Dr. P. M. Armenante
New Jersey Institute of Technology
September 1, 2009

Principles of Pharmacokinetics and Drug Delivery
PhEn 618

Syllabus

Term: 2009 Fall Semester

NJIT Course Title: Principles of Pharmacokinetics and Drug Delivery

NJIT Course Number: PhEn 618, Section 101

Course Instructor: Piero M. Armenante, Ph.D.
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Instructor's Office Hours:

- Tuesday 5:00-6:00 pm
- Wednesday 5:00-6:00 pm

However, students are strongly encouraged to contact Prof. Armenante via e-mail to arrange for a meeting. *Please note that Prof. Armenante will **not** be available for consultation when he is on business travel.*

Grader: Kwanseok Kim, ChE Ph.D. Candidate

Course Day and Time: Tuesday, 6:00 - 9:05 p.m.

Classroom: NJIT, GITC 5602

Course Notes, Textbooks, and Other Reference Material:

- **Notes**: Armenante, P. M., 2009, *Pharmacokinetics and Drug Delivery Course Notes.* The *Notes* are duplications of the overheads used in class. The *Notes* are available on the internet and can be accessed using the procedure described below.
- **Textbook**: The following book is recommended but not required as a textbook:

- Shargel, L., Wu-Pong, S. and Yu, A. B. C., *Applied Biopharmaceutics and Pharmacokinetics*, 5th Edition, McGraw-Hill, New York, 2005.

Additional reference books (not required) are:

- Welling, P. G., *Pharmacokinetics: Processes, Mathematics, and Applications*, American Chemical Society, 1997.
- Allen, L. V., Popovich, N. G., and Ansel, H. C., *Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems*, 8th Edition, Lippincott Williams & Wilkins Publishers, 2005. [Remark: this is the textbook used in PhEn601].
- Lieberman, H. A., Rieger, M. M., and Banker, G. S. (eds.), *Pharmaceutical Dosage Forms: Dispersed Systems*, Vol. 1, Marcel Dekker, 1996.
- Lieberman, H. A., Lachman, L., and Schwartz, J. B. (eds.), *Pharmaceutical Dosage Forms: Tablets*, Vol. 1, Marcel Dekker, 1989.
- Avis, K. E., Lieberman, H. A., and Lachman, L. (eds.), *Pharmaceutical Dosage Forms: Parenteral Medications*, Vol. 1, Marcel Dekker, 1991.

- A list of reference books is attached.

Availability of Course Notes, Homework Assignments, Textbook, and References:

- The *Course Notes* will be posted on the internet as PDF files (i.e., you will need Adobe Acrobat to read and print them). The *Course Notes* can be downloaded from the NJIT website using Moodle. Students can **either** access Moodle directly (http://moodle.njit.edu/) and follow the instructions there, **or** go through Highlander Pipeline as follows:
    1. Go to http://my.njit.edu and login using your UCID.
    2. Click on the "My Courses" tab
    3. Click on the link towards the bottom of the screen for "NJIT Moodle Rooms: Click here to access your course in Moodle"
    4. You will automatically be logged into NJIT's new Moodle server.
    5. Locate your course and click on the link with the course title.
    6. If at any time you are experiencing problems and are unable to log in please let the helpdesk know at 973-596-2900.
- The homework is also posted weekly through Moodle
- The Shargel et al. book, and Allen et al. book are available in the NJIT bookstore (973-596-3200; www.njit.edu, then click on "Bookstore under "Quick Links") or from the publishers.
- Additional material (reading material, etc.) will be distributed in class. For additional information, please contact Prof. Armenante.
- Most additional references (not required as textbooks) as well as the textbooks are available in most university libraries, including the NJIT library.

Course Prerequisites: PhEn 601 (this requirement can be waived – please discuss this with Prof. Armenante); **and** successful completion of the bridge program (PhEn 500, PhEn 501 and PhEn 502) if required, **as well as** any other undergraduate-level courses specified in the student's admission conditions, if any. PhEn students who do not have these prerequisites will have to **drop** the course. Students enrolled in other degree programs should talk to the instructor to make sure that they have the appropriate prerequisites.

Course Objectives: The course is one of the common core courses for the Pharmaceutical Engineering M.S. Degree Program. The main objectives of the course are to present the different pharmacokinetics principles affecting drug adsorption, distribution, metabolism and excretion; quantitatively study and apply mathematical models used to describe these phenomena; and provide the students with basic concepts of drug delivery, preformulation, and formulation design.

Course Description: The course covers the basic principles of pharmacokinetics, including absorption, transport distribution, metabolism, and excretion of drugs and metabolites in the human body, drug transport, parenteral and enteral routes of drug administration, and factors affecting drug absorption, distribution, and metabolism. Mathematical pharmacokinetic models and drug delivery processes are also presented and quantitatively studied. The course also covers basic aspects of preformulation, formulation and drug delivery of different drug delivery systems and dosage forms.

