1. (a)(i)	distance travelled per unit time / rate of change of distance		B1
(ii)	speed has magnitude only (allow size but not quantity)		B1
	velocity has magnitude and direction		B1
	(speed is a scalar and velocity is a vector scores 1)		
	(velocity has direction but speed does not scores 1)		
(b)	$t = (v - u) / a$ or $t = 2s / (u + v)$		C1
	substitution:		
	$s = (u + v)(v - u) / 2a = ((v^2 - u^2) / 2a)$		
	$v = u + 2as / (u + v)$		B1
	hence $v^2 = u^2 + 2as$		A0
(c)(i)	$v = u + at$ $u = 0$		C1
	$= (0 +) 9.81 \times 0.9$		M1
	hence $v = 8.8$ (29) m s^{-1}		A0
(ii)	if scale diagram used:		
	scale given		B1
	correct triangle drawn (shape)		B1
	velocity = 10.4 ± 0.2 m s^{-1}		B1
	angle to the horizontal = $57 \pm 2°$		B1
	if calculated:		
	triangle drawn (shape correct but arrows not required)		B1
	algebra given		C1
	velocity = 10.45 m s^{-1} (allow 10.4 or 10.5)		A1
	angle = 57.6°		A1
(iii)	vertical distance = $(8.8 \times 0.9) / 2$		C1
	= 3.96 m (3.97 if 8.829 is used)		A1
	(3.95 if 9.81 and 8.8 used)		
	(allow 4.0 but not 4)		
	horizontal distance = $5.6 \times 0.9 = 5.0$ m		B1
		Total	[14]

2. (a)(i)	$a = 1.8 / 0.8$ $= 2.25$ (m s^{-2})		C1 A1
(ii)	$F = ma$ $= 0.8 \times 2.25$ $= 1.8$ (N)		C1 A1
(iii)	area under the graph or $s = (u + v) t / 2$ etc distance = $(1.8 \times 0.8) / 2$ hence distance = 0.72 m		C1 M1 A0
(b)(i)	distance BC = $2 - 0.72 = 1.28$ (m) time = $1.28 / 1.8$ time = 0.71 (s)		C1 C1 A1
(ii)	straight horizontal line of at least 2 small squares until 1.5 (s) [note ecf from (b)(i) i.e. 0.8 + (b)(i)] within ½ square steep line (do not consider shape) to zero speed (max of two squares)		B1 B1 B1
		Total	[12]
3. (a)	kg m s^{-2}		B1
(b)(i)	$W = 80 \times 9.81$ = 785 (N) (allow 784 if 9.8 is used, do not allow use of g = 10)		B1
(ii)	horizontal force = 250 cos30 = 217 (N) (not 216 but allow 216.5)		C1 A1
(iii)	vertical component = 250sin30 = (125) force exerted on the ground = 785 – 125 = 660 (N) (allow 659 using 9.8) (allow one mark for an answer of 125)		C1 C1 A1
(c)(i)	for constant velocity resultant force is zero / in equilibrium other forces must act against / resistive / friction / opposite to the pulling force		B1 B1
(ii)	greater force exerted on the ground vertical component acts downwards (allow 2 for calculated value of 910/909)		B1 B1
		Total	[11]

