GCE

Physics A

Combined Mark Schemes
And Report on the Units

June 2005

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MARK SCHEMES ON THE UNITS

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Mark Scheme 2821
June 2005

JUNE 2005
AS MODULE 2821 FORCES AND MOTION
FINAL MARK SCHEME

Q1   **(a)(i)**   velocity = displacement / time   **B1**

     (ii) acceleration = change in velocity / time   **B1**

(Ratio must be clear. i.e. allow per but not over, in or with time)
(Allow rate of change of…. or per unit time)

    (b)(i)   reduced fuel or smaller tank means less mass   **B1**
              hence greater acceleration / deceleration(for the same force)   **B1**

     (ii) smooth tyres give greater area of contact or more friction in the dry
             or there is less friction in the wet   **B1**
             tread required in the wet to channel the water away   **B1**

    (c)(i) $v^2 = u^2 + 2as$ **C1**
            $0 = (80)^2 + 2 \times a \times 120$ **C1**
              $a = (-) 26.7 \ (m \ s^{-2})$ ignore sign   **A1**

     (ii) $t = (0 - 80) / - 26.7$ **C1**
              $t = 3.0 \ (s)$ **A1**

    (d)   **(**time lost by) car A = (3 + 9 + 4) = 16   **B1**
            car B was 17 behind   **C1**
            Car B takes 2 s to travel the 160 m / Car B 19 behind   **B1**
            Hence car A 3 s ahead   (19 – 16)   **A1**

Total: [15]

Q2   **(a)**   v comp decreases going up   **B1**
               as gravitational force / acceleration is against motion or downwards
               or -9.8 ms^{-2} or is constant   **B1**
               vertical comp is zero at P   **B1**

               h comp no change   **B1**
               as no resistive force/gravitational force has no effect   **B1**

               v comp increases on way down   **B1**
               as gravitational force / acceleration is in same direction as motion or
               downwards or + 9.8 ms^{-2} or is constant   **B1**

               vertical comp more than horizontal at start but gets smaller than
               horizontal as it goes up   **B1**

               Penalise confusion of horizontal and vertical twice and then apply ecf

                                                    MAX 5

  2   **(b)**   k.e. decreases on way up / k.e. increases on the way down   **B1**
               k.e. not zero at top of flight / k.e. min at P (top)   **B1**
               p.e. increases on way up / p.e. max at P / decreases on way down **B1**
               loss of ke =gain in pe at any point on flight / k.e. converted to p.e.   **B1**
               k.e. = p.e halfway up / pe. + k.e. = constant   **B1**
               k.e. the same as starting value at G   **B1**
               p.e. zero at G / p.e. same as starting value at G   **B1**

                                                         MAX 4

        (c)   air resistance/drag slows down the ball or reduces vertical or
               horizontal component or reduces k.e.   **B1**
               height reached is less   **B1**
               range is less   **B1**
               acceleration is no longer constant   **B1**
               acceleration greater than g when going up or greater than – 9.8
               going up or less than 9.8 coming down   **B1**
               h comp reduces when going up and coming down   **B1**
               k.e. at G less than k.e. at T / k.e. transfers to thermal   **B1**
               terminal velocity (may be) reached on the way down   **B1**

                                                         MAX 3

               QWC:
               Technical language: uses terms correctly such as vert. and horizontal components,
               kinetic and potential energies, velocity force acceleration   **B1**
               SPAG: written work has less than four errors in spelling, punctuation and sentence
               formation, at least two sentences in each section   **B1**
                                           Total: [14]

3   **(a)**   (pulley wheel) at rest / in equilibrium / acceleration is zero   **B1**

     (b)(i)   500 N force down and general shape correct   **B1**
              angles correct (one angle labelled correctly)   **B1**
              T_1 and T_2 directions labelled correctly   **B1**
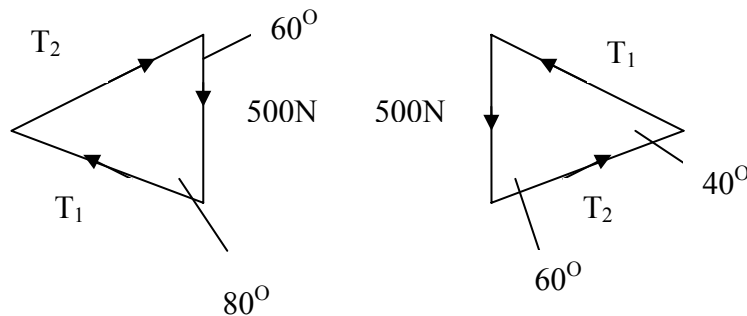
     (ii)   Formulae correct (resolving or sin rule) / scale diagram drawn correctly with scale
              given   **B1**
              T_1 = 674 (N) allow 650 to 700 for scale diagram   **A1**
              T_2 = 766 (N) allow 740 to 790 for scale diagram   **A1**

                                         Total: [7]

Q4   **(a)** $P = F / A$ **C1**

            $F = 1.0 \times 10^5 \times 0.25 = 25000$ (N)   **A1**

     (b) $\rho = m / V$ **C1**

            $m = 800 \times 0.25 \times 0.75 = 150$ **C1**

            $W = 1470$ (N)   **A1**

     (c)   26470 (N)   **B1**
                                       Total: [6]

Q5   **(a)(i)**   carries on going / carries on with the same velocity / slides forwards
                                                         B1
                as there is no force to slow it down / (not enough) friction or resistance or restraining
                force   **B1**

       (ii)   arrow to the left   **B1**

     (b)   the seat belt produces the force (restraining force) / holds passenger in seat
                                                       B1
               in the opposite direction to the motion of the car   **B1**
               stops the passenger continuing to move forward / hitting the front
               seats / windscreen in front / the driver is not hit from behind   **B1**
               seat belts stretch to increase the time/distance   **M1**
               hence force is reduced   **A1**

seat belts have wide area   **M1**
hence pressure reduced   **A1**

                                                            MAX 3
                                                      Total: [6]

Q6   **(a)(i)**   F = kx / k is the gradient of the graph   **C1**

         k = 2.0 / 250 x 10^{-3} = 8.0   **A1**

         Correct unit for value given in (a)(i)
          i.e. 0.008 or 8 x 10^{-3} requires N mm^{-1}.
         Allow N m^{-1} / kg s^{-2} if no working in (a)(i).
         Do not allow unit mark if incorrect physics in part (a)(i)   **B1**

    (ii)   W = ½ (F x extension) / area under the graph   **C1**
              = ½ x 2.0 x 0.250
                = 0.25 (J)   **A1**

(b)(i)   F = 8 x 0.15 = 1.2 (N)   **A1**

    (ii)   Hooke's law continues to be obeyed / graph continues as a straight
              line / k is constant / elastic limit has not been reached   **B1**

(c)(i)   1. correct time marked on the graph with a V (t = 0.75 s or 1.75 s)   **B1**

         2. tangent in the correct place for downward velocity or implied by values
                                                                                   B1
         value between 0.95 to 1.1(m s^{-1})   **A1**

    (ii)   1. X marked in a correct place (maximum or minimum on graph)   **M1**

         2. relates the extension / compression to F = kx to explain why the force is a
         maximum or maximum extension gives max force or maximum extension gives max
         acceleration   **A1**

                                                      Total: [12]

Mark Scheme 2822
June 2005

1

(a) 3×10^8 (ms^{-1}) (Do not allow 'speed of light' / c)   B1

(b)(i) $v = f\lambda$ C1

           $3.0 \times 10^8 = f\lambda$ / $3.0 \times 10^8 = f \times 8.8 \times 10^{-7}$

           frequency $= 3.41 \times 10^{14}$ (Hz) $\approx 3.4 \times 10^{14}$ (Hz)   A1

(b)(ii)   (e.m.f =) $\dfrac{W}{Q}$, with W = energy (transformed to electrical) and Q = charge

                                                                            (B1)

           Or

           Energy transformed by / per unit charge / 1C (from chemical to electrical)   B1

           (Allow: 'energy gained by / per unit charge / 1C / one coulomb')

(b)(iii) $I = \dfrac{\Delta Q}{\Delta t}$ Allow any subject, with or without Δ notation   B1

(b)(iv) $Q = 1.4 \times 10^{-3} \times 0.20$ C1

           charge $= 2.8 \times 10^{-4}$ (C)   A1

(b)(v) $W = VQ$ /   energy $= VQ$ C1

           $W = 3.0 \times 2.8 \times 10^{-4}$

           energy $= 8.4 \times 10^{-4}$ (J)   (Possible ecf)   A1

(c)   Radio waves: 1.5×10^3 m   B1

           Filament lamp: 5.0×10^{-7} m   / 8.8×10^{-7} m   B1

           X-Ray machine: 8.0×10^{-9} m   B1

                                                                  [Total: 12]

2

(a)   length   B1

           (cross-sectional) area   (Allow: radius / diameter / thickness / width)   B1

(b)(i) $R = \dfrac{\rho L}{A}$ (Allow any subject)

                                                                         C1

           $\rho = \dfrac{0.54 \times [\pi \times (0.135 \times 10^{-3})^2]}{1.8}$

                                                                       C1

           $\rho = 1.72 \times 10^{-8} \approx 1.7 \times 10^{-8}$ (Deduct one mark for 10^n error)   A1

           ($\rho = 6.87 \times 10^{-8}$ scores 2/3 if 'diameter' is used)

           ($\rho = 1.72 \times 10^{-5}$ Ω mm   scores 4/4)

           unit: Ω m   B1

(b)(ii)   Any <u>four</u> from: (Allow AW)

           1. Resistance of the wire increases (as the temperature is increased)   B1

           2. The current decreases / the ammeter reading falls   B1

           3. The decrease in current justified in terms of '$I = V/R$'   B1

           4. The voltage remains the same / the voltmeter reading remains the same   B1

           5. The electrons (within the wire) collide <u>more</u> (often with the atoms) / the

atoms vibrate <u>more</u>	(Do not allow 'particles' vibrate more)	B1
QWC for 'spelling and grammar'		B1

[Total: 11]

3

(a)

Correct direction of the magnetic field	B1
The magnetic field pattern is correct and 'symmetrical' ($\geq$ 2 lines)	B1
'Parallel' field lines within the core of the solenoid	B1

(b)(i)

$(B =) \dfrac{F}{IL}$ F = force (on conductor), I = current and L = length (in field)   (B1)

Or

Force (experienced) per / by unit length of conductor carrying a unit current   B1
(Reference to 1m or 1A scores 0/1)
The (magnetic) field is at right angles to the conductor / current   B1

(b)(ii)

$F = BIL$ (Allow any subject)	C1
force = $6F$ / increased by a factor of 6	A1
(Do not allow 'increase by' 6)	

[Total: 7]

4

(a)

$E = I(R + r)$ or $E = V + Ir$ / $R_T = \dfrac{1.5}{0.60} = (2.5)$ / $V_R = 1.8 \times 0.6$ C1

$1.5 = 0.60 (r + 1.8)$ / $r = 2.5 - 1.8$ / $r = \dfrac{1.5 - 1.08}{0.6}$ C1

$r = 0.70 \ (\Omega)$ (Allow 1sf answer)   A1

(b)(i)

$P = \dfrac{V^2}{R}$ / $P = VI$ <u>and</u> $V = IR$ C1

$36 = \dfrac{12^2}{R}$ / $I = 3.0$ (A) hence $R = \dfrac{12}{3.0}$

resistance = 4.0 (Ω) (Allow 1 sf answer)   A1

(b)(ii)

R_{series} = 30 (Ω) C1

$R = \dfrac{30 \times 4.0}{30 + 4.0}$ / $\dfrac{1}{R} = \dfrac{1}{30} + \dfrac{1}{4}$ / $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$ C1

resistance = 3.53 $\approx$ 3.5 (Ω) (Possible ecf)   A1

(b)(iii)

$I_{lamp} = \dfrac{36}{12}$ or 3.0 (A)   / $I_{20\Omega} = \dfrac{12}{30}$ or 0.40 (A)   C1

ratio = 7.5   / ratio = $\dfrac{30}{4}$ A1

[Total: 10]

5

(a)   No current (in circuit) / 'open' circuit / p.d. between **X** and **Y** is 5.0 V   B1

(b) $V = \dfrac{R_2}{R_1 + R_2} \times V_0$ / $\dfrac{V_1}{V_2} = \dfrac{R_1}{R_2}$ / $I = \dfrac{3.4}{168} \ (= 2.02 \times 10^{-2}\,\text{mA})$ C1

        $3.4 = \dfrac{168}{168 + R} \times 5.0$ / $\dfrac{1.6}{3.4} = \dfrac{R}{168}$ / $R = \dfrac{1.6}{2.02 \times 10^{-2}}$ C1

        resistance ≈ 79 (kΩ)   (Total resistance of 250 kΩ scores 2/3)   A1

                                                                                      [Total: 4]

6

(a)   × ✓ ✓ ×   B1 × 2

        All correct 2 marks;   Three correct 1 mark; Two (or less) correct   0 mark

(b)   Any <u>six</u> from: (Allow AW)
1. <u>Photoelectric</u> <u>effect</u> is the removal of electrons (from metals) when exposed to light / u.v. /e.m. radiation / photons   B1
2. <u>Surface</u> electrons are involved / electrons released from the <u>surface</u>   B1
3. A single photon interacts with a single electron   B1
4. Energy is <u>conserved</u> (in the interaction)   B1
5. Energy of photon = hf or $\dfrac{hc}{\lambda}$ B1
6. Reference to Einstein's photoelectric equation: $hf = \phi + \text{KE}_{(max)}$ C1
7. photon energy = work function (energy) + (maximum) KE (of electron)   A1
8. PE effect takes place / electron(s) released when $hf > \phi$ / $hf = \phi$ / frequency is greater / equal to threshold frequency   B1
9. The (maximum) KE of electron is independent of intensity when electrons are emitted   B1
10. Intensity increases the rate / number of electrons when emission occurs   B1
11. PE effect does not take place / no electrons emitted when $hf < \phi$ / frequency < threshold frequency   B1
12. Intensity has 'no effect' when there is no emission of electrons   B1
QWC for 'organisation'   B1

(c)(i)1. $E = hf$ / $E = \dfrac{hc}{\lambda}$ / $f = 7.5 \times 10^{17}$ (Hz)   C1

        ('$E = hf$' can be secured either in **(c)(i)1.** or **(b)**)

        $E = \dfrac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{4.0 \times 10^{-10}}$ / $E = 6.63 \times 10^{-34} \times 7.5 \times 10^{17}$ C1

        energy = 4.97 × 10⁻¹⁶ (J) ≈ 5.0 × 10⁻¹⁶ (J)   (Allow 1 sf answer here)   A1

(c)(i)2. $E = \dfrac{4.97 \times 10^{-16}}{1.6 \times 10^{-19}}$ (Possible ecf from **(c)(i)**)

        energy = 3.1 × 10³ (eV)   B1

(c)(ii)   The answer to **(c)(i)1.** and 1.4 (W) are used to determine the rate of photons   C1

        number = $\dfrac{1.4}{4.97 \times 10^{-16}}$ (Possible ecf)   C1

        number = 2.8 × 10¹⁵ (s⁻¹)   (If 3100 eV is used, then allow 2/3 for 4.5 × 10⁻⁴)   A1

                                                                                      [Total: 16]

Mark Scheme 2823/01
June 2005

1.   (a) (i)   **NORMAL**   B1   [1]

          (ii)   recall of n = sin i/sin r C1
                        valid substitution: e.g. 1.31 = sin 60/sinr   C1
                                  r = **41°** (allow 41.3 and 41.4)   A1   [3]

         (iii)   ray refracted **TOWARDS** NORMAL (NO ARROW NEEDED)   B1
                  angle of refraction r or '41' labelled between ray and normal   B1   [2]

         (iv)   light CHANGES SPEED (or slows down)   B1   [1]

         (b)   RI or n = λ_1/λ_2 C1
                  new wavelength = $6.5 \times 10^{-7}/1.3$ = **5.0×10^{-7}** m (expect 4.96)   A1   [2]

4.44×10^{-7} comes from 41/60 x 6.5×10^{-7} and scores ZERO
8.45×10^{-7} comes from 6.5×10^{-7} x 1.3 scores 1 mark

         (c)   NO CHANGE OF DIRECTION (judged by eye)   B1   [1]
                  wavefronts CLOSER TOGETHER (uniformity generously judged by eye) -B1   [1]

                                                    QUESTION TOTAL = 11

2.   (a)   ray leaving S that is internally reflected at the core/cladding interface   B1
                  LARGE angle of incidence – i.e no more than **3** points of contact/reflections
                  shown   B1   [2]
                  (sine wave may score second mark only)

         (b)   1. R.I of core > R.I of cladding (OR density of core>density of cladding)   B1
                  (allow " light must travel from dense to less dense medium" WTTE)

                  2. <u>angle</u> of incidence greater than the critical angle (WTTE)   B1   [2]

         (c)   *explanation of change of shape:*
                  different rays follow different paths OR reference to "multipath dispersion" B1
                  some rays arrive before others (WTTE referring to time)   B1
                  (allow 1 mark for idea of energy or intensity loss
                  (allow 1 mark for idea that light of different wavelengths travel at different speeds)

                  explanation of how problem is overcome:
                  <u>any</u> valid method: e.g use a very narrow fibre OR a MONOMODE fibre   B1
                  so that effectively there is only one path (WTTE)   B1   [4]

         (d)   (Light is moving from core to cladding hence correct formula for n is)
                            n = sinC   C1
                            n = sin 80 = **0.985** (allow 0.98)   A1

                  Allow simple <u>substitution</u> into n = 1/sinC: e.g. n = 1/sin80   C1
                            n = **1.02**   (allow 1.0 or 1 if sin80 is seen)   A1   [2]

                                                    QUESTION TOTAL = 10

3.   (a)   any **two** valid points: e.g
             in longitudinal waves the vibrations are parallel to wave direction (WTTE)   }
             in transverse waves the vibrations are perpendicular to wave direction (WTTE) }
             transverse waves <u>can</u> be polarised (OR longitudinal waves are not be polarised) }
             (all) longitudinal waves need a medium   } B1+B1 [2]

      (b)   (i) vibrations "V" correctly labelled   OR   (NOT   )   B1   [1]
             (ii) compression "C" correctly shown anywhere on the spring   B1   [1]
             (iii) wavelength "λ" correctly shown: e.g. between neighbouring compressions

                                                                                  B1   [1]

             (generously judged: i.e. somewhere between 28 and 34 mm)

      (c)   wavelength REDUCES   B1
             because v=fλ AND v remains constant (WTTE)   B1   [2]

                                                              QUESTION TOTAL = 7

4.   (a)   DIFFRACTION   B1   [1]

      (b)   a constant phase difference/relation (WTTE)   B1   [1]
             (allow "zero phase difference" and "in phase")

      (c)   constructive interference produces bright lines <u>AND</u> destructive for dark lines   B1

             in phase for bright AND antiphase (allow 'out of phase') for dark   B1
             (ALLOW diagrams showing crests/troughs meeting crests/troughs for this mark)
             path difference = whole number of wavelengths {allow nλ} for bright   B1
             (ALLOW path difference = λ but NOT path difference = ZERO)
             path difference = odd number of half wavelengths {allow (n+1/2)λ} for dark B1   [4]
             (ALLOW path difference = ½λ)

      (d)   recall of λ **= ax/D** (in any valid form)   C1
             valid substitution: e.g. x = $(6.5 \times 10^{-7} \times 1.5)/0.25 \times 10^{-3}$ C1
             x = **3.9×10^{-3}** m   A1   [3]
             (3.9×10^{-6} scores 2 marks)

                                                              QUESTION TOTAL = 9

5.   (a) (i)   node: point of ZERO amplitude/displacement/movement/disruption etc.   B1   [1]
          (ii)   antinode: a point of MAXIMUM **<u>AMPLITUDE</u>**   B1   [1]

      (b) (i)   node **N** labelled at the bottom AND antinode **A** labelled at the top   M1
                 evidence of 'fundamental' i.e only <u>one</u> **A** at top and <u>one</u> **N** at bottom   A1   [2]
                 {allow ecf from (a) i.e. if A and N are defined oppositely}

          (ii)   (length of air column = ¼λ) $\Rightarrow$ λ = 4 x 0.32 = **1.28** m   B1   [1]
                 {NO ecf from incorrect wave in (i)}

          (iii) recall of v=f λ OR frequency of tuning fork = frequency of standing wave   C1
                 valid substitution: e.g f = 330/1.28   C1
                                     f =   **258** Hz   A1   [3]
                 {allow ecf from(ii) e.g if λ= 0.32 is used f = 1030Hz scores 3 marks}

                                                              QUESTION TOTAL = 8

Mark Scheme 2823/03
June 2005

Planning Exercise - Skill P

A1   <u>Workable</u> procedure   **P1**
           (i.e. measure temp. and resistance across faces P and Q, vary temp. and
           measure new resistance. Could be in a table)

A2   Suitable method for achieving temperature of brick (e.g. oven/kiln)   **P1**
           Do not allow 'Bunsen burner' methods

A3   Allow time for temperature of brick to stabilise   **P1**
           Do not award this mark if brick is removed from kiln.

A4   Use of appropriate thermometer (e.g. thermocouple/thermistor/platinum resistance   **P1**
           radiation pyrometer). Do not allow mercury-in-glass or alcohol thermometers. Do not
           allow vague
           reference to datalogger - detail such as thermocouple probe needed.

B1   Correct circuit diagram. Accept use of ohmmeter. "Multimeter" needs further detail.   **P1**

B2   Method of measuring small current (e.g. edspot galvanometer/microammeter)   **P1**
           Milliammeter or ammeter scores zero. Could be shown on the diagram.
           If a ohmmeter has been employed, then this mark may be scored from a discussion
           of the range of the ohmmeter (e.g. set to high resistance value).

B3   <u>Method</u> of electrical contact with faces P and Q   **P1**
           (e.g. wires connected to a conducting medium e.g plate, foil, gel, rods and medium is firmly
           attached to brick e.g. G-clamp, springs, <u>conducting</u> glue).

C1/2   Two separate relevant safety precautions use of high voltages/temperatures   **P2/1/0**
           High Voltages (>99V):switch off when not in use; keep away from equipment when
           switched on;
           no bare leads or crocodile clips
           High Temperatures: handle brick with tongs or gloves; wait for brick to cool down before
           moving;
           use bare wire in oven so rubber/plastic does not catch fire, safety screen.
           Do not allow vague statements such as 'great care should be taken with the experiment as
           electricity is very dangerous' or 'protective clothing'.

R1/2   Evidence of the sources of the researched material   **P2/1/0**
           Two or more (vague) references and/or one detailed reference score one mark.
           Two or more detailed references scores two marks.
           Detailed references should have page or be internet pages.

D   Any further relevant detail. Examples of creditworthy points might be;   **P3/2/1/0**
           Place thermometer near to brick to allow for local variations in temperature
           Value quoted for resistivity of brick
           Calculation of resistance from resistivity
           Use solder or choice of metal with a high melting point
           Use high voltage (E.H.T. or H.T.) supply (to give measurable current)
           Evidence of preliminary experimental work in laboratory/<u>good</u> use of research
           Problems with variable moisture content of brick below 100 ^{o}C
           Discussion of resistance problems e.g. with surface on which brick rests or contact etc.
           Different types of house bricks may perform differently
           Do not allow vague 'repeat readings' ideas.

Underline and tick each relevant point in the body of the text. The ticks must have a subscript showing <u>which</u> marking point is being rewarded (e.g. ✓$_{D1}$).

Q1/2   Quality of written communication   **P2/1/0**
This is for the organisation and sentence construction. Accounts that are rambling, or where the material is not presented in a logical order will not score these marks. Do not award both of these marks if the word count exceeds the recommended length by more than 50%.

16 marks total

Question 1

(a)   Circuit set up correctly with no help   **l2**
         Minor correction made by Supervisor (e.g. reverse connections to milliammeter,
         or help with <u>one</u> of the resistor arrangements) scores 1.
         Circuit constructed for candidate, or help with combination of <u>more</u> than one set of
         resistors: score zero.

(b)   First value of current in range 9 mA to 11 mA   **l1**

(c)   Measurements: **l2**
         Write the number of readings as a ringed total next to the table of results.
         6 sets of readings for I and R scores two marks.
         5 sets scores one mark.
         Less than five sets scores zero.

(c)   Values of $1/I$ and R **l2**
         Check a value for $1/I$. If correct award one mark. Underline checked value.
         Ignore small rounding errors. Tick if correct. If incorrect, write in correct value and score
         zero.

         Check values for R. If correct award one mark.
         These should be 15.7/23.5/31.3/47/70.5/94/141 (any six will do)

(c)   Column headings in the table   **l2**
         One mark for correct column heading and unit for R.
         One mark for correct column heading and unit for $1/I$ e.g. for unit allow A^{-1}
         Ignore units in the body of the table.

