Nelson Thornes
Distance Learning

AS Physics

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First edition published in 2009. This edition published in 2010 by:
Nelson Thornes Distance Learning
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27 Bath Road
CHELTENHAM
GL53 7TH
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10 11 12 13 14 15 16 / 10 9 8 7 6 5 4 3 2

Printed in Great Britain by Berforts Group

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Contents

INTRODUCTION

This course is based on the AQA board syllabus: subject code 1451.

DISTANCE LEARNING

You are about to start on your Physics AS course this year which you are going to be studying using distance learning. There are several features of distance learning that make it different from the normal in-school experience, and it is probably best if you spend a few minutes reading through the following points to familiarise yourself with the method by which you are going to study Physics this year.

- Course notes

  The first part of any distance learning course will be a distance learning package consisting of printed material. This is your source of all information and guidance. You are reading the first page of the distance learning package at the moment, and the content of this course will be explained to you a little later on.

- Video conferencing

  The second major part of any distance learning process is contact with your tutor, and this contact will be largely by a video conference on a timetabled time, regularly for an hour once per week. The tutor will discuss the topics with you, give you certain tasks to perform, and will expect you to do a certain amount of work to be carried out during the next week in preparation for next week's tutorial.

- Textbook

  The third part of distance learning involves the use of the course textbook; follow the references to that during the course. Read the specified pages when you are asked to, and attempt any questions that follow. Be ready to discuss any problems you have had with this at your next video conference.

- Practical work

  The fourth part of distance learning involves you carrying out regular practical work. For this you will be guided through practical work using common laboratory apparatus. You will be asked to collect results from the practicals you are doing, and report these back to your tutor.

- Handing in your work

  Every topic is followed by a series of questions to be completed in your own time. You must provide complete written answers to these questions including all calculations. This is then sent to your tutor. Your work will be marked and returned to you. You will be informed of your results at the same time. Your marks are also archived so that your tutor can assess your progress.

  Your week's work is not complete until this is done.

- Visits

  There will also be a programme of visits by your tutor to you. Your tutor will come and visit you in school first of all in September/October, to carry out introductions in person and discuss with you setting up the course, to explain to you what you have to do in order to be successful. There will also be another visit to be arranged later on in the year, usually around Easter time. In this way your tutor will be able to keep in touch with you on a personal level.

In general, distance learning is successful for students who:

- **take part in the regular video conferences**
- **study the course notes carefully**
- **carry out all the practicals**
- **use the course textbook wisely wherever asked to**
- **hand in their work on time.**

A lot of this will be more familiar to you in a few weeks' time when you have had a chance to make a start on your Physics course with your tutor.

PHYSICS AS

This year you will be studying two separate theory modules and you will be undergoing an assessment of your investigative and practical skills as the third module.

The first theory module you will be studying is actually the second module offered by AQA, PHYA2, entitled ‘Mechanics, Materials and Waves’. The reason for this is that it is more suited to distance learning to start here. This will take approximately the first term to complete. The first module test is available in January.

