Quantitative Reasoning: Understanding the Mathematical Patterns in Nature
Tentative Syllabus: Fall 2008

This is a week-by-week list of topics (1 week = 2 lectures). Not all material in the text will be covered this semester. Please note that the material on Probability (Chapter 4) is covered before we take up Chapter 3. This is done because many find Probability the most challenging topic, and we want to deal with it well before the end of the term, when everyone begins to panic about final exams.

Lecture Syllabus

Week 1: Sections 1.1, 1.2, 1.3 (start). Can other species do mathematics? Use of scientific notation on the calculator; the size of things in the natural world; geological "deep time" – the Timeline Project and Sagan's *Cosmic Calendar*; dealing with physical units.

Week 2: 1.3 (finish) – the speed of light; radar ranging the planets. 1.4 (begin) – the art of making estimates: the meaning of Archimedes' Sand Reckoner problem, how big are atoms and how do we know it?

Week 3: 1.4 (finish) – the Basic Sampling Principle and its significance; animal population studies (tagging); sphere packing and its significance in the natural world; quantifying information content of a picture.

Week 4: 2.1 – geometric growth patterns; atomic isotopes and radioactive decay; half-life and doubling time. 2.2 – mathematical models of growth and decay; 2.3 (begin) – the growth of money, continuous compounding and the magic number "e"; the concept of present value, constant dollars, inflation.

Week 5: 2.3 (finish) – geometric sums, cost-benefit analysis, investments; the concepts of inflation, "constant dollars", and the Consumer Price Index (CPI).

Week 6: 2.4 – the meaning and importance of logarithms; construction of predictive growth and decay models. Carbon-14 dating – its historical development and applications in archaeology.

> **No classes on Monday, Oct.13**

Week 7: 2.5 A case study in scientific inquiry: potassium-argon dating; the age of the Universe; meteorite impacts and the demise of the dinosaurs. 4.1 (start) - naive probability: the Hustler's Game; lists and ways to count them.

> **In-Class Midterm Exam (Sections 1.1-1.6, 2.1-2.4) will be held sometime during Week 8, Oct. 20-24 (the exact date to be annouced).**

Week 8: 4.1 (contd) – Describing outcomes as lists; Basic Counting Principle; card games; the Divide-and-Conquer counting strategy.

Week 9: 4.1 (finish) – Ordered vs unordered lists; counting unordered lists. Combinatorics – the "3 Aces" problem as the key to all the hard ones. 4.2 (begin) – The mathematical concept of probability; the Frequency Interpretation of mathematical probabilities in the real world. Valid counting protocols in probability; some paradoxes – how probability calculations go wrong; what works and what doesn't.

Week 10: 4.2 (contd.) – Addition Laws for probabilities; extensive discussion of applied examples; the birthday problem; dealing with objects that are not distinct; sampling for defects and other applications.

Week 11: 4.2 (finish) – expected value and its applications; fair games; 4.3 – independence and multiplication law for probabilities; binomial probabilities; applications in genetics and other areas. 3.1, 3.3 – Scaling operations and review of basic geometry: Pythagoras' Theorem, 180° in a triangle, matching angles when parallel lines are traversed.

Week 12: 3.3 – The Greek determination of the size of the Earth (Step 1 in the Cosmic Distance Ladder); 3.4 – congruence and similarity of triangles. Trigonometry – invariance of edge ratios under scaling; the basic trig ratios; trig tables, calculator usage in trigonometry, applied trangulation problems.

> **On wed., November 26 classes run on Monday schedule.**

Week 13: 3.5 – Inverse trig functions on the calculator. Applications – resolving power of the human eye, resolving power in astronomy; what does an "arc-second" really mean? 3.6 – The parallax effect; initial steps on the Cosmic Distance Ladder – the early Greek efforts; radar ranging the planets; the distance to the nearest stars.

Week 14: 3.7 – Modern steps on the Cosmic Distance Ladder. Getting beyond our galaxy: Cepheid variables, supernovas, and the method of "Standard Candles." Term review.

Important Dates

Columbus Day Holiday: Monday, October 13.

Thanksgiving Recess: Thursday, November 27 - Sunday, November 30.

Last lecture: Wednesday, December 10.

Reading Day: Thursday, December 12.

Final Examination: Monday December 15; 2pm-3.50pm, location TBA.