THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

THIRD YEAR MINING ENGINEERING

2021 FIRST SEMESTER

MN312 UNDERGROUND MINING

DATE 16TH JUNE 2021

VENUE MN003

TIME ALLOWED 3 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read through the instructions and questions carefully. You are NOT ALLOWED to attempt any questions during this time.
2. There are two (2) parts to the exam. Part A has 2 questions and Part B has 7 questions. There are total of 9 questions.
3. For Part A, answer ALL two (2) questions.
   For Part B, answer ANY FIVE (5) out of the seven (7) questions.
4. You MUST show all working out and express the numbers in correct units of measurement.
5. Calculators, biros and rulers ARE ALLOWED in the exam. Notes, mobile phones and any other electronic devices are strictly NOT ALLOWED.
6. Useful formulas are provided.
7. Write ALL answers on the answer sheet provided. No other materials will be accepted.
8. Write your NAME and NUMBER on the answer book. DO THIS NOW

PART A: SHORT ANSWERS

QUESTION 1 (15 marks)

Differentiate between the underground terminologies given below.

i) Cemented aggregate fill and cemented rock fill (3 marks)

ii) Overhand and underhand (3 marks)

iii) Spacing and burden (3 marks)

iv) Transverse and longitudinal (3 marks)

v) Capital and operating (3 marks)

QUESTION 2 (15 marks)

Caving methods can be high tonnage and low operating cost methods. Define the common terminologies used in caving methods provided below.

i) Panel caving (3 marks)

ii) Dilution entry (3 marks)

iii) Bridge (3 marks)

iv) Undercut (3 marks)

v) Drawbell (3 marks)

PART B: LONG ANSWERS & CALCULATION

QUESTION 3 (15 marks)

Irumafimpa (K92) mine initially used the 'shrinkage' mining method to mine the orebody. However, the mining method changed to 'cut and fill' and later to 'sublevel stoping (Avoca)'.

i) Identify and explain briefly the two (2) obvious differences between a 'shrinkage' and 'cut and fill' method. (5 marks)

ii) Sketch a neat longitudinal section view of a 'Pure Avoca' method and indicate on the view the cycle of production. (5 marks)

iii) Dilution was the main reason why K92 switched from shrinkage to cut and fill. Explain briefly what could have happened that contributed to dilution. (5 marks)

QUESTION 4 (15 marks)

A mine employing 'sublevel caving' has level spacing of 20m. You are to design a slot pattern to open up a 2m x 2m slot box with adequate void ratio.

Information provided;

Ore rock density	= 2.8 g/cc
Youngs Modulus of elasticity	= 40 GPa
Explosive type	= ANFO
Explosive density	= 0.95 g/cc
Blasthole diameter	= 102 mm
Relief hole diameter	= 165 mm

i) Determine the number of reamers and critical separation distance. (5 marks)

ii) Draw neatly the slot pattern indicating the critical separation distance. (5 marks)

iii) Calculate and verify that the void ratio is adequate. (5 marks)

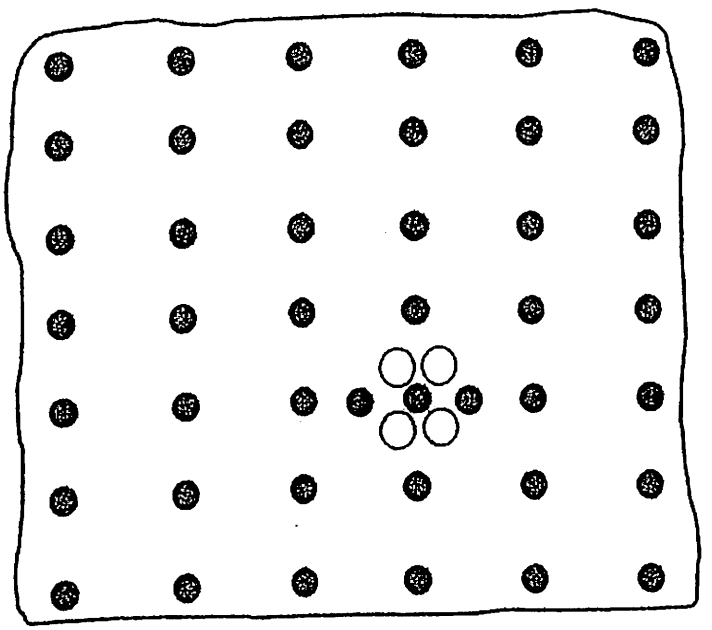
QUESTION 5 (15 marks)

