JANUARY 2005
AS MODULE 2821 FORCES AND MOTION
FINAL MARK SCHEME

Q1 (a)

scalar	vector
density	acceleration
energy	displacement
power	weight
speed	
time	

All correct scores 4
6, 7 correct scores 3
4, 5 correct scores 2
2, 3 correct scores 1 **[4]**

(b)(i) 1. speed = distance / time **C1**
= 22 / 2.4
= 9.2 (9.17) (m s^{-1}) **A1**

2. velocity = displacement / time **C1**
= 14 / 2.4
= 5.8 (5.83) (m s^{-1}) **A1**

(ii) displacement is not equal to the distance **B1**
displacement is in a straight line (which is always less than or equal to the total distance) **B1**

TOTAL [10]

Q2 (a) 1. sum of the moments (about any point) is zero / no resultant torque **B1**

2. sum of all the forces acting is zero / no resultant force **B1**

(b)(i) F_B x 1.7 = 80 x 0.85 + 650 x 1.3 **B2**
One moment correct allow 1
Analysis leading to 537 N i.e. F_B = 913 / 1.7 **B1**

F = 540 (537) (N) **A0**

(ii) F_A = 650 + 80 –540 or F x 1.7 = 650 x 0.4 + 80 x 0.85 **C1**

= 190 (N) (193 N) **A1**

(iii) $\mathbf{F_A}$ goes up **B1**
$\mathbf{F_B}$ goes down **B1**
To obtain the same moment a smaller force is required if the distance from the pivot increases / (F_A + F_B) is a constant / weight (of painter) transfers from support B to support A **B1**

TOTAL [10]

Q3	**(a)**	change in velocity / time taken or rate of change of velocity	**B1**
	(b)	area under line or using equation s = (u + v) t / 2 or s = ut + ½ at^2	**B1**
		= (5.6 x 0.57) / 2	**B1**
		= 1.6 (m)	**A0**
	(c)(i)	using Δv = 5.6 or 5.1 ($m\ s^{-1}$)	**C1**
		= [-5.1 – (5.6)] / 20 x 10^{-3}	**C1**
		= (-)535 ($m\ s^{-2}$)	**A1**
	(c)(ii)	line starts from 0.59 / 0.58 and –5.1	**B1**
		straight line drawn of positive gradient (to the time axis)	**B1**
		same gradient as OA and to the time axis	**B1**
	(d)(i)	potential energy = mgh	**C1**
		or potential energy change = 0.025 x 9.81 (1.3 – 1.6)	
		= (-) 0.074	**A1**
		unit J	**B1**
	(ii)	(energy transformed) / lost to thermal / internal energy of the ball at the rebound (allow the energy losses are due to air resistance)	**B1**
			TOTAL [13]
Q4	**(a)(i)**	work done = force x distance (moved in the direction of the force)	**B1**
	(ii)	watt is a joule per second	**B1**
	(b)(i)	gradient = 360000 / 60	**C1**
		= 6000 ($J\ m^{-1}$)	**A1**
	(ii)	work done = loss in k.e. (E_k)	**B1**
		F x x = E_k so F = E_k / x is the gradient of the graph	**B1**
	(iii)	F = ma	**C1**
		a = 6000 / 800 = 7.5 ($m\ s^{-2}$)	**A1**
	(iv)	greater	**B1**
		E_k is larger hence distance is larger (from graph) or using F =ma acceleration is less hence distance is larger	**B1**
			TOTAL [10]

Q5 **(a)(i)** strain = extension /original length **B1**
(ii) stress = force / (cross-sectional) area **B1**

(b) **diagram**:
suitably fixed wire at one end, allow wooden clamps labelled on bench top arrangement or girder in a ceiling support / two wires used
masses used as load at other end wire, allow labelling of a 'rectangular block' to be masses, load, force, weight(s)
appropriate length of wire used marked to a pointer,
extension measured with suitable apparatus that is labelled
apparatus that will work is needed for these points to score (a maximum of can be awarded for a load labelled for apparatus that is not applicable I e a wire in a clamp and stand)
(max 3) **B3**

readings:
diameter, mass / load / force, extension, original length **B2**
all 4 scores 2, 2 or 3 score 1

method of obtaining the readings:
diameter with a micrometer,
in several places,
mass weighed on a balance,
several loads used,
extension using micrometer or vernier or metre rule,
correct original length using metre rule.
repeat readings on unloading
(max 4) **B4**

determination of the Young modulus:
Young modulus = stress / strain,
force/load given by mg,
diameter gives area using $\pi d^2/4$,
plot a graph of force against extension,
gradient of graph determined, E = (gradient x length) /A,
or equivalent using stress / strain graph
gradient = Young modulus,
within the elastic limit i.e. where the line is straight or other good physics point
(max 4) **B4**

QWC: technical language (correct terms used for the readings to be measured and instruments to be used e.g. mass – balance, diameter – micrometer, length – ruler, extension – ruler and / or correct terms for determination of YM correct link with force and mass, diameter and area, YM and stress and strain related)
majority of these correct **B1**
SPAG (written work has less than four errors in spelling and punctuation grammar and sentence formation) **B1**

Total [17]

[Total 60]

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

1

(a)	Electron flow is in opposite direction (to conventional current)	B1
(b)	Correct symbol for the LDR	B1
	(Resistance of LDR) decreases with increased intensity / brightness / light (AW)	B1
(c)	current $\propto$ p.d. (Allow 'voltage' instead of p.d.)	B1
	(provided the) temperature (of metallic conductor) remains constant	B1
	(voltage = current × resistance scores 0/2)	
	($V = IR$ and R = constant scores 0/2)	
(d)(i)1.	*R*-*V* graph for metallic conductor:	
	shows R = constant / 'horizontal line'	B1
(d)(i)2.	*R*-*V* graph for thermistor:	
	shows R has a <u>finite</u> value at $V = 0$	B1
	shows R decreases as V increases (Allow a 'curve' or 'straight line')	B1
(d)(ii)1.	Any <u>two</u> from:	
	The resistances larger / line (graph) higher (and horizontal) (Can score on Fig.1.2 a)	
	The electrons collide more often / frequently (with vibrating atoms)	
	The atoms / ions vibrate 'more' (Do not allow '*particles'* vibrate)	B1 × 2
(d)(ii)2.	The resistance increases / doubles (Can be scored on Fig.1.2a)	M1
	Mention of: $R \propto L$ or $R = \dfrac{\rho l}{A}$.	A1

[Total: 12]

2

(a)	(Magnetic) flux density / (magnetic) field strength	B1
(b)	$B = \dfrac{F}{Il}$ <u>and</u> T → N/(Am)	B1
(c)(i)	First / index (finger): (Direction of magnetic) field	
	Second / middle (finger): (Direction of conventional) current	
	Thumb: (Direction of) force or motion	
	Correct identification of fingers and thumb	B1
(c)(ii)	Out from (the plane of) paper (Do not allow 'upwards')	B1
(d)	$F = BIl$ Allow any subject	C1
	$B = \dfrac{1.4}{0.078}$	C1
	$B = 17.949 \approx 18$ (T) (10^n error: 1.8×10^{-2} (T) scores 2/3)	A1

[Total: 7]

3

(a)	The e<u>nergy</u> transformed by a 1 kW device in a time of 1 hour	B1
(b)(i)1.	time = 4.0 × 7 = 28 (hours) / power = 0.11 (kW)	C1
	number of kW h = 0.110 × 28	
	number of kW h = 3.08 ≈ 3.1 (If 4 hours used, them 0.44 scores 1/2)	A1
(b)(i)2.	cost = 3.08 × 7.5 (Possible ecf)	
	cost = 23 (p)	B1
(b)(ii)	$Q = I\,t$ (With or without Δ notation)	C1
	$Q = 0.48 \times 28 \times 3600$ / $Q = 0.48 \times (1.008 \times 10^5)$ (Allow $t = 1 \times 10^5$ (s))	C1
	$Q = 4.84 \times 10^4 \approx 4.8 \times 10^4$ (C)	A1
	(If t = 28 used, then Q = 13.4 allow 2/3) (If t = 4 used, then Q = 1.92 allow 1/3) (If 1.44×10^4 s used, then 6.91×10^3 scores 2/3)	
(b)(iii)1.	$E = hf$ / $E = \dfrac{hc}{\lambda}$ / $f \approx 5.4 \times 10^{14}$ (Hz)	C1
	$E = \dfrac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{5.5 \times 10^{-7}}$ / $E = 6.63 \times 10^{-34} \times 5.455 \times 10^{14}$	C1
	$E = 3.62 \times 10^{-19} \approx 3.6 \times 10^{-19}$ (J)	A1
(b)(iii)2.	number = $\dfrac{8.0}{3.62 \times 10^{-19}}$	C1
	number = $2.21 \times 10^{19} \approx 2.2 \times 10^{19}$ (s^{-1}) (Possible ecf)	A1

[Total: 12]

4

(a)	**Maximum** of **five** marks	
	Up to four from:	
	$\lambda = \frac{h}{mv}$ / $\lambda = \frac{h}{p}$	M1
	All symbols (λ, h, m and v or p) defined	A1
	Electrons travel / move / propagate (through space) as a wave	B1
	Electrons are diffracted / 'spread out'	M1
	by the atoms / spacing between the atoms	A1
	The electrons are diffracted when their wavelength is less than or comparable or same as size of atoms / gap between the atoms	B1
	Up to two from:	
	(When the speed of electrons is increased) the rings 'get smaller'	B1
	(At greater speed of electrons) the wavelength is shorter	B1
	(At greater speed of electrons) there is less diffraction	B1
	QWC Organisation	B1
	Spelling, punctuation & grammar	B1
(b)	Electrons have mass / momentum / charge / can be 'accelerated'	B1
		[Total : 8]

5

(a)	For e.m.f. the energy transfer to electrical / from other forms or 'charges gain energy' Or For p.d. the transfer is from electrical / to heat / to other forms or 'charges lose energy'		B1
(b)	The sum of currents entering point / junction is equal to the sum of currents out of that point / junction		B2
	(The algebraic sum of current at a point = 0 scores 2/2)		
	(-1 if sum is not mentioned and -1 if point / junction is not mentioned)		
(c)(i)	current = 0.80 – 0.20		
	current = 0.60 (A)		B1
(c)(ii)	$V = IR$ / $V = 0.60 \times 18$	(Possible ecf)	C1
	$V = 10.8 \approx 11$ (V)		A1
(c)(iii)	$R_T = \dfrac{10.8}{0.20} = 54\ \Omega$	(Possible ecf)	C1
	$R_{diode} = 54 - 46$		C1
	$R_{diode} = 8.0\ (\Omega)$		A1
	(Alternatively: $V_{46\Omega} = 46 \times 0.20 = 9.2$ (V)	C1	
	$V_{diode} = 10.8 - 9.2\ (= 1.6)$	C1	
	$R_{diode} = \dfrac{1.6}{0.20} = 8.0\ (\Omega)$	A1)	
(c)(iv)	$P = \dfrac{V^2}{R}$ / $P = I^2R$ / $P = VI$		C1
	$P = 0.20^2 \times 8.0$	(Possible ecf)	
	$P = 0.32$ (W)		A1

[Total: 11]

6

(a)(i)	Photoelectric (effect)		B1
(a)(ii)	10^{-9} (m) ≤ wavelength ≤ 4 × 10^{-7} (m)		B1
(b)(i)	(Minimum) energy needed to free an electron /an electron to escape (from the metal surface)		B1
(b)(ii)	speed of light / 3 × 10^{8} (m s^{-1}) / *c*		B1
(b)(iii)1.	$hf = \phi + KE_{(max)}$	(Allow any subject)	C1
	$KE_{max} = 2.8 - 1.1 = 1.7$ (eV)		C1
	$KE_{max} = 1.7 \times 1.6 \times 10^{-19}$		
	$KE_{max} = 2.7 \times 10^{-19}$ (J)		A1
(b)(iii)2.	$\frac{1}{2} mv^2 = 2.7 \times 10^{-19}$	(Possible ecf)	C1
	$v = \sqrt{\frac{2 \times 2.7 \times 10^{-19}}{9.1 \times 10^{-31}}}$		
	$v = 7.7 \times 10^{5}$ (m s^{-1})		A1
(b)(iv)	No change (because the energy of the photon remains the same)		B1

[Total: 10]

1. (a) symbol c represents speed of light/wave --- M1
c_i = speed of light in air/vacuum (or speed of incident ray or WTTE) **AND**
c_r = speed of light in medium (or speed of refracted ray or WTTE) ----------- A1 [2]

(b) (i) recall of R.I = sini/sinr -- - C1
correct substitution into this formula : e.g. 1.47 = sin 50/sinr ------------------ C1
r = 31 (or 31.4 or 31.42) degrees --- A1
(NB 50/1.47 = 34.01)

(ii) r = 0 degrees -- A1
[4]
[6]

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2. (a) (i) labelled diagram with light from dense to less dense medium (or stated) B1
critical angle correctly labelled: refracted ray on surface (arrows not needed)-- B1
{written description with no diagram scores 1 mark max). [2]

(ii) ray shown to be INTERNALLY reflected (ignore angles, arrows not needed) B1
diagram with incident angle > than critical angle and symmetrical (by eye)- B1
{written description with no diagram scores 1 mark max). [2]

(b) valid <u>substitution</u> in RI = 1/sinC: e.g. 1.76 = 1/sinC ----------------------------- C1
C = 35 (or 34.6) ^{o} --- A1 [2]

[6]

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3. (a) (i) any valid example - e.g. LIGHT, MICROWAVES (any em waves) ------ B1 [1]
(allow "water" /"sea" but reject 'slinky' unless explained/shown)

(ii) any valid example: e.g. SOUND --- B1 [1]
(allow 'pressure wave'; reject "water" and 'slinky' unless explained/shown)

(b)(i) *transverse* = vibrations perpendicular to wave (direction) (WTTE) ----------- B1 [1]
(allow "motion is perpendicular to wave", reject vague answers: e.g "vibrate up+down")

(ii) *longitudinal* = vibrations parallel to wave direction (WTTE) ------------------- - B1 [1]
(allow "motion is perpendicular to wave" reject vague answers: e.g "vibrate back and for)

Wave phenomenon	Transverse waves	Longitudinal waves	
REFLECTION	YES	YES	
REFRACTION	**YES**	**YES**	B1
DIFFRACTION	**YES**	**YES**	B1 [3]
POLARISATION	**YES**	**NO**	B1

[7]

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4. (a) (i) amplitude correctly labelled (by **A** or in words) ------------------------------- B1 [1]
(reject "A" as a point i.e. with no arrows)

(ii) wavelength correctly labelled (by λ or in words) ---------------------------- B1 [1]

(b) (i) same shape --- B1
moved slightly to the right consistently drawn for both waves --------------- B1 [2]
(do not allow shift of more than ¼ wavelength)

(ii) movement is VERTICAL --- M1
Q moves UP ↑ <u>AND</u> S moves DOWN ↓ shown ----------------------------- A1 [2]

(c) phase difference = 180^o (degrees) OR π --- B1 [1]
{allow "in antiphase" do not allow "out of phase"}

(d) (i) recall of T = 1/f -- C1
T = 1/25 = 0.04 s --- A1 [2]

(ii) recall of v= fλ -- C1
valid substitution: e.g. v = 25 x .036 --- C1
v = 0.90 ms^{-1} --- A1 [3]
(there are 2 possible errors – incorrect wavelength and wrong units, so
v = 90 m/s scores 2 marks
v = 0.45 m/s scores 2 marks but allow 3 marks for ecf from cand's λ in (a) (ii)
v = 45 m/s scores 1 mark but allow 2 marks for ecf from cand's λ in (a) (ii)

(e) (i) any valid suggestion: e.g. change <u>depth of water</u> ------------------------------- B1 [1]

(ii) wavelength will reduce --- C1
halved
{OR new wavelength = 1.8cm OR half cand's value shown in (d) ii} --------- A1 [2]

[15]

5. (a) COHERENT (allow coherence) -- B1 [1]

(b) ***constructive interference:*** valid diagram and/or explanation: e.g.

when waves (from coherent sources) meet in phase (or nλ path diff.) --------- B1
waves reinforce: resultant has increased displacement/amplitude -------------- B1
correctly shown on diagram or stated

destructive interference: valid diagram and/or explanation: e.g.
when waves meet in antiphase/180^{o} phase diff. {or (n+1/2)λ path diff.} --- B1
waves cancel: resultant has reduced displacement/amplitude --------------- B1
correctly shown on diagram or stated

[4]

(c) ***diagram***:
laser OR light source and single-slit in front of double slit ------------------- B1
screen (WTTE) (or travelling microscope) behind double-slit --------------- B1
(if 'screen' is not labelled mark can be obtained by reference to 'screen' in text)

measurements:
measure distance between double-slit and screen ------------------------------ B1
measure distance between neighbouring dark/bright images ----------------- B1
(allow 'fringe spacing' or measure distance for n fringes)

formula:
recall of **λ = ax/D** -- B1

ALL symbols correctly defined
a = distance between slits ---}
x = fringe separation (WTTE) --} B1
D = distance between slits and screen ---} [6]

(If candidate uses their own symbols they must be used correctly to score the formula recall mark)
(do not penalise careless use of d and D: i.e. being interposed)

[11]

OCR
RECOGNISING ACHIEVEMENT

Subject: Physics Practical AS Level

Paper number: 2823/03

Session: January 2005

Mark Scheme

Final Markscheme

Maximum Mark	**60**

Planning Exercise - Skill P

A1	Correct procedure i.e. measure θ and v; change v and measure new θ. Method <u>must</u> be workable.	**P1**
A2	Method of measuring angle Bald protractor scores 1 mark. Measuring lengths and using trig ratio, or large protractor, or projection methods scores 2/2.	**P2/1/0**
A3	Use of plumbline Mark could be awarded if plumbline is shown on the diagram.	**P1**
B1	Method of producing airstream (e.g. fan)	**P1**
B2	<u>Method</u> of varying airspeed (e.g. potentiometer/rheostat with fan/variable power supply) Three speed fan scores 1 mark	**P2/1/0**
B3	Method of measuring airspeed Use airspeed indicator. Could be shown on diagram. $v = d/t$ methods using small pieces of paper in the airstream can score one mark.	**P1**
R	Evidence of the sources of the researched material Two or more (vague) references or one detailed reference score one mark. Two or more detailed references scores two marks. Detailed references should have page or chapter numbers or be internet pages.	**P2/1/0**
D1/2/3/4	Any further relevant detail Evidence of preliminary experiment Evidence of good use of research material Examples of creditworthy points might be; Circuit showing rheostat in series with fan motor Measure airspeed with no board present (as board may affect airspeed)/where board will be Use heavy bob to prevent deflection of plumbline in airstream Use large fan so size of airstream > size of board Problems with oscillations of board Problems/solutions with friction at point of suspension (reducing deflection of board)/sensible method of suspension (could be on diagram) <u>Method</u> of ensuring that the airstream is normal to the board <u>Reason</u> for fan-board distance being constant. <u>Method</u> of preventing supports moving <u>Reason</u> for board Wait for steady angle Reduce draughts Safety: explicit to experiment <u>and</u> reasoned.	**P4**

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. $\checkmark_{D1}$).
Do not allow repeats or vague general safety statements

QWC Quality of written communication **2/1/0**

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.

