Cambridge Assessment International Education

Skills Pack

Stretching springs

Cambridge IGCSE®

Physics

0625

This *Skills Pack* can also be used with the following syllabuses:
- Cambridge IGCSE® (9–1) Physics **0625**
- Cambridge IGCSE® Combined Science **0653**
- Cambridge IGCSE® Co-ordinated Science **0654**
- Cambridge O Level Physics **5090**

Version 0.1

Contents

Contents 3
Introduction 5
Experiment: Stretching springs 6
Briefing lesson: Planning 7
Lab lesson: Option 1 – run the experiment 8
Teacher notes 10
Teacher method 12
Lab lesson: Option 2 – virtual experiment 13
Debriefing lesson: Processing data 15
Worksheets and answers 16
Worksheet A: Planning 17
Worksheet B: A perfect plan? 19
Worksheet C1: Method 22
Worksheet C2: Method 24
Worksheet C3: Another experiment 26
Worksheet D: A puzzle 28
Worksheet E: What's wrong? 29
Worksheet F1: Processing the data 30
Worksheet F2: Processing the data 32
Worksheet G: Bungee jumping 34
Worksheet A: Answers 37
Worksheet B: Answers 37
Worksheet C1: Answers 37
Worksheet C2: Answers 37
Worksheet C3: Answers 38
Worksheet D: Answers 38
Worksheet E: Answers 38
Worksheet F1: Answers 39
Worksheet F2: Answers 39
Worksheet G: Answers 40

Icons used in this pack:

Briefing lesson

Lab lesson: Option 1 – run the experiment

Lab lesson: Option 2 – virtual experiment

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Skills Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Skills Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this pack will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Stretching springs

This *Skills Pack* focuses on stretching a spring and Hooke's Law

In this experiment, you add masses to a suspended spring and see what effect this has on the extension. You will also use your results to find the mass of an unknown object.

This experiment has links to the following syllabus content (see syllabus for detail):

- 1.5.1 Effects of Forces

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- take readings from apparatus (analogue or digital) or from diagrams of apparatus
- process data, including for use in further calculations or for graph plotting, using a calculator as appropriate
- present data graphically, including the use of best fit lines where appropriate
- describe experimental procedures

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 1.1 Physical quantities and measurement techniques
- 1.3 Mass and weight

Going forward

The knowledge and skills gained from this experiment can be used for when you teach learners skills about

- planning experiments and identifying variables,
- Making and recording observations, measurements and estimates
- interpreting and evaluating experimental data.

Briefing lesson: Planning

Resources	• Apparatus listed in the Teachers' Notes • Worksheet A
Learning objectives	By the end of the lesson: • ***all*** learners should select appropriate equipment for the experiment • ***most*** learners should be able to produce a simple plan for the experiment • ***some*** learners will be able to produce a detailed plan for the experiment including how they will plan to make accurate measurements

Timings	Activity
10 minutes	**Starter/Introduction** Show learners an object of unknown mass. Ask them, in groups, to think of as many ways as possible to find the mass of the object. Get them to brainstorm all the ways they can think of. The more imaginative the better. Show them a spring balance being used to weigh the object but don't allow them to actually see the measurement itself. Explain that the heavier the object is the more the spring will stretch and that a numbered kilogram scale can be attached to this.
30 minutes	**Main lesson** Explain to learners that you want them to plan an experiment that will allow them to obtain results that could be used to find the mass of the object as accurately as possible without using the spring balance or any other balance. Show them the setup using the retort stand, spring and slotted masses Explain that the mass of the object is somewhere between the mass of 1 slotted mass and 6 slotted masses - but we don't know exactly where. Put learners into groups and ask them to use **worksheet A** to plan an experiment that will generate the data that we could use. You may wish to "hide" equipment around the room so that learners who are finding this difficult have some prompts Each group could have a nominated 'envoy' to go to other groups for ideas.
20 minutes	**Plenary** Get the groups to swap their copies of **worksheet A** with those from another group. The groups read through the worksheet they have collected from the other group. They can then evaluate other groups plans. Is this going to work? Does it contain enough detail? Is there anything in this plan that we don't have in ours?

Lab lesson: Option 1 – run the experiment

Resources	• Apparatus listed in the Teachers' Notes • Completed worksheet A • Worksheet B • Worksheet C1 • Worksheet C3 • Worksheet D
Learning objectives	By the end of the lesson: • ***all*** learners should be able to collect some experimental data, perhaps with help • ***most*** learners should be able to collect the experimental data by using the equipment appropriately • ***some*** learners will be able to evaluate experimental procedure to identify and correct common mistakes

Timings	Activity
10 minutes	**Starter/Introduction** Show **Worksheet B.** Ask learners to compare their plan with the 'perfect' one on **Worksheet B.** Have they included everything? Have they missed anything? Have we missed anything in our plan? What features make our plan worth a high mark?
40 minutes	**Main lesson** Learners follow the instructions on **Worksheet C1** and do the experiment. The experiment itself is fairly simple however there are several errors that students are likely to make: • they will try to measure the length of the spring and include the loops at either end • they will put the ruler upside down - since they used the measurements of length to calculate an extension, this will not make a difference to the final results but it is worth watching for this when you circulate around the room • they will often plot the *lengths* on their graph rather than the *extension* • parallax error figures heavily in this experiment - some students will use a set square to align the bottom of the spring with the ruler before taking a reading • some may forget to measure the unstretched length of the spring **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate. • safety goggles should be worn to protect the eyes in case a spring snaps under tension • students must avoid having their hands and feet directly beneath the suspended masses • the retort stand is unstable and should be G-clamped to the table

	If time permits learners can do the activity from **Worksheet C3** Learners are provided with three complete methods for a different experiment. One of them is excellent, one of them is rather poor and the other one is somewhere in between. Learners need to identify which one is which, why the best one is best and advise how they would improve each one.
10 minutes	**Plenary** **Worksheet D** contains a question for learners to think about. Ask them to think about how they would work out the answer. Would a diagram help?

