Question Number	Answer	Acceptable answers	Mark
1(ai)	**B** momentum (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(aii)	power (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
1 (bi)	Substitution: ½ x0.8 x 25^2 (1) Evaluation 250 (1) 0.25 kJ scores 3 marks J bod j (1)	 Allow both marks for correct answer with no method shown. Ignore power of 10 until evaluation e.g. 2 marks for 25 J 1mark for 25 W Nm ignore kg $(m/s)^2$ Unit mark is independent of numerical answer.	**(3)**

Question Number	Answer	Acceptable answers	Mark
1 (bii)	250 (1) Ignore any unit given by the candidate	Allow ecf from 1(bi)	**(1)**

Question Number	Answer	Acceptable answers	Mark
1 (biii)	A suggestion to include: work done = force x distance (1) (force) used over a longer distance (1)	ignore references to more power, greater speed, longer time, larger force, momentum and how far javelin travels. the longer they are pushing (it/the javelin) [bod distance] they can push the javelin (forward) for longer [bod distance] the arm can move further	**(2)**

(Total for Question 2 =8 marks)

Question Number	Answer	Acceptable answers	Mark
2 (a)(i)	C - power		**(1)**

Question Number	Answer	Acceptable answers	Mark
2 (a)(ii)	energy work	Must be in correct order	**(1)**

Question Number	Answer	Acceptable answers	Mark
2 a(iii)	Substitution 50 x 4 (1) Evaluation 200 (kg m/s) (1)	 Allow full marks for correct answer with no working shown	**(2)**

Question Number	Answer	Acceptable answers	Mark
2 a(iv)	Substitution 450 / 1.5 (1) Evaluation 300 (N) (1)	 Allow full marks for correct answer with no working shown Allow (1) for 167 (N) obtained by 450-200 / 1.5	**(2)**

Question Number	Answer	Acceptable answers	Mark
2 (a)(v)	An explanation to include (quantity has) a size and a direction	ignore any named examples	**(1)**

Question Number	Answer	Acceptable answers	Mark
2 (b)	An explanation which uses conservation of momentum to link three from Mother and daughter have different mass (1) Momentum is conserved / is zero to start with (1) Both have same size momentum (after the push) (1) so speed of the daughter is greater than that of the mother (1)	An explanation based on Newton's laws and linking three from Each have a different mass (1) Each experience the same size force / action and reaction are equal (1) Each experiences a different acceleration (1) so speed of the daughter is greater than that of the mother (1)	**(3)**

(Total for Question 3 = 10 marks)

Question Number	Answer	Acceptable answers	Mark
3 (a) (i)	D the same size as the driving force		**(1)**

Question Number	Answer	Acceptable answers	Mark
3 (a) (ii)	transposition: (1) {change in) speed= accelerationxtime substitution: (1) speed = 12 x 4 evaluation: (1) 48 (m/s) (1)	transposition and substitution can be in either order substitution mark can be scored when incorrectly transposed word/symbol equation is given Give full marks for correct answer no working	**(3)**

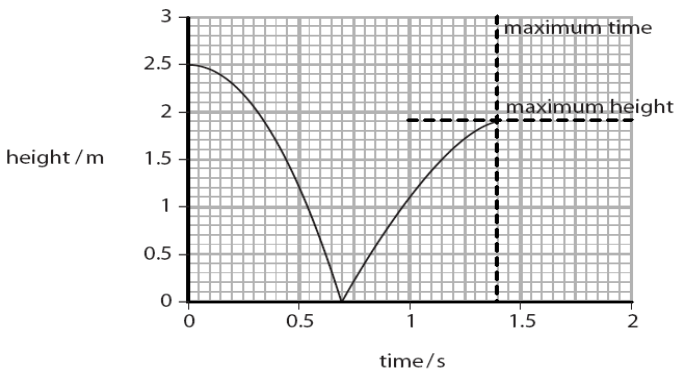
Question Number	Answer	Acceptable answers	Mark
3 (b)	An explanation linking • {acceleration of sports is 2x / time to reach 30 m/s is ½} that of family car / RA (1) • mass of sports car LESS than ½ that of family car or RA (1) (so resultant force required is less)	Attempt to use f = m x a scores one mark e.g. 4200 OR 3600 scores 1 Correct numerical comparison scores both marks e.g. 4200:3600 numerically or in words scores 2 marks	**(2)**