16 marks total.

Question 1

(a)	Measure height of thread above bench in two different places	**I1**
(b)	Calculation of *F* using Use of $F = mg$ scores one mark 0.098 scores one mark Unit of *F* (Newton) scores one mark.	**A2/1/0, I1**
(b)	No friction in the pulley	**E1**
(c)	Measurements 6 sets of readings for θ and *F* scores 2 marks. 5 sets scores 1 mark. Less than five sets zero. Minor help from Supervisor (e.g. with angle measurement) then –1. Major help (equipment set up for the candidate) then –2. No trend (i.e. random scatter of plots) then –2.	**I2/1/0**
	Repeats Quality of results Judge by scatter of points about the line of best fit.	**I2/1/0**
	Check a value for tan θ. Tick if correct and score 1 mark. If incorrect write in correct value and do not award the mark. Column heading for *F* Ignore units in the body of the table. Accept *F*/N, *F* (N) or *F* in N.	**I2/1/0**
	Consistency of raw readings Apply to θ and *m* only. One mark each. Values of θ must be given to the nearest degree or nearest ½ degree. Values of *m* must be either 10 g or 0.010 kg	**I2/1/0**
(d)	Improvement Measure lengths instead of angle/Use larger protractor	**E1**
(e)	Axes Sensible scales must be used. Awkward scale (e.g. 3:10) are not allowed. Plotted points must occupy at least half the graph grid in both *x* and *y* directions Axes must be labelled. Ignore units.	**A2/1/0**
	Plotting of points Count the number of plots and write as a ringed number on the graph grid. All observations must be 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. All observations must be plotted.	**A2/1/0**
	Line of best fit Judge by scatter of points about the line. There must be a fair scatter of points either side of the line of best fit.	**A2/1/0**

(e)	Gradient The hypotenuse of Δ> half the length of the drawn line scores one mark. Read-offs accurate to half a small square & ratio correct scores one mark.	**A2/1/0**
(f)	Gradient equated with $\frac{2}{mg}$	
	Correct working to give *m* This mark cannot be scored if the gradient has not been equated with $\frac{2}{mg}$.	**A2/1/0**
(f)	Unit of *m* (consistent with working)	**A1**
(f)	Significant figures in *m* Accept 2 or 3 sf only.	**A1**
(g)	Second value for mass of the rule within 20% of the larger value	**I1**
	Comment - qualified Anything sensible; e.g. small scatter of points on graph so agreement should be good, % difference calculated Do not allow vague answers such as they are different.	**E1**

28 marks in total (11I; 14A; 3E)

Question 2

(a) (ii) Description of depth measurement: **I1**
Wait for the water to become still/place rule vertically/measure in different places/mark measurements on the side of the container.

(b) Speed of waves measurement **I1**
Speed = distance /time correct

(c) Percentage uncertainty in *v* **E3/2/1**
Percentage uncertainty ratio ideas scores one mark
Δt (0.1 s – 0.5 s) and Δl (1-5 mm) scores one mark
Percentage uncertainties added (1 mark)

(e) New wave speed greater than (b) **I1**

(f) Proportionality ideas between *v* and $\sqrt{d}$ **A2/1/0**
One mark for calculation of *k* in each case.
One mark for answer consistent with values.
Incorrect working scores zero.

(g) Evaluation of procedure **E6**
Relevant points must be underlined and ticked. Some of these might be:

Reason for difficulties in timing (e.g. starting and stopping stopwatch/reaction time)
Reason for difficulties in measuring length/depth (e.g. uneven base/sloping sides/surface tension/refraction
Time many reflections
Repeat the readings of time
Use longer tank
Measure *d* in different places and average the results
Problems with amplitude of wave decreasing with many reflections
Add dye to the water
Raising/lowering tank alters depth of water through which wave travels/difficulty in consistent start
Touch the surface with a bar to produce the wave
Time for reflection may be significant
Use corks + cards + light gates to remove human error (detail needed)
Two readings of *v* and *d* are not sufficient to verify the suggestion
Take many readings of *v* and *d* and plot a graph
Use two people
Transparent tray
Video etc with detail
Improvements to tray (e.g. vertical sides, flat base)

Allow other relevant points (6 maximum).
Marks may be awarded on the basis of 'one for the problem and one for the solution'.

Quality of written communication (SPAG) **E2/1/0**

16 marks in total (I3; A2; E11)

Sample results and theory for question one

Taking moments about the pin:

$$Fl\cos\theta = \frac{Wl}{2}\sin\theta$$

Hence:

$$\tan\theta = \frac{2F}{W}$$

ignoring the friction in the pulley.

m/g	*F/N*	θ/degrees	*Tan* θ
10	0.098	27	0.51
20	0.196	38	0.78
30	0.294	47	1.07
40	0.392	53	1.32
50	0.490	58	1.60
60	0.588	62	1.80

A graph of tan θ *against F should give a straight line that passes through the origin and has gradient 2/W.*

The graph shows a significant y-intercept, showing that the pulley does not have negligible friction.

Sample results for question two

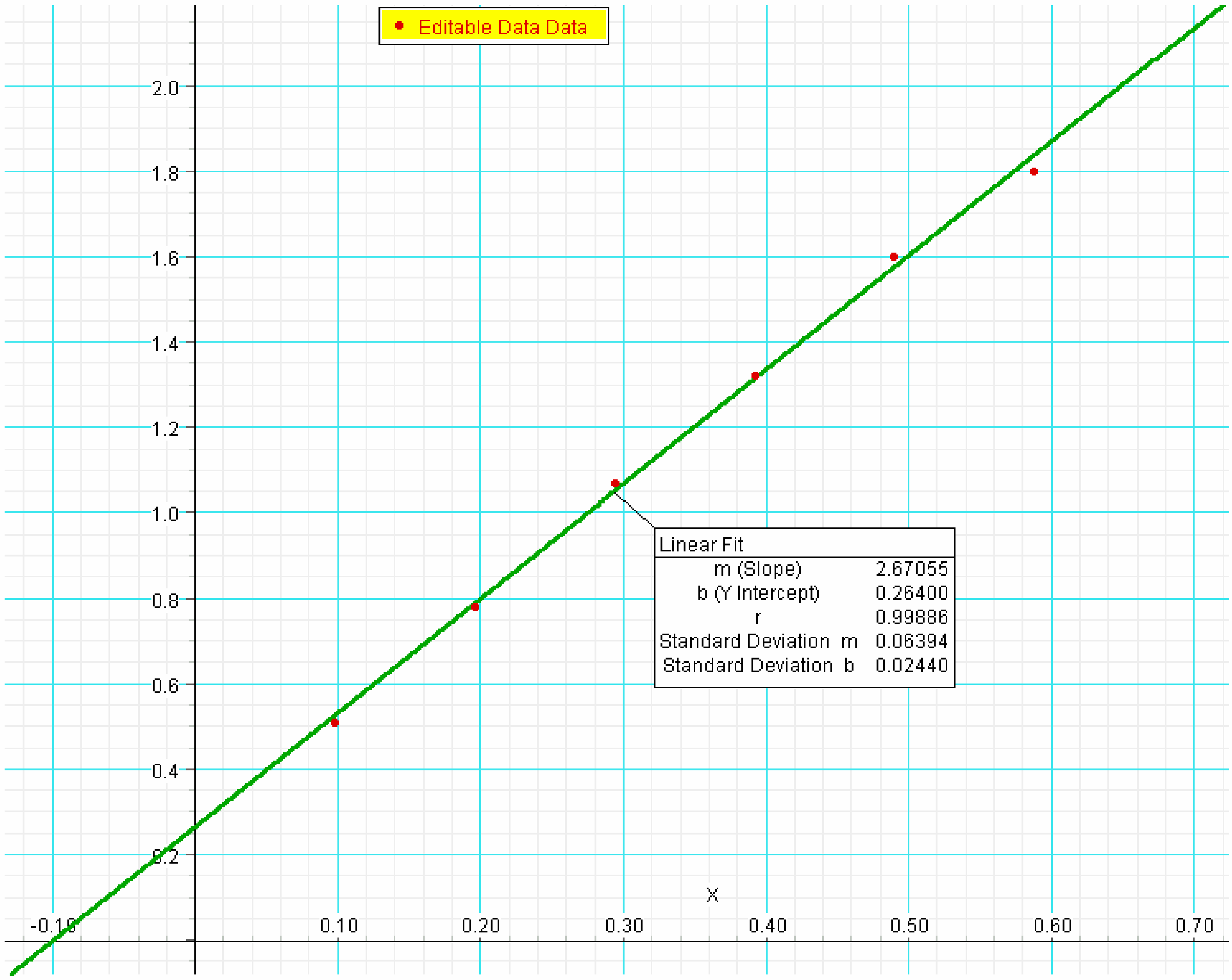
When d = 1 cm, t = 2.13 s

When d = 2 cm, t= 1.59 s

The length of the tray is 35.5 cm.

This gives speeds of 16.7 cm s^{-1} *and 22.19 cm* s^{-1}*. Relation might hold for these depths as both values of k (17 and 16) are similar.*

Graph of tan θ against F for question one.



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

SFP	Significant figure penalty
ECF	Error carried forward
AE	Arithmetical error
POTE	Power of ten error
NV	Not valid
NR	Not relevant
NBL	Not best line
NOL	Not on line
FO	False origin
NGE	Not good enough
MU	Mixed units
BOD	Benefit of the doubt
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)
✓Δ	Used to show that the size of a triangle is appropriate
✓M3	Used to show the type of mark awarded for a particular piece of work
✓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

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

Question			**Expected Answers**	**Marks**	
1	**a**	**i**	acceleration $\propto$ displacement; indication of restoring force by negative	**1**	
			sign/acc. in opp. direction to displacement/acc. towards origin/AW	**1**	
		ii	linear graph through origin; negative gradient	**2**	**4**
	b	**i**	0.05 (m)	**1**	
		ii	$4\pi^2 f^2 = a/A$; = 12.5/0.05 = 250 so f = 2.5(1) Hz; T = 1/f (= 0.4 s)	**3**	**4**
	c	**i**	cosine wave; correct period of 0.4 s; correct amplitude of 0.05 m	**3**	**3**
		ii	0; 0.1/0.3/0.5/0.7/0.9 (s)	**2**	**2**
			Total		**13**
2	**a**	**i**	$\rho = m/V = m/Av$; $m = A\rho v = 7.5 \times 10^{-5} \times 1000 \times v = 0.09$	**2**	
			giving $v = 1.2$ m s^{-1}		
		ii	2.4 (m s^{-1})	**1**	
		iii	F = d (mv)/dt /AW; F = 0.09 x (2.4 – 1.2) ;= 0.11 (N) ; *ecf (a)ii*	**3**	
		iv	towards or into shower head/backwards *ecf (a)iii*	**1**	**7**
	b	**i**	$P = (m/s)c\theta$; = 0.09 x 4200 x (27 – 15); = 4536 or 4500; W or 4.5 kW	**4**	
		ii	energy losses in pipe from heater to shower head/ less than 100% energy transfer from heater to water/AW	**1**	
		iii	15 + 24 = 39(^{o}C)	**1**	**6**
			Total		**13**
3	**a**		equally spaced horizontal parallel lines from plate to plate; arrows	**1**	
			towards B; quality mark	**2**	**3**
	b		E = V/d ; = 600/0.04 ;(= 1.5×10^{4} V m^{-1})	**2**	**2**
	c		F = QE / $1.6 \times 10^{-19} \times 1.5 \times 10^{4}$;= 2.4×10^{-15} (N)	**2**	**2**
	d		$1/2mv^2 = Fd$ **or** QV ; = $1.6 \times 10^{-19} \times 600$ or = $2.4 \times 10^{-15} \times 0.04$ *ecf (c)* **or** alternative method by constant acceleration formulae; (either method giving $v^2 = 2.1 \times 10^{14}$ and $v = 1.45 \times 10^{7}$ m s^{-1})	**2**	**2**
	e		$\sqrt{2}v = 2.05 \times 10^{7}$ (m s^{-1})	**1**	**1**
	f		fewer electrons will reach grid B **or** C (as higher initial speed required);	**1**	
			so current will fall (to zero if beam is taken to be monoenergetic)	**1**	**2**
			Total		**12**

Question			Expected Answers	Marks	
4	a	i	C = Q/V or gradient of graph / = 24 μC/3V ; = 8.0 (μF)	2	
		ii	E = ½ CV^2 / = $^1/_2$ x 8 x 3^2 ; = 36 (μJ) *ecf a(i)* or ½ QV / = ½ x 24 x 3 ; = 36 (μJ)	2	
		iii	T = RC = (0.04) ; R = 0.04/8.0μ = 5.0 x 10^3 (Ω) *ecf a(i)*	2	
		iv	idea of exponential/constant ratio in equal times; which is independent of initial value/AW or argued mathematically in terms of $Q/Q_o = e^{-t/RC}$ *give 1 mark for statement that time depends only on time constant/RC*	2	8
	b	i	C_p = C + C = 6 μF; $1/C_s$ = 1/2C + 1/C ; = 3/2C giving C_s = 2C/3 = (2 μF)	3	
		ii	2 sets of (3 in series) in parallel/ 3 sets of (2 in parallel) in series	2	5
			Total		13
5	a	i	number of decays/atoms/nuclei decaying per second/unit time in the source/AW	1	
			count (rate) without source present/AW	1	
		ii	distance of detector from source/dimensions of source or detector window/efficiency of detector/rate of emission v detection, e.g dead time correction/other sensible suggestion;	1	
			reason/effect on count rate	1	4
	b	i	(take lns of both sides) appreciate ln $e^{-\lambda t}$ = -λt ; and ln C/C_o = ln C - ln C_o **or** when multipyling logs add	2	
		ii	gradient = 0.056 h^{-1} *allow ± 0.002 h*$^-$;T = ln2/λ =ln2/gradient = ln2/0.056 h; T = 12.4 h *allow ± 0.4 h*	3	5
	c		mass change/charge change/range/speed of emission/monoenergetic v range of speed/alpha emitted from only high mass nuclei/number of particles in the decay/other sensible suggestion **or** further detail *any three*	3	3
			Total		12
6	a	i	BA / = 0.05 x 0.05 x 0.026 ; = 6.5 x 10^{-5}; Wb/T m^2	3	
		ii	BA sin 45^o/BAcos 45^o = 4.6 x 10^{-5} Wb *ecf (a)i*	1	
		iii	0	1	5
	b	i	a point where curve crosses t-axis	1	
		ii	voltage is proportional to the rate of change of flux linking the coil; rate of flux change is zero/very small when the flux linking the coil is a maximum	1 1	
		iii	sinusoidal curve; of double the amplitude; and half the period	3	6
			Total		11

Question		Expected Answers	Marks	
7	**a**	proves existence of a nucleus to the atom;	**1**	
		containing most of the atomic mass; because of bouncing back;	**2**	
		of very small size; because of few scattered through any angles at all;	**2**	
		containing charged particles; because the scattering is consistent with	**1**	
		the pattern predicted by Coulomb/electrostatic repulsion;	**1**	
		electrons have opposite/smaller charge; and a much smaller mass;	**2**	
		a diffraction pattern is observed (superimposed on the Rutherford scattering curve);	**1**	
		as the electrons behave like waves; with a λ of the order of d for	**1**	
		significant scattering/having a de Broglie wavelength;	**1**	
		pattern/size of ring enables radius of the nucleus to be found *max 7*	**1**	**7**
	b	Diagram showing **or** description of incident beam scattered by or diffracted through crystal at only certain angles;	**1**	
		moveable detector to measure angles;	**1**	
		electrons are scattered from crystal planes like a diffraction grating/because of the regular array of atoms;	**1**	
		constructive interference only occurs at certain angles ; depending on λ	**1**	
		and d;	**1**	
		pattern of maximum signals can be very complex depending on structure/AW;	**1**	
		must achieve λ of the order of d for significant scattering;	**1**	
		size of pattern depends on ratio of λ/d **or** maxima occur at angles of about nλ/d;	**1**	
		de Broglie's relation p = h/λ for electrons shows why different energies are needed *with this detail worth 2 marks*;	**2**	
		further detail, e.g. electrons accelerated to MeV for nuclei or a few keV for atomic spacing	**1**	
		as λ is known d can be found *max 5*	**1**	**5**
		Quality of Written Communication		**4**
		Total		**16**

1.	(a)	Any 2 from		
		Sun in centre	1	
		Circular orbits	1	
		Constant orbital speed	1	
	(b)	Any 2 from		
		Elliptical orbits	1	
		Sun at <u>focus</u> (accept diagram)	1	
		Non-constant speed (accept equal areas in equal times)	1	
		No epicycles	1	Total 4
2.	(a)	i. $F = GMm/r^2$ or $F \alpha Mm/r^2$ <u>with labels</u>	1	
		ii finite universe contracts/ resultant force on stars	1	
	(b)	Any 2 from		
		i. (satellite B) has larger circumference/smaller velocity	1	
		(satellite B) Gravitational field strength is less	1	
		(satellite B) Centripetal force is less	1	
		ii.(accept calculation from either satellite)		
		$r_1^3/ T_1^2 = r_2^3/ T_2^2$	1	
		satellite A — satellite B		
		$r_2^3 = 7000^3 \times 57.2^2 / 1.63^2$ — $r_2^3 = 67100^3 \times 57.2^2 / 1.63^2$	1	
		$r_2 =$ 75,030 km — $r_2 =$ 75, 320 km	1	
		(= 75,000 km) — (= 75,000 km)		
	(c)	i. measure of brightness as seen from Earth.	1	
		ii. $m_1 – m_2 = 2.5(1) \log (I_2/ I_1)$	1	
		$10^{12/2.5} = I_2/ I_1$	1	
		$I_2/ I_1 = 60,000$	1	
		Accept:		
		ratio of 2.5 for each unit of apparent magnitude intensity	1	
		$I_2/ I_1 = (2.5)^{12}$	1	
		$I_2/ I_1 = 60,000$	1	
		interchanging I_2 and I_1 numerically gives 2/3		
	(d)	Land-based are (any 3) 1 mark for each		
		more light can be collected/ made larger		
		more stable		
		more manoeuvrable		
		cheaper to build/repair		
		longer lifetime/ not exposed to high velocity particles		
		greater access	Total	14

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3.	(a)	uniform intensity detected in all directions/ isotropic	1
	(b)	Hydrogen and helium in early stars and sun	1
		Sun has greater proportion of helium than early stars/ H changed to He by fusion in sun.	1
		Virtually no higher elements in first stars/ sun contains traces of higher elements (accept specific examples up to iron)	1
	(c)	Any 4 from (each point scores 1 mark)	
		Dark lines	
		Crossing continuous spectrum	
		Absorption occurs in stellar atmosphere	
		Only get information about atmosphere	
		Measurement of wavelength	
		Combinaton of lines unique to element.	Total 8
4.	(a)	1. correct position of M	1
		2. correct position of W	1
	(b)	(i) Any 3 from	
		A has red giants / B has no red giants	1
		A has white dwarfs/ B has no white dwarfs	1
		A has high and low mass stars/ B has high mass only	1
		Reference to spectral types	1
		(ii) Any 2 from	
		B has an excess of hot/bright/main sequence stars	1
		presence of red giants/ white dwarfs in A with reference to timescale.	1
		High mass stars shorter lived than low mass	1
			Total 7
5.	(a)	Any 5 from	
		red shift data for galaxies (accept stars)	1
		calculate velocity from red shift	1
		galaxies/ stars receding from Earth	1
		distance data for galaxies/ stars	1
		velocity α distance / v/r = constant / v-r graph straight line	1
		universe began at a single point	1
	(b)	Any two	
		stars rotate around galactic centre	1
		star with velocity component towards Earth	1
		reference to motion/shape of galaxy	1
		or other valid points eg blue shift	
	(c)	$H_o = 75/\ 3x\ 10^{19}\ s^{-1}$	1
		$t \approx 1/\ 2.5\ x\ 10^{-18}$	1
		$t \approx 4\ x\ 10^{17}\ s$	1

