

## 4.1 Vectors in mechanics

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 25 marks

KEY WORDS bearing • resultant

### Vectors in mechanics

#### Objective

Work with displacements, velocities and forces as vectors in  $\mathbf{i}, \mathbf{j}$  form: magnitudes, resultants, position vectors at time  $t$ , relative position, and bearings (objectives 2.1–2.2).

#### 1 Key knowledge and worked examples

**Toolkit.**  $|a\mathbf{i} + b\mathbf{j}| = \sqrt{a^2 + b^2}$ . Resultants add component-wise. Position at time  $t$ :  $\mathbf{r}(t) = \mathbf{r}_0 + t\mathbf{v}$  for constant velocity, built from any known instant. Bearings are clockwise from north: with  $\mathbf{i}$  east and  $\mathbf{j}$  north, the vector  $x\mathbf{i} + y\mathbf{j}$  with  $x < 0, y < 0$  points south-west, at  $\tan^{-1}(|x/y|)$  west of due south.

**Worked example – position vectors and a bearing (WME01 June 2025 Q2).** A has  $\mathbf{r}_A(2) = -5\mathbf{i} + 16\mathbf{j}$ ,  $\mathbf{r}_A(5) = 10\mathbf{i} + 4\mathbf{j}$ : velocity  $= \frac{15\mathbf{i} - 12\mathbf{j}}{3} = 5\mathbf{i} - 4\mathbf{j}$ , and  $\mathbf{r}_A(t) = (5t - 15)\mathbf{i} + (24 - 4t)\mathbf{j}$ . B sits at  $-5\mathbf{i} + 7\mathbf{j} + t(2\mathbf{i} - 3\mathbf{j})$ ; at  $t = 5$ ,  $\overrightarrow{AB} = -5\mathbf{i} - 12\mathbf{j}$ , which is  $22.6^\circ$  west of south – bearing  $203^\circ$ .

#### 2 Practice

**2.1** Find the magnitude of the velocity  $3\mathbf{i} - 4\mathbf{j} \text{ m s}^{-1}$  and the bearing on which the particle moves. [3]

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**2.2** Forces  $(2\mathbf{i} + \mathbf{j})$  N and  $(4\mathbf{i} - 3\mathbf{j})$  N act on a particle. Find the magnitude and direction of the resultant force. [3]

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**2.3** A particle has position vector  $3\mathbf{i} - 2\mathbf{j}$  m when  $t = 1$  and  $12\mathbf{i} + 7\mathbf{j}$  m when  $t = 4$ . Find its velocity and its position vector at time  $t$  seconds. [4]

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**2.4** Find the value of  $\lambda$  for which  $\lambda\mathbf{i} + 2\mathbf{j}$  is perpendicular to  $3\mathbf{i} - 4\mathbf{j}$ . [3]

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### 3 Exam-style questions

**3.1** (*Edexcel IAL WME01 June 2025 Q2.*) At time  $t$  seconds, the position vector of particle A is  $\mathbf{r}$  metres. When  $t = 2$ ,  $\mathbf{r} = (-5\mathbf{i} + 16\mathbf{j})$ ; when  $t = 5$ ,  $\mathbf{r} = (10\mathbf{i} + 4\mathbf{j})$ . Particle B has position vector  $\mathbf{s} = -5\mathbf{i} + 7\mathbf{j} + t(2\mathbf{i} - 3\mathbf{j})$  metres. (a) Find the velocity of A. (b) Find  $\mathbf{r}$  in terms of  $t$ . (c) Find the bearing of B from A when  $t = 5$ , giving your answer to the nearest degree. [7]

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**3.2** (*Original.*) A ship leaves the point with position vector  $(2\mathbf{i} - \mathbf{j})$  km and moves with constant velocity  $(3\mathbf{i} + 4\mathbf{j})$  km h<sup>-1</sup>, where  $\mathbf{i}$  and  $\mathbf{j}$  point east and north. (a) Find the bearing of the ship from the origin at the moment it leaves. (b) Find  $t$  when the ship is due east of the origin, and its distance from the origin then. [5]

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