Name: ______________________
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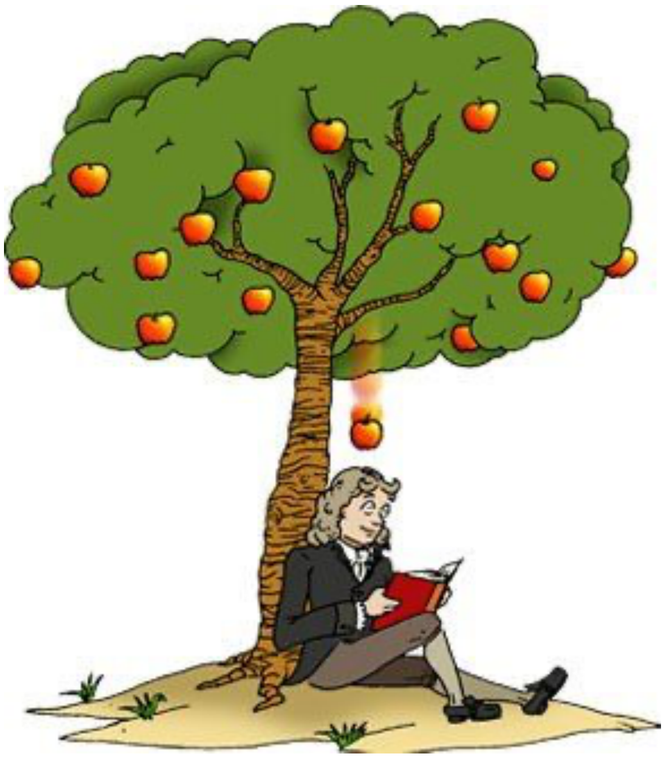


FORCES

YEAR 10 PHYSICS

2025

Learning Outcomes

- Define the term force and outline some examples
- Outline Newton's First Law of Motion and inertia
- Analyse some situations involving Newton's First law
- State Newton's Third Law of Motion
- Identify action-reaction force pairs
- Analyse some situations involving Newton's Third Law
- State Newton's Second Law of Motion
- Analyse some situations involving Newton's Second Law
- Draw diagrams to identify forces on stationary and moving objects
- Perform some calculations using F=ma
- Describe the difference between mass and weight
- Calculate the weight of some objects
- Apply Newton's Laws to explain the physics of car safety features

Formulas

Newton's 2nd Law

$$a = \frac{F_{net}}{m} \qquad or \qquad F_{net} = ma$$

Weight force

$$F_w = mg$$

Acceleration

$$\boldsymbol{a} = \frac{\Delta \boldsymbol{v}}{\boldsymbol{t}} \qquad or \qquad v = u + at$$

Acceleration due to gravity, g

g = 9.8 m/s^2 on Earth *(= 9.8 N/kg)*

Stile lessons

The following Stile lessons in the 'Newton's Laws of Motion' unit can be completed for extra practise, review or extension of the concepts in this topic. You may be asked to complete them or you may complete some in your own time.

- 1.2 – The first law of motion
- 1.3 – Inertia on Earth
- 1.4 – Free body diagrams
- 2.2 – The third law of motion
- 2.3 – Gravity and the third law
- 2.4 – Extension: Recoil, jets and collisions
- 3.2 – The second law of motion
- 3.3 – Applying the second law
- 3.4 – Extension: Flying car simulation
- Test: Newton's laws of motion

What is a force?

A force is a ___________ or a __________ on an object that causes it to:

-
-
-
-

It is measured in _______________.

A force is a ***vector.*** This means it must have ____________ , ________ and _____________.

Forces can be organised into two categories: ___________ **forces & field (____ _______). forces**

Categorise the following forces to contact and non-contact.

Force	Description	Contact/Non-contact?
Friction	The force between two surfaces that are sliding, or trying to slide, past each other.	
Air resistance	The force that acts in the opposite direction to an object's movement as it moves through the air.	
Gravitational	The force acting on an object due to gravity.	
Reaction/Normal	The force that supports an object on a solid surface.	
Tension	The force transmitted through a rope, string or wire when pulled by forces acting from opposite ends.	
Buoyancy	The upward force exerted by a fluid (liquid or gas) on an object floating in it.	
Magnetic	The force exerted by a magnet field on a steel object.	
Can you name this one? ________	The force that acts between a positively charged object and a negatively charge object.	

What do forces do? *Why do objects 'slow down' when not pushed?*

Consider riding your bike along a flat road. Do you need to keep applying force?

What about on ice skates?

Aristotle (BC)	Galileo 1590
The 'Natural State' of objects *Earthly objects* _________ *so long as* ________________ *If no (net) force acting* __________________________________ .	• Ball rolling ***down a slope*** ________________ *(does what?)* • Ball rolling ***UP a slope***, __________ • So, Ball rolls on ***smooth*** ***flat*** surface _________________ ** ○ ** Best example(s)**?** : ________ _

Summary:

- Objects at rest want to ____.
  - I,e, Velocity = ___

- Objects ***in motion*** want to ____ .
  - *E.g. Velocity =* ____ ____ _______

Put another way, objects ***RESIST CHANGES*** in *motion.*

This is the concept of inertia

An object that is in motion will ____________ ___ _______________ *velocity* Put another way, they will continue at _________ speed and ____ ___________ ******unless* **acted on by __________ ________ force.**

More simply, we can say….

INERTIA is the

____

… UNLESS acted on by a (unbalanced or 'net') force

Forces cause objects to accelerate (change speed and direction). Name the force that is acting in each of the situations described below.

Situation	**Name of force**
The force that keeps a car on the ground..	
The force of the table acting on a book that is resting on the table	
The force that holds up a decoration that is hanging from a string.	
The force that causes a paperclip to be attracted to a magnet.	
The force of the wind as you ride your bike in to a head wind.	
The force of the water acting on a boat that keeps it afloat.	
The force that holds together sodium and chloride ions to make salt.	
The force of the doormat on your shoes when you wipe your feet.	

Newton’s First Law

Predict-Observe-Explain – Newton’s Apple

Your teacher is going to hit a knife that is part way through an apple.

Predict what is going to happen when the knife is hit.

Observe: Describe what happened when the knife was hit.

Explain: In groups, try to explain what happened. Use a diagram if it helps. Use arrows with labels to show any forces you think were involved.

Newton’s First Law - Inertia

Newton’s 1st law simply states that an object’s motion won’t change unless an overall force acts on it: a force can make an object accelerate (change speed or direction).

IN the moment after you throw a ball upwards, what happens to ball as it ascends? ***Why***?

If an astronaut throws a ball in space, what happens to that ball? ***Why***?

