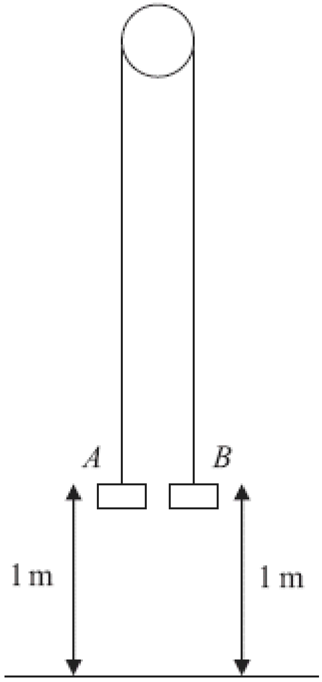
1.



Two particles A and B have mass 0.4 kg and 0.3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed above a horizontal floor. Both particles are held, with the string taut, at a height of 1m above the floor, as shown in the diagram above. The particles are released from rest and in the subsequent motion B does not reach the pulley.

(a) Find the tension in the string immediately after the particles are released.

(6)

(b) Find the acceleration of A immediately after the particles are released.

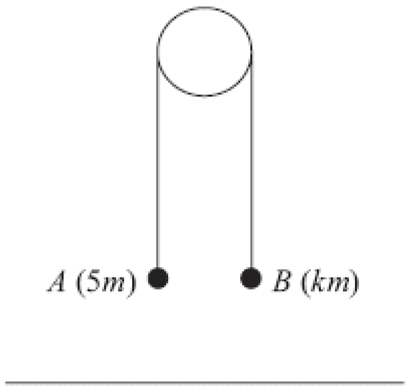
(2)

When the particles have been moving for 0.5 s, the string breaks.

(c) Find the further time that elapses until B hits the floor.

(9)
(Total 17 marks)

2.



Two particles A and B have masses $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane, as shown in Figure 4. The system is released from rest. After release, A descends with acceleration $\frac{1}{4}g$.

(a) Show that the tension in the string as A descends is $\frac{15}{4}mg$.

(3)

(b) Find the value of k.

(3)

(c) State how you have used the information that the pulley is smooth.

(1)

After descending for 1.2 s, the particle A reaches the plane. It is immediately brought to rest by the impact with the plane. The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.

(d) Find the greatest height reached by B above the plane.

(7)
(Total 14 marks)

3. A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(a) the acceleration of the car and trailer,

(3)

(b) the magnitude of the tension in the towbar.

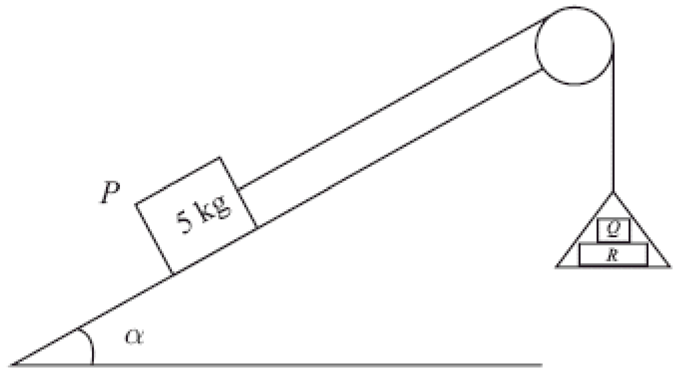
(3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(c) find the value of F.

(7)
(Total 13 marks)

4.



One end of a light inextensible string is attached to a block *P* of mass 5 kg. The block *P* is held at rest on a smooth fixed plane which is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{3}{5}$. The string lies along a line of greatest slope of the plane and passes over a smooth light pulley which is fixed at the top of the plane. The other end of the string is attached to a light scale pan which carries two blocks *Q* and *R*, with block *Q* on top of block *R*, as shown in Figure 3. The mass of block *Q* is 5 kg and the mass of block *R* is 10 kg. The scale pan hangs at rest and the system is released from rest. By modelling the blocks as particles, ignoring air resistance and assuming the motion is uninterrupted, find

(a) (i) the acceleration of the scale pan,

(ii) the tension in the string,

(8)

(b) the magnitude of the force exerted on block *Q* by block *R*,

(3)

(c) the magnitude of the force exerted on the pulley by the string.

(5)
(Total 16 marks)

5.

Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough horizontal table. The string passes over a small smooth pulley P fixed on the edge of the table. The particle B hangs freely below the pulley, as shown in the diagram above. The coefficient of friction between A and the table is μ. The particles are released from rest with the string taut. Immediately after release, the magnitude of the acceleration of A and B is $\frac{4}{9}g$. By writing down separate equations of motion for A and B,

(a) find the tension in the string immediately after the particles begin to move,

(3)

(b) show that $\mu = \frac{2}{3}$.

(5)

When B has fallen a distance h, it hits the ground and does not rebound. Particle A is then a distance $\frac{1}{3}h$ from P.

(c) Find the speed of A as it reaches P.

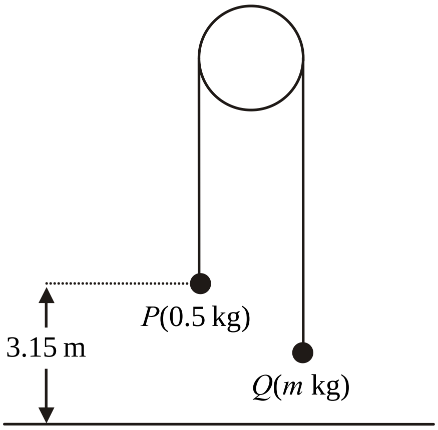
(6)

(d) State how you have used the information that the string is light.

(1)

(Total 15 marks)

6.



Two particles P and Q have mass 0.5 kg and m kg respectively, where $m < 0.5$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley. Initially P is 3.15 m above horizontal ground. The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown in the diagram above. After P has been descending for 1.5 s, it strikes the ground. Particle P reaches the ground before Q has reached the pulley.

(a) Show that the acceleration of P as it descends is 2.8 m s^{-2}.

(3)

(b) Find the tension in the string as P descends.

(3)

(c) Show that $m = \dfrac{5}{18}$.

(4)

(d) State how you have used the information that the string is inextensible.

