MAEG5140 Materials Characterization Techniques Midterm Exam (30 points)
Time: 17/10/2023 4:30 pm – 6:15 pm
Notes and a calculator are allowed. No other electronic devices are allowed (e.g., cell phone, iPad).

1. (1) What is the characteristic X-ray spectrum? (1 point)
(2) Why are there two characteristic wavelengths (K_α and K_β)? Which one has a shorter wavelength ($\lambda_{K\alpha}$ or $\lambda_{K\beta}$) and why? (2 points)
(3) Which wave will be eliminated (absorbed) when selecting a filter in the experiment? If we use copper as the target (anode), which material should we use for the filter? (2 points)

2. (1) Please draw the following crystal planes of the cubic crystal system: (100), (011), (111), and (021). (2 points)
(2) Calculate the interplanar distance d of these planes (assume **a** = 0.1 nm). (1 point)
(3) Please draw the corresponding reciprocal vectors (g_{hkl}) of these planes and calculate the absolute values of g_{hkl}. (2 points)

3. (1) Please derive Bragg's equation (you can use a plot to illustrate). (2 points)
(2) What do d, θ, n, and λ refer? (1 point)
(3) What is Bragg's equation used for? (2 points)

4. (1) Please draw a reflection sphere, reciprocal spheres of crystal planes (111) and (200). (2 points)
(2) What is the radius of the reflection sphere and the radius of two reciprocal spheres? (1 point)
(3) Mark the incident X-ray, diffraction ray, diffraction angle (2θ), and reciprocal vectors. (2 points)

5. (1) What does "structure factor" mean? (1 point)
(2) What are the conditions of "system extinction" for simple, face-centered, and body-centered cubic lattice systems? Which of the following planes can produce system extinction for simple, face-centered, and body-centered cubic lattice systems? (100), (110), (111), (120), (300), (311). (2 points)
(3) What are the other factors that affect the intensity of diffraction intensity? (2 points)

6. (1) When we use X-ray diffraction to determine the lattice parameters, what is the main source of error? $a = \frac{\lambda\sqrt{H^2+K^2+L^2}}{2\sin\theta}$ (1 point)
(2) Which strategies will be used to minimize the errors? (1 point)

7. What kinds of internal stresses may exist in a cold-rolled steel plate? What are the characteristics of their diffraction spectra? (3 points)