4. (a)(i)	work: product of force and distance moved in the direction of the force		B1
	power: rate of doing work / work done per unit time		B1
	(allow power or work as the subject)		
(ii)	joule: work done when (a force of) one newton moves (its point of application) one metre (in the direction of the force)		B1
(b)(i)	g.p.e. = mgh		C1
	60 x 80 x 9.81 x 900		
	42379200 (allow use of 9.8 and answer of 42336000) (J)		
	(42 MJ)		A1
(ii)	total energy input = 6800 x 9.81 x 900		
	or 42379200 + 2000 x 9.81 x 900		C1
	power = 60037200 / (5 x 60)		
	or (42379200 + 17658000) / (5 x 60)		C1
	= 200124 W (200kW) (199920 using 9.8)		A1
	unit penalty		-1
	Total		[8]
5. (a)(i)	moment: force x perpendicular distance to the pivot / axis / point		B1
(ii)	for equilibrium / balanced the sum of the clockwise moments about a pivot is equal to the sum of anticlockwise moments (about the same pivot/axis/point)		B2
	(clockwise moments equal the anticlockwise moments scores one only)		
(b)(i)	total mass = (1000 + 250) / 9.81		C1
	= (127.42) or (127.55 if 9.8 used)		
	(allow one mark for the individual masses being calculated)		
	volume = $2 \times 3.5 \times 10^{-2}$		C1
	= (7.0×10^{-2})		
	density = mass / volume		
	= 127.42 / (7.0×10^{-2})		M1
	hence density = 1820 (kgm^{-3}) (1822 using 9.8)		A0
(c)(i)	moments about P (or other named and suitable point)		B1
	1000 x 0.2 = 200	or equivalent moment	C1
	equals 250 x 0.8 = 200	or equivalent moment	C1
	hence P is 0.4 + 0.8 = 1.2 m from B		A0
(ii)	P is the centre of gravity / mass (of the whole pillar)		B1
	(Allow the point where the total weight acts)		
	Total		[10]

6. (a)	force / load if proportional to extension	B1
(b)(i)	force constant = 100 / (40 x 10^{-3}) or equivalent	C1
	= 2500 N m^{-1} / kg s^{-2} (2.5 N mm^{-1})	A1
	unit penalty	-1
(ii)	work done = area under graph / (force x extension) / 2	C1
	= (120 x 48 x 10^{-3}) / 2	M1
	= 2.88 (2.9 to 2sf) (J)	A0
(c)(i)	k.e = ½ mv^2	C1
	v^2 = (2.9 x 2) / 0.015	C1
	v = 19.7 (ms^{-1}) (19.6 if 2.88 J is used)	A1
(ii)	(energy lost due to) friction in the gun	B1
	air resistance	B1
	(allow energy loss if type identified and place given)	
	(allow recoil of the gun)	
	Total	[10]
7. (a)(i)	Young modulus = tensile stress / tensile strain	B2
	(stress / strain scores 1, with definitions of stress and strain scores 2)	
(ii)	elastic limit: maximum force / load / stress / strain / extension which can be applied to an object and it will regain its original length when the force / load stress is removed	B2
(iii)	elastic returns to original length when load is removed	B1
	plastic returns some deformation (when load is removed)	B1
	penalise 'when load is removed' once only in (ii) and (iii)	
(b)	a. brittle substance / glass / cast iron / perspex	B1
	b. ductile substance / metal / polythene	B1
	c. polymeric substance / rubber / elastic	B1
	extends uniformly and then breaks for a	B1
	plastic behaviour for b	B1
	elastic but energy stored in the material when load removed for c / elastic but not uniform	B1
	max 5 marks	
	Total	[11]

8. (a) air bags: increase time / distance of impact
reduces force / reduces deceleration
increase area of contact
reduces pressure
prevents collision with steering wheel / windscreen / dashboard
instant deflation to reduce recoil / neck injury / whiplash

crumple zones: increase time/distance
reduces force
absorbs energy

seat belt: restraining force to prevent collision with steering wheel/ windscreen/dashboard
area of belt made large to reduce pressure

(collision with the steering wheel/windscreen scores once only if no explanation is given)
5 marks (must include all three items for maximum of five to be scored) B5

(b) braking distance:
distance vehicle travels after the brakes have been applied (until it stops) B1

road surface B1
tread of tyres needed when the road is wet B1
friction between the road and tyre B1
speed of vehicle B1
proportional to v^2 B1

(one point given B1, amplification of why and how it affects the braking distance B1) This done twice for the four marks max 4 points

Total [10]
QWC [4]