Monday, 20 July 2026

Connect

Title
SI Units – Forces and motion equations

Today's Targets

Identify equations for forces and motion

Select which equations from a given list would be used for a specified engineering product or project

Every discipline of engineering involves taking measurements, understanding them and then communicating them to others. Which means, with global trading, we all have to **speak the same basic language**, to provide a **consistent way of communicating** size, mass, shape, temperature, time, amount, energy, power, and speed. The SI system **is used around the world**.

What you can see and touch

Aesthetics
Texture

Reporting of Injuries, Diseases and Dangerous Occurrences Regulations

NCFE Level 1 / 2 Technical Award in Engineering

CA2 - Applied science and mathematics in engineering

2.2.1 SI Units of Measurement - equations
Forces and motion
Lesson 4

Monday, 20 July 2026

Today's title: SI units – forces and motion equations

Today's Targets

Identify equations for forces & motion

Select which equations from a given list would be used

Today's Learning:

You must be able to:

Define and differentiate speed and acceleration.

Define and differentiate force and pressure.

Define and differentiate momentum and moment.

You may also be able to:

Apply the formula to solve engineering problems.

Prior Learning

CA1 Engineering disciplines

Future Learning

CA3

Reading engineering drawings

Literacy

International System (SI)   Equation

Forces and motion

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Today's title: 2.2: Engineering equations 1

Your target

- Identify equations for energy and forces & motion
- Select which equations from a given list would be used for a specified engineering product or project

Steps to success

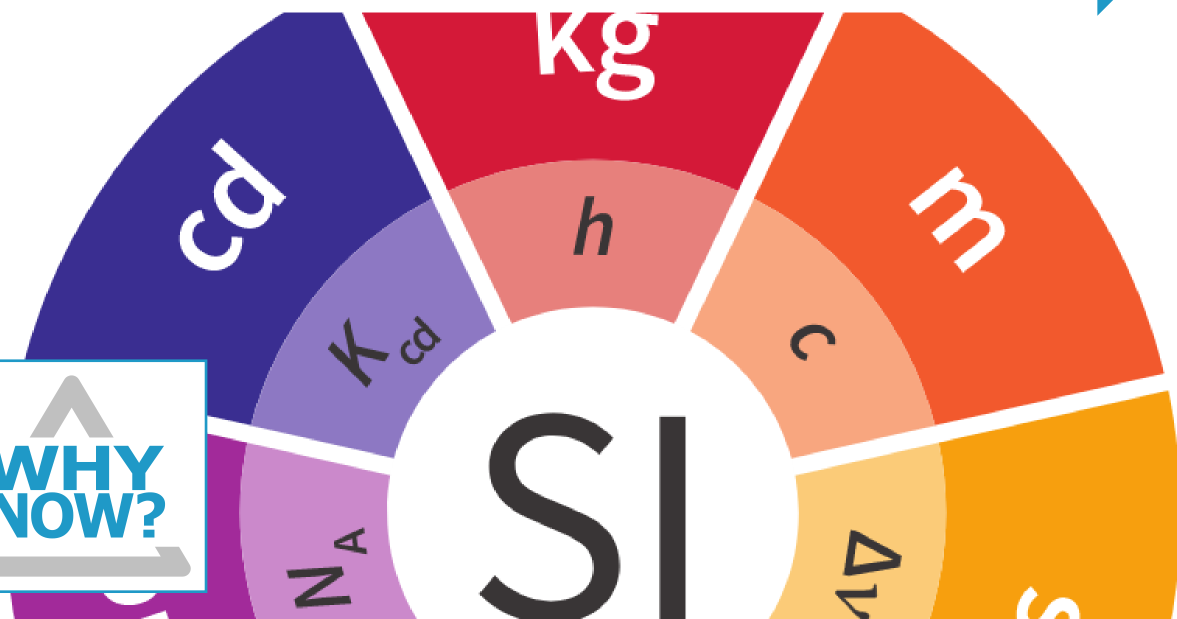
- Apply data to a selected equation to complete a calculation for a specified engineering product or project

Path to progress

- Justify the selection of the equation
- Assess whether the correct calculation has been used

Key terms

International System (SI)
Equation
Energy



WHY NOW?

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Introduction

It is important to understand how mathematical and scientific equations are used in engineering disciplines to calculate the properties of:

- Forces and motion

In the development of products and projects.

The equations provided are not exhaustive, however, they are the ones most relevant to this level of study.

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Complete the table with correct SI unit

Name	Unit
Force	N newton
Pressure	Pa pascal
Speed	mps
Momentum	kg·m/s
Acceleration	metres/second2 (m/s2)
Moment	Newton-meter (Nm)

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Forces and motion

Motion is the changing of position or location. But motion requires a force to cause that change. Force is just a fancy word for pushing or pulling.

Force makes things move or, more accurately, makes things change their motion.

Newton's first law of motion states: A body in motion tends to remain in motion, a body at rest tends to remain at rest unless acted on by an outside force.

Newton's second law of motion states that a force, acting on an object, will change its velocity by changing either its speed or its direction or both.

