marks except answers to 4.6 and 4.7 which are worth three marks each for a total of 20 marks.

Question 4 Backfill

Question 4.1 Is Backfill Essential (2 marks)

Backfill is an essential component of several mining methods. What mining methods and/or host rock characteristics make the use of backfill essential.

Question 4.2 Making Backfill (2 marks)

What methods are used in mine processing plants (mills) to make backfill suitable for support and filling voids left by mining.

Question 4.3 Backfill Sequencing (2 marks)

How does the mine and mill cope with backfill sequencing, i.e. the mill produces a relatively constant supply of suitable material but the mine may demand large quantities of fill on an intermittent basis.

Question 4.4 **Backfill Additives** **(2 marks)**

Discuss backfill additives such as cement, fly ash, slag, ground glass, flocculants and etc. Your answer should include material on the availability and cost of additives in remote mine locations, and the increase is fill strength. Typical mixes consists of 8 or 32 parts cyclone mill tailings with one part cement. Where are these mixes used and to what purpose.

Question 4.5 **Backfill Types** **(2 marks)**

There are two broad types of backfill produced by mills/processing plants, and sometimes augmented by gravel from local gravel pits which are placed in stopes. What are they.

Question 4.6 **Backfill Transportation** **(3 marks)**

The backfill must be transported to depths of typically up to 1000m (3000ft) and the pressure on a direct line would be too great.

How is conventional fill transported down to the various working levels. Draw a neat sketch of the piping arrangements used to reduce the pressure such that the backfill pressure will be within the strength parameters of pipelines, but sufficient to reach workings some approximately horizontal distance away in the stoping area.

Question 4.7 **Paste Fill** **(3 marks)**

Paste fill technology is relatively difficult to apply in many mines. Describe how such fill is produced in a mill/processing plant, transported underground and placed. What are the major advantages of pastefill over more conventional fill products. What difficulties can be anticipated with paste fill production, transportation and placement with respect to the size distribution and water content.

Question 4.8 **Providing Support** **(2 marks)**

Backfill provides support from rock pressure, blasting and earthquakes. Describe how the various types of fill and method of stowage affect the ability to protect from such occurrences.

Question 4.9 **Backfill Water Saturation** **(2 marks)**

Describe how saturation could affect the strength of backfill, and the possible resulting damage.

Section C **Optional Question 5** **Innovative Shaft Sinking** **(20 marks)**

Syllabus *"Description and usage of underground mining methods, underground design and cost/time estimation", "Requirements for development and services including: shafts, hoists, ramp and multi-level access design".*

Section C, Answer only one question from this section, either 5 or 6. This is one of two optional questions worth 20 marks each. Do not answer this question if it is not the question you have chosen to answer from Section C (questions 5 and 6)

Note Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A), 2 from Section B and 1 from the following section C.

Question 5 **Shaft Deepening while Hoisting from the Shaft** **(total 20 marks)**

Note *For question 5 and especially 5.7.1 and 5.7.2, use the whole of several pages to draw neat and legible diagrams and charts*

A shaft is 600m (2000ft) feet deep. The host rock, hanging wall, foot wall and ore are very competent. The shaft does not need lining and any support is provided by long roof bolts as required. The shaft can be circular, 10m (30ft) diameter or rectanglular, 10x8m (30x25ft) and your choice will not adversely affect your marks. Only this shaft is suitable for hoisting. There are ore and waste loading pockets and storage in the present shaft.

Because the mining company must continue to hoist in the present shaft without interruption, it is decided to sink the future ore pass to 1000m (3200 ft) and cross cut over to the location of the future shaft extension as required. It will then be possible to remove the rock beneath the present shaft without affecting production, and quickly install all the required shaft steel and timber prior to attaching a new and longer hoist rope and loading pocket at the base of the ore pass. A koepe winder is used for ore (and waste) hoisting

Question 5.1 **Equipment** **(3 marks)**

5.1.1 What equipment will be required to hoist broken waste rock up the internal ore pass to the present waste loading pocket. (1.5 marks)

5.1.2 What equipment will be required to move broken rock from cross cuts under the present shaft. (1.5 marks)

Question 5.2 Drilling and Blasting (6 marks)

5.2.1 Explain the drilling and blasting required to open the ground in several short vertical segments beneath the (present short) shaft. (2 marks)

5.2.2 How will the drilling be accomplished, loaded with explosive and blasted to open the ground given that somewhat similar methods are used in stope mining. (2 marks)

5.2.3 On completion of drilling of each of several short lengths of (new) shaft sections, how will blasting be carried out to ensure the ground does not "freeze" in place. (2 marks)

