UNIT G481	Module 1	1.1.2	Scalars & Vectors

- ***Candidates should be able to :***

  - *Define **scalar** and **vector** quantities and give examples.*

  - *Draw and use a **vector triangle** to determine the **resultant** of two **coplanar vectors**, such as **displacement**, **velocity** and **force**.*

  - *Calculate the **resultant** of two **perpendicular vectors** such as **displacement**, **velocity** and **force**.*

  - ***Resolve** a vector such as **displacement**, **velocity** and **force** into two **perpendicular components**.*

- ***SCALAR AND VECTOR QUANTITIES***

- *Some physical quantities can be fully defined by specifying their **magnitude** with a **unit**, but others also require their **direction** to be specified.*

> *A **VECTOR** quantity is one which has both **SIZE** and **DIRECTION**.*
>
> *A **SCALAR** quantity is one which has **SIZE** but no **DIREC-***

- ***Examples of Scalar and Vector Quantities***

QUANTITY	VECTOR	SCALAR
length		
distance		
displacement		
area		
volume		
speed		
velocity		
pressure		
energy		
force		
time		
mass		
acceleration		
weight		
density		
momentum		
power		

- ***Representing Vector Quantities***

*A vector quantity may be represented as an arrow drawn to scale. The **length** of the arrow represents the **magnitude** of the vector quantity and the **direction** of the arrow represents the **direction** of the vector quantity.*

- **PRACTICE QUESTIONS (1)**

1 Draw vectors to represent each of the following :

(a) A velocity of ***35 m s^{-1}*** in a direction ***20° south of east.***

(scale : 1 cm = 10 m s^{-1})

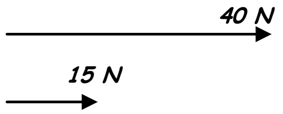
(b) A force of ***4 N*** at an angle of ***30° above the horizontal.***

(scale : 1 cm = 1 N)

- ***VECTOR ADDITION***

*When two or more vectors act together they are added **vectorially** to produce the equivalent effect of a single vector called the __RESULTANT__.*

- ***<u>Vectors acting in the same direction</u>***



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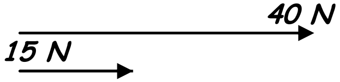
- ***<u>Vectors acting in opposite directions</u>***



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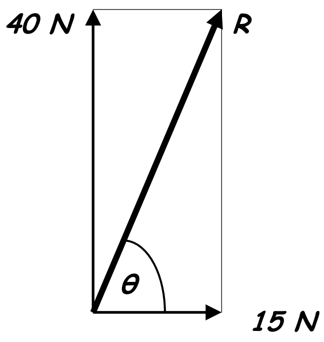
- ***<u>Vectors acting at right angles</u>***



*The **magnitude of R** is obtained using **Pythagoras'** Theorem :*

$R^2 = 40^2 + 15^2$

$R =$

$=$

*The **direction of R** is obtained from :*

$\tan\theta = \dfrac{\quad}{\quad}$

$\theta = \tan^{-1}$ ____ = ____

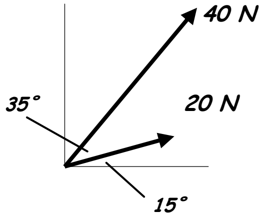
*Therefore, **the RESULTANT (R) is a force of** ____ **N acting at an angle of** ____ **° to the 15 N force.***

<u>NOTE</u> : The RESULTANT (R) may also be obtained from a scale drawing.

- ***Obtaining the RESULTANT by scale drawing***

  - *Choose a suitable scale (In this case say **1 cm = 5 N**).*
  - *Draw a vector to represent the **15 N** force (a horizontal line which is **3 cm** long).*
  - *Then draw the vector to represent the **40 N** force (a vertical line which is **8 cm** long) with its **tail starting at the tip** of the 15 N force vector.*
  - *The **RESULTANT** is the vector which closes the triangle. Its **magnitude** is then obtained by measuring **the length of the vector** and its **direction** is obtained using a protractor. Try this yourself.*