Newton’s third law states that for every force and action, there is an equal and opposite reaction.

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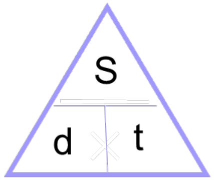
Forces and motion: Speed

speed = distance ÷ time
s = d ÷ t

The speed of an object tells you how fast or slow it's moving. The faster something moves, the greater the distance it covers in a given time, or the less time it takes to cover a given distance.

In calculating the performance in the continued development of any product from **automotive or aeronautical engineering**, tests are done to consider capabilities. Speed is a critical test of performance, as this can inform the application of a number of other equations, such as acceleration and force.

$$\boxed{\text{Speed} = \frac{\text{distance (m)}}{\text{time (s)}}}$$



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Forces and motion: Acceleration

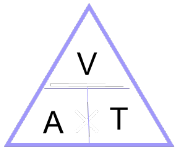
acceleration = change in velocity ÷ time
a = (v-u) ÷ t

When we think of the word 'accelerate' we think of something increasing in speed, but it actually means a change in speed so can also mean when something slows down.
Acceleration is dependent upon 2 things:

How much the **speed** changes by
How much **time** the change in speed has taken

In the **design of underground trains** it is important to calculate the potential speed changes for the trains moving short distances between stations increasing and decreasing speeds in short spaces of time over short distances.

$$\boxed{\text{Acceleration} = \frac{\text{change in velocity (ms}^{-1}\text{)}}{\text{time (s)}}}$$



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Forces and motion: Force

force = mass x acceleration
f = m x a

Force is a push or pull on an object and is directly linked to Newton's second law of motion states that a force, acting on an object, will change its velocity by changing either its speed or its direction or both. The net force on an object is equal to the mass of the object multiplied by the acceleration of the object.

In the **engineering of bridges** consideration must be made for its own weight plus the weight of the cars driving across it pulling downward. The force of gravity pulling down on the bridge must be calculated to allow it to be balanced by tension in the suspension cables pulling it back up again. By calculating the pushing force on the bridge designers can balance with pulling forces to avoid collapse.

Force = mass x acceleration

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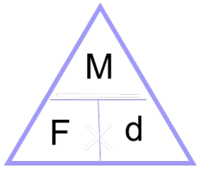
Forces and motion: Moment of force

moment = force x perpendicular distance from pivot
m = f x d

Forces can make objects turn if there is a pivot point, this is known as the moment. Imagine a set of old fashioned scales. The pivot is the point in the middle. When something is added to one end of the scale it tips up. This turning point around the pivot is the moment. To calculate moment we need to know the size of the force being added and the distance away from the pivot point.

A simple example of a moment in engineering could be when **using a spanner to turn around a fixed nut**. The pivot point is where the spanner is connected to the nut, the distance is the length from the nut to the hand and the force is the amount of pressure being used by the hand.

Moment of force
= Force (N) x perpendicular distance from pivot (m)



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Forces and motion: Weight

weight = mass x gravity
w = m x g

Weight is **not** the same as mass. Mass is a measure of how much stuff is in an object. Weight is a force acting on that stuff.

For example you would weigh less on the Moon because the gravitational field strength of the Moon is 1/6 of that of the Earth. But note that your mass (the amount of you) would stay the same.

*In **aeronautical engineering** weight is one of the four forces of flight. Weight is the force that pulls an airplane back towards the Earth, due to the mass of the aircraft and the gravitational pull. The weight must be overcome by lift to achieve flight. The lift must be greater than the weight of an airplane for the airplane to climb.*

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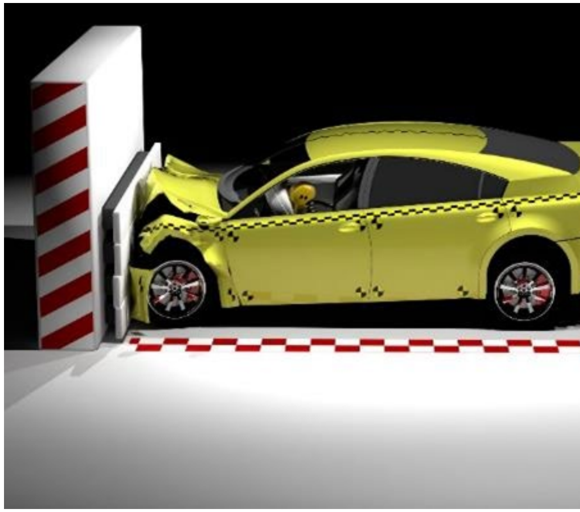
Forces and motion: Momentum

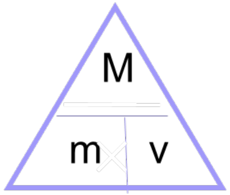
momentum = mass x velocity
p = m x v



A moving object has momentum. This is the tendency of the object to keep moving in the same direction. It is difficult to change the direction of movement of an object with a lot of momentum. Think about when you are sat in a car and the drive brakes hard, you jerk forward as your body is still moving in the same direction.

