Background pattern

Description automatically generated with low confidence

**Year 10 – Teacher Booklet B**

**KS4 Forces 1**

Graphical user interface, text, application

Description automatically generated

A cartoon of a person sitting under a tree

Description automatically generated with medium confidence

Shape

Description automatically generated with medium confidenceShape

Description automatically generated with medium confidenceShape

Description automatically generated with medium confidenceShape

Description automatically generated with medium confidence



**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 6: Teacher notes**

AQA Content

Students should be able to:

• give examples of the forces involved in stretching, bending or compressing an object

• explain why, to change the shape of an object (by stretching, bending or compressing), more than one force has to be applied – this is limited to stationary objects only

• describe the difference between elastic deformation and inelastic deformation caused by stretching forces. The extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.

force = spring constant × extension

F  = k e  force, F, in newtons, N spring constant, k, in newtons per metre, N/m extension, e, in metres, m

This relationship also applies to the compression of an elastic object, where ‘e’ would be the compression of the object.

A force that stretches (or compresses) a spring does work and elastic potential energy is stored in the spring. Provided the spring is not inelastically deformed, the work done on the spring and the elastic potential energy stored are equal.

**Students should be able to:**

• describe the difference between a linear and non-linear relationship between force and extension

• calculate a spring constant in linear cases

• interpret data from an investigation of the relationship between force and extension **(see RP)**

• calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation: elastic potential energy = 0.5 × spring constant × extension squared

Ee    = 1/2  k e2

**Key direct and explicit teacher explanations:**

This lesson provides the background theory for the required practical. The sequence of lessons is as follows:

1. Theory lesson – reduces cognitive load during required practical.
2. Practical lesson – the disciplinary knowledge demands for this RP are quite high (see notes for next lesson). Students will be asked to evaluate their data (reliability, reproducibility, precision, accuracy , errors etc).
3. Analysis.

This is quite a demanding lesson as it covers:

1. Elastic / inelastic deformation (which is picked up in the graph for the RP).
2. Why more than one force is required to change shape (refers back to interaction pairs).
3. An equation relating F, k & e.
4. Work done leading to energy transfers from one energy store to others.

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

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**Lesson 6:**

**Objective: To demonstrate understanding of elasticity and the difference between elastic and inelastic deformation. This will inform your required practical for lesson 7.**

**Do It Now**

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

**I wasn’t there, but I still care.**

Write out the formula for calculating work done.

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List three situations where work is done (in a scientific sense).

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**Connect:**

Every day you do work. Describe the work you have done since last evening and the energy store changes that have been made in doing that work. Think of all the appliances that you have also used and the work they have done in transferring energy.

Use key words from the last lesson.

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Forces can stretch things as well as make them move or change direction. When you apply a force to an object you can cause it to BEND, STRETCH or COMPRESS. To do this you need more than one force acting on the object in opposing directions. Otherwise, the object would just move in the direction of the applied force instead of changing its shape.

An object has been ELASTICALLY DEFORMED if it CAN go back to its original shape and length after the force has been removed. We say objects like this are ELASTIC e.g. springs, rubber bands, hair bobbles.

An object has been INELASTICALLY DEFORMED if it CANNOT go back to its original shape and length e.g. old springs, old rubber bands.

Work is done when a force stretches or compresses an object and causes energy to be transferred to the ELASTIC POTENTIAL ENERGY store.

**Extension of a spring.**

**The extension of a spring is directly proportional to the force applied to it. That means as the force or mass increases so does the extension of the spring. Extension is the change in length from the original length to the stretched length with the mass/force applied.**

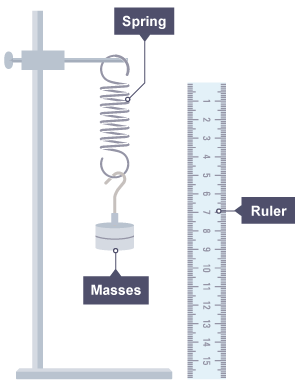
If we support a spring at the top and apply a mass or force at the bottom it will stretch. The extension is directly proportional to the mass or force, and we use this equation,

F = k x e

F = Force (N) k = Spring Constant (N/m) E = Extension (m)

The spring constant depends on the material the spring is made from. A stronger spring has a higher spring constant than a softer spring.

spring constant will vary depending on the material the spring is made from, for example a stiff spring will have a greater spring constant than a softeer spring.

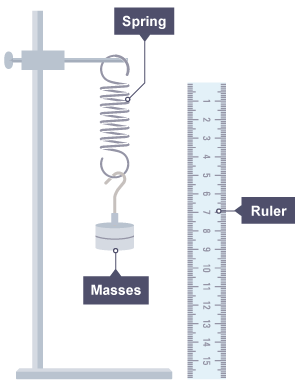


**I do**

A spring is fixed at one end and has a force of 1N applied at the other extends by 2 cm. Calculate the spring constant of this spring.

Remember to convert the units for extension; standard units are metres.

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Convert units to standard units: 2cm / 100 = 0.02m

F = k x e

1 = k x 0.02

1 / 0.02 = k

50 N/m = k

**Hooke’s Law Problems**

***Take g = 10 m/s2 and use F = ke   
(don’t forget Weight (force) = mass x g)***

1. A spring extends by 10 cm when a mass of 100 g is attached to it. What is the spring constant? (Calculate your answer in N/m)

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2. What will be the extension of this spring if the load is a) 4N and b) 75 g?

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3. If an identical spring were connected in parallel (do a sketch), what mass would need to be attached to produce an extension of 15 cm?

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4. What mass would be needed if two of these springs were placed in series (do a sketch) and an extension of 30 cm was required?

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5. Under a 3N force, two identical springs in parallel stretch12.5cm. What is the spring constant for one of these springs?

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**ANSWERS**

**Hooke’s Law Problems**

***Take g = 10 m/s2 and use F = ke***

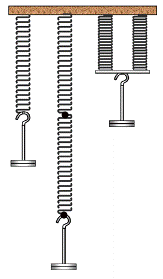
1. A spring extends by 10 cm when a mass of 100 g is attached to it. What is the spring constant? (Calculate your answer in N/m)

Using F = ke hence k = F/e = 1/0.1 = 10 N/m

2. What will be the extension of this spring if the load is a) 4N and b) 75 g?

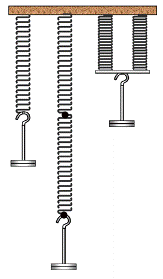
a) e = F/k = 4/10 = 0.4 = 40 cm

b) e = F/k = 0.75/10 = 0.075 = 7.5cm

3. If an identical spring were connected in parallel (do a sketch), what mass would need to be attached to produce an extension of 15 cm?

Double spring becomes twice as strong/stiff so k1 becomes 20 N/m, and gradient in sketch of Load against Extension doubles in value.

Using F = k1 e = 20 x 0.15 = 3N = 300g

4. What mass would be needed if two of these springs were placed in series (do a sketch) and an extension of 30 cm was required?

Gradient in sketch of Load against Extension halves in value, spring now becomes half as strong/stiff so k2 = 5 N/m because   
1/k = 1/kx + 1/ky = 1/10 + 1/10 = 1/5

F = k2 x = 5 x 0.3 = 1.5N = 150g

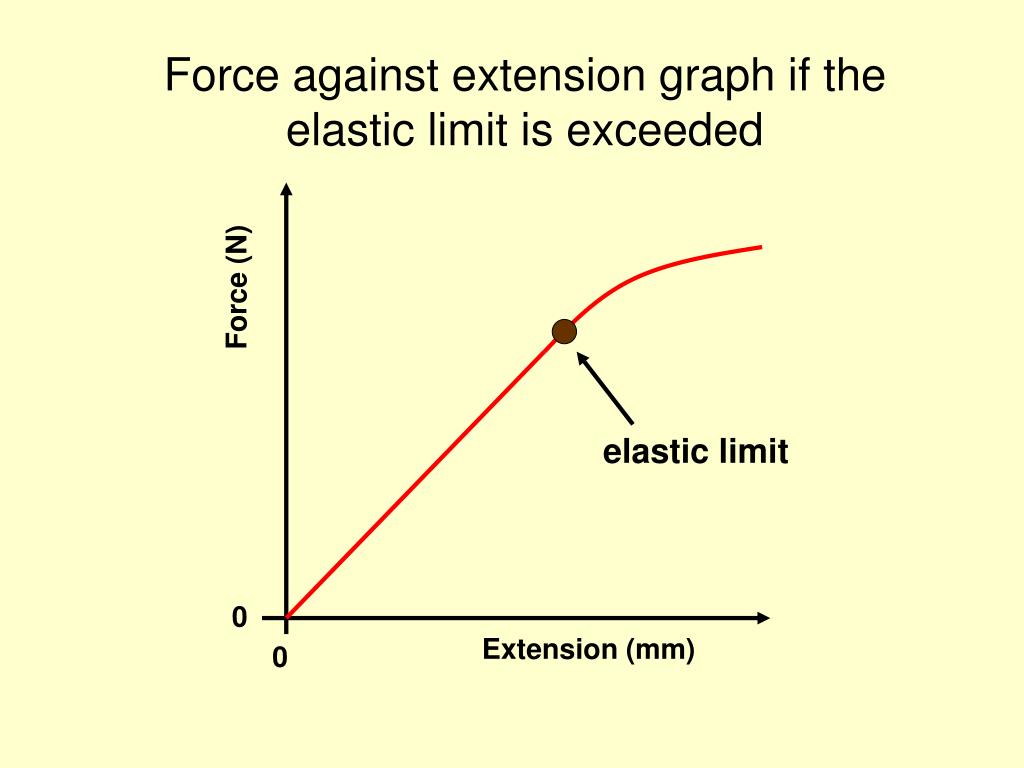
5. Under a 3N force, two identical springs in parallel stretch12.5cm. What is the spring constant for one of these springs?

