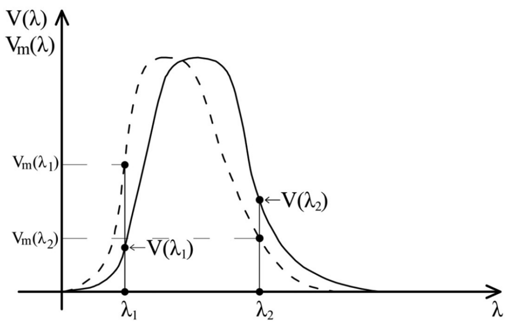
3. Two spectral lines, corresponding to wavelengths λ_1 and λ_2, are distinguished in a lamp spectrum. Their radiant powers amount to 12% and 18% of the lamp total radiant power, respectively. The remaining part of the spectrum produces 70% of the lamp photopic luminous flux. Under photopic conditions $V(\lambda_2) = 2V(\lambda_1)$ and K = 683 lm/W, while under a luminance level of 1 cd/m^2 (mesopic vision) $V_m(\lambda_1) = 3V(\lambda_1)$, $V_m(\lambda_2) = 0.6V(\lambda_2)$ and K_m = 930 lm/W. Knowing that the lamp luminous flux produced by the remaining part of the spectrum did not change moving from photopic to the specified mesopic conditions, calculate the percentage change of the lamp luminous flux.

Solution:



$$\frac{\Phi(\lambda_1)}{\Phi(\lambda_2)} = \frac{683 \cdot V(\lambda_1) \cdot 0.12P_r}{683 \cdot V(\lambda_2) \cdot 0.18P_r} = \frac{1}{3}$$

(P_r is the lamp total radiant power).

Since $\Phi(\lambda_1) + \Phi(\lambda_2) = 0.3\Phi_l$, the following is true: $\Phi(\lambda_1) = 0.075\Phi_l$ and $\Phi(\lambda_2) = 0.225\Phi_l$

(Φ_l is the lamp luminous flux under photopic conditions).

$$\frac{\Phi_m(\lambda_1)}{\Phi(\lambda_1)} = \frac{k_m \cdot V_m(\lambda_1) \cdot 0.12P_r}{k \cdot V(\lambda_1) \cdot 0.12P_r} \Rightarrow \Phi_m(\lambda_1) = \frac{k_m}{k} \cdot 3 \cdot \Phi(\lambda_1) = \frac{930}{683} \cdot 3 \cdot 0.075\Phi_l = 0.306\Phi_l$$

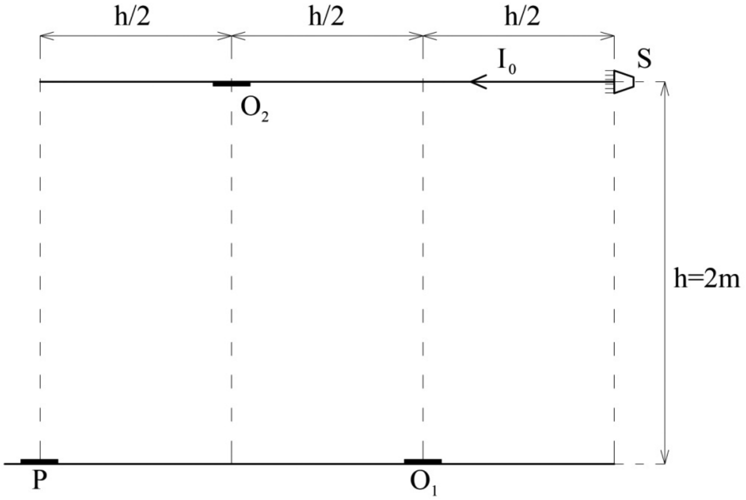
$$\frac{\Phi_m(\lambda_2)}{\Phi(\lambda_2)} = \frac{k_m \cdot V_m(\lambda_2) \cdot 0.18P_r}{k \cdot V(\lambda_2) \cdot 0.18P_r} \Rightarrow \Phi_m(\lambda_2) = \frac{k_m}{k} \cdot 0.6 \cdot \Phi(\lambda_2) = \frac{930}{683} \cdot 0.6 \cdot 0.225\Phi_l = 0.184\Phi_l$$

(the lamp spectral power distribution does not depend on the conditions of vision).

