Write your name here

| Surname | Other names |
|---|---|
| | |

Centre Number

Candidate Number

**Edexcel GCE**

# Physics

## Advanced Level
## Unit 6B: Experimental Physics
## International Alternative to Internal Assessment

Tuesday 1 February 2011 – Morning
**Time: 1 hour 20 minutes**

Paper Reference
**6PH08/01**

**You must have:**
Protractor, ruler.

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

## Information

- The total mark for this paper is 40.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

## Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶





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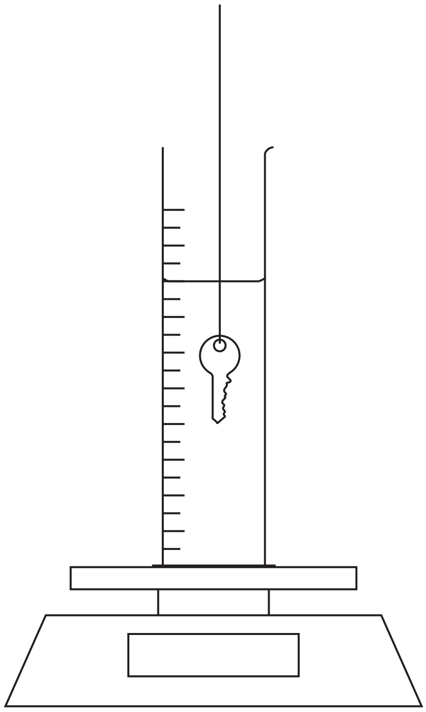
**Answer ALL questions.**

1 A student wants to find the density of a key by using a top pan balance to measure the upthrust acting on the key when it is suspended in water.



(a) First, she finds the density of the water.

Using a top pan balance calibrated in newtons, she measures the weight of an empty measuring cylinder as 2.2305 N. She puts 191 $cm^3$ of water into the cylinder and measures the new weight as 4.1408 N. The measuring cylinder is left on the balance.

(i) Use these measurements to calculate the weight of water in the cylinder.

**(1)**

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Weight of water = ....................................................

(ii) Show that the density of the water is about 1000 kg $m^{-3}$.

**(2)**

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(b) When an object is submerged in a fluid it experiences an upthrust equal to the weight of fluid displaced. In this experiment the balance reading will increase by the amount of this upthrust.

(i) The student now suspends the key in the water and notes that the balance reading increases to 4.1671 N. Calculate the upthrust.

**(1)**

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Upthrust = ..............................................

(ii) The upthrust $U$ on the key is given by

$$U = V\rho g$$

where $V$ is the volume of the key and $\rho$ is the density of the water.

Calculate the volume of the key.

**(2)**

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Volume = ..............................................

(iii) She measures the mass of the key on its own as 9.38 g.

Calculate the density of the key.

