UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *MINING ENGINEERING* BACCALAURIUS TECHNOLOGIAE *MRM*
SUBJECT	:	**MINING TECHNICAL SERVICES III**
CODE	:	**MTL3211**
DATE	:	SUMMER EXAMINATION 2015 16 NOVEMBER 2015
DURATION	:	(SESSION 1) 08:30 - 11:30
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:

1.1.2 Absolute pressure and gauge pressure. (2)
1.1.3 Static pressure and velocity pressure. (2)

1.2 List four factors that affect the resistance of an airway. (2)

1.3 List four techniques used to combat dust in mines. (2)

1.4 Distinguish between primary and secondary sources of dust in mines and give two examples of each. (3)

1.5 List the properties of the following gases under the headings of "Chemical symbol", "SG", "Sources", and "Hazards".

1.5.1 Carbon monoxide. (2)
1.5.2 Hydrogen sulphide. (2)

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QUESTION 2

2.1 Given that the barometric pressure at mean sea level is 100kPa, calculate the barometric pressure at a point that is 1 420m above mean sea level. (2)

2.2 Calculate the density of air at a pressure of 82kPa and a temperature of 24°C, given that R = 0,2871. (2)

2.3 A tunnel that is 470m long has a mean height of 3,3m and a mean width of 3,8m, and conveys a volumetric flow of air equal to $47m^3/s$ into a mining section at a density of $1,16kg/m^3$. The friction factor is $0,01Ns^2/m^4$.

2.3.1 What is the velocity of the air? (1)
2.3.2 Design a regulator that will restrict the flow to $36m^3/s$. (4)

2.4 Two airways are connected in parallel. Airway 1 is a circular raisebore hole that is 55m long with a diameter of 3,4m, and a friction factor of $0,0086Ns^2/m^4$. Airway 2 is a rectangular tunnel that is 300m long with a mean height of 2,8m, a mean width of 3,2m, and a friction factor of $0,01Ns^2/m^4$. If the combined volumetric air flow through this system is $26m^3/s$ at a density of $1,1kg/m^3$, estimate the pressure drop across the system and the flow through each individual airway. (4)

2.5 You need to supply a quantity of 5,2m^3/s to the face of a prospect winze, and this requires the installation of a fan in a 570mm diameter galvanised ventilation column that is 134m long. The friction factor of the column is 0,003Ns^2/m^4, and the air density is 1,15kg/m^3. You have a fan available, of which the characteristic curve is attached in Appendix A. The fan was tested at a density of 1,15kg/m^3.

2.5.1 Estimate whether the fan will deliver the required volume. (5)
2.5.2 Would this be a good long-term solution? (2)

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QUESTION 3

3.1 What is an emergency? Give two examples. (2)

3.2 List the four main causes of emergencies in mines. (2)

3.3 List four items that should be in place to ensure emergency preparedness/readiness. (2)

3.4 A tunnel that is ventilated with a force-exhaust overlap system has intersected methane, and the concentration measured in the return air is 5,2%. The fan quantity is 4,2m^3/s. By how much must the fan quantity be increased to reduce the methane concentration to the OEL? (4)

3.5 Under what circumstances would it be inappropriate to increase the fan quantity? (1)

3.6 Using the data in the table below, construct a fully labelled Coward's Diagram for methane gas. (4)

Gas	Flammable Limits (%)		Nose Limits (%)		N^+
	Lower	Upper	Gas	Oxygen	
CH_4	5,0	14,0	5,9	12,2	6,07
CO	12,5	74,2	13,8	6,1	4,13
H_2	4,0	74,2	4,3	5,1	16,59

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QUESTION 4

4.1 Distinguish between:

4.1.1 Shear stress and tensile stress. (2)
4.1.2 Virgin stress and induced stress. (2)
4.1.3 Axial strain and radial strain. (2)

4.2 Explain the following terms:

4.2.1 UCS. (3)
4.2.2 Poisson's Ratio. (3)
4.2.3 Support Resistance. (3)

4.3 Calculate the vertical virgin stress in a coal seam at a depth of 85m, given that the overburden contains two dolerite sills with a combined thickness of 27m. (2)

4.4 Draw a neat free-hand sketch of a Mohr circle, and clearly label all of its components. (3)

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QUESTION 5

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

Mean depth	2 600m
Young's Modulus	75GPa
Poisson's ratio	0,21
Overburden density	2 750kg/m^3
UCS	220MPa
Stoping width	1,1m

Calculate:

5.1.1 The elastic convergence at a point 12m from the face when the half span is 85m. (2)
5.1.2 Critical half span. (2)
5.1.3 Vertical stress on the face when the half span is 100m. (2)

