Section B: Mechanics

Question	Scheme	Marks	AOs
6.	Equation in t only	M1	2.1
	$-2 = 9t - \frac{1}{2} \times 10t^2$	A1	1.1b
	$5t^2 - 9t - 2 = 0 = (5t + 1)(t - 2)$	DM1	1.1b
	$T = 2$ (only)	A1	1.1b
		(4)	
			(4 marks)

Notes:

M1: Complete method to give equation in t only. This mark is for a complete method for the TOTAL time i.e. for finding sufficient equations, with usual rules, correct no. of terms in each equation but condone sign errors and g does not need to be substituted

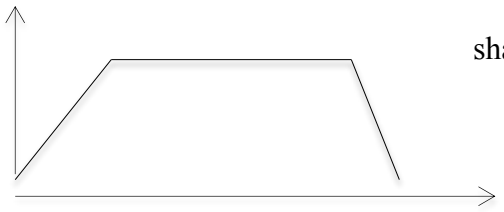
A1: A correct equation **or** correct equations (e.g. if they find the speed, 11 ms^{-1}, when the ball strikes the ground and then use that to find the total time **or** if they split the time (e.g. 0.9s up and 1.1s down or 0.9s + 0.9s + 0.2s))

N.B. $g = 10$ must be substituted in all equations used.

DM1: Dependent on first M1, for solving a 3 term quadratic to find T **or** for solving their equations to find T **or** for solving their equations and adding their split times to find T

A1: $T = 2$ only (i.e. A0 if they give two times)

N.B. If solving a correct quadratic, the DM1 can be implied by a correct answer i.e. the method does not need to be shown, but if there is no method shown and the answer is wrong then award DM0 A0.

Question	Scheme	Marks	AOs
7(a) (i)	24 (m s^{-1})	B1	1.1b
(ii)	48 (s)	B1	1.1b
(iii)	 shape	B1	1.1b
		(3)	
(b)	Equating area under graph to 4800 to give equation in one unknown	M1	3.1b
	$\frac{1}{2}(T+T+80+48)\times 24 = 4800$ **OR** $(\frac{1}{2}\times 80\times 24)+24T+(\frac{1}{2}\times 48\times 24)=4800$ **oe**	A1**ft**	1.1b
	T = 136 so total time is 264 (s)	A1	1.1b
		(3)	
(c)	Accept **Either**: a smooth change from acceleration to constant velocity or from constant velocity to deceleration. **Or** have train accelerating and/or decelerating at a variable rate Do not accept e.g. Comments on air resistance or resistive forces, straightness of track, horizontal track, friction, length of train, mass of train, not having train moving with constant velocity. B0 if either an incorrect extra is included or an incorrect reason for a valid improvement is included. N.B. Variable acceleration due to air resistance is B0 **BUT** Variable acceleration due to **variable** air resistance is B1	B1	3.5c
		(1)	
			(7 marks)

Notes:

(a)

(i) B1: 24 (m s^{-1})Must be stated i.e. not just inserted on the graph

(ii) B1: 48 (s) (Allow – 48 changed to 48) Must be stated i.e. not just inserted on the graph

(iii) B1: A trapezium starting at the origin and ending on the *t*-axis.

(b)

M1: Complete method to find area of trapezium using trapezium rule with correct structure or using two triangles and a rectangle and equate to 4800 to give equation in *one* unknown

N.B. $\frac{1}{2}(T+80+48)\times 24 = 4800$ is M0 (equivalent to using three triangles)

OR they may use *suvat* on one or more sections (must have $a = 0$ for middle section) and equate total distance travelled to 4800 to give equation in *one* unknown

A1ft: For a correct equation in their unknown **ft** on their 24 and 48 (but must be positive times)

A1: For 264 (s)

(c)

B1:

Either: Include time to change from constant accln to constant velocity and/or time to change from constant velocity to constant deceleration oe

