Teacher Support Materials

Maths GCE

Paper Reference MM1A

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Question 1

1 A hot air balloon is at rest on the ground. When the balloon is released, it rises to a height of 320 metres in 80 seconds. The balloon moves under the action of its weight and a vertical lift force. Assume that the balloon has a constant acceleration during this motion.

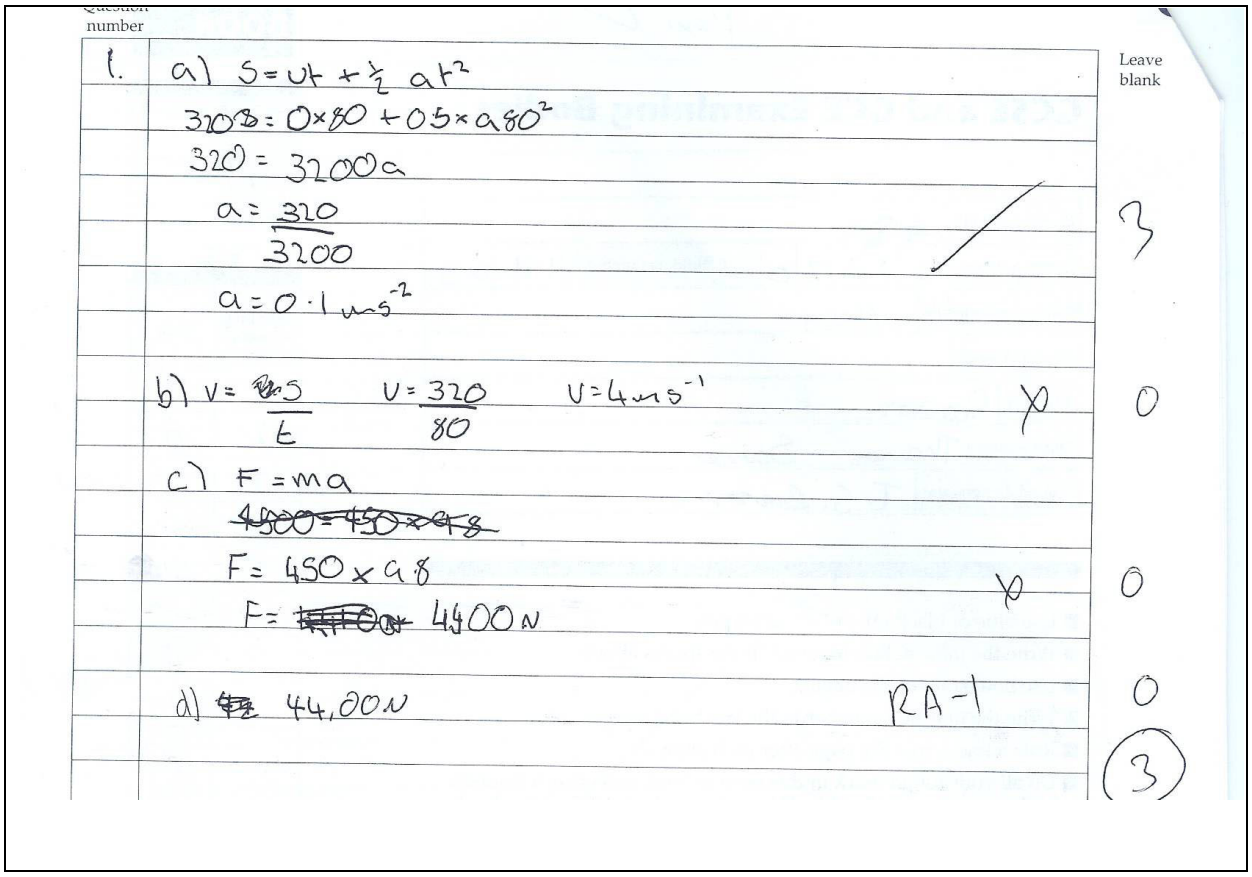
(a) Show that the acceleration of the balloon is $0.1\,\text{m s}^{-2}$. *(3 marks)*

(b) Find the speed of the balloon when it reaches a height of 320 metres. *(2 marks)*

(c) The mass of the balloon is 450 kg. Show that the magnitude of the vertical lift force is 4500 N, correct to two significant figures. *(3 marks)*

(d) After a while, the vertical lift force is reduced so that the balloon rises at a constant speed. State the magnitude of the vertical lift force when this is the case. *(1 mark)*

Student Response



Commentary

This candidate produces a good solution to part (a) of the question. The following parts all contain errors that result in the loss of all the available marks.

