Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 7 5 4 / 0 1	Signature	

Paper Reference(s)

6754/01
Edexcel GCE
Salters Horners Physics
Advanced Level
Unit Test PSA4

Monday 21 January 2008 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Answer **ALL** of the questions, writing your answers in this question booklet.
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

The mark for individual questions and the parts of questions are shown in round brackets. There are six questions in this 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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1. A student is finding out about the many chargers for electrical devices, such as mobile phones, which are used around his house.

(a) He notes the following values from a particular charger:

Input 230 V 50 Hz 6 W
Output 4.5 V

The charger uses a transformer to produce a 4.5 V output from a 230 V input.

(i) Explain how a transformer works.

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(4)

(ii) The primary coil consists of 1950 turns. Calculate the number of turns on the secondary coil.

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Number of turns = ...

(2)

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(iii) The table shows the diameter of wire needed for a given maximum current.

Maximum current / A	Diameter /mm
0.010	0.081
0.023	0.122
0.059	0.193
0.118	0.274
0.222	0.376
0.493	0.560
1.301	0.910

Find, from the wires above, the minimum diameter suitable for the primary coil of this charger's transformer.

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Minimum diameter = ...

(3)

(b) When designing a practical transformer coil, competing factors have to be taken into account. For cost and space considerations, thinner wire would be chosen for the coils, whereas for efficiency and insulator life, thicker wire would be chosen.

Explain why thicker wire would improve efficiency and insulator life.

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(2)

Q1

(Total 11 marks)

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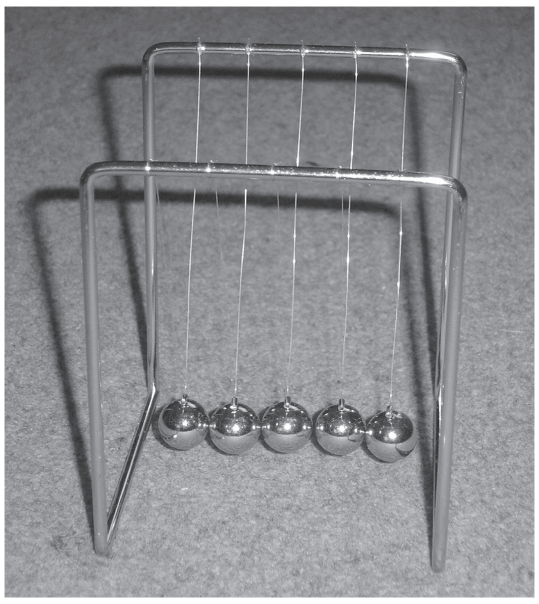
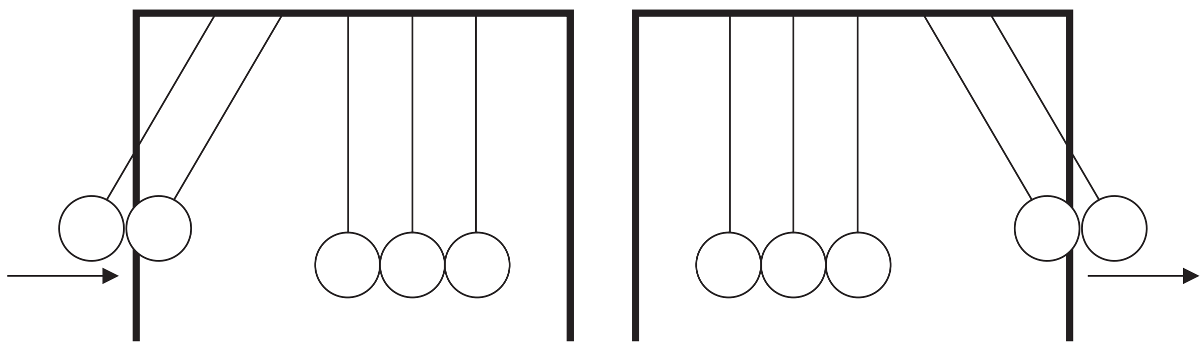
2. The photograph shows an arrangement known as Newton's cradle. Five steel balls are freely suspended from a frame. One or more balls on one side may be pulled back and then released so that they collide with the remaining balls.



