

Q1) a) Power = Lumen / Lumen per watt  
 $= 1000 / 200 = 5 \text{ W}$

b) Resolution of eye  $> 1/60$   
 min feature  $> \frac{1}{60} \times 25 > 0.075 \text{ mm}$   
 $\hookrightarrow 0.003 \text{ rad.}$

resn.  $1/0.075 \text{ mm}$   
 $\approx 13.3 \text{ per mm}$

Q2) a)  $\lambda = \frac{2.898 \times 10^{-3}}{T}$   
 for a fusion  $\lambda = \frac{2.898 \times 10^{-3}}{310} = 9.38 \mu\text{m}$

CMB  $\lambda = \frac{2.898 \times 10^{-3}}{2.74} = 1.066 \text{ mm}$

b)  $\lambda = 780 \text{ nm}$   
 $T = \frac{2.898 \times 10^{-3}}{780 \times 10^{-9}} = 4140 \text{ K}$

c)  $P = \sigma A T^4$   $A = 2 \text{ m}^2$   $\sigma = 5.67 \times 10^{-8}$   
 $T = 310$

$P = 1046 \text{ W}$

$$1 \approx (1046 \text{ nm})$$

Q3) a)  $2 \times 45^\circ$  degree rotation  
half plate

$$\delta = \frac{2\pi d (n_{\text{slow}} - n_{\text{fast}})}{\lambda} = \pi$$

$$d = \frac{\lambda}{2(n_{\text{slow}} - n_{\text{fast}})}$$

(600 nm)

1.658  $\rightarrow$  1.486

$$d \approx 1.74 \mu\text{m}$$

b)  $\delta = \frac{\pi}{2} = \frac{2\pi d (n_{\text{slow}} - n_{\text{fast}})}{\lambda}$

$$\Rightarrow \lambda = 4d (n_{\text{slow}} - n_{\text{fast}})$$

$$= \frac{600 \times 10^{-9}}{4 \times 0.172}$$

$$\approx 0.87 \mu\text{m}$$

c) ?

Q4)

$$\phi = \frac{\omega n_0^3 r_{63} V}{c}$$

$$V = \frac{c \phi}{\omega n_0^3 r_{63}}$$

$$\omega = 2\pi/\lambda$$

$$\phi = \pi$$

$$V = \frac{c \pi}{\omega n_0^3 r_{63}}$$

$$= \lambda$$

wh 0.63

$$V = \frac{c\lambda}{(2\pi/n) n_0^3 V_{63}} = \frac{1}{2 n_0^3 V_{63}}$$

$$\lambda = 750 \text{ nm}$$

$$n_0 = 1.51$$

$$V_{63} = 10.6 \times 10^{-12} \text{ m/V}$$

$$V = \frac{750 \times 10^{-9}}{2(1.51)^3 \cdot 10.6 \times 10^{-12}}$$

$$\approx 10650$$

$$\text{10.6 kV}$$

Q5) a)  $\lambda = 750 \text{ nm}$

$$D = 1 \text{ cm}$$

$$I_{\text{acoustic}} = 1 \text{ W}$$

$$\text{beam area} = 1 \text{ mm}^2$$

$$I_{\text{acoustic}} / \text{area} = 1 / 10^{-6}$$

$$= 10^6 \text{ W/m}^2$$

$$M = \frac{n^6 p^2}{\rho v_s^3}$$

$$n = 2.25$$

$$p = 0.15$$

$$\rho = 4780$$

$$v_s = 7400 \text{ m/s}$$

$$Q = \frac{1}{\text{rad/s}}$$

$$n_s = v_s / f$$

$$= \frac{7400}{100 \times 10^6}$$

$$= 7.4 \times 10^{-5}$$

$$Q = \frac{700 \times 10^{-1}}{2 \cdot 2.25 \cdot 7.4 \times 10^{-1}}$$

$$\approx 0.12$$

rad/s.

b)

$$\frac{I_d}{I_i} = \sin^2 \left( \frac{\pi \sqrt{M I_{\text{acoustic}}}}{d \sqrt{2}} \right) \approx 10^{-4}$$

$$\frac{2d}{\lambda_i} = \sin^2 \left( \frac{\pi \cdot 0.01 \sqrt{10^{-4} \times 10^6}}{700 \times 10^{-9} \sqrt{2}} \right)$$

$$\approx \sin^2(0.32) \approx 0.1$$

$$10\%$$

c)

$$N = df T$$

$$n \quad n / \quad = 0.01$$

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N.  $\Delta f'$ 

$$\uparrow = D/N_s \quad \sim \frac{0.01}{7900}$$

$$\approx 1.35 \times 10^{-6}$$

$$1f = 1000/P$$

$$\approx 700 \times 10^6 \text{ Hz}$$