1. A particle P of mass 0.5 kg is moving under the action of a single force **F** newtons. At time t seconds,

$$\mathbf{F} = (6t - 5)\,\mathbf{i} + (t^2 - 2t)\,\mathbf{j}.$$

The velocity of P at time t seconds is **v** m s–1. When $t = 0$, $\mathbf{v} = \mathbf{i} - 4\mathbf{j}$.

(a) Find **v** at time t seconds.

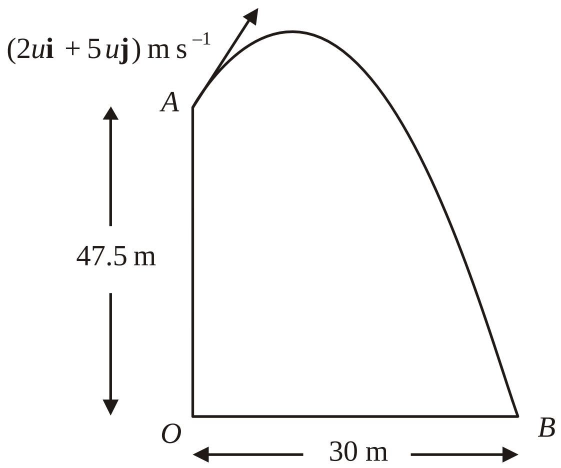
(6)

When $t = 3$, the particle P receives an impulse $(-5\mathbf{i} + 12\mathbf{j})$ N s.

(b) Find the speed of P immediately after it receives the impulse.

(6)
(Total 12 marks)

2.



[*In this question, the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertical.*]

A particle P is projected from the point A which has position vector 47.5**j** metres with respect to a fixed origin O. The velocity of projection of P is $(2u\mathbf{i} + 5u\mathbf{j})$ m s^{-1}. The particle moves freely under gravity passing through the point B with position vector 30**i** metres, as shown in the diagram above.

(a) Show that the time taken for P to move from A to B is 5 s.

(6)

(b) Find the value of *u*.

(2)

(c) Find the speed of *P* at *B*.

(5)
(Total 13 marks)

3. A particle *P* of mass 0.5 kg moves under the action of a single force **F** newtons. At time *t* seconds, the velocity **v** m s^{-1} of *P* is given by

$$\mathbf{v} = 3t^2\mathbf{i} + (1 - 4t)\mathbf{j}.$$

Find

(a) the acceleration of *P* at time *t* seconds,

(2)

(b) the magnitude of **F** when $t = 2$.

(4)
(Total 6 marks)

4. A particle *P* of mass 0.5 kg is moving under the action of a single force **F** newtons. At time *t* seconds, $\mathbf{F} = (1.5t^2 - 3)\mathbf{i} + 2t\mathbf{j}$. When $t = 2$, the velocity of *P* is $(-4\mathbf{i} + 5\mathbf{j})$ m s^{-1}.

(a) Find the acceleration of *P* at time *t* seconds.

(2)

(b) Show that, when $t = 3$, the velocity of *P* is $(9\mathbf{i} + 15\mathbf{j})$ m s^{-1}.

(5)

When $t = 3$, the particle *P* receives an impulse **Q** N s. Immediately after the impulse the velocity of *P* is $(-3\mathbf{i} + 20\mathbf{j})$ m s^{-1}. Find

(c) the magnitude of **Q**,

(3)

(d) the angle between **Q** and **i**.

(3)
(Total 13 marks)

5. A cricket ball of mass 0.5 kg is struck by a bat. Immediately before being struck, the velocity of the ball is (–30**i**) m s^{-1}. Immediately after being struck, the velocity of the ball is (16**i** + 20**j**) m s^{-1}.

(a) Find the magnitude of the impulse exerted on the ball by the bat.

(4)

In the subsequent motion, the position vector of the ball is **r** metres at time t seconds. In a model of the situation, it is assumed that **r** = [16t**i** + $(20t - 5t^2)$**j**]. Using this model,

(b) find the speed of the ball when $t = 3$.

(4)
(Total 8 marks)

6. A particle P of mass 0.4 kg is moving so that its position vector **r** metres at time t seconds is given by

$$\mathbf{r} = (t^2 + 4t)\mathbf{i} + (3t - t^3)\mathbf{j}.$$

(a) Calculate the speed of P when $t = 3$.