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5.	(d)	critical density is that for flat universe	1
		density > p_0 universe closed/contracts/big crunch	1
		density < p_0 universe open/ expands forever	1
		any 2 from	
		fate unknown because size/mass/density universe uncertain	1
		fate unknown because p_0 / H_0 not known	1
			Total 15
6.	(a)	(i) 7 points plotted correctly	1
		all points plotted correctly	1
		(ii)both sides of graph correct	1
		peak drawn/ lines merge assymtotically	1
		(iii) 10 days ± 1/2 day	1
	(b)	(i) one ray with correct curvature	1
		second ray drawn, deviation correct, rays meet at Earth.	1
		(ii)reference to focussing effect	1
		max intensity when Earth in line (with star-black hole)	1
	(c)	gravity causes space-time curvature	1
		light takes shortest path	1
		alternative explanation:	
		acceleration leads to curvature of light beam.	1
		use of principle of equivalence	1
			Total 11

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7.	(a)	speed of light invariable	1
		All inertial reference frames equivalent/no frame preferred/ laws of physics are the same in all inertial frames.	1
	(b)	Any 5	
		Observer A at rest at midpoint of tunnel	1
		Observer B moving in train (at constant speed)	1
		Train same length as tunnel according to stationary observer A (who sees lights flash simultaneously)	1
		Train longer than tunnel according to observer B (who sees lights flash at different times)	1
		Explanation of what length contraction is.	1
		Any other valid point: symmetry, c is constant, how lights come on.	1
	(c)	(i) $v = 11000 \times 10^{3} / 2.73 \times 10^{-13}$ (= 4.03×10^{19} ms^{-1})	1
		(ii) velocity > c	1
		no matter/energy/information/transferred between Earth observatories/ reference to c as limiting speed	1
		(iii) $v = 2\pi \times 9.46 \times 10^{18} / 1.49$ (= 4×10^{19} ms^{-1})	1
8.		As for common question in Telecommunications unit.	
		Total	11

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1 (a) one mark for each correct arrow
vertical arrow pointing up on Fig.1.1 (1)
resultant (of vertical and left horizontal) on Fig.1.2 (1)
through point of contact of heel with ground (1)
or vertical arrow through point of contact (1)
horizontal arrow to the left (1)

(b) Friction reduces (to zero) (1)

2 (a) curve with min at 10^{-12} W m^{-2} (1) and 2-3 kHz (1)
within 20 Hz to 20 kHz (1)

(b) Responses e.g.not as sensitive / needs greater sound intensity at all frequencies to detect sound / only louder sounds detected (1)
does not detect lower frequencies / or reference to 20 Hz (1)
does not detect higher frequencies / reference to 20 k Hz (1)

3 (a) The nearest point that an eye can focus on comfortably / see clearly (1)

(b) (i) p = 1 / f
59= 1 / f (1)
f = 0.0169 m (1)

(ii) 0.0169 m or 0.017 m (1) ecf (i)

(iii) 1 / u + 1 / v = 1 / f (1)
1 / 0.40 + 1 / 0.0169 = P (1)
P = 61.5 D (1) (allow 61.67 D / 61.32 D / 62 D)

(c) p = 1 / u + 1 / v
p = 1 / 0.0169 + 1 / 0.25 (1)
p = 63 D or 62.8 D (1)

(d) 63 D – 61.5 D (1) ecf from (b)(iii) and (c)
= 1.5 D (1)

(d) long sight / hypermetropia (1)

4 (a) surface area of sphere at r = 3 m is 4 x π x 3^2 = 113.09 m^2 (1)
intensity = 400 / 113.09 (1)
intensity = 3.536 W m^{-2} (0)

(b)(i) intensity level = 10 lg I / I_0 (0)
intensity level = 10 lg 3.5 / 10^{-12} (1)
intensity level = 125 (1)
unit dB (1) allow B if consistent with answer or if no numerical answer

(ii) 120 dB is the threshold of feeling / discomfort (1)
so above this threshold damage could occur / or sound is very loud (1)

5 to a max. 8 e.g.
scotopic:
vision in dim light (1)
rods responsible for scotopic vision (1)
rods sensitive to (changes in) low light intensity (1)
rods don't differentiate colour (1) or rods give black and white vision
rods found around the fovea on the retina (1)
so responsible for peripheral vision (1)
rods give outline / low detail (1)

photopic:
cones responsible for
cones sensitive in bright light (1)
3 types of cone, red, green and blue (1)
cones differentiate colour (1)
give more detail (1)
cones found on fovea (1)
as falling light intensity, image loses colour (1)
and detail (1) or reference to peripheral vision

6 to a max. of 7 e.g.
absorption of X-rays is dependent on Z (1)
if little difference in Z, then poor contrast (1)
use of contrast medium with high Z (1)
(to give a contrast with) soft tissue of low Z (1)
attenuation proportional to Z^3 (1)
allow credit for detail e.g. reference to photoelectric effect (1)
e.g. Barium (meal) (1)
gives high attenuation in contrast medium (1)
so less X-rays reach film (1)
so less fogging / leading to shadow on X-ray film / detector (1)
example of use e.g. intestine investigation (1)

7 (a) ref. to <u>energy</u> (1)
<u>absorbed</u> (by the volume of tissue) (1)
(b) bone has a higher atomic number (allow density) compared to soft tissue/
or bone has higher attenuation / absorbs more (1)
(c) values of first three cells (in a row) calculated as 20,10,10 (1)
values of last three cells (in a row) calculated as 10,20,20 (1)
values of middle cells calculated as 20,20,10 (1)
so cell *Y* is made up of <u>soft tissue</u> (1) allow ecf if Y = 20

8 (a) In coherent bundle the relative positions of the fibres at one end is the same as the positions at the other end. (1)
incoherent fibres are 'jumbled' (1)
(b)(i) purpose is to carry the light from the source to the object (1)
(ii) purpose to carry light from the object to the viewer (1)
(c)(i) water content of cell is vaporised (1)
cell shrivels / dies (1)
(ii) ref. to darker colours / black having greater absorption (1)
(d)(i) $0.12 / 0.75 \times 10^{-3}$ or 160 W (1)
$160 / 1.2 \times 10^{-6}$ (1)
$= 1.33 \times 10^{8}$ W m^{-2} (1)
(ii) $E = h f = hc/\lambda$ (1)
$6.6 \times 10^{-34} \times 3.0 \times 10^{8} / 1060 \times 10^{-9}$ (1)
$= 1.87 \times 10^{-19}$ J (1)
$0.12 / 1.87 \times 10^{-19}$ (0)
$= 6.4 \times 10^{17}$ (1)

9 (a) the charge (of one sign) (1)
produced in 1 kg <u>of air</u> (1)

(b) total number of unit charges = $2.5 \times 10^{-6} / 1.6 \times 10^{-19}$ (= 1.56×10^{13}) (1)
$5.4 \times 10^{-18} \times 1.56 \times 10^{13} = 8.4 \times 10^{-5}$ (1)
Gy (1) allow J kg^{-1}

10. As for synoptic question in Telecommunications Module.

1.	(a)		Idea of 2 forces;	(1)	
			attractive force between atoms = repulsive force between atoms.	(1)	[2]
	(b)	(i)	3.0×10^{-10} m		[1]
		(ii)	Graph is a straight line from $x = 2.8 \times 10^{-10}$ m to $x = 3.2 \times 10^{-10}$ m / within given range.		[1]
	(c)		Theoretical breaking stress = $8.0 \times 10^{-10} / (3.0 \times 10^{-10})^2$	(1)	
			$= 8.9 \times 10^9$	(1)	
			Pa / N m^{-2}	(1)	[3]
	(d)	(i)	Elastic extension as atoms are pulled apart;	(1)	
			Plastic extension as planes of atoms slide over each other;	(1)	
			Wire forms a neck (and snaps).	(1)	[3]
2.	(a)		Single crystals have a <u>regular array of atoms</u> extending through it.	(1)	
			Example: e.g. a diamond, a quartz crystal.	(1)	
			Polycrystalline materials have grains each with a regular array separated by <u>grain boundaries</u>.	(1)	
			Example: e.g. a metal.	(1)	[4]
	(b)	(i)	Vacancy / missing atom;	(1)	
			Impurity atom (substitutional or interstitial) .	(1)	[2]
		(ii)	Plastic deformation involves planes of atoms sliding past each other;	(1)	
			The planes of atoms between which sliding / slip occurs are called slip planes.	(1)	[2]
	(c)	(i)	A dislocation.		[1]
		(ii)	Diagram showing any movement of the dislocation;	(1)	
			in the correct direction i.e. from left to right.	(1)	[2]
3.	(a)	(i)	An electron in the conduction band.		[1]
		(ii)	(High speed) random motion (due to thermal energy); (1)		
			due to thermal energy; (1)		
			(Low speed) motion superimposed (on this random motion); (1)		
			in opposite direction to current / applied voltage / electric field; (1)	max (3)	
			Drift velocity: <u>average</u> rate of movement due to the current.	(1)	[4]
	(b)	(i)	$v = I / nAe = 0.0025 / (8.5 \times 10^{28} \times 1.1 \times 10^{-7} \times 1.6 \times 10^{-19})$	(1)	
			$= 1.67 \times 10^{-6}$ m s^{-1}	(1)	[2]
		(ii)	Free electron concentration (or wtte) is much smaller in the thermistor than in the wire.		[1]
	(c)		More free electrons become available for conduction;	(1)	
			as more electrons transfer from valence conduction band (due to increase in thermal energy).	(1)	[2]

4. (a) Above 8.2 K resistivity increases with temperature; (1)
At 8.2 K <u>steep</u> / vertical drop to zero resistivity; (1)
zero resistivity below 8.2 K. (1) [3]

(b) Superconducting coils cooled by liquid helium / nitrogen; (1)
kept in vacuum-walled tank; (1)
Very high current can flow in coils without loss of energy as heat; (1)
Very strong magnetic field produced by high current; (1)
Electromagnet made with superconductor can be much smaller than conventional electromagnet producing the same field strength; (1)
No need for iron core so sample can be inside coil; (1)
No need for equipment to remove excess heat; (1)
Longer running times possible as heat does not build up; (1) max (6)

Use: e.g. magnetic resonance imaging, floating vehicles, etc. (1) [7]

5. (a) (i) $P = IV$ (1)
$= 3.0 \times 12 = 36$ W (1) [2]

(ii) $P_s = 0.96\ P_p$ (1)
$I_p = P_s / 0.96 \times V_p$ (1)
$= 36 / (0.96 \times 230) = 0.163$ A (1) [3]

(b) Hysteresis loop of reasonable shape. (1)
x-axis: flux density of magnetising field / current in magnetising coil. (1)
y-axis: flux density in (ferromagnetic) material. (1) [3]
[Allow 1 of last 2 marks for reference to flux density]

(c) Energy loss in 1 a.c. cycle is proportional to / depends on area enclosed by hysteresis loop; (1)
As frequency / no. of cycles per second increases, amount of energy loss increases proportionately. (1) [2]

(d) A: Heat loss due to current in windings; (1)
B: Heat loss due to eddy currents in core; (1)
C: Heat loss due to hysteresis of core / energy loss due to work done in moving domain walls (or wtte); (1)
D: Flux losses. (1) max(3)

Further explanation must be linked to the above.

A minimised by using (copper) wire of large cross-section. (1)
giving low resistance for I^2R losses or wtte; (1)

B minimised by laminated structure of core; (1)
giving high resistance paths for eddy currents; (1)

C minimised by use of soft magnetic material / ferrite / metallic glass for core; (1)
which have hysteresis loops of small area. (1)

D minimised by making core a complete loop; (1)

			or winding secondary coils on top of primary coils.	(1)	max(4)	[7]
6.	(a)	(i)	Path in Y is closer to the normal.		(1)	
			Radiation travels slower in medium Y.		(1)	[2]
	(b)	(i)	sin c		(1)	
			= $2.03 \times 10^4 / 2.04 \times 10^4$		(1)	
			c = 84.3^o		(1)	[3]
		(ii)	angle of reflection = angle of incidence.			[1]
	(c)		Three reasons with explanation required; e.g.			
			Laser emits more power than an LED;		(1)	
			so travels farther in fibre before amplification needed.		(1)	
			Laser beam is directional, radiation from an LED diverges;		(1)	
			so easier to direct beam into a fibre / more power input into a fibre.		(1)	
			Lasers switch much faster;		(1)	
			so can transmit more information in a given time.		(1)	
			Light from a laser has a narrower spread of frequencies;		(1)	
			so time of transit through a fibre is more uniform / so wavelength multiplexing is possible.		(1)	[6]
7.			As for synoptic question in Telecommunications unit.			

Subject: Nuclear and Particle Physics, Code: 2825/04

Session: …Jan..... Year: …2005….

Mark Scheme (sixth draft, operational)

MAXIMUM MARK (including common question)	90

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
   You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

   x = incorrect response (errors may also be underlined)
   ^ = omission mark
   bod = benefit of the doubt (where professional judgement has been used)
   ecf = error carried forward (in consequential marking)
   con = contradiction (in cases where candidates contradict themselves in the same response)
   sf = error in the number of significant figures

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

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)	repulsion/attraction correctly labelled on axis;	1 [1]
(b)(i)	correct point N - where strong line crosses distance axis; at N (resultant) force is zero; (1) so neutrons must be at equilibrium; (1) any 1 not just 'forces equal'	1 1 [2]
(ii)	correct point P; at P electrostatic and strong forces balance (or AW);	1 1 [2]
(c)	crosses axis at P; allow P on either curve if forces equal crosses e/s force line at point vertically above N; generally correct shape, entirely above strong line;	1 1 1 [3]
(d)(i)	$(F =)\ Q^2/[4\pi\varepsilon_0(x)^2]$ allow $(F =)\ Q_1 Q_2/[4\pi\varepsilon_0(x)^2]$	1 [1]
(ii)	$25 = (1.6 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} [d]^2)$ subs. $d = 3.0(3) \times 10^{-15}$ m allow 3×10^{-15} m	1 1 [2]
2(a)	*either* produced in a nuclear (fission) reactor *or* bombard (natural) uranium with neutrons (1) uranium 238 (nucleus) absorbs / captures a neutron (1) product (uranium 239) undergoes β-decay (1) any 2	 2 [2]
(b)(i)	alpha particle	1 [1]
(ii)	${}^{239}_{94}Pu \rightarrow {}^{4}_{2}He + {}^{235}_{92}U$ each correct product nucleus gets (1)	2 [2]
(c)(i)	24000 years / 7.57×10^{11} s	1 [1]
(ii)	*either* $\lambda = 0.693/24000$ *or* $N = N_0 (½)^{9000/24000}$ equation(s) $= 2.89 \times 10^{-5}\ y^{-1}$ $= 5 \times 10^{20} (½)^{0.375}$ subs. $N = N_0 e^{-\lambda t}$ $(= 3.85 \times 10^{20})$ $= 5 \times 10^{20} \exp(-2.89 \times 10^{-5} \times 9000)$ $(= 3.85 \times 10^{20})$	1 1 [2]

(d)(i)	ratio = 4.0	1	[1]
(ii)	original ratio N_{240}/N_{239} = 40 x 10^{20}/(5 x 10^{20}) = 8 (ratio after 9000 years = 4) equal numbers after another 9000 + 9000 = 18000 years so total time = 9000 + 18000 = 27000 years	1 1 1	 [3]
3(a)	plasma is electron-nuclei/ion mixture; give nuclei enough energy to overcome Coulomb barrier; nuclei get close enough to fuse; plasma: matter at high temperature / fourth state of matter; (1) electrons stripped off atom / pulled away from nucleus; (1) high temperatures: give electrons energy to escape from nucleus; (1) explains Coulomb barrier - repulsion between positive nuclei; (1) confinement: increases plasma density / brings nuclei closer together; (1) methods: gravitational (eg in Sun) detail: strong gravity field pulls plasma together; (1) inertial; detail: (inward-acting) lasers push plasma together / compress plasma; (1) magnetic; detail: nuclei / ions / electrons spiral along *B* lines; (1) any 3	1 1 1 1 1 1 3	 [9]
(b)	*either* number of atoms of ^4_2He in 1.0 kg = (1 / 0.004) x 6.02 x 10^{23} (= 1.51 x 10^{26}) so total energy = 1.51 x 10^{26} x 28.4 x 1.6 x 10^{-19} x 10^6 = 6.9 x 10^{14} J (accept 6.8 x 10^{14} J) *or* mass of ^4_2He = 4 x 1.67 x 10^{-27} (= 6.68 x 10^{-27} kg) so number of ^4_2He in 1.0 kg = 1 / (6.68 x 10^{-27}) (= 1.50 x 10^{26}) (1) and energy generated = 1.50 x 10^{26} x 28.4 MeV (= 4.25 x 10^{33} eV) (1) = 4.25 x 10^{33} x 1.6 x 10^{-19} J = 6.8 x 10^{14} J (1)	 1 1 1	 [3]
4(a)	equation ^1_1H + ^2_1H -> ^3_2He (+ energy)	1	[1]
(b)(i)	ke of nuclei converted to (electric) potential energy all ke is converted	1 1	 [2]
(ii)	pe = (1.6 x 10^{-19}) x (1.6 x 10^{-19}) / (4π x 8.85 x 10^{-12} x 3.07 x 10^{-13}) correct charge subs. (1) correct remaining subs. (1) (= 7.5 x 10^{-16} J)	2	 [2]
(iii)	initial momentum = final momentum or equivalent $mu - (2m)v = 0$ (so $u = 2v$)	1 1	 [2]

(iv)	ke = ½ $m v^2$ ke of deuterium = ½ (2 m) v^2 (= $m v^2$) ke of hydrogen = ½ m (2v)^2 (= 2$m v^2$) so deuterium has $^1/_3$ of total ke) hydrogen has $^2/_3$) working so ke of hydrogen = $^2/_3$ x 7.5 x 10^{-16} = 0.50 x 10^{-15} J) ke of deuterium = $^1/_3$ x 7.5 x 10^{-16} = 0.25 x 10^{-15} J)	1 2 1	[4]
5(a)	principle of acceleration: charged particles move between electrodes at different voltages / charged electrodes / through electric field; magnetic fields to bend beam(s) / exert motor force; *either* magnetic field strength is increased as particles accelerate / gain energy *or* frequency of accelerating voltage changes to synchronise with particles; linear accelerator / linac for injecting particles into synchrotron; (1) accelerators on circular path to increase / maintain speed / energy of particles; (1) (magnetic force) provides centripetal force / force perpendicular to path; (1) magnetic field for focusing (particle beam); (1) any 2	1 1 1 2	[5]
(b)	energy of $^0_0$Z = $m c^2$ = (1.63 x 10^{-25}) x (3.0 x 10^8)^2 (= 1.46 x 10^{-8} J) = 1.46 x 10^{-8} / (1.6 x 10^{-19} x 10^9) (= 91.7) GeV subs.	1 1	[2]
(c)(i)	minimum particle energy = (91.7)/2 = 45.8 GeV *or* 92/2 = 46 GeV because both particle energies are used / available and $^0_0$Z (particle) can (in theory) be at rest / have zero energy after collision	1 1 1	[3]
(ii)	product particles must have some ke because initial mtm. (of system) not zero, so final mtm. not zero	1 1	[2]

