Lesson 2

A-Level Applied Mathematics
Mechanics : Dynamics I : Year 1

Newton's Laws of Motion	
1st Law	An object will remain at rest or will continue to move in a straight line at a constant velocity unless it is acted upon by a resultant force.
2nd Law	$F = m\,a$
3rd Law	Every action has an equal and opposite reaction.

2.1 Newton's Second Law

In the second law, m is the mass of an object, modelled as a particle, and a is the acceleration of that object when it is acted upon by a resultant force, F.
In lesson 1 we looked at techniques to find a single resultant force replacement for several forces acting on a particle.
You may find it helpful to think of the F in $F = ma$ as the force left over after as much balancing of forces has been done as possible. This left over force, the resultant, is what causes acceleration as the F in $F = ma$.
If the forces on an object all balance, then, because the resultant, F, is zero, the acceleration a is also zero.

2.2 Example

Close to Earth's surface, the acceleration due to gravity is about 9.8 m s^{-2} in magnitude.

(i) By Newton's 2nd Law, what force will act on a mass of 8 kg ?

(ii) What are the SI units of force ?

(iii) What special word is used to describe this force ?

(iv) When one person incorrectly asks another person, “What is your weight ?”, what should they more correctly say ?

2.3 Exercise

Question 1
A large crate of mass 87 kg sits on a lake of ice.
Find the resultant force required to accelerate the crate at 2.5 m s^{-2}

Question 2
A particle of mass 280 kg is acted on by a resultant force of 120 Newtons
Find the acceleration of the particle.

Question 3
How many Newtons does an apple of mass 0.22 kg weigh ?

Question 4
Find the mass of a particle whose weight is 388N.

Question 5
On the surface of the Earth, an astronaut has a weight of 735N.
On the surface of the Moon the acceleration due to gravity is about 1.6 m s^{-2}.
Find the weight of the astronaut when he is walking on, walking on, the Moon.

Question 6

I'm designing a sports car that has a mass of 850 kg.
I'd like it to accelerate from 0 to 90 km h^{-1} in 5 seconds.
Assuming no friction, what driving force does the engine need to produce ?

Question 7

A car of mass 640 kg travels a distance of 40 m along a straight horizontal road while uniformly accelerating from rest to 26 m s^{-1}.

(i) Find the car's acceleration.

(ii) What is the magnitude of the accelerating force ?

Question 8

A 800 kg car is travelling at 25 m s^{-1}.
When a traffic light changes to red, it stops in 6 seconds.
Find the constant breaking force applied.

Question 9

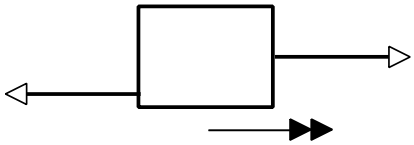
An Eddie Stobart lorry of mass 8 tonnes experiences resistance totalling 900 N as it travels along a horizontal road.

The engine's driving force is 3500 N.

(i) Add the forces 900 N, 3500 N, and a mass in kg to the diagram below.

(ii) What is the force available to cause acceleration ?

(iii) Find the constant acceleration of the lorry.



Question 10

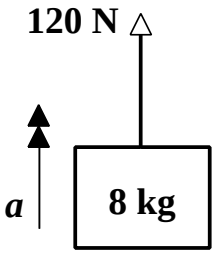
An 8 kg crate is being raised with a rope such that it accelerates upwards.

The tension in the rope is 120 N.

(i) On the diagram add on (as a force) the weight of the crate.

(ii) What is the force available to cause acceleration ?

(iii) Calculate the acceleration of the crate, *a*.

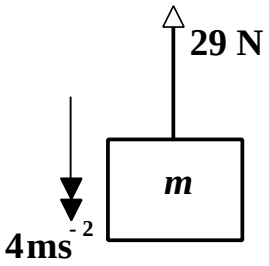


Question 11

A crate is being lowered with a rope such that it accelerates downwards at 4 m s^{-2}. The tension in the rope is 29 N.

(i) On the diagram add on (as a force) the weight of the crate in terms of *m*.

(ii) Calculate the mass of the crate, *m*, in kg.

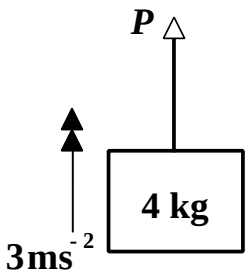


Question 12

A 4 kg crate is being raised with a rope such that it accelerates upwards at 3 m s^{-2}.

(i) On the diagram add on (as a force) the weight of the crate.

(ii) Calculate the tension in the rope, *P*.



Question 13

A 7 kg crate is being lowered with a rope such that it accelerates downwards at 6 m s^{-2}.

(i) On the diagram add on (as a force) the weight of the crate.

(ii) Calculate the tension in the rope, *P*.