

B.E CHEM ENGG 2nd Year SECOND SEMESTER EXAMINATION 2024
(2nd year, 2nd Semester)

MECHANICAL OPERATIONS

Time: three hours

Full marks 100

(50 marks for each Part)

Use Separate Answer Script for each Part.

PART I

Answer any five questions

All questions carry equal marks.

Assume any data missing

- Show that $\log f_D = \log 24 - \log R_e$ when flow of solids through fluid is laminar
- For centrifugal filtration show (using all usual notations) that
$$\frac{dv}{d\theta} = \frac{\nabla P_g \cdot g_c}{\mu \left(\frac{\alpha \omega v}{A_m \cdot A_{lm}} + \frac{R_{M'}}{A_c} \right)}$$
- "The hindered-settling velocity is less than the free settling velocity".
State with reasons.
 - Discuss about "Continuous Thickeners" and its importance in chemical process Industry. (5*2)
- A biological sludge from a secondary waste treatment facility is to be concentrated from 2500 mg/l to 10,900 mg/l in a continuous thickener. Flow to the unit is 4.5×10^6 l/day. Determine the area required from batch-test data given below:

Test Data

θ , min	0	1	2	3	5	8	12	16	20	25
Height of the interface	51	43.5	37.0	30.6	23.0	17.9	14.3	12.2	11.2	10.7

[Turn over

5. Determine the average specific cake resistance (α) that applies for the filtration of ZnS slurry at a $(-\Delta P_c)$ of 70 Psia. Compression permeability data for this slurry are given below

P(Psia)	α_p (ft/lb)
1	0.85×10^{12}
10	6.0×10^{12}
20	10.5×10^{12}
30	16×10^{12}
50	29×10^{12}
70	45×10^{12}

6. Calculate the terminal velocity (u_t) of glass spheres of 50 microns diameter in water at 25°C. (a) in viscous region (b) in turbulent region. Density of glass is 2.5 g/cc and $\mu_w = 0.01$ cp

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PART II

Use separate answer script for each Part (50 Marks)

1. (a) A stainless steel over wire screen with a square aperture had an aperture of 4.0 mm square. The diameter of the wire was 1.5 mm. Determine: (i) % of open area when the screen was operated in a horizontal position (ii) % of open area when the screen was operated at a slope of 30° and (iii) The mesh size of the screen. (6)

(b) Find out the sphericity of a cylindrical particle whose Length is equal to its Diameter (4)

2. (a) Estimate the cut diameter and overall collection efficiency of a cyclone given the particle size distribution of dust from cement kiln. (7)

Particle size distribution and other parameter are given below:

Average particle size (μm)	1	5	10	20	30	40	50	60
Weight Percent	5	20	16	22	15	10	6	2

(b) Derive the expression of critical speed of a ball mill. (5)

(c) Differentiate open and closed circuit grinding. (3)

3. (a) A six-blade turbine agitator of diameter 50 cm is installed centrally in tank with flat bottom of diameter 200 cm, at a height of 60 cm from the bottom. The tank is filled with a solution of viscosity 10 Cp and of 1.5 g/ml density. The speed of agitation is 90 rpm. The tank is baffled. Calculate the power required. (7)

(b) show the preventive routes of vortex formation during mixing. (3)

4. (a) Sulphuric acid is to be pumped at a rate of 4.0 kg/s through a 60 mm i.d. pipe over a straight run of 800 m and is then raised vertically 15 m. If the pump is electrically driven and has an efficiency of 50%, find the power required by the pump. (10)

Density of the acid = 1250 kg/m^3 . Viscosity of the acid = $7.2 \text{ mPa}\cdot\text{s}$.

(b) Schematically show the working principle of a reciprocating pump. (5)

5. Fill in the blanks: (5)

----- crusher works on the principle of compression and impact.

----- classifier can be used for separation of pulp.

----- classifier is best for fine separation.

----- filter may prove suitable for filtering volatile liquid.

----- combination of the flow pattern can be observed in an open turbine.