

By the light of the Moon (and the Earth)

This month marks the 50th anniversary of the Apollo 11 moon landing. To commemorate the event, this newsletter takes a visual ergonomics look at the illuminance of moonlight on Earth and earthshine on the Moon.

Moonlight

Moonlight on Earth is sunlight reflected off the moon's surface (see diagram to the right). The moon reflects about 7% of light¹. The resulting illuminance on Earth (moonlight) depends on many factors including the Moon phase (e.g. full moon, quarter moon), the height of the Moon above the Earth's horizon, the distance of the Moon from Earth, atmospheric conditions on Earth and cloud cover¹.



What is the illuminance on Earth from moonlight?

There are claims that the illuminance from moonlight is as high as 0.5 lux to 1.0 lux², but empirical calculations indicate it is much less: approximately 0.215 lux at full moon when the Moon is at zenith (at its highest in the sky)¹. This calculated value is similar to field measurements reported by Shotbolt and Cowling in Australia (Woy Woy, -33°29' latitude, and Darwin, -12°27' latitude): illuminance at full moon ranged between 0.24 lux and 0.32 lux². To put this into perspective with indoor lighting requirements, emergency escape lighting should provide a minimum of 0.2 lux³.

Earthshine

Earthshine is the faint outline of the Moon's shape that can be seen when the Moon phase is close to a new moon (crescent-shaped). The faint glow is caused by light reflected from the Earth's surface, and was described by Michael Collins, one of the Apollo 11 lunar astronauts, as "a bluish eerie glow" on the Moon's surface⁴.



The Earth is more reflective than the Moon (average reflectance 36.7%), with snow and clouds reflecting more light (60—90%) than the oceans (10%) and land (10—25%)⁵. Therefore, the Earth appears brighter than the moon in space.

What is the illuminance on the Moon from earthshine?

There are no reports of illuminance measured on the Moon by astronauts, but there are theoretical calculations of the illuminance on the Moon based on the reflectance of the Earth. Earthshine is estimated as 30.7 lux when sunlight is reflected from thick clouds or snow, and 3.4 lux when sunlight is reflected from the oceans⁵. To put this into perspective with indoor lighting requirements, 20 lux is the minimum illuminance to comply with standards for safe movement⁶.

References: 1. *Journal of Applied Ecology* (1976) 13(3): 741-748 2. *Lighting Magazine* (2014) June/July 40-48 3. AS/NZS 2293.1:2018
4. "Flying to the moon; An astronaut's story" (2019) 5. *European Journal of Physics* (2016) 37: 035601 6. AS/NZS 1680.0:2009

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