Laser Physics I — test II
Monday, November 20, 2023
Due Monday, November 27, 2023, before 1 pm.

1 Laser stability/instability

This question relates to the linewidth of any laser. We take as example a single mode laser. At $t = 0$ the laser starts to oscillate on a longitudinal mode resonant with its Fabry-Perot cavity. The two cavity mirrors are mounted on posts that are not infinitely rigid, causing the cavity length to fluctuate. As the cavity expands, the original frequency of the intracavity beam is no longer resonant with the drifting cavity. One would expect the laser power to drop, until another cavity mode develops at the new cavity resonance, resulting in amplitude fluctuations of the output. That is not what is observed. The output power is constant, but the width (in frequency) of the mode corresponds to the length fluctuation of the cavity.
Can you explain?
To make you explanation quantitative, consider one mirror fixed, and the other moving at a constant velocity (take for instance 1 μm per ms).

2 Phase on axis

A collimated beam (large diameter) is focused by a lens of focal distance $f \gg z_0$, where z_0 is the Rayleigh range of the focused beam. A circular hole at the center of the lens lets a plane wave pass through the center of the lens. Assume that the plane wave and focusing beam are in phase, on axis, at the position of the lens ($z \to -\infty$). At which location along the beam axis will they be 90$^{\text{o}}$ out of phase? At which location along the beam axis will they be 180$^{\text{o}}$ out of phase?

3 Laser beam focusing

You are given a 1 kW CO_2 laser at 10.6 μm with a Gaussian beam waist at its flat output mirroir of w_0 = 10 mm.

3.1 Optimum focusing on a target

You are given a collection of lenses that can sustain at most a Gaussian beam of $w = 23$ mm. Your target is at 60 from the laser. To achieve a maximum intensity on target, you can select a system of two lenses 1 m apart, the first one being located at the output mirror. What is the maximum intensity you can achieve on target?

3.2 Sketch the optimal lens arrangement

3.3 Feedback on the laser

Estimate the amount of light reflected back into the laser, assuming the "target" to be a 6 mm diameter plane reflector.
Knowing that the laser was operated at 80% of saturation, and that the laser output coupler had 10%

transmission, find the change in laser power induced by the target reflection. Assume that the laser was at threshold (before introducing the reflector), and that the power supplied by the source remains constant, as well as the overall efficiency.