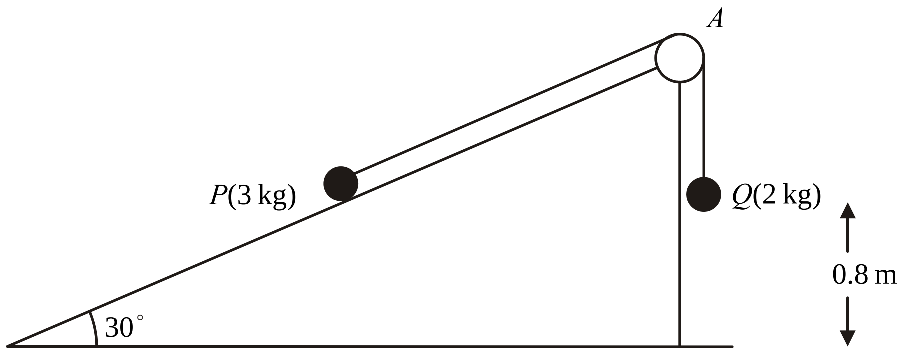
(1)

When P strikes the ground, P does not rebound and the string becomes slack. Particle Q then moves freely under gravity, without reaching the pulley, until the string becomes taut again.

(e) Find the time between the instant when P strikes the ground and the instant when the string becomes taut again.

(6)
(Total 17 marks)

7.



The diagram above shows two particles P and Q, of mass 3 kg and 2 kg respectively, connected by a light inextensible string. Initially P is held at rest on a fixed smooth plane inclined at 30° to the horizontal. The string passes over a small smooth light pulley A fixed at the top of the plane. The part of the string from P to A is parallel to a line of greatest slope of the plane. The particle Q hangs freely below A. The system is released from rest with the string taut.

(a) Write down an equation of motion for P and an equation of motion for Q.

(4)

(b) Hence show that the acceleration of Q is 0.98 m s^{-2}.

(2)

(c) Find the tension in the string.

(2)

(d) State where in your calculations you have used the information that the string is inextensible.

(1)

On release, Q is at a height of 0.8 m above the ground. When Q reaches the ground, it is brought to rest immediately by the impact with the ground and does not rebound. The initial distance of P from A is such that in the subsequent motion P does not reach A. Find

(e) the speed of Q as it reaches the ground,

(2)

(f) the time between the instant when Q reaches the ground and the instant when the string becomes taut again.

(5)
(Total 16 marks)

8. A car is towing a trailer along a straight horizontal road by means of a horizontal tow-rope. The mass of the car is 1400 kg. The mass of the trailer is 700 kg. The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The resistances to motion of the car and the trailer are assumed to be constant and of magnitude 630 N and 280 N respectively. The driving force on the car, due to its engine, is 2380 N. Find

(a) the acceleration of the car,

(3)

(b) the tension in the tow-rope.

(3)

When the car and trailer are moving at 12 m s^{-1}, the tow-rope breaks. Assuming that the driving force on the car and the resistances to motion are unchanged,

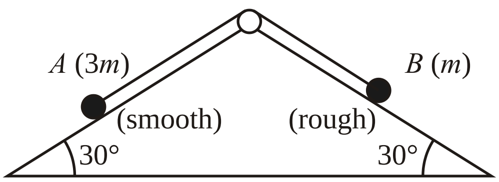
(c) find the distance moved by the car in the first 4 s after the tow-rope breaks.

(6)

(d) State how you have used the modelling assumption that the tow-rope is inextensible.

(1)
(Total 13 marks)

9.



A fixed wedge has two plane faces, each inclined at 30° to the horizontal. Two particles A and B, of mass $3m$ and m respectively, are attached to the ends of a light inextensible string. Each particle moves on one of the plane faces of the wedge. The string passes over a small smooth light pulley fixed at the top of the wedge. The face on which A moves is smooth. The face on which B moves is rough. The coefficient of friction between B and this face is μ. Particle A is held at rest with the string taut. The string lies in the same vertical plane as lines of greatest slope on each plane face of the wedge, as shown in the figure above.

The particles are released from rest and start to move. Particle A moves downwards and B moves upwards. The accelerations of A and B each have magnitude $\frac{1}{10}g$.

(a) By considering the motion of A, find, in terms of m and g, the tension in the string.

(3)

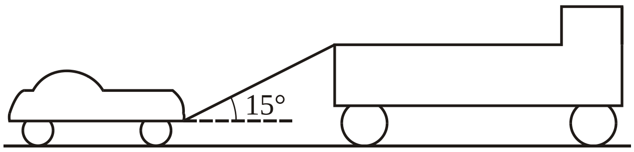
(b) By considering the motion of B, find the value of μ.

(8)

(c) Find the resultant force exerted by the string on the pulley, giving its magnitude and direction.

(3)
(Total 14 marks)

10.



This figure shows a lorry of mass 1600 kg towing a car of mass 900 kg along a straight horizontal road. The two vehicles are joined by a light towbar which is at an angle of 15° to the road. The lorry and the car experience constant resistances to motion of magnitude 600 N and 300 N respectively. The lorry's engine produces a constant horizontal force on the lorry of magnitude 1500 N. Find

(a) the acceleration of the lorry and the car,

(3)

(b) the tension in the towbar.

(4)

When the speed of the vehicles is 6 m s^{-1}, the towbar breaks. Assuming that the resistance to the motion of the car remains of constant magnitude 300 N,

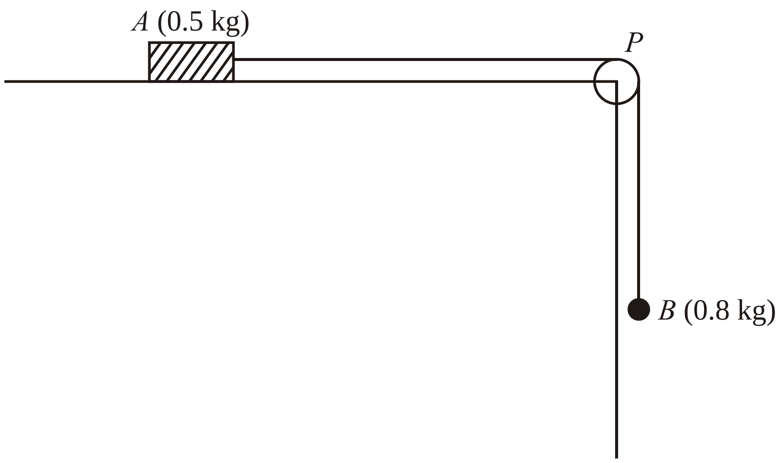
(c) find the distance moved by the car from the moment the towbar breaks to the moment when the car comes to rest.

(4)

(d) State whether, when the towbar breaks, the normal reaction of the road on the car is increased, decreased or remains constant. Give a reason for your answer.

