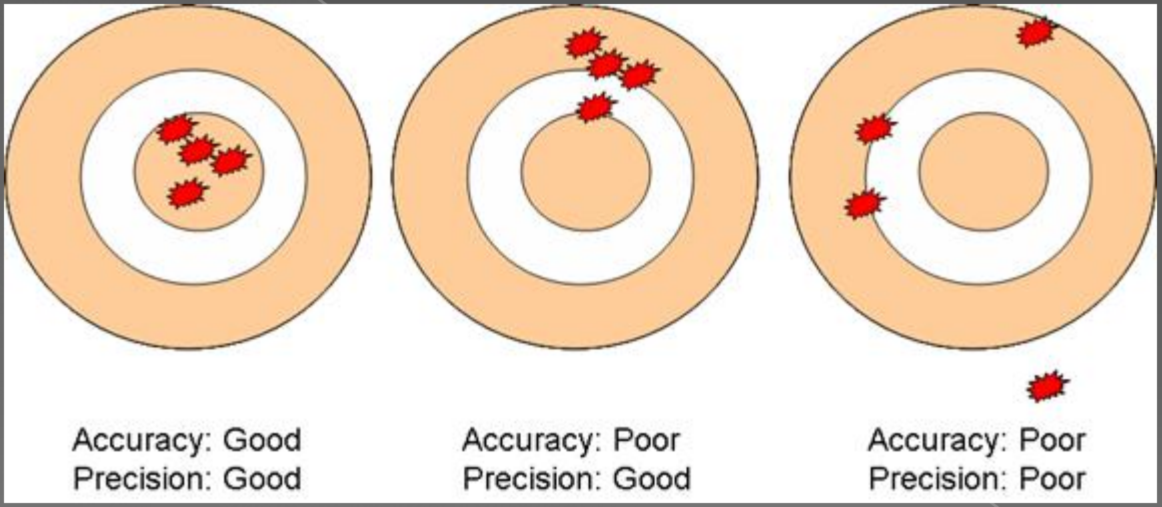
Units 1 & 2; Physical Quantities, Units and Measurement Techniques

Year 3 Physics Notes
2013

Accuracy & Precision

- Precision
  - Refers to how close together a group of measurements are
  - Has nothing to do with the actual value; hence readings can be completely inaccurate but very precise
- Accuracy
  - Refers to how close the measured value is to the actual value
  - Can be determined by just one measurement

Dartboard Analogy



Dartboard Analogy

- Often used to demonstrate accuracy and precision
  - Accuracy will be measured by how close the shots are to the bull's eye
  - Precision will be measured by how close they are together, no matter the distance from the bull's eye

The International System of Measurements (SI)

- Seven SI base units, for length, mass, time, current, temperature, amount of substance and luminous intensity
- Everything that is measurable can be measured by these or units derived from these

SI Units

- These are the basic SI units

TABLE 1.4 SI Base Units

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s[a]
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A
Luminous intensity	Candela	cd

[a] The abbreviation sec is frequently used.

Prefixes

- Used in front of base units
- All prefixes represent some factor of 10, and can be used with any of the SI base units

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	µ
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p
10^{2}	hecto	h	10^{-15}	femto	f
10	deca	d	10^{-18}	atto	a

Significant Figures & Decimal Places

- If a number does not have a decimal point, and ends with 0, it is unclear as to how many S.F it has
  - Eg. 20 cm, can be interpreted as 2 S.F, as it is exactly 20 cm, or it can be interpreted as 1 S.F, since the number 18 had been rounded up to 1 S.F

Calculating with SF & DP

- The general rule is to round the answer to the least precise measurement used in calculation
- Decimal places in addition & subtraction
  - 28.7 + 2.75 = 31.5 (calculated value: 31.45)
  - 0.04529 + 0.0028 = 0.0481 (calculated value: 0.04809)

Calculating with SF & DP

- Significant Figures with multiplication and division
  - 2.4 x 8.23 = 20 (calculated value= 19.752)
  - 0.0872 x 7.552 = 0.659 (calculated value = 0.6585344)

Unit 3: Waves

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Introduction

- Described as a disturbance that travels through a medium from one location to another
- Considered an energy transport phenomenon
- Transports energy without transporting matter

Introduction

- Mechanical Waves require a medium through which they propagate
- EM waves do not require any medium; they can travel even through vacuum

