

Force diagrams and vector resultants

AQA GCSE Combined Science Trilogy 8464 and Separate Physics 8463 | Paper 2 | F/H pathways

Worked answers | 28 parts and 43 marks per pathway | 34 printed parts

Specification points covered

8463 4.5.1.1 and 4.5.1.2 / 8464 6.5.1.1 and 6.5.1.2: vectors and interactions
8463 4.5.1.3 / 8464 6.5.1.3: weight and gravitational field strength
8463 4.5.1.4 / 8464 6.5.1.4: resultants; free-body and 2D drawings Higher only
8463 4.5.6.2.3 / 8464 6.5.4.2.3: Newton's Third Law and force pairs

A harbour team uses ropes to position a floating service platform. You will check force records and explain which objects interact. Each trial is separate. The upward contact force from water is called upthrust; no fluid-pressure calculations are needed.

Original PhysicsUK practice, not an official AQA resource. Foundation: pages 1–5. Higher: pages 1–4 and 6–7. Each route has 28 parts and 43 marks. Credit equivalent correct wording and sensible follow-through. For Higher, check the construction, arrowheads, scale and an angle referenced to east. Use the written construction steps with Figure 3.

1 Checking the quantities

The unloaded service platform has total mass 600 kg. Its equipment is included in that figure. The toolbox mentioned in 1(d) is a separate item, not part of the 600 kg.

1(a) What two features must be specified to describe a force as a vector? **[1 mark]**

Answer / mark points: Magnitude/size and direction. [1 for both] A force value alone is incomplete.

1(b) What is meant by the resultant force on an object? **[1 mark]**

Answer / mark points: The single force that has the same effect as all the forces acting on that object together. [1]

1(c) Calculate the weight of the 600 kg unloaded platform. **[1 mark]**

Answer / mark points: $W = mg = 600 \times 9.8 = 5880 \text{ N}$, downwards. [1]

1(d) A toolbox is labelled “weight = 12 kg”. Explain the error and calculate its weight. **[2 marks]**

Answer / mark points: 12 kg is its mass; weight is a force measured in N. [1]
 $W = 12 \times 9.8 = 117.6 \text{ N}$, downwards. [1] Accept about 118 N.



2 Adding forces on the platform

Figure 1 shows the platform from above. In this trial, the rope exerts 400 N east on the platform and the water exerts a 150 N west drag force on it. These are the only horizontal forces. Consider the horizontal forces only.

2(a) Add the two horizontal force arrows to Figure 1. Show their directions and label each with its force name and magnitude. **[2 marks]**

Answer / mark points: One arrow east/right ON the platform, labelled tension/rope force 400 N. [1]
One arrow west/left ON the platform, labelled water drag/resistance 150 N. [1] No vertical or resultant arrow is required.

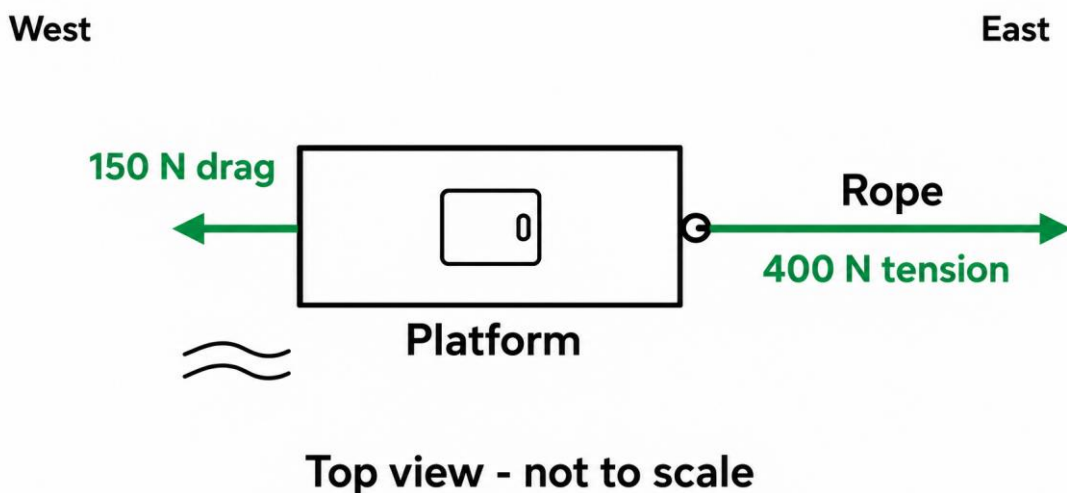


Figure 1

2(b) Calculate the horizontal resultant force on the platform. Include its direction. **[1 mark]**

