**Quasars & Cosmology — ASTR-1510-02**
**Activity 1**
**Distance Scales in the Universe**

**Note:** I give the answers to more digits than you needed to supply. This is to help you find errors, if necessary.

## Solutions

**1. (5 pts)** In one year, light travels a distance

$$d = ct = 3.00 \times 10^{10} \text{ cm/s} \times 3.16 \times 10^{7} \text{ s} \;=\; \boxed{9.48 \times 10^{17} \text{ cm.}} \tag{1}$$

**2. (5 pts)** Light travels one Earth diameter, $D$, in a time

$$t = \frac{D}{c} = \frac{2 \times 6.37 \times 10^{8} \text{ cm}}{3.00 \times 10^{10} \text{ cm/s}} \;=\; \boxed{0.0424 \text{ s}} \tag{2}$$

**3. (5 pts)** If $d$ is the distance from the Earth to the Sun, then light travels from the Earth to the Sun in a time

$$t = \frac{d}{c} = \frac{1.50 \times 10^{13} \text{ cm}}{3.00 \times 10^{10} \text{ cm/s}} \;=\; 500 \text{ s} \;=\; \boxed{8.33 \text{ min}} \tag{3}$$

**4. (5 pts)** If $d$ is the distance from the Sun to Pluto, then light travels from the Sun to Pluto in a time

$$t = \frac{d}{c} = \frac{5.91 \times 10^{9} \text{ km}}{3.00 \times 10^{10} \text{ cm/s}} \times \frac{10^{5} \text{ cm}}{\text{km}} \;=\; 1.97 \times 10^{4} \text{ s} \;=\; \boxed{5.47 \text{ hr}} \tag{4}$$

**5. (5 pts)** If Alpha Cen is 4.3 light years away it takes $\boxed{4.3 \text{ yr}}$ for light to reach Alpha Cen.

**6. (5 pts)** First find the conversion between parsecs (pc) and light years (ly):

$$1 \text{ pc} \;=\; 3.09 \times 10^{18} \text{ cm} \times \frac{1 \text{ ly}}{9.48 \times 10^{17} \text{ cm}} \;=\; 3.26 \text{ ly.} \tag{5}$$

Then the distance to Rho Oph in light years is

$$d = 150 \text{ pc} \times \frac{3.26 \text{ ly}}{\text{pc}} \;=\; 489 \text{ ly.} \tag{6}$$

So light takes $\boxed{489 \text{ yr}}$ to go from Rho Oph to us.

**7. (5 pts)** The distance to the Galactic Center in light years is

$$8.5 \times 10^3 \text{ pc} \times \frac{3.26 \text{ ly}}{\text{pc}} = 27,000 \text{ ly} \tag{7}$$

so it takes $\boxed{27{,}000 \text{ yr}}$.

**8. (5 pts)** The radius of the Galaxy is

$$R = \frac{3}{2} \times 27,000 \text{ ly} = 40,500 \text{ ly} \tag{8}$$

so the diameter of the Galaxy is

$$\boxed{D = 2R = 81,000 \text{ ly}.} \tag{9}$$

**9 (5 pts each).** If $d$ is the distance to the object and $D$ is the Milky Way diameter, then $N = d/D$ is the distance in units of the diameter and $s = N \times 25$ cm is the distance in a scale model where one diameter equals 25 cm. Using this to fill in the table gives

| | $d$ (ly) | $N$ | $s$ |
|---|---|---|---|
| Andromeda | $2.9 \times 10^6$ | 36 | 900 cm = 9 m |
| Virgo | $4.25 \times 10^7$ | 525 | $1.3 \times 10^4$ cm = 0.1 km |
| Farthest galaxy | $1.3 \times 10^{10}$ | $1.6 \times 10^5$ | $4 \times 10^6$ cm = 40 km |