Suvat and speed time Graph As level Edexcel Mechanics Maths Past Papers Answers

01.

Question	Scheme	Marks	AOs
	Using distance = total area under graph (e.g. area of rectangle + triangle or trapezium or rectangle – triangle)	M1	2.1
	e.g. $D = UT + \frac{1}{2} Th$, where h is height of triangle	A1	1.1b
	Using gradient = acceleration to substitute $h = aT$	M1	1.1b
	$D = UT + \frac{1}{2} aT^2$ *	A1 *	1.1b
		4	

(4 marks)

Notes

1st M1 for use of distance = total area to give an equation in D, U, T and one other variable
1st A1 for a correct equation
2nd M1 for using gradient = a to eliminate other variable to give an equation in D, U, T and a *only*
2nd A1* for a correct **given answer**

02.

Question	Scheme	Marks	AOs
(i)(ii)	Using a correct strategy for solving the problem by setting up two equations in a and u only and solving for either	M1	3.1b
	Equation in a and u only	M1	3.1b
	$22 = 2u + \frac{1}{2} a 2^2$	A1	1.1b
	Another equation in a and u only	M1	3.1b
	$126 = 6u + \frac{1}{2} a 6^2$	A1	1.1b
	5 m s^{-2}	A1	1.1b
	6 m s^{-1}	A1 ft	1.1b

(7 marks)

Notes

1st M1 for solving the problem by setting up two equations in a and u only and solving for either
2nd M1 use of (one or more) *suvat* formulae to produce equation in u and a only
1st A1 for a correct equation
3rd M1 use of (one or more) *suvat* formulae to produce another equation in u and a only
2nd A1 for a correct equation
3rd A1 for correct accln 5 m s^{-2}
4th A1 for correct speed 6 m s^{-1} (The second of these A marks is an **ft** mark, following an incorrect value for u or a, depending on which has been found first)
N.B. Do not award the **ft** mark for absurd answers e.g. $a > 15$, $u > 50$

See alternative on next page

Question	Scheme	Marks	AOs
(i)(ii)	Using a correct strategy for solving the problem by obtaining actual speeds at two times and using $a =$ change in speed / time taken.	M1	3.1b
	Actual speed at $t = 1$ = Average speed over interval	M1	3.1b
	$22/2 = 11$	A1	1.1b
	Actual speed at $t = 4$ = Average speed over interval	M1	3.1b
	$104/4 = 26$	A1	1.1b
	$5\ m\ s^{-2}$	A1	1.1b
	$6\ m\ s^{-1}$	A1 ft	1.1b
			(7 marks)

Notes

1st M1 for solving the problem by obtaining two actual speeds and use of $a = (v - u)/t$
2nd M1 use of speed at half-time = av speed over interval to produce a speed at $t = 1$
1st A1 for a correct speed
3rd M1 use of speed at half-time = av speed over interval to produce a speed at $t = 4$
2nd A1 for a correct speed
3rd A1 for correct accln $5\ m\ s^{-2}$
4th A1 **ft** for correct speed $6\ m\ s^{-1}$ (This is an ft mark, following an incorrect value of a)
N.B. Do not award the **ft** mark for absurd answers e.g. $a > 15$, $u > 50$

03.

Question	Scheme	Marks	AOs
	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.

04.

Question	Scheme	Marks	AOs
a (i)	24 ($m\,s^{-1}$)	B1	1.1b
(ii)	48 (s)	B1	1.1b
(iii)		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**	A1ft	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)

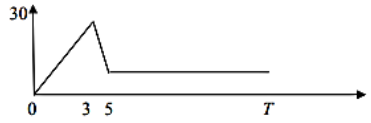
(c)

B1:

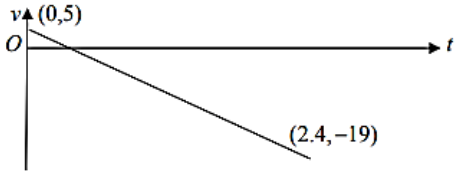
Either: Include time to change from constant accln to constant velocity and/or time to change from constant velocity to constant deceleration oe

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

05.

