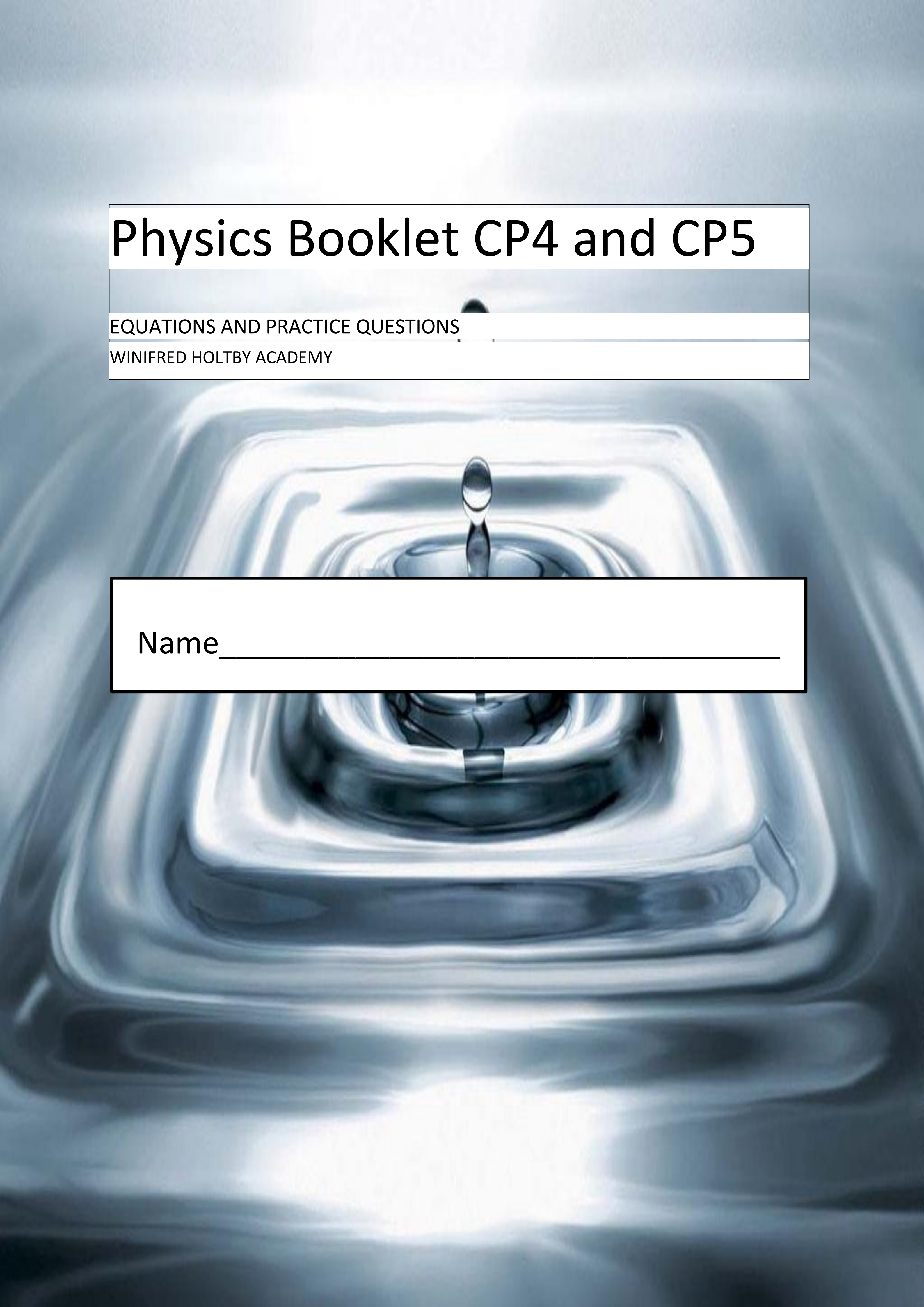


Physics Booklet CP4 and CP5

EQUATIONS AND PRACTICE QUESTIONS

WINIFRED HOLTBY ACADEMY

Name______________________________________

Write as many of the equations as you can remember in this box. Correct them in green pen using the equations sheet on the back.

CP4b.2

You will be expected to recall the equation linking wave speed, distance and time in your examination, and also the one linking speed, frequency and wavelength. You will need to choose the correct equation to answer the question and you should also be able to change the subject of the equations and to use the correct units.

