

Surname		Other Names	
Centre Number			Candidate Number
Candidate Signature			

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General Certificate of Education
 June 2006
 Advanced Level Examination



**PHYSICS (SPECIFICATION A)
 Practical (Units 5–9)**

PHAP

Wednesday 24 May 2006 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a pencil and 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 questions in the spaces provided.
- Show all your working
- Do all rough work in this book. Cross through any work you do not want 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			
Number	Mark	Number	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.

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	$\omega_2 = \omega_1 + at$	$\theta = \frac{\lambda}{D}$		
(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}	$\Delta Q = \Delta U + \Delta W$	Electricity		
atomic mass unit	u	1.661×10^{-27}	kg	$\Delta W = p\Delta V$	$\epsilon = \frac{E}{Q}$		
(1u is equivalent to 931.3 MeV)				$pV^\gamma = \text{constant}$	$\epsilon = I(R + r)$		
Fundamental particles				$\text{work done per cycle} = \text{area of loop}$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$		
<i>Class</i>	<i>Name</i>	<i>Symbol</i>	<i>Rest energy</i>	$\text{input power} = \text{calorific value} \times \text{fuel flow rate}$	$R_T = R_1 + R_2 + R_3 + \dots$		
			/MeV	$\text{indicated power as (area of } p-V \text{ loop)} \times (\text{no. of cycles/s}) \times (\text{no. of cylinders})$	$P = I^2 R$		
photon	photon	γ	0	$\text{friction power} = \text{indicated power} - \text{brake power}$	$E = \frac{F}{Q} = \frac{V}{d}$		
lepton	neutrino	ν_e	0	$\text{efficiency} = \frac{W}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$	$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$		
		ν_μ	0	$\text{maximum possible efficiency} = \frac{T_H - T_C}{T_H}$	$E = \frac{1}{2} QV$		
	electron	e^\pm	0.510999		$F = BI l$		
mesons	pion	μ^\pm	105.659		$F = BQv$		
		π^\pm	139.576		$Q_2 = Q_1 e^{-t/RC}$		
	kaon	π^0	134.972				
		K^\pm	493.821				
baryons	proton	K^0	497.762				
	neutron	p	938.257				
		n	939.551				
Properties of quarks							
<i>Type</i>	<i>Charge</i>	<i>Baryon number</i>	<i>Strangeness</i>				
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 = $4\pi r^2$							

$$\text{magnitude of induced e.m.f.} = N \frac{\Delta\Phi}{\Delta t}$$

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

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

Mechanical and Thermal Properties

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

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

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

$$\Delta Q = ml$$

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

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

Nuclear Physics and Turning Points in Physics

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

$$\text{force} = Bev$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Turn over for the first question

Answer **both** questions.

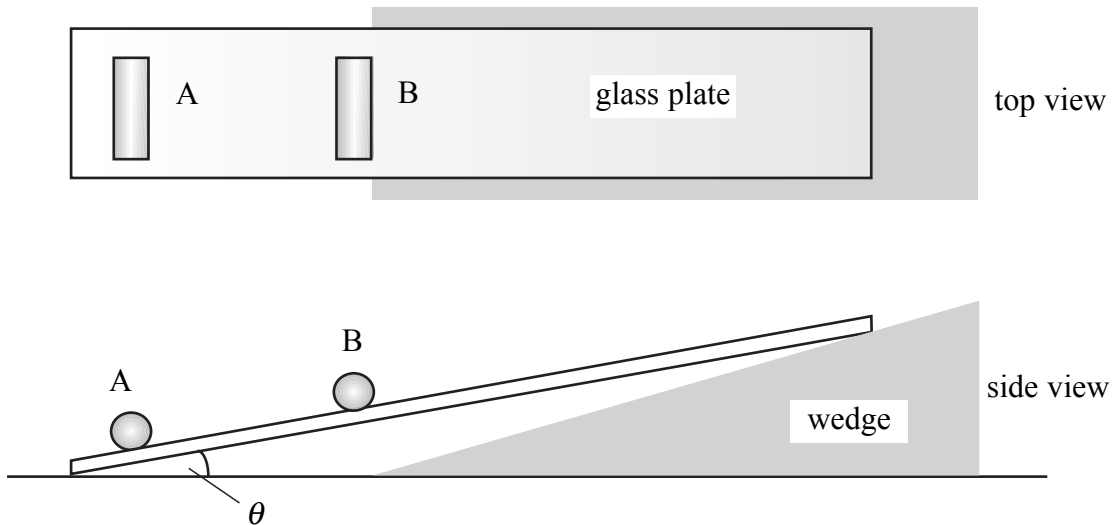
You are advised to spend no more than 30 minutes on Question 1.

