ANSWERS - QUESTION 1

Multiple Questions

1.1 During normal support design in dynamic conditions the general rule requires the support to cater for a rock travelling at: *(Ryder & Jager, pg 309)*

a)	30E3 mm/min (0.5m/s)	b)	60E3 mm/min (1m/s)	
c)	$\boxed{\text{180E3 mm/min (3m/s)}}$	d)	300E3 mm/min (5m/s)	(2)

1.2 What are the generally accepted units for ERR? *(Ryder & Jager, pg 234)*

a)	mN/m^2	b)	MPa	
c)	$\boxed{MJ/m^2}$	d)	It has no units. It is a ratio	(1)

1.3 According to Barton, the expression ESR is related to: *(Ryder & Jager, pg 375)*

a)	$\boxed{\text{Excavation Support Ratio}}$	b)	Excavation Span Ratio	
c)	Excavation Stress Ratio	d)	Excavation Size Ratio	(1)

1.4 What will be the maximum vertical subsidence calculated when using the following formula: *(Rock engineering for underground coal mining, pg 241)*

$$Sm = 0.39\,h \left[\frac{W}{H}\right]^{0.32}$$

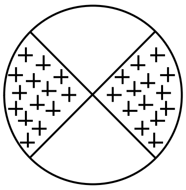
$$= 0.39\,(1m)\left[\frac{80}{100}\right]^{0.32}$$

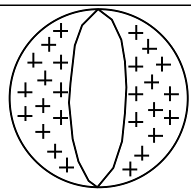
$$= 363mm$$

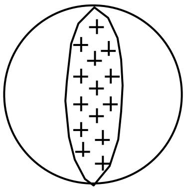
Where the stoping width is 100cm, the depth is 100m and the stoping span is 80m?

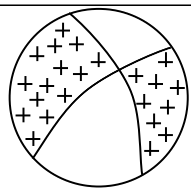
a)	$\boxed{\text{363mm}}$	b)	158mm	
c)	4.06mm	d)	931mm	(2)

1.5 In seismic focal mechanisms for common faults, which of the representations represent a pure normal fault slip (shade areas are marked with +++) which denotes compression P wave motions? *(Ryder & Jager, pg 216)*

a) 

b) 

c) 

d) 

(1)

1.6 What criterion (for metals) states that the yielding occurs at a maximum elastic shear strain energy? *(Ryder & Jager, pg 427)*

a)	Fulcram	b)	Von Mises	
c)	Voussoir	d)	Lame	(1)

1.7 In slope stability when the material is said to be in a state of “limit equilibrium” this is called the: *(Ryder & Jager, pg 177)*

a)	Rankine state	b)	Maxwell state	
c)	Newtonian state	d)	Kelvin state	(1)

1.8 The MRMR system in rockmass characterization and classification was introduced by: *(Ryder & Jager, pg 369)*

a)	Bienawski	b)	Barton	
c)	Laubscher	d)	Hoek	(1)

1.9 The acronym GSI for jointed rock masses developed in 2003 by Hoek refers to: *(Rock mechanics for underground mining, Brady & Brown, p 469)*

a)	Ground Span Index	b)	Geological Stress Index	
c)	Ground Support Index	d)	Geological Strength Index	(1)

1.10 The clear vertical distance between the top of a pile of caved ore and the in-situ cave back is called the ___________. *(Rock mechanics for underground mining, Brady & Brown, pg 469)*

a) Cave boundary b) Goaf
c) Air gap d) Chimney (1)

1.12 Which one does not fit? *(Brady & Brown, pg 71)*

a) Stereographic projection b) Wulff projection
c) Equal angle projection d) Equal area projection (1)

1.13 Which criteria do not fit? *(Ryder & Jager, pg 65)*

a) Griffith Crack Analysis b) Hoek & Brown Empirical Strength criteria
c) Lade Empirical Strength Criteria d) Tresca's Criterion (1)

