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ASSESSMENT and QUALIFICATIONS ALLIANCE

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.

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

PHB5 Fields and their Applications

Question 1 (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) **or** equation M0 : masses defined A1 separation defined A1	**B1** **B1**	**2**
(b) (i)	appreciation that potential x distance from centre of sun = constant **or** calculation of Vr for two sets of values (1.33 x 10^{20}) **or** 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)	**C1** **A1**	**2**
(ii)	$V = GM/r$ and $g = GM/r^2$ **or** $g = V/r$ (no mark for E or $g= V/d$ or $E = V/r$) substitution of one set of data to obtain GM (1.33 x 10^{20}) or 19 x 10^{10}/7 x 10^8 seen 271 N kg^{-1} (m s^{-2}) (J kg^{-1} m^{-1})	**B1** **B1** **B1**	**3**
(iii)	potential energy of the Earth = (–)GMm/r or potential difference formula + $r_2 = \infty$ or potential at position of Earth = –8.87 x 10^8 J kg^{-1} (from Vr =1.33 x 10^{20}) correct substitution (allow ecf for GM from (ii)) or potential energy = potential x mass of Earth change in PE = 5.32 x 10^{33} J (cnao) Fd approach is PE so 0 marks	**C1** **C1** **A1**	**3**
(iv)	speed of Earth round Sun = $2\pi r/T$ or $\sqrt{\frac{GM}{r}}$ or 3.0 x 10^4 m s^{-1} or KE= $\frac{GMm}{2r}$ KE of Earth = ½ 6 x 10^{24} x their v^2 (2.68 x 10^{33}J) energy needed = difference between (iii) and orbital KE (2.64 x 10^{33} J) or KE in orbit = half total energy needed to escape (−1 for AE)	**B1** **B1** **B1**	**3**

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

Question 3 (a) (i)	4.6×10^{-3} Wb s^{-1} (T m^2 s^{-1})	**B1** **B1**	**2**
(ii)	there is a potential difference/voltage loss across the diode	**B1**	**1**
(iii)	the direction of the **induced emf** is reversed the diode is reverse biased/will not conduct/only conducts one way	**B1** **B1**	**2**
(b)	energy input = *mgh* 0.0368 (J) energy output = ½ CV^2 or ½ QV and $Q=VC$ 2.12×10^{-5}(J) efficiency = 0.058(0.0576)% (if 0.058 then % essential) or 5.8×10^{-4}	**C1** **C1** **C1** **C1** **C1**	**5**

Question 4 (a) (i)	half life = 1.44×10^{10} s or half life = 0.69/λ or ln2/λ 450 (449) y (or 460(456)y if they use 3.15×10^7 s = 1y)	**C1** **A1**	**2**
(ii)	$A = \lambda N$ 7.7×10^{14}	**C1** **A1**	**2**
(iii)	$A = A_o \, e^{-\lambda t}$ correct substitution ($A = 3.7\times10^4 e^{-4.8\times10^{-11}\times50\times3.2\times10^7}$) 3.4×10^4 Bq	**C1** **C1** **A1**	**3**
(iv)	the decay products/neptunium may also be radioactive	**B1**	**1**
(b) (i)	attempt to determine mass change or quotes $E = mc^2$ mass change = 1.00×10^{-29} kg 9.0×10^{-13} J or 5.63 MeV (condone correct answer in J followed by incorrect attempt to convert to MeV)	**C1** **C1** **A1**	**3**
(ii)	decays without the need for any external stimulus (owtte) mass of products must be less than original mass (of nucleus for possible spontaneous decay)	**B1** **B1**	**2**

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

Question 6 (a)	force/thrust = rate of change of momentum or $\Delta(mv)/\Delta t$ or $v(\Delta m/\Delta t)$ 270 x 2000/3600 or 270 x 2 x 10^6 seen or 2000 000/3600 (555 m s^{-1}) **not** $F = ma$ 150 kN	C1 A1	2
(b)	energy $Q = mc\Delta\theta$ **or** temperature change = 1750 K or (1800 – 50) seen energy removed per s = 270 x 990 x 1750 = 4.68 x 10^8 J (condone J s^{-1} or W)	C1 A1	2
(c)	mass of water per second = 8 x 10^6/3600 or energy/h = 4.7 x 10^8 x 3600 **or** their (b)/(8 x 10^6 x 4200) (answer is then their (b)/3.4 x 10^{10}) temperature rise of water = 50(.1)K or °C (e.c.f. their (b)/9.3 x 10^6)	C1 A1	2
Question 7 (a)	resistance increases increase in pressure changes curvature/stretches/expands diaphragm resistor/strain gauge is longer and/or thinner	B1 B1 B1	3
(b) (i)	5(.0) V **n.b.** condone 1 sf	B1	1
(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)	C1 A1	2
(iii)	0.2 V (2 x {(i) – (ii)})	B1	1

Question 8 (a)	current carrying conductor/wire in a magnetic field there is a force on the wire or $F = BIL$ the force changes **direction** (as current direction changes)	B1 B1 B1	3
(b) (i)	the **forcing frequency** = **natural frequency** of the wire or frequency of ac =natural frequency	B1	1

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

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

Question 10 (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	**B1** **B1**	**2**
(b)	signal: becomes poorer quality/corrupted/distorted amplitude falls/weakens suffers $I^2 R$ losses in cable pulses are spread affected by noise interference	**B1**	**1**

Question 11 (a)	$F = mv^2/r$ or $mr\omega^2$ $\omega = \frac{2\pi 9000}{60}$ or 942 (rad s^{-1}) or v = 471 (ms^{-1}) 0.090 kg	**C1** **C1** **A1**	**3**
(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	**B1** **B1**	**2**