Cambridge Assessment International Education

Skills Pack

Investigating the effect of physical activity on the heart (pulse) rate

Cambridge IGCSE®

Biology

0610

This *Skills Pack* can also be used with the following syllabuses:
- Cambridge IGCSE® (9–1) Biology **0970**
- Cambridge IGCSE® Combined Science **0653**
- Cambridge IGCSE® Coordinated Science **0654**
- Cambridge O Level Biology **5090**

Version 0.1

Contents

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*.

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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*.

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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: Investigating the effect of physical activity on the heart (pulse) rate

This *Skills Pack* focuses on an investigation into the effect of physical activity on the heart rate, measured by feeling the pulse.

The heart is a muscular pump. It forces blood around the circulatory system to deliver oxygen and glucose to respiring cells, and to remove their waste products. During exercise or other types of physical activity, the heart pumps faster and more forcefully. This increase the rate of delivery and removal of substances to respiring cells. In this investigation, you will investigate the effect of physical activity on the heart rate.

This experiment has links to the following syllabus content (2023–2025 syllabus):

- **9.2.4.** Investigate and describe the effect of physical activity on the heart rate.
- **9.2.11.** Explain the effect of physical activity on the heart rate.

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

- demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- plan experiments and investigations
- make and record observations, measurements and estimates.
- interpret and evaluate experimental observations and data.
- evaluate methods and suggest possible improvements.

Prior knowledge

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

- **9.2.1.** Identify in diagrams and images the structures of the mammalian heart, limited to: muscular wall, septum, left and right ventricles, left and right atria, one-way valves and coronary arteries.
- **9.2.2.** State that blood is pumped away from the heart in arteries and returns to the heart in veins.

Going forward

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

Briefing lesson: Circulatory system review

Resources	• Worksheet A
Learning objectives	By the end of the lesson: • **all** learners will be able to outline how to recognise the independent and dependent variables in an investigation into the effect of physical activity on the heart (pulse) rate. • **most** learners will be able to describe how to change the independent and measure the dependent variables in an investigation into the effect of physical activity on the heart (pulse) rate • **some** learners will be able suggest some of the problems and how they can be overcome during an investigation into the effect of physical activity on the heart (pulse) rate

Timings	Activity
5 minutes	**Starter/Introduction** Challenge learners to work in pairs to list all the words they know that relate to the heart. Ask for some suggestions and build up a mind map on the class whiteboard to review prior knowledge.
45 minutes	**Main lesson** Inform learners that they will move to a large, open area, and help to form a model of a closed, double circulatory system. Provide a large piece of thick string or rope and ask two learners to each hold one end of the string, then place a third learner in the middle holding a pair of scissors. Ask the other members of the class to give suggestions and instructions to enable the three learners to use the string to show how the double circulatory system in humans is arranged. Suggestions may include: • The blood flow is represented by the string. • The first learner and second learner meet and make a loop. • The third learner represents the heart and uses scissors to make cuts in the string to allow for the blood to pass into the atria (his or her two arms) and out of the legs (the two ventricles). Move around the learners during the activity and ask questions to extend understanding. For example, which structure keeps oxygenated blood and deoxygenated blood separate from one another in the heart? Suggest why there is a difference in the thickness of the walls of the right and left ventricles. Provide learners with **Worksheet A**. This extends their knowledge from the starter activity and consists of a series of questions related to the subject matter they will encounter in this investigation. Provide them with around 15 minutes to complete this task, before engaging learners with the mark scheme displayed on the board.

5 minutes	**Plenary** To promote higher-order thinking about the method and the underlying scientific basis, hold a brief round of closed '*always true/ sometimes true/ never true*' statements, which are aimed at refreshing prior knowledge. These could include the following examples: o 'The heart has oxygenated blood on its right side.' (never true) o 'The heart beats faster.' (sometimes true – during exercise) o 'The heart has four valves.' (always true) If the class is large, then learners could be provided with a sheet of paper with 'true' and 'false' printed upside down. When they hold up their pieces of paper, you will be able to assess all members of the class. To indicate that their answer is 'sometimes true,' learners could put their other hand in the air when they hold up 'true' to indicate that they have a justification to make. or The cardiac cycle is a very dynamic process, which learners can find difficult to visualise. Challenge them to make a flip-book, which consists of several similar images that are drawn on 15–20 different pieces of paper. Stapling these pieces of paper together will allow another person to 'bring the images to life' by quickly flicking between them. To support, provide a series of statements that describe the cardiac cycle that learners need to organise into the correct order.

