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**Year 10 – Teacher Booklet A**

**KS4 Forces 1**

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**Lesson Breakdown**

Lesson 1: Classifying forces (4.5.1.1 & 4.5.1.2)

Lesson 2: Gravity, mass & weight (4.5.1.3)

Lesson 3:  Resultant forces & resolving resulting forces (4.5.1.4)

Lesson 4: Resolving resultant forces – Higher tier only

Lesson 5: Work done (4.5.2)

Lesson 6: Forces and elasticity (4.5.3) - theory

Lesson 7: Required practical (4.5.3) - extension of a spring

Lesson 8: Required practical (4.5.3) - analysis

Lesson 9: Moments, levers and gears (4.5.4) - Physics only

Lesson 10: Pressure in fluids – Physics only

Lesson 11: Pressure at right angles to a surface – Physics only

Lesson 12: Atmospheric pressure – Physics only

**Keystone words**

1. **Vector**
2. **Scalar**
3. **Contact**
4. **Non-contact**
5. **Resultant**
6. **Extension**

**Lesson 1: Teacher notes**

AQA Content

Scalar quantities have magnitude only.

Vector quantities have magnitude and an associated direction.

A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the vector quantity.

A force is a push or pull that acts on an object due to the interaction with another object.

All forces between objects are either:

• contact forces – the objects are physically touching

• non-contact forces – the objects are physically separated.

Examples of contact forces include friction, air resistance, tension and normal contact force.

Examples of non-contact forces are gravitational force, electrostatic force and magnetic force. Force is a vector quantity.

**Students should be able to** describe the interaction between pairs of objects which produce a force on each object. The forces to be represented as vectors.

**Key direct and explicit teacher explanations:**

* **Scalar and vector quantities.**

Scientists measure many things. We say that they quantify them.

The measurements that are made can be divided into two groups, scalar and vector quantities.

Scalar quantities have a magnitude (a number). For example, the mass of a person might be 75kg; the length of a desk might be 1 metre.

Vector quantities are different; they have a magnitude and a direction. For example, displacement (as opposed to distance), forces and velocity (as opposed to speed).

**Needs lots of examples.**

* **Classifying forces (push / pull, contact / non-contact).**

Forces can cause three effects on objects. They can:

1. Change their speed.
2. Change their direction.
3. Change their shape.

**Needs examples.**

We can classify forces depending on how they interact with objects. They can be classified as push or pull forces. We can also classify forces as contact forces and non-contact forces (or fields). Contact forces act when objects or surfaces touch. For example, friction is a contact force that might exist between your feet and the floor (if it didn’t, the floor would be very slippery). Other contact forces include normal contact force, tension and air resistance.

Non-contact forces act through space. For example, gravity can attract other objects without it having to touch them. Also, magnets can attract or repel other magnets without touching them. The non-contact forces are formally called gravitational force, electrostatic force and magnetic force.

All forces are vector quantities because they have a magnitude and a direction.

**Needs examples.**

* **Describing interactions.**

When two or more objects interact, all of the objects experience forces. Or example, when you kick a ball, the ball experiences a force so it moves. You also experience a force on your foot (you feel the pressure of the ball pushing against your foot).

The forces are equal and opposite. We call the pairs of forces, interaction pairs.

**Needs examples.**

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 1: Classifying forces**

**Objective: You are learning to classify forces as contact / non-contact or push / pull forces.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there, but I still care.**

This is the first lesson of the topic.

Complete the ‘Do It Now’ activity shown above.

**Connect**

**Q1.**

The picture shows a man called Aristotle. He lived in Greece over 2000 years ago.

A person with a beard

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          Aristotle said that the heavier an object is, the faster it will fall to the ground.

(a)     The drawings below show a bowling ball, a cricket ball and a ping-pong ball.  
Lila dropped them all at the same time from the same height.

A close up of a ball

Description automatically generated with medium confidence                           A close up of a ball

Description automatically generated                                

bowling ball                               cricket ball                         ping-pong  
mass = 5 000 g                         mass = 160 g                    mass = 2.5 g

          If Aristotle was correct, which of the three balls would you expect to reach the ground first?  
Give the reason for your answer.

.....................................................................................................................

.....................................................................................................................

1 mark

(b)     Joe said that it would be a fairer test if Lila had only used a cricket ball and a hollow plastic ball as shown below.

A close up of a ball

Description automatically generated                                   A picture containing circle, oval, mirror, dishware

Description automatically generated

cricket ball                            hollow plastic ball  
mass = 160 g                            mass = 56 g

          Why was Joe correct?