- 1 A student discovers a novel way of measuring the force that acts between two cylindrical bar magnets.

Two such magnets, A and B, are placed on a smooth, flat glass plate with the poles aligned so that the magnets repel one another. Magnet A is glued in place. A wedge is then introduced under one edge of the glass plate so that the plate is inclined at an angle, θ , to the desk.

Magnet B, which is free to roll, comes to rest in the position shown by the views given in **Figure 1**.

Figure 1



The student sketches a force diagram, shown in **Figure 2**, for the forces acting on magnet B. These are

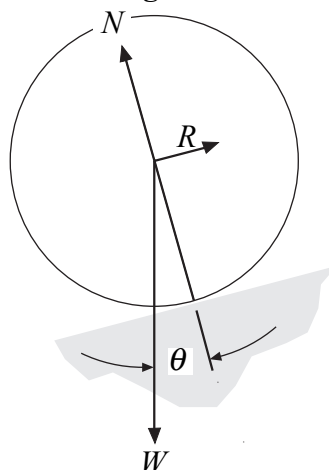
W , the weight of the rolling magnet,

N , the contact force **normal** to the glass plate and

R , the repulsive force due to the fixed magnet, acting **parallel** to the glass plate.

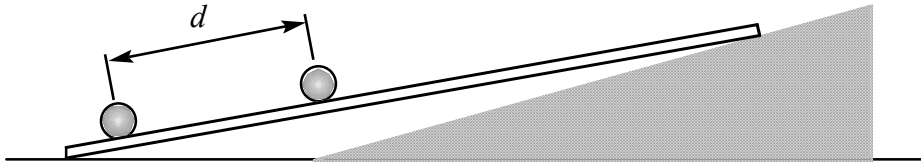
Realising that these forces are in equilibrium, the student plans to use this diagram to determine the magnitude of R .

Figure 2



It is suggested that R might vary as $\frac{1}{d^2}$, where d is the separation of the magnets, as shown in **Figure 3**.

Figure 3



Design an experiment that enables the student to determine whether R varies as $\frac{1}{d^2}$.

You should assume that the normal laboratory apparatus used in schools and colleges is available. You may wish to draw a diagram to illustrate your answer.

In your answer you should:

- Identify the quantities you intend to measure and explain how you will measure them.
- Explain how you propose to use your measurements to determine if R varies as $\frac{1}{d^2}$. 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.

