Ngā Whetū Resources

Physics Year 13 (Level 8)

Summary Waves

Travelling Waves require a medium in which particles can vibrate. Along the line of propagation all particles perform SHM. For **Transversal waves** the motion is perpendicular to the direction of propagation, for **Longitudinal waves** the motion is along that direction.

Doppler Effect

Relative to the source the waves

- leave at slower speed
- have shorter wavelength
- **have no change in frequency**

Relative to the observer the waves

- **arrive at normal speed**
- have shorter wavelength
- have higher frequency

Doppler shifted wavelength $\boxed{\lambda' = \frac{v_w \pm v_s}{f}}$ v_w = wave velocity; v_s = source velocity

With $v = f\lambda$ this leads to the alternative formula's: $\boxed{\lambda' = \frac{v_w \pm v_s}{v_w}\lambda}$ and $\boxed{f' = \frac{v_w}{v_w \pm v_s} f}$

Redshift of spectral lines from stars supports the theory of the **expanding universe**.

Earthquake waves **Primary** (faster) waves are **longitudinal**
Secondary (slower) waves are **transversal** (and do not penetrate the earth's core)

Standing Waves in string (transversal) and pipes (longitudinal). Travelling wave is reflected at end and the reflecting wave interferes with original wave, producing Standing Wave with **Anti-nodes** and **Nodes** at fixed positions. In strings and pipes these standing waves occur only at **harmonic** wavelengths or frequencies (**fundamental** and **higher harmonics**).

Fundamental wavelengths

String	Closed Pipe	Open Pipe
$\lambda_n = \frac{2}{n}L; n = 1,2,3,..$	$\lambda_n = \frac{4}{n}L; n = 1,3,5,..$	$\lambda_n = \frac{2}{n}L; n = 1,2,3,..$

(see hand-out for wave forms)

Wave speed in string varies with tension F and string density μ as: $v = \sqrt{\frac{F}{\mu}}$

Interference of waves

Two waves of **slightly different frequency** produce beat frequency $f_{beat} = f_1 - f_2$

Two or more waves with **identical frequency** produce:

- **constructive interference** (re-enforcement) if phase difference is zero, thus when path difference $= n\lambda$
- **destructive interference** (cancellation) if phase difference is 180°, thus when path difference $= (n + \frac{1}{2})\lambda$

With **Thin Film interference** a phase change of 180° occurs at front reflection. Therefore constructive interference occurs at a path difference (twice the thickness) of $= (n + \frac{1}{2})\lambda$.

Interference Patterns in 2D produce **Anti-nodal lines** where path difference $= n\lambda$ and **Nodal lines** where path difference $= (n + \frac{1}{2})\lambda$.

Diffraction of a wave occurs through narrow gap (narrow in terms of wavelength)

With two (or more) gaps diffracted waves **interfere** producing **Anti-nodal** and **nodal lines** and consequently bright and dark areas (**fringes**) on a screen.

Geometry of diffraction through grating

- **bright fringes** at a distance *x* from central image according to $n\lambda = \frac{dx}{L}$ where d is distance between two consecutive lines of the grating, L is distance to the screen
- **Spectrum angle** of bright fringes at $n\lambda = d.\sin\theta$ and dark areas at $(n + \frac{1}{2})\lambda = d.\sin\theta$