UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

SCHOOL OF ENGINEERING

MAIN EXAMINATIONS: JUNE 2019

COURSE AND CODE: FLUID AND SOLIDS TRANSPORT ENCH3FS

DURATION: 3 HOURS **TOTAL MARKS:** 100

INTERNAL EXAMINERS: MR. E. M. OBWAKA
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EXTERNAL EXAMINER: PROF B. BAKARE

INSTRUCTIONS:

1. This question paper consists of two sections: Section A (Questions 1 – 2) and Section B (Questions 3 – 4).
   Two answer books are provided. Answer Section A in Book A and Section B in Book B.
   The maximum marks for each question is 25.
2. Attempt all questions.
3. Any programmable or non-programmable calculator may be used provided it has been cleared of any information that would subvert the purpose of the test.
4. Calculations must be shown in sufficient detail to illustrate your understanding of the procedure.

SECTION A

QUESTION 1

A centrifugal water pump designed to operate at $\omega = 1300$ rpm has dimensions given in Table 1.1:

Table 1.1: Dimensions of idealised centrifugal pump

Parameter (dimension)	Inlet, Section 1	Outlet, Section 1
Radius, r (mm)	100	175
Blade width, b (mm)	10	7.5
Blade angle, β (degrees)	?	40

1.1) Assuming a purely radial inlet velocity of the fluid, draw the inlet velocity diagram if $\vec{v}_1 = \vec{W}_1 + \vec{U}_1$, with the following vector definitions:
$\vec{W}_1$: The fluid flow velocity relative to the rotating blade
$\vec{v}_1$: The fluid inlet velocity in the reference frame of the earth
$\vec{U}_1$: The tangential tip speed of the inlet impeller

(6)

1.2) Calculate the inlet blade angle (β_1) for a volumetric flowrate of 35 litres per second.

(8)

1.3) If the outlet tangential velocity of the fluid is given by

$$\vec{v}_{t2} = \omega r_2 - \frac{Q \cot(\beta_2)}{2\pi r_2 b_2},$$

calculate the outlet absolute flow angle (α_2) measured relative to the normal direction. Marks will be awarded for including a correctly labelled diagram in your solution

(11)

TOTAL /25/

SECTION B

QUESTION 3

A mixture of galena (A) and silica (B) solid particles having a size range of 1.27×10^{-2} mm to 5.08×10^{-2} mm is to be separated by hydraulic classification using free settling conditions in water at 20 °C. The specific gravity of galena is 7.5 while that of silica is 2.65. The settling is in the laminar region, hence the drag coefficients will be reasonably close to that for spheres. The viscosity of water at 20 °C is $1.005 * 10^{-3}$ Pa.s and its density is 998 kg/m^3.

3.1 Calculate the value of the largest Reynolds number occurring and determine the resultant flow regime

(4)

3.2 Derive the required equation for d_{pA}/d_{pB} as a function of densities

(4)

3.3 Sketch a graph of terminal velocity versus particle size for galena and silica and show the two equal terminal velocities and their corresponding diameters

(6)

3.4 Calculate the size range of the various fractions obtained in the settling.

(11)

Useful information:

Stokes' Law: $u_t = \dfrac{g(\rho_p - \rho)d_p^2}{18\mu}$

Three regimes:

Stokes' Law Region:	$Re_p < 1$
Transition Region:	$1 < Re_p < 10^3$
Turbulent Plateau:	$10^3 < Re_p < 10^5$

TOTAL /25/

QUESTION 4

The concentrate from an evaporation system has a flowrate, L = 2025.7 kg/h and contains 37.75 wt% $MgSO_4$ at 77 °C and 138 kPa. It is mixed with 4472.4 kg/h of a saturated aqueous recycle filtrate of $MgSO_4$ at 29 °C and 4 kPa in the vapour space, to produce water vapour, W, and magma, M, of 20.8 wt% crystals while the balance is a saturated solution. The magma is sent to a filter, from which filtrate is recycled.

Reference should be made to Figure 4.1.
$MW_{MgSO4} = 120.38$ and $MW_{MgSO4.7H2O} = 246.49$ kg/kmol.

4.1 Sketch the above process showing the important pieces of equipment, streams and stream conditions.

(6)

4.2 State a major assumption and determine the mass flow rate of water vapour and the maximum production rate of crystals in kg/h.

(15)

4.3 What does the ΔL Law of Crystal Growth state?

(4)

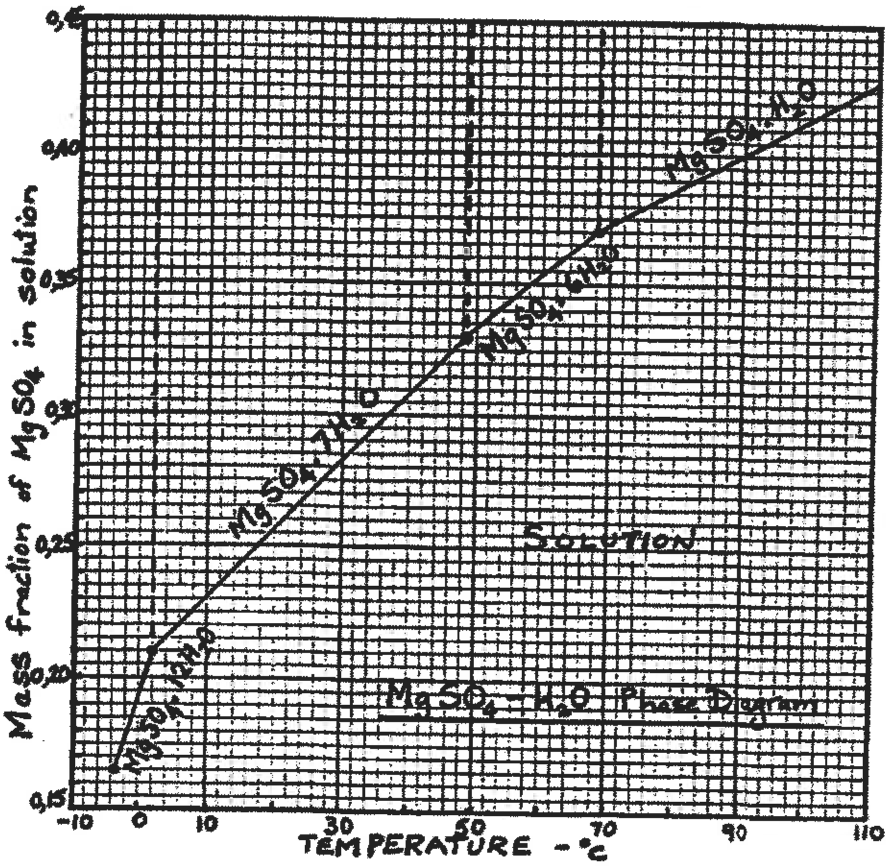

FIGURE 4.1: Phase diagram for $MgSO_4.H_2O$

TOTAL /25/