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Mark Scheme (Results)
June 2010

GCE

GCE Physics (6PH01)

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Summer 2010

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Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. **Mark scheme format**
   - 1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'
   - 1.2 Bold lower case will be used for emphasis.
   - 1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
   - 1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. **Unit error penalties**
   - 2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.
   - 2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
   - 2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given.
   - 2.4 The same missing or incorrect unit will not be penalised more than once within one question.
   - 2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
   - 2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. **Significant figures**
   - 3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

'Show that' calculation of weight

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	A	**(1)**
2	D	**(1)**
3	C	**(1)**
4	A	**(1)**
5	C	**(1)**
6	B	**(1)**
7	A	**(1)**
8	C	**(1)**
9	D	**(1)**
10	D	**(1)**

Question Number	Answer	Mark
11	Complete the diagram Before A = laminar flow – minimum of 2 continuous smooth lines roughly parallel to wing surface which don't cross After A = turbulent flow – lines crossing, eddies, sudden changes in direction, change in direction > 90°, lines disappearing and appearing	**(1)** **(1)**
	Total for question 11	**2**

Question Number	Answer	Mark
12	Explain the difference between elastic deformation and plastic deformation QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Elastic – returns to original shape when deforming force/stress removed /no permanent deformation Plastic – doesn't return to original shape when deforming force/stress removed / permanent deformation Suitable material or object named which undergoes elastic and plastic deformation, e.g. spring/wire/strawberry laces – do not accept rubber / elastic band but accept balloon Illustration comparing both types of deformation under different force / stress / strain / amount of deformation for material / object (independent of material mark)	**(1)** **(1)** **(1)** **(1)**
	Total for question 12	**4**

Question Number	Answer	Mark
13(a) (i)	Show that the initial horizontal component of velocity for the drop is about 1 m s^{-1}. Shows a correct, relevant trigonometrical relationship Correct answer for horizontal component (1.2 (m s^{-1})) Example of calculation $v_h = v \cos\theta$ = 3.5 m s^{-1} x cos70° = 1.2 m s^{-1}	 **(1)** **(1)**
13(a)(ii)	Calculate the vertical distance to the insect if the shot is successful. Use of equation of motion suitable for time Calculates time (allow 1/3) Use of trigonometry or Pythagoras suitable to find vertical component of speed Use of equation of motion suitable to find distance Correct answer (0.55 m) If using $v^2 = u^2 + 2as$: Use of trigonometry or Pythagoras suitable to find vertical component of speed(1) Use of equation of motion suitable to find distance (1) Substitute $v = 0$ (1) Substitute g negative (1) Correct answer (1) Answers based on $mgh = 1/2\ mv^2$ coincidentally giving correct answer are not credited as $v^2 = u^2 + 2as$ unless conservation of energy fully described, i.e. ke at bottom using u = 3.5 m s^{-1} and ke at top due to only horizontal motion accounted for Example of calculation $t = s/v$ = 0.4 m / 1.2 m s^{-1} = 0.33 s $v_v = v \sin\theta$ = 3.5 m s^{-1} x sin 70° = 3.3 m s^{-1} $s = ut + 1/2\ at^2$ = 3.3 m s^{-1} x 0.33 s - 1/2 x 9.81 m s^{-2} x $(0.33\ s)^2$ = 0.55 m	 **(1)** **(1)** **(1)** **(1)** **(1)**
13(b)	Sketch the path of the water droplet Any section of an approximate parabolic path	 **(1)**
	Total for question 13	**8**

Question Number	Answer	Mark
14 (a)	Show that the upthrust is about 8×10^{-4} N Use of mass = density x volume Correct answer for upthrust (= 8.3×10^{-4} (N)) <u>Example of calculation</u> mass of liquid displaced = density x volume = 1300 kg m^{-3} x 6.5×10^{-8} m^3 = 8.45×10^{-5} kg upthrust = 8.45×10^{-5} kg x 9.81 m s^{-2} = 8.3×10^{-4} N	**(1)** **(1)**
14 (b)	Show that the viscosity of the liquid is about 2 kg m^{-1} s^{-1} Correct summary of forces, e.g. V = W - U Use of $F = 6\pi\eta rv$ Correct answer for viscosity (1.8 (kg m^{-1} s^{-1})) <u>Example of calculation</u> Viscous drag = W – U = 4.8×10^{-3} N - 8.3×10^{-4} N = 3.97×10^{-3} N $F = 6\pi\eta rv$ η = 3.97×10^{-3} N / (6 x π x 4.6×10^{-2} m s^{-1} x 2.5×10^{-3} m) = 1.8 kg m^{-1} s^{-1} [Watch out for out of clip answers]	**(1)** **(1)** **(1)**
14 (c)	State a relevant variable to control <u>Temperature</u>	**(1)**
	Total for question 14	**6**

Question Number	Answer	Mark
15(a)	Explain the meaning of the terms: Ductile – can be made/drawn into wires / shows significant/large/lots of plastic deformation / large plastic region Brittle - shatters when subject to impact / sudden force fails/breaks/cracks with little or no plastic deformation / breaks just beyond elastic limit / breaks just beyond limit of proportionality / breaks under stress due to propagation of cracks	**(1)** **(1)**
15(b)	Calculate the mass that would produce this load. Use of $W = mg$ Correct answer (3600 kg) <u>Example of calculation</u> $W = mg$ m = 35 000 N / 9.81 N kg^{-1} = 3570 kg	**(1)** **(1)**
	Total for question 15	**4**

Question Number	Answer	Mark
16(a)	Show that the acceleration is about 2 m s^{-2}. Use of equation of motion suitable to find acceleration Correct answer (1.5 (m s^{-2})) <u>Example of calculation</u> $s = ut + 1/2\ at^2$ a = 2 x 2 500 000 m / ((30 x 60)s)^2 = 1.54 m s^{-2}	 **(1)** **(1)**
16 (b)	Calculate the maximum speed. Use of equation of motion suitable to find maximum speed Correct answer (2700 m s^{-1}) <u>Example of calculation</u> $v = u + at$ = 0 + 1.5 m s^{-2} x (30 x 60)s = 1.5 m s^{-2} x (30 x 60)s = 2700 m s^{-1} (Use of 2 m s^{-2} → 3600 m s^{-1}, 1.54 m s^{-2} → 2772 m s^{-1}),	 **(1)** **(1)**
16 (c)	Calculate the force which must be applied to decelerate the train. Use of $F = ma$ Correct answer (680 000 N) <u>Example of calculation</u> $F = ma$ = 4.5 x 10^5 kg x 1.5 m s^{-2} = 675 000 N (Use of 2 m s^{-2} → 900 000 N, 1.54 m s^{-2} → 693 000 N)	 **(1)** **(1)**
	Total for question 16	**6**

Question Number	Answer	Mark
17(a)	Sketch a vector diagram Correct diagram – closed polygon, accept a triangle using the resultant of lift and weight, but arrows must follow correctly. Must show sequence of tip-to-tail arrowed vectors.	**(1)**
17(b)	Find the tension in the string. Use of trigonometrical function for the horizontal angle (allow mark for vertical angle if correct and shown on dia) Correct answer for <u>horizontal</u> angle (32.8°) Use of Pythagoras or trigonometrical function for the tension Correct answer for tension magnitude (7.1 N) <u>Example of calculation</u> weight – lift = 3.86 N from horizontal, tan (angle) = 3.86 N/ 6.0 N angle = 32.8° $T^2 = F_h^2 + F_v^2$ $= (6.0\text{ N})^2 + (3.86\text{ N})^2$ $T = 7.1$ N	**(1)** **(1)** **(1)** **(1)**
17(c) (i)	Calculate the work done by the girl. Use of $W = Fs$ Correct answer (150 J) <u>Example of calculation</u> $W = Fs = 6.0\text{ N} \times 25\text{ m}$ $= 150$ J	**(1)** **(1)**
17(c) (ii)	Calculate rate at which work is done Finds time Correct rate (12 W) <u>Example of calculation</u> $t = s/v = 25\text{ m} / 2.0\text{ m s}^{-1} = 12.5$ s $P = 150\text{ J} / 12.5\text{ s}$ $= 12$ W	**(1)** **(1)**
	Total for question 17	**9**