1.14 When positioning two parallel tunnels to avoid stress interaction, the rule of thumb is to place the tunnels how far apart? *(Ryder & Jager, pg 202)*

a) The combined width of the tunnels b) 3 x The width of the largest tunnel
c) 2 x The combined width of the 2 tunnels d) 3 x The combined width of the 2 tunnels (1)

1.15 On the analysis of seismicity in time, the slope of the $\sum V_A$ (Cumulative Apparent Volume) reflects changes in the: *(Ryder & Jager, pg 300)*

a) Strain rate b) Stress
c) Viscosity d) Energy (1)

1.16 When using MRMR values to determine slopes and the value calculated is 20, by using your engineering judgment, what will your anticipated overall slope angle be? *(Rock engineering for shallow and open cast mines, pg 28)*

a)	< 35º	b)	$\boxed{36 – 50º}$	
c)	51 – 75º	d)	76 – 100º	(1)

1.17 When designing shaft pillars and associated excavations, the major principal stress to limit deformation should be reduced to the <u>critical stress</u> which is normally given as: *(Rock engineering for shallow and open cast mines, pg 43)*

a)	σ_c	b)	$\boxed{\frac{\sigma_c}{3}}$	
c)	$\frac{\sigma_c}{4}$	d)	$\frac{\sigma_c}{2}$	(1)

1.18 In monitoring and instrumentation, the deviation of the output or reading from a <u>known input</u>, indicates the: *(Ryder & Jager, pg 450)*

a)	Error	b)	$\boxed{\text{Accuracy}}$	
c)	Drift	d)	Precision	(1)

1.19 The Hoek and Brown failure criteria is best suited in a discontinuum model where two fault planes are the main modes of failure.

a)	True	b)	$\boxed{\text{False}}$	(1)

[20]

ANSWERS - QUESTION 2

SUPPORT DESIGN

2.1 Given:

Maximum tolerable displacement is 500mm.

Energy at 500mm is 25kJ

Calculate yield force:

$$YF = \frac{\text{Energy (J)}}{\text{Displacement (m)}}$$

$$YF = \frac{25 \times 10^3 \text{ J}}{0.5\text{m}}$$

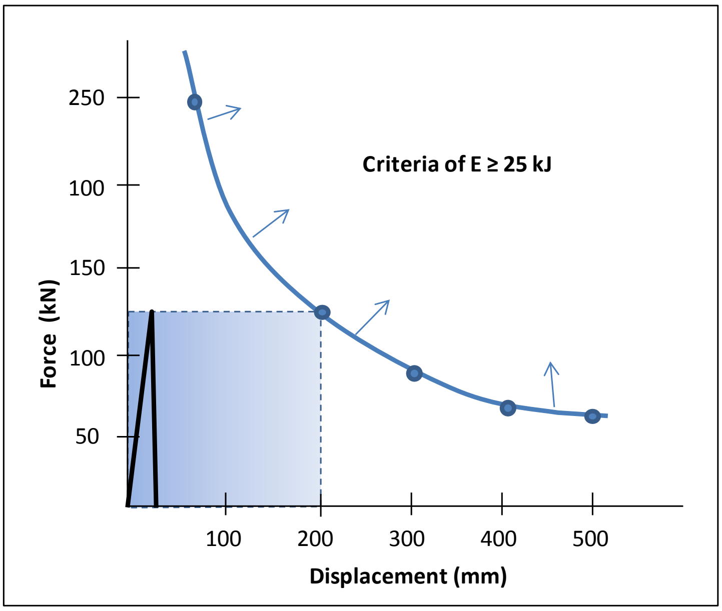
$$YF = 50\ 000 \text{ N}$$

$$YF = 50 \text{ kN}$$

Displacement (mm)	Minimum Yield Force (kN)
100	250 ($^{1}/_{2}$)
200	125 ($^{1}/_{2}$)
300	83.3 ($^{1}/_{2}$)
400	62.5 ($^{1}/_{2}$)
500	50 ($^{1}/_{2}$)