(c)   Consistency of raw readings and Significant figures   **l2**
         Consistency of I only. All the readings must be given to the same number of decimal places.

         Significant figures in $1/I$
         The sf in $1/I$ must be the same as, or one better than, the sf in I. (e.g. 2sf in I, 2 or 3 sf in $1/I$)

(d)   Axes
         A2/1/0
         Sensible scales must be used. Awkward scales (e.g. 3:10, 6:10, 7:10) are not allowed.
         The scales must be labelled with the quantities plotted. Ignore units.
         Do not allow more than three large squares without a scale label.
         Plotted points must occupy at least half the graph grid in both x and y directions (i.e. 4 x 6)
         One mark for each correct axis.
         Tick each axes if correct.
         Circle origin or write FO if a false origin.

(d)   Plotting of points   **A2/1/0**
         All observations must be plotted on the grid.
         Count the number of plots and write as a ringed number. Zero marks if not all points plotted.
         Check a suspect plot. Tick if correct otherwise indicate the correct position.
         If the plot is accurate $\leq$ half a small square, then two marks awarded.
         One mark if the plot is out by > half a small square and < than one small square.

(d)   Line of best fit   **A1**
             Judge by scatter of points about the line.
             There must be a fair scatter of points either side of the line of best fit.
             Allow line through five trend plots for full credit (if done well).
             Do not allow a line through a curved trend.

(d)   Quality of results   **I1**
             Judge by scatter of points about the line of best fit.
             Five trend plots needed for one mark to be scored.
             Large scatter/wrong trend/only four trend plots (or less) will score zero.

(d)   Gradient   **A2/1/0**
             The hypotenuse of the Δ must be $\geq$ half the length of the drawn line. 1 mark.
             Read-offs must be accurate to half a small square and ratio correct. 1 mark.

(d)   *y*-intercept   **A1**
             Expect the value to be read from the *y*-axis to an accuracy of half a small square.
             Or correct substitution from point on line into $y = mx + c$.

(e)   Justification of sf in $1/I$ **E2/1/0**
             Expect to see sf in I related to sf in $1/I$.
             Vague answers relating to 'raw data' can score one mark.
             Do not allow answers in terms of decimal places or related to graph (score zero).
             Ignore table values.

(f)   Value of *E*   **A2/1/0**
             Gradient equated with $\dfrac{1}{E}$ scores 1 mark
             Value of *E* (= 1/gradient) in the range 1.2 V to 1.8 V.
             Do not allow this mark if the gradient has not been used.

(f)   Value of *X*   **A2/1/0**
             y-intercept equated with $\dfrac{X}{E}$ scores one mark
             Value of *X* (= *E* x *y*-intercept)
                   Do not allow this mark if the *y*-intercept has not been used. Method must be valid.
             Allow ecf.
             Beware of errors of factors of 1000.

(f)   Significant figures and units for *X* and *E*   **A2/1/0**
             Accept 2 or 3 sf <u>only</u> for both values. Ignore trailing zeros. This scores one mark.
             <u>Both</u> units must be correct for this mark to be awarded. This scores one mark.

             28 marks total. Write total as in a ring at the bottom of page 5.

             N.B.   If the *y*-intercept is zero (candidate had possibly removed *X*) then in part (d) the quality of results is zero and the 2nd mark for the value of *X* is zero.

Question 2

(b)   Measurement of both lengths   **I1**

(c)   Method of measuring d **I1**
         How tip of pencil was located or position of meniscus

(d)   Percentage uncertainty in d **E2/1/0**
         Δd in the range 1 mm to 10 mm (one mark)
         Ratio idea correct and x 100 (one mark)

(f)   <u>Method</u> of calculation of k for both sets of data   **A1**
         Check initial substitution. Evidence of calculating two numerical values needed for this
         mark.
         Conclusion consistent candidate's numerical values following valid method   **A1**
         (e.g. k values significantly different, <u>hence</u> relationship does not hold)
         (References to proportionality loses this second mark)

(g)   Evaluation of procedure   **E8**
         Relevant points must be underlined and ticked with the appropriate marking letter.

	Problem	Solution
A	Human error in measuring h and/or d	Use two people to perform the experiment (as it is difficult to release the pencil and watch the water at the same time) Video methods / Scale on container Clamp rule so distances can be found more easily
B	Parallax /meniscus problems Meniscus changes during experiment (by displacement)	Eye to be level Use fiducial marker to locate position of tip of pencil
C	Difficulty with release e.g. wobble/angle/friction	Cut with scissors Burn through thread
D	Difficulty with motion of pencil e.g. not vertical/ colliding sides of container/ Possible friction between thread and metal hook/Drag from cotton will be variable	Thread needs to be attached to the centre axis Use thin thread
E	Water absorption by pencil	Paint or waterproof pencils/use similar pencils/use saturated pencils
F	Two readings are not enough to verify the relation between h and d	Take many readings of a range of h and d <u>and</u> plot a graph (i.e. d v h or d^2 v h)

One mark for each box to a maximum of 8.

No credit for simple 'repeats', 'movement of pencil', 'light gates', 'use a smaller/larger vessel' or 'micrometer screw gauge/vernier callipers/travelling microscope'.

Quality of written communication (i.e. spelling, sentence construction, grammar)   **E2**
Capital letters at the beginning of sentences, full stops at the end scores one mark
Correct spelling scores one mark. Allow max two errors.
                                                               16 marks total

Sample results and theory for unknown resistance experiment

Ignoring the resistance of the milliammeter and the internal resistance of the cell, Kirchhoff's law gives

$$E = IR + IX$$

$$\therefore \frac{1}{I} = \left(\frac{1}{E}\right)R + \frac{X}{E}$$

Hence a graph of 1/I against R gives a straight line of gradient $\frac{1}{E}$ and y-intercept $\frac{X}{E}$.

R/Ω	I/mA	I^{-1}/A^{-1}
16	13.3	74.9
24	12.5	79.9
31	11.8	84.7
47	10.4	96.2
71	9.1	110
94	8.0	125
141	6.5	155

From graph, gradient is 0.64; hence E = 1/0.64 = 1.56 V.

y-intercept = 64.7 = X/E; hence X = 64.7 x 1.56 = 101 Ω.

Sample results for falling pencil experiment

$h_1 = 5.0$ cm; $d_1 = 15.0$ cm; $h_2 = 10.0$ cm; $d_2 = 19.5$ cm.

L = 8.5 cm.

Substituting into the expression to give two values of k (2.0 and 2.8). The values are significantly different, and therefore the suggested relation does not hold.

It is very difficult to measure d to a reasonable degree of accuracy.

Summary of shorthand notation which may be used in annotating scripts:

SFP   Significant figure penalty

ECF   Error carried forward

AE   Arithmetical error

POT   Power of ten error

NV   Not valid

NR   Not relevant

GAP   Insufficient scale markings on an axis

NBL   Not best line

FO   False origin

NGE   Not good enough

BOD   Benefit of the doubt

R   Point repeated (no further credit)

NA   Not allowed

SV   Supervisor's value

SR   Supervisor's report

OOR   Candidate's value is out of range

CON   Contradictory physics (not to be credited)

✓△   Used to show that the size of a triangle is appropriate (gradient calculation)

✓C   Used to show that the raw readings are consistent

✓SF   Used to show calculated quantities have been given to an appropriate number of significant figures

^   Piece of work missing (one mark penalty)

^^   Several pieces of work missing (more than one mark penalty)

↔   Scale can be doubled in the x-direction

↕   Scale can be doubled in the y-direction

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June 2005

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Abbreviations,	/	= alternative and acceptable answers for the same marking point
annotations and	;	= separates marking points
conventions used	()	= words which are not essential to gain credit
in the Mark Scheme	ecf	= error carried forward
	AW	= alternative wording

Question			Expected Answers		Marks	
1	**a**	**i**	48 (N) 0.25 (s)		**1**	
		ii	estimating area under graph or mean F; 6.5 $\pm$ 1		**2**	**3**
	b	**i**	a = F/m or = 48/0.5 ; = 96 (m s^{-2}) *ecf a(i)*		**2**	
		ii	Ft = mv; v = *a(ii)*/0.5 = 2*a(ii)* (m s^{-1}) *ecf a(ii)*		**2**	
		iii	k.e. = ½ mv^2 or = ½ x 0.5 x b(ii)^2 ; = a(ii)^2 (J) *ecf b(ii)*		**2**	**6**
	c		Ft = mv $\pm$ mu or = 0.5 (8 $\pm$ 14) ;		**1**	
			F = 11/0.18 ; = 61(.1) (N) *aliter mean a = 12(2) m s^{-2} F = ma*		**2**	**3**
				Total		**12**
2	**a**		force (of attraction) on unit mass (at that point in space/at the surface of a planet)		**1**	**1**
	b	**i**	(mgh =) 1500 x 40 x 1.5 x 10^5 ; = 9.0 x 10^9 (J)		**2**	
		ii	(larger as) g decreases with height		**1**	
		iii	v = 2πR/T ; = 2π x 2.0 x 10^7/(4.5 x 10^3) = 2.8 x 10^4 m s^{-1}		**2**	
			½ mv^2; = 0.5 x 1500 x (2.8 x 10^4)^2 = 5.9 x 10^{11} (J)		**2**	**7**
			aliter: F = mv^2/R ; = mg ; so ½ mv^2 = ½ mgR ;= 6.0 x 10^{11} (J)			
	c	**i**	4.5 (N kg^{-1})		**1**	
		ii	g = (-)GM/r^2		**1**	
		iii	g $\propto$ 1/r^2 ;so value is 40/9 = 4.4(4) (N kg^{-1}) *ecf c(i)*		**2**	**4**
				Total		**12**
3	**a**		when pressure or volume or (internal) energy of an ideal gas tends to zero, the temperature must tend to zero; the temperature scale with this zero of temperature is the kelvin scale/AW		**1** **1**	**2**
	b		applying pV/T = constant; V/290 = 0.01 x 10^6/230 ; V = 1.26 x 10^4 (m^3)		**3**	**3**
	c	**i**	n = pV/RT = 1.0 x 10^5 x 1.26 x 10^4/(8.31 x 290) ; = 5.2 x 10^5 *allow 5.4*		**2**	
		ii	4.0 x 10^{-3} x 5.2 x 10^5 = 2.1 x 10^3 (kg) *ecf c(i)*		**1**	**3**
	d		internal energy $\propto$ T /AW; E = 1.9 x 230/290 = 1500 (MJ)		**2**	**2**
	e	**i**	two vertical arrows with line of action passing through the centre of mass of the balloon (the upward one longer than the downward one); labelled 1.3 x 10^5 N/upward force/upthrust/lift and Mg/weight		**1** **1**	**2**
		ii	Ma = U – Mg ; 27 M = 1.3 x 10^5 – Mg		**2**	
			giving M = 3.5 x 10^3 kg *give 1 mark out of 3 for M = 4.8 x 10^3 kg*		**1**	**3**
				Total		**15**

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Question			Expected Answers	Marks	
4	**a**		the splitting of a nucleus into two (or more) smaller nuclei/particles/fragments (spontaneously/after absorption of a neutron)	1	
	b		$^{235}_{92}U + {}^1_0n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^1_0n$ *-1 mark per error*	2	
	c		$\Delta E = c^2\Delta m$; $\Delta m = 0.186$ u $(= 3.09 \times 10^{-28}$ kg) ;	2	
			$\Delta E = 9 \times 10^{16} \times 0.186 \times 1.66 \times 10^{-27} = 2.78 \times 10^{-11}$ (J)	1	
	d		$F = kQ_1Q_2/r^2$; $Q_1 = 56e$, $Q_2 = 36e$;	2	
			$F = 9 \times 10^9 \times 56 \times 36 \times (1.6 \times 10^{-19})^2/(1.3 \times 10^{-14})^2$; $= 2.7(4) \times 10^3$ (N)	2	
			Total		**10**
5	**a**		$B = F/Il$ with symbols explained or appropriate statement in words;	1	
			explicit reference to I and B at right angles/define from $F = BQv$ etc	1	2
	b	**i**	arrow towards centre of circle	1	
		ii	field out of paper; Fleming's L.H.rule/moving protons act as conventional current	1 1	
		iii	$F = Bev$ *allow BQv*	1	
		iv	$F = mv^2/r$; $Bev = mv^2/r$;	2	
			$B = mv/er = 1.67 \times 10^{-27} \times 1.5 \times 10^7/(1.6 \times 10^{-19} \times 60)$; $= 0.0026$; T *allow Wb m^{-2}*	3	
		v	the field must be doubled ; $B \propto v$ (as m, e and r are fixed)/an increased force is required to maintain the same radius	1 1	11
			Total		**13**
6	**a**	**i**	cosine curve;	1	
			sensible (exponential) decay of amplitude with time;	1	
			correct period	1	
		ii	amplitude will decay more rapidly; greater damping/air resistance on wings **or** greater damping; air resistance on wings **or** oscillation will effectively cease in shorter time; greater energy/amplitude loss per cycle **or** AW	2	
			frequency will decrease/period increase; greater mass/inertia of system	2	7
	b	•	resonance occurs at /close to the natural frequency of an oscillating object/system	1	
			caused by driving force (at this frequency)	1	
			when maximum energy transfer between driver and driven/maximum amplitude achieved *max 2 marks*	1	
		•	small amplitude ($\approx$ that of driver) at low frequencies/less than 1.0 Hz; *driver and driven in phase*	1	
			amplitude rises to maximum; at 1.0 Hz *driver and driven 90° out of phase*	2	
			(very) small amplitude at high frequencies/greater than 1.0 Hz	1	
			driver and driven (180°) out of phase (up to 2 marks can be credited for accurate reference to phase shifts as shown in italics) but max 3 marks	2	5
			Total		**12**

Question	Expected Answers	Marks	
7 **a**	α helium nucleus β electron γ photon/e-m radiation/energy	**1**	
	α charge +(2e) mass 4m$_p$/4u β charge –(e) mass m$_e$ γ charge 0 mass 0	**2**	
	α emission energy 3 – 7 MeV β emission energy 1 – 2 MeV γ emission energy about 1 – 2 MeV **or** all of the same order of magnitude/AW	**1**	
	α monoenergetic from given nuclide β range of emission energies from given nuclide from zero to a maximum γ monoenergetic from given nuclide **or** comparison in terms of velocities	**1**	
	α range 3 – 7 cm of air β range 1 – 2 m of air γ range inverse square law in air/ order of kms	**1**	
	α absorbed by paper β absorbed by thin/ 1 mm Al sheet γ up to cm of Pb sheet	**1**	
	α strongly ionising β weakly ionising γ hardly ionising at all	**1**	
	any other sensible comparison *max 6 marks*	**1**	**6**
b	range/penetration/absorption/deflection experiment suggested *but no further progress made to answer question otherwise:*	**1**	
	suitable arrangement and choice of apparatus *all can be shown on a diagram*	**2**	
•	range/penetration/absorption experiment:		
	α place detector very close/ 2cm from source; measure count rate, use paper screen or move back to 10 cm or more, measure count rate, interpret result; contrast to background count level/ other emissions from same source	**3**	
	β place detector e.g. 10 cm from source measure count rate, add thin sheets of Al until count drops to very low or almost constant value; interpret result	**2**	
	γ place detector e.g. 10 cm from source measure count rate, add thin sheets of Pb until count drops to very low/background level; interpret result *max 6 marks*	**2**	
•	*aliter* deflection experiment:		
	needs vacuum for α experiment;	**1**	
	source for radiation passes through region of E- or B- field;	**1**	
	deflection or not of particles detected by detector to distinguish emissions;	**1**	
	detail of directions; *all 3 correct – 2 marks can only score max of 1 mark unless vacuum mentioned*	**2**	
	amount of curvature determines energy of emission; and nature of particle *max 6 marks*	**1**	
		1	**6**
	Quality of written communication		**4**
	Total		**16**

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1	a.i.	Venus		1
	a.ii.	Appears smallest when separation is greatest (AW)		1
	b.i.	**Any two from**:		
		Fewer epicycles/no need for epicycles	1	
		Sun in centre	1	
		Earth in orbit/moving (around Sun)	1	
		Earth rotates	1	2

b.ii   Either, any **two pieces of evidence**:

Jupiter's moons	1	
craters/mountains on moon	1	
rings of Saturn	1	

Or:

Evidence with correct explanation gains 2 marks.

Jupiter's moons	1: all bodies do not orbit the Earth	1	
Mountains on moon	1: not a perfect (sphere)	1	
Rings of Saturn	1: all bodies do not orbit the Earth	1	2

<div align="right">Total 6</div>

2	a.	Planets move in <u>ellipses</u> (Sun at one focus)		1
		Planet sweeps out equal <u>areas</u> in equal times.		1
		Period^2 α radius^3 / T^2/ r^3 = constant	1	
	b.i.	v/c = Δλ / λ		1
		Δλ = 656.3 x 10^{-9} x 6.1 / 3 x 10^8 (ignore minus sign)		1
		Δλ = 1.33 x 10^{-14} m		1
	b.ii.	Graph: any 4 points plotted correctly		1
		all correct		1
	b.iii.	graph: draw curve, reasonable attempt		1
	b.iv.	Either point where star moves perpendicular to line of sight		1
	b.v.	time = 72 h ± 1h (ecf read value from their graph ± 1h)		1
	b.vi.	r = $^3\sqrt{}$ (6.7 x 10^{-11} x 4 x 10^{30}x [72x 3600]^2/ 4π^2) ecf		1
		r = 7.70 x 10^9 m ecf .		1
		(use of t = 72h 1/2)		

<div align="right">Total 13</div>

3.   a.   correct reference to 1 AU   1

            parallax of 1 arcsecond
            (marks can be gained on <u>labelled</u> diagram)   1

   b.i.   Diphda   1
            (Diphda) has smallest apparent magnitude   1

   b.ii.   Menka is largest as absolute magnitude is least   1

   c.   m – M = 5log (d/10) / correct substitution   1

         d/ 10 = $10^{(m- M)/5}$ 1

         d = 39.8 pc   1

                                                   Total 8

4.   a.   **Any 6 from**
            Nuclear/hydrogen burning ends   1

            Mass > Chandrasekhar limit   1

            Expanding gas/planetary nebular/red giant   1

            Gravitational collapse /ref. to burning He or higher metals   1

            Correct ref. to (Fermi) <u>pressure</u>/ radiation <u>pressure</u>   1
            (must have ref. to pressure or force from radiation.)

            Neutron <u>star</u>   (neutron by itself, not enough)   1

            Correct reference to Schwarzschild radius/
            allow mass> 3M/ allow ref. critical radius   1

            Black Hole   1   6

   b.i.   Mass = 3.8×10^{26} / $(3\times 10^{8})^{2}$ 1

         Mass = $4.2(2) \times 10^{9}$ kg s^{-1} 1

   b.ii. 3.8×10^{26} = 10^{44} / time   1

         time = $8.2(2) \times 10^{9}$ y   1

                                                    Total 10

5	a.	Universe is isotropic/ same in all directions	1	
		homogenous/ evenly distributed	1	

	b.	**Any 5 from**		
		Uniform intensity in all directions/ everywhere	1	
		Structure in background intensity/ripples	1	
		Produced when matter and radiation decoupled	1	
		Originally gamma radiation	1	
		(gamma) red-shifted to microwave/originally higher energy	1	
		Evidence that universe began with big bang.	1	
		Temperature corresponds to 2.7K / 3K / that predicted by big bang model	1	5

	c.	**Any 2 from**		
		No experimental evidence/ no physical evidence	1	
		State of matter unknown/ laws of physics unknown	1	
		Energies unreproducible/ ref. to very high temperature	1	2

Total 9

6	a.	Open: Universe expands for all time	1
		Flat: expands to a limit (but never reaches it)	1
		Closed: Universe contracts/ collapses back	1
		reference to role of gravity/ critical density	1

Marks for a. can be gained on <u>labelled</u> diagram.

	b.	$H_o^2 = 1 \times 10^{-26} \times 8 \times \pi \times 6.67 \times 10^{-11} / 3$	1
		$H_o = 2.36 \times 10^{-18} \text{ s}^{-1}$	1

Total 6

7.	a.	Situation; 2 observers, clocks, relative motion and time interval defined	1
		Speed of light constant	1
		Interval measured	1
		Improper observer measures longer time because longer path.	1
		Other detail	1

	b.i.	$t = 2\pi\,900\,/\,0.94c$	1
	bii.	fraction remaining = 0.25	1
	b.iii.	$\sqrt{(1 - v^2/c^2)} = 0.34$ / $\gamma = 2.93$	1
		$t = t_o/\sqrt{(1 - v^2/c^2)}$ / $t = \gamma\,t_o$	1
		$t = 5.88 \times 10^{-5}$ s ecf from b.i.	1
	b.iv.	ref. to time dilation	1
		'clocks' / time of stationary particles same rate as lab./ half life shorter	1

Total 12

| 8. | a. | <u>gravitational fields/gravity</u> and <u>acceleration</u> | 1 |
| | | produce the same effect / cannot be distinguished | 1 |

	b.i.	spacecraft is accelerating/ larger equivalent gravitational field	1
		clock in <u>spacecraft</u> runs slower	1
		give BOD to:	
		acceleration of rocket is small compared to Earth	1
		clocks synchronous	1
	b.ii.	Moon: smaller gravitational field	1
		Clock in <u>spacecraft</u> runs faster	1

Total 6

Mark Scheme 2825/02
June 2005

1 (a)   correct position of arrow   (1)

(b)   lowering arm:
        triceps string is pulled / in tension
        + raising arm:
        biceps string is pulled / in tension   (1)

         lowering arm :
         biceps string / released or muscle relaxed

  or

        raising arm:
        triceps string relaxed   (1)

        ref. to (tension representing) <u>muscle</u> contraction (1)

(c)   clockwise moments = anticlockwise moments (for equilibrium)   (1)

        B x 0.020m = 0.075 x 9.8 x 0.20 + 0.135 x 9.8 x 0.30   (1)

        do not penalise distance in cm
        2 / 3 if g = 10 m s^{-2} leading to 27.7 N

        B = 27.2 N   (1)   allow 27 N

2 (a)   the change in power / focal length of the refracting system of the eye / lens   (1)

        by changing the shape of the lens   (1)

        (ref. to diagram i.e. Fig.2.2) the lens bulges to increase the power (as more
        refraction is required) / or ….to bend the rays more   or Fig.2.2 + statement
        with ref. to more power etc.   (1)

   (b) (i) short sight / myopia   (1)

       (ii)   lines meet in front of the retina   (1)
            <u>refraction</u> shown <u>at cornea</u> + continues ray to retina + originate from object (1)

   (c) (i) p = 1/ f = 1/u + 1/v   (1)

          64 = 1 / 0.60 + 1 / v   (1)

          v = 0.016(0) m   (1) do not allow 0.02 m
       (ii) p = 1 / 0.016 + 1 / ∞ (1)
               p = 62.3 D   (1)   allow 62.5 D
       (iii) 62.3 – 64   (1)   or 62.5 – 64
          -1.67 D allow –1.7 D (1)   or - 1.5 D

3(a) 1 each to a maximum of 3:-

- Relates frequencies to minimum audible intensities.

- Lowest audible frequency 20 Hz -25 Hz.

- Highest audible frequency 15-20 kHz.

- The ear is most sensitive at 1-3 kHz …

- … where it can detect sounds of intensity 10^{-12} W m^{-2} ….

- … due to resonance in outer ear.

- the ability to detect small changes in frequency

- from 20 – 1000 Hz small changes in frequency are detectable

(b)1 each to a maximum of 3:-

- With age, frequency response becomes less sensitive / weaker / worse / decreases.

- Any sensible reason (eg ear drum is less elastic, etc.)

- Frequency range becomes narrower / highest audible frequency is less, etc.

- Minimum intensities for detecting sounds become greater.

4   any for 1 each to a max. 7 e.g.

cause: uneven curvature of the cornea / cornea not spherical / uneven shape (1)

      causing different focal lengths / powers in different planes   (1) allow different directions

test: identical black lines in different orientations / diagram   (1)

      should appear equally black/ clear (1) allow sharp

      an astigmatic eye will see some lines darker and more sharply in focus than others   (1)

corrective lens:
     defect may be corrected with a cylindrical (contact) lens   (1)
     diagram   (1)

     such that light in one plane is less deviated while light in the other plane is refracted   (1)

    description of different focal lengths / powers in different planes (1)

    diagram of rays in one plane converging differently to rays in another plane

    (1) or explanation

5

1 each to a maximum of 7:-

- Electrons are emitted from C / (hot) cathode.
- There is a <u>high</u> voltage between C and A …. or stated p.d. >1000 V
- … (so) electrons are <u>accelerated</u> towards A / anode.
- Electrical energy becomes KE (of electron).
- Electrons undergo a sudden deceleration at A / collide with A
- (Some of) the <u>KE</u> is converted to <u>X-rays</u> / (electromagnetic) radiation
- The X-rays are produced by the deceleration / reference to bremsstrahlung
- X-rays characteristic of target produced).
- <u>Most</u> of the (kinetic) energy becomes heat / thermal energy.
- The reason for the vacuum.

