Set 6, #1

The magnitude of 3C48 in V is $m_V = 16.20$.

Its redshift is $z = 0.369$.

Ned Wright's calculator yields $D_L = 1994$ Mpc

We can compute distance modulus

$$(m-M) = 5\log D_L - 5 = 5\log_{10}(1994\times 10^6) - 5$$
$$= 41.50$$

So the absolute mag of 3C48 is

$$M_V = m_V - 41.50 = -25.30$$

Now, the Sun's absolute magnitude is $M_\odot = +4.83$. Thus

$$\frac{L_{3C48}}{L_\odot} = 10^{0.4(M_\odot - M_{3C48})} = 10^{12.05}$$

$$\Rightarrow L_{3C48} = 1.13\times 10^{12}\ L_\odot$$

Set #6, 1 continued

We know $L_\odot = 3.83 \times 10^{26}$ J/s.

Suppose a supermassive black hole at center of 3C48 has

$$M_{BH} = 261 \times 10^6 \text{ solar masses}$$
$$= 5.19 \times 10^{38} \text{ kg}$$

The radius of event horizon is

$$R = \frac{2GM_{BH}}{c^2} = 7.71 \times 10^{11} \text{ m}$$

So grav potential energy of objects very far from BH is

$$U = \frac{GM_{BH}\, m}{R} = \frac{\cancel{G M_{BH}}\, m}{1} \cdot \frac{c^2}{2\cancel{G M_{BH}}}$$
$$= \tfrac{1}{2} mc^2$$

In other words, the grav potential energy of mass m far from any black hole, no matter what BH mass, is just $\frac{1}{2}mc^2$. Cool. So if 3C48's BH converts half of that into visible light, in one year

per year $\frac{1}{4}mc^2 = 1.13 \times 10^{12} L_\odot * 3.83 \times 10^{26} \frac{\text{J/s}}{L_\odot} * 3.15 \times 10^7 \frac{\text{s}}{\text{yr}}$

$$\Rightarrow m = 6.07 \times 10^{29} \text{ kg/year} = 0.30\ M_\odot/\text{yr}$$