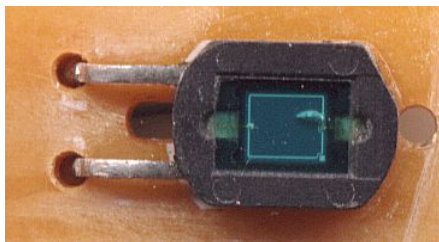


Measurement Scales and tables

Measure milli-candles photodiode with "BS520"



Resistor ohm	Full Scale lux	Minimum step lux	Current full scale	Current minimum step
200	200 000	100	1 mA	500 nA
2 k	20 000	10	100 uA	50 nA
20 k	2000	1	10 uA	5 nA
200 K	200	0.1	1 uA	500 pA
2 mega	20	0.01	100 nA	50 pA
20 mega	2	0.001	10 nA	5 pA

With serene sun should be measured approximately one hundred thousand lux.

Bring in milli-candles if you measure 333 mm from the LED

Resistor ohm	Full Scale a thousand candles	Minimum step a thousand candles
200	20000000	10 000
2 k	2000000	1000
20 k	200 000	100
200 K	20 000	10
2 mega	2000	1
20 mega	200	0.1

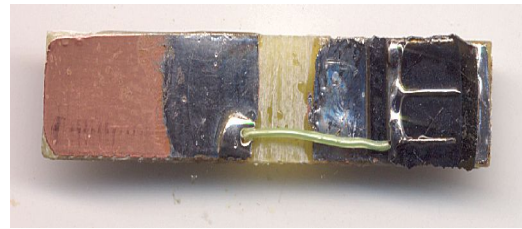
Bring in milli-candles if you measure 100 mm from the LED

Resistor ohm	Full Scale a thousand candles	Minimum step a thousand candles
200	2000000	1000
2 k	200 000	100
20 k	20 000	10
200 K	2000	1
2 mega	200	0.1
20 mega	20	0.01

Measure the total light output with "Solar Cell"

Values obtained from my fragment of the test cell.

Area	= 64 mmq
Full sun	= 64 mW
64 mW	= 15 mA
1 mA	= 4.3 mW
1 mW	= 0.23 mA
efficiency	= 7.75 %



The milliamps multiplied by 4.3 give, approximately, the total light power in milliwatts emitted by the LED or Laser.

A value of 4.3 is valid only for my test cell, with 7.75% yield, different cells must be calibrated to the sun, as shown in the paper "Measuring the LEDs"

Measure the total light output with photo-diode "BPW34"

Area	= 7.5 mmq
Full sun	= 7.5 mW
7.5 mW	= 3 mA
1 mA	= 2.5 mW
1 mW	= 0.4 mA
efficiency	= 13%



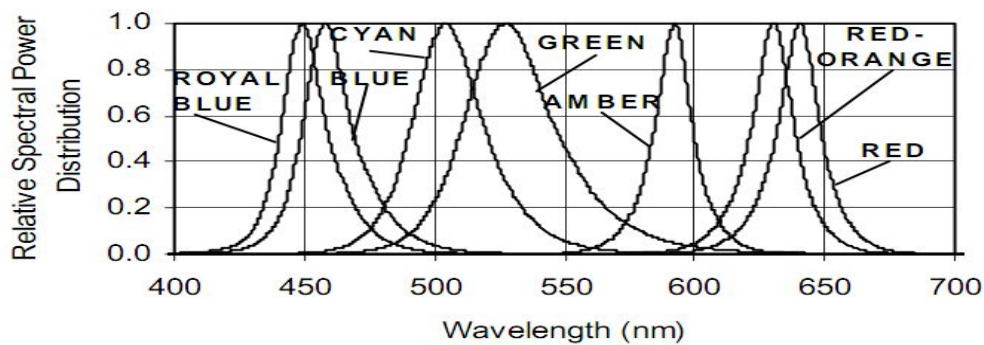
The measured milliamps multiplied by 2.5 give approximately the total light power in milliwatts emitted by the LED or Laser.

