



ASSESSMENT and  
QUALIFICATIONS  
ALLIANCE

# Mark scheme

# June 2003

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## GCE

## Physics B

### Unit PHB5

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# PHB5

## Question 1

(a)(i)	(magnetic) flux	Not flux linkage	B1	1
(ii)	weber or tesla-metre <sup>2</sup> or Wb or T m <sup>2</sup>		B1	1
(b)(i)	max dB/dt determined using tangent drawn at $t = 0, 0.5$ s or 1.0 s (value should be in range 0.5 to 0.8 ( $\times 10^{-2}$ T s <sup>-1</sup> ) or coordinates in an equation) (condone powers of 10)		B1	
	Attempt to apply $\Delta(BAN)/t$ e.g. induced emf = $240 \times 2.5 \times 10^{-4} \times dB/dt$ (ignore powers of 10 here) (any $B$ divided by any $t$ is sufficient evidence e.g. 0.24 s or 1 s)		C1	
	Answer <b>using correct method</b> in range 0.30 – 0.50 mV (allow 1, 2 or 3 sf answers)		A1	3
(ii)	Graph showing positive and negative values zero emf at approximately correct times (0.20 to 0.26 s and 0.70 to 0.76 s) maximum at correct times <b>and</b> correct shape Ignore phase; Must show positive and negative emfs		M0 A1 A1	2
(iii)	Pendulum has to be shorter Length reduced to $\frac{1}{4}$ original length		C1 A1	2
(iv)	the (maximum) speed of the magnet increases (condone angular speed) the (maximum) rate of change of flux increases <b>or</b> wires/coil cuts flux at a higher rate		B1 B1	2
(v)	<b>ANY 2 from</b> use a stronger/more powerful magnet use a coil with more turns (allow more coils) (use a coil with) greater area ( <b>Not</b> magnet with greater area ) use a soft iron core in the coil use a larger amplitude of oscillation of the magnet		B1 B1 B1 B1 B1	<b>Max</b> 2

- (vi) output/voltage would be sampled  
**or**  
 sample at a frequency (much) higher than that of the pendulum B1
- changed to digital/binary form  
**or**  
 processed by an A – D converter B1 2

**Total 15**

**Question 2**

- (a) the radius/diameter of the planet **not** ‘size’ B1  
 the mass (or density) of the planet B1 2

- (b)(i) volume of the granite =  $\frac{4}{3} \pi r^3$   
**or**  
 radius of the granite = 0.2 km (may be seen in an incorrect equation) B1  
 $200^3$  or  $\frac{4}{3} \pi 0.2^3$  **or**  $3.35 \times 10^7 \text{m}^3$  B1  
 Mass = density x volume used with any density and their volume  
 (Volume may be in formula form)  
 If they use correct volume then either  $1.24 \times 10^{11}$  or  $7.37 \times 10^{10}$  gets  
 the mark) B1  
 $(3700-2200) \times 3.35 \times 10^7$  **or**  $1500 \times 3.35 \times 10^7$  kg  
**or**  $(1.24 \times 10^{11} - 7.37 \times 10^{10})$  **or**  $5.025 \times 10^{10}$  **or**  $5.03 \times 10^{10}$  seen  
 Condone rounding off early leading to  $4.6 \times 10^{10}$  kg B1 4

**NB**

- 1)the fourth mark is not for  $5.0 \times 10^{10}$  – all working must be shown  
 2)those who do not show conversion of radius from km to m in the  
 calculation but otherwise correct will get 3

- (ii) Gravitation field strength  $g = GM/r^2$   
**or**  
 uses distance of 0.4 km for  $r$  C1  
 Substitution for extra field strength =  $6.7 \times 10^{-11} \times 5.0 \times$   
 $10^{10}/(0.4 \times 10^3)^2$   
 Condone  $r = 0.4$  for this mark C1  
 Correct substitution for the extra field strength with **correct** powers  
 of 10 C1  
 $2.1 \times 10^{-5} \text{ N kg}^{-1}$  (condone  $\text{m s}^{-2}$ )  
**or**  
 $1.9 \times 10^{-5}$  if  $4.6 \times 10^{10}$  carried forward from (i) A1 4
- (iii) Correct general shape always below original curve B1 1

**Total 11**

- Alternative scheme for different approach to (ii)**
- (ii) Gravitation field strength =  $GM/r^2$   
 or  
 uses distance of 0.4 km for  $r$  C1
- Correct substitution for field strength for granite (or soil)  
 $6.7 \times 10^{-11} \times 1.24 \times 10^{11} / (0.4 \times 10^3)^2$  or  $6.7 \times 10^{-11} \times 7.37 \times 10^{10} / (0.4 \times 10^3)^2$   
 Condone  $r = 0.4$  for this mark C1  
 Correct substitution for field strength for soil (or granite) C1  
 $2.1 \times 10^{-5} \text{ N kg}^{-1}$  (condone  $\text{m s}^{-2}$ ) A1 **4**

