

Surname						Other Names					
Centre Number						Candidate Number					
Candidate Signature											

For Examiner's Use

General Certificate of Education
 June 2007
 Advanced Subsidiary Examination



**PHYSICS (SPECIFICATION A)
 Practical (Unit 3)**

PHA3/P

Wednesday 16 May 2007 1.30 pm to 3.15 pm

<p>For this paper you must have:</p> <ul style="list-style-type: none"> • a calculator • a pencil and a ruler.

Time allowed: 1 hour 45 minutes

Instructions

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **both** questions.
- Answer the questions in the spaces provided.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The maximum mark for this paper is 30.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- You are advised to spend no more than 30 minutes on Question 1.

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

Data Sheet

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

Data Sheet

Fundamental constants and values				Mechanics and Applied Physics		Fields, Waves, Quantum Phenomena	
Quantity	Symbol	Value	Units				
speed of light in vacuo	c	3.00×10^8	m s^{-1}	$v = u + at$	$g = \frac{F}{m}$		
permeability of free space	μ_0	$4\pi \times 10^{-7}$	H m^{-1}	$s = \left(\frac{u+v}{2}\right)t$	$g = -\frac{GM}{r^2}$		
permittivity of free space	ϵ_0	8.85×10^{-12}	F m^{-1}	$s = ut + \frac{at^2}{2}$	$g = -\frac{\Delta V}{\Delta x}$		
charge of electron	e	1.60×10^{-19}	C	$v^2 = u^2 + 2as$	$V = -\frac{GM}{r}$		
the Planck constant	h	6.63×10^{-34}	J s	$F = \frac{\Delta(mv)}{\Delta t}$	$a = -(2\pi f)^2 x$		
gravitational constant	G	6.67×10^{-11}	$\text{N m}^2 \text{kg}^{-2}$	$P = Fv$	$v = \pm 2\pi f \sqrt{A^2 - x^2}$		
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}	$\text{efficiency} = \frac{\text{power output}}{\text{power input}}$	$x = A \cos 2\pi ft$		
molar gas constant	R	8.31	$\text{J K}^{-1} \text{mol}^{-1}$	$\omega = \frac{v}{r} = 2\pi f$	$T = 2\pi\sqrt{\frac{m}{k}}$		
the Boltzmann constant	k	1.38×10^{-23}	J K^{-1}	$a = \frac{v^2}{r} = r\omega^2$	$T = 2\pi\sqrt{\frac{l}{g}}$		
the Stefan constant	σ	5.67×10^{-8}	$\text{W m}^{-2} \text{K}^{-4}$	$I = \sum mr^2$	$\lambda = \frac{\omega s}{D}$		
the Wien constant	α	2.90×10^{-3}	m K	$E_k = \frac{1}{2} I\omega^2$	$d \sin \theta = n\lambda$		
electron rest mass	m_e	9.11×10^{-31}	kg	$\omega_2 = \omega_1 + at$	$\theta \approx \frac{\lambda}{D}$		
(equivalent to $5.5 \times 10^{-4}u$)				$\theta = \omega_1 t + \frac{1}{2} at^2$	$1n_2 = \frac{\sin \theta_1}{\sin \theta_2} = \frac{c_1}{c_2}$		
electron charge/mass ratio	e/m_e	1.76×10^{11}	C kg^{-1}	$\omega_2^2 = \omega_1^2 + 2\alpha\theta$	$1n_2 = \frac{n_2}{n_1}$		
proton rest mass	m_p	1.67×10^{-27}	kg	$\theta = \frac{1}{2}(\omega_1 + \omega_2)t$	$\sin \theta_c = \frac{1}{n}$		
(equivalent to 1.00728u)				$T = I\alpha$	$E = hf$		
proton charge/mass ratio	e/m_p	9.58×10^7	C kg^{-1}	$\text{angular momentum} = I\omega$	$hf = \phi + E_k$		
neutron rest mass	m_n	1.67×10^{-27}	kg	$W = T\theta$	$hf = E_1 - E_2$		
(equivalent to 1.00867u)				$P = T\omega$	$\lambda = \frac{h}{p} = \frac{h}{mv}$		
gravitational field strength	g	9.81	N kg^{-1}	$\text{angular impulse} = \text{change of angular momentum} = Tt$	$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$		
acceleration due to gravity	g	9.81	m s^{-2}	$\Delta Q = \Delta U + \Delta W$			
atomic mass unit	u	1.661×10^{-27}	kg	$\Delta W = p\Delta V$			
(1u is equivalent to 931.3 MeV)				$pV^\gamma = \text{constant}$			
Fundamental particles				$\text{work done per cycle} = \text{area of loop}$	Electricity		
Class	Name	Symbol	Rest energy /MeV	$\text{input power} = \text{calorific value} \times \text{fuel flow rate}$	$\epsilon = \frac{E}{Q}$		
photon	photon	γ	0	$\text{indicated power as (area of } p-v \text{ loop)} \times (\text{no. of cycles/s}) \times (\text{no. of cylinders})$	$\epsilon = I(R+r)$		
lepton	neutrino	ν_e	0	$\text{friction power} = \text{indicated power} - \text{brake power}$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$		
		ν_μ	0	$\text{efficiency} = \frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$	$R_T = R_1 + R_2 + R_3 + \dots$		
	electron	e^\pm	0.510999	$\text{maximum possible efficiency} = \frac{T_H - T_C}{T_H}$	$P = I^2 R$		
	muon	μ^\pm	105.659		$E = \frac{F}{Q} = \frac{V}{d}$		
mesons	pion	π^\pm	139.576		$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$		
		π^0	134.972		$E = \frac{1}{2} QV$		
	kaon	K^\pm	493.821		$F = BIl$		
		K^0	497.762		$F = BQv$		
baryons	proton	p	938.257				
	neutron	n	939.551				
Properties of quarks							
Type	Charge	Baryon number	Strangeness				
u	$+\frac{2}{3}$	$+\frac{1}{3}$	0				
d	$-\frac{1}{3}$	$+\frac{1}{3}$	0				
s	$-\frac{1}{3}$	$+\frac{1}{3}$	-1				
Geometrical equations							
arc length = $r\theta$							
circumference of circle = $2\pi r$							
area of circle = πr^2							
area of cylinder = $2\pi rh$							
volume of cylinder = $\pi r^2 h$							
area of sphere = $4\pi r^2$							

