InkMaths

ANSWER BOOK

Connected particles and pulleys

Mechanics · Year 12-13

6 questions · 20 marks

NAVY EDITION

SECTION A · Warm-up

A1 Inextensible: the string cannot stretch, so the ends move together and their accelerations match in magnitude. Light string, smooth pulley: nothing along the way absorbs force, so the tension is the same at both ends. [2]

A2 Newton's second law applies body by body, to the forces on that body alone: the 7 kg mass feels its weight and the tension, and nothing else. Writing one equation per particle, then combining them, is the entire method. [2]

SECTION B · Standard

B1 Heavy side: $7g - T = 7a$. Light side: $T - 3g = 3a$. Adding kills T: $4g = 10a$, so $a = 2g/5 = 3.92$ m s^{-2}. Then $T = 3(g + a) = 3 \times 13.72 = 41.2$ N. The check: T sits between $3g = 29.4$ N and $7g = 68.6$ N, as the middleman must. [4]

B2 Whole system: $(2000 - 500) = 1250a$, so $a = 1.2$ m s^{-2}. Trailer alone: $T - 100 = 250 \times 1.2$, so $T = 400$ N. The system equation never sees the towbar tension, which is exactly why it finds a so cleanly; the trailer's own equation then exposes T. [4]

B3 Hanging mass: $2g - T = 2a$. Block: $T = 4a$, since the table is smooth. Adding: $2g = 6a$, so $a = g/3 = 3.27$ m s^{-2} and $T = 4a = 13.1$ N. Only the hanging weight drives the system, but it must move the whole 6 kg: the block's mass appears in the denominator despite gravity never pulling it sideways. [4]

SECTION C · Stretch

C1 If T equalled the heavy weight, that mass would not accelerate; if it equalled the light one, the light mass would not. A moving system needs T strictly between the weights, which the answer 41.2 N respects. A rough pulley absorbs force in friction, so the two sides would carry different tensions and the neat cancellation would be lost. [4]