Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
June 2004
Advanced Level Examination

PHYSICS (SPECIFICATION B) **PHB6/2**
Unit 6 Exercise 2

Friday 21 May 2004 Morning Session

In addition to this paper you will require:
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Instructions
- Use blue or black ink or ball-point pen.
- Answer **all** questions.
- *Formulae Sheets* are provided on pages 3 and 4. Detach this perforated page at the start of the examination.
- There are two questions in this paper. 45 minutes are allowed for Question 1 and 45 minutes for Question 2.
- All working must be shown. Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 39.
- Mark allocations are shown in brackets.
- You are expected to use a calculator where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate.
- The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

Advice
- Before commencing the first part of any question, read the question through completely.
- Ensure that **all** measurements taken, including repeated readings, gradients, derived quantities, etc., are recorded to an appropriate number of significant figures with due regard to the accuracy of measurement.
- If an experiment does not operate correctly, you should request assistance from the Supervisor. The Supervisor will give the minimum help necessary to make the experiment operate and will report the action taken to the Examiner. If the fault is due to your inability to make the experiment operate, a deduction of marks will be made, but it will be possible for you to complete the remainder of the question and gain marks for the later parts of that question.

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Answer **all** questions in the spaces provided.

Total for this question: ***20 marks***

1 You are first going to determine a value for the specific heat capacity of sand. You will go on to plan an improved experiment.

You have been provided with the apparatus shown in **Figure 1**.

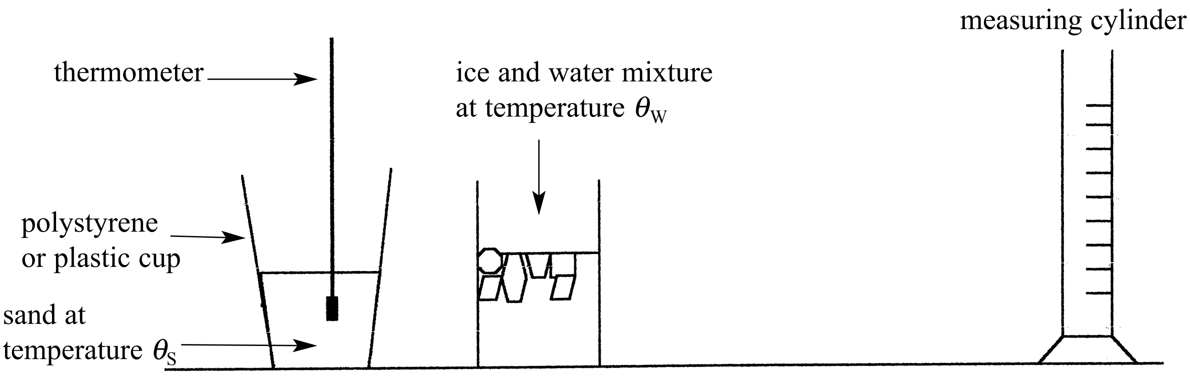


Figure 1

The polystyrene or plastic cup contains (0.120 ± 0.001) kg of dry sand.

(a) (i) In this part make all temperature measurements to the nearest 0.5 °C. Clean and/or dry the thermometer between measurements using the paper towels provided.

Record the initial temperature, θ_S, of the sand and the initial temperature, θ_W, of the ice and water mixture.

Measure 60 cm^3 of water taking care not to transfer any ice to the measuring cylinder.

Add the water to the sand and stir the mixture.

Record the lowest temperature, θ_F, reached by the mixture of water and sand.

You are not required to repeat this procedure.

