

Q1.

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

Q2.

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

Q3.

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

Q4.

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

**Q5.**

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

**Q6.**

- 3 (a) (i)  $v^2 = 2as$   
 $1.2^2 = 2 \times a \times 1.9$   
 $a = 0.38 \text{ m s}^{-2}$  M1  
A1 [2]
- (ii)  $F = ma$   
 $= 42 \times 0.38$  M1  
 $= 16 \text{ N}$  A0 [1]
- (b)  $\text{power} = Fv$  C1  
 $= 16 \times 1.2$   
 $= 19 \text{ W}$  A1 [2]
- (c) (i)  $\text{component} = 42 \times 9.8 \times \sin 2.8$  C1  
 $= 20.1 \text{ N}$  A1 [2]
- (ii)  $\text{accelerating force} = 20.1 - 16 = 4.1 \text{ N}$  C1  
 $\text{acceleration of trolley} = 4.1 / 42 = 0.098 \text{ m s}^{-2}$  C1  
 $s = \frac{1}{2}at^2$   
 $3.5 = \frac{1}{2} \times 0.098 \times t^2$  C1  
 $t = 8.5 \text{ s}$  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  
 $k = \{32 / (4 \times 10^{-2})\} = 800 \text{ N m}^{-1}$  A1 [2]
- (ii) *either*  $\text{energy} = \text{average force} \times \text{extension}$  *or*  $\frac{1}{2}kx^2$   
*or* area under graph line C1  
 $\text{energy} = \frac{1}{2} \times 800 \times (3.5 \times 10^{-2})^2$  *or*  $\frac{1}{2} \times 28 \times 3.5 \times 10^{-2}$  M1  
 $\text{energy} = 0.49 \text{ J}$  A0 [2]
- (b) (i)  $\text{momentum before cutting thread} = \text{momentum after}$  C1  
 $0 = 2400 \times V - 800 \times v$  M1  
 $v / V = 3.0$  A0 [2]
- (ii)  $\text{energy stored in spring} = \text{kinetic energy of trolleys}$  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  
 $v = 0.96 \text{ m s}^{-1}$  A1 [3]  
*(if only one trolley considered, or masses combined, allow max 1 mark)*

## Q8.

2	(a)	ball moving in <u>opposite</u> 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 <sup>-1</sup> .....	A1	[2]
	(d)	either speed of approach = 4.0 m s <sup>-1</sup> and speed of separation = 2.4 m s <sup>-1</sup> .....	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 <i>either</i> 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 = $(\frac{1}{2} \times 2.4 \times 9.0) - (\frac{1}{2} \times 1.6 \times 6.0)$ .....	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 $4.2 \pm 0.2$ ) .....	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) $g = \text{weight} / \text{mass}$ .....	C1	
		= $2.9 / 0.78$		
		= $3.7 \text{ m s}^{-2}$ .....	A1	[2]

Q11.

3	(a)	either energy (stored)/work done represented by area under graph or energy = <u>average</u> force $\times$ extension .....	B1	
		energy = $\frac{1}{2} \times 180 \times 4.0 \times 10^{-2}$ .....	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 $M_1 V_1 = M_2 V_2$ .....	B1	[1]
		2 $E = \frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 V_2^2$ .....	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.**

<b>3 (a) (i)</b>	force is rate of change of momentum .....	B1	[1]
<b>(ii)</b>	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>(b) (i)</b>	1 $F_A = -F_B$ .....	B1	[1]
	2 $t_A = t_B$ .....	B1	[1]
<b>(ii)</b>	$\Delta p = F_A t_A = -F_B t_B$ .....	B1	[1]
<b>(c)</b>	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.**

<b>2 (a)</b>	no resultant force/sum of forces zero	B1	
	no resultant moment/torque/sum of moments/torques zero	B1	[2]
<b>(b) (i)</b>	each force is represented by the side of a triangle/by an arrow in magnitude and direction	M1	
	arrows joined, head to tail	A1	
	(could be shown on a sketch diagram)	B1	[3]
<b>(ii)</b>	if the triangle is 'closed' (then the forces are in equilibrium)	B1	[1]
<b>(c)</b>	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]
<b>(d)</b>	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 may be considered to act	M1 A1 [2]
	(b) product of the force and the <u>perpendicular</u> 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) $W \times 0.2 = 80 \times 0.5 + 70 \times 1.3$ $= 40 + 91$ $W = 655 \text{ N}$ <i>(allow 2/3 for one error in distance but 0/3 if two errors)</i>	C1 C1 A1 [3]
	(iii) move pivot to left gives greater clockwise moment / smaller anticlockwise moment <i>or</i> move W to right gives smaller anticlockwise moment	(M1) (A1) (M1) (A1) [2]

Q15.