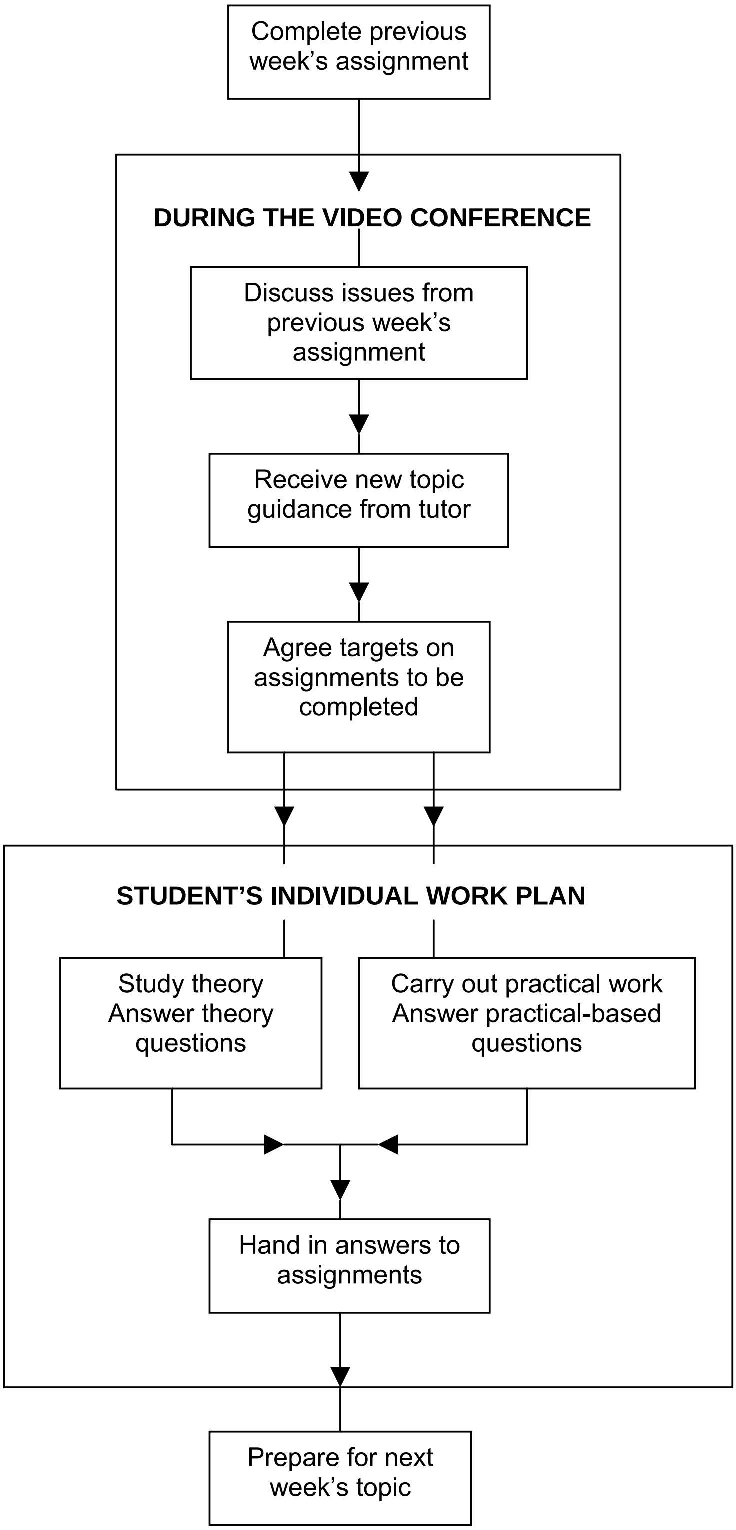
Later that January, module PHYA1 entitled ‘Particles, Quantum Phenomena and Electricity’ will be started, and this will continue until around Easter. After this you will begin preparation for the Theory Module Tests in May/June.

You will be preparing for the third module, PHYA3, the ‘Investigative and Practical Skills Assessment’ continually during the whole course by completing the practicals in each section.

Time lines

	THEORY	**PRACTICAL**
Sept	↑	↑
	PHYA2	
Dec	↓	
		Set practical work for each topic
Jan	Module Test	
	↑	
	PHYA1	
April	↓	
May	↑	↓
	Module Test	ISA PHYA3
June	↓	

A Typical Week on a Distance Learning Course



PHYA2 Mechanics, Materials and Waves

This section is a **complete list** of all the topics covered in **PHYA2**.

The boxes are for you to use as a checklist to confirm you have completed **all the work**. When you have completed a topic, indicate this by writing in the box the **page number(s)** where you have found the relevant theory on that topic. In this way you will build your own index which will be useful when you come to revise for the Module Test.

PHYA2 is found in unit 3.2 of the specification.

Unit	Section	Topic	Skills	Page
3.2.1	Mechanics			
		Statics	Scalars and vectors	
			Moments	
		Kinematics	Motion along a straight line	
			Projectile motion	
			Newton's laws of motion	
		Energy	Work, energy and power	
			Conservation of energy	
3.2.2	Materials			
		Solid properties	Density	
			Hooke's law	
		Strength	Stress and strain	
			Young Modulus	
3.2.3	Waves			
		Types of waves	Progressive waves	
			Longitudinal and transverse waves	
		Wave properties	Refraction	
			Superposition	
		Advanced properties	Interference	
			Diffraction	

Mechanics: Statics

AIMS: ***This section will help you to understand:***

The difference between scalars and vectors	
Addition of vectors	
Resolution of vectors	
Equilibrium	
The principle of moments	
Turning force, torque	
Stability	

Tick the boxes when you have achieved each aim.

READING: Use the course textbook 'Physics A'

Start at Unit 2, Mechanics, Materials and Waves on page 88.