1 The table on the right shows how far some different waves travel in different times.

Use the equation relating wave speed, distance and time to calculate the missing numbers in the table.

	Wave speed (m/s)	Distance (m)	Time (s)
a		2000	6
b		50	0.5
c	5000		4
d	3000	600 000	
e	200		25
f	1500	3000	

2 Sound travels at approximately 1500 m/s in water.

a How long will it take a whale song to travel 100 km? (*Hint:* remember to change the distance into metres.)

b If a diver hears a whale song 10 minutes after the whale made the noise, how far away is she?

3 A student is measuring the speed of sound in air. He hears an echo from a wall 50 m away 0.3 s after he made the sound. Calculate the speed of sound. (*Hint:* remember the sound has to travel to the wall and back again.)

4 Sound travels at different speeds in different materials.

Use the equation relating wave speed, frequency and wavelength to calculate the missing numbers in the table on the right.

Material	Speed of sound (m/s)	Frequency (Hz)	Wavelength (m)
a steel		12 200	0.5
b wood		50	80
c air	330		1.65
d water	1500	15 000	
e concrete	3500	500	
f rubber	150		0.015

5 Waves in a spring have a frequency of 8 Hz and travel at a speed of 4 m/s. Calculate their wavelength.

6 Water waves with a wavelength of 1.5 cm travel across a tank at 0.021 m/s. Calculate their frequency.

7 Radio waves travel at 3×10^8 m/s in a vacuum. This means that, if controllers on the ground are communicating to astronauts or space probes, there will be a delay before they receive a reply.

Use the information in the table to calculate the time delay in receiving a reply from:

a astronauts on the International Space Station (ISS)

b a probe on the surface of Mars

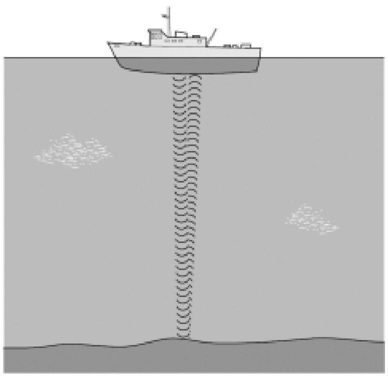
c the New Horizons probe passing Pluto.

Location	Distance (m)
ISS	322 000
Mars	2.25×10^{11}
Pluto	4.9×10^{12}

8 There is a time delay of 4 hours when sending messages to a space probe. How far from Earth is the probe?

Many ships are fitted with a sonar system. This sends out 'pings' of sound, and then detects the echo when the sound is reflected by the sea bed or by fish beneath the ship.

Sound travels at approximately 1533 m/s in sea water and 1493 m/s in fresh water.



9 An anchored fishing boat uses sonar to work out how deep the sea is. It sends out a 'ping' of sound and detects the echo 2 s later.

a How deep is the water?

b If the boat was on a freshwater lake instead of the sea, how deep would the water be if the echo took 2 s to return?

c A little while later, the sonar detects two echoes from a ping, after 0.05 s and 0.7 s. These echoes are from fish in the sea beneath the boat. Calculate how far below the boat the fish are.

10 A sonar system can use sound waves with a frequency of 120 kHz or 200 kHz.

d What is the wavelength of each of these waves when they are sent through sea water?

e What are their wavelengths in freshwater?

f The ship operating these sonar systems is in sea water with a depth of 3 km. How long will it take an echo to return to the ship after a 'ping'?

11 A sonar 'ping' with a frequency of 50 kHz covers a distance of 300 m in 0.2 s. What is the wavelength of the sound?

Answer the questions using the F.R.S.A.U format and a calculator.

CP4b.5

1 A longitudinal seismic wave travels through 2 km of granite in 2.5 s. Calculate the speed of the wave.

2 A transverse seismic wave travels at 3000 m/s in rock. How long will it take this wave to travel 10 km?

3 The call of a whale has a frequency of 30 Hz. Sound travels at a velocity of around 1500 m/s in sea water.

a Calculate the wavelength of the sound waves.

b How far will the sound travel in 5 minutes?

4 A hunter fires a gun and hears an echo from a cliff face 5 s later. He knows the cliff is 850 m away. How fast is the sound travelling where the hunter is?

