RECOGNISING ACHIEVEMENT

Friday 18 January 2013 – Morning

AS GCE PHYSICS B (ADVANCING PHYSICS)

G492/01 Understanding Processes / Experimentation and Data Handling

INSERT

Duration: 2 hours

G411650113

INSTRUCTIONS TO CANDIDATES

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

INFORMATION FOR CANDIDATES

- This document consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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1 Simple measurements of stress and strain

You may wish to try this experiment at school. Remember to apply the appropriate safety procedures.

Using simple equipment, the stress and strain of common metal wires like copper can easily be measured and the Young modulus of the material obtained. Fig. 1.1 shows a basic arrangement of the apparatus.

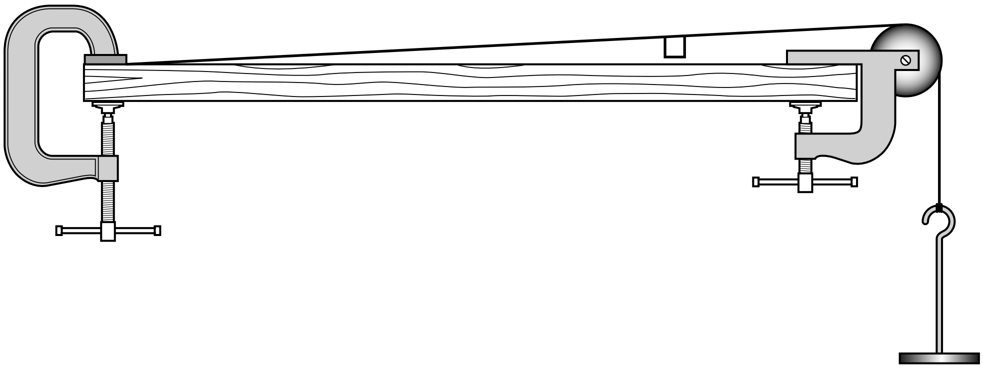

Fig. 1.1

A micrometer should be used to make measurements of the wire's diameter. It is important to note the limitations of the measuring equipment, particularly the resolution, as well as the need to repeat measurements. Another priority is to identify which measurement produces the most significant uncertainty, as uncertainties in the measurements will produce uncertainties in the calculated values of the stress and strain. Design of the experiment must take into account the fact that the strain must be kept low (below 1%) for any extension to be elastic.

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2 The performance of wind turbines

Wind turbines are increasingly being used as viable alternatives to the burning of fossil fuels for generating electricity. It is therefore important that the performance of different commercially-produced wind turbines can be measured and compared.

Results from a comparison of the power outputs of three small turbines **A**, **B** and **C** for a range of wind speeds are shown in Table 2.1. The three turbines were all designed to work at this range of wind speeds in similar conditions.

	Power output / kW		
Wind speed / $m\,s^{-1}$	**Turbine A**	**Turbine B**	**Turbine C**
0	0.00	0.00	0.00
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.11	0.08
4	0.08	0.33	0.30
5	0.50	0.66	0.69
6	0.97	1.14	1.17
7	1.48	1.76	1.73
8	2.20	2.51	2.37
9	3.06	3.39	3.34
10	4.22	4.16	4.13

Table 2.1

Different conditions require different designs of turbines. The size of the blades and their angle of tilt to the oncoming wind will affect the amount of air ‘trapped’. Also, wind speeds vary greatly with height and with geographical location.

However, one important variable to consider for any turbine is the area swept out by the rotor blades, as shown in Fig. 2.2. The electrical output of a wind turbine is directly related to this area, so the larger the area swept out by the rotor blades, the higher the output.

A modest increase in the rotor diameter will lead to significant increases in both the area swept out by the rotor blades and the amount of electricity that the turbine can generate.

Table 2.3 shows the dependence of the maximum theoretical power output for different rotor diameters in a constant wind speed of $10\,m\,s^{-1}$.

Rotor diameter/m	Theoretical power output/kW
1	0.4
2	1.6
4	6.3
6	14.1
8	25.1
9	31.8

Table 2.3

The actual power production from a wind turbine will be influenced by many other factors, such as the efficiency, the height at which the turbine is located, and internal friction. For a particular wind speed, it is expected that the power output *P* will be directly proportional to the area *A* swept out by the rotor blades:

$$P = kA$$

where *k* is a constant.