k= F/e = 3/0.125 = 24

Each spring is half as strong, so k =12

Sometimes though this doesn’t work like this. This happens if the force is too great, and the extension doesn’t increase proportionally. There is a limit to the force you can apply.

The graph is a straight line until the LIMIT of PROPORTIONALITY has been reached and then it begins to curve. Shown by black dot.



Providing a spring is not stretched PAST its LIMIT of PROPORTIONALITY the work done in stretching the spring or compressing it can be found using:

Ee = ½ x k x e2

Elastic Potential Energy (Ee) (Joules)

Spring Constant (k) (N/m)

Extension (e) (m)

This formula can be used to calculate the energy stored in a springs elastic energy store store. It is also the amount of energy transferred to the spring as it deforms or as it returns to its original shape.

YOU DO:

A spring with a constant of 40N/m extends elastically by 2.5 cm. what is the energy store in its Ee store.

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

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**Answers**

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**Lesson 7: Teacher notes**

AQA Content

**Disciplinary knowledge: LESSONS 7 & 8.**

**"RP: Force and extension: Identify IV and DV and how they are measured. Identify CV and how they are controlled.**

**"** **RP: Force and extension: Method from RP Handbook lacks detail so this can be improved.**

**Risk assessment: Hazards, assess risk, control / reduction methods:**

**RP Force & extension: Identify hazard (toppling).**

**"RP Force & extension: Assess risk using standard criteria:**

**1. The way the hazard causes harm.**

**2. Likelyhood of exposure to harm.**

**3. How serious the effects of the hazard would be."**

**RP Force & extension: Identify sensible control or reduction measures and explain their significance.**

**Completing repetitions (accessing repeatability & reproducibility.**

**Sources of error (systematic error if length not extension measured).**

**Evaluating data for: Precision, repeatability, reproducibility, anomalies, systematic and random errors.**

**Identify pattern as directly proportional up to limit of proportionality. Use data to support.**

**Conclusion consistent with data.**

**Judge extent to which conclusion is supported by data / observations.**

**Lesson 7: Investigating Hooke’s Law**

**Objective: You are learning about the relationship between force and the extension of a spring**

**Do It Now**

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

**I wasn’t there, but I still care.**

**Using the equation Work done (J) = Force (N) x distance (m) (W = Fs), calculate:**

1. Calculate the **work done** if:
2. F = 5 N, s = 5 m \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. F = 150 N, s = 0.1 m \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. F = 0.2 N, s = 200 m \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. F = 2000 N, s = 1.5 m \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. F = 800 N, s = 25 m \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Connect**

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1. Which of the above images shows the force-extension graph for a soft spring? How can you tell?

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1. What is meant by the term extension?

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1. Which equation links force (F), extension (e) and spring constant (k)?

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

1. If a spring has a force of 10N applied to it which extends it by 60mm, what is its spring constant?

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

Hooke’s Law:

Hooke’s Law is named English physicist Robert Hooke. He performed a number of experiments on springs and elasticity in the 1600’s and found out that:

‘the extension of an elastic object (like a spring) is directly proportional to the force applied’

(directly proportional means that both variables increase at the same rate i.e. if one doubles, so does the other).

The full definition has a key bit of information on the end, so the full definition reads:

The extension of an elastic object is directly proportional to the force applied, provided that the limit of proportionality is not exceeded’.

**Task 1:**

Investigating Hooke’s Law.

Read the method given below carefully and identify the following:

1. The independent variable: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. The dependent variable:

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

1. Control variables:

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

**Method:**

1. Hang the spring on a clamp and add a splint so it’s easier to read the length.
2. Making sure the splint is horizontal, take a reading on the ruler – this is the length of the unstretched spring (at Weight = 0.0 N)
3. Carefully hook the 100g mass hanger onto the bottom of the spring. This weighs 1.0 newton (1.0 N).
4. Take a reading of the length of the spring.
5. Add further masses. Measure and record the length of the spring each time. Get at least 8 results.
6. Calculate the extension i.e. the amount the string has stretched. To calculate this you subtract the length of the unstretched spring from each of your length readings.

The spring used.

Temperature of the spring.

Extension of the spring.

Weight applied to the spring.

**The method given below is quite good because it includes all of the key steps in a logical order. However, it could be improved because it lacks some detail. This means that it would be hard for another person to reproduce the experiment without asking further questions.**

**On the lines under each step, include additional detail that would be useful for the experimenter.**

**Method:**

1. Hang the spring on a clamp and add a splint so it’s easier to read the length.

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

1. Making sure the splint is horizontal, take a reading on the ruler – this is the length of the unstretched spring (at weight = 0.0 N).

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

1. Carefully hook the 100g mass hanger onto the bottom of the spring. This weighs 1.0 newton (1.0 N).

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

1. Take a reading of the length of the spring.

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

1. Add further masses. Measure and record the length of the spring each time. Get at least 8 results.

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

1. Calculate the extension i.e. the amount the string has stretched. To calculate this you subtract the length of the unstretched spring from each of your length readings.

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

Resolution should be stated.

Resolution should be stated. E.g. to nearest millimetre.

Range and intervals should be specified. Failure to do so means it may not be possible to assess reproducibility.

The spring will oscillate. The experimenter needs to know to wait until this stops before moving to the next step. Failure to do so introduces a random error.

The position of the ruler has not been defined – presumably it has to be attached vertically to the clamp alongside the spring. This has the potential to introduce systematic errors.

The splint should be added to the bottom of the spring. Other positions introduce systematic errors.

A picture containing diagram, sketch, skeleton, design

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|  |  |  |
| --- | --- | --- |
| Hazard | Risk | Control/reduction measure |
|  |  |  |
|  |  |  |

Wear goggles.

Use new or well-maintained springs (e.g. not rusty springs).

Potential for puncture wounds.

Unlikely to happen with new springs.

Effects are serious.

The steel springs can snap.

Stabilise by adding masses to the base of the stand, or secure in place with a clamp.

May land on feet etc.

Likely when higher masses used.

Likely soft tissue damage. Potential for fractures.

The stand can topple over.

Use the diagram to the left to identify the main hazards in this experiment. Then complete the table below.

When assessing risk, consider the following criteria:

* **1. The way the hazard causes harm.**
* **2. Likelihood of exposure to harm.**
* **3. How serious the effects of the hazard would be.**

Recording results: You will need to do each reading at least twice. This is so you can evaluate your data for reproducibility.