.....................................................................................................................

.....................................................................................................................

1 mark

(c)     About 400 years ago in Italy, a man called Galileo had a different idea. He said that all objects dropped from the same height would reach the ground at the same time.

(i)      Lila dropped a hammer and a feather at the same time from the same height.

A picture containing text, sketch, white, hammer

Description automatically generated    A black and white feather

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         If Galileo was correct, which, if either, would reach the ground first?

.............................................................................................................

1 mark

(ii)     Gravity acts on both the hammer and the feather as they fall. Give the name of **one** other force which acts on them as they fall.

..........................................

1 mark

(iii)     An astronaut on the moon dropped a hammer and a feather at the same time from the same height.

A child in an astronaut suit

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         How would the results of the astronaut’s experiment on the Moon be different from Lila’s experiment on the Earth?

.............................................................................................................

         Explain your answer.

.............................................................................................................

.............................................................................................................

2 marks

Maximum 6 marks

c)     About 400 years ago in Italy, a man called Galileo had a different idea. He said that all objects dropped from the same height would reach the ground at the same time.

(i)      Lila dropped a hammer and a feather at the same time from the same height.

A picture containing text, sketch, white, hammer

Description automatically generated    A black and white feather

Description automatically generated with low confidence

         If Galileo was correct, which, if either, would reach the ground first?

.............................................................................................................

1 mark

(ii)     Gravity acts on both the hammer and the feather as they fall. Give the name of **one** other force which acts on them as they fall.

..........................................

1 mark

(iii)     An astronaut on the moon dropped a hammer and a feather at the same time from the same height.

A child in an astronaut suit

Description automatically generated with medium confidence

         How would the results of the astronaut’s experiment on the Moon be different from Lila’s experiment on the Earth?

.............................................................................................................

         Explain your answer.

.............................................................................................................

.............................................................................................................

2 marks

Mark schemes

**Q1.**

(a)     **Both the correct ball and the correct reason are required for the mark.**

the bowling ball because it has the greatest mass **or** it is the heaviest

*do* ***not*** *accept ‘because it is bigger’*

*‘the bowling ball because it is bigger’ insufficient*

**1 (L5)**

(b)     any **one** from

•    they are the same diameter

*accept ‘they are the same size’*

•    they produce the same air resistance **or** friction

**1 (L5)**

(c)     (i)      they would both reach the ground at the same time

**1 (L5)**

(ii)     air resistance

*accept ‘friction’*

**1 (L5)**

(iii)     **either**

•    the feather and the hammer landed at the same time

**1 (L6)**

•    there is no atmosphere **or** air resistance **or** air on the moon

**1 (L6)**

**or**

•    they would take longer to fall on the moon

**1 (L6)**

          because there is lower gravity than on the Earth

*do* ***not*** *accept* *‘there is no gravity on the moon’*

**1 (L6)**

**[6]**

**Information**

Scientists often make measurements. The physical quantities they measure fall into two categories: scalars and vectors. Scalar and vector quantities are treated differently in calculations.

**A scalar** is a physical quantity is something that can be measured. Scalar quantities only have a magnitude.

**Examples of scalar quantities**

Some examples of scalar quantities include:

* temperature, eg 10 degrees Celsius (°C)
* mass, eg 5 kilograms (kg)
* energy, eg 2,000 joules (J)
* distance, eg 19 metres (m)
* speed, eg 8 metres per second (m/s)
* density, eg 1,500 kilograms per metre cubed (kg/m³)

A **vector** quantity has both magnitude and an associated direction. This makes them different from scalar quantities, which just have magnitude.

**Examples of vector quantities**

Some examples of vector quantities include:

* force, eg 20 newtons (N) to the left
* displacement, eg 50 kilometres (km) east
* velocity, eg 11 metres per second (m/s) upwards
* acceleration, eg 9.8 metres per second squared (m/s²) downwards
* momentum, eg 250 kilogram metres per second (kg m/s) south west

Task 1: Put a tick in the box stating if the below Scalar or Vector ?

|  |  |  |
| --- | --- | --- |
| **Quantity** | **Scalar** | **Vector** |
| Weight |  |  |
| Distance |  |  |
| 6m West |  |  |
| 125 J |  |  |
| 68 Kg |  |  |
| Force |  |  |
| Displacement |  |  |
| 750 N Down |  |  |
| Speed |  |  |
| 30 m/s at 30° from North |  |  |
| Mass |  |  |

