AS Level Physics

Chapter 2 – Mechanics

2.1.2 Scalar and Vector Quantity

Worked Examples

Question 1

(a) State a similarity and a difference between distance and displacement.
(b) Fig. 1.1 shows two airports A and C.

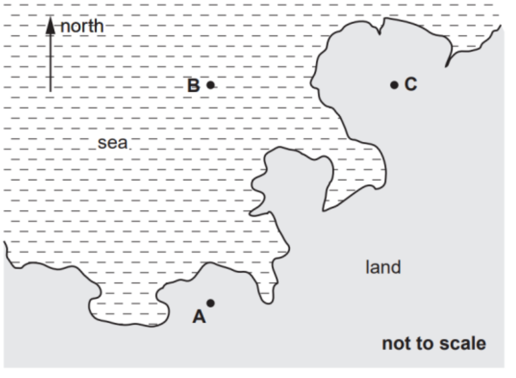


Fig. 1.1

An aircraft flies due north from A for a distance of 360 km ($3.6 \times 10^5\ m$) to point B. Its average speed between A and B is 170 $m\ s^{-1}$. At B the aircraft is forced to change course and flies due east for a distance of 100 km to arrive at C.

(i) Calculate the time of the journey from A to B.

(ii) Draw a labelled displacement vector triangle and use it to determine the magnitude of the displacement in km of the aircraft at C from A.

(a) State a similarity and a difference between distance and displacement:
Similarity: **Both have magnitude and have the same units (metre/m)**
Difference: **Displacement is a vector quantity where as distance is a scalar quantity.**

(bi) Calculate the time of the journey from A to B:

$$speed\ (m\ s^{-1}) = \frac{distance\ (m)}{time\ (s)}$$

$$time = \frac{3.6\ \times 10^5\ m}{170\ ms^{-1}}$$

$$\boldsymbol{time = 2118\ s}$$

Question 1

(bii) Draw a labelled displacement vector triangle and determine the magnitude of the displacement in km of the aircraft at C from A:

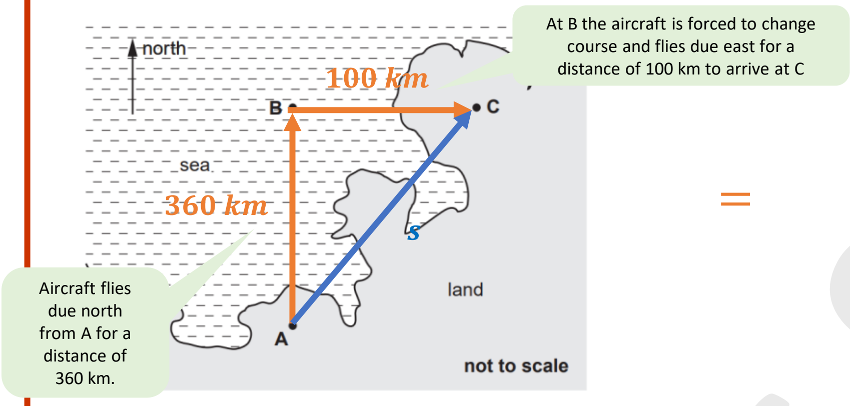
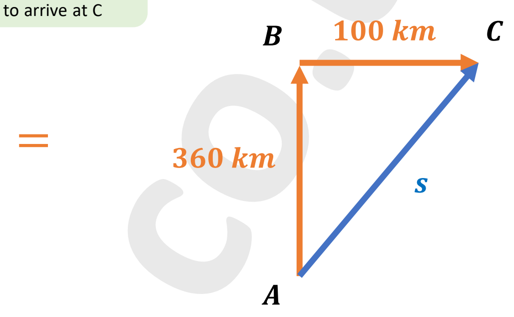


Fig. 1.1



$Use\ Pythagoras\ theorem:$

$$s^2 = 360^2 + 100^2$$

$$s = \sqrt{360^2 + 100^2}$$

$$s = 373.6\ km$$

Question 2

(ai) State what is meant by a scalar quantity.
(ii) State two examples of scalar quantities

(b) An object is acted upon by two forces at right angles to each other. One of the forces has a magnitude of 5.0 N and the resultant force produced on the object is 9.5 N.
Determine:
(i) The magnitude of the other force,
(ii) The angle between the resultant force and the 5.0 N force.

