NAME:_____

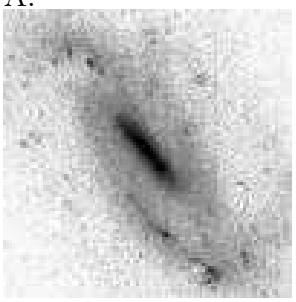
EXAM # 1
Wednesday May 1st

Astro 323 – Spring 2002
Extragalactic Astronomy & Cosmology

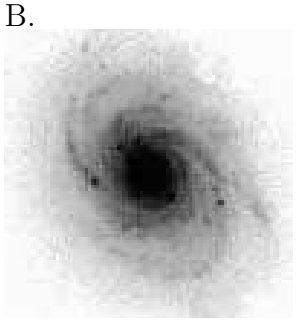
Problem 1: Galaxy Classification [8 points]

a) Match the galaxies with their most likely classification. Not every classification will have a match, and some classifications may be used more than once.

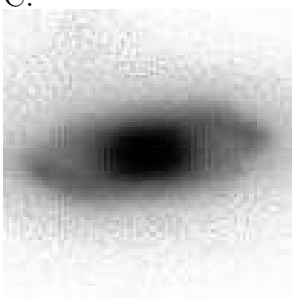
A.



B.

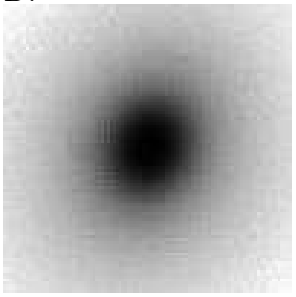


C.

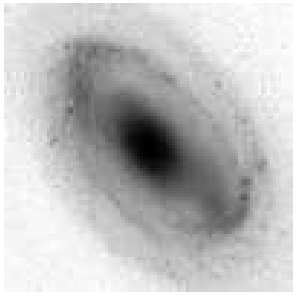


1. E2
2. SBb
3. SBcd
4. Sa
5. S0
6. Sbc
7. E6
8. Sm

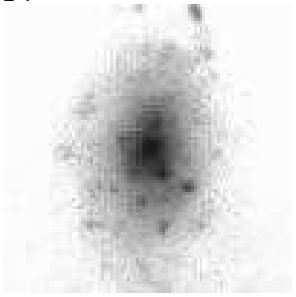
D.



E.



F.



b) Place the galaxies in order from early type to late type.

Problem 2: Luminosity Functions [10 points]

The luminosity function of galaxies is usually described with a Schechter function:

$$\Phi(L) = \Phi_* \left(L/L_*\right)^{\alpha} e^{-(L/L_*)}$$

where $\Phi(L)\, dL$ is the number of galaxies per unit volume with luminosity between L and $L + dL$.

Using the Tully-Fisher relationship, astronomers have derived that the mass-to-light ratio $\Upsilon = M/L$ varies systematically as a function of a galaxy's luminosity as:

$$\Upsilon(L) = \left(M_\odot/L_\odot\right) \left(L/L_*\right)^{1/2}$$

What is the mass density in the universe of galaxies with luminosities brighter than L_*? Set up the equation you would need to solve to derive this quantity, **BUT DO NOT ACTUALLY SOLVE IT!!!**.

Problem 3: Dynamical Measuments of Elliptical Galaxies [16 points]

FOR THIS PROBLEM, PLEASE EXPRESS YOUR ANSWERS IN A FEW WORDS AND/OR WELL LABELLED, EASILY INTERPRETED DIAGRAMS!!!!! (I.E. DO NOT ASSUME THAT I WILL "KNOW" WHAT YOU MEAN BY YOUR DIAGRAM!)

a) What is a velocity dispersion?

b) What is velocity anisotropy?

c) In words, why can velocity anisotropy lead to the flattening of a galaxy?

d) How is the velocity dispersion of an elliptical galaxy measured? Please detail all of the principal steps involved, from aquisition of data onwards.

Problem 4: Interpreting the Colors and Spectra of Galaxies [16 points]

a) You observe that a nearby galaxy is extremely blue. However, it shows no sign of Hα emission. What is your interpretation of why the stars in this galaxy are so blue?

b) You observe that a nearby galaxy is extremely red. However, a spectrum of the galaxy shows that it has very strong current star formation. What is your interpetation of why this galaxy appears to be so red?

c) You measure the spectrum of a galaxy and note that it has absorption line features similar to a K-giant star. Why does that imply that the galaxy formed most of its stars more than 10 Gyr ago?

d) Draw and label a plot of a possible isochrone for stars which make up the galaxy in part (c).

e) Was this galaxy brighter or dimmer in the past?

f) How would the *spectrum* of the galaxy change if it began forming stars again?

Problem 5: Deducing the Age of the Milky Way's Components [10 pts]

From observations of stars in the Milky Way, astronomers have deduced that stars in the stellar halo are very metal-poor, stars in the thin disk have solar metallicity, and stars in the bulge are somewhere in between.

a) Using the information above, place the components in order of increasing formation epoch (i.e. oldest component listed first).

b) Fully justify why you could use the metallicity to derive the particular order you chose in part (a).

Problem 6: Gas and Star Formation [12 points]

a) What are the three major phases of gas in spiral galaxies?

b) Rank these phases in order of increasing temperature?

c) Rank these phases in order of increasing gas density?

d) Briefly describe what role each of these phases play in the process of star formation and stellar evolution.

Problem 7: Sensible or Goofy? [16 points]

Based upon your knowledge of astronomy, would the following statements be reasonable to conclude, or the sign of a deranged mind?

SANE	INSANE	Deriving the masses of elliptical galaxies depends upon assuming that they're in virial equilibrium.
SANE	INSANE	Low angular momentum regions of the early universe are likely to form spiral galaxies.
SANE	INSANE	Face-on galaxies are ideal for measuring rotation curves.
SANE	INSANE	Moderate changes in the low mass slope of the Initial Mass Function (IMF) can drastically change the luminosity of a galaxy.
SANE	INSANE	Because elliptical galaxy spectra are similar to the spectra of A-type stars, star-formation must have ended more than several gigayears ago.
SANE	INSANE	Ionized gas can be created by shock heating.
SANE	INSANE	When large galaxies merge together, the remnant eventually looks like an elliptical galaxy.
SANE	INSANE	The rotation curves of spiral galaxies can only be measured in the optical.

Problem 8: Dark Matter in the Bizarro Universe. [12 points]

In an alternate universe, Astronomy 323 students learn that rotation curves of galaxies are not flat, but instead increase like $V \propto \sqrt{r}$ in their outer regions.

a) At a given radius r, how is the rotational velocity related to the mass of the galaxy?

b) How does the mass of a shell at radius r relate to the density at that radius?

c) Show that the density of the Bizarro galaxy halo falls off as $\rho(r) \propto r^{-1}$.

d) Does the density fall off more quickly or more slowly than the density of galaxies in our universe?