



**GWANDA STATE UNIVERSITY**  
**FACULTY OF ENGINEERING AND ENVIRONMENT**  
**DEPARTMENT OF METALLURGICAL ENGINEERING**  
**PARTICULATE SYSTEMS**

**EMR 5201**

**Part V Second Semester Examination Paper**

**April 2024**

This examination paper consists of 5 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                            |

## ANSWER ANY FIVE (5) QUESTIONS

### Question 1

- a) Explain how particle size and composition of gold ore affect route selection for the ore beneficiation [4]
- b) Describe the mode of operation of a press filter giving an example of where it is applied. [5]
- c) A cuboid particle has the following dimensions 3 x 6 x10 mm. Calculate the following diameters. Explain where each of these diameters can be applied.
- i. Projected area diameter [4]
  - ii. Surface-volume diameter [4]
  - iii. Sieve diameter [3]

### Question 2

- (a) Using equations explain the two forces that affect the motion of coal particles being dried in a fluidised bed reactor [4]
- (b) Slurry pipelines can be used to transport minerals such as coal and iron over long distances. Explain the effects of changes in pipeline diameter on the Reynolds number of the particles [3]
- (c) Explain two assumptions made when a solid particle is exposed to a fluid flowing in the Stokes regime [4]
- (d) A particle of 2 mm in diameter and density of  $2500 \text{ kg/m}^3$  is settling in a stagnant fluid in the Stokes' flow regime. The fluid density is  $1000 \text{ kg/m}^3$  and the particle falls at a terminal velocity of 4 mm/s. Calculate
- i. the viscosity of the fluid [3]
  - ii. the drag force on the particle [4]
  - iii. What is the particle drag coefficient [2]

### Question 3

- a) With the aid of examples and diagrams describe the following types of filtration processes
- i. Filtration with cake-formation, [3]
  - ii. Filtration without cake-formation [4]
  - iii. Deep filtration [4]
- b) A packed bed of solid particles of density  $2500 \text{ kg/m}^3$ , occupies a depth of 1 m in a vessel of cross-sectional area  $0.04 \text{ m}^2$ . The mass of solids in the bed is 50 kg and the surface volume mean diameter of the particles is 1 mm. A liquid of density  $800 \text{ kg/m}^3$  and viscosity  $0.002 \text{ Pa s}$  flows upwards through the bed.
- i. Calculate the voidage (volume fraction occupied by voids) of the bed. [2]
  - ii. Calculate the pressure drop across the bed when the volume flow rate of liquid is  $1.44 \text{ m}^3/\text{h}$ . [4]
  - iii. Calculate the pressure drop across, the bed when it becomes fluidized. [3]

### Question 4

- (a) You are a metallurgist at company X. You are to justify using a fluidised bed reactor to dry coal fines over using a fixed bed.
- i. Explain three reasons for your choice [3]
  - ii. Why it is important to determine the point of incipient fluidisation and minimum fluidisation velocity of the coal fines. [5]
- (b) List and explain two factors that you consider when selecting filtration equipment [4]
- (c) The screen analysis below is of crushed quartz. The density of the particles is  $2650 \text{ kg/m}^3$  whereas the shape factors are  $= 0.8$  and  $\phi_s = 0.571$ .

| 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) Determine the number of particles,  $N$ , in the 150/200 mesh increment [4]

(e) What fraction of the total number of particles is in the 150/200 mesh increment? [4]

### Question 5

a) You are an Engineer at the company X and you are to recommend the use of a drum filter for a solid/liquid solution separation

i. Explain how a drum filter operates. [6]

ii. Explain four properties of your solid suspension that can affect the efficiency of a drum filter [4]

b) Describe how you can determine particle size using the following methods

i. Electrical sensing zone [4]

ii. Laser diffraction spectroscopy [4]

c) Calculate the mass of solids and water in a cake formed during filtration given that the density of the particles in the cake is  $3000 \text{ kg/m}^3$ ,  $A = 8 \text{ m}^2$  and  $L_c$  is 10 cm [2]

### Question 6

- a) With the aid of a diagram explain incipient fluidisation [5]
- b) Describe sphericity [3]
- c) Describe how you can use a fluidised reactor to reduce iron ore [6]
- d) A plate and frame filter press is to be designed for the filtration of a slurry consisting of 250 kg magnesite in  $10 \text{ m}^3$  water. Filtration is conducted under a constant pressure of 200 kPa. The specific cake resistance is  $3 \times 10^{10} \text{ m/kg}$  and the cake density is  $1400 \text{ kg solid/m}^3$  of wet cake.
- i. Find the number of plates if the filter dimensions measure  $12 \text{ m} \times 12 \text{ m}$  [3]
- ii. Estimate the thickness of the frames [3]

**END OF QUESTION PAPER**