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

Q16.

- 3 (a) weight =  $m \times g$   
 $= 130.5 \times 9.81 = 1280 \text{ N}$  A1 [1]
- (b) (i)  $F = ma$   
 $T - 1280 = 130.5 \times 0.57$  C1  
 $T = 1280 + 74.4 = 1350 \text{ N}$  A1 [2]
- (ii) 1280 N A1 [1]
- (c)  $1240 - 1280 = 130.5 \times a$  C1  
 $a = (-) 0.31 \text{ ms}^{-2}$  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  
 $= 19.0(4) \text{ ms}^{-1}$  (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  $19 \text{ ms}^{-1}$ )
- (ii) either  $s = ut + \frac{1}{2} at^2$  (or  $v^2 = u^2 + 2as$  etc.) C1  
 $= 4.23 \times 1.51 + 0.5 \times 9.81 \times (1.51)^2$  A1 [2]  
 $= 17.6 \text{ m}$  (or 17.5m)  
(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  
 $= 140 \text{ N}$  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  
 $= 17.6 \text{ m}$  (2 s.f. -1) A1 [2]  
(Use of  $19 \text{ ms}^{-1}$ , 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 no resultant force (and no resultant torque) hence in equilibrium M1 A1 [2]
- (ii) component of weight =  $450 \times 9.81 \times \sin 12^\circ (= 917.8)$  C1  
tension =  $650 + 450 g \sin 12^\circ = (650 + 917.8)$  C1  
= 1600 (1570)N A1 [3]
- (iii) work done against frictional force or friction between log and slope output power greater than the gain in PE / s M1 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 =  $452 \times 9.81$   
 component down the slope =  $452 \times 9.81 \times \sin 14^\circ$   
 $= 1072.7 = 1070 \text{ N}$  M1  
 A0 [1]
- (b) (i)  $F = ma$  C1  
 $T - (1070 + 525) = 452 \times 0.13$  C1  
 $T = 1650 (1653.76) \text{ N}$  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  
 $t = [(2 \times 10) / 0.13]^{1/2} = 12.4 \text{ or } 12 \text{ s}$  A1 [2]
2.  $v = (0 + 2 \times 0.13 \times 10)^{1/2} = 1.61 \text{ or } 1.6 \text{ ms}^{-1}$  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 =  $mg = 4.9 \times 9.81 (= 48.07)$  C1  
 $69 \sin \theta = mg$  C1  
 $\theta = 44.(1)^\circ$  A1 [3]  
*scale drawing allow  $\pm 2^\circ$*   
*use of cos or tan 1/3 only*
2.  $T = 69 \cos \theta$  C1  
 $= 49.6 / 50 \text{ N}$  A1 [2]  
*scale drawing  $50 \pm 2 (2/2)$   $50 \pm 4 (1/2)$*
- 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  $\pm$   $\frac{1}{2}$  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) (i) the point where (all) the weight (of the body) M1  
is considered / seems to act A1 [2]
- (b) (i) vertical component of  $T (= 30 \cos 40^\circ) = 23$  N A1 [1]
- (ii) the sum of the clockwise moments about a point equals the sum of the B1  
anticlockwise moments (about the same point) [1]
- (iii) (moments about A):  $23 \times 1.2$  (27.58) M1  
 $= 8.5 \times 0.60 + 1.2 \times W$  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 B1 [1]  
[allow elastic: relative speed of approach equals relative speed of separation]

- (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  
 $v = (13.3 - 4.5) / 4.2 = 2.1 \text{ ms}^{-1}$  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 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 =  $150 \times 0.3 = 45 \text{ N m}$  (1 sig. fig. -1) ..... A1
- (ii)2 torque =  $45 \text{ N m}$  i.e. same as (i) ..... A1
- (ii)3  $45 = 0.12 \times T$  ..... C1  
 $T = 375 \text{ N}$  ..... A1 [4]

Q27.

- 2 (a) point where whole weight of body (allow mass) M1  
 may be considered 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.

