MECHANICAL OPERATION
(CHEN 2101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) 200 mesh screen is the basis for
(a) BSS Screen (b) Tyler screen
(c) IS screen (d) none of these.

(ii) The value of sphericity for cube is
(a) 2 (b) 1 (c) 1.75 (d) 0.65.

(iii) Angle of nip is inherent with
(a) toothed roll crushers (b) impactors
(c) smooth roll crushers (d) none of these.

(iv) Fluid energy mill is a
(a) crusher (b) grinder
(c) ultrafine grinder (d) none of these.

(v) Which conveyor is most suitable for handling lumpy and heavy material?
(a) Screw (b) Belt (c) Flight (d) Apron.

(vi) For a spherical particle settling through a liquid under Stoke's Law regime, Drag coefficient C_D varies with Reynold's Number (Re) as
(a) $C_D \alpha 1/Re$ (b) $C_D \alpha 1/Re^2$
(c) $C_D \alpha Re$ (d) C_D is constant.

(vii) For a mixing tank operating in the laminar regime, the power number varies with Reynolds number (Re) as
(a) $Re^{-1/2}$ (b) $Re^{1/2}$ (c) Re (d) Re^{-1}.

(viii) In constant pressure filtration, the rate of filtration follows the relation (v = filtrate volume, t = time, K and C constant)
(a) $dv/dt = Kv + C$ (b) $dv/dt = 1/Kv + C$
(c) $dv/dt = Kv$ (d) $dv/dt = Kv^2$.

(ix) The power number for a stirred tank becomes constant at high Reynolds number. In this limit, the variation of power input with impeller rotational speed (N) is proportional to
(a) N^0 (b) N^1 (c) N^2 (d) N^3.

(x) An example of a hydraulic classifier is
(a) cyclone separator (b) colloid mill
(c) screw mixer (d) spitzkasten.

Group – B

2. (a) What are the utilities of screening? What is the need for standard sets of screens?

(b) Calculate the volume surface mean diameter for the following particulate solid:

Size of screen opening (μ)	-800+400	-400+200	-200+100	-100+50	Pan
Mass of particle in range (g)	25	37.5	62.5	75	50

(2 + 3) + 7 = 12

3. (a) On what factors does the power requirement for a belt conveyor depend? Explain the function of idlers in belt conveyors. What is the difference between a conveyor and an elevator?

(b) Explain the working principle of a dense phase vacuum pneumatic conveying system with a neat diagram. What types of materials are generally transported by this system?

(3 + 2 + 1) + (5 + 1) = 12

Group – C

4. (a) A material is crushed in a jaw crusher and the average size of the particle is reduced from 20 cm to 5 cm with consumption of energy 2.64×10^4 J/kg. What will be the consumption of energy to crush the same material from 12 cm to 1 cm, assuming (i) Rittinger's law (ii) Kick's law?

(b) Derive Kick's law and Bond's law from the generalized crushing law.

(3 + 3) + (3 + 3) = 12

5. (a) What are the four possible actions through which size reduction can be achieved? Define work index.

(b) A pair of rolls takes a feed equivalent to spheres of 8 cm in diameter and crushes them to spheres of 1cm in diameter. If μ = 0.29, what will be the diameter of the rolls?

(4 + 2) + 6 = 12

Group – D

6. (a) The terminal settling velocity of a 6 mm diameter glass sphere (density = 2500 kg/m^3) in a viscous Newtonian liquid (density = 1500 kg/m^3) is 100 μm/s. If the particle Reynolds number is small and the value of acceleration due to gravity is 9.81 m/s^2, what is the viscosity of the liquid?

(b) For a spherical particle settling through a liquid, derive the expression for terminal settling velocity when the particle Reynold's number is less than 0.1.

4 + 8 = 12

7. (a) An aqueous slurry containing 1.2 percent by weight of solid (specific gravity = 2.0) is to be clarified by continuous sedimentation. Feed to the thickener is 3600 m^3 per day and the underflow from the unit analyses 8% solid. A batch sedimentation test on the feed material gave the following information:

Time (min)	0	5	10	20	40	60	180	240	α
Height of interface (cm)	31	21	10	3.2	2.2	2.1	2.0	1.96	1.94

Determine the rate of sedimentation at 30 minutes and the sedimentation constant.

(b) (i) In the stokes regime, the terminal velocity of particles for centrifugal sedimentation is given by

$$u_t = \frac{\omega^2 r(\rho_p - \rho)d_p^2}{18\mu}$$

Where, ω = angular velocity, r = distance of the particle from the axis of rotation, ρ_p = density of the particle, ρ = density of the fluid, d_p = diameter of the particle and μ = viscosity of the fluid. In a bowl centrifugal classifier operating at 80 rpm with water (μ = 0.001 kg/m-s), what will be the time taken for a particle (d_p = 0.0002 m, specific gravity = 2.5) in second to traverse a distance of 0.04 m from the liquid surface?

(ii) Briefly state the assumptions of 'Kynch theory'.

6 + (4 + 2) = 12

Group – E

8. A leaf filter with 1.0 m^2 of filtering surface operated at a constant pressure of 1.8 bar (gage) gave the following results:

Filtrate volume (m^3)	3.99	6.09	7.65	9.63	11.33
Time (min)	10	20	30	45	60

The original slurry contained 10% by weight of solid calcium carbonate (specific gravity = 2.72) in water and the cake formed is essentially incompressible. Determine the time required to wash cake formed at the end of 70 minutes of filtering at the same pressure using 3.0 m^3 of wash water.

12

9. Write short notes on (any 4) **(4 × 3) = 12**
   (i) Compressible filter cake
   (ii) Filter medium resistance
   (iii) Gravity settling tank
   (iv) Froth floatation
   (v) Filter media
   (vi) Filter aids