Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch

545/01

PHYSICS

ASSESSMENT UNIT PH5: FIELDS, FORCES AND NUCLEI

A.M. THURSDAY, 14 June 2007

(1 hour 30 minutes)

ADDITIONAL MATERIALS

In addition to this paper, you may require a calculator.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

You are advised to spend not more than 45 minutes on questions 1 to 5.

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
Total	

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 90.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Your attention is drawn to the information "Mathematical Data and Relationships" on the back page of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Fundamental Constants

Avogadro constant	N_A	=	$6{\cdot}0 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}6 \times 10^{-19}$ C
Mass of an electron	m_e	=	$9{\cdot}1 \times 10^{-31}$ kg
Mass of a proton	m_p	=	$1{\cdot}67 \times 10^{-27}$ kg
Molar gas constant	R	=	$8{\cdot}3$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	=	$9{\cdot}8$ m s^{-2}
[Gravitational field strength at sea level	g	=	$9{\cdot}8$ N kg^{-1}]
Universal constant of gravitation	G	=	$6{\cdot}7 \times 10^{-11}$ N m^{2} kg^{-2}
Planck constant	h	=	$6{\cdot}6 \times 10^{-34}$ J s
Unified mass unit	1 u	=	$1{\cdot}66 \times 10^{-27}$ kg
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}$ J K^{-1}
Speed of light *in vacuo*	c	=	$3{\cdot}0 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_o	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}

Examiner only
Arholwr yn unig

1. A reaction used in nuclear power plants is the fission of Uranium 235.

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \longrightarrow ^{89}_{36}\text{Kr} + ^{144}_{56}\text{Ba} + 3^{1}_{0}\text{n}$$

(a) Use the following data to calculate the energy obtained from the above reaction (1u = 931 MeV). [3]

Mass of $^{235}_{92}$U = 235·04392u, Mass of $^{89}_{36}$Kr = 88·91763u

Mass of $^{144}_{56}$Ba = 143·92062u, Mass of $^{1}_{0}$n = 1·00866u

....

....

....

....

(b) Explain briefly how the above reaction can lead to a chain reaction. [3]

....

....

....

....

(c) Explain the purpose of a moderator in a nuclear reactor. [2]

....

....

....

(d) Explain the purpose of control rods in a nuclear reactor. [2]

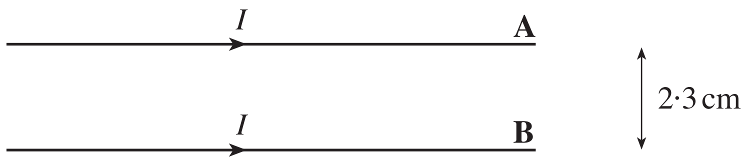
....

....

....

Turn over.

2. **A** and **B** are parallel long straight wires in a vacuum 2·3 cm apart. Wire **A** and wire **B** carry an equal current I.



(a) Explain why wire **A** exerts a force on wire **B**. [3]

....

....

....

....

(b) In which direction is this force on wire **B**? Explain briefly how you obtained your answer. [3]

....

....

....

....

(c) Calculate the current I given that both wires experience a force of $3{\cdot}2 \times 10^{-9}$ N per unit of length. [4]

$$B = \frac{\mu_0 I}{2\pi a}, \text{ for a long straight wire.}$$

....

....

....

....

....

....

....

3. *(a)* State the laws of electromagnetic induction (Faraday's law and Lenz's law). [2,2]

....

....

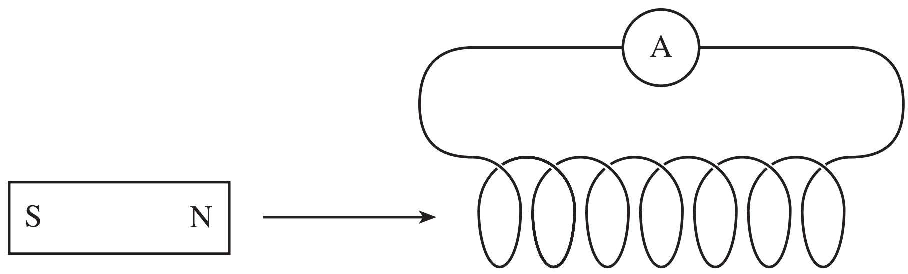
....

....

....

....

