Individual, final examination

in Electro-optics, SK2401
January 11, 2013, 13:00-15:00

and in Quantum Electronics with Electro-optics, SK2400
January 11, 2013, 13:00-17:00

Allowed: “Dirac PM”, notes, course book, calculator, tables of mathematical
and/or physical formulae and constants.
Forbidden: Computers, mobile phones, all means of communication.

1. The numerical aperture of a fibre is defined as the sine of the maximum acceptance
angle ($\theta_\text{in}$) of the entrance ray that can be trapped in the core, i.e.: $\text{NA} = \sin \theta_\text{in}$, where
$\theta_\text{in}$ is measured with respect to the axis of the fibre, as illustrated by the figure below.

(a) Determine the numerical aperture in air for a step-index fibre with a cladding index
$n_1 = 1.4$, a core index $n_2 = 1.44$.
(b) If the fibre was immersed in a biological specimen with refractive index $n = 1.38$,
what would be the value of its acceptance angle?
(c) Assume now the same (single-mode) fibre to be used for the transmission of 80
telecom channels. Each channel is transmitted at a different carrier frequency. The
carrier frequencies are spaced by 50 GHz. Suppose you want to extract the first
channel, at 200 THz, with a Fabry-Perot cavity made by two mirrors (#1 and #2)
and comprising a fibre section of length $L = 11 \mu$m and an adjustable air gap of
length $l$, as sketched here below:

Assuming the refractive index of the medium in the air-gap to match exactly the
effective index of the guided-mode in the fibre ($N_{\text{eff}} = 1.42$), calculate the maximum
length of the air-gap which still allows selecting only the desired channel.