Use the following results table to record your results:

**Trial 1:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mass (kg) | Force (N) | Length (mm) | Extension (mm) | Extension (m) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Trial 2:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mass (kg) | Force (N) | Length (mm) | Extension (mm) | Extension (m) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Trial 3:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mass (kg) | Force (N) | Length (mm) | Extension (mm) | Extension (m) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

For each weight (force) added to the spring:

1. Identify anomalies by circling them.
2. Calculate the mean extension (remember to remove anomalies before calculating the mean).
3. Obtain mean data from another group.

|  |  |  |
| --- | --- | --- |
| Force (N) | Own data: Mean extension (m) | Data from another group: Mean extension (m) |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

**Evaluating the quality of the data**

1. **Repeatability:** Look at the trials that you did for this experiment.
2. Are the data repeatable? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How do you know this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. **Reproducibility:** Compare your mean data to that from the other group.
2. Are the data reproducible? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How do you know this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. **Precision:** Compare the data for your trials to the mean value.
2. Are the data precise? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How do you know this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. **Accuracy:** Compare the data from your trials to the mean.
2. Are the data accurate? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How do you know this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. **Anomalies:** Look at your individual trials for each weight used.
2. Did you have any anomalies? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. If you had anomalies, what errors occurred during the experiments that could cause anomalies? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**By referring to your answers to the questions above, decide whether your data are of high quality.**

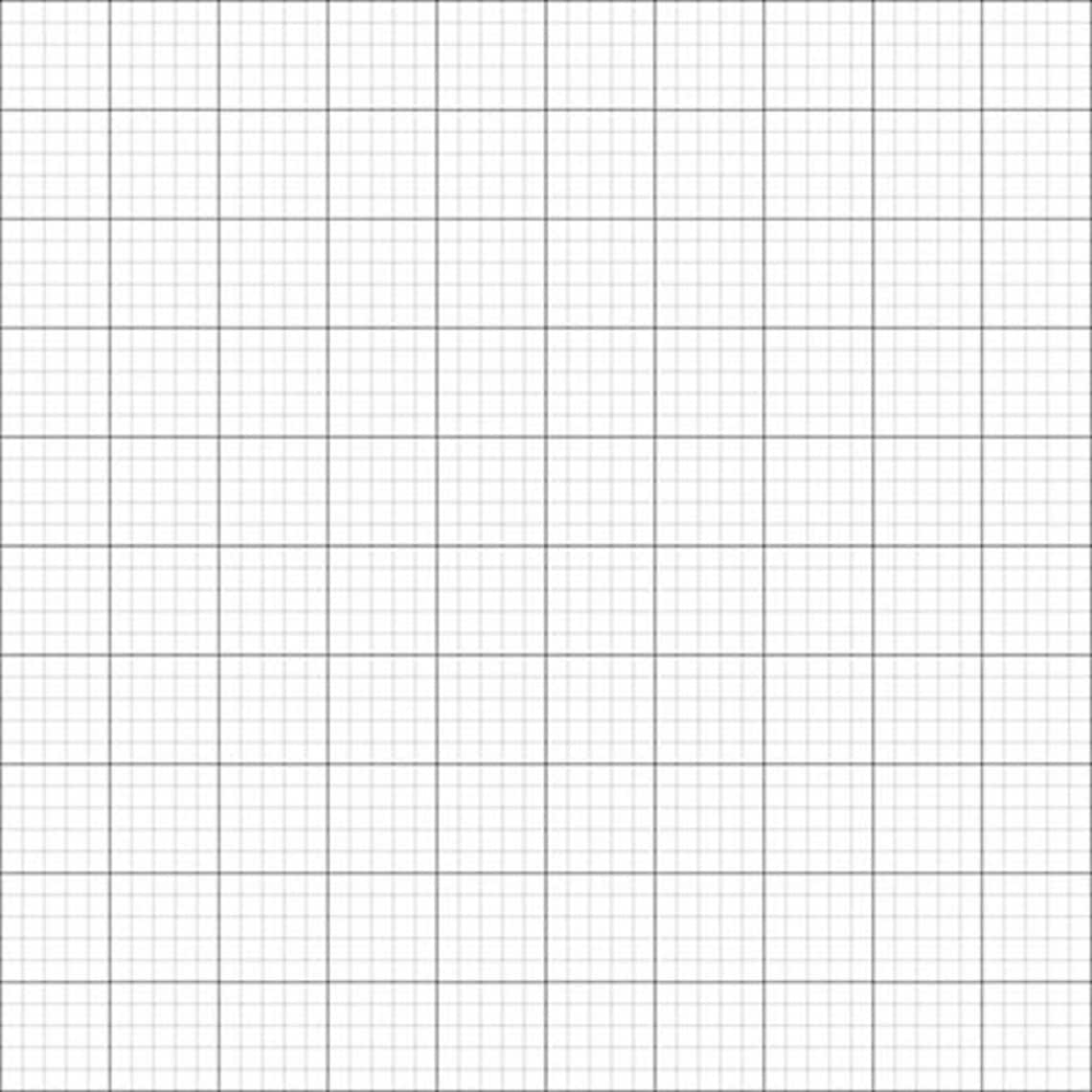
Are your data of high quality? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Give at least three pieces of evidence that support your answer:

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Plot your data on the graph paper below.**

* Force (weight) goes on the y-axis.
* Extension goes on the x-axis.
* You obtain the spring constant by calculating the gradient of the linear part of the graph.



**Lesson 8: Teacher notes**

**Conclusion:**

Describe the relationship between the independent and dependent variable.

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Use data from the graph to support your conclusion.

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AQA Content

**See lesson 7.**

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

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**Lesson 8: Analysing Required Practical**

**Objective: You are learning how to interpret Hooke’s Law data and use associated equations**

**Do It Now**

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

**I wasn’t there, but I still care.**

**Last lesson was a required practical. Process the example results below:**

**A picture containing black, darkness

Description automatically generated**

**Connect**

Last lesson you completed the required practical to investigate Hooke’s law

1. Define Hooke’s Law:

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

1. What is the equation that links force (F), extension (e) and spring constant (k)?

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1. In what form is the energy stored in an extended or compressed spring?

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

1. What equation could be used to calculate the value of this energy store?

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

1. What were the variables in your investigation:

Independent:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Dependent:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Controls (x2):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

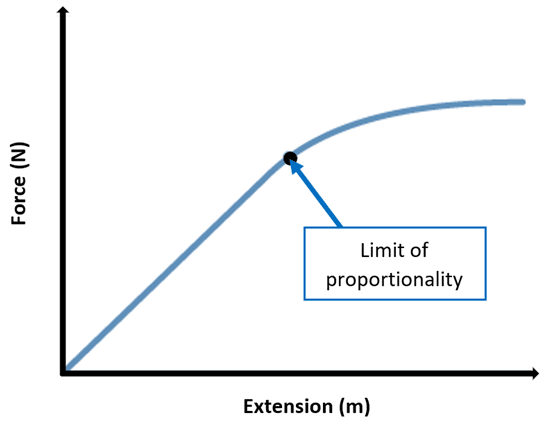
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_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

1. Your investigation may have included sources of error. Where would these errors have come from?

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**Interpreting Hooke’s Law:**

You graph may have looked like the following:



Hooke’s Law states that force and extension are directly proportional until the limit of proportionality is exceeded. You may be able to identify the limit of proportionality in your data. Look for when your spring constant value differs from your other values. Once a spring passes its limit of proportionality it becomes **elastically deformed**. This means that it will no longer return to its original shape and its original shape has been changed.

Applied forces change the shape of an elastic object. This is either through extension or compression. As such, when an elastic object, like a spring, is extended or compressed, work is done. The stretched or compressed elastic object stores elastic potential energy.

**Calculations using Hooke’s Law:**

Hooke’s Law uses the following formula:

Force (N) = Spring constant (N/m) x extension (m)

And is abbreviated to:

F = ke

I do:

If the spring constant is 30 N/m and a spring is stretched by 0.3m, how much force has been applied?

1. Write out the equation: F = k x e
2. Fill in the data: F = 30 x 0.3
3. Complete calculation: F = 9
4. Add units: F = **9N**

We do:

If the spring constant is 12.6 N/m and a spring is stretched by 0.25m, how much force has been applied?

1. Write out the equation: F = k x e
2. Fill in the data: F = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Complete the calculation: F = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Add units: F = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

You do:

What force would be needed to extend a spring with a spring constant k = 10 N/m by an extension of 0.3 m?

1. Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Fill in the data: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Complete the calculation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Add units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

F = k x e

F = 10 x 0.3

F = 3

F = 3J

The calculation can be rearranged to make either spring constant or extension the subject:

Spring constant =

Extension =

Complete:

Calculate the spring constant if:

1. F = 150 N, e = 0.075 m.
2. Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Fill in the data: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Complete the calculation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Add units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. F = 50 N, e = 0.1 m.
7. Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. Fill in the data: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. Complete the calculation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Add units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Calculate the extension if:

1. F = 15 N, k = 150 N/m.
2. Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Fill in the data: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Complete the calculation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Add units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. F = 45 N, k = 90 N/m.
7. Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. Fill in the data: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. Complete the calculation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Add units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

k = F ÷ e

k = 150 ÷ 0.075

k = 2000

k = 2000N/m

e = F ÷ k

e = 45 ÷ 90

e = 0.5

e = 0.5m

e = F ÷ k

e = 15 ÷ 150

e = 0.1

e = 0.1m

k = F ÷ e

k = 50 ÷ 0.1

k = 150

k = 150N/m

k = F ÷ e

e = F ÷ k

0.5 x 450 x 0.132

0.5 x 450 x 0.0169

3.80

3.80JJ

The energy stored by elastic objects can also be calculated. You first met this equation in the energy unit:

Elastic energy (J) = ½ x spring constant (N/m) x extension2 (m)

Ee = ½ke2

**I do:**

Spring constant k = 5 N/m, spring extension e = 0.1 m.

