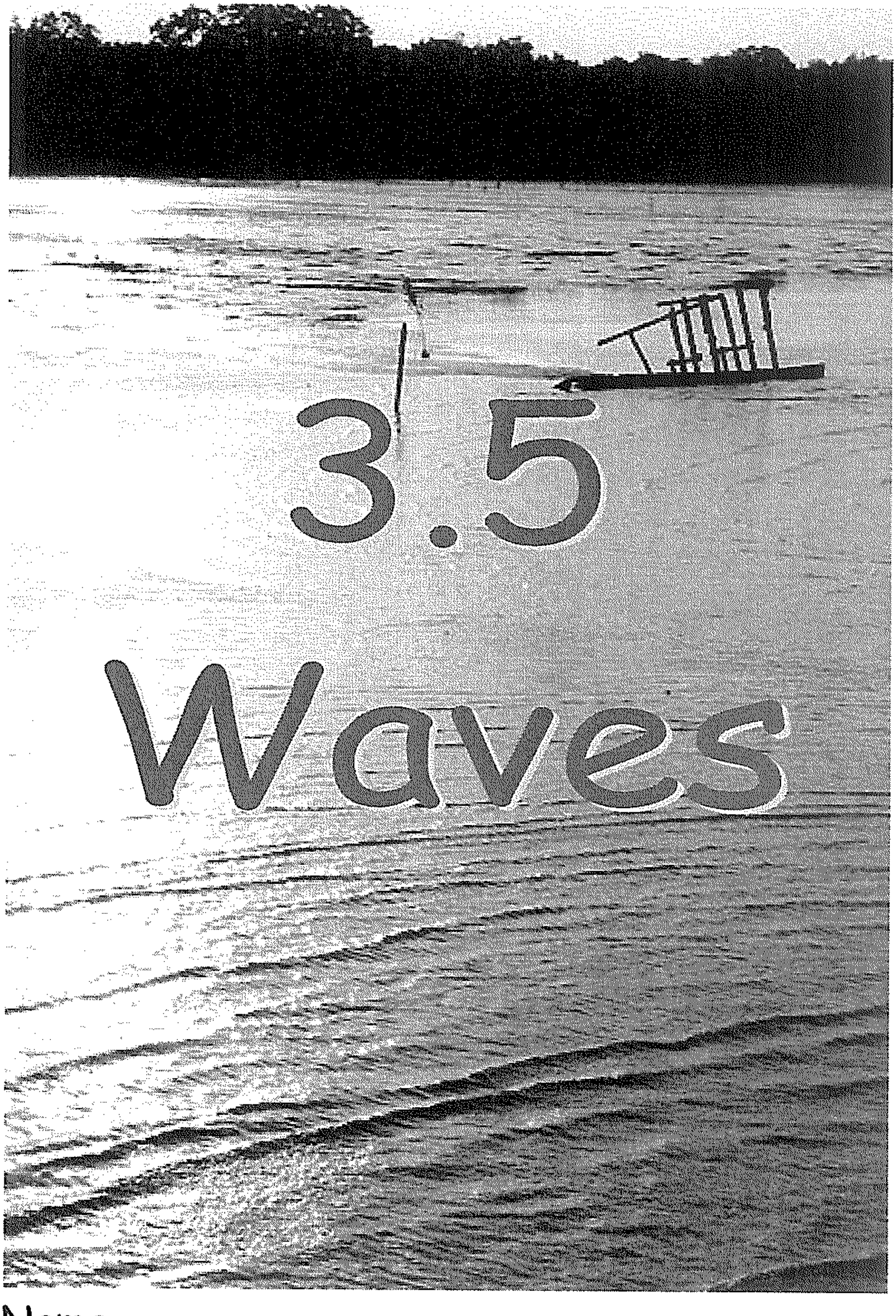


Name ....

Achievement Standard

Subject Reference		Physics 3.3			
Title		Demonstrate understanding of wave systems			
Level	3	**Credits**	4	**Assessment**	External

This achievement standard involves knowledge and understanding of phenomena, concepts, principles and relationships related to wave systems, and the use of appropriate methods to solve related problems.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Identify or describe aspects of phenomena, concepts or principles.	• Give descriptions or explanations in terms of phenomena, concepts, principles and/or relationships.	• Give concise explanations, that show clear understanding in terms of phenomena, concepts, principles and/or relationships.
• Solve straightforward problems.	• Solve problems.	• Solve complex problems.

