(2/10, 20 minutes) If you are looking at faint, background-limited, stars, how much fainter can you see (i.e., measure at the same S/N) if you have 0.3 arcsec instead of 1.0 arcsec images? Express your answer in magnitudes.

For background-limited stars, the signals and their corresponding telescope sizes (diameters) are related as

$$S_2 = \sqrt{\frac{T_1}{T_2}} S_1$$

or

$$\frac{S_2}{S_1} = \sqrt{\frac{T_1}{T_2}}$$

Since the telescope size and resolution are inversely proportional ($\theta = 1.22\lambda/T$), a resolution that is $3\times$ smaller (at the same wavelength) would mean you have a telescope that is $3\times$ bigger.