**Vector Information**

* Vectors have both size and direction. We represent them using arrows.
* The **length** of the arrow represents the magnitude.
* An arrow twice as long will have a magnitude twice as big. If possible draw the length to scale.
* The **direction** of the arrow represents the direction.
* The direction of a vector can be given in several ways:
* Compass bearing e.g. 45m m/s East or 12 m/s at 133o
* Arrow with a value e.g. à 20m/s
* Using a sign convention e.g. positive for upwards and negative for downwards

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Answers

**1-C, 2-A, 3-C,4-B, 5-D, 6-B, 7-A, 8-B, 9-B , 10-D**

**Classifying forces (push / pull, contact / non-contact).**

Forces can cause three effects on objects. They can:

1. Change their speed.
2. Change their direction.
3. ****Change their shape



We can classify forces depending on how they interact with objects. They can be classified as push or pull forces. We can also classify forces as contact forces and non-contact forces (or fields). Contact forces act when objects or surfaces touch. For example, friction is a contact force that might exist between your feet and the floor (if it didn’t, the floor would be very slippery). Other contact forces include normal contact force, tension and air resistance.

Non-contact forces act through space. For example, gravity can attract other objects without it having to touch them. Also, magnets can attract or repel other magnets without touching them. The non-contact forces are formally called gravitational force, electrostatic force and magnetic force.

All forces are vector quantities because they have a magnitude and a direction.

**Describing interactions.**

When two or more objects interact, all of the objects experience forces. E.g, when you kick a ball, the ball experiences a force so it moves. You also experience a force on your foot (you feel the pressure of the ball pushing against your foot).

The forces are equal and opposite. We call the pairs of forces, interaction pairs.

**Questions:**

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1. Describe the unit of measurement of forces and name the piece of equipment we use to measure forces?

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1. Describe the difference between a scalar and a vector quantity?

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1. Explain why we use arrows to represent forces?

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1. Explain the effect applying a force has on an object?

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1. Explain the difference between a contact and a non-contact forces and give examples of each?

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**Answers**

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2. Newtons, Newton meter

3. Scalar has a magnitude, vector has a magnitude and direction

4. To show the varying directions forces are acting, forces work in pairs

5. A force can, change the speed, direction and shape of an object

6. A contact force has to have direct contact on it to work, a non-contact does not need to be touching an object for it to effect it. It can work at a distance.

**Lesson 2: Teacher notes**

AQA Content

Weight is the force acting on an object due to gravity.

The force of gravity close to the Earth is due to the gravitational field around the Earth.

The weight of an object depends on the gravitational field strength at the point where the object is.

The weight of an object can be calculated using the equation:

weight  = mass  × gravitational field strength

W  = m g

weight, W, in newtons,

N mass, m, in kilograms, kg

gravitational field strength, g, in newtons per kilogram, N/kg

(In any calculation the value of the gravitational field strength (g) will be given.)

The weight of an object may be considered to act at a single point referred to as the object’s ‘centre of mass’.

The weight of an object and the mass of an object are directly proportional.

Weight is measured using a calibrated spring-balance (a newton meter)

**Key direct and explicit teacher explanations:**

* The difference between mass and weight.

Everything that is made up of particles has mass; mass is a measure of how much matter is in an object.

Everything that has mass also has a gravitational field. The magnitude of the gravitational field depends on the mass; mass is directly proportional to the gravitational field. The gravitational field pulls other objects towards it; this is a non-contact force because gravity exerts a force using a field.

Weight is the force acting on an object due to gravity. As with all forces, we measure weight in Newtons. Weight is always directly proportional to the mass of an object.

* Calculating weight (using knowledge of mass and gravitational field strength).

The relationship between mass, weight and gravitational field strength is given by the equation:

weight  = mass  × gravitational field strength

W  = m g

Weight is measured in Newtons.

Mass has units of kg.

Gravitational field strength has units of N/kg.

Gravitational field strength varies depending on the mass of the planet or moon we are on. On Earth, gravitational field strength is 9.81N/kg. Sometimes we round this to 10N/kg (exam questions usually tell you which one to use). On the moon, which has much less mass than the Earth, the gravitational field strength is 1.6N/kg.

* Measuring weight using a Newton-meter.

We can measure the weight of an object using a Newton meter. His device is calibrated so that it takes into account the gravitational field strength on Earth.