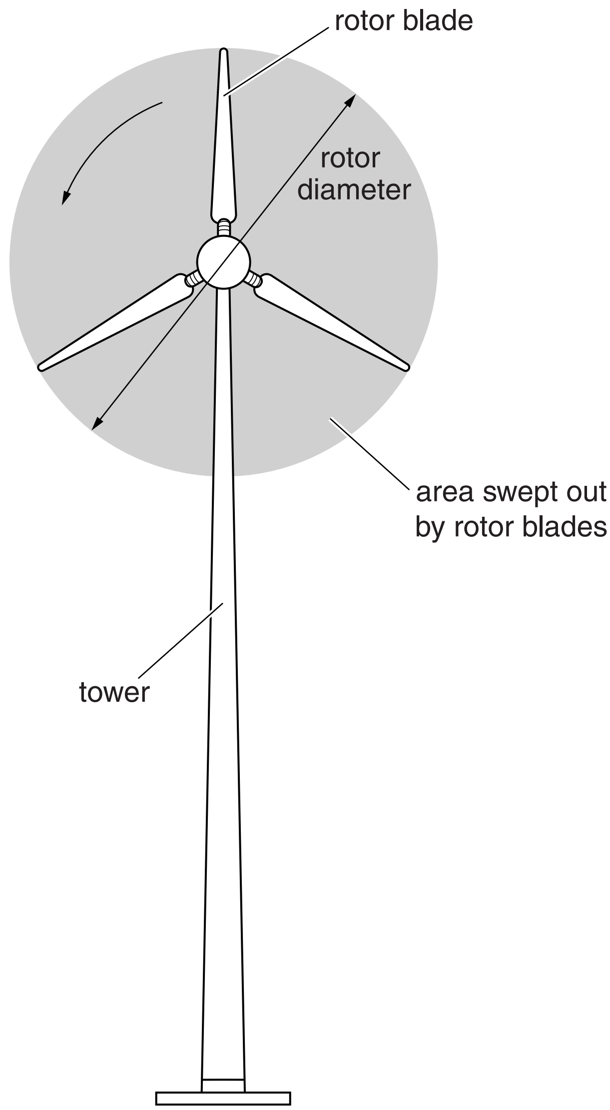

Fig. 2.2

3 Calculating longitude

The most common way to locate places on the surface of the Earth is by using co-ordinates called **latitude** and **longitude**, as shown in Fig. 3.1. These co-ordinates are measured in degrees, and represent specific places on the Earth. Calculating latitude is straightforward and latitudes have been known accurately for well over 2000 years.

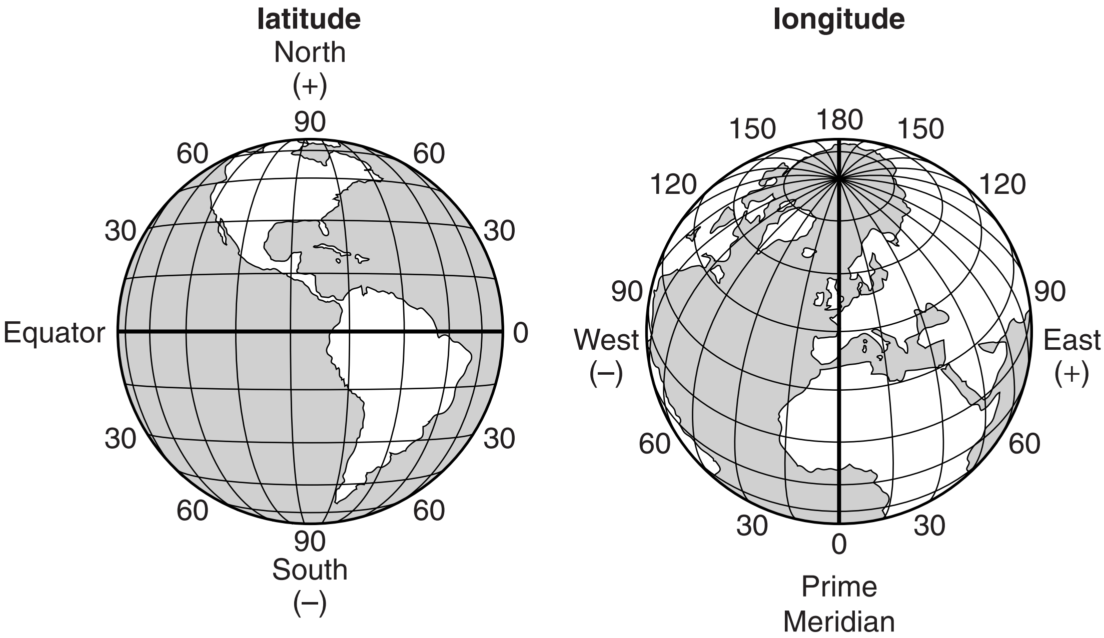

Fig. 3.1

Lines of longitude, called meridians, run perpendicular to lines of latitude, and pass through both Poles. By international agreement, the meridian line through Greenwich, in London, is given the value of zero degrees of longitude. This is known as the Prime Meridian.

Longitude is the angle between the Prime Meridian and any point east or west of it on the surface of the Earth. It takes 24 hours for a complete rotation of the Earth (relative to the Sun) and the circumference of the Earth can be divided into 360° of longitude.

If the difference between local time and Greenwich Mean Time (GMT) is known, then the longitude can be calculated. If your local time is ahead of GMT, you are to the east of Greenwich; if your local time is later, you are to the west. In each case, there are 15° of longitude for each hour of difference between local time and GMT.

Precise calculations of longitude require accurate and reliable time measurements. This was a problem that vexed civilisation for a long time. Near the Equator, one degree of longitude corresponds to approximately 100 km, so measurements need to be made to within a fraction of a degree, corresponding to a time of less than a minute. Very accurate pendulum clocks have been made since the beginning of the 18th century. Making an accurate clock which would stay in time for many months when carried around the world on a ship, so that you could always know the correct Greenwich time, presented a number of difficulties for navigators. It was not until the end of the 18th century that a suitable mechanical clock was made by John Harrison. This clock did not use a pendulum.

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