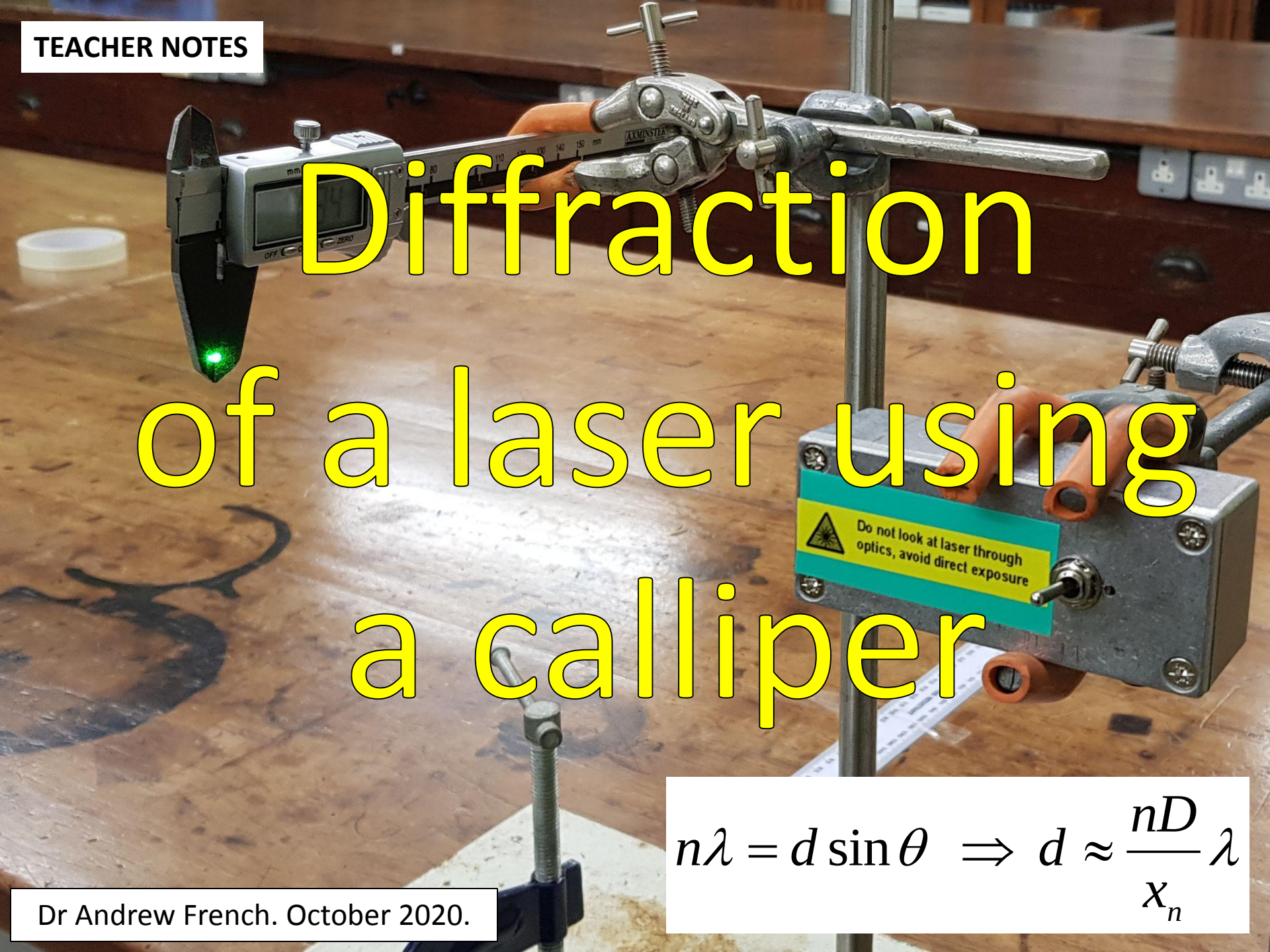
TEACHER NOTES

Diffraction of a laser using a calliper



$$n\lambda = d\sin\theta \;\Rightarrow\; d \approx \frac{nD}{x_n}\lambda$$

Dr Andrew French. October 2020.

