End-Spring Semester Examination, 2016

Mechanical Engineering Department

Indian Institute of Technology, Kharagpur

Subject: Micromechanics and Nanomechanics (ME 60432)

Full Marks: 50 Time : 3 Hrs

Answer all questions and assume reasonably wherever necessary

1. Prove that the bounds of the effective linear elastic properties of a composite are given by

$$[C^R] \le [C] \le [C^V]$$

where $[C^R]$ is the Reuss lower bound, $[C]$ is the effective linear elastic properties of the composite and $[C^V]$ is the Voigt upper bound. (10)

2. (a) In case of Method of Cells for estimating the effective elastic properties of unidirectional continuous fiber-reinforced composite, write the interfacial traction continuity conditions at the interface between the subcells. (5)

(b) Prove that according to Levin's theorem effective thermal expansion coefficients of a composite can be extracted from the effective elastic properties of the composite. (5)

3. (a) In a system of atoms, the pair-wise interaction potential energy between any two atoms is given by the Lennard-Jone potential (V_{LJ}) as

$$V_{LJ}(r) = -\frac{A}{r^6} + \frac{B}{r^{12}}$$

where the constants A and B determine the strengths of the attractive and the repulsive interactions, respectively and r is the distance between the atoms. Determine the equilibrium distance between the atoms and show that the binding energy between the atoms is $A^2 / 4B$. (5)

(b) In a lattice structure, what is called Wigner-Seitz primitive cell? Write the potential energy of an atom located at the lattice point (n, m) of a hexagonal lattice as shown in Fig. 1. Derive the stiffness matrices $[K_{-1,1}]$ and $[K_{1,-1}]$ corresponding to this atom. (3+3+4)

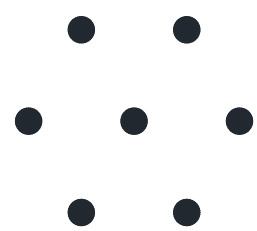

Fig. 1

4. (a) What is the difference between an "arm chair" **CNT** and a "zig zag" **CNT** ? Determine the diameter of an (m , n) **SWCNT**. (1+2)

(b) Employing a variational principle, derive an analytical model for estimating the effective young's modulus of an "arm chair" type **SWCNT**. (7)

5. Briefly explain how the waviness of **CNT** is modeled for estimating the effective Young's modulus of a unidirectional wavy **CNT**-reinforced nanocomposite. (5)