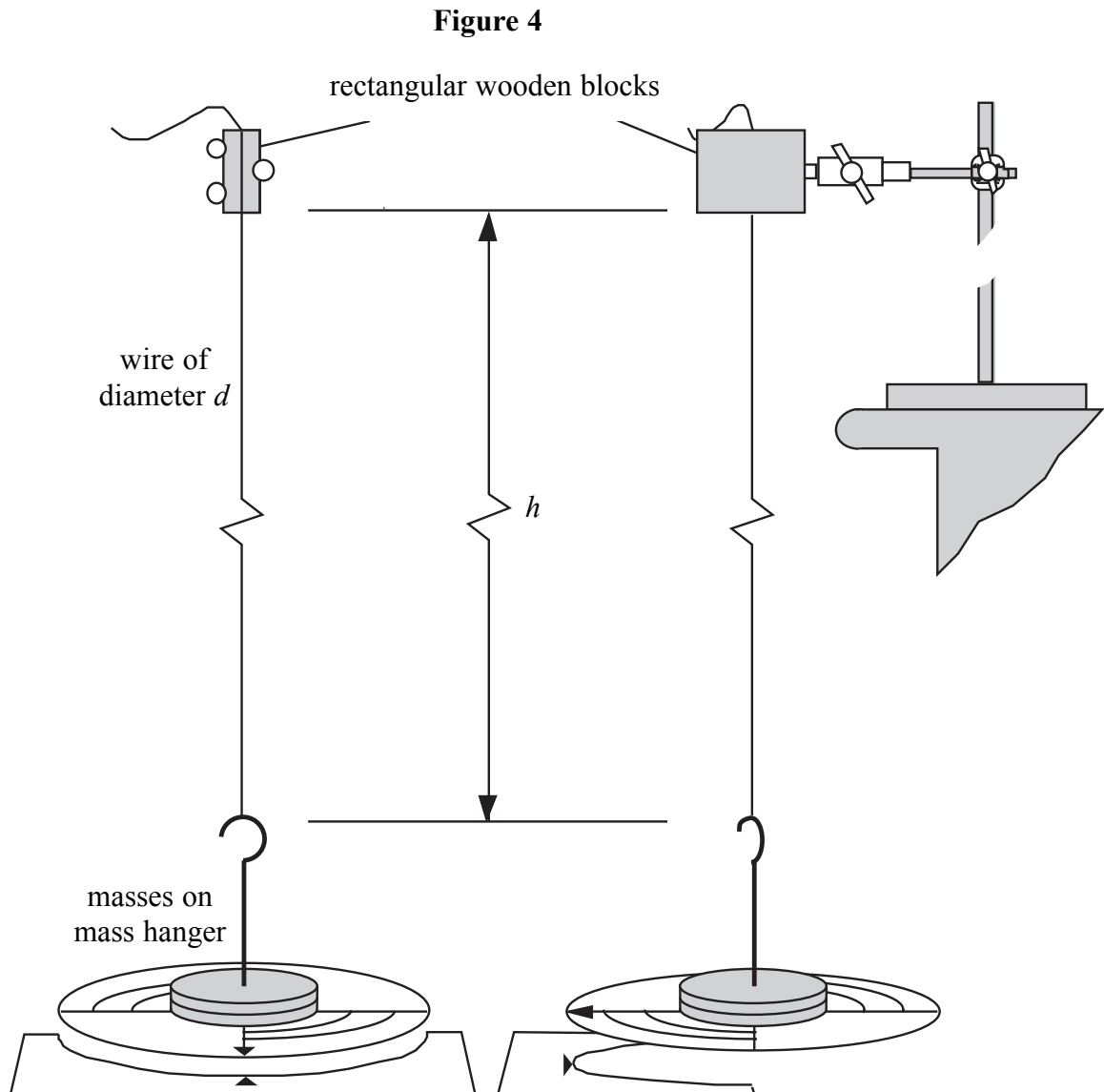
Write your answers to Question 1 on **pages 8 and 9** of this booklet.

(8 marks)

Handwriting practice area consisting of 20 horizontal dotted lines.



- 2 You are to investigate the rotational oscillations of a mass suspended from a wire, as the length, h , of the wire is varied. The arrangement of the apparatus is shown in front view and side view in **Figure 4**.



- (a) Use the micrometer screw gauge to determine the mean diameter, d , of the wire.