A3 paper taped to blackout screen

Diffraction pattern

Laptop or lab book to record data and plot graphs

Smartphone – for photographing the diffraction pattern

30cm ruler taped to A3 paper

2m ruler + 30cm rulers (about four needed)

Digital calliper (0.01mm resolution) with matt black paint

Green laser

G-clamps

Retort stands, bosses, clamps

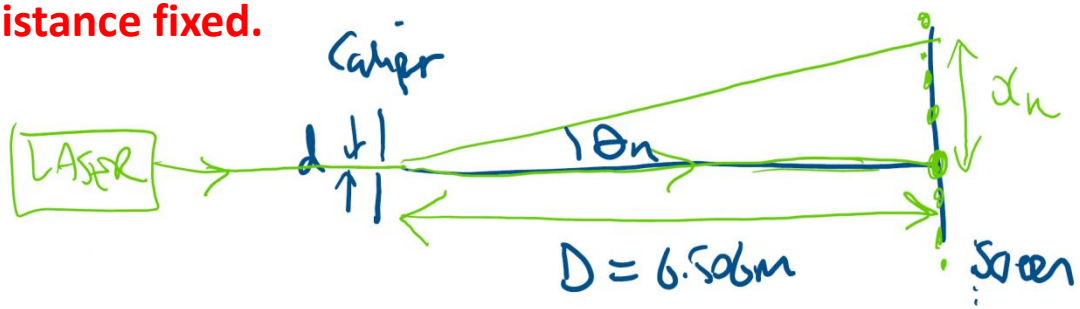
Caution: DO NOT stare directly into the laser beam.
Use the matt black callipers to minimize backscatter.