6(a)

	hadron	baryon	lepton
neutron	✓	✓	
proton	✓	✓	
electron			✓
neutrino			✓

4 lines correct 2/2: 3 lines correct 1/2: 2 or 1 line correct 0/2 — 2 [2]

(b)(i)	10 -15 minutes - any value within range	1	[1]
(ii)	weak force / interaction	1	[1]
(iii)	d -> u + e^- + ν (-bar) omits e^- or ν loses 1 each (u) (u) (d) (d)	2	[2]
(iv)	charge: $-\frac{1}{3}$ ($+\frac{2}{3} -\frac{1}{3}$) -> $\frac{2}{3}$ ($+\frac{2}{3} -\frac{1}{3}$) -1 (+0) baryon number: $\frac{1}{3}$ ($+\frac{1}{3} + \frac{1}{3}$) -> $\frac{1}{3}$ ($+\frac{1}{3} + \frac{1}{3}$) + 0 (+0) *nuclear* values: charge 0 = 1 - 1 (+ 0) *and* baryon no. 1 = 1 + 0 gets 1/2	1 1	[2]
(c)(i)	arrowed line plus 'resultant' / p_r label	1	[1]
(ii)	anti- (1) neutrino (1) is emitted carries away some momentum (1) shows neutrino momentum vector (1) any 3	3	[3]
7.	As for synoptic question in Telecommunications unit.		[20]

TELECOMMUNICATIONS

Question 1	Expected Answers	Marks

(a) (i) Peak output voltage = 10 V 1 [1]

(ii) Peak input voltage = 0.02 V 1 [1]

(iii) Voltage gain = - 10 / 0.02 1

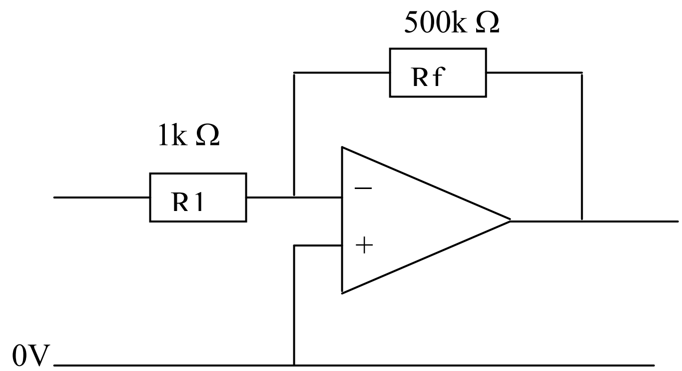
= - 500 1(deduct 1 mark if no negative sign)[2]

(iv) Frequency = 1 / 8 ms 1

= 125 Hz 1 [2]

(b) The amplifier is inverting. 1 [1]
(allow "linear" as answer)

(c)



Op-amp circuit diagram correct with + and - right way round (allow ecf non-inverting amplifier consistent answer to (a)(iii))
0V line marked
Resistors in range 1 kΩ to 10 MΩ
Resistor ratio correct for gain of -500 (allow mark for gain = R_f / R_1) [5]

Question 2	Expected Answers	Marks

(a) Two reasonable shaped parabolic reflectors facing each other

Transmitter radiator labelled

At focus of one reflector

Receiving element labelled

At focus of other reflector

At least three rays correctly drawn between radiator and receiver Max [5]

(b) The distance between satellite and ground is huge (in the order of 35000 km)

The power loss is huge (in the order of 200 dB)

The wavelengths used for transmission are small (in the order of cm)

The reflector diameter for these wavelengths does not have to be huge

The reflector can produce a near parallel directed transmission to satellite

The reflector focuses much greater power on to receiver than would otherwise occur

Thus the received signal-to-noise ratio is greatly increased

The parabolic shape can also reject off-axis satellites

For transmission to satellite the dish must be large to concentrate power

For transmission from satellite dish size can govern footprint size Max [5]

(c) Terrestrial TV uses carrier frequencies in the order of 100s of MHz

Wavelengths at these frequencies are in the order of 1m

Parabolic dishes would have to be in the order of 10 x λ and thus huge

With all the attendant high costs and meteorological instability

Anyway, terrestrial TV transmitters are not very far away (in order of 30km max)

Anyway Yagi array directional aerials pick up a sufficiently strong signal-to-noise ratio Max [3]

Question 3	Expected Answers	Marks

(a) Electromagnetic waves at audio frequencies do not propagate very far 1

Unless huge powers are used 1

Huge aerials would be required at audio frequencies 1 [3]

(b) The audio must be made to control a carrier wave

The carrier must have a much higher frequency

The carrier can be made AM or FM

Suitable description of AM

Plus acceptable diagram

Suitable description of FM

Plus acceptable diagram

(Allow up to 4 marks for any one modulation process but maximum is 6 for question)

(c) The LF waveband propagates for up to 1000 km

And broadcast should only be of interest locally

VHF has a broadcast range of only 20 to 30 km which is ideal for a city Max [2]

Question 4	Expected Answers	Marks

(a) Attenuation The gradual loss in Power (or Energy) as a signal passes along a cable 1

(b) (i) The cable will attenuate higher frequencies more than lower ones 1

(4km of $10dBkm^{-1}$ means a 40dB loss which means a 10^4 fold power loss)

the music will lose its treble and sound bassy 1

(ii) The attenuation below 3kHz is more or less constant

So all frequencies in range will be equally attenuated

And speech will sound the same (albeit quieter) as that transmitted Max [2]

(c) (i) Signal-to-noise ratio $28 = 10 \log P_{min} / 4.2 \times 10^{-6}$ 1

Thus $P_{min} = 10^{2.8} \times 4.2 \times 10^{-6}$

$= 2.65$ mW 1 [2]

(ii) Total attenuation $= 10 \log 2.65 \text{ mW} / 1.33$ 1

$= -27$ dB 1 [2]

(iii) Max uninterrupted length $= 27 / 4.4$

$= 6.14$ km 1 [1]

(iv) The signal must be amplified 1

Each amplifier must have a gain of (10 log 1.33 / 2.65 mW) 27 dB 1

There must be amplifiers placed every 6.14 km thus 24 / 6.14 = 4 are needed 1

Max [2]

Question 5	Expected Answers	Marks

(a) Core correctly labelled

Cladding correctly labelled

Core diameter drawn significantly smaller than cladding diameter (say less than a quarter) [2]

(b) Light ray drawn in core in straight line [1]

(c)	Laser	(generously allow LED)	1	
	Photodiode or Phototransistor	(do <u>not</u> allow LDR)	1	[2]

(d) In multimode fibres, multipath dispersion occurs

Input pulses each become stretched in time

And so smear into each other with the consequent loss of information

Hence data transmission rates are very low

(any two points)

In monomode fibres all the light rays travel in same direction at same speed

So signal smearing does not occur

And data transmission rates are much faster so reducing costs per user

(any two points) [4]

Question 6	Expected Answers	Marks
Exchange	All local subscribers connected to a single building (or wtte)	
	Within this single building all connections are made	
	Exchanges are linked by trunk lines to allow long-distance calls	
	Exchanges now automated to allow faster access	Max [3]
Multiplexing	Trunk lines can be shared by several users	
	By restricting the bandwidth per user	
	Can be Frequency Division or Time Division multiplexing	
	Any suitable description of FDM or TDM	Max [2]
Digital Electronics	Modern electronics now switches / operates at high frequencies	
	Digital signals can be regenerated perfectly	
	Digital signals can be easily controlled by computers	
	Digital signals can be easily stored in memories	
	Digital signals can be encrypted for security	
	Digital signals can use error correction codes	Max [4]
	(can transfer 1 mark to previous part if good answer)	
Differences	Much lower cost	
	Hence use by ordinary people	
	Taken for granted as a part of everyday life (in the first world)	
	Allows use for data communications as well as voice	
	Allows easy access to people and information through mobile network	
	Any suitable description of use of modern telephone system	Max [4]

Answer Scheme

7(a) $v = $ dist. / time (or implied by answer) [1]
$= 54 \times 10^3 / 3600$ [1]

(b) (i) $v^2 = u^2 + 2as$ [1]
$a = 15^2 / 2 \times 1.25 = 90\ ms^{-2}$ (ignore any -ve sign) [1]

(ii) $v = u + at$ or $s = ½ (u + v) \times t$ [1]
(any other equation used must show correct substitution to gain mark)
$t = 15 / 90 = 0.167\ s = 167\ ms$ [1]

(c) (i) $F = kx$ [1]
$= 30 \times 0.036 = 1.08\ N$ [1]

(ii) deceleration $a = F / m = 1.08 / 0.120 = 9.0\ ms^{-2}$ [1]

(d) $P_1 V_1 = P_2 V_2$ or $PV / T = $ constant (or implied by answer) [1]

Pressure $= 250 \times 10^3 \times (0.06 + 0.0003) / 0.0003$

$= 50\ MPa$ [1]

(e) $PV = nRT$ $n = 50 \times 10^6 \times 0.0003 / 8.3 \times (273 + 17)$ [1]
$= 6.23$ moles
number of molecules $= 3.75 \times 10^{24}$ molecules [1]
Loss $= 20\% \times 3.75 \times 10^{24} / 4 \times 7 \times 24 \times 3600$ [1]
$= 3.1 \times 10^{17}$ molecules sec^{-1} [1]

For incorrect answer, allow
correct process to calculate the number of moles [1]
correct conversion of moles to molecules [1]
correct use of the 20% [1]
correct use of 241920 seconds [1]

(f) (i) Resistance of filament $= \rho L / A$ [1]

$= 1.5 \times 10^{-6} \times 0.022 / 2.75 \times 10^{-8}$ [1]

$= 1.2\ \Omega$

(ii) Current in filament $= 12V / 1.2\ \Omega = 10\ A$

Power $= 12V \times 10A = 120\ W$ [1]

Time for detonation $=$ energy / power $= 0.96 / 120$ [1]

$= 8\ ms$ [1]

RECOGNISING ACHIEVEMENT

Subject: Physics, Unified Concepts Code: 2826/01

Session: January Year: 2005

Mark Scheme

MAXIMUM MARK	60

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

1	(a)	Impossible graph is A	1	
		The object is in two different places at the same time	1	2
		OR object requires infinite speed (during the vertical part of the graph only)		
	(b)	B.		
		The direction in which the object is travelling is suddenly reversed	1	
		This occurs when something hits a vertical wall	1	
		very large acceleration is required	1	
		example e.g. ball bouncing against a wall	1	
		OR tennis ball hit by tennis racket		3
		MAXIMUM 3		
		C.		
		acceleration going from zero to a high value	1	
		example e.g. letting go of a ball, dropping an egg	1	
		acceleration changes suddenly as the force holding the object in place is removed	1	3
		D.		
		e.g. constant force being applied drops to zero suddenly	1	
		example e.g. taking foot off car accelerator	1	
		OR ceasing to pedal bicycle		
		so zero subsequent acceleration	1	3
		[Overall 1 for explaining what is happening 1 for sensible example 1 for relating example to sketch graph]		

2	(a)	Kirchhoff's (first) law OR conservation of charge	1	
		for electric current into house must equal current out of house	1	
		need for difference in potential for a current	1	
		gas supply is used in the house (chemically)	1	
		waste gas (combustion products) go up the chimney	1	3
		MAXIMUM 3		
	(b) (i)	unit of Q/t is $J\ s^{-1}$		
		unit of A is m^2		
		unit of $(\theta_2 - \theta_2) / d$ is $K\ m^{-1}$ (allow $°C\ m^{-1}$)	1	
		reorganise to unit of k is $J\ s^{-1} / m^2\ K\ m^{-1}$	1	
		unit of $k = J\ s^{-1}\ m^{-1}\ K^{-1}$ OR $W\ m^{-1}\ K^{-1}$ OR $kg\ m\ s^{-3}\ K^1$	1	3
	(ii)	$Q/t = 0.35 \times 12 \times (22 - 8)/ 0.10$	1	
		$= 588\ J\ s^{-1}$ or 588 (W)	1	2
	(c) (i)	$Q/t = I = V/R$ $R = \rho l/A$	1	
		$Q/t = AV/\rho l$	1	2
	(ii)	1. $(\theta_2 - \theta_2)$ OR temperature difference	1	
		2. $1/k$	1	2
	(d) (i)	$V/t = Ap/cl$ OR $m/t = Ap/cl$	1	
		where V/t is volume of gas per unit time		
		m/t is mass of gas per unit time		
		c is a constant and	1	
		p is the pressure (difference)	1	3
	(ii)	$V_1 /160 = 22^2/15^2$	1	
		$V_1 = 160 \times 484 /225 = 344$ ($cm^3\ s^{-1}$)	1	2

3(a)	Force per unit (positive) charge (allow potential gradient)	1	1
(b)	A tangent to the curve at A away from the frame (NOT directly away from the rod)	1	1
(c)	negative		
	(induced) charge due to presence of + charge on rod (even though at zero potential)	1	1
(d)	ring approximately half way between 200 V and 300 V	1	1
(e) (i)	$E = \Delta V/d$	1	
	values e.g. 100 V across 0.7 cm; 300 V across 2 cm	1	
	E = 100 / 0.007 = 14 000; 300/0.02 = 15 000	1	
	V m^{-1} OR N C^{-1}	1	4
(ii)	Force = EQ	1	
	= 15 000 x 1.6 x 10^{-19} = 2.4 x 10^{-15}	1	
	to the left	1	3
(f)	e.g.		
	3 ceramic magnets	1	
	south poles inwards	1	
	top of a magnet between them	1	
	north pole upwards	1	3
	MAXIMUM 3		
(g)	e.g. <u>All matter has gravitational field towards it</u>	1	
	an object emitting gravitational field is impossible	1	
	long rectangular bodies are not found in space	1	
	gravitational field in the laboratory is mostly just that due to the Earth	1	
	this is just a parallel field	1	3
	2 reasons required up to two for each reason, properly explained		
	MAXIMUM 3		

4 (a)(i)	shortest: gamma	1	
	allow any wavelength between 10^{-12} and 10^{-16} (m)	1	
	longest: radio	1	
	allow any wavelength between 10^{2} and 10^{5} (m)	1	4
(ii)	candidates ratio e.g. $10^{4} / 10^{-14} = 10^{18}$	1	1
(iii)	e.g. $10^{18} = 2^{x}$	1	
	x = 18/lg 2 = 60	1	2
(iv)	knowing equation and what each term means	1	
	e.g. $E = hc/\lambda = 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / 10^{-14}$		
	$E = 2 \times 10^{-11}$	1	2
(b)	e.g. all are transverse waves	1	
	so all can be polarised (under suitable conditions)	1	
	all can travel in a vacuum	1	
	at the same speed	1	
	MAXIMUM 2 for first part		
	Discussion of other wave phenomena and how they change as wavelength changes		
	e.g. diffraction		
	refraction		
	or such things as		
	the sensitivity of the eye to certain wavelengths		
	photographic film for certain wavelengths		
	heating effect, particularly of infra-red		
	radio and its effect on electrons		
	quantum effects – minimal for radio, predominant for gamma		
	4 marks can be given as 2,2 or 2,1,1	4	6
	i.e. 2 topics dealt with fully or 1 topic dealt with fully and 2 topics outlined		

Subject: Physics Practical A2

Paper number: 2826/03

Session: January 2005

Final Mark Scheme

Maximum Mark	**60**

Planning Exercise

A1 Diagram showing workable arrangement of apparatus **1**

A2 Workable method **1**
(i.e. measure diameter and torque; change radius of wire and repeat)

B1 Method of measuring angle of twist (e.g. pointers attached to wire/mirrors) **1**

B2 Use of protractor(s) to measure angle of twist **1**

B3 Method of applying couple to wire **2**
(e.g. two pulleys with loads and strings attached to cylindrical mass on end of wire)
Allow one mark if no cylinder shown

B4 Method of measuring diameter of wire **1**
(e.g. micrometer screw gauge or travelling microscope)

C Use constant length of wire **1**
(or use wires made of same material)

R Evidence of research of material **2**
i.e. at least two references given OR it must be clear from reading the account that an appropriate research has been done (e.g. couple α r^4)

D1-4 Any further relevant detail, e.g. **4**

Measure diameter of wire at several places along its length and average
Wire supports a load to keep it under tension as the couple is applied
Use of (pin) vice to grip wire
Torque = 2 x load x radius of cylinder
Top end of wire shown to be fixed
Any reasonable safety precaution
Maintain constant temperature during experiment
May be problems with elastic limit
Use long length of wire to give large deflection for small torque

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

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

16 marks for this question.

Question 1

(a) (ii) First value of *w* (= 6.0 cm $\pm$ 0.1 cm) **1**
Value must be given to the nearest millimetre.

(a) (iv) Repeats of raw times and correct calculation of period **1**

(b) (i) Percentage uncertainty in *w* **1**
(0.1/6.0 x 100 = 1.7% or 2%. Allow uncertainty of $\pm$ 1 mm in *w* to give 4%)

(b) (ii) Travelling microscope/vernier callipers/micrometer **1**

(b) (iii) Calculation of number of oscillations **2**
Absolute uncertainty in *t* is 0.1 s to 0.4 s: 1 mark
Relative (or %) uncertainty in *T* = *N* x relative (or %) uncertainty in *w* (or equivalent correct reasoning): 1 mark

(b) (iv) Reason for fiducial marker at equilibrium position of rule. **1**
(e.g. less time spent by rule at equilibrium position/marker cannot be placed at max. displacement as amplitude decreases)

(b) (v) Damping **1**

(d) Readings **3**
Write the number of readings as a ringed total by the results table.
6 sets of readings scores 1 mark. Check a value for lg(*T*/s) and a value for lg(*w*/cm). Underline checked values. Ignore small rounding errors. Tick if correct. Score one mark each. Allow ln values. If incorrect then write in correct value and -1.
If minor help is given, then -1. If excessive help is given 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) Most raw times > 20 s **1**

(d) Quality of results **2**
Judge by scatter of points about the line of best fit. 6 trend plots with little scatter scores two marks. 6 trend plots with fair scatter, or 5 trend plots, scores one mark. The plots must occupy more than two large squares in the *y*-direction for 2 marks.

(d) Column headings **1**
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 *w* and *t*. Expect to see *t* to either 0.01 s or 0.1 s.
Expect to see all the values of *w* given to the nearest millimetre.
Indicate using $\checkmark_C$ at the foot of each column of raw readings if correct.

