Q1.

2	(a)	(i)	distance from a (fixed) point	M1	
			in a specified direction	A1	
			(Allow 1 mark for 'distance in a given direction')		
		(ii)	(displacement from start is zero if) car at its starting position	B1	[3]
	(b)	(i)1	$v^2 = u^2 + 2as$		
			$28^2 = 2 \times a \times 450$ (use of component of 450 scores no marks)	C1	
			$a = 0.87$ m s^{-2}	A1	[2]
			(-1 for 1 sig. fig. but once only in the question)		
		(i)2	$v = u + at$ or any appropriate equation		
			$28 = 0.87t$ or appropriate substitution	C1	
			t = 32 s	A1	[2]
		(i)3	$E_k = ½mv^2$	C1	
			$= ½ \times 800 \times 28^2$		
			$= 3.14 \times 10^5$ J	A1	[2]
		(i)4	$E_p = mgh$	C1	
			$= 800 \times 9.8 \times 450 \sin 5$	C1	
			$= 3.07 \times 10^5$ J	A1	[3]
		(ii)	power = energy/time	C1	
			$=(6.21 \times 10^5)/32.2$	C1	
			$= 1.93 \times 10^4$ W	A1	[3]
			(power = Fv with $F = mg \sin\theta$ scores no marks)		
		(iii)	some work also done against friction forces	M1	
			location of frictional forces identified	A1	[2]

(allow reasonable alternatives)

Q2.

5	(a)	(i)	distance = $2\pi nr$	B1	
		(ii)	work done = $F \times 2\pi nr$ *(accept e.c.f.)*	B1	[2]
	(b)		total work done = $2 \times F \times 2\pi nr$	B1	
			but torque $T = 2Fr$	B1	
			hence work done = $T \times 2\pi n$	A0	[2]
	(c)		power = work done/time (= $470 \times 2\pi \times 2400)/60$)		
			$= 1.2 \times 10^5$ W	A1	[2]
			Total		**[6]**

Q3.

3	**(a) (i)** $\Delta E_p = mg\Delta h$ $= 0.602 \times 9.8 \times 0.086$ $= 0.51$ J (do not allow g = 10, m = 0.600 or answer 0.50 J)	C1 A1	 **[2]**
	(ii) $v^2 = (2gh =)\ 2 \times 9.8 \times 0.086$ <u>or</u> $(2 \times 0.51)/0.602$ $v = 1.3$ (m s^{-1})	M1 A0	 **[1]**
	(b) $2 \times V = 602 \times 1.3$ (allow 600) $V = 390$ m s^{-1}	C1 A1	 **[2]**
	(c) (i) $E_k = ½mv^2$ $= ½ \times 0.002 \times 390^2$ $= 152$ J or 153 J or 150 J	C1 A1	 **[2]**
	(ii) E_k not the same/changes <u>or</u> E_k before impact>E_k after/E_p after so must be inelastic collision (allow 1 mark for 'bullet embeds itself in block' etc.)	 M1 A1	 **[2]**

Q4.

4	**(a) (i)** (change in) potential energy = *mgh* $= 0.056 \times 9.8 \times 16$ $= 8.78$ J (*allow 8.8*)	C1 A1	 [2]
	(ii) (initial) kinetic energy = $½mv^2$ $= ½ \times 0.056 \times 18^2$ $= 9.07$ J (*allow 9.1*) total kinetic energy = 8.78 + 9.07 = 17.9 J	C1 C1 A1	 [3]
	(b) kinetic energy = $½mv^2$ $17.9 = ½ \times 0.056 \times v^2$ and $v = 25(.3)$ m s^{-1}	 B1	 [1]
	(c) horizontal velocity = 18 m s^{-1}	B1	[1]
	(d) (i) correct shape of diagram (two sides of right-angled triangle with correct orientation)	 B1	
	(ii) angle = 41° → 48° (allow trig. solution based on diagram) (*for angle 38° → 41° or 48° → 51°, allow 1 mark*)	A2	[3]

Q5.