1. Write out the equation: Ee = ½ x k x e2
2. Fill in the data: Ee = 0.5 x 5 x 0.12
3. Square e: Ee = 0.5 x 5 x 0.01
4. Complete calculation: Ee =0.025
5. Add units: Ee = 0.025J

**You do:**

Spring constant k = 20 N/m, spring extension e = 0.15 m.

1. Write out the equation: Ee = ½ x k x e2
2. Fill in the data: Ee =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Square e: Ee =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Complete calculation: Ee =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Add units: Ee = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Complete:**

A spring with k = 450 N/m is compressed by 0.13m. How much **energy** is stored?

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

0.5 x 20 x 0.152

0.5 x 20 x 0.0225

0.225

0.225J

Multistep equations (HT)

There is the expectation that you can complete a multistep equation using both F=ke and Ee = ½ke2 to calculate the energy contained in a stretched or compressed elastic object using experimental data.

An example:

A spring is extended by 0.2m when a force of 20N is applied. How much energy is stored by the spring?

To determine the energy value, we need to use Ee = ½ke2, however the question does not include a value for k (spring constant). This means we first have to calculate spring constant using F = ke, and then calculate energy stored using Ee = ½ke2:

1. Write out equation: k = F ÷ e
2. Fill in the data: k = 20 ÷ 0.2
3. Complete calculation: k = 100N/m

Now we can calculate elastic energy stored:

1. Write out equation: Ee = ½ x k x e2
2. Fill in the data: Ee = 0.5 x 100 x 0.22
3. Square e: Ee = 0.5 x 100 x 0.04
4. Complete calculation: Ee = 2J

Multistep equations SLOP

A spring has a weight of 50N hanging on it, and is stretched from a length of 0.05m to a length of 0.15 m. How much energy is stored by the spring?

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A spring has a weight of 20N hanging on it, and is stretched from a length of 0.20m to a length of 0.45m. How much energy is stored by the spring?

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k = F ÷ e

k = 50 ÷ 0.10

k = 500N/m

Ee = ½ x k x e2

Ee = 0.5 x 500 x 0.102

Ee = 0.5 x 500 x 0.01

Ee = 2.5J

k = F ÷ e

k = 20 ÷ 0.25

k = 80N/m

Ee = ½ x k x e2

Ee = 0.5 x 80 x 0.252

Ee = 0.5 x 80 x 0.0625

Ee = 2.5J

**Q1.**

A student investigated how the extension of a spring varied with the force acting on the spring.

The diagram below shows the equipment the student used and a ruler scale between 10 cm and 15 cm

A diagram of a measuring device

Description automatically generated with low confidence

(a)     Describe how the student should determine the extension of the spring.

A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(b)     Write down the equation which links extension (*e*), force (*F*) and spring constant (*k*).

A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(c)     The extension of the spring was 0.12 m when the force was 3.0 N

Calculate the spring constant of the spring.

A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Spring constant = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N/m

**(3)**

(d)     Determine the energy stored by the spring using your calculation from (c)

Use the Physics Equations Sheet.

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

A screenshot of a computer

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Energy stored = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ J

**(3)**

**(Total 9 marks)**

**Extra exam practice**

A student investigated the behaviour of springs. She had a box of identical springs.

(a)     When a force acts on a spring, the shape of the spring changes.

The student suspended a spring from a rod by one of its loops. A force was applied to the spring by suspending a mass from it.

**Figure 1** shows a spring before and after a mass had been suspended from it.

**Figure 1**

|  |  |  |
| --- | --- | --- |
| **Before** |  | **After** |

**A picture containing design

Description automatically generated with low confidence**

(i)      State **two** ways in which the shape of the spring has changed.

A screenshot of a computer

Description automatically generated1. \_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(ii)     No other masses were provided.

Explain how the student could test if the spring was behaving elastically.

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

A screenshot of a computer

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**(2)**

(b)     In a second investigation, a student took a set of measurements of force and extension.

Her results are shown in **Table 1** .

**Table 1**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Force in newtons** | 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 |
| **Extension in cm** | 0.0 | 4.0 |  | 12.0 | 16.0 | 22.0 | 31.0 |

(i)      Add the missing value to **Table 1**.

Explain why you chose this value.

\_\_\_\_\_\_\_\_\_ A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(ii)     During this investigation the spring exceeded its limit of proportionality.

Suggest a value of force at which this happened.

Give a reason for your answer.

Force = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

Reason \_\_\_\_\_\_\_ A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     In a third investigation the student:

•        suspended a 100 g mass from a spring

•        pulled the mass down as shown in **Figure 2**

•        released the mass so that it oscillated up and down

•        measured the time for 10 complete oscillations of the mass

•        repeated for masses of 200 g, 300 g and 400 g.

**Figure 2**

**A picture containing sketch, crane

Description automatically generated**

Her results are shown in **Table 2**.

**Table 2**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Time for 10 complete oscillations in seconds** | | | |
| **Mass in g** | **Test 1** | **Test 2** | **Test 3** | **Mean** |
| 100 | 4.34 | 5.20 | 4.32 | 4.6 |
| 200 | 5.93 | 5.99 | 5.86 | 5.9 |
| 300 | 7.01 | 7.12 | 7.08 | 7.1 |
| 400 | 8.23 | 8.22 | 8.25 | 8.2 |

(i)      Before the mass is released, the spring stores energy.

What type of energy does the spring store?

Tick () **one** box.

|  |  |
| --- | --- |
|  | **Tick ()** |
| Elastic potential energy | ü |
| Gravitational potential energy |  |
| Kinetic energy |  |

**(1)**

(ii)     The value of time for the 100 g mass in **Test 2** is anomalous.

Suggest **two** likely causes of this anomalous result.

Tick () **two** boxes.

|  |  |
| --- | --- |
|  | **Tick ()** |
| Misread stopwatch | ü |
| Pulled the mass down too far |  |
| Timed half oscillations, not complete oscillations |  |
| Timed too few complete oscillations |  |
| Timed too many complete oscillations | ü |

**(2)**

(iii)    Calculate the correct mean value of time for the 100 g mass in **Table 2**.

\_\_\_\_\_\_\_ A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Mean value = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ s

**(1)**

(iv)    Although the raw data in **Table 2** is given to 3 significant figures, the mean values are correctly given to 2 significant figures.

Suggest why.

\_\_\_\_\_\_\_\_\_\_ A screenshot of a computer

Description automatically generated\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(v)     The student wanted to plot her results on a graph. She thought that four sets of results were not enough.

What extra equipment would she need to get more results?

\_\_\_\_\_\_\_\_\_ A screenshot of a computer

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**(2)**

**(Total 17 marks)**

**Lesson 9: Teacher notes**

AQA Content

A force or a system of forces may cause an object to rotate.

**Students should be able to** describe examples in which forces cause rotation.

The turning effect of a force is called the moment of the force. The size of the moment is defined by the equation:

moment o f a force = force × distance

M   =  F d moment of a force, M, in newton-metres, Nm force, F, in newtons, N distance, d, is the perpendicular distance from the pivot to the line of action of the force, in metres, m.

If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot.

**Students should be able to** calculate the size of a force, or its distance from a pivot, acting on an object that is balanced.

A simple lever and a simple gear system can both be used to transmit the rotational effects of forces.

**Students should be able to** explain how levers and gears transmit the rotational effects of forces.

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

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

**Objective: Today we are learning about moments (rotational effects of forces), and how they relate to gears and levers.**

**Do It Now**

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

**If too much force is added, the spring will stretch more than predicted, as it has gone beyond its limit of proportionality**

**Directly proportional**

**As the force increases, the extension of the spring will also increase.**

**I wasn’t there, but I still care.**

**The last lesson involved the analysis of results from the Hooke’s law required practical. Use the AQA Physics textbook (page 158-159) to answer the following questions:**

1. **What happens to the extension of a spring as more force is added?**

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1. **What is the relationship between force and extension?**

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1. **What eventually happens to a spring if too much force is added? Why does this happen?**

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**Connect**

You have looked at moments previously in the **KS3 Work** topic. You have seen that a moment is: “the turning effect of a force around a fixed point or axis”.

