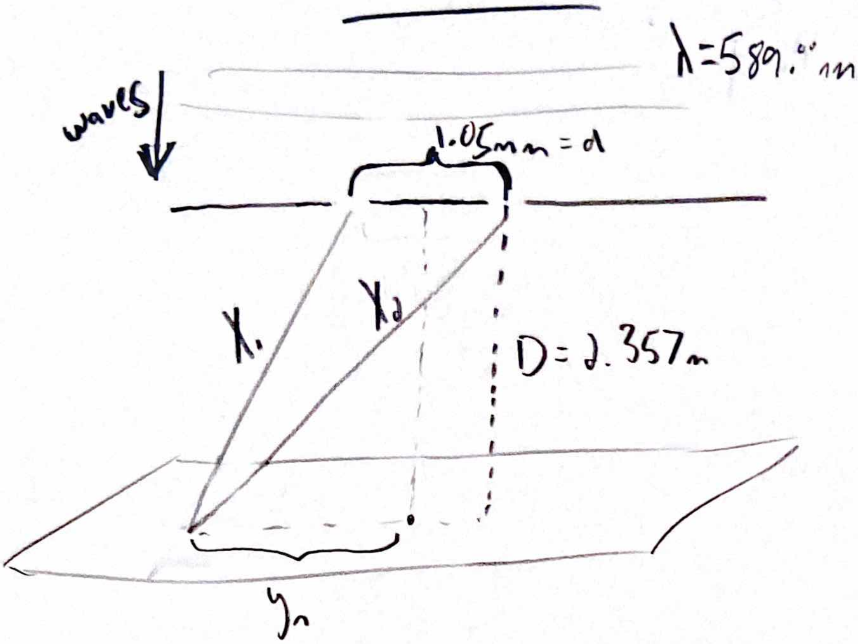
Problem 1



From the geometry of the experimental setup above, we can solve for the distance from the center of the screen to the point on the screen where one beam must travel an integer multiple of the wave length farther than the other beam. Call this distance y_n $\forall n \in \mathbb{N}$.

Pythagorus gives $y_n = (X_1 - X_2)\frac{D}{d}$. With this, and with the condition for constructive inteference described above as $|X_1 - X_2| = n\lambda$ $\forall n \in \mathbb{N}$, we can solve for the distance from the $n=1$ maxima to the $n=2$ maxima as follows:

$$|Y_2 - Y_1| = \left|2\cdot\lambda\cdot\frac{D}{d} - 1\cdot\lambda\cdot\frac{D}{d}\right| = \left|\lambda\frac{D}{d}(2-1)\right| = \lambda\cdot\frac{D}{d} = (589\,nm)\cdot\frac{2.357\,m}{1.05\,mm}$$

$$= \boxed{1.322\,mm}$$

Problem 2

Example 3.1 gives $d = 0.282$.

Therefore, $\underline{\theta} = \sin^{-1}\left(\frac{n\lambda}{2d}\right)$

$$= \sin^{-1}\left(\frac{2\lambda}{2d}\right)$$

$$= \sin^{-1}\left(\frac{\lambda}{d}\right)$$

$$= \sin^{-1}\left(\frac{0.25\ \text{nm}}{0.282\ \text{nm}}\right) = \boxed{62.44^\circ}$$

PROBLEM 3 (#7 KRANE)

a.) IF $E = \frac{hc}{\lambda} = 10\,keV$ (3.21) WE HAVE

$$\lambda = \frac{hc}{10\,keV} = \frac{1240\,eV\cdot nm}{10{,}000\,eV} = \boxed{0.124\,nm}.$$

b.) $E = \frac{hc}{\lambda} = 1\,MeV \Rightarrow \lambda = \frac{hc}{1\,MeV} = \frac{1240\,eV\cdot nm}{10^6\,eV} = \boxed{0.00124\,nm}$

c.) $350_{nm} \leq \lambda \leq 700_{nm} \Rightarrow \frac{1}{700_{nm}} \leq \frac{1}{\lambda} \leq \frac{1}{350_{nm}}$

$$\Rightarrow \frac{1240\,eV\cdot nm}{700\,nm} \leq \frac{1240\,eV\cdot nm}{\lambda} \leq \frac{1240\,eV\cdot nm}{350\,nm}$$

$$\Rightarrow \boxed{1.77\,eV \leq E \leq 3.54\,eV}$$

WHICH THE RANGE OF ENERGIES OF VISIBLE LIGHT.

$1 \leq a \leq b \leq c$

$\Rightarrow \frac{a}{abc} \leq \frac{b}{abc} \leq \frac{c}{abc}$

$\Rightarrow \frac{1}{bc} \leq \frac{1}{ac} + \frac{1}{ac} \leq \frac{1}{ab}$

$\Rightarrow \frac{1}{b} \leq \frac{1}{a} + \frac{1}{c} \leq \frac{1}{b}$

$\Rightarrow \boxed{\frac{1}{c} \leq \frac{1}{b} \leq \frac{1}{a}}$

PROBLEM 4 (KRANE #8)

TABLE 3.1 GIVES ϕ OF Al AS 4.08eV.

