Physics
What's the Problem?

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PHYSICS

What's the problem?

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Authors' preface

The authors feel that many pupils find considerable difficulty in relating the problems which they are required to solve to the underlying theory. With a packed syllabus to cover, the teachers, however willing, cannot always find the time to develop the pupils' examination techniques as well as they would like to. It is hoped that '*Physics – What's the Problem?*' will go some way towards overcoming these difficulties.

The book is presented in such a way that it can be used by pupils who want an effective method of revising Ordinary Grade/Level Physics for examinations, or by pupils who want to improve their problem-solving techniques. In the introductory section on 'How to Use this Book', we have stressed that the book has been structured to cater for different individual needs. There are five units in the text covering the principal subject areas encountered in most O-Grade/Level courses (Waves, Mechanics, Heat and the Gas Laws, Electricity & Radioactivity). Within each Unit, the topics are covered by a sequence of examples to which **fully worked solutions are provided**. The examples and their solutions are printed in separate sections of the book so that the reader can study the material in a variety of ways.

S.I. Units have been used throughout, and all numerical calculations have been kept simple so that the physics is not obscured by a maze of complex arithmetic. The Worked Examples have been given a mark allocation but this is only included for guidance.

We hope that '*Physics – What's the Problem?*' will appeal to teachers searching for problems, and to pupils searching for answers.

Robert H. C. Neill

George Sydserff

Edinburgh, December, 1977.

Acknowledgments

We are indebted to our artist, Tony Merriman, for his excellent interpretation of our own, very basic sketches. His professional involvement in teaching physics and his irrepressible sense of humour are apparent in his illustrations and diagrams.

How to use this book

How this book is set out

There are five **UNITS** in this book, covering the five major topics of most Ordinary Grade/Level Physics courses:

unit W on **Wave motion**
unit M on **Mechanics**
unit H on **Heat and the gas laws**
unit E on **Electricity**
unit R on **Radioactivity**

Each Unit has two main parts:

(a) A set of questions presented in an acceptable teaching order.
(b) A corresponding set of detailed solutions to these questions.

In addition, each Unit has a batch of practice problems which are modelled on the above worked examples. Answers only are supplied for these practice problems and these are given at the end of the book.

There are several ways of using this book

- If you want a way to revise your physics course **quickly** for an examination, read each example in conjunction with its solution and work your way steadily through the Units.
- If you want to practice solving physics questions try to do each question yourself without looking at its solution. Then check your answer carefully against the solution provided.
- If you want to study questions on a particular topic (e.g. Ohm's Law) look up this topic in the index at the back of the book to find a list of all the relevant examples. Then study these carefully.

Remember to try the practice problems. They will test your progress.

Contents

UNIT W

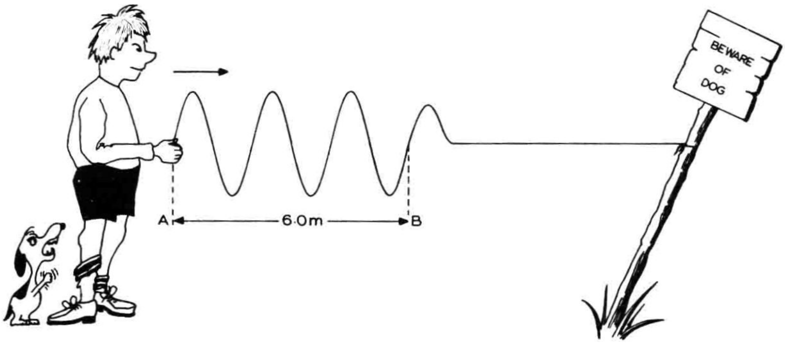
Wave motion

Content List of Topic Areas

Worked Examples

W1

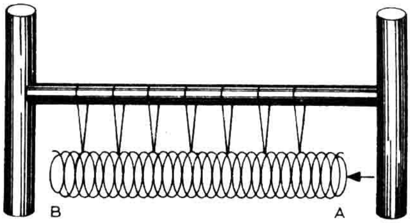
Introducing Dave, dog and travelling waves.



