NANO 703/703L – Fall 2016
Homework 1
Due: F-9/9, 10:00 AM

Numerical answers should be stated with appropriate units and significant figures.

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1) Are there any advantages to using high-energy electrons instead of visible light to image nanomaterials? Explain.

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2) These questions involve the wavelength λ of electrons accelerated to relativistic energy E.
a) Write a formula for λ.

b) Compute λ (in nm) for the energies listed below:
i) 78 KeV ii) 4.1×10^{2} KeV iii) 1.96 MeV
Express your answers with appropriate significant figures.

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3) Express the following lengths in units of nm:
a) 5.8×10^{-6} in b) 0.082 μm c) 66 Å

d) the distance light travels in a vacuum in 1.05 fs. (1 fs $=10^{-15}$ s)

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4) These questions involve angles and solid angles.
a) Find the angle θ (in rad) subtended by an arc of length $\ell = 0.51\text{ mm}$ with radius of curvature $R = 9.3\text{ mm}$.
b) Find the solid angle Ω (in srad) subtended by a solid arc of surface area $A = 8.0\,\text{cm}^2$ with radius of curvature $R = 72\text{ cm}$.

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5) The interference pattern at small angles from two narrow slits using a parallel electron beam of wavelength $\lambda = 0.77\text{ nm}$ shows an angular splitting between fringes of $\Delta\theta = 5.9\text{ mrad}$.
Find the slit separation d (in nm).

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6) A beam of electrons (with unspecified energy) is partially transmitted through a thin In foil.

a) From a reliable source, find the mass density (at room temp.) and molar mass of In.
Calculate the density of atoms n (in atoms/cm^3, or just cm^{-3}) for In.

b) For a foil of thickness $T = 87\text{ nm}$, the transmitted electron beam has 58% of the incident-beam intensity. Determine the mean free path length Λ (in nm) for scattering in In (at this energy).

c) Determine the total atomic scattering cross section σ_0 for a In atom at this energy. Use appropriate units.