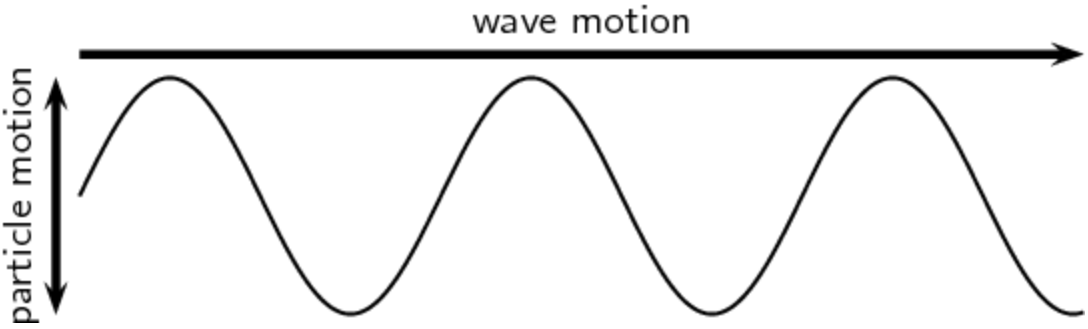
Physics (Mechanics, Materials & Waves)

Waves

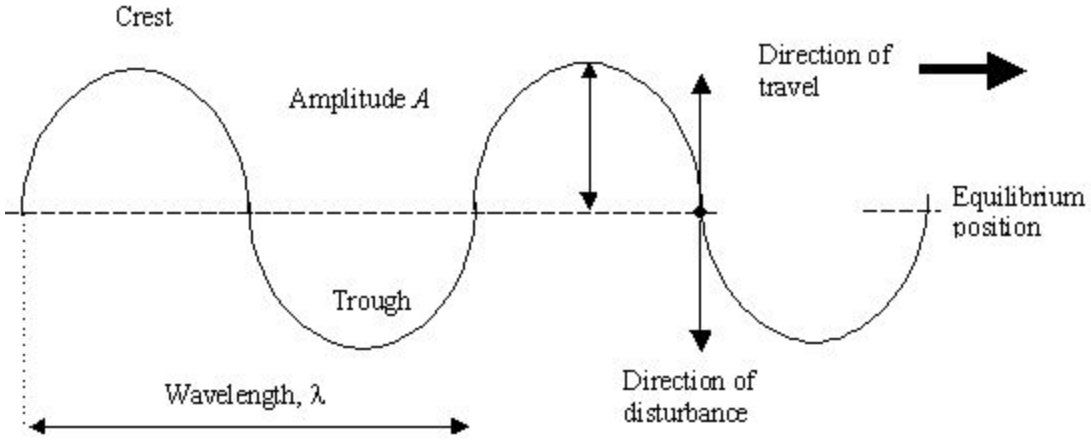
- Progressive waves are waves that transfer energy from one place to another
- **Amplitude** - is the maximum displacement of a vibrating particle, in a transverse wave this is the distance between the normal line to the maximum
- **Wavelength** - is the distance between two identical points on a wave
- **Frequency** - Is the number wavelength produced in a second
- **Speed** - The apparent distance moved by a crest in a given time
- **Path difference** - Is the fraction of a cycle between two waves, these are measured in degrees or radians
- **The wave equation**

$$v = f\lambda$$

- **Two types of waves**
    - Transverse Waves - Electromagnetic Radiation



    - Longitudinal Waves - Sound



- Polarisation is the mechanism of making all vibrations occur in one plane, this can be used in sunglasses, as light in other planes is blocked
    - Aerials are aligned to pick up signals of a certain polarisation so that more data can be transmitted.
- The refractive index of a substance can be found by

$$n = \frac{C}{C_s}$$

- The refraction of a ray of light crossing a boundary is found using

$$n_1 sin\theta_1 = n_2 sin\theta_2$$

- Stationary waves are formed when two waves of the same frequency travelling in opposite directions superimpose, the distance between adjacent nodes is found by:

$$\tfrac{1}{2}\lambda$$

- **Coherent** - two sources of waves are coherent if they emit waves with a constant phase difference.
- The fringe spacing in the double slit experiment is found using