Lab lesson: Option 1 – run the experiment.

Resources	• Worksheets B, C1 and C2 • Teacher instructions • Graph paper • Timer (e.g. on mobile phone) • Calculator (e.g. on mobile phone)
Learning objectives	By the end of the lesson: • **all** learners should describe how to investigate the effect of physical activity on the heart (pulse) rate. • **most** learners should be able to explain some of the considerations that are taken during an investigation into the effect of physical activity on the heart (pulse) rate. • **some** learners will be able to suggest improvements to an investigation into the effect of physical activity on the heart (pulse) rate.

Timings	Activity
15 minutes	**Starter/Introduction** Through a class discussion, ask learners to think back to their work on the need for transport systems. Discuss how the needs of mammals such as humans are likely to differ from those of plants, and why the type of transport system found in plants would not be adequate for an active mammal. • oxygen / glucose / water / other nutrients entering the cell • carbon dioxide / urea leaving the cell. They may know that these substances are brought to and from the cell in the blood. They may also give other details, such as that oxygen enters the blood in the lungs, or that nutrients enter the blood in the small intestine. Inform learners of the task ahead of them: to the effect of physical activity on the heart (pulse) rate. Inform learners of the approach that they will adopt – measuring the pulse in the neck or wrist – and encourage them to consider a plan for this investigation using the prompts on **Worksheet B**.
35 minutes	**Main lesson** Share a copy of **Worksheet C1** with each learner, which provides the method for the investigation. When they have had an opportunity to consider the missing words, then share **Worksheet C2** for self-assessment. Ask learners to read the method carefully and underline the verbs in each instruction. Provide an opportunity for learners to ask questions about the method. During the investigation, and as you circulate around the class, use appropriate prompts to stimulate discussion, examples of which are listed in **Teacher Instructions 1** that are targeted to learners of different abilities.

	As they undertake the experiment, ask learners to identify any steps in the method with which they experienced problems or difficulties; these notes will be useful when they come to evaluate the procedure in the *Debriefing lesson*. **Safety** Always circulate the classroom during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.
10 minutes	**Plenary** Learners will be at different stages of the practical activity towards the end of the lesson, with some likely to need the full hour to finish. If any learners finish early, provide them with graph paper and encourage them to plot a graph of their results (inform learners of the orientation of the axes). They should complete this for homework in advance of the *Debriefing lesson*.

Teacher notes

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

Each group will require:
- Timer (e.g. on mobile phone)
- Calculator (e.g. on mobile phone)

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.

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.

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 2–4 learners)
- the amount of equipment/chemicals required.

Experiment

Walk around the learners during the experiment in case they encounter any difficulties.

Step	Notes
1. Sit down for 5 minutes to be completely at rest.	Rationale for step 1: It is important to determine your resting heart rate.
2. Find the pulse in your wrist by putting the tip of your first finger on the inside of your wrist.	Rationale for step 2: N/A
3. Count how many heart beats you can feel for 20 seconds and record this number.	Rationale for step 3: N/A
4. Repeat this procedure five times and record the data.	Rationale for step 4: N/A
5. From this data, calculate your mean resting heart rate.	Rationale for step 5: N/A
6. Undertake some intense physical activity for 3-4 minutes.	Rationale for step 6: This will increase the heart rate.
7. Immediately after you have stopped exercising, measure and count your pulse for 20 seconds.	Rationale for step 7: N/A
8. Immediately after you have stopped exercising, take your pulse for 20 seconds at 30 second intervals for 5 minutes. Again, measure and count your pulse for 20 seconds.	Rationale for step 8: N/A

9. This process is repeated until the end of the period available for the practical.	Rationale for step 9: N/A

Clean-up

After the experiment learners should:

- tidy up their workspace.
- return all equipment to you.

Lab lesson: Option 2 – virtual experiment

Resources	• Worksheets B and C2 • Graph paper • Timer (e.g. on mobile phone) • Calculator (e.g. on mobile phone)
Learning objectives	By the end of the lesson: • ***all*** learners should describe how to investigate the effect of physical activity on the heart (pulse) rate. • ***most*** learners should be able to explain some of the considerations that are taken during an investigation into the effect of physical activity on the heart (pulse) rate. • ***some*** learners will be able to suggest improvements to an investigation into the effect of physical activity on the heart (pulse) rate.