(ai) what is meant by a scalar quantity:
A scalar quantity is a quantity that only has magnitude and has no direction.

(aii) State two examples of scalar quantities:
Scalar quantity: speed, mass, time, energy, power, temperature, etc….

(bi and bii) Determine the magnitude and angle:
Remember that the 9.5N is the resultant force and the 5.0N is one of the components of the resultant force. Knowing this information you can draw the diagram shown below:

(bi) Magnitude of F:

Use Pythagoras Theorem to solve for F

$$9.5^2 = 5.0^2 + F^2$$

$$F^2 = 9.5^2 - 5.0^2$$

$$F = \sqrt{9.5^2 - 5.0^2}$$

$$F = 8.1N$$

(bii) Angle θ:

$$cos\theta = \frac{5.0}{9.5}$$

$$\theta = \cos^{-1}\left(\frac{5.0}{9.5}\right)$$

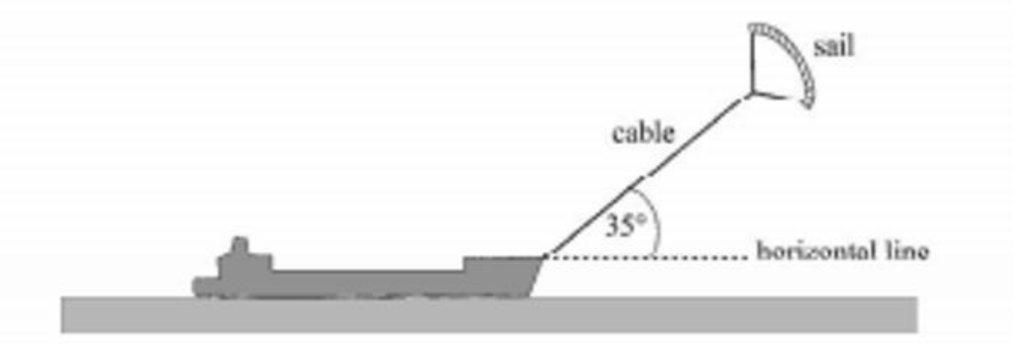
$$\theta = 58°$$

Question 3

(ai) State the difference between a scalar quantity and a vector quantity.
(ii) State two examples of a scalar quantity and a vector quantity.

(b) Figure 1 shows a ship fitted with a sail attached to a cable. The force of the wind on the sail assists the driving force of the ships propellers.

Figure 1

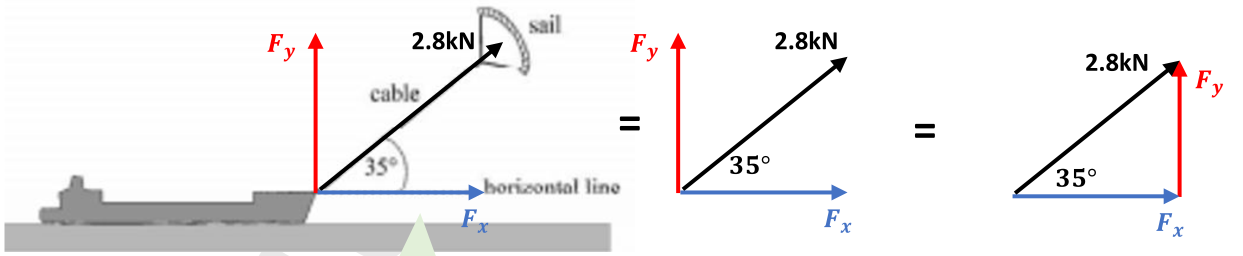


The cable exerts a steady force of 2.8kN on the ship at an angle of 35° above a horizontal line.
Calculate the horizontal and vertical components of this force.

(ai) State the difference between a scalar and a vector quantity:
A vector quantity has both magnitude and direction, whereas the scalar quantity only has magnitude.

(ai) State two examples of scalar and vector quantities:
Scalar quantity: speed, mass, time, energy, power, etc….
Vector quantity: displacement, velocity, acceleration, force, weight, etc….

(b) Calculate the horizontal and vertical components of the force:
Resolve the force on the cable into its vertical and horizontal components:



Resolve the force into its horizontal and vertical component.

