Monday 9 June 2014 – Morning

AS GCE PHYSICS B (ADVANCING PHYSICS)

G492/01 Understanding Processes/Experimentation and Data Handling

ADVANCE NOTICE

Duration: 2 hours

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INSTRUCTIONS TO CANDIDATES

- Take the article away and read through it carefully. Spend some time looking up any technical terms or phrases you do not understand. You are **not** required to research further the particular topic described in part **1**. You will find it helpful to try out the measurement ideas described in part **3**.
- For the examination on Monday 9 June 2014 you will be given a fresh copy of this article, together with a question paper. You will not be able to take your original copy into the examination with you.
- The values of standard physical constants will be given in the Advancing Physics Data, Formulae and Relationships booklet. Any additional data required are given in the appropriate question.

INFORMATION FOR CANDIDATES

- Questions in Section C of paper G492/01 (Understanding Processes, Experimentation and Data Handling) will refer to this Advance Notice material and may give additional data related to it.
- Section C will be worth about 40 marks.
- Sections A and B of paper G492/01 will be worth about 60 marks, and will examine the *Understanding Processes* section of the specification.
- There will be 2 marks for quality of written communication (QWC) assessed in Sections B and C.
- This document consists of **4** pages. Any blank pages are indicated.

1 Oscilloscopes

For many years cathode-ray oscilloscopes (CROs) were the only way to display rapidly changing voltages. The voltage input to a CRO moves a beam of electrons ('cathode rays') vertically on the screen, while an electronic circuit simultaneously moves the beam sideways at a steady rate. Once the trace reaches the end of the screen, the circuit moves the beam quickly back to the start and waits for the signal to reach the same phase before starting again. This ensures that the next trace exactly follows the pattern of the previous one. The glowing phosphor on the screen and the persistence of vision of the user give a steady graph of the voltage-time signal as shown in Fig. 1.

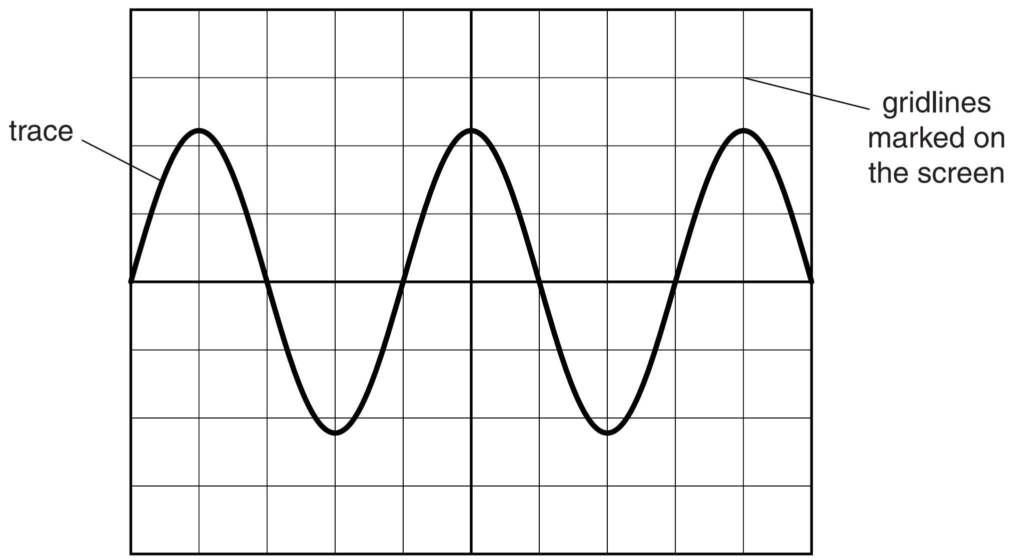

Fig. 1

The *x*-axis is called the time base and each square (division) represents a unit of time. The unit of measurement on the *y*-axis is volts per division (volts/div). Values for the amplitude, time period and frequency of the signal can easily be obtained, though the screen display has limited precision.

The CRO can display a great range of voltages from microvolt pulses from a heart monitor to hundreds of volts from the mains. The low inertia of the electron beam – the 'pointer' of this meter – means that very rapid changes can be plotted. Although the oscilloscope has excellent time resolution, only repeating signals can be displayed.

