Q1.

1 (a)	scalar: magnitude only	B1	
	vector: magnitude and direction *(allow scalar with direction)*	B1	[2]
	(allow 1 mark for scalar has no direction, vector has direction)		
(b)	diagram has correct shape	M1	
	with arrows in correct directions	A1	
	resultant = 13.2 ± 0.2 N *(allow 2 sig. fig)*	A2	[4]
	(for 12.8 → 13.0 and 13.4 → 13.6, allow 1 mark)		
	(calculated answer with a correct sketch, allow max 4 marks)		
	(calculated answer with no sketch – no marks)		
	Total		[6]

Q2.

4 (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)	$\Delta p = 0.035\ (4.5 + 3.5)$ 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 57.1) (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 $= \frac{1}{2} \times 0.035\ (4.5^2 - 3.5^2)$	C1	
	= 0.14 J	A1	[2]
	(No credit for $0.28^2/(2 \times 0.035) = 1.12$ 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]

Q3.

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 x 2π x 2400)/60)		
	= 1.2 x 10^5 W	A1	[2]
	Total		[6]

Q4.

3	(a) (i)	$\Delta E_p = mg\Delta h$	C1	
		$= 0.602 \times 9.8 \times 0.086$		
		$= 0.51$ J	A1	[2]
		(do not allow g = 10, m = 0.600 or answer 0.50 J)		
	(ii)	$v^2 = (2gh =)\ 2 \times 9.8 \times 0.086$ or $(2 \times 0.51)/0.602$	M1	
		$v = 1.3$ (m s^{-1})	A0	[1]
	(b)	$2 \times V = 602 \times 1.3$ (allow 600)	C1	
		$V = 390$ m s^{-1}	A1	[2]
	(c) (i)	$E_k = ½mv^2$	C1	
		$= ½ \times 0.002 \times 390^2$		
		= 152 J or 153 J or 150 J	A1	[2]
	(ii)	E_k not the same/changes		
		or 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.)		

Q5.

2	(a) (i)	point at which whole weight of body		M1	
		may be considered to act		A1	[2]
	(ii)	sum of forces in any direction is zero		B1	
		sum of moments about any point is zero		B1	[2]
	(b)	*either*:			
		T and *W* have zero moment about P		M1	
		so *F* must have zero moment, i.e. pass through P		A1	[2]
		or:			
		if all pass through P, distance from P is zero for all forces	(M1)		
		so sum of moments about P is zero	(A1)		
	(c) (i)	$F\cos\alpha = T\cos\beta$		B1	[1]
	(ii)	$W = F\sin\alpha + T\sin\beta$		B1	[1]
	(iii)	$2W = 3T\sin\beta$		B1	[1]

Q6.

3 (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]

(c) (i) component $= 42 \times 9.8 \times \sin 2.8$ C1
$= 20.1$ N A1 [2]

(ii) accelerating force $= 20.1 - 16 = 4.1$ N C1
acceleration of trolley $= 4.1 / 42 = 0.098$ m s^{-2} C1
$s = \frac{1}{2}at^2$
$3.5 = \frac{1}{2} \times 0.098 \times t^2$ C1
$t = 8.5$ s A1 [4]

(d) *either* allows plenty of time to stop runaway trolley
or speed of trolley increases gradually
or trolley will travel faster B1 [1]
(answer must be unambiguous when read in conjunction with question)

Q7.

2 (a) (i) k is the reciprocal of the gradient of the graph C1
$k = \{32 / (4 \times 10^{-2}) = \}$ 800 N m^{-1} A1 [2]

(ii) *either* energy = average force × extension *or* $\frac{1}{2}kx^2$
or area under graph line C1
energy $= \frac{1}{2} \times 800 \times (3.5 \times 10^{-2})^2$ *or* $\frac{1}{2} \times 28 \times 3.5 \times 10^{-2}$ M1
energy $= 0.49$ J A0 [2]

(b) (i) momentum before cutting thread = momentum after C1
$0 = 2400 \times V - 800 \times v$ M1
$v / V = 3.0$ A0 [2]

(ii) energy stored in spring = kinetic energy of trolleys C1
$0.49 = \frac{1}{2} \times 2.4 \times (\frac{1}{3}v)^2 + \frac{1}{2} \times 0.8 \times v^2$ C1
$v = 0.96$ m s^{-1} A1 [3]
(if only one trolley considered, or masses combined, allow max 1 mark)

Q8.

