1.3
Situation: Transition in the visible range in thermal equilibrium at room temperature.
Questions: What is the relative population? What is the visible range?
Problem: Which law governs the distribution?
Solution: Use Boltzmann statistics to find population in thermal equilibrium for wavelengths between 400nm and 800nm.

1.4
Situation: Transition in thermal equilibrium with a given population ratio.
Question: What is the transition frequency? What part of the spectrum does it belong to?
Problem: How is the relative population related to the transition wavelength?
Solution: Use same law as in 1.3. The transition occurs in the mid-IR region (10-100μm).

1.5
Situation: A given laser cavity.
Question: Logarithmic single-pass loss? Inversion at threshold?
Problem: How large is the total loss? How to determine the threshold inversion?
Solution: Obtain round-trip loss as 1 minus round-trip feedback. Single-pass loss is half of it. Logarithmise. To obtain threshold, equal gain and loss and solve with respect to inversion, which in the case of equality is the critical inversion (threshold inversion).

1.6
Situation: A laser beam with given wavelength is delivered over a certain distance via a limited aperture.
Question: How large is the beam after travelling the given distance?
Problem: How does a diffracted beam propagate?
Solution: Calculate the divergence from diffraction theory (1.4.1) and from this the diameter.

1.7
Situation: Specifications of a flash lamp and an Ar-ion laser are given.
Question: Compare them in terms of brightness.
Problem: What is brightness?
Solution: Brightness is the power a source emits per area and solid angle. Use the definition (1.4.4) to find the laser's brightness, which is about a million times bigger than the lamp's.

2.3
Problem: What is the maximum of the spectral energy density as a function of wavelength? Show Wien's law (wavelength of maximum spectral energy density times temperature is a constant).
Solution: Find the equation for the spectral energy density. Derivate with respect to wavelength and set equal to zero. This gives the desired relation, where $y = hc/kT\lambda$. The resulting implicit equation can be solved iteratively with respect to y.

2.7
Situation: Properties of a Ne-laser transition are given.
Question: How large is the peak cross section of that transition?
Problem: Cross section? What does it depend on? How does the line-shape function look like? Where does the life-time come into play?
Solution: The cross section can be rewritten as a function of the Einstein A-coefficient (inverse life-time) and the line-shape of the transition. If homogeneous broadening is neglected, the convolution is

equal to the inhomogeneous line-shape. The line-shape's maximum can be calculated and used to calculate the maximum cross-section.

Example 2.1
Situation: An estimate is made for the Einstein A-coefficient (and thus the spontaneous life time) for an electric dipole transition in the visible wavelength region. If the electric dipole transition is forbidden, a magnetic dipole is the most like candidate for radiation of energy. Its moment, however, is approximately 1e5 times smaller, leading to a considerable longer life time.

Example 2.4
Situation: The natural line width for a transition is calculated, from the corresponding life time estimated in Ex. 2.1.