Question Number	Answer	Mark
18 (a)	Explain this demonstration and the need for the precautions. QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Max 4 from this part It will not strike the student's face / at most will just touch / returns to starting point The total energy of the pendulum is constant / energy is conserved It cannot move higher than its starting point … … because that would require extra gpe (consequent on previous mark) Mention specific energy transfer: gpe → ke / ke → gpe Energy dissipated against air resistance … … will stop it quite reaching its starting point (consequent on attempt at describing energy loss mechanism) Max 4 from this part Pushing does work on the ball / pushing provides extra energy If pushed, it can move higher (accept further) … will hit the student If the face moves (forward) the ball may reach it (before it is at its maximum height) OR if the face moves (back) the ball won't reach it	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **Max 6**
18 (b) (i)	Calculate the gravitational potential energy gained by the ball. Use of gpe = *mgh* Correct answer (100 J) <u>Example of calculation</u> gpe = *mgh* = 7 kg x 9.81 N kg^{-1} x 1.5 m = 103 J	**(1)** **(1)**
18 (b) (ii)	Calculate the speed of the ball at the bottom of its swing Use of ke = 1/2 mv^2 Correct answer (5.4 m s^{-1}) <u>Example of calculation</u> 103 J = 1/2 mv^2 $v = \sqrt{}$(2 x 103 J / 7 kg) = 5.4 m s^{-1} (Use of 100 J → 5.3 m s^{-1})	**(1)** **(1)**
	Total for question 18	**10**

Question Number	Answer	Mark
19 (a)	Explain whether the spring obeys Hooke's law. States: Straight line shown / constant gradient (So) extension or change in length proportional to force (accept Δx or Δl or e proportional to F) / k constant (Yes, because extension or change in length proportional to force gets 2)	 **(1)** **(1)**
19 (b)	Show that the stiffness of the spring is about 20 N m^{-1} Indication of use of (inverse) gradient, e.g. $k = F/\Delta x$ or with values obtainable from graph (accept extension/force for first mark) Substitution of values as force/extension Correct answer (16 (N m^{-1})) <u>Example of calculation</u> $k = F/\Delta x$ k = 1.6 N / (0.51 m – 0.41 m) k = 1.6 N / 0.1 m = 16 N m^{-1}	 **(1)** **(1)** **(1)**
19 (c) (i)	Calculate force on spring Use of $F = k\Delta x$ (must be extension, not length) Correct answer (5.1 N) [ecf] <u>Example of calculation</u> $F = k\Delta x$ = 16 N m^{-1} x (0.41 m – 0.09 m) = 5.1 N (Use of 20 N m^{-1} → 6.4 N)	 **(1)** **(1)**
19 (c) (ii)	Calculate energy stored Use of E = ½ $F\Delta x$ = = ½ $k(\Delta x)^2$ Correct answer (0.82 J) <u>Example of calculation</u> E = 1/2 $F\Delta x$ = 0.5 x 5.1 N x (0.41 m – 0.09 m) = 0.82 J	 **(1)** **(1)**

19 (d)	Explain effect on spring QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Change in length greater / compression greater More force More elastic energy / more strain energy / more energy stored / more potential energy / greater ½ $k(\Delta x)^2$ / more work done (on spring) Greater acceleration (Therefore) more kinetic energy (and) greater speed	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **max 3**
	Total for question 19	**12**

Question Number	Answer	Mark
20 (a)	Use Newton's laws 1 and 3 to explain motion Uses N3 – force (backward) on air by balloon/car, (so/=) force (forward) on balloon/car by air Uses N1 – resultant force / forces unbalanced / force on balloon > drag, (so) there is an acceleration / moves from rest / <u>starts</u> moving Identifies the <u>use</u> of N1 or N3 (by name or description) correctly, linking it to the context	 **(1)** **(1)** **(1)**
20 (b) (i)	Show that maximum speed is between 100 and 150 cm s^{-1} Draw tangent on graph / state use gradient / show use of gradient Identify max speed between 1.2 and 1.4 s (from position of gradient or values used) Correct answer (120 (cm s^{-1})) <u>Example of calculation</u> v = 120 cm – 0 cm / 1.9 s – 0.9 s = 120 cm s^{-1} (allow answers which are in range 100 and 150 cm s^{-1} when rounded to 2 sf)	 **(1)** **(1)** **(1)**
20 (b) (ii)	Sketch graph Shows: Speed increasing from 0 and then decreases Max speed at correct time (accept between 1.0 and 1.5 s) OR correct magnitude (must be indicated) Speed decreasing to 0 at between 3.4 and 4.0 s	 **(1)** **(1)** **(1)**
	Total for question 20	**9**

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[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

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'Show that' calculation of weight

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

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Question Number	Answer	Mark
1	A	**(1)**
2	D	**(1)**
3	C	**(1)**
4	B	**(1)**
5	D	**(1)**
6	B	**(1)**
7	A	**(1)**
8	C	**(1)**
9	C	**(1)**
10	C	**(1)**

Question Number	Answer	Mark
11	See $c = 3 \times 10^8$ (m s^{-1}) converts MHz to Hz $\lambda = 3.13$ m Example of calculation $\lambda =$ (3×10^8 m s^{-1}) / 95.8×10^6 Hz $\lambda = 3.13$ m	**(1)** **(1)** **(1)**
	Total for question 11	**3**

Question Number	Answer	Mark
12(a)	Resistivity is a constant for the material / metal OR resistivity depends on / is a property of the material / metal Resistance depends on (resistivity and) length / area /dimensions OR $R = \rho l/A$ with terms defined (do not credit rearranged equation)	**(1)** **(1)**
12(b)	Correct substitution into the $R = \rho l/A$ formula $R = 0.0085\ \Omega$ [ue applies. Common error is to rearrange eqn and confuse R and ρ gives answer 3.4×10^{-14} scores zero] Example of calculation $R = (1.7 \times 10^{-8}\ \Omega$ m $\times$ 0.5 m) / 1×10^{-6} m^2 $R = 0.0085\ \Omega$	**(1)** **(1)**
12	**Total for question 12**	**4**

Question Number	Answer	Mark
13(a)(i)	Resistance at 20 °C = 1250 - 1300 (Ω)	**(1)**
13(a)(ii)	Converts kΩ → Ω [look for 1000 (Ω)] Use of potential divider formula **OR** use of 2300 (Ω) to find current Reading on voltmeter = 2.6 – 2.7 V (ecf value from (a)(i)) <u>Example of calculation</u> V = (1000 Ω ÷ 2300 Ω) × 6 V V = 2.6 V	**(1)** **(1)** **(1)**
13(b)	(decreasing temp causes) resistance of <u>thermistor</u> to increase Voltmeter reading decreases Candidates who think resistance will decrease leading to voltmeter increase can get 2nd mark.	**(1)** **(1)**
	Total for question 13	**6**

