Topic: 9. Wave Phenomena

~~If θ is 0, then:~~

I recommend looking at questions in notes book, if you don't get a theory.

Formulae

$\omega = \frac{2\pi}{T} = 2\pi f$

Derivative of the velocity, for SHM: $a = -\omega^2 x_0 \sin(\omega t)$; $\omega^2 x_0 \cos(\omega t)$ NDB

$a = -\omega^2 x$ Acceleration in SHM

$E_{K\max} = E_T = \frac{1}{2} m \omega^2 x_0^2$ as x^2 is 0 at x_0.

Pendulum: $T = 2\pi\sqrt{\frac{L}{g}}$ Period of oscillation

Mass-spring: $T = 2\pi\sqrt{\frac{m}{k}}$ k = spring constant

$x = x_0 \sin\omega t$; $x_0 \cos\omega t$ ~~Depends if oscillation starts from 0 or max~~

$\theta = \omega t$ Check common diagrams (Depends if horizontal or vertical displacement)

Common Formula for Mass-spring: $F = -kx = Ma$ NDB explicitly

Also this: $E_T = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$ NDB explicitly

$V = \omega x_0 \cos(\omega t)$; $-\omega x_0 \sin(\omega t)$ Velocity in SHM. Just derivatives

$V = \pm\omega\sqrt{(x_0^2) - x^2}$ Velocity in SHM too. Usually quite often.

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2(x_0^2 - x^2)$ E_K in SHM $E_p = \frac{1}{2}m\omega^2 x^2$ NDB

Remember that if $x = x_0$, then the angles either equal 1 (cos) or 0 (sin).

$\theta = \frac{\lambda}{b} = \frac{x}{D}$ ← Here θ is First minimum distance from center. Imagine it.

θ is angle at which First minimum occurs in single slit dif.

b = width of slit.

If I, is intensity of single-slit (central maximum), then if N = number of slits

$I_N = N^2 I_1$ NDB

Diffraction Grading

$n\lambda = d\sin\theta$ n = order of Maxima, if 0, it means central max.

d = slit spacing (very small)

θ = angle of Maxima from central. E.g. θ = 56°

For 3rd order: So, $3\lambda = d\sin 56$

Explained in other notes:

$2dn = m\lambda$ Destructive

$2dn = (m + \frac{1}{2})\lambda$ Constructive

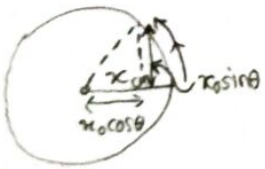
Required Definitions

Angular velocity: Radians per second. rads^{-1}, AKA Angular Frequency.

Diffraction: the spreading out of waves by passing through a narrow aperture or across an edge.

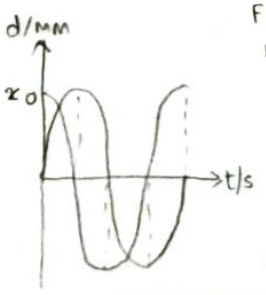
Huygen's Principle: Each point on a wave front emits a spherical wavelength of same velocity & wavelength.

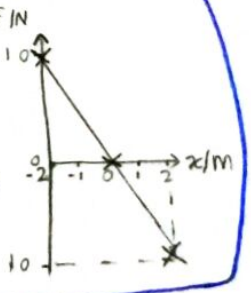
Common Diagrams



$\theta = \omega t$

Horizontal $x = x_0 \cos\omega t$ Vertical $x = x_0 \sin\omega t$





Understand Path difference λ = distance between each wavefront (circle)

Constructive

Destructive

Here, one path is integer λ and other is $(n+\frac{1}{2})\lambda$. So, we have path difference as ~~integer~~ the difference between those. E.g. $2.5\lambda - 1\lambda = 1.5\lambda$

