Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
January 2004
Advanced Level Examination

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

Monday 2 February 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 Sheeets* 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.

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

1 You are to investigate the light emitted by a light-emitting diode.

Figure 1 shows a circuit that has been set up for you. It consists of a light-emitting diode (LED) in series with a current-limiting resistor, a variable power supply, a milliammeter and a voltmeter.

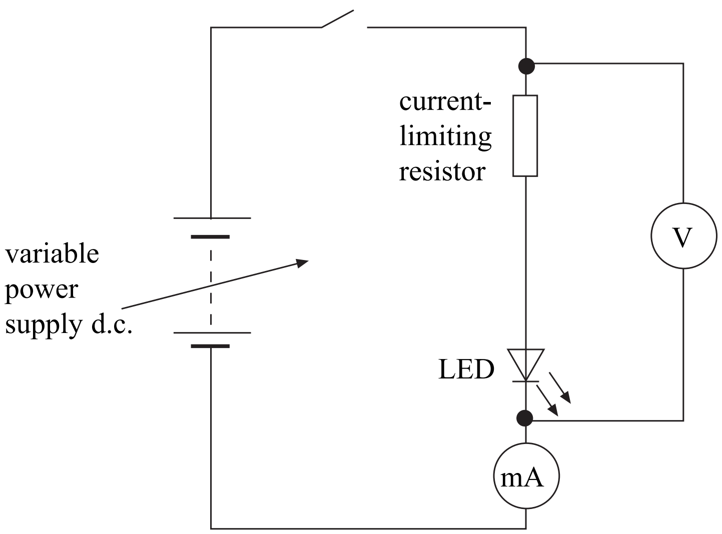


Figure 1

Close the switch in the circuit and increase the current until the LED just emits light.

(a) Record

(i) a value for the current flowing in the current-limiting resistor and LED,

(1 mark)

(ii) a value for the potential difference across the LED-resistor combination.

(1 mark)

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

moment of force $= Fd$

$$v = u + at$$

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

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

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

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

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

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

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	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{u}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{d}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

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

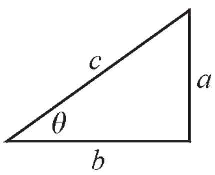
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

Turn over

Detach this perforated page at the start of the examination.

Circular Motion and Oscillations

$v = r\omega$

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

$x = A\cos 2\pi ft$

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

maximum $v = 2\pi fA$

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

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

Fields and their Applications

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

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

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

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

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

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

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

for a straight wire, $F = BIl$

for a moving charge, $F = BQv$

$\phi = BA$

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

$E = mc^2$

Temperature and Molecular Kinetic Theory

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

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

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

Heating and Working

$\Delta U = Q + W$

$Q = mc\Delta\theta$

$Q = ml$

$P = Fv$

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

work done on gas $= p\Delta V$

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

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

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

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

Capacitance and Exponential Change

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

in parallel, $C = C_1 + C_2$

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

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

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

time constant $= RC$

time to halve $= 0.69\,RC$

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

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

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

Momentum and Quantum Phenomena

$Ft = \Delta(mv)$

$E = hf$

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

$hf = E_2 - E_1$

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

(b) Assuming the charge on the electron, $e = -1.6 \times 10^{-19}$ C, calculate

(i) the energy lost by **one** electron as it moves through the LED-resistor combination,

(2 marks)

(ii) the number of electrons flowing through the LED every second.

(2 marks)

(c) As each electron moves through the LED, it donates **some** of its energy to a single photon of light that is released by the LED.

Suggest another mechanism by which an electron may lose energy as it moves through the LED.

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(1 mark)

Turn over

(d) In another experiment, four LEDs, each emitting a different colour of light were tested. The experimenter collected data of the minimum potential difference, V_{min}, at which each LED began to emit light and the wavelength, λ, of the emitted light. **Table 1** shows these data of V_{min} and λ.

		this column is for your convenience in answering parts (i) and (ii)
V_{min}/V	λ/nm	
2.00	626	
2.10	592	
2.45	505	
2.65	470	

Table 1

The energy, E, of a photon is related to its frequency, f, by the equation

$$E = hf$$

where h is the Planck constant.

(i) Use a **non-graphical** method to show that V_{min} is inversely proportional to λ. Make your reasoning clear.

(3 marks)

(ii) V_{min} is given by

$$V_{min} = \frac{hc}{e\lambda}$$

where c is the speed of electromagnetic radiation, $3.00 \times 10^8\,\text{m s}^{-1}$, and h is the Planck constant.

