Kinematics with Constant Acceleration (SUVAT) (Sheet 2) Mark Scheme

Q1.

Question Number	Scheme	Marks
(a)	$27 = 0 + \frac{1}{2}.a.3^2 \Rightarrow a = \underline{6}$	M1 A1 (2)
(b)	$v = 6 \times 3 = \underline{18 \text{ m s}^{-1}}$	M1 A1 f.t. (2)
(c)	From $t = 3$ to $t = 5$, $s = 18 \times 2 - \frac{1}{2} \times 9.8 \times 2^2$	M1 A1 f.t.
	Total ht. $= s + 27 = \underline{43.4 \text{ m}, 43 \text{ m}}$	M1 A1 (4)
		8

Q2.

Question	Scheme	Marks	AOs
(a)	$14.7 = -14.7 + 9.8T$ or $0 = 14.7T - \frac{1}{2} \times 9.8T^2$ or $0 = 14.7 - 9.8 \times \left(\frac{1}{2}T\right)$ oe	M1	3.4
	$T = 3$	A1	1.1b
		(2)	
(b)	$s_1 = \frac{(14.7 + 0)}{2} \times 1.5$ $(11.025 \text{ or } \frac{441}{40})$	M1	1.1b
	$s_2 = \frac{1}{2} \times 9.8 \times 2.5^2$ $(30.625 \text{ or } \frac{245}{8})$ **OR** $s_3 = 14.7 \times 1 + \frac{1}{2} \times 9.8 \times 1^2$ $(19.6 \text{ or } \frac{98}{5})$ **OR** $-s_3 = 14.7 \times 4 - \frac{1}{2} \times 9.8 \times 4^2$ (- 19.6) (allow omission of – on LHS)	M1	1.1b
	Total distance $= s_1 + s_2$ **OR** $2s_1 + s_3$	M1	2.1
	$= 41.7$ m or 42 m	A1	1.1b
		(4)	
(c)	e.g. Take account of the dimensions of the stone (e.g. allow for spin), do not model the stone as a particle, use a more accurate value for g	B1	3.5c
		(1)	
			(7 marks)

Q3.

Question Number	Scheme	Marks
(a)	$-6.45 = u - 9.8\times 0.75$ $0.9 = u$ **	M1 A1 A1 (3)
(b)	$0 = 0.81 - 2\times 9.8\times s$ $s = 0.041$ or 0.0413	M1 A1 (2)
(c)	$h = -0.9\times 0.75 + 4.9\times 0.75^2$ $h = 2.1$ or 2.08	M1 A1 A1 (3) **[8]**

Q4.

Question Number	Scheme	Marks
(a)	$0^2 = u^2 - 2\text{x}9.8\text{x}40$ $u = 28\ \text{m s}^{-1}$ ** GIVEN ANSWER	M1 A1 A1 (3)
(b)	$33.6 = 28t - \frac{1}{2}9.8t^2$ $4.9t^2 - 28t + 33.6 = 0$ $t = \frac{28 \pm \sqrt{28^2 - 4\text{x}4.9\text{x}33.6}}{9.8}$ $= 4$ s or (1.7 s or 1.71 s)	M1 A1 M1 A1 A1 (5) **8**

Q5.

Question Number	Scheme	Marks
(a)	$240=\frac{1}{2}(u+34)10$	M1 A1
	$u=14$	A1
		(3)
(b)	$34=14+10a \Rightarrow a=2$	M1 A1
	$120=14t+\frac{1}{2}\times 2\times t^2$	M1 A1
	$t^2+14t-120=0$	
	Solving, $t=-20$ or 6	**DM**1
	$t=6$	A1
	OR	
	$34=14+10a \Rightarrow a=2$	M1 A1
	$v^2=14^2+2\times 2\times 120 \Rightarrow v=26$	
	AND $26=14+2t$	M1 A1
	$t=6$	**DM**1 A1
		(6)
		[9]
	Notes for Question	
Q (a)	First M1 for a complete method to produce an equation in u only. First A1 for a correct equation. ($u^2-48u+476=0$ oe is possible). Second A1 for $u = 14$.	
Q (b)	**EITHER** First M1 for an equation in a only. (M0 if $v = 34$ when $s = 120$ is used) First A1 for $a = 2$. (This may have been found in part (a)) Second M1 for a 3-term quadratic equation in t only, allow sign errors (must have found a value of a. (M0 if $v = 34$ when $s = 120$ is used) Second A1 for a correct equaton. Third M1 dependent on previous M1 for solving for t. Third A1 for $t = 6$ **OR** First M1 for an equation in a only. First A1 for $a = 2$. (This may have been found in part (a)) Second M1 for a complete method to obtain an equation in t only, allow sign errors. (must have found a value of a) Second A1 for a correct equaton. Third M1 dependent on previous M1 for solving for t. Third A1 for $t = 6$	

Q6.

Question Number	Scheme	Marks
(a)	$v = u + at(\uparrow) \Rightarrow 0 = u - g(\frac{25}{14})$ $u = 17\frac{1}{2}$ *	M1 M(A)1 A1 (3)
(b)	$v^2 = u^2 + 2as(\uparrow) \Rightarrow 0^2 = 17.5^2 - 2gs$ $s = 15.6$ (m) or 16 (m)	M1 A1 (2)
(c)	$s = ut + \frac{1}{2}at^2(\uparrow) \Rightarrow 6.6 = 17.5t - \frac{1}{2}gt^2$ $4.9t^2 - 17.5t + 6.6 = 0$ $t = \frac{17.5 \pm \sqrt{(17.5^2 - 129.36)}}{9.8} = \frac{17.5 \pm 13.3}{9.8}$ $t = 3.142..$ (22/7) or $0.428...$(3/7) $T = t_2 - t_1 = 2.71$ (2.7)	M1 A1 DM1 A1 DM1 A1 (6)
	OR $v^2 = u^2 + 2as(\uparrow) \Rightarrow v^2 = 17.5^2 - 2g\text{x}6.6$ $v = \pm 13.3$ $v = u + at(\uparrow) \Rightarrow \pm 13.3 = 17.5 - gt$ $t = \frac{17.5 \pm 13.3}{9.8}$ $= 3.14..$ (22/7) or $0.428..$(3/7) $T = 3.14.. - 0.428.. = 2.71$ or 2.7	M1A1 DM1 A1 DM1 A1 (6)
	OR $v^2 = u^2 + 2as(\uparrow) \Rightarrow v^2 = 17.5^2 - 2g\text{x}6.6$ or $0^2 = u^2 - 2g\text{x}(15.625 - 6.6)$ $v = 13.3$ $\quad u = 13.3$ $v = u + at(\uparrow) \Rightarrow 0 = 13.3 - gt$ $t = \frac{13.3}{g}$ $T = 2\text{ x }\frac{13.3}{g} = 2.7$ or 2.71	M1 A1 DM1 A1 DM1 A1 (6) **11**

Q7.

Question Number	Scheme	Marks
(a)	$s = vt - \frac{1}{2}at^2$ $40 = 10 \times 5 - \frac{1}{2}a5^2$ $a = 0.8$	M1 A2 A1 (4)
(b)	Finding u $(=6)$ $s = ut + \frac{1}{2}at^2$ $(A \text{ to } M)$ $20 = 6t + \frac{1}{2}0.8t^2$ $t = \frac{-15 \pm \sqrt{225+200}}{2}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM1** A1 (5)
	Alternative : Finding v $(=\sqrt{68})$ $s = vt - \frac{1}{2}at^2$ $(A \text{ to } M)$ $20 = \sqrt{68}t - \frac{1}{2}0.8t^2$ $t = \frac{\sqrt{68} \pm \sqrt{68-32}}{0.8}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM1** A1 (5)
	Alternative : $s = vt_1 - \frac{1}{2}at_1^2$ $(M \text{ to } B)$ $20 = 10t_1 - \frac{1}{2}0.8t_1^2$ $t_1 = \frac{10 \pm \sqrt{100-32}}{0.8}$ $= 2.192$ $t = 5 - t_1 = 2.8$ or 2.81 or better	M2 A1 **DM1** A1 (5) **9**

Q8.

Question Number	Scheme	Marks
(a)	Max ht $v=0$. $v=u-gt \Rightarrow T=\frac{u}{g}$	M1A1 (2)
(b)	Max ht $H=ut+\frac{1}{2}at^2=\frac{u^2}{g}-\frac{u^2}{2g}=\frac{u^2}{2g}$ * Given answer* Or use of $v^2=u^2+2as$	M1A1 (2)
(c)	$-3\times\frac{u^2}{2g}=ut-\frac{1}{2}gt^2$ $-3u^2=2ugt-g^2t^2$ $g^2t^2-2ugt-3u^2=0, \quad gt=\frac{2u\pm\sqrt{4u^2+12u^2}}{2}$ $t=\frac{3u}{g}=3T$	M1 DM1 A1 A1 (4)
(c) alt	$-4H=-\frac{1}{2}gt^2$ Total time $=T+\sqrt{\frac{8H}{g}}=T+\sqrt{\frac{8u^2}{2g^2}}$ $=T+2T=3T$	M1 DM1A1 A1 (4)
		[8]

Notes for Question

Question

In this question, condone sign errors in a *suvat* equation for the M mark, but a missing term is M0 or an incorrect term is M0. An incorrect *suvat* formula is M0

Allow use of symmetry of motion.

e.g. in (a), using $v = u + at$, *either* $0 = u - gT$ *or* $u = 0 + gT$

Question (a)

M1 for use of *suvat* to obtain an equation in T, u and g only.

A1 for $T = u/g$ correctly obtained.

Question (b)

M1 for use of *suvat* to obtain an equation in H, u and g only.

A1 for $H = u^2/2g$ correctly obtained **(given answer)**

Question (c) *Watch out for t / T confusion* **(N.B. if only *T*'s used, M0DM0)**

First M1 for a complete method to find the *total* time in terms of u, g, H or T:-

either: $3H = -ut + \frac{1}{2} gt^2$

or: $4H = \frac{1}{2} gt^2$ and $t + T$

or: $v^2 = u^2 + 6gH$ and $v = -u + gt$,with v eliminated

Second M1, **dependent on first M1**, for producing an expression, in terms of u, g, H or T, for the total time, by solving a quadratic

First A1 for any correct expression for the total time in terms of u, g, H or T.

Second A1 for $3T$ cso

Q9.

Question Number	Scheme	Marks
(a)	Use of $s = ut + \frac{1}{2}at^2$	M1
	$-2t + \frac{1}{2}gt^2$ (+ or – 50)	A1
	$20t - \frac{1}{2}gt^2$ (+ or – 50)	A1
	$50 = -2T + \frac{1}{2}gT^2 + 20T - \frac{1}{2}gT^2 = 18T$	M1
	$T = \frac{50}{18} = 2.777.... = 2.8$ or better	A1
		(5)
(b)	$h = 20 \times T - 4.9 \times T^2 = 17.74.... \approx 17.7$ (18 to 2 s.f.) (use of 2.8 gives 17.584)	M1A1
		(2) [7]

Notes on Question

Q (a)	First M1 for use of $s = ut + 1/2at^2$ (or use of 2 *suvat* formulae AND eliminating v, to give an equation in s and t). N.B. M0 if they use $s = 50$ or $u = 0$ or $v = 0$) First A1 with $u = 2$ and $a = -g$ or -9.8 to obtain a distance, possibly with 50 added or subtracted. (2 and 4.9 must have *opposite* signs) Second A1 with $u = 20$ and $a = -g$ or -9.8 to obtain a distance, possibly with 50 added or subtracted. (2 and 4.9 must have *opposite* signs) Second M1 dependent on first M1 for a *correct* equation obtained correctly in T only. Third A1 for 25/9 oe, 2.8 or better
Q (b)	First M1 for substituting their T value (allow –ve changed to +ve but A mark is then unavailable) into an appropriate equation First A1 for 17.7 or 18 (m). (A0 if they then add 50)