Exercise 11.1: Transient absorption

Explain briefly how an optical delay line works and calculate the length that is necessary in an ultrafast transient absorption experiment to measure a signal that completely decays in 20 ns. Is this a realistic experiment? What alternative experiment is possible when measuring signals on a similar timescale?

Exercise 11.2: Quantum size effects

Estimate the temperature at which quantum size effects would be important for a semiconductor layer of thickness 1 μm if the effective mass of the electrons is 0.1 m_0. (m_0 = 9.11 x 10^{-31} kg)

Exercise 11.3: Absorption in quantum wells

Using the data for GaAs listed the table below, estimate the difference in the wavelength of the absorption edge of a 20 nm GaAs quantum well and bulk GaAs at 300 K.

Table D.2 Band structure parameters for selected direct gap III–V semiconductors with the zinc-blende structure. The parameters listed refer to the four-band model shown in Fig. 3.5. E_g: band gap; Δ: spin–orbit splitting; m_e^*: electron effective mass; m_{hh}^*: heavy-hole effective mass; m_{lh}^*: light-hole effective mass; m_{so}^*: split-off hole effective mass. The effective masses are expressed in units of the free electron mass m_0. After Madelung (1996) and Madelung (1982).

Crystal	E_g (eV) (0 K)	E_g (eV) (300 K)	Δ (eV)	m_e^*	m_{hh}^*	m_{lh}^*	m_{so}^*
GaAs	1.519	1.424	0.34	0.067	0.5	0.08	0.15
GaSb	0.81	0.75	0.76	0.041	0.28	0.05	0.14
InP	1.42	1.34	0.11	0.077	0.6	0.12	0.12
InAs	0.42	0.35	0.38	0.022	0.4	0.026	0.14
InSb	0.24	0.18	0.85	0.014	0.4	0.016	0.47