Calculate the value of h suggested by the above data.

(3 marks)

(e) Single wavelengths are quoted for the light emitted by the LEDs. In fact, a light-emitting diode produces a range of wavelengths approximately centred on this single value.

Describe a method by which you could measure the range of wavelengths emitted by one of these light-emitting diodes.

Your description should include;
- details of the apparatus and the measurements you would take with it,
- an account of the way in which you would analyse the data,
- details of any precautions that you would take.

Two of the 7 marks are available for the quality of your written communication.

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(7 marks)

20

Total for this question: ***19 marks***

2 You are to investigate the fundamental frequency of a stationary wave on a stretched wire.

Figure 2 shows the arrangement that has been set up for you. A source of alternating current is connected to a wire under tension. The wire passes between the opposite poles of two magnets.

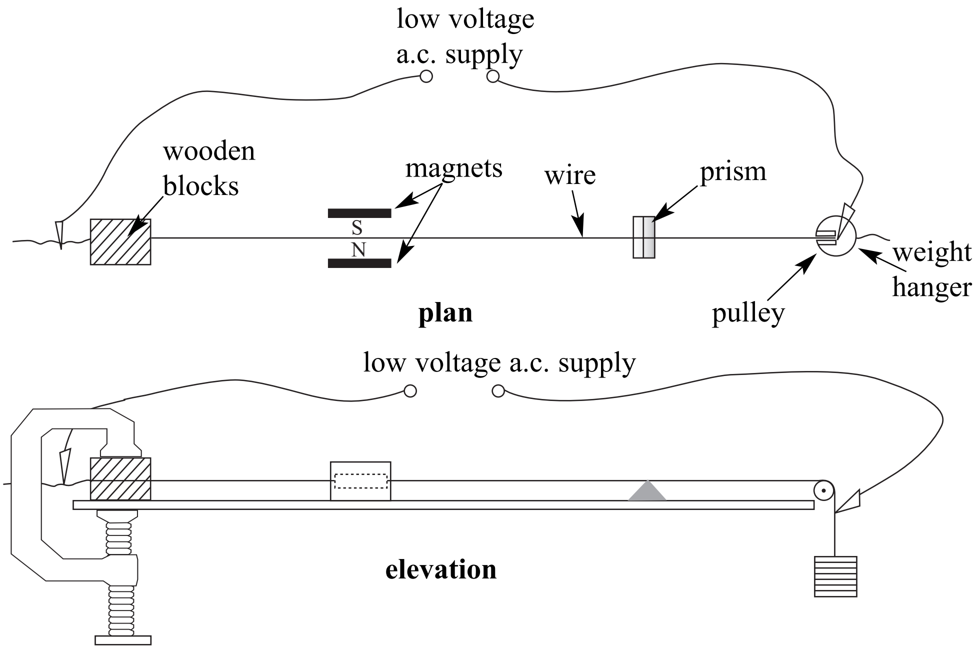

Figure 2

(a) Switch on the low voltage a.c. supply and alter the length of the stretched wire by adjusting the position of the small moveable prism so that the wire oscillates with as large an amplitude as possible in a single loop.

(i) Collect data in order to measure the oscillating length, l, in metres of wire. Record your data in the space below.

(1 mark)

LEAVE MARGIN BLANK

SWITCH OFF THE POWER SUPPLY BEFORE YOU CONTINUE.

(ii) State the frequency of the mains supply. …………….

State the tension in the wire. ………………………
gravitational field strength, $g = 9.81\,\text{N}\,\text{kg}^{-1}$

(2 marks)

(iii) The tension, *T,* in the wire is related to *l* and the frequency of oscillation, *f* , by

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

where μ is the mass in kg of a one metre length of the wire.

Calculate μ.

(1 mark)

(b) (i) Estimate the absolute uncertainty in your measurement of *l*.

(1 mark)

(ii) Assume that the value of *f* is exact and that *T* is known to the nearest 0.01 N.
Calculate the percentage uncertainty in your value of μ.

(3 marks)

QUESTION 2 CONTINUES ON THE NEXT PAGE

(c) Explain why the wire oscillates and why, for a particular length of wire, the oscillation has a large amplitude.

Two of the 7 marks are available for the quality of your written communication.

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(7 marks)

LEAVE MARGIN BLANK

(d) The equation stated in part (a)(iii) suggests that f^2 is directly proportional to T. Explain how you would modify the experiment you carried out in part (a) in order to test this proportionality. Give clear details of the analysis you would carry out.

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(4 marks)

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END OF QUESTIONS