Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 7 5 6 / 0 1	Signature	

Paper Reference(s)

6756/01

Edexcel GCE

Salters Horners Physics

Advanced Level

Unit Test PSA6: Synoptic Paper

Thursday 21 June 2007 – Afternoon

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Nil	Nil

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
Total	

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Answer ALL questions in the spaces provided in this question paper.
In calculations you should show all the steps in your working, giving your answer at each stage.
Calculators may be used.
Include diagrams in your answers where these are helpful.

Information for Candidates

This question paper is designed to give you the opportunity to make connections between different areas of Physics and to use skills and ideas developed throughout the course in new contexts. You should include in your answers relevant information from the whole of your course, where appropriate.
The marks for individual questions and the parts of questions are shown in round brackets.
There are 4 questions in this question paper. The total mark for this paper is 60.
The list of data, formulae and relationships is printed at the end of this booklet.

Advice to Candidates

You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, taking account of your use of grammar, punctuation and spelling.

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Read the following passage carefully and then answer questions 1 and 2.

The Ultimate Clock?

Why bother to improve atomic clocks?

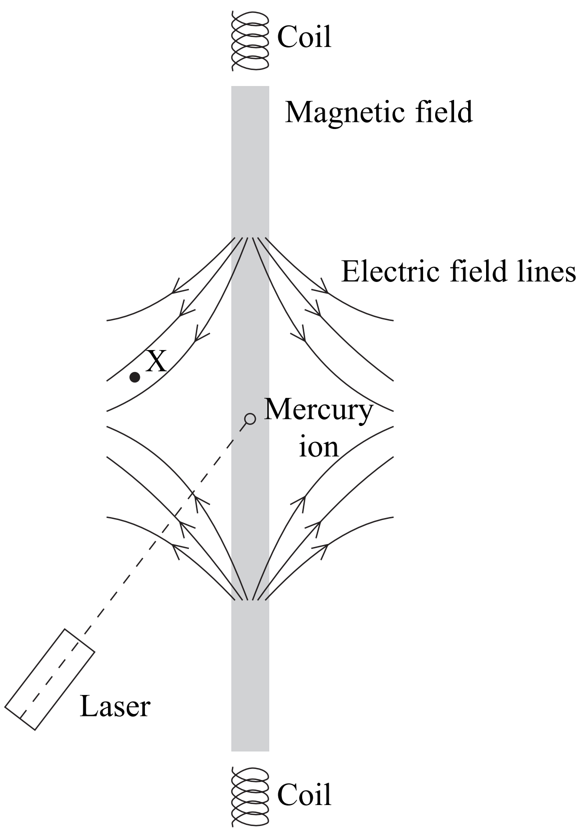
The duration of the second can already be measured to 14 decimal places. One reason for improving this precision is that the second is becoming the fundamental unit. Units such as the metre and ampere already can be defined in terms of the second. The kilogram could also be defined using the equation $\Delta E = c^2 \Delta m$. A given mass Δm has an equivalent energy ΔE which could be written as the number of photons of a particular frequency that would have the same total energy.

How do different clocks work?

Most clocks have an oscillator and a mechanism for counting the oscillations and converting this count into seconds. In a grandfather clock, the oscillations of a pendulum of a fixed length, hence fixed time period, are counted by gears and displayed by hands on a face. In a quartz watch, an oscillating voltage is applied across a quartz crystal surface, which causes the crystal to oscillate at a particular frequency. These oscillations then produce regular pulses which are counted and displayed by a digital circuit.

Design for an ultimate clock

In a mercury atomic clock, atoms of mercury are ionized leaving them with a positive charge. They can then be trapped by a combination of electric fields and a magnetic field as shown.



[Adapted from an article in Scientific American, Sept. 2002: *Ultimate Clocks* by W. Wayt Gibbs.]

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The laser emits ultra violet radiation (uv). A particular frequency causes an outer electron in a mercury ion to jump between energy levels. The laser frequency is adjusted until this effect is detected. The frequency of uv radiation which causes this effect is known accurately. If the number of cycles of this radiation can be detected and counted, then a period of one second can be measured with a high degree of precision.

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1. (a) State an equation that relates the quantities current and time.

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(1)

(b) Describe how the metre could be defined in terms of one second and the speed of light.

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(2)

(c) (i) Show that the energy of a photon with a frequency 7.5×10^{14} Hz is about 5×10^{-19} J.