Teacher notes

Watch the spring video (teacher version) and read these notes.

Each group will require:

- a spring
- retort stand and clamp
- G-clamp
- 6 x 100g slotted masses
- metre rule
- safety goggles
- set square
- an object with unknown mass e.g. a small bag of coins or sand with a mass between 300 and 500 grams
- balance

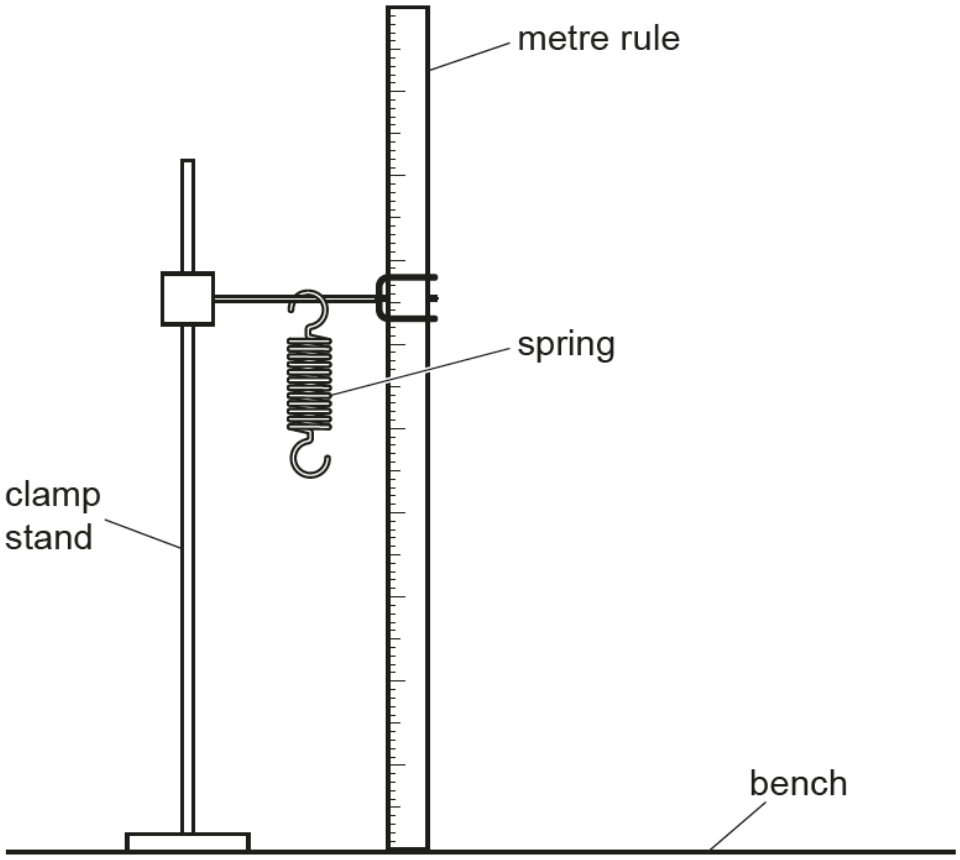
Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
	Stretched springs can snap and potentially cause eye injury so goggles should be worn	
	There is a risk the slotted masses could fall so student should ensure that hands and feet are never directly below the suspended masses	
	The retort stand is unstable and should be g-clamped to the table to avoid it toppling over	

Experiment set-up



Teacher method

This is your version of the method for this experiment that accompanies the *Teacher walkthrough* video.

Do not share this method with learners. Give them **Worksheet C1 or C2**.

Note: The real life practical session uses masses in grams but the video based lesson uses weights in newtons.

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of groups you will need (group size 1-2 learners)
- the amount of equipment required

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.
The five bullet points in the main lesson part of the lesson plan are the usual areas of difficulty.

Clean-up

After the experiment learners should:

- tidy up their work space
- return all equipment to you.

Lab lesson: Option 2 – virtual experiment

Resources	• Apparatus listed in the Teachers' Notes • Completed Worksheet A • Worksheet B • Worksheet C2 • Worksheet C3 • Worksheet D
Learning objectives	By the end of the lesson: • ***all*** learners should be able to take accurate and precise readings of length • ***most*** learners should be able to identify the features of a good method • ***some*** learners will be able to suggest improvements to methods that would enable another person to do the experiment

Timings	Activity
10 minutes	**Starter/Introduction** Show **Worksheet B.** Ask learners to compare their plan with the 'perfect' one on **Worksheet B.** Have they included everything? Have they missed anything? Have we missed anything in our plan? What features make our plan worth a high mark?
40 minutes	**Main lesson:** Learners work through **Worksheet C2.** The teacher will need to show them the video and pause it to allow learners to write down the measurements in their table on **Worksheet C2.** Learners can work through **Worksheet C3**. Here they are asked to plan a different, but related experiment. First of all, they work in small groups to analyse the question. What are they being asked to do? What information is provided? Then consider how they would structure the answer before they consider what they would write. Bullet points or prose? Section headings? They are provided with three complete methods for this experiment. One of them is excellent, one of them is rather poor and the other one is somewhere in between. Learners need to identify which one is which, justify their choice and advise how they would improve each one. Review this with the class.

10 minutes	**Plenary** **Worksheet D** contains a question for learners to think about. Ask them to think about how they would work out the answer. Would a diagram help?