Timings	Activity
15 minutes	**Starter/Introduction** Inform learners of the approach that they will adopt – measuring the pulse in the neck or wrist – and encourage them to consider a plan for this investigation using the prompts on **Worksheet B**.
30 minutes	**Main lesson** Learners watch the video as a summary of the experiment. Ask your learners to identify any key points they have missed out of their own method. You may then wish to give them some time to adjust their plan. Learners should take a few minutes to think about the answers, reflecting on the tasks of the main lesson to help them. Then they should be asked to discuss the answers with a partner for another 2 minutes, before writing down their final answers. If necessary, prompt discussion to elicit deeper understanding. All learners circulate around the room to compare and contrast their final answers. Share **Worksheet C2** with learners and discuss the method.
15 minutes	**Plenary** Provide learners with graph paper and encourage them to plot a graph of their results (they should place the independent variable on the x-axis and the dependent variable on the y-axis). This will be analysed in the *Debriefing lesson*.

Debriefing lesson: Modifying an investigation

Resources	• Worksheets D and E
Learning objectives	By the end of the lesson: • ***all*** learners should be able to analyse their data to make a conclusion regarding the effect of physical activity on the heart (pulse) rate. • ***most*** learners should be able to modify their method to investigate the effect of physical activity on the heart (pulse) rate. • ***some*** learners should be able to evaluate a method to investigate the effect of physical activity on the heart (pulse) rate.

Timings	Activity
15 minutes	**Starter/Introduction** Ask learners to consider their graphs from the *Lab lesson*. Group pairs of learners together and ask them to spend 2–3 minutes comparing each other's work – did they obtain similar results?
40 minutes	**Main lesson** Challenge learners to answer **Worksheet D** on their own. This activity shows an alternative set of data. The questions ask learners to consider what they did during the practical, and why, and encourage further analysis and evaluation of their data. Ask learners to discuss their answers with a partner. Invite each pair to offer their refined answers to the class and generate a class-wide discussion. Secondly, arrange learners into groups of 3–4 and explain that you want them to modify the method they employed in the Lab lesson to investigate the effect of a change in another factor on the effect of physical activity on the heart (pulse) rate. Provide each learner with a copy of **Worksheet E**. Inform them that they will need to collaboratively evaluate the method they employed in the previous lesson and decide which steps should be modified, how and why. Provide learners with the factor that they should investigate; an example is described in the Answers. You can withhold the checklist on **Worksheet E** for the first 5 minutes to keep the discussion regarding evaluation and planning more open, and then provide an opportunity for learners to reflect on what they had missed in their initial plan. Conclude with a whole-class discussion to give learners the opportunity to reflect on their work. The expected outcomes of this activity are given in the answers to **Worksheet E**; use this to make sure all learners have met the expected outcomes and to extend their thinking.
5 minutes	**Plenary** Encourage learners to construct Venn diagrams to compare the practical investigation involving temperature, and the practical investigation that they have just modified.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson:*		
Teacher Instructions: Planning prompts	**16**	**N/A**
A: Exploring the heart	**17**	**24**
For use in *Lab lesson:*		
B: Planning sequence	**19**	**N/A**
C1: Method	**20**	**N/A**
C2: Method: missing statements	**21**	**N/A**
For use in the *Debriefing lesson:*		
D: Analysing data	**22**	**N/A**
E: Modifying an investigation	**23**	**25**

Teacher instructions: Planning prompts

While your learners engage with **Worksheet A**, circulate and provide some prompts as necessary to aid discussions. Choose appropriate prompts based on the ability of the learners.