(e) (i)	Axes Each axis must be labelled with a quantity and a unit. Scales must be such that the plotted points occupy more than 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, etc.).	**1**
(e) (i)	Plotting of points 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 this mark 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.	**1**
(e) (ii)	Line of best fit There must be a reasonable balance of points about the line of best fit. If one of the plots is a long way from the trend of the other plots then allow this plot to be ignored when the line is drawn. One mark can be awarded if the line of best fit is 'reasonable', but not quite right.	**1**
(e) (iii)	Measurement of gradient The hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Please indicate the vertices of the triangle used by labelling with Δ. 1 mark for correct read-offs: 1 mark for negative gradient.	**2**
(e) (iii)	*y*-intercept Check the read-off. Accept correct substitution from a point on the line into $y = mx + c$.	**1**
(f) (i)	$\lg T = n \lg w + \lg k$ This can be implied from the working.	**1**
(f) (i)	Value for *n* (<u>from</u> <u>gradient</u>). Ignore unit.	**1**
(f) (i)	Value for *k* (<u>from</u> <u>$10^{y\text{-intercept}}$</u>). Ignore unit.	**1**
(f) (i)	SF in *n* and *k*. Allow 2 or 3 sf in both quantities	**1**
(f) (ii)	Value of *w* for $T = 120$ s ecf from (i). Method of working must be correct.	**1**
(f) (ii)	A thin strip may be too weak to support the half metre rule It may be too difficult to support the rule horizontally with such a thin strip of paper. Too difficult to accurately cut the paper strip this thin.	**1**

28 marks for this question.

Question 2

(a)	Measurement of mass and temperatures	**1**
(b)	Thermal energy given to water One mark for correct temperature rise One mark for correct substitution into $Q = mc\Delta\theta$ One mark for correct answer with a correct unit (Joule) Muddled units (grams/kilograms) – one mark penalty	**3**
(c)	Specific heat capacity of metal One mark for correct temperature fall One mark for correct working and value Allow error carried forward from **(b)**.	**2**
(d)	Evaluation of procedure Relevant points must be underlined and ticked. Some of these might be:	**8**

Heat given to plastic cup
Use $mc\Delta\theta$ for the plastic cup
Heat given to thermometer
Use thermocouple (or thermometer with small heat capacity)
Heat lost by metal on transfer to plastic cup
Place plastic cup close to beaker of boiling water
Hot water transferred with metal to plastic cup
Heat lost by plastic cup to surroundings as metal cools down
Insulate the plastic cup to reduce heat loss as metal cools down
Use water below room temperature so heat loss = heat gain from room
Thermometer reading may be inaccurate
Small temperature rise of water gives large percentage uncertainty in $\Delta\theta$
Use smaller amount of water or larger mass of metal
Rusting on surface means sample is not pure
Clean sample before use

Allow other relevant points (8 maximum). Marks can 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 for this question.

Sample results for torsional oscillations of 50 cm rule.

w/cm	t_1/s	t_2/s	*T/s*	*n*	*log (T/s)*	*log(w/cm)*
6.0	20.91	20.87	4.18	5	0.621	0.78
5.0	25.94	25.95	5.19	5	0.715	0.70
4.0	34.79	34.46	6.93	5	0.841	0.60
3.0	50.03	49.96	10.0	5	1.000	0.48
2.0	97.40	94.92	19.2	5	1.283	0.30
1.0	77.15	79.45	39.2	2	1.593	0

Period is dependent on amplitude (can be $\pm$ 10%)

$\lg T = n \lg w + \lg k$

n = gradient = -1.3

log k = y-intercept = 1.62, therefore k = 39.8

When T = 120 s, w = 0.44 cm

Sample results for specific heat capacity of metal experiment

Initial temperature of water = 21 ^{O}C

Final temperature of water = 28 ^{O}C

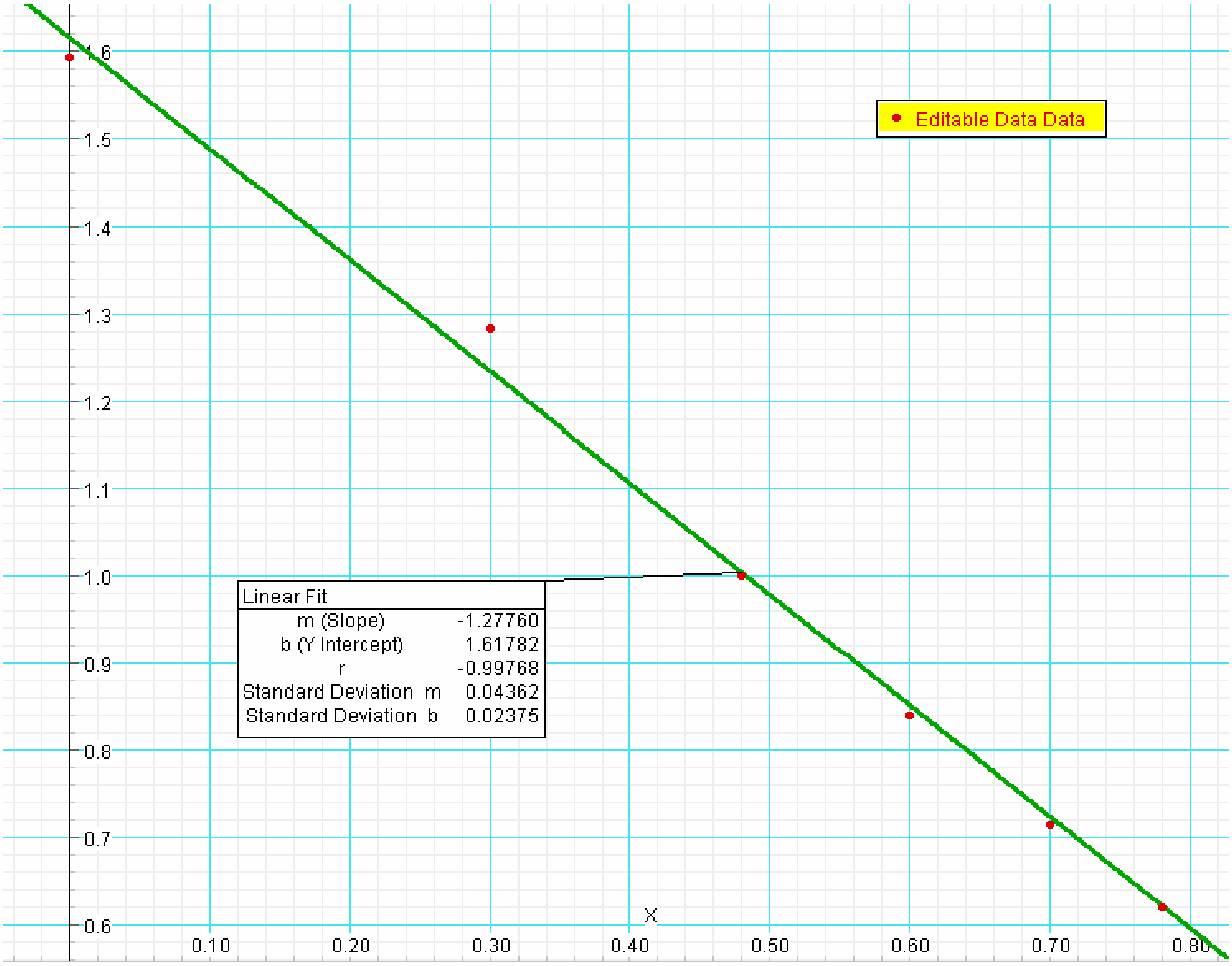
Mass of water = 81 g

Heat lost by iron = heat gained by water

0.1 x c x (100 – 28) = 0.081 x 4200 x (28 – 21)

Therefore c = 330 J kg^{-1} K^{-1}

Graph of sample results for question 1



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

SFP	Significant figure penalty
ECF	Error carried forward
AE	Arithmetical error
POTE	Power of ten error
NV	Not valid
NR	Not relevant
NBL	Not best line
NOL	Not on line
FO	False origin
NGE	Not good enough
MU	Mixed units
BOD	Benefit of the doubt
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
✓$_{\Delta}$	Used to show that the size of a triangle is appropriate
✓$_{M3}$	Used to show the type of mark awarded for a particular piece of work
✓$_{C}$	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

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 and 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 less than in previous years. The mean mark for candidates this session was 4 marks lower than that obtained in the January 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 experiment for the Young modulus of a metal wire in question five. There seemed to be more Centres this year where the candidates did not appear to have covered all the topics in the specification. 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 14 out of 20. Questions three and four then proved more of a test with a wide range of performance becoming evident. The better candidates were able to demonstrate their greater ability in interpretation and explanation. There were a few sections on the paper in which even the most able failed to score as highly as was expected. 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, coping well with the recall of formulae and definitions. 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 correct with the vast majority of the candidates finishing the paper in the required time. However, a significant minority of candidates failed to complete some of the latter parts of question five and appeared not to have allocated time adequately to each question or were not prepared for this type of question. 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 to spell the required technical terms correctly.

Comments on Individual Questions

Question one

In part (a) few candidates scored less than three marks. The common errors were to give weight as a scalar quantity or density, power or energy as a vector quantity. In part (b)(i) the majority of answers were correct. However some calculated the total distance for the ball to return to the staring point and then gave the average velocity as zero. It would appear that these candidates did not read the question carefully. Very few confused speed and velocity but a significant minority gave velocity as speed divided by time. The last part of the question was set to test those of high ability and was reasonably successful. Candidates were able to suggest that distance and displacement were different but few gave the displacement as being always less than or equal to the distance because it was taken as being in a straight line from the start tot the finish. Many weaker answers merely gave the difference between a scalar and a vector and this was not asked in the question.

Question two

In part (a) correct definitions such as no resultant force and no resultant torque were given by the average to good candidates. The weaker candidates gave poor unacceptable answers. Such answers as forces are balanced, the system is at rest or upward forces equal downward forces were not given any credit. In part (b)(i) the good candidates generally accepted the help given to candidates of the point to take moments about and many gave the correct analysis. However there were a number of candidates that continued to show confusion with this type of question. Often different pivots were used for the given forces and on some occasions the same force was used for two different pivot points. Many candidates could only give one correct moment or after calculating the clockwise moments correctly could not equate this with the anticlockwise moments. The second calculation was often more successful for the average candidate as the idea of equilibrium was used to quote that the resultant force had to be zero. In part (iii) the average and able candidates were able to score the first two marks. The last mark was considered a high level mark but not many candidates continued the explanation with the idea that the total upward force still had to maintain equilibrium and the force at A and the force at B had to have a constant total. A significant number of candidates thought that the force at A would increase as the painter approach that point. Perhaps they should experiment with a plank on their shoulder and a heavy load moved towards their point of support.

Question three

Part (a) was answered correctly by many candidates but a number often used speed or did not give the change in velocity in their definition of acceleration. Some answers gave an equation with no explanation of terms and therefore did not score. It was apparent that some candidates missed answering part (b). Candidates should be advised to read the entire question carefully and ensure that they answer all parts to questions using the number of marks in the square brackets as their guide. This part was a 'show' and full explanation or working must be given in such questions. Hence the distance is the 'area under the graph' was required for the first mark. In part (c)(i) few candidates were able to calculate the acceleration correctly with many errors being made in the conversion of the 20 ms into seconds. The correct signs for the initial and final velocities were seldom used correctly even by the most able candidates. The graph was only correctly completed by the able candidates. Both these parts were aimed at the high ability candidates. In part (d) many scored two or three marks. Only the weaker candidates failed to give the correct unit or quote the equation for the change in potential energy. One mark was sometimes lost due to only one significant figure being given. In part (d)(ii) many misread the question and considered only the change from potential energy into kinetic energy.

Question four

In part (a) the majority of candidates answered part (i) the definition of work correctly but many did not include that the distance was in the same direction as the direction of the force. Many could not define the watt and confused units with quantities and gave the definition of power. In part (b) the kJ was frequently missed on the graph and hence the gradient was calculated incorrectly. The error was continued consistently in the calculation for the acceleration and therefore full marks were obtained in (b)(iii). The link between work and kinetic energy was seldom given by candidates in (b)(ii). Part (b)(iv) the correct link between deceleration and increased mass was given by many candidates. However, a significant number did not read the question and discussed the need for an increased force or that the initial velocity would be different.

Question five

Part (a) was often answered correctly but a significant minority failed to include the original length in their definition of strain. The answers to part (b) varied from centre to centre. Many poor answers had a wire supported from a stand and clamp. Diagrams were often poorly drawn with ink diagrams being common and many were drawn without the use of a ruler. The candidates that used an arrangement along a bench often did not mark the length of wire being investigated correctly and the marker used for noting the extension was often placed near to the clamped end of the wire. The measurements required were correctly quoted by many candidates but often the area was given as a quantity that was measured directly. The method of taking the measurements varied considerably. Many could not give the name of the micrometer used for the diameter or used it to measure the area or failed to determine the value for the masses using a balance. A sizeable minority failed to use a graphical approach to determine the value for the Young modulus. Below average students were able to score a number of marks on this question (as was intended for this question) but this did depend greatly on whether this topic had been covered.
Many candidates did not read the question through before starting their answer. Hence there was little order to the presentation of their description of the experiment.

2822 Electrons and Photons

General comments

The module paper gave a good spread of marks, with some excellent scripts from Centres with a larger number of candidates. A significant number of candidates secured more than 50 marks and the proportion of weaker scripts were on par with previous January sessions. For some candidates, manipulating equations remains a daunting task, but in general, analytical solutions were well presented and due consideration was given to significant figures and units. It is worth reiterating that candidates cannot secure marks for substituting numbers into an incorrectly recalled equation. It is a great pity that a significant number of candidates cannot recall the basic equations and definitions from the 2822 specification.
The Quality of Written Communication (QWC) was assessed in **Q4**. The standard of spelling and grammar was marginally better. The vast majority of the candidates finished the paper in the allotted time but there was some evidence of rushed solutions towards the end of the paper.

Comments on Individual Questions

Question One
The majority of candidates made good start with **(a)** by demonstrating a clear understanding of the difference between electron flow and conventional current. The most popular statement was that '*the directions are opposite*'. In **(b)**, it was very rare to find a correctly drawn symbol for the LDR. The majority of candidates drew a symbol for a resistor with a single arrow pointing towards it. There were a considerable number of poorly drawn symbols, some clearly hybrids of component symbols. For the LDR symbol, it was not uncommon to find symbols for a thermistor, a variable resistor or a photodiode. A disappointing number of candidates failed to recall how the resistance of the LDR was affected by the intensity of light. A disturbing number of candidates wrote that '*the resistance of the LDR increases as the light intensity increases*'. The answers for Ohm's law in **(c)** were quite disappointing. For many candidates, '$V = IR$' represents this important law. Weaker candidates made correct reference to temperature being kept constant, but then spoilt their answer by stating that the resistance was directly proportional to the current or the potential difference. The most challenging part of the question was **(d)**. The sketches for Fig.1.2a and Fig.1.2b were either poor or simply incorrect. For many candidates, the resistance of the metallic conductor was directly proportional to the voltage V. A straight line through the origin in Fig.1.2a illustrated this incorrect physics. Only a small number of candidates managed to sketch the correct variation for the resistance of a thermistor. Sadly, the majority of sketches for the thermistor graph were grossly incorrect and candidates made no use of the important information given in Fig.1.1b. The descriptions in **(d)(ii)** lacked clarity, but many candidates did appreciate that the resistance of the metallic conductor increased at the higher temperature and the resistance of the conductor doubled when its length was doubled.

Question two
This was a well-attempted question with many candidates securing high marks. The majority of the candidates correctly identified '*magnetic flux density*' as the answer to **(a)**. However, some candidates did opt for the '*tesla*' or '*magnetic flux*'. The answers to **(b)** were quite pleasing, with most solutions showing clear development of ideas. In **(c)**, candidates had a good comprehension of Fleming's left-hand rule. Some candidates referred to the thumb as the '*first finger*'. A range of answers was given for **(c)(ii)**, but on the whole, candidates either wrote '*out of paper*' or '*up toward me*' and picked up a mark. Questions similar to **(d)** have appeared in numerous other papers, so it was comforting to find that that the majority of the candidates had done the preparation and gained full marks. A small number of candidates got the value of the flux density as 0.018 T because of their failure to convert the current from

milliamperes to amperes. A small number of candidates had severe problems rearranging the equation $F = BIL$. There were no marks awarded for candidates started off with the wrong equation $B = \frac{IL}{F}$. Poor algebraic skills are the Achilles heel of many candidates.

Question three

In spite of **(a)** being studied at GCSE level, a disturbing number of candidates gave poor definitions for the kilowatt-hour. Some answers showed a total lack of understanding with statements like: '*The kWh is the amount of power used per hour'*. Full credit was given to a candidate for writing '1 kWh = 3.6 MJ', even though this statement is not strictly a definition for the kilowatt-hour. Surprisingly, candidates found **(b)(i)** rather difficult. Two of the most common mistakes were failing to change the power into kW and ignoring the four hours given in the question. The answers were anything from 0.77 kWh to 1.1×10^7 kWh. This gave very interesting high answers for the cost of the energy in **(b)(i)2**, but most candidates did manage to score a mark through the rule of 'error carried forward'. The record cost of using the computer for a period of one week was 83 million pounds. The answers to **(b)(ii)** were much better. The majority of the candidates did well by using $Q = It$ and substituting the correct value for the time. A significant number of candidates used 168 hours rather than 28 hours. A good number of candidates wrote the correct equation for the energy of the photon in **(b)(iii)**. However, a significant number of candidates went seriously wrong by writing:

$$E = hf = h\lambda = 6.63\times10^{-34} \times 5.5\times10^{-7} = 3.65\times10^{-40} \text{ J.}$$

A very small number of candidates even tried applying the de Broglie equation in this question. Candidates who eventually went on to secure grades A or B, encountered no problems and went on to secure full marks for **(b)(iii)2**. For some candidates, the last section of the question proved too overwhelming and the space was left blank.

Question four

This type of question has appeared on many previous papers and the key marking points have been well documented. However, the question once again revealed a range of common misconceptions about matter waves and de Broglie equation. In **(a)**, almost all candidates credited the experiment depicted by Fig.4.1 to be performed and executed de Broglie himself. Weaker candidates were baffled with this question and gave answers more to do with the diffraction of light waves rather than electrons. Most candidates did not appreciate that the diffraction was due to the carbon atoms and the spacing between these atoms. A disappointing number of candidates thought that the diffraction came about because of '*slits'* or '*holes'* in the graphite. Not many candidates took advantage of stating or explaining the significance of the de Broglie equation $\lambda = \frac{h}{mv}$. A good number of candidates did appreciate that the wavelength of the electrons decreased as their speed was increased. However, this was not correctly translated to the appearance of the rings. Some candidates thought that '*the rings get smaller because the electrons do not spend too much time in the graphite*'. The majority of candidates managed to secure both marks for their Quality of Written Communication. Candidates need to be reminded not to write their entire answer in capitals letters when such marks are being awarded in a question. A small number of candidates did quite badly with their spellings. This included words like 'Broglie' and 'diffraction' that were already given in the question. In **(b)**, many candidates made reference to the particle-like property of the electrons when they were hitting the fluorescent screen. However, the question wanted the particle behaviour of the electron within the electron-gun. A good number of candidates mentioned that the electron has mass or charge.

