Electrical current and potential difference

Electric current	$I = nAQv$	
Electric power	$P = I^2R$	

Electrical circuits

Terminal potential difference	$V = \mathcal{E} - Ir$	(E.m.f. $\mathcal{E}$; Internal resistance r)
Circuit e.m.f.	$\Sigma\mathcal{E} = \Sigma IR$	
Resistors in series	$R = R_1 + R_2 + R_3$	
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	

Heating matter

Change of state:	energy transfer $= l\Delta m$	(Specific latent heat or specific enthalpy change l)
Heating and cooling:	energy transfer $= mc\Delta T$	(Specific heat capacity c; Temperature change ΔT)
Celsius temperature	$\theta/°\text{C} = T/\text{K} - 273$	

Kinetic theory of matter

	$T \propto$ Average kinetic energy of molecules
Kinetic theory	$p = \frac{1}{3}\rho\langle c^2\rangle$

Conservation of energy

Change of internal energy	$\Delta U = \Delta Q + \Delta W$	(Energy transferred thermally ΔQ; Work done on body ΔW)
Efficiency of energy transfer	$= \frac{\text{Useful output}}{\text{Input}}$	
For a heat engine, maximum efficiency	$= \frac{T_1 - T_2}{T_1}$	

Experimental physics

$$\text{Percentage uncertainty} = \frac{\text{Estimated uncertainty} \times 100\%}{\text{Average value}}$$

Mathematics

	$\sin(90° - \theta) = \cos\theta$	
Equation of a straight line	$y = mx + c$	
Surface area	cylinder $= 2\pi rh + 2\pi r^2$	
	sphere $= 4\pi r^2$	
Volume	cylinder $= \pi r^2 h$	
	sphere $= \frac{4}{3}\pi r^3$	
For small angles:	$\sin\theta \approx \tan\theta \approx \theta$	(in radians)
	$\cos\theta \approx 1$	

N 3 1 2 0 2 A 0 1 2 1 2

Pre-Standardisation

Centre No.						Paper Reference							Surname	Other names
Candidate No.						6	7	3	3	/	2	A	Signature	

Edexcel GCE

Physics

Advanced Subsidiary

Unit Test PHY3 Practical Test

Group 1

Wednesday 14 May 2008 – Afternoon

Time: 1 hour 30 minutes

For Examiner's use only	
For Team Leader's use only	
Question numbers	Leave blank
1A	
1B	
Total	

Supervisor's Data and Comments			
1A	a(i)	Tick if circuit set up for candidate (Give details below)	
	a(ii)	Tick if the candidate needed assistance connecting the voltmeter	
1B		Weight of the suspended rule	
Comments			

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, other names and signature.

PHY3 consists of questions 1A and 1B. Each question is allowed 35 minutes plus 5 minutes writing-up time. There is a further 10 minutes for writing-up at the end. The Supervisor will tell you which experiment to attempt first.

Write all your results, calculations and answers in the spaces provided in this question booklet.

In calculations you should show all the steps in your working, giving your answer at each stage.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets.

The total mark for this paper is 48.

The list of data, formulae and relationships is printed at the end of this booklet.

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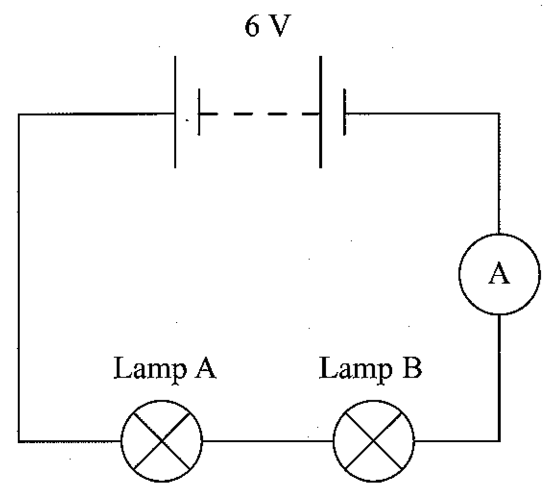
Question 1A

(a) (i) Set up the circuit as shown in the diagram below. Note at this stage the voltmeter with which you have been provided is not used.