Debriefing lesson: Processing data

Resources	• Worksheet E • Worksheet F1 • Worksheet F2 • Worksheet G
Learning objectives	By the end of the lesson: • ***all*** learners should be able to find the mass of the unknown object • ***most*** learners should be able to plot a graph of their results and calculate the gradient • ***some*** learners will be able to explain whether their experiment was completed to a suitable degree of scientific accuracy

Timings	Activity
10 minutes	**Starter/Introduction** Learners can work through **Worksheet E** This shows someone carrying out the experiment they did in the previous lesson, but they are making lots of mistakes. Learners can identify the mistakes and explain what they need to do in order to do it correctly.
20 minutes	**Main lesson** Using their results from the experiment they did learners can process the data they collected by working through **Worksheet F1.** Use **Worksheet F2** if you did the virtual lesson.
20 minutes	**Plenary** **Worksheet G** links the experiment to a real life situation and brings everything together.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson:*		
A: Planning	x	x
For use in *Lab lesson: Option 1:*		
A: Planning - completed	x	x
B: A perfect plan?	x	x
C1: Method	x	x
C3: Another experiment	x	x
D: A puzzle	x	x
For use in *Lab lesson: Option 2:*		
A: Planning - completed	x	x
B: A perfect plan?	x	x
C2: Method	x	x
C3: Another experiment	x	x
D: A puzzle	x	x
For use in the *Debriefing lesson:*		
E: What's wrong	x	X
F1: Processing the data	x	x
F2: Processing the data	x	x
G: bungee jumping	x	x

Worksheet A: Planning

How does the mass attached to a spring affect the extension of the spring?

Measurements

Make a list of all the variables you could measure

Equipment

What equipment would you need to measure this variable?

Independent variable – Which variable are you deliberately going to change?

Dependent variable – which variable will you measure as a result of changing your independent variable?

Control variables – which other variables will you keep the same to make the experiment fair?

Method

What are you going to do with the equipment to complete the investigation? This is best set out in numbered bullet points like a cooking recipe. Include enough detail so that someone else can follow your method without having to make too many decisions for themselves.

Sources of error – How will you ensure your results are as accurate as possible?

Results table

Safety precautions

What is unsafe?	Why is it unsafe?	How can you reduce the risk?

Worksheet B: A perfect plan?

How does the mass attached to a spring affect the extension of the spring?

Independent variable – Which variable are you deliberately going to change?

Mass attached to the spring

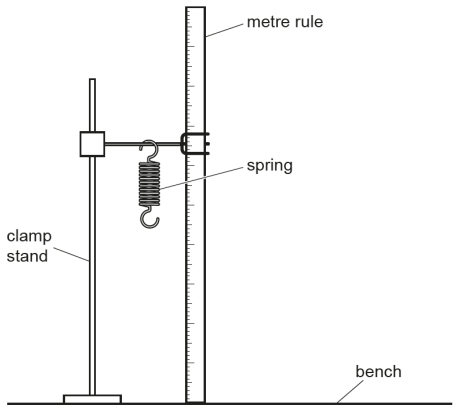
Dependent variable – which variable will you measure as a result of changing your independent variable?

Position of the end of the spring against the ruler

Measurements	**Equipment**
Make a list of all the variables you could measure	What equipment would you need to measure this variable?
Mass of weights hanging from spring	*Balance – or the value is stamped on the mass*
Position of top of spring	*Metre ruler*
Position of bottom of spring with different weights	*Metre ruler*

Method

What are you going to do with the equipment to complete the investigation? This is best set out in numbered bullet points like a cooking recipe. Include enough detail so that someone else can follow your method without having to make too many decisions for themselves.



1. *Set up apparatus as in the diagram*
2. *Carefully measure and record the position of the top of the coiled section of the spring. Not including the loop or hook.*
3. *Carefully measure and record the position of the bottom of the coiled section of the spring. Not including the loop or hook.*
4. *Add a 100 g mass to the spring and wait until it stops moving.*
5. *Repeat step 3.*
6. *Add 100 g masses, one at a time and repeat step 3 until 600 g is added to the spring.*
7. *Calculate the extension for each of the different masses.*

Sources of error – How will you ensure your results are as accurate as possible?

- *Read scale of ruler at with eye at 90°*
- *Ensure spring is not moving when taking readings*
- *Use a set square to align the position of the bottom of the spring with the ruler*

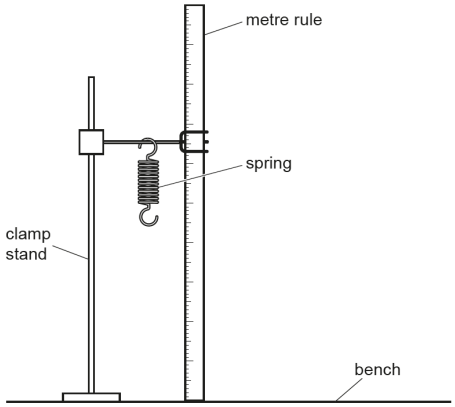
Results table

Mass / g	Position of top of spring / cm	Position of bottom of spring / cm	Extension / cm
0			
100			
200			
300			
400			
500			
600			

Safety precautions

What is unsafe?	**Why is it unsafe?**	**How can you reduce the risk?**
Spring could snap	*Could go in my eye*	*Wear safety goggles*
Weights could fall on hands or feet	*Hurt hands/feet*	*Make sure hands/feet are not below suspended masses*
Stand and clamp unstable	*Could fall over and injure*	*G clamp to table*

Worksheet C1: Method



1. Assemble the equipment as shown in the diagram. Make sure that the zero end of the ruler is at the top.

2. Use the set square to ensure the metre rule is vertical and at 90 degrees to the bench.

3. Using the set square, carefully and accurately measure and record the position of the bottom of the spring against the ruler. Do not include the hooks or loops at the end of the spring - only the coiled part.

4. Record this value in your table for a load of 0 g. Repeat this so that you have three readings of the same measurement in your table

5. Suspend the object with unknown mass from the spring and carefully measure and record the position of the bottom of the spring.

6. Remove and replace the object and re-measure the position so you have three measurements.

7. Put the object to one side.

8. Add the slotted mass hanger and carefully measure the position of the bottom of the spring. Record this in your table for mass = 100 g. Remove and replace the mass and re-measure the position so you have three measurements.

9. Carefully add one of the slotted masses to the hanger and repeat the measurement. This is mass = 200 g. Remove and replace the mass and re-measure the position so you have three measurements.