2	(a)	ball moving in opposite direction (after collision)	B1	[1]
	(b) (i)	change in momentum = 1.2 (4.0 + 0.8) .... (*correct values, 1 mark; correct sign {values added}, 1 mark*) = 5.76 N s ...(*allow* 5.8)	C2 A1	[3]
	(ii)	force = $\Delta p / \Delta t$ or $m\Delta v / \Delta t$ .... = 5.76 / 0.08 or 1.2 × 4.8 / 0.08 .... = 72 N	C1 C1 A1	[3]
	(c)	5.76 = 3.6 × V .... V = 1.6 m s^{-1}	C1 A1	[2]
	(d)	*either* speed of approach = 4.0 m s^{-1} and speed of separation = 2.4 m s^{-1} .... not equal and so inelastic .... *or* kinetic energy before = 9.6 J and kinetic energy after collision = 4.99 J .... kinetic energy after is less / not conserved so inelastic	 M1 A1 M1 A1	[2]

Q9.

3	(a)	product of (magnitude of one) force and distance between forces .... reference to *either* perpendicular distance between forces *or* line of action of forces and perpendicular distance	M1 A1	[2]
	(b) (i)	90°	B1	[1]
	(ii)	130 = F × 0.45 (*allow e.c.f. for angle in **(i)***) .... F = 290 N .... (*allow 1 mark only if angle stated in **(i)** is not used in **(ii)***)	C1 A1	[2]

Q10.

2 (a) 2.4 s .... A1 [1]

(b) in (b) and (c), allow answers as (+) or (–)
recognises distance travelled as area under graph line C1
height = (½ × 2.4 × 9.0) – (½ × 1.6 × 6.0) C1
= 6.0 m (*allow 6 m*) .... A1 [3]
(*answer 15.6 scores 2 marks*
answer 10.8 or 4.8 scores 1 mark)

alternative solution: $s = ut - \frac{1}{2}at^2$
$= (9 \times 4) - \frac{1}{2} \times (9 / 2.4) \times 4^2$
$= 6.0$ m
(*answer 66 scores 2 marks*
answer 36 or 30 scores 1 mark)

(c) (i) change in momentum = 0.78 (9.0 + 4.2) (*allow 4.2 ± 0.2*) C1
= 10.3 N s (allow 10 N s) .... A1 [2]

(ii) force = $\Delta p / \Delta t$ or $m\Delta v / \Delta t$ C1
= 10.3 / 3.5 / 0.08
= 2.9 N .... A1 [2]

(d) (i) 2.9 N .... A1 [1]

(ii) g = weight / mass C1
= 2.9 / 0.78
= 3.7 m s^{-2} .... A1 [2]

Q11.

3 (a) *either* energy (stored)/work done represented by area under graph
or energy = average 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 momenta (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 $E = \frac{1}{2} M_1V_1^2 + \frac{1}{2} M_2V_2^2$ .... B1 [1]

(iii) 1 $E_K = \frac{1}{2}mv^2$ 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]

Q12.

3	(a)	(i)	force is rate of change of momentum	B1	[1]
		(ii)	force on body A is equal in magnitude to force on body B (from A)	M1	
			forces are in opposite directions	A1	
			forces are of the same kind	A1	[3]
	(b)	(i)	1 $F_A = -F_B$	B1	[1]
			2 $t_A = t_B$	B1	[1]
		(ii)	$\Delta p = F_A t_A = -F_B t_B$	B1	[1]
	(c)		graph: momentum change occurs at same times for both spheres	B1	
			final momentum of sphere B is to the right	M1	
			and of magnitude 5 N s	A1	[3]

Q13.

