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## Question 1: Plastic Straws; Question 2: Casino Sevens

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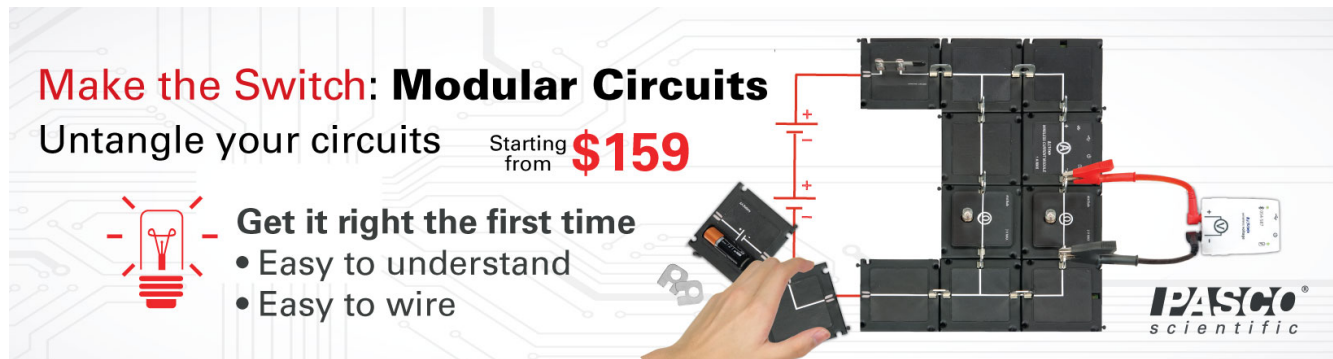
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served from the Moon during full moon, when the phase angle<sup>5</sup> is close to 0°. The reflected sunlight from the Moon falls on the night side of Earth, bounces back towards the Moon, and its observation from the Moon may be referred to as moonshine (Fig. 3). One can work out the amount of light being observed in either astronomical phenomenon as follows. The sunlight intercepted by Earth (Moon), averaging about  $123 \times 10^3$  lx, bounces between Earth and Moon, and its intensity diminishes as per the inverse square law making earthshine and moonshine alike rather feeble,<sup>6</sup> lying in between  $8.5 \times 10^{-6}$  lx and  $7.6 \times 10^{-5}$  lx, depending on whether the light has encountered oceans or mountains of ice over Earth in its journey. It may be added here that the moonshine and earthshine values can be used to estimate the current albedo of both the Moon and Earth.

### References

1. Peter Thejll, Chris Flynn, Hans Gleisner, and Andrew Mattingly, "Earthshine: Not just for romantics," *Astron. Geophys.* **49**, 15–20 (2008).

2. The eccentricity of an elliptical orbit determines its closeness to a circle; it is the ratio of the distance between its two focal points to length of its major axis.
3. P. R. Goode, J. Qiu, V. Yurchyshyn, J. Hickey, M-C. Chu, E. Kolbe, C. T. Brown, and S. E. Koonin, "Earthshine observations of the Earth's reflectance," *Geophys. Res. Lett.* **28**, 1671–74 (2001).
4. "Reflectivity values of reflective surfaces," The Encyclopedia of Earth, [https://editors.eol.org/eoearth/wiki/File:Table\\_1.jpg](https://editors.eol.org/eoearth/wiki/File:Table_1.jpg).
5. The Moon's phase angle is simply that angle at the Moon that is subtended by Earth and the Sun.
6. The expression for earthshine or moonshine luminous flux would be

$$122.7 \times 10^3 \cdot \kappa_{\text{Earth}} \cdot \kappa_{\text{Moon}} \cdot \frac{R_{\text{Earth}}^2}{\ell^2} \cdot \frac{R_{\text{Moon}}^2}{\ell^2}.$$

Here  $R_{\text{Earth}} = 6.37 \times 10^6$  m is the radius of the Earth,  $R_{\text{Moon}} = 1.74 \times 10^6$  m is the radius of the Moon,  $\ell = 3.82 \times 10^8$  m is the mean distance between Earth and the Moon,  $\kappa_{\text{Earth}}$  (10%-90%) and  $\kappa_{\text{Moon}}$  (12%) are albedos of Earth and Moon, respectively; here moonlight flux is

$$122.7 \times 10^3 \cdot \kappa_{\text{Moon}} \cdot \frac{R_{\text{Moon}}^2}{\ell^2} = 0.30 \text{ lx}.$$

## Fermi Questions

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### ► Question 1: Plastic straws

Starbucks recently announced that it will stop providing plastic straws by 2020. How much impact do American plastic straws have on the environment?

### ► Question 2: Casino sevens

In casino craps games, players repeatedly roll two six-sided dice, giving totals from two to twelve. What is the probable longest streak of consecutive sevens in the entire history of Las Vegas? (*Thanks to Phil in Virginia Beach for inspiring the question.*)

Look for the answers online at [tpt.aapt.org](http://tpt.aapt.org)

Question suggestions are always welcome!

For more Fermi questions and answers, see *Guesstimation 2.0: Solving Today's Problems on the Back of a Napkin*, by Lawrence Weinstein (Princeton University Press, 2012).

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