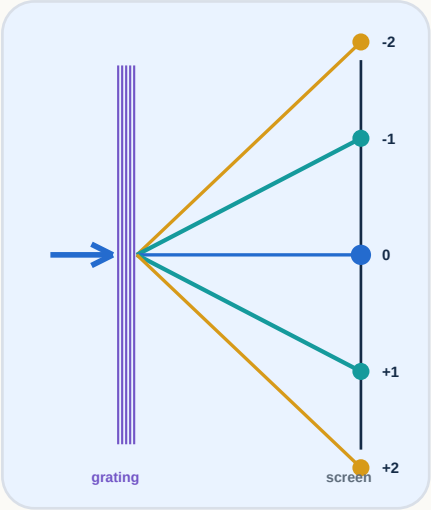
PEARSON EDEXCEL IAL PHYSICS | UNIT 2

LESSON 2.1.4

Diffraction Gratings

and Wavelength Measurement

A grating uses many equally spaced slits to produce sharp interference maxima at predictable angles.



THE GRATING RELATIONSHIPS

MAXIMUM CONDITION

$$n\lambda = d \sin \theta$$

n = order number

GRATING SPACING

$$d = 1/N$$

N in lines per metre

SCREEN GEOMETRY

$$\tan \theta = x/D$$

measure from order zero

WHAT THE SYMBOLS MEAN

n

integer order: 0, 1, 2, ...

λ

wavelength in metres

d

distance between adjacent slits

θ

angle from the central normal

THE INTERFERENCE IDEA

WHY BRIGHT ORDERS FORM



Adjacent rays reinforce when their path difference is a whole number of wavelengths.

path difference = $d \sin \theta = n\lambda$

UNIT TRAP

Convert lines per millimetre to lines per metre before using d = 1/N. Multiply the quoted line density by 1000.

1 A complete diffraction-grating calculation

A laser of wavelength 589 nm strikes a grating with 600 lines per millimetre. Find the first-order angle and the highest possible order.

TURN THE DATA INTO SI UNITS

LINE DENSITY

$N = 6.00 \times 10^{5}\ m^{-1}$

convert 600 lines per mm to lines per metre

WAVELENGTH

$\lambda = 5.89 \times 10^{-7}\ m$

convert 589 nm to metres

FIRST-ORDER ANGLE

1 FIND d

$d = 1/N$

$d = 1.67 \times 10^{-6}\ m$

2 SUBSTITUTE

$\sin\theta = n\lambda/d$

$= 0.3534$

3 ANSWER

$\theta = \sin^{-1}(0.3534)$

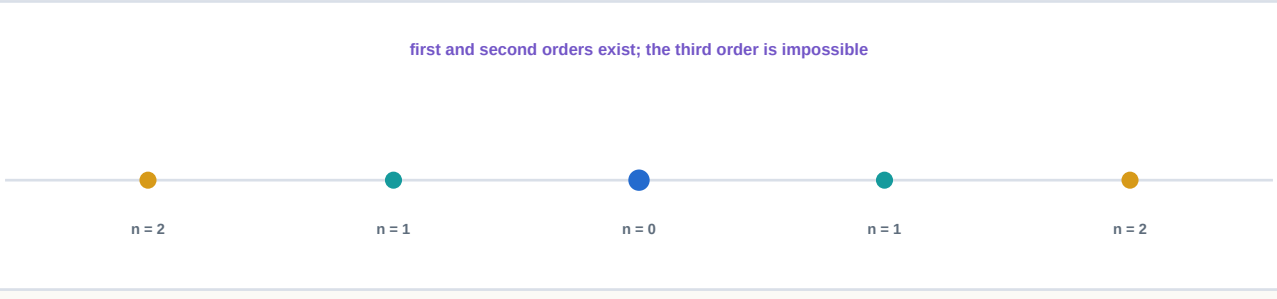
$\theta = 20.7°$

HOW MANY ORDERS ARE POSSIBLE?

$\sin\theta \le 1$, so $n\lambda/d \le 1$ and $n \le d/\lambda$

$n \le (1.67 \times 10^{-6})/(5.89 \times 10^{-7}) = 2.84$

Highest whole-number order: n = 2

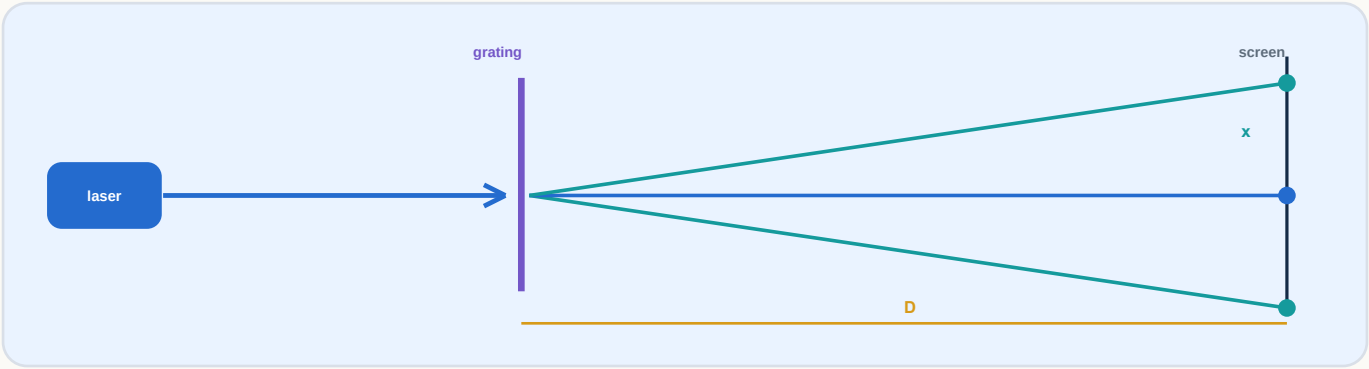


An order is possible only when $n\lambda/d$ gives $\sin\theta \le 1$.

2 Core Practical 6: measure wavelength

Use a laser or other monochromatic source and a diffraction grating. Measure a geometry angle, then apply $n\lambda = d \sin \theta$.

APPARATUS AND MEASUREMENTS



METHOD

1. Convert the grating line density N to lines per metre, then calculate d = 1/N.
2. Measure the grating-to-screen distance D perpendicular to the screen.
3. Measure equal-order positions on both sides; halve their separation to find x.
4. Use tan θ = x/D to find θ, then calculate λ = d sin θ/n. Repeat for more orders.

GRAPH METHOD

$n\lambda = d \sin \theta \rightarrow \sin \theta = (\lambda/d)n$

Plot sin θ on the y-axis against order n on the x-axis. Gradient = λ/d, so λ = gradient × d.

QUALITY AND SAFETY

PRECISION

Use a large D and measure between matching orders on both sides.

RELIABILITY

Repeat positions and include several visible orders or a best-fit graph.

LASER SAFETY

Never look into the beam; keep it below eye level and control reflections.

Measure θ from the central normal, not between neighbouring bright spots.