(2)
(Total 13 marks)

11.



A block of wood A of mass 0.5 kg rests on a rough horizontal table and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the table. The other end of the string is attached to a ball B of mass 0.8 kg which hangs freely below the pulley, as shown in the diagram above. The coefficient of friction between A and the table is μ. The system is released from rest with the string taut. After release, B descends a distance of 0.4 m in 0.5 s. Modelling A and B as particles, calculate

(a) the acceleration of B,

(3)

(b) the tension in the string,

(4)

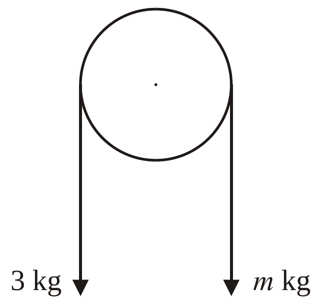
(c) the value of μ.

(5)

(d) State how in your calculations you have used the information that the string is inextensible.

(1)
(Total 13 marks)

12.



The particles have mass 3 kg and m kg, where $m < 3$. They are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The particles are held in position with the string taut and the hanging parts of the string vertical, as shown in the diagram above. The particles are then released from rest. The initial acceleration of each particle has magnitude $\frac{3}{7}g$. Find

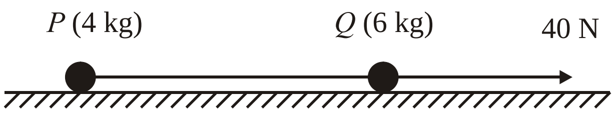
(a) the tension in the string immediately after the particles are released,

(3)

(b) the value of m.

(4)
(Total 7 marks)

13.



Two particles P and Q, of mass 4 kg and 6 kg respectively, are joined by a light inextensible string. Initially the particles are at rest on a rough horizontal plane with the string taut. The coefficient of friction between each particle and the plane is $\frac{2}{7}$. A constant force of magnitude 40 N is then applied to Q in the direction PQ, as shown in the diagram above.

(a) Show that the acceleration of Q is 1.2 m s^{-2}.

(4)

(b) Calculate the tension in the string when the system is moving.

(3)

(c) State how you have used the information that the string is inextensible.

(1)

After the particles have been moving for 7 s, the string breaks. The particle Q remains under the action of the force of magnitude 40 N.

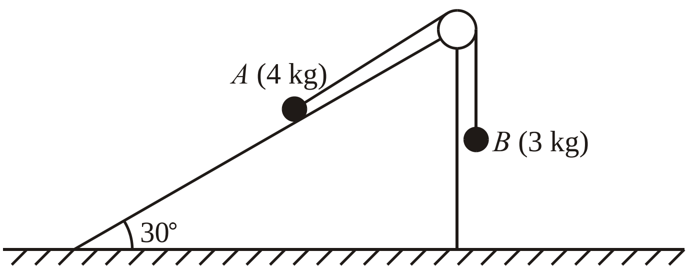
(d) Show that P continues to move for a further 3 seconds.

(5)

(e) Calculate the speed of Q at the instant when P comes to rest.

(4)
(Total 17 marks)

14.



A particle *A* of mass 4 kg moves on the inclined face of a smooth wedge. This face is inclined at 30° to the horizontal. The wedge is fixed on horizontal ground. Particle *A* is connected to a particle *B*, of mass 3 kg, by a light inextensible string. The string passes over a small light smooth pulley which is fixed at the top of the plane. The section of the string from *A* to the pulley lies in a line of greatest slope of the wedge. The particle *B* hangs freely below the pulley, as shown in the diagram above. The system is released from rest with the string taut. For the motion before *A* reaches the pulley and before *B* hits the ground, find

(a) the tension in the string,

(6)

(b) the magnitude of the resultant force exerted by the string on the pulley.

(3)

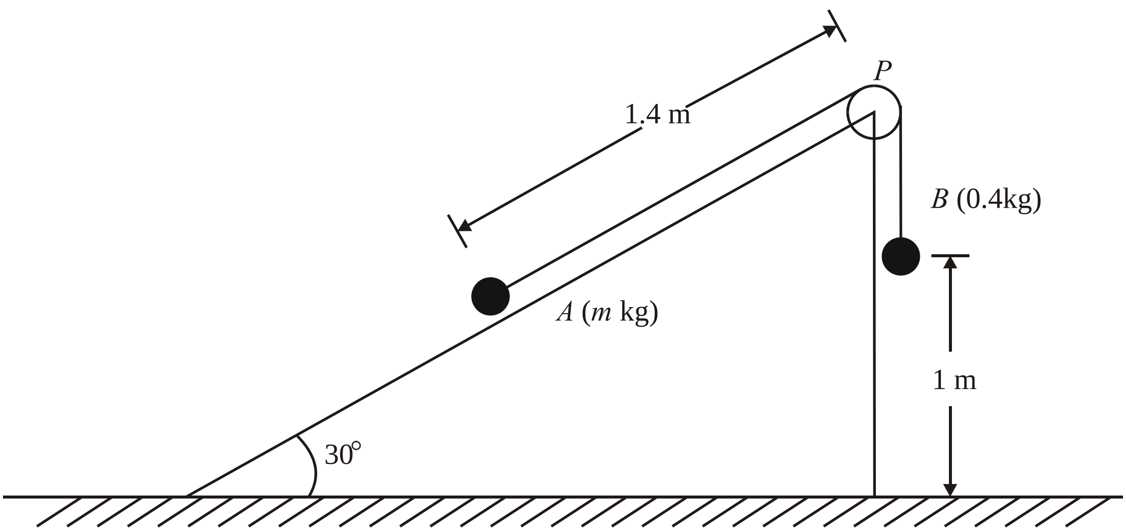
(c) The string in this question is described as being 'light'.

(i) Write down what you understand by this description.

(ii) State how you have used the fact that the string is light in your answer to part (a).

(2)
(Total 11 marks)

15.



The diagram above shows two particles A and B, of mass m kg and 0.4 kg respectively, connected by a light inextensible string. Initially A is held at rest on a fixed smooth plane inclined at 30° to the horizontal. The string passes over a small light smooth pulley P fixed at the top of the plane. The section of the string from A to P is parallel to a line of greatest slope of the plane. The particle B hangs freely below P. The system is released from rest with the string taut and B descends with acceleration $\frac{1}{5}g$.

(a) Write down an equation of motion for B.

(2)

(b) Find the tension in the string.

(2)

(c) Prove that $m = \frac{16}{35}$.

