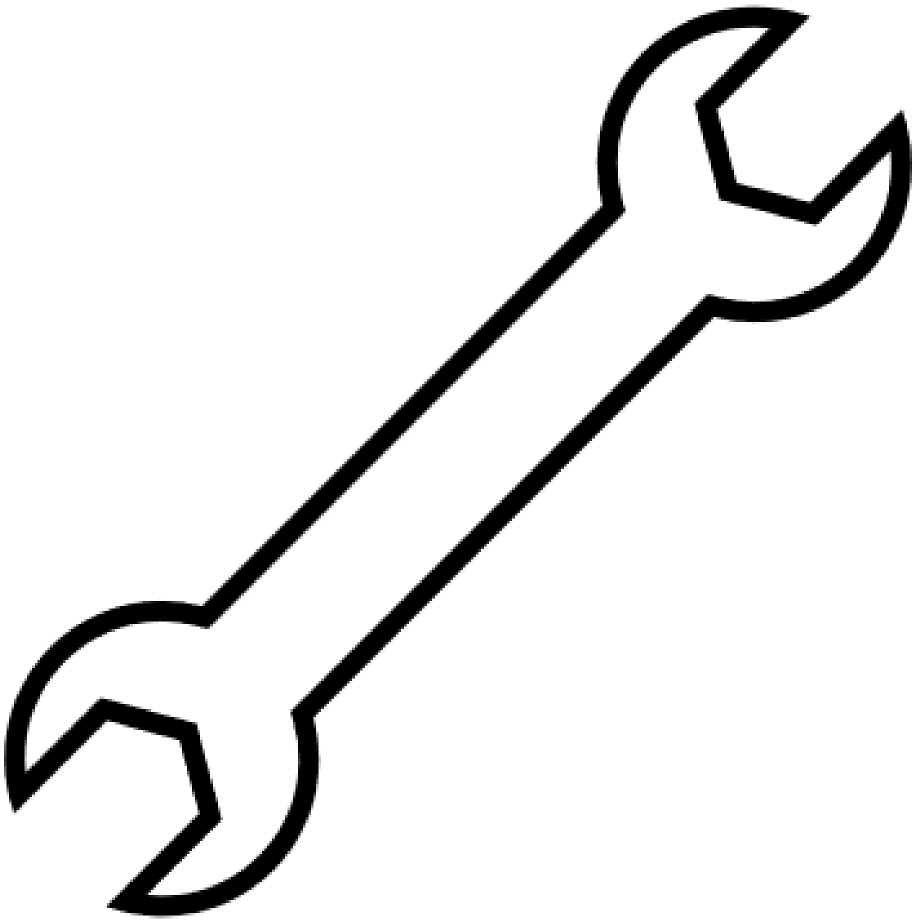
More about forces



L1 Balanced and unbalanced forces

Imagine you're playing tug-of-war with your friends. If both teams are pulling with the same amount of force, the rope doesn't move. This is because the forces are balanced.

- **Balanced forces** occur when two forces acting on an object are equal in size but opposite in direction.
- When forces are balanced, they cancel each other out, and there is no change in motion. The object stays still if it was already still or keeps moving at the same speed and direction if it was already moving.

Another example of this is if you have two friends pushing a box from opposite sides with the same amount of force, the box won't move because the forces are balanced.

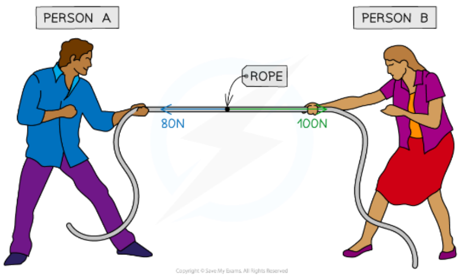
Unbalanced Forces

Now imagine the same tug-of-war game, but this time one team is stronger and pulls harder than the other team. The rope will move towards the stronger team. This happens because the forces are unbalanced.

- **Unbalanced forces** occur when two forces acting on an object are not equal in size, causing the object to move in the direction of the larger force.
- When forces are unbalanced, they do not cancel each other out, and there is a change in motion. The object will either start to move, speed up, slow down (accelerate), or change direction.

In the example below there is an unbalanced force of 100N – 80N =20N

This will means there is a resultant force of 20N towards person B, meaning there will be an acceleration towards person B.



