

Using the BEST resources in your physics teaching (with a focus on Electric Circuits)

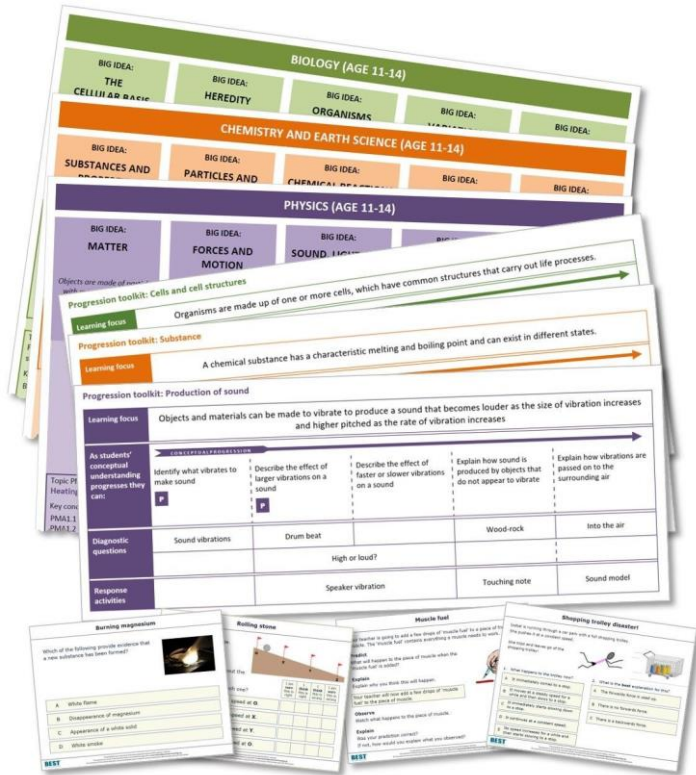
48th Stirling Physics Teachers Meeting
Thursday 25th May 2023

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- Physics Teacher at Banchory Academy, Aberdeenshire
- [@aphysicsteacher](https://twitter.com/aphysicsteacher)



Brief introduction to BEST resources



BEST 11-16 Physics:

- 479 diagnostic questions
- 257 response activities
- 77 learning progressions

The best teaching draws on the best evidence

BEST™

Best Evidence Science Teaching

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Salters'
Institute

IOP
Institute of Physics

- Research evidence-informed progression toolkits for key concepts in 11-16 science
- appropriately-sequenced steps for learning progression

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Is it a bird...?



Colour change

Compound A and compound B are added to a small glass jar. Both compounds are white. A lid is placed on the jar. The jar is shaken. A yellow colour appears.



What do you think about each statement?

	I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong
1 A yellow substance has been released from the white powder.				
2 The white powder has changed colour.				
3 One of the white substances has changed into a yellow substance.				
4 A new yellow substance has been formed.				

Comparing melting

Steady force

A dynamics trolley is pulled with a steady force. It is pulled by a weight hanging over a pulley.



Predict

What do you think a distance-time graph of the trolley's movement will look like?

Explain

Why do you think the graph will look like this?

Watch the demonstration

Observe

Sketch a distance-time graph of how the trolley moves.

Explain

Were your prediction and explanation correct? Try to improve your first explanation to explain what happens more clearly.

Progression toolkit: Production of sound
A substance can be made to vibrate to produce a sound that becomes louder as the size of vibration increases

Progression toolkit: Cells and cell structures
Organisms are made up of one or more cells, which have common structures that carry out life processes.

Progression toolkit: Substance

Learning focus	A chemical substance has a characteristic melting and boiling point and can exist in different states.				
As students' conceptual understanding progresses they can:	CONCEPTUAL PROGRESSION →				
	Recognise that a substance may exist in the solid, liquid or gas state, depending upon the temperature.	Match observations of melting (or cooling) to the temperature at which they take place.	Match observations of boiling to the temperature at which they take place.	Distinguish the scientific use of the word pure from the everyday meaning.	Distinguish a pure sample of a substance from an impure sample (mixture) by recognizing that a sharp melting point is characteristic of a pure sample of a substance.
Diagnostic questions	Possible states	Melting observations	Boiling observations	Pure or mixture?	Melting and purity
		Cooling observations			
Response activities	Unusual states	Comparing melting		All that glitters...	Contamination mystery