Answer / mark points: $400 - 150 = 250$ N east. [1 for magnitude and direction]

2(c) The platform also pulls west on the rope. Why must that force not be added when finding the resultant ON THE PLATFORM? **[1 mark]**

Answer / mark points: It acts on the rope, not on the platform. [1] Only forces on the selected body belong in its resultant.

2(d) In a separate trial, the only horizontal forces are a rope force east and a 150 N water force west. What eastward rope force would give zero horizontal resultant? **[1 mark]**

Answer / mark points: 150 N east. [1] The two platform forces then balance.

2(e) In another trial the rope force is 100 N east and water drag is 150 N west. Calculate the horizontal resultant, including direction. **[1 mark]**

Answer / mark points: $150 - 100 = 50$ N west. [1] Opposing forces subtract; do not automatically give the rope's direction.

2(f) Classify the rope force and Earth's gravitational force as contact or non-contact forces. Explain each choice. **[2 marks]**

Answer / mark points: Tension is a contact force: rope and platform touch/interact through their attachment. [1]

Gravity is non-contact: Earth attracts the platform through its gravitational field without physical contact. [1]



3 Comparing the towing records

Table 1 gives the only two horizontal forces ON THE PLATFORM in three separate trials. The first force is eastwards and the second westwards. All values are magnitudes.

Table 1

Trial	Rope force east / N	Water force west / N
A	500	200
B	300	300
C	200	350

3(a) Calculate the resultant force in trial A. Include its direction. **[1 mark]**

Answer / mark points: $500 - 200 = 300$ N east. [1]

3(b) Calculate the resultant force in trial B. **[1 mark]**

Answer / mark points: $300 - 300 = 0$ N. [1] A zero vector has no direction.

3(c) Calculate the resultant force in trial C. Include its direction. **[1 mark]**

Answer / mark points: $350 - 200 = 150$ N west. [1]

3(d) A trainee says that trial B has no forces acting because its resultant is zero. Use the table to explain why this is wrong. **[2 marks]**

Answer / mark points: Two non-zero forces, each 300 N, act on the platform. [1]
They have opposite directions and balance, giving zero resultant. [1] Zero resultant is not absence of forces.

3(e) In trial A the rope force is halved but water resistance stays 200 N west. Calculate the new resultant and explain why it is not half the original resultant. **[2 marks]**

Answer / mark points: New rope force = 250 N east; resultant = $250 - 200 = 50$ N east. [1]
Only the rope force was halved; the opposing 200 N was not, so the resultant is not simply halved. [1]

3(f) The log records the trial C resultant as "150 N". What information must be added to make this a complete vector description? **[1 mark]**

Answer / mark points: Its direction: west. [1] Do not add another unit instead of the missing direction.



4 Identifying interaction partners

Use Newton's Third Law. Name the body exerting the force and the body receiving it. For the unloaded platform, its downward weight and upward water force are each 5880 N.

4(a) A crew member's hand pulls west on a rope with 350 N. State the magnitude and direction of the force the rope exerts on the hand. **[2 marks]**

Answer / mark points: 350 N [1], eastwards [1], acting on the hand. These are forces between the same two interacting bodies, on different bodies.

4(b) The rope pulls east on the platform with 400 N. Describe its Newton's Third Law partner, stating both objects and the magnitude and direction. **[2 marks]**

Answer / mark points: The platform exerts a force on the rope. [1]
It is 400 N westwards, equal in size and opposite in direction. [1] It is not a water force.