Other good point (eg anode rotated / inner shell electron of target atom knocked out / higher pd gives more penetrating X-rays/higher energy photons).

6 (a) Low energy X-rays are absorbed by the skin / undesirable as can cause damage / greater ionising (1)

(b) $I = I_0 e^{-\mu x}$ (1) $\ln I = \ln I_o - \mu x$

$I_o = \dfrac{347}{e^{-250 \times 0.025}}$ (1) $\ln Io = \ln 347 + 250 \times 0.025$

$I_o = 1.79 \times 10^5 \ Wm^{-2}$ (1)

(c) $P = I \times A$ (0)

$P = 347 \times \pi \times (0.10 \times 10^{-2})^2$ (1)

$P = 1.09 \times 10^{-3} \ W$ (1)

(d)(i) $P = 18 \times 100 / 0.15$ (1)
$P = 12000 \ W$ (1)

(ii) $12000 / 7.5 \times 10^{17}$ $(= 1.6 \times 10^{-14} \ J =$ energy of each electron) (1)

$0.5 \ m \ v^2 = 1.6 \times 10^{-14}$ (0)

$v = 1.9 \times 10^8 \ ms^{-1}$ (1)

(iii) tube current $= 7.5 \times 10^{17} \times 1.6 \times 10^{-19} = 0.12 \ A$ (1)

$V \times I = 12000$ (1)

$V = 12000 / 0.12 = 100,000 \ V$ or $100 \ kV$ (1)

7 (a)   <u>density</u> (of medium) (1)

   <u>speed</u> of <u>ultrasound</u> (in the medium)   (1) or any factors that affect the speed of ultrasound in the medium e.g. the Young modulus

(b)(i) blood:
$f = (1.59 \times 10^6 - 1.63 \times 10^6)^2 / (1.59 \times 10^6 + 1.63 \times 10^6)^2$ (0)
$f = 1.54.x.10^{-4}$ (1)

   muscle:
$f = (1.70 \times 10^6 - 1.63 \times 10^6)^2 / (1.70 \times 10^6 + 1.63 \times 10^6)^2$ (1)
$f = 4.4 \times 10^{-4}$ (1)

   so the medium is muscle   (1) bald muscle gets 0/4

(ii) $(s = u \times t)$

   $s = 1.54 \times 10^3 \times 26.5 \times 10^{-6} = 0.0408$ m   (1)

   0408 / 2 = 0.020 m   (1)

(iii) $1.54 \times 10^3 / 3.5 \times 10^6 = \lambda$ (1)

   4.4×10^{-4} m   (1) 4.4×10^{-7} m gets full credit if 10^3 penalised in (ii)

8 (a)   no threshold dose / there is always some possibility of effect occurring /
   probability increases with dose / random effect   (1)

(b)   e.g. threshold dose (above which the effect occurs)   and
   severity increases with dose   (1)
   relates skin burn to threshold or severity increase due to prolonged exposure
   (1)

(c)(i) dose equivalent = absorbed dose x quality factor   (1)   (must give words)

(ii)   14 mSv = absorbed dose x 20   (1)

   absorbed dose = 0.70   (1)

   mGy (1)   mJ kg^{-1} (allow Gy if answer wrong or J kg^{-1})

9. (a)(i)   speed $v = 2\pi r / t$

$v = 2 \times \pi \times 122/2 \, /(30 \times 60)$ (1)

$v = 0.21 \text{ m s}^{-1}$ (1)   allow 0.2 m s^{-1}

(ii)   F = 12.5 kN x 16 = 200 kN   (1)

(iii)   W = F x s   or

= 200 k x 2 x π x 122 / 2   (1)   ecf (ii)   allow ecf for distance from (i)

= 7.7 x 10^7 J   (1) allow 8 x 10^7

(iv)   P = W / t   energy / time   or   F x v   or

= 7.67 x 10^7 / (30 x 60)   (1)   or   ecf (iii) / (30 x 60)

= 42.6 kW   (1)   allow 43 kW   only allow 40 kW if working shown

(v)

- Friction force at bearing opposes motion so not useful   (1)
- Friction force of tyres on rim drives wheel, so is useful   (1)
- Electrical energy supplies power to drive wheels / useful implied (1)
- <u>Input</u> <u>energy</u> (electrical or energy supplied to motor) is converted into <u>heat</u> (1)

Last point to do with the idea that once moving with constant speed e.g.

- <u>All</u> work is done against <u>friction</u>
- No input energy is converted into E_k
- <u>All</u> input energy ends up as <u>heat</u>
- Any other relevant point relating to energy   (1)

(b)(i)   X is bigger than Y (as X is under greater tension due to the weight of the bike)   (1)

(ii)   Q is bigger than P (due to the weight of the wheel causing compression in P)   (1)

(c)(i)   k = F / x

= 1.8 x 10^6 / 0.90   (1)

= 2.0 x 10^6 Nm^{-1} (1)

(ii)   f = (1 /2π (k/m)$^{0.5}$ (0)

= (1 /2π (2.0 x 10^6 / 9.5 x 10^5)$^{0.5}$ (1)

= 0.23 Hz   (1)

(iii)   If wind energy causes this frequency in the structure, the amplitude increases /
resonance occurs / or explanation of resonance / ref. to natural frequency (1)
e.g. damping is necessary / mass change to shift resonant frequency /
change spring constant(1)

Mark Scheme 2825/03
June 2005

1. (a) (i)   The atoms (of a substance) occupy the minimum possible space /
               The atoms have the maximum number of nearest neighbours / or wtte
               Suitable diagram.   [1]

    (b) (i)   Volume = mass ÷ density / 1 ÷ 4510   (1)
                        = 2.21 x 10^{-4} m^3 (1)   [2]

        (ii)   No. of atoms = 1 / 7.98 x 10^{-26} (1)
                             = 1.25 x 10^{25} (1)   [2]

    (c) (i)   Volume = 4/3 π r^3 (1)
                        = 4/3 x π x (1.46 x 10^{-10})^3 (1)
                        (= 1.30 x 10^{-29} m^3)   [2]

        (ii)   Vol occupied by atoms = 1.25 x 10^{25} x 1.30 x 10^{-29} (= 1.63 x 10^{-4} m^3)   (1)

               % = (1.25 x 10^{25} x 1.30 x 10^{-29} / 2.21 x 10^{-4}) x 100 (= 73.9)   (1)   [2]

    (d)   decrease in density (1);   due to expansion during rise to 883 ^{o}C;   (1)

               Body-centred cubic is not a close-packed structure, (so change at 883degC) . (1)   [3]

2. (a)   Graph correct for x less than equilibrium separation;   (1)
               Graph correct for x greater than equilibrium separation;   (1)
               Correct regions for attractive and repulsive forces, <u>shown on F-axis</u> .   (1)   [3]

    (b)   Attractive force: Attraction between unlike charges;   (1)
                               Ionic, covalent or Van der Waal's bonding;   (1)
                               Increases as separation decreases;   (1)
               Repulsive force: Repulsion between like charges;   (1)
                                Occurs when electron clouds overlap;   (1)
                               Increases as separation decreases;   (1)
               Resultant force is (vector) sum of attractive and repulsive forces;   (1)
               Equilibrium (F=0) when attractive force = repulsive force;   (1)
               Resultant attractive force when stretching force removed;   (1)

        Resultant repulsive force when compressing force removed;   (1)
                                                                                        max   [8]

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3. (a) (i)   1. Element is a gas / vapour.
             2. Element is a solid / liquid.   [1]

   (ii)   The atoms of the element come closer together;   (1)
          The outer electrons of the atoms interact;   (1)
          The sharp levels split into many different energy levels.   (1)   [3]

   (b) (i)   Diagram labelled to show valence band;   (1)
                                       conduction band;   (1)
                                       energy gap.   (1)   [3]

   (ii)   Electrons in valence band are bound / do not take part in conduction;   (1)
          Electrons in conduction band are free / can take part in conduction;   (1)

          Insulator has empty conduction band and large energy gap;   (1)
          Electrons do not gain enough energy to cross the gap so no conduction;   (1)

          Semiconductor has narrow energy gap;   (1)
          Electrons can gain enough energy to cross into conduction band so
          semiconductor conducts;   (1)
          More electrons cross gap as temperature rises so conductivity rises /
          resistivity falls with increasing temperature;   (1)

          Metal has a partially filled conduction band/valence & conduction bands overlap (1)
          Electrons permanently available to take part in conduction;   (1)
          No change in number of conduction band electrons with change of
          temperature.   (1)
                                                                                       max   [7]

4. (a)   No of free electrons in length l of wire = nA l
                /Number of free electrons passing a point in 1 s = nAv;   (1)
          Charge of these electrons, Q = nAve / Q=nA l e   (1)
          I = Q/t = nAve/1 (= nAve)/ I = Q/t (=nAve) as v = l/t (1)   [3]

   (b) (i)   v = I/nAe = 0.025/(8.7 x 10^{28} x 5.0 x 10^{-5} x 8.0 x 10^{-3} x 1.6 x 10^{-19}) /
          correct substitution in I = nAve;   (1)
          v = 4.49 x 10^{-6} m s^{-1} (1)   [2]

   (ii) V_H = Bvd   (1)
              = 0.15 x 4.49 x 10^{-6} x 8.0 x 10^{-3} (1)
              = 5.39 x 10^{-9} V   (1)   [3]

   (iii) X and Y marked at sides of strip, opposite each other, by eye.   [1]

   (c)   Semiconductor has (much) smaller concentration of free electrons;   (1)
          (For same current) drift velocity is (much) higher;   (1)

   (In same field) Hall voltage is (much) higher so more accurately measurable.   (1)   [3]

5. (a) (i) I = V/R = 12/50   (1)
              = 0.24 A   (1)   [2]

     (ii) Power in primary = power in secondary / $I_pV_p = I_sV_s$ (1)
          I_p = 0.24 x 12 / 230 = 0.0125 A   (1)   [2]

    (b) (i) Laminated structure;   (1)
             Made of soft iron / material with hysteresis loop of small area;   (1)
             Core is a complete loop.   (1)
                                                                                     max   [2]

        (ii) Laminated structure:
             Induced voltage / current in core proportional to rate of change of flux; (1)
             Induced voltage / current increases with frequency;   (1)
             Energy lost increases with frequency/
             Power loss = I^2R / V^2/R (1)
             Efficiency decreases as frequency increases.   (1)   [4]
             OR
             Hysteresis effect:
             Area enclosed by hysteresis loop is a measure of energy lost as heat per
             cycle of loop;   (1)
             Heat generated per second increases as number of hysteresis cycles per
             second increases;   (1)
             Heat generated per second increases as frequency increases;   (1)
             Efficiency decreases as frequency increases.   (1)   [4]
             OR
             Primary coil produces varying magnetic flux;   (1)
             This varying flux induces voltage in secondary coil;   (1)
             Complete loop ensures that maximum possible flux produced by primary
             coil liks with the secondary coil.   (2)   [4]

6   (a)   Free electrons in the conduction band occupy the lower energy levels;   (1)
           Energy levels in the conduction band are very close together;   (1)
           All visible light photons are absorbed by exciting electrons into higher energy
           levels in the conduction band.   (1)   [3]

    (b)   Energy of photon of wavelength 550 nm = hc/λ   (1)
                                    = $\frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{550 \times 10^{-9}}$
                                    = 3.62×10^{-19} J   (1)
                                    = 3.62×10^{-19} / 1.6×10^{-19}
                                    = 2.26 eV   (1)
           This energy is less than the energy gap so the photon will not be absorbed /
           will pass through the insulator.   (1)   [4]

    (c) (i) The amount of Rayleigh scattering is proportional to $1/\lambda^4$ /decreases with λ   (1)
            Visible light has a smaller wavelength (than infra-red) so loses a bigger
            proportion of its intensity.   (1)   [2]

        (ii) $\frac{\% \text{ loss of infra-red}}{\% \text{ loss of visible light}}$ = $\frac{600^4}{1200^4}$ (1)

            % loss of infra-red = $\frac{600^4 \times 72}{1200^4}$ = 4.5   (1)   [2]

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7 (a) (i)   s = 2 π r / t
                     = 2 x π x 122/2 /(30 x 60)   (1)
                     = 0.21 m s⁻¹   (1)

   (ii)   F = 2.5 kN x 16 = 200,000 N or 200 kN   (1)

   (iii)   W = f x s
                     = 200 k x 2 x π x 122 / 2   (1)
                     = 7.67 x 10⁷ J   (1)

   (iv)   P = W / t
                     = 7.67 x 10⁷ / (30 x 60)   (1)
                     = 42,600 W   or 42.6 kW   (1)

   (v)
                 <u>all</u> work is done against friction   (1)
                 as constant k.e.   (1)
                 friction force at bearing opposes rotation, so work done against this   (1)
                 friction force of tyres on rim drives wheel, so useful   (1)
                 electrical energy supplies power to drive wheels   (1)
                 work done by tyres equals work done against bearing friction (1)
                 some of the electrical energy supplied goes to heating of wires (I²R)   (1)
                 to max.5

(b)   (i)   X is bigger than Y as X is under greater tension due to the weight of the bike
                                                                                                (1)

      (ii) Q is bigger than P due to the weight of the wheel causing compression in P (1)

(c)   (i)   k = F / x
                     = 1.8 x 10⁶ / 0.90   (1)
                     = 2.0 x 10⁶ Nm⁻¹   (1)

      (ii)   f = 2 π (k/m)⁰·⁵   (0)
                     = 2 π (2.0 x 10⁶ / 9.5 x 10⁵)⁰·⁵   (1)
                     = 0.225 Hz   (1)

(d)   If wind energy causes this frequency in the structure, the amplitude builds up /
                 resonance occurs (1)
                 damping is necessary / to reduce amplitude or mass change to shift resonant
                 frequency (1)

                                                                                                20

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**Mark Scheme 2825/04
June 2005**

Mark Scheme	Unit Code 2825 / 04	Session June	Year 2005	Version Fourth draft (pre-standardisation)
Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument			

Question	Expected Answers	Marks	
1 (a)(i)	$\frac{4}{3}\pi r_0^3$ $\frac{4}{3}\pi r^3$ alone gets 0	1	[1]
(ii)	$A\,\frac{4}{3}\pi r_0^3$ allow ecf from (i)	1	[1]
(iii)	equates volumes: $\frac{4}{3}\pi r^3 = A\,\frac{4}{3}\pi r_0^3$ cancels ($\frac{4}{3}$) and π allow ecf giving $r^3 = A r_0^3$ providing expression includes π	1 1	[2]
(iv)	graph: straight line through origin, drawn with ruler (2) attempted straight line through origin, drawn freehand gets 1/2 gradient = r_0^3 allow even if line was a curve (1)	3	[3]
(b)(i)	density = m / V = $197 \times 1.67 \times 10^{-27} / (197 \times \frac{4}{3}\pi\,[1.4 \times 10^{-15}]^3)$ = $1.5 \times 10^{17}\ \mathrm{kg\,m^{-3}}$ accept 1.4×10^{17} to 1.5×10^{17} uses 1.6×10^{-27} to give 1.39×10^{17} gets 1,0,1 = 2/3	1 1 1	[3]
(ii)	correct method: *either* correct ratio of densities *or* correct ratio of volumes stated clearly or clear from working; $m = \rho V$ so $\rho_n V_n = \rho_a V_a$ $V_n / V_a = \rho_a / \rho_n = 1.9 \times 10^4 / (1.5 \times 10^{17}) = 1.3 \times 10^{-13}$ so 1.3×10^{-11} % ans	1 1	[2]
		12	

2(a)(i)	*either* (mass / mass-energy / energy of separate nucleons) - (mass / mass-energy / energy of whole nucleus) or AW; *or* energy needed to separate / split / break apart neutrons and protons (completely); *or* energy released when separate nucleons / protons and neutrons combine to form nucleus; but NOT energy that binds / holds nucleus together NOT energy to break bonds between nucleons 'atoms' gets 0	1	[1]
(ii)	*either* high binding energy (/ nucleon) means greater stability / less likely to fuse or fission *or* nuclides (tend to) move to / react towards the lowest potential energy/ highest binding energy (/nucleon) can be won in any of C, U, or Fe explanations or as separate statement; $^{12}_{6}C$ can undergo fusion; $^{235}_{92}U$ can undergo fission; $^{12}_{6}C$ and $^{235}_{92}U$ are both unstable gets 1/2 $^{56}_{26}Fe$ is stable / does not experience fission or fusion;	1 1 1 1	 [4]
(b)(i)	*either* neutron that is at (thermal) equilibrium with medium / substance / material through which it is passing *or* neutron whose (kinetic) energy is equal / comparable / similar / to energy of atoms / molecules through which it is passing *or* slow moving neutron *or* neutron having low (kinetic) energy / energy of 1 - 10 eV;	1	[1]
(ii)	$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U$ '+ neutrino' gets 0	1	[1]
(iii)	$^{236}_{92}U \rightarrow ^{135}_{53}I + ^{95}_{39}Y + 6 ^{1}_{0}n$ accept $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{135}_{53}I + ^{95}_{39}Y + 6 ^{1}_{0}n$ for 1/1	1	[1]

(iv)	$^{235}_{92}U$: 7.6 $^{135}_{53}I$: 8.4 $^{95}_{39}Y$: 8.6 MeV
	read from graph, nuclides identified with readings
	
	total BE: $^{235}_{92}U$: 7.6 x 235 (= 1786)
	            $^{135}_{53}I$: 8.4 x 135 (= 1134)
	            $^{95}_{39}Y$: 8.6 x 95 (= 817) three expressions
	
	so energy released = 1134 + 817 - 1786
	                  = 165 MeV
	
	8.4 + 8.6 - 7.6 = 9.4 MeV gets 1,0,1,0 = 2/4
	uses 236 to get 157.4 MeV gets 3/4
		1
		
		1
		
		1
		1
			
			[4]

			12

3(a)	energy $= V\,I\,t$ $\quad = V \times$ (area under I-t graph) $\quad = 1.2 \times 4 \times 10^6 \times (20 + 5)$ $\quad = 1.2 \times 10^8$ J no V gets 0/4 *except* if stated 'area under graph = charge' which gets 1/4 area calculation errors eg wrong triangle areas can get 3/4 omits 10^6 can get 3/4	1 1 1 1	 [4]
(b)	nuclei have (net) charge but atoms don't; nuclei would be deflected by B field / atoms are not;	1 1	 [2]
(c)	(momentum conservation: $m_H v_H = m_n v_n$ $m_H = 4 m_n$ so) $v_n = 4 v_H$ $\qquad$ ke $= \tfrac{1}{2} m v^2$ ke of $^1_0$n $= \tfrac{1}{2} m (4 v_H)^2 = 8 m v_H{}^2$ } ke of $^4_2$He $= \tfrac{1}{2} \times 4 m v_H{}^2 = 2 m v_H{}^2$ } subs. so (ke of $^1_0$n) $= 4 \times$ (ke of He) (so $^1_0$n has 80%, $^4_2$He has 20% of total ke)	1 1 1 1	 [4]
		.	**10**
4(a)(i)	energy $= 30 + 10 \times 50 = 530$ keV	1	[1]
(ii)	$\qquad\qquad \tfrac{1}{2} m v^2 = V e$ $\tfrac{1}{2} \times 1.67 \times 10^{-27} v^2 = 530 \times 10^3 \times 1.6 \times 10^{-19}$ $\qquad\qquad\qquad v = 1.01 \times 10^7 \text{ m s}^{-1}$ allow 1.0 or $1 \times 10^7 \text{ m s}^{-1}$ omits 10^3 and gets 3.2×10^5 2/3 omits 1.6×10^{-19} and gets 2.5×10^{16} 1/3 omits 1.67×10^{-27} and gets 4.1×10^{-7} 1/3 ecf from (i): 500 keV to give 9.8×10^6 $\qquad\qquad\qquad$ 300 keV to give 7.6×10^6 $\qquad\qquad\qquad$ 40 keV to give 2.8×10^6 all can get 3/3	1 1 1	 [3]

(b)(i)	$4.3 \times 10^8 \, \mathrm{m \, s^{-1}}$ is greater than speed of light; nothing can travel faster than light;	1 1	[2]
(ii)	protons accelerate so travel greater distance in same time (1) positrons (much) less massive than protons; (1) so same energy means greater speed (for positrons); (1) positron speeds approach speed of light; (1) cannot exceed it, so speed becomes (approx.) constant; (1) - aware positrons are affected by relativity can get 1/2 of these marks electrodes of equal length means (positron) speeds are constant; (1) any 3	3	[3]
(c)	rest energy + kinetic energy = $2hf$ omits rest energy or ke 1/2 $2 \times (9.11 \times 10^{-31})(3 \times 10^8)^2 + 650 \times 10^3 \times 1.6 \times 10^{-19} = 2 \times 6.63 \times 10^{-34} f$ (1.64×10^{-13} + 1.04×10^{-13} = $13.3 \times 10^{-34} f$) f = 2.02×10^{20} Hz omits rest energy and gets 7.82×10^{19} Hz 2/4 omits kinetic energy and gets 1.23×10^{20} Hz 2/4 any further error (-1) each, to zero	2 1 1	[4] **13**

5(a)	sketch showing: 2 dees + alternating source connected;
	
	                          (uniform) magnetic field, in region of dees and normal to
	                              diagram;
	
	                          path - continuous circular loops of increasing radius
	                              entering both dees at every revolution with direction of
	                              travel shown eg by arrow;
		1
		
		 1
		
		 1
			[3]

(b)	*either* magnetic field exerts a force (on particle) *or* force from Fleming's left hand rule ; *either* force (always) at right angles to (direction of) motion *or* force has no component along direction of motion / changes only *direction* of motion / doesn't change speed; NOT direction of travel perpendicular to magnetic field (so) acts as a centripetal force / experiences force towards centre of circle;	1 1 1 [3]

(c)	magnetic force = mass x acceleration
	         BQv = mv^2/R or $F = BQv$ (1) and $F = mv^2/R$ (1)
	
	         v = BQR/m
	
	 time for one orbit T = $2\pi R/v$
	                 = $2\pi m/(BQ)$
	
	 frequency f = $1/T$ or $T = 1/f$
	                 = $BQ/(2\pi m)$
	
	 T = $\pi R/v$ to give f = B$Q/(\pi m)$ can get 2,0,1,1 = 4/5
		2
		
		 1
		
		 1
		 1 [5]
		
		 11

6(a)	**baryon**: two examples proton; (1)
	                           neutron; (1)
	 3 particles quoted, including one wrong gets 1/2 only
	
	  quark composition: proton uud; (1)
	
	                    neutron udd; (1)
	
	 (aware consists of 3 quarks, unspecified, gets 1/2)
	
	 stability: proton stable inside (stable) nucleus; (1)
	
	         proton possible decay / half life = 10^{32} years when free; (1)
	                        allow any half life > 10^{30} years
	
	         neutron stable inside (stable) nucleus; (1)
	
	         neutron half life = 10/15 minutes when free; (1)
	
	                                            any 6
		6

(b)	**lepton**: two examples: electron; (1)		
	positron; (1)		
	neutrino; (1) any 2 (2)		
	(allow muon, tauon)		
	3 particles including one wrong gets 1 only		
	composition: fundamental (- no quark components); (1)		
	forces: weak force / interaction; (1)		
	electron / positron - (also) electromagnetic / electrostatic force; (1)		
	where found: electron - in atom, outside nucleus		
	or in β^- decay ; (1)		
	positron (rarely) emerging from (high mass) radioisotopes /		
	in β^+ decay / accelerating-colliding machines; (1)		
	neutrino - travelling in space eg from Sun		
	or emitted (with electron / positron) in beta decay ; (1)		
	allow ONCE 'resulting from high energy particle collisions'	6	[12]
	any 6		
			12

Mark Scheme 2825/05
June 2005

Mark Scheme	Unit Code	Session	Year	Version
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Question 1	Expected Answers			Marks

(a)   Typical carrier frequency on MW   300 kHz to 3MHz   1

(b)   λ   = c / f   = 3×10^8 / f

   = 1000 m   to   100 m   (must use their frequency to calculate λ)   1

   Dipole length should be λ / 2 which is too long.   1

(c)   The aerial picks up all three stations so could not discriminate

   The aerial signal will be too weak to drive a moving coil loudspeaker

   The average value of the AM aerial signal is zero anyway   (any two sensible points)   1   1

(d)
       1   1   1   1   (deduct 1 mark for each
wrong order)

Tuning circuit	RF amplifier	Demodulator	AF amplifier	Loudspeaker
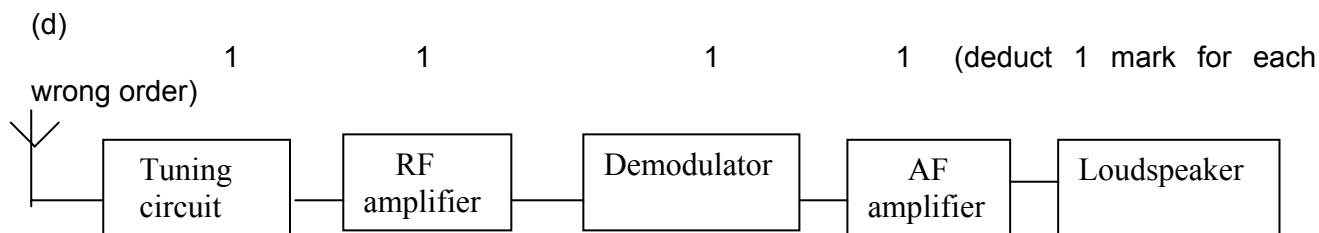
Aerial   Converts e.m. waves into tiny ac currents
Loudspeaker   Converts electrical signal into sound
                                    (any sensible comment on either)   1

Tuning circuit   Selects one carrier frequency and rejects others   1

RF amplifier   Amplifies carrier frequency so the demodulator can work   1

Demodulator   Extracts audio signal from carrier and rejects carrier   1

AF amplifier   Amplifies audio signal to be able to drive loudspeaker   1

Mark Scheme	Unit Code	Session	Year	Version
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Question 2	Expected Answers			Marks

(a)   If the voltage A is greater than B the op-amp output will saturate + vely
      If the voltage A is less than B the op-amp output will saturate - vely   1

      If the voltage at A is equal to B the op-amp output will be zero   1

(b)   LDR symbol ringed   1

(c)   Voltage at B   =   (27 / 27 + 48) x 15   1

              =   5.4 V   1   (for an answer of 9.6V allow 1 mark)

(d)   Voltage at A   =   (3.3 / 3.3 + 6.2) x 15

              =   5.2V   1

      So the op-amp output will be <u>- ve</u> 14 V   1   (allow saturation -13V to -15V)

      And the LED will be ON   1   (watch out for e.c.f.)

