Question-writing taster workshop

Dr. Nicki Humphry-Baker, Kimlam Nguyen and Ingrid Murray

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Developing question-writing with Isaac

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Writing for a purpose

Nicki Humphry-Baker

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My Aims

- Practise the fundamentals of physics
- Develop intuition
- Become comfortable with the maths
- Challenge misconceptions

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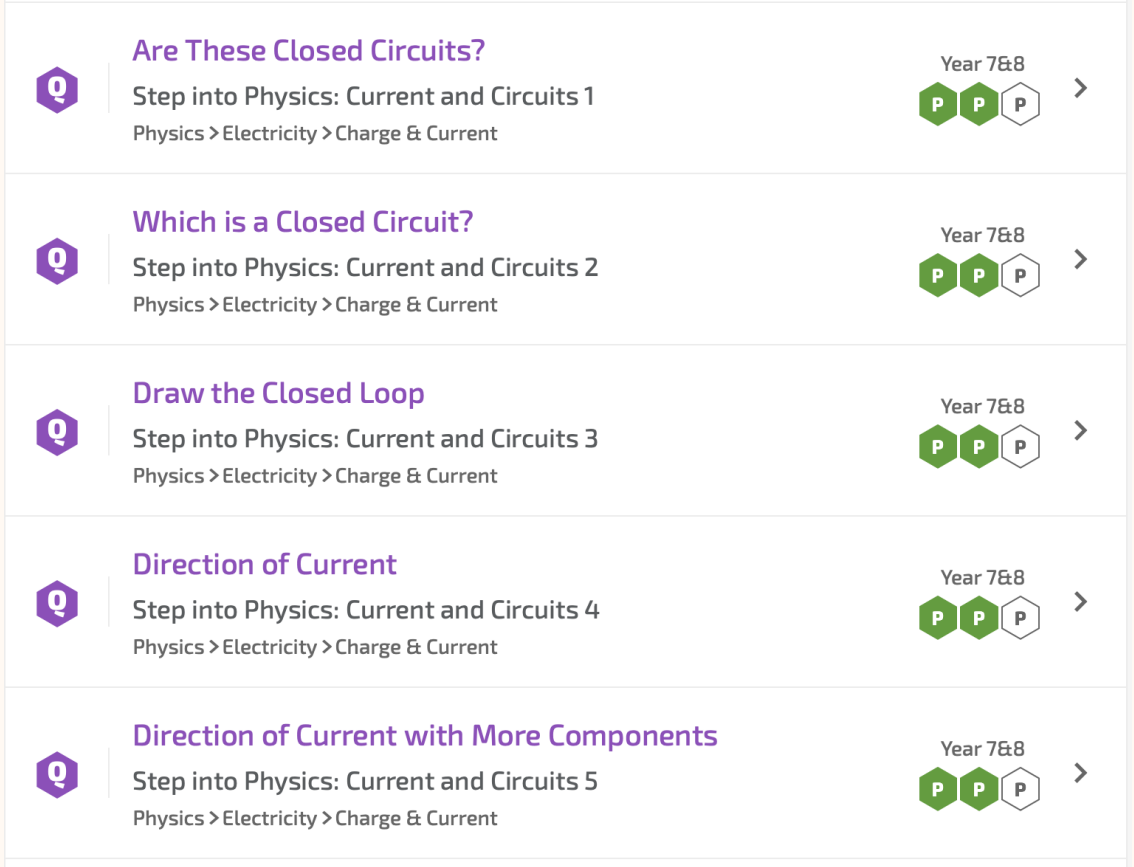
Practise the Fundamentals

Design:

- set of questions on one concept
- increase difficulty of each question – more complicated situations, novel situations



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Develop Intuition

- Questions that are subtly different to a previous one
- One or two questions that combine concepts
- Make it relatable

Helps the students to start developing their problem solving skills.