(3)

2.2



(3)

2.3 No.

The tendon fails at 20mm displacement and falls below the required energy criteria of 25 kJ. (2)

2.4 Energy = ½ (Yield Force (kN) x Displacement (m))

= ½ (125 kN x 0.02m)

= 1.25 kJ (2)

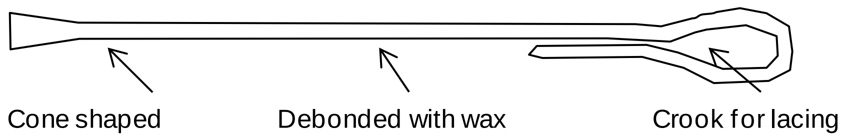
2.5 $$YF = \frac{\text{Energy (J)}}{\text{Displacement (m)}}$$

$$D = \frac{\text{Energy (J)}}{\text{YF (kN)}}$$

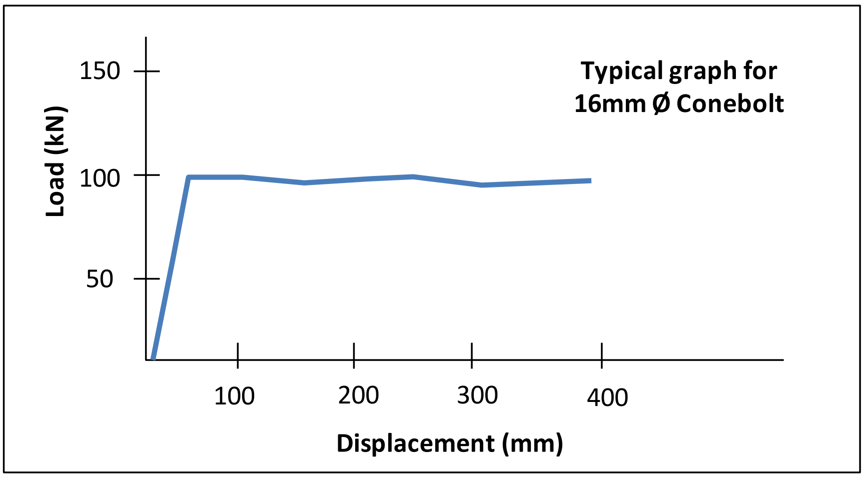
$$D = \frac{25 \text{ kJ}}{125 \text{ kN}}$$

$$D = 200\text{mm}$$ (2)

2.6 Cone bolt

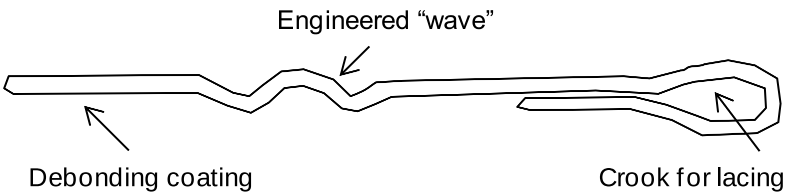


- The cone shape tendon is grouted into a hole.
- The steel rod is coated with a special debonding agent.
- Mode of yield, the debonded tendon pulls through the grout maintaining a support resistance / load while yielding.

