SCIENCE DEPARTMENT
BGS

Year 7

Physics Friend

Forces

This booklet contains information to support your work in Physics lessons. You <u>must</u> bring it with you to all Physics lessons on the Forces topic. Replacement booklets must be paid for at a cost of £1.

Name:

Form:

Science Teacher:

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Key Words

BALANCED	HOOKE'S LAW	PULL	DENSITY
KILOGRAM	PUSH	EXTENSION	LUBRICANT
UNBALANCED	FORCE	MASS	UPTHRUST
FRICTION	NEWTON	VOLUME	GRAVITY
NEWTONMETER	WEIGHT	VECTOR	SCALAR
VELOCITY	ACCELERATION	RESULTANT	REACTION

Now, find these words in the wordsearch below:

O	P	E	R	W	E	I	G	H	T	N	A	C	H	I	V	N	A
U	U	K	T	S	K	I	L	O	G	R	A	M	T	I	E	C	O
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T	C	U	T	N	A	T	L	U	S	E	R	A	R	A	N	O	N
Y	T	E	D	E	L	E	O	O	A	D	T	O	O	B	E	O	L

What is a force?

A force is a push or a pull. Forces can affect the motion and/or the shape of an object. The unit of force is the newton (N) and they can be measured using a newtonmeter.

We represent forces on a diagram using an arrow. The direction of the arrow represents the direction of the force while the length of the arrow denotes the size of the force.

Force is an example of a vector quantity, which means it has both a magnitude (size) and a direction. Some other quantities, known as scalars, have only magnitude and no direction associated with them (e.g. mass, temperature, energy). When we talk about forces, we specify a number for their magnitude, a unit (usually N) and a direction.

Forces are sometimes divided into contact and non-contact forces according to whether the objects that are exerting forces on each other are actually touching. Some type of force, such as gravity, act over very long ranges. In fact, the range of the gravitational force is infinite, so you are currently exerting a gravitational pull on objects that are billions of light years away…

The distinction between contact and non-contact forces is a slightly false one. When two objects are 'touching', what is actually happening is that the atoms in one of the objects are coming close to the atoms in the other and they are repelling each other, which is what produces a force between the objects. It is debatable whether any two objects are ever really 'touching', or even what this really means…

Questions:

1. Define what a force is and give two examples.

2. What is the unit of force, and what instrument is used to measure it?

3. Explain the difference between a vector and a scalar quantity. Give an example of each.

4. Why might it be misleading to say that two objects are "touching" when they interact?

5. Gravity is a non-contact force. Explain how it can still affect objects millions of kilometres apart.

Speed, Velocity and Acceleration

The speed of an object is the distance it travels in a certain amount of time. In physics, we usually measure it in metres per second (m/s), although other units (such as miles per hour) are appropriate in certain situations.

$$Speed = \frac{Distance}{Time}$$

You need to be able to use this equation to do calculations. However, this equation can be rearranged to find distance or time.

$$Distance = Speed \times Time \qquad\qquad Time = \frac{Distance}{Speed}$$

The velocity of an object is defined as its speed in a given direction. Velocity is a vector quantity, while speed is a scalar.

Whenever the velocity of an object is changing, we say that it is accelerating. There are three things that the object could be doing: speeding up, slowing down, or changing direction.

Questions:

1. A cyclist travels 200 m in 40 s. What is their speed?

2. How is velocity different from speed?

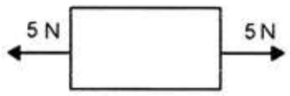
3. List three situations in which an object might be accelerating.

4. A car travels in a circle at a constant speed. Is it accelerating? Explain your answer using the definition of acceleration.

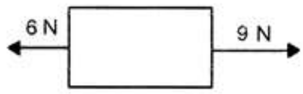
5. Why is acceleration considered a vector? Can an object accelerate without speeding up?

Balanced and unbalanced forces

As you've probably realised from the forces circus, most objects are acted on by more than one force at a time. To tell what will happen to an object we must first determine whether the forces are balanced or not. Consider the examples below.



