Transit:

Kepler-based SNR equation from Howard et al 2012 (check Sample paper):

$$SNR = \frac{\delta}{\sigma_{CDPP}} \sqrt{\frac{n_{tr} t_{dur}}{3\ hr}}$$

δ = transit depth

σ_{CDPP} = Combined Differential Photometric Precision

t_{dur} = transit duration

n_{tr} = # of transits in 90 days

$\delta = 0.01$

σ_{CDPP}: From Vanderburg et al. (2017) (from Week 2 exoplanet Powerpoint)

Figure 2: $\sigma = 0.0002 \Rightarrow 200$ ppm

$\frac{\sigma}{2\pi} = 31.83$ ppm $= \sigma_{CDPP}$

b/c data is a Gaussian distribution

$$t_{dur} = \frac{P_{Jup} R_{\odot}}{\pi a_{Jup}} = \frac{4333\ \text{days}\ (695700\ \text{km})}{\pi (778.479 \times 10^{6}\ \text{km})}$$

$= 1.23$ days $= 29.58$ hours

$$n_{tr} = \frac{90}{4333}$$

$$\Rightarrow SNR = \frac{0.01}{30\,ppm}\sqrt{\frac{\left(\frac{90}{4333}\right)(29.58 \text{ hours})}{3 \text{ hours}}}$$

$$= 1.51 \times 10^{-4}$$

Howard et al. only included stars with SNR > 10, so this method would not detect this test case.

Direct imaging:

Rayleigh limit: $\theta \sim 1.22 \frac{\lambda}{D}$

Peak black body wavelength given by Wein's law:

$$\lambda_{peak} = \frac{2898 \mu m.K}{T}$$

Jupiter blackbody temp from NASA planetary fact sheet: 109.9 K

$$\Rightarrow \lambda_{peak} = \frac{2898 \mu m.K}{109.9 \text{ K}} = 26.37 \mu m$$

Gemini Planet Imager, Gemini South telescope has diameter D = 8.1 m (from Macintosh et al 2017 in week 2 exoplanet Powerpoint)

$$\Rightarrow \theta \sim 1.22 \frac{26.37 \times 10^{-6}\,m}{8.1\ m} = 3.97 \times 10^{-6}\ rad$$

$$3.97 \times 10^{-6} = \frac{R_{Jup}}{d_{min}} \Rightarrow d_{min} = \frac{66854\ km}{3.97 \times 10^{-6}} = 1.68 \times 10^{10}\ km$$

$$\simeq 112\ AU$$