(4)

(d) State where in the calculations you have used the information that P is a light smooth pulley.

(1)

On release, B is at a height of one metre above the ground and AP = 1.4 m. The particle B strikes the ground and does not rebound.

(e) Calculate the speed of B as it reaches the ground.

(2)

(f) Show that A comes to rest as it reaches P.

(5)
(Total 16 marks)

16. A car which has run out of petrol is being towed by a breakdown truck along a straight horizontal road. The truck has mass 1200 kg and the car has mass 800 kg. The truck is connected to the car by a horizontal rope which is modelled as light and inextensible. The truck's engine provides a constant driving force of 2400 N. The resistances to motion of the truck and the car are modelled as constant and of magnitude 600 N and 400 N respectively. Find

(a) the acceleration of the truck and the car,

(3)

(b) the tension in the rope.

(3)

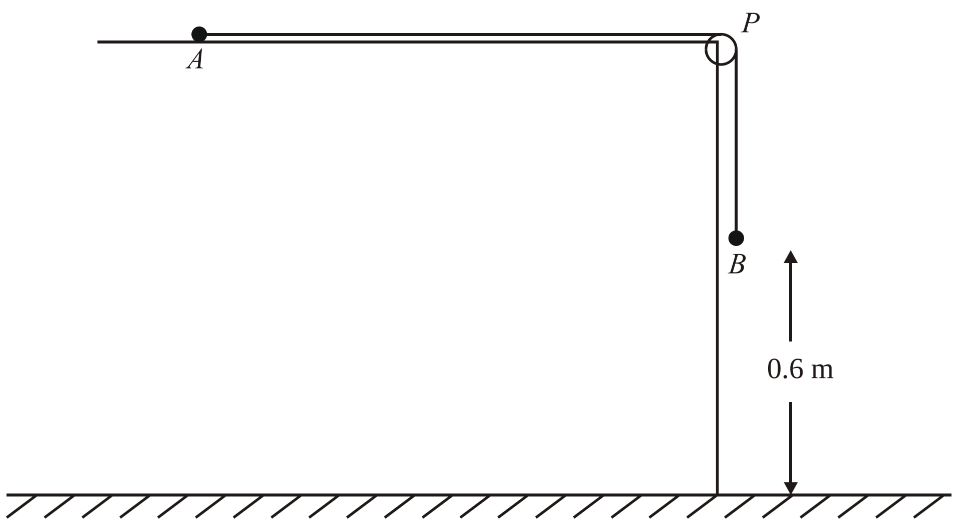
When the truck and car are moving at 20 m s^{-1}, the rope breaks. The engine of the truck provides the same driving force as before. The magnitude of the resistance to the motion of the truck remains 600 N.

(c) Show that the truck reaches a speed of 28 m s^{-1} approximately 6 s earlier than it would have done if the rope had not broken.

(7)

(Total 13 marks)

17.



A particle A of mass 0.8 kg rests on a horizontal table and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the table. The other end of the string is attached to a particle B of mass 1.2 kg which hangs freely below the pulley, as shown in the diagram above. The system is released from rest with the string taut and with B at a height of 0.6 m above the ground. In the subsequent motion A does not reach P before B reaches the ground. In an initial model of the situation, the table is assumed to be smooth. Using this model, find

(a) the tension in the string before B reaches the ground,

(5)

(b) the time taken by B to reach the ground.

(3)

In a refinement of the model, it is assumed that the table is rough and that the coefficient of friction between A and the table is $\frac{1}{5}$. Using this refined model,

(c) find the time taken by B to reach the ground.

(8)
(Total 16 marks)

1.	(a)	$(\downarrow) 0.4g - T = 0.4a$	M1 A1	
		$(\uparrow) T - 0.3g = 0.3a$	M1 A1	
		solving for T	DM1	
		T = 3.36 or 3.4 or 12g/35 (N)	A1	6
	(b)	$0.4g - 0.3g = 0.7a$	DM1	
		$a = 1.4$ m s^{-2}, $g/7$	A1	2
	(c)	$(\uparrow) v = u + at$		
		$v = 0.5$ x 1.4	M1	
		= 0.7	A1 ft on a	
		$(\uparrow) s = ut + \frac{1}{2}at^2$		
		$s = 0.5$ x 1.4 x 0.5^2	M1	
		$= 0.175$	A1 ft on a	
		$(\downarrow) s = ut + \frac{1}{2}at^2$		
		$1.175 = -0.7t + 4.9t^2$	DM1 A1 ft	
		$4.9t^2 - 0.7t - 1.175 = 0$		
		$t = \dfrac{0.7 \pm \sqrt{0.7^2 + 19.6 \text{ x } 1.175}}{9.8}$	DM1 A1 cao	
		$= 0.5663..$or $-...$		
		Ans 0.57 or 0.566 s	A1 cao	9

[17]

2.	(a)	N2L A: $5mg - T = 5m \times \frac{1}{4}g$		M1 A1	
		$T = \frac{15}{4}mg$ *	cso	A1	3
	(b)	N2L B: $T - kmg = km \times \frac{1}{4}g$		M1 A1	
		$k = 3$		A1	3
	(c)	The tensions in the two parts of the string are the same		B1	1

	(d)	Distance of A above ground $s_1 = \frac{1}{2} \times \frac{1}{4} g \times 1.2^2 = 0.18g(\approx 1.764)$	M1 A1	
		Speed on reaching ground $v = \frac{1}{4} g \times 1.2 = 0.3g(\approx 2.94)$	M1 A1	
		For B under gravity $(0.3g)^2 = 2gs_2 \Rightarrow s_2 = \frac{(0.3)^2}{2} g = (\approx 0.441)$	M1 A1	
		$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m)	A1	7

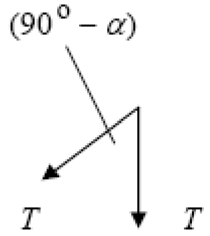
[14]

3.	(a)	For whole system: 1200 – 400 – 200 = 1000a	M1 A1	
		$a = 0.6$ m s^{-2}	A1	3
	(b)	For trailer: T – 200 = 200 × 0.6	M1 A1 **ft**	
		T = 320 N	A1	
			OR:	
		OR: For car: 1200 – 400 – T = 800 × 0.6	M1 A1 **ft**	
		T = 320 N	A1	3
	(c)	For trailer: 200 + 100 = 200f or –200f	M1 A1	
		$f = 1.5$ m s^{-2} (–1.5)	A1	
		For car: 400 + F – 100 = 800f or –800f	M1 A2	
		F = 900	A1	7
		(N.B. For both: 400 + 200 + F = 1000f)		

