Final Exam for the course on Galaxies, 2003-2004

(Please write down your name and student ID on every page.)

1. *The cosmic distance scale.*
   Describe a method that could be used to derive the distance to the nearest cluster of galaxies (the Virgo cluster). Mention whether this distance relies on absolute or relative distance indicators. If the latter is the case, what intermediate steps or methods would be needed to compute the distance?

2. *The motions of stars and gas in the Milky Way.*
   Explain what is the Local Standard of Rest. What are the kinematics of stars in the Galactic disk? How can we derive their motions? Mention in your explanation the Oort constants.

3. *Elaborate on a topic (discussed in the lectures) of your choice.*
   Explain the concepts in relatively large detail (do not use more than one page), you may use formulae if you wish.

4. *Scaling relations for elliptical galaxies.*
   Assuming that both the velocity dispersion σ and the mass-to-light ratio M/L are constant throughout a galaxy, and that no dark matter is present, use the (scalar form of the) virial theorem to show that

   - Since the potential energy $W \propto -GM^2/R_e$, where M is the total mass of the galaxy and R_e its effective radius, and the kinetic energy $K \sim M\sigma^2/2$, so the mass of the galaxy should be $M \propto \sigma^2 R_e$.
   - If the surface brightness $I(R)$ of all elliptical galaxies could be described by Sersic's law $I(R) = I_e \exp[-b(R/R_e)^{1/n} - 1]$ with the same value of n, explain why their total luminosity L should follow $L \propto I_e R_e^2$.
   - If all elliptical galaxies had the same mass-to-light ratio M/L and surface brightness at the effective radius I_e, the Faber-Jackson relation is expected.

5. Show that if the mass density ρ in a spherical galaxy is constant, then a star moving on a circular orbit has a constant angular speed $\Omega(r) = V_c(r)/r$.