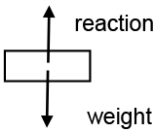
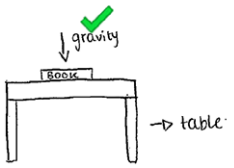
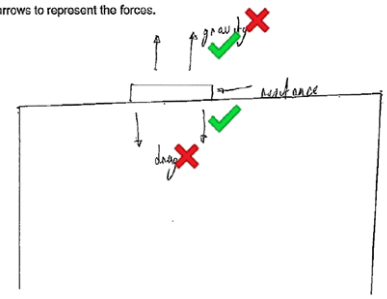
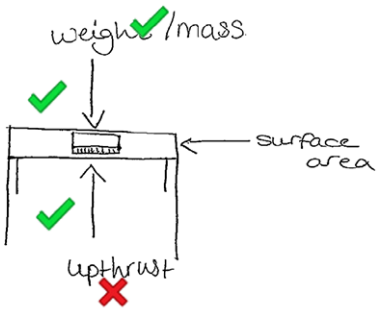
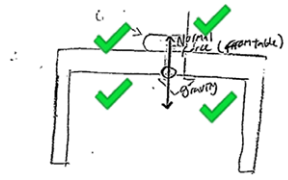
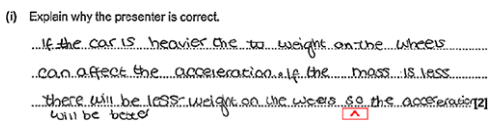
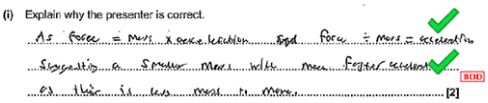
Mark scheme – Newton's Laws (F)

Question			Answer/Indicative content	Marks	Guidance
1			**B** ✓	1 (AO2.1)	**Examiner's Comments** This was the hardest multiple-choice question, with one in six candidates getting it right. Most candidates did not convert cm into m.
			Total	**1**	
2			**A** ✓	1(AO1.1)	
			Total	**1**	
3			**B** ✓	1 (AO2.1)	**Examiner's Comments** This question was very well answered. Candidates correctly squared the speed. Again, higher ability candidates used the space around the question for their working.
			Total	**1**	
4			**C** ✓	1 (AO2.1)	**Examiner's Comments** This question was answered well with candidates being able to recall the equation relating acceleration, force and mass.
			Total	**1**	
5			B	1 (AO2.1)	
			Total	**1**	
6			D	1	
			Total	**1**	
7			C	1	
			Total	**1**	
8	a		C (1) The product of force × distance is the most / **AW** (1)	2	
	b		A and B (1)	1	Both needed for this mark Any order
	c		Reduce random errors / identify anomalies / **AW** (1) Allows a mean / average to be calculated (1)	2	

	d		Power = energy / time (1) Conversion of time into seconds (1) (120 × 12)/30 (1) 48 (W) (1)	4	**ALLOW ECF** from **(a)**
			Total	**9**	
9		i	Use of graph to calculate time / t = 2.25 − 0.75 / t = 1.5 (1) Substitution into acceleration formula: 8 / 1.5 (1) (−) 5.3 (1) m/s^2 (1)	4	
		ii	5 000 × 6 (1) 30 000 (J)	2	
			Total	**6**	
10			Re-arrange and substitute into WD = F × D: 217 000 / 6 500 (1) 33 (m) (1)	2	**ALLOW** 33.4 (m)
			Total	**2**	
11	a		**Any one from:** electrostatics ✓ gravity/weight ✓ magnetism ✓ (normal) contact force ✓ friction ✓	1 (AO1.1)	Allow 'static electricity' but not just 'static' **ALLOW** reaction force **ALLOW** drag/air resistance **Examiner's Comments** Most candidates were able to name an appropriate force. The most common misconception was to name kinetic energy as a type of force.
	b		Two arrows drawn of equal length ✓ One up and one down ✓ The downwards arrow labelled weight/gravity ✓ The upwards arrow labelled contact/reaction force ✓	4 (AO4 × 2.1)	e.g.  **Examiner's Comments**