[13]

4.	(a)	$T - 5g\sin\alpha = 5a$	M1 A1	
		$15g - T = 15a$	M1 A1	
		solving for a	M1	
		$a = 0.6g$	A1	
		solving for T	M1	
		$T = 6g$	A1	8
	(b)	For Q: $5g - N = 5a$	M1 A1	
		$N = 2g$	A1 f.t.	3

(c)



	$F = 2T\cos(\frac{90° - \alpha}{2})$	M1 A2	
	= 12gcos 26.56..°	A1 f.t.	
	= 105 N	A1	5

[16]

5. (a) B: $2mg - T = 2m \times 4g/9$ — M1A1
$\Rightarrow T = \underline{10mg/9}$ — A1 — 3

(b) A: $T - \underline{\mu mg} = m \times 4g/9$ — M1B1A1
Sub for T and solve: $\mu = 2/3$***** — DM1A1 — 5

(c) When B hits: $v^2 = 2 \times 4g/9 \times h$ — M1A1
Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$ — M1A1ft
Speed of A at P: $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$ — DM1
$\Rightarrow V = \frac{2}{3}\sqrt{(gh)}$ — A1 — 6

(d) Same tension on A and B — B1 — 1

[15]

6. (a) $s = ut + \frac{1}{2}at^2 \Rightarrow 3.15 = \frac{1}{2}a \times \frac{9}{4}$ — M1A1
$a = 2.8$ (m s^{-2}) * — cso — A1 — 3

(b) N2L for P: $0.5g - T = 0.5 \times 2.8$ — M1A1
$T = 3.5$ (N) — A1 — 3

(c) N2L for Q: $T - mg = 2.8m$ — M1A1
$m = \frac{3.5}{12.6} = \frac{5}{18}$ * — cso — DM1A1 — 4

	(d)	The acceleration of P is equal to the acceleration of Q.		B1	1
	(e)	$v = u + at \Rightarrow v = 2.8 \times 1.5$ (or $v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 2.8 \times 3.15$) ($v^2 = 17.64$, $v = 4.2$)		M1A1	
		$v = u + at \Rightarrow 4.2 = –4.2 + 9.8t$		DM1A1	
		$t = \frac{6}{7}$, 0.86, 0.857 (s)		DM1A1	6

[17]

7.	(a)	N2L Q $2g – T = 2a$		M1 A1	
		N2L P $T – 3g \sin 30° = 3a$		M1 A1	4
	(b)	$2g – 3g \sin 30° = 5a$		M1	
		$a = 0.98$ (m s$^{–2}$) *	cso	A1	2
	(c)	$T = 2(g – a)$	or equivalent	M1	
		≈18 (N)	accept 17.6	A1	2
	(d)	The (magnitudes of the) accelerations of P and Q are equal		B1	1
	(e)	$v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 0.98 \times 0.8$ (=1.568)		M1	
		$v \approx 1.3$ (m s$^{–1}$)	accept 1.25	A1	2
	(f)	N2L for P $–3g \sin 30° = 3a$			
		$a = (–)\frac{1}{2}g$		M1 A1	
		$s = ut + \frac{1}{2}at^2 \Rightarrow 0 = \sqrt{1.568}t – \frac{1}{2}4.9t^2$	or equivalent	M1 A1	
		$t = 0.51$ (s)	accept 0.511	A1	5

[16]

A maximum of one mark can be lost for giving too great accuracy.

8.	(a)	Car + trailer: $2100a = 2380 – 280 – 630$		M1 A1	
		$= 1470 \Rightarrow a = 0.7$ m s$^{–2}$		A1	3
		M1 for a complete (potential) valid method to get a			

(b) e.g. trailer $700 \times 0.7 = T - 280$ M1 A1ft

$\Rightarrow T = 770$ N A1 3

If consider car: then get 1400a = 2380 – 630 – T.
Allow M1 A1 for equn of motion for car or trailer wherever seen (e.g. in (a)).

So if consider two separately in (a), can get M1 A1 from (b) for one equation; then M1 A1 from (a) for second equation, and then A1 [(a)] for a and A1 [(b)] for T.

In equations of motion, M1 requires no missing or extra terms and dimensionally correct (e.g. extra force, or missing mass, is M0).
If unclear which body is being considered, assume that the body is determined by the mass used. Hence if '1400a' used, assume it is the car and mark forces etc accordingly.
But allow e.g. 630/280 confused as an A error.

(c) Car: $1400a' = 2380 - 630$ M1 A1

$\Rightarrow a' = 1.25$ ms^{-2} A1

distance $= 12 \times 4 + ½ \times 1.25 \times 4^2$ M1 A1ft

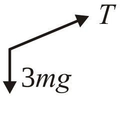
$= 58$ m A1 6

Must be finding a new acceleration here. (If they get 1.25 erroneously in (a), and then simply assume it is the same acceln here, it is M0).

(d) Same acceleration for car and trailer B1 1

Allow o.e. but you must be convinced they are saying that it is same acceleration for both bodies.
E.g. 'acceleration constant' on its own is B0
Ignore extras, but 'acceleration and tension same at A and B' is B0

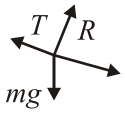
[13]

9. (a) 

A: $3mg - \sin 30 - T = 3m. \frac{1}{10} g$ M1 A1

$\Rightarrow$ T = $\frac{6}{5} mg$ A1 3

(b)



F: R(perp): $R = mg \cos 30$ M1 A1

R(//): $T - mg \sin 30 - F = m.\frac{1}{10}g$ M1 A2, 1, 0

Using $F = \mu R$ M1

$\frac{6}{5}mg - \frac{1}{2}mg - \mu mg\frac{\sqrt{3}}{2} = \frac{1}{10}mg$ M1

$\rightarrow$ $\mu = 0.693$ or 0.69 or $\frac{2\sqrt{3}}{5}$ A1 8

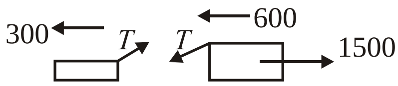
(c)

Magn of force on pulley = $2T\cos 60 = \frac{6}{5}mg$ M1 A1ft

Direction is vertically downwards B1 (cso) 3

[14]

10. (a)



