



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). [2]
Example scalar: speed (or energy, distance); example vector: velocity (or force) (1).
- A3** Along one line vectors add with sign: $9.0 - 4.0$ (1) [2]
5.0 N, to the right (1)

SECTION B · Standard

- B1** $R = \sqrt{(3.0^2 + 4.0^2)}$ (1) [4]
 $R = 5.0 \text{ N}$ (1)
 $\tan \theta = 4.0/3.0$ (1)
 $\theta = 53^\circ$ from the 3.0 N force (1)
- B2** Horizontal component = $12.0 \cos 30^\circ$, vertical = $12.0 \sin 30^\circ$ (1) [3]
Horizontal: 10.4 N (1)
Vertical: 6.0 N (1)
- B3** Horizontal component = $60 \cos 25^\circ$, vertical = $60 \sin 25^\circ$ (1) [3]
Horizontal: 54.4 m s^{-1} (1)
Vertical: 25.4 m s^{-1} (1)
- B4** (a) Distance is the path length: $3.0 + 4.0 = 7.0 \text{ km}$ (1) [4]
(b) $\sqrt{(3.0^2 + 4.0^2)} = 5.0 \text{ km}$ (1)
(c) $\tan \theta = 3.0/4.0$ east of north (1)
Bearing 37° (1)
- B5** Parallel: $20 \sin 35^\circ = 11.5 \text{ N}$ (1) [4]
Perpendicular: $20 \cos 35^\circ = 16.4 \text{ N}$ (1)
Check: $\sqrt{(11.5^2 + 16.4^2)}$ (1)
 $= 20 \text{ N}$, 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)
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- C2** Along the 8.0 N direction: $8.0 + 5.0 \cos 60^\circ = 10.5$ N (1) [5]
 Perpendicular: $5.0 \sin 60^\circ = 4.33$ 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)
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- C3** Drawn head to tail the three forces close a triangle, so their vector sum is zero [3]
 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).
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SECTION A · Warm-up

- A4** The resultant force (the vector sum of the three forces) is zero (1). [1]
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- A5** Distance = $8.0 + 6.0 = 14.0$ km (1). Displacement = $8.0 - 6.0 = 2.0$ km due north [2]
 (1).
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- A6** (a) 180° (the forces are opposite and cancel) (1). (b) 0° (the forces are in the [2]
 same direction and add to 14 N) (1).
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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 [4]
 component across the river: $t = 42/1.4 = 30$ s (1). (c) $x = 0.50 \times 30 = 15$ m downstream
 (1).
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- B7** Resolving vertically: $2T \sin 55^\circ = 24$ (1). $T = 24/(2 \sin 55^\circ)$ (1) = 14.6 N (1). [3]
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- B8** The components perpendicular to the canal are equal and opposite, so they [3]
 cancel; only the components along the canal remain (1). $R = 2 \times 850 \times \cos 25^\circ$ (1) = 1541
 N ≈ 1.5 kN (1).
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SECTION C · Stretch

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- C4** Resolving vertically: $2T \sin 12^\circ = 1800$ (1). $T = 1800 / (2 \sin 12^\circ) = 4329 \text{ N} \approx 4.3 \text{ kN}$ (1). [4]
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).
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- C5** East component: $4.0 + 3.0 \sin 30^\circ = 5.5 \text{ km}$ (1); north component: $3.0 \cos 30^\circ = 2.60 \text{ km}$ (1). Magnitude = $\sqrt{5.5^2 + 2.60^2} = 6.1 \text{ km}$ (1). Bearing: $\tan \theta = 5.5/2.60$ east of north, giving 65° , bearing 065° (1). [4]
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- C6** (a) Constant speed means equilibrium along the slope, so the tension [5]
balances the weight component: $T = W \sin \theta$ (1). $T = 620 \sin 20^\circ = 212 \text{ N} \approx 210 \text{ N}$ (1). (b) At the limit $260 = 620 \sin \theta$ (1), so $\sin \theta = 0.419$ (1), giving $\theta = 25^\circ$ (1).
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