OXFORD CAMBRIDGE AND RSA EXAMINATIONS

ADVANCED SUBSIDIARY GCE

G492

PHYSICS B (ADVANCING PHYSICS)

Unit G492: Understanding Processes / Experimentation and Data Handling

INSERT

MONDAY 6 JUNE 2011: Afternoon
DURATION: 2 hours

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

INSTRUCTIONS TO CANDIDATES

- **This insert contains the article required to answer the questions in Section C.**

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- **Do not send this insert for marking; it should be retained in the centre or destroyed.**

DC (CW/SW) 11MEP06322 47823

1 USING THE SPEED OF WATER WAVES TO DETERMINE *g*

You may wish to try out these ideas in the laboratory so that you know in advance what the difficulties might be, how the experiment works and how the data can be used.

The simple arrangement of Fig. 1 can be used to carry out the practical task.

v = velocity of the waves
d = depth of water

Fig. 1

Waves can be generated in a number of ways, such as pushing a ruler to and fro in the water, or just simply lifting one end of the tank about 1 cm and then lowering it quickly onto the bench.

The depth of water can be easily changed, but the velocity of the wave can prove to be problematic to measure. Although simple, the most practical way of measuring the speed is to use a stop watch to time how long the waves take to travel the length of the tank and back again. The velocity can then be calculated. In making these measurements, it is important to consider possible systematic errors.

The relationship $v = \sqrt{gd}$ can be applied to the experimental data and used to determine a value for g, the acceleration due to gravity.

2 ROLLING FRICTION IN BICYCLE TYRES – INTERPRETING TRENDS IN DATA

In the competitive world of bicycle manufacturing, it is widely recognised that it is very difficult to compare the performance of different tyres due to the fact that there are many unwanted variables such as differing tyre constructions, sizes, widths, treads and designed running pressures.

One simplified way of looking at the performance of tyres is to attempt to measure the relationship between rolling friction and inflation pressure for different tyres. The greater the rolling friction, the greater the energy losses in travelling.

The rolling friction for two types of tyres was measured in the same apparatus under the same conditions. In the test, a bicycle wheel rotating at a fixed speed was placed on rollers and the time taken for it to slow down to a stop was measured (Fig. 2).

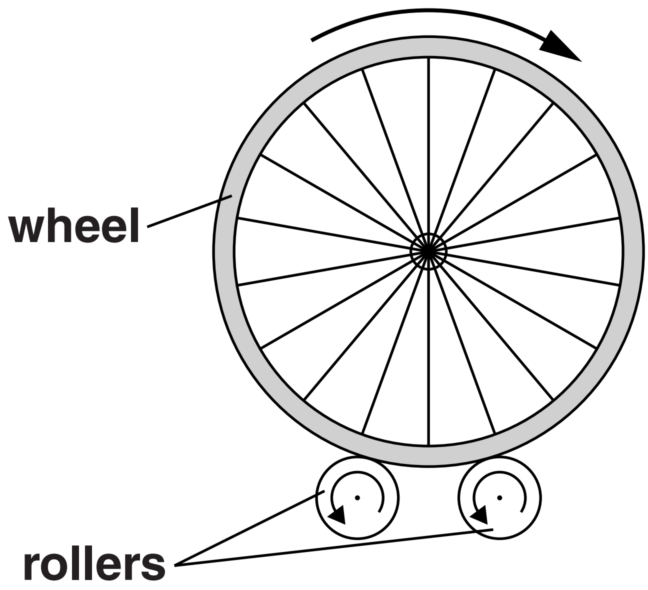

Fig. 2

From this time, the force of rolling friction could be calculated. The test was repeated at a range of inflation pressures for three examples of each tyre.

The table below gives the data produced in the measurements.

INFLATION PRESSURE / $N\,cm^{-2}$	ROLLING FRICTION / N					
	TYPE A TYRES			TYPE B TYRES		
	TYRE 1	TYRE 2	TYRE 3	TYRE 1	TYRE 2	TYRE 3
35	5.76	5.96	5.75	4.80	4.83	4.82
40	5.22	5.40	5.20	4.37	4.37	4.36
45	4.83	5.03	4.80	3.99	4.01	3.98
50	4.52	4.74	4.55	3.73	3.72	3.73
55	4.27	4.49	4.29	3.51	3.50	3.50
60	4.02	4.20	4.02	3.34	3.33	3.65
65	3.79	3.99	3.77	3.20	3.22	3.18
70	3.62	3.79	3.62	3.09	3.06	3.09
75	3.48	3.65	3.46	2.97	2.97	2.95
80	3.35	3.55	3.36	2.86	2.85	2.86

Inspection of the data, without any calculation, suggests that the tests on one tyre were subject to a systematic error.

Furthermore, patterns can be seen which reveal characteristics of the different types of tyre.

