Feedback Coursework 1 MNM - Spring 2023

Because this was an open-book coursework, it was set up to test understanding of previous examples and your ability to apply this understanding. There were seven sub-questions that could be answered independently to provide opportunities to gain marks on different parts of the material covered. Unfortunately, many people appear to not have taken the time to carefully read the questions and often did not use all information given in the questions and interpreted several of the questions as significantly more complex than intended and/or appear to have gotten caught up in looking through the notes to find exact workflows to follow. In consideration of this, some moderation of the marking was done (as explained below).

(a)
It was disappointing to see how confused people got about question (a). This question is very similar to Problem 8 from the workbook of Lecture 4, except that in the case in the coursework, the flow is driven by a body force (gravity) rather than a constant pressure gradient, and the top is stress free (i.e. $\partial v_1/\partial x_2 = 0$ at $x_2=0$) rather than zero slip. Stephen worked through similar examples in his lectures, so we expected this would be a familiar problem.
People made a lot of mistakes in writing the equations, including writing some terms as vectors and others as scalars, and not or incorrectly specifying the components of **v** or **x**. Before integration, one needs to at least write the equation in components (you can not just integrate nabla(**v**)), and do not forget that there are integration constants. Even noting that the resulting equation for v_1 needs to be integrated twice and that two boundary conditions are needed would have given you some points.
In consideration of the confusion people felt over this question, it was moderated such that any marks above 15 resulted in full marks for the question, while any marks below 15 were scaled as 20/15 to ensure the question's weight did not change.

(b)
This was straightforward and done well by most. The most common mistakes were sign errors on the curl and forgetting to add the unit vector that indicates that the curl is a vector in x_3 direction. The best answers would have commented on the direction of rotation and dependence on x_2 (clockwise when looking in positive x_3 direction).

(c)
This question largely followed the example in the Lecture 4 notebook. Most followed this and determined stress from the strain rate tensor and pressure. From part (a) where it was given that the gradient of p = 0, it could have been inferred that p is a constant term. However answers with just -p on the diagonal or p consistent with answers under (a) were also counted as correct. Quite a few people did not answer the question about the maximum shear stress (for which we did not expect you to diagonalise the stress tensor).

(d)
Many people appear to have gotten confused by this question. It should have been straightforward to determine the new position of four corner points using the velocity field was given. The shape could have even been guessed from simply considering

what happens to a square in a flow that is moving down a slope. *x_2* coordinates should have stayed the same during flow, because *v_2* =0, while *x_1* coordinates shift downslope, and do so more for smaller values of *x_2* (i.e towards the top of the flow). That is the sides of the volume aligned with the x_1 direction stay parallel to it, while the sides of the volume originally in *x_2* direction take on a parabolic shape. Quite a few answers suggested shapes that not physically reasonable, including rotating fluid into the underlying rigid slope.

(e)
Most people could write down the transformation matrix **T**, based on the notes, although quite a few gave the transpose of the matrix. You could have checked whether you had obtained the correct form of **T** by using trigonometry to determine the components of velocity in the *x,y* coordinate system. Most also wrote down that to transform the stress tensor, it needs to be multiplied (dot product) by the transpose of **T** and by **T**. Because of the symmetry of the stress tensor both **T**^T dot **sigma** dot **T** and **T** dot **sigma** dot **T**^T give the correct result. Answers using the form of the stress tensor from (c) were counted as correct. Matrix multiplication could have been made easier by writing the stress tensor as a sum of its isotropic part (which only has -*p* on its diagonal) and deviatoric part (which in this case should have contained zeroes on the diagonal), and transforming the two components separately and then adding them. Almost everyone forgot that *x_2*, which appears in the stress tensor, also needs to be written in terms of *x* and *y*.

(f)
Most people do not appear to have read the question well. Few people tried to actually first write out the equation (as asked in the question) in its appropriate form for the problem of the question, i.e. in terms of *x_1* and *x_2* and using the fact that v_2=0 and A=0. Although the velocity field of the flow is steady-state, the temperature is a result of a balance between conduction and advection, i.e. it is not true that $DT/Dt=0$ (only $\partial T/\partial t=0$). The hints specified how to non-dimensionalise the different parameters, and there was no need to apply Buckingham Pi theory (and in fact this is a much harder route than using the hints given), although marks were given for writing this out correctly.

(g)
Because quite a few people did not get as far as (g) this was marked as a bonus question. That is, the total coursework was marked out of 90 rather than 100 points. Those who did answer often gave some good information, including the expression for the Peclet number for this case, and what it means, as well as quite a few sensible sketches that needed to have labels along the axes and clear labelling of which curve is for a diffusion-dominated and which curve for an advection-dominated case.