Question 5.3 Disrupting Production (2 marks)

The top length (section) of the shaft extension must be mined last to avoid disrupting production from the present shorter production shaft. How will the last section be removed. (2 marks)

Question 5.4 Rope(s), Shaft Infrastructure (1.5 marks)

The hoist rope must be replaced, and new steel and timber for the shaft extension must be installed. How will this work be accomplished in the shortest time while still hoisting from the old shorter section of shaft. (1.5 marks)

Question 5.5 Shaft Loading Pocket (2 marks)

It will be possible to hoist ore from the old ore (and waste) loading pocket. Why has the mine decided to hoist from the new loading pocket some 200m (600ft) deeper. (2 marks)

Question 5.6 Plans and Sections (1.5 marks)

Draw neat plans and sections showing how the work will be completed in the shortest time with minimal disruption of production. (1.5 marks)

Question 5.7 Schedules and Costs (4 marks)

5.7.1 Make a detailed flow sheet (time line or critical path) of the work, which will ensure that all activities are scheduled and progress to complete the tasks in the shortest time possible. (2 marks)

5.7.2 Estimated time taken and costs of each of the mining activities in 5.7.1 included in your flow sheet . (2 marks)

Section C Optional Question 6 Mining Methods (20 marks)

Syllabus "Description and usage of the following underground mining methods - room and pillar, long-hole, longwall, open stoping, ***shrinkage****, cut and fill sub-level stoping, timbered stoping, top slicing, under-hand and overhand stoping, block caving, sublevel caving, and vertical crater retreat. "*

Section C, Answer only One Question in this section, either 5 or 6. Each question is worth 20 marks. Only the first question answered from Section C in your answer book will be marked. Do not answer this question if it is not the question you have chosen to answer from Section C (questions 5 and 6)

Note Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A), 2 from Section B and 1 from section C.

Question 6 Shrinkage & Comparison with other Mining Methods (total 20 marks)

It has been suggested that many other mining methods with all sorts of imaginative or elaborate names are really modifications of shrinkage stoping.

Question 6.1 Resemblance to Shrinkage (3 marks)

List and describe two other such elaborately named methods which are very similar to underhand and/or overhand shrinkage. Include a statement of how and why such methods have a good resemblance to shrinkage.

Question 6.2 Comparison with Other Mining Methods (14 marks)

Compare and contrast the shrinkage with **each** of your 2 above named similar mining methods with special emphasis on the following;

6.2.1 Geology, orebody shape, size and orientation (2 x 0.5 mark, 2 total)
6.2.2 Host and ore rock properties, ground support (2 x 1 mark, 2 total)
6.2.3 Mining sequence and mill feed rate (2 x 1 mark, 1 total)

Question 6.2 Continued

6.2.4 Development size, amount, cost and time taken to start extraction (2 x 0.5 mark, 1 total)

6.2.5 Number and skills of mining personnel (2 x 0.5 mark, 1 total)

6.2.6 Types and numbers of mechanized equipment (2 x 0.5 mark, 1 total)

6.2.7 Cost of mining (2 x 0.5 mark, 1 total)

6.2.8 Mine life (2 x 0.5 mark, 1 total)

6.2.9 Mining rate (2 x 0.5 mark, 1 total)

6.2.10 Dilution and recovery (2 x 0.5 mark, 1 total)

6.2.11 Methods and costs of any pillar recovery (2 x 0.5 mark, 1 total)

6.2.12 Post mining stabilization (2 x 0.5 mark, 1 total)

(2 mining methods, 12 x 2 answers, 0.5 marks each, except 6.2.2 and 6.2.3, 1 mark each, 2x(10x0,5+2x1) or 2x7 gives a total of 14 marks)

Your answer must be comprehensive and may be in detailed table format if you feel this makes your answers more understandable.

6.3 Dissimilar Mining Method **(3 marks)**

List and describe one other stoping method which bears no similarity to underhand and/or overhand shrinkage which could not be used in your two comparison examples. .

Be sure you have Answered Only

- **Section A, Question 1**
- **Your choice of 2 questions from the three in Section B (2, 3 & 4)**
- **Your choice of 1 question from the two in Section C (5 & 6)**

(Questions after Hartman, H., and J, Mutmansky, 2002, Introductory mining engineering, 2ed., Wiley and Sons, New Jersey, USA; Hartman, H., editor, 1992, SME mining engineering handbook, 2ed., SME, Littleton, Colorado, USA; and Hartman, H., J. Mutmansky, R. Ramani, and Y. Yang, 1991, Mine ventilation and air conditioning, 3ed. Wiley and Sons, New York, USA.)

End of Exam

End of Exam