(2 marks)

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

moment of force $= Fd$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

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

$s = \frac{1}{2}(u + v)t$

for a spring, $F = k\Delta l$

energy stored in a spring $= \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$

$T = \dfrac{1}{f}$

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

in series circuit, $R = R_1 + R_2 + R_3 + ...$

in parallel circuit, $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + ...$

output voltage across $R_1 = \left(\dfrac{R_1}{R_1 + R_2}\right) \times$ input voltage

Waves and Nuclear Physics Formulae

fringe spacing $= \dfrac{\lambda D}{d}$

single slit diffraction minimum $\sin\theta = \dfrac{\lambda}{b}$

diffraction grating $n\lambda = d\sin\theta$

Doppler shift $\dfrac{\Delta f}{f} = \dfrac{v}{c}$ for $v << c$

Hubble law $v = Hd$

radioactive decay $A = \lambda N$

Properties of Quarks

Type of quark	Charge	Baryon number
up u	$+\frac{2}{3}e$	$+\frac{1}{3}$
down d	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{\text{u}}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{\text{d}}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

Lepton Numbers

Particle	Lepton number L		
	L_e	L_μ	L_τ
e^-	1		
e^+	–1		
ν_e	1		
$\overline{\nu}_e$	–1		
μ^-		1	
μ^+		–1	
ν_μ		1	
$\overline{\nu}_\mu$		–1	
τ^-			1
τ^+			–1
ν_τ			1
$\overline{\nu}_\tau$			–1

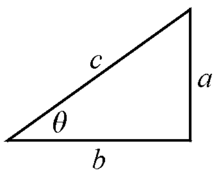
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

area of a circle $= \pi r^2$

surface area of sphere $= 4\pi r^2$

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



$\sin\theta = \dfrac{a}{c}$

$\cos\theta = \dfrac{b}{c}$

$\tan\theta = \dfrac{a}{b}$

$c^2 = a^2 + b^2$

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Circular Motion and Oscillations

$$v = r\omega$$

$$a = -(2\pi f)^2 x$$

$$x = A\cos 2\pi f t$$

$$\text{maximum } a = (2\pi f)^2 A$$

$$\text{maximum } v = 2\pi f A$$

$$\text{for a mass-spring system, } T = 2\pi\sqrt{\frac{m}{k}}$$

$$\text{for a simple pendulum, } T = 2\pi\sqrt{\frac{l}{g}}$$

Fields and their Applications

$$\text{uniform electric field strength, } E = \frac{V}{d} = \frac{F}{Q}$$

$$\text{for a radial field, } E = \frac{kQ}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$g = \frac{F}{m}$$

$$g = \frac{GM}{r^2}$$

$$\text{for point masses, } \Delta E_p = GM_1M_2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\text{for point charges, } \Delta E_p = kQ_1Q_2\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\text{for a straight wire, } F = BIl$$

$$\text{for a moving charge, } F = BQv$$

$$\phi = BA$$

$$\text{induced emf} = \frac{\Delta(N\phi)}{t}$$

$$E = mc^2$$

Temperature and Molecular Kinetic Theory

$$T/\text{K} = \frac{(pV)_T}{(pV)_{tr}} \times 273.16$$

$$pV = \tfrac{1}{3} Nm\langle c^2\rangle$$

$$\text{energy of a molecule} = \tfrac{3}{2} kT$$

Heating and Working

$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

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

$$\text{work done on gas} = p\Delta V$$

$$\text{work done on a solid} = \tfrac{1}{2} F\Delta l$$

$$\text{stress} = \frac{F}{A}$$

$$\text{strain} = \frac{\Delta l}{l}$$

$$\text{Young modulus} = \frac{\text{stress}}{\text{strain}}$$

Capacitance and Exponential Change

$$\text{in series, } \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{in parallel, } C = C_1 + \mathrm{C}_2$$

$$\text{energy stored by capacitor} = \tfrac{1}{2} QV$$

$$\text{parallel plate capacitance, } C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

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

$$\text{time constant} = RC$$

$$\text{time to halve} = 0.69\,RC$$

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

$$A = A_0 e^{-\lambda t}$$

$$\text{half-life, } t_{\frac{1}{2}} = \frac{0.69}{\lambda}$$

Momentum and Quantum Phenomena

$$Ft = \Delta(mv)$$

$$E = hf$$

$$hf = \Phi + E_{k(\max)}$$

$$hf = E_2 - E_1$$

$$\lambda = \frac{h}{mv}$$

(ii) The specific heat capacity of the sand is given by the equation

$$Mc_W(\theta_F - \theta_W) = mc(\theta_S - \theta_F)$$

where M is the mass of the water added to the sand, (0.060 ± 0.001) kg
m is the mass of the sand, (0.120 ± 0.001) kg
c_W is the specific heat capacity of water, $(4200 \pm 20)\,\mathrm{J\,kg^{-1}\,K^{-1}}$
c is the specific heat capacity of sand.