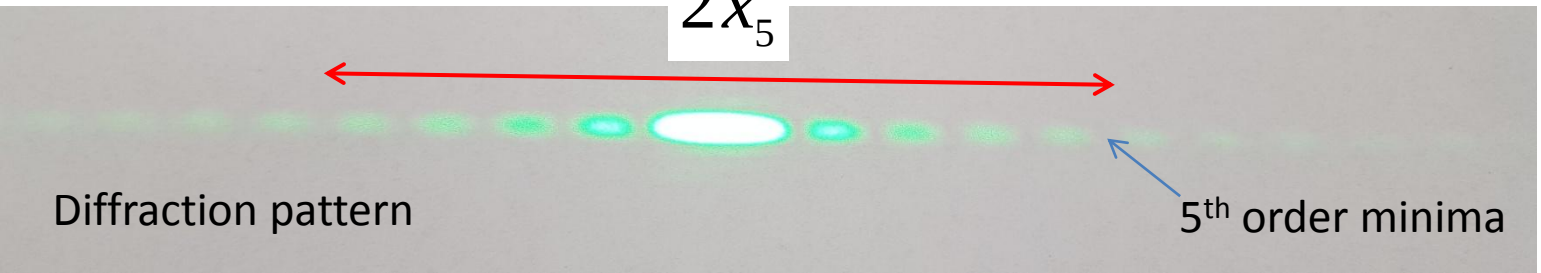
Equipment setup

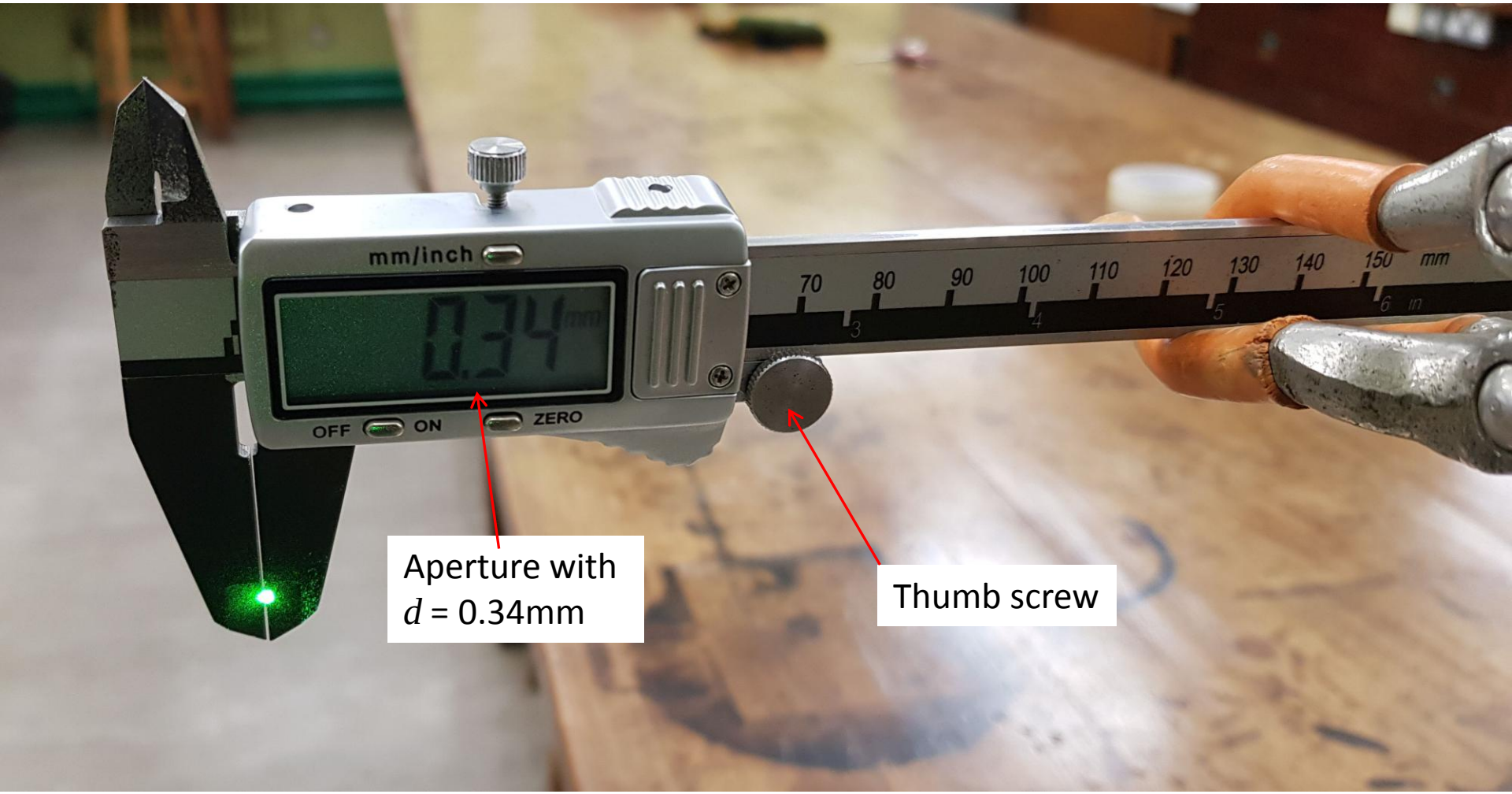
Diffraction pattern

$D = 6506\text{mm}$

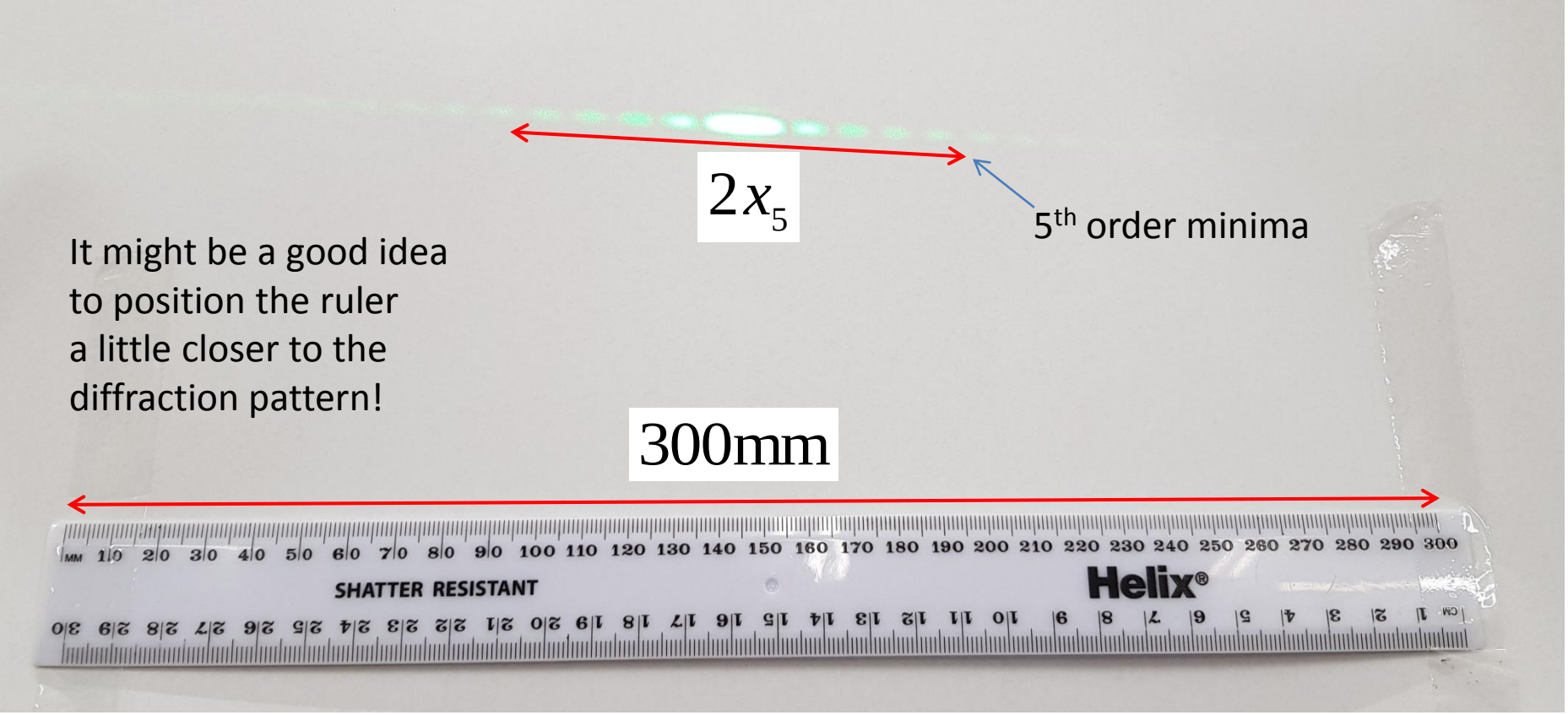
Carefully measure distance D from calliper jaws to screen using a 2.00m stick, and a few 30cm rulers. **Keep this distance fixed.**







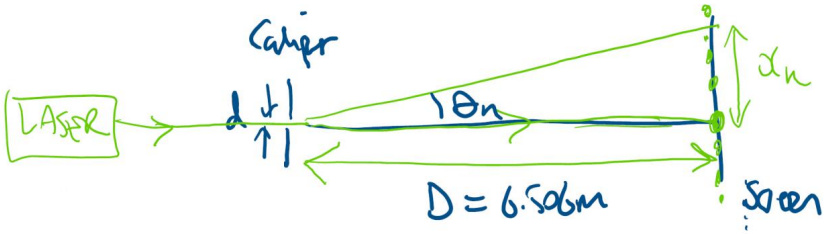
Shine laser at smallest gap between calliper jaws. Zero calliper and use thumbscrew to vary the opening between 0.10mm and 1.7mm. Photograph /take direct measurements from the diffraction pattern on the screen for each aperture width. You may find it tricky to achieve the smaller apertures, so it is important that the calliper is securely held via the clamp.