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(2)

(ii) Calculate the number of photons of this frequency needed to give an equivalent energy to 1 kg of mass.

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Number of photons = ...

(3)

Leave blank

(d) Describe the difference between an analogue and a digital signal.

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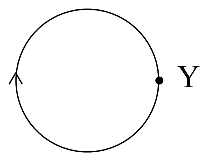
(2)

(e) A mercury ion is at position X in the diagram in the passage. Add an arrowed line to the diagram **on page 2** to show the direction of the force acting on the ion due to the electric field.
(2)

(f) The path of a mercury ion trapped within a uniform magnetic field is shown below. The direction of this magnetic field is out of the page. Draw an arrow on this diagram to indicate the direction of the force due to the magnetic field on the ion when it is at position Y. Hence explain why the ion follows the path shown.



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(3)

(g) Draw an energy level diagram to show what happens to an outer electron when a mercury ion absorbs a photon.

(2)

N 2 0 9 2 5 A 0 4 1 6

Leave blank

(h) (i) In a mercury atomic clock the wavelength of the photon absorbed by a mercury ion is 282 nm. Calculate the number of cycles of this light in one second.

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Number of cycles in one second = ...

(3)

(ii) Assume the mechanism for counting the cycles of this light made an error of one cycle whilst counting for one second. Use this assumption to calculate the accuracy with which a period of one second can be measured by this device.

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Accuracy = ...

(2)

Q1

(Total 22 marks)

Leave blank

2. The following is an extract from a student's plan for a practical which will involve timing the period of an oscillation of a pendulum mass on the end of a length of string. "I will start the stop clock as soon as I have released the mass from its highest position and then stop the stop clock when the mass passes through the same position again."

(a) The student was told he should make his measurements more precise. State one way in which he could do this.

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(1)

(b) The following table of his results shows how the period T varies with the length l of the pendulum.

l/m	T/s	
0.20	1.00	
0.40	1.35	
0.60	1.62	
0.80	1.85	
1.00	2.06	
1.20	2.24	

State the precision of the length measurements and comment on its suitability.

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(2)

(c) The student reads that the equation relating these two quantities is

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where g is a constant.

(i) Plot a suitable graph to test how well the data fit this relationship. You may wish to use the extra column in the table above.

(6)

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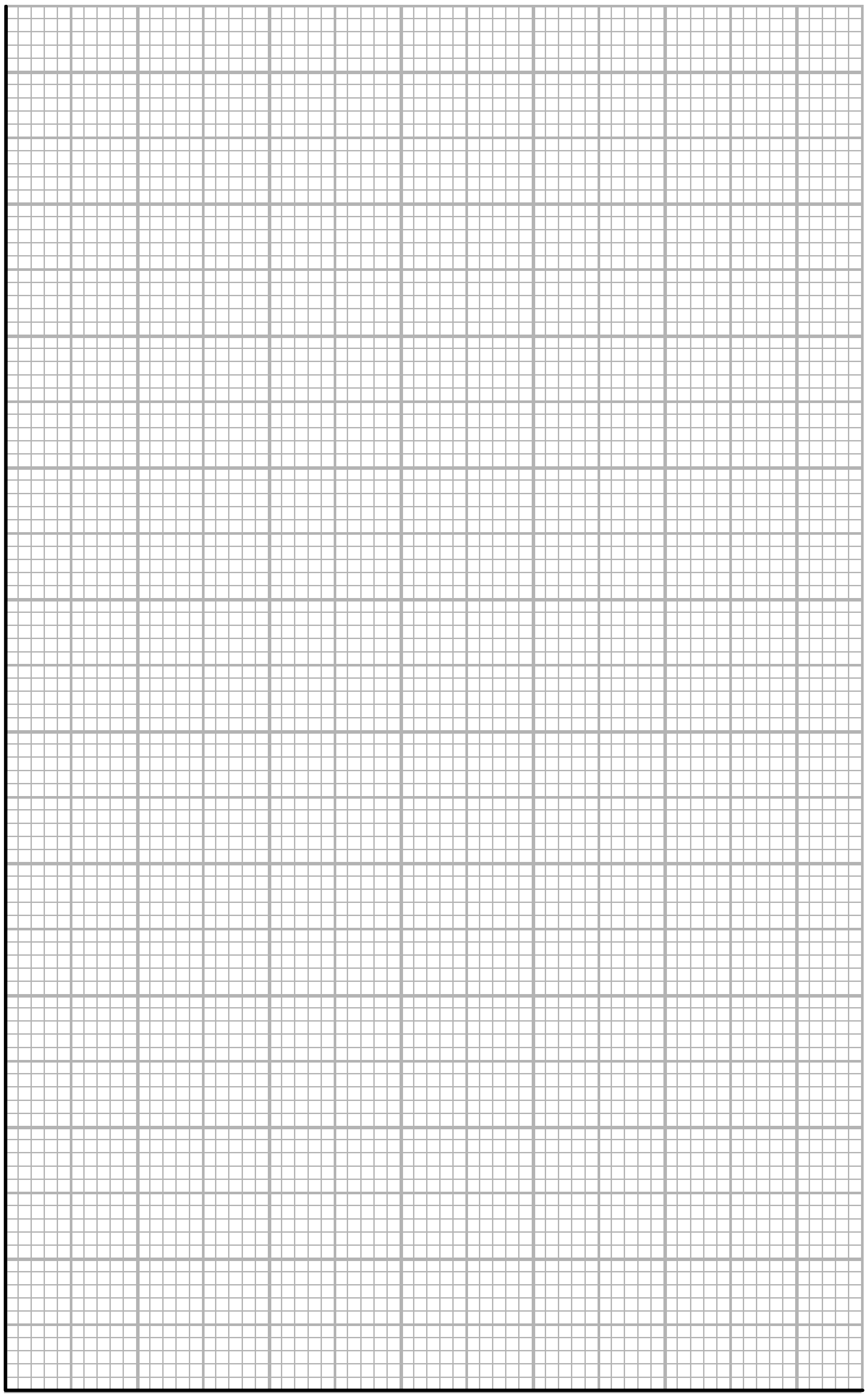