Question Number	Answer	Mark
14	QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Identifies two rays of light Two rays have same frequency/come from same source/are coherent Path difference (between the two reflected rays) They superpose (when they meet) /constructive and destructive interference occur If they meet in phase/nλ /λ path difference, constructive interference/ bright fringe If they meet in antiphase / (n+ ½)λ / ½ λ path difference, destructive interference/dark fringe	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max 5)**
	Total for question 14	**5**

Question Number	Answer	Mark
15(a)	Volt is a Joule coulomb $^{-1}$ or V = J C^{-1} or $V = W/Q$ (not rearranged) Amp is a Coulomb sec^{-1} or A = C s^{-1} or $I = Q/t$ (not rearranged) Show units/symbols cancelling and **equating to a watt**. This mark can only be given if <u>both</u> the other marks scored. Method must be clear, do not allow 'let t = 1'.	**(1)** **(1)** **(1)**
15(b)(i)	Use of energy = power × time Energy = 2.9 × 10^5 J <u>Example of calculation</u> E = 700 × 7 × 60 E = 294 000 J	**(1)** **(1)**
15(b)(ii)	QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence See internal resistance / r Current will be less Less energy/power is lost in internal resistance OR wasted energy/power is reduced OR reduced lost volts OR it is more efficient	 **(1)** **(1)** **(1)**
	Total for question 15	**8**

Question Number	Answer	Mark
16(a)	n = sin 48 / sin 30 n = 1.5 (common answer will be 1.49) (n = 0.67 scores 1 mark for idea of ratio of sin of angles)	**(1)** **(1)**
16(b)(i)	QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence As x increases, y increases **OR** At a certain angle / critical angle, y = 90° / the light travels along the boundary (do not allow reflects at 90°) For angles greater than the <u>critical</u> angle (in glass) <u>total internal reflection</u> occurs (do not accept TIR)	 **(1)** **(1)** **(1)**
16(b)(ii)	Use of sin c = 1/n c = 42^O ecf n from (a) unless n= 0.67 which scores 0 here	**(1)** **(1)**
	Total for question 16	**7**

Question Number	Answer	Mark
17(a)	Photon energy is too small / less than work function (**do not** credit the frequency is less than the threshold frequency or electrons have not been given enough energy)	**(1)**
17(b)	**Method 1: Use of intercept x-axis** Use of $E = hf$ with $f = 10 \times 10^{14}$ Hz Divide by 1.6×10^{-19} to convert to eV (this mark can be scored even if wrong frequency used) $\Phi = 4.1$ (eV) Unit given on paper so no ue and ignore reference to J **OR** **Method 2:Use of Photoelectric Equation** Use of $hf = \Phi + E_{max}$ with any pair of values Divide by 1.6×10^{-19} to convert to eV $\Phi = 4.1 - 4.5$ (eV) Unit given on paper so no ue and ignore reference to J	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max 3)**
17(c)	Gradient of graph is Planck's constant/e (accept just Planck's constant)	**(1)**
17(d)	Graph parallel to original graph cutting X axis with a value less than 10	**(1)** **(1)**
	Total for question 17	**7**

Question Number	Answer	Mark
18(a)	There must be a circuit with a power supply **and** a labelled wire/identifiable ends of a wire/wavy line/resistor/lamp in order to score any marks **ANY TWO** Ammeter symbol in series with wire (not in the middle of) Voltmeter symbol in parallel with wire Variable power supply/variable resistor	 **(1)** **(1)** **(1)** **(max 2)**
18(b)	Use of $P = VI$ Rate of work = 4.5 W / J s^{-1}	**(1)** **(1)**
18(c)(i)	Correct use of $I = nqvA$ with e = 1.6×10^{-19} C $v = 3.0 \times 10^{-5}$ ms^{-1} <u>Example of calculation</u> $v = 1.5/ (1.0 \times 10^{29} \times 1 .6 \times 10^{-19} \times 3.1 \times 10^{-6}$ $v = 3.02 \times 10^{-5}$ ms^{-1}	**(1)** **(1)**
18(c)(ii)	Increased lattice/ions/atoms vibrations (causing) resistance to increase OR increased electron collisions with ions/atoms (This leads to a) reduction in the drift velocity / v	**(1)** **(1)** **(1)**
	Total for question 18	**9**

Question Number	Answer	Mark
19(a)(i)	$v = f\lambda$ (words or symbols not numbers) length of string = $\lambda/2$ OR wavelength = 2 x length OR node to node = $\lambda/2$	**(1)** **(1)**
19(a)(ii)	$\pi d^2/4$ OR $\pi(D3/2)^2$ OR π(D3/2)^2 (this mark is lost if there is a *length / A3) (ignore powers of ten)	**(1)**
19(a)(iii)	E4*density OR E4*7800 (ignore powers of ten) **OR** volume of 1 metre length x density	**(1)**
19(a)(iv)	5.12 (spreadsheet answers must be correct to same number dec places so do not accept 5.116 or 5.11) (correct answer on spreadsheet scores mark irrespective of what's written on next page)	**(1)**
19(a)(v)	See $T = v^2 \mu$ **OR** $\surd T = v\surd \mu$ (not just quoting given equation) T = 82 (N) (do not penalise dec places twice, 82.1 could score both marks if more than 3 dec places given in (iv)) (correct answer on spreadsheet scores both marks)	**(1)** **(1)**
19(b)	Plot a graph of $v \rightarrow \surd T$, $v^2 \rightarrow T$, $f \rightarrow \surd T$, or $f^2 \rightarrow T$ Graph should be a straight line through the origin Statement of what gradient equals (consistent with what has been plotted) (For this experiment μ is a constant. A graph using a variable μ can score max 1 mark for the correct gradient)	**(1)** **(1)** **(1)**
	Total for question 19	**10**

Question Number	Answer	Mark
20(a)	Wavelength of microwaves < wavelength radiowaves OR statement that wavelength of radiowaves is larger (need some comparison and do not credit frequency) Less / no diffraction **OR** beam spreads out less	 **(1)** **(1)**
20(b)(i)	Frequency (of reflected wave) would be higher	**(1)**
20(b)(ii)	There is a link between frequency (change) and speed(ing) (Car is speeding) when frequency (change) exceeds some limit (answers may be given in terms of wavelength)	**(1)** **(1)**
20(c)(i)	Use of intensity × area × 0.08 energy/sec = 6 J or J s^{-1} or W <u>Example of calculation</u> Energy per second = 500 W m^{-2} × 0.5 m × 0.3 m × 0.08 = 6 J	**(1)** **(1)** **(1)**
20(c)(ii)	Use of $E = Pt$ with any relevant time e.g. 8 hours, 480 min or 28800s t = 28800 s Number of flashes = 1700 Ecf answer to (c)(i) [Take their answer to (c)(i) and multiply by 288 to check their answer for full marks] <u>Example of calculation</u> Number of flashes = (6 × 8 × 3600)/100 =1728	**(1)** **(1)** **(1)**
	Total for question 20	**11**

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Summer 2010

GCE

GCE Physics (6PH07) Paper 1

Unit 3B: Exploring Physics

International Alternative to Internal Assessment

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Question Number	Answer	Mark
1(a)	C	**(1)**
(b)	B	**(1)**
	Total marks for question 1	**2**

Question Number	Answer	Mark
2(a)	A	**(1)**
(b)	D	**(1)**
	Total marks for question 2	**2**

Question Number	Answer	Mark
3(a)	A	**(1)**
	Total marks for question 3	**1**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>4</td><td>1 mark for each appropriate idea explained. Do not credit converse for a second mark: see table for examples. Do not penalise incorrect comments.
1 mark for each correct row to a maximum of 4

