Question 1 **10 Marks**

In Addition to the legal duties and appointments of Environmental Engineering and Occupational Hygiene, [(Regulation 5.1(1), 9.2(3) and 16.1(1)], normal work of the department entails?

(Any 10) 1 mark each

- The general planning, distribution and control of the ventilating air of a Mine.
- Checking the condition and effectiveness of ventilation appliances, for example, booster and auxiliary fans, ducts, doors, regulators, etc. and the efficiency of air utilization.
- Measuring and recording the air distribution system of a mine (airflow surveys) and update the Ventilation and Rescue Plans.
- Carry out pressure surveys.
- Checking on the application and adherence of the applicable regulations.
- "Trouble Shooting" in areas where there are gas, air borne pollutants or airflow problems.
- Checking for any ventilation leakage and control thereof.
- Selecting, controlling and issuing auxiliary fans.
- Planning for ventilation control in case of Main or Booster fan failures, fires, explosions, seismic events or any other emergency procedures related to Environmental Control.
- Ordering and issue ventilation stores and equipment.
- Routine environmental observations in all workings, and reporting on conditions recorded.

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Question 2 **20 Marks**

2.1 List the main causes of underground fires? **(Any 6) 1 mark each**

- Electrical sources.
- Frictional sources (Scraper ropes, conveyor belts – etc.)
- Blasting and incorrect use of ignitor cord.
- Welding torches.
- Smoking or contraband.
- Diesel engines and fuel.
- Flammable fluid of gasses.
- PVC or similar materials.
- Methane or other gas explosions.
- Impacting generating sparks.
- Discharges of accumulation of static electricity.
- Spontaneous combustion
- Arson

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2.2 List the main causes of surface fires? **(Any 4) 1 mark each**

- Electrical sources.
- Frictional sources (Scraper ropes, conveyor belts – etc.)
- Cutting and welding sources.
- Smoking or contraband.
- Spontaneous ignition.

- Veld fires.
- Arson

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2.3 What forms an integral part of the escape strategy of a mine and describe what they should comply to?

1 mark each

- Escape Routes. Must be easily accessible and free from obstructions.
- Displayed at the waiting place of all underground working places as well as surface structures.
- Reviewed / revised and updated on a regular basis, preferable after a routine inspection of the working place and following ventilation change overs.
- Escape routes must be clearly demarcated with symbolic signs from the working place to the applicable refuge bay.
- Installation of lifelines where required.

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2.4 What factors are essential to an effective escape strategy?

(Any 3) 1 mark each

- Training
- Regular fire drills
- Demarcation of the route
- Accessibility of the route.
- Shortest route to the refuge bay.

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2.5 What is the role of an Early Warning device within the work place? **1 mark each**

- To Sense the first signs of a fire or explosion.
- Communicate an alarm so that evacuation of the mine or part of the mine can take place safely.
- Through reasonable uncontaminated, obstruction free escape routes and control measure can be taken at the earliest time.

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Question 3 **20 Marks**

3.1 What is the pressure loss when air at a velocity of 16.0m/s flows along a galvanised duct that has a friction factor of $0.004Ns^2/m^4$, a length of 350m and diameter of 610mm, the density is $0.93kg/m^3$?

Given that K = $0.004Ns^2/m^4$

$L = 350m$
$V = 16.0m/s$
$C = \pi D = (3.14 \times 0.61) = 1.915m^2$ (1)
$A = \frac{\pi D^2}{4} = \frac{(3.14 \times 0.61)^2}{4} = 0.292m2$ (1)
$w = 0.93kg/m^3$

Now $P = \frac{KCLV^2}{A} \times \frac{w}{1.2}$

$= \frac{0.004 \times 1.915 \times 350 \times (16)^2}{0.292} \times \frac{0.93}{1.2}$ (6)

$= 1822Pa$ (2)

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3.2 Calculate the friction factor of a haulage in which $57.2m^3/s$ flow at a pressure loss of 250pa. The length of the haulage is 170m and is 2.5m x 3.0m. The prevailing density is $1.15kg/m^3$. Is this a rock lined or heavy supported airway?

