4	The only correct answer is **C** C is correct because acceleration is 30/7.5 A is not correct because 0.53 is $30/7.5^2$ B is not correct because 2.0 is 30/(2×7.5) D is not correct because 8.0 is 2×30/7.5	1

5	**C 0.850 m**	1
	Incorrect Answers: a metre rule measures to 3 sf so the final answer must be to 3 sf regardless of the units used A – answer to 2 sf in cm B – answer to 2 sf in m D – answer to 2 sf in m (using standard form)	

2	**B is the correct answer** A is not the correct answer as force per unit length has no meaning. C is not the correct answer as this is the gravitational force. D is not the correct answer as this is gravitational potential.	**(1)**

2	**The only correct answer is C (initial acceleration is same for coin and feather, and time taken to reach the ground is less for coin)** A is not correct because both objects have the same initial acceleration B is not correct because both objects have the same initial acceleration and object A has a greater terminal velocity D is not correct because object A has a greater terminal velocity	1

Question Number	Answer		Mark
13(a)	**<u>Method 1</u> – Calculate the vertical displacement at 102 m.** See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1})	(1)	
	Use of v = s/t with s = 102 m for the time of flight needed **Or** Use of v = s/t with s = 10 m for the extra time of flight needed	(1)	
	Use of equation(s) to determine the vertical displacement at the time calculated	(1)	
	Vertical displacement = (–) 5.8 to 6.0 m	(1)	
	Comparison with required height **AND** height is insufficient (Allow correct conclusion based on the calculated height)	(1)	
	<u>Method 2</u> – Calculate the horizontal displacement for a height of 4.5 m. See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1})	(1)	
	Use of vertical equation(s) with s = (−)4.5 m to determine the actual time of flight **Or** to determine the time beyond 92 m	(1)	
	Use of v = s/t to determine the range **Or** Use of v = s/t for the extra displacement beyond 92 m	(1)	
	Horizontal displacement = 98 to 101 m **Or** extra displacement = 7.7 to 7.9 m	(1)	
	Comparison with required displacement **AND** height is insufficient **Or** Comparison of extra displacement **AND** height is insufficient (Allow correct conclusion based on the calculated distance)	(1)	
	<u>Method 3</u> – Calculate the actual time of flight and that needed for 102 m See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1})	(1)	
	Use of v = s/t with s = 102 m for the time of flight needed	(1)	
	Use of vertical equation(s) to determine the actual time of flight	(1)	
	Time of flight needed = 3.5 s **AND** actual time of flight = 3.4 s	(1)	**(5)**
	Time needed > actual time **AND** height is insufficient (Allow correct conclusion based on the calculated times)	(1)	
	<u>Example of calculation</u> u_v = (33m s^{-1}) sin28 ° = 15.5 m s^{-1} u_h = (33 m s^{-1}) cos28 °= 29.1m s^{-1} $t = \frac{102 \text{ m}}{29.1 \text{ m s}^{-1}}$ t = 3.50 s s = (15.5 m s^{-1} × 3.50 s) + (½ × (–9.81 N kg^{-1}) ×(3.50 s)^2) s = – 5.87 m		

***13(b)**

This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.
The following table shows how the marks should be awarded for indicative content and lines of reasoning.

IC points	IC mark	Max linkage mark available	Max final mark
6	4	2	**6**
5	3	2	**5**
4	3	1	**4**
3	2	1	**3**
2	2	0	**2**
1	1	0	**1**
0	0	0	**0**

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content
With air resistance:
Vertical motion

- When moving up weight and (vertical component of) air resistance are acting.
  Or When moving up air resistance increases the resultant force.
- (When moving up,) downwards/vertical acceleration/deceleration increases
  Or upward velocity decreases more quickly.
- (So maximum) height is lower.

Horizontal motion

- There is a horizontal deceleration/force (due to air resistance).
- (So the average) horizontal velocity is lower.
- The (ball travels a) shorter (total) distance.

(6)

Total for question 13 **11**

Question Number	Answer	Mark
15(a)	• Use of $v^2 = u^2 + 2as$ AND $u = 0$ (1) **Or** $mgh = \frac{1}{2}mv^2$ • $v = 3.4$ (m s^{-1}) (1) Example of calculation $v^2 = 2 \times 9.81$ m s^{-2} $\times$ 0.60 m $v = \sqrt{11.77}$ m s^{-1} $v = 3.43$ m s^{-1}	**(2)**
15(b)	• Horizontal 3.4 × sin 70° **Or** 3.4 × cos 20° **Or** calculated value. (1) • Vertical 3.4 × cos 70° **Or** 3.4 × sin 20° 1.16 **Or** calculated value. (1) Allow e.c.f. from part (a)	**(2)**

