Solution: The thin layer reflects the monochromatic light of the wavelength λ in the best way, if the following equation holds true

$$2nd\cos\beta = (2k+1)\frac{\lambda}{2}\,, \quad k = 0, 1, 2, \dots\,, \tag{1}$$

where k denotes an integer and β is the angle of refraction satisfying

$$\frac{\sin\alpha}{\sin\beta} = n\,.$$

Hence,

$$\cos\beta = \sqrt{1-\sin^2\beta} = \frac{1}{n}\sqrt{n^2-\sin^2\alpha}\,.$$

Substituting to (1) we obtain

$$2d\sqrt{n^2-\sin^2\alpha} = (2k+1)\frac{\lambda}{2}\,. \tag{2}$$

If the white light falls on a layer, the colors of wavelengths obeying (2) are reinforced in the reflected light. If the wavelength of the reflected light is λ_0, the thickness of the layer satisfies for the kth order interference

$$d_k = \frac{(2k+1)\lambda_0}{4\sqrt{n^2-\sin^2\alpha}} = (2k+1)d_0\,.$$

For given values and $k = 0$ we obtain $d_0 = 1.01 \cdot 10^{-7}$ m.

a) The mass of the soap film is $m_k = \varrho_k b\,h\,d_k$. Substituting the given values, we get $m_0 = 6.06 \cdot 10^{-2}$ mg, $m_1 = 18.2 \cdot 10^{-2}$ mg, $m_2 = 30.3 \cdot 10^{-8}$ mg, etc. The mass of the thinnest film thus cannot be determined by given laboratory scales.

b) If the light falls at the angle of 30° then the film seen from the perpendicular direction cannot be colored. It would appear dark.

Problem 3. An electron gun T emits electrons accelerated by a potential difference U in a vacuum in the direction of the line a as shown in Fig. 2. The target M is placed at a distance d from the electron gun in such a way that the line segment connecting the points T and M and the line a subtend the angle α as shown in Fig. 2. Find the magnetic induction B of the uniform magnetic field

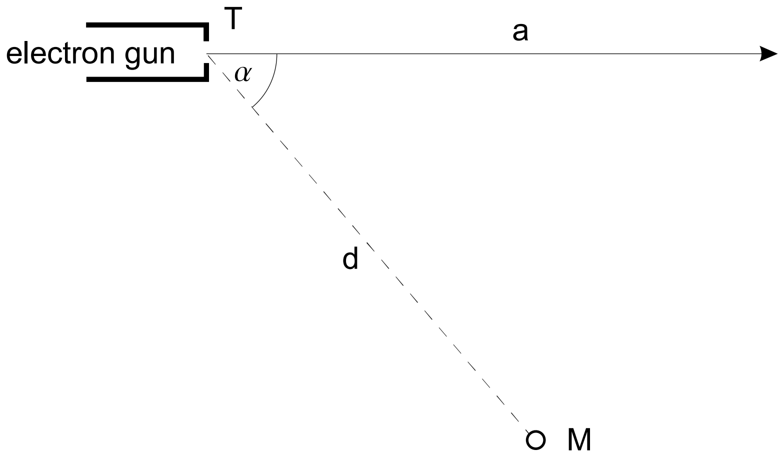

Figure 2:

a) perpendicular to the plane determined by the line a and the point M

b) parallel to the segment TM

in order that the electrons hit the target M. Find first the general solution and then substitute the following values: $U = 1000$ V, $e = 1.60 \cdot 10^{-19}$ C, $m_e = 9.11 \cdot 10^{-31}$ kg, $\alpha = 60^\circ$, $d = 5.0$ cm, $B < 0.030$ T.

Solution: a) If a uniform magnetic field is perpendicular to the initial direction of motion of an electron beam, the electrons will be deflected by a force that is always perpendicular to their velocity and to the magnetic field. Consequently, the beam will be deflected into a circular trajectory. The origin of the centripetal force is the Lorentz force, so

$$Bev = \frac{m_e v^2}{r}\,. \tag{3}$$

Geometrical considerations yield that the radius of the trajectory obeys (cf. Fig. 3).

$$r = \frac{d}{2\sin\alpha}\,. \tag{4}$$