Horizontal component (F_x):

$$F_x = F\ cos\theta$$

$$F_x = 2.8cos35$$

$$T_x = 2.3kN$$

Vertical Component (F_y):

Use trigonometry to solve the problem.

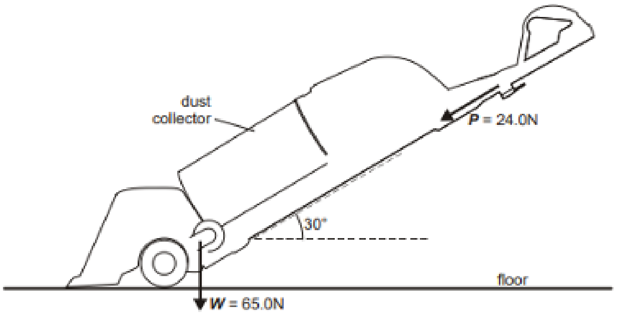
$$F_y = F\ sin\theta$$

$$F_y = 2.8sin33$$

$$F_y = 1.6kN$$

Question 4

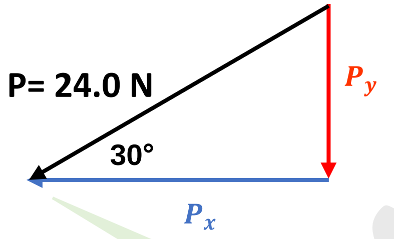
The figure below shows a vacuum cleaner of weight W being pushed with a force P.
The force P acts at 30° to the horizontal.



The weight W is 65.0 N and the magnitude of force P is 24.0 N.
(ai) Calculate:
The horizontal component of the force P.
The vertical component of the force P.

<u>**(ai) Calculate the horizontal and vertical component of the force P:**</u>

Resolve the vector P into its horizontal and vertical components:



Resolve the P vector into its horizontal and vertical component.

Horizontal component (P_x):

$$P_x = P\cos\theta$$

$$P_x = 24cos30$$

$$\boldsymbol{P_x = 20.8N}$$

Vertical Component (P_y):

$$P_y = P\ sin\theta$$

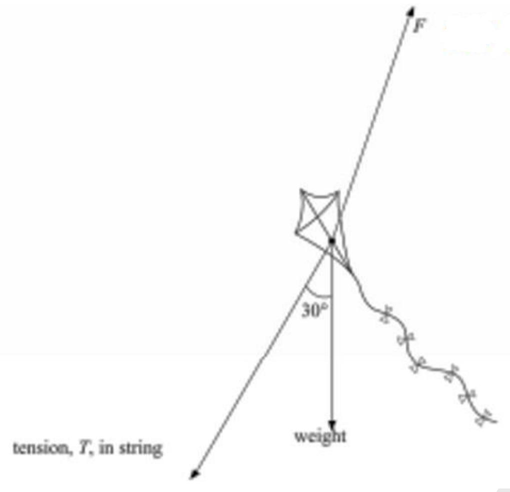
$$P_y = 24\ sin30$$

$$\boldsymbol{P_y = 12.0N}$$

Use trigonometry to solve the problem.

