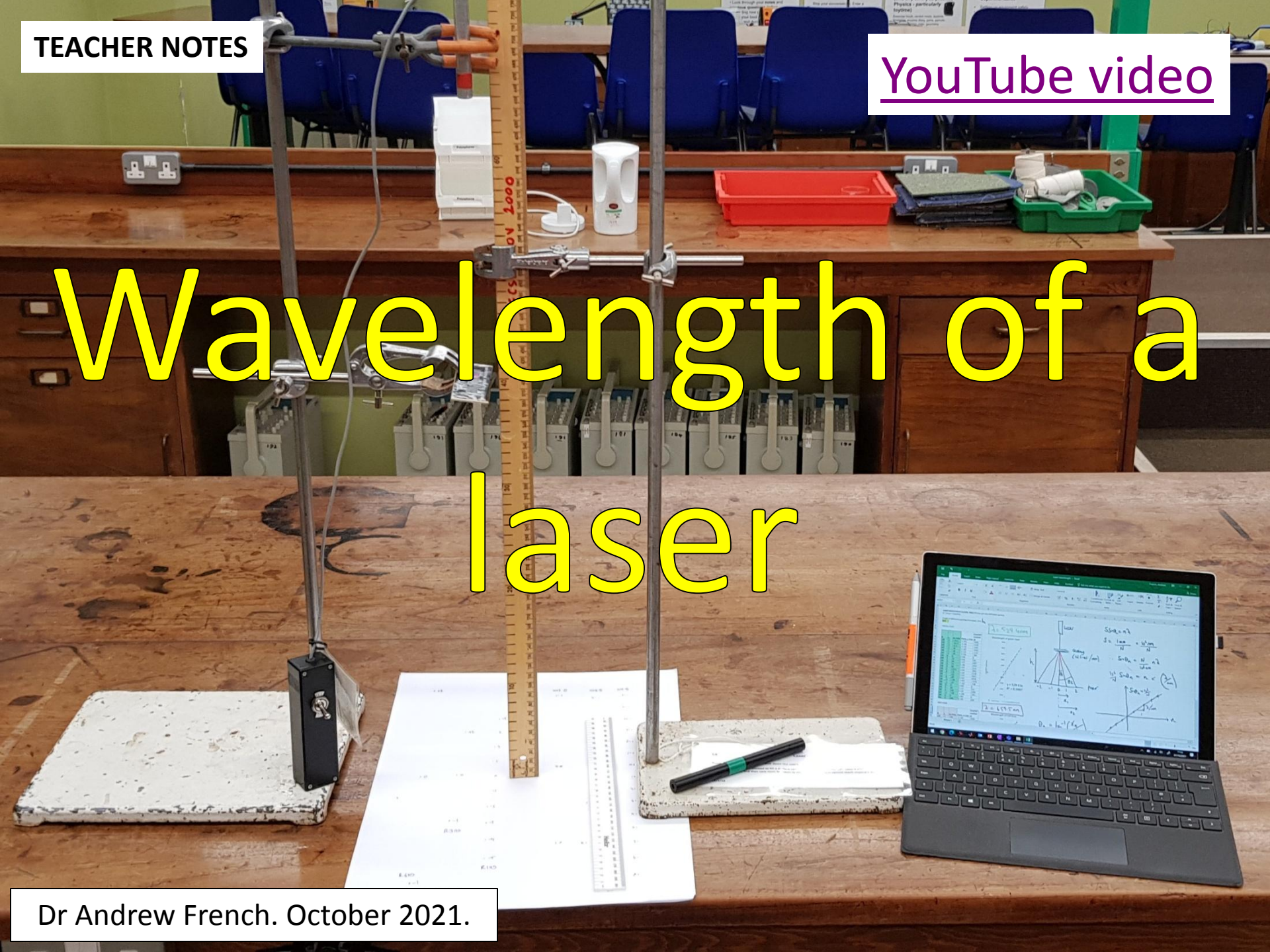


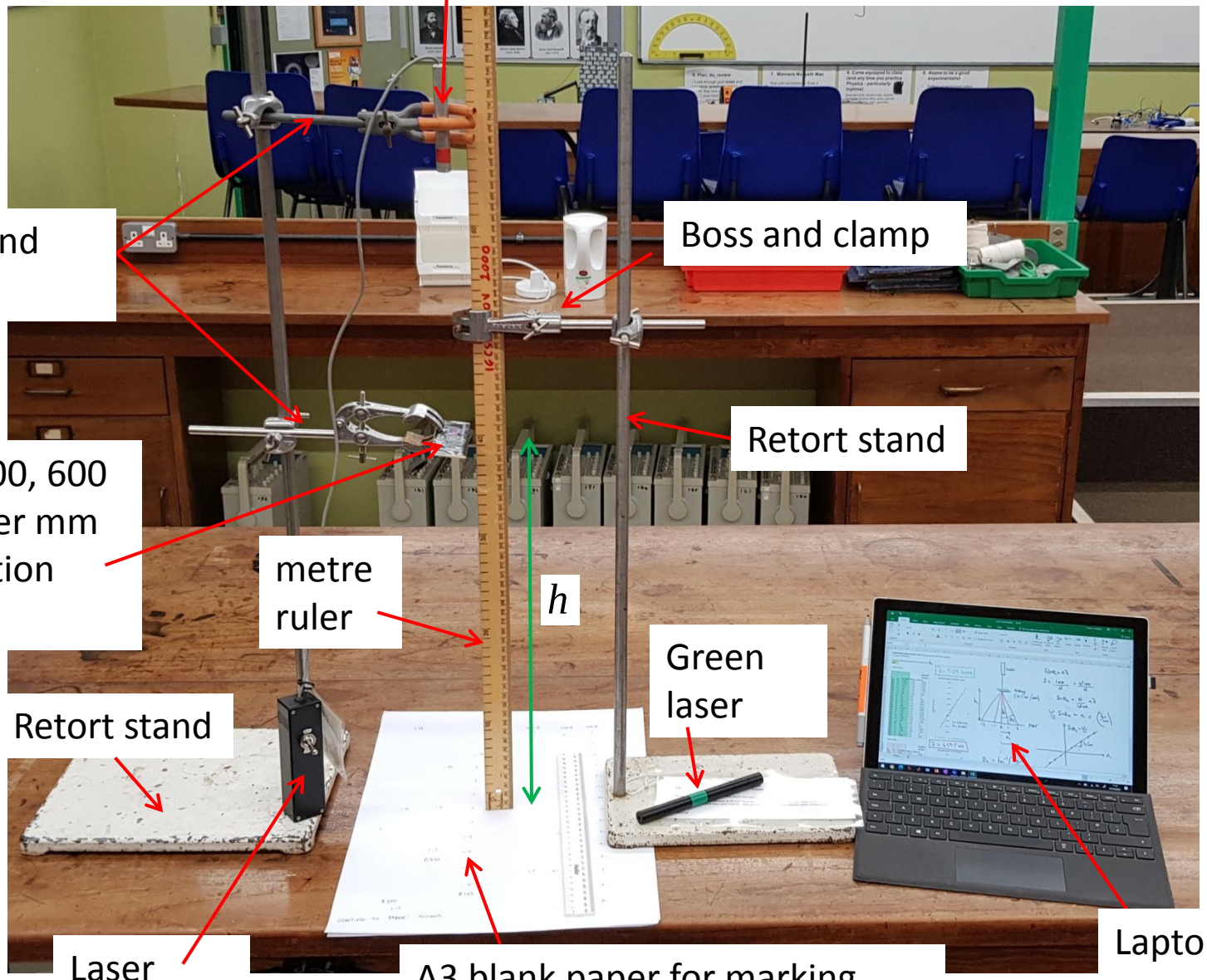
TEACHER NOTES