In this case, the forces are acting in opposite directions and are of equal size. They therefore cancel each other out and the object acts as if no forces are acting on it. We say the forces are **balanced**.



On the other hand, here the forces are still opposite but not equal. We say the forces are unbalanced. The overall force, called the resultant force will be 3N to the right since 9N-6N=3N. It is important to give the resultant force a size and a direction.

If the forces on an object are balanced (there is zero resultant force), it will remain stationary or keep moving with constant velocity. In other words, without a resultant force, objects simply keep doing what they are already doing. The is called Newton's 1st Law of Motion.

When the forces on an object are unbalanced (non-zero resultant force), the object will accelerate in the direction of the resultant force. This means it will either speed up, slow down, or change direction

Questions:

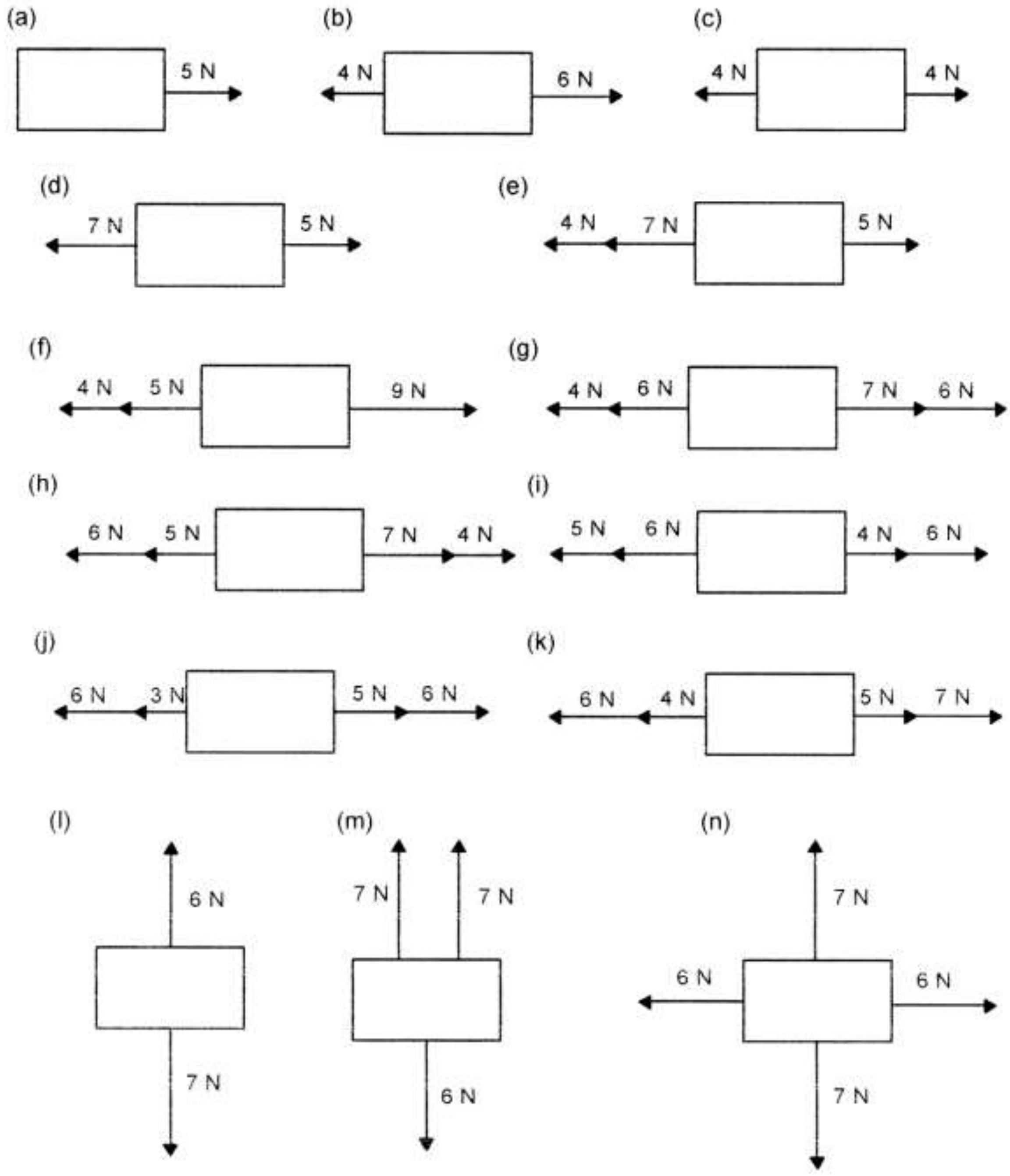
1. What is meant by a balanced force?

