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Centre Number		Candidate Number	
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For Examiner's Use

General Certificate of Education
 January 2009
 Advanced Subsidiary Examination



PHYSICS (SPECIFICATION A) PHA3/W
Unit 3 Current Electricity and Elastic Properties of Solids

Tuesday 13 January 2009 1.30 pm to 2.30 pm

<p>For this paper you must have:</p> <ul style="list-style-type: none"> • a pencil and a ruler • a calculator • a data sheet insert.
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Time allowed: 1 hour

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- 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 50. This includes up to 2 marks for the Quality of Written Communication.
- The marks for questions are shown in brackets.
- A *Data Sheet* is provided as a loose insert.
- You are expected to use a calculator where appropriate.
- Questions 1(a)(iii) and 4(b) should be answered in continuous prose. In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
Quality of Written Communication			
TOTAL			
Examiner's Initials			



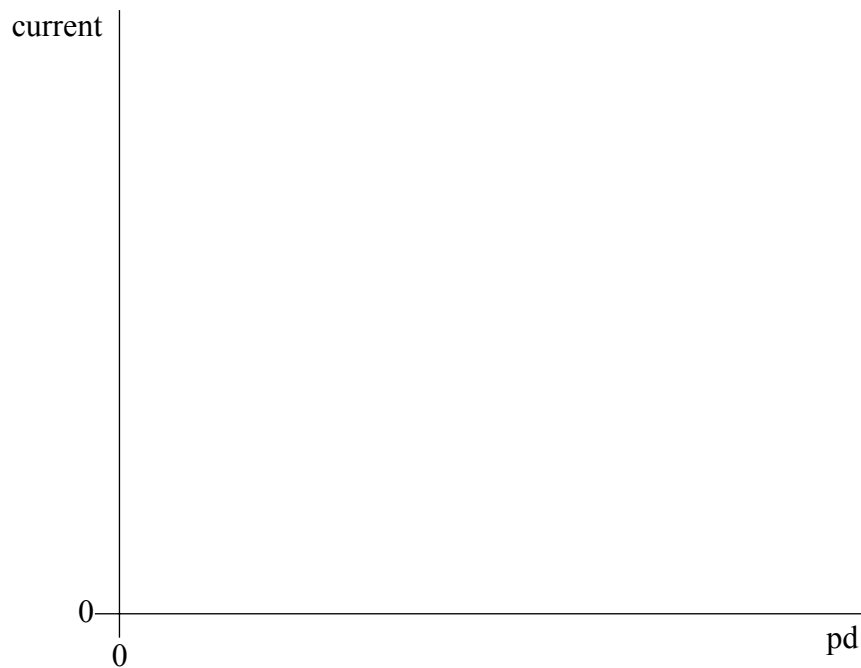
J A N O 9 P H A 3 W O 1

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

1 A student investigates how the current through a 6.0V filament lamp varies as the potential difference across it is changed up to 6.0V.

1 (a) (i) Draw a suitable circuit diagram for this investigation.

1 (a) (ii) Use the axes below to sketch a graph showing how the current through the lamp varies with the potential difference across it.



1 (a) (iii) Explain the shape of the graph.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(8 marks)

1 (b) When the potential difference across the lamp is 6.0V, the current through it is 0.30A. The lamp filament consists of a metal wire of area of cross-section $1.1 \times 10^{-8} \text{ m}^2$.

1 (b) (i) Calculate the resistance of the filament wire for this current.

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1 (b) (ii) Calculate the length of the filament wire.

resistivity of the wire at the operating temperature of the filament = $1.2 \times 10^{-6} \Omega \text{ m}$

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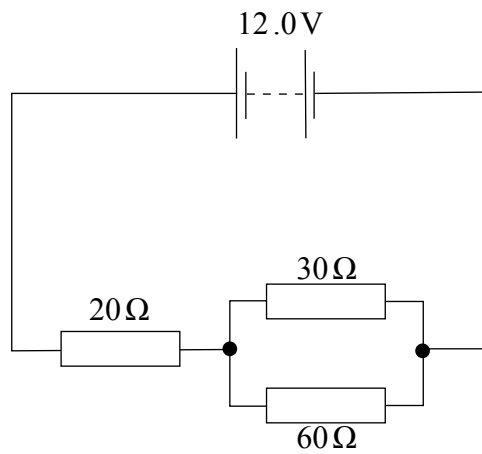
(3 marks)

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2 **Figure 1** shows a circuit containing a battery of emf 12.0V and negligible internal resistance.

Figure 1



2 (a) (i) Calculate the total circuit resistance.

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2 (a) (ii) Show that the potential difference across each resistor is 6.0V.

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(5 marks)



2 (b) Explain, without further calculation, why the power supplied to the $20\ \Omega$ resistor is the same as the power supplied to the parallel combination of the $30\ \Omega$ resistor and the $60\ \Omega$ resistor.