(e)   In darkness the voltage at A < B so the LED is ON   1

      It will stay ON <u>without a change in brightness</u>   1

      Then it will go out and stay out as the conditions darken   1
      (LDR resistance at switch point is 5.87 kΩ)

(f)   R   =   pd / current   (must have 30V or 29V or 28V across system)
          =   (15 - 2 - - 14) / 5 mA   1   (must consider any LED turn on, even
0.7V, or
                                        make a sensible comment on need for
a value
          =   27 / 5 mA   1   lower than 6 kΩ)

          =   5400 Ω 1

      (allow 1 mark for any sensible comment on switch on voltage of LED)
      (for 30V / 5ma = 6 kΩ allow 2 marks   for   15V / 5ma = 3 kΩ allow 1 mark)

Mark Scheme	Unit Code	Session	Year	Version
Page 3 of 5	2825	June	2005	
Question 3	Expected Answers			Marks

(a)   Separation of successive samples are 1/25 = 40 ms   1

(b)
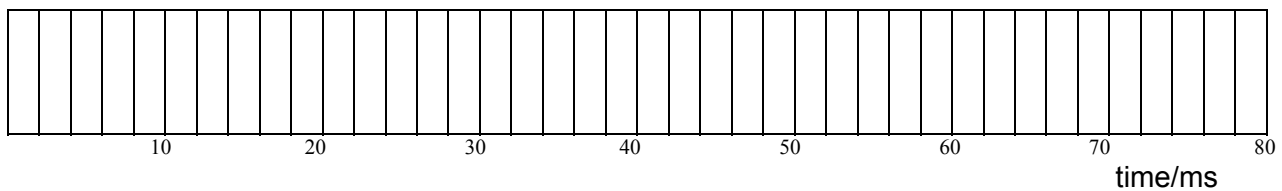
     Correct binary equivalents   111   (all five signals in binary order 3 marks, deduct 1 mark per error)
     Correct position in time of digital signals   1
     (If not in TDM order then mark up to max of 2 / 4)

     Most significant bit marked   1

(c)   Each sample lasts for 4 x 2 ms   = 8 ms   1

         Time between samples = 1 / 25   = 40 ms

         Maximum number = 40 / 8   = 5   1   (allow 1 mark for 40 / 10 = 4)

(d)   Maximum signal frequency must be less than 2 x sampling frequency   1

         Hence less than 12.5 Hz   (but allow 12.5 Hz)   1

(e)   To increase the number of TDM signals

         1.   Reduce the 2ms bit duration   1

         2.   Reduce the number 4 of bits per sample   1

         3.   Reduce the 25 Hz sampling frequency   1

Mark Scheme	Unit Code	Session	Year	Version
Page 4 of 5	2825	June	2005	
Question 4	Expected Answers			Marks

(a) The extreme purity means very low power loss / low attenuation   1
This allows the signal to be amplified / regenerated much less frequently   1
The different refractive indices means the core can be a higher n than the cladding   1
This allows protection of core but still allowing total internal reflection to occur   1

eg

Optic fibre has higher bandwidth   so greater multiplexing / information capacity

Optic fibres do not radiate energy   so there is no cross-talk between fibres

Optic fibre is immune to em waves   so can be used in noisy environments

Optic fibre cannot be tapped   so is much more secure

Optic fibre is thinner and lighter   so is easier for technicians to handle

Optic fibre glass is common substance   so is cheaper than copper

(allow any 3 sensible state & explains x 2 marks each)

(b) (i) Signal-to-noise   25 $= 10 \log P_{sig} / 6.3 \times 10^{-6}$ 1

lowest signal power P_{sig} $= 6.3 \times 10^{-6} \times 10^{2.5}$

$= 2.0 \times 10^{-3}$ W   1

(ii) Total attenuation in fibre $= 10 \log 38 \times 10^{-3} / 2.0 \times 10^{-3}$

$= 12.79$ dB   1

Attenuation per unit length $= 12.79 / 80$

$= 0.16$ 1   dB km^{-1} 1 (for unit)

(iii) Speed of light in fibre $= 3.0 \times 10^8 / 1.5$

$= 2.0 \times 10^8$ 1

minimum time $= 80 \times 10^3 / 2.0 \times 10^8$

$= 400$ µs   1   (allow 1 mark for 267µs)

Mark Scheme	Unit Code	Session	Year	Version
Page 5 of 5	2825	June	2005	
Question 5	Expected Answers			Marks

(a) *Audio*   refers to frequencies between 20 Hz and 20 kHz   or
                   refers to sound waves that can be heard by human ear   1

     Analogue   refers to a signal which is analogous to the quantity which generated it
                   It varies continuously in time
                   And can have any value between two limits   1   (any point)

     Digital   This is a coded representation of information
                   Can only have one of two values   1   (either point)

(b)
(i)   Total number of bits stored   = 2 x 16 x 44100 x 3600   1
                                       = 5.08×10^9 1

(ii) Received bit rate   = 5.08×10^9 / 3600
                                       = 1.4×10^6 s^{-1} 1

(c)   Advantages of digital   Digital signals can be perfectly regenerated
                                 Digital signals can be easily stored in memories
                                 Digital signals can be easily controlled by computers
                                 Digital signals can be companded
                                 Digital signals can be encrypted
                                 Digital signals can have error correction
                                 Digital allows store of greater volume of information
                                              (any two sensible points)   1 1

(d)
(i)   Total number of combinations   = $2^{\text{number of bits}}$

      2^7 = 128   so 7 bits required   1

(ii) Typical page of text ≈   40 lines / page x 60 characters / line   x 7 bits per character

                            ≈   16800   11 (accept any reasonable and explained answer)

(iii) Total number of pages ≈ 5.08×10^9 / 16800

                             ≈ 3×10^5 pages   (must be (b)(i) / (d)(ii))   1

Mark Scheme: 2825 Synoptic Common question

(a)(i)   speed $v = 2\pi r / t$
         $v = 2 \times \pi \times 122/2 /(30 \times 60)$ (1)
         $v = 0.21$ m s^{-1} (1) allow 0.2 m s^{-1}

(ii) $F = 12.5$ kN $\times 16 = 200$ kN   (1)

(iii) $W = F \times s$ or
         $= 200$ k $\times 2 \times \pi \times 122 / 2$ (1)   ecf (ii)   allow ecf for distance from (i)
         $= 7.7 \times 10^7$ J (1) allow 8×10^7

(iv) $P = W / t$ energy / time   or $F \times v$ or
         $= 7.67 \times 10^7 / (30 \times 60)$ (1)   or   ecf (iii) / (30 × 60)
         $= 42.6$ kW   (1)   allow 43 kW   only allow 40 kW if working shown

(v)
   • Friction force at bearing opposes motion so not useful   (1)
   • Friction force of tyres on rim drives wheel, so is useful   (1)
   • Electrical energy supplies power to drive wheels / useful implied (1)
   • Input <u>energy</u> (electrical or energy supplied to motor) is converted into <u>heat</u> (1)
   Last point to do with the idea that once moving with constant speed e.g.
      • <u>All</u> work is done against <u>friction</u>
      • No input energy is converted into E_k
      • <u>All</u> input energy ends up as <u>heat</u>
      • Any other relevant point relating to energy   (1)

(b)(i)   X is bigger than Y (as X is under greater tension due to the weight of the bike)   (1)

  (iii)   Q is bigger than P (due to the weight of the wheel causing compression in P) (1)

(c)(i) $k = F / x$
         $= 1.8 \times 10^6 / 0.90$ (1)
         $= 2.0 \times 10^6$ Nm^{-1} (1)
   (ii) $f = (1 /2\pi (k/m)^{0.5}$ (0)
           $= (1 /2\pi (2.0 \times 10^6 / 9.5 \times 10^5)^{0.5}$ (1)
           $= 0.23$ Hz   (1)
   (iii) If wind energy causes this frequency in the structure, the amplitude increases /
          resonance occurs / or explanation of resonance / ref. to natural frequency (1)
          e.g. damping is necessary / mass change to shift resonant frequency / change spring
          constant (1)

Mark Scheme 2826/01
June 2005

1   **(a)** $v = u + at$ no, but if u is zero then v is proportional to t 1

        provided a is constant   1   2

        $pV = nRT$ not unless T is in kelvin   1

        and both n and V are constant (R is a constant)   1   2

        $P = Fv$ yes if v is constant   1

        but all three terms can vary so proportion unlikely   1

        then EITHER if v is constant then P and F will also be constant

        OR P is proportional to F when going up hills of different gradient

        (at constant v)   1   2

MAXIMUM 2

        $A = \pi r^2$ yes (π is a constant and A is directly proportional to r^2)   1   1

(b)   graph must be a straight line   1

        graph must go through the origin   1   2

2   **(a)**   The air in the forest is heated and expands (so it becomes less dense)   1

        and rises   1

        (cooler) air coming in to take its place (is the wind)   1   3

        {just saying convection current one of first two marks only}

(b)   A shiny surface reflects light   1

        a black surface absorbs light   1

        shoe itself is black because it does not reflect light   1

        surface layer (transparent) or polish on shoe reflects light   1

        reflection depends on texture of surface   1   3

MAXIMUM 3

(c)	the pendulum bob is travelling in a circle	1	
	so it is accelerating towards the centre	1	
	(it has a constant speed in the time interval just before vertical to just after vertical)		
	bob is not in equilibrium	1	
	so the tension must be (slightly) <u>larger</u> than the weight of the bob	1	3

<div align="center">MAXIMUM 3</div>

(d)	X-rays have a very small wavelength (compared with 0.1 mm)	1	
	angle of diffraction increases as size of opening decreases	1	
	little diffraction when size of opening is much greater than the wavelength	1	
	quantitative values - e.g. gap is 10^6 wavelengths	1	3

<div align="center">MAXIMUM 3</div>

(e)	sound waves are longitudinal waves	1	
	longitudinal waves cannot be polarised	1	2

(f)	the heat is extracted from the air in the room	1	
	and pumped out the back of the refrigerator	1	
	the motor requires power	1	
	and its waste heat heats the kitchen	1	2

<div align="center">MAXIMUM 2</div>

3	**(a)**	**(**a lower resistance will) take a larger current from the supply	1	
		(power = $V \times I$) so power to/ brightness of headlamps is greater	1	2
	(b)	(first position) has no lights on at all	1	
		(second position just) lights the sidelights	1	
		(third position turns off the sidelights and) just illuminates the headlamps	1	3
	(c)	4 *V* across the internal resistance of the generator	1	
		so current = 4 V / 0.50 Ω = 8.0 A	1	2

(d) (i) 12 V across headlamp   1

so current = 12 V / 4.0 Ω = 3.0 A   1   2

(ii) power = *V x I,* total current = 6.0 A   1

power supplied = 12 V x 6.0 A = 72   1

watt   1   3

(e) 8 A from generator but only 6 A to headlamps   1

therefore current to battery is 2 A (allow –2 A)   1

battery is being charged   1   3

(f) (i) constant voltage maintained across bulbs (and other components)   1

so brightness of bulbs does not vary (when other components

are being used   1

less energy wastage   1

can give high current (for starter motor)   1   2

MAXIMUM 2

(ii) If the emf of the generator is (equal to or) less than the emf of the battery

it is impossible to have it supply more current than the circuit uses   1

Charging the battery is then impossible   1

battery would become discharged   1

or other valid response   1   2

MAXIMUM 2

4   (a) (i) **radioactive** implies the emission of ionising radiation   1

OR emits alpha, beta and gamma radiation   1   1

(ii) **nuclide** refers to a particular nuclear structure (with a stated number

of protons and neutrons)   1

(iii) **half-life** is the (average) time taken for the activity to fall to half its

original value   1

(b)

time / hour	activity of material / Bq	activity of nuclide **X** /Bq	activity of nuclide **Y** /Bq
0	4600	4200	400
6	3713	3334	**379**
12	3002	2646	**356**
18	2436	**2100**	**336**
24	1984	**1667**	**317**
30	1619	1323	296
36	1333	**1050**	**283**

(i) and **(ii)**   2100 as first figure to be filled in for nuclide **X**   1

        1667   1

        1050   1

        idea of subtraction for nuclide **Y**   1

        correct values for the ones given in nuclide **Y** column   1   5

(c) sensible graph plotted   1

    extrapolation done   1

    value 70 ± 5 hours   1   3

OR $A = A_0\, e^{-\lambda t}$ 1

    $\ln A = \ln A_0 - \lambda t$

    e.g. when $A = 296$, $t = 30$ h

    $5.6904 = 5.9915 - \lambda \times 30$ 1

    $0.3011/30 = 0.01004 = \lambda$

    $\tau = \ln 2/\lambda = 69.0$ h answers will vary slightly dependent on starting and

    finishing times   1   3

(d)   separate the two nuclides (before starting the count)   1

        by chemical means (if possible)   1

  OR using a centrifuge or diffusion (if isotopes)

  OR sensible idea about shielding against one of the emitted particles

(e)   decay constants or half lives are different   1

        half-life at the start is approximately that for **X**   1

        X decays more rapidly than **Y** so after a long time the half-life is that for **Y**   1

        in between it has a value intermediate between the two (which varies)   1   3

                           MAXIMUM 3

  OR dealt with mathematically, along the lines of

        two separate exponential decays   1

        when added together do not give an exponential graph   1

        with back up maths   1   3

Mark Scheme 2826/03
June 2005

A1   Valid method for calibration of Hall probe (e.g. using solenoid/Helmholtz coils)   **1**

A2   Detail relating to calibration
          3/2/1/0
          Any three relevant points; one mark each
          (e.g.   place Hall probe in (centre of) solenoid/Helmholtz coils, one mark;
                     measure current through solenoid/Helmholtz coils, one mark;
                     find B using $\mu_0 nI$, $0.72\mu_0 nI/r$ etc. one mark;
                     compare B with reading on millivoltmeter, one mark
                     repeat for different values of B (or I) or calibration graph, one mark)
    Wrong procedure (e.g. vary separation of coils) scores max 2/3.

B1   Do not perform experiment near magnetic materials/use <u>wooden</u> rule or clamps etc.   **1**

B2   Diagram or text indicating <u>workable</u> arrangement of apparatus   1

          (e.g. two <u>clamped</u>/<u>fixed</u> bar magnets (with opposite poles facing each other),
          and Hall probe placed mid-way between them).
          If circuitry is clearly incorrect, do not award this mark.

B3   <u>Workable</u> method   **1**
          (i.e. measure B and d, change d and repeat)
          Could be given as a table in the body of the text.

C   Place Hall probe <u>perpendicular</u> to magnetic field   **1**

D   Any further relevant detail, e.g.
          4/3/2/1/0

          Detail relating to Hall probe (e.g. measure p.d. across current-carrying s/c slice)
          Knowledge of magnitude of Hall voltage (i.e. mV)
          Zero adjustment of output of probe
          Perform zero adjustment away from other magnetic fields
          Separation of Helmholtz coils = radius of one of the coils
          Align solenoid/Helmholtz coil in E – W direction
          Position of probe well within solenoid/Helmholtz coils not important
          Circuit diagram containing solenoid/ammeter/psu
          Evidence of relevant preliminary experimental work done in the laboratory
          Method of finding n for solenoid

R   Evidence of research of material
          2/1/0
          i.e. at least two detailed references have been given (i.e. chapter and/or page
          numbers must be given). Allow Internet <u>pages</u> to be sourced.
          Two or more vague references (i.e. no chapter or page reference) scores one mark.
          One detailed reference scores one mark. One vague reference scores zero.

Underline and tick each relevant point in the body of the text. The ticks must have a subscript
showing <u>which</u> marking point is being rewarded (e.g. $\checkmark_{D1}$).

Q   **2 marks** are reserved for quality of written communication (organisation)   **2**
          Rambling and poorly presented material cannot score both marks.

                                                                            16 marks in total

Question 1

(a) (iii) Principle of moments applied correctly scores one mark   **2/1/0**
        If g is omitted or m in grams or incorrect distance in **(a) (ii)** then one mark only
        Value of $W \pm$ 10% of SV scores one mark (ignore sf)

(b) (ii) Value of d_2 > initial value   **1**
        d_2 > 50 cm will not score this mark

(b) (iii) Percentage uncertainty in value of d_2 **2/1/0**
        Sensible Δd (0.5 mm, 1 mm or 2 mm or half the range); one mark
        Correct ratio idea and 'x 100'; one mark
        Ignore final calculated final. Insist on correct method of working.
        Bald answer with no working scores zero.

(b) (iv) Method for ensuring that d_2 is reasonably accurate   **1**
        e.g. find approx. position and then move M in 1 mm or 2 mm steps
        Allow repeated readings (and average)

(c)   Correct value for F (must be checked); two marks.   **2/0**
        Allow d_2 to be in metre with no penalty and ecf as far as possible.
        Algebraic error or AE or wrong quantites scores zero.

(d)   Readings   **2/1/0**

        Write the number of readings as a ringed total by the results table.
        6 sets of values for F and n scores one mark.
        Values of n in range and reasonably spaced (i.e. $\Delta n \geq 5$), one mark.
        If minor help is given (e.g. initial balancing of rule), then -1.
        If excessive help is given (i.e. no idea about moments) then -2.
        Please indicate when help has been given to a candidate by writing **SR** at the top of the
        front page of the candidate's script. Also, please indicate the type of help that has been
        given by writing a brief comment by the table of results.

(d)   Repeated readings   **1**
        Do not award this mark if all repeats are identical.

(d)   Column headings   **2/1/0**
        The columns for F and d_2 must be headed with a quantity and a unit. One mark each.
        There must be some distinguishing mark between the quantity and its unit.
        Please ✓ each correct column heading to show that it has been seen.

(d)   Consistency of raw readings in the table of results   **1**
        Apply to d_2 only. Expect all the values to be given to the nearest millimetre.
        Values in the table must agree with the unit at the head of the column.

(e) (i) Axes   **1**
        Each axis must be labelled with a quantity.
        Scales must be such that the plotted points occupy at least half the graph grid in
        both the x and y directions.
        Do not allow more than 3 large squares between scale markings.
        Do not allow awkward scales (e.g. 3:10, 6:10, 7:10, 8:10 etc.).

(e) (i) Plotting of points   **1**

Count the number of plots on the grid and write this value by the line and ring it.
Do not allow plots in the margin area.
The number of plots must correspond to the number of observations.
Do not award these marks if the number of plots is less than the number of observations.
Check one suspect plot. Circle this plot. Tick if correct.
If incorrect then mark the correct position with a small cross and use an arrow
to indicate where the plot should have been.
Allow errors up to and including half a small square.

(e) (ii) Curve of best fit   **1**

There must be a reasonable balance of points about the curve.
These marks can only be awarded if a curve has been drawn through a curved trend

(e) (ii) Quality of results   **1**

Judge by scatter of points about the curve of best fit.
There must be at least five plots on the graph for this mark to be awarded.

(e) (iii) Measurement of gradient of tangent   **3/2/1/0**

Read-offs must be accurate to half a small square and the ratio must be correct.
Please indicate the vertices of the triangle used by labelling with Δ.
One mark for quality of tangent to curve
(tangent must be of reasonable length, i.e. at least 10cm long)
One mark for read-offs and ratio correct.
One mark for negative value of a line with a negative gradient.

(f) (i) ln F vs n or ln F vs -n scores two marks   **2/1/0**

Allow any base to be used (i.e. log F vs n)
log F = -Bn + log A (with no reference to base and no statement of what is to be plotted),
scores one mark.

(f) (ii) -B = gradient, or B = gradient (consistent with working), or equivalent, one mark   **2/1/0**
ln A = intercept (or A = $e^{intercept}$), or equivalent, one mark.
If the base is not specified in **(f) (i)** (i.e. log F), or base 10 has been used, then
these marks cannot be scored unless log_{10} e has been used correctly. The working
must be consistent with **(f) (i)**.

(g) (i) Micrometer screw gauge reading for n = 40. Must be $\pm$ 0.10 mm of SV.   **1**
The value must be given to 3 s.f..

(g) (ii) Value of n for separation of 3 mm. Working must be checked (one mark).   **2/1/0**
Value of F for separation of 3 mm <u>using the graph</u> (one mark).
Allow ecf from first part.

28 marks in total

Question 2

(a) (iii) Raw time > 10 s recorded to at least 1 d.p. and *T* correct (= *t*/*n*)   **1**

(a) (iv) Justification for number of sf in *T*   **1**

        i.e. same sf as *t* (allow 'raw data' ideas) or sensible reference to human reaction time.
        Do not allow d.p. ideas. Answer must be consistent with **(a) (iii)**.

(b)   New value of *T* (< first value of *T*), one mark.   **2/1/0**
        Repeated readings of raw times for second value of *T*, one mark.

(c)   Product *Td* is constant (or *T* halves if *d* doubles)   **2/1/0**

        One mark for product idea, or calculation of *k*'s
        One mark for conclusion that *T* is inversely proportional to *d* which follows
        from the reasoning (only if *k* values are within 10% of each other).
        Vague '*T* might be inversely proportional to *d*' or *T* is not inversely proportional to *d*'
        does not score this second mark.

(d)   Evaluation of procedure   **8**

        Relevant points must be underlined and ticked. Some of these might be:
        Raw time too small
        Time more oscillations
        Use motion sensor
        Problems with varying amplitude/damping
        Displace rule and wait for torsion oscillations to settle before timing
        Human error in timing/hard to see when the oscillation begins/ends
        Two readings is not enough (to draw a conclusion)
        Take several/many readings of *d* and *T* (and plot a graph). Possible cf from **(c)**.
        Thick string makes measuring *d* difficult
        Use thinner string (to improve precision of measurement of *d*)
        Use a (fiducial) marker
        Place the marker at the centre of the oscillation
        Metre rule may not be horizontal
        Check with a spirit level/measure from bench
        Oscillations may not be completely torsional (allow vague 'the rule wobbles' or 'sways')
        Draughts may be a problem
        Shut windows/close doors to stop draughts

        Do not allow repeat readings.
        Do not allow vague 'use light gates', 'use a computer' or 'video the rule' unless further
        clarification has been given.
        Allow other relevant points (8 maximum). Marks could be awarded on the basis of 'one for
        the problem and one for the solution'.

2 marks are reserved for quality of written communication (SPAG)   **2**

                                           16 marks maximum to be awarded

Sample results for bar magnet investigation.

