Trigonometry and vectors for physics

35–40 minutes independent work + 15–20 minutes review | 34 marks

AQA A Level 7408 and OCR A A Level H556 | Mathematical skills

Skills practised and specification links

Choose trig ratios from the angle; resolve signed components; construct a vector triangle; solve force balances and calculate work by an angled force.
AQA maths MS 0.6, 2.3–2.4, 4.1–4.2, 4.4–4.5; selected applications 3.4.1.1, 3.4.1.7.
OCR A maths M0.6, M2.3–M2.4, M4.1–M4.2, M4.4–M4.5; 2.3.1(a)–(d); 3.2.1(c)–(e); 3.2.3(f); 3.3.1(a)–(b).

An inspection team uses cables and an access rail. Each stage is a separate test. Use a ruler, protractor and calculator in degree mode; g = 9.81 m s^{-2}. Figures are schematic: use the stated values.

1 Read the angle before choosing sin or cos [3 marks]

Locate the angle in a right triangle: adjacent = F cos θ; opposite = F sin θ. Retain component signs and check the quadrant after using inverse trig.

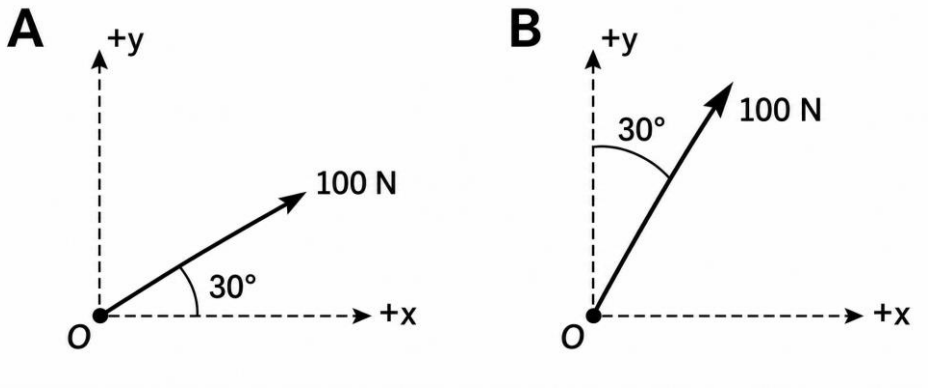


Figure 1 Two positioning forces: the same angle is measured from different axes.

(a) Calculate the horizontal component of the 100 N force in panel A. [1 mark]

(b) Calculate the horizontal component of the 100 N force in panel B. [1 mark]

(c) A technician reports a 112 N horizontal component for a 100 N force. Explain why this is impossible. [1 mark]

2 Resolve the pod’s support force [6 marks]

In a separate test, an inspection pod is held at rest by a support cable and a horizontal control rope. Cable tension T = 1.20 kN acts upward and left, at 25.0° to the vertical. The control rope pulls horizontally right with force H. The only other force is the pod’s weight W. Take right as +x and up as +y.

(a) Draw a labelled free-body diagram of the pod. Include all three forces and the 25.0° angle. [2 marks]

(b) Calculate the signed horizontal component T_x, in newtons. [1 mark]

(c) Calculate the signed vertical component T_y, in newtons. [1 mark]

(d) In a new setup, $T_y = 0.800T$. Find the acute angle β between the cable and the vertical. [1 mark]

(e) Explain why both perpendicular components cannot each have magnitude T. [1 mark]

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

3 Construct a resultant for two oblique forces [5 marks]

During a positioning trial, two horizontal-plane forces act on a ring: F_1 = 400 N along +x, and F_2 = 300 N at 120° anticlockwise from +x. Here +y is the perpendicular direction in the same plane. For part (a), use a scale of 1.0 cm to 50 N.

A vector may be translated without rotating it. Draw the second arrow from the head of the first, keeping its direction relative to +x. The resultant runs from the first tail to the final head.

(a) Draw a head-to-tail scale construction and use it to estimate the resultant's magnitude. [2 marks]

(b) A logger reports the resultant's perpendicular components as R_x = +250 N and R_y = +260 N. Calculate its magnitude from these components. [1 mark]

(c) Use the logger's components to find the resultant's direction relative to +x. [1 mark]

(d) Explain why adding 400 N and 300 N to obtain 700 N gives the wrong resultant magnitude here. [1 mark]

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

4 Find the tensions in the platform supports [7 marks]

Figure 3 shows the upper suspension ring O. Treat the ring as a particle of negligible weight at rest. Upper cables A and B are at 40.0° and 45.0° to the horizontal. The lower link transmits ONE load force L to the ring, with components L_x = +250 N and L_y = −1200 N. Thus only three forces act on O: T_A, T_B and L. Take right and up as positive.

