Question number	Answer	Notes	Marks
1 (a)	(metre) ruler;	allow set square, tape measure, digital callipers ignore metre stick	1
(b)	Up to five marks, no more than 3 from each section:- Recording data Any three of - MP1. measure original length; MP2. add a (known) weight/force/load/mass; MP3. measure the new length / extension; MP4. Repeat for range of values of load; MP5. Experimental detail; Handling data / conclusions Any three of - MP6. Calculate extension; MP7. Plot graph of extension/length against force/weight/load; MP8. Graph should be a straight line; MP9. Extension graph should pass through origin; MP10. Force proportional to extension;	 e.g. • distance measurements from the same point each time • use of pointer/indicator • reduce parallax • repeats and average (for each load) Allow length, but not mass calculate k from data k is constant Not for length graph allow load for force	5

Total 6 marks

Question number	Answer	Notes	Marks
2 (a) (i)	kinetic energy = ½ × mass × velocity^2	Accept symbols KE = ½ × m × v^2	1
(ii)	Conversion of units; Substitution and rearrangement into correct formula; Calculation; e.g. 18 MJ = 18 000 000 J v^2 = 18 000 000 × 2 ÷ 250 000 (= 144) v = 12 (m/s)	at any stage POT error max 2 marks e.g. 3.8 x 10^n or 1.2 x 10^n	3
(iii)	Energy is transferred to surroundings;	Allow to heat, sound, other forms / energy decreases	1
(b) (i)	Any two of - MP1. GPE = m.g.h; MP2. passengers have moved to a higher point/upwards; MP3. work is done to move the passengers; MP4. passengers are further from the centre of the earth;	allow 'lift' for 'passengers' 'gravity force' (still) acts below ground level, reject 'gravity' moved in opposite direction to force of gravity	2
(ii)	max of 3 from each list to total of 4 When entering station- MP1. KE → GPE; MP2. Less work done by the brakes (to stop the train); MP3. Less (braking) force needed (to stop) ; MP4. train stops more quickly OR brakes are needed for less time (to stop); When leaving station- MP5. GPE → KE; MP6. Less work done by the motor (to accelerate); MP7. Less force needed (to accelerate	Allow energy for work an effect on the brakes, e.g. don't get so hot / are quieter / last longer / are less worn Allow less power/ current	4

	the train); MP8. train accelerates more quickly OR force needed for a shorter time (to reach a given speed);	needed motor lasts longer / is less worn	

Total 11 marks

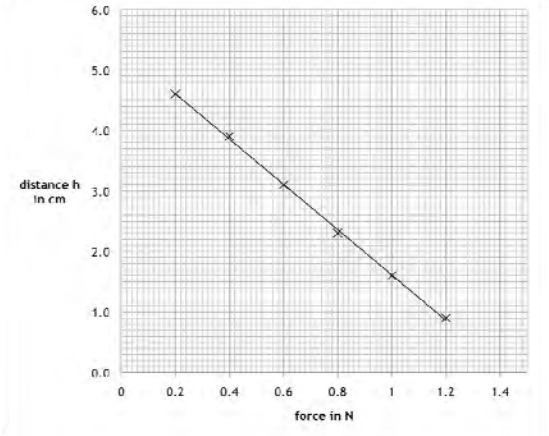
Question number	Answer	Notes	Marks
3 (a)	9100 (N)		1
(b) (i)	F = m x a;	accept standard symbols or in words or rearranged	1
(ii)	substitution and rearrangement; evaluation; e.g. (a =) 400/910 (a =) 0.44	-1 for POT error allow 0.4, 0.43956044 0.43 gains 1 mark only	2
(c)	any three from: MP1. speed increases; MP2. so drag {starts to act / increases}; MP3. downward forces increase; MP4. (hence) acceleration decreases;	ignore references to the initial acceleration award 1 mark for mention of terminal velocity if no other mark awarded allow air resistance / friction increases allow unbalanced force decreases	3
(d)	acceleration increases; with any one from: • weight decreases / downward force reduces; • unbalanced force increases; • mass decreases;	total marks = 9	2