**Students ought to have the opportunity to use Newton meters.**

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 2: Gravity, Mass and Weight**

**Objective: You are learning about mass and weight and how they are related.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there, but I still care**

Define Scalar: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Define Vector:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

State 2 examples of a scalar and vector quantity:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

State the difference between a scalar and a vector quantity:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Connect**

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Suggest reasons why weight is different on different planets but mass remains constant. Write in full sentences and use at least two connectives in your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Gravitational field strength**

On Earth, the downward force of gravity on a 1 kg mass is 10 N.

This is called the gravitational field strength (g).

Gravitational field strength g = 10 N/kg (some questions will ask you to use 9.81 N/kg).

The relationship between the weight of an object in N, its mass in kg and the gravitational field strength N/kg is given by the equation:

**weight W in N = mass m x gravitational field strength g**

W = mg

W = weight in N

m = mass in kg

g = gravitational field strength in N/kg

g = 10 N/kg

A mass of 1 kg has a weight of 10 N.

A mass of 6 kg has a weight of 60 N.

Mass is a measure of how much matter is in an object. The mass of an object is constant, when the object is on Earth, Mars or even in the middle of space it’s mass will be the same. **The units of mass are the kilogram (kg). We measure mass using a balance.**

Weight is a measure of the force pulling an object down due to gravity. This can change due to the strength of gravity. **The unit of Weight is the Newton (N). Weight is measured using a calibrated Newton meter.** The weight of an object appears to act from a point called the **center of mass.**

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**Teacher Modelling:** Calculate the weight of a student whose mass is 72kg.

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**1 tonne (t) = 1000 kg**

**Questions 1 to 5 are asking about weight on earth, assume the gravitational field**

**strength on earth is 9.81 N/kg**

1. Calculate the weight of a student whose mass is 72kg

2. Calculate the weight of a wheelbarrow of concrete, total mass 105 kg

3. Calculate the weight of a pillow, total mass 0.5 kg

4. Calculate the weight of a 25g sachet of pickling spice

5. Calculate the weight of a 44t lorry (1 tonne = 1000 kg)

**In all the questions below g stands for “gravitational field strength”.**

6. Calculate the weight of a 25 kg sack of potatoes on earth, assume g = 9.8 N/kg

7. Calculate the weight of a 25 kg sack of potatoes on the moon where g = 1.6 N/kg

8. Calculate the weight of a 25 kg sack of potatoes on mars where g = 3.8 N/kg

9. Calculate the weight of a 1.5 tonne landing vehicle on mars (g = 3.8 N/kg )

10. Calculate the weight of 20 g of moon dust on earth (g = 9.8 N/kg )

11. Calculate the mass of a rover which weighs 500N on the moon where g = 1.6 N/kg

12. Calculate the mass of an astronaut whose weight is 400N on mars (g = 3.8 N/kg )

13. Calculate the mass of space dust whose weight is 4N on jupiter (g = 26.9 N/kg )

14. Calculate the mass of space dust whose weight is 89 mN on on Venus (g = 8.9 N/kg )

15. Convert the answer to Question 19 into grams.

16. If 1 kg has a weight of 2N on the planet zog, what is the value of g on the planet zog?

17. If a 25 kg lander weighs 110 N on the exoplanet proxima b what is the value of g on proxima b?

18. If a 450 t meteorite weighs 1350 kN, what is the value of g?

19. What would a 0.5 g paracetamol tablet weigh on mars (g = 3.8 N/kg )

20. If a 0.5 g paracetamol tablet weighs 0.8 mN, where might it be? (work out the value of g first...)

21. Using the answers to questions 11 to 13 above, on which of earth, mars and the moon does a 10kg

object weigh the most? Is this true for an object of any mass?

**Answers**

1. 72 x 9.81 = 706.32 = 710N

2. 105 x 9.81 = 1030.05= 1030 N

3. 0.5 x 9.81 = 4.905 = 5 N

4. 25 x 10-3 = 0.025 kg

0.025 x 9.81 = 0.24525 = 0.25 N or 250 mN

5. 44 x 103  = 44,000 kg

44,000 x 9.81 = 431640 = 430,000 N or 430 kN

6. 25 x 9.8 = 245 = 250 N

7. 25 x 1.6 = 40 N

8. 25 x 3.8 = 95 N

9.1.5 x103 x 3.8 = 5700 N

10. 20 x 10-3 = 0.020 kg

0.020 x 9.8 = 0.196 = 0.20 N

11. 500 / 1.6 = 312.5 = 310 kg

12. 400 / 3.8 = 105.263 = 110 kg

13. 4 / 26.9 = 0.148kg = 0.1 kg (2 sf)

