Answer key — Young's double slit

A Coherence

The upper strip still shows fringes at every instant — interference has not stopped — but they jump to a new position each time the simulation re-rolls the phase, and the lower strip, which adds those instants up, flattens to an even glow within a second or two. Two separate sources have no fixed phase relationship, so the pattern they make will not hold still; anything slower than the drift, which means any eye, screen or meter, records only the average. One source lighting both slits is what fixes the phase difference at zero and keeps the pattern in one place long enough to be seen. **Watch for** the answer that says two lamps produce no interference. They produce nothing that lasts, which is not the same thing, and the two strips are there to make the difference visible.

B The pattern

Figure 1 holds 23 bands: all 22 gaps span 66.0 mm, so s = 3.00 mm. Accept 2.9–3.1 mm. The simulation reads 3.001 mm, which no ruler can tell from 3.00 mm — that is the point of B2, not a discrepancy to explain away.

C Where the bands fall

m	y / mm	S_1P / mm	S_2P / mm	$S_2P - S_1P$ / nm	in λ
0	0.000	1500.0000	1500.0000	0.0	0
1	3.000	1500.0027	1500.0033	600.0	1
2	6.000	1500.0114	1500.0126	1200.0	2
3	9.000	1500.0261	1500.0279	1800.0	3

Path difference = $m\lambda$, a whole number of wavelengths — the same rule as the ripple tank. A dark band is at $(m + ½)\lambda$: 300 nm, 900 nm, 1500 nm.

D The derivation

1. The short side is $d \sin\theta$.
2. $d \sin\theta = m\lambda$.
3. $\theta = 0.1146°$, $\sin\theta = 0.002000000$, $\tan\theta = 0.002000004$. Identical to six significant figures. They differ by a factor of $\cos\theta = 0.9999980$.
4. $\tan\theta = y / D$.
5. $d \sin\theta \approx d \tan\theta = d\,y / D = m\lambda$, so $y_m = m\lambda D / d$.
6. $s = (m+1)\lambda D/d - m\lambda D/d = \lambda D / d$.
7. The spacing does not depend on which pair of bands you pick, so the bands are evenly spaced. Worth dwelling on: that is a prediction, and Figure 1 is the evidence for it.

E Testing it

1. A straight line through the origin: $s \propto D$. Through the origin matters — a line of the same gradient not through the origin would mean $s = \lambda D/d$ + constant, which is a different claim.
2. Gradient = $\lambda / d = 600\times10^{-9} / 0.30\times10^{-3} = 2.00\times10^{-3}$, and one millimetre per metre *is* 10^{-3}, so the panel reads 2.00 mm m^{-1}. The unit conversion is the part they get wrong.
3. $s \propto 1/d$, so s against d is a curve — halving d doubles s, and no straight line does that. Against $1/d$ the same points lie on a straight line through the origin, of gradient λD. Taking the reciprocal is what turns a relationship you can only guess at into one a ruler can test.

F The microwave bench

1. $\lambda D/d = (30\times10^{-3} \times 1.20) / (250\times10^{-3}) = 0.144$ m = **14.4 cm** predicted. The simulation measures **14.58 cm** — 1.3% higher, far outside any reading error.
2. Both approximations at the slits. On this bench the first-order fringe is at $\theta = 6.93°$, not the 0.1146° of the light bench, because λ/d is 0.12 instead of 0.002. So **tan** $\theta \approx$ **sin** θ is no longer free: they differ by $1/\cos\theta = 1.0074$. And the two paths are no longer **parallel**, since the slits are a fifth of the way to the screen rather than two parts in ten thousand of it, which accounts for the rest. Neither has anything to do with the wave being microwaves: it is the ratio λ/d, and a light bench with slits a few wavelengths apart would misbehave in exactly the same way.

Students who predicted 14.4 cm and measured 14.58 cm have not made a mistake and should not go looking for one. $s = \lambda D/d$ is a small-angle formula, and this is what the small-angle assumption costs when you stop being able to afford it.