1.3 Vectors & Scalars

Mark Schemes

Course	DP IB Physics
Section	1. Measurement & Uncertainties
Topic	1.3 Vectors & Scalars
Difficulty	Medium

To be used by all students preparing for DP IB Physics HL
Students of other boards may also find this useful

1

The correct answer is **A** because:

- The length of a vector arrow represents the magnitude of the quantity represented
- Velocity has both magnitude (speed) in a given direction
    - Therefore, the length of its vector arrow represents the speed

B is incorrect as	magnitude is not a **quantity**, it is what the size of the vector arrow represents
C is incorrect as	acceleration is a vector itself, defined as the rate of change of velocity. Therefore, it cannot be represented by the magnitude of velocity
D is incorrect as	distance is the magnitude of a displacement vector. Therefore, it cannot be represented by the magnitude of velocity

This is a strange question but just requires you to understand that the length of a vector arrow represents its magnitude.

2

The correct answer is **B** because:

- Impulse is a vector:
    - Impulse is the change in **momentum**
    - Since momentum is a vector (it equal to the force × velocity, which are both vectors) therefore impulse is also a vector

- Current is a scalar:
  - Although current can sometimes we written as negative, this is just the convention we use for the direction of the current
  - Current addition follows the scalar addition and not vector addition
  - This means it is a scalar

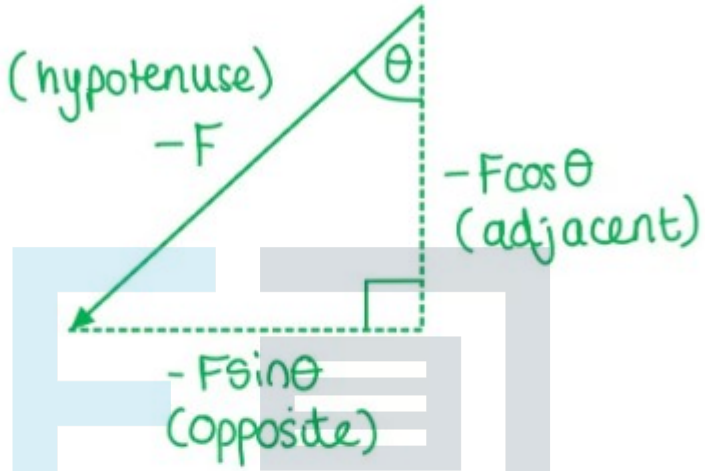
A is incorrect as	electric charge is a scalar and not a vector quantity, even though it can be negative. This however, is not necessarily the direction of the charge. Weight is a type of force, and so is a vector and not a scalar.
C is incorrect as	temperature is a scalar and not a vector. Temperature can be positive or negative. This represents the value of the thermal energy and not the **direction** of the thermal energy. Pressure is a vector quantity because it is the **force** per unit area. Since force is a vector quantity, so is pressure
D is incorrect as	time is a scalar and not a vector since it only has one direction (as far as we know...). Work done is equal to the force times distance, since force is a vector, so is work done. A negative work done normally implies work done against resistive forces.

Think carefully about these quantities about their properties. Try not to think of vectors and 'quantities that can be positive or negative' because as you have seen in this mark scheme, that is not always the case.

3

The correct answer is **A** because:

- According to the rules of trigonometry:
  - $-F$ is the hypotenuse



- The x-component is the opposite side of the right-angled triangle
  - opposite = sin θ × hypotenuse
  - opposite = $-F\sin\theta$
- The y-component is the adjacent side of the right angled triangle
  - adjacent = cos θ × hypotenuse
  - adjacent = $-F\cos\theta$

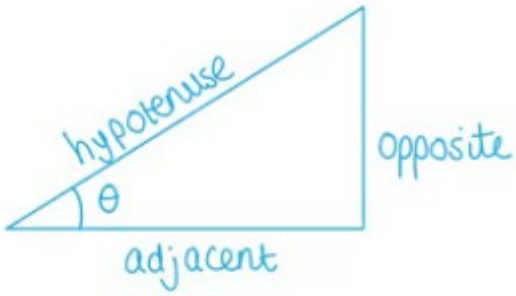
B is incorrect as	tanθ cannot be used to resolve the vector into components because $-F$ is the hypotenuse. $\tan\theta = \frac{\text{Opposite}}{\text{Adjacent}}$
C is incorrect as	the x-component should include $-F$ not just F
D is incorrect as	the x-component and y-component are the wrong way around

