This a bit of a guide to the preparation of the examination for Geophysicists. As I say several times during the course, I realize students come from a range of different academic backgrounds and some may be scared when they see the lecture notes, with their the quite bulky mathematical apparatus and the level of technical detail. But while a certain amount of explicit calculation is necessary, as it intrinsic to the development of the physical modelling and useful to a better insight, I do not intend to ask for all of it during the examination: The understanding of the physical phenomena is the final goal and the core of the exam discussion.

The following indications are not strictly "the questions" I ask during the examination, but they should make you understand what is important to retain and be comfortable with of the subjects presented during the course. Keep in mind that it is not about being able give a straight answer to a question with a formula, a number, a definition; the core is about being able to build a fluent, consequential presentation about a subject, showing physical understanding of a phenomenon.

Note: In general, the appendices are supplementary material added for your better understanding and they are not formally unless explicitly stated otherwise.

Memories from thermodynamics + A supposedly fun thing with tensors, parts 1-2
These are essentially recaps of important background. I do not ask direct questions about these during the exam, which does not mean you can flat out ignore them: What is important is having a working knowledge of these concepts, since basics of thermodynamics and tensor notation will be used constantly during the course.

Folio 1
I expect candidates to be able to explain the basic concepts here – what the continuum approximation is, what a fluid is, the Lagrangian and Eulerian approach. Explaining the concept and explicitly writing down the mathematical derivation of the total derivative are also essential.

Folio 2
Material derivative of volume integrals (Reynolds transport theorem), integral/local form of physical laws, material derivative of line integrals: Here I present the full calculations for the sake of understanding, but I will not require them. Just know the results, as they are used a lot in the following. Continuity equation: Explicit derivation of the equation and of the incompressibility condition are required.

Folio3
Here I require understanding of the whole stress/stress tensor discussion, the explicit calculation of the isotropy of pressure and of the continuity of pressure at interfaces, and just a qualitative understanding of what surface tension is.

Folio 4
The explicit derivation of Euler's equation is required, together with the understanding of the related boundary conditions and of the concept of isentropic flow.

Folio 5
The calculations and discussion on the hydrostatic equation, the examples, the isothermal and isentropic equilibrium of the atmosphere are required. The calculation for the stability condition inequality is not required, but the inequality for stable equilibrium and its physical interpretation should be known.

Folio 6

Candidates should know the derivation of Stevin's law (quite straightforward…), understand and be able to explain (only qualitatively, no equations) the examples.

Folio 7
Candidates should master the concepts of streamlines, pathlines etc. Calculations for the momentum and energy balance are not required, but candidates should be able to comment on the respective equations when shown them, and discuss their physical interpretation.

Folio 8
Candidates must be able to derive explicitly Bernoulli's law, the Venturi effect and Torricelli's law, while for the other examples a qualitative physical discussion is sufficient.

Folio 9
Candidates should discuss the physical interpretation of the incompressibility condition inequalities, explicitly derive Kelvin's circulation theorem and interpret it, and qualitatively discuss the concept of potential flow leading to the generalized Bernoulli's equation (no derivation, just interpretation).
Drag in potential flow: being able to draw the streamlines (in both reference frames) and understanding the basic concepts of drag, lift and induced mass tensor is enough (no calculations).

Folio 10
Candidates must be able to explain the general physical concept of kinematic and dynamics conditions, and know the final form of the linearized conditions. The whole mathematical treatment leading to them is not required.
Examples: The paradigmatic example (gravity waves in infinitely deep basin) should be known well, down to the calculations (since all problems of this kind are solved in the same way). Calculations for the other examples are not required; candidates should be able to write down the system of equations describing the problems and interpret physically the final solution, especially the dispersion relation with its limit cases and observations (see finite-depth basin).

Folio 11
Candidates should just understand the calculation and know that the energy is transported at the group velocity of the wave. Also, the appendix about phase and group velocity may be a useful recap for those who do not master these concepts.

Folio 12
Velocity gradient tensor: All that is required here is the geometrical/physical interpretation of the parts of the tensor's decomposition. No calculation.
The mathematical derivation of the Cauchy's stress theorem is required.
Derivation of the stress tensor for a Newtonian fluid/Navier-Stokes equation: no calculation required, but the candidates must be able to write down and interpret the three conditions for this type of fluid, the Navier-Stokes equation for a viscous incompressible fluid and the relevant boundary conditions.