1. The size of a moment depends on two factors. What are these two factors? State the units they are measured in.

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

1. Recall the equation that connects moments with the two factors stated above.

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

1. In terms of forces, how does a lever make work easier?

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**A lever makes work easier by reducing the force needed to complete the same amount of work.**

**Size of the force – Newtons (N)**

**Distance from the pivot – Metres (m)**

**Modelling progress**

A moment is the turning effect of a force around a fixed point or axis. It is defined by the equation below:

This means that increasing either the size of the force or the perpendicular distance of that force from the pivot will increase the moment.

**I DO**

Calculate the moment when a force of 300 N is applied to a seesaw, 0.5 m from the pivot.

STEP 1: Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 2: Substitute in the values: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 3: Calculate the answer with units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**WE DO**

Calculate the moment on a door when it is closed with a force of 25 N. The door handle is 1.5 m away from the hinges.

STEP 1: Write out the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 2: Substitute in the values: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 3: Calculate the answer with units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Moment = force x distance**

**Moment = 25 x 1.5**

**Moment = 37.5 Nm**

**Moment = force x distance**

**Moment = 300 x 0.5**

**Moment = 150 Nm**

**YOU DO** (task 1)

1. Calculate the moment in each of the following cases:
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Moment = force x distance**

**Moment = 20 x 0.07**

**Moment = 1.4 Nm**

**Moment = force x distance**

**Moment = 20 x 0.08**

**Moment = 1.6 Nm**

**Moment = force x distance**

**Moment = 240 x 1.5**

**Moment = 360 Nm**

**Moment = force x distance**

**Moment = 650 x 0.85**

**Moment = 722.5 Nm**

1. Rearrange the equation to calculate:
   1. The size of the force when a moment of 250 Nm is produced 12.5 m from the pivot.

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

* 1. The perpendicular distance from the pivot when a moment of 76 Nm is produced from a 12 N force.

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

1. Multiple moments can act on the same object, in different directions.
   1. Calculate both the clockwise and counter-clockwise moments on the see-saw below:

Clockwise moment: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Counter-clockwise moment: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* 1. Would this see-saw balance? Explain your answer.

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

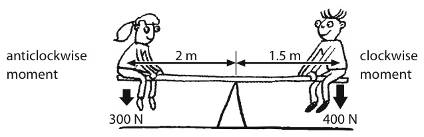
**The see-saw would balance because the clockwise and counter-clockwise moments are the same (even though the forces are different.**

**Moment = 300 x 2**

**Moment = 600 Nm**

**Moment = 400 x 1.5**

**Moment = 600 Nm**



**Clockwise moment**

**Counter-clockwise moment**

**Moment = force x distance**

**76 = 12 x d à d = 76/12**

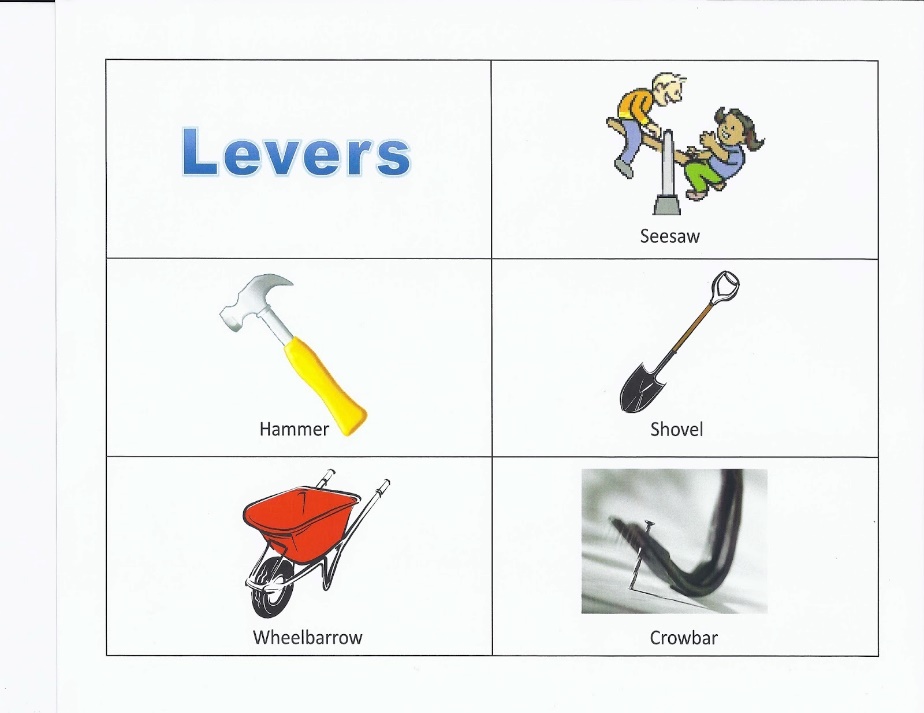
**Distance = 6.33 m**

**Moment = force x distance**

**250 = F x 12.5 à F = 250 / 12.5**

**Force = 20 N**

**A close-up of a gear

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**Modelling progress**

Levers and gears transmit the rotational effects of forces (moments). This means they reduce the amount of **work** we need to do when turning objects. By reducing the amount of work needed to turn objects, less **force** is needed to turn objects.

**Gears**

**Examples of levers:**

**YOU DO** (task 2) – Complete these exam questions relating to levers:

**Q1.** The diagram shows a crane which is loading containers onto a ship.

A drawing of a crane and boxes

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(a)     Calculate the moment of the container which is being loaded.

Show clearly how you work out your answer and give the unit.

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

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

Moment of the container = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(3)**

(b)     Suggest and explain the purpose of the large concrete blocks.

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

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**(3)**

**(Total 6 marks)**

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**Q2.**

(a)     **Figure 1** shows a girl standing on a diving board.

**Figure 1**

**A diagram of a swimmer

Description automatically generated with low confidence**

Calculate the total clockwise moment of the weight of the diving board and the weight of the girl about Point **A**. Give the unit.

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

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Total clockwise moment about Point **A** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(4)**

(b)     **Figure 2** shows the girl standing at a different place on the diving board.

The support provides an upward force **F** to keep the diving board balanced.

**Figure 2**

**A diagram of a person diving

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**Figure 3** shows how the upward force **F** varies with the distance of the girl from Point **A**.

**Figure 3**

**A picture containing line, receipt, plot, diagram

Description automatically generated**                Distance of girl from Point **A** in metres

Explain, in terms of clockwise and anticlockwise moments, why the upward force **F** increases as shown in **Figure 3**.

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**(3)**

**(Total 7 marks)**

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**Lesson 10: Teacher notes**

AQA Content

The pressure due to a column of liquid can be calculated using the equation:

Pressure = height of the column × density of the liquid × gravitational field strength

[ p = h ρ g ] pressure, p, in pascals, Pa height of the column, h, in metres, m density, ρ, in kilograms per metre cubed, kg/m3 gravitational field strength, g, in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength (g) will be given.)

**Students should be able to** explain why, in a liquid, pressure at a point increases with the height of the column of liquid above that point and with the density of the liquid.

**Students should be able to** calculate the differences in pressure at different depths in a liquid.

A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards. This force is called the upthrust.

**Students should be able to** describe the factors which influence floating and sinking.

**Key direct and explicit teacher explanations:**

Fluids are substances that **flow.**  Liquids and gases are both fluids.​

​

When there is a pressure in a fluid a force is produced at right angles to the **surface containing the fluid.**​

A diagram of a glass with a rectangular object in it

Description automatically generated with low confidence

The size of the force acting at the surface of a fluid can be calculated using the equation:​

Pressure (Pa) = Force normal to a surface (N)​

                               Area of that surface (m²)​

p = 𝑭/𝑨​

The pressure in a liquid is different at different depths. **Pressure increases as the depth increases**. The pressure in a liquid is due to the weight of the column of water above. Since the particles in a liquid are tightly packed, this pressure acts in all directions. For example, the pressure acting on a dam at the bottom of a reservoir is greater than the pressure acting near the top. This is why dam walls are usually wedge-shaped.

A picture containing text, design

Description automatically generated

**Key direct and explicit teacher explanations:**

Explain why the water at the bottom of the bottle travels further than the water at the top of the bottle?​

A picture containing text, diagram, screenshot, line

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As you go down a column of water the pressure at the bottom of the column is greater than the pressure at the top of the column.  There is more weight of water above you if you are at the bottom of the column.  ​

​

The pressure at a certain depth in a liquid depends on the height of liquid above the base (h), the density of a liquid (⍴) and the gravitational field strength (g)​

The pressure caused by a column of liquid can be calculated using the equation: ​

​

**pressure = height of column × density of the liquid × gravitational field strength**​

**p =**h⍴g​

This is when:  pressure (p) is measured in pascals (Pa)​

                   height of column (h) is measured in metres (m)​

                   density (ρ) is measured in kilograms per metre cubed (kg/m3)                                    ​

                  gravitational field strength (g) is measured in newtons per kilogram (N/kg)​

A floating object experiences a greater pressure on the bottom surface than on the top of the surface.  This creates a resultant force upwards.  This force is called **upthrust.**​

When solid objects are placed in water they will float or sink depending on the density of the solid material compared to the density of the water.  ​

​

If the object is denser than water, it will sink.  This is because the weight is greater than upthrust.​

If the object is less dense than water, it will float because the upthrust is greater than weight.​

​

Submarines can adjust the depth they float at by adding or removing water from ballast tanks.  Scuba divers use air in a jacket to control their depth.  Fish have swim bladders which serve a similar purpose.