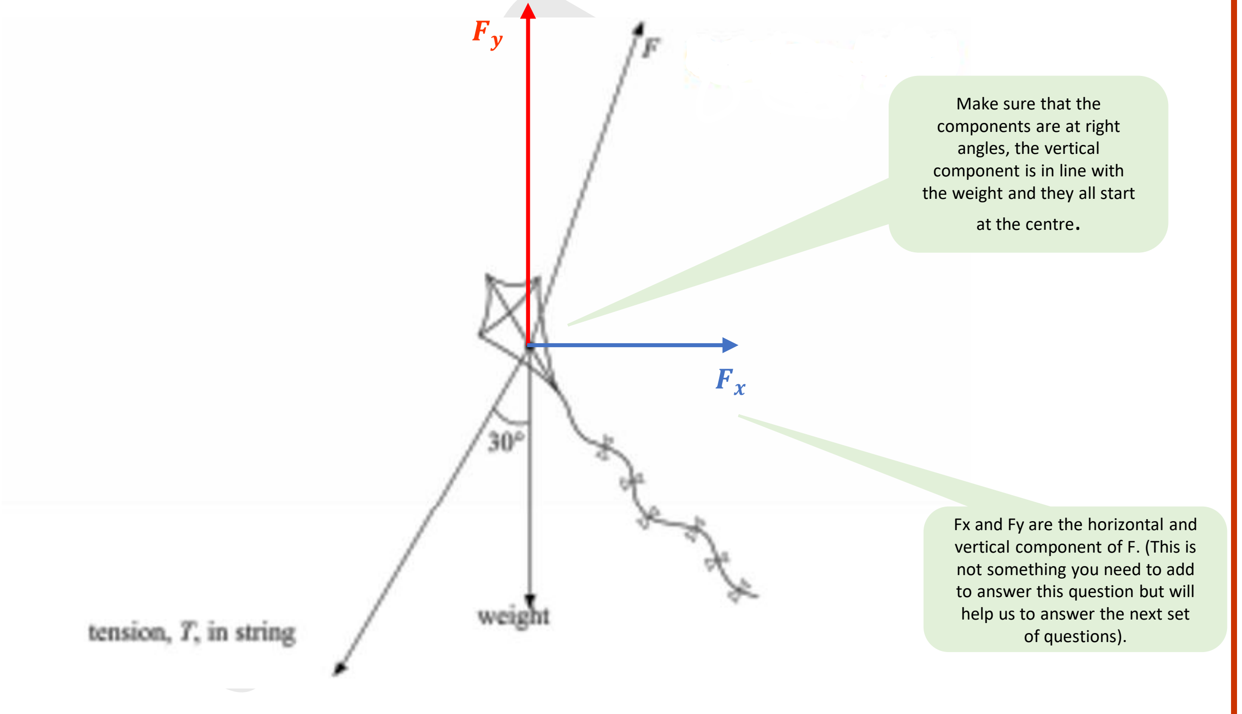
Question 5

The diagram shows the forces acting on a stationary kite. The force F is the force that the air exerts on the kite.



(a) Show on the diagram how the force F can be resolved into horizontal and vertical components.
The magnitude of the tension, T, is 25 N.
Calculate
(bi) The horizontal component of the tension.
(bii) The vertical component of the tension.

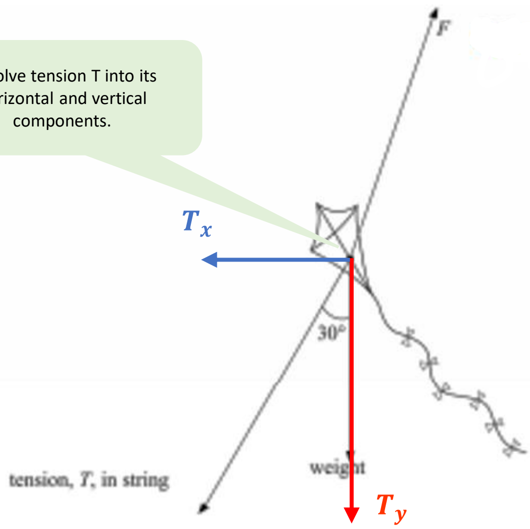
(a) Show on the diagram how the force F can be resolved into horizontal and vertical components:



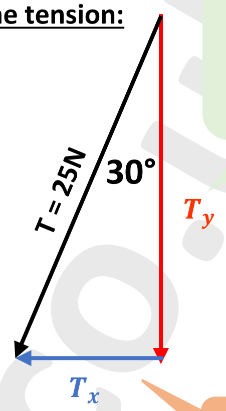
Question 5

(bi and bii) Calculate the horizontal and vertical component of the tension:

Resolve tension T into its horizontal and vertical components.



=



Use the horizontal and vertical components for tension, T to make a right angle triangle and then use trigonometry to solve for the components.

Do not change the direction of any of the vectors.

Horizontal component (T_x):

$$T_x = T \sin \theta$$

$$T_x = 25sin30$$

$$\mathbf{T_x = 12.5N = 13N}$$

Vertical Component (T_y):

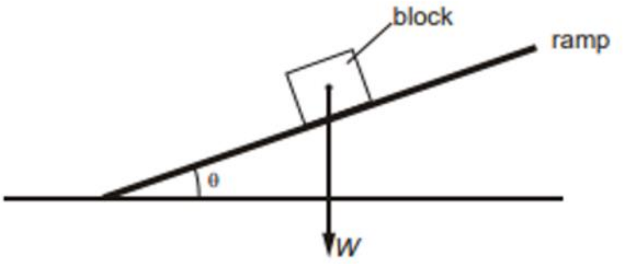
$$T_y = P\ cos\theta$$

$$T_y = 25cos30$$

$$\mathbf{T_y = 21.7N = 22N}$$

Question 6

The figure below shows a wooden block motionless on an inclined ramp.