3 ERATOSTHENES' MEASUREMENT OF THE EARTH'S CIRCUMFERENCE

Eratosthenes, a Greek mathematician, poet, athlete, geographer, and astronomer, was born in 276 BC. He lived in Egypt, which then belonged to Greece. He made several discoveries and inventions including a system of latitude and longitude. In about 240 BC he was the first person to calculate the circumference of the Earth (with remarkable accuracy), using trigonometry and knowledge of the angle of elevation of the Sun.

The calculation was based on the assumption that the Earth is spherical and that the Sun is so far away that its rays can be taken as parallel.

At Syene (now Aswan), the Sun would appear at noon on the summer solstice at the zenith, directly overhead, as its reflection could be seen at the bottom of a deep well. Eratosthenes also knew, from measurement of the length of a shadow cast by a vertical post, that in his hometown of Alexandria, at noon on the same date, sunlight fell at an angle of about 7° from the vertical. This is shown in a sectional view through the Earth in Fig. 3.

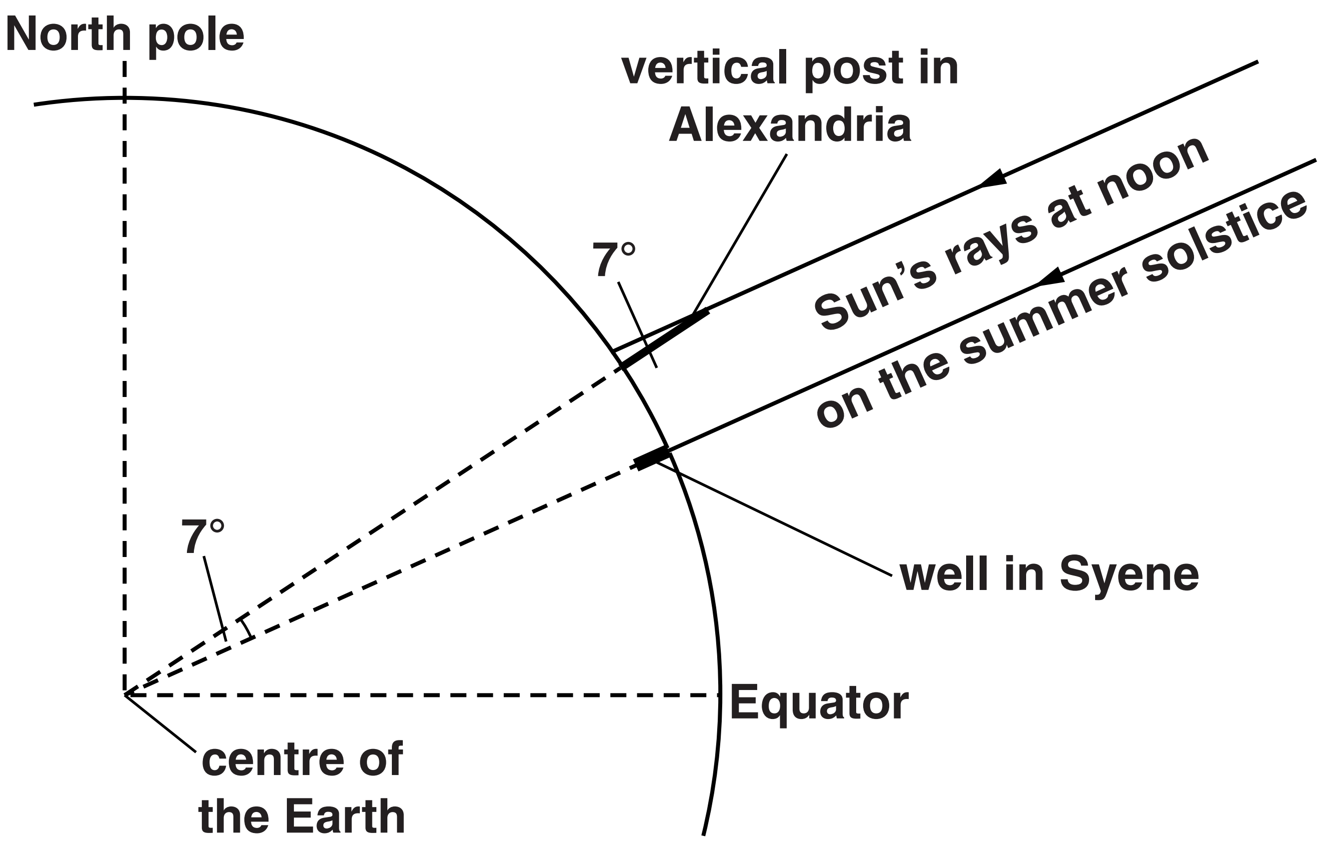

Fig. 3

Eratosthenes concluded that the distance from Alexandria to Syene must be 7/360 of the total circumference of the Earth.