15(c)	Use of $v = s/t$ to determine time to end of ramp (0.38 s).		
	• Use of $s = ut - \frac{1}{2} g t^2$ to determine drop in altitude after time t (0.27 m).	(1)	
	• Ball does not bounce on the ramp.	(1)	
	• Justifies conclusion from numbers calculated. e.g. $0.86 - 0.27 > 0.00$ means has not reached ground by end of ramp.	(1)	
	Example of calculation	(1)	
	$t = \frac{1.23 \text{ m}}{3.4 \text{ m s}^{-1} \times \sin 70°}$		
	$t = 0.39$ s		
	$s = (3.4 \text{ (m s}^{-1}) \times \cos 70° \times 0.39 \text{ s}) + (\frac{1}{2} \times (-9.81 \text{ m s}^{-2}) \times (0.39 \text{ s})^2)$		
	$s = -0.28$ m		
	Or		
	• Use of $s = ut - \frac{1}{2} g t^2$ to determine time to $s = -0.86$		
	• Use of $s = vt$ to calculate s	(1)	
	• Ball does not bounce on the ramp.	(1)	
	• Justifies conclusion from numbers calculated. e.g. $1.23 < 1.79$	(1)	
	Or		
	• Use of $v = u - gt_1$ with $v = 0$ to get time to max height (0.12s) **and** use of $s = \frac{1}{2} g t_1^2$ to get gain in height (0.07m) **and** use of $s = ut + \frac{1}{2} g t_2^2$ with $u = 0$ and $s = 0.93$ to get time from there to the ground (0.44s) Total time $t = t_1 + t_2$.	(1) (1)	
	• Use of $s = vt$ to calculate s	(1)	
	• Ball does not bounce on the ramp.	(1)	
	• Justifies conclusion from numbers calculated. e.g. $1.23 < 1.79$	(1)	**(4)**
	Total for question 15		**8**

Question Number	Acceptable Answer		Additional Guidance	Mark
17(a)(i)	Initial angle at 30° (with a parabolic shape) (judge by eye)	**(1)**	Example diagram 	**1**
17(a)(ii)	Use of $v^2 = u^2 + 2as$ (with $v = 0$) Use of appropriate trigonometry to determine initial velocity $u = 57$ (m s^{-1}) (to at least 2 significant figures)	**(1)** **(1)** **(1)**	Allow use of appropriate suvat equations to determine u Example calculation $0^2 = (u_{\text{vertical}})^2 + 2 \times (-9.81\ \text{m s}^{-2}) \times 42\ \text{m}$ $u_{\text{vertical}} = \sqrt{824} = 28.7\ \text{m s}^{-1}$ $u = \frac{28.7\ \text{m s}^{-1}}{\sin(30°)} = 57.4\ \text{m s}^{-1}$	**3**
17(a)(iii)	Use of suitable equation(s) of motion for vertical motion to determine the time of flight (with a—9.81) Use of appropriate trigonometry to determine horizontal component of velocity Use of $s = ut + \frac{1}{2}at^2$ for horizontal motion (with $a = 0$) Total horizontal distance travelled = 290 m, which is greater than 200 m so flare can be seen (show that value gives 320 m) (ecf from (a)(ii))	**(1)** **(1)** **(1)**	Example calculation $t = \frac{2 \times 57.4\ \text{m s}^{-1} \times \sin(30°)}{9.81\ \text{m s}^{-2}} = \frac{57.4\ \text{m s}^{-1}}{9.81\ \text{m s}^{-2}} = 5.85\ s$ $u_{\text{horizontal}} = 57.4\ \text{m s}^{-1} \times \cos(30°) = 49.7\ \text{m s}^{-1}$ $s = 49.7\ \text{m s}^{-1} \times 5.85\ \text{s} = 291\ \text{m}$ 291 m < 200 m so yes	
	Or Horizontal distance to maximum height = 150 m, which is less than 200 m so flare cannot be seen (show that value gives 160 m) (ecf from (a)(ii))	**(1)**	**OR** $t = \frac{57.4\ \text{m s}^{-1} \times \sin(30°)}{9.81\ \text{m s}^{-2}} = \frac{28.7\ \text{m s}^{-1}}{9.81\ \text{m s}^{-2}} = 2.93\ s$ $u_{\text{horizontal}} = 57.4\ \text{m s}^{-1} \times \cos(30°) = 49.7\ \text{m s}^{-1}$ $s = 49.7\ \text{m s}^{-1} \times 2.93\ \text{s} = 146\ \text{m}$ 146 m < 200 m so no	**4**

(Total for Question 17 = 8 marks)