Mechanics – Kinematics Assessment

Question 1

A particle is accelerated from 1m/s to 5m/s over a distance of 15m.
Find the acceleration and the time taken.

Question 2

A car accelerates uniformly from 5m/s to 15m/s taking 7.5 seconds.
How far did it travel during this period?

Question 3

(a) A small stone is dropped from a height of 25 metres above the ground.

(i) Find the time taken for the stone to reach the ground. *(2 marks)*

(ii) Find the speed of the stone as it reaches the ground. *(2 marks)*

(b) A large package is dropped from the same height as the stone. Explain briefly why the time taken for the package to reach the ground is likely to be different from that for the stone. *(2 marks)*

Question 4

A particle P moves with acceleration $(-3\mathbf{i} + 12\mathbf{j})\,\mathrm{m\,s^{-2}}$. Initially the velocity of P is $4\mathbf{i}\,\mathrm{m\,s^{-1}}$.

(a) Find the velocity of P at time t seconds. *(2 marks)*

(b) Find the speed of P when $t = 0.5$. *(3 marks)*

Question 5

A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

During the first stage, the car accelerates uniformly from rest to a velocity of $10\,\mathrm{m\,s^{-1}}$ in 6 seconds.

During the second stage, the car travels with a constant velocity of $10\,\mathrm{m\,s^{-1}}$ for a further 4 seconds.

During the third stage of the motion, the car travels with a uniform retardation of magnitude $0.8\,\mathrm{m\,s^{-2}}$ until it comes to rest.

(a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. *(2 marks)*

(b) Sketch a velocity–time graph for the car during the three stages of the motion. *(4 marks)*

(c) Find the total distance travelled by the car during the motion. *(3 marks)*

(d) State one criticism of the model of the motion. *(1 mark)*

Question 6

A car is driven with constant acceleration, $a\,\mathrm{m\,s^{2}}$, along a straight road. Its speed when it passes a road sign is $u\,\mathrm{m\,s^{1}}$. The car travels 14 m in the 2 seconds after passing the sign; 5 seconds after passing the sign it has a speed of $19\,\mathrm{m\,s^{1}}$.

(i) Write down two equations connecting a and u. Hence find the values of a and u. [5]

(ii) What distance does the car travel in the 5 seconds after passing the road sign? [2]

Question 7

The displacement, x m, from the origin O of a particle on the x-axis is given by

$$x = 10 + 36t + 3t^2 - 2t^3,$$

where t is the time in seconds and $-4 \leqslant t \leqslant 6$.

(i) Write down the displacement of the particle when $t = 0$. [1]

(ii) Find an expression in terms of t for the velocity, $v\,\text{m s}^{-1}$, of the particle. [2]

(iii) Find an expression in terms of t for the acceleration of the particle. [2]

(iv) Find the maximum value of v in the interval $-4 \leqslant t \leqslant 6$. [3]

(v) Show that $v = 0$ only when $t = -2$ and when $t = 3$. Find the values of x at these times. [5]

(vi) Calculate the *distance* travelled by the particle from $t = 0$ to $t = 4$. [3]

(vii) Determine how many times the particle passes through O in the interval $-4 \leqslant t \leqslant 6$. [3]

Question 1

(a) $s = ½ (u + v) t$
$15 = ½ (1 + 5) \times t$
$t = 30/6$
$t = 5$ seconds [1]

(b) $v^2 = u^2+2as$
$25 = 1 + 2 \times a \times 15$
$a = 24/30$
$a = 0.8\ ms^{-2}$ [1]

Question 2

A car accelerates uniformly from 5m/s to 15m/s taking 7.5 seconds.
How far did it travel during this period?

$s = ½ (u + v) t$
$s = ½ (5 + 15) \times 7.5$
$s = ½ \times 20 \times 7.5$
$s = 75m$ [1]

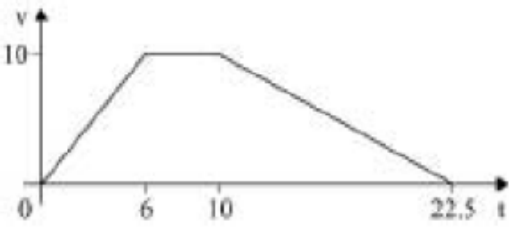
Question 3

(a)(i)	$s = ut + \frac{1}{2}at^2$ $25 = 0 + 4.9t^2$ $t = 2.26\,\text{sec}$ (2.236) $(\text{if } g = 10)$ (2.259)	M1 A1	2	full method
(ii)	$v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 9.8 \times 25$ $v = 22.1\,\text{m s}^{-1}$ (21.913) (22.14)	M1 A1	2	
(b)	(Time longer) air resistance slows down motion, links with motion, no contradictions	M1 A1	2	(or Time less) package large so less distance to travel
	Total		**6**	