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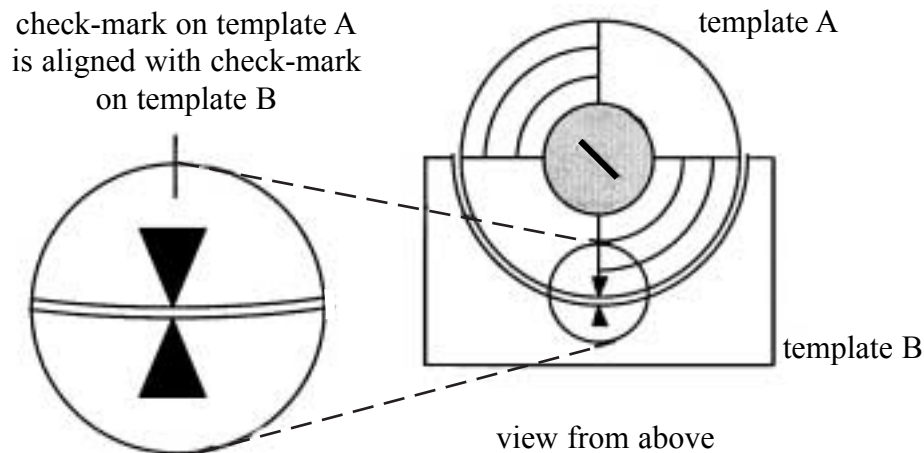
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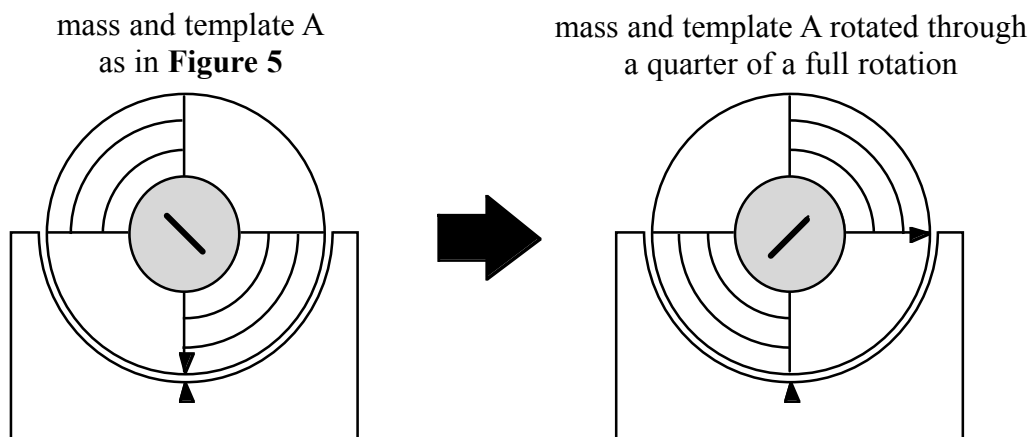
$d =$

(1 mark)

- (b) Template A is a piece of card that is trapped between the mass hanger and slotted masses. Template B is another piece of card that can be placed on the floor below the suspended mass. Printed on both templates are check marks that you should use when measuring the period of rotational oscillations of the suspended mass. Rotate template A on its own until the check-mark is pointing away from the edge of the bench. Position template B so that it is directly below the suspended mass and the check-mark is aligned with that on template A, as shown in **Figure 5**.

Figure 5

Keeping the wire vertical, rotate the stem of the mass hanger so that the suspended mass turns through approximately a quarter of a full rotation, i.e. 90° , as shown in **Figure 6**.

Figure 6

Release the stem of the mass hanger so that the suspended mass performs rotational oscillations.

Make suitable measurements to determine the period, T , of the rotational oscillations and the length of wire, h , as defined in **Figure 4**.

Repeat the procedure to find values of T for four smaller values of h .
Record all the measurements you make on the following page.

Measurements and observations.

(4 marks)

- (c) Using the grid on **page 13**, plot a graph with $\log_{10}(h/m)$ on the vertical axis and $\log_{10}(T/s)$ on the horizontal axis.
Tabulate below the data you will plot on your graph.

