

Question 1

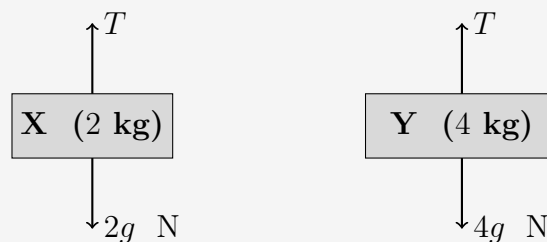
Worked Solution

Part (i)

(A) The pulleys are *smooth* and the string is *light* — these two facts ensure the tension is the same throughout.

(B) The string is *inextensible* — this means neither end can gain length over the other, so both particles must have the same speed at all times, and hence the same magnitude of acceleration.

Part (ii) — Force diagrams



Part (iii) — Equations of motion

Since the 4 kg mass is heavier, it accelerates *downward* and the 2 kg mass accelerates *upward*. Take **upward as positive** for X and **downward as positive** for Y.

For particle X (2 kg), N2L upwards:

$$T - 2g = 2a \quad (1)$$

For particle Y (4 kg), N2L downwards:

$$4g - T = 4a \quad (2)$$

Adding (1) and (2):

$$2g = 6a \implies a = \frac{g}{3}$$

$$a = \frac{g}{3} \approx 3.27 \text{ m s}^{-2}$$

Substituting into (1):

$$T = 2g + 2a = 2g + \frac{2g}{3} = \frac{8g}{3}$$

$$T = \frac{8g}{3} \approx 26.1 \text{ N}$$

Question 2

Worked Solution

Part (i) — Driving force

Consider the **entire system** (car + trailer) as one object.

Total mass: $900 + 700 = 1600$ kg Total resistance: $100 + 300 = 400$ N

N2L in direction of motion:

$$D - 400 = 1600 \times 1.5 \implies D = 2800 \text{ N}$$

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Part (ii) — Force in the coupling

Consider the **trailer alone**. Let C be the coupling force.

N2L on trailer:

$$C - 300 = 700 \times 1.5 \implies C = 1350 \text{ N}$$

$$C = 1350 \text{ N (tension)}$$

Question 3

Worked Solution

Part (i) — Equations of motion

The sphere accelerates *downward*; the block accelerates *horizontally*.

For the block (4 kg), N2L horizontally:

$$T - 14.8 = 4a \quad (1)$$

For the sphere (2 kg), N2L downwards (using $g = 9.8$):

$$19.6 - T = 2a \quad (2)$$

Part (ii) — Solve for T and a

Adding (1) and (2):

$$19.6 - 14.8 = 6a \implies 4.8 = 6a$$

$$a = 0.8 \text{ ms}^{-2}$$

Substituting into (1):

$$T = 14.8 + 4(0.8) = 14.8 + 3.2$$

$$T = 18 \text{ N}$$

Question 4

Worked Solution

Part (i)

The string is **light** and the pulley is **smooth** — therefore the tension is the same throughout.

Part (ii) — Force in the rod

Since Q hangs in equilibrium: $T = 15g$ N

Forces on P (20 kg) vertically:

- Weight downward: $20g$ N
- String tension upward: $15g$ N
- Rod force: F (direction unknown)

Equilibrium of P (upward positive):

$$15g + F - 20g = 0 \implies F = 5g \approx 49 \text{ N}$$

Since F acts upward on P, the rod is pushing P up — it is in **compression**.

$$F = 5g \approx 49 \text{ N} \quad (\text{thrust})$$

Question 5

Worked Solution

Part (i) — Finding P

Total mass: 20 000 kg Total resistance: 800 N

N2L for whole system:

$$P - 800 = 20\,000 \times 0.2 = 4000$$

$$P = 4800 \text{ N}$$

Part (ii) — New acceleration

New total resistance: $500 + 2000 + 300 = 2800 \text{ N}$

$$4800 - 2800 = 20\,000a \implies 2000 = 20\,000a$$

$$a = 0.1 \text{ m s}^{-2}$$

Part (iii) — Force in coupling

Consider **truck B alone**. Resistance 300 N, acceleration 0.1 m s^{-2} :

$$C - 300 = 10\,000 \times 0.1 = 1000$$

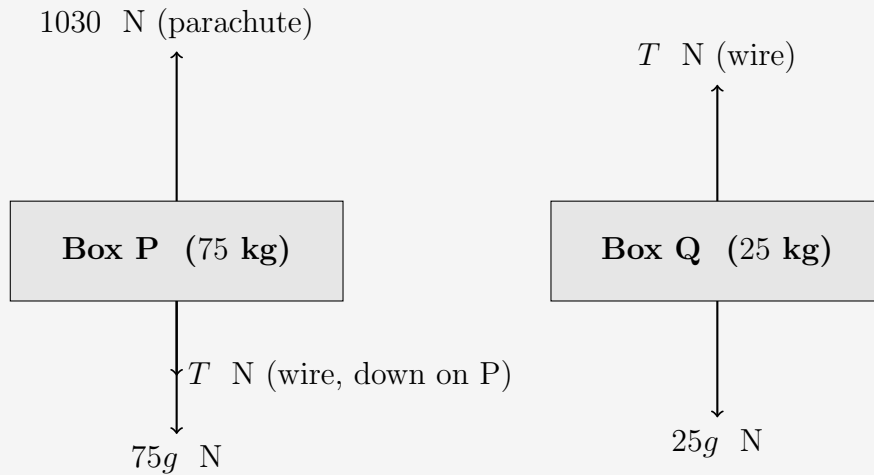
$$C = 1300 \text{ N}$$

Check via truck A: $4800 - 500 - 2000 - C = 10\,000 \times 0.1 \implies C = 1300 \text{ N}$. ✓