Question 4

(a)	$\mathbf{v} = 4\mathbf{i} + (-3\mathbf{i} + 12\mathbf{j})t$	M1 A1	2	use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$
(b)	$t = 0.5, \quad \mathbf{v} = 2.5\mathbf{i} + 6\mathbf{j}$	B1√		√ 2 terms and t subs
	Speed $= \sqrt{(2.5^2 + 6^2)}$	M1		2 terms
	Speed $= 6.5\,\text{m s}^{-1}$	A1√	3	√ 2 terms
	Total		**5**	

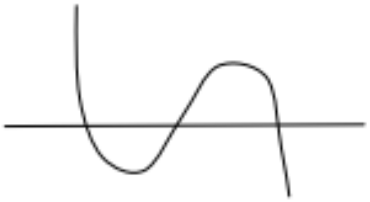
Question 5

(a)	$v = u + at$ $0 = 10 + (-0.8) \times t$	M1		Full method with u, v used correctly Accept ±0.8
	$t = 12.5$ sec	A1	2	CAO (correct subs and answer)
(b)		B1 B1 B1		each line, straight and correct end points SC: B1 for 3 lines giving correct shape but no values shown SC: first error in labelling times loses B1, repeated errors no further penalty
		B1	4	axes labelled v, t
(c)	distance $= \frac{1}{2} \times 10 \times (4 + 22.5)$	M1		Full correct method
		A1F		Correct subs, FT graph if final $t = 12.5$
	$= 132.5$ metres	A1F	3	FT one slip, AWRT 133
(d)	Acceleration unlikely to: change so abruptly or be constant or velocity unlikely to be constant	B1	1	
	Total		**10**	

Question 6

		mark		Sub
4(i)	$14 = 2u + 0.5a \times 4$ $19 = u + 5a$ Solving gives $u = 4$ and $a = 3$	**M1** A1 **A1** M1 F1	U of appropriate *uvast* for either equn Any form y form Attempt at solution of 2 equns in 2 unknowns. At least one value found . Must have complete correct solution to **their** equns. .	5
(ii)	$19^2 = 4^2 + 2 \times 3 \times s$ or $s = 4 \times 5 + 0.5 \times 3 \times 25$ $s =$ 57.5 so 57.5 m	M1 A1	Use of appropriate *uvast* and **their** u, a & t = 5. cao [Accept 50 if $t = 7$ instead of $t = 5$ in (i) for 2/2]	2
				7

Question 7

1(i)	**10 m**	B1		1
(ii)	$v = 36 + 6t - 6t^2$	M1 A1	Attempt at differentiation	2
(iii)	$a = 6 - 12t$	M1 F1	Attempt at differentiation	2
(iv)	Take $a = 0$ so $t = 0.5$ and v = 37.5 so 37.5 m s^{-1}	M1 A1 A1	Allow table if maximum indicated or implied FT **their** a cao Accept no justification given that this is maximum	3
(v)	**either** Solving $36 + 6t - 6t^2 = 0$ so t = -2 or t = 3 **or** Sub the values in the expression for v Both shown to be zero A quadratic so the only roots **then** x(-2) = -34 x(3) = 91	M1 B1 E1 M1 E1 B1 B1 B1	A method for two roots using **their** v Factorization or formula or … of **their** expression Shown Allow just 1 substitution shown Both shown Must be a clear argument cao cao	5
(vi)	$\lvert x(3) - x(0)\rvert + \lvert x(4) - x(3)\rvert$ = $\lvert 91 - 10\rvert + \lvert 74 - 91\rvert$ = 98 so 98 m	M1 A1 A1	Considering two parts Either correct cao [SC 1 for $s(4) - s(0) = 64$]	3
(vii)	At the SP of v x(-2) = -34 i.e. < 0 and x(3) = 91 i.e. > 0 Also x(-4) = 42 > 0 and x(6) = -98 < 0  so three times	M1 B1 B1	Or any other valid argument e.g find all the zeros, sketch, consider sign changes. Must have some working. If only a sketch, must have correct shape. Doing appropriate calculations e.g. find all 3 zeros; sketch cubic reasonably (showing 3 roots); sign changes in range 3 times seen	3
		19		