10. Repeat until you have used all of the slotted masses.

11. Remove the slotted masses and hanger.

12. Use the balance to find the mass of the object with unknown mass and write this result below the table.

13. Calculate the extension of the spring for each mass. This can be found by subtracting the length at 0 g from each of the different mean lengths. Be sure to subtract the same number each time - that is the number for 0 g.

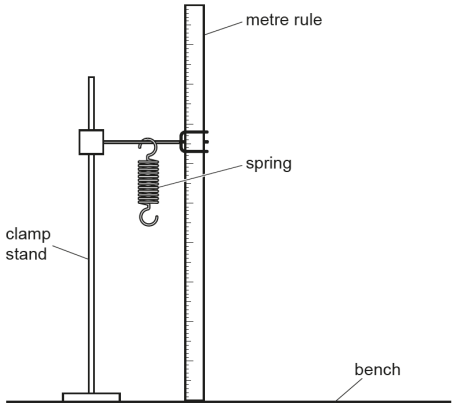
Mass / g	**Position of bottom of spring / cm**				**Mean extension / cm**
	1	**2**	**3**	**Mean**	
0					
Unknown object					
100					
200					
300					
400					
500					
600					

Mass of unknown object measured with balance …….g

Before you put the equipment away:

- Check your results for anomalies.
  If you find any, then repeat those readings now while you still have the equipment.
- Calculate your means.

Worksheet C2: Method



1. Assemble the equipment as shown in the diagram. Make sure that the zero end of the ruler is at the top.

2. Use the set square to ensure the metre rule is vertical and at 90 degrees to the bench.

3. Using the set square, carefully and accurately measure and record the position of the bottom of the spring against the ruler. Do not include the hooks or loops at the end of the spring - only the coiled part.

4. Record this value in your table for a weight of 0 N. Repeat this so that you have three readings of the same measurement in your table

5. Suspend the object with unknown weight from the spring and carefully measure and record the position of the bottom of the spring.

6. Remove and replace the object and re-measure the position so you have three measurements.

7. Put the object to one side.

8. Add the slotted mass hanger and carefully measure the position of the bottom of the spring. Record this in your table for weight = 2 N. Remove and replace the mass and re-measure the position so you have three measurements.

9. Carefully add the slotted masses to the hanger and repeat the measurement. This next weight is weight = 4 N. Remove and replace the mass and re-measure the position so you have three measurements.

10. Repeat until you have used all of the slotted masses.

11. Remove the slotted masses and hanger.

12. Use the balance to find the mass of the object with unknown mass and write this result below the table.

13. Calculate the extension of the spring for each mass. This can be found by subtracting the length at 0 N from each of the different lengths. Be sure to subtract the same number each time - that is the number for zero newtons.

weight / N	**Position of bottom of spring / cm**				**Mean extension / cm**
	1	**2**	**3**	**Mean**	
0					
Unknown object					
2					
4					
6					
8					
10					
12					

Mass of unknown object measured with balance …….g

- Calculate your means.

Worksheet C3: Another experiment

Below are three answers to the planning question.
Decide which is the best answer and why.
What makes this the best answer?
How would you improve the other two?

PLANNING QUESTION

Plan an experiment which would enable you to test the extension of springs made from different metals.

The following apparatus is available:

- Wires made of different metals.
- A set of 10 g masses and a set of 100 g masses, both with hangers
- A wooden rod, approximately 1 cm in diameter
- Other standard laboratory equipment

In your plan, you should include:

- Instructions for making a spring from the wire that is provided
- What you will measure
- Instructions for doing the experiment
- The variables you will keep the same to ensure the comparison is a fair test
- Any precautions you will take to ensure accurate results
- How you will process your results to reach a conclusion

You may draw a diagram if it helps to explain your plan.

You are **not** required to do the experiment.

ANSWER 1
I will make 5 springs by winding the different metal wires round the rod one at a time until I have 5 springs. Each one made of a different metal.
Suspend one of the springs from the stand and clamp and suspend different weights from it.
Use a ruler to measure the length of each spring at each mass until you have used 5 different masses. Repeat this procedure two more times so you have 3 lengths for each mass and then calculate the average extension for each mass.
Do this for all 5 metals.
Ensure the length of each spring is always the same and each spring is made with wire of the same diameter.
Look at the ruler with eye perpendicular to the scale.
Plot a graph of extension against mass for each metal.

ANSWER 2
Take springs made from 5 different metals and suspend different masses from them.
Measure the length of the spring with each different mass suspended from it.
Repeat and average these results.
Repeat with other metals.
Use wire with the same length.
Plot 5 graphs. One for each spring.

ANSWER 3

Making the spring:
I will wind the wire around the wooden rod so that each spring has a diameter of 1cm.

Measurements:
I will measure the length of the spring before and after stretching it.
I will measure the masses I suspend from the spring.

Procedure:
Make 5 springs as described above. Use steel, copper, zinc, aluminium and brass wires.
Attach the steel spring to a clamp and stand.
Suspend different masses from the steel spring and measure the length of the spring for each mass with a ruler.
Use 5 different masses.
Repeat each mass so you have 3 readings for each length.
Repeat with the other metals.

Control variables:
I will use the same length and thickness of wire for each spring. Each spring will have a 1 cm diameter.

Precautions for accuracy:
I will read the ruler scale with my eyes at 90 degrees and use a set square to ensure the bottom of the spring is level with the reading.

Processing:
I will calculate the average length for each mass and then the extension (final length - original length) for each mass for each metal.
I will draw a graph of average extension against mass for each metal – using 5 different coloured lines.

Worksheet D: A puzzle

A 5N weight is suspended from a spring.
The spring is 160 mm long.

When 10N weight is suspended from the spring, it is 200 mm long.

How long is the spring with no extension?

How long is the spring with a load of 8N?

Worksheet E: What's wrong?

