COURSE NO: PH401	COURSE TITLE: Introduction to Nanomaterials
Duration: 3hours Dt-21-11-2015	Full Marks: 50

(If you find question is wrong, mention in the answer book without asking in the exam hall)

1. **Answer all the questions:** [6x2]

   i. Draw a schematic diagram of coercivity field verses particle diameter from 1nm to 1mm of hard ferromagnetic material. How it will be different for a soft ferromagnetic material?

   ii. Write a short note on class of materials.

   iii. Write a short note on resolution of SEM.

   iv. Why strength of the material increases with the decrease in the grain size? Explain with the block diagram.

   v. What are the materials properties (used for designing the engineering products) enhanced for the nanograin size materials compare to its bulk properties?

   vi. Describe multiuser MEMS/NEMS processes.

2. **Answer all the questions:** [6x3]

   i. Determine the diameter for the following nanotubes: (6,6) and (13,72). Identify the electrical nature of these nanotubes.

   ii. Two Cu nanoparticles of diameter 1 nm each combined and make a bigger nanoparticle. What is the net resistance of bigger Cu nanoparticle if the individual Cu nanoparticle (1 nm) resistance is 12 mΩ.

   iii. What are the differences between TEM and SEM.?

   iv. Give an example of a microscope which doesn't have an electromagnetic source for imaging the nanomaterials. Justify your answer by explaining the principle of imaging with block diagram of the microscope.

   v. How SAXS and GID techniques are used to characterize nanomaterials? Which technique is better for quantum dot (0-D material) and which is used for 2-D materials?

   vi. Describe nanomechanical resonator. How a MEMS device can be used as a pressure sensor?

3. **Answer all the questions:** [5x4]

   i. XRD pattern of a nanocrystalline material is having the following data. Three numbers of peaks have been observed at 38.52^0, 44.76^0 and 65.13^0 with FWHM at 1.8×10^{-3}, 1.2×10^{-3} and 1.6×10^{-3} radian respectively. The pattern has been recorded at 0.02 steps and scan rate is 1 sec per step. Calculate the crystallite size and maximum possible error on it. Take the instrumental broadening 0.015^0 for all peaks.

   ii. Write three electron microscopy techniques which are used to characterize the nanomaterials. Which types of electrons are detected for the corresponding electron microscopy (three microscopes)? Discuss the working principle of any one type of electron detector.

   iii. Calculate the melting point of 1nm, 10nm, 100nm, 200nm, and 5μm gold nanoparticle and conclude your results. (Surface tension coefficient for liquid- solid interface is 1.162N/m, Bulk melting point of gold = 1064°C, Particle density = $1.25g/cm^3$, Latent heat of fusion = 63kJ/kg or 15Cal/g).

   iv. What is half pitch? How it is very important in nanoelectronics? Define the coulomb blockade.

   v. Write a short note on magnetic recording media (give the design of both magnetic recording and magneto resistive recording media). How nanotechnology has helped to improve the permanent memory devices?

-------------------BEST OF LUCK--------------