UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *MINING ENGINEERING* BACCALAURIUS TECHNOLOGIAE *MRM*
SUBJECT	:	**MINING TECHNICAL SERVICES III**
CODE	:	**MTL3211**
DATE	:	SUMMER SSA EXAMINATION 2015 7 DECEMBER 2015
DURATION	:	(SESSION 3) 15:00 - 18:00
WEIGHT	:	60% OF FINAL MARK
TOTAL MARKS	:	100

EXAMINER	:	MR H STRAUSS
MODERATOR	:	MR DA ARNOLD
NUMBER OF PAGES	:	10

INSTRUCTIONS	:	ANSWER ALL QUESTIONS
REQUIREMENTS	:	ONE EXAMINATION SCRIPT, SECOND ON REQUEST

INSTRUCTIONS TO CANDIDATES:

ANSWER ALL THE QUESTIONS
SHOW ALL CALCULATIONS AND SI UNITS
REMEMBER TO HAND IN YOUR GRAPHICAL WORK
DO YOUR OWN WORK
DO NOT USE CORRECTION FLUID OR A RED PEN

QUESTION 1

1.1 Distinguish between:

- 1.1.1 Work and power. (2)
- 1.1.2 Density and specific volume. (2)
- 1.1.3 Quantity and mass flow. (2)

1.2 Make a neat sketch of a force-exhaust overlap system, showing all components and distances. (6)

1.3 State two advantages and two disadvantages of the system that you have sketched. (4)

1.4 Name two diseases caused by the inhalation of dust in mines. (2)

1.5 Explain the term "terminal velocity". (2)

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QUESTION 2

2.1 Calculate the mass of air contained within a volume $253m^3$ at a pressure of 101,5kPa, and a temperature of 28,5°C, given that R for dry air is 0,2871. (3)

2.2 What pressure would be required to overcome the resistance of a 760mm diameter galvanised ventilation column, 90m long, with a friction factor of $0{,}003Ns^2/m^4$, in order to effect a volumetric air flow of $15m^3/s$ at a density of $0{,}98kg/m^3$? (3)

2.3 Calculate the air velocity of the air stream described in 2.2. (1)

2.4 A very important raise within your area of responsibility was stopped because the fan had broken down. You have a spare fan available, but you are uncertain whether it will meet the requirements of the raise. The ventilation column is a 500mm galvanised column with a friction factor of $0{,}004Ns^2/m^4$, and it is 260m long. The air density in the raise is $1{,}2kg/m^3$. The test data of the fan is tabulated in Appendix A. You may assume that the test was done at the same density as in the raise, therefore no curve adjustment would be required. Determine the fan duty (quantity and pressure) if this fan is installed to replace the broken one. Comment on the result. Show all calculations and assumptions. (13)

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QUESTION 3

3.1 Mention six primary precautions that should be taken to practically reduce the risk of a coal dust explosion. (6)

3.2 List four important requirements of an emergency control room. (4)

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QUESTION 4

4.1 The stress at a point underground is given by the matrix below. Calculate the magnitude and direction of the principal stress components, as well as the maximum shear stress. (6)

$$\begin{vmatrix} 40 & -20 \\ 20 & 85 \end{vmatrix}$$

4.2 Confirm your calculations with the construction of a Mohr Circle. (4)

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QUESTION 5

5.1 The following is known about a narrow tabular stoping section:

Mean depth	3 100m
Young's Modulus	70GPa
Poisson's ratio	0,2
Overburden density	2 750kg/m^3
UCS	220MPa
Stoping width	1,1m
Span	186m

Calculate:

5.1.1 The Energy Release Rate. (3)
5.1.2 The vertical stress 10m from the face. (2)

5.2 How is ERR reduced? (2)

5.3 Why should excessive leads and lags be avoided in deep narrow tabular stopes? (4)

5.4 What do you understand about the term "clamping forces"? What are their significance? (4)

5.5 Calculate the maximum tangential stress on a tunnel situated at a point where σ_1 is vertical, with a magnitude of 280MPa. (k = 0,5). (2)

5.6 Show with a neat free-hand sketch where the maximum tangential stress contemplated in 5.5 will be. (2)

5.7 A tunnel in your mine is approaching a thick dyke that is associated with very poor rock mass conditions. Discuss two strategies that you would consider in order to ensure stability in the tunnel walls where it intersects this dyke. (4)

5.8 Calculate the support resistance required to support a hanging wall beam that is 1,4m thick, and has a density of 3 240kg/m^3. (2)

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QUESTION 6

6.1 You are planning to open up a conventional bord and pillar coal mining section at a mean depth (to seam floor) of 86m. The seam has a mean thickness of 3,2m, and you plan to establish bord widths of 6m, with square pillars 10m x 10m.

Calculate the expected pillar strength, pillar load, and the safety factor. (6)

6.2 Comment on the feasibility of this intended layout. (2)

6.3 If this coal seam was overlain by a jointed sandstone layer with a thickness of 65cm, what maximum tension would you anticipate in the roof beam? (2)

6.4 Answer "True" or "False" to the following:

6.4.1 Split sets are regarded as active support. (1)

6.4.2 Mechanical anchors are regarded as stiff support. (1)

6.4.3 Bolts on the edge of a roadway are more important in preventing beam bending than those in the center of the roadway. (1)

6.4.4 Guttering is caused by high horizontal stress. (1)

6.4.5 Over thrusting is caused by excessive tension in the roof beam. (1)

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TOTAL MARKS **[100]**

Appendix A – Fan test data.