DIAGNOSTIC
QUESTIONS

RESPONSE
ACTIVITIES

PROGRESSION
TOOLKITS IOP Institute of Physics
Scotland



BEST Biology (age 11 to 16)



The cellular basis of life



Heredity and life cycles



Organisms and their environment



Variation, adaptation and evolution



Health and disease



BEST Chemistry and Earth Science (age 11 to 16)



Substances and properties



Particles and structure



Chemical reactions



Earth chemistry



Dynamic Earth



BEST Physics (age 11 to 16)



Matter



Forces and motion



Sound, light and waves



Electricity and magnetism



Earth in space

Physics Map of “Big Ideas”

- Matter (PMA)
- Forces and Motion (PFM)
- Sound, Light and Waves (PSL)
- Electricity and Magnetism (PEM)
- Earth in Space (PES)

Where's energy?

- Can something happen, not will it happen
- Calculations based on assumptions
- Does not explain how or why

Energy features in each of the “Big Ideas” of physics.

Primers



Using diagnostic questions

An introduction to using diagnostic questions to provide evidence of learning, diagnose misunderstandings and decide what to do next.



Using response activities

An introduction to using response activities to challenge misunderstandings, encourage metacognition and facilitate progress in



Teaching energy

An introduction to building students' understanding of energy using the stores and pathways approach.

Diagnostic Questions

help you to collect:

- evidence of where your students are in their conceptual progression
- evidence of common misunderstandings and preconceptions.

Can be used formatively to decide what to do next.

Response Activities

- encourage students to talk and think about what they're thinking (metacognition)
- facilitate purposeful practical work
- encourage meaning making.

Help to challenge misunderstandings and overcome barriers to conceptual development.

Big Ideas (PEM)

- Guidance notes
 - Challenging content, so teach late in 11-14
 - Battery v cell
 - Voltage v potential difference
- Learning progression
 - Science story at age 5-11, 11-14, 14-16

Big Ideas (PEM)

- Key concepts with suggested order

11-14:

Topic PEM1

Simple electric circuits

Key concepts:

- PEM1.1 Making circuits
- PEM1.2 Electric current
- PEM1.3 Voltage
- PEM1.4 Static electricity

Topic PEM2

More electric circuits

Key concepts:

- PEM2.1 Resistance
- PEM2.2 Parallel circuits

Topic PEM3

Magnets and electromagnets

Key concepts:

- PEM3.1 Magnetic fields
- PEM3.2 Electromagnets

14-16:

Topic PEM4

Electric fields

Key concepts:

- PEM4.1 Moving charge

Topic PEM5

Circuit calculations

Key concepts:

- PEM5.1 Analysing series circuits
- PEM5.2 Analysing parallel circuits

Topic PEM6

Circuit components

Key concepts:

- PEM6.1 Components with changing resistance
- PEM6.2 Sensing components

PEM Topics for age 11-14*

- Simple electric circuits
- More electric circuits
- Magnets and electromagnets

* Some BGE content will be in the 14-16 materials

PEM Topics for age 14-16


- Electric fields
- Circuit calculations
- Circuit components
- Electromagnetism
- Mains electricity

Key concept teacher notes (PEM1.1: Making circuits)

- Developing understanding of big idea
 - foundations for understanding of unfamiliar concepts such as current and voltage (PEM 1.2 and PEM 1.3)
- Progression Toolkit(s)
- Research notes
- Guidance

Progression toolkit (PEM1.1 1 of 2)

Progression toolkit: Circuit diagrams

Learning focus	Electric circuits are represented using circuit symbols and specific circuit diagram conventions				
<p>As students' conceptual understanding progresses they can:</p>					
Diagnostic questions	Circuit from a picture	Circuit symbols	Circuit diagrams (1)	Circuit from a diagram	Circuit diagrams (2)
Response activities	Building circuits (1)			Building circuits (2)	Drawing circuits
	<p>Build simple circuits from pictures or demonstrations.</p> <p>P</p>	<p>Identify components from their circuit symbols, and draw the circuit symbol for common components.</p> <p>P</p>	<p>Identify circuit diagrams that represent a series circuit by tracing round the circuit.</p> <p>P</p>	<p>Interpret circuit diagrams to build series circuits.</p> <p>P</p>	<p>Use circuit symbols and circuit diagram conventions to draw clear and precise circuit diagrams of electrical circuits.</p> <p>P</p>

Key:


P Prior understanding from earlier stages of learning

DQs and RAs (PEM1.1 1 of 2)



BEST STUDENT WORKSHEET



Circuit from a picture

Can you tell what electrical circuit is shown in the picture below?



