G492 – Understanding Processes, Experimentation and Data Handling

Qn	Expected Answers	Marks	Additional guidance
1	(a) hf and $\frac{1}{2}mv^2$ (1) (b) $d \sin \theta$ and $\frac{1}{2}at^2$ (1)	1 1	Both needed (either order) in each part.
2	$\frac{1}{4}\lambda$ (1)	1	Allow ringing, underlining, etc. of $\frac{1}{4}\lambda$ in list
3	$v = \sqrt{(200^2 - 50^2)} = 190$ m s^{-1} (1); θ = arcsin(50/200) (1); = arcsin (0.25) = 14.47° = 14° (1)	3	Ignore any vector triangle with θ to the east instead of west. Allow resultant = 200 km h^{-1} or assuming v = hypotenuse = 206 km h^{-1} Allow θ = arctan(50/200)= 14.0° in either case Alternatives: 193.6 km h^{-1} & 14.5°, 200 km h^{-1} & 14.0°, 206 km h^{-1} & 14.0° For scale drawing allow greater tolerance.
4	**X** = $\frac{1}{2}at^2$ (3rd box) **Y** = ut (4th box)	2	One for each correct tick. If more than one choice for X or for Y, ignore that area.
5	$\lambda/d = \sin\theta \approx x/L$ (1) $d = \lambda L/x$ = 590 × 10^{-9} m × 1.2 m/3.5 × 10^{-3} m (1) = 2.0 × 10^{-4} m (1)	3	Or quote $\lambda = xd/L$, etc. Rearrange/substitute. Must be correct from first stage (no ecf). θ =0.17°. Eval.; allow 0.20 mm
6	(a) $f = E/h$ = 3.5 × 10^{-19} J/6.6 × 10^{-34} J s (1) = 5.3 × 10^{14} Hz (1) (b) P = NE/t = 1.2 × 10^{17} × 3.5 × 10^{-19} J / 1 s = 0.042 W (1)m (1)e	2 2	Method/substitution Evaluation
7	(a) $E = mgh$ = 6.0 × 10^{-3} kg × 9.8 m s^{-2} × 0.50 m (1) = 0.029 J (1) (b) displacement x = (30 - 9) × 10^{-3} m = 0.021 m (1) $W = Fx$ = 3 N × 0.021 m (1) = 0.063 J (1)	2 3	Method/substitution Evaluation Can be incorporated into calc. of W Method/substitution Evaluation. Penalise 1 mark for use of mm instead of m.
	Section A total:	**20**	

Qn	Expected Answers	Marks	Additional guidance
8 (a)	(i) between 0.1 and 0.3 s (1) (ii) demonstrating that either area under graph or (average speed × time) (1); is considerably less than 200m / ≈ 100 m (1)	1 2	Must use data from **both** axes. method mark for getting a typical/average speed & time and multiplying, or indicating that total area = distance and indicating area (1); evaluation mark for comparison with 100 m (1) (final speed × time) gets only (1) unless qualified e.g. final speed is about the average.
(b)	(i) a = 4 m s^{-1}/(0.7 s – 0.2 s) = 8 m s^{-2} (1)m; (1)e; $F = ma$ = 88 × 8 = 704 N ≈ 700 N (1) (ii) assumes no resistive forces/reference to lack of precision in data from graph (1)	3 1	Method is gradient of straight line: must have Δv > 1 m s^{-1} and allow for reaction time (1); Evaluation ± 2 m s^{-2} (1) ecf for *a;* may see answers (with correct *a*) from 530-880 N
(c)	Drop in speed noticeable in last 1.2 – 1.7 s / after 8s (1); Mean speed over this time is 11.5 – 11.8 m s^{-1} (1); Combining above & comparing with 20 m.(1)	3	First two points and combination can be done by area: needs comparison with 20 m for 3rd mark. Third mark is the QWC 'organise information clearly' mark.
	Total:	**10**	
9 (a)	(i) F (1) (ii) A and B (1)	1 1	 Both needed
(b)	First out from the centre (on each side) = A (1); Outermost (on each side) = F (1)	2	
(c)	(i) $f = c/\lambda$ = c = 3.0 × 10^{8} m s^{-1}/360 × 10^{-9} m = 8.3 × 10^{14} Hz (1)m; (1)e $E = hf$ = 6.6 × 10^{-34} J s × 8.3 × 10^{14} Hz = 5.5 × 10^{-19} J (1) (ii) Comparing electron energy from table (0.82 × 10^{-19} J) with photon energy (5.5 × 10^{-19} J) (1); Difference ≈ 4.7 × 10^{-19} J (1)	3 2	Allow ecf. "Show that" so needs 2 sf. Give all 3 marks for $E=h\,c/\lambda$ & eval. photon energy e.c.f. from (i) Can calculate photon energy for 435 nm for both marks.
	Total:	**9**	