An object’s resistance to any change in its motion (or its **inertia**) is related to its mass: the greater the mass, the greater the inertia (i.e. the bigger the force needed to get it moving – or to stop it)

In other words:

- Objects at rest want to ____
- Objects in motion want to ____

Describe some examples where you have experienced <u>inertia</u> in your everyday life:

Questions

1. Imagine you are sitting in a moving car. The brakes are suddenly applied very hard! You are immediately ‘thrown forward’! is there a name for the force that threw you forward? Or maybe that is NOT ‘thrown’. What happened?

2. **Explain** what happens to you sitting in a car seat when the car suddenly accelerates **rapidly** from rest.

3. Imagine you are in the front seat of the car and you left a soccer ball in the middle of the back seat. The car goes around the corner to the left.
   a. Describe what happens to the soccer ball when you turn the corner.

   b. Provide an explanation for your answer. ***Draw a picture to support*** your answer.

4. Describe the safety features used in cars to reduce the effects of inertia.

5. A car on ice is almost impossible to stop.

a. Use Newton’s First Law to explain why.

b. Identify the force required to gain control.

6. If you were being chased by an elephant (they can run up to 40 km/h), what would be the best way to avoid getting trampled?

Complete Stile lesson 1.3: Inertia on Earth

Summarise your learning from the Stile lesson here:

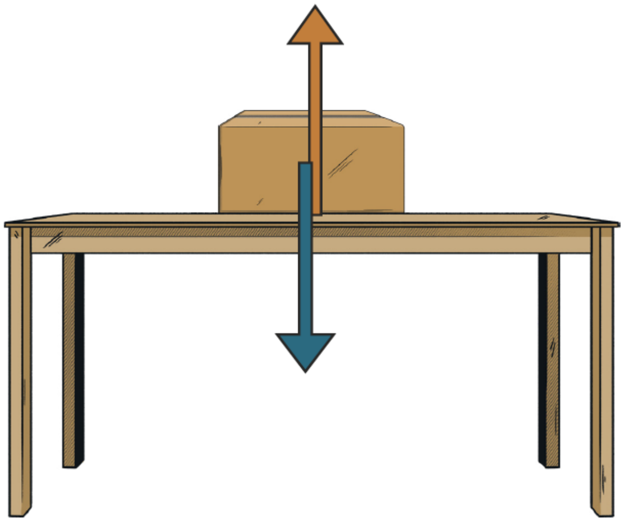
Force diagrams

The forces acting on an object can be represented using arrows. Force arrows point in the direction the force acts in. The length of the arrow represents the size of the force.

The arrows **<u>must touch the object</u>** in the diagram and **<u>must start from the object</u>**.

If the object is stationary or moving at a **constant speed**, the forces on it are **balanced**.

The forces in the diagram below ***are balanced***.



The upwards arrow represents the **reaction** force.
This is the force of the table supporting the box.

The downwards arrow represents the gravitational force acting on the box, also known as **weight.**
This is the force of the Earth acting on the box.

If forces are acting on an object are *unbalanced*, the object ***MUST be accelerating or slowing down***.

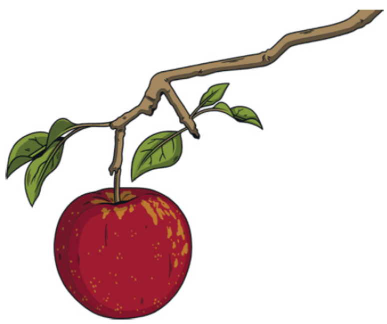
If an object is speeding up, the forward arrow will be larger.

If an object is slowing down, the backward arrow will be larger.

Examples: Add ***force arrows*** to each diagram. Label the arrows with the force and add descriptions to say whether the forces are balanced or unbalanced.

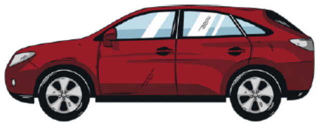
A **person** sitting on a chair.

An **apple** hanging from a tree.

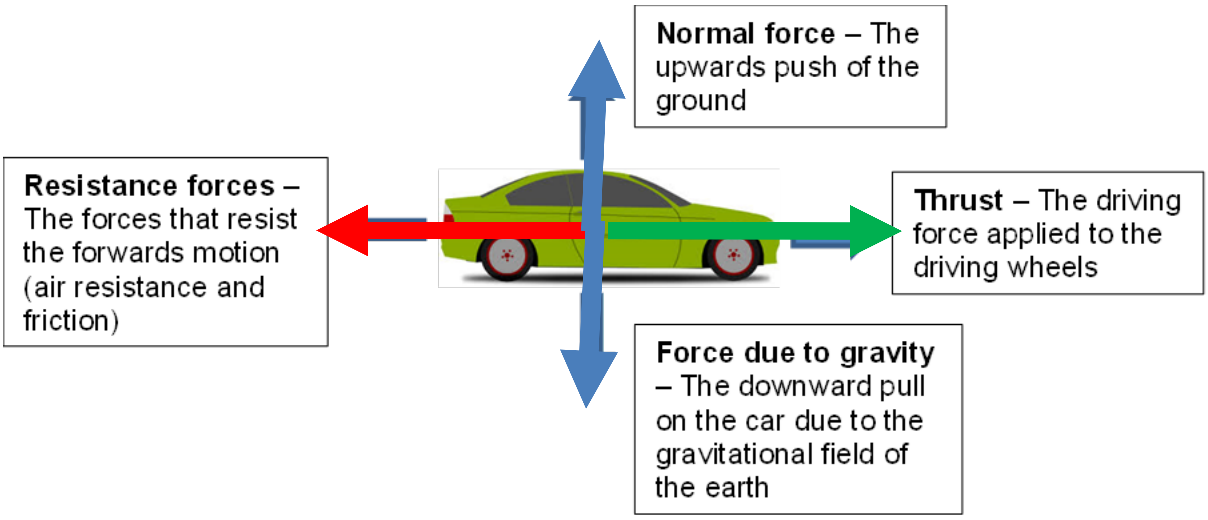


A **ball falling (**accelerating!) downwards.

A **car** travelling at a ***constant*** speed.



Forces on a vehicle



Net Force: $F_{net} = F$ (*forwards*) – F(***backwards*** such as air resistance, rolling resistance)

Different types of 'motion' of a car

*Complete the table below by adding **appropriately sized force vectors** to each diagram and by describing the net force in the box below for each stage. Remember that force (vector) arrows must start from object*

			
Stationary	**Accelerating**	**Constant velocity**	**Decelerating**

Complete Stile lesson 1.4: Free body diagrams

Questions

Construct force diagrams for the situations described below. You may represent the object with a small box or dot. Remember the force arrows need to be proportional to each other, and if the object is accelerating, a greater force needs to act in the direction of the acceleration.