Question	Scheme	Marks	AOs	Notes
a	$V = 30\ (\text{m s}^{-1})$	B1	3.4	cao
		(1)		
(b)	 shape	B1	1.1b	Overall shape of the graph, starting at the origin. Dotted vertical line at end is OK but solid vertical line is B0
	figs	B1ft	1.1b	3, 5 and T marked on the t-axis, and **ft** on their 30 marked on the speed axis. 3 must be where graph reaches a peak. Allow delineators: 3, 2 and $T-5$ or a mixture
		(2)		
(c)	Using total area = 550 to set up an equation in **one unknown,** Or they may use *suvat* on one or more of the sections (but must still be considering all sections) M0 if they use one *suvat* equation for the whole motion	M1	2.1	Need all sections to be included, with correct structure for each section. e.g. triangle + trapezium + rectangle oe = 550 to give an equation in **one unknown (may not be *T*)**
	$\frac{1}{2}\times3\times30+\frac{(30+6)}{2}\times2+6(T-5)=550$ **OR:** $\frac{1}{2}\times3\times30+\frac{1}{2}\times2\times24+6(T-3)=550$ **OR:** $\frac{1}{2}\times3\times30+\frac{1}{2}\times2\times24+(2\times6)+6(T-5)=550$	A2 ft	1.1b	**ft** on their answer to (a). **-1** each error. **N.B.** If '6' is incorrect, treat as one error, unless it is correct ft from their 30.
	Solve for T	M1	1.1b	Attempt to solve for T provided they have tried to find the area using at least 3 sections. (M0 if they only solve for their unknown and never try to find T)
	$T = 83$ (nearest whole number)	A1	1.1b	83 is the only answer
		(5)		
(d)	New value of T would be bigger (ignore their reasons whether correct or not)	B1	3.5a	Clear statement about the value of T Allow '*it* would increase, get larger etc' B0 for 'Takes longer' or 'the value of T would be longer'
		(1)		
(e)	e.g. effect of wind; allow for dimensions of parachutist; use a more accurate value for g; parachutist does not fall vertically after chute opens; smooth changes in v; time for parachute to open; deceleration not constant (but B0 if they say *acceleration* not constant); smooth changes in a; B0 for: moves horizontally; mass/weight of parachutist; upthrust; air pressure;air resistance; terminal velocity	B1	3.5c	Any appropriate refinement of the model. B0 if incorrect (or irrelevant) extras
		(1)		
		(10 marks)		

06.

Question	Scheme	Marks	AOs
a	$19^2 = (-U)^2 + 2\times10\times16.8$ (Allow use of $g = 9.8$ for this M mark)	M1	2.1
	$U = 5$ *	A1*	1.1b
		(2)	
	For consistent use of $g = 9.8$ in parts (b), (c) and (d), treat as a MR. i.e. max (b) M1A0 (c)M1A0M(A)0A1ft (d)B1B1ft		
(b)	$19 = -5 + 10T$ **OR** $16.8 = \frac{(-5+19)}{2}T$ **OR** $16.8 = -5T + \frac{1}{2}\times10T^2$ **OR** $16.8 = 19T - \frac{1}{2}\times10T^2$	M1	2.1
	$T = 2.4$	A1	1.1b
		(2)	
(c)	$1.2 = -5t + \frac{1}{2}\times10\times t^2$	M1	2.1
	$5t^2 - 5t - 1.2 = 0$	A1	1.1b
		M(A)1	1.1b
	$t = 1.2$ (s)	A1	1.1b
		(4)	
(d)		B1 shape	1.1b
	(0,5) and (2.4, −19) Allow these to be marked on the axes.	B1ft	1.1b
		(2)	
(e)	Greater since air resistance would slow the ball down.	B1	3.5a
		(1)	
(f)	Take into account: spin, wind effects, use a more accurate value of g, not model the ball as a particle	B1	3.5c
		(1)	

	(12 marks)