Read the introduction and check what you should already know,

and then turn to section 7, Forces in Equilibrium, on page 96.

Read the following sections as you study this section:

7.1 Vectors and scalars on pages 90–93
7.2 Balanced forces on pages 94–96
7.3 The principle of moments on pages 97–98
7.4 More on moments on pages 99–100
7.5 Stability on pages 101–103
7.6 Equilibrium rules on pages 104–107

Scalars and Vectors

A scalar quantity is one in which you are given only its size.

We do not get very far in Physics without referring to measurements of the size of various quantities we are interested in.

Some quantities are simple measurements of size only. A simple, single piece of information like this is called a **scalar** quantity, and all we get to find out is how big it is.

Other quantities give us two pieces of information. As well as its size, we are also given a direction. These quantities are called **vectors**. Vectors are more useful since they give us more information.

Think of a Police Officer giving evidence of identification of a suspect in a courtroom:

> *"As I was travelling at 30mph along the High Street, I saw the Defendant driving his car".*

Did the Officer get a good view? If the Officer was travelling one way and the Defendant in the opposite direction, they may have passed each other at a combined speed of 60mph and all the Officer would have seen was a quick glimpse as the Defendant flashed past. If the Officer was travelling in the same direction, he could have been travelling alongside the Defendant for some time and able to clearly see him. That is why the Police Officer will always say:

> *"As I was travelling **south** at **30mph** along the High Steet …."*

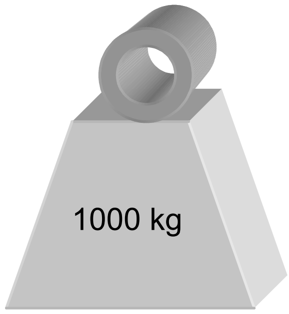
The vector quantity is much more useful in this case.

Remember:

A **scalar** quantity gives only **one** piece of information.

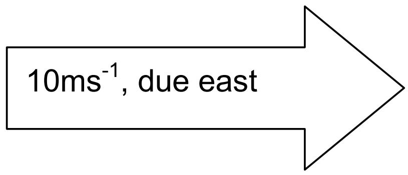
A **vector** quantity gives **two** pieces of information.

A scalar quantity



Mass

A vector quantity



Velocity

Addition of Vectors

Adding scalar quantities is easy – it is just a matter of arithmetic. Two 1000kg masses when combined will always form a mass of 2000kg.

Adding vectors is a little more complex - as well as the size, the directions also have to be combined.

Using a Scale Diagram to add vectors

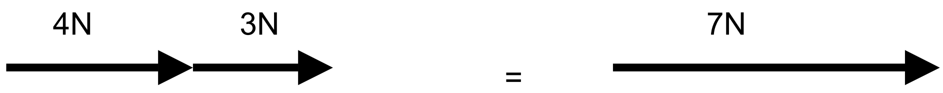
A carefully drawn, accurate scale diagram can be used to add vectors. A suitable scale must be chosen, and the first vector to be added is drawn to scale in a direction relating to the information given. The second vector is drawn according to the same rules, but starting from the end of the first vector. The result, called the **resultant vector** is now drawn from the **start** of the **first** vector to the **end** of the **second** vector.

Vectors Acting Along a Straight Line

Two vectors acting along a straight line and in the same direction can simply be added together.

Example**:**

Find the resultant of a force of 4N and another of 3N acting in the same direction.



Mathematically: $\mathbf{F_R = F_1 + F_2}$

Two vectors acting along a straight line in opposite directions can be subtracted.

Example:

Find the resultant of a force of 4N acting from left to right, and another of 3N acting from right to left.