Before you connect your circuit to the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will only lose two marks for this.



Circuit set up correctly without help. **(2)** 2.

(ii) Connect the power supply and measure the current I in the circuit.

I = 0.055 A. | I to 1mA or better between 50mA and 65mA with unit **(1)** 1

(iii) Observe lamps A and B. State and explain your observations.

Lamp B is brighter than lamp A | (1)

Temperature of lamp B must be greater than temperature of lamp A. | (1)

(2) 2.

(iv) Use the voltmeter to measure the potential difference V_A across lamp A and then the potential difference V_B across lamp B. If you do not know how to connect the voltmeter into the circuit, ask the Supervisor for assistance. You will only lose one mark for this.

V_A = 0.22 V | Both measured to 0.01V or better with unit (1)

V_B = 5.66 V. | $V_B >> V_A$ with $5.0V \leq V_A + V_B \leq 6.5V$ (1)

Disconnect the power supply.

No indication that Supervisor gave help (1)

N 3 1 2 0 2 A 0 2 1 2

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$	
Acceleration of free fall	$g = 9.81\text{m s}^{-2}$	(close to the Earth)
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to the Earth)
Elementary (proton) charge	$e = 1.60 \times 10^{-19}\ \text{C}$	
Electronic mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$	

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$
$$x = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2ax$$

Forces and moments

Moment of F about O = $F \times$ (Perpendicular distance from F to O)

Sum of clockwise moments about any point in a plane = Sum of anticlockwise moments about that point

Dynamics

Force $F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

Impulse $F\Delta t = \Delta p$

Mechanical energy

Power $P = Fv$

Radioactive decay and the nuclear atom

Activity $A = \lambda N$ (Decay constant λ)

Half-life $\lambda t_{\frac{1}{2}} = 0.69$

N 3 1 2 0 2 A 0 1 1 1 2

(g) A student wishes to investigate how $T \sin\theta$ depends on the mass suspended from the rule at the 90.0 cm mark. You are to plan this investigation. Your plan should include:

(i) an indication of the values in the equation which are constant,

(ii) a description of how the experiment would be performed,

(iii) a sketch of the graph to be plotted,

(iv) an indication of the expected results.

i) p, q, W and g are constant (1)

ii) Vary M (1)
Change the height of the boss holding the dowel to make the rule horizontal (1)
Measure h_2 (and h_1) to determine θ (and $\sin\theta$) (1)
Measure the length of the stretched spring (to find the extension) (1)
Use the calibration graph to determine the force. (1)
} Max (3)

iii) Plot $T \sin\theta$ against M. (1)

iv) Straight line +VE intercept (1)
Slope = $g(q/p)$, Intercept = W. (1)

(8)

8

Q1B 24

(Total 24 marks)

TOTAL FOR PAPER: 48 MARKS

END

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The normal operating voltage of both lamps is 6 V. Explain the relevance of your values of V_A and V_B to your observations in (iii).

$V_B \approx 6$ V, hence lamp close to normal operating voltage (1)
$V_A << 6$ V, much smaller than normal operating voltage (1)
Hence lamp B is close to normal brightness and lamp A is dim or does not glow. (1)

(6)

6

(b) (i) You have been provided with an inclined runway. Determine the time t taken for the sphere to travel a distance x of 0.800 m down the runway.

t = 1.41, 1.41, 1.41, 1.38, 1.43 s
$\bar{t}$ = 1.41 s.

t from ≥ 3 results + unit (2)
[2 results (1)]

(2)

2

(ii) The final speed v of the sphere at the end of the distance x is given by $v = \frac{2x}{t}$. Calculate v.

$$v = \frac{2 \times 0.8}{1.41}$$
= 1.13 m/s.

Correct calc. ≥ 2 s.f. + unit (1)

(1)

1

(iii) Use the top pan balance to measure the mass m of the sphere. Hence find the linear kinetic energy of the sphere after travelling 0.800 m down the runway.