Definition of Terms

- Displacement – Distance of oscillating particle in a wave from its equilibrium position
- Amplitude – Maximum displacement of the oscillating particle in a wave from equilibrium position
- Period – (T), time taken to complete one oscillation of wave

Definition of Terms

- Frequency – (f) is the number of oscillations made by the wave per unit time. *Measured* in Hertz (Hz)
- $F = 1/T$
- Crests & Troughs – Highest and Lowest points on a transverse wave
- Wavelength – (λ) is the distance between corresponding points in two successive crests or troughs

Wave Speed

- Particles of a wave do not travel with the propagation of the wave; they only vibrate about their equilibrium positions with different phases within one wavelength
- In a time of one period, the waveform moves a distance of one wavelength
- Velocity = Wavlength / Period
- Therefore, velocity = frequency x wavelength

Transverse & Longitudinal Waves

- A longitudinal wave is a wave in which particles of the medium move in a direction parallel to the direction of travel of the wave
  - Eg. Sound Waves
- A transverse wave is a wave in which particles of the medium move in a direction perpendicular to the direction of travel of the wave
  - Eg. EM waves

Unit 4; Sound & C.R.O

Year 3 Physics Notes
2013

Propagation of Sound

- Sound waves are longitudinal
- Comprises of a series of compressions and rarefactions
- Propagate energy from one point to another

Sound and Medium

- Relationship between medium type and speed of sound
  - The closer the particles are to each other in the object, the faster the speed of sound
  - Hence, sound travels fastest in solids and slowest in air

Echoes

- When you hear the sound after it has hit a surface and is on its way bacl
- Formula
  - V = (2xdistance)/t

Pitch & Loudness of Sound

- The loudness of sound is dependant on the amplitude of the sound wave; the larger the amplitude, the greater the amount of energy carried, and therefore, the sound is loueder
- The pitch of sound (How low of high a sound is) is dependant on the frequency of the wave. A sound wave of higher frequency produces a higher pitch note

Doppler Effect

- As a sound approaches, the sound waves are closer together
- Causes the wavelength to be shorter
- Hence, the pitch of the sound increases as the sound approaches you

Timbre

- Quality of a sound
- For example, a guitar and a piano playing at the same loudness and pitch may produce different sounds
- The difference is due to a difference in timbre
- Timbre is dependant on waveform

Ultrasound & Infrasound

- The audible range of frequencies for an average human being is 20Hz – 20kHz
- This range decreases as we grow older though, since our ears lose sensitivity to the extreme ends of the frequency range

Ultrasound and Infrasound

- Sounds above the upper hearing limit → Ultrasound
- Sounds below the lower hearing limit → Infrasound
- Though we aren't able to hear them, there are several applications
  - Ultrasounds used for sonography

Echoes & Reverberations

- Echo → Reflection of sound
- When the surface is rigid and smooth, the fraction of sound reflected is larger
- When the surface is soft and irregular, the fraction is smaller
- Energy not reflected is probably absorbed or transmitted

Echoes & Reverberations

- Sound reflects from a smooth surface the same way light does
- When there are multiple reflections of sound, reverberation occurs
- Applications
  - Acoustics;
    - Eg. In an auditorium, a balance must be found between absorption and reverberations

Cathode-Ray Oscilloscope

- Plots a graph of voltage against time
- Scales on x and y axis can be adjusted using the time base and the voltage gain controls

Unit 5; EM Spectrum

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Properties

- Produced by the simultaneous vibration of electric and magnetic fields
- All EM waves are transverse waves
- Travel through vacuum at the speed of light (3×10^8)

Radio Waves

- Longest wavelength (Longer than 1m)
- Therefore, frequency is lowest (less than 300 megahertz)
- Applications
  - Radio & TV communication
  - Mobile Phones
  - Wireless Networking

Microwaves

- Wavelength between 1mm and 1m
- Frequencies between 300 megahertz and 300 gigahertz
- Applications
  - Telephones
  - Satellite Television
  - Traffic Speed Camera
  - Microwave

Infra-red waves

- Wavelengths between 760nm and 1mm
- Frequencies between 300 gigahertz and 400 terahertz
- Applications
  - Intruder Alarms
  - Night Vision
  - TV remote controllers