**Key direct and explicit teacher explanations:**

Answers to calculations:

Connect

**I Do**: p=f/a p=12/0.02 p=600Pa

**We Do**: p=f/a p=1250/0.5 p=2500Pa 2.5kPa

**You Do**: p=f/a p=18/0.015 p=1200Pa 1.2kPa

p=hpg p=50x1030x9.8 p=504700Pa 504.7kPa

1. P=0.1x1000x9.8 p=980Pa
2. p=hpg 267800 = h x 1030 x 9.8

267800/(1030x9.8) = 26.53m

1. Pressure would increase, greater pressure on the outside of the can than the inside, can would implode
2. Air is introduced to ballast tanks, reducing the pressure and density inside the tank. Pressure inside is less than the pressure of the water as the particles in a gas are further apart so the submarine rises.
3. P= (60+15) x 1100 x 9.8 p=75 x 1100 x 9.8 p=808500Pa p=808.5kPa

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

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**Lesson 10: Pressure in Fluids**

**Objective: I can explain what happens to the pressure in a liquid the deeper you go into the liquid and calculate pressure at different depths.**

**Do It Now**

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

**I wasn’t there, but I still care.**

A force or system of forces may cause an object to turn. A **moment** is the turning effect of a force. Moments act about a point in a clockwise or anticlockwise direction. ​

The point chosen could be any point on the object, but the pivot - also known as the fulcrum - is usually chosen.

The **magnitude (size)** of a moment can be calculated using the equation:​

​

**moment of a force = force × distance**​

​

**M =**Fxd​

​

This is when:​

moment (M) is measured in newton-metres (Nm)​

force (F) is measured in newtons (N)​

distance (d) is measured in metres (m)​

1. A force of 15 N is applied to a door handle, 12 cm from the pivot. Calculate the moment of the force.

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1. A force of 40 N is applied to a spanner to turn a nut. The perpendicular distance is 30 cm. Calculate the moment of the force.

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A picture containing text, screenshot, design

Description automatically generated

**Connect**

Fluids are substances that **flow.**  Liquids and gases are both fluids.​

​

When there is a pressure in a fluid a force is produced at right angles to the **surface containing the fluid.**​

A diagram of a glass with a rectangular object in it

Description automatically generated with low confidence

The size of the force acting at the surface of a fluid can be calculated using the equation:​

Pressure (Pa) = Force normal to a surface (N)​

                               Area of that surface (m²)​

p = 𝑭/𝑨​

**I Do**

Work out the pressure in a fluid when the fluid applies a force of 12 N on a surface of area 0.02 m². \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**We Do**

In a bath full of water a force of 1250 N acts on an area of 0.5m²at the bottom of the bath.  Calculate the pressure acting on the bottom of the bath.

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**You Do**

A force of 18 N acts on a surface that has an area of 0.015 m².  Work out the pressure acting on the surface.

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**Higher**

The pressure in a liquid is different at different depths. **Pressure increases as the depth increases**. The pressure in a liquid is due to the weight of the column of water above. Since the particles in a liquid are tightly packed, this pressure acts in all directions. For example, the pressure acting on a dam at the bottom of a reservoir is greater than the pressure acting near the top. This is why dam walls are usually wedge-shaped.

A picture containing text, design

Description automatically generated

Watch this Demonstration.

Explain why the water at the bottom of the bottle travels further than the water at the top of the bottle?​

In your answer use the words:​

Speed​

Pressure​

particles​

A picture containing bottle, plastic, indoor, container

Description automatically generated

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As you go down a column of water the pressure at the bottom of the column is greater than the pressure at the top of the column.  There is more weight of water above you if you are at the bottom of the column.  ​

​

The pressure at a certain depth in a liquid depends on the height of liquid above the base (h), the density of a liquid (⍴) and the gravitational field strength (g)​

The pressure caused by a column of liquid can be calculated using the equation: ​

​

**pressure = height of column × density of the liquid × gravitational field strength**​

**p =**h⍴g​

This is when:  pressure (p) is measured in pascals (Pa)​

                   height of column (h) is measured in metres (m)​

                   density (ρ) is measured in kilograms per metre cubed (kg/m3)                                    ​

                  gravitational field strength (g) is measured in newtons per kilogram (N/kg)​

The top of a submarine is 50 m underwater.  The density of seawater is 1030 kg/m³.

Work out the pressure on the top of the submarine.  Take g = 9.8 N/kg.

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A floating object experiences a greater pressure on the bottom surface than on the top of the surface.  This creates a resultant force upwards.  This force is called **upthrust.**​

When solid objects are placed in water they will float or sink depending on the density of the solid material compared to the density of the water.  ​

​

If the object is denser than water, it will sink.  This is because the weight is greater than upthrust.​

If the object is less dense than water, it will float because the upthrust is greater than weight.​

​

Submarines can adjust the depth they float at by adding or removing water from ballast tanks.  Scuba divers use air in a jacket to control their depth.  Fish have swim bladders which serve a similar purpose.

1. A beaker is filled to a depth of 10 cm with water.  Water has a density of 1000 kg/m3.  Calculate the pressure acting at the bottom of the beaker.

Take g = 9.8 N/kg.​

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1. A scuba diver is diving in the sea.  The pressure acting on the scuba diver is 267 800 Pa. Salt water has a density of 1030 kg/m3.  Calculate the depth of the scuba diver.​

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1. Imagine taking a sealed tin can on a dive.  As you take it down deeper what​

would happen to the pressure, and the can, if you take it deep enough?​

​

​\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4.  Explain how a submarine can move up and down in the water.  Use the​ following keywords:  density, weight, pressure, particles, upthrust.

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5. Calculate the upthrust on a submarine that has a height of 15 m and is submerged at a depth of 60 m (to the top of the submarine).  The submarine has a surface area of 100 m² on the top and on the bottom of the submarine.  ​

​

Take the density of sea water to be 1100 kg/m³ and the gravitational field strength of the Earth to be 9.8 N/kg.

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**Lesson 11: Teacher notes**

AQA Content

A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface. The pressure at the surface of a fluid can be calculated using the equation:

pressure = force normal to a surface area of that surface

p = F A

pressure, p, in pascals, Pa force, F, in newtons, N area, A, in metres squared, m2

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

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

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

**Objective: Today we will be learning that pressure in fluids causes a force normal to any surface, and how to calculate this pressure.**

**Do It Now**

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

**I wasn’t there, but I still care.**

**Last lesson we learned about pressure in fluids, how to calculate it, and the effect of column height and density on pressure. Use the AQA Physics text book (page164-165) to answer the following questions.**

1. What happens to the pressure in a liquid as the liquid depth increases?

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

1. Describe the pressure along a horizontal line in a liquid.

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1. Describe the relationship between density and pressure in a liquid.

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

**The greater the density of a liquid, the greater the pressure in that liquid.**

**The pressure along a horizontal line in a liquid is constant**

**As depth increases, pressure also increases**

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**Connect**

We have looked at pressure in fluids previously in this topic.

You will have learned how to calculate area in maths.

Answer the following questions:

1. What equation is used to calculate the pressure due to a column of liquid?

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

1. How would you calculate the surface area of a square/rectangle?

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

1. What is a “right-angle”?

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

1. Calculate the area of the surfaces below:
2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

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

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

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

**Area = length x width**

**Area = 6.7 x 0.87**

**Area = 5.829 m2**

**Area = length x width**

**Area = 1.6 x 1.6**

**Area = 2.56 m2**

**An angle that is exactly 90o**

**Surface area = length x width**

**Pressure = height x density x gravitational field strength**

**Modelling progress**

In science, fluids can be considered to be either **liquids** or **gases**. When a fluid causes pressure on a surface, this pressure is normal (at a right angle/90o) to that surface. We can calculate the pressure on a surface by using the following equation:

Pressure on a surface à Pascals (Pa)

Force à Newtons (N)

Surface area à Metres squared (m2)

**I DO**

Calculate the pressure on a surface when 500 N of force is applied against a surface with an area of 12.5 m2.

