27-750, Spring 2016
Homework 4

Due – 11:59pm Feb. 10th

1. [50] For this homework, I want you to keep a journal or notebook of your work to learn how to use MTex (inside Matlab). Be thorough in documenting the work. If all you do is to paste a series of pictures into the document you will lose points. To ensure that you receive full credit, give explanations of each step and what your interpretation is of each result. It does not have to be exactly correct in this exercise – I mainly am interested in seeing you learn how to use the mtex analysis tool. Later on we will review the textures that are typically found in metals and calculate the anisotropy of their properties. In fact some basic tools are found in MTEX, such as elastic anisotropy.

1A. [40] Input and analyze the EBSD dataset called fw-ar-IF1-avtr12-corr.ctf, which was acquired on a sample of a so-called interstitial-free (IF) steel. Make a plot of the microstructure with and without grain boundaries. Plot pole figures, inverse pole figures, ODF sections and 3D view of ODF. Comment on the texture and compare to what you can find in the notes or in the literature on rolled bcc metals since this is a rolled interstitial-free steel. In particular comment on the strengths of the alpha and gamma fibers in this texture. Hint: you can find most of this analysis in the MTEX lecture notes.

Again, the lecture notes provide most of the comparison points for this effort. Since rolled bcc textures have not been described, it would be particularly useful to highlight the presence of the gamma fiber i.e. crystals with <111> parallel to the ND (and the near absence of the alpha fiber, <110> // RD). In this material, the gamma fiber is strong and the alpha fiber is weak.

1B. [10] Referring back to the application example shown of the effect of texture on the earing of sheets formed into cups, do you expect the r-value of this steel to be high or low? What about the variation in the r-value with direction in the sheet (Δr)?
The strong <111>//ND (gamma) fiber texture means that the r-value should be high (around 2, in fact). Since the alpha fiber is weak and the texture is dominated by the gamma fiber, there is little variation in the r-value so Δr is small.

2. [30] In addition to the MTEX exercises, answer the following questions. Two or three sentences should be sufficient.

2A. [10]
Explain in your own words why a defocussing correction must be applied to an experimentally measured x-ray pole figure.
When a pole figure is measured with a standard x-ray diffractometer, the sample is tilted over with respect to the plane of the input and diffracted beams. This

causes the spot to spread out on the surface of the sample, which, in turn, causes the diffracted rays from the edges of the spot to escape (not impinge on) the detector. Thus the intensity decreases towards the edge of the pole figure, corresponding to large tilt angles and becomes zero at the edge.

2B. [5]

Explain in your own words why the data (i.e. the intensity values) in an experimental pole figure must be normalized.

The experimental measurement provides a number of counts for each cell (i.e. each combination of tilt and azimuth angles). These values have to be normalized to arrive at units of MRD.

2C. [5]

Write down the formula for the entropy associated with a texture (i.e. the orientation distribution).

2D. [5]

The value of the OD is allowed to be exactly zero. How is this problem dealt with when computing the entropy? Hint: the answer can be found either online or in one of the sets of lecture notes that deals with pole figures.

One computes the entropy of an OD as $S=-\Sigma f(g)\ln(f(g))$. There is an apparent problem about what to do with zero values. However, in the case of $p(x_i) = 0$ for some *i*, the value of the corresponding entropy term $[0 \log(0)]$ is taken to be 0, which is consistent with the well-known limit: $limit\{p \rightarrow 0^+\}\ p\,ln(p) = 0$. Strong textures will exhibit large entropies and a perfectly uniform (random) texture will have an entropy of zero.

2E. [5]

Explain why the entropy associated with a texture is zero for a perfectly random texture and increases with the texture strength. Comment on whether this makes physical sense to you i.e. that the most random condition corresponds to zero entropy.

A perfectly random (uniform) texture has the same value of unity everywhere; the log of 1 is zero, and thus the log(intensity)=0 and the entropy also = 0. It is ironic that a random texture is one in which there is the most disorder in the crystal orientations and yet the computed entropy is minimized. A single crystal has physically the least variation in orientation and yet has a numerically large “entropy”.

3. [20] Volume fraction calculation

3A. [10] For cell-edge binning with a 5° increment (cell width), if all the orientations of a material fall into a single cell with Φ=0°, what (to 2 significant figures) is the intensity (in MRD) associated with that cell?

Clearly we can follow the same procedure as laid out in the lecture notes, but with a different cell volume (in orientation space). The answer is 85,000 MRD.

3B. [10] For cell-edge binning with a 5° increment (cell width), if all the orientations of a material fall into a single cell with Φ=55°, what (to 2 significant figures) is the intensity (in MRD) associated with that cell?

Clearly we can follow the same procedure as laid out in the lecture notes, but with a different cell volume (in orientation space). The answer is 4,700 MRD.