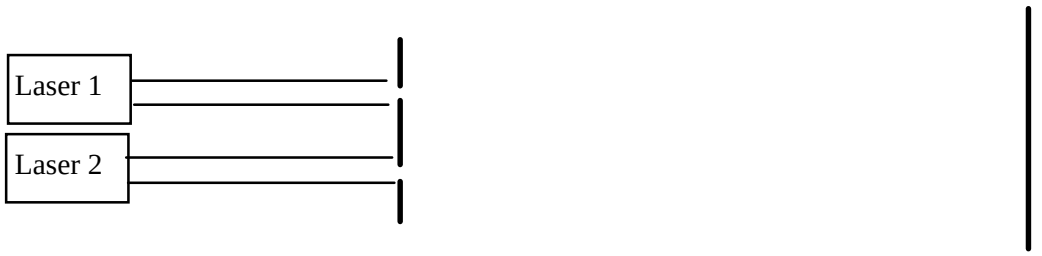
PHY2208 Optics Problem sheet 4

1) The output beam from a laser cavity diverges slightly due to diffraction. If the minimum beam diameter (the "*beam waist*") of a helium-neon laser beam (λ=632nm) is 0.5mm, estimate the apparent angular divergence of the beam far from the cavity. What will the beam diameter be, approximately, after propagating 100m?
[*Ans. 1.27 milli-radians, 12.7cm*]

2) A Neodymium-YAG laser (λ_0 = 1 μm), used routinely for laser surgery, produces its output beam in the form of a series of very short pulses. Each pulse has a duration of 30 ps and a total energy of 1 mJ. The beam is focused by a diffraction limited lens of focal ratio 3.0 (i.e. an F3.0 lens). Calculate the intensity of light in the focused spot. The intensity of a light beam I (power per unit area) can be related by EM theory to the strength of the electric field due to the light beam E by $I = \varepsilon_0 c E^2$. Hence calculate the electric field strength generated in the focused spot. Compare it to the electric field needed to ionise air (~4×10^9 Vm^{-1}) and comment. [3×10^{18} Wm^{-2}]

3) Estimate the coherence length of unfiltered sunlight. *[~ 1.2 μm]*

4) A student attempts to perform Young's slits experiment by illuminating the slits with two different lasers :



The lasers are ultra-stable Helium-Neon devices, each generating a single wavelength λ_0 = 543nm (i.e. operating in a "single mode"), with $\Delta\lambda=10^{-8}$nm . Calculate the temporal coherence time of the lasers, τ_c. Explain why the student probably couldn't observe the interference fringes by eye. *[Ans. τ_c ~ 0.098 millisecond]*