Calculate a value for c.

(3 marks)

(b) (i) Calculate the absolute uncertainty in $(\theta_F - \theta_W)$ and $(\theta_S - \theta_F)$.

(1 mark)

(ii) Calculate the percentage uncertainty in your value for c.

(3 marks)

(c) For the water, state and explain whether ΔU, W and Q increase, decrease or remain unchanged during the process in part (a)(i), when the water is added to the sand.
ΔU, W and Q are the usual symbols used in the first law of thermodynamics.

ΔU ....

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W ....

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Q ....

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(3 marks)

QUESTION 1 CONTINUES ON THE NEXT PAGE

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(d) Consider the reasons why the design of the apparatus and/or the procedure used in the experiment makes your value for *c* inaccurate. Describe how you would change the apparatus or procedure to determine a more reliable value for *c*. Your answer should include reasons for the changes you suggest.

Two of the 8 marks in this question are available for the quality of your written communication.

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(8 marks)

20

TURN OVER FOR THE NEXT QUESTION

Total for this question: *19 marks*

2 **Figure 2** shows a simplified view of an arrangement that can be used to investigate the variation of the electrostatic force, F, between two similarly charged spheres **A** and **B** with r, the separation of their centres.

You have been provided with the arrangement shown in **Figure 3**. This can be used to investigate magnetic forces in a similar way to that used in **Figure 2**.

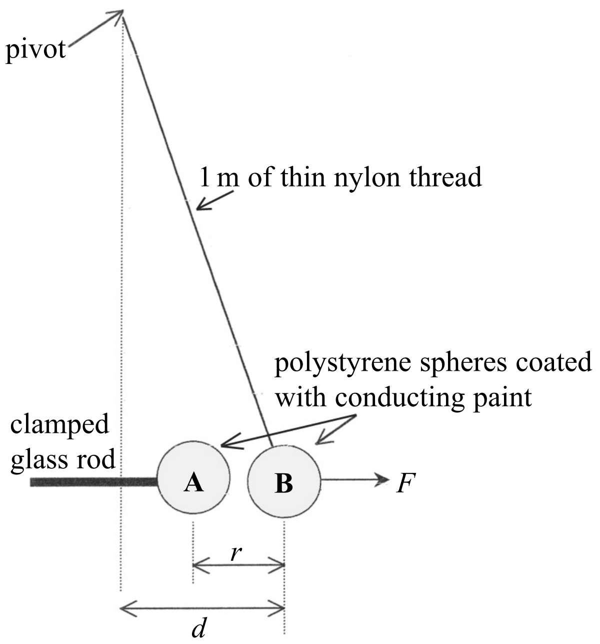

Figure 2

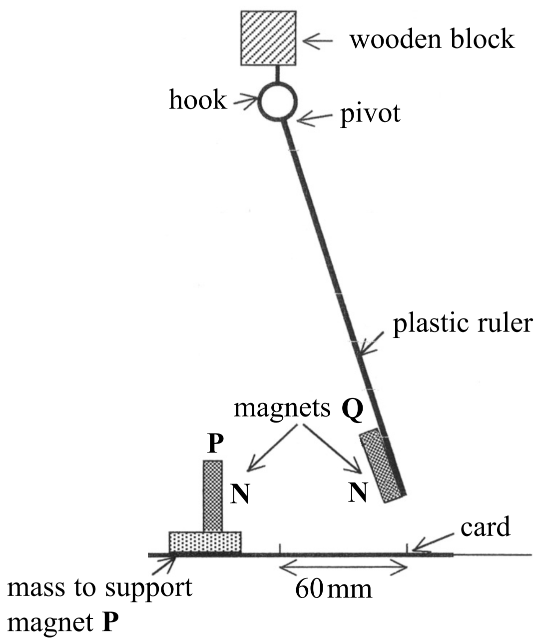

Figure 3

(a) (i) When magnet **P** is not present **Q** hangs at rest approximately vertically. Align the left hand line on the card with the bottom edge of the plastic ruler with **P** removed.

