GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

PARTICULATE SYSTEMS

EMR 5201/EMR 2101

Part V Second Semester Examination Paper

June 2023

This examination paper consists of 4 printed pages

Time Allowed: **3 hours**

Total Marks: **100**

INSTRUCTIONS

1. Answer **ALL questions in Section A and any TWO from Section B**
2. Each question carries 25 marks
3. Use of calculators is permissible

Additional Requirements

1. Calculator
2. Graph paper

MARK ALLOCATION

Section A	50 Marks
Section B	50 Marks
Part Marks	As shown in each part question
Total Attainable	100

SECTION A (50 MARKS)

ANSWER ALL QUESTIONS

Question A1

a) Explain how sieve analysis is used in determining the particle size of gold ore **[6]**

b) Using an example of a metallurgical process, describe how a drum filter operates **[5]**

c) Give three differences and three similarities between deep bed filtration and filtration with cake formation **[6]**

d) Calculate the upper limit of particle diameter, $x_{max,}$ as a function of particle density ρ_p for gravity sedimentation in the Stokes' law regime. Plot the results as x_{max} versus ρ_p over the range $0 \leq \rho_p \leq$ 8000 kg/m^3 for settling in water and in air at ambient conditions. Assume that the particles are spherical and that Stokes' law holds for $Re_p \leq 0{:}3$. **[8]**

Question A2

(a) Describe how you can use the sedimentation process to determine particle size. **[5]**

(b) With the aid of diagrams explain the following

i. Martin's diameter **[3]**

ii. Feret's diameter **[3]**

(c) Determine the sphericity of a particle which has a surface area of 20 mm^2 and volume of 4 mm^3 . **[5]**

(d) A sphere of diameter 10 mm and density 7700 kg/m^3 falls under gravity at terminal conditions through a liquid of density 900 kg/m^3 in a tube of diameter 12 mm. The measured terminal velocity of the particle is 1.6 mm/s. Calculate:

i. Viscosity of the fluid. **[4]**

ii. Verify that Stokes' law applies. **[4]**

SECTION B (50 MARKS)

ANSWER ANY TWO QUESTIONS

Question B1

(a) Explain the effect of particle shape on the following properties of particulate solids.

i. Packing **[3]**

ii. Flowability **[3]**

(b) Describe how density and viscosity affect the terminal velocity of particles **[4]**

(c) Compare and contrast sprouted and bubbling fluidisation. Explain one application for each fluidisation **[10]**

(d) Coal particles having a diameter of 0.24 mm are fluidised using air. The particles have a shape factor of 0.79.The air is injected at a pressure of 3 atm and at a temperature of 25 ^{o}C. The air has a viscosity of 1.845 x 10^{-5} kg/ms and a molecular weight of 28.97. The voidage of the bed at minimum fluidiation is 0.42. Calculate the minimum fluidisation velocity. **[5]**

Question B2

(a) Explain four factors affecting cake formation during filtration **[8]**

(b) You are a metallurgist drying coal fines using a fluidised bed reactor. Explain why it is important to determine the following

i. Point of incipient fluidisation **[4]**

ii. Minimum fluidisation velocity of the coal fines. **[3]**

(c) The screen analysis below is of crushed quartz. The density of the particles is 2650 kg/m^3 whereas the shape factors are = 0.8 and ϕ_s = 0.571.

Plot graphs to show

i. Cumulative fraction larger than D_{pi} **[6]**

ii. Differential or fractional distribution **[4]**

i	Mesh	Screen opening, D_{pi}, (mm)	Mass fraction
14	4	4.699	0
13	6	3.327	0.0251
12	8	2.362	0.1250
11	10	1.651	0.3207
10	14	1.168	0.2570
9	20	0.833	0.1590
8	28	0.589	0.0538
7	35	0.417	0.021
6	48	0.295	0.0102
5	65	0.208	0.0077
4	100	0.147	0.0058
3	150	0.104	0.0041
2	200	0.074	0.0031
1	pan	-	0.0075

Question B3

a) Briefly describe how you can determine the size of gold particles **[3]**

b) With the aid of metallurgical applications, explain why it is important to determine the following properties

i. Porosity of particles,

ii. Voidage in a particle mixture,

iii. Total surface area of a mixture **[12]**

c) A uniform particulate sample consist of spherical particles of size 2 mm and density 2650 kg/m^3. If the mass of the sample is 20 kg calculate:

i. The total number of particles **[5]**

ii. The total surface area of the particles **[5]**

END OF QUESTION PAPER