$$\text{magnitude of induced emf} = N \frac{\Delta\Phi}{\Delta t}$$

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

Mechanical and Thermal Properties

$$\text{the Young modulus} = \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F l}{A e}$$

$$\text{energy stored} = \frac{1}{2} Fe$$

$$\Delta Q = mc \Delta\theta$$

$$\Delta Q = ml$$

$$pV = \frac{1}{3} Nmc^2$$

$$\frac{1}{2} mc^2 = \frac{3}{2} kT = \frac{3RT}{2N_A}$$

Nuclear Physics and Turning Points in Physics

$$\text{force} = \frac{eV_p}{d}$$

$$\text{force} = Bev$$

$$\text{radius of curvature} = \frac{mv}{Be}$$

$$\frac{eV}{d} = mg$$

$$\text{work done} = eV$$

$$F = 6\pi\eta rv$$

$$I = k \frac{I_0}{x^2}$$

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$\lambda = \frac{h}{\sqrt{2meV}}$$

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

$$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

$$R = r_0 A^{\frac{1}{3}}$$

$$E = mc^2 = \frac{m_0 c^2}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

$$l = l_0 \left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}$$

$$t = \frac{t_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

Astrophysics and Medical Physics

Body	Mass/kg	Mean radius/m
Sun	2.00×10^{30}	7.00×10^8
Earth	6.00×10^{24}	6.40×10^6

$$1 \text{ astronomical unit} = 1.50 \times 10^{11} \text{ m}$$

$$1 \text{ parsec} = 206265 \text{ AU} = 3.08 \times 10^{16} \text{ m} = 3.26 \text{ ly}$$

$$1 \text{ light year} = 9.45 \times 10^{15} \text{ m}$$

$$\text{Hubble constant (H)} = 65 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

$$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$$

$$M = \frac{f_o}{f_c}$$

$$m - M = 5 \log \frac{d}{10}$$

$$\lambda_{\text{max}} T = \text{constant} = 0.0029 \text{ m K}$$

$$v = Hd$$

$$P = \sigma AT^4$$

$$\frac{\Delta f}{f} = \frac{v}{c}$$

$$\frac{\Delta \lambda}{\lambda} = -\frac{v}{c}$$

$$R_s \approx \frac{2GM}{c^2}$$

Medical Physics

$$\text{power} = \frac{1}{f}$$

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \text{ and } m = \frac{v}{u}$$

$$\text{intensity level} = 10 \log \frac{I}{I_0}$$

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

$$\mu_m = \frac{\mu}{\rho}$$

Electronics

Resistors

Preferred values for resistors (E24)
Series: 1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1 ohms
and multiples that are ten times greater

$$Z = \frac{V_{\text{rms}}}{I_{\text{rms}}}$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$

$$C_T = C_1 + C_2 + C_3 + \dots$$

$$X_C = \frac{1}{2\pi fC}$$

Alternating Currents

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

Operational amplifier

$$G = \frac{V_{\text{out}}}{V_{\text{in}}} \quad \text{voltage gain}$$

$$G = -\frac{R_f}{R_1} \quad \text{inverting}$$

$$G = 1 + \frac{R_f}{R_1} \quad \text{non-inverting}$$

$$V_{\text{out}} = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right) \text{ summing}$$

