Exercise walk-through

5.4
Connected particles and pulleys

Pearson Edexcel · International A-Level · Mathematics

Check yourself

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State modelling assumptions and their consequences; vector velocities, positions, bearings; multi-phase suvat and motion graphs; paired equations over a pulley with the 2T pulley force; impulse on one body and momentum conservation with rebounds; μR moving versus capped at rest; equilibrium by two resolutions; moments about successive tilting pivots.

Exercises 2.1·2.3

2.1 Masses of 3 kg and 5 kg hang over a light smooth pulley. Find the acceleration and the tension while they move. [4]

2.2 A 2 kg block on a smooth horizontal table is connected by a light inextensible string, passing over a light smooth pulley at the table edge, to a 3 kg hanging mass. Find the acceleration and the tension. [4]

2.3 For question 2.1, state the magnitude of the force exerted on the pulley by the string. [3]

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2.1 Equations: $5g - T = 5a$, $T - 3g = 3a$. Adding: $2g = 8a$, so $a = 2.45\ \mathrm{m\,s^{-2}}$; $T = 3(9.8 + 2.45) = 36.75$ N (37).

2.2 A 2 kg block on a smooth horizontal table is connected by a light inextensible string, passing over a light smooth pulley at the table edge, to a 3 kg hanging mass. Find the acceleration and the tension. [4]

2.2 Block (along table): $T = 2a$; hanging: $3g - T = 3a$. Adding: $3g = 5a$, so $a = 5.88\ \mathrm{m\,s^{-2}}$; $T = 2(5.88) = 11.76$ N (12).

2.3 For question 2.1, state the magnitude of the force exerted on the pulley by the string. [3]

2.3 The two string parts pull down with T each: force $= 2T = 73.5$ N (74).

Exercise 2.4

2.4 After the system in 2.2 has been moving for a while, the hanging mass reaches the floor and the string goes slack. Describe the subsequent motion of the block on the table and the acceleration it experiences. [3]

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2.4 The string goes slack (tension zero), so the only horizontal force on the block is none – it continues at constant speed (Newton I); friction is absent (smooth table). If the table were rough it would decelerate at μg.

Exercise 3.1

3.1 *(Edexcel IAL WME01 June 2025 Q8a–d, condensed.)* Two small balls P (mass kM) and Q (mass $3M$), $k < 3$, are attached to the ends of a light inextensible string which passes over a fixed light smooth pulley. The balls are held at rest with the hanging parts of the string vertical and released. P moves with acceleration of magnitude $\frac{1}{5}g$. (a) Write down the equation of motion for P. (b) Find k. (c) Given $M = 0.5$ kg, find the magnitude of the force exerted on the pulley by the string while Q is moving down. (d) At release, P is more than 2.5 m below the pulley and Q is 2.5 m above horizontal ground. After Q hits the ground it rebounds with speed $0.4\ \mathrm{m\,s^{-1}}$. Find the magnitude of the impulse Q receives when it hits the ground. [11]

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3.1 (a) $T - kMg = kM \cdot \frac{g}{5}$. (b) For Q: $3Mg - T = 3M \cdot \frac{g}{5}$. Adding the two equations: $(3-k)g = \frac{g}{5}(3+k)$, so $5(3-k) = 3+k$, $k = 2$. (c) With $k = 2$, $M = 0.5$: P has mass 1 kg, so $T = 1(g + \frac{g}{5}) = 1.2g = 11.76$ N; force on pulley $= 2T = 23.5$ N (24). (d) Speed on landing: $v^2 = 2(\frac{g}{5})(2.5) = g$, so $v = 3.13\ \mathrm{m\,s^{-1}}$. Impulse (reversal): $I = 1.5(3.13 + 0.4) = 5.3$ N s (5.30).

Local review guidance: paired equations with the correct mass on the right of each; k found exactly; $2T$ for the pulley with the landing speed from the descent phase; impulse using velocity change with signs. This is authored classroom guidance.