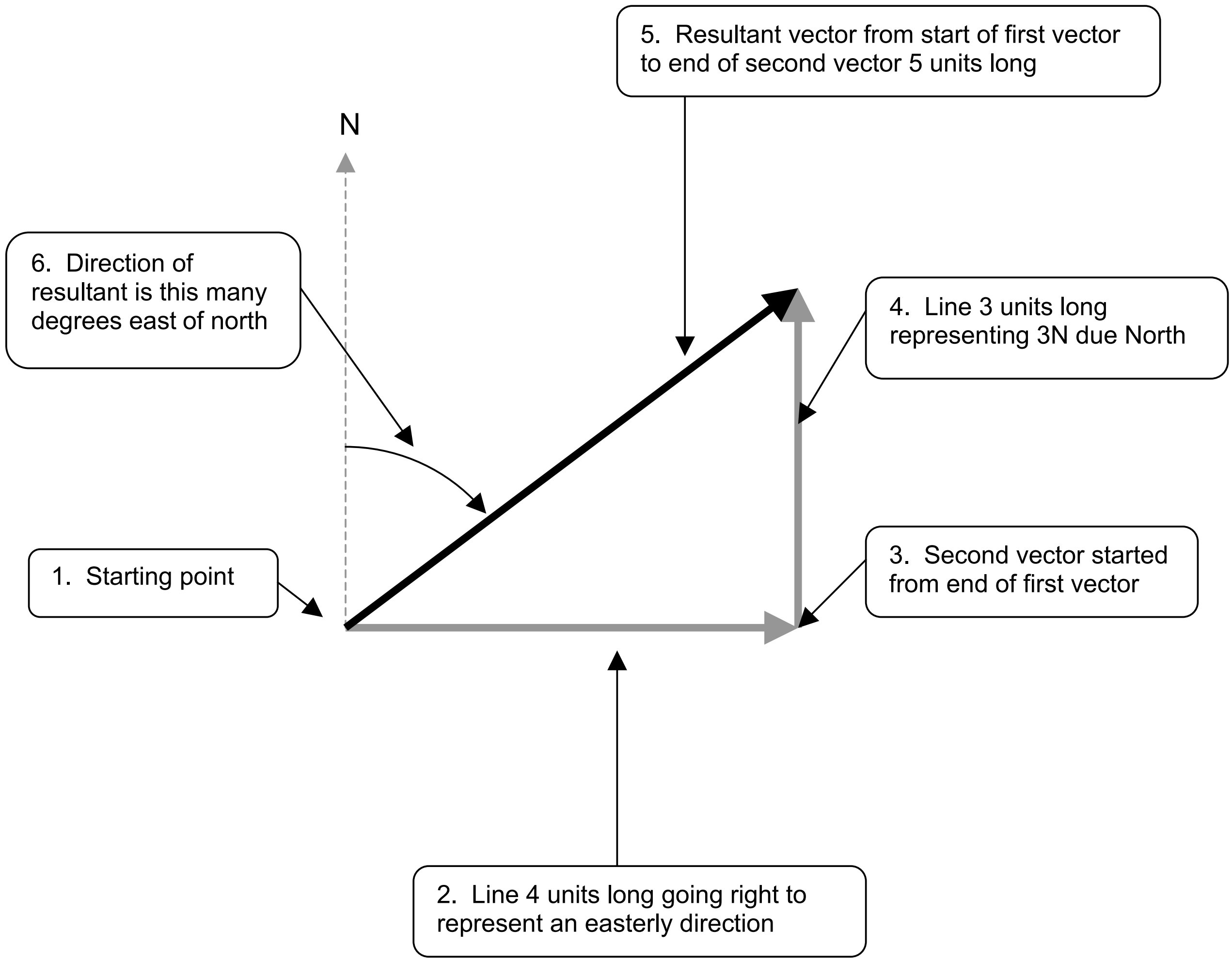
Mathematically: $\mathbf{F_R = F_1 + (-F_2)}$ (taking forces to the right as positive)

Vectors Acting at Right Angles (1)

The same principle is applied, but in this case the vectors are not in a straight line, but are mutually perpendicular. This method will also work for any angle between two vectors as long as the correct angle is drawn between the vectors.

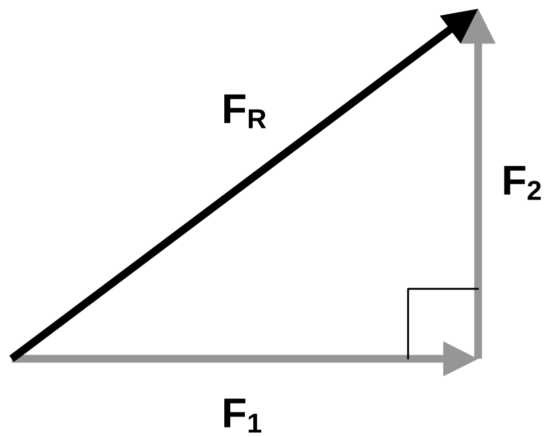
Example:

A force of 4N acting due east is applied to an object as well as another force of 3N acting due north. Find the resultant vector and give its size and direction.



Vectors Acting at Right Angles (2), by Calculation

The resultant of two vectors acting at right angles can be calculated using Pythagoras' theorem, since the two vectors and the resultant form a right-angled triangle.



