M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING EXAM 2018
FIRST YEAR SECOND SEMESTER

QUANTUM WELL AND NANOSTRUCTURED DEVICES

Time: 3 Hours *(Use separate answer scripts for each part.)* Full Marks: 100

PART I (Marks: 70)

Answer any FOUR: 4x7

1. a) Describe *Virtual crystal approximation* and its significance in relation to semiconductor alloys.

b) Classify semiconductor hetero-interfaces.

c) What is *Real space transfer*? Explain how such transfer may take place in a finite quantum well (QW).

d) Give outlines of the Variational technique to determine the ground state energy of a QW perturbed by some external agency.

e) Describe the scheme for growth of a strained superlattice (SL). Also sketch the variation of strain along its direction of growth.

f) Discuss the approaches for performance improvement in Resonant tunneling diode.

2. Answer any THREE: 3x14

a. i) Describe Multiple QW and SL with their energy band diagrams. 5
ii) Compare the structures and features of Compositionally graded SL and Doping SL. 9

b.i) Employ *Transfer matrix method* to determine the bound state energies in a multi-layered heterostructure comprised of two semiconductors. 9
ii) Modify the above structure appropriately and derive the condition that will yield transmission coefficient for it. 5

c) Derive and sketch the *Density-of-state (DOS) function* in a QW and QWW. 10+4

d) Describe the modifications introduced in valence band structure of a bulk semiconductor due to (i) Quantum size effect, (ii) Coherent strain. 4+8+2
Also highlight two important features that may arise if above modifications are

appropriately combined.

e. i) Prove that the DOS function in bulk semiconductor exhibits singularities in presence of a quantizing magnetic field. 7

ii) What is Shubnikov-de Haas (sdH) effect? Suggest two different schemes to observe it in a MOSFET. 3+4

PART II (Marks: 30)

Answer any TWO: 2×15

3. a) Describe spin polarization (P), and show that the value of magnetoresistance (MR) for a spin valve geometry is equal to $P^2/(1-P^2)$. 2+5

b) What are carbon nanotubes (CNTs)? Write down some advantages of CNTs. Calculate the diameter of a single-walled nanotube if $n = m = 5$ and the length of the unit vector is 0.246nm. 2+3+3

4. a) What is exciton? Describe different types of exciton and explain why excitonic effect in bulk is more pronounced at low temperature. 2+3+2

b) Explain quantum confined stark effect (QCSE) and how it is utilized in the operation of an optical switch. 4+4

5. What is coulomb blockade? Describe conditions required to observe charging energy on the metal island. Draw the schematic and explain operation of single electron transistor (SET). 3+5+7