In recent years, developments in electronics have transformed oscilloscopes. Large, high-speed computer memories allow great quantities of voltage data to be stored and accessed rapidly, and sensors with rapid response times give digital storage oscilloscopes time resolutions to compete with CROs. Just as the old electron-beam televisions and computer monitors have been replaced by LCD and plasma screens, so CROs have been replaced by digital storage oscilloscopes in laboratories.

2 Powering electric cars

Electric vehicles, driven by electric motors powered by batteries, were first developed before internal combustion engines. However, their low speeds and short ranges meant that the introduction of petrol-driven vehicles drove them from the streets in the 1920s.

In recent years, the environmental damage caused by burning fossil fuels led to new research into electric vehicles. They had never gone away completely: milk floats have silently carried milk deliveries around towns and cities in the very early morning at 10 mph, and many factories and stores use electric forklift trucks to lift and move goods, where the very heavy lead-acid battery in the base of the truck is a distinct advantage.

Since the 1990s nickel-metal hydride (NiMH) batteries have been used in some vehicles. These have several advantages over lead-acid batteries, but have a tendency to self-discharge, where charge flows within the battery itself. This self-discharge becomes worse with an increase in temperature.

A more recent development is the lithium-ion battery, used in most modern electric cars. These do not have the self-discharge problems of the NiMH batteries, but are more expensive.

Table 1 compares these three types of battery.

Battery type	Max energy density / $Wh\,kg^{-1}$	Percentage energy efficiency in discharging	Battery cost per kWh capacity
lead-acid	35	85	£65
NiMH	80	80	£320
lithium-ion	200	90	£500

Table 1

Performance data for electric cars using lithium-ion batteries are shown in Table 2.

Car	Mass / kg	Maximum power / kW	Charging time / h	Time / s to accelerate from 0–27 $m\,s^{-1}$	Battery capacity / kWh
Ford Focus Electric	1640	107	4	9.5	23
Nissan Leaf	1540	80	7	11.9	24
Peugeot Ion	1170	49	7	15.4	16
Volvo Electric C30	1650	83	7	11.0	24

Table 2

Electric cars are rather expensive. Continued developments in electric motor and battery technology, as well as pressure from governments, are likely to make electric cars more and more common in the future.

3 Simple pendulum experiment

You may wish to try out this experiment in the laboratory so that you know in advance how the experiment works, how to analyse the data collected and what the uncertainties are. The simple arrangement of Fig. 3 can be used to carry out the practical task.

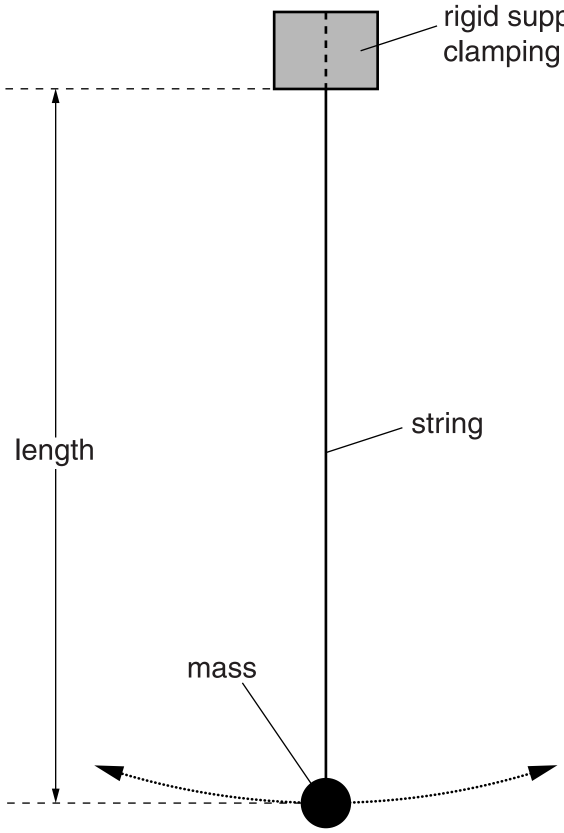

Fig. 3

A simple pendulum consists of a mass suspended from a fixed point by a string. If set into motion with care, the mass oscillates about the rest position. The time taken for one complete oscillation is called the period, T. For small amplitude oscillations the relationship between the period T and length L of the pendulum is given by

$$T = 2\pi\sqrt{\frac{L}{g}}.$$

You are not required to know the theory for this equation in AS Physics.

By timing an appropriate number of oscillations of pendulums of different lengths you can determine a value for g, the acceleration due to gravity.