Question 6

Worked Solution

Part (i) — Force diagrams



Part (ii) — Equations of motion

The system decelerates in descent, so acceleration a is directed **upward**. Take upward as positive.

For box P (75 kg), N2L upwards:

$$1030 - 75g - T = 75a \quad (1)$$

For box Q (25 kg), N2L upwards:

$$T - 25g = 25a \quad (2)$$

Part (iii) — Find T

Adding (1) and (2):

$$1030 - 100g = 100a \implies 50 = 100a \implies a = 0.5 \text{ m s}^{-2}$$

Substituting into (2):

$$T = 25g + 25(0.5) = 245 + 12.5$$

$$T = 257.5 \text{ N}$$

Question 7

Worked Solution

Total mass: 10 kg. Forces F (leftward) and 30 N (rightward) oppose each other. Since only the magnitude of acceleration (2 m s^{-2}) is given, there are two cases.

Case 1: Acceleration to the RIGHT

N2L for system (rightward positive):

$$30 - F = 10 \times 2 = 20$$

$$F = 10 \text{ N}$$

Tension from 6 kg block alone:

$$30 - T = 6 \times 2 \implies T = 18$$

$$T = 18 \text{ N}$$

Case 2: Acceleration to the LEFT

N2L for system (leftward positive):

$$F - 30 = 10 \times 2 = 20$$

$$F = 50 \text{ N}$$

Tension from 6 kg block alone (leftward positive):

$$T - 30 = 6 \times 2 \implies T = 42$$

$$T = 42 \text{ N}$$

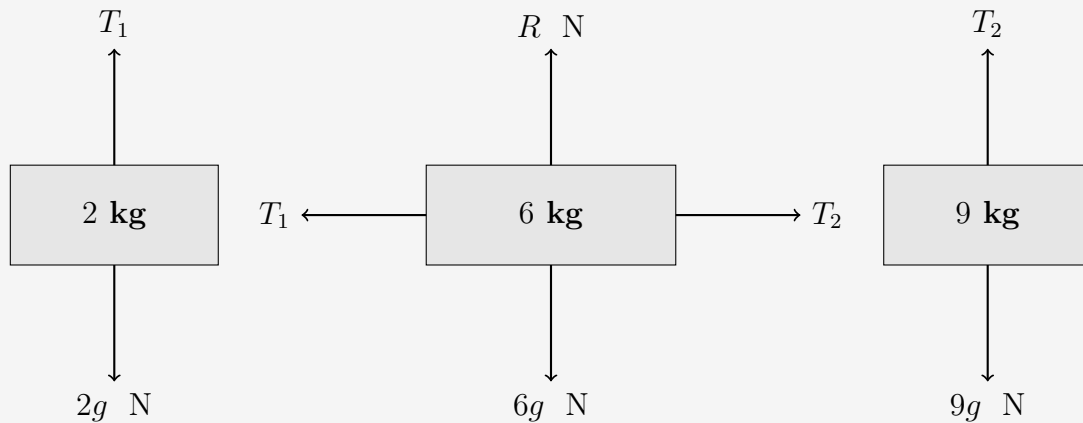
Check via 4 kg block: $50 - 42 = 4 \times 2 = 8$. ✓

Question 8

Worked Solution

Part (i) — Force diagrams

Let T_1 = tension to 2 kg block, T_2 = tension to 9 kg block. Positive direction: 9 kg descends, 2 kg ascends, 6 kg moves right.



Part (ii) — Equations of motion

For 9 kg block, N2L downwards:

$$9g - T_2 = 9a \quad (1)$$

For 6 kg block, N2L to the right:

$$T_2 - T_1 = 6a \quad (2)$$

For 2 kg block, N2L upwards:

$$T_1 - 2g = 2a \quad (3)$$

Adding (1), (2) and (3):

$$9g - 2g = 17a \implies 7g = 17a$$

$$a = \frac{7g}{17} \approx 4.04 \text{ ms}^{-2}$$

Finding T_1 from (3):

$$T_1 = 2g + \frac{14g}{17} = \frac{48g}{17}$$

$$T_1 = \frac{48g}{17} \approx 27.7 \text{ N}$$

Finding T_2 from (1):

$$T_2 = 9g - \frac{63g}{17} = \frac{90g}{17}$$

$$T_2 = \frac{90g}{17} \approx 51.9 \text{ N}$$

Check via (2): $T_2 - T_1 = \frac{42g}{17} = 6 \times \frac{7g}{17} = 6a. \checkmark$

End of Worked Solutions — ALevelMathsRevision.com