1. A skydiver is at ***terminal*** velocity (no longer accelerating)

2. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces.

3. A leftward force is applied to a book in order to move it across a desk at *constant velocity*. *Consider frictional forces.*

4. A hot air balloon is ***accelerating*** upwards.

5. 0.5s after throwing a cricket ball upwards. so still travelling ***upwards*** *but* ***slowing down***

6. A car is coasting to the right and slowing down.

Net force (F_{net})

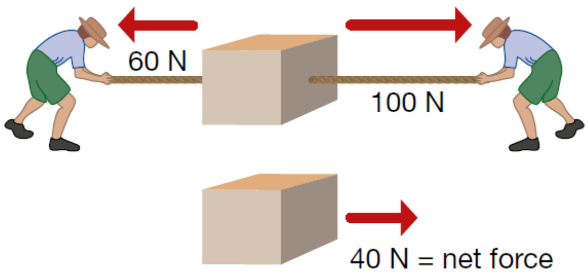
Typically, there is more than one force acting on an object.

The sum of all the forces acting on an object is called the net force.

Sometimes this is also referred to as the **resultant force**.

To find the net force, add any forces acting in the same direction and subject any forces acting in the opposite direction.

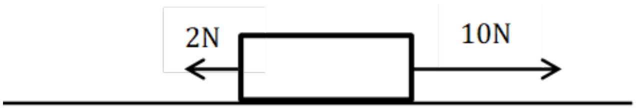
When two forces have the same strength but in opposite directions, they will cancel each other out. This means the **net force will be zero** and the forces will be **balanced**.



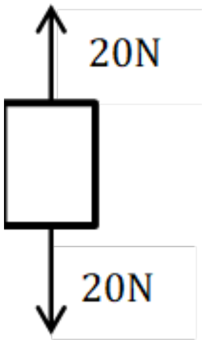
If there is an overall net force, then the forces are **unbalanced** and the object will begin to accelerate.

Examples

1. *A force of 10N to the right is applied to an object. The object also experiences a frictional force of 2N that resists the object's motion. What is the net force on the object? Is it balanced or unbalanced? Describe the object's motion.*

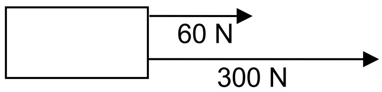


2. *An object is falling through the air and is experiencing a downwards force due to gravity (weight) of 20N. It is also experiencing a force due to air resistance of 20N. What is the net force acting on the object? Is it balanced or unbalanced? What is the object's motion?*



Questions

For each problem, find the net force, its direction. Indicate if the forces acting on the object is balanced or unbalanced.

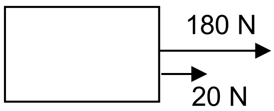


Net force:

Direction:

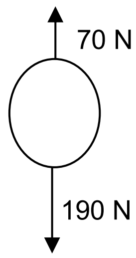
Net force:

Direction:



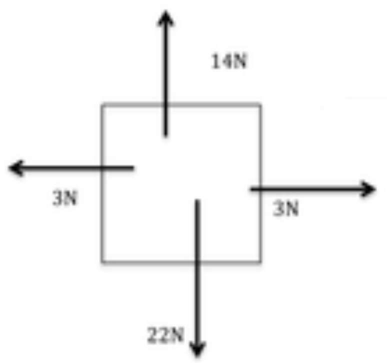
Net force:

Direction:



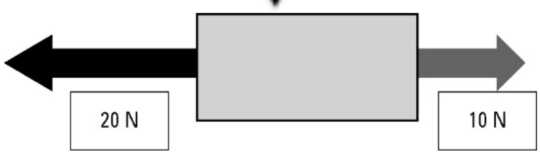
Net force:

Direction:



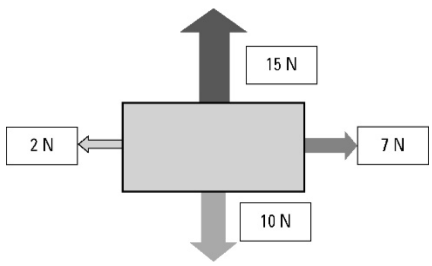
Net force:

Direction:



Net force:

Direction:



Net force:

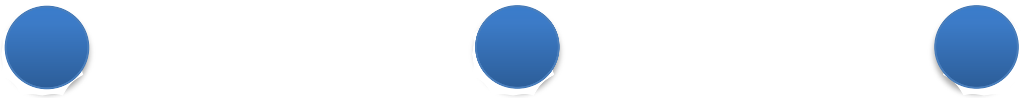
Direction:

Newton's Second Law

Consider a falling table tennis ball

1. *A table tennis ball of mass 2.5g is dropped from a high balcony. Show the force(s) acting on the ball as it starts to fall . What will the ball be 'doing'?*
2. *After falling for approximately one second, would there be any changes? What happens to the forces and what is happening in terms of motion.*
3. *Lastly, if it falls for long enough, what will be happening? What has happened to forces?*

<u>Early</u> **2. *<u>later</u>*** **3. *<u>Falling for a long time</u>***



<u>Acceleration?</u>

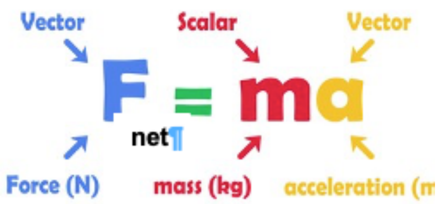
EFFECT OF UNBALANCED FORCES

When (all) the forces on an object do ***NOT balance***, there is a ***net force*** <u>acting</u>.

When a NET force acts, the object **MUST** ______________

So, if a net force acts for a time, this will cause a ***change in velocity***.

This leads to **<u>Newton's SECOND law.</u>** $F_{net.}\Delta t = m.\Delta v$



So, Newton's 2nd law states that when a **<u>*(net)* force acts</u>** on an object, it cannot stay at the same velocity, it **<u>must</u>** ___________ . It <u>must</u> _______ _______OR , __________. (or ____________)

What is meant by ***NET*** force?

$F_{net} = F_{forwards} - F_{backwards}$

Hint: Use this one»»> $\mathbf{F_{net} = F_f - F_b = ma}$

Overall, a net force <u>causes</u> an object to _________ .