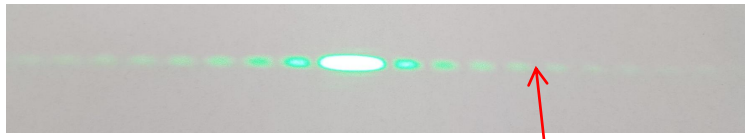


- If photographing the diffraction pattern, squat low below the beam to take a picture without obscuring the laser.
- Open the image in a graphics package such as **IrfanView**. Use the crop tool to measure the number of pixels that corresponds to 300mm, i.e. the length of the ruler.
- Then use the crop tool again to measure the distance between the **highest order minima** you can observe.
- Divide both pixel numbers, and then multiply by 300mm to obtain $2x_n$ in mm.

Or simply take a direct measurement from the pattern – but try not to obscure the beam!

Analysis





5th order minima

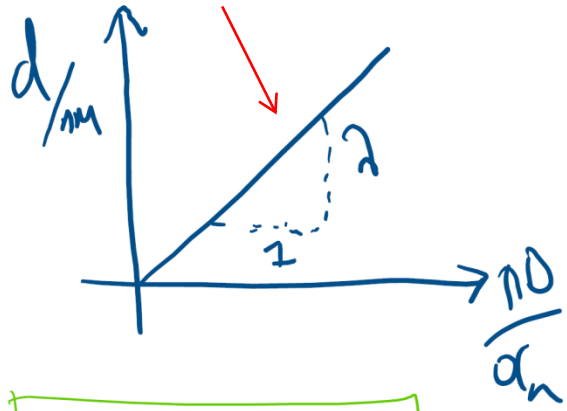
$$\theta_n = \tan^{-1}\left(\frac{x_n}{D}\right)$$

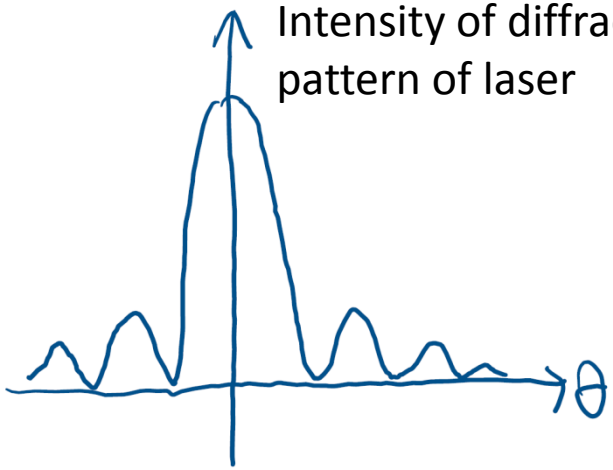
Since D/x_n is very large, we can use a small angle approximation for θ.