Using a strong (new) magnet:

n	d/cm	F/N
10	45.1	3.59
15	36.9	2.79
20	31.4	2.25
25	27.4	1.86
30	24.0	1.52
35	21.4	1.27
40	19.7	1.10

And using an 'old' magnet:

n	d/cm	F/N
5	48.1	1.59
10	38.8	1.13
15	33.2	0.858
20	29.4	0.672
25	27.0	0.554
30	25.1	0.461

Using a **strong** bar magnet (new); d_L = 20.1 cm, d_R = 8.5 cm and ***m* = 200 g** gives a mass of the bar magnet of 84.6 g.

Using a **weak** bar magnet (old); d_L = 20.0 cm, d_R = 15.7 cm and ***m* = 100 g** gives a mass of the bar magnet of 78.5 g.

Sample results for torsional oscillations of metre rule.

n	t_1/s	t_2/s	t_3/s	T_{av}/s	d/m	Td/sm
8	32.4	32.4	32.5	4.05	0.200	0.81
15	30.4	30.4	30.5	2.03	0.400	0.81

Value of Td is constant at 0.81 sm showing that T is inversely proportional to d.

Graph of sample results for question 1 (strong magnet)
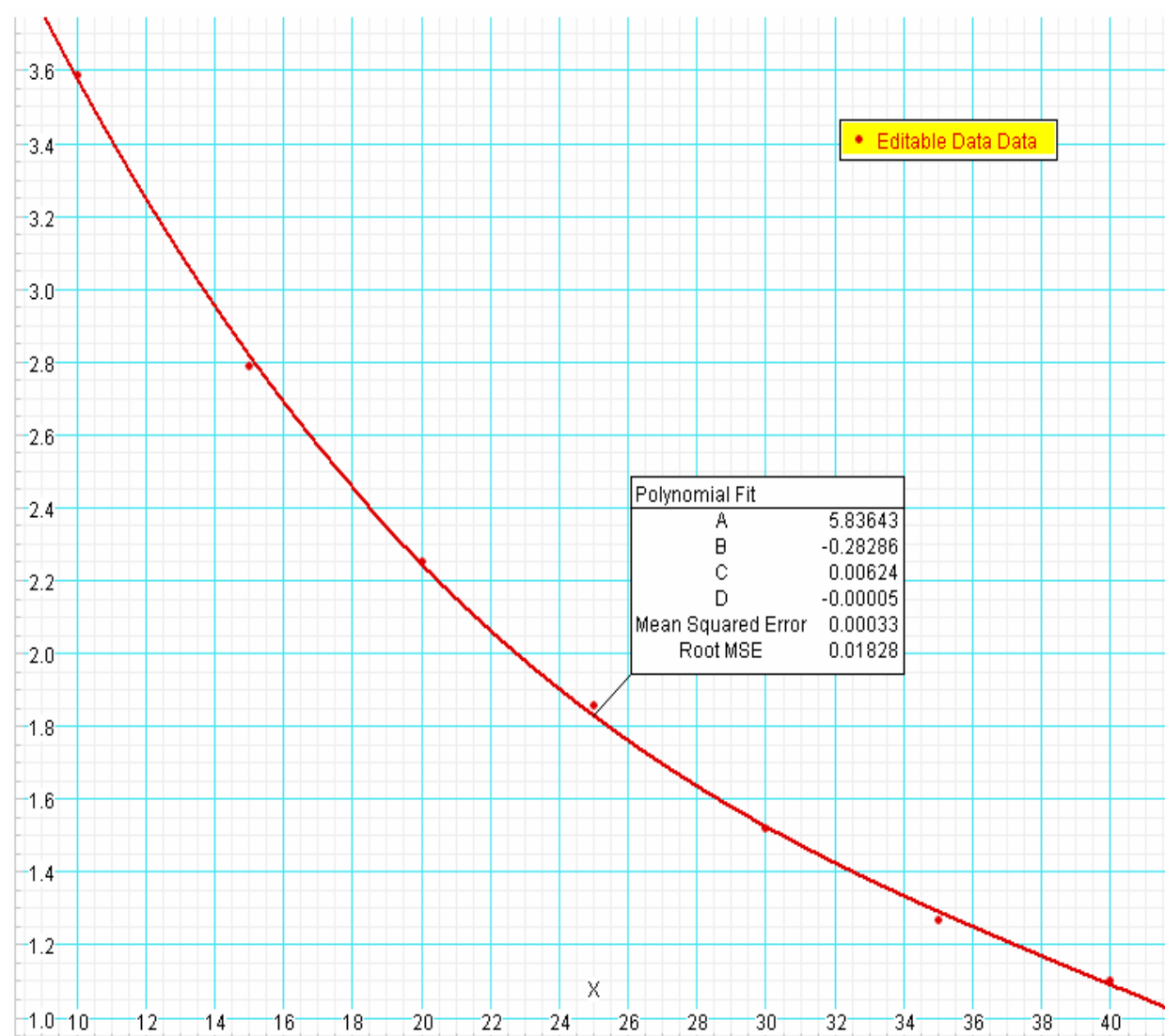
Graph of sample results for question 1 (weak magnet)

Summary of shorthand notation which may be used in annotating scripts:

SFP   Significant figure penalty

ECF   Error carried forward

AE   Arithmetical error

POT   Power of ten error

NV   Not valid

NR   Not relevant

GAP   Insufficient scale markings on an axis

NBL   Not best line

FO   False origin

NGE   Not good enough

BOD   Benefit of the doubt

R   Point repeated (no further credit)

NA   Not allowed

SV   Supervisor's value

SR   Supervisor's report

OOR   Candidate's value is out of range

wtte   Words to that effect

CON   Contradictory physics not to be credited

$\checkmark\Delta$ Used to show that the size of a triangle is appropriate (gradient calculation)

$\checkmark$A3   Used to show the type of mark awarded for a particular piece of work

$\checkmark$C   Used to show that the raw readings are consistent

$\checkmark$SF   Used to show calculated quantities have been given to an appropriate number of significant figures

^   Piece of work missing (one mark penalty)

^^   Several pieces of work missing (more than one mark penalty)

$\leftrightarrow$ Scale can be doubled in the x-direction

$\updownarrow$ Scale can be doubled in the y-direction

Report on the Units
June 2005

Chief Examiner's Report

AS level Specification 3883

Papers 2821, Forces and Motion
       2822, Electrons and Photons
       2823/01, Wave Properties
       2823/02, Coursework
       2823/03, Practical Examination

Introduction

9675 candidates took the Electrons and photons paper, of whom 1380 were re-sits from June 2004. This is an increase from June 2004 when there were 9470 candidates. The reason for the increase is probably the relaxation of the rules for re-sitting. Of the 9600 candidates taking the Wave Properties paper 6320 took the practical paper and 3020 submitted coursework. The remainder used carried forward coursework. Candidates took all three theory papers during the same morning, which poses considerable logistical problems for Centres but there is a national problem with fitting all the examinations into a reasonably compact period of time.

All the examinations went smoothly this year and the following standardisation meetings, marking, awarding meetings and reviews did not uncover any undue problems. Generally the papers were accessible to the candidates taking the papers and there was no evidence from any of them that they were too long to be completed in the allotted time. There were marginally fewer grade A scripts this year; there is no creeping increase grades awarded in this physics specification.

Some candidates do not do as well as they might as a result of illegibility and there are a considerable number of candidates who, given an unfamiliar question, leave a completely blank answer space. This inevitably results in zero marks. Candidates ought to make a plausible guess instead of leaving a space. Some of what they write may well get a few marks. Another serious problem is candidates' total reliance on anything their calculator shows. In particular there are three specific causes of error which need to be addressed. The first is with a calculation such as 12 / 2 x 3. Candidates get the answer 18 because they do not use the division sign twice. The second is in a calculation such as $6 / 3 \times 10^2$ where, even if they do not fall into the previous trap, they get the answer 2×10^{-3}. This results from using the EXP button and putting in 10 as well. The third, and more serious mistake, is their unwillingness to look critically at the number itself, particularly with regard to powers of 10. It is patently absurd to get a charge of 1.6×10^{19} C on an electron or to find the wavelength of light as 500 m. Candidates must do more checking of their work so that they find their own careless mistakes rather than letting the examiner find them. Quick checking needs to be done at the end of every line rather than being left to the end of a question or the end of the exam paper. Careless mistakes which the candidate makes can in some cases result in a grade drop from an A to a C or even a D. Thoughtful work is really missing from some candidates and it is not always the weaker candidates who suffer.

A2 level Specification 7883

Papers 2824, Forces, Fields and Energy
2825, Options
01 Cosmology
01 Health Physics
03 Materials
04 Nuclear and Particle Physics
05 Telecommunications
2826/01, Unifying Concepts in Physics
2826/02, Coursework
2826/03, Practical Examination

Introduction

The examination procedure for Physics A, from setting to awarding, worked smoothly this year. Aggregation was carried out for 5509 candidates and of these 26% were awarded a Grade A. Both of these figures are very slightly lower than last year but there is no great decline in the number taking the examination. The Options papers, in order of popularity, are still Cosmology, Nuclear and Particle Physics, Health Physics, Materials and Telecommunications. The Principal Examiner for Telecommunications was particularly disappointed that a subject with such practical applications showed a significant drop in numbers this year.

As with AS, careless work, thoughtless work and illegible work all contribute to candidates performing less well than they should do. There are some Centres where good practice minimises these problems and, unfortunately, there are Centres where the problems are rife. All candidates should have practice at doing past papers in the run up to the examination itself and having their responses critically assessed in order that they see what is required.

2821 - FORCES AND MOTION

General comments

The general impression of the Examiners who marked the paper for this module was that the level of difficulty of the questions was appropriate for the candidates for whom it was intended. The paper consisted of a wide range of questions and candidates produced a very wide range of responses so good differentiation was obtained. There was an almost complete range of marks but very few scored less than 10, while the number of candidates scoring more than 50 was more than in previous years. However, the mean mark for candidates this session was 33.4: this was 1.2 marks lower than the mean mark obtained in the June session in 2004.

Most candidates were able to gain some marks on each question and very few candidates left parts of questions unanswered. The responses differed widely, depending on the Centre and this was particularly noticeable in the description of the motion of a projectile in question two. There seemed to be more Centres this year where the candidates did not appear to have prepared for the specification. The lack of precision, poor use of English and failure to read the question carefully reduced the marks of many candidates of the full range of abilities. However, the majority of candidates were able to give good answers to some parts of every question. Candidates from the whole ability range were able to gain marks for definitions but the weaker ones tended to write more simplistic and hence unacceptable versions.

Questions one and two allowed a good proportion of the candidates to get off to a good start with the paper. There were many totals in excess of 20 out of 29. Questions three then proved more of a test with a wide range of performance becoming evident. The better candidates were able to demonstrate their greater ability by applying their knowledge and understanding to novel situations. It should be noted that a significant number of candidates of all abilities failed to read some questions carefully and therefore answered them incorrectly. In general, the most able candidates scored highly in all the questions except question six, coping well with the required definitions and with the recall of formulae and their application in numerical problems. They also completed calculations correctly and gave precise and accurate explanations. Those with average ability tended to be less precise in their recall of definitions but generally knew the required formulae and succeeded with most calculations.

The length of the paper was considered to be about right with the vast majority of the candidates finishing the paper in the required time. The standard of written communication was generally adequate with a significant number of candidates scoring at least one of the marks available for written communication. Marks were lost by a significant number of candidates who failed to write their answers in sentences, or did not use the required technical language.

Comments on Individual Questions

Question one

Candidates generally scored well on this question. In part (a) the definitions were generally well answered. It was pleasing to see that fewer candidates now think that 'speed in a given direction' is adequate for velocity. A significant minority are failing to gain credit by giving symbols that are not then explained. Surprisingly, the definition of velocity seemed to cause more of a problem to candidates than acceleration. In some centres the statements that use displacement over time and change in velocity over time is still being used and continues not to gain credit, as the ratio is not clear. In part (b) there was broad agreement that less fuel reduced the mass of the car. However, the word mass was often omitted and the technical language used tended to be poor. The second mark was a good discriminator as only the better candidate referred to the effect on the acceleration of the car. Many considered that the extra mass would control the maximum speed of the car. The words slippery, traction and grip were often used to explain the difference between

wet and dry conditions on the road without credit being awarded. Marks were only given for answers that included the word friction. The reason why smooth tyres could be used in dry conditions was often not described by candidates. The channelling of the water by the tread in wet conditions was often poorly described. In part (c) the majority of average to good candidates were able to obtain the correct answers. Weaker candidates failed to use the equations of uniformly accelerated motion and guessed a time to use in the speed = distance / time equation. Part (d) was a good discriminator particularly as a check to see if the question had been read carefully. The full range of marks was obtained. The candidates who failed to present their working with any logical order or a few words of explanation made the marking difficult. It would have helped if the candidates had given some identification or explanation to each number or series of numbers they gave for the times. A large majority failed to include one of the components in calculating the overall difference in time between the cars.

Question two

In part (a) there were many candidates who gave good answers. However, there was a significant majority of candidates who were not able to describe the situation that combined a uniform horizontal velocity with an up/down one of uniform acceleration under a gravitational force. There were many that described the pre-Newtonian concept of the ball having a force due to its motion that exactly balanced the weight of the ball when it reached its maximum height at P. The idea that the ball had zero velocity at P was a common misconception. Some candidates did not separate the two components of velocity and were vague about the accelerations or forces involved. There was some confusion over the terms velocity, force and energy. A number of candidates still believed gravity to be a force rather than a concept. The better candidates used the terms gravitational force and acceleration due to gravity.
In part (b) many candidates discussed the energy transformation before point T. and failed to answer the question. The good candidates scored full marks in this section and generally this part scored more highly than the other two parts. However, the conversion of kinetic energy to potential energy on the way up was not described clearly by many candidates. There were many answers that implied that the change did not take place until the ball reached P. In part (c) the majority of candidates understood the effect of air resistance on the height and range of the ball. The third mark was often missed as the candidates referred to the motion of the ball rather than the precise term of velocity.

Spelling was disappointing and many candidates were unable to copy words correctly from the question. Others used abbreviations and unexplained symbols.

Question three

Many candidates answered part (a) correctly but a number repeated the question as their answer. The answers to part (b) varied between those candidates who had been prepared for a question on the vector triangle of forces and those who had not. The triangle was drawn correctly and some of the appropriate labels were included by a large number of candidates. Marks were lost for the values of the angles being omitted or the arrows being omitted or given in the wrong direction. In part (ii) very few drew scale diagrams but those that did were often successful. The resolving of vectors was done in the more difficult vertical and horizontal directions and this led to difficult equations to solve. Only the better candidates were able to obtain correct solutions. Resolving along one of the forces in the rope and perpendicular to this allows answers to be obtained more easily. The sin rule also leads to easier solutions. The weaker candidates did not draw a triangle in part (i) they often drew the diagram in Fig. 3.2. Other candidates after drawing a triangle in part (i) did not use it in part (ii) but started with another diagram.

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Question four

Parts (a) and (b) were generally well done by a large majority of candidates. A surprising number of candidates started with the correct formula and then failed to rearrange it correctly. In part (b) many average candidates did not know the formula for density or mass and weight were often confused in their answers. Part (c) was only answered correctly by the better candidates and proved to be a good discriminator for this question. Many candidates gave one of their answers to parts (a) or (b) very few added their answers even though they knew that the forces up must equal the forces down.

Question five

Many candidates scored high marks on this question with the vast majority scoring at least two out of three in part (a). The mark that was missed was often the lack of explanation in part (i). Again some candidates lost marks as they referred to a force acting on the crate because of its motion. In part (b) the main errors were to describe the passenger as being thrown forward in a collision. Good candidates described how the time of collision was increased leading to reduced acceleration or a reduced rate of change of momentum and hence a reduced force.

Question six

Good candidates scored well on parts (a) and (b). Many candidates were unable to calculate the spring constant or the strain energy in the spring. A common misconception was to relate the spring constant with the inverse gradient of the graph. Many also attempted to calculate the strain in the spring for part (ii). A significant number of candidates failed to convert the units correctly. The total force was often given in part (b)(i) rather than the force F. This was probably because the candidates failed to read the question carefully. Part (b)(ii) was often well answered. Part (c) had been designed to test the high ability candidate. The marks obtained were generally lower than expected by these candidates. The correct positions on the graph were often given correctly. However, only a minority knew how to determine the velocity from the gradient of a tangent to the curve. The explanation for the position of X was rarely given correctly. The question gave a good range of marks but far too many candidates did not understand how the two graphs could be used to determine the answers to the question asked.

2822 - Electrons and Photons

General comments

The candidates managed to acquire marks covering almost the entire range from zero to sixty. On the whole, candidates were better prepared to tackle the complexities of this paper and demonstrated a decent understanding of the material. This was particularly noticeable for candidates securing the higher grades. Such candidates produced almost flawless and well-structured solutions. There was a significant improvement on the correct use of scientific vocabulary. Candidates who thoroughly prepared themselves by doing past papers did markedly well. Their analytical solutions were often concise and well presented. However, a significant percentage of candidates continue to struggle with basic arithmetic, algebra, units and recalling definitions that are clearly signposted in the specification. For some candidates, rearranging equations remains a formidable task. Centres are once again reminded that candidates cannot secure any marks for using an incorrectly recalled equation.

The Quality of Written Communication (QWC) was assessed in **Q2** and **Q6**. The majority of the candidates secured two marks for spelling & grammar and organisation of their answers. However, the handwriting of some candidates was very difficult to decipher. Almost all candidates finished the paper in the scheduled one hour.

Comments on Individual Questions

Question One
This question was accessible to all candidates with a large number securing more than eight marks. Almost all candidates successfully wrote the correct speed of the electromagnetic waves in **(a)**. The most popular incorrect answer was 330 ms^{-1}.

A significant number of candidates gave flawless answers for **(b)(i)**. Most candidates managed to recall the equation $v = f\lambda$ and substitute the correct values. A disappointing number of candidates substituted 3.0 V for the value of *v* in this equation. Weaker candidates struggled with rearranging this simple equation. The majority of candidates could not correctly recall the definition for electromotive force. For many candidates, this important quantity remains an enigma. Many candidates wrote that e.m.f. '*was a force responsible for pushing the charges through the battery*'. Some candidates quoted the difference between voltage and electromotive force, but this was not asked in the question. The majority of candidates secured full marks for **(b)(iii)** and **(b)(iv)**. Most candidates successfully used either $W = VQ$ or $W = VIt$ to determine the energy transformed by the battery in the time interval of 0.20 s. A few desperate candidates multiplied all the quantities given in the question in the hope of securing some marks. It is pleasing to report that a significant proportion of the candidates correctly identified the wavelengths required in **(c)**. Since filament lamps predominantly emits infra-red radiation, examiners agreed to award a mark for matching the filament lamp with the wavelength of either 8.8 × 10^{-7} m or 5.0 × 10^{-7} m.

Question two

Almost all of the candidates made a very good start with **(a)**. Most candidates quoted the expected answers of '*cross-sectional area*' and '*length*'. Some candidates repeated the factors mentioned in the stem of the question or wrote down '*voltage*' and '*current*'. The marking for this question was eased a bit to allow credit for answers like '*diameter*' and '*thickness*'. This generosity is unlikely to be extended in this future.

Candidates were well prepared for **(b)**. The majority of the solutions were logically set out. There were the inevitable problems with using the diameter of the wire instead of the radius when

determining the cross-sectional area and failing to correctly convert the radius from millimetres to metres. It is comforting that there were fewer answers in the format 1.7E-8. A disturbing number of candidates struggled with the unit for resistivity. Examiners had agreed to credit '$\Omega \ m^2 \ m^{-1}$' on this occasion, but nothing could be given for erroneous units like the '*newton*', '*tesla*', '*pascal*' and '*ohm*'. It was a mystery as to why candidates decided to write a statement for Ohm's law in **(b)(ii)**. Candidates are reminded to carefully scrutinise questions before answering. Most candidates appreciated that the resistance of the copper bundle increased and this led to a reduction in the current. Some candidates attempted to explain the decrease in the current in terms of '*electrons making more collisions with each other*' or '*because particles started to vibrate more*'. No credit was given for either response. In the latter case, it was not clear whether the particles were the electrons or the atoms of copper. A number of candidates secured some marks through the ruling of error-carried-forward. However, candidates were not allowed any marks for contradictory statements. Most of these inconsistent statements were centred on the voltmeter reading. Candidates had incorrectly used $V = IR$ to argue that the '*voltmeter reading will increase because $V \propto R$*'.

Question three

Most candidates struggled to collect marks from this question. An estimated third of the candidates overlooked **(a)** and consequently drew nothing on Fig.3.1. The modal mark for **(a)** was one. The magnetic field patterns for the solenoid were poorly sketched. The vast majority of candidates failed to identify the direction of the magnetic field and also omitted the magnetic field lines within the core. A few sketches for the field patterns resembling that created by iron filing when sprinkled around a bar magnet. No credit could be given for such artistic endeavours.

Most of the candidates were at a loss defining magnetic flux density in **(b)(i)**. Many salvaged a mark by quoting $B = \dfrac{F}{IL}$ and defining all the terms. Sadly, many of the statements were imprecise. These included '*magnetic flux density shows the closeness of the field lines*' and '*magnetic flux density shows the strength of the field*'. Only a few candidates appreciated that in the definition for the magnetic flux density, the magnetic field is at right angles to the current or the conductor. The layout for **(b)(ii)** was inexcusable. Candidates did not carefully read the question. The final answer had to be in terms of *F*. Most candidates ended up with either $F = 4B \times 3I \times \dfrac{L}{2}$ or *F* = 6. No credit could be given for an answer like *F* = 6 N.

Question four

Most candidates managed to acquire more than half of the marks for this question. Many of the candidates made an excellent start with **(a)**. Candidates generally showed a sound understanding of resistors in series. It was also pleasing to see several routes used to secure the final answer of 0.70 Ω. Some candidates only determined the total resistance of the circuit by dividing the e.m.f. and the current. A small cohort of candidates interchanged terminal p.d. for e.m.f. and consequently ended up with a negative value for the internal resistance *r*.

(b)(i) was well answered with most candidates using the equations $P = VI$ and $V = IR$. A significant number of candidates correctly used $P = \dfrac{V^2}{R}$ to get the answer of 4.0 Ω. **(b)(ii)** caused some common misconceptions to surface. Some candidates determined the total resistance by assuming that the lamp, the 20 Ω resistor and the 10 Ω resistor were all in a parallel combination. The most popular answer for **(b)(iii)** was 5.0. A significant number of candidates correctly determined the current in the filament lamp. However, many candidates assumed that the potential

difference across the 20 Ω resistor was 12 V and this gave an incorrect value for the current in the resistors.

Question five

In previous papers, candidates have struggled with potential dividers. This was not so in this paper. Almost all candidates gave a correct response for **(a)**.
Many candidates used first principles to determine the resistance of the skin in **(b)**. Most candidates used the potential divider equation to determine the resistance of the skin. There were the inevitable struggle with algebra but candidates survived the ordeal and picked up two or three marks. A few candidates used incorrect equations like $V = \dfrac{R_1 + R_2}{R_2} \times V_{out}$. A small number of candidates forgot to convert their resistance values to kΩ.

Question six

Most candidates demonstrated a good knowledge of photons and secured full marks in **(a)**. Once again, the marks gained by candidates for **(b)** on the photoelectric effect were very much Centre-dependent. Questions similar to this have appeared in earlier module papers and therefore the answers from some Centres were almost perfect. Candidates must again be reminded to carefully read the question before answering. There were too many answers involving the experimental details of the gold-leaf electroscope and the u.v. radiation. Although the answers were correct in terms of physics, the actual salient points about the photoelectric effect were absent. Important terms like the work function energy and the threshold frequency were randomly sprinkled amongst the text. Sadly, some candidates confused threshold frequency with work function energy. A disappointing number of candidates believed that it was the photons that were being removed from the metal surface. Only a small percentage of candidates made reference to the fundamental Einstein's photoelectric equation or the effect of intensity on the rate of emission of photoelectrons. High-achieving candidates did well in **(c)**. A pleasing number of candidates correctly determined the energy of a single photon in **(c)(i)**. Inevitably, some candidates tried using $E = h\lambda$ and even $E = P\lambda$. The electronvolt as a unit of energy remains an aloof concept. On many scripts candidates multiplied elementary charge and their answer to **(c)(i)**. For most candidates, **(c)(ii)** remained mysterious. Many candidates tried to use the value of the elementary charge instead of 1.4W to determine the rate of photon emission from the X-ray machine.

2823/01 - Wave Properties June 2005

General Comments

The general standard of work was similar to last year and the paper provided ample opportunity for candidates to demonstrate their knowledge and understanding of the module content. There was no evidence of candidates being short of time with the vast majority of students being able to attempt every question in full.