Question number	Answer	Notes	Marks
4 (a) (i)	6 (m/s);		1
(ii)	10 (s);		1
(b) (i)	Acceleration = $\frac{\text{change in velocity}}{\text{time (taken)}}$;	allow accepted symbols	1
(ii)	Substitution in correct equation; Evaluation; Unit; e.g. 12 ÷ 10 = 1.2 m/s^2	 ms^{-2} condone m/s/s	3
(c) (i)	(average) speed = $\frac{\text{distance (moved)}}{\text{time}}$;	allow accepted symbols	1
(ii)	Substitution in correct equation; Evaluation; e.g. 390 ÷ 60 6.5 (m/s)	 (388.5 ÷ 60 = 6.475)	2
(d)	MP1 Idea that distance is given by area under the graph; MP2 Comparison of the two areas (by eye or by calculation);	ignore steepness of lines, velocity, acceleration, width NOTE: a valid comparison that includes MP1 +MP2 gains both marks e.g. the first 30s area is larger than the last 30s	2

Total 11 marks

Question number	Answer	Notes	Marks
5 (a)	Any two of - MP1. mention of no zero error; MP2. Mention that ruler is should be vertical; MP3. use of a fiducial marker; MP4. use of ruler with finer calibrations; MP5. means to reduce parallax; MP6. use of calliper;	Ignore (more) accurate ruler e.g. a pin Allow • more detailed ruler • smaller intervals ignore proximity	2
(b) (i)	Distance		1
(ii)	Any two of - MP1. Idea of weight is the force on the mass / W=mg ; MP2. change grams to kilogram; MP3. 1N of force for every 100g; MP4. g is 10 (N/kg);	in any form including numerical Accept ÷ 1000 Ignore ÷ 100 without further explanation Allow idea of gravitational field strength Accept x 10	2

Continued

Question number	Answer	Notes	Marks
5 (b) (iii)	Suitable linear scale chosen (>50% of grid used);	no awkward scale	5
(iv)	Axes labelled with quantities and unit; Plotting correct to nearest half square (minus one for each plotting error);; Line of best fit acceptable;  	Orientation unimportant i.e. two plotting errors = no marks for plotting i.e. straight line Force in N / Distance *h* in cm 0.2 / 4.6 0.4 / 3.9 0.6 / 3.1 0.8 / 2.3 1.0 / 1.6 1.2 / 0.9	
(iv)	straight line seen extended to the force axis; 1.40 ≤ F ≤1.46 (N);	F value to 3 SF unless line goes through 1.40 accept force = 1.4 Answer in range = two marks	2
(v)	NO mark for Yes/No answer Any two of - MP1. Correct statement of Hooke's law; MP2. graph shows equal decrements for distance with force MP3. (line goes down because) different distance has been measured; MP4. graph does not pass through the origin;	Allow extension is (directly) proportional to force • equal steps • the line is straight ignore graph is • directly proportional • inversely proportional • negative correlation • the "wrong" distance is measured • extension can be worked out from data • more force = larger extension	2

Total 14 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>6 (a) (i)</td><td>weight (of toy car);</td><td>allow mass</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>(ii)</td><td>speed (of toy car);</td><td>allow:
velocity
time (to go down the slope)</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>(b)</td><td>any 2 of:

MP1. angle/gradient/incline/steepness/height of slope;

MP2. same car/eq;

MP3. surface of slope;

MP4. force at launch;

MP5. initial speed;

MP6. starting height/position/point (of car);

MP7. distance travelled/length of slope;</td><td>ignore
weather conditions</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>(c)</td><td><table><tr><td>battery</td><td></td></tr><tr><td>joulemeter</td><td></td></tr><tr><td>micrometer</td><td></td></tr><tr><td>newtonmeter</td><td>✓</td></tr><tr><td>ruler</td><td>(✓)</td></tr><tr><td>stopwatch</td><td>✓</td></tr><tr><td>thermometer</td><td></td></tr></table>
one correct tick;
two correct ticks;;</td><td>allow clear alternative indications e.g.
- crosses
- shading

if more than 2 ticks, -1 for each incorrect tick</td><td>2</td></tr>
</table>

(d)	any **5** of: MP1. measure weight/mass; MP2. measure distance (down slope)/start from same point; MP3. measure time/speed (with light gate); MP4. equation seen or described in words: speed = distance / time; MP5. idea that different weights used; MP6. repeat experiment AND average/remove anomalies; MP7. method to improve accuracy, e.g. use of light gates, reaction time considered;	Allow 'find out' for measure	5

Total 11 marks