Not all BPW34 are equal, it is good to calibrate the sun, as shown in the paper "Measuring the LEDs"

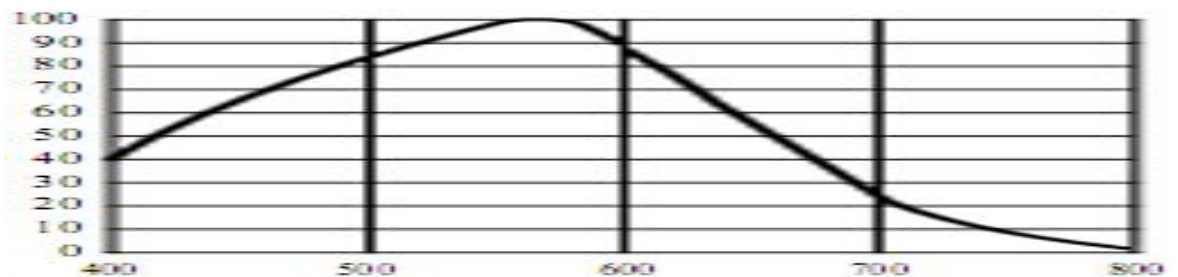
Errors due to the nonlinear response of the BS520

The response of the photodiode type BS520, similar to that of the human eye, it is useful to give an idea of the perceived brightness but the values measured in millicandles are just right for the amber and green LEDs. For all other colors is necessary to correct the measured values.

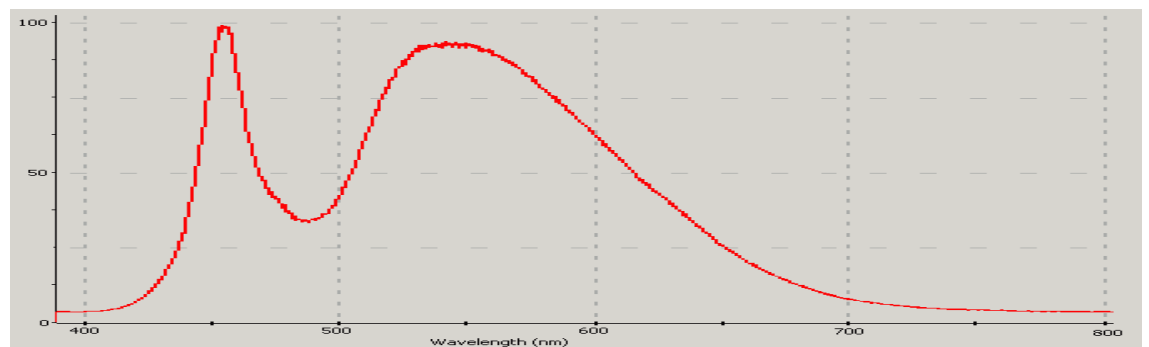
Visible spectrum



Photodiode BS520



White LED

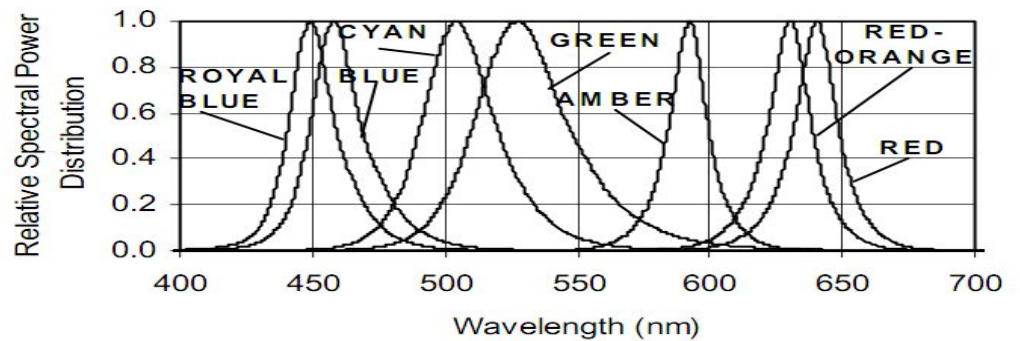


From these curves leads to the following corrections (approximate) to be applied to the measured values