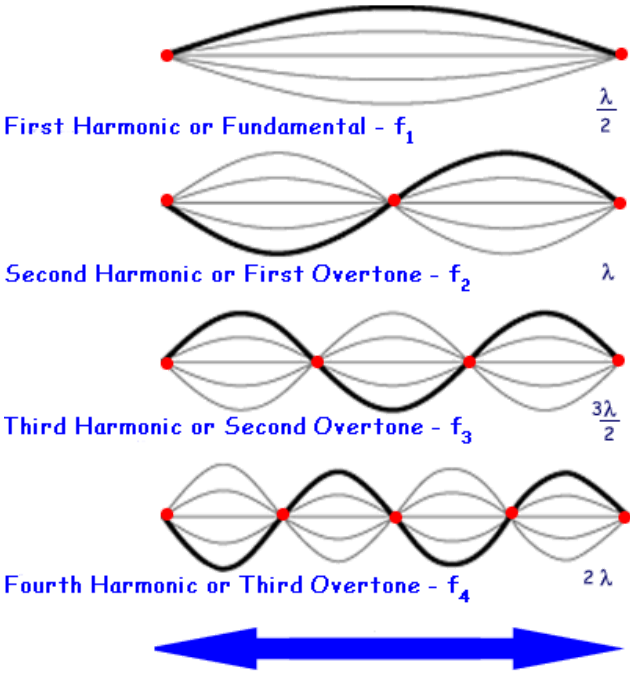
$$W = \frac{\lambda D}{s}$$

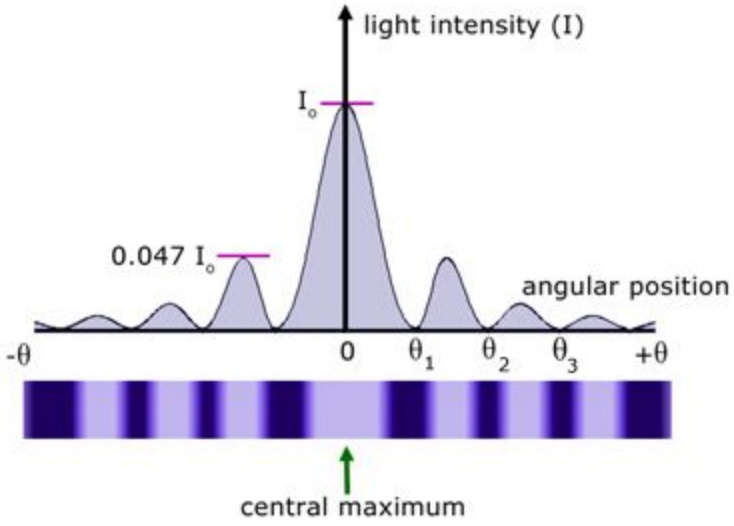
- For a diffraction grating the equation

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

Where n is the order of the maxima

- Single slit diffraction pattern





- **Derivation of dsinθ = nλ**

Mechanics

- **Scalars and Vectors**
  - An object is in equilibrium when it has no resultant force acting upon it.
- **Moments**
  - The moment of a force is the force multiplied by perpendicular distance from the point to the force
  - Also known as torque
  - **The principle of moments is:**
    - When an object is in equilibrium the clockwise moments are equal to the anticlockwise moments.
  - The centre of mass is the point through which a single force on the body has no turning effect
- **Straight line motion**
  - Velocity is a vector and speed is a scalar
  - g is the acceleration due to gravity and on earth is $9.81ms^{-2}$
- **Projectile Motion**
  - Vertical and horizontal motion are independent
- **Newton's Laws of Motion**
  - **First Law -** Objects either stay at rest or remain in uniform motion unless acted upon by a force
  - **Second Law -** The resultant force on an object is proportional to its acceleration, $F = ma$.
  - **Third Law** - For every action there is an equal and opposite reaction
    - Acts on different objects
- **Work, Energy and Power**

- **Work** is done on an object when a force acting on it makes it move in the direction of motion
- Work is measured in joules
- Work can be calculated by
- **Work = Force × distance moved in the direction of the force**

$$W = Fd$$

- When a force acts at an angle to the direction of travel

$$W = Fscos\theta$$

- **Power** is the rate of work done
- Power is calculated by

$$P = \frac{\Delta W}{\Delta t}$$

- For a powered vehicle by a constant force *F* moving at speed *v*

The work done per second = force × distance moved per second

- Therefore, the output power of the engine, ***P = Fv***

- **Density**
  - Density is equal to the object's mass over its volume

$$\rho = \frac{Mass}{Volume}$$

- **Conservation of energy**
  - Energy cannot be created as destroyed
  - Change in potential energy is calculated by

$$\Delta E_P = mg\Delta h$$

  - The kinetic energy of an object can be calculated by

$$E_k = \frac{1}{2}mv^2$$

- **Stretching**
  - Hooke's law states that the force needed to stretch a spring is directly proportional to the extension of the spring from its natural length
  - This can be written by

$$F = k\Delta L$$

    - Where is k is the spring constant
  - Hooke's law is true up to the elastic limit, after this when the force is removed the spring will not return to its initial length
  - **Combining Springs**
    - Two springs in parallel will combine to have an effective spring constant, $k = k_1 + k_2$
    - Two springs in series will combine to have an effective spring constant k where, $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2}$
  - **Stress** is measured in pascals and calculated using

$$\sigma = \frac{T}{A}$$

    Where T is the tension and A is the cross sectional area of the wire
  - **Strain** is the ratio between the wire's original length and its stretched length and is therefore unitless, it is calculated using

$$\varepsilon = \frac{\Delta L}{L}$$

- The energy stored in a string is equal to $\frac{1}{2}F\Delta L$ because:
  - When the graph of force against distance stretched is plotted the area under the curve is the energy stored, a triangle so the area can be found using ½bh, ½×F×ΔL.
  - Because the work done to stretch a spring by extension ΔL is equal to ½FΔL this work is stored as elastic potential energy so E_p = ½FΔL
  - Since $F = k\Delta L$ where k is the spring constant, $E_p = \frac{1}{2}k\Delta L^2$

- Graph