ASTRONOMY 2 — Overview of the Universe
Second Practice Problem Set

1. Consider a 2 $M_\odot$ neutron star. The mass of a neutron is 1.67×10^{-24} g, and 1 $M_\odot = 2 \times 10^{33}$ g.

(i) How many neutrons are in this neutron star? (*1 point*)

A. 6.0×10^{23} neutrons
B. 1.2×10^{23} neutrons
C. 1.2×10^{57} neutrons
D. 2.4×10^{57} neutrons
E. 6.7×10^{9} neutrons

(ii) Assuming the energy released during core bounce and supernova phase of this neutron star was 2 MeV per neutron, calculate the total energy output of the supernova in ergs. Note that 1 MeV $= 1.6 \times 10^{-6}$ ergs. (*2 points*)

A. 1.5×10^{63} ergs
B. 3.8×10^{51} ergs
C. 7.7×10^{51} ergs
D. 7.7×10^{57} ergs
E. 4.8×10^{57} ergs

2. Galaxy A is observed to have a velocity of $v_{\text{obs}} = -350$ km/s and is known to have a peculiar velocity of $v_{\text{pec}} = -500$ km/s.

(i) Use the formula: $v_{\text{obs}} = v_{\text{Hubble}} + v_{\text{pec}}$, to calculate the Hubble expansion velocity v_{Hubble} for this galaxy. (*1 point*)

A. 150 km/s
B. -150 km/s
C. -850 km/s
D. 850 km/s
E. π km/s

(ii) Galaxy B has a Hubble expansion velocity of $v_{\text{Hubble}} = 2.8$ km/s. Using Hubble's Law $v_{\text{Hubble}} = H_0\, d$ where $H_0 = 70$ km/s/Mpc, determine the distance d to this galaxy. (*2 points*)

A. -196 Mpc
B. 0.04 Mpc
C. 196. Mpc
D. 25 Mpc
E. -0.04 Mpc

(iii) What is the most likely identity of galaxy B? (*1 point*)

A. Milky Way galaxy
B. Large Magellanic Cloud galaxy
C. Andromeda galaxy
D. The most distant known galaxy
E. The most distant known quasar

3. Our neighbor galaxy, Andromeda, has a luminosity (intrinsic brightness) 3 times as bright as the Luminosity of our Milky Way galaxy, $L_{\text{Andromeda}} = 3L_{\text{MW}}$, and is at a distance of $d_{\text{Andromeda}} = 0.7$ Mpc. The flux we observe from the Andromeda galaxy (apparent brightness) is 10,000 times brighter than the flux observed from a distant quasar, $f_{\text{Andromeda}} = 10^4 f_{\text{quasar}}$. This quasar has a luminosity that is 1000 times the luminosity of our Milky Way galaxy, $L_{\text{quasar}} = 10^3 L_{\text{MW}}$. What is the distance d to the quasar? (*4 points*)

[**HINT:** *Use the formula:* $f \propto L/d^2$. *Write two relations, one for Andromeda and another for the quasar. Divide one relation by the other.*]

A. 1.28×10^{-1} Mpc
B. 3.85 Mpc
C. 1.28×10^{3} Mpc
D. 2.36×10^{6} Mpc
E. 3.85×10^{12} Mpc

4. An astronomer observes a bright star (Altair) that has a parallax angle of $p = 0.20$ arcseconds. The flux f from Altair is approximately 9.4×10^{-12} times the flux from the Sun. The distance d from the Earth to the Sun is (1/206265) pc.

(a) What is the distance d to Altair star in units of parsecs (pc)? (*2 points*)

[**HINT**— *Use the formula:* $d = 1/p$, *with distance* d *in units of pc and parallax* p *in units of arcseconds.*]

A. 0.20 pc
B. 2.06 pc
C. 3.14 pc
D. 5 pc
E. 50 pc

(b) What is the luminosity L of Altair in units of the solar luminosity $L_\odot$? (*4 points*)
[**HINT**— *Use the formula:* $f \propto \frac{L}{d^2}$ *or* $f = C\frac{L}{d^2}$, *where* C *is a constant. Write one equation for Altair and one for the sun. Divide one equation by the other.*]

A. $2.35 \times 10^{-}10\ L_\odot$
B. $0.016\ L_\odot$
C. $0.40\ L_\odot$
D. $1.00\ L_\odot$
E. $10.00\ L_\odot$

5. A distant quasar is observed to have a redshift $v/c = 0.15$, where v is the recession velocity of the quasar, and $c = 300,000$ km/s is the speed of light.

(a) What is the recession velocity v of the quasar in units of km/s? (*2 points*)

A. 7.47×10^{-5} km/s
B. 45,000 km/s
C. 0.059 km/s
D. 1.43 km/s
E. 1.97×10^6 km/s

(b) Using the Hubble expansion formula: $v = H_0 d$, where the Hubble constant $H_0 =$ 70 km/s/Mpc, calculate the distance d to the quasar in units of Mpc? (*3 points*)

A. 642.9 Mpc
B. 0.038 Mpc
C. 4.77×10^{-12} Mpc
D. 6.77 Mpc
E. 5.35×10^{10} Mpc

(c) How long ago was the light we are now seeing from the quasar emitted? Note, 1 Mpc = 3.26 million light years. (*3 points*)

A. 2.96×10^{-14} million years
B. 0.00032 million years
C. 2.096×10^3 million years
D. 1.66×10^{-4} million years
E. 9.27 million years