Connected Particles

SCAN ME

REVISE THIS TOPIC

1 A car of mass 1500 kg pulls a trailer of mass 250 kg along a straight horizontal road using a tow-rope. The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 100 N respectively.

The engine of the car produces a constant horizontal driving force of magnitude 1200 N.

(a) Find the acceleration of the car and trailer. **(3)**

(b) Find the magnitude of the tension in the tow-rope. **(3)**

The driving force produced by the car's engine is then changed so that the car and trailer travel at a constant speed. Assuming the resistances to motion of the car and trailer remain the same,

(c) find the magnitude of the new driving force. **(2)**

(a) For the whole system

$$1200 - 400 - 100 = (1500 + 250)a$$

$$700 = 1750a$$

$$a = \mathbf{0.4\ ms^{-2}}$$

(b) For the trailer

$$T - 100 = 250 \times 0.4$$

$$T - 100 = 100$$

$$T = \mathbf{200\ N}$$

(c) Constant speed so $a = 0$

For the whole system

$$F - 400 - 100 = 0$$

$$F = \mathbf{500\ N}$$

(Total for Question 1 is 8 marks)

www.1stclassmaths.com © 2026 1stclassmaths @1stclassmaths

2 A car of mass 1500 kg pulls a trailer of mass 600 kg along a straight horizontal road using a tow-rope.
The car and the trailer are modelled as particles and the tow-rope as a light inextensible string.
The horizontal resistance to motion of the car has magnitude 350 N.
The engine of the car produces a constant horizontal driving force of magnitude 2900 N.
The car and trailer accelerate at 1.1 ms^{-2}

(a) Find the magnitude of the resistance to motion of the trailer. **(3)**

(b) Find the magnitude of the tension in the tow-rope. **(3)**

(c) State how you have used the modelling assumption that the tow-rope is inextensible. **(1)**

The car and trailer are initially travelling at a speed of 4 ms^{-1}.

(d) Find the time taken for the car and trailer to reach a speed of 15 ms^{-1} **(2)**

(a) For the whole system

$2900 - 350 - R = (1500 + 600) \times 1.1$

$2550 - R = 2310$

$R =$ **240 N**

(b) For the trailer

$T - 240 = 600 \times 1.1$

$T - 240 = 660$

$T =$ **900 N**

(c) The car and the trailer have the same acceleration.

(d) $s = s$ $\quad v = u + at$

$u = 4$ $\quad 15 = 4 + 1.1t$

$v = 15$ $\quad 11 = 1.1t$

$a = 1.1$ $\quad t =$ **10 seconds**

$t = t$

(Total for Question 2 is 9 marks)

www.1stclassmaths.com © 2026 1stclassmaths

3 A car pulls a trailer along a straight horizontal road using a towbar.

The mass of the trailer is $\frac{1}{5}$ of the mass of the car.

The car and the trailer are modelled as particles and the towbar as a light inextensible rod.
The horizontal resistances to motion of the car and the trailer have magnitudes 270 N and 50 N respectively.
The engine of the car produces a constant horizontal driving force of magnitude 1400 N.
The car and trailer accelerate at 0.8 ms^{-2}

(a) Find the mass of the trailer. **(3)**

(b) Find the magnitude of the tension in the towbar. **(3)**

(c) State how you have used the modelling assumption that the towbar is light. **(1)**

The driver of the car sees a hazard and reduces the driving force produced by the engine to zero and applies the brakes. The brakes produce a horizontal force on the car of magnitude F N and the car and the trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 400 N,

(d) find the value of F. **(6)**

(a) Mass of trailer = m

Mass of car = $5m$

For the whole system

$1400 - 270 - 50 = 6m \times 0.8$

$1080 = 4.8m$

$m =$ **225 kg**

(b) For the trailer

$T - 50 = 225 \times 0.8$

$T - 50 = 180$

$T =$ **230 N**

(c) The tension has the same magnitude throughout the entire towbar.

(d) For the trailer

$-400 - 50 = 225 \times a$

$-450 = 225a$

$a = -2\ ms^{-2}$

For the car

$400 - 270 - F = 1125 \times (-2)$

$130 - F = -2250$

$F =$ **2380 N**

(Total for Question 3 is 13 marks)

www.1stclassmaths.com © 2026 1stclassmaths

4 A car of mass 1200 kg pulls a trailer of mass 300 kg along a straight horizontal road using a towbar.
The car and trailer are modelled as particles and the towbar as a light inextensible rod.
The horizontal resistance to motion of the car has magnitude 450 N.
The engine of the car produces a constant horizontal driving force of magnitude 1900 N.
The car and trailer accelerate at 0.6 ms^{-2}

(a) Find the magnitude of the resistance to motion of the trailer. **(3)**

(b) Find the magnitude of the tension in the towbar. **(3)**

The car and trailer are travelling at a speed of 12 ms^{-1} when the driver sees a hazard ahead.
The driving force produced by the engine is reduced to zero and the brakes are applied.
The car and the trailer come to rest 5 seconds later.
Given that the resistances to motion of the car and trailer remain unchanged find,