Since $F_R^2 = F_1^2 + F_2^2$

then $F_R = \sqrt{F_1^2 + F_2^2}$

Example:

A force of 4N acting due east is applied to an object as well as another force of 3N acting due north. Find the resultant vector and give its size and direction.

$$F_R = \sqrt{16 + 9}$$
$$= \sqrt{25}$$
$$= 5N$$

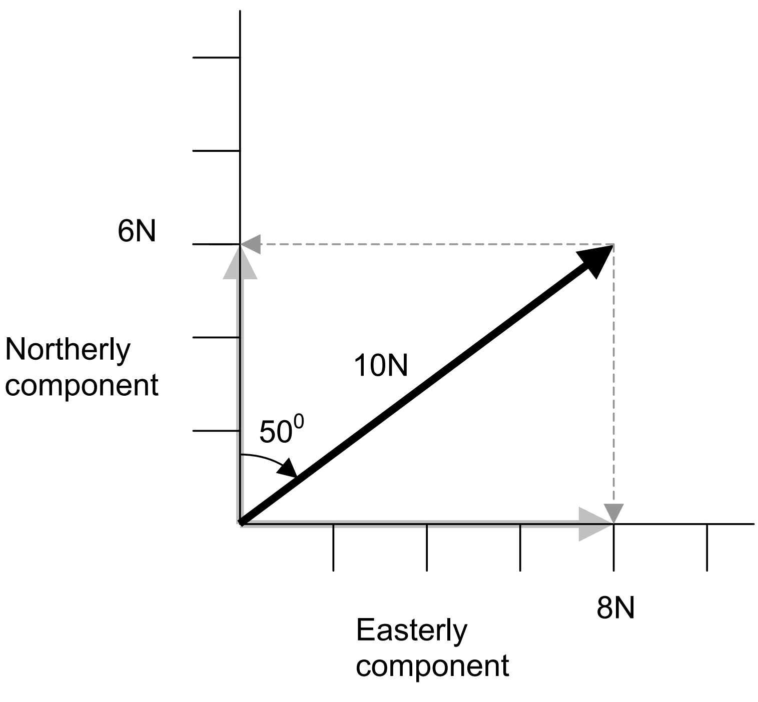
Resolving Vectors (1) by Scale Drawing

Any vector can be resolved (or separated) into two components at right angles. This is really just the opposite process to addition of vectors at right angles.

Using graph paper, the vector to be resolved is plotted to scale and in the correct direction, with respect to the resolved components. The magnitude of each component is obtained by projecting the end of the vector onto the appropriate scale.

Example:

The wind blows at $10ms^{-1}$ in a direction 50° east of north. Find its northerly and easterly components.



It should be noted that this method gives only an approximate answer due to inaccuracy in drawing. Compare the answers to the next section where the resultant is calculated.

Resolving Vectors (2) by Calculation

Using the same example as can be seen in the previous section, the components can be resolved using trigonometry.

It can be shown that the easterly component is equal to: **10 cos 40° = 7.7N**, and the northerly component is equal to: **10 cos 50° = 6.4N**.

In general, a vector V can be resolved into two components, C_1 and C_2, where:

$$C_1 = V \cos(\text{angle between } C_1 \text{ and } V)$$

and

$$C_2 = V \cos(\text{angle between } C_2 \text{ and } V).$$

Scalar and Vector Questions

You have now completed the part of this topic on scalars and vectors.
Make sure you have studied the textbook pages on this

Now attempt the following questions:

Assignment 1

Summary questions page 93	1, 2, and 4
Summary questions page 96	1, 2, and 4

Write and draw your answers to these questions showing all your working and hand them in to your link teacher who will post them to your tutor.
Your tutor will mark them and discuss these with you at the next tutorial.

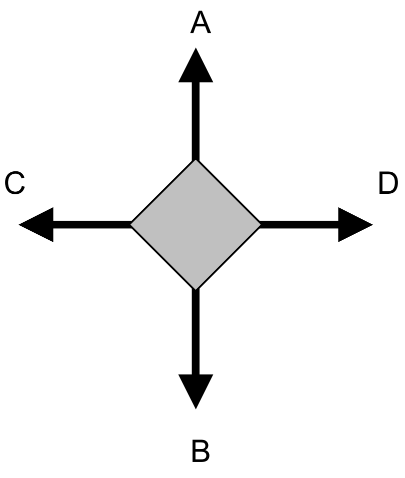
Equilibrium

An object is in equilibrium when all the forces on it are balanced. This means that equal downward forces cancel out upward forces, and sideways forces also cancel each other out.

