

Minerals Council South Africa

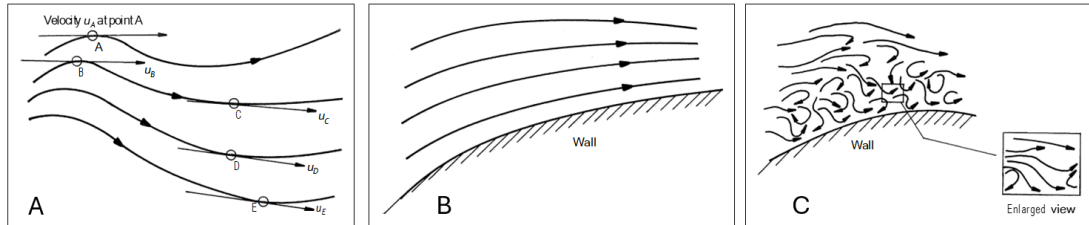


EXAMINATION PAPER

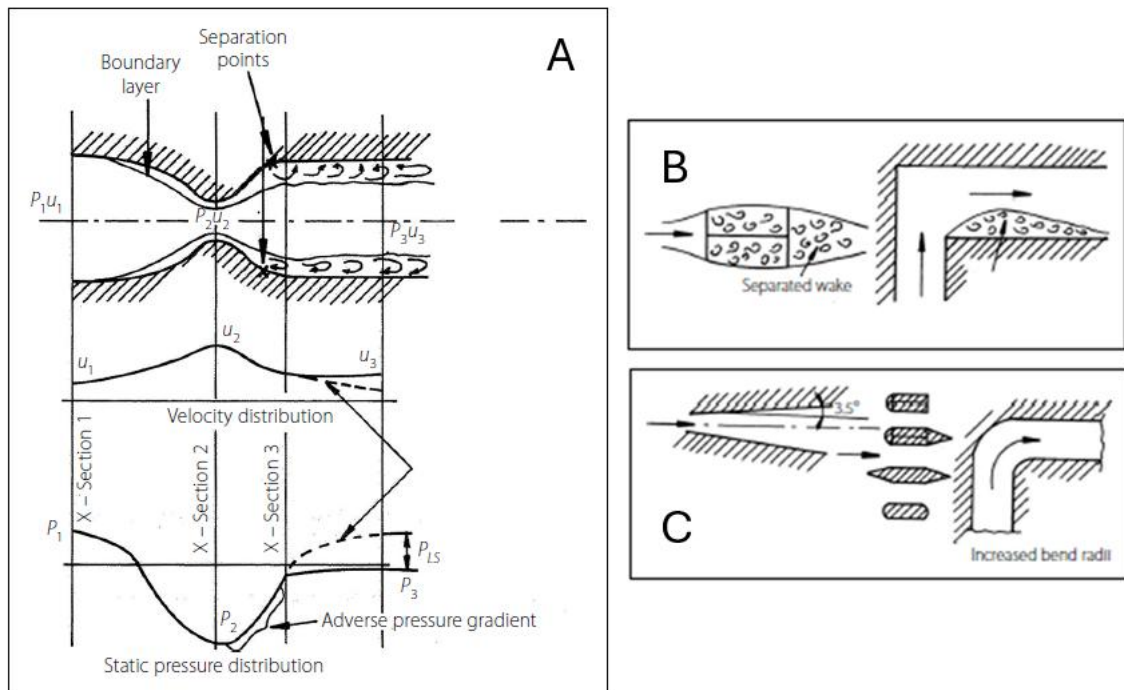
SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 1 - FLOW DYNAMICS, AIRFLOW, FANS, MINE WATER SUBJECT CODE: COMMEC1 EXAMINATION DATE: 11 MAY 2026 TIME: 14:00 – 17:00 (3 HOURS)	EXAMINER: George Mapele MODERATOR: Marthinus van der Bank TOTAL MARKS: [100] PASS MARK: (60%)
NUMBER OF PAGES: 7 (including this page)	
<u>SPECIAL REQUIREMENTS:</u> <p style="color: red; text-align: center;"><i>All candidates are advised to read the below instructions/requirements and adhere to them. Not adhering to them could lead to the loss of marks.</i></p> <p>THIS IS <u>NOT</u> AN <u>OPEN BOOK EXAMINATION</u>. FORMULA HANDOUTS AVAILABLE</p> <ol style="list-style-type: none"> Answer all 4 questions <u>legibly</u> in English. Write your <u>ID number</u> on the outside cover of each book used and on any graph paper or other loose sheets handed in. <p><u>NB:</u> Your name must not appear on any answer book or loose sheets.</p> <ol style="list-style-type: none"> Show all calculations and check calculations on which the answers are based. Hand-held electronic calculators may be used for calculations. Write <u>legibly</u> in ink on the <u>right-hand page</u> only – <u>left hand pages will not be marked</u>. Illustrate your answers by means of sketches or diagrams wherever possible. Answers must be given to an accuracy which is typical of practical conditions. <p><u>NB:</u> Ensure that the correct unit of measure (SI unit) is recorded as marks will be deducted from answers if the incorrect or no units are used. (Even if the calculated value is correct).</p> <ol style="list-style-type: none"> Please note that you are not allowed to contact your examiner or moderator regarding this examination. Cell phones and any other electronic devices are <u>NOT</u> allowed in the examination room. <u>Only Calculator</u> You are encouraged to make use of the CoMCert Tip-off Hotline whenever you witness or suspect any wrongdoing related to the CoMCert Examinations on landline 0800 118 998 or alternatively you can use email COMCert@tip-offs.com. This tip-off hotline and tip-off email is managed anonymously and confidentially through an independent service provider. 	

