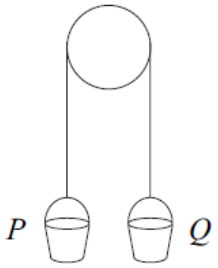
Newtons Laws Questions

7 A builder ties two identical buckets, P and Q, to the ends of a light inextensible rope. He hangs the rope over a smooth beam so that the buckets hang in equilibrium, as shown in the diagram.



The buckets are each of mass 0.6 kg.

(a) (i) State the magnitude of the tension in the rope. *(1 mark)*

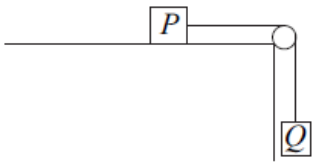
(ii) State the magnitude and direction of the force exerted on the beam by the rope. *(2 marks)*

(b) The bucket Q is held at rest while a stone, of mass 0.2 kg, is placed inside it. The system is then released from rest and, in the subsequent motion, bucket Q moves vertically downwards with the stone inside.

(i) By forming an equation of motion for each bucket, show that the magnitude of the tension in the rope during the motion is 6.72 newtons, correct to three significant figures. *(6 marks)*

(ii) State the magnitude of the force exerted on the beam by the rope while the motion takes place. *(1 mark)*

5 A small block P is attached to another small block Q by a light inextensible string. The block P rests on a rough horizontal surface and the string hangs over a smooth peg so that Q hangs freely, as shown in the diagram.



The block P has mass 0.4 kg and the coefficient of friction between P and the surface is 0.5 .

The block Q has mass 0.3 kg.

The system is released from rest and Q moves vertically downwards.

(a) (i) Draw a diagram to show the forces acting on P. *(1 mark)*

(ii) Show that the frictional force between P and the surface has magnitude 1.96 newtons. *(2 marks)*

(b) By forming an equation of motion for each block, show that the magnitude of the acceleration of each block is $1.4\,\mathrm{m\,s^{-2}}$. *(5 marks)*

(c) Find the speed of the blocks after 3 seconds of motion. *(2 marks)*

(d) After 3 seconds of motion, the string breaks. The blocks continue to move. Comment on how the speed of each block will change in the subsequent motion. For each block, give a reason for your answer. *(4 marks)*

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2 A lift rises vertically from rest with a constant acceleration.

After 4 seconds, it is moving upwards with a velocity of $2\,\mathrm{m\,s^{-1}}$.

It then moves with a constant velocity for 5 seconds.

The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

(a) Sketch a velocity–time graph for the motion of the lift. *(4 marks)*

(b) Calculate the total distance travelled by the lift. *(2 marks)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. *(4 marks)*

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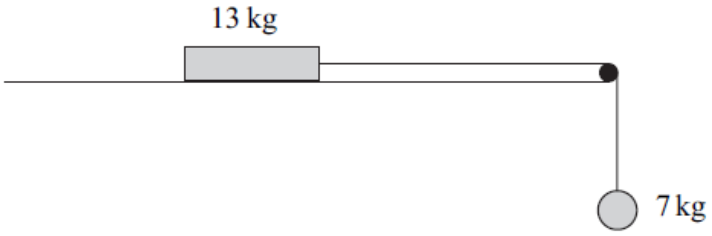
4 The diagram shows a block, of mass 13 kg, on a rough horizontal surface. It is attached by a string that passes over a smooth peg to a sphere of mass 7 kg, as shown in the diagram.



The system is released from rest, and after 4 seconds the block and the sphere both have speed $6\,\text{m}\,\text{s}^{-1}$, and the block has **not** reached the peg.

(a) State **two** assumptions that you should make about the string in order to model the motion of the sphere and the block. *(2 marks)*

(b) Show that the acceleration of the sphere is $1.5\,\text{m}\,\text{s}^{-2}$. *(2 marks)*

(c) Find the tension in the string. *(3 marks)*

(d) Find the coefficient of friction between the block and the surface. *(6 marks)*

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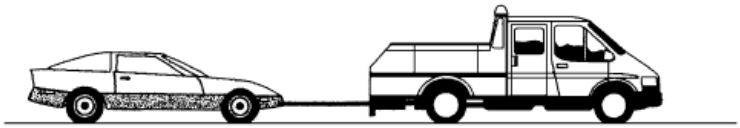
4 A car, of mass 1200 kg, is connected by a tow rope to a truck, of mass 2800 kg. The truck tows the car in a straight line along a horizontal road. Assume that the tow rope is horizontal. A horizontal driving force of magnitude 3000 N acts on the truck. A horizontal resistance force of magnitude 800 N acts on the car. The car and truck accelerate at $0.4\,\text{m}\,\text{s}^{-2}$.



(a) Find the tension in the tow rope. *(3 marks)*

(b) Show that the magnitude of the horizontal resistance force acting on the truck is 600 N. *(4 marks)*

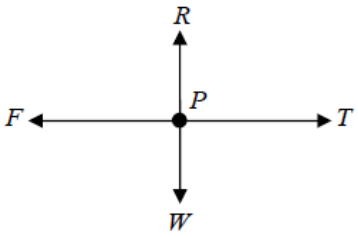
(c) In fact, the tow rope is **not** horizontal. Assume that the resistance forces and the driving force are unchanged.