Comments on Individual Questions

Q1.   This was a relatively straightforward opener with most candidates scoring high marks – at least 9 out of 11. Some made a mistake in the determination of the wavelength of the laser light in ice, with many suggesting that it would remain unchanged at 6.5×10^{-7} m even though there was a 2 mark allocation for this part of the question.

Q2.   Most candidates also scored well in this question but a common error in part (a) was to fail to show that only rays with a large angle of incidence will be internally reflected inside the core of the fibre. Explanations of 'multipath dispersion' required in part (c) were generally good and most candidates were able to calculate the value of the refractive index of the core/cladding interface.

Q3.   Explanations of the differences between transverse and longitudinal waves were often too vague to score full marks. Phrases such as vibrations being 'up and down' or from 'left to right' are ambiguous since they could equally apply to both types of waves. It was also difficult to be certain what the candidate was referring to when using the words 'motion' and/or 'travel'. To score full marks explanations were required which clearly stated that the vibrations are perpendicular or parallel to the wave direction. In part (c) most realised that the wavelength would decrease but many failed to score both marks by omitting to state that the wave speed was constant.

Q4   Virtually all candidates scored the first mark by stating 'diffraction' but fewer than 50% were able to spell it correctly! Most could also correctly state the meaning of coherence but full marks were rare in part (c) with many students ignoring the instruction to explain the interference pattern '<u>in terms of the path difference</u>'. Virtually all could recall the 'double-slit' formula: $\lambda = ax/D$ but some were careless in using consistent units – many forgot to change the value of the slit separation from mm to m.

Q5   Most candidates appeared to know the difference between nodes and antinodes but marks were lost by those who incorrectly referred to displacement instead of amplitude. Accurately labelling the correct position of a node and an antinode in the air column was done by a minority of candidates with many indicating an antinode at the water surface. Most finished on a high note by correctly calculating the frequency of the tuning fork!

PRINCIPAL MODERATOR'S REPORT FOR 2823/02 AND 2826/02

General Comments

The quality of presentation by Centres continues to improve, with careful marking of candidates' scripts. The clear annotations offered by many Centres greatly assists the moderation process. As a consequence very few Centres suffered any adjustment to their marks. Where adjustments have been made, Centres are strongly encouraged to take note of the individual Centre report from the moderator. The one or two Centres still suffering major adjustments would benefit from attending one of the INSET sessions this season.

Almost all Centres now closely follow the marking scheme and pay strict attention to the hierarchical nature of the scheme and to the use of the intermediate mark.

The highest marks are available for the very best candidates but Centres should take note that the A grade threshold is still at the 80% level that was set as the original design target. Where the top mark of 8 is awarded to a candidate in Planning or Analysis, the Centre is advised to show very clearly their justification of that mark.

Often the work presented at AS shows a great deal of guidance is being offered by the Centres; it must be borne in mind that in order to score heavily, it is the student's work that should be considered and not the teacher's. At A2, the level of guidance offered should be kept to a minimum so that the quality of original work offered by the candidate may be considered.

There are still rather too many experiments that do not comfortably match the mark descriptors. If the investigation does not end up giving a straight-line relationship on a graph, the higher descriptors in analysis are very difficult to obtain.
All the descriptors may be assessed on a single piece of work with one graph; there is no need to do investigations involving comparisons that simply offer a series of repeat observations. A really fine piece of work may well be completed in less than 10 or 12 sides.
The major problem with A2 remains the linking of work back to other areas of the specification (bold type in the mark scheme); this must be done to get above level 3. Candidates should be encouraged to make these cross links clear in their work and where this is done an annotation from the marker would be of great assistance.

Planning

Attention should be paid to the progressive increase in scientific knowledge and understanding as the basis of the mark descriptors. There should be a variety of external sources referred to in the text. A detailed discussion on the choice of equipment to be used (in terms of precision and reliability) is essential.

Implementing

All results should be recorded to the degree of precision available from the apparatus e.g. to 1mm with a metre rule, and they should be consistent. All observations should be repeated and tabulated properly with units. Care should be taken that we are only looking at direct observations in this section and any inconsistencies in derived figures should be assessed at A7a.

Analysing

It is difficult to progress in this section with anything other than the analysis of a straight-line relationship. Very few candidates take the statistical route though these descriptors and the

measurement of a gradient or intercept is more usual. The use of small triangles when taking a gradient is to be discouraged due to the large uncertainty that this would introduce. Only one gradient is needed to assess the mark.

Where ICT is used, strict attention should be paid to the significant figure problems that may be introduced. Again, the use of good scientific knowledge and understanding is at the root of these descriptors.

Evaluating

The numerical evaluation of uncertainties is required and then the combination of these uncertainties into the final values to give, where possible, an "x +/- y" result.

Comparison with a recognised value is of use to assess reliability but is not what this section is about. The level of work involved needs only to be similar to that found in the appendix of "Physics 1"

Once the uncertainties of observations or procedures have been looked at, improvements should be suggested to increase the reliability of the investigation. This should really be attempted in some detail rather than the simple addition of a computer without the description of how it might be used and to what level the improvement might be.

2823/03 - Practical Examination 1

General Comments

The general standard of the work done by candidates was very similar to last year. Plans submitted are still very Centre dependent. Presentation of results and graphical work continues to be done reasonably well although weaker candidates do not always gain some of the marks due to lack of care. Candidates are still experiencing difficulties with both the analysis section in question one and the evaluation section in question two.

There were no reported difficulties from Centres in obtaining the necessary apparatus.

Candidates appeared to complete the paper within the necessary time allocation. Some candidates received help from the Supervisor in the set up of the circuit and the arrangement of the resistors in Question 1. Candidates should be encouraged to show all the steps clearly when carrying out calculations. In addition candidates should be encouraged to include greater detail in their answers to descriptive type questions, giving explanations where necessary.

Practical examinations rely very much on the preparation from Supervisors within Centres. Both the Supervisors' report and a specimen set of results should be completed and sent with the scripts to the Examiner. Where candidates do not submit a plan, it would be very helpful if this could be indicated on the Supervisor's report. Centres are reminded that the cover sheet of the plan needs to be signed by both the candidate on page 2 and the Supervisor on the front page. It is also extremely helpful if Supervisors could arrange the candidates' scripts so that the Test is attached to the Plan with the Test on top.

During the practical examination Supervisors must be particularly vigilant to ensure that candidates have set up their particular experiments correctly. Supervisors may give assistance with the physical set up of an experiment so as to enable a candidate to gain results. The extent of the help given to any candidate must be detailed in the Supervisor's report. Supervisor's are reminded that help with the presentation and analysis of results is **not** permitted.

Comments on Individual Questions

Plan

Candidates were required to plan an experiment to investigate how the resistance of a house brick varies with the temperature in the range 20 °C to 800 °C. It is pleasing to note that the majority of the plans were about an appropriate length and few candidates reproduced downloaded pages from the internet or photocopied pages.

Parts **(a)** to **(g)** on the planning sheet are designed to focus candidates' attention to relevant areas where marks will be awarded. Candidates should be encouraged to give a response to each section with reasoning.

In part **(a)** candidates should have described the procedure to be followed and included the range of readings that should have been taken. Large labelled diagrams are very helpful. Some candidates did not explain their procedure clearly. It was expected that candidates would state that they would measure the resistance of the brick at a certain temperature and then change the temperature and measure the new resistance. Good candidates usually included a specimen table of results. Apparatus lists are very useful.

Candidates generally included relevant circuit diagrams. It was expected that a voltmeter would have been used. Most candidates realised that to gain a measurable current an E.H.T. power supply should be used, often in conjunction with a microammeter or galvanometer. Where candidates chose to use an ohmmeter again a relevant circuit diagram was expected and to gain full credit the appropriate range should have been given. Credit was not given for the (vague) use of a multimeter. It is expected that candidates will use the correct circuit symbols.

Most candidates suggested both the use of a kiln as a suitable method of heating the brick and a thermocouple to measure the temperature. Few candidates mentioned the need to allow time for the temperature of the brick to stabilise and a large number of candidates removed the brick from the kiln before taking their measurements.

Part **(c)** guided candidates towards suggesting how the connecting wires should be attached to faces **P** and **Q**. Few candidates suggested the use of large metal plates and the use of an insulated G-clamp.

Two marks were awarded for appropriate safety precautions. Vague answers did not score. Safety precautions should be relevant to the experiment being planned and clearly explained. Good candidates often discussed precautions taken when using high voltage supplies and high temperatures.

Further marks were awarded for further detail such as:
the value of resistivity of brick;
the calculation of resistance;
problems with moisture in the brick below 100 ˚C;
the use of a (named) metal with a high melting point;
measuring the temperature of the brick in several places to allow for local variation in temperature.
There was also a mark awarded for good evidence of preliminary experimental work.
Candidates should be encouraged to explain their ideas clearly.

In the notes for guidance for the plan it is stated that candidates should list clearly the sources that have been used. Two marks were available for evidence of the sources of the researched material. Detailed references should have page numbers or be internet pages. Two or more detailed references scored two marks. Two or more vague references or one detailed reference scored one mark.

Most of the more able candidates were able to score two marks for the quality of written communication which were awarded for the organisation and sentence construction of the Plan. Plans that were greater than 750 words did not gain both marks. Candidates are asked to indicate the number of words in the margin at approximately 100 word intervals.

1) In this experiment candidates were required to determine the resistance of an unknown resistor and the e.m.f. of a cell using a set of resistors of known resistance and a milliammeter.

(a) Candidates were initially asked to set up a circuit. Two marks were awarded for correct circuits. Marks were deducted depending on the amount of help given by Supervisors. Marks were also deducted if help was given in the arrangement of resistors.

(b) Almost all candidates measured the initial current correctly.

(c) The majority of candidates took the necessary readings and calculated $1/I$. Several candidates had difficulties in calculating the value of R correctly particularly for the parallel cases. Results tables were generally well presented. Most candidates labelled the columns correctly although a large number of candidates did not correctly gain the unit of $1/I$. It was expected to see either A^{-1} or mA^{-1}. It is expected that all raw data should be included in a table of results.
The majority of the candidates recorded their raw data to an appropriate number of decimal places. There was a mark available for calculating $1/I$ to an appropriate number of significant figures. It was expected that candidates should have used the same number of significant figures, or one better than, the significant figures in I.

(d) Graphical work was generally done well. Weaker candidates often used either less than half of the graph grid in the *y*-direction or awkward scales in the *x*-direction. Points were usually plotted accurately to the nearest half square. Where errors were made it was often very obvious and candidates could have rectified the problem by re-checking their plots. The majority of candidates drew their line of best fit with a fair balance of points.

It is expected that the gradient should be calculated from points on their best fit line which are at least half the length of their line apart. Weaker candidates often lost marks either by using triangles that were too small or by working out $\Delta x/\Delta y$. Good candidates indicate the points that they have used and show their calculation clearly. Some silly marks were lost by misreading the graphs.
The *y*-intercept was usually accurately determined. Weaker candidates did not always realise that they had used a false origin. Where a false origin is used it expected that candidates will use their value for the gradient and substitute a point from their best fit line into $y = mx + c$.

(e) This part asked candidates to justify the number of significant figures used for $1/I$. This was often poorly answered with too many candidates referring to decimal places in raw data or needing three significant figures to plot a graph. Good answers referred to the number of significant figures in I.

(f) The analysis section still causes the most difficulty on question 1. Large numbers of candidates do not follow the question which tells them to use their answer from **(d)(iii)** to determine a value for E and X. Candidates who substitute values from their table of results into the given equation did not gain credit. Good candidates equated the gradient to $1/E$, equated the intercept to X/E and gave sensible answers with appropriate units and significant figures. Weaker candidates often gave answers to 4sf, 5sf etc. and omitted the units. Some candidates did not change mA to A thus producing an e.m.f. of about 1500 V!

2) In this question candidates were required to test a relationship modelling the behaviour of a diver and then write an evaluation of the procedure.

(b) The majority of candidates measured the height and depth appropriately

(c) There were many vague answers which did not gain credit. It was expected that candidates would mention the use of the marker pen.

(d) Weaker candidates had difficulty in calculating the percentage uncertainty. It was expected that Δd was in the range of 1 mm to 10 mm.

(f) Candidates were asked whether their results supported the relationship given between d and h, explaining there reasoning clearly. No marks were awarded without reasoning. Weak candidates often stated that "as d increases h increases" and many candidates referred to h being proportional to d. A very large number of candidates found it very difficult mathematically to find k. Good candidates calculated a constant of proportionality using their results and then drew an appropriate conclusion.

(g) Weak candidates are still evaluating experiments by describing the procedure they followed. Good candidates scored well by describing relevant problems and suggesting specific ways to overcome them. Vague suggestions such as "use a datalogger" without explanation did not gain credit.
The following problem areas were credited:
Human error in measuring h and/or d (with some detail)
Parallax/meniscus problems or meniscus changes during experiment (by displacement)
Difficulty with release e.g. wobble/angle/friction
Difficulty with motion of pencil e.g. not vertical/colliding with the sides of the container/possible friction between thread and metal hook/drag from cotton will be variable
Water absorption by pencil
Two readings are not enough to verify the relation between h and d

For each problem area there was a mark available for a relevant detailed solution. Some of the creditworthy solutions include:
Use two people to perform the experiment (as it is difficult to release the pencil and watch the water at the same time);
Thread needs to be attached to the centre axis of the pencil;
Paint or waterproof pencils;
Take many readings of a range of h and d <u>and</u> plot a graph of d^2 v h.

Two marks were available for spelling, punctuation and grammar in this part.

2824 - Forces, Fields and Energy (Written Examination)

General Comments

Candidates appeared to be very familiar with the layout and style of the question paper which has remained unchanged. Most candidates appeared to have no difficulty in completing all questions. There was more descriptive writing on this paper than has been the custom. Also many candidates solved several of the numerical problems by a circuitous route rather than a direct one. Despite these hurdles it was the norm to see two full sides written on Q7. Almost all parts of all questions were attempted. Many middle of the range candidates scored widely different marks on different questions, showing significant knowledge of some topics and little of others. To gain an A grade it is necessary to have a knowledge of the full specification. It is a deliberate policy to set each paper in such a way that it covers as wide a range of topics from the specification as possible. The most successfully answered questions by all candidates were Q2 and Q4. Most of the weaker candidates found something familiar and were able to show their knowledge to score some marks. Many candidates, very often the otherwise more able ones, are unable to give basic definitions, thus failing to gain the 'easy' marks, as one assistant examiner has described them.

Comments on Individual Questions

Q1 (a) Some candidates misinterpreted the graph and took the time at which the boot and ball lost contact to be 0.17 s or 0.18 s. In (ii) it was necessary to indicate that either an area or an average force was being estimated to gain full marks.

(b) (i) This was usually answered correctly. In (ii), the final speed calculation, many attempted to use equations of motion with the maximum acceleration in (i) rather than a mean acceleration; only a minority equated the impulse from (a)(ii) to the change of momentum. Almost all scored the mark for the kinetic energy formula and most gained the second mark through error carried forward. A common error here and in other parts of the paper is to write the correct formula, which contains a squared quantity and then at the substitution stage to forget to include the square.

(c) This last part was a good discriminator with the better candidates obtaining full marks. The most common error was to make a simple numerical subtraction of the velocities rather than a vector subtraction leading to an answer of 16.7 N instead of 61.1 N.

Q2 (a) About half of the candidates were able to define gravitational field strength clearly and accurately.

(b) In (i) the two common errors occurred through not reading the question. Firstly 9.81 was substituted as the value of g instead of 40 and secondly the radius of the planet was added in for the value of height above the surface. Most gave the correct reasoning for (ii) although there was confusion over whether this meant it was a larger or smaller estimate. The mark was given for the reason alone. In (iii) the formulae were usually correct with substitution errors of the kind mentioned above or other arithmetic errors being the only reasons for loss of marks.

(c) Many wrote down the value as 10 N kg^{-1}. Part (ii) was usually correct and in (iii) a significant number of those who had written 10 N kg^{-1} gained full marks by misreading the graph a second time in an error carried forward situation. Overall this was a high scoring question for most candidates and also acted as a good discriminator.

Q3   (a)   The reasoning required for this answer was attempted quite well but only the more able managed to gain both marks. Most answers progressed along the lines of relating absolute temperature to the internal energy of the gas giving zero energy with zero temperature.

        (b)   Those who were confident with the gas laws scored highly here. A common approach was initially to use the data for the upper atmosphere to calculate the number of moles of gas in the balloon, namely the answer to (c)(i). Those who used the given answer to (b) in (c)(i) to calculate n and then substituted this value into the equation in (b), i.e. a circular argument scored no marks for (b).

        (c)   Both sections were usually correct, even from those who could not complete (b0 correctly.

        (d)   More candidates obtained the correct answer to this part than have done in previous questions where this concept has been examined. However there were many correct answers where there was little reasoning or clear calculation.

        (e)   The force vectors and labels were usually correct but again only the best candidates obtained the correct answer for M. The most common solution was to treat 1.3×10^5 N at the net force rather than the buoyancy force. This approach was given some credit.

Q4   (a)   This was often the best answered question. Candidates often wrote nuclei for nucleus. Common errors were to use such words as nucleon, atom, element or molecule.

        (b)   This part was done well. Often the symbol for nitrogen was given for the neutron. Another error was to write 3n as ^{3}n. Candidates were expected to give the mass and charge numbers as superscript and subscript in the formula.

        (c)   The method for the calculation was usually correct although a substantial number failed to convert atomic mass units into kilogrammes.

        (d)   Most gained a mark for the correct formula. Those who could read the values for the two charges from part (b) then carried on to score full marks.

Q5   (a)   This question proved to be another good discriminator. About half of the candidates attempted to define magnetic flux density in terms of flux and area instead of the force on unit length of a current carrying conductor at right angles to the field. Only a minority remembered to include the required geometry in their definition.

        (b)   The first three parts were done well but in (iv) too many answers had a variety of equations offered. Better candidates completed the problem accurately and many of the weaker candidates managed to score a mark for the unit which was well known. In (v) many candidates misread the question and suggested that the radius of the tube should be doubled. To gain both marks in (v) it was necessary to explain why the magnetic flux density should be doubled.

Q6   (a)   Completion of the graph was usually done well, although the drawing was often poor. In (ii) although increases to period and damping were recognised as possibilities, the correct reasons were often incomplete or mixed up. Few were able accurately to isolate the causes for both changes.

        (b)   The conditions for resonance were well known. A large number then assumed that the resonance frequency was 2.0 Hz and not 1.0 Hz. This led to an incorrect or incomplete description of the vertical oscillations of the aeroplane. Most descriptions of the changes in motion were vague. The best answers included a sketch graph of amplitude against frequency.

Q7   (a)   Generally well attempted by even the weakest candidates, although a few tended to stray into 'uses' and 'harmful effects'. Few gave quantitative values for the magnitudes of the mass, charge and speed of the radiations.

    (b)   This final part was not answered as well as part (a). Penetration experiments were the most popular, followed by electric field deflection experiments. There were also some descriptions of film badges. Explanations of how to take readings and then how to use them to determine the nature of the emissions were often weak or imprecise. Details, such as adjustment for background count, necessity for a vacuum in some situations, the proximity of the source and counter, were rare. Diagrams were often too vague or badly labelled to score any marks. Few attempted a method of determining the energy of the emissions. Full marks could be scored without addressing this part of the question. Only an indication of the relative energy was expected, for example, through measurement of the curvature of cloud chamber tracks or the depth of penetration through standard materials. The quality of presentation and the standard of writing varied very considerably from excellent to almost illegible. In part (a) many showed some element of planning by presenting a logical comparison of the properties of the radiations.

2825/01 - Cosmology

General

The entry was similar to that of recent years and a wide range of performance exhibited. Presentation of work was generally very good and many candidates had clearly prepared well for the exam.

The standard of graphical work was generally very high but lines drawn in ink or with an unnecessarily thick pencil were often of inferior quality. A small number of lines were nearly the same width as the grid, effectively reducing the precision of the velocity data by one significant figure. A sharp pencil proved to be a useful aid.

Many of the errors made by candidates are simple omissions or slips and many candidates would gain if they adopted a habit of checking their work as they progressed through the paper.

Where a candidate wishes to write more than the allotted space on the paper allows, they should not use the margin reserved for the examiner but go to a blank page at the front or back of the booklet. Examiners will check and mark these pages.

Comments on Individual Questions

1)   (a)   (i)A large majority of candidates correctly identified the planet as Venus.

                       (ii)Fewer deduced the reason for the change in it's apparent size. Any answer which directly implied a change of distance between Earth and Venus gained credit, but statements which referred to the motion of just one of the planets, such as *'because Venus orbits the Sun'* were not enough. Some candidates attempted to discuss the reason for the phases.

          (b)   (i)The heliocentric nature of the new model and the move away from epicycles was known by many, but a significant number thought the planetary orbits were elliptical and reference to the necessary rotation of Earth was rare.

                       (ii)The opportunity to discuss the discovery of Jupiter's moon was taken up by many. Mountains or craters on the Moon were also well known and the reason given was invariably a bland statement as to the heavens being imperfect, without reference to the Ptolemaic notion of perfect spheres or circles. Answers discussing retrograde motion missed the point that the question asked for evidence.

2)   (a)   Kepler's laws were stated correctly by most candidates. The position of the Sun at one focus was often given in addition to the elliptical nature of the orbits for the first law. The second law required the statement of equal areas in equal times and poor expression sometimes led to loss of credit. For instance, "*planets sweep out the same area in any time/ any period*" does not imply the constancy that exists in the rate of change of area. The third law was stated in algebraic form by a high proportion of candidates, many without identifying the letters. Generally, marks are not awarded for the use of unlabelled letters or diagrams. In this instance an exception was made so $T^2 \propto r^3$ or T2 = kr^3 was accepted without further explanation but only for the letters *T* or *t* for time and *r* or *d* for distance. The strong advice to candidates remains that they risk losing marks by not labelling letters or diagrams, as did those in this question who used *c* for a constant.

          (b)   Again, many candidates scored well in this part. The Doppler equation was usually stated and full working shown. Where problems arose they were usually caused by difficulties in changing nanometres to metres or errors in arithmetic.

          (b)   (i)Most candidates successfully plotted the remaining points to an accuracy of half a square. Common errors were to plot the last point as negative or to omit a point altogether, both understandable slips in exam conditions but easy to spot perhaps, if a quick check is made.

(ii)The accuracy to which lines were drawn showed quite a wide variation. A smooth and continuous curve was expected.

(iii)Identifying the point of the planet's orbit which corresponded to zero velocity on the graph proved demanding. Many marked a position on the line joining P and S. Little latitude was allowed here and only the centre of the cross was used to judge position. A change of mind by a candidate should be clearly indicated as marks were not awarded where doubt remained. For instance, it was not assumed that the larger of two crosses was the one intended.

(iv)Little trouble was found in determining the period of the motion.

Measuring half the period from the graph and doubling this value was quite acceptable, given the symmetry of the curve.

(v)A surprising number of straightforward errors were made in the course of the calculation: using hours or minutes for T; failing to square T or taking the square root instead of the cube root. Candidates who showed their working were at an advantage here.

3. (a) Accurate and detailed   diagrams accompanied many explanations
   of the parsec. Full marks were frequently gained from a diagram which was labelled with a distance of 1 AU and a corresponding angle of 1". Answers which attempted to explain the origin of the term 'parsec' often fell short. *'The distance of a star when it has 1 (p)arcsec of angle'* does not by itself convey sufficient information for credit.

   (b) (i)The concept of apparent magnitude was well understood. Answers stating that 1 was the upper end of the scale were accepted in the context of this question, but could lead to confusion where negative values are under consideration.

   (ii)This proved more difficult but many examples were seen of explanations which avoided the temptation of stating that the absolute magnitude was larger. In discussing apparent or absolute magnitude -2 is taken to be smaller than +1.

   (iii)The relationship between apparent and absolute magnitudes was quoted by many, who often went on to make correct substitutions. Errors in manipulating the logarithms were common so comparatively few candidates scored the second and third marks.

4. (a)Descriptions were often detailed and clearly expressed. High marks were not uncommon. Hydrogen depletion followed by a giant phase, further metal burning ending with collapse and a supernova with subsequent neutron star or black hole were well known. The Chandrasekhar limit was often replaced by vaguer phrases such as *'if the star is big enough or above a certain limit'.* Radiation pressure and Fermi pressure are outside the scope of this syllabus, but credit could be gained if either of these were used appropriately.

   (b) (i)The question prompts the mass-energy relationship $E = mc^2$ but about half of all candidates had difficulty translating this into power and rate of change of mass, thereby not gaining the first mark for substitution of data. Where arithmetic errors were made, it was again an advantage to have given full working.