The diagram shows what happens when two balls are released.



A student makes these measurements:

mass of each ball = 0.024 kg
speed of the two incoming balls at impact = 0.88 m s^{-1}

(a) Calculate the total momentum of the two moving balls before the collision.

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Total momentum = ...

(2)

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(b) Show that the kinetic energy of the two moving balls before the collision is about 0.019 J.

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(2)

(c) The student notices that the number of balls moving away after the collision is always the same as the number of balls released. To understand why two balls move away after this particular collision, the student uses a spreadsheet to model the situation. He applies the principle of conservation of momentum to find the theoretical speeds at which different numbers of balls would move away together. He also finds the kinetic energy that these balls would have.

	A	B	C	D
1	number	mass	speed after	KE after
2	of balls moving	of balls moving	collision	collision
3	away after collision	after collision	(m s^{-1})	(J)
4		(kg)		
5				
6	1	0.024	1.76	0.0372
7	2	0.048	0.88	0.0186
8	3	0.072	0.59	0.0124
9	4	0.096	0.44	0.0093
10	5	0.12	0.35	0.0074

(i) State the condition required for the total momentum of all the balls to be conserved.

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(1)

(ii) Show that the value in cell C8 has been correctly calculated.

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(1)

(iii) What would be a suitable formula for the calculation of cell D9?

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(1)

Leave blank

(iv) Explain how the spreadsheet calculations show that two balls moving away is the only likely outcome of the collision.

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(3)

(d) The two balls that moved away then swing back and collide, and the pattern is repeated. After a number of collisions, depending on the quality of the cradle, the pattern breaks down. Eventually more than two balls will be in motion, and they will not all have the same speed.

Suggest why this occurs, making reference to the spreadsheet.

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(2)

Q2

(Total 12 marks)

Leave blank

3. Research suggests that big capacitors may soon be able to act alongside batteries as a way of storing significant amounts of energy. Researchers used a capacitor of capacitance 2500 F.

One part of the research concerns the leakage of charge through the insulating material between the two capacitor plates.

In one experiment, researchers charged the 2500 F capacitor to a potential difference (p.d.) of 8.00 V.

(a) Calculate how much energy this capacitor stores when charged to a p.d. of 2.0 V.

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Energy = ...

(2)

They then measured the p.d. across the plates every ten days.

The first two columns in the table are the results they obtained.

Time / days	p.d. across plates/ V	ln(p.d. / V)
0	8.00	2.08
10	6.32	1.84
20	5.04	
30	4.00	
40	3.20	

They suspect that the p.d. is falling exponentially with time. To check this idea, they first find the natural logarithms of all the p.d. values, and enter them in the third column of the table.

(b) Complete the table by filling in the three remaining natural logarithm values.

(2)

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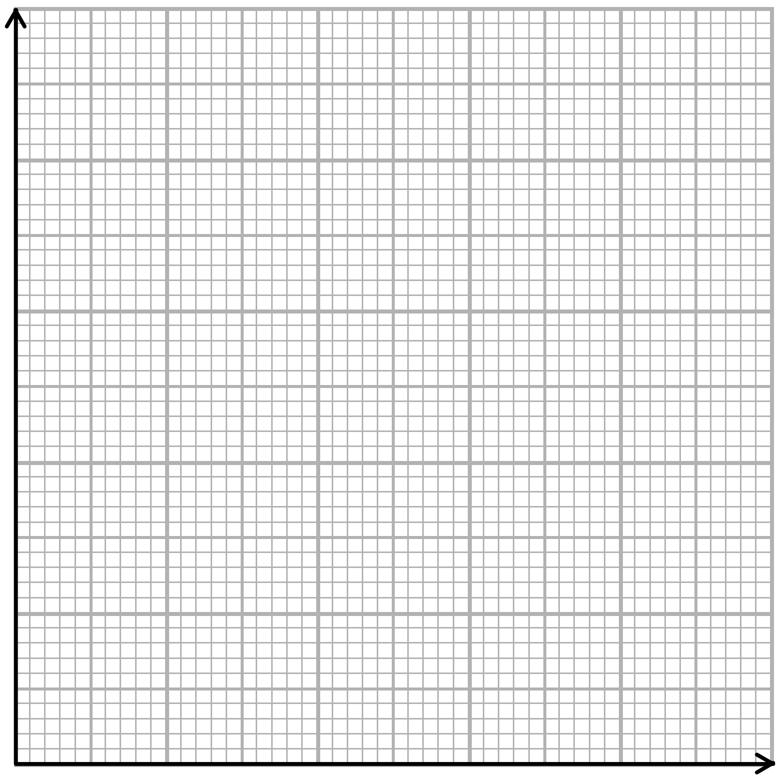
(c) Plot an appropriate graph on the grid below to show that the p.d. is falling exponentially.