Lorry + Car: $2500a = 1500 - 300 - 600$ M1 A1

$a = \underline{0.24 \text{ m s}^{-2}}$ A1 3

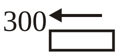
(b) Car: $T \cos 15 - 300 = 900a$

OR Lorry: $1500 - T \cos 15 - 600 = 1600a$ M1 A1

↓↓

Sub and solve: $T \approx \underline{534 \text{ N}}$ M1 A1 4

(c)



Deceleration of car = 300/900 = 1/3 m s^{-1} M1 A1

Hence $6^2 = 2 \times 1/3 \times s \Rightarrow s = \underline{54 \text{ m}}$ M1 A1 4

(d) Vertical component of T now removed M1

Hence normal reaction is increased A1cso 2

[13]

11.	(a)	'$s = ut + ½at^2$' for B: 0.4 = ½ $a(0.5)^2$	M1 A1	
		a = <u>3.2 m s^{-2}</u>	A1	3
	(b)	N2L for B: 0.8g – T = 0.8 × 3.2	M1 A1ft ↓	
		T = <u>5.28 or 5.3 N</u>	M1 A1	4
	(c)	A: $F = \mu \times 0.5g$	B1	
		N2L for A: $T - F = 0.5a$	M1 A1 ↓	
		Sub and solve μ = <u>0.75 or 0.751</u>	M1 A1	5
	(d)	Same acceleration for A and B.	B1	1

[13]

12.	(a)	3 kg: $3g - T = 3 \times \frac{3g}{7}$	M1 A1	
		$\Rightarrow T = \frac{12g}{7}$ <u>or 16.8 N or 17 N</u>	A1	3
	(b)	m kg: $T - mg = m.\frac{3g}{7}$	M1 A1 ↓	
		$\frac{12g}{7} = mg + \frac{3mg}{7}$ (Sub for T and solve)	M1	
		$\Rightarrow m$ = <u>1.2</u>	A1	4

[7]

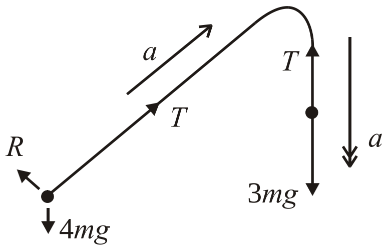
13.

(a)	$F_1 = \frac{2}{7} \times 4g$ (= 11.2) or $F_2 = \frac{2}{7} \times 6g$ (= 16.8)	B1	
	System: $40 - \frac{2}{7} \times 4g - \frac{2}{7} \times 6g = 10a$ (equn in a and not T)	M1 A1	
	$\Rightarrow$ <u>$a = 1.2$ m s^{-2}</u> (*)	A1	4

	(b)	P: $T - \frac{8}{7}g = 4 \times 1.2$ **or** Q: $40 - T - \frac{12}{7}g = 6 \times 1.2$	M1 A1	
		$\Rightarrow T = \underline{16 \text{ N}}$	A1	3
	(c)	Accelerations of P and Q are same	B1	1
	(d)	$v = 1.2 \times 7 = 8.4$	B1	
		P: $(–)\ \frac{8}{7}g = 4a \Rightarrow a = (–)\ \frac{2}{7}g = 2.8$	M1 A1	
			↓	
		$0 = 8.4 – 2.8t \Rightarrow \underline{t = 3 \text{ s}}$ (*)	M1 A1	5
	(e)	Q: $40 - \frac{12}{7}\ g = 6a$ ($\Rightarrow a \approx 3.867$)	M1 A1	
			↓	
		$v = 8.4 + 3.867 \times 3 = \underline{20 \text{ m s}^{-1}}$	M1 A1	4

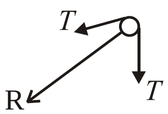
[17]

14. (a)



A: $T - 4g \sin 30 = 4a$	M1 A1	
B: $3g - T = 3a$	M1 A1	
$\Rightarrow T = \frac{18g}{7} = \underline{25.2 \text{ N}}$	M1 A1	6

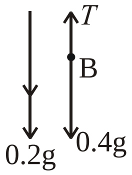
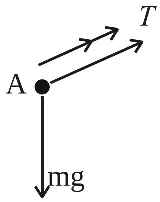
(b)



$R = 2T \cos 30$	M1 A1	
$\approx \underline{44 \text{ or } 43.6 \text{ N}}$	A1	3

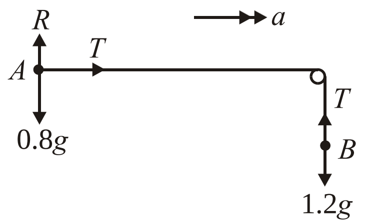
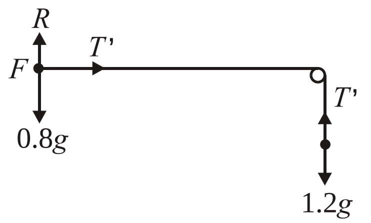
(c)	(i)	String has no weight/mass	B1	
	(ii)	Tension in string constant, i.e. same at A and B	B1	2

[11]

15.	(a)			
		$0.4g - T = 0.4 \times \frac{1}{5}g$	M1 A1	2
	(b)	$T = \underline{\frac{8}{25}}\,\underline{g \quad \text{or} \quad 3.14 \quad \text{or} \quad 3.1}$ N	M1 A1	2
	(c)			
		$T - mg \sin 30° = m \times \frac{1}{5}g$	M1 A1	
		$\rightarrow m = \underline{\frac{16}{35}}$ (*)	M1 A1	4
	(d)	Same T for A & B	B1	1
	(e)	$v^2 = 2 \times \frac{1}{5}g \times 1$	M1	
		$v = \underline{\sqrt{\frac{2g}{5}}} \cong 1.98 \quad \text{or} \quad 2 \text{ ms}^{-1}$	A1	2
	(f)	A: $-\frac{1}{2}mg = ma \Rightarrow a = -\frac{1}{2}g$	M1 A1	
		$v^2 = \frac{2g}{5} - 2 \times \frac{1}{2}g \times 0.4$	M1 A1	
		$\Rightarrow v = 0$	A1	5

[16]

16.	(a)	Car + truck: $2000a = 2400 - 600 - 400$	M1 A1	
		$a = 0.7 \text{ m s}^{-2}$	A1	3