(5)

When $t = 3$, the particle P is given an impulse (8**i** – 12**j**) N s.

(b) Find the velocity of P immediately after the impulse.

(3)
(Total 8 marks)

7. A particle P of mass 0.4 kg is moving under the action of a single force **F** newtons. At time t seconds, the velocity of P, **v** m s^{-1}, is given by

$$\mathbf{v} = (6t + 4)\mathbf{i} + (t^2 + 3t)\mathbf{j}.$$

When $t = 0$, P is at the point with position vector $(-3\mathbf{i} + 4\mathbf{j})$ m. When $t = 4$, P is at the point S.

(a) Calculate the magnitude of **F** when $t = 4$.

(4)

(b) Calculate the distance OS.

(5)
(Total 9 marks)

8. At time t seconds, the velocity of a particle P is $[(4t - 7)\mathbf{i} - 5\mathbf{j}]$ m s^{-1}. When $t = 0$, P is at the point with position vector $(3\mathbf{i} + 5\mathbf{j})$ m relative to a fixed origin O.

(a) Find an expression for the position vector of P after t seconds, giving your answer in the form $(a\mathbf{i} + b\mathbf{j})$ m.

(4)

A second particle Q moves with constant velocity $(2\mathbf{i} - 3\mathbf{j})$ m s^{-1}. When $t = 0$, the position vector of Q is $(-7\mathbf{i})$ m.

(b) Prove that P and Q collide.

(6)
(Total 10 marks)

9. A particle P of mass 0.75 kg is moving under the action of a single force **F** newtons. At time t seconds, the velocity **v** m s^{-1} of P is given by

$$\mathbf{v} = (t^2 + 2)\,\mathbf{i} - 6t\mathbf{j}.$$

(a) Find the magnitude of **F** when $t = 4$.

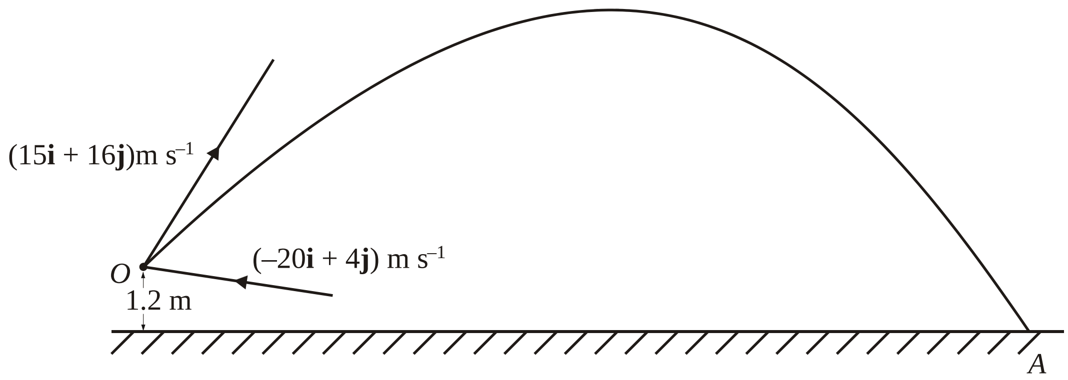
(5)

When $t = 5$, the particle P receives an impulse of magnitude $9\sqrt{2}$ Ns in the direction of the vector $\mathbf{i} - \mathbf{j}$.

(b) Find the velocity of *P* immediately after the impulse.

(4)
(Total 9 marks)

10.



A ball *B* of mass 0.4 kg is struck by a bat at a point *O* which is 1.2 m above horizontal ground. The unit vectors **i** and **j** are respectively horizontal and vertical. Immediately before being struck, *B* has velocity (–20**i** + 4**j**) m s^{-1}. Immediately after being struck it has velocity (15**i** + 16**j**) m s^{-1}.

After *B* has been struck, it moves freely under gravity and strikes the ground at the point *A*, as shown in the diagram above. The ball is modelled as a particle.

(a) Calculate the magnitude of the impulse exerted by the bat on *B*.

(4)

(b) By using the principle of conservation of energy, or otherwise, find the speed of *B* when it reaches *A*.