(a) Are the waves which Dave produces longitudinal or transverse? (1)
(b) Describe how he produces this wave motion in the rope (2)
(c) What name is given to the horizontal distance between one crest and the next crest? (1)
(d) What would this distance be if AB is 6.0 metres? (1)
(e) Dave makes 10 complete, up-and-down movements of his arm in 5.0 seconds. At what speed do the waves travel along the rope? (2)
(f) How long would it take one wave to travel the distance AB? (2)
(g) What would happen at the fixed end (the post) when the waves arrive? (1)

W2

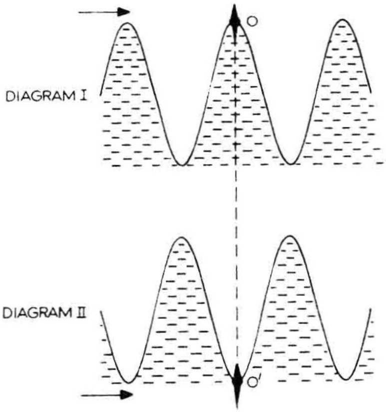
As you can see, physicists can be sportsmen too! This time, the rugby posts and the crossbar have come in useful for an experiment on wave motion. A long coil spring (or 'Slinky') is suspended horizontally by a number of strings attached to the crossbar.



(a) If the coils at end A are given a short, sharp push in the direction shown, what will happen? (2)
(b) End B is now fixed to the upright post. Describe what happens when end A is given another short, sharp push. (1)
(c) What kind of wave motion, longitudinal or transverse, is being produced in (a) and (b)? (1)
(d) How would you adapt the result observed in (a) to describe what happens when a long steel rod is hit, end on, with a hammer? (3)
(e) How would you measure the speed at which a pulse travels along the spring? (3)

W3

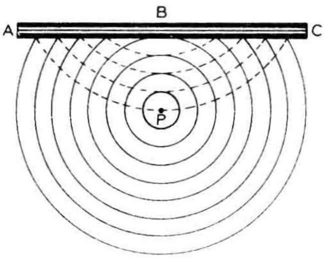
These two diagrams represent cross-sections, or profiles, of water waves produced by a plane wave vibrator in a ripple tank.
A small fishing float is shown on the water surface at O in diagram I. It is shown, 0.1 second later, in position O′ in diagram II. During this time interval, the wave moves to the right and the float drops to a position 2.0 cm below position O.



(a) What name is given to the part of the wave near to O in diagram I? (1)
(b) What name is given to the part of the wave near to O′ in diagram II? (1)
(c) If O and O′ are the highest and lowest positions of the float, what is the wave amplitude in the region near the float? (1)
(d) Calculate the frequency of the plane wave vibrator in Hz. (2)
(e) If the waves travel across the water at 20 cm s^{-1}, what is their wavelength? (2)
(f) Energy will be needed to raise the cork up to O again. Where will this energy come from? (2)
(g) Would the motion of the float be the same if it were repositioned further away from the source of the waves? (1)

W4

A point dipper P is moved in and out of the water in a ripple tank at a regular frequency, producing circular waves as shown. A flexible metal strip ABC acts as a barrier to the waves.

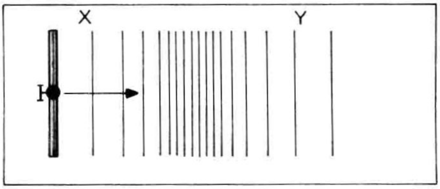


All of the waves shown in the above diagram were produced by the dipper in 0.5 s. The metal barrier is 0.02 m away from P.
(a) Calculate (i) the wavelength,
(ii) the frequency,
(iii) the speed of the waves. (3)

(b) What do the broken lines in the diagram represent? (1)
(c) What happens to (i) the speed, and (ii) the frequency of the waves after they strike the barrier? (2)
(d) What device could you use to produce an apparently stationary pattern like that shown in the diagram? Describe briefly how you would use the device you have chosen. (2)
(e) If ends A and C of the barrier are pulled down to make it curved, how would this affect the wave reflecting from the barrier? (2)

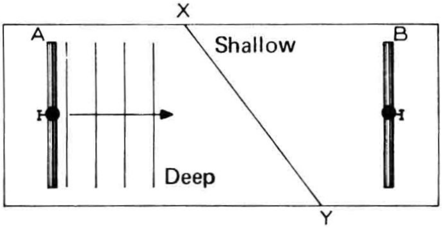
W5

(a) This is a pupil's eye view of a ripple tank. The vibrator is sending plane waves across the tank from left to right.



(i) What is happening to the waves over region XY? (2)
(ii) Explain how this effect is produced. A diagram would assist your answer. (3)

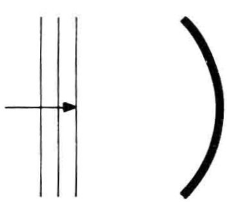
(b) In the ripple tank below, there are two wave generators, A and B. A is in the deeper water to the left of the line XY and B is in the shallower water to the right of XY. The generators produce waves of the same frequency.