Folio 13
None of this is required.

Folio 14
Angular momentum and symmetry considerations may be skipped. Candidates should qualitatively understand and explain the concept of mechanical vs thermodynamic pressure for viscous fluids. No calculation is asked for the momentum and energy balance equations, but the final results and their physical meaning are required (compare them to the ideal fluid case).

Folio 15
All of these fundamental examples are required, down to the calculations.

Folio 16
This topic is required in full, starting from the similarity concepts to the derivation of the dimensionless the Navier-Stokes equation. Dimensionless numbers and their interpretation are of special importance.

Folio 17
The calculations for the velocity field in the Stokes' flow approximation are not required. Candidates should be able to comment on the velocity field formula and compare it to the case for an ideal fluid.

Folio 18
Infinitely deep basin: This case is exemplary and should be known, including the calculations. For the successive two examples, setting up the equations and knowing the physical interpretation of the results is enough. For the general case, a qualitative understanding of the general concepts is enough – take special attention to the interpretation of the dissipative and inertial parts of the drag.

Folio 19
Damping of gravity waves: just notice that energy damping is exponential and the exponent depends on the wavelength, in a different way whether in a deep or shallow basin.
Ekman layer: just know the observation, how to set up the problem's equations and the result with its interpretation.

Folio 20
Stability with respect to arbitrary perturbations is not required.
Instability of tangential discontinuities: no calculation is required, just setting up the physical case and commenting (in depth) the dispersion relation with its special cases (Rayleigh-Taylor, Kelvin-Helmholtz).

Folio 21
Energy balance equation: Candidates must be able to write and comment on the interpretation of the equation in its integral form (no calculation).
Entropy balance: Candidates must be able to write and comment on the interpretation of the equation (Clausius-Duhem equation) in its integral form (no calculation). The discussion of the entropy production terms, leading to Fourier's law, is of special importance and the derivation of the latter equation is required.
Heat equation for an incompressible fluid: Candidates must be able to write and comment on the interpretation of the heat equation.

Folio 22
Boundary conditions for the heat equation: Candidates are required to write and discuss upon the different conditions and their whole physical interpretation.
Examples of heat transport at the crust's surface: The first and simplest example is required in full, with explicit calculations. The following examples should be just qualitatively described in the form of the equations and boundary conditions, and commented upon in physical terms.

Folio 23
Green's function method: This can be omitted (Green functions will be reprised in another course).
Similarity law for the heat equation: Candidates should know how to choose rescaling quantities, as well as the dimensionless form of the heat equation, the dimensionless numbers involved and their

interpretation, including the limit cases (high, low Reynolds). They should also understand the meaning and context of the Nusselt number.

Folio 24
Natural convection: Candidates should be able to qualitatively discuss the assumptions made to model natural convection and write down the equations for the Boussinesq approximation, including the dimensionless form and the dimensionless numbers involved with their interpretation.

Folio 25
Rayleigh-Bénard instability: This is an advanced and completely optional topic. If they like so, candidates may present the physics case and qualitatively comment on the results obtained for the marginally stable case (convective cells).

Folio 26
Candidates should be able to discuss the phenomenology of elasticity and the elastic moduli (their expressions and relations, without the mathematical derivation).
Similarly, a qualitative discussion is required about the strain and stress tensors, their constitutive relation (with its founding hypotheses) and the Lamé coefficients.

Folio 27
Statics: Candidates should be able to introduce the hypotheses for the lithostatic stress tensor and explicitly derive its form.
Dynamics: Candidates should be able to explicitly derive and discuss the Navier equation.

Folio 28
Candidates should be able to list and qualitatively discuss the starting hypotheses, including which forces are neglected in the context of elastic waves. They should also be able to formally deduce the equations for P and S waves, and to qualitatively discuss them in the one-dimensional case.
Beyond pure elasticity: Candidates should be able to write the constitutive relations for the Kelvin-Voigt and Maxwell model and to qualitatively comment on them.