(b) A magnet moves towards a coil as shown. Use Lenz's law to explain in which direction the current will flow through the turns of the coil. Indicate this direction on the diagram. [2]

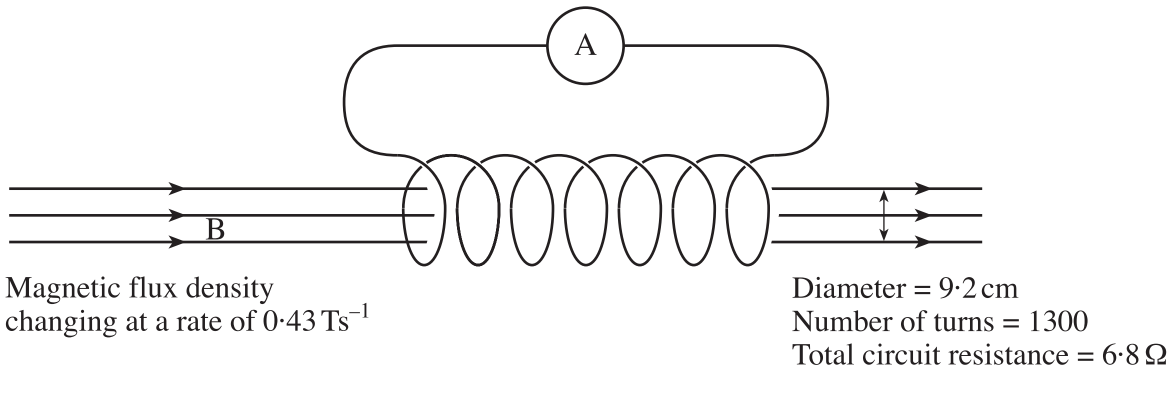


....

....

....

(c) The coil is now situated in a uniform magnetic field changing at a rate of 0·43 Ts^{-1}.



Calculate the current flowing in the ammeter. [4]

....

....

....

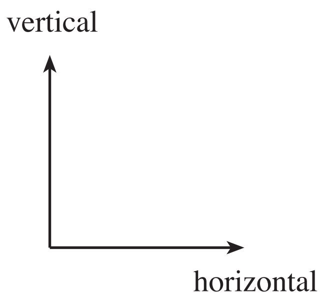
....

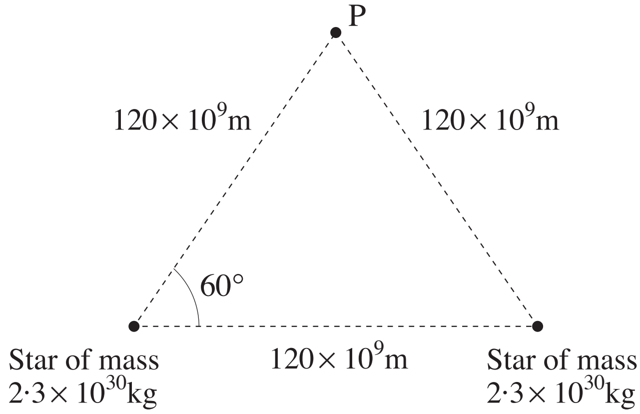
....

 Turn over.

Examiner only
Arholwr yn unig

4. Two stars and point P form an equilateral triangle of side 120×10^9 m.





(a) Draw **two** arrows at P to represent the directions of the gravitational fields at **P** due to each of the two stars. [1]

(b) Explain why the horizontal component of the resultant gravitational field strength at **P** due to the two stars is zero. [2]

....

....

....

(c) Calculate the resultant gravitational field at **P** due to the two stars. [3]

....

....

....

....

(d) Mark with an X in the above diagram the point where the resultant gravitational field strength is zero. [1]

(e) Calculate the gravitational potential at **P**. [3]

....

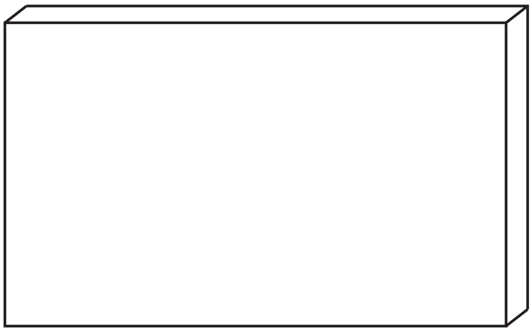
....

....

....