The *<u>size</u>* of the acceleration depends on __________________ and __________________

Examples

1. What force is required to accelerate a 10 kg mass at 2 m/s^2?

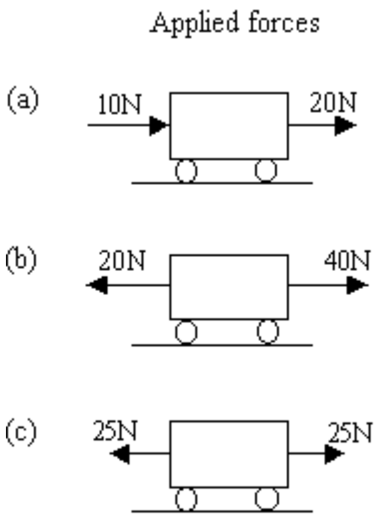
2. If a 100 N force is applied to a 5 kg mass, calculate its acceleration.

Complete Stile lesson 2.1 : The second law of motion and 2.1: Applying the second law

Watch: [Shedding Light on Motion Episode 7: Newton's Second Law of Motion] and complete the question sheet

Questions

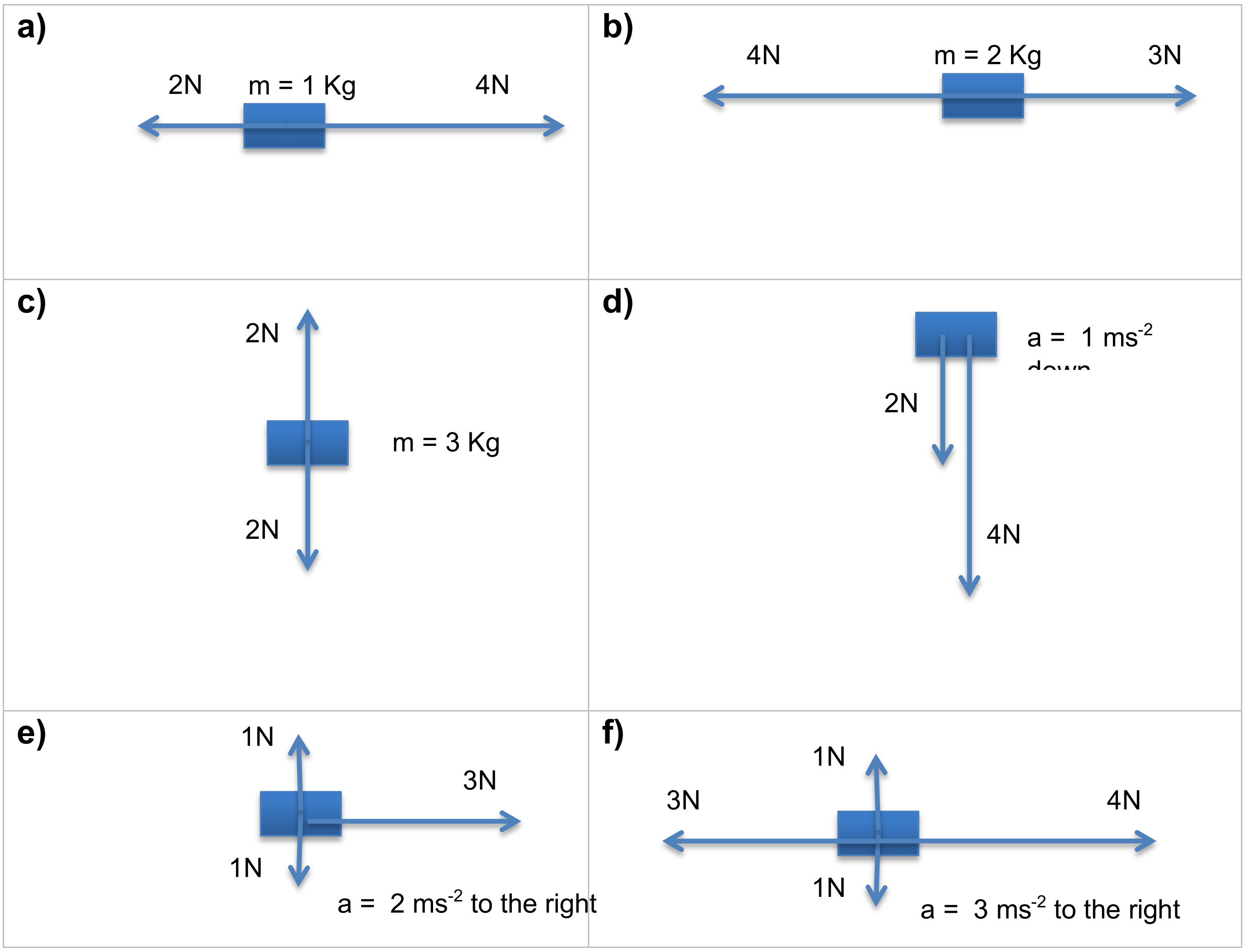
1. For each of the following, calculate the net force and its acceleration, assuming that the cart is 3 kg.



2. What force would be needed to give a 2.5 kg mass an acceleration of 4 m/s^2 to the east?

3. Calculate the acceleration of a 3 kg toy car if a force of 15 N north was applied to it.

4. . Calculate the net force in each of the following. Remember to include both magnitude and direction (and units too, of course!):



Now, review a, b and c and ***properly describe*** the motion (or otherwise) of the object in each case.

a) b) c)

Next, can you ***rank*** the objects in d, e and f, ***in order*** from lightest to heaviest mass.

5. How fast would a 5 kg test rocket be going if it started from rest and was accelerated by a 50 N force for 15 s? (Hint: Determine acceleration then *apply* $a = \Delta v/\Delta t$)

6. What mass would be given an acceleration of magnitude 1.5 m/s^2 when a 12 N force was applied to it?

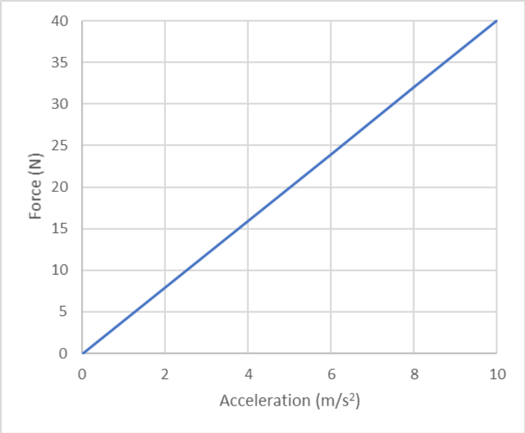
7. What force would be needed to give a 9.0 kg mass an acceleration of 2 m/s^2 west?