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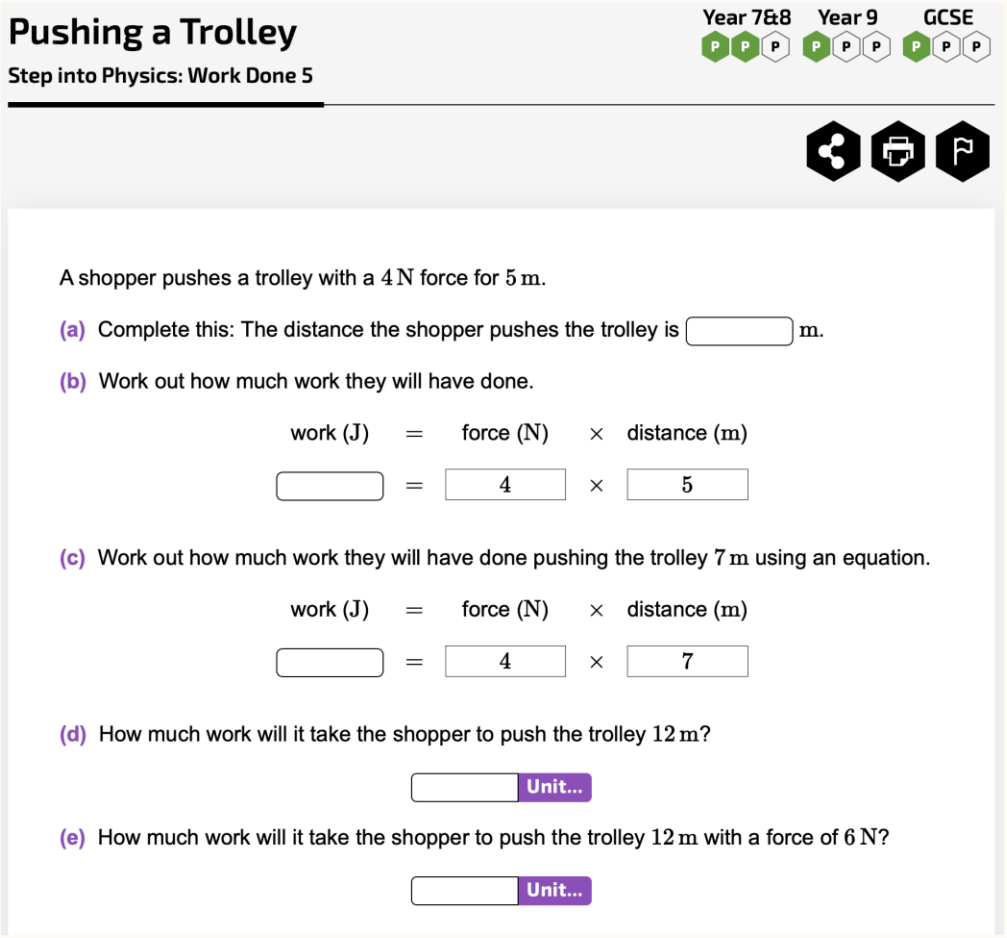
Become Comfortable with the Maths

- Use their maths skills in the questions
- Scaffold it



Pushing a Trolley

Year 7&8 Year 9 GCSE

Step into Physics: Work Done 5

A shopper pushes a trolley with a $4\,\mathrm{N}$ force for $5\,\mathrm{m}$.

(a) Complete this: The distance the shopper pushes the trolley is [ ] m.

(b) Work out how much work they will have done.

work (J) = force (N) × distance (m)

[ ] = 4 × 5

(c) Work out how much work they will have done pushing the trolley $7\,\mathrm{m}$ using an equation.

work (J) = force (N) × distance (m)

[ ] = 4 × 7

(d) How much work will it take the shopper to push the trolley $12\,\mathrm{m}$?

[ ] Unit...

(e) How much work will it take the shopper to push the trolley $12\,\mathrm{m}$ with a force of $6\,\mathrm{N}$?

[ ] Unit...

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Challenge Misconceptions

- Set of questions to challenge a misconception
- Use set of questions practising fundamentals to avoid the misconception earlier on, or as a refresher

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My Inspiration

- World around me
- What students get stuck on or misconceptions
- What I know from experience they don’t understand well

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Practice & confidence-building questions

Task:

- Choose an equation your students need practice with

- Write 6-10 practice questions involving this equation.
  - First questions just involve ‘plugging numbers’
  - Later ones involve more complex re-arrangement
  - One or two can involve a challenge
  - Make the contexts of some questions relevant to applications
  - Make a question or two have visual impact
  - Ensure it is easy to mark!

Example: GCSE: $E = qV$

- Write 6-10 practice questions involving this equation.
  - How much energy is given to a 0.002C charge by a 9V battery?
  - Calculate the potential difference needed to give 50J to 0.25C of charge.
  - How much energy does a 240V supply give to 9nC?
  - Calculate the kinetic energy of an electron accelerated across 10kV in an X-ray machine.
  - A cat stands on a carpet and rubs itself against a sofa gaining 5mJ of electrostatically stored energy and 10nC of charge. What is its potential difference?