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(2 marks)

7

Turn over for the next question

Turn over ▶



3 An electric cooker is designed to operate from a 230V rms mains supply. On full power, the cooker operates at 5.3kW.

3 (a) (i) Calculate the peak voltage of the mains supply.

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3 (a) (ii) Calculate the rms current supplied to the cooker when it is operating at full power.

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(3 marks)

3 (b) The cooker is connected permanently to the ac mains electricity supply using its own connecting cable of length 5.2 m. Each metre of the connecting cable has a resistance of $0.020\ \Omega$.

3 (b) (i) Calculate the voltage drop along the cable when the cooker operates at full power.

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3 (b) (ii) Calculate the average power wasted in the cable due to the heating effect of the electric current passing through it when the cooker operates at full power.

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3 (b) (iii) Explain why the connecting cable needs to have such a low resistance per metre.

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(6 marks)

9

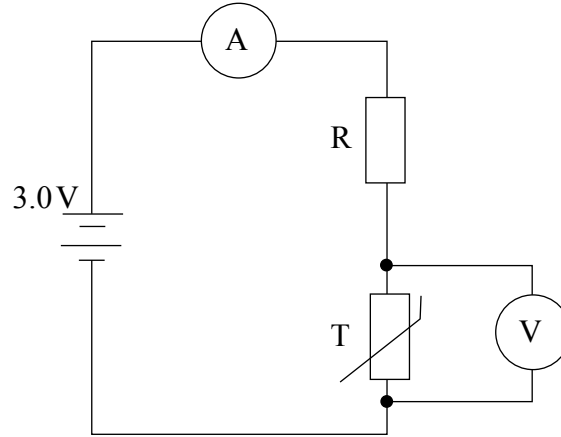
Turn over for the next question

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- 4 **Figure 2** shows a circuit used to measure the resistance of a thermistor, T. The circuit includes a 3.0 V battery of negligible internal resistance. The resistance of T increases when its temperature is decreased.

Figure 2



With the thermistor maintained at a constant temperature, the ammeter reading is 0.60 mA and the voltmeter reading is 1.2 V.

- 4 (a) (i) Calculate the resistance of the thermistor at this temperature.

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- 4 (a) (ii) Calculate the resistance of R.

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(4 marks)



4 (b) Discuss how the ammeter reading and the voltmeter reading would change if the temperature of the thermistor were reduced.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(5 marks)

9

Turn over for the next question

Turn over ▶



5 A metal wire is suspended vertically and a weight, sufficient to make the wire taut, is fixed to the free end.

5 (a) The load on the wire is increased by adding a 30N weight. The extension of the wire from its initial length is then measured accurately and found to be 1.28mm.

5 (a) (i) Assuming the wire obeys Hooke's Law, calculate the elastic energy stored in the wire after the 30 N weight has been added.

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5 (a) (ii) Two further measurements need to be made to determine the Young modulus of the material of the wire. State what these measurements are and describe how you would make them.

measurement 1

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measurement 2

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5 (a) (iii) Show how you would use these measurements and the data above to calculate the Young modulus of the material of the wire.

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(8 marks)



- 5 (b) When an additional 30 N weight was added, the total extension of the wire became 2.73 mm. The total load of 60 N was then removed and the wire regained its initial length.

Discuss whether or not the assumption made in part (a)(i) is still valid and describe the behaviour of the wire in terms of elasticity and Hooke’s Law when it was loaded and unloaded.

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(4 marks)

12

Quality of Written Communication (2 marks)

2

END OF QUESTIONS



There are no questions printed on this page

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PHYSICS (SPECIFICATION A)

PHA3W

Unit 3 Current Electricity and Elastic Properties of Solids

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}	$\omega_2^2 = \omega_1^2 + 2a\theta$		${}^1n_2 = \frac{n_2}{n_1}$	
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	$\text{maximum possible efficiency} = \frac{T_H - T_C}{T_H}$		$E = \frac{1}{2} QV$	
		e^\pm	0.510999			$F = BIl$	
mesons	electron	e^\pm	0.510999			$F = BQv$	
	muon	μ^\pm	105.659			$Q = Q_0 e^{-t/RC}$	
	pion	π^\pm	139.576			$\Phi = BA$	
		π^0	134.972				
baryons	kaon	K^\pm	493.821				
	proton	K^0	497.762				
		neutron	p	938.257			
	neutron	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 = $4\pi r^2$							
volume of sphere = $\frac{4}{3}\pi r^3$							

Turn over ►

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

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

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

Mechanical and Thermal Properties

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

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

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

$$\Delta Q = ml$$

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

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

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

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

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

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

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

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

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

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

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

$$v = Hd$$

$$P = \sigma AT^4$$

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

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

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

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

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

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

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

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