### Question 3

- (a)(i) zero potential is taken to be at 'infinity' (or a long way from the charge) B1
- in this system  
 work has to be done to take a positive charge to infinity/away from Q  
 or energy has to be put in to take a positive charge to infinity/away from Q  
 or positive charge loses PE as it moves from infinity/toward Q  
 or positive charge gains PE as it moves to infinity/away from Q B1 **2**
- Not**  
 the field is such that positive charge is attracted  
 potentials are negative because charge is negative
- (ii) three radial lines drawn (condone more than three)  
 all toward the charge by eye (-1 for poor quality) B1  
 at least one arrow shown directed toward the charge B1 **2**
- (b)(i)  $V = q/4\pi\epsilon_0 r$  C1  
 Correct substitution of any pair of  $V$  and  $r$   
 e.g.  $10 \times (4\pi \times 8.9 \times 10^{-12} \times 4.0 \times 10^{-2})$  (=  $4.47 \times 10^{-11} \text{ C}$ ) A1 **2**
- (ii)  $E = q/4\pi\epsilon_0 r^2$  or  $V/r$  (**not**  $V/d$ ) M1  
 $250$  (251)  $\text{V m}^{-1}$  ( $\text{N C}^{-1}$ ) (ignore lack of direction indication) A1 **2**
- (c) energy transferred =  $Vq$   
 or  
 potential difference = 30 V  
 or  
 $\frac{Q_1 Q_2}{4\pi\epsilon_0} \left[ \frac{1}{r_1} - \frac{1}{r_2} \right]$  or  $\frac{1.6 \times 10^{-19} \times 4.5 \times 10^{-11}}{4\pi \times 8.9 \times 10^{-12}} \left[ \frac{1}{0.01} - \frac{1}{0.04} \right]$  (condone  
 1/1-1/4) C1  
 $4.8(3) \times 10^{-18} \text{ J}$   
 ecf for their incorrect charge from (b)(i) A1 **2**

(ii)	(As it moves away)		
	electron loses PE <b>or</b> work is done on the electron		
	or		
	the electron is repelled by the negative charge	B1	
	wavelength will decrease	B1	
	<b>plus 2 from</b>		
	as the electron moves away speed will increase	B1	
	as the electron moves away the momentum will increase	B1	
	$\lambda = h/mv$ <b>or</b> $h/p$ <b>or</b> $\lambda \propto 1/v$ <b>or</b> $\lambda \propto 1/mv$	B1	<b>4</b>
	<b>At least 3 marks for physics</b> + use of Physics is accurate, the answer is fluent/well argued with few errors in spelling, punctuation and grammar		<b>2</b>
	<b>At least 1 mark for physics</b> the use of Physics is accurate, but the answer lacks coherence or spelling, punctuation and grammar are poor		<b>1</b>
	the use of Physics is inaccurate, the answer is disjointed, with significant errors in spelling, punctuation and grammar		<b>0</b>
			<b>Max</b>
			<b>2</b>
			<b>6</b>
			<b>Total 16</b>

#### Question 4

(a)(i)	1 N per A per m		
	<b>or</b> $1 \text{ Wb m}^{-2}$		
	<b>or</b> quotes: $B = F/IL$ with terms defined		
	<b>or</b> induced $EMF = \Delta BAN/t$ with terms defined		
	<b>or</b> a slightly flawed attempt at the definition in statement form	C1	
	It is the flux density (perpendicular to a wire) that produces a force of 1N per m on the wire when the current is 1A		
	<b>or</b>		
	$B = F/IL$ <b>and</b> 1 T is flux density when $F = 1\text{N}$ ; $I = 1\text{A}$ and $L = 1\text{ m}$		
	<b>or</b> induced $EMF = \Delta BAN/t$ and 1 T is the flux change when emf = 1V for $A=1$ $N=1$ and $t=1$ or similar	A1	<b>2</b>
(ii)	force on charge due to $E$ field, $F_E = Eq$ <b>or</b> $Vq/d$		
	<b>and</b>		
	force due to $B$ field, $F_B = Bqv$		
	<b>or</b> $Eq = Bqv$	B1	
	$= Bqv$ ; cancels $q$ <b>and states explicitly</b> $v = \frac{E}{B}$ <b>or</b> $v = \frac{V}{dB}$	B1	<b>2</b>
(iii)	$v = 20000/0.14$ (seen) <b>or</b> $143 \times 10^3 \text{ m s}^{-1}$	B1	<b>1</b>

