

**Exercise  
48**

**DETERMINATION OF PLANCK CONSTANT BASED ON  
CURRENT-VOLTAGE CHARACTERISTICS OF LEDS**

**Measurement procedure**

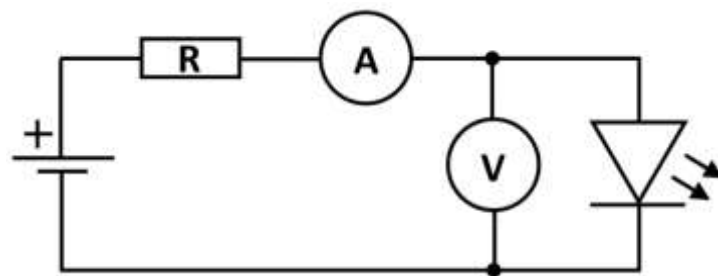
**1. List of equipment**

- Tunable power supply
- Electroluminescent diode
- Digital multimeters
- Monochromator
- Photoresistor

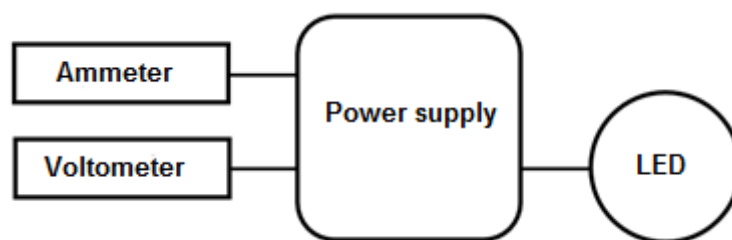
**2. Goals**

- Measurement of the current-voltage characteristic for different diodes in forward direction (forward bias)
- Determination of the emission wavelength for investigated diodes
- Calculation of Planck constant and related uncertainties

**3. Experimental setup**



**Fig. 1.** The electrical circuit used to measure the current-voltage characteristic for forward-biased diodes.



**Fig. 2.** The block-diagram of the experimental setup used for determination of the current-voltage characteristic of an LED diode.

#### 4. Measurements plan

- a) Connect the required elements according to Fig. 2.
- b) Set the power supply potentiometer to the lowest position (turn potentiometer to the left).
- c) Set the power supply to forward bias.
- d) Measure the current-voltage characteristic. Use the potentiometer to increase the applied voltage. Conduct these measurements in as wide a range of voltages as possible. Chose more measurement points for voltages where current changes are rapid. Write down the measured voltage  $U$  and current  $I$ . You should have at least 20 data points measured.
- e) Determine the emission wavelength of a diode using one of the following methods:
  - i. By the eye:
    - Set the power supply to the maximum.
    - Place the diode at the rear entrance of the monochromator.
    - Change the wavelength of light transmitted to the exit slit of the monochromator (by turning the selection knob) so that its intensity is the highest.
    - Read the wavelength  $\lambda$  from the selection knob.
    - Assume  $\Delta\lambda = 10$  nm for the uncertainty.
  - ii. Photoresistor:
    - Set the power supply to the maximum.
    - Place the diode at the rear entrance of the monochromator.
    - Place the photoresistor in front of the monochromator.
    - Change the wavelength of light transmitted to the exit slit of the monochromator (by turning the selection knob) so that the resistance magnitude is the lowest.
    - Read the wavelength  $\lambda$  from the selection knob.
    - Assume  $\Delta\lambda = 5$  nm for the uncertainty.
- f) Repeat the measurements for other diodes.

#### 5. Analysis of results

- a) Plot the current-voltage characteristics for measured diodes.
- b) Using linear regression method, fit a straight line  $y = ax + b$  to the linear part of the measured current-voltage characteristic (forward direction only).
- c) Calculate the potential barrier  $U_b$  of the diode, according to equation:  $U_b = -\frac{b}{a}$ .
- d) Estimate the uncertainty  $u_c(U_b)$  related to  $U_b$
- e) Calculate the Planck constant using the following equation

$$h = \frac{e}{c} \lambda U_b,$$

where  $e$  is the elementary charge and  $c$  is the velocity of light in vacuum.

- f) Calculate the uncertainty  $u_c(h)$  related to the determined Planck constant.

## 6. Table for measurements of the current-voltage characteristic

Table 1. Results of your experiment.

lp.	$U$ [V]	$u(U)$ [V]	$I$ [mA]	$u(I)$ [mA]	$\lambda$ [nm]	$u(\lambda)$ [nm]	$U_b$ [V]	$u_c(U_b)$ [V]	$h$ [J·s]	$u_c(h)$ [J·s]
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