This question requires you to use your knowledge of trigonometry for maths, as studied at GCSE.

$$\sin\theta = \frac{opp}{hyp}$$

$$\cos\theta = \frac{adj}{hyp}$$

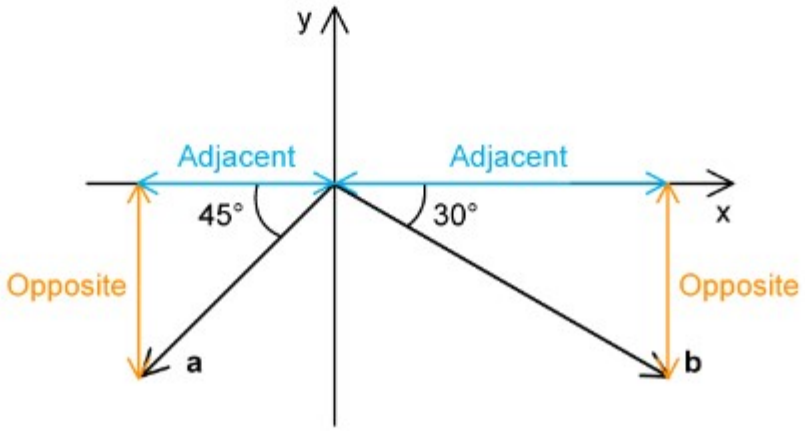
$$\tan\theta = \frac{opp}{adj}$$



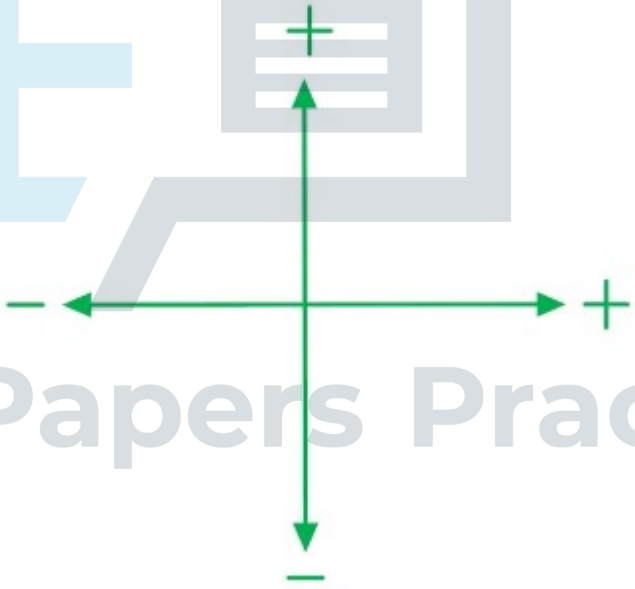
4

The correct answer is **C** because:

- Use the rules of trigonometry to label your diagram:
  - The horizontal component of the forces is calculated using cosine, as this is the adjacent side of the triangles
  - The vertical component of the forces is calculated using sine, as this is the opposite side of the triangles
- Annotate the diagram from the question with the correct sides of each triangle



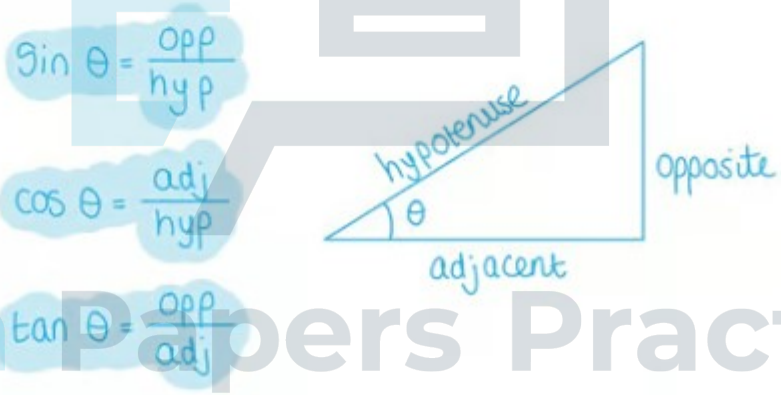
- Calculate the horizontal component of each force:
  - $\boldsymbol{a}\cos\theta = 15\cos(45) = 15 \times \frac{\sqrt{2}}{2} = 7.5\sqrt{2}$
  - $\boldsymbol{b}\cos\theta = 30\cos(30) = 15\sqrt{3}$
- Calculate the vertical component of each force:
  - $\boldsymbol{a}\cos\theta = 15\sin(45) = 15 \times \frac{\sqrt{2}}{2} = 7.5\sqrt{2}$
  - $\boldsymbol{b}\cos\theta = 30\sin(30) = 30 \times \frac{1}{2} = 15$
- Calculate the resultant force horizontally and vertically:
  - Consider the direction of each force
  - Use the directions from a graph axis to help



