











- Photograph shows plumber's candle.
- A plumber's candle emits a luminous intensity of 1 candela (cd). The cd is historical origin of all photometric units.
 - photometric unit is relevant when it comes to light perception by a human being.
- First definition (now obsolete) : The luminous intensity of a standardized candle is 1 cd.
- Second definition (now obsolete) : 1 cm² of platinum (Pt) at 1042K (temperature of solidification) has a luminous intensity of 20.17 cd.
- Third definition (current) : A monochromatic light source emitting an optical power of (1/683)Watt at 555 nm into the solid angle of 1 steradian (sr) has a luminous intensity of 1 cd.
- Candlepower and candle are obsolete units. Candlepower and candle measure luminous intensity and are approximately equal to 1 cd.

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• Luminous flux : A light source with a luminous intensity of 1 cd emits a luminous flux of 1 lm into a solid angle of 1 steradian.

• An isotropic light source with a luminous intensity of 1 cd emits a total luminous flux of 4π Im = 12.56 Im.

• Illuminance : If a 1m² surface receives a luminous flux of 1 lm, then the illuminance of the surface is 1 lux. Im/m²

Ex) Moonlight 1 lux; street light 10 lux; home lighting 30-300 lux, office desk light 10²-10³ lux; surgery light 10⁴ lux; direct sunlight 10⁵ lux

• Luminance is the luminous intensity emitted per unit area of a light source. Luminance is a figure of merit for displays. Typical displays have a luminance of 100- 500 cd/m².

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Typical i	Typical illuminance in different environments					
	Illumination condition	Illuminance	ľ			
	Full moon					
	Street lighting	10 lux				
	Home lighting	30 to 300 lux				
	Office desk lighting	100 to 1000 lux				
	Surgery lighting	10000 lux				
	Direct sunlight	100 000 lux				
			-			
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ommon units								
Conversion be	tween common	n Si a	nd non-Si	units f	or lumir	nances		
Unit	Common na	Common name		Unit		non name		
1 cd/cm ²	1 stilb	1 stilb		π) cd/m²		stilb		
(1/π) cd/cm ²	1 lambert	1 lambert		l/ft ² 1 foot		lambert		
1 cd/m ²	1 nit							
Device	Luminance (cd/m²)	Devi	ice	Lumina (cd/m ²)	ance)	Typical values fo the luminance of displays		
Display	100 (operation)	Orga	nic LED	100-100	00	uispiays		
Display	250-750 (max)	III-V	LED	1 M-10N	1			
Photometric Unit	Dimension	Radi	ometric unit	Dimens	ion	1		
Luminous flux	Im Rad (opt		ant flux cal power)	w		 Photometric and corresponding radiometric unit 		
Luminous intensity	lm/sr = cd Radi		ant intensity	W/sr				
Illuminance	lm/m ² = lux lrrac (pov		iance er density)	W / m²]		
Luminance	Im/(sr m ²)=cd/m ² Rad		ance	W/(srr	n²)			







Light sourse		Luminous efficiency
Incandescent	Edison's first light bulb (C filament)	1.4 lm/W
	Tungsten filament light bulbs	15-20 lm/W
	Quartz halogen light bulbs	20-25 lm/W
luorescent ources	Fluorescent light tubes	50-80 lm/W
	Mercury vapor light bulbs	50-60 lm/W
IID (High- ntensitv	Metal halide light bulbs	80-125 lm/W
discharge)	High pressure sodium vapor light bulbs	100-140 lm/W

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Summary of photometric, radiometric, and quantum performance measures for LEDs

Figure of merit	Explanation		
Luminous efficacy	Luminous flux per optical unit power	lm/W	
Luminous efficiency	Luminous flux per input electrical unit power	lm/W	
Luminous intensity efficiency	Luminous flux per sr per input electrical unit power	cd/W	
Luminance	Luminous flux per sr per chip unit area	cd/m ²	
Power efficiency	Optical output power per input electrical unit power	%	
Internal quantum efficiency	Photons emitted in active region per electron injected	%	
External quantum efficiency	Photons emitted from LED per electron injected	%	
Extraction efficiency	Escape probability of photons emitted in active region	%	



