



## General Certificate of Education

# Physics 6456 *Specification B*

### *PHB5 Fields and their Applications*

## Mark Scheme

### *2005 examination – June series*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

## Notes for Examiners

Letters are used to distinguish between different types of marks in the scheme.

### **M** indicates OBLIGATORY METHOD MARK

This is usually awarded for the physical principles involved, or for a particular point in the argument or definition. It is followed by one or more accuracy marks which cannot be scored unless the M mark has already been scored.

### **C** indicates COMPENSATION METHOD MARK

This is awarded for the correct method or physical principle. In this case the method can be seen or implied by a correct answer or other correct subsequent steps. In this way an answer might score full marks even if some working has been omitted.

### **A** indicates ACCURACY MARK

These marks are awarded for correct calculation or further detail. They follow an M mark or a C mark.

### **B** indicates INDEPENDENT MARK

This is a mark which is independent of M and C marks.

**e.c.f** is used to indicate that marks can be awarded if an error has been carried forward (e.c.f. must be written on the script). This is also referred to as a 'transferred error' or 'consequential marking'.

Where a correct answer only (**c.a.o.**) is required, this means that the answer must be as in the Marking Scheme, including significant figures and units.

**c.n.a.o.** is used to indicate that the answer must be numerically correct but the unit is only penalised if it is the first error or omission in the section (see below).

Only **one** unit penalty (**u.p.**) in this paper unless there is a mark allocated specifically for giving a correct unit in the marking. Note that the unit is only penalised in the final answer to the question.

Only **one** significant figure penalty (**s.f.**) in this paper.

Allow 2 or 3 s.f. unless otherwise stated. s.f. penalties include recurring figures and fractions for answers.

Marks should be awarded for **correct** alternative approaches to numerical questions that are not covered by the marking scheme. A correct answer from working that contains a physics error (PE) should not be given credit. Examiners should contact the Team Leader or Principal Examiner for confirmation of the validity of the method, if in doubt.

## Quality of Written Communication

Before accessing marks for the Quality of Written Communication (QWC) a candidate must first score a minimum of one mark for the physics that is being communicated – this will allow access to 1 mark for QWC. If the candidate scores more marks for physics (a minimum of two or three – depending upon the total mark for that part of the question) then this will allow access to 2 marks for QWC.

<b>Good QWC:</b> the answer is fluent/well argued with few errors in spelling, punctuation and grammar	<b>2</b>	
<b>Poor QWC:</b> the answer lacks coherence or spelling, punctuation and grammar are poor	<b>1</b>	<b>Max 2</b>
<b>Very Poor QWC:</b> the answer is disjointed, with significant errors in spelling, punctuation and grammar	<b>0</b>	

## PHB5 Fields and their Applications

<b>Question 1</b> (a)	force is proportional to the product of the two masses  force is inversely proportional to the square of their separation (condone radius between masses) <b>or</b> equation M0 : masses defined A1 separation defined A1	<b>B1</b>   <b>B1</b>	   <b>2</b>
(b) (i)	appreciation that potential x distance from centre of sun = constant <b>or</b> calculation of $Vr$ for two sets of values ( $1.33 \times 10^{20}$ ) <b>or</b> uses distance ratio to calculate new $V$ or $r$  calculation of all three + conclusion or uses distance ratios twice+ conclusion conclusion must be more than 'numbers are same' (condone 'signs' and no use of powers of 10)	<b>C1</b>   <b>A1</b>	   <b>2</b>
(ii)	$V = GM/r$ and $g = GM/r^2$ <b>or</b> $g = V/r$ (no mark for $E$ or $g = V/d$ or $E = V/r$ )  substitution of one set of data to obtain $GM$ ( $1.33 \times 10^{20}$ ) or $19 \times 10^{10}/7 \times 10^8$ seen  $271 \text{ N kg}^{-1} (\text{m s}^{-2}) (\text{J kg}^{-1} \text{ m}^{-1})$	<b>B1</b>   <b>B1</b>   <b>B1</b>	   <b>3</b>
(iii)	potential energy of the Earth = $(-)GMm/r$ or potential difference formula + $r_2 = \infty$ or potential at position of Earth = $-8.87 \times 10^8 \text{ J kg}^{-1}$ (from $Vr = 1.33 \times 10^{20}$ )  correct substitution (allow ecf for $GM$ from (ii)) or potential energy = potential x mass of Earth  change in PE = $5.32 \times 10^{33} \text{ J}$ (cnao) <i>Fd</i> approach is PE so 0 marks	<b>C1</b>   <b>C1</b>   <b>A1</b>	   <b>3</b>
(iv)	speed of Earth round Sun = $2\pi r/T$ or $\sqrt{\frac{GM}{r}}$ or $3.0 \times 10^4 \text{ m s}^{-1}$  or $\text{KE} = \frac{GMm}{2r}$  KE of Earth = $\frac{1}{2} 6 \times 10^{24} \times \text{their } v^2$ ( $2.68 \times 10^{33} \text{ J}$ )  energy needed = difference between (iii) and orbital KE ( $2.64 \times 10^{33} \text{ J}$ )  or KE in orbit = half total energy needed to escape (-1 for AE)	<b>B1</b>   <b>B1</b>   <b>B1</b>	   <b>3</b>

