North Carolina State University
Department of Food, Bioprocessing and Nutrition Sciences
(http://fbns.ncsu.edu)

FS 231: Principles of Food and Bioprocess Engineering (4 Credits)

Instructor: K.P. Sandeep
Feedback Forms

Course Expectations
Why are you taking this course?
What do you hope to get out of it?
Impact Statement

What impact has FS 231 had on you?
What did you get out of it?
What could be changed about it?
Would you recommend it to others? Why or why not?

Approximately half page write-up

Due towards end of semester (see syllabus) for extra credit (0.5 points)
Pilot Plant Tour Report

You will get a tour of our pilot plant facilities towards the end of the semester (see syllabus for date)

Write-up: What are the different pieces of equipment you saw? What are their applications and limitations?

Approximately one page write-up

Due towards end of semester (see syllabus) for extra credit (0.5 points)
Overview of FS 231

• Fundamentals of Food and Bioprocess Engineering
• Computer skills
• Math skills
  – Logarithms, interpolation, weighted mean
• Practical considerations (design or comprehensive review)
• Presentation skills
• Writing skills
FS 231 Website

http://ncsu.edu/project/foodengineer/231

Listserv: fs231001@lists.ncsu.edu
Preferred email other than NC State email can be added
Information on Website

- Syllabus
- Notes, practice problems, short answer questions
  - Suggestion: Print and bring these to class
- Quizzes and exams from past years
- Laboratory write-ups
  - Print and bring these to lab
- Summary of grades
- Anonymous feedback
Schedule

Lectures: Mon, Wed, Fri (9:35 am to 10:25 am in 103 Schaub)
Some lectures will include problem solving (bring CALCULATOR to class every day)

Lab: Thu (3:00 pm to 5:45 pm)
Location varies (meet in 105 Schaub for most labs)

Many lab sessions will begin with a quiz (see syllabus)
Some lab sessions may be used for lectures or problem solving
Instructor

K.P. Sandeep
Office: 100B Schaub Hall
Phone: 919-515-2957
E-mail: sandeep@ncsu.edu
URL: ncsu.edu/project/foodengineer

Office Hours: Mon (10:30 am to 11:30 am), Thu (10:00 am to 11:00 am)
Appointments or walk-ins are okay if I’m available

Roles: Interim Department Head, FBNS
Site Director, CAPPS (http://u.osu.edu/capps)
Teaching Assistants

Trisha Bhatia
Office: 102 Schaub Hall
E-mail: tbhatia@ncsu.edu
Office Hour: Wednesday (2:00 pm to 3:00 pm)

Morgan Caudill
Office: 102 Schaub Hall
E-mail: mfcaudil@ncsu.edu
Office Hour: Wednesday (10:30 am to 11:30 am)

Wendy Rivero Pena
Office: 102 Schaub Hall
E-mail: wcrivero@ncsu.edu
Office Hour: Tuesday (3:00 pm to 4:00 pm)
Prerequisite

PY 211
OR
PY 205 and PY 206
OR
Equivalent course
OR
Permission of instructor
Textbook (Required)

**Title:** Introduction to Food Engineering  
**Authors:** R.P. Singh, D.R. Heldman  
**Publisher:** Academic Press, Inc.

**Edition:** 5th  
**Year:** 2013

**Availability:** Online

Bring textbook to class every day (we may use tables, charts etc.)
Primary Course Objectives

1. Use and transform engineering units and dimensions
2. Use steam tables to determine properties of steam
3. Apply the laws of conservation of mass and energy to various food processes
4. Characterize the flow behavior of Newtonian and non-Newtonian fluids
5. Determine friction losses and pumping requirements for various processes
6. Compute the rate of heat transfer for steady state conduction and convection heat transfer
7. Perform a heat transfer analysis for unsteady state heat transfer
8. Evaluate the effectiveness of different types of heat exchangers
9. Compute refrigerant requirements using pressure-enthalpy tables for cooling various foods
10. Estimate freezing times of products with simple geometrical shapes
11. Compute the heating requirements in single and multiple-effect evaporators
12. Use a psychrometric chart to perform calculations and design a drying process
13. Estimate drying times for food dehydration
14. Compare the choice of thermal/alternative processing technologies for various applications
Secondary Course Objectives

1. Use a spreadsheet software to perform data analysis, regression, and draw graphs
2. Perform searches on various topics using the library database and the internet
3. Present reports in accordance with the Journal of Food Science style guide
4. Deliver presentations using a computer software
# Grades

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<td>90-93 %</td>
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Extra credit: Can be an in-class or take-home task (unannounced dates)

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<tr>
<td>Project (Report)</td>
<td>10%</td>
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<tr>
<td>Laboratory Reports</td>
<td>15%</td>
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<tr>
<td>Quiz (Best 8)</td>
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<td>Exam I</td>
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<tr>
<td>Exam II</td>
<td>15%</td>
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<tr>
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<td><strong>TOTAL</strong></td>
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<tr>
<td>Extra Credit</td>
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Reports

• Lab reports: Due by 3:00 pm on the due date
  – Lab #1 (Hand-written): Corner staple report
    • Lab handout (printed from website) should be the first page of your lab report
  – Lab #2 (MS Word doc): Email as one file [filename: “Smith-Jane(Lab-2).docx”] to fs231tas@lists.ncsu.edu
  – Lab #3 - #10 (MS Excel doc): Email as one file [filename: “Smith-John(Lab-3).xlsx”] to fs231tas@lists.ncsu.edu

• HW assignments: Due by 5:00 pm on due date (corner staple ALL reports)
  – HW question sheet should be the first page of your HW report