Visible Light

- Wavelengths between 380 and 760 nm
- Frequencies between 400 and 800 terahertz
- Applications
  - Optical Fibres
  - Telecommunication
  - Medical uses

Ultra-Violet

- Wavelengths between 10 and 380 nm
- Frequencies between 400 and 800 terahertz and 30 petahertz
- Applications
  - Sun beds
  - Sterilisation
  - Forensics
  - Security
    - Checking Fake bank notes

X Rays

- Wavelengths between 0.01 and 10nm
- Frequencies between 30 petahertz and 30 exahertz
- Applications
  - Hospital use
  - Astronomy
  - Airport Security

Gamma Rays

- Shortest Wavelength (<0.01nm)
- Therefore, largest frequency higher than 30 exahertz
- Applications
  - Cancer treatment
  - Sterilising Medical Equipment
  - Change properties of semi-precious stones

Effects of Absorbing EM waves

- All EM waves carry energy
- Hence an object that absorbs EM waves will increase in energy by
  - Getting hotter (Microwave)
  - By getting ionised (Produce free electrons)

If a body absorbs high-energy waves (UV, X Rays, Gamma), living cells and tissues can be damaged

Unit 6: Lenses

Year 3 Physics Notes
2013

Refraction of Light

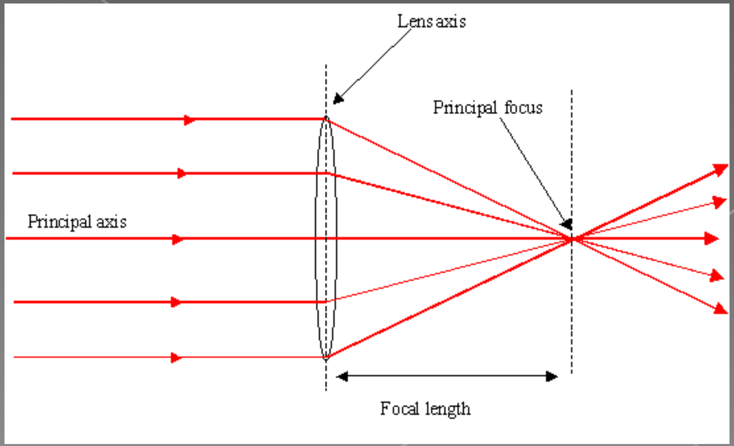
- Occurs because light travels at different speeds in different media
- Less Dense → More dense = Bend Towards
- More Dense → Less Dense = Bend away
- Greater the refractive index, the slower the speed of light

Formulae

- n*i* sin (incident angle, *i*) = n*r* sin (refracted angle, *r*)
  - n1 and n2 refer to the refractive indexes of the two media

Thin Converging Lenses

- Principal Axis: Line passing through centre of lens
- Focal Point: A point on the principal axis where the lines parallel to the principal axis converge after going through the lens
- Focal Length: The dist between principal focus and centre of the lens



