

Astronomy 2110

Spring 2024

Homework #3

Due Thursday, Feb 7 in class.

For full credit you must write your solutions neatly and include all work. Do not forget the units.

1) On Earth, a 50-kg astronaut weighs 490 newtons. What would she weigh if she landed on Jupiter's moon Callisto? What fraction is this of her weight on Earth. See appendix 3 in the book for relevant data about Callisto or use google.

2) Imagine a planet like Earth orbiting a star with 4 times the mass of the Sun. If the semi-major axis of the planet's orbit is 1 AU, what would be the planet's sidereal period? Compared with the case of the Earth orbiting the Sun, by what factor has the quantity $(m_1 + m_2)$ changed? Has a changed? By what factor must P change?

3) A satellite is said to be in a "geosynchronous" orbit if it appears to always remain over the exact same spot above the Earth. (a) What is the period of this orbit? (b) At what distance from the center of the Earth are such satellites found? (c) Explain why geosynchronous orbits must be in the plane of the Earth's equator.

4) Suppose a newly discovered asteroid is in a circular orbit with synodic period 1.25 years. The asteroid lies between the orbits of Mars and Jupiter. (a) Find the sidereal period of the orbit; (b) Find the distance between the asteroid and the Sun.

5) The average distance from the Moon to the center of the Earth is 384,400 km, and the diameter of the Earth is 12,756 km. Calculate the gravitational force that the Moon exerts on: (a) a 1-kg rock at the point on the Earth's surface closest to the Moon; (b) on a 1-kg rock at the point on the Earth's surface farthest from the Moon. (c) Now find the difference between the forces you calculated in parts (a) and (b). This is the tidal force pulling these two rocks away from each other. (d) Explain why tidal forces cause only a very small deformation of the Earth.

6) How long does it take light to travel from the Sun to the Earth, a distance of 1 AU?

7) A light source emits infrared radiation at a wavelength of 1150 nm. What is the frequency of this radiation?

8) (a) What is a blackbody? (b) In what way is a blackbody black? (c) If a blackbody is black, how can it emit light? (d) If you were to shine a flashlight on a perfect blackbody, what would happen to the light?

9) (a) Describe an experiment in which light behaves like a wave. (b) Describe an experiment in which light behaves like a particle.

10) How is the energy of a photon related to its wavelength? What kind of photons carry the most energy? What kind of photons carry the least energy?