Which picture shows this circuit set up in the right way?

A  B 

C  D 


Simple multiple choice

BEST STUDENT WORKSHEET

Circuit symbols





How can you use circuit symbols to make a circuit diagram?

1. Symbols



What is the circuit symbol for a bulb?

What is the circuit symbol for a battery?


A  B  C  D 

Simple multiple choice

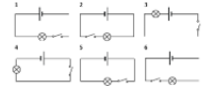
BEST STUDENT WORKSHEET

Circuit diagrams (1)

Look at this circuit



Which circuit diagram shows the circuit in the right way?



Which of the circuit diagrams shows how to connect the circuit?

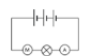
A. Circuit diagram 1 B. Circuit diagram 2 C. Circuit diagram 3 D. Circuit diagram 4

Simple multiple choice



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

Circuit from a diagram

Look at this circuit



Which picture shows this circuit set up in the right way?


A  B 

C  D 

Simple multiple choice

BEST STUDENT WORKSHEET

Circuit diagrams (2)



Identify the circuit that is not the best practice use of symbols. Also identify the best diagram.

How did you do? Best score for best practice using symbols is 10. How did you do? Best score for best practice using symbols is 10.

Worksheet	Part 1 (10 marks)	Part 2 (10 marks)	Part 3 (10 marks)	Part 4 (10 marks)	Part 5 (10 marks)
A					
B					
C					
D					
E					

Confidence grid

BEST STUDENT WORKSHEET



Building circuits (1)



Prepare and assemble

- 1 x 3.0 V battery
- 1 x 2.0 V bulb
- 1 x 1.5 V bulb
- 1 x 1.0 V bulb
- 1 x 0.5 V bulb
- 1 x 0.2 V bulb

Procedure

1. Build each circuit.
2. For each circuit, build the circuit as compared to each circuit.

Circuit 1  Circuit 2 

Circuit 3  Circuit 4 

Application and practice - practical

BEST STUDENT WORKSHEET



Building circuits (2)



Prepare and assemble

- 1 x 3.0 V battery
- 1 x 2.0 V bulb
- 1 x 1.5 V bulb
- 1 x 1.0 V bulb
- 1 x 0.5 V bulb
- 1 x 0.2 V bulb

Procedure

1. Build each circuit.
2. For each circuit, build the circuit as compared to each circuit.

Circuit 1  Circuit 2 

Circuit 3  Circuit 4 

Application and practice - practical

BEST STUDENT WORKSHEET

Drawing circuits

Make a circuit diagram for the bulb

Procedure

1. Build each circuit.
2. For each circuit, draw a circuit diagram.

Check to make

1. Are the circuit symbols used for the battery, bulb, and switch?
2. Are the circuit symbols used for the battery, bulb, and switch?
3. Are the circuit symbols used for the battery, bulb, and switch?
4. Are the circuit symbols used for the battery, bulb, and switch?
5. Are the circuit symbols used for the battery, bulb, and switch?
6. Are the circuit symbols used for the battery, bulb, and switch?
7. Are the circuit symbols used for the battery, bulb, and switch?


Application and practice - practical

Diagnostic Question PowerPoints

Bulb in a circuit

A torch battery has two contact points. It has one at each end.

A torch bulb has two contact points. One is at the top and the other is on the screw thread.




BEST

1

Bulb in a circuit

a. Will the bulb light?



A

Lit

B


Not lit

BEST

2

Bulb in a circuit

b. Will the bulb light?



A

Lit

B


Not lit

BEST

3

Bulb in a circuit

c. Will the bulb light?



A

Lit

B


Not lit

BEST

4

Bulb in a circuit

d. Will the bulb light?



A

Lit

B


Not lit

BEST

5

Bulb in a circuit

e. Will the bulb light?



