



کراچی یونیورسٹی

University of Karachi

Department of Mathematics

## MATH 803: Modeling and Simulation of Biological Systems I (2+1)

| Activity               | Dates                    | Class Schedule          |
|------------------------|--------------------------|-------------------------|
| Introduction day       | September 24             | Thursday 1530h – 1709h  |
| Teaching               | September 25 – March 01, | Room No. 9, Mathematics |
| Proposal Presentations | January 1–31 2010        | Office Hours            |
| Final Examination      | March 04, 2010 (1530h)   | Thursday 1710h          |
| Vacations              | December 06–31 (Winter)  | Saturday 1255h          |

**Course Supervisor:** Professor Dr. Syed Arif Kamal

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### Course Objectives

To give the students a sound background in the techniques & the methods of modeling and simulation of biological systems, in particular, human physiological systems, with applications in clinical medicine.

### Course Outline

**Section A:** Fundamentals of scientific method, inductive and deductive logic, handling of scientific projects, accuracy, precision, reproducibility of measurements

**Section B:** Modeling growth of children, precedence and influence graphs in the physical examination of children

**Section C:** Moiré fringe topography and rasterstereography, applications in face recognition

**Section D:** Mathematics and geometry of the cardiovascular system, static modeling of the human heart, mapping of location of heart from 3-D stereophotogrammetric techniques

**Section E:** Mathematics and geometry of the skeleton,

static modeling of the human spinal column, study of posture of children, 3-D generation of human spinal column, application to quantify curvatures of spinal column (scoliosis, kyphosis and lordosis)

**Section F:** Sound in medicine, geometry of the ear, mathematics of hearing, physics of eyes and vision

**Section G:** Mathematics of diagnostic X rays, radiation penetration, X-ray image formation and contrast, photographic process and film sensitivity, radiographic detail, image noise

**Project:** Must demonstrate knowledge of Visual Basic and C++ to code and simulate a problem related to clinical mathematics.

**Laboratory:** Reproducibility in measurement of height and weight, determination of optimum weight for height, facial features from moiré fringe topography and rasterstereography, softwares to determine obesity profile, validate frequency-size relationship of human heart, size of heart from PMI readings, back- asymmetry quantification using moiré fringe topography and rasterstereography

### Recommended Reading

- J. W. Heafner, *Modeling Biological Systems: Principles and Applications*, Springer, New York, 2005
- M. Ruth & B. Hannon, *Modeling Dynamic Biological Systems*, Springer, New York, 1997

\* For course announcements, assignments and past papers, go to *Pedagogical Section*, click on “Courses (offered during the current semester)”.



## MATH 803: Course Plan

| <i>Date</i>    | <i>Topic</i>                                    | <i>Date</i> | <i>Topic</i>                                   |
|----------------|-------------------------------------------------|-------------|------------------------------------------------|
| SEPTEMBER 2009 |                                                 |             |                                                |
| 24             | Scientific method, handling scientific projects |             |                                                |
| OCTOBER 2009   |                                                 |             |                                                |
| 01             | Accuracy, precision and reproducibility         | 08          | No Class                                       |
| 15             | Modeling growth of children                     | 22          | Precedence & influence graphs in physical exam |
| 29             | Moiré fringe topography & rasterstereography    |             |                                                |
| NOVEMBER 2009  |                                                 |             |                                                |
| 05             | 3-D imaging in face recognition                 | 12          | Mathematics of cardiovascular system           |
| 19             | Heart as a system of standing waves             | 26          | The human spinal column, posture, curvatures   |
| DECEMBER 2009  |                                                 |             |                                                |
| 03             | 3-D modeling of the human spinal column         |             |                                                |
| JANUARY 2010   |                                                 |             |                                                |
| 07             | Quantification of spinal curvatures             | 14          | Sound in medicine, geometry of the ear         |
| 21             | Mathematics of hearing                          | 28          | Physics of eyes and vision                     |
| FEBRUARY 2010  |                                                 |             |                                                |
| 04             | Diagnostic X rays, radiation penetration        | 11          | X-ray image formation and contrast             |
| 18             | Photographic process and film sensitivity       | 25          | Radiographic detail, image noise               |

## MATH 803: Laboratory

Students are supposed to perform experiments 1-3 and 5 experiments selected from 4–10:

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|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| i) Must demonstrate reproducibility (stability & objectivity) in measurement of height              | vi) Software to determine obesity profiles of adult                                                                    |
| ii) Must demonstrate reproducibility (stability & objectivity) in measurement of weight             | vii) Software to validate the relationship of frequencies of phonocardiogram with the size of heart                    |
| iii) Measurement of height and weight of a classmate and determination of optimum weight for height | viii) Software to validate method of determining size and shape of heart from readings obtained from stethoscope in 2D |
| iv) Extraction of facial features (height map) using moiré fringe topography                        | ix) Software for back-asymmetry quantification using moiré fringe topography                                           |
| v) Extraction of facial features (curvature map) using rasterstereography                           | x) Back-asymmetry quantification using Rasterstereography                                                              |

## MATH 803: Marks Breakdown

| <i>Evaluation Parameter</i>     | <i>Marks</i> |
|---------------------------------|--------------|
| Class Attendance                | 10           |
| Research Proposal               | 10           |
| Programming + Laboratory Report | 30           |
| Final Examination               | 50           |

**Total 100**