(c) the magnitude of the thrust in the towbar. **(4)**

(d) The magnitude of the braking force acting on the car. **(3)**

(a) For the whole system

$1900 - 450 - R = (1200 + 300) \times 0.6$

$1450 - R = 900$

$R =$ **550 N**

(b) For the trailer

$T - 550 = 300 \times 0.6$

$T - 550 = 180$

$T =$ **730 N**

(c) $s = s$

$u = 12$

$v = 0$

$a = a$

$t = 5$

$v = u + at$

$0 = 12 + 5a$

$a = -2.4$ ms^{-2}

For the trailer

$-T - 550 = 300 \times (-2.4)$

$-T - 550 = -720$

$T =$ **170 N**

(d) For the car

$170 - 450 - F = 1200 \times (-2.4)$

$-280 - F = -2880$

$F =$ **2600 N**

(Total for Question 4 is 13 marks)

www.1stclassmaths.com © 2026 1stclassmaths

5 Two particles A and B, of masses 8 kg and 4 kg respectively, are connected by a light inextensible string. Particle B hangs directly below particle A.

A vertical force of magnitude 144 N is applied upwards to particle A, causing the particles to accelerate vertically upwards.

(a) Find the magnitude of the acceleration of the particles. **(3)**

(b) Find the tension in the string. **(2)**

When the particles reach a speed of 11 ms^{-1} the string breaks.
The vertical force of magnitude 144 N continues to be applied to particle A but particle B moves freely under gravity.

(c) Find the magnitude of the acceleration of particle A after the string breaks. **(2)**

(d) Find the time taken for particle B to reach its greatest height after the string breaks. **(2)**

(a) For the whole system

$144 - 8g - 4g = (8 + 4)a$

$144 - 12g = 12a$

$a = \mathbf{2.2\ ms^{-2}}$

(b) For particle B

$T - 4g = 4 \times 2.2$

$T - 4g = 8.8$

$T = \mathbf{48\ N}$

(c) String breaks so tension = 0 N

For particle A

$144 - 8g = 8a$

$a = \mathbf{8.2\ ms^{-2}}$

(d) $s = s$

$u = 11$

$v = 0$

$a = -9.8$

$t = t$

$v = u + at$

$0 = 11 + -9.8t$

$t = \mathbf{1.12\ seconds}$

(Total for Question 5 is 9 marks)

www.1stclassmaths.com © 2026 1stclassmaths

6 Two particles P and Q, of masses m kg and 7 kg respectively, are connected by a light inextensible rod. Particle Q is directly below particle P.

A vertical force of magnitude 138 N is applied upwards to particle Q, causing both particles to accelerate vertically upwards.

The magnitude of the thrust in the rod is 54 N.

(a) Find the magnitude of the acceleration of the particles. **(3)**

(b) Find m. **(2)**

The magnitude of the vertical force applied to Q is reduced and the particles now accelerate downwards at 1.4 ms^{-2}

(c) Find the magnitude of the reduced vertical force applied to Q. **(3)**

(d) Find the magnitude of the thrust in the rod after the vertical force has been reduced. **(3)**

(a) For particle Q

$138 - 54 - 7g = 7a$

$a = \mathbf{2.2\ ms^{-2}}$

(b) For particle P

$54 - mg = m \times 2.2$

$54 - 9.8m = 2.2m$

$54 = 12m$

$m = \mathbf{4.5\ kg}$

(c) For the whole system

$F - 4.5g - 7g = (4.5 + 7)(-1.4)$

$F - 11.5g = -16.1$

$F = \mathbf{96.6\ N}$

(d) For particle P

$T - 4.5g = 4.5(-1.4)$

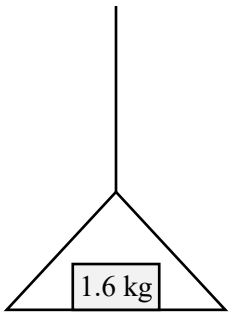
$T - 4.5g = -6.3$

$T = \mathbf{37.8\ N}$

(Total for Question 6 is 11 marks)

www.1stclassmaths.com © 2026 1stclassmaths

7



A scale pan of mass 0.4 kg is attached to the lower end of a vertical light inextensible string.
The scale pan carries a box of mass 1.6 kg and is raised vertically with constant acceleration 1.5 ms^{-2}

(a) Find the tension in the string. **(3)**

(b) Find the magnitude of the force exerted on the scale pan by the box. **(3)**

The scale pan starts from rest.

(c) Find the distance the scale pan rises in the first 4 seconds. **(1)**

(a) For the whole system

$T - 1.6g - 0.4g = (1.6 + 0.4) \times 1.5$

$T - 2g = 3$

$T =$ **22.6 N**

(b) The magnitude of the force exerted on the scale pan by the box is the same as the magnitude of the force exerted on the box by the scale pan.