A

Lit

B

Not lit

BEST

6

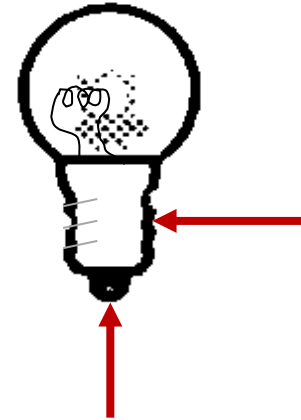
Bulb in a circuit

A torch battery has two contact points. It has one at each end.



A torch bulb has two contact points.

One is at the tip and the other is on the screw thread.



Bulb in a circuit

d. Will the bulb light?



A Lit


B Not lit

Diagnostic Question Word Documents


BEST STUDENT WORKSHEET

Bulb in a circuit

A torch battery has two contact points. It has one at each end.





A torch bulb has two contact points. One is at the tip and the other is on the screw thread.





Look at the pictures below. They show different ways of connecting the battery and the bulb.


For each, tick one box (✓) to show if the bulb is lit or not.


a.  Lit Not lit

b.  Lit Not lit

c.  Lit Not lit

d.  Lit Not lit

e.  Lit Not lit

f.  Lit Not lit

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BEST TEACHER NOTES

Physics • Big Idea PEM: Electricity and magnetism • Topic PEM: Simple electric circuits • Key concept PEM 2: Making circuits

Diagnostic question

Bulb in a circuit

Overview

Learning focus:	An electric circuit is a closed conducting loop containing a battery.
Observable learning outcome:	Describe how a simple circuit can be used to test for faulty components, and trace the circuit through components to identify breaks in the conducting loop.
Question type:	Simple multiple choice
Key words:	Bulb, battery, complete circuit

What does the research say?

Building complete circuits is an idea that many students have seen earlier in their learning, but it is in their first experience of electric circuit work in a new school that unfamiliar equipment and surroundings will impair their ability to recall what they know (Björman, 2000). Familiarisation with new equipment is an important part of this task.

When given a bulb, battery (not in holders) and a connecting wire, many 8-12 year olds, and many older students too, cannot make the bulb light up (Shapiro, 1985). These students typically treat the bulb as a one-terminal sink and connect the wire only one connection point. Usually the one on the end of the bulb.

What most students can identify a complete circuit from a picture or a circuit diagram (Best, 1994), this activity develops understanding of how current needs to flow through the components as well as through the wires, and supports the scientific model for the conservation of current.

Being able to build a circuit successfully is essential if students are to use electric circuits to develop their understanding of electricity.

Ways to use this question

Students should complete the question individually. This could be a pencil and paper exercise, or you could use an electronic wiring board or mini-white boards and the PowerPoint presentation. The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did, ask another student to explain why they agree with them, ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

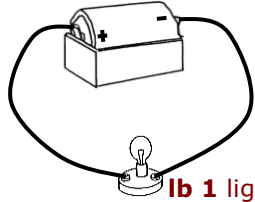
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- Student Worksheet
 - Laminate or assign online
- Teacher Notes
 - What is being checked
 - What the research says
 - Usage ideas
 - Answers
 - Next steps

Building circuits (1)

Build these circuits

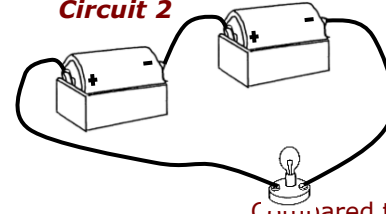
Circuit 1



bulb 1 lights up

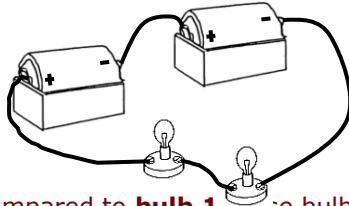
this bulb is

Circuit 2



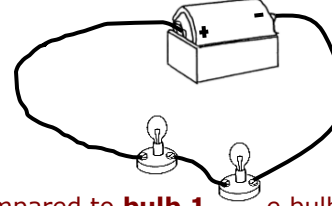
Compared to **bulb 1**

Circuit 3



Compared to **bulb 1** these bulbs are

Circuit 4



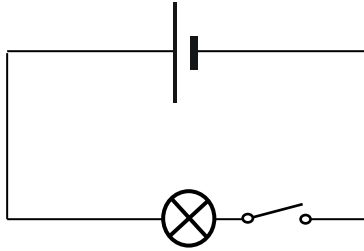
Compared to **bulb 1** these bulbs are

Building circuits (2)

