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RECOGNISING ACHIEVEMENT

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced GCE**

# SCIENCE 2846/01

Science and Global Processes

Tuesday **20 JUNE 2006** Morning 1 hour

Candidates answer on the question paper.
Additional materials:
Electronic calculator

| Candidate Name | Centre Number | Candidate Number |
|---|---|---|
| | | |

**TIME** 1 hour

## INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully to make sure you know what you have to do before starting your answer.

## INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Qu.** | **Max.** | **Mark** |
| **1** | **16** | |
| **2** | **10** | |
| **3** | **18** | |
| **4** | **16** | |
| **TOTAL** | **60** | |

**This question paper consists of 11 printed pages and 1 blank page.**

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Registered Charity Number: 1066969
**[Turn over**

Answer **all** the questions.

**1** The location of a place – its latitude, longitude and altitude – can be determined using GPS (global positioning system). The system is based on a 'constellation' of 24 satellites orbiting the Earth. Each satellite is continuously giving out signals that identify the satellite and the exact time at which the signal is sent. Signals are detected by GPS receivers on Earth. By calculating the time taken for a signal to reach it, a receiver can measure how far it is from a particular satellite. Using signals from different satellites, a receiver is able to pinpoint its own location.

All GPS satellites transmit electromagnetic radiation on the same frequency: 1575.42 MHz. The satellites orbit at a height of 20 200 km above sea level.

**(a) (i)** Write 20 200 km, in standard form, in metres.

..... m [1]

**(ii)** Calculate the time taken for a signal from a GPS satellite to travel 20 200 km to Earth. Take the speed at which electromagnetic radiation travels to be $3.00 \times 10^8\,\text{m}\,\text{s}^{-1}$.

time = ..... s [3]

**(b) (i)** To how many significant figures is the frequency of 1575.42 MHz given?

..... [1]

**(ii)** Electromagnetic radiation is a transverse wave.
Explain what is meant by the terms *transverse* and *electromagnetic*.

transverse .....

.....

electromagnetic .....

..... [3]

**(c) (i)** The speed of electromagnetic radiation depends on the density of the material through which it travels. Explain why, in reality, the speed of a signal given out by a GPS satellite changes as it travels to a receiver.

.....

.....

..... [2]

**(ii)** Fig. 1.1 shows the path of a ray of electromagnetic radiation.
Complete Fig. 1.1 to show what happens to the ray when it passes into the more dense material.

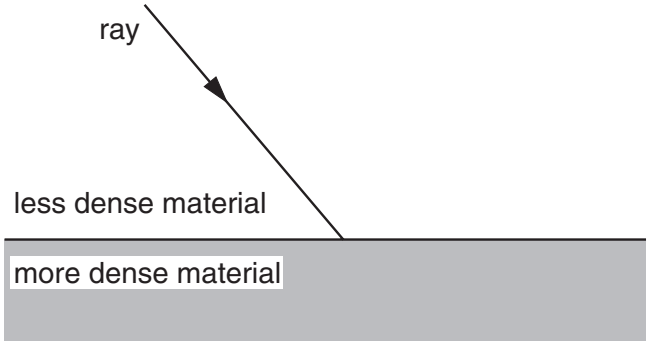


**Fig. 1.1**

[1]

**(iii)** Name the process shown in the completed Fig. 1.1.

..... [1]

**(d)** RADAR, like GPS, uses electromagnetic radiation.
RADAR is a form of active remote sensing.
Outline the technique used in active remote sensing.

.....

.....

.....

.....

.....

..... [4]

[Total: 16]

**2** **(a)** Scientists have found that the town of Camborne, in Cornwall, 'bounces' up and down by 100 mm approximately twice each day. Camborne has been found to have the biggest 'bounce' of anywhere in the UK. The change in altitude is caused by the tides, which change the weight of water on the continental shelf around the coast. At high tide, the greater weight of water pushes the UK further into the Earth than at low tide.

The time interval between successive high tides is 12.5 hours.
The change in altitude at Camborne is 100 mm.
The 'bouncing' is similar to simple harmonic motion.

**(i)** Sketch a displacement/time graph for the change in altitude of Camborne on Fig. 2.1. Include appropriate scales on your sketch.


**Fig. 2.1**

[3]

**(ii)** Label your graph to show a point at which Camborne is rising most rapidly. [1]

**(iii)** Suggest **one** benefit of knowing to what extent a place 'bounces' like this.

.....

..... [1]

**(iv)** State **one** other natural phenomenon that varies with time in a way similar to simple harmonic motion.

..... [1]

**(b)** The lithosphere is one layer in a model for the structure of the Earth.

**(i)** Where is the lithosphere?

..... [1]

**(ii)** Name **one other** layer in this model for the structure of the Earth.

..... [1]

**(iii)** Models for the layered structure of the Earth arise from observation and measurement.

Describe how **one** type of observation has been important in establishing that the Earth has a layered structure.

