

Name:

Student Number:

Quiz 4 ELEC 4705
Tuesday Nov 29 2011

1. (5 marks) Nano-structures:

- (a) What is the type of physics that is generally needed to understand and design nano-structures? **Quantum Mechanics**
- (b) Why is this the theoretical framework that must be used? **The wavelength of the electron is large wrt to the structure**
- (c) What is a quantum dot? **A nano-meter sized piece of semi-conductor**
- (d) How do we model the electronic/optical properties of a quantum dot? **Schrodinger's Equation for a small well – generally a sphere**
- (e) Are these properties size dependent and if so why? **The eigenvalues and eigenvectors (Energies and wave-functions) are specifically a function of the radius of the sphere.**

2. (5 marks) Optical Fibre

- (a) Describe the basic geometry of an optical fibre **High index core surrounded by a lower index cladding**
- (b) Describe the operation of an optical fibre using light rays and simple optics. **Oblique incidence light travels down the fiber reflecting by total internal reflection**
- (c) If we use a more careful analysis of the fibre using Maxwell's equations what effects are found to be important. **Maxwells Eq. and the solution to the resultant wave equation imply the presence of modes each with a characteristic group velocity and effective index**

3. (5 marks) Lasers

(a) What are the key components of a laser?

- **Gain medium**
- **Pumping mechanism**
- **Parallel mirrors at the two ends.**

(b) Draw the basic structure of a laser.

Mirror – Gain Medium – Mirror

(c) What is a population inversion and how do we achieve it in a semi-conductor laser?

$$n_2 > n_1$$

(d) What is the a “threshold current” in a semi-conductor laser? Define it in terms of the laser operation. **The threshold current is the current at which number of photons being produced by stimulated emission due to the recombination of the electrons and holes in the active regions is equal to all optical losses in the system. Above this current the system starts to “lase”.**