5.2 Explain the mining strategy "Mine towards solid". Make use of a sketch to support your answer. (4)

5.3 What is a gully siding, and what is its purpose? (4)

5.4 You have to develop a twin airway system at a depth of 2 400m. Both tunnels will have a width of 3,5m, and a height of 3,3m. How far apart will you place these tunnels, and for what reason? (4)

5.5 You have to design a support system for a shallow stoping section where the rock density is 3 200kg/m^3 and the height of instability is 1,1m. You intend using 180kN support units. Because of the width of the scraper used, you require a strike spacing of at least 1,8m. Recommend a suitable dip spacing. (Assume that no safety factor is required). (2)

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QUESTION 6

6.1 A CM section in a coal mine has a road width of 6,2m. The roof is composed of a shale layer with a thickness of 85cm.

6.1.1 Estimate the maximum tension in the roof beam, given that it is unjointed. (2)

6.1.2 What would the maximum deflection be? (2)

6.2 Discuss the following failure mechanisms in terms of causes and remedies:

6.2.1 Thin falls between bolts, no rock left between washer & roof. (3)

6.2.2 Thin falls between bolts, rock left between washer & roof. (3)

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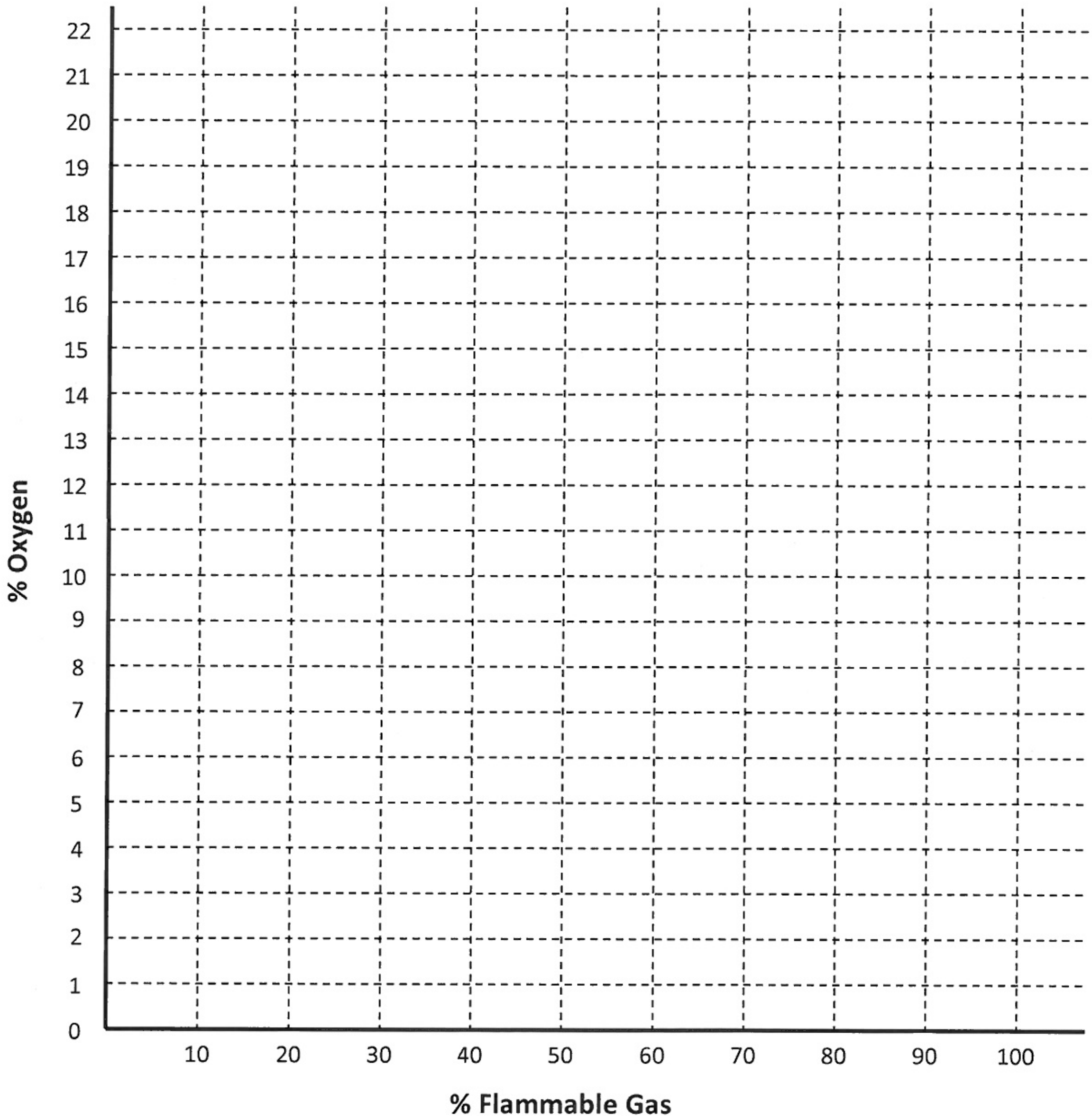
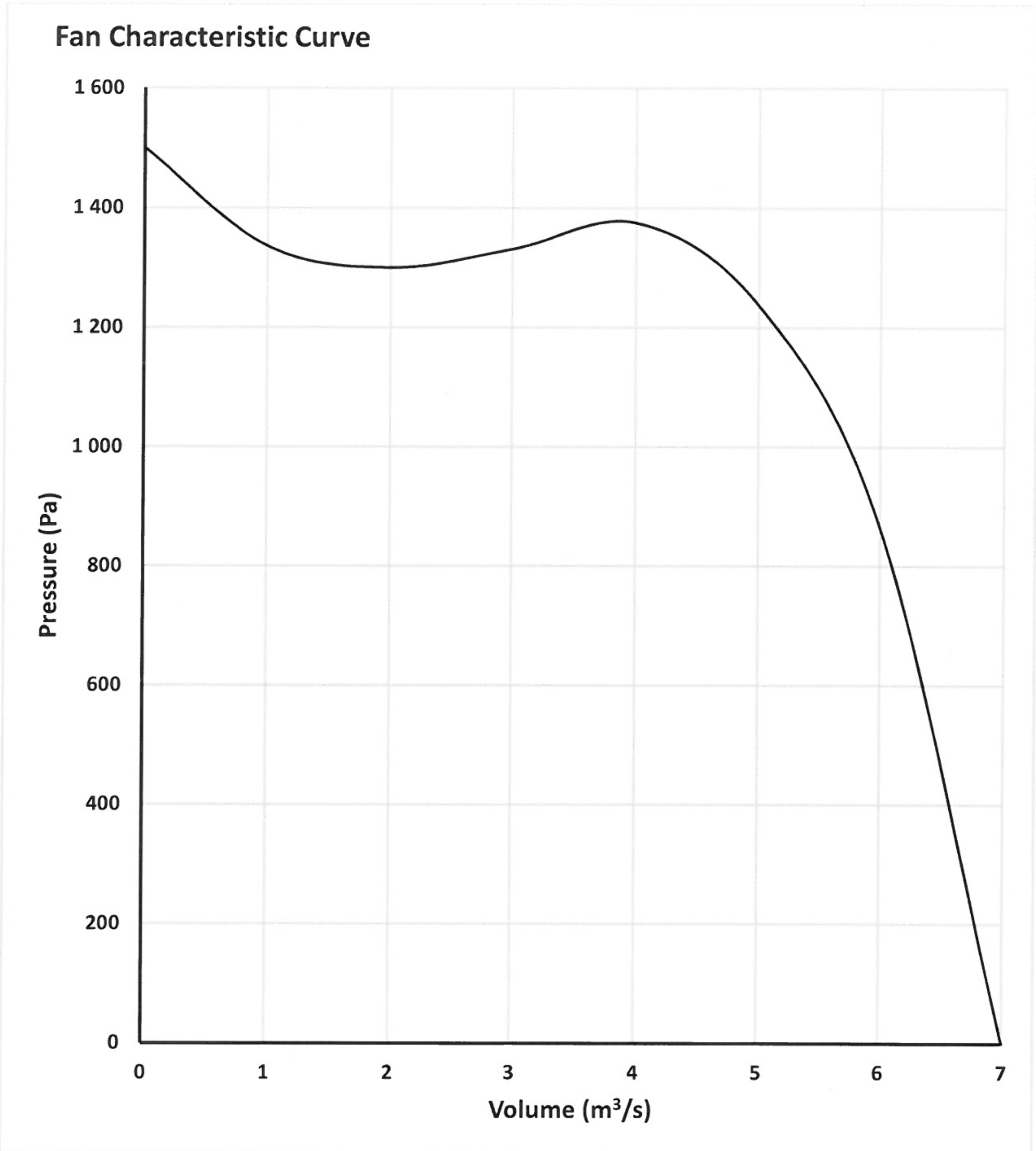
TOTAL MARKS **[100]**

Student Number: ....



Appendix A
Submit if used. Student Number: ....



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/m^3)*
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	$\mathrm{R} = \frac{KCL}{A^3} \times \frac{\rho}{1{,}2}$
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	$\%Gas = \frac{Q_{Gas}}{Q_{Mixture}} \times 100$