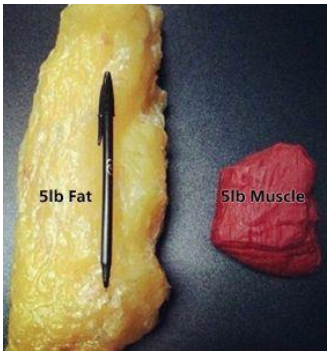
Revision sheet - IGCSE Physics

Lesson 3: Mass, weight and gravity

Many people think mass and weight are the same. They are not.

UNDERSTANDING MASS

- The **mass** of an object is how much stuff it's made from.
- This 'stuff' is more scientifically called **matter**.
- Matter is another name for atoms.
- Every atom in the periodic table has a different number of subatomic particles called protons, neutrons and electrons. This means different atoms are different sizes i.e. they have different masses. The number of atoms and type of atoms that make up an object gives you the mass of that object.
- A small object can still have a large mass, by having dense/tightly packed particles. For example, a gold bar can be very hard to lift, but it is not very big in size.
- A large object can have a reasonably low mass. For example, muscle is denser than fat, so a body builder could have the same mass as an obese person despite looking smaller.



- The unit of mass is kilograms (kg), and therefore also grams (g). It is measured using a **balance**.
- Mass is different to weight.

Modern balances look like electronic scales, but they still work as a balance.

UNDERSTANDING WEIGHT

- Weight is your mass, taking in to account where you are.

- Your **mass never changes** depending on where you are. You will have the same number of atoms whether you are standing on Mars or standing on Earth. You will weigh different though.
- This is all due to the force of gravity (more specifically gravitational field strength).
- We say that **the weight of an object is the force that acts on it because of gravity**.
- That's why writing weight or gravity on a force diagram means the same thing.
- The unit of weight is N and is measured using **scales** or a **newton metre**.

WHY ARE MY BATHROOM SCALES NOT IN NEWTONS (N)?

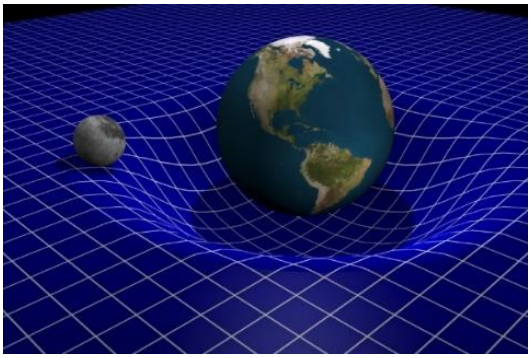
They should be, but we have all got so used to stones and kilograms, manufacturers (the people who make things for us) don't want to change. It doesn't really matter though, because we are all measuring ourselves on Earth so it's all relative.

UNDERSTANDING GRAVITY

- Gravity is the force of attraction between the mass of two (or more) objects.
- The closer the two objects are the greater the force due to gravity.
- Everything with mass has gravity, but only things with huge masses have gravity that we can measure easily. We say the greater the mass of an object the greater the force due to gravity.
- That's why the Earth pulls me, or this apple towards the Earth, but I don't pull the Earth towards me.
- Sir Issac Newton discovered the force of gravity. He did lots of work on forces in general. That's why the unit of force is called a Newton (N).

EXTENSION (NOT ON THE IGCSE SYLLABUS. MORE LIKE UNIVERSITY PHYSICS!)

- Einstein took gravity to a whole new level. He discovered that objects with lots of mass pull things towards them because space and time have been bent. Oooo er!
- You can think of space and time like a blanket. Big objects dent the blanket more, pulling the smaller ones towards it.

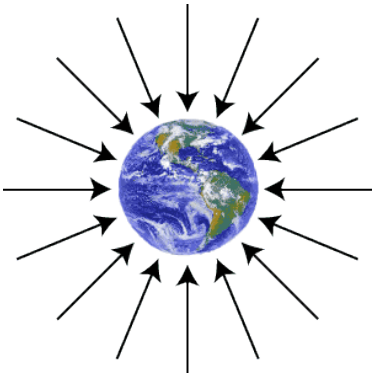


GRAVITATIONAL FIELD STRENGTH IS DIFFERENT FROM GRAVITY

- Gravitational field strength is the amount of force placed on one of those objects by the other. An objects gravitational field strength will stay the same unless its mass changes.
- More specifically, it is **the force in Newtons that acts on each kilogram of mass**.
- For this reason, gravitational field strength is measured in **Newtons per Kilogram (N/Kg)**.
- The gravitational field strength of planet Earth is **9.81N/Kg**. This is often rounded to

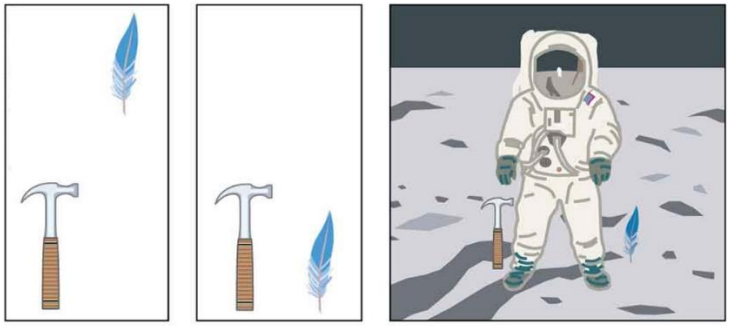
  9.8N/Kg or 10N/kg. Your exam often tells you which of these it wants you to use at the beginning in of the exam paper. If not, any should be fine.