	(b)	Car only: T – 400 = 800 × 0.7	M1 A1 ft	
		[*or* truck only: 2400 – T – 600 = 1200 × 0.7]		
		T = 960 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 m s^{-1} = $\dfrac{28-20}{1.5}$ = 5.33 s	M1 A1	
		Time to reach 28 m s^{-1} if rope had not broken = $\dfrac{28-20}{0.7}$ = 11.43 s	M1 A1	
		Difference = 6.1 s ≈ <u>6 s</u> (*)	A1	7
				[13]
17.	(a)			
		A: $T = 0.8a$	B1	
		B: $1.2g - T = 1.2a$	M1 A1	
		Solve: $T = 0.48g = 4.7$ N	M1 A1	5
	(b)	$a = 0.6g = 5.88$	M1	
		Hence $0.6 = ½ \times 0.6g \times t^2$	M1	
		$t = 0.45$ or 0.452 s	A1	3
				
		$F = \mu R = \dfrac{1}{5} \times 0.8g$	B1	
		A: $T' - F = 0.8a'$	M1 A1	
		B: $1.2g - T' = 1.2a'$	B1	
		Solve: $a' = 0.52g$	M1 A1	
		$0.6 = ½ \times 0.52g \times t^2$	M1	
		$t = 0.49$ or 0.485 s	A1	8
				[16]

1. In parts (a) and (b), most were able to make a reasonable attempt at two equations of motion, but there were errors in signs and solutions. This was not helped by the fact that T was asked for first rather than a and some candidates lost marks due to trying to solve for T first rather than the easier route of solving for a. A few attempted the whole system equation and these solutions were in general less successful than those who used two separate equations to start with. In the last part, too many candidates were unable to visualise the situation clearly and then deal with it in a methodical fashion. If they failed to find both the velocity of A on impact with the ground and the distance that it had travelled they were unable to progress any further. Only the more able students managed correct solutions. Of those that managed to progress in part (c), there were sign errors which caused problems. Many chose to split the motion of B into two parts and these were usually quite successful provided that the extra distance travelled by B in the upward direction was taken into account.

2. Part (a) was reasonably well done by the majority of students, with good use of the printed answer to correct sign errors etc. but there was less success in the second part, with omission of m and/or g from some terms. The mark in part (c) was very rarely scored and candidates should be aware that if they give a 'list' of answers they will not be awarded the mark, even if the correct answer appears in their list. The final part was a good discriminator and led to this question being the worst answered question on the paper. Consideration of two stages to the motion was required, with two distinct accelerations. Many completely omitted the motion under gravity and found the distance moved by A and either gave that as their answer or else just doubled it.

3. Part (a) was well done by the majority of candidates and a good number went on to use the answer correctly in part (b). If mistakes were made they were the usual sign errors or more seriously, in terms of marks lost, missing terms.

The third part was poorly done. There was confusion over the direction of the forces and the concept of thrust. A few candidates halved the thrust and used 50N in each equation. Some used the values of the acceleration and tension from previous parts.

4. In part (a), most candidates were able to set up the two equations of motion, one for each of the two particles and most then went on to solve these correctly to find values for both T and a. A few persist in trying to use a "whole system" equation to find a, usually with limited success. In the second part the vast majority of candidates were unable to select the correct particle, forces or equation to score any of the marks. Part (c) also proved to be discriminating, with some weaker candidates not attempting it. Only a minority of candidates managed to produce a correct solution. Of those who did, many used the cosine rule applied to a vector triangle, or a resolution into two perpendicular components. Common misconceptions involved using just T + Tsin/cos alpha or answers involving components of 5g and 15g. Many had difficulty in identifying the correct size for the angle whichever method was attempted. A few very good candidates realised that the force acted along the angle bisector and scored five quick marks.

5. Most candidates attempted parts (a) and (b) using simultaneous equations, with the most common mistake being to cancel out either m or g when it was not a factor in every term. This resulted in the m term of T being missing. A relatively large number of candidates also lost the final A1 mark for part (b) as they worked through the question using decimals.

The first section of part (c) for calculating the velocity of A after B hits the ground was often calculated correctly although a common mistake was to use $h/3$. A large number of candidates took this to be the new velocity and finished the question at this point. Some continued to calculate the new acceleration but then struggled to form the final equation and a number used either g as the acceleration or 4g/9.

6. (a) Many candidates seemed to expect that the first part of the question would require equations of motion for each particle. Once into relevant calculations, however, most candidates were very successful in obtaining 2.8 m s^{-2}. The majority of successful candidates attempted this part directly using $s = ut + \frac{1}{2}at^2$. Others used a two step approach using $v = u + at$ to give $v = 4.2$, followed by use of another *suvat* formula to get 2.8. A very few tried a verification method which did gain them maximum marks at this stage.

(b) Candidates generally formed an $F = ma$ equation with the majority obtaining the correct equation and getting $T = 3.5$N. However there was still a sizeable number who mistakenly wrote $T - 0.5g = 0.5a = 1.4$. It is noticeable that despite regular comment from Edexcel some candidates still use g = 9.81 which leads to marks being lost in a variety of places where accuracy matters.

(c) Many candidates formed a relevant equation, using the correct forces, reaching the stage of $T = 3.5 = (2.8 + g)\, m$ and then went straight to $m = 5/18$, resulting in the loss of a mark. For many candidates there is still a lack of dexterity with the manipulation of fractions. Moreover, there is still a sizeable number of candidates who try to use one equation of motion for the whole system, despite advice to the contrary in several recent examiners reports.

(d) In this part, modelling was being tested and candidates needed to show that they really knew what was happening. A large number of candidates gave the correct answer that "both particles move with same acceleration" , gaining the single mark available. However candidates who tried to play safe and included another irrelevant reason, such as same tension, had not shown full understanding of the model and therefore were penalised. Other wrong answers included saying that acceleration was constant.

(e) Here, candidates first needed to find the speed of the system when the particle hit the ground. This required the calculation of $v = 4.2$ which some candidates merely quoted. This is the part of the question where candidates began to lose marks and common errors at this stage included using an incorrect value for acceleration. The question then continued with testing vertical motion under gravity. Successful candidates used a variety of equivalent methods. Some worked out the time to the top , followed by a calculation of distance followed by a calculation for time to fall back to launch point, followed by the addition of the two times, giving the answer to the correct degree of accuracy. Some took a more direct approach and used $s = ut + \frac{1}{2}at^2$ or $v = u + at$, for the whole of the remaining motion i.e. up and down. Many only found the time to the top and lost the final two marks. Common errors involved use of incorrect accelerations, displacements and times. Again candidates seem to want to work in decimals rather than in fractions. Candidates should be encouraged to make greater use of diagrams.