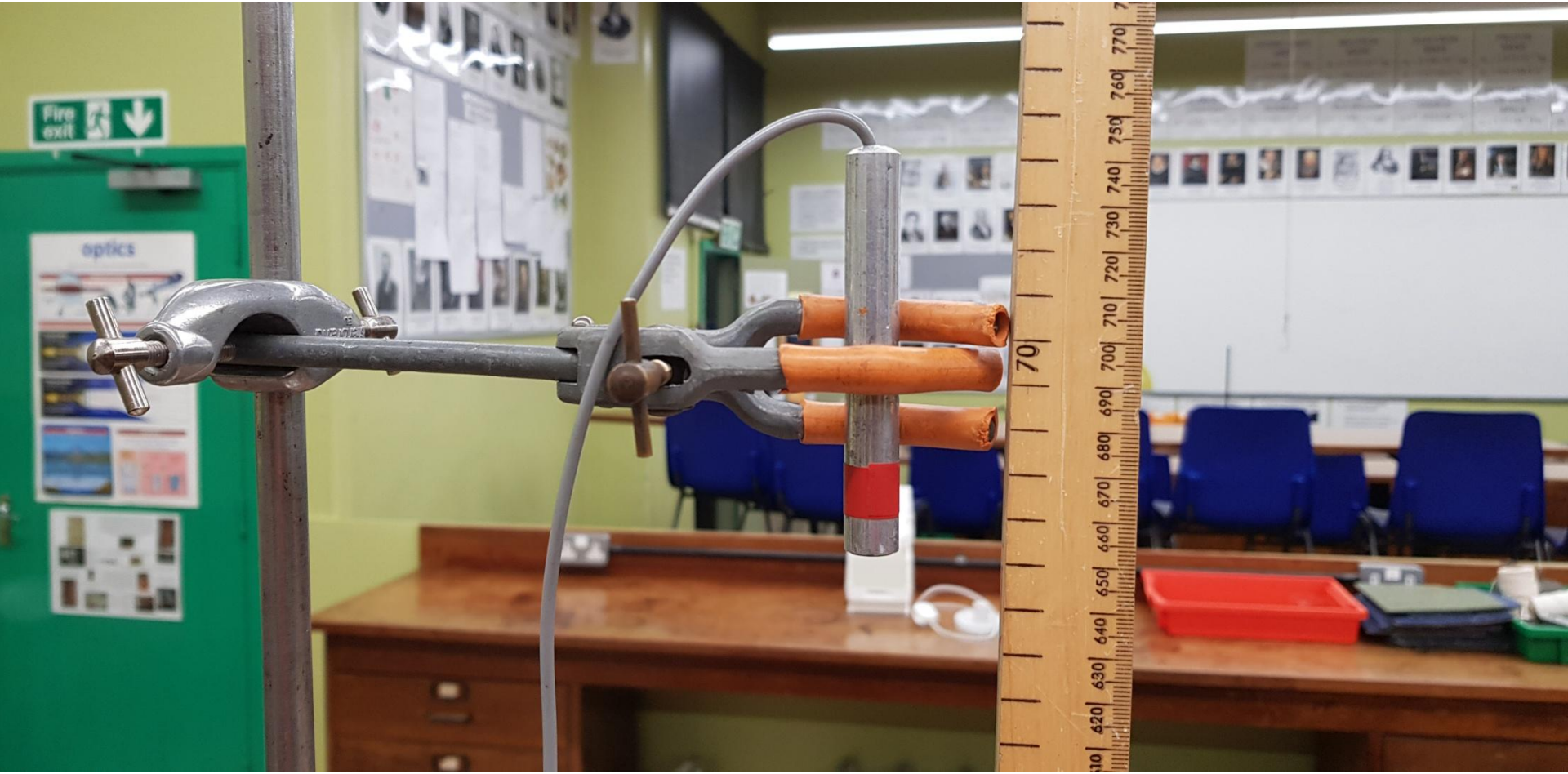
YouTube video

Wavelength of a laser

Dr Andrew French. October 2021.

Equipment setup