  - Overall horizontal component = horizontal component of $\boldsymbol{b}$ – horizontal component of $\boldsymbol{a} = 15\sqrt{3} - 7.5\sqrt{2}$
  - Overall vertical component is in the downward negative direction = –(vertical component of $\boldsymbol{b}$ + vertical component of $\boldsymbol{a}$) = – (15 + $7.5\sqrt{2}$)

A is incorrect as	both the vertical components of ***a*** and ***b*** act in the same direction so should both be $15\sqrt{3}$
B is incorrect as	***a*** and ***b*** are both forces, so the final answers are components of forces and measured in Newtons N and not degrees °
D is incorrect as	the horizontal component of the forces are the adjacent side of the triangle, so use cosine and not sine the vertical component of the forces are the opposite side of the triangle, so use sine and not cosine

This question requires you to use your knowledge of trigonometry for maths, as studied at GCSE.



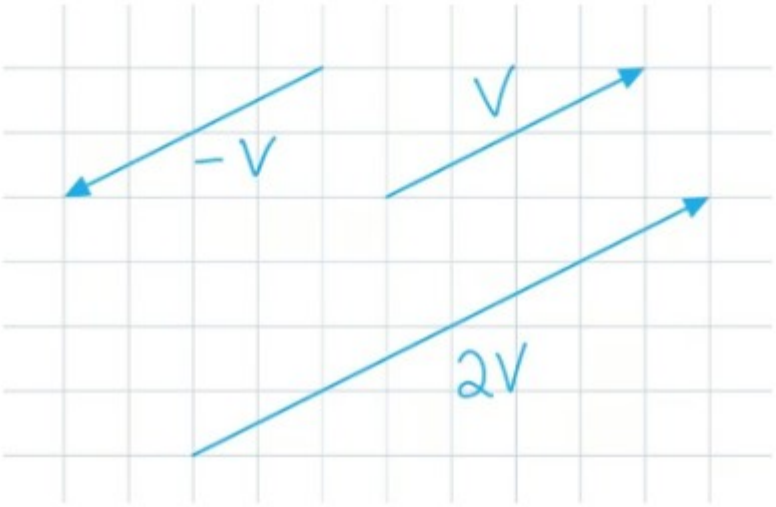
5

The correct answer is **C** because:

- A vector multiplied by a scalar changes the **magnitude** (length) of the vector only and **not** it's direction
  - The only direction it changes if it's in completely the opposite direction to which it started pointing in
- represents $\boldsymbol{p}$ multiplied by $-1 = -\boldsymbol{p}$ as it is a vector in completely the opposite direction
- represents $\boldsymbol{p}$ multiplied by $\frac{1}{2} = \frac{1}{2}\boldsymbol{p}$

A is incorrect as	1. is in a different direction to $\boldsymbol{p}$ so cannot be $\boldsymbol{p}$ multiplied by a scalar
B is incorrect as	both 2. and 4. $\boldsymbol{p}$ multiplied by a scalar and not just 2.
D is incorrect as	1. is in a different direction to $\boldsymbol{p}$ so cannot be $\boldsymbol{p}$ multiplied by a scalar

