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Question 1: Goosed; Question 2: Buying Groceries

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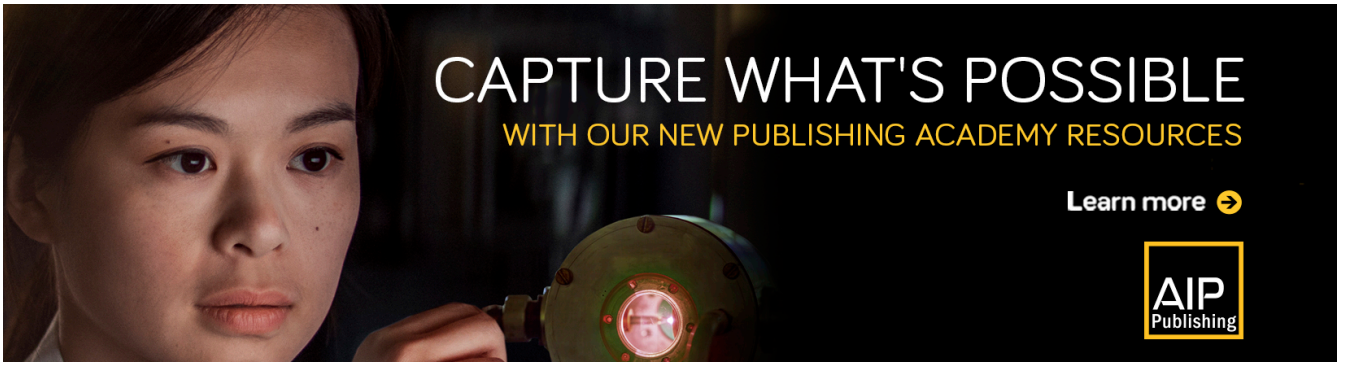

the analog of terrestrial longitude is called **right ascension**, denoted by α or RA, and is the angle measured around the celestial equator from a point called the vernal equinox to the desired point. It is directly analogous to longitude except that, for reasons that become apparent in other contexts, it is measured in hours, minutes, and seconds of time rather than in degrees, minutes, and seconds of arc. The analog of terrestrial latitude in this system is called **declination**, denoted by Δ or DEC, and is the acute angle between the celestial equator and the desired object, measured toward the nearest celestial pole. Right ascension is measured from 0 to 24 hours and declination is measured from 0 to 90°. One can think of the celestial equator and its poles (the north and south celestial poles) as "attached" to the sky. When the observer moves to another place on Earth, the celestial equator and celestial poles move relative to the observer. They are not "attached" to the observer. Though attached to the sky, the celestial equator and celestial poles are projections of features associated with Earth's surface.

There is a third fundamental plane that forms a useful coordinate system along with its associated poles. Imagine observing the Sun's motion around the sky relative to the background stars for an entire year (think of how difficult this must have been for the ancient observers who first accomplished this feat!). Careful observation shows this path constitutes another great circle around the sky, and this particular great circle is called the **ecliptic**. It is no coincidence that this looks like the word eclipse; the two are indeed intimately related. The ecliptic's corresponding poles are called the **north ecliptic pole** and the **south ecliptic pole**. Because the ecliptic and celestial equator lie in different planes, the ecliptic poles do not coincide with the celestial poles and are more difficult to visually locate on the sky. As you may have already guessed, the ecliptic and its poles define a coordinate system that uses **ecliptic longitude** (also called **celestial longitude**), usually denoted by λ, as the analog to terrestrial longitude and **ecliptic latitude** (or **celestial latitude**), usually denoted by β, as the analog to terrestrial latitude. The former, like right ascension, is measured from the vernal equinox. Both right ascension and ecliptic longitude are measured in the direction of the Sun's annual motion around the sky (that is, eastward). One can think of the ecliptic and the ecliptic poles as also being "attached" to the sky, but they are projections not of Earth's features, but features of our own solar system! In other words, the ecliptic is the plane of the solar system projected onto the sky.

So it all boils down to three fundamental planes (the horizon, the celestial equator, and the ecliptic and their associated poles) all projected onto the sky. The geometry is such that as an observer moves on Earth's surface, the horizon, zenith, and nadir all stay fixed relative to the observer while the other features defined here change where they are on the sky. Stars and galaxies are "attached" to the sky and stay (for the most part) relative to the celestial equator, the celestial poles, the ecliptic, and its poles. The Sun, Moon, planets, asteroids, and comets "slide" around the sky in predictable ways but stay near the ecliptic (Pluto, some comets, and some asteroids are notable exceptions). Forthcoming installments will address questions raised here (like the connection between the ecliptic and eclipses) and many more interesting questions and applications.

Reference

1. These are usually included in any good introductory astronomy or astrophysics textbook such as Bradley W. Carroll and Dale A. Ostlie, *Introduction to Modern Astrophysics*, 2nd ed. (Cambridge University Press, 2017) or Karttunen et al., *Fundamental Astronomy*, 6th ed. (Springer, 2017).

Fermi Questions

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Question 1: Goosed

Twenty years ago, on April 1, 1999, Busch Gardens Williamsburg opened the Apollo's Chariot roller coaster. On its inaugural ride, the featured celebrity was injured by colliding with a goose. What was the probability of this collision? (*Thanks to Christine Ploen of Old Dominion University for suggesting the question.*)

Question 2: Buying groceries

What would it cost to purchase the contents of your local large supermarket? (*Thanks to Sarah Overstreet Solomon of Old Dominion University and Steven Shapiro of Lesley University for suggesting the question.*)

Look for the answers online at *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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