Qn	Expected Answers	Marks	Additional guidance
10 (a)	(i) wave <u>reflects</u> (at open end) (1); resonance idea e.g. sets up right frequency (1); there is <u>superposition</u> / <u>interference</u> between waves (in opposite directions) (1); nodes = destructive interference/out of phase (1); antinodes = constructive interference/in phase (1) QWC is 'spelling, punctuation and grammar' of <u>reflection</u> and <u>interference</u> or <u>superposition</u>	3	Allow pressure N & A if clear. Any three points. Incorrect spelling of underlined terms means max 2. Allow paraphrases for the marking point.
	(ii) length of didgeridoo = ¼ λ so λ = 6.4 m (1); $f = c/\lambda$ = 340 m s^{-1}/6.4 m = 53 Hz (2)	3	m & e; ecf for λ
	(iii) A at open end and N at 'mouth' end (1); A and N alternate and equally spaced (1); pattern A N A N (1)	3	
(b)	Test: <u>constant</u> $f:T$ /straight line graph through origin (1) $f:T$ = 4.93, 3.01, 2.19 (1) conclusion: not proportional. (1)	3	If test for linearity proposed and done correctly (equal differences, so looks linear) give 1 mark. {for ref: $T:f$ = 0.203, 0.332, 0.457}
	Total:	**12**	
11(a)	5 m s^{-1} × 0.2 s = 1.0 m (1); Horizontal motion not affected by gravity/$F_{resultant}$ =0 (1)	2	Allow 'no horizontal acceleration'
(b)	(i) Straight line segments (1); $x \propto t$ so velocity = gradient = constant / acceleration would produce curve (1)	2	Second mark requires recognition that $x \propto t$ so straight line is constant velocity as y-x graph is same shape as y-t graph.
	(ii) $x \approx$ 3.5 m (at $y \approx 0$) (1); $t = x/v_x \approx$ 3.5 m/5 m s^{-1}=0.7 s (1)/ there are 4 line segments (1); each segment is 0.2 s (so total is 0.8 s) (1)	2	
	(iii) $s = ½at^2 \Rightarrow t = \sqrt{(2s/g)} = \sqrt{(2\times1.6\text{ m}/ 9.8\text{ m s}^{-2})}$ = 0.57 s (< 0.7 s) (1)m; (1)e	2	
	(iv) Velocity at start of each interval used / velocity changes constantly/ time interval too big (1);	1	
(c)	Use smaller time intervals / more steps per second (1) so v updated more often / true v modelled better (1)	2	Or include acceleration during time intervals in the model (1) so true v modelled better (1)
	Total:	**11**	
	Section B total:	**42**	