<table>
<tr><th>Idea</th><th>Datalogger</th><th></th><th>Liquid-in-glass + Stopwatch</th><th>Mark</th></tr>
<tr><td>Number of Readings</td><td>Advantage – large number of readings or small time interval between readings.</td><td>or</td><td>Disadvantage - small number of readings
Or large time interval between readings</td><td>1</td></tr>
<tr><td>Graph</td><td>Advantage - drawn automatically</td><td></td><td></td><td>1</td></tr>
<tr><td>Simultaneity</td><td>Advantage – simultaneous reading of temperature and time.</td><td>or</td><td>Disadvantage – reaction time (means readings are not simultaneous)</td><td>1</td></tr>
<tr><td>Conduction</td><td>Advantage – metal is a good conductor.</td><td>or</td><td>Disadvantage – glass is a poor conductor</td><td>1</td></tr>
<tr><td>Power supply</td><td>Disadvantage – power supply (or electricity) needed.</td><td>or</td><td>Advantage – no power supply required</td><td>1</td></tr>
<tr><td>Errors</td><td>Disadvantage – may be zero or systematic errors</td><td>or</td><td>Disadvantage – may be random, systematic or parallax errors</td><td>1</td></tr>
<tr><td>Transport</td><td></td><td></td><td>Advantage – easily transportable</td><td>1</td></tr>
<tr><td>Breakages</td><td></td><td></td><td>Disadvantage – easily broken</td><td>1</td></tr>
<tr><td>Cost</td><td>Disadvantage - expensive</td><td></td><td>Advantage - cheaper</td><td></td></tr>
</table>
</td><td>(4)</td></tr>
<tr><td></td><td>Total marks for question 4</td><td>4</td></tr>
</table>

Question Number	Answer	Mark
5(a)	Calculation using one pair of values (e.g. 0.18 s and 159 mm) Identifies $s = 0.5at^2$ or $s = ut + 0.5at^2$ with $u = 0$ Substitution of s and g, t and g, or s and t Correct evaluation of t, s or a for chosen values <u>Examples:</u> $t = \sqrt{}(2 \times 0.071 \text{ m} / 9.8 \text{ m s}^{-2}) = 0.12$ (s) $s = 0.5 \times 9.8 \text{ m s}^{-2} \times (0.18 \text{ s})^2 = 0.159$ (m) $a = 2 \times 0.012 \text{ m} / (0.05 \text{ s})^2 = 9.6$ (m s^{-2})	**(1)** **(1)** **(1)**
5(b)	<u>Examples:</u> • Hold/drop the rule vertically • Drop the rule cleanly • Release from rest • Ensure your fingers are just at the end of the rule • Practice • Repeat • Use the same bit of your fingers for measurement • Avoid parallax errors in the reading **Do not reward contradictory statements**	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max 3)**
5(c)	Value, uncertainty – I mark each Value : 0.19 (s) Absolute uncertainty seen or implied: $\pm$ 0.01 if anomalous result ignored or $\pm$ 0.06 if not Allow uncertainty as percentage eg 5(.3)% or 37(.5)% Note 0.16 ± 0.06 scores second mark only 0.19 ± 0.06 scores first mark only	**(1)** **(1)**
	Total marks for question 5	**8**

Question Number	Answer	Mark
6(a)	Calculation correct plus unit Example of calculation: $\pi d^2/4 = \pi$ $(0.12 \times 10^{-3})^2/4 = 1.1(3) \times 10^{-8}$ m^2 (or $1.1(3) \times 10^{-2}$ mm^2)	**(1)**
6(b)	1 mm (in 100 mm) is reasonable (allow 1/100 or 1%)	**(1)**
6(c)(i)	ρ and A are constants or ρ/A is constant $R \propto l$ or comparison to $y = mx + c$	**(1)** **(1)**
6(c)(ii)	• 41.9 x answer for (a) (ignore inconsistent units) • answer in range 4.55 – 4.80 x 10^{-7} Ω m • correct answer to 2 sig fig	**(1)** **(1)** **(1)**
6(d)	Valid points, do not reward single word responses Ignore comments on length **2 max** Examples: • Small diameter or diameter only measured once • Any zero error • Kinks in wire • Contact resistance • Resistance of connecting wires • Accuracy of ohmmeter	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max 2)**
	Total marks for question 6	**9**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>7(a)</td><td>Refraction towards normal (r > 0) at first face, away at second
Angle of incidence and refraction marked correctly <u>at first face</u></td><td>(1)
(1)</td></tr>
<tr><td>7(b)</td><td>Mark the emergent ray OR Mark the point of emergence
Appropriate joining up statement to give path of ray through block</td><td>(1)
(1)</td></tr>
<tr><td>7(c)</td><td>Too few values
Limited range
Should use protractor with 0.5 degree markings
Repeat measurements <u>at second face</u></td><td>(1)
(1)
(1)
(1)
(max 2)</td></tr>
<tr><td>7(d)</td><td>Correct completion of sin i and sin r rows
(values consistent to 2 or 3 sf and penalise rounding errors)

<table>
<tr><td>i/°</td><td>20</td><td>30</td><td>40</td><td>50</td></tr>
<tr><td>r/°</td><td>15</td><td>20</td><td>26</td><td>32</td></tr>
<tr><td>sin i</td><td>0.34/0.342</td><td>0.50/0.500</td><td>0.64/0.643</td><td>0.77/0.766</td></tr>
<tr><td>sin r</td><td>0.26/0.259</td><td>0.34/0.342</td><td>0.44/0.438</td><td>0.53/0.530</td></tr>
</table>
Suitable scales, starting at zero
Labels on axes
Correct plotting of points using sensible scale</td><td>(1)

(1)
(1)
(1)</td></tr>
<tr><td>7(e)</td><td>Line of best fit

Valid comment on whether the line should / should not go through the origin

<u>Example of calculation:</u>

when i = 0, r = 0, therefore should
sin i = n sin r, therefore should
sin i ∝ sin r (or <u>directly</u> proportional), therefore should
maybe systematic error, therefore not</td><td>(1)

(1)</td></tr>
<tr><td>7(f)</td><td>Large triangle ≥ 60 mm horizontally to determine gradient
Answer in range 1.35 - 1.64</td><td>(1)
(1)</td></tr>
<tr><td></td><td>Total marks for question 7</td><td>14</td></tr>
</table>

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Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'

1.2 Bold lower case will be used for emphasis.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.

2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.

2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given.