Quantity (m^3/s)	Static Pressure (Pa)
0.00	2 475
0.50	2 310
1.00	2 150
1.50	2 070
2.00	2 160
2.50	2 310
3.00	2 327
3.50	2 193
4.00	1 916
4.50	1 590
5.00	1 210
5.50	835
6.00	411
6.50	0

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MTL3211 – Formulae

Rock Mechanics	
Elasticity	
Stress	$\sigma = \frac{F}{A}$
Strain	$\varepsilon_1 = \frac{\Delta l}{l}$; $\varepsilon_2 = \frac{\Delta d}{d}$
Young's Modulus	$E = \frac{\sigma}{\varepsilon_1}$
Poisson's Ratio	$v = \frac{\varepsilon_2}{\varepsilon_1}$
Modulus of Rigidity	$G = \frac{E}{2(1+v)}$
Principal stress	
Virgin stress	$q_v = \rho g h;\ q_h = k q_v$ $\sigma_v = 0{,}025(H - D) + 0{,}03D$
Stress at a point	$\sigma_y = \frac{qX}{\sqrt{X^2 - L^2}};\ \sigma_x = q(k-1) + \frac{qX}{\sqrt{X^2 - L^2}}$
Stress on the face	$\sigma_{RMS} = 2{,}51q\sqrt{\frac{L}{S_m}}$
Tangential stress	$\sigma_\theta = \frac{q}{2}(1+k)\left(1 + \frac{R^2}{r^2}\right) + \frac{q}{2}(1-k)\left(1 + 3\frac{R^4}{r^4}\right)cos2\theta$
Radial stress	$\sigma_r = \frac{q}{2}\left(1 - \frac{R^2}{r^2}\right) - \frac{q}{2}(1-k)\left(1 - 4\frac{R^2}{r^2} + 3\frac{R^4}{r^4}\right)cos2\theta$
Direction of principal stress	$tan2\theta_p = \frac{2\tau_{12}}{\tau_{11} - \tau_{22}}$
Magnitude of principal stress	$\sigma_p = \frac{\tau_{11} + \tau_{22}}{2} + \frac{\tau_{11} - \tau_{22}}{2}cos2\theta + \tau_{12}sin2\theta$
Maximum shear stress	$\tau_{Max} = \frac{\sigma_1 - \sigma_2}{2}$

Convergence, Critical span, ERR	
Convergence at a point	$S_z = \frac{2(1-v)q}{G}\sqrt{L^2 - X^2}$
Average convergence	$S_{Ave} = \frac{\pi(1-v)Lq}{2G}\ if\ L \leq L_c$ $S_{Ave} = 0{,}79S_m\ if\ L > L_c$
Critical half span	$L_c = \frac{S_m G}{2(1-v)q}$
Energy Release Rate	$ERR = S_{Ave} \times q$
Support	
Support resistance	$\frac{F}{A_T} = \rho g b$
Pillar load	$Load = \frac{25HC_1C_2}{w_1w_2}$
Pillar strength	$Strength = 7\,176\frac{w_e^{0,46}}{h^{0,66}};\ w_e = \frac{4A}{C}$
Pillar Factor of Safety	$SF = 288\frac{w_e^{2,46}}{HC_1C_2h^{0,66}}$
Beam behaviour	
Tension	$\sigma_t = \frac{\gamma L^2}{2t}\ or\ \frac{3\gamma L^2}{t}$
Deflection	$\eta = \frac{\gamma L^4}{32Et^2}$

Rock Properties

Rock type	*UCS (MPa)*	*UTS (MPa)*	*Shear Strength (MPa)*	*Young's Modulus (GPa)*	*Density (kg/m³)*
Sandstone	75	5	15	13	2 480
Shale	75	5	7	15	2 480
Siltstone	70	6	8	1	2 480
Mudstone	40	5	8	7	2 480
Dolerite	190	14	20	100	3 000
Coal	25	5	8	5	1 500

Mine Ventilation	
Airflow	
Pressure drop	$p = RQ^2 = \frac{KCLQ^2}{A^3} \times \frac{\rho}{1,2}$
Resistance	$R = \frac{KCL}{A^3} \times \frac{\rho}{1,2}$
Regulator area	$A = 1,2Q\sqrt{\frac{\rho}{p}}$
Reynolds' Number	$R_e = \frac{\rho v D}{\mu}$
Mechanical ventilation	
Input power	$P_{Input} = VI \times pf \times \sqrt{n}$
Air power	$W_A = \frac{pQ}{1\,000}$
Efficiency	$\eta = \frac{W_A}{P_{Input}} \times 100$
Fan laws:	
Varying speed & constant density	$Q_2 = Q_1\frac{S_2}{S_1};\ p_2 = p_1\left(\frac{S_2}{S_1}\right)^2;\ P_2 = P_1\left(\frac{S_2}{S_1}\right)^3$
Varying density and constant speed	$Q_1 = Q_2;\ p_2 = p_1\frac{\rho_2}{\rho_1};\ P_2 = P_1\frac{\rho_2}{\rho_1}$
Networks	
Resistances in series	$R_{Total} = \sum_{1}^{n} R_n$
Resistances in parallel	$\frac{1}{\sqrt{R_{Total}}} = \sum_1^n \frac{1}{\sqrt{R_n}}$
Gases & mixing of air streams	
Gas concentration	$\%Gas = \frac{Q_{Gas}}{Q_{Mixture}} \times 100$