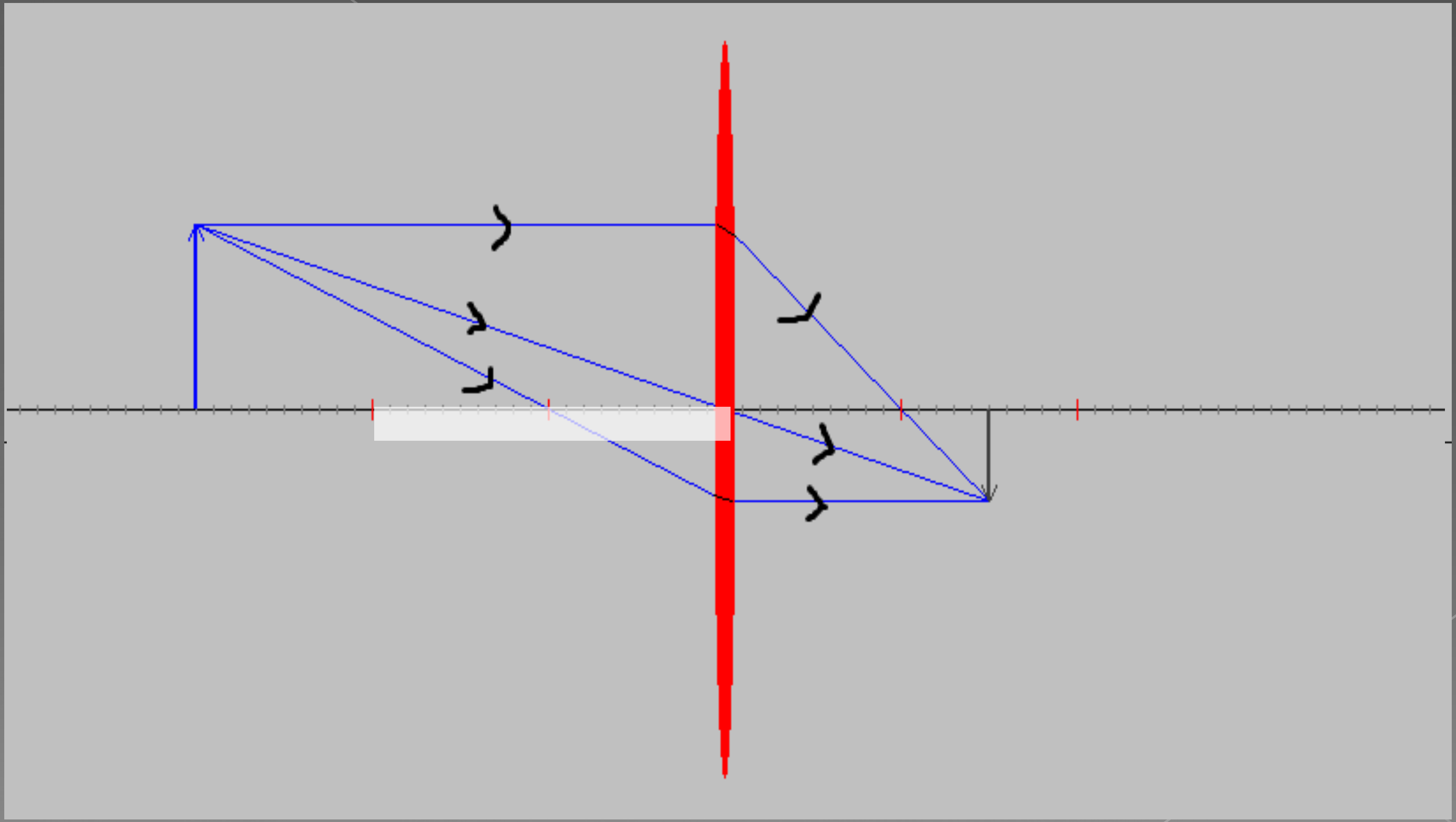
Linear Magnification

- Ratio of image size to the object size
- If the image is larger than the object, the magnification factor is larger than 1
- If the image is smaller, the magnification factor is smaller than 1