2.4 The same missing or incorrect unit will not be penalised more than once within one question.

2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

'Show that' calculation of weight

Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark] [Bald answer scores 0, reverse calculation 2/3]	✓	**3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	B	**(1)**
2	B	**(1)**
3	C	**(1)**
4	D	**(1)**
5	D	**(1)**
6	A	**(1)**
7	B	**(1)**
8	A	**(1)**
9	B	**(1)**
10	C	**(1)**

Question Number	Answer	Mark
11	Use of $W=mg$ Use of $F=BIL$ B = 0.04 T	**(1)** **(1)** **(1)**
	Total for question 11	**3**

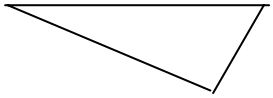
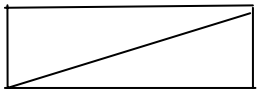
Question Number	Answer	Mark
12(a)	(Magnetic) Flux linkage	**(1)** **(1)**
12(b)	QWC (i and iii) – spelling of technical terms must be correct and the answer must be organised in a logical sequence Lenz's law / conservation of energy induced current/emf (direction) Opposes the change (that produced it)	 **(1)** **(1)** **(1)**
	Total for question	**5**

Question Number	Answer	Mark
13(a)	Conversion from per minute to per second Conversion from revolutions to radians Example of calculation 20 revolutions = 20 x 2π /60 (= 2.1 rads s^{-1})	**(1)** **(1)**
13(b)	Use of $r\omega^2$ Answer in range 6 – 13 ms^{-2}	**(1)** **(1)** **(1)**
	Total for question 13	**5**

Question Number	Answer	Mark
14	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence Momentum conservation Total/initial momentum = 0 Momentum of slime equal momentum of bacteria (Bacteria) moves in <u>opposite</u> direction [backwards or forwards OK] OR Force on slime Equal and opposite force (on bacteria) Cause rate of change of momentum / $\Delta mv/t$ /ma to bacteria (Bacteria) moves in <u>opposite</u> direction [backwards or forwards OK]	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max 4)**
	Total for question 14	**4**

Question Number	Answer	Mark
15(a)	At least 3 parallel straight lines <u>ALL</u> Equispaced (except ignore a large gap in middle) [be firm] Arrow left to right	**(1)** **(1)** **(1)**
15(b)	Use of eV [eg 1.6 x10^{-19} or 2000/4000] (=) ½ mv^2 Use of 2000	**(1)** **(1)** **(1)**
15(c)	Use of $v = s/t$ [eg = 1.5 / 23 (x 10^{-6})] (= 65000) Sub into previous equation m = 1.5 x 10^{-25} kg	**(1)** **(1)** **(1)**
15(d)	Some of the molecules in sample will travel further/less/not midway Duration of laser pulse Might emerge not horizontal Molecules may be doubly/integer ionised Time very small Not perfect vacuum / collides with other molecules	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(max2)**
	Total for question 15	**11**

Question Number	Answer	Mark
16(a)	(Trace) always positive/not negative/not below 0/ if it was AC the graph would be positive and negative Indicating one/same direction	**(1)** **(1)**
16(b)(i)	Capacitor stores charge/charges up (If voltage is constant) capacitor doesn't discharge	**(1)** **(1)**
16(b)(ii)	Recall of $E = ½ CV^2$ or use of $Q=CV$ and $QV/2$ Substitution of C and any reasonable V [ignore power of 10 for C] eg $= ½ 10 \times 10^{-6} \times 5.5^2/5.6^2$ $= 1.5 \times 10^{-4}$ - 1.6×10^{-4} J	**(1)** **(1)** **(1)**
16(c)(i)	Capacitor charges up From the supply (then) Capacitor discharges Through circuit / exponentially	**(1)** **(1)** **(1)** **(1)** **(max 3)**
16(c)(ii)	Corresponding time interval for a change in V eg 6-7 ms for $\Delta V = 2V$ $V = V_o e^{-t/RC}$ or rearrangement seen [eg Ln $0.7 = 6 \times 10^{-3}/RC$] R approx 1700 Ω (allow 1600 – 1800) or Time constant = 14 – 20 ms T = RC seen R approx 1700 Ω (allow 1600 – 1800) or Corresponding time interval for a change in V eg 6-7 ms for $\Delta V = 2V$ $Q = C V$ and $I = Q/t$ seen R approx 1700 Ω (allow 1600 – 1800)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**
16(c)(iii)	Use larger capacitor	**(1)**
	Total for question 16	**14**

Question Number	Answer	Mark
17(a)	(Total / sum of) Kinetic energy conserved	**(1)**
17(b)	These diagrams could appear in part c and should be credited in (b)   [allow first mark for any triangle or parallelogram ie do not insist on right angle] right angle labelled or approximately by eye / diagonal should be labelled "before" or "initial" or appropriately recognisable as incoming particle	**(1)** **(1)**
17(c)	KE as formula eg ½ mu^2 = ½ mv^2 + ½ ms^2 / $p^2/2m = p^2/2m + p^2/2m$ Recognition of "Pythagoras"	**(1)** **(1)**
17(d)(i)	Electric field Does work on proton/applies a force /repel/attract qV / Fd / Eq	**(1)** **(1)** **(1)**
17(d)(ii)	Mass of incoming proton larger (than rest mass) Due to moving near speed of light/high speed/high energy/relativistic Alt answer : image not in plane of two protons after the event	**(1)** **(1)** **(2)** **(max 2)**
17(e)	Out of the plane of paper	**(1)**
	Total for question 17	**11**

Question Number	Answer	Mark
18(a)	2/3 that of a proton / 2/3 x 1.6 x 10^{-19} (C)	**(1)**
18(b)	Mass = 80 MeV/c^2 charge = +1/3	**(1)** **(1)**
18(c)	Recognition M means 10^6 Convert eV to J or divide by c^2 eg 4 x 10^6 x1.6 x 10^{-19} or /9x10^{16} Answer 7.1 x 10^{-30} (kg)	**(1)** **(1)** **(1)**
18(d)(i)	Kaon Meson Omega baryon	**(1)** **(1)**
18(ii)	K^- + p = K^+ + K^o + Ω^- [accept p or p^+ ;do not accept K for K^o ;signs must be top right]	**(1)** **(1)**
18(iii)	Kaon plus = u $\bar{s}$ Kaon neutral = d $\bar{s}$ or s $\bar{d}$ [both marks can be inferred if equation in d(ii) is fully written in quark combinations)	**(1)** **(1)**
18(iv)	QWC i and iii – Spelling of technical terms must be correct and the answer must be organised in a logical sequence Momentum conserved Charge conserved Energy / mass conserved E =mc^2 <u>Kinetic</u> Energy (of kaon minus) is responsible Momentum of three particles after = momentum of kaon before Total charge 0 / charge before and after is 0 Conservation of Baryon no, quark no, strangeness	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(allow only 1 mark max from these 3)**
		5 max
	Total for question 18	**17**

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Summer 2010

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Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'
1.2 Bold lower case will be used for emphasis.
1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
3.2 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

'Show that' calculation of weight

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

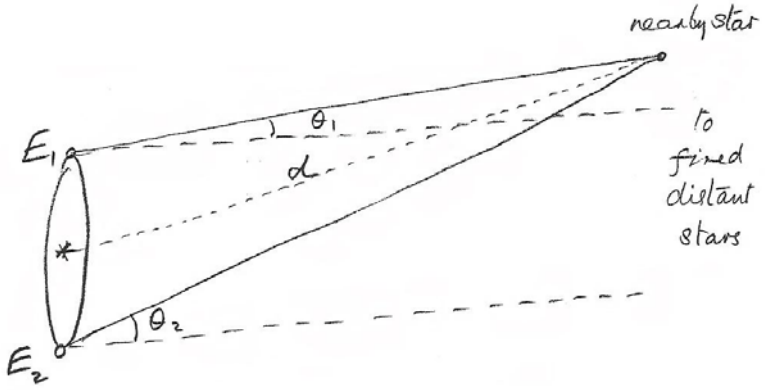
- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

6.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	B	**(1)**
2	D	**(1)**
3	A	**(1)**
4	B	**(1)**
5	C	**(1)**
6	D	**(1)**
7	C	**(1)**
8	C	**(1)**
9	C	**(1)**
10	B	**(1)**

