

MATH5185 Lectures on Thermodynamics, Semester 1, 2013, UNSW

The six pdf files in this folder contain the 18 hours of lectures on seawater and ocean thermodynamics given by Trevor McDougall in semester 1, 2013. Here is a table of contents.

Topic	Page Number
Motivation for the first several lectures	1
The route to answering our question, “what is “heat” in the ocean?”	3
Nomenclature	3
A brief introduction to Absolute Salinity and Practical Salinity	4
Who was J. W. Gibbs?	8
Basic Thermodynamic Concepts: internal energy, enthalpy and PdV work	11
Entropy and the Second Law of Thermodynamics	12
The Fundamental Thermodynamic Relation (or Gibbs relation)	12
A <u>rough derivation</u> of the First Law of Thermodynamics for a pure substance	15
A <u>false start</u> at deriving the First Law of Thermodynamics for seawater	15
The proper derivation of the First Law of Thermodynamics for seawater	17
Reference states	23
Now we can play	24
Enthalpy is “isobaric conservative”	24
“adiabatic”, “isohaline” and “isentropic”; reversible and irreversible processes	27
potential temperature of seawater	28
potential temperature of a perfect gas	29
potential enthalpy	30
Conservative Temperature	31
The “conservative” and “isobaric conservative” properties	31
The “potential” property	32
Proof that $\theta = \theta(S_A, \eta)$ and $\Theta = \Theta(S_A, \theta)$	35
Various isobaric derivatives of specific enthalpy	35

Differential relationships between η , θ , Θ and S_A	36
The First Law of Thermodynamics in terms of θ , η and Θ	37
Non-conservative production of entropy	40
Non-conservative production of potential temperature	43
How <u>NOT</u> to quantify the error involved in using potential temperature	45
How to quantify the error involved in using potential temperature	45
Non-conservative production of Conservative Temperature	49
Non-conservative production of specific volume	52
Depth-integrated measures of the non-conservation of θ , η and Θ	54
Advective and diffusive “heat” fluxes	55
Keeping track of “heat” in the ocean; advection and diffusion of heat	56
The intuitive explanation of why Conservative Temperature makes sense	56
The correct explanation of the adiabatic lapse rate Γ	57
Buoyancy frequency N	59
The neutral tangent plane	60
Why do we think that the strong lateral mixing of mesoscale eddies is epineutral?	62
Fictitious dianeutral diffusion	63
Averaging the Conservation Equations	64
The dianeutral velocity \tilde{e}	68
The importance of the dianeutral velocity \tilde{e} in the deep ocean	69
Measuring the dissipation of kinetic energy: shear probes	69
Breaking internal gravity waves; the main process causing D	70
Dianeutral advection by Thermobaricity and cabbeling	71
Double-diffusive convection; “salt-fingers”	75
The “budget method” of estimating the vertical diffusivity D	75
The water-mass transformation equation	76
A review of our basic conservation equations	77
Potential density ρ^\ominus or ρ^θ	78
Calculating the thermodynamic properties of seawater using the GSW Oceanographic Toolbox	80
Freezing temperature and isobaric melting enthalpy	81

The vertical gradient of potential density	82
Geostrophic, hydrostatic and “thermal wind” equations	87
Neutral helicity	88
The geometrical interpretation of neutral helicity	89
The skinny nature of the ocean; why is the ocean 95% empty?	90
The skinny nature of the ocean; implication for neutral helicity	92
The skinny nature of the ocean; demonstrated from data at constant pressure	92
The skinny nature of the ocean; demonstrated from data on Neutral Density surfaces	93
Consequences of non-zero neutral helicity	95
Rotation of the horizontal velocity with height	98
The absolute velocity vector in the ocean	99
Planetary potential vorticity	100