Course Title: Marine Hydrodynamics (MSCI/GEOL 582)

Instructor: Richard Styles, EWS Room 504, 777-4588, rstyles@geol.sc.edu
http://sampit.geol.sc.edu
Prerequisites: Differential equations and PHYS 201 or 211
Meeting Time: Tuesday/Thursday 12:30-1:45
Location: EWS 208
Office Hours: Monday 5:00 – 6:00 pm

Criteria for Student Grading (Undergraduate):	Homework (40%) 3 Exams (20% each)
Criteria for Student Grading (Graduate):	Homework+Project (40%) 3 Exams (20% each)

In addition to the homework and tests, the graduate students must also complete a paper review.

1. Relationship of this course to the Marine Science/Geological Sciences program curriculum.

This course is one of the highly recommended courses in the physical oceanographic sequence for both the Undergraduate and Graduate Program in Marine Science. It also is a recommended course for geological, biological and chemical oceanography students who plan to conduct interdisciplinary scientific research. The objective is, in one integrated course, to systematically develop in our marine science students, regardless of discipline, a firm understanding of the physical processes associated with fluid-sediment interactions on the continental shelf.

2. Relationship of the new course to courses offered by other graduate programs or undergraduate departments.

This course covers material not presently treated or emphasized in other graduate courses. Portions of the basic material are sometimes introduced in the undergraduate courses Physical Oceanography (312), taught by Professor Bjorn Kjerfve, and Coastal Processes (557), taught by Professor George Voulgaris, as part of the undergraduate curriculum in Marine Science or as the introductory courses for first semester graduate students. Although some of the topics have headings similar to topics offered in courses by Civil and Environmental Engineering (CEE), the preferred topics for the Marine Science Program are not assembled in a single course and the CEE emphasis is quite different. MSCI/GEOL 582 emphasizes interdisciplinary scientific research applications on the continental shelf outside the littoral zone. The CEE courses emphasize engineering applications (for example, marine structure design) for inland reservoirs, channels, rivers, estuaries and the littoral zone. MSCI/GEOL 582, therefore, bridges the gap between the other courses offered by Marine Science and the coastal courses offered by CEE.

3. Brief description of the course not to exceed 30 words.

Governing equations for turbulent geophysical flows; Ekman's elementary current system; upwelling/downwelling; tides; linear wave theory; wave and current boundary layers; fluid-sediment-biological interactions; bedload and suspended sediment transport.

4. Course Outline:

Week 1: Calculus review, equations of motion on a rotating earth, scaling arguments.

Week 2: Velocity potential, stream function, boundary conditions.

Week 3: Flow partitioning into current, wave and turbulent components. Turbulent shear stresses and eddy viscosities. Governing equations for currents.

Week 4: Geostrophic flow. Wind driven surface Ekman layers, pressure gradient driven bottom Ekman layers, Ekman's elementary current system on the continental shelf. Upwelling and downwelling.

Week 5: Tides, equilibrium theory, dynamic tidal analysis.

Exam 1

Week 6: Governing equations and boundary conditions for linear surface waves in arbitrary water depths.

Week 7: Linear wave theory- dispersion relation, wavelength, phase speed.

Week 8: Linear wave theory- pressure, velocity and acceleration fields, particle orbits.

Week 9: Superposition of linear waves, wave energy, group velocity, spectra.

Week 10: Wind seas versus swells. Wave transformation across the continental shelf, including shoaling, refraction and breaking.

Exam 2

Week 11: Wave boundary layers and wave dissipation, current constant stress layer, combined wave and current boundary layers.

Week 12: Sediment characteristics, equations of motion, initiation of motion, fall velocity.

Week 13: Wave formed ripples. Movable bed roughness, physically and biologically induced sources.

Week 14: Sediment transport in combined waves and currents on the continental shelf.

Week 15: Suspended sediment transport in combined waves and currents on the continental shelf. Role of tidal advection.

Exam 3 Final - Friday, May 2nd, 2:00 pm

Texts:

Open University, 1989. Waves, tides and shallow water processes, Pergaman Press, New York.

Dean, R.G. and R.A. Dalrymple, Water wave mechanics for engineers and scientists, World Scientific Publishing Company, Teaneck, NJ.

References:

Butman, C.A., and W.D. Grant, 1986. Potential biological effects on sediment transport and bottom flows on coastal embayments, Can. Tech. Rep. Fish. Aquat. Sci., 1458, 11.

Cacchione, D.A., W.D. Grant, D.E. Drake, and S.M. Glenn, 1987. Observations of near bottom suspended sediment effect during storms, Journal of Geophysical Research, 92, pp. 1817-1827.

Drake, D.E., 1976. Suspended sediment transport and mud deposition on continental shelves, in Marine Sediment Transport and Environmental Management, D. Stanley and D. Swift, Editors, John Wiley & Sons, New York, pp. 127-158.

Glenn, S.M. and W.D. Grant, 1987. A suspended sediment stratification correction for combined wave and current flows, Journal of Geophysical Research, 92, pp. 8244-8264.

Grant, W.D. and O.S. Madsen, 1979. Combined wave and current interaction with a rough bottom, Journal of Geophysical Research, 84, pp. 1797-1808.

Grant, W.D. and O.S. Madsen, 1982. Moveable bed roughness in unsteady oscillatory flow, Journal of Geophysical Research, 87, pp. 469-481.

Grant, W.D. and O.S. Madsen, 1986. The continental shelf bottom boundary layer, in M.Van Dyke (ed.), Annual Review of Fluid Mechanics, Vol. 18, pp. 265-305.

Grant, W.D., L.Boyer and L.P. Sanford, 1987. The effects of bioturbation on the initiation of motion of intertidal sands, Journal of Marine Research, 40, 659-677.

Grant, W.D., A.J. Williams, and S.M. Glenn, 1984. Bottom stress estimates and their prediction on the northern California shelf during CODE-1: The importance of wave-current interaction, Journal of Physical Oceanography, 14, pp. 506-527.

Madsen, O.S., 1976. Wave climate of the continental margin: Elements of its mathematical description, in Marine Sediment Transport and Environmental Management, D. Stanley and D. Swift, Editors, John Wiley & Sons, New York, pp. 65-85.

Nielsen, P., 1992. Coastal bottom boundary layers and sediment transport. World Scientific. Advance Series on Engineering, Vol. 4, 324 pp.

Smith, J.D., 1977. Modeling of sediment transport on continental shelves, in The Sea, Vol. 6, edited by E.D. Goldberg, I.N. McCave, J.J. O'Brien and J.H. Steele, Interscience, New York, 539-577.

Swift, D.J.P., 1976. Continental shelf sedimentation, in Marine Sediment Transport and Environmental Management, D. Stanley and D. Swift, Editors, John Wiley & Sons, New York, pp. 311-350.