Name: _____ Student ID _____

Prince of Songkla University
Faculty of Engineering

Exam: Final Exam, Semester II　　　　　**Academic Year: 2009 – 2010**
Date: February 17, 2010　　　　　　　　**Time: 1:30 – 4:30 PM**
Subject: 230-560 Food Unit Operations　**Room: S201**

ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

Instructions: This exam is a Closed Book Exam. The points for each problem are **not** distributed evenly. Place your name and the student ID number on every page. Students are allowed to use **only** a pen or pencil and a calculator. Write your English Nickname and your Team Name above.

Points Distribution (For Grader Only)		
Part	**Points Value**	**Score**
I	45	
II	30	
III	45	
IV	45	
V	35	
Total	**200**	

Exam prepared by
Ram Yamsaengsung
February 14, 2010

PLEASE CHECK TO MAKE SURE THAT
YOU HAVE ALL 13 PAGES OF THE EXAM BEFORE BEGINNING
(not including the cover sheet).
GOOD LUCK!

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CLOSED BOOK EXAM (200 points)

Part I. Fill in the blanks (45 points)

1. For turbulent flow to occur in Power-Law and Bingham Plastic fluids, the Reynolds ($N_{Re,PL}$ or $N_{Re,B}$) number must be more than the _____ _____.

2. _____ is the process of using heat from the processed product to raise the temperature of the incoming "raw" product.

3. The _____ (negative/positive) sign in the heat conduction equation indicates that heat flows from high temperature region to low temperature region.

4. The two types of flow direction that can occur in a double-pipe tubular heat exchanger are _____ and _____.

5. The _____ heat exchanger is useful in removing fouling from the tube wall.

6. The friction loss coefficients (k_f) values _____ (increase/decrease) with _____ (increasing/decreasing) pipe diameter.

7. There are two major types of heat exchangers. The _____ type includes the steam infusion and surface injection, while the _____ type includes the plate, tubular, shell-in-tube, and scraped surface.

8. The thermal process that produces products that does not require refrigeration is called _____.

9. It is easier for material with _____ (high/low) yield stress to achieve turbulence.

10. Under _____ conditions, some Newtonian fluid can become turbulent at Reynolds number of 1,350.

11. Conduction heat flux is proportional to the _____ of the material and inversely proportional to the _____ of the material.

12. _____ convection is due to the density difference caused by temperature gradients or turbulent flow, while _____ convection involves the use of some mechanical means, such as pumps or fans, to induce the movement of the fluid.

13. For _____ (laminar/turbulent) flow of _____ (Newtonian/Power-Law/Herschel Bulkley/Bingham Plastic), the kinetic energy correction factor (α) is always 1.

14. The Biot number is a ratio of the _____ and the _____.

15. For a Biot number less than 0.1, the _____ can be neglected (ignored).
16. _____ products do not require refrigeration.
17. Sterilization takes place at about _____ degree Celsius.
18. The two major types of friction losses that occur in the flow of fluid through a pipe are _____ and _____.
19. The _____ is the ~~time~~ required to cause a 90% reduction in the decimal reduction time.   *temperature*
20. The thermal process that produces products that require refrigeration is called _____.
21. Products in glass containers require _____ (quick/slow) heating and cooling for an effective thermal treatment.
22. The decimal reduction time _____ (increases/decreases) with increasing process temperature.
23. Rapid freezing _____ (increases/decreases) the number of nuclei formed.
24. Most microorganisms can grow best at _____ (low/intermediate) pH and _____ (high/low) a_w.
25. The metabolic activity of microorganisms can _____ (increase/decrease) the pH of foods.
26. During thermal processing, the population of the microorganisms is reduced in a _____ (linear/logarithmic) manner.
27.
28. _____ is the process of using heat from the processed product to raise the temperature of the incoming "raw" product.
29. Chemical preservatives, such as _____ and _____, can be added to foods to help prevent microbial growths.
30. The _____ is generally 12 times that of the decimal reduction time.
31. The _____ can be obtained by plotting a semi-log plot between the decimal reduction time and temperature.
32. _____ can be used to fry high sugar products such as ripened bananas and durian chips.
33. _____ is generally used to heat mushrooms in canned containers.
34. Superior quality products require _____ (high/low) temperature and _____ (long/short) time for thermal treatment.
35. The _____ is a plot between the change in microbial population versus thermal treatment time.

Part II. Flow Through Pipe (30 points)

1. Beginning with the relationship between shear stress and shear rate, derive the velocity profile for a Power Law fluid flowing through a tube viscometer. Please, show all your work. **(10 points)**

$$u(r) = \left[\frac{\Delta P}{2LK}\right]^{1/n}\left[\frac{n}{n+1}\right]\left[R^{\frac{(n+1)}{n}} - r^{\frac{(n+1)}{n}}\right] \tag{1}$$

2. From (1), show that the volumetric flow rate (Q) is given by the following equation. **(10 points)**

$$Q = \pi \left[\frac{\Delta P}{2KL} \right]^{1/n} \left[\frac{n}{3n+1} \right] R^{(3n+1)/n} \qquad (2)$$

3. For flow of a Power-Law fluid with a $K = 5.2$ Pa s^n and $n = 0.50$, is the flow laminar or turbulent if the diameter of the pipe is 5.0 cm and the average velocity is 3.0 m/s. The density of the fluid is constant ($\rho = 1200$ kg/m^3). **(10 points)**

Part III. Shorts Answers (45 points)

1. Name 6 different units or ways that can be used to cook chicken. **(6 points)**

2. Discuss the differences between steaming and microwave cooking. What is the heat and mass transfer mechanism of each? **(8 points)**

