



Name :
Roll No. :
Invigilator's Signature :

CS / B.TECH (CHE) / SEM-4 / CHE-402 / 2011

2011

MECHANICAL OPERATIONS

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

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

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

10 × 1 = 10

i) For spherical particle, the sphericity is

a) 0

b) 1

c) $\frac{1}{2}$

d) 2.

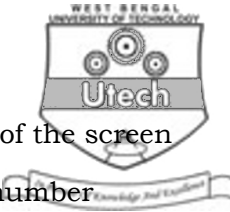
ii) The sphericity for the cylindrical particle whose diameter equals its height is

a) 0.53

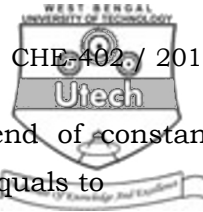
b) 0

c) 0.874

d) 1.



- iii) In ISS screen series, the aperture size of the screen
- a) increases with increase of mesh number
 - b) decreases with increase of mesh number
 - c) both (a) and (b)
 - d) none of these.
- iv) Angle of nip is inherent with
- a) toothed roll crushers
 - b) impactors
 - c) smooth roll crushers
 - d) all of these.
- v) Gaudin-Schumann size distribution law is applied for estimating size distribution
- a) fine particles that retained on the pan
 - b) oversize particles that retained on any screen
 - c) undersize particles of the top screen
 - d) none of these.
- vi) For a sphere falling in a constant drag coefficient regime, its terminal velocity depends on its diameter ' d ' as
- a) d
 - b) $d^{0.5}$
 - c) d^2
 - d) $1/d$.
- vii) At very low rpm, the power required for agitation is proportional to diameter ' D ' as
- a) D
 - b) D^2
 - c) D^3
 - d) D^5 .



- viii) During washing of the filter at the end of constant pressure filtration, the rate of washing equals to
- a) rate of filtration at time zero
 - b) rate of filtration at the end of the filtration
 - c) rate of filtration when half the filtration has been obtained
 - d) rate of filtration at the end of filtration but decreases with time subsequently.
- ix) The power correlations for agitated vessels the effect of Froude number appears
- a) for baffled vessels when Reynolds number is less than 300
 - b) for unbaffled vessels when the Reynolds number is greater than 300
 - c) when there is no vortex formation
 - d) when the Reynolds number is less than 300.
- x) Stoke's equation is valid in the Re range
- a) <1
 - b) 1 to 2
 - c) 2 to 10
 - d) 10 to 100.
- xi) For separating particles of different densities, the differential settling method used a liquid sorting medium of density
- a) intermediate between those of the light and heavy ones
 - b) less than that of either one
 - c) greater than that of either one
 - d) of any arbitrary value.



- xii) Energy consumed for ball mill depends on
- its speed
 - its ball load
 - the density of material being grinding
 - all of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* questions. 3 × 5 = 15

2. Explain the operation of a smooth roll crusher. Derive the expression for angle of nip of a smooth roll crusher with roll diameter D_r , accepting a feed of size D_f and giving a product of size D_p . 2 + 3
3. Why is agitation carried out in industries ? Indicate the main types of impellers used for agitation mentioning also their applicabilities. 2 + 3
4. In a ball mill of diameter 2000 mm, 100 mm diameter steel balls are being used for grinding. Presently, for the material being ground, the mill is run at 15 rpm. At what speed will the mill have to run if the 100 mm balls are replaced by 50 mm balls, all other conditions remaining same ?
5. What is hindered settling ? Why is hindered settling velocity lower than free settling velocity ? 2 + 3
6. What are the requirements to be fulfilled for selecting a filtering septum in any filter ? Mention the necessary condition for incompressible cakes. 4 + 1



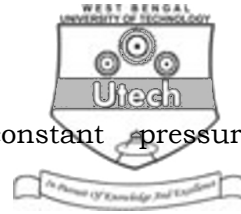
GROUP - C

(Long Answer Type Questions)

Answer any *three* of the following.

$3 \times 15 = 45$

7. a) The following data are given for a horizontal screw conveyor for handling moulding sand in a foundry :
- | | |
|---------------------------------|--------------------------|
| Bulk density of the material | = 1600 kg/m ³ |
| Screw pitch | = 0.32 m |
| Filling coefficient | = 0.125 |
| Reducer frequency | = 0.77 |
| Diameter of screw | = 0.4 m |
| Conveying length | = 15 m |
| Speed of the screw shaft | = 40 rpm |
| Total coefficient of resistance | = 4.0 |
- Determine :
- (i) the rate conveying of the material in kg/hr
 - (ii) the motor power.
- b) Define screen efficiency specifying its significance.
- c) How can you calculate the total pressure drop in pneumatic transport through a horizontal pipe ?
- 5 + 3 + 7
8. a) Derive the expressions for the power consumption in agitated vessels for laminar and turbulent regimes. State the significance of flow number and power number.
- b) An agitated vessel is being used to prepare a uniform solution of viscosity 2 cP, running the agitator at 100 rpm, so as to obtain a Reynolds number of 50,000. If the contents of the vessel are replaced by a solution of viscosity 4 cP, and the agitator rpm is increased to 200, by how much will the power requirement change ?
- c) Explain mixing effectiveness and mixing index. 5 + 5 + 5



9. a) What are constant rate and constant pressure filtrations ?

b) Describe the operation of a rotary drum filter with the help of a schematic diagram.

c) The volumetric flow rate during constant pressure filtration is :

$$dV/dt = 1/(K_c V + 1/q_0)$$

where V is the total volume of filtrate collected in time t , and K_c and Q_0 are constants.

i) Integrate the above equation to obtain a relation between V and t .

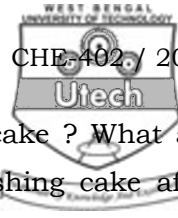
ii) Make a sketch of t/V vs. V from your results.

iii) Given $V = 1$ litre at $t = 41.3$ second, and $V = 2$ litre at $t = 108.3$ second, find K_c . 3 + 7 + 5

10. a) In a solid - liquid mixing, how settling velocity of the solid plays a role on the mixing operation ?

b) Determine the power requirement for 3.0 m dia, 6 flat blade turbine impeller mixture running at 15 rpm in a 10 m dia mixing tank of standard configuration. Also compute the power / 1000 m³ of volume. Assuming the fluid being mixed is water where water depth is 9 m, temperature is 15°C, Viscosity is 1.139 Nu-s/m², Power function is 4.6 & $\rho_{\text{water}} = 999.1$ kg/m³.

c) Write a note on cyclone separator. 4 + 6 + 5



11. a) What is the objective of washing filter cake ? What are the characteristics observed during washing cake after filtration through a plate & frame press ?
- b) A plate and frame filter press filtering a slurry, gave a total of 25 m³ of filtrate in 30 minutes and 35 m³ in 60 minutes when filtration was stopped. Estimate the washing time in minutes if 10 m³ of wash water are used. The resistance of the cloth can be neglected and a constant pressure was used throughout.
- c) What assumptions are considered during the process of centrifugal filtration ? (1 + 4) + 6 + 4
12. Write short notes on any *three* of the following : 3 × 5 = 15
- a) Cyclone separator
 - b) Forth floatation
 - c) Bag filter
 - d) Power number
 - e) Bins and silos.

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