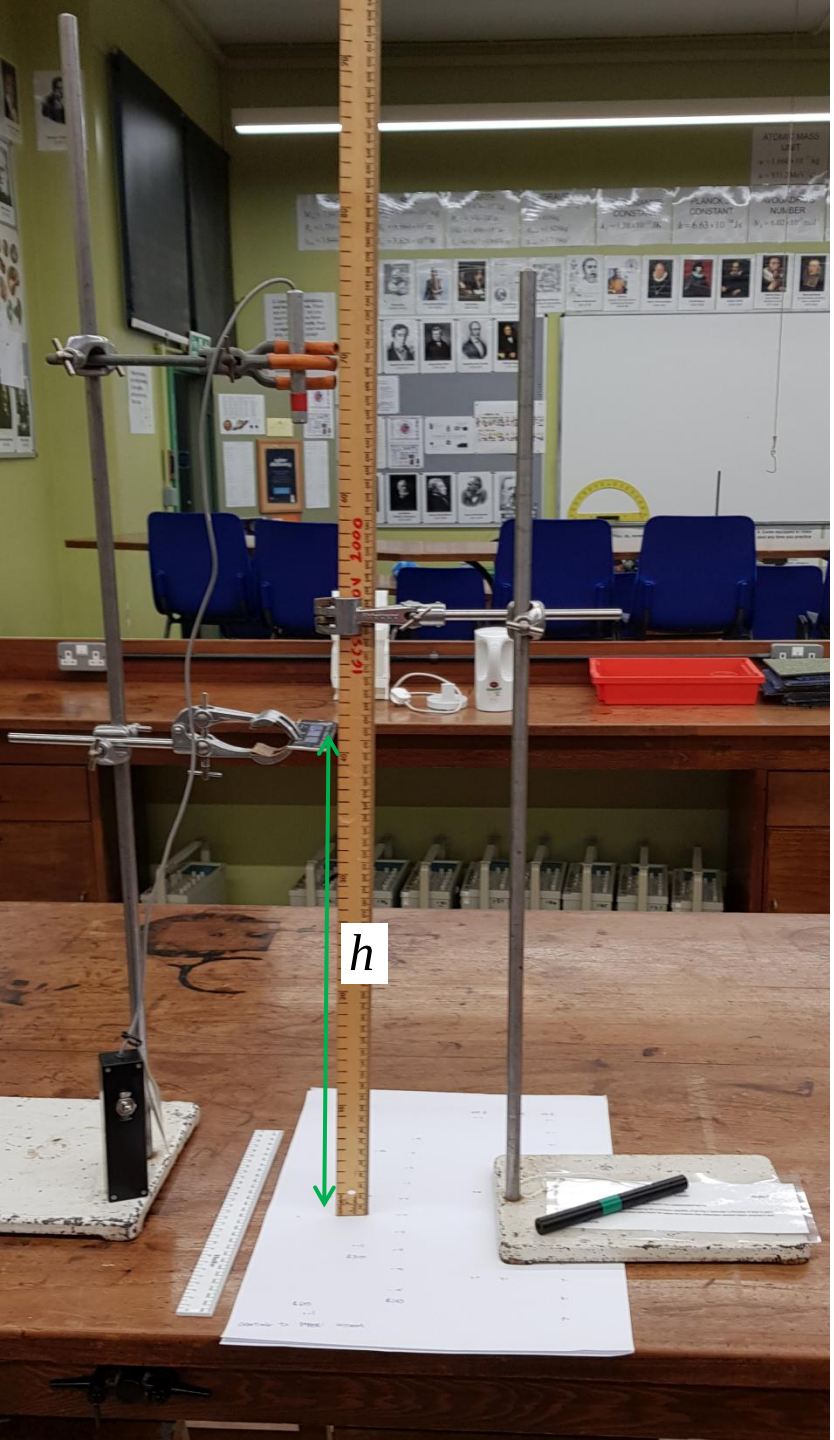


Laser (in this case red) mounted vertically using a retort stand, boss and clamp.