3. What is the difference between PSL and HQL? Give two examples of a product that needs to have HQL. **(5 points)**

4. Draw a typical drying curve (plot between the moisture content and the drying time) for dried bananas. Name 3 major drying parameters that affect the rate of drying of food products? What is the general final moisture content for dried or fried snack food? **(8 points)**

5. What is the difference between the crust region and the crumb region of a product? Draw a picture showing these regions and give 3 examples of foods that have both regions. **(6 points)**

6. Discuss the heat and mass transfer processes that take place during the frying of French fries. Draw a diagram and use arrows to show direction of heat and mass transfer. What are some major differences between French fries and potato chips? Which contains more oil? **(12 points)**

Part IV. Short Calculations (45 points)

1. Experimental results with a concentric cylinder viscometer used for banana puree at 340 K were as followed:

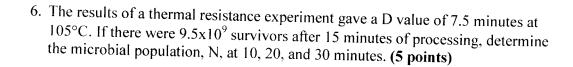| Shear Rate $[10^{-3} \times 1/s]$	Shear Stress $[10^{-4} \times Pa]$
1.0	2.40
1.5	3.20
2.0	3.50
3.0	4.50
4.0	4.60
5.0	4.90
6.0	5.20
7.0	5.30

Assuming Power-Law behavior, determine the rheological parameters required to describe the product. (**8 points**)

2. If the maximum velocity of a power law fluid flowing through a pipeline system is 2.0 times that of the average velocity, what is the flow behavior index of the material? (**2 points**)

8

3. For the pasteurization of guava juice, a regenerative heating/cooling section is used. After the "starter" raw juice has been heated to 77°C, it is passed through a holding loop and into a regeneration section. The juice then heats up the incoming raw juice from 30°C to 59°C. While the "starter" juice temperature decreases to 39°C. Compute the % regeneration of the system. **(5 points)**

4. For Problem 3, what is the flow rate of the chilled water required to reduce the temperature of pasteurized juice from 39°C to 5°C? The specific heat of pineapple juice is 3.95 kJ/kg°C and the specific heat of the chilled water is 4.18 kJ/kg°C, and the mass flow rate of the pineapple juice is 1000 kg/hr. Chilled water enters the heat exchanger counter-currently at 2°C and leaves at 10°C. **(5 points)**

5. What does LMTD stand for (abbreviation for)? For a countercurrent flow regime in Problem 4, if a double pipe heat exchanger is used, what is the LMTD of the system? What is the length of the pipe if the internal diameter of the pipe is 8 cm and the overall heat transfer coefficient is 2,000 W/m² K? **(10 points)**

6. The results of a thermal resistance experiment gave a D value of 7.5 minutes at 105°C. If there were 9.5×10^9 survivors after 15 minutes of processing, determine the microbial population, N, at 10, 20, and 30 minutes. **(5 points)**

7. If the decimal reduction time at 105°C, D_{105}, is 3.5 minutes, how long does it take to reduce the number of microorganisms from 505,000,000,000 to 1 at 121°C if the thermal resistance constant equals 8°C? **(5 points)**

8. If the thermal death time is $F^{7.5}_{115}$, what is the spoilage probability of a 300-seconds process at 130°C, when $D_{115} = 15$ minutes and the initial population is 10^7 per container. **(5 points)**

Part V: Food Processes (35 points)

1. Name the following product and commercia processes that your friends presented based on the information given. You must be EXACT to obtain full credit. **(10 points)**

    1.1 Cooking oil, onions, carrots, tomato, garlic, chicken, salt: _____.

    1.2. Bread crumbs, chicken, Chinese broccoli, salad cream: _____.

    1.3. Sweet potato, sugar, flour, salt, sesame seeds, vegetable oil: _____.

    1.4. Flour, baking soda, sugar, salt, sesame seed: _____.

    1.5. Sticky rice flour, salt, shredded coconut, sesame, pandanus: _____.

    1.6. Crushing, Fermentation, Aging, Bottling: _____.

    1.7. Mixing of Flour, Baking: _____.

    1.8. Crystallization, Purification: _____.

    1.9. Pre-cooking, Raw-Packing, Sealing, Retorting: _____.

    1.10 Washing, Peeling, Slicing, Blanching, Frying: _____.

2. You just won the Thailand lottery worth 10,000,000 baht and have inside news that countries in the Middle East, Europe, and China are very interested in Thai desserts and snacks. Using YOUR TEAM'S PRODUCT, discuss your new dessert, food, or snack products that you plan to export to Europe, China or the Middle East. List the **major ingredients, how to make it,** what **processes and equipment** will you need, how to **package** it, the **price per unit**, the **units per package**, etc. Finally, discuss additional **marketing strategies** that could be used to increase profit. Don't forget to **name your product** and give a **slogan. (25 points)**

Useful Equations:

$$\sigma = \frac{\Delta \text{Pr}}{2L}$$

$$Q = \int_0^R u(r) 2\pi r \, dr = \bar{u} A$$

$$\frac{u_{max}}{\bar{u}} = \frac{1+3n}{1+n}$$

$$N_{Re,PL} = \left(\frac{D^n (\bar{u})^{2-n} \rho}{8^{n-1} K} \right) \left(\frac{4n}{3n+1} \right)^n$$

$$\left(N_{Re,PL} \right)_{critical} = \frac{6464n}{(1+3n)^2 \left(\dfrac{1}{2+n} \right)^{(2+n)/(1+n)}}$$

$$\frac{N}{N_0} = \left(10^{-\frac{t}{D}} \right)$$

$$\frac{1}{r} = (N_0) \left(10^{-\frac{t}{D}} \right)$$

$$z = \frac{T_2 - T_1}{\log D_{T_1} - \log D_{T_2}}$$

END OF EXAM!
CONGRATULATIONS!
GOOD LUCK ON YOUR JOB SEARCH
AND
HAVE A GOOD VACATION!