

NANO 703/703L  
Exam 1 - Study Guide

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**Chap. 1: The TEM**

- Units and unit conversion: length, angle, solid angle
  - Small -angle approximation
  - Relativistic electron wavelength
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**Chap. 2: Scattering and Diffraction**

- Terminology: elastic/inelastic, coherent/incoherent, forward/back scattering
  - Scattering cross-section (units), mean free path
  - Two-slit interference, diffraction from single slit, Rayleigh criterion
  - Convergence & collection angles
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**Chap. 3: Elastic Scattering**

- Wave parameters: amplitude, phase, wavelength, frequency, velocity, wave number, wave vector
  - Complex exponential form of a wave, finding magnitude squared (intensity)
  - Atomic scattering amplitude (form factor), nature of the interaction of electrons with atomic matter
  - Weak-phase-object approximation, structure factor, Bragg law
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**Chap. 4: Inelastic Scattering**

- Inelastic scattering processes: collective excitations, X-ray emission, secondary electrons, excitons,...
  - Effects of ionization: characteristic X-ray emission, Auger electron emission
  - Bremstrahlung: braking radiation
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**Chap. 5: Electron Sources**

- Thermionic and field-emission types
  - Brightness definition, conservation of brightness
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**Chap. 6: Lenses, Apertures, and Resolution**

- Lens equation
- Lateral and angular magnification
- Depths of field and focus
- Spherical aberration, effect on focal length, effect on image resolution
- Factors affecting practical resolution
- Operating principles of a magnetic electron lens, axially symmetric B-field, Lorentz force

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**Chap. 8: Pumps and Gauges (& Holders)**

- Vacuum terminology: LV, HV, UHV
- Pumps: Mechanical rotary; oil diffusion, turbomolecular, ion getter
- Gauges: Pirani (thermal), Penning (ion)
- Specimen loading, tilt axes

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**Chap. 9: The Instrument**

- Condenser system, lateral demagnification
- Influences of C1, C2, and C3 on probe size; influence of CA on convergence angle
- Deflection lenses: beam tilt and shift
- Lens planes, back focal plane vs. image plane
- Imaging modes: bright-field, off-axis dark-field, centered dark-field

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**Chap. 11: Diffraction in TEM**

- Direct lattice, reciprocal lattice
- Miller indices, interplanar spacing,  $\mathbf{g}$  vector
- Selected-area diffraction

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**Significant figures and round off**

- Reasonable number of significant figures based on information available
- Rules for rounding off

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**Lab 1: TEM Magnification Calibration****Lab 2: TEM Diffraction Calibration****Lab 3: TEM Analysis of Nanoparticles****Lab 4: TEM Analysis of Carbon Nanotubes****Lab 5: Individual TEM**