The angle between the ramp and the horizontal is θ.

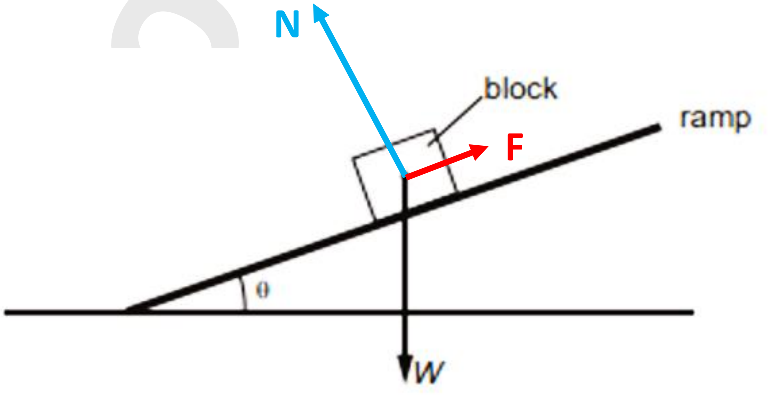
(a) The weight W of the block is already shown on the figure. Complete the diagram by showing the normal contact (reaction) force N and the frictional force F acting on the block.

(b) Write an equation to show how F is related to W and θ.

(a) Complete the diagram by showing the normal contact (reaction) force N and the frictional force F acting on the block.

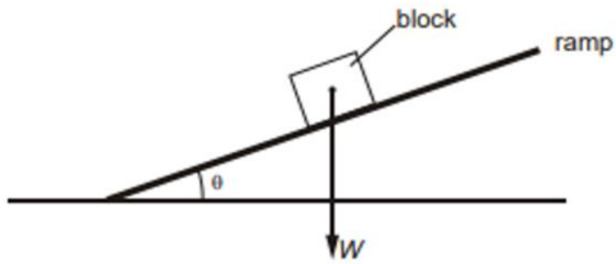
This question is just asking us to draw a Free Body Diagram (FBD). FBD shows the magnitude and directions of all the forces acting on an object in a given situation.
To answer this question we have to represent 3 forces: Weight, Normal force and Frictional force.

- **Weight (W):** Force due to gravity. Pulls objects towards the Earth and the Weight force always acts directly downwards.
- **Normal contact (reaction) force (N):** Force that acts between two objects touching each other. This force acts **perpendicular** to the **objects surface**. In this case the normal force acts perpendicular (or at right angles) to the ramp.
- **Frictional Force (F):** A resistive force which acts between two surfaces that slide across each other. The force acts **parallel** to the contact surface and acts in the **opposite direction of the sliding motion** (e.g. if an object is sliding to the left the frictional force will act to the right).



Question 6

The figure below shows a wooden block motionless on an inclined ramp.



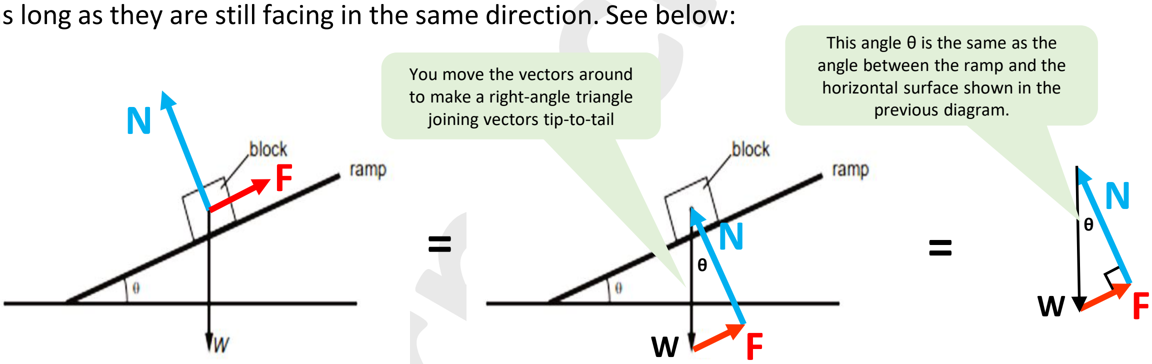
The angle between the ramp and the horizontal is θ.

