AQA GCSE Physics (4403)
Unit 1: Physics 1 (PH1) Specification

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This booklet is for your use. In order to help you with your revision, it contains a copy of the AQA specification for this unit (this material is copyright © 2011 AQA and its licensors, all rights reserved). The specification for this unit has 54 points (for both foundation and higher tiers). By the examination itself, you ought to aim to be able to cope with answering questions on as many as possible of these.

To assist you in measuring your progress during your revision, there is a checklist on the back page of the booklet, where you can self-assess your understanding and confidence in answering questions for each point on the specification. I suggest using a 3 point scale for this, as follows

α–Understand this specification point totally; very happy if this comes up on the exam
β–Pretty confident on this specification point; could cope with this in an exam question
γ–Not clear about this specification point; unsure how to deal with an exam question on this

Here is a table for you to record the total numbers of αs, βs and γs, and thus show a measure of your increasing confidence with the unit's material during your revision:

	24 May	1 June	12 June	19 June
α				
β				
γ				
Total	54	54	54	54

3.3 Unit 1: Physics 1

P1.1 The transfer of energy by heating processes and the factors that affect the rate at which that energy is transferred

Energy can be transferred from one place to another by work or by heating processes. We need to know how this energy is transferred and which heating processes are most important in a particular situation.

Candidates should use their skills, knowledge and understanding to:	Additional guidance:
■ compare ways in which energy is transferred in and out of objects by heating and ways in which the rates of these transfers can be varied	Examples should include the design of a vacuum flask, how to reduce the energy transfer from a building and how humans and animals cope with low temperatures.
■ evaluate the design of everyday appliances that transfer energy by heating, including economic considerations	Examples include radiators and heat sinks.
■ evaluate the effectiveness of different types of material used for insulation, including U-values and economic factors including payback time	Examples include loft insulation and cavity wall insulation.
■ evaluate different materials according to their specific heat capacities.	Examples include the use of water, which has a very high specific heat capacity, oil-filled radiators and electric storage heaters containing concrete or bricks.

P1.1.1 Infrared radiation

a) All objects emit and absorb infrared radiation.

b) The hotter an object is the more infrared radiation it radiates in a given time.

c) Dark, matt surfaces are good absorbers and good emitters of infrared radiation.

d) Light, shiny surfaces are poor absorbers and poor emitters of infrared radiation.

e) Light, shiny surfaces are good reflectors of infrared radiation

P1.1.2 Kinetic theory

	Additional guidance:
a) The use of kinetic theory to explain the different states of matter.	Candidates should be able to recognise simple diagrams to model the difference between solids, liquids and gases.
b) The particles of solids, liquids and gases have different amounts of energy.	An understanding of specific latent heat is **not** required.

P1.1.3 Energy transfer by heating

	Additional guidance:
a) The transfer of energy by conduction, convection, evaporation and condensation involves particles, and how this transfer takes place.	Candidates should understand in simple terms how the arrangement and movement of particles determine whether a material is a conductor or an insulator. Candidates should understand the role of free electrons in conduction through a metal. Candidates should be able to use the idea of particles moving apart to make a fluid less dense, to explain simple applications of convection.
b) The factors that affect the rate of evaporation and condensation.	Candidates should be able to explain evaporation and the cooling effect this causes using the kinetic theory. Candidates should be able to explain the design of devices in terms of energy transfer, for example, cooling fins.
c) The rate at which an object transfers energy by heating depends on: ▪ surface area and volume ▪ the material from which the object is made ▪ the nature of the surface with which the object is in contact.	Candidates should be able to explain animal adaptations in terms of energy transfer, for example, relative ear size of animals in cold and warm climates.
d) The bigger the temperature difference between an object and its surroundings, the faster the rate at which energy is transferred by heating.	

P1.1.4 Heating and insulating buildings

a) U-values measure how effective a material is as an insulator.

Additional guidance:

Knowledge of the U-values of specific materials is **not** required, nor is the equation that defines a U-value.

b) The lower the U-value, the better the material is as an insulator.

c) Solar panels may contain water that is heated by radiation from the Sun. This water may then be used to heat buildings or provide domestic hot water.

d) The specific heat capacity of a substance is the amount of energy required to change the temperature of one kilogram of the substance by one degree Celsius.

