Revision – Forces and Motion - Year 12 - Mark Scheme

1.

(a) Car + Van: $3200a = 2320 - 800 - 240$

$a = 0.4\ ms^{-2}$ — M1 A1 A1 (3)

(b) Car: 240 ← a → T $\quad 1200a = T - 240$

$\rightarrow T = 720\ N$ — M1 A2✓ –1 e.e. A1 (4)

[OR Van: T ← 800, → 2320 $\quad 2000a = 2320 - 800 - T$

$\rightarrow T = 720$]

NB If use equ^{n}s for car + van alone, allow M1 A2 for one equ^{n} involving T, then M1 A1 for a second equ^{n} provided it is part of a complete method to find a/T. Then A1 A1 for a & T.

2.

(*a*)	Car + truck: $2000a = 2400 - 600 - 400$	M1 A1	
	$a = 0.7\ \text{m s}^{-2}$	A1	(3)
(*b*)	Car only: $T - 400 = 800 \times 0.7$	M1 A1 ft	
	[*or* truck only: $2400 - T - 600 = 1200 \times 0.7$]		
	$T = 960\ \text{N}$	A1	(3)
(*c*)	New acceleration of truck a' given by $1200\,a' = 2400 - 600$	M1	
	$a' = 2400 - 600 = 1.5\ \text{m s}^{-1}$	A1	
	Time to reach $28\ \text{m s}^{-1} = \dfrac{28-20}{1.5} = 5.33\ \text{s}$	M1 A1	
	Time to reach $28\ \text{m s}^{-1}$ if rope had not broken $= \dfrac{28-20}{0.7} = 11.43\ \text{s}$	M1 A1	
	Difference $= 6.1\ \text{s} \approx 6\ \text{s}$ (*)	A1	(7)

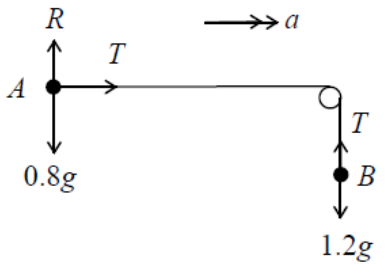
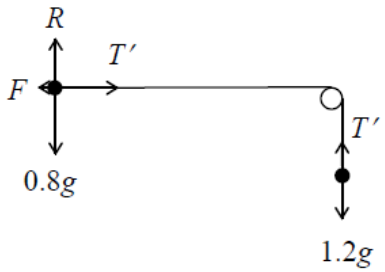
3.

(i)	$2000 = 1000a$ so $a = 2$ so 2 m s^{-2}	B1		
		M1	Use of appropriate *uvast* for t	
	$12.5 = 5 + 2t$ so $t = 3.75$ so 3.75 s	A1	cao	3
(ii)	$2000 - R = 1000 \times 1.4$	M1	N2L. Accept $F = mga$. Accept sign errors. Both forces present. Must use $a = 1.4$	
	$R = 600$ so 600 N (AG)	E1		2
(iii)	$2000 - 600 - S = 1800 \times 0.7$	M1	N2L overall or 2 paired equations. $F = ma$ and use 0.7. Mass must be correct. Allow sign errors and 600 omitted.	
		A1	All correct	
	$S = 140$ so 140 N (AG)	E1	Clearly shown	3
(iv)	$T - 140 = 800 \times 0.7$	M1	N2L on trailer (or car). $F = 800a$ (or $1000a$). Condone missing resistance otherwise all forces present. Condone sign errors.	
		B1	Use of 140 (or 2000 – 600) and 0.7	
	$T = 700$ so 700 N	A1		3
(v)	N2L in direction of motion car and trailer			
	$-600 - 140 - 610 = 1800a$	M1	Use of $F = 1800a$ to find new accn. Condone 2000 included but not T. Allow missing forces.	
		A1	All forces present; no extra ones Allow sign errors.	
	$a = -0.75$	A1	Accept ± . cao.	
	For trailer $T - 140 = -0.75 \times 800$	M1	N2Lwith their a ($\neq 0.7$) on trailer or car. Must have correct mass and forces. Accept sign errors	
	so $T = -460$ so 460	A1	cao. Accept ±460	
	thrust	F1	Dep on M1. Take tension as +ve unless clear other convention	6

4.

(i)	N2L in direction of motion			
	$D - (100 + 300) = (900 + 700) \times 1.5$	M1	Apply N2L. Allow 1 resistance omitted and sign error but total mass must be used. Condone use of $F = mga$. No extra forces.	
		A1	All correct	
	D = 2800 so 2800 N	A1	cao	3
(ii)	N2L on trailer			
	$T - 300 = 700 \times 1.5$	M1	Use either car or trailer. All forces present. No extras. Correct mass and a Allow sign error. Must use $F = ma$.	
	$T = 1350$ so 1350 N	A1	cao	2

5.