7. Despite having asked for separate equations of motion for each mass in many previous papers, there were still some candidates who were unable to provide the correct equations. Parts (b) and (c) were generally correct if part (a) was, but there were some problems with over-accurate answers. Only a tiny minority were able to supply the correct answer to part (d). The next part, however, was the best-answered question on the whole paper, with almost everyone getting the two marks. Despite a familiar scenario in the final part, part (f) did provide a good discriminator at the end of the paper, and only the best candidates were able to see their way through to a correct solution.

8. For those who could handle connected bodies, parts (a) and (b) proved to be straightforward; however, others found difficulty in sorting out the forces acting on each body, showing failure to understand the basic mechanics involved in the situation. In part (c) candidates could recover provided they realised that the situation was now different from that in part (a): however, those who simply carried their answer from (a) to use here, without attempting to find a new acceleration, gained no credit. Answers to part (d) were generally disappointing with very few apparently showing awareness of the implications of the fact that the rope was inextensible.

9. Equations in part (a) often clearly started on the right lines with the correct number of terms; but equally often they produced a variety of errors, with missing *m*'s, *g*'s, some using cos instead of sin etc, and a number of students were unable to reduce their answer to a single multiple of *mg*. In part (b), most who attempted this could find the normal reaction, and also write down an equation of motion for *B* with the correct number of terms; again the same kind of errors were seen as in part (a) for the details. Correct answers to part (c) were rarely seen, many assuming that the force on the pulley was made up of the components of the two weights, and very few indeed realising that the resultant force acted vertically downwards,

10. Candidates found this question more challenging and fully correct answers to all parts were not so common, though many could make good progress with some parts of the question. In part (a), many could do this correctly, and many this time did adopt the approach of considering the whole system (car + trailer together) to obtain the acceleration correctly. Considerably more problems were found with part (b) and only the best candidates seemed able to work out correctly the relevant forces acting on the car or the trailer. Many simply ignored the fact that the tension was acting at an angle and so failed to make any attempt to resolve it. However, many managed to recover well and produce correct answers to part (c) where it was pleasing to see so many correctly coping with the changed situation in terms of the forces. A common error was to assume that the acceleration found in (a) was now the deceleration of the car on its own. In part (d) a number of well argued answers were given, explaining that the normal reaction increased. Some however gave totally irrelevant reasons (e.g. that the friction changed, or that the weight remained constant and hence the normal reaction remained constant). This part again proved to be a good discriminator for more able candidates.

11. This question was generally well answered and it was pleasing to see candidates being able to write down equations of motion for the two particles separately. Mistakes from weaker candidates arose from sometime including the weight of A in the (horizontal) equation of motion for A, or confusing the two particles and the forces acting on them. Most realised that they had to use the given data to solve part (a) though a few launched straight into writing down the equations of motion and then floundering when they did not have enough information to solve these. Answers to part (d) were almost uniformly incorrect: the vast majority stated that the inextensibility of the string meant that the tensions were the same (or constant throughout the string).

12. Again this was generally well done with candidates showing themselves able to write down separate equations of motion for each particle with very attempting the (mathematically spurious) ‘equation for the whole system’ approach. However, some mistakes occurred with missing g’s. Also some failed to realise the mechanical significance of the condition ‘$m < 3$’ and assumed that acceleration was in the wrong direction.

13. The question was generally well done by some candidates, but some evidently failed to understand the mechanics of connected bodies. For those who knew what they were doing, setting up and solving the relevant equations of motion was relatively easy, though quite a few failed to take the easiest route for part (a) by considering the motion of the whole system. The existence of the given answer in part (a) also led to a number of ‘fudged’ solutions here. It was disappointing to see virtually no correct answers to part (c): the vast majority stated that the inextensibility of the string meant that the tension was the same at both ends (or ‘constant’). In parts (d) and (e), terms were sometimes omitted in calculations of the accelerations, and weaker candidates assumed that the acceleration was still 1.2 m s^{-2}. Again, somewhat messy working often hindered many candidates in this question. Standard of presentation was often quite poor with working sometimes apparently distributed randomly over the paper.

14. This type of connected particle question seemed to be much more familiar to many, and hence part (a) was generally well done: most could write down two equations of motion and solve them successfully. Some however failed to realise that the weight of A needed resolving when considering the motion up/down the slope. Very few however realised what was required in part (b). Again the fact that the tensions at the different ends of the string were the same in magnitude did not seem to be appreciated, so that quite a few appeared to think that the resultant force on the pulley was made up of the components of the two weights; others simply assumed that the two tensions were acting perpendicular to each other. A number who realised what to do also lost a mark by failing to round their answer to no more than 3 significant figures. In part (c), most realised that a ‘light’ string is one that has no weight/mass; but very few realised what the implications of this were for the equations they had written down earlier, viz. that the tension in the string remained constant throughout its length.

15. In part (a), several evidently did not understand what was meant by an ‘equation of motion’, though many managed to recover by actually producing the relevant equation in their working for part (b). In part (b), most could produce an equation for the tension, but several again lost a mark by failing to give their answers to an ‘appropriate’ degree of accuracy (again 2 or 3 s.f.). In part (c), most could write down the equation of motion for A, but several fudged the working which required ‘proof’ that the answer was exactly the given fraction: several produced a decimal and verified that the given fraction was (approximately) the same. It was though disappointing to see a number of candidates failing to make any attempt to resolve the weight when considering the motion up the inclined plane. In part (d), few realised the significance of the modelling assumption as implying that the tension was constant throughout. Part (e) was generally well done, but in part (f) the majority failed to find a new acceleration and simply assumed that the acceleration was still $g/5$. For those who did, there were still some problems with the signs given to the various quantities and fully correct solutions here characterised the stronger candidates.

16. It was pleasing to be able to report good overall performance on this question. Candidates showed general confidence in dealing with equations of motion. Most difficulty occurred in part (b) where one vehicle alone had to be considered, and some failed to put the tension correctly into their equations. Part (c) was also generally well done with most showing that they realised that they had to find a new acceleration for the new situation; several fully correct solutions were seen here.

17. This proved to be a popular question, and nearly all seemed to have been taught to use separate equations for the motion of each particle, which was pleasing to see. Perhaps surprisingly, candidates found the first part (assuming no friction) more challenging than the last part (bringing friction in). Several felt compelled to bring in the weight of A in the equation of horizontal motion for A. Several too failed to round their answer for T to an ‘appropriate’ degree of accuracy, leaving their answer to 4 significant figures despite having used a value of g as 9.8. Part (c) was generally well done, though weaker candidates failed to realise that the tension could not be assumed to have the same value as before and so unjustifiably used the value from the earlier part of the question.