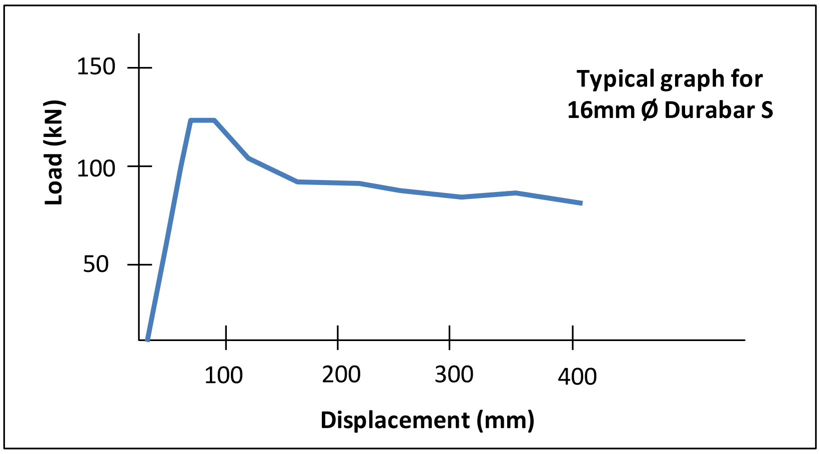


(4)

<u>Durabar</u>



- Tendon grouted into hole.
- Rod coated with debonding agent.
- Mode of yield. Slips through grout with smooth load / deformation characteristics through the wave path created in the grout by the shape "wave" of the bar.



(4)

Shepherd's Crook (smoothbar)

[20]

ANSWERS - QUESTION 3

Support Assessment

3.1 Calculate the volume (m^3) supported by each bolt.

Calculate the load (kN) applied to each bolt based on the volume density and gravity.

Calculate the factor of safety.

Hangingwall	Sidewall
Volume = 2m x 2m x 1,5m	Volume = 2m x 2m x 0.5m
= $6m^3$/bolt (1)	= $2m^3$/bolt (1)
Load = $6m^3$ x 2.71 tons/m^3	Load = $2m^3$ x 2.71 tons/m^3
= 16.26 tons x 9.8m/s^2	= 5.42 tons x 9.81m/s^2
= 159.51kN/bolt	= 53.17kN/bolt
Or	Or
= 39.87kN/m² (2)	= 13.29kN/m² (2)
FOS = 120kN ÷ 159.51kN	FOS = 120kN ÷ 53.17kN
= 0.75	= 2.25
Or	Or
FOS = 30kN/m² ÷ 39.87kN/m²	FOS = 30kN/m² ÷ 13.29kN/m²
= 0.75 (1)	= 2.25 (1) (8)

3.2 The support resistance offered in the hangingwall is inadequate to prevent a fall of 1.5m occurring. (1)

The sidewall support is <u>adequate</u>. (1) (2)

3.3 Given: FOS = 2

$$2 = \frac{120kN}{x}$$

$$x = \frac{120kN}{2}$$

x = 60kN (1)

60kN ÷ 9.81 m/s^2 = 6.11 tons (1)

6.11 tons ÷ 2.71 ton/m^3 = $2.25m^3$ (1)

Demand = 39.87kN/m² x 2

$$FOS = \frac{SR}{Demand}$$

2 x 39.87kN/m² = 120kN/m²

$$x = \frac{120kN/m^2}{79.74kN/m^2}$$ (1)

Volume = $2.25m^3$ $\rightarrow$	
m^2 = volume ÷ 1.5m	
m^2 = $2.25m^3$ ÷ 1.5m	
= $1.5m^2$ (1)	
Spacing = $\sqrt{1.5}$	Spacing = $\sqrt{1.5}$
= 1.22m x 1.22	= 1.22m x 1.22
Or	Or
= 1.5m x 1m (1)	= 1.5m x 1m (1) (5)

3.4 No. At an excavation width of 5.0m and using a 1.8m long-end anchored rockstud is too short. (1)

Rule of thumb bolt length = ½ excavation width

= 2.5m long (1)

Tensile zone ± 2.5m (2)

3.5 The inclusion of grouting for the end-anchored rockstuds. (1)

The inclusion of shotcrete, both for corrosion. (1)

(Must identify a return airway and therefore corrosion). (2)