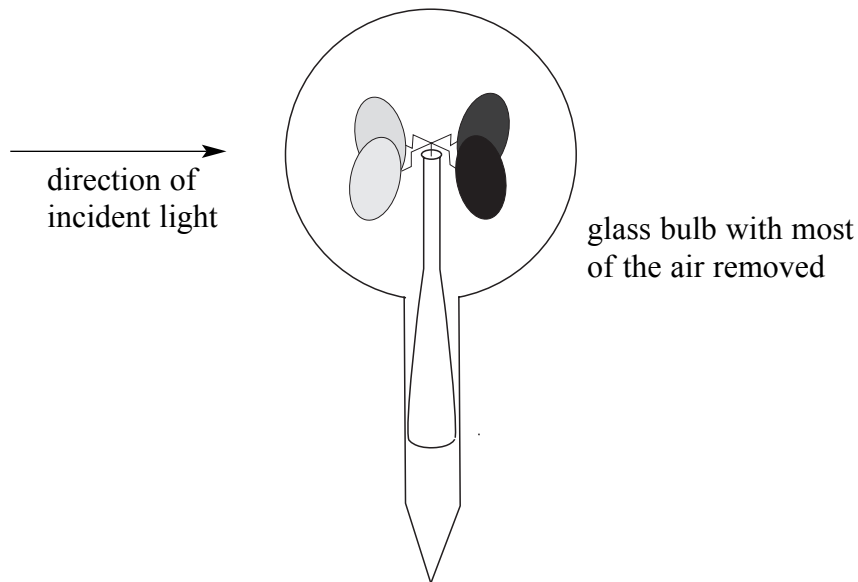
Turn over for the first question

Answer **both** questions.

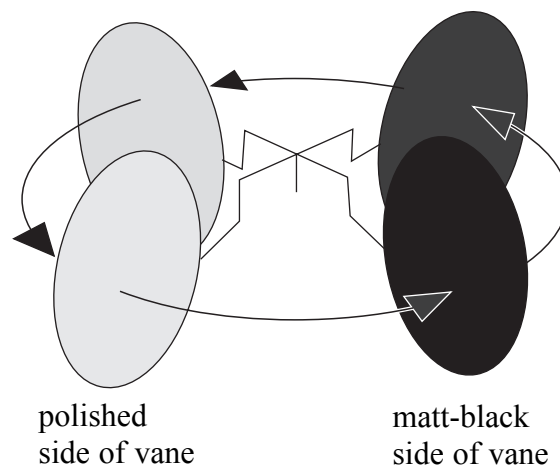
You are advised to spend no more than 30 minutes on Question 1.

- 1 The instrument shown in **Figure 1** is called a Crookes' radiometer.

Figure 1



enlarged view of the rotor to show direction of rotation when light is incident on the radiometer



The radiometer consists of a glass bulb from which most of the air has been removed. Inside the bulb is a rotor mounted on a vertical low-friction spindle. Attached to the rotor are four metal vanes of low mass. One side of each vane is highly polished and the other side is painted matt-black. When the radiometer is illuminated by light from a filament lamp, the rotor rotates slowly as shown. The time for one rotation of the rotor is seen to decrease when some of the incident light is absorbed by placing a transparent material in the path of the light from the source to the radiometer.

A student intends to use such a radiometer to compare the absorption of light by two different transparent materials.

Available to the student are several clear perspex discs of similar dimensions to an audio CD. The thickness of each disc is known to be 2.0 mm. Also available is a rectangular block of glass of uniform thickness about 1 cm.

Design an experiment that the student could perform to discover how the absorption of light by the perspex discs compares with the absorption by the glass block.

You should assume that the normal laboratory apparatus used in schools and colleges is available.

- Identify the quantities you intend to measure and explain how you will measure them.
- Explain how you propose to use your measurements to make a **fair comparison** between the absorption of light by perspex and by glass. You may wish to draw a diagram to illustrate this part of your answer.
- List any factor(s) you will need to control and explain how you will do this.
- Identify any difficulties you might encounter in obtaining reliable results and explain how these could be overcome.

