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Exercises and Complements for the Introduction to Physics II

for Students

of Biology, Pharmacy and Geoscience

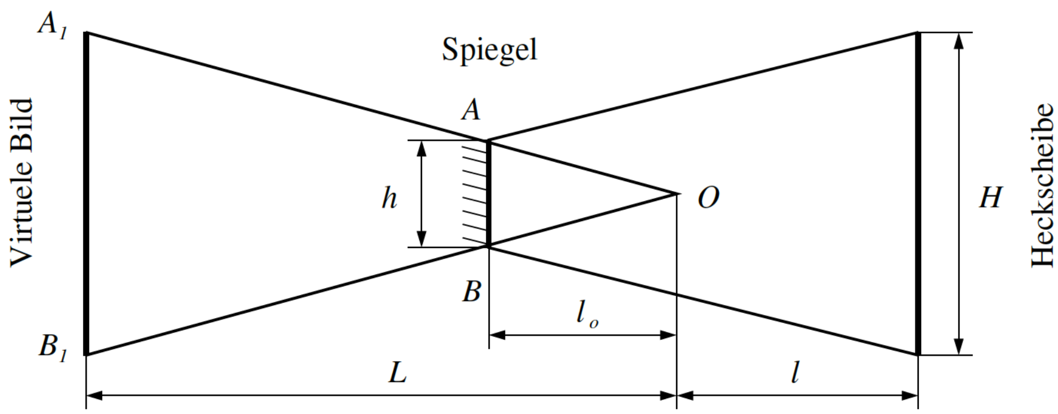
Sheet 7 / 13.04.2022 **Solutions**

Exercise 25.

Optical path a) is wrong, the beam cannot pass vertically through the glass if the incidence angle is not perpendicular to the glass surface. e), f), and g) are also wrong, the beam is refracted over the perpendicular. c) and d) are also wrong. No total reflection can take place at the glass-to-air interface. b) is correct.

Exercise 26.

First we determine the mirror height h. Because the image in the mirror is mirror-symmetrical to the original, the distance between the observer O and the image A_1B_1 is $L = l + 2l_0 = 3$ m. Since the



triangles OAB and OA_1B_1 are similar, we get:

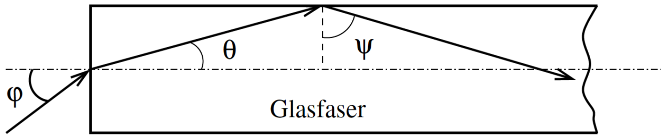
$$h = \frac{Hl_0}{L} = 7.5 \text{ cm}$$

The mirror width is calculated analogously to the height:

$$w = \frac{Wl_0}{L} = 20 \text{ cm}$$

Exercise 27.

See script 403-2/3



a) Total reflection angle ψ:

$$\sin\psi = \frac{n_{Luft}}{n_F} = \frac{1.00}{1.40} = 0.71 \Rightarrow \psi = 45.48°$$

$$\theta = 180° - 90° - \psi = 44.52°$$

Determine the coupling angle φ via the law of refraction:

$$\frac{\sin\varphi}{\sin\theta} = \frac{n_F}{n_{air}} \Rightarrow \sin\varphi = \frac{1.40}{1.00} \cdot \sin 44.42° \Rightarrow \varphi = 78.46°$$

b) Repalce n_{air} with $n_{water} = 1.33$:

$$\psi = 71.81°, \theta = 18.20°, \varphi = 19.20°$$

Exercise 28.

(a) The refraction index can be understood as the factor with which the speed of light is slowed down inside a material:

$$n = \frac{c_0}{c} \qquad \text{with} \qquad c_0 = 3 \cdot 10^8 \text{ m/s} \qquad \text{and thus} \qquad c = \frac{c_0}{n} = 2 \cdot 10^8 \text{ m/s}$$

(b) The frequency of the wave remains unchanged. The following applies:

$$f_{\text{air}} = f_{\text{glass}} = f = \frac{c_0}{\lambda_{\text{air}}} = 4 \cdot 10^{14} \text{ Hz}$$

For the wavelength inside the glass it follows:

$$\lambda_{glass} = \frac{c_{\text{glass}}}{f} = \frac{c_0}{f \cdot n} = 500 \text{ nm}$$

(c) When entering the glass plate, the light is bent towards the perpendicular (the angle of refraction follows from the law of refraction $\sin\alpha_{air}/\sin\alpha_{glass} = n$ and $\alpha_{glass} \approx 28°$).
Thus, the angle of refraction of the light γ corresponds to the difference between the angle of incidence α_{air} and angle of reflection α_{glass}:

$$\gamma = \alpha_{air} - \alpha_{glass} = 45° - 28.1° = 16.9°$$

(d) When it leaves the pane, the light-wave is refracted away from the perpendicular by the same angle, such that only a parallel shift takes place. The light wave leaves the glass pane at an angle of 45°.