8. Calculate the acceleration of a 4 kg toy car if a force of 12 N east was applied to it.

9. What mass would gain an acceleration of 2.5 m/s^2 if a 15 N force was applied to it?

10. The graph shows how the acceleration of an object changes as the force applied to it changes.

a. What force was needed to produce an acceleration of 2 m/s^2?



b. What acceleration would be produced by a force of 60 N?

c. What was the mass of the object?

11. The typical acceleration produced when a car moving at 60 km/h crashes into another car can be around 150 m/s^2 (or more!) Imagine a mother holding a 20 kg child in the front seat ***without*** a seatbelt.

a. What net force does the mother need to apply *to ensure the child stays in the mother's arms? **(i.e. child must decelerate with the mother and the*** car at 150m/s^2)?

b. If the mother applied this force to a set of weightlifter's weights, what mass would she have to lift to exert the same force?

c. How possible is this?

d. What implications does this have for holding an unbelted child in a car?

Extension

1. A force of magnitude 30 N acted on a 0.6 kg rocket until its speed reach 150 m/s. For how long did the force act?

2. A mass of 4 kg is moving at 50 m/s east when a force of 12 N west acts on it for 15 s. (Think carefully about how you interpret the negative answer you should get.)
    a. What is the acceleration of the mass?

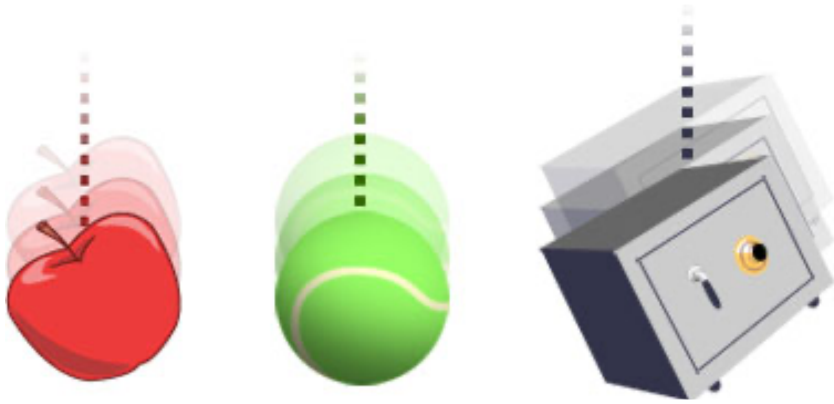
    b. What is its final velocity?

3. A force of 24 N south acts on an object and changes its velocity from 4.0 m/s south to 19 m/s south in 5s.
    a. What is the acceleration of the object?

    b. What is its mass?

Weight and mass

Which object will hit the ground first?



Mass

Mass is a measure how much ***matter*** is in an object.

It is measured in ______________.

Weight

Weight is the ***force* of gravity** pulling down on an object, It is also known as the ***weight force.***

This is measured in _________________.

The weight force is caused by the gravitational pull on an object. We can calculate it using Newton's 2nd Law, where acceleration is acceleration due to gravity, g.

F = ma

F_w = mg

At Earth's surface:
g = 9.8 m/s² or 9.8 N/kg

Weight force = mass x acceleration due to gravity

Example

1. Suppose you have a mass of 60 kg. What is your weight?

2. A small car has a weight of 13,000N. What is the mass of the car?

3. An astronaut has a mass of 80kg.
    a. What is her mass and weight on earth?
    b. What is her mass and weight on the surface of the Moon where gravity is one sixth that of Earth *(On the Moon, g = 1.6 m/s^2 or 1.6 N/kg)*

Questions

1. What is the force on a 1 kg ball that is falling freely due to the pull of gravity (on Earth)?

2. What is the mass of a person who weighs 500 N on Earth?

3. The value of the gravitational pull (g) on the moon is 1.6 m/s^2. What is the weight of a 75 kg astronaut on the moon?

4. A spaceship has a mass of 9000 kg. The spaceship is launched from Earth and lands on a distant planet where it has a weight of 390,000 N. What is the acceleration due to gravity on this planet?

5. Using your approximate mass, complete the table below to find your weight on different planets (and the moon).

Planet (or celestial body)	**Gravitational force (g, N/kg)**	**Weight (N)**
Mercury	3.7	
Earth	9.8	
Moon	1.63	
Neptune	11.0	
Saturn	9.0	
Jupiter	23.1	

6. Revisit the objects at the beginning of this section, if they were dropped the same way, which one would hit the ground first and why? What if they were dropped in a vacuum?

More 2nd Law Practice Questions

Where possible show a diagram and show your working. Use $g = 9.8\ m/s^2$ when needed.

Many of these problems require two steps, not just one, and may require some deep thinking!

1. During a tennis serve, a 0.057kg tennis ball was accelerated from rest to 30 m/s in 0.07s.
    a. Determine the acceleration of the ball in m/s^2.

    b. Determine the size of the average net force acting on the ball.

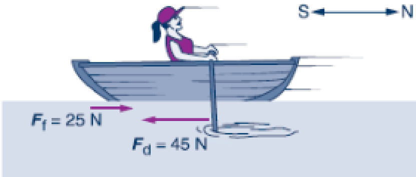
2. 1200kg car has to come to rest from 60km/h in 6s.
    a. Determine the deceleration of the car. Answer in km/h/s and m/s^2.

    b. Determine the average braking force required to achieve this deceleration.

3. Use Newton's Laws to explain why a 1.0 kg shot-put can be thrown further than a 1.5 kg shot-put thrown by the same person.

4. When travelling at 100 km/h a car has a drag force due to air resistance of 800N. If the car has a mass of 1500kg, determine the forward force that the motor needs to apply if it is to accelerate at $1.5\ m/s^2$. (Step 1: Draw a diagram and then use calculations).

5. Mary is paddling a canoe in Albert Park Lake. The paddles are providing a constant driving force of 45 N south and the frictional forces total 25 N north. These forces are shown in the diagram below. The mass of the canoe is 15 kg and Mary has a mass of 50 kg.



a. Calculate Mary's weight.

b. Calculate the net force acting on the canoe.

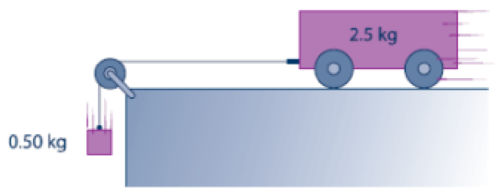
c. Calculate the **time** for the canoe to accelerate from rest to 6 km/h. (Hint: Calculate the acceleration and use that. Take care with units)

6. On the surface of the Earth a geological hammer has a mass of 1.5 kg.
   a. What is the weight force of the hammer on earth?

   b. Determine its mass and weight on Mars where g = 3.6 m/s^2.