Photograph of feet or hands beneath the suspended masses

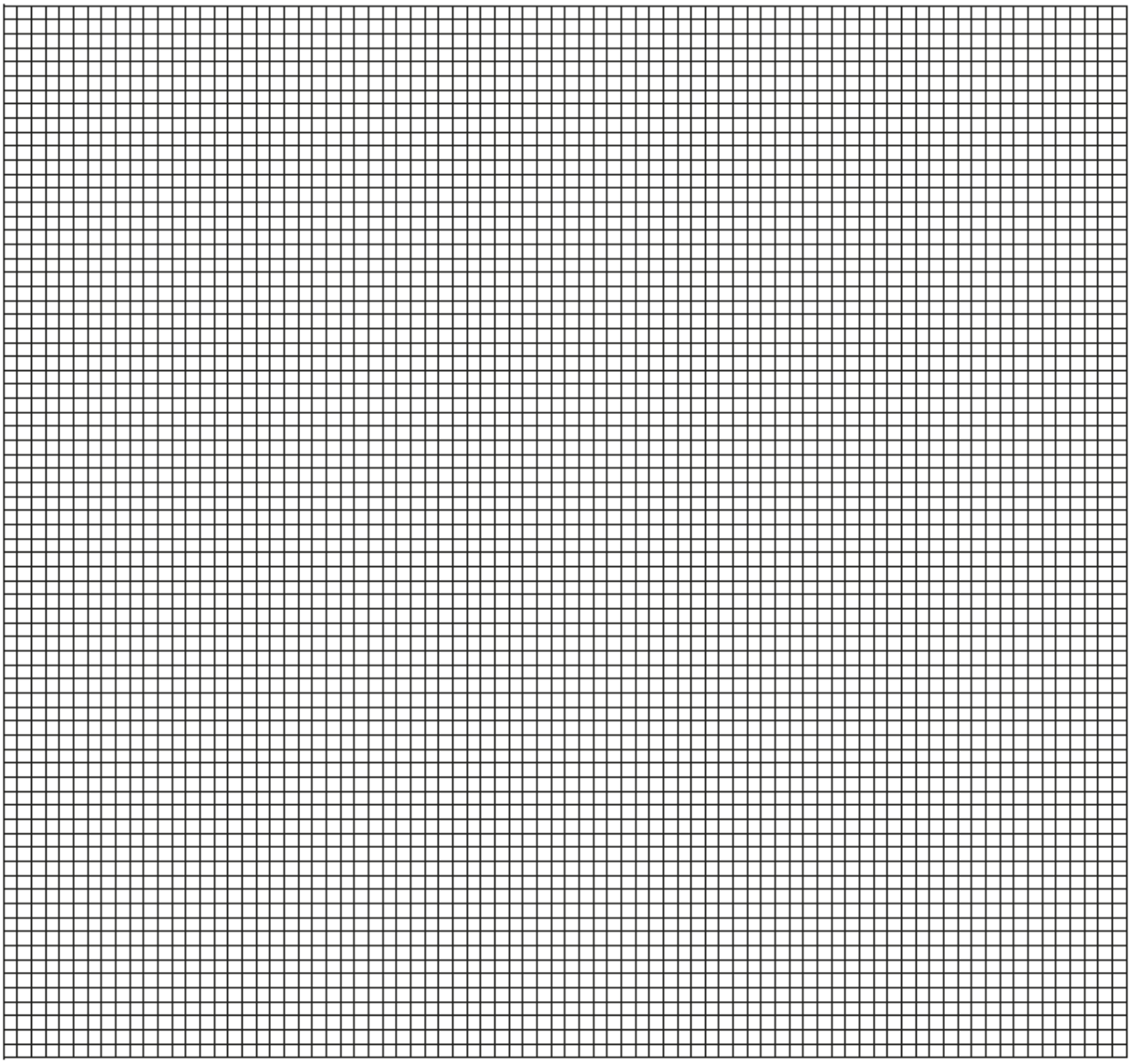
Picture of apparatus with ruler upside down

Picture of measurement being taken with eye level with bottom of the loop rather than the bottom of the spring

Picture of measurement being taken with parallax error or moving spring or ruler at an angle or zero error with ruler

Worksheet F1: Processing the data

a) Using your data from the experiment, plot a graph of mass on the Y axis against extension on the X axis.



b) Draw a straight line of best fit for your points .

c) Use your graph to find the mass of the unknown object. Show clearly on your graph how you do this.

Mass of object _____ g

d) The gradient of your graph can be used to find the spring constant of the spring.

Use your graph to calculate the gradient and show on the graph how you do this.

Gradient = ……..

Use the equation to calculate the spring constant of the spring.

spring constant = 10 x gradient

Spring constant …… N/cm

e) During the experimental procedure you should have measured the mass of the unknown object.