*** DON'T SHINE THE LASER INTO YOUR EYES ***

Diffraction grating (100, 300 and 600 lines per mm)

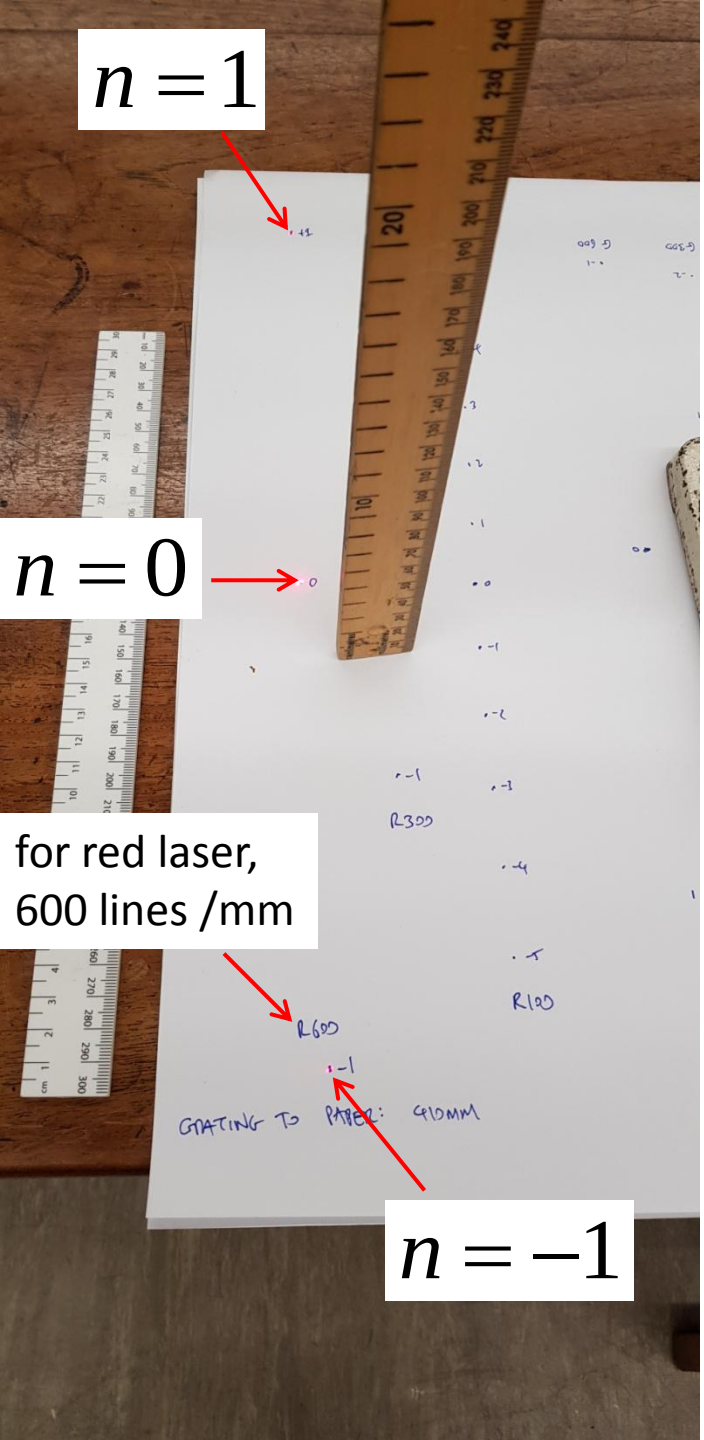
Keep the diffraction grating at a fixed height h (in mm) above the paper.
Make sure you record what this is in your spreadsheet for the experiment.



