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2 hou

40 marks

CLL 331 Fluid Particle Mechanics

Please return BOTH your question paper and answer sheet Use Minor copy for Part-1 and Major copy for part-2

Drag force on a stationary rigid spherical particle of diameter, d in uniform flow of velocity, U in a fluid of viscosity, μ in the Stokes law regime is $3\pi\mu dU$. terminal velocity in Newtons law regime $V_t = 1.74\left[\frac{d_p g(\rho_p - \rho)}{\rho}\right]$

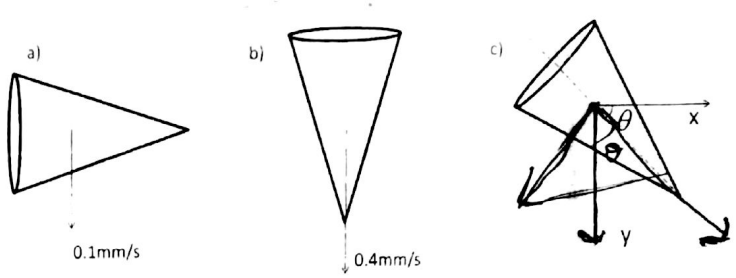
Viscosity of water is 10^{-3} Pa.s=1cp

Ergun equation- $$\frac{-\Delta p}{L} = 150\frac{\mu U(1-\varepsilon)^2}{d^2\varepsilon^3} + 1.75\frac{\rho_f U^2(1-\varepsilon)}{d\,\varepsilon^3}$$

Part-1

Q1.

In a settling experiment, sedimentation velocity of a particle in orientation (a) is found to be 0.1 mm/s and sedimentation velocity in orientation (b) is found to be 0.4 mm/s. What is the maximum distance the particle can travel perpendicular (in x- direction) to gravity (y-direction) during the time it falls 1 cm vertically? At what angle (θ) would that happen? Assume Stokes flow.



(5)

Q2. Calculate pressure drop across a packed bed of 1 m length and 1 m diameter containing spherical particles of diameter 1cm and density 2000 kg/m^3. Water is flowing through the bed at a flow rate of 1 m^3/s. Assume voidage of the bed to be 0.5. (1)

Q3. Answer the following questions regarding internals of packed beds - (4)

(a) Difference between a full redistributor and a wall wiper redistributor.

(b) Name two types of distributors.

(c) What is the purpose of a hold down plate in a packed bed?

(d) Mention couple of desired features of the packings used in the packed beds.

Part-2: Write answer in Major answer booklet

(4) A cylinder is packed with a mixture of 1:1 (by weight) two different size particles of diameters 40 μm and 80 μm as shown in figure. The densities of the small and big size particles are 4 and 2gm/cc respectively. The smaller size particles are located at the bottom of the bed. The bed is fluidized with water density (1gm/cc). Find out the relative change in the bed densities of the two beds formed by only small heavy particles and big lighter particles with the change in superficial velocity of the liquid water. Assume that the terminal velocity of the particles be given by Newton's law regime.

(ii)Find out the Vmf of 1m bed formed by 40μm size particles. Assume porosity to be 0.5.

Marks :3+2

(5) Match the following items given in the column-1, 2 and 3.

	Column-1	Column-2	Column-3
I	C type particles	0-30μm	No bubbles
Ii	A type particle	30-100 μm	Maximum bubble size
Iii	B type particles	100-1000 μm	No limit of bubble size
Iv	D type particles	>1000 μm	Spouting

Marks :4

(6) (a) Fill the blanks in table to match column-1, 2 and 3.

Column-1	Feed Particle size range and product particle size range	Differential form of the equation describing the energy required for grinding process is : $dE/dx=-C/x^n$
Rittingers law		n=
Kick's law		n=
Bond' law		n=

(b) What is power number? How Power number varies with Reynolds number? Marks :2+2

(7) (a)Explain mathematically the reason of trajectory segregation

(b) The performance of a solids mixer was assessed by calculating the variance occurring in the mass fraction of a component amongst a selection of samples withdrawn from the mixture. If the component analysed represents 20 per cent of the mixture by mass and each of the samples removed contains approximately 100 particles, find out the **upper and lower limits of mixture variance.** Marks:4

(8) From the data given the table below find out the **grade efficiency** and **total efficiency** of cyclone.

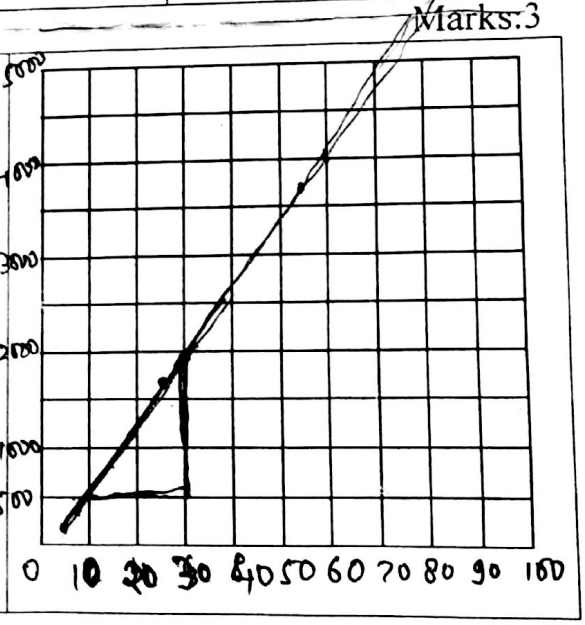
Size range (μm)	10-30	30-100	100-150	150-200	200-250
Mass of **powder in air** enter in a cyclone in gm in the size range	0.2	0.3	0.5	0.6	0.4
Mass of powder **collected** from a cyclone in gm in the size range	0.03	0.21	0.47	0.59	0.4

Marks:3

(9) A filtration was carried out, with a product slurry, on a laboratory filter press under a constant pressure of 340 kPa and volumes of filtrate were collected as follows:

Filtrate volume (litre)	20	40	60	80
Time (min)	8	26	54.5	93

The area of the laboratory filter was 0.186 m^2. Find out the specific cake resistance and equivalent length of cake corresponding to resistance of filter media. Given: The slurry contains 0.2 kg non-porous particle (true density 2gm/cc) per kg of the medium. The porosity of cake is 0.45. The density and viscosity of the medium are 1000kg/m^3 and 1cp. Marks: 5



(10) A suspension consisting of particles of density 2300 kg/m^3 in the size range 1–10 μm is introduced into a centrifuge with a basket 450 mm diameter rotating at 80 Hz. If the suspension forms a layer 75 mm thick in the basket, approximately how long will it take for the smallest particle to settle out? Also find out the approximate pressure due to liquid on the wall of the centrifuge. The properties of medium are as follows: density 800 kg/m^3 and viscosity 0.8**cp.**

Marks:5