# SOLUTION SET 3
## Physics 2022

**1.** $F = 2f$ $\quad M = F / f = 2f / f = 2$

**2.** Fraction = Area (cage) / Area (mirror) = $\pi R^2$ (cage) / $\pi R^2$ (mirror)

$= (1 / 5)^2 = 1 / 25 = 0.04$

**3.** LGA $\propto$ Area

LGA(1) $\propto (300\ m)^2$ $\quad$ LGA(2) $\propto (50\ m)^2$

LGA(1) / LGA(2) $= (300 / 50)^2 = (6)^2 = 36$ times

**4.** LGA(1) / LGA(2) = (Diameter / 1)$^2$ = Diameter$^2$ = 1000 m$^2$

Diameter = 31.6 m

**5a.** Light Gathering Power = Area (Subaru) / Area (Hubble)

$= \pi R^2$ (Subaru) / $\pi R^2$ (Hubble) $= (8.3\ m / 2.4\ m)^2 = 12.0$ X

**5b.** Subaru has a larger aperture, so it can detect fainter objects.

Hubble is outside the Earth's atmosphere, so it achieves a higher resolution.

**6a.** Magnification = F / f = 2 m / 9mm = 2000 mm / 9mm = 222 X

**6b.** Magnification = F / f = 2000 mm / 20 mm = 100 X

**6c.** Magnification = F / f = 2000 mm / 55 mm = 36.4 X

**6d.** $\alpha = 2.5 \times 10^5 \lambda / D = 2.5 \times 10^5 / 0.20\ \lambda = 1.25 \times 10^6 \lambda$

where $\lambda$ and D are in meters

$\lambda = 600$ nm $= 600 \times 10^{-9}$ m then $\alpha = (1.25 \times 10^6)(600 \times 10^{-9}) = 0.75$ arcsec

**7a.** $D = d \tan \alpha = (6.28 \times 10^8 \text{ km}) \tan [(0.1 \text{ arcsec}) / (60 \times 60)] = 304.5 \text{ km}$

**Hubble's resolution on Io.**

**7b.** $D = d \tan \alpha = (3.844 \times 10^5 \text{ km}) \tan [(1.0 \text{ arcmin}) / (60)] = 111.8 \text{ km}$

**Human eye's resolution on the Moon.**

**8a.** $D = d \tan \alpha = (7 \times 10^7 \text{ ly}) \tan ( 0.1 / 3600 ) = 34 \text{ ly}$

**8b.** $d = D / \tan \alpha = (1.8 \times 10^{-5} \text{ km}) / \tan ( 0.1 / 3600 ) = 37 \text{ km}$

**9.** $\alpha = 250{,}000 \lambda / D \quad \lambda_1 = 5 \times 10^{-7} \text{ m} \quad D_1 = 4 \text{ m} \quad \lambda_2 = 10^{-4} \text{ m}$

$\lambda_1 / D_1 = \lambda_2 / D_2$

$D_2 = D_1 \lambda_2 / \lambda_1 = (4 \text{ m}) (10^{-4} \text{ m}) / (5 \times 10^{-7} \text{ m}) = 800 \text{ m}$

**10.** $\alpha = 250{,}000 \lambda / D$

$10^{-3} \text{ arcsec} = 250{,}000 (550 \times 10^{-9} \text{ m}) / D$

$D = 250{,}000 (550 \times 10^{-9} \text{ m}) / (10^{-3} \text{ arcsec})$

$D = 137.5 \text{ m}$