InkPhysics

ANSWER BOOK

Scalars and vectors

Mechanics · Year 12

AQA 3.4.1.1 · CIE 1.4.1, 1.4.2, 1.4.3, 4.2.3 · OCR A 2.3.1(a), 2.3.1(b), 2.3.1(c), 2.3.1(d), 3.2.3(f)

20 questions · 66 marks

NAVY EDITION

SECTION A · Warm-up

A1 Scalars: distance, energy, temperature, speed (2). Vectors: velocity, momentum, force, displacement (2). One mark for each two correct. [4]

A2 A scalar has magnitude only; a vector has magnitude and direction (1). Example scalar: speed (or energy, distance); example vector: velocity (or force) (1). [2]

A3 Along one line vectors add with sign: 9.0 - 4.0 (1)
5.0 N, to the right (1) [2]

SECTION B · Standard

B1 $R = \sqrt{3.0^2 + 4.0^2}$ (1) [4]
$R = 5.0$ N (1)
$\tan\theta = 4.0/3.0$ (1)
$\theta = 53°$ from the 3.0 N force (1)

B2 Horizontal component = 12.0 cos 30°, vertical = 12.0 sin 30° (1) [3]
Horizontal: 10.4 N (1)
Vertical: 6.0 N (1)

B3 Horizontal component = 60 cos 25°, vertical = 60 sin 25° (1) [3]
Horizontal: 54.4 m s^{-1} (1)
Vertical: 25.4 m s^{-1} (1)

B4 (a) Distance is the path length: 3.0 + 4.0 = 7.0 km (1) [4]
(b) $\sqrt{3.0^2 + 4.0^2} = 5.0$ km (1)
(c) $\tan\theta = 3.0/4.0$ east of north (1)
Bearing 37° (1)

B5 Parallel: 20 sin 35° = 11.5 N (1) [4]
Perpendicular: 20 cos 35° = 16.4 N (1)
Check: $\sqrt{11.5^2 + 16.4^2}$ (1)
= 20 N, the original weight (1)

SECTION C · Stretch

C1 The third force balances the resultant of the other two (1) [4]
Magnitude = $\sqrt{(6.0^2 + 8.0^2)}$ (1)
= 10 N (1)
Directed opposite the resultant: bearing 217° (1)

C2 Along the 8.0 N direction: 8.0 + 5.0 cos 60° = 10.5 N (1) [5]
Perpendicular: 5.0 sin 60° = 4.33 N (1)
R = $\sqrt{(10.5^2 + 4.33^2)}$ (1)
R = 11.4 N (1)
At 22° to the 8.0 N force (1)

C3 Drawn head to tail the three forces close a triangle, so their vector sum is zero and equilibrium is possible (1). Since $5^2 + 12^2 = 13^2$, the triangle is right-angled (1): the angle between the 5.0 N and 12 N forces is 90° (1). [3]

SECTION A · Warm-up

A4 The resultant force (the vector sum of the three forces) is zero (1). [1]

A5 Distance = 8.0 + 6.0 = 14.0 km (1). Displacement = 8.0 - 6.0 = 2.0 km due north (1). [2]

A6 (a) 180° (the forces are opposite and cancel) (1). (b) 0° (the forces are in the same direction and add to 14 N) (1). [2]

SECTION B · Standard

B6 (a) R = $\sqrt{(1.4^2 + 0.50^2)}$ (1) = 1.5 m s^{-1} (1). (b) The crossing depends only on the component across the river: t = 42/1.4 = 30 s (1). (c) x = 0.50 × 30 = 15 m downstream (1). [4]

B7 Resolving vertically: 2T sin 55° = 24 (1). T = 24/(2 sin 55°) (1) = 14.6 N (1). [3]

B8 The components perpendicular to the canal are equal and opposite, so they cancel; only the components along the canal remain (1). R = 2 × 850 × cos 25° (1) = 1541 N ≈ 1.5 kN (1). [3]

SECTION C · Stretch

C4 Resolving vertically: $2T \sin 12° = 1800$ (1). $T = 1800/(2 \sin 12°) = 4329$ N ≈ 4.3 kN (1). Comparison: 4.3 kN is less than the 4.5 kN limit (1), so the tension is safe, though with a margin of only about 171 N; a smaller sag angle would exceed the limit (1). [4]

C5 East component: $4.0 + 3.0 \sin 30° = 5.5$ km (1); north component: $3.0 \cos 30° = 2.60$ km (1). Magnitude $= \sqrt{(5.5^2 + 2.60^2)} = 6.1$ km (1). Bearing: $\tan \theta = 5.5/2.60$ east of north, giving 65°, bearing 065° (1). [4]

C6 (a) Constant speed means equilibrium along the slope, so the tension balances the weight component: $T = W \sin \theta$ (1). $T = 620 \sin 20° = 212$ N ≈ 210 N (1). (b) At the limit $260 = 620 \sin \theta$ (1), so $\sin \theta = 0.419$ (1), giving $\theta = 25°$ (1). [5]