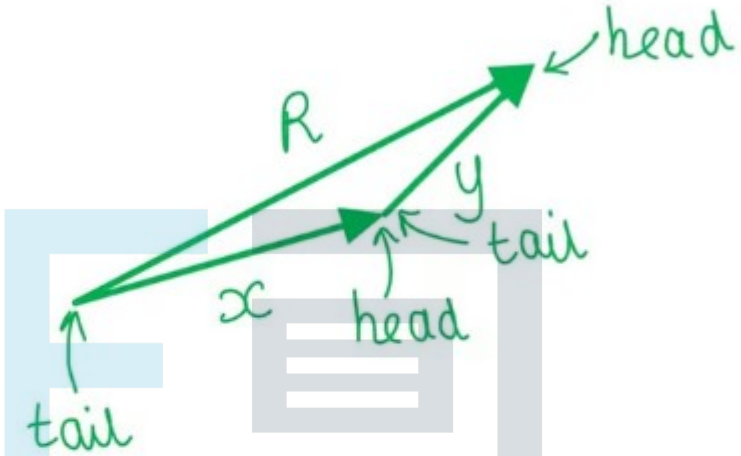
This question requires you to know the meaning of multiplying by a scalar. This changes the magnitude (length) of the vector. This is shown in the diagram below for vector $\boldsymbol{v}$.



6

The correct answer is **A** because:

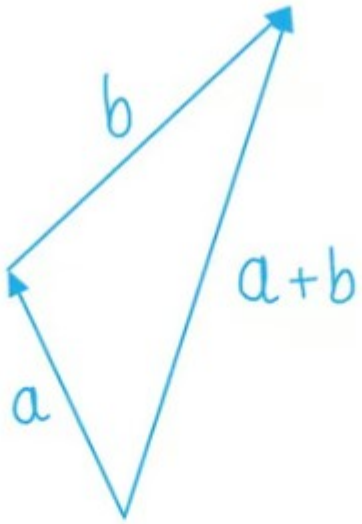
- Vectors ***x*** and ***y*** are added tip to tail
  - This gives resultant vector ***R***



B is incorrect as	vectors ***x*** and ***y*** are not added head to tail. They are added tail to tail
C is incorrect as	vectors ***x*** and ***y*** are not added head to tail. They are added head to head
D is incorrect as	this is not ***x*** plus ***y*** vector ***x*** has had its magnitude and direction changed

This question requires you to look carefully at the diagrams and identify where vectors have been added tip to tail to give the resultant. $x + y = R$

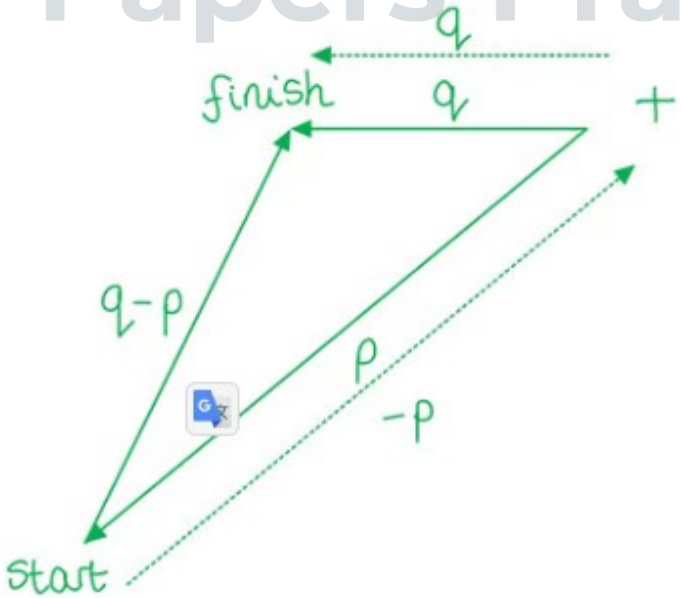
An example is shown in the diagram below:



7

The correct answer is **A** because:

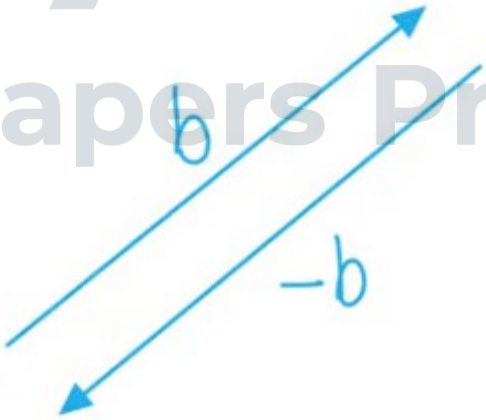
- Following the vector labelled $\boldsymbol{q} - \boldsymbol{p}$ from the tail to the head it first goes backwards along $\boldsymbol{p}$ and then forwards along $\boldsymbol{q}$
  - This means the vector is correctly labelled as $\boldsymbol{q} - \boldsymbol{p}$