<b>3</b>	<b>(a)</b>	<u>change</u> in velocity/time (taken)	B1	<b>[1]</b>
	<b>(b)</b>	velocity is a vector/velocity has magnitude & direction direction changing so must be accelerating	B1 B1	<b>[2]</b>
	<b>(c)</b>	<i>either</i> $6.1 \times \cos 35 = 4.99 \text{ N}$ so no resultant vertical force $6.1 \sin 35 = 3.5 \text{ N}$ horizontally	<i>or</i> scale shown triangle of correct shape resultant = $3.5 \pm 0.2 \text{ N}$ horizontal $\pm 3^\circ$	B1 B1 B1 B1 <b>[4]</b>
		<i>allow answer based on centripetal force:</i> resultant is centripetal force (which is horizontal) resultant is horizontal component of tension $6.1 \sin 35 = 3.5 \text{ N}$ horizontally	(B1) (B1) (B1) (B1)	

**Q29.**

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

**Q30.**

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

Q31.

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

Q32.

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

- (c)  $(1.7 \times 10^7)^2 = 2 \times \text{deceleration} \times 4.5 \times 10^{-2}$  ..... C1  
 deceleration /  $a = 3.2 \times 10^{15} \text{ m s}^{-2}$  ..... A1 [2]  
 (accept calculation based on calculating  $F = 2.22 \times 10^{11} \text{ N}$   
 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  
 $= 1.33 \text{ kg m s}^{-1}$  A1 [2]
- (ii) force =  $1.33 / 0.04$  M1  
 $= 33.3 \text{ N}$  A0 [1]
- (c) (i) taking moments about B C1  
 $(33 \times 75) + (0.45 \times g \times 25) = F_A \times 20$  C1  
 $F_A = 129 \text{ N}$  A1 [3]
- (ii)  $F_B = 33 + 129 + 0.45g$  C1  
 $= 166 \text{ N}$  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  $\pm 5 \text{ mm}$  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 B1  
 allow C vertically below the rod B1 [2]  
 so that weight does not have a moment about the pivot / rod

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 =  $8 \times 1.5 = 12 \text{ Nm}$  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)  $B \times 1.2 = 2.4 \times 0.45$  C1  
 $B = 0.9(0) \text{ N}$  A1 [2]
- (ii)  $A = 2.4 - 0.9 = 1.5 \text{ N}$  / 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  $W = \text{force} \times \text{distance } s$  A1 [1]
- (ii)  $as = (v^2 - u^2) / 2$  any subject M1  
 $W = mas$  hence  $W = m(v^2 - u^2) / 2$  M1  
RHS represents terms of energy or with  $u = 0$   $KE = \frac{1}{2}mv^2$  A1 [3]
- (c) (i) work done =  $\frac{1}{2} \times 1500 \times [(30)^2 - (15)^2]$  (=506250) C1  
distance =  $WD / F = 506250 / 3800 = 133 \text{ m}$  A1 [2]  
or  $F = ma$   $a = 2.533 \text{ (m s}^{-2}\text{)}$  C1  
 $v^2 = u^2 + 2as$   $s = 133 \text{ m}$  A1
- (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) A1 [1]
- allow: same acceleration, same time, so greater average speed and greater  
distance

### 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: $7.5 \cos 40^\circ / 7.5 \sin 50^\circ = 5.7(45) / 5.75$ <u>not</u> 5.8 N	A1 [1]
	(ii) vertically: $7.5 \sin 40^\circ / 7.5 \cos 50^\circ = 4.8(2)$ N	A1 [1]
	(d) <i>either</i> correct shaped triangle correct labelling of two forces, three arrows and two angles <i>or</i> correct resolving: $T_2 \cos 40^\circ = T_1 \cos 50^\circ$ $T_1 \sin 50^\circ + T_2 \sin 40^\circ = 7.5$ $T_1 = 5.7(45)$ (N) $T_2 = 4.8$ (N) (allow $\pm 0.2$ 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 = $\frac{1}{2} \times 29.5 \times 3 = 44.3$ 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 = $(v_2 - v_1) / t = (20 - 50) / (17 - 15)$ = (-) $15 \text{ m s}^{-2}$	C1 A1 [2]
	2. $W - F = ma$ $W = 95 \times 9.81 (= 932)$ $F = (95 \times 15) + 932 = 2400$ (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 but in the opposite direction M1  
(statement of Newton's third law can score one mark) A1 [2]
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 B1  
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 =  $g \sin 15^\circ$  C1  
 $s = 0 + \frac{1}{2} at^2$   $s = 0.26 / \sin 15^\circ = 1.0$  C1
- $t^2 = \frac{1.0 \times 2}{9.8 \times \sin 15^\circ}$   $t = 0.89 \text{ s}$  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  $\frac{1}{2} mv^2 = mgh$   $h_2 = 0.5 \times (2.26)^2 / 9.81 = 0.26 \text{ m}$   
 $x = 0.26 / \sin 30^\circ = 0.52 \text{ m}$  A1 [2]

#### Q41.

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