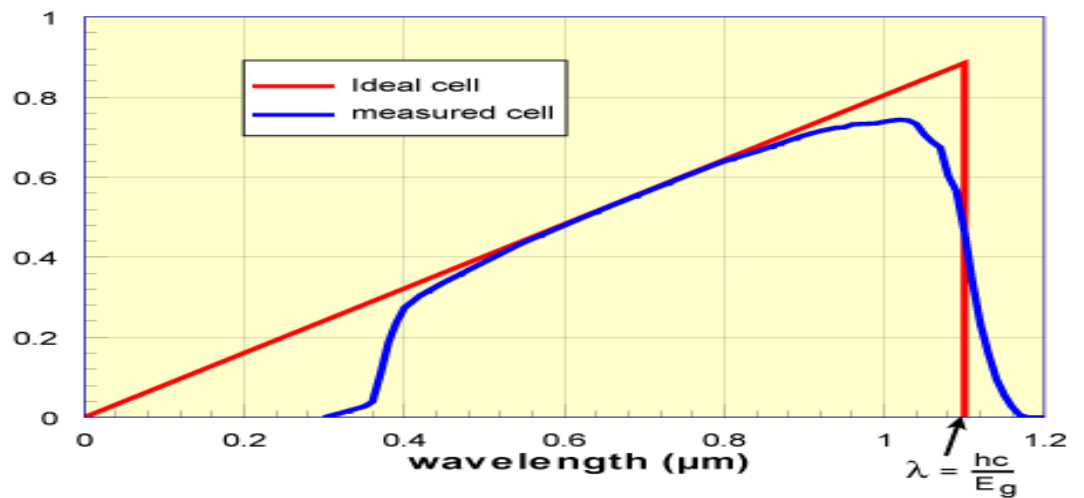
RoyalBlue	x 1.5
Blue	x 1.4
Cyan	x 1.2
Green	x 1.1
Amber	x 1.1
Orange	x 1.4
Red	x 1.5
White	x 1.4 (White LEDs have a peak at 550 nm but emit most part of the light in areas where the response is not 100%)

Measurement errors due to the nonlinear response of the solar cells and silicon photodiodes

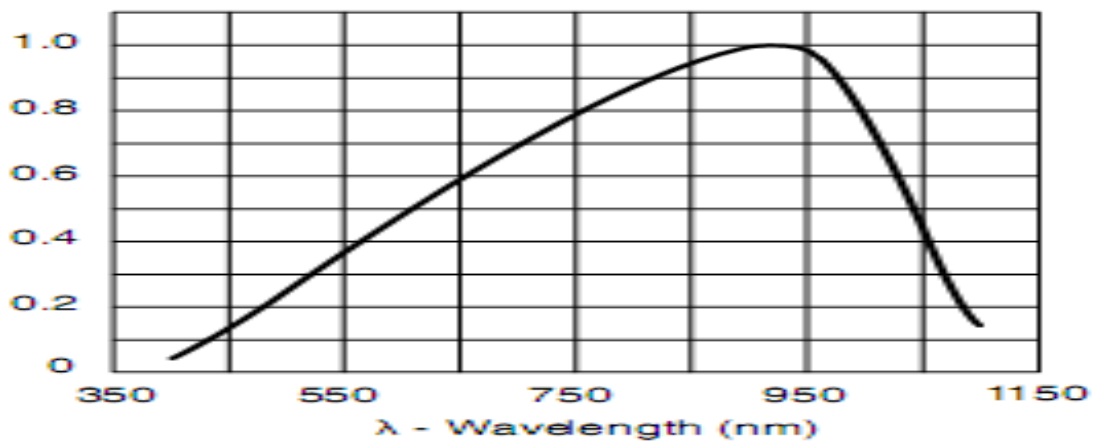
Visible spectrum



Solar Cells



Photodiode BPW34



If you tare the sunlight measured values will be right at the center of the visible area (green LED - 500 nm) and are correct in all other cases.

RoyalBlue	x 1.2	
Blue	x 1.15	
Cyan	x 1.1	
Green	x 1	
Orange	x 0.85	
Red	x 0.8	
White	x 1.2	(White LEDs have a peak at 550 nm but emit most part of the light in areas where the response is not 100%)

From "Watt" to "Lumen" and finally to "Milli-Candles"

From Watts you can go directly to the Lumen multiplying by 683
(1 watt = 683 lumens)

Knowing the "Watt light" or "Lumen" and the opening of the LED in "degrees" you can use the program "LedCalc" to get the "Milli-Candle"