(i) Draw a diagram of the waves produced in the tank when A is operating on its own. (3)
(ii) As in (i), but with B operating on its own. (2)

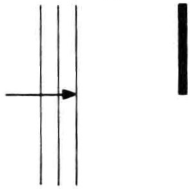
W6

(a) Copy and complete the diagrams shown. Each one represents plane waves encountering a barrier.

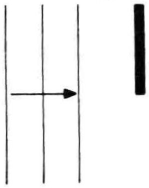


(i)

(ii)



(iii)



(iv)

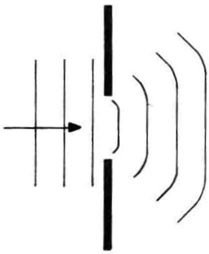
(6)

(b) In the study of water waves, what is meant by the terms constructive and destructive interference? Explain how each comes about. (2)

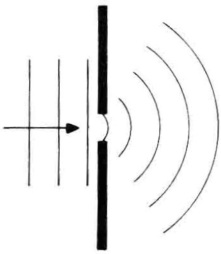
(c) A regular interference pattern is to be produced in a ripple tank by using two point dippers. Describe how you would set them up. (2)

W7

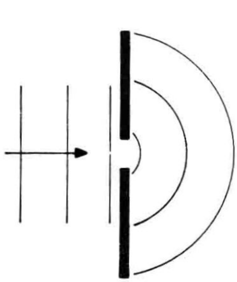
The following diagrams illustrate how plane water waves change shape when they pass through gaps in barriers.



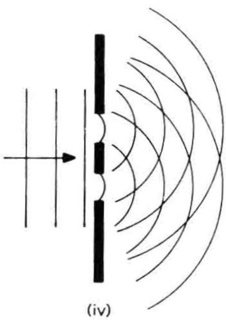
(i)



(ii)



(iii)

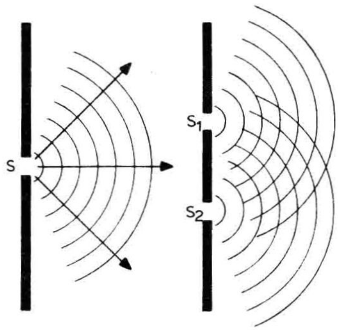


(iv)

(a) What is this bending effect called? (2)
(b) What do the diagrams indicate
  (i) about the relationship between the gap width and the amount of bending?
  (ii) about the relationship between the wavelength and the amount of bending? (4)
(c) A small barrier inserted into the wide gap of diagram (i) produces the wave pattern shown in diagram (iv). What other property of waves is now evident in the region where the waves overlap? Explain how such an effect comes about. (4)

W8

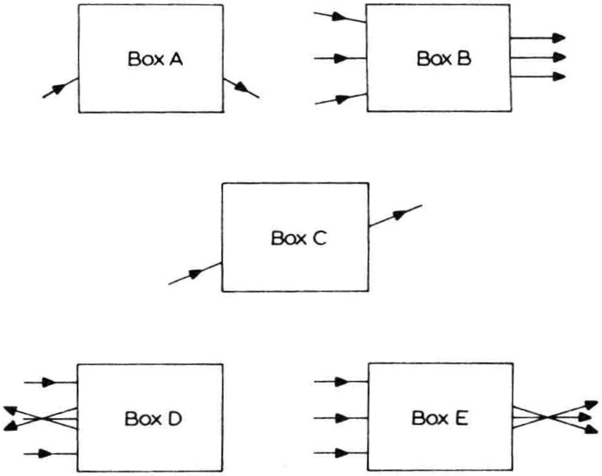
(a) Assuming that light has wave properties, what property of the wave would determine
  (i) the colour,
  (ii) the brightness, or intensity, of the light? (2)
(b) Explain why red light shows more diffraction than blue light when each is passed in turn through a very narrow slit. (2)
(c) The diagram below represents an interference effect that can be readily produced with light waves.



