1)

(a) $v^2 = 2gh$
$v^2 = 2 \times 9.8 \times 1.6$ C1
$v = 5.6 \text{ m s}^{-1}$ .... A1 [2]

(b) (i) working leading to idea that $h = 0.90 \times 1.6$ C1
$h = 1.44$ m A1
(ii) $mgh = \frac{1}{2}mv^2$
$v^2 = 2 \times 9.8 \times 1.44$ C1
$v = 5.3 \text{ m s}^{-1}$ .... A1 [4]

2)

(a) increase the height of the cylinder .... B1 [1]

(b) take heat out of gas OR expand gas OR cool it .... B1 [1]

(c) compress the gas OR increase pressure OR heat at constant volume .... B1 [1]

3)

(a) $m = \rho V$ B1 **[1]**

(b) pressure in liquid depends on depth B1
bottom of sphere has greater pressure on it than top M1
so resultant force <u>or</u> pressure is upwards A1 **[3]**

(c) (i) **1.** kinetic energy $= \frac{1}{2}mv^2$ C1

$= \frac{1}{2} \times 2 \times 10^{-3} \times (6 \times 10^{-2})^2$ A1

$= 3.6 \times 10^{-6}$ J C1

2. potential energy $= mgh$ C1
rate of loss $= mgv$
$= 2 \times 10^{-3} \times 9.8 \times 6 \times 10^{-2}$ A1 **[5]**
$= 1.2 \times 10^{-3} \text{ J s}^{-1}$

(no reference to time in **2.**, maximum $^2/_3$)

(ii) potential energy of sphere is given/lost <u>to the liquid</u> B1
to overcome drag forces or to produce eddies or friction etc B1 **[2]**

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 $mg\Delta h$)

5)

(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 x a x 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 x 800 x 28^2
= 3.14 x 10^5 J.. A1 [2]

(i)4 E_p = mgh C1
= 800 x 9.8 x 450 sin5 .... C1
= 3.07 x 10^5 J .... A1 [3]

(ii) power = energy/time... C1
=(6.21 x 10^5)/32.2 .... C1
= 1.93 x 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)

6)

(a)	**(i)**	(p =) mv	B1	
	(ii)	$E_k = \frac{1}{2}mv^2$	B1	
		algebra leading to	M1	
		$E_k = p^2/2m$	A0	**[3]**
(b)	**(i)**	Δp = 0.035 (4.5 + 3.5) OR a = (4.5 + 3.5)/0.14	C1	
		= 0.28 N s = 57.1 m s^{-2}		
		force= $\Delta p/\Delta t$ (= 0.28/0.14) OR F = ma (= 0.035 x 575.1) (allow e.c.f.)	C1	
		= 2.0 N	A1	
		Note: candidate may add mg = 0.34 N to this answer, deduct 1 mark		
		upwards	B1	**[4]**
	(ii)	loss = $\frac{1}{2}$ x 0.035 (4.5^2 – 3.5^2)	C1	
		= 0.14 J	A1	**[2]**
		(No credit for 0.28^2/(2 x 0.035) = 1.12 J)		
(c)		e.g. plate (and Earth) gain momentum		
		i.e. discusses a 'system'	B1	
		equal and opposite to the change for the ball		
		i.e. discusses force/momentum	M1	
		so momentum is conserved		
		i.e. discusses consequence	A1	**[3]**
		Total		**[12]**

7)

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

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]**

9)

(a)	no hysteresis loop/no permanent deformation	M1	
	(*do not allow 'force proportional to extension'*)		
	so elastic change	A0	**[1]**
(b)	work done = area under graph line OR average force × distance	B1	
	= $\frac{1}{2}Fx$ $\quad$ $\frac{1}{2}(F_2 + F_1)(x_2 - x_1)$	A1	
	$F = kx$, so work done = = $\frac{1}{2}kx^2$ $\quad$ $\frac{1}{2}k(x_2 + x_1)(x_2 - x_1)$	A1	
	work done = $\frac{1}{2}k(x_2^2 - x_1^2)$	A0	**[3]**
(c)	gain in energy of trolley = $\frac{1}{2}k(0.060^2 - 0.045^2) + \frac{1}{2}k(0.030^2 - 0.045^2)$	C1	
	= 0.36 J	C1	
	kinetic energy = $\frac{1}{2} \times 0.85 \times v^2 = 0.36$	C1	
	$v = 0.92$ m s^{-1}	A1	**[4]**

10)

(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)		

11)

(a) **(i)** (change in) potential energy = mgh	C1	
$= 0.056 \times 9.8 \times 16$		
$= 8.78$ J (*allow 8.8*)	A1	[2]
(ii) (initial) kinetic energy = $\frac{1}{2}mv^2$	C1	
$= \frac{1}{2} \times 0.056 \times 18^2$		
$= 9.07$ J (*allow 9.1*)	C1	
total kinetic energy = 8.78 + 9.07 = 17.9 J	A1	[3]
(b) kinetic energy = $\frac{1}{2}mv^2$		
$17.9 = \frac{1}{2} \times 0.056 \times v^2$ 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 = $41° \rightarrow 48°$ (allow trig. solution based on diagram)	A2	[3]
(*for angle $38° \rightarrow 41°$ or $48° \rightarrow 51°$, allow 1 mark*)		

12)

(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]

13)

(a) **(i)** $v^2 = 2as$		
$1.2^2 = 2 \times a \times 1.9$	M1	
$a = 0.38$ m s^{-2}	A1	[2]
(ii) $F = ma$		
$= 42 \times 0.38$	M1	
$= 16$ N	A0	[1]
(b) *power* = Fv	C1	
$= 16 \times 1.2$		
$= 19$ W	A1	[2]

14)

(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 (= $470 \times 2\pi \times 2400)/60$)		
		= 1.2×10^5 W	A1	**[2]**
		Total		**[6]**