So $$d = \frac{n}{\sin\left[\tan^{-1}\left(\frac{x_n}{D}\right)\right]}\lambda$$

$$d \simeq \frac{nD}{x_n}\lambda$$

Obtain wavelength from gradient of this graph





Intensity of diffraction pattern of laser

Minima when $d\sin\theta = n\lambda$ for single slit pattern

Green laser : $\lambda \simeq 532\,nm$

(Some are 520nm)
" " 515nm

https://en.wikipedia.org/wiki/Laser_pointer

MEASURING THE WAVELENGTH OF GREEN LASER LIGHT USING DIFFRACTION FROM A DIGITAL CALIPER

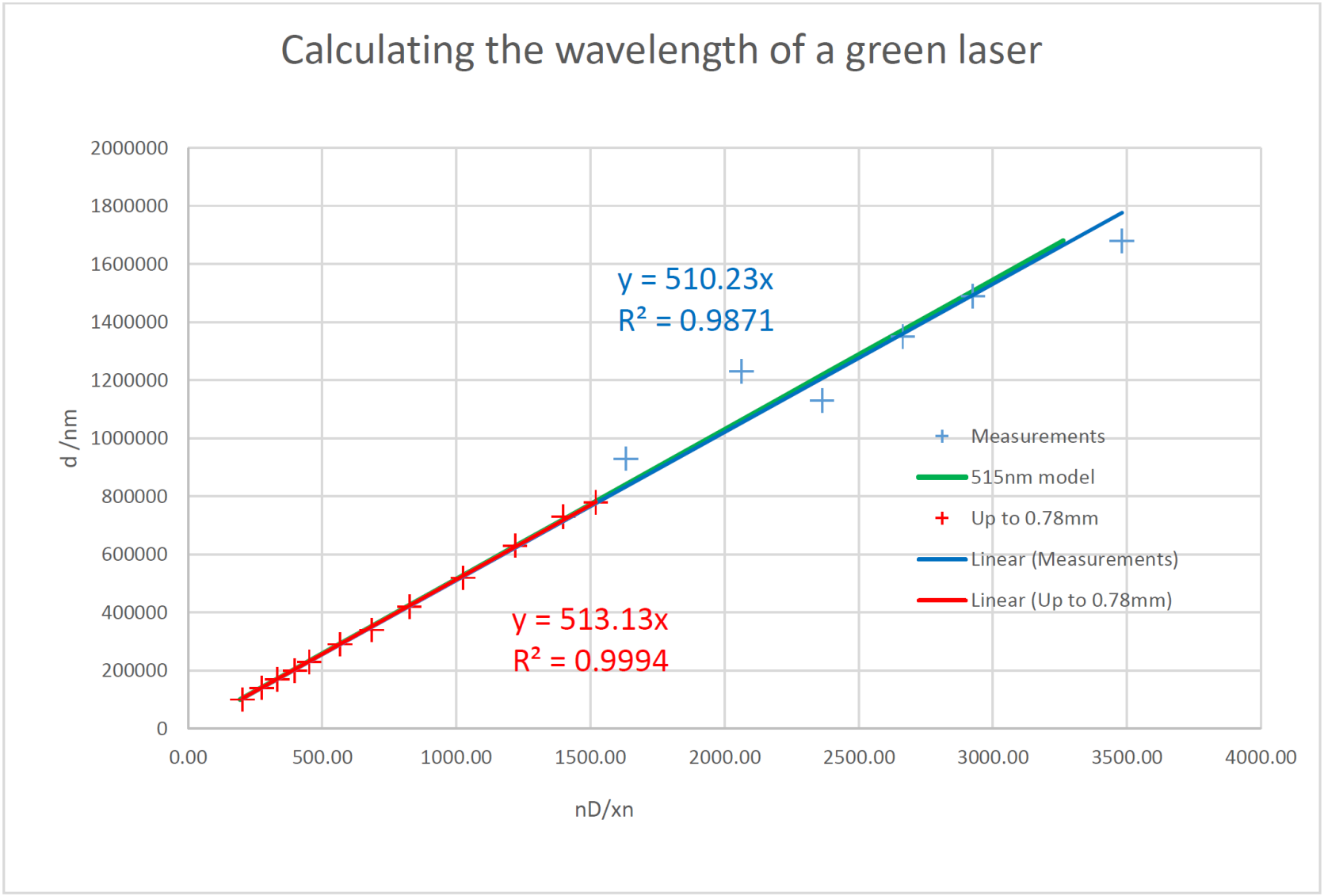
Dr Andrew French. Winchester College P5. 23/10/2020.