Course Outline by Topic Areas: Introduction; pharmacokinetics and its role in drug discovery; drug development and process development; drug absorption, distribution, metabolism, and excretion; routes of drug administration; drug absorption by different routes of administration; enteral and parenteral routes; drug transport in biological systems; solute diffusion in homogeneous and heterogeneous systems; drug permeation through biological barriers; permeability; drug distribution; transcapillary exchange of drugs; perfusion-limited and permeability-limited distribution; binding of drugs to proteins; physiological barriers; renal excretion; renal clearance; drug metabolism; metabolic clearance; mathematical approach to pharmacokinetic modeling; one-compartment open models and data analysis; multiple-dose pharmacokinetics; two-compartment open models; physiological pharmacokinetic models; nonlinear pharmacokinetics; metabolite pharmacokinetics; pharmacokinetic-pharmacodynamic modeling; preformulation, and drug product characterization; drug modifications and formulation.

Course Requirements:

- Examinations: Two exams, i.e., a midterm exam and a final exam
- Homework: Assigned by the instructor at the end of each class
- Projects: One, or possibly two, short projects will be assigned after the midterm exam (see below for details)

Grading Policy*:

- Midterm exam* 38%
- Final exam* 38%
- Homework 9%
- Projects 15%

  Total 100%

(*) Students performing very poorly on the exams will **fail** the course *irrespective* of their performance in the homework and projects, as specified below.

Course Final Grade: a tentative guideline for the assignment of final grades is the following:

Cumulative Points	Overall Grade
85-100%	A
70-85%	B/B+
60-70%	C/C+
50-60%	"D"
0-50%	F

The grade of "D" is not assigned to students taking graduate courses. Students averaging a cumulative point score corresponding to a "D" in the above table could receive either a C or an F, depending on their overall performance.

Please remember that this is only a guideline designed to help the students understand how they are performing in the course. Dr. Armenante will feel free to change the grading scale (both ways) when assigning the final grades.

Important Remark: Each exam (midterm and final) will be graded on a point scale from 0 to 100 (100 points in an exam=38% of the final grade; see above). However, **failing to achieve a combined average of at least 55/100 in the two exams** will imply **failing the course (F grade) *irrespective* of the points obtained through the homework and the projects.** In other words, students who perform extremely poorly in the exams will not be able to use the homework and the projects to pass the course. If this minimum requirement is satisfied, the final grade will be assigned based on the grading policy outlined above.

Exams:

- a calendar of exams is included in the Course Outline given below;
- all exams are typically 3 hours long unless otherwise stated;
- all exams are typically open-book and open-note. However, changes could be made and will be announced by the instructor prior to the exams;
- the final exam will be on all material covered throughout the course (although the main emphasis of the exam will be on the material covered after the midterm exam);
- make-up exams will only be given to students who cannot attend the regular exam time, *and only under documented and extraordinary circumstances*. In any case, no student will be allowed to take a make-up exam unless he/she has the prior consent of the instructor. *If a student will simply not come to an exam, the exam grade will automatically be zero.*

Homework: it will be assigned at the end of selected class periods, collected the following week at the beginning of the class period, and returned the week after that. No late homework will be accepted. The homework problems will be posted on the internet and can be retrieved by the students as described previously for the *Class Notes*. If appropriate (typically for quantitative problems) homework

solutions will be posted on the internet (as described for the *Class Notes*) after the homework has been collected.

> **Important**: Previous experience has clearly shown that those students who do not work on the assigned problems (or at least seriously try to solve them) typically perform *very poorly* on the exams.

Homework Grading: The homework will be graded using a simplified grading scale, i.e., 0 (no or minimal effort); 5 (intermediate effort); 10 (significant effort).

Projects: Every student will complete one, or possibly two, small projects, which will be assigned after the midterm exam and collected on the day of the final exam. The first project will consist of critically reviewing (critiquing) 2 papers published in scientific journals (as if the papers had been submitted for publication to the student). The papers will have to be related to each other and to be within the scope of the course. The students will be asked to write a short review of the papers. The student will have to justify whatever conclusions he/she may reach. The second project (if assigned) will consist of a small case study assigned by the instructor. The problem will be open-ended to allow each student to come up with his/her own analysis of the problem and solution.

Class Attendance: As for all graduate courses at NJIT, attendance is not mandatory, but strongly recommended. Experience shows that students who do not regularly attend class typically perform poorly in the course. In addition, examples are worked out during the lectures. These examples are not in the *Class Notes*. Students are responsible for all material covered in class.