Qn	Expected Answers	Marks	Additional guidance
12 (a)	(i) 5000 Ω (1) (ii) 5000 Ω (1) (iii) 50 000 Ω (1)	1 1 1	
(b)	ΔV = (4.0 – 2.6) V = 1.4 V (1); Sensitivity = $\Delta V/\Delta T$ = 1.4 V / 20 °C = 0.070 (1)m; (1)e With units V °C $^{-1}$ (1)	4	Values 20°C, 4 V and 2.6 V imply use of graph. 0.01 V ÷ gradient of line is valid: ΔV mark from triangle. If 'insensitivity' in °C V^{-1} calculated, maximum 3/4 if completely correct.
(c)	Identifies voltage range is 2.4 – 2.6 V to 3.0 V i.e. 0.4 – 0.6 V (1) Dividing this by 0.01 V gives 40 – 60 steps in range (1) Temp. resolution = 10°C /(40 to 60) = 0.25 to 0.17°C (1)	3	Look for gradient 0.4 to 0.6 V °C^{-1}. Can use values at 50°C and 60°C. Compares with ± 0.01V. Ecf from first step for factor. Translates to °C. Ecf of factor from second step.
	Total:	**10**	
13 (a)	(i) P = 1/0.21 m – 1/0.11 m = 4.76 D – 9.09 D = -4.3(3) D (ii) measured to nearest 0.01 m (so ± 0.005 m) (1) (iii) P_1 = 1/0.215 m – 1/0.105 m = -4.87 D (1) P_2 = 1/0.205 m – 1/0.115 m = -3.82 D (1) Range = 1.05 D so uncertainty = 0.525 D (1); =0.5 D (1)	1 1 4	Accept any clear recognition of 2 s.f./2 d.p. implying ± ½ of last digit. If v_{max} and $\underline{u}_{max}$ (& mins) used in same calc, get P_1 = -4.65 D and P_2 = -4.04 D; in this case give 1/2 for both calculations together. Ecf from P_1 & P_2 for 3rd mark (above gives 0.61/2 = 0.3 D) 1 s.f. for 4th mark (even if answer wrong); 0.525 D or 0.53 D gets 3/4 total If one extreme and mean used, completely correct answer would get 3 /4.
(b)	(i) 9.1 4.8 8.3 4.2 7.7 3.4 Annotation: put ✕ on any wrong numbers (ii) All correct (2); one wrongly plotted (1) (iii) best-fit line (1); P = – 1/u when v = 0 = - 4.4 to - 4.5 D (1)	2 2 2	One mark for each correct column Allow 3 s.f. but not 4 or more; 3 s.f. → 9.09 4.76 8.33 4.17 7.69 3.45 Overlay to be used. Ecf from (i) if needed. By eye: must have points both sides of line. Ecf: allow any method using line on graph, e.g. subst. values of 1/u,1/v from line
	Total:	**12**	

Qn	Expected Answers	Marks	Additional guidance
14 (a)	(i) 13 900 km/ 902 km h^{-1} = 15.4 h (≈ 15 h) (1)	1	ora
	(ii) fuel used = 15.4 h × 9800 L h^{-1} = 151 000 L (1) 80% of 195 600 = 156 000 L (1) > 151 000 L (1)	2	15.4 h = 77%; 15h = 75%
	(iii) Plausible suggestion (1); Explains effect of suggestion on fuel needed – must have correct physics reasoning (1)	2	e.g. head winds / diversion from route / delays in landing (1); so plane must stay longer in the air (1) or more fuel needed at take-off (1); work done in accelerating/overcoming turbulence/denser air at ground level (1)
(b)	(i) F = 3 × 270 000 = 810 000 N (1) $a = F/m$ = 810 000 N/273 900 kg = 2.96 m s^{-2} (1)	2	Calc. of a from wrong F can gain 1 mark.
	(ii) $s = v^2/2a$ = (81 m s^{-1})^2/2×2.96 m s^{-2} = 1100 m (1)m; (1)e	2	Calc. of s from wrong v can gain 1 mark.
	(iii) Plausible suggestion (1); Explains effect of suggestion on take-off distance – must have correct physics reasoning (1)	2	e.g. May not reach required v due to wind / other traffic on runway / turbulence (1) If v not reached, plane would crash /need space to slow down to a halt(1)
(c)	Lift must equal weight (1); weight = mg so Lift $\propto m$ (1)	2	
(d)	Best-fit line excluding Boeing 777 point (1); Larger mass planes have larger wing area (1); Identifying Boeing 777 as different from the others (1); suggestion for odd position of Boeing 777 (1)	3	Line should obviously exclude Boeing 777 and should be reasonable best fit of other points by eye, i.e. have points on each side Any **two** of these explanations/descriptions. Can credit use of other data related to Boeing 777 e.g. fuel capacity.
	Total:	**16**	
	Section C total:	**40**	