					The best answers were offered by candidates who drew diagrammatic side view of a book on a table with opposing vertical forces shown by arrows pointing outwards from the centre of the book (see exemplar 11 below). Many candidates had drawn vertical arrows of equal length with the downward force labelled 'gravity' (see exemplars 8 and 9), the use of the correct force ''weight' was rare (see exemplars 10 and 11). Fewer candidates labelled the counter-force 'reaction' or 'contact force'. The position of the arrows emanating from a point/box representing the centre of mass of the book was not an enforced marking point. Exemplar 8 Use arrows to represent the forces.  [4] Exemplar 9 Use arrows to represent the forces.  [4] Exemplar 10

					 [4] Exemplar 11  [4]
	c		**Any two from:** (glider) accelerates during the push ✓ (then has) constant/steady/uniform speed/velocity ✓ (because) there are no other/horizontal/external (unbalanced) forces acting on it / AW ✓ there is (slight) deceleration due to air resistance ✓	2 (AO2 × 1.2)	**Examiner's Comments** Many candidates did not seem to know what an air-track glider was and as a result there answers showed limited understanding of the practical activity. Other candidates had seen an air-track glider and discussed the (relatively) unhindered movement of the glider and the action of air resistance. The most able candidates gained credit for discussing the motion of the glider during the initial push given by the teacher.
	d	i	*F* = *ma* / force equals mass times acceleration ✓ so reducing mass means the same engine force will cause greater acceleration ✓	2 (AO1.2) (AO2.2)	Must start with Newton II NOT less force for same acceleration **Examiner's Comments** Few candidates identified that this question was about the implications of the equation F = ma. Candidates did not recognise that the force would be the same for both the heaver and the lighter model of car. Most candidates discussed the effects of friction on the car. For the order of magnitude for changes in mass between different models of a car frictional forces would have no measurable effect on acceleration. Exemplar 12 

					This answer only considers the marginal changes in friction caused by a very small increase in the contact area of the tyres but ignores the more significant effect that the same force applied to a smaller mass will have on acceleration. Exemplar 13  This candidate's answer shows very clearly why using a more mathematical approach in physics saves time and increases understanding. They have identified the appropriate equation (F=ma), changed the subject to acceleration and then drawn the correct conclusion. Using this approach their answer was shorter, clearer and more relevant than exemplar 12. **AfL** As a starter exercise show students the question and ask them to select the equation that will answer the question. Helping students to be more comfortable using equations will help them overcome their reluctance to answer physics questions using maths.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5 (m/s^2) award 3 marks** change in speed = 25−5 = 20 (m/s) ✓ acceleration = 20 ÷ 4 (m/s^2) ✓ = 5 (m/s^2) ✓	3 (AO2.1) (AO2.1) (AO2.1)	e.c.f. incorrect change in speed if subtraction attempted **Examiner's Comments** This calculation was well done with most candidates being credited with all three marks.
			Total	**12**	
12		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 60 000 (J) award 2 marks** 48 000 + 12 000 ✓	**2** **(AO 2.2)**	Check table **Examiner's Comments** Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in

			= 60 000 (J) ✓	**(AO 2.2)**	answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		ii	C ✓	**1 (AO 3.2b)**	**Examiner's Comments** Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		iii	B ✓	**1 (AO 3.2b)**	**Examiner's Comments** Part was answered well by most candidates. Many candidates showed workings and completed the table which helped them in answering. However, around one in five candidates gave incorrect responses. Most of these candidates had nether completed the table nor shown any workings.
		iv	Heat / sound / KE of particles passed to other particles / AW ✓	**1 (AO 1.1)**	**ALLOW** (energy) transferred to surroundings / by friction **Examiner's Comments** A large number of candidates correctly stated that the motor would produce heat and/or sound or indicated that the energy was 'wasted' through friction. Some candidates wrote out all the energy transfers in an electric motor (e.g. "heat, sound and kinetic energy") which could not gain credit as it did not describe how energy is 'wasted'. Credit was given when it was clear that the 'waste' resulted from the transfer of the kinetic energy store of particles passed on to other particles or to the surroundings but not a vague transfer of 'kinetic energy to the atmosphere'.
		v	Lubrication / oil ✓	**1 (AO 2.1)**	**ALLOW** reduce friction **Examiner's Comments** Candidates found this question extremely challenging. There were very few suggestions of specific improvements to the electric motor such as lubricating it or applying oil to the moving parts. Many candidates suggested general energy efficiency tips such as switching it off when it not in use, running the motor at a slower speed or putting insulation around the motor.
			Total	**6**	