B is incorrect as	following the vector labelled $\boldsymbol{p} - \boldsymbol{q}$ from the tail to the head it goes first along $\boldsymbol{p}$ backwards and then along $\boldsymbol{q}$. However, the arrow here is shows $\boldsymbol{q} - \boldsymbol{p}$ and not $\boldsymbol{p} - \boldsymbol{q}$
C is incorrect as	the vector labelled $\boldsymbol{p} - \boldsymbol{q}$ is the resultant vector of $\boldsymbol{p} + \boldsymbol{q}$
D is incorrect as	in this diagram the vectors $\boldsymbol{p}$ and $\boldsymbol{q}$ are drawn the wrong way round, so the answer is incorrect

You can think of the individual vectors $\boldsymbol{p}$ and $\boldsymbol{q}$ as a different path to start from the same point and end at the same point as vector $\boldsymbol{q} - \boldsymbol{p}$.

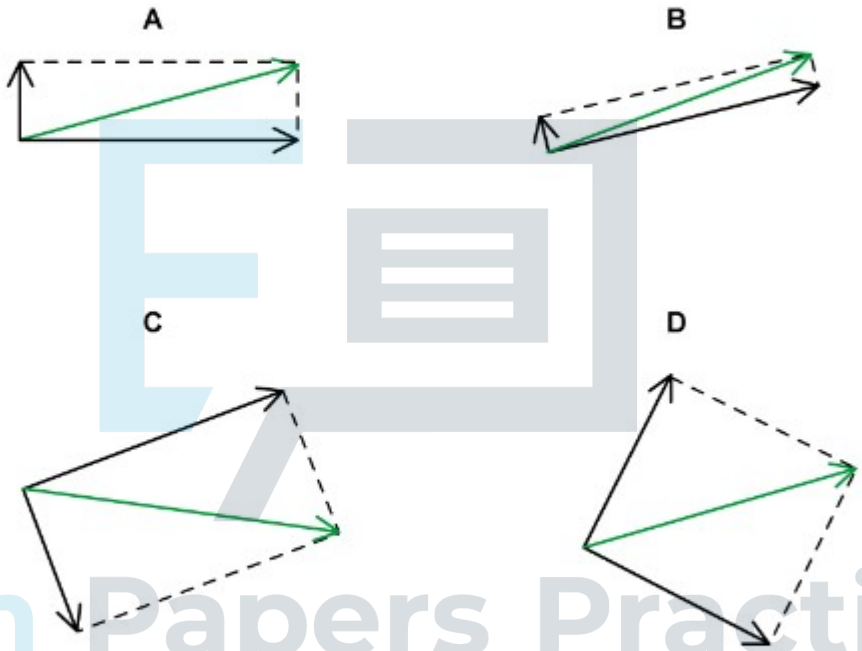
Remember that if the path goes **backwards** i.e. in the opposite direction to the arrow, this means it becomes $-\boldsymbol{p}$ or $-\boldsymbol{q}$.



8

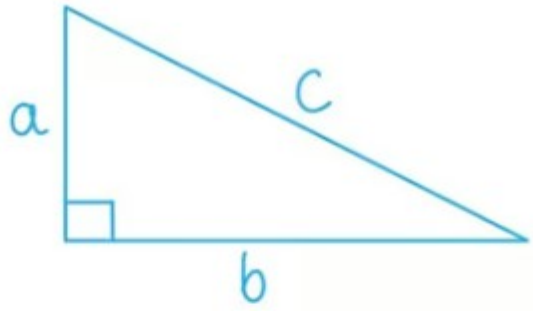
The correct answer is **C** because:

- The vector sum of the two perpendicular components should provide a resultant vector equal to the vector **R**
- If we complete the diagrams, we can see that option **C** is the odd one out as it produces a resultant vector in a downward direction, therefore, it cannot be equal to vector **R**



A, **B** and **D** are incorrect as the diagrams all show the two vector components adding to give resultant vector **R**.

