



FACULTY OF ENGINEERING AND THE ENVIRONMENT
DEPARTMENT OF METALLURGICAL ENGINEERING
PARTICULATE SYSTEMS
EMG 5201
Final Examination Paper
June 2025

This paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner: Dr L. Mugwagwa

INSTRUCTIONS

1. This paper contains ONE section with **SIX (6)** questions.
2. Answer any **FIVE (5)** questions.
3. Each question carries 20 marks.
4. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
5. Illustrate your answer, where appropriate, with clearly labeled diagrams.
6. Started each question on a new page.
7. This paper comprises of 4 printed pages

Additional requirements:

Calculator

Question 1

- a) Explain how laser diffraction spectrometry is used to determine particle size [4]
- 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 [3]
 - ii. Minimum fluidisation velocity of the coal fine [3]
- c) List and explain two factors that you consider when selecting filtration equipment [4]
- d) Calculate the equivalent volume sphere diameter and the surface-volume equivalent sphere diameter of a cuboid particle of side length 10 mm x 6 mm x 5mm [6]

Question 2

- a) Explain how microscopy is used in analysing the size of nanoparticles. Give two advantages and two disadvantages of microscopy. [6]
- b) Using a diagram describe how bed height affects the drying of coal particles using a fluidised bed reactor [4]
- c) Sketch a plot of pressure drop across a bed of powder versus velocity of the fluid flowing upwards through it. Include packed bed and fluidized bed regions. Mark on the incipient fluidization velocity [4]
- d) There are six spherical particles with diameters 1, 2, 3, 4, 5, and 6 cm. Calculate the following:
 - i. the mean length diameter, [2]
 - ii. mean surface diameter, [2]
 - iii. the mean volume diameter [2]

Question 3

- a) With the aid of a diagram explain the concept of terminal velocity, highlighting the forces that affect the motion of a particle in a fluid. [6]
- b) You are an engineer for company X, you are tasked to carry out sieve analysis of gold ore. Explain three challenges you may face that may hinder you from obtaining accurate results [6]

- c) Explain the following terms
- i. Particle density, [2]
 - ii. voidage [2]
- d) What is the total number of particles and total surface area of uniform particulate material sample consisting of cylindrical particles of diameter 2 mm and height 1.5 mm each and density 2650 kg/m^3 if the sample mass is 50 kg [4]

Question 4

- a) Distinguish between constant pressure filtration and constant rate filtration [4]
- b) Explain the mode of operation of a continuous rotary vacuum filter [4]
- c) Explain three factors to consider when selecting a filter medium [6]
- d) 12 kg of spherical resin particles of density 1200 kg/m^3 and uniform diameter 70 mm are fluidized by water (density 1000 kg/m^3 and viscosity 0.001 Pa s) in a vessel of diameter 0.3 m and form an expanded bed of height 0.25 m.
- i. Calculate the difference in pressure between the base and the top of the bed. [2]
 - ii. If the flow rate of water is increased to $7 \text{ cm}^3/\text{s}$, what will be the resultant bed height and bed voidage. [4]

Question 5

- a) Define sphericity [2]
- b) What are the advantages and disadvantages of dry screening [6]
- c) Explain Stokes Law [4]
- d) 3.6 kg of solid particles of density 2590 kg/m^3 and surface-volume mean size 748 μm form a packed bed of height 0.475 m in a circular fluidised bed vessel of diameter 0.0757 m. Water of density 1000 kg/m^3 and viscosity 0.001 Pa s is passed upwards through the bed. Calculate
- i. the bed pressure drop at incipient fluidization, [3]
 - ii. the superficial liquid velocity at incipient fluidization, [2]
 - iii. the mean bed voidage at a superficial liquid velocity of 1.0 cm/s , [3]

Question 6

- a) With the aid of diagrams and examples distinguish between deep filtration and filtration with cake formation [6]
- b) Describe how you can apply the concept of sedimentation in determining particle size of gold ore [5]
- c) A 0.1 L beaker weighs 100 g when full of powder and 10 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. Determine
- i. Bulk density [3]
 - ii. Particle density [3]
 - iii. Material density [3]

END OF EXAMINATION PAPER