5 A tsunami is a wave caused when a landslide falls into the sea, or when there is an earthquake on the sea bed. A tsunami off the coast of Japan can travel 8600 km to the coast of California in 17 hours.

a Calculate the velocity of the tsunami wave.

b How long would it take a similar wave to travel from Sumatra to Sri Lanka (a distance of approximately 1500 km)?

6 The seismic waves caused by earthquakes and landslides travel through the Earth and are detected by seismometers. If the earthquake is detected by several seismometers in different places, scientists can work out the location of the earthquake.

If warnings are given as soon as the seismic waves are detected, calculate the length of time people would have to evacuate in the coastal areas below.
(Use the value for the speed of a seismic wave that you calculated in question **1**.)

a California, 8600 km from Japan

b Sri Lanka, 1500 km from Sumatra.

7 Light waves are part of a family of waves (called electromagnetic waves) that all travel at 3×10^8 m/s when travelling through a vacuum.

The table shows some typical frequencies or wavelengths for the different parts of the electromagnetic spectrum.

Calculate the missing values in the table.

Name of wave	Frequency (Hz)	Wavelength (m)
a radio		100
b microwaves	3×10^{10}	
c visible light		1×10^{-6}
d infrared	3×10^{12}	
e ultraviolet		1×10^{-7}
f X-rays	3×10^{19}	

Extra challenge

8 In 1969 the Apollo astronauts left a laser reflector on the Moon. This was to be used to help scientists to make very accurate measurements of the distance between the Earth and the Moon. The mean distance between the centres of the Earth and Moon is 385 000 km, and light travels at 3×10^8 m/s.

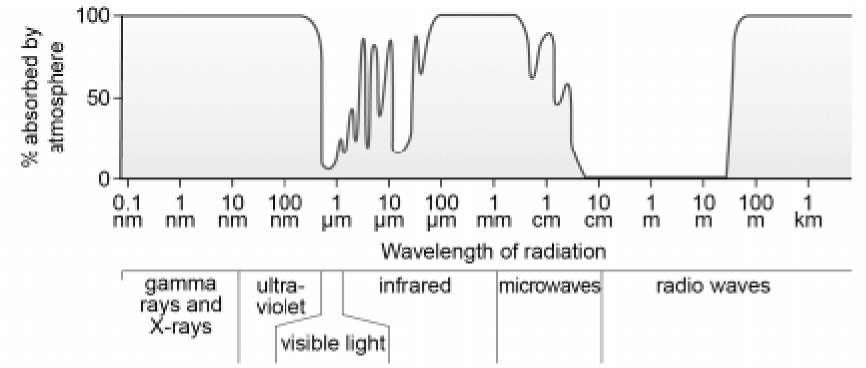
a How long would it take a beam of light to travel between the centres of the Earth and Moon?

b The diameter of the Earth is 12 742 km and the diameter of the Moon is 3480 km. How long would it be before the reflection of a laser beam fired from Earth was detected on the Earth? State any assumptions you make in working out your answer.

Write as many of the equations as you can remember in this box. Correct them in green pen using the equations sheet on the back.

CP5b.5

The diagram shows how the atmosphere absorbs or transmits different parts of the **electromagnetic spectrum**.



1 Gamma ray telescopes can be used on Earth.

- **a** Explain why Earth-based gamma ray telescopes are located on the tops of mountains.
- **b** Explain one advantage and one disadvantage of using a gamma ray telescope on a satellite.
- **c** Suggest one other type of telescope that is best located in space.

2 The diagram shows the wavelengths in nm, µm, mm, cm, m and km. Give the full name for each of these units.

3 The numbers on the diagram can all be expressed in metres, using numbers in standard form. For example, 1 nm = 1×10^{-9} m, and 10 cm = 1×10^{-1} m. Give the following lengths in metres and standard form.

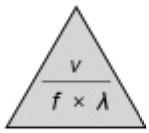
a 100 nm **b** 1 µm **c** 10 µm **d** 1 km

The velocity of electromagnetic waves in a vacuum is 3×10^8 m/s.
The speed, frequency and wavelength of any wave are linked by this equation:

wave speed (m/s) = frequency (Hz) × wavelength (m)

or

$v = f \times \lambda$



4 Use the equation to calculate the frequency of a typical wave in each group of the electromagnetic spectrum. One example has been done for you on the right.

5 A student says: 'Ultraviolet waves are 100 times longer than the waves in gamma rays'.

- **a** Explain whether the student is correct.
- **b** Write a similar statement to compare microwaves and radio waves.