Examiner only
Arholwr yn unig

5. *(a)* The wafer of metal shown below is to be used as a Hall probe to measure the strengths of magnetic fields. Explain, using the diagram, the processes involved in the production of the Hall voltage. State which forces act on the free electrons and give their directions (equations are not required). [6]



....

....

....

....

....

....

....

....

(b) A uniform electric field E of 66·0 Vm^{-1} is applied within the wafer of metal. Calculate the resistivity of the metal if the drift velocity of the free electrons is 0·0042 ms^{-1} and the number of free electrons per unit volume within the metal is $8{\cdot}2 \times 10^{28}\ \text{m}^{-3}$. [4]

You will require the following equations from outside of the PH5 syllabus.

$V = IR$, $\qquad I = nAve$, $\qquad R = \dfrac{\rho l}{A}$

....

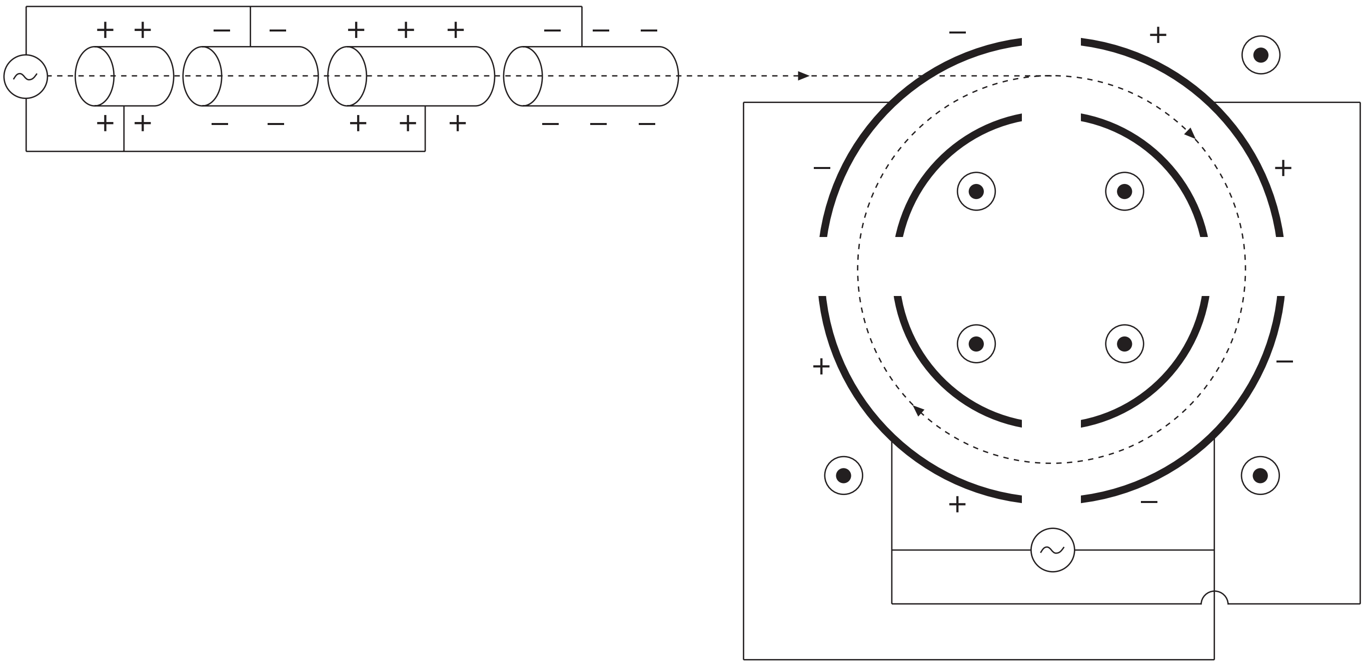
....

....

....

....

6. *(a)* Shown below is a simplified diagram of a proton LINAC (linear accelerator) and synchrotron. The protons are accelerated by the LINAC before entering the synchrotron.



In the LINAC, the protons are accelerated from rest through 3 gaps each with an accelerating p.d. of 36 kV.

(i) What is the kinetic energy **in eV** of the protons as they enter the synchrotron? [1]

....

....

(ii) Show that this kinetic energy is equivalent to approximately $1{\cdot}7 \times 10^{-14}$ J. [1]

....

....

(iii) Calculate the speed of the protons as they enter the synchrotron. [3]

....

....