2. What is the resultant force on an object with 6N pulling left and 4N pulling right?

3. State Newton's First Law and explain what it means for a moving object.

4. A rocket in space continues moving without its engines firing. Use Newton's 1st Law to explain why.

5. In each of the examples below, decide whether the forces are balanced or unbalanced. If they are unbalanced, determine the size and direction of the resultant force.



Mass and Weight

Many people get confused when using the terms 'weight' and 'mass'. In physics, weight means something very specific and is different to mass.

- Mass is a measure of the amount of matter in an object and is measured in kg.
- Weight is the force of gravity and is measured in N (because it is a force!)

Whilst mass and weight are different, they are very closely related.

Calculating Weight

Mass and weight are related using a formula:

$$Weight = mass \times gravitational\ field\ strength$$

Since scientists are lazy, we tend to shorten these words into single letters or symbols:

$$W = m \times g$$

where m is the mass measured in kg and W is the weight measured in N.
g is the gravitational field strength which tells us the weight for each kilogram of mass. It is given the units newtons per kilogram (written N/kg). On Earth g = 10N/kg. In other words, on Earth there are 10N of weight for every kilogram of mass. Different planets have different values for g but these will be discussed in the Space and Gravity topic.
You need to be able to use this equation to do calculations, however this equation can be rearranged it to find mass or gravitational field strength

$$m = \frac{W}{g} \qquad\qquad g = \frac{W}{m}$$

Questions:

1. What is the equation that links weight and mass?

2. Calculate the weight of a 12 kg object on Earth (g = 10 N/kg).

3. Why does your weight change on different planets but your mass stays the same?

4. A student weighs 700 N on Earth. What would their weight be on the Moon where g = 1.6 N/kg?

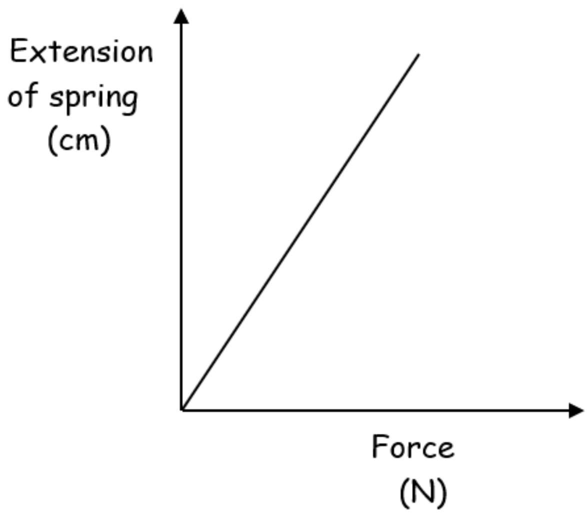
5. Why do astronauts on the International Space Station appear weightless, even though gravity is still acting on them?

Springs

Forces can change the shape of the object they act on. You investigated the stretch (extension) of a spring as bigger forces were exerted on it. You practised a lot of experimental techniques which you have written in your exercise book. You also found:

<u>Hooke's Law</u>

This says that the extension (increase in length) of a spring is 'directly proportional' to the extending force. This of spring really means that if you double the force applied, the extension doubles. Another way of saying the same thing is that the spring extends by the same amount every time you increase the force by 1N. (But if you overstretch the spring beyond its elastic limit, this pattern no longer is true and the line on the graph becomes a curve for bigger forces



It takes energy to stretch a spring and this energy is stored in the spring. When a spring is stretched, it stores **elastic potential energy**. We'll talk more about energy in physics in Year 9.

