Ocean Wave Energy Fundamentals – 23.05.2005 – 03.06.2005

Course Content (as actually taught)

Day 1 – Monday, 23rd: (Course start, 6 lectures.) Introduction; wave energy, resources and potential, examples from passed and current R&D. Simplified wave theory, orbits, propagation velocities, stored & transported wave energy. Different types (and classification) of wave-energy converters. Principles for primary conversion. Simplified example: immersed heaving body, mechanical resistance, impedance, reactance. Energy and power aspects: delivered/stored/ consumed, instantaneous/average, active/reactive. Optimum condition for max. absorbed wave power.	Day 6 – Monday, 30th: (3 lectures, exercise work.) Hydrodynamic boundary-value problem. Green's theorem. A useful surface integral taken on the totality of wave-generating surfaces. Waves satisfying the radiation condition. Proof of symmetry of radiation impedance matrix. Radiation resistance in terms of a far-field surface integral. Evanescent "waves". Wave generation in a wave channel, and the associated radiation resistance and added mass. Added-mass' association with evanescent waves (or more generally: with the near field waves).
Day 2 – Tuesday, 24th: (3 lect., exerc.wk., video.) Sinusoidal oscillations: phasors, complex amplitudes, complex mechanical impedance. Waves in different branches of physics: dispersion, propagation velocities. Stored and transported wave energy, intensity related to transported wave energy. Radiation resistance, impedance, reactance, and "added" mass. Absorption of wave energy, resonance absorption, resonance bandwidth.	Day 7 – Tuesday, 31st: (3 lectures, exercise work.) Motion of a buoy in regular waves. Wave excitation and radiation forces. Resultant heave motion. Numerical results for radiation impedance and excitation force for various body geometries. Reciprocity relations: Haskind relation, radiation resistance in terms of far-field coefficients and in terms of excitation-force coefficients. Far-field coefficients referred to local vs. global origin.
Day 3 – Wednesday, 25th: (3 lect., ex'c .wk, video.) Practical issues: primary interface types, device survival, materials, machinery for power take-off and for control (reactive/latching). Potential theory, Bernoulli's equation, Laplace equation, boundary conditions, linearisation. Fluid velocity in terms of velocity potential. Harmonic plane waves. Phase velocity and group velocity for waves propagating on water.	Day 8 – Wednesday, 1st: (3 lectures, exercise wk.) Froude-Kriloff force and diffraction force, small-body approximation, Morison's formula. Areas of validity of diffraction, mass and viscous forces. Experiments with latched point absorbers. Array of wave-power absorbers. Linear time-invariant systems. Fourier transforms. Transfer functions and impulse response functions. Causal systems. Kramers-Kronig relations.
Day 4 – Thursday, 26th: (3 lect., exerc.wk., video.) Real sea waves, shoaling, refraction and diffraction. Finite-height waves on deep and shallow water. Fourier analysis of irregular waves, measured wave spectrum, standard spectra, synthesised irregular wave, directional sea, wave measurements and data, wave parameters derived from spectral moments. Wave elevation and hydrodynamic pressure in terms of velocity potential.	Day 9 – Thursday, 2nd: (3 lectures, exercise wk.) An energy relation for non-sinusoidal oscillation. Causal/non-causal system for hydrodynamic radiation/diffraction problem. Non-causal relation between hydrodynamic pressure and wave elevation just above. Optimum (reactive) and sub-optimum (e.g. latching) control for maximising converted power. Problems related to non-causality in relation to optimum control.
Day 5 – Friday, 27th: (4 lect., exerc. work, video.) Wave's stored potential energy and kinetic energy. Energy transport, wave-power level. Circular waves, far-field coefficients, far field and near field. Introduction to interaction between waves and a system of oscillators, immersed bodies and pressure distributions (OWCs). Single body interaction, six modes of motion, excitation force vector and radiation impedance matrix.	Day 10 – Friday, 3rd: (4 lectures, course closure.) Several bodies interacting with waves: phenomenological discussion, boundary conditions on wet body surfaces. Axisymmetric system of bodies: radiation impedance, radiation resistance and excitation force, numerical 2-body example. Conversion of wave power by a single OWC: diffraction (excitation) volume flow, radiation admittance, radiation conductance, pneumatic power take-off, turbine admittance, influence of air compressibility.

Morning session (9-12): 3 lectures every day.
Afternoon session (13-16): Additional lectures (days 1, 5 and 10). Observation and measurements, in a small wave channel, of wave dispersion, group and phase velocities (days 2 and 3). Otherwise the students worked on exercises: Problems 2.5 - 2.7, 2.12, 3.1, 3.4, 3.5, 3.7 - 3.9, 4.3 - 4.12, 4.15, 5.2 - 5.5, 5.7, 5.11, 5.12, 6.1 - 6.4 in the course's main textbook, J. Falnes: *Ocean Waves and Oscillating Systems*, (days 2-9).
After the exercise sessions, videos were shown (days 2, 3, 4 and 5) that presented wave-energy R&D in Edinburgh 1973-2002, in Norway 1978-86, and in Sweden around 1980.
The course was closed day 10 at approx. 14:15.