<b>Question 2</b> (a) (i)	a current that circulates/swirls/in circular path within a conductor accept diagram representation	<b>B1</b>	<b>4</b>
	alternating/changing current (in coil)	<b>B1</b>	
	alternating/changing magnetic field in the core (condone 'around')	<b>B1</b>	<b>Max 2</b>
	$I^2R$ losses/heating/change in internal energy in the core	<b>B1</b>	
	At least 2 marks for physics + <b>Good QWC</b>	<b>2</b>	
	At least 2 marks for physics + <b>Poor QWC</b>	<b>1</b>	
	At least 2 marks for physics + <b>Very Poor QWC</b>	<b>0</b>	
	1 or 2 marks for physics + sufficient attempt + <b>Poor QWC</b>	<b>1</b>	
	1 or 2 marks for physics + insufficient attempt or <b>Very Poor QWC</b>	<b>0</b>	
	No marks for physics or <b>Very Poor QWC</b>	<b>0</b>	
(ii)	<b>core is laminated</b> {or core made from layers (of iron and insulator)} ( <b>n.b. not</b> the transformer is laminated)	<b>M1</b>	<b>2</b>
	(reduce heating because) resistance increased or (eddy) current reduced/minimised	<b>A1</b>	
(b) (i)	current (in each lamp) = 3 A	<b>C1</b>	<b>2</b>
	ammeter reading = 9 A	<b>A1</b>	
(ii)	total secondary power = 108 W or $V_s I_s = V_p I_p$ <b>or</b> since voltage is stepped down x 4, current is stepped up x 4	<b>C1</b>	<b>2</b>
	2.25 A (allow ecf for use of secondary current = 3 A giving 0.75 A)	<b>A1</b>	
(iii)	60	<b>B1</b>	<b>1</b>

<b>Question 3</b> (a) (i)	$4.6 \times 10^{-3}$	<b>B1</b>	<b>2</b>
	$\text{Wb s}^{-1} (\text{T m}^2 \text{s}^{-1})$	<b>B1</b>	
(ii)	there is a potential difference/voltage loss across the diode	<b>B1</b>	<b>1</b>
(iii)	the direction of the <b>induced emf</b> is reversed	<b>B1</b>	<b>2</b>
	the diode is reverse biased/will not conduct/only conducts one way	<b>B1</b>	
(b)	energy input = $mgh$	<b>C1</b>	<b>5</b>
	0.0368 (J)	<b>C1</b>	
	energy output = $\frac{1}{2} CV^2$ or $\frac{1}{2} QV$ and $Q=VC$	<b>C1</b>	
	$2.12 \times 10^{-5}(\text{J})$	<b>C1</b>	
	efficiency = 0.058(0.0576)% (if 0.058 then % essential) or $5.8 \times 10^{-4}$	<b>C1</b>	

