EXPERIMENT 4
LED SPECIFICATIONS

PURPOSE

You will perform several experiments to obtain the following specifications of an LED: electrical power, I-V curve, spectral distribution and angular light distribution.

EQUIPMENT

Variable DC source, luxmeter, spectometer, multimeter, turn table.

THEORY

The term LED stands for Light Emmiting Diode. Like laser diode, LED is a semiconduction light source. An LED can produce the visible, ultraviolet or infrared wavelengths with very high brightness. Its light output power is proportional to forward bias current, see Figure 1.

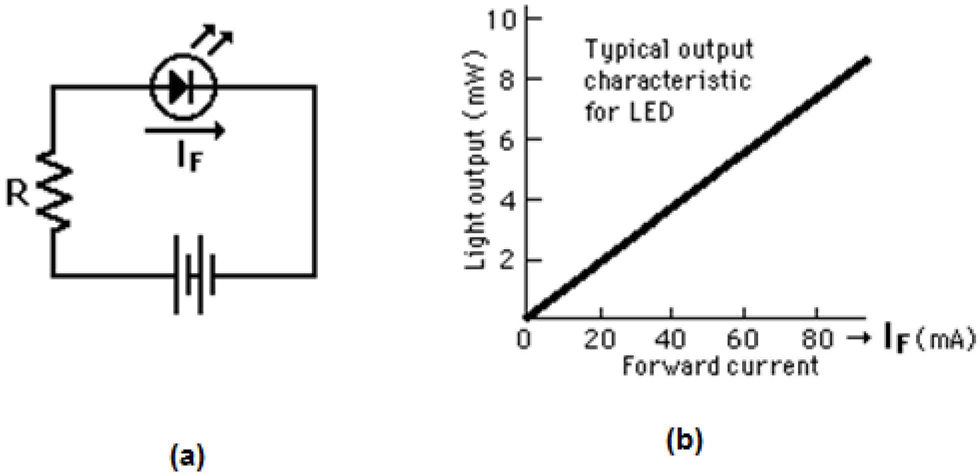

Figure 1: (a) Circuit diagram for a typical LED and resistor. (b) output light power of LED

Since the beam divergence of an LED is too large compared to common Laser, total light power emmited from LED can be measured by an integrating sphere. However, its irradiance (optical power per unit area) can be measured by powermeter or luxmeter. An example luxmeter shown in Figure 2. Note that, you need to remember radiometric and photometric units and their conversions as listed below.

Table 1: Some radiometric and photometric units and their conversions.
V_λ is known as luminosity function. See your lecture notes on photometry for details.

Quantity	Unit	Conversion	Measurement Device
Radiometric power (Φ)	Watt	$\Phi_v = 683\ V_\lambda\ \Phi$	Integrating shepere
Photometric power (Φ_v)	Lumen		Integrating shepere
Irradiance (E)	Watt/m^2	$E_v = 683\ V_\lambda\ E$	Powermeter
Illiminace (E_v)	Lumen/m^2 = lux		Luxmeter

We use spectro-photo-meter to extract the relative spectral power distribution (intensity) of a light source as a function of wavelength. An example, that we have used in lab, is shown in Figure 3. The light data can be taken via a fiber cable. The wavelength range covers UV to NIR (200-1000 nm).

(a) (b)

Figure 2: (a) An integrating sphere (b) A typical luxmeter and its detector.

Figure 3: A CCD spectro photo meter its fiber. It is directly connected to a computer via USB cable.

For a point light source, the magnitude of the light intensity (irradiance or illiminance) is inversely proportional to the square of the distance from a the source. Matematically,

$$E = k/r^2 \tag{1}$$

where k is a constant and r is the distance from the source. For a fixed distance from the point source, if the radiation direction makes an angle θ with the normal of the irradiated (illuminated) surface, as in Figure 2, then the intensity is given by Equation (2). This equations is known as Lambert Cosine law.

$$E = E_{\max} \cos(\theta) \tag{2}$$

At a relatively large distance from LED, it behaves almost like a point source. So, an LED may obey the inverse square law. However, its angular distribution may not satisfy Equation (2).

Finally, Current and Voltage (I-V) data of LED can be displayed by means of simple multimeter. A typical I-V curve of an LED is shown in Figure 5.