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Problem solving questions for A Level Physics

Kimlam Nguyen
Content Developer

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Writing problem solving questions

- **Audience**: A Level students who enjoy Physics & Maths and want to apply their knowledge from the course to challenging problems

- **Aims**:
  - To write problems which test a student's problem-solving skills
  - To reinforce the connection between Physics and Maths
  - To improve fluency in applying and manipulating equations
  - To consolidate A Level concepts and using them in unfamiliar situations

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What makes a good question?

- Something a bit different:
  - Unusual setups / unfamiliar applications
- Familiar concepts:
  - Should be topics covered on the specification – no extra reading
- Multiple-step reasoning (may be more than one valid method):
  - ’first use this equation, then this assumption, then another equation’
- Avoids unnecessary complexity:
  - E.g. awkward unit conversions (lbf/in^2 -> MPa)
- Provides enough information to clearly define the setup, but also concise
- Neat answer (not always necessary)

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Step 1: Come up with an idea

- Often the most difficult part!
- Choose a pair of topics/concepts, and think of ways to combine them
- Choose an interesting set-up/geometry
- Has to be physically correct, but doesn't have to be practical!
- Look at past papers/Olympiad papers
- Random inspiration (write down the idea for later)

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Step 2: Do the algebra

- The question may fail:
  - Not the right level
  - Equations too complicated
  - Too many assumptions
  - Back to Step 1!

- Decide whether the answer should be numeric or symbolic

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Step 3: Write it up

- Decide whether you will give the diagram in the question, or expect the student to draw their own based on the information given
- State assumptions, variables, constants
- Check if values given are sensible
- Length:
  - I usually aim for ½ A4 page of algebra for a typical challenge question

- Number of parts?
  - Typically 1–3 parts; too much structure will guide the student along a particular method

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Step 4: Review

- Give to a student or another teacher (or AI?)
- Question might need rewording / diagram might need changes etc.
- Useful to see another person's method
- Should be challenging yet solvable and fun!

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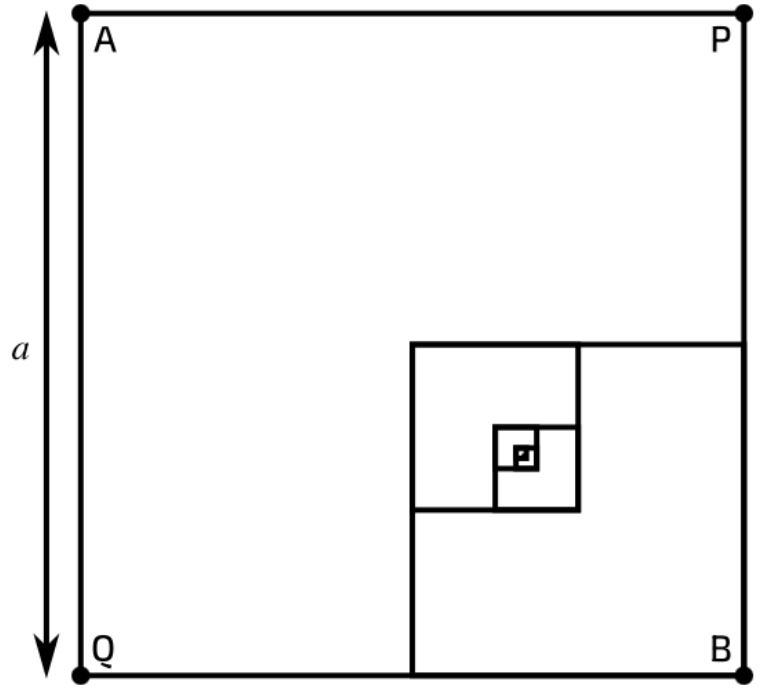
Example: Resistor Recursion (A Level C2)

The pattern in **Figure 1** shows a square of side length a.

From the midpoints of two adjacent sides, straight lines of equal length are drawn to divide the square into the ratio $3 : 1$ by area. The process is repeated infinitely within the smaller piece of the square each time.

This pattern is recreated using a thin wire, with uniform resistance per unit length k. Although it is not physically possible to perfectly recreate this infinitely repeating pattern, we are interested in the limit of large numbers of repetitions.



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Example: Moving Fringes (A Level C3)

A double slit aperture is printed on a thin, transparent and flexible film. The film is stretched from the sides with a time-varying force so that the slit separation d is given as a function of time t as

$$d(t) = d_0 \left(1 + \frac{2}{7} \sin \omega t\right),$$

where d_0 and ω are constants.

Coherent monochromatic light of wavelength λ passing normally through the aperture produces a diffraction pattern on a screen placed a distance L away from it. The fringes can be assumed to be evenly spaced on the screen.