Question five

Candidates generally showed a good grasp of this question. Most candidates gave plausible answers for **(a)**. The most popular response mentioned that the term p.d. was used when '*charges lose energy'* and e.m.f. was used to denote '*charges gaining energy'*. Although many candidates did score full marks for the statement for Kirchhoff's first law in **(b)**, there were some sloppy answers. Some candidates made reference to a '*circuit'* instead of a '*point'* in this definition. Inevitably, some candidates wrote an elegant and flawless statement for Kirchhoff's second law. It was nice to see that most candidates sailed effortlessly through **(c)(i)** and **(c)(ii)**. The most challenging aspect of the question was **(c)(iii)**. Most candidates had severe problems analysing the circuit given in Fig.5.1. Many candidates took the potential difference across the diode to be 10.8 V. Others tried to determine the resistance of the diode as if the diode, the 46 Ω resistor and the 18 Ω resistor were all in a parallel combination. Some candidates even managed to get as far as

$$(0.20 \times R_{diode}) + (0.20 \times 46) = 0.06 \times 18$$

but then were let down by the lack of decent algebraic skills. The majority of the candidates managed to secure a mark for writing one of the power equations in **(c)(iv)** but only a small number of candidates managed to substitute the appropriate values and get the correct value for the power dissipated by the diode of 0.32 W.

Question six

Candidates increasing appear to have a better understanding of the photon and the phenomenon of the photoelectric effect. It is nice to report that this was a reasonably answered question by students of all abilities. The answers to **(a)** were generally quite good with many correct values for the wavelength of ultraviolet radiation. Work function energy was adequately defined in **(b)(i)**, however, some candidates incorrect mentioned that '*the work function was the energy required to remove a photon from the metal*'. The answers to **(b)(ii)** were quite varied. A few candidates wrote down the values of 2.8 or 1.1 for the speed of the photons. A significant number of candidates correctly wrote down the speed light. **(b)(iii)** was the most challenging part of the question. Many candidates correctly applied Einstein's photoelectric equation and managed to get as far as the maximum energy of the electron to be 1.7 eV. The correct answer was not accessible because candidates could not convert the energy from electronvolts to joules. There were many scripts with the kinetic energy of the electron as 1.06×10^{19} J because the answer of 1.7 eV had been divided by 1.6×10^{-19} J. Weaker candidates tried using

$$\text{kinetic energy} = \frac{1}{2} \times 9.11 \times 10^{-31} \times (3.0 \times 10^{8})^{2}.$$

A good number of candidates did manage to either determine the correct maximum speed of the electron or at least apply the correct physics to their wrong answer to **(b)(iii)1**. Some candidates were not deterred by speed that were ridiculously too small or greater than the speed of light in a vacuum. The answers to **(b)(iv)** were generally quite comprehensive and showed a good understanding of intensity in relation to the rate of arrival of photons.

2823/01 Wave Properties

General Comments

The general standard of work was above that of 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 an easy opening question that was answered well by the majority of candidates. In part (a) virtually all were able to correctly identify the symbols given as the speed of light in air and the speed of light in the medium. The most common error was for some students to suggest that the symbols represented the angles of incidence and refraction. In part (b), virtually all were able to quote the refractive index formula in terms of the angles of incidence and refraction and most were able to correctly calculate that the angle of refraction was 31^o. Again, virtually all realised that a ray traveling along the normal (i =0) will be undeviated, making the angle of refraction also 0^o.

Q2. This was also found to be a straightforward question by most candidates. Despite the question stating that fully labelled diagrams were required a minority of candidates chose not to draw diagrams. Some were also careless about labelling the media involved – e.g. glass/air or more/less dense. A mark was allocated for students showing that light must be travelling from a dense to a less dense medium. Almost all could recall the critical angle formula and use it successfully to calculate the critical angle for the ruby/air interface as 35^o.

Q3. Virtually all could correctly state examples of transverse and longitudinal waves, but answers describing the nature of the vibrations involved in each type of wave were less certain. Some used vague language such as vibrations are “up and down” or “back and for” and failed to relate the direction of the vibrations with that of the wave. Most appeared to see the significance of part c) by correctly identifying that longitudinal waves cannot be polarised but that otherwise both waves exhibit all wave phenomena.

Q4 This was a long question which tested candidates’ understanding of what a wave is and how it behaves. Most provided good answers to most parts of the question. Wave amplitude and wavelength were correctly labelled and the majority correctly drew an identical wave slightly shifted to the right. However, a significant number had difficulty in identifying how particles Q and S would move in this short time interval – even if they had correctly drawn the new position of the wave. The most common error was to draw the particles moving along the wave instead of perpendicular to the wave direction. Most could quote that the phase difference between points P and Q was 180^o – the most common errors were to guess that it might be 0^o or 90^o. In part (d) almost everyone scored 2 marks for calculating that the period was 0.04s but there was the inevitable confusion over using the correct units to determine the wave speed. While most realised that the wavelength was 3.6 cm (2x1.8cm) a significant number failed to change the value to 0.036 m thereby losing one mark in the calculation. In the final part of the question most could explain that the wavelength would be halved when the wave speed was halved but few appreciated that it was the depth of water in the ripple tank that determined the speed of the waves.

Q5. This is a regularly examined aspect of the specification and most candidates showed a very good awareness of the double-slit arrangement. Virtually all correctly stated ‘coherent’ in part (a) and explanations of the meaning of constructive and destructive interference were generally very good with helpful diagrams being drawn. In part (c) some candidates recklessly lost marks by failing to answer the question set. Many ignored the instruction to 'list the measurements required to determine the wavelength of the light'. Virtually all could recall the 'fringe separation' formula: $\lambda = ax/D$ but again some were careless in the way they identified the symbols – e.g. indicating the ***a*** was the width of a slit instead of the double-slit separation) and that ***x*** was the fringe width instead of the distance between neighbouring bright (or dark) fringes

2823/03: Practical Examination 1

General Comments

The general standard of the work done by candidates was very similar to last year. Presentation of results and graphical work continues to be done reasonably well. 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 and most candidates were able to complete question one and two without help from the supervisor. 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 reasons where necessary.

Plans are still centre specific. Centres are reminded that the planning sheet should be signed by both the candidate on page two and the teacher on the front page.

Comments on Individual Questions

Plan

Candidates were required to plan an experiment to investigate how the angle of a board depends on the speed of horizontally moving air. It is pleasing to note that the majority of the plans were about an appropriate length. Few candidates reproduced downloaded pages from the internet or photocopied pages.

Parts **(a)** to **(f)** 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.

Most candidates just stated that the angle would be measured using a protractor. Better candidates suggested the use of a larger protractor or trigonometry methods. Some candidates proposed the use of projection methods. Few candidates detailed the use of a plumb line to enable the angle to be measured accurately to a vertical reference point.

The majority of candidates suggested the use of a fan as the method of producing the stream of air and the use of an anemometer to measure the speed of the air. Three speed fans did not gain full credit. Few candidates gave sufficient detail as to where the anemometer should be placed so as to measure the speed of the air as it hits the board.

There are always marks awarded for further detail such as:
the **reason** for the choice of material used for the board,
a correct circuit diagram indicating how the speed of the fan may be changed,
the **method** for producing a **horizontal** air stream,
method for reducing friction where the board is suspended.

Safety precautions should be relevant to the experiment being designed and not general laboratory rules.

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 or chapter numbers or be internet pages. Two or more detailed references score two marks. Two or more vague references 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.

1) In this experiment candidates were required to investigate how the angle between a rule suspended from one end varies with the horizontal force applied to it.

(a) Candidates were initially asked how they would ensure that the thread attached to the rule was horizontal. Most candidates realised the need to measure the height of the thread above the bench at two (or more) places.

(b) Most candidates calculated the force acting by using $F=mg$ and converted grams to kilograms. A few candidates tried to resolve forces using θ. Most candidates assumed that there was no friction in the pulley.

(c) The majority of candidates took the necessary readings with very little help from Supervisors. Large numbers of candidates also repeated the experiment. Generally candidates that repeated the experiment had less scatter on their graphs. Where curved trends were produced it was probably due to candidates not ensuring that the string was horizontal.

A significant number of candidates did not calculate tanθ.

Results tables were generally well presented with the majority of candidates labelled the columns with both a quantity and the appropriate unit. Some candidates omitted to record the mass values. It is expected that all raw data should be included in a table of results.

(d) Candidates were asked to suggest an improvement to the experiment. Vague answers such as "use a more accurate protractor" did not gain credit. "Repeating the experiment" did not gain credit since it is hoped that candidates would do this as part of their standard laboratory procedures. Marks were awarded either for using trigonometry to calculate tanθ or the use of a larger protractor.

(e) Graphical work was generally done well. Weaker candidates often used either less than half of the graph grid or awkward scales particularly in the *x*-direction where 0.098, 0.196, etc. was seen on several occasions. There were also a larger than usual number of candidates who did not label the axes. Points were usually plotted accurately to the nearest half square. The majority of candidates drew their line of best fit with a fair balance of points. Again a significant number of candidates lost marks by forcing their best fit line through the origin.

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 clearly indicate the points that they have used and show their calculation.

(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 **(e)(ii)** to determine a value for *m*. Candidates who substitute values from their table of results into the given equation did not gain credit. Good candidates equated the gradient to $2/mg$ and gave an answer in kilograms. Some weaker candidates equated the gradient to *k*. It is expected that candidates should also give their final answer to an appropriate number of significant figures. A number of candidates gave answers to 4sf, 5sf etc.

(g) Candidates were asked to measure the mass of the rule using a top pan balance and comment on the two answers which they obtained. Weaker candidates often gave a vague comment such as "they are different". There were four answer line given for this part which should indicate to candidates that some detail was required. Good candidates often compared the two values quantitatively often by finding a percentage difference. It was hoped that candidates would perhaps refer to the scatter on their graphs.

2) In this question candidates were required to test a relationship between the speed of waves and the depth of water and then write an evaluation of the procedure. Some candidates were confused between the depth of water *d* and the length of the tray *l*.

(a) Good candidates explained that to measure the depth the rule was vertical or several readings were taken so that an average cold be found.

(b) To determine the speed of the wave it was expected that there would be some evidence of speed = distance/time. Some candidates attempted to use $v=f\lambda$.

(c) Weak candidates often did not attempt this part. Other weak candidates determined the percentage uncertainty in v by estimating the absolute uncertainty in v. Very good candidates determined the percentage uncertainties in both l and t using appropriate values for Δl *and* Δt before adding these percentage uncertainties to determine the percentage uncertainty in v. Too often candidates quoted Δt as 0.01 s without any thought to reaction time.

(e) The majority of candidates calculated a larger value of v for the increased depth.

(f) Candidates were asked whether their results supported the relationship given between v and d, explaining there reasoning clearly. No marks were awarded without reasoning. Weak candidates often stated that "as d increases v increases". 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" or "use a video" without explanation did not gain credit.
Some credit worthy points are:
<u>Reason</u> for difficulties in timing (e.g. starting and stopping stopwatch/reaction time)
<u>Reason</u> for difficulties in measuring length/depth (e.g. uneven base/sloping sides/surface tension/refraction
Use a longer tank to reduce percentage uncertainty
Measure d in different places and average the results
Problems with amplitude of wave decreasing with many reflections
Add dye to the water
Touch the surface with a <u>bar</u> to produce the wave
Time for reflection may be significant
Two readings of v and d are not sufficient to verify the suggestion
Take many readings of v and d and plot a graph
Use two people
Transparent tray with markings
Video etc <u>with</u> detail
Improvements to tray (e.g. vertical sides, flat base)

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. Candidates appeared to have adequate time to complete all questions. In fact the majority wrote two full sides on Q7. Very few left parts of questions unanswered. 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 Q1 and Q4. Candidates should be reminded that it is important that they must not only show their working but also explain or justify it in order to gain full marks. This is especially true in Q2(a)(i), Q3(b), Q4(b)(i) and Q5(b)(i) in this paper. Candidates should also be reminded that it is worthwhile allowing adequate time to draw graphs and/or diagrams carefully if they wish to gain full marks. For example, some sketches of the sinusoidal curves in Q1 and Q6 lost marks through lack of care. The use of a ruler to answer Q3(a) gave candidates a much better chance of gaining the quality mark allocated to this part of the question.

Comments on Individual Questions

Q1 (a) Most candidates obtained full marks. A few thought that the acceleration was inversely proportional to the displacement. Candidates should realise that *proportional* means a linear relationship passing through the origin. Many considered a statement that the graph was a straight line was an adequate explanation of this point.

(b) Most candidates obtained the correct amplitude. A few wrote the amplitude to be 50 m; others change the ‘m’ to ‘mm’. The second part was a good discriminator with the better candidates obtaining full marks. Weaker ones were unable to relate the gradient of the graph to $4\pi^2f^2$.

(c) Almost all candidates scored at least two marks for the sinusoidal curve. A few did draw a sine wave. Again most realised that the kinetic energy is a maximum when the displacement is zero. Overall this was a high scoring question for most candidates.

Q2 (a) Many candidates used the numbers to obtain the correct answer but did not show that they knew what they were doing. The examiners were looking for at least a minimum statement such as mass/s = density x volume/s. Most realised that the speed of the water doubled but then failed to apply Newton’s Second law in terms of change in momentum per second. It was common to find the formula F = ma stated but with no follow on to a = (v-u)/t and appropriate substitution. Whatever had been written before, most candidates gave the correct direction of the force on the shower head.

(b) Most candidates obtained the correct answer for the power of the shower but a few gave the unit as joules and not watts. A few got themselves tied up by using the kelvin scale of temperature. Some of the reasons for more power being required were rather vague or inconsequential missing the main points. However most answers gained the mark. The most common wrong answer for the final temperature was 24 ^{o}C instead of 39 ^{o}C.

Q3 (a) Most candidates scored marks for this part. Many did not give the direction of the field lines and others lost the quality mark because the lines were too short or not straight enough or not giving the impression of being equally spaced.

(b) Some candidates lost a mark by omitting the formula E = V/d. Almost all were able to arrive at the given value for the electric field strength

(c) Many candidates obtained full marks for the force calculation, but too many introduced an equation including the magnetic field strength B in it. They did not seem to know the definition of an electric field F =QE.

(d) Only the better candidates appeared to be able to find the minimum speed of an electron. Both methods (i.e. energy method and force method) were used by good candidates to obtain the correct answer.

(e) Again only the best candidates obtained the correct answer. The most common wrong answer was double the answer for part (d).

(f) Most candidates failed to realise that the negatively charged electrons were repelled more strongly by grid B. It was common for only the part of the path from B to C to be considered. Also a common erroneous argument involved V=IR to reach the conclusion that the current would increase.

Q4 (a) This was the best answered question. Very few candidates were confused by the units until asked to calculate the resistance. Almost all knew that the time constant T = RC but some then used 8 F for C and so obtained a value for R a million times too small. The last part proved to be a good discriminator for the better candidates. Many candidates obtained 1 mark for this part but failed to give a full answer, for example, in terms of a constant fraction in equal time argument.

(b) This part was done well. Most candidates made it clear enough how they added capacitances in series and parallel to obtain full marks. The most common error was to write their answers carelessly by stating that ½ = 2 at the end of their argument; forgetting that the subject of the equation was still 1/C. The diagrams for the capacitor arrangement for the last part were mostly very good.

Q5 (a) The explanation of the terms often lacked clear thinking. For example some candidates said ‘activity was the amount of decays per second.’ Others said ‘it was the rate of decays per second.’ Many were not able to give a satisfactory answer. Usually either a correct answer was given to explaining the term background rather than background count rate or the word 'background' was repeated here without any further explanation. The second part was only answered correctly by a few candidates. Many thought the constant in the given equation depended on the size/mass of the source or was the decay constant, so discussed the decay constant being related to the half life, etc. Only a few realised that the constant related to the geometry of the situation or the tube efficiency.

(b) Some candidates failed to justify the linear form using expressions like 'multiply both sides by ln' or ‘ln e cancels’ or by just stating the final equation as given. There were also many candidates who knew clearly what to do. Despite being given an equation for a straight line graph and a linear graph, only good candidates could do this part. Most did not know how to relate the equation to the graph and when they did, they were unable to obtain the correct gradient.

(c) Many candidates obtained full marks for this part but a significant number also failed to do so because either they did not compare the two decays as asked or they did not give a sufficiently detailed contrast to deserve the marks. For example it was not good enough to say that the mass changes were different. Detail such as a change of four nucleons against no change in mass was required

Q6 (a) Many candidates obtained full marks for this part. The most common mistake was to take 0.050 to be the area of the coil. Some gave the unit as 'W' for weber and others as 'T'. Another confusion was to quote the magnetic field strength definition formula, $F = BIl \sin \theta$ instead of the one for magnetic flux.

(b) This part was a good discriminator, with only the best candidates gaining full marks. The most common mistake was to place 'X' at a point where the voltage was 50 mV and the explanation for this (although most knew that the induced e.m.f. was proportional to rate of change of flux linkage) was that the induced e.m.f. was largest when the flux linking the coil was largest. Again good candidates scored full marks for drawing the new graph. Weaker candidates either missed the fact that the amplitude doubled or did not realise that the time period halved, scoring only 2 marks out of 3.

Q7 (a) Nearly all candidates scored some marks on this question. On average, part (a) was answered much better than (b). Most good candidates obtained the 7 marks for part (a). Many candidates described the experiment but did not link the observations with the results or just described the experiment and so lost marks. A majority of the candidates do not appear to be able to distinguish between the following words *reflect*, *scatter*, *diffract* (or *defract*), *refract*, which they seem to use indiscriminately, having no regard whatsoever for their defined meanings. Many candidates did not understand the reasons for or results of using high speed electrons in place of alpha-particles.

(b) This final part was not answered as well as part (a). Good candidates and those who had obviously covered this subject in some detail gained high if not full marks. On the other hand, some candidates referred to X-ray diffraction. Many candidates knew the de Broglie equation for the wavelength but some said that the energy of the electrons was given by $E = hf$. Some candidates gave good diagrams of the apparatus used but few candidates showed the rings produced by the diffraction or diagrams showing diffraction from the layers of a polycrystalline material. Most were aware that significant diffraction can only be observed when the de Broglie wavelength of the electrons is close to the spacing of the atoms in the lattice. The quality of presentation and the standard of writing have maintained the same higher standard reached after the first two or three examinations. There were also more attempts, sadly not always useful, at drawing diagrams in the space provided.

2825/01: Cosmology

General Comments

The exam was taken by approximately 130 candidates. The entry covered the full ability range and many scripts showed evidence of careful preparation . The large majority of candidates made attempts at all parts of the paper, but some made little or no progress with the last question. This part of the paper is assigned 20 marks and candidates are well advised to give it due attention. Standards of presentation are generally good: graphs were plotted and drawn accurately and ray diagrams were clear. Some candidates, having drawn a graph in pencil, needlessly went over the line in ink. This uses up time and if the lines are not very well matched, risks the loss of marks by having effectively drawn two separate curves.
Candidates generally benefit by including equations as part of their answer when appropriate and by checking numerical calculations, particularly those involving powers of ten. The use of logarithms continues to present problems for some. A good start is to quote the correct equation and then substitute data, as this will always gain credit; indeed this is probably a sensible approach to all numerical calculations.