Given that
$P = 250Pa$
$C = 2(3.0 \times 2.5) = 11.0m$ (1/2)
$A = (3.0 \times 2.5) = 7.5m^2$ (1/2)
$Q = 57.2m^3/s$
$L = 170m$
$w = 1.15kg/m^3$

Now $P = \frac{KCLV^2}{A} \times \frac{w}{1.2}$

Re-arranging the formula

$K = \frac{PA^3}{CLQ^2} \times \frac{1.2}{W}$ (1)

$= \frac{250 \times (7.5)^3 \times 1.2}{11.0 \times 170 \times (57.2)^2 \times 1.115}$ (5)

$= 0.018Ns^2/m^4$ (1)

Interpretation of the result: .... (2)
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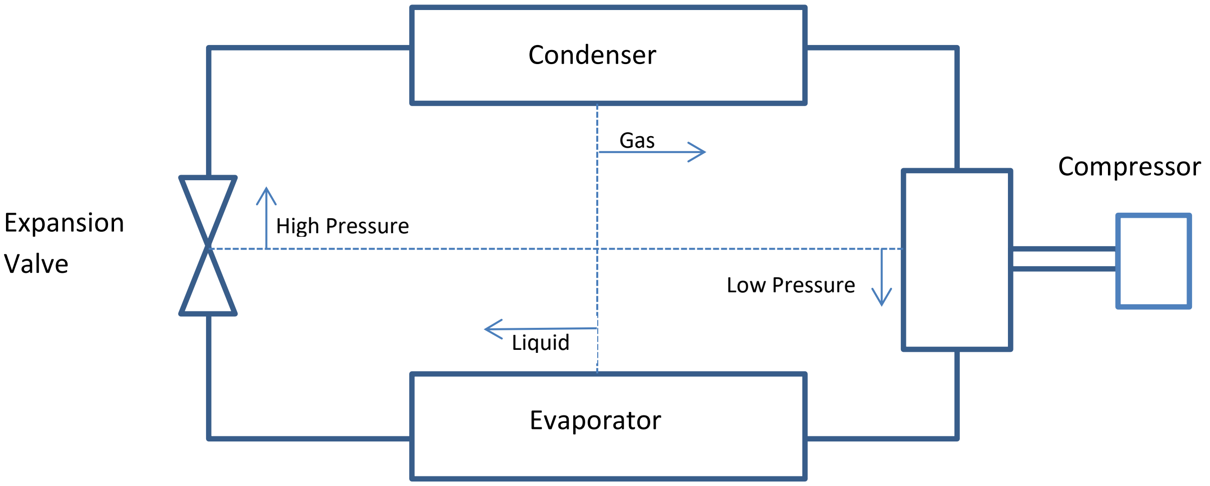
Question 4 **20 Marks**

4.1 Sketch a Vapour Compression Refrigeration Cycle. List all components and associated information of a typical refrigeration plant. (8)



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4.2 List and describe the function of each main component of the Vapour Compression Refrigeration Cycle

(3) Marks each (12)

Evaporator
The refrigerant enters the evaporator as a cool liquid and absorbs heat from the medium to be cooled (usually water) which flows inside the evaporator tubes. As the refrigerant liquid absorbs the heat from the warmer water, it starts to evaporate into a refrigerant gas by absorbing latent heat at a constant temperature. The refrigerant leaves the evaporator as a gas at a low temperature and pressure.

Compressor
The refrigerant gas at a low temperature and pressure is sucked into the compressor where it is compressed, aging sensible heat to the gas. The refrigerant gas now leaves the compressor at a high temperature and pressure.

