1 Stars & Galaxies, Galaxies example class 1, answers

Question 1.

1. Spiral: disk, old+young stars, in field, contain dust vs Elliptical spheroidal, old stars, in groups and clusters, no dust.
2. Disk (most of the light, planar, spiral arms, exponential surface brightness), Central spheroidal bulge ($r^{1/4}$ law, most of the remaining light), spheroidal power-law halo, containing globular clusters.
3. A gas cloud where the hydrogem gas is photo-ionised by light from massive stars. They trace spiral arms because (the massive) stars are born in the spiral arms, and they are short lived, so cannot drift out of the arms.
4. The visual light from the bulge is absorbed by dust in the intervening interstellar medium.
5. The angular extent θ of 1AU is 1" from 1 parsec distance, by definition, hence $1\text{pc} = 1\text{AU}/\theta$. Therefore $1\text{pc} = 1\text{AU}/(!pi/180 * 3600) = 3.085 \times 10^{16}\, m$. (The factor $!pi/180 * 3600$ converts arc seconds to radians.
6. In the absence of absorption, the observed flux from a star with luminosity L decreases with distance r as flux $= L/(4\pi r^2)$. Since magnitude $m = -2.5\log(\text{flux}) + c$, where c is a constant, this gives $m = 5\log(r) - 2.5\log(L/4\pi) + c$. By definition, the apparent magnitude m and the absolute magnitude M are the same, when $r = 10\text{pc}$. Hence $M = 5 - 2.5\log(L/4\pi) + c$. ($r$ in pc). Substracting these two equations yields $m - M = 5\log(r) - 5$.

Question 2

1.

$$\begin{aligned} F &= L_{\mathrm{B}}/4\pi r^2 = 6.4 \times 10^{-20}\,\mathrm{W\,m^{-2}} \\ m &= 5.48 - 5 + 5\log(r) = +29.7\,. \end{aligned} \tag{1}$$

2. $\sigma = 2\int_0^\infty \exp(-z/z_0)\, dz = 200\ \mathrm{pc}^{-2}$.

3. The surface are of the square is $(r\theta)^2$, when θ is expressed in radians, since $\theta \ll 1$. The number of stars in the square is $N = \sigma\, S$, so the flux

$$F = N\, L_{\rm B}/4\pi r^2 = \sigma\theta^2\, L_{\rm B}/4\pi\,. \tag{2}$$

is distance independent. The surface brightness is

$$\begin{aligned}\mu &= -2.5\log(F) + C \\ &= -2.5\log(L_{\rm B}/4\pi) - 2.5\log(\sigma\theta^2) + C\,,\end{aligned} \tag{3}$$

with $\sigma = 200$ and $\theta = 1./206265$ an arc second in radians. For solar type stars, $M_{\rm B} = 5.48 = -2.5\log(L_{\rm B}) + 5 + C$. Collecting terms gives $\mu_{\rm B} = 21.3$

4. We just need to replace n_0 by $n_0\exp(-R/R_0)$ in the previous analysis, yielding $\mu_{\rm B} = 21.3 + 2.5\log(e)\,(R/R_0)$.