(i) Suggest a suitable source of light for this experiment. (1)
(ii) How would you construct the double slit arrangement S_1 and S_2? (2)
(iii) How would you view the interference effect? (1)
(iv) Describe briefly what you would expect to see. (2)

W9

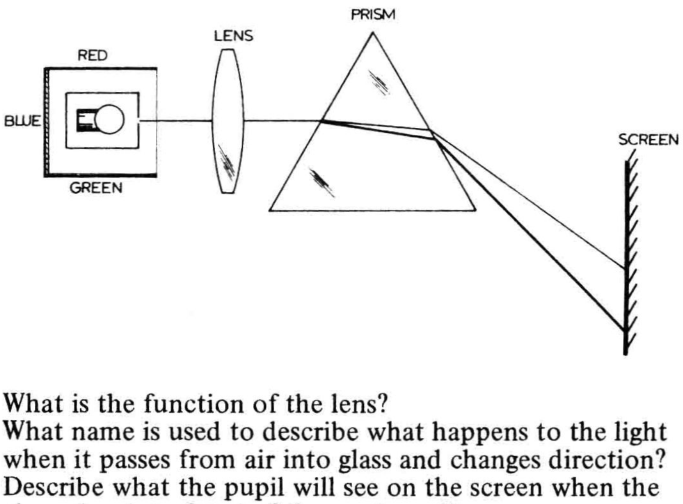
Each of the following diagrams shows a ray (or rays) of white light entering boxes which have glass windows on two opposite sides. Looking from above, it is impossible to see what is inside each one. The contents of the boxes affect the light in the following ways:



Copy and complete the diagrams to show the contents of each box and the effect of the contents on the light. (5 x 2)

W10

A pupil modifies a ray box by surrounding it with a rigid structure of three colour filters and a piece of clear glass. She then places it, along with a lens, in front of a glass prism. The ray diagram obtained with the clear glass transmitting the light is shown below.



(a) What is the function of the lens? (1)

(b) What name is used to describe what happens to the light when it passes from air into glass and changes direction? (1)

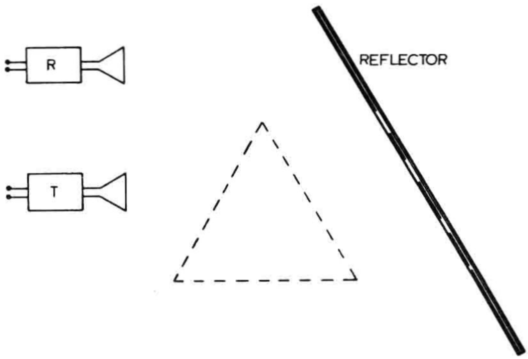
(c) Describe what the pupil will see on the screen when the clear glass is in front of the ray box slit. (2)

(d) What will she see on the white screen when each colour filter is placed, in turn, in front of the ray box slit? (2)

(e) She then demonstrates to her friend that infra-red radiation is falling on the screen when the clear glass is in position.
  (i) What kind of detector could she use to detect the infra-red radiation? (2)
  (ii) Where should she place the detector to pick up an infra-red signal near the screen? (2)

W11

In the diagram, T represents a short wave radio transmitter, often referred to as a microwave transmitter. R is a receiver which is connected to an amplifier and loudspeaker unit. The transmitter is positioned in front of a reflector as shown.

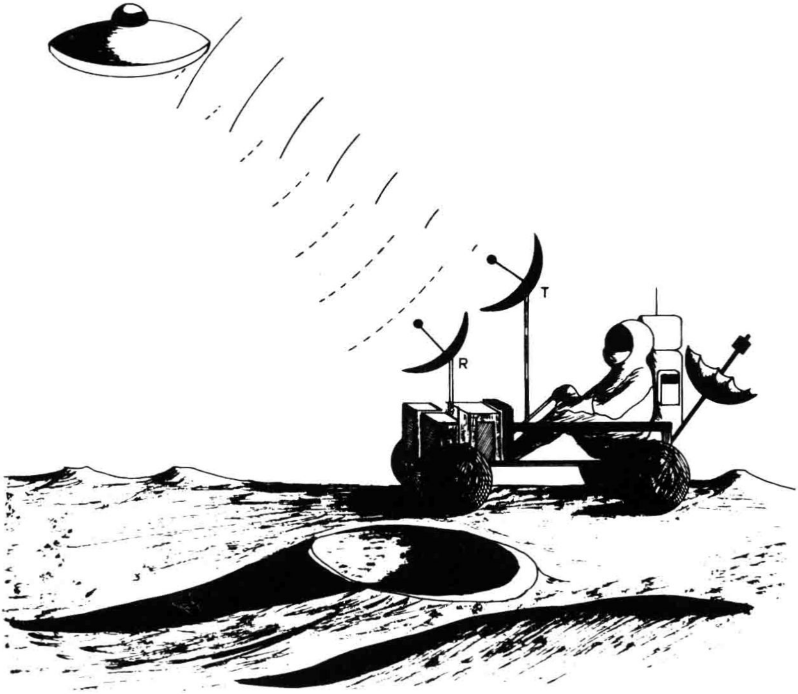


(a) What material would make a suitable reflector? (1)
(b) Draw a diagram to show where the receiver should be placed to obtain the maximum reflected signal. (2)
(c) A prism filled with paraffin is placed over the dotted outline and the receiver is then repositioned for maximum reception. Redraw the diagram to show the path taken by the microwaves and to show where the receiver should now be placed. (3)
(d) If other pieces of suitable reflector are available, show how you would demonstrate to a friend that wave interference is possible with microwaves. (4)

