ABE 303 – Homework 5
Fall 2017
Due October 31 - Total 100 points

Question 1

The Casson Model is the accepted rheological model for molten milk chocolate:

$$\sqrt{\sigma} = \sqrt{\sigma_o} + K\sqrt{\dot{\gamma}}$$

Get an equation to calculate the apparent viscosity of the Casson model

(10 Points)

Question 2

The following data is available for liquid protein:

$T(C)$	$\mu, c\text{P}$
5	19.0
30	6.4
40	5.5
50	4.1
60	3.1

Determine the equation to estimate the viscosity of the material as a function of temperature

(20 Points)

Question 3

(a) Use the same approach than that used in class for Newtonian fluids to derive an expression to calculate the pressure loss of a straight pipe of radius *R* and length *L* for a power-law fluid with rheological parameters *k* and *n* as a function of the volumetric flow rate *Q*. Equations given below can be used for the derivation:

$$\frac{\mathrm{Q}}{\pi \mathrm{R}^3} = \frac{1}{\sigma_{\mathrm{w}}^3} \int_0^{\sigma_{\mathrm{w}}} \sigma^2 \, \mathrm{f}(\sigma) \mathrm{d}\sigma$$

$$\sigma_w = k\dot{\gamma}_w^n$$

$$\sigma_w = \frac{\Delta p \, R}{2L}$$

Also obtain an expression to estimate the shear at the wall $\dot{\gamma}_w$

(b) The apparent viscosity μ_{app} of a suspension was obtained as a function of the shear rate $\dot{\gamma}$

$\dot{\gamma}$ (1/sec)	μ_{app} (mPa.s)
1	331
1.2	275
2.5	145
4.8	91
12.1	58

What is the rheological behavior of this suspension? Determine its rheological parameters.

(c) Calculate the apparent viscosity of the suspension for a shear rate of 20 1/sec.

(30 points)

Question 4

A shear sensitive non-Newtonian protein solution having a density of 1041 kg/m3 is flowing through 14.9 meters of tubing having an inside diameter of 5.24 cm. Capillary viscometer measurements have shown that the solution is time-independent and that, for the flow conditions in the processing line the following rheological parameters apply n = 0.4 and k = 15.2 $Pa.s^{0.4}$. The mass flow rate is 590 kg/h.

(a) What is the type of flow behavior being exhibited by the fluid? Explain your answer, i.e., why do you think the protein solution is exhibiting that behavior?

[10 marks]

(b) Calculate the pressure drop due to viscous friction in the pipeline assuming laminar flow.

[10 marks]

(c) An increase in the throughput requires increasing the mass flowrate 50%. An existing spare pump can deliver the new required flowrate but at a maximum permissible discharge pressure of 50kPa (gauge). Determine whether that pump will do the job or it would be necessary to acquire one with a higher maximum permissible discharge pressure.

[10 marks]

(d) The maximum shear rate that can be applied without causing the protein to denature is 2001/s. Find if the new flow given in (c) will cause shear denaturation on the protein

[10 marks]