Although forces may cancel out, care must be taken to note any forces not acting along the same line, as they will give rise to a turning force or torque (see later on). In this case, the object will rotate, which shows equilibrium is not possible.

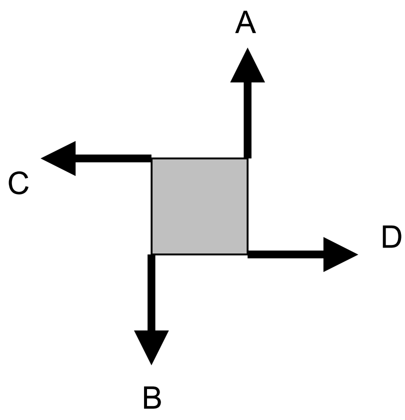
<u>Equilibrium is only achieved when forces are balanced and there is no turning force present</u>.

object in equilibrium



If A = B and C = D, the object is in equilibrium.

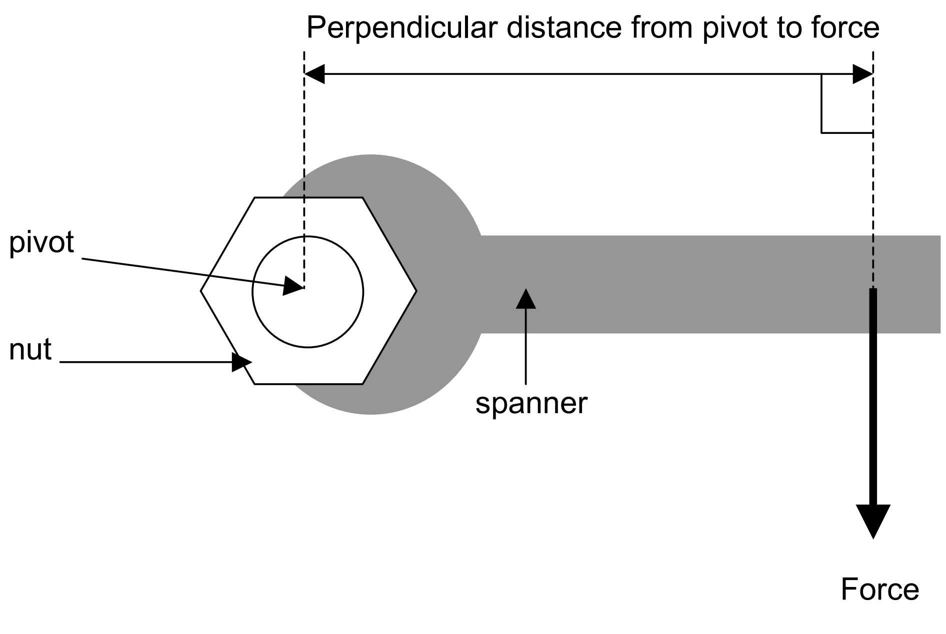
object not in equilibrium



Although A = B and C = D, they generate turning forces and the object is not in equilibrium.

Turning Forces

Imagine a garage mechanic trying to remove a nut from a bolt. The turning force that is required to do this is called a **moment** in Physics, and a **torque** in mechanical engineering. Most nuts cannot be removed by hand, and a spanner is required. The spanner not only forms a convenient holder for the nut, but allows the force to be exerted further from the centre of rotation of the nut, the pivot. This is useful since the moment of the force depends not only on the turning force, but also on its distance from the pivot. If the nut is reluctant to unscrew, the mechanic will either find a longer spanner, or put a tube on the handle to lengthen the spanner. Either of these actions will increase the distance to the pivot and therefore increase the moment, or torque.



Calculating Moments

The moment of a force = force × perpendicular force-pivot distance.

Since force is measured in N and distance in m, then the correct units for a moment are Nm.

Now study sections 7.3 and 7.4 in the textbook. Moments are explained there, as are couples, which are simply where two equal forces act in opposition but not in a straight line. Because the forces are equal and opposite there is no resultant force, but a turning effect is produced.

Principle of Moments

The principle of moments states that:

When an object is in equilibrium, the sum of the clockwise moments is equal to the sum of the anticlockwise moments.

In other words, there is no net turning force and so the object will be in equilibrium.

