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Exercises and Complements for the Introduction to Physics II  
for Students  
of Biology, Pharmacy and Geoscience

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Sheet 11 / 11.05.2022

**Solutions**

**Exercise 41.**

(a) With  $f = c/\lambda$  we have:

$$E_{Ph} = hf = \frac{hc}{\lambda} = 2.88 \cdot 10^{-19} \text{ J } (\approx 1.8 \text{ eV})$$

$$m_{Ph} = \frac{E_{Ph}}{c^2} = \frac{hf}{c^2} = 3.2 \cdot 10^{-36} \text{ kg}$$

$$p_{Ph} = m_{Ph}c = 9.6 \cdot 10^{-28} \text{ kg m/s}$$

The number of photons emitted per unit time is:

$$\dot{N}_{Ph} = \frac{P}{E_{Ph}} = 1.74 \cdot 10^{19} \text{ s}^{-1}$$

(b)

$$P = \dot{N}_{Ph,A} E_{Ph} = 1.44 \cdot 10^{-18} \text{ W}$$

**Exercise 42.**

(a) The radiant flux density  $S_s$  of a black body of absolute temperature  $T$  over all wavelengths  $\lambda$  contained in the radiation is

$$S_s = \sigma T^4$$

with  $\sigma = 5.67 \cdot 10^{-8} \text{ W}/(\text{m}^2\text{K}^4)$ . We then obtain  $T_S = 5800 \text{ K}$  for the total radiant power from the solar surface  $A_S = 4\pi R_S^2 = 6.1 \cdot 10^{18} \text{ m}^2$ .

$$P_S = S_S A_S = \sigma A_S T_S^4 = 3.92 \cdot 10^{26} \text{ W}$$

(b) The surface of an imaginary sphere around the sun with the distance sun-earth  $r_E$  as radius has the surface area  $A = 4\pi r_E^2 = 2.83 \cdot 10^{23} \text{ m}^2$ . Accordingly, the energy received from the sun per  $\text{m}^2$ , or the so-called solar constant, is

$$E_S = \frac{P_S}{A} \approx 1385 \text{ J}/(\text{m}^2\text{s})$$

**Exercise 43.**

It follows from Wien's law

$$\lambda_{\max} T = 2.898 \cdot 10^{-3} \text{ m} \cdot \text{K}$$

After that, the position of the maximum of the spectral radiance shifts more and more to the short-wavelength part of the spectrum with increasing temperature. We obtain for  $\lambda_{\max}$

- (a) 966 nm (infrared range)
- (b) 500 nm (Range of visible light, green)
- (c)  $1.07 \cdot 10^{-3} \text{ m} = 1.07 \text{ mm}$  (Microwave range)

**Exercise 44.**

For the de Broglie wavelength, we have:

$$\lambda = \frac{h}{p} = \frac{h}{m \cdot v} = \frac{6.626 \cdot 10^{-34} \text{ Js}}{9.109 \cdot 10^{-31} \text{ kg} \cdot 0.01 \cdot 2.9979 \cdot 10^8 \text{ m/s}} = 2.43 \text{ \AA}$$