2	(a)		no resultant force/sum of forces zero	B1	
			no resultant moment/torque/sum of moments/torques zero	B1	[2]
	(b)	(i)	each force is represented by the side of a triangle/by an arrow	M1	
			in magnitude and direction	A1	
			arrows joined, head to tail	B1	[3]
			(*could be shown on a sketch diagram*)		
		(ii)	if the triangle is 'closed' (then the forces are in equilibrium)	B1	[1]
	(c)		triangle drawn with correct shape (incorrect arrows loses this mark)	B1	
			$T_1 = 5.4 \pm 0.2$ N	B1	
			$T_2 = 4.0 \pm 0.2$ N	B1	[3]
	(d)		forces in strings would be horizontal	B1	
			(so) no vertical force to support the weight	B1	[2]

Q14.

3 **(a)** point where the weight of an object / gravitational force	M1	
may be considered to act	A1	[2]
(b) product of the force and the perpendicular distance (to the pivot)	B1	[1]
(c) **(i)** 1. sum / net / resultant force is zero	B1	
2. net / resultant moment is zero		
sum of clockwise moments = sum of anticlockwise moments	B1	[2]
(ii) $W \times 0.2 = 80 \times 0.5 + 70 \times 1.3$	C1	
$= 40 + 91$	C1	
$W = 655$ N	A1	[3]
(*allow 2/3 for one error in distance but 0/3 if two errors*)		
(iii) move pivot to left	(M1)	
gives greater clockwise moment / smaller anticlockwise moment	(A1)	
or		
move W to right	(M1)	
gives smaller anticlockwise moment	(A1)	[2]

Q15.

2 **(a)** resultant moment = zero / sum of clockwise moments = sum of anticlockwise moments		B1	
resultant force = 0		B1	[2]
(b) shape and orientation correct and forces labelled and arrows correct		M1	
angles correct / labelled		A1	[2]
(c) **(i)** $T\cos 18° = W$	Scale diagram:	C1	
$T = 520 / \cos 18° = 547$ N	± 20 N	A1	[2]
(ii) $R = T\sin 18°$			
$= 169$ N	± 20 N	A1	[1]
(d) θ is larger hence $\cos\theta$ is smaller, $T = W / \cos\theta$		M1	
hence T is larger		A0	[1]

Q16.

3 (a) weight = $m \times g$
= 130.5 × 9.81 = 1280 N — A1 [1]

(b) (i) $F = ma$
T – 1280 = 130.5 × 0.57 — C1
T = 1280 + 74.4 = 1350 N — A1 [2]

(ii) 1280 N — A1 [1]

(c) 1240 – 1280 = 130.5 × a — C1
a = (–) 0.31 m s^{-2} — A1 [2]

(d) (i) 1. 3.5 s — A1 [1]

2. 6.5 s — A1 [1]

(ii) basic shape — M1
correct points — A1 [2]

Q17.

2 (a) (i) $v = u + at$ — C1
= 4.23 + 9.81 × 1.51 — M1
= 19.0(4) m s^{-1} (Allow 2 s.f.) — A0 [2]
(*Use of –g max 1/2. Use of g = 10 max 1/2. Allow use of 9.8. Allow 19 m s*$^{-1}$)

(ii) either $s = ut + \frac{1}{2}at^2$ (or $v^2 = u^2 + 2as$ etc.)
= 4.23 × 1.51 + 0.5 × 9.81 × (1.51)^2 — C1
= 17.6 m (*or 17.5 m*) — A1 [2]
(*Use of –g here wrong physics (0/2)*)

(b) (i) $F = \Delta P / \Delta t$ *need idea of change in momentum* — C1
= [0.0465 × (18.6 + 19)] / 12.5 × 10^{-3} — C1
= 140 N — A1
(*Use of – sign max 2/4. Ignore –ve sign in answer*)
Direction: upwards — B1 [4]

(ii) $h = \frac{1}{2} \times (18.6)^2 / 9.81$ — C1
= 17.6 m (*2 s.f. –1*) — A1 [2]
(*Use of 19 m s*$^{-1}$*, 0/2 wrong physics*)

(c) *either* kinetic energy of the ball is not conserved on impact
or speed before impact is not equal to speed after hence inelastic — B1 [1]

Q18.