Mass = 4.78 g.
$K.E. = \frac{1}{2} \times 4.78 \times 10^{-3} \times 1.13^2$
$= 3.05 \times 10^{-3}$ J.

Correct S.I. substitution (1)
Correct calc 2/3 s.f. + unit (1)

(2)

2

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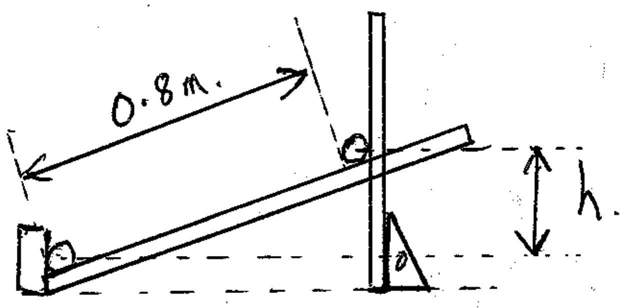
(iv) In the space below draw a diagram of the inclined runway. Show carefully on your diagram the vertical height h through which the sphere moved when it travelled a distance of 0.800 m down the runway.



Runway clear. (not just a triangle) and 0.8m shown (1)

h shown correctly (1)

Determine the height h. State any techniques you used to obtain an accurate value for h.

$h = 10.2$ cm — h recorded to nearest mm or better with unit (1)

Vertical rule checked with set square / Eye level with reading (1)

Hence find the gravitational potential energy lost by the sphere as it moved down the runway.

$mgh = 4.78\times10^{-3} \times 9.81 \times 0.102$

$= 4.78\times10^{-3}$ J. — Correct calc ≥ 2s.f. + unit (1)

(5)

5

Leave blank

(e) Measure the stretched length s of the coiled part of the spring. Using your value of l from part (a) determine the extension e of the spring.

$s =$ 174 mm. — s recorded to the nearest mm or better and in the region of 20cm. (1)

$e =$ 174 − 23 = 151 mm. — e calculated correctly with unit seen somewhere. (1)

Using the calibration graph from part (b) determine the tension T in the spring.

$T =$ 4.4 N. — Force read off graph correctly with unit (1)

(3)

3

(f) When the rule is horizontal and in equilibrium, the following equation applies:

$$T \sin\theta = g\left(\frac{q}{p}\right)M + W \qquad \text{where}$$

p = distance from the centre of the nail to the centre of mass of the rule, which may be assumed to be at the 50.0 cm mark,

q = distance from the centre of the nail to the position on the rule from which mass M is suspended,

W = weight of the metre rule.

Determine p and q and use the information from parts (d) and (e) to calculate W.

$p = 40.0$ cm.

$q = 80.0$ cm. — p and q correct (1)

$W = T\sin\theta - Mg\left(\frac{q}{p}\right)$

$= 4.4\sin(44.6) - 0.1\times9.81 \times \left(\frac{0.8}{0.4}\right)$ — Correct substitution (1)

$= 3.09 - 1.96$

$= 1.13$ N. — Correct calc of W to 2/3 s.f. + unit (1)

(3)