In part (b), the candidate uses $v = \frac{s}{t}$ to calculate the average velocity of the balloon. Using results like this is quite common and almost always results in the loss of marks. Candidates should be encouraged to use the constant acceleration equations in questions like this. Only when asked for average velocities should a candidate use the approach illustrated.

In part (c), the candidate simply calculates the weight of the balloon and no account is taken of the fact that it is accelerating.

In part (d), the candidate states the weight that had been calculated in part (b). However as the answer is only given to 2 significant figures instead of the 3 requested in the rubric, the candidates loses a mark for not working to the required accuracy and hence ends up with a mark of zero. It is worth noting that candidates are only penalised once for not working to the required accuracy, so this candidate would not be penalised in this way again on this paper.

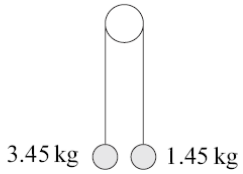
Mark Scheme

MM1A

Q	Solution	Marks	Total	Comments
1(a)	$320 = \frac{1}{2} \times a \times 80^2$	M1		Use of constant acceleration equation with $u = 0$
		A1		Correct equation
	$a = \frac{2 \times 320}{80^2} = 0.1 \text{ ms}^{-2}$	A1	3	AG Correct acceleration from correct working
(b)	$v = 0 + 0.1 \times 80$	M1		Use of constant acceleration equation with $u = 0$
	$= 8 \text{ ms}^{-1}$	A1	2	Correct velocity
(c)	$L - 450 \times 9.8 = 450 \times 0.1$	M1		Three term equation of motion
		A1		Correct equation
	$L = 45 + 4410$ $= 4455$ $= 4500\text{N}$ (to 3sf)	A1	3	AG Correct force
(d)	4410 N	B1	1	Correct force
	Total		**9**	

Question 4

4 Two particles, of masses 3.45 kg and 1.45 kg, are connected by a light string that passes over a smooth peg. The particles are released from rest with the strings vertical, as shown in the diagram.



(a) By forming an equation of motion for each particle, show that the magnitude of the acceleration of each particle is $4\,\text{m s}^{-2}$. *(5 marks)*

(b) Find the tension in the string. *(2 marks)*

(c) Initially the particles are at the same level.

Find the speed of the heavier particle when it is 1 metre lower than the lighter particle. Assume that neither particle hits the floor or the peg. *(3 marks)*

Student response

Question number

Leave blank

$3.45g - t = a \times 3.45$

$t - 1.45g = 1.45a$

Solve simultaneously:-

$2g = 4.9a$

$19.6 = 4.9a$

$4 = a$

Ans = $4\,ms^{-2}$ 5

b)

$t - (1.45 \times g) = 1.45a$

$t - (1.45 \times g) = 1.45 \times 4$

$t = 20.01$

tension = 20.01 N 2

c) 1m down

$u = 0$

$v = ?$

$a = 4ms^{-2}$

$s = 1m$

$t = t$

$v^2 = u^2 + 2as$

$v^2 = 2 \times 4 \times 1$

$v^2 = 8$

$v = 2.83$ M1

Ans = $2.83\,ms^{-1}$ 1

8

Commentary

This candidate gives good solutions to parts (a) and (b) of the question, but makes a common error in part (c).

In part (a), two equations of motion are clearly stated and then solved. This is exactly the approach that is required to gain full marks on this type of question. One of these equations is then used in part (b) to find the tension correctly.

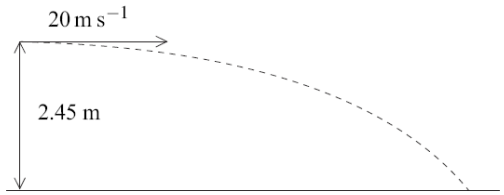
In part (c), the candidate does not realise that when the particles are 1 metre apart, each particle will have moved 0.5 metres. The candidate's solution is based on the assumption that each particle has moved 1 metre. This was a fairly common error. Solutions of this type were awarded 1 method mark.

Mark Scheme

4(a)	$3.45g - T = 3.45a$	M1		Three term equation of motion for one particle
		A1		Correct equation
	$T - 1.45g = 1.45a$	M1		Three term equation of motion for other particle
		A1		Correct equation
	$2g = 4.9a$			
	$a = \frac{2\times 9.8}{4.9} = 4 \text{ ms}^{-2}$	A1	5	AG Correct acceleration from correct working
(b)	$T = 1.45\times 4 + 1.45\times 9.8$	M1		Use of one equation from (a) to find T
	$= 20.01$			
	$= 20.0$ N (to 3 sf)	A1	2	Correct T
(c)	$s = \frac{1}{2} = 0.5$ m	M1		Use of $s = \frac{1}{2}$
	$v^2 = 2\times 4\times 0.5$	M1		Use of constant acceleration equation with $u = 0$
	$v = 2 \text{ ms}^{-1}$	A1	3	Correct speed (no negative sign)
			10	

Question 6

6 A tennis ball is hit from a height of 2.45 metres above horizontal ground. Initially it travels horizontally at a speed of $20\,\text{m s}^{-1}$, as shown in the diagram.