3 **(a)** A body continues at rest or constant velocity unless acted on by a resultant (external) force — B1 [1]

(b) **(i)** constant velocity/zero acceleration and therefore no resultant force — M1
no resultant force (and no resultant torque) hence in equilibrium — A1 [2]

(ii) <u>component of weight</u> = 450 × 9.81 × sin 12° (= *917.8*) — C1
tension = 650 + 450 g sin12° = (650 + 917.8) — C1
= 1600 (1570) N — A1 [3]

(iii) work done against frictional force or friction between log and slope — M1
output power greater than the gain in PE / s — A1 [2]

Q19.

1 **(a)** displacement is a vector, distance is a scalar — B1
displacement is straight line between two points / distance is sum of lengths moved / example showing difference — B1 [2]
(either one of the definitions for the second mark)

(b) a body continues at rest or at constant velocity unless acted on by a <u>resultant</u> (external) force — B1 [1]

(c) **(i)** sum of T_1 and T_2 equals frictional force — B1
these two forces are in opposite directions — B1 [2]
(allow for 1/2 for travelling in straight line hence no rotation / no resultant torque)

(ii) **1.** scale vector triangle with correct orientation / vector triangle with correct orientation both with arrows — B1
scale given or mathematical analysis for tensions — B1 [2]

2. $T_1 = 10.1 \times 10^3$ ($\pm 0.5 \times 10^3$) N — A1
$T_2 = 16.4 \times 10^3$ ($\pm 0.5 \times 10^3$) N — A1 [2]

Q20.

2	(a)	weight = 452 × 9.81		
		component down the slope = 452 × 9.81 × sin 14°	M1	
		= 1072.7 = 1070 N	A0	[1]
	(b) (i)	$F = ma$	C1	
		T – (1070 + 525) = 452 × 0.13	C1	
		T = 1650 (1653.76) N *any forces missing 1/3*	A1	[3]
	(ii) 1.	$s = ut + ½at^2$ hence 10 = 0 + ½ × 0.13t^2	C1	
		t = [(2 × 10) / 0.13]$^{1/2}$ = 12.4 or 12 s	A1	[2]
	2.	v = (0 + 2 × 0.13 × 10)$^{1/2}$ = 1.61 or 1.6 m s^{-1}	A1	[1]
	(c)	straight line from the origin	B1	
		line down to zero velocity in short time compared to stage 1	B1	
		line less steep negative gradient	B1	
		final velocity larger than final velocity in the first part – at least 2×	B1	[4]

Q21.

2	(a)	mass is the property of a body resisting changes in motion / quantity of matter in a body / measure of inertia to changes in motion	B1	
		weight is the force due to the gravitational field/force due to gravity or gravitational force	B1	[2]
		Allow 1/2 for *'mass is scalar weight is vector'*		
	(b) (i)	arrow vertically down through O	B1	
		tension forces in correct direction on rope	B1	[2]
	(ii) 1.	weight = mg = 4.9 × 9.81 (= 48.07)	C1	
		69 sin $\theta = mg$	C1	
		θ = 44.(1)° *scale drawing allow ± 2°*	A1	[3]
		use of cos or tan 1/3 only		
	2.	T = 69 cos θ	C1	
		= 49.6 / 50 N *scale drawing 50 ±2 (2/2) 50 ±4 (1/2)*	A1	[2]
		correct answers obtained using scale diagram or triangle of forces will score full marks		
		cos in **1.** *then sin in* **2.** *(2/2)*		

Q22.

2	(a)		force = rate of change of momentum	A1	[1]
	(b)	(i)	horizontal line on graph from t = 0 to t about 2.0 s ± ½ square, a > 0	M1	
			horizontal line at 3.5 on graph from 0 to 2 s	A1	
			vertical line at t = 2.0 s to a = 0 or sharp step without a line	B1	
			horizontal line from t = 2 s to t = 4 s with a = 0	B1	[4]
		(ii)	straight line and positive gradient	M1	
			starting at (0,0)	A1	
			finishing at (2,16.8)	A1	
			horizontal line from 16.8	M1	
			from 2.0 to 4.0	A1	[5]

Q23.

3	(a)		the point where (all) the weight (of the body)	M1	
			is considered / seems to act	A1	[2]
	(b)	(i)	vertical component of T (= 30 cos 40°) = 23 N	A1	[1]
		(ii)	the sum of the clockwise moments about a point equals the sum of the anticlockwise moments (about the same point)	B1	[1]
		(iii)	(moments about A): 23 × 1.2 (27.58)	M1	
			= 8.5 × 0.60 + 1.2 × W	M1	
			working to show W = 19 or answer of 18.73 (N)	A1	[3]
		(iv)	(M = W / g = 18.73 / 9.81 =) 1.9(09) kg	A1	[1]
	(c)		(for equilibrium) resultant force (and moment) = 0	B1	
			upward force does not equal downward force / horizontal component of T not balanced by forces shown	B1	[2]

Q24.

3	(a)	(i)	the total momentum of a system (of interacting bodies) remains constant	M1	
			provided there are no resultant external forces / isolated system	A1	[2]
		(ii)	elastic: total kinetic energy is conserved, inelastic: loss of kinetic energy [allow elastic: relative speed of approach equals relative speed of separation]	B1	[1]

(b) (i) initial mom: 4.2 × 3.6 – 1.2 × 1.5 (= 15.12 – 1.8 = 13.3) C1
final mom: 4.2 × v + 1.5 × 3 C1
v = (13.3 – 4.5) / 4.2 = 2.1 m s^{-1} A1 [3]

(ii) initial kinetic energy = ½ $m_A(v_A)^2$ + ½ $m_B(v_B)^2$
= 27.21 + 1.08 = 28(.28) M1
final kinetic energy = 9.26 + 6.75 = 16 M1
initial KE is not the same as final KE hence inelastic A1 [3]
provided final KE less than initial KE
[allow in terms of relative speeds of approach and separation]

Q25.

2 (a) mass: measure of body's resistance/inertia to changes in velocity/motion B1
weight: effect of gravitational field on mass or force of gravity B1
any further comment e.g. mass constant, weight varies/ weight = mg/scalar and vector .... B1 [3]

(b) e.g. where gravitational field strength changes
(change) in fluid surrounding body.... *1 each, max 2* .... B2 [2]

Q26.

3 (a) force x perpendicular distance M1
(of the force) from the pivot .... A1 [2]

(b) no resultant force (in any direction) B1
no resultant moment (about any point) .... B1 [2]

(c) (i) correct direction in both .... B1 [1]

(ii)1 moment = 150 x 0.3 = 45 N m (1 sig. fig. -1) A1

(ii)2 torque = 45 N m i.e. same is (i) A1

(ii)3 45 = 0.12 x T C1
T = 375 N .... A1 [4]

Q27.

2 (a) point where whole weight of body (allow mass) M1
may be <u>considered</u> to act (do not allow 'acts') A1 **[2]**

(b) when CG below pivot, weight acts through the pivot B1
(so) weight has no turning effect about pivot B1 **[2]**

Q28.

3	(a)	change in velocity/time (taken)		B1	[1]
	(b)	velocity is a vector/velocity has magnitude & direction		B1	
		direction changing so must be accelerating		B1	[2]
	(c)	*either* 6.1 × cos35 = 4.99 N	*or* scale shown	B1	
		so no resultant vertical force	triangle of correct shape	B1	
		6.1 sin35 = 3.5 N	resultant = 3.5 ± 0.2 N	B1	
		horizontally	horizontal ± 3°	B1	[4]
		allow answer based on centripetal force:			
		resultant is centripetal force (which is horizontal)		(B1)	
		resultant is horizontal component of tension		(B1)	
		6.1 sin35 = 3.5 N		(B1)	
		horizontally		(B1)	

Q29.

4	(a)	(i)	use of tangent at time $t = 0$	B1	
			acceleration = 42 ± 4 cm s^{-2}	A1	[2]
		(ii)	use of area of loop	B1	
			distance = 0.031 ± 0.001 m	B2	[3]
			allow 1 mark if 0.031 ± 0.002 m)		
	(b)	(i)	$F = ma$	C1	
			= 0.93 × 0.42 {allow e.c.f. from (a)(i)}		
			= 0.39 N	A1	[2]
		(ii)	force reduces to zero in first 0.3 s	B1	
			then increases again in next 0.3 s	M1	
			in the opposite direction	A1	[3]

Q30.

3	(a)		helium nucleus OR contains two protons and two neutrons	B1	[1]
	(b)		kinetic energy = $\frac{1}{2}mv^2$	C1	
			$\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 = 1.07 \times 10^{-12}$	A1	
			$v = 1.8 \times 10^7$ m s^{-1}	A0	[2]
	(c)	(i)	sum of momenta (in any direction) is constant		
			/ total momemtum is constant	M1	
			in a closed system / no external force	A1	[2]
		(ii)	momentum of francium (= 0) = momentum of α + momentum of astatine	C1	
			$204 \times V = 4 \times 1.8 \times 10^7$	C1	
			$V = 3.5 \times 10^5$ m s^{-1}	A1	[3]
			(*nuclei incorrectly identified, 0/3*		
			nuclei correctly identified but incorrect masses, -1 each error)		
	(d)		another particle / photon is emitted	M1	
			at an angle to the direction of the α-particle	A1	[2]
			(allow 1 mark for 'Francium nucleus is not stationary')		

Q31.

3	(a)	moment:	force × <u>perpendicular</u> distance	M1	
			of force from pivot / axis / point	A1	
		couple:	(magnitude of) one force × <u>perpendicular</u> distance	M1	
			between the two forces	A1	[4]
			(*penalise the 'perpendicular' omission once only*)		
	(b)	(i)	$W \times 4.8 = (12 \times 84) + (2.5 \times 72)$	C1	
			$W = 250$ N (248 N)	A1	[2]
		(ii)	*either* friction <u>at the pivot</u> *or* small movement of weights	B1	[1]

Q32.

3	(a)	(i)	*either* sum / total momentum (of system of bodies) is constant		
			or <u>total</u> momentum before = <u>total</u> momentum after	M1	
			for an isolated system / no (external) force acts on system	A1	[2]
		(ii)	zero momentum before / after decay	M1	
			so α-particle and nucleus D must have <u>momenta</u> in opposite directions	A1	[2]
	(b)	(i)	kinetic energy = $\frac{1}{2}mv^2$	C1	
			$1.0 \times 10^{-12} = \frac{1}{2} \times 4 \times \underline{1.66} \times 10^{-27} \times v^2$	M1	
			$v = 1.7 \times 10^7$ m s^{-1}	A0	[2]
		(ii)	$1.7 \times 10^7 \times 4u = 216u \times V$	C1	
			$V = 3.1 \times 10^5$ m s^{-1}	A1	[2]
			(*accept* 3.2×10^5 *m s*$^{-1}$, *do not accept 220 rather than 216*)		

(c) $(1.7 \times 10^7)^2 = 2 \times$ *deceleration* $\times 4.5 \times 10^{-2}$ C1
deceleration / a $= 3.2 \times 10^{15}$ m s^{-2} .... A1 [2]
(*accept calculation based on calculating F* $= 2.22 \times 10^{11}$ *N*
and then use of F = ma)

[Total: 10]

Q33.

3 (a) force = rate of change of momentum (allow symbols if defined)	B1	[1]
(b) (i) $\Delta p = 140 \times 10^{-3} \times (5.5 + 4.0)$	C1	
$= 1.33$ kg m s^{-1}	A1	[2]
(ii) force = 1.33 / 0.04	M1	
= 33.3 N	A0	[1]
(c) (i) taking moments about B	C1	
$(33 \times 75) + (0.45 \times g \times 25) = F_A \times 20$	C1	
$F_A = 129$ N	A1	[3]
(ii) $F_B = 33 + 129 + 0.45g$	C1	
= 166 N	A1	[2]

Q34.

3 (a) point at which (whole) weight (of body) (allow mass for weight)	M1	
appears / seems to act ... (for mass need 'appears to be concentrated')	A1	[2]
(b) (i) point C shown at centre of rectangle ± 5 mm	B1	[1]
(ii) arrow vertically downwards, from C with arrow starting from the same margin of error as in **(b)(i)**	B1	[1]
(c) (i) reaction / upwards / supporting / normal reaction force	M1	
friction	M1	
force(s) at the rod	A1	[3]
(ii) comes to rest with (line of action of) weight acting through rod		
allow C vertically below the rod	B1	
so that weight does not have a moment about the pivot / rod	B1	[2]

Q35.

2	(a)	torque is the product of one of the forces and the distance between forces the perpendicular distance between the forces	M1 A1	[2]
	(b) (i)	torque = 8 × 1.5 = 12 N m	A1	[1]
	(ii)	there is a resultant torque / sum of the moments is not zero (the rod rotates) and is not in equilibrium	M1 A1	[2]
	(c) (i)	B × 1.2 = 2.4 × 0.45 B = 0.9(0) N	C1 A1	[2]
	(ii)	A = 2.4 – 0.9 = 1.5 N / moments calculation	A1	[1]

Q36.

2	(a) (i)	force is rate of change of momentum	B1	[1]
	(ii)	work done is the product of the force and the distance moved in the direction of the force	B1	[1]
	(b) (i)	$W = Fs$ **or** $W = mas$ **or** $W = m(v^2 - u^2) / 2$ **or** W = force × distance s	A1	[1]
	(ii)	$as = (v^2 - u^2) / 2$ any subject $W = mas$ hence $W = m(v^2 - u^2) / 2$ RHS represents terms of energy **or** with $u = 0$ KE = $\frac{1}{2}mv^2$	M1 M1 A1	[3]
	(c) (i)	work done = ½ × 1500 × [(30)^2 – (15)^2] (=506250) distance = WD / F = 506250 / 3800 = 133 m **or** $F = ma$ a = 2.533 (m s^{-2}) $v^2 = u^2 + 2as$ s = 133 m	C1 A1 C1 A1	[2]
	(ii)	the change in kinetic energy is greater or the work done by the force has to be greater, hence distance is greater (for same force) allow: same acceleration, same time, so greater average speed and greater distance	A1	[1]

Q37.

1	(a)		scalar has magnitude/size, vector has magnitude/size and direction	B1	[1]
	(b)		acceleration, momentum, weight *(–1 for each addition or omission but stop at zero)*	B2	[2]
	(c)	(i)	horizontally: 7.5 cos 40° / 7.5 sin 50° = 5.7(45) / 5.75 <u>not</u> 5.8 N	A1	[1]
		(ii)	vertically: 7.5 sin 40° / 7.5 cos 50° = 4.8(2) N	A1	[1]
	(d)		*either* correct shaped triangle correct labelling of two forces, three arrows and two angles *or* correct resolving: $T_2 \cos 40° = T_1 \cos 50°$ $T_1 \sin 50° + T_2 \sin 40° = 7.5$ T_1 = 5.7(45) (N) T_2 = 4.8 (N) *(allow ± 0.2 N for scale diagram)*	M1 A1 (B1) (B1) A1 A1	 [4]

Q38.