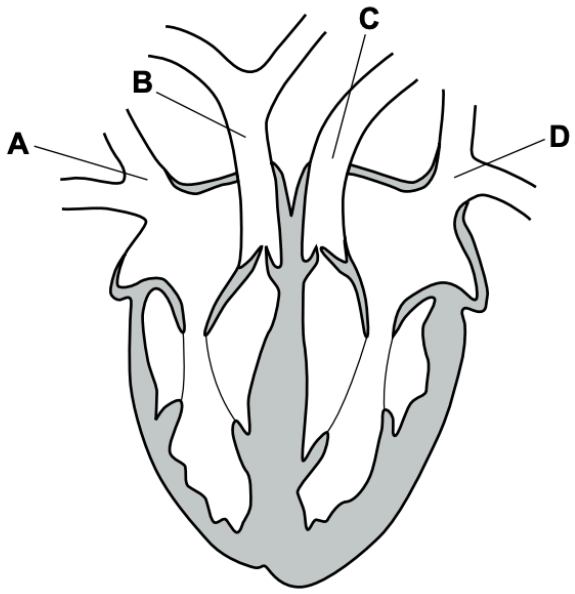
demand	prompt
LOW	is this a safe experiment?
	what is the title of the experiment?
	what is the difference between the independent and dependent variables?
	think about the order in which you will do things.
	consider what you would predict and phrase this as a hypothesis.
MEDIUM	think about the dependent variable – how will you judge how long to take your pulse?
	why should we keep all factors apart from the period of physical activity constant?
	why should we repeat the experiment on a different day?
	what is a 'control?' Is it necessary?
HIGH	think more about the independent variable – consider the terms 'range' and 'interval.'

Worksheet A: Exploring the heart

Question 1

The diagram shows a section through a human heart.

Which blood vessel is the pulmonary vein?



Question 2

What happens to the heart valves when the ventricles contract?

	atrioventricular valves	semilunar valves
A	close	close
B	close	open
C	open	close
D	open	open

Question 3

A student performed different types of activity.

She measured her heart rate during each type of activity in beats per minute (bpm).

The results are shown in Fig. 2.1.

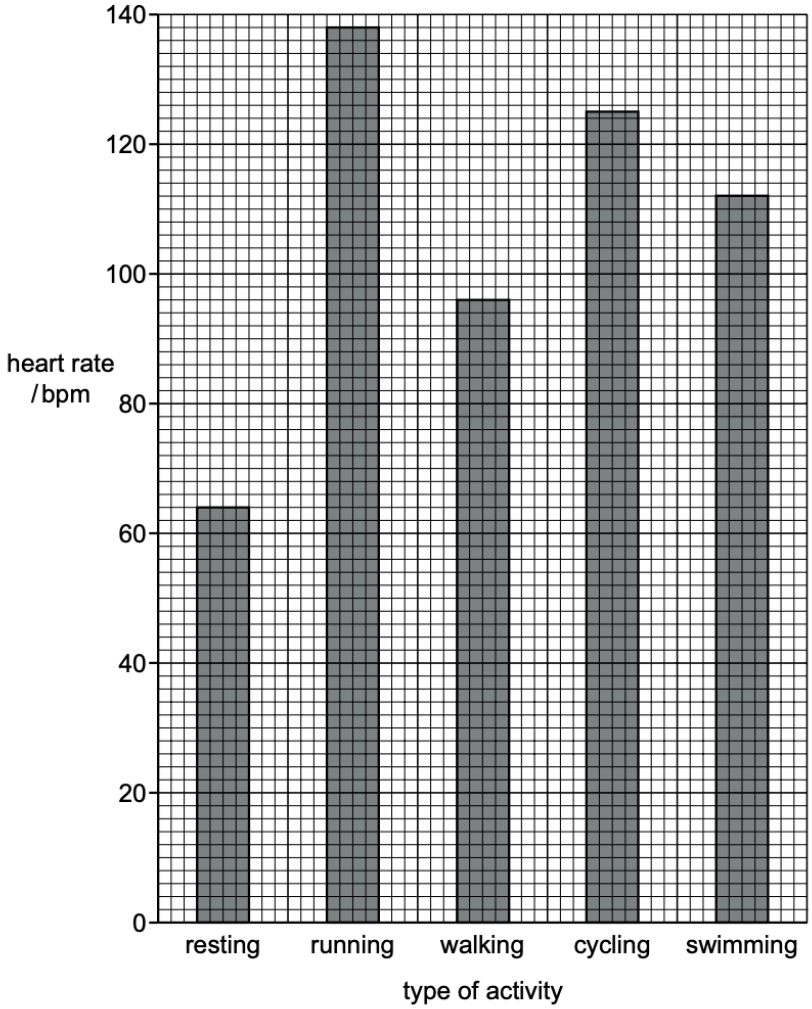


Fig. 2.1

(i) State the type of activity that results in the highest heart rate in Fig. 2.1.

