1. (20%) A star can be classified according to its spectral type, such as the O, B, A, F, G, K, M, L, T, or Y type. (a) Which physical quantity of a star is this spectral sequence related to? Why is the sequence not in the alphabetical order? (b) What is the main feature seen in an A type stellar spectrum? In an M type spectrum? (c) Other than the spectral type, a spectrum can be further classified into the luminosity class, e.g., the Sun being of type G2 V. What does it mean for a star to be G2 III? How about G2 IV? (d) How is the spectrum of a G2 III star different from that of a G2 V star? (5% each)

2. (20%) Use 1-2 sentences to describe the *appearance* of each of the following celestial objects: moon, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, Titan, Io. (2% each)

3. (20%) The most distant cosmic object currently known is a protogalaxy dubbed UDFj-39546284. It has a measured redshift of about 11.9. Given a Hubble constant $H_0 = 70$ km/s/Mpc, *discuss* how to estimate the distance to this object. You do not need to actually derive the value, but you should state explicitly the assumptions that would have gone into your calculation.

4. (20%) The following table compares some properties of M45 (Pleiades) and M67, two prominent Galactic open clusters. Answer the questions according to the table and the two color-magnitude diagrams below.

Cluster	RA (J2000)	DEC (J2000)	Age	Distance
M 45	$3^h 47^m$	$+24° 07'$	100 Myr	130 pc
M67	$8^h 51^m$	$+11° 48'$	4 Gyr	? pc
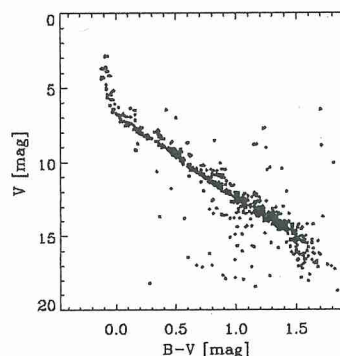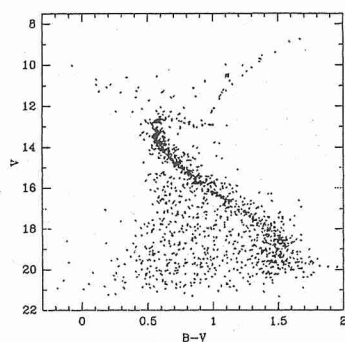
(a) Which one, the left or the right figure, is for M45? Explain why. (4%)
(b) M45 is much younger than M67. Describe a method to infer the age of a star cluster, i.e., how to derive the 4 Gyr age for M67. (8%)
(c) Estimate the distance to M67 in unit of pc. Explain each step of your derivation. (8%)

5. (20%) Barnard's Star is the third nearest star from us, after the Sun, and Proxima Centauri (in a three-star system). Barnard's Star has a parallax about 0.5 arcseconds, and a proper motion of 10.3 arcseconds per year. Its apparent magnitudes are B=11.3 mag, V=9.54, and R=8.7 mag. (a) Compute for Barnard's Star its distance (in unit of parsec or light years), absolute V-band magnitude, and transverse space speed (in unit of km/s). (Note: $\log 2 \approx 0.3$) (12%) (b) From its brightness at different bands, i.e., much brighter at longer wavelengths, comment on the possible spectral type for Barnard's Star. (2%) (c) Is Barnard's Star visible to the unaided eye? (2%) (d) If another star shows an identical spectrum to Barnard's Star, but is 10 times farther away. Which of the following may be its most likely apparent magnitude, V=20, 15, 10 mag? Explain your reasoning. (4%)