FROM EQUATION 3.25 WE HAVE A CUTOFF WAVELENGTH OF $\lambda_c = \frac{1240 \text{ eV} \cdot \text{nm}}{4.08 \text{ eV}} = \boxed{303.92 \text{ nm}}$.

PROBLEM 5

IF 1 eV IS THE AMOUNT OF ENERGY GAINED BY AN ELECTRON THROUGH ONE VOLT, 3eV SHOULD BE THE ENERGY GAINED BY ELECTRON THROUGH 3 VOLTS (b). CONVERTING TO JOULES GIVES $3 \cdot 1.6 \cdot 10^{-19} \text{ J} \approx \boxed{4.8 \cdot 10^{-19} \text{ J}}$

PROBLEM 6

THE LASER IS OUTPUTTING $25\,kW = 25{,}000\ W = 25{,}000\ J/s$.

EACH PHOTON WITH WAVELENGTH $1.06\,\mu m$ WILL HAVE

$$E = \frac{1240\,eV\cdot nm}{1060\,nm} = 1.17\,eV = 1.87\cdot 10^{-19}\,J.$$

THE # OF PHOTONS PER SECOND IS

THEREFORE $\frac{25{,}000}{1.87\cdot 10^{-19}}$ photons per second.

$$= \boxed{1.34\cdot 10^{23} \text{ PHOTONS PER SECOND.}}$$

PROBLEM 7

NO PHOTOELECTRONS EMITTED ABOVE 270 nm IMPLIES

THAT $\lambda_c = 270\,nm = \frac{hc}{\phi}$. IF THE RESEARCHER WANTS

TO ACHIEVE $K_{max} = 2\,eV$, USING EQUATION 3.23,

WE HAVE $K_{max} = 2\,eV = hf - \frac{hc}{270\,nm}$

$$\Rightarrow \quad f = \frac{1}{h}\left(2\,eV + \frac{1240\,eV\cdot nm}{270\,nm}\right) = \frac{1}{h}\cdot 6.59\,eV$$

$$= \frac{6.59\,eV}{4.14\cdot 10^{-15}\,eV\cdot s} = \boxed{1.59\cdot 10^{15}\,s^{-1}}$$

PROBLEM 8 (35 KRANE)

a.) WIEN'S LAW GIVES

$$\lambda_{max} = \frac{2.8978 \cdot 10^{-3}\,m \cdot K}{1150\,K}$$

$$= \boxed{2519.82\,nm.}$$

b.) FROM PLANK'S BLACK BODY DISTRIBUTION

WE HAVE THAT

$$\frac{I(2\lambda_{max})}{I(\lambda_{max})} = \frac{\frac{\cancel{2\pi hc^2}}{2^5 \cancel{\lambda_{max}^5}} \cdot \frac{1}{\exp\left\{\frac{hc}{2\lambda_{max}kT}\right\}-1}}{\frac{\cancel{2\pi hc^2}}{\cancel{\lambda_{max}^5}} \cdot \frac{1}{\exp\left\{\frac{hc}{\lambda_{max}kT}\right\}-1}}$$

$$= \frac{\exp\left\{\frac{hc}{\lambda_{max}kT}\right\}-1}{2^5\left[\exp\left\{\frac{hc}{2\lambda_{max}kT}\right\}-1\right]}.$$

PLUGGING IN CONSTANTS AND T = 1150K GIVES

$$\frac{I(2\lambda_{max})}{I(\lambda_{max})} = \boxed{.407.}$$

PROBLEM 9

a.) Let $\phi_s = 1.2eV$. EQUATION GIVES THAT

$$\lambda_c = \frac{1240eV \cdot nm}{1.2eV} = 1033.33\ nm.$$

GOOGLE HAS THIS JUST ABOVE THE VISIBLE SPECTRUM. VISIBLE LIGHT SHOULD WELL PRODUCE CURRENT IN SI SOLAR CELLS.

b.) 1 A IS EQUAL TO $6.2 \cdot 10^{18}$ ELECTRONS WORTH OF CHARGE PER SECOND. ASSUMING THE CELL ABSORBS 100% OF THE INCIDENT PHOTONS, THIS SHOULD MEAN $\boxed{6.2 \cdot 10^{18}}$ PHOTONS INCIDENT ON THE CELL PER SECOND.