(6)

(c) Calculate the angle which the velocity of *B* makes with the ground when *B* reaches *A*.

(4)

(d) State two additional physical factors which could be taken into account in a refinement of the model of the situation which would make it more realistic.

(2)
(Total 16 marks)

11. At time t seconds the acceleration, $\mathbf{a}$ m s^{-2}, of a particle P relative to a fixed origin O, is given by $\mathbf{a} = 2\mathbf{i} + 6t\mathbf{j}$. Initially the velocity of P is $(2\mathbf{i} - 4\mathbf{j})$ m s^{-1}.

(a) Find the velocity of P at time t seconds.

(3)

At time $t = 2$ seconds the particle P is given an impulse $(3\mathbf{i} - 1.5\mathbf{j})$ Ns. Given that the particle P has mass 0.5 kg,

(b) find the speed of P immediately after the impulse has been applied.

(6)
(Total 9 marks)

1.	(a)	N2L $(6t-5)\mathbf{i}+(t^2-2t)\mathbf{j}=0.5\mathbf{a}$		M1	
		$\mathbf{a}=(12t-10)\mathbf{i}+(2t^2-4t)\mathbf{j}$		A1	
		$\mathbf{v}=(6t^2-10t)\mathbf{i}+\left(\frac{2}{3}t^3-2t^2\right)\mathbf{j}\ (+\mathbf{C})$	ft their **a**	M1A1ft+A1ft	
		$\mathbf{v}=(6t^2-10t+1)\mathbf{i}+\left(\frac{2}{3}t^3-2t^2-4\right)\mathbf{j}$		A1	6
	(b)	When $t=3$, $\mathbf{v}_3=25\mathbf{i}-4\mathbf{j}$		M1	
		$-5\mathbf{i}+12\mathbf{j}=0.5(\mathbf{v}-(25\mathbf{i}-4\mathbf{j}))$	ft their $\mathbf{v}_3$	M1A1ft	
		$\mathbf{v}=15\mathbf{i}+20\mathbf{j}$		A1	
		$\lvert\mathbf{v}\rvert=\sqrt{(15^2+20^2)}=25\ (\text{m s}^{-1})$	cso	M1A1	6

[12]

2.	(a)	$\rightarrow\ 30=2ut$		B1	
		$\uparrow\ -47.5=5ut-4.9t^2$		M1 A1	
		$-47.5=75-4.9t^2$	eliminating u or t	DM1	
		$t^2=\frac{75+47.5}{4.9}\ (=25)$		DM1	
		$t=5$ *	cso	A1	6
	(b)	$30=2ut\Rightarrow 30=10u\Rightarrow u=3$		M1A1	2
	(c)	$\uparrow\ \dot{y}=5u-9.8t=-34$	M1 requires both	M1A1	
		$\rightarrow\ \dot{x}=2u=6$	$\dot{x}$ and $\dot{y}$	A1	
		$v^2=6^2+(-34)^2$		DM1	
		$v\approx 34.5\ (\text{m s}^{-1})$	accept 35	A1	5
		Alternative			
		$\frac{1}{2}mv_B^2-\frac{1}{2}mv_A^2=m\times g\times 47.5$ with $v_A^2=6^2+15^2=261$		M1A1(2,1,0)	
		$v_B^2=261+2\times 9.8\times 47.5\ (=1192)$		DM1	
		$v_B\approx 34.5\ (\text{m s}^{-1})$	accept 35	A1	5
		BEWARE : Watch out for incorrect use of $v^2=u^2+2as$			

[13]

3.	(a)	$\mathbf{a}=\text{d}\mathbf{v}/\text{d}t=6t\mathbf{i}-4\mathbf{j}$		M1A1	2
	(b)	Using $\mathbf{F}=½\mathbf{a}$, sub $t=2$, finding modulus		M1, M1, M1	
		e.g. at $t=2$, $\mathbf{a}=12\mathbf{i}-4\mathbf{j}$			
		$\mathbf{F}=6\mathbf{i}-2\mathbf{j}$			
		$\lvert\mathbf{F}\rvert=\sqrt{(6^2+2^2)}\approx$ <u>6.32 N</u>		A1(CSO)	4

M1 Clear attempt to differentiate. Condone **i** or **j** missing.