14. 89 x 10-3 = 0.089 N

0.089 / 8.9 = 0.010 kg

15. 10 g

16. 2 / 1 = 2 N/kg

17. 110 / 25 = 4.4 N/kg

18. 1350x103 / 450x103  = 3.0 = 3.0 N/kg

19. 0.5 x 10-3 = 0.0005 kg

0.0005 x 3.8 = 0.0019 = 0.002 N or 2 mN

20. 0.8x10-3 / 0.5x10-3 = 1.6 N/kg, which is the value of g on the moon

21. Earth, yes

|  |  |  |
| --- | --- | --- |
| **Object**  **Using the Newton meters calculate the weight of various everyday objects. You must show your calculations.** | **Mass (kg)** | **Weight (N)** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| **Show your working out below:**  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  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**Lesson 3: Teacher notes**

AQA Content

A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together.

This single force is called the resultant force.

**Students should be able to** calculate the resultant of two forces that act in a straight line.

**(HT only) Students should be able to:**

* describe examples of the forces acting on an isolated object or system.
* use free body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object, including balanced forces when the resultant force is zero.

**Key direct and explicit teacher explanations:**

* What is a resultant force?

Forces are vector quantities because they have a magnitude and a direction. This affects how we treat them if more than one force acts on an object.

When more than one force acts on an object, we can calculate an overall force. This makes it easier to think about how the object will be affected by the forces. We call the overall force, a resultant force.

* Calculating resultant forces using forces acting in the same plane.

When two or more forces act on the same object and in tea me direction, we add them together.

If the forces oppose each other, we subtract the smallest from the largest force.

In this way we can calculate the overall, or resultant, force.

* Representing forces on free-body diagrams.

We can show al of the forces acting on an object tin a free body diagram. The forces are identified using arrows. The length of the arrow is proportional to the magnitude of the force. The direction of the arrow shows the direction that the forces acts in.

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 3: Resultant forces acting in a straight line**

**Objective: You are learning to calculate the resultant of forces acting in a straight line.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

Mass is the amount of matter in an object. It is measured in kilograms.

Weight is a force caused by the interaction of that matter with a gravitational field.

**I wasn’t there, but I still care.**

Recall the difference between mass & weight.

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**Connect**

Identify which arrow represents which force.

Conclude what overall effect the forces have on the car?



**Isaac Newton’s 3rd Law states:​**

* ***Each action has an equal and opposite reaction*​**

**​**

* In other words, if you exert a force on an object, the object exerts a force of the same magnitude back​

​

* E.g., a boxer who punches a punch bag with a force of 100N experiences an equal and opposite force of 100N from the bag​

These can be shown by force diagrams. Examples of force diagrams include:

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A picture containing screenshot, text, diagram, graphic design

Description automatically generated

A picture containing transport, air travel, plane, vehicle

Description automatically generated

Answers

A picture containing text, screenshot, font, line

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Answers

a). 30 - 10= 20N

b). to the right (90o )

c). a scaled arrow

d). vector

**Task 1:**

A orange rectangular object with wheels

Description automatically generated with low confidence

1. What is the **magnitude** (size) of the **resultant force**?
2. What is the **direction** of the **resultant force**?
3. How could this be represented?
4. Because the resultant force has direction AND size it means that force is a…?

**Task 2**: Resolve the resultant forces

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Free body diagrams

Show the forces acting on an object in a free body diagram. The arrows represent the size and direction of the forces acting. When drawing a force diagram:

A picture containing diagram, line, font, rectangle

Description automatically generated

* represent the object with a small box or dot
* draw the arrows with a pencil and ruler
* draw the arrows from the centre of the box or dot
* label the arrow with the name of the force and the size of the force

**Task3:**

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Answers

0N 50N down 50N up

0N 0N 19N right

**Task4:**

For each question:

a) Draw a free body diagram in your book showing all the forces acting on the object

b) State the size and direction of the resultant force

Remember for free body diagrams:

• The length of the arrow represents the size of the force.

• The direction of the arrow represents the direction of the force.

• Represent the object by a box.

• Draw the arrow from the centre or edge of the box outward in the direction the force is acting.

1. A car drives along a road, travelling to the right. The driving force from the engine is 8000 N. The force of air resistance is 2000 N.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. A Skydiver falls through the air and opens their parachute. Their weight is 700 N and the air resistance is 1000 N.

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3. An egg with a weight of 5 N is falling with no air resistance.

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4. A book with a weight of 10 N is at rest on a table. (Hint: there is a second force to think about).