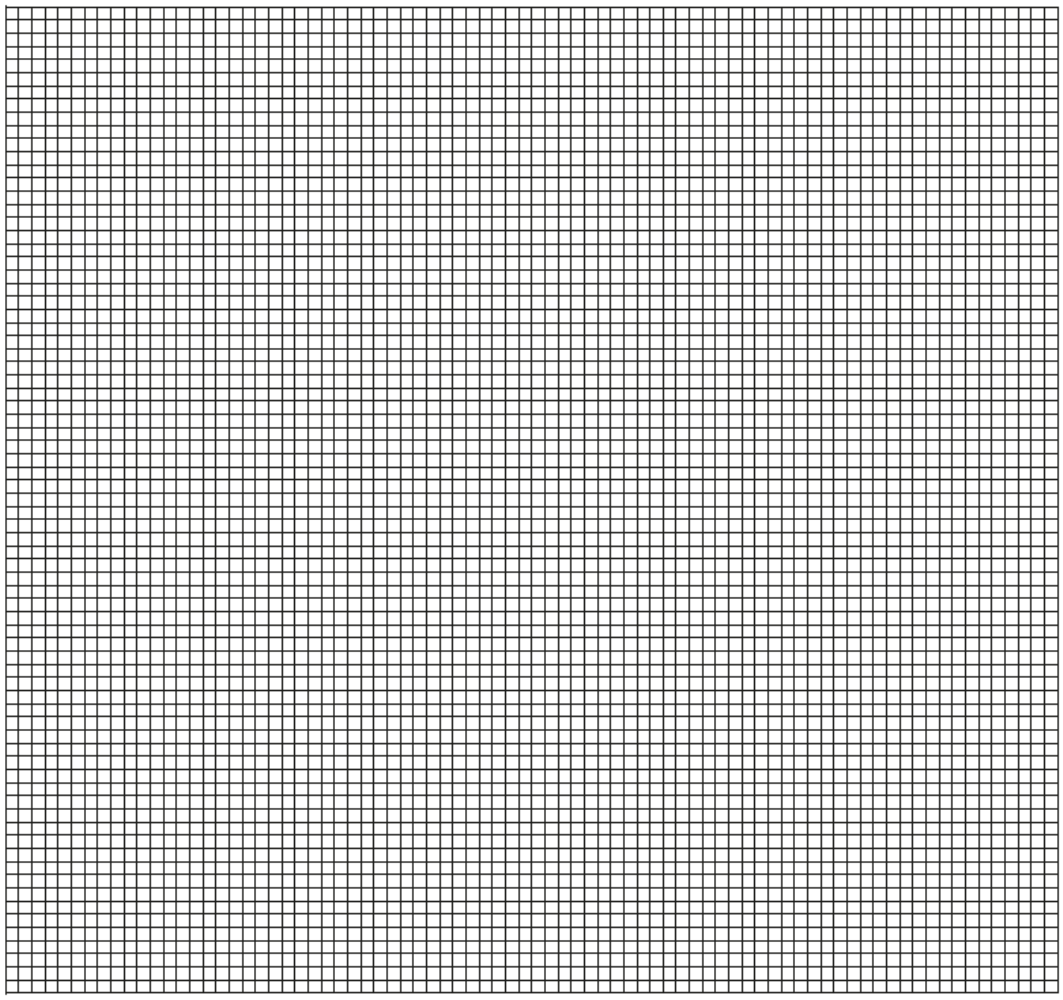
Two values are considered to be the same within the limits of experimental accuracy if they are within 10% of each other.

Explain if your measured mass and the mass from your graph are the same within the limits of experimental accuracy.

Worksheet F2: Processing the data

a) Using the following data from the experiment, plot a graph of weight on the Y axis against extension on the X axis.

Weight / N	Extension / cm
0	0.0
Unknown object	6.2
2	5.5
4	9.2
6	13.1
8	17.4
10	20.9
12	24.8



b) Draw a straight line of best fit for your points .

c) Use your graph to find the mass of the unknown object. Show clearly on your graph how you do this.

Mass of object _____ g

d) The gradient of your graph is equal to the spring constant.

Use your graph to calculate the gradient and show on the graph how you do this.

Spring constant …… N/cm

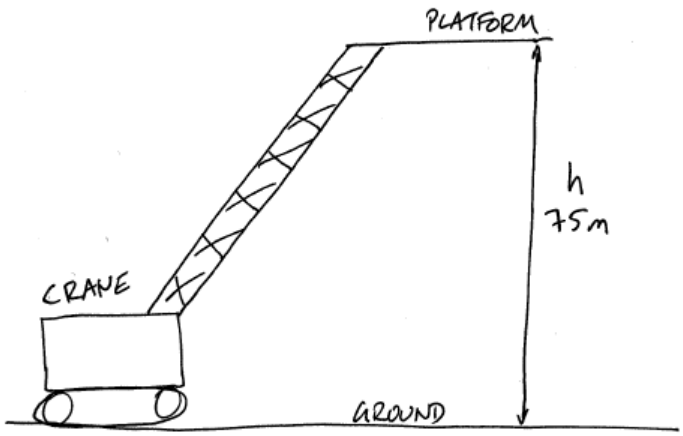
e) Two values are considered to be the same within the limits of experimental accuracy if they are within 10% of each other.

Explain if your measured mass and the mass from your graph are the same within the limits of experimental accuracy.

Worksheet G: Bungee jumping

Bungee jumping involves a person being tied to a large elastic rope and then jumping from a high platform. When the person reaches the bottom of the fall the elastic rope pulls them back up.

A company is planning to offer people the opportunity to do bungee jumps.
The diagram shows the setup that the company will use.



The company has a choice of three different bungee ropes - all of unstretched length 10 m.
Before they can open for business they must test the ropes to ensure they are safe.

They conduct an experiment where they attach concrete blocks with different masses to the end of the rope, push them from the platform and observe what happens.

ai) Suggest what the range of masses should be and give reasons for your choice.

From …….. to ……..

Because

……
……
……
……
……..

aii) suggest a control variable for their experiment.

……
……
……
……
……

b) The table shows their results

Mass of blocks / kg	Extension rope A /m	Extension rope B / m	Extension rope C / m
20	20	36	53
40	23	38	62
60	27	40	68
80	30	43	73
100	33	47	78
120	42	42	87
140	47	53	95
160	50	55	106
180	53	60	112

i) One of the ropes can be disregarded straight away. Which rope is it and why?