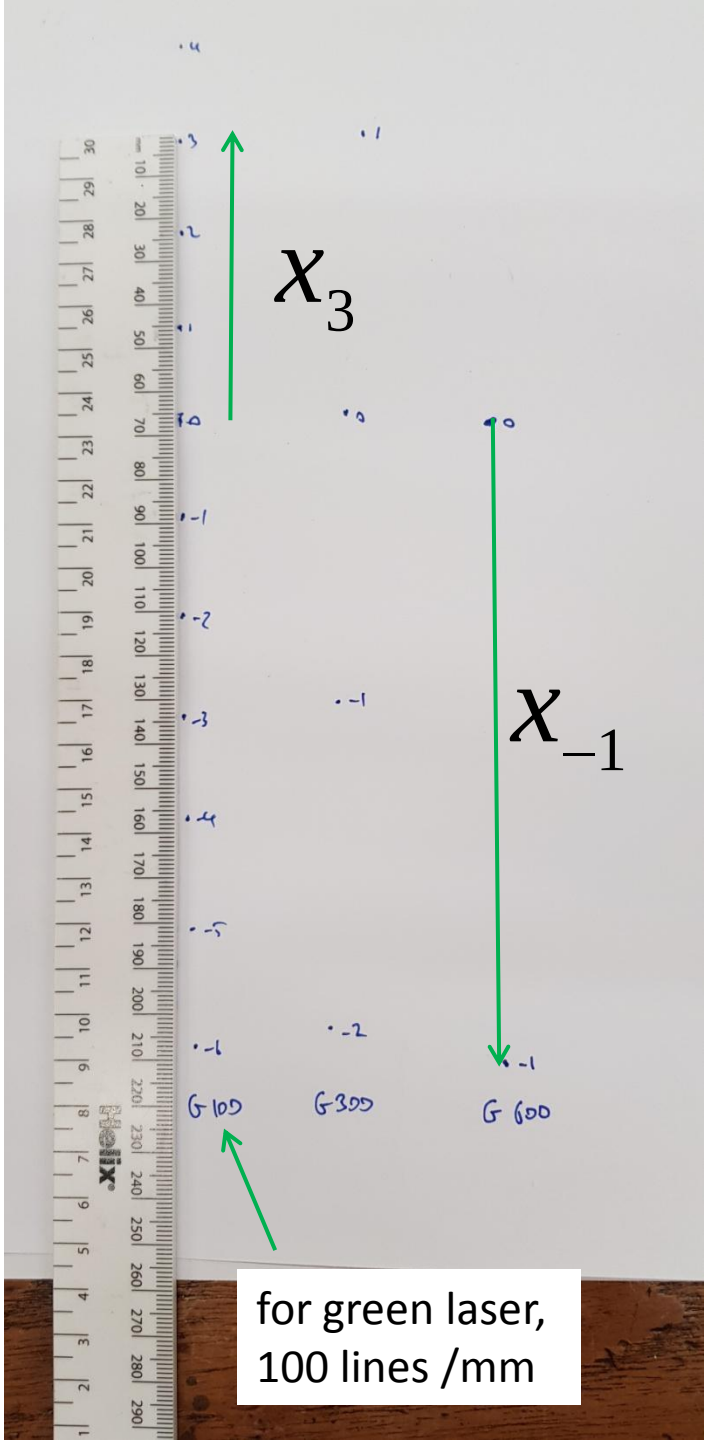
- Mount laser vertically using a retort stand, boss and clamp. Mount a diffraction grating (100,300,600 lines per mm) underneath the laser. Set so that by moving the grating, the laser beam illuminates the centre of the grating windows.

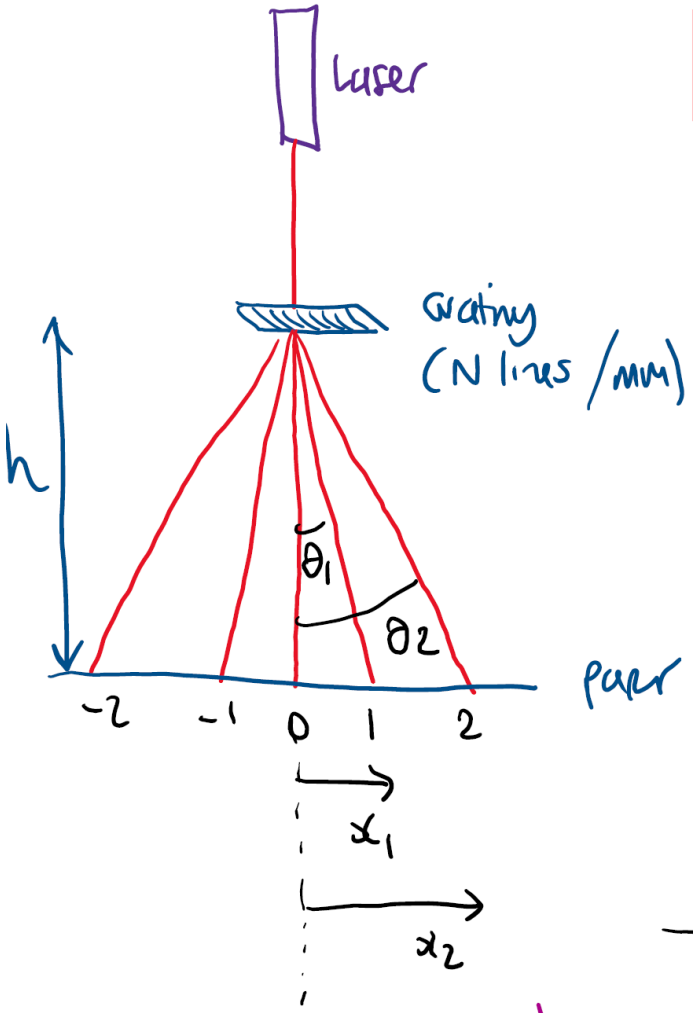
- Measure height h (in mm) of the grating above a sheet of blank A3 paper on a bench. Fix this for the experiment. i.e. move the laser when swapping from red to green, but *not* the grating.

- Record the positions of diffraction maxima on the paper using a pen or pencil. Use both lasers, and all three gratings. i.e. six set of dots in all. Don't forget to label each dot by maxima number (n), grating and laser colour.



Use a 30cm ruler to determine the distance between the $n=0$ spot and subsequent higher order spots, *for each laser* and *for each grating.*