3

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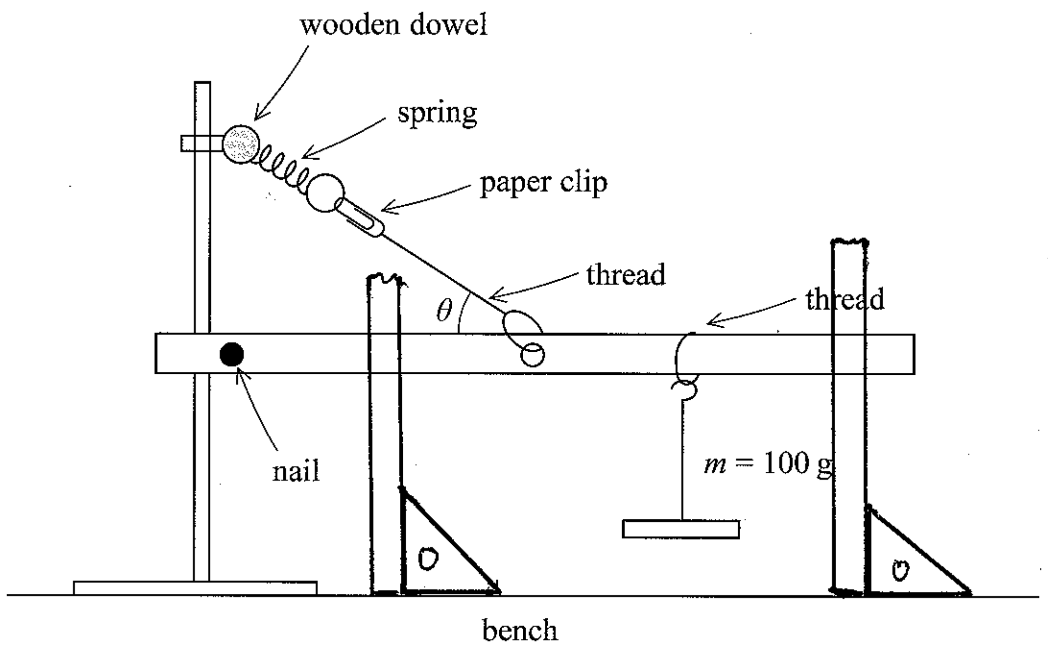
(c) The apparatus shown in the diagram below has already been set up for you. Move the mass $M = 100$ g so that it is suspended from the 90.0 cm mark on the rule.



Adjust the height of the boss holding the wooden dowel until the metre rule is horizontal. Explain how you ensured that the metre rule was horizontal. You may add to the above diagram if you wish.

Measured the height above the bench at 2 places. (1)

Used set square as shown to check metre rule vertical (1)

(2) 2

(d) Measure the height h_1 of the centre of the nail above the bench and the height h_2 of the centre of the dowel above the bench. Hence calculate the angle θ between the metre rule and the thread.

$h_1 = 345$ mm

$h_2 = \frac{1}{2}(747 + 735) = 741$ mm

$\tan\theta = \frac{741 - 345}{400}$

$= 0.99$

$\theta = 44.6°$

heights recorded to the nearest mm with units seen once (1)

Correct calc of θ, $\geq$ 2s.f. + unit (1)

(2) 2

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(v) Calculate the value of $\frac{\text{Kinetic energy gained by the sphere}}{\text{Gravitational potential energy lost}}$.

$\frac{3.05 \times 10^{-3}}{4.78 \times 10^{-3}}$

$= 0.64$

Value $0.60 \to 0.80$ (2)

[$0.50 \to 0.90$ (1)]

Calculate the percentage difference between your value of this ratio and the theoretical value which is 0.71.

% diff $= \frac{0.64 - 0.71}{0.71} \times 100\%$

$= 9.9\%$

Correct calc with 0.71 as denominator (1)

(3) 3

Q1A 24

(Total 24 marks)

N 3 1 2 0 2 A 0 5 1 2

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Question 1B

(a) Many modern road bridges have a single pillar from which the bridge is suspended. You are to investigate a model of this arrangement using the extension of a spring to measure the force.

An identical spring to the one used in the experimental arrangement must first be calibrated. Measure the unstretched length l of the coiled part of the vertically suspended spring.

l = 47.3 − 45.0 = 2.3 cm | l recorded to nearest mm or better and in range 1.6 cm to 2.4 cm with unit. (1)

Add the 100 g mass hanger to the spring and determine the extension x of the spring. Add further 100 g masses and determine the corresponding extensions.

The force F extending the spring is given by:

$$F = mg$$

where m = total mass suspended from the spring and g = gravitational field strength.

Use the table below for your results. The force F has been calculated for you. You may use the additional column to assist in the recording of your results.

m/kg	F/N	Position of lowest point/cm	x/mm
0.00	0.00	45.0	0
0.10	0.98	42.4	26
0.20	1.96	38.7	63
0.30	2.94	35.1	99
0.40	3.92	31.6	134
0.50	4.91	28.0	170

(4) 4

(b) Using the grid on page 7 plot a graph of x against F.

