# Instruction manual for 5060.00 Planck's Constant Apparatus

14.05.12 Ae 5060.00

## Description

This apparatus is designed for the determination of Planck's constant using the knee voltage in the characteristic curves of a number of light emitting diodes (LED's). The experiment is based on graphing the LED limit voltages as a function of the frequencies of the emitted light. The LED's used emit UV (ultraviolet), NIR (near infrared) and three wavelengths in the visible region. The LED's have been carefully selected to emit light within a narrow, well-defined wavelength interval. Either the built in 9 V block battery or an external 9-12 VDC line adapter can be used as power supply.

## Required Accessories

- 9 V block battery (3510.10) or 9 VDC line adapter (3550.10).
- Voltmeter (3810.60).
- Ammeter (3810.70).

**Important!**
This apparatus is battery operated. The battery supplied with it is wrapped in insulating cellophane and placed in the battery holder. Unwrap the battery and place it in the holder before operation.

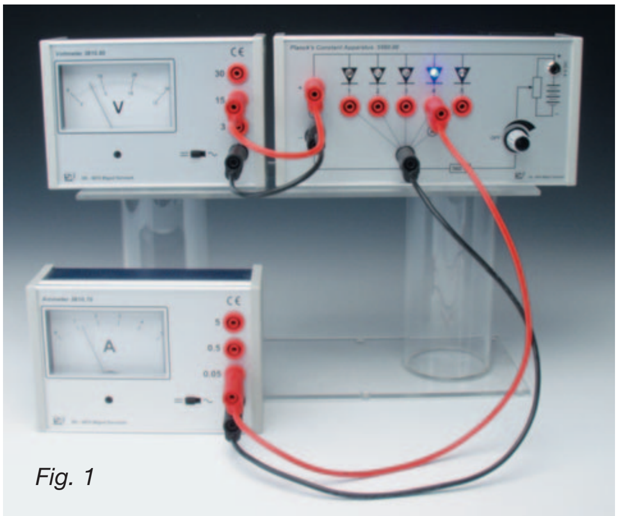
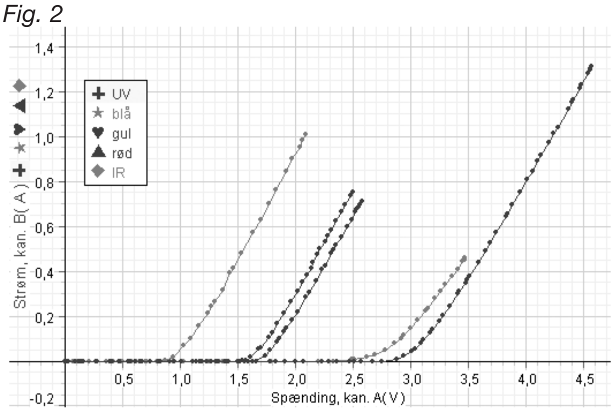


*Fig. 1*

## Operating Instructions

The equipment is set up as shown in Figure 1. By adjusting the potentiometer on the Planck Apparatus the characteristic curve for each LED can be obtained. This can be done by reading off pairs of values manually or by using data collection equipment. This has been done to collect the data shown in Figure 2.

*Fig. 2*




*Characteristic curves for the various light emitting diodes recorded using the Pasco Science Workshop Interface and DataStudio software*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The knee voltage is determined for each of the characteristic curves by reading off the voltage values for which current just begins to flow through the pn-junction of the diode (e.g. at the 5 milli-ampere level).

The energy involved when an electron-hole pair passes the pn-junction is $e \cdot U$, where $e = 1.602 \cdot 10^{-19}$ C is the charge on the electron, and U is the voltage. The photon energy of a photon with frequency f is equal to $h \cdot f$ , where $h = 6.63 \cdot 10^{-34}$ Js is Planck's constant. Equating these quantities:

$e \cdot U = h \cdot f$

Plotting the graph of $e \cdot U$ on the Y-axis versus the photon frequency f on the X-axis yields a graph, where the slope should equal Planck's constant.

The peak wavelengths of the LED's in the Planck Apparatus can be seen in the spectral graphs of Figure 3. Frequencies can then be computed from $f = c/\lambda$ where $c = 3.00 \cdot 10^8$ m/s is the speed of light, and $\lambda$ is the wavelength of light in meters. Figure 4 shows typical results.