Find an expression for the maximum speed of the 3rd order maxima as viewed on the screen.

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Example: Toroidal Motion (A Level C3)

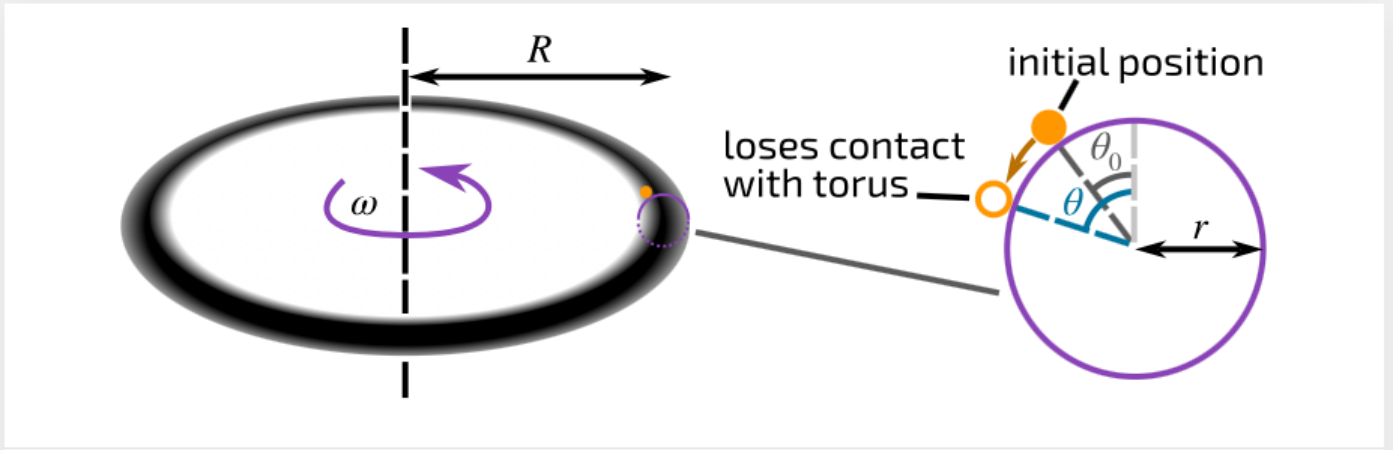

Figure 1: A torus of outer radius R, rotating at angular velocity ω. A close-up of the cross-section which contains the mass. [*A torus is the shape of a doughnut. Specifically, it is the surface which is created when a circle is revolved completely about an axis in the same plane. In this question, this axis is far outside of the circle.*]

A smooth rigid torus is rotating at angular velocity ω about a vertical axis through its centre. It has two radii, r and R as shown in **Figure 1**, and $r \ll R$.

A point mass lies on the outer surface of the torus, and is co-rotating with it in a horizontal plane (it is moving in the **toroidal direction**). It is given a very small impulse, perpendicular to its velocity, and begins to slide downwards along a cross-sectional circle of radius r (it starts moving in the **poloidal direction**). The acceleration due to gravity g is downwards.

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Task 2:
Developing skills: writing for a purpose

- Pick a particular purpose and decide on the appropriate format, style, tone, content.
- Try to write a question for a stated purpose e.g. exam question for Year 11 on series and parallel resistor rules.
- Will you include a diagram? Why did you take this decision?

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Embedding diversity and inclusion in question-writing

- Who writes the questions?
- Who reads the questions?
- What do questions teach us about physics?
- What do questions teach us about society?

- **Increasing the diversity of teachers who feel confident to write questions will enrich our perspective on physics and make students and teachers feel more welcome in the physics community**

1 Discuss, in terms of quantitative relationships where possible, the factors that determine the acceleration of a skier on a ski slope. [8 *marks*]

A small sphere is released from rest and, after falling a vertical distance of 0·5 m, bounces on a smooth plane which is inclined at 10° to the horizontal. If the sphere loses no energy during the impact, why do its directions of motion immediately before and immediately after the impact make equal angles with the normal to the plane? [4 *marks*]

Find the distance, measured down the plane, between this impact and the next. [8 *marks*]

https://www.cambridgeassessment.org.uk/Images/1974j-physics-alevel-questionpaper.pdf

Two skaters are standing, at rest, opposite each other on an ice rink.

Skater **A** has a mass of 40 kg and skater **B** has a mass of 50 kg.

Skater **A** pushes against skater **B** with a force of 30 N.

(a) **(i)** What does Newton's third law tell us about the force that skater **A** experiences from skater **B**?

https://www.ocr.org.uk/Images/678042-question-paper-paper-3.pdf

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