For the box

$R - 1.6g = 1.6 \times 1.5$

$R - 1.6g = 2.4$

$R =$ **18.1 N**

(c) $s = s$ $\quad s = ut + \frac{1}{2}at^2$

$u = 0$ $\quad s = 0t + \frac{1}{2}(1.5)(4)^2$

$v = v$ $\quad s =$ **12 m**

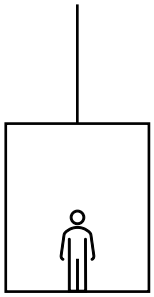
$a = 1.5$

$t = 4$

(Total for Question 7 is 7 marks)

www.1stclassmaths.com © 2026 1stclassmaths

8



A person of mass 67 kg is standing on the floor of a lift of mass 850 kg.
The lift is supported by a vertical cable which is modelled as light and inextensible.
The lift is accelerating upwards at 1.2 ms^{-2}

(a) Find the tension in the cable. **(3)**

(b) Find the magnitude of the force exerted on the person by the floor of the lift. **(3)**

Shortly afterward, the lift continues to move upwards but **decelerates** at 0.8 ms^{-2}

(c) Find the tension in the cable whilst the lift decelerates. **(3)**

(d) Find the magnitude of the force exerted on the person by the floor of the lift whilst it decelerates. **(3)**

(a) For the whole system

$T - 850g - 67g = (850 + 67) \times 1.2$

$T - 917g = 1100.4$

$T =$ **10087 N**

(b) For the person

$R - 67g = 67 \times 1.2$

$R - 67g = 80.4$

$R =$ **737 N**

(c) For the whole system

$T - 850g - 67g = (850 + 67) \times (-0.8)$

$T - 917g = -733.6$

$T =$ **8253 N**

(d) For the person

$R - 67g = 67 \times (-0.8)$

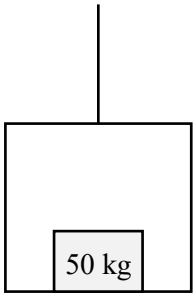
$R - 67g = -53.6$

$R =$ **603 N**

(Total for Question 8 is 12 marks)

www.1stclassmaths.com © 2026 1stclassmaths

9



A lift of mass 700 kg contains a crate of mass 50 kg.
The lift is moving vertically upwards and is decelerating.

The magnitude of the normal reaction of the floor of the lift on the crate is 390 N.

(a) Find the magnitude of the force exerted on the floor of the lift by the crate. **(1)**

(b) Find the magnitude of the deceleration of the lift. **(3)**

(c) Find the tension in the vertical cable supporting the lift. **(3)**

(a) The magnitude of the force exerted on the floor of the lift by the crate is the same as the magnitude of the force exerted on the crate by the floor of the lift.

Answer: **390 N**

(b) For the crate

$390 - 50g = 50a$

$a = -2 \text{ ms}^{-2}$

Magnitude of acceleration = **2 ms^{-2}**

(c) For the whole system

$T - 700g - 50g = (700 + 50) \times (-2)$

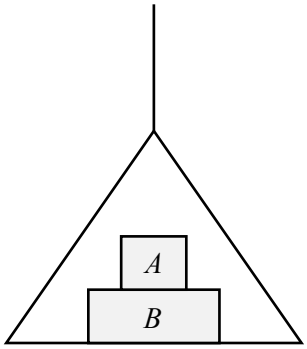
$T - 750g = -1500$

$T =$ **5850 N**

(Total for Question 9 is 7 marks)

www.1stclassmaths.com © 2026 1stclassmaths

10



A scale pan of mass 0.5 kg is attached to the lower end of a vertical light inextensible string.
The scale pan carries two boxes, A and B, with box A resting on top of box B.
The mass of box B is twice the mass of box A.

The scale pan is raised vertically with constant acceleration 2.2 ms^{-2} and the tension in the string is 51 N.

(a) Find the mass of box A. **(4)**

(b) Find the magnitude of the force exerted on box A by box B. **(3)**

(c) Find the magnitude of the force exerted on box B by the scale pan. **(3)**

(a) Let m be the mass of box A (and therefore $2m$ be the mass of box B)

For the whole system

$$51 - mg - 2mg - 0.5g = (m + 2m + 0.5) \times (2.2)$$

$$51 - (3m + 0.5)g = (3m + 0.5) \times (2.2)$$

$$51 - 29.4m - 4.9 = 6.6m + 1.1$$

$$45 = 36m$$

$$m = \mathbf{1.25\ kg}$$

(b) Let R be the force exerted on A by B then for box A

$$R - 1.25g = 1.25 \times 2.2$$

$$R = \mathbf{15\ N}$$

(c) Let R be the force exerted on B by the scale pan then for box B

$$R - 2.5g - 15 = 2.5 \times 2.2$$

$$R = \mathbf{45\ N}$$

(Total for Question 10 is 10 marks)

www.1stclassmaths.com © 2026 1stclassmaths