$E = m \times c \times \theta$

Additional guidance:

E is energy transferred in joules, J

m is mass in kilograms, kg

θ is temperature change in degrees Celsius, °C

c is specific heat capacity in J / kg °C

Suggested ideas for practical work to develop skills and understanding include the following:

- passing white light through a prism and detecting the infrared radiation with a thermometer
- demonstration using balls in a tray to show the behaviour of particles in substances in different states
- measuring the cooling effect produced by evaporation; putting wet cotton wool over the bulb of a thermometer or temperature probe
- plan and carry out an investigation into factors that affect the rate of cooling of a can of water, eg shape, volume, and colour of can
- using Leslie's cube to demonstrate the effect on radiation of altering the nature of the surface
- plan and carry out an investigation using immersion heaters in a metal block to measure specific heat capacity
- investigating thermal conduction using rods of different materials.

P1.2 Energy and efficiency

Appliances transfer energy but they rarely transfer all of the energy to the place we want. We need to know the efficiency of appliances so that we can choose between them, including how cost effective they are, and try to improve them.

Candidates should use their skills, knowledge and understanding to:	**Additional guidance:**
■ compare the efficiency and cost effectiveness of methods used to reduce 'energy consumption'	The term 'pay-back time' should be understood. Given relevant data, candidates should be able to make judgements about the cost effectiveness of different methods of reducing energy consumption over a set period of time. This is **not** restricted to a consideration of building insulation but may include: ■ low energy light bulbs and LED lighting ■ replacing old appliances with energy efficient ones ■ ways in which 'waste' energy can be useful, eg heat exchangers.
■ describe the energy transfers and the main energy wastages that occur with a range of appliances	Common electrical appliances found in the home will be examined. Examples will **not** be limited to electrical appliances; however, in this case all the information would be given in the question.
■ interpret and draw a Sankey diagram.	Candidates should be able to use a Sankey diagram to calculate the efficiency of an appliance.

P1.2.1 Energy transfers and efficiency

a) Energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed.

b) When energy is transferred only part of it may be usefully transferred, the rest is 'wasted'.

c) Wasted energy is eventually transferred to the surroundings, which become warmer. The wasted energy becomes increasingly spread out and so becomes less useful.

d) To calculate the efficiency of a device using:

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}} (\times 100\%)$$

$$\text{efficiency} = \frac{\text{useful power out}}{\text{total power in}} (\times 100\%)$$

Additional guidance:

Candidates may be required to calculate efficiency as a decimal or as a percentage.

Suggested ideas for practical work to develop skills and understanding include the following:

- an energy 'circus' to demonstrate various energy transfers
- plan and carry out an investigation by constructing a model house, using sensors and data logger to measure temperatures with and without various types of insulation.

P1.3 The usefulness of electrical appliances

We often use electrical appliances because they transfer energy at the flick of a switch. We can calculate how much energy is transferred by an appliance and how much the appliance costs to run.

Candidates should use their skills, knowledge and understanding to:

- compare the advantages and disadvantages of using different electrical appliances for a particular application

Additional guidance:

Candidates will be required to compare different electrical appliances, using data provided.

- consider the implications of instances when electricity is not available.

P1.3.1 Transferring electrical energy

a) Examples of energy transfers that everyday electrical appliances are designed to bring about.

b) The amount of energy an appliance transfers depends on how long the appliance is switched on and its power.

c) To calculate the amount of energy transferred from the mains using:

$$E = P \times t$$

Additional guidance:

Candidates will **not** be required to convert between kilowatt-hours and joules.

E is energy transferred in kilowatt-hours, kWh

P is power in kilowatts, kW

t is time in hours, h

This equation may also be used when:

E is energy transferred in joules, J

P is power in watts, W

t is time in seconds, s

d) To calculate the cost of mains electricity given the cost per kilowatt-hour.

Additional guidance:

This includes both the cost of using individual appliances and the interpretation of electricity meter readings to calculate total cost over a period of time.

Suggested ideas for practical work to develop skills and understanding include the following:

- candidates reading the electricity meter at home on a daily or weekly basis. They could then look for trends in usage and try to explain these, eg in terms of weather conditions
- plan and carry out an investigation using an electrical joulemeter to measure the energy transferred by low voltage bulbs of different powers, low voltage motors and low voltage immersion heaters.

P1.4 Methods we use to generate electricity

Various energy sources can be used to generate the electricity we need. We must carefully consider the advantages and disadvantages of using each energy source before deciding which energy source(s) it would be best to use in any particular situation. Electricity is distributed via the National Grid.