....

....

(b) (i) Once the protons are inside the synchrotron, the synchrotron accelerates the protons further while maintaining a path of constant radius. Explain briefly how this is achieved. [3]

....

....

....

....

(ii) The radius of the synchrotron is 12·5 m. Calculate the value of the magnetic flux density in the synchrotron when the speed of the protons is $9{\cdot}4 \times 10^6$ ms^{-1}. [4]

....

....

....

....

....

....

....

(iii) Calculate the number of revolutions per second performed by the protons when maintained at this constant speed of $9{\cdot}4 \times 10^6$ ms^{-1}. [3]

....

....

....

....

....

(iv) State the number of occasions the proton speed is increased in one complete revolution. [1]

....

(v) It takes the protons 14 complete revolutions to achieve a kinetic energy of $7{\cdot}4 \times 10^{-14}$ J. Calculate the accelerating p.d. applied between the synchrotron tubes. [4]

....

....

....

....

....

....

....

Examiner only
Arhholwr yn unig

7. *(a)* Identify the types of ionising radiation (X, Y, Z) produced in the following reactions. [3]

$^{131}_{53}\text{I} \longrightarrow ^{131}_{54}\text{Xe} + \text{X}$ X ....

$^{222}_{88}\text{Ra} \longrightarrow ^{218}_{86}\text{Rn} + \text{Y}$ Y ....

$^{12}_{6}\text{C}^{*} \longrightarrow ^{12}_{6}\text{C} + \text{Z}$ Z ....

(b) A drum of nuclear waste contains 150 kg of unstable nuclei **A** and 150 kg of unstable nuclei **B.** **A** has a half life of 28 years and **B** has a half life of 5 200 years **(1 year = 3·16 × 10^{7} s)**.

(i) Show that the decay constants of **A** and **B** are $7{\cdot}83 \times 10^{-10}\ \text{s}^{-1}$ and $4{\cdot}22 \times 10^{-12}\ \text{s}^{-1}$ respectively. [2]

....

....

....

(ii) Both **A** and **B** have an approximate nuclear mass of 170 u. Show that the initial number of nuclei of each of **A** and **B** is $5{\cdot}3 \times 10^{26}$. [2]

....

....

....

(iii) Calculate the initial activity due to

(I) the **A** nuclei, [1]

....

....

(II) the **B** nuclei. [1]

....

....

(iv) Calculate the number of nuclei present after 500 years ($1{\cdot}58 \times 10^{10}$ s)

(I) of **A**, [1]

....

....

(II) of **B**. [1]

....

....

Examiner only
Arholwr yn unig

(v) Calculate the activity after 500 years ($1{\cdot}58 \times 10^{10}$ s)

(I) of **A**, [1]

....

....

(II) of **B**. [1]

....

....

(c) Calculate the time at which the activity due to **A** is equal to the activity due to **B**. [4]

....

....

....

....

....

....

....

(d) Which of **A** or **B** presents the greater hazard to society? [3]

....

....

....

....

Examiner only
Arholwr yn unig

Examiner only
Arholwr yn unig

BLANK PAGE

BLANK PAGE

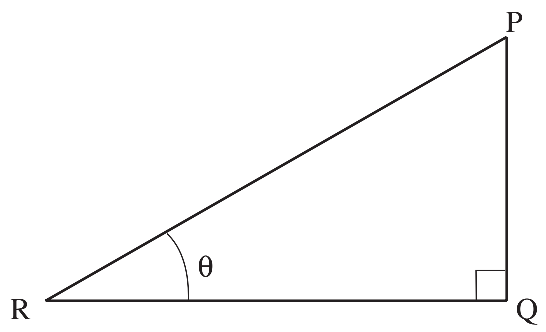
Mathematical Data and Relationships

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Geometry and trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

Areas and Volumes

Area of a circle $= \pi r^2 = \dfrac{\pi d^2}{4}$

Area of a triangle = ½ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Logarithms

[Unless otherwise specified 'log' can be $\log_e$ (i.e. ln) or $\log_{10}$.]

$\log(ab) = \log a + \log b$

$\log\left(\dfrac{a}{b}\right) = \log a - \log b$

$\log(x^n) = n\log x$

$\log(kx^n) = \log k + n\log x$

$\log_e(e^{kx}) = \ln(e^{kx}) = kx$

$\log_e 2 = \ln 2 = 0{\cdot}693$