Question Number		Indicative Content	Mark
QWC	*)	An explanation including some of the following ideas • brakes apply a force to the car • this force from brakes makes the car decelerate/ lose velocity • a force also acts on the driver • driver decelerates at same rate as the car • does not move with respect to car/ stays in the driving seat • moves slightly because belt stretches • small/ no horizontal force acts on the shopping bag • shopping bag continues at similar/ same velocity • until shopping bag falls off seat / hits dashboard • ideas can be expressed in terms of energy, momentum and/or by reference to Newton's laws	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• A limited explanation of the difference in decelerations of at least two of the objects Car **(C)**, Shopping **(S)** and Passenger **(P)** mainly describing the effects. E.g. (at start) **C** stops (very quickly) while {**P / S**} carries on moving (for a longer time) OR **S** {carries on at same speed / hits the dashboard} while **P** is {held back / slowed down} (by the seatbelt) • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• A simple explanation of the difference in decelerations of at least **two** of the objects Car, Shopping and Passenger, including a reason for at least one of the decelerations. E.g.(at start) **C** stops (very quickly) **because of** friction at the brakes and at the road while {**P / S**} carries on moving (for a longer time) OR **S** {carries on moving (at same speed) / hits the dashboard} while **P** is {held back / slowed down} **because of** stretching force from the seatbelt) • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	

3	**5 - 6**	• A detailed explanation of the relative decelerations of **C**, **S and P** including mention of the physical principles involved in any two such as that named forces are needed to change given motions. E.g. (The force of) friction is large for **C** to {slow down / stop} quickly but is low for **P** and **S**. {**<u>So / thus / therefore etc</u>**} **P** or **S** carry on at the same speed (initially). **P** decelerates more slowly than **C** {**because / as a result etc**} of the stretching (force) of the seatbelt. OR *The idea of {*Newton's first law / inertia / need for a force to change motion} and the role of friction and {elastic / tension / stretching} force in producing the **three** named decelerations. OR Named force needed for a described change in {momentum/kinetic energy} to {stop / slow down} each of the **three** objects. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Question Number	Answer	Acceptable answers	Mark
4 (a)(i)	2.5 (m)	Allow answers between (and including) 2.45 & 2.55	**(1)**

Question Number	Answer	Acceptable answers	Mark
4 (a)(ii)	0.7 (s)	Allow answers between (and including) 0.68 & 0.72	**(1)**

Question Number	Answer	Acceptable answers	Mark
4 (a)(iii)	 line: same shape as original (1) peak at 1.9 m (1) time taken < 0.7 s (1)	Ignore any part of the graph after the peak	**(3)**

Question Number	Answer	Acceptable answers	Mark
4 (a)(iv)	An explanation linking: <u>energy</u> lost (1) in collision with ground / air resistance (1)	Inelastic collision worth (2) as sound or heat	**(2)**

Question Number	Answer	Acceptable answers	Mark
4 (b)(i)	shown using data Any two from kinetic energy before = 12.5 + 0 (=12.5) (1) kinetic energy after = 4.5 + 8 (=12.5) (1) Kinetic energy is the same before and after the collision (1)	 Kinetic energy is conserved/no energy lost	 **(2)**

Question Number	Answer	Acceptable answers	Mark
4 (b)(ii)	cyclotron (1)	named particle accelerator accept CERN	**(1)**

Total mark for question 4 = 10

Question Number	Answer	Acceptable answers	Mark
5(a)(i)	momentum = 0.03 × 170 (1)	Accept 5.1 seen	**(1)**

Question Number	Answer	Acceptable answers	Mark
5(a)(ii)	momentum before = momentum after (1) 5.1 = 0.83 × v (1) v = 6.1 (m/s) (1)	allow 5.0 = 0.80 x v for 1 mark max 5.0 = 0.83 x v v = 6.0 (m/s) allow ecf from (a)(i) give full marks for correct answer, no working	**(3)**

Question Number	Answer	Acceptable answers	Mark
5(a)(iii)	Statement to include any two from • kinetic energy is not conserved (1) • (lost ke) appears as heat/sound (1) • momentum is conserved (1)	ke not conserved / some ke lost no momentum lost	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(b)(i)	an explanation linking • momentum (must be) conserved (1) • so must have positive and negative momentum (1)	photons move in opposite directions indication of movement in opposite directions (e.g. opposite velocities)	**(2)**

Question Number	Answer	Acceptable answers	Mark
5(b)(ii)	E = (2 ×) 9.1 × 10^{-31} × [3 × 10^{8}]^{2} (1) = 1.6 × 10^{-13} (J) (1)	8.2 × 10^{-14} (0.82 × 10^{-13}) for 1 mark give full marks for correct answer, no working	**(2)**