- **Balanced forces**: Equal forces in opposite directions, no change in motion.
- **Unbalanced forces**: Unequal forces, causing a change in motion

Independent practice

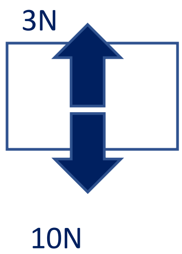
1. **For each block:**
    - Calculate the resultant force
    - State whether the block moves the left, right, up or down

A)

B)

C)

D)



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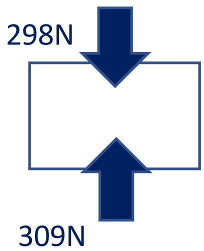

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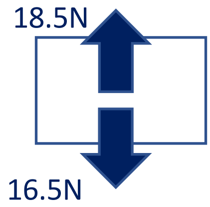

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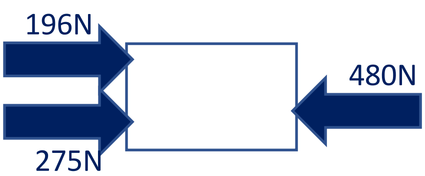
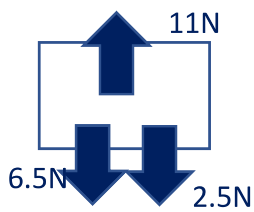
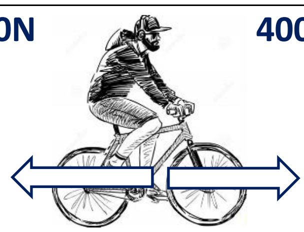


H)

I)



2. **For each picture that shows a moving cyclist**
    a) Calculate the resultant force and use an arrow to show the direction of this force.
    b) State whether the cyclist will accelerate, decelerate or travel at constant speed
    The first one has been done for you

300N **600N** 	**300N** **440N** 	**400N** **400N** 
E.g. a) 600N – 300N = 300N → b) accelerates		

Answer these in your exercise book**.**

3. What is a resultant force?

4. Complete the sentences below:

   - Some people think that when a striker kicks the ball during a penalty that there is a constant force pushing the ball forward, they are wrong because….
   - Some people think that when a car is travelling at a constant speed there must be a resultant force pushing forward, they are wrong because….

5. (a) A boat produces a thrust of 500N and experiences a drag of 300N, draw a force diagram to show this.
   (b) Work out the resultant force acting on the boat.

6. A 50N, 100N and 150N are applied to an object, what is the maximum and minimum resultant forces possible?

7. Sally pulls a sledge in the snow at a constant speed.
   (a) Draw a force diagram to show this.

   The sledge starts on the grass but moves onto the snow, friction is lower on the snow than it is on the grass.

   (b) What will happen to the motion of the sledge if Sally pulls with the same force?

L2 Weight

Gravity is a force that pulls objects toward each other. It's what makes things fall to the ground when you drop them. The strength of this force depends on two things: the mass of the objects and the distance between them. When we talk about gravity on Earth, we often use a number called gravitational field strength, which tells us how strong the pull of gravity is at the surface of the Earth.

Gravity Force and Weight

First, let's understand the difference between mass and weight. Mass is the amount of matter (stuff) in an object and is measured in kilograms (kg). Weight, on the other hand, is the force of gravity acting on that mass. It's measured in newtons (N).

The formula to calculate weight is:

Weight=Mass × Gravitational Field Strength (g)

On Earth, the gravitational field strength (ggg) is approximately 10 newtons per kilogram (N/kg). This means that for every kilogram of mass, the force of gravity is 10 newtons.

Example Calculation

Let's say you have a mass of 50 kg. To find your weight on Earth, you would use the formula:

Weight=50kg×10N/kg

Weight=500 N

So, if your mass is 50 kg, your weight on Earth is 500 newtons.

Gravitational Field Strength on Other Planets

The gravitational field strength is different on other planets and stars because their masses and sizes are different from Earth's. Here are a few examples:

- **Moon:** The Moon's gravitational field strength is about 1.6 N/kg. If you were 50 kg, your weight would be:

Weight=50 kg×1.6 N/kg=80 N

So, on the Moon, you would weigh only 80 newtons.

- **Mars:** Mars has a gravitational field strength of about 3.7 N/kg. If you were 50 kg, your weight would be:

Weight=50 kg×3.7 N/kg=185 N

On Mars, you would weigh 185 newtons.

- **Jupiter:** Jupiter is much larger than Earth, with a gravitational field strength of about 24.5 N/kg. If you were 50 kg, your weight would be:

Weight=50 kg×24.5 N/kg=1225 N

On Jupiter, you would weigh 1225 newtons!

Understanding Gravitational Field Strength

The gravitational field strength (g) tells us how strong the gravity is in a particular place. Higher g means stronger gravity, and lower g means weaker gravity. This value depends on the mass of the planet or star and how far you are from its centre.

For example, Earth's g is 10 N/kg because of its mass and size. The Moon is smaller and has less mass, so its g is only 1.6 N/kg. Jupiter, being much bigger and having more mass, has a g of 24.5 N/kg.

Why Does This Matter?

Understanding gravity and how it changes on different planets helps scientists plan space missions. It also explains why astronauts can jump higher on the Moon than on Earth and why they would find it very hard to move on Jupiter due to its strong gravity.