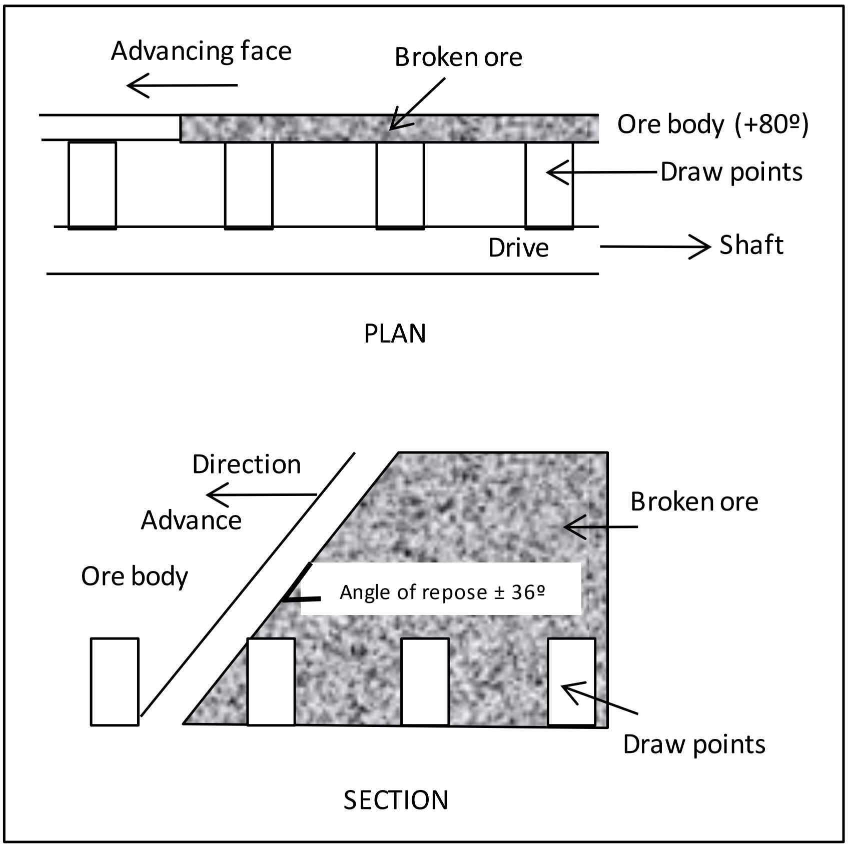
3.6
- Collapsible ring when tensioned.
- Luminous indicator that is protruded when tensioned.
- Dome plate that can be flattened (rockstuds). (1)

[20]

ANSWERS - QUESTION 4

General Mining

4.1



(2)

4.2 (i) Support installed in the draw points and drive:

- Type
- Spacing
- Distance to face
- Condition (corrosion, quality of installation, etc.)

(ii) Geology in draw points and drive:

- Faulting
- Dykes
- Sympathetic jointing, jointing
- Water seepage

(iii) Ground related conditions:

- Stress influence from abutments and pillars
- Rockwall conditions (blocky)
- Brow at stope

(iv) Size of exaction:

- Dimensions, width and height

(v) Possible rolling rocks from stope (sizes)

(vi) Effects of secondary blasting in draw point on:

- The brow and rockwall conditions
- The support installed

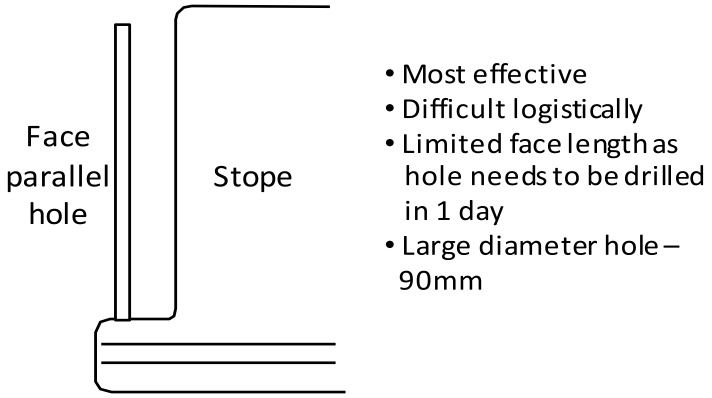
(vii) Other:

- Rock strength
- Hang ups of ore
- Damage from machinery
- Blast damage to excavations (10)

4.3 (i) Pre-conditioning prevents the accumulation of strain energy ahead of the face or at least controls its release.