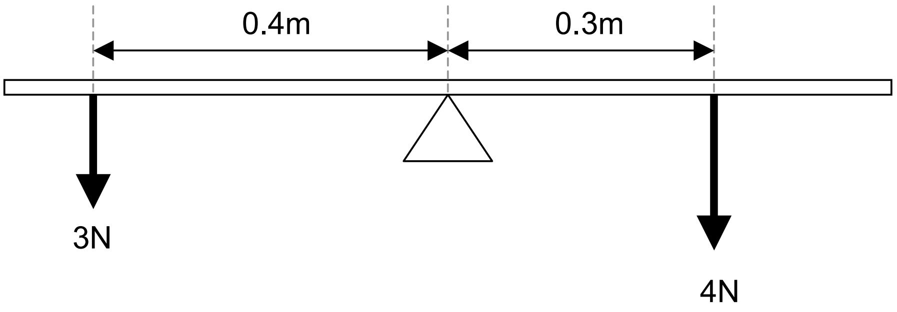
Stability

An object is in stable equilibrium if when displaced, it moves back to its equilibrium position, (a pendulum does this). If the object moves further away, it is in unstable equilibrium, it is theoretically possible to balance one football on top of another, but the slightest movement will cause the top football to roll off.

An object will topple (fall over) when tipped so far that the line of action of its weight, (a line drawn from its centre of gravity vertically downwards) is outside its base area. See sections 7.5 and 7.6 for more on this.

Moments and equilibrium example

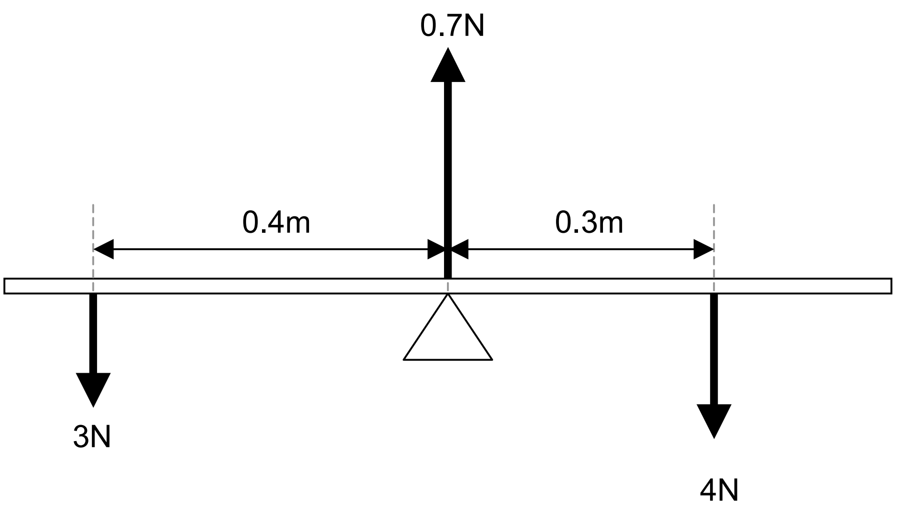
Take as an example, a uniform meter rule pivoted at its centre (so the ruler itself will balance). Forces of 3N on the left hand side, 0.4m from the pivot, and 4N on the right hand side, 0.3m from the pivot, are applied. This is shown in the diagram below.



Clockwise moment = $4 \times 0.3 = 1.2$ Nm

Anticlockwise moment = $3 \times 0.4 = 1.2$ Nm, equal to the clockwise moment

So the ruler is in equilibrium from the point of view of moments, it will not turn.
The equilibrium of the ruler is complete; the pivot will provide a reaction force of 0.7N to balance the total downward force, so the complete picture from the points of view of both moments and linear forces is as below:



Equilibrium and moments Questions

You have now completed the part of this topic on equilibrium and moments.
Make sure you have studied the textbook pages on this

Now attempt the following questions:

Assignment 2

Summary questions page 98	1, 2
Summary questions page 100	1, 2
Summary questions page 103	1, 2
Summary questions page 107	1, 2

Write and draw your answers to these questions showing all your working and hand them in to your link teacher who will post them to your tutor.
Your tutor will mark them and discuss these with you at the next tutorial.

Practical work to support and reinforce the theory in this topic is described on the following pages; you should do all of this. The skills that you will build up will be assessed later in the year as the third module PHYA3. There are three different types of practical with which you should become familiar:

- The rough trial experiment, often with simple apparatus requiring only a few readings.
- The longer more involved experiment, requiring careful observations using more complex apparatus and some calculations on the results.
- The investigation, you design and carry out a procedure to investigate a given situation.

