Dispersive Fabry-Perot Interferometer

Part a:

A symmetric Fabry-Perot interferometer consists of two mirrors with the same intensity reflectivity R and separated by distance l. The space between the two mirrors is filled with dispersive medium whose refractive index $n(\omega)$ is a function a frequency ω. See the figure below. The complex transmission coefficient of the field can be expressed as:

$$\frac{E_t}{E_i} = \frac{1-R}{1-Re^{-i\delta}} e^{-i\delta}$$

Derive an analytic expression for the phase delay Ψ of the transmitted beam as a function of the round trip phase delay $\delta = 2n(\omega)\omega l/c$ for normal incident light beam (i.e. θ=0). Ignore the mirror phase shifts. (1 points)

Part b:

Group delay describes the flight time for a short pulse to transmit an optical system. It is defined as $\tau = d\Psi/d\omega$, the derivative of phase delay with respect to angular frequency.

1) Derive an expression for the group delay τ of the transmitted beam in the Fabry-Perot interferometer, taking into account of the dispersion of the medium expressed in its group index n_g. (2 points)

2) Find the maximum and minimum values of the group delay. (1 point)