Extension

7. A 0.50 kg metal block is attached by a piece of string to a dynamics cart as shown. The block is allowed to fall from rest, dragging the cart along. The mass of the cart is 2.5 kg.



a) What is the total mass of the system?

b) What is force applied on the system by the falling mass?

c) If friction is ignored, what is the acceleration of the block as it falls?

d) How fast will the block be travelling after 0.5 seconds?

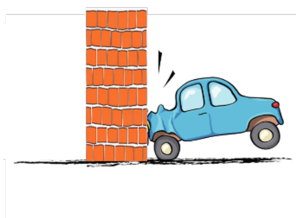
e) If a frictional force of 4.3 N acts on the cart, what will its acceleration be?

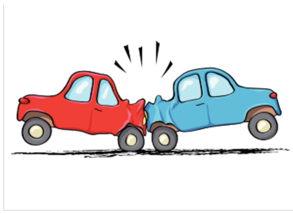
For more extension: Complete Stile 2.4 Recoil, jets and collisions and Stile 3.4 Flying car simulation

Newton's Third Law

Predict-Observe-Explain

What do you think will cause more damage? A car crashing into a wall at 50 km/h or two cars each travelling at 50 km/h colliding head on?



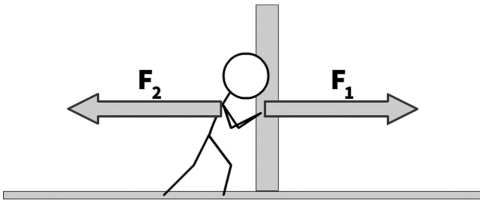


Write your prediction here:

We will return to this later…

Newton's 3rd law states that:

"For every action, there is an equal and opposite reaction"



Forces always Come in Pairs:
You Push on a Wall
the Wall Pushes Back

This means for every force there is a force of the same size acting in the opposite direction

Object A = Person   Object B = Wall

$$\mathbf{F_1 = -F_2}$$

$$\mathbf{F_{A\ on\ B} = -F_{B\ on\ A}}$$

$$\mathbf{F_{person\ on\ wall} = -F_{wall\ on\ person}}$$

When an object applies a force to a second object, the second object applies an equal and opposite force to the first object. By this we mean that ***forces always exist in pairs***, an object cannot push on a second object without the second object pushing back on it. An example of this could be a girl pushing on a wall, and the wall pushing back on the girl.

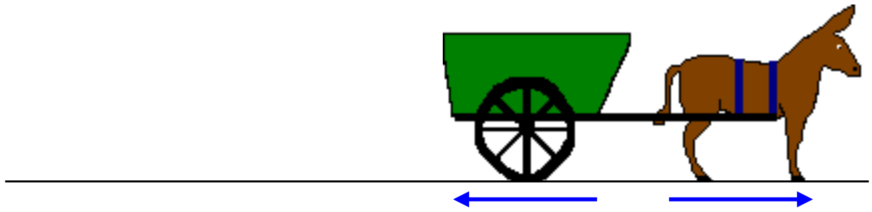
If object A exerts a force on object B, then object B exerts the same kind of force on object A with the same magnitude and opposite direction.

Action-reaction pairs

In every interaction, there is always a **pair** of forces acting on the two interacting objects. An **action force** and the corresponding **reaction force** are called an **action-reaction force pair**.
The action-reaction pair must:

- Be the same type of force
- Acting on different objects

Example 1



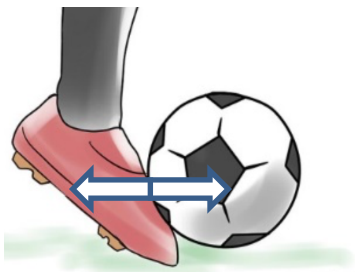
Force on the donkey from the wagon. ***Force on the wagon from the donkey****.*

- Action force: Force ***on the*** __wagon__ ***by the***___horse__ to the __right__.
- Reaction force: Force on the ___________ by the ___________ to _________.

*(As per Newton's 2nd Law, if the net force **on either object** is non-zero the object will accelerate in the direction of the net force)*

Example 2

A soccer player kicks a ball to the right.



		Action force:	*Force on ___________ by the ________ pushing ball to the ________.*
		Effect of action force:	*The ball ____________ to the _________ (away from the _____).*
Reaction force:	*Force on ________ ________ ____________.*		
Effect of reaction force:	*Note: Before striking the ball, the foot was travelling towards the right*		

Steps for determining action-reaction pairs and the resulting acceleration

1: Identify the two objects involved (objects A and B).
e.g. foot and ball

2: Identify the type of force (push or pull).
e.g. push

3: Write a sentence to describe the force object A applies to object B and add a direction.
e.g. "foot pushes ball to the right"

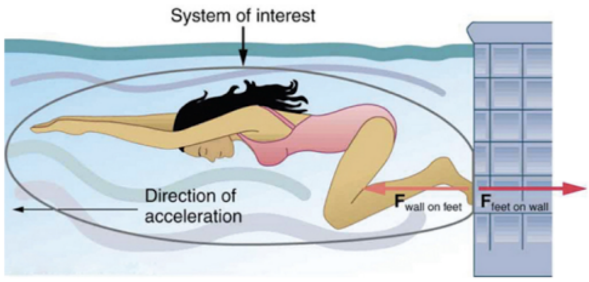
4: Write a sentence to describe the force object B applies to object A and reverse the direction (remember it is always the same type of force)
e.g. "ball pushes foot to the left"

5: Write a sentence to describe the acceleration of object B as a result of the force applied by object A and include a direction (hint: acceleration will always be in the direction as the force applied)
e.g. "ball accelerates to the right"

6: Write a sentence to describe the acceleration of object A as a result of the force applied by object B and include a direction (remember: acceleration will always be in the same direction as the force applied)
e.g. "foot accelerates to the left" (this means the foot decelerates as it moves to the right).

Your turn!

Use Newton's 3rd law to explain why pushing off a wall propels the swimmer forwards.



1. Identify the two objects involved:
    a. Object A:

    b. Object B:
2. Identify the type of force (push or pull)

3. Write a sentence to describe the force object A applies to object B and add a direction.

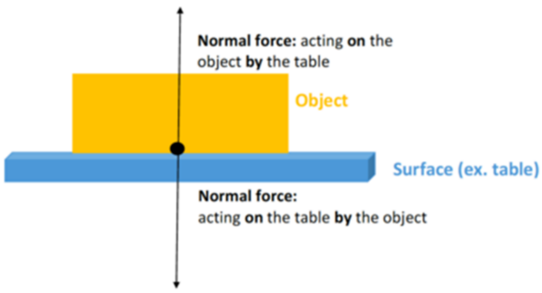
4. Write a sentence to describe the force object B applies to object A, and reverse the direction.