4(c) Earth pulls down on the unloaded platform with 5880 N. Describe the Third Law partner to this gravitational force. **[2 marks]**

Answer / mark points: The platform gravitationally attracts Earth. [1]
That force is 5880 N, towards the platform/opposite to Earth's pull on the platform. [1] Accept "upwards on Earth" in this local side view; the receiving body must be Earth, not the water.

4(d) Why are the platform's 5880 N weight and 5880 N upthrust a pair of balancing forces but NOT a Newton's Third Law pair? **[2 marks]**

Answer / mark points: Both act on the same platform, in opposite directions with equal magnitude, so they balance. [1]
A Third Law pair acts on two different bodies in one interaction; these forces come from different Earth–platform and water–platform interactions. [1]

4(e) A trainee claims the platform can pull harder on the rope than the rope pulls on the platform. State whether this is possible for that interaction and give the relevant reason. **[1 mark]**

Answer / mark points: No: the two forces in that interaction are always equal in magnitude by Newton's Third Law. [1] The forces need not be balancing forces on one object.

4(f) During a docking test, a magnet on the platform attracts an iron buoy with 180 N west. State the force the buoy exerts on the magnet and classify this interaction as contact or non-contact. **[2 marks]**

Answer / mark points: 180 N east on the magnet. [1 for magnitude, direction and receiving object]
Magnetic/non-contact. [1] There is no need for the magnet and buoy to touch.



5 Foundation replacement section

Foundation: complete this page after sections 1–4, then stop. Higher pupils skip it. In a separate trial, two ropes exert 250 N east and 150 N east on the platform. Water drag is 180 N west.

5(a) Calculate the combined eastward force of the two ropes. [1 mark]

Answer / mark points: $250 + 150 = 400$ N east. [1]

5(b) Include the 180 N west drag and calculate the horizontal resultant. [1 mark]

Answer / mark points: $400 - 180 = 220$ N east. [1]

5(c) A third horizontal rope force is added to make the resultant zero. State its magnitude and direction. [2 marks]

Answer / mark points: 220 N [1], west [1]. It balances the existing 220 N east resultant.

5(d) In the blank space, draw and label ONE arrow for a 300 N westward water force on the platform. Use a scale of 1.0 cm for 100 N. [2 marks]

Answer / mark points: Draw a straight arrow 3.0 cm long, measured from tail to tip. [1; accept 2.8–3.2 cm]

Arrowhead points west/left and label identifies water force/drag 300 N on the platform. [1] Only one arrow: this is a vector representation, not a formal free-body diagram.

5(e) Another pupil draws a 3.0 cm arrow EAST for that 300 N westward force. State what must change and what should stay the same. [2 marks]

Answer / mark points: Reverse the direction/arrowhead to west. [1]

Keep the 3.0 cm tail-to-tip length representing 300 N at the stated scale. [1] Correct magnitude does not compensate for a wrong direction.

5(f) The platform's total mass is increased from 600 kg to 800 kg. Calculate its new weight and the increase in upthrust needed to keep the vertical resultant zero. Explain the force balance. [3 marks]

Answer / mark points: New weight = $800 \times 9.8 = 7840$ N. [1]

For zero vertical resultant the upthrust must equal the new weight, 7840 N. [1]

Increase in upthrust = $7840 - 5880 = 1960$ N. [1] No fluid-pressure or displaced-volume equation is required.

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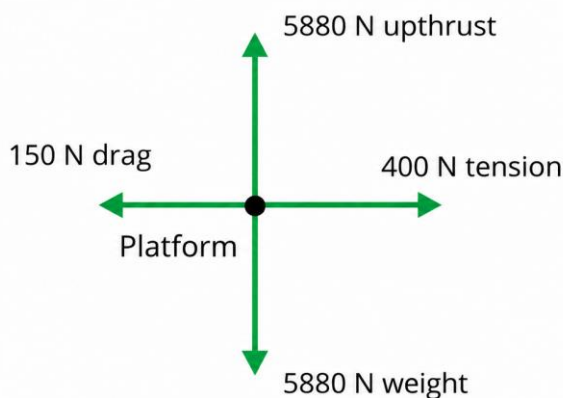


6 Higher only free body diagram

Higher only: complete sections 6–7 INSTEAD of section 5. Figure 2 represents the platform by a point, seen from the side. The rope force is 400 N right, water drag is 150 N left, weight is 5880 N down and upthrust is 5880 N up. There are no other forces in this model.