The practicals on this course will give you practice at all of these.

PRACTICAL 1 Addition of Vectors

APPARATUS:

- 2 retort stands and clamps
- 0 – 10N newtonmeter
- 0 – 2.5N newtonmeter
- 500g mass
- string
- protractor

AIM:

To demonstrate vector addition.

METHOD:

Use string tied to the 500g mass to form a Y shape so that the two newtonmeters can be used hanging from the retort stands to support the mass. Adjust the position of the newtonmeters so that each is making a reading on its scale and the angle between them is exactly 90°. The apparatus should look like this:

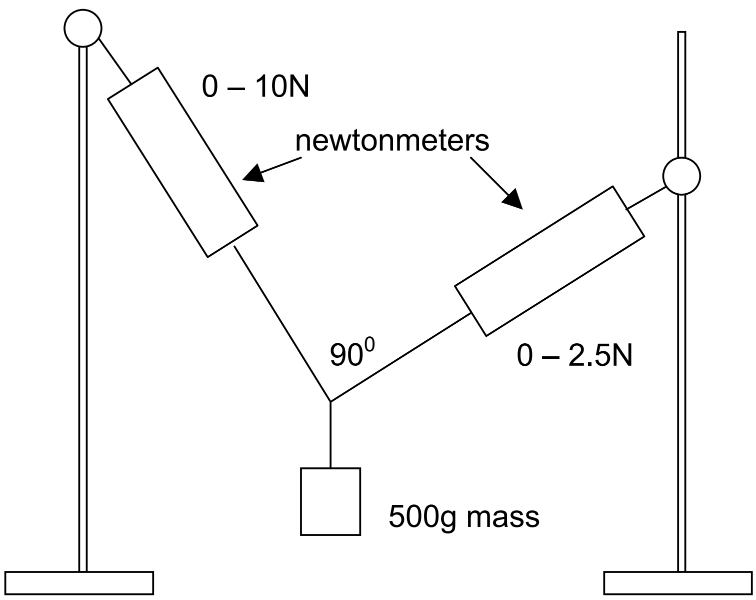


Photo of experiment

Try three different positions for the newtonmeters, always making sure that there is exactly 90° between the two strings going to each newtonmeter.
Ensure that the 0 – 2.5N newtonmeter reads on its scale. It will always require mounting lower than the 0 – 10N newtonmeter to achieve this.

RESULTS:
Record your results in the table and complete the calculations.

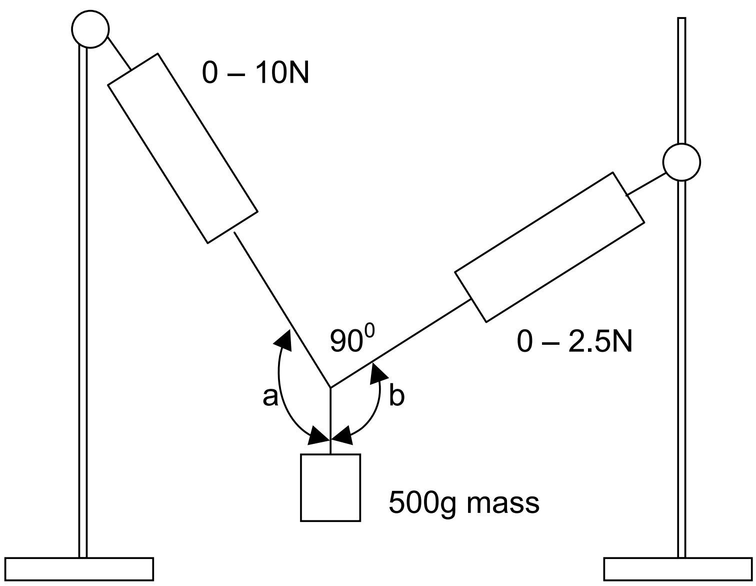
Readings on newtonmeters		**Calculations**		
A (N)	B (N)	A^2	B^2	$\sqrt{A^2 + B^2}$

CONCLUSION:

The weight of a 500g mass is actually 4.9N. Comment on your results:

FURTHER WORK:

Record the angles a and b (see below) for one of your three attempts. Using a scale of 2cm = 1N or larger, complete the vector triangle to show how the two components measured as A and B combine to form the 4.9N downwards force.



VECTOR TRIANGLE

CONCLUSION:

Comment on your diagram: