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 $F = ma\ (= 0.035 \times 575.1)$ (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 $= \frac{1}{2} \times 0.035\ (4.5^2 - 3.5^2)$	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 $(= 470 \times 2\pi \times 2400)/60)$		
			$= 1.2 \times 10^5$ 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)	C2		
		(correct values, 1 mark; correct sign {values added}, 1 mark)			
		= 5.76 N s …(*allow 5.8*)	A1		[3]
	(ii)	force = $\Delta p / \Delta t$ or $m\Delta v / \Delta t$	C1		
		= 5.76 / 0.08 or 1.2 × 4.8 / 0.08	C1		
		= 72 N	A1		[3]
	(c)	5.76 = 3.6 × V	C1		
		V = 1.6 m s^{-1}	A1		[2]
	(d)	*either* speed of approach = 4.0 m s^{-1} and			
		speed of separation = 2.4 m s^{-1}	M1		
		not equal and so inelastic	A1		
		or kinetic energy before = 9.6 J and			
		kinetic energy after collision = 4.99 J	M1		
		kinetic energy after is less / not conserved so inelastic	A1		[2]

Q9.

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

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 = <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 $\underline{E} = \frac{1}{2} M_1V_1^2 + \frac{1}{2} M_2V_2^2$ ..... 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	
			$T_1 = 5.4 \pm 0.2\,\text{N}$	B1	
			$T_2 = 4.0 \pm 0.2\,\text{N}$	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)** $F = ma$
$T - 1280 = 130.5 \times 0.57$ — C1
$T = 1280 + 74.4 = 1350$ N — A1 [2]

(ii) 1280 N — A1 [1]

(c) $1240 - 1280 = 130.5 \times a$ — 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
$= 4.23 + 9.81 \times 1.51$ — 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.)
$= 4.23 \times 1.51 + 0.5 \times 9.81 \times (1.51)^2$ — C1
= 17.6 m (*or 17.5m*) — A1 [2]
(*Use of –g here wrong physics (0/2)*)

(b) **(i)** $F = \Delta P / \Delta t$ *need idea of change in momentum* — C1
$= [0.0465 \times (18.6 + 19)] / 12.5 \times 10^{-3}$ — 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)	component of weight = $450 \times 9.81 \times \sin 12°$ (= *917.8*)	C1	
		tension = $650 + 450\,g \sin 12° = (650 + 917.8)$	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 resultant (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
$T - (1070 + 525) = 452 \times 0.13$ C1
T = 1650 (1653.76) N *any forces missing 1/3* A1 [3]

(ii) **1.** $s = ut + \frac{1}{2}at^2$ hence $10 = 0 + \frac{1}{2} \times 0.13t^2$ C1
$t = [(2 \times 10) / 0.13]^{1/2}$ = 12.4 or 12 s A1 [2]

2. $v = (0 + 2 \times 0.13 \times 10)^{1/2}$ = 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: $4.2 \times 3.6 - 1.2 \times 1.5$ (= 15.12 – 1.8 = 13.3)	C1	
		final mom: $4.2 \times v + 1.5 \times 3$	C1	
		$v = (13.3 - 4.5) / 4.2 = 2.1\ \text{m s}^{-1}$	A1	[3]
	(ii)	initial kinetic energy $= \frac{1}{2} m_A(v_A)^2 + \frac{1}{2} m_B(v_B)^2$		
		$= 27.21 + 1.08 = 28(.28)$	M1	
		final kinetic energy = 9.26 + 6.75 = 16	M1	
		initial KE is not the same as final KE hence inelastic *provided final KE less than initial KE* [allow in terms of relative speeds of approach and separation]	A1	[3]

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) may be <u>considered</u> to act (do not allow 'acts')	M1 A1	**[2]**
	(b)	when CG below pivot, weight acts through the pivot (so) weight has no turning effect about pivot	B1 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* $6.1 \times \cos 35 = 4.99$ N	*or* scale shown	B1	
			so no resultant vertical force	triangle of correct shape	B1	
			$6.1 \sin 35 = 3.5$ N	resultant = 3.5 ± 0.2 N	B1	
			horizontally	horizontal $\pm 3°$	B1	[4]
			allow answer based on centripetal force:			
			resultant is centripetal force (which is horizontal)		(B1)	
			resultant is horizontal component of tension		(B1)	
			$6.1 \sin 35 = 3.5$ 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	
			$= 0.93 \times 0.42$ {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 = $\frac{1}{2} \times 1500 \times [(30)^2 - (15)^2]$ (=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	M1	
		correct labelling of two forces, three arrows and two angles	A1	
		or correct resolving: $T_2\cos 40° = T_1\cos 50°$	(B1)	
		$T_1\sin 50° + T_2\sin 40° = 7.5$	(B1)	
		$T_1 = 5.7(45)$ (N)	A1	
		$T_2 = 4.8$ (N)	A1	[4]
		(allow ± 0.2 N for scale diagram)		

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		C1	
		distance = ½ × 29.5 × 3 = 44.3 m (accept 43.5 m for 29 to 45 m for 30)		A1	[2]
	(ii)	resultant force = weight – frictional force		B1	
		frictional force increases with speed		B1	
		at start frictional force = 0 / at end weight = frictional force		B1	[3]
	(iii)	**1.** frictional force increases		B1	[1]
		2. frictional force (constant) and then decreases		B1	[1]
	(iv)	**1.** acceleration = $(v_2 - v_1) / t = (20 - 50) / (17 - 15)$		C1	
		$= (-)\ 15\ \text{m s}^{-2}$		A1	[2]
		2. $W - F = ma$		C1	
		$W = 95 \times 9.81$ (= 932)		C1	
		$F = (95 \times 15) + 932 = 2400$ (2360) (2357) N		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 B1 [1]
(Allow relative speed of approach does not equal relative speed of separation.)

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
$s = 0 + \frac{1}{2} at^2$ $s = 0.26 / \sin 15° = 1.0$ C1

$t^2 - \frac{1.0 \times 2}{9.8 \times \sin 15°}$ $t = 0.89\ \text{s}$ 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 $\frac{1}{2} mv^2 = mgh$ $h_2 = 0.5 \times (2.26)^2 / 9.81 = 0.26\ \text{m}$
$x = 0.26 / \sin 30° = 0.52\ \text{m}$ A1 [2]

Q41.

4	**(a)**	torque of a couple = <u>one</u> of the forces / a force × distance	M1	
		multiplied by the <u>perpendicular distance between the forces</u>	A1	[2]
	(b) **(i)**	weight at P (vertically) down	B1	
		normal reaction OR contact force at (point of contact with the pin) P (vertically) up	B1	[2]
	(ii)	torque = 35 × 0.25 (or 25) × 2	C1	
		= 18 (17.5) Nm	A1	[2]
	(iii)	the two 35N 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]