**(2)**

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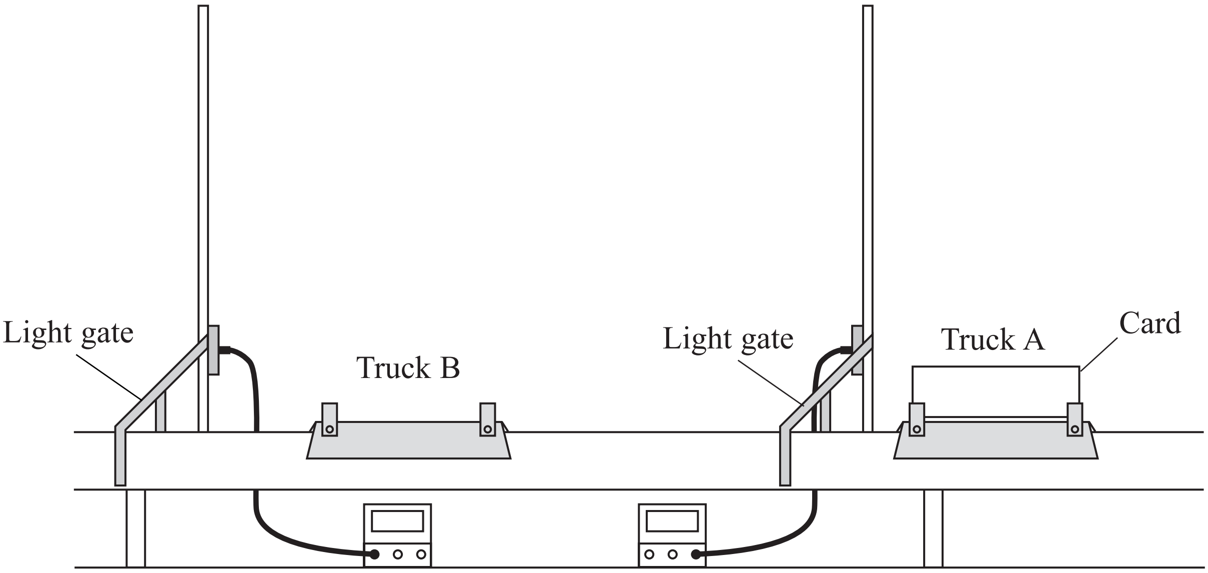
Density = ..............................................

**(Total for Question 1 = 8 marks)**

**2** A student has an air track which has two trucks, A and B, supported by a cushion of air. He does an experiment to see whether momentum is conserved when the two trucks collide.




(a) Using an air track reduces friction on the trucks. State why this is important in a momentum conservation experiment.

**(1)**

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(b) The student uses two light gates as shown in the diagram. Truck A carries a card of negligible mass and length *l*. A light gate records the time *t* taken by the card to pass through it.

Explain how you would show that the air track is horizontal before starting the experiment.

**(2)**

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N 3 7 5 0 5 A 0 4 1 6

(c) Truck B carries no card and is placed so that it is stationary between the light gates. Truck A is set off towards truck B. As the card passes through the first gate it records a time $t_1$. Truck A then collides with truck B. They stick together and move through the second gate which records the time $t_2$.

Both trucks have the same mass. Explain why $t_2 = 2t_1$ if momentum is conserved.

**(3)**

(d) The student records the following data for 5 separate collisions:

| | | | | | |
|---|---|---|---|---|---|
| $t_1$/s | 0.34 | 0.15 | 0.21 | 0.28 | 0.24 |
| $t_2$/s | 0.70 | 0.35 | 0.39 | 0.55 | 0.52 |
| $t_2$/ $t_1$ | 2.1 | 2.3 | 1.9 | 2.0 | 2.2 |

Use this data to discuss whether momentum can be considered to be conserved in this experiment.

**(3)**

**(Total for Question 2 = 9 marks)**

**3** A student measures the energy stored in a capacitor of unknown capacitance.

She charges the capacitor to a potential difference $V$ using a battery and then discharges the capacitor through a joulemeter which records the energy $W$ stored in the capacitor. She uses two different batteries and records the following readings.

| $V$/V | $W$/mJ | | | Mean $W$/mJ | $C$/mF |
|---|---|---|---|---|---|
| 4.5 | 19.57 | 19.51 | 19.63 | | |
| 6.0 | 36.14 | 36.12 | 36.22 | | |

(a) (i) For each potential difference, calculate the mean energy $W$ stored in the capacitor. Hence calculate the capacitance $C$ using the formula $W = \frac{1}{2} CV^2$.

Add your values to the table.

**(2)**

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(ii) Calculate the percentage difference between your two values of $C$.

**(1)**

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Percentage difference = ..............................................

(b) The uncertainty in the values of potential difference in the table is 0.1 V.

(i) Estimate the uncertainty in your mean value of *W* when using the 4.5 V battery.

**(1)**

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Uncertainty = ..............................................