(4)

(d) Use your graph to find a value for the resistance of the insulating material between the plates of the capacitor.

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Resistance = ...

(4)

Q3

(Total 12 marks)

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4. In 2007 the Large Hadron Collider (LHC) was opened at CERN. The circular accelerator is 27 km in circumference and has five thousand superconducting magnets. The LHC can give a proton an energy of up to 7 TeV.

$$1\ \text{TeV} = 1 \times 10^{12}\ \text{eV}$$

(a) One of the experiments on the LHC will attempt to create the Higgs particle, which has not been created by any of the existing, lower energy accelerators. The theoretical upper limit for the rest mass of the Higgs particle is 251 GeV/c^2.

Explain why the LHC should be able to create the Higgs particle.

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(2)

(b) Provided the energy of an accelerated particle is much greater than its rest-mass energy, its momentum may be calculated using

$$\text{momentum} = \frac{\text{particle energy}}{c}$$

(i) Show that a 7 TeV proton has energy much greater than its rest-mass energy.

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(2)

(ii) Show that the momentum of a 7 TeV proton is about 4×10^{-15} kg m s^{-1}.

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(2)

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(iii) Calculate the magnetic flux density provided by the superconducting magnets.

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Magnetic flux density = ...

(4)

(iv) A student says "The magnetic field needs to be in the vertical direction to cause the protons to travel in a horizontal circle". Comment on this statement.

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(2)

Q4

(Total 12 marks)

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5. When songs by groups such as The Beatles were recorded in the 1960s, they were recorded in analogue form onto magnetic tape.

(a) More recently, all significant music from that time has been digitally remastered.

Outline the principles of this process.

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(5)

(b) Give **two** reasons why it is desirable to remaster digitally.

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(2)

Q5

(Total 7 marks)

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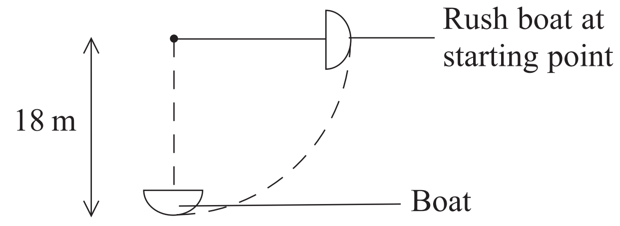
6. On one type of theme park ride, a boat swings freely along a circular path from successively higher starting positions. As the boat moves through the lowest point on its swing, the riders are travelling at high speeds, and feel quite big forces on them.

With some rides, such as Rush at Thorpe Park, the highest starting point is with the supporting arm horizontal as shown.



The length of the supporting arm of Rush is 18 m. The mass of a typical rider is 70 kg.

(a) Calculate the maximum "g-force" felt by a typical rider on Rush.

$$\text{“g-force”} = \frac{\text{force from seat}}{\text{weight of rider}}$$

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(5)

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(b) Two students in the queue are having a discussion.

A says: "If they made a new ride twice as big the g-force at the bottom would be amazing!"

B says: "I think the g-force wouldn't be any different."

With reference to your calculation, explain which student is correct.

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(1) **Q6**

(Total 6 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	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
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	$E = -d(N\Phi)/dt$

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