So, $= (n + \frac{1}{2})\lambda$

Easy to Understand

Constructive $n\lambda$

Constructive troughs $n\lambda$

Destructive $(n+\frac{1}{2})\lambda$

$(a+\frac{1}{2})\lambda - b\lambda = (n+\frac{1}{2})\lambda$

Path difference = 0 per central maximas

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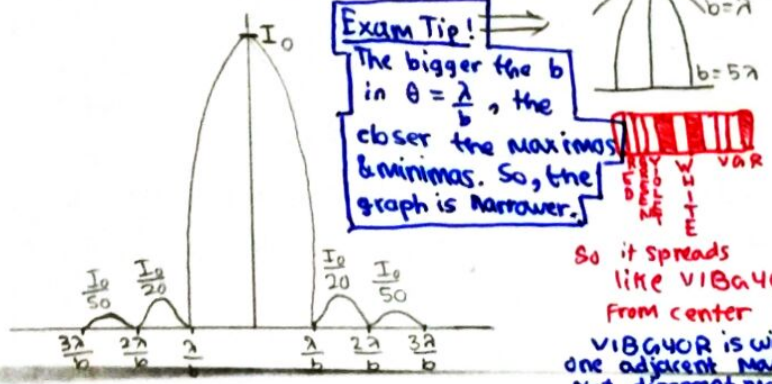
Common Graphs

Intensity of single-slit diffraction pattern

- Must know relative intensities of maximas
- Must know positioning of minimas.



Exam Tip!
The bigger the b in $\theta = \frac{\lambda}{b}$, the closer the maximas & minimas. So, the graph is narrower.

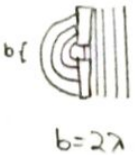
So it spreads like VIBGYOR from center

VIBGYOR is within one adjacent Maxima. Not different maxima, different colour.

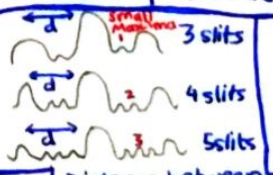
Experiment Summaries

If aperture is much larger than wavelength, diffraction is less.
If aperture is much smaller than wavelength, diffraction is more.
The aperture size is always in order of wavelength:

$b = 6\lambda$
Bigger aperture
Lesser Diffraction



$b = 2\lambda$
Smaller aperture
More Diffraction



- Distance between adjacent maximas remains constant.

d = distance between adjacent slits.
b = width of 1 slit

The more the no. of slits in interference, the higher the central Max intensity. $I_N = N^2 I_1$, NDB
So, for 2 slits $I_{max} = 4I_1$

Other Notes Learned From Past Papers

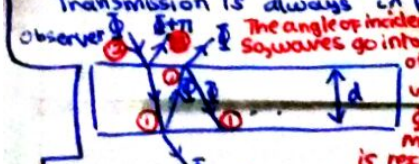
- Don't forget to convert ~~to~~ units ~~to~~ from mm or ms.
- b is ~~slit~~ slit width and d is slit spacing or distance between 2 slits.
- For double-slit, take s as distance between a max to a central Maximas. For single slit take it as distance between First minima and central Maxima.
- Question per diffraction grating.
  If 750 lines per mm. $d = \frac{1}{750000}$
- Thin film interference

$s = \frac{\lambda D}{d}$ ~~d = slit~~ applies ~~to both cases~~ d: slit spacing

$s = \frac{\lambda D}{b}$ b = slit width

$\theta = \frac{\lambda}{b} = \frac{s}{\lambda D}$

(1) If wave enters from slower speed to higher, it reflects & transmits in phase.
(2) If wave enters from higher speed to lower, it reflects out of phase.
Transmission is always in phase.



If both rays are π out of phase, like ϕ & $\phi+\pi$, or the observer is below in diagram, then reverse the formulas.

$(m\lambda$ = distance)
(m = no. of wavelengths)
d = width of medium
length
n = refractive index of medium

$2dn = m\lambda$
$2dn = (m+\frac{1}{2})\lambda$ (constructive)