Write your answer to Question 1 on **pages 8 and 9** of this booklet.

(8 marks)

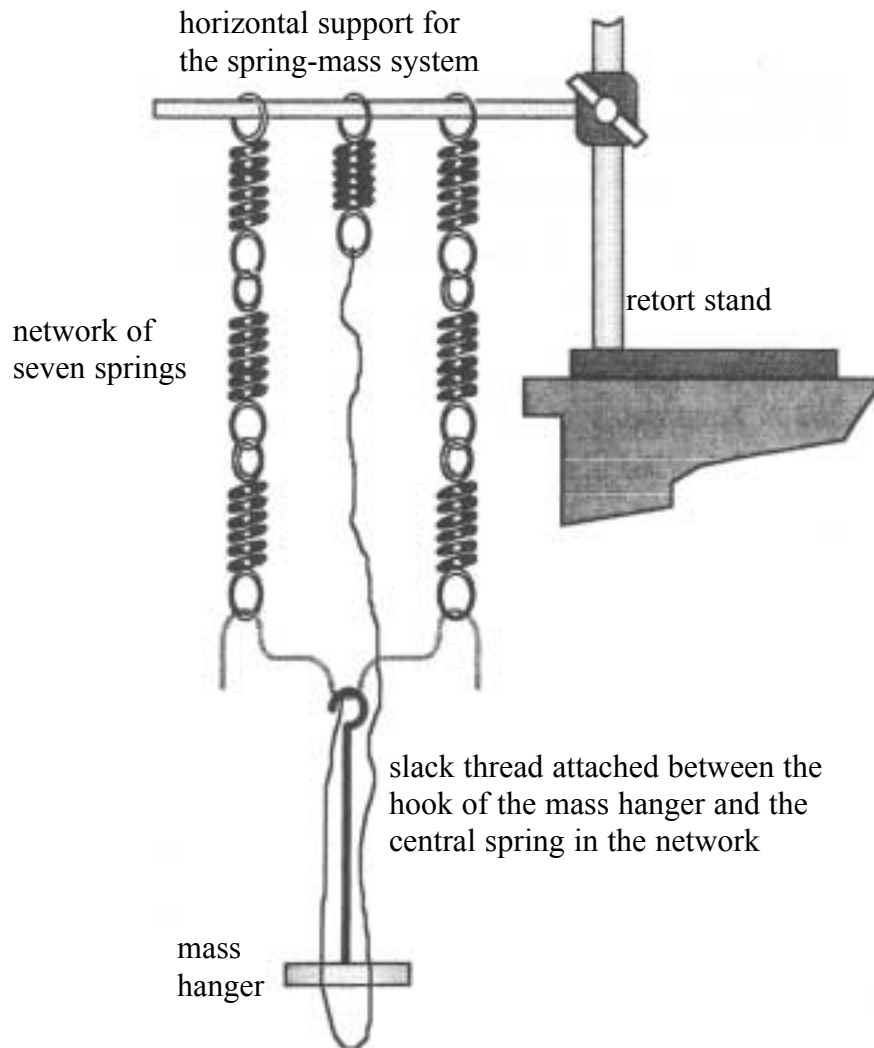
- 2 You are to investigate the characteristics of a system consisting of seven springs and a variable mass.

No description of the experiment is required.

You are provided with the apparatus shown in **Figure 2**.

Check that the central spring is not under tension and the thread joining this spring to the mass hanger is hanging freely, as shown.

Figure 2



- (a) (i) Record the mass, m , attached to the spring system.

$m = \dots\dots\dots$

- (ii) Measure and record the vertical height, h , between the lower surface of the mass hanger and the floor.

$h = \dots\dots\dots$

(1 mark)

- (b) You are provided with additional slotted masses. Add these masses, in turn, to the mass hanger so that m increases in several stages until all the masses have been used. Make suitable measurements to determine values of h that correspond to each different value of m .

Record all your observations on **page 12**.

Question 2 continues on the next page

Measurements and observations.

(7 marks)

- (c) Plot a graph of the measurements made in parts (a) and (b) with m on the vertical axis and h on the horizontal axis.

(5 marks)

- (d) (i) Measure and record the gradient, G_1 , in the region on your graph where $m = 250$ g.

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$$G_1 = \dots\dots\dots$$

- (ii) Measure and record the gradient, G_2 , in the region where $m = 750$ g.