STEP 1: Write down the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 2: Substitute in the values: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 3: Calculate the answer with units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**WE DO**

Calculate the pressure on a surface when 160 N of force is applied against a surface with an area of 2.6 m2.

STEP 1: Write down the equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 2: Substitute in the values: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

STEP 3: Calculate the answer with units: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Pressure = force x surface area**

**Pressure – 160 x 2.6**

**Pressure = 416 Pa**

**Pressure = force x surface area**

**Pressure – 500 x 12.5**

**Pressure = 6250 Pa**

**YOU DO** (task 1)

Calculate the pressure on the following surfaces. Calculate the surface area if needed using the equation: surface area = length x width.

1. A force of 230 N is applied to this surface:

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

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

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

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

1. A force of 112 N is applied to this surface:

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

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

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

1. A force of 75 N is applied to this surface:

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

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

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

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

1. A force of 96.7 N is applied to this surface:

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

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

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**Surface area = 0.6 x 0.8 = 0.48**

**Pressure = force x surface area**

**Pressure – 96.7 x 0.48**

**Pressure = 46.416 Pa**

**Surface area = 1.2 x 2.1 = 2.52**

**Pressure = force x surface area**

**Pressure – 75 x 2.52**

**Pressure = 189 Pa**

**Pressure = force x surface area**

**Pressure – 112 x 3.32**

**Pressure = 371.84 Pa**

**Pressure = force x surface area**

**Pressure – 230 x 6.5**

**Pressure = 1495 Pa**

Rearrange the equation to calculate the size of the force in the following questions:

1. A pressure of 680 Pa against a surface with an area of 6.5 m2.

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

1. A pressure of 45.6 Pa against a surface with an area of 1.5 m2.

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

1. A pressure of 6.5 kPa against a surface with an area of 30 m2.

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

1. A pressure of 0.9 kPa against a surface with an area of 2.2 m2.

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

**Pressure = force x surface area**

**900 = F x 2.2 à F = 900 / 2.2**

**Force = 409.1 N**

**Pressure = force x surface area**

**6500 = F x 30 à F = 6500 / 30**

**Force = 216.7 N**

**Pressure = force x surface area**

**45.6 = F x 1.5 à F = 45.6 / 1.5**

**Force = 30.4 N**

**Pressure = force x surface area**

**680 = F x 6.5 à F = 680 / 6.5**

**Force = 104.6 N**

**YOU DO** (task 2) – Complete these exam questions relating to pressure at right angles:

**Q1.** Mountain bike riders use brakes to slow down.

A person riding a bike on a rocky hill

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© Ljupco Smokovski/Shutterstock

Some mountain bikes use liquid-filled pipes to transmit the force from the rider’s hand on the brake lever to the brake pads. These brakes are called hydraulic brakes.

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(a)     Draw a ring around the correct answer to complete each sentence.

(i)      Liquids can be used to transmit the forces in a brake system,

|  |  |
| --- | --- |
|  | are incompressible. |
| because liquids | can flow. |
|  | take the shape of the container. |

**(1)**

(ii)

|  |  |
| --- | --- |
|  | against force **F** only. |
| The pressure in the liquid is transmitted | downwards only. |
|  | in all directions. |

**(1)**

(b)     When the rider’s hand pulls on the brake lever, the force **F** applied to the liquid by the master piston is 80 N. The cross-sectional area of this piston is 50 mm2.

Calculate the pressure, in N/mm2, exerted on the liquid by the master piston.

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

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

Pressure = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N/mm2

**(2)**

(c)     The unit N/mm2 is **not** the usual unit of pressure.

Which unit is usually used when calculating pressure?

Draw a ring around the correct answer.

|  |  |  |
| --- | --- | --- |
| N | Nm2 | Pa |

**(1)**

(d)     The rider applies a larger force to the brake lever. How would this increase in force affect the pressure in the liquid?

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

**(1)**

**(Total 6 marks)**

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**Q2. Figure 1** shows how atmospheric pressure varies with altitude.

**Figure 1**

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(a)     Explain why atmospheric pressure decreases with increasing altitude.

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

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**(3)**

(b)     When flying, the pressure inside the cabin of an aircraft is kept at 70 kPa. The aircraft window has an area of 810 cm2.

Use data from **Figure 1** to calculate the resultant force acting on an aircraft window when the aircraft is flying at an altitude of 12 km.

Give your answer to two significant figures

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

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

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Resultant force = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

**(5)**

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(c)     **Figure 2** shows the cross-section of one type of aircraft window.

**Figure 2**

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Explain why the window has been designed to have this shape.

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

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

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

**(2)**

**(Total 10 marks)**

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**Lesson 12: Teacher notes**

AQA Content

The atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude.

Air molecules colliding with a surface create atmospheric pressure. The number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases. So as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure decreases with an increase in height.

**Students should be able to:**

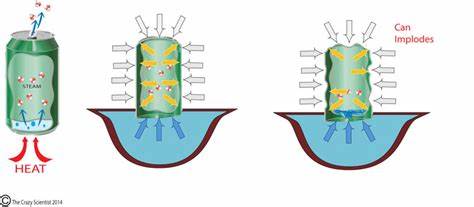
• describe a simple model of the Earth’s atmosphere and of atmospheric pressure

• explain why atmospheric pressure varies with height above a surface.

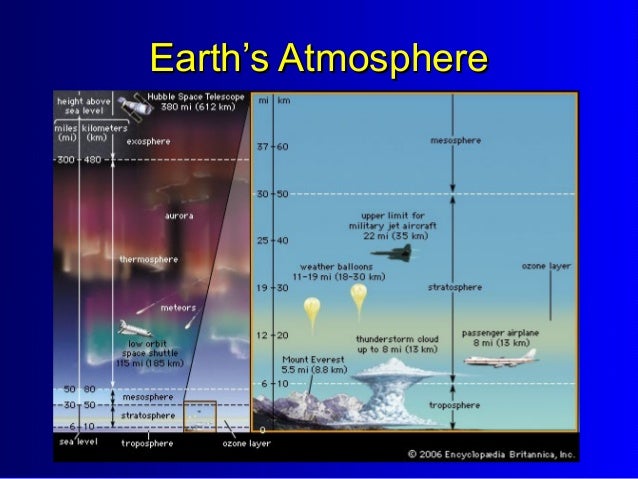
Heating the can increases the energy of the particles inside. These particles move further apart reducing the pressure inside. The further apart the particles, the lower the density. Turning the can over, seals the opening so no additional particles can enter. The pressure on the outside is greater than the pressure on the inside causing the can to collapse.

**Practical work**

Watch the demo of a collapsing can and explain why the can collapses once turned over.  In your answer use the keywords:   particles, pressure, density​.



**Key direct and explicit teacher explanations:**



The Earth’s atmosphere can be thought of as a column of particles many kilometres high above a point on the ground. These particles are pulled towards the centre of the Earth by its gravitational field. This weight of particles is known as the atmospheric pressure. A person standing on the ground is being has a pressure of **1 atmosphere** on them. The higher a person or object travels above the Earth’s surface (for example to the top of a high mountain or in an aeroplane) the fewer particles there are above them. This means that the pressure is reduced. When the pressure is less, the particles move further apart. In everyday language we say the “air is thinner”, we mean that there are fewer particle in the same volume. This means that a mountaineer would get less oxygen in each breath when they are at altitude.