In summary, your weight depends on both your mass and the gravitational field strength of the planet you are on. While your mass doesn't change, your weight can vary greatly depending on where you are in the universe!

Independent practice

1. What is the difference between mass and weight?
2. Why is your weight different on the Moon compared to on Earth?
3. How does the gravitational field strength of a planet affect the weight of an object on that planet?
4. If the gravitational field strength on Jupiter is 24.5 N/kg, what does this tell you about Jupiter's gravity compared to Earth's?

Calculation Questions

1. If an object has a mass of 20 kg, what is its weight on Earth (g = 10 N/kg)?
2. A person weighs 600 N on Earth. What is their mass?
3. What is the weight of a 10 kg object on the Moon (g = 1.6 N/kg)?
4. An astronaut with a mass of 70 kg travels to Mars. What is their weight on Mars (g = 3.7 N/kg)?
5. Calculate the weight of a 25 kg object on Jupiter (g = 24.5 N/kg).

Harder Calculation Questions (Re-arrangement Required)

1. An object weighs 250 N on a planet where the gravitational field strength is 5 N/kg. What is the mass of the object?
2. A person has a mass of 80 kg and weighs 720 N on a certain planet. What is the gravitational field strength on that planet?
3. If an object's weight is 480 N on a planet with a gravitational field strength of 12 N/kg, what is its mass?
4. On an unknown planet, an object with a mass of 15 kg weighs 225 N. What is the gravitational field strength on this planet?
5. A 60 kg astronaut weighs 540 N on a distant planet. Determine the gravitational field strength of this plane

L3 Work Done

Imagine you have a box and you want to move it across the room. To do that, you have to push it with a certain force. The box moves because of the force you apply, and the movement is called "displacement."

Work done is simply a way to measure how much energy you use to move the box. We can calculate it using a simple equation:

Work Done = Force x Distance moved

Force (F): This is how hard you push or pull something. It's measured in newtons (N).

Distance (d): This is how far you move the object. It's measured in meters (m).

The SI unit for work done is the Joule (J)

So, if you push a box with a force of 10 Newtons for a distance of 5 meters, the work done is:

Work done = Force x Distance

Work done = 10 x 5

Work Done = 50 J

- If you push but the box doesn't move, no work is done. Even if you're using a lot of force, if there's no movement, the work done is zero.

- If the box moves but you don't push (like it sliding down a hill on its own), you didn't do the work. The hill did!

Understanding work done helps us know how much energy we use to move things, whether it's pushing a box, lifting a book, or pulling a sled.

Independent practice

1. Calculate Work Done:

Force = 8 N, Distance = 5 m

2. Calculate Work Done:

Force = 12 N, Distance = 3 m

3. Calculate Work Done

Force = 15 N, Distance = 7 m

4. Calculate Work Done:

Force = 5 N, Distance = 10 m

5. Calculate Work Done:

Force = 9 N, Distance = 4 m

6. Find the Force:

Work done = 50 J, Distance = 10 m

7. Find the Force:

Work done = 75 J, Distance = 15 m

8. Find the Distance:

Work done = 60 kJ, Force = 20 N

9. Find the Distance:

Work done = 100 J, Force = 25 kN

10. Find the Force:

Work done = 90 kJ, Distance = 6 km

Worded questions

1. A car engine does 500 J of work to move the car 50 m. What force is exerted by the engine?
2. A person applies a force of 25 N to push a box, doing 200 J of work. How far does the box move?
3. A machine does 450 J of work to lift a weight to a height of 9 m. What force does the machine apply?
4. A horse pulls a plough with a force of 30 N and does 600 J of work. How far does the plough move?

L 4 Hooke's Law

Forces and Deforming Objects

Imagine you have a spring in your hand. If you pull on it, you're applying a force that stretches the spring, making it longer. If you push it, you're squashing it, making it shorter. This process of changing the shape of an object by applying a force is called deformation.

Springs are perfect examples to study how forces work because they are designed to stretch and compress easily. When you apply a force to a spring, it either extends (stretches) or compresses (squashes).

Stretch and Compression Measurements

When you change the force applied to a spring, you can measure how much the spring stretches or compresses. Imagine you have a spring, and you gradually add weights to it. Each time you add a weight, the spring stretches a little more. You can measure the length of the spring each time you add a weight. This length is called the extension when the spring is stretched, and compression when it is squashed.

The Force-Extension Relationship

As you keep adding weights, you might notice something interesting: the amount the spring stretches (extension) is directly proportional to the force you apply. This means if you double the force, the extension doubles too. This direct relationship between force and extension is what we call a linear relationship.

To visualize this, imagine plotting a graph with force on the vertical axis and extension on the horizontal axis. If you add equal amounts of force, the points you plot on the graph will form a straight line. This straight-line relationship shows that the spring is behaving in a predictable way.