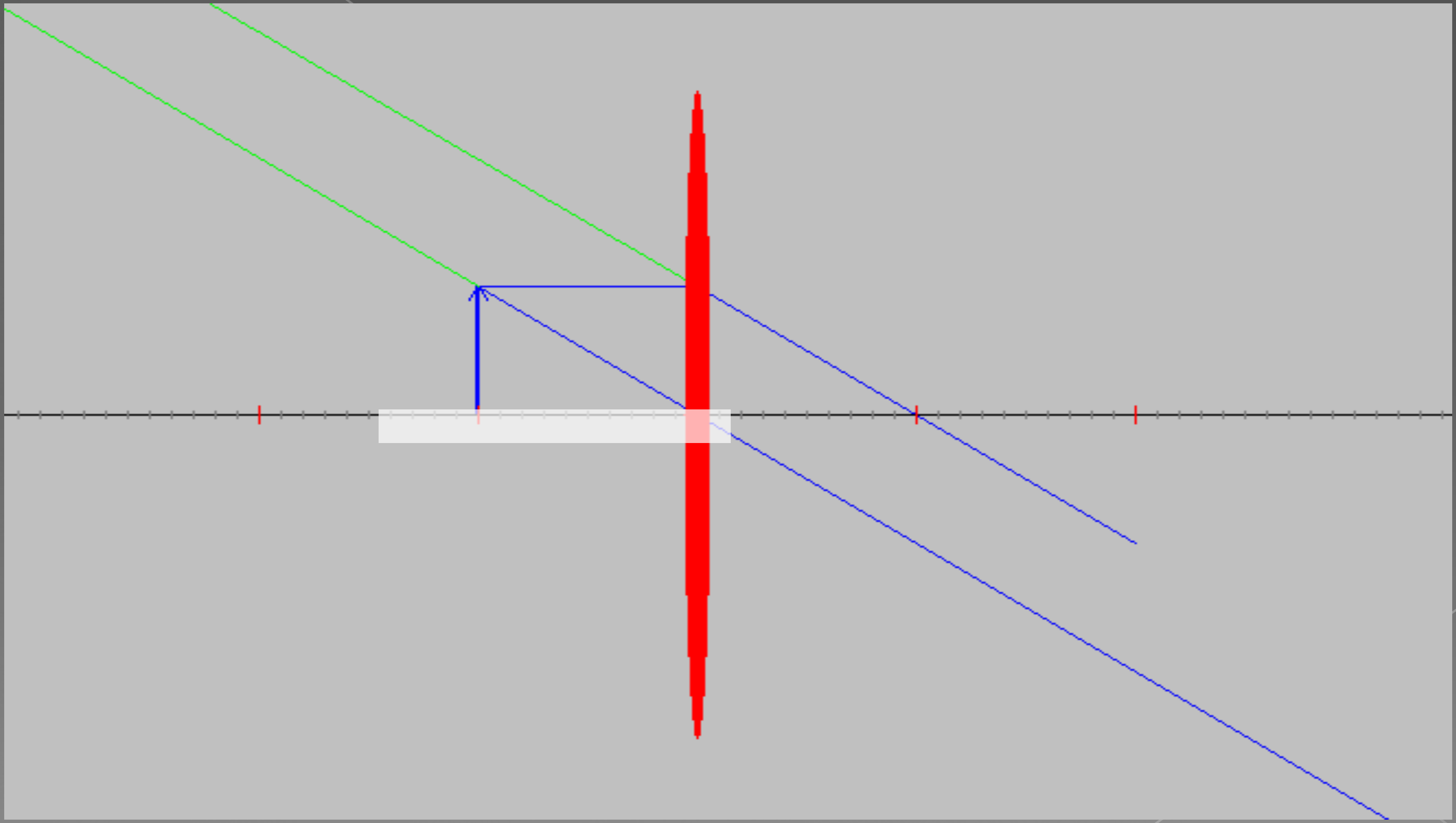
Lens Equation

- $1/f = 1/u + 1/v$
  - F = focal length
  - U= object distance
  - V= image distance