$$\theta_n = \tan^{-1}\left(\frac{x_n}{h}\right)$$

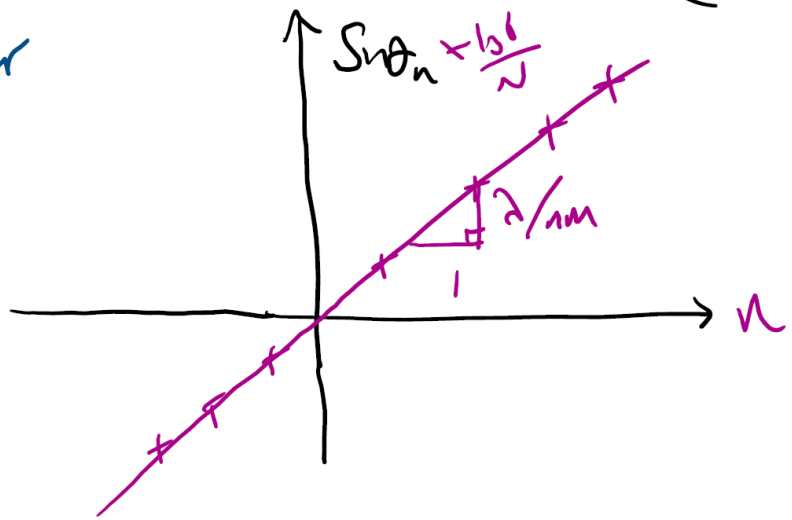
$$S\sin\theta_n = n\lambda$$

For constructive interference

$$S = \frac{1\,mm}{N} = \frac{10^6\,nm}{N}$$

$$\therefore \sin\theta_n = \frac{N}{10^6\,nm}\, n\lambda$$

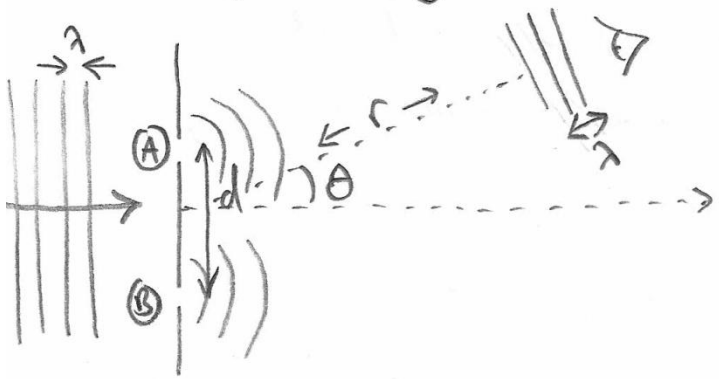
$$\frac{10^6}{N}\sin\theta_n = n \times \left(\frac{\lambda}{nm}\right)$$



Plot this graph for each laser.

The gradient will be the wavelength in nm.

Consider plane waves striking an obstacle with two thin slits separated by distance d. Slit width $\ll \lambda, d$

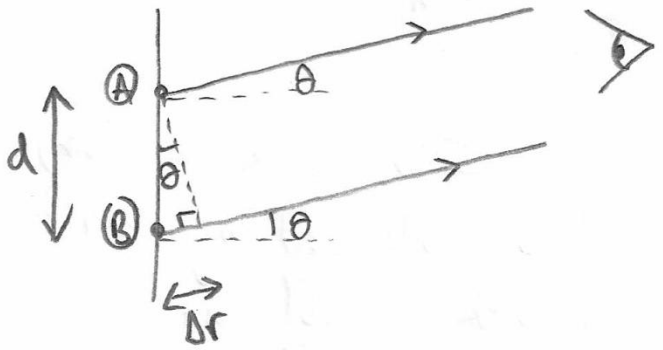


Thin slits A, B separated by distance d

observe superposition of diffracted waves at distance $r \gg \frac{d^2}{\lambda}$

This is the 'Far field' and at this point can regard waves at angle θ to be planar

We observe an interference pattern vs θ of a series of bright and dark fringes.



Using the approximation of plane waves (i.e. // rays) at ∞

constructive interference when path difference $\Delta r = n\lambda$

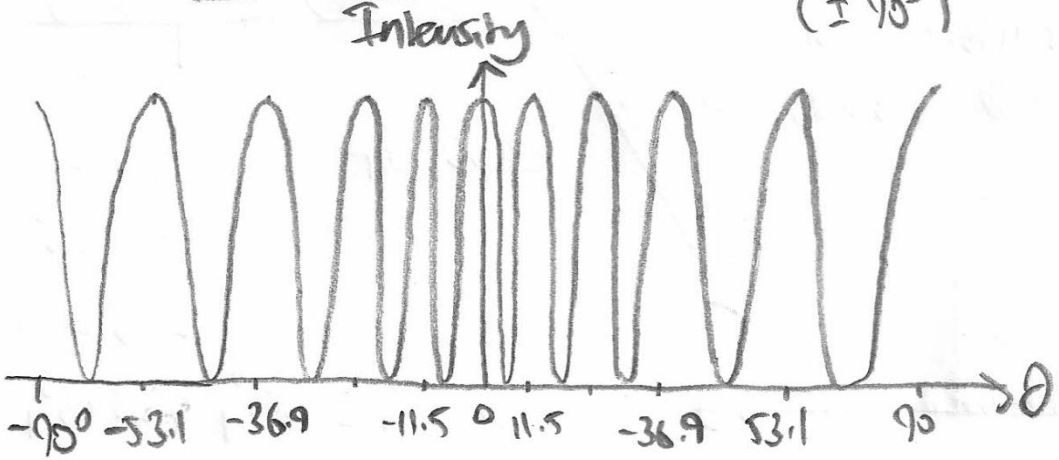
n = integer

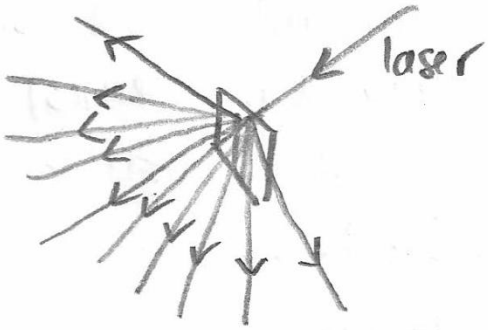
From diagram above: $d\sin\theta = \Delta r$