Comments on Individual Questions

1. **(a)** The Copernican heliocentric model, with planets moving in circular orbits was well known. Fewer candidates referred to the constant speed of planets.
(b) Kepler's model was also well known. Almost all candidates understood the progression to elliptical orbits; about half of candidates stated that the orbital speed was not constant and relatively few referred to the position of the Sun. On this latter point, it was insufficient to say that the Sun was no longer at the centre; reference to the focus of the ellipse was required.

2. (a)(i) A few candidates gave $T^2 = 4\pi^2r^3 / GM$ as Newton's law. Some answers confused force and field strength but otherwise this mark was gained on most papers.
(a)(ii) This point has not been asked frequently in past exams, but the majority of candidates correctly understood why Newton required an infinite (and static) universe.
(b)(i) This question was aimed at the background to Kepler's 3rd law. Some good explanations were seen in terms of decreasing gravitational force which was related to centripetal force and speed. Candidates who derived $T^2 = 4\pi^2r^3 / GM$ gained full marks.
(b)(ii)The relationship for Kepler's 3rd law was well known and a good proportion gained full marks. The errors here were almost entirely arithmetic in the use of cubes, squares and their corresponding roots. Candidates who worked in km and years were more likely to be successful than those who converted the data to metres and seconds.
(c)(i) Apparent brightness was known by just about all candidates.
(b)(ii) About a quarter of candidates gained full marks on this calculation, while a similar number made no attempt all. When errors were made, they occurred at all stages. As mention earlier, it is evident that a number of candidates are not confident in the use of logarithms.
(d) Many good reasons were offered and it was pleasing to see that a good number of candidates appreciated issues such as dish diameter and

exposure to radiation. The suggestion or implication that land-based telescopes are stationary was not uncommon.

3. (a) That the intensity of background microwave radiation is uniform was well known, but few referred to the directional characteristics. Candidates who wish to discuss the variation of intensity should make clear that the changes, or ripples, are *very* small to gain credit.
(b) In answering this question many candidates did not make a comparison between the two stars. Candidates were able to discuss the Sun in some detail; many new that early stars contained both hydrogen and helium, but fewer than about half of candidates stated both points together. That the Sun contains traces of higher elements was very well known, but a comment on this aspect of early stars was necessary to gain the mark.
(c) The principle of spectral analysis was known by many candidates and there were many good descriptions of absorption lines together with identification by comparison with the corresponding emission spectra. The most common area of confusion was to state that the received light came in the form of line emission spectra. Relatively few candidates stated that the spectra provide information about the Sun's atmosphere only.

4. (a) Most candidates marked the position of M correctly in the left side of the main sequence on the HR diagram and nearly all candidates knew the position of white dwarfs.
(b)(i) Most candidates discussed the presence of red giants and white dwarfs with little difficulty but only a small number compared the range of masses in the two galaxies, despite the prompt given in the first part.
(b)(ii) Relating the presence or absence of red giants and white dwarfs to timescale proved to be straightforward but few candidates realised that large mass stars burn hydrogen quickly and consequently are relatively short-lived.

5. (a) This question generated a wide range of scores. The idea of red-shift and the recession of galaxies was explained by many, but a reference to the calculation of velocity from this change in wavelength was not always included. The link between velocity and distance was frequently referred to, but candidates were generally shy of quoting Hubble's law. That Hubble had to obtain data on the distance of the galaxies was overlooked by many.
(b) Candidates successfully used the opportunity to describe the motion of stars within our galaxy, but it was sufficient to point out, for example, that blue-shifts show some stars are moving towards us. The erroneous idea that the proximity of stars within our galaxy leads to immeasurably small redshifts was attractive to some candidates.
(c) The relationship between time and the Hubble constant was recalled in many answers and most were able to attempt a conversion to SI units. Candidates that converted parsecs to light-years and thence to seconds were prone to making arithmetic errors or omissions. The most successful answers were generally those that used the smallest number of steps but in this question it was very much in the candidates' best interests to show all their working out.
(d) The conditions for an open, closed or flat Universe have been examined several times and all candidates knew at least two of the possible outcomes. Many scripts contained very well written answers with clear explanations and it was not uncommon for sketch graphs to be added, but these were not considered without labels. A recurring error was to compare the critical *density* with the total *mass* of the Universe and while many were aware of

uncertainties in our knowledge of the Universe's mass, fewer appreciated the implications of not knowing a precise value for ρ_0 or H_0.

6. (a)(i) Graphical skills were good and there were few errors plotting points. Of these, most were out by 10 on the scale of intensity or a day on the time axis and could have been readily spotted if checked. There were two examples where incorrect points were left on the grid unlabelled, having been re-plotted by the candidate. It seems unnecessary to risk one two marks by not crossing through points such as these.
(a)(ii) Curves were well-drawn, but as already mentioned, it is not necessary to go over a pencil line in ink.
(a)(iii) The peak of the graph was read with little difficulty.
(b)(i) The rays drawn fell into 3 categories, with roughly equal numbers of each example: rays that converged, as with a convex lens; rays that suffered no deviation at all and rays that diverged away from the black hole.
(b)(ii) A good number of candidates made the link between the graph and the Earth's motion, but some decided that the intensity in the position shown must be zero, the black hole pulling in all rays of light.
(c) This was a difficult question, but it was pleasing to see a good number of answers refer to the curvature or bending of space-time and light taking the shortest route. Less common was the explanation in terms of an accelerating frame and the principle of equivalence.

7. (a) This was generally well answered, but a statement such as 'the laws of physics are always the same' is too vague.
(b) Answers showed candidates had been very well prepared for this question and descriptions were generally complete and well-expressed. Diagrams proved helpful in a few instances to confirm a point, but had to be labelled to be considered. Where marks were lost, this was usually due to omission or muddling up the separate scenarios where lights are on the tunnel or placed on the train.
(c)(i) The calculation was completed by most candidates with just a few omitting the conversion of km to m.
(c)(ii) Most candidates realised that the answer was greater than the speed of light and that *c* is a limiting speed.
(d) Many candidates made a sensible calculation to confirm either the period of rotation or the velocity.

1.

2825/02: Health Physics

General Comments

This paper produced a good spread of marks. It was clear that a significant number of candidates were attempting this topic for the first time. Most of these were unable to attempt specific elements of the synoptic question in the paper as the content related to module 2826, Forces, Fields and Energy, and this had not been covered. In general, workings were well explained. Diagrams, however, are still being drawn in a casual way, often in pen and many containing scribbles.

Comments on Individual Questions

Q 1

(a) Most candidates were able to gain marks for a vertical arrow (or arrows at the points of contact of the foot with the ground). Very few candidates labelled their arrow. This was only penalised when more than one arrow (e.g. the weight) was also drawn.

(b) The most common error was to put the frictional force in the wrong direction. Once again it was rare to see any labels on the arrows. The quality of the diagrams was generally poor with many arrows completely missing the point of contact of the heel with the ground.

Q 2

(a) This sketch was poorly drawn by about half of the candidates. It was common to find that a normal person could detect frequencies of less that 10^1 Hz. Little care was taken when drawing the position of the minimum with many graphs putting it at a frequency value of less than 10^3 Hz.

(b) Most candidates discussed the hearing in numerical terms and many were able to correctly compare the hearing with that of a normal person.

Q 3

(a) The most common omission was that of ‘clearly’ or ‘in focus’. Otherwise this was well answered.

(b) A number of responses began with an unexplained numerical equation. ‘Show that….’ questions should start with a word equation. Most candidates were able to successfully recall and use the lens equation. The most common error here was the failure to convert distances to metres.

(c) This was very well answered by most candidates.

(d) The most common error was to subtract the powers so that the sign of the answer was negative.

(e) Most candidates were able to state the correct defect. A small number gave alternative names for the defect and while many were successful a small number got it wrong, cancelling out their first attempt.

(b)(i) 0.0169 m (ii) 0.0169 m (iii) 61.5 D (c) 63 D (d) 1.5 D

Q 4

(a) This was well answered. Again it was common to find an absence of explanation for the workings.

(b) The intensity level equation was correctly used by half of the candidates. There was a very common incorrect answer of 115 dB offered for this question. This is obtained when candidates put '10×10^{-12}' into their calculators instead of '1×10^{-12}'.
(b) 125 dB

Q 5

This was well answered. Candidates rarely made errors. The most common of the errors was to get the terms scotopic and photopic the wrong way round.

Q 6

Candidates were generally able to score well here. This was less well understood compared with the essay response of Q. 5. A number of candidates described the intensifying screen or the production of X-rays.

Q 7

(a) This question seemed to get very good responses from the weakest candidates who had correctly interpreted the information.
(b) Again candidates were thinking well and most gained credit for their responses.
(c) The most common mistake was to add the contents of the cells so that they added up to the output number rather than subtract them from the input number to achieve the output number.

Q 8

(a) Most candidates found it difficult to put into words the idea of coherent. The markers were sympathetic to the problem. It was not uncommon to find that *coherent arrangement* had been explained with no reference to *non-coherent arrangement.* In other words, candidates had expected the absence of a response to be an implied response that ' non-coherent fibres are not….'
(b) The use of these arrangements of fibres was understood. Once again the wording was frequently wrong although the idea was correct. e.g. it was common to see phrases such as ' images are carried by coherent fibres'.
(c) A number of responses confused the answer with that of treatment of cancerous tissue by ionising radiation. Many responses made reference to greater absorption by darker pigments. A few candidates indicated that it would be easier to see the tissue.
(d)(i) This was well answered by most candidates. The most common error was the failure to convert correctly from mm^2 to m^2.
(ii) Less than half of the candidates were able to answer fully this part of the question. Many were unable to recall the equation $E = h\,c / \lambda$.
(d)(i) 1.3×10^8 W m^{-2} (ii) 6.4×10^{17}

Q 9

(a) It was rare to find reference made to air in the explanation of the term *exposure*.
(b) Many candidates found this part of the question difficult. Many were able to gain some credit by stating correctly the unit.
8.4×10^{-5} Gy

Q 10

(a) Most candidates gained full credit for this part.
(b)(i) This was well answered with an appropriate equation of motion and correct workings to the answer.

(ii) The most common error here was to assume that the initial velocity $u = 0$ m s^{-1} and then to use $s = ut + ½ at^2$.

(c) This was well answered by most candidates. The most common error was the failure to convert cm to m.

(d) About two thirds of candidates were able to obtain the correct answer. The most common mistake was to omit the k when calculating the pressure leading to an answer that was out by a factor of 10^3.

(e) Most candidates found this part difficult. Very few were able to calculate the number of moles of gas that escaped. Most were able to gain some credit where they explained the steps that they were taking (e.g. calculating 20% of the pressure etc.).

(f)(i) The equation relating resistivity to resistance was recalled and used well.

(ii) The most common error was to rearrange one of the equations for power incorrectly. Credit was then subsequently given for the correct route to an answer.

(b)(i) 90 m s^{-2} (ii) 0.167 s (c)(i) 1.08 N (ii) 9.0 m s^{-2} (d) 50 M Pa
(e) 3.1×10^{17} (f)(ii) 8.0 ms

2825/04 Nuclear an Particles Physics

General Comments

The entry was very varied. A significant minority were clearly very well prepared and scored excellent marks. Sadly, a larger number appeared inadequately or totally unprepared and some of these scored derisory marks. Since this module relies heavily upon principles taught in 2824 and earlier modules, it was surprising that so many candidates had covered sufficient ground to be considered ready for this examination.
Candidates continued to show an improved use of terminology, failing less often to distinguish between 'nucleus', 'atom', 'nucleon', 'neutron' and 'nuclide', though 'nuclei' was sometimes used as both the singular and the plural of 'nucleus'. Some candidates made the examiner's task more difficult (and probably lost credit in a few places) by poor setting out of their answers. Candidates perhaps also need reminding again of the difference between the instructions 'calculate' and 'show that'. The latter requires every step to be shown. The appearance of the correct answer does not lead to the award of full credit because in a 'show that' question, this is always given.

Comments on Individual Questions

1(a) A surprisingly large proportion of candidates were unable correctly to label the areas of attraction and repulsion on the vertical axis of the graph. The mark was also lost by those who marked places other than the axis. Others either reversed the labels or failed to show the regions at all.
(b)(i) Candidates were expected to label N as the point where the strong force line crossed the distance axis and to justify this by stating that there is no electrostatic force, so the equilibrium position of the two neutrons is where the strong force is zero. Less than half the candidates were able to do this; N was often shown to the left of its true position.
(ii) Candidates were expected to mark P at a point on the distance axis equidistant between the two curves because it is the place where the strong and electrostatic forces are equal and opposite ie they balance. Only a
minority were able to do this. Common misconceptions included showing P below the crossing point of the two curves on the grounds that at this point the two forces are equal. Unfortunately, of course, at this point they act in the *same* direction and so cannot balance. Others simply showed P to the right of N, justifying this by the comment that since protons repel, the extra (electrostatic) force will push them further apart.
(c) This proved a challenging part for the majority of candidates. They were expected to add the two forces and arrive at a curve which lay entirely above the strong line (because the electrostatic force is always positive) and to cross the distance axis at P. It should also cross the electrostatic line vertically above N, since there only the electrostatic force acts. To some extent candidates' success here depended on their earlier responses, so the number scoring full marks in this part was small. Many seemed to have no idea how to sketch the graph. As a result, graphs sometimes crossed the strong line, especially at the point of intersection of the original two curves, had peaks or troughs and occasionally were straight, originating from 0-0.
(d)(i) Most candidates were able to write a valid equation for the electrostatic force between two charges. Candidates who used Q_1 and Q_2 rather than Q or who used r instead of x, as requested, were not penalised.
(ii) Most then went on successfully to calculate the distance between two protons. Among the few errors, the commonest was failure to take the square root at the end.

(d)(ii) 3.0(3) x 10^{-15} m

2(a) This question asked, in effect, for an overview of the production of plutonium-239. So candidates were expected to state that uranium-238 is subjected to free neutrons which causes a neutron to be absorbed by a uranium-238 nucleus. This undergoes two beta-emissions, producing plutonium-239. It was generally well answered. The minority who lost marks usually stated that *fission* was a part of the process, or failed to specify uranium-*238* as the relevant nuclide.
(b)(i) A surprisingly large number, perhaps distracted by the earlier reference to beta emission, gave this, rather than alpha-emission as the decay process undergone by Plutonium-239.

(ii) Of those who had correctly identified the decay process in *(i)*, most were able to write a valid equation giving the products as $^{4}_{2}He$ and $^{235}_{92}U$. Unsurprisingly, those who had opted for beta emission in *(i)* usually failed to score here.
(c)(i) Most candidates knew that the half-life of plutonium-239 is 24000 years. A few gained the mark by giving the value in seconds. Those who lost the mark had presumably failed to memorise this value.
(ii) Candidates were expected to quote both the formula for decay constant λ (given in data) and the decay equation. This enabled them to first calculate the value of λ and then to find the number of plutonium-239 atoms left after 9000 years. Better candidates were able to do this. Those who failed had usually not been able to identify the relevant equations to begin with.
(d)(i) Most candidates, even those who had little success otherwise with this question, were able to calculate the ratio of the numbers of atoms of the two isotopes.
(ii) Here candidates were expected to spot that originally there were 8.0 times as many 239 atoms as 240 atoms, but that after 9000 years this ratio had fallen to 4.0. It was then a short step to deduce that the ratio would fall to 2.0 after a further 9000 years and so to 1.0 after one further 9000 year period, making 27000 years in all. The question resulted in widely different scores. Many simply failed to approach it in a helpful way, usually scoring zero. Some, no doubt encouraged by *(c)(ii)* tried to use one or other of the relevant equations, usually without success. Of those who did approach it in the right way, a significant number, having deduced that it takes two 9000 year periods to reach a ratio of 2:1. then made the invalid deduction that the 1:1 ratio requires a further 18000 years, giving 36000 years in all. These candidates scored partial credit. It was pleasing to see that a few candidates who had scored little in *(c)* nevertheless went on to score full marks here.

(d)(i) 4.0 *(ii)* 27000 years

3(a) Most candidates were able to state that a plasma exists at a high temperature and consists of a mixture of free nucleons and electrons. Many were also aware that a plasma is formed as a result of electrons being stripped from nuclei because of the energy which electrons gain as a result of the high temperature. Most were able to state that nucleons gain enough energy to overcome the Coulomb barrier and a few then went on to state
that they can get close enough to fuse. Candidates who went on to explain the term Coulomb barrier as the repulsion between nucleons also scored. Candidates were less successful in explaining why confinement is necessary. The commonly held view was that it was required to keep the plasma out of contact with the walls of the containing vessel, forgetting that this relates only to the JET-type reaction and has no relevance to either the nuclear fusion inside a star or to laser-induced fusion. Candidates were asked for brief descriptions of the three confinement methods and so stating the names of these three, namely magnetic, gravitational and inertial was sufficient. Some candidates however confused the action of the magnetic field in providing confinement with the role of the large electric current in generating the heat energy necessary to raise the temperature of the plasma. Candidates who went on to describe the confinement methods in detail were able to score further but those who cited 'hold the plasma in place' as the confinement mechanism did not. A minority of candidates lapsed into 'atoms' rather than 'nuclei' in this part. The question was generally well answered and a large number of candidates were able to score close to full marks.
(b) Candidates were expected first to calculate the number of nuclei in 1.00 kg of helium-4. This could be achieved either by using either the Avagadro constant or the mass in kg of the atomic mass unit; then to multiply by the 28.4 MeV, and make the necessary unit conversions, first to eV and then to joule. As implied above, the relevant conversion factors, 1.6×10^{-19} and 10^{6} needed to be shown.

(b) 6.8×10^{14} J

4(a) Most candidates were able to write the equation representing the fusion of hydrogen and deuterium. Some, however, lost the mark by failing to represent the product (^3_2He) correctly, showing it instead as ^3_2H.
(b)(i) It was pleasing to see that most candidates were able to state that as the nuclei approach, kinetic energy is converted into potential energy and that when they are at rest all of this kinetic energy will have been so converted.
(ii) Few candidates had any trouble in correctly substituting into the potential energy equation to arrive at the figure given for the combined kinetic energy. Candidates were not expected to state that the initial kinetic energy is equal to the potential energy stored since this had already been required in *(i)*. A mark was sometimes lost however where a candidate failed to show the substitution for ε_0 in this 'show that' question.
(iii) Candidates were expected to state and use the principle of conservation of momentum in order to show that the hydrogen nucleus has a speed twice as great as the deuterium nucleus. Many failed to score by attempting to use kinetic energy rather than momentum.
(iv) There were a number of ways of solving this problem. The most straightforward, and the one most often employed successfully, was to realise that, since the masses of the hydrogen and deuterium were in the ratio 1:2 and their velocities in the ratio 2:1, their kinetic energy's are in the ratio 2:1. Since their combined kinetic energy was 7.5×10^{-16} J it was then straightforward to deduce that the separate kinetic energies were 5.0×10^{-16} and 2.5×10^{-16} J. However, although some candidates successfully adopted this approach, confusion sometimes arose and the values became reversed. Some candidates took the longer route and by equating the total kinetic energy to 7.5×10^{-16} J were able to calculate a value for the speed *v* of the deuterium nucleus. This could then be substituted back to find the separate kinetic energies. Other, unsuccessful approaches included unwittingly assuming that the two speeds were equal. This should have (but didn't always) lead to equal kinetic energies. Some candidates simply stated that since the speeds were *v* and 2*v* respectively ie 3*v* in total, the total kinetic energy should be divided in the same ratio. Although this gave the correct answers it was totally erroneous and did not score.