QUESTION 1

- 1.1. Explain in **Figure 1 (A to C)** below what is a streamline in fluid flow, and how does the arrangement of streamlines indicate whether the flow is laminar (streamlined) or turbulent? (6)

**Figure 1 (A to C)**

- 1.2 Using Bernoulli's equation, explain in **Figure 2 (A to C)** below why the airflow shown in the figure experiences boundary-layer separation at Sections 2 and 3. In your answer, discuss how the changes in velocity distribution (u_1, u_2, u_3) and static pressure distribution (P_1, P_2, P_3) along the surface contribute to the formation of an adverse pressure gradient and the resulting dead-air regions. (11)

**Figure 2**

- 1.3 Explain which law is illustrated below in **Figure 3** and explain how Newton's second law relates to that law. (3)

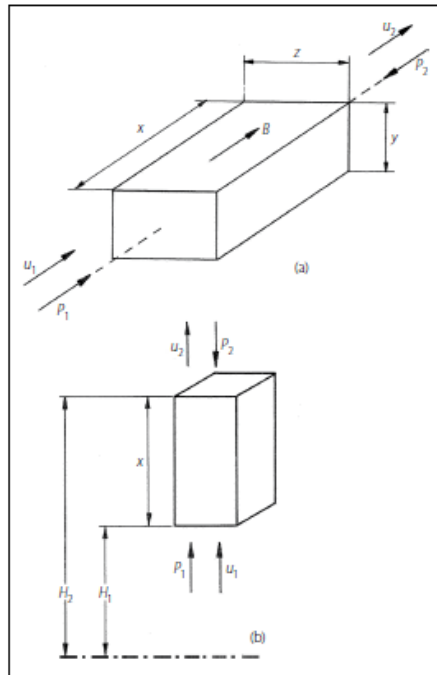


Figure 3

- 1.4 Explain how tunnel ventilation systems maintain a safe and comfortable environment under normal, congested, emergency, and maintenance modes.

In your answer, describe the roles of natural ventilation, vehicle-induced airflow (piston effect), and mechanical ventilation, and discuss why uni-directional and bi-directional tunnels differ in their ventilation needs. (10)

[30]

QUESTION 2

- 2.1 At an existing mine it has been decided to extend mining by an additional 350 m of vertical depth using a new sub-vertical shaft system.

The following information was obtained during the execution plan for the shaft extension and ventilation requirements:

Airflow available at A = $150\text{m}^3/\text{s}$

Air density = $1.2\text{kg}/\text{m}^3$ (Ignore compressibility effects.)

Airway Dimensions and Lengths			
Airway	Size	Length	Comment
A–B	5.5 m diameter	320m	Sub-vertical shaft
B–C	Twin $3.0 \times 3.2\text{m}$	1 000m	Twin crosscuts
C–E1	$3.0 \times 3.2\text{m}$	1 300m	Footwall drive
C–D1	$3.0 \times 3.2\text{m}$	1 800m	Footwall drive
F1–H	$3.0 \times 3.0\text{m}$	1 950m	Return airway
G1–H	$2.8 \times 3.0\text{m}$	1 200m	Return airway
H–I	$4.0 \times 4.4\text{m}$	350m	Return airway

Additional information

Friction factors	
Horizontal airways	$k = 0.014\text{Ns}^2/\text{m}^4$
Sub-vertical shaft	$k = 0.018\text{Ns}^2/\text{m}^4$
Raise-line resistances	
Each raise line	$R = 0.10\text{Ns}^2/\text{m}^8$
Distance between raise lines	180m

Determine the total pressure difference between points A and I.

(20)

[20]

QUESTION 3

The information below represents a leakage free ventilation system consisting of two parallel branches supplied by a single fan through a main duct AB.

- **Main duct AB** carries a total airflow of **12m³/s**.
- At point **B**, the airflow splits into two branches:

Branch	Airflow	Pipe Diameter
BC	4m ³ /s	520mm
BD	8m ³ /s	880mm

Additional information:

- Static pressure at the fan intake (**point A**) = **-2.6kPa**
- Static pressure at point **B** = **-1.8kPa**
- Air density = **1.25kg/m³**
- The existing fan curve is to be drawn in the answer script.
- Due to operational changes, an equal airflow is now required in both branches.
- It has been decided that the most economical approach is to install a regulator in the **880mm branch (BD)**.

