inkPhysics

ANSWER BOOK

Moments and equilibrium

Mechanics · Year 12

AQA 3.4.1.2 · CIE 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2
OCR A 3.2.3(a), 3.2.3(b), 3.2.3(c), 3.2.3(d), 3.2.3(e)

19 questions · 58 marks

NAVY EDITION

SECTION A · Warm-up

A1 Moment = force × perpendicular distance from the pivot to the line of action of the force (1). Unit: newton metre, N m (1). [2]

A2 Moment = 15 × 0.40 (1)
Moment = 6.0 N m (1) [2]

A3 For a body in equilibrium, the sum of the clockwise moments about any point (1) equals the sum of the anticlockwise moments about that point (1). [2]

SECTION B · Standard

B1 Clockwise moment = anticlockwise moment: 2.0 × 0.20 = 4.0 × d (1) [3]
d = (2.0 × 0.20)/4.0 (1)
d = 0.10 m to the right of the pivot (1)

B2 Clockwise moment = anticlockwise moment: 300 × 1.2 = 450 × d (1) [3]
d = (300 × 1.2)/450 (1)
d = 0.80 m (1)

B3 Taking moments about A: R_B × 4.0 = 120 × 2.0 + 200 × 1.0 (1) [4]
R_B = 110 N (1)
Vertically: R_A = (120 + 200) - 110 (1)
R_A = 210 N (1)

B4 This is a couple (1) [3]
Its moment (torque) = one force × the separation = 8.0 × 0.25 (1)
Moment = 2.0 N m (1)

SECTION C · Stretch

C1 Moments about the hinge: T × 2.0 = 40 × 1.0 (1) [4]
T = 20 N (1)
Vertically: hinge force = 40 - 20 (1)
Hinge force = 20 N upwards (1)

C2 The centre of mass is (0.65 - 0.40) = 0.25 m from the pivot (1) [4]
Moments about the pivot: 2.0 × 0.40 = W × 0.25 (1)
W = 0.80 / 0.25 (1)
W = 3.2 N (1)

C3 The moment of the applied force equals force × perpendicular distance from the hinge (1). Placing the handle far from the hinge maximises that distance (1), so a smaller force produces the moment needed to open the door (1). [3]

SECTION A · Warm-up

A4 Moment = 300 × 0.17 (1) = 51 N m (1). [2]

A5 The resultant force on the body is zero (1). The resultant moment about any point is zero (1). [2]

A6 The perpendicular distance from the pivot to the line of action is zero, so the moment F × d is zero (1). [1]

SECTION B · Standard

B5 Perpendicular distance = 0.240 sin 55° (240 mm converted to m) (1). Moment = 90 × 0.240 × sin 55° (1) = 17.7 N m (1). [3]

B6 The rule is uniform, so its weight 1.18 N acts at the 50.0 cm mark, 0.150 m from the pivot (1). Moments about the pivot: W × 0.300 = 1.18 × 0.150 (1), so W = 0.59 N (1). Mass = W/g = 60 g (0.060 kg) (1). [4]

B7 Moments about the pivot: F × 0.045 = 120 × 0.55 (1), so F = 66/0.045 (1) = 1467 N ≈ 1.5 kN (1). [3]

SECTION C · Stretch

C4 Taking moments about A with the decorator a distance x from A: R_B × 3.0 = 150 × 1.5 + 720x (1). With x = 3.0 m, R_B = 795 N, which exceeds 600 N, so the decorator cannot reach B (1). Setting R_B = 600 N: 600 × 3.0 = 225 + 720x (1), so x = 2.2 m from A (1). [4]

C5 The component of the tension perpendicular to the bar is T sin 30°, acting 1.2 m from the hinge (1). Moments about the hinge: T sin 30° × 1.2 = 35 × 0.60 + 90 × 1.0 (1), so 0.60T = 111 N m (1), giving T = 185 N (1). [4]

C6 Place the rule on the pivot away from its centre and position the 50 g mass on the shorter side, adjusting until the rule balances horizontally (1). Measure the distance d_1 from the pivot to the centre of the 50 g mass, and the distance d_2 from the pivot to the 50.0 cm mark (1). The weight of a uniform rule acts at its centre of mass, the 50.0 cm mark (1). By the principle of moments: $0.050g \times d_1 = mg \times d_2$, so $m = 0.050\, d_1/d_2$ (g cancels) (1). Repeat with the pivot at different positions and average the values of m to reduce random error (1). [5]