3 **(a)** *either* energy (stored)/work done represented by area under graph			
or energy = <u>average</u> force × extension	....	B1	
energy = ½ × 180 × 4.0 × 10^{-2}	....	C1	
= 3.6 J	....	A1	[3]

(b) **(i)** *either* momentum before release is zero	....	M1	
so sum of <u>momenta</u> (of trolleys) after release is zero	....	A1	
or force = rate of change of momentum	(M1)		
force on trolleys equal and opposite	(A1)		
or impulse = change in momentum	(M1)		
impulse on each equal and opposite	(A1)		[2]
(ii) 1 $M_1V_1 = M_2V_2$	....	B1	[1]
2 $\underline{E} = ½ M_1V_1^2 + ½ M_2V_2^2$	....	B1	[1]
(iii) 1 $E_K = ½mv^2$ and $p = mv$ combined to give	....	M1	
$E_K = p^2 / 2m$	....	A0	[1]
2 m smaller, E_K is larger because p is the same/constant	....	M1	
so trolley B	....	A0	[1]

Q6.

2 **(a)** work done is the force × the distance moved / displacement in the direction of the force *or* work is done when a force moves in the direction of the force	B1	[1]
(b) component of weight = 850 × 9.81 × sin 7.5°	C1	
= 1090 N	A1	[2]
(*use of incorrect trigonometric function, 0/2*)		
(c) **(i)** ΣF = 4600 – 1090 = (3510)	M1	
deceleration = 3510 / 850	A1	
= 4.1 m s^{-2}	A0	[2]
(ii) $v^2 = u^2 + 2as$		
0 = 25^2 + 2 × – 4.1 × s	C1	
s = 625 / 8.2		
= 76 m	A1	[2]
(*allow full credit for calculation of time (6.05 s) & then s*)		
(iii) **1.** kinetic energy = ½ mv^2	C1	
= 0.5 × 850 × 25^2		
= 2.7 × 10^5 J	A1	[2]
2. work done = 4600 × 75.7		
= 3.5 × 10^5 J	A1	[1]
(iv) difference is the loss in potential energy (*owtte*)	B1	[1]

Q7.

3 (a)	evidence of use of area below the line	B1	
	distance = 39 m (*allow ±0.5m*)	A2	[3]
	(*if > ±0.5m but ≤ 1.0 m, then allow 1 mark*)		
(b) (i) 1	$E_K = ½mv^2$	C1	
	$\Delta E_K = ½ \times 92 \times (6^2 - 3^2)$		
	= 1240 J	A1	[2]
2	$E_P = mgh$	C1	
	$\Delta E_P = 92 \times 9.8 \times 1.3$		
	= 1170 J	A1	[2]
(ii)	$E = Pt$	C1	
	$E = 75 \times 8$		
	= 600 J	A1	[2]
(c) (i)	energy = (1240 + 600) – 1170	M1	
	= 670 J	A0	[1]
(ii)	force = 670/39 = 17 N	A1	[1]
(d)	frictional forces include air resistance	B1	
	air resistance decreases with decrease of speed	B1	[2]

Q8.

3 (a) (i)	work done equals force × distance moved / displacement in the direction of the force	B1	[1]
(ii)	power is the rate of doing work / work done per unit time	B1	[1]
(b) (i)	kinetic energy = $½ mv^2$	C1	
	= $0.5 \times 600\ (9.5)^2$	C1	
	= 27075 (J) = 27 kJ	A1	[3]
(ii)	potential energy = mgh		
	= 600 × 9.81 × 4.1	M1	
	= 24132 (J)	A1	
	= 24 kJ	A0	[2]
(iii)	work done = 27 – 24 = 3.0 kJ	A1	[1]
(iv)	resistive force = 3000 / 8.2 (distance along slope = 4.1 / sin 30°)	C1	
	= 366 N	A1	[2]

Q9.