Development advance is drilled and blasted with either a 'burn cut' or 'angle cut' pattern. A burn cut pattern for a face is given below.

i) Use the Dyno's LP detonators provided and sequence the whole blast (do that on the separate sheet provided). (5 marks)

ii) Explain briefly why low density explosives are used in the perimeter holes. (5 marks)

iii) Explain briefly why package explosives are used in the lifter holes. (5 marks)



LP Delay	
Det#	ms
0	25
1	200
2	400
3	600
4	1000
5	1400
6	1800
7	2400
8	3000
9	3800
10	4600
11	5500
12	6400
13	7400
14	8500
15	9600

QUESTION 6 (15 marks)

A mine employing 'sublevel stoping' method is in the design process of determining a stable opening. You are required to determine whether opening a 60m strike length proposed for a stope within a 30m level spacing is stable for extraction or not and propose a stable strike length.

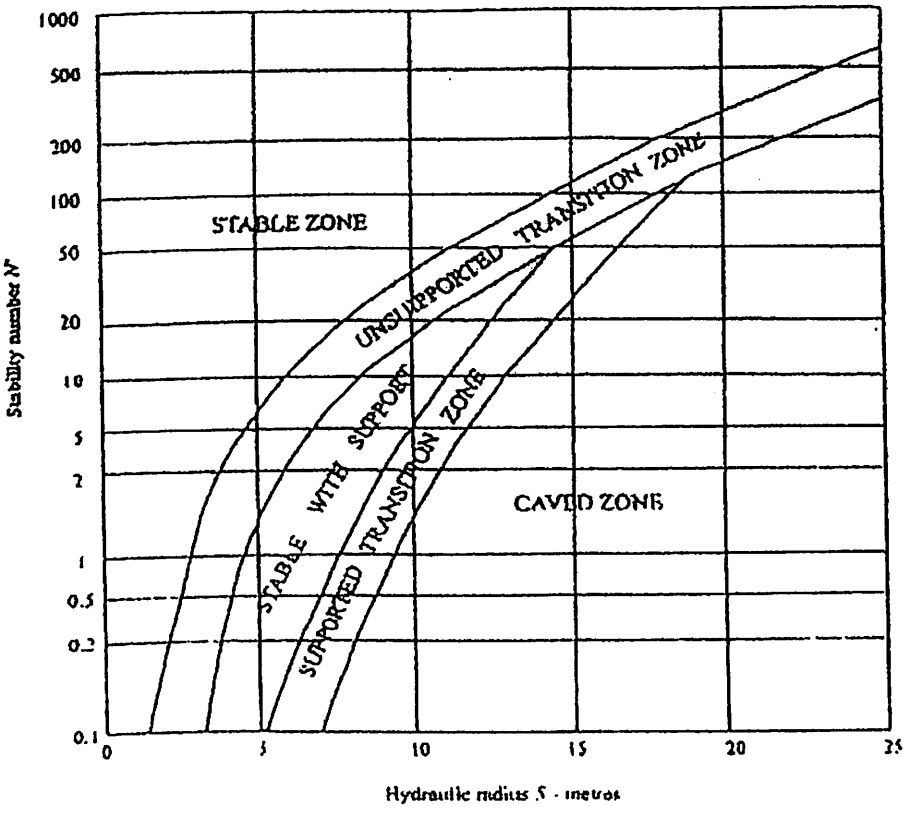
Information provided;

Modified quality index	= 2
Stress factor	= 0.3
Joint orientation factor	= 0.4
Gravity factor	= 3

i) Determine and plot on the stability chart the location of the proposed strike length (do that on the separate sheet provided). (5 marks)

ii) Recommend and verify a revised stable strike length with cable support. (5 marks)

iii) Sketch a cross-section view showing the cable support on the hanging wall. (5 marks)