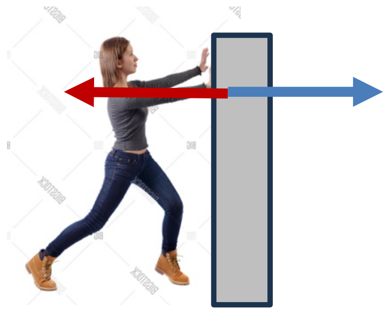
5. Write a sentence to describe the acceleration of object B as a result of the force applied by object A, include a direction.

6. Write a sentence to describe the acceleration of object A as a result of the force applied by object B, include a direction.

The Normal Force (or reaction force)

The normal force is a force that acts ***perpendicular to a surface*** as a result of a force applied TO that surface (e.g. what stops you falling through your chair).

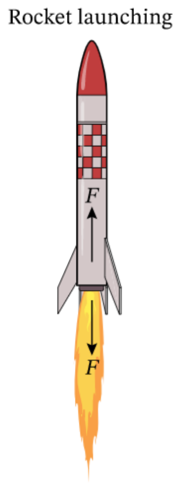
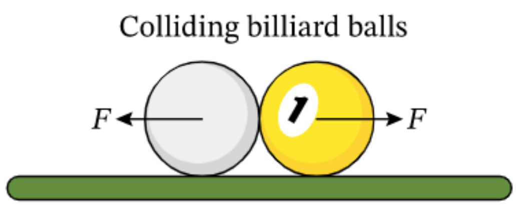


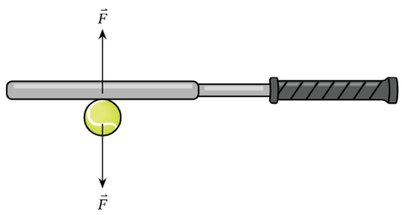
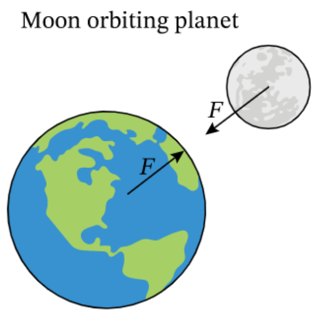
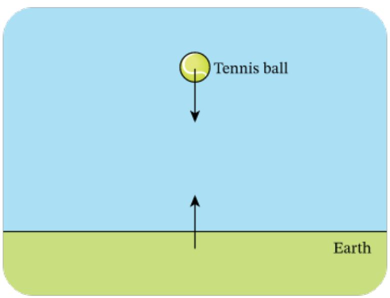
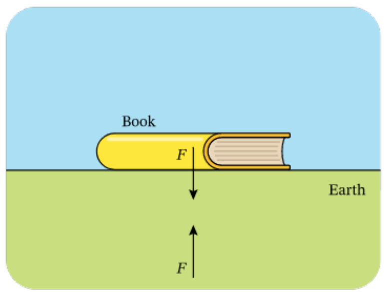


Detail: The downward force shown is the force **on the table by the object**. *It is* *__not__ the force "on the object by earth" .It is not the weight force.* *So, even though weight and normal forces are* ***often*** *equal in size and opposite in direction, they are* ***NOT a Newton's third law 'action-reaction' pair.***

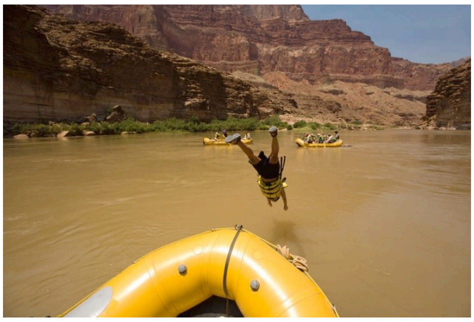
Questions

1. For each of these scenarios in the table, identify the action-reaction pairs and **describe** the acceleration as a result of each force.

	
Newtons 3rd law force pair: *Force on __hot gas__ by __rocket__* ***downwards****.*	***Newtons 3rd law force pair:*** *Force on ___________ by ___________left/right*
Force on __rocket__ by __hot gas__ _________.	*Force on ___________ by ___________ _______*
Effect(s): *The __rocket__ accelerates upwards* *and the __gas__ accelerates ___________.*	***Effect(s):*** *The white ball accelerates ______* ***and*** *_________ _________ ______.*

	
Force on _______ by ______ ______	*Force on _______ by ______ _______*
Force on _______ by ______ _______	*Force on _______ by ______ _______*
Effect(s): *The _______ accelerates downwards* *Conversely, the raquet _________ _________.* *That typically means it continues to moving downwards but it slows down in that short time when it was in contact with the ball.*	***Effect(s):*** *The **Moon** is continually 'pulled' towards the earth. This causes it to 'orbit' around the Earth along a circular path!* *The Earth remains (mostly) stationary because it is so much more massive!! Note that the pulling force of the moon does however cause the movement of water on earth's surafce and so causes tides.*
 *Hint: its gravity*	 *Hint: this is also gravity*
(Weight) force on _______ by ______ ______	*Weight Force on __________ by _________ ______*
Force on _______ by ______ ________	*Force on _______ by ______ ________*
Effect(s): The force causes 56g Ball to acccelete downwards towards earth *(Note: Acceleation of ball = 9.8m/s^2 until air resistance builds)* Same force on Earth causes____________ because it is ***so massive!!*** *(Note: **<u>Same</u> <u>size</u> <u>force!</u>** as that on ball **<u>but</u>** Mass of Earth = 6,000,000,000,000,000,000,000,000 kg!!)*	Effect:

2. A diver dives off a rafter. State (properly describe) the ***two*** forces involved. Then apply Newton's 3rd law to describe what happens to the diver and to the raft.



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3. A tennis racquet his a tennis ball. If the tennis ball accelerates forwards, why doesn't the tennis racquet swing backwards as it hits the ball? *Shouldn't it swing back because of action-reaction forces?*

4. Terry and Chris are each standing on their own skateboards facing each other. They then push against the other person.
    a. What happens to each person?
    b. Draw a diagram to show the forces acting each person.
    c. Compare the force on Chris to the force on Terry. Are they the same or different?

5. Over the next year, Terry has a growth spurt and ends up much bigger and heavier (more mass) than Chris. They play the same game with each standing on their skateboards and pushing away.
    a. What happens to each person now?
    b. Compare the force on Chris to the force on Terry this time.