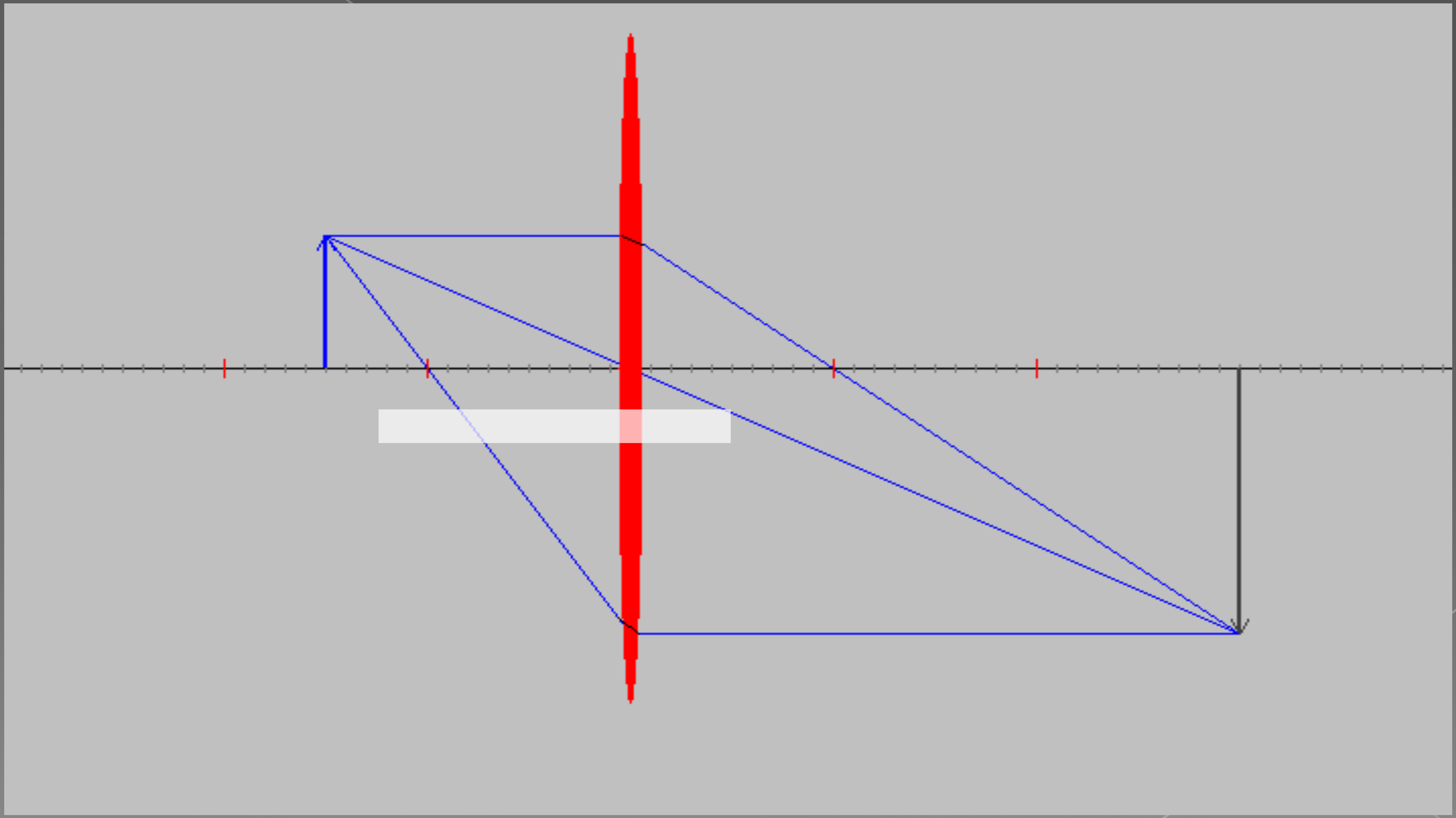
Ray Diagrams; Camera



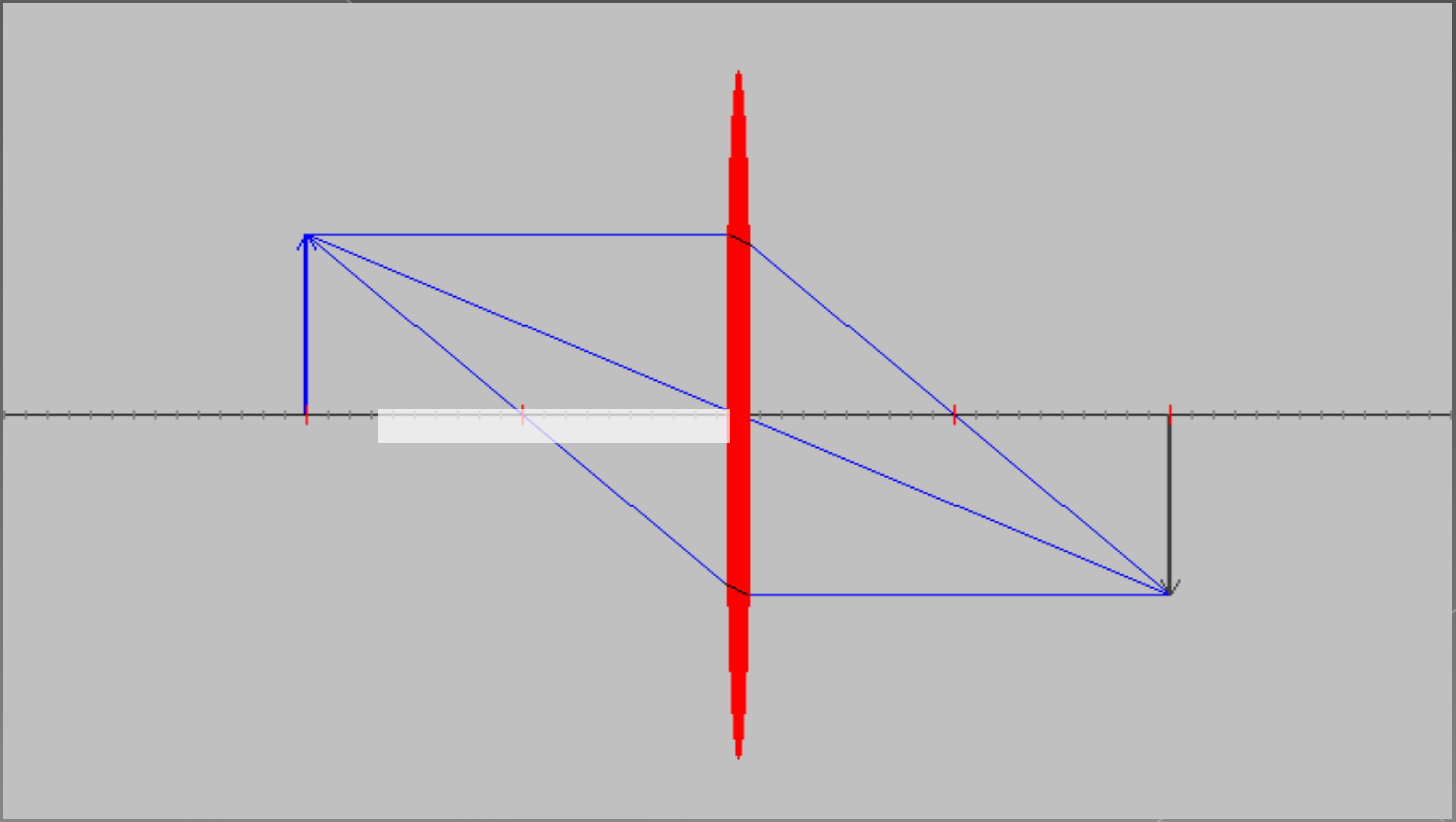
Ray Diagram; Spotlight



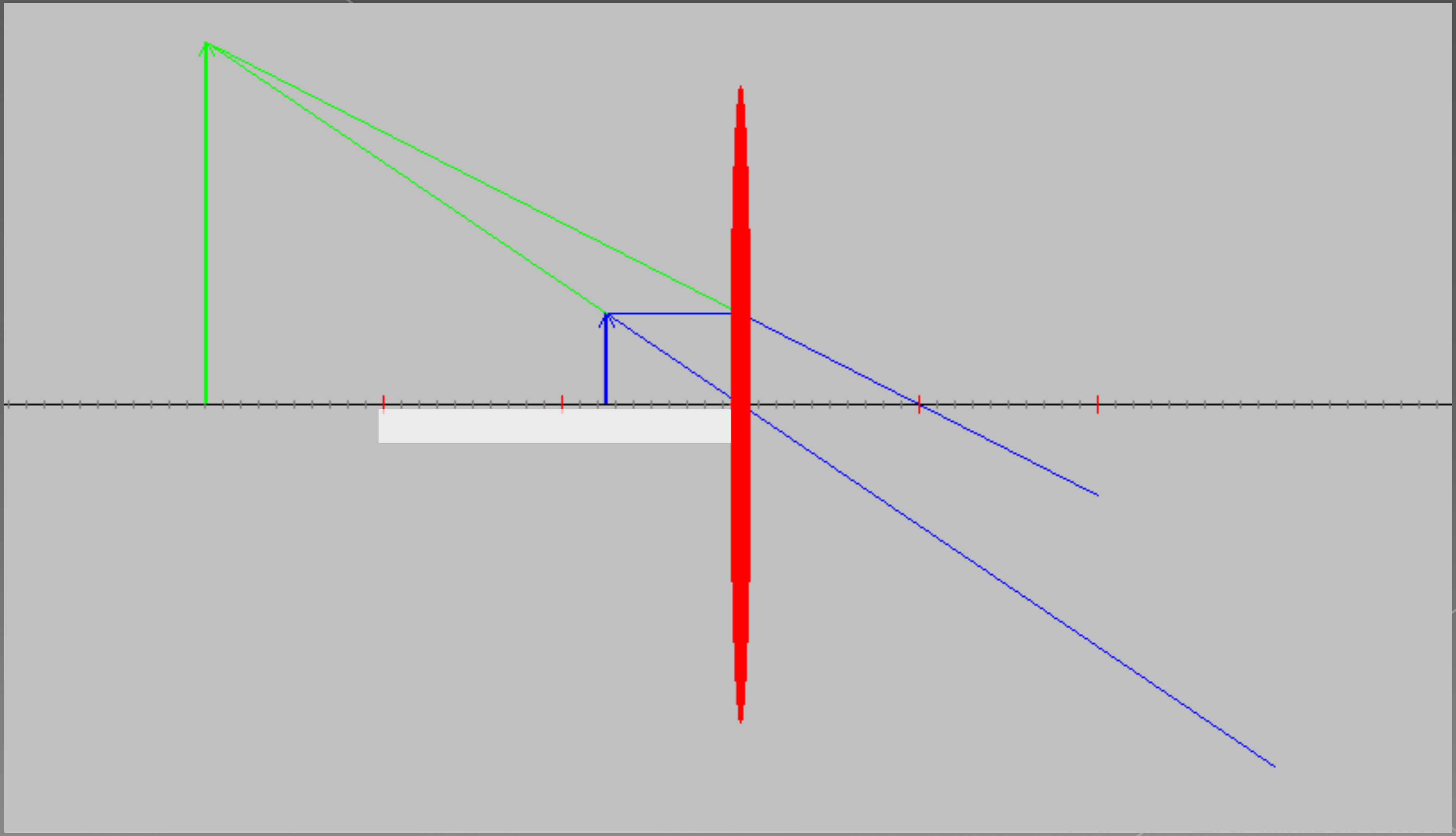
Ray Diagram; Projector



Ray Diagram; Photocopier



Ray Diagram; Magnifying Glass



Ray Diagrams

- Camera Image; Real, Inverted, Diminished
- Spotlight: Image formed at infinity; real and inverted
- Projector: Real, Inverted, Magnified
- Photocopier: Real, Inverted, Same size
- Magnifying Glass: Virtual, Upright (As it grows closer to F, the larger it gets
- Telescope: Real, inverted, diminished

Compound Microscope

- Made up of 2 converging lens; the objective lens (nearer to the object being observed) and the eyepiece (nearer to the observer)
- Objective lens produces a real image, and the eyepiece produces a virtual larger image of the first image
- Magnifying power of the microscope is the product of the magnifications factors of the objective lens and the eyepiece

Far-Sightedness

- Result of an abnormally short eyeball or the lens being too weak.
- Image formed behind the retina, hence out of focus
- Convex lens pulls the image towards the surface of the retina
- Far-sighted guy would have sharper vision under water

Near Sightedness

- Result of an abnormally long eyeball or the eye lens being too strong
- Image of a distant object falls in front of the retina
- Diverging lens help to push the image back to the retina

Unit 7; Kinematics

Year 3 Physics Notes
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Displacement, Speed and Velocity

- Displacement: Distance moved in a specified direction
- Speed: Rate of change of distance with respect to time
- Velocity: Rate of change of displacement with respect to time

Instantaneous & Average Velocity

- Instantaneous Velocity: Rate of change displacement at a particular instant of time
- Given by the gradient of the tangent at a particular period of time
- Average velocity is the total displacement divided by the total time taken

Acceleration

- Instantaneous acceleration is defined as the rate of change in velocity at a particular instant of time
- When the acceleration remains constant, the average velocity is given by;
  - Average Velocity = (u+v)/2
  - Where u is the initial velocity and v is the final velocity

Acceleration

- Acceleration = (final velocity – initial velocity) / time
- It hence follows that displacement (s) =
  - ½ (u + v)t
  - Where t is the time taken

Graphical Representations

- Displacement Time Graph
  - Gradient = Velocity
  - Straight horizontal line means it is moving at a constant velocity

Graphical Representations

- Velocity-Time Graph
  - Gradient = Acceleration
  - Area = Displacement
  - Straight line means that there is constant acceleration

Acceleration-Time Graph

- Area = Change in Velocity

Air Resistance and Terminal Velocity

- The faster the object drops, the greater the air resistance
- The weight of the person and the air resistance are opposite forces
- When the air resistance is equal to the weight, the resultant force becomes 0
- $F = ma$
- Since mass is a constant, and F is now 0, acceleration becomes 0 as well
- This is known as terminal velocity
- Resistance is proportionate to velocity in calm conditions and (velocity)^2 in turbulence

Unit 8; Scalars & Vectors

Year 3 Physics Notes
2013

Difference

- Scalars – Fully described by the magnitude alone
- Vectors – Fully described by both a magnitude and a direction