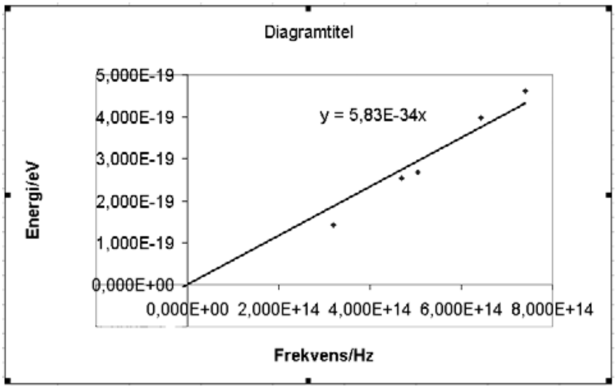


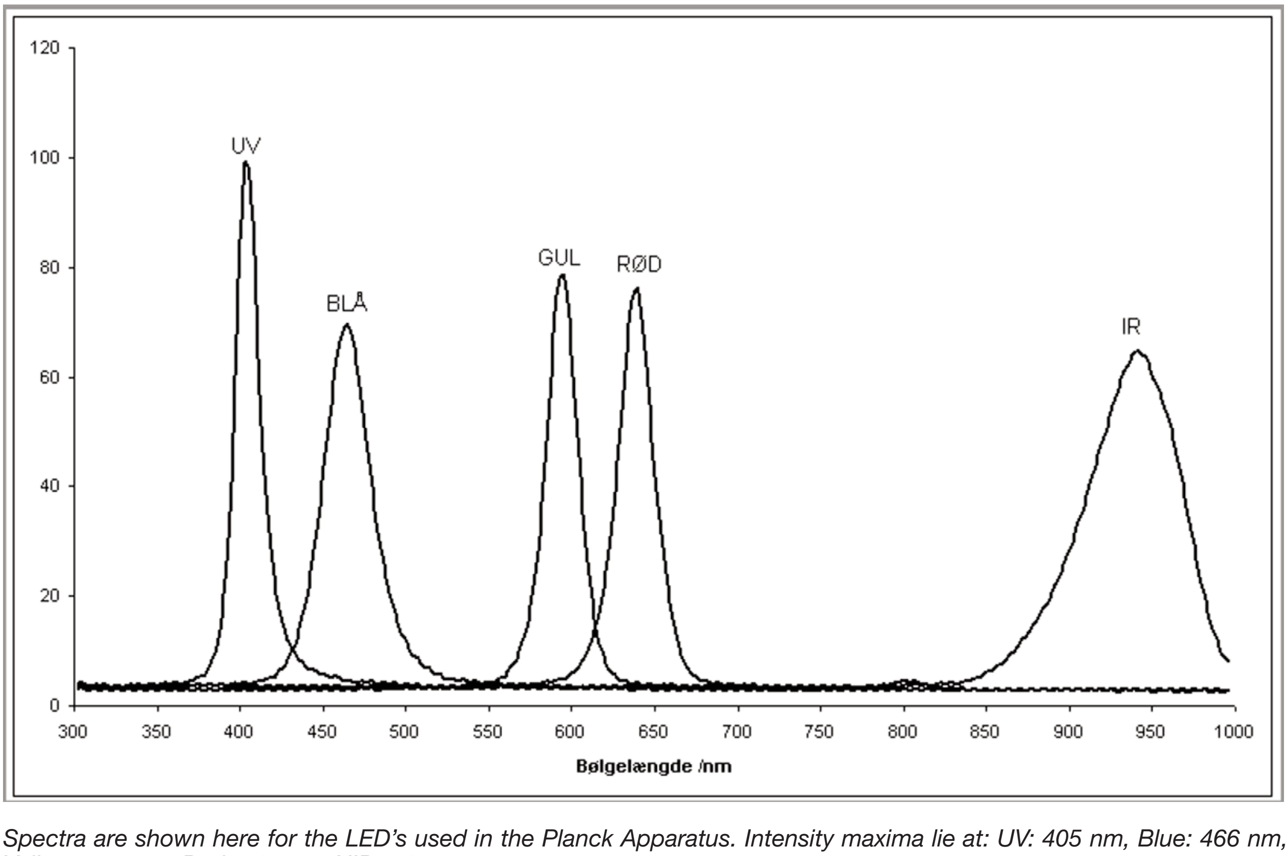

*Fig. 3*

*U · e plotted against photon frequency f. The experimental value for Planck's constant is the slope of the straight line.*

**Further Reading:**

Am.J.Phys., Vol. 66, No. 1, January 1998.

*Fig. 4*




*Spectra are shown here for the LED's used in the Planck Apparatus. Intensity maxima lie at: UV: 405 nm, Blue: 466 nm, Yellow: 595 nm, Red: 640 nm, NIR: 940 nm.*

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