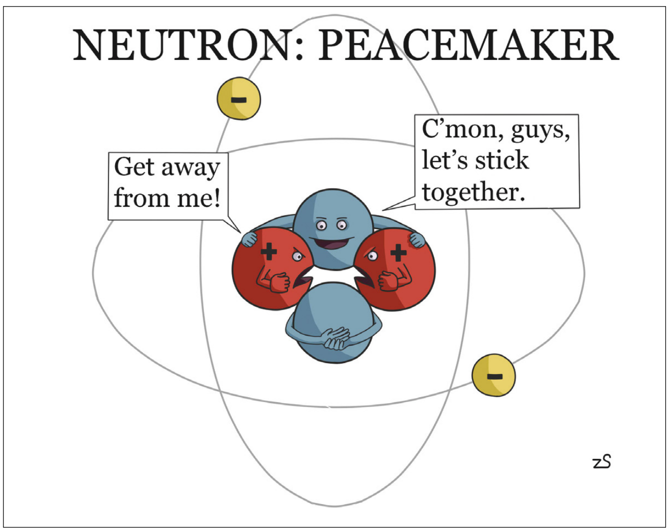
"Character" izing Physics

Although I teach 6th-grade general science, *The Physics Teacher* has been my favorite professional journal for nearly 20 years. In particular many "Figuring Physics" and "Little Gems" articles have helped inspire my students to think more deeply about physics concepts. I try to present ideas in creative ways to capture my students' imaginations. This current cartoon is one example.

My students often question the importance of neutrons (since they have no charge) when we study electricity. I stand between two students pretending they can't stand one another and wish to move apart. I tell them the neutron is kind of a buffer keeping protons together—kind of a peacemaker. This fall I envisioned my theatrics as a cartoon. Simply *telling* students things makes less of an impression on many than *showing* them an intriguing visual (such as this cartoon, and many "Figuring Physics" columns). Some of my cartoons include questions for my students to answer; others, like this one, I ask them to explain. I have published two previous original cartoons in this magazine, but here my high school freshman son (hoping to attend art school) created the art.



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Revisiting smartphone astronomy

In the article "Smartphone astronomy" on p. 440 of the October 2014 issue of *The Physics Teacher,*[1] the authors describe a simple method to determine the velocity of the ISS using a smartphone. To do this, they propose a formula (1) linking this velocity to the apparent angular velocity of the satellite. However, this formula only produces the satisfying results given in Table I if h_{ISS} is interpreted to be the distance of the space shuttle from the observer, contrary to what the text and Fig. 1 indicate.* There are some other caveats about this formula that I would note:

- The angular velocity ω is measured when the satellite is closest to the observer (during a short moment it then moves perpendicularly to the direction of observation). If it is measured when the ISS is at 45° from the closest point, the calculated angular velocity is about 30% too small.
- As mentioned above, and most importantly: h_{ISS} is the distance between the observer and the ISS (not the distance between the ISS and the center of Earth, as shown in Fig. 1 and alluded to in the text). h_{ISS} corresponds to the height relative to the surface of Earth only if the ISS passes vertically above the observer. In two consecutive transits, h_{ISS} (or better, d_{ISS}) should generally have quite different values and be significantly larger than the height above ground (a factor of 2 for an elevation angle of 30°).
- v is the velocity of the ISS with respect to the observer. As the ISS turns around Earth in the same way as Earth itself, this apparent velocity v will be about 270 m/s smaller than the velocity with respect to the center of Earth, which represents a difference of about 4% (the exact value depends in a complicated way on the latitude of the observer and the orientation of the orbit of the ISS).
- If the smartphone has a zoom, the FOV *must* be determined experimentally (with the method described in the article).

Given these stipulations, I would like to propose another challenge for the students, slightly more complex, but probably more accurate: *determine the height (above ground) of the ISS.*

The procedure would consist of the following steps:

- Calculate the orbital velocity using the well-known formula $v = \sqrt{(GM/r)}$, with r slightly bigger than the radius of Earth as suggested in the article (and perhaps corrected by the relative velocity: subtract 270 m/s). This is a rather good approximation as v is proportional to the inverse square root of r.
- Measure or estimate the angle between the horizon and the ISS when the ISS is closest to the observer (or consult