.....

.....

.....

..... [2]

[Total: 10]

3 Fig. 3.1 shows the directions of ocean currents in the southern part of the Pacific Ocean. The ocean currents are driven by the prevailing winds. The coupling of ocean and atmosphere also leads to an area of high atmospheric pressure near South America and an area of low atmospheric pressure near Australia.

**A diagram has been removed due to third party copyright restrictions**

Details:

A diagram showing the directions of ocean currents in the southern part of the Pacific Ocean.

Fig. 3.1

(a) State two factors, other than prevailing winds, that influence the direction of ocean currents.

1. .....

2. ..... [2]

(b) At intervals of 4 – 10 years, this pattern of ocean/atmosphere behaviour changes. The warm equatorial current now flows from Australia to South America, and the positions of the areas of low and high atmospheric pressure are reversed. This is called an El Niño event. It is also known as the Southern Oscillation. Typically it lasts for about 9 months.

(i) Suggest why the term Southern Oscillation is used to describe such an event.

.....

.....

..... [2]

(ii) Suggest two ways in which an El Niño event affects the climate of the neighbouring region of South America.

1. .....

2. ..... [2]

**(c)** Water has an unusually high specific heat capacity.

**(i)** What is the meaning of the term *specific heat capacity*?

.....

.....

..... [3]

**(ii)** Explain why the high specific heat capacity of water has a significant effect on the temperature of a coastal region.

.....

.....

..... [2]

**(iii)** Hydrogen bonding is one type of intermolecular bonding present in water. How is a hydrogen bond formed?

.....

.....

.....

..... [3]

**(iv)** Explain, in terms of the behaviour of molecules, why water has an unusually high specific heat capacity.

.....

.....

.....

.....

..... [4]

[Total: 18]

**4** A disused Cornish tin mine, at Botallack, has been identified as the site for a project to harness the power of the Atlantic waves to generate electricity. The mine head is sited on top of cliffs, next to the sea. The mine has a vertical shaft, containing air, that is connected below sea-level to a horizontal tunnel, filled with seawater. As waves pound into the cliff, seawater is pushed into the tunnel. This forces air up the shaft. Air is sucked back, down the shaft, as waves retreat. Electricity is generated by a turbine, housed in the shaft. The turbine is driven by the flow of air up and down the shaft.

**(a)** Draw a labelled diagram to illustrate this wave power project.

[4]

**(b)** Air is forced through the shaft at speeds up to $100\,m\,s^{-1}$.
Assume that the average air speed is $50\,m\,s^{-1}$.
Assume that the shaft has a circular cross-section with a radius, $r$, of 1 m.

**(i)** Calculate the cross-sectional area, $A$, of the shaft.
($A = \pi r^2$, where $\pi = 3.14$)

$A$ = ..... $m^2$ [1]

**(ii)** Calculate the average volume of air that passes through the turbine per second.

average volume = ..... $m^3$ [1]

**(iii)** The density of air, under normal atmospheric conditions, is $28.8\,kg\,m^{-3}$.
Calculate the average mass of air that passes through the turbine per second.

average mass = ..... kg [1]

**(c)** **(i)** Write down the equation that relates kinetic energy, $E_K$, to mass, $m$, and velocity, $v$.

..... [1]

**(ii)** Calculate the kinetic energy of the air that passes, on average, through the turbine per second. (Your answer will have units of J.)

kinetic energy = ..... J [1]

**(iii)** Assume that 40% of the kinetic energy of the air passing through the turbine is transferred to the turbine.
Calculate the average power generated by the turbine.
Give your answer in MW. ($1\,W = 1\,J\,s^{-1}$)

power = ..... MW [2]

**(d)** The power output of this wave power project is likely to be similar to that of a wind farm consisting of about 20 wind turbines. Suggest **two** advantages of the wave power project over generating power from wind turbines.

1. .....

.....

2. .....

..... [2]

**(e)** Waves and winds are renewable sources of energy. Fossil fuels (coal, oil and natural gas) are non-renewable sources of energy. Fig. 4.1 contains data about energy consumption in more economically developed countries (MEDCs) and less economically developed countries (LEDCs).

| type of country | energy consumption in 1989 / $10^{15}$ J | | | |
|---|---|---|---|---|
| | from fossil fuels | from renewable sources of energy | from nuclear energy | total |
| MEDC | 208 593 | 5 087 | 6 443 | 220 123 |
| LEDC | 75 143 | 2 593 | 340 | 78 076 |

**Fig. 4.1**

It is sometimes claimed that MEDCs (also called industrialised countries) rely more heavily on non-renewable sources of energy than do LEDCs (developing countries). Comment on this claim in the light of the data in Fig. 4.1.

.....

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.....

..... [3]

[Total: 16]

**END OF QUESTION PAPER**

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