6. If Chris is standing on a skateboard and pushes off a wall, what happens? Use Newton's 3rd Law to explain.

7. **Return back to your prediction about the cars crashing at 50km/h in to a wall or in to each other. Do you still think the same? Or different? Can you explain why? Watch:** Mythbusters Car Collision 2of2 Final - YouTube to find out what happens.

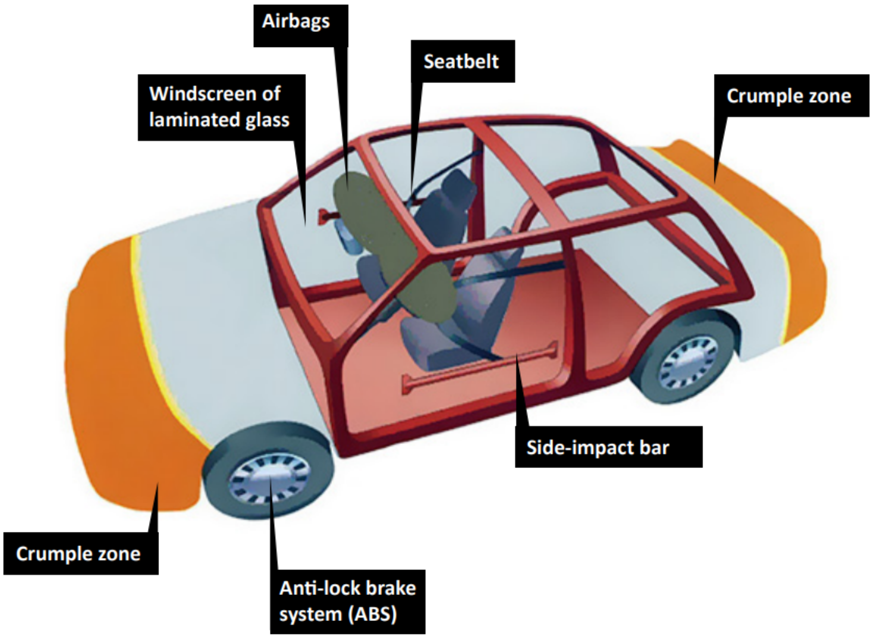
8. An astronaut is 'floating' (stationary) in space, when his safety cord back to the spacecraft is accidentally severed.
   Can he move back towards the spaceship?
   How? *(If yes, describe the forces / objects involved)*

Complete Stile lesson 2.2: The third law of motion and 2.23: Gravity and the third law

Physics of Car Safety

Car safety features

Over the years, clever engineering has dramatically reduced the number of injuries and deaths, by developing safety features that absorb the energy of the crash in a controlled way and decrease the forces acting on the passengers.



Complete the cloze passage to explain how each of the following car safety features applies Newton's Laws. The first letter of each word is provided.

Seat belts

Seat belts stop you tumbling around inside the car if there is a c__________. Upon sensing a collision, the seat belts l______ in place. When the car crashes, there is no unbalanced f______ acting on the person, so they continue f_______ (Newton's _______ Law). The person moves against the seat belt, e_________ a force on it. The seat belt then exerts a force back on the p_______ (Newton's _______ Law). This causes a controlled d_____________ of the person.

Air bags

Air bags increase the t______ taken for the motion of a car occupant's head to d___________ from maximum speed to zero. A short sharp deceleration would involve a very l_________ force, i___________ the chance of a head injury. A longer time s____________ down decreases deceleration thereby r_____________ the size of the force acting and decreasing the chance of i_____________.

Crumple zones

Crumple zones are areas of a vehicle that are designed to c________ in a c_____________ way in a collision. They i__________ the time taken for the vehicle to s_________ down in an impact (like an airbag). This r__________ the force exerted on the p___________. The deformation (crumpling) of the car also a_________ energy from the collision meaning that l________ energy is transferred to the passengers.

Questions

1. A driver has a mass of 100 kg and is travelling at 20 m/s (approx. 70 km/h). Calculate their acceleration if they come to rest in:
    a. 0.01 s
    b. 0.5 s
2. Calculate the force that the driver experiences in these two situations.
3. What happens to the acceleration and hence the force experienced if the stopping time is increased?
4. In your own words, explain how air bags and crumple zones help reduce the injuries to passengers.

Apply Newton's Three Laws

Some common observations that can be explained by Newton's Laws are listed in the boxes:

1. Passengers standing in a bus fall forwards when the bus stops suddenly.	6. A truck takes longer to stop than a car travelling at the same speed.
2. In collisions, large trucks usually cause greater damage than small cars.	7. A strong gust of wind might make a volleyball start to roll – but not a shot put.
3. A firearm recoils (springs back) after being fired.	8. Steering a full shopping trolley round corners takes more force than steering an empty one.
4. Collisions at high speeds usually cause worse injuries than collisions at low speeds.	9. A ball thrown at a wall will bounce back.
5. Passengers standing in a bus fall backwards when the bus accelerates quickly.	10. Cars usually take off faster after stopping at traffic lights than trucks.

Below are explanations using Newton's Laws. Write the number of the observation next to the correct explanation and identify the correct law (1st, 2nd or 3rd)

Explanation	Observation	Newton's Law
The greater an object's mass, the greater its inertia, therefore the greater the force required to change its motion.		
The greater an object's mass, the greater its inertia, therefore the greater the force required to change its motion.		
When a force is applied, the greater an object's mass, the smaller its acceleration.		
When a force is applied, the greater an object's mass, the smaller its acceleration.		
A moving object will keep moving at the same speed and in the same direction unless a force acts on it.		
A moving object will keep moving at the same speed and in the same direction unless a force acts on it.		
When one object exerts a force on another, the second object exerts an equal force back in the opposite direction on the first object		
When one object exerts a force on another, the second object exerts an equal force back in the opposite direction on the first object.		
The greater a moving object's mass, the greater the force required to stop it and the greater the force it will exert in a collision.		
The faster an object's speed, the greater the force needed to stop it and the greater the force it will exert in a collision.		

Reflect on your learning

Red light = I do not know this. I need to ask for help.

Yellow light = I understand this, but need more practice.

Green light = I understand this, and I could help someone else.

Learning Outcome	**Red**	**Yellow**	**Green**
Define the term force and outline some examples			
Outline Newton's First Law of Motion and inertia			
Analyse some situations involving Newton's First law			
State Newton's Third Law of Motion			
Analyse some situations involving Newton's Third Law			
State Newton's Second Law of Motion			
Analyse some situations involving Newton's Second Law			
Draw diagrams to identify forces on stationary and moving objects			
Perform some calculations using F=ma			
Describe the difference between mass and weight			
Calculate the weight of some objects			
Apply Newton's Laws to explain the physics of car safety features			