<u>A bit more on springs…</u>

At this stage, you don't need to know any more about springs than mentioned above. However, you might be interested in knowing a little more and you will look at this in more detail in Year 10.

How stiff a spring can be quantified using a spring constant. This is the force required, in N, to stretch the spring by 1m. It is measured in N/m (newtons per metre). The larger this number, the more force required to stretch the spring and therefore the stiffer the spring.

You can also arrange springs in different arrangement. Just like electrical circuits, you can arrange them in parallel. How they are arranged will affect how far they will stretch when the whole system is subject to a force. See what you can find out about series and parallel springs and how they work.

Questions:

1. A spring is 20cm long when a load of 10N is hanging from it, and 30cm long when a load of 20N is hanging from it.

   Draw diagrams and work out the length of the spring when
   a) there is no load on it
   b) there is a load of 5N on it.

2 In a spring experiment, the results were:

Load (N)	0	1	2	3	4	5	6	7
Length (mm)	50	58	70	74	82	90	102	125
Extension (mm)								

   a) What is the length of the spring when unstretched? This is called its natural length.
   b) Complete the table.
   c) Plot a graph of extension (y-axis) against load (x-axis).

Use your graph for these questions

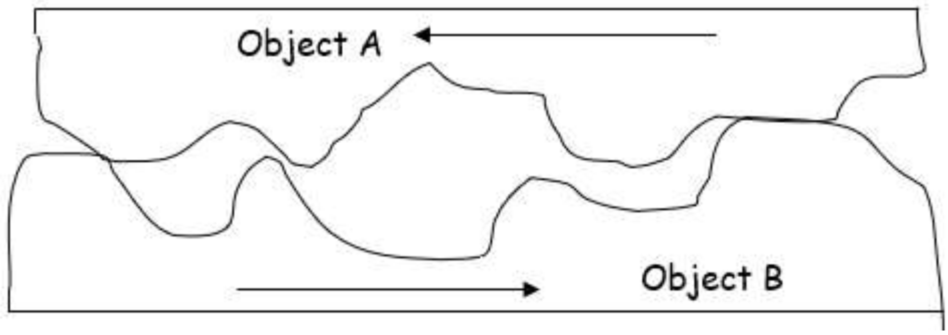
   d) One of the results does not fit the pattern of the rest of the data (an anomaly). Which is it? What do you think it should be?
   e) Mark the elastic limit on your graph.
   f) What load would give an extension of 30mm?
   g) What would be the spring length for a load of 4.5N

3. Find out the meanings of the following words:

   a) elastic
   b) rigid
   c) hardness
   d) ductile
   e) malleable.

Friction

Friction is a contact force. It acts when one surface tries to slide over another. Friction tries to oppose the movement of the object. But how does friction happen? Think about two surfaces moving against one another. They may look smooth, but, if you look at them under a microscope, you will see that they are rough:



Suppose A is moving to the left and B is moving to the right. The bumps of one surface have to get over the bumps of the other. This is difficult and we say that a frictional force is acting. Each surface exerts a frictional force on the other. Whenever a frictional force acts, heat is produced.

Sometimes it is useful and sometimes it is a nuisance. When it is a nuisance, we can reduce friction using a substance called a lubricant, such as oil or WD40. A lubricant reduces the contact forces between the two surfaces helping them to slide over one another.

Questions:

1. What is friction and when is it useful?

2. Give two ways in which friction can be reduced.

3. Why does rubbing your hands together produce heat?

4. Explain how friction acts at a microscopic level between two surfaces.

5. Below is a list of places where friction occurs. Decide in each case whether the friction is useful or unwanted and put into the correct column of the table. If it is unwanted, try to think of a way that friction is reduced.

- When we apply the brakes to stop the car
- To keep our shoelaces tied up
- Gears on your bike making it difficult to pedal
- Air resistance when moving fast (air resistance is a type of friction)
- Between our shoes and the floor to enable us to walk.
- Water resistance when moving through water.