(b)(i)	$Bqv = mv^2/r$ or $r = mv/Bq$ ( allow $e$ instead of $q$ ) mass of ion = $1.7 \times 10^{-27} \times 58$ (may be in equation) <b>or</b> ( $9.86 \times 10^{-26}$ kg seen ) <b>or</b> radius = 0.14 m (may be in equation) Substitutes and arrives at 0.62 to 0.63 T	C1  C1 A1	   <b>3</b>
(ii)	Calculates new radius (0.145 m) or diameter (0.288 m) using $r \propto m$ or otherwise <b>allowing ecf</b>  0.010 m (condone 0.01 m) or 0.0096 – 0.0097 m (Allow 0.0079 m or 0.008 m due to use of different sfs for $B$ and $v$ )	C1  A1	  <b>2</b>
			<b>Total 10</b>

### Question 5

(a)	1	B1	<b>1</b>
(b)(i)	$E_k = E_p$ when the protons touch <b>or</b> $E_k = q^2/4\pi\epsilon_0 r$ <b>or</b> separation when they touch = $3.0 \times 10^{-15}$ m <b>or</b> $V = q/4\pi\epsilon_0 r$ $E_k = (1.6 \times 10^{-19})^2/4\pi (8.9 \times 10^{-12}) (3.0 \times 10^{-15})$ <b>or</b> $E_k = (1.6 \times 10^{-19})^2/4\pi (8.9 \times 10^{-12}) (1.5 \times 10^{-15})$ $7.6(1) \times 10^{-14}$ J (cao)	C1  C1 A1	   <b>3</b>
(ii)	incident proton will stop and the stationary proton will move off at velocity/speed of the incident proton <b>or</b> All KE/momentum is transferred to the stationary particle <b>NB</b> not they will not touch	  B1	  <b>1</b>
(iii)	protons travel in the opposite directions or velocity is reversed with initial speeds total momentum before = 0 so momentum after must be 0 <b>or</b> <b>provided they have said that speeds are the same</b> total KE is same before and after the collision <b>or</b> the collision is elastic	M1 A1  B1	   <b>3</b>
(iv)	mention of strong nuclear force <b>or</b> the repulsive force is overcome  the strong nuclear force is greater than the electrostatic repulsion <b>or</b> the strong nuclear force is effective when the protons touch	  C1  A1	   <b>2</b>

- (c)  $E = mc^2$  C1  
 mass increase =  $\{(2 \times 2.2) - (2 \times 1.7)\} \times 10^{-27} \text{ kg} = 1.0 \times 10^{-27} \text{ kg}$   
**or**  
 calculates initial energy equivalence of 2 protons  
**or**  
 final energy equivalence of 2 delta + particles C1  
 $8.6 \text{ or } 9 \times 10^{-11} \text{ J}$  (i.e. allow 1sf) c.a.o.  
 (NB Adding on the answer to (b)(i) is correct but it has no influence on the answer to 2 sf so its absence is condoned)  
 A1 **3**  
**Total 13**

### Question 6

- (a) Escape energy =  $\frac{GMm}{r}$  **or**  $\frac{GM}{r}$   
**or**  $\frac{GMm}{r} = \frac{1}{2}mv^2$  B1  
 $6.7 \times 10^{-11} \times 6.0 \times 10^{24} / 6400 \times 10^3 = 63 \text{ MJ}$   
**or**  
 Calculates escape velocity using  $\frac{GMm}{r} = \frac{1}{2}mv^2$  giving  $11\,200 \text{ m s}^{-1}$   
**or** recalls escape velocity as  $11\,000$  or  $11\,200 \text{ m s}^{-1}$   
**or**  
 Calculates velocity using  $80 \times 10^6 = \frac{1}{2}v^2$  giving  $12\,600 \text{ m s}^{-1}$  B1  
 63 MJ per kg so 80 MJ is more than enough (OWTTE)  
**or**  
 Calculates the other velocity and draws a conclusion  
 Recall of escape speed and showing escape energy = 63 MJ with conclusion gets last two marks  
**NB** Arriving at 63 MJ using  $mgh$  is a physics error and gains no marks.  
 (These candidates get 63 MJ using  $g = 9.8 \text{ m s}^{-2}$  and the radius of the Earth for  $h$ ) B1 **3**
- (b) Gases have to be given a velocity/momentum  
**or**  
 Gas must have an equal and opposite force on it to that on the rocket B1  
 The gases have kinetic energy B1  
**or**  
 If all KE given to the rocket there is no gas ejected from the exhaust M1  
 Momentum would not then be conserved A1 **2**
- (c) fuel has to be provided to move the fuel needed for later parts of the journey  
**or** to move the fuel itself B1

the ratio of payload to original mass that has to be moved is very low.