It is believed that Eratosthenes calculated the distance between Syene and Alexandria from the time taken for a caravan of camels to travel between them. The Greek unit of distance was the *stadion* (plural *stadia*). This was originally the length of an athletics field. A camel caravan travelled about 100 stadia each day, and took 50 days to travel between Syene and Alexandria, implying that they are 5000 stadia apart.

Eratosthenes calculated the distance along the Earth's surface corresponding to one degree of longitude, and rounded his result to 700 stadia per degree. This gave him a value for the Earth's circumference of 252 000 stadia. The Greek stadion and Egyptian stadion were slightly different and it is not certain which Eratosthenes used. Combining them gives a value of 170 m with an uncertainty of about 5%.

In his calculations, Eratosthenes assumed that Syene was due south of Alexandria. In fact, it is east of south, as shown in Fig. 4. This systematic error would not have greatly affected his accuracy, as the percentage uncertainty involved in his measurement of the angle of the shadow to $\pm 1^\circ$ was much greater.

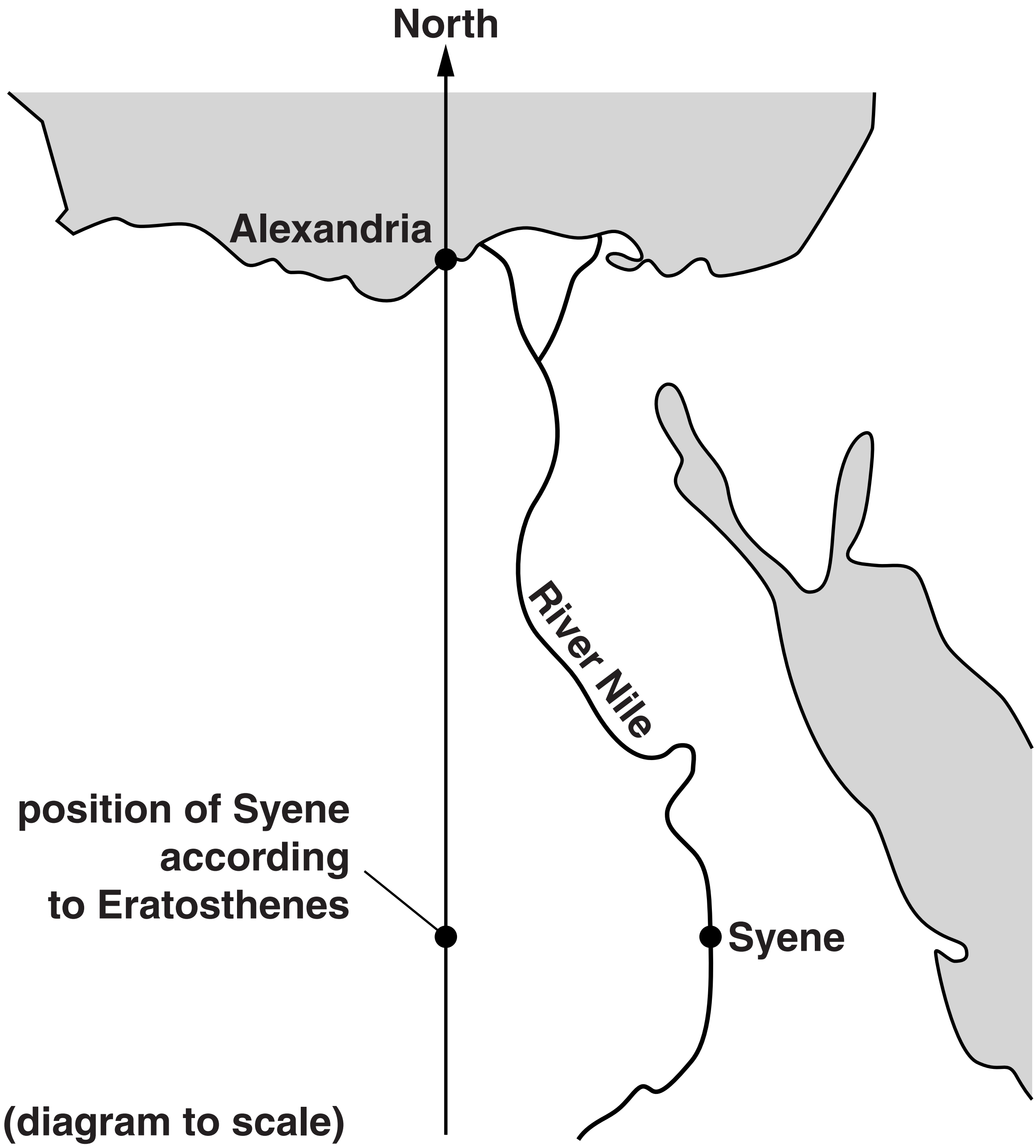

Fig. 4

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