Led Calculator

File Help

Single Led Params

Angle (2 * half) (deg) 120

Millicandles (mcd) 18000

Lux (meter-candles) (lux) 193.752

Lumen (lm) 56.549

Light power (milliwatt) 82.795

Led supply voltage (Volt) 3.2

Led supply current (mA) 20

Led supply power (milliwatt) 64

Efficiency (lumen / watt) 883.58

Array Params

Resistance (ohm) 10

V-Drop (volt) 0.2

N-Led per column 5

N Columns 22

Supply voltage (volt) 16.2

Panel supply current (mA) 440

Panel supply power (watt) 7.128

Total resistor losses (watt) 0.088

Panel light output (lumens) 6220.39

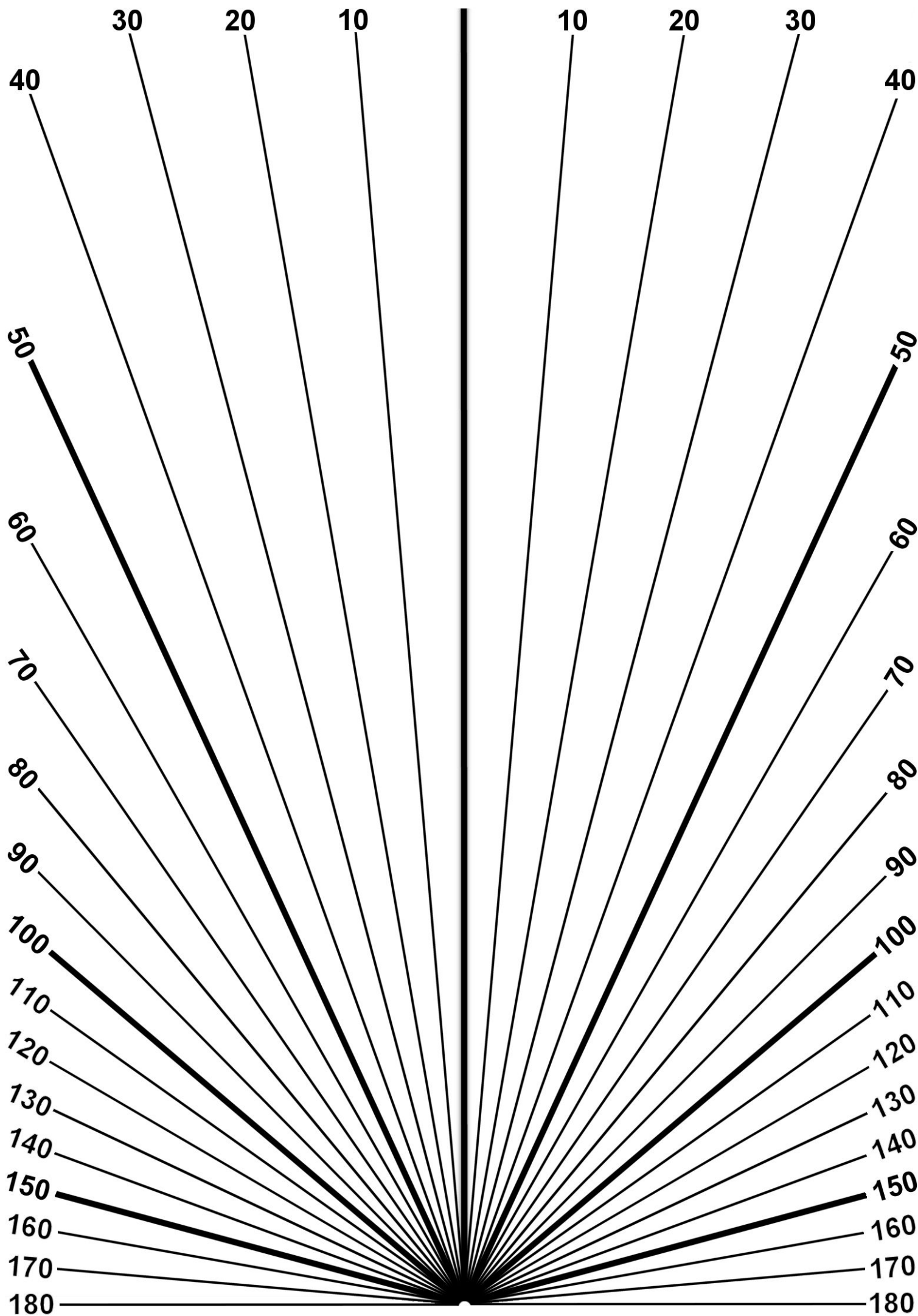
Equivalent incandescent lamp (watt) 414.693

Panel Efficiency (lumen / watt) 872.67

- 1) Set angle "deg" as a first step, before you set the other values.
- 2) Set the "light power" or "lumen" value
- 3) Read the value in "milli-candles"

Measure the opening angle of the beam

Print the following page on an A4 sheet, place the LED in the center and measure approximatively.



Tables and useful data

1 lux = 1 lumen per square meter = 1 candle per square meter

1 Foot-candle = 1 lumen per square foot = 1 candle per square foot

1 foot = 12 inches = 304.8 mm

1 lux (meter-candles) = 0.09290304 foot-candle

1 foot-candle = 10.76391042 lux (meter-candles)

1 watt = 683 lumens

1 lux at 550 nm = 0.001464 W/m²

1 lux at 550 nm = 1.464 mW/m²

1 lux at 550 nm = 1464 µW/m²

1 lux at 550 nm = 0.1464 µW/cm²

A candle is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and radiant intensity in that direction by 1/683 of watts per steradian.