A1 both terms correct (column vectors are OK)

The 3 method marks can be tackled in any order, but for consistency on epen grid please enter as:

M1 **F** = m**a** (their **a**, (correct **a** or following from (a)), not **v**, **F** = $\frac{1}{2}$**a**).

Condone **a** not a vector for this mark.

M1 subst t = 2 into candidate's vector **F** or **a** (**a** correct or following from (a), not **v**)

M1 Modulus of candidate's **F** or **a** (not **v**)

A1 CSO All correct (beware fortuitous answers e.g. from 6t**i** + 4**j**))

Accept 6.3, awrt 6.32, any exact equivalent e.g. $2\sqrt{10}$, $\sqrt{40}$, $\frac{\sqrt{160}}{2}$

[6]

4	(a)	N2L $(1.5t^2 - 3)$**i** + $2t$**j** = 0.5**a**		Ml	
		a = $(3t^2 - 6)$**i** + $4t$**j**		Al	2
	(b)	**v** = $(t^3 - 6t)$**i** + $2t^2$**j** (+c)		Ml Al	
		t = 2 –4**i** + 5**j** = –4**i** + 8**j** + **c** (c = –3j)		Ml	
		v = $(t^3 - 6t)$**i** – $(2t^2 - 3)$**j** (m s^{-1})		Al	
		t = 3 **v** = 9**i** + 15**j** (m s^{-1}) *	cso	Al	5
	(c)	**Q** = 0.5(–3**i** + 20**j** – (9**i** + 15j)) (=0.5(–12**i** + 5**j**))		Ml	
		$\lvert$**Q**$\rvert$ = $0.5\sqrt{(5^2 + 12^2)}$ = 6.5		Ml Al	3
	(d)	acute angle is $\arctan\frac{5}{12} \approx 23°$		M1A1	
		or required angle is $\arctan\frac{-5}{12}$			
		or acute angle is $\arccos\frac{12}{13} \approx 23°$			
		or required angle is $\arccos\frac{-12}{13}$			
		required angle is 157°	awrt 157°, 203°	Al	3

[13]

5.	(a)	I = ±0.5(16**i** + 20**j** – (–30**i**))	M1
		= ±(23**i** + 10j)	Indep M1

		magn = $\sqrt{(23^2 + 10^2)} \approx$ <u>25.1 Ns</u>		Indep M1 A1	4
	(b)	$v = 16\mathbf{i} + (20 - 10t)\mathbf{j}$		M1	
		$t = 3 \Rightarrow \mathbf{v} = 16\mathbf{i} - 10\mathbf{j}$		indep M1	
		$v = \sqrt{(16^2 + 10^2)} \quad \approx 18.9 \text{ ms}^{-1}$		indep M1 A1	4
					[8]
6.	(a)	$\dot{\mathbf{r}} = (2t + 4)\mathbf{i} + (3 - 3t^2)\mathbf{j}$		M1 A1	
		$\dot{\mathbf{r}}_3 = 10\mathbf{i} - 24\mathbf{j}$	substituting $t = 3$	M1	
		$\lvert \dot{\mathbf{r}}_3 \rvert = \sqrt{(10^2 + 24^2)}) = 26 \text{ (m s}^{-1})$		M1 A1	5
	(b)	$0.4 (\mathbf{v} - (10\mathbf{i} - 0\ 24\mathbf{j}) = 8\mathbf{i} - 12\mathbf{j}$	ft their $\dot{\mathbf{r}}_3$	M1 A1ft	
		$\mathbf{v} = 30\ \mathbf{I} - 54\mathbf{j} \quad (\text{m s}^{-1})$		A1	3
					[8]