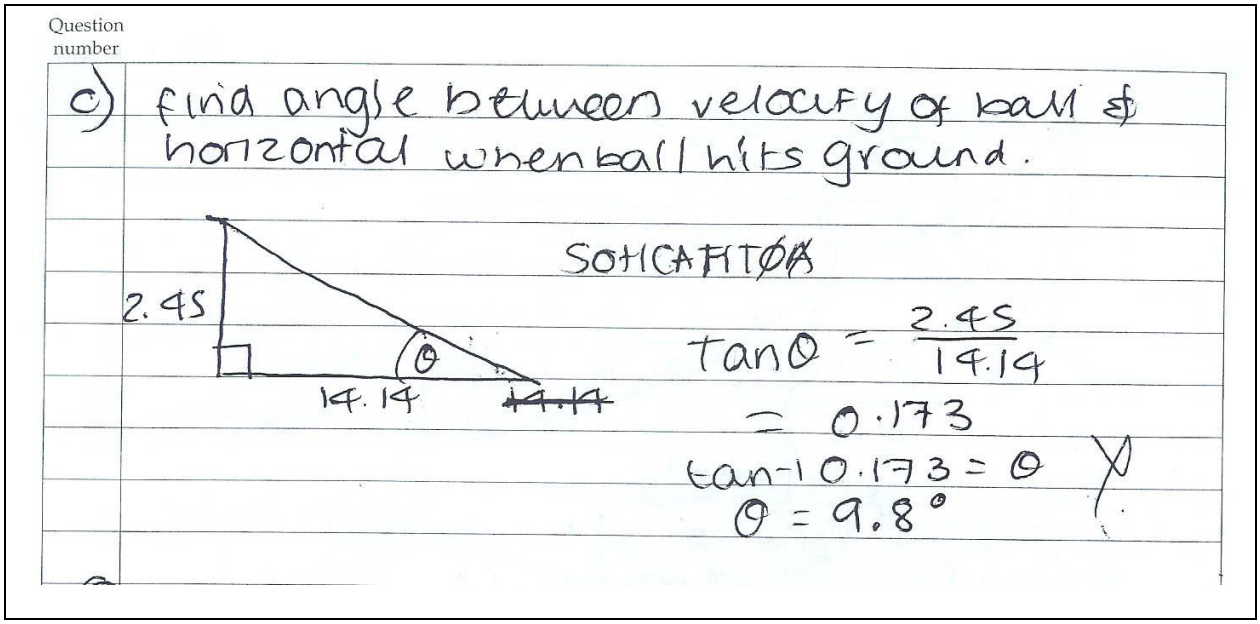


(a) Show that the time taken for the tennis ball to reach the ground is 0.707 seconds, correct to three significant figures. *(3 marks)*

(b) Find the horizontal distance travelled by the ball when it hits the ground. *(2 marks)*

(c) Find the angle between the velocity of the ball and the horizontal when the ball hits the ground. *(4 marks)*

Student Response



Commentary

In part (c) of this question, a common error was to calculate an angle based on displacements rather than on velocities. This candidate uses the value of 2.45, which was the initial height of the ball and 14.14, which was the horizontal distance travelled by the ball. The candidate did not make any attempt to find the vertical component of the velocity or use the horizontal component which was given in the question. Because the candidates used displacements rather than velocities, solutions like this did not gain any credit.

Mark Scheme

6(a)	$2.45 = \frac{1}{2} \times 9.8t^2$	M1 A1		Equation for time to ground Correct equation
	$t = \sqrt{\frac{2.45}{4.9}} = 0.707$ seconds (to 3 sf)	A1	3	AG Correct time from correct working
(b)	$s = 20 \times 0.707 = 14.1$ m (to 3sf)	M1 A1	2	Using 20 × time from part (a) Correct distance
(c)	$v_y = 0.707 \times 9.8 = 6.929$	M1 A1		Finding vertical component of velocity Correct vertical component
	$\theta = \tan^{-1}\left(\frac{6.929}{20}\right) = 19.1°$	dM1 A1	4	Using tan to find the angle Correct angle
	Total		**9**	