For visible light:

$$\text{frequency} = \frac{\text{wave speed}}{\text{wavelength}} = \frac{3 \times 10^8 \text{ m/s}}{1 \times 10^{-6} \text{ m}} = 3 \times 10^{14} \text{ Hz}$$

Extra challenge

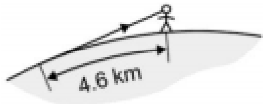
6 Light travels at around 2×10^8 m/s in glass. When light enters a glass block its frequency does not change. Calculate the wavelength of visible light in glass.

7 Gamma rays with a wavelength of 5 nm have a frequency of 2.4×10^{16} Hz when they pass through lead. Calculate the speed of gamma rays in lead.

Answer the questions using the F.R.S.A.U format and a calculator.

CP5c.2

If you are standing on flat ground, the furthest you can see is about 4.7 km. The distance depends on the height of your eyes above the ground. You can work out the approximate distance using the equation in the box on the right.



not to scale

The value of 4.7 km is for a person whose eyes are 1.7 m above the ground.

distance ~ 3570 × √ height distance and height are both in metres (You don't need to remember this equation.)

1 This equation applies to visible light waves. Explain why you can also use this equation to calculate how far you can be from a mobile phone mast and still receive a signal.

2 Explain why many mobile phone masts are put on the tops of buildings.

3 In the UK, many mobile phone masts are about 15 metres tall.

- **a** Calculate the maximum range of the mast (from how far away signals from it can be received).
- **b** What is the range of a mast 25 metres high?
- **c** Suggest one advantage and one disadvantage of using such tall masts in the countryside.
- **d** Suggest two reasons why the maximum range of a mobile phone mast may not be as great as the values you calculated.
- **e** In the middle of cities, some masts are less than 1 km apart. Suggest why this is.

Transmitters for radio and TV broadcasts are often built on hills. The highest transmitter in the UK is the transmission mast on Winter Hill in Lancashire. The mast is 309 metres tall and stands on a hill 456 metres above sea level.

4 The land to the west of Winter Hill is fairly flat and not far above sea level. Use the equation above to calculate the maximum distance the radio transmitter could reach.

5 **H** The greatest range of the Winter Hill mast is larger than the distance you calculated in question **4**. Explain why this is so. Use the words 'refract' or 'refraction' in your answer.

Microwaves for mobile phone communications are produced in a similar way to radio waves. The length of an antenna has to be roughly half the wavelength of the electromagnetic waves it is sending or receiving.

Type of signal	Typical frequency
mobile phone	800 MHz
FM radio	100 MHz
longwave radio	270 kHz

All electromagnetic waves travel at 3×10^8 m/s in air.

6 Calculate the wavelength of the three types of wave in the table. You need to use the equation:

$$\text{wavelength} = \frac{\text{wave speed}}{\text{frequency}}$$

7 How long would the antenna have to be for each type of wave?

	distance travelled = average speed × time	
	acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{(v - u)}{t}$
	force = mass × acceleration	$F = m \times a$
	weight = mass × gravitational field strength	$W = m \times g$
	efficiency = $\frac{\text{(useful energy transferred by the device)}}{\text{(total energy supplied to the device)}}$	
HT	**momentum = mass × velocity**	$p = m \times v$
	wave speed = frequency × wavelength	$v = f \times \lambda$
	wave speed = distance ÷ time	$v = \frac{x}{t}$
	density = mass ÷ volume	$\rho = \frac{m}{V}$
	work done = force × distance moved in direction of force	$E = F \times d$
	change in gravitational potential energy = mass × gravitational field strength × change in vertical height	$\Delta GPE = m \times g \times \Delta h$
	kinetic energy = ½ × mass × (speed)^2	$KE = ½ \times m \times v^2$
	power = work done ÷ time taken	$P = \frac{E}{t}$
	energy transferred = charge moved × potential difference	$E = Q \times V$
	charge = current × time	$Q = I \times t$
	potential difference = current × resistance	$V = I \times R$
	power = energy transferred ÷ time taken	$P = \frac{E}{t}$
	electrical power = current × potential difference	$P = I \times V$
	electrical power = current squared × resistance	$P = I^2 \times R$
	force exerted on a spring = spring constant × extension	$F = k \times x$

GCSE (9–1) Physics, you also need to learn these extra equations:

moment of a force = force × distance normal to the direction of the force	
pressure = force normal to surface ÷ area of that surface	$P = \frac{F}{A}$