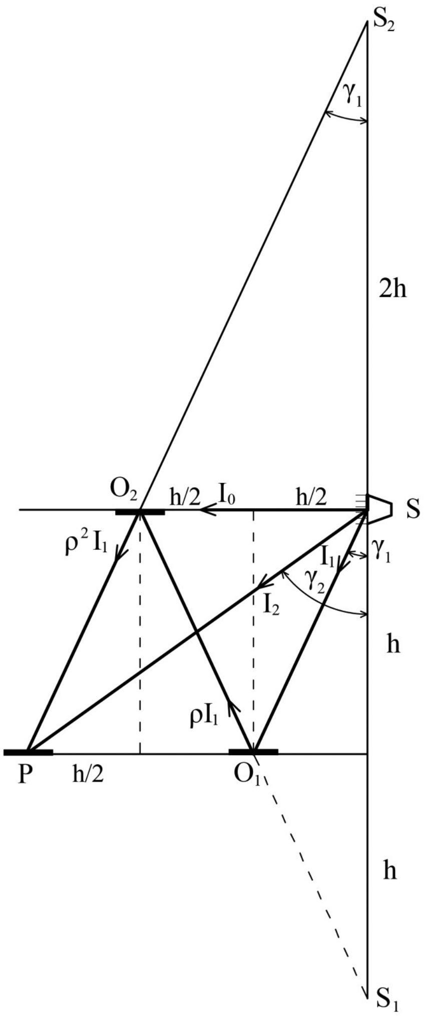
$$\Phi_{ml} = \Phi_m(\lambda_1) + \Phi_m(\lambda_2) + 0.7\Phi_l = 1.19\Phi_l$$

(the lamp luminous flux under the specified mesopic conditions (Φ_{ml}) increased 19% compared to that existing under photopic conditions).

8. A small rotationally symmetric luminaire S, which emits light according to Lambert's cosine law and has the light output ratio (LOR) of 0.65, illuminates a small horizontal surface P characterised by perfect diffuse reflection (ρ_p = 0.3). The luminaire contains a lamp with luminous flux of 17,167 lm. Knowing that the luminance of surface P is 14.23 cd/m², calculate the reflectance of the identical mirrors O_1 and O_2.



Solution:



$$I_0 = \frac{\Phi_{lum.}}{\pi} = \frac{LOR \cdot \Phi_{lamp}}{\pi} = \frac{0.65 \cdot 17167}{\pi} = 3552 \text{ cd}$$

(LOR is defined as the ratio between the luminaire and lamp luminous fluxes)

$$\tan \gamma_1 = \frac{1}{2} \ (\cos \gamma_1 = 0.894,\ \sin \gamma_1 = 0.447)$$

$$\tan \gamma_2 = \frac{3}{2} \ (\cos \gamma_2 = 0.555,\ \sin \gamma_1 = 0.832)$$

$$I_1 = I_0 \cdot \cos\left(\frac{\pi}{2} - \gamma_1\right) = I_0 \sin \gamma_1 = 1587.7 \text{ cd}$$

$$I_2 = I_0 \cdot \cos\left(\frac{\pi}{2} - \gamma_2\right) = I_0 \sin \gamma_2 = 2955.3 \text{ cd}$$

$$E_{1hP} = \frac{\rho^2 I_1}{9h^2} \cdot \cos^3 \gamma_1 = 31.51 \cdot \rho^2 \ (\text{lx})$$

$$E_{2hP} = \frac{I_2}{h^2} \cdot \cos^3 \gamma_2 = 126.3 \text{ lx}$$

$$L_P = \frac{\rho_P}{\pi} \cdot E_{hP} = \frac{0.3}{\pi} \cdot (31.51\rho^2 + 126.3) = 14.23 \text{ cd/m}^2$$

$$\Rightarrow \rho = 0.85$$