(2) 2

Scale readings shown (1)
5 points ± 2mm from examiners best fit line (2)
[4 points .... (1)]

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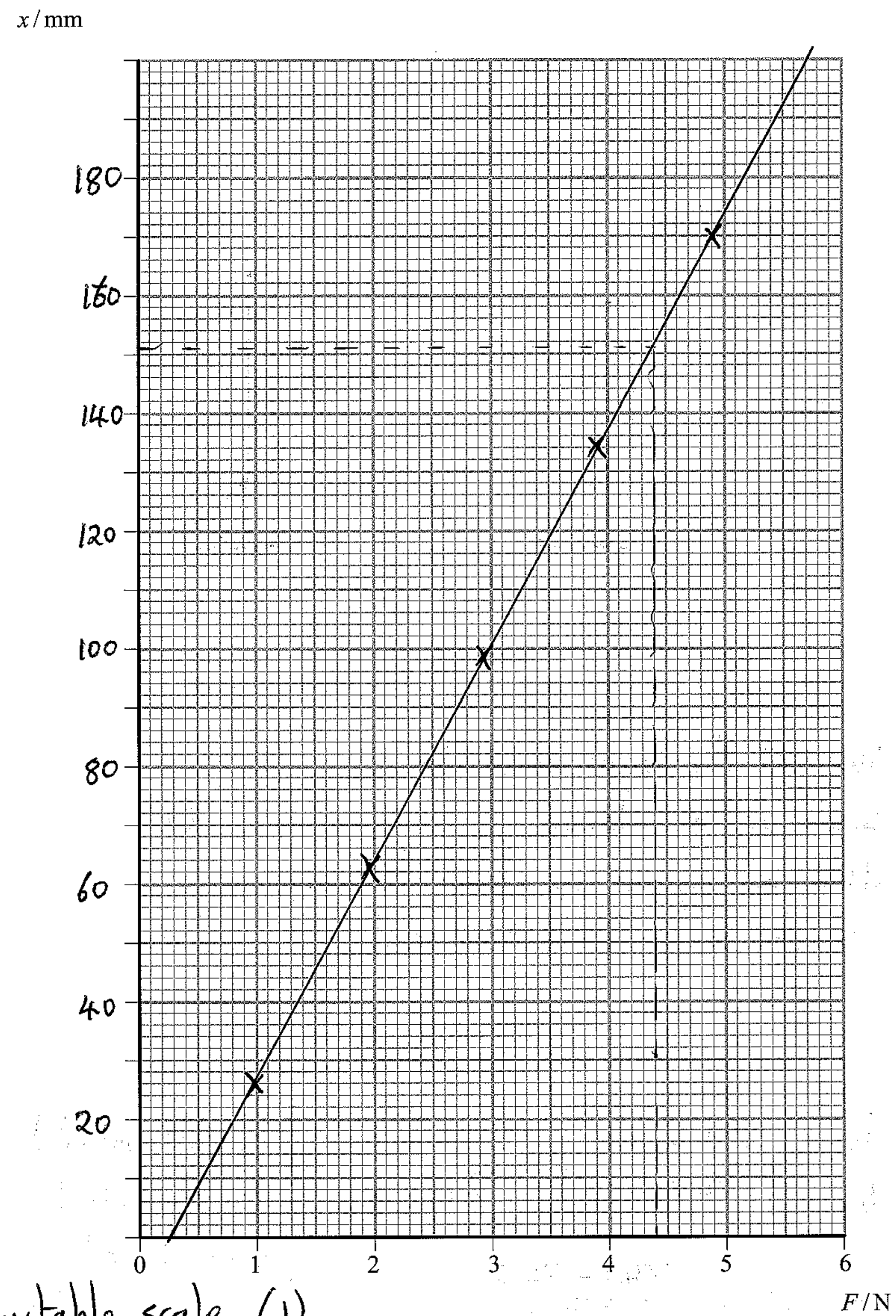

Suitable scale (1)
Plots and line (1)

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