**or**

a lot of fuel is needed (for a small payload)(which is expensive)

**or**

parts of the rocket that containing fuel are discarded on the journey

**or**

propulsion by burning fuel is inefficient

(or other sensible reason for inefficiency)

B1 2

**Total 7**

### Question 7

(a) Superconductors have **no** resistance  
so **no** heating occurs

B1

**or**

**no**  $I^2R$  losses

B1 2

(b) Magnet moving producing changing magnetic flux  
 $I^2R$  losses/heating of track (due to induced/eddy currents in the  
(resistive) track)

B1

B1

the direction of the induced current oppose the change producing it

**or**

mention of Lenz's law

B1

the induced current is in the magnetic field of the magnet so has a  
force on it

**or**

the induced current sets up a field that tries to prevent the magnet  
moving

**or**

track behaves like a magnet and attracts the superconducting magnet B1  
The faster the motion **or** the greater the rate of change of magnetic  
flux,

the greater the induced currents

B1

Faster vehicle leads to greater resistive/power losses

**or**

Faster vehicle leads to greater magnetic drag forces

B1

**At least 3 marks for physics** + use of Physics is accurate, the  
answer is fluent/well argued with few errors in spelling, punctuation  
and grammar

2

**At least 1 mark for physics + some incorrect work** the use of  
Physics is accurate, but the answer lacks coherence or spelling,  
punctuation and grammar are poor

1

the use of Physics is inaccurate, the answer is disjointed, with  
significant errors in spelling, punctuation and grammar

0

8

**Total 10**



**Question 8**

- (a)(i) energy per pulse =  $10\,000/28 = 360$  (357) J B1 1
- (ii) one photon =  $hc/\lambda$  or  $hf$  C1
- energy of one photon =  $1.86 \times 10^{-19}$  J
- or
- $6.6 \times 10^{-34} \times 3 \times 10^8/1060 \times 10^{-9}$  (ignore power of 10 for wavelength) C1
- $1.88 - 1.94 \times 10^{21}$  (i.e. their (a)(i)/ $1.86 \times 10^{-19}$ ) A1 3
- Total 4**

**Question 9**

- (a)(i)  $v^2 = u^2 + 2as$  C1
- $a = 48 \text{ m s}^{-2}$
- (negative answer is a physics error;  $u$  and  $v$  wrong way round loses A1 mark) A1 2
- (ii)  $v = u + at$  or  $s = \frac{1}{2}(u + v)t$  or  $s = ut + \frac{1}{2}at^2$  B1
- $1700 = 48t$  or  $30\,000 = \frac{1}{2}1700t$  or  $850t$  or  $30\,000 = 0.5 \times 48t^2$   
(N.B. seen explicitly) B1 2
- (b)(i) PE =  $mgh$  or  $G M m (1/r_1 - 1/r_2)$  or KE =  $\frac{1}{2}mv^2$
- or one energy change calculated
- PE 588 000 J; KE 2 890 000 J (using  $m = 2 \text{ kg}$ )
- or PE = 294 000 J or KE = 1 450 000 J (using  $m = 1 \text{ kg}$ ) C1
- Two energy changes calculated correctly using  $m = 1$  or  $2 \text{ kg}$  C1
- 3.5 (3.48) MJ (c.n.a.o.) A1 3
- (ii) Energy supplied = 35 MJ
- or 0.35 MW (using power = 10 kW) but no second mark allowed C1
- Efficiency = (9.9% or 0.099 if correct)
- (5.0% or 0.050 if fuel ignored)
- Condone 1sf answers in these cases
- e.c.f. from (b)(i)**
- (1.7% if PE only calculated in (i) 8.3% if KE only calculated in (i)) A1 2
- (c) Diameter of the mirror needed = 42 m B1 1
- (d)(i)  $p/T = \text{constant}$  C1
- $P = 1 \times 10^5 \times 40\,000/300 = 1.3 \times 10^7 \text{ Pa}$  A1 2
- (ii) There will be little or no air/atmosphere (at 30 km height) M1
- The system works by air/gas expanding A1
- or the system works by heating air/gas
- or the thrust will be decreased or no thrust or no propulsion

or fewer molecules ejected so rate of change of momentum is lower  
(or lower thrust

**2**

Allow B1 for problems associated with not capturing energy due to  
the beam divergence beyond 30km (i.e. considering hydrogen power  
as a different method of propulsion to overcome this problem)

**Total 14**