<b>Question 4</b> (a) (i)	half life = $1.44 \times 10^{10}$ s or half life = $0.69/\lambda$ or $\ln 2/\lambda$	<b>C1</b>	<b>2</b>
	450 (449) y (or 460(456)y if they use $3.15 \times 10^7$ s = 1y)	<b>A1</b>	
(ii)	$A = \lambda N$	<b>C1</b>	<b>2</b>
	$7.7 \times 10^{14}$	<b>A1</b>	
(iii)	$A = A_0 e^{-\lambda t}$	<b>C1</b>	<b>3</b>
	correct substitution ( $A = 3.7 \times 10^4 e^{-4.8 \times 10^{-11} \times 50 \times 3.2 \times 10^7}$ )	<b>C1</b>	
	$3.4 \times 10^4$ Bq	<b>A1</b>	
(iv)	the decay products/neptunium may also be radioactive	<b>B1</b>	<b>1</b>
(b) (i)	attempt to determine mass change or quotes $E = mc^2$	<b>C1</b>	<b>3</b>
	mass change = $1.00 \times 10^{-29}$ kg	<b>C1</b>	
	$9.0 \times 10^{-13}$ J or 5.63 MeV (condone correct answer in J followed by incorrect attempt to convert to MeV)	<b>A1</b>	
(ii)	decays without the need for any external stimulus (owtte)	<b>B1</b>	<b>2</b>
	mass of products must be less than original mass (of nucleus for possible spontaneous decay)	<b>B1</b>	

<b>Question 5</b> (a)	curved path toward the negative plate	<b>B1</b>	<b>2</b>
	curved path toward the top of the page	<b>B1</b>	
(b) (i)	force per unit charge (or Newton's per coulomb) or voltage (change) per metre (condone force acting on a given charge but <b>not</b> force on any charge)	<b>B1</b>	<b>2</b>
	field strength is the same at all points in the field ( <b>not</b> constant)	<b>B1</b>	
(ii)	$E = V/d$	<b>C1</b>	<b>2</b>
	900 V	<b>A1</b>	
(c) (i)	$F = Eq$	<b>C1</b>	<b>2</b>
	$1.28 \times 10^{-14} \text{ N}$	<b>A1</b>	
(ii)	$F = Bqv$ or $v = E/B$	<b>C1</b>	<b>2</b>
	$1.18 \times 10^5 \text{ m s}^{-1}$ {e.c.f. (c) (i)/ $1.09 \times 10^{-19}$ }	<b>A1</b>	
(d)	<b>in an electric field</b> force is always in the same direction/at 90° to a plate/downwards or there is a pd between the plates	<b>B1</b>	<b>Max 3</b>
	there is an acceleration in the direction of the force/ at 90° to a plate/downwards/towards the negative plate or work is done on the charge	<b>B1</b>	
	increases in speed (vertically)	<b>B1</b>	
	horizontal speed constant	<b>B1</b>	<b>Max 3</b>
	<b>in magnetic field</b> force/acceleration always perpendicular to direction of motion	<b>B1</b>	
	no component of force/acceleration in the direction of motion or no work done so no change in KE	<b>B1</b>	
	no component of force/acceleration in the direction of motion or no work done so no change in KE	<b>B1</b>	
	motion is in a circular path	<b>B1</b>	<b>Max 5</b>
	At least 2 marks for physics + <b>Good QWC</b>	<b>2</b>	<b>Max 2</b>
	At least 2 marks for physics + <b>Poor QWC</b>	<b>1</b>	
At least 2 marks for physics + <b>Very Poor QWC</b>	<b>0</b>		
1 or 2 marks for physics + sufficient attempt + <b>Poor QWC</b>	<b>1</b>		
1 or 2 marks for physics + insufficient attempt or <b>Very Poor QWC</b>	<b>0</b>		
No marks for physics or <b>Very Poor QWC</b>	<b>0</b>		