Notes:		
(a)	M1	Complete method to find U, condone sign errors and use of $g = 9.8$
	A1*	$U = 5$ cao correctly obtained – allow U^2 instead of $(-U)^2$. Allow verification.
(b)	M1	Complete method to find T, condone sign errors
	A1	$T = 2.4$
(c)	M1	Complete method to find t, condone sign errors
	A1	Correct equation with at most one error
	(A)1	Correct equation
	A1	$t = 1.2$ (s)
(d)	B1	Graph could be reflected in the t-axis.
	B1**ft**	Follow through on their T value. If graph is reflected, $(0, -5)$ and $(2.4, 19)$
(e)	B1	Any similar appropriate comment
(f)	B1	B0 if any incorrect extras e.g. weight/mass included

07.

Question	Scheme	Marks	AOs
a	$14.7=-14.7+9.8T$ or $0=14.7T-\frac{1}{2}\times9.8T^2$ or $0=14.7-9.8\times\left(\frac{1}{2}T\right)$ oe	M1	3.4
	$T=3$	A1	1.1b
		(2)	
(b)	$s_1=\frac{(14.7+0)}{2}\times1.5$ $(11.025$ or $\frac{441}{40})$	M1	1.1b
	$s_2=\frac{1}{2}\times9.8\times2.5^2$ $(30.625$ or $\frac{245}{8})$ **OR** $s_3=14.7\times1+\frac{1}{2}\times9.8\times1^2$ $(19.6$ or $\frac{98}{5})$ **OR** $-s_3=14.7\times4-\frac{1}{2}\times9.8\times4^2$ (- 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)

Notes:		**If they use g = 9.81 or 10, penalise once for whole question.**
a	M1	Complete method to find T, condone sign errors (M0 if they only find time to top)
	A1	$T=3$ correctly obtained.
b	M1	Complete method to find one key distance
	M1	Correct method to find another key distance
	M1	Complete method to find the total distance
	A1	41.7 or 42 (after use of $g=9.8$)
c	B1	B0 if there are incorrect extra refinements but ignore extra incorrect statements.

08.

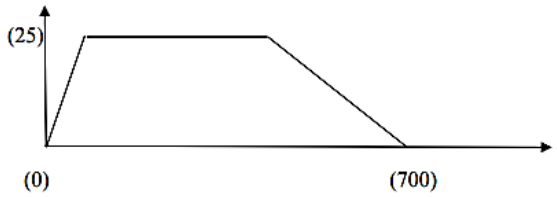
Question	Scheme	Marks	AOs
a	Complete method to produce an equation in U only	M1	3.4
	e.g. $10^2 = U^2 + 2\times g\times 1.8$ oe	A1	1.1b
	OR a **complete** method where they find T first and use it to find an equation in U only M1		
	A correct equation in U only. A1		
	$U = 8$ (only this answer)	A1	1.1b
		(3)	
(b)	Complete method to find an equation in T only: $10 = -8 + gT$ or $1.8 = 10T - \frac{1}{2}gT^2$ or $1.8 = \frac{(-8+10)}{2}T$ or $1.8 = -8T + \frac{1}{2}gT^2$ **OR** a **complete** method if they split the time. In both cases, the M1 is only earned on the final line when they try to add the two times to give an equation in T. **ALT 1**: time up + time down e.g. $0 = 8 - gt_{UP}$ $(\Rightarrow t_{UP} = 0.8)$ $h_{UP} = \frac{(8+0)}{2}\times 0.8$ $(= 3.2)$ $(h_{UP} + 1.8) = \frac{(0+10)}{2}\times t_{DOWN}$ $(\Rightarrow t_{DOWN} = 1)$ $T = t_{UP} + t_{DOWN}$	M1	3.4
	ALT 2: time to A + time from A to ground e.g. $8 = -8 + gt_A$ $(\Rightarrow t_A = 1.6)$ $1.8 = \frac{(8+10)}{2}\times t_{AG}$ $(\Rightarrow t_{AG} = 0.2)$ $T = t_A + t_{AG}$		
	$T = 1.8$ oe e.g. 9/5	A1	1.1b
		(2)	
(c)	e.g. Use a more accurate (less rounded) value for g (or gravity), use $g = 9.8$ or $g = 9.81$, allow for wind effects, allow for the spin of the stone, include dimensions of stone (not a particle), shape and/or size of stone, allow for variable acceleration. If air resistance is mentioned as an extra, ignore it.	B1	3.5c