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(ii) State and explain whether the graph verifies this relationship.

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(2)

(d) An extract from the student's evaluation reads "I wasn't sure exactly where to measure the length to".

Discuss what your graph tells you about this student's problem with this measurement.

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(3)

(e) Determine the gradient of your graph and use it to calculate the value of the constant *g*.

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$g =$ ....
(4)

Q2

(Total 18 marks)

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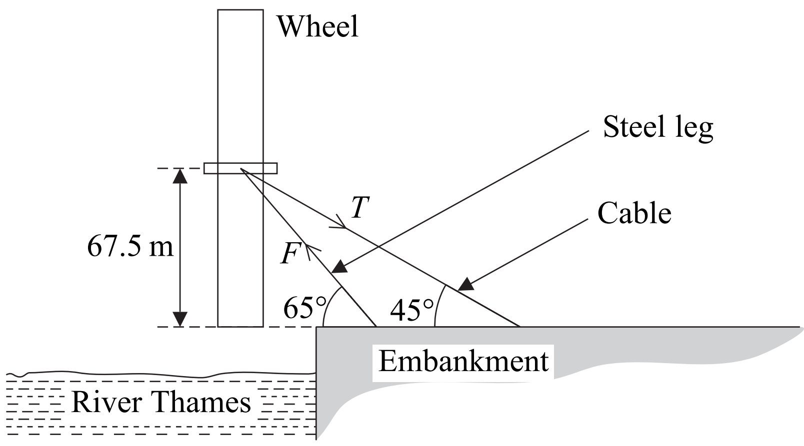
3. The London Eye is the largest observation wheel ever built, having a height of 135 m. On a clear day visitors can see the whole of London from the top. The diagram shows a simplified side-on view of the wheel and its supports. The supports have been simplified to a steel leg inclined at 65° to the horizontal, and a cable inclined at 45° to the horizontal. There is a force F in the leg and a tension T in the cable.



(a) (i) The mass of the fully loaded wheel is 1.06×10^6 kg. Calculate its weight.

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Weight = ...

(1)

(ii) By calculation or scale drawing show that the tension T in the cable is about 10^7 N.

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(4)

N 2 0 9 2 5 A 0 1 0 1 6

Leave blank

(b) The cable is of circular cross-section diameter 0.190 m. Calculate the energy stored in the cable if the Young modulus of the material is 160 GPa.

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Energy = ...

(5)

(c) In strong but unsteady wind conditions it is possible for the wheel to vibrate in such a way that its amplitude of vibration reaches a very large value. State the name of this phenomenon and explain the cause.