   (ii)This part was quite well done and answered successfully by candidates of most abilities. Answers larger by a factor of 10x presumably resulted from entering 10^{44} incorrectly into the calculator. An order of magnitude would be an appropriate number of significant figures here, but candidates who used the full display of their calculator were not penalised.

5. (a) Isotropy, or appearing the same in every direction, was
   known by many candidates. Homogeneity, or the even distribution of matter, was not so well understood. The scale over which this can be considered was not a part of the mark scheme.

   (b) The quality of responses to this part varied widely. The equivalent

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black body temperature of 2.7K (3K was accepted) and their importance as evidence for the Big Bang theory were widely quoted. Fewer answers referred to gamma waves or the subsequent red shift and fewer still to re-combination or transparency. Many candidates were able to say that 'the microwaves are the same everywhere or in every direction', perhaps prompted by their answer to part (a) but to gain a mark here they needed to make the point that the *intensity* is constant. Some references were seen to ripples in the intensity and these gained credit, as did references to the red shift of gamma rays, but this sometimes led into a discussion of Hubble's law.

(c)   Most candidates scored at least 1 mark here and full marks was not uncommon. References to unattainable temperatures, lack of *experimental* evidence and breakdown of physical laws all gained credit. Answers such as *'we do not know what the Universe was like'* were too vague, but not uncommon.

6.   (a)   Questions on this topic have been asked recently and many candidates scored well. The terms *open* and *closed* were explained well; *flat* was sometimes called *marginally bounded*, which needed further explanation. The relation between density and critical density was generally well understood, although some answers had the condition inverted. References to the *mass* and *critical mass* of the Universe were not given full credit.

(b)   Again, many candidates gained full marks on this part. Only a small number of candidates had problems manipulating the equation and the incidence of arithmetic errors was low.

7.   (a)Many candidates gave long and detailed accounts. The two most common experiments were those involving parallel mirrors either moving in opposite directions or travelling together and having an external observer. Small diagrams of the ray paths as seen from each observer, often improved the level of explanation. Some candidates described a workable arrangement but, without stating that the speed of light is constant, went on to pluck a conclusion from the air such as *'because time moves more slowly the beam can move further'* The conclusion of the experiment hinges upon the constancy of the speed of light and that reference to this was comparatively rare suggests some candidates learnt the account with less than complete understanding.
Other appropriate thought experiments received full credit but descriptions of muons or examples where time dilation occurred gained few or no marks.

(b)   (i)Correct answers were shown by a large majority of candidates but in this type of question the mark cannot be awarded without the candidate showing some working.
(ii)This was again very well answered.
(iii)This was quite a demanding question, nevertheless many candidates made a good attempt. Very common errors included the omission of the squared factor for v/c; writing v^2/c^2 but then forgetting to do this in the calculation and other simple arithmetical errors. Some candidates were unclear how to use the time dilation equation. The language used in this question was softened to avoid the use of the term reference frame. If this made the question more accessible is not easy to tell but correct answers were limited to those candidates in the top half of the ability range.
(iv)The majority of candidates realised that time dilation was no longer a factor, but making a conclusion about what change would be measured in the rate of muon decay was more challenging.

Throughout this question the adjective used to describe the passing of time could cause some confusion. A '*shorter'* or *'longer'* time is usually preferable to one which is *'quicker'* or *'slower'* and phrases such as *'the rate at which time passes increases'* and *'the rate of clocks increases'* remove all possible doubt.

8   (a)   More than half of all candidates knew that acceleration and gravitational fields were indistinguishable. Phrases such as *'have the same effect'* were accepted but answers which stated blandly that they were equal were rejected. *'Equivalent'* was was a part of the question and not accepted.

   (b)   This was a challenging question for those who did not realise that the rocket is accelerating. Even then the application of the principle of equivalence to a novel situation proved demanding for many.

(i)There was more success on this part, which was perhaps more easily related to past questions on this topic. Quite a number of candidates knew the effect of a gravitational field on the rate of clocks and gratifyingly few thought the Moon's gravitational field on the surface to be zero.

2825/02 - Health Physics

General Comments

This paper produced a wide range of marks. At the top end, candidates were well-prepared and paid attention to detail. There was a large tail end where many candidates failed to communicate their understanding through a lack of basic English. It was common to find sentences which, by the nature of their construction, contradicted the ideas that candidates were trying to express. There were many cases where candidates failed to explain their numerical workings, and where the answer was wrong, it was not possible to award part marks for the method followed.

Comments on Individual Questions

1 a While many candidates described correctly the position of a tendon, it was common to find an arrow, drawn carelessly, which overshot its target and identified a bone.

b Most candidates were able to describe correctly, the strings to pull to lower and raise the arm. It was less common to see a relating of the strings to the action of muscles.

c Most candidates had the idea that an equation involving moments was required. A significant number of candidates ignored *g* and ended up with a numerical equation relating the product of each mass and corresponding distance to pivot. Where candidates failed to write a word equation and launched into 'mass x distance' calculations, no marks were awarded.

2 a Many candidates repeated information given in the introductory sentence for this question. The mechanism by which accommodation occurs was frequently explained (i.e. the action of the ciliary muscles) without reference to the consequential effect on the lens (i.e. the change in shape and hence power / focal length).

b Most candidates were able to identify correctly, the eye defect. It was not as common to find lines drawn with care and with the use of a ruler. Many responses showed all of the refraction occurring at the lens.

c The most common error made here was the failure to convert 60 cm into 0.60 m. The negative sign was frequently omitted in the answer to the corrective lens.

3 Many responses to this question were vague. Comments such as 'the frequency response is how the ear responds to sound' and 'the ear deteriorates with age' were often presented. Candidates were expected to make specific comments which included detail such as the 'range of detectable frequencies', the 'variation with frequency of the minimum detectable intensity' or 'the ability to discriminate changes in frequency'.

4 This was generally well known although candidates were frequently unable to express their knowledge. The idea that 'light from different planes could not be simultaneously focused' became 'the eye can only focus on one plane at a time'. The test for astigmatism was again well known. Where the test chart was not drawn, there was a general inability to describe the idea of identical *radial* lines.

5 A significant number of candidates showed a lack of understanding of basic electricity in their answers to this question. Many responses discussed 'the high *voltage flowing* through the

cathode' as the reason for the emission of electrons from the cathode. It was difficult to extract creditable physics from the middle of sentences that were flawed with physics errors. Many candidates ignored the part of the question which required energy conversions within the tube. The photoelectric effect was often explained as the reason for the emission of x-rays from the target.

6a Most candidates were able to suggest that low energy x-ray photons would be increase the absorption of energy by a patient.

b Where candidates were able to recall the equation, it was common to see full marks for this question. Some candidates substituted values into the equation and then wrote that the answer was about 2×10^5 W m^{-2}. It is essential that the actual answer is shown as evidence that the candidate has performed this calculation and verified the value.

c Many candidates made silly errors in calculating the area. The slips ranged from using the diameter instead of the radius to failure to convert successfully from cm to m. Another common error was for candidates to substitute 2×10^5 W m^{-2} instead of 347 W m^{-2} for the intensity.

d (i) Many candidates were unable to calculate the overall power when given that 18 W represented 0.15% of this power. space for this part of the

(ii) Where candidates had no idea, the space for this answer was filled with a jumble of numbers. It is essential that some order is maintained if part marks are to be awarded.
(iii) Where candidates knew what they were doing, full marks were usually awarded. It was rare to see part marks awarded due to poor explanation.

7 a Most candidates were able to state that 'density' was a factor. A number of candidates stated simply 'speed' as the other factor and lost the second mark.

b (i) The mathematical calculation proved difficult for many candidates. Most candidates substituted values for Z_1 and Z_2 to find the fraction reflected. A smaller number tackled the problem by solving for Z_2. This more arduous route caused problems for most who followed it. Candidates should be advised that if they end up with a lengthy mathematical problem, then they have missed the straightforward route and might be better off starting again.

(ii) This was fairly well answered with many getting one of the two available marks. Over half of candidates did not take into account that the ultrasound had to travel to and from the boundary and so the distance travelled had to be divided by two to obtain the depth.

(iii) This was generally very well answered. Where marks were lost it was due to careless conversions from km to m or μs to s. On a number of scripts, the speed used was 3×10^8 m s^{-1}.

8 a This question caused candidates problems throughout. Reference to *stochastic* as a *random* effect or to *no threshold needed* was required.

b Having failed to define successfully *stochastic* many candidates were unable to continue to discuss *non-stochastic*.

c (i) This was well answered.

(ii) The most common error was to try to work our the total absorbed dose rather than the absorbed dose from the alpha-source alone.

9 a (i) The most common error was to use the diameter instead of the radius when calculating the distance travelled.

(ii) This was well answered.

(iii) Where unfamiliar numbers were used for the distance moved by the force, and where candidates did not start with a word equation, no marks were awarded.

(iv) This was well answered.

(v) Few candidates appreciated that if the wheel was turning at a constant speed, then <u>all</u> input energy was used to do work against resistive forces. It was common to see 'electrical energy supplied to the motor is useful as it drives the wheel'. Most candidates were able to say that 'friction in the bearings was not useful'. A number confused the terms *friction* and *energy*.

(b) This proved difficult for many candidates. The most common response indicated that the tensions were equal.

(c)(i) This was well answered. A common error was to fail to convert 90 cm to 0.90 m.

(ii) This was well answered.

(iii) Most candidates gave reference to resonance and proceeded to discuss damping as a cure.

2825/03 - MATERIALS

The vast majority of the candidates were clearly well prepared for this paper. As the number of past papers in the option increases the facility with which the answers are written seems to increase. It is clear that the use of past papers plays a big part in the candidates' revision. At the same time there was a tendency on the part of some candidates to read questions with insufficient care and thus to infer that an answer to a previous similar question was required again. In some cases therefore, required information was missing, and extraneous material was given, sometimes producing answers of excessive length.

In previous papers there have been frequent examples of careless use of data; for example, a current given in milliamps has not been converted to amps for use in a calculation. Commendably, this type of error has been far less prevalent in this paper.

There was no evidence from scripts in general that the time allowed for the paper was insufficient. However, there were examples, especially in extended written answers, that a few candidates were hurrying unnecessarily, to the extent that handwriting was difficult to decipher.

In spite of the negative aspects mentioned above, the trend is a general improvement in the ability to handle the requirements of this option.

1.   (a) Several different explanations were acceptable, most of which required the use of the words 'as possible'. Expressions such as 'the atoms touch each other' were not rewarded
        (b) (i) Many candidates only got as far as volume = mass/density for 1 mark, but then proceeded to use the mass of one atom, rather than 1 kg.
        (b) (ii) More were successful with this calculation.
        (c) (i) Only the comparatively few candidates who do not know the expression for the volume of a sphere failed to gain the 2 marks.
        (c) (ii) Several legitimate ways were found to arrive at the required result of 74 %, some quite ingenious. A method which used the wrong answer to (b)(i) were given the benefit of the doubt.
        (d) Answers referring to density reduction as a result of expansion during heating, and change of crystal structure at 883 $^{\circ}$C were required. Those who wrote about increased atomic vibration without mentioning expansion did not gain the expansion mark.

2.   (a) Most graphs were of acceptable shape, but the words attraction and repulsion were frequently written in inappropriate places, rather than on the force axis as required, and entailed a mark penalty.
        (b) Poor attention to the wording of the question was common. Many candidates omitted a discussion of the nature of the forces. Several of those who did attempt the discussion referred to gravitational forces of attraction. The equilibrium separation of atoms is generally understood as is the basis of elastic behaviour. However, confusion between elastic behaviour and adherence to Hooke's law was evident. This led in many cases to a substitute for or an addition to the required response.

3.   (a) The subject matter of this section, though conceptually demanding, was text-book material and previously unexamined. Few candidates gained more than 2 of the 4 marks available.
        (b) (i) In contrast with (a) above, the 3 marks here were almost universally gained.

(b) (ii) Here the candidates were on fairly familiar ground, and good marks were frequently awarded. Few candidates however made any reference to the effects of temperature change.

4.   (a) Few candidates clarified the meaning of the symbol they used for a length of wire by a sketch or other means, and so jeopardised their chance of full marks for this section.
(b) There were very many successful calculations. In (i) the commonest error was in converting the cross-sectional area to square metres if this was done in a preliminary calculation. In (ii) it was gratifying that so many used the correct dimension of the foil for the Hall voltage calculation. In (iii) mistakes in placing X and Y were uncommon.
(c) On the whole, the candidates who failed to give a satisfactory explanation had missed the instruction to refer to the calculation they had successfully carried out in (b).

5   (a) (i) There were few problems with this calculation.
(a) (ii) In contrast with (i) surprisingly few candidates could cope with this calculation. A majority assumed that the current increased from primary to secondary in the same, rather than the inverse, ratio as the voltage.
(a) (i) Most candidates could identify two relevant features.
(b) (ii) There were many correct statements and sound explanations. The ideas about hysteresis were particularly well explained.

6.   (a) Candidates had to refer to closely spaced energy levels in the conduction band, and the promotion of electrons between them by photons. Few candidates identified the band or the proximity of the levels.
(b) There were two common approaches. Candidates could start with the wavelength and calculate the corresponding photon energy, or start with the energy gap and work out the wavelength of a photon corresponding to this energy. Many succeeded by one of these methods. Some of these then failed to make a further appropriate statement based upon their calculation to answer the question fully.
(b) (i) Most knew that the wavelength of visible light was shorter than that of infra-red, and that Rayleigh scattering reduces with increased wavelength.
(c) (ii) Calculations based upon the inverse fourth power of wavelength have proved difficult in previous papers. However in this case a good proportion of the candidates were successful.

2825/04 - Nuclear an Particles Physics

General Comments

Most candidates were well prepared for this paper, were able to respond to all questions and show the extent of their knowledge and understanding. The general standard achieved was comparable with previous years and included excellent performances by some candidates but it was noticed that some centres performed poorly on particular questions.

More specifically, many candidates did not seem to have a satisfactory overview of high energy particle physics. There seemed to be widespread unawareness of the fact that in most high energy experiments the particles are travelling close to the speed of light and that, in this situation, additional energy will result in an increase of mass rather than much further increase in speed. This was apparent in answers to *Q.4*.

Candidates should perhaps be reminded of the importance of showing all steps in their method. Marks were sometimes lost by shortcomings in this area, especially in *3(a)*. A few candidates also lost credit by failing to write their answers legibly. Candidates must understand that marks can be given only for information which is legible and therefore comprehensible to the examiner. The setting out of quantitative answers also left much to be desired in some cases.

A small number of candidates appeared to be short of time for the last question but the great majority appeared to have enough time to answer all questions fully.

Comments on Individual Questions

1(a)(i) Most candidates were able to state the volume of a nucleon. A few lost this mark by using r rather than r_0, thus stating either merely the general expression for the volume of a sphere or the volume of a nucleus.

  (ii)   Most stated that the volume of a nucleus is the nucleon volume (stated in *(i)*) times A. A minority failed to score here by trying to make a deduction from *(iii)*, thus ignoring the instruction to use their answer to *(i)*.

  (iii)   Candidates were expected to equate the volume of the nucleus deduced in terms of the nucleons to the nuclear volume expressed in terms of the nuclear radius r. Cancellation of   and $^4/_3$ then led to the desired equation. Candidates lost marks in a variety of ways; some appeared not to understand what the question required and lost themselves in algebraic statements which led nowhere. Others lost partial credit by failing to show the cancellation steps, thus ignoring the instruction to 'show that..'.

(iv)   Most candidates realised that r^3 is proportional to A and so were able to draw a straight line graph through the origin, though in some cases credit was lost because of the quality of the line. A significant minority sketched a curve, presumably thinking they were dealing with an r versus A graph. Fewer were able to state the gradient of their straight line as A. Various incorrect responses were given, among which r_0, 1 and $^1/_3$ were probably the commonest. Some simply stated it to be r^3 / A. Even candidates who had drawn a curve usually quoted a gradient for it, seemingly unconcerned about this anomaly.

(b)(i)   This part was generally well done. Candidates were expected to divide the mass of the gold nucleus, determined by using the mass of a proton read from data, by its volume. Many were able to do this successfully. Where marks were lost the cause was usually omission on either the top or bottom of the fraction of the nucleon number 197. Of course candidates who omitted it altogether and in effect found the density of a nucleon, could score full credit. A small minority of candidates used the proton number, 79. A few were able to score full credit using the Avagadro constant to find the mass of the gold nucleus. Calculating errors, usually associated with the cubing operation caused many to lose marks.

(ii) It was pleasing to note that a high proportion of candidates were able to approach this seemingly challenging part in the correct manner. In order to estimate the percentage of the gold atom which is occupied by the nucleus, the simplest solution was to divide the density of gold metal by the nuclear density. Many did this. Others adopted the slightly longer but equally correct method of finding the ratio of the volume of the nucleus to the volume of a gold atom. It was of course necessary to multiply by 100 for percentage and nearly all candidates did this.

2(a)(i) Most candidates who scored in this part defined nuclear binding energy as the energy needed to separate all the nucleons. Other acceptable answers included the idea of energy given out when the nucleons combine or the energy difference between the separate nucleons and the nucleus. The mark was often lost however by candidates who used incorrect terminology e.g. 'particles', 'nuclei' or 'nuclides' instead of 'nucleons'. A few lost

credit for stating that it is 'the energy per nucleon ...'. Others defined it as 'the energy needed to bind the nucleons together' and failed to score.

(ii) Candidates were expected to state that higher binding energy per nucleon is associated with greater stability and that iron-56 is stable; also that carbon-12 can undergo fusion and uranium-295 can fission. A common misconception was that these fission/fusion reactions produce iron-56 but these candidates did not usually lose credit. Others referred either to stability or to high binding energy but did not make a connection between them. Others again failed to refer to all three of the specified nuclides as requested. A few candidates thought that both carbon and uranium nuclei could undergo either fission or fusion.

(b)(i) Candidates were able to score in a variety of ways. They could have defined 'thermal neutron' as one which is at thermal equilibrium with the medium through which it is passing or one which has kinetic energy comparable with the energies of the atoms through which it is passing. Alternatively they could simply have stated that it is a slow neutron, or given its energy as between 1 and 10 eV. Answers to the effect that they are neutrons at a low temperature were rejected on the grounds that a neutron cannot meaningfully be stated to have a temperature since this concept has meaning only in relation to a population of particles. Many lost credit in this way.

(ii) Most candidates were able correctly to write the equation for the absorption of a neutron by a uranium-235 nucleus to give uranium-236.

(iii) Many also succeeded in writing the fission equation which produces iodine-135 and yttrium-95 together with 6 neutrons. As might be expected, the commonest error was to state the wrong number of neutrons or to omit them altogether. A minority lost the mark by adding a(nother) neutron to uranium-236 and deducing that there would be 7 product neutrons.

(iv) The calculation of the energy released, using data from the graph, was often well answered and many scored full marks. A significant minority however forgot to multiply the binding energies per nucleon by the nucleon numbers and so could score only partial credit. A few candidates tried to use the equation $E = mc^2$ and so failed to score.

3 This proved a challenging question and was the least well answered on the paper. One wondered whether some candidates had actually read all the information at the start of the question before attempting their answer.

(a) This part was synoptic and candidates were expected to remember that electrical energy used can be calculated using VIt and that the charge It is equal to the area under the I - t graph. A minority, were able to do this though some lost a mark though incorrect calculation of the area.

Surprisingly, a significant minority omitted the 4 and gave the current as simply 10^6 A. More seriously, many thought that the area itself represents the energy. Others, presumably thinking of capacitors, quoted 'energy = ½ Q V '. As always, answers based upon wrong physics did not score. This was a question where the injunction 'to show all the steps in your calculation' which appears in the rubric was particularly relevant; right and wrong answers were sometimes separated only by a single figure. Where the candidates has explained their method this did not need to cause much loss of marks but where the figures are the only guide to the candidate's method it could lead to a mark of zero.

(b) Very few candidates were able to score full credit on this part. It was expected that they would realise that since the plasma in the JET reactor is contained within a strong magnetic field, it would be impossible to inject charged deuterium nuclei because they would be deflected away by the field. An uncharged deuterium nucleus, however would be able to penetrate the field and so transfer the energy of the nucleus, by collision, to the nuclei within the plasma. The commonest response was to state that the injected material had to be neutral otherwise it would unbalance the equal numbers of nuclei and electrons within the plasma. Others stated that the deuterium atom is bigger and so more likely to collide with nuclei in the plasma.

(c) Although somewhat more successful on this part than in *(b)*, candidates also scored poorly here. They were expected to follow up the hint in the question and equate the momentum of the product particles to zero, thus discovering that the neutron has a speed 4 times greater than the helium nucleus. Substitution of these speeds and the masses into the kinetic energy expression quickly showed that the neutron must possess 4 times as much kinetic energy as the helium nucleus. It was then a short step to realise that the neutron has $^4/_5$ of the energy while the helium nucleus has only $^1/_5$ of it. Some candidates, having discovered the 4:1 speed ratio simply stated that therefore the kinetic energy must also be in the ratio of 4:1. Weaker candidates simply stated that since the masses were in a 4:1 ratio, the energies must be in the same ratio (even though the more massive particle has the smaller energy).

4(a)(i) Disappointing answers from many candidates. A surprisingly high proportion failed to appreciate that ten accelerations through 50 keV each plus an initial energy of 30 keV would give a final energy of 530 keV. There were many wrong answers but 300 keV was the commonest, presumably caused by multiplying the 30 keV by 10 instead of the 50 keV.

(ii) Candidates were expected to convert the 530 keV to joule and equate to ½ $m v^2$. Candidates who lost marks here usually did so by omitting the conversion from eV into joule. The 10^3 factor was also sometimes missed. Incorrect answers to *(i)* could of course achieve full marks here providing the earlier answer was faithfully carried forward. Some candidates gave answers far in excess of the speed of light, without comment. These candidates often lost the marks in *(b)(i)* also.

(b)(i) Most candidates realised that the calculated value was greater than the speed of light and stated that therefore it could not have been correct as nothing can travel at a speed in excess of the speed of light. Although (perhaps because) these were simple statements some candidates failed to state one or other clearly enough to score full credit. As always, addressing the answer to the question asked is an important discipline which candidates need to practise.

(ii) This was to many candidates a novel question and the marking scheme was flexible enough to allow them to answer in a variety of ways. They could have commented that the increasing length of the electrodes in the proton accelerator was because an accelerating proton needs this extra length so that it spends the same time in each electrode. In addressing the question that electrodes in a positron accelerator are of equal length candidates needed to state that the positron is a much less massive particle than the proton and that it accelerates very rapidly, quickly reaching a speed close to the speed of light. This means that from then on its

speed is sensibly constant. Although not specifically rewarded, candidates who pointed out that the positron from then on is gaining mass rather than extra speed showed that they fully understood the situation and they usually scored full marks. Sadly, as commented in the general remarks above, many candidates seemed unaware that the positron would approach the speed of light and so gave totally spurious answers such as that the positron has hardly any mass and therefore is not accelerated like a proton. Others stated that in the positron accelerator the frequency changes to keep it synchronised with the particles. Candidates wishing to point out the difference between the proton and the positron would do well to use the word 'mass' rather than words such as 'lighter' or 'weight'.

(c) This was a challenging calculation which few candidates solved fully. To calculate the frequency of one of the gamma rays produced, candidates needed to evaluate both the kinetic and the rest energy available, in joule and equate this to $2\,h\nu$. Most attempted to find one or other energy amount but only a minority made a satisfactory calculation of their sum. There were also several other ways of erring; these included omitting the conversion factor from eV into joule, omitting the factor 10^6, omitting the factor 2 because the energy is divided between two photons and omitting the factor of 2 arising from the two rest masses.

5(a) Diagrams to show the principal features of the cyclotron should have shown two dees connected by an alternating power supply, a magnetic field perpendicular to the plane of the dees and an outward spiral path of a proton. Candidates lost marks partly because they did not try to include all these essential elements and partly because their diagram skills were not up to the task of communicating clearly to the examiner that these were all present. Common omissions were failing to indicate that the magnetic field acts within the dees and not somewhere around them, failing to show the direction of travel of the protons, omitting, or wrongly representing the a.c. source or connecting both sides of it to the same dee. Some candidates labelled 'a.c. source' but showed a d.c. source on the sketch, thus contradicting themselves. It was also not always clear that the field was perpendicular to the dees. This could best have been done by using the symbol for a magnetic field into or out of the paper. Where this could not be recalled, candidates should have stated that the field is perpendicular.

(b) This is a question which has been asked in various forms several times over the years and candidates have become progressively better at answering it. Many were able to state that the magnetic field exerts (not 'induces') a force on a charged particle and that this force acts at right angles to the particle's direction of travel.