(a) The weight W of the block is already shown on the figure. Complete the diagram by showing the normal contact (reaction) force N and the frictional force F acting on the block.

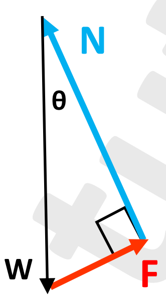
(b) Write an equation to show how F is related to W and θ.

(b) Write an equation to show how F is related to W and θ

For this question you will need to know trigonometry and the fact that vectors can be moved around as long as they are still facing in the same direction. See below:



Now that we have the right-angle triangle you use trigonometry to get the equation for F relating to W and θ:



$$sin\theta = \frac{opposite}{hypotenuse}$$

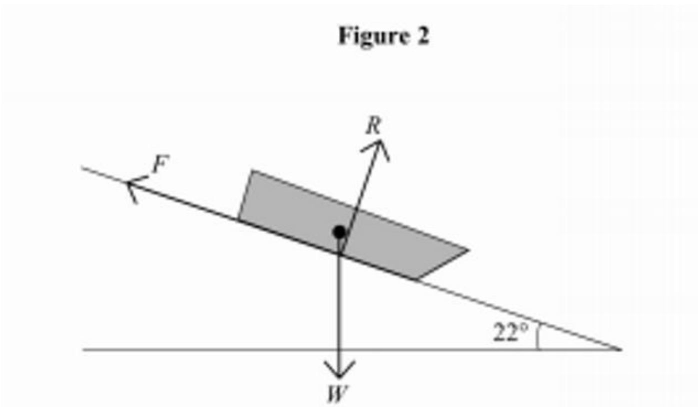
$$sin\theta = \frac{F}{W}$$

$$\therefore F = Wsin\theta$$

And this is the equation that relates F to W and θ.

Question 7

Figure 2 shows a sledge moving down a slope at constant velocity.
The angle of the slope is 22deg.



The three forces acting on the sledge are weight, W, friction, F, and the normal reaction force, R, of the ground on the sledge.

(a) The mass of the sledge is 4.5kg. Calculate the component of W,

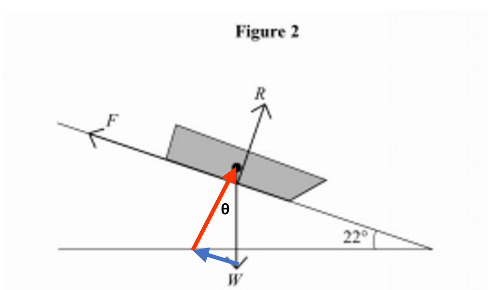
(i) Parallel to the slope,

(ii) Perpendicular to the slope.

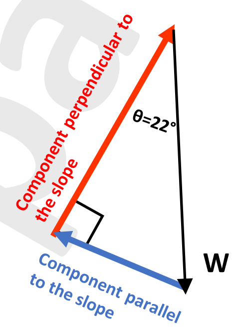
(b) State the values of F and R.

(ai and aii) Calculate the component of W:

Draw the free body diagram first:



=



Weight = mass x acceleration due to gravity

$$\boldsymbol{W} = 4.5kg \times 9.81ms^{-2} = \mathbf{44.145N}$$

Parallel component:

$$Parallel\ component = W\ sin\theta$$

$$Parallel\ component = 44.145sin22$$

$$\boldsymbol{Parallel\ component = 16.5N}$$

Perpendicular Component:

$$Perpendicular\ component = W\ cos\theta$$

$$\text{Perpendicular } component = 44.145cos22$$

$$\boldsymbol{Perpendicular\ component = 41N}$$

(b) State the value of F and R:

$$\boldsymbol{F} = Parallel\ component\ of\ Weight = \mathbf{16.5N}$$

$$\boldsymbol{R} = Perpendicular\ component\ of\ Weight = \mathbf{41N}$$

Please see the '2.1.1 Scalar and Vector Quantity Notes' for revision notes.

For revision notes, tutorials, worked examples and more help visit www.tutorpacks.co.uk.