Question Number	Answer	Mark
11(a)	(Net force) $(\Delta)F=-k(\Delta)x$ (1) Used with F=ma (1)	**(2)**
11(b)	Use of F=(-)kx (1) Correct answer for k OR substitution of expression for k into formula below (1) Use of $\omega^2=k/m$ OR $T = 2\pi\sqrt{\frac{m}{k}}$ OR $a_{max} = -\omega^2 A$, with a_{max}=9.81 Nkg^{-1} (1) Use of $\omega=2\pi f$ OR $f=1/T$ (1) Correct answer for f (1) Example of calculation: $k = \frac{0.15\,\text{kg} \times 9.81\,\text{N kg}^{-1}}{0.2\,\text{m}} = 7.4\,\text{N m}^{-1}$ $\omega = \sqrt{\frac{7.4\,\text{N m}^{-1}}{0.15\,\text{kg}}} = 7.0\left(\text{rad s}^{-1}\right)$ $f = \frac{\omega}{2\pi} = \frac{7\,\text{s}^{-1}}{2\pi} = 1.1\,\text{Hz}$	**(5)**
	Total for question 11	**(7)**

Question Number	Answer	Mark
12(a)	β-particles can (easily) penetrate the body/skin (1) Since they are not very ionising OR reference to what will stop them (1)	**(2)**
12(b)(i)	Use idea that number of unstable atoms halves every 8 days OR that 24 days represents 3 half-lives (1) Correct answer (1) Example calculation: $N_0 \rightarrow \frac{N_0}{2} \rightarrow \frac{N_0}{4} \rightarrow \frac{N_0}{8}$ $t = 0 \quad t = t_{1/2} \quad t = 2t_{1/2} \quad t = 3t_{1/2}$ Fraction decayed = 100% - 12.5% = 87.5%	**(2)**
12(b)(ii)	Use of $\lambda\, T_{1/2} = \ln 2$ (1) Use of an appropriate decay equation (1) Correct answer (1) Example of calculation: $\lambda = \frac{\ln 2}{T_{1/2}} = \frac{0.693}{8\,\text{day}} = 0.0866\,\text{day}^{-1}$ $1.50\,\text{MBq} = A_0\, e^{-0.0866\ \text{day}^{-1} \times 1\,\text{day}}$ $A_0 = 1.50\,\text{MBq}\, e^{0.0866} = 1.64\,\text{MBq}$	**(3)**
	Total for question 12	**(7)**

Question Number	Answer	Mark
13(a)	Idea that the Earth is orbiting the Sun (1) Reference to (trigonometric) parallax (1) Idea that more distant stars have "fixed" positions (1)	**(3)**
13(b)	Diagram to show how to measure angular displacement of star over a 6 month period e.g.  (1) [Diagram should indicate the Earth in two positions at opposite ends of a diameter, with lines drawn heading towards a point with a relevant angle marked; accept the symmetrical diagram seen in many textbooks.] Use trigonometry to calculate the distance to the star (1) [May be indicated by an appropriate trigonometric formula. Do not accept use of Pythagoras] Need to know the diameter/radius of the Earth's orbit about the Sun (1) [This may be marked on the diagram or seen in a trigonometric formula]	**(3)**
13(c)	Standard candle/Cepheid variable/supernovae (1)	**(1)**
	Total for question 13	**(7)**

Question Number	Answer	Mark
14(a)	Alpha-radiation only has a range of a few cm in air / cannot penetrate walls of container / skin (1)	**(1)**
14(b)(i)	Top line: $^{241}Am\ ^{237}Np\ ^{4}\alpha$ (1) Bottom line: $_{95}Am\ _{93}Np\ _{2}\alpha$ (1)	**(2)**
14(b)(ii)	Attempt at calculation of mass defect (1) Use of $(\Delta)E=c^2(\Delta)m$ OR use of 1 u = 931.5 MeV (1) Correct answer [5.65 MeV; accept 5.6 – 5.7 MeV] (1) Example of calculation: $\Delta m = 241.056822\,u - 237.048166\,u - 4.002603\,u = 0.006053\,u$ $\Delta m = 0.006053\,u \times 1.66 \times 10^{-27}\ kg\,u^{-1} = 1.005 \times 10^{-29}\ kg$ $E = 1.005 \times 10^{-29}\ kg \times \left(3 \times 10^{8}\ ms^{-1}\right)^2 = 9.04 \times 10^{-13}\ J$ $E = \frac{9.04 \times 10^{-13}\ J}{1.6 \times 10^{-13}\ MeV\,J^{-1}} = 5.65\,MeV$	**(3)**
14(c)	Reference to half-life and typical lifespan (1)	**(1)**
	Total for question 14	**(7)**

Question Number	Answer	Mark
15(a)(i)	Use of $\lambda_{max}T=2.898 \times 10^{-3}$ (1) Correct answer (1) Example of calculation: $T = \frac{2.898 \times 10^{-3}\ \text{mK}}{5.2 \times 10^{-7}\ \text{m}} = 5570\ \text{K}$	**(2)**
15(a)(ii)	Use of $F=L/4\pi d^2$ (1) Correct answer (1) Example of calculation: $L = 1370\ \text{Wm}^{-2} \times 4\pi \times (1.49 \times 10^{11}\ \text{m})^2 = 3.8 \times 10^{26}\ \text{W}$	**(2)**
15(a)(iii)	Use of $L=4\pi r^2\sigma T^4$ (1) Correct answer (7.46×10^8 m) (1) Example of calculation: $r^2 = \frac{3.82 \times 10^{26}\ \text{W}}{4\pi \times 5.67 \times 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4} \times (5570\ \text{K})^4} = 5.57 \times 10^{17}\ \text{m}^2$ $r = \sqrt{5.57 \times 10^{17}\ \text{m}^2} = 7.46 \times 10^8\ \text{m}$ | | **3.8×10^{-26} W** | **4×10^{26} W** | | **5570 K** | 7.46 | 7.6 | | **6000 K** | 6.4 | 6.6 |	**(2)**
15(b) **QWC**	The answer must be clear, use an appropriate style and be organised in a logical sequence High temperature AND high density/pressure (1) Any **two** reasons from: Overcome coulomb/electrostatic repulsion (1) Nuclei come close enough to fuse/for strong (nuclear) force to act (1) High collision rate/collision rate is sufficient (1)	**(max 3)**
	Total for question 15	**(9)**

Question Number	Answer	Mark
16(a)	Any two from: Air behaves as an ideal gas (1) Temperature (in the lungs) stays constant (1) Implication of no change in mass of gas (1)	**(max 2)**
16(b)(i)	Use of $\rho=m/V$ (1) Correct answer (1.3×10^{-4} kg s^{-1}) (1) Example of calculation: $m = V.\rho = 2.5\times10^{-4}\ m^3 \times 1.2\,kg\,m^{-3} = 3\times10^{-4}\ kg$ $\frac{\Delta m}{\Delta t} = 3\times10^{-4}\ kg \times \frac{25}{60\,s} = 1.25\times10^{-4}\ kg\,s^{-1}$	**(2)**
16(b)(ii)	Use of $\Delta E=mc\Delta\theta$ (1) Correct answer (2.2 W) ecf (1) Example of calculation: $P = 1.25\times10^{-4}\ kg\,s^{-1} \times 1000\,J\,kg^{-1}\,K^{-1} \times (37.6-20.0)K = 2.2\,W$	**(2)**
	Total for question 16	**(6)**