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**Lesson 4: Teacher notes**

AQA Content

**(HT only)** A single force can be resolved into two components acting at right angles to each other. The two component forces together have the same effect as the single force.

**(HT only)** Students should be able to use vector diagrams to illustrate resolution of forces, equilibrium situations and determine the resultant of two forces, to include both magnitude and direction (scale drawings only).

**Key direct and explicit teacher explanations: (HT only)**

* Resolving single forces into horizontal and vertical components using vector diagrams.
* Determining the resultant force of two forces acting at right angles to each other.
* Determining the resultant force of two forces acting at angles other than a right angle.

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 4: resultant forces acting at angles to each other (HT)**

**Objective: You are learning to use vector diagrams to resolve resultant forces acting at angles to one another.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there, but I still care.**

1.What is meant by resultant force?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2.Determine the resultant force on the object below.

A picture containing screenshot, line, font, diagram

Description automatically generated

3. **Draw a free body diagram** that shows the forces acting on an aeroplane that weighs 2500N. It has 3000N of thrust from the engines, 700N of air resistance and experiences 3000N of lift. **Determine the resultant force** on the aeroplane and **describe its motion.**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Connect**

A picture containing text, wheel, diagram, vehicle

Description automatically generated

A picture containing text, screenshot, font, diagram

Description automatically generated

A picture containing text, screenshot, font, line

Description automatically generated

AnswerA picture containing line, font, text, diagram

Description automatically generated

Answers

**M2.**          (a)     A then E

*for one mark*

**1**

(b)     A > E  
A = E  
A < E

*in this order for 1 mark each*

**3**

(c)

     when van stops / is stationary / is parked

*for one mark*

**1**

A picture containing text, screenshot, font, diagram

Description automatically generated

A picture containing pattern, line, square

Description automatically generated

**I do:**

A picture containing text, screenshot, font, line

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**Task 1:**

**Resultant Forces at angles**

**Draw free body diagrams for the following situations.**

**Then draw the vectors again head-to-tail (make sure they are to scale!)**

**Measure the resultant vector and describe the direction.**

**Use square paper to help you**

1. **A box is pushed to the right with a force of 60 N.   
   at the same time it is being pushed downwards with a force of 100 N**

**Use the scale 1 cm : 10 N**

1. **What is the size of the resultant force?**
2. **Use a protractor to find the direction of the resultant force.**

A picture containing pattern, line, square

Description automatically generated

**ANSWERS**

1. 117N
2. 510N
3. 21,500N
4. **A man jumps up with an overall force of 500 N  
   The wind is blowing him right with a force of 100 N**

**Use the scale 1 cm : 100 N**

1. **What is the size of the resultant force?**
2. **Use a protractor to find the direction of the resultant force.**

A picture containing pattern, line, square

Description automatically generated

1. **The weight of a submarine is 20000 N**

**It is driving to the left with a force of 8000 N**

**Use the scale 1 cm : 2000 N**

1. **What is the size of the resultant force?**
2. **Use a protractor to find the direction of the resultant force.**

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**A diagram of forces with red and blue arrows

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**A picture containing text, screenshot, font, line

Description automatically generated**

Answer

**Resultant**

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**Task 2:**

(a)     A fisherman pulls a boat towards land.

The forces acting on the boat are shown in **Diagram 1**.

The fisherman exerts a force of 300 N on the boat.  
The sea exerts a resistive force of 250 N on the boat.

**Diagram 1**

A picture containing line, design

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(i)      Describe the motion of the boat.

………………………………………………………………………………………………………………

……………………………............................................................................................................ (2)

(ii)     When the boat reaches land, the resistive force increases to 300 N.  
 The fisherman continues to exert a force of 300 N.

Describe the motion of the boat. Tick (✓) **one** box.

|  |  |  |
| --- | --- | --- |
|  | Accelerating to the right |  |
|  | Constant velocity to the right |  |
|  | Stationary |  |

(1)

(iii)    Explain your answer to part **(a)(ii)**.

………………………………………………………………………………………………………………

…………………………............................................................................................................... (2)

(iv) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in **Diagram 2**.

