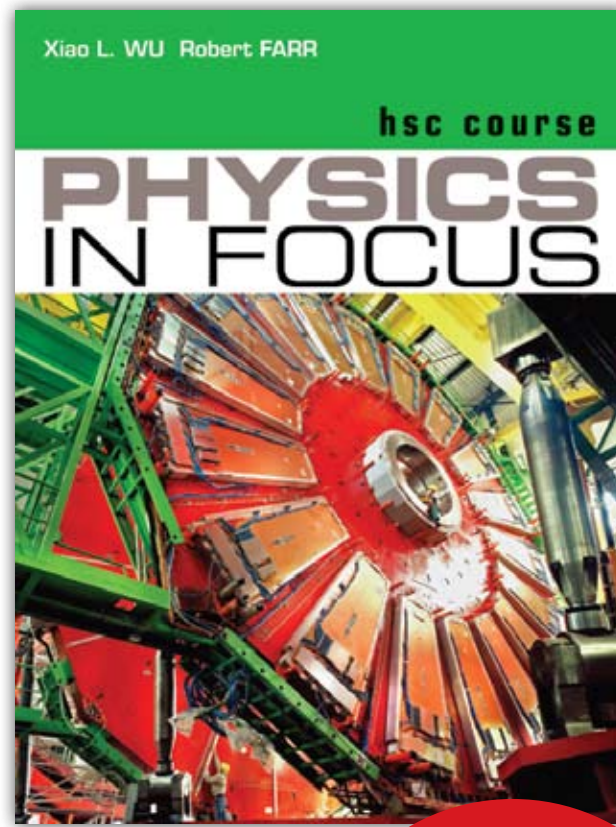
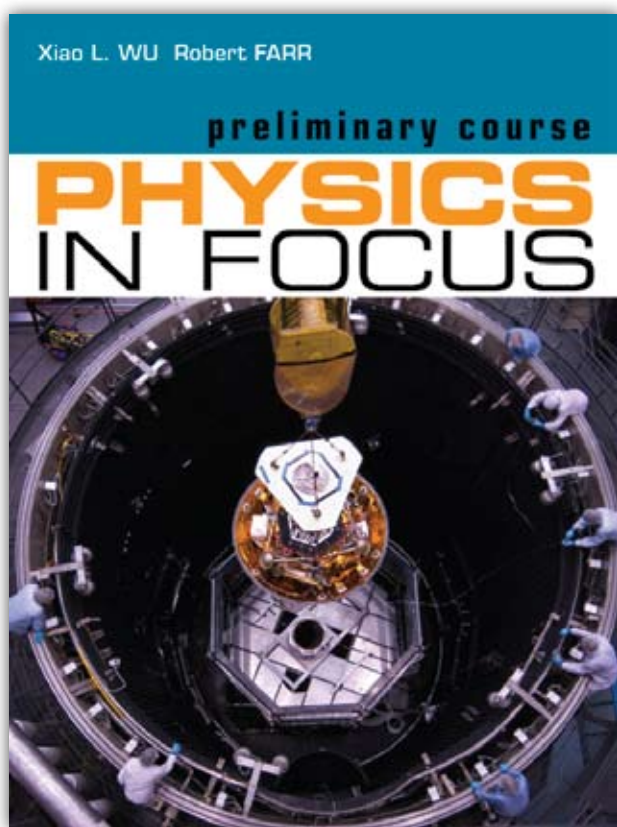


PHYSICS IN FOCUS



**Mc
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Ensure exam success with the unique 'dot point' approach of Physics in Focus

FOCUS ON RESULTS

Authors: Xiao L. Wu and Robert Farr

FOCUS ON RESULTS

The dynamic new series *Physics in Focus* aims to motivate students and encourage an interest in Physics by giving it new relevance and looking at its impacts on society and the environment throughout history.

Physics in Focus offers a straightforward approach that takes the guesswork out of teaching and learning the NSW Stage 6 Physics syllabus, with a comprehensive format that addresses each syllabus dot point and integrates first-hand and secondary source investigations throughout. Practice questions are included at the end of each chapter and each module to ensure that students are given the opportunity to continually revise.