7.	(a)	$\ddot{\mathbf{r}} = 6\mathbf{i} + (2t + 3)\mathbf{j}$	B1	
		$\mathbf{F} = 0.4(6\mathbf{i} + 11\mathbf{j})$	M1	
		0.4× something obtained by differentiation, with t = 4		
		$\|\mathbf{F}\| = \sqrt{(2.4^2 + 4.4^2)}$	M1	
		modulus of a vector		
		≈ 5.0	A1	4
		accept more accurate answers		
	(b)	$\mathbf{r} = (3t^2 + 4t)\mathbf{i} + (\frac{1}{3}t^3 + \frac{3}{2}t^2)\mathbf{j}(+C)$	M1	
		Using boundary values, $\mathbf{r} = (3t^2 + 4t - 3)\mathbf{i} + (\frac{1}{3}t^3 + \frac{3}{2}t^2 + 4)\mathbf{j}$	A1	
		$t = 4$, $\mathbf{r} = 61\mathbf{i} + 49\frac{1}{3}\mathbf{j}$	A1	
		$OS = \sqrt{(61^2 + 49\frac{1}{3}^2)} \approx 78$ (m)	M1 A1	5
		accept more accurate answers		

[9]

8.	(a)	$\mathbf{p} = (2t^2 - 7t)\mathbf{I} - 5t\mathbf{j}, + 3\mathbf{i} + 5\mathbf{j}$	M1, M1	
		$= (2t^2 - 7t + 3)\mathbf{I} + (5 - 5t)\mathbf{j}$	A1+A1	4
	(b)	$\mathbf{q} = (2\mathbf{i} - 3\mathbf{j})t - 7\mathbf{i}$	M1 A1	
		$\mathbf{j}$: $5 - 5t = -3t \Rightarrow t = 2.5$ equating and solving	M1 A1	
		At $t = 2.5$ $\mathbf{i}$: $p_x = 2 \times 2.5^2 - 7 \times 2.5 + 3 = -2$		
		$q_x = 2 \times 2.5 - 7 = -2$ both	M1	
		$p_x = q_x \Rightarrow$ collision	cso A1	6

[10]

Alternative in (b)

$\mathbf{i}$: $2t^2 - 7t + 3 = 2t - 7 \Rightarrow 2t^2 - 9t + 10 = 0$	
$t = 2, 2.5$ equating and solving	M1 A1
At $t = 2.5$ $\mathbf{j}$: $p_y = 5 - 5 \times 2.5 = -7.5$	
$q_y = -3 \times 2.5 = -7.5$	both M1
$p_y = q_y \Rightarrow$ collision	cso A1

In alternative, ignore any working associated with t = 2

9.	(a)	$\mathbf{a} = 2t\mathbf{i} - 6\mathbf{j}$	M1	
		$t = 4$: $\mathbf{a} = 8\mathbf{i} - 6\mathbf{j}$	**dep**. M1	
		$\lvert\mathbf{F}\rvert = 0.75\sqrt{(8^2 + 6^2)} = 7.5\text{N}$	M1 M1 A1	5
	(b)	$\mathbf{I} = 9\mathbf{i} - 9\mathbf{j}$	B1	
		$9\mathbf{i} - 9\mathbf{j} = \frac{3}{4}(\mathbf{v} - (27\mathbf{i} - 30\mathbf{j}))$	M1 A1 f.t.	
		$\mathbf{v} = 39\mathbf{i} - 42\mathbf{j}$ m s^{-1}	A1	4

[9]

10.	(a)	$\mathbf{I} = 0.4(15\mathbf{i} + 16\mathbf{j} + 20\mathbf{i} - 4\mathbf{j})$ $(= 0.4(35\mathbf{i} + 12\mathbf{j}) = 14\mathbf{i} + 4.8\mathbf{j})$	M1	
		$\lvert\mathbf{I}\rvert = \sqrt{(14^2 + 4.8^2)}$ *or* $0.4\sqrt{(35^2 + 12^2)}$	M1 A1	
		M1 for any magnitude		
		$= 14.8$ (Ns)	A1	4
	(b)	Initial K.E. = $\frac{1}{2}m(15^2 + 16^2)$ $(= 240.5m = 96.2$ J$)$	M1	
		$\frac{1}{2}mv^2 = \frac{1}{2}m(15^2 + 16^2) = m \times 9.8 \times 1.2$	M1 A2, 1,0	
		–1 each incorrect term		
		$v^2 = 504.52$	M1	
		$v = 22$ (m s^{-1})		
		accept 22.5	A1	6
	(c)	$\arccos \frac{15}{22.5} = 48°$	M1 A1 A1 A1	4
		accept 48.1°		
	(d)	Air resistance	B1, B1	2
		Wind (problem not 2 dimensional)		
		Rotation of ball (ball is not a particle)		
		any 2		