Question Number	Answer	Mark
17(a)(i)	Calculation of time period (1) Use of $v = \frac{\Delta s}{\Delta t}$ *or* $\omega = \frac{2\pi}{T}$ (1) Use of $a = \frac{v^2}{r}$ *or* $a = r\omega^2$ (1) Correct answer (1) Example of calculation: $T = \frac{24 \times 60 \times 60\, s}{15} = 5760\, s$ $v = \frac{2\pi r}{T} = \frac{2\pi \times 6.94 \times 10^6\, m}{5760\, s} = 7.57 \times 10^3\, ms^{-1}$ $a = \frac{v^2}{r} = \frac{\left(7.6 \times 10^3\, ms^{-1}\right)^2}{6.94 \times 10^6\, m} = 8.26\, ms^{-2}$ OR $\omega = \frac{2\pi}{T} = \frac{2\pi}{5760\, s} = 1.09 \times 10^{-3}\, ms^{-1}$ $a = r\omega^2 = 6.94 \times 10^6 \times \left(1.09 \times 10^{-3}\right)^2 = 8.26\, ms^{-2}$	**(4)**
17(a)(ii)	mg equated to gravitational force expression (1) g (= a) = 8.3 ms^{-2} substituted (1) Correct answer (1) Example of calculation: $mg = \frac{GMm}{r^2}$ $\therefore 8.3\,ms^{-2} = \frac{6.67 \times 10^{-11}\,Nm^2\,kg^{-2}M}{\left(6.94 \times 10^6\,m\right)^2}$ $\therefore M = \frac{8.3\ ms^{-1} \times \left(6.94 \times 10^6\,m\right)^2}{6.67 \times 10^{-11}\,Nm^2kg^{-2}} = 6.0 \times 10^{24}\,kg$	**(3)**
17(b)	The observed wavelength is longer than the actual wavelength / the wavelength is stretched out (1) One from: The universe is expanding (1) (All distant) galaxies are moving apart (1) The (recessional) velocity of galaxies is proportional to distance (1) The furthest out galaxies move fastest (1)	**(max 2)**

17(c)(i)	A light year is the distance travelled (in a vacuum) in 1 year by light / em-radiation (1) The idea that light has only been able to travel to us for a time equal to the age of the universe. (1)	**(2)**
17(c)(ii)	(Use of v = H_o d to show) $H_o = \frac{1}{t}$ (1) Correct answer (1) Example of calculation: $H_o = \frac{1}{t} = \frac{1}{12 \times 3.15 \times 10^{16}\ s} = 2.65 \times 10^{-18}\ s^{-1}$	**(2)**
17(c)(iii) **QWC**	The answer must be clear and be organised in a logical sequence There is considerable uncertainty in the value of the Hubble constant (1) Any sensible reason for uncertainty (1) Idea that a guess implies a value obtained with little supporting evidence OR the errors are so large that our value is little better than a guess (1)	**(3)**
	Total for question 17	**(16)**

Question Number	Answer	Mark
18(a)	Resonance (1) System driven at / near its <u>natural</u> frequency (1)	**(2)**
18(b)(i)	Any zero velocity point (1)	**(1)**
18(b)(ii)	Any maximum/minimum velocity point (1)	**(1)**
18(c)	Select 70 mm distance from passage/see 35 mm (1) Use of $a = -\omega^2 x$ (1) Use of $v = \omega A$ (1) Correct answer (1) Example of calculation: $\omega = \sqrt{\frac{0.89\,\text{ms}^{-1}}{3.5\times10^{-2}\,\text{m}}} = 5.04\,\text{rad s}^{-1}$ $v = \omega A = 5.04\,\text{s}^{-1} \times 3.5\times10^{-2}\,\text{m} = 0.18\,\text{m s}^{-1}$	**(4)**
18(d) **QWC**	The answer must be clear and be organised in a logical sequence The springs/dampers absorb energy (from the bridge) (1) (Because) the <u>springs</u> deform/oscillate with natural frequency of the bridge (1) Hence there is an efficient/maximum transfer of energy (1) Springs/dampers must not return energy to bridge / must dissipate the energy (1)	**(max 3)**
	Total for question 18	**(11)**

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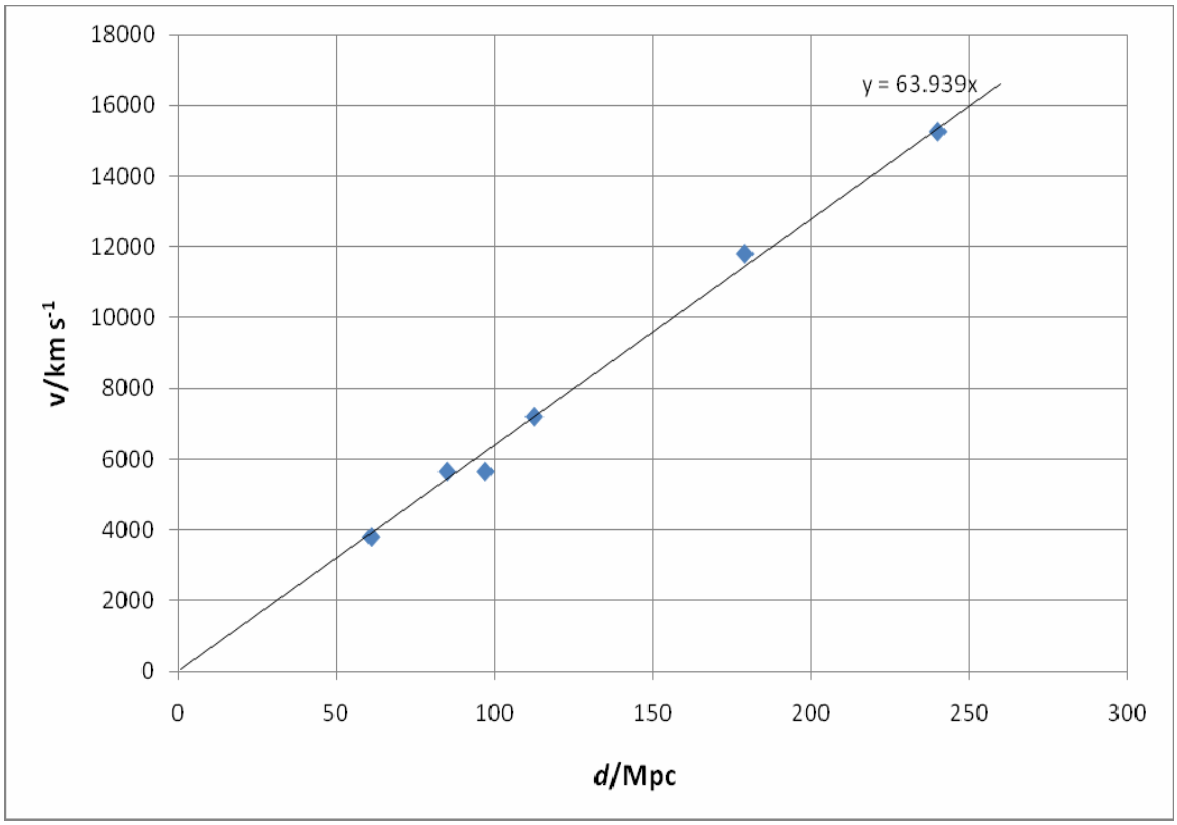
Question Number	Answer	Mark
1 (a) (i)	Ignore the anomalous 0.77 OR add the four good readings and divide by four	**(1)**
(ii)	0.27 mm	**(1)**
(iii)	Divides 0.015 *or* 0.02 *or* 0.03 by their mean value to calculate correct percentage Example of calculation 0.02/0.27 = 7%	**(1)** **(1)**
1 (b) (i)	Use of $\pi r^2 l$ Produces correct answer with consistent unit Example of calculation $\pi(0.135 \times 10^{-3}\ m)^2 \times 663 \times 10^{-3}\ m = 3.80 \times 10^{-8}\ m^3$	**(1)** **(1)**
1 (b) (ii)	Use of mass/volume Answer to 2 s.f. with unit for density consistent with mass used Example of calculation $0.32 \times 10^{-3}\ kg / 3.80 \times 10^{-8}\ m^3 = 8400\ kg\ m^{-3}$	**(1)** **(1)**
1 (c)	Material is Nichrome Thickness is 32 (swg)	**(1)** **(1)**
	Total for question 1	**10**