**Diagram 2** is drawn to scale.

Add to **Diagram 2** to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

**Diagram 2**

A picture containing line, diagram, plot, white

Description automatically generated

Resultant force = .................................... N (4) **(Total 9 marks)**

Answers

**M1.** (a)     (i)       forwards / to the right / in the direction of the 300 N force **1**

*answers in either order*

accelerating **1**

(ii)     constant velocity to the right

**1**

(iii)    resultant force is zero

*accept forces are equal / balanced* **1**

so boat continues in the same direction at the same speed **1**

(iv)    parallelogram or triangle is correctly drawn with resultant  
 A picture containing line

Description automatically generated

**3**

value of resultant in the range 545 N – 595 N **(PLEASE NOTE THAT THE SCALE OF THE DIAGRAM IS NOT 1 CM to 100N, MARKS ARE TO BE AWARDED BASED ON THE PROCESS AND STUDENTS INDIVIDAUL WORKING OUT BASED ON THEIR INTEREPRETATION OF THE SCALE)**

*parallelogram drawn without resultant gains* ***1*** *mark*

*If no triangle or parallelogram drawn:*

*drawn resultant line is* ***between*** *the two 300 N forces gains* ***1*** *mark*

*drawn resultant line is between and longer than the two 300 N forces gains* ***2*** *marks*

**1**

**[9]**

**To be used for part (iv) of Task 2.**

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**Lesson 5: Teacher notes**

AQA Content

When a force causes an object to move through a distance work is done on the object. So, a force does work on an object when the force causes a displacement of the object.

The work done by a force on an object can be calculated using the equation:

work done = force × distance moved along the line of action of the force

W  = F s

work done, W, in joules, J

force, F, in newtons, N

distance, s, in metres

One joule of work is done when a force of one newton causes a displacement of one metre. 1 joule = 1 newton-metre

**Students should be able to** describe the energy transfer involved when work is done.

**Students should be able to** convert between newton-metres and joules.

Work done against the frictional forces acting on an object causes a rise in the temperature of the object.

**Notes on key direct and explicit teacher explanations:**

The language used must be that of energy stores and energy pathways. The work done refers to the pathway (e.g. work is done using the mechanical pathway). Students need to be able to describe the transfer of energy from one store into others when work is done.

For frictional forces, students need to refer to energy being transferred into the thermal energy store of the surroundings.

Good opportunity to revisit the accounting model for energy transfers (last used in the Energy Changes booklet).

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 5:**

**Objective: You are learning to how work is done in a scientific context.**

**Do It Now**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**I wasn’t there, but I still care.**

**Define resultant force:**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Complete the sentences using the words listed.**

**Push. Pull. Add. Subtract. Physically touching. Physically separated.**

When forces act in the same direction, we \_\_\_\_\_\_\_them together.

When forces act in the opposite direction to each other we \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_them.

A force is either a \_\_\_\_\_\_\_ or a \_\_\_\_\_\_\_\_\_\_\_

Contact forces are when objects are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Non-contact forces are when objects are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Connect**

**What have all the following got in common? What do they all involve?**

A work-out

Housework

Going to work

Horse work

Hard work

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The energy store that is filled when an object is raised higher up.

The energy store that is filled when an object moves faster.

The energy store that is filled when an object becomes hotter.

**Using physics textbooks, look up the following key words. Then write down one example of it or something that contains it.**

**Work**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Energy store**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Force**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Friction**

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**Thermal energy**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Kinetic energy store**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Gravitational energy store**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

E.g. between the wheels of a car and the road.

Credit any example that results in a change of speed, direction or shape of an object.

e.g. The kinetic energy store of particles in a gas.

e.g. The force from the engine of the car moving the car. Credit any example of a force being applied to an object.

**How do we keep fit**?

Lifting weights, biking, walking, running? Any or all of these involve us moving something. When we move something, we apply a force. **The work you do causes a transfer of energy.**

**Complete the sentence:**

Energy cannot be \_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ just \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_between energy stores. This principle tells us that energy is conserved (the total amount of energy in the Universe is a constant).

**Examples of energy transfers.**

A picture containing screenshot, design

Description automatically generated

transferred

destroyed

created

I do – using an accounting diagram to show the results of work being done**.**

**Transferring energy**

In each of these examples, energy is transferred by one of the following four types of energy transfer:

* **Mechanical work** - a force moving an object through a distance.
* **Electrical work** - charges moving due to a potential difference.
* **Heating** - due to temperature difference caused electrically or by chemical reaction.
* **Radiation** - energy transferred as a wave, e.g. light and infrared - light radiation and infrared radiation are emitted from the sun

Doing 'work' is the scientific way of saying that energy has been transferred. For example, a grazing cow, a firing catapult and a boiling kettle are all doing 'work', as energy is being transferred from one store to another.