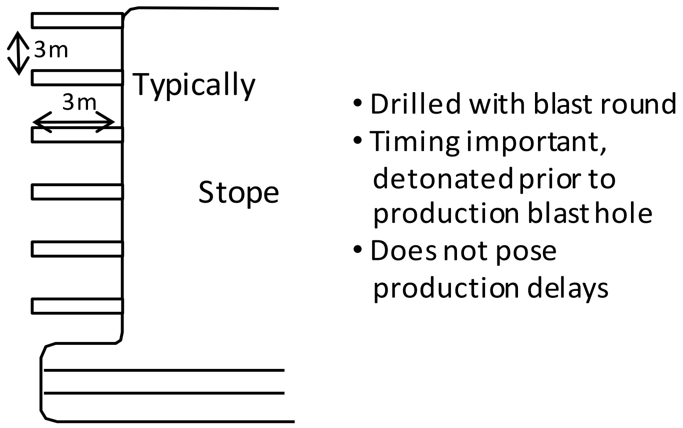
Gas and shock generated by blast in the fracture zone can remobilize the blocks by shearing through asperities that cause the lockup of strain energy. (2)

(ii) Face Parallel Preconditioning:



(3)

Face Perpendicular Pre-conditioning



(3)

[20]

ANSWERS - QUESTION 5

General

5.1 Fill in the missing words:

i) A seismic event is the result of strain (energy) accumulation in rock due to stress. (1)
(Specific outcomes for mine seismology, pg 22)

ii) The moment and energy released by a mine seismic event can be calculated directly from geophone data. *(Specific outcomes for mine seismology, pg 32)* (2)

iii) Two types of body waves are generated during a seismic event. Only the p-wave can be transmitted in solid, materials, gases and liquids.
(Specific outcomes for mine seismology, pg 23) (1)

iv) The formula: 4 x pillar area / pillar perimeter is the formula for effective pillar width. *(Practical rock engineering practice for shallow and open cast mines, pg 38)* (1)

v) The mapping of unknown structures based on a rapid, non-destructive, high resolution, electromagnetic reflection is generally referred to as Ground Penetrating Radar. *(Ryder & Jager, pg 473)* (1)

vi) Geologists use a reliable diagnostic test of relative hardness to identify minerals in the field. This is called the Mohs Scale of Mineral Hardness. (1) [7]

5.2 $5.0 = \frac{L^2}{4 \times L}$ (Mark for formula)

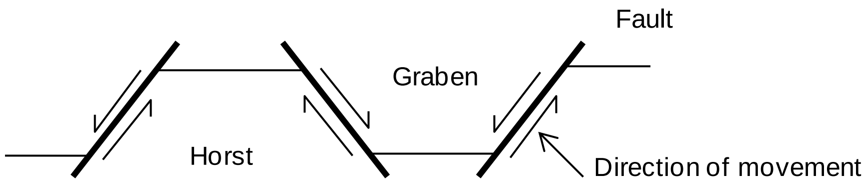
$L = 20$ (3)

5.3 Elastic vs. inelastic due to mining.
Convergence - elastic deformation
Closure - elastic and inelastic components of deformation (2)

5.4 Siligna / Gum (1)

5.5 450 MPa (1)

5.6



(3)

5.7 Using your knowledge of a periodic table, write down the correct symbol for the following minerals:

a) Gold <u>Au</u>
b) Copper <u>Cu</u>
c) Lead <u>Pb</u>
d) Silver <u>Ag</u>
e) Platinum <u>Pt</u>
f) Iron <u>Fe</u> (3)

[20]