# Path and Phase Difference 11.1

A Level

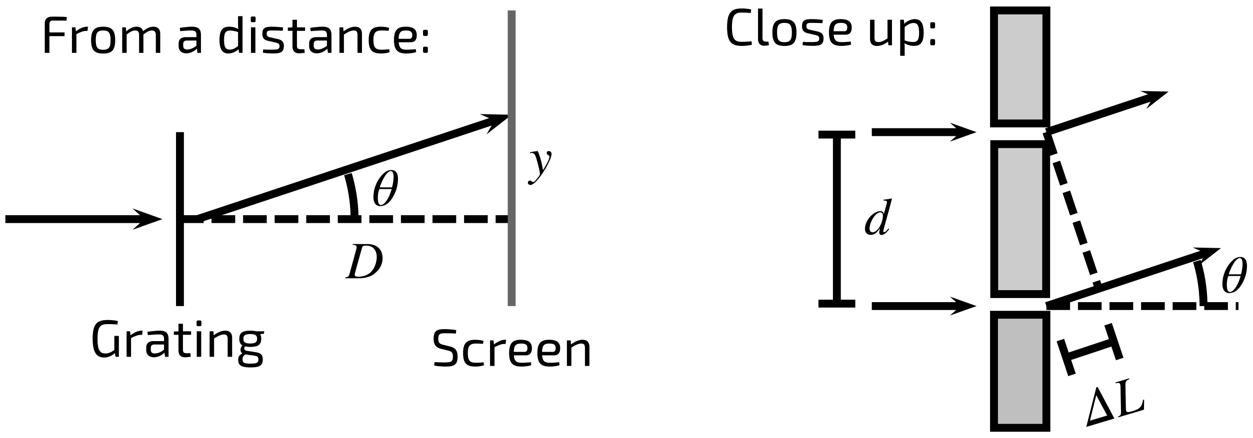


**Figure 1:** A diffraction grating from a distance and close up.

Quantities:

$\lambda$ wavelength $(\mathrm{m})$
$v$ wave speed $(\mathrm{m\,s^{-1}})$
$D$ distance to screen $(\mathrm{m})$
$d$ slit separation $(\mathrm{m})$
$\theta$ angle from axis $(^\circ)$
$n$ order of interference (no unit)

$n = 0, 1, 2, 3...$ if constructive

$f$ frequency $(\mathrm{Hz})$
$\Delta L$ path difference $(\mathrm{m})$
$\Delta\phi$ phase difference $(^\circ)$
$N$ slits per mm $(\mathrm{mm^{-1}})$
$y$ distance from axis $(\mathrm{m})$

Equations:

$$v = f\lambda \qquad \Delta\phi = \frac{\Delta L}{\lambda} \times 360^\circ \qquad y = D\tan\theta \qquad d = \frac{1\,\mathrm{mm}}{N}$$

For slits: $\Delta L = d\sin\theta$ Small angles: $\tan\theta \approx \sin\theta$

Use the equations above to derive expressions for:

## Part A The phase difference $\Delta\phi$

the phase difference $\Delta\phi$ in terms of $d$, $\theta$ and $\lambda$.

The following symbols may be useful: `Delta, d, lambda, phi, sin(), theta`

## Part B $\sin\theta$ in terms of $\lambda$, $n$ and $d$

$\sin\theta$ for constructive interference in terms of $\lambda$, $n$ and $d$.

The following symbols may be useful: `d, lambda, n, sin(), theta`

## Part C $\sin\theta$ in terms of $\lambda$, $n$ and $N$

$\sin\theta$ for constructive interference in terms of $\lambda$, $n$ and $N$.

The following symbols may be useful: `N, lambda, n, sin(), theta`

## Part D $\sin\theta$ in terms of $n$, $N$, $f$ and $v$

$\sin\theta$ for constructive interference in terms of $n$, $N$, $f$ and $v$.

The following symbols may be useful: `N, f, n, sin(), theta, v`

## Part E $y$ for $n = 1$

$y$ for $n = 1$ in terms of $\lambda$, $D$ and $d$ if $\theta$ is small.

The following symbols may be useful: `D, d, lambda, theta, y`

## Part F $y$ for $n = 5$

$y$ for $n = 5$ in terms of $f$, $v$, $D$ and $d$ if $\theta$ is small.

The following symbols may be useful: `D, d, f, theta, v, y`

## Part G $\Delta L$ for a microphone placed between two speakers

$\Delta L$ for a microphone placed between two speakers connected to the same signal. The speakers are a distance $D$ apart, and the microphone is a distance $y$ from the mid point.