Position the magnet **P** as shown in **Figure 3** and adjust its position so that the bottom edge of the plastic ruler is aligned with the right hand line on the card.

Determine the separation of the centres of the two **N** pole faces of the magnets.

(1 mark)

(ii) State and explain how the displacement of **Q** from its original position varies with the separation of the two **N** pole faces. You are **not** required to do any quantitative analysis in this part.

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(2 marks)

(b) When a horizontal force, *F,* is applied to **B**, it is displaced a distance *d* as shown in **Figure 2**.

(i) Show, on **Figure 2**, the other forces acting on **B** when it is at rest in the position shown. *(2 marks)*

(ii) Use the principle of moments to show that *d* is proportional to *F* for small displacements.

(2 marks)

(c) A student used the apparatus shown in **Figure 2** and measured four corresponding values of *r* and *d*. The table below shows the measurements that were made.

r/mm	*d*/mm
15	65
23	27
31	15
40	9

It is suggested that, for the arrangement in **Figure 2**, the relationship between the horizontal electrostatic force, *F,* and separation, *r,* is

$$F \propto \frac{1}{r^2}$$

Without drawing a graph use the measurements in the table to test whether they support this relationship. Show your method and state your conclusions clearly.

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(5 marks)

QUESTION 2 CONTINUES ON THE NEXT PAGE

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(d) In practice the electrostatic data was obtained remotely using photography. A more detailed view of the apparatus is shown in **Figure 4**.

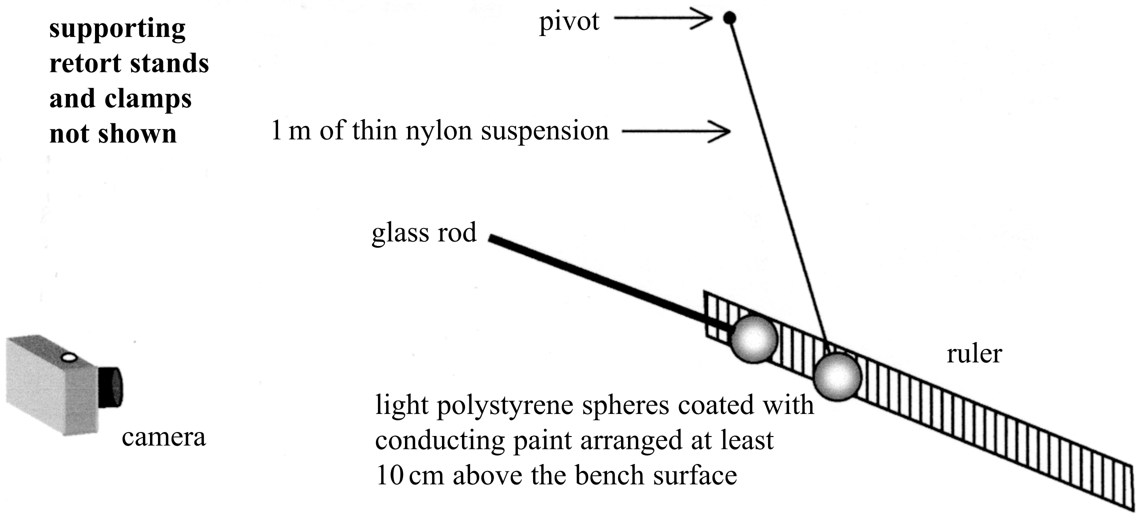

Figure 4

Compare the arrangement in **Figure 4** with that shown in **Figure 3** which you used in your answer to part (a)(i). Explain why it was necessary for the experimenter to make the measurements remotely. Go on to explain the reasons for other differences in the design of the apparatus between the two experiments.

Two of the 7 marks in this question are for the quality of your written communication.

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(7 marks)

19

END OF QUESTIONS

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