भारतीय प्रौद्योगिकी संस्थान पटना
Indian Institute of Technology Patna
End Semester Examination (End-Sem) (Aug-Nov-2012)

COURSE NO: PH401 **COURSE TITLE: Introduction to Nanomaterials**

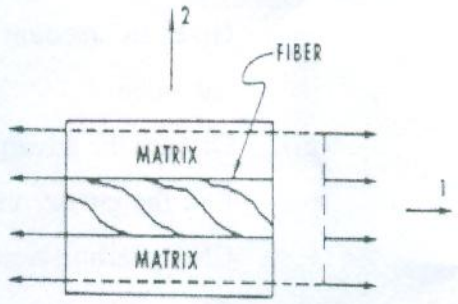
Duration: 3hours **Full Marks: 50**

1. Answer All the questions: [5x3=15]
   (i) X-ray diffraction pattern of a nancrystalline material exhibits 3 peaks ($2\theta = 30.2^0$, 41.3^o, 56.6^o with respective FWHM 0.1143, 0.1432 and 0.2142). Experiment was carried out by using CuK_α radiation ($\lambda = 1.5418$Å). Calculate the crystallite size by assuming uniform circular nanocrystals. Use constant instrumental broadening (FWHM) = 0.0628.
   (ii) Give an account of physical, thermal and mechanical properties of carbon nanotube.
   (iii) Discuss the advantage and disadvantage of nanocomposites.
   (iv) Plot the energy versus DOS (Density of States) for (a) (9,9) metallic conducting CNT (Carbon Nanotubes) and (b) (11,7) semiconducting CNT.
   (v) Discuss the three common connectivity schemes to prepare nanocomposites.
2. Draw the graph between force (between AFM tip and sample) and distance (AFM tip-sample). Mark the contact, non-contact and intermittent region. Write any 5 different scanning probe methods along with the basic principle. [4]
3. What is the tensile strength (σ_s) of C-C (bond order = 1, Bond length = 0.154 and bond dissociation energy = 348kJ.mol^{-1}) and C⁼C (bond order = 1.33, Bond length = 0.142 and bond dissociation energy = 480kJ.mol^{-1})? How much mass under earth's gravitational pull are these bonds able to hold without braking? [5]
4. Determine the chiral angle and diameter for the following nanotubes: (6,6), (10,10), (12,0), (9,3) and (11,7). Identify the conducting and semiconducting nature of the nanotubes. [5]
5. Describe the method of solid thin film or ceramic sample preparation technique for TEM measurement. Discuss the limitations of TEM technique. [4]

6. What determines the resolution of an SEM? What are the signals in an SEM that one can use for imaging? How can topographic constant be achieved? Why is it sometimes necessary to make the sample surface conductive? What options are used for this purpose? [4]

7. Write short note on coulomb blockade. How it is applied to nanotransistors i.e. single electron transistor? Plot the V-I characteristic of nanoconductors. Two Cu nanoparticles of diameter 4 nm each combined and make a bigger nanoparticle. What is the net resistance of bigger Cu nanoparticle if the individual Cu nanoparticle (4 nm) resistance is 4 mΩ. [4]

8. A unidirectional carbon/epoxy lamina with $E_f = 250$ GPa, $E_m = 1.2$ GPa, and $V_f = 0.35$. (i) Estimate the value of the composite longitudinal modulus E_1. (ii) Estimate the value of the composite transverse modulus E_2 . (iii) If fiber Poisson's ratio $n_f = 0.21$ and $n_m = 0.39$, find the lamina Poisson's ratio n_{12}? (iv) One can increase E_m by reinforcing randomly carbon nanotubes. For example, 5% and 25% volume fraction of V_{NT} can modify the E_m to 4GPa and 10GPa respectively. Can E_1 increases upto stiffness of aluminum ($E = 69$ GPa) by reinforcing carbon nanotube into the matrix? [4]



9. How can MEMS cantilever beams being used as biosensors, temperature sensors, charge sensors, pressure sensor and magnetic sensors? Can one MEMS device integrate all the above sensors? [5]

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