The following symbols may be useful: `D, Delta, L, y`

# Path and Phase Difference 11.3

A Level

P P P

A $440\,\mathrm{Hz}$ sound wave reaches a microphone by two routes. The sound travels $2.50\,\mathrm{m}$ directly and travels $4.00\,\mathrm{m}$ if it reflects off a wall on the way. Calculate the phase difference on arrival. Assume that the wave speed $v = 330\,\mathrm{m\,s^{-1}}$.

Gameboard:

**STEM SMART Physics 44 - Revision - Waves**

# Essential Pre-Uni Physics D4.6

A Level

A teacher is trying to demonstrate 'Young's fringes' using green $(530\,\mathrm{nm})$ light. Assuming that the slit separation is $0.050\,\mathrm{mm}$, how far away from the slits will she need to put the screen to ensure that the fringe spacing is at least $1.0\,\mathrm{mm}$?

Gameboard:

**STEM SMART Physics 44 - Revision - Waves**

# Essential Pre-Uni Physics D4.3

A Level

C C C

A diffraction grating has $600\,\mathrm{lines/mm}$. Yellow light from a street lamp is shone onto the grating. The yellow light contains two main wavelengths - of $589.6\,\mathrm{nm}$ and $589.0\,\mathrm{nm}$. Calculate the angular separation of the second order ($n = 2$) of these two components as they emerge from the grating. Give your answer to 2 significant figures.

Gameboard:

**STEM SMART Physics 44 - Revision - Waves**

# Essential Pre-Uni Physics D5.2

A Level

P P P

Consider a particle that is at a particular antinode of a standing wave, which we'll call point A. Fill in the table below to state how the motion of certain other particles will compare to this one. [For amplitude, state whether it will be smaller/larger/the same; for phase, state the phase difference in degrees.]

| Position of Particle | Amplitude | Difference in Phase |
|---|---|---|
| Between point A and the next node along | (a) | (b) |

## Part A Amplitude

a) Amplitude compared to point A?

- The same
- Larger
- Smaller

## Part B Phase

b) Phase relative to point A?

# Standing Waves on a String 15.4

A Level

A standing wave has $4$ nodes including the two at each end. The length of the vibrating string is $85.0\,\mathrm{cm}$, the tension in the string is $75.0\,\mathrm{N}$, and it vibrates at a frequency of $50\,\mathrm{Hz}$. Calculate the linear mass density $\mu$ of the string.

Gameboard:

**STEM SMART Physics 44 - Revision - Waves**

# Essential Pre-Uni Physics D8.3

A Level

Physical constants which may be necessary to answer the problems on this page can be found within the hint tabs.

Refractive index of crown glass: $1.51$

Refractive index of flint glass: $1.61$

Refractive index of water: $1.34$

Refractive index of cubic zirconia: $2.16$

Refractive index of diamond: $2.42$

Take the refractive index of air to be $1.00$.

Complete the table to show the missing angles. In some cases, refraction is impossible. **In these cases give your answer as "$99$" with the unit "none".**

Consider all angles to have been given to $2$ significant figures.

| Light passing from ... | | ...to | |
|---|---|---|---|
| **Material** | **Angle of Incidence / °** | **Material** | **Angle of Refraction / °** |
| Water | **(a)** | Air | $60$ |
| Flint Glass | **(b)** | Air | $90$ |

## Part A Water to air

| Light passing from ... | | ...to | |
|---|---|---|---|
| **Material** | **Angle of Incidence / °** | **Material** | **Angle of Refraction / °** |
| Water | **(a)** | Air | $60$ |

a) What is the angle of incidence in degrees?

## Part B Flint glass to air

| Light passing from ... | | ...to | |
|---|---|---|---|
| **Material** | **Angle of Incidence / °** | **Material** | **Angle of Refraction / °** |
| Flint Glass | **(b)** | Air | $90$ |

b) What is the angle of incidence in degrees?

Gameboard:

**STEM SMART Physics 44 - Revision - Waves**

# Essential Pre-Uni Physics D8.9

A Level

Physical constants which may be necessary to answer the problem on this page can be found within the hint tabs.

Refractive index of crown glass: $1.51$

Refractive index of flint glass: $1.61$

Refractive index of water: $1.34$

Refractive index of cubic zirconia: $2.16$

Refractive index of diamond: $2.42$

Take the refractive index of air to be $1.00$.

When light passes from water into ice at an incident angle of $38.0\,^{\circ}$, the angle of refraction is $39.0\,^{\circ}$. Calculate the refractive index of ice. Give your answer to 3 significant figures.