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(3)

Q3

(Total 13 marks)

Leave blank

4. A new piano has been invented which can automatically tune itself to the right notes. In tuning mode the strings, which are metal, are all tensioned so that they produce frequencies of sound slightly above normal. There are two coils positioned close to each string. A warming current is sent down each string which reduces the tension. A separate small alternating current is directed through the first coil. This forces the string to vibrate. A computer then measures the frequency of the induced current in the second coil. The warming current is adjusted automatically until the string produces the correct note. The piano can then be played with the warming current maintaining the correct tension in each string.

Explain the physics principles behind each of the described features of this invention.

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.... **Q4**

(Total 7 marks)

TOTAL FOR PAPER: 60 MARKS

END

List of data, formulae and relationships

Data

Gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$	
Acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$	(close to Earth's surface)
Gravitational field strength	$g = 9.81\,\mathrm{N\,kg^{-1}}$	(close to Earth's surface)
Electronic charge	$e = -1.60 \times 10^{-19}\,\mathrm{C}$	
Electronic mass	$m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$	
Electronvolt	$1\,\mathrm{eV} = 1.60 \times 10^{-19}\,\mathrm{J}$	
Proton mass	$m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$	
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$	
Molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$	
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$	
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$	
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{N\,A^{-2}}$	

Unit 1

Physics at work, rest and play

Mechanics

Kinematic equations of motion $s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

Energy

% *efficiency* = [*useful energy* (or power) *output/total energy* (or power) *input*] × 100%

Heating $\Delta E = mc\Delta\theta$

Quantum Phenomena

Photon model $E = hf$

Waves and Oscillations

For waves on a wire or string $v = \sqrt{(T/\mu)}$

For a lens $P = 1/f$

Unit 2

Physics for life

Quantum Phenomena

Photoelectric effect $hf = \phi + \frac{1}{2}mv^2_{max}$

Materials

Elastic strain energy $\Delta E_{el} = F\Delta x/2$

Stress $\sigma = F/A$

Strain $\varepsilon = \Delta x/x$

Young modulus $E = \sigma/\varepsilon$

Stokes' law $F = 6\pi\eta rv$

Waves and Oscillations

Refraction $\mu = \sin i/\sin r = v_1/v_2$

For lenses $P = P_1 + P_2$

$1/u + 1/v = 1/f$

Mathematics

Volume of sphere $V = \frac{4}{3}\pi r^3$

Unit 4

Moving with physics

Mechanics

Motion in a circle $v = \omega r$

$T = 2\pi/\omega$

Energy

Attenuation $I = I_0 e^{-\mu x}$

Nuclear Physics

Mass-energy $\Delta E = c^2\Delta m$

Quantum Phenomena

de Broglie wavelength $\lambda = h/p$

Fields

Electric field $E = F/Q$

$E = V/d$

In a magnetic field $F = BIl\sin\theta$

$F = Bqv\sin\theta$

$r = p/BQ$

Energy stored in capacitor $W = \frac{1}{2}QV$

Capacitor discharge $Q = Q_0 e^{-t/RC}$

Magnetic Effects of Currents

Faraday's and Lenz's Laws $E = -d(N\Phi)/dt$

N 2 0 9 2 5 A 0 1 4 1 6

Unit 5

Physics from creation to collapse

Energy

Radiant energy flux $F = L / 4\pi d^2$

Molecular kinetic theory $\frac{1}{2} m\langle c^2 \rangle = \frac{3}{2} kT$

Nuclear Physics

Radioactive decay $\mathrm{d}N / \mathrm{d}t = -\lambda N$

$\lambda = \ln 2 / t_{1/2}$

$N = N_0 \mathrm{e}^{-\lambda t}$

Waves and Oscillations

Waves in a solid $v = \sqrt{(E/\rho)}$

Redshift of electromagnetic radiation $z = \Delta\lambda / \lambda \approx \Delta f / f \approx v / c$

Cosmological redshift $z = \Delta\lambda / \lambda = H_0 d / c$

Simple harmonic motion $a = -\omega^2 x$

$a = -A\omega^2 \cos \omega t$

$x = A \cos \omega t$

$$E = E_\mathrm{k} + E_\mathrm{p} = \tfrac{1}{2} m v^2 + \tfrac{1}{2} k x^2$$

$$= \tfrac{1}{2} m\omega^2 x^2 + \tfrac{1}{2} m\omega^2 (A^2 - x^2)$$

$$= \tfrac{1}{2} m\omega^2 A^2$$

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