

B.E. CHEMICAL ENGINEERING SECOND YEAR SECOND SEMESTER EXAM 2025

MECHANICAL OPERATIONS

Time: Three hours

FM-100

1. (a) Determine the Sphericity of a cuboid whose length breadth and depth are in the ratio of 7:5:2. (5)

(b) Dolomite mixture having the following screen analysis is screened through a standard 150 mesh screen. Calculate the effectiveness of the screen and the mass ratios of overflow and underflow to feed. (10)

Screen analysis :

Mesh	Feed	Oversize	Undersize (weight %)
35	7.07	13.67	0.00
48	16.60	32.09	0.00
65	14.02	27.12	0.00
100	11.82	20.70	2.32
150	9.07	4.35	14.32
200	7.62	2.07	13.34
- 200	33.80	0.00	70.02
	100	100	100

(c) Discuss the operating principle of "Froth Flotation". (5)

2. (a) A certain set of crushing rolls has rolls of 1200 mm diameter and 400 mm width face. They are set so that the crushing faces are 15 mm apart. The manufacturer recommends their speed to be 50 to 100 r.p.m. They are employed to crush a rock having specific gravity 2.5 and the angle of nip is $31^\circ 30'$. What is the maximum permissible size of the feed and maximum actual capacity of rolls in tonnes per hour if the actual capacity is 15% of the theoretical?

Theoretical capacity in t/h, $Q = 4.3 \times 10^{-7} N.D.w.d.s$

where N in r.p.m., D (roll diameter) in mm, w (width) in mm, d (half the gap/width between roll surface) in mm and s (specific gravity). (8)

(b) Estimate the cut diameter and overall collection efficiency of a cyclone given the particle size distribution of dust from cement kiln. (8)

Particle size distribution and other parameter are given below:

Avg particle size in range d_p , μm	1	5	10	20	30	40	50	60	>60
Wt percent	03	20	15	20	16	10	06	03	07

Gas viscosity = 0.02 Cp; Specific Gravity of the particle = 3.0

Inlet gas velocity of cyclone = 48 ft/sec

Effective number of turns within cyclone = 5

Cyclone diameter = 8 ft

Cyclone inlet width = 2 ft

(c) Show the Flow pattern in a baffled vessel with (i) turbine impeller and (ii) centrally mounted propeller agitator. (4)

3. (a) A pressure filter is operated in the constant rate mode to yield 10 m^3 in the first 10 minute, as the pressure increases from zero. In the next 20 minutes the filtration was continued at constant pressure, after which it was stopped. Assume filter medium resistance is negligible and the cake is incompressible. (i) Estimate the total

[Turn over

volume of filtration obtained. (ii) Determine washing time if the volume of wash liquid equals the volume of filtrate obtained. (10)

Or

A filter press is used to filter a sludge forming a nonuniform compressible cake. At a constant pressure difference, 6000 litre of filtrate is obtained in 1 hour. Washing is done with 1200 litre of water, it proceeds exactly as filtration. The filtrate has the same properties as the wash water. Neglecting the resistance of filter cloth, calculate the washing time required.

Given: Rate of washing = $1/4$ (final rate of filtration) for a filter press.

(b) Batch Sedimentation data is given as:

Time (minute)	0	1	2	3	5	8	12	16	20	25
Interface Height (cm)	51	43	37	30	23	18	14	12	11	10

Calculate: (i) Critical time and height and (ii) the area of a continuous thickener to treat a biological sludge to reach Desired sludge concentration (C_u) of 10000 mg/l from Initial feed concentration (C_o) of 2500 mg/l (10).

Data Given: Flow to unit = 5×10^6 l/day

4. (a) What are factors contributing to Cavitation of pump. Define duty point of a pump. (3+2)

(b) Water is to be pumped from a tank, located on the ground, to a cooling tower. The tank is open to the atmosphere. The difference between the level of water in the tank and discharge point is 15 metres. The velocity of water through a 40 mm internal diameter discharge pipe is 3 m/s. In the pipe line there is a valve which is equivalent to 200 pipe diameters and a fitting equivalent to 150 pipe diameters. The length of the entire piping is 30 metres. Calculate the power requirement of the pump. (15)

Data: Viscosity of water = 0.0008 Pa.s; Friction factor 'f' = 0.004; The pump efficiency is 60%.

5. (a) Pick the correct answer with proper justification (any five): (10)

(i) Which of the following is true, when operating speed is less than critical speed?

a) Bold grinding b) Effective grinding c) No grinding d) Best grinding

(ii) Which of the following involves vibrations?

a) Hammer mill b) Ball mill c) Roll mill d) Grizzly screen

(iii) Which of the following filter may prove unsuitable for filtering volatile liquid?

a) Vacuum b) Centrifugal c) Gravity d) Pressure

(iv) Which of the following combination of the flow pattern can be observed in an open turbine?

a) Axial only b) Radial only c) Mixed d) Radial and axial

(v) Which of the following is the principle of mixing?

a) Centrifugal force b) Perpendicular force c) Shear force d) Gravitational force

(vi) In azeotropic distillation, why is an entrainer added?

a) To increase the boiling point of the mixture b) To decrease the boiling point of the mixture c) To form a minimum boiling point azeotrope d) To form two immiscible phases

(b) Write short note on (any two): (i) Electrostatic separation (ii) Fluid Energy mill (iii) Open vs Closed circuit grinding (10)