2 (a) (i) $v^2 = u^2 + 2as$
$= (8.4)^2 + 2 \times 9.81 \times 5$ — C1
$= 12.99\ \text{m s}^{-1}$ *(allow 13 to 2 s.f. but not 12.9)* — A1 [2]

(ii) $t = (v - u) / a$ or $s = ut + ½at^2$
$= (12.99 - 8.4) / 9.81$ or $5 = 8.4t + ½ \times 9.81t^2$ — M1
$t = 0.468\ \text{s}$ — A0 [1]

(b) reasonable shape — M1
suitable scale — A1
correctly plotted 1st and last points at (0,8.4) and (0.88 – 0.96,0)
with non-vertical line at 0.47 s — A1 [3]

(c) (i) 1. kinetic energy at end is zero so $\Delta KE = ½\ mv^2$ or $\Delta KE = ½\ mu^2 - ½\ mv^2$ — C1
$= ½ \times 0.05 \times (8.4)^2$
$= (–)\ 1.8\ \text{J}$ — A1 [2]

2. final maximum height $= (4.2)^2 / (2 \times 9.8) = (0.9\ \text{(m)})$
change in PE $= mgh_2 - mgh_1$ — C1
$= 0.05 \times 9.8 \times (0.9 - 5)$ — C1
$= (–)\ 2.0\ \text{J}$ — A1 [3]

(ii) change is – 3.8 (J) — B1
energy lost to ground (on impact) / energy of deformation of the ball / thermal energy in ball — B1 [2]

Q10.

3 (a) loss in potential energy due to decrease in height (as P.E. = mgh) — (B1)
gain in kinetic energy due to increase in speed (as K.E. = $½\ mv^2$) — (B1)
special case 'as PE decreases KE increases' (1/2)
increase in thermal energy due to work done against air resistance — (B1)
loss in P.E. equals gain in K.E. and thermal energy — (B1)
max. 3 [3]

(b) (i) kinetic energy $= ½\ mv^2$ — C1
$= ½ \times 0.150 \times (25)^2$ — C1
$= 46.875 = 47\ \text{J}$ — A1 [3]

(ii) 1. potential energy (= mgh) $= 0.150 \times 9.81 \times 21$ — C1
loss = KE – mgh = 46.875 – (30.9) — C1
= 15.97 = 16 J — A1 [3]

2. work done = 16 J
work done = force × distance — C1
$F = 16 / 21 = 0.76\ \text{N}$ — A1 [2]

Q11.

4 (a)	force × distance <u>moved</u>	M1	
	in the direction of the force	A1	[2]
(b)	weight / force = mg	M1	
	$\Delta E_p = mg \times \underline{\Delta h}$	A1	[2]
	(no marks for quote of $mg\Delta h$)		

Q12.

8	(a)		product of force and distance	M1	
			moved in the direction of the force	A1	**[2]**
	(b)	(i)	falls from rest	B1	
			decreasing acceleration	B1	
			reaches a constant speed	B1	**[3]**
		(ii)	straight line with negative gradient	B1	
			y-axis intercept above maximum E_K	B1	
			reasonable gradient (same magnitude as that for E_K initially)	B1	**[3]**

Q13.

1	(a)	(i)	product of force and distance <u>moved</u>	M1	
			(by force) in the direction of the force	A1	[2]
		(ii)	work (done) per unit time (*idea of ratio needed*)	B1	[1]
	(b)		*either* work/time *or* power = (force × distance)/time	M1	
			to give power = force × velocity	A1	[2]
	(c)	(i)	kinetic energy (= $\frac{1}{2}mv^2$) = $\frac{1}{2} \times 1900 \times 27^2$	C1	
			power = 692550 / 8.1 = 8.55×10^4 W	A1	[2]
		(ii)	*either* for equal increments of speed, increments of E_K are different	M1	
			so longer time (to increase speed) at high speeds	A1	[2]
			or air resistance increases with speed (M1)		
			so driving force (and acceleration) reduced (A1)		
			or P (= Fv) = mav (M1)		
			(P and m constant) so when v increases, a decreases (A1)		

Q14.

