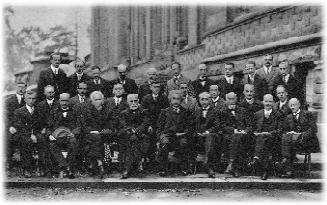
SPH4U UNIVERSITY PHYSICS

REVOLUTIONS IN MODERN PHYSICS: ...

- Introduction (P.568-571)

Matter & Energy

The turn of the 20th century was a time of excitement and turmoil in science. In 1888, Heinrich Hertz demonstrated the existence of radio waves and then, in 1895, Wilhelm Conrad Rontgen discovered X-rays. The following year, Antoine Henri Becquerel discovered radioactivity and, a year later, J.J. Thomson discovered the electron. Then, Philip Lenard observed the photoelectric effect in which light ejected electrons from metals.



Matter & Energy

Along with these discoveries came a number of puzzles. How could radioactive substances emit radiation without any apparent source of energy? Why could only certain colours of light eject electrons from metals? Why does each element give off a unique spectrum of light? How does light cross the vacuum of space between Earth and the stars? In this unit, we hope to discover the answers to these and other questions.

Overall Expectations

By the end of this unit, students will:

1. analyse, with reference to quantum mechanics and relativity, how the introduction of new conceptual models and theories can influence and/or change scientific thought and lead to the development of new technologies;
2. investigate special relativity and quantum mechanics, and solve related problems;
3. demonstrate an understanding of the evidence that supports the basic concepts of quantum mechanics and Einstein's theory of special relativity.

Big Ideas

Concepts that students should retain long after this course are:

- Light can show particle-like and wave-like behaviour, and particles can show wave-like behaviour.
- The behaviour of light as a particle and the behaviour of particles as waves can be described mathematically.

Big Ideas

Concepts that students should retain long after this course are:

- Time is relative to a person's frame of reference.
- The effects of relativistic motion can be described mathematically.
- New theories can change scientific thought and lead to the development of new technologies.

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

1. A child stands in the aisle of a train moving eastward at 40 m/s. For a short time, the child runs forward in the same direction as the train is moving at a constant speed, covering 15 m in 3 s.
   (a) Calculate the velocity of the child relative to an observer on the train.

(a) 5.0 m/s[E]

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

1. A child stands in the aisle of a train moving eastward at 40 m/s. For a short time, the child runs forward in the same direction as the train is moving at a constant speed, covering 15 m in 3 s.
   (b) Calculate the velocity of the child relative to an observer on the ground.

(b) 45 m/s[E]

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

1. A child stands in the aisle of a train moving eastward at 40 m/s. For a short time, the child runs forward in the same direction as the train is moving at a constant speed, covering 15 m in 3 s.
   (c) A second train moves westward at a speed of 30 m/s. Calculate the velocity of the child relative to an observer on the second train.

(c) 75 m/s[E]

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

2. For each situation, identify whether the person is in an inertial or a non-inertial frame of reference. Explain your choices.
   (a) a taxi driver accelerating away from a stop light

   (a) non-inertial FOR – taxi is accelerating

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

2. For each situation, identify whether the person is in an inertial or a non-inertial frame of reference. Explain your choices.
   (b) a child riding around the outer edge of a carousel

   (b) non-inertial FOR – centripetal motion = centripetal acceleration

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

2. For each situation, identify whether the person is in an inertial or a non-inertial frame of reference. Explain your choices.
   (c) a race car travelling at 200 km/h down a straight section of track

   (c) inertial FOR – uniform motion (constant speed & direction)

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

2. For each situation, identify whether the person is in an inertial or a non-inertial frame of reference. Explain your choices.
   (d) a driver backing straight back at a slow and constant speed

   (d) inertial FOR – uniform motion (constant speed & direction)

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

2. For each situation, identify whether the person is in an inertial or a non-inertial frame of reference. Explain your choices.
   (e) a student riding swiftly down the first hill of a roller coaster

   (e) non-inertial – coaster is accelerating down the hill

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

3. A student tries using two white LEDs as light sources in a double-slit interference experiment. Unfortunately, the student does not see the expected bright fringes. Explain why.

   the two sources are (a) out of phase, and (b) too far apart

Getting Started: Useful Concepts & Skills

CONCEPTS REVIEW

4. Match each term below with the most appropriate description.

(a) hypothesis	iii	(i) an explanation that has been tested and confirmed as a general principle to explain a natural phenomenon
(b) postulate	iv	(ii) a generally accepted formal statement about the occurrence of a natural phenomenon
(c) scientific theory	ii	(iii) a predicted answer to a testable question
(d) scientific law	i	(iv) a statement assumed to be true from which a theory is developed

Getting Started: Useful Concepts & Skills

SKILLS REVIEW

5. Use the wave equation to calculate the frequency of each of the wavelengths below.
   (a) 640 nm
   (b) 510 nm
   (c) 320 nm

   (a) 4.7×10^{14} Hz
   (b) 5.9×10^{14} Hz
   (c) 9.4×10^{14} Hz

Getting Started: Useful Concepts & Skills

SKILLS REVIEW

6. Which wavelength from the previous question has the highest energy?
   (a) 640 nm (4.7×10^{14} Hz)
   (b) 510 nm (5.9×10^{14} Hz)
   (c) 320 nm (9.4×10^{14} Hz)

   (c) 320 nm ($E = hf$ or hc/λ)

   NOTE!
   The smaller the wavelength the more energy it has. Recall that radio waves have a long wavelength (and thus little energy) so they do not hurt us. However, UV rays have a much shorter wavelength (and thus more energy) and they do hurt us (i.e. sunburns).