Condenser
The hot refrigerant gas at a high pressure flows into the condenser and transfer the heat to a medium (water), which flows inside the condenser tubes. The water absorbs the sensible heat add by the compressor and the latent heat added by the evaporator. The refrigerant gas condenses to a liquid and leaves the condenser at a high temperature and pressure.

Expansion Valve
The refrigerant liquid then enters the expansion valve where the pressure is released, and the refrigerant liquid expands, cools down and flows back to the evaporator, where the whole cycle is repeated, continuously.

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Question 5 **30 Marks**

5.1 The following figures were obtained from a fan test conducted on a direct driven axial flow fan:

Fan speed: 15.5 r/s
Air density: 1.012 kg/m^3

Quantity (m3/s)	Pressure (Pa)	Input Power (kW)
0	930	3.6
2	840	4.6
4	870	5.9
6	910	7.8
8	860	10.0
10	730	12.4
12	490	14.7
13	310	15.0
14	0	14.6

From these figures draw a complete fan performance curve, including power and efficiency curves.

Determine the fan operating point, input power and efficiency of this fan if it is installed in a 760mm galvanised ducting, 54m long, having a frictional factor of 0.0035 Ns/m^8 at a prevailing density of 1.012kg/m^3.

Fan performance curve

- Plot Quantity on (horizontal or x-axis) against pressure (vertical or y-axis)
- Plot quantity against input power (y-axis) on left side of graph
- Indicate the fan efficiency and power consumption scales on the right hand side of the graph.

(6)

Calculate the Air-power and fan efficiency

Air-power = $\frac{PQ}{1000}$ (1)

Efficiency = $\frac{\text{Airpower}}{\text{Fan input power}}$ x 100% (1)

(1/2 each) (1/2 each) (8)

Quantity (m3/s)	Pressure (Pa)	Input Power (kW)	Air-Power kW **Wa = $\frac{PQ}{1000}$**	Efficiency % **= $\frac{\text{Airpower}}{\text{Fan input power}}$ x 100%**
0	930	3.6	0	0
2	840	4.6	1.7	37.0
4	870	5.9	3.5	59.0
6	910	7.8	5.5	70.0
8	860	10.0	6.9	69.0
10	730	12.4	7.3	59.0
12	490	14.7	5.9	40.0
13	310	15.0	4.0	27.0
14	0	14.6	0	0

From the above table, draw the efficiency curve by plotting the quantity (x-axis) against the (y-axis) on the same graph paper.

(1 for each curve)

The fan is to be installed in a 760mm galvanised, 54m long, having a frictional factor of 0.0035 Ns/m^8 at a prevailing density of 1.012kg/m^3. The system resistance can now be calculated:

$$R = \frac{KCL}{A^3}$$

(Note w/1.2 was not included as both the fan and system density are at a density of 1.012 kg/m³)

$$= \frac{0.0035 \times 2.386 \times 54}{(0.453)^3} \qquad (1)$$

$$= 4.85\ Ns^2/m^8 \qquad (1)$$

Calculate the points on the graph for the system resistance curve, use $P = RQ^2$

(6)

Q	2	4	6	8	10	12	14
R	4.85	4.85	4.85	4.85	4.85	4.85	4.85
P	19	78	15	310	485	686	951

175 698

From the above table, draw the efficiency curve by plotting the quantity (x-axis) against the (y-axis) on the same graph paper.

(1)

Read off the Fan Operating Point (FOP) from the graph.
System resistance curve intersects the fan characteristic curve.

Pressure = 610 Pa
Quantity = 11.2 m^3/s

Read off the Fan efficiency from the quantity line intersection of the Efficiency curve on the right hand efficiency scale.
Efficiency = 49 %

Read off the Input power of the fan, from the quantity line vertically up till it intersects the power curve on the right hand power scale.
Input power = 13.8 kW

Thus the F O P = 11.2 m3/s @ 610 Pa (1)

Fan input power = 13.8 kW (1)

Fan Efficiency = 49 % (1)

Total [100 Marks]