NANO 703/703L
Homework 3
Due: F-10/21, 10:00 AM

Use Excel or another program for repeated calculations. Pay attention to units.

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1) A cylindrical magnetic lens has uniform field along the lens axis ($-a \le z < a$), with no field extending outside the bore. The strength of the lens is given by $ka = 3\pi/13$. Assume $a = 1.00$ cm. Find:

a) the focal length f (in cm).

b) the rotation angle $2\phi(a)$ [in deg (°)] of the image with respect to the object.

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2) A TEM is equipped with a three-lens condenser system, with the three thin, ideal lenses equally spaced by $L = 12.0$ cm. The first crossover (source) is formed by C1 at $P = 8.0$ cm above C2. The final image (probe) is formed at $Q = 4.0$ cm below C3. Find the following:

a) The net magnification *M* with C2 off;

b) The focal length f_3 of C3 with C2 off;

c) The focal length f_2 of C2, such that M' (the net magnification with C2 on) is 10% of M [the net magnification with C2 off, from (a), i.e., $M' = r \cdot M$, where $r = 0.10$].

d) The focal length f_3 of C3 for the condition in c).

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3) The basis lattice vectors in direct space for a particular crystal are given (in Cartesian coordinates) by:

$\mathbf{a}_1 = (0.40\hat{\mathbf{x}})\,\text{nm}$ $\mathbf{a}_2 = (0.20\hat{\mathbf{x}} + 0.30\hat{\mathbf{y}})\,\text{nm}$ $\mathbf{a}_3 = (0.60\hat{\mathbf{z}})\,\text{nm}$

Find the following:

a) The volume of the unit cell.

b) The three lattice constants a_1, a_2, and a_3 (in nm) and the three angles α_1, α_2, and α_3 (in °) between the basis vectors ($\mathbf{a}_i \cdot \mathbf{a}_j = a_i a_j \cos\alpha_k$, for $i \neq j \neq k \neq i$).

c) The reciprocal-lattice basis vectors $\mathbf{b}_1$, $\mathbf{b}_2$, and $\mathbf{b}_3$.

d) The lengths of the following vectors: i) $[3\bar{3}1]$ and $(3\bar{3}1)$ (with appropriate units).

e) The angle between the vectors in d).

Please clearly show work leading to your answers.

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4) For electrons with energy 2.4×10^2 KeV. Find:

a) The radius of the Ewald sphere; b) The volume of the Ewald sphere.

Assume the beam is tilted by $\theta = 12.0$ mrad from the normal to the ZOLZ of a crystal. Find:

c) The diameter of the circular intersection of the Ewald sphere with the ZOLZ.