Astron 211 Problem Set 8

Given: Nov 8. Due: Nov 15 at the beginning of class

Homework Policy: You can consult class notes and books. Always try to solve the problems yourself; if you cannot make progress after some effort, you can discuss with your classmates or ask the instructor. However, you cannot copy other's work: what you turn in must be your own. Make sure you are clear about the process you use to solve the problems: partial credit will be awarded.

Reading: Kutner Chapter 11, 14, 15

Problem 1   Kutner 11.6

A uniform density sphere of mass M has initial radius r_0 and an angular speed ω_0. It collapses under its own gravity to a radius r, conserving angular momentum ($L = I\omega$, with $I = (2/5)Mr^2$ the moment of inertia).

a. How do the initial and final kinetic energies of rotation $(1/2)I\omega^2$ compare? Be specific: what is the difference in kinetic energy?

b. How do you account for any difference? Where does any energy come from or go to?

Problem 2   Kutner 11.7

a. What is the escape speed from a $1.5\,M_\odot$ neutron star of radius $10\,\mathrm{km}$?

b. How does it compare with the speed of light?

Problem 3   Kutner 14.9

How far must a dust grain with albedo 0 be from a $10^4\,\mathrm{K}$ star for it to have a temperature of $1000\,\mathrm{K}$?

Problem 4   Kutner 15.3

Suppose that a cloud contracts to one-tenth of its initial size? How do the Jeans length and mass compare with those in the original cloud? Write them in terms of the mass of the cloud M, the temperature T, and the initial density ρ_0.

Problem 5   Kutner 15.4

Compare the density and pressure of a dense interstellar cloud with those of the gas you your room.

Problem 6   Order of Magnitude: 747s

We can assume that a 747 can fit about 500 people, can fly about 10,000 km, holds 240,000 l of fuel, flies at 1000 km/h, has dimenions 70 m long and 6 m wide, and can lift 100,000 kg.

    a. What is the fuel consumption, in passenger-miles per gallon, of a 747 jumbo jet?

    b. How many DVDs can fit in a 747 (you can do this problem using USB sticks if you prefer)? Will the number of DVDs be limited by the space they take up (volume) or the weight the 747 can carry?

    c. Assume that each DVD can hold 5 GB. What is the total amount of data that can be carried by the 747?

    d. What is the data rate (bits/s) of a 747 filled with DVDs crossing the Atlantic?

    e. Is it cheaper to send a 747 full of DVDs across the Atlantic or to send the same amount of data using your cellphone as a modem? How about using SMS? You should look up the rates for international SMS or data transfer.