A group of people climbing a mountain

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**Key direct and explicit teacher explanations:**

You Do Question Answers

**Q1.**

(a)  100 km

**1**

(b)  gas

**1**

(c)  90 000 Pa (*allow 89 500 to 90 500)*

**1**

(d)  101 000 – 90 000 = 11 000 Pa (*allow ecf from question* ***(c))***

**1**

(e)  the density of the air decreases

**1**

the mass of air above the student decreases

**1**

(f)  P = 188 000 000/2000

**1**

94 000 (Pa)

**1**

**[8]**

**Q2.**

(a)  longer arrow pointing vertically downwards (*one arrow only)*

**1**

labelled weight - *allow (force of) gravity*

**1**

(b)  initially air resistance is less than weight / gravity so the skydiver accelerates

*allow drag for air resistance / allow increased velocity / speed for accelerates*

**1**

acceleration causes the air resistance to increase

*acceleration* ***or*** *increased velocity / speed is not required here if given in the first mark point*

**1**

resultant force decreases to zero

*allow air resistance becomes equal to weight / gravity*

**1**

so the skydiver falls at terminal velocity

*allow constant velocity/speed for terminal velocity*

*ignore any mention of subsequent motion and use of parachute*

**1**

(c)

*an answer of 50 (m/s) scores* ***3*** *marks*

distance at 7s = 200 (m)

distance at 12s = 450 (m)

***both*** *distances required*

**1**

****

*allow correct use of their two distances divided by 5*

**1**

50 (m/s)

*allow an answer consistent with their two distances*

**1**

(d)  The higher the altitude the less dense the air

**1**

so the air resistance on the skydiver (falling from 39000 m) was less (at the same speed)

**1**

so the skydiver was able to accelerate for longer before reaching (a higher) terminal velocity

*allow constant velocity/speed for terminal velocity*

**1**

**or**

so the skydiver was able to accelerate for longer before air resistance = weight / gravity

**[12]**

**Q3.**

(a)     air molecules colliding with a surface create pressure

**1**

at increasing altitude distance between molecules increases

**or**

at increasing altitude fewer molecules (above a surface)

**1**

so number of collisions with a surface decreases

**or**

or so always less weight of air than below (the surface)

**1**

(b)     atmospheric pressure = 20 kPa from graph **and** conversion of 810 cm2 to 0.081 m2

*allow ecf for an incorrect value clearly obtained from the graph*

**1**

5 × 104 =  F

       0.081

**1**

F = 5 × 104 × 0.081

**1**

4050

**1**

4100 (N)

**1**

*allow 4100 (N) with no working shown for* ***5*** *marks*

*allow 4050 with no working shown for* ***4*** *marks*

(c)     force from air pressure acting from inside to outside bigger than force acting inwards

**1**

so keeps the window in position

**1**

**[10]**

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

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**Lesson 12: Atmospheric Pressure**

**Objective: I can describe a simple model of the Earth’s atmosphere and of atmospheric pressure, and I can explain why atmospheric pressure varies with height above a surface.**

**Do It Now**

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

**A diagram of a tap

Description automatically generated with medium confidence**

**I wasn’t there, but I still care.**

**A diagram of a rubber stopper

Description automatically generated with low confidence**

**The diagram** shows a container filled with water. The three holes in the side of the container are sealed with rubber stoppers. The water exerts a force of 27 N on the bottom of the container. The cross-sectional area of the bottom of the container is 0.009 m2.

Calculate the pressure exerted by the water on the bottom of the container.

Use the equation:



Choose the unit.

|  |  |  |
| --- | --- | --- |
| **kg/m3** | **N/m** | **Pa** |

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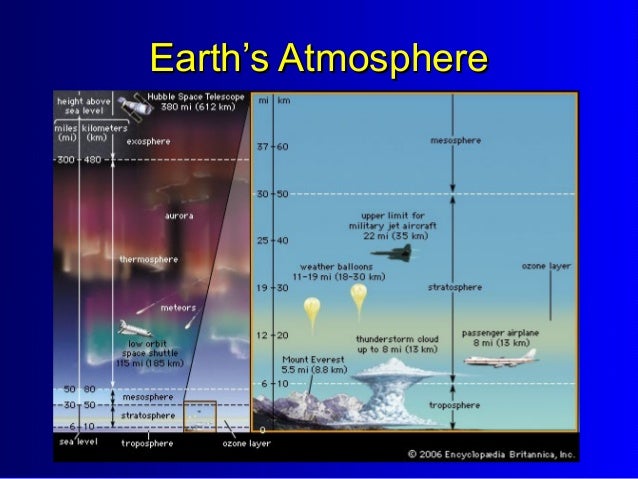
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Pressure = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Unit = \_\_\_\_\_\_\_\_\_\_

**(3)**

**Connect**



The Earth’s atmosphere can be thought of as a column of particles many kilometres high above a point on the ground. These particles are pulled towards the centre of the Earth by its gravitational field. This weight of particles is known as the atmospheric pressure. A person standing on the ground is being has a pressure of **1 atmosphere** on them. The higher a person or object travels above the Earth’s surface (for example to the top of a high mountain or in an aeroplane) the fewer particles there are above them. This means that the pressure is reduced. When the pressure is less, the particles move further apart. In everyday language we say the “air is thinner”, we mean that there are fewer particle in the same volume. This means that a mountaineer would get less oxygen in each breath when they are at altitude.

A group of people climbing a mountain

Description automatically generated with medium confidence

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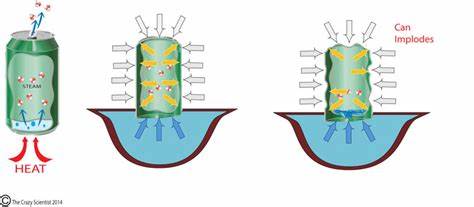
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**Demonstration**

Watch the demo of a collapsing can and explain why the can collapses once turned over.  In your answer use the keywords:   particles, pressure, density​.



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

**You Do Questions**

**Q1.**

The Earth is surrounded by an atmosphere.

(a)  The radius of the Earth is 6400 km.

Which of the following could be an approximate depth of the Earth’s atmosphere?

Tick (**✓**) **one** box.

|  |  |
| --- | --- |
| 100 km |  |
| 6400 km |  |
| 100 000 km |  |
| 640 000 km |  |

**(1)**

(b)  What state of matter is most of the Earth’s atmosphere?

Tick (**✓**) **one** box.

|  |  |
| --- | --- |
| Gas |  |
| Liquid |  |
| Solid |  |

**(1)**

**Figure 1** shows how atmospheric pressure varies with height above sea level.

**Figure 1**

**A picture containing text, line, diagram, plot

Description automatically generated**

(c)  The highest point above sea level in England is the top of a mountain called Scafell Pike.

The height above sea level of Scafell Pike is 978 m.

Determine the atmospheric pressure at the top of Scafell Pike.

Use **Figure 1**.

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

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Atmospheric pressure = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Pa

**(1)**

(d)  Determine the difference between the atmospheric pressure at sea level and at the top of Scafell Pike.

Use **Figure 1** and your answer from part (c)

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

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Difference in atmospheric pressure = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Pa

**(1)**

(e)  A student climbs Scafell Pike.

Why does the atmospheric pressure decrease as the student climbs higher?

Tick (**✓**) **two** boxes.

|  |  |
| --- | --- |
| The air exerts a greater force on the student. |  |
| The density of the air decreases. |  |
| The mass of air above the student decreases. |  |
| The temperature of the air increases. |  |
| The volume of air above the student increases. |  |

**(2)**

(f)  **Figure 2** shows a mountain lake.

**Figure 2**

**A body of water with trees and mountains in the background

Description automatically generated with low confidence**

The lake has a surface area of 2000 m2.

Atmospheric pressure exerts a force of 188 000 000 N on the surface of the lake.

Calculate the atmospheric pressure at the surface of the lake.

Use the equation:

pressure = 

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

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Atmospheric pressure = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Pa

**(2)**

**(Total 8 marks)**

**Q2.**

An aeroplane is 4000 m above the Earth’s surface.

A skydiver jumps from the aeroplane and falls vertically.

**Figure 1** shows the distance the skydiver falls during the first 12 seconds after jumping.

**Figure 1**

**A graph with a line

Description automatically generated with low confidence**

(a)  **Figure 2** shows part of the free body diagram for the skydiver three seconds after jumping.

Complete the free body diagram for the skydiver.

**Figure 2**

**A picture containing screenshot, black and white, line, font

Description automatically generated**

**(2)**

(b)  Explain the changing motion of the skydiver in terms of the forces acting on the skydiver.

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**(4)**

(c)  Use **Figure 1** to determine the speed of the skydiver between 7 seconds and 12 seconds.

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Speed = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ m/s

(d)  In 2012 a skydiver jumped from a helium balloon 39 000 metres above the Earth’s surface. The skydiver reached a maximum speed of 377 m/s

Jumping from 39 000 metres allowed the skydiver to reach a much higher speed than a skydiver jumping from 4000 metres.

Explain why.

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**(3)**

**(Total 12 marks)**

**Q3.**

**Figure 1** shows how atmospheric pressure varies with altitude.

**Figure 1**

**A picture containing line, diagram, plot

Description automatically generated**

(a)     Explain why atmospheric pressure decreases with increasing altitude.

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

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**(3)**

(b)     When flying, the pressure inside the cabin of an aircraft is kept at 70 kPa.

The aircraft window has an area of 810 cm2.

Use data from **Figure 1** to calculate the resultant force acting on an aircraft window when the aircraft is flying at an altitude of 12 km.

Give your answer to two significant figures

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Resultant force = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ N

**(5)**

(c)     **Figure 2** shows the cross-section of one type of aircraft window.

**Figure 2**

**A picture containing text, white, font, design

Description automatically generated**

Explain why the window has been designed to have this shape.

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**(2)**