1.

a)

$$\vec{e}_1 = (0,1,0) \qquad \vec{e}_2 = (\cos\alpha, 0, -\sin\alpha)$$

Note that signs are not fixed by the specifications of this problem.

b) Normal dispersion

$$\theta_c \approx 44 \qquad \theta_B \approx 56$$

in degrees

c) Many possible answers, e.g.: sound wave in gas is longitudinal, electromagnetic is transverse,...

d) E.g. plane waves and spherical waves, also bessel beams. BUT: Not cylindrical waves in the form given in the class — because those are approximations.

Note that this is poorly worded question: You could give sol_1 as an exact solution to wave, and claim $1.1 sol_1$ is another exact solution — but I was obviously not asking that.

e) It is useful to remember that one micron corresponds to roughly $E_{ph} = 1.24$ eV which approximately 1.99×10^{-19}J.

Photon flux: $P/E_{ph} = 0.5 \times 10^{19}\text{s}^{-1}$.

f) Angular momentum is transferred to the plate.

g) Airy disk is the bright central spot of the far-field diffraction pattern for a circular apperture. Equivalently, it may be the bright spot in the focus of a lens (with an apperture).

h)

One of the slits closed: $I = I_b/4$.

Slits illuminated by perpendicularly polarized light: $I = I_b/2$.

2.

b) Use divergennce equation (Gauss laws). Calculation:

$$0 = \nabla.\vec{E} = \nabla.\hat{e}E_0 e^{i\vec{k}.\vec{r}-i\omega t} = i\vec{k}.\hat{e}E_0 e^{i\vec{k}.\vec{r}-i\omega t}$$

which implies:

$$\vec{k}.\hat{e} = 0$$

I.E. the wave-vector and the polarization vector are perpendicular.

c)

$$\nabla \times \vec{H} = \partial_t \vec{D}$$

$$i\vec{k} \times \vec{H} = -i\omega\vec{D}$$

$$i\vec{k} \times \vec{B} = -i\omega\mu_0\epsilon_0\epsilon_r\vec{E}$$

$$i\vec{k} \times \hat{b}B_0 = -i\omega\mu_0\epsilon_0\epsilon_r\hat{e}E_0$$

$$i\hat{k} \times \hat{b}|k|B_0 = -i\omega\mu_0\epsilon_0\epsilon_r\hat{e}E_0$$

separate the vector and amplitude portions of the above to get:

$$\hat{k} \times \hat{b} = -\hat{e} \qquad |k|B_0 = \omega n(\omega)/cB_0 = \omega\mu_0\epsilon_0\epsilon_r E_0 = \omega/c^2 n(\omega)^2 E_0 \to c/n(\omega)B_0 = E_0$$

3:

a) Insert $\theta = 0$. NOTE: that there may be a different convention in which they will differ in the sign. It does NOT mean physical difference, of course.

b) Evaluating:

$$r_s = \frac{1-n}{1+n} \to r_s = \frac{1-1/n}{1+1/n} = -\frac{1-n}{1+n}$$

so the sign changes, but intensity reflectivity scales with r^2 so it has no effect.

d) The jones matrix is diagonal with reflection coefficients on diagonal, because polarization s or p is preserved on reflection. Note that signs may depend on the orientation of the chosen frame of reference.

e) Use Brewster angle of incidence, p polarization.

4:

a) It is possible to have $T = 1$ when exactly at resonance $\Delta/2 = k\pi$. Finite reflectivity does not contradict, because there is infinite number of reflections from mirrors, each contributing to the transmission.

b)

$$\mathcal{F} = \pi\frac{\sqrt{R}}{1-R} \qquad \frac{c}{2d} \qquad \frac{2d}{\lambda}$$

5:

e) It is the second picture. The reason is that each set of edges contributes a perpendicular streak to the diffraction pattern. In the second picture, the diagonal streak is perpendicular to the hypotenuse of the triangle aperture.

f) The symmetry that MUST be present in te Franuhoffer pattern is that if a point X, Y has intensity I, the same intensity must be found at point $-X, -Y$. This is called inversion symmetry. The pattern shown does not have this symmetry, it is therefore NOT a Fraunhofer diffraction pattern.