- ***Vectors acting at any angle***
  - *Scale : **1 cm = 5 N.***



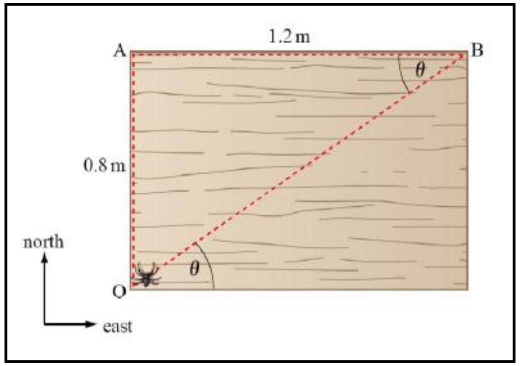
- *The scale drawing method we have used is called the **TRIANGLE OF VECTORS**. The three forces involved form a closed triangle.*

- *Vector addition can be used to solve problems involving more Than three vectors and the method is then called the **POLYGON OF VECTORS**.*

- **PRACTICE QUESTIONS (2)**

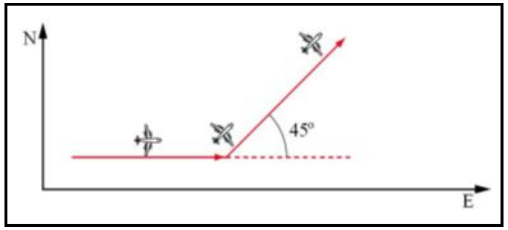
1 A spider runs along side *OA* of a table and then does a 90° turn and runs along side *AB* (see diagram opposite).

Calculate the ***magnitude*** and ***direction*** of its displacement.



2 An aircraft flies ***20 km due east*** and then ***30 km north-east.***

Use a scale diagram to determine the ***magnitude and direction*** of the aircraft's final displacement. (***1 cm = 5 km*** is a suitable scale).

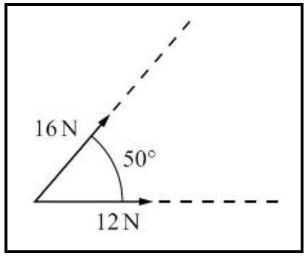


3 (a) (i) Explain the difference between ***scalar*** and ***vector*** quantities.

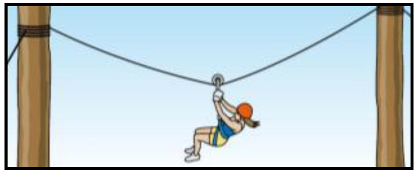
(ii) Which of the quantities shown below are ***vector*** quantities ?

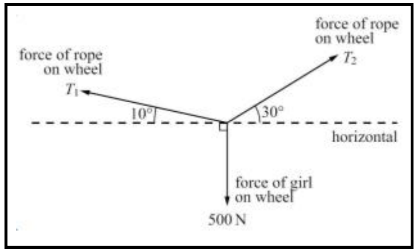
Acceleration ***energy*** ***force*** ***power*** ***speed***

(b) Use a vector diagram drawn to scale to determine the ***magnitude and direction*** of the two forces shown in the diagram opposite.



4 A girl travels down a pulley-rope system which has been set up between two large trees. The picture opposite shows the girl at a point on her run where she has come to rest. All the forces acting on the pulley wheel are shown in the diagram opposite.





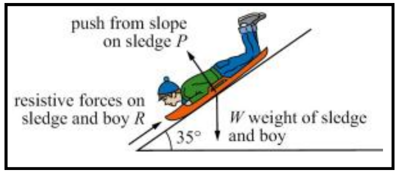
(a) Explain why the ***vector sum*** of the three forces must be equal to ***zero.***

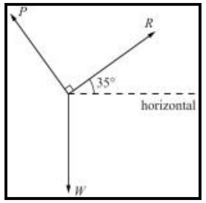
(b) (i) Sketch a ***labelled vector triangle*** of the forces acting on the pulley wheel.

(ii) Use a scale diagram to determine the tension forces ***T_1 and T_2*** which the rope exerts on the pulley wheel.

(OCR Module 2821—June 2005)

5 The diagram opposite shows a boy on a sledge (Total weight = ***600 N***) sliding at ***constant speed*** down a slope inclined at ***35° to horizontal.*** The second diagram shows all the forces acting on the boy and sledge.





(a) Use a scale drawing to determine :

(i) The magnitude of the ***resistive force R,***

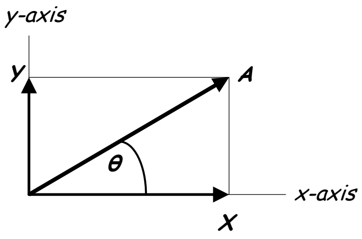
(ii) The component of the ***weight*** that acts at 90° to the slope.

(b) ***Explain*** why the boy and sledge are travelling at constant speed.