<b>Question 6</b> (a)	force/thrust = rate of change of momentum or $\Delta(mv)/\Delta t$ or $v$ ( $\Delta m/\Delta t$ ) $270 \times 2000/3600$ or $270 \times 2 \times 10^6$ seen or $2000\ 000/3600$ ( $555\ \text{m s}^{-1}$ ) <b>not</b> $F = ma$  150 kN	<b>C1</b>  <b>A1</b>	<b>2</b>
(b)	energy $Q = mc\Delta\theta$ <b>or</b> temperature change = 1750 K or (1800 – 50) seen  energy removed per s = $270 \times 990 \times 1750 = 4.68 \times 10^8$ J (condone $\text{J s}^{-1}$ or W)	<b>C1</b>  <b>A1</b>	<b>2</b>
(c)	mass of water per second = $8 \times 10^6/3600$ or energy/h = $4.7 \times 10^8$ $\times 3600$ <b>or</b> their (b)/( $8 \times 10^6 \times 4200$ ) (answer is then their (b)/ $3.4 \times 10^{10}$ )  temperature rise of water = 50(.1)K or °C (e.c.f. their (b)/ $9.3 \times 10^6$ )	<b>C1</b>  <b>A1</b>	<b>2</b>
<b>Question 7</b> (a)	resistance increases  increase in pressure changes curvature/stretching/expands diaphragm  resistor/strain gauge is longer and/or thinner	<b>B1</b>  <b>B1</b>  <b>B1</b>	<b>3</b>
(b) (i)	5(.0) V <b>n.b.</b> condone 1 sf	<b>B1</b>	<b>1</b>
(ii)	quote potential divider formula or substitution e.g. $(\frac{49}{49+51} \times 10)$ (may be e.c.f 5V not 10V) or calculates current correctly ( $10/100 = 0.1$ A)  4.9 V (if (b) (i) = 2.5 V use of 5.0 for $V_{in}$ then 2.45 is e.c.f)	<b>C1</b>  <b>A1</b>	<b>2</b>
(iii)	0.2 V (2 x {(i) – (ii)})	<b>B1</b>	<b>1</b>
<b>Question 8</b> (a)	current carrying conductor/wire in a magnetic field  there is a force on the wire or $F = BIL$  the force changes <b>direction</b> (as current direction changes)	<b>B1</b>  <b>B1</b>  <b>B1</b>	<b>3</b>
(b) (i)	the <b>forcing frequency</b> = <b>natural frequency</b> of the wire or frequency of ac = natural frequency	<b>B1</b>	<b>1</b>

(ii)	length of the wire (between fixed ends/nodes)	<b>B1</b>	<b>2</b>
	mass per unit length of the wire ( <b>not</b> material from which the wire is made)	<b>B1</b>	
(iii)	decreases/falls	<b>B1</b>	<b>2</b>
	tension in the wire reduced or wire slackens	<b>B1</b>	

<b>Question 9</b> (a)	temperature above triple point = 1800 K or final temperature = 2073 K	<b>C1</b>	<b>Max 3</b>
	voltage change = $40 \times 1800 \mu\text{V} = 72 \text{ mV}$ (40 x recognisable temperature gets this mark only)	<b>C1</b>	
or $\text{emf} = \left(\frac{2073}{273} \times 11\right) = 83.5 \text{ mV}$	<b>C1</b>		
or $(40 \times 2073) = 82.9 \text{ mV}$	<b>C1</b>		
83 mV	<b>A1</b>		
<b>or</b>			
temperature change = 50 K or final temperature = 323 K	<b>C1</b>	<b>Max 2</b>	
voltage change = $40 \times 50 \mu\text{V} = 2 \text{ mV}$	<b>C1</b>		
or $\text{emf} = \left(\frac{323}{273} \times 11\right)$ or $(40 \times 323)$	<b>C1</b>		
12.9(13) mV	<b>A1</b>		
	<b>A1</b>		
(b)	mass/volume/surface area	<b>B1</b>	<b>Max 2</b>
	the specific heat capacity (of the components)	<b>B1</b>	
	the (thermal) conductivity of the material (allow thermal resistance but not resistance)	<b>B1</b>	
	allow alternatives such as how fast heat is conducted	<b>B1</b>	

<b>Question 10</b> (a)	each sensor/signal is sampled /monitored in turn or signals extracted in turn or differentiated at the other end  signals sent (down cable) one after the other (idea of time sharing) transmitted sequentially but not simultaneously	<b>B1</b>   <b>B1</b>	   <b>2</b>
(b)	signal: becomes poorer quality/corrupted/distorted amplitude falls/weakens suffers $I^2 R$ losses in cable pulses are spread affected by noise interference	<b>B1</b>	<b>1</b>
<b>Question 11</b> (a)	$F = mv^2/r$ or $mr\omega^2$  $\omega = \frac{2\pi 9000}{60}$ or 942 (rad s <sup>-1</sup> ) or $v = 471$ (ms <sup>-1</sup> )  0.090 kg	<b>C1</b>  <b>C1</b>  <b>A1</b>	  <b>3</b>
(b)	the direction of the unbalanced/centripetal force on the ice changes direction  a periodic force (acts on the engine) or forced vibrations produced or resonant vibrations produced	<b>B1</b>  <b>B1</b>	  <b>2</b>