**Something POWERFUL does a lot of work in a short time. That means it transfers energy quickly.**

**What have you got at home that is powerful?**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Power just measures how quickly work is done or energy is transferred. The units are Watts (W) or (KW). We use this formula to work out the power/

Power (W) = Energy Transferred (J)

Time(s)

Energy accounting models show the energy before and after transfers.

**Modelling**. Your teacher will model some examples and then you can have a go at some others.

Remember energy at the start must equal energy at the end. It will just be in a different store.

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E.g. Kettle, electric hob etc.

Your teacher will model how energy is transferred not lost using these accountancy diagrams.

Remember energy is not lost or gained but transferred from one store to another.

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Work is done through the mechanical pathway and radiation pathway.

Chemical Elastic Thermal

Chemical Elastic Thermal

A person stretches a spring. In the process of doing this, 100J of work is done. 100J of the energy in their chemical energy store is transferred. 80J is transferred to the elastic energy store of the spring. 20J is transferred to the thermal energy store of the surroundings.

**Represent this on the accounting diagram above.**

**YOU DO**

Chemical Kinetic Thermal

Chemical Kinetic Thermal

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A person carries a box of exercise from one desk to another. 200 J of work is done. 200 J of energy is transferred from the persons chemical energy store. 140 J is transferred to the kinetic energy store of the book box. 60 J is transferred to the thermal energy store of the surroundings.

**Represent this on the accounting diagram above.**

**Work is done on an object when a force makes the object move.**

Energy transferred = work done. We use the formula:

W = F x s

W = work done (Joules, J)

F = The force (Newtons, N)

s = The distance moved (Metres, M)

One joule of work is done when a force of 1N causes an object to move by 1m in the direction of the force.

**Worked example:**

A builder pushed a wheelbarrow a distance of 10 m across the ground. He used a force of 50 N. How much work did the builder do?

Solution:

Work done = Force x distance moved

Work done = 50N x 10m

Work done = 500J

**You Do task:**

How much work is done if a lorry was pulled by Britain’s strongest man over 40m using a pull force of 2000N.

**Set out the answer like the one above.**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Work done = force x distance moved

Work done = 2000 n x 40 m

Work done = 80,000 J

**TOP TIP:**

**If you calculate the work done this is the same as the energy transferred.**

**The force must move to do work so, a person lifting a box does work but, when they stand still, just holding the box, they do not do any work as no energy is transferred.**

**Energy transferred = work done**

Any work you do causes you to transfer energy. When an object is moved by a force, work is done by the force. Energy is transferred to the object from the force. The amount of energy is equal to the work done.

If you raise an object you need to overcome the force of gravity which holds it down. If the work you do on the object is 20J then the energy transferred must be 20 J. As we are increasing the height of this object its gravitational potential energy has increased by 20J

**We work out Gravitational potential energy using the formula:**

**E= m x g x f**

**E = Gravitational potential energy (Joules)**

**m = Mass (Kgs)**

**g = Gravitational field strength (9.8 N/Kg rounded to 10Kg)**

**h = Height (M)**

Gravitational Potential energy (GPe) store of an object increases when you it moves up and decreases when it moves down. It increases when it moves up because work must be done to lift it to overcome the force of gravity.

**TOP TIP:**

**If an object goes up a slope you need to make sure you look at the height gained NOT the distance along the slope**

**Worked example.**

A student lifts some heavy books onto a shelf 5M high. The books weigh 10Kg. Calculate the Ep.

Ep = m x g x h

Ep = 10 x 10 x 5

Ep = 500 joules.

**You do.**

What is the gravitational potential energy gained by a 6kg rabbit that is lifted 0.5 m by its owner.

Set out as shown in the previous example**.**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

6 x 10 x 0.5

= 30 J

**Friction and work.**

**Work done to overcome friction is transferred as heat.**

If you rub your hands together, they get warm. Your muscles are doing work to overcome the friction between your hands. The work you do is transferred as energy that warms your hands.

**I do**

**Using physics textbook page 9, explain using force and energy transfers, how brake pads get hot if the brakes are kept on too long.**

Force is applied to the brake pedal.

Brake pads ae pushed against the brake disc.

Friction is present between the rake pads and brake disc.

Work is done mechanically.

Energy is transferred to the thermal energy store of the brake pad.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**You Do**

**Explain using the following terms how we see meteorites (shooting stars)**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

When the meteorite enters the atmosphere, frictional forces cause work to be done.

Energy is transferred from the kinetic energy store of the object to the thermal energy store of the surroundings. Some of the energy is also transferred to the electromagnetic store of the surroundings. This is seen by the person.