(ii) Use these uncertainties to estimate the percentage uncertainty in the value of *C* obtained using the 4.5 V battery.

**(2)**

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Percentage uncertainty = ..............................................

(c) Explain whether the unknown capacitor could be a 2200 μF capacitor with a tolerance of 20%.

**(2)**

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**(Total for Question 3 = 8 marks)**

**4** *You are to plan an experiment to investigate the rate of cooling of cooking oil. You are then to analyse a set of data from such an experiment.*

(a) You are provided with a thermometer and a stop clock to record temperature and time. You also have access to all usual laboratory apparatus.

A liquid loses heat at a rate proportional to its temperature difference above its surroundings. This leads to the temperature difference $\Delta\theta$ at a time $t$ being given by

$$\Delta\theta = \Delta\theta_0 \, e^{-kt}$$

where $k$ is a constant for the liquid.

Describe the measurements you would make to verify this relationship. Your description should include:

- a variable you will control to make it a fair investigation
- how you will make your results as accurate as possible.

**(5)**

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(b) The following data were obtained using cooking oil. $\theta$ is the temperature at time $t$.
Room temperature = 22 °C

| $t$/s | $\theta$/°C | | |
|---|---|---|---|
| 0 | 70 | | |
| 60 | 63 | | |
| 120 | 56 | | |
| 180 | 51 | | |
| 240 | 46 | | |
| 300 | 43 | | |
| 360 | 39 | | |

(i) Explain why a graph of $\ln \Delta\theta$ against $t$ should be a straight line.

**(1)**

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(ii) Use the column(s) provided for your processed data, and then plot a suitable graph on the grid below to show that these data are consistent with $\Delta\theta = \Delta\theta_0 e^{-kt}$.

**(5)**

(iii) Use your graph to determine a value of the constant $k$ for the oil.

**(3)**

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$k$ = ..............................................

(c) Your teacher suggests using a temperature sensor and a data logger in place of the thermometer and stop clock.

State an advantage of using a temperature sensor and a data logger in this experiment.

**(1)**

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**(Total for Question 4 = 15 marks)**

**TOTAL FOR PAPER = 40 MARKS**

## List of data, formulae and relationships

| | | |
|---|---|---|
| Acceleration of free fall | $g = 9.81 \text{ m s}^{-2}$ | (close to Earth's surface) |
| Boltzmann constant | $k = 1.38 \times 10^{-23} \text{ J K}^{-1}$ | |
| Coulomb's law constant | $k = 1/4\pi\varepsilon_0$ | |
| | $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$ | |
| Electron charge | $e = -1.60 \times 10^{-19} \text{ C}$ | |
| Electron mass | $m_e = 9.11 \times 10^{-31} \text{ kg}$ | |
| Electronvolt | $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$ | |
| Gravitational constant | $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ | |
| Gravitational field strength | $g = 9.81 \text{ N kg}^{-1}$ | (close to Earth's surface) |
| Permittivity of free space | $\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ | |
| Planck constant | $h = 6.63 \times 10^{-34} \text{ J s}$ | |
| Proton mass | $m_p = 1.67 \times 10^{-27} \text{ kg}$ | |
| Speed of light in a vacuum | $c = 3.00 \times 10^8 \text{ m s}^{-1}$ | |
| Stefan-Boltzmann constant | $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ | |
| Unified atomic mass unit | $u = 1.66 \times 10^{-27} \text{ kg}$ | |

### *Unit 1*

*Mechanics*

| | |
|---|---|
| Kinematic equations of motion | $v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| Forces | $\Sigma F = ma$<br>$g = F/m$<br>$W = mg$ |
| Work and energy | $\Delta W = F\Delta s$<br>$E_k = \frac{1}{2}mv^2$<br>$\Delta E_{grav} = mg\Delta h$ |