1	(a)	(i)		acceleration = change in velocity / time (taken) or acceleration = rate of change of velocity	B1	[1]
		(ii)		a body continues at constant velocity unless acted on by a resultant force	B1	[1]
	(b)	(i)		distance is represented by the area under graph distance = ½ × 29.5 × 3 = 44.3 m (accept 43.5 m for 29 to 45 m for 30)	C1 A1	 [2]
		(ii)		resultant force = weight – frictional force frictional force increases with speed at start frictional force = 0 / at end weight = frictional force	B1 B1 B1	 [3]
		(iii)	1.	frictional force increases	B1	[1]
			2.	frictional force (constant) and then decreases	B1	[1]
		(iv)	1.	acceleration = $(v_2 - v_1) / t$ = (20 – 50) / (17 – 15) = (–) 15 m s^{-2}	C1 A1	 [2]
			2.	$W - F = ma$ W = 95 × 9.81 (= 932) F = (95 × 15) + 932 = 2400 (2360) (2357) N	C1 C1 A1	 [3]

Q39.

2	**(a)** (resultant) force = rate of change of momentum / allow proportional to or change in momentum / time (taken)	B1	[1]
	(b) (i) $\Delta p = (-)\ 65 \times 10^{-3}\ (5.2 + 3.7)$	C1	
	$= (-)\ 0.58\ \text{N s}$	A1	[2]
	(ii) $F = 0.58 / 7.5 \times 10^{-3}$		
	$= 77(.3)\ \text{N}$	A1	[1]
	(c) (i) 1. force on the wall from the ball is equal to the force on ball from the wall	M1	
	but in the opposite direction	A1	[2]
	(statement of Newton's third law can score one mark)		
	2. momentum change of ball is equal and opposite to momentum change of the wall / change of momentum of ball and wall is zero	B1	[1]
	(ii) kinetic energy (of ball and wall) is reduced / not conserved so inelastic (Allow relative speed of approach does not equal relative speed of separation.)	B1	[1]

Q40.

2	**(a) (i)** accelerations (A to B and B to C) are same magnitude	B1	
	accelerations (A to B and B to C) are opposite directions or both accelerations are toward B	B1	
	(A to B and B to C) the component of the weight down the slope provides the acceleration	B1	[3]
	(ii) acceleration = $g \sin 15°$	C1	
	$s = 0 + ½at^2$ $\quad s = 0.26 / \sin 15° = 1.0$	C1	
	$t^2 = \dfrac{1.0 \times 2}{9.8 \times \sin 15°}$ $\quad t = 0.89\ \text{s}$	A1	[3]
	(iii) $v = 0 + g\sin 15 t$ or $v^2 = 0 + 2g\sin 15 \times 1.0$	C1	
	$v = 2.26\ \text{m s}^{-1}$	A1	[2]
	(using loss of GPE = gain KE can score full marks)		
	(b) loss of GPE at A = gain in GPE at C or loss of KE at B = gain in GPE at C	B1	
	$h_1 = h_2 = 0.26\ \text{m}$ or $½mv^2 = mgh$ $\quad h_2 = 0.5 \times (2.26)^2 / 9.81 = 0.26\ \text{m}$		
	$x = 0.26 / \sin 30° = 0.52\ \text{m}$	A1	[2]

Q41.

4	**(a)**	torque of a couple = <u>one</u> of the forces / a force × distance multiplied by the <u>perpendicular distance between the forces</u>	M1 A1	[2]
	(b) (i)	weight at P (vertically) down normal reaction OR contact force at (point of contact with the pin) P (vertically) up	B1 B1	[2]
	(ii)	torque = 35 × 0.25 (or 25) × 2 = 18 (17.5) N m	C1 A1	[2]
	(iii)	the two 35 N forces are equal and opposite and the weight and the upward / contact / reaction force are equal and opposite	B1	[1]
	(iv)	not in equilibrium as the (resultant) torque is not zero	B1	[1]