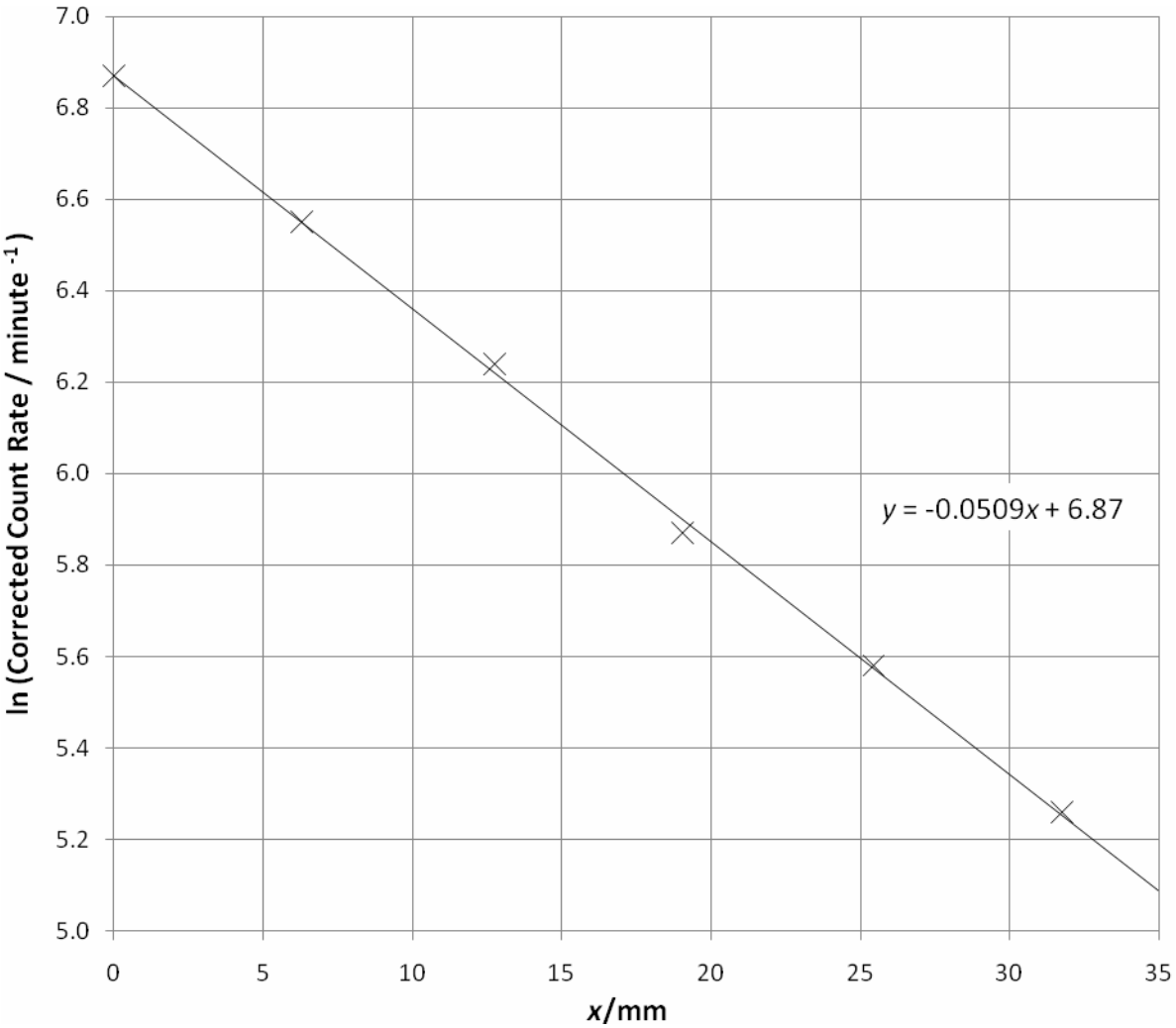
Question Number	Answer	Mark
2(a)	metre rule shown to be vertical with set square on floor OR set square aligned with weight and rule OR eye level with bottom of weight	**(1)**
2 (b)(i)	Uncertainty in *h* is 1 *or* 2 mm **(1)**	**(1)**
2(ii)	Uncertainty in *t* is 0.26 *or* 0.27 *or* 0.52 s only	**(1)**
2(iii)	v = 0.584 m s^{-1}	**(1)**
2(iv)	Calculates value for kinetic energy Example of calculation 0.5 x 0.96 kg x (0.584 m s^{-1})^2 = 0.164 J	**(1)**
2(v)	Calculates % uncertainty in *h* and *t*(*or v*) Example of calculation 0.11% and 8.6% Combines % uncertainties Example of calculation 2 × 0.11% + 2 x 8.6 % = 17 %	**(1)** **(1)**
	Total for question 2	**7**

Question Number	Answer	Mark
3(a)	Red shift OR Doppler shift OR frequency of electromagnetic radiation/light OR wavelength of electromagnetic radiation/light	**(1)**
3(b)(i)	Line of best fit	**(1)**
3(b)(ii)	large triangle used gradient in range 62.0 - 66.0 with 2/3SF <u>Example of calculation</u> (16000 – 0)/(250 – 0) = 64 (ignore unit)	**(1)** **(1)**
3(c)(i)	Yes, as best fit line is <u>straight</u> and passes through origin OR No, as best fit line does not pass through origin	**(1)**
3(c)(ii)	Percentage difference calculated using 71 as denominator <u>Example of calculation</u> (71 – 64)/71 = 10%	**(1)**
	Total for question 3	**6**



Question Number	Answer	Mark
4 (a)	Record background count (rate) Place thick aluminium/thin lead between source & detector OR Distance greater than 25 cm between source and detector Count rate detected above background	**(1)** **(1)** **(1)**
4 (b)	Keep distance between the source and detector constant Any **four** from: • Record count (rate) for different thicknesses • Record count for a specified time • Subtract background count • Take several readings at each thickness • Measure thickness with micrometer screw gauge/vernier callipers Keep people away from source/use tongs to handle source /use tongs to handle lead sheets/ensure source held securely	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(Max 4)** **(1)**
4 (c)	$\ln A = -\mu x + \ln A_0$ **and** identifies $-\mu$ as gradient	**(1)**
4 (d)	Corrected count rate to at least 3SF and with correct units **and** ln A to at least 3SF and with correct units Axes labelled for suitable graph(ignore units) Suitable scales Plots Line	**(1)** **(1)** **(1)** **(1)** **(1)**
4 (e)	Triangle base at least 40 small squares and correct calculation of gradient (ignore sign and unit) μ = 0.050 to 0.052 mm^{-1} with unit and 2/3SF (no ecf) <u>Example of calculation</u> $(5.40 - 6.86)/(28.8 - 0) = 0.0507\ mm^{-1}$	**(1)** **(1)**
	Total for question 4	**17**

x/mm	Measured Count Rate / minute^{-1}	Corrected Count Rate / minute^{-1}	ln (Corrected Count Rate / minute^{-1})
0	1002	962	6.87
6.30	739	699	6.55
12.74	553	513	6.24
19.04	394	354	5.87
25.44	304	264	5.58
31.74	232	192	5.26



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