[16]

Alt (b)

Resolve ↑ with 16 and 9.8	M1	
(↑) $v_y^2 = 16^2 + 2 \times (-9.8) \times (-1.2)$	M1 A1	
($v_y^2 = 279.52$, $v_y \approx 16.7$…..)		
$v^2 = 15^2 + 279.52$	M1 A1	
$v = 22$ (m s^{-1})	A1	6
accept 22.5		

Alt (c)

$\arctan \frac{16.7}{15} = 48°$	M1 A1 A1 A1	4

[10]

11.	(a)	$\mathbf{v} = \int 2\mathbf{i} + 6t\mathbf{j}\, dt = 2t\mathbf{i} + 3t^2\,\mathbf{j}$ (+ $\mathbf{c}$)	M1 A1	
		c = 2i **– 4**j	A1	3
		$\mathbf{v} = (2t + 2)\mathbf{i} + (3t^2 - 4)\mathbf{j}$		
	(b)	$t = 2$: $\mathbf{v} = 6\mathbf{i} + 8\mathbf{j}$	B1	
		$3\mathbf{i} - 1.5\mathbf{j} = 0.5(\mathbf{v} - (6\mathbf{i} + 8\mathbf{j}))$	M1 A1	
		$\Rightarrow \mathbf{v} = 12\mathbf{i} + 5\mathbf{j}$	A1	
		$\Rightarrow |\mathbf{v}| = \sqrt{(12^2 + 5^2)} = 13$ m s^{-1}	M1 A1	6

[9]

1. This was generally well answered. The mechanical principles were well understood by nearly all candidates.

(a) Many fully correct answers were seen. The most frequent errors were due either to problems in dividing by 0.5, or because candidates integrated $\boldsymbol{F}$ rather than $\boldsymbol{a}$. The use of $v = u + at$ or differentiation instead of integration were occasionally seen. Another, less common, error was to substitute $t = 0$ first. Also the constant of integration was very occasionally written with '–1' instead of '+1' in the **i** term. The great majority of candidates remembered the initial conditions although a few lost the final A mark for omission of **i** – 4**j**.

(b) In many cases correct use of the impulse equation resulting in a velocity of 15**i** + 20**j** was seen but then too many candidates did not go on to find the speed of the particle. Use of the initial velocity as **i** – 4**j** was a common error. Less common, but costly, was to start by finding the magnitude of the impulse and attempt to use this. Also, some candidates attempted an impulse equation but ignored the mass of the particle. Candidates with errors early in the question were often able to gain a mark at the end for finding the speed from their velocity.

2. This question proved to be very challenging for many candidates. The best candidates worked through swiftly and efficiently scoring full marks in a relatively short solution. A number eliminated t rather than u in part (a), thus finding u first but this did not cause any great difficulty.

Unfortunately, several candidates were completely unprepared to deal with the initial velocity in vector form. Many of these went on to recombine the components and find a speed and angle of projection, then faithfully worked on with sin/cos and $\sqrt{29}$ without realising that it came back to 2 and 5! The candidates who made the least progress were those who tried to use the equations of motion with the velocity in complete vector form and the displacement and acceleration as scalars.

Although it created considerable extra work, and invariably went wrong, a small proportion of candidates tried to break the task down by working from the point of projection to the highest point and then from the highest point to B. Several candidates who arrived at a correct equation in u and t then went on to apply the quadratic formula inappropriately to obtain an expression for t in terms of u. A number also got the wrong answer for t in part (a) but did not then pick up the given answer of $t = 5$; they persevered with their incorrect result and hence lost many more marks.

In part (c) we encountered all the usual errors, although it was good to find far fewer candidates making inappropriate use of $v^2 = u + 2as$. Most students understood the need to find both the horizontal and the vertical component of the velocity at B. Several candidates were not sufficiently clear about the direction of motion, and made errors due to confusion over signs. A minority of candidates used conservation of energy without being required to do so, and were usually successful. Too many candidates lost the final mark due to an inappropriate level of accuracy in their final answers.

