GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

PARTICULATE SYSTEMS

EMG 2102

Part II First Semester Examination Paper

November 2023

This examination paper consists of 6 printed pages

Time Allowed: **3 hours**

Total Marks: **100**

INSTRUCTIONS

1. Answer **any FIVE questions**
2. Each question carries 20 marks
3. Use of calculators is permissible

Additional Requirements

1. Calculator
2. Graph paper

MARK ALLOCATION

Part Marks	As shown in each part question
Total Attainable	100

Question 1

a) Explain how you can use the sedimentation method to determine the particle size distribution, giving two assumptions you will make during the process. **[5]**

b) Particle size is an important factor to consider in metallurgical processes. Explain with an example the effect of particle size on the processes below

i. Dissolution of solid chemicals in liquids **[3]**

ii. Flow properties of powders through channels **[4]**

c) A cuboid particle has the following dimensions, 1mm x 2 mm x 4 mm. Calculate

i. the equivalent volume sphere diameter **[3]**

ii. the surface-volume equivalent sphere diameter **[5]**

Question 2

(a) What do you understand by sphericity? **[2]**

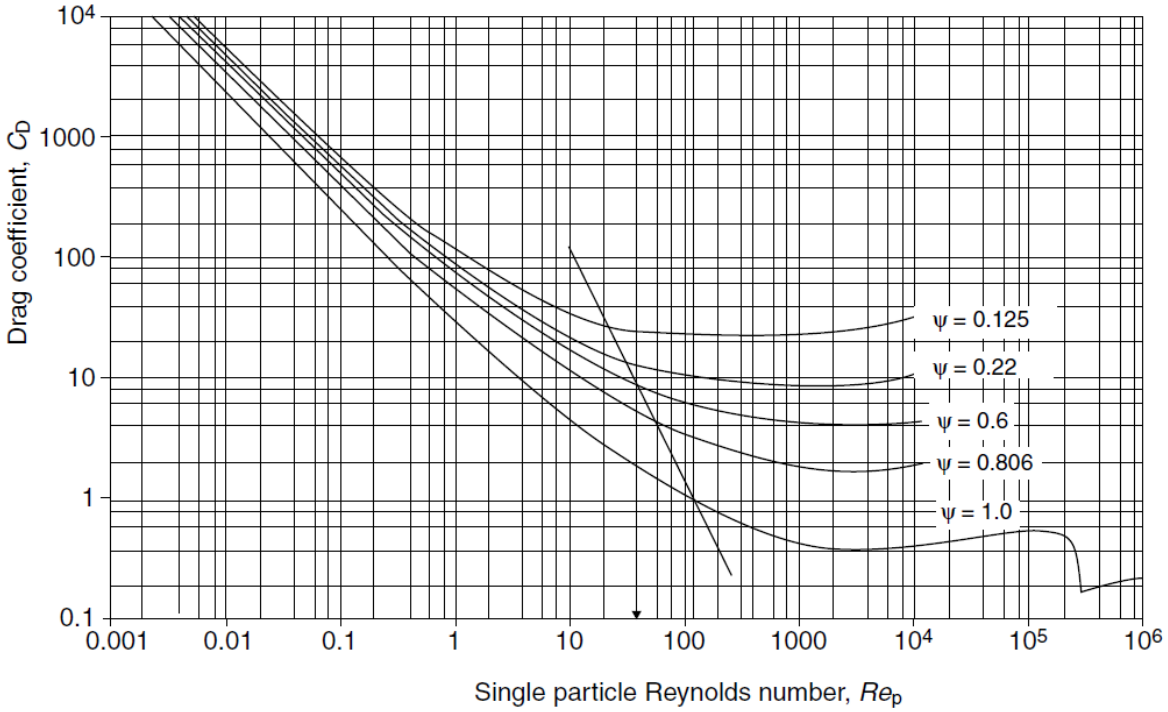
(b) Explain two ways used to develop a pressure difference during filtration **[4]**

(c) Give and explain one filtration method used to increase the solid concentration of a suspension **[3]**

(d) You are the metallurgical engineer for company X. You are responsible for the blast furnace for iron refining. Why do you think it is important to know the properties of chemical particles (e.g limestone) you load into the blast furnace **[5]**

(e) A particle of equivalent volume diameter 0.5 mm, density 2000 kg/m^3 and sphericity 0.6 falls freely under gravity in a fluid of density 1.6 kg/m^3 and viscosity 2 x 10^{-5} Pa s.

Estimate the terminal velocity reached by the particle. **[6]**



Question 3

(a) Explain how elutriation is used in determining the particle size of gold ore **[4]**

(b) You have been tasked to determine the particle size of diamond particles using a microscope. Explain how you will do it **[4]**

(c) Briefly describe equivalent circle diameter and explain where it can be applied **[2]**

i	Mesh	D_{pi} (mm)	x_i
14	4	4.699	0.0000
13	6	3.327	0.0251
12	8	2.362	0.1251
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	0.0210
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

d) Using the screen analysis above to determine the following

A_w **[5]**

N_w **[5]**

Question 4

(a) List and explain two forces that affect the terminal velocity of particles falling under gravity in a liquid **[5]**

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

i. shape of particles, **[4]**

ii. average particle size in a mixture, **[3]**

iii. and composition of a mixture **[2]**

c) Oil, of density 900 kg/m^3 and viscosity 3 mN s/m^2, is passed vertically upwards through a bed of catalyst consisting of approximately spherical particles of diameter 0.1 mm and density 2600 kg/m^3. At approximately what mass rate of flow per unit area of bed will

i. Fluidization take place, **[4]**

ii. transport of particles occur **[2]**

Question 5

a) Explain the effects of particle shape on voidage **[2]**

b) Briefly describe 2 advantages and 2 disadvantages of vacuum filtration **[4]**

c) With the aid of an example, explain how you can determine the total surface area of a mixture of solid particles **[6]**

d) The following data belong to lab tests undertaken on a calcium carbonate slurry. The filter area equals 0.045 m^2 and the solid concentration in the slurry is 24 kg/$m^{3.}$ Evaluate

i. the mean specific cake resistance **[4]**

ii. the filter medium resistance at a fixed pressure of 50 kPa. **[4]**

Question 6

a) Sketch a plot of pressure drop across a bed of powder versus velocity of the fluid flowing upwards through it in a fluidised bed reactor. Indicate the packed bed, fluidized bed regions and the incipient fluidization velocity. **[5]**

b) A 200 mL beaker weighs 200 g when full of a powder and 50 g when empty.

The bed voidage can be taken to be 0.45, the mean particle diameter is 200 μm, and the proportion of each particle occupied by pores is 0.3. Calculate

i. bulk density, **[3]**

ii. particle density, **[3]**

iii. material density **[4]**

c) A reactor contains cylindrically shaped catalyst particles. The particles have a diameter of 1.25 cm and a height of 2 cm. A gas having a density of 1.28 kg/m^3 and a viscosity of 1.73 x 10^{-5} Pa s flows at a steady rate through the bed. The bed has a voidage of 0.4. If the superficial velocity established is 0.6 m/s and the pressure drop through the bed is 2.5 kPa. Calculate the bed height **[5]**

END OF QUESTION PAPER