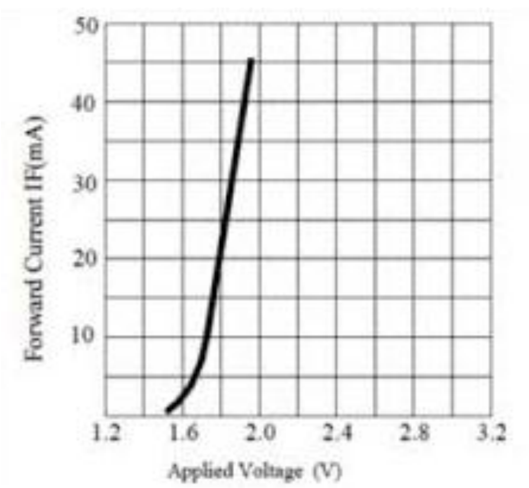

Figure 4: I-V curve of LED

PROCEDURE

Part 1 *Spectral Light Distribution*

Setup is shown in Figure 5. First connect spectrophotometer (SPM) to computer via USB. Then, turn on the LED and direct its output to the SPM. Finally, observe the spectral light data in computer. Save data to file.

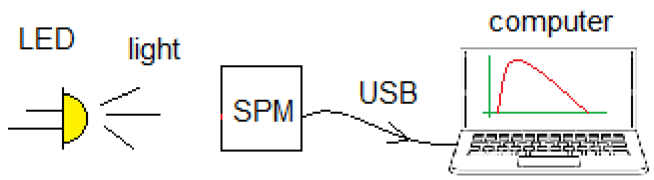

Figure 5: Exp. 1

Part 2 *Illuminace Measurement*

Setup is shown in Figure 6. LED is connected to a variable DC source. You can measure current and voltage supplied to the circuit via multimeter. Illumination is measured at an arbitrary distance by the luxmeter. Fill Table 2.

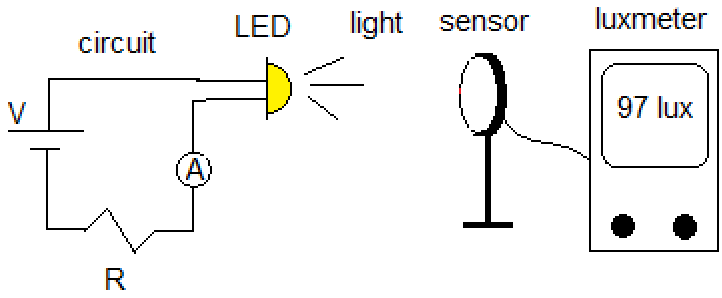

Figure 6: Exp. 2

Part 3 *Angular Light Distribution*

Setup is shown in Figure 7. Use rotary motion sensor to obtain angular measurements and High Sensitive Light Sensor for the relative light intensity measurements. Turn off most of the room lights. Click RECORD to acquire intensity vs polar angle (θ) data. Save your data to a file. Click STOP. Save data to a file. Press Delete Last Run button.

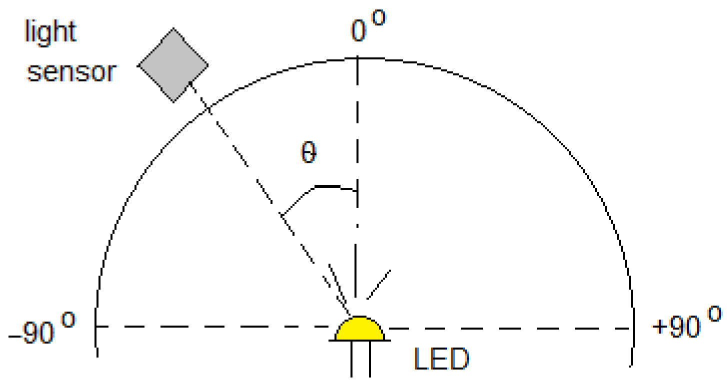

Figure 7: Exp. 3

QUESTIONS

For each question, write down your conculution briefly.

1. Plot the spectral distribution of the LED.
2. Plot I-V curve fromTable 2
3. Plot I vs E_v data from Table 2 (forward bias current vs illuminace)
4. Plot angular light distribution (intensity vs polar angle graph) in polar coordinate system. Also, plot Equation (2) with E_{max} = 1 on top of your data. Verify if the LED obeys Lambert's cosine law. (For a Lambertian Source, the shape will be a circle in polar coordinate since E = constant x $\cos\theta$).

Table 2: Data for Exp 2

Current, Ampere I	**Voltage, Volts V**	**Electrical power P = I*V**	**Illimunance (lux) E_v**