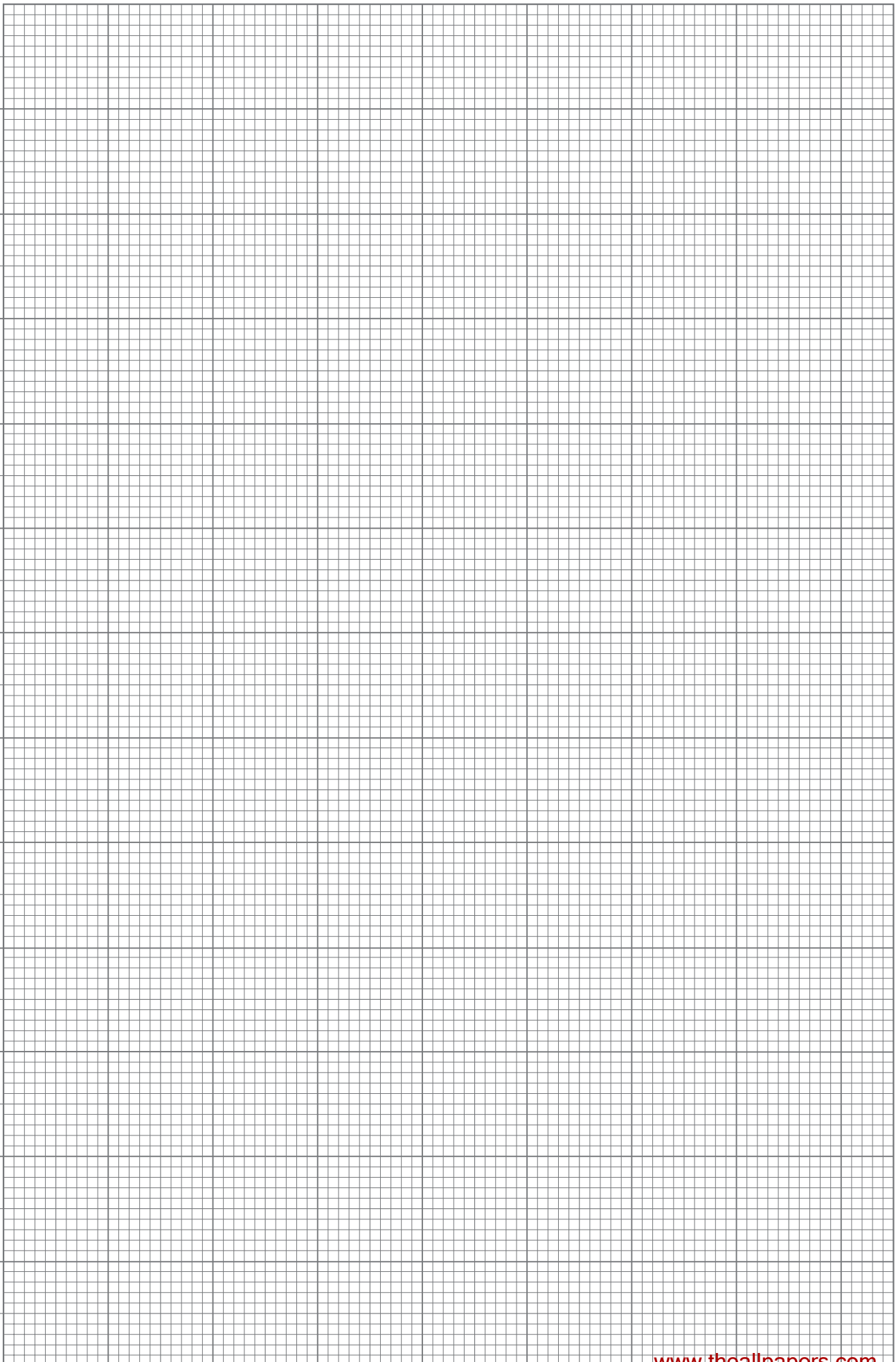
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$$G_2 = \dots\dots\dots$$

- (iii) Evaluate $\frac{G_2}{G_1}$.

$$\frac{G_2}{G_1} = \dots\dots\dots$$

(3 marks)



(e) (i) State any precautions you took to reduce the uncertainty in your values of h .

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(ii) Explain why the results for G_1 and G_2 are different.

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(iii) Suppose that you were to repeat the experiment without the central spring. Explain, with the aid of a sketch, how you could use your existing graph to predict the value of h that would correspond to $m = 1.000$ kg in this new experiment.
State any assumption you have made in making this prediction.

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(6 marks)

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