Important Dates According to NJIT Calendar (Fall 2009):

August 31	Semester begins
September 8	Last day to add a course
September 14	Last day for a refund based on a partial withdrawal
October 15	Deadline to apply for **January graduation**
October 19	Last day for a refund based on a complete withdrawal
November 2	***Last day to withdraw from course(s)***
November 10	Spring registration begins
November 15	Deadline for applying for **May graduation and commencement**
November 24 (Tuesday)	Classes follow a Thursday schedule – **No Tuesday classes**
November 26-29	Thanksgiving recess — No classes
December 10	Reading day
December 11-17	Final exam period

Additional important dates are available on the web (http://www.njit.edu/registrar/calendars/index.php)

Course Outline

Week	Date	Topic
1	September 1	Introduction; pharmacokinetics and its role in drug discovery; drug development and process development; drug absorption, distribution, metabolism, and excretion; routes of drug administration
2	September 8	Drug absorption by different routes of administration; enteral and parenteral routes
3	September 15	Drug transport in biological systems; solute diffusion in homogeneous and heterogeneous systems
4	September 22	Drug transport in biological systems (continued); drug permeation through biological barriers; permeability
5	September 29	Drug distribution; transcapillary exchange of drugs; perfusion-limited and permeability-limited distribution; binding of drugs to proteins; physiological barriers
6	October 6	Renal excretion; renal clearance; Drug metabolism; metabolic clearance; mathematical approach to pharmacokinetic modeling
7	October 13	Mathematical approach to pharmacokinetic modeling; one-compartment open models and data analysis
8	October 20	One-compartment open models and data analysis
9	**October 27**	**Midterm exam**
10	November 3	One-compartment open models and data analysis, multiple-dose pharmacokinetics
11	November 10	Multiple-dose pharmacokinetics
12	November 17	Two-compartment open models; physiological pharmacokinetic models; nonlinear pharmacokinetics; metabolite pharmacokinetics
13	December 1	Pharmacokinetic-pharmacodynamic modeling
14	December 8	Preformulation, and drug product characterization; drug modifications and formulation
15	December 15	**Final exam**

Important: It is conceivable that some changes in the above outline will take place, depending on the overall performance of the class and the time actually required to cover the most important subjects of the course.

Reference Books

- *The United States Pharmacopoeia & The National Formulary. The Official Compendia of Standards, USP 30–NF 25*, Pharmacopeial Convention Inc. November 2008 (official as of January 1, 2009 until December 31, 2009).
- Amiji, M. M. and Sandmann, B. J., *Applied Physical Pharmacy*, McGraw-Hill, New York, 2003.
- Allen, L. V., Popovich, N. G., and Ansel, H. C., *Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems*, 8th Edition, Lippincott Williams & Wilkins Publishers, 2005.
- Banker, G. S. and Rhodes, C. T., *Modern Pharmaceutics*, 3rd Edition, Marcel Dekker, New York, 1995.
- Boroujerdi, M. *Pharmacokinetics: Principles and Applications*, McGraw-Hill, New York, 2002.
- Chien, Y. W., *Novel Drug Delivery Systems*, 2nd Edition, Marcel Dekker, New York, 1991.
- Gennaro, A. R. (editor), *Remington: The Science and Practice of Pharmacy*, 20th Edition, Philadelphia College of Pharmacy and Science, 2000.
- Lieberman, H. A., Rieger, M. M., and Banker, G. S., *Pharmaceutical Dosage Forms: Dispersed Systems*, Vol. 1 (1996); Vol. 2 (1996), Vol. 3, (1998), Marcel Dekker, New York.
- Lieberman, H. A., Lachman, L., and Schwartz, J. B., (eds.), *Pharmaceutical Dosage Forms: Tablets*, Vol. 1 (1989); Vol. 2 (1990), Vol. 3 (1990), Marcel Dekker, New York.
- Avis, K. E., Lieberman, H. A., and Lachman, L., (eds.), *Pharmaceutical Dosage Forms: Parenteral Medications*, Vol. 1 (1991); Vol. 2 (1992), Vol. 3 (1993), Marcel Dekker, New York.
- Martin, A. N., Bustamante, P. and Chun, A. H. C., *Physical Pharmacy: Physical Chemical Principles in the Pharmaceutical Sciences*, Lippincott Williams & Wilkins Publishers, Philadelphia, 1993.
- Notari, R. E., *Biopharmaceutics and Clinical Pharmacokinetics: An Introduction*, Marcel Dekker, New York, 1986.
- Shargel, L., Wu-Pong, S. and Yu, A. B. C., *Applied Biopharmaceutics and Pharmacokinetics*, 5th Edition, McGraw-Hill, New York, 2005.
- Tyle, P. (ed.) *Drug Delivery Devices: Fundamentals and Applications*, Marcel Dekker, New York, 1988.
- Welling, P. G., *Pharmacokinetics: Processes, Mathematics, and Applications*, American Chemical Society, 1997.
- Welling, P. G. and Tse, F. L. I. (eds.), *Pharmacokinetics: Regulatory-Industrial-Academic Perspectives*; 2nd Edition, Marcel Dekker, New York, 1995.