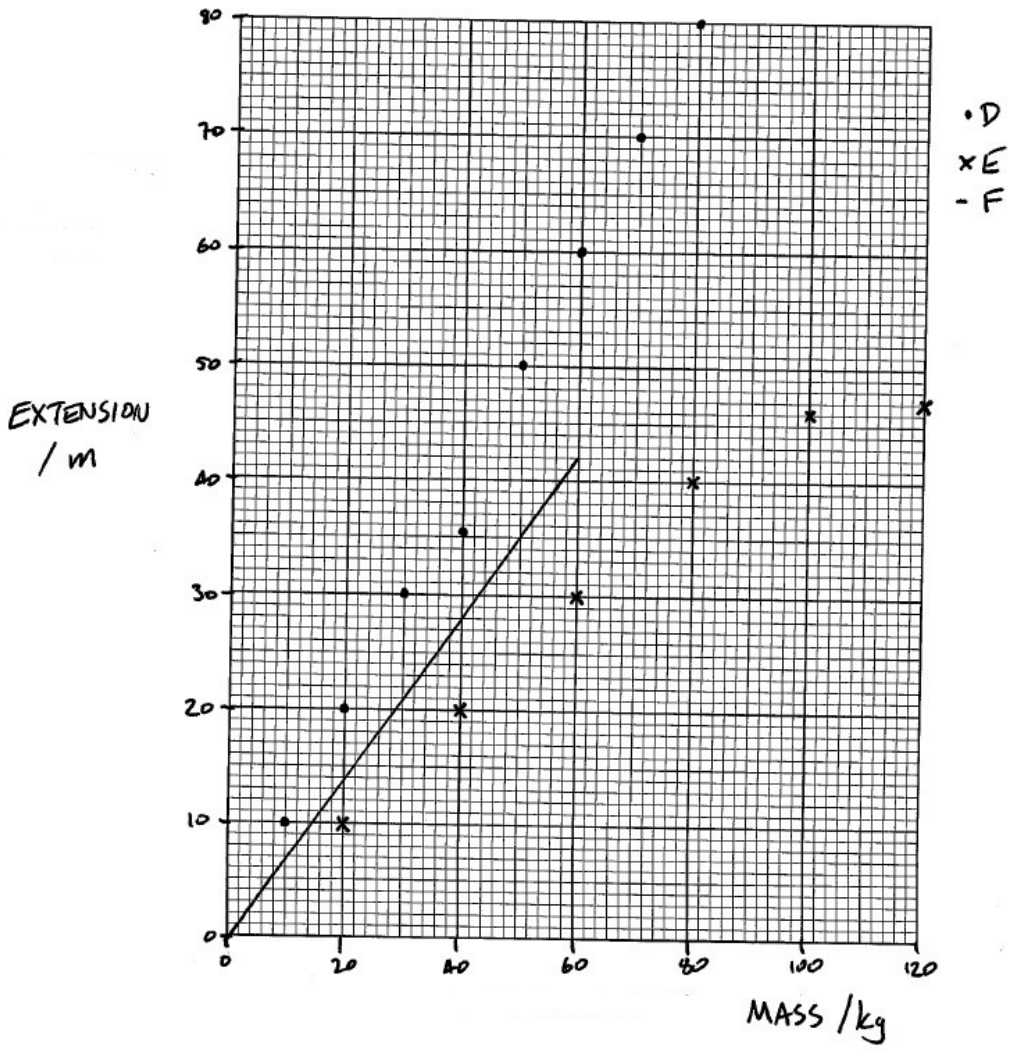
……
……
……

ii) Carefully analyse the results for the other two ropes.
Comment on anything you notice and suggest how they could improve these results.

……
……
……

c) The company decides that none of the ropes are suitable and they performed the same experiment for other types of bungee rope from a different supplier.

A student produced the graph to show the mass and extension for 3 new ropes.



i) Complete the lines of best fit for ropes D and E.

ii) What extension would an 80 kg mass produce for rope F?

……
……
……

iii) Hooke's Law states that *extension is proportional to the mass applied.*
The manufacturer says all the ropes obey Hooke's law.
Explain whether this is true.

……
……
……

iv) The company has to have a mass restriction for safety.
They choose rope F as their final choice.

All measurements of extension have a potential 10% error in them.
What is the highest mass of person they can safely allow?

……
……
……

Worksheet A: Answers

See Worksheet B

Worksheet B: Answers

No answers required. Worksheet B is one possible answer to Worksheet A

Worksheet C1: Answers

Answers dependent on measurements recorded by the student

Worksheet C2: Answers

weight / N	Position of bottom of spring / cm				Mean extension / cm
	1	2	3	Mean	
0	54.8	54.7	54.9	54.8	0.0
Unknown object	48.5	48.2	48.9	48.6	6.2
2	49.2	49.8	50.0	49.3	5.5
4	45.3	45.7	45.8	45.6	9.2
6	41.3	41.5	41.6	41.7	13.1
8	37.5	37.3	37.5	37.4	17.4
10	33.8	33.8	34.0	33.9	20.9
12	30.0	29.8	30.3	30.0	24.8

Mass of unknown object measured with balance ……302.53……g

Worksheet C3: Answers

Answer 3 is the best. It has a good structure using headings that ensure the student answers all the points in the question. It contains sufficient detail so that someone else could follow it without having to make many decisions themselves.
Some improvements could be: mention to not include the loops on the spring in the measurement of length and to wait for the spring to stop moving before measuring. The values of masses used would be a nice addition.

Answer 2 is the lowest scoring answer. It does not tell us how to make the springs using the rod and does not mention suspending the spring. It asks us to take measurements of the length of spring but does not give us any detail on what these measurements are.
It asks us to repeat and average these results - but does not specify which results we are repeating and averaging. Are we finding the average length of the spring at each individual mass or are we finding the average length of the spring for all the masses combined?
The sentence “use wire with the same length” does not give us any detail about what we are using this for. Presumably we would use it to make springs using the rod but they do not tell us this.
“Plot 5 graphs” gives us no detail about what graphs we are plotting. What goes on their axes? Is this a line graph or a bar chart?
This answer does not provide a method that another person could easily follow and so it is not given many marks.

Answer 1 is somewhere between the other two.
It contains a reasonable amount of detail but could be improved by telling us which masses to use, by telling us exactly what length we are measuring – i.e. between which two points on the spring.
Also this student has written one continuous paragraph rather than using the nice headings that student 3 used so we have had to look through the answer several times to find the things that we are looking for.
It's not a bad answer - it just lacks some details and structure.

Worksheet D: Answers

A 5 N increase in weight causes an extension of 40 mm.
So if we remove the original 5 N from the spring, then we would expect its length to decrease by 40 mm.
The length of the unstretched spring is 160 – 40 = 120 mm

If 5 N causes an extension of 40 mm.
Then 1 N causes an extension of 8 mm.