So expect maxima when $\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right)$

Example: If a red laser illuminates a pair of slits with $d = 5\lambda$ ($\lambda = 650\text{nm}$)

Maxima at: $\boxed{\theta = \sin^{-1}\left(\frac{n}{5}\right)}$ $= 0°, \pm 11.5°, \pm 23.6°, \pm 36.9°, \pm 53.1°$ $(\pm 90°)$





LASER WAVELENGTH A-LEVEL PRACTI N lines per mm diffraction grating

A. French 7/10/2021

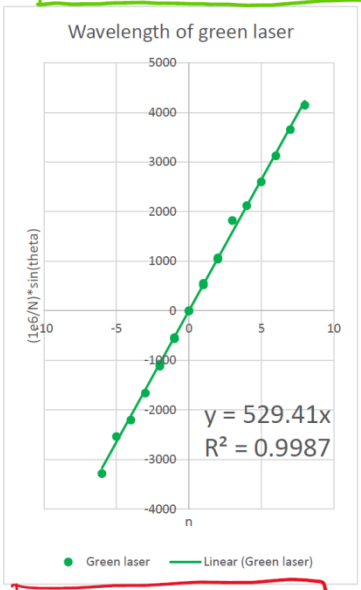
Height of diffraction grating from paper /mm h

410

GREEN LASER

N	n	xn /mm	theta_n /rad	(1e6/N)*sin(theta)
100	-6	-142.5	-0.335	-3283
100	-5	-107.5	-0.256	-2536
100	-4	-92.5	-0.222	-2201
100	-3	-69	-0.167	-1660
100	-2	-46	-0.112	-1115
100	-1	-23	-0.056	-560
100	0	0	0.000	0
100	1	22	0.054	536
100	2	44	0.107	1067
100	3	76	0.183	1823
100	4	89	0.214	2121
100	5	110.5	0.263	2602
100	6	135	0.318	3128
100	7	161	0.374	3655
100	8	187	0.428	4150
300	-2	-139	-0.327	-1070
300	-1	-67	-0.162	-538
300	0	0	0.000	0
300	1	65	0.157	522
300	2	135	0.318	1043
600	-1	-145	-0.340	-556
600	0	0	0.000	0
600	1	145	0.340	556

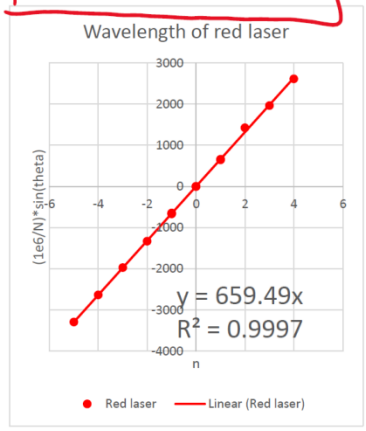
$\lambda = 529.4\text{nm}$

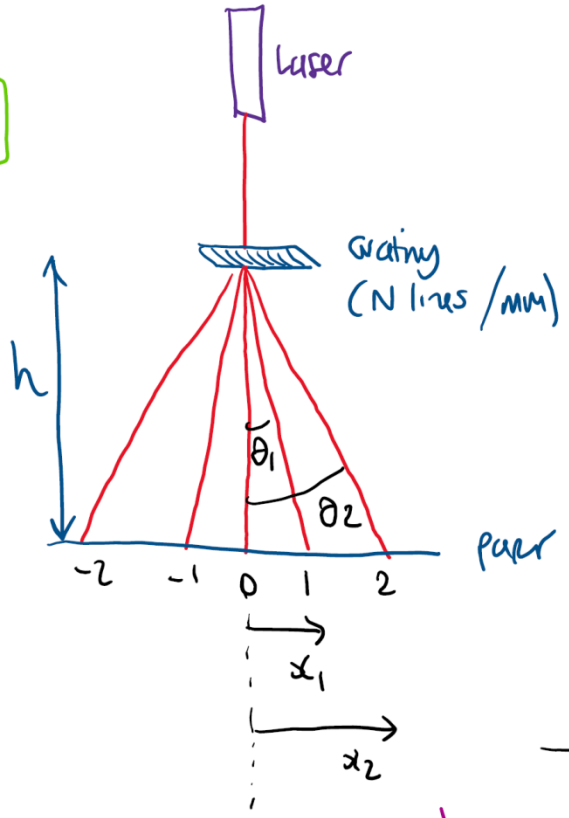


RED LASER

N	n	xn /mm	theta_n /rad	(1e6/N)*sin(theta)
100	-5	-143	-0.336	-3293
100	-4	-112	-0.267	-2635
100	-3	-82.5	-0.199	-1973
100	-2	-55	-0.133	-1330
100	-1	-27	-0.066	-657
100	0	0	0.000	0
100	1	27	0.066	657
100	2	59	0.143	1424
100	3	82	0.197	1961
100	4	111	0.264	2613
300	-1	-81	-0.195	-646
300	0	0	0.000	0
300	1	81	0.195	646
600	-1	-179	-0.412	-667
600	0	0	0.000	0
600	1	174.5	0.402	653