*Materials*

| | |
|---|---|
| Stokes' law | $F = 6\pi\eta rv$ |
| Hooke's law | $F = k\Delta x$ |
| Density | $\rho = m/V$ |
| Pressure | $p = F/A$ |
| Young's modulus | $E = \sigma/\varepsilon$ where<br>Stress $\sigma = F/A$<br>Strain $\varepsilon = \Delta x/x$ |
| Elastic strain energy | $E_{el} = \frac{1}{2}F\Delta x$ |

**_Unit 2_**

*Waves*

| | |
|---|---|
| Wave speed | $v = f\lambda$ |
| Refractive index | ${}_1\mu_2 = \sin i/\sin r = v_1/v_2$ |

*Electricity*

| | |
|---|---|
| Potential difference | $V = W/Q$ |
| Resistance | $R = V/I$ |
| Electrical power, energy and efficiency | $P = VI$<br>$P = I^2R$<br>$P = V^2/R$<br>$W = VIt$ |

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{power input}} \times 100$$

| | |
|---|---|
| Resistivity | $R = \rho l/A$ |
| Current | $I = \Delta Q/\Delta t$<br>$I = nqvA$ |
| Resistors in series | $R = R_1 + R_2 + R_3$ |
| Resistors in parallel | $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ |

*Quantum physics*

| | |
|---|---|
| Photon model | $E = hf$ |
| Einstein's photoelectric equation | $hf = \phi + \frac{1}{2}mv^2_{max}$ |

***Unit 4***

*Mechanics*

| | |
|---|---|
| Momentum | $p = mv$ |
| Kinetic energy of a non-relativistic particle | $E_k = p^2/2m$ |
| Motion in a circle | $v = \omega r$<br>$T = 2\pi/\omega$<br>$F = ma = mv^2/r$<br>$a = v^2/r$<br>$a = r\omega^2$ |

*Fields*

| | |
|---|---|
| Coulomb's law | $F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$ |
| Electric field | $E = F/Q$<br>$E = kQ/r^2$<br>$E = V/d$ |
| Capacitance | $C = Q/V$ |
| Energy stored in capacitor | $W = \frac{1}{2}QV$ |
| Capacitor discharge | $Q = Q_0 e^{-t/RC}$ |
| In a magnetic field | $F = BIl \sin\theta$<br>$F = Bqv \sin\theta$<br>$r = p/BQ$ |
| Faraday's and Lenz's Laws | $\varepsilon = -d(N\phi)/dt$ |

*Particle physics*

| | |
|---|---|
| Mass-energy | $\Delta E = c^2 \Delta m$ |
| de Broglie wavelength | $\lambda = h/p$ |

***Unit 5***

*Energy and matter*

| | |
|---|---|
| Heating | $\Delta E = mc\Delta\theta$ |
| Molecular kinetic theory | $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ |
| Ideal gas equation | $pV = NkT$ |

*Nuclear Physics*

| | |
|---|---|
| Radioactive decay | $\mathrm{d}N/\mathrm{d}t = -\lambda N$ |
| | $\lambda = \ln 2/t_{½}$ |
| | $N = N_0 e^{-\lambda t}$ |

*Mechanics*

| | |
|---|---|
| Simple harmonic motion | $a = -\omega^2 x$<br>$a = -A\omega^2 \cos \omega t$<br>$v = -A\omega \sin \omega t$<br>$x = A \cos \omega t$<br>$T = 1/f = 2\pi/\omega$ |
| Gravitational force | $F = Gm_1m_2/r^2$ |

*Observing the universe*

| | |
|---|---|
| Radiant energy flux | $F = L/4\pi d^2$ |
| Stefan-Boltzmann law | $L = \sigma T^4 A$<br>$L = 4\pi r^2 \sigma T^4$ |
| Wien's Law | $\lambda_{max} T = 2.898 \times 10^{-3}$ m K |
| Redshift of electromagnetic radiation | $z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$ |
| Cosmological expansion | $v = H_0 d$ |

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