Hooke's Law

This linear relationship is described by Hooke's Law, which is a special rule about springs. Hooke's Law states that the extension of a spring is directly proportional to the force applied to it, as long as the spring is not stretched or compressed beyond its limit (called the elastic limit). Mathematically, Hooke's Law is written as:

$$\mathbf{F = k \times e}$$

where:

- F is the force in newtons (N)
- e is the extension in meters (m)
- k is the spring constant, which tells you how stiff or stretchy the spring is. It's measured in newtons per meter (N/m).

So, if you know the spring constant k and measure the extension e, you can calculate the force F. Conversely, if you know the force and the spring constant, you can find out how much the spring will stretch.

Independent practice

1 What is the process of changing the shape of an object by applying a force called?

2 Explain how a spring behaves when a force is applied to it.

3. What unit is used to measure forces, and who is it named after?

4. Describe how a spring scale measures force.

5. If you hang a 2 N weight on a spring and it stretches by 0.04 meters, what is the spring constant?

6. A spring has a spring constant of 50 N/m. How much force is needed to stretch the spring by 0.1 meters?

7. If a spring has a spring constant of 30 N/m and it compresses by 0.05 meters, what is the force applied to the spring?

8. Explain the shape of the graph when plotting force versus extension for a spring that follows Hooke's Law.

9. If you double the force applied to a spring, what happens to the extension according to Hooke’s Law?

10. What happens when a spring is stretched beyond its elastic limit?

11. A spring with a spring constant of 75 N/m is stretched with a force of 15 N. What is the extension of the spring?

12. You measure an extension of 0.2 meters when a force of 8 N is applied to a spring. What is the spring constant?

13. If the spring constant of a spring is 120 N/m, what force is needed to compress the spring by 0.03 meters?

14. Describe an experiment to verify Hooke’s Law using a spring and a set of known weights.

15. If a spring stretches by 0.15 meters when a force of 30 N is applied, what will be the extension if the applied force is increased to 45 N?

L5 Momentum

Momentum is a way to measure how much motion an object has. Think of momentum as how difficult an object is to stop!

The equation for momentum is:

Momentum = Mass x Velocity

Momentum: (kg m/s)

Mass (m): This is how much stuff is in the object. It's usually measured in kilograms (kg).

Velocity (v):This is how fast the object is moving and in which direction. It's measured in meters per second (m/s).

Imagine a big truck that isn't moving very fast. Even though it's slow, because the truck is so heavy, it still has a lot of momentum. Now think about a baseball. It's much lighter than the truck, but if you throw it really fast, it has a lot of momentum too.

Why is Momentum Important?

Momentum helps us understand how objects move and collide. For example:

Car Crashes: In a car crash, a car with a lot of momentum will be harder to stop than one with less momentum.

Sports: In sports like football or soccer, players with more momentum (because they're running fast or they're heavier) are harder to stop.

Law of Conservation of Momentum

There's a really cool rule about momentum called the **Law of Conservation of Momentum**. It says that when two objects collide, their total momentum before the collision is the same as their total momentum after the collision. This helps scientists and engineers predict the outcomes of collisions.

Imagine you're on a skateboard, and you throw a heavy ball forward. You'll roll backward! Why? Because the total momentum before and after you throw the ball has to stay the same. When the ball goes forward, you go backward to keep the total momentum constant.

Independent practice

1. Find the Momentum:

Mass = 2 kg, Velocity = 3 m/s

2. Find the Momentum:

Mass = 5 kg, Velocity = 4 m/s

3. Find the Momentum:

Mass = 10 kg, Velocity = 1 m/s

4. Find the Mass:

Momentum = 24 kg m/s, Velocity = 6 m/s

5. Find the Velocity:

Momentum = 15 kg m/s, Mass = 3 kg

6. Find the Momentum:

Mass = 7 kg, Velocity = 2.5 m/s

7. Find the Mass:

Momentum = 40 kg m/s, Velocity = 8 m/s

8. Find the Velocity:

Momentum = 100 kg m/s, Mass = 20 kg

9. Find the Momentum:

Mass = 50 kg, Velocity = 1.2 m/s

10. Find the Velocity:

Momentum = 250 kg m/s, Mass = 25 kg

Worded questions

1. A car with a mass of 1500 kg is moving with a velocity of 20 m/s. What is the momentum of the car?

2. A ball has a momentum of 50 kg m/s and is moving with a velocity of 5 m/s. What is the mass of the ball?

3. Rocket Launch: A rocket has a momentum of 2000 kg m/s and a mass of 250 kg. How fast is the rocket moving?

4. Freight Train: A freight train with a mass of 5000 kg is moving with a velocity of 15 m/s. Calculate the train's momentum.

5. A motorcycle has a momentum of 600 kg m/s and a mass of 150 kg. Determine the motorcycle's velocity.