In this question you need to recall that two vector components perpendicular to each other can be combined to give a resultant as the hypotenuse of the triangle using Pythagoras' Theorem.

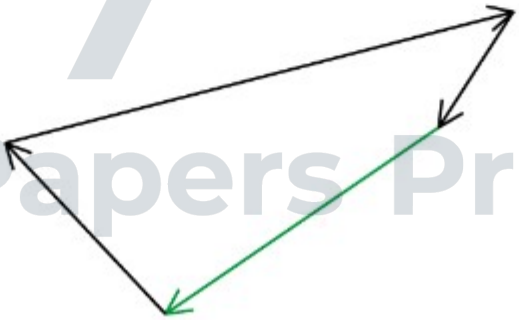


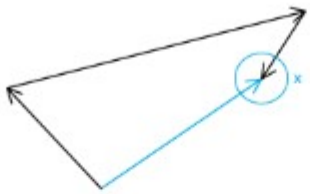
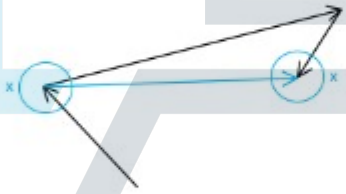
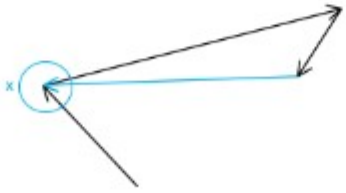
$a^2 + b^2 = c^2$

9

The correct answer is **A** because:

- All arrows are connected head to tail
- This gives an overall resultant force vector of zero



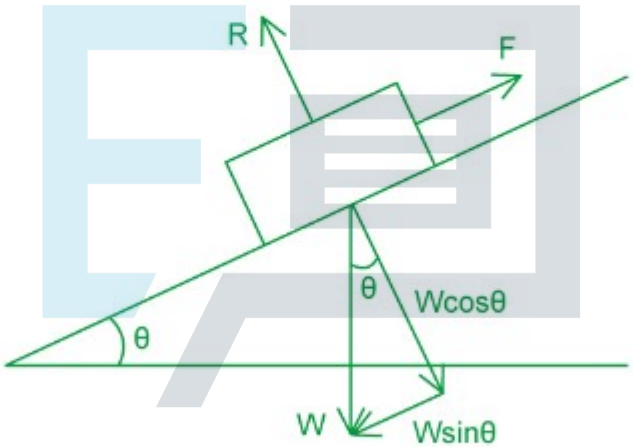
B is incorrect as	the vector arrow is not in the correct direction for the tip to connect to the tail of the next vector. All vectors should connect tip to tail 
C is incorrect as	this vector is in the wrong place. It does not link between the tip and the tail of the adjacent vectors in the gap in the diagram. For the resultant force to be zero then there should also be no heads connected 
D is incorrect as	this vector is in the wrong place. It does not link between the tip and the tail of the adjacent vectors in the gap in the diagram 

This question requires you to realise that there is no resultant vector when all the vectors are joined together head to tail with no gap.

10

The correct answer is **D** because:

- The object is not moving perpendicular to the slope
- This means *R* is equal to the component of the weight that is perpendicular to the incline surface
  - This is equal to $W\cos\theta$ or $mg\cos\theta$
- The friction force acts up the plane of the incline
- This means *F* is equal to the component of the weight that is parallel to the incline surface
  - This is equal to $F\sin\theta$ or $mg\sin\theta$



A is incorrect as	if the object is at rest, this means there is no resultant force and it therefore has no driving force. F must therefore be friction
B is incorrect as	W is the force of weight of the object and not the object's mass
C is incorrect as	R is not friction. It is the reaction force of the weight K of the object. Friction acts parallel to the slope between the object and the inclined plane W is the force of weight of the object and not the object's mass F is friction and not reaction force. The reaction force acts in the opposite direction to the weight

Friction always acts in the **opposite** direction to the motion of the object. Since there are no other forces on the object since it is as rest, this means the friction is enough for it to stay in the same position and therefore must be acting up the slope since it would naturally want to move down the slope due to its weight.

This question requires you to recall the components of the forces on an inclined plane.