① $g_{th} = \alpha_{eff} + \frac{1}{2L} \ln\left(\frac{1}{R_1 R_2}\right) = 0 + \frac{1}{2 \times 0.2} \ln\left(\frac{1}{0.98}\right) = \underline{0.05\ m^{-1}}$

$t_c = \frac{n_0}{c g_{th}} = \frac{1}{3 \times 10^8 \times 0.05} = 6.67 \times 10^{-8}\ s = \underline{66.7\ ns}$

FWHM, $\Delta\nu_p = \frac{\nu_0}{Q} = \frac{\nu_0}{t_c \cdot 2\pi\nu_0} = 2.38 \times 10^6\ Hz \approx \underline{2.4\ MHz}$

$\delta\nu = \frac{c}{2 n_0 L} = \frac{3 \times 10^8}{2 \times 1 \times 0.2} = 7.5 \times 10^8\ Hz \approx \underline{750\ MHz}$

② $g_{th} = \alpha_{eff} + \frac{1}{2L} \ln\left(\frac{1}{R_1 R_2}\right) = 0 + \frac{1}{2 \times 500 \times 10^{-6}} \ln\left(\frac{1}{0.09}\right)$

$= \underline{2.40 \times 10^3\ m^{-1}}$

$t_c = \frac{n_0}{c g_{th}} = \frac{3.5}{3 \times 10^8 \times 2.40 \times 10^3} = \underline{4.86 \times 10^{-12}\ s}$

FWHM, $\Delta\nu_p = \frac{\nu_0}{Q} = \frac{1}{2\pi t_c} = 3.27 \times 10^{10}\ Hz \approx \underline{3.3 \times 10^{10}\ Hz}$

③ $\Delta\nu = \frac{c}{2 n_0 L}$, $\nu = \frac{c}{\lambda} \Rightarrow |\Delta\nu| = \frac{c}{\lambda^2} |\Delta\lambda| \Rightarrow |\Delta\lambda| = \frac{\lambda^2}{2 n_0 L}$

$\Rightarrow 1 = \frac{\Delta\lambda_{HW}}{\Delta\lambda} \Rightarrow 1 = \frac{2 \times 10^{-12}}{[(6328 \times 10^{-10})^2 / 2 \times 1 \times L]} \Rightarrow \underline{L = 10\ cm}$

④ $m = \frac{\Delta\lambda_{HW}}{\Delta\lambda} = \frac{\Delta\lambda_{HW}}{[\lambda^2 / 2 n_0 L]} = \frac{2 n_0 L\, \Delta\lambda_{HW}}{\lambda^2} = \frac{2 \times 1 \times 0.3 \times 2 \times 10^{-12}}{(6328 \times 10^{-10})^2}$

$\Rightarrow m = \underline{3}$

⑤ (a) $g_1 g_2 = \left(1 - \frac{d}{R_1}\right)\left(1 - \frac{d}{R_2}\right) = 0.121$ (stable)

(b) $g_1 g_2 = -0.0345$ (unstable)

(c) $g_1 g_2 = -0.067$ (unstable)

(d) $g_1 g_2 = 0$ (on the edge of stability)

⑥ $\Delta\nu = \frac{c}{2 n_0 L} = \frac{3 \times 10^8}{2 \times 1 \times 0.1} = 15 \times 10^8\ Hz = \underline{1500\ MHz}$, $\nu_0 = 6 \times 10^{14}\ Hz$

$m = \frac{2 n_0 L \nu_0}{c} = \frac{2 \times 1 \times 0.1 \times 6 \times 10^{14}}{3 \times 10^8} = 4 \times 10^6 = \underline{40,00,000}$

output beam will have frequencies $\nu_0 - 2\Delta\nu$, $\nu_0 - \Delta\nu$, ν_0, $\nu_0 + \Delta\nu$, $\nu_0 + 2\Delta\nu$
corresponding to m = (39,99,998); (39,99,999); (40,00,000); (40,00,001); (40,00,002)