6(a) Complete Figure 2 as a free-body diagram. Show and label all four forces ON the platform. Do not add a separate resultant arrow. **[2 marks]**

Answer / mark points: Correct labelled horizontal pair: tension 400 N right, drag 150 N left. [1]
Correct labelled vertical pair: upthrust 5880 N up, weight 5880 N down. [1] Arrows start at the point and point outwards. Vertical forces balance; horizontal forces do not. This is qualitative, not a scale drawing.



Side view - not to scale

Figure 2

6(b) Why is “400 N west, platform on rope” not one of the four arrows in Figure 2? **[1 mark]**

Answer / mark points: It acts on the rope, not on the selected platform. [1] The Third Law partner acts on a different body.



7 Higher only scale construction

Higher only. This is a NEW TOP-VIEW trial: one rope pulls 300 N east and a second pulls 400 N north. Both horizontal forces act through the same point; ignore other horizontal forces and turning effects. On Figure 3, each grid square represents 100 N. Use scale drawing, not trigonometry. Measure angles from east.

7(a) Starting at O on Figure 3, draw the 300 N east and 400 N north forces head-to-tail to scale. Label both arrows and draw a single resultant arrow. **[2 marks]**

Answer / mark points: Define B three squares right of O on the bottom boundary; draw $O \rightarrow B$ east, labelled 300 N. [1]

C is four squares above B on the top boundary. Draw $B \rightarrow C$ north, labelled 400 N, and resultant $O \rightarrow C$, arrowhead at C. [1]

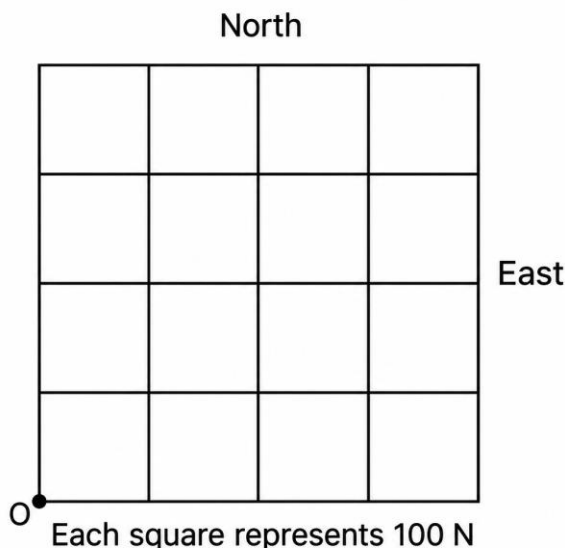


Figure 3

7(b) Use your drawing to determine the resultant magnitude and its angle north of east. Show the direction clearly. **[2 marks]**

Answer / mark points: Five square-side lengths give 500 N. [1; accept 490–510 N from a suitable drawing]

About 53° north of east. [1; accept $51\text{--}55^\circ$ referenced to east] “North-east” alone is insufficient. A vector diagram is required.

7(c) What single additional horizontal force through the same point would make the platform's horizontal resultant zero? Give its magnitude and direction. **[2 marks]**

Answer / mark points: 500 N. [1; allow consistent follow-through]

Opposite the resultant: about 53° south of west, or bearing 217° . [1] This balancing force is $C \rightarrow O$ in the force triangle.

7(d) A single diagonal rope force now replaces the two original pulls and has exactly the same effect. Use the drawing to state its eastward and northward components. **[2 marks]**

Answer / mark points: Eastward = 300 N. [1] Northward = 400 N. [1]

These components represent the single 500 N force; they are not extra physical forces alongside it.

Review and improve

A third-law pair acts on different objects; balancing forces act on the same object. Resolve or replace a force, not add its components as extra forces. Assign one tier pathway only. Timing is estimated and untried.

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