- The gravitational field strength of an object such as Earth will exert this force on you know matter where you are on the planet. This diagram shows what I mean. No matter where you are on Earth, you will be pulled to the ground with a force of 10N/Kg for every kilogram of you. In reality, the whole Earth would be covered in arrows, but I can't fit them all in! You get the picture.



INTERESTINGLY …..

- If an object is falling straight down towards Earth (not from space, but from your hand, for example) it will accelerate (speed up) at a set rate of approximately 9.8 m/s (metres per second).
- For this reason a feather and hammer will hit the ground at the same time if dropped from the same height. Earth is pulling them down with the same acceleration due to its gravitational field strength.
- BUT, in reality this doesn't happen. This is because air resistance is opposing the motion of the feather more than the hammer, therefore, slowing it down.
- You'd need to drop them both in a vacuum where there are no air particles (like oxygen) floating around getting in the way. Space is a natural example of a vacuum. But, we can create a vacuum in a laboratory as well.
- More on the **acceleration due to gravity** in (T3L6).



In air | In a vacuum | In a vacuum (the hard way)

CALCULATING WEIGHT, MASS AND GRAVITATIONAL FIELD STRENGTH

- We say that weight, mass and gravitational field strength are related. If we change one, the others will change too.
- We can calculate any of these variables using the formula:

Word formula → **Weight = mass x gravitational field strength**

Algebraic symbols → **W = m x g**

Units (what each variable is measured in) → **N kg N/Kg**

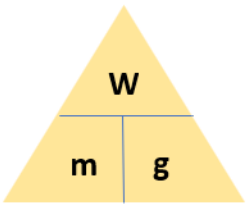
UNITS AND ALGEBRAIC SYMBOLS ARE NOT THE SAME! WE MEASURE MY MASS IN Kg, NOT m's. ALGEBRAIC SYMBOLS ARE JUST A 'NICKNAME' FOR VARIABLES. IMAGINE DOING PAGES OF MATHS WRITING OUT ALL THESE WORDS! NO THANKS!

- It's important that m and g are written as lowercase letters.
- Using this formula, I can calculate my weight on different planets.
- Lets say I have a mass of 60 Kg and I'm standing on Earth with a gravitational field strength of 10 N/Kg (approximately). What will my weight be?

W = 60 x 10

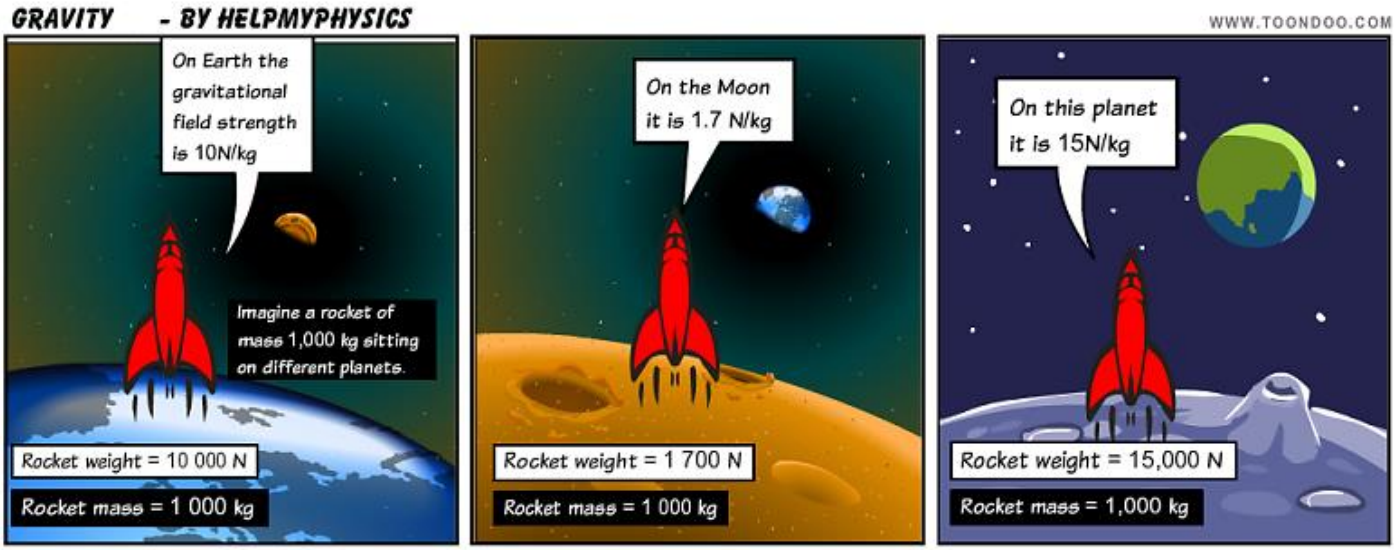
W = 600 N

- In the formulas crash course you did not focus on units to help you understand the maths. But, units are very important. You should include them in all your answers!
- You can also rearrange the formula to find mass or gravitational field strength. You can use the line, pyramid or advanced method. Your choice.
- This gives you:



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

- You must remember from memory the gravitational field strength of Earth. It's a good idea to know, roughly, some of the other bodies (things with mass) in our solar system too. For example, the moon's gravitational field strength will be lower than Earths, and Jupiter's will be much bigger. You don't need to memorise all their gravitational field strengths in detail.



UNITS

We know that force is measured in units of Newtons (N). This is the preferred unit for most exam questions. However, sometimes the force in newtons is so large it is easier to write in terms of Kilonewtons (kN) or Meganewtons (MN). Be ready to convert between these in calculations.

Unit have	**Unit want**	**Formula**
kN	N	x 1000
N	kN	÷ 1000
MN	N	x 1,000,000
N	MN	÷ 1,000,000
mN	N	÷ 1000
N	mN	x 1000