Candidates should use their skills, knowledge and understanding to:

- evaluate different methods of generating electricity

Additional guidance:

Candidates should be able to evaluate different methods of generating electricity given data including start-up times, costs of electricity generation and the total cost of generating electricity when factors such as building and decommissioning are taken into account. The reliability of different methods should also be understood.

Knowledge of the actual values of start-up times and why they are different is **not** needed, but the implications of such differences are important.

- evaluate ways of matching supply with demand, either by increasing supply or decreasing demand

Candidates should be aware of the fact that, of the fossil fuel power stations, gas-fired have the shortest start-up time. They should also be aware of the advantages of pumped storage systems in order to meet peak demand, and as a means of storing energy for later use.

- compare the advantages and disadvantages of overhead power lines and underground cables.

P1.4.1 Generating electricity

a) In some power stations an energy source is used to heat water. The steam produced drives a turbine that is coupled to an electrical generator.

Energy sources include:

- the fossil fuels (coal, oil and gas) which are burned to heat water or air
- uranium and plutonium, when energy from nuclear fission is used to heat water
- biofuels that can be burned to heat water.

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	Additional guidance:
b) Water and wind can be used to drive turbines directly.	Energy sources used in this way include, but are not limited to, wind, waves, tides and the falling of water in hydroelectric schemes.
c) Electricity can be produced directly from the Sun's radiation.	Candidates should know that solar cells can be used to generate electricity and should be able to describe the advantages and disadvantages of their use.
d) In some volcanic areas hot water and steam rise to the surface. The steam can be tapped and used to drive turbines. This is known as geothermal energy.	

	Additional guidance:
e) Small-scale production of electricity may be useful in some areas and for some uses, eg hydroelectricity in remote areas and solar cells for roadside signs.	Candidates should understand that while small-scale production can be locally useful it is sometimes uneconomic to connect such generation to the National Grid.
f) Using different energy resources has different effects on the environment. These effects include: ■ the release of substances into the atmosphere ■ the production of waste materials ■ noise and visual pollution ■ the destruction of wildlife habitats.	Candidates should understand that carbon capture and storage is a rapidly evolving technology. To prevent carbon dioxide building up in the atmosphere we can catch and store it. Some of the best natural containers are old oil and gas fields, such as those under the North Sea.

P1.4.2 The National Grid

	Additional guidance:
a) Electricity is distributed from power stations to consumers along the National Grid.	Candidates should be able to identify and label the essential parts of the National Grid.
b) For a given power increasing the voltage reduces the current required and this reduces the energy losses in the cables.	Candidates should know why transformers are an essential part of the National Grid.
c) The uses of step-up and step-down transformers in the National Grid.	Details of the structure of a transformer and how a transformer works are **not** required.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigating the effect of changing different variables on the output of solar cells, eg distance from the light source, the use of different coloured filters and the area of the solar cells
- planning and carrying out an investigation into the effect of changing different variables on the output of model wind turbines, eg the number or pitch of the blades, the wind velocity
- demonstrating a model water turbine linked to a generator
- modelling the National Grid.

P1.5 The use of waves for communication and to provide evidence that the universe is expanding

Electromagnetic radiations travel as waves and move energy from one place to another. They can all travel through a vacuum and do so at the same speed. The waves cover a continuous range of wavelengths called the electromagnetic spectrum.

Sound waves and some mechanical waves are longitudinal, and cannot travel through a vacuum.

Current evidence suggests that the universe is expanding and that matter and space expanded violently and rapidly from a very small initial 'point', ie the universe began with a 'big bang'.

Candidates should use their skills, knowledge and understanding to:

- compare the use of different types of waves for communication

Additional guidance:

Knowledge and understanding of waves used for communication is limited to sound, light, microwaves, radio waves and infrared waves.

- evaluate the possible risks involving the use of mobile phones
- consider the limitations of the model that scientists use to explain how the universe began and why the universe continues to expand.

P1.5.1 General properties of waves

a) Waves transfer energy.

b) Waves may be either transverse or longitudinal.

Additional guidance:

Candidates should understand that in a transverse wave the oscillations are perpendicular to the direction of energy transfer. In a longitudinal wave the oscillations are parallel to the direction of energy transfer.

c) Electromagnetic waves are transverse, sound waves are longitudinal and mechanical waves may be either transverse or longitudinal.

d) All types of electromagnetic waves travel at the same speed through a vacuum (space).

e) Electromagnetic waves form a continuous spectrum.