A candle is the intensity of light of a candle standard view from the distance of a foot (= 12 inches = 304.8 mm)

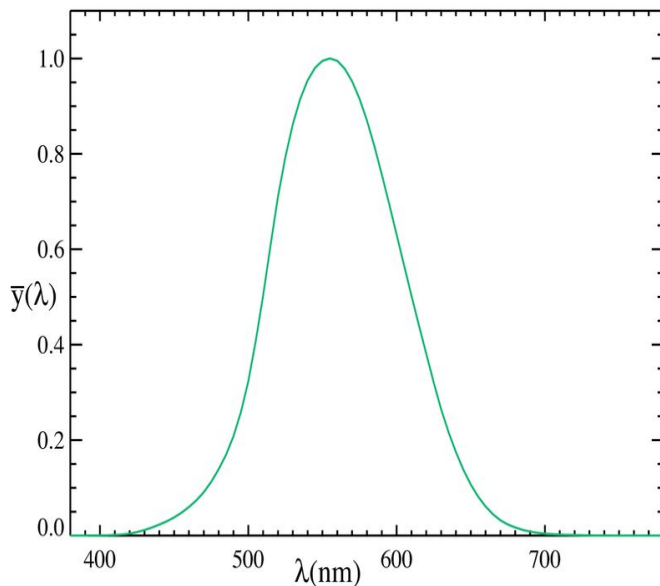
A standard candle is approximately equal to a 2-watt incandescent bulb.

	Foot Candles	LUX	µW/cm ² (550 nm)	W/m ² (550 nm)
Noon Sun	10 000	100000	14640	146.4
The surgical table	1000	10 000	1464	14.64
Office	50 .. 200	500 .. 2000	73.2 .. 292.8	0.732 .. 2.928
Gallery	10 .. 50	100 .. 500	14.64 .. 73.2	0.1464 .. 0.732
Full Moon	0.1	1	0.1464	0.001464
Starlight	0.000005	0.00005	0.00000732	

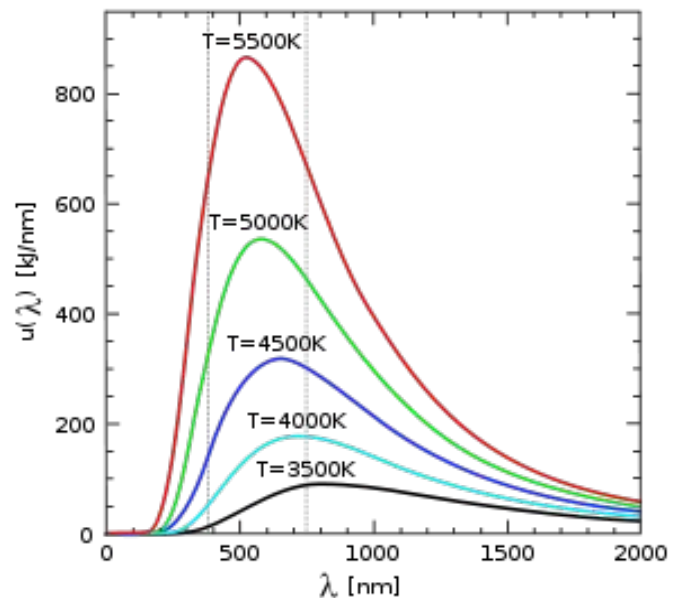
	Lumen per Watt	Efficiency	Life (hours)
Incandescent lamps	10 to 20	from 1.5% to 3%	from 750 to 1000
Incandescent lamps	13 to 17	from 2% to 2.5%	from 2000 to 4000
Fluorescent lamps	50 to 70	from 7.5% to 10%	10000 to 20000
Led	10 to 100	from 1.5% to 15%	50000 to 100000
Maximum efficiency	683	100%	

Color temperatures and wavelengths

Wavelength nm	Color Name	Color Sample
over 1100	Infrared	
770-1100	Longwave NIR	
770-700	Shortwave NIR	
700-640	Red	
640-625	Orange-Red	
625-615	Orange	
615-600	Amber	
600-585	Yellow	
585-555	Yellow-Green	
555-520	Green	
520-480	Blue-Green	
480-450	Blue	
450-430	Indigo	
430-395	Violet	
395-320	UV-A	
320-280	UV-B	
280-100	UV-C	



Sensitivity of the 'human eye



Temperature and light produced