..... [1]

(ii) State the heart rate of the student when she was cycling.

..... bpm [1]

(iii) Calculate the percentage increase in her heart rate between resting and walking.

.....%
[2]

Worksheet B: Planning sequence

Your teacher informed you of an approach that you should use to investigate the effect of physical activity on the heart (pulse) rate.

Plan an investigation to determine the effect of physical activity on the heart (pulse) rate. Number them from 1 to 10 to create a suitable sequence. Then use them as prompts to write your own plan.

Remember that a good plan requires you to focus on **what** will be investigated and **how** this will be achieved.

Decide how to measure the dependent variable, how often to measure it and consider whether you need to try to standardise the measuring procedure.	
Write a clear title for the experiment to clearly define the purpose of the experiment.	
Use the title to write a hypothesis.	
Identify any variables you should standardise. These are variables that may alter the results if they change. Decide how to keep them the same.	
Assess the risks of the procedure as low, medium or high by considering the hazards.	
Identify the independent and dependent variables, in other words, consider what you will change and what you will measure. The title and hypothesis can help with this – consider how the experiment will test your hypothesis.	
Decide how many times you will repeat each measurement to identify any anomalous results and to get a mean value.	
Decide how to change and measure the independent variable, the range of values to use, how many values to use and the intervals between the values.	
Work out the order in which you would need to do everything.	
Decide on a control that removes the effect of the independent variable.	

Worksheet C1: Method

1. Sit down for _____ minutes to be completely at rest.

2. Find the _____ in your wrist by putting the tip of your first finger on the inside of your wrist.

3. Count how many heart beats you can feel for _____ seconds and record this number.

4. Repeat this procedure _____ times and record the data.

5. From this data, calculate your _____ resting heart rate.

6. Undertake some intense physical activity for _____ minutes.

7. Immediately after you have stopped exercising, measure and count your pulse for _____ seconds.

8. Immediately after you have stopped exercising, take your pulse for 20 seconds at _____ second intervals for 5 minutes. Again, measure and count your pulse for 20 seconds.

Worksheet C2: Method: missing statements

1. Sit down for 5 minutes to be completely at rest.

2. Find the pulse in your wrist by putting the tip of your first finger on the inside of your wrist.

3. Count how many heart beats you can feel for 20 seconds and record this number.

4. Repeat this procedure five times and record the data.

5. From this data, calculate your mean resting heart rate.

6. Undertake some intense physical activity for 3-4 minutes.

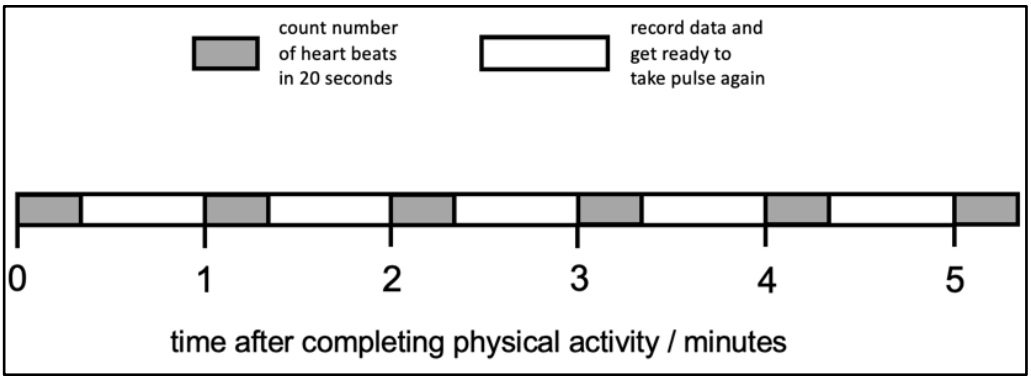
7. Immediately after you have stopped exercising, measure and count your pulse for 20 seconds.