Additional guidance:

Candidates should know the order of electromagnetic waves within the spectrum, in terms of energy, frequency and wavelength.

Candidates should appreciate that the wavelengths vary from about 10^{-15} metres to more than 10^4 metres.

f) Longitudinal waves show areas of compression and rarefaction.

g) Waves can be reflected, refracted and diffracted.

> **Additional guidance:**
>
> Candidates should appreciate that significant diffraction only occurs when the wavelength of the wave is of the same order of magnitude as the size of the gap or obstacle.

h) Waves undergo a change of direction when they are refracted at an interface.

> Waves are not refracted if travelling along the normal. Snell's law and the reason why waves are refracted are **not** required.

i) The terms frequency, wavelength and amplitude.

j) All waves obey the wave equation:

$v = f \times \lambda$

> **Additional guidance:**
>
> v is speed in metres per second, m/s
>
> f is frequency in hertz, Hz
>
> λ is wavelength in metres, m
>
> Candidates are **not** required to recall the value of the speed of electromagnetic waves through a vacuum.

k) Radio waves, microwaves, infrared and visible light can be used for communication.

> Candidates will be expected to be familiar with situations in which such waves are typically used and any associated hazards, eg:
>
> - radio waves – television, and radio (including diffraction effects)
> - microwaves – mobile phones and satellite television
> - infrared – remote controls
> - visible light – photography.

P1.5.2 Reflection

a) The normal is a construction line perpendicular to the reflecting surface at the point of incidence.

b) The angle of incidence is equal to the angle of reflection.

c) The image produced in a plane mirror is virtual, upright and laterally inverted.

> **Additional guidance:**
>
> Candidates will be expected to be able to construct ray diagrams.

P1.5.3 Sound

a) Sound waves are longitudinal waves and cause vibrations in a medium, which are detected as sound.

> **Additional guidance:**
>
> Sound is limited to human hearing and **no** details of the structure of the ear are required.

b) The pitch of a sound is determined by its frequency and loudness by its amplitude.

c) Echoes are reflections of sounds.

P1.5.4 Red-shift

a) If a wave source is moving relative to an observer there will be a change in the observed wavelength and frequency. This is known as the Doppler effect.

Additional guidance:

The following should be included:

- the wave source could be light, sound or microwaves
- when the source moves away from the observer, the observed wavelength increases and the frequency decreases
- when the source moves towards the observer, the observed wavelength decreases and the frequency increases.

b) There is an observed increase in the wavelength of light from most distant galaxies. The further away the galaxies are, the faster they are moving, and the bigger the observed increase in wavelength. This effect is called red-shift.

c) How the observed red-shift provides evidence that the universe is expanding and supports the 'Big Bang' theory (that the universe began from a very small initial point).

d) Cosmic microwave background radiation (CMBR) is a form of electromagnetic radiation filling the universe. It comes from radiation that was present shortly after the beginning of the universe.

e) The 'Big Bang' theory is currently the only theory that can explain the existence of CMBR.

Suggested ideas for practical work to develop skills and understanding include the following:

- reflecting light off a plane mirror at different angles
- using a class set of skipping ropes to investigate frequency and wavelength
- demonstrating transverse and longitudinal waves with a slinky spring
- carrying out refraction investigations using a glass block
- carrying out investigations using ripple tanks, including the relationship between depth of water and speed of wave
- investigating the range of Bluetooth or infrared communications between mobile phones and laptops
- demonstrating the Doppler effect for sound.

Checklist

Specification points	24 May	1 June	12 June	19 June
P1.1.1 a)				
b)				
c)				
d)				
e)				
P1.1.2 a)				
b)				
P1.1.3 a)				
b)				
c)				
d)				
P1.1.4 a)				
b)				
c)				
d)				
P1.2.1 a)				
b)				
c)				
d)				
P1.3.1 a)				
b)				
c)				
d)				
P1.4.1 a)				
b)				
c)				
d)				
e)				
f)				
P1.4.2 a)				
b)				
c)				
P1.5.1 a)				
b)				
c)				
d)				
e)				
f)				
g)				
h)				
i)				
j)				
k)				
P1.5.2 a)				
b)				
c)				
P1.5.3 a)				
b)				
c)				
P1.5.4 a)				
b)				
c)				
d)				
e)				

α–Understand this specification point totally; very happy if this comes up on the exam
β–Pretty confident on this specification point; could cope with this in an exam question
γ–Not clear about this specification point; unsure how to deal with an exam question on this