PEU 438 Assignment 1

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1 Problem 1

1.1 Blackbody Radiation Energy Inside the Eye

Volume of the Eye (V_{eye}):

$$V_{\text{eye}} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(0.015\,\text{m})^3 = 1.4137 \times 10^{-5}\,\text{m}^3$$

(Here, $r = 1.5\,\text{cm} = 0.015\,\text{m}$)

Energy Density of Blackbody Radiation (u):

$$u = aT^4$$

Where $a = 7.5657 \times 10^{-16}\,\text{J} \cdot \text{m}^{-3} \cdot \text{K}^{-4}$ is the radiation constant, and $T = 37°\text{C} = 310.15\,\text{K}$.

$$T^4 = (310.15\,\text{K})^4 = 9.254 \times 10^9\,\text{K}^4$$

Then,

$$u = (7.5657 \times 10^{-16}\,\text{J} \cdot \text{m}^{-3} \cdot \text{K}^{-4})(9.254 \times 10^9\,\text{K}^4) = 7.0013 \times 10^{-6}\,\text{J/m}^3$$

Total Energy Inside the Eye (E_{eye}):

$$E_{\text{eye}} = u \times V_{\text{eye}} = (7.0013 \times 10^{-6}\,\text{J/m}^3)(1.4137 \times 10^{-5}\,\text{m}^3) = 9.9 \times 10^{-11}\,\text{J}$$

1.2 Energy Entering the Eye from Light Bulb

Intensity at 1 Meter (I):

$$I = \frac{\text{Power}}{4\pi r^2} = \frac{100\,\text{W}}{4\pi(1\,\text{m})^2} = 7.9577\,\text{W/m}^2$$

Area of the Pupil (A_{pupil}):

$$A_{\text{pupil}} = 0.1\,\text{cm}^2 = 1 \times 10^{-5}\,\text{m}^2$$

Power Entering the Eye (P_{eye}):

$$P_{\text{eye}} = I \times A_{\text{pupil}} = (7.9577\,\text{W/m}^2)(1 \times 10^{-5}\,\text{m}^2) = 7.9577 \times 10^{-5}\,\text{W}$$

Energy Entering the Eye in 1 Second (E_{in}):

$$E_{\text{in}} = P_{\text{eye}} \times t = (7.9577 \times 10^{-5}\,\text{W})(1\,\text{s}) = 7.9577 \times 10^{-5}\,\text{J}$$

1.3 Comparison

$$\frac{E_{\text{in}}}{E_{\text{eye}}} = \frac{7.9577 \times 10^{-5}\,\text{J}}{9.9 \times 10^{-11}\,\text{J}} \approx 8 \times 10^5$$

1.4 Answer

The reason it's dark when you close your eyes is that the energy of the blackbody photons inside your eye is extremely low—far below the threshold needed to stimulate the photoreceptor cells in your retina.

2 Problem 2

3 Problem 3

4 Problem 4

5 Problem 5

References

[1] M.H. El-Deeb. PEU-438 Assignments.