

## PROBLEM SET 5

### Physics 2021

1. When the Voyager 2 spacecraft sent back pictures of Neptune during its flyby of the planet in 1989, the spacecraft's radio signals traveled for 4 hours at the speed of light to reach Earth. How far away was the spacecraft? Give your answer in kilometers, using powers-of-ten notation.
2. What is the wavelength of light that has a frequency of  $3 \times 10^{16}$  Hz? In what part of the spectrum does this radiation occur?
3. Saturn is ten times farther from the Sun than is the Earth. How does the flux of solar energy at Saturn compare with that at the Earth?
4. Suppose atoms at rest emit visible light with a wavelength of 500 nm. At what wavelength would the light from the atoms be observed if the atoms were moving toward the Earth at a speed of 20,000 km/s?
5. The wavelength of  $H_{\beta}$  in the spectrum of the star Megrez in the Big Dipper (part of the constellation Ursa Major, the Great Bear) is 486.112 nm. Laboratory measurements demonstrate that the normal wavelength of this spectral line is 486.133 nm. Is the star coming toward us or moving away from us? At what speed?
6. You are given a traffic ticket for going through a red light (wavelength 700 nm). You tell the police officer that because you were approaching the light, the Doppler effect caused a blueshift that made the light appear green (wavelength 500 nm). How fast would you have had to be going for this to be true? Would the speeding ticket be justified? Explain.