So 8 N would cause an extension of 64 mm.
Adding this on to the original length of 120 mm gives a final answer of 184 mm.

Worksheet E: Answers

Hands/feet below the suspended masses. If the spring was to break then this person could be injured.

The ruler is upside down. Zero should be at the top.

The student is measuring the length of the spring and is including the loop. They should measure the coiled part only.

Here the student has introduced parallax error. They should look at the rulers scale at 90°.

Worksheet F1: Answers

Answers here will depend on the student's values in the experiment.

a) The graph should have a linear scale that enables the student to use 50% of the graph paper in both directions.
The axes should be labelled with the quantity and unit.
All the plotted points should be correct.

b) The student should draw a line of best fit that matches the distribution of their points. If it is a curve then it should be a single free hand smooth curve. If it is a straight line then it should be one single continuous straight line drawn with a ruler.

c) The student should use the mean extension for the unknown object and draw a vertical line on their graph upwards from this value. This line should touch the line of best fit. Then they should draw a horizontal line from this point and read off the correct value of mass.

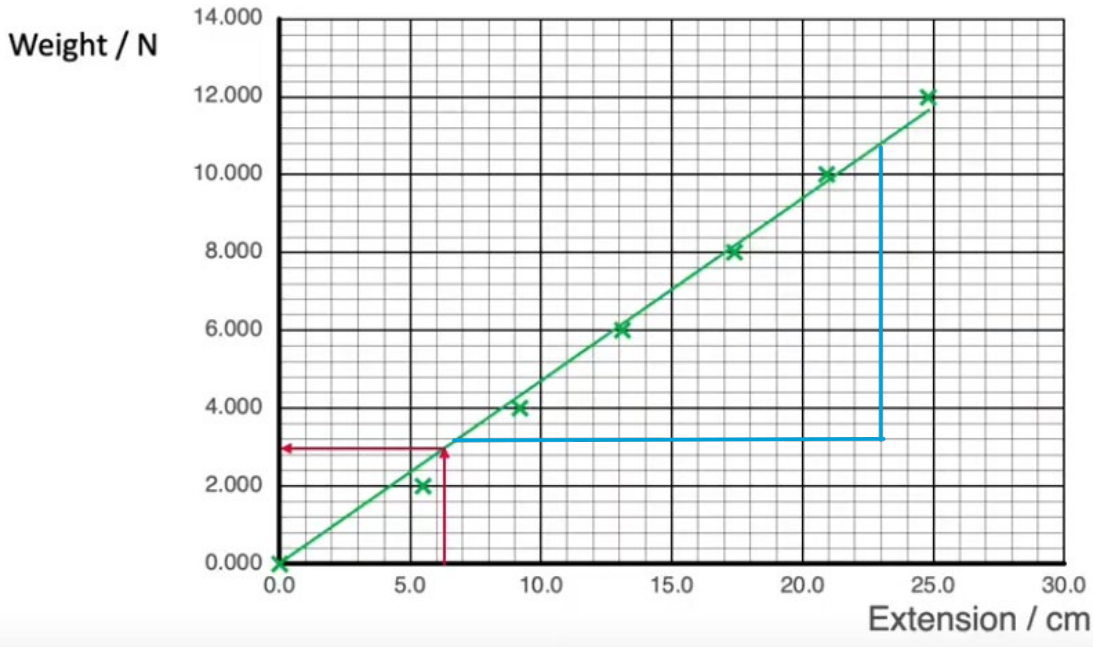
d) The student should draw a large triangle and make it clear which points they are using in their calculation. The triangle should be shown on the graph and then correct values of gradient and spring constant should be calculated.

e) The student should calculate 10% of one of the two values and then add and subtract this to the original value. They should then compare the other value with this range and state clearly whether this second value is within the 10% range of the first.

Worksheet F2: Answers

a) The graph should have a scale that enables the student to use 50% of the graph paper in both directions.
The axes should be labelled with the quantity and unit and the scale should increase linearly.
All the plotted points should be correct.
For example:

a)



b) Note this is a single continuous line of best fit that extends to the first and last plotted point.

c) The unknown object causes an extension of 6.2 cm. If we read upwards (red arrows) from the 6.2 centimetre mark on the horizontal axis we then touch the line of best fit at around 3 N. This would equate to 300 g

d) We draw a large triangle (blue) and make it clear which points we are using in the calculation. The triangle is shown on the graph.
The values are (6.5, 3.2) and (23.0, 10.8) making a gradient of 10.8-3.2 / 23.0-6.5 = 0.46 N/cm

e) The mass was measured as 302.53 g. The value from part c) was 300g.
10% of 300 g = 30 g. So the minimum value that is within experimental accuracy is 270 g and the highest is 330 g. 302.53 g is within this range and so they are equal.

Worksheet G: Answers

ai) E.g. 20 -120 kg and this is a reasonable range for the mass of one person.

aii) Ropes made from the same substance and have the same extension per kilogram.

bi) Rope C - the rope can go longer than the height of the drop / 75 m.

bii) The result for Rope B at 120 kg is an anomalous result. They should repeat this test.

ci) The line for D should be a single straight line and drawn with a ruler. The line of E should be a smooth curve.

cii) The line for F should be extended using a ruler and then read off the value of extension for 80 kg mass. Approximately 56 m.

ciii) Ropes D and F obey Hooke's Law as their lines are directly proportional. The are straight and pass through the origin. Rope E does not obey Hooke's Law as it curves.

civ) The maximum extension is 65m. As the ropes are 10m and the drop is 75 m.
The error is 10% so the 65 m wire could be as short as 65 - 6.5 m = 58.5 m and still extend to 65m
Using the extended line from ci) and reading across from 58.5 m , we find mass of 82 kg.

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554
e: **info@cambridgeinternational.org** **www.cambridgeinternational.org**