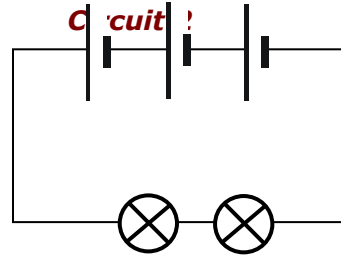
Build these circuits

For each circuit describe what happens

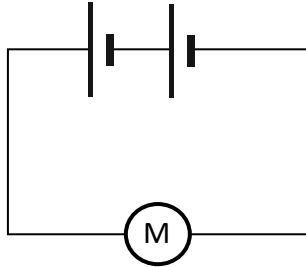
Circuit 1



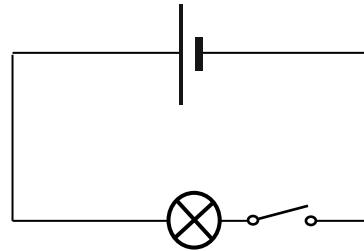
Circuit 2



Circuit 3



Circuit 4



Response Activities

BEST STUDENT WORKSHEET

Building circuits (1)

A practical activity to make electric circuits from pictures.


Apparatus and materials

- X2 1.5 V battery in holder
- x2 2.5 V bulb in holder
- x4 connecting leads

Procedure

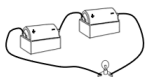
1. Set up each circuit.
2. Write down how bright the bulbs are compared to bulb 1.

Circuit 1



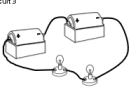
Bulb 1 lights up

Circuit 2



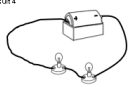
Compared to bulb 1 this bulb is _____

Circuit 3



Compared to bulb 1 these bulbs are _____

Circuit 4



Compared to bulb 1 these bulbs are _____

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BEST TEACHER NOTES

Physics > Big Year PDM: Electricity and magnetism > Topic PDM1: Simple electric circuits > Key concept PDM1.1: Making circuits

Response activity

Building circuits (1)

Overview

Learning focus:	Electric circuits are represented using circuit symbols and specific circuit diagrams: conventions.
Observable learning outcome:	Build simple circuits from pictures or demonstrations.
Activity type:	Application and practice - practical
Key words:	Electric circuit, circuit symbol, connecting wire, battery, bulb

This activity can help develop students' understanding by addressing the sticking points revealed by the following diagnostic question:

- Diagnostic question: Circuit from a picture

P **PRIOR UNDERSTANDING**
This activity explores ideas that are usually taught stages 5-11, to aid transition from earlier stages of learning.

What does the research say?

Building complete circuits is an idea that many students have seen earlier in their learning, but if this is their first experience of electric circuit work in a new school then unfamiliar equipment and terminology will impact their ability to recall what they know (Spencer, 2000).

Students generally set up circuits correctly if they approach circuit building in a systematic way. Eg starting at one point in the circuit and connecting each component or wire in order, going clockwise or anti-clockwise from that point. However if students always start at the battery, then this may reinforce the misconception that electric charge originates at the battery and moves sequentially through each component in turn. Starting with different components each time mitigates this concern.

Ways to use this activity

This practical activity gives students the opportunity to build circuits from pictures and describe what happens in the working circuits. Each individual student needs to construct the circuits, so if they are working in pairs they need to take turns.

Observing individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

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- Student Worksheet
 - Poly-pocket / card
- Teacher Notes
 - What is being checked
 - What the research says
 - Equipment list
 - Technician notes
 - Health and Safety
 - Expected Answers

For a quick win

- Download a single key concept
- Check progression toolkit order
- Find 1 DQ that gives the best formative assessment and embed into teaching
- Realise how useful it is, then add more

Getting the most out of BEST

- Download a whole Big Area
- Check each key concept order and guidance
- Print progression toolkit(s) and DQ/RA list
- Pick the best and embed

Handouts

- (How) Would you add these to your teaching?
- Do you have any questions?