Icons indicate related content available on the Student Resource CD-ROM

Notes are included throughout the text, highlighting tips and hints or clarifying difficult concepts

Secondary Source Investigations are clearly marked, with the related PFA and corresponding outcomes listed

11.8 Using Einstein's explanation to investigate the photoelectric effect

In section 11.5 (page 197) we listed some properties of the photoelectric effect and, as mentioned in the same section, these properties **cannot** be explained by classical physics. However, it is easy to explain them using Einstein's quantum mechanical approach.

Most of the answers lie in Einstein's equation: $E_k = hf - W$. In order for the photoelectric effect to take place, hf needs to be larger than W (in order to make E_k positive), since h is a constant, it follows that f needs to be above a certain value. Once photoelectrons are emitted, what determines their kinetic energy is the frequency of the incident EMR and the value of the work function. Since intensity is not part of the equation, it plays no role in determining the kinetic energy of the photoelectrons.

The **all or none principle** also has its own important consequences. If the photons have the right energy (this frequency) to cause a photoelectric effect, they may transfer all their energy instantaneously, so emission of the photoelectrons is instantaneous. However, if the photons have insufficient energy, then no energy is transferred. This effectively means there is no accumulation of the energy level of the electrons. Consequently no matter how long they are illuminated by the photons, their energy will never exceed the threshold value to cause a photoelectric effect.

Although **intensity** has no effect on the kinetic energy, it does determine the number of photoelectrons released per unit time, if the frequency is above the threshold value. This is because intensity is a measure of how many photons are received per unit time. Higher intensity means more photons are bombarding the electrons, which means more photoelectrons are emitted. Since current is defined as the number of charges passing through a point in a second (recall: $I = \frac{dq}{dt}$), the more photoelectrons, the higher the current.

NOTE: However, it is important to note that if the frequency is below the threshold frequency, then the intensity has no influence on the photoelectric effect.

CHAPTER 11 FROM THE PHOTOELECTRIC EFFECT TO PHOTO CELLS

Later, when Millikan performed his experiment to analyse the relationship between the frequencies of the incident EMR and the kinetic energies of the photoelectrons released by different metal surfaces, he plotted them as shown in Figure 11.6. Not only he was able to verify Einstein's equation for the photoelectric effect, he was also able to determine a more precise value for h by examining the gradient of the line. This was the first time Planck's constant h could be derived experimentally. Before that, the value for h could only be determined empirically by fitting the mathematically derived black body radiation curve with the one obtained experimentally (in other words, by trial and error). This further strengthened the connection between the photoelectric effect, the black body radiation curve and Planck's hypothesis, which form the heart of quantum physics.

Applications of the photoelectric effect: The implementation

- Identify data sources, gather, process and present information to summarise the use of the photoelectric effect in:
 - photocells
- Identify data sources, gather, process and present information to summarise the effect of light on semiconductors in solar cells

We turn to the implementation part of the photoelectric effect. Two devices will be examined: photocells and phototubes (solar cells).

Photocells

Definition
Photocells are electronic devices with resistances that alter in the presence of light.

A fundamental photocell, called a phototube, consists of a low-pressure glass bulb, in which is embedded an anode and a large cathode coated with a photosensitive material. Figure 11.8 shows a schematic representation of a phototube.

Solid state photocells
Solid state photocells consist of semiconductor material that changes its electrical resistance when light strikes it. With no light, it has a high

The cathode is coated with a light sensitive material. Cathode with a large surface area to maximise the photoelectric effect. Electrons emitted in light strike the photosensitive cathode—the photoelectric effect.

Free electrons are easily accelerated towards the anode to produce the conductivity of the phototube.

Connected to a circuit.

Figure 11.8 The structure of a phototube.

11.9 Einstein's contributions to quantum physics and black body radiation

Planck is believed to have been the instigator of quantum physics. When Planck first proposed the idea of the quantisation of energy, it was thought to be radical and even Planck himself could not be convinced that this was true. However, when Einstein 'borrowed' this idea and used it to successfully explain the photoelectric effect, it provided convincing evidence to back up this radical hypothesis. Einstein's idea of the quantisation of the energy of light led many scientists at the time to realise there was a whole new area of physics opening up.