Distance from caliper to screen D /mm 6506 **caliper separation error /nm** 5000

Caliper separation /mm	Pixels of 300mm ruler	Pixel separation between nth minima either side of central maxima	xn /mm	n	nD/xn	n/sin(atan(xn/D))	d /nm	d/515nm
0.10	1947	828	63.79	2	203.98	203.99	100000	194.17
0.14	2342	741	47.46	2	274.17	274.18	140000	271.84
0.17	1872	731	58.57	3	333.22	333.23	170000	330.10
0.20	2282	993	65.27	4	398.70	398.72	200000	388.35
0.23	2461	944	57.54	4	452.30	452.31	230000	446.60
0.29	2333	713	45.84	4	567.69	567.70	290000	563.11
0.34	2581	981	57.01	6	684.69	684.71	340000	660.19
0.42	2521	795	47.30	6	825.24	825.26	420000	815.53
0.52	2547	754	44.41	7	1025.60	1025.62	520000	1009.71
0.63	2273	485	32.01	6	1219.64	1219.66	630000	1223.30
0.73	2359	585	37.20	8	1399.22	1399.24	730000	1417.48
0.78	2378	475	29.96	7	1519.98	1520.00	780000	1514.56
0.93	2551	339	19.93	5	1631.94	1631.95	930000	1805.83
1.13	2507	322	19.27	7	2363.85	2363.86	1130000	2194.17
1.23	2501	368	22.07	7	2063.42	2063.43	1230000	2388.35
1.35	2631	257	14.65	6	2664.17	2664.18	1350000	2621.36
1.49	2741	325	17.79	8	2926.43	2926.44	1490000	2893.20
1.68	2867	250	13.08	7	3481.84	3481.84	1680000	3262.14

Photographs of diffraction patterns + 30cm ruler.

Notice *inverse relationship* between minima spacing x and aperture width d



Looks like the laser is probably 515nm wavelength.

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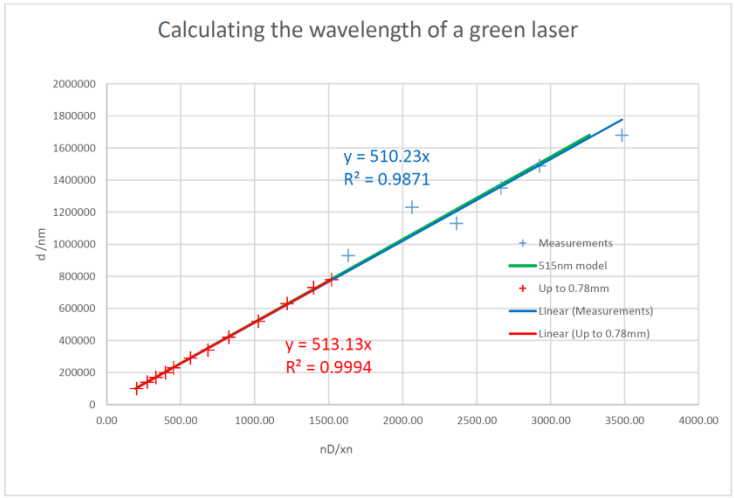

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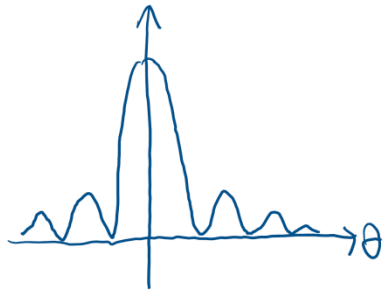

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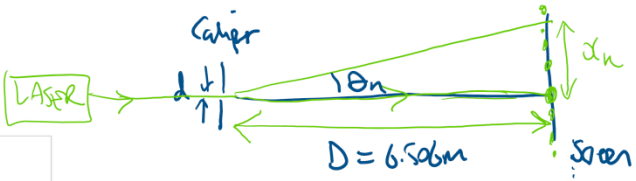

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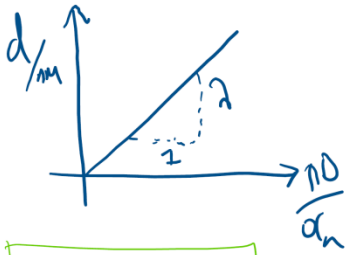

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