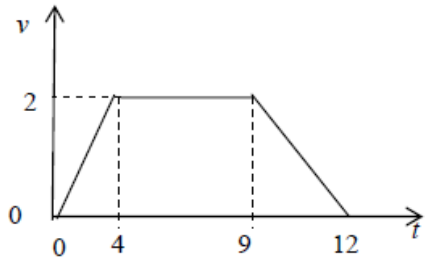
Is the tension in the tow rope greater or less than in part (a)?

Explain why. *(2 marks)*

Newtons Laws Answers

7(a)(i)	$T = 0.6\times 9.8 = 5.88N$ Or $0.6g$	B1	1	
(ii)	Force $= 2T = \downarrow 11.76N$ Or 11.8 N	B1		Magnitude
	Or $1.2g$	B1	2	Direction
(b)(i)	$Q: 0.8g - T = 0.8a$	M1 A1		Either equation
	$T - 0.6g = 0.6a$	A1		
	$0.2g = 1.4a$	m1		Alternative for m1 A1 if solving for T
	$a = 1.4$	A1		m1 method for solving, A1 accurate attempt
	$T = 6.72$N	A1	6	cao | SC whole string to find a :$0.2g = 1.4a$ M1 $a = 1.4$ A1
(ii)	Force $= 2T = 13.44$N	B1	1	cao | to find T :M1 A1
	Total		**10**	

5(a)(i)		B1	1	Accept mg, $0.4g$ or 3.92 for weight Arrows and labels needed
(ii)	$F = 0.5\times(0.4\times 9.8)$	M1		Need to see 0.4×9.8 or 3.92 used
	$F = 1.96$N	A1	2	
(b)	$T - 1.96 = 0.4a$	M1A1		Consistent reversal of signs in both equations 4 marks; reversal of signs in one equation, M1 A1 M1 A0
	$0.3g - T = 0.3a$	M1A1		
	$a = 1.4\text{ms}^{-2}$	A1	5	Sign change needs justification (whole string: equation, $0.3g - 1.96 = 0.7a$ M1A1 $a = 1.4$ A1) max 3/5
(c)	$v = 1.4\times 3$	M1		Full method
	$v = 4.2\text{ms}^{-2}$	A1	2	CAO
(d)	P : Friction will cause speed to decrease	M1 A1		Accept decelerate or comes to rest
	Q : Gravity will cause speed to increase	M1 A1	4	Accept accelerate
	Total		**14**	

2(a)		B1 B1 B1 B1	4	Starts and finishes at rest Correct shape Correct values on t-axis Correct values on v-axis Condone omission of the origin
(b)	$s=\frac{1}{2}(5+12)\times 2$ **or** $s=\frac{1}{2}\times 2\times 4+5\times 2+\frac{1}{2}\times 2\times 3=17$ $=17$	M1 A1	2	Use of the area under the graph (or equivalent) to find s Correct distance **SC** When 21 used instead of 12 allow full marks for $s=26$
(c)	$\max a=\frac{2}{4}=0.5$ $300\times 0.5=T-300\times 9.8$ $T=2940+150=3090$	B1 M1 A1 A1	4	Maximum acceleration Three term equation of motion using their a Correct equation using $a=0.5$ Correct tension
			10	

4(a)	The string is light and inextensible or inelastic or taut	B1 B1	2	First assumption Second assumption
(b)	$6=0+4a$ $a=\frac{6}{4}=1.5$	M1 A1	2	Finding a using a CA equation Correct a from correct working
(c)	$7\times 9.8-T=7\times 1.5$ $T=68.6-10.5=58.1$	M1A1 A1	3	Three term equation of motion with F for the 7 kg particle. Correct equation Correct tension
(d)	$58.1-F=13\times 1.5$ $F=58.1-19.5=38.6$ $R=13.98=127.4$ $38.6=\mu\times 127.4$ $\mu=\frac{38.6}{127.4}=0.303$	M1A1 A1 B1 dM1 A1	6	Three term equation of motion with F for the 13 kg particle. Correct equation Correct F Correct R Use of $F=\mu R$ Correct coefficient of friction
			13	

4(a)	$T - 800 = 1200 \times 0.4$ $T = 800 + 480$ $= 1280$ N	M1 A1 A1	 3	Three term equation of motion for the car Correct equation Correct tension Treat calculation of two tensions as two methods unless one selected Treat sum or difference of two tensions as an incorrect method
(b)	$3000 - 800 - F = 4000 \times 0.4$ $F = 3000 - 800 - 1600$ $F = 600$ N **OR** $3000 - 1280 - F = 2800 \times 0.4$ $F = 3000 - 1280 - 1120$ $F = 600$ N	M1 A1 A1 A1	 4	Four term equation of motion (truck or both) Correct terms Correct signs AG Correct resistance force from correct working
(c)	Increase, because a greater tension would be needed so that the horizontal component would be the same as the tension above.	B1 B1	 2	Greater Reason Second B1 dependent on the first B1 mark
	Total		**9**	