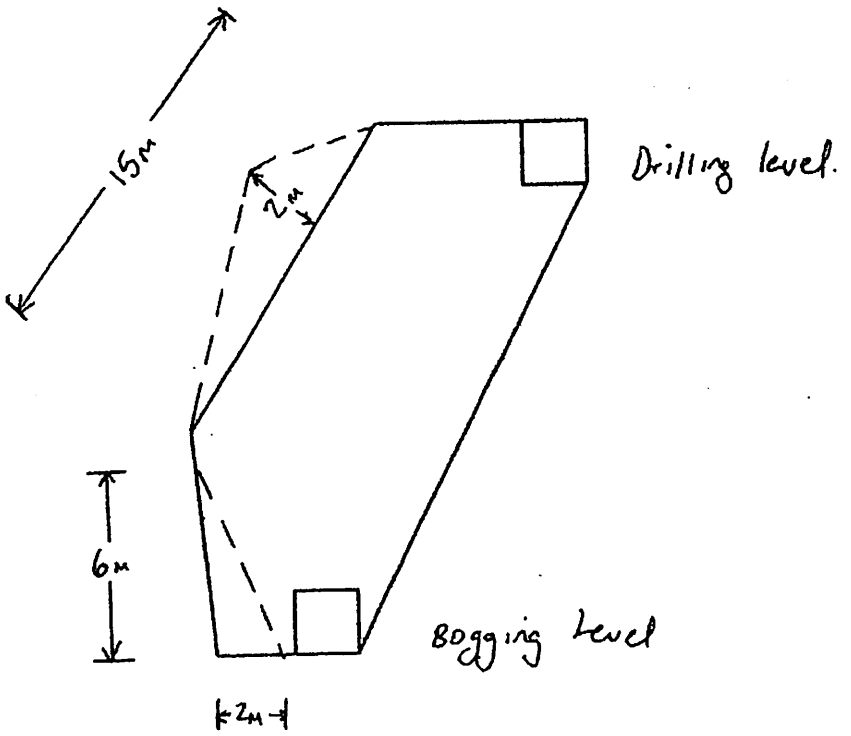


QUESTION 7 (15 marks)

A stope utilizing the sublevel stoping method was mined out and cavity monitoring system (CMS) of the void was completed. A cross section is shown below for stope reconciliation.

Information provided;

Cross section area	= 300 m^2	(assume the same profile for the entire stope)
Ring burden	= 3 m	
Total rings in the stope	= 8	
Ore density	= 2.8 t/m^3	
Stope design grade	= 6.5 g/t	
Over break grade	= 2.0 g/t	
Under break grade	= 6.5 g/t	



i) Calculate dilution (%) and mine recovery (%). (5 marks)

ii) Determine the mined tonnes and grade. (5 marks)

iii) Explain briefly how under break can be minimized. (5 marks)

QUESTION 8 (15 marks)

An UG mine has gone through optimization process when the cost of operation has increased from $200/t to $250/t.

Information provided;

Mill recovery	= 80 %
Royalty	= 2 %
Inflation	= 5 %
Gold price	=$ 1,500 /oz

Table of reserve physicals

Stope	Category	Tonnes (t)	Grade (g/t)
CD23-80	Proven	14,900	8.5
CA92-62	Proven	13,500	5.7
CD90-80	Proven	10,300	8.3
CD22-71	Probable	12,000	7.2
CA08-71	Probable	9,000	6.3
CD86-74	Probable	15,500	8.5

i) Determine the total revised reserve physicals at the increased cost of production at $250/t. (5 marks)

ii) Determine the loss in ounces (oz) and loss in profit ($) due to the increase in cost. (5 marks)

iii) Explain briefly your understanding of mine 'optimization' process. (5 marks)

QUESTION 9 (15 marks)

A coal mine uses the 'room and pillar' method. Empirical methods are used for the design of the dimensions of the opening. The recommended factor of safety for the opening is > 1.

Information provided;