$\lambda = 659.5\text{nm}$





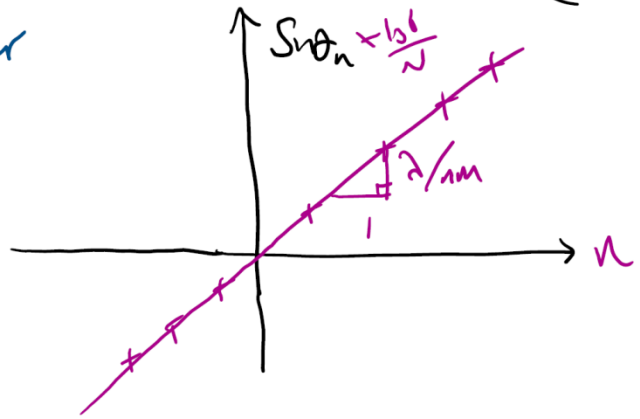
$\theta_n = \tan^{-1}\left(\frac{x_n}{h}\right)$

$S \sin\theta_n = n\lambda$

$S = \frac{1\text{mm}}{N} = \frac{10^6\text{nm}}{N}$

$\therefore \sin\theta_n = \frac{N}{10^6\text{nm}} n\lambda$

$\frac{10^6}{N} \sin\theta_n = n \times \left(\frac{\lambda}{\text{nm}}\right)$



Plot this graph for each laser.

Spreadsheet for experiment

RED LASER

$\frac{10^6}{N} \sin\theta_n = n \times \left(\frac{\lambda}{nm}\right)$

$\lambda = 659.5\ nm$

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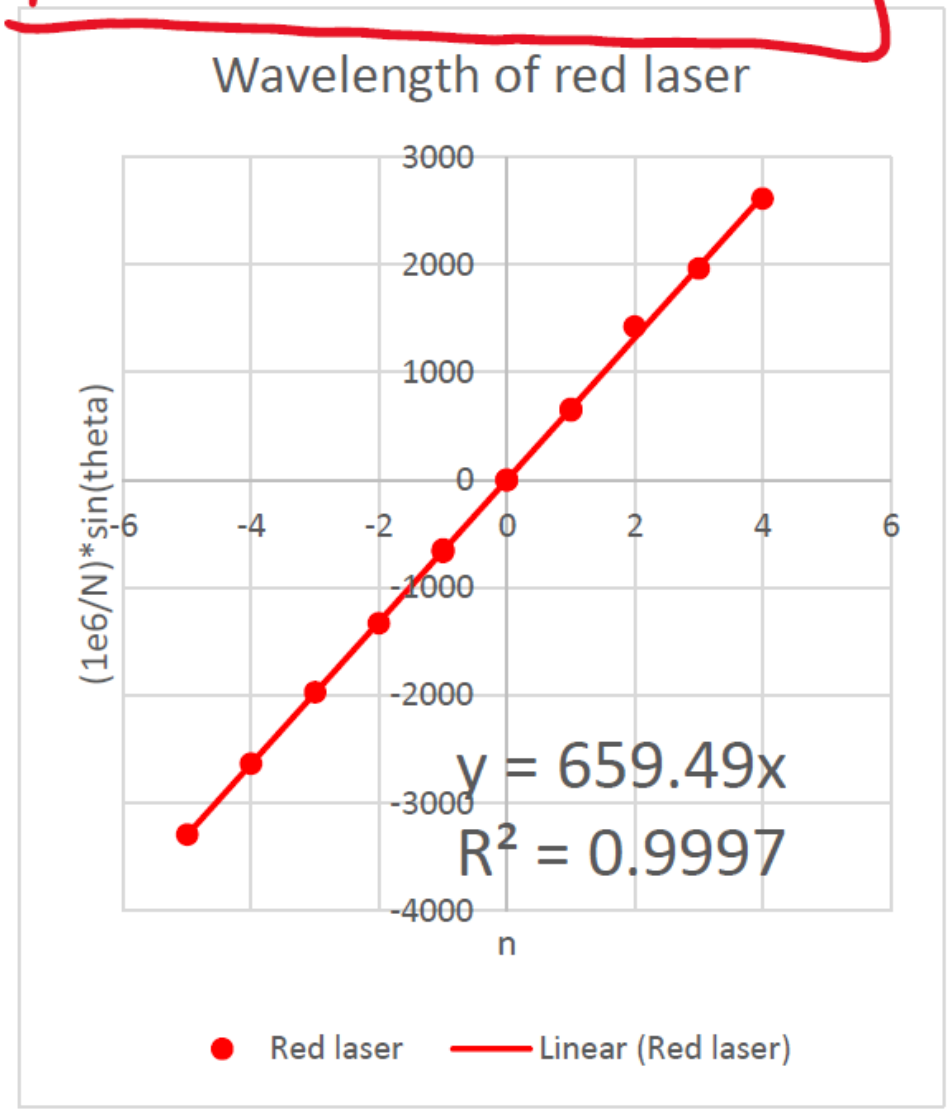

Height of diffraction grating from paper /mm

410

h

$\lambda = 529.4\text{nm}$

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$\sin\theta_n = n \times \frac{\lambda}{N}$