3.1 Determine:

3.1.1 The pressure loss in the main duct **AB**. (3)

3.1.2 The pressure loss across the parallel section **BC // BD**. (3)

3.2 Using the given flowrates and pipe diameters:

3.2.1 Calculate the flow resistance of branches **BC** and **BD** using (2)

$$R = \frac{p}{Q^2}$$

3.2.2 Determine the additional resistance that must be added to the **BD** branch so that both branches carry **equal flowrates** of **6m³/s** each. (2)

3.2.3 Calculate the required **pressure drop** across the regulator at this new equal-flow condition. (2)

3.2.4 Determine the required regulator throat area. (2)

3.3 The regulator equalises the resistances of both branches.

3.3.1 Determine the new combined resistance of the parallel branches. (3)

3.3.2 Determine the total system resistance, including duct AB. (1)

3.3.3 Using the system resistance, estimate the new fan volume flowrate and corresponding fan pressure by plotting the system curve onto the fan curve and identifying the operating point. (3)

3.4 In mining practice:

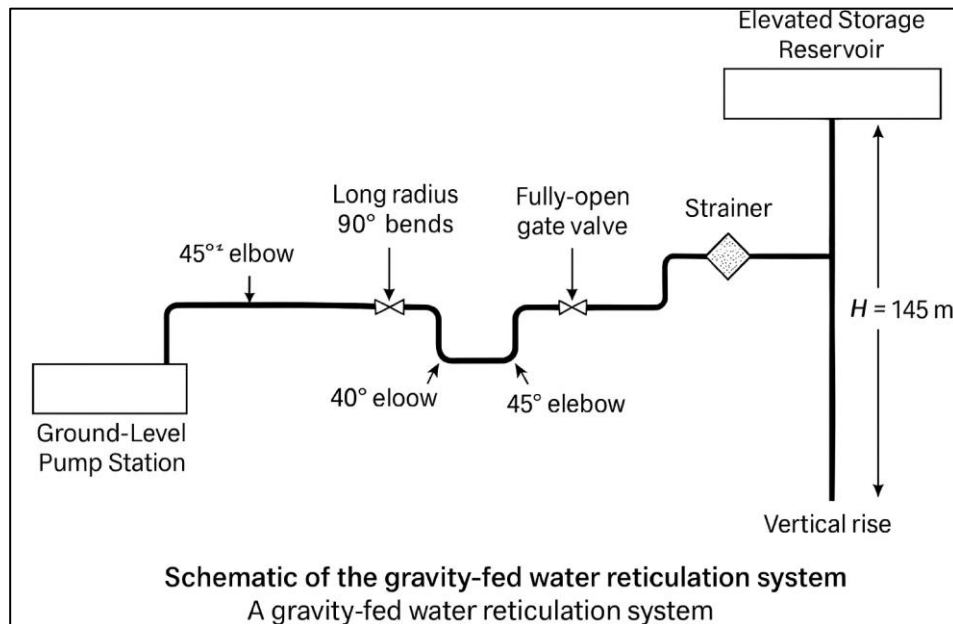
3.4.1 Where should the regulator in the BD branch be installed? (1)

3.4.2 Briefly justify your choice of regulator position with at least two engineering reasons related to performance, accessibility, or measurement reliability. (3)

[25]

QUESTION 4

A new gravity fed water reticulation line is installed to supply an elevated storage reservoir from a ground-level pump station. The system layout is shown below (you may assume a similar sketch format to the one in the source example, but the geometry and dimensions below define the system):



- Vertical rise: $H = 145m$
- Total horizontal distance: $1\,420m$
- Pipe material: Ductile iron
- Internal pipe diameter: $d = 225mm$
- Flow rate: $Q = 42L/s$
- Water temperature: $20^{\circ}C$
- Water density: $\rho = 998kg/m^3$

Pipe fittings present in the system:

1. **6 × 45° elbows**
 - Equivalent length per elbow = $2.8m$
2. **3 × 90° bends (long radius)**
 - Equivalent length per bend = $4.5m$
3. **2 × gate valves (fully open)**
 - Equivalent length per valve = $1.7m$
4. **1 × strainer**
 - Equivalent length = $12m$
5. **Pipe entrance from pump manifold**
 - Equivalent length = $4.2m$

Friction characteristics:

- Darcy–Weisbach friction factor (assume): $f = 0.021$

- | | | |
|-----|---|-----|
| 4.1 | Determine the total equivalent length of the reticulation system. | (5) |
| 4.2 | Using the Darcy-Weisbach equation, calculate the friction head loss. | (8) |
| 4.3 | Determine the total dynamic head (THD) required from the pump system. | (4) |
| 4.4 | Express the total head loss in kilopascals (kPa). | (4) |
| 4.5 | Provide a short engineering comment on whether the selected pipe diameter (225 mm) is appropriate for the flow rate, based on typical recommended velocities. | (4) |

[25]

TOTAL MARKS: [100]