inkMaths

ANSWER BOOK

Forces and Newton's laws

Mechanics · Year 12–13

6 questions · 21 marks

NAVY EDITION

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SECTION A · Warm-up

A1 A body keeps a constant velocity unless a resultant force acts on it. Steady speed in a straight line therefore means zero resultant, so the driving force exactly balances the resistances. The car's speed is irrelevant to that conclusion. Fast and steady needs no more resultant force than slow and steady. B1 for the law, B1 for the zero resultant. [2]

A2 $F = ma$ applies to the resultant, so $D - 500 = 1000 \times 2$ and $D = 2500$ N. The engine has two jobs, causing the acceleration and paying off the resistance. Forgetting the second gives 2000 N and loses the accuracy mark. M1 for the equation of motion, A1 for 2500 N. [2]

SECTION B · Standard

B1 Along the motion the resultant is $42 - 12 = 30$ N, so $a = 30/6 = 5$ m s^{-2}. Vertically the crate neither rises nor falls, so $R = mg = 6 \times 9.8 = 58.8$ N. The two directions are handled separately, and the vertical equation is an equilibrium even though the crate is accelerating horizontally. M1 for the horizontal resultant, A1 for $a = 5$, M1 for $R = mg$, A1 for 58.8 N. Draw the force diagram before writing either equation; the four forces on it are the first mark. [4]

B2 Take upwards as positive. Accelerating up, $R - mg = ma$ gives $R = 70(9.8 + 1.5) = 791$ N, heavier than the true weight of 686 N. Accelerating down, $mg - R = ma$ gives $R = 70(9.8 - 1.5) = 581$ N, lighter. The scales read the normal reaction, not the weight, and the reaction is whatever $F = ma$ demands. Both answers must straddle 686 N; if they do not, a sign has gone wrong. M1 for $R - mg = ma$, A1 for 791 N, M1 for $mg - R = ma$, A1 for 581 N. [4]

B3 The partner is the push of the book down on the table. Same type of force, same magnitude, opposite direction, acting on the other body. The weight's own partner is the gravitational pull of the book on the Earth. Reaction and weight act on the same body and can differ in size, as they do in a lift, so they fail both tests for a third-law pair. B1 for naming the partner, B1 for the weight's own partner, B1 for the reason the pairing fails. [3]

SECTION C · Stretch

C1 On the level, $v^2 = u^2 + 2as$ gives $0 = 400 + 100a$, so $a = -4$ m s^{-2} and the braking force is $F = 900 \times 4 = 3600$ N against the motion. On the slope the weight now has a component down the hill of $900 \times 9.8 \times \sin 5° = 769$ N, which works with the car. Taking down the slope as positive, $769 - 3600 = 900a$ gives $a = -3.15$ m s^{-2}. Then $0 = 400 + 2(-3.15)s$, so $s = 63.6$ m. M1 A1 for the suvat step and the braking force, M1 for resolving the weight along the slope, A1 for the new acceleration, M1 A1 for the stopping distance. Two ideas are being tested at once. Suvat supplies the acceleration and Newton's second law prices it in force. On the slope, only the component $mg \sin \theta$ acts along the motion, and the fact that the car takes 13.6 m longer to stop is the whole point of the question. [6]