PFA H1

PFA H2

RO4

Secondary Source Investigation

PFA

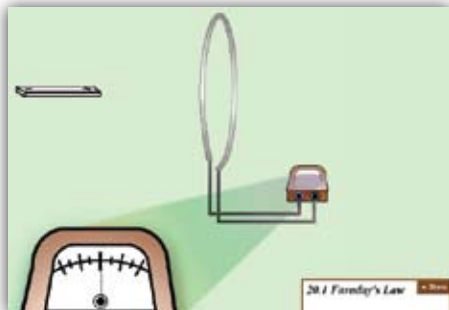
RO

SKILLS OUTCOMES

H12 SA, D
H13 1A, B, C, D, E
H14 1Q

Each text clearly indicates where Prescribed Focus Areas (PFAs) are being addressed and reduces the confusion surrounding these concepts by providing specific examples and information relating to these broader issues

Detailed figures and diagrams



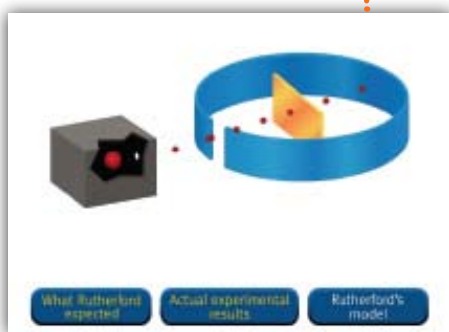
Faraday's Law

FREE STUDENT RESOURCE CD-ROM

The accompanying Student Resource CD-ROM aims to strengthen students' understanding of the topic by making available extra resources such as animated simulations, worked examples and further mathematical work related to the 'solve' and 'analyse' dot points. Extra features include module and option mind maps, videos demonstrating surgical procedures and answers to all chapter questions.

Simulations illustrate different physics concepts to aid understanding

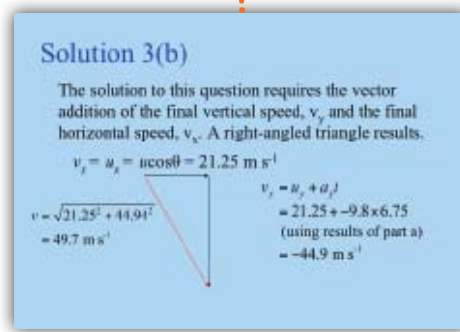
Worked examples take students through problems step-by-step



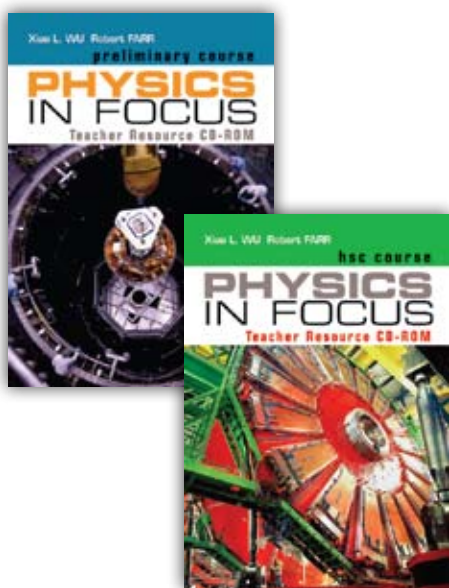
Interactive Rutherford Model



Time Dilation Isolate



Worked Example 3: Projectile Motion



RESOURCES FOR TEACHERS

The *Physics in Focus Teacher Resource CD-ROMs* have been designed in alignment with the student texts and offer a variety of supplementary material to assist teachers in planning lessons that are relevant and engaging.

KEY FEATURES

- Mapping the PFAs — chart illustrating the PFAs within the context of the Physics syllabus
- Working with the Verbs — a series of scaffolds that break down Board of Studies terminology and assist students in answering the higher order verb questions
- Marking rubrics and general marking criteria for extended response answers to higher order verb questions
- Sample answers for the higher order verb revision questions
- Risk Assessment Matrix