• HW & Lab reports must be written independently (group discussion is okay); show ALL work/calculations; write UNITS along with numbers, especially for final answer

• For every working day the report is late, 20% of the max score will be deducted

• Reports that can not be easily read by the grader will result in a 20% of the max score being deducted
Attendance

- Attendance is mandatory for lectures, labs, and all assignments
- Missed labs, quizzes or quizzes can be made up only under extenuating circumstances accompanied with appropriate documentation
- University attendance policy
  - [http://policies.ncsu.edu/regulation/reg-02-20-03](http://policies.ncsu.edu/regulation/reg-02-20-03)
Students with Disabilities

• If you have a disability that affects your participation in class, please let me know
  – At the end of class, stop by my office, or email me

• You can also contact the Office of Institutional Equity & Diversity
  – http://oied.ncsu.edu/oied

• NC State’s policy on academic accommodations for students with disabilities
  – http://policies.ncsu.edu/regulation/reg-02-20-01
Academic Integrity

• All students are expected to adhere to the code of student conduct
  – Must not receive or give unauthorized aid for any aspect of the course

• Office of student conduct
  – http://studentconduct.ncsu.edu
Laboratory Topics

1. Temperature measurement
   Steam quality (mass and energy balance)
2. Fermentation in a bioreactor
3. Viscometry
4. Pumps and pipe friction
5. Thermal conductivity
6. Heat exchangers and overall heat transfer coefficient
7. Convective heat transfer coefficient
8. Refrigeration
9. Freezing
10. Psychrometrics

Lab calculations are best done in a spreadsheet software such as MS Excel rather than using a calculator.

Lab Safety: [http://www.ncsu.edu/project/foodengineer/231/labs/Lab-Safety.pdf](http://www.ncsu.edu/project/foodengineer/231/labs/Lab-Safety.pdf)
Design/Overview Project
(Report and Presentation)

Design of a Food Engineering Related Operation

OR

Comprehensive Overview

• Project Report (Group)
• Project Presentation (Group)
• Evaluation of contribution of each team member
Other Details in Syllabus

• Daily reading assignments from textbook

• Due dates for assignments

• Lab, quiz, and exam dates
Suggested List of Things to Bring to Class

• Textbook and/or charts & tables from textbook
• Printed notes, practice problems from website
• Calculator
• Printed lab write-up from website for lab sessions
Topics in FS 231
List of Topics Covered

• Units and Dimensions
• Mass and Energy Balances
• Bioreactors and Fermentation
• Fluid Flow
• Energy in Food Processing
• Heat Transfer
• Refrigeration
• Freezing
• Evaporation
• Psychrometrics
• Drying/Dehydration
• Thermal Processing
• Alternative Technologies
Units and Dimensions

• Essential throughout this course and also in other courses
• Physical quantities MUST be accompanied with units
• Check dimensional consistency of equations
Mass and Energy Balances

• Useful in various food processing operations (evaporation/concentration, mixing, dehydration)
• Use of steam in heating
• Use of cold water for cooling
Fermentation in Bioreactors

- Bioprocess
- Biofuel
- Enzyme, catalyst
- Yeast
- Fermentation
- Bioreactor
  - Factors affecting performance
Fluid Flow

- Types of fluids (Newtonian, non-Newtonian)
- Types of flows (laminar, transition, turbulent)
- Viscosity and factors that affect it
- Pumps, viscometers, flow measuring devices
- Pumping requirements
- Friction (Moody diagram)
- Bernoulli’s equation (energy balance)
Energy in Food Processing

- Steam generation
- Fuel utilization
- Electric power utilization
Heat Transfer

- Phase diagram of water (Solid, liquid, gas)
- Properties of steam & steam tables (T, P, H)
- Modes of heat transfer (conduction, conv., rad.)
- Types of heat exchangers (plate, tubular....)
- Thermal properties (specific heat, thermal cond.)
- Steady and unsteady state heat transfer (Time)
- Dimensionless numbers (No units)
Refrigeration

- Components of a refrigeration system
- Refrigeration cycle
- Pressure-enthalpy charts
- Coefficient of performance
- Design of a refrigeration system
- Multi-stage systems
Freezing

- Types of freezing systems
- Frozen food properties
- Freezing time prediction (Planck’s equation)
- Depression in freezing point
- Quality changes during freezing
- Design of a freezing system
Evaporation

- Types of Evaporators
- Boiling point elevation
- Multiple-effect evaporators
- Vapor recompression (thermal, mechanical)
- Design of an evaporator
Psychrometrics

- Dry and wet bulb temperatures
- Properties: Dry air, water vapor, air-vapor mixtures
- Psychrometric chart
- Heating, mixing, drying of air
- Adiabatic saturation of air
Drying/Dehydration

• Water activity, moisture diffusion
• Drying rate curves
• Heat and mass transfer
• Types of dehydration systems
• Spray and freeze drying
• Drying time prediction
• Design of dehydration systems
Thermal Processing

- Classification of foods based on pH and water activity ($a_w$)
- Microbiology
- Blanching, pasteurization, extended shelf life (ESL) products, UHT/Aseptic, canning, hot fill, minimal processing
- Equipment
- Kinetics: $D$, $z$, $F$ values
- Time temperature integrators (TTIs)
Alternative Technologies

• Infrared heating
• Ohmic heating
• Radio frequency heating
• Microwave heating
• High pressure
• Ultrasonic waves
• Membranes
• Pulsed light
• Pulsed electric field
• Irradiation
• Ultraviolet radiation
• Ozone