Useful friction	**Unwanted friction**

Density

Density is a way of fairly comparing different materials. Think about the following statement:

'Steel is heavier than feathers.'

Is this true? A large bag of feathers is heavier than a teaspoon. It only makes sense if we compare the masses of equal volumes of the materials. Density does this.

The **density of a material** is the mass of unit volume ($1cm^3$) of the substance. We calculate it using the equation:

$$density = \frac{mass\ (in\ g)}{volume\ (in\ cm^3)}$$

Or in symbols (lazy scientists!!):

$$\rho = \frac{m}{V}$$

ρ is the Greek letter rho which is used because scientists ran out of standard letters! The units of density are **g/cm^3**, which is said "grams per centimetre cubed".

For example, the volume of 100g of water is $100cm^3$. What is the density of water?

$$density = \frac{mass}{volume} = \frac{100g}{100cm^3} = 1g/cm^3$$

We can also rearrange the equation to work out masses and volumes.

$$m = \rho \times V \qquad\qquad V = \frac{m}{\rho}$$

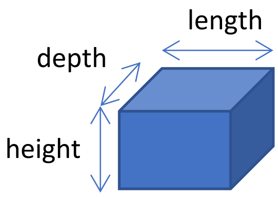
An ice cube has a volume of 60 cm^3, quite a big ice cube! If the density of ice is 920 g/cm^3, what is the mass of the ice cube?

$$mass = density \times volume = \frac{0.920g}{cm^3} \times 60cm^3$$

$\underline{mass = 55.2g}$

Measuring volumes

1. **Cuboids**



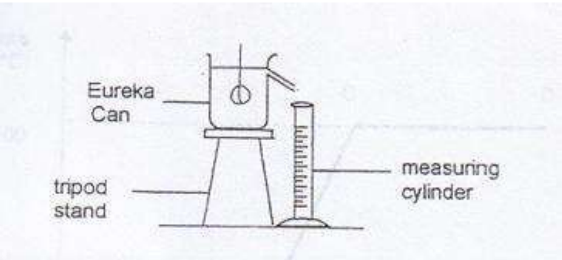
The volume of a cuboid can be found by multiplying the length by the height and multiplying this by the depth.

2. **Liquids**

Liquids can be measured using a measuring cylinder. 1ml is equal to $1cm^3$.

3. **Irregular solids**

Lumpy shapes cannot be measure directly. To find the volume of a so-called irregular solid, you use a Eureka can. The Eureka can is filled with water to the spout and then the object is placed in the can. The water that falls out of the spout is collected in a measuring cylinder and this is the volume of the solid.



This piece of apparatus is named after Archimedes' famous exclamation when he first realised how to measure the volume of an irregular solid.

Questions:

1. What is the equation for density?

2. A block has a mass of 250 g and a volume of 50 cm^3. What is its density?

3. Describe how you would find the volume of an irregular object.

4. Why is steel heavier than feathers even though both can have the same mass?

5. A rock has a mass of 3.6 kg and displaces 1.2 litres of water when fully submerged. What is the density of the rock in g/cm^3?

(Hint: 1 litre = 1000 cm^3**)**

Floating and Upthrust

When we weigh something while it is immersed in water, it seems to weigh less than it does in the air. This is because the fluid the object is in exerts an upward force, that we call **upthrust**. This force opposes the weight and when the upthrust is equal to the weight, the two are **balanced** and the object floats.

Denser fluids (liquids/gases) exert a bigger upthrust than less dense fluids. An object will float in a fluid if it is less dense than the fluid, and it will sink if it is has a higher density than the fluid.

An iron boat will float in water even though the density of iron is much greater than the density of water. This is because it is 'hollowed out' to make the volume larger. As a result, the average density (of iron and the air inside the boat) is less than 1 g/cm^3.

Measuring upthrust

In the experiment, you are going to use a newtonmeter to find out how much different objects seem to weigh when they are suspended in air and in water.

You will need: A newtonmeter, a clamp stand and clamp, thread, scissors, a beaker of water and several blocks made of different materials.