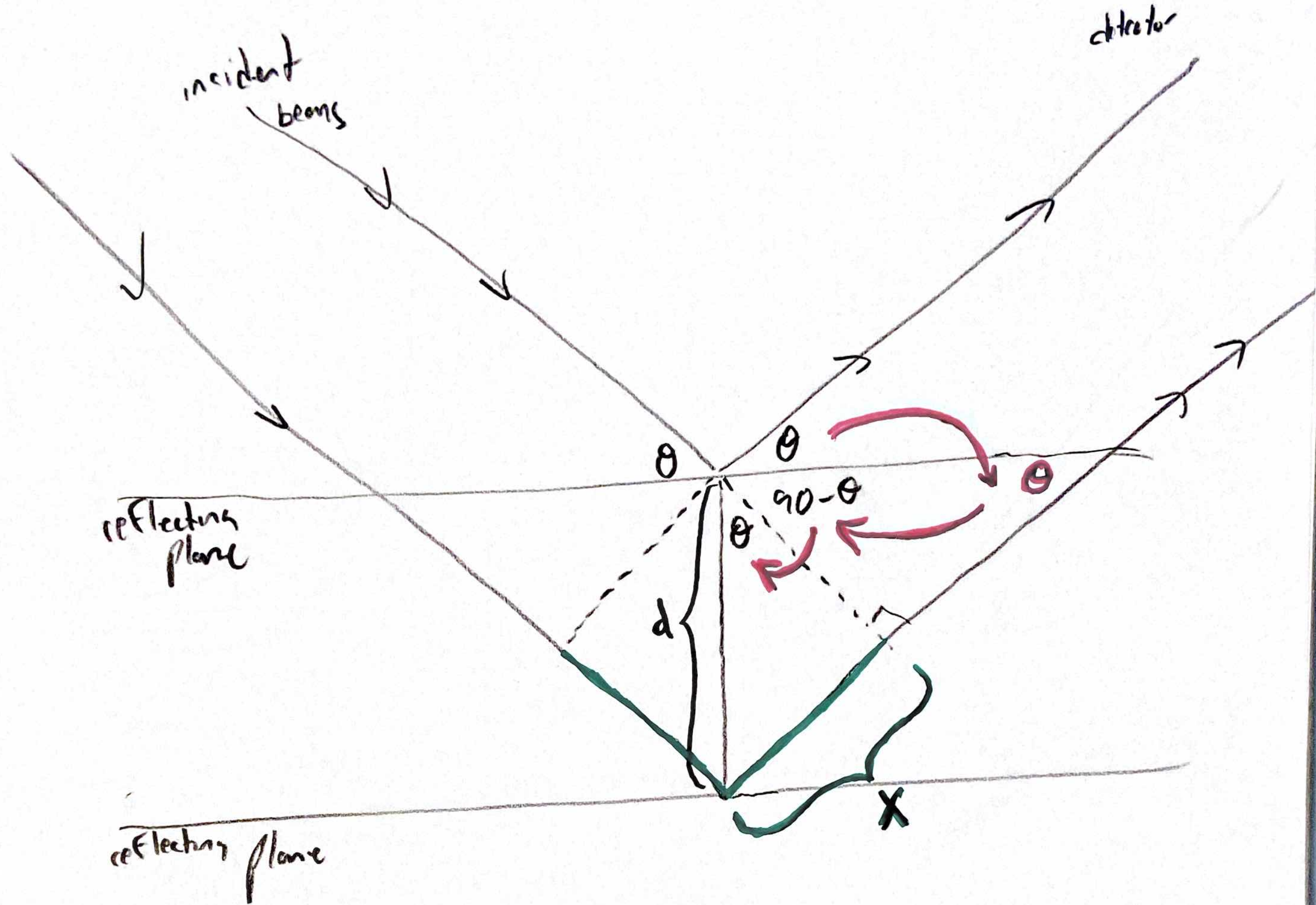
c.) THE ENERGY OF ONE PHOTON IS

$$\frac{1240\ eV \cdot nm}{1033.33\ nm} = 1.2\ eV.$$

THE POWER THEN IS AS FOLLOWS

$$\underline{Power} = 6.2 \cdot 10^{18} \cdot 1.2eV\ s^{-1} = 1.14\ Js^{-1} = \boxed{1.14\ Watts.}$$

PROBLEM 10



FROM THE DIAGRAM ABOVE WE CAN SEE THAT THE TWO BEAMS TRAVEL THE SAME DISTANCE UPON ENTRY AND EXIT. THE LOWER BEAM ADDS THE LENGTHS LABELLED X (green) TO ITS PATH. FOLLOWING THE GEOMETRIC LOGIC OF THE PINK ARROW PLACES A THETA IN THE RIGHT TRIANGLE AND ALLOW FOR THE FOLLOWING SOLUTION FOR $2x$:

$$2x = 2d\sin\theta.$$

IF THIS DISTANCE ALIGNS WITH PERIODICITY OF THE BEAMS, I.E. $n\lambda = 2d\sin\theta$, THAT MEANS THE BEAM CAN BOUNCE OFF ALL THE PLANES.