Explanatory Notes

Assessment will be limited to a selection of the following:

Phenomena, Concepts and Principles:
Interference (quantitative) of electromagnetic and sound waves, including multi-slit interference and diffraction gratings; standing waves in strings and pipes; harmonics and overtones; resonance; beats; Doppler Effect (stationary observer).

Relationships:

$$d\sin\theta = n\lambda \qquad n\lambda = \frac{dx}{L} \qquad f' = f\frac{v_w}{v_w \pm v_s}$$

$$v = f\lambda \qquad f = \frac{1}{T}$$

Travelling Waves

In this unit we will look at three topics:

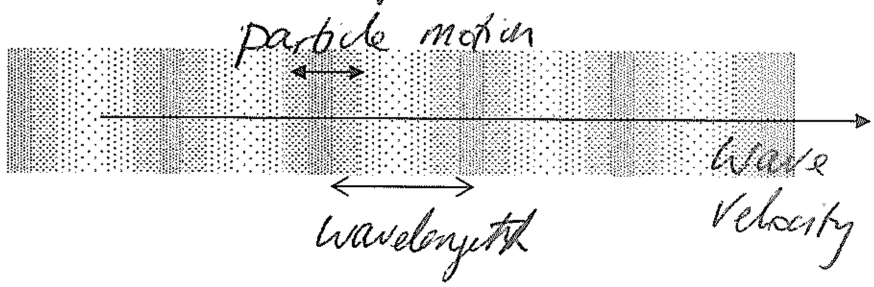
- Travelling Waves.
- Standing Waves .
- Interference.

Let's revise travelling waves.

A wave is a means of transferring ......energy...... without transferring ......matter.

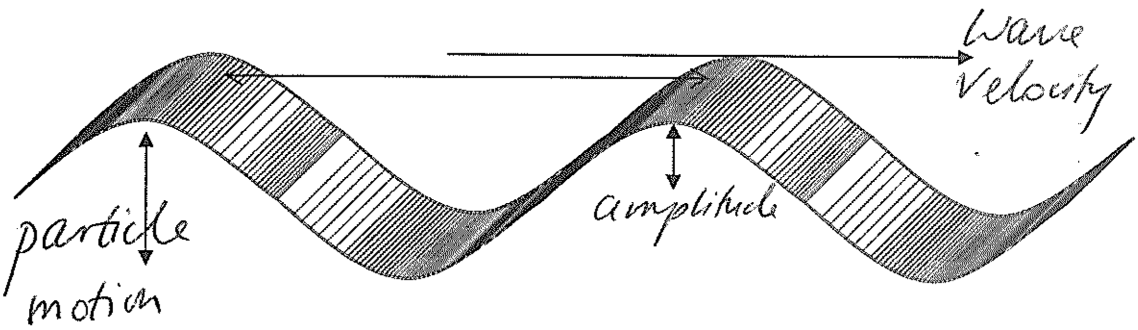
Waves are periodic in ......space...... For example, two different *places* in the sea have the same motion as waves pass through them.

Waves travel in two ways: ......longitudinal......



e.g. sound

......transverse......



e.g water, light
(in fact water waves are partly longitudinal)

Describing waves:

Amplitude: maximum distance from equilibrium

Displacement: distance from equilibrium

Wavelength: distance from crest to crest (compression to compression)

Period: time for one wave to pass.

Frequency: number of waves passing in one second

Wave Equation

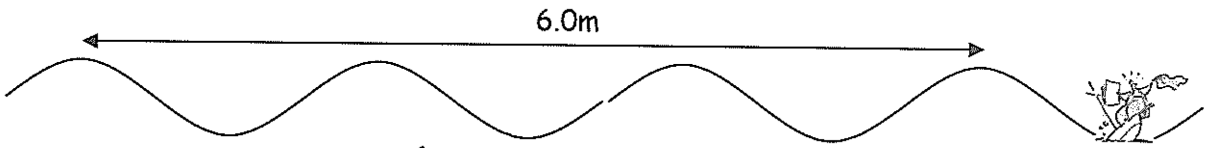
$v = \frac{d}{t}$ if the wave moves forward **one wavelength**, the time taken is called one ......period......

$v = \frac{\lambda}{T}$

$$v = f\lambda$$

(check by looking at units)

e.g. A boat bobs up and down five times in 30s..
Calculate the wavelength, frequency and speed of the wave..