(b)(iv) hydrogen: 5.0×10^{-16} J ; deuterium: 2.5×10^{-16} J

5(a)(i) Candidates were expected to explain the principle behind the acceleration of protons in a synchrotron, namely that the charged protons are made to move through an electric field, created by charged electrodes and that as a result they accelerate and gain energy. They are made to follow a curved path because of the motor force due to the magnetic field directed at right angles to the path of the protons. The circular path results from the magnetic force being perpendicular to the direction of motion ie it is a centripetal force. It was possible to score further by stating that, in order to keep the protons in a circle of constant radius, the magnetic field strength may be increased and/or the frequency of the alternating voltage may be increased. Additional points included explaining the role of the accelerators, namely to increase or maintain the particle energy; also that a linear accelerator is used to inject the protons into the synchrotron at an appropriate speed. Additionally, a mark could have been won by referring to the magnetic focusing which is essential in such a machine. Candidates were less successful in this part than in *3(a)*. For some this was because they were mistakenly describing the cyclotron rather than the synchrotron. The commonest weakness however was to omit the *principles* of the machine ie to fail to describe the accelerating and magnetic deflection processes in simple terms. Many candidates discussed the acceleration process in terms of the *current* flowing, rather than the p.d. This usually did not result in any loss of credit but showed a poor understanding nevertheless.
(b) Most candidates were aware that the equation $E = mc^2$ was needed to calculate the rest energy of the Z particle and most were able to convert this number of joule into GeV. Again this was a 'show that' question so every step needed to be shown. However, candidates who arrived at 9.2×10^{10} eV and equated this to 92 GeV were awarded full credit (without actually showing the 10^9 factor). But it was necessary to show the factor of 1.6×10^{-19} J eV^{-1} . A few candidates lost credit for subtracting the rest masses of the electron and positron, thus using the mass *defect* rather than the actual mass of the product particle.
(c)(i) Many candidates were able to deduce the minimum particle energy to create the Z particle as half of the total ie 46 GeV and to justify this by stating that since the energy of both particles is available, each needs only half of the total. Many who did this then failed to point out that the initial momentum of the system is zero so the Z particle can be at rest after the collision and will not carry away any energy, and *all* the initial energy is available to create the new particle.

(ii) Candidates were expected to realise that when the target particles are at rest the total momentum of the system is *not* zero so the product particle has to have momentum, and therefore kinetic energy, which means that some of the input energy is not available for creating the Z; thus the 92 GeV will not be enough. Only a minority scored both marks here. The commonest error was to state that since the target particles were at rest,
they did not contribute any energy to the creation of the Z.

6(a) Nearly all candidates were able correctly to complete the table.

(b)(i) Likewise nearly all were able to state a value of half life for the neutron decay which lay between 10 and 15 minutes.

(ii) Most knew that the force responsible for beta decay is the weak force.

(iii) It was expected that candidates would show an equation to represent the change of a down quark into an up quark, an electron and an antineutrino. A few did this; rather more included the other down quark and the up quark which are unaffected by the decay process. No credit was lost for this. Marks were lost usually for omission of either the electron or the antineutrino. The small number of candidates who in disregard of the question gave a *nucleon* equation, did not score.

(iv) Candidates were expected to give two equations showing the charges and baryon numbers of the *quarks* to show that both equations balance. Many gave charge and baryon number equations for the *nucleons* and scored only partial credit.

(c)(i) Most were able correctly to show the resultant momentum vector and label it.

(ii) In answering *(b)(iii)*, candidates should have been aware that the proton and the neutrino were not the only products of the decay and therefore realised that the antineutrino would also have some of the momentum. A significant minority did and scored full credit. Some candidates who realised that the antineutrino was the cause nevertheless attributed the discrepancy to its kinetic energy. This was an understandable misconception to candidates who were not aware that the antineutrino has virtually zero mass, but since the question was framed entirely in terms of *momentum*, no credit could be given. A small number attributed the momentum difference to the loss of mass in creating the antineutrino but again failed to score.

7 This question as always tested earlier work and candidates who were in any case poorly prepared for the Nuclear and Particles work were often even less happy with this synoptic question. Consequently there was a wide divergence among the scores achieved by candidates, ranging from zero to almost full marks.

(a) Nearly all candidates were able to convert the km into metre and the hours into seconds and so score full marks.

(b)(i) Application of the equation $v^2 = u^2 - 2as$ enabled most candidates to arrive quickly at the required acceleration.

(ii) Again, use of standard equations $v = u + at$ or $s = ½(u + v)t$ quickly led to the required time interval. Both parts were well done by the majority of candidates.

(c)(i) Most candidates were able to multiply the compression by the force constant and deduce the force needed for compression. A few lost credit by attempting to use $F = ma$. Others tried to use the formula $T = \lambda x / l$, presumably learnt in Maths. where λ was taken to represent the spring constant. This approach could not score.

(ii) This time $F = ma$ did lead to the deceleration of the steel ball. As usual, candidates who had arrived at erroneous answers in earlier parts were able to benefit from error carried forward. So most candidates scored full credit.

(d) Candidates were expected to apply the gas law in the form $P_1 V_1 = P_2 V_2$ or equivalent to deduce the initial pressure in the storage cylinder. Many succeeded in doing this, albeit sometimes *via* a more circuitous route. A minority lost credit by applying the volume ratio the wrong way round. Many would have been more successful if they had *quoted* the formula rather than attempting to apply a seemingly arbitrary volume ratio and getting it the wrong way up.

(e) This proved the hardest part of the paper. Candidates needed to find the number of moles by using the full equation of state for a gas. They could then multiply this figure by the Avagadro constant to get the number of molecules. Twenty percent of these were known to escape, so this figure divided by the time in seconds in 4 weeks led to the answer. Calculating the moles and molecules proved the stumbling block in most cases. Many failed to score at all on this part.

(f)(i) Most candidates were able to state the relationship between resistance and resistivity and so substitute to show that the heater filament had the stated resistance and so were able to gain full credit on this part.
(ii) In this part candidates were expected to use either the energy equation or to calculate the power of the heater filament and divide this into the required energy in order to find the time taken. Many were able to do this and to score full credit.
(b)(i) 90 m s^{-2} *(ii)* 0.167 ms *(c)(i)* 1.08 N *(ii)* 9.0 m s^{-2} *(d)* 50 MPa *(e)* 3.1 x 10^{17} molecules s^{-1} *(f)(ii)* 8 ms

2826/01 Unifying Concepts in Physics

General Comments

One of the problems with writing a report such as this, is that many of the comments made in previous reports could be repeated over and over again. This is not a criticism of teachers because I know that a great deal of effort is made to instil good, careful habits in the students they teach. Unfortunately, since the students themselves change year by year, it is a never ending task to try to get them to work in ways which lead to good results. Careless mistakes and thoughtless answers still cost many students good results. Physics is not best studied by memorising equations and hoping that by simply substituting numbers into them good marks will follow. Understanding and thoughtful working are the keys to success. This is particularly true with paper 2826/01. The paper this January, marked out of 60, resulted in a mean mark of 33.5 and a large standard deviation of 11.2. No candidate scored less than 12 and the highest mark was 58. One feature of many candidates' work which resulted in unnecessary mistakes was the way in which they do not make use of units within an equation to act as a check. Once they have an equation many seem concerned to ignore the units associated with the figures. If the units are inserted into the equation as well then they act as a sure sign of a mistake if they do not cancel out to give the correct unit of the answer. Since no one taking this paper was short of time it is a pity that not enough time was spent by candidates checking their answers. Continuous checking must be done if mistakes are to be consistently avoided.

Comments on Individual Questions

1. All the candidates had a good go at this question but it did prove to be quite a good discriminator. Most chose A as the impossible graph, but those who made a reasoned response to other choices did score marks for sensible reasoning. The main mistake which was made was not to take sufficient notice of what was plotted on the y-axis. In describing the motion in C, for example, too many candidates ended up by saying that the object ended up at a constant speed. Surprisingly few candidates realised that this graph is a graph of the simple act of dropping something. B can be a bounce off a vertical wall, and D could be pressing the clutch pedal in a car so that it goes into neutral. With this graph many candidates stated that the objected stopped when the force is reduced to zero. Candidates might know Newton's first law – but lots of them do not believe it!

2. This question also discriminated well. There were some extraordinary answers to part (a) where the second wire was frequently described as the earth wire and which siphoned off any electricity which was not required. Weaker candidates often got muddled with (b)(i) but almost everyone could answer (b)(ii). Part (c) was not done well since too many candidates did not start with $R = \rho l/A = V/I$. Those who did start with these statements soon realised that ρ appears on the bottom of the flow equation. Having dealt with flow of heat and flow of charge flow of gas is similar but with a pressure difference causing the flow. The better candidates had no problem with this but the only equation that many weaker candidates could think of was $pV = nRT$. Since A appears in every equation in the same place It was hoped that candidates would realise that the area was required in (d)(ii). Many however just used proportion to get 235 $cm^3\ s^{-1}$ rather than the correct answer of 344 $cm^3\ s^{-1}$.

3. This was another question which produced good discrimination. A problem with electric field is that many candidates know that it is the force per unit charge and many know that it can be found from V/d. The percentage who know both of these facts is small however. Another fundamental problem which showed itself on many papers is that many candidates think that electric fields are magnetic fields and that magnets have positive and negative poles. This was

shown clearly in some answers to part (b) where the direction of the force was given at right angles to the field line; other candidates incorrectly showed the direction as being directly away from the positive charge instead of along a tangent to the field. Parts (c) and (d) were done well and in part (e) a wide variety of values was accepted. Candidates could have used 600 V across a gap of 0.031 m but too many used 150 V/ 0.031 m or 450 V/ 0.031 m. Answers to (f) were very varied, with some ingenious suggestions. Use of ceramic flat magnets was not as frequent as expected; candidates were expected to suggest how an isolated N pole might be achieved and many drew sensible diagrams showing the S pole down underneath the N pole. The use of the arrangement in a loudspeaker was another common suggestion. Answers to (g) usually included the idea that a gravitational field cannot exist away from a mass but many candidates incorrectly stated that a gravitational field cannot be curved.

4. This question gave ample opportunity for candidates to score well. Those who did not do so often showed how little they appreciated the uses of the electromagnetic spectrum. A very wide range of values was accepted for the wavelengths of radio waves and gamma radiation. A curious mistake of cancelling the tens was seen too often in such expressions as $10^5/10^{-15} = 1^{20}$ and too many candidates managed to get the expression upside down. Handling powers of ten does not come easily to many. Part (a)(iii) was, expectedly, a discriminating question, but most could answer (a)(iv), though the conversion from wavelength to frequency was often done incorrectly or not at all. Answers to the extended writing part of the question varied as might be expected. While a concise answer from a good candidate might only occupy half the allocated space, many answers from weak candidates were far too short and did not contain sufficient information. This was meant to be a discussion, so a statement such as “We can only see light” is barely sufficient for even one mark. This can be improved to a clear two mark answer by writing “ Of all the different radiations only light, with its wavelength between about 400 nm and 700 nm, is capable of affecting the retina at the back of the eye and hence is visible.” This feeds in extra information and communicates well to the examiner. This should be the aim of all candidates.

2826/03: Unit Name (Physics Practical Test: A2)

General Comments

The general standard of the work done by the candidates was similar to last year. Virtually all candidates attempted all sections of the paper, and there was no evidence of candidates being short of time.

There were no reported difficulties from Centres with the apparatus requirements or the functioning of the equipment. In carrying out the experiments in questions one and two, very little assistance was given to the candidates by Supervisors.

As in previous years the analysis section in question one and the evaluation section in question two proved to be good discriminators between candidates.

Comments on Individual Questions

Planning Exercise

In this exercise candidates were required to design a laboratory experiment to investigate how the torque required to produce an angular deflection of 45^{O} depends on the radius of wire.

Most candidates drew a workable arrangement of the apparatus, although some candidates clearly spent far too much time using computer-drawing packages to produce an overcomplicated diagram. Most diagrams illustrated a situation involving a suspended wire attached to a rod. The ends of the rod were attached to strings running over two pulleys and supporting loads. This was an acceptable arrangement. The most common fault was to produce an angular twist of 45^{O}, but then not to resolve the tension in the strings when the strings made an angle of 45^{O} with the rod. Many candidates overcame this problem by attaching a cylinder to the end of the wire.

Most candidates suggested using a micrometer screw gauge to measure the diameter of the wire, and many candidates gained a further detail mark by suggesting that the diameter should be measured at several different places along the length of the wire and the averaging the results.

Most candidates described a workable procedure (i.e. measure a diameter and a torque; change the diameter of the wire and measure the new torque).

It was pleasing to see many candidates scoring 'extra detail marks' by giving suggestions such as how to find the torque applied to the wire from the measurements taken, or how the upper end of the wire would be suspended. Some candidates gave sensible suggestions about safety precautions (such as 'wear goggles in case the wire snaps' or 'safety screens').

In the Notes for Guidance given to candidates on page 2, section 4, it states that 'You should show that you have consulted an appropriate range and variety of sources'. Many candidates are failing to gain full credit in this section because they have given only one reference, or given very vague references. It is expected that candidates will give at least two references with page/chapter numbers.

A small number of candidates were not able to score full marks in the 'quality of written communication section' as their accounts contained too much irrelevant detail, and did not focus on the task that had been set. Most candidates gave accounts of between 400 and 700 words, which was quite acceptable. Candidates should not be overly concerned with the length of their plans. It was clear from a number of scripts that a few candidates, having reached the 500 word 'limit', just stopped writing and did not fully complete their plans, which was a pity.

Question 1 In this question candidates were required to investigate how the period of torsional oscillations of a paper strip carrying a half-metre rule depends on the width of the strip.

Most candidates were able to set up the apparatus correctly and take six sets of readings of time and width of strip. It is expected that the width of the strip will be given to the nearest centimetre since a rule with a millimetre scale is used to make the measurement.

A number of weaker candidates did not repeat the readings of raw times when timing the oscillations of the rule.

Most candidates were able to calculate the percentage uncertainty in *w* correctly.

In **(b) (iii)** many of the weaker candidates were unable to compare the relative uncertainties in *w* and *T*. This section was sometimes not attempted by the weaker candidates.

In **(b) (iv)** the expected answer was that the rule spends less time at the equilibrium position than at the position of maximum displacement, and hence the time of oscillation can be measured more precisely. However, since the motion of the rule was heavily damped, the answer given by many candidates (that the rule did not reach the same position of maximum displacement every time) was also credited.

Most candidates presented their results in a table and correctly calculated values of lg (*T*/s) and lg (*w*/cm). A few candidates calculated ln (*T*/s) and ln (*w*/cm). This was allowed without penalty provided that consistent analysis had been given in later sections.

Candidates were required to plot a graph of lg (*T*/s) vs lg (*w*/cm). It was pleasing to see that this had been done quite well by the vast majority of candidates. The most common error was in using compressed scales (where the plotted points occupied less than half the graph grid in the *y*-direction). The points were usually plotted correctly. Sometimes the weaker candidates used small triangles in the determination of gradient. Generally it is expected that the hypotenuse of this triangle will be greater than half the length of the drawn line.

In section **(f)** the weaker candidates were unable to express the given power law in logarithmic form and many left this section blank. Common mistakes made by other candidates included attempts to calculate values for *n* and *k* using data from the table. This was not acceptable as the question instructs candidates to use their answers from **(e) (ii)**. A few candidates who did manage to obtain answers for *n* and *k* gave the values to inappropriate numbers of significant figures (2 or 3 sf would have been acceptable).

In the last section the width of strip that would have given a period of 120 seconds was very small, and would be unlikely to support the weight of the rule.

Few candidates mentioned this problem, or other possible problems, such as the cutting of a strip of paper of such a small width. Many candidates thought that damping would be a significant factor, even though the speed of the suspended rule would be very small.

Question 2 In this question candidates were required to perform a simple experiment to determine the specific heat capacity of a metal by transferring a hot piece of metal to a container of cold water. Most candidates were able to make measurements and perform the calculation correctly, although significant numbers of weaker candidates muddled the temperature rise of the cold water and the temperature fall of the hot metal.

There were many flaws in the procedure that gave candidates the opportunity to comment in the evaluation section. Again, as in previous years, the weaker candidates found this section very challenging and many simply wrote down the procedure that they had followed. Responses such as these scored little, if any, credit. It may be helpful to these candidates if they could be encouraged to write their responses in the form 'identify a problem with your procedure, then write down what you would do about it'. Four or five ideas in a bullet point form have a much better chance of scoring here.

There were a wide variety of possible evaluation responses that could have scored. Examples of some of these are given below:

Heat given to plastic cup
Use $mc\Delta\theta$ for the plastic cup
Heat given to thermometer
Use thermocouple (or thermometer with small heat capacity)
Heat lost by metal on transfer to plastic cup
Place plastic cup close to beaker of boiling water
Hot water transferred with metal to plastic cup
Heat lost by plastic cup to surroundings as metal cools down
Insulate the plastic cup to reduce heat loss as metal cools down
Use water below room temperature so heat loss = heat gain from room
Small temperature rise of water gives large percentage uncertainty in $\Delta\theta$
Use smaller amount of water or larger mass of metal

Advanced Subsidiary GCE Physics A (3883)
January 2005 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2821	Raw	60	41	36	31	27	23	0
	UMS	90	72	63	54	45	36	0
2822	Raw	60	47	41	36	31	26	0
	UMS	90	72	63	54	45	36	0
2823A	Raw	120	101	91	81	71	62	0
	UMS	120	96	84	72	60	48	0
2823B	Raw	120	101	91	81	71	62	0
	UMS	120	96	84	72	60	48	0
2823C	Raw	120	97	89	81	73	65	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	18.5	36.6	55.1	78.2	93.8	100.0	264

Advanced GCE Physics A (7883)
January 2005 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2824	Raw	90	62	55	49	43	37	0
	UMS	90	72	63	54	45	36	0
2825/01	Raw	90	61	55	49	43	37	0
	UMS	90	72	63	54	45	36	0
2825/02	Raw	90	70	63	56	49	43	0
	UMS	90	72	63	54	45	36	0
2825/03	Raw	90	65	57	50	43	36	0
	UMS	90	72	63	54	45	36	0
2825/04	Raw	90	68	60	52	44	37	0
	UMS	90	72	63	54	45	36	0
2825/05	Raw	90	64	56	48	41	34	0
	UMS	90	72	63	54	45	36	0
2826A	Raw	120	91	80	69	59	49	0
	UMS	120	96	84	72	60	48	0
2826B	Raw	120	91	80	69	59	49	0
	UMS	120	96	84	72	60	48	0
2826C	Raw	120	89	80	71	63	55	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

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

	A	B	C	D	E	U	Total Number of Candidates
7883	13.3	33.3	53.3	84.4	97.8	100.0	57