13			**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 800 (kg) award 3 marks** Recall: force = mass × acceleration ✓ 4000 ÷ 5 ✓ 800 (kg) ✓	**3** **(AO 1.2)** **(AO 2.1)** **(AO 2.1)**	**ALLOW** 0.8 for two marks **Examiner's Comments** Some candidates divided their calculated answer by 1000 so that there answer was actually in tonnes rather than kilograms. Because the equation uses force in N and acceleration in m/s^2 the computed mass will be kilograms. Other candidates divided 4000 by 5^2 perhaps thinking that 5 m/s^2 implied it needed to be squared.
			Total	**3**	
14	a	i	Bar C drawn to the correct height of 12s ✓	1 (AO1.2)	**Examiner's Comments** Most candidates drew the correct bar in (a)(i) and then went on to carry out an accurate calculation of the mean time.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 12 (s) award 2 marks** 14 + 10 + 12 = 36 / (14 + 10 + 12)/3 without the 36 ✓ 36 ÷ 3 = 12 (s) ✓	2 (AO3.1a) (AO1.2)	**ECF** from **(a)(i)** **ECF** from mp1 above **Examiner's Comments** Most candidates drew the correct bar in (a)(i) and then went on to carry out an accurate calculation of the mean time.
		iii	Lift B ✓ Takes the least time (power is work done ÷ time taken)/AW ✓	2 (AO3.1b) (AO1.2)	If A chosen and correct explanation (for B) given, award mp2 but not mp1 **Examiner's Comments** Many candidates identified lift B uses the

					most power correctly but did not provide an explanation of why it use the most power for the second mark. Some candidates clearly thought the highest bar in the bar chart indicated a greater height reached by the lift and so chose lift A.
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 4166.7 (W) award 4 marks** *P* = *E* ÷ *t* / power = work done ÷ time taken ✓ *P* = 50000 ÷ 12 ✓ *P* = 4166.666667 (W) ✓ *P* = 4166.7 (W) (1dp)✓	4 (AO1.2) (AO2.1) (AO2.1) (AO1.2)	**ALLOW** energy (transferred) ÷ time taken **ALLOW** 4166.7 for 2 marks if more dp not given **ECF** own calculated power to 1 dp **Examiner's Comments** Part (i): required candidates to round their answer to one decimal place. Many candidates did the calculation well and gained 4/4, or 3/4 with incorrect rounding. Any calculation error in finding the power of the lift could still earn the candidate the last mark if their result was rounded correctly. Part (ii) was done correctly by the majority of candidates. The stem of the question contained some data that they did not need to complete the calculation, which made this a more challenging task than it may appear to be.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 3000 (J) award 3 marks** ✓ Work done = force × distance ✓ *W* = 750 x 4 ✓ *W* = 3000 (J) ✓	3 (AO1.2) (AO2.1) (AO2.1)	
			Total	**12**	
15	a	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 20 (N) award 2 marks** 5 x 4 ✓ = 20 (N) ✓	2 (AO2.1) (AO2.1)	

		ii	**Any one from:** Not all energy is transferred to motion ✓ (Air) resistance ✓ Drag ✓ Friction ✓	1 (AO3.2a)	**ALLOW** Energy losses
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1500 (J) award 2 marks** 30 x 50 ✓ = 1500 (J) ✓	2 (AO2.1) (AO2.1)	
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 20 (W) award 3 marks** work done ÷ time ✓ 1500 ÷ 75 ✓ = 20 (W) ✓	3 (AO1.2) (AO2.1) (AO2.1)	**ALLOW** ecf from (i) **ALLOW** P = WD ÷ t
			Total	**8**	