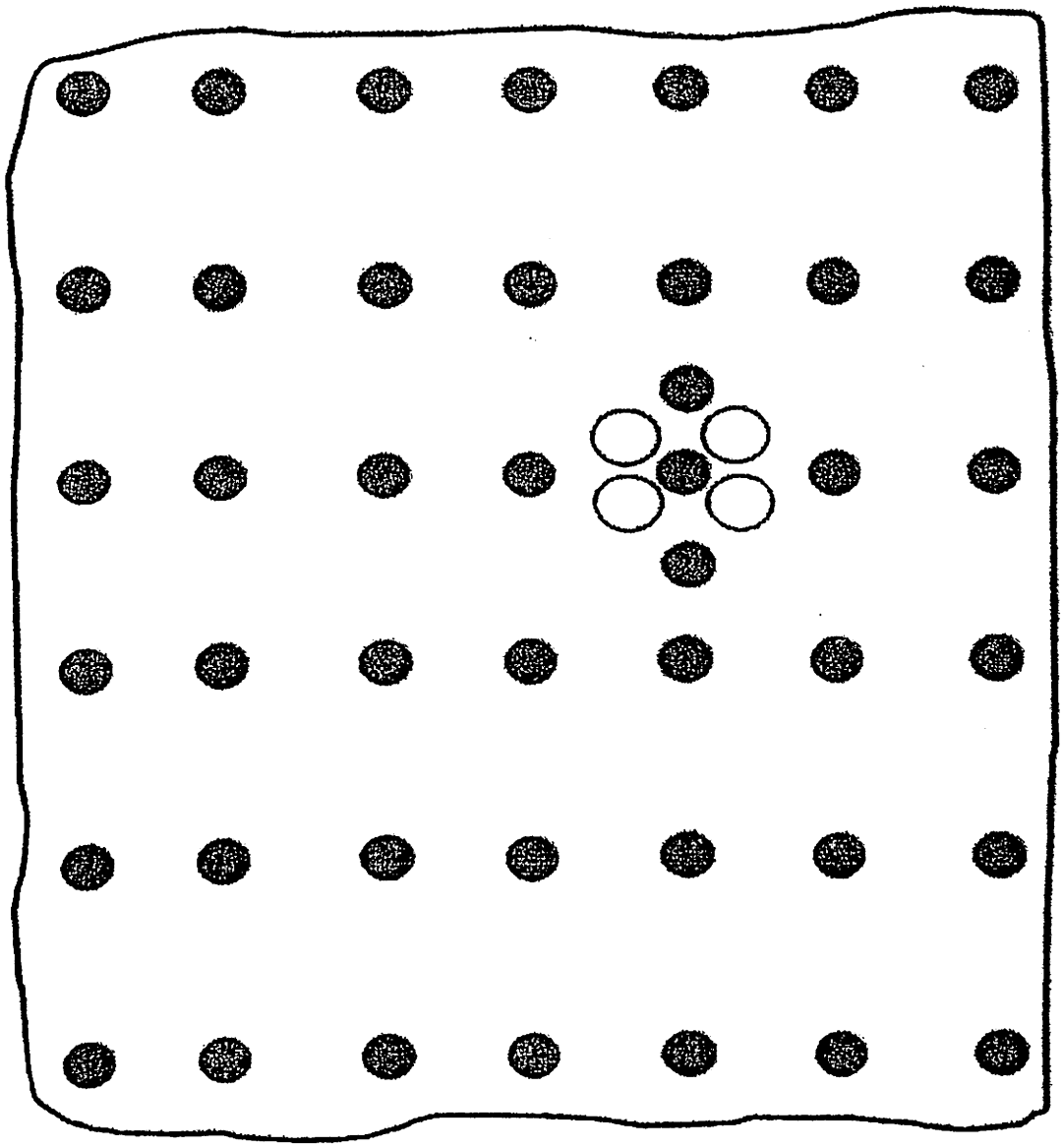
Strength of cube of coal (specimen)	= 9 MPa
Depth of mining horizon from surface	= 100 m
Unit weight of overlying rock	= 22 kN/m^3
Overburden density	= 2.5 t/m^3
Pillar height	= 3 m
Pillar width (proposed)	= 2 m
Pillar length (proposed)	= 4 m
Room width (proposed)	= 3 m

i) Determine the factor of safety from the proposed dimensions. (5 marks)

