

**ECE 278 Winter quarter 2002**  
**Intro. background survey.**

What does the acronym “Laser” stand for?

Light Amplification by Stimulated Emission of Radiation  
16/30 students answered correct

Write down all four of Maxwell’s equations.

$$\vec{\nabla} \cdot \vec{e} = \rho / \epsilon_0$$

$$\vec{\nabla} \cdot \vec{b} = 0$$

$$\vec{\nabla} \times \vec{e} = -\frac{\partial \vec{b}}{\partial t}$$

$$\vec{\nabla} \times \vec{b} = \mu_0 \epsilon_0 \frac{\partial \vec{e}}{\partial t} + \mu_0 \vec{j}$$

4/30 students answered correct

What is the speed of light in vacuum (numerically)?

$3 \cdot 10^8$  m/s

30/30 students answered correct

A plane wave propagating in a medium with index of refraction  $n_1$  is incident on another medium with index of refraction  $n_2$ . What is the reflection coefficient of the plane wave at the interface? Express it either as an amplitude reflection coefficient or a power reflection coefficient.

$(n_1 - n_2) / (n_1 + n_2)$

12/30 students answered correct

Write down Schroedingers equation (time-dependent form).

$$i\hbar \frac{\partial}{\partial t} \Psi = \left( \frac{p^2}{2m} + V \right) \Psi$$

3/30 students answered correct

Briefly explain the Pauli Exclusion Principle (1-2 sentences).

No more than one electron can be in the same quantum state at the same time.

8/30 students answered correct

What is the binding energy of an electron to a proton in a hydrogen atom? (I.e. a Rydberg). Use whatever units you want.

13.6 eV

2/30 students answered correct

What is the bandgap (numerically) in Silicon, and in GaAs?

1.1 eV (Si), 1.4 eV (GaAs)

8/10 got answer roughly correct

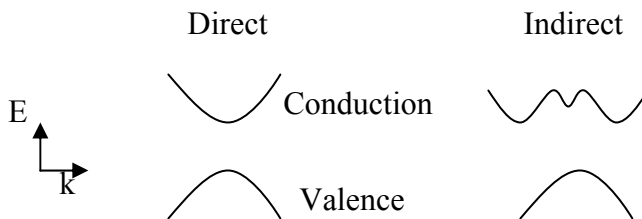
State Bloch's theorem.

In a periodic potential, the quantum wavefunctions have the form

$$\psi_k(r) = u_k(r)e^{ikr}$$

where  $u(r)$  has the periodicity of the lattice, i.e.  $u(r) = u(r+T)$ , with  $T$  a lattice vector.

What is the difference between a direct and an indirect bandgap? (One or two sentences and/or a diagram.) 1/30 students got approximately correct



11/30 students got correct

Is silicon a direct or indirect bandgap material?

Indirect 9/30 students got correct

Is GaAs a direct or indirect bandgap material?

Direct 9/30 students got correct

What is the Fourier transform of a sine wave?

Delta function 6/30 students got correct

A quantum particle with two possible energy levels  $E_1$  and  $E_2$  is in thermal equilibrium with a reservoir at a temperature  $T$ . What is the relative probability of finding the particle in level 2 vs. level 1, in terms of the energies  $E_1$ ,  $E_2$ , and  $T$ ?

$$p \propto e^{(E_2 - E_1)/kT} \quad 5/30 \text{ students got correct}$$