(a)		A: $T = 0.8a$ B: $1.2g - T = 1.2a$ Solve: $T = 0.48g = 4.7$ N	B1 M1 A1 M1 A1	**(5)**
(b)	$a = 0.6g = 5.88$ Hence $0.6 = ½ \times 0.6g \times t^2$ $t = 0.45$ or 0.452 s		M1 M1 A1	**(3)**
		$F = \mu R = \frac{1}{5} \times 0.8g$ A: $T' - F = 0.8a'$ B: $1.2g - T' = 1.2a'$	B1 M1 A1 B1	
	Solve: $a' = 0.52g$ $0.6 = ½ \times 0.52g \times t^2$ $t = 0.49$ or 0.485 s		M1 A1 M1 A1	**(8)**

6.

a $3.2\,\text{m s}^{-2}$ **b** 5.3 N (2 s.f.) **c** $F = 3.7$ (2 s.f.)
d The information that the string is inextensible has been use in part **c** when the acceleration of A has been taken to be equal to the acceleration of B.

7.

(a)	For particle A $T - 3mg = 3ma$ (Note $T - mg = ma$ or $T - m = ma$ etc scores M1) $T - 3mg = 3m\left(\frac{2}{5}g\right) \rightarrow T = \frac{21}{5}mg$	M1 A1 → A1 (3)
(b)	String is inextensible	B1 (1)
(c)	For particle B $kmg - T = kma$ $kg - \frac{21}{5}g = \frac{2}{5}kg$ (or equivalent equation in k only) Solving DM1 dependent on first M1 in (c) $k = 7$	M1 A1 f.t. DM1 A1 cao (4)

(d) | Tension is of same magnitude throughout the string | B1 (1)

8.

(a)	$3g - T = 3a$ $T - g = a$ $2g = 4a$ $a = \frac{g}{2} = 4.9 \text{ m s}^{-2}$	M1A1 M1A1 A1	5	M1: Three term equation of motion with $3g$ or 29.4, T and $3a$. A1: Correct equation. M1: Three term equation of motion with g or 9.8, T and a. A1: Correct equation. A1: Correct final answer. Accept $\frac{g}{2}$ Note: Do not penalise candidates who consistently use signs in the opposite direction throughout, provided they then give their final answer as 4.9, having seen –4.9 in their working. If the final answer is –4.9 don't award the final A1 mark. Special Case: Whole string method $2g = 4a$ and $a = \frac{2g}{4} = 4.9$ OE scores M1A1A1
(b)	$v^2 = 0^2 + 2 \times 4.9 \times 0.4$ $v = \sqrt{3.92} = 1.98 \text{ m s}^{-1}$	M1 A1F	2	M1: Use of a constant acceleration equation to find v, with $u = 0$, their value for a from part (a) and $s = 0.4$ or 40. A1F: Correct speed. Follow through their acceleration from part (a). Use $v = \sqrt{0.8a}$ for FT. Accept 1.97 . If candidates use two equations, award no marks until they have an equation for v. (Note use of $t = 0.404$ or better required for A1)

9.

i	$s = 0.5 \times 1.4 \times 0.8^2$	M1	Uses $s = 0.5x1.4t^2$
	$s = 0.448$ m	A1	Not 0.45
	$v = 1.4 \times 0.8$	M1	Uses $v = 1.4t$
	$v = 1.12$ ms^{-1}	A1	
		[4]	
ii	$0^2 = 1.12^2 - 2 \times 9.8s$	M1	Uses $0^2 = u^2 - 2gs$ or $u^2 = 2gs$
	$s = 0.064$ m	A1	Allow verification
	$0 = 1.12 - 9.8t$ $(t = 0.114s)$	M1	or $0.064 = 1.12t - 4.9t^2$
	$t = (0.114 + 0.8) = 0.914s$	A1	Allow 0.91 {or $0 = 1.12t - 4.9t^2$ and halve t
		[4]	
iii	Scalene triangle, base on t axis	B1	NB Award A1 for 0.91 on t axis if total
	right edge steeper and terminates on axis, or crosses axis at t = 0.91	B1	time not given in (ii)
		[2]	
iv		M1	Uses N2L for A or B with attempt at 2 forces
		A1	Either
	$1.4xA = 9.8xA - 5.88$ or $1.4xB = 5.88 - 9.8xB$	A1	
	$A = 0.7$	A1	Not 0.53
va	$B = 0.525$	[4]	
		M1	Uses tension and 0.5g without particle weights
	$T = 0.5 \times 9.8 + 2 \times 5.88$		
vb	$T = 16.66$ N	A1	Allow 16.7
		[2]	
	$T = 4.9$ N	B1	
		[1]	

(c)	$0^2 = \left(\sqrt{3.92}\right)^2 + 2 \times (-9.8)s$	M1		M1: Use of a constant acceleration equation with $v = 0$, $a = \pm 9.8$ and their speed from (b).
	$s = \dfrac{3.92}{2 \times 9.8} = 0.2$ m	A1		A1: Correct distance.
	Total $= 0.2 + 0.4 = 0.6$ m	A1	3	A1: Correct total distance. Allow 60 cm from correct working.
				Note $0^2 = \left(\sqrt{392}\right)^2 + 2 \times (-9.8)s$ $s = \dfrac{392}{2 \times 9.8} = 20$ scores M1A0A0
				If candidates use two equations, award no marks until they have an equation for s. (Note use of $t = 0.202$ or better required for A marks)