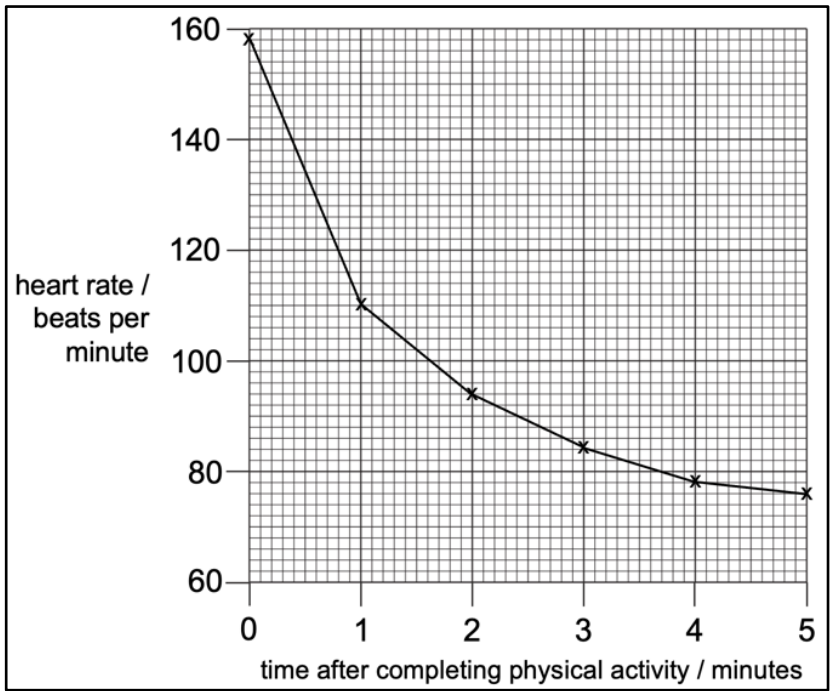
8. Immediately after you have stopped exercising, take your pulse for 20 seconds at 30 second intervals for 5 minutes. Again, measure and count your pulse for 20 seconds.

Worksheet D: Analysing data

The table and graph below should look like the one that you have prepared. Use this to help you answer the questions that follow.

mean resting heart rate / beats per minute	heart rate after completing physical activity / beats per minute					
66	158	110	94	86	78	76





Questions

1. On how many occasions did the student measure their heart rate after exercise?

2. What is the percentage decrease in heart (pulse) rate during the 5 minutes after exercise?

3. Explain the relationship shown in the graph.

Worksheet E: Modifying an investigation

In this activity, you will modify the method you used in your investigation to explore the effect of a different factor on the heart (pulse) rate.

Write the research question provided by your teacher below:

How does a change in _____ affect the heart (pulse) rate?

1. Complete the table below to compare the investigation you carried out with the investigation you are required to plan.

feature	previous investigation	modified investigation
independent variable (IV)		
range of IV		
intervals of IV		
standardised variables (min. 3)		
control experiment		

You will need to consider how you could check for anomalous readings in your data and calculate a mean in another way to ensure that your results are reliable.

You will present your method as a poster to the rest of the class.

To help structure your poster, use the following checklist.

Has your group:

1. Identified an appropriate range and internal for your independent variable?
2. Described how other variables that could affect heart (pulse) rate will be controlled?
3. Described how the dependent variable can be objectively and precisely measured to minimise the effect of random and systematic errors on the accuracy of the data?
4. Identified a hazard in the experiment and how a safety precaution will be followed to minimise risk?
5. Shown how you will record your data in a table and how you will improve the reliability of your data?
6. Made a prediction?

Worksheet A: Answers

Question 1
D

Question 2
B

Question 3
(i) running
(ii) 125 beats per minute (bpm)
(iii) 50%

Worksheet D: Answers

Suggested answers to questions

1. On how many occasions did the student measure their heart rate after exercise?

   There were six occasions during which the student counted the number of heart beats during a twenty-second period.

2. What is the percentage decrease in heart (pulse) rate during the 5 minutes after exercise?

   Percentage decrease = (final heart rate minus initial heart rate) divided by initial heart rate. This is (76 – 158) / 158. This gives a value of –52%.

3. Explain the relationship shown in the graph.

   Immediately after exercise, the lactic acid produced anaerobically by the muscles of the student, during the period of intensive exercise, must be broken down using oxygen. The heart rate is high to deliver a high volume of blood to the muscles, to remove this lactic acid, and to the liver to supply this oxygen. As time goes on, less lactic acid remains, which means that the heart does not need to beat as fast.

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