4B11: Photonic Systems
Examples Paper 2

1. a) What are the main advantages of an $1/f$ joint transform correlator (JTC) over the more traditional non-linearity approach? Sketch the basic architecture of the $1/f$ JTC and describe the process of how it is operated.

b) Why is edge enhancement a useful algorithm in processing the joint power spectrum in a binary phase-only $1/f$ JTC?

c) Explain why an $1/f$ JTC is more suitable to the process of inspecting frames in a video sequence for object motion, than the matched filter?

2. a) What is the main difference between the ray approach versus the Huygens wavelets when solving an optical problem. Explain which is better for (i) designing a lens (ii) creating a hologram.

b) Use the basic principles of ray optics, time of flight and refractive index to prove Snell's law for the system in figure 1.

c) Could you prove this using Huygens principle?

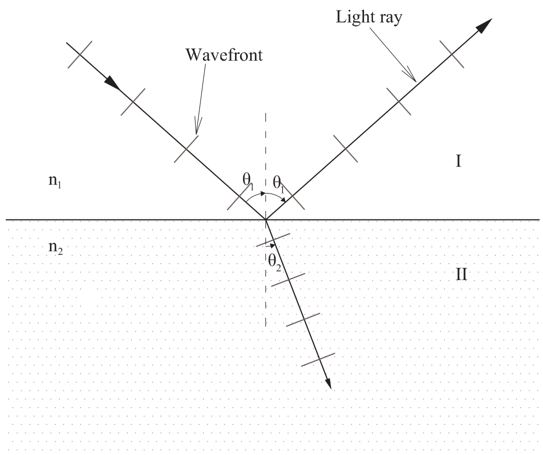

Figure 1

3. a) In an optical boundary between two transparent mediums, what are the two physical laws that must be obeyed?

b) Describe how these physical laws are observed in the case of total internal reflection.

4. A Cambridge student is riding his bicycle on a rainy day. Parts of the street are wet causing unwanted reflections from the sun. What change in the ratio of the unwanted reflections and dry-road reflections occurs when the rider wears (i) normal sunglasses and (ii) polarised sunglasses. You may use equations from the handout without derivation. State any assumptions made and use D=10m and H=1.5m. (iii) How this contrast ratio would change for a car driver if H=1.5m and D=50m?

5. a) Using Maxwell equations show that in a long waveguide

$$\gamma E_x - \frac{\partial E_z}{\partial x} = j\omega\mu_0 H_y \tag{1}$$

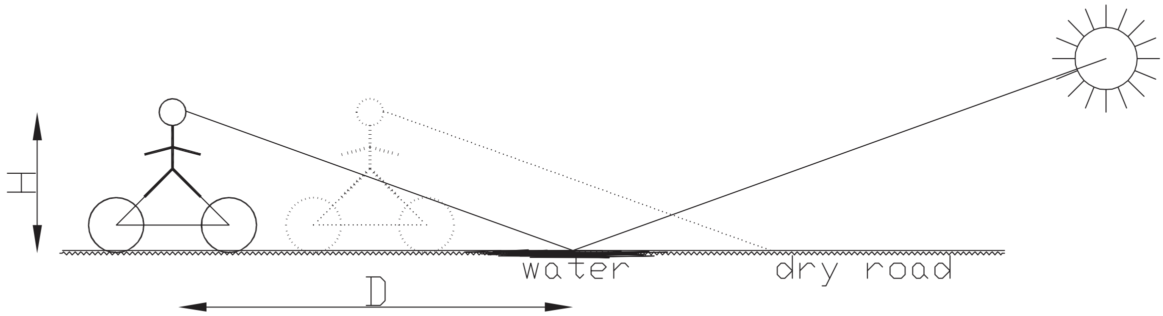

Figure 2

b) Explain what is the meaning of γ. What its value should be in an optimised waveguide?
c) The approximate solution for E_z for a square waveguide with dimensions $a \times b$ is given by:

$$E_z = A \sin(k_1 x + \phi_1) \sin(k_2 y + \phi_2) e^{-\gamma z} \tag{2}$$

What are the constrains on k_1, k_2, ϕ_1 and ϕ_1. Why?

6. Long distance optical telecommunication operate either in the 1.3μm wavelength or 1.5μm because of the low loss in glass fibres. What are the three main loss mechanisms that make these wavelengths the optimum ones? Given the small range of wavelengths what other factors will influence the choice between the two bands?

7. An optical link of 10km length was designed for 1.3μm operation and now is required to operate at 1.5μm. The transmitter is a laser source with bandwidth of 20nm centred at 1.55μm (assume that the laser has a square spectrum). At what bit rate the energy at 1.55μm - 10nm will arrive exactly one bit period after the 1.55μm + 10nm part of the pulse? Obtain chromatic dispersion data from figure 2.

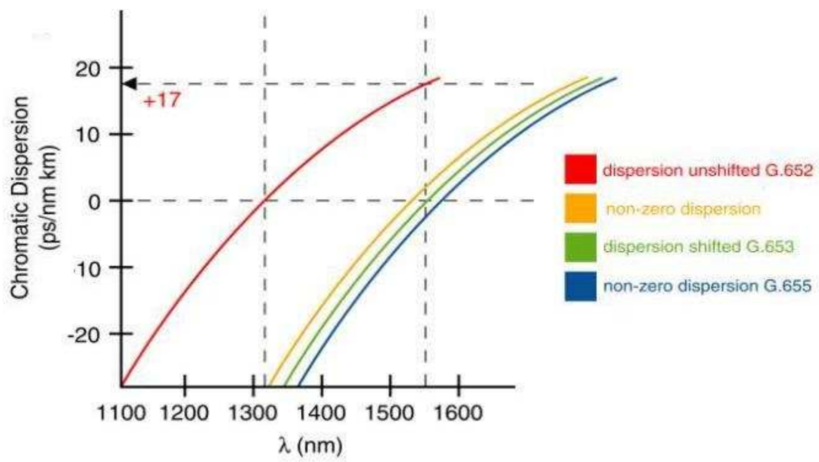

Figure 3