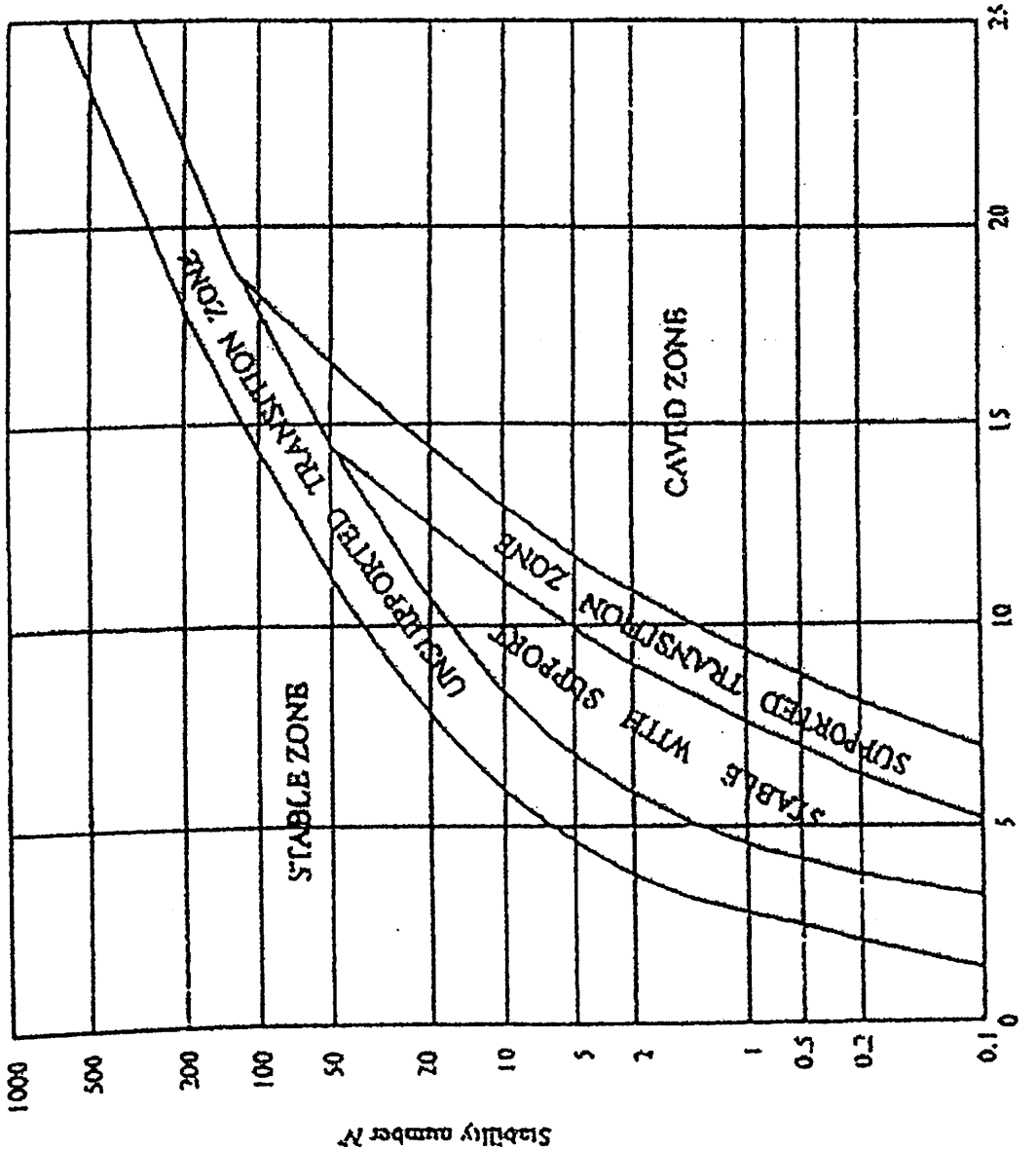
ii) Recommend and verify the stable dimensions of the opening to satisfy the FOS >1. (Show all calculations). (5 marks)

iii) Briefly differentiate between a 'conventional' and 'continuous' mining in a room and pillar method. (5 marks)

FOR QUESTION 5



FOR QUESTION 6



Formula

$$P_s = K[0.778 + 0.222(\tfrac{w}{h})].$$

$$CS = 2 \times \Phi_{eff} \times \frac{E}{E_0} \times \frac{REE}{100}$$

$$N' = Q' \times A \times B \times C$$

$$\sigma_s = \lambda H \left(\frac{A_T}{A_P}\right)$$

$$d_{ek} = \frac{B \times 1000}{(24\,\delta_{ek}/\delta_r) + 18}$$

$$S = (1 \text{ to } 1.15)\,B$$

$$\Phi_{eff} = 110 + (15.4)\,L$$

$$\Phi_{eff} = \Phi \times n^{0.5}$$