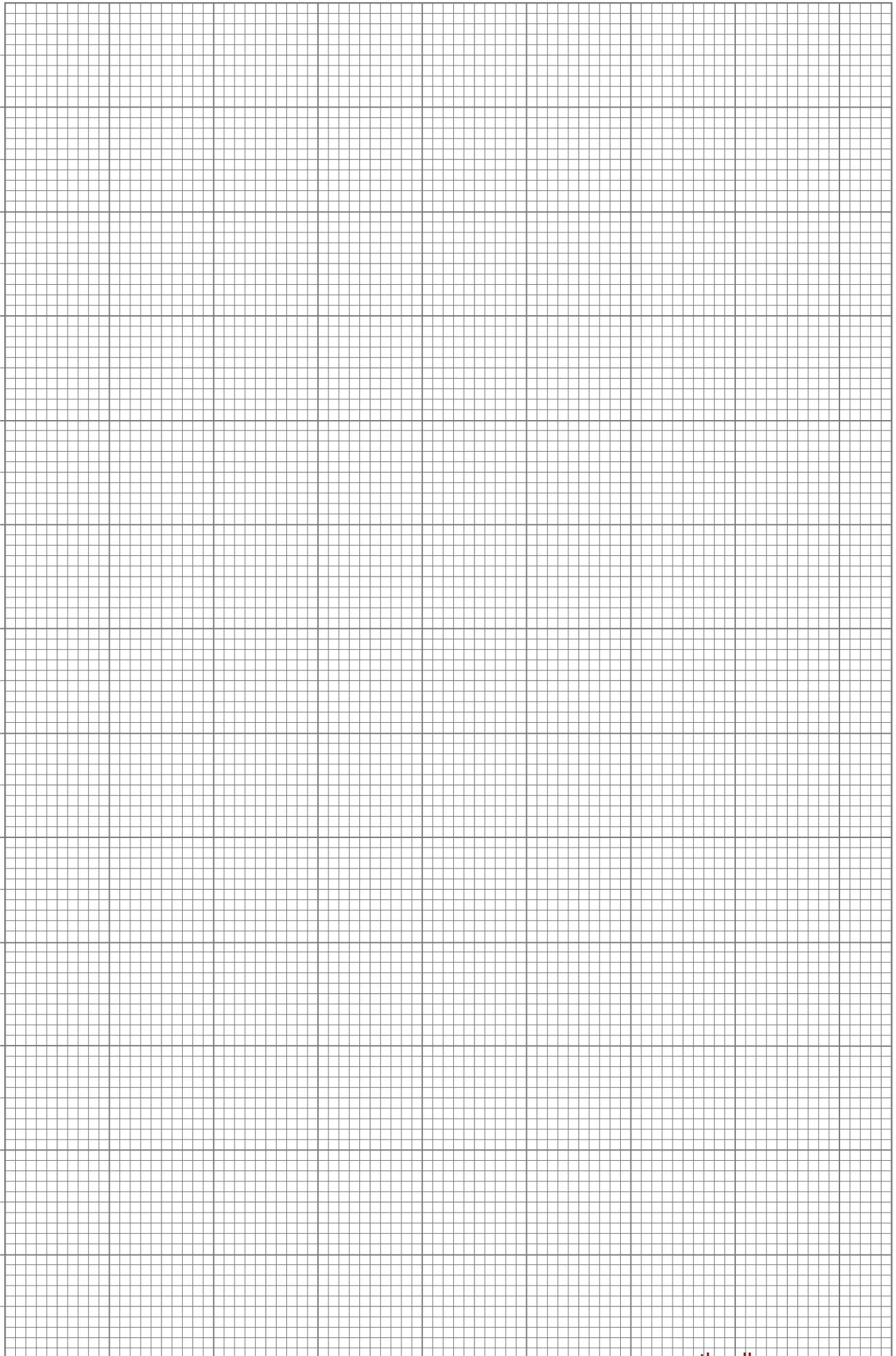
(8 marks)

- (d) Measure and record the gradient, G , of your graph.

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.....
.....

$G =$

(3 marks)



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