(OCR Module 2821—June 2003)

- ***RESOLVING VECTORS***

- ***ESSENTIAL TRIGONOMETRY***



*Consider a vector **A** at an angle **θ** to the x-axis. Then :*

sin θ = opposite / hypotenuse = Y/A

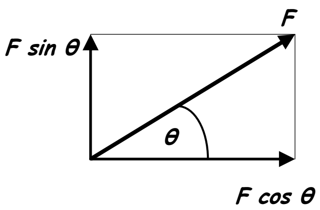
So ***Y = A sin θ***

cos θ = adjacent / hypotenuse = X/A

So ***X = A cos θ***

- *Applying the above to any single vector **F**, it can be seen that the vector can be **RESOLVED** into two **perpendicular** vectors.*

*The diagram opposite shows a **force F** which has been resolved into two perpendicular components.*

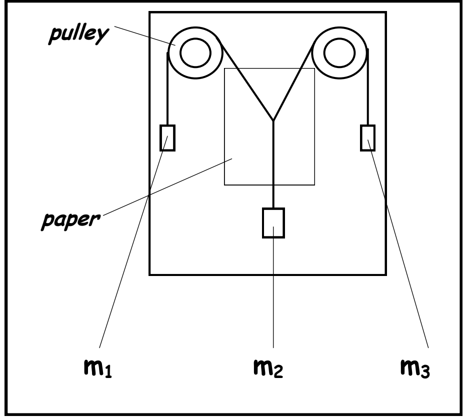


Vertical component, $F_y = F\sin\theta$

Horizontal component, $F_x = F\cos\theta$

- PRACTICAL - THREE-FORCE EQUILIBRIUM

- The pulleys and masses are set up as shown.



- Masses are placed on the three mass hangers and they are then allowed to move until they stabilise.

- The string pattern is then drawn on the paper behind the pulleys.

- The forces acting at point P are then calculated from W = m g.

- A vector diagram is drawn to find the **RESULTANT** of the two upward forces. Is this equal and opposite to the downward force ?

- **PRACTICE QUESTIONS (3)**

1 An athlete throws a javelin into the air at an angle of ***38° to the horizontal***. If the ***initial horizontal component*** of the javelin's velocity is ***19.7 m s^{-1}***, calculate :

(a) The ***initial velocity*** of the javelin.

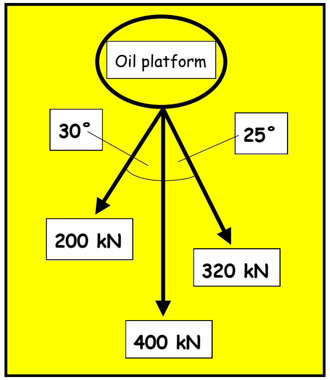
(b) The ***initial vertical component*** of the javelin's velocity.

2 A shell is fired from a gun at ***400 m s^{-1}*** at an angle of ***30°*** to the horizontal.

(a) What is the ***initial horizontal component*** of the shell's velocity ?

(b) If the shell is in the air for ***40 s*** and the ground is horizontal, how far does it land from its original position ? (Assume that air resistance is negligible).

3 The diagram opposite shows the forces exerted by three tugs which are being used to move a floating oil platform.



By resolving the forces calculate the ***RESULTANT*** force on the platform.

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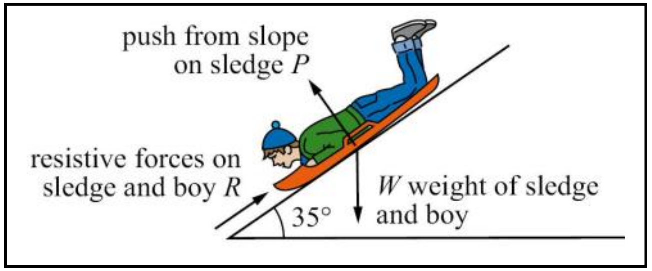


The diagram above shows a boy on a sledge (Total weight = ***600 N***) sliding at ***constant speed*** down a slope inclined at ***35° to horizontal.***

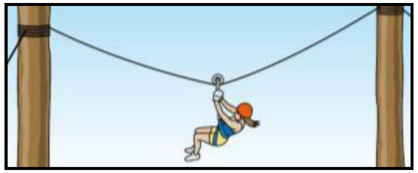
By ***resolving*** the forces acting on the boy and sledge, determine :

(a) The magnitude of the ***RESISTIVE FORCE (R).***

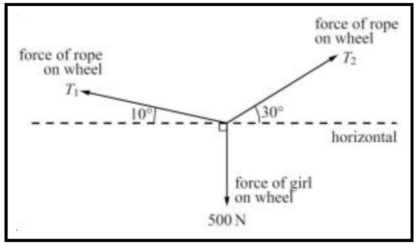
(b) The component of the **WEIGHT (W)** that acts perpendicular to the slope.