		(1)	
(d)	*U* would be greater. Allow without *U*, e.g it would be greater, or just 'greater' oe ISW	B1	3.5a
		(1)	
			(7 marks)

Notes:

a	M1	Use the model to obtain an equation in *U* only, condone sign errors, but M0 if using an incorrect formula.
	A1	A correct equation in *U* only, *g* does not need to be substituted (so allow $g = 9.8$ or 9.81)
	A1	cao (A0 if $g = 10$ has not been used)
b	M1	Use the model to obtain an equation in *T* only , *g* does not need to be substituted (so allow $g = 9.8$ or 9.81) condone sign errors, but M0 if using an incorrect formula. Follow through on their *U* where necessary
	A1	cao (A0 if $g = 10$ has not been used) A0 if they give two answers.
c	B1	Any appropriate refinement. B0 if an incorrect extra is given e.g. the mass or weight is mentioned
d	B1	cao

09.

Question	Scheme	Marks	AOs
a		B1	1.1b
		(1)	
(b)	Using *total* area = 15000 to set up an *equation* in **one unknown** Or they may use *suvat* on one or more sections (but must still be considering *all* sections) Allow an attempt at a clear explicit verification using $t = 40$ e.g. the following would score M1A1A1*: $4\times40=160$ then $700-40-160=500$ $\frac{(700+500)}{2}\times25=15000=15$ km Withhold A1* if they don't include = 15 km **N.B.** M0 if a single *suvat* formula is used for the whole journey.	M1	3.4
	$\frac{1}{2}(700+700-t-4t)\times25=15000$ **OR** $\frac{1}{2}\times25\times t+25(700-t-4t)+\frac{1}{2}\times25\times4t=15000$	A1	1.1b
	$t = 40$ (s)*	A1*	1.1b
		(3)	
(c)	0.63 or 0.625 or $\frac{5}{8}$ oe ($m\,s^{-2}$) isw	B1	1.1b/ (2.2a)
		(1)	
(d)	Complete method to find the speed or velocity at $t = 572$ e.g $\pm\left(25-(32\times\frac{5}{32})\right)$ or $\pm\left(128\times\frac{5}{32}\right)$ oe	M1	3.1b
	20 ($m\,s^{-1}$)	A1	1.1b
		(2)	
(e)	e.g. (the train) cannot instantaneously change acceleration, (the train) won't move with constant acceleration , (the train) won't move with constant speed Allow negatives of these:	B1	3.5b

	e.g. (The train) moving at constant speed, or just 'constant speed' or 'constant acceleration' (is a limitation of the model) Must be a limitation of the model, so friction or air resistance or size of train is B0. **N.B.** Ignore incorrect **reasons** following a correct answer.		
		(1)	
			(8 marks)

Notes:		
a	B1	Overall shape of graph, starting at the origin, with deceleration phase *longer* than the acceleration phase if nothing on the t-axis but ignore the relative lengths and allow if t (or 40) and $4t$ (or 160) are clearly and correctly marked. Ignore incorrect figs on the axes. This mark can be earned if the graph appears anywhere in qu 2.
b	M1	Need *all* sections to be included, with correct structure for each section, with $\frac{1}{2}$'s where appropriate. Allow = 15 or 150 or 1500 etc instead of 15000
	A1	A correct equation **in their t only, seen or implied** (or with $t = 40$ for verification)
	A1*	cso. At least one line of working with brackets removed and t's collected, or equivalent
c	B1	cao
d	M1	Any complete method, must have correct figs, but condone sign errors
	A1	cao. Must be positive and exact i.e must not come from rounding.
e	B1	Any appropriate limitation of the model. B0 if any incorrect extra **answers.**

10.