*In **automotive engineering** momentum is used to calculate, stopping distances and for crash testing to safeguard passengers in the event of a collision.*

$\boxed{\text{Momentum} = \text{mass (kg) x velocity } (\text{ms}^{-1})}$ →



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Forces and motion: Density

density = mass / volume
d = m / v

Density is the mass of an object divided by its volume. In simple terms how much is packed into a space. When a shoebox is filled with small polystyrene balls it has more density than it the same box were filled with ping pong balls.

*In **biomedical engineering** the equation for calculating density is used to calculate bone density prior to prosthetics implants.*

Density calculations are also use in chemical engineering when working with oil and gas. Oil is less dense than water which means is floats on the surface of water and in the event of oil spillages such as Deep Water Horizon, density is calculated in the coordination of a clean up operation. Gases expand to fit their container and density calculations are used when working with compressed gases.

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Forces and motion: Pressure

pressure = force ÷ area
p = f ÷ a

$$P = \frac{\text{Force (F)}}{\text{Area } (m^{2})}$$

If a force is distributed over a larger area the pressure is reduced. If someone stands on your foot in a high heel shoe with a fine point there is a lot of pressure. If the same person stood on your foot in a flat shoe without a build heel, there would be less pressure and it would be a lot less painful. As it is the same person the Force is constant but the surface area is reduced in the stiletto compares to the flat shoe.

The use of this principle is applied in the development of **prosthetic legs limbs**. If the socket of the prosthetic can spread the area of the force placed on it, the pressure is reduces, making the prosthetic more comfortable.

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Question time

Using the equations and in your pairs, can you solve the following problems:

1. A flight from London to New York takes 8 hours and covers a distance of 5540 km. Calculate the speed that the aircraft must be travelling at. Give your answer in kilometres per hour (km/h).
2. Calculate the average speed of a car that travels 200 kilometres in 4 hours.
3. An engineer is tightening a bolt on the front wheel of an electric motorcycle. The engineer applies 45 N of force at a distance of 400 mm from the bolt. Calculate the moment of force being applied to the bolt.

force and motion:

- speed $s = d \div t$ speed = distance ÷ time
- acceleration $a = (v - u) \div t$ acceleration = change in velocity ÷ time
- force $F = m \times a$ force = mass x acceleration
- moment of force $m = F \times d$ moment = force x perpendicular distance from pivot
- momentum $p = m \times v$ momentum = mass x velocity
- pressure $p = F \div A$ pressure = force ÷ area

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Question time - *answers*

In your pairs, can you solve the following problems:

1. Speed = 5540 ÷ 8 = **692.5 Km/h or 692.5**
2. Speed = 200 ÷ 4 = **50kph**
3. Moment = (400 ÷ 1000 = 0.4m). 45N x 0.4m = **18Nm**

force and motion:

- speed   s = d ÷ t   speed = distance ÷ time
- acceleration   a = (v - u) ÷ t   acceleration = change in velocity ÷ time
- force   F = m x a   force = mass x acceleration
- moment of force   m = F x d   moment = force x perpendicular distance from pivot
- momentum   p = m x v   momentum = mass x velocity
- pressure   p = F ÷ A   pressure = force ÷ area

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Demonstrate

1. What is a km a measure of? [1 mark] A Current B Length C Mass D Volume

2. A flight from London to New York takes 8 hours and covers a distance of 5540 km.
Calculate the **speed** that the aircraft must be travelling at. Give your answer in km/h.
Show your working. [2 marks]

____

____

3. Calculate the average **speed** of a car that travels 200 kilometres in 4 hours.
Show your working. [2 marks]

____

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4. An engineer is tightening a bolt on the front wheel of an electric motorcycle. The engineer applies 45 N of force at a distance of 400 mm from the bolt.
Calculate the **moment of force** being applied to the bolt.
Show your working. [2 marks]

____

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5. Figure 1 shows a box with a base measuring 500 mm by500 mm on a shelf. The box applies a force of 175 N over its base.
Calculate the **pressure** applied to the shelf shown in Figure 1. Show your working. [2 marks]

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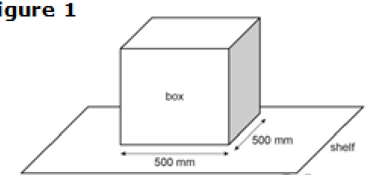
Figure 1



*A 25500 g electric scooter is used in a crash test to test its safety. It accelerates into a brick wall at 8 metres per second. Calculate its **force** in Newtons. Show your working. [2 marks]*

25 minutes!

force and motion:

- speed $s = d \div t$ speed = distance ÷ time
- acceleration $a = (v - u) \div t$ acceleration = change in velocity ÷ time
- force $F = m \times a$ force = mass x acceleration
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Consolidate

Can you now?

- Define and differentiate speed and acceleration?
- Define and differentiate force and pressure?
- Define and differentiate momentum and moment?
- Apply the formula to solve engineering problems?

Next lesson…

We will learn about…

…how science and mathematics is applied in engineering and the equations which are used to describe and calculate mass and weight.