(NOTE : You have already attempted this question by scale drawing)

5 A girl travels down a pulley-rope system which has been set up between two large trees. The picture opposite shows the girl at a point on her run where she has come to rest.



All the forces acting on the pulley wheel are shown in the diagram opposite.



By ***resolving*** the forces acting, determine the tension forces ***T_1*** and ***T_2*** which the rope exerts on the pulley wheel.

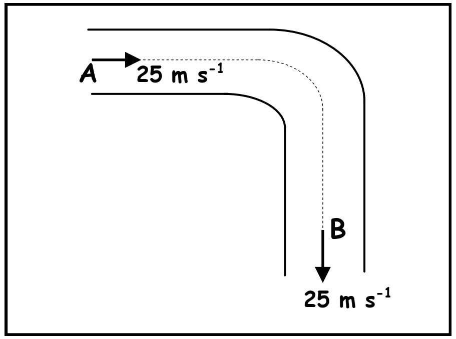
(NOTE : You have already attempted this question by scale drawing)

- **HOMEWORK QUESTIONS**

1 Hailstones fall vertically in still air with a constant velocity of ***15 m s^{-1}.*** If a gale suddenly springs up and the wind blows horizontally at ***20 m s^{-1},*** calculate the magnitude and direction of the ***RESULTANT*** velocity of the hailstones.

2 (a) Explain the difference between a ***VECTOR*** quantity and a ***SCALAR*** quantity. Give ***two*** examples of each.

(b)



The diagram above shows the path followed by a car as it travels around a right-angled bend. The car travels from point ***A*** to point ***B*** in ***7.6 s*** at a constant speed of ***25 m s^{-1}.***

(i) Calculate the ***distance travelled*** by the car in ***7.6 s.***

(ii) Sketch the diagram and draw a line to show the ***DISPLACEMENT*** of the car having travelled from ***A to B.***

(iii) Explain why the ***velocity*** of the car changes as it travels from A to B although the ***speed remains constant.***

(iv) Using a labelled ***vector triangle***, calculate the ***magnitude of the change in velocity of the car.***

(OCR Module 2821 - June 2004)

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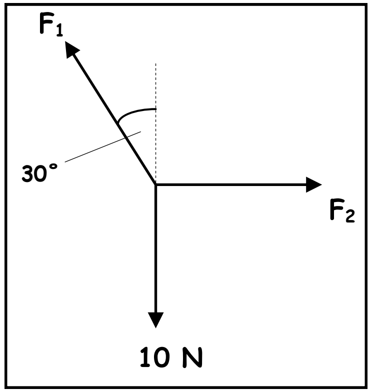

The diagram opposite shows three forces in equilibrium. Determine the magnitude of the forces ***F_1*** and ***F_2*** :

(a) Using a ***scale drawing.***

(b) By ***calculation.***

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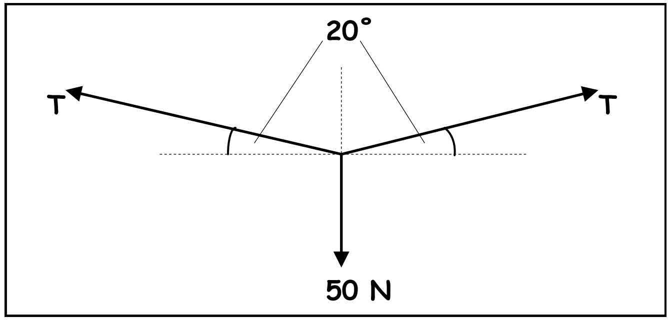

The diagram above shows a weight of ***50 N*** hanging from the centre of a piece of string.

Use the process of ***RESOLVING*** to calculate the ***tension (T)*** in the string.

5 A boat moves forward at **10.0 m s^{-1}**. A sailor walks at a speed of 3 m s^{-1} across the deck at an angle of **60°** to the boat's direction of motion. Calculate :

(a) The ***forward component*** of the sailor's ***velocity relative to the boat.***

(b) The sailor's ***total forward velocity.***