0	1

Eric the Astronaut is stranded in deep space, where the local gravitational field strength if 0 N/kg.

0	1	.	1

State Newton's first law, and explain what it can tell us about the motion of Eric in deep space.

If there is no resultant (net) force acting on an object [1] then it will not accelerate / it will remain at constant velocity [1]. This means that Eric's velocity will be constant [1].

Remember here that *constant velocity* can mean v = 0 or stationary!

0	1	.	2

Fortunately, Eric is rescued by a passing spacecraft. Before returning to Earth, he stops to complete his mission to make a few repairs to a small satellite which is orbiting the Earth at a constant **speed**, as shown below.

Derek hears about this exciting mission back down on Earth, and says that Newton's first law still applies to the motion of Eric. Is he correct? Explain your answer.

No [1]. There will now be a resultant (net) force acting on Eric (his weight / the gravitational force exerted on him by the Earth) which means that his acceleration will no longer be zero [1].

You may spot here that his weight (the gravitational force acting on him) is an example of a centripetal force – it is the force that causes him to orbit the Earth together with the satellite. His acceleration is no longer zero because he is constantly accelerating towards the centre of the Earth (this is what causes his velocity to constantly change as he orbits the Earth). Remember that velocity is the vector version of speed – even though the speed of the satellite is constant, its velocity is constantly changing because its direction of motion is constantly changing.

0 2 Newton's second law is often written in symbol form as follows:

$$F = m a$$

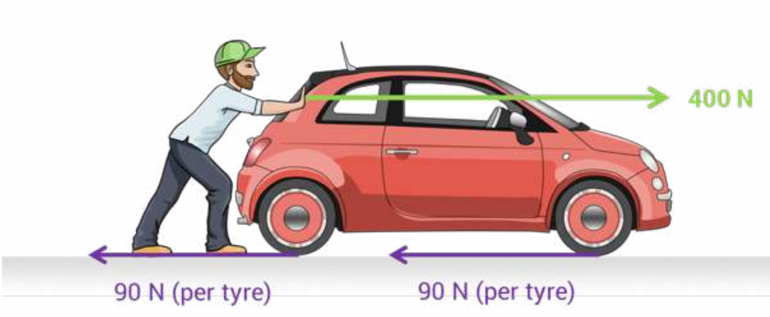
0 2 . 1 State the meaning of the term **F** in the above equation.

Resultant (net) force [1]
(0 marks for 'force' alone)

0 2 . 2 State the meaning of Newton's second law in words.

The acceleration of an object is proportional to the resultant force acting on it [1] (and in the same direction as this resultant force) and inversely proportional [1] to its (inertial) mass [1].

0 2 . 3 Pádraig is trying to push-start his car by applying a force of 400 N to it, as shown below.



If the force of friction acting between **each tyre** and the road is 90 N and the mass of the car is 1600 kg, calculate its acceleration. You may neglect the effects of air resistance in answering this question.

Resultant force, F = 400 – (4 × 90) = 400 – 360 = 40 N
a = F ÷ m = 40 ÷ 1600 = **<u>0.025 m/s²</u>**

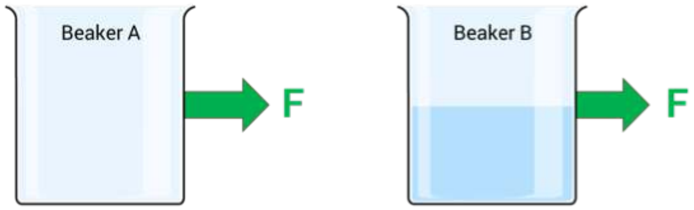
0 2 . 4 The road surface on which the car is sitting is perfectly flat. Calculate the reaction force exerted on the car **at each wheel**. Take g = 9.8 N/kg.

Total normal reaction force = weight = m g = 1600 × 9.8 = 15,680 N
Normal reaction force at each wheel = **<u>3,920 N</u>**

Vertically, the car is in equilibrium (there is no vertical resultant force or acceleration) and so the total downwards force (weight) must be equal to the total upwards force (normal reaction)

03

Prav sets two beakers onto a table. Beaker A is empty, and beaker B contains 200 cm^3 of water. He then taps each beaker, applying the same force to each, and notices that beaker A moves further than beaker B.



03.1

Explain what is meant by the **inertial mass** of an object.

The ratio of the resultant force acting on an object [1] to its acceleration [1] (or, in words, resultant force divided by acceleration).

03.2

Explain why beaker A moved further than beaker B.

Beaker A has a lower (inertial) mass than beaker B [1], so it will have the greater acceleration when the same force is applied to both beakers [1] (or reference to $a = F \div m$).

04

Newton's third law is often misunderstood. It explains many important things, such as how we use friction to enable us to walk.

04.1

State Newton's third law.

When object A exerts a force on object B, object B will exert an equal [1] and opposite force [1] (of the same type) on object A.

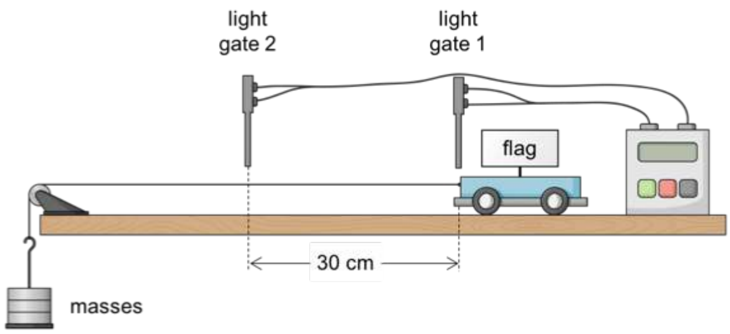
04.2

Explain, making reference to Newton's third law, how the force of friction allows us to walk across a surface.

When we walk forwards, we push our foot backwards. Because of friction, the force we exert is transferred to the ground [1]. By Newton's third law, the ground exerts an equal and opposite force on our foot [1], pushing us forwards.

0 5

The below setup is being used to investigate how the acceleration of a trolley is affected by the resultant force which is exerted on it.



The light gates are set up so as to measure the average velocity at which the trolley is moving as it passes through them.

0 5 . 1

Show that the force of tension in the string is approximately equal to 3 N when a mass of 300 g is attached to its end. Take g = 9.8 N/kg.

$T = m\,g = 0.3 \times 9.8 = 2.94$ N ≈ **3 N**

0 5 . 2

On a given run of the trolley, with a resultant force of 3 N still acting on it, the following results are obtained:

Velocity in light gate 1 = 0.20 m/s
Velocity in light gate 2 = 0.72 m/s

The flag which is attached to the top of the trolley is 10 cm long. Calculate how long the trolley took to pass through **light gate 1**.

$s = v\,t$
$t = s \div v = 0.1 \div 0.2 =$ **0.5 seconds**

0 5 . 3

Use the correct equation from the *Physics equation sheet* to calculate the acceleration of the trolley on this run.

$v^2 - u^2 = 2\,a\,s$
$0.72^2 - 0.20^2 = 2 \times a \times 0.3$
$0.4784 = 0.6\,a$
$a =$ **0.80 m/s^2** (2 d.p.)

0 5 . 4

Hence calculate the mass of the trolley.

$F = m\,a$
$3 = m \times 0.8$
$m =$ **3.75 kg** (accept 3.675 kg if F = 2.94 N used instead)