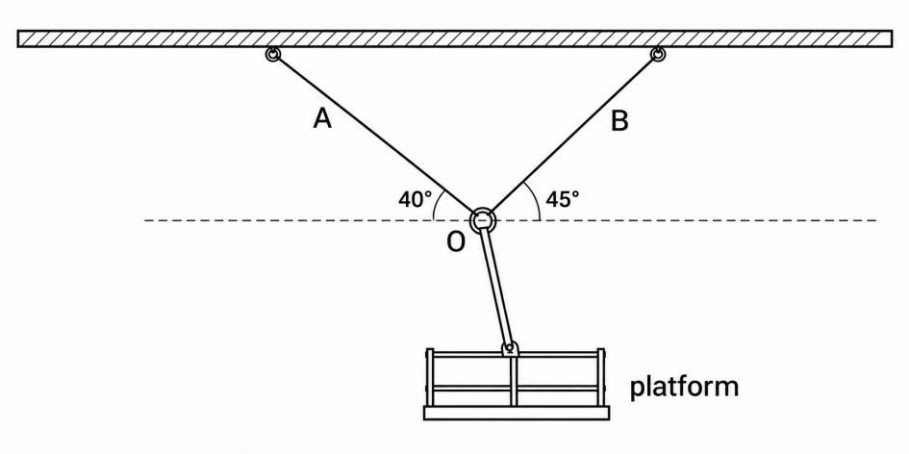


Figure 3 Forces on the ring are transmitted along its three connections; schematic.

(a) Write the horizontal equilibrium equation in terms of T_A and T_B. [1 mark]

(b) Write the vertical equilibrium equation. [1 mark]

(c) Use cos 45° = sin 45° to eliminate T_B, then calculate both tensions. [2 marks]

(d) Check your tensions by substituting them into both signed component balances. [1 mark]

(e) Available cables have permitted working tensions of 0.950 kN or 1.20 kN. Select the smallest rating suitable for both upper cables and justify it. [2 marks]

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

5 Resolve forces on the access rail [8 marks]

A separate 40.0 kg inspection carriage moves uphill at constant velocity along the straight frictionless rail in Figure 4, inclined at 18.0° to the horizontal. Its pulling force P acts at 10.0° above the uphill rail direction, away from the rail. The normal contact force has magnitude R. Air resistance is negligible.

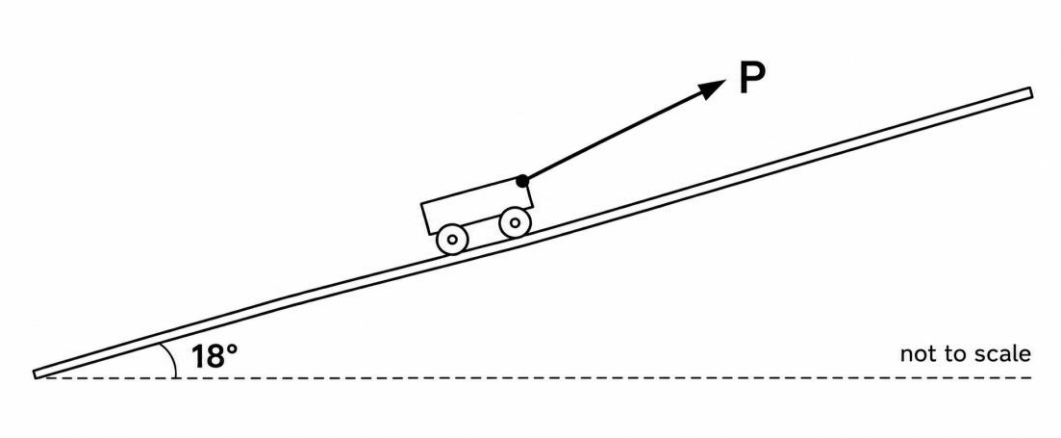


Figure 4 The pull is 10.0° above the rail, as specified in the text; schematic.

(a) Sketch axes parallel and perpendicular to the rail, then a weight-component triangle. Find the weight components down the rail and into it. [2 marks]

(b) Use the balance along the rail to calculate P. [2 marks]

(c) Use the perpendicular balance to calculate R. Explain why R is less than mg cos 18°. [2 marks]

(d) Calculate the work done by P over 4.00 m uphill. Explain why P × 4.00 m would be incorrect. [2 marks]

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk

6 Diagnose the vector mistakes [5 marks]

(a) A pupil draws a tension T and both its perpendicular components as three independent forces on the same object. Sketch a correct component representation and explain the error. [2 marks]

(b) Another force has $F_x = -120$ N and $F_y = +160$ N. A calculator gives $\tan^{-1}(160/-120) = -53.1°$. Give its correct direction anticlockwise from +x and explain the quadrant. [2 marks]

(c) A pupil proposes a “horizontal component” of the carriage’s kinetic energy. Explain why this is not a valid vector resolution. [1 mark]

Final check Locate the angle, choose axes, retain component signs, name the direction and check the magnitude and units.

Continue your physics journey
Videos, practice and support for your next step
www.physicsuk.co.uk