Or: Have train accelerating and/or decelerating at a variable rate

Question	Scheme	Marks	AOs
8(a)	Multiply out and differentiate *wrt* to time (or use of product rule i.e. must have two terms with correct structure)	M1	1.1a
	$v = 2t^3 - 3t^2 + t$	A1	1.1b
	$2t^3 - 3t^2 + t = 0$ and solve: $t(2t - 1)(t - 1) = 0$	**DM**1	1.1b
	$t = 0$ or $t = \frac{1}{2}$ or $t = 1$; any two	A1	1.1b
	All three	A1	1.1b
		(5)	
(b)	Find x when $t = 0$, $\frac{1}{2}$, 1 and 2 : $(0, \frac{1}{32}, 0, 2)$	M1	2.1
	Distance = $\frac{1}{32} + \frac{1}{32} + 2$	M1	2.1
	$2\frac{1}{16}$ (m) oe or 2.06 or better	A1	1.1b
		(3)	
(c)	$x = \frac{1}{2}t^2(t - 1)^2$	M1	3.1a
	$\frac{1}{2}$ perfect square so $x \geq 0$ i.e. never negative	A1 cso	2.4
		(2)	
			(10 marks)

Notes:

(a)

M1: Must have 3 terms and at least two powers going down by 1

A1: A correct expression

DM1: Dependent on first M, for equating to zero and attempting to solve a cubic

A1: Any two of the three values (Two correct answers can imply a correct method)

A1: The third value

(b)

M1: For attempting to find the values of x (at least two) at their t values found in (a) or at $t = 2$ or equivalent e.g. they may integrate their v and sub in at least two of their t values

M1: Using a correct strategy to combine their distances (must have at least 3 distances)

A1: $2\frac{1}{16}$ (m) oe or 2.06 or better
(c) **M1:** Identify strategy to solve the problem such as: (i) writing x as $\frac{1}{2} \times$ perfect square (ii) or using x values identified in (b). (iii) or using calculus i.e. identifying min points on x–t graph. (iv) or using x-t graph. **A1 cso :** Fully correct explanation to show that $x \geq 0$ i.e. never negative

Question	Scheme	Marks	AOs
9(a)	Equation of motion for P	M1	3.3
	$2mg - T = 2m \times \frac{5g}{7}$	A1	1.1b
	$T = \frac{4mg}{7}$	A1	1.1b
		(3)	
(b)	Since the string is modelled as being inextensible	B1	3.4
		(1)	
(c)	Equation of motion for Q **OR** for whole system	M1	3.3
	$T - kmg = km \times \frac{5g}{7}$ **OR** $2mg - kmg = (km + 2m)\frac{5g}{7}$	A1	1.1b
	$\frac{4mg}{7} - kmg = km \times \frac{5g}{7}$ oe and <u>solve for k</u>	DM1	1.1b
	$k = \frac{1}{3}$ or 0.333 or better	A1	1.1b
		(4)	
(d)	e.g The model does not take account of the mass of the string (see notes below for alternatives)	B1	3.5b
		(1)	
			(9 marks)

Notes: Condone both equations of motion appearing in (a) if used in (c)

(a)

M1: Resolving vertically for P with usual rules, correct no. of terms but condone sign errors and a does not need to be substituted (N.B. inconsistent omission of m is M0). Allow ma on RHS for M1

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

A1: A correct answer of form cmg, where $c = \frac{4}{7}$ oe or 0.57 or better

(b)

B1: String is inextensible. <u>N.B. B0 if any extras (wrong or irrelevant) given</u>

(c)

M1: Resolving vertically for Q or for a whole system equation, with usual rules, correct no. of terms but condone sign errors and neither T nor a does need to be substituted

(N.B. inconsistent omission of m is M0 and M0 if k is omitted from LHS or RHS or both.)

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

DM1: Sub for T using their answer from (a), if necessary, and solve to give a numerical value of k (i.e. m's must cancel)

A1: $k = \frac{1}{3}$ or 0.333 or better.

(d)

B1: e.g. Pulley may not be smooth
Pulley may not be light
Particles may not be moving freely e.g. air resistance
Balls may not be particles
String may not be light
String may not be inextensible
(but allow converses in all cases e.g. 'pulley smooth')

N.B. B0 if any extra incorrect answer is given BUT ignore incorrect consequence of a correct answer.

Also note: B0 : Use of a more accurate value of g