3	(a)	(i)	potential energy: stored energy available to do work	B1	[1]
		(ii)	gravitational: due to height/position of mass OR distance from mass OR moving mass from one point to another	B1	
			elastic: due to deformation/stretching/compressing	B1	[2]
	(b)	(i)	height raised = (61 – {61 cos18} =) 3.0 cm	C1	
			energy = (mgh = 0.051 × 9.8 × 0.030 =) 1.5 × 10^{-2} J	A1	[2]
		(ii)	moment = force × perpendicular distance		
			= 0.051 × 9.8 × 0.61 × sin18	C1	
			= 0.094 N m	A1	[2]

Q15.

4	(a)		electrical potential energy (stored) when charge moved and gravitational potential energy (stored) when mass moved	B1	
			due to work done in electric field and work done in gravitational field	B1	[2]
	(b)		work done = force × distance moved (in direction of force) and force = mg	M1	
			$mg \times h$ or $mg \times \Delta h$	A1	[2]
	(c)	(i)	0.1 × mgh = ½ mv^2	B1	
			0.1 × m × 9.81 × 120 = 0.5 × m × v^2	B1	
			v = 15.3 m s^{-1}	A0	[2]
		(ii)	$P = 0.5\, m\, v^2 / t$	C1	
			m / t = 110 × 10^3 / [0.25 × 0.5 × $(15.3)^2$]	C1	
			= 3740 kg s^{-1}	A1	[3]

Q16.

3	**(a)**	**(i)**	power = work done per unit time / energy transferred per unit time / rate of work done	B1 [1]
		(ii)	Young modulus = stress / strain	B1 [1]
	(b)	**(i)**	**1.** $E = T / (A \times \text{strain})$ *(allow strain = ε)*	C1
			$T = E \times A \times \text{strain} = 2.4 \times 10^{11} \times 1.3 \times 10^{-4} \times 0.001$	M1
			$= 3.12 \times 10^4$ N	A0 [2]
			2. $T - W = ma$	C1
			$[3.12 \times 10^4 - 1800 \times 9.81] = 1800a$	C1
			$a = 7.52$ m s^{-2}	A1 [3]
		(ii)	**1.** $T = 1800 \times 9.81 = 1.8 \times 10^4$ N	A1 [1]
			2. potential energy gain $= mgh$	C1
			$= 1800 \times 9.81 \times 15$	
			$= 2.7 \times 10^5$ J	A1 [2]
		(iii)	$P = Fv$	C1
			$= 1800 \times 9.81 \times 0.55$	C1
			input power $= 9712 \times (100/30) = 32.4 \times 10^3$ W	A1 [3]

Q17.

3	**(a)**		(work =) force × distance <u>moved</u> / displacement in the direction of the force OR when a force moves in the direction of the force work is done	B1 [1]
	(b)		kinetic energy = ½ mv^2	C1
			= ½ 0.4 (2.5)^2 = 1.25 / 1.3 J	A1 [2]
	(c)	**(i)**	area under graph is work done / work done = ½ Fx	C1
			$1.25 = (14\,x) / 2$	C1
			$x = 0.18$ (0.179) m [allow $x = 0.19$ m using kinetic energy = 1.3 J]	A1 [3]
		(ii)	smooth curve from $v = 2.5$ at $x = 0$ to $v = 0$ at Q	M1
			curve with increasing gradient	A1 [2]

Q18.

4	**(a)** gravitational PE is energy of a mass due to its position in a gravitational field	B1	
	elastic PE energy stored (in an object) due to (a force) changing its shape / deformation / being compressed / stretched / strained	B1	[2]
	(b) (i) 1. kinetic energy = ½ mv^2	C1	
	= ½ × 0.065 × 16^2 = 8.3(2) J	A1	[2]
	2. $v^2 = 2gh$ OR PE = mgh	C1	
	h = 16^2 / (2 × 9.81) = 13(.05) m	A1	[2]
	(ii) speed at t = ½ total time = 8 (m s^{-1}) or total t = 1.63 or $t_{1/2}$ = 0.815 s	C1	
	KE is ¼ or h at $t_{1/2}$ = 9.78 (m)	C1	
	and PE is ¾ of max ratio = 3 or ratio = 9.78 / 3.26 = 3	A1	[3]
	(iii) time is less because (average) acceleration is greater OR average force is greater	B1	[1]