3. There were many correct solutions to this question. Only a small minority of candidates failed to differentiate **v** to find **a** in part (a), and most candidates obtained the correct value for the magnitude of the force in part (b). Incorrect answers were usually due to arithmetic errors, or originated from the sign error **a** = 6*t***i** + 4**j** in part (a). Other common differentiation errors gave **a** = 6*t***i** – 4*t***j** or **a** = 6*t***i** +(1 – 4)**j**

4. Candidates were confident in their solutions to this question with many scoring all but the last mark. It was pleasing to see much competent use of calculus and vector mechanics. Only a few failed to include a constant in working towards the given solution for (b). It was disappointing to find candidates with an incorrect answer in (b) attempting to fudge the given answer rather than look for the error in their working. Attempts to find the impulse ***Q*** were usually correct, but several candidates with a correct ***Q*** did not go on to find the magnitude. Errors in ***Q*** were often due to arithmetic errors in the subtraction, but some candidates did omit the mass. In (d), many candidates failed to score the final mark. There appeared to be little appreciation of the actual angle required, even from some candidates who had drawn a correct diagram.

5. There were few errors on this question Only a few candidates failed to use vectors to calculate the impulse in part (a) but some forgot to calculate the magnitude of their vector. The second part was mostly completely correct. Candidates need to read the question carefully and ensure that they answer the question asked. Those who forgot to calculate magnitudes lost four marks in this question!

6. Most candidates realised that they needed to differentiate, although there was the odd integration. Having found a velocity vector some then failed to find the modulus to obtain the speed. In part (b), a few used **I** = *m*(**u** – **v**) and a very small number worked with scalars, but generally candidates reached the correct vector solution. Some candidates thought they then had to find the magnitude of their vector – they were not penalised for this.

7. This was an excellent source of marks for the great majority of candidates, although there were a few who differentiated where they should have integrated and vice versa. In part (a), a few candidates stopped when they had found **F**. In part (b), the use of the inappropriate formula $\mathbf{r} = \mathbf{r}_0 + \mathbf{V}t$ was less frequently seen than in some recent examinations. Some candidates, having found the constant of integration, added it again, or subtracted it. This usually arose from not recognising the convention that *O* referred to the origin.

8. Most recognised that integration was needed in part (a), although a few used an inappropriate formula such as $\mathbf{r} = \mathbf{r}_0 + \mathbf{V}t$. Almost all candidates knew how to incorporate the initial position but errors in manipulation were seen and an error in bracketing frequently led to the incorrect $\left(2t^2 - 7t + 3\right)\mathbf{i} - \left(5 + 5t\right)\mathbf{j}$. This lost the last mark in (a) and from this result it was impossible to complete part (b) correctly. However nearly all candidates were able to demonstrate the method needed in (b) and the question was a substantial source of marks for the great majority of candidates.

9. The majority of candidates were successful in part (a). A few candidates wrongly tried integrating or using constant acceleration formulae. Part (b) was far less successful with only a small minority of candidates producing a correct solution. A further few had the correct idea but either made numerical slips (particularly with the negative coefficient of the j component of the impulse) or by having the impulse as $k(\mathbf{i} - \mathbf{j})$ where $k = 9$. About half of the candidates failed to realise that impulse is a vector quantity and either equated the given magnitude of the impulse to a vector velocity or to the speed.

10. As is appropriate for the last question, this proved the most difficult on the paper. Those who were confident with vector notation often produced accurate and concise solutions. Many lost marks in part (a) by not seeing that the question asked for the *magnitude* of the impulse. Others found $m(|v| - |u|)$. Part (b) caused a lot of confusion among candidates. They were often uncertain whether they should be using vectors, scalars, component velocities or the resultant and often ended up using unacceptable combinations of these. It was common to see $v^2 = u^2 - 2gs$ being used with $u^2 = 15^2 + 16^2$ and, also, for the final vertical velocity component to be given as the required speed. Part (c) caused less confusion and most candidates were aware that they had to draw a triangle and use trigonometry to find the required angle. At the relatively low speeds on this question, it was thought that sensible answers to part (d) were air resistance and the possibility of cross winds. A number of candidates mentioned that the initial impact between the bat and ball would probably impart some spin or rotation to the ball and that a full analysis of the motion would take this into account and not consider the ball as a particle. This was accepted.

11. No Report available for this question.