Weigh each block in water and then in air, recording your results in a table showing:

- The name of the material
- The weight in air
- The apparent weight in water

DON'T FORGET THE UNITS IN YOUR TABLE HEADINGS!

QUESTIONS

1. What patterns do you notice in your results?
2. Can you suggest reasons for these observations? (We will be doing some more experiments that will help you to refine your ideas.)
3. Would the readings on the newtonmeter be the same, more or less, do you think, if the object was immersed in cooking oil rather than in water?
4. The Dead Sea is very salty. How does this affect the ability of people to float in it?
5. The side of a ship has markings on it called the 'load line' or 'Plimsoll line'. Try to find out what they look like, what they are for and why they were first put on the side of every ship.

Revision questions

1. What type of force is air resistance: contact or non-contact?

2. A force causes a change in motion or shape. Name two everyday examples of this happening.

3. What does the length of an arrow represent in a force diagram?

4. Which unit do we use for mass, and which for force?

5. A snail moves 0.6 m in 30 seconds. What is its speed in m/s?

6. Which physical quantity must always be stated with a direction: speed or velocity?

7. What do we mean by the term "resultant force"?

8. If an object is moving at a constant speed in a straight line, what can we say about the forces acting on it?

9. Describe what would happen to a moving object if all forces acting on it suddenly became balanced.

10. Write the equation used to calculate weight and define each variable.

11. An object on Earth weighs 120 N. What is its mass?

12. A student travels to a planet where g = 5 N/kg. If their mass is 50 kg, what is their weight on that planet?

13. Why should you not add more than 8N to a spring during an experiment?

14. What is meant by a spring behaving "elastically"?

15. When drawing a graph of force versus extension, what does a straight line through the origin tell us?

16. Describe what a lubricant does and give one example of where it might be used.

17. Explain how you could measure the density of a liquid in a school lab.

18. Why do objects with lower density than water float?

19. A steel cube sinks in water but a hollow steel boat floats. Explain why.

20. Why is the upthrust on a block greater in salt water than in fresh water?

BALANCED AND UNBALANCED FORCES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
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FLOATING AND SINKING

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
22																	23								

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A R _   _ _ _ A _   _ _   _ _ _   _ _ R _ _ _   A R _
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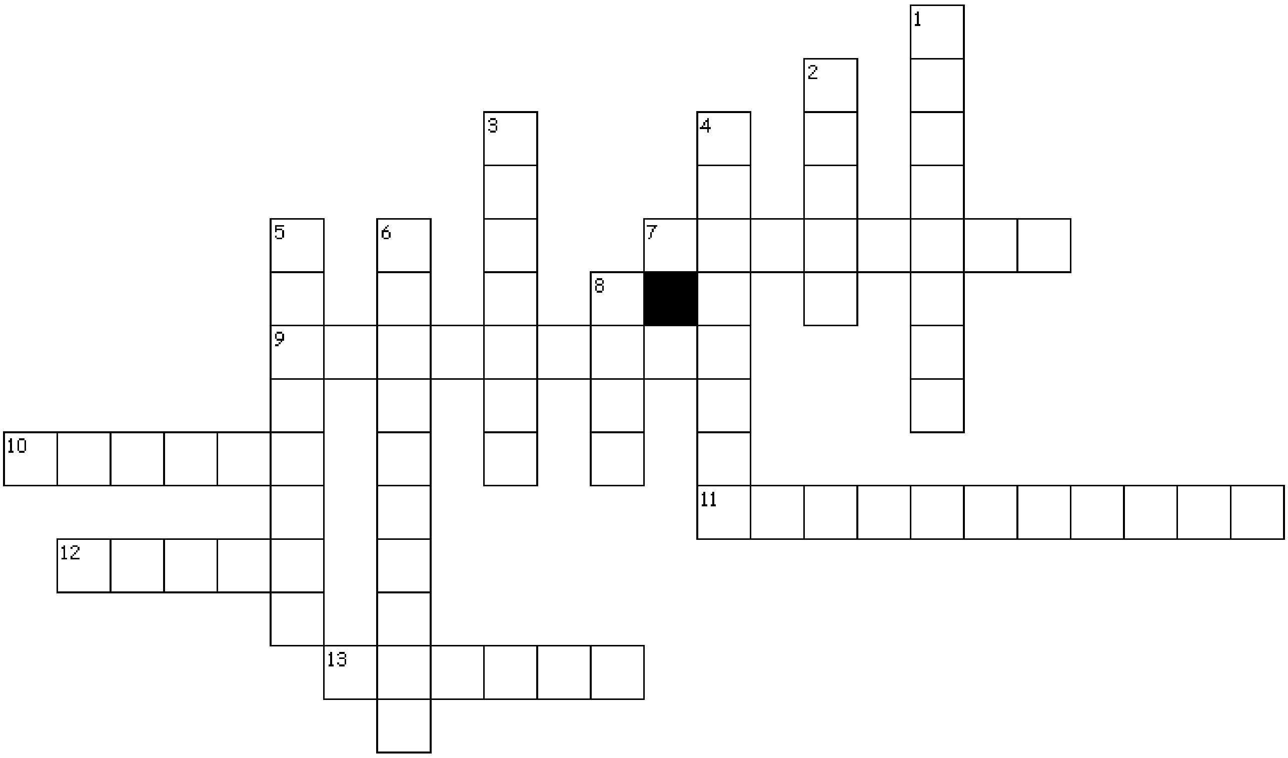
FORCES AND THEIR EFFECTS CROSSWORD