Question	Scheme	Marks	AOs
a	Because the distances travelled or displacements are equal oe. If they mention the times are the same as well, ignore it.	B1	2.4
		(1)	
b	0.8 or 4/5 ($m\,s^{-2}$)	B1	1.1b
		(1)	
c	$\frac{1}{2}\times5\times4+(4\times22.5)$ **OR** $\frac{1}{2}(27.5+22.5)\times4$ **OR** $27.5\times4-\frac{1}{2}\times5\times4$	M1	3.1b
	100 (m)	A1	1.1b
		(2)	
c	Total area under graph = their answer for part (c)	M1	3.1b
	$\frac{1}{2}X\times X+X(27.5-X)=100$	A1ft	1.1b
	OR $\frac{1}{2}(27.5+27.5-X)\times X=100$ **OR** $27.5X-\frac{1}{2}X^2=100$	A1ft	1.1b
	$X = 3.92$ to 3sf	A1	1.1b
		(4)	
			(8 marks)

Notes:		
a	B1	Must mention distances being equal specifically.
b	B1	cao
c	M1	Clear attempt to find the **total** area under the *P* graph, with the correct structure i.e. (triangle + rectangle) **OR** trapezium **OR** (rectangle – triangle); must see use of ½ where appropriate. **OR** they may use *suvat* to find the distance covered by *P* in one or more of the sections. **N.B.** M0 for use of a single *suvat* formula for the whole motion
	A1	cao
d	M1	Clear attempt to equate the total area under the *S* graph, with the correct structure, i.e. (triangle + rectangle) **OR** trapezium **OR** (rectangle – triangle), must see use of ½ where appropriate, to their answer for (c) to give a quadratic equation in *X* only **N.B.** they may use *suvat* to find the distance covered by *S* in one or more of the sections. **N.B.** M0 for use of a single *suvat* formula for the whole motion
	A1ft	Correct unsimplified quadratic equation in *X* only with at most one error, follow their answer for (c)
	A1ft	Correct unsimplified quadratic equation in *X* only, follow their answer for (c)
	A1	cao

11.

Question	Scheme	Marks	AOs
a	Attempt to find the displacement after 10 s	M1	3.1b
	$39.2\times10-\frac{1}{2}g\times10^2$ **OR** $-39.2\times10+\frac{1}{2}g\times10^2$	A1	1.1b
	98 (m) (must be positive)	A1	1.1b
		(3)	
b	Complete method to find either half the time or the full time	M1	3.1b
	Correct equation e.g. $0=24.5-gt$ **OR** $-24.5=24.5-gt$	A1	1.1b
	5 (s)	A1	1.1b
		(3)	
c	e.g. (include) air resistance	B1	3.5c
		(1)	
			(7 marks)

Notes:		**Penalise explicit use of *g* = 9.81 or 10 once for the whole question the first time it occurs.**
a	M1	Complete method, using $s=ut+\frac{1}{2}at^2$ or possibly $s=vt-\frac{1}{2}at^2$ with the motion reversed, or an 'up and down' method i.e an appropriate equation for the motion from *O* to the top **AND** an appropriate equation from the top down to the ground **AND** combining to give the total distance
	A1	Correct expression (s) **N.B.** If using an 'up and down method', this mark is for **all** the intermediate values: Distance up = 78.4, Time up = 4, time down = 6, distance down = 176.4 **AND** combining correctly i.e. (176.4 – 78.4) or (78.4 –176.4) These are the values for *g* = 9.8
	A1	cao
b	M1	Complete method to find half the time or the full time. Allow inequalities. e.g. for half the time, they may find *t* = 4 and *t* = 1.5 and subtract e.g. for the full time, they may find *t* = 6.5 and *t* = 1.5 and subtract
	A1	Correct equation or equations if they are using more than one.
	A1	cao
c	B1	e.g. (use) a more accurate value of *g*, (include) spin of the stone, (include)shape of the stone, (include) size of the stone, (include) wind effects , rotation B0 if any incorrect extras are included e.g. the mass or weight of the stone DO NOT ALLOW NEGATIVES OF THESE e.g there is no air resistance