W12

Our roving, lunar radar station consists of a transmitter T, a receiver R and a monitoring oscilloscope. The transmitter sends out regular pulses of high frequency radio waves and these are reflected back from distant objects to the receiver. The monitor is an oscilloscope which displays the received pulses on the screen. In practice, the objects are so far away, compared with the distance separating T and

R, that the reflected waves reaching the receiver travel in almost the same straight line as the outgoing waves.



(a) The frequency of the transmitter is 1.5×10^{10} Hz and the radio waves travel at 3.0×10^{8} m s^{-1}. Calculate the wavelength of the waves. (2)

(b) If the time lapse between the transmission of a pulse and the reception of its reflection from a stationary object is 3.0×10^{-4} s, how far away is the target? (2)

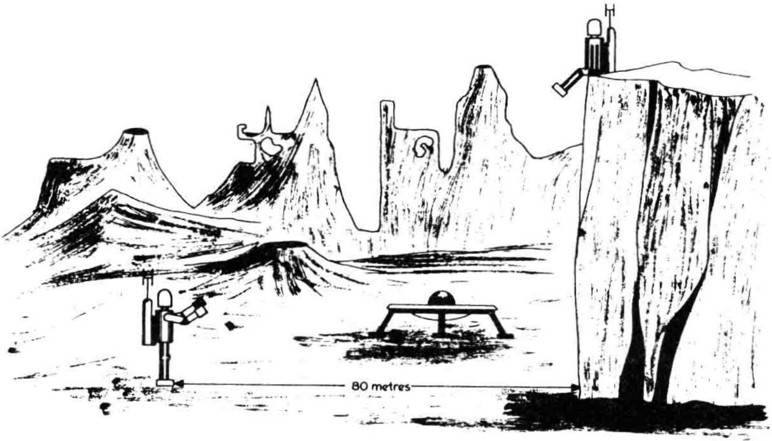
(c) Would the rarer atmosphere on the Moon have much effect on the speed of the radio waves? (2)

(d) Why would targets made of metal give traces of greater amplitude on the monitor screen? (2)

(e) If the lunar 'buggy' is stationary and the time between sending out a pulse and receiving its echo is decreasing, what does this tell you about the target? (2)

W13

A robot on planet X walks slowly back from a vertical rock wall clapping his 'hands' once every two seconds.



When he is 80 metres from the wall, his recording system registers sound echoes exactly mid-way between claps.

(a) (i) At what frequency will echoes reach the robot's sensors? (1)

(ii) Use the above information to calculate the speed of sound on planet X. (3)

(iii) What does this value for the speed of sound suggest about the atmosphere on planet X? (2)

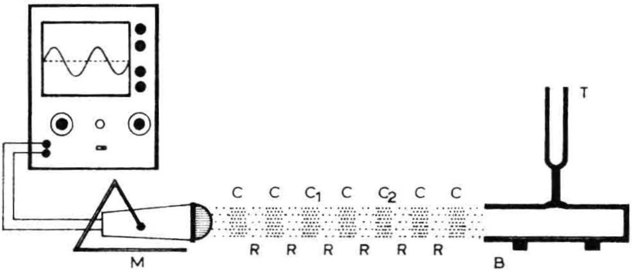
(b) A second robot seated on top of the rock wall 'hears' each clap 1.25 s after it is produced.

(i) How far apart are the robots? (2)

(ii) How high is the rock wall? (2)

W14

A tuning fork T, attached to a box amplifier B is set vibrating and it produces sound waves in the air. The waves are picked up by a microphone M, which is connected to an oscilloscope as shown. The air between B and M has been represented in diagrammatic form.



(a) What advantage is there in attaching the tuning fork to a wooden box, B, which is open at one end? (1)

(b) What do the letters C and R on the diagram stand for? (2)

(c) What kind of waves are sound waves? (1)

(d) If the frequency of the tuning fork is 600 Hz, calculate