Thus the force acts as a centripetal force. Common omissions however included failing to state that moving charged particles do experience a force in a magnetic field and that this force is at right angles to the direction of travel (and not just to the magnetic field).

(c) It was pleasing to note that many candidates were able fully to derive the equation for the frequency of the a.c. source in the cyclotron. Clearly these candidates had revised this carefully and many were able to score full marks. Some used angular instead of translational velocity but were still able to present valid derivations. A small number of candidates made algebraic errors which caused part marks to be lost.

6(a) Most candidates were able to choose two baryons, usually the proton and the neutron, to describe their quark composition and to describe their stability both when inside and outside a nucleus. Very high marks were scored by many candidates, indeed many achieved full marks. Where marks were lost it was usually though failing to distinguish between stability inside and outside the nucleus. Some candidates wasted time by describing the charge or baryon numbers for the up and down quarks and demonstrating that they add up to one or zero.

(b) This part was also very well answered. Most chose two leptons from the electron, the neutrino and the positron, though others were sometimes named. Most realised that leptons are fundamental particles and so cannot be subdivided but a few thought that leptons consisted of pairs of quarks (thus confusing them with mesons). Most were able to state that all leptons are acted on by the weak force and that the charged ones also feel electromagnetic and electrostatic forces. Electrons were usually stated to be situated in the cloud around the nucleus of an atom, though some pointed out that they are present in β^- radiation instead. Some realised that neutrinos are also produced in beta decay, especially that which occurs as part of the carbon and hydrogen cycles in the Sun.

7 This question testing general physics was well done by the great majority of candidates and many achieved high scores. A small number, presumably running out of time, left spaces blank.
(a)(i) Most candidates were able to calculate correctly the speed of the wheel rim. Those who failed usually omitted either π or the factor 2 needed to calculate radius from diameter. A small number used 30 (minutes) instead of 1800 (seconds).

(ii) Nearly all candidates were able to calculate the total force exerted as 16 times the force exerted by a single tyre.

(iii) Most candidates were able to state that work done is the product of force and distance moved by the force and so calculate a correct value. Those who were penalised for an incorrect circumference in *(i)* and used the same erroneous value here were not penalised twice.

(iv) Candidates were able to calculate the power needed by dividing the work done by the time taken. Most were able to do this. A few also scored full credit by using the relationship that power is equal to the product of force and velocity.

(v) Most candidates were able to state that friction in the bearings is not useful because it opposes movement of the wheel, that friction between the tyres and the rim is useful because it enables the tyres to grip the wheel in order to turn it and that electrical energy is useful because it provides the power to drive the wheels. Candidates were less successful in applying the conservation of energy to the situation. They could have done this in several ways; they could have pointed out that all the input energy goes to overcome friction because, since the wheel has a constant speed its kinetic energy is constant, hence all input energy ends up as heat.

(b) Candidates were expected to use their general understanding of structures to realise that in *(i)* the upward reaction from the ground would have the effect of reducing the tension in Y and increasing it in X. In *(ii)* the opposite happened; the weight of the wheel will reduce the tension in P and increase it in Q. This part was not well done. Every possible combination of answers was given, including the statement that the tensions in X and Y / P and Q were equal.

(c)(i) Most candidates were able to find the spring constant by dividing the force by the displacement. The few who lost marks did so either by inverting the fraction or by failing to convert 90 cm into metre.

(ii) This question proved straightforward to the majority of candidates who simply substituted into the formula given and then calculated their answer. Probably the commonest error was (in effect) to multiply by π instead of dividing, thus introducing an error factor of about 10.

(iii) Many candidates were able to state that the biggest danger is that the wind may cause resonance of the wheel structure and that this can be avoided either by using a damping mechanism or by having a mass or spring constant that ensures that the resonant frequency is outside the range of frequencies which the wind can generate. Candidates who stated that the

wheel might oscillate with large amplitude were doing little more than repeating information given in the question and so failed to score.

2825/05 - Telecommunications

There was, sadly, a significant drop in the number of Telecommunications candidates for this examination with only one hundred and forty presenting themselves for it. This lack of interest is surprising when one considers how important the topic now is in the developed world. Indeed, one could successfully argue that, of the options available, the one which most directly influences the lives of sixth formers these days is Telecommunications.

Question 1

(a)   Surprisingly, a large number of candidates were unable to provide a carrier frequency in the medium wave network.

(b)   While most candidates seemed to know that the dipole length is half a wavelength, there were many errors made in the calculation of it.

(c)   Most candidates seemed to appreciate that the loudspeaker could not be driven directly from the aerial and there were several responses which were acceptable. It could be pointed out that the tiny currents in the aerial were unlikely to do much for a moving-coil loudspeaker and anyway, the mean value of the RF signal is zero.

(d)   Most candidates made a reasonable effort to explain the workings of the AM radio receiver although some produced unacceptably woolly answers. For example, "the RF amplifier amplifies the RF signal" was awarded no marks, as it is essential to point out that the purpose of the RF amp is to boost the carrier so that the demodulator can turn on / work.

Question 2

(a)   Very few candidates indeed scored both the available marks for explaining that the op-amp output voltage will saturate +vely when A > B, will output zero when A = B and will saturate -vely when A < B .

(b)   Almost all candidates correctly circled the LDR.

(c)   While most candidates knew how to calculate a potential divider voltage a large proportion of them calculated B to be 9.6V instead of 5.4V by using the wrong resistor.

(d)   Only a minority of candidates correctly calculated A to be 5.2V and then stated the output will therefore saturate -vely to make the LED turn on.

(e)   Very few candidates indeed scored full marks for an explanation of how the LED responds to a change from darkness to light. The essential point to make is that the LED is either on at full brightness (in the dark) or it is off.

(f)   Similarly, very few candidates scored all three marks for their calculation of a suitable series resistor to allow 5 mA in the LED. Many responded as follows:
R = 15V / 5mA = 3kΩ and for this they were awarded only 1 mark because there are <u>two</u> errors in this answer. Firstly, the pd driving the LED when it is in the on state is 30V (or 29V or 28V depending on what the candidate chose as their -ve saturation voltage). Secondly, the LED itself requires a share of this voltage (anything sensible around 2Vwas acceptable) so the calculation should have been, R = (30 - 2) V / 5mA = 5.6 kΩ.

Question 3

(a)   Most candidates were able to show that the 40 ms time is derived from 1 / 25.

(b)   While almost all candidates were able to transform decimal into binary there were many errors made in arranging the signals in their correct Time Division Multiplexed order and with the appropriate time spacing between them.

(c)   The majority of candidates were able to show that the maximum number of similarly digitised signals which could share the transmission line is 5, although many tried to argue that because each sample appears to be allocated a time slot of 10ms the answer should be 4.

(d)   A majority of candidates correctly stated the maximum signal frequency to be 12.5Hz because it must be less than half the sampling frequency.

(e)   Almost all candidates scored some of the available marks for stating some of the three changes which would increase the number of signals sharing the line. The answer was to reduce the bit duration, reduce the word length and reduce the sampling frequency.

Question 4

(a)   Almost all candidates made a very commendable effort in this extended writing question on optic fibres. Clearly, this is a topic which is generally well understood and many continued writing well beyond the space allocated to them.

(b)   Not nearly so many candidates were able to continue as successfully into the calculations using decibels. While quite a few correctly worked out the lowest signal power to be 2 mW they then got into difficulties over the calculation of the 0.16 dB km^{-1} attenuation in the fibre. However, the calculation to find the shortest time for the light pulse in the fibre was generally well done.

Question 5

(a)   While almost all candidates knew what was meant by the words *analogue* and *digital*, a disappointingly large number were unable to explain the meaning of the word *audio*. Indeed, many used the word audio in their answer; eg "audio means audio sounds" (unacceptable) or "audio means it is a sound" (also unacceptable since it could be ultrasound). The response sought was any frequency between 20 Hz and 20kHz (yet very few candidates answered this way).

(b)   Most candidates correctly calculated the number of stored bits to be 5.08×10^9 and the received bit rate to be 1.4×10^6 s^{-1}.

(c)   Most candidates scored at least one of the available marks for their advantages of digital over analogue.

(d)   This final question on the estimation of the number of pages a CD ROM could hold was generally well done and most candidates made sensible suggestions as to the number of bits required to store a typical page of text.

Question 6

(a)   Almost all candidates scored some marks (and a few scored them all) for their calculations of the linear wheel speed, the driving force, the work done, the power required and for their applications of the law of the conservation of energy.

(b)   Most candidates failed to explain that the tension in X is greater than that in Y and that the tension in Q is greater than that in P.

(c)   The calculations of 2×10^6 Nm^{-1} for the spring constant and its subsequent use in the formula for the natural frequency $f = 0.23$ Hz was generally well done. Finally, most candidates correctly stated that the wind problem was due to resonance which could be solved by damping.

2826/01 - Unifying Concepts in Physics, Written Paper

General Comments

The spread of marks on this paper was not as high as in January. Most candidates were able to score at least 20 marks out of the 60 available, although from some centres there were rather too many candidates with marks in the teens. At the top end, only really able candidates were able to score 42 marks or more. Often the best candidate in any centre had a mark in the high 40s; it would have been nice to see more candidates gaining 50+ marks. There was no indication of candidates being short of time for the paper.

The standard of explanation in many answers, both numerical and descriptive, was poor. In descriptive questions, a list of thoughts were often in not logical order and in numerical questions words were often totally omitted. An adjective is often the key to a correct answer. For example, in an electrical question R = ….. or *resistance* = is insufficient. It needs to be replaced by, perhaps *total resistance* = …. . All too often when a basic equation like $V = IR$ is used the V, the I and the R do not refer to the same part of the circuit.

If this report is compared with the published mark scheme, please be aware that there are many other answers than those published which do gain credit. The published mark scheme is a final version, produced after looking at some of the candidates work. Inevitably, with 5509 candidates there is a great variety of different answers and examiners do have to use their judgment when comparing what a particular candidate wrote and the mark scheme itself. It is definitely not a question of the candidate having to write exactly what the mark scheme states.

Comments on Individual Questions

1.   This question showed up many misconceptions about proportion. There were some general misconceptions, such as (i) any straight line graph shows proportion, (ii) the gradient necessary for proportion must be 1, (iii) one of the quantities needs to be zero – often m in the $y = mx + c$ equation. In the first equation there were a surprising number of candidates who thought that a needed to be zero because u is a constant. In the second equation candidates often did not say that both V and n need to be constant for proportion and it was rare to find anyone who stated that T must be in kelvin. The equation $P=Fv$ is rather different in that if v is constant then P and F will usually also be constant. Candidates were expected, for the second mark, to comment on this difference in some way. Most realised that A is proportional to r^2. Many marks were lost in (b) by not stating that the line must go through the origin – often called 0, rather than 0,0 if the word origin was not used.

2.   Candidates are usually happier answering numerical rather than descriptive questions so, for many, this question proved difficult. Candidates need to practise answering descriptive questions as well as numerical ones. The question discriminated well with candidates scoring between 1 and 16 marks. The question is deliberately set in a way which expects candidates to think out their answer in the exam room rather than to have learnt an answer form a teacher or book. The marking scheme takes this into account and examiners were told to award credit to plausible answers if they were backed up by correct physics. Many candidates gave answers which showed good ability to think but also there were some common mistakes which showed how little understanding some candidates have of the work which they do. For example, in (c) there were many answers which showed that candidates simply do not believe Newton's first law. Statements on the lines of 'there is a force on the bob at the mid point in order to keep it going'.

        The published mark scheme gives an idealized answer; lots more approaches are credited. The ideas involved in (a) were known by most candidates but there was a great deal of 'sucking in of oxygen'. By and large (b) caused no difficulty. Candidates realised the paradox that black absorbs light and shiny reflects it. A large majority realised that the texture of the surface matters. The good candidates mentioned a transparent layer on the surface. Part (c) caused most difficulty. Apart from the answers referred to above many tried to deal with components of forces. Comparatively few stated that because the bob is travelling in a circle (at constant speed for the

brief time just before to just after it is vertically beneath the support) it has an upward acceleration and so the tension in the string must be greater than the weight. Parts (d) and (e) are routine questions and part (f) can be answered using the principle of conservation of energy. A refrigerator must be connected to a power supply. The power it receives is dissipated as heat in the kitchen so the temperature of the kitchen must rise. Many candidates sensibly introduced the idea of the warmth coming from the back of any refrigerator. There were too many blank spaces on some papers. Candidates need to be encouraged to make an attempt at questions such as this and to be assured that, even if their answer is wrong, they cannot not lose any marks by trying.

3.   This question produced good discrimination. The early parts of the question were done well by most candidates but there were far too many candidates who showed very poor understanding of electrical principles. Working parrot fashion with electrical equations is a recipe for disaster. Apart from those who get equations the wrong way round ($V \times R = I$ was not uncommon) there are those who simply apply equations thoughtlessly. In (c) about 80% of candidates used I = 12 V / 0.5 Ω= 24 A or I = 16 V / 0.5 Ω= 32 A. This lack of practice with electrical problems is of serious concern. It is the principles which are needed for solving questions such as this. Since there are stated to be 16 V across the cell and only 12 V across the battery there must be 4 V across the internal resistance, implying a current of 8 A. Since, later in the question there are seen to be 6 A through the headlights there must be 2 A through the battery charging it up. These principles, which are Kirchhoff's laws, are not given the rightful place at the heart of any electrical problem. Luckily for candidates, having gained no marks for (c) they could proceed to gain marks for (d) (e) and (f), with error carried forward. The weak candidates often filled the space for the answer with lengthy fractions, and many mistakes, rather than simply stating 12 V / 4 Ω= 3 A. Answers ranged from hundreds of amperes to a few milliamps and were followed by powers ranging from megawatts to microwatts, without any comment from the candidate that these figures are improbable. In answering (f)(i) candidates should realise the advantage in being able to produce a large current as many devices in a car may all need current at the same time. Many candidates got marks by writing about the smaller amount of energy being wasted if the internal resistance is low and a few candidates with insight realised that the most important feature of low internal resistance is that the terminal voltage remains largely constant for a wide range of supplied currents. You do not want your headlights going dim when you switch on the rear window demister. The answer expected for (f)(ii) concerned the need to charge the battery. A surprising number of candidates thought that the battery was used to operate the generator.

4.   Part (a) proved to be quite discriminating. For (i) it was not deemed to be sufficient to say that a radioactive material gave off radiation. Some mention of alpha, beta or gamma radiation was accepted as was ionising radiation. Many candidates did not know what a nuclide was. They often stated that it must be radioactive or they assumed it meant nucleus. The responses from candidates illustrated that the vocabulary for this topic, over which OCR has no control, has too many words which are too similar – neutron, neutral, nucleus, nuclear, nuclide to name five of them. Half-life, too, was ill defined by many. Half the mass and half the nuclei were common mistakes. Candidates are on much firmer ground if the write about half the activity. The table in question 4 did not prove to be very discriminating because almost all candidates filled in the values as expected. The extrapolation of the graph was quite tricky to do well but a wide variety of answers was accepted – but not wide enough to cover the value obtained by those candidates who chose to consider the graph to be a straight line. If working by calculation, candidates who used the values over only the first six hours were also outside the acceptable range. Using a wider range of values would have avoided the loss of one mark. A brief answer was all that was required for (d) and the first mark was for stating that separation will be necessary. The second mark was for some indication of how that could be done, chemically if possible or some other different feature if isotopes are considered. Part (e) was primarily for the grade A candidate but many other candidates scored one or two marks. Adding two exponentials does not give an exponential. The mark scheme allowed for different approaches – for example most of the initial decay may, as in this case, be dominated by one of the nuclides while later on most of this nuclide may have decayed, at which time it is the other nuclide which dominates.

2826/03 - Unifying Concepts in Physics, Practical Examination

General comments

The standard of the candidate's papers were very similar to last year. Again it was pleasing to see a number of very able candidates scoring marks close to the paper maximum. There were few very weak candidates. The marks tended to be Centre specific (i.e. some Centres prepared *all* their candidates well for this paper). Most candidates were well prepared in routine work (presentation of results and graphs).

Virtually all Centres were able to obtain the necessary equipment for this test without difficulty. There were some variations on the size and strength of the bar magnets employed, but this did not affect candidates' performance.

Most candidates were able to complete questions one and two without help from Supervisors.

There was no evidence that candidates were short of time, although many of the weaker candidates did not attempt parts of the analysis section in question one and gave very brief answers to the evaluation section in question two.

There were no common misinterpretations of the rubric.

Planning Exercise

In this question candidates were required to design an experiment to calibrate a Hall probe and explain how it would be used to investigate how the magnetic flux density between opposite poles of two permanent bar magnets varies with the separation of the magnets.

Generally this was done quite well by the majority of better candidates. Marks given in this section were often very 'Centre dependent'. Most candidates gave reasonably concise accounts of between 500 and 700 words.
A number of candidates clearly benefited from experience of preliminary experimental work in the laboratory, and a number of photographs were included. However, it was still possible for candidates who did not do this to score full marks in the planning section.

Most candidates drew a diagram showing a workable arrangement of apparatus. This usually involved a Hall probe and either a pair of Helmholtz coils or a solenoid. Most candidates were able to give a workable procedure (i.e. place probe in the centre of the solenoid; measure the current in the solenoid and the Hall voltage; change the current in the solenoid and measure the new Hall voltage). The expression used to find *B* was usually included (e.g. $B = \mu_0 n I$).

Most candidates were able to describe a workable method for part 2. Credit was given for a variety of relevant detail, such as

Perform the experiment away from magnetic materials
Clamp the magnets
Place the semiconductor slice perpendicular to the magnetic field
Knowledge of the magnitude of the Hall voltage (i.e. millivolts)
Circuit diagram containing the solenoid, ammeter and power supply

In the notes for guidance on page 2 of the planning exercise it is stated that a range and variety of sources should be consulted. Candidates can only be given credit in this section if it is clear that some relevant research has been done. At least two references (with chapters and/or page numbers) must be given for both of these marks to be scored. Internet based research was also

accepted, provided that particular pages had been referred to. Many candidates were unable to score both marks as the references were too vague.

As in previous examinations candidates who had written concise plans and given the material in a logical order that was easy to follow were able to score both of the quality of written communication marks that were available.

Question 1

In this question candidates were required to investigate how the force required to pull a bar magnet away from a metal plate varies as the number of sheets of paper separating the magnet and the plate is changed.

Most candidates were able to set up the apparatus correctly although many of the weaker candidates did not know how to use moments to determine a value for the weight of the magnet. A significant minority calculated the weight of M and proceeded no further. Others omitted g from the calculation.

In **(b) (ii)** most candidates were successful in the calculation of the percentage uncertainty in d_2. . Credit was given for a sensible value of Δd and a correct ratio idea. A number of weaker candidates did not attempt this section.

Candidates were required to explain how the measurement of d_2 was made as accurate as possible. It was expected that M would be moved in 1 mm or 2 mm steps, or the readings would be repeated. A number of candidates' answers were too vague to be given credit.

In **(c)** many weaker candidates were unable to perform the required algebraic manipulation to determine a value for F. A number of candidates substituted the value for d_2 in metre instead of centimetre, but were not penalised.

In part **(d)** most candidates were able to obtain six sets of readings for F and n, although many did not repeat the readings. It is expected that all the raw readings will be recorded. A significant number of candidates did not record the values of d_2. A few candidates calculated values for F/n (probable confusion with F/N (?)).

Candidates were required to plot a graph of F against n. weaker candidates used compressed scales. It is expected that candidates will use at least half the graph grid in both the x and y directions (i.e. at least four squares in the x direction and six squares in the y direction). It is expected that candidates will choose scales that are easy to work with (i.e. 2:10, 5:10 etc., and not 3:10 or 6:10). An accuracy of half a small square is expected in the plotting of the points. Candidates who had done the experiment carefully, and obtained little scatter of points about a smooth curve were awarded a quality mark. At least five trend plots were required for this.

Candidates were required to determine the rate of change of F with n when n = 20. The weaker candidates did not understand what was required and simply read off the F scale when n = 20. Other candidates either drew tangents of poor quality, or drew tangents that were too short (i.e. less than 10 cm). A few candidates used $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$. It is expected that the read-offs will be accurate to half a small square.

In the analysis section many candidates gave vague answers such as 'I would plot a logarithmic graph'. A few stated the logarithmic form of the given power law, and gained partial credit. It was expected that candidates would suggest plotting ln F against n. In **(f) (ii)** candidates often incorrectly stated that the constant B would be found from the gradient (instead of $–B$) and that A would be the y-intercept (instead of ln A). A number of candidates muddled base 10 with base e.

In part **(g)** candidates were asked to measure the thickness of 40 sheets of paper using a micrometer screw gauge and determine a value for *F* when the separation of the magnet and plate is 3 mm. A surprising number of candidates misread the micrometer. In **(ii)** some of the weaker candidates attempted to substitute into a formula given in **(c)** or **(f)** instead of using the graph. A number of candidates did not read the value of *F* correctly from the graph.

Question 2

In this question candidates were required to investigate how the period of torsional oscillation of a rule varied with the separation of two strings supporting the rule.

A significant number of candidates recorded times which were too small (i.e. less than ten seconds) or miscalculated the period. It is expected that a reasonable number of oscillations will be timed (not just one). A number of weaker candidates misread the stopwatch (e.g. recording a time of 0.047 s instead of 4.7 s).

In the justification of significant figures most candidates correctly related the sf in *t* to the sf in *T* or made some sensible comment about reaction times.

In part **(b)** credit was given for repeating the readings of raw times and for obtaining a value of T which was less than the first value of *T* obtained in part **(a)**. Surprising numbers of candidates did not repeat the readings, although most obtained a value of period which was half that in part **(a)**.

In part **(c)** candidates were asked to explain whether the results of their experiment supported the suggestion that the period of oscillation of the mass was inversely proportional to the separation of the strings supporting the rule. The majority of candidates managed to calculate a constant of proportionality and make a sensible comment, although some candidates were not prepared to commit themselves to $T \propto 1/d$ even when the values of the constant of proportionality were within 1% of each other. The experiment is quite reliable, and should yield results of good quality. Therefore the candidates who stated that *T* was not inversely proportional to *d* were not able to gain full credit. Weaker candidates often did not attempt this section, or gave vague responses, such as '*T* increases as *d* decreases' which was not credited. In a number of cases the working was poorly presented and could not be followed.

In the evaluation section many weaker candidates again either wrote about the <u>procedure</u> that they had followed or gave very brief answers with little relevant detail. There are no marks that can be scored for procedure in part **(d)**. It would be helpful to candidates if they were advised to concentrate on the <u>difficulties</u> that they had in actually carrying out the experiment, and how these difficulties might be overcome. The easiest way for candidates to score marks in this section is 'one mark for the problem and one mark for the solution'.

Some examples of valid points made by candidates are as follows:

Raw time too small
Time more oscillations
Use a motion sensor
Problems with varying amplitude/damping
Displace rule and wait for torsion oscillations to settle before timing
Human error in timing/hard to see when the oscillation begins/ends
Two readings is not enough to draw a conclusion
Take several/many readings (and plot a graph)
Use a fiducial marker
Thick string makes measurement of *d* difficult
Use thinner string
Place the marker at the centre of the oscillation

The rule may not be horizontal
Use a spirit level to check
Draughts may be a problem
Shut windows/close doors to stop draughts

Marks were not awarded for vague suggestions such as 'use light gates (without clarification), 'use a computer' or 'repeat the readings'.

Two marks were available in this section for quality of written communication (spelling, punctuation and grammar). The majority of candidates were able to score both of these marks.

Advanced Subsidiary GCE Physics (3883)
June 2005 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2821	Raw	60	45	39	33	28	23	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	47	41	35	30	25	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	99	88	77	66	55	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	99	88	77	66	55	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	95	85	75	65	56	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3883	300	240	210	180	150	120	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3883	18.9	37.2	54.9	70.7	83.4	100.0	6627

Advanced GCE Physics A (7883)
June 2005 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2824	Raw	90	62	55	48	42	36	0
	UMS	90	72	63	54	45	36	0
2825/01	Raw	90	68	61	54	48	42	0
	UMS	90	72	63	54	45	36	0
2825/02	Raw	90	63	57	51	45	40	0
	UMS	90	72	63	54	45	36	0
2825/03	Raw	90	66	60	54	48	43	0
	UMS	90	72	63	54	45	36	0
2825/04	Raw	90	64	57	50	44	38	0
	UMS	90	72	63	54	45	36	0
2825/05	Raw	90	68	61	55	49	43	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	86	77	68	59	51	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	86	77	68	59	51	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	82	74	67	60	53	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
7883	600	480	420	360	300	240	0

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OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Information Bureau

(General Qualifications)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: helpdesk@ocr.org.uk

www.ocr.org.uk

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