Across
7. The unit of mass (8)
9. A substance to reduce friction (9)
10. The unit of force (6)
11. The instrument used to measure a force (11)
12. The surname of the scientist that has a law about springs (5)
13. The force of gravity acting on an object (6)

Down
1. The upwards force experienced by objects in liquid or gases (8)
2. These are used to represent the size and direction of a force (5)
3. The mass per unit volume of an object (7)
4. The force that opposes motion between two rough surfaces in contact (8)
5. If the forces are ________, the object will continue to move at the same speed in the same direction (8)
6. If the forces are __________, the object will change speed, direction or shape (10)
8. The amount of matter an object is made of (4)

KEY CONCEPTS

Clue											
FERCO				7	19						
ROTWEEMENNT		11			9				13		
LAEDACBN			2		12						
SASM		15									
HGWIET		17	14	21		5					
TRIFCINO		20	6					18			
NICLARBUT	16						3				
SETINDY		1					22				
STHURPUT		8	10				4				

1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16		17	18	19	20	21	22

Unscramble each of the clue words.
Copy the letters in the numbered cells to other cells with the same number.

MASS, GRAVITY AND WEIGHT

O R C	A V I	S I	H T	G R A	S M	D I	M A S
M S ,	A F	E .	N O N	G R	A N	E I G	A P
U R E	N K	D W	I L O	E A S	T Y	I S	I S
O M E	H E N						

Unscramble the tiles to reveal a message.

Year 7 physics equation sheet

$$Distance = Speed \times Time$$

$$Speed = \frac{Distance}{Time} \qquad Time = \frac{Distance}{Speed}$$

$$Mass = Density \times Volume$$

$$Density = \frac{Mass}{Volume} \qquad Volume = \frac{Mass}{Density}$$

$$Gravitational\ field\ strength = \frac{Weight}{Mass}$$

$$Weight = Mass \times Gravitational\ field\ strength$$

$$Mass = \frac{Weight}{Gravitational\ field\ strength}$$

$$Charge = Current \times Time$$

$$Current = \frac{Charge}{Time} \qquad Time = \frac{Charge}{Current}$$

$$Charge = \frac{Energy\ Transferred}{Potential\ Difference}$$

$$Energy\ Transferred = Charge \times Potential\ Difference$$

$$Potential\ Difference = \frac{Energy\ Transferred}{Charge}$$

$$Resistance = \frac{Potential\ Difference}{Current}$$

$$Potential\ Difference = Current \times Resistance$$

$$Current = \frac{Potential\ Difference}{Resistance}$$