$\lambda = 2.0\ m$ $f = \frac{1}{6}\ Hz$ $T = 6s$

Types of waves

e.g

<u>Electromagnetic Waves</u>	<u>Mechanical Waves</u>
gamma	ocean
↓	sound
radio	seismic

Properties of Mechanical waves:

- They require a ...Medium... to travel through, e.g. ...air...
- They can be t..ransverse... or ...longitudinal...
- Their speed depends on the medium eg

    speed of sound in air = $330\ ms^{-1}$

    speed of sound in water = $1500\ ms^{-1}$

Speed is proportional to the **elasticity** factor.

Speed is inversely proportional to **inertia** factor.

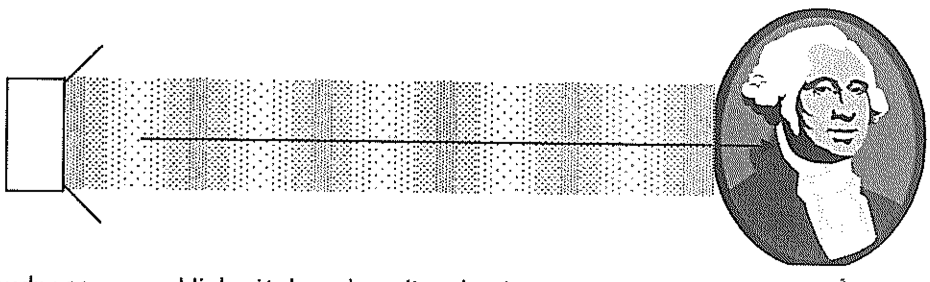
Types of Mechanical Waves.

Sound

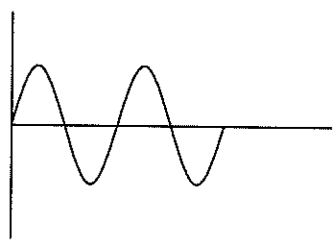
Sound is produced by things ...vibrating... .They travel (propagate) through matter in ...longitudinal... waves. The vibration is passed from one particle to the next. Sound is detected by ...ears..., ...microphones... etc. (Sound waves make the eardrum vibrate.)

If the eardrum vibrates at high frequency, the brain interprets this as ...high... pitch.

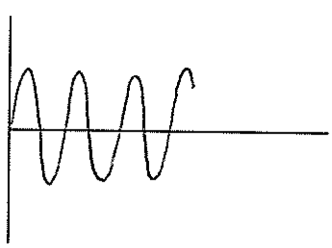
If the eardrum vibrates at large amplitude, the brain interprets this as ...loud... .



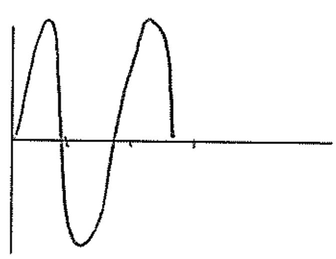
Medium pitch and loudness



High pitch and medium loudness

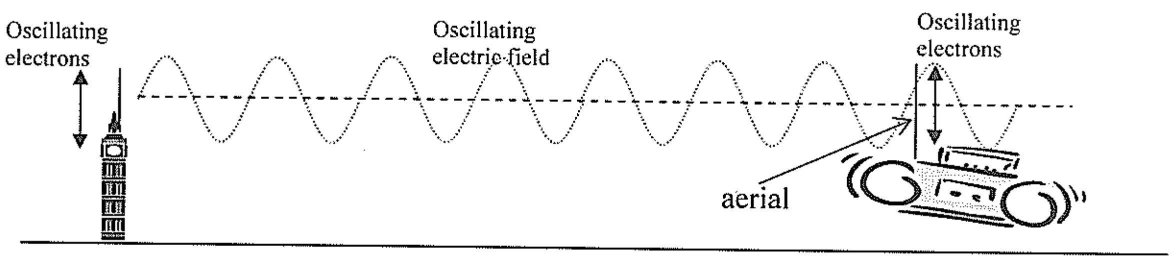


Medium pitch, loud



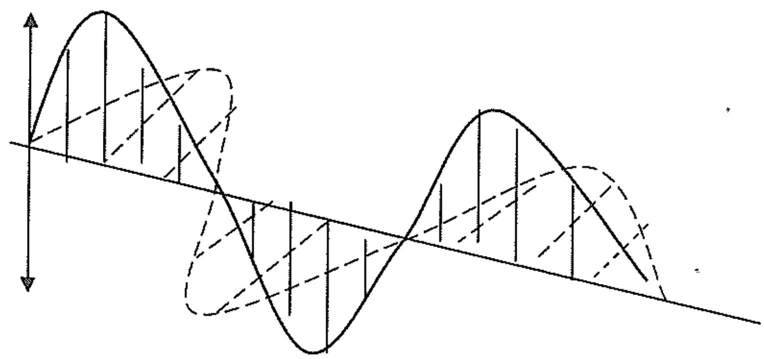
Properties of Electromagnetic Waves:

- Can pass through matter and ...vacuum...
- All travel at same speed in same medium. (...$3 \times 10^8 ms^{-1}$...) in vacuum.
- All t.ransverse........ (evidence, they can be ..polarised.........)
- All produced by moving charges. e.g Radio waves are produced by making ..electrons..... oscillate (wiggle) up and down in an transmitter aerial. This produces an oscillating electric and magnetic field that moves outwards.



Electrons in your radio aerial are caused to oscillate at the same f.reqency. Your radio converts this alternating electric current into sound.

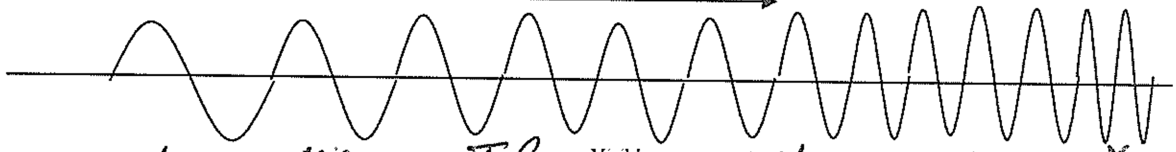
This diagram shows how the electric and magnetic field change. The oscillations of each field are ..perpendicular
The electric and magnetic fields swap energy with each other.



All types of electromagnetic radiation are the same apart from their f.reqrency....... (and w.avelength...........)

Label the parts of the electromagnetic spectrum.

Increasing ...frequency...



radio Micro IR Visible light UV Xrays γ rays

Increasing ...Wavelength...

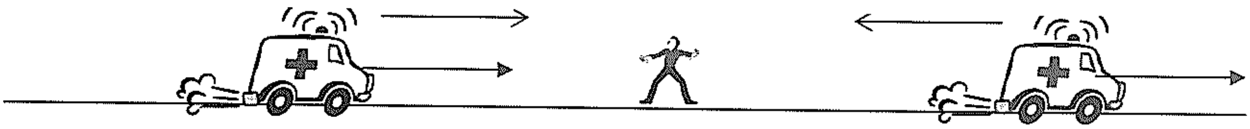
Doppler Effect

When a source of sound moves towards you, the received frequency is ...higher... than normal. When it moves away, the received frequency is ...lower... than normal. This is called the ...doppler... effect, after ...Hans Christian Doppler...

A passing motorbike sounds like this:

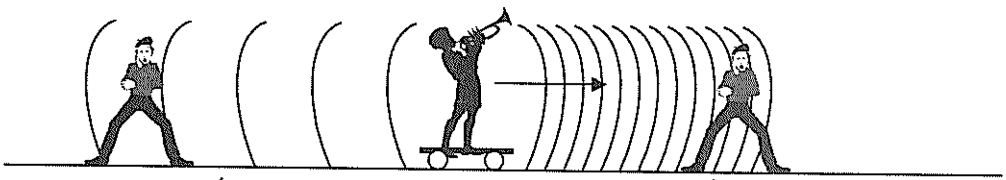
rrrrrrrrrrrrrrrrrraaaaaawwwwwwwwwwwwwwww

...high... frequency ...low... frequency



This is because the waves are squashed up, (...Shorter... wavelength) in front of the moving source and ...stretched..., (...longer... wavelength) behind the moving source.

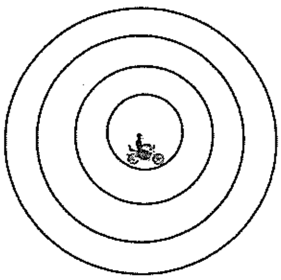
Stationary source

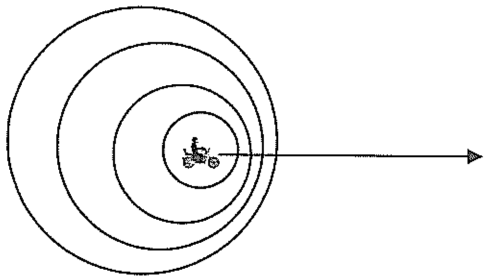


Kate hears ...low... frequency. Kristin hears ...high... frequency

EXPERIMENT NOTE: Doppler shift can be demonstrated by swinging a buzzer on a string in a circle in front of students.

Stationary source of waves. Moving source of waves.





Explain the diagrams

Stationary source – λ is the same in all directions. If source moves to the right, it tends to catch up with the waves it produces so the wavelength is shorter

Doppler Shift Equation.

When a source moves towards a receiver, the received frequency is given by:

$$f' = f \times \frac{v_w}{v_w - v_s}$$

f' = observed frequency
f = source frequency
Vw = wave speed
Vs = source speed

If the source is moving away, the denominator is $V_w + V_s$

eg. Amy is late for rehearsal and Mr McPhail is getting annoyed. She runs in at $10ms^{-1}$ playing "A" (440Hz). What frequency does Mr McPhail hear? (speed of sound is $340ms^{-1}$)

$f' = 453$ Hz

Explain why the frequency **he** hears is different to the frequency **she** hears.

She is not moving relative to the waves. So she hears the normal frequency of 440Hz

Describe the sound **he** hears as **she** slows down

Pitch would slowly drop to 440Hz (when she stops)

Mr McPhail has perfect pitch and later hears her playing 442Hz. How fast is she moving relative to him?

$V_s = 1{\cdot}54\ ms^{-1}$

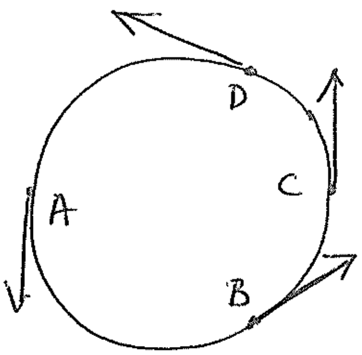
Extension. You drop a cell phone from the top floor of the atrium. Describe and explain how the sound heard by a person below would change after release.

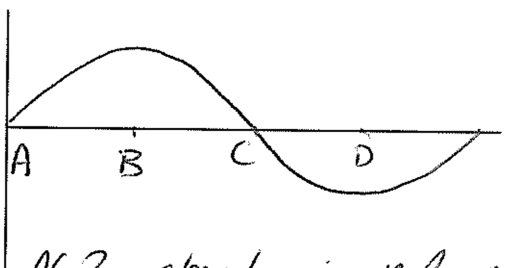
The source is accelerating away, so the frequency would be low and get lower.

How would the sound you hear change?

frequency would be high & get higher

Extension. A model aircraft flies in a 10 m radius circle at 15 ms^{-1} circle emitting a sound of 500 Hz. You are outside the circle. Describe the sound heard, and draw a graph of frequency/time. (take c= 340ms^{-1})



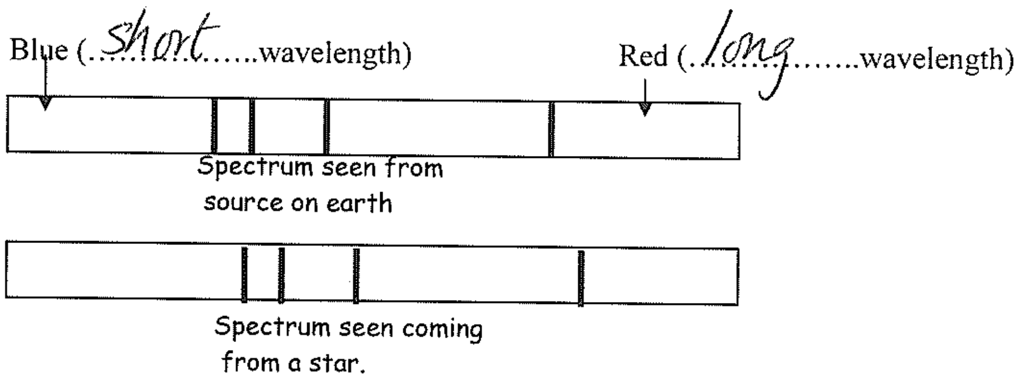


N.B graph is not a sine curve!

NB The Doppler effect is most noticeable with sound waves, but it can occur in all types of wave.

Red Shift

All stars emit certain wavelengths of light depending on the elements they contain. Astronomers can determine the type of element present by analysing the wavelength bands in the absorbtion spectrum. (we discuss this in quantum physics.) For most stars, the wavelengths bands observed are all slightly longer than measured on earth. (i.e. the frequency is ...lower... than expected) Explain why.



The light from the star has a ...longer... wavelength than normal. i.e